RICHMOND ROAD UPGRADE
ELARA BOULEVARD TO HERITAGE ROAD
FLOODING AND DRAINAGE INVESTIGATION

VOLUME 1 - REPORT

DRAFT FOR CLIENT REVIEW

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S1 SUMMARY AND RECOMMENDATIONS

S1.1 Background and Report Layout

This report presents the findings of a flooding and drainage investigation that was undertaken by Lyall & Associates on behalf of Transport for NSW (**TfNSW**) to develop a concept drainage strategy for the planned upgrade of a section of Richmond Road in Marsden Park (**the project**). **Figure 1.1** (2 sheets) shows the route of the project, as well as the watercourses and minor drainage lines that are located in its vicinity.

Chapter 2 of this report provides a brief description of the three primary mechanisms of flooding which influence flood behaviour in the vicinity of the project. It also includes a brief description of the existing drainage system in the area. **Chapters 3** and **4** provide background to the development of the hydrologic and hydraulic models that were used to define the nature of flooding under pre- project conditions. The latter also includes a brief description of existing flood behaviour in the vicinity of the project under pre- project conditions. **Chapter 5** provides details of the concept drainage strategy that was developed as part of the present investigation, as well as a description of the impact that the project would have on flood behaviour under post-project conditions. **Chapter 6** outlines the requirements for the control of erosion and sediment transport during the construction phase of the project. A list of references referred to in this report is contained in **Chapter 7**. The figures referred to in this report are bound in a separate A3 document which is denoted **Volume 2 - Figures**.

S1.2 Present Day Flood behaviour

The corridor along which the project runs (**project corridor**) is subject to the following three primary mechanisms of flooding:

- **Hawkesbury-Nepean River Flooding**, which occurs when floodwater backs up the main arm of South Creek from the Hawkesbury-Nepean River.
- **Major Tributary Flooding**, which occurs when heavy rain falls over the South Creek catchment, causing floodwater to surcharge the banks of the watercourse and its major tributaries.
- **Minor Tributary Flooding**, which occurs when runoff is experienced in the minor drainage lines which cross the project corridor.

Backwater flooding from Hawkesbury-Nepean River Flooding commences to inundate Richmond Road where it crosses the floodplain of South Creek during events greater than 5% Annual Exceedance Probability (**AEP**) in magnitude. During a 1% AEP event depths of inundation along Richmond Road will exceed 3 m, when about a 1 km length of the project corridor would be inundated by floodwater. The road would be inundated for a period of several days during a Hawkesbury-Nepean River flood of this magnitude. Backwater flooding from the Hawkesbury-Nepean River will also inundate a section of Richmond Road at its low point that is located about 480 m to the north of Elara Boulevard during events greater than 1% AEP in magnitude.

Figure 4.2 (2 sheets) shows the indicative extent of Hawkesbury-Nepean River Flooding in the vicinity of the project corridor for design floods with AEPs of 20%, 10%, 5%, 2%, 1%, 0.05%, as well as the Probable Maximum Flood (**PMF**), while **Figures 4.3** and **4.4** (2 sheets each) show the indicative depth of inundation for a 5% and 1% AEP Hawkesbury-Nepean River flood event, respectively.

In addition to being impacted by backwater flooding from the Hawkesbury-Nepean River, sections of the project corridor are also impacted by Minor Tributary Flooding. For example, overtopping of Richmond Road occurs at its low point to the north of Elara Boulevard due to flow that surcharges an existing transverse drainage structure during a 20% AEP event.

Table 2.1 in **Chapter 2** of the report contains details of the existing transverse drainage, as well as the approximate hydrologic standard of Richmond Road in the immediate vicinity of each structure. **Table 4.2** provides a breakdown of the distribution of flow across Richmond Road due to local catchment runoff that approaches the transverse drainage structure that is located about 480 m north of Elara Boulevard (denoted herein as "transverse drainage structure EXD01"). **Figures 4.5** to **4.9** show the indicative extent and depth of inundation in the vicinity of the project corridor for a range of design flood events.

S1.3 Concept Drainage Strategy

Figure 5.1 (2 sheets) shows the layout of the concept drainage strategy that was developed as part of the present investigation, while **Table S1** at the end of this **Summary** provides details of the upgrade requirements for transverse drainage structure EXD01[1].

Richmond Road forms part of the flood evacuation strategy for the Hawkesbury Nepean Valley that is set out in the *Hawkesbury Nepean Flood Plan* (NSW State Emergency Service (**NSW SES**), 2015). As part of future improvements to the flood evacuation strategy it is proposed to upgrade the existing bridge over South Creek, which is located immediately to the north of the project corridor. In order to accommodate the future upgrade of the bridge, the concept road alignment rises from its tie in with the existing bridge over South Creek to a minimum elevation of RL 20.3 m AHD. It is noted that this minimum road elevation is approximately equal to the 0.2% AEP flood level due to Hawkesbury Nepean River flooding.

The minimum road level set by the proposed tie in with the future upgrade of the bridge over South Creek is higher than the minimum road level required to achieve a 0.2% AEP level of flood immunity against Minor Tributary Flooding, or to provide minimum cover over the upgraded transverse drainage structure PXD01.

The minimum road level set by the proposed tie in with the future upgrade of the bridge over South Creek would require raising the existing level of Richmond Road by up to 3 m. The increase in road level has the potential to obstruct flow that surcharges the inlet to transverse drainage structure PXD01 either as a result of a partial blockage and/or flows in excess of the culvert capacity. The design of transverse drainage structure PXD01 has therefore taken into consideration the potential for blockage, as well as the impact of the project on local catchment flooding for events up to the PMF.

S1.4 Impact of the Project on Flood Behaviour

<u>Hawkesbury-Nepean River Flooding</u>

In order to mitigate the impact that the project would have on peak flood levels associated with backwater flooding from the Hawkesbury-Nepean River it would be necessary to provide compensatory excavation to offset the volume of temporary floodplain storage that would be displaced by the proposed road works.

[1] The upgraded transverse drainage structure has been assigned the identifier "PXD01".

It is estimated that the project would displace a total volume of temporary floodplain storage of about 82,500 m^3, of which it would be feasible to offset about 6,000 m^3 through the provision of channels along both sides of the road. It would therefore be necessary to provide an additional 76,500 m^3 of compensatory excavation external to the project corridor in order to recapture all of the displaced temporary flood storage.

Major and Minor Tributary Flooding

Figures 5.2 to **5.6** (3 sheets each) show the impact that the project would have on Minor and Major Tributary Flooding for events with AEPs of between 20% and 0.2% as well as the PMF.

There would be an increase in the depth of overland flow along the drainage line downstream of transverse drainage structure PXD01, as well as the downstream reach of Unnamed Tributary No. 1 for all events up to the PMF. While the areas impacted are presently undeveloped, they form part of the future Marsden Park North Precinct. The *Draft Indicative Layout Plan for the Marsden Park North Precinct* (DPE, 2018) shows that the drainage line downstream of transverse drainage structure PXD01 is located in an area that is proposed for future commercial development, while impacts along Unnamed Tributary No. 1 are confined to areas of future drainage, environmental conservation or rural transition.

As part of the future commercial development to the east (downstream) of transverse drainage structure PXD01 it will be necessary to incorporate a drainage easement to convey flow from the structure to Unnamed Tributary No. 1. It is recommended that TfNSW liaise with Blacktown City Council to gain a better understanding of drainage provisions within the proposed future development precinct and to ensure that flows discharging from transverse drainage structure PXD01 are accommodated in the future development of the Marsden Park North Precinct.

