ORICA Southlands Remediation and Development Project Hydraulic Modelling Report and Response to Exhibition Submissions/Comments
ORICA

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Contents

1. Introduction

1.1 Background

Orica propose to develop a high quality industrial estate land known as “Southlands” at Banksmeadow near Botany Bay. The land is located in the lower part of the water catchment of Springvale and Floodvale Drains (**Figure 1** in **Appendix A**). The proposal involves a 3 stage development of the Southlands site (**Figure 2** in **Appendix A**) and includes in Stage 2 delivery of a new site access road from Botany Road to McPherson Street along with enhanced drainage infrastructure to alleviate long term flooding issues within the general area.

In 2007, Aurecon undertook a flood investigation of the proposed Orica Southlands site and surrounding areas using a MIKE 11 1D hydraulic model. The investigation involved survey, hydrologic modelling using RAFTS and hydraulic modelling which considered flooding under both the existing scenario and the proposed Stage 1 works. A preliminary analysis of the Stage 2 concept design was also undertaken, although no extensive hydraulic modelling was carried out for the Stage 2 works. Aurecon submitted the report *ORICA/Goodman Southlands Remediation/Development Project* in March 2009 describing the modelling and interpretation of results.

The NSW Department of Planning (DoP) undertook a review of the previous modelling works using independent consultants (Webb McKeown & Associates). Comment on the development was also accepted from surrounding landholders. A meeting with DoP to discuss comments from the review suggested a number of additional tasks, primarily that 2D hydraulic modelling be undertaken to address most of these comments. Responses to comments received are provided in Section 5.

A detailed description of the existing catchment, proposed Stage 1 and Stage 2 development scenarios and previous studies are included in the previous Aurecon study (2009).

The present study was undertaken to address comments received from the DoP following exhibition of the Application. It involved extending the modelling exercise by utilising a two-dimensional hydraulic model, updating the model to include changes in the surrounding area and new developments that have occurred since the original model. The study also included alterations to the development plans to incorporate further flood mitigation measures to ensure no adverse flood impacts thus satisfying the planning criteria.

1.2 Scope of works

Aurecon has undertaken linked 1D/2D hydraulic modelling of the Orica Southlands proposed development and surrounding area to address the DoP and adjoining landowner comments, and to further the modelling to investigate the proposed Stage 2 works.

The scope of works for this portion of the project is:

- Examine issues raised by DoP and adjoining landowners, namely Hynlong Pty Ltd, Solvay Interox Pty Ltd and Sydney Ports Corporation
- Review hydrology to include Climate Change impacts and determine the Probable Maximum Precipitation (PMP) event flows
- Review the terrain model and collect additional survey data
- Develop a linked 1D/2D hydraulic model for the Existing (2009) and proposed Stage 1 development scenario
- Run hydraulic model for the Existing and Stage 1 scenarios
- Develop a linked 1D/2D model for the proposed Stage 2 development scenario
- Run model for the Stage 2 scenario
- Analyse and present the results and reporting
- Liaise with DoP peer reviewer (Webb McKeown & Associates) to ensure DoP comments are addressed within the study

1.3 Structure

The report is presented in the following sections:

Section 1: Introduction – provides a background to the current study, the scope of works and the structure of this report.

Section 2: Description of the Development – Describes the Southlands site and the proposed development which is the subject of the Application.

Section3: Hydrological Analysis – Describes the hydrology of the catchment, the hydrological modelling and the hydrographs developed for use in the hydraulic modelling.

Section 4: Hydraulic Model Setup – Describes the model setup and parameters used for each model scenario to investigate the flood impacts of each stage of the proposed Southlands development.

Section 5: Hydraulic Model Results – provides the results of the hydraulics modelling and defines the flood impacts of each of the model scenarios. Discussion of the results and responses to comments received following exhibition of the Application.

Section 6: Conclusion and Recommendations – provides conclusions drawn from the present study and presents recommendations for approval and future actions.

All figures are presented in **Appendix A** to **Appendix D**.

2. Description of the Development

2.1 Southlands Site

The 19 hectare Southlands site is bounded by McPherson Street on its southern boundary, the port railway line on the east and Floodvale Drain on the west. Springvale Drain runs through the site (**Figure 1**). These “drains” are likely to have been the remnants of previous water courses that have been enlarged over time to assist in draining this previously swampy area.

The Southlands property is the last remaining significant development site on McPherson Street and is the last major development site within its catchment. As a consequence of this, development of the Southlands property is burdened with addressing a flood regime that is a result of all previous development. The result of this is that the Southlands site, to some extent, currently operates as a de-facto flood storage area during major flood events, providing flood storage for other developed sites in the catchment. Contours for the existing site are shown in **Figure 3**.

2.2 Proposed Development

The proposed development envisaged for the Southlands site has been determined in association with a team of consultants and the proponents. The review of flood issues at the site has been a significant part of this process. The final proposal includes construction of a number of warehouses, ancillary office space, access roads and detention basins as set out in the development plans contained in the Environmental Assessment prepared by URS consultants. The area of the proposed development will occupy flood prone areas of the present site and hence the flood study is required to demonstrate that the design does not have an adverse flooding impact on properties upstream or downstream of the site. In addition, capping of the topsoil will provide additional assurances with respect to encountering residual soil contaminants such as asbestos. Further details are provided in the Remedial Action Plan (RAP) (URS, 2007). The high water table and contaminated groundwater also constrain regrading of the site.

The proposed development is to be advanced to the Minister for Planning to seek Project Approval under Part 3A of the Environmental Planning and Assessment Act, 1979. The Part 3A Application proposes a redevelopment of the site on a Staged basis as follows:

- Stage 1 – generally involving the western portion of the site between Floodvale and Springvale Drains and interim flood detention in the Stage 2 area
- Stage 2 – generally involving the south eastern portion of the site, Link Road and drainage downstream
- Stage 3 – generally involving the north eastern portion of the site.

The current Project Application will seek Approval for Stages 1 and 2 of the Project whilst Stage 3 will be the subject of a later approval. Details of the proposed works associated with flood mitigation at the site are given in Section 2.2.1 to Section 2.2.3 below.

As part of the Application process, Director General’s Requirements (DGR’s) have been sought on issues to be covered in the Environmental Assessment. The DGR’s did not note any specific hydrology and flooding issues but it has been determined by the Proponent that this issue needs to be fully reviewed in respect of the new development. Therefore this report provides an overview of flood issues for the entire site (Stages 1 – 3) and more detailed analysis of flooding issues and mitigation measures to be undertaken in Stages 1 and 2 (the subject of the current application).

Furthermore, detailed investigations and design will be required on the Stage 2 works prior to a Construction Certificate for that stage of works, however a workable drainage solution is demonstrated in this report.

Future development of the Stage 3 area will be the subject of a future Project Application based on the flooding parameters set out in this report.

This report thus focuses on the flood mitigation issues for the Stages 1 and 2 of the Development.

2.2.1 Stage 1

The proposed development incorporates filling of areas to the west of Springvale drain that currently provide flood storage. In order to compensate for this loss of flood storage the drainage design required careful consideration of the site geometry. The stage 1 floodplain storage area has been designed to accommodate the flood requirements for the development.

The south-eastern region of the site was identified as potential interim compensatory storage for the Stage 1 development pending development of Stage 2 when the enhancements to Springvale Drain downstream of the site are designed to accommodate reduced flood levels. A potential storage volume curve for the basin east of Nant St was developed from the digital terrain model. Sufficient storage is available in the south eastern section of the site with the proposed earthworks.

Bulk earthworks drawings for the Stage 1 detention area have been reviewed by Golders and Associates and compared to historic groundwater levels. The final detention basin arrangement will be determined in coordination with the onsite environmental management and agreed with the site auditor to optimise the flood storage and groundwater treatment requirements.

The hydraulic model was restructured to utilise this area and thereby offset the existing floodplain storage lost to the proposed Stage 1 development area. This includes regrading the easement along the north of the Southlands site to RL 3.0 m AHD to provide a flood flow path from Floodvale to Springvale Drain. In addition, a set-back of 18 m from Floodvale Drain in the north-western portion of the site has been provided to ensure no development within this area.

The existing Stage 2 area comprises a number of mounds, ridges and holes that would be graded to produce a surface with finished ground levels. A 1.0 m high visual screening embankment is proposed along the McPherson Street boundary. Within the Stage 2 area this embankment also serves as the detention basin embankment (or bund) and as such is designed to a minimum level of RL 4.5 m AHD. This bund will continue at RL 4.5 m AHD along Springvale Drain to the north for approximately 40 m.

A level control structure has been incorporated within Springvale Drain approximately 25 m upstream of McPherson Street to raise water levels upstream of the structure during large events to divert flood waters to the detention area. The structure is effectively a compound weir with crest at RL 3.2 m AHD and a 3 m wide low flow cut-out. This reduces the channel width to 3 m from the bed to RL 3.2 m, above which flow is allowed to pass over the wing walls. A different weir or other control structure design that has an equivalent rating curve could be used as an alternative to this design. To facilitate the effectiveness of the structure localised regrading of the existing Nant St access track and the Springvale Drain western bank will be needed to create high points at RL4.0 m AHD adjacent to the level control structure.

The basin has a minimum longitudinal slope of 0.33% to allow free drainage. The basin extents do not impact on the easements to the east of Stage 2 area. The basin interface with existing levels has been achieved using a batter slope of 1 in 6 for safety reasons. Given the relatively large basin surface area, batter slopes do not have a significant influence on the stage-storage curve of the basin.

The Stage 3 area would largely remain undeveloped as part of the Stage 1 works, with the exception of earthworks in the south-eastern portion of this area to provide additional storage. The existing levels provide an overflow path between Springvale Drain and the interim Stage 2 flood detention area.

The proposed earthworks design was consequently developed to utilise the south-eastern quadrant of the site as an interim floodplain storage area thus, the design incorporates the developed Stage 1 area in the western half, a large detention basin in the south-eastern area (Stage 2) with the north-eastern area (Stage 3) remaining largely in its existing state.

The impact of the proposed Stage 1 development was then assessed by running the MIKE FLOOD model with the revised terrain model and structures and comparing results with the existing terrain results for the same inflow events.

The modelled earthworks plan for Stage 1 is shown in **Figure 4**.

2.2.2 Stage 2

Stage 2 of the development involves the introduction of new drainage infrastructure in tandem with the new link road (from Botany Road to McPherson Street) allowing a significant improvement for the drainage of Springvale and Floodvale catchments. However as the new road is not proposed until Stage 2 of the Project, detailed consideration has been given to the options and alternatives for developing the Stage 1 area of the site that will not cause any significant impact on surrounding properties.

The proposed Stage 2 development aims to alleviate flooding by enlarging the culverts and channel dimensions to contain 1% AEP flood flows within the banks of the refurbished Springvale Drain within and downstream of the Southlands site. A plan view of the proposed Stage 2 Springvale Drain enhancement activities is shown in **Figure 5**.

The works would include the following:

- Enlarging the Stage 1 culverts under the new Stage 1 access road crossing of Springvale Drain
- New culverts under McPherson Street and the new roundabout
- Additional culverts running in tandem with the new link road between McPherson Street and the Southern and Western Suburbs Ocean Outfall Sewer (SWSOOS)
- Improved siphon under the SWSOOS
- New open channel in tandem with the new link road through Discovery Cove to the new intersection at Botany Road
- A new road crossing for new culverts under Botany Road to connect with the existing open channel at the Caltex property that forms the effective entry to the Penrhyn Estuary (Botany Bay).

As discussed previously (SKM, 1992) the design of these upgrades would allow for detention, trash racks and gross pollutant traps.

2.2.3 Stage 3

Stage 3 of the development would involve further filling of the Stage 3 area to house more warehouses and would include internal access roads and detention basins. As discussed above, future development of the Stage 3 area will be the subject of a future Project Application.

3. Hydrological Analysis

3.1 Introduction

The peer review undertaken for the previous study (Aurecon, 2009) requested that the 2D hydraulic model be run for the Probable Maximum Flood (PMF) and 1% Annual Exceedance Probability (AEP) event with the predicted impacts of Climate Change included.

Where possible the inflow hydrographs from the previous study (Aurecon, 2009) have been used as input into the hydraulic model. The existing RAFTS model was used to simulate the Probable Maximum Precipitation (PMP) event and 1% AEP event with predicted climate change impacts included. The development of these additional runs is discussed in the Section 3.3. Inflow Hydrographs used in the hydraulic modelling are shown in **Appendix B**.

3.2 Existing RAFTS hydrological model

The hydrological analysis undertaken in the previous study (Aurecon, 2009) utilised the RAFTS hydrological modelling software package. The model for the Southlands site was adopted from the existing RAFTS model of Springvale and Floodvale drains (**Figure 6**), prepared previously by Lawson and Treloar (May, 2003) and detailed in Appendix I of the Port Botany Expansion Environmental Impact Statement (Volume 4). The Lawson and Treloar model was modified to incorporate more detail in the proposed Southlands development area to accommodate assessment of the impacts on the drainage. The revised sub-catchments included an increase in the impervious area percentage within the Southlands site from 0% in the existing situation to 80% for the developed situation.

The RAFTS model was run with the same assumptions and input values as used previously by Lawson and Treloar. These values appear appropriate for the catchment and have been tested by various validation methods outlined in Lawson and Treloar. Use of the same values also allows the results from the two studies to be compared. The model assumptions and input parameter values are outlined in **Table 3.1** below.

Table 3.1 RAFTS model assumptions and input parameters

Parameter	Value	Comment
Pervious Surface – Initial Loss	50 mm	This value is higher than many other catchments due to the high hydraulic conductivity of the local botany sands. Using a higher pervious surface loss is conservative in that it will lead to larger detention basins in the proposed development when highly pervious areas are paved.
Pervious Surface – Continuing Loss	15 mm/hr	As above
Pervious Surface – Manning's n	0.025	This is a conservative (with reference to hydrology rather than hydraulics) value, associated with short grass. It is considered appropriate as most pervious areas within the catchments are of an urban nature, being golf courses, gravel roads or grassed areas.
Impervious Surface – Initial Loss	1 mm	Typical of paved areas
Impervious Surface – Continuing Loss	1 mm/hr	Typical of paved areas

Parameter	Value	Comment
Impervious Surface – Manning's n	0.010	This is a conservative (with reference to hydrology rather than hydraulics) value, associated with a piped stormwater system that can convey flows rapidly through the catchment.

The RAFTS model was run for a range of storm events including Average Recurrence Intervals (ARI's) of 1, 2, 10, 20, 50 and 100 years and durations of 15, 20, 45 minutes and 1, 1.5, 2, 3, 6, 9 and 12 hours.

Generally the critical storm for Floodvale drain was found to be a 60 minute event and the critical storm for Springvale drain was found to be a 90 minute event. To simplify the analysis, however, a 90 minute duration storm was adopted for both drains since the volume of water in a 90 minute storm is greater than that of a 60 minute storm. The difference in peak flows resulting from this assumption is outlined in the previous report (Aurecon, 2009) and was considered negligible.

A 90 minute storm duration has been assumed for both the Floodvale and Springvale Drains for this study (see **Appendix B**).

3.3 Hydrology review

The inflow hydrographs from the previous Aurecon study have been used as input into the linked 1D/2D hydraulic model developed for this study.

The existing RAFTS model was not set-up to simulate the PMP storm event or to incorporate the predicted impacts of climate change into individual design ARI storm event simulations. The existing RAFTS hydrologic model has been modified to simulate the PMP and 1% AEP event (with predicted Climate Change impacts). The model development and RAFTS model results from these two additional scenarios are discussed in the Section 3.3.1 and 3.3.2.

3.3.1 Probable Maximum Flood

The Probable Maximum Flood (PMP) has been calculated for the Floodvale/Springvale Drain catchment using "The Estimation of PMP in Australia: Generalised Short-Duration Method" (Bureau of Meteorology, 2003). The PMP was calculated for a range of storm durations to determine the critical duration for the catchment. It is noted that the PMP design temporal pattern from the Generalised Short-Duration Method (GSDM) is different to the AR&R temporal patterns used for the standard ARI design storms and therefore the critical storm duration may be different for the PMP storm event. The PMP has been calculated as 290mm, 340mm, 390mm and 430mm for the 45 minute, 60 minute, 90 minute and 120 minute storm durations respectively.

The RAFTS model has been modified to include Probable Maximum Flood runs for the above storm durations. This simulation uses the PMP rainfall intensity and PMP design temporal distribution from the GSDM.

The catchment initial loss and continuing losses for the PMP storm event have been updated as per recommendations in "Australian Rainfall & Runoff (AR&R) Book VI" (Institution of Engineers Australia, 1998). An initial loss of 0 mm and continuing loss of 1mm/hr has been used for the PMP storm simulated in RAFTS.

The critical storm for Floodvale drain was found to be a 45 minute event and the critical storm for Springvale drain was found to be a 60 minute event. However, to simplify the analysis a 60 minute duration storm was adopted for both drains since the volume of water in a 60 minute storm is greater than that of a 45 minute storm.

The peak PMF discharge for Floodvale Drain and Springvale Drain has been estimated as 87.7m^3/s and 147.0m^3/s, respectively. Inflow hydrographs were extracted from RAFTS to be used as inflows into the linked 1D/2D hydraulic model.

Plot of the hydrographs for the PMF and 1% AEP event (with climate change included) are presented in **Appendix B**. Refer Section 3.3.2 for a discussion of the 1% AEP inflows with climate change impacts included.

3.3.2 Climate change impacts

In addition to the rainfall events modelled previously a simulation of the effects of climate change on the 1% AEP event was also requested.

The predicted increase in rainfall intensity was sourced from the "Floodplain Risk Management Guideline: Practical Consideration of Climate Change", (DECC, 2007). For Sydney Metropolitan catchments the extreme rainfall projected change is +12%.

The 1% AEP event IFD rainfall intensities were increased by 12% in the RAFTS hydrologic model and inflow hydrographs were extracted for use as upstream boundary inflows to the linked 1D/2D hydraulic model.

The peak discharge for both the 1% AEP and future 1% AEP with climate change are presented for Floodvale and Springvale Drains in **Table 3.2** below.

Table 3.2 Comparison of 1% AEP peak discharges from RAFTS analysis

Drain	Peak RAFTS Discharge (m^3/s)	
	1% AEP	1% AEP (with CC)
Floodvale	25.5	28.9
Springvale	39.3	45.3

It is noted that the future 1% AEP with climate change impacts is considered to be of a similar magnitude to the current 0.5% AEP flood event and hence results of this storm may be used to infer the effects of the current 0.5% AEP event.

3.4 Hydraulic model inflow boundary conditions

Inflow hydrographs for the 50% AEP, 10% AEP, 1% AEP, 1% AEP with CC and PMF events were extracted from the RAFTS hydrologic model to be used as inflows into the linked 1D/2D hydraulic model.

Peak discharges for all design events modelled are presented in **Table 3.3** below for Floodvale and Springvale Drains respectively.

Input hydrographs for the developed case were the same as the input hydrographs for the existing case, based on the assumption that additional runoff generated by the developed site will be detained/attenuated on site in the Stage 1 detention basin area.

Table 3.3 Peak flood discharges upstream of the Southlands site

AEP (%)	Peak RAFTS Discharge (m^3/s)	
	Floodvale Drain	Springvale Drain
50	10.8	14.0
10	16.7	23.9
1	25.5	39.3
1 with CC	28.9	45.3
PMF	75.2	142.4

4. Hydraulic Model Setup

4.1 Introduction

As discussed in Section 1, the hydraulic model has been developed to be run with various topography and inflow scenarios. The previous model setups were used as the basis for the current work with recent changes to topography, changed structures and blockage incorporated. Scenarios modelled in this study are listed below:

- **Existing (2009 Topography)** – Based on the existing "2005 topography" survey used for the previous Aurecon study but with the modifications to sites at 15 McPherson Street and at the corner of McPherson Street and Exell Street including earthworks and new buildings that have been developed since the previous Aurecon study. Bridges across Springvale Drain and associated culverts that were removed have been removed from the model. Additional survey was undertaken to obtain more ground levels within the Mobil site including bunds around the tanks. Survey also obtained information about a recently constructed concrete channel along the northern boundary of the Mobil site which connects Springvale drain to Floodvale drain upstream of Mobil and the Southlands site. Coal Pier Road and Bridge and trash racks upstream of the McPherson St culverts on both drains were also surveyed and incorporated in the model. This was done to ensure the present study represents the current topography within the model domain.

- **Stage 1 Development (based on 2009 Topography) –** Develop the Stage 1 area for industrial uses (include building platform) and provide interim floodplain storage in the future Stage 2 area (with minor regrading) and overland flow across the Stage 3 area.

- **Stage 2 Development (based on 2009 Topography) –** Develop the Stage 2 area following construction of the proposed Link Road and enhancements to the Springvale Drain culverts within and downstream of the ORICA Southlands site.

Blockage factors have been applied to all hydraulic structures (refer to Section 4.3.1).

A detailed description of the Existing, Stage 1 development and Stage 2 development scenarios are included in Section 2. Figures showing the model setup are presented in **Appendix C**.

4.2 Modelling approach

As discussed in Section 1.1, the NSW Department of Planning (DoP) undertook a review of the previous modelling works using an independent consultant Webb McKeown & Associates. Comment on the proposed development was also accepted from surrounding landholders. During a meeting with DoP to discuss comments from the reviewers it was suggested to undertake a number of additional tasks, primarily that 2D modelling be undertaken to address issues raised and improve the level of confidence in the predicted flooding characteristics.

Hydraulic modelling for this study was undertaken using the MIKE FLOOD Software Package developed by DHI. MIKE FLOOD integrates the two-dimensional MIKE 21 and one-dimensional MIKE 11 hydraulic modelling packages into a single, dynamically coupled hydraulic modelling system. Using this 1D/2D coupled approach enables the best features of both one-dimensional and two-dimensional models to be utilised, whilst at the same time avoiding many of the limitations of resolution and accuracy encountered when using MIKE 11 or MIKE 21 separately (DHI, 2008).

Complex overland flow paths are best represented by a two-dimensional hydraulic model. MIKE 21 is a comprehensive modelling system for two-dimensional free surface flows where stratification can be neglected. MIKE 21 simulates the water level variations and flows in response to a variety of forcing functions in floodplains, lakes, estuaries, bays and coastal areas. The water levels and flows are resolved on a rectangular grid covering the area of interest when provided with the bathymetry (topography), bed resistance coefficients and hydrographical boundary conditions.

The following hydraulic models have been developed for this study:

- 1D MIKE 11 hydraulic model of the Floodvale and Springvale Drains only and all structures included within the drains such as culverts, inverted syphons, weirs and trash racks.

- 2D MIKE 21 hydraulic model of the floodplain between the Floodvale and Springvale Drains as well as the greater catchment.

- 1D/2D coupled MIKE FLOOD hydraulic model to link the MIKE 11 and MIKE 21 models into a single, dynamically coupled hydraulic modelling system. The lateral links allow floodwater that overflows a 1D channel onto a floodplain or vice versa by allowing MIKE 21 cells to be laterally linked to a given 1D reach in MIKE 11.

It is noted that due to the narrow/deep nature of the Floodvale and Springvale Drains it is not possible to adequately resolve the topography of the drains onto a 2D MIKE 21 model topography within the limitations of the 2D MIKE 21 governing equations. The Floodvale and Springvale Drains are considered to be sub grid scale structures and must therefore be included in a 1D MIKE 11 model which is dynamically coupled to the 2D hydraulic model.

The hydraulic model development is discussed in the following sections.

4.3 Model development

The development of the 1D MIKE 11 model, 2D MIKE 21 model and 1D/2D coupled MIKE FLOOD model are discussed in the following sections.

4.3.1 MIKE 11 – 1D model development

Floodvale and Springvale Drains have been modelled using DHI's 1D MIKE 11 hydraulic modelling software. This approach ensures that the drain conveyance is accurately resolved and allows structures within the drains to be accurately modelled. It is important that hydraulic control structures such as culverts and inverted syphons are accurately modelled as these structures control the proportion of flood water that overflows onto the floodplain within the ORICA site.

Individual elements of the MIKE 11 model development are discussed below.

Existing Scenario

- **Model extent** – The 1D MIKE 11 network includes the Floodvale Drain, Springvale Drain and the concrete channel that connects Springvale Drain to Floodvale Drain just upstream of the Mobil site. The two drains extend downstream to Botany Bay.

- **Cross-sections** – Cross-sections at various chainages along the drains have been extracted from the previous study catchment ground survey. The existing ground survey was carried out by AAMHatch Pty Ltd (2005). Additional survey was carried out by Aurecon as part of this study. The model cross sections only represent the main drains between the left and right banks. When the flood level exceeds the bank elevations, floodwater can spill out of the MIKE 11 channel into MIKE 21 via the MIKE FLOOD lateral links and vice versa.

- **Upstream Inflows** – Design inflows to the upstream boundaries of Floodvale and Springvale Drain have been taken from the RAFTS hydrologic model (Refer Section 3).

- **Boundary Conditions** – The downstream boundary condition has been set to a constant water level of 1m AHD. This value was used in the previous Aurecon study (2007) and is approximately equal to the High Water tide level in Botany Bay. It is noted that flooding within the ORICA site is governed mainly by the hydraulic controls at the inverted syphons under the SWSOOS and downstream ocean tide levels have negligible effect on the Orica site flood levels. As such, the 1% AEP (with CC impacts) scenario was run with a downstream boundary condition of 1m AHD and did not account for predicted sea level rise.

- **Roughness –** The roughness values for Floodvale and Springvale Drains have been selected based on a visual inspection and aerial photography. Manning's n value of 0.07 and 0.06 has been selected for the Floodvale and Springvale Drains, respectively due to significant vegetation growth within the channels.
- **Structures –** Culverts, inverted syphons, piped sections and trash racks on Floodvale and Springvale Drains have been included in the MIKE 11 model. A list of structures and modelled blockage factor is presented in **Table 4.1** below.

