13. Hydrology and surface water

This Chapter is based on the hydraulic analysis undertaken to assess the potential impacts on hydrology and surface water from the proposed SWRL (see Technical Paper 2 in Volume 2 of this report). The existing hydrology and surface water characteristics of the proposed SWRL corridor are detailed in Section 5.2.2 of this report. Figure 5-6 shows the crossing locations referred to in this Chapter.

Sections 13.2 and 13.3 of this Chapter describe and assess the potential direct hydraulic impacts of the SWRL at each waterway crossing, including changes to flood behaviour and local drainage. Section 13.4 describes the further assessment requirements and management /mitigation methods and commitments.

13.1 Assessment approach

The methodology adopted for the flood and drainage assessment involved the following key tasks:

- assessment of potential flood impacts at waterway crossings through the development of preliminary flood models for pre- and post-SWRL scenarios (applies to Crossings 1-3, 7–10)
- preliminary flood modelling of waterway crossings at Edmondson Park Station (Crossings 4, 5 and 6) to provide a preliminary assessment of potential flood impacts and flood risk at the Station (A more detailed assessment is to be undertaken following the Environmental Assessment)
- flood modelling and assessment of the potential flood impacts of the waterway crossings in the vicinity of Leppington Station (Crossings 11–14)
- liaison with Campbelltown City Council in order to establish the design requirements of the (potentially) proposed Glenfield flood detention basin and provide advice on ways to ensure the SWRL design is compatible.

Investigation, analysis and design works were consistent with the guiding principles of a number of documents, including:

- *Australian Rainfall and Runoff: A guide to flood estimation* (Institution of Engineers, Australia 1987)
- *Floodplain Development Manual* (NSW Government 2005a)
- specific design guidelines produced by local councils or other approved authorities.

Topographic information was generally obtained from two metre contour information available from orthophoto maps, with the exception of the Leppington Station locality where topographic cross-section survey data was obtained for Scalabrini Creek between Bringelly Road and Ingleburn Road, and for Kemps Creek between Bringelly Road and Eastwood Road.

Detailed ground survey of waterway channel depths in the vicinity of Edmondson Park station was also undertaken.

For the purposes of the hydraulic analysis and this assessment it was assumed that the crossing structures would comprise multi-celled reinforced concrete box culverts, which represents a worst-case flooding assessment. Consideration of the use of bridge structures in selected locations would be given during the future design work to address specific local design and environmental requirements (see Section 13.4).

Hydraulic modelling was undertaken using a one-dimensional HEC-RAS model. Predictions of flood levels were made pre- and post- SWRL for the 100-year average recurrence interval (ARI) flood and, for selected locations, the probable maximum flood (PMF). The 100-year ARI flood is typically used as a benchmark for assessing potential flood impacts on existing and future development. The PMF is an estimate of the largest flood that could occur and is typically used to consider implications arising from the design of major infrastructure and flood evacuation. The assumed recurrence interval of the PMF for the catchment areas considered in this study was 1 in 10 million years.

Based on the waterway crossing assessment considerations presented in Section 4 of Technical Paper 2 (Volume 2 of this report), the following hydraulic design criteria were adopted for determining the potential size of the waterway crossings:

- no increase in post-SWRL 100-year ARI flood levels upstream of the SWRL alignment for unblocked culvert conditions
- not more then a 0.1 metre increase in post-SWRL 100-year ARI flood levels upstream of the rail alignment for 25 % blockage of culverts
- no overtopping of the rail level for the 100-year ARI event with 25 % blockage of culverts.

The consequences of culvert blockage for the SWRL project and surrounding development are potentially significant and, therefore, the proposed waterway crossings would need to be appropriately sized so that the consequences of a reasonable degree of blockage (25 % for this assessment) are manageable.

Additionally, the sensitivity of the results to an increased amount of culvert blockage was evaluated and documented (using a 50 % blockage scenario).

Further detail on the assessment approach taken at specific locations is provided below.

13.1.1 Crossings 1–3, 7–10

A qualitative assessment of the key flood and drainage issues was undertaken for Crossings 1 and 2, and one-dimensional HEC-RAS hydraulic models were established for Crossings 3 and 7–10. The preliminary flood models were established for the specific purpose of assessing the relative potential impacts in flood levels between pre- and post-SWRL scenarios.