There would be an increase in the depth and extent of inundation during the PMF in an area to the west (upstream) of transverse drainage structure PXD01 that is presently undeveloped but forms part of the future Marsden Park Precinct. It is recommended that TfNSW liaise with Blacktown City Council to gain a better understanding of finished levels of future development in this area and to ensure it is compatible with peak flood levels under post-project conditions. In this regard it will be necessary to confirm that the peak PMF level upstream of transverse drainage structure PXD01 of RL 20.0 m AHD does not result in hazardous flooding conditions to future development in this area.

Impact of Future Climate Change on Flood Behaviour

It is expected that there would be relatively minor increases in flood impacts attributable to the project under future climate change conditions given that there are only minor increases in flood level impacts between a 1% and 0.2% AEP event[2]. As the proposed road level is located above the PMF level due to local catchment flooding it was also concluded that flooding under future climate conditions would not impact the flood immunity of the road against Minor Tributary Flooding.

[2] The 0.2% AEP event was adopted as a proxy for assessing the sensitivity to an increase in rainfall intensity on the 1% AEP event due to future climate change.

S1.4 Erosion and Sediment Control Strategy

Providing that the construction of the project is staged in a manner that limits areas of disturbance to no greater than the control areas shown on **Figure 6.1** (2 sheets) then large scale sediment retention basins do not necessarily need to form part of the Soil and Water Management Plan (or similar) in order to comply with the guidelines set out in *"Soils and Construction – Managing Urban Stormwater"* Volume 1 (Landcom, 2004) and Volume 2D (DECC, 2008).

It is recommended that localised erosion and sediment control measures, including temporary sediment sumps where practicable, form the basis of a detailed Soil and Water Management Plan for the control of erosion and sediment that will need to be developed as part of the construction documentation for the project. **Figure 6.1** (2 sheets) shows the layout of the currently assessed erosion and sediment control strategy during the construction of the project.

TABLE S1
SUMMARY OF TRANSVERSE DRAINAGE

Catchment	Transverse Drainage Structure Identifier		Transverse Drainage Structure Dimensions		Upstream Invert Level (m AHD)	Downstream Invert Level (m AHD)	Peak 1% AEP Flood Level (m AHD)(1)	Peak 0.2% AEP Flood Level (m AHD)(1)	Minimum Road Level Requirements		
	Post-Project	Pre-Project	Existing	Proposed					Current Level (m AHD)(2)	Minimum Required Level (m AHD)	Constraint Type
Unnamed Tributary No. 1	EXD01	PXD01	3 off 600 mm diameter pipes	5 off 2400 mm x 1800 mm box culverts	16.83	16.52	17.9	18.1	20.5	19.9	Minimum Cover

1. Relates to Minor and Major Tributary Flooding in the absence of Hawkesbury-Nepean River Flooding.
2. Refers to elevation of road in the current version of the strategic design.
3. Based on 1.2 m cover to recommended pipe/culvert arrangement.

1 INTRODUCTION

1.1 Background

Transport for NSW (**TfNSW**) is currently developing a strategic design for the upgrade of Richmond Road where it runs between Elara Boulevard and Heritage Road in Marsden Park (**the project**). **Figure 1.1** (2 sheets) shows the route of the project in relation to the watercourses and major drainage lines that are located in its vicinity.

The objective of this present investigation was to undertake an assessment of flooding and drainage requirements associated with the proposed road works. The findings of the investigation will assist in the development of the strategic road design and the preparation of an environmental assessment for the road upgrade. The scope of work for the investigation broadly involved:

- the definition of flooding and drainage patterns in the vicinity of the project corridor under present day (i.e. pre-project) conditions;
- the development of a concept transverse and pavement drainage strategy for the project;
- an assessment of the impact that the project would have on regional type flood behaviour (denoted herein as "**Hawkesbury-Nepean River Flooding**");
- an assessment of the impact that the project would have on mainstream flooding in South Creek and its tributaries (denoted herein as "**Major Tributary Flooding**");
- an assessment of the impact that the project would have on flooding and drainage patterns in the local catchments that drain across the project corridor (denoted herein as "**Minor Tributary Flooding**"); and
- a preliminary assessment of erosion and sediment control requirements during the construction of the project.

This report deals with the findings of these investigations and recommends a series of measures that should be incorporated into the concept and detailed design of the project in order to mitigate the flooding and drainage related impacts associated with both its construction and operation phases.

1.2 Study Tasks

The study tasks were as follows:

- Undertake a review of previous studies and available data, including details of the planned developments within the Marsden Park and Marsden Park North precincts of the North West Growth Centre.
- Use available hydrologic and hydraulic models to define flooding patterns in the vicinity of the project corridor under present day conditions due to Hawkesbury-Nepean River Flooding.
- Update an existing hydrologic model and develop a new hydraulic model to define flooding and drainage patterns under present day conditions due to Minor and Major Tributary Flooding.

- Assess the requirements for the recapture of floodplain storage that will be displaced by the project in order to mitigate its impact on Hawkesbury-Nepean River Flooding.
- Undertake hydrologic and hydraulic analyses for post-project conditions to assess changes in Major and Minor Tributary Flooding and to determine transverse and pavement drainage requirements.
- Assess requirements for temporary sediment retention basins that may be needed along the project corridor to treat runoff from the project corridor during the construction phase of the project.

1.3 Outline of Report

Chapter 2 of this report provides a brief description of the catchments that contribute runoff to the existing transverse drainage along the project corridor, as well as the three mechanisms that influence flood behaviour along its length. Also provided is a brief overview of recent studies that have been undertaken to define flood behaviour in the vicinity of the project.

Chapter 3 provides background to the development of the hydrologic (DRAINS) model that was used to generate discharge hydrographs for input to the hydraulic (TUFLOW) model.

Chapter 4 provides background to the development of the TUFLOW model that was used to define flood behaviour in the vicinity of the project corridor under present day conditions. The model was also used to assess the impact the project would have on flood behaviour, as well as the transverse drainage upgrade requirements. This chapter also contains a description of flood behaviour along the project corridor under present day (i.e. pre-upgrade) conditions for a range of design storm events. Results are presented as plans showing indicative extents and depths of inundation for design storms with Annual Exceedance Probabilities (**AEPs**) of 20% (1 in 5), 5% (1 in 20), 1% (1 in 100), 0.5% (1 in 200) and 0.2% (1 in 500), as well as the Probable Maximum Flood (**PMF**).

Chapter 5 presents the findings of a preliminary assessment of the transverse and pavement drainage requirements for the project. Also presented are the findings of an investigation into the impact the project would have on flood behaviour should TfNSW adopt the concept drainage strategy that is set out in this report. Results are presented as plans showing the difference between peak pre- and post-project flood levels (referred to as “afflux”). The resulting change in the extent of inundation is also shown on the plans.

Chapter 6 provides a summary of the approach that was adopted in developing an erosion and sediment control strategy for the construction phase of the road upgrade works. This includes requirements for, and preliminary design of temporary control measures that will be required along the length of the project corridor.

Chapter 7 contains a list of references that are referred to in this report.

Volume 2 of the report contains all referenced figures.

1.4 Available Data

TfNSW made the following data available for the present investigation:

- Ortho-rectified aerial photography covering the study area.
- Detailed ground survey covering the project corridor.
- Airborne laser scanning (**ALS**) survey data covering the study area, which was flown in 2017 and 2019.
- Strategic road design models.
- Property boundary information in GIS format.
- Issued for Construction (**IFC**) drainage drawings associated with the *Upgrading of MR 537 Richmond Road at Marsden Park Precinct Access 2* project.