Table 4.1 Structure blockage factors

Structure	Description	Blockage Factor (%)
Floodvale Drain		
Culvert	Pipeline under Mobil site	50
Bridge	Coal Pier Rd Bridge (just downstream of Mobil site)	50
Trash Rack	Trash rack upstream of McPherson St Bridge	100
Culvert	McPherson St.	50
Inverted syphon	Inverted syphon under the SWSOOS	70
Culvert	Pipeline beneath Botany Golf Course. Discharges into Botany Bay	50
Springvale Drain		
Trash Rack	Trash rack upstream of McPherson St Bridge	100
Culvert	McPherson St.	50
Inverted syphon/ Culvert	Inverted syphon under the SWSOOS and then pipeline though the Discovery Cove Site.	70
Culvert	Culverts beneath Penrhyn Rd. Discharges into Botany Bay.	50

Stage 1 Development Scenario

All variables have been maintained other than the introduction of a level control structure approximately 25m upstream of McPherson Street on Springvale Drain. The weir is effectively a constriction to reduce the channel width to 3m between the bed and an elevation of 3.2m AHD (approximate bank level by the construction of wing walls that extend into the bank). This allows low flows to be maintained with relatively little impact while larger flows are diverted into the detention basin through raising the water level.

Stage 2 Development Scenario

The Springvale Drain has been altered to introduce the planned structures described in Section 2 and shown in **Figure 5**. The new structures have had a 50% blockage factor applied assuming reasonable maintenance of the structures with the introduction of a Gross Pollutant Trap device upstream of the inverted siphon under the SWSOOS. The significant number and width of the culvert set under McPherson Street allows the assumption that a significant blockage of these structures is unlikely and hence a 25% blockage factor has been applied. The bed roughness values have been reduced to 0.04 to represent the channel improvement and the less likely overgrowth/vegetation that can occur in future.

4.3.2 MIKE 21 – 2D model development

Given the wide unconfined nature of the existing catchment topography, overland flow is better represented by a two-dimensional hydraulic model. MIKE 21 is a comprehensive modelling system for dynamic two-dimensional free surface flows. The water levels and flows are resolved on a rectangular grid covering the area of interest when provided with the topography, bed resistance coefficients and hydrographical boundary conditions.

An overview of the MIKE 21 model development, key assumptions and model parameters are presented below:

Existing Scenario

- **Topography** – The model topography has been derived from detailed survey of the Southlands site carried out by AAMHatch Pty Ltd (2005) and Airborne Laser Survey (ALS) data of the catchment. Additional detailed ground survey undertaken for this study has also been incorporated in the model topography in areas where new buildings (including the Toll Warehouse) or changes to structures have been made. The site topography has been represented on a rectangular grid with a cell size of six (6) metres. Floodvale and Springvale Drains below bank level have been blocked out of the MIKE 21 topography to prevent the MIKE FLOOD model duplicating conveyance and storage in both MIKE 11 and MIKE 21. The storage tanks on the Mobil and Qenos sites have been blocked out of the topography since it is not possible for floodwaters to flow through the tanks. Major buildings around the area have been blocked out and smaller buildings are incorporated through increased roughness. The existing levees around the Mobil storage tanks have been included into the MIKE 21 topography. The existing levees have been represented as two cells wide. This is required because MIKE 21 requires two cells to calculate the transition between sub and super-critical flow and this is also required to reduce numeric instabilities in the model. The Stage 1 development topography includes the proposed building platform and interim floodplain storage in the future Stage 2 area (with minor regrading). The Stage 2 development topography includes construction of the proposed Link Road and enhancements to the Springvale Drain culverts within and downstream of the ORICA Southlands site. Maps of model topography for the Existing (2009 Topography), Stage 1 development and Stage 2 development are presented in **Appendix C**.

- **Boundary Conditions -** The downstream boundary condition has been set to 1m AHD. This value was used in the previous Aurecon study and is approximately equal to the High Water in Botany Bay. Inflow hydrographs from RAFTS have been entered into the MIKE 11 hydraulic model at the upstream extent of Floodvale and Springvale Drains. This includes an additional flow to incorporate the contribution from the post-development Southlands site runoff.

- **Bed Resistance** – The bed resistance (roughness) of the site was represented using roughness coefficients over the rectangular grid. Manning's roughness coefficients used for this study are presented in **Table 4.2**.

Table 4.2 Manning's Roughness Coefficients for 2D Hydraulic Model

Surface Type	Value	Comment
Roads (concrete)	0.015	Concrete roads and surfaces
Roads (asphalt/gravel)	0.02	Asphalt and gravel surfaces
Floodplain	0.05	Vegetation between Floodvale and Springvale Drains
Grass	0.03	Short grass regularly mown such as the Botany Golf Course (water depth > grass height)
Thick vegetation	0.1	Some areas on the floodplain include very thick vegetation with closely spaced trees, regular shrubs and difficult to walk through
Buildings (which have not been blocked out)	0.4	The increased energy dissipation of water flowing through and around buildings has been represented by increasing the bed resistance parameter. This approach is favoured over blocking out the building as it includes the storage effects of the building being inundated.

Bed resistance maps used in the MIKE 21 model topographies as presented in **Appendix C**.

Stage 1 Development Scenario

- **Topography** – Differences in the topography for this scenario include the proposed Stage 1 Southlands development site, the earthworks to create the detention basin in the Stage 2 area, setbacks and minor regrading surrounding the site to provide flood flow paths and high points adjacent to the level control weir structure in Springvale Drain approximately 25 metres upstream of McPherson St. Terrain models of the proposed Stage 1 area were created and a flood model grid for the proposed system extracted to represent the developed ground surface. The new terrain model for the Stage 1 development is presented in **Appendix C**.

- **Boundary Conditions -** The same downstream boundary condition and inflow hydrographs have been used as for the Existing scenario.

- **Bed Resistance** – Bed resistance remains unchanged for undeveloped areas and in the detention basin area. Bed resistance on the Southlands site has been set to 0.015 and 0.02 for paved areas, although this is largely inconsequential as the site is predominantly raised above the 100 year flood level.

Stage 2 Development Scenario

- **Topography** – Differences in the topography for this scenario include the filling of the proposed Stage 2 Southlands development site to raise it to proposed levels. The new Link road has been introduced and all associated Stage 2 development buildings have been appropriately adjusted and blocked out such that water cannot flow through them. In addition the topography has been modified where minor earthworks are required in the vicinity of channel improvements in the Springvale Drain downstream of the Southlands site such as at the drain widening to incorporate new larger structures.

- **Boundary Conditions -** The same downstream boundary condition and inflow hydrographs have been used as for the Existing scenario.

- **Bed Resistance** – Bed resistance remains unchanged for undeveloped areas and in the detention basin area. Bed resistance on the Southlands site has been set to 0.015 and 0.02 for paved areas, although this is largely inconsequential as the site is predominantly raised above the 100 year flood level.

4.3.3 MIKE FLOOD – Linked 1D/2D model development

MIKE FLOOD integrates the two-dimensional MIKE 21 and one-dimensional MIKE 11 hydraulic modelling packages into a single, dynamically coupled hydraulic modelling system.

Lateral links located along both banks of the two drains allow floodwaters to overflow from the 1D drain onto a floodplain or vice versa by allowing MIKE 21 cells to be laterally linked to a given 1D reach in MIKE 11.

All model simulations were undertaken using the linked 1D/2D MIKE FLOOD model.

Table 4.3 presents a list of all the lateral links included within the Existing (2000 Topography) and Existing (2009 Topography) MIKE FLOOD models. **Table 4.3** presents a schematic of the 2D MIKE 21 topography, 1D MIKE 11 network (Floodvale and Springvale Drains) and location of the 1D/2D MIKE FLOOD lateral links.

Table 4.3 Existing Scenario MIKE FLOOD lateral link locations

Link Id left / right side of drain	Upstream extent of lateral link	Downstream extent of lateral link
Floodvale Drain		
1/2*	Upstream end of Floodvale Drain	Upstream of Mobil site
3/4*	Downstream of Mobil site	Upstream of Coal Pier Road Bridge
5/6*	Downstream of Coal Pier Road Bridge	Upstream of McPherson Street Bridge
7/8*	Downstream of McPherson Street Bridge	Upstream of SWSOOS No.2
9/10*	Downstream of SWSOOS No.2	Foreshore Road
Springvale Drain		
11/12*	Upstream end of Springvale Drain	Upstream of McPherson Street Bridge
13/14*	Downstream of McPherson Street Bridge	Upstream of SWSOOS No.2
Link Channel (from Springvale Drain to upstream end of Floodvale Drain)		
15/16*	Springvale Drain	Upstream end of Floodvale Drain

NOTE: (*) Lateral link provided on the true left and true right bank of the drain.

Stage 1 Development Scenario

The MIKE FLOOD links have been updated for the Stage 1 development scenario. Lateral links 11 and 12 (refer **Table 4.3** above) have been modified to accommodate the proposed level control structure by including lateral links upstream and downstream of the structure. An explicit link has been included to allow floodwater in the interim detention basin to flow back into Springvale Drain (when the flood level drops) via the proposed low flow culvert.

Stage 2 Development Scenario

The MIKE FLOOD links have been further updated for the Stage 2 development scenario to accommodate the proposed changes to the Springvale Drain.

4.4 Model Scenarios

The MIKE FLOOD scenarios simulated for this study are presented in **Table 4.4** below.

Table 4.4 Model scenarios

Topography Scenario	Flood Event Scenario (AEP)				
	50%	10%	1%	1% with Climate Change	PMF
Existing (2009)	X	X	X		
Stage 1 (2009)	X	X	X	X	X
Stage 2 (2009)	X	X	X	X	

Hydraulic model results are discussed in Section 5 below.

5. Model results

Flooding in the Springvale and Floodvale Drains catchment is a result of the complex interaction of runoff from key storm events coupled with flat terrain, significant development for industrial purposes in the catchment and undersized, poorly maintained drainage infrastructure. The recent construction of a concrete channel north of the Mobil site connected Springvale Drain to Floodvale Drain along with new developments since the previous hydraulic model study have further altered the flood behaviour.

Development of the Southlands site is further complicated by the relatively high groundwater table and groundwater contamination under the site, reducing opportunities for extensive site grading works to increase storage capacity and thereby accommodate major flood events. Importantly though, the key objective of the revised modelling and development is to deliver 'no impact' on any adjacent property. Consequently, numerous development options were reviewed but only the preferred hydraulic options are presented as part of this Project Application.

It is assumed that the existing drains and other structures are partially blocked as observed on site and as per guidelines in the NSW Floodplain Development Manual (2005).

Model results for all scenarios are presented as a maximum flood level map showing the extent of flooding. The Stage 1 and Stage 2 development scenarios also present a flood level difference map to show the comparison with the existing scenario. These are presented in **Appendix D**.

The hydraulic modelling assumes the water flow characteristics are well resolved by the representation of the actual drainage channels on site and the model equations that represent the hydraulics. Given the ALS accuracy, assumptions about the hydraulics and a range of contributing factors the absolute accuracy of the model results is difficult to define. This is typical of flood models where limited data for calibration is available. However, relative accuracy is likely to be in the order of ±10 millimetres. As such, in presentation of the results, a flood difference of 10 millimetres or less is considered 'no impact' as agreed with the peer reviewer.

5.1 Existing

The results for the existing flooding situation during the 1% AEP event (**Figure 8**) show that the Southlands site currently acts as a flood storage area for the wider catchment receiving overbank flows from both drains. Flooding occurs over the northwest and southeast areas of the Southlands site as well as adjacent areas both upstream and downstream of the site. A major reason for this is the inadequacy of the capacity of the drainage infrastructure as well as the high propensity for blockage of these structures, further reducing their capacity.

Maximum flood level results for the 50%, 10% and 1% AEP events under existing conditions are shown in **Appendix D**. The results show that with the applied roughness and blockage factors described above, flood waters will overtop the banks of both the Floodvale and Springvale Drains. The small capacity of the drains causes flooding of the Southlands site and adjacent properties for the 50% AEP event and larger events. The following findings can be made:

- The flows enter the Southlands site from the Mobil site and Floodvale Drain and flow across towards the Springvale Drain where flows also overtop the banks spilling into the site.
- There are a number of hydraulic controls along both drains which influence flood behaviour, particularly when partially blocked.
- Flood levels at the Southlands site are predominantly controlled by the top level of the Southern and Western Suburbs Ocean Outfall Sewer (SWSOOS). The SWSOOS runs from west to east, approximately halfway between Botany Road and McPherson Street. It consists of an approximately 3m wide x 2m high rectangular concrete structure that crosses above both Springvale and Floodvale drains.
- The SWSOOS crossing of Floodvale drain creates a short siphon (approximately 10m along the direction of flow), where the drain flows under the concrete sewer. This appears to operate

effectively during low flows, however in a 1% AEP event the siphon cannot accommodate the peak flows. The SWSOOS begins to act as a dam wall that is overtopped in the peak event, particularly in its current partially blocked state. This results in a backwater effect, with the upstream water surface elevation determined by the depth of flow over the top of the SWSOOS.

- The trash racks upstream of the culverts under McPherson St in both Floodvale and Springvale Drains are significantly blocked with vegetative debris and general gross pollutants such that the trash racks effectively act as weirs, raising the upstream water levels.
- The two drains are hydraulically linked, with overbank flow moving between Floodvale and Springvale Drains at a number of locations: upstream of the Mobil site, through the Mobile site, through the Southlands site, at the SWSOOS and again downstream through the Discovery Cove industrial complex area.
- The newly constructed concrete channel north of the Mobil site appears to encourage additional flow from Springvale Drain towards Floodvale Drain during flood events.

5.2 Stage 1

Model runs for the existing system indicated a maximum flood level in Springvale drain of around RL 4.15 m AHD and that approximately 20,000 m^3 of water flooded over the proposed Stage 1 development area. The south-eastern region of the site was identified as potential interim compensatory storage for the Stage 1 development pending development of Stage 2 when the enhancements to Springvale Drain downstream of the site are designed to accommodate reduced flood levels.

A potential storage volume curve for the basin east of Nant St was developed from the digital terrain model. At an elevation of RL 4.2 m AHD some 50,000 m^3 of storage is available in the south eastern section of the site with the proposed earthworks, which is sufficient to offset the filling of the Stage 1 development area.

The Stage 1 development scenario 1% AEP flood extents (**Figure 9**) show similar extents to those for the existing flood extents. Due to the filling of the site, flood waters no longer enter the northern portion of the Southlands site, but are diverted along the northern boundary of the site from Floodvale Drain towards Springvale Drain. Within the site itself the distribution of flood depths shifts from the proposed Stage 1 development area west of Springvale Drain to the Stage 2 area east of the drain. The flood level difference map (**Figure 10**) indicates that there is no off-site increase in flood levels.

Maximum flood level results for the 50% AEP, 10% AEP and 1% AEP events with the proposed Stage 1 development scenario are shown in **Appendix D**. Flood level difference maps for all design events indicate that the proposed development has no adverse flood impacts to any surrounding properties and the flood waters are successfully diverted and detained within the Southlands site. The following findings can be made:

- The flows are diverted from Floodvale Drain to Springvale Drain through the easement along the northern boundary of the Southlands site
- The proposed level control structure upstream of Springvale Drain raises water levels within Springvale Drain on the Southlands site, which allows flood waters to enter the Stage 1 detention basin.
- As flows recede, stored flood waters are able to flow back into Springvale Drain from the detention basin either back over the banks or through a low flow outlet to be constructed at the low point in the basin.
- Flood levels remain the same or are in many circumstances lower on adjoining properties following the Stage 1 development. This is particularly the case for properties downstream of the site adjacent to Springvale Drain.

To demonstrate the effectiveness of the detention basin, the following **Table 5.1** shows the flood storage volumes within the Stage 1 and Stage 2 and 3 areas of the site for the existing case and the

Stage 1 development scenario. Volumes are shown at RL 4.1 m AHD and RL 4.2 m AHD, which encompasses the 1% AEP flood levels for both scenarios in both Drains.

Table 5.1 Flood storage volumes - Existing and Stage 1 development scenarios

Scenario	Flood Storage Volume (m^3)		
	Stage 1	**Stage 2 and 3**	**Total**
At RL 4.1 m AHD			
Existing	34,700	20,000	54,700
Stage 1 Development	14,300	44,100	58,400
At RL 4.2 m AHD			
Existing	41, 400	23,400	64,800
Stage 1 Development	16,200	49,600	65,800

The Stage 1 modelling assumes existing Nant Street access track levels, which flood waters can pass over to enter the detention basin. If the elevation of this track is raised, additional works will be required to provide culverts or similar under the road to allow flows to enter the detention basin.

Results for the PMF event are also shown to indicate the maximum extent of flooding expected (**Figure D13**).

5.2.1 Factors affecting Stage 1 and 2 floor and road levels

Building finished floor levels within the Stage 1 and 2 area are required to be set above the 1 in 1% AEP flood event including Climate Change impacts (**Figure11**).

The design floor levels for the warehouse areas of the proposed development are subject to a number of criteria including:

- 1% AEP Flood (including Climate Change) level plus 300 mm freeboard.
- The ability to drain stormwater from the site.
- Site remediation levels as defined in the preferred remediation strategy documented in URS (2007)

The design floor level needs to be set at the highest of these constraints, which may vary for different locations on the Southlands property and may be reduced as a result of the Stage 2 works, however initial Stage 1 filling works will need to meet current flood conditions as proposed in Stage 1.

The 1% AEP event with Climate Change results indicate maximum flood levels along the northern boundary of the Southlands site are RL 4.2m AHD near Floodvale Drain. Incorporating 300mm freeboard results in a minimum finished floor level to satisfy flood criteria of 4.5 m AHD at this point.

Maximum flood levels along the southern boundary of the Southlands site are RL 4.1m AHD near Springvale Drain. Incorporating 300mm freeboard results in a minimum finished floor level to satisfy flood criteria of 4.4 m AHD at this point.

5.3 Stage 2

The Stage 2 development aims to confine the flood flows within the refurbished Springvale Drain. Downstream of the Southlands site the new Link road will be tied into McPherson St and Botany Road and most likely will include a bridge over the SWSOOS. This component of the project will require negotiations with a number of stakeholders including property owners, council and asset managers to formulate a detailed plan.

The proposed Stage 2 development scenario maximum flood level results for the 1% AEP event along with a flood level difference map is shown in **Figure 12** and **Figure 13** as well as **Appendix D**. Maximum flood level results for the 50% AEP, 10% AEP and 1% AEP events with the proposed Stage 2 development scenario are shown in **Appendix D**.

These results demonstrate that the improvements to Springvale Drain as part of the Stage 2 development works will largely contain the 1% AEP event such that there are no adverse impacts off-site as a result of Stage 2 and Stage 3 developments.

The proposed improvements to the hydraulic capacity of Springvale Drain would lead to a reduction in the duration of the flood hydrograph and an associated increase in the peak flow rate passing to Botany Bay. An increase in peak flow rate has potential to affect the outlet to Botany Bay and the surrounding Penrhyn Estuary wetlands. Possible issues including scour near the outlet channel and wetland degradation may result without sufficient mitigation measures. Detailed design of the new infrastructure will therefore need to incorporate mitigating design features, prior to construction. These measures will be designed and modelled prior to any Stage 2 works being undertaken, and will ensure an optimal design solution resulting in negligible impact on the wetlands and Botany Bay.

Detailed design measures to be investigated will therefore include:

- Scour prevention by increased vegetation of the banks immediately downstream of the outlet
- Upstream detention by the incorporation of additional in-ground detention areas on the Southlands site, where possible
- Upstream detention in the land adjacent to the section of drain between Foreshore Drive and Penrhyn Road. This could be achieved through excavation of a wider channel, a secondary channel or a detention basin in this area. Approval would need to be sought from the landowner.
- Pollutant removal through measures such as a detention basin or rock weirs in the channel upstream of Penrhyn Road to reduce sediment loading and a trash rack at the inlet to the culvert under Penrhyn Road.

Initial modelling and design resolution confirms that these measures are possible and will reduce flow and scour impacts in the Penrhyn estuary, but detailed design and incorporation of these mitigating items will be required prior to the issuance of a Construction Certificate for the Stage 2 works.

These upgrade works are to a large extent as noted in the SKM (1992) report to Council, as improvements for the local catchment and should be recognised as an issue for all landowners in the area. These works could therefore reasonably be seen as an appropriate S.94 Plan for the area, rather than delivering the burden onto a single land owner. Nevertheless, the upgrade works as proposed in Stage 2 on lands downstream of the Southlands site are proposed as part of the current Project Application.

5.4 Discussion

The existing flooding situation shows flooding over the northwest and southeast areas of the Southlands site as well as adjacent areas both upstream and downstream of the site for all events greater than the 50% AEP. A major reason for this is the inadequacy of the capacity of the drainage infrastructure as well as the high propensity for blockage of these structures, further reducing their capacity. The Southlands site currently acts as a flood storage area for the surrounding industrial area receiving overbank flows from both drains.

The area exhibits complex hydraulics and careful consideration was required to develop appropriate flood mitigation options within each stage of the development. Adjustments to the proposed Stage 1 development have been made to introduce flood mitigation measures including the lowering of the easement to the north of the site to provide a flow path between Floodvale and Springvale drains along with additional storage provisions in the Stage 2 and Stage 3 areas. The results presented in this report are for those configurations modelled and any variation to the scenarios modelled would need to be carefully considered and possibly re-modelled if necessary.

The flood levels and discharges for the 1% AEP event for each scenario at key locations are summarised in **Table 5.1** and **Table 5.2**.

Table 5.1 Summary of 1% AEP event peak flood levels at key locations

Location	Peak Flood Level (m AHD)		
	Existing	**Stage 1**	**Stage 2**
Upstream end of Southlands site			
Floodvale Drain	4.14	4.15	4.14
Springvale Drain	4.20	4.12	4.08
Upstream of McPherson St			
Floodvale Drain	4.13	4.03	4.02
Springvale Drain	4.03	4.03	3.85
Upstream of SWSOOS			
Floodvale Drain	3.95	3.94	3.93
Springvale Drain	4.03	3.97	3.66

Table 5.2 Summary of 1% AEP event peak flood discharges at key locations

Location	Peak Discharge (m^3/s)		
	Existing	**Stage 1**	**Stage 2**
Downstream of McPherson Street			
Floodvale Drain	20.00	20.48	20.87
Springvale Drain	7.62	6.69	20.56

Modelling shows that the proposed Stage 1 development has no adverse impact on flood levels within either Floodvale or Springvale drains and will lower flood levels in many areas. Similarly, construction of proposed improvements to Springvale drain as part of Stage 2 works would allow filling of the Stage 2 and Stage 3 areas to above the 1% AEP event flood levels without adversely impacting any surrounding properties. The above table shows similar peak flows in Floodvale Drain for all scenarios, while the peak discharge in Springvale Drain is increased for the Stage 2 development which is adequately conveyed with the increased capacity of the proposed channel improvements.

While the Stage 3 area is undeveloped, storage will still occur on this area of the site resulting in lower flood levels than those determined as part of the Stage 2 modelling. It may be possible to maintain some portion of this storage volume in detention basins in the Stage 3 development, the details of which are not the subject of this Application.

5.5 Responses to Comments

The following section is a summary response to comments raised by each respondent to the public exhibition of the Development Application.

5.5.1 Department of Planning (DoP)

The following specific responses are made in relation to comments from DoP.

Climate Change

Climate Change impacts have been added to the 1% AEP discharges for the Stage 1 development scenario and results presented in relation to setting Flood Planning Levels

On-site Stormwater Detention (OSD)

OSD has been removed from the site and additional storage volume included in the Stage 1 detention basin. This was agreed with the DoP flood modelling peer reviewer.

Stage 1 Detention Basin

Floodplain storage volumes are provided in Section 5.

Hydraulic Modelling

The MIKE FLOOD 1D/2D coupled model has been utilised for the revised modelling detailed in Section 4 of this report.

Peak flood levels and peak flows at key locations have been provided along with peak flood maps and flood level difference maps.

70% blockage factors have been applied to the inverted syphons under the SWSOOS in both Floodvale and Springvale Drains.

Stage 2

Proposed Stage 2 improvement works on Springvale Drain have been simulated with the 1D/2D coupled model and results and discussion presented in Section 5 this report.

5.5.2 Hynlong Pty Ltd

The following general responses are made to comments from Hynlong Pty Ltd:

Previous Studies

Modelling has been completely revised to utilise a 1D/2D coupled model with Airborne Laser Survey (ALS) data supplemented with ground survey. The area has undergone significant development since the SKM (1992) study and the resolution of the model data is significantly different. As such it is inappropriate to draw comparisons between the absolute flood level results of the previous study and the current study.

Present Day Circumstances

As discussed above, modelling has been updated to utilise 1D/2D coupled model to provide more confidence in model results for all stakeholders. Additional survey was also undertaken as part of the present study to obtain information to reflect the present day conditions including:

- new developments at 15 McPherson Street and at the corner of McPherson St and Exell Street
- Coal Pier Road and Bridge
- bridges across Springvale Drain and associated culverts that were removed have been removed from the model.
- a newly developed concrete channel north of the Mobil site
- tank bunds within the Mobil site
- trash racks in both drains upstream of McPherson Street

- revised roughness and structure blockage factors to reflect current conditions.

Development at 15 McPherson Street

This development was undertaken by a separate developer and it is not the responsibility of Orica to investigate the impacts of this development. The development has been included in the present study to reflect current conditions and is included in all model scenarios to allow a relative comparison of the impacts of the Southlands development.

Presentation of Flood Model Results and Flood Impacts

In accordance with the comments, the following flood model results have been provided in this report to further define the flood extents and impacts of the proposed Southlands Stage 1 and Stage 2 development scenarios:

- Flood extents and flood difference maps
- Tabulation of peak flood levels and peak discharges at key locations
- Flood storage volumes for the Stage 1 detention basin

The above results demonstrate 'no impact' for either the Stage 1 or Stage 2 development and importantly, indicate lower flood levels on the Hynlong property.