13.1.2 Edmondson Park Station (Crossings 4–6)

The proposed site of Edmondson Park Station would be located within a cutting and adjoin a low point in the rail alignment. As a result, there is the possibility for overflows from Crossings 4, 5 and 6 (tributaries of Maxwells Creek) to potentially impact on the Station. Preliminary flood modelling was undertaken to address the Environmental Assessment

requirements. The preliminary flood models were established to assess the relative potential impacts in flood levels between pre- and post-SWRL scenarios.

The modelling approach involved establishing one-dimensional HEC-RAS hydraulic models for waterway crossings 4 and 6. It was assumed that the flows from the upstream catchment of Crossing 5 would be diverted to the waterway for Crossing 4.

13.1.3 Leppington Station and stabling facility (Crossings 11–14)

The flood assessment at the proposed Leppington Station and stabling facility incorporated hydraulic modelling of Bonds (Crossing 11), Scalabrini (Crossing 13) and Kemps (Crossing 14) Creeks using one-dimensional HEC-RAS hydraulic models. A qualitative flood assessment was also undertaken for a minor tributary of Scalabrini Creek (Crossing 12). A broad review and comparison of the existing flood and road levels, at locations crossed by the SWRL was also undertaken.

13.2 Crossing impacts

Fourteen waterway crossings have been identified to date along the proposed SWRL corridor (see Figure 5-6). The watercourses that would be crossed by the SWRL include Cabramatta, Bonds, Scalabrini and Kemps Creeks, and associated tributaries. The watercourses all drain in a general northerly direction and make up parts of the Georges River and Hawkesbury-Nepean River catchments. Further details are provided in Section 5.2.2.

13.2.1 Crossing 1

Crossing 1 would be located on the floodplain of Bunbury Curran Creek immediately to the west of Glenfield South Junction. This locality has been identified by Campbelltown City Council as the site for the potential Glenfield flood detention basin. Council is currently evaluating the need for this flood detention basin, including analysis using a two-dimensional hydraulic flood model. A crossing consisting of a series of box culvert cells with a total width in the order of 20 metres would be required.

The implication of the SWRL at this location is a potential loss of storage capacity due to the location of the SWRL embankment within the floodplain. Once Council's investigations are complete, the potential impacts of the proposed SWRL on flooding and the requirements of the waterway opening for Crossing 1 would be further evaluated (see Section 13.4).

13.2.2 Crossing 2

Crossing 2 would be located approximately 200 metres to the east of the Hume Highway and along the alignment of Quarter Sessions Road. As the SWRL would be in a cutting at this location it is proposed that upstream flows from this minor catchment be intercepted and conveyed to the rail level via a drop structure or other suitable drainage device. It is proposed that this run-off (together with run-off from the face of the cutting) be conveyed along the base of the cutting to discharge at natural ground level some 300 metres to the east, which is part of the catchment for the proposed Glenfield flood detention basin. The implications of this proposed transfer of flows would be assessed following the completion of Council's investigations for the flood detention basin (refer Section 13.2.1 above).

13.2.3 Crossing 3

Crossing 3 would be over a tributary of Maxwells Creek, approximately 100 metres east of Campbelltown Road. A crossing comprising five culverts (each 3.3 metres wide by 1.2 metres) is proposed to satisfy the adopted design criteria.

The hydraulic modelling for a 100-year ARI event at this location shows that for an unblocked crossing there would be no measurable increase in the duration of inundation or flood hazard. For 25 % blockage, a potential increase of up to 0.04 metres is predicted and for a 50 %, blockage a potential increase of up to 0.85 metres is predicted.

For larger flood events that exceed the capacity of the waterway, overflows would be directed along the SWRL alignment to the east and would discharge in the vicinity of Crossing 1. Overflows would flow to the east along the rail formation and cutting and through the proposed underpass structure neath the Hume Highway to Crossing 1.