The following additional information was obtained from other sources:

- Draft Indicative layout plan for the Marsden Park North precinct (NSW Department of Planning and Environment (**DPE**), 2018)
- *Marsden Park North Precinct – Watercycle & Flood Management Strategy Report* (J. Wyndham Prince (**JWP**), 2018)
- Indicative layout plan for the Marsden Park precinct (NSW Department of Planning and Infrastructure (**DPI**), 2013)
- Draft catchment plan of the Marsden Park precinct (JWP, 2019).
- Marsden Park Residential Precinct Post Exhibition Water Cycle & Flood Management Strategy Report (JWP, 2013).
- Blacktown City Council NWGC Stormwater Management Strategy Review (Gutteridge, Haskins and Davey (**GHD**), 2018)
- *South Creek Flood Study* (Water Resources Commission (**WRC**), 1985)
- *Warragamba Flood Mitigation Dam Environmental Impact Statement Flood Study* (Water Board (**WB**), 1994)
- *Hawkesbury Floodplain Risk Management Study & Plan* (Bewsher, 2012)
- *Windsor Bridge Replacement – Detailed Design – Hydrology and Hydraulics Report* (Sinclair Knight Merz (**SKM**), 2013)
- *Updated South Creek Flood Study* (Worley Parsons (**WP**), 2015)
- *Hawkesbury Nepean Flood Plan* (NSW State Emergency Service (**NSW SES**), 2015)
- *Bandon Road Upgrade Flooding and Drainage Investigation* (Lyall & Associates (**L&A**), 2018)
- *Garfield Road West Upgrade Flooding and Drainage Investigation* (L&A, 2019)

1.5 Flood Modelling Approach

Flood behaviour along the project corridor is influenced by the following three flooding mechanisms:

- Hawkesbury-Nepean River Flooding,
- Major Tributary Flooding, and
- Minor Tributary Flooding.

A brief description of the three flooding mechanisms is provided in **Section 2.3** of this report, while the approach adopted to define flood behaviour based on each is outlined below.

Hawkesbury-Nepean River Flooding

The definition of Hawkesbury-Nepean River Flooding was based on a hydraulic model that was originally developed as part of SKM, 2013 and later updated as part of L&A, 2018 and L&A, 2019 (denoted herein the **Hawkesbury-Nepean River Flood Model**). Design discharge hydrographs used as input to the Hawkesbury-Nepean River Flood Model were extracted from the RUBICON model that was originally developed as part of WB, 1994. As part of L&A, 2018 and L&A, 2019 the Hawkesbury-Nepean River Flood Model was updated to more accurately define flooding patterns in the vicinity of the respective projects, while inflow boundaries and hydraulic roughness were adjusted to more closely match peak flood levels that were presented in Bewsher, 2012 and NSW SES, 2015.

For the purpose of the present investigation no adjustments were made to the structure of the Hawkesbury-Nepean River Flood Model that was developed as part of L&A, 2019. A summary of peak flood levels due to Hawkesbury-Nepean River Flooding is provided in **Table 2.2** in **Section 2.3.2** of this report.

Major and Minor Tributary Flooding

The definition of Major and Minor Tributary Flooding along South Creek and its tributaries was based on a hydrologic model that was originally developed as part of L&A, 2018 and updated as part of L&A, 2019, while a new hydraulic model was developed as part of the present investigation to define flood behaviour in the vicinity of the project corridor (denoted herein the **South Creek TUFLOW Model**).

The hydrologic model that was developed as part of the earlier investigations comprised a DRAINS model of the South Creek catchment (denoted herein the **South Creek DRAINS Model**). For the purpose of the present investigation the South Creek DRAINS Model was modified in order to more accurately define the extent and runoff characteristics of the local catchments that drain across the project corridor. The design discharge hydrographs that were generated by the South Creek DRAINS Model were used as inflows to the South Creek TUFLOW Model.

2 EXISTING ENVIRONMENT

2.1 General

This section of the report contains a brief description of the existing drainage system in the vicinity of the project corridor, as well as the three primary mechanisms that influence flood behaviour along its length. **Figure 1.1**, sheet 2 shows the extent of the catchments which contribute to flow in the existing transverse drainage that are located along and to the immediate north of the project corridor, while **Figure 2.2** (2 sheets) shows the layout of the existing drainage system in the immediate vicinity of the project corridor. Both figures should be referred to when reading the following sections of this report.

Table 2.1 over provides details of the three transverse drainage structures that are located along and immediately to the north of the project corridor.

2.2 Brief Description of Existing Drainage System

The section of Richmond Road that forms the project corridor is located within the catchments of South Creek and an unnamed tributary to its east (denoted herein as "**Unnamed Tributary No. 1**").

Transverse drainage structure EXD01 is located about 480 m to the north of Elara Boulevard and controls runoff from an urbanised area that forms part of the Marsden Park Precinct development. Stormwater discharging from transverse drainage structure EXD01 is conveyed along a vegetated channel that discharges into Unnamed Tributary No. 1 on its western bank about 240 m to the north of Richmond Road.

Transverse drainage structures EXD02 and EXD03 are located about 90 m and 200 m to the north of the project corridor, respectively. Both of these structures control runoff from a portion of the Marsden Park Precinct development that is currently under construction. Stormwater discharging from transverse drainage structures EXD02 and EXD03 is conveyed along a vegetated channel a relatively short distance downstream of Richmond Road before discharging into South Creek on its southern bank.

The main arm of South Creek crosses Richmond Road about 300 m to the north of the project corridor via a 100 m long four span bridge.

While the area to the east (downstream) of the project corridor is typically of a rural nature, future development is proposed as part of the Marsden Park North Precinct that will include commercial type development and playing fields.

The southern portion of Richmond Road has been built largely at-grade. The middle portion of the road is located in a cutting that is up to 6 m deep, while its northern portion is located on a fill embankment as it approaches the aforementioned bridge crossing of South Creek.

TABLE 2.1
DETAILS OF EXISTING TRANSVERSE DRAINAGE

Catchment	Transverse Drainage Structure Identifier[1]	Location	Dimensions / Type[2] (mm)	Catchment Area (ha)	Upstream Invert Level (m AHD)	Downstream Invert Level (m AHD)	Approximate Hydrologic Standard of Transverse Drainage Structure[3] (% AEP)	
							HNF[4]	MMTF
Unnamed Tributary No. 1	EXD01	480 m north of Elara Boulevarde	3 off 600 RCPs	40.9	16.59	16.38	1	50[5]
South Creek	EXD02	270 m south of South Creek bridge crossing	2 off 1050 RCPs	31.0	7.53	6.93	5	>0.2
	EXD03	140 m south of South Creek bridge crossing	2 off 1800 RCPs	110	2.61	2.36	5	>0.2

1. Refer **Figures 2.1** (2 sheets) and **Figure 2.2** (2 sheets) for location of Transverse Drainage Identifiers.
2. RCP = Reinforced Concrete Pipe.
3. HNF = Hawkesbury-Nepean River Flooding   MMTF = Minor and Major Tributary Flooding
4. Indicates when the section of road adjacent to the transverse drainage structure is first overtopped by Hawkesbury-Nepean River Flooding.
5. The section of Richmond Road to the north of transverse drainage structure EXD01 is inundated by floodwater that surcharges the table drain that runs along the western side of the road.