The present flood modelling has been undertaken in consultation with the DoP independent flood modelling peer reviewer to ensure to robustness of the results.

Responsibility for Flood Improvement Works

As discussed within this report, the Southlands site in its existing condition acts as a de facto flood storage area for the wider catchment. This is the result of a long history of development with insufficient infrastructure and flood planning in the area. This has lead to the current situation where the potential for Orica to develop their site is being hindered by this legacy.

This report demonstrates that the proposed development is viable without adversely affecting properties when compared with the current situation, however, inundation of properties remains an issue. The flood problem in the area is a concern for all surrounding property holders and it is in the interest of all involved to improve the flooding situation. It is therefore prudent that the potential shared responsibility for any improvement works be considered, including a Section 94 Plan.

5.5.3 Solvay Interox Pty Ltd

Orica have not contributed to the existing flood problem on the Solvay Interox property and the stated raising of building floor levels on the Solvay Interox site to prevent flooding are likely to have adversely impacted on flood storage and levels in the wider area.

As discussed above, the additional survey has been undertaken and modelling updated to represent prevailing conditions. This includes revised roughness coefficients and blockage factors in both drains and associated infrastructure to reflect the vegetative cover and debris that is present.

The Stage 1 detention basin has been regraded to obtain the additional storage required to offset the filling of the Stage 1 area. The Stage 1 detention basin ensures that flood levels within Floodvale drain are not increased and whether Stage 2 proceeds or not, the flood situation in Floodvale drain would be no worse than presently exists. Stage 2 works are not required as part of Stage 1 and the Stage 2 channel improvement works would have a greater benefit for Springvale Drain than Floodvale Drain. Additional works on Floodvale Drain would be required to improve the flood situation within Floodvale Drain and is not a requirement of this Application.

5.5.4 Sydney Ports Corporation

Development Stage 1

The Stage 1 detention basin surface will be re-vegetated following any earthworks to regrade the area, providing a stable surface to prevent suspension of sediments during flood events. Further, due to the low velocities present in the storage area it is unlikely that sediments will be transported into Springvale Drain and will settle in the basin itself.

With regards to contaminated groundwater, a substantial groundwater treatment plant has already been in operation for some time and the management of environmental issues on the site is monitored and proven. Any changes to these requirements as a result of the Stage 1 works will be determined and appropriately managed as part of the environmental management plan and with agreement from the Site Auditor.

Development Stage 2

The present modelling has included a more detailed assessment of the proposed Stage 2 Springvale Drain improvement works to establish the potential for this solution to achieve the desired outcomes.

Modelling for the Stage 2 development indicates that peak discharge velocities from Springvale Drain into Penrhyn Estuary are approximately 3.05 m/s through the 50% blocked Penrhyn Road culverts and 1.95 m/s into the estuary with the high tide boundary of 1.0 m AHD. Lower velocities would prevail with fewer blockages of the culverts. Erosion protection measures have been suggested, and measures to mitigate these impacts will be incorporated into the detailed design for Stage 2 works.

For the main part, the total volume of freshwater flows will not be increased, but rather the shape of the flood hydrograph changed such that the peak flow is increased while the duration is decreased. The flows will be re-distributed from Floodvale Drain to Springvale Drain, both of which discharge to the estuary. As such there will be no net increase in freshwater flows to the estuary from the wider catchment.

Any net increases in runoff occurring from the Stage 1 development area will be catered for in the Stage 1 detention basin. Both Stage 2 and Stage 3 plans include areas for detention basins to manage site stormwater runoff. WSUD measures will seek to further minimise these post-development flows. While the Stage 3 area is undeveloped, storage will still occur on this site. Some portion of this storage may be able to be maintained in detention basins in the Stage 3 development, the details of which are not the subject of this Application.

Flooding

Modelling of the Stage 2 Springvale Drain improvement works indicates that the SWSOOS syphon and Botany Road culverts will remain as control points in relation to flooding upstream. Downstream of the SWSOOS, there is sufficient gradient in the channel and the capacity of the channel adjacent to the Caltex carpark is sufficient to convey the increased flows with flood waters remaining in-bank. As such, flooding of Penrhyn Road or the Port Botany rail line will not occur.

6. Conclusions and Recommendations

The NSW Department of Planning (DoP) undertook a review of the previous 2007 flood modelling works (Aurecon, 2009) using independent consultants (Webb McKeown & Associates). Comment on the development was also accepted from surrounding landholders. A meeting with DoP to discuss comments from the review suggested a number of additional tasks, primarily that 2D hydraulic modelling be undertaken to address most of these comments. In response to these comments, Aurecon has undertaken linked 1D/2D hydraulic modelling of the Orica Southlands proposed development and the surrounding area for a range of inflow scenarios.

The revised modelling has incorporated a number of changes and additional survey which was undertaken to better define certain areas. This includes:

- new developments at 15 McPherson Street and at the corner of McPherson St and Exell Street
- Coal Pier Road and Bridge
- bridges across Springvale Drain and associated culverts that were removed have been removed from the model.
- a newly developed concrete channel north of the Mobil site
- tank bunds within the Mobil site
- trash racks in both drains upstream of McPherson Street
- revised roughness and structure blockage factors to reflect current conditions.

The existing flooding situation shows flooding over the northwest and southeast areas of the Southlands site as well as adjacent areas both upstream and downstream of the site for all events greater than the 50% AEP event. A major reason for this is the inadequacy of the capacity of the drainage infrastructure as well as the high propensity for blockage of these structures, further reducing their capacity. The Southlands site currently acts as a flood storage area for the wider catchment and surrounding industrial area receiving overbank flows from both Floodvale and Springvale Drains.

The area exhibits complex hydraulics and careful consideration was required to develop appropriate flood mitigation options within each stage of the development. Adjustments to the proposed Stage 1 development have been made to introduce flood mitigation measures including the lowering of the easement to the north of the site to provide a flow path between Floodvale and Springvale Drains along with additional storage provisions in the Stage 2 and Stage 3 areas. The results presented in this report are for those configurations modelled and any variation to the scenarios modelled would need to be carefully considered and possibly re-modelled if necessary.

Modelling shows that with the recommended storage and ancillary works, the proposed Stage 1 development has no adverse impact on flood levels on adjacent properties within either Floodvale or Springvale Drains and will lower flood levels in many areas.

Importantly, the modelling work predicts no significant adverse impacts on flood levels either upstream or downstream of the Southlands development site as a result of the Stage 1 works and contains all major flood events within the eastern (Stage 2 and Stage 3) portion of the site. The eastern half of the Southlands site operates effectively as an interim compensatory flood storage area for the Stage 1 development and this flow will be transferred downstream through the increased capacity of Springvale Drain and the culverts following the Stage 2 development. This report has focused on surface water drainage and further mitigation measures may be required in order to manage groundwater interaction with surface flows in the interim stage compensatory flood storage area.

Stage 2 works will serve to significantly increase hydraulic capacity of Springvale Drain through to Botany Bay. The result of adding this new infrastructure will see a significant positive impact on flood levels in the area allowing the subsequent filling of Stages 2 and 3 without any impact on any adjoining properties. Likely changes in flow characteristics of the proposed Stage 2 channel system have been considered and various mitigating measures designed to reduce impacts from increased flows are noted in Section 5 of this report. Further detailed design of these measures will be required during the detailed design phase and prior to the issuance of a Construction Certificate for Stage 2 works, with more detailed hydraulic model investigation to ensure the incorporation of appropriate mitigative measures, as required.

Improvements to Floodvale Drain as identified by SKM (1992) would further seek to improve the flooding situation, however are not the subject of this investigation.

Development of Stage 3 will be the subject of future Project Application. Stage 3 will benefit from the major new infrastructure works undertaken in Stage 2 which will essentially allow both Stages 2 and 3 to be filled as required to above 1% AEP flood levels.

Filling of the site generally in accordance with the levels proposed in the Stage 1 and 2 of this Application and as included in this report would be acceptable and will not result in any off site flood impacts on surrounding properties.

The works required for Stage 1 and Stage 2 are indicated on **Figure 4** and **Figure 5** in **Appendix A**, respectively. Storage volumes are presented in Section 5 of this report.

The Springvale and Floodvale Drain culverts under the SWSOOS should be cleared and maintained to allow maximum flow in Stage 1.

It is recommended that Council consider the preparation of an appropriate Section 94 Plan to deal with the catchment wide flooding issues as outlined in the SKM Report to Botany Bay City Council (1992). This wider approach would facilitate ownership of flooding issues by all affected stakeholders rather than relying on individual landowners to solve catchment wide issues.

7. References

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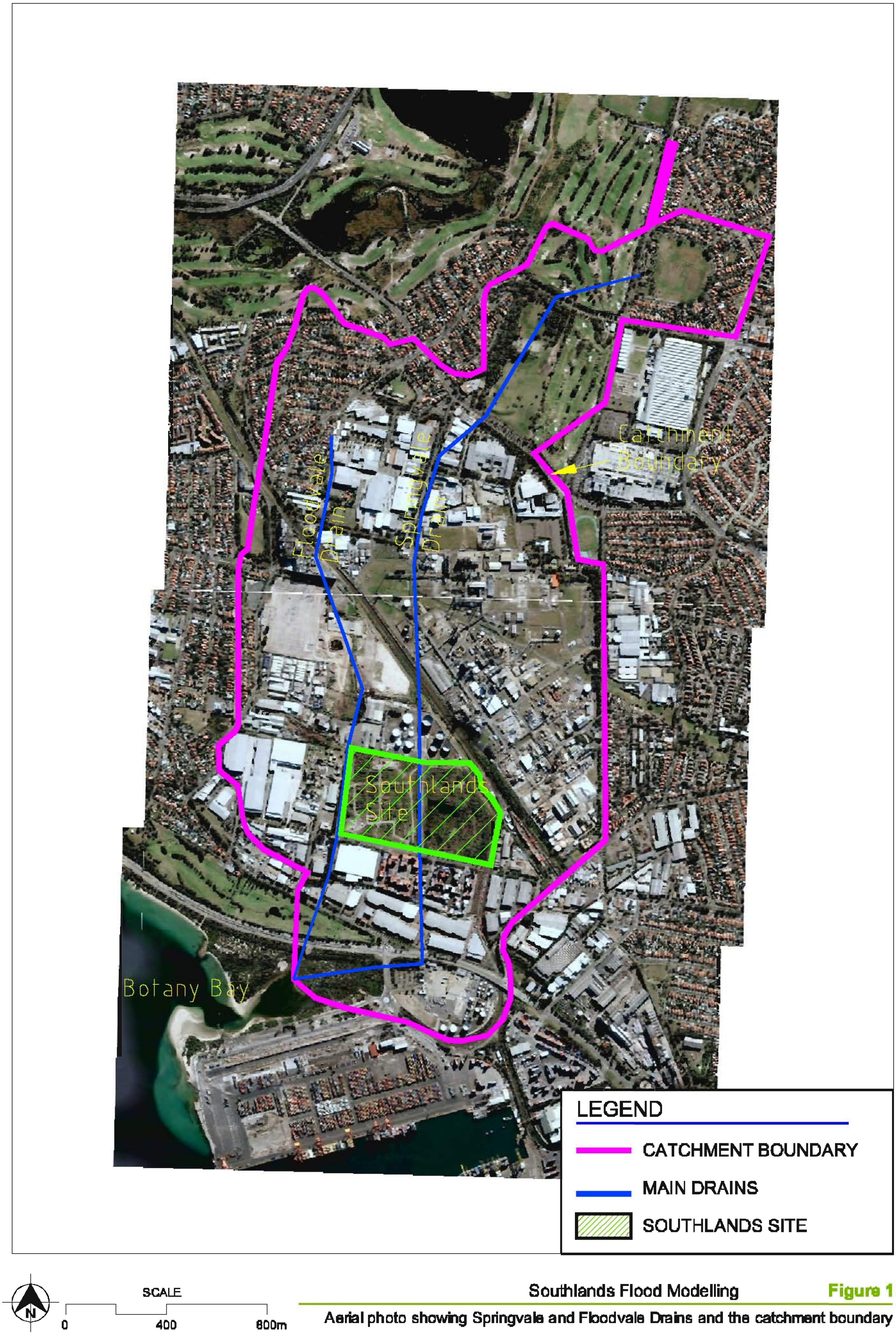
URS (2007), *Southlands Remediation/Development Project Remediation Action Plan*