13.2.4 Edmondson Park Station (Crossings 4 to 6)

Overview

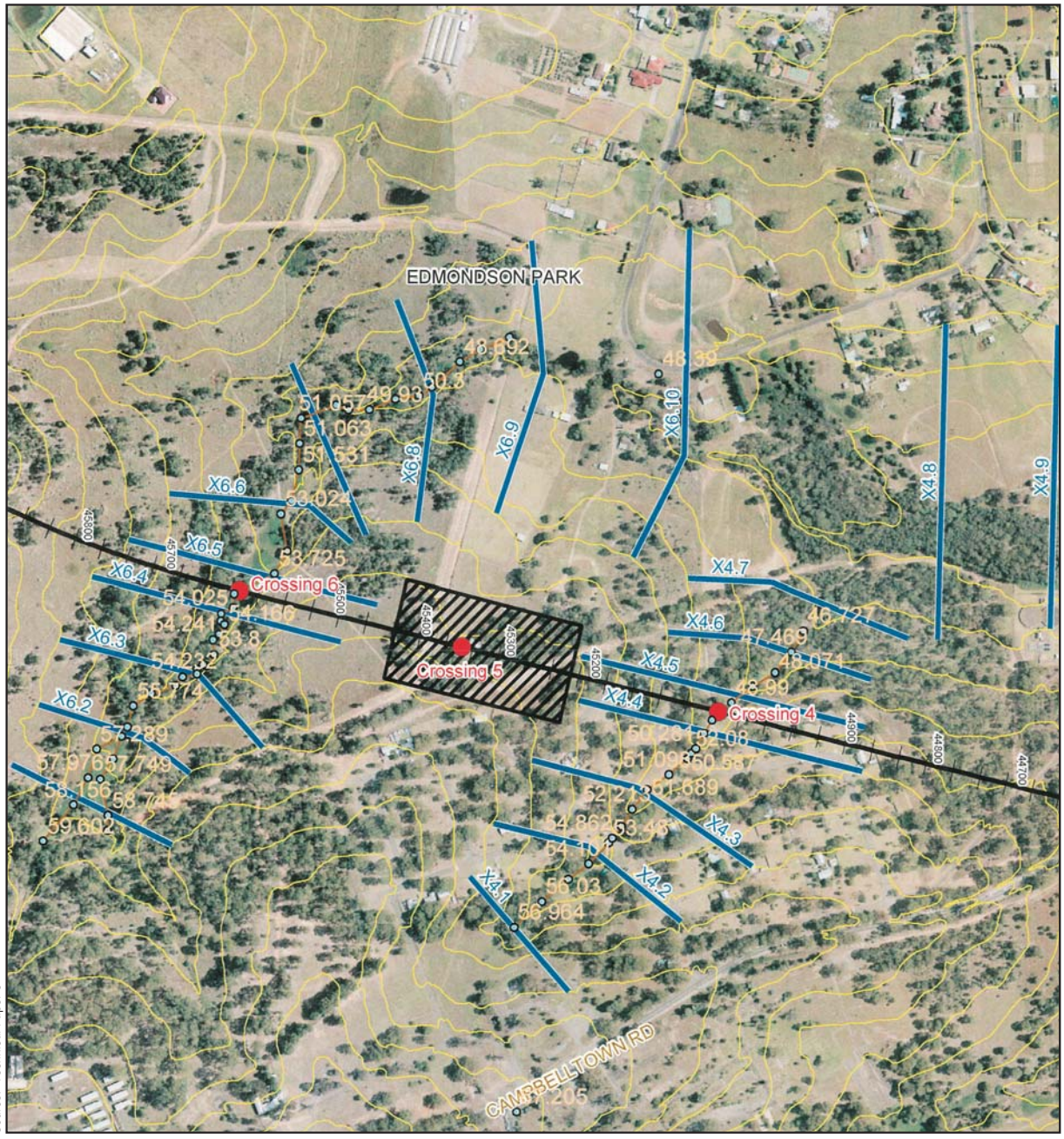
Edmondson Park Station would be located in the vicinity of three tributaries of Maxwells Creek, as shown in Figure 13-1. Due to the interaction of flood flows from these tributaries and because the Station is proposed to be located in a cutting crossing one of the overland flow paths, the management of floodwaters and design of the proposed Crossings 4 and 6 is more complex than for other crossings along the SWRL.

Hydraulic modelling of Crossings 4 and 6 was undertaken based on the current indicative vertical alignment of the SWRL. This modelling work indicated that, assuming the current indicative alignment, lowering of the watercourse upstream and downstream of the rail alignment would be required to increase the culvert head, obtain adequate cover from the SWRL level to the culvert and to allow gravity drainage of the Station. At Crossing 4 this would involve lowering the watercourse channel by up to 1.5 metres in depth. Similarly, at Crossing 6, lowering of the watercourse channel could be by up to 3.0 metres.

Further preliminary design has been undertaken to demonstrate that the vertical alignment in the vicinity of Edmondson Park Station can be modified to further reduce (or extinguish) any required lowering of the watercourse channels at Crossings 4 and 6.

Edmondson Park Station would be located in a cutting between Crossings 4 and 6. The vertical alignment of the rail line and elevation of the Station would be refined during the design development to minimise the risk and hazard associated with flood flows from Crossing 6 being transferred through the cutting and Station through to Crossing 4. Further detailed two-dimensional flood modelling, detailed ground survey and consideration of the Station design is proposed to address this issue. The results presented below are from the preliminary one-dimensional HEC-RAS flood model.

The proposed SWRL corridor traverses the small catchment area of Crossing 5. Run-off from the upstream section of this catchment would be diverted to Crossing 4 (300 metres to the east) prior to construction of the cutting. Alternatively, given the small magnitude of peak flows from this catchment, the run-off could be accommodated by the Station drainage. The track drainage requirements in the vicinity of Edmondson Park Station would be considered and resolved early in the future design work process for the project. This would include consideration of the effect of additional flows at Crossing 4 should run-off from Crossing 5 be diverted. Should the diversion proceed, there would be no flow immediately downstream of the SWRL alignment at Crossing 5.



Source: Technical Paper 5

0 200
metres

- Waterway crossings
- Railway alignment
- Cross-sections
- Contours (2 metres)
- Proposed Edmondson Park Station location
- Creek invert survey points

Figure 13-1 Crossings 4 to 6 at location of Edmondson Park Station

Hydraulic impacts

The potential impacts of the project on peak water levels at Crossings 4 (incorporating diverted flows from Crossing 5) and 6 were evaluated through relative comparison of pre- and post-SWRL conditions. The relative potential hydraulic impacts for the 100-year ARI and PMF events are summarised in Tables 8 and 9 of Technical Paper 2 in Volume 2 of this report.

The results for the 100-year ARI event indicate a reduction in peak flows immediately up- and downstream of the proposed SWRL alignment for the range of modelled flood events at both crossings. This reduction would result from lowering of the watercourse channels; or alternative design measures including amendment of the vertical alignment.

The waterway crossings in these locations would be designed to avoid overtopping of the rail level for the 100-year ARI event with 25 % culvert blockage. As a result of the lowering of the waterways (or alternative design measures), for larger floods and/or occurrences where blockage of the waterway exceeds 25 %, there would be no increase in the upstream peak flood levels. For larger flood events, including the PMF, there would also be no increase in the upstream peak flood levels, because of the proposed lowering of the waterway channels or alternative design measures. There would however, be an increase in the peak flood levels downstream of Crossing 4, due to the diversion of overflows from Crossing 6.

While increased flood magnitude and/or blockage would not result in increased post-SWRL peak flood levels upstream of the SWRL alignment, it could potentially result in overflow of floodwaters into the rail cutting and Edmondson Park Station. Further detailed hydraulic assessment using two-dimensional flood modelling would be undertaken to better define flood behaviour and the flood hazard at the Edmondson Park Station area, and to allow for investigation of potential options to minimise the potential flood risk and hazard. This modelling and associated detailed ground survey would also be used to refine the Station level and to define the extent of modification to the watercourse channels (see Section 13.5).

13.2.5 Crossing 7

Crossing 7 would be over Cabramatta Creek at Chainage 46.85 kilometres and near to the eastern boundary of the Denham Court residential area. A waterway crossing comprising seven 3.6 metres wide and 1.5 metres high culverts would be required.