2.3 Flood Producing Mechanisms

2.3.1 General

The nature of flooding along the project corridor varies significantly based on the prevailing weather conditions. For example, parts of Richmond Road are subject to “flash flooding” which can last for a few minutes during local severe thunderstorms. This can be contrasted with flooding which may occur due to more widespread storm activity over the South Creek catchment, where water levels on the main arm of the watercourse rise more slowly but result in higher peak levels and flow velocities. Inundation for some days may also occur as a result of backwater flooding due to major flood events on the Hawkesbury-Nepean River system. The following sections of the report provide a brief description of the three different mechanisms of flooding which influence flood behaviour along the project corridor.

2.3.2 Hawkesbury-Nepean River Flooding

Major flooding on the Hawkesbury-Nepean River (denoted herein as “**Hawkesbury-Nepean River Flooding**”) can result in backwater flooding on the lower floodplains of South Creek and Unnamed Tributary No. 1, even in the absence of heavy rainfall over these catchments. Backwater flooding from the Hawkesbury-Nepean River is a result of a constriction that is imposed on flow at the Sackville Gorge and is of a ponding nature in the vicinity of the project corridor. This type of flooding is relatively slow rising in nature, with the peak of the flood typically occurring more than 24 hours after the onset of flood producing rain.

Table 2.2 sets out the design peak flood levels for Windsor which are presented in WB 1994, Bewsher 2012, NSW SES 2015 and L&A, 2019.

TABLE 2.2
DESIGN PEAK FLOOD LEVELS AT WINDSOR
HAWKESBURY-NEPEAN RIVER FLOODING ONLY

Design Flood Event (% AEP) [A]	Previous Studies			
	WB 1994 [B]	Bewsher 2012 [C]	NSW SES 2015 [D]	L&A, 2019 [E]
20	11.0	11.1	11.1	10.9
10	12.2	12.3	12.3	12.2
5	13.6	13.7	13.7	13.6
2	15.7	15.7	15.7	15.6
1	17.3	17.3	17.3	17.3
0.5	-	18.7	18.7	-
0.2	-	20.2	20.2	-
0.1		21.9	21.9	-
0.05	-	-	-	22.8
PMF	25.5	26.4	26.8	26.8

2.3.3 Major Tributary Flooding

Widespread, medium duration rainfall of the order of 2–9 hours over the South Creek and Unnamed Tributary No. 1 catchments typically maximise flows along the main arms of the two watercourses in the vicinity of the project.

While this type of flooding (denoted herein as "**Major Tributary Flooding**") will result in depths of inundation on the overbank area of South Creek of over a metre in places, the resulting peak flood levels are several metres lower than those generated by Hawkesbury-Nepean River Flooding. That said, flow velocities resulting from Major Tributary Flooding will be much higher in the absence of coincident backwater flooding from the Hawkesbury-Nepean River.

2.3.4 Minor Tributary Flooding

There are several relatively small catchments which drain across and along the project corridor onto the floodplains of South Creek and Unnamed Tributary No. 1. Runoff from these catchments contributes to flow in the existing transverse drainage, ephemeral watercourses and natural depressions which run along across and along the project corridor. These catchments would respond very quickly to heavy rainfall and will need to be catered for in the design of drainage works associated with the project. This type of flooding is denoted herein as "**Minor Tributary Flooding**".

3 CATCHMENT HYDROLOGY

3.1 General

The assessment of the runoff characteristics of the South Creek catchment was undertaken using the DRAINS software. DRAINS is a simulation program that converts both historic and design rainfall patterns to stormwater runoff and generates discharge hydrographs. The design discharge hydrographs generated by DRAINS were used as inflows to the hydraulic (TUFLOW) model that was developed as part of the present investigation (refer **Chapter 4** for details).

In addition to the above, design discharge hydrographs were extracted from the hydraulic model that was developed as part of L&A, 2019 and applied as inflows to the TUFLOW model along the main arm of Unnamed Tributary No. 1.

The hydrologic modelling that has been relied upon for assessing the drainage requirements for the project is based on the procedures set out in the 1987 edition of *Australian Rainfall and Runoff (***ARR 1987**) (Institution of Engineers Australia (**IEAust**), 1987). An initial assessment was carried out into the impact that the adoption of the procedures set out in the recently released edition of *Australian Rainfall and Runoff* (**ARR 2019**) (Geoscience Australia, 2019) would have on the definition of flood behaviour. The assessment found that the adoption of ARR 2019 procedures would result in an increase in peak flow estimates at transverse drainage structure EXD01 of about 20 per cent. Based on this finding, the impact of flows in excess of the 1% AEP event has been taken into consideration in the design of the upgrade of transverse drainage structure EXD01. It is recommended that the adoption of ARR 2019 procedures be further assessed during concept and detailed design.

3.2 DRAINS Model Development and Results

3.2.1 General

A number of hydrologic sub-models are available within the DRAINS software to simulate the conversion of rainfall to runoff, such as ILSAX, RAFTS, RORB and WBNM. The ILSAX and RAFTS sub-models have been used as part of the present investigation as they are best suited to simulate the rainfall-runoff process in urban and rural/semi-rural areas, respectively.

As noted in **Section 1.5**, the DRAINS models that was developed as part of L&A, 2019 for the South Creek catchment was used as the basis for the present investigation. However, it was necessary to modify the sub-catchment layout in order to more accurately define runoff characteristics in the drainage lines that are located in the vicinity of the project corridor. **Figure 3.1** (2 sheets) shows the layout of the sub-catchments which comprise the South Creek DRAINS Model.

Sub-catchment boundaries in the South Creek DRAINS Model were digitised based on contour information derived from the available LiDAR survey data, while sub-catchment slopes used as input to the ILSAX and RAFTS sub-models were derived using the average sub-catchment slope and vector averaged slope approaches, respectively. Aerial photography and site observations were used to assess the degree of urbanisation that is present in each sub-catchment.

Recent aerial photography shows that a significant portion of the Marsden Park Precinct is currently under construction. Sub-catchment boundaries and fractions imperviousness in the South Creek DRAINS Model were therefore adjusted based on a review of indicative layout and catchment plans of the precinct in order to reflect likely catchment conditions following the completion of the construction within the precinct.

3.2.2 Design Storms

Rainfall intensities for design storms ranging between 20% (1 in 5) and 0.2% (1 in 500) AEP were derived using procedures outlined in ARR1987 for storm durations ranging between 25 minutes and 24 hours. The design rainfalls were converted into rainfall hyetographs using the temporal patterns presented in ARR1987.

Areal Reduction Factors (**ARF**) were applied to the design rainfall intensities obtained from ARR1987 along the main arm of South Creek. **Table 3.1** sets out the ARFs that were adopted for a design storm of 24 hours duration, which is critical for maximising flows on the main arm of South Creek at Richmond Road.

TABLE 3.1
ADOPTED AREAL REDUCTION FACTORS

Duration (hours)	20% AEP	10% AEP	5% AEP	1% AEP
24	0.89	0.89	0.89	0.88

Estimates of probable maximum precipitation (**PMP**) for the local catchments draining to the project corridor (for the definition of Minor Tributary Flooding) were derived using the Generalised Short Duration Method (**GSDM**) as described in *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method* (BoM 2003). This method is appropriate for estimating extreme rainfall depths for catchments up to 1000 square kilometres in area and storm durations up to six hours.