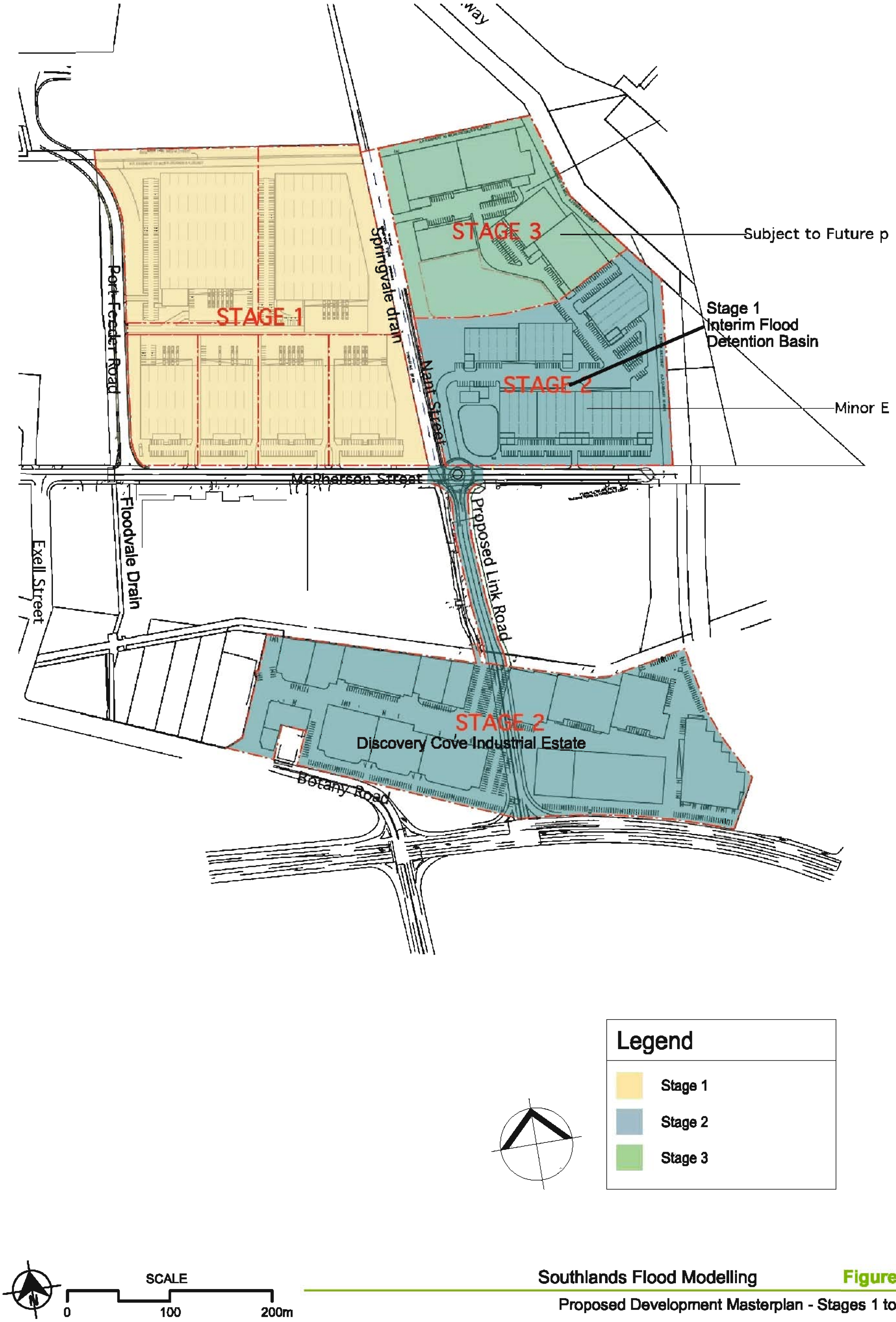
Appendix A
Figures



Southlands Flood Modelling

Figure 1

Aerial photo showing Springvale and Floodvale Drains and the catchment boundary



Southlands Flood Modelling

Figure 2

Proposed Development Masterplan - Stages 1 to 3

Southlands Flood Modelling **Figure 3**

Existing Site Elevation Contours and October 2004 Groundwater Contours

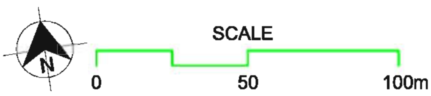
SCALE

0 40 80 m

Southlands Flood Modelling

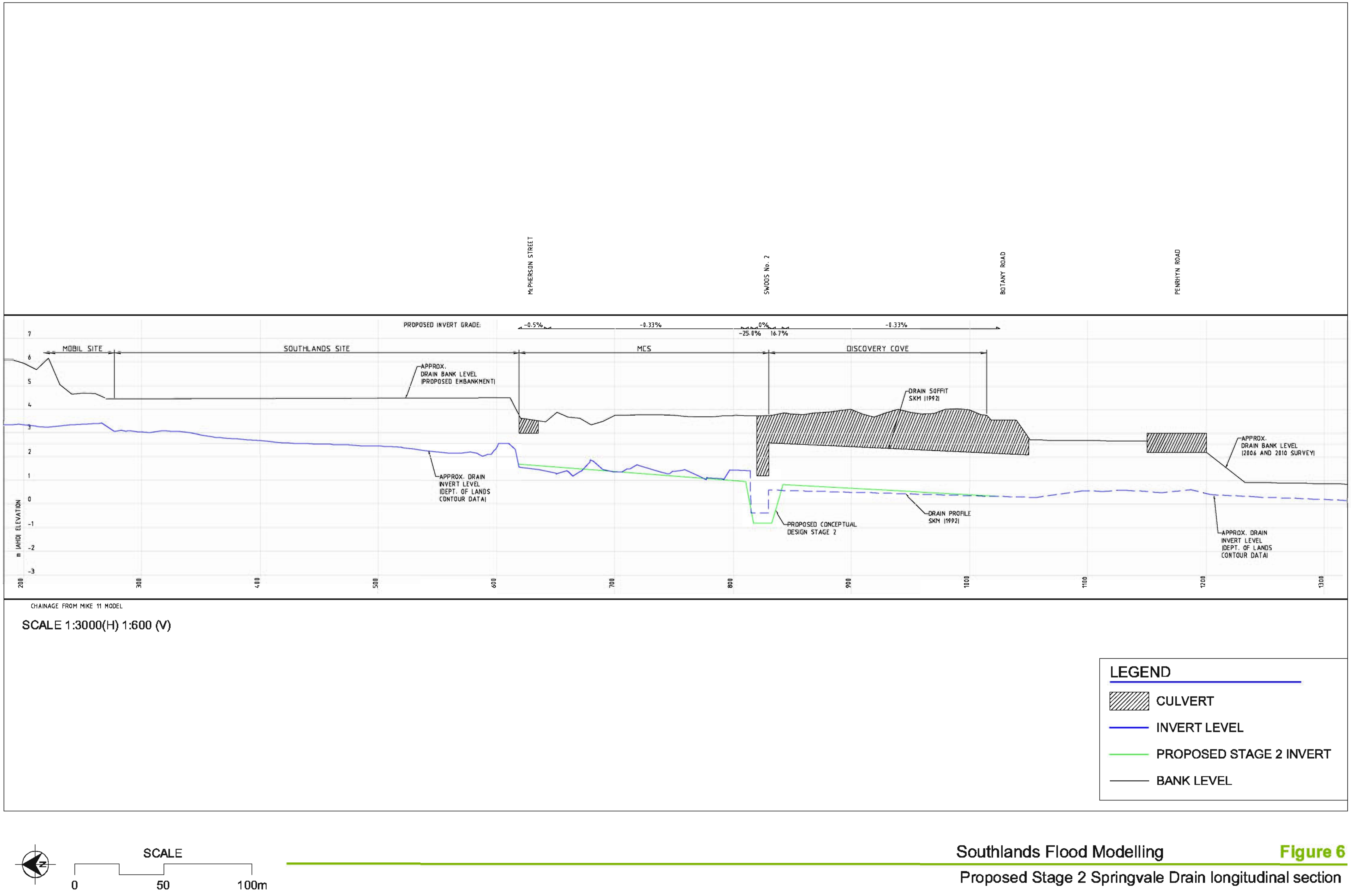
Figure 4

Proposed Stage 1 Interim Flood Flow Paths



Southlands Flood Modelling **Figure 5**

Stage 2 Conceptual Hydraulic Design

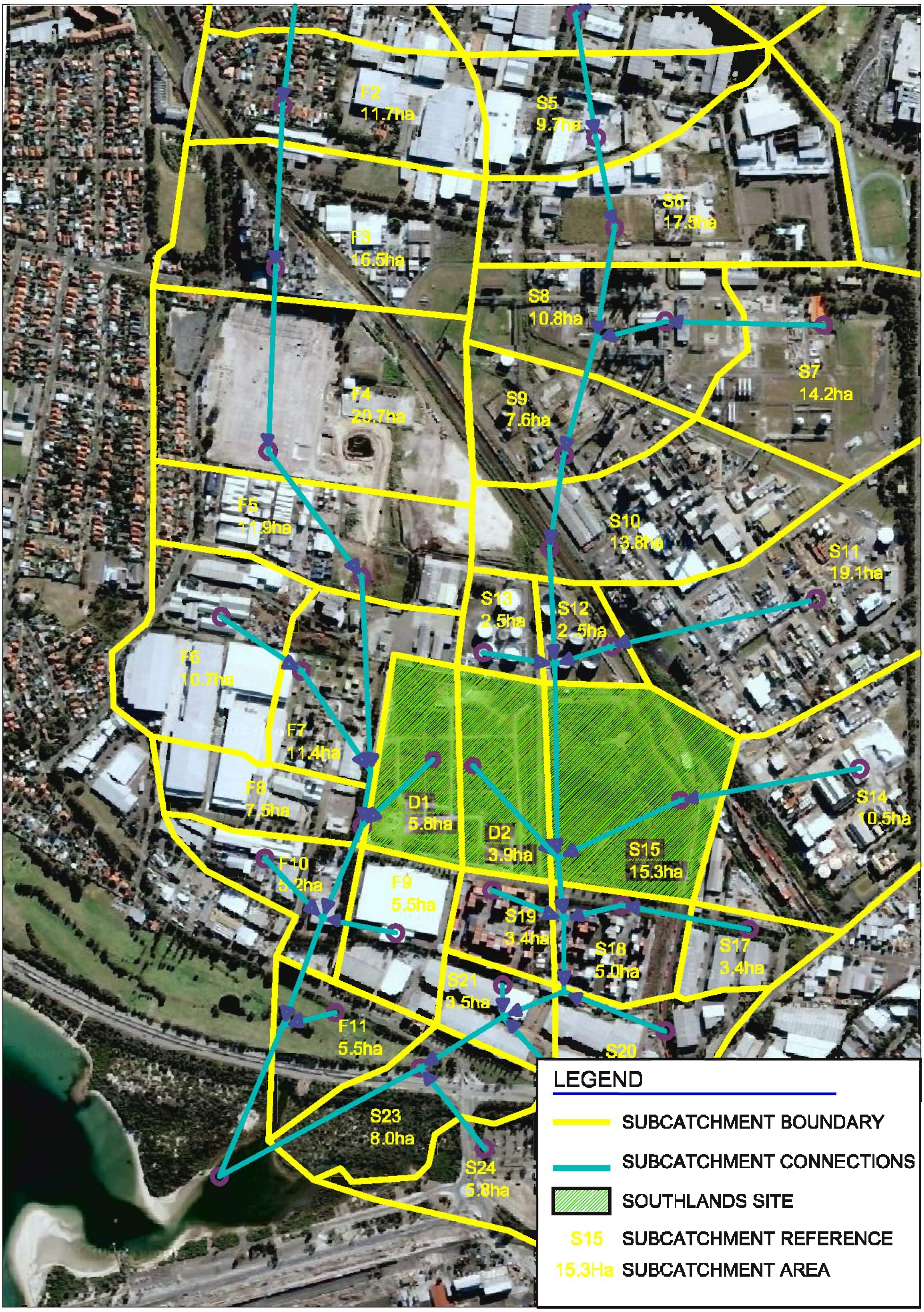


Southlands Flood Modelling

Figure 6

Proposed Stage 2 Springvale Drain longitudinal section

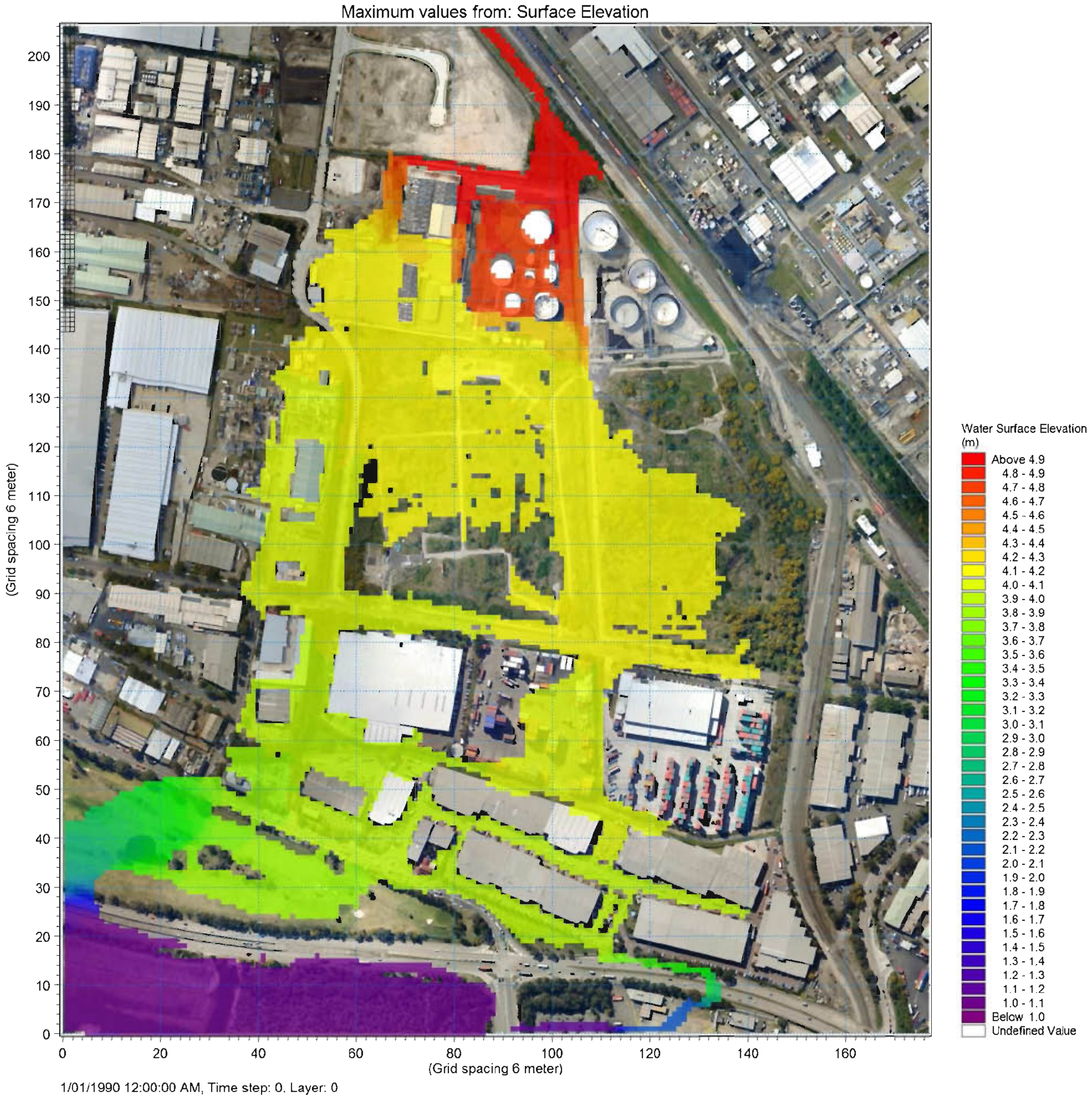
aurecon



Southlands Flood Modelling

Figure 7

RAFTS Rainfall-Runoff Model Catchments Plan

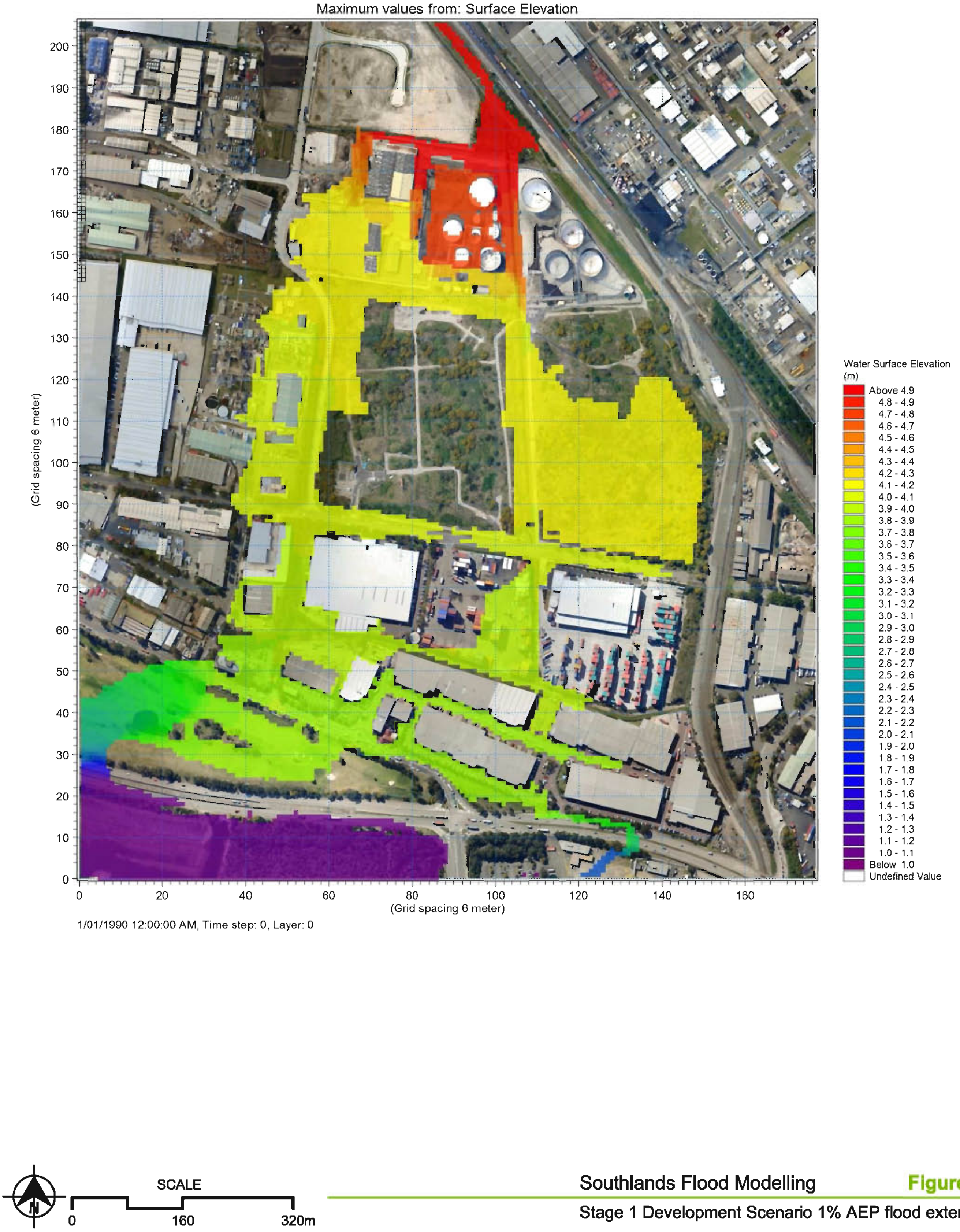


SCALE

0 160 320m

Southlands Flood Modelling **Figure 8**

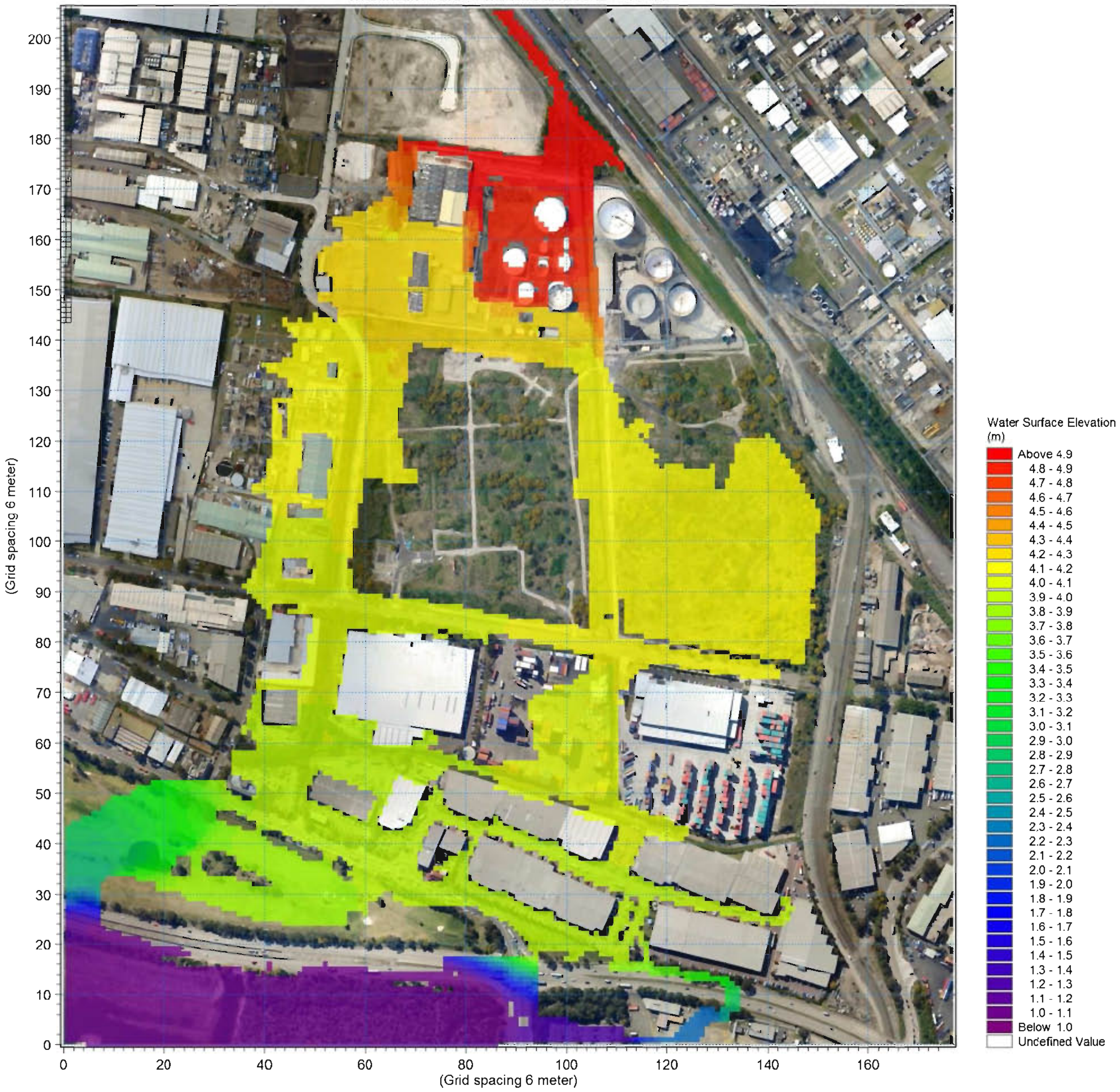
Existing Scenario 1% AEP flood extents



Southlands Flood Modelling **Figure 9**

Stage 1 Development Scenario 1% AEP flood extents

Maximum values from: Surface Elevation



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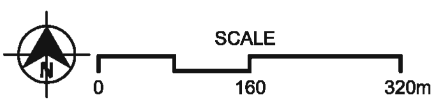
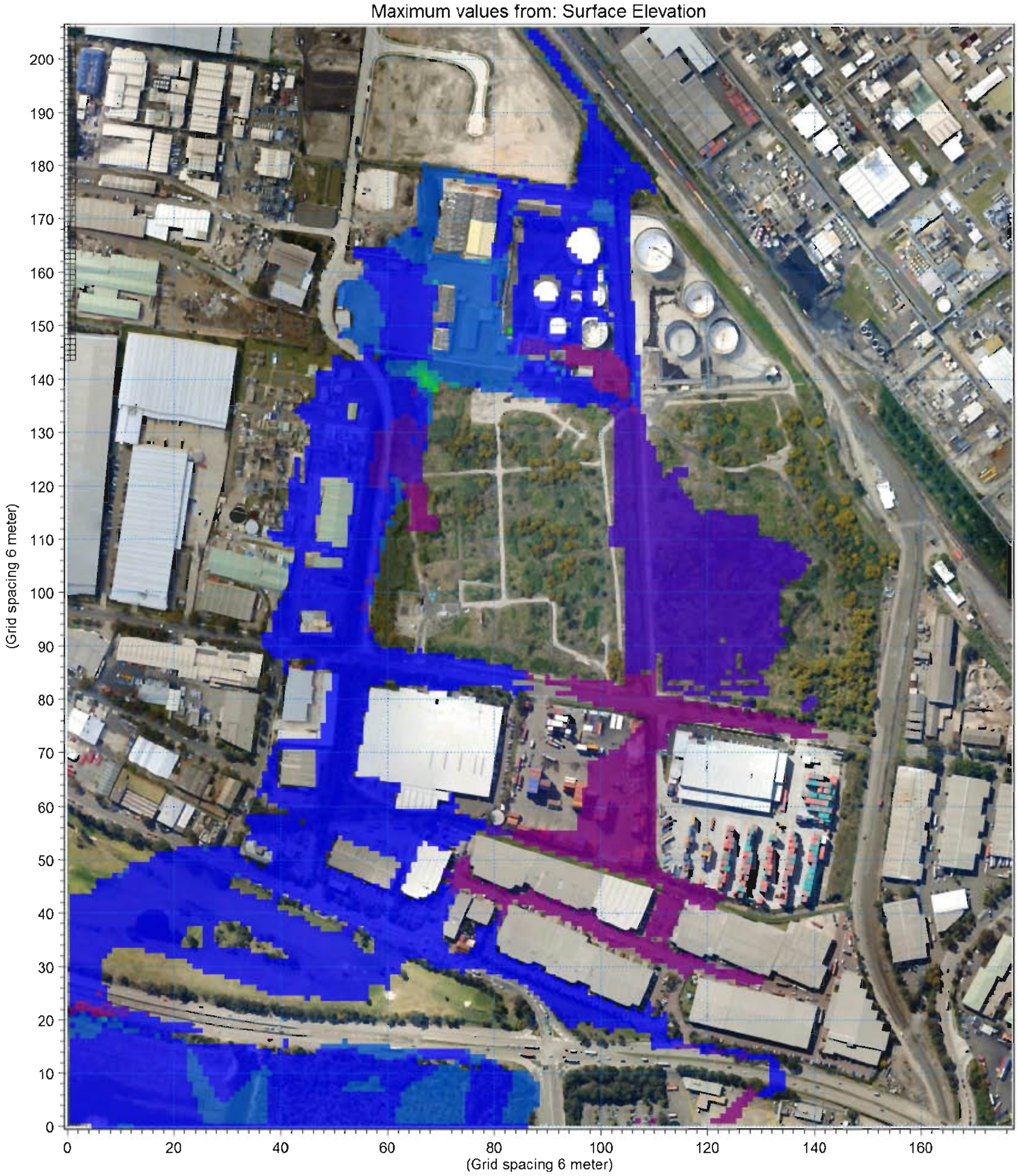


Southlands Flood Modelling **Figure 10**

Stage 1 Development Scenario 1% AEP with Climate Change flood extent

Maximum values from: Surface Elevation



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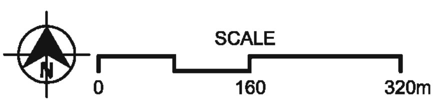
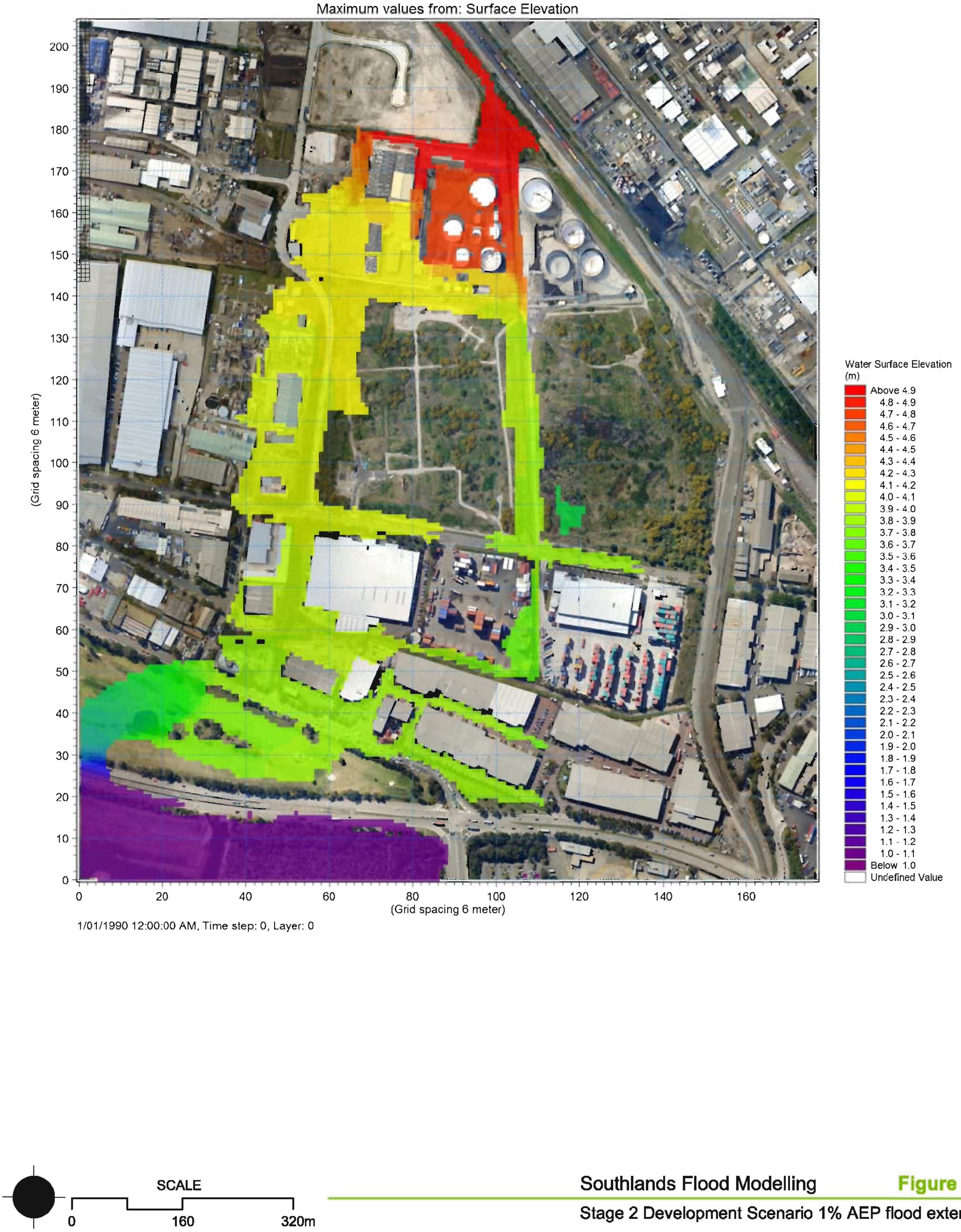


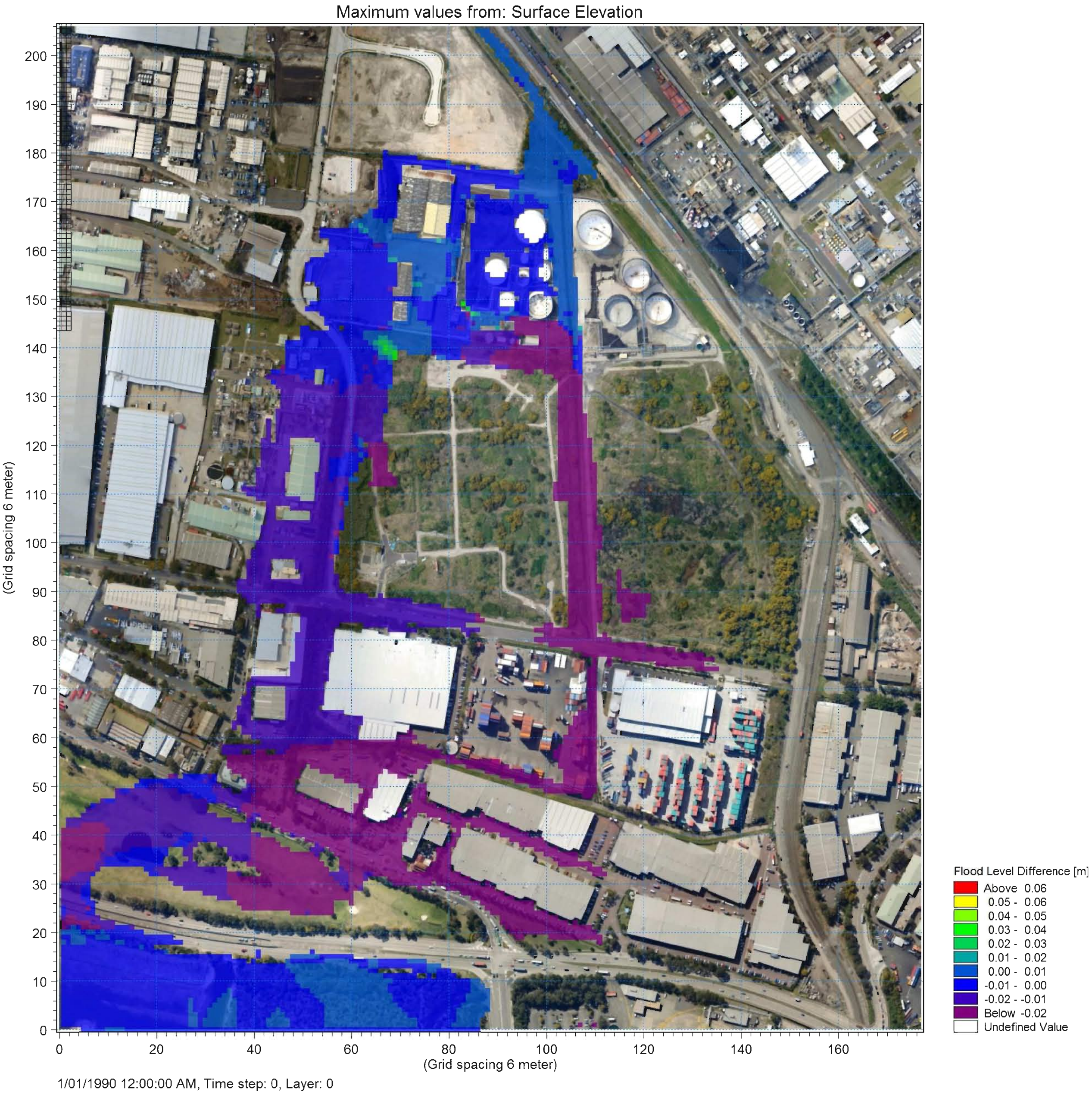
Southlands Flood Modelling **Figure 11**

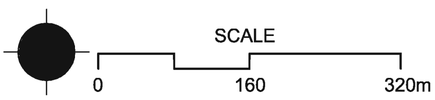
Stage 1 Development Scenario 1% AEP flood level difference map



