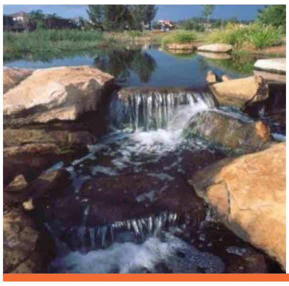
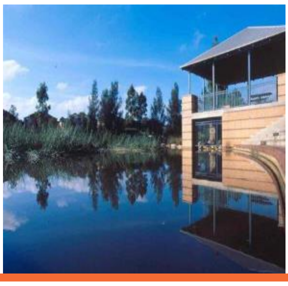
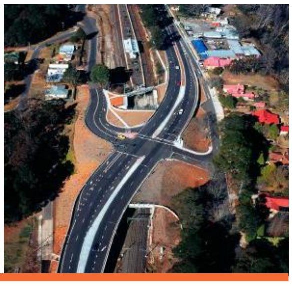
Appendix K

Hydrology and hydraulic assessment

WestConnex Enabling Works
Airport East Precinct
Hydrologic and Hydraulic Assessment Report



Prepared for:

Roads and Maritime Services

May 2014

9833Rpt1C.docx

Prepared by:

J. WYNDHAM PRINCE

CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS

PO Box 4366
WESTFIELD NSW 2750
DX 8032 PENRITH
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au

J. WYNDHAM PRINCE

CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS

WESTCONNEX ENABLING WORKS, AIRPORT EAST PRECINCT HYDROLOGIC AND HYDRAULIC ASSESSMENT

- DOCUMENT CONTROL SHEET -

Issue No.	Amendment	Prepared By & Date	Checked By and Date	Approved By and Date
A	Draft Issue	JC (24-02-14)	DG (25-02-14)	DC (27-02-14)
B	Second Draft Issue	JC (30-04-14)	DG (30-04-14)	DG (30-04-14)
C	Final Draft Issue	JC (27-05-14)	DG (27-05-14)	DC (27-05-14)
D	First Issue	DC (08-07-14)	DC (08-07-14)	DC (08-07-14)
	Signatures:			
	File Location:	J:\9833 - Westconnex Enabling Works\Design Report\9833Rpt1C.docx		

J. WYNDHAM PRINCE

CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS

WESTCONNEX ENABLING WORKS, AIRPORT EAST PRECINCT
HYDROLOGIC AND HYDRAULIC ASSESSMENT

- CONTENTS -

- LIST OF TABLES-

- LIST OF PLATES-

- LIST OF APPENDICES-

- LIST OF FIGURES-

General Figures

General Flood Mapping Figures

Sensitivity Assessment Flood Mapping Figures

Pump-Out Assessment Flood Mapping Figures

1. EXECUTIVE SUMMARY

Roads and Maritime Services have engaged J. Wyndham Prince to undertake a hydrologic and hydraulic (flood) assessment in support of the proposed Westconnex Enabling Works, Airport East Precinct (from here on referred to as the Airport East Precinct Works), which includes road network improvements proposed to reduce traffic congestion at General Holmes Drive, Joyce Drive, Mill Pond Road and Botany Road, adjacent to Sydney Airport.

Key aspects of the project include:

- Closing the level crossing at General Holmes Drive and providing an alternative rail crossing.
- Extending Wentworth Avenue from Botany Road through to General Holmes Drive, with an underpass across the rail line and a culvert crossing of the open stormwater channel.
- Widening the roads and providing additional through lanes on General Holmes Drive, Botany Road and Wentworth Avenue.
- Upgrading intersections, including General Holmes Drive with Mill Pond Road as well as Wentworth Avenue with Botany Road, to accommodate additional traffic. Creation of a new intersection between General Holmes Drive and Wentworth Avenue.

The objectives of the project are to:

- Provide sufficient capacity to support increased volumes of taxis and buses accessing the Sydney Airport Precinct.
- Allow for future duplication of the Port Botany Rail Line and the separation of road and rail infrastructure to improve freight rail throughput.
- Support the Sydney Airport Corporation Ltd in its development of the adjacent airport gateway road improvements to Joyce Drive and Qantas Drive, Robey Street and O'Riordan Street.

An investigation was undertaken by Roads and Maritime Services to evaluate a series of options tabled for the Airport East Precinct Works (RMS, 2013).

A schematic layout of the adopted option is shown in Appendix A

Together with the construction of the required roadworks, one major culvert crossing is required over the existing open stormwater channel through the site. A hydraulic assessment was undertaken on two culvert options to inform RMS's concept design process.

The two culvert options considered for the Stormwater Channel crossing were 2 x 4.2m x 3.0m (Culvert Option 1) and 3 x 3.3m x 3.0m (Culvert Option 2). Both options were assessed and found to be adequately sized to accept the 1% AEP event.

Our investigations have determined that small increases in flood levels to the north of the proposed crossing and areas upstream of the site as a result of nominal afflux through the proposed culvert. This is caused by the very low hydraulic grade (approximately 0.1%), with increases in flood levels, resulting from the culvert obstruction, being projected significantly upstream before returning to existing flood levels.

Notwithstanding this outcome, the increase in flood levels upstream of the site as a result of the proposed culvert crossing is minor, with the culvert Option 2 providing the least impact.

An additional assessment has also been undertaken to determine the pump-out requirements to dewater the stormwater which accumulates at the proposed Wentworth Avenue underpass, during the peak 10% AEP storm event. A new drainage system upstream of the site is required to divert the majority of inflows to reduce the pump-out requirement at the underpass. The assessment determined that a peak pump-out flow rate of up to 2.2 m^3/s of stormwater is required to be managed at the site during the peak 10% AEP storm event.

2. INTRODUCTION

The Roads and Maritime Services has engaged J. Wyndham Prince to undertake a hydrologic and hydraulic assessment for the proposed road network improvements for the Airport East Precinct Works. The site of the Airport East Precinct Works is located within Mascot, south of the Sydney CBD.

The Airport East Precinct works are generally bounded by General Holmes Drive to the west, Joyce Drive to the north, Mill Pond Road to the south, and Botany Road and Wentworth Avenue to the east.

The Airport East Precinct Works incorporates road network improvements proposed to reduce traffic congestion in and around the Airport Precinct.

An open stormwater channel currently runs though the site from the north near the railway crossing of General Holmes Drive, towards Mill Pond to the south. There is currently one major crossing of the stormwater channel at Mill Pond Road, which is expected to remain. A new crossing is proposed with the extension of Wentworth Avenue near the proposed intersection with General Holmes Drive. The proposed crossing is expected to be a significant culvert arrangement.

This report details the procedures used and presents the results of investigations undertaken by J. Wyndham Prince in developing a hydrologic and hydraulic assessment for the Airport East Precinct works. The results of the investigation will inform Roads and Maritime Services detailed concept design process and environmental assessment. The objective of the assessment is primarily to establish peak flows on the watercourse for a range of storm events and undertake flood modelling to determine appropriate design culvert size for the proposed Wentworth Avenue crossing over the existing open stormwater channel.

The investigation involved the following specific tasks:

- Prepare new hydrologic model representing the upstream catchment under existing conditions and determine peak flows for use in the hydraulic model.
- Undertake hydraulic modelling to determine existing case flood levels within and adjacent to the proposed works site.
- Modify the hydraulic model to include the proposed design landform for the Airport East Precinct Works, the proposed bridge/culvert structures and other culvert crossings.
- Assess multiple culvert options to determine the impact of the proposed roadworks on adjacent properties to the site.
- Undertake a sensitivity analysis to determine the effect of changes in the parameters used in the hydraulic model (surface roughness and blockages), and the associated impact on flood levels adjacent to the proposed Airport East Precinct Works.
- Undertake an investigation to review the drainage and pump-out requirements for the Wentworth Avenue underpass during the 10% AEP storm events.
- Prepare a Hydrologic and Hydraulic Assessment Report to support the detailed concept design for the Airport East Precinct Works, detailing the investigations, findings, calculations and design details.

3. PREVIOUS STUDIES

There are no previous investigations that have been undertaken that are relevant to the works, with regards to hydrologic, hydraulic and concept designs.

There is one (1) previous investigation undertaken to review the Airport East Precinct road improvement requirements and options review

3.1. WestConnex Enabling Works Project Proposal Report

Sinclair Knight Mertz prepared the project proposal report on behalf of the Roads and Maritime Services in 2013 to document the various options and option evaluation to improve traffic conditions associated with the Sydney Airport Precinct.

The purpose of the project is to:

- Provide sufficient capacity to support increased volumes of taxis and buses accessing the Sydney Airport Precinct.
- Allow for the future duplication of the Port Botany rail line and the separation of road and rail infrastructure to improve rail freight throughput.
- Support the Sydney Airport Corporation Ltd in its development of the adjacent airport gateway road improvements to Joyce Drive and Qantas Drive, Robey Street and O'Riordan Street.

Following assessment, Roads and Maritime Services selected the most appropriate option for the proposal, then made a series of revisions from a subsequent value management workshop which were considered to add value to the proposed option. Subsequent to displaying the project proposal, a number of additional environmental and technical investigations including evaluation of community feedback has resulted in a number of design changes.

The works proposed for the adopted option together with revisions would involve:

- Closing the General Holmes Drive rail level crossing
- Construction of a new road underpass between General Holmes Drive and Wentworth Avenue.
- An additional through lane in both directions on General Holmes Drive and Joyce Drive.
- Changing the General Holmes Drive and Joyce Drive intersection.
- Changing the Wentworth Avenue and Botany Road intersection.
- Changing the Botany Road and Mill Pond Road intersection
- Creating a new intersection at General Holmes Drive and Wentworth Avenue.

The study found that the adopted option together with the recommended revisions would meet the project objectives by:

- Improving network traffic capacity in the study area.
- Providing a road underpass between Wentworth Avenue and General Holmes Drive with full access to over-height vehicles.
- Accommodating the future duplication of the Port Botany rail line, while achieving permanent separation of road and rail infrastructure, which would support the planned increase in rail freight throughput.
- Complementing road improvements proposed for Joyce Drive and General Holmes Drive.

The schematic overview of the proposed works is provided in Appendix A

4. THE EXISTING ENVIRONMENT

4.1. The Site and Existing Drainage Configuration

The Airport East Precinct Works site is generally bounded by Mill Pond Road to the south, General Holmes Drive to the west and north, and Botany Road to the east. An existing goods rail line runs along the north-eastern portion of the site, with an existing open drainage channel in the central/western portion of the site, draining from north to south. The proposed works are located an area that is predominantly undeveloped with the exception of buildings including workshops in the far northern portion of the site. The surrounding area is predominantly urbanised, with the Sydney International Airport immediately to the west of the site and the urban suburb of Mascot to the north and east. The Airport East Precinct Works are proposed to facilitate access to and from the Sydney International Airport.

The open stormwater drainage channel within the subject site conveys flows from the catchments to the north and east, towards Mill Pond to the south of the site. The location of the Airport East Precinct Works is indicated below on Plate 4.1 and in more detail on Figure 4.1.

Plate 4.1 Location of the Airport East Precinct Works Site
(Aerial Imagery courtesy of Google Maps)

There is a significant catchment of approximately 300 hectares upstream (to the north) of the site, over 200 hectares of which drains into the localised low point east of Botany Road and north of Wentworth Avenue. Discharges from this low point are directed by existing piped systems to the head of the existing stormwater channel, which results in significant flows and flooding within the site. Refer to Figure 5.1 for further detail and the adopted subcatchment extents.

Overflows from this area discharge to the west of Botany Road, or south across Wentworth Avenue. Other flows contribute to the flooding from Botany Road to the east, and the Airport land to the west, through smaller drainage lines.

Refer to Plate 4.2 below for a schematic representation of overland flows around the study area.

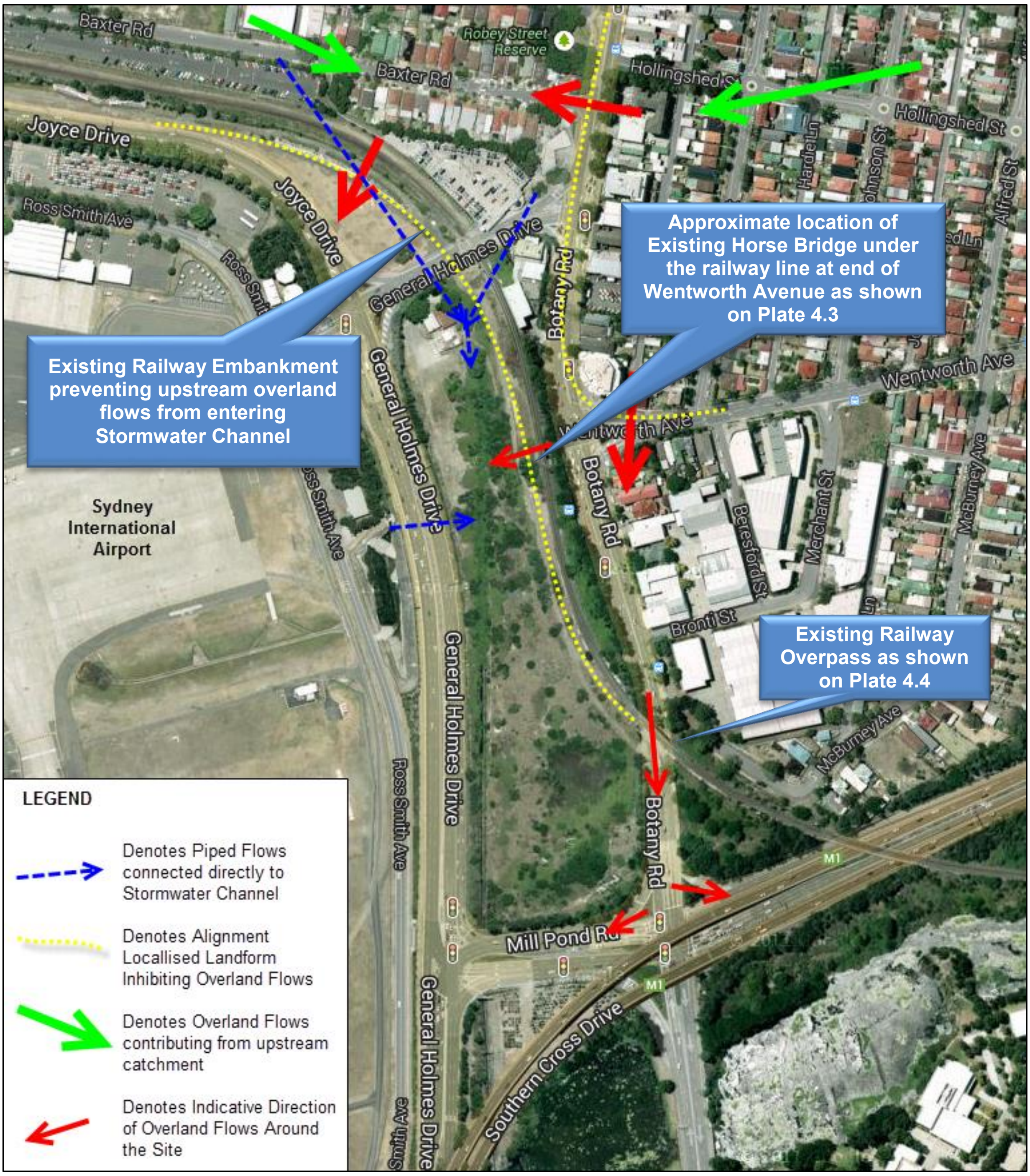


Plate 4.2 Schematic Diagram of Flows Around the Airport East Precinct Works Site
(Aerial Imagery courtesy of Google Maps)

Plate 4.3 Existing "Horse" Bridge Under Railway Line At End of Wentworth Avenue

Plate 4.4 Existing Railway Overpass of Botany Road

Plate 4.5 Existing Crossing Over Stormwater Channel at Mill Pond Road

Plate 4.6 Existing Stormwater Channel Looking Downstream From Discharge Culvert

Limited reliable road drainage information has been provided by Botany Bay City Council and Roads and Maritime Services, and, as a result, most of the piped drainage was not considered in the assessment. Therefore, the flood extents shown in the assessment results conservatively ignore the benefits provided by existing stormwater drainage networks.

4.2. The Proposed Development

The Airport East Precinct Works involves the extension of Wentworth Road, through the intersection with Botany Road, under the existing goods rail line, over the stormwater channel, and intersecting with General Holmes Drive, as shown above in Plate 4.1, and in more detail in Appendix A.

The level crossing of the rail line at General Holmes Drive will be closed to traffic, with a cul-de-sac formed at each “dead end” caused by the closure. Additional through lanes will be provided in both directions on General Holmes Drive and Joyce Drive. There will be adjustments to the General Holmes Drive and Joyce Drive intersection as well as to the Wentworth Avenue and Botany Road intersection.

Construction of the new intersection at General Holmes Drive and Wentworth Avenue will include a new major culvert structure over the existing open stormwater channel. Two culvert options were assessed for the proposed crossing, utilising either 2 x 4.2m x 3.0m RCBC’s (Culvert Option 1), or 3 x 3.3m x 3.0m RCBC’s (Culvert Option 2).

The existing bridge structure of the Mill Pond Road crossing over the stormwater channel is expected to remain unaltered. A new bridge will also be provided for Wentworth Avenue to underpass the existing goods rail line through the site.

The proposed road vertical alignment of the adjusted portion of Wentworth Avenue generally involves at-grade intersections with Botany Road and General Holmes Drive at each end, with a low point at the rail underpass. The concept design for the proposed roadworks was provided by the Roads and Maritime Services and the design surface provided to J Wyndham Prince for input to the flood modelling. The concept design information adopted in the modelling is included in Appendix A (Westconnex Enabling Works Option 4).

Existing piped drainage was conservatively ignored in the assessment for the flood extents.

Refer to Figure 4.2 for the layout of the roadworks and location of proposed culvert in context of the study area.

Available existing piped drainage system information was used in the detailed drainage assessment for the 10% AEP storm events in designing the drainage infrastructure for the proposed Wentworth Avenue underpass.

Refer to Figure 4.3 for the layout of the existing and proposed drainage infrastructure in context of the study area, which includes a detailed layout of the proposed drainage arrangement in the vicinity of the proposed road works and railway underpass.

5. HYDROLOGIC ANALYSIS

The hydrologic analyses for this study were undertaken using the rainfall - runoff flood routing model XP-RAFTS (Runoff and Flow Training Simulation with XP Graphical Interface). The hydrologic analysis for the Airport East Precinct works was undertaken to determine peak flow hydrographs for input to the hydraulic model.

5.1. Sub Catchments

Sub-catchment areas contributing to the drainage system were established through site investigations and assessment of a Digital Elevation Model provided by Botany Bay City Council, which covered the study area and upstream catchment.

CatchmentSIM was used to facilitate the determination of catchment areas under existing conditions. CatchmentSIM automatically delineates sub catchments and calculates their associated spatial and topographic characteristics to assist in the development of a hydrologic model. The catchment extents were reviewed and adjusted manually based on visual inspection and detailed assessment.

Sub-catchment boundaries for the existing areas contributing to the drainage system are shown on Figure 5.1.

The modelling has included catchments to the Mill Pond, downstream of the Airport East Precinct Works study area, to ensure that a meaningful analysis of any potential impacts that the development of the Airport East Precinct Works may have on downstream areas can be assessed.

Detailed flow information for a range of storm events modelled is provided in Appendix B.

5.2. Impact of Wentworth Avenue Upgrade on Peak Flows

There is a significant catchment area upstream of the Airport East Precinct Works site. The extra impervious areas resulting from the proposed road construction within the catchment is approximately 1-2 ha and significantly less than 1% of the total catchment area. Therefore, the increase in peak flows within the catchment as a result of these works is considered to be negligible.

It was therefore assumed that the existing case peak flows will be an accurate representation for the developed case scenarios for the flood modelling. The catchment areas in both the existing and developed condition assessments remain unchanged.

5.3. Rainfall Data & XP Rafts Modelling Parameters

Botany Bay Council (BBCC, 2013) do not indicate a specific runoff coefficient for developed site conditions. Therefore, we have taken a conservative position as a result of reviewing existing aerial imagery and undertaking a detailed site inspection, a percentage imperviousness of 90% was adopted for residential catchments under current site conditions.

The Automatic Storm Generator tool was used in the generation of synthetic storms for assessment in XP-RAFTS. This tool requires inputs based on the 2% and 50% AEP rainfall intensities for the 1, 12 and 72 hour storm events to generate IFD information automatically. The basic rainfall input data used in the hydrologic study is consistent with the values extracted from Botany Bay City Council's Rainfall Intensity Frequency Duration data (Table 2 in Botany Bay City Council's DCP *"Stormwater Management Technical Guidelines"*), the values adopted are shown below in Table 5.1.

Table 5.1 Rainfall Values Adopted in XP-RAFTS Model to Generate IFD Coefficients

	Adopted Rainfall Intensity (mm/h)		
	1 hr	12 hr	72 hr
2% AEP	84.2	16.1	5
50% AEP	40.9	8.1	2.5

Location Skewness	0
Latitude	33.95
Longitude	151.2

Botany Bay City Council's Stormwater Management Guidelines do not provide recommended values to adopt for PERN (n) values and losses. The values adopted in the XP-RAFTS modelling are outlined in Table 5.2 below.

Table 5.2 Parameter Values Adopted in Hydrologic Model

Parameter		Pervious	Impervious
PERN	(n)	0.015	0.025
LOSSES			
Initial	(mm)	10.0	1.0
Continuing	(mm/hr)	2.5	0.0

5.4. Calibration of Hydrologic Model

It is normal practice for flood routing models such as XP-RAFTS to be calibrated with historical rainfall and stream flow data for the catchment being investigated in order to produce the most reliable results. The model parameter values (in particular Bx) are adjusted so that the model adequately reproduces observed hydrographs. However, no stream flow records were available for the site and a Site Storage Coefficient Multiplication Factor (Bx value) of 1.0 was adopted and compared to Probabilistic Rational Method (PRM) and Australian Regional Flood Frequency (ARFF) calculations for checking.

The results of 1% AEP calculation checks indicate that the XP-RAFTS results were reasonably comparable to the average provided by the PRM and ARFF calculations, therefore a Bx value of 1.0 was adopted. A summary of the comparison of peak flows between the models is given in Table 5.3.

Table 5.3 Comparison of Peak Flows With Hydrologic Calculation Checks

Node	Catchment Area (ha)	PRM (m^3/s)	ARFF (m^3/s)	Calculation Average (m^3/s)	XP-RAFTS (Bx=1.0) (m^3/s)
1.09	322	95.3	124.4	109.9	117.7
1.11	378	107.9	136.5	122.2	131.6

5.5. Catchment Diversions

A preliminary assessment of the surface model and extraction of catchment using CatchmentSIM indicate that the natural catchment upstream of the Airport East Precinct Site (to the north and east) is effectively cut-off by the railway line embankment. There is existing piped stormwater drainage infrastructure in this area contributing directly to the stormwater channel within the site. However, much of the infrastructure is either undocumented, or does not provide the level of detail necessary for its inclusion in the hydraulic model.

The information provided by Botany Bay City Council (with limitations regarding its reliability) and a site inspection was able to verify only a portion of the existing infrastructure. The scope of this study did not include a detailed survey of existing drainage infrastructure. Therefore, the information provided for the drainage infrastructure directly upstream of the site has been adopted, with a view that this information is consistent under existing and developed conditions, thereby allowing a direct comparison to determine the impact of the proposed development on flooding throughout the site.

The stormwater drainage infrastructure adopted in the flood modelling is shown on Figure 4.1 under existing conditions, and in Figure 4.2 for developed conditions.

There is existing drainage infrastructure comprising of a combined concrete lined canal and box culvert system, collecting discharges from the area north of King Street and diverting them west towards Alexandra Canal. The existing landform forces overland flows to continue south and contribute discharges towards Baxter Street and the Airport East Precinct Works site.

The indicative cross-sectional area of the drainage canal diverting flows from the catchment is up to 3 m² (2.29 m wide x 1.3 m deep). It was assumed that this system would flow full, which would divert up to 6.0 m³/s out of the system. This diversion was incorporated in the hydrological model, with primary flows less than 6.0m³/s upstream of node 8.02 being diverted out of the system, and remaining overflows continuing south towards Baxter Street. The peak 10% AEP discharge to Node 8.02 was 28.9 m³/s, with the initial 6.0 m³/s diverted out of the system, the remaining 22.9 m³/s was kept in the system to continue south towards Baxter Street and contribute to the flood model. Refer to Figure 5.1 which indicates the location of the drainage canal diverting primary flows out of the system.

The hydrologic information from the catchment upstream of Hardie Street (XP-RAFTS node 1.06 to the east of Botany Road) as well as west of the lowpoint in Baxter Street (XP-RAFTS node 8.03) contribute as total hydrographs into the flood model. From this point within the flood model, the majority of the flows are allowed to travel overland in accordance with the surface used in the hydraulic model.

The peak flows from the XP-RAFTS model at key locations for the investigation are shown below in Table 5.4, locations of the key locations are indicated in Figure 4.1.

Table 5.4 Summary of Peak Flows at Key Locations

XP-RAFTS Node	Location Description	Catchment Area (ha)	Peak Flow (m³/s)		
			10% AEP	1% AEP	PMF
1.06	Hardie Street	190	52.0	78.0	356
1.07	Botany Road at General Holmes Drive	204	54.1	81.4	368
1.08 *	Baxter Street Lowpoint	118	27.8	44.4	215
1.09 *	Head of Stormwater Channel Upstream of Site	322	76.2	117.7	566
9.03	Airport Land	38	13.9	19.8	121
10.01	Botany Road at Railway Bridge	10	4.5	6.2	43
1.10 *	Site at Mill Pond Road	374	84.5	130.7	610
1.11 *	Outfall Into Mill Pond	375	84.9	131.6	614

* Peak discharges downstream of XP-RAFTS node 8.02 exclude up to 6.0 m³/s of diverted flows as a result of upstream channel diversions

6. FLOOD MODELLING

The 2D flood modelling of the Westconnex Enabling Works site and the surrounding areas was undertaken using TUFLOW (Two-Dimensional Unsteady Flow) which is a computational engine that provides two-dimensional (2D) and one-dimensional (1D) solutions of the free-surface flow equations to simulate flood and tidal wave propagation. TUFLOW is specifically beneficial where the hydrodynamic behaviour in coastal waters, estuaries, rivers, floodplains and urban drainage environments have complex 2D flow patterns that would be difficult to represent using traditional 1D network models.

All flows within the stormwater channel and within the adjoining catchment areas were modelled as 2D flows. A 2D model provides a better estimation of the effects of momentum transfer between in-bank and overbank flows and the energy losses due to meanders or bends in creeks.

Piped systems, including the existing and developed case culvert crossings over the stormwater channel were included as 1D networks within the model.

MapInfo, a GIS based software, was used for interrogating and plotting the results as well as creating the flood extents and the flood level difference maps.

Flood modelling for the existing case and proposed development case (including the two culvert crossing options) was undertaken to determine the impact of the Airport East Precinct works on the flood levels in the stormwater channel and on surrounding areas.

6.1. TUFLOW Model Set Up and Modelling Assumptions

As with any flood modelling a number of assumptions are necessary to allow for the modelling process to proceed. Summarised below are the assumptions made within the TUFLOW model for the Airport East Precinct works assessment.

6.1.1. Digital Terrain Model (DTM)

The terrain for the TUFLOW model consists of the LIDAR data provided by Botany Bay City Council. Detailed survey within the proposed works area was provided by the Roads and Maritime Services and incorporated in the modelling.

The proposed road design for the Airport East Precinct works, including the Wentworth Avenue extension through the site was undertaken by the Roads and Maritime Services. A surface representing the road upgrade works were also incorporated in the developed case scenarios.

A grid size of 2 m was adopted in the TUFLOW model. This grid size was found to be a reasonable balance between computing time and flooding definition together with the level of accuracy of the greater catchment surface information.

6.1.2. Catchment Roughness

One of the advantages of using TUFLOW for the hydraulic assessment is that different landuse can be assigned different roughness factors. For the Airport East Precinct works investigation the roughness assumptions adopted in the modelling are consistent with those recommended in Australian Rainfall and Runoff Project 15 (ARR, 2012), and are summarised below in Table 6.1.

The Stormwater Channel is essentially a concrete lined trapezoidal channel with a low level invert down the centreline and 1.5 metre high concrete batters at 1.5:1. The overall top of bank channel width is generally 10 metres, with a base width of 5 metres. Much of the channel is unmaintained, has areas that are silted and is heavily weeded in the current state (see Plate 4.6). An assumed channel Manning's roughness n value of 0.02 has been adopted for the assessment, consistent with a maintained concrete lined channel.

A sensitivity assessment has also been undertaken which provides results of an assessment where the roughness coefficients throughout the site are increased by 25%.

Table 6.1 TUFLOW Adopted Material Roughness

Material ID	Mannings 'n'	Description
1	0.035	Floodplain General Urban (default)
3	0.07	Moderate Vegetation
6	0.03	Pond / Estuary
7	0.2	Residential Areas (including building, gardens, fences etc)
8	0.035	Turf / Open Grassed areas
9	0.02	Roads, Paved surfaces
13	0.3	Buildings or Significant Houses

6.1.3. Boundary Conditions

The boundary conditions adopted in the TUFLOW model are as follows:

- UPSTREAM – Total Flow hydrographs, extracted from the XP-RAFTS model, were applied as inputs at the upstream boundary of the model.

- LOCAL INFLOWS – Local inflow hydrographs were included in the model at locations representing the additional sub-catchments between the upstream and downstream model boundary extents.

- DOWNSTREAM – The area is partially affected by coastal and tidal impacts directly from Botany Bay. The Regional Astronomical High Tide level of RL 0.96 m AHD coupled with high storm surge of 0.6 m (CMM, 1990), results in a tailwater control level of just under 1.6 m AHD, which was adopted as the downstream control for flood modelling assessments. The impacts of wave setup and wave run-up were ignored, as it was assumed that Botany Bay and pond systems would dampen these effects.

6.2. Hydraulic Structures

6.2.1. Existing Hydraulic Structures

There are a number of existing culvert structures that discharge stormwater flows directly to the site. Some of these culvert structures have been located in the detailed survey provided by Roads and Maritime Services and incorporated into the existing case model to establish base flood levels. The majority of the structures were not detailed on the survey. Limited reliable information was able to be provided by Council on the existing drainage infrastructure at the time of the initial staging of the modelling process. A further site investigation was unable to physically verify many more details as access to existing infrastructure was limited.

The existing concrete-lined open stormwater channel through the site formed part of the detailed survey. However, the channel profile detailed in the survey did not provide continual fall to the Mill Pond as our site inspection confirmed. Adjustments were made to the surface model to ensure consistent fall to the south for the full length of the stormwater channel from the culvert outlet (IL 2.40 m AHD) to the Mill Pond outfall (IL 1.60 m AHD).

There are existing drainage networks which convey stormwater flows from the north-eastern side of the railway line directly into the head of the stormwater channel. A simplified arrangement of the main drainage infrastructure contributing discharges to the head of the stormwater channel was introduced into the model to provide a conservative assessment of the expected flood extents and evaluation of the culvert options.

Inflows to these pipes have been maximised in an effort to mimic the upstream drainage infrastructure (i.e. pipes running full) so that the discharges through the pipes is controlled by the capacity of the infrastructure, not the capacity of the inlet systems.

The existing bridge crossing of Mill Pond Road over the drainage channel was modelled as an irregular shaped culvert, consistent with the existing profile of the stormwater channel.

Due to access restrictions, the existing piped crossing under General Holmes Drive linking the existing water body within the Airport Land to the stormwater drainage channel through the site was unable to be verified for culvert size and invert levels. However, the pipe only provides a flow balancing function between the subject channel and the Airport's spill contaminant pond and will not influence modelling results.

The assumptions taken in setting up the model of the existing drainage infrastructure are conservative and are consistent in all scenarios assessed. This allows a direct comparison between each of the development scenarios and existing conditions. The location and configuration of the existing drainage network used in the modelling of the flood extents is shown on Figure 6.1.

6.2.2. Proposed Hydraulic Structures and Options Assessment

Two (2) options for a major culvert structure were assessed for the proposed Wentworth Avenue extension over the stormwater channel. The culvert options were nominated by Roads and Maritime Services and were selected on the basis that they have a total waterway area comparable to that of the existing Mill Pond Road culvert crossing downstream of the study area. These culvert options have been incorporated into the hydraulic model as one dimensional (1D) drainage networks, in accordance with the TUFLOW manual. Modelling the culverts in this way allows for the sensitivity analysis testing on the effect of blockages by increasing the percentage of blockage of the element. Two culvert span options were considered in the investigation to allow a detailed cost benefit analysis to be undertaken. The modelling considered adjustments to the Stormwater Channel profile immediately upstream and downstream of the proposed culvert by incorporating reshaping which simulates proposed aprons to allow smooth transition of flows in and out of the proposed culvert. Refer to Table 6.2 for a summary of the culvert option information.

Table 6.2 Culvert Options Assessed for the Proposed Wentworth Avenue Crossing

Modelling Option	Culvert Arrangement Assessed	Number of Cells
Culvert Option 1	4200 x 3000 RCBC	2
Culvert Option 2	3300 x 3000 RCBC	3

A sensitivity analysis has been undertaken on the major drainage infrastructure in the study area with both the existing bridge crossing and proposed culverts incorporate a 50% blockage factor. The location of the proposed culvert structure is indicated in Figure 4.2 and details of the results of the sensitivity blockage assessment are included in Figures 6.19 – 6.22.

6.3. Flood Mapping

A series of plans have been developed to illustrate the flood regime under various conditions and flood events. Details of the plans provided are detailed below.

6.3.1. Flood Modelling Scenarios

Flood modelling has been undertaken for the 10% and 1% AEP as well as the PMF events under the following site conditions.

1. Existing Site Conditions.

2. Developed Site Conditions - Culvert Option 1.
3. Developed Site Conditions - Culvert Option 2.

Flood mapping for the existing case scenario is shown on Figures 6.2 – 6.4 and represents the flood extent, depth and level of the three (3) AEP scenarios assessed.

Under post development conditions the following maps have been developed for the two culvert options for the various AEP events assessed:

4. Extent, Depth and Level Profile (10% AEP, 1% AEP and PMF) for Culvert Option 1 on Figures 6.5 – 6.7.
5. Extent, Depth and Level Profile (10% AEP, 1% AEP and PMF) for Culvert Option 2 on Figures 6.8 – 6.10.

6.3.2. Flood Difference Mapping

Flood difference maps have been prepared which indicate the difference in 10% and 1% AEP flood levels as a result of the proposed culvert option when compared to the existing case.

6. Flood Difference Mapping (10% AEP and 1% AEP) for Culvert Option 1 on Figures 6.11 and 6.12, respectively.
7. Flood Difference Mapping (10% AEP and 1% AEP) for Culvert Option 2 on Figures 6.13 and 6.14, respectively.

6.4. Discussion of Results

6.4.1. Flood Extents

The results of the flood modelling indicate that significant flows from upstream are restricted from entering the open channel system by the existing rail embankment. Piped discharges are limited to the capacity of the existing drainage infrastructure, with overflows breaching the railway embankment north of the study area into Joyce Drive in the 10% AEP event. A significant amount of flow (20%) is also directed south, along Botany Road towards Mill Pond Road. Some of these flows enter the site through the existing horse bridge under the railway line opposite the end of Wentworth Road, with the remainder of the overflows continuing along Botany Road, under the Railway overpass, to enter the southern portion of the site or continue on towards the Mill Pond Road intersection.

6.4.2. Flood Difference Mapping

The results of the flood modelling indicate that there is no noticeable increase in flooding levels within the adjacent Airport Land as a result of the proposed culvert crossing, regardless of which culvert option is adopted

Flood Modelling results also indicate negligible impact (less than 0.01 m) on the upstream catchment to the north and to the north-west of the site.

Construction of the Wentworth Avenue extension under the railway embankment has provided a relief point for overland flows to escape the flooded area along Botany Road to the east of the site, which dramatically reduces flood levels in this developed area by up to 0.21 m, thus reducing the flood risk to existing development in this area. As a result of this relief point in Botany Road, more flows are introduced to the channel, thereby causing increased flooding within the site and resulting in more flows within the channel when compared to existing conditions. The Wentworth Avenue underpass allows up to 3.2 m^3/s additional flow in the 10% AEP and approximately 7.5 m^3/s additional flow during the 1% AEP events.

Flood difference mapping for the various scenarios listed in Section 6.3.1 shows that there would be noticeable increase in flood levels within the channel as a result of the proposed culvert crossing, regardless of the culvert option adopted. The impact of increased flood levels is mainly restricted to the area within the site, generally upstream of the proposed culvert crossing, where flood levels are increased by up to 0.21 m for Culvert Option 1 and by up to 0.13 m for Culvert Option 2, upstream of the proposed culvert crossing. This increase is primarily due to the influx of additional flows being introduced to the area by the opening in the railway embankment due to the Wentworth Avenue underpass. The afflux affecting flood levels within the channel across the culvert crossing is up to 0.13 m for Culvert Option 1, and up to 0.10 m for Culvert Option 2.

The hydraulic grade within the Stormwater Channel in the vicinity of the proposed Wentworth Avenue crossing is very small (approximately 0.1% grade). Therefore any increases in flood levels are projected significantly upstream before returning to existing flood levels.

The flood difference mapping for both of the culvert crossing scenarios is shown on Figures 6.11 and 6.12 for culvert crossing Option 1, and Figures 6.13 and 6.14 for culvert crossing Option 2.

6.5. Comparison of Hydrologic & Hydraulic Model Peak Flows

The hydraulic modelling indicates that peak discharges are considerably less than the peak flows through the site when compared to the hydrologic model, despite using hydrographs from the same hydrologic model. For example, the peak existing case 1% AEP flow at the downstream boundary of the model, as extracted from the hydraulic model, is 38 m^3/s (compared to 131.6 m^3/s [28.9%] in the hydrologic model), while the peak flow north of the channel is 52.2 m^3/s (compared to 117.7 m^3/s [44.4%] in the hydrologic model). Whereas the discharges extracted at the upstream end of the hydraulic model to the north-east (weir flows over Botany Road and at Wentworth Avenue) is 74.5 m^3/s (compared to 81.4 m^3/s [91.5%] in the hydrologic model).

This indicates that there is significant flood storage within the existing residential development area to the north of the site which would appear to be attenuating flows. The presence of the railway embankment diverts the majority of the flows away from the existing channel which results in significant flooding in Baxter Street and Botany Road in the vicinity of the General Holmes Drive intersection. The overflows breaching the railway embankment to the north of the channel discharge into Joyce Drive, and are then directed into the adjacent Airport Land, without contributing into the stormwater channel.

6.6. Sensitivity Assessments

Sensitivity assessments were also undertaken to determine the impact of the modelling assumptions on the flooding results. The sensitivity of the hydraulic model was tested by altering two (2) input variables, to gain an understanding of the effect of varying these parameters on the flood levels.

A total of two (2) sensitivity scenarios were considered, with a summary of the scenarios listed below in Table 6.3. The sensitivity scenario based on catchment roughness focussed on the key land use within the study area: residential areas.

Table 6.3 Sensitivity Scenarios

Sensitivity Scenario	Parameter Tested	Percent Change in Parameter
1	Key Roughness - Residential Areas	25%
2	Blockage to Culvert Crossings	50%

6.6.1. Surface Roughness Sensitivity Assessment

The Manning's surface roughness coefficients (i.e. the impedance of the catchment surface to flows) of the residential areas in the model were increased by 25% over the adopted roughness values.

The increases in 1% AEP flood levels resulting from the increased surface roughness coefficient of the residential areas are insignificant, nominally up to 0.01 m, which is within the threshold of modelling accuracy. There is a localised increase of up to 0.02 m at the inflow of the model and within the airport land. However, the majority of increases are generally less than 0.01 m within the developed areas upstream of the site.

The results of the hydraulic assessment with increased surface roughness are indicated on the following plans:

1. Extent, Depth and Level Profile (1% AEP) with increased surface roughness for culvert Option 1 on Figure 6.15.
2. Flood Difference Mapping (1% AEP) comparing initial results to increased roughness for culvert Option 1 on Figure 6.16

6.6.2. Culvert Blockage Sensitivity Assessment

The culvert blockage sensitivity assessment was undertaken to assess the impact on 1% AEP flood levels should the proposed culvert and existing culvert downstream (under Mill Pond Road) become 50% blocked.

The increases in 1% AEP flood levels resulting from the culvert blockage show that the majority of increases in the surrounding areas are less than 0.01 m; with some localised increases of up to 0.02 m in parts of the Airport Land. However, flood levels increase more significantly in the channel immediately upstream of the proposed road crossing. Culvert Option 1 provides an increase of up to 0.34 m, and the assessment indicates that there is no impact on flood levels within surrounding developed areas, including General Holmes Drive and Botany Road. There is a slight decrease in flood levels within the channel between the culverts, most likely due to the reduction in flows owing to the blockage in the upstream culvert.

The results of the hydraulic assessment with 50% culvert blockage are indicated on the following plans:

3. Extent, Depth and Level Profile (1% AEP) with 50% blockage for culvert Option 1 on Figure 6.17.
4. Flood Difference Mapping (1% AEP) comparing initial results to 50% blockage for culvert Option 1 on Figure 6.18

6.7. Detailed Assessment of Drainage for Wentworth Avenue Underpass

A detailed assessment was undertaken to determine the drainage and pumping requirements to effectively drain upstream flows and the localised lowpoint in Wentworth Avenue at the proposed railway underpass during the peak 10% AEP storm event. The purpose of the investigation was to provide a drainage system that allows the proposed Wentworth Avenue underpass to remain serviceable during the 10% AEP storm events.

The following assumptions have also formed the bases of this assessment:

- A 5 metre long internal weir within the low point of the drainage networks which overflows in a 20 m² pump chamber.

These are the parameters necessary for the 2d modelling software. The hydraulically design of the pump chamber would need to be undertaken by RMS and/or a pump contractor at the detailed design phase of the proejct

Notwithstanding this further design, the investigation included the introduction of Council's existing drainage system throughout the modelled area, as well as the design of a new drainage system for the proposed Wentworth Avenue alignment, including a pump-out system for the Wentworth Avenue underpass.

Significant flows are diverted from the catchments to the north, along Botany Road and Botany Lane towards Wentworth Avenue and the proposed underpass site. The intention is to intercept as much of the overland flow from these areas as possible, and divert the intercepted flows (up to 4.5 m^3/s) through the proposed box culvert, under the existing horse bridge. Discharges are then conveyed directly into the stormwater channel, before they discharge into the underpass area. This is expected to minimise the amount of stormwater required to be pumped from the proposed underpass area.

A range of 10% AEP storm events were assessed to determine the peak discharges which is required to be managed by the proposed pump system.

The assessments indicated that the peak pump-out rate of 2.2 m^3/s is required to maintain the 10% AEP serviceability of the underpass. Note that a portion of the stormwater volume to the underpass can be conveyed by a conventional gravity stormwater drainage system, which has the capacity to drain up to 0.35 m^3/s from the underpass directly to the stormwater channel. The results of the assessments indicate that the maximum depth of ponding at the lowpoint within the underpass is 0.20 m during the peak 10% AEP storm event.

7. SUMMARY & CONCLUSION

The hydrology and hydraulic study for Westconnex Enabling Works Airport East Precinct site has been prepared to inform RMS of the impact of various culvert options for the proposed Wentworth Avenue crossing of the existing stormwater drainage channel in Mascot. The assessment considered the impact of both local and broader flood impacts.

Assessment of flooding under existing site conditions has determined that discharges into the site are influenced by the existing goods railway embankment, cutting off flows from the upstream catchment resulting in significant flooding of larger areas in Mascot. The railway embankment only allows piped flows to enter the site via discharges directly into the head of the channel, which is effectively limited to the existing piped infrastructure. Some overland flows enter the site either over the railway embankment to the north at General Holmes Drive level crossing, or further south through the existing horse bridge under the railway embankment at the end of Wentworth Avenue.

Two (2) culvert options were assessed for the Proposed Wentworth Avenue extension crossing over the stormwater channel, being 2 x 4.2m x 3.0m RCBC (Culvert Option 1), and 3 x 3.3m x 3.0m RCBC (Culvert Option 2). These investigations showed that Culvert Option 2 would result in less afflux upstream of the crossing when compared to Culvert Option 1.

The proposed works together with the nominated culvert options have been assessed to not provide any significant impact on flooding levels to surrounding properties.

The Wentworth Avenue extension also allows for overland flows to enter the drainage channel via the proposed railway underpass, thereby potentially reducing flooding levels on the eastern side of the railway embankment along Botany Road by up to 210mm in the 1% AEP event.

Sensitivity assessments were also undertaken to determine the impact of increased roughness, or culvert blockage would have on the performance of the proposed culvert systems. An increased roughness coefficient to the residential areas showed that there was only minor increases in flood levels. An introduced blockage of 50% to the design culvert and existing culvert under Mill Pond Road showed that the majority of the flood level increases occurred mainly within the stormwater channel, upstream of the proposed culvert location.

An additional assessment was undertaken to determine the pumping requirements to drain the localised lowpoint in Wentworth Avenue at the railway underpass. A series of 10% AEP storm events were assessed, where it was determined that the peak pumping delivery rate of 2.2 m^3/s is required to manage stormwater discharges to this area. This is with the inclusion of a drainage system intercepting overland flows to the Wentworth Avenue – Botany Road intersection and diverting them directly to the stormwater channel via the existing horse bridge. The drainage system has been introduced to minimise the pumping requirements at the proposed underpass.

The hydrology and hydraulic investigation completed by J Wyndham Prince informs Roads and Maritime Services current concept development phase for Westconnex Enabling Works Airport East Precinct site and will provide the basis for future detailed design phases.

8. REFERENCES

Botany Bay City Council (2013). Development Control Plan 2013

Botany Bay City Council (2013). Stormwater Management Technical Guidelines

Department of Environment and Climate Change (2008). Managing Urban Stormwater – Soils and Construction – Volume 2D: Main Road Construction

Engineers Australia (1999) Australian Rainfall and Runoff

Engineers Australia (2012) Australian Rainfall and Runoff – Project 15 Two Dimensional Modelling in Urban and Rural Floodplains

Landcom (2004). Managing Urban Stormwater – Soils and Construction – 4th Edition

New South Wales Government (1990). Coastal Management Manual

Roads and Maritime Services (2013). Draft Proposed Option Report for the WestConnex Enabling Works

APPENDIX A – SCHEMATIC LAYOUT PLANS OF PREFERRED OPTION 4 FOR WESTCONNEX ENABLING WORKS AIRPORT EAST PRECINCT


LIMIT OF WORKS
ROAD CLOSED
ROAD CLOSED
LIMIT OF WORKS
LIMIT OF WORKS
LIMIT OF WORKS
LIMIT OF WORKS

APPENDIX B – HYDROLOGIC MODELLING CHECK CALCULATION RESULTS

J. Wyndham Prince Pty. Ltd.

PRM - PROBABILISTIC RATIONAL METHOD - SMALL RURAL CATCHMENTS

LOCATION			**MASCOT**		
COEFFICIENTS LOCATION		**=**	SYDNEY AIRPORT		
TOTAL SITE AREA	(Ar)	=	322.00	ha.	
Time of Conc.	(tcr)	=	71.11	min.	
West of Line		=	0		(1=yes, 0=no)
Runoff Coefficient	(C10)	=	0.86		(Volume 2 ARR - 1987)
Elevation	(El)	=	2.00	m	

ARI (yr)	C	I (mm/hr)	Q (cu.m/s)
1	0.533	27.5	13.132
2	0.636	35.8	20.401
5	0.757	47.5	32.130
10	0.860	54.4	41.850
20	0.963	63.4	54.620
50	1.121	75.3	75.524
100	1.262	84.5	95.349

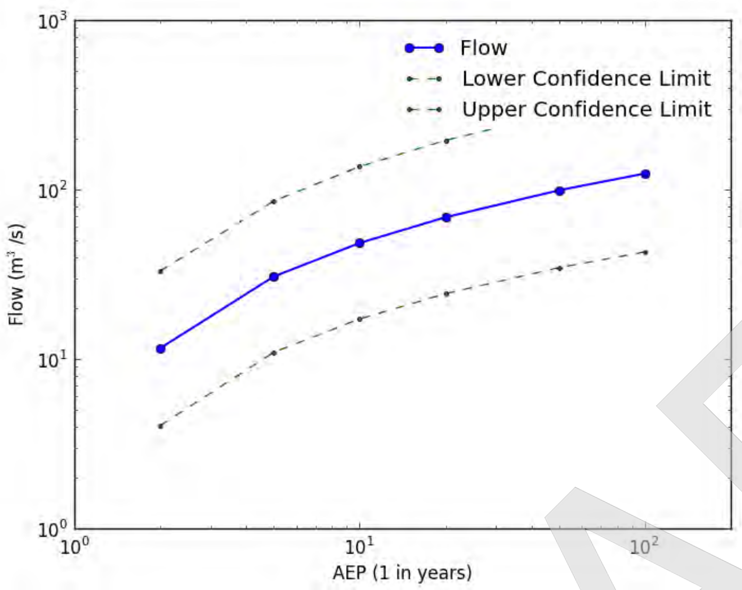
J. Wyndham Prince Pty. Ltd.

PRM - PROBABILISTIC RATIONAL METHOD - SMALL RURAL CATCHMENTS

LOCATION			**MASCOT**	
COEFFICIENTS LOCATION		**=**	SYDNEY AIRPORT	
TOTAL SITE AREA	(Ar)	=	378.00 ha.	
Time of Conc.	(tcr)	=	75.58 min.	
West of Line		=	0	(1=yes, 0=no)
Runoff Coefficient	(C10)	=	0.86	(Volume 2 ARR - 1987)
Elevation	(El)	=	2.00 m	

ARI (yr)	C	I (mm/hr)	Q (cu.m/s)
1	0.533	26.5	14.851
2	0.636	34.5	23.073
5	0.757	45.7	36.342
10	0.860	52.4	47.339
20	0.963	61.1	61.785
50	1.121	72.6	85.435
100	1.262	81.4	107.865

RESULTS - AUSTRALIAN REGIONAL FLOOD FREQUENCY MODEL



AEP (1 in years)	Flow (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
2	11.6	4.0	33.1
5	30.7	11.0	85.5
10	48.4	17.2	136.7
20	68.6	24.3	195.1
50	99.0	34.6	284.0
100	124.4	42.8	359.2

Input Data	
Date and Time	Mar 05, 2014, 10:51:54
Catchment Name	1.09
Latitude	-33.95
Longitude	151.2
Catchment Area (sq km)	3.2
Distance to Nearest Gauged Catchment (km)	26.3
2y12h Rainfall Intensity (mm/h)	8.1
Rainfall Intensity Source (User/Auto)	User
Region	VIC + NSW + ACT + QLD
Region Version	0.1
Region Source (User/Auto)	Auto

CAUTION: THIS METHOD IS STILL UNDER DEVELOPMENT AND MUST NOT BE USED IN PRACTICE.

Method by Dr Ataur Rahman and Khaled Haddad from the University of Western Sydney for the Australian Rainfall and Runoff Project. Full project description of the project can be found here.

This method was made possible by financial support from DCCEE.

This document generated with software written by Peter Stensmyr at WMAwater 2012.