3.2.3 Model Parameters

As the catchments that contribute runoff to the existing transverse drainage are ungauged, it was not possible to calibrate model parameters to reproduce recorded flows. A comparison of the peak flows generated by the hydrologic models developed as part of the present investigation was therefore made with those derived as part of previous flood studies, as well as by the Probabilistic Rational Method (**PRM**) of flood estimation as described in ARR 1987.

Model parameters were adjusted until reasonable correspondence was achieved with peak flows presented in previous studies that have been undertaken for the South Creek catchment, as well as those derived using the PRM approach.

Adopted ILSAX sub-model parameters comprised initial losses of 2 and 10 mm for paved and grassed areas, respectively. ILSAX uses the Hortonian loss modelling approach which does not require the user to input a continuing loss rate. Instead, a soil type and antecedent moisture condition (**AMC**) are used to define the continuing loss over time. The soil type was set equal to 3, which corresponds with a soil of comparatively high runoff potential, while an AMC of 3 was adopted reflecting rather wet conditions prior to the onset of runoff producing rainfall.

Adopted RAFTS sub-model parameters comprised initial losses of 2 and 15 mm, and continuing loss rates of 0 and 2.5 mm/h for paved and grassed areas, respectively. A storage routing coefficient multiplier (Bx factor) of 1.0 was adopted after comparison of peak flows from a range of sub-catchments with those derived using the PRM.

Lagging was used to model the translation of the discharge hydrographs between sub-catchment outlets within the ILSAX and RAFTS sub-models (referred to as links). This approach required a flow velocity to be assumed in each link. A flow velocity of 1.5 m/s was applied to routing of sub-catchment flows along the main arm of South Creek and Unnamed Tributary No. 1, while a flow velocity of 1.0 m/s was applied to the routing of local sub-catchments draining to the project corridor. These values were adopted based on consideration of flow path slopes and comparison of results with those derived from previous studies and the PRM approach.

3.2.1 Comparison of Results

Table 3.2 compares peak 1% AEP flows generated by the South Creek DRAINS Model that was relied upon for the present investigation with those derived using the PRM approach, as well as those presented in the *South Creek Flood Study* (Department of Water Resources (**DWR**), 1990) and the *Updated South Creek Flood Study* (WorleyParsons (**WP**), 2015).

The peak flow in South Creek from the present investigation compares reasonably with those set out in the previous studies, as well as that derived using the PRM approach. Peak flows derived from the present investigation at transverse drainage structures EXD01, EXD02 and EXD03 for undeveloped catchment conditions are within minus 20 and plus 10 per cent of the corresponding estimates using the PRM approach. Urbanisation of the catchments draining to transverse drainage structures EXD01, EXD02 and EXD03 as part of the Marsden Park Precinct development will increase peak flow estimates by between 60 and 100 per cent.[3]

TABLE 3.2
COMPARISON OF DESIGN PEAK 1% AEP FLOW ESTIMATES
(m^3/s)

Location	Area (ha)	PRM	DWR 1990	WP 2015	Present Investigation	
					Undeveloped	Developed
Transverse Drainage Structure EXD01	41.4	6.0			4.9(1)	10.0(2)
Transverse Drainage Structure EXD02	31.0	4.8			5.3(1)	8.3(2)
Transverse Drainage Structure EXD03	110	13.0			12.7(1)	24.5(2)
South Creek at Richmond Road	41,660	1,275	1,365	1,433	1,307	

1. Derived for the purpose of comparison with PRM estimates only.
2. Adopted for the present investigation.

[3] Note that the information relating to development within the Marsden Park Precinct shows that no detention basins are proposed in the catchments which contribute to flow in transverse drainage structures EXD01, EXD02 and EXD03. Refer Section 5.2.5 of this report

4 ASSESSMENT OF PRESENT DAY FLOODING CONDITIONS

4.1 General

Detailed two-dimensional hydraulic modelling was undertaken using the TUFLOW software to define flood behaviour along the project corridor under present day (i.e. pre-upgrade) and post-upgrade conditions.

This chapter provides background to the development of the TUFLOW model that was used to define flood behaviour along the project corridor under present day conditions. Also presented are the results of running the model for design flood events with AEPs ranging between 20 and 0.2 per cent, as well as the PMF.

4.2 The TUFLOW Modelling Approach

TUFLOW is a two-dimensional hydraulic model that does not rely on a prior knowledge of the pattern of flood flows in order to set up the various fluvial and weir type linkages that describe the passage of a flood wave through a drainage system.

The basic equations of TUFLOW involve all of the terms of the St Venant equations of unsteady flow. Consequently the model is "fully dynamic" and once tuned will provide an accurate representation of the passage of the floodwave through a drainage system in terms of extent, depth, velocity and distribution of flow.

TUFLOW solves the equations of flow at each point of a rectangular grid system that represent overland flow on the floodplain and along streets. The grid system may also be used to describe the waterway area available in the channel system. Channel systems can also be modelled as one-dimensional elements embedded in the larger two-dimensional domain that typically represents the wider floodplain. Flows are able to move between the one and two-dimensional elements of the model depending on the capacity characteristics of the drainage system being modelled.

The approach adopted in the present investigation was to model culverts and piped reaches as one-dimensional elements with open channels, roads and other topographic features of the broader floodplain included in the larger two-dimensional domain. The choice of grid point spacing depends on the need to accurately represent features on the floodplain that influence hydraulic behaviour and flow patterns (e.g. buildings, streets, changes in floodplain dimensions, hydraulic structures that influence flow patterns, etc.).

4.3 TUFLOW Model Development

4.3.1 Model Layout

While the TUFLOW model that was developed as part of L&A, 2019 (denoted herein as the Hawkesbury-Nepean River Flood Model) has been relied upon to define the nature of Hawkesbury-Nepean River Flooding, a new TUFLOW model was developed as part of the present investigation to define the nature of Minor and Major Tributary Flooding in the vicinity of the project corridor (denoted herein as the South Creek TUFLOW Model). The layout of the South Creek TUFLOW model is shown on **Figure 4.1**.

A grid spacing of 2 m was adopted as it provided an appropriate level of definition of features which influence the passage of flow over the natural surface (e.g. roads, buildings and drainage paths) whilst maintaining a reasonable simulation run time.

Grid elevations were based on detailed ground survey along the project corridor and its immediate vicinity, which was supplemented with ALS survey data across the remainder of the model extent that was flown in 2017 and 2019. Ridge and gully lines were added to the model where the grid spacing was considered too coarse to accurately represent important topographic features that influence the passage of overland flow.

The stormwater drainage network along Richmond Road was defined based on detailed ground survey and *Issued for Construction* drainage drawings for the upgrade of Richmond Road at its intersection with Elara Boulevard.

Where invert levels were not available, pit surface levels were estimated based on the ALS survey data, while an assumed cover of 700 mm was adopted for setting invert levels of individual pipe reaches. This assumed cover was then adjusted where necessary to ensure that the drainage system had positive fall in the downstream direction.

Details of the existing transverse drainage structures set out in **Table 2.1** were incorporated into the TUFLOW model.

4.3.2 Model Boundary Conditions

The discharge hydrographs that were generated by the South Creek DRAINS Model described in **Chapter 3** were applied to the South Creek TUFLOW Model as both external and internal inflow boundaries, the locations of which are shown on **Figure 4.1**.[4]

The external inflow boundary that was applied to Unnamed Tributary No. 1 was based on discharge hydrographs that were extracted from the TUFLOW model that was developed as part of L&A, 2019.