Southlands Flood Modelling **Figure 12**

Stage 2 Development Scenario 1% AEP flood extents



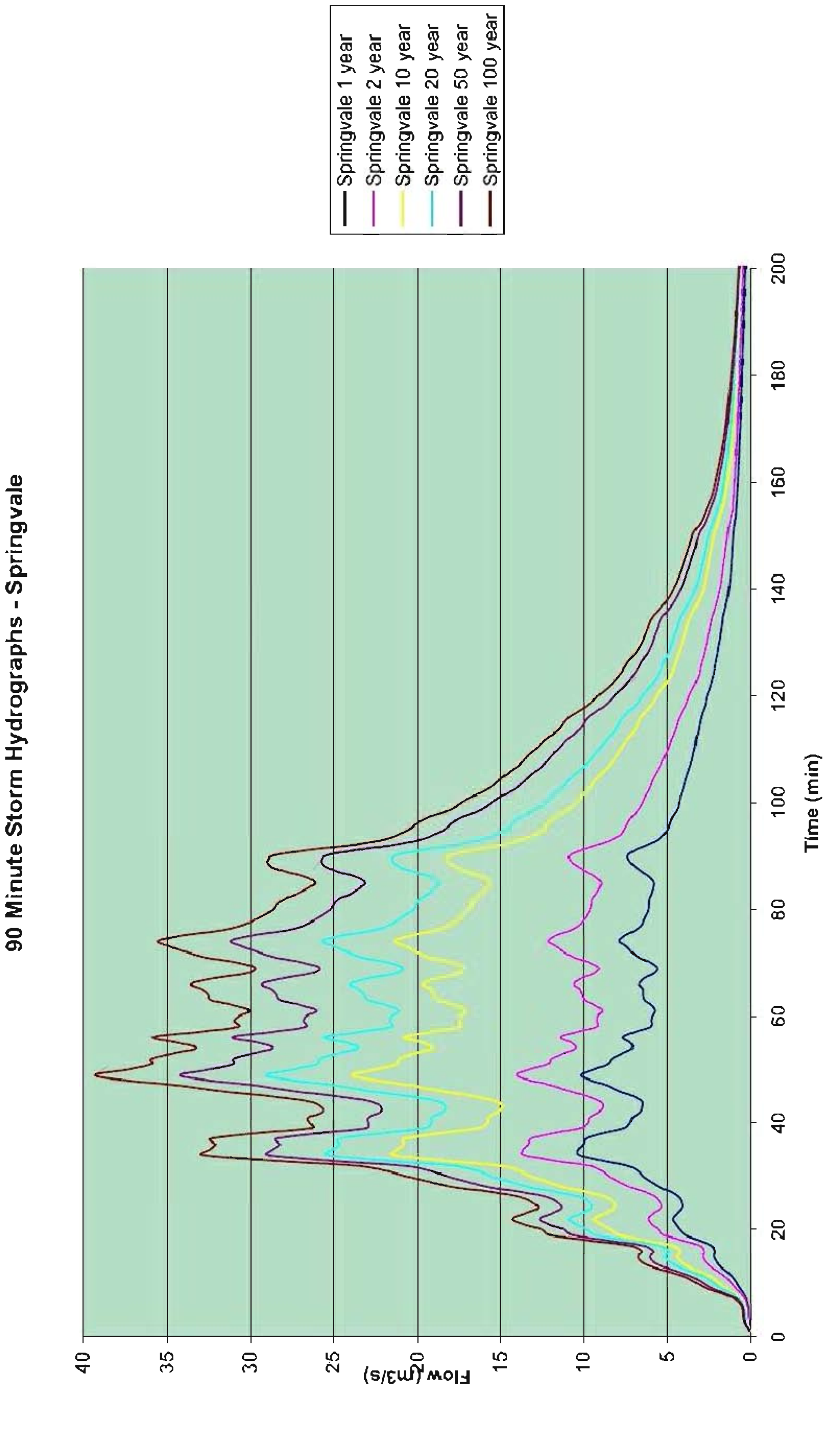


Southlands Flood Modelling

Figure 13

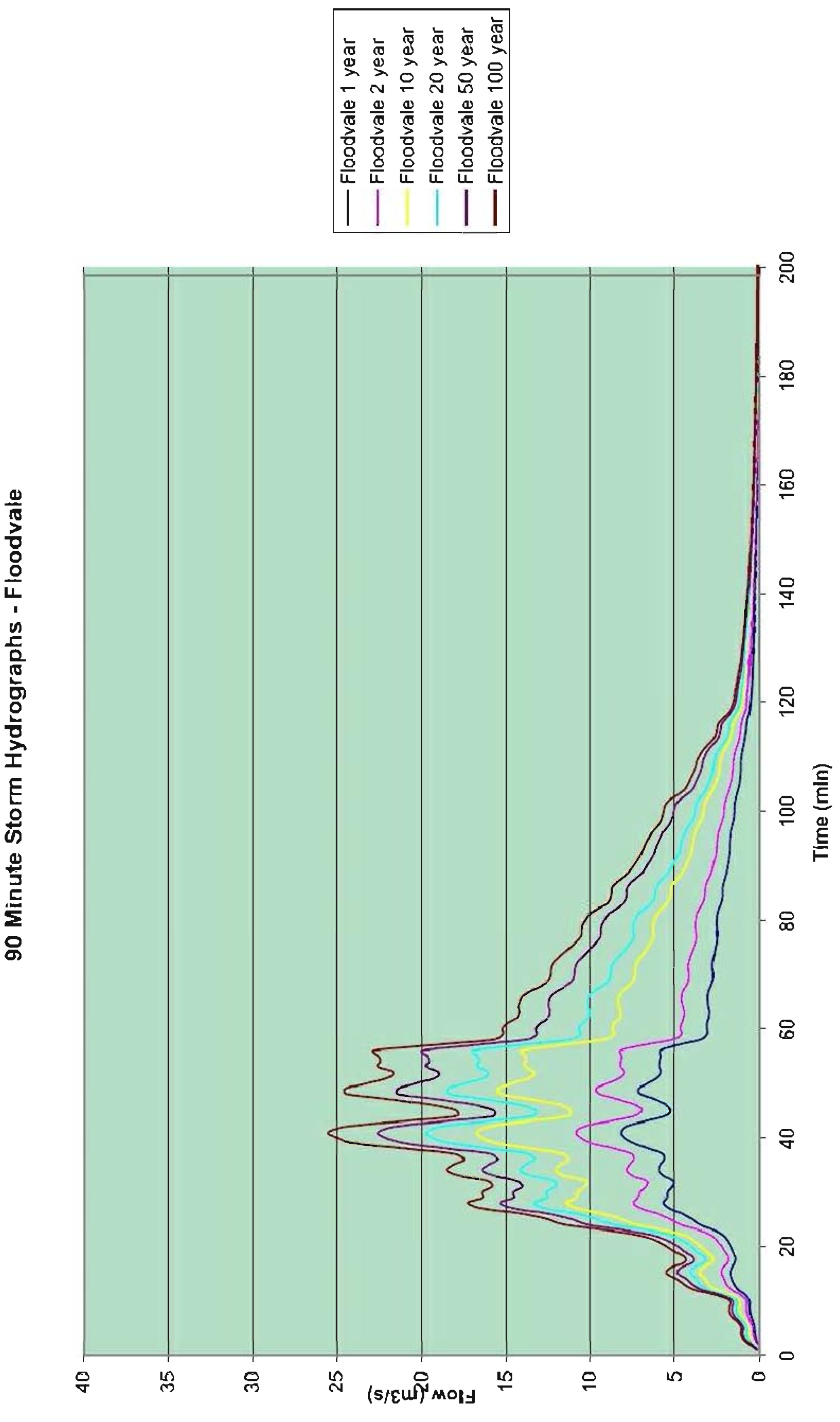
Stage 2 Development Scenario 1% AEP flood level difference map

Appendix B
RAFTS Hydrological Model Results



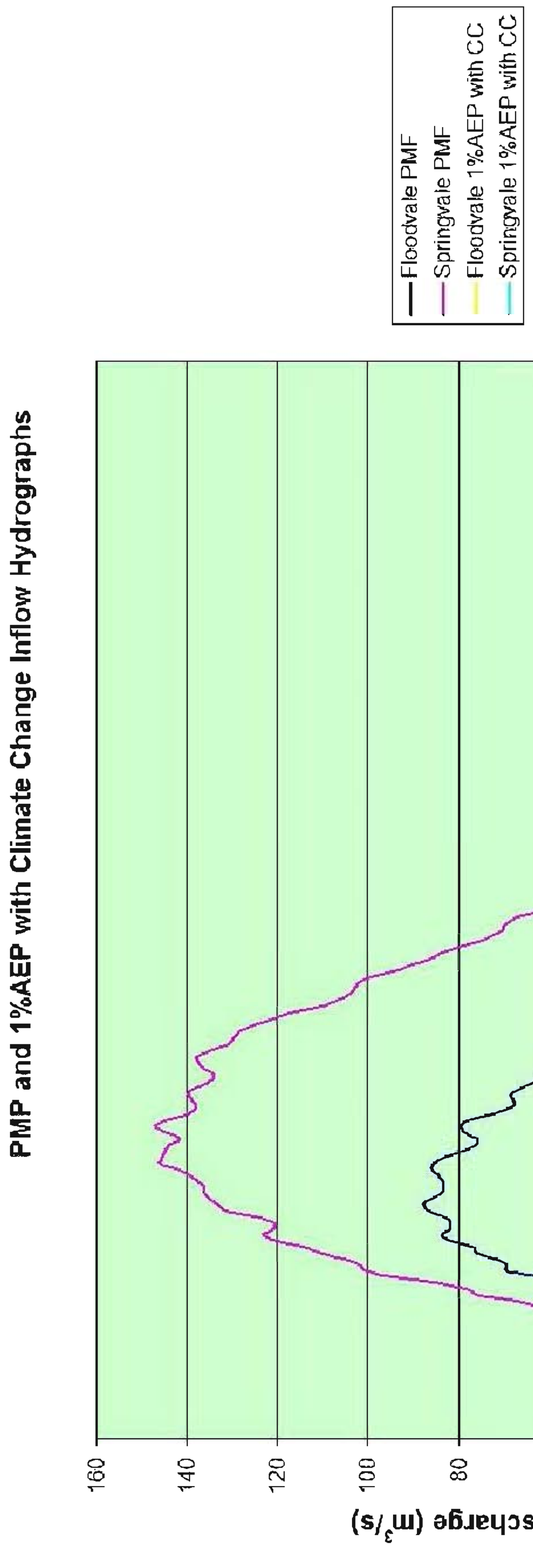
Southlands Flood Modelling **Figure B1**

Springvale Drain discharge hydrographs at different recurrence intervals for 90 minute rainfall event



Southlands Flood Modelling **Figure B2**

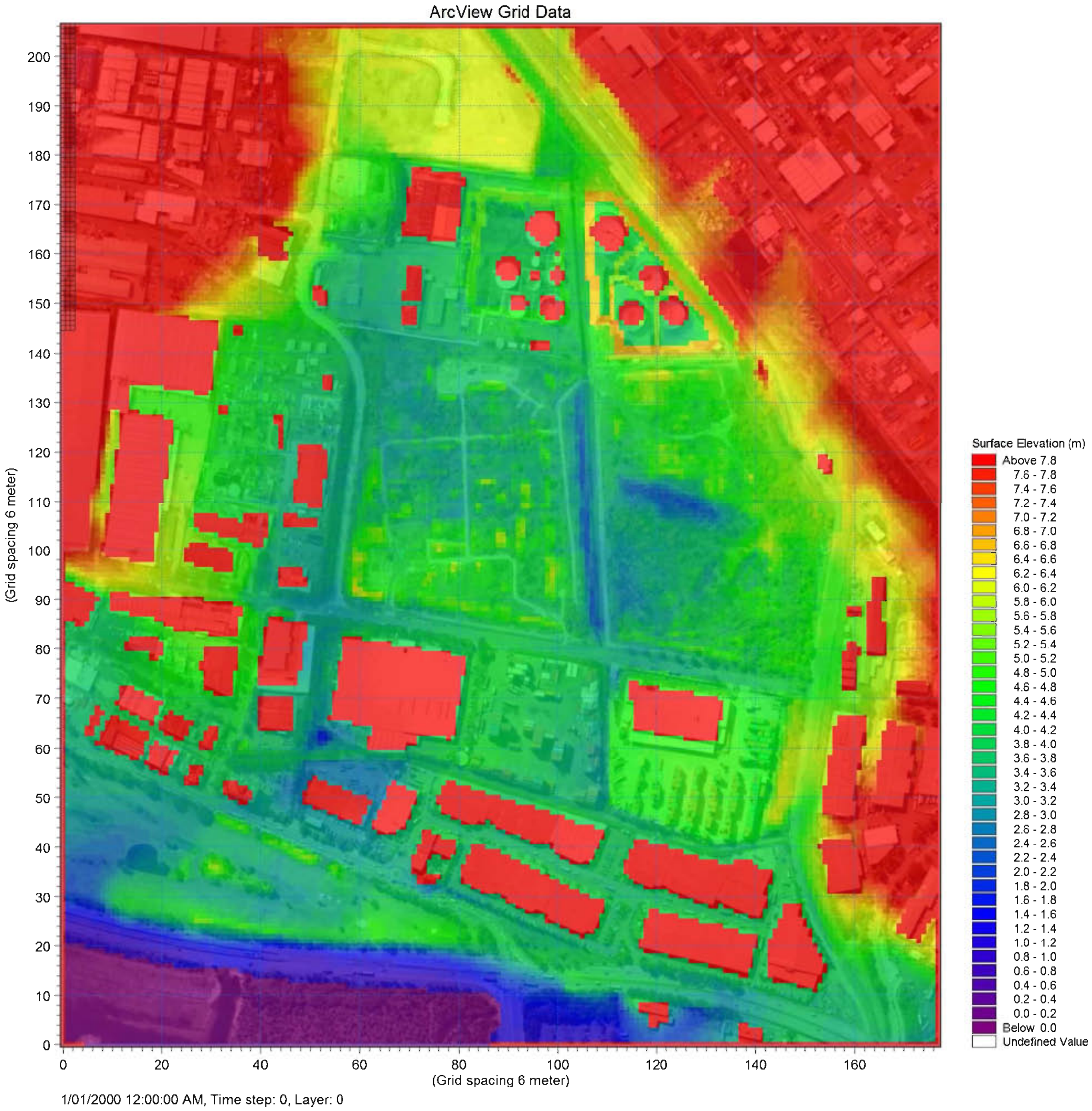
Floodvale Drain discharge hydrographs at different recurrence intervals for 90 minute rainfall event



PMP and 1%AEP with Climate Change Inflow Hydrographs
Floodvale PMF
Springvale PMF
Floodvale 1%AEP with CC
Springvale 1%AEP with CC
Discharge (m3/s)
0
20
40
60
80
100
120
140
160
Time (mins)
0
20
40
60
80
100
120
140
160
180

Appendix C
Flood Model Setup

aurecon



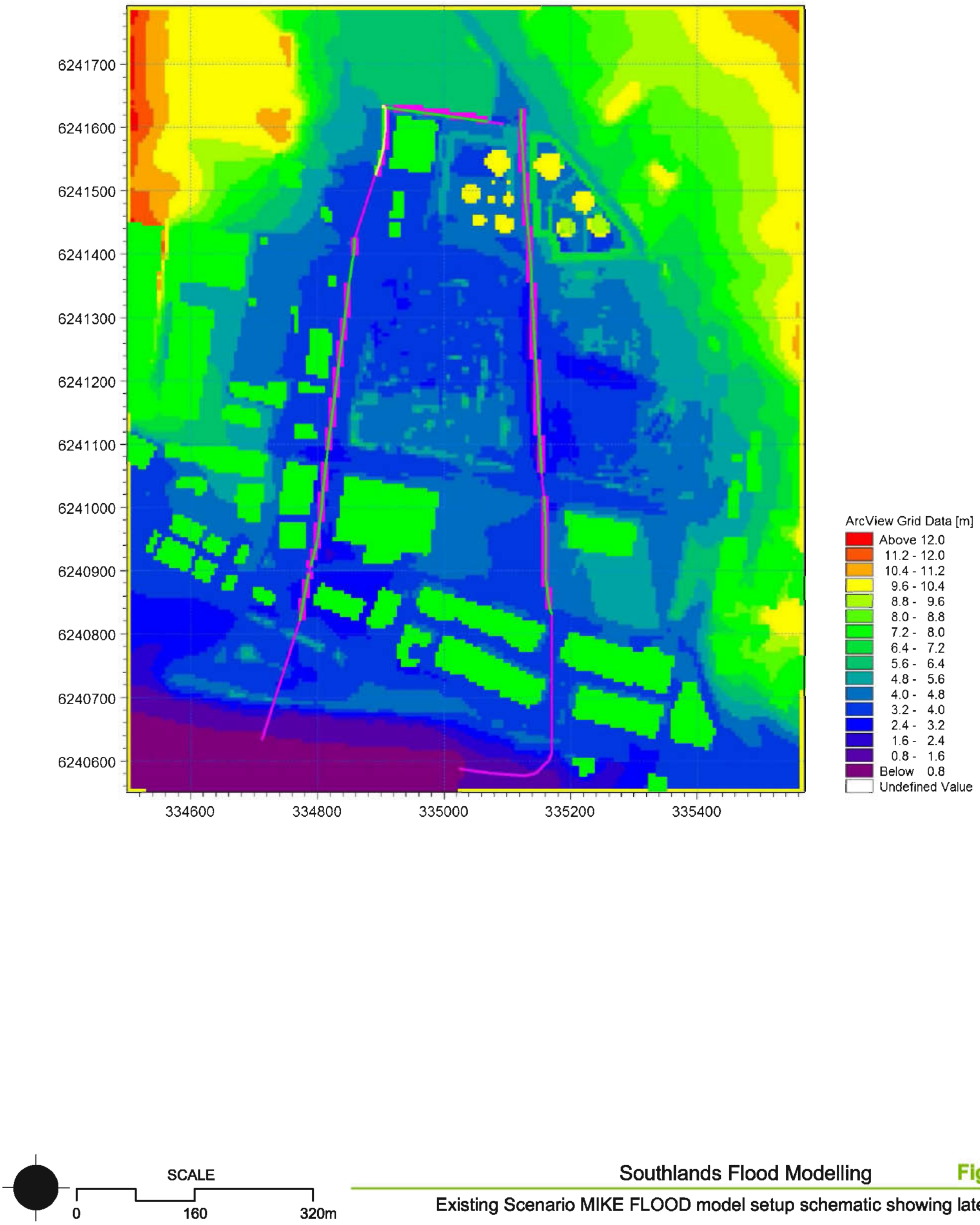
SCALE
0 160 320m

Southlands Flood Modelling **Figure C1**

Existing Scenario MIKE 21 terrain model

Southlands Flood Modelling **Figure C2**

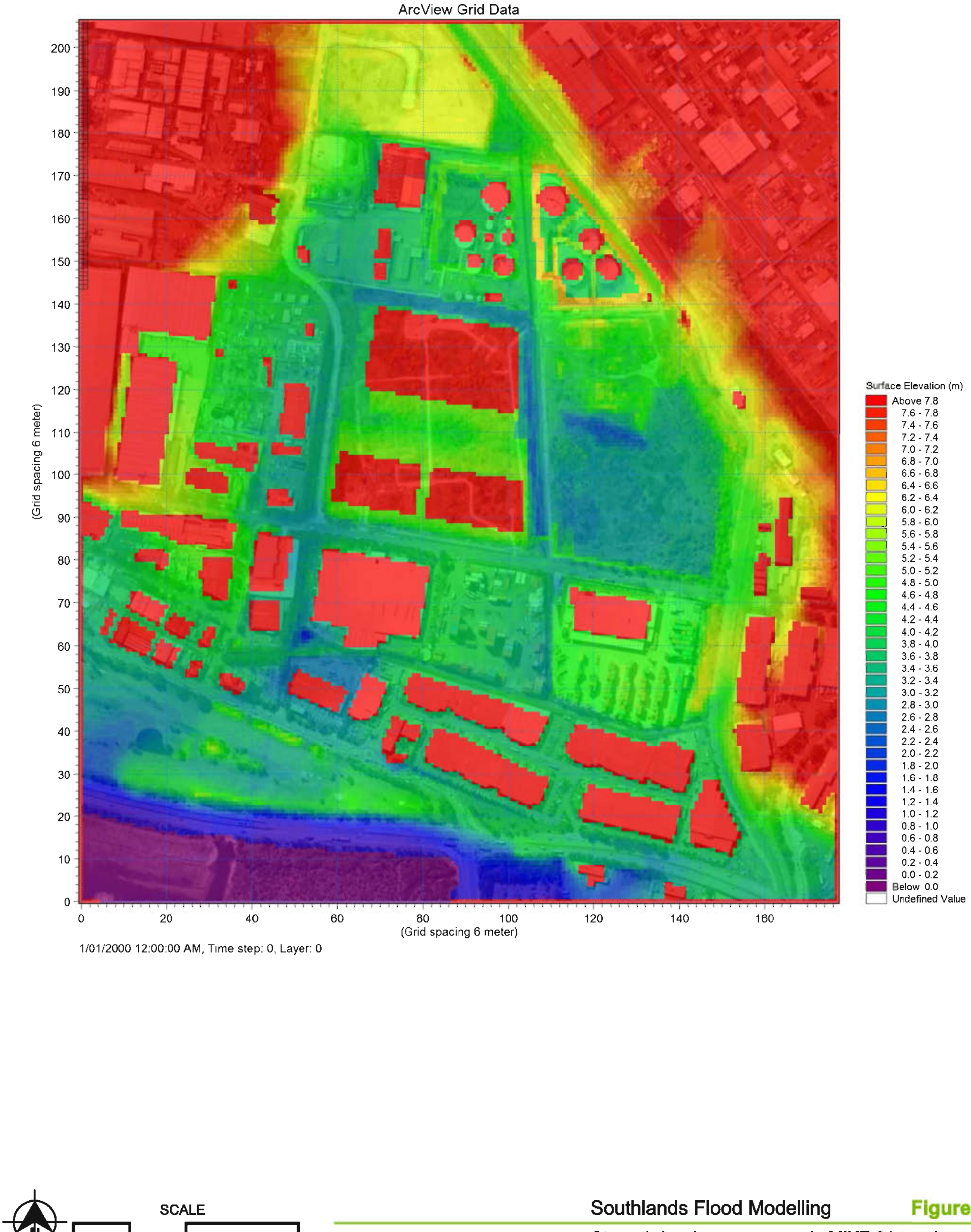
Existing Scenario MIKE 21 Manning M (1/n) roughness parameters



Southlands Flood Modelling

Figure C3

Existing Scenario MIKE FLOOD model setup schematic showing lateral links



Southlands Flood Modelling

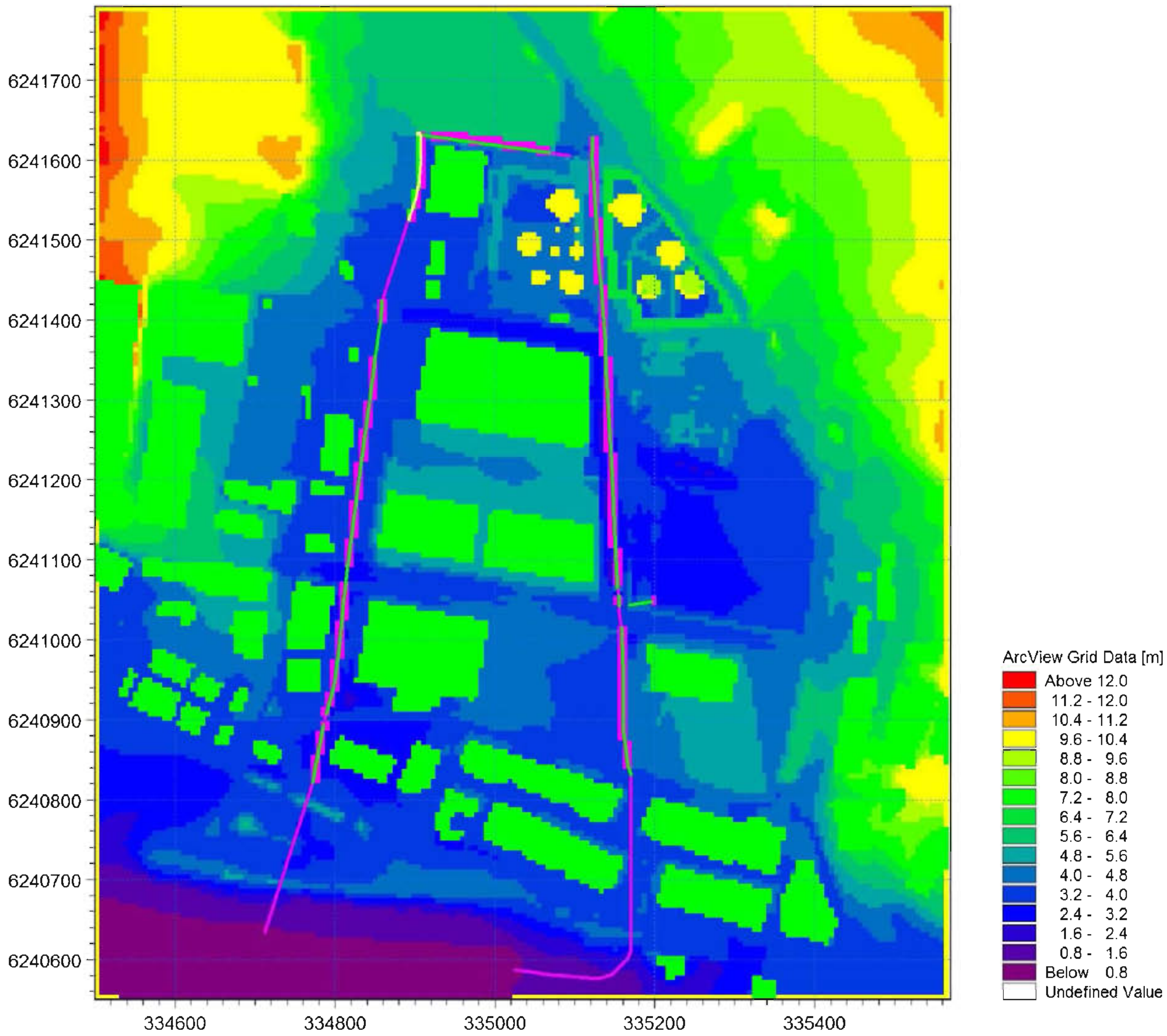
Figure C4

Stage 1 development scenario MIKE 21 terrain model

Southlands Flood Modelling

Figure C5

Stage 1 development scenario MIKE 21 Manning M (1/n) roughness parameters



SCALE
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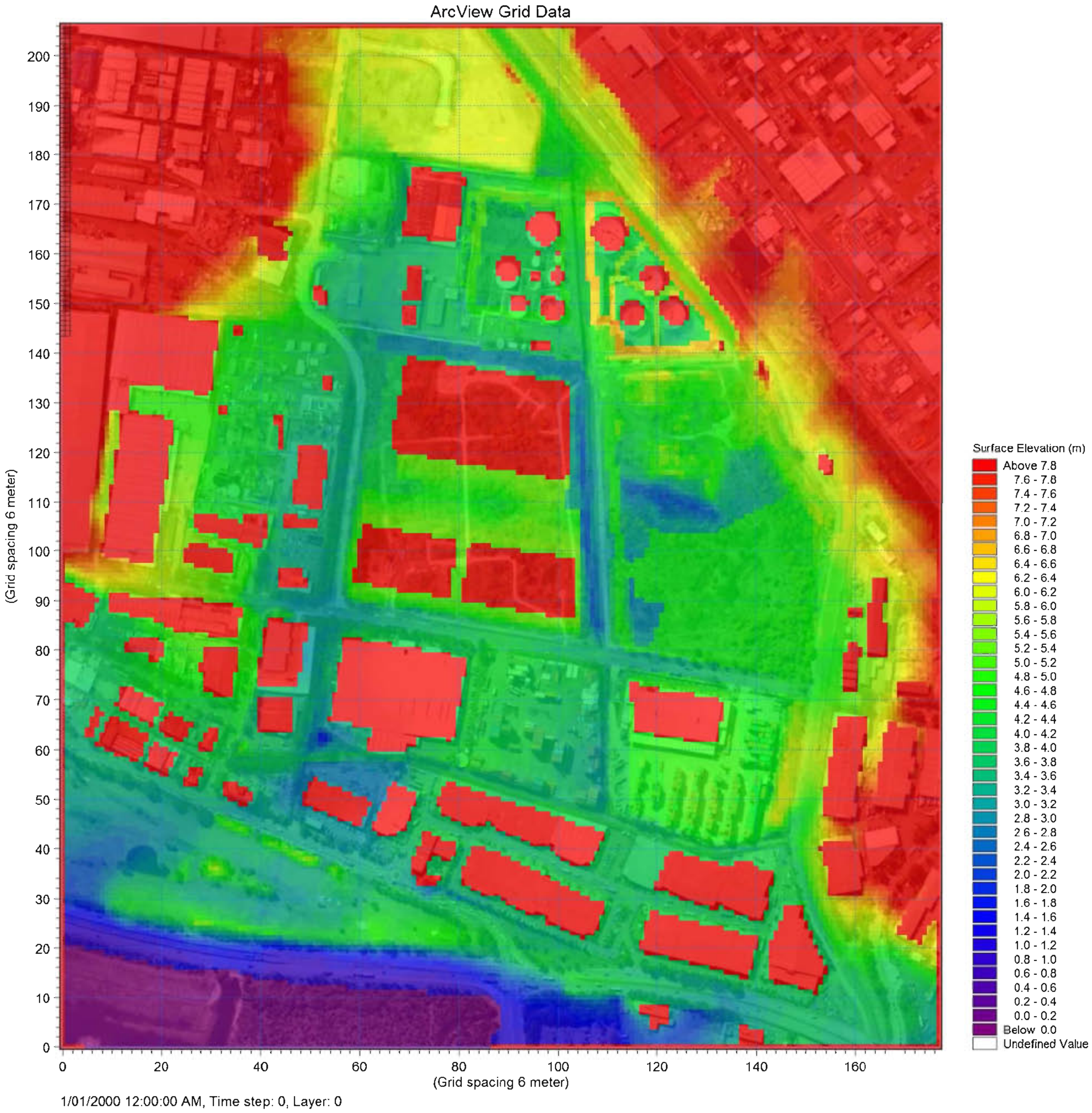
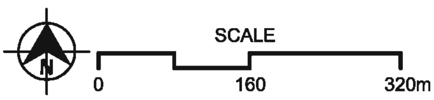
Southlands Flood Modelling **Figure C6**