University of Western Sydney

ENGINEERS AUSTRALIA

RESULTS FROM AUSTRALIAN REGIONAL FLOOD FREQUENCY MODEL ANALYSIS: ARR2012 METHOD - VERSION 0.1 ALPHA

Date: Mar 05, 2014, 10:51:54

Catchment name: 1.09

Latitude: -33.950

Longitude: 151.200

Catchment area (sq km): 3.220

Distance to nearest gauged catchment (km): 26.281

2 year 12 hour design rainfall intensity (mm/h): 8.100

Rainfall intensity source (User/Auto): User

Region: 1 (VIC + NSW + ACT + QLD)

Region version: 0.1

Region source (User/Auto): Auto

ESTIMATED FLOOD QUANTILES:

AEP (1 in y) Expected quantiles (m^3/s) 5% CL (m3^s) 95% CL (m3^s)

2 11.58 4.05 33.12

5 30.66 10.96 85.46

10 48.37 17.24 136.66

20 68.62 24.28 195.11

50 98.99 34.60 283.96

100 124.37 42.83 359.19

DATA FOR FITTING MULTI-NORMAL DISTRIBUTION FOR BUILDING CONFIDENCE LIMITS:

Mean (loge flow): 2.349

St dev (loge flow): 1.255

Skew (loge flow): -0.482

MOMENTS AND CORRELATIONS:

No Most probable Std dev Correlation

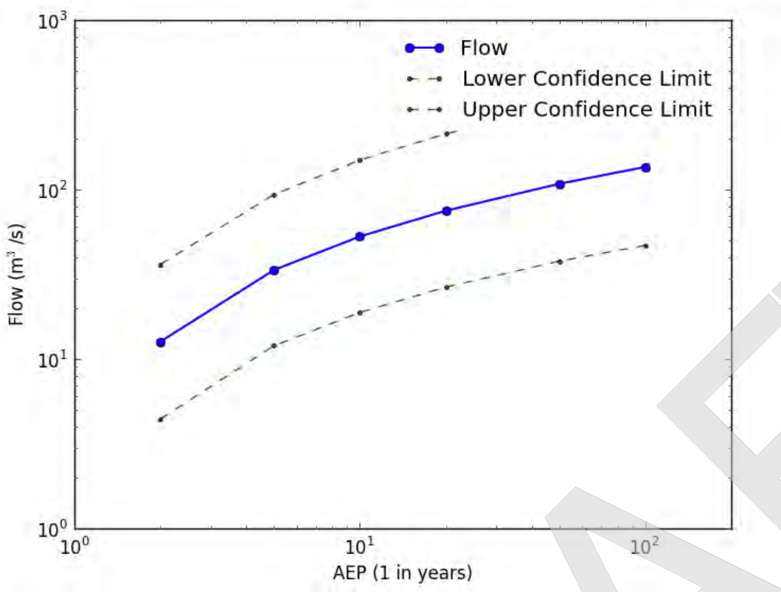
1 2.349 0.637 1.000

1 1.255 0.180 -0.210 1.000

1 -0.482 0.126 -0.040 -0.410 1.000

CAUTION: These results are for test purpose only and must not be used in design/practice!

RESULTS - AUSTRALIAN REGIONAL FLOOD FREQUENCY MODEL



AEP (1 in years)	Flow (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
2	12.7	4.4	36.2
5	33.5	12.0	93.4
10	52.9	18.8	149.3
20	75.0	26.5	213.2
50	108.2	37.8	310.3
100	135.9	46.8	392.5

Input Data	
Date and Time	Mar 05, 2014, 10:52:03
Catchment Name	1.11
Latitude	-33.95
Longitude	151.2
Catchment Area (sq km)	3.8
Distance to Nearest Gauged Catchment (km)	26.3
2y12h Rainfall Intensity (mm/h)	8.1
Rainfall Intensity Source (User/Auto)	User
Region	VIC + NSW + ACT + QLD
Region Version	0.1
Region Source (User/Auto)	Auto

CAUTION: THIS METHOD IS STILL UNDER DEVELOPMENT AND MUST NOT BE USED IN PRACTICE.

Method by Dr Ataur Rahman and Khaled Haddad from the University of Western Sydney for the Australian Rainfall and Runoff Project. Full project description of the project can be found here.

This method was made possible by financial support from DCCEE.

This document generated with software written by Peter Stensmyr at WMAwater 2012.

University of Western Sydney

ENGINEERS AUSTRALIA

RESULTS FROM AUSTRALIAN REGIONAL FLOOD FREQUENCY MODEL ANALYSIS: ARR2012 METHOD - VERSION 0.1 ALPHA

Date: Mar 05, 2014, 10:52:03

Catchment name: 1.11

Latitude: -33.950

Longitude: 151.200

Catchment area (sq km): 3.750

Distance to nearest gauged catchment (km): 26.281

2 year 12 hour design rainfall intensity (mm/h): 8.100

Rainfall intensity source (User/Auto): User

Region: 1 (VIC + NSW + ACT + QLD)

Region version: 0.1

Region source (User/Auto): Auto

ESTIMATED FLOOD QUANTILES:

AEP (1 in y) Expected quantiles (m^3/s) 5% CL (m3^s) 95% CL (m3^s)

2 12.66 4.42 36.19

5 33.50 11.98 93.39

10 52.86 18.83 149.33

20 74.98 26.54 213.21

50 108.17 37.81 310.29

100 135.91 46.80 392.50

DATA FOR FITTING MULTI-NORMAL DISTRIBUTION FOR BUILDING CONFIDENCE LIMITS:

Mean (loge flow): 2.438

St dev (loge flow): 1.255

Skew (loge flow): -0.482

MOMENTS AND CORRELATIONS:

No Most probable Std dev Correlation

1 2.438 0.637 1.000

1 1.255 0.180 -0.210 1.000

1 -0.482 0.126 -0.040 -0.410 1.000

CAUTION: These results are for test purpose only and must not be used in design/practice!

APPENDIX C – HYDROLOGIC MODELLING RESULTS FOR 10%, 1% AND PMP STORM EVENTS

10% AEP Peak Discharges - Existing Site Conditions (m^3/s)								
Node	Storm Duration (minutes)							
	25	60	90	120	180	360	720	1440
7.01	5.88	5.47	5.75	5.41	2.95	1.91	1.65	1.08
6.01	6.25	5.82	6.14	5.80	3.15	2.03	1.75	1.14
5.01	5.11	4.77	5.03	4.73	2.58	1.66	1.43	0.93
5.02	11.12	10.25	10.80	10.10	5.63	3.64	3.13	2.05
5.03	20.17	17.74	17.86	19.08	12.15	8.13	7.05	4.67
5.04	22.05	20.09	19.62	21.43	14.68	10.12	8.88	5.96
2.01	4.29	4.02	4.26	3.98	2.24	1.51	1.30	0.86
2.02	8.89	8.21	8.68	8.08	4.58	3.11	2.70	1.80
3.01	5.08	4.78	5.05	4.83	2.59	1.63	1.40	0.91
1.01	4.82	4.48	4.71	4.43	2.42	1.57	1.35	0.89
1.02	19.85	19.23	19.28	20.31	12.18	8.06	6.98	4.61
1.03	20.92	21.22	20.73	21.89	14.34	9.66	8.38	5.56
4.01	5.12	4.77	5.03	4.74	2.58	1.67	1.43	0.94
1.04	23.05	26.13	23.83	24.66	18.01	12.94	11.25	7.50
1.05	42.54	47.78	43.56	45.49	32.52	24.27	21.27	14.29
1.06	44.98	51.98	50.93	50.91	36.93	27.50	24.11	16.20
1.07	46.00	54.12	52.74	52.64	38.84	29.42	25.87	17.41
8.01	4.10	3.78	3.99	3.73	2.10	1.43	1.29	0.88
11.00	7.09	6.56	6.90	6.52	3.53	2.30	1.98	1.30
12.00	5.79	5.39	5.67	5.34	2.91	1.89	1.62	1.07
11.01	17.64	15.54	15.40	17.06	10.38	6.77	5.84	3.84
11.02	22.15	18.80	18.70	20.41	13.54	8.87	7.66	5.06
11.03	24.49	22.92	21.14	22.75	16.74	11.12	9.65	6.40
8.02	28.10	28.93	25.63	25.55	20.13	13.98	12.23	8.18
8.03	24.78	26.36	25.75	23.35	17.03	10.18	8.13	3.44
1.08	25.65	27.80	27.34	25.31	18.07	11.18	9.04	4.07
1.09	70.70	76.19	74.27	73.96	57.00	40.69	34.92	21.52
10.01	4.46	4.02	4.22	3.87	2.22	1.44	1.26	0.83
9.01	1.40	1.34	1.45	1.33	0.84	0.82	0.84	0.65
9.02	8.46	7.85	8.33	7.74	4.47	3.19	2.99	2.08
9.03	13.94	12.88	13.60	12.57	7.28	5.01	4.56	3.12
1.10	75.05	84.47	80.46	78.89	61.93	46.64	40.05	25.71
13.01	0.63	0.62	0.68	0.60	0.43	0.36	0.33	0.23
1.11	75.27	84.93	80.89	79.30	62.29	47.02	40.32	25.96

1% AEP Peak Discharges - Existing Site Conditions (m^3/s)								
Node	Storm Duration (minutes)							
	25	60	90	120	180	360	720	1440
7.01	7.99	7.90	8.22	7.77	4.25	2.72	2.32	1.52
6.01	8.50	8.42	8.80	8.27	4.55	2.89	2.46	1.61
5.01	6.96	6.89	7.18	6.81	3.72	2.36	2.01	1.31
5.02	15.16	14.97	15.63	14.53	8.13	5.16	4.40	2.88
5.03	28.13	26.19	26.12	27.93	17.70	11.65	9.96	6.60
5.04	31.30	30.05	29.14	31.82	21.56	14.66	12.63	8.46
2.01	5.86	5.89	6.21	5.78	3.32	2.16	1.84	1.22
2.02	12.16	12.07	12.65	11.80	6.73	4.47	3.83	2.54
3.01	6.98	6.99	7.27	6.82	3.70	2.31	1.97	1.28
1.01	6.56	6.49	6.77	6.37	3.48	2.23	1.90	1.25
1.02	27.63	28.35	28.16	29.68	17.65	11.52	9.84	6.50
1.03	29.87	31.54	30.48	32.16	20.87	13.79	11.82	7.84
4.01	6.98	6.91	7.20	6.84	3.72	2.37	2.02	1.32
1.04	34.01	38.86	35.30	36.36	26.30	18.51	15.88	10.58
1.05	63.53	71.47	65.01	66.93	47.71	35.01	30.15	20.23
1.06	68.01	77.98	75.68	74.91	54.09	39.65	34.17	22.94
1.07	69.70	81.40	78.51	77.52	56.75	42.47	36.64	24.65
8.01	5.61	5.56	5.82	5.40	3.05	2.11	1.85	1.25
11.00	9.63	9.48	9.87	9.32	5.08	3.27	2.79	1.83
12.00	7.88	7.79	8.11	7.67	4.19	2.68	2.29	1.50
11.01	24.32	22.78	22.36	24.67	14.94	9.63	8.22	5.41
11.02	30.87	27.61	27.42	29.75	19.51	12.63	10.79	7.12
11.03	34.63	34.12	31.15	33.33	24.28	15.91	13.63	9.04
8.02	41.24	43.07	38.10	37.67	29.32	20.14	17.32	11.56
8.03	39.08	41.94	40.73	37.35	27.58	17.30	14.02	7.35
1.08	40.67	44.36	43.11	40.38	29.05	18.75	15.30	8.24
1.09	105.80	117.70	113.38	112.13	85.94	61.32	51.96	32.95
10.01	6.08	5.95	6.18	5.72	3.20	2.07	1.78	1.18
9.01	1.97	2.07	2.25	2.00	1.37	1.34	1.28	0.98
9.02	11.62	11.59	12.20	11.26	6.70	4.81	4.33	3.01
9.03	19.10	18.88	19.82	18.22	10.72	7.39	6.54	4.46
1.10	114.69	130.72	123.43	120.17	93.64	70.29	59.43	38.95
13.01	0.90	0.97	1.07	0.93	0.69	0.55	0.47	0.33
1.11	115.08	131.56	124.18	120.85	94.24	70.86	59.82	39.31

PMP Peak Discharges - Existing Site Conditions (m³/s)								
Node	Storm Duration (minutes)							
	15	30	45	60	90	120	150	180
7.01	61.83	52.72	47.61	44.96	37.34	32.09	27.85	25.26
6.01	67.12	57.31	52.25	47.92	39.79	34.40	29.88	26.89
5.01	54.98	47.84	43.23	39.35	32.50	28.00	24.36	22.01
5.02	89.08	85.02	81.63	76.80	67.90	60.57	52.69	47.93
5.03	127.50	135.74	142.37	141.59	133.66	122.26	110.97	104.86
5.04	134.60	150.46	158.88	160.81	158.36	148.87	134.68	126.46
2.01	46.55	40.12	36.39	33.85	28.10	24.49	21.45	19.69
2.02	71.21	71.14	67.86	63.60	56.30	50.20	44.15	40.49
3.01	55.08	50.01	46.10	40.10	32.56	28.08	24.44	21.98
1.01	50.87	43.23	38.49	37.04	30.41	26.18	22.85	20.69
1.02	149.00	150.11	151.79	149.31	139.44	125.13	112.74	105.74
1.03	150.63	155.77	160.57	159.51	152.34	141.01	130.70	121.99
4.01	54.78	47.34	42.62	39.50	32.59	28.06	24.41	22.05
1.04	153.67	164.86	176.12	177.19	177.97	168.25	163.18	152.43
1.05	244.41	285.71	313.67	320.98	309.59	295.17	279.16	264.00
1.06	254.13	303.91	342.49	355.75	346.67	332.03	308.48	290.61
1.07	255.63	309.71	351.58	367.90	359.77	351.05	326.17	306.55
8.01	41.03	34.61	33.01	30.89	26.59	23.31	20.84	19.19
11.00	73.22	61.13	56.64	53.48	44.30	38.31	33.49	30.36
12.00	61.07	52.16	47.10	44.40	36.85	31.66	27.50	24.92
11.01	134.85	133.10	140.20	133.42	116.38	105.55	97.08	89.23
11.02	140.47	144.52	154.74	156.33	140.98	130.74	119.40	111.97
11.03	143.84	154.92	169.47	171.59	166.73	157.43	144.53	134.57
8.02	147.89	172.49	188.22	192.54	193.75	189.98	176.12	164.47
8.03	154.92	186.83	205.43	203.56	204.81	204.95	192.14	179.79
1.08	158.97	194.98	215.06	215.03	215.35	214.24	201.43	190.04
1.09	376.68	463.96	536.41	559.52	562.97	565.90	521.96	493.47
10.01	42.79	37.21	34.83	32.05	27.92	24.26	21.24	19.28
9.01	14.16	12.40	12.21	11.90	10.85	11.22	11.09	10.95
9.02	81.08	68.91	65.74	62.48	55.04	50.67	45.40	42.69
9.03	121.35	115.30	107.65	99.55	88.02	80.12	71.55	66.29
1.10	384.41	488.57	564.02	595.59	604.49	610.29	584.01	554.58
13.01	6.57	6.14	5.86	5.71	5.35	5.16	4.70	4.51
1.11	385.45	490.86	566.47	598.35	607.64	613.58	587.46	558.88

APPENDIX D – HYDRAULIC MODELLING CHECK CALCULATION RESULTS

Hydraulic Analysis Report

Project Data

Project Title: 9833 - Westconnex

Designer: JWP

Project Date: Thursday, February 27, 2014

Project Units: SI Units (Metric)

Notes: Manning's check on flows through the existing open stormwater channel through the Westconnex Enabling Works site.

Adoption of cross section measured at Mill Pond Road crossing with assumed invert of RL 2.0

Adopted hydraulic gradient of 0.14% as typical for all Creek Sections
 along reach

CHANNELCALC
CHANNELNAME "Channel Analysis - Stormwater Channel

Channel Analysis: Channel Analysis - Stormwater Channel

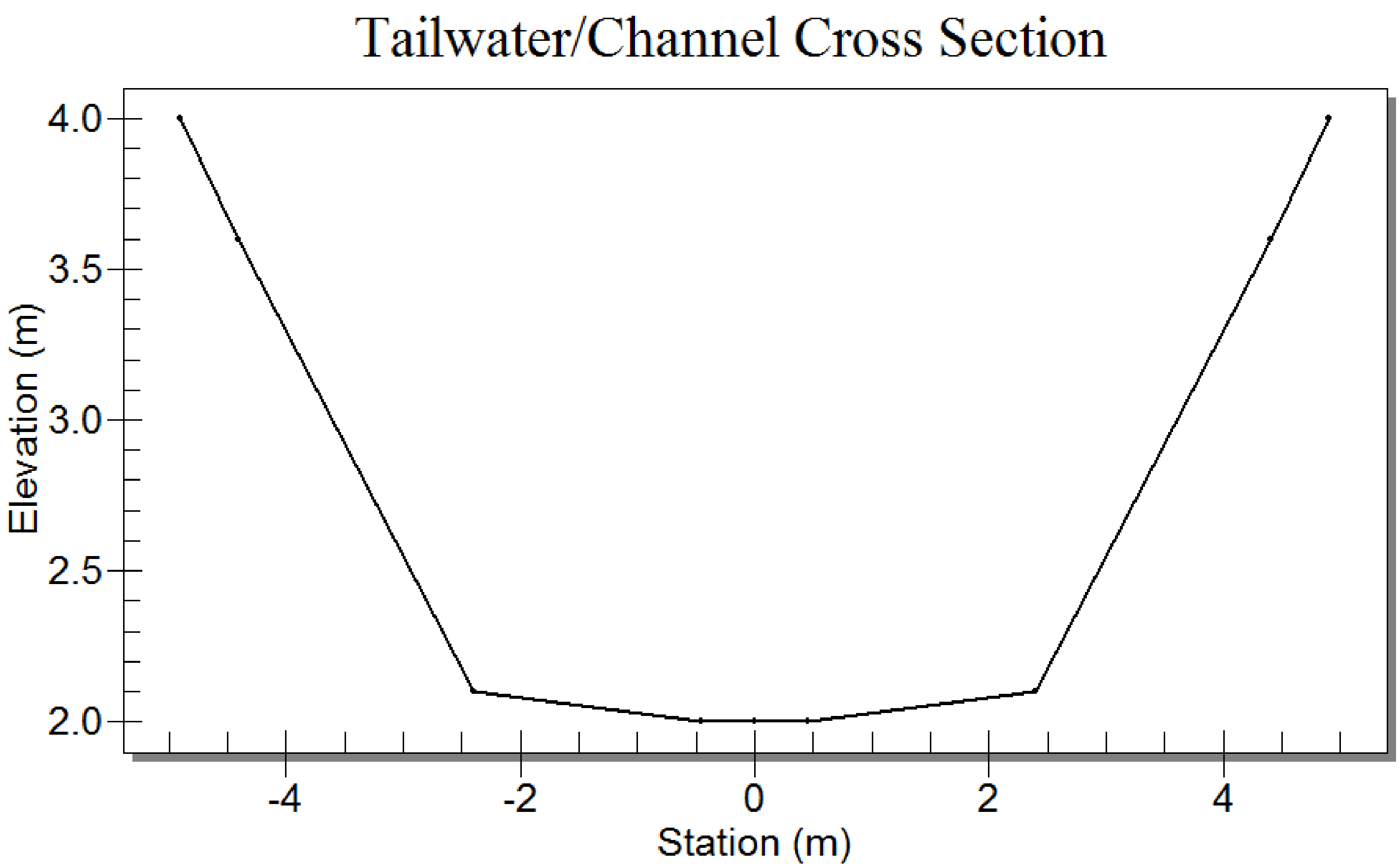
Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Station (m)	Elevation (m)	Manning's n
-4.90	4.00	0.0350
-4.40	3.60	0.0150
-2.40	2.10	0.0150
-0.45	2.00	0.0150
0.00	2.00	0.0150
0.45	2.00	0.0150
2.40	2.10	0.0150
4.40	3.60	0.0350
4.90	4.00	-----



Longitudinal Slope: 0.0014 (m/m)

Flow: 20.0000 (cms)

Result Parameters

Depth: 1.3526 (m)

Area of Flow: 8.3896 (m^2)

Wetted Perimeter: 8.9805 (m)

Average Velocity: 2.3839 (m/s)

Top Width: 8.1403 (m)

Froude Number: 0.7496

Critical Depth: 1.1453 (m)

Critical Velocity: 2.9587 (m/s)

Critical Slope: 0.0026 (m/m)

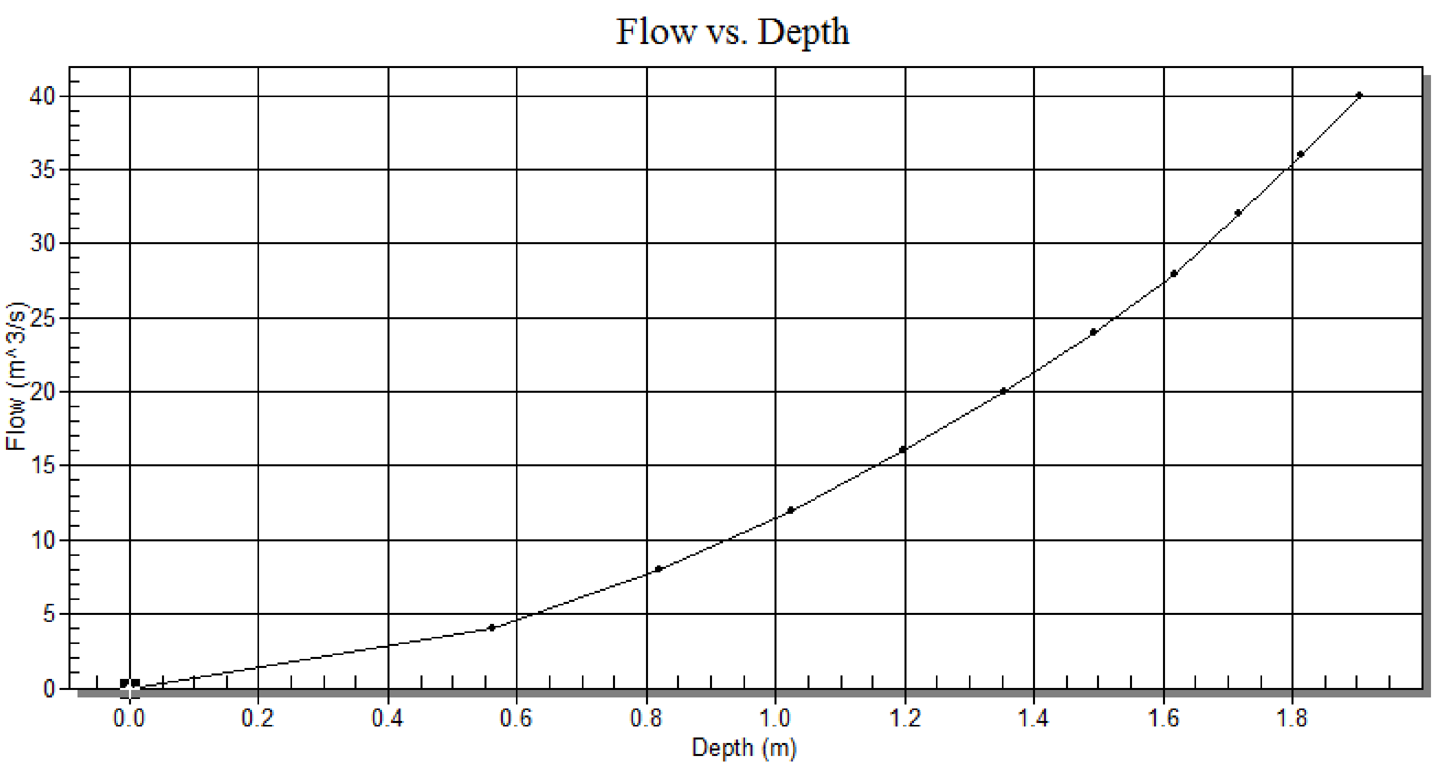
Critical Top Width: 7.5876 (m)

Calculated Max Shear Stress: 18.5620 (N/m^2)

Calculated Avg Shear Stress: 12.8201 (N/m^2)

Composite Manning's n Equation: Lotter method

Manning's n: 0.0150

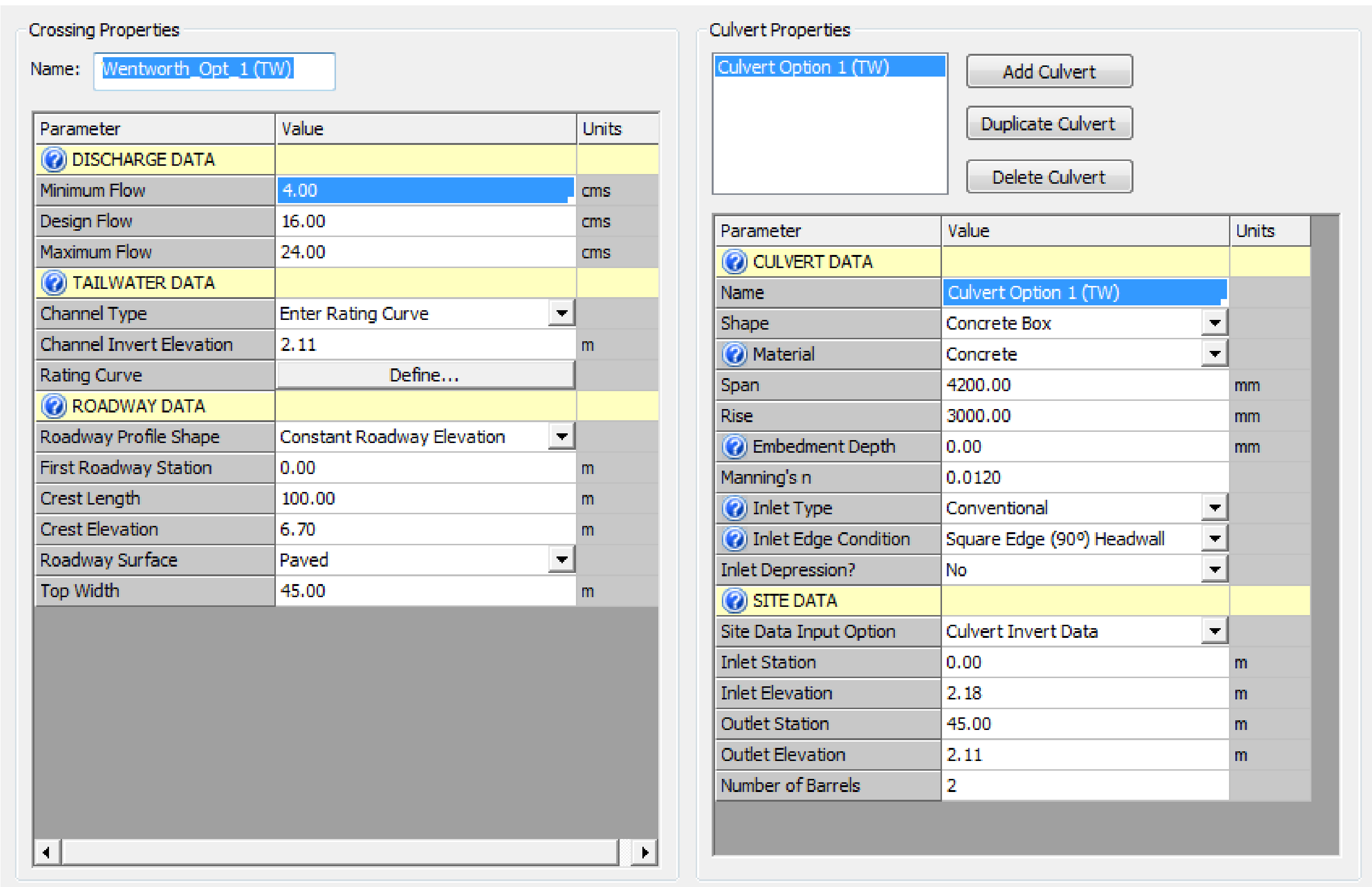


HY-8 Analysis Results

Crossing Summary Table

Culvert Crossing: Wentworth_Opt_1 (TW)