The downstream boundary of the South Creek TUFLOW Model comprised water level hydrographs that were also extracted from the TUFLOW model that was developed as part of L&A, 2019 of the Eastern Creek and South Creek floodplains.

4.3.3 Model Parameters

The main physical parameter represented in TUFLOW is hydraulic roughness, which is required for each of the various types of surfaces comprising the overland flow paths in the two-dimensional domain, as well as for the culverts and pipes that were incorporated in the model as one-dimensional elements. In addition to the energy lost by bed friction, obstructions to flow also dissipate energy by forcing water to change direction and velocity, and by forming eddies. Hydraulic modelling traditionally represents all of these effects via the surface roughness parameter known as "Mannings n".

Hydraulic roughness values adopted for design purposes were selected based on site inspection, past experience and values contained in the engineering literature (refer **Table 4.1** over).

[4] In parts of the modelled area, inflow hydrographs were applied over individual regions called "Rain Boundaries". The Rain Boundaries act to "inject" flow into the one and two-dimensional domains of the TUFLOW model, firstly at a point which has the lowest elevation, and then progressively over the extent of the Rain Boundary as the grid in the two-dimensional model domain becomes wet as a result of overland flow.

TABLE 4.1
"BEST ESTIMATE" OF HYDRAULIC ROUGHNESS VALUES
ADOPTED FOR TUFLOW MODELLING

Surface Treatment	Manning's n Value
Reinforced concrete pipes and box culverts	0.015
Roads	0.02
Remnant cleared pasture land	0.045
Macrophytes	0.06
Trees and scrub	0.07
Buildings	10

4.4 TUFLOW Model Results

Figure 4.2 (2 sheets) shows the indicative extent of Hawkesbury-Nepean River Flooding in the vicinity of the project corridor for design floods with AEPs of 20%, 10%, 5%, 2%, 1%, 0.05%, as well as the PMF, while **Figures 4.3** and **4.4** (2 sheets each) show the indicative depth of inundation for a 5% and 1% AEP Hawkesbury-Nepean River flood event, respectively.

Figures 4.5 to **4.9** (2 sheets each) show the indicative extent and depth of inundation resulting from Minor and Major Tributary Flooding for events with AEPs of 20%, 10%, 1%, 0.2% and the PMF.

Table 2.1 in **Chapter 2** sets out the minimum hydrologic standard of the existing transverse drainage in the case of Minor and Major Tributary Flooding, and also when each structure is first backwater influenced from Hawkesbury-Nepean River Flooding.

<u>Transverse Drainage Structure EXD01</u>

Transverse drainage structure EXD01 is influenced by backwater flooding from the Hawkesbury-Nepean River during a 2% AEP event, with a depth of ponding of 1.0 m occurring at its inlet.

Backwater flooding from Hawkesbury-Nepean River Flooding will inundate the section of Richmond Road adjacent to transverse drainage structure EXD01 during events greater than 1% AEP in magnitude (refer **Figure 4.2**, sheet 2).

Transverse drainage structure EXD01 is not influence by backwater flooding from Unnamed Tributary No. 1 for all events up to 0.2% AEP in magnitude. The peak 0.2% AEP flood level in Unnamed Tributary No. 1 adjacent to transverse drainage structure EXD01 is RL 16.1 m AHD, which is 0.3 m below the downstream invert level of the culvert structure.

Flow due to local catchment runoff will surcharge the inlet of transverse drainage structure EXD01 during events more frequent than 20% AEP, where it will run in a northerly direction along the table drain that is located along the western side of Richmond Road toward the inlet to transverse drainage structure EXD02. The resulting surcharge flow will overtop a section of Richmond Road to the north of transverse drainage structure EXD01 during a 20% AEP event, while overtopping of the road occurs both to the north and south of the transverse drainage structure during a 10% AEP event.

Table 4.2 provides a breakdown of the distribution of flow across Richmond Road due to local catchment runoff that approaches transverse drainage structure EXD01. By inspection of the values in **Table 4.2**, during a 1% AEP event a peak flow of 1.6 m^3/s discharges through transverse drainage structure EXD01, 2.5 m^3/s surcharges across Richmond Road to its south, while 5.3 m^3/s discharges in a northerly direction along the road and its adjacent table drain. The resulting depth of inundation along the adjacent section of Richmond Road is less than 0.2 m.

TABLE 4.2
DISTRIBUTION OF FLOW ACROSS RICHMOND ROAD AT TRANSVERSE DRAINAGE STRUCTURE EXD01
(m^3/s)

Conveyance Path	Design Flood Event				
	20% AEP	**10% AEP**	**1% AEP**	**0.2% AEP**	**PMF**
Through Transverse Drainage Structure EXD01	1.5	1.5	1.6	1.6	1.9
Overtopping Richmond Road south of Transverse Drainage Structure EXD01	-	0.1	2.7	5.2	57.9
Discharging in a northerly direction along Richmond Road	4.1	4.7	5.7	6.1	10.4
Total	**5.6**	**6.3**	**10.0**	**12.9**	**70.2**

Transverse Drainage Structures EXD02 and EXD03

Transverse drainage structures EXD02 and EXD03 are both influenced by backwater flooding from the Hawkesbury-Nepean River during a 20% AEP event, with depths of ponding of 8.3 m and 3.4 m occurring at their inlets, respectively.

Backwater flooding from Hawkesbury-Nepean River Flooding will inundate the section of Richmond Road adjacent to transverse drainage structures EXD02 and EXD03 during events greater than 5% AEP in magnitude. Depths of inundation will exceed 3 m in a 1% AEP Hawkesbury-Nepean River flood, when about a 1 km length of the project corridor will be inundated by floodwater. The road would be inundated for a period of several days during a Hawkesbury-Nepean River flood of this magnitude.

Flow due to local catchment runoff will surcharge the inlet to transverse drainage structure EXD02 during a 20% AEP event where it will discharge toward the inlet to transverse drainage structure EXD03.

Flow in South Creek will surcharge its southern bank and discharge toward the inlet to transverse drainage structure EXD03 during a 20% AEP event.

Richmond Road is not impacted by flooding from South Creek for all events up to 0.2% AEP.

5 FLOOD IMPACT ASSESSMENT

5.1 General

A preliminary assessment was undertaken of the drainage upgrade requirements for the project. **Figure 5.1** (2 sheets) shows the layout of the concept drainage strategy to control flow within and immediately adjacent to the project corridor. Also shown on **Figure 5.1** is the extent of new road pavement that is assumed to discharge to the various receiving drainage lines, as well as its point of discharge.

This chapter of the report also deals with the impact that the project would have on flood behaviour should TfNSW adopt the concept drainage strategy that is set out in this report.

5.2 Design Considerations

5.2.1 Flood Immunity of the Project

The concept road alignment has been designed to accommodate a future upgrade of the bridge over South Creek as part of proposed improvements to the flood evacuation strategy for the Hawkesbury Nepean Valley that is set out in NSW SES, 2015. As a result, the proposed road alignment rises from its connection with the existing bridge over South Creek to a minimum elevation of RL 20.3 m AHD.[5] This minimum road elevation is approximately equal to the 0.2% AEP flood level due to Hawkesbury Nepean River flooding.

As Richmond Road forms part of the flood evacuation strategy for the Hawkesbury Nepean Valley transverse drainage would need to be designed for a 0.2% AEP event due to local catchment (i.e. Minor Tributary) flooding in accordance with the objectives set out in NSW SES, 2015. However, the present investigation found that the minimum road level set by the proposed tie in with the future upgrade of the bridge over South Creek is more than 2 m higher than the peak 0.2% flood level due to Minor Tributary Flooding at transverse drainage structure PXD01.

5.2.2 Assessment of Flood Impacts

In accordance with the *Floodplain Development Manual* (DIPNR, 2005), floods up to the 1% AEP event were used to assess the impact of the project on flood behaviour in existing residential, and by default industrial and commercial development, while floods up to the PMF event were used to assess the impact of the project on critical infrastructure and significant increases in the hazardous nature of flooding.

5.2.3 Minimum Cover Requirements

For the purpose of the present investigation a minimum cover of 1 m has been adopted where possible beneath each carriageway to all transverse drainage structures. This minimum cover has been set based on past project experience and would allow for a 0.3 m depth of cover below the base of a nominal 0.7 m thick pavement.

At transverse drainage structure PXD01 the minimum road level set by the proposed tie in with the future upgrade of the bridge over South Creek is about 0.4 m higher than the level required for minimum cover over the transverse drainage structure.

[5] It is understood that a minimum road elevation of RL 20.3 m AHD has been adopted by TfNSW as this is 1.5 m above the elevation of the designated flood evacuation out of Bligh Park.

5.2.4 Blockage Potential and the Impact of Flows in Excess of a 1% AEP event

The minimum road level that has been set by the proposed tie in with the future upgrade of the bridge over South Creek would require raising the existing level of Richmond Road by up to 3 m. The raised level of Richmond Road would have the potential to obstruct flow that surcharges the inlet of transverse drainage structure PXD01 should this occur as a result of a partial blockage and/or flows in excess of the culvert capacity. In order to manage the impact that the raised level of the road could have on flood behaviour, the concept arrangement for transverse drainage structure PXD01 includes:

- a 50% allowance for a partial blockage of its waterway area,
- the provision of a minimum freeboard of 0.5 m between the 0.2% AEP peak flood level and the obvert of the culvert structure, and
- the sizing of the culvert structure in order to limit increases in peak flood levels during a PMF event that would otherwise result in a significant increase in hazardous flooding conditions in existing and proposed developed.

5.2.5 Impact of Future Development on Catchment Hydrology

As noted previously, areas of the Marsden Park Precinct development that drain to the project corridor have either recently been constructed or are currently under construction. The assessment of drainage requirements for the project was therefore based on peak flow estimates that are representative of catchment conditions following the construction of the Marsden Park Precinct development.

While JWP, 2013 shows that it was originally proposed to provide detention basins to control runoff from the areas of the development that drain to the project corridor, GHD, 2018 shows that runoff draining to the project corridor would no longer be attenuated based on the revised stormwater management strategy that was developed on behalf of Blacktown Council.

5.2.6 Impact of Future Climate Change

While the assessment of flood behaviour and the sizing of drainage upgrade requirements has been based on present day climatic conditions, a preliminary assessment of the potential impact that future climate change could have on flood behaviour was made by comparing flood behaviour during a 1% and 0.2% AEP[6] events. The findings of this preliminary assessment are presented in **Section 5.3.4**.

5.2.7 Utilities

The location and depth of utilities and their impact on the proposed drainage measures <u>have not</u> been considered as part of the present investigation. Detailed investigations will therefore need to be carried out during the preparation of the concept design for the project to identify any conflicts and to scope any utility relocation requirements.

[6] The 0.2% AEP event was adopted as a proxy for assessing the sensitivity to an increase in rainfall intensity on the 1% AEP event due to future climate change.

5.3 Assessment of Post-Project Flood behaviour

5.3.1 Adjustments to Hydrologic and Hydraulic Models

The DRAINS and TUFLOW models representing pre-upgrade conditions were modified in order to assess the impact the project would have on flooding and drainage patterns.

The South Creek DRAINS Model was modified by adjusting catchment boundaries and characteristics such as per cent impervious and overland flow path lengths. Areas of road pavement were modelled using the ILSAX sub-model.

Ground elevations in the South Creek TUFLOW Model were adjusted using a 3D model of the road upgrade and associated earthworks that was developed as part of the concept design.

The drainage system in the TUFLOW model was modified to reflect the details of the concept drainage strategy, which included:

- the upgrade of transverse drainage structure PXD01 from 3 off 600 mm diameter pipes to 5 off 2400 mm wide by 1800 mm high reinforced concrete box culverts; and
- a series of drainage channels and culvert crossings of local roads to control runoff from the section of road upgrade and the adjoining catchments.

Inflow boundaries in the South Creek TUFLOW model were adjusted to reflect the locations where it is envisaged that the new pavement drainage system will discharge to the receiving drainage lines. **Figure 5.1** (2 sheets) shows the extent of the area controlled by the new pavement drainage system and the locations where it is envisaged that it will discharge.

5.3.2 Impact of Project on Hawkesbury Nepean River Flooding

In order to mitigate the impact that the project would have on peak flood levels associated with backwater flooding from the Hawkesbury-Nepean River it would be necessary to provide compensatory excavation to offset the volume of temporary floodplain storage that is displaced by the proposed road works**.** **Table 5.1** over shows the volume of temporary floodplain storage that is displaced by the proposed road works below the peak 1% AEP flood level on the Hawkesbury-Nepean River of RL 17.3 m AHD.

Of the estimated 82,500 m^3 of temporary floodplain storage that would be displaced by the project, it would be feasible to provide compensatory excavation of about 6,000 m^3 through the provision of channels along both sides of the road[7]. It would therefore be necessary to provide an additional 76,500 m^3 of compensatory excavation external to the project corridor in order to recapture all of the displaced temporary floodplain storage.[8]

[7] The estimated volume is based on 1 m deep channels with a base width of 4 m and a top width of 10 m.
[8] It needs to be noted that the "elevation versus volume of temporary floodplain storage" recaptured by way of compensatory excavation must match as closely as practicable the "elevation versus volume of displaced temporary floodplain storage attributable to the project", the relationship for which is set out in **Table 5.2**.

TABLE 5.1
ELEVATION VERSUS VOLUME OF TEMPORARY FLOODPLAIN STORAGE DISPLACED BY THE PROJECT

Elevation (m AHD)	Volume (m^3)
9.8	0
10.3	10
10.8	120
11.3	660
11.8	1,810
12.3	3,470
12.8	6,050
13.3	9,880
13.8	14,380
14.3	19,620
14.8	27,410
15.3	35,940
15.8	45,450
16.3	56,180
16.8	68,310
17.3	82,460

5.3.3 Impact of Project on Major and Minor Tributary Flooding

Figures 5.2 to **5.6** (3 sheets each) show the impact that the project would have on Minor and Major Tributary Flooding for design events with AEPs of between 20% and 0.2%, as well as the PMF.

There will be an increase in the depth of overland flow along the drainage line downstream of transverse drainage structure PXD01, as well as the downstream reach of Unnamed Tributary No. 1 for all events up to the PMF. For example, during a 1% AEP event depths of inundation would be increased by a maximum of 0.14 m along the drainage line downstream of transverse drainage structure PXD01, and by a maximum of 0.03 m along Unnamed Tributary No. 1. These increases are primarily due to the upgrade of transverse drainage structure PXD01 and the resulting diversion of flow that presently surcharges the inlet of the culvert and discharges in a northerly direction along Richmond Road.