Stage1 development scenario MIKE FLOOD model setup schematic showing lateral links

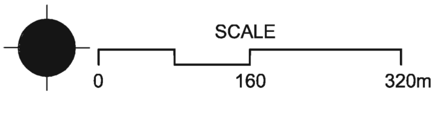




Southlands Flood Modelling

Figure C7

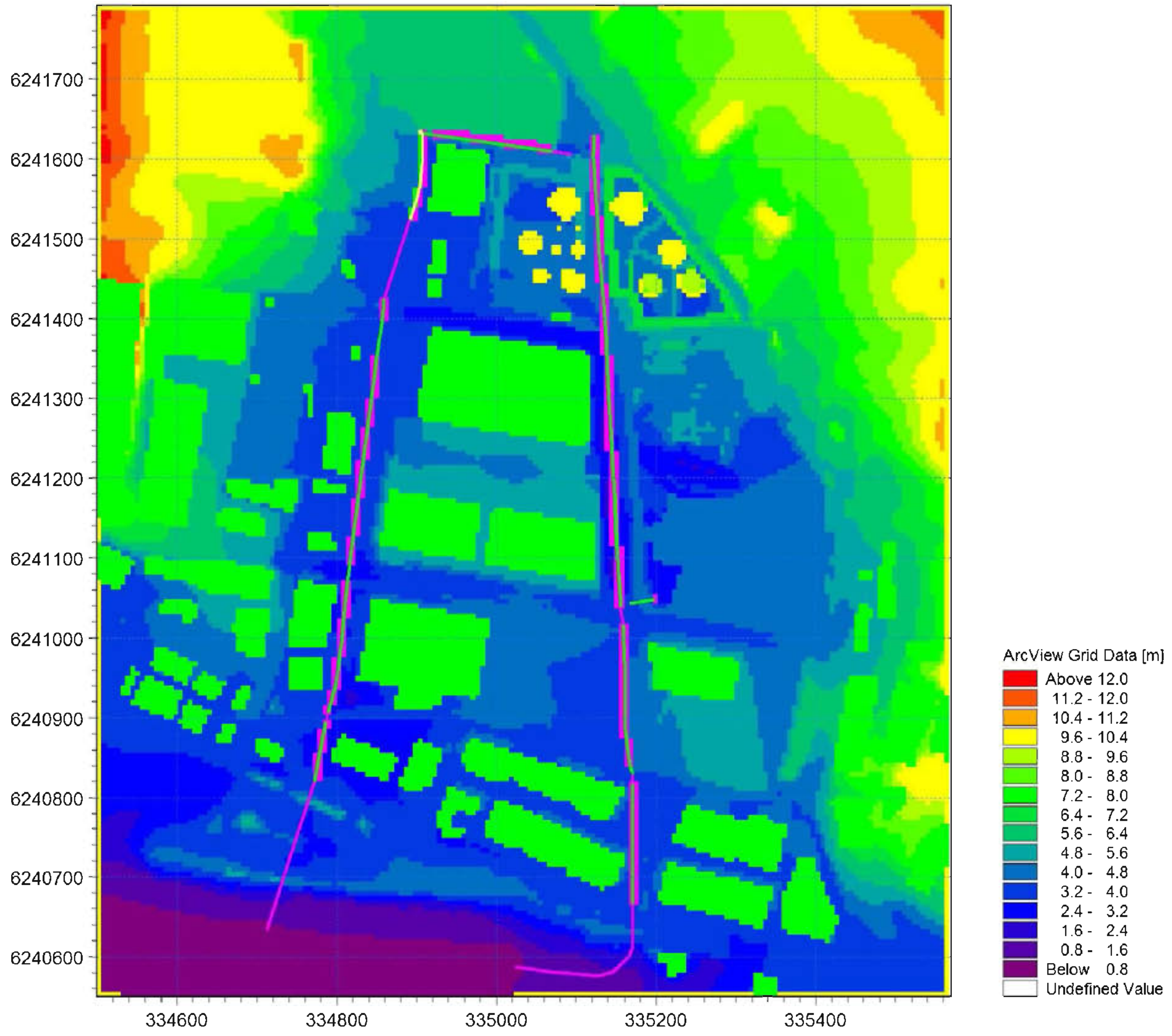
Stage 2 development scenario MIKE 21 terrain model



Southlands Flood Modelling

Figure C8

Stage 2 development scenario MIKE 21 Manning M (1/n) roughness parameters



SCALE
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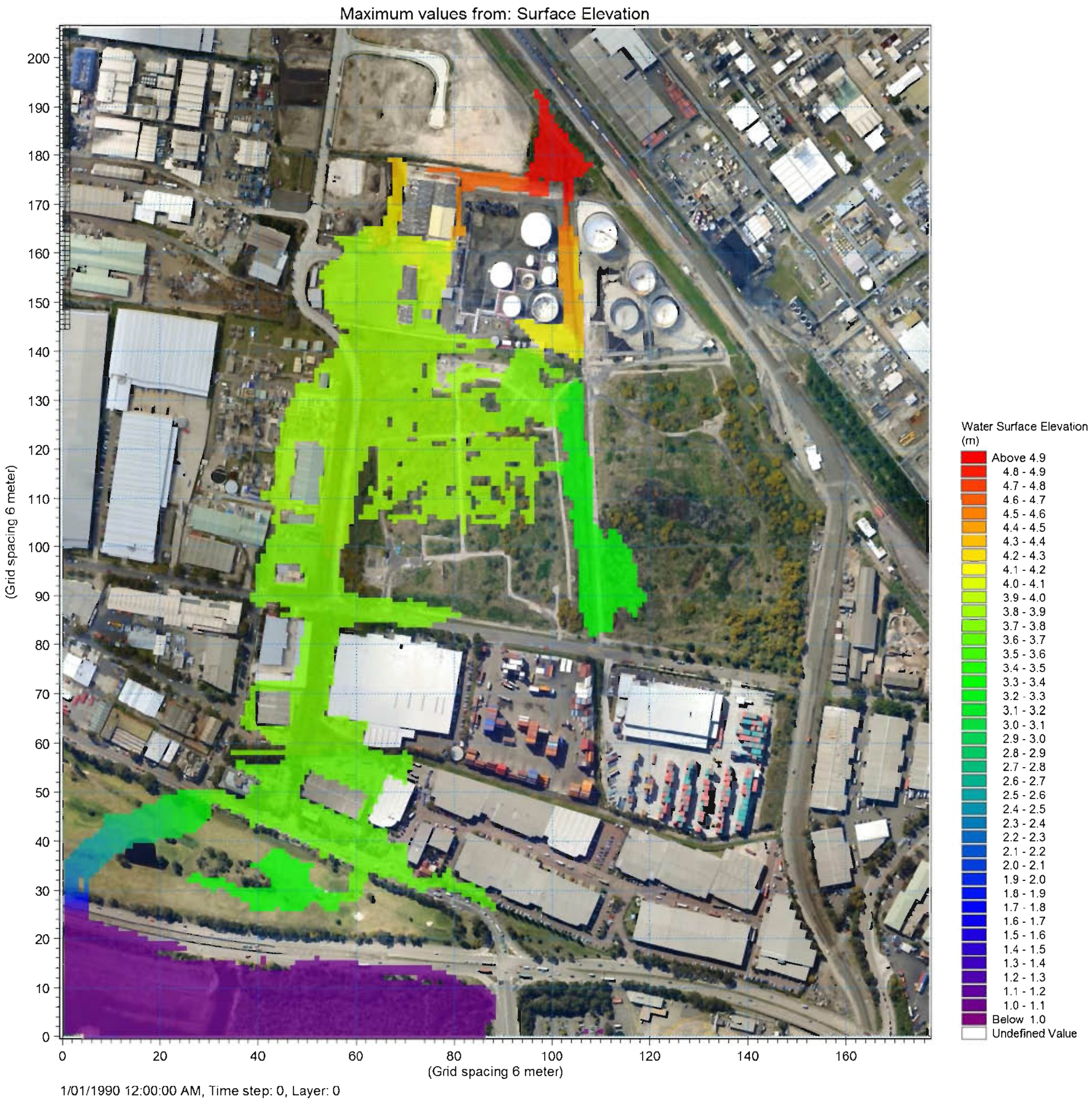
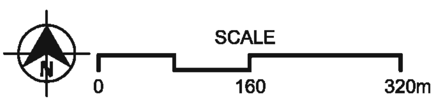
Southlands Flood Modelling **Figure C9**

Stage 2 development scenario MIKE FLOOD model setup schematic showing lateral links

Appendix D
Flood Model Results

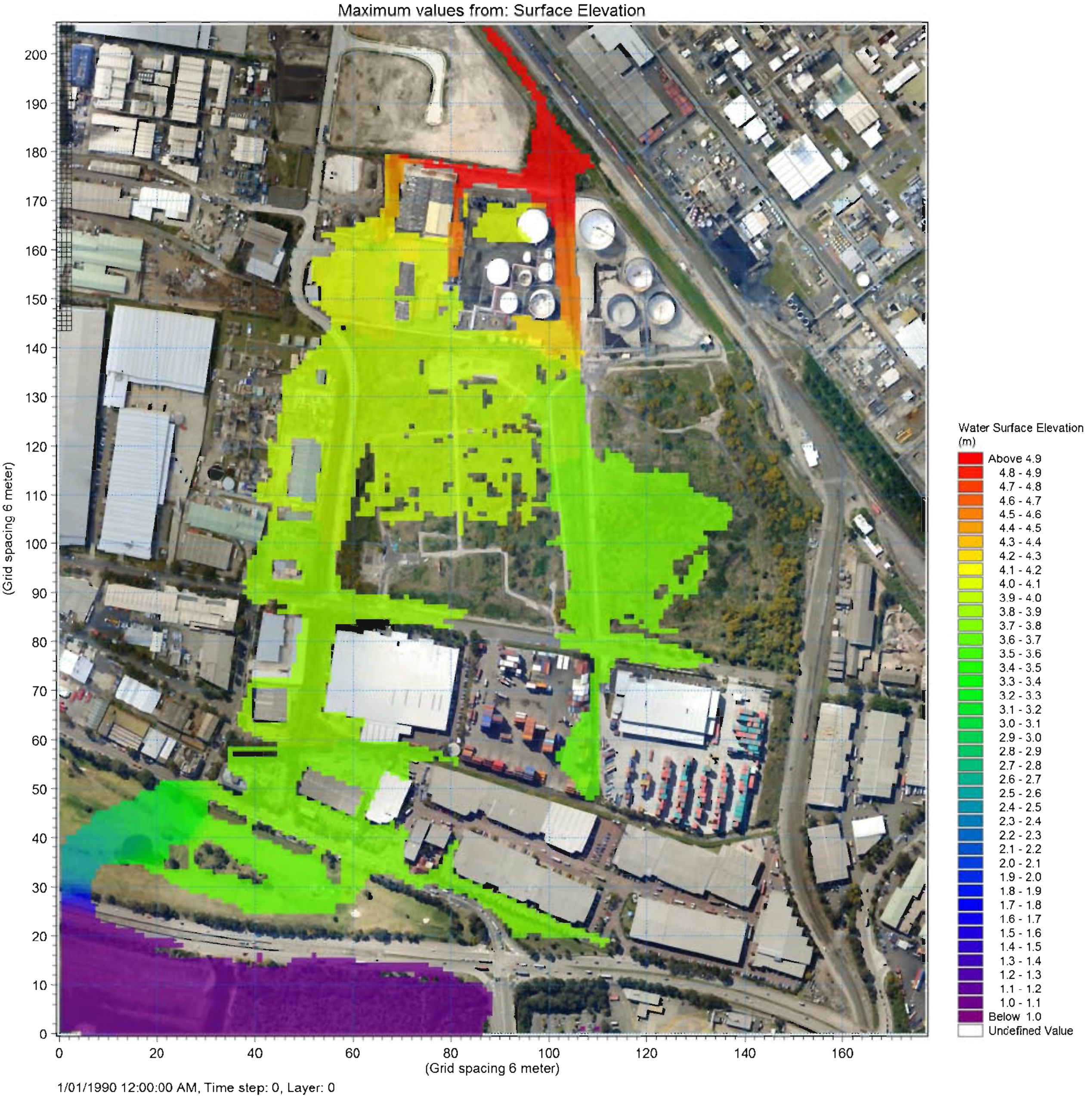




Southlands Flood Modelling

Figure D1

Existing Scenario 50% AEP flood extents



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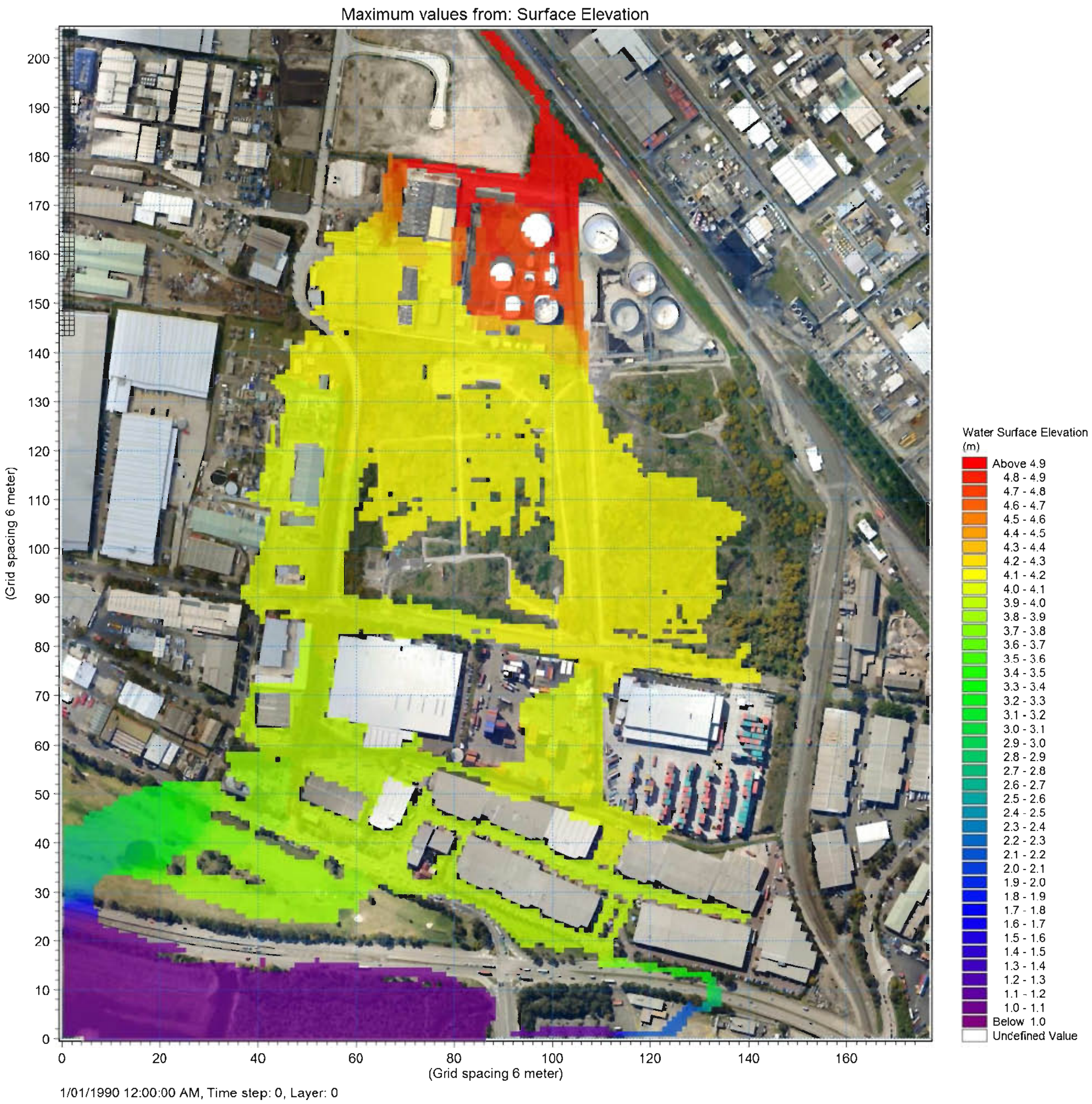
Southlands Flood Modelling **Figure D2**

Existing Scenario 10% AEP flood extents



SCALE
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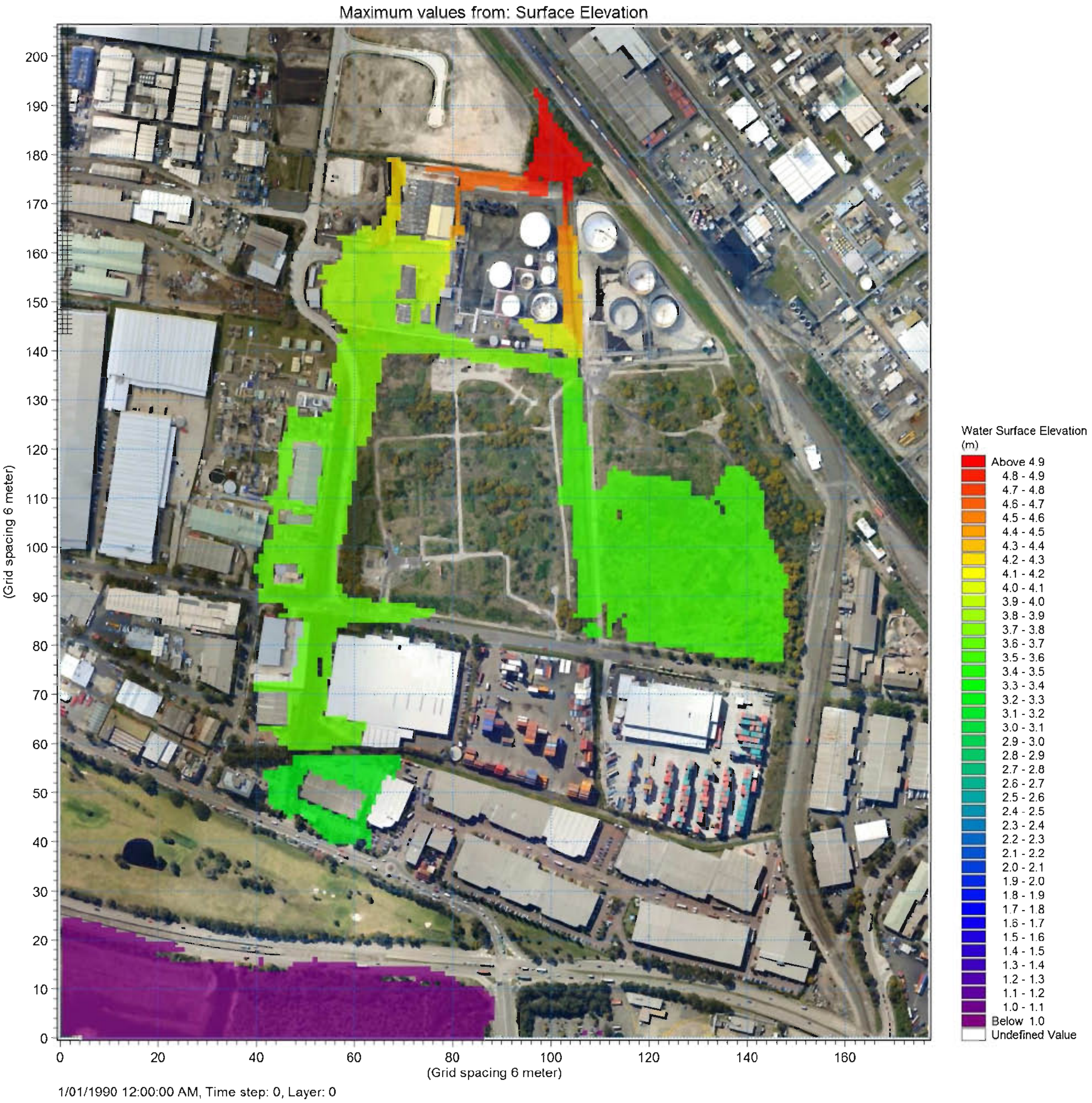
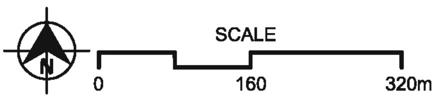
Southlands Flood Modelling **Figure D3**

Existing Scenario 1% AEP flood extents

aurecon

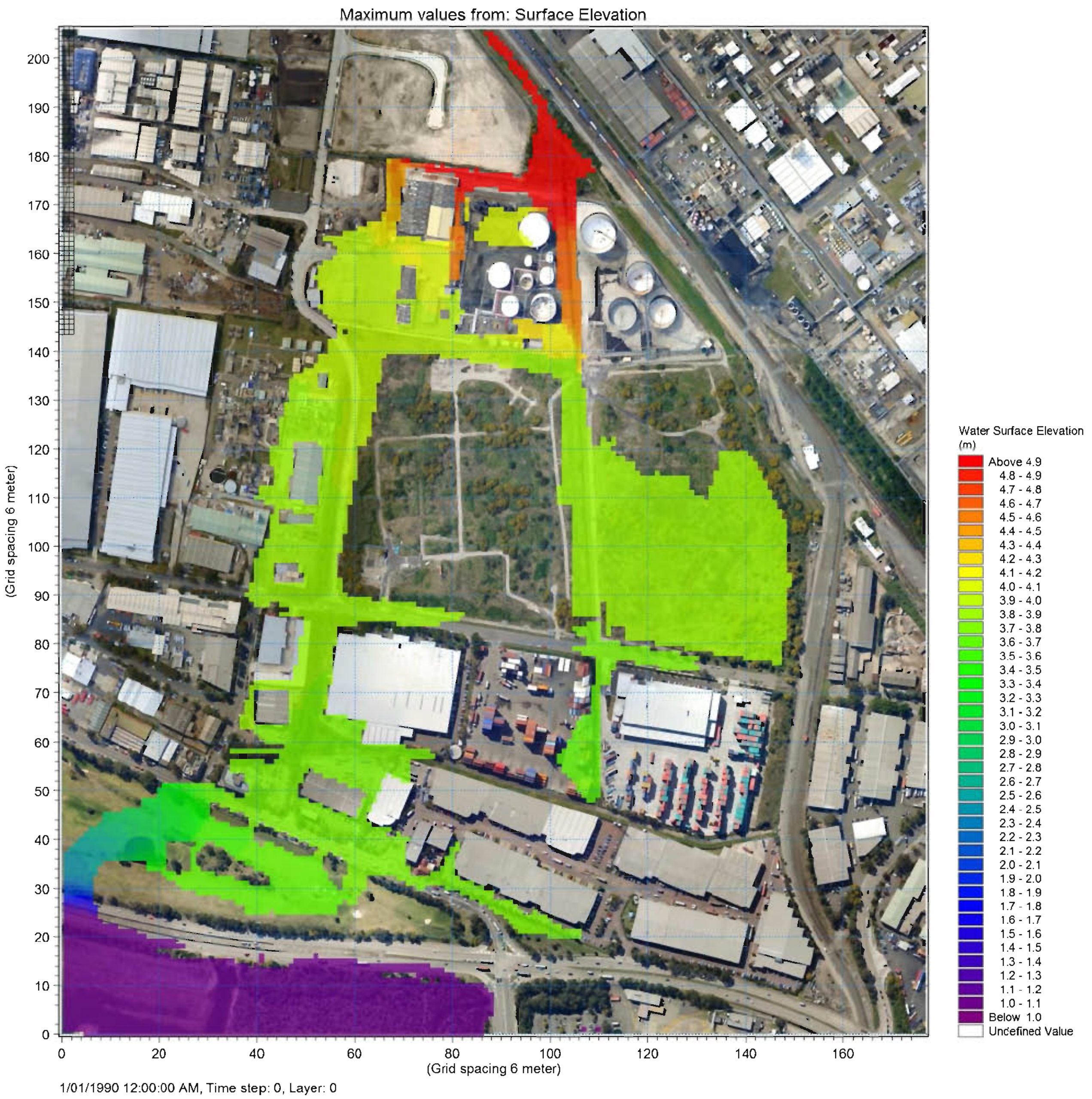




Southlands Flood Modelling **Figure D4**

Stage 1 Development Scenario 50% AEP flood extents

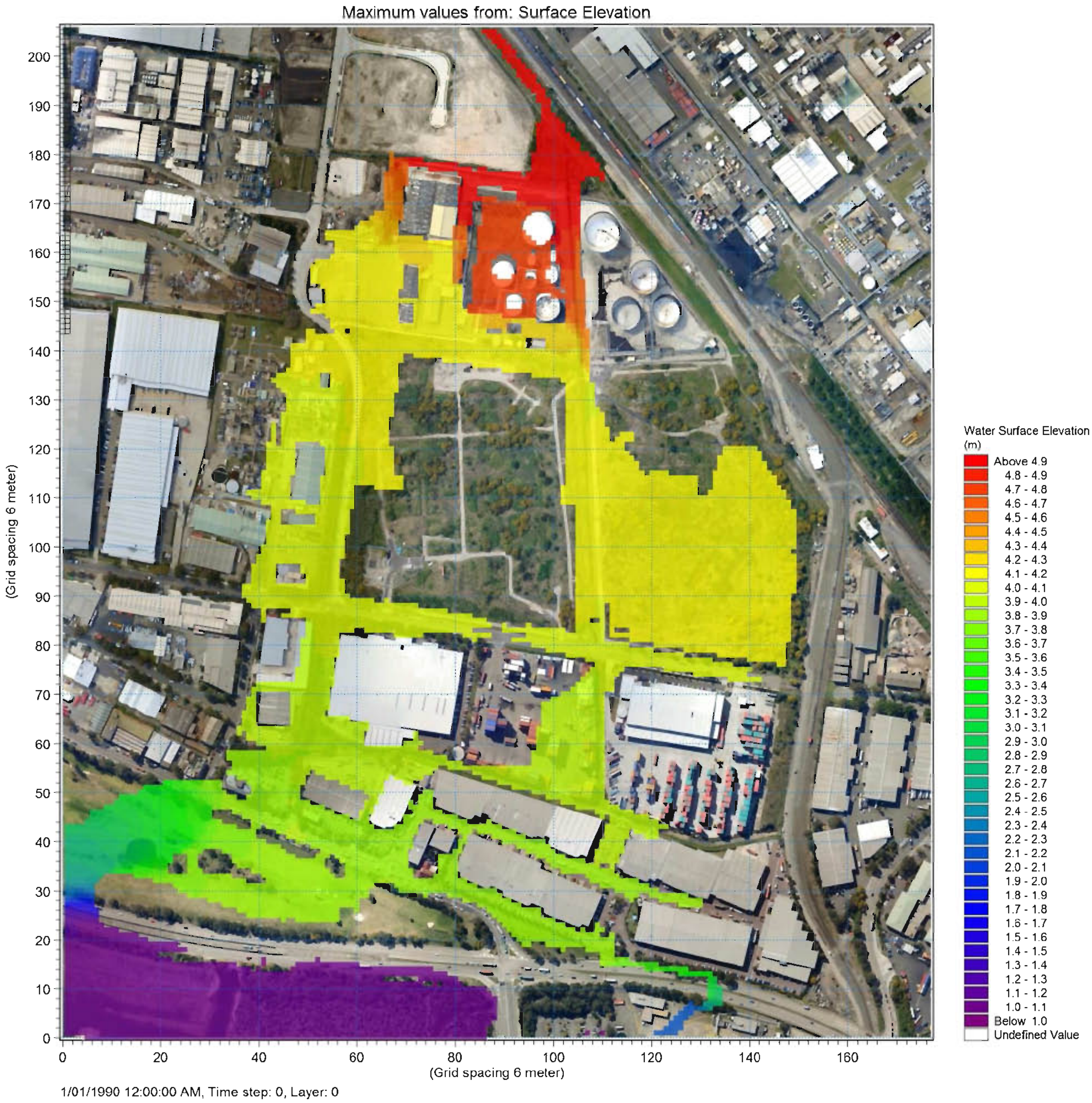
aurecon

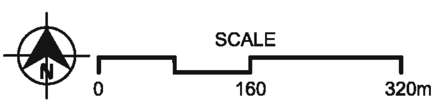


SCALE
0 160 320m

Southlands Flood Modelling **Figure D5**

Stage 1 Development Scenario 10% AEP flood extents



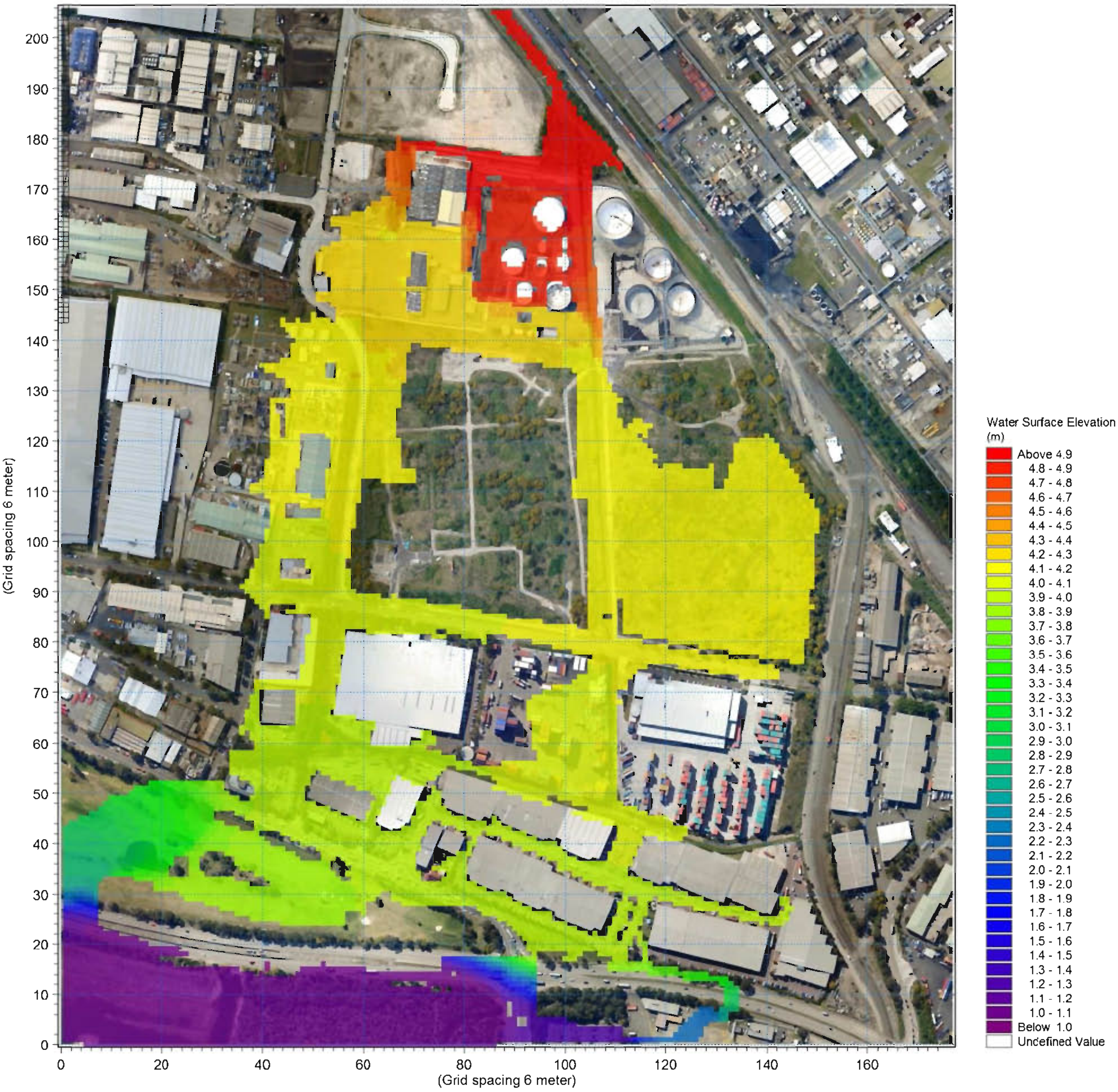


Southlands Flood Modelling

Figure D6

Stage 1 Development Scenario 1% AEP flood extents

Maximum values from: Surface Elevation



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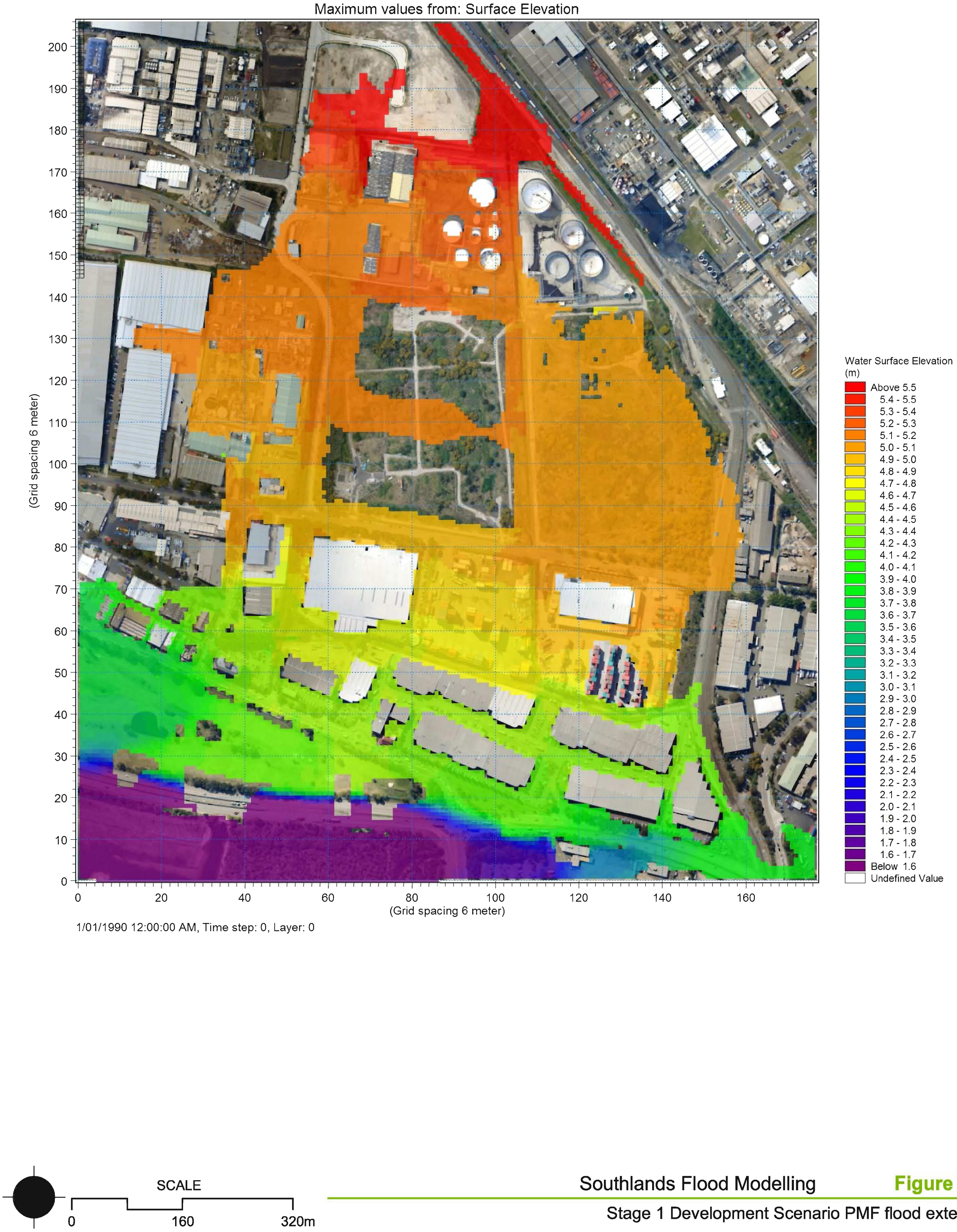
SCALE 0 160 320m

Southlands Flood Modelling **Figure D7**

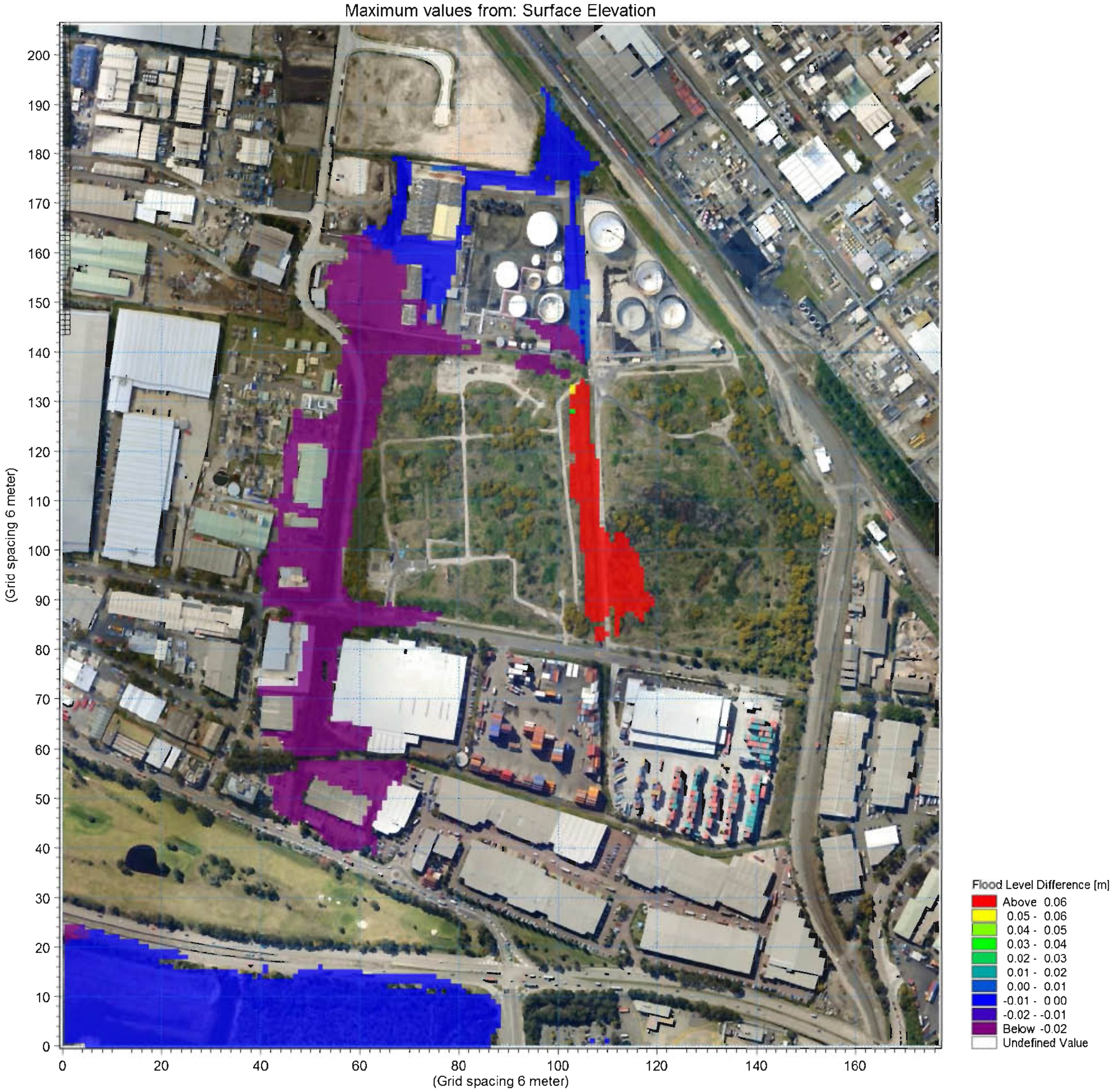
Stage 1 Development Scenario 1% AEP with Climate Change flood extents



Southlands Flood Modelling **Figure D8**

Stage 1 Development Scenario PMF flood extents

Maximum values from: Surface Elevation



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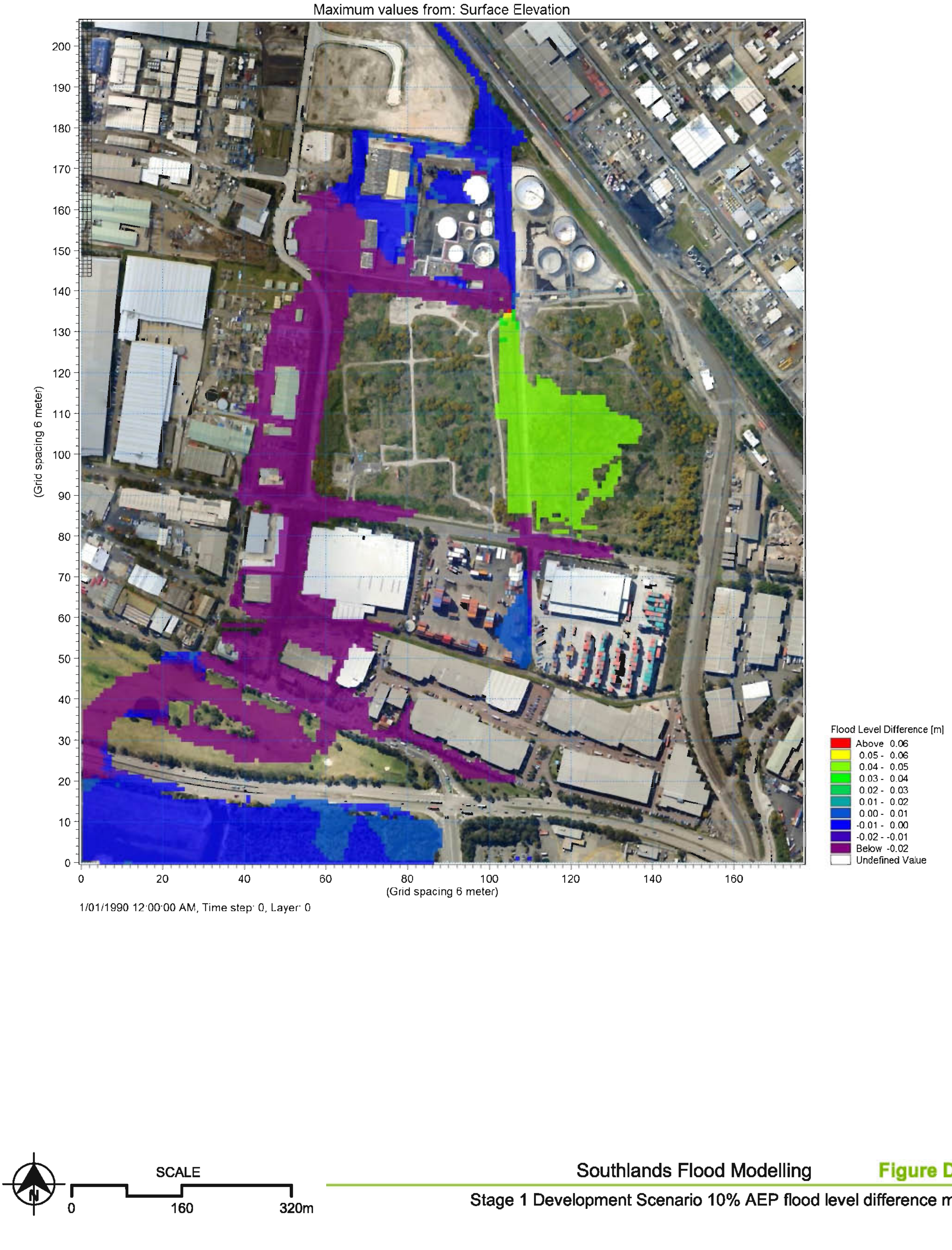
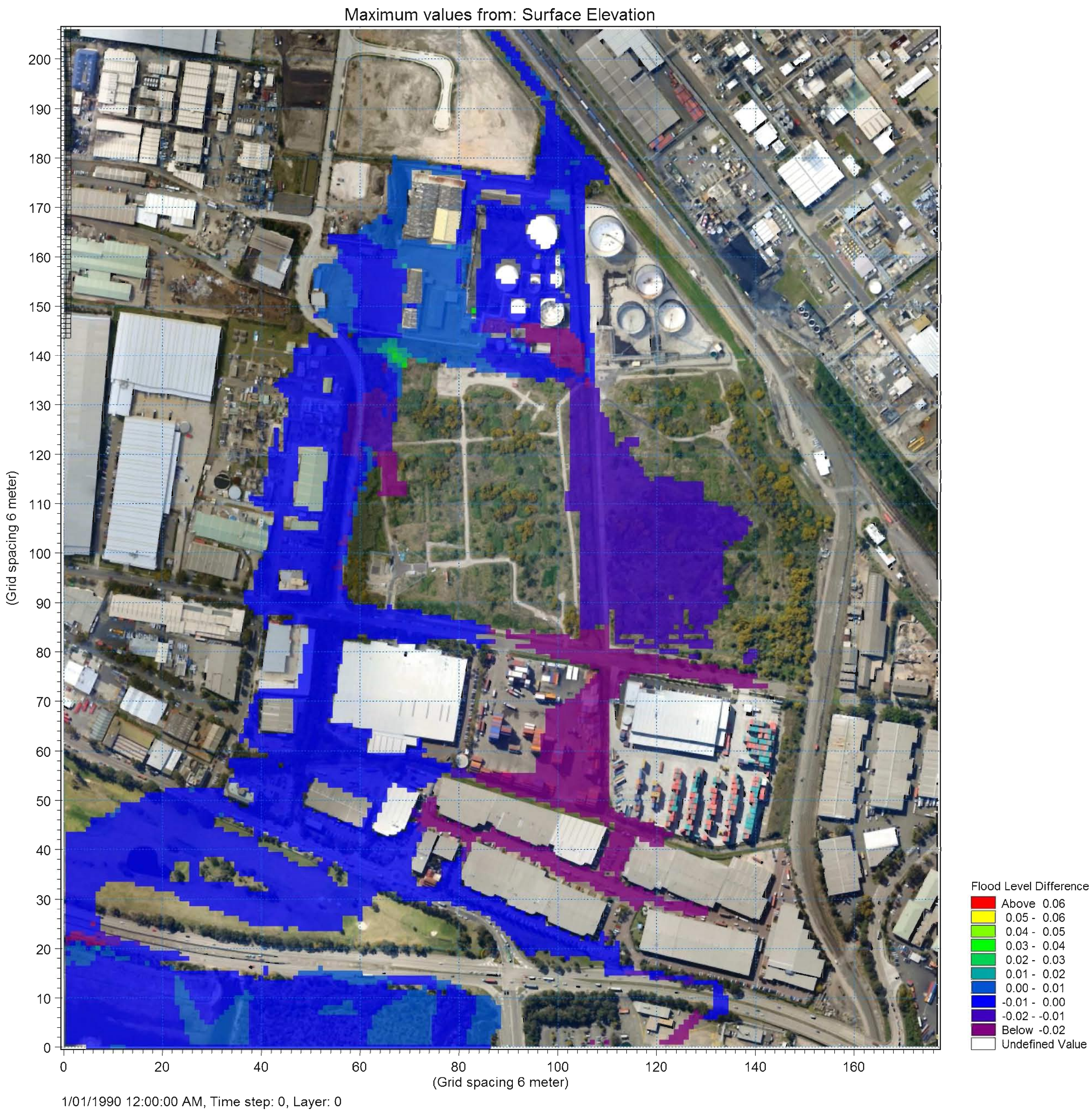
SCALE 0 160 320m

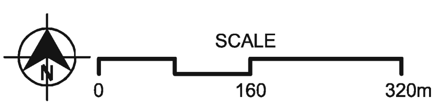
Southlands Flood Modelling

Figure D9

Stage 1 Development Scenario 50% AEP flood level difference map


Maximum values from: Surface Elevation
(Grid spacing 6 meter)
(Grid spacing 6 meter)
1/01/1990 12:00:00 AM, Time step: 0, Layer: 0
Flood Level Difference [m]
Above 0.06
0.05 - 0.06
0.04 - 0.05
0.03 - 0.04
0.02 - 0.03
0.01 - 0.02
0.00 - 0.01
-0.01 - 0.00
-0.02 - -0.01
Below -0.02
Undefined Value
SCALE
0
160
320m



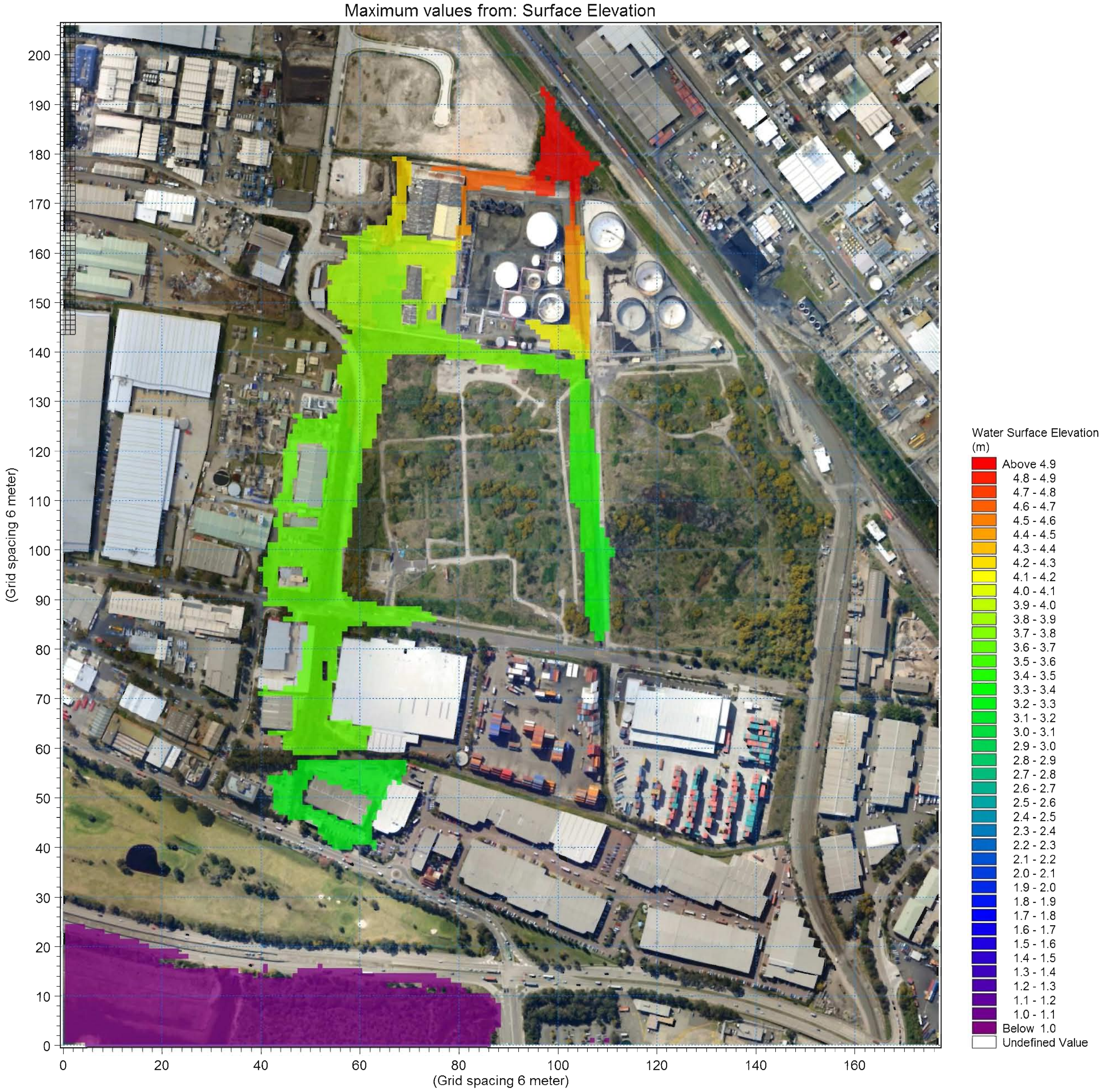


Southlands Flood Modelling

Figure D11

Stage 1 Development Scenario 1% AEP flood level difference map

Maximum values from: Surface Elevation



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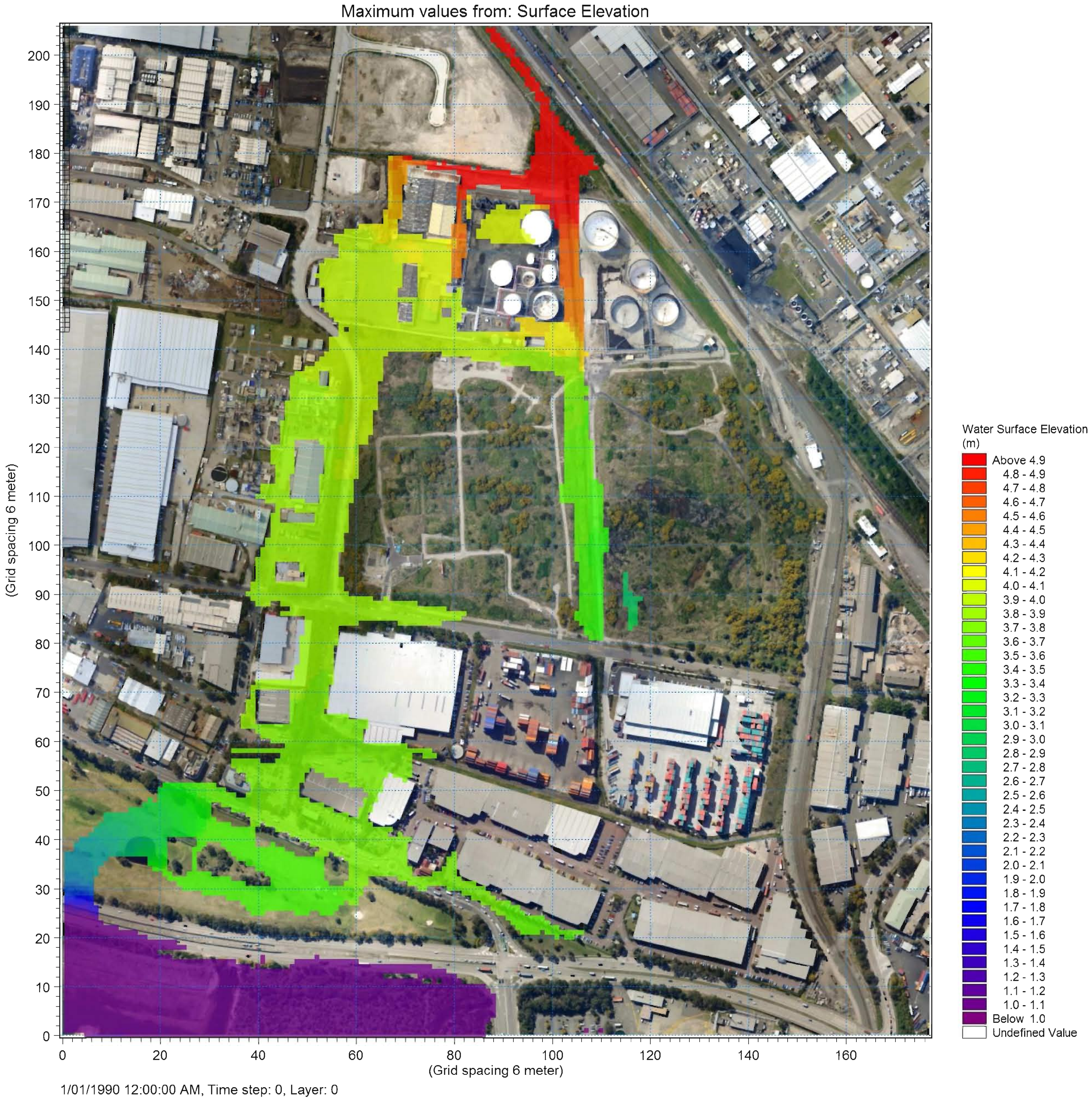
SCALE
0 160 320m

Southlands Flood Modelling **Figure D12**

Stage 2 Development Scenario 50% AEP flood extents

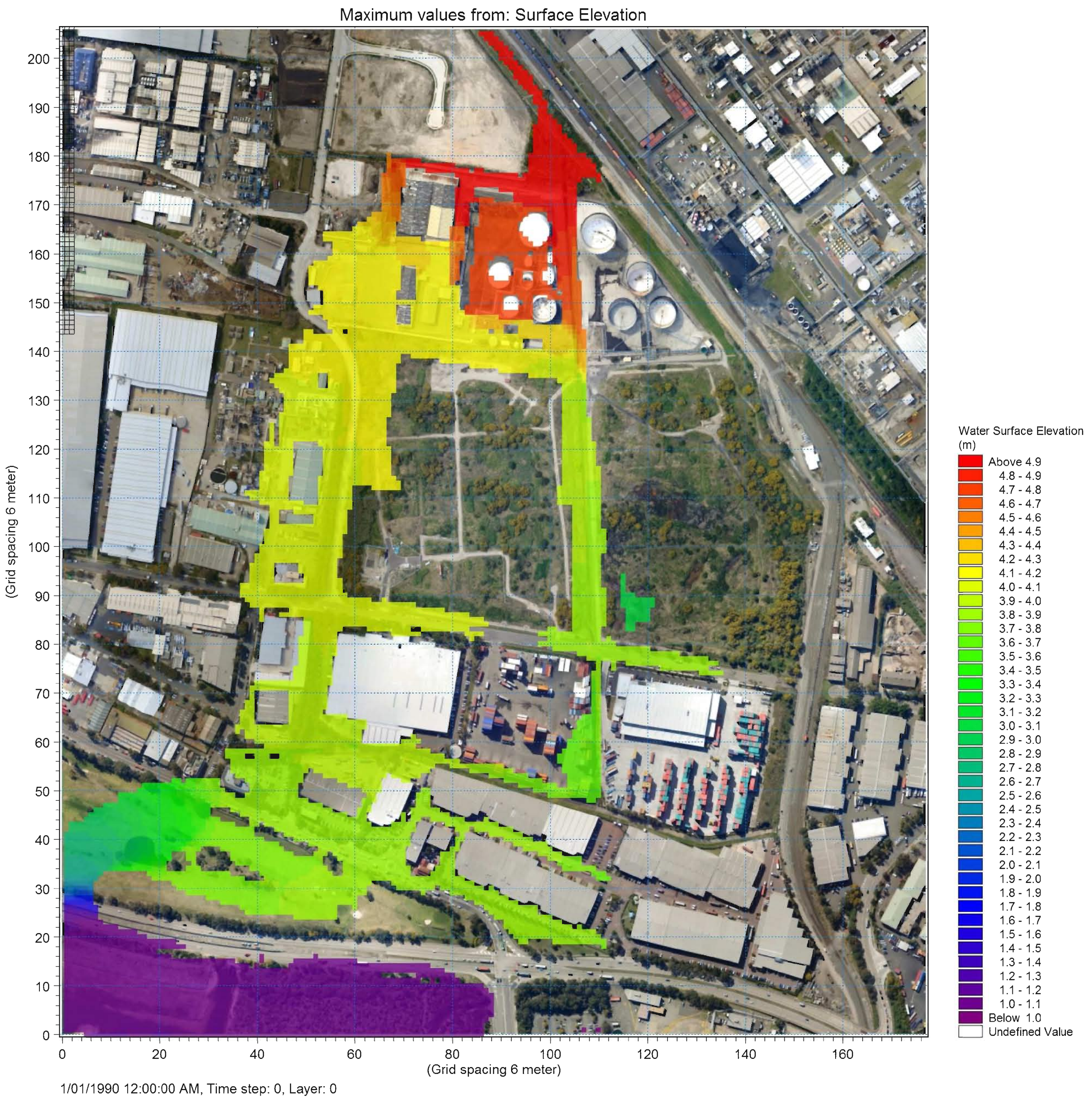


SCALE

0 160 320m

Southlands Flood Modelling **Figure D13**

Stage 2 Development Scenario 10% AEP flood extents

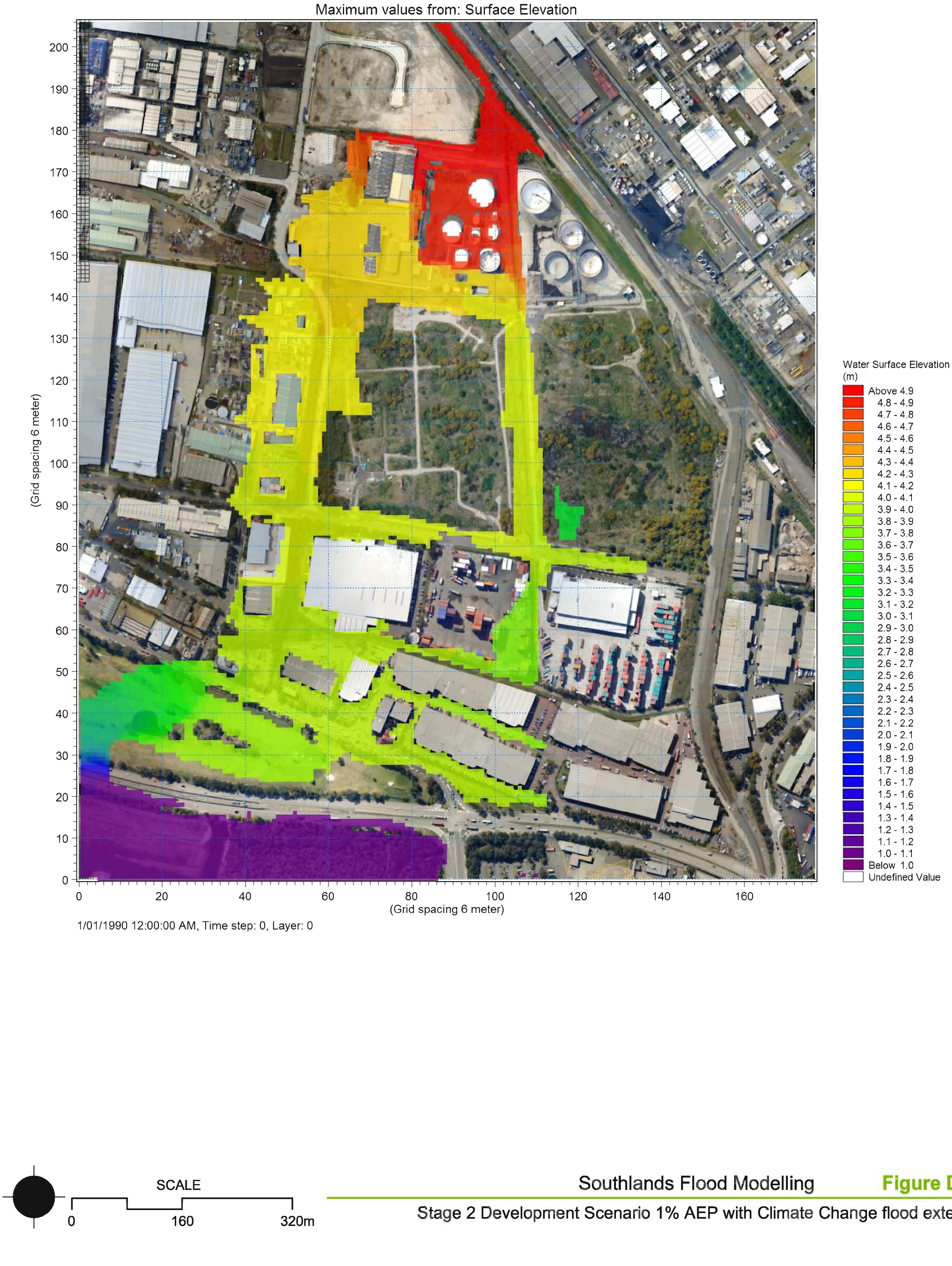


SCALE

0 160 320m

Southlands Flood Modelling **Figure D14**

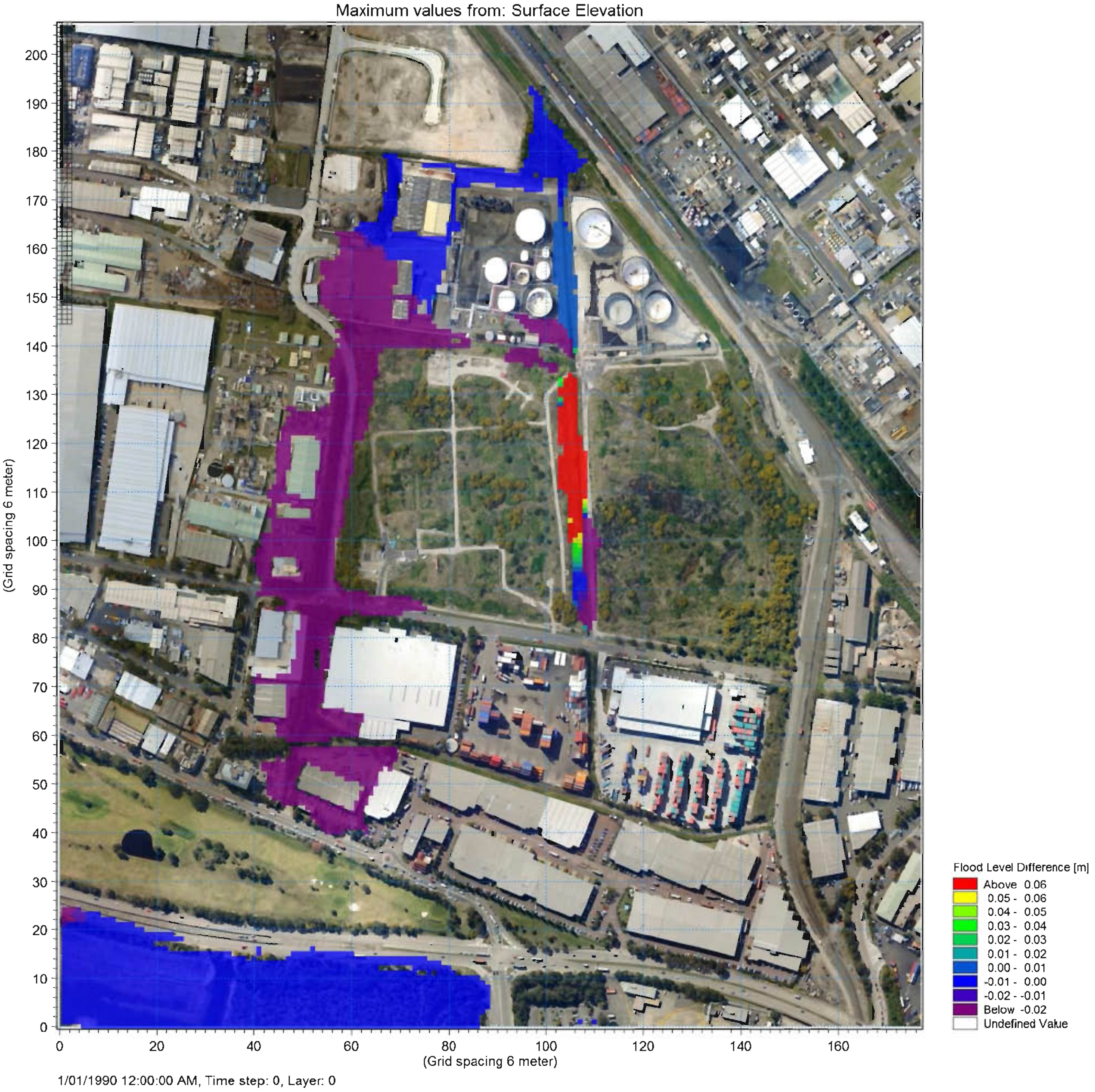
Stage 2 Development Scenario 1% AEP flood extents



Southlands Flood Modelling

Figure D15

Stage 2 Development Scenario 1% AEP with Climate Change flood extents



SCALE
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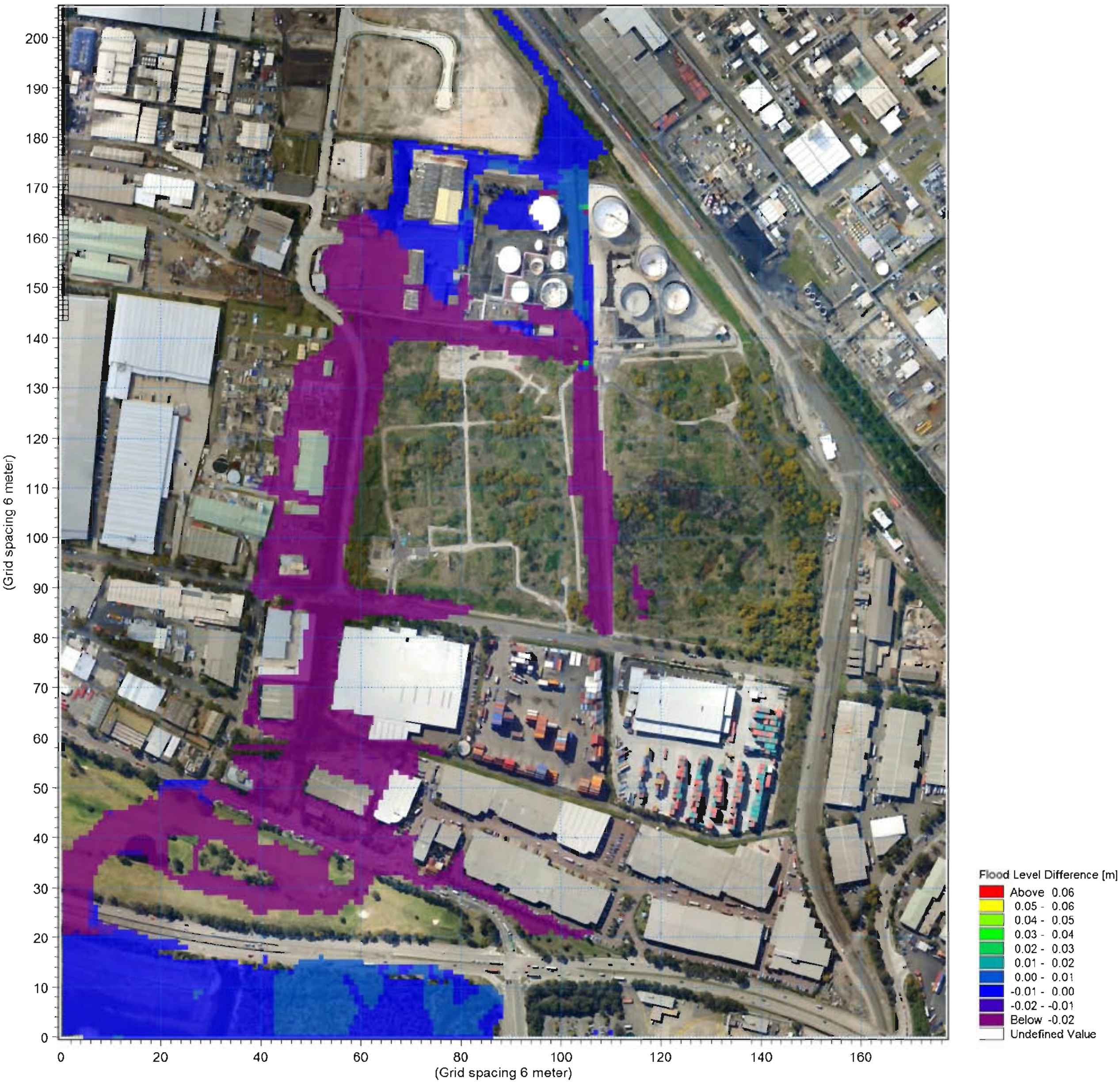
Stage 2 Development Scenario 50% AEP flood level difference map

aurecon

Maximum values from: Surface Elevation



1/01/1990 12:00:00 AM, Time step: 0, Layer: 0

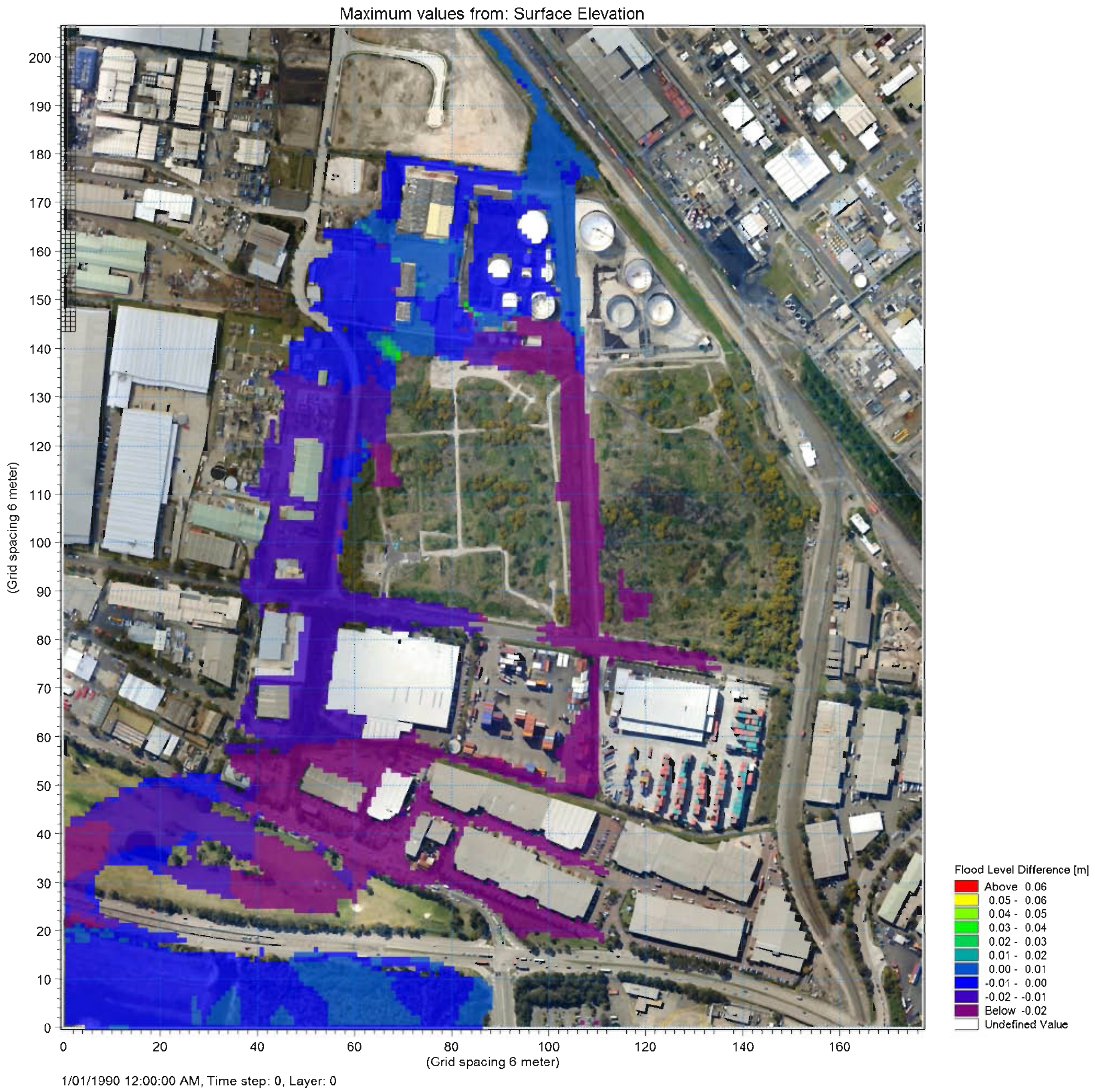
SCALE

0 160 320m

Southlands Flood Modelling **Figure D17**

Stage 2 Development Scenario 10% AEP flood level difference map

aurecon



SCALE
0 160 320m

Southlands Flood Modelling **Figure D18**

Stage 2 Development Scenario 1% AEP flood level difference map