Headwater Elevation (m)	Total Discharge (cms)	Culvert Option 1 (TW) Discharge (cms)	Roadway Discharge (cms)	Iterations
3.03	4.00	4.00	0.00	1
3.19	6.00	6.00	0.00	1
3.37	8.00	8.00	0.00	1
3.54	10.00	10.00	0.00	1
3.71	12.00	12.00	0.00	1
3.87	14.00	14.00	0.00	1
4.01	16.00	16.00	0.00	1
4.13	18.00	18.00	0.00	1
4.24	20.00	20.00	0.00	1
4.34	22.00	22.00	0.00	1
4.44	24.00	24.00	0.00	1
6.70	64.91	64.91	0.00	Overtopping

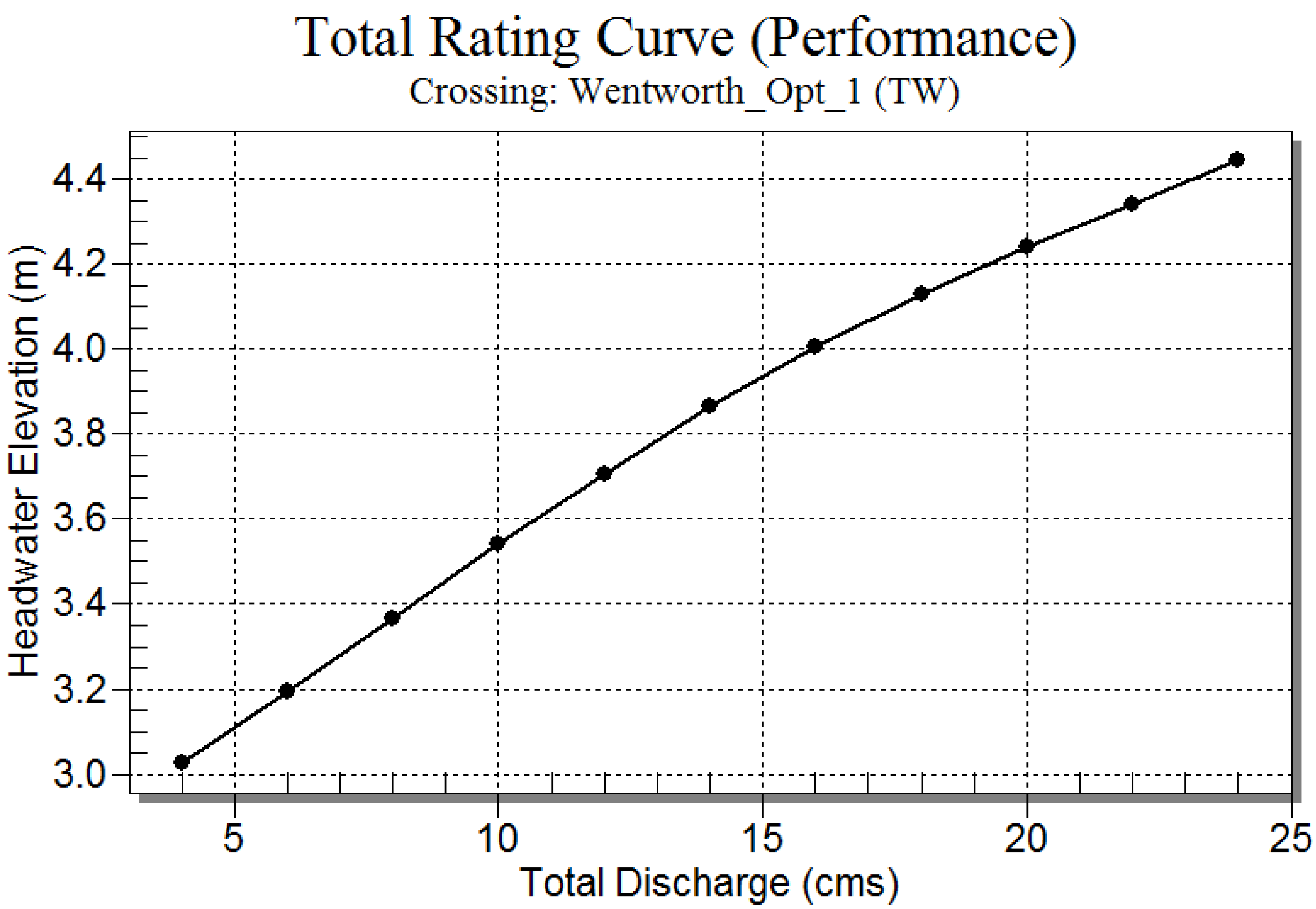


HY-8 Analysis Results

Culvert Summary Table - Culvert Option 1 (TW)

Culvert Crossing: Wentworth_Opt_1 (TW)

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth(m)	Outlet Control Depth(m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
4.00	4.00	3.03	0.49	0.85	3-M1t	0.33	0.29	0.89	0.89	0.54	0.00
6.00	6.00	3.19	0.65	1.01	3-M1t	0.42	0.37	1.04	1.04	0.69	0.00
8.00	8.00	3.37	0.78	1.19	3-M1t	0.51	0.45	1.20	1.20	0.79	0.00
10.00	10.00	3.54	0.90	1.36	3-M1t	0.60	0.53	1.36	1.36	0.88	0.00
12.00	12.00	3.71	1.02	1.53	3-M1t	0.67	0.59	1.52	1.52	0.94	0.00
14.00	14.00	3.87	1.13	1.69	3-M1t	0.74	0.66	1.67	1.67	1.00	0.00
16.00	16.00	4.01	1.23	1.83	3-M1t	0.82	0.72	1.80	1.80	1.06	0.00
18.00	18.00	4.13	1.34	1.95	3-M1t	0.89	0.78	1.91	1.91	1.12	0.00
20.00	20.00	4.24	1.43	2.06	3-M1t	0.95	0.83	2.01	2.01	1.18	0.00
22.00	22.00	4.34	1.52	2.16	3-M1t	1.02	0.89	2.10	2.10	1.25	0.00
24.00	24.00	4.44	1.61	2.26	3-M1t	1.08	0.94	2.19	2.19	1.30	0.00

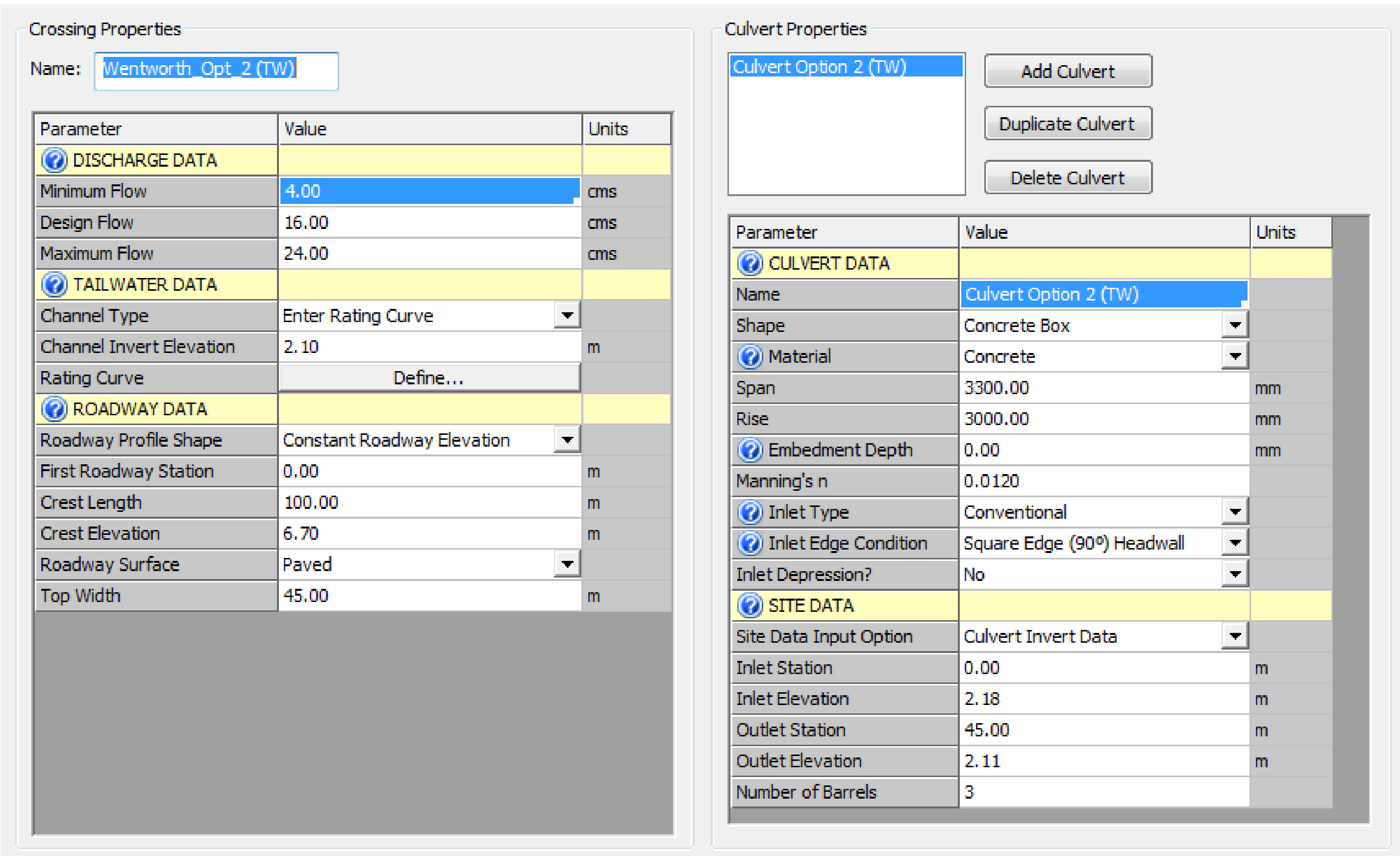


HY-8 Analysis Results

Crossing Summary Table

Culvert Crossing: Wentworth_Opt_2 (TW)

Headwater Elevation (m)	Total Discharge (cms)	Culvert Option 2 (TW) Discharge (cms)	Roadway Discharge (cms)	Iterations
3.02	4.00	4.00	0.00	1
3.18	6.00	6.00	0.00	1
3.35	8.00	8.00	0.00	1
3.52	10.00	10.00	0.00	1
3.69	12.00	12.00	0.00	1
3.84	14.00	14.00	0.00	1
3.98	16.00	16.00	0.00	1
4.10	18.00	18.00	0.00	1
4.21	20.00	20.00	0.00	1
4.31	22.00	22.00	0.00	1
4.41	24.00	24.00	0.00	1
6.70	67.51	67.51	0.00	Overtopping


Crossing Properties

Name: Wentworth_Opt_2 (TW)

Parameter	Value	Units
DISCHARGE DATA		
Minimum Flow	4.00	cms
Design Flow	16.00	cms
Maximum Flow	24.00	cms
TAILWATER DATA		
Channel Type	Enter Rating Curve	
Channel Invert Elevation	2.10	m
Rating Curve	Define...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.00	m
Crest Length	100.00	m
Crest Elevation	6.70	m
Roadway Surface	Paved	
Top Width	45.00	m

Culvert Properties

Culvert Option 2 (TW)

Add Culvert

Duplicate Culvert

Delete Culvert

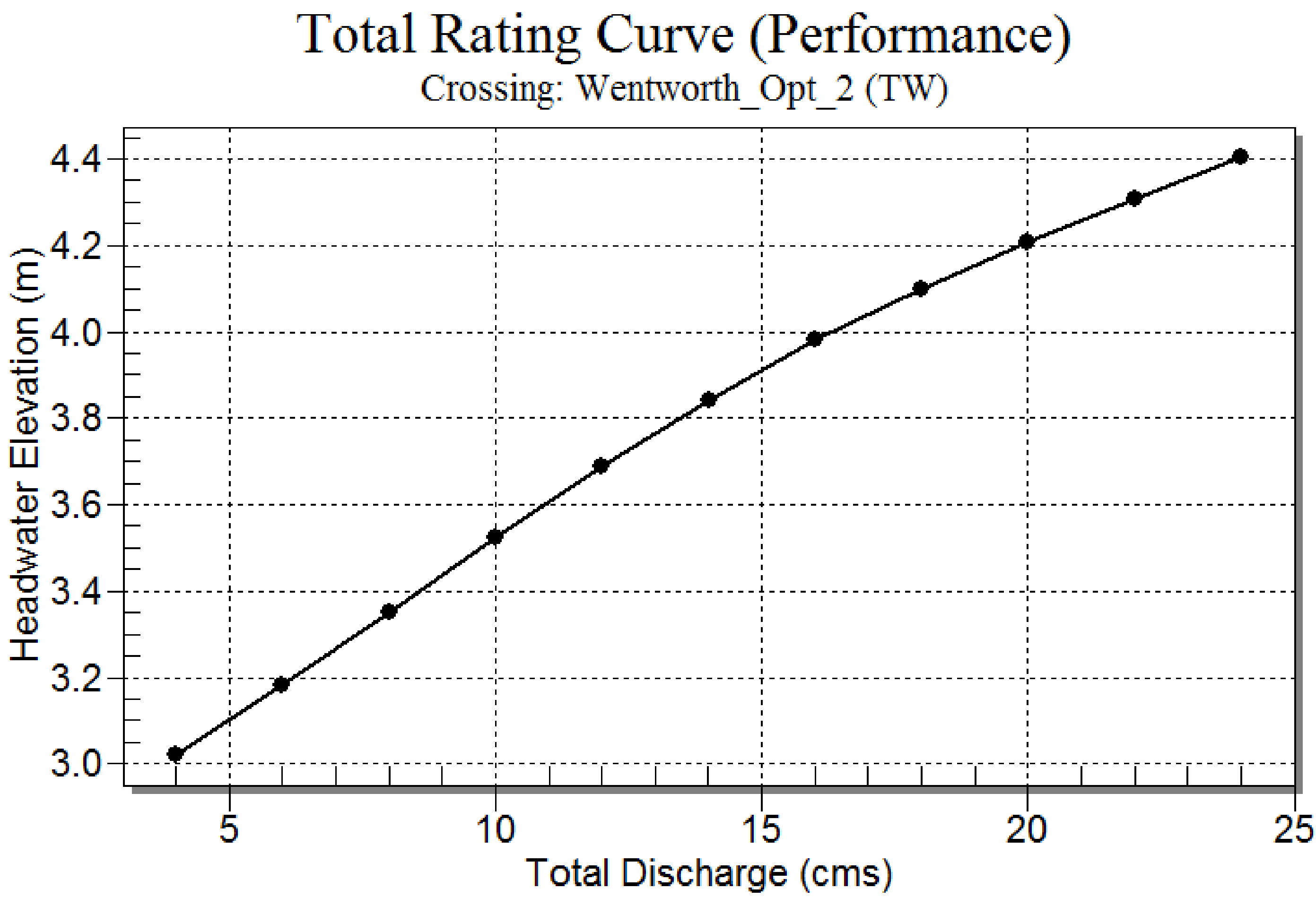
Parameter	Value	Units
CULVERT DATA		
Name	Culvert Option 2 (TW)	
Shape	Concrete Box	
Material	Concrete	
Span	3300.00	mm
Rise	3000.00	mm
Embedment Depth	0.00	mm
Manning's n	0.0120	
Inlet Type	Conventional	
Inlet Edge Condition	Square Edge (90º) Headwall	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.00	m
Inlet Elevation	2.18	m
Outlet Station	45.00	m
Outlet Elevation	2.11	m
Number of Barrels	3	

HY-8 Analysis Results

Culvert Summary Table - Culvert Option 2 (TW)

Culvert Crossing: Wentworth_Opt_2 (TW)

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth(m)	Outlet Control Depth(m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
4.00	4.00	3.02	0.45	0.84	3-M1t	0.30	0.26	0.89	0.90	0.45	0.00
6.00	6.00	3.18	0.58	1.00	3-M1t	0.38	0.34	1.04	1.05	0.58	0.00
8.00	8.00	3.35	0.70	1.17	3-M1t	0.47	0.41	1.20	1.21	0.67	0.00
10.00	10.00	3.52	0.81	1.34	3-M1t	0.55	0.47	1.36	1.37	0.74	0.00
12.00	12.00	3.69	0.92	1.51	3-M1t	0.62	0.53	1.52	1.53	0.80	0.00
14.00	14.00	3.84	1.01	1.66	3-M1t	0.69	0.59	1.67	1.68	0.85	0.00
16.00	16.00	3.98	1.11	1.80	3-M1t	0.75	0.64	1.80	1.81	0.90	0.00
18.00	18.00	4.10	1.20	1.92	3-M1t	0.82	0.70	1.91	1.92	0.95	0.00
20.00	20.00	4.21	1.28	2.03	3-M1t	0.88	0.75	2.01	2.02	1.01	0.00
22.00	22.00	4.31	1.37	2.13	3-M1t	0.95	0.80	2.10	2.11	1.06	0.00
24.00	24.00	4.41	1.45	2.23	3-M1t	1.00	0.84	2.19	2.20	1.11	0.00

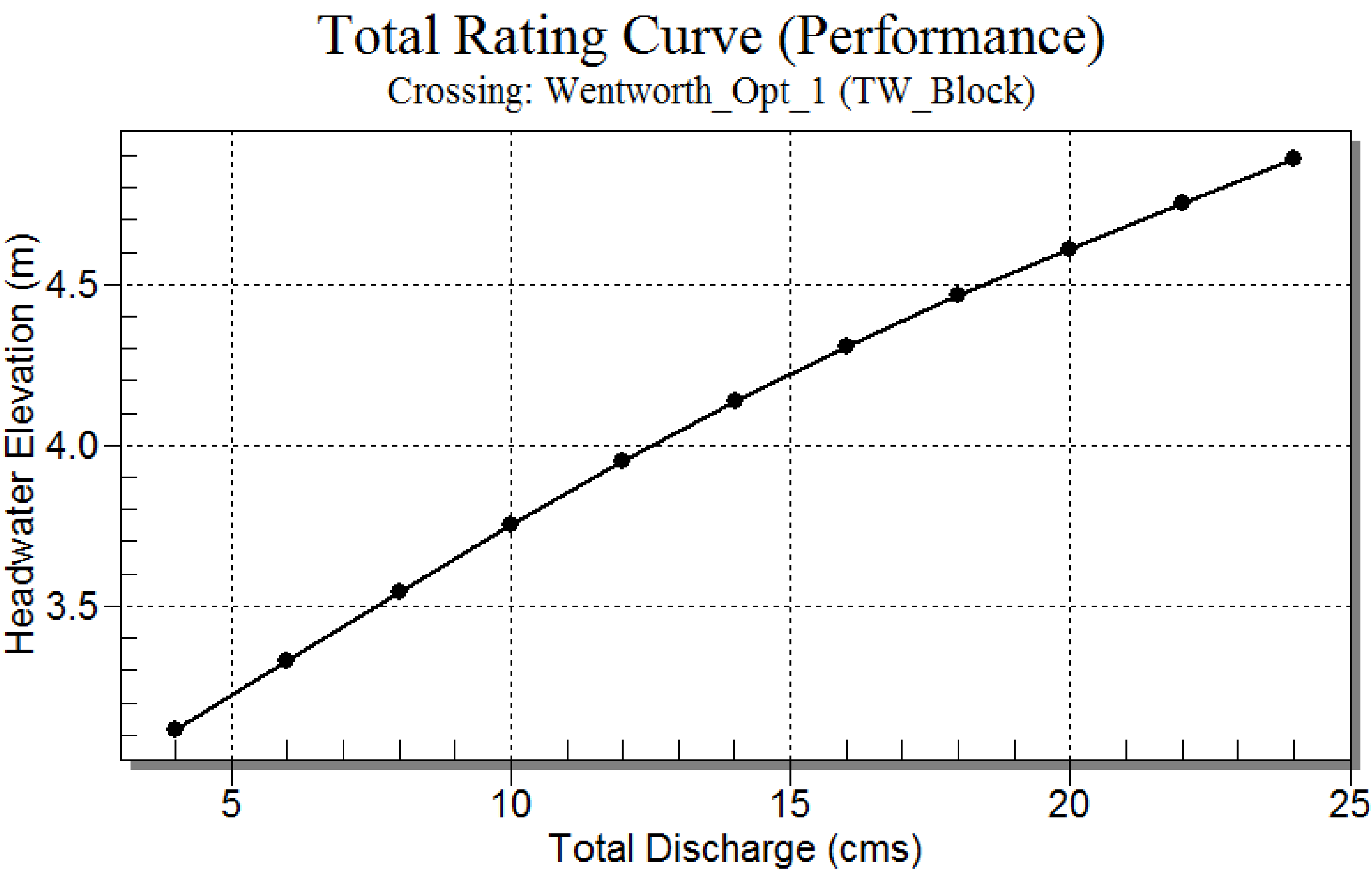


HY-8 Analysis Results

Culvert Summary Table - Culvert Option 1 (TW_Block)

Culvert Crossing: Wentworth_Opt_1 (TW_Block)

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth(m)	Outlet Control Depth(m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
4.00	4.00	3.11	0.78	0.93	3-M1t	0.56	0.45	0.89	0.89	1.07	0.00
6.00	6.00	3.33	1.02	1.15	3-M1t	0.75	0.59	1.04	1.04	1.37	0.00
8.00	8.00	3.54	1.23	1.36	3-M1t	0.93	0.72	1.20	1.20	1.59	0.00
10.00	10.00	3.75	1.43	1.57	3-M1t	1.09	0.83	1.36	1.36	1.75	0.00
12.00	12.00	3.95	1.61	1.77	3-M1t	1.26	0.94	1.52	1.52	1.88	0.00
14.00	14.00	4.14	1.78	1.96	3-M1t	1.42	1.04	1.67	1.67	2.00	0.00
16.00	16.00	4.31	1.94	2.13	3-M1t	1.57	1.14	1.80	1.80	2.12	0.00
18.00	18.00	4.46	2.09	2.28	3-M1t	1.73	1.23	1.91	1.91	2.24	0.00
20.00	20.00	4.61	2.24	2.43	3-M1t	1.88	1.32	2.01	2.01	2.37	0.00
22.00	22.00	4.75	2.38	2.57	3-M1t	2.03	1.41	2.10	2.10	2.49	0.00
24.00	24.00	4.89	2.52	2.71	3-M1t	2.18	1.50	2.19	2.19	2.61	0.00

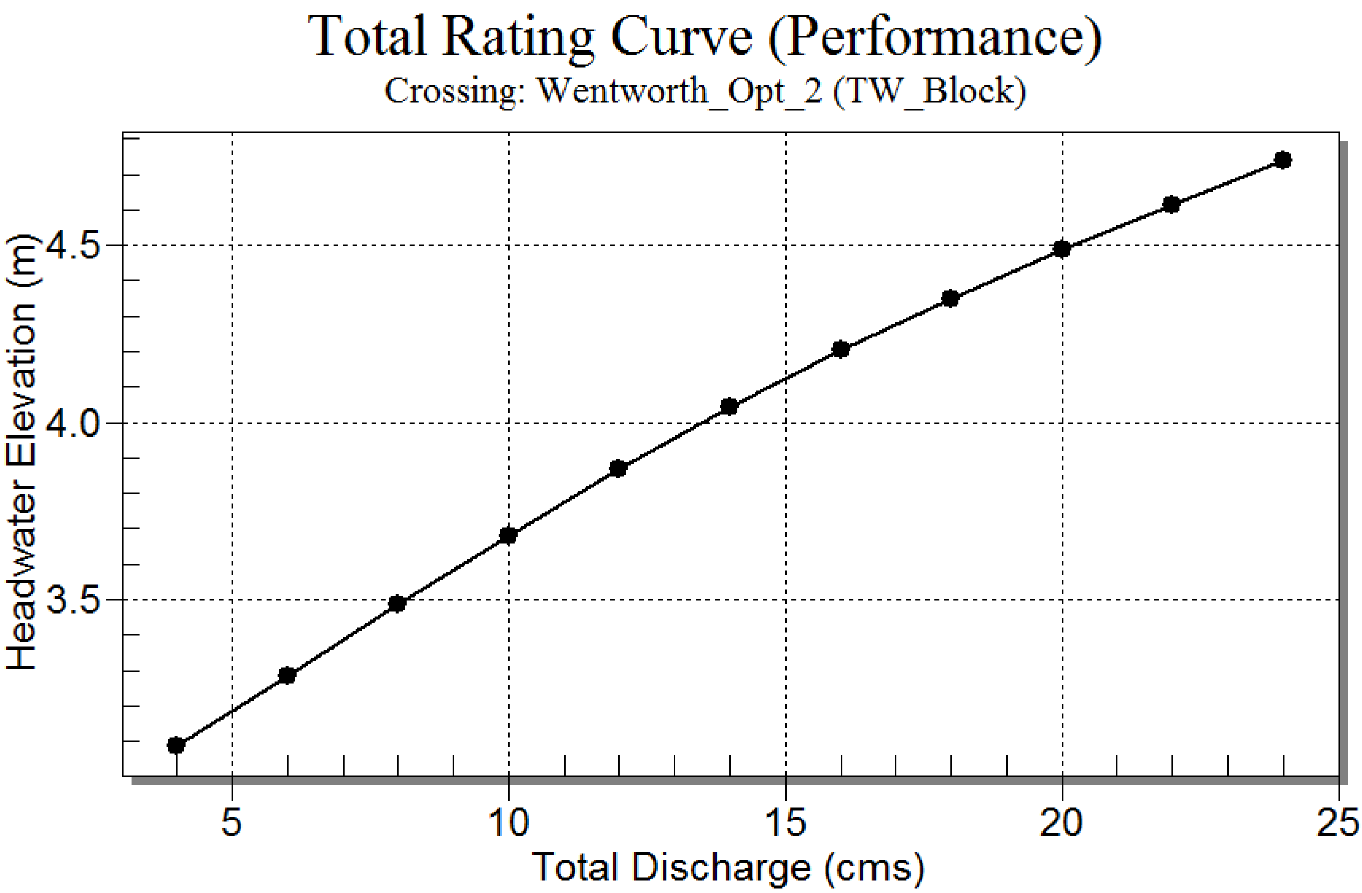


HY-8 Analysis Results

Culvert Summary Table - Culvert Option 2 (TW_Block)

Culvert Crossing: Wentworth_Opt_2 (TW_Block)

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth(m)	Outlet Control Depth(m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
4.00	4.00	3.09	0.70	0.91	3-M1t	0.52	0.41	0.89	0.90	0.91	0.00
6.00	6.00	3.28	0.92	1.10	3-M1t	0.70	0.53	1.04	1.05	1.17	0.00
8.00	8.00	3.48	1.11	1.30	3-M1t	0.87	0.64	1.20	1.21	1.35	0.00
10.00	10.00	3.68	1.28	1.50	3-M1t	1.03	0.75	1.36	1.37	1.49	0.00
12.00	12.00	3.87	1.45	1.69	3-M1t	1.19	0.84	1.52	1.53	1.59	0.00
14.00	14.00	4.04	1.60	1.86	3-M1t	1.34	0.94	1.67	1.68	1.69	0.00
16.00	16.00	4.20	1.74	2.02	3-M1t	1.50	1.02	1.80	1.81	1.80	0.00
18.00	18.00	4.35	1.88	2.17	3-M1t	1.65	1.11	1.91	1.92	1.90	0.00
20.00	20.00	4.49	2.01	2.31	3-M1t	1.79	1.19	2.01	2.02	2.01	0.00
22.00	22.00	4.61	2.14	2.43	3-M1t	1.94	1.27	2.10	2.11	2.12	0.00
24.00	24.00	4.74	2.27	2.56	3-M1t	2.09	1.34	2.19	2.20	2.21	0.00



GENERAL FIGURES

Transport Roads & Maritime Services

NSW GOVERNMENT

J. WYNDHAM PRINCE

CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS

PO Box 4366 PENRITH WESTFIELD NSW 2750

P 02 4720 3300 W www.jwprince.com.au

F 02 4721 7638 E jwp@jwprince.com.au

VIEWPORT EXTENT

LEGEND

- AIRPORT EAST PRECINCT AREA
- EXISTING CADASTRAL SURVEY
- EXISTING STORMWATER PIPES
- EXISTING STORMWATER PITS
- EXISTING GOODS RAIL LINE
- 9.03 LOCATION OF XP-RAFTS NODE

N W E S

Scale 1: 3,000 @ A3

100 0 m

Aerial Image Sourced from: Spatial Information Exchange, NSW

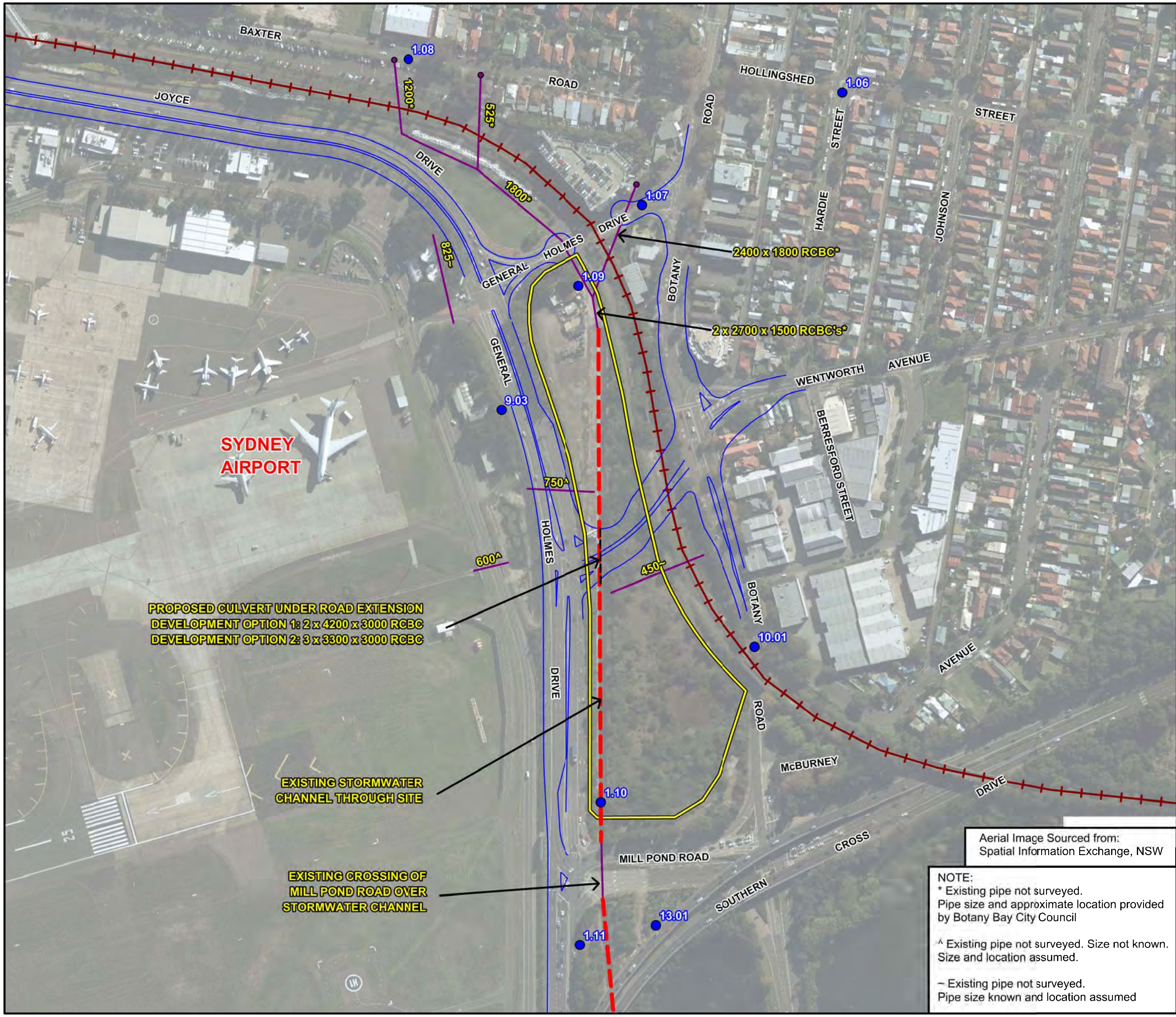
Figure 4.1

Airport East Precinct Works

Existing Site Layout

File Name: Fig4.1 - ExiSite

Date : 24/04/14 Issue : B



NSW GOVERNMENT Transport Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au

Aerial Image Sourced from:
Spatial Information Exchange, NSW

NOTE:
* Existing pipe not surveyed.
Pipe size and approximate location provided by Botany Bay City Council

^ Existing pipe not surveyed. Size not known.
Size and location assumed.

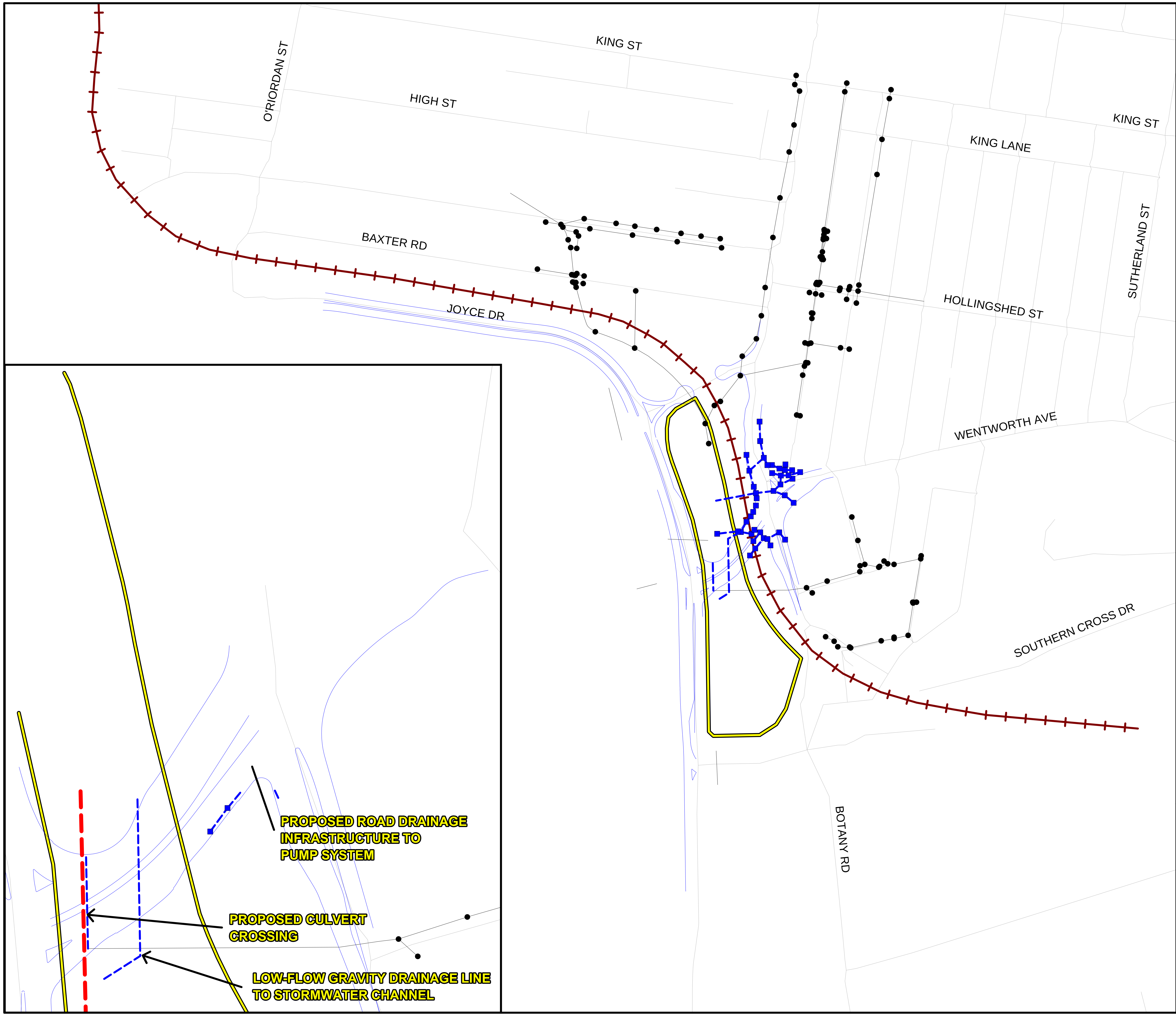
~ Existing pipe not surveyed.
Pipe size known and location assumed

Figure 4.2

Airport East Precinct Works

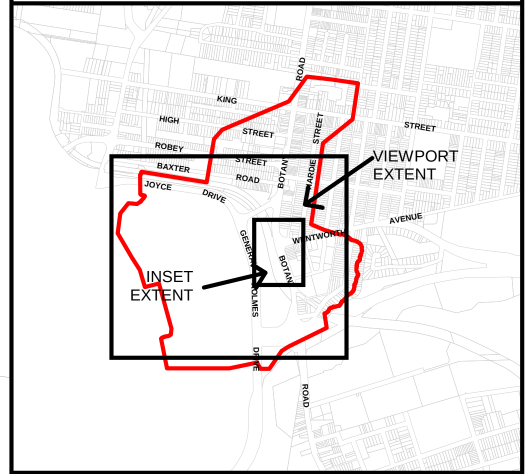
Proposed Site Layout

File Name: Fig4.2 - Prop Road
Date : 22/04/14
Issue : B



Transport
Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au



LEGEND

- AIRPORT EAST PRECINCT AREA
- EXISTING ROAD
- PROPOSED ROAD DEVELOPMENT
- EXISTING STORMWATER PIPES
- EXISTING STORMWATER PITS
- PROPOSED STORMWATER PIPES
- EXISTING GOODS RAIL LINE
- EXISTING STORMWATER CHANNEL

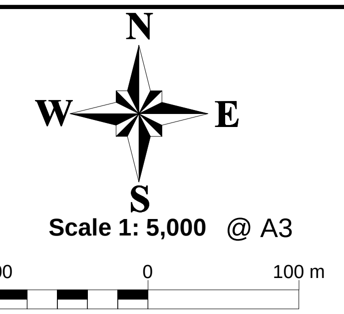
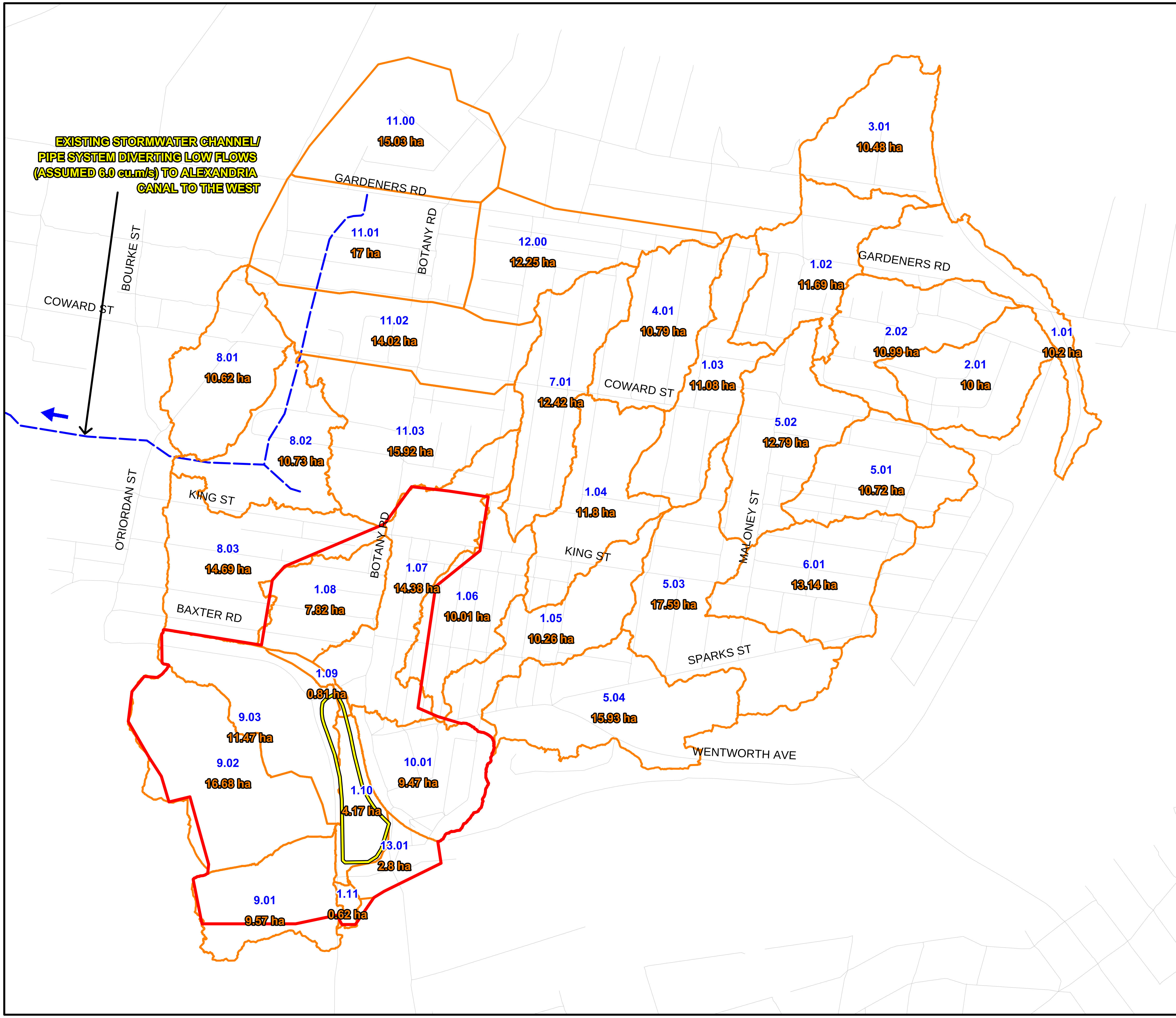


Figure 4.3

Airport East Precinct Works

Pump-Out Assessment Study Area and Drainage Layout

File Name: Fig4.3 - PropPump
Date : 22/04/14 Issue : A



Transport
Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au

LEGEND

- AIRPORT EAST PRECINCT AREA
- TUFLOW BOUNDARY
- CATCHMENT BOUNDARY
- 8.03 CATCHMENT ID
- 22.54 ha CATCHMENT AREA

N W E S

Scale 1: 10,000 @ A3

200 0 200 m

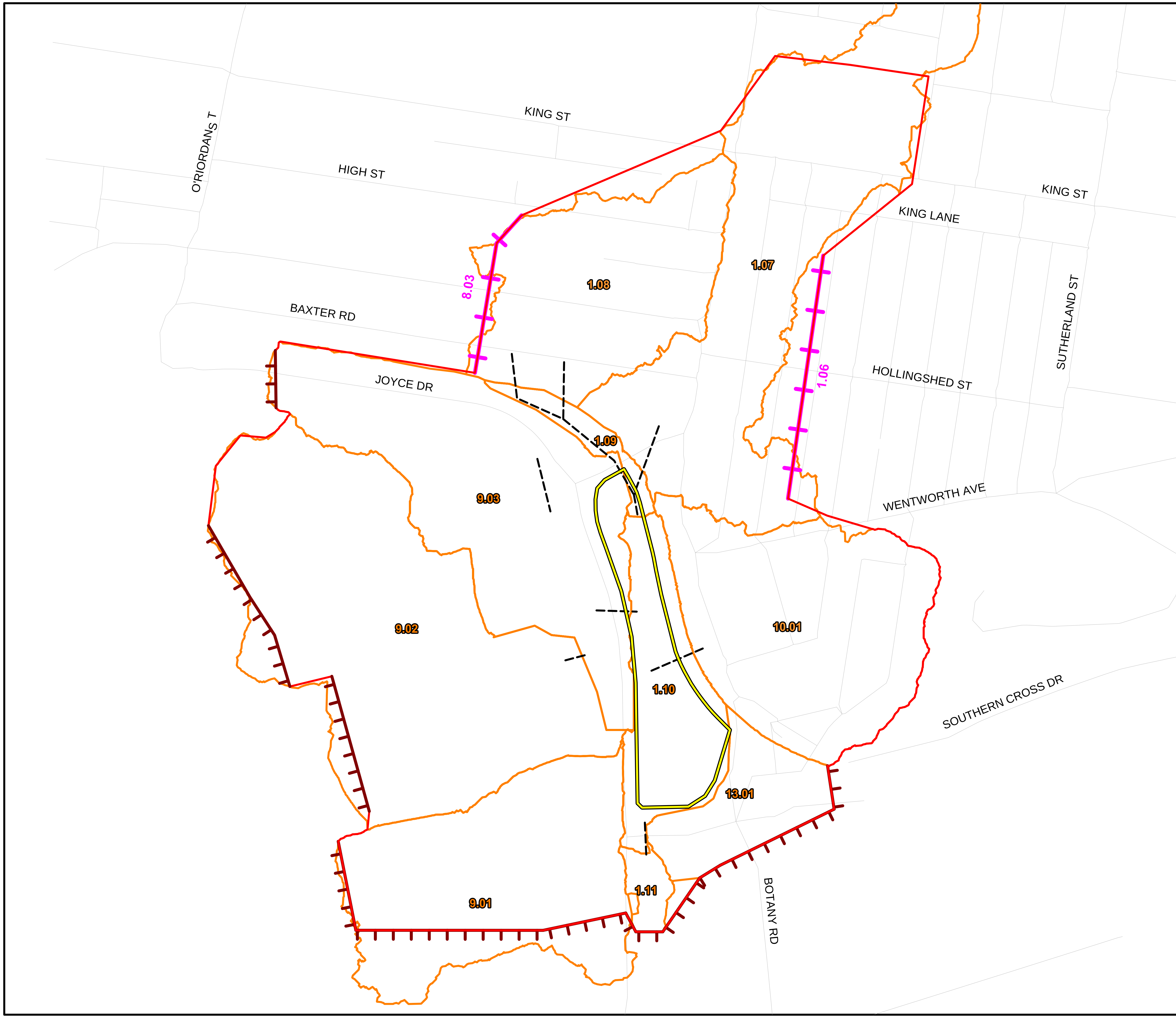
Figure 5.1

Airport East Precinct Works

Hydrological Model Catchment Layout

File Name: Fig5.1 - Catchment
Date : 27/05/14
Issue : C

GENERAL FLOOD MAPPING FIGURES



Transport Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au

LEGEND

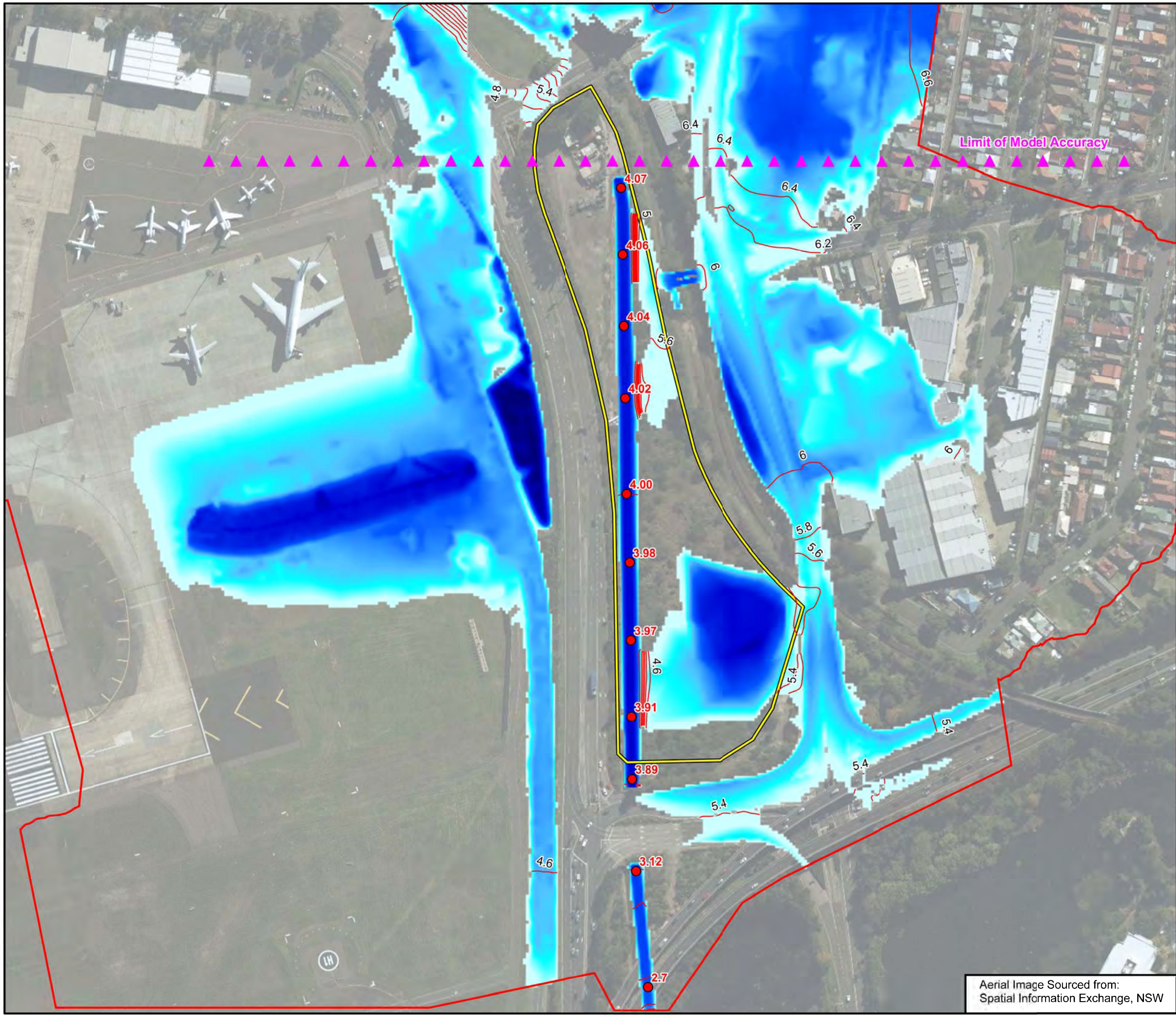
- AIRPORT EAST PRECINCT AREA
- TUFLOW BOUNDARY
- SOURCE AREA (SA) CATCHMENT BOUNDARY
- HQ MODEL OUTLET
- EXTERNAL CATCHMENT FLOW INPUTS
- 1D ELEMENT

Figure 6.1

Airport East Precinct Works

TUFLOW Model Layout

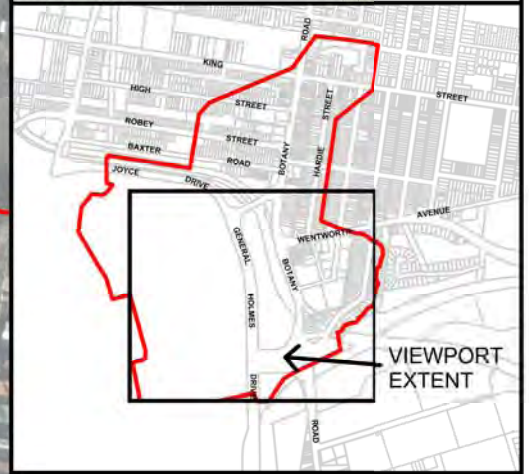
File Name: Fig6.1 - TUFLOW Model
Date : 22/04/14 Issue : B



