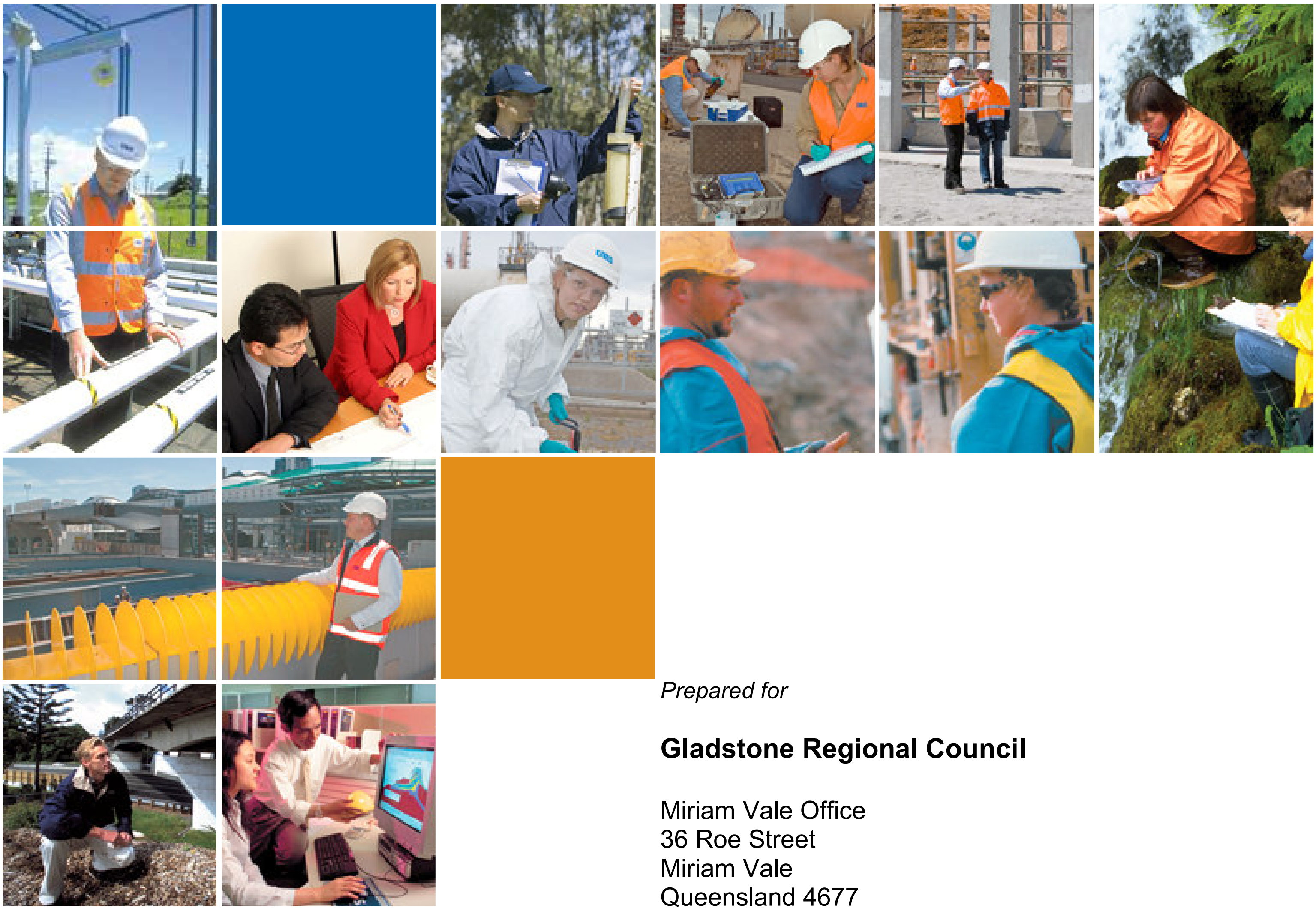
FINAL REPORT

Concept Flood Storage and Conveyance Improvement Assessment at Agnes Water



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Section 1 Introduction

Gladstone Regional Council (formerly Miriam Vale Shire Council) is currently preparing a Drainage Priority Infrastructure Plan (PIP) with the aim of mitigating the impact of future development on flooding in Agnes Water. The mitigation measures include:

- Flood storage improvements upstream of Agnes Creek; and
- Flow conveyance improvements.

URS Australia Pty Ltd (URS) was commissioned by Gladstone Regional Council (GRC) to assess the effectiveness of various flood storage and conveyance improvement options. The scope of URS' commission is detailed in the 'Agnes Water Concept Detention Basin Proposal' dated the 24th January 2008. This project utilises hydrology and hydraulic models developed by URS on behalf of GRC, for the Design and Project Management of Flood Mitigation Works at Agnes Water.

The scope of this report includes:

- Description of flood storage basin options, assessment and evaluation – Section 2;
- Description of conveyance improvement options, assessment and evaluation – Section 3; and
- Summary of results (including cost estimates for the recommended options)– Section 4.

This document reports on concept designs only, therefore further analysis and design of flood storage and conveyance improvement options will be required before construction can occur.

1.1 Flood Storage and Conveyance Improvement Options

The proposed flood storage and conveyance improvement options (as suggested by GRC and discussed during site visits) include:

1. Flood storage locations:
    a. Basin 1 – located between Starfish Road, Round Hill Road and Heights Entrance Road;
    b. Basin 2 – located on Council land between Sunlover Avenue and Banksia Drive;
    c. Basin 3 – located between Sunlover Avenue and Cabbage Palm Drive;
    d. Basin 4 – located adjacent to Round Hill Road and Captain Cook Drive intersection;
    e. Basin 5 – located between Clowes Lane, Springs Road and Jeffery Court.
2. Conveyance improvement areas:
    a. Endeavour Plaza (cnr Captain Cook Drive and Round Hill Road);
    b. Easements behind Endeavour Plaza and Beach Club;
    c. Graham Colyer Drive;
    d. Intersection of Jeffery Court and Agnes Street through Tucker property (on the Main Beach side of the Mango Tree Motel) to Agnes Creek (Tucker property conveyance).

Figure 1-1 illustrates the location and extents of the concept flood storage basins and conveyance improvement options listed above.

The flood storage and conveyance improvement options were evaluated for the following scenarios:

- Existing development;
- Existing development with concept flood storage basins and conveyance improvement options; and

- Future development with concept flood storage basins and conveyance improvement options.

1.2 Agnes Water Hydrology Background

Agnes Creek is situated in the low lying area behind the coastal dune formations of the Agnes Water Main Beach. The town of Agnes Water is located in the lower part of the Agnes Creek catchment which collects runoff from steep hills surrounding the town.

The coastal dunes form the lower boundary of the catchment. The Agnes Creek outlet to the Coral Sea is periodically blocked by sand bars during the dry season (July – October). Agnes Creek features tidal intrusion during infrequent high tides and/or as a result of flood events that remove sand deposits from the creek outlet.

The open channel reach of the creek begins at an ornamental pond adjacent to Agnes Street and within the Beach Houses Estate. The creek meanders through Agnes Water in a horseshoe shape that runs parallel to the coastline before the creek outlets into the ocean. The creek bed has a very low gradient, with sