South West Rail Link
Glenfield to Leppington rail line

Environmental Assessment
Volume 2b - Technical Reports 3 to 7

South West Rail Link Glenfield to Leppington Rail Line Project Approval Environmental Assessment

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Transport Infrastructure Development Corporation

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SOUTH WEST RAIL LIINK HYDROLOGICAL ASSESSMENT

FINAL FOR ENVIRONMENTAL ASSESSMENT

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GLENFIELD TO LEPPINGTON RAIL LINE – HYDROLOGICAL REPORT

FINAL FOR ENVIRONMENTAL ASSESSMENT

MAY, 2010

Project Glenfield to Leppington Rail Line – Hydrological Report	**Project Number** 28054
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GLENFIELD TO LEPPINGTON RAIL LINE – HYDROLOGICAL REPORT

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EXECUTIVE SUMMARY

General

The proposed South West Rail Link (SWRL) will provide an important public transport link for proposed new residential areas in the south west of Sydney (Figure 1).

The SWRL is being delivered as a two-stage process, comprising:

- **Glenfield Transport Interchange** – delivery of all components associated with the Stage A and Stage B1 works as defined in the Concept Plan, as well as additional early works approved under Part 5 of the EP&A Act (in separate Review of Environmental Factors reports)
- **Glenfield to Leppington Rail Line** – delivery of all components associated with the Stage B2 works.

This study forms part of the Environmental Assessment (EA) which has been prepared to satisfy the assessment and project approval requirements for the SWRL Stage B2 works (which are hereafter referred to as the 'Glenfield to Leppington Rail Line' or 'the project') under Part 3A of the *Environmental Planning and Assessment Act (EP&A) 1979*.

Objectives

The key purpose of this investigation is to identify potential hydrologic impacts associated with the proposed Glenfield to Leppington Rail Line and to recommend mitigation measures to inform detailed design. The types of hydrologic impacts considered include environmental issues (such as impacts on fish and fauna passage, water quality and changes in flow regime), flood impacts (such as changes in peak flows, flood levels, velocities and hazards) and flood risk to existing and proposed infrastructure.

Study Area

The proposed Glenfield to Leppington Rail Line crosses the Bunbury Curran Creek floodplain as well as the upper tributaries of Cabramatta, Bonds and Kemps Creeks. The proposed Edmondson Park Station is to be located between Maxwells Creek and one of its tributaries (Maxwells Creek is a tributary to Cabramatta Creek). Leppington Station would be sited between Bonds and Scalabrini Creeks (a tributary of Bonds Creek).

The catchment areas upstream of the Glenfield to Leppington Rail Line are varied in respect of their size and degree of urbanisation. The catchments considered in this assessment range in size from around 3 hectares up to areas of approximately 750 hectares (Figure 2). For the most part, the catchments consist of cleared pastoral or naturally vegetated lands. Some areas are relatively open and consist of rural-residential or relatively low density development, while others have minimal development and are heavily vegetated. Future development is expected to significantly alter the nature of the catchments, particularly in the vicinity of the Edmondson Park and Leppington town centres. A catchment summary of each waterway crossing along the Glenfield to Leppington Rail Line route is provided in Table 1.

Future land use planning associated with the South West Growth Centre (SWGC) has been considered in this investigation. For Edmondson Park, information on proposed future land use was sourced from the *Edmondson Park Precinct Development Control Plan* (Reference 1). This information was used to establish the flood models (both hydrologic and hydraulic models) to represent both pre- and post- Glenfield to Leppington Rail Line development conditions (Figures 3 to 6). Future land use planning was also taken into consideration in the assessment of riparian corridors, blockage potential at the waterway crossings and the consequences of flood impacts. For Leppington, no proposed land use information was available for the wider catchment. In the absence of land use planning information, design parameters similar to those adopted for the Edmondson Park assessment were adopted at Leppington within the hydrologic models (defining the conversion of rainfall to runoff from the catchment). Hydraulic model layouts, consideration of riparian significance and blockage potential of waterway crossings were based on existing conditions. It is recommended that the final masterplan layout for Leppington (yet to be produced) be reviewed in the context of design assumptions made for the purposes of this assessment.

Environmental Assessment Requirements

The Statement of Commitments prepared by Transport Infrastructure Development Corporation (TIDC) and the Minister's Conditions of Approval form the compliance requirements of the EA, including hydrologic related requirements addressed by this study. Hydrologic related issues can be broadly divided into environmental requirements and flood related issues (including flood impacts and risks).

Environmental Considerations

The assessment of environmental requirements for the waterway crossings has considered the relevant guidelines for the passage of fish and fauna (References 2 and 3), the significance of the riparian habitat present (including the former Department of Water and Energy's (now the Department of Environment, Climate Change and Water) (DECCW) stream classification) (Reference 4) and included consultation with the Department of Primary Industries (DPI) and DECCW. Recommendations are provided on waterway crossing treatments that are compatible with the significance of the riparian corridor at each crossing (refer to Table 1). In locations where culverts are to be implemented, appropriate measures should be incorporated into the design to promote fish and fauna passage. These types of measures including setting the culvert inverts lower than the creek invert would minimise any vertical barriers and make provision for a natural bed for the base of the culvert. In the case of multiple cells, a lower central cell should be provided for low flows, whilst still allowing for dry fauna passage through the higher cells.

The proposed Glenfield to Leppington Rail Line has the potential to impact on water quality during both the construction and operational phases of the project. To this end, the potential for erosion and sedimentation from cuttings, embankments and scouring downstream of culverts as well as polluted runoff due to oils, greases and gross litter, etc. would need to be controlled in accordance with all statutory and environmental protection requirements. Minimum environmental management requirements would need to include appropriate erosion and sediment control measures in accordance with *Managing Urban Stormwater: Soils and Construction*, *Edmondson Park Precinct DCP* (Reference 1) and the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000). The appropriate water quality treatment measures are to be incorporated into the detailed drainage design.

Flood Impact and Risk

The flood assessments undertaken for this study were based on the Glenfield to Leppington Rail Line Concept Design prepared by *Aurecon AECOM Joint Venture* (TIDC's technical advisor). The assessment analysed flood risk and impacts, the outcomes of which were used to determine the size of proposed waterway crossings and other significant watercourse works/modifications. The design criteria adopted for the assessment is based on appropriate design standards and objectives and considered the consequences of waterway blockage by flood debris, the effects of climate change and the potential impacts on existing and future development. The design standard adopted for the sizing of waterway crossings is based on the 1% Annual Exceedance Probability (AEP) (1 in 100 year) design storm event. This is considered appropriate in general circumstances, although design decisions also need to consider the flood risks arising from any failure of the drainage system (where "failure" could mean, for example, system capacity is exceeded due to the volume of floodwaters, blockage by debris, or a combination of both).

A number of locations have been identified where there is the potential for significant flood risks in storms larger than the 1% AEP (1 in 100 year) event and/or overflows due to a substantial amount of culvert blockage. This is especially relevant to the area at and around the proposed Edmondson Park Station (Crossings 4 to 6).

Flood risks were also identified at proposed electrical substations, proposed stations and commuter carparks, in addition to potential site compounds, stockpile sites and construction access roads.

Climate Change Impacts

Work by Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Bureau of Meteorology (BOM) on climate change impacts is currently in its infancy and is an active area of research. However, general trends from research to date indicate that there is a potential for climate change to result in more intense rainfall during extreme storm events. Consequently, climate change impacts could potentially increase the likelihood of flows in excess of the design standard.

Locations where climate change impacts have been identified as a potential flood risk are also locations where there is a risk of culvert blockage. At these locations the assessment process has involved consideration of both blockage and climate change risks. However, risk and impacts of blockage are significantly greater than those due to climate change. Therefore, additional culvert capacity that has been provided at critical locations to allow for blockage should also accommodate potential increased flood risk due to climate change.

Overview of Glenfield to Leppington Rail Line Crossings

Crossing 1 is located on the Bunbury Curran floodplain in an area potentially allocated for a detention basin by CCC. Consequently the final design for Crossing 1 would be dependent on whether the proposed basin goes ahead or not. CCC is yet to make a final decision regarding the flood detention basin for James Meehan Estate. Studies are currently underway to determine the need for the basin.

Crossing 2 comprises a small catchment draining along Quarter Sessions Road. The rail alignment at this crossing is located in a cutting under the existing road. It is proposed to divert flows from Crossing 2 toward downstream of Crossing 1. The impact of this diversion on both the existing flow regime and flooding in downstream areas is not likely to be significant, given the relative size of the diversion catchment compared to the receiving catchment. However, a more detailed assessment of flood impacts on Bunbury Curran Creek should be undertaken as part of the detailed design assessment of Crossing 1. The catchment area draining to Crossing 2 is relatively small (5 hectares) relative to that of Bunbury Curran Creek (11,000 hectares) and there is no significant vegetation downstream that would be affected by this proposed change in flow regime. However, provision would need to be made to safely convey diverted flows along the rail corridor to discharge into Bunbury Curran Creek. This may necessitate widening of the rail corridor.

The rail alignment passes under the Hume Highway immediately west of Crossing 2. The Hume Highway contains an open drain running central to the north and south bound lanes that conveys runoff from the road. The bored tunnel proposed for the highway would need to maintain the drainage capacity and function of this central drain.

In comparison to Crossings 1 and 2, **Crossing 3** would be largely conventional (referring to the relatively simple design of the proposed crossing through the Glenfield to Leppington Rail Line embankment). Consequently, flood modelling has been undertaken in sufficient detail to estimate the relative impact on flood levels due to the proposed Glenfield to Leppington Rail Line and determine waterway requirements to inform detailed design. Excessive ponding at the inlet to the crossing could impact on Campbelltown Road. This has been addressed in the assessment and the corresponding design recommendations. An upgrade is proposed for Campbelltown Road, downstream of Crossing 3. The detailed design of Crossing 3 should consider the affects of this upgrade.

The flood assessment for Crossing 3 has considered the proposed detention basin on Maxwells Creek located upstream of the Glenfield to Leppington Rail Line. This basin is proposed as part of the stormwater management strategy for the Edmondson Park urban release area. Assessment was based on details in the *Edmondson Park Flood Study* (Reference 5) and are therefore preliminary. Final details of the basin layout and detention characteristics should be reviewed when available and any changes in flow behaviour at Crossing 3 should be incorporated into future design stages.

Edmondson Park Station is proposed to be located in a cutting that adjoins a low point in the Glenfield to Leppington Rail Line alignment in the vicinity of Crossings 4, 5 and 6 (refer Figure 1). As a result there is the possibility for overflows from these crossings to impact the station. Detailed flood modelling has been undertaken in this area to define flood behaviour, assess relative flood impacts between pre- and post- Glenfield to Leppington Rail Line scenarios and quantify flood risk to rail commuters, staff and infrastructure.

Results from the flood modelling indicate that flows in excess of the 1% AEP (1 in 100 year) event and/or overflows due to culvert blockage would result in overtopping of Crossings 4 and 6 and result in flow travelling along the rail corridor (Figures 32 and 33). Consequently, mitigation measures are recommended to reduce the likelihood of blockage. Flood modelling also indicates that flooding in excess of the 0.5% AEP (1 in 200 year) event could potentially affect the operation of trains and cause damage to rail infrastructure. Consequently, a Flood Risk Management Plan shall be prepared to address the potential risk to operation of trains and damage to rail infrastructure for flood events in excess of the 0.5% AEP (1 in 200 year) storm.

The design of Crossing 7a is largely conventional (refer Figure 1). Consequently, flood modelling has been undertaken in sufficient detail to estimate the relative impact on flood levels due to the proposed Glenfield to Leppington Rail Line and to determine appropriate waterway requirements to inform detailed design (Figures 19a to 20). This crossing drains a relatively large catchment with some areas having significant riparian vegetation upstream and downstream. Accordingly, a bridge is recommended to maintain connectivity of the riparian zone and to minimise the potential for blockage. Flood modelling has been undertaken to provide a preliminary assessment of the required bridge span between abutments. Pier arrangements and channel works would need to be confirmed through hydraulic assessment in future design stages.

Crossing 7b is located to the immediate west of Crossing 7a. It is propose to divert runoff from this catchment to Crossing 7a. This diversion of flow would affect an existing farm dam located immediately downstream of the Glenfield to Leppington Rail Line embankment. However, it is understood that the property containing this dam is to be acquired to construct the Glenfield to Leppington Rail Line. Therefore it is assumed that the function of the dam is not required postdevelopment.

CH. 47.500 drains a relatively small catchment that largely runs parallel to the rail alignment. In this location the existing watercourse would need to be diverted to run along the base of the embankment. It is recommended that provision be made to convey flows up to the 1% AEP (1 in 100 year) design storm along the rail corridor to discharge at Crossing 8. The partial diversion is not expected to have a significant effect either on peak flows or the existing flow regime.

In the vicinity of Crossings 8, 9 and 10a there are localised areas where the proposed rail embankment encroaches on the existing floodplain, restricting the conveyance of floodwaters and creating impacts on adjacent areas. During future design stages it would be necessary to make provision in the design of drainage works to provide for the conveyance of floodwaters along the rail corridor to manage impacts on adjacent properties. This may require widening of the rail corridor.

Crossing 10a is located where the rail alignment crosses Camden Valley Way. The existing watercourse runs along the proposed location for the rail embankment. Consequently, it would be necessary to realign the existing watercourse downstream of Crossing 10a to run along the base of the rail embankment to Crossing 9. This would result in flood impacts on the property immediately downstream of Crossing 10a. However, it is understood that this property is to be acquired and would become open space in future land use planning for the area. Therefore, flood impacts are considered acceptable for the proposed land use. Crossing 10b is located to the east of Crossing 11 and the Sydney Water Upper Canal. This crossing drains a small catchment and the design can be fully addressed in future design stages. Diversion of this crossing through to Crossing 11 is not recommended as flows would likely impact on the Sydney Water Upper Canal.

The Sydney Water Upper Canal, supplying water to Prospect Reservoir, crosses the rail alignment approximately 200 m west of Crossing 10b. Provision would need to be made in the detailed design to divert all track drainage away from the canal. A suitable design standard for track drainage in the vicinity of the canal should be adopted in consultation with the Sydney Catchment Authority.

Crossing 11 is located on Bonds Creek. While this crossing is largely conventional, it drains a sizable catchment (781 Ha). A bridge would be preferable to a series of culverts as it would be less susceptible to blockage as well as providing a more environmentally appropriate solution. However, the final design should also be guided by proposed land use upstream (and therefore the potential for generation of blockage material). The nature of proposed land use upstream is currently subject to the final masterplan for the Leppington town centre, however planning to date indicates that the creek corridor would remain in its natural state, maintaining the crossings susceptibility to blockage. Due to the broad nature of the floodplain at this location a combination of bridge over the main creek with culverts to convey flows from the overbank areas is likely to be the most cost effective solution whilst also addressing the various flood and environmental related requirements.

Leppington Station is located between Crossings 11 and 12. While the station is located in a cutting, it is situated outside the floodplain and any flood risk can therefore be managed through appropriate drainage design at the detailed design stage.

Crossing 12 drains a relatively small catchment that largely runs parallel to the rail alignment. Part of the proposed rail embankment sits over the existing watercourse. In this location the existing watercourse would need to be diverted to run along the base of the embankment. It is recommended that provision be made to convey flows up to 1% AEP (1 in 100 year) design storm along the rail corridor to discharge at Crossing 13. The partial diversion is not expected to have a significant effect either on peak flows or the existing flow regime.

Crossings 13 and 14 are located on Scalabrini and Kemps Creeks respectively. Detailed flood modelling was undertaken at these crossings to define flood behaviour and assess flood impacts (Figures 28 and 29). Both of these crossings drain large catchment areas and therefore bridges are recommended in preference of a series of box culverts to minimise the potential for blockage and maintain riparian connectivity. However, the final design should also be guided by the proposed land use upstream which is subject to the final masterplan for the Leppington release area. Flood modelling has been undertaken to provide a preliminary assessment of the required bridge span between abutments. Pier arrangements and channel works would need to be confirmed through hydraulic assessment in future design stages.

To manage water consumption and the potential for pollutants from the Glenfield to Leppington Rail Line entering the adjoining watercourse, a hydrologic assessment is being undertaken by TIDC and *Parsons Brinckerhoff*. A key recommendation of this assessment is to maximise water reuse through the capture, treatment and recycling of water from the proposed stations.

A train stabling facility is proposed to the west of Crossing 14. This facility poses a footprint of approximately 3.7 hectares. Hydrologic modelling shows that the facility would have negligible impact on peaks flows in Kemps Creek. However, mitigation measures would be required to control pollutants entering the downstream creek and scouring at drainage outlets.

General Findings and Recommendations

Preliminary sizings have been developed for waterway crossings where culverts are proposed such that flood impacts are generally negligible or manageable for events up to and including the 1% AEP (1 in 100 year) storm.

At all the waterway crossings where hydraulic modelling was undertaken, the results (for an unblocked waterway crossing) indicate that for flood events up to and including the 1% AEP (1 in 100 year) event any adverse flood level impacts upstream of the waterway crossings would generally be contained within the rail corridor. Any adverse impacts on adjacent land could be managed in the design of inlet treatments and surface drains in the future design stages. The design and extent of this drainage would need to be confirmed through flood modelling in future design stages. Future design of inlet works should also include a refinement of the preliminary culvert sizings presented in this assessment.

For crossings that are proposed to be bridged (Crossings 7a, 11, 13 and 14), further hydraulic assessment would be required in future design stages to guide channel works upstream and downstream of the crossing and final pier and span arrangements.

There are some areas, particularly in the vicinity of Crossings 8, 9 and 10a where the proposed rail embankment encroaches on the existing floodplain, restricting the conveyance of floodwaters and creating impacts on adjacent areas. During future design stages it would be necessary to provide adequate drainage works such as diversion drains to provide for the conveyance of floodwaters along the rail corridor to manage adverse flood impacts on adjacent properties. The design of these diversion drains would need to be confirmed through detailed flood modelling and may require local widening of the rail embankment to accommodate such works.

The analysis indicates that flood behaviour at many of the proposed waterway crossings is sensitive to blockage. Consequently, an assessment has been made of the potential for blockage (based on the nature of the upstream catchment and proposed land use) and consequences of blockage. Where appropriate, mitigation measures have been proposed to reduce the potential for blockage at each location. Such measures include the provision of debris control structures at the inlet, providing additional waterway area (eg. additional culverts) to allow for blockage, or adopting a bridge structure in lieu of culverts.

Table 1 Waterway Crossing Summary

Crossing	Rail Line Chainage	Catchment	Catchment Area (Ha)	1% AEP Flows (m^3/s)	Future Development		Existing Riparian	DECCW Stream Classification [3]	Recommended Crossing Treatment	Consequences of Crossing Failure	Potential for Blockage	Blockage Mitigation Works	Comments/Other Recommendations	Preliminary Sizing Considering Blockage[2]
					Upstream	Downstream								
1 (Drainage Depression)	42.930	Bunbury Curran Creek	77.4	32.4	James Meehan Estate	Existing Railway Line	Highly modified catchment, weeds, no defined creek	3	Viaducts considered adequate for environmental requirements. Viaduct piers to be located such that the impacts minimized to significant flora identified in the depression adjacent to BCC.	Potential flood impacts including increase in duration and depth of inundation through the area of the proposed James Meehan Estate. Minimal flood impacts in Bunbury Curran Creek.	Low, depends on the development upstream of the viaducts.	At least 0.5m and preferably 1m freeboard from 1% AEP flood level to underside of viaduct.	Viaduct arrangement to be confirmed during detailed design and consultation with CCC regarding the proposed detention basin.	90m and 150m Viaducts.
2 (Tributary to Maxwells Creek)	43.800	Maxwells Creek	4.6	1.6	Existing School	Existing Macquarie Links Estate	Highly modified catchment, drainage along road.	Not Classified	Divert to Crossing 1	Overflows from channel diversion would flow into rail cutting.	N/A	N/A	Flows up to 1% AEP storm to be conveyed within rail reserve to safely discharge into Bunbury Curran Creek.	Can be fully addressed in detailed design.
3 (Maxwells Creek)	44.530	Maxwells Creek	164	32.6	Public Recreation Area	Nature Reserve	Defined creek, dense vegetation	2	Series of culverts	Excessive ponding at inlet would impact on Campbelltown Road.	High - open space with natural vegetation upstream.	Provide debris capture structure upstream.	Culverts to be sized to prevent adverse impacts on Campbelltown Road. Culverts should be aligned with existing watercourse.	3.3m(W) x 1.2m(H) RCBC (7 of)
4 (Tributary to Maxwells Creek)	45.130	Maxwells Creek	24	9.7	Edmondson Park Town Centre	Nature Reserve	Drainage depression rather than creek, highly modified catchment	2	Series of culverts	Excessive ponding at inlet would impact on Edmondson Park station.	High under existing conditions, moderate once upstream catchment developed.	Debris control to be provided during development of the upstream catchment.	Culverts to be sized to minimise impacts on Edmondson Park station. Culverts should be aligned with existing watercourse. Flood Risk Management Plan is required to manage flooding to rail in events larger than 0.5% AEP.	3.6m(W) x 0.9m(H) RCBC (3 of)
5 (Tributary to Maxwells Creek)	45.430	Maxwells Creek	1.5	0.7	Edmondson Park Town Centre	Public Recreation Area	Highly Modified catchment, no defined creek	Not Classified	Diversion to Crossing 4	N/A	N/A	N/A	N/A	Can be fully addressed in detailed design.
6 (Unnamed Creek - Tributary to Maxwells Creek)	45.700	Maxwells Creek	66	12.9	Nature Reserve	Public Recreation Area	Defined Creek, dense vegetation, standing water	2	Culverts considered adequate for environmental requirements. Other factors (e.g. blockage mitigation) may warrant use of a bridge.	Overflows would travel along cutting and impact on Edmondson Park Station.	High - open space with natural vegetation upstream.	Provide additional culverts to make allowance for blockage. Debris control structure upstream of crossing also recommended. Bridge would also reduce potential for blockage but only if clearance in excess of 1.2m could be achieved.	Culverts to be sized to minimise impacts on Edmondson Park station. Culverts should be aligned with existing watercourse. Flood Risk Management Plan is required to manage flooding to rail in events larger than 0.5% AEP.	3.3m(W x 0.9m(H) RCBC (6 of)
7a (Cabramatta Creek)	46.930	Cabramatta Creek	417	55.7	Existing and Proposed Rural Residential	Public Recreation Area	Modified catchment, defined creek, dense vegetation, standing water	1	Bridge	Any adverse flood impacts could potentially affect upstream properties.	High potential for debris from upstream catchment. However, potential for blockage reduced through use of a bridge.	At least 0.5m and preferably 1m freeboard from 1% AEP flood level to underside of bridge.	Concept earthworks design showing embankment arrangement has been assessed.	Approx. span between abutments 70m, subject to hydraulic assessment of pier arrangement and compensatory channel works.
7b (Tributary to Cabramatta Creek)	47.190	Cabramatta Creek	3.99	1.4	Existing Rural Residential	Future Residential	Drainage depression rather than creek, highly modified catchment	Not Classified	Diversion to Crossing 7a, however the long term viability of the d/s farm dam needs to be confirmed.	Overflows from channel diversion would flow into rail cutting.			Flows up to 1% AEP storm to be conveyed within rail reserve to safely discharge at Crossing 7a. Confirm long term viability of d/s farm dam.	Can be fully addressed in detailed design.

Crossing	Rail Line Chainage	Catchment	Catchment Area (Ha)	1% AEP Flows (m^3/s)	Future Development		Existing Riparian	DECCW Stream Classification [3]	Recommended Crossing Treatment	Consequences of Crossing Failure	Potential for Blockage	Blockage Mitigation Works	Comments/Other Recommendations	Preliminary Sizing Considering Blockage[2]
					Upstream	Downstream								
CH. 47.500 Unnamed Drainage Depressio	47.500	Cabramatta Creek	2.4	1.0	Existing Rural Residential	Future Residential	Drainage depression rather than creek, highly modified catchment	Not Classified	Diversion to Crossing 8	N/A	N/A	N/A	Flows up to 1% AEP storm to be conveyed within rail reserve to safely discharge at Crossing 8.	Can be fully addressed in detailed design.
8 (Tributary to Cabramatta Creek)	47.900	Cabramatta Creek	32	7.6	Existing Cemetery	Public Recreation Area	Drainage depression rather than creek, highly modified catchment	2	Series of culverts	Flood impacts on Cemetery.	High - natural vegetation upstream.	Provide debris capture structure upstream.		3.3m(W) x 0.9m(H) RCBC (4 of)
9 (Tributary to Cabramatta Creek)	48.170	Cabramatta Creek	80	11.6	Existing Cemetery	Public Recreation Area	Drainage depression rather than creek, highly modified catchment with ponds	2	Series of culverts	Flood impacts on Cemetery.	Moderate - cemetery grounds upstream.	Provide debris capture structure upstream.	Existing ponds likely to provide a level of debris capture.	3.3m(W) x 0.9m(H) RCBC (7 of)
10a (Tributary to Cabramatta Creek)	48.440	Cabramatta Creek	37	8.1	Future urban use	Public Recreation Area	Drainage depression rather than creek, highly modified catchment, ponded water upstream	2	Series of culverts	Depends on nature of proposed development upstream.	Depends on proposed development upstream.		Inlets required north and south of rail line to collect runoff west of Camden Valley Way.	2.7m(W) x 1.2m(H) RCBC (2 of)
10b (Unnamed Drainage Depression)	49.430	Bonds Creek	5.8	2.2	Future urban use	Future urban use	Drainage depression rather than creek, highly modified catchment	Not Classified	Series of culverts	Excessive ponding would divert along the rail corridor toward the Sydney Water Upper Canal.	High - small but well vegetated catchment upstream.	Debris control structure to be provided at inlet and a blockage allowance considered in culvert sizing.	Relatively small crossing can be fully addressed during detailed design.	Can be fully addressed in detailed design.
11 (Bonds Creek)	50.120	Bonds Creek	781	76.5	Leppington Urban Release Precinct	Leppington North Urban Release Precinct. Western Sydney Parklands north of Bringelly Road.	Defined creek, weeds and bank collapse, modified catchment, standing water	1	Culverts considered adequate for environmental requirements. Other factors (e.g. blockage mitigation) warrant consideration of a bridge.	Depends on proposed development upstream.	Ultimately depends on development upstream, however existing catchment has high potential for debris causing blockage.	Provide bridge or additional culverts to make allowance for blockage.	Bridge arrangement to be confirmed through flood modelling during detailed design.	Approx. span between abutments 20m, with 3.6m(W) x 0.9m(H) RCBC (21 of) in overbank area.
12 (Tributary to Scalabrini Creek)	51.340	Scalabrini Creek	9	3.3	Leppington Urban Release Precinct	Leppington North Urban Release Precinct	Drainage depression rather than creek, highly modified catchment	Not Classified	Channelled to Crossing 13	Depends on nature of proposed development upstream.	N/A	N/A	Flows up to 1% AEP storm to be conveyed within rail reserve to safely discharge at Crossing 13.	Can be fully addressed in detailed design.
13 (Scalabrini Creek)	51.58	Scalabrini Creek	410	47.6	Leppington Urban Release Precinct	Leppington North Urban Release Precinct	Defined creek, weeds and bank collapse, modified catchment	2	Bridge	Depends on nature of proposed development upstream.	Ultimately depends on development upstream, however existing catchment has high potential for debris causing blockage.	At least 0.5m and preferably 1m freeboard from 1% AEP flood level to underside of bridge.	Bridge arrangement to be confirmed through flood modelling during detailed design.	Approx. span between abutments 40m, subject to hydraulic assessment of pier arrangement and compensatory channel works.
14 (Kemps Creek)	52.74	Kemps Creek	499	65.5	Rossmore/Leppington Urban Release Precinct	Rossmore/ Leppington North Urban Release Precinct	Modified catchment, defined channel, dense vegetation, standing water	1	Bridge	Depends on nature of proposed development upstream.	Ultimately depends on development upstream, however existing catchment has high potential for debris causing blockage.	At least 0.5m and preferably 1m freeboard from 1% AEP flood level to underside of bridge.	Bridge arrangement to be confirmed through flood modelling during detailed design.	Approx. span between abutments 40m, subject to hydraulic assessment of pier arrangement and compensatory channel works.

Notes

1. The significance of riparian vegetation upstream of Crossings 11-14 and potential for blockage ultimately depends on the type of land use proposed as part of the Leppington masterplan.
2. Preliminary sizing of culvert takes into consideration an appropriate allowance of blockage.
3. Stream Categorisation is based on the interpretation of maps provided by DECCW.

1. INTRODUCTION

1.1. Background

The NSW Government is proposing to construct the South West Rail Link (SWRL) (refer Figure 1). The rail line will provide an important public transport link for new residential areas proposed in the south west of Sydney.

The proposed SWRL is approximately 11 km in length, extending from the tie in with the existing rail network at Glenfield Junction to a new stabling facility at Rossmore. Two stations are proposed along the rail line to be located at Edmondson Park and Leppington.

The proposed rail alignment crosses the Bunbury Curran Creek floodplain as well as the upper tributaries of Cabramatta (including Maxwells), Bonds and Kemps Creeks. Edmondson Park Station is proposed to be located between Maxwells Creek and one of its tributaries, while Leppington Station is to be sited between Bonds and Scalabrini (a tributary of Bonds) Creeks.

The SWRL is being delivered as a two-stage process, comprising:

- **Glenfield Transport Interchange** – delivery of all components associated with the Stage A and Stage B1 works as defined in the Concept Plan, as well as additional early works approved under Part 5 of the EP&A Act (in separate Review of Environmental Factors reports)
- **Glenfield to Leppington Rail Line** – delivery of all components associated with the stage B2 works.

This study forms part of the Environmental Assessment (EA) which has been prepared to satisfy the assessment and project approval requirements for the SWRL Stage B2 works (which are hereafter referred to as the 'Glenfield to Leppington Rail Line' or 'the project') under Part 3A of the *Environmental Planning and Assessment Act (EP&A) 1979*.

WMAwater (Crossings 3 – 14) in association with *Parsons Brinkerhoff* (Crossings 1 and 2) have undertaken the hydrological assessment presented in this report.

1.2. Study Objectives

The purpose of this report is to identify and document potential hydrologic impacts associated with the proposed SWRL concept design for Stage 2 and provide recommended mitigation measures to direct the future design stages. The hydrologic impacts to be considered include:

- environmental issues (such as fish passage requirements, water quality and changes in flow regimes),
- flood impacts (changes in peak flows and flood levels, velocity and hazard),
- flood risk to existing and proposed infrastructure.

The specific objectives of this report are defined by the compliance requirements to be addressed in the Stage 2 EA. These requirements are outlined in the following section.

1.3. Summary of Compliance Requirements

Following the presentation of the Stage 1 EA and Concept Plan Stage 1 EA in 2006, a Submissions Report was prepared by the Transport Infrastructure Development Corporation (TIDC) documenting and responding to submissions received. As part of this Submissions Report an updated Statement of Commitments (SoC) was prepared to incorporate any proposed changes or requirements of the project.

The SoC, combined with the Minister's Conditions of Approval, form the compliance requirements for the EA. Requirements relating to the hydrologic assessment addressed in this report are outlined below in Table 2.

Table 2 Compliance Requirements – Hydrologic Assessment

Statement of Commitments		
B19.	A detailed flood assessment would be undertaken in accordance with appropriate NSW Government guidelines and in consultation with Councils and relevant Government agencies.	Flood modelling (hydrology and hydraulic modelling) was undertaken for waterway crossings along the proposed SWRL corridor to assess flood behaviour under pre and post SWRL conditions. Requirements and considerations of this assessment are outlined in Section 2.5.2. Hydrologic and hydraulic modelling is presented in Sections 3 and 4 respectively.
	The assessment would confirm the extent of flooding impacts and inform future design development, in particular the type, location and size of drainage structures along the project corridor.	Flood impacts at each waterway crossing have been assessed and where appropriate mitigation measures are provided to direct future design stages. Flood model results are presented in Section 4. Flood impacts and mitigation measures are outlined in Section 5.
B20.	Additional flooding assessment to that undertaken in the Environmental Assessment and vertical rail alignment design work would be undertaken at Edmondson Park Station and surrounds and coordinated with Landcom, the Growth Centres Commission (now Strategic Land Release Project Office of the NSW Department of Planning) and Councils.	Detailed flood modelling was undertaken in the vicinity of Edmondson Park Station to assess flood behaviour at the station and the potential flood risk to commuters, rail staff and infrastructure. This assessment considered proposed future development as outlined in the *Edmondson Park Precinct DCP* (Liverpool City Council (LCC), 2008). Flood modelling is outlined in Section 4. Assessment of flood impacts and risk is presented in Section 5.
B21.	Design of waterway crossings and structures would be undertaken with reference to the Guidelines for Design of Fish and Fauna Friendly Waterway Crossings (Fairfull and Witheridge 2003) and Fish Passage Requirements for Waterway Crossings (2003) and considering the quality of riparian habitat present, in consultation with the Department of Primary Industries (NSW Fisheries) and other relevant Government agencies.	The significance of each waterway crossing has been assessed in relation to the various environmental requirements and appropriate measures have been outlined to guide future design stages. Requirements considered are outlined in Section 2.5.1. Assessment and recommended measures are presented in Section 5.

Minister's Conditions of Approval		
2.4(f)	Hydrology: for all aspects of the project (as relevant), confirm flood impacts on existing and planned future receivers and infrastructure based on modelling of the full range of flood sizes up to and including the PMF at each waterway crossing in accordance with the *NSW Floodplain Development Manual* (2005). Describe the impacts of flow alterations at each crossing, on upstream and downstream ecology and riparian zones.	Flood modelling was undertaken for the 50%, 5%, 1% and 0.5% Annual Exceedance Probability (AEP) events and the Probable Maximum Flood (PMF) and is outlined in Sections 3 and 4. Considerations and requirements of the flood assessment undertaken (including the *NSW Floodplain Development Manual* (2005)) are outlined in Section 2.5.2. Impacts of flow alterations on upstream and downstream ecology are presented in Section 5.
6.5	The Proponent shall ensure that the detailed design of any project related to this concept plan approval does not preclude Campbelltown City Council's plans to construct a flood detention basin at James Meehan Estate, unless otherwise agreed to by Campbelltown City Council and the Director-General.	Further assessment of CCC's proposal to construct a flood detention basin at James Meehan Estate prior to detailed design is outlined in Section 5.

1.4. Study Scope and Methodology

To satisfy the compliance requirements of the EA the following key tasks have been undertaken:

- collation and review of background information (previous studies, survey and mapping data) relevant to the project,
- consultation with government agencies and stakeholders. This consultation was undertaken by TIDC, A*urecon AECOM Joint Venture* (TIDC's technical advisor) and *WMAwater*,
- identification of guiding principles for the assessment of hydrologic issues considering environmental, floodplain management and others requirements,
- flood modelling (combination of hydrologic & hydraulic models) to quantify flood impacts and flood risk to existing and proposed development along the Glenfield to Leppington Rail Line alignment,
- assessment of potential impacts and identification of mitigation measures.

2. BACKGROUND INFORMATION

2.1. Previous Studies and Reports

Hydrologic studies and reports relating to the Project:

- *South West Rail Link Feasibility Report – Hydrologic Assessment, Webb McKeown and Associates (now WMAwater)* (April 2006) (Reference 6),
- *South West Rail Link Environmental Assessment – Technical Paper 2 Hydraulic Analysis, Webb McKeown and Associates (now WMAwater)* (October 2006) (Reference 7),
- *South West Rail Link TA300 - Glenfield Junction Flooding Assessment Concept Report, Global Arc* (July 2008) (Reference 8).

Hydrologic studies and reports relating to the Edmondson Park Release Area:

- *Edmondson Park Master Planning Water Cycle Management - Stormwater, GHD* (October 2003) (Reference 9),
- *Edmondson Park Master Planning Water Cycle Management – Stormwater Addendum to October 2003 Report, GHD* (March 2006) (Reference 10),
- *Edmondson Park Flood Study, Webb McKeown and Associates (now WMAwater)* (September 2007) (Reference 5).

Previous flood studies undertaken within the area:

- *Austral Floodplain Management Study, Perrens Consultants/Lyall & Macoun* (September 2003) (Reference 11),
- *Casa Paloma Caravan Park – Flooding Constraints and Opportunities Study Stages C and D, Patterson Britton* (March 2005) (Reference 12).

Other reports relating to the Project:

- *South West Rail Link – Project Application and Preliminary Environmental Assessment, Parsons Brinckerhoff* (April 2006) (Reference 13).
- *Edmondson Park Development Control Plan*, Liverpool City Council (May 2008) (Reference 1),
- *Leppington Concept Plan*, Strategic Land Release Project Office of the Department of Planning (Reference 14)
- *South West Rail Link – Concept Plan and Environmental Assessment, Parsons Brinckerhoff* (November 2006)

The current assessment builds on from the Stage 1 EA hydrologic assessment presented in *South West Rail Link Feasibility Report – Hydrologic Assessment,* Webb McKeown and Associates (April 2006) (Reference 6). Key areas where the Stage 1 EA report has been updated include:

- A more detailed flood assessment at Edmondson Park Station (Crossings 4, 5 and 6) to quantify flood behaviour and risk to rail commuters, staff and infrastructure.
- Updated flood modelling at other crossings in light of the most recent concept design.
- A detailed assessment of environmental considerations at each waterway crossing and recommended treatment measures.
- A detailed assessment of blockage potential at each waterway crossing and recommended mitigation measures.

2.2. Available Survey and Mapping Data

Ground survey collected as part of the SWRL Concept Design:

- *South West Rail Link – Contract 301 Glenfield South to Leppington Stabling – Survey General Arrangement* (29 sheets), *Global Arc* (12/6/08).

Ground survey undertaken for previous hydraulic assessments:

- *Surveyed cross sections and culvert details for Scalabrini and Bonds Creeks, Peter Bolan and Associates* (July 2006).

Other survey data:

- Aerial Laser Survey (ALS) of the LCC Local Government Area,
- Photogrammetry survey,
- Orthophotomap data showing 2 m contour information.

Geographical Information System (GIS) data:

- Aerial photography,
- Cadastral information.

2.3. Relevant Guidelines

Relevant guidelines and standards that have been considered in this assessment include:

- *Floodplain Development Manual*, NSW Government (2005) (Reference 15),
- *Australian Rainfall and Runoff*, Institute of Engineers Australia (1987) (Reference 16),
- *Guidelines for Design of Fish and Fauna Friendly Waterway Crossings*, Fairfull and Witheridge (2003) (Reference 2),
- *Fish Passage Requirements for Waterway Crossings* (2003) (Reference 3),
- *Draft Floodplain Risk Management Guideline – Practical Considerations of Climate Change*, Former NSW Department of Environment and Climate Change now Department of Environment, Climate Change and Water (DECCW) (2007) (Reference 17),
- *Riparian Stream Classification*, former NSW Department of Water and Energy now Department of Environment, Climate Change and Water (DECCW) (Reference 4).

2.4. Existing Environment

2.4.1. Waterway Crossings

There are fourteen (14) waterway crossings along the Glenfield to Leppington Rail Line corridor that were identified as part of the Plan Stage One EA (Reference 7). An additional three (3) crossings have been identified in the Concept Design that drain small catchments less than 6 Ha (refer Figure 1). These are relatively minor crossings that can largely be addressed in the future design stages. However, critical issues for consideration have been identified in the current assessment.

The catchments upstream of the Glenfield to Leppington Rail Line are reasonably varied in respect to their size, urbanisation and vegetation characteristics (Figure 2). Future development of the South West Growth Centre (SWCG) would alter the characteristics of a number these catchments, particularly within Edmondson Park and Leppington. Table 3 provides an overview of each of the waterway crossings considered in this assessment.

Table 3 Glenfield to Leppington Rail Line Proposed Waterway Crossings – Overview

Crossing	Rail Line Chainage	Catchment	Proposed Development		Existing Vegetation at Rail Line Crossing	DECCW Stream Classification
			Upstream	Downstream		
1 (Drainage Depression)	42.93	Bunbury Curran Creek	James Meehan Estate	Existing Railway Line	Highly modified catchment, weeds, no defined creek	3
2 (Tributary to Maxwells Creek)	43.80	Maxwells Creek	Existing School	Existing Macquarie Links Estate	Highly modified catchment, no defined creek	Not classified
3 (Maxwells Creek)	44.53	Maxwells Creek	Public Recreation Area	Nature Reserve	Defined creek, dense vegetation	2
4 (Tributary to Maxwells Creek)	45.13	Maxwells Creek	Edmondson Park Town Centre	Nature Reserve	Drainage depression rather than creek, highly modified catchment	2
5 (Tributary to Maxwells Creek)	45.43	Maxwells Creek	Edmondson Park Town Centre	Public Recreation Area	Highly modified catchment, no defined creek	Not classified
6 (Unnamed Creek - Tributary to Maxwells Creek)	45.70	Maxwells Creek	Nature Reserve	Public Recreation Area	Defined Creek, dense vegetation, standing water	2
7a (Cabramatta Creek)	46.93	Cabramatta Creek	Existing and Proposed Rural Residential	Public Recreation Area	Modified catchment, defined creek, dense vegetation, standing water	1
7b (Tributary to Cabramatta Creek)	47.19	Cabramatta Creek	Existing Rural Residential	Future Residential	Drainage depression, modified/urbanised catchment.	Not classified
Unnamed Drainage Depression	47.50	Cabramatta Creek	Existing Rural Residential	Future Residential	Drainage depression, modified/urbanised catchment.	Not classified
8 (Tributary to Cabramatta Creek)	47.90	Cabramatta Creek	Existing Cemetery	Public Recreation Area	Drainage depression rather than creek, highly modified catchment	2
9 (Tributary to Cabramatta Creek)	48.17	Cabramatta Creek	Existing Cemetery	Public Recreation Area	Drainage depression rather than creek, highly modified catchment with ponds	2
10a (Tributary to Cabramatta Creek)	48.44	Cabramatta Creek	Future urban use	Public Recreation Area	Drainage depression rather than creek, highly modified catchment, ponded water upstream	2
10b (Unnamed Drainage Depression)	49.43	Bonds Creek	Future urban use	Future urban use	Drainage depression	Not Classified
11 (Bonds Creek)	50.12	Bonds Creek	Leppington Urban Release Precinct	Leppington North Urban Release Precinct. Western Sydney Parklands north of Bringelly Road.	Defined creek, weeds and bank collapse, modified catchment, standing water	1

Table 3 (cont'd) Glenfield to Leppington Rail Line Proposed Waterway Crossings - Overview

Crossing	Rail Line Chainage	Catchment	Proposed Development		Existing Vegetation	DECCW Stream Classification
			Upstream	Downstream		
12 (Tributary to Scalabrini Creek)	51.34	Scalabrini Creek	Leppington Urban Release Precinct	Leppington North Urban Release Precinct	Drainage depression rather than creek, highly modified catchment	Not Classified
13 (Scalabrini Creek)	51.58	Scalabrini Creek	Leppington Urban Release Precinct	Leppington North Urban Release Precinct	Defined creek, weeds and bank collapse, modified catchment	2
14 (Kemps Creek)	52.74	Kemps Creek	Rossmore/Leppington Urban Release Precinct	Rossmore/Leppington North Urban Release Precinct	Modified catchment, defined channel, dense vegetation, standing water	1

2.4.2. Pre Glenfield to Leppington Rail Line Conditions

The Glenfield to Leppington Rail Line alignment crosses or intersects the catchment of seventeen (17) waterways identified as part of this assessment (refer Section 2.4.1) (Figure 1). A number of these waterways are already prone to flooding. Significant growth and urbanisation is expected to occur in this area in the near future as part of the SWGC. This level of development is likely to result in changes to flood behaviour caused by increased runoff due to urbanisation, changes to peak flow due to compensatory detention and confinement of the floodplains. For the purposes of this assessment the base or pre- Glenfield to Leppington Rail Line development scenario considers that the SWGC catchments upstream and downstream of the Glenfield to Leppington Rail Line have been fully developed as per the current proposal. This assumption is reflected in the percentage impervious adopted in the hydrologic modelling.

Land use categories for those areas covered by the *Edmondson Park Precinct DCP* (Reference 1) assume full development according to the DCP. Planning for the wider Leppington urban release area is currently progressing. It was therefore assumed that the development density for the Leppington area would be similar to that of Edmondson Park. It is expected that the proposed Leppington town centre would have a higher density of development than that proposed for Edmondson Park, however the development would have a localised effect and is not likely to significantly affect the peak runoff at the railway line. This assumption should be reviewed when more information on the Leppington Masterplan becomes available. Further detail of these assumptions is provided in Section 3.

The *Edmondson Park Precinct DCP* guided the extent of development and therefore the available floodplain within the hydraulic modelling.

Hydrologic and hydraulic modelling has been undertaken to define the pre- Glenfield to Leppington Rail Line development scenario. Definition of the pre- Glenfield to Leppington Rail Line flood behaviour is detailed in Section 4 and illustrated on Figures 8,11a, 15a, 19a, 23a and 27 – 29.

2.5. Hydrologic Assessment Considerations

The environmental and floodplain management design criteria set out below are based on thorough consideration of appropriate design standards and objectives in accordance with current best practice.

2.5.1. Environmental Requirements

Assessment of the environmental requirements for waterway crossing design should be consistent with a number of guidelines, including:

- *Guidelines for Design of Fish and Fauna Friendly Waterway Crossings*, Fairfull and Witheridge (2003) (Reference 2),
- *Fish Passage Requirements for Waterway Crossings* (2003) (Reference 3).

The above guidelines inform the design of waterway crossing treatments giving consideration to fish and fauna passage and riparian corridor condition. The adopted design should also consider factors that influence the environmental significance of the waterways such as proposed development upstream and downstream, catchment area, the nature of riparian habitat and other riparian connectivity constraints. The significance of each waterway should also consider the DECCW stream classifications (Reference 4).

Consultation with DPI and DECCW has been undertaken as part of the EA process and their input has been considered in this assessment.

The proposed Glenfield to Leppington Rail Line has the potential to impact on water quality during both the construction and operational phases of the project. Consequently the design, construction and operation of the Glenfield to Leppington Rail Line needs to consider relevant environmental protection requirements including:

- *Managing Urban Stormwater: Soils and Construction*, Landcom (2004),
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, ANZECC (2000),
- *Edmondson Park Precinct Development Control Plan*, Liverpool City Council (2008) (Reference 1).

2.5.2. Floodplain Management Requirements

Investigation, analysis and design of drainage works should be consistent with the guiding principles of a number of floodplain management references, including:

- *Floodplain Development Manual*, NSW Government (2005) (Reference 15),
- *Australian Rainfall and Runoff*, Institute of Engineers Australia (1987) (Reference 16),
- *Draft Floodplain Risk Management Guideline – Practical Considerations of Climate Change*, Former NSW Department of Environment and Climate Change now Department of Environment, Climate Change and Water (DECCW) (2007) (Reference 17),

Guiding principles derived from these references include:

- that hydrologic and hydraulic assessments should be undertaken in accordance with current Australian practice,
- that consideration of blockage by debris is an integral part of a hydraulic assessment under major storm conditions,
- that consideration of climate change is an integral part of a hydraulic assessment,
- trunk drainage works (large capacity channels and/or culverts) should *"carry and … control the passage of floods up to some high magnitude, without overflowing and causing damage"* (Reference 16, p. 334) and *"In addition to the ARI used for design, the performance of larger trunk drainage systems should be evaluated for extreme events such as probable maximum floods. This is to ensure that systems will fail in a predictable and relatively safe manner in such events, although significant damages should be expected"* (Reference 16, p. 297).

A 1% AEP (1 in 100 year) flood standard was adopted for the assessment and design of the waterway crossings. It is common practice to consider the full range of flood events up to and including the Probable Maximum Flood (PMF), and the detailed assessment of flood risks for events in excess of the design standard is particularly warranted at some locations. This is especially relevant to the area around the proposed Edmondson Park Station (Crossings 4, 5 and 6) where the potential flood risk in events that exceed the design standard is significant. Further discussion of Edmondson Park Station is provided in Section 5.

At other locations, there is the potential for significant amounts of overflow to occur once the waterway capacity is exceeded. This is relevant to Crossing 3. This is discussed further in Section 5.5.2. Elsewhere, in areas where the Glenfield to Leppington Rail Line would be elevated above the floodplain, there is the potential for significant increases in flood levels to occur upstream of the Glenfield to Leppington Rail Line alignment once the waterway capacity is exceeded. This is the case for Crossings 7 to 14. The assessment and minimisation of potential flood impacts is critical for existing development upstream of the Glenfield to Leppington Rail Line alignment. Further discussion is provided in Section 5.5.2.

Blockage of the waterway crossings by debris could also significantly increase flood levels upstream of the Glenfield to Leppington Rail Line alignment and result in adverse impacts when overflow occurs. While culvert blockage is generally a recognised problem, historically, little practical guidance has been provided in regard to how much culvert blockage should be considered for design purposes (refer Section 5.5.3). This is particularly difficult to quantify given the number of factors that can contribute to blockage including, upstream development, time since last significant event and the size of the waterway inlet. Based on past flooding in other catchments it has been shown that 100% blockage of culverts is possible in catchments having a significant amount and variety of potential sources of flood debris.

The catchment areas upstream of the proposed Glenfield to Leppington Rail Line alignment are reasonably varied in respect to their size and their degree of existing and proposed urbanisation (Figure 2). A number of the existing catchments are reasonably natural, while others have existing rural residential development. As further development is proposed in a large portion of the areas upstream of the Glenfield to Leppington Rail Line alignment, the potential for blockage and the consequences of blockage are likely to change.

The potential for blockage is likely to vary from one crossing to another, depending on the nature and extent of the catchment upstream. The need for or extent of blockage mitigation measures should also consider the consequences of crossing failure, which again varies from crossing to crossing. Consequently, each crossing has been assessed for blockage potential and consequences, with mitigation measures recommended accordingly.

The proposed Glenfield to Leppington Rail Line also has the potential to influence flow behaviour through a change in runoff characteristics (due to increased imperviousness) and diversion of catchment flows through regrading works. This assessment has considered the impact of the Glenfield to Leppington Rail Line on flow behaviour in the wider catchment. Further discussion is provided in Section 5.4.1 and 5.4.2.

2.5.3. Edmondson Park and Leppington Masterplans

The SWGC is planned to provide approximately 115,000 dwellings and associated infrastructure (such as the SWRL) in order to accommodate up to 300,000 people. The areas of Edmondson Park and Leppington form part of the SWGC. Two stations at each of the Edmondson Park and Leppington town centres are proposed as part of the Glenfield to Leppington Rail Line.

Master Planning for the Edmondson Park precinct is well underway and as such the *Development Control Plan* (Reference 1) of the area has been adopted as the base case for assessing relative impacts of the Glenfield to Leppington Rail Line.

Master Planning for the Leppington precinct is progressing. Indicative land use zoning for the town centre is available and has been adopted in the base case however planning for the remainder of the land release was not available. Where appropriate, information on proposed development layouts for Edmondson Park were adopted for Leppington.

Information from the *Edmondson Park Precinct DCP* (Reference 1) has been used to define the flood models (both hydrologic and hydraulic models) under both pre- and post- Glenfield to Leppington Rail Line development conditions (Figures 3 to 6). Future land use planning information was also taken into consideration when assessing the significance of riparian corridors, the blockage potential at the waterway crossings and the consequence of flood impacts.

For the Leppington precinct, for those areas beyond the town centre, the hydrologic models were based on similar design parameters to Edmondson Park regarding development densities. However, other aspects of this assessment required more specific details of proposed future land use. Therefore, in the absence of this information the hydraulic model layouts, consideration of riparian significance and blockage potential of waterway crossings have been based on existing conditions. It is recommended that the final masterplan layout for the whole land release at Leppington be reviewed in the context of design assumptions made for the purposes of this assessment.

2.5.4. Climate Change Impacts

Research into the potential impacts of climate change has been rapidly evolving over recent years. Current reports indicate that climate change is likely to result in more frequent and intense storms as well as sea level rises. Changes in flood behaviour due to climate change have the potential to increase the risk of inundation and associated impacts of the Glenfield to Leppington Rail Line.

The study area is prone to inundation from a number of creeks, and is proposed to accommodate a large portion of Sydney's growing population. The impacts of climate change and associated ramifications on development decisions can be significant and an assessment of the potential impacts on flood behaviour is therefore essential.

Studies undertaken by the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) in conjunction with the Bureau of Meteorology (BOM) in 2007 investigated past and likely future changes to climate in NSW (Reference 18). The outcomes estimate that extreme rainfall (defined as a 1 in 40 year 1 day total rainfall event) would be likely to increase by up to 12% for the Sydney metropolitan catchments as well as the Hawkesbury-Nepean catchment by 2030.

The Former NSW Department of Environment and Climate Change now Department of Environment, Climate Change and Water (DECCW) Draft Floodplain Risk Management Guideline – Practical Consideration of Climate Change (Reference 17) recommends a sensitivity analysis for increases in rainfall of between 10% and 30%. However, given the research undertaken by CSIRO/BOM, it is considered that a rainfall increase of 10% would provide an appropriate assessment of the effects of increases in rainfall due to climate change on the catchments of the Glenfield to Leppington Rail Line. Consideration of increases in rainfall and the effects on flooding are discussed further in Sections 3 and 4.

3. HYDROLOGIC ANALYSIS

3.1. Overview

The hydrologic modelling undertaken for the Glenfield to Leppington Rail Line Stage One EA was based on the Probabilistic Rational Method (PRM). As the PRM is limited in its ability to represent changes in flow behaviour as a result of urbanisation, a revision of the hydrology was required for the present assessment. Hydrologic models suitable for design flood estimation are described in Australian Rainfall and Runoff 1987 (AR&R) (Reference 16). In Australian engineering practice, examples of the more commonly used runoff routing models currently used include RORB, XP-RAFTS and the Watershed Bounded Network Model (WBNM). These models allow rainfall depth to vary both spatially and temporally over the catchment and readily lend themselves to calibration against recorded data.

Based on a review of available data and previous experience in the Cabramatta and Maxwells Creek catchments, a WBNM model was selected for the present study for Crossings 3 – 14 (Reference 19). WBNM is widely used throughout Australia and particularly NSW. The WBNM model has been used for previous studies undertaken on the catchments in the Glenfield to Leppington Rail Line study area. WBNM models were established to represent the creek systems including Cabramatta Creek, Maxwells Creek, Bonds Creek, Scalabrini Creek and Kemps Creek (Figure 2).

Crossings 1 is located within the catchments of Bunbury Curran Creek and on the boundary between Stage 1 – Stage B1 (Glenfield Station Interchange) and Stage 2 works. CCC is in the process of undertaking floodplain risk management planning for the Bunbury Curran Creek catchment. As part of the planning a flood model of the catchment has been developed. An XP-RAFTS hydrologic model was developed as part of that project. Flow hydrographs for the 50%, 20%, 10%, 5%, 2% and 1% (2 and 9 hour storms) AEP events were provided by Campbelltown City Council (CCC) for use in this study.

Hydrologic modelling undertaken for the assessment assumed that the SWGC urban release areas of Edmondson Park and Leppington upstream of the Glenfield to Leppington Rail Line were developed.

3.2. Model Configuration

3.2.1. General

A WBNM model simulates a catchment and its tributaries as a series of sub-catchment areas based on watershed boundaries linked together to replicate the rainfall/runoff process through the natural stream network. Input data includes definition of physical characteristics such as:

- surface area of the sub-catchments,
- proportion of urbanised or developed (imperviousness) catchment area, and
- stream length.

Four hydrologic models were created for different parts of the proposed Glenfield to Leppington Rail Line, with the separate models containing catchments which drain to (Figure 2):

1. Crossing 1 (XP-RAFTS),
2. Crossing 2 (WBNM),
3. Crossings 3 to 10 (including 7a, 7b, 10a and 10b) (WBNM),
4. Crossings 11 to 14 (WBNM).

For Crossings 3 to 10, the sub-catchment layout and percentage imperviousness were based on the post-development scenario from modelling undertaken for the *Edmondson Park Flood Study* (Reference 5). Each sub-catchment was delineated using 2 m topographic contours based on Land Property Information mapping provided in GIS format by Liverpool City Council (LCC). Further confirmation of sub-area boundaries in parts of the catchment was undertaken using 0.5 m topographic contours generated from Airborne Laser Scanning (ALS) data provided by LCC. The sub-catchments were further refined where necessary to account for the proposed Glenfield to Leppington Rail Line, and to provide inflow hydrographs at appropriate locations for the hydraulic model (Section 4).

The modelling for Crossings 3 to 10 included the tributaries of Cabramatta Creek and Maxwells Creek (upstream of Camden Valley Way and the Hume Highway). Land use types for determining percentage imperviousness assumed that the Edmondson Park urban release area upstream of the proposed Glenfield to Leppington Rail Line was fully developed according to the DCP (Reference 1). The increased catchment imperviousness caused by the development would result in higher peak flows at the railway line drainage crossings than current catchment conditions. Compensation basins for the Edmondson Park development are proposed but in some instances would be located downstream (for instance downstream of Crossing 7a) of the Glenfield to Leppington Rail Line (refer to Reference 5). Therefore the rail line crossings must cater for the full development flow. A compensation basin is proposed to be located upstream of Crossing 3.

For Crossings 11 to 14, the sub-catchment layout for the hydrologic modelling was based on 2 m contours from topographic maps, and included the tributaries of Bonds Creek, Scalabrini Creek and Kemps Creek. The Leppington urban release area was assumed to be fully developed for modelling purposes. Since details of the intended land-use for the area were not specified in the concept plan for the area (Reference 14), it was assumed that the density of urbanisation would be similar to Edmondson Park. The impervious proportion of the affected sub-catchments was therefore set equivalent to the average imperviousness of sub-catchments in the proposed Edmondson Park development. It is expected that development density of the Leppington Town Centre would be greater than that of Edmondson Park, however the development would have a localised effect and is not likely to significantly affect the peak runoff at the railway line. This assumption should be reviewed when more information on the Leppington Masterplan becomes available.

Modelling for Crossing 2 included a relatively small local catchment area of 4.6 Ha, draining into Maxwells Creek downstream of the Glenfield to Leppington Rail Line crossing. Catchment delineation was determined from 0.5 m topographic contours provided by LCC. For the purposes of estimating the impervious catchment area, the land-use was assumed to be residential to allow for future possible development of the catchment.

A hydrologic model encompassing the location of Crossing 1 was established as part of CCC assessment of the Bunbury Curran Creek catchment. Hydrologic outflow hydrographs were provided by CCC for the 50%, 20%, 10%, 5%, 2% and 1% AEP events. Full details of the XP-RAFTS model were not available for inclusion in this report.

The sub-catchments were delineated such that a sufficient level of spatial detail was achieved while avoiding unnecessary complexity due to an excessive number of catchments. The adopted sub-catchment division is shown on Figure 2.

3.2.2. Key Model Input Parameters

Key parameters for the WBNM model represent the physical characteristics of the catchment. Typical model parameters include:

- The proportion of urbanised or developed area within each sub-catchment (imperviousness).
- *Rainfall Losses*: Two values, initial and continuing loss, modify the amount of rainfall excess to be routed through the model catchments.
- *Lag Parameter*: This parameter affects the timing of the runoff response to the rainfall and is subject to catchment size, shape and slope.

The parameters adopted for this study were based on a review of values used in previous studies (References 5, 9 and 10), those recommended in AR&R 1987 (Reference 16) and previous experience.

Suggested ranges of percentage impervious for various land uses are documented in both LCC's and CCC's stormwater guidelines (References 20 and 21). These values were reviewed considering aerial images and the type of development proposed, to determine the percentage of impervious area for each land use type. Table 4 provides a summary of the guideline values compared to those adopted for use in the WBNM model.

Table 4 Suggested/Adopted Percentage Imperviousness for Various Land Uses

Land Use Type	Imperviousness (%)		
	LCC	CCC	Adopted
Natural	-	0	0
Rural (including Open Space)	Site Measured	10-50	10
Rural Residential	-	20-60	25
Higher Density Rural Residential (Denham Court)	-	-	30
New Residential (20 lots/ha)	-	70-90	70
New Residential (25 lots/ha)	-	-	80
New Residential (40 lots/ha)	-	-	85
Medium/High Density (55 lots/ha)	90	70-100	90
Industrial	90	90-100	90
Commercial	100	90-100	90
Roads	95	-	95

Investigation of the effect of the change to catchment imperviousness due to the construction of the Glenfield to Leppington Rail Line itself was included in the *Edmondson Park Flood Study* (Reference 5), and was generally found to have an insignificant effect on the peak catchment flows. Impacts were assumed to be accounted for in the mitigation measures adopted for development of the urban release area. Therefore the hydrologic modelling undertaken assumed the rail line was fully constructed (refer Section 5.4.1).

Loss rates for the WBNM model were adopted in accordance with values recommended in AR&R 1987. These values are at the lower end of the suggested range. For pervious areas, an initial loss of 15 mm and a continuing loss of 2.5 mm/hr were adopted. For impervious areas, an initial loss of 1.5 mm and a continuing loss of 0 mm/hr were used.

A lag parameter value of C = 1.29 was adopted for all scenarios (based on recommended values for ungauged catchments reported in Reference 19).

3.2.3. Design Rainfall

Both CCC and LCC provide catchment wide rainfall intensities, although there was no site specific design rainfall data available for the relevant catchments. Hence for the present study site specific design rainfall intensities and temporal patterns were derived from AR&R 1987 (Reference 16). The adopted rainfall intensities compared reasonably well to those values provided in both CCC's and LCC's stormwater guidelines (Reference 20 and 21). The adopted design rainfalls for various storm durations and frequencies are summarised in Table 5. Due to the relatively small overall catchment sizes, uniform rainfall depths with zero areal reduction factors were applied for each catchment.

Table 5 Design Rainfall Intensities and Depths

Duration		Average Recurrence Interval (years)						
		1 in 5	**1 in 10**	**1 in 20**	**1 in 50**	**1 in 100**	**1 in 200**	**1 in 500**
30 minutes	Intensity in mm/hr	61	69	79	92	102	112	125
	Depth in mm	30	34	39	46	51	56	63
1 hour	Intensity in mm/hr	42	47	54	63	69	76	85
	Depth in mm	42	47	54	63	69	76	85
1.5 hours	Intensity in mm/hr	32	36	42	49	54	59	67
	Depth in mm	48	54	63	73	81	89	100
2 hours	Intensity in mm/hr	27	30	35	41	45	50	56
	Depth in mm	54	60	70	81	90	99	111
3 hours	Intensity in mm/hr	21	23	27	31	35	38	43
	Depth in mm	62	70	80	94	105	115	130
4.5 hours	Intensity in mm/hr	16	18	21	24	27	30	33
	Depth in mm	71	81	93	109	121	134	150
6 hours	Intensity in mm/hr	13	15	17	20	23	25	28
	Depth in mm	79	90	103	121	135	149	167
9 hours	Intensity in mm/hr	10	12	13	16	17	19	22
	Depth in mm	91	104	119	140	156	173	194
12 hours	Intensity in mm/hr	8.4	10	11	13	15	16	18
	Depth in mm	101	115	133	156	174	192	216

3.3. Hydrologic Modelling Outcomes

3.3.1. Design Event Modelling

Each WBNM model was run for the 50%, 5%, 1% and 0.5% Annual Exceedance Probability (AEP) events and the PMF event for a range of storm durations (ranging from 30 minutes to 6 hours). A summary of peak flow estimates at each Glenfield to Leppington Rail Line crossing is provided in Table 6.

Table 6 Results of Hydrologic Modelling at Key Locations

Crossing	Area (ha)	Assumed Impervious Area (%)	Peak Flow (m^3/s) and Critical Duration (mins)				
			50% AEP	5% AEP	1% AEP	0.5% AEP	PMF
1	77.4	Not Available	8.2 (120 min)	23.8 (120 min)	32.4 (120 min)	Not Available	Not Available
2	4.6	20	0.5 (90 min)	1.2 (90 min)	1.6 (90 min)	1.8 (90 min)	6.0 (30 min)
3	164	68	12.0 (120 min)	24.4 (120 min)	32.6 (120 min)	36.8 (120 min)	166.9 (45 min)
4	24	85	4.5 (90 min)	7.9 (90 min)	9.7 (90 min)	10.7 (90 min)	39.0 (15 min)
5	1.5	60	0.3 (90 min)	0.6 (90 min)	0.7 (90 min)	0.8 (90 min)	2.7 (15 min)
6	66	36.5	4.3 (120 min)	9.4 (120 min)	12.9 (120 min)	14.7 (120 min)	66.8 (45 min)
7a	417	22.2	16.7 (120 min)	39.3 (120 min)	55.7 (120 min)	63.3 (120 min)	369.0 (60 min)
7b	3.99	20	0.4 (90 min)	1.1 (90 min)	1.4 (90 min)	1.6 (90 min)	5.3 (30 min)
8	32	20	2.4 (90 min)	5.6 (90 min)	7.6 (90 min)	8.6 (90 min)	34.4 (30 min)
9	80	10.8	3.4 (120 min)	7.9 (120 min)	11.6 (120 min)	13.4 (120 min)	75.2 (45 min)
10a	37	39.0	2.2 (120 min)	5.7 (120 min)	8.1 (120 min)	9.3 (120 min)	42.5 (30 min)
10b	5.8	40	0.8 (90 min)	1.7 (90 min)	2.2 (90 min)	2.5 (90 min)	7.9 (30 min)
11	781	34.2	29.9 (540 min)	58.6 (540 min)	76.5 (120 min)	87.0 (120 min)	438.5 (90 min)
12	9	45.0	1.3 (90 min)	2.6 (90 min)	3.3 (90 min)	3.7 (90 min)	11.2 (15 min)
13	410	34.0	17.6 (90 min)	35.6 (90 min)	47.6 (120 min)	54.0 (120 min)	247.7 (60 min)
14	499	34.5	23 (90 min)	47.4 (120 min)	65.5 (120 min)	74.4 (120 min)	323.9 (60 min)

Notes: Crossing 1 flows assessed as part of the Bunbury Creek Flood Study.
Crossings 2, 7b, CH. 47.500 and 10b to be assessed during detailed design stage (refer to Section 5).

Crossing 1 lies on the boundary of Stage 1 – Stage B1 (Glenfield Station Interchange) and Stage 2 and the assessment of this crossing utilised hydrologic modelling that was established as part of the *Bunbury Curran Creek Flood Study* undertaken by CCC.

It is noted that the peak flow estimates are generally higher than those determined for the Stage One EA (Reference 7). This is mainly due to the greater extent of upstream development assumed for this assessment, particularly as a result of development of the Edmondson Park and Leppington urban release areas.

The critical duration for many of the catchments draining to the crossings was found to be between 90 and 120 minutes.

3.3.2. Climate Change

The 2005 Floodplain Development Manual also requires that Flood Assessments consider the impacts of climate change on flood behaviour. The study area is prone to inundation from a number of creeks, and is proposed to accommodate a large portion of Sydney's growing population. Hence, the sensitivity of the model results to various Climate Change scenarios was assessed in order to highlight potential ramifications on development decisions.

In accordance with the DECCW Guideline 2007, the following climate change scenarios are considered:

- increase in peak rainfall and storm volume:
  - low level rainfall increase = 10%,
  - medium level rainfall increase = 20%,
  - high level rainfall increase = 30%.

The outcomes of these sensitivity analyses are presented in Table 7 and are discussed further in the following sections.

Table 7 Climate Change Assessment

Crossing	1% AEP Peak Flow (m^3/s)			
	Design	**10% Rainfall Increase**	**20% Rainfall Increase**	**30% Rainfall Increase**
1	32.4	35.6	38.9	42.1
2	1.6	1.8	2.0	2.2
3	32.6	36.8	41.1	45.4
4	9.7	10.7	11.7	12.7
5	0.7	0.8	0.9	0.9
6	12.9	14.7	16.5	18.4
7a	55.7	63.3	71.0	79.2
7b	1.4	1.6	1.8	1.9
8	7.6	8.6	9.7	10.8
9	11.6	13.5	15.4	17.4
10a	8.1	9.2	10.4	11.6
10b	2.2	2.5	2.7	3.0
11	76.5	86.9	97.6	108.9
12	3.3	3.4	3.8	4.2
13	47.6	54.0	60.6	67.4
14	65.5	75.5	84.7	93.9

As the XP-RAFTS hydrologic model was not provided by CCC, to account for climate change at Crossing 1, the hydrographs provided by CCC were factored up by 10%, 20% and 30%. For detailed design, the original hydrologic model should be utilised to undertake the climate change assessment for consistency with the other crossing assessments.

4. HYDRAULIC ANALYSIS

4.1. General

The Stage One EA identified crossing locations where hydraulic analysis was warranted and/or feasible (Reference 7). As part of the Stage One EA, steady-flow computational hydraulic models of these identified locations were established using the HEC-RAS one-dimensional (1D) modelling package. The outcomes of the Stage One EA indicated that several crossing locations (Crossings 3 to 6) required a more detailed assessment of the likely flood risk and impacts caused by the proposed rail line. As part of this current assessment, it was further identified that more detailed investigation of Crossings 7 to 10 would also be beneficial.

For this assessment, different modelling approaches were used depending on the complexity of flow behaviour at each crossing. For the crossings identified as requiring more detailed hydraulic assessment, a two-dimensional (2D) model was used, while the remainder were modelled in 1D.

In general a two-dimensional (2D) model provides better definition of flow paths and greater flexibility than a 1D model, particularly in locations where flow behaviour is not restricted to well-defined channels or where flow direction changes suddenly. A 2D model is therefore appropriate for the representation of overland flow paths and flow behaviour along the railway line cuttings. Potential diversions of flow due to the Glenfield to Leppington Rail Line are largely addressed by the ground definition in the 2D model layout. In comparison, the direction of overland flow and the definition of flow paths in a 1D model are pre-defined by the model user.

Additionally, 2D models provide a more accurate representation of floodplain storage, and therefore produce more reliable results where storage is a key factor controlling the flow behaviour (such as with detention basins). 2D models can therefore more adequately assess the hydraulic behaviour in such areas.

The 2D hydraulic modelling for this assessment was undertaken using the SOBEK and TUFLOW software packages, which are both widely used in flood engineering within Australia and internationally. Both provide a proven tool for the dynamic modelling of development within floodplains, such as the proposed Glenfield to Leppington Rail Line. For the crossings where flow behaviour is less complex and 2D modelling was not warranted, the 1D steady-flow HEC-RAS modelling package was used.

In summary, the following hydraulic models were established:

- Crossings 1 and 2 were represented together in a single TUFLOW model (Figure 3)
- Crossings 3 to 6 were represented together in a single SOBEK model (Figures 4 and 5);
- Crossings 7 to 10 were represented together in a single SOBEK model (Figures 6 and 7); and
- individual HEC-RAS models for each of Crossings 11, 12, 13 and 14 (Figures 27 to 29).

As noted previously hydraulic modelling of Crossing 1 has being undertaken using the hydraulic model established as part of the *Bunbury Creek Flood Study* by CCC.

Furthermore it was considered that detailed modelling of Crossing 2, 7b, CH. 47.500 and 10a was not warranted, as the catchments are relatively small and the crossings (consisting of diversion drains and/or pipes) are simple enough to be sized at the detailed design stage using the peak flows estimated from the hydrologic modelling.

4.2. Model Configuration

Input data required to establish the hydraulic models includes:

- Topographic information, in the form of a Digital Terrain Model (DTM) for 2D models, and cross-section survey of channels for 1D models;
- Energy loss parameters typically represented by the Manning's "n" roughness parameter; and
- Boundary conditions, such as inflows from upstream catchments and tailwater levels.

For each model, a pre- Glenfield to Leppington Rail Line and a post- Glenfield to Leppington Rail Line development scenario was established. The pre- Glenfield to Leppington Rail Line case was used to provide a benchmark against which the impacts of the Glenfield to Leppington Rail Line could be assessed. It is important to note that the pre- Glenfield to Leppington Rail Line scenario does not necessarily reflect current catchment conditions, as in some cases it includes assumed developments which have been approved or planned but not yet constructed, and are likely to influence flow behaviour in the vicinity of the proposed rail line. For the purposes of this assessment, the only difference between the hydraulic models of the pre- and the post- Glenfield to Leppington Rail Line development scenarios is the inclusion of the proposed Glenfield to Leppington Rail Line and associated infrastructure for the post- Glenfield to Leppington Rail Line scenario.

The following sections outline the data sources, development assumptions, key parameters and boundary conditions for the various hydraulic models used in this assessment.

4.2.1. 2D TUFLOW Model

The TUFLOW model was provided by CCC. This model is a truncated version of the regional catchment model developed by CCC for their Flood Study and was approved for investigation of flooding processes and flood mitigation measures for the Glenfield to Leppington Rail Line. CCC provided the model to TIDC and the Glenfield Junction Alliance in June 2009. It is noted that the model provided was not stable for all hydraulic conditions analysed and required some minor modifications of the 2D grid to fix instabilities. These modifications were approved by CCC (pers. comm. Rob Leslie of GJA and David Crompton of CCC 03/08/2009). It should be noted that the modified model still includes areas of instability and is not capable of running certain hydraulic conditions such as very high order flood events.

The TUFLOW model represents the Bunbury Curran Creek and respective floodplain in the vicinity of the Glenfield to Leppington Rail Line Glenfield Junction Stages 1 and 2. The extent of the model is illustrated in Figure 3.

The proposed Glenfield Junctiondevelopment was manually input into the TUFLOW model. The rail corridor widening of Stage 1 and new rail development of Stage 2 were represented by a series of z-lines to alter the modelled ground surface by raising or lowering grid elevations to those proposed for the embankments in the concept design. The proposed viaducts in Stage 2 were represented by flow constrictions in the 2D domain. The eastern viaduct has been modelled as a dual bridge, the northern being 75m in length and the southern being 90m in length (as per drawing SWRL-300-CD-0120-ST-005). The western viaduct has been modelled as a single bridge of 150m in length (as per drawings SWRL-300-CD-0120-ST-006 and SWRL-300-CD-0120-ST-007). The deck levels and pier sizes and types were represented in the model based on assumptions made from the concept design information available at the time (as per drawing SWRL-300-CD-0120-ST-0025).

At the time of writing the latest concept design for Stage 1 development had the existing culvert under the railway, in the vicinity of Salisbury Avenue, as blocked. Therefore this culvert is not present in the current TUFLOW model.

4.2.2. 2D SOBEK Models

Two Digital Terrain Models (DTM) covering parts of the study area were available from the previous *Edmondson Park Flood Study* (Reference 5). These DTMs were used as a basis for creating the hydraulic models used in this assessment. The DTM was supplemented with additional data obtained as part of this project in the vicinity of Crossing 3.

One DTM included the catchments draining to Crossings 3, 4, 5 and 6, and the other included Crossing 7. The latter DTM was extended for this assessment to include Crossings 8, 9 and 10. The models used for the base case were established using the assumptions from the post-development scenario from the *Edmondson Park Flood Study* (that is, fully developed according to the Edmondson Park Masterplan available at the time of the Flood Study), with some additional design detail of development and compensation basins to reflect the current development concept.

It should be noted that the flood model layout for Crossing 3 includes the proposed detention basin on Maxwells Creek located upstream of the Glenfield to Leppington Rail Line. This basin is proposed as part of the stormwater management plan of the Edmondson Park urban release area. Details of this basin are based on those in the *Edmondson Park Flood Study* (Reference 5) and are therefore preliminary at this stage. The final basin layout and detention characteristics should be reviewed when available and any changes in flow behaviour at Crossing 3 should be incorporated into future design stages.

The models were extended where necessary to incorporate additional features in the study area (e.g. Crossings 9 and 10). The DTM was also updated to include additional detailed survey of current ground levels along the proposed rail corridor, as provided by TIDC. These models were used for the pre-Glenfield to Leppington Rail Line scenario.

Each model was then modified to reflect the construction of the proposed Glenfield to Leppington Rail Line for the post-Glenfield to Leppington Rail Line development scenario, based on SWRL concept design data provided by TIDC.

The various 2D model schematisations are shown on Figures 3 to 7.

4.2.3. 1D HEC-RAS Models

Previous HEC-RAS models of Crossings 11, 12, 13 and 14 were available from the SWRL Stage One EA. Both the pre- and post-Glenfield to Leppington Rail Line models were updated to incorporate the additional detailed survey of the rail corridor that has since become available.

Each model was then modified to establish the post-Glenfield to Leppington Rail Line development scenario based on concept design information for the Glenfield to Leppington Rail Line. The various HEC-RAS model layouts are shown on Figures 27 to 29.

4.2.4. Key Model Parameters

The main assumed parameter affecting hydraulic behaviour in the SOBEK and TUFLOW models is the Manning's "n" roughness value, which represents energy losses due to friction and is often used to incorporate additional energy losses from other physical processes. In comparison to a 1D model, a 2D model generally provides a better representation of losses along a creek due to directional changes around bends, or form losses from the expansion and contraction of flow. By comparison, an allowance for these losses is usually factored into the Manning's "n" values adopted for 1D models. Consequently in a 2D model, the Manning's "n" values are typically lower than the 1D model values for a similar environment, since these additional losses are explicitly accounted for.

Manning's "n" values for the current assessment were based on a review of vegetation types in the study area, proposed development land-use types, and previous experience within the study area. There are limited historical studies available that cover the creek reaches within this study area, however those available were reviewed (Reference 5, 11 and 24) and Manning's 'n' values were adopted that were consistent with these previous studies. Reference 24 included comprehensive calibration against various historical events along South Creek and its tributaries, including Kemps Creek.

The Manning' "n" values used for the 2D models were in the range of 0.04 to 0.045 for in-bank areas, 0.03 to 0.06 for overbank areas and 0.02 for roads. For the 1D models, values ranging from 0.04 to 0.1 were used, depending on the specific site conditions at each crossing.

The TUFLOW model used in the assessment of Crossing 1 also applied a very high Manning's "n" value to represent the restriction presented by buildings and other built up areas within the floodplain.

4.2.5. Boundary Conditions

The pre- and post-Glenfield to Leppington Rail Line scenario SOBEK models (Crossing 3 – 10) were run for the 50%, 5%, 1%, and 0.5% AEP events and the PMF event, using the critical duration as determined from the hydrologic modelling. The TUFLOW model representing Crossing 1 was run for the 1% AEP design event. For the 2D models, which included multiple sub-catchments, a catchment-wide critical duration of 2 hours was used. For the 1D models the critical duration from the sub-catchment upstream of the crossing was used (see Table 6). Inflows were taken from the hydrological modelling undertaken for this assessment (Section 3). The 2D models were run using the full time-series hydrographs to estimate the dynamic flood behaviour of the catchment, whereas for the 1D models the peak flows were used in a steady-state simulation.

For the SOBEK and 1D models, boundary conditions at the downstream model extents were based on stage-discharge relationships, assuming uniform flow at the outlet cross-sections. For the TUFLOW model, the downstream boundary was defined by a tailwater level within the Georges River, consistent with the design event being modelled. Tailwater levels for each design storm were provided by CCC and were based on the Upper Georges River Flood Study (Reference 23).

4.2.6. Additional Scenarios

4.2.6.1. Blockage

To estimate the sensitivity of the proposed culvert crossings to blockage from debris, additional scenarios incorporating blockage of 25% and 50% at these crossings were modelled, where appropriate. The culverts at Crossings 3, 4, 6, 8, 9, 10a and 11 were deemed to be susceptible to blockage and therefore the additional blockage scenarios were modelled. The remaining crossings were either not hydraulically modelled or bridges are proposed which are less susceptible to blockage. At crossing locations where the potential impacts of blockage were identified as severe, a 100% blockage situation was also modelled to assess the 'worst-case' consequences at these locations. These results were used to inform the types of mitigation options to be investigated. In the course of the assessment, it was identified that blockage at Crossings 3, 4 and 6 had the potential to produce significantly adverse flood behaviour (Figures 11b, 15b, 31, 32 and 33).

4.2.6.2. Climate Change

To estimate the potential consequences of an increase in rainfall due to climate change on the proposed crossings, additional scenarios incorporating rainfall increases of 10%, 20% and 30% at each crossing were modelled.

4.3. Hydraulic Modelling Outcomes

4.3.1. Crossing Sizing Requirements

During the course of the hydraulic modelling, the performances of the crossing dimensions based on the current concept design were assessed, and the dimensions were revised where appropriate. Full details of recommended dimensions are provided in Chapter 5.

Preliminary sizings have been developed for waterway crossing such that flood impacts are generally negligible or manageable for events up to and including the 1% AEP (1 in 100 year) storm.

At all the waterway crossings where hydraulic modelling was undertaken, the results (for an unblocked waterway crossing) indicate that for flood events up to and including the 1% AEP (1 in 100 year) event any adverse flood level impacts upstream of the waterway crossings would be localised to the culvert inlet and generally contained within the rail corridor. Any adverse impacts on adjacent land would need to be managed in the design of inlet treatments and surface drains in the future design stages. Future design of inlet works should also include a refinement of the preliminary culvert sizings (refer Table 13).

Assessment of bridge openings was initially based on the concept earthworks design showing batter extents. Where the proposed earthworks extents was found to result in adverse flood impacts, the earthworks batters were modified to determine the required overall bridge span between abutments. Preliminary overall spans between abutments are provided for each proposed bridge crossing. No assessment has been made of pier arrangements or compensatory channel works. Final bridge arrangements, including pier sizes, spacings and locations and compensatory channel works would need to be confirmed through detailed hydraulic modelling during future design stages.

4.3.2. Design Flood Modelling

Plans of the inundation extents for the post-Glenfield to Leppington Rail Line development scenario, as estimated from the hydraulic modelling, are shown on Figures 11a, 15a, 19a, 23a and 27 to 29. Comparisons of peak flood levels for the pre- and post-Glenfield to Leppington Rail Line scenarios are shown on Figures 12, 16, 20 and 24.

A summary of peak flood levels at key locations for the 1% AEP (1 in 100 year) event, including each of the blockage scenarios for both pre- and post-Glenfield to Leppington Rail Line conditions, is given in the tables in Appendix B.

A discussion of the outcomes of the hydraulic assessment with regards to the compliance requirements (refer to Section 5) is given in the following section.

4.3.3. Climate Change Design Flood Modelling

The former NSW Department of Environment and Climate Change now Department of Environment, Climate Change and Water (DECCW) Draft Floodplain Risk Management Guideline – Practical Consideration of Climate Change (Reference 17) recommends a sensitivity analysis for increases in rainfall of between 10% and 30%. However, given the research undertaken by CSIRO/BOM, it is considered that a rainfall increase of 10% would provide an appropriate assessment of the effects of increases in rainfall due to climate change on the catchments of the Glenfield to Leppington Rail Line.

The potential effects of climate change on rainfall for the 1% AEP (1 in 100 year) event were considered. As discussed previously (Section 2.5.4), a 10% increase in severe rainfall intensities over the medium to long term (~70 years) was adopted for this study.

Plans of the peak flood level impact for the post-Glenfield to Leppington Rail Line development scenario, including a 10% increase in rainfall as estimated from the hydraulic modelling are shown in Figures 14, 18, 22 and 26. Modelling results for the 20% and 30% rainfall increase scenarios are provided in Appendix C.

As expected, peak flood levels generally increased with corresponding increases in rainfall. Whilst there appeared to be a general increasing trend between the different scenarios, the relative increase was sometimes found to be influenced by local hydraulic behaviour. For example, upstream of certain crossings the results indicate that the relative increase between the 20% and 30% rainfall scenarios was reasonably small. This reflects situations where the particular road has been overtopped and is able to carry the additional runoff volume with little increase in flood level.

5. POTENTIAL IMPACTS FROM PROPOSED WORKS

5.1. Construction

5.1.1. General

The construction or 'land disturbance' phase of the Glenfield to Leppington Rail Line project arguably represents the period of greatest erosion and sedimentation potential. Consequently, appropriate control measures would be essential to minimising the erosion of soils and sedimentation and pollution of downstream waterways.

Erosion and sedimentation from disturbed areas during construction would need to be controlled in accordance with *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004). For each component of work (such as the construction of the railway line, stations, ancillary facilities such as car parks, etc) an Erosion and Sediment Control Plan or a Soil and Water Management Plan shall be prepared and incorporated into the Construction Environmental Management Plan (CEMP). The CEMP shall include a monitoring program to assess the water quality upstream and downstream of the Glenfield to Leppington Rail Line both during and after construction.

Measures to control erosion and sedimentation should include:

- appropriate staging of works to minimise the extent of disturbance at any one time,
- mitigation/control of onsite soil erosion through surface stabilisation and minimisation of slope length and gradient,
- control of the movement of water onto, through, and off the site such as diversion drains to direct upstream runoff around the site and collection and treatment of runoff prior to discharge from the site.

Treatment of runoff prior to discharge from the site shall include the provision of sediment ponds to minimise the dispersion of sediments into downstream watercourses. For preliminary purposes an indicative extent of sediment ponds required is provided on Figures 30a, b, c and d. This extent has been prepared for indicative purposes only and does not consider construction staging or the location of haulage roads and stockpile areas.

The exact location and sizing of sediment ponds would need to be finalized during future design stages. Design shall be in accordance with Section 6 of *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004).

5.1.2. Proposed Construction Roads

There are three construction access roads proposed as part of the project which cross existing waterways. They are located upstream of Crossing 4, downstream of Crossing 6 and downstream of Crossing 10b. The catchment flow in the event of a flood needs to be accommodated at these crossings, however given the short term nature of a construction access road a lesser design standard than the 1% AEP (1 in 100 year), such as the 5% AEP (1 in 20 year) could be appropriate. However, it is proposed that the construction access roads at Crossings 4 and 6 would become permanent and would need to meet the 1% AEP design standard. Table 8 below provides a summary of the proposed construction access road crossings.

Table 8 Proposed Construction Access Roads

Location	5% AEP Peak Flow (m^3/s)	1% AEP Peak Flow (m^3/s)	Comment/ Recommendations
Upstream Crossing 4	3.1	3.8	Ensure adequate capacity is provided to convey the catchment flow. Crossing proposed to become permanent and would be designed to a 1% AEP design standard. Can be fully addressed in detailed design.
Downstream Crossing 6	13.3	18.4	Crossing proposed to become permanent and would be designed to a 1% AEP design standard. Given the significance of the 1% AEP flow at this crossing and potential interaction with Crossing 6, a fully hydraulic assessment of the crossing should be undertaken in detailed design.
Downstream Crossing 10b	1.7	2.2	Ensure adequate capacity is provided to convey the catchment flow. Can be fully addressed in detailed design.

The most significant flow occurs at the crossing downstream of Crossing 6 with a 1% AEP (1 in 100 year) design flow of 18.4m^3/s. It is essential that adequate capacity is provided at this location as this crossing is located downstream of Crossing 6 and insufficient capacity may also reduce the efficiency of Crossing 6. A suitable crossing would be designed so that this flow is not obstructed. A full hydraulic assessment of this crossing should be undertaken in detailed design.

The access road crossings upstream of Crossing 4 and downstream of Crossing 10b need to convey relatively minor catchment flows and can be fully addressed in detailed design.

5.1.3. Proposed Site Compounds and Stockpiles

During construction a number of site compounds and stockpile sites would be located along the proposed Glenfield to Leppington Rail Line route. These have the potential to impact on flood behaviour, subject to site specific factors. For example such works may divert flow, create localised increases in flood levels. Further there is the potential for construction activities to be disrupted due to inundation of the site during an event. An overview flood assessment at proposed site compounds and stockpile sites is provided in Table 9 (refer also to Figures 34a and 34b). These outcomes are based on a desktop review of existing hydraulic modelling of proposed waterway crossings for the Glenfield to Leppington Rail Line.

Table 9 Site Compounds and Stockpiles

Site Compounds	Location (Refer Figures 34a and 34b)	Comments	Recommendations
SC1 (Approved)	Adjacent to (North of) Crossings 1 and 2	Approximately 50% of the site compound would be inundated during a 1% AEP (1 in 100 year) event (Refer Figure 34 a) with flood levels ranging from 18m AHD in the south east (Location A Figure 34a) corner to 26.3m AHD midway along the site compound (Location B Figure 34b). Velocity approaches 2m/s through the south eastern portion of the proposed site compound.	Provide adequate site drainage through the site compound to Crossing 1 and provide adequate capacity for any diversion of Crossing 2. Drainage and water quality issues should be addressed in the CEMP. High value materials and equipment should be located beyond the 1% AEP flood extent in the western portion of the site compound. Given the flow conditions on the eastern portion of the site is recommended that a detailed review of overland flow and hazard across the site for a full range of events be undertaken.
SC2 (Potential)	South of Crossing 2	Site compound located within the small catchment draining to Crossing 2, while no hydraulic modelling has been undertaken it is unlikely to be inundated during a 1% AEP (1 in 100 year) event. Crossing 2 is proposed to be diverted to Crossing 1.	Provide adequate site drainage through the site compound and minimise any obstruction of the proposed diversion. Drainage and water quality issues should be addressed in the CEMP.
SC3 (Potential)	East of Crossing 4	Site compound located between catchments draining to Crossing 3 and Crossing 4 and would not be inundated during a 1% AEP (1 in 100 year) event.	Provide adequate site drainage through the site compound for overland runoff. Drainage and water quality should be addressed in the CEMP.
SC4 (Potential)	North of Crossing 5	Site compound located downstream of Crossing 5, which is proposed to be diverted. Site compound would not be inundated during a 1% AEP (1 in 100 year) event.	
SC5 (Potential)	North of Crossing 7a	Site compound located downstream of Crossing 7a. Site compound is not likely to be inundated during a 1% AEP (1 in 100 year) event. The 1% AEP flood level at the south western boundary of the site compound is 48.4m AHD and the 1% AEP 10% rainfall increase to account for climate change flood level at the same location is 48.5m AHD.	Provide adequate site drainage through the site compound for overland runoff. Drainage and water quality should be addressed in the CEMP
SC6 and SC7	North of Crossing 10a	Site compound located within the small catchment draining to Crossing 10a. Site	Provide adequate site drainage through the site compound for overland runoff. Drainage

Site Compounds	Location (Refer Figures 34a and 34b)	Comments	Recommendations
(Potential)		compound is not likely to be inundated during a 1% AEP (1 in 100 year) event. The 1% AEP and 1% AEP 10% rainfall increase climate change flood level at the southern corner of SC6 is 56.6m AHD.	and water quality should be addressed in the CEMP
SC8 (Potential)	East of Crossing 11	Site compound located downstream of Crossing 11. Site would not be inundated during a 1% AEP (1 in 100 year) event.	
SC9 (Potential)	East of Crossing 12	Site compound located downstream of Crossing 12, which is proposed to be diverted. Site compound would not be inundated during a 1% AEP (1 in 100 year) event.	
SC10 (Potential)	West of Crossing 13	Site compound located downstream of Crossing 13. Site compound would not be inundated during a 1% AEP (1 in 100 year) event.	Provide adequate site drainage through the site compound for overland runoff. Drainage and water quality issues should be addressed in the CEMP.
SC11 and SC12 (Potential)	East and West of Crossing 14	Site compounds located within the catchment draining to Crossing 14. Site compounds would not be inundated during a 1% AEP (1 in 100 year) event.	
Stockpile Sites			
SSA and SSAB	Adjacent to Crossing 2	Stockpile Sites located within the catchment draining to Crossing 1. Sites would not be inundated during a 1% AEP (1 in 100 year) event.	Provide adequate site drainage through the sites for overland runoff. Drainage and water quality issues should be addressed in the CEMP. SSA should not obstruct the diversion of Crossing 2.
SSC	South of Crossing 5	Stockpile Site located within the catchment draining to Crossing 5, which is proposed to be diverted. Site would not be inundated during the 1% AEP (1 in 100 year) event.	Provide adequate site drainage through the site compound for overland runoff. Drainage and water quality issues should be addressed in the CEMP.
SSD	North of Crossing 7a	Stockpile Site located downstream of Crossing 7a. Site would not be inundated during a 1% AEP (1 in 100 year) event.	
SSE	East of Crossing 10b	Site located within the catchment draining to Crossing 10b, while no hydraulic modelling has been undertaken it is unlikely to be inundated during a 1% AEP (1 in 100 year) event.	
SSF	East of Crossing 12	Site located within the catchment draining to Crossing 12, while no hydraulic modelling has been undertaken it is unlikely to be inundated during a 1% AEP (1 in 100 year) event.	
SSG	West of Crossing 13	Site located between catchments draining to Crossing 13 and 14 and would not be inundated during the 1% AEP (1 in 100 year) event.	Provide adequate site drainage through the site compound for overland runoff. Drainage and water quality issues should be addressed in the CEMP.
SSH	West of Crossing 14	Site located within the catchment draining to Crossing 14, however would not be inundated during the 1% AEP (1 in 100 year) event.	

5.2. Water Quality

Under existing conditions the Glenfield to Leppington Rail Line corridor is predominantly cleared pastoral or naturally vegetated land with some areas of rural residential or low density development. In contrast, the proposed Glenfield to Leppington Rail Line with its associated stations, car parks and other ancillary infrastructure represents a significant change in landuse with a resulting change in the potential for and type of pollutants generated.

With the proposed Glenfield to Leppington Rail Line there is the potential for erosion and sedimentation from cuttings and embankments, scouring downstream of waterway crossings and runoff generated pollutants such as oils, greases and gross matter. The potential for scour, erosion and pollutant generation would need to be controlled through the adoption of appropriate water quality measures in accordance with all statutory and environmental protection requirements, including the *Edmondson Park Precinct DCP* (Reference 1) and the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000).

Where practical, water quality measures should be incorporated into the design of the drainage system, such as the use of grassed swales in lieu of concrete or bitumen lining and absorption trenches with slotted pipes in lieu of unslotted pipes.

Where the proposed measures are not practical or inadequate for the expected pollutant loadings then end source solutions should also be implemented. These types of measures may include water quality ponds and/or proprietary pollutant control devices. The provision of water quality measures would need to consider ongoing maintenance requirements.

5.3. Soil Salinity

Soil salinity has been identified as a potential risk in the Western Sydney area and in particular the Edmondson Park Release Area (*Edmondson Park Precinct DCP* (Reference 1)). It is recommended that the presence of soil salinity be identified and appropriate mitigation measures adopted in accordance with the *Edmondson Park Precinct DCP* as required.

5.4. Water Quantity

The proposed Glenfield to Leppington Rail Line has the potential to change runoff behaviour from the catchments that cross the rail alignment through:

- changes in the amount of impervious area,
- diversion of flows between adjoining catchments through regrading works.

5.4.1. Changes in Impervious Area

The Glenfield to Leppington Rail Line would result in a net increase in the proportion of impervious area. Increasing the amount of impervious area within a catchment alters the flow behaviour and the total volume of runoff from the catchment. Changes in peak flow behaviour within areas downstream of the rail alignment depend on the extent of the rail corridor relative to the overall size and nature of the upstream catchment. Consequently, in assessing peak flow impacts on downstream areas consideration needs to be made of the interaction of flows from the rail corridor with runoff from the upstream catchment and not just consideration of the change in flow behaviour from the rail corridor in isolation. An assessment of the Glenfield to Leppington Rail Line in isolation showed that the increase in imperviousness due to the rail line would result in a maximum increase in peak flow downstream of approximately 5%, with increases no greater than $2.5m^3/s$.

Crossings 3 to 10a lie within the Edmondson Park urban release area. Urbanisation of the catchments both upstream and downstream of these crossings would increase imperviousness. A stormwater management plan and detention basin strategy has been developed (documented in the *Edmondson Park Flood Study* (Reference 5)) to manage changes in flow behaviour due to proposed urbanisation of the catchments within the Edmondson Park urban release area. This basin strategy was developed taking into consideration the change in land use proposed for the Glenfield to Leppington Rail Line. This holistic approach to stormwater management and detention basin strategy is generally more effective and efficient than multiple detention basin systems for separate infrastructure.

For all crossings within the Edmondson Park area except Crossing 3, the proposed strategy provides for detention basins downstream of the rail corridor. Following the development of the Edmondson Park urban release area the peak flows at these crossings would therefore be greater than existing flows. Peak flows following development of the wider Edmondson Park urban release area have been considered in the flood assessment of these waterway crossings. This is considered a reasonable trade off, whereby the Glenfield to Leppington Rail Line deals with developed flows from the upstream area and any impacts from the Glenfield to Leppington Rail Line on flow behaviour are addressed in the broader stormwater management strategy for the Edmondson Park urban release area.

Crossings 10b to 14 are located within the Leppington urban release area. Detailed planning for the Leppington urban release area is progressing and a stormwater management strategy is not currently available. Consequently, it is not possible to assess the integration of the Glenfield to Leppington Rail Line with development of the broader area. As a result an assessment has been made of the potential changes in peak flow behaviour on areas downstream of the rail alignment as a result of the increased impervious areas located within the rail corridor.

Hydrologic modelling was undertaken to assess the change in peak flows downstream of Crossings 10b to 14 as a result of development of the Glenfield to Leppington Rail Line (Figure 2). Pre- and post-Glenfield to Leppington Rail Line peak 1% AEP (1 in 100 year) flows are summarised in Table 10.

Table 10 Changes in Peak Flows downstream of Glenfield to Leppington Rail Line – Crossings 10b to 14 (m^3/s)

Crossing	**Pre-**Glenfield to Leppington Rail Line	**Post-**Glenfield to Leppington Rail Line
10b	1.9	2.0
11	76.5	76.5
12	3.1	3.3
13	47.6	47.6
14	64.2	64.3

The results presented in the Table 10 show that the Glenfield to Leppington Rail Line would have a negligible impact on peak flows downstream of the rail corridor. Therefore a similar strategy should be adopted as that recommended for Edmondson Park whereby the development of the Glenfield to Leppington Rail Line is taken into consideration in development of the stormwater management strategy for the broader Leppington area.

In comparison to a natural watercourse the installation of culverts tends to have a minor attenuation effect, slightly reducing peak flow. Development of broader area stormwater management strategies in addition to the culvert attenuation would account for any minor increases in peak flow due to a change in the catchment imperviousness as a result of the Glenfield to Leppington Rail Line.

Crossing 1 is located in the Bunbury Curran Creek floodplain, while Crossing 2 is proposed to be diverted to Bunbury Curran Creek. The area of the rail corridor draining to Crossings 1 and 2 is significantly smaller than the catchment draining to Bunbury Curran Creek. Consequently, changes in peak flow behaviour in Bunbury Curran Creek due to the Glenfield to Leppington Rail Line are expected to be negligible.

It is understood that future residential development is proposed in the area to the north of Crossing 1, this area is referred to as the James Meehan Estate. The development is likely to change the impervious area of the catchment, and subsequently the runoff generated during rainfall events. A potential detention basin is proposed to the north west of Crossing 1. Details of the development are currently not available; however CCC is currently undertaking hydrologic studies of the proposed estate. Finding of these assessments including the location of any proposed detention basins should be considered in future design stages.

5.4.2. Diversion of Catchment Flows

The Concept Design identifies five proposed flow diversions as summarised in Table 11.

Table 11 Proposed Flow Diversion

Crossing	Catchment Area (Ha)	1% AEP Peak Flow (m^3/s)	Receiving Crossing
2 – CH. 43.800	4.6	1.6	1
5 – CH. 45.430	1.5	0.7	4
7b – CH. 47.200	3.99	1.4	7
CH. 47.500	2.4	1.0	8
12 – CH. 51.400	9.0	3.3	13

The proposed diversion of Crossing 2 drains the second largest area of the proposed catchment diversions. Crossing 2 would be diverted to downstream (southern side) of Crossing 1 and into Bunbury Curran Creek. However, relative to Crossing 2 the receiving catchment of Bunbury Curran Creek is significantly larger. Hydraulic modelling at Crossing 1 has shown a flood level impact on the upstream (northern) side of the embankment. The time to peak of runoff from the catchment draining to Crossing 2 would occur significantly earlier than the corresponding time to peak in the main creek. Consequently, while no detailed flood assessment has been undertaken, impacts on the creek are expected to be minimal and it is expected that there would not be any additional increases in flood level on the upstream (northern) side of the embankment. As previously noted, CCC have developed a flood model for the Bunbury Curran Creek floodplain. Assessment of the impacts of the flow diversion for Crossing 2 should be undertaken using this model during detailed design.

The proposed diversions of Crossings 7b and the minor watercourse at Chainage 47.500 km are included in the flood model for Crossings 7a, 8, 9 and 10a. It should be noted that this flood model is based on the development of the Edmondson Park urban release area. Therefore the impacts of these diversions have been assessed relative to the proposed Edmondson Park urban release, rather than existing conditions. Flood model results indicate that, taking the full development of the Edmondson Park urban release area as the base case, flood impacts due to these flow diversions are considered to be negligible.

Crossing 12 involves a realignment of the existing watercourse where it runs along the proposed alignment. The existing watercourse joins up with Scalabrini Creek within the rail corridor. Consequently, no impacts are expected providing diverted flows are contained within the rail corridor up to the 1% AEP flood event.

For all catchment diversions it is recommended that all flows up to the 1% AEP design storm are conveyed safely within the rail corridor to the adjacent crossing to minimise impacts on adjacent land up to the design standard. Details of the locations and required capacity of the proposed flow diversions are provided in Figure 35.

5.5. Waterway Crossings

5.5.1. Environmental Requirements

The proposed Glenfield to Leppington Rail Line alignment crosses the Bunbury Curran Creek floodplain as well as the upper tributaries of Cabramatta Creek (including Maxwells Creek), Bonds Creek (including Scalabrini) and Kemps Creek (Figure 1). A number of these creeks provide significant habitat for aquatic and terrestrial fauna, in addition to significant riparian vegetation. Maintaining connectivity for fish and/or fauna is an important consideration in the design process.

The environmental significance of each waterway crossing has been assessed taking into consideration the extent of catchment area upstream, the condition of the existing riparian corridor, the nature of development upstream and downstream under the proposed Edmondson Park and Leppington urban release areas and DECCW's stream classification. This assessment is summarised in Table 12. Note that DECCW's stream classification was based on interpretation of available mapping information.

Recommendations are provided on the treatment of each waterway crossing, taking into consideration the environmental assessment undertaken, relevant guidelines outlined in Section 2.5.1 and consultation with the DPI and DECCW. Recommendations are also summarised in Table 12 and can generally be divided into three categories as follows:

- Bridge – where the watercourse is determined to be significant in terms of aquatic habitat and riparian corridor.
- Series of culverts – for watercourses with significant riparian corridor but less significant (but still important) aquatic habitat.
- Catchment diversions – only permitted where the volume of runoff to be diverted is considered insignificant and the downstream receiving area is highly modified with no significant vegetation.

The design of bridges should consider the location of piers and abutments to minimise impacts on the existing creek bed. Scouring around piers and abutments would need to be assessed during future design stages and mitigation measures provided where appropriate.

Where culverts are recommended, measures should be incorporated into the design to promote fish and fauna passage. Such measures including setting the culvert lower than the creek invert so that they do not form a vertical barrier, provide a natural bed to the base of the culvert and in the case of multiple cells provide a lower central cell for low flows and fish passage while allowing dry fauna passage through the higher cells.

Note that this assessment has considered the nature of proposed land use upstream and downstream of the rail corridor since this would ultimately affect the environmental connectivity of the riparian corridor. Consequently, final design solutions within the Leppington urban release area need to consider the final masterplan layout and be consistent with proposed land use type.

Table 12 Recommended Waterway Crossing Treatment

Crossing	Catchment Area (Ha)	Future Development		Existing Riparian Habitat	DECCW Stream Classification	Recommended Crossing Treatment
		Upstream	Downstream			
1	77.4	James Meehan Estate	Existing Railway Line	Highly modified catchment, weeds, no defined creek	3	Viaducts considered adequate for environmental requirements. Viaduct piers to be located such that the impacts minimized to significant flora identified in the depression adjacent to BCC.
2	4.6	Existing School	Existing Macquarie Links Estate	Highly modified catchment, drainage along road.	Not Classified	Divert to Crossing 1
3	164	Public Recreation Area	Nature Reserve	Defined creek, dense vegetation	2	Series of culverts
4	24	Edmondson Park Town Centre	Nature Reserve	Drainage depression rather than creek, highly modified catchment	2	Series of culverts
5	1.5	Edmondson Park Town Centre	Public Recreation Area	Highly modified catchment, no defined creek	Not Classified	Diversion to Crossing 4
6	66	Nature Reserve	Public Recreation Area	Defined creek, dense vegetation, standing water	2	Culverts considered adequate for environmental requirements. Other factors (e.g. blockage mitigation) may warrant use of a bridge.
7a	417	Existing and Proposed Rural Residential	Public Recreation Area	Modified catchment, defined creek, dense vegetation, standing water	1	Bridge
7b	3.99	Existing Rural Residential	Future Residential	Drainage depression rather than creek, highly modified catchment	Not Classified	Diversion to Crossing 7a
CH. 47.500	2.4	Existing Rural Residential	Future Residential	Drainage depression rather than creek, highly modified catchment	Not Classified	Diversion to Crossing 8
8	32	Existing Cemetery	Public Recreation Area	Drainage depression rather than creek, highly modified catchment	2	Series of culverts
9	80	Existing Cemetery	Public Recreation Area	Drainage depression rather than creek, highly modified catchment with ponds	2	Series of culverts
10a	37	Future urban use	Public Recreation Area	Drainage depression rather than creek, highly modified catchment, ponded water upstream	2	Series of culverts
10b	5.8	Future urban use	Future urban use	Drainage depression rather than creek, highly modified catchment	Not Classified	Series of culverts
11	781	Leppington Urban Release Precinct	Leppington North Urban Release Precinct. Western Sydney Parkland	Defined creek, weeds and bank collapse, modified catchment, standing water	1	Bridge

Crossing	Catchment Area (Ha)	Future Development		Existing Riparian Habitat	DECCW Stream Classification	Recommended Crossing Treatment
		Upstream	Downstream			
			north of Bringelly Road.			
12	9	Leppington Urban Release Precinct	Leppington North Urban Release Precinct	Drainage depression rather than creek, highly modified catchment	Not Classified	Channeled to Crossing 13
13	410	Leppington Urban Release Precinct	Leppington North Urban Release Precinct	Defined creek, weeds and bank collapse, modified catchment	2	Bridge
14	499	Rossmore/Leppington Urban Release Precinct	Rossmore/Leppington North Urban Release Precinct	Modified catchment, defined channel, dense vegetation, standing water	1	Bridge

5.5.2. Flows in Excess of the Design Standard

As identified in Section 2.5.2, the 1% AEP (1 in 100 year) design flood standard was adopted for the design of waterway crossings. However, floods in excess of the 1% AEP (1 in 100 year) event would occur. Detailed assessment of flood risks for events in excess of the design standard is particularly warranted at Edmondson Park Station and Crossings 3, 4 and 6.

Edmondson Park Station

For the area around Edmondson Park Station (Crossings 4, 5 and 6) the potential flood risk in events that exceed the design standard is high. Flood model results indicate that flows in excess of the 0.5% AEP (1 in 200 year) storm would potentially affect the rail line and cause damage to infrastructure and risk to the operation of trains. The cost of repairs to flood damages needs to consider the likely frequency of flooding causing damage occurring. The potential for floods in excess of the 0.5% AEP storm to affect the operation of the rail line needs to be considered in flood emergency procedures. The management of flood risks and damages needs to be incorporated into a flood risk management plan for the station.

Flood modelling for the PMF (Figure 33) indicates that flooding would inundate the station platform and travel along the rail line at a depth of approximately 1 m above track level. Flooding of the station platform would be relatively shallow with depths typically less than 50 mm. Flood risk to rail staff and commuters at Edmondson Park Station are considered to be manageable for flood events up to the PMF.

Due to the consequences of blockage at the station the scenario of Crossings 4 and 6 becoming completely blocked was assessed for the 1% AEP (1 in 100 year) event. Model results are presented in Figure 32.

In light of the assessment of flood consequences at Edmondson Park Station, the following flood mitigation measures are recommended to be incorporated into the proposed Glenfield to Leppington Rail Line design:

- Local bunding around the inlet to Crossing 6 to provide 500 mm freeboard to the 1% AEP (1 in 100 year) flood level.
- Amplify the culvert capacity of Crossings 4 and 6 to allow for blockage.
- Provision of debris control devices upstream of Crossings 4 and 6 as a complimentary measure to manage blockage. The debris control devices shall target debris capable of causing blockage to culverts and therefore a clear opening of 1 m is recommended.
- Preparation of a Floodplain Risk Management Plan to manage flood risks and damages for flood events in excess of the 0.5% AEP (1 in 200 year) design event.

Other Glenfield to Leppington Rail Line Crossings

At Crossing 3 flows in excess of the design standard have the potential to impact on Campbelltown Road. The scenario of Crossing 3 becoming completely blocked was assessed for the 1% AEP event, model results are presented in Figure 31. The model results show that should Crossing 3 become completely blocked, flows would pond behind the embankment to depths of 3.3 m and would extend towards the Campbelltown Road bridge. The eastern side of Campbelltown Road may potentially be inundated by shallow depths of less than 0.2 m. The rail line at Crossing 3 is above the peak flood level and would not be inundated should the culvert become completely blocked, however flows also extend back to the east and may enter the rail cutting or potentially extent into the proposed residential development to the east. Preventing the flow from entering the rail cutting could be controlled by local bunding. While the likelihood of Crossing 3 becoming completely blocked is quite rare, the consequences are significant although they are considered manageable by the installation of local bunding and debris control structures.

Elsewhere, in areas where the Glenfield to Leppington Rail Line would be elevated above the adjoining floodplain, there is the potential for significant increases in flood levels to occur upstream of the Glenfield to Leppington Rail Line alignment once the waterway crossing capacity is exceeded, that is for events in excess of the design standard. This is the case for Crossings 7 to 14.

For all waterway crossings where flood modelling was undertaken, an assessment has been made for the 0.5% AEP (1 in 200 year) design event and PMF. Flood model results are documented in Appendix C.

An assessment of events in excess of the design standard was not possible at Crossing 1 with the information provided by CCC. This assessment should be undertaken in future design stages when the information becomes available. In particular, consideration should be given to the consequences of failure of Crossing 1 on the proposed residential development located to the north of Crossing 1.

5.5.3. Culvert Blockage

The potential blockage of culverts and inlet sumps by debris could significantly increase flood levels experienced upstream of the Glenfield to Leppington Rail Line and create adverse impacts due to overflows. Flood modelling presented in Section 4.2.6.1 indicates that many of the proposed waterway crossings are sensitive to blockage. Therefore, consideration needs to be given to management of potential waterway blockage within future design development.

Waterway blockage could be managed in a number of ways including upstream debris controls structures (e.g. trash racks), increasing waterway crossing capacity to make an allowance for blockage or use of a bridge structure in lieu of culverts. Consideration of a bridge structure should also take into account the significance of the riparian corridor and fish passage requirements for the waterway.

Recommendations to manage the potential for blockage have been developed based on an assessment of the potential for, and consequences of blockage at each waterway crossing. This assessment and recommendations are summarised in Table 13.

Table 13 Blockage Assessment

Crossing	Catchment Area (Ha)	Recommended Crossing Treatment	Preliminary Sizing Assuming 0% Blockage	Consequences of Crossing Failure	Potential For Blockage	Blockage Mitigation Works	Comments/Other Recommendations	Preliminary Sizing Considering Blockage[2]
1	77.4	Viaducts considered adequate for environmental requirements. Viaduct piers to be located such that the impacts minimized to significant flora identified in the depression adjacent to BCC.	90m and 150m.	Potential flood impacts including increase in duration and depth of inundation through the area of the proposed James Meehan Estate. Minimal flood impacts in Bunbury Curran Creek.	Low, depends on the development upstream of the viaducts.	At least 0.5m and preferably 1m freeboard from 1% AEP flood level to underside of viaduct.	Viaduct arrangement to be confirmed during detailed design and consultation with CCC regarding the proposed detention basin.	90m and 150m Viaducts.
2	4.6	Divert to Crossing 1	Not Modelled	Overflows from channel diversion would flow into rail cutting.	N/A	N/A	Flows up to 1% AEP storm to be conveyed within rail reserve to safely discharge into Bunbury Curran Creek.	Can be fully addressed in detailed design.
3	164	Series of culverts	3.3m(h) x 1.2m(w) RCBC (5 of)	Excessive ponding at inlet would impact on Campbelltown Road.	High - open space with natural vegetation upstream.	Provide debris capture structure upstream.	Culverts should be aligned with existing watercourse.	3.3m(h) x 1.2m(w) RCBC (7 of)
4	24	Series of culverts	3.6m(h) x 0.9m(w) RCBC (1 of)	Excessive ponding at inlet would impact on Edmondson Park station.	High under existing conditions, moderate once upstream catchment developed.	Debris control to be provided during development of the upstream catchment.	Culverts to be sized to minimise impacts on Edmondson Park station. Culverts should be aligned with existing watercourse.	3.6m(h) x 0.9m(w) RCBC (3 of)
5	1.5	Diversion to Crossing 4	-	-	-	-	-	Can be fully addressed in detailed design.
6	66	Culverts considered adequate for environmental requirements. Other factors (e.g. blockage mitigation) may warrant use of a bridge.	3.3m(h) x 0.9m(w) RCBC (3 of)	Overflows would travel along cutting and impact on Edmondson Park Station.	High - open space with natural vegetation upstream.	Provide additional culverts to make allowance for blockage. Debris control structure upstream of crossing also recommended. Bridge would also reduce potential for blockage but only if clearance in excess of 1.2m could be achieved.	Culverts to be sized to minimise impacts on Edmondson Park station. Culverts should be aligned with existing watercourse.	3.3m(h) x 0.9m(w) RCBC (6 of)
7a	417	Bridge	Bridge	Any adverse flood impacts could potentially affect upstream properties.	High potential for debris from upstream catchment. However, potential for blockage reduced through use	At least 0.5m and preferably 1m freeboard from 1% AEP flood level to underside of bridge.	Concept earthworks design showing embankment arrangement has been assessed.	Bridge

Crossing	Catchment Area (Ha)	Recommended Crossing Treatment	Preliminary Sizing Assuming 0% Blockage	Consequences of Crossing Failure	Potential For Blockage	Blockage Mitigation Works	Comments/Other Recommendations	Preliminary Sizing Considering Blockage[2]
					of a bridge.			
7b	3.99	Diversion to Crossing 7a, assuming the property containing the d/s farm dam is to be acquired as part of the Glenfield to Leppington Rail Line.	Not Modelled	Overflows from channel diversion would flow into rail cutting.			Flows up to 1% AEP storm to be conveyed within rail reserve to safely discharge at Crossing 7.	Can be fully addressed in detailed design.
CH. 47.500	2.4	Diversion to Crossing 8	-	-	-	-	-	Can be fully addressed in detailed design.
8	32	Series of culverts	3.3m(w) x 0.9m(h) RCBC (2 of)	Flood impacts on Cemetery.	High - natural vegetation upstream.	Provide additional culverts to allow for blockage.		3.3m(w) x 0.9m(h) RCBC (4 of)
9	80	Series of culverts	3.3m(w) x 0.9m(h) RCBC (5 of)	Flood impacts on Cemetery.	Moderate – Cemetery ground upstream.	Provide additional culverts to allow for blockage.	Existing ponds likely to provide a level of debris capture.	3.3m(w) x 0.9m(h) RCBC (7 of)
10a	37	Series of culverts	2.7m(w) x 1.2m(h) RCBC (2 of)	Upstream impacts would be similar to existing conditions and would be controlled by flow over Camden Valley Way. Downstream impacts are not significant on the basis that the downstream property is to be acquired and incorporated into future open space.	Depends on proposed development upstream.	Not required. However, if the property downstream of the crossing is to be developed then additional measures would be required to manage the potential for overflows.	Culvert inlets are required north and south of the rail line to collect runoff west of Camden Valley Way.	2.7m(w) x 1.2m(h) RCBC (2 of)
10b	6	Series of culverts	Not Modelled	Excessive ponding would divert along the rail corridor toward the Sydney Water Upper Canal.	High - small but well vegetated catchment upstream.	Debris control structure to be provided at inlet and a blockage allowance to be considered in culvert sizing.	Relatively small crossing can be fully addressed during detailed design.	Can be fully addressed in detailed design.
11	781	Culverts considered adequate for environmental requirements. Other factors (e.g. blockage mitigation) warrant consideration of a bridge.	3.6m(w) x 1.8m(h) RCBC (9 of) (if culvert adopted)	Depends on nature of proposed development upstream.	Ultimately depends on development upstream, however existing catchment has high potential for debris causing blockage.	Provide bridge or additional culverts to make allowance for blockage.	Bridge arrangement to be confirmed through flood modelling during detailed design.	Bridge

Crossing	Catchment Area (Ha)	Recommended Crossing Treatment	Preliminary Sizing Assuming 0% Blockage	Consequences of Crossing Failure	Potential For Blockage	Blockage Mitigation Works	Comments/Other Recommendations	Preliminary Sizing Considering Blockage[2]
12	9	Channelled to Crossing 13	Not modelled	Depends on nature of proposed development upstream.			Flows up to 1% AEP storm to be conveyed within rail reserve to safely discharge at Crossing 13.	Can be fully addressed in detailed design.
13	410	Bridge	Bridge	Depends on nature of proposed development upstream.	Ultimately depends on development upstream, however existing catchment has high potential for debris causing blockage.	At least 0.5m and preferably 1m freeboard from 1% AEP flood level to underside of bridge.	Bridge arrangement to be confirmed through flood modelling during detailed design.	Bridge
14	499	Bridge	Bridge	Depends on nature of proposed development upstream.	Ultimately depends on development upstream, however existing catchment has high potential for debris causing blockage.	At least 0.5m and preferably 1m freeboard from 1% AEP flood level to underside of bridge.	Bridge arrangement to be confirmed through flood modelling during detailed design.	Bridge

Notes

1 The significance of riparian vegetation upstream of Crossings 11-14 and potential for blockage ultimately depends on the type of land use proposed as part of the Leppington masterplan.

2 Preliminary sizing of culvert takes into consideration an appropriate allowance of blockage.

5.5.4. Flood Impacts

Detailed hydraulic modelling has been undertaken as part of this assessment to identify potential impacts on flood behaviour at waterway crossings due to the proposed Glenfield to Leppington Rail Line. The hydraulic modelling undertaken is discussed in Section 4. The type and extent of flood modelling carried out at each crossing depended on the complexity of flow behaviour and the nature of the rail alignment at each crossing.

Preliminary sizings have been developed for waterway crossings such that flood impacts are generally negligible or manageable for events up to and including the 1% AEP storm. For these crossings assessed in the hydraulic modelling, the analysis results (for an unblocked waterway crossing) indicate that for flood events up to and including the 1% AEP event any adverse flood level impacts upstream of the waterway crossings would be localised to the culvert inlet and generally contained within the rail corridor. Any adverse impacts on adjacent land can be largely addressed in the design of inlet treatments and surface drains in the future design stages. The future design of inlet works should also include a refinement of the preliminary culvert sizings presented in this assessment.

Two dimensional hydraulic modelling was undertaken for Crossing 1 and Crossings 3 to 10a (Figures 3 to 7). This method of modelling lends itself to the graphical representation of impacts due to the proposed Glenfield to Leppington Rail Line. Flood impact maps for Crossings 3 to 10a are presented in Figures 12, 16, 20 and 24.

At Crossing 1, there are localised impacts of up to 0.3m where the embankment encroaches into the existing floodplain removing existing floodplain storage. These impacts are localised and occur immediately adjacent to the railway embankment. Impacts beyond the rail corridor remain relatively minor. A larger area of impacts (up to 0.24 m) occurs where the rail line branches off from the existing railway line. The impact is limited to the area of a large floodplain storage and does not impact on existing infrastructure. At this location the rail line is above the peak flood level and therefore this flood level increase would not impact on the rail line. These impacts are however considered manageable during the detailed design by inlet design and the inclusion of drains as well as future land use management. The impacts are in the vicinity of the proposed CCC flood detention basin. If the basin is to be constructed then these impacts would need to be considered.

At Crossings 3 and 6 upstream impacts are considered manageable given the proposed open space areas upstream and localised nature. At Crossing 4 localised impacts at the culvert inlet can be largely addressed in the future design of culvert inlet works. Any residual impacts are expected to be minor and can be addressed in the design of the town centre.

At Crossing 7a it would be necessary to minimise the impact of the proposed Glenfield to Leppington Rail Line on upstream properties in Denham Court. Modelling of the post Glenfield to Leppington Rail Line scenario was based on the current earthworks concept design showing proposed batter extents. Model results show that there are some localised impacts on upstream properties. However, further flood modelling has shown that flood impacts on upstream properties could be managed through the use of retaining structures at the bridge abutments to reduce the embankment encroachment on the waterway area. It should be noted that further flood assessment would be required at future design stages to confirm any channel works, bridge piers and abutment details.

In the vicinity of Crossings 8, 9 and 10a there are localised areas where the proposed rail embankment encroaches on the existing floodplain, restricting the conveyance of floodwaters and creating impacts on adjacent areas. The nature of existing flooding in these areas is typically broad and shallow. During future design stages it would be necessary to make provision in the design of drainage works to provide for the equivalent conveyance of floodwaters along the rail corridor as under existing conditions. At Crossing 10a the rail embankment is located over the existing watercourse. Consequently there is a significant potential for flood impacts on the adjacent property north of the crossing. To minimise such impacts it is proposed to extend the culvert to discharge at the downstream end of Crossing 9. However, this concentration of flow at the downstream end of Crossing 9 in turn has the potential for localised flood impacts. Model results show the culvert extension from Crossing 10a to Crossing 9 would result in impacts downstream of the outlet of up to 0.1 m (refer to Figure 24). A summary of flood level impacts immediately upstream of the rail line are provided in Table 14 below.

5.5.5. Climate Change Impacts

The criteria for the assessment of climate change impacts are outlined in Section 2.5.4, while the methodology undertaken to assess climate change impacts is described in Section 3.3.2.

Work by CSIRO and BOM on climate change impacts is currently an active area of research. Studies investigated past and likely future changes to climate in NSW (Reference 18). The outcomes estimate that extreme rainfall (defined as a 1 in 40 year 1 day total rainfall event) would be likely to increase by up to 12% for the Sydney metropolitan catchments as well as the Hawkesbury-Nepean catchment by 2030. Research undertaken by CSIRO in conjunction with the BOM in 2007 suggests that an increase in rainfall intensity of 10% would provide a reasonable upper bound for assessment of the effects of increases in rainfall due to climate change within the study area. The results show that there is generally no significant additional risk to the project as a result of the potential increase in rainfall intensity due to climate change.

It should be noted that consideration has been made to the consequences of failure of the waterway crossings as a result of either flows in excess of the design standard and/or culvert blockage (refer Sections 5.5.2 and 5.5.3). Climate change impacts could potentially increase the likelihood of flows in excess of the design standard. Locations where climate change impacts have been identified as a potential risk are also locations where there is a risk should blockage of the culverts occur. At these locations the risk and impacts of blockage are significantly greater than those due to climate change. Additional culvert capacity that has been provided at critical locations to allow for blockage could potentially accommodate increased flood risk due to climate change.

Increases in flood levels as a result of climate change may also impact on the Glenfield to Leppington Rail Line itself, potentially increasing required track levels. Table 14 provides a summary of the peak flood levels immediately upstream of the rail line for the 1% AEP event pre and post rail line scenarios, in addition to the 10% rainfall increase climate change scenario.

Table 14 Peak Flood Levels

Crossing	1% AEP Peak Flood Level (m AHD)		1% AEP Peak Flood Level – Climate Change 10% Rainfall Increase (m AHD)
	Pre-Rail Line	Post-Rail Line	Post-Rail Line
1	17.7, 18.5	18,18.8	N/A
2	-	-	-
3	45.2	45.6	45.7
4	50.7	51.0	51.2
5	-	-	-
6	54.9	55.2	55.3
7a	49.1	48.9	49.1
7b	-	-	-
CH. 47.500	-	-	-
8	50.0	50.3	50.5
9	51.2	51.9	52.1
10a	55.5	55.6	55.8
10b	-	-	-
11	75.9	75.9	76.0
12	-	-	-
13	76.4	75.7	75.9
14	76.7	76.7	76.8

The most significant location where there could potentially be a risk from climate change (and culvert blockage) is at Edmondson Park Station. Flood modelling at the station shows that overflows from Crossing 6 would occur in the 1% AEP (under the climate change scenario of 10% rainfall increase). However, overflows would be contained to the drainage line and access road and should not impact on the rail line provided that preparation of a Flood Risk Management Plan is prepared for Edmondson Park Station.

The impacts of climate change at Crossing 1 have not been assessed quantitatively. However, it is likely that climate change impacts can be mitigated, if required, through relatively minor reconfiguration of the proposed works at later stages of design.

It is recommended that the potential impacts of climate change at Crossing 1 be assessed hydraulically in future design stages.

5.6. Proposed Stations, Commuter Carparks and Stabling Facility

As part of the project two stations would be constructed at Edmondson Park and Leppington in addition to a train stabling facility at Rossmore. Commuter carparks are also proposed at these stations.

Edmondson Park Station is proposed to be located in a cutting that adjoins a low point in the Glenfield to Leppington Rail Line alignment in the vicinity of Crossings 4, 5 and 6 (refer Figure 1). As a result there is the possibility for overflows from these crossings to impact the station. Results from the flood modelling indicate that flows in excess of the 1% AEP (1 in 100 year) event and/or overflows due to culvert blockage would result in overtopping of Crossings 4 and 6 and result in flow travelling along the rail corridor (Figures 32 and 33). Consequently, mitigation measures are recommended to reduce the likelihood of blockage. Flood modelling also indicates that flooding in excess of the 0.5% AEP (1 in 200 year) event could potentially affect the operation of trains and cause damage to rail infrastructure. The potential for floods in excess of the 0.5% AEP storm to affect the operation of the rail line needs to be considered in flood emergency procedures. The management of flood risks and damages needs to be incorporated into a flood risk management plan for the station.

Flood modelling for the PMF (Figure 33) indicates that flooding would inundate the station platform and travel along the rail line at a depth of approximately 1 m above track level. Flooding of the station platform would be relatively shallow with depths typically less than 50 mm. Flood risk to rail staff and commuters at Edmondson Park Station are considered to be manageable for flood events up to the PMF. Once the station design is completed more detailed modelling of flood events in excess of the design standard would be undertaken.

Commuter carparks are proposed to the north and south of Edmondson Park station, adjacent to the location of Crossing 5. Both the north and south carparks would not be inundated in the 1% AEP (1 in 100 year) event. It is proposed to divert Crossing 5 and as such adequate drainage to convey the diversion flow should be provided at the southern carpark. At both the north and south carpark location any filling of the drainage depression should be compensated with adequate drainage to convey the overland runoff from the drainage depression.

Leppington Station is located between Crossings 11 and 12. While the station is located in a cutting, it is situated outside the floodplain and any flood risk can therefore be managed through appropriate design at the detailed design stage.

Commuter carparks are proposed to the north and south of Leppington Station. The northern carpark would not be inundated during the 1% AEP (1 in 100 year) event. The southern carpark is located in the catchment draining to Crossing 12, and while no hydraulic modelling has been undertaken, the catchment is relatively small and the site would not likely be inundated during the 1% AEP (1 in 100 year) event. As it is proposed to divert Crossing 12, adequate capacity in the diversion channel would reduce the likelihood of overland flow through the southern carpark. Filling of the drainage depression of Crossing 12 should be compensated with adequate drainage to convey the overland runoff from the drainage depression.

The proposed stabling facility at Rossmore is located to the west of Crossing 14. The stabling facility is proposed on fill and sits beyond the extent of the 1% AEP (1 in 100 year) event and any flood risk can therefore be managed though appropriate design during future design stages.

5.7. Proposed Electrical Substations

Two electrical substations along with a section hut are proposed along the Glenfield to Leppington Rail Line alignment (Figures 34a and 34b). The substations and section hut should be designed in accordance with relevant standards including any minimum floor levels and allowance for freeboard. Table 15 provides a summary of flooding at the three proposed sites.

Table 15 Substations and Section Hut

Location	Comments
1 – Upstream of Crossing 6	The proposed section hut is located adjacent to Crossing 6 and is to be located within the cutting for Edmondson Park station. Overtopping at Crossings 4 and 6 results in flooding within the access road and the drainage line adjacent to the station. The section hut may potentially be inundated during the 1% AEP (1 in 100 year) event (assuming a 10% increase in rainfall to account for potential impacts of Climate Change) to a level of 54.0m AHD and to 54.8m AHD during the PMF event. The site would not be inundated during a 1% AEP (1 in 100 year) event. These levels should be confirmed once the station design and flood risks are finalised during future design stages.
2 – Upstream of Crossing 8	The proposed substation is located upstream of Crossing 8, adjacent to the creek. The north-western portion of the site may be inundated during the 1% AEP (1 in 100 year) event to a level of 51.2m AHD. An assessment of the risk of Climate Change assuming a 10% increase in rainfall indicates that there would be no further increase in flood level at this location. The PMF flood level for the same location is 53.2m AHD. Field survey should be undertaken to confirm the ground level of the proposed substation.
3 – West of Crossing 10a	The proposed substation is located in the catchment draining to Crossing 10a. The site would not be inundated during the 1% AEP (1 in 100 year) event.

5.8. Mitigation Measures and Further Assessment

In light of the assessment presented in the preceding sections of this report, the following mitigation measures and further assessment is recommended to manage hydrologic related impacts associated with the Glenfield to Leppington Rail Line.

5.8.1. Construction

A CEMP shall be prepared to address water quality, flooding and soil salinity issues during the construction stage. The CEMP would need to incorporate an Erosion and Sediment Control Plan or a Soil and Water Management Plan for each component of work in accordance with *Managing Urban Stormwater Soils and Construction*, (Landcom, 2004).

The CEMP shall also include a monitoring program to assess the water quality upstream and downstream of the Glenfield to Leppington Rail Line. The monitoring program should be established prior to construction to develop an appropriate base condition and continue for a period after construction.

5.8.2. Water Quality

Water quality measures shall be incorporated into the design of the Glenfield to Leppington Rail Line in accordance with all statutory and environmental protection requirements, including the *Edmondson Park Precinct DCP* (Reference 1) and the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000).

5.8.3. Soil Salinity

The presence of soil salinity shall be confirmed and appropriate mitigation measures adopted in accordance with the *Edmondson Park Precinct DCP* (Reference 1).

5.8.4. Waterway Crossings

Recommended measures at each waterway crossing are outlined in Table 14 to address environmental considerations and floodplain management requirements. Further discussion on environmental and floodplain management measures at each crossing are provided below.

Table 16 Waterway Crossing Summary

Crossing	Recommended Crossing Treatment	Blockage Mitigation Works	Comments/Other Recommendations	Preliminary Sizing Considering Blockage
1	Viaducts considered adequate for environmental requirements. Viaduct piers to be located such that the impacts minimized to significant flora identified in the depression adjacent to BCC.	At least 0.5m and preferably 1m freeboard from 1% AEP flood level to underside of viaducts.	Viaduct arrangement to be confirmed during detailed design and consultation with CCC regarding the proposed detention basin.	90m and 150m Viaducts.
2	Divert to Crossing 1	N/A	Flows up to 1% AEP storm to be conveyed within rail reserve to safely discharge into Bunbury Curran Creek.	Can be fully addressed in detailed design.
3	Series of culverts	Provide debris control structure upstream of crossing	Blockage control measures required to reduce likelihood of adverse impacts on Campbelltown Road. Culverts should be aligned with existing watercourse.	3.3m(W) x 1.2m(H) RCBC (7 of)
4	Series of culverts	Debris control to be provided during development of the upstream catchment.	Culverts to be sized to minimise impacts on Edmondson Park station. Culverts should be aligned with existing watercourse. Flood Risk Management Plan to be prepared to manage flooding to rail line in excess of 0.5% AEP event.	3.6m(W) x 0.9m(H) RCBC (3 of)
5	Diversion to Crossing 4	N/A	N/A	Can be fully addressed in detailed design.
6	Culverts considered adequate for environmental requirements. Other factors (e.g. blockage mitigation) may warrant use of a bridge.	Provide additional culverts to make allowance for blockage. Debris control structure upstream of crossing also recommended. Bridge would also reduce potential for blockage but only if clearance in excess of 1.2m could be achieved.	Culverts to be sized to minimise impacts on Edmondson Park station. Culverts should be aligned with existing watercourse. Flood Risk Management Plan to be prepared to manage flooding to rail line in excess of 0.5% AEP event.	3.3m(W x 0.9m(H) RCBC (6 of)
7a	Bridge	At least 0.5m and preferably 1m freeboard from 1% AEP flood level to underside of bridge.	Concept earthworks design showing embankment arrangement has been assessed.	Approx. span between abutments 70m, subject to hydraulic assessment of pier arrangement and compensatory channel works..
7b	Diversion to Crossing 7a, however the long term viability of the d/s farm dam needs to be confirmed.		Flows up to 1% AEP storm to be conveyed within rail reserve to safely discharge at Crossing 7. Confirm long term viability of d/s farm dam.	Can be fully addressed in detailed design.
CH.47.500	Diversion to Crossing 8	N/A	Flows up to 1% AEP storm to be conveyed within rail reserve to safely discharge at Crossing 8.	Can be fully addressed in detailed design.
8	Series of culverts	Provide debris capture structure upstream.		3.3m(W) x 0.9m(H) RCBC (4 of)

Crossing	Recommended Crossing Treatment	Blockage Mitigation Works	Comments/Other Recommendations	Preliminary Sizing Considering Blockage
9	Series of culverts	Provide debris capture structure upstream.	Existing ponds likely to provide a level of debris capture.	3.3m(W x 0.9m(H) RCBC (7 of)
10a	Series of culverts		It is assumed that the property immediately downstream of crossing is to be acquired for future open space, otherwise flood mitigation works would be required.	2.7m(W) x 1.2m(H) RCBC (2 of)
10b	Series of culverts	Debris control structure to be provided at inlet and a blockage allowance considered in culvert sizing.	Relatively small crossing can be fully addressed during detailed design.	Can be fully addressed in detailed design.
11	Culverts considered adequate for environmental requirements. Other factors (e.g. blockage mitigation) warrant consideration of a bridge.	Provide bridge or additional culverts to make allowance for blockage.	Bridge arrangement to be confirmed through flood modelling during detailed design.	Approx. span between abutments 20m, with 3.6m(W) x 0.9m(H) RCBC (21 of) along overbanks.
12	Channelled to Crossing 13	N/A	Flows up to 1% AEP storm to be conveyed within rail reserve to safely discharge at Crossing 13.	Can be fully addressed in detailed design.
13	Bridge	At least 0.5m and preferably 1m freeboard from 1% AEP flood level to underside of bridge.	Bridge arrangement to be confirmed through flood modelling during detailed design.	Approx. span between abutments 40m, subject to hydraulic assessment of pier arrangement and compensatory channel works.
14	Bridge	At least 0.5m and preferably 1m freeboard from 1% AEP flood level to underside of bridge.	Bridge arrangement to be confirmed through flood modelling during detailed design.	Approx. span between abutments 40m, subject to hydraulic assessment of pier arrangement and compensatory channel works.

Environmental Measures

Recommended environmental measures at waterway crossings fall into three categories:

- Bridge – where the watercourse is determined to be significant in terms aquatic habitat and riparian corridor.
- Series of culverts – for watercourses with significant riparian corridor but less significant (but still important) aquatic habitat.
- Catchment diversion – only permitted where the volume of runoff to be diverted is considered insignificant and the downstream receiving area is highly modified with no significant vegetation.

The design of bridges needs to consider the location of piers and abutments in accordance with *Fish Passage Requirements for Waterway Crossings* to minimise impacts on the existing creek bed. As part of the detailed design it would be necessary to assess the potential for scour around piers and abutments through hydraulic modelling and develop scour protection measures accordingly.

The design of culverts shall incorporate measures to promote fish and fauna passage and riparian connectivity. Such measures are to include setting the invert of the culverts lower than the creek invert so that they do not form a vertical barrier, provision of a natural bed to the base of the culvert and (in the case of multiple cell culvert crossings) providing a lower central cell for low flows and fish passage while allowing dry fauna passage through the higher cells.

Further discussion of impacts of flow alterations is provided in Sections 2.4 and 5.5.1 in addition to Table 6-3 in the Technical Report covering ecology.

The proposed diversion of Crossing 7b would affect an existing farm dam located immediately downstream of the Glenfield to Leppington Rail Line embankment. Further details of future land use planning for Edmondson Park are required to determine the long term viability of this dam and the need to maintain existing flows.

Floodplain Management Measures

Preliminary sizings have been developed for waterway crossings where culverts are proposed such that flood impacts are generally negligible or manageable for flood events up to and including the 1% AEP storm.

At all the waterway crossings where hydraulic modelling was undertaken, the results (for an unblocked waterway crossing) indicate that for flood events up to and including the 1% AEP event any adverse flood level impacts immediately upstream of the waterway crossings would generally be contained within the rail corridor. Adverse impacts on adjacent land could be managed in the design of inlet treatments and surface drains in the future design stages. The design and extent of such measures to manage adverse flood impacts would need to be confirmed through flood modelling at the detailed design stage. Future design of inlet works should also include a refinement of the preliminary culvert sizings presented in this assessment.

For crossings that are proposed to be bridged (Crossings 7a, 11, 13 and 14), further hydraulic assessment would be required in future design stages to guide channel works upstream and downstream of the crossing and final pier and span arrangements.

There are some areas, particularly in the vicinity of Crossings 8, 9 and 10a where the proposed rail embankment encroaches on the existing floodplain, restricting the conveyance of floodwaters and creating impacts on adjacent areas. During future design stages it would be necessary to provide adequate drainage works to provide for the conveyance of floodwaters along the rail corridor to manage adverse flood impacts on adjacent properties. Design of such measures should be verified through detailed flood modelling and may require local widening of the rail corridor to accommodate drainage works.

Where appropriate, mitigation measures have been proposed to reduce the potential for blockage at each location. Measures are presented in Table 14 and include the provision of debris control structures at the inlet, providing additional waterway area (eg. additional culverts) to allow for blockage, or adopting a bridge structure in lieu of culverts.

Crossing 1 is located on the Bunbury Curran floodplain in an area potentially allocated for a detention basin by CCC. Consequently the final design for Crossing 1 would be dependent on whether the proposed basin goes ahead or not. CCC is yet to make a final decision regarding the flood detention basin for James Meehan Estate. Studies are currently underway to determine the need for the basin.

Crossing 2 comprises a small catchment draining along Quarter Sessions Road. The rail alignment at this crossing is located in a cutting under the existing road. Hence it is proposed to divert flows from Crossing 2 toward Crossing 1. Provision would need to be made in the detailed design of the drainage system to safely convey this diverted flow along the rail corridor to discharge into Bunbury Curran Creek for all events up to the 1% AEP design event. This may necessitate widening of the rail corridor.

The impact of the proposed diversion of Crossing 2 on both the existing flow regime and flooding in downstream areas is not likely to be significant. However, a more detailed assessment of flood impacts on Bunbury Curran Creek should be undertaken as part of the detailed design assessment of Crossing 1.

In comparison to Crossings 1 and 2, **Crossing 3** would be largely conventional (referring to the relatively typical nature of the proposed crossing through the Glenfield to Leppington Rail Line embankment). Nevertheless, excessive ponding at the inlet to the crossing could impact on Campbelltown Road. Consequently, Crossing 3 should be sized to minimise impact on Campbelltown Road for flood events up to and including the 1% AEP storm, taking into consideration an allowance for blockage. A preliminary culvert sizing is presented in Table 14. The final sizing would be subject to detailed design.

For the area around Edmondson Park Station (in the vicinity of **Crossings 4, 5 and 6**) the potential flood risk in events that exceed the design standard is high. Flood modelling indicates that while risks to rail staff and commuters at the station platform is manageable for flood events up to the PMF, flooding in excess of the 0.5% AEP event could potentially affect the operation of trains and cause damage to rail infrastructure. Consequently, a Flood Risk Management Plan shall be prepared to address the potential risk to operation of trains and damage to rail infrastructure for flood events in excess of the 0.5% AEP storm.

At **Crossing 7a** it would be necessary to minimise the impact of the proposed Glenfield to Leppington Rail Line on upstream properties in Denham Court. A bridged crossing is proposed due to the size and nature of the catchment upstream and the implications for crossing blockage. The underside of the bridge should be at least 500 mm above the 1% AEP flood level to minimise the likelihood for blockage of the bridge. Modelling of the post Glenfield to Leppington Rail Line scenario was based on the earthworks concept design. Model results show that there are some localised impacts on upstream properties. However, further flood modelling has shown that flood impacts on upstream properties could be managed through the use of retaining structures at the bridge abutments to reduce the embankment encroachment on the waterway area. It should be noted that further flood assessment would be required at future design stages to confirm any channel works, bridge piers and abutment details.

Crossing 7b is located to the immediate west of Crossing 7a. It is proposed to divert runoff from this catchment to Crossing 7a. Provision would need to be made in the detailed design of the drainage system to safely convey this diverted flow along the rail corridor to discharge into Cabramatta Creek for all events up to the 1% AEP design event. This may necessitate widening of the rail corridor.

In the vicinity of **Crossings 8, 9 and 10a** there are localised areas where the proposed rail embankment encroaches on the existing floodplain, restricting the conveyance of floodwaters and creating impacts on adjacent areas. During future design stages it would be necessary to make provision in the design of drainage works to provide for the conveyance of floodwaters along the rail corridor to manage impacts on adjacent properties. This may require localised widening of the rail corridor to accommodate these drainage works.

At Crossing 10a the rail embankment is located over the existing watercourse. Consequently, it would be necessary to realign the existing watercourse downstream of Crossing 10a to run along the base of the rail embankment to Crossing 9. This would result in flood impacts on the property immediately downstream of Crossing 10a. However, it is understood that this property is to be acquired and would become open space in future land use planning for the area. Therefore, flood impacts are considered acceptable for the proposed land use. **Crossing 10b** is located to the east of Crossing 11 and the Sydney Water Upper Canal. This crossing drains a small catchment and the design can be fully addressed in future design stages. Diversion of this crossing through to Crossing 11 is not recommended as flows would likely impact on the Sydney Water Upper Canal.

Crossing 11 is located on Bonds Creek. While this crossing is largely conventional, it drains a sizable catchment (781 Ha). A bridge is recommended over a series of culverts as it would be less susceptible to blockage (as well as providing a more environmentally appropriate solution). The underside of the bridge should be at least 500 mm above the 1% AEP flood level to minimise the likelihood for blockage of the bridge. Due to the broad nature of the floodplain at this location a combination of bridge over the main creek with culverts to convey flows from the overbank areas is likely to be the most cost effective solution whilst also addressing the various flood and environmental related requirements.

Crossing 12 drains a relatively small catchment that largely runs parallel to the rail alignment. In this location the existing watercourse is proposed to be diverted to run along the base of the embankment. It is recommended that provision be made to convey flows up to 1% AEP design storm along the rail corridor to discharge at Crossing 13.

Crossings 13 and 14 are located on Scalabrini and Kemps Creeks respectively. Both of these crossings drain large catchment areas and therefore bridges are recommended in preference to a series of box culverts to minimise the potential for blockage (as well as maintain riparian connectivity). The underside of the bridge should be at least 500 mm above the 1% AEP flood level to minimise the likelihood for blockage of the bridge. Further flood assessment would be required at future design stages to confirm any channel works, bridge piers and abutment details.

5.8.5. Other Mitigation Measures

Other potential hydrologic impacts associated with the proposed Glenfield to Leppington Rail Line that would need to be addressed in future design stages include:

- A train stabling yard is proposed to the west of Crossing 14. This yard poses a footprint of approximately 3.7 hectares. Mitigation measures would be required to control pollutants entering the downstream creek and scouring at drainage outlets.
- The rail alignment passes under the Hume Highway immediately west of Crossing 2. The Hume Highway contains an open drain running central to the north and south bound lanes that conveys runoff from the road. The bored tunnel proposed for the highway would need to maintain the drainage capacity and function of this central drain.
- The Sydney Water Upper Canal, supplying water to Prospect Reservoir, crosses the rail alignment approximately 200 m west of Crossing 10b. Provision would need to be made in the detailed design to divert all track drainage away from the canal. A suitable design standard for track drainage in the vicinity of the canal should be adopted in consultation with the Sydney Catchment Authority.
- Leppington Station is located between Crossings 11 and 12. While the station is located in a cutting, it is situated outside the floodplain and any flood risk can therefore be managed through appropriate drainage design at the detailed design stage.

6. CONCLUSION

Assessment and review of relevant waterway crossing guidelines was required under the Statement of Commitments and Ministers Conditions of Approval (forming the compliance requirements) for the EA for the Glenfield to Leppington Rail Line. In accordance with these requirements a detailed investigation has been undertaken to identify potential hydrologic impacts associated with the proposed Glenfield to Leppington Rail Line.

The types of hydrologic impacts and risks considered included environmental issues (such as impacts on fish and fauna passage, water quality and changes in flow regime), flood impacts (such as changes in peak flows, flood levels, velocities and hazards) and flood risk to existing and proposed infrastructure.

The assessment presented in this report builds on from the Stage 1 EA hydrologic assessment - (*South West Rail Link Feasibility Report – Hydrologic Assessment, Webb McKeown and Associates (April 2006) (Reference 6)*. Key areas where the Stage 1 EA report has been updated include a more detailed flood assessment at Edmondson Park Station; updated flood modelling at other crossings in light of the most recent concept design; detailed assessment of environmental considerations at each waterway crossing; and a detailed assessment of blockage potential at each waterway crossing.

Recommendations regarding waterway crossing treatments have been provided (summarised in Table 1 and Table 14) to address environmental requirements commensurate with the significance of the riparian corridor and future land use planning upstream and downstream of the rail alignment. Bridges are recommended where the watercourse is considered significant in terms of aquatic habitat and riparian corridor. A series of culverts is considered appropriate for watercourses with a significant riparian corridor but less significant (but still important) aquatic habitat. Catchment diversions are only permitted where the volume of runoff to be diverted is considered insignificant and the downstream receiving area is highly modified with no significant vegetation. The design of bridges and culverts needs to include measures for fish and fauna passage and riparian connectivity in accordance with relevant guidelines.

The flood assessment undertaken for this study is based on the SWRL Concept Design prepared by Aurecon AECOM Joint Venture (technical advisor to TIDC). The assessment has analysed flood impacts and risks including the potential for and consequences of blockage. The outcomes of this assessment were used to determine minimum requirements at each waterway crossing in terms of crossing sizes and compensatory works. Minimum requirements at each crossing are summarised in Table 1.

The design standard adopted for the sizing of waterway crossings is based on the 1% AEP (1 in 100 year) design storm event. However, consideration has also been made of flood risks arising from any failure of the drainage system (where "failure" could mean, for example, system capacity is exceeded due to the volume of floodwaters, blockage by debris, or a combination of both).

Climate change has the potential to increase the likelihood of flows in excess of the design standard. However, where a flood risk due to climate change has been identified, the risk and consequences of blockage are considered to be significantly greater. At these locations additional culvert capacity that has been provided to manage blockage should also accommodate potential flood risks due to climate change.

A number of locations are identified where there is potential for significant flood risks in storms larger than the 1% AEP (1 in 100 year) event and/or overflows due to a substantial amount of blockage. This is especially relevant to the area at and around the proposed Edmondson Park Station (Crossings 4 to 6).

Detailed flood modelling undertaken for the area around Edmondson Park Station indicates that flows in excess of the 1% AEP (1 in 100 year) event and/or overflows due to culvert blockage would result in overtopping of Crossings 4 and 6 and flow along the rail corridor (Figures 31 and 32). Consequently, mitigation measures are recommended to reduce the likelihood of blockage. Flood modelling also indicates that flooding in excess of the 0.5% AEP (1 in 200 year) event could potentially affect the operation of trains and cause damage to rail infrastructure.

Given the potential flood risk at Edmondson Park Station it is recommended that a Floodplain Risk Management Plan be prepared that evaluates the risk to life and infrastructure. The Plan would need to confirm that there are no unexpected overflow paths as a result of the detailed design. The Plan shall set required flood management and mitigation measures, minimum culvert requirements and culvert overflow levels. For this purpose outcomes from this assessment and mitigation measures identified for Crossings 4 and 6 would be incorporated into the Plan.

As noted, this assessment has been based on the current Concept Design. Further refinement of proposed measures would be required at the detailed design stage.

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