Aerial Image Sourced from:
Spatial Information Exchange, NSW

Transport Roads & Maritime Services
NSW GOVERNMENT

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au



LEGEND

- AIRPORT EAST PRECINCT AREA
- TUFLOW BOUNDARY

DEPTH (m)
- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

5.4 0.2m FLOOD CONTOUR

SPOT LEVEL (m AHD)

N W E S

Scale 1: 2,500 @ A3

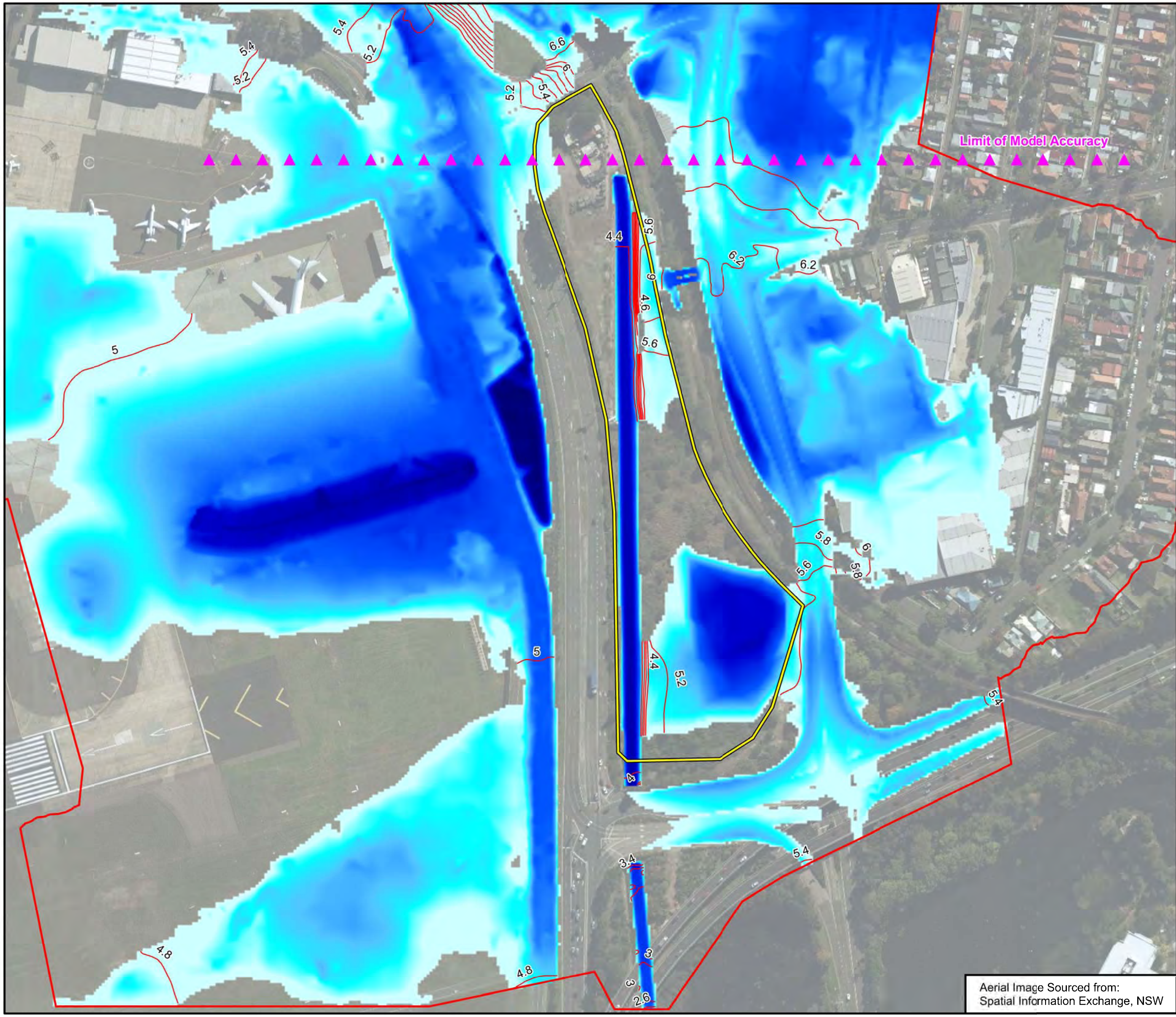
100 0 m

Figure 6.2

Airport East Precinct Works

Flood Depth and Levels
10% AEP
Existing Conditions

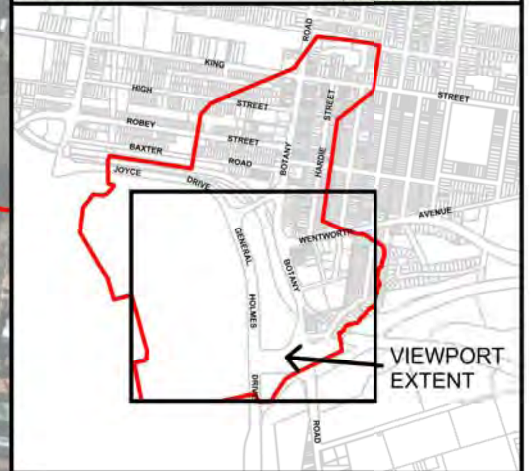
File Name: Fig6.2 - 10%AEP Exi
Date : 23/04/14
Issue : B



Aerial Image Sourced from:
Spatial Information Exchange, NSW

NSW GOVERNMENT
Transport Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au



LEGEND

- AIRPORT EAST PRECINCT AREA
- TUFLOW BOUNDARY

DEPTH (m)
- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

5.4 — 0.2m FLOOD CONTOUR

N W E S

Scale 1: 2,500 @ A3

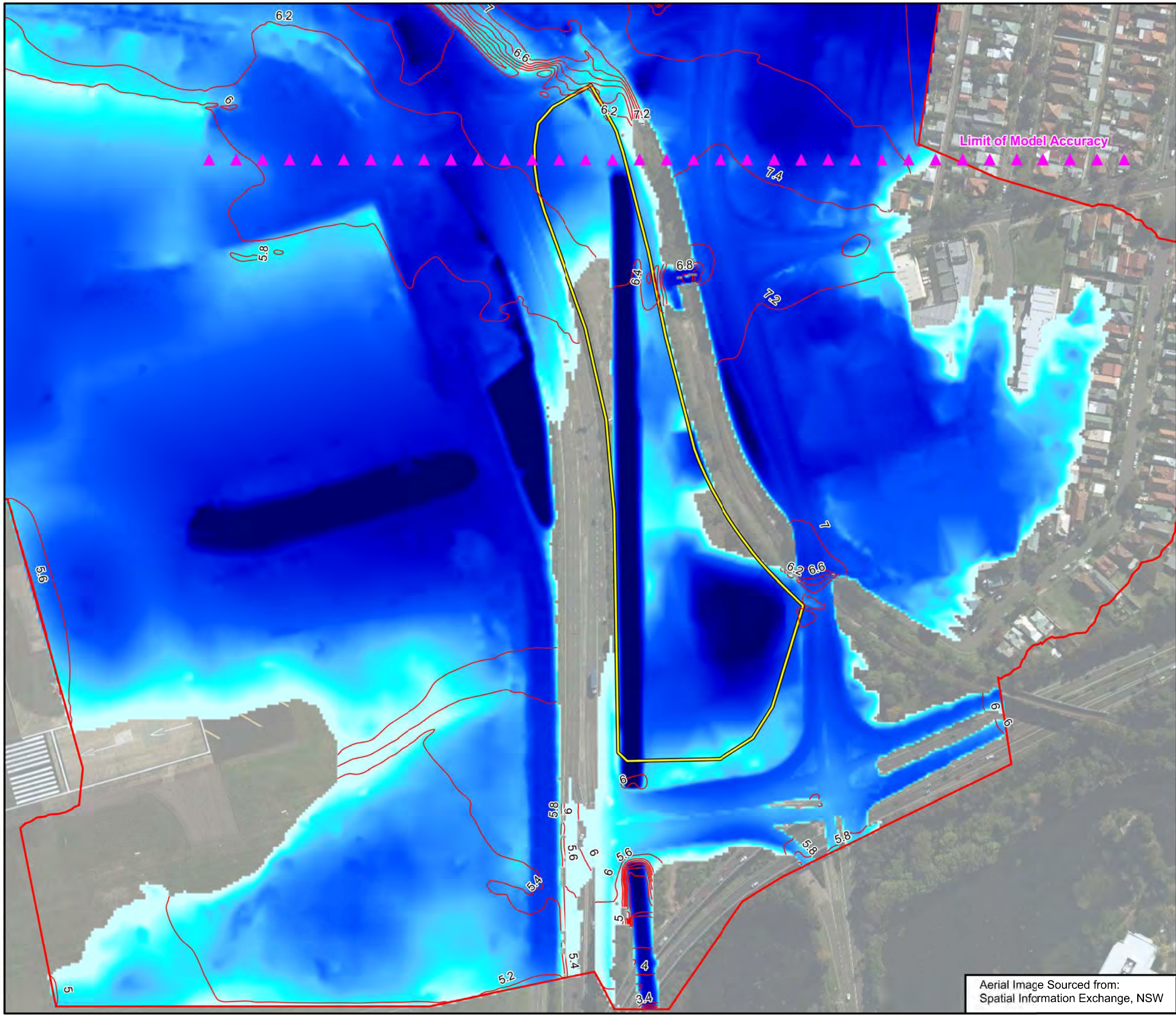
100 0 m

Figure 6.3

Airport East Precinct Works

Flood Depth and Levels
1% AEP
Existing Conditions

File Name: Fig6.3 - 1%AEP Exi
Date : 29/05/14
Issue : C



Transport Roads & Maritime Services

NSW GOVERNMENT

J. WYNDHAM PRINCE

CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS

PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au

LEGEND

AIRPORT EAST PRECINCT AREA

TUFLOW BOUNDARY

DEPTH (m)

- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

5.4 0.2m FLOOD CONTOUR

N W E S

Scale 1: 2,500 @ A3

100 0 m

Figure 6.4

Airport East Precinct Works

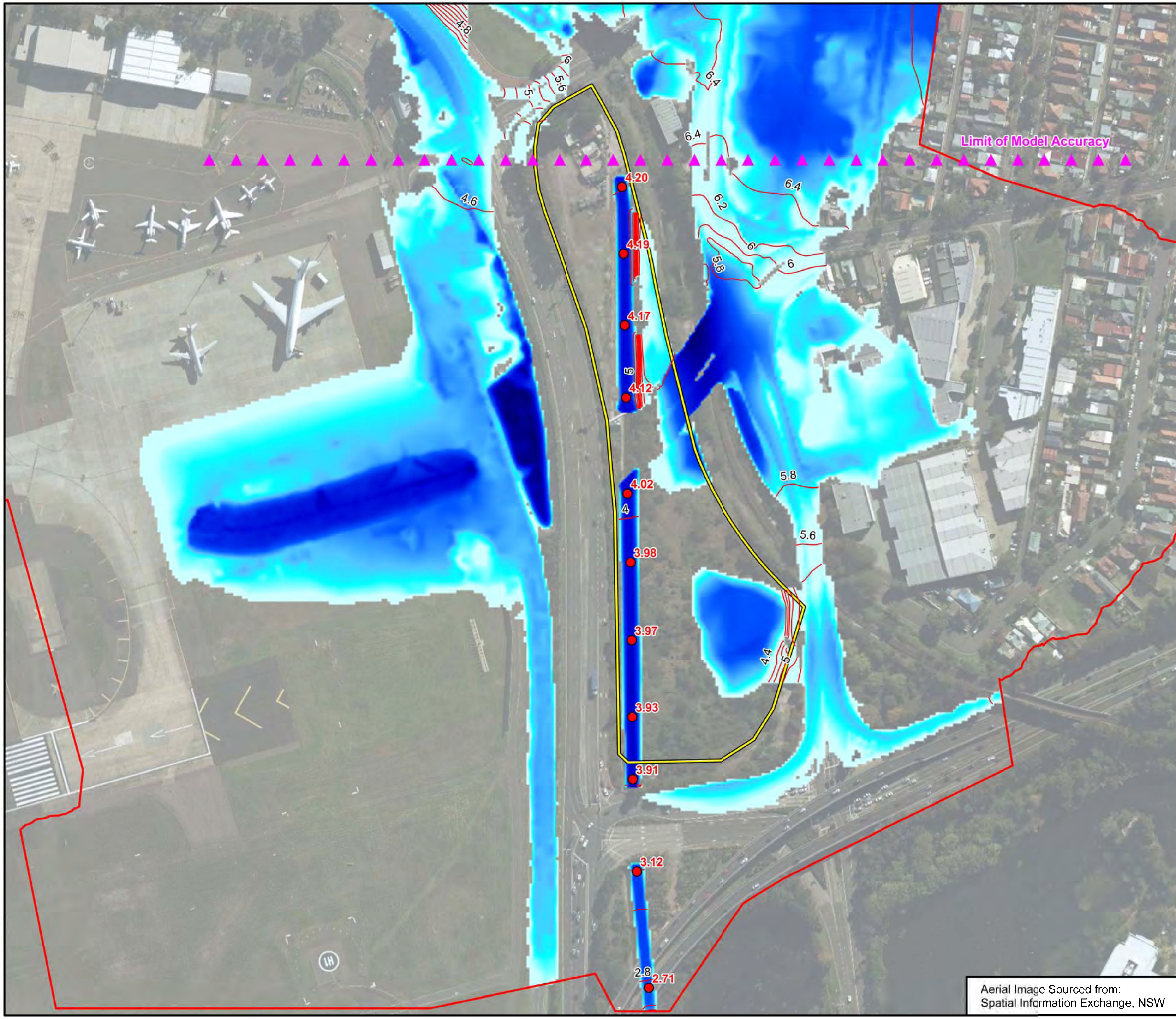
Flood Depth and Levels PMF Existing Conditions

Aerial Image Sourced from: Spatial Information Exchange, NSW

File Name: Fig6.4 - PMFExi

Date : 08/04/14

Issue : B



Transport Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS

PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

LEGEND

- AIRPORT EAST PRECINCT AREA
- TUFLOW BOUNDARY
- DEPTH (m)
  - 0.0 to 0.2
  - 0.2 to 0.3
  - 0.3 to 0.5
  - 0.5 to 1.0
  - 1.0 to 2.0
  - 2.0 to 3.0
  - 3.0 +
- 5.4 0.2m FLOOD CONTOUR
- SPOT LEVEL (m AHD)

N W E S

Scale 1: 2,500 @ A3

100 0 m

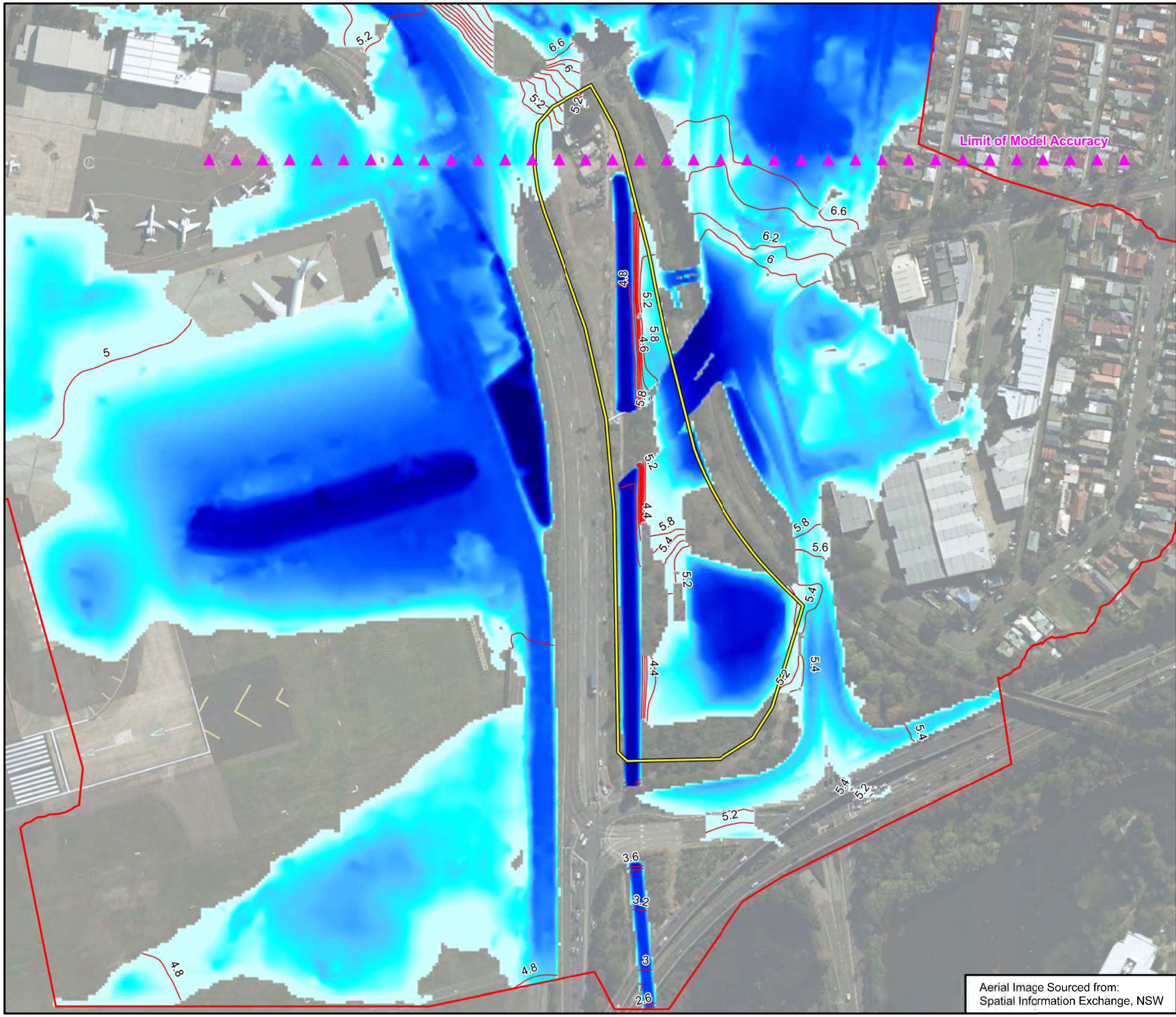
Figure 6.5

Airport East Precinct Works

Flood Depth and Levels
10% AEP
Culvert Option 1 Conditions

Aerial Image Sourced from: Spatial Information Exchange, NSW

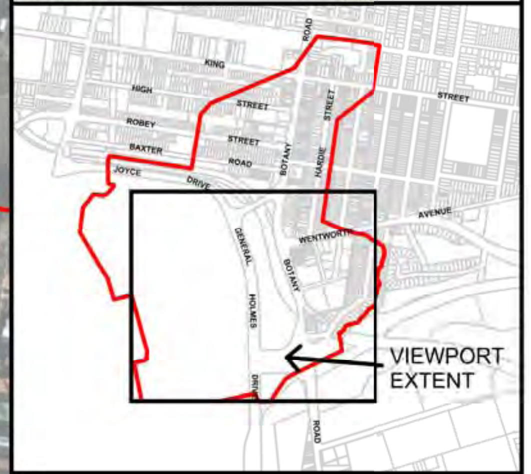
File Name: Fig6.5 - 10%AEP Dev1
Date : 23/04/14 Issue : B



Aerial Image Sourced from:
Spatial Information Exchange, NSW

NSW GOVERNMENT | Transport Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au



LEGEND

AIRPORT EAST PRECINCT AREA
TUFLOW BOUNDARY
DEPTH (m)
- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

5.4 0.2m FLOOD CONTOUR

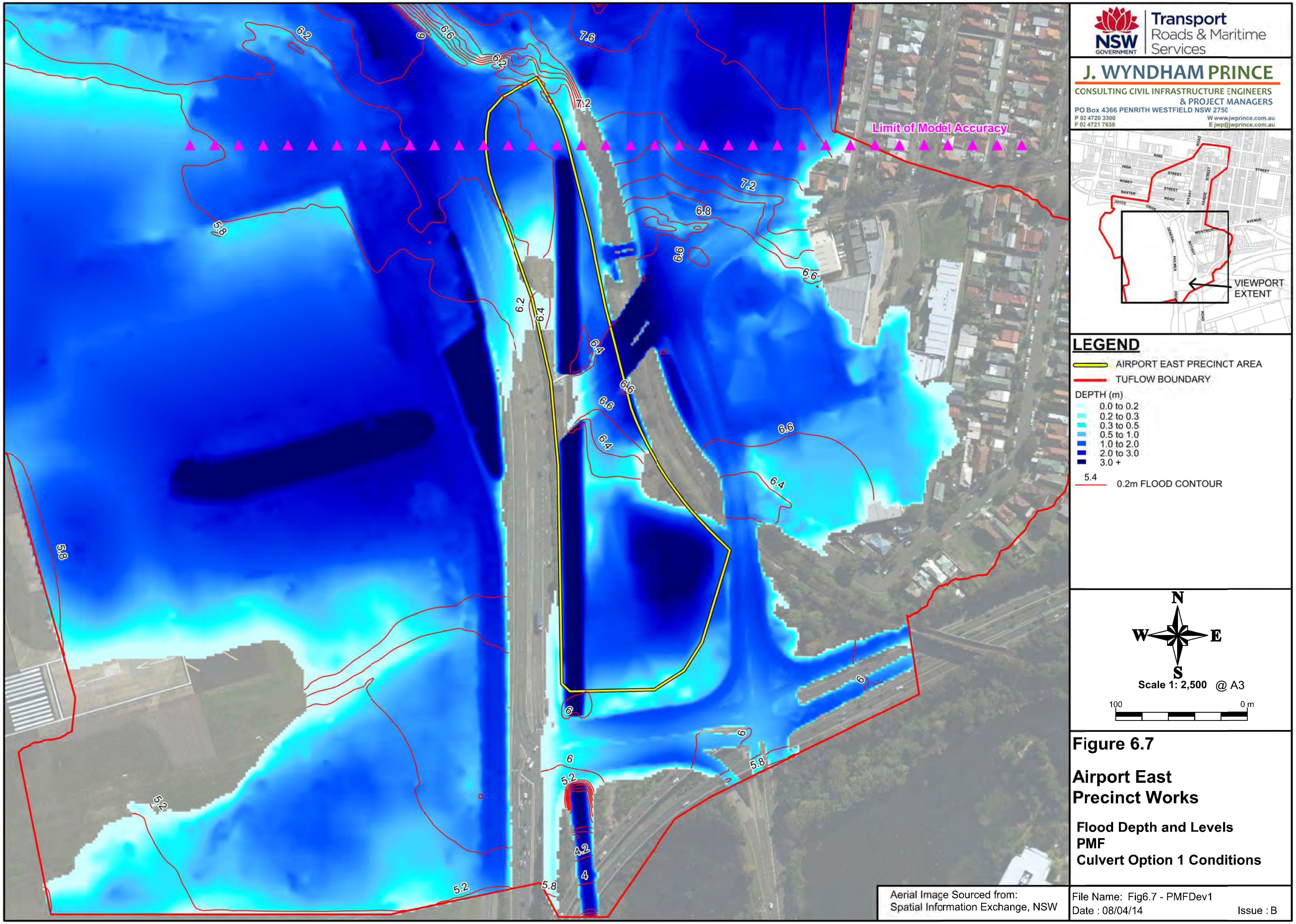
N W E S
Scale 1: 2,500 @ A3
100 0 m

Figure 6.6

Airport East Precinct Works

Flood Depth and Levels 1% AEP Culvert Option 1 Conditions

File Name: Fig6.6 - 1%AEP Dev1
Date : 23/04/14
Issue : B



Transport Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au

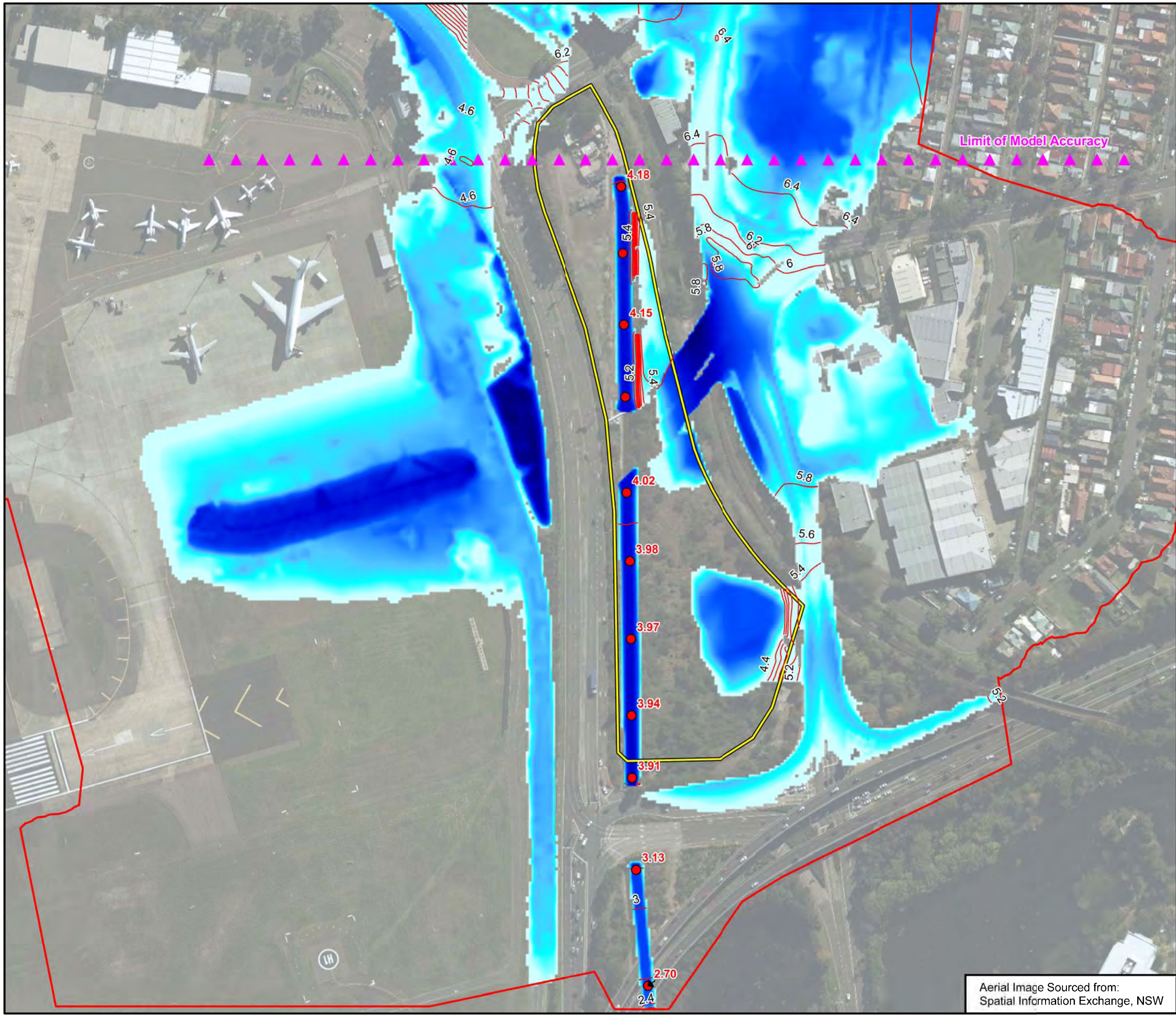
Figure 6.7

Airport East Precinct Works

Flood Depth and Levels
PMF
Culvert Option 1 Conditions

Aerial Image Sourced from: Spatial Information Exchange, NSW

File Name: Fig6.7 - PMFDev1
Date : 08/04/14
Issue : B



NSW GOVERNMENT Transport Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

VIEWPORT EXTENT

LEGEND

- AIRPORT EAST PRECINCT AREA
- TUFLOW BOUNDARY

DEPTH (m)
- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

5.4 0.2m FLOOD CONTOUR

SPOT LEVEL (m AHD)

N W E S

Scale 1: 2,500 @ A3

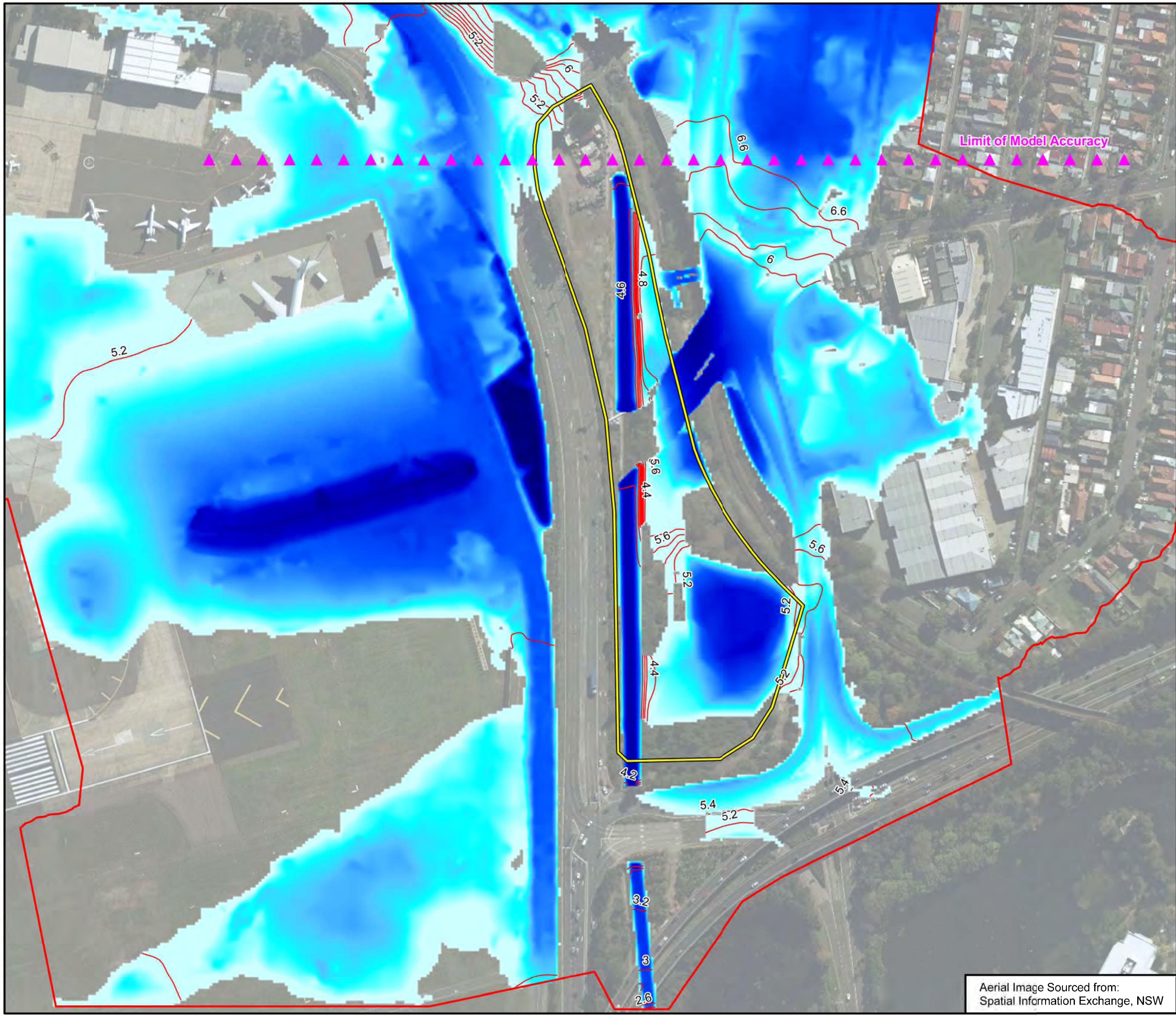
100 0 m

Figure 6.8

Airport East Precinct Works

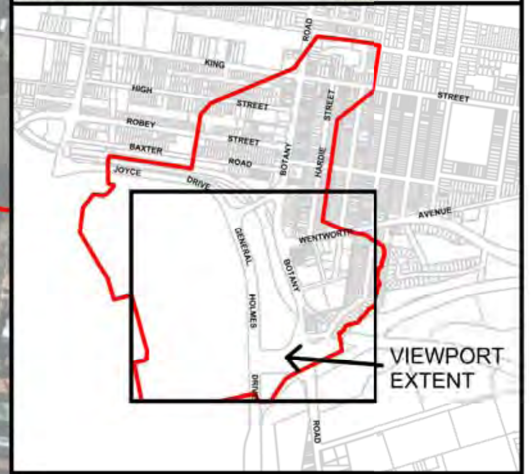
Flood Depth and Levels
10% AEP
Culvert Option 2 Conditions

File Name: Fig6.8 - 10%AEP Dev2
Date : 23/04/14 Issue : B



NSW GOVERNMENT
Transport
Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au



LEGEND

AIRPORT EAST PRECINCT AREA
TUFLOW BOUNDARY

DEPTH (m)
- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

5.4 0.2m FLOOD CONTOUR

N W E S

Scale 1: 2,500 @ A3

100 0 m

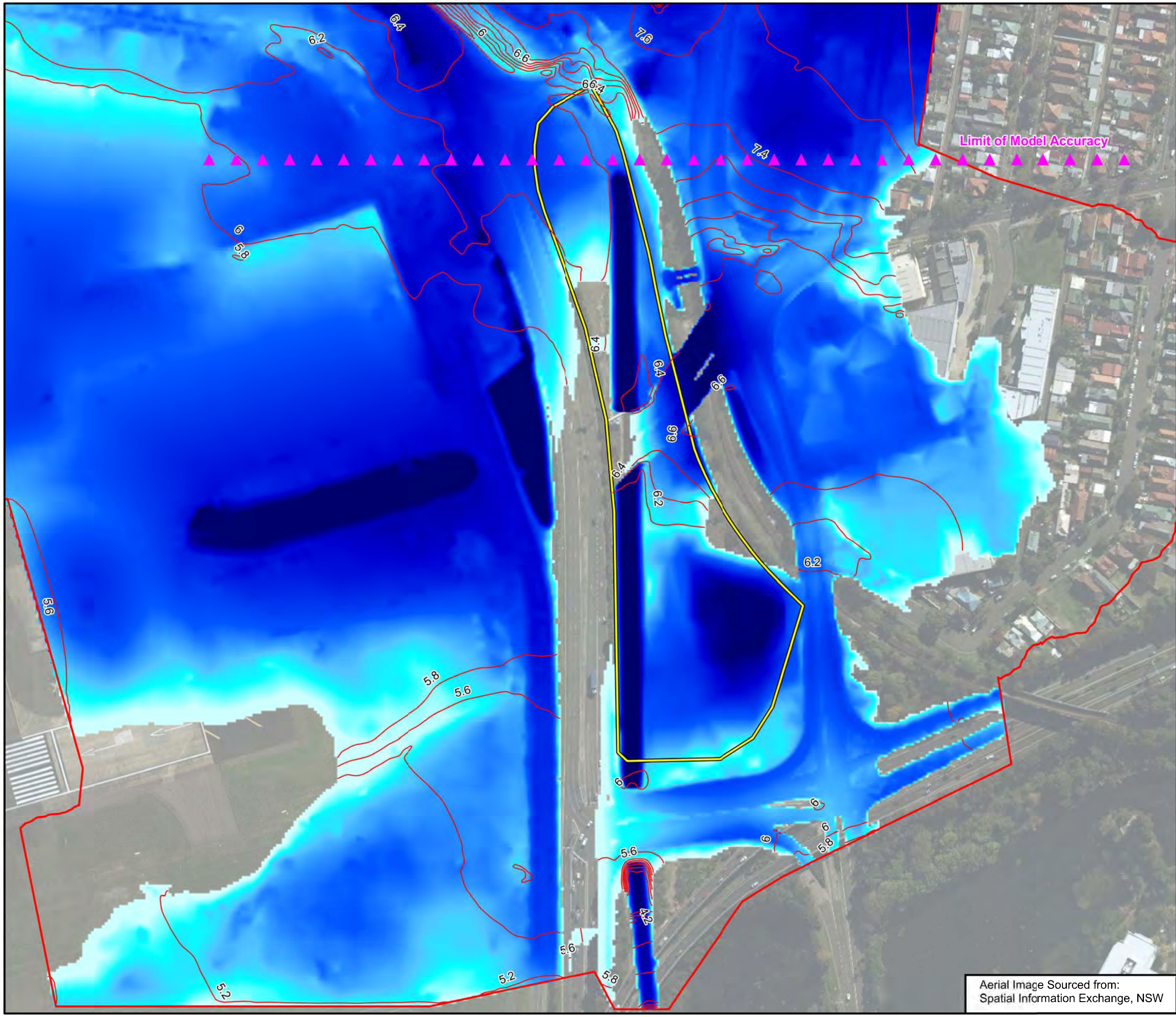
Figure 6.9

Airport East Precinct Works

Flood Depth and Levels
1% AEP
Culvert Option 2 Conditions

Aerial Image Sourced from: Spatial Information Exchange, NSW

File Name: Fig6.9 - 1%AEP Dev2
Date : 23/04/14
Issue : B



Transport Roads & Maritime Services

NSW GOVERNMENT

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au

VIEWPORT EXTENT

LEGEND

AIRPORT EAST PRECINCT AREA

TUFLOW BOUNDARY

DEPTH (m)

- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

5.4 0.2m FLOOD CONTOUR

N W E S

Scale 1: 2,500 @ A3

100 0 m

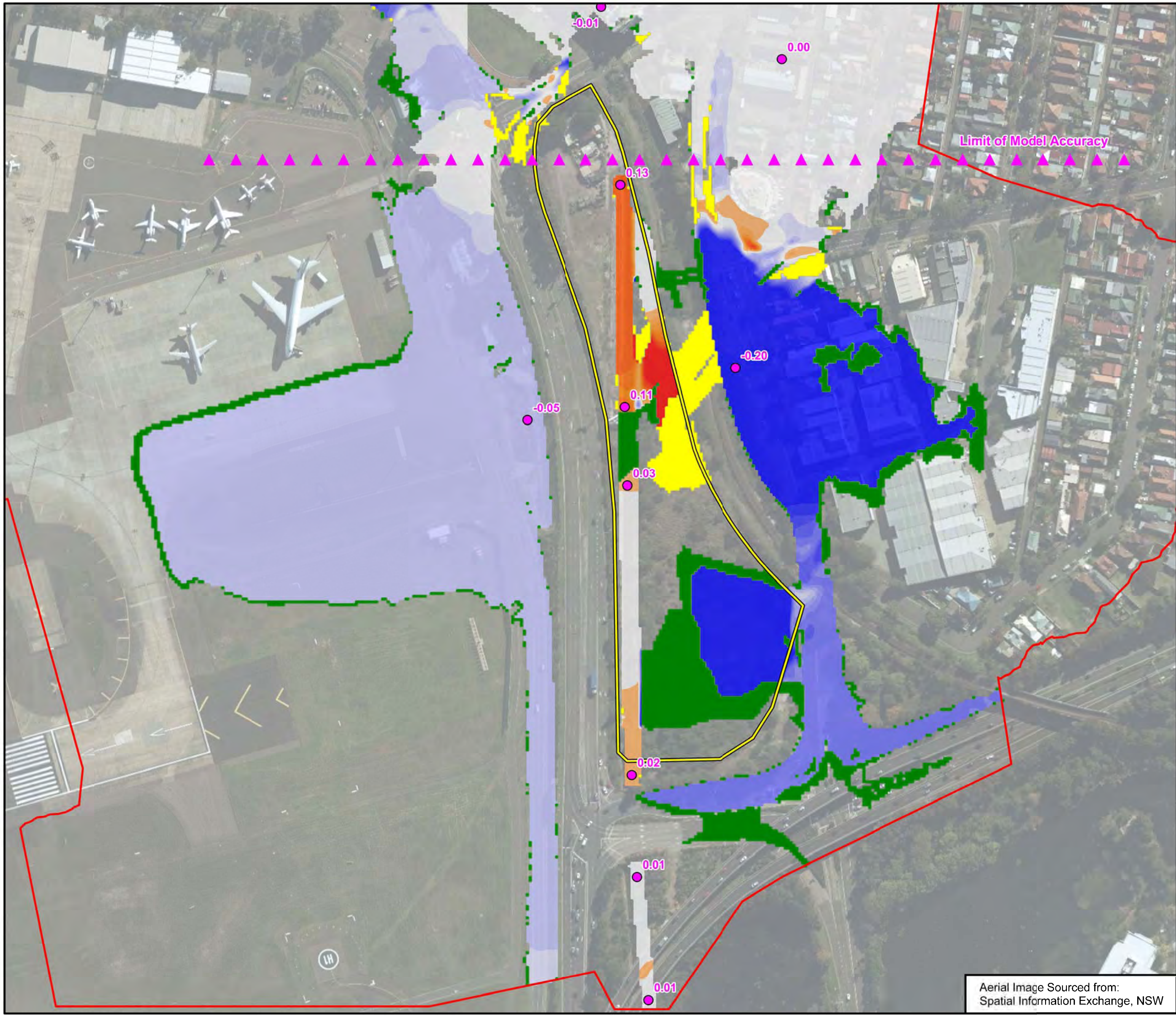
Figure 6.10

Airport East Precinct Works

Flood Depth and Levels
PMF
Culvert Option 2 Conditions

Aerial Image Sourced from: Spatial Information Exchange, NSW

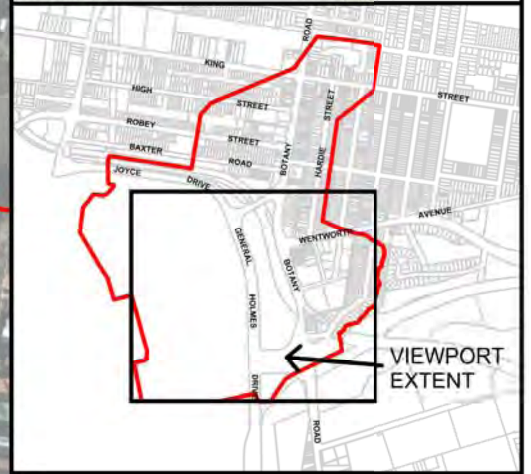
File Name: Fig6.10 - PMFDev2
Date : 08/04/14
Issue : B



Aerial Image Sourced from:
Spatial Information Exchange, NSW

NSW GOVERNMENT | Transport Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au



LEGEND

- AIRPORT EAST PRECINCT AREA
- TUFLOW BOUNDARY
- FLOOD DIFFERENCE (m)

INCREASE IN FLOOD LEVELS (m)

-0.2+	0.02
-0.18	0.04
-0.16	0.06
-0.14	0.08
-0.12	0.10
-0.10	0.12
-0.08	0.14
-0.06	0.16
-0.04	0.18
-0.02	0.2+
-0.02 to +0.02	

- AREAS NOW FLOOD FREE IN MODELLED EVENT
- AREAS NOW FLOOD AFFECTED IN MODELLED EVENT

N W E S

Scale 1: 2,500 @ A3

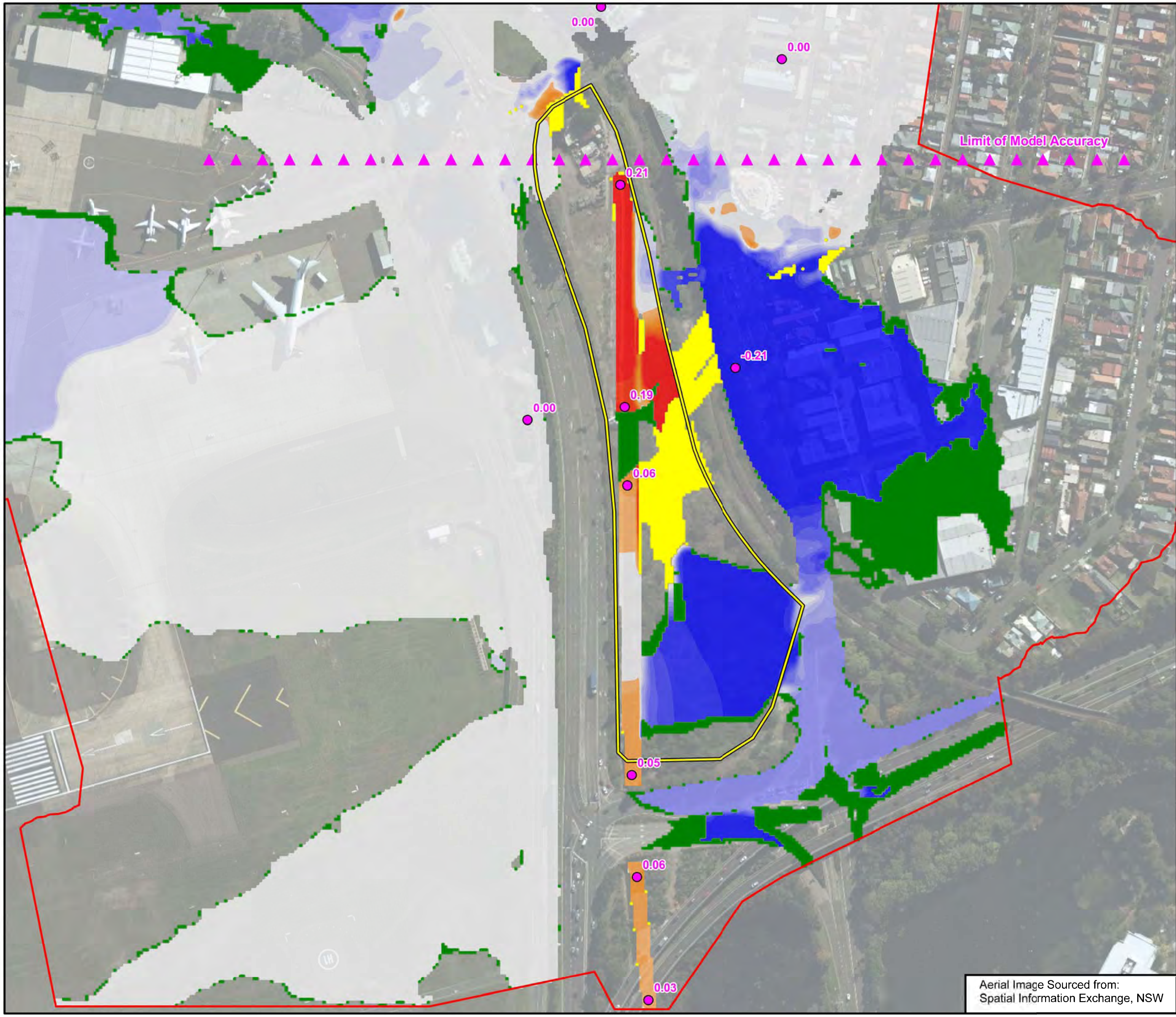
100 0 m

Figure 6.11

Airport East Precinct Works

Flood Difference
10% AEP
Culvert Option 1 - Existing

File Name: Fig6.11 - 10%AEP DiffDev1
Date : 23/04/14 Issue : B



Transport Roads & Maritime Services

NSW GOVERNMENT

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

VIEWPORT EXTENT

LEGEND

- AIRPORT EAST PRECINCT AREA
- TUFLOW BOUNDARY
- FLOOD DIFFERENCE (m)

INCREASE IN FLOOD LEVELS (m)

-0.2+	0.02
-0.18	0.04
-0.16	0.06
-0.14	0.08
-0.12	0.10
-0.10	0.12
-0.08	0.14
-0.06	0.16
-0.04	0.18
-0.02	0.2+
-0.02 to +0.02	

- AREAS NOW FLOOD FREE IN MODELLED EVENT
- AREAS NOW FLOOD AFFECTED IN MODELLED EVENT

N W E S

Scale 1: 2,500 @ A3

100 0 m

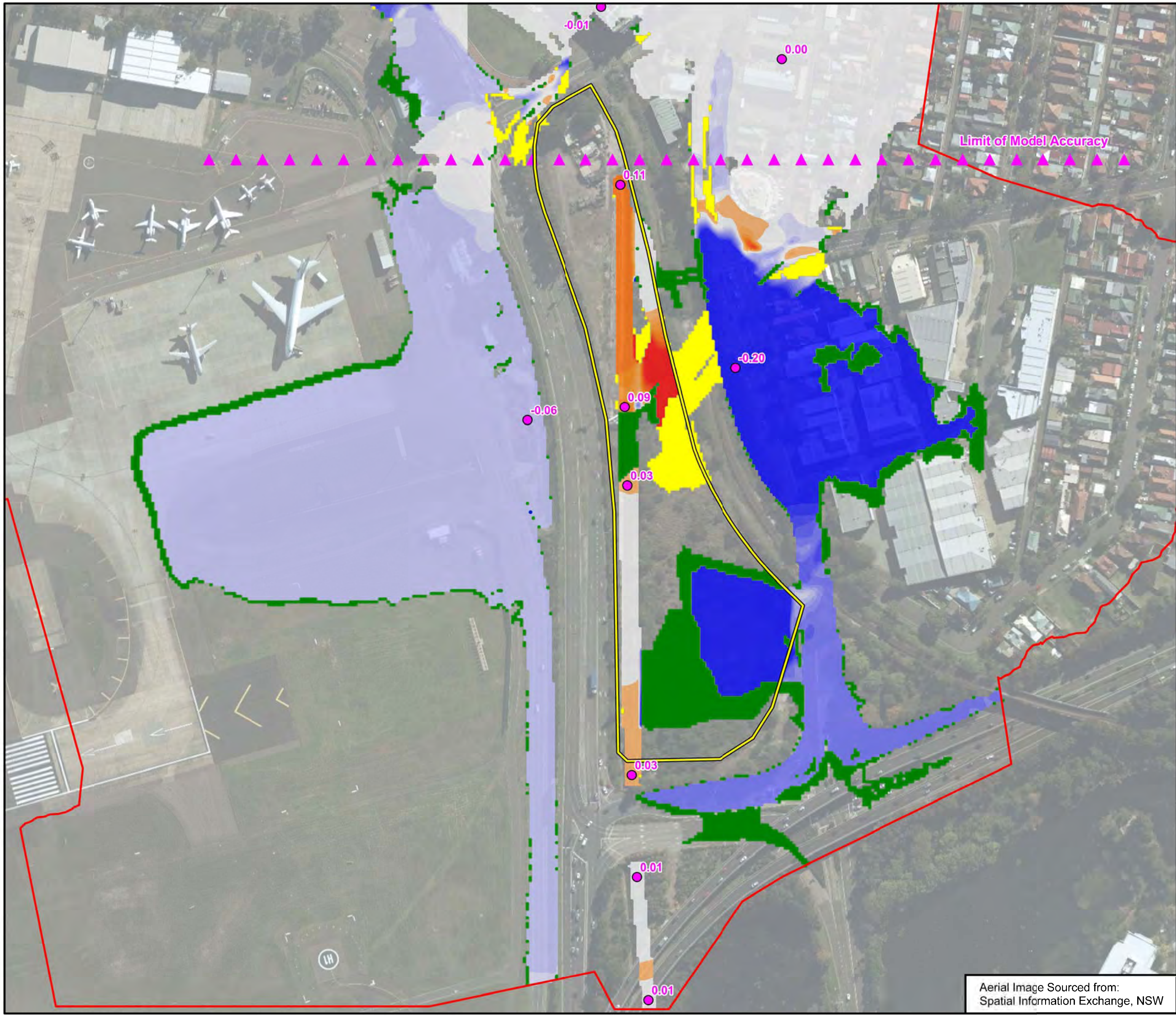
Figure 6.12

Airport East Precinct Works

Flood Difference
1% AEP
Culvert Option 1 - Existing

Aerial Image Sourced from: Spatial Information Exchange, NSW

File Name: Fig6.12 - 1%AEP DiffDev1
Date : 23/04/14 Issue : B



NSW GOVERNMENT Transport Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

VIEWPORT EXTENT

LEGEND

- AIRPORT EAST PRECINCT AREA
- TUFLOW BOUNDARY
- FLOOD DIFFERENCE (m)

INCREASE IN FLOOD LEVELS (m)

-0.2+	0.02
-0.18	0.04
-0.16	0.06
-0.14	0.08
-0.12	0.10
-0.10	0.12
-0.08	0.14
-0.06	0.16
-0.04	0.18
-0.02	0.2+
-0.02 to +0.02	

- AREAS NOW FLOOD FREE IN MODELLED EVENT
- AREAS NOW FLOOD AFFECTED IN MODELLED EVENT

N W E S

Scale 1: 2,500 @ A3

100 0 m

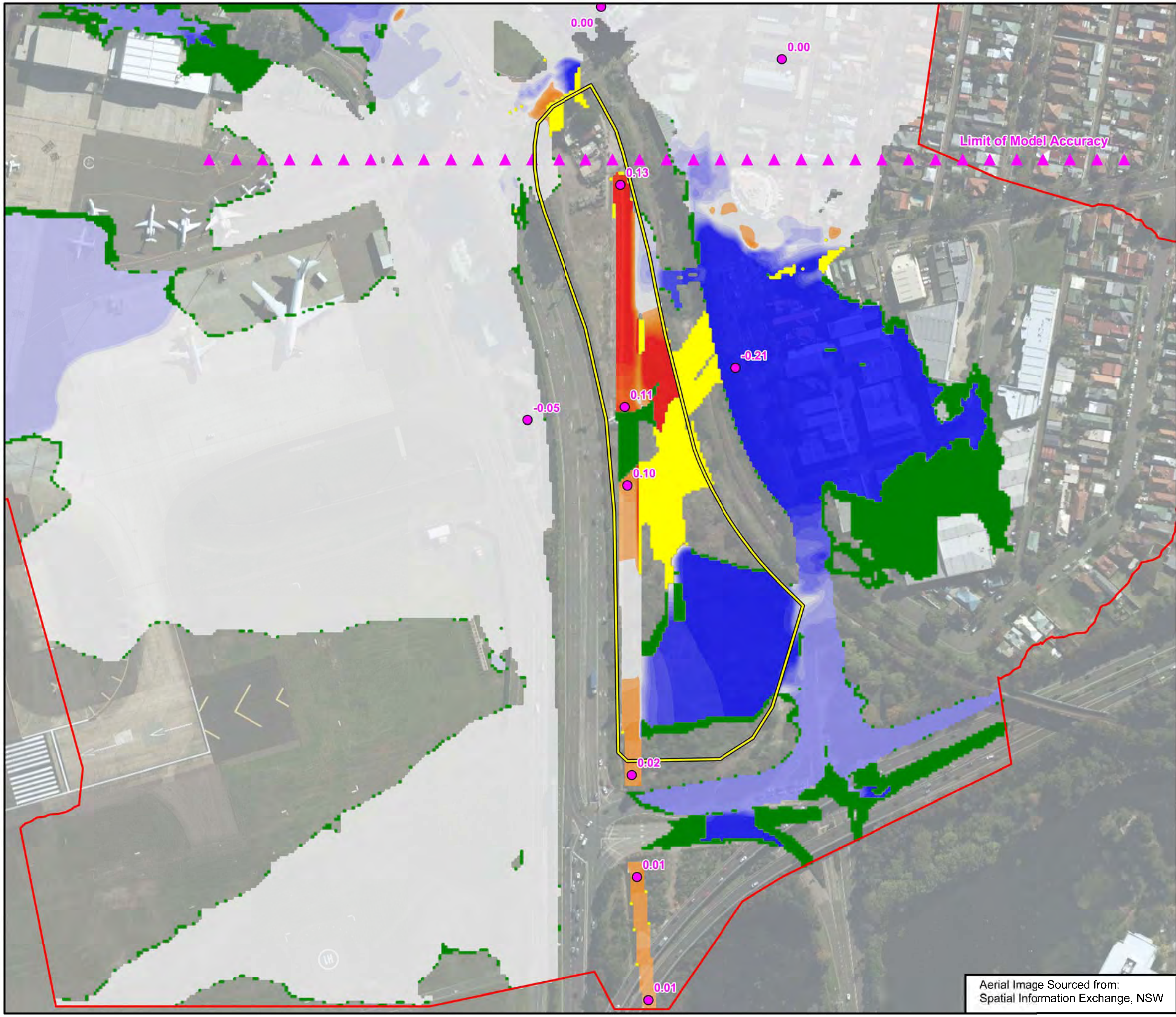
Figure 6.13

Airport East Precinct Works

Flood Difference
10% AEP
Culvert Option 2 - Existing

Aerial Image Sourced from: Spatial Information Exchange, NSW

File Name: Fig6.13 - 10%AEP DiffDev2
Date : 23/04/14 Issue : B



NSW GOVERNMENT Transport Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

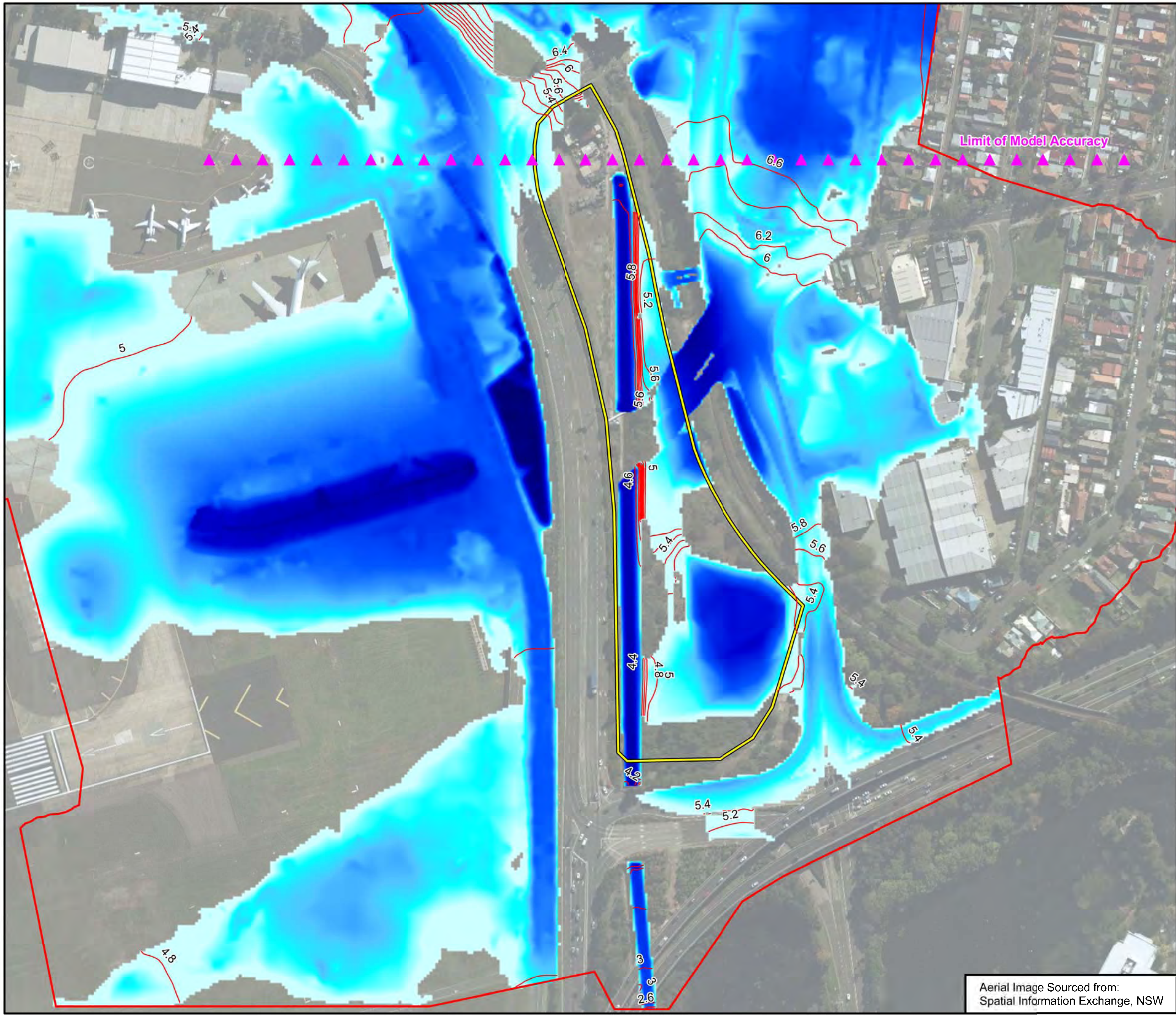
Figure 6.14

Airport East Precinct Works

Flood Difference
1% AEP
Culvert Option 2 - Existing

File Name: Fig6.14 - 1%AEP DiffDev2
Date : 23/04/14 Issue : B

SENSITIVITY ASSESSMENT FLOOD MAPPING FIGURES



NSW GOVERNMENT Transport Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

Figure 6.15

Airport East Precinct Works

Flood Depth and Levels 1% AEP Sensitivity Assessment Culvert Option 1 Increased Roughness (+25%)

File Name: Fig6.15 - 1%AEP Rough
Date : 23/04/14 Issue : B

Transport Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

LEGEND

- AIRPORT EAST PRECINCT AREA
- TUFLOW BOUNDARY
- FLOOD DIFFERENCE (m)

INCREASE IN FLOOD LEVELS (m)

-0.2+	0.02
-0.18	0.04
-0.16	0.06
-0.14	0.08
-0.12	0.10
-0.10	0.12
-0.08	0.14
-0.06	0.16
-0.04	0.18
-0.02	0.2+
-0.02 to +0.02	

- AREAS NOW FLOOD FREE IN MODELLED EVENT
- AREAS NOW FLOOD AFFECTED IN MODELLED EVENT

N W E S

Scale 1: 2,500 @ A3

100 0 m

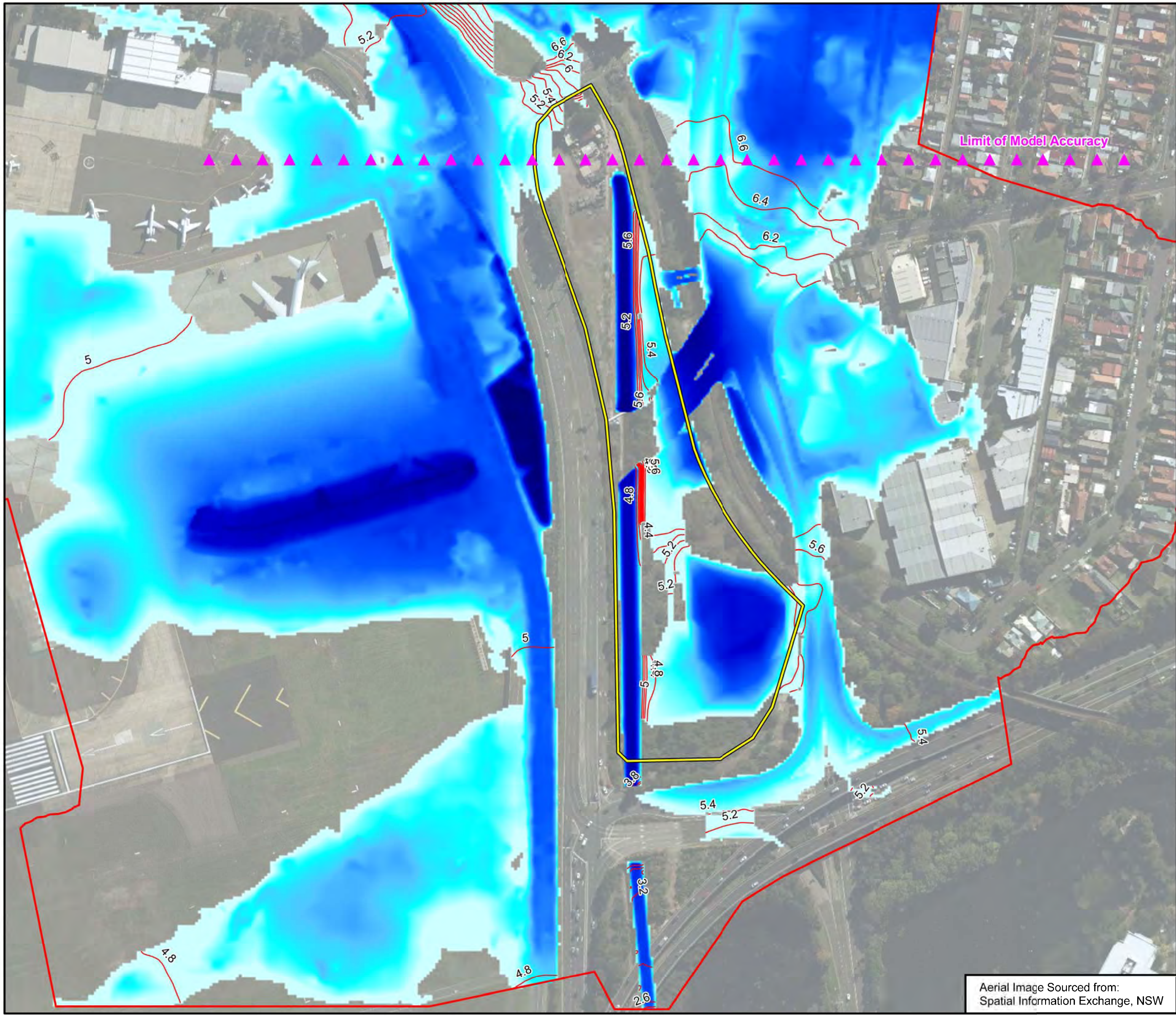
Figure 6.16

Airport East Precinct Works

Flood Difference 1% AEP Sensitivity Assessment Culvert Option 1 Increased Roughness (+25%)

Aerial Image Sourced from: Spatial Information Exchange, NSW

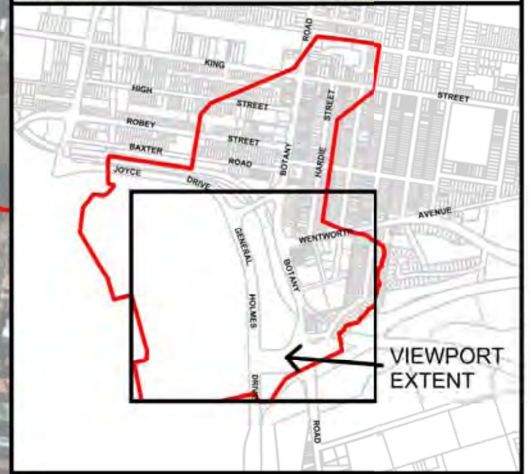
File Name: Fig6.16 - 1%AEP DiffDev1 Rough
Date : 23/04/14 Issue : A



Aerial Image Sourced from:
Spatial Information Exchange, NSW

Transport
Roads & Maritime
Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au



LEGEND

AIRPORT EAST PRECINCT AREA
TUFLOW BOUNDARY

DEPTH (m)
- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

5.4 0.2m FLOOD CONTOUR

N W E S

Scale 1: 2,500 @ A3

100 0 m

Figure 6.17

Airport East Precinct Works

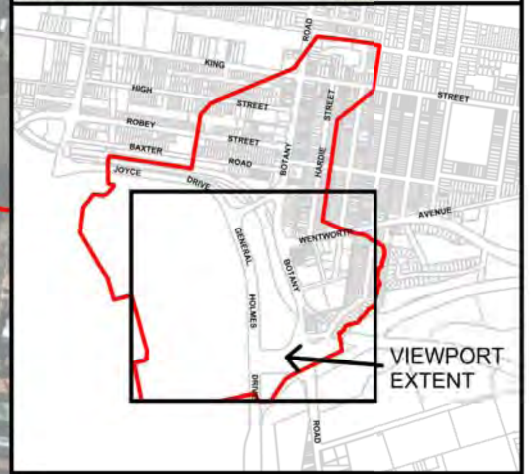
Flood Depth and Levels 1% AEP
Sensitivity Assessment
Culvert Option 1
50% Blockage Conditions

File Name: Fig6.17 - 1%AEP Dev1 Block
Date : 23/04/14 Issue : A

Transport
Roads & Maritime
Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

Aerial Image Sourced from:
Spatial Information Exchange, NSW



LEGEND

- AIRPORT EAST PRECINCT AREA
- TUFLOW BOUNDARY
- FLOOD DIFFERENCE (m)

INCREASE IN FLOOD LEVELS (m)

-0.2+	0.02
-0.18	0.04
-0.16	0.06
-0.14	0.08
-0.12	0.10
-0.10	0.12
-0.08	0.14
-0.06	0.16
-0.04	0.18
-0.02	0.2+
-0.02 to +0.02	

- AREAS NOW FLOOD FREE IN MODELLED EVENT
- AREAS NOW FLOOD AFFECTED IN MODELLED EVENT

N W E S

Scale 1: 2,500 @ A3

100 0 m

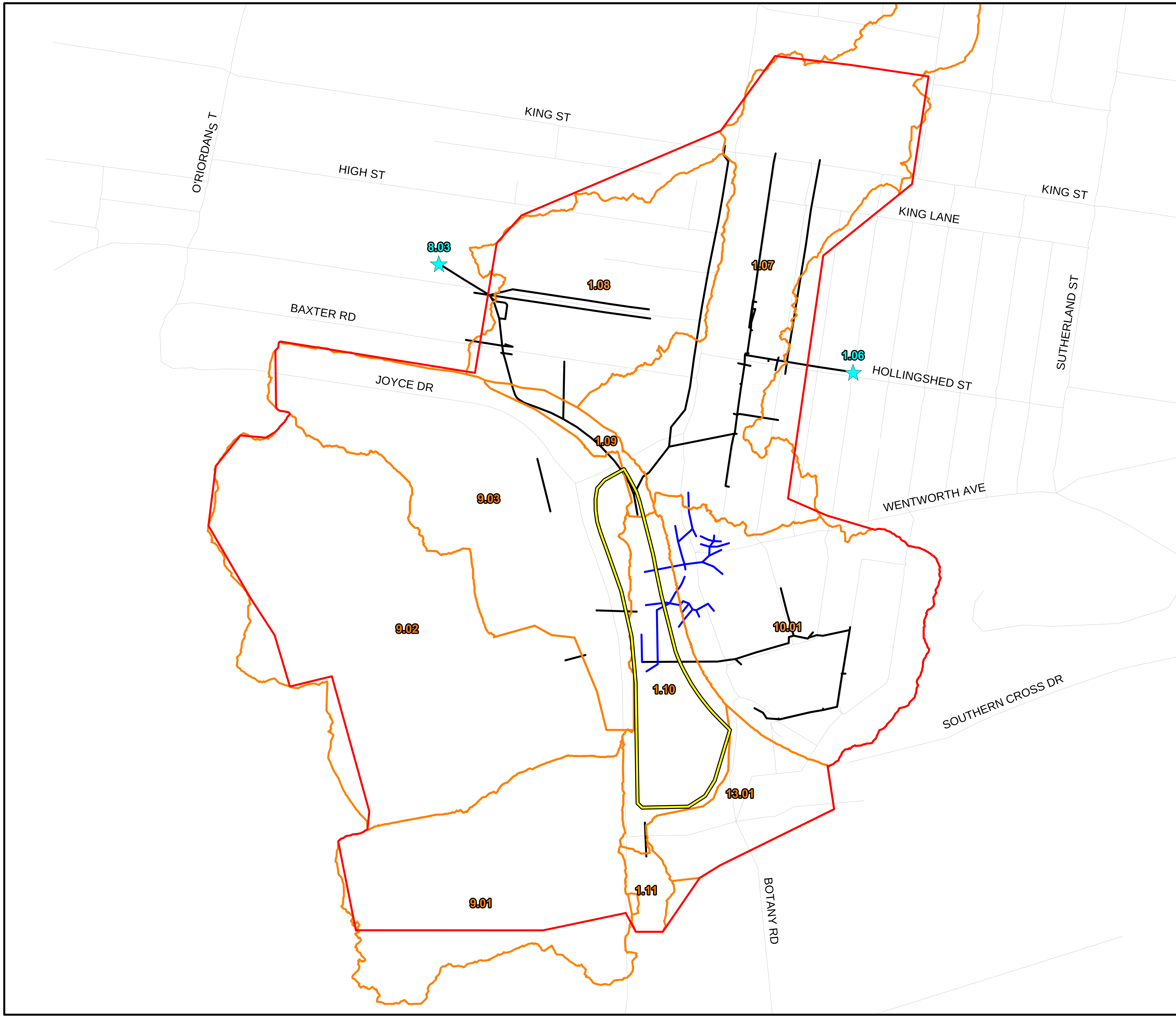
Figure 6.18

Airport East Precinct Works

Flood Difference 1% AEP Sensitivity Assessment Culvert Option 1 50% Blockage Conditions

File Name: Fig6.18 - 1%AEP DiffDev1 Block
Date : 23/04/14 Issue : A

PUMP-OUT ASSESSMENT FLOOD MAPPING FIGURES



NSW GOVERNMENT | Transport Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

Figure 6.19

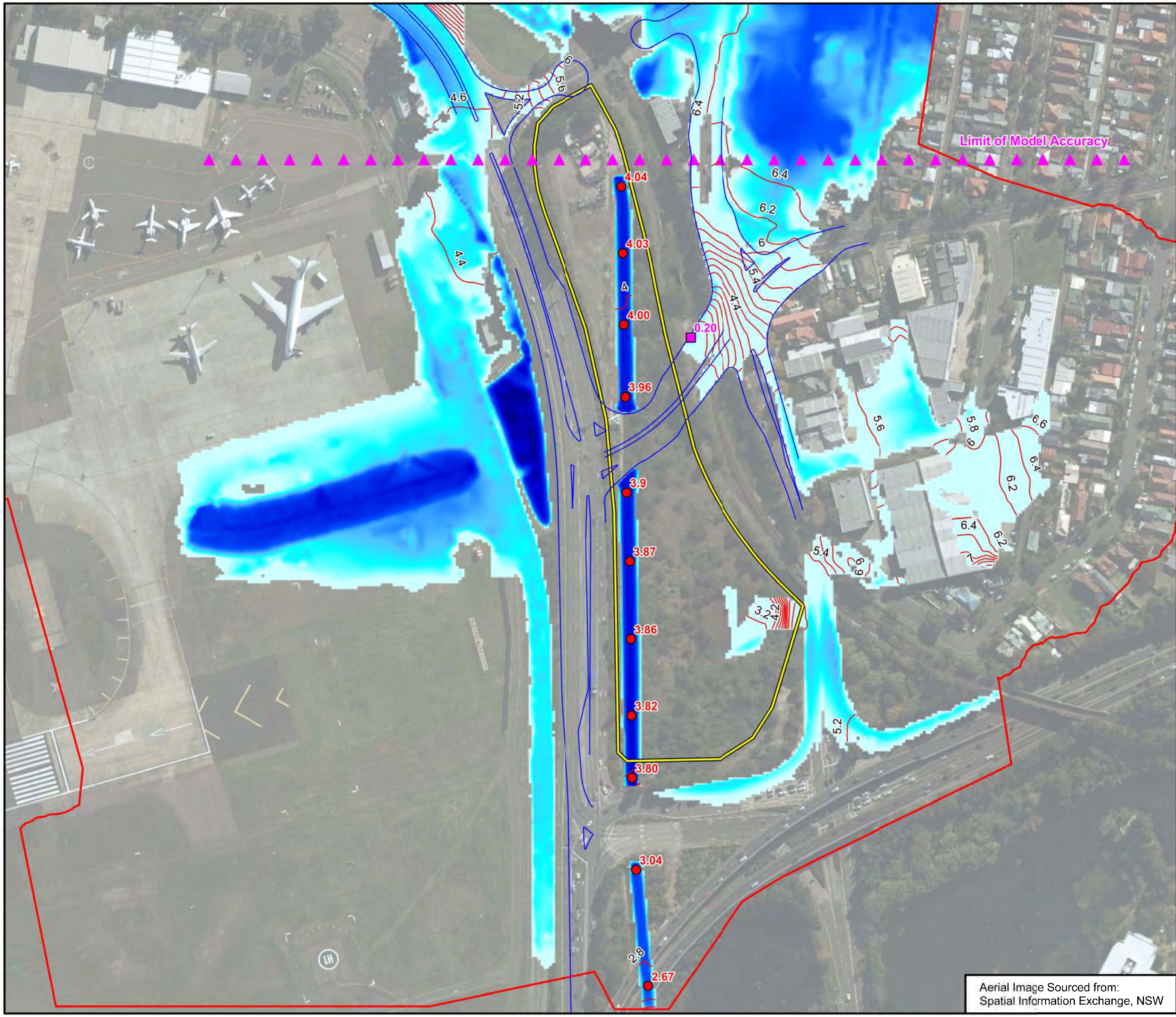
Airport East Precinct Works

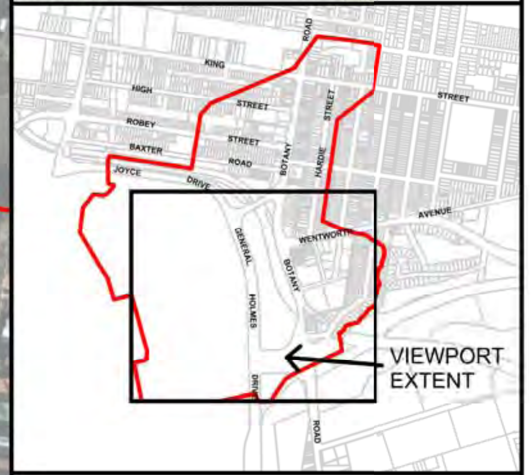
TUFLOW Model Layout Proposed Pump Conditions

File Name: Fig6.19 - TUFLOW Pump
Date : 22/04/14 Issue : A

Transport
Roads & Maritime Services

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au





LEGEND

AIRPORT EAST PRECINCT AREA
TUFLOW BOUNDARY

DEPTH (m)
- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

5.4 0.2m FLOOD CONTOUR
SPOT LEVEL (m AHD)
SPOT DEPTH (m)
PROPOSED ROAD DEVELOPMENT

N W E S
Scale 1: 2,500 @ A3
100 0 m

Figure 6.20

Airport East Precinct Works

Flood Depth and Levels 10% AEP Proposed Pump Conditions

Aerial Image Sourced from:
Spatial Information Exchange, NSW

File Name: Fig6.20 - 10%AEPPump
Date : 22/04/14
Issue : A