Hydraulic modelling undertaken for the 100-year ARI flood event indicates:

- minor decreases in flood levels immediately upstream and downstream with an unblocked waterway crossing
- a potential increase in flood level of up to 0.10 metres immediately upstream with a 25 % blockage
- a potential increase in flood level of up to 0.84 metres immediately upstream with a 50 % blockage.

Review of existing aerial photography indicates that these increases are not likely to affect any existing houses or buildings.

For larger flood events up to the PMF, there is the potential for a significant increase in flood levels upstream of the SWRL alignment. Potential impacts would be further considered during the future design work phase.

13.2.6 Crossings 8, 9 and 10

Crossings 8, 9 and 10 would be over tributaries of Cabramatta Creek, adjacent to the northern boundary of the Forest Lawn Memorial Gardens Cemetery. Waterway crossings were adopted as follows to meet the design criteria:

- Crossing 8: two 3.3 metres wide by 0.9 metres high culverts
- Crossing 9: five 3.3 metres wide by 0.9 metres high culverts
- Crossing 10: two 2.7 metres wide by 0.9 metres high culverts.

Localised widening of the watercourse sections is proposed immediately upstream and downstream of the waterway crossing to accommodate the proposed structures.

Hydraulic modelling undertaken for the 100-year ARI flood event indicates the following:

- minor decreases in flood levels immediately upstream and downstream with an unblocked waterway crossing
- a potential increase in flood level of up to 0.09 metres immediately upstream with a 25 % blockage
- a potential increase in flood level of up to 0.43 metres immediately upstream with a 50 % blockage.

There are no residences or buildings immediately upstream that would be affected by these increases in flood levels. Assessment of larger floods was not undertaken and these would be further considered during future design work.

13.2.7 Leppington Station and stabling facility (Crossings 11–14)

Overview

A significant factor considered in determining the design rail level and most suitable location for Leppington Station is the design flood level at Scalabrini Creek. The proposed SWRL alignment crosses Scalabrini Creek at Crossing 13, which is located approximately 400 metres to the west of the planned location for Leppington Station (see Figure 5-6). In addition to the main crossing of Scalabrini Creek, two other watercourses would be crossed by the proposed SWRL corridor in the vicinity of the Station: Bonds Creek (Crossing 11) and a minor tributary of Scalabrini Creek (Crossing 12). Kemps Creek would be crossed by the SWRL corridor just to the east of the proposed stabling facility.

Results of the hydraulic analysis for each of these crossings are discussed below.

Hydraulic impacts

Crossing 11

Crossing 11 would be over Bonds Creek at approximately Chainage 50.00 kilometres. A waterway crossing comprising nine 3.6 metres by 1.8 metres high RCBCs was adopted to satisfy the design criteria.

Hydraulic modelling undertaken for the 100-year ARI flood event indicates the following:

- minor decreases in flood levels immediately upstream and downstream with an unblocked waterway crossing

- a potential increase in flood level of up to 0.03 metres immediately upstream with a 25 % blockage
- a potential increase in flood level of up to 0.70 metres immediately upstream with a 50 % blockage.

For larger flood events up to the PMF, the predicted increases in flood level are significant with an increase of up to 4.0 metres predicted for the 50 % blockage scenario.

Crossing 12

Crossing 12 would be over a small tributary of Scalabrini Creek near Chainage 51.27 kilometres. A waterway crossing of two 2.4 metres wide by 0.9 metres high culverts would be required. This is a minor waterway and no hydraulic modelling has been undertaken at this stage. Hydraulic modelling of this waterway would be undertaken during future design work (see Section 13.4).

Crossing 13

Crossing 13 would be over Scalabrini Creek at approximately Chainage 51.50 kilometres. A waterway crossing of five 3.3 metres wide by 1.8 metres high culverts would be required.

Hydraulic modelling undertaken for the 100-year ARI flood event indicates the following:

- minor decreases in flood levels immediately upstream and downstream with an unblocked waterway crossing
- a potential increase in flood level of up to 0.03 metres immediately upstream with a 25 % blockage
- a potential increase in flood level of up to 0.77 metres immediately upstream with a 50 % blockage.

For larger flood events up to the PMF, the predicted increases in flood level are significant with an increase of up to 5.5 metres predicted for the 50 % blockage scenario.

Crossing 14

Crossing 14 would be over Kemps Creek at approximately Chainage 52.600 kilometres, immediately to the east of the proposed stabling facility. A waterway crossing of six 3.6 metres wide by 1.8 metres high culverts would be required.

Hydraulic modelling undertaken for the 100-year ARI flood event indicates the following:

- minor decreases in flood levels immediately upstream and downstream with an unblocked waterway crossing
- a potential increase in flood level of up to 0.04 metres immediately upstream with a 25 % blockage
- a potential increase in flood level of up to 0.66 metres immediately upstream with a 50 % blockage.

For larger flood events up to the PMF, the predicted increases in flood level are significant with an increase of up to 2.30 metres predicted for the 50 % blockage scenario.

Flood impacts on properties and infrastructure

The modelling results show that the proposed SWRL level in the vicinity of each crossing is set well above the estimated 100-year ARI flood level for the relevant watercourse. Even in the event of 50 % blockage of the crossing, the 100-year ARI flood level is below the design SWRL level. Under this scenario, however, ponding would occur behind the rail embankment in each location. The potential impact of such ponding on the embankment would need to be considered during future design work.

In the event of 50 % blockage of the crossing, the PMF event would overtop the proposed rail level at each of the three crossings. In this case, the resultant ponding behind the rail embankment could be significant.

A preliminary assessment of the number of existing properties affected by flooding was made based on aerial photography and two metre orthophoto contour interval information. The number of properties expected to be inundated under pre- and post-SWRL 100-year ARI and PMF conditions are summarised in Table 13-1 below. These numbers are a preliminary guide only; further assessment using detailed property and floor level survey information is proposed in the next phase of the design (see Section 13.4).

Table 13-1 Number of properties potentially affected by flooding upstream of Crossings 11, 13 and 14

Crossing	100-year ARI peak flood		PMF		
	pre-SWRL	post-SWRL[1]	pre-SWRL	post-SWRL[2]	post-SWRL[3]
Crossing 11[4]	15	15	23	23	25
Crossing 13	8	8	15	15	19
Crossing 14	11	11	17	18	22

Notes: 1: With up to 25% culvert blockage; 2: With no culvert blockage; 3: With 25% culvert blockage; 4: Upstream to Cowpasture Road

As shown in Table 13-1, only a small number of additional properties would be potentially affected by the predicted flood increases for larger floods up to the PMF. The extent of this flood increase would generally be limited to between 300 to 500 metres upstream of each of these crossings.

Consideration was also given to the potential flood implications on proposed road crossings. Only one road crossing was found to be potentially affected: Eastwood Road, which is located 450 metres east of Crossing 14 over Kemps Creek. Hydraulic modelling results in this locality show that the 100-year ARI flood peak flood level would be approximately 4.4 metres below the adjoining Eastwood Road level in this locality; therefore, the SWRL would be unlikely to adversely affect flooding of existing roads.

13.3 Future land uses

The assessment has assumed that future development of the South West Growth Centre will include provisions to ensure there is no increase in peak catchment flows. This assumption is supported by studies such as the *Edmondson Park Master Planning Water Cycle Management: Stormwater Final Report* (GHD 2003), which details proposed basins for attenuating any increase in flood flows resulting from future urbanisation.

Similarly, compensatory flood storage would be required should the SWRL project result in the removal of existing flood storages (including any significant farm dams etc), which are shown to have an effect on peak flows and flood levels. Any such storages would be surveyed and assessed as the SWRL design is developed.

The maps accompanying State Environmental Planning Policy (Sydney Region Growth Centres) 2006 identify areas of 'Flood Prone and Major Creeks Land' in the South West Growth Centre, which includes tributaries of Kemps Creek that cross the proposed SWRL corridor. The Policy establishes controls for the development of land in these areas, which will be considered in the future precinct/locality planning and rezoning in the Growth Centre to avoid and minimise potential flooding impacts.