While the areas impacted by an increase in the depth of inundation downstream of transverse drainage structure PXD01 are presently undeveloped, they do form part of the future Marsden Park North Precinct. The *Draft Indicative Layout Plan for the Marsden Park North Precinct* (DPE, 2018) shows that the drainage line downstream of transverse drainage structure PXD01 is located in an area that is proposed for future commercial development, while impacts along

Unnamed Tributary No. 1 are confined to areas of future drainage, environmental conservation or rural transition.

As part of the future commercial development to the east (downstream) of transverse drainage structure PXD01 it will be necessary to incorporate a drainage easement to convey flow from the structure to Unnamed Tributary No. 1. It is recommended that TfNSW liaise with Blacktown City Council to gain a better understanding of drainage provisions within the proposed future development precinct and to ensure that flows discharging from transverse drainage structure PXD01 are accommodated in the future development of the Marsden Park North Precinct.

While the widening of Richmond Road will result in an increase in the depth and extent of inundation upstream of transverse drainage structure PXD01, impacts in areas of existing development would be confined to the drainage reserve that is located immediately west of the project corridor and would not impact on adjoining residential development for all events up to the PMF.

During the PMF there would also be an increase in the depth and extent of inundation upstream of transverse drainage structure PXD01 in an area to its west that is presently undeveloped but forms part of the future Marsden Park Precinct. It is recommended that TfNSW liaise with Blacktown City Council to gain a better understanding of finished levels of future development in this area and to ensure it is compatible with peak flood levels under post-project conditions. In this regard it will be necessary to confirm that the peak PMF level upstream of transverse drainage structure PXD01 of RL 20.0 m AHD does not result in hazardous flooding conditions to future development in this area.

There would be either no change or a slight reduction in the depth and extent of inundation within areas adjacent to the section of the project corridor to the north of transverse drainage structure PXD01 for all events up to 0.2% AEP. This is due to the upgrade of transverse drainage structure PXD01, which would lead to a reduction in the rate of flow that presently surcharges the inlet of the transverse drainage structure and discharges in a northerly direction along the road.

5.3.4 Impact of Future Climate Change on Flood Behaviour

Comparison of **Figures 5.4** and **5.5** shows only minor increases in flood level impacts between a 1% and 0.2% AEP event. On this basis it is concluded that there would be relatively minor increases in flood impacts attributable to the project under future climate change conditions.

As the proposed road level is located above the PMF level due to local catchment flooding it is also concluded that flooding under future climate conditions would not impact the flood immunity of the road against Minor Tributary Flooding.

6 EROSION AND SEDIMENT CONTROL STRATEGY

6.1 General

A strategy aimed at mitigating the adverse impacts of the construction phase of the road upgrade on water quality in existing downstream drainage lines and watercourses was developed as part of the present investigation.

Figure 6.1 (2 sheets) shows the recommended erosion and sediment control strategy along the route of the proposed road upgrade and should be referred to when reading the following sections of the report. The strategy addresses the increase in potential for both erosion and sediment mobilisation within the construction corridor, and transport of this sediment into downstream watercourses via sediment-laden runoff (herein referred to as 'dirty water') leaving areas disturbed by the road works.

It is recommended that the strategy presented in this section of the report be used as the starting point for the preparation of a *"Soil and Water Management Plan"* (**SWMP**) (or similar) that will need to be developed as part of final design and/or construction documentation for the road upgrade works. However, it should be recognised that ultimate requirements for controlling erosion and sediment during construction will be dictated by final design of the road upgrade works, proposed construction methods, staging and site management practices, all of which are yet to be finalised.

The strategy has been developed based on the principles and design guidelines set out in the following documents:

- *Soils and Construction – Managing Urban Stormwater* series (herein referred to as the *"Blue Book"*), comprising:
  - Volume 1 (Landcom, 2004)
  - Volume 2D – Main Roads (DECC, 2008); and
- *Roads and Maritime Services Erosion and Sedimentation Management Procedure* (Roads and Maritime, 2008); and
- *Roads and Maritime Services QA Specification G38* (Roads and Maritime, 2011).

6.2 Key Elements of the Strategy

The primary principles for effective erosion and sediment control are firstly to minimise erosion, and to then capture sediment from disturbed areas where erosion cannot be prevented.

Whilst this present investigation deals primarily with the control of sediment, and the structural measures that will be required to capture dirty water and bypass clean water through the construction site, a range of erosion control principles will need to be incorporated into the future SWMP including:

- staging the project works to ensure that drainage channels upslope of Richmond Road are implemented during the initial stages of construction to control runoff which presently discharges onto the project corridor from the west;

- staging the construction of drainage culverts and channels to control runoff through the site, including the provision of temporary drainage diversions for new culverts and channels;
- appropriate location and treatment of site access and stockpile sites;
- conservation of existing topsoil for later site rehabilitation;
- minimisation of disturbed areas, and stabilisation using batter blanketing, surface mulching or vegetation;
- scour protection along drainage lines through the site;
- separation of clean and dirty water wherever possible;
- site maintenance requirements; and
- progressive site rehabilitation.

The Blue Book allows for localised erosion and sediment control measures to be used in the absence of large scale sediment retention basins where the average annual soil loss from a disturbed area, as derived by application of the Revised Universal Soil Loss Equation (RUSLE) 3, is less than 150 m^3.

Figure 6.1 (2 sheets) shows the extent of land which will be disturbed during the construction phase of the project. For the purpose of undertaking an initial assessment of erosion and sediment control requirements the total area of disturbance was divided into thirteen (13) control areas based on the likely staging of construction and nominated locations for the controlled discharge of runoff from the site. As it will be necessary to maintain traffic flow along Richmond Road during construction it was assumed that earthworks would be undertaken in areas to the east of the existing road, which would then be stabilised before traffic is switched over and work is undertaken along the existing section of Richmond Road and areas to its west.

Based on the layout of control areas shown on **Figure 6.1** (2 sheets) it is estimated that the average annual soil loss from each area will not exceed the threshold value of 150 m^3. The implementation of effective localised erosion and sediment control measures aimed at minimising the volume of sediment which is transported from disturbed areas will therefore be key to the control of sediment from the project corridor in the absence of any large-scale sediment retention basins. Key structural elements of the strategy for control of dirty water are outlined below.

<u>Temporary diversion channels</u>

A series of diversion channels and associated earth bunding would be used to control dirty water along the downslope side of disturbed areas and direct this water towards temporary sediment retention sumps. The location of the proposed channels is shown on **Figure 6.1** (2 sheets).

<u>Local erosion and sediment control measures</u>

Localised erosion and sediment control measures may be provided to augment or replace sediment sumps for smaller disturbed catchments. Localised erosion and sediment control measures would include use of the following smaller scale elements:

- staging of works to minimise the extent of disturbance at any one time;

- temporary catch drains and earth bunding to divert on-site and off-site water toward receiving drainage lines
- temporary stabilisation or revegetation/rehabilitation works to reduce the extent of disturbed surfaces;
- application of temporary surface treatments or blanketing on exposed earth surfaces;
- sediment barriers in series where necessary;
- vegetative buffer strips; and
- stabilised drainage lines incorporating rock check dams at regular intervals.

6.3 Concluding Remark

The erosion and sediment control strategy set out in this chapter of the report does not constitute a detailed SWMP, but rather provides an initial guidance on the measures which will need to be implemented during construction of the road works. Additional erosion and sediment control measures, as well as standard maintenance measures which should be implemented during construction are outlined in Volumes 1 and 2D of the Blue Book. A detailed SWMP will therefore need to be prepared prior to the commencement of construction activities.

7 REFERENCES

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