13.4 Summary of predicted changes to flood behaviour

The above analyses indicate the following general trends:

- The design of the waterway structures proposed for the SWRL can accommodate the 100-year ARI flood; however, further consideration of the potential for blockage of culvert cells during flood events is required or consideration of alternative bridge structures.
- Significant increases in flood levels are likely for larger flood events up to the PMF; however only a small number of additional existing properties would be affected by the increase (or afflux) and this increase would be generally contained to between 300 to 500 metres upstream of the crossing locations.
- The flood behaviour in the vicinity of Edmondson Park Station is complex due the interaction of three tributaries of Maxwells Creek and the siting of the Station in a cutting. Further preliminary design has demonstrated that the vertical alignment in this area can be modified to further reduce the extent of any lowering of the watercourse channels at Crossings 4 and 6. The horizontal alignment is confirmed. Further detailed analysis of flood behaviour in this locality is proposed as set out below.

Generally the predicted flooding impacts would have minor impacts on existing property and can be managed through appropriate crossing design and with additional assessment and the incorporation of appropriate mitigation measures as set out below.

13.5 Recommendations for further assessment and mitigation

13.5.1 Further assessment

Further hydraulic assessment is recommended to inform the future design development to be undertaken as part of the next stage of the assessment and design process, as detailed in Section 7 of Technical Paper 2 in Volume 2 of this report, and summarised below.

The following general assessment requirements are recommended:

- collection of further detailed topographic survey data along the proposed SWRL corridor alignment and watercourses at each of the waterway crossings

- undertaking of flood modelling for a range of design flood events to assess in detail the pre- and post-SWRL flood behaviour and hazard (including the potential for blockage of culvert cells during flood events)
- collecting property survey data including ground levels at property boundaries and floor levels of buildings
- assessing changes to flood levels and hazard
- investigating and recommending flood mitigation/flood modification measures to be incorporated into the project design
- where ponding behind rail embankments is predicted under flood conditions (e.g. Crossing 14), considering the potential impact of such ponding on the stability of the embankments.

Specific recommendations at Crossings 1–3 and 7–10 comprise:

- establish a detailed flood modelling platform, comprising a run-off-routing hydrologic model and an appropriate hydraulic model (likely to be an unsteady one-dimensional model)
- once Campbelltown City Council's investigations regarding the Glenfield flood detention basin are complete, further evaluate the potential impacts of the proposed SWRL on flooding and the requirements of the waterway opening for Crossing 1
- Undertake environmental studies to consider the potential riparian impacts of the proposed flow diversion and the potential impacts of the proposed length of deep cutting on salinity.

Specific recommendations at Edmondson Park Station (Crossings 4, 5 and 6) comprise:

- consider and resolve the track drainage requirements in the vicinity of Edmondson Park Station early in the future design work process, including consideration of the effect of additional flows at Crossing 4 should run-off from Crossing 5 be diverted
- establish a detailed flood modelling platform, comprising a run-off-routing hydrologic model and a two-dimensional hydraulic model
- assess flood risks to rail commuters, staff and infrastructure
- evaluate the reliability and security of available flood evacuation routes and other flood emergency measures
- undertake environmental studies to consider the potential riparian impacts of the proposed lowering of the watercourse channels and flow diversion.

Specific recommendations at Leppington Station (Crossings 11–14) comprise:

- refine the established flood models as appropriate with the additional survey data
- undertake a quantitative flood assessment for Crossing 12, concurrently with the future design work and analysis of Crossing 13
- define flood extents and identify properties affected and buildings inundated
- assess potential flood impacts at Eastwood Road and McCann Road.

13.5.2 Management/mitigation options

It is recommended that all crossings are designed to comply with the requirements of *Guidelines for Design of Fish and Fauna Friendly Waterway Crossings* (Fairfull and Witheridge 2003) and in consultation with NSW Fisheries (see Chapter 14 –Biodiversity).

Given the sensitivity of the potential hydraulic impacts to an increase in the amount of blockage at all of the watercourse crossings in the vicinity of the Edmondson Park and Leppington Stations (Crossings 4, 6, 11, 13 and 14) and Crossings 1 and 7, consideration should be given to bridge structures in these locations. The expected large openings of a bridge structure compared to a standard culvert crossing would reduce the likelihood of blockage and may provide reduced impacts on the riparian environment. Proposed waterway crossings should be appropriately sized so that the consequences of a reasonable degree of blockage (25 % for this assessment) are manageable.

The incorporation of trash racks should also be considered at specific locations to reduce the likelihood of culvert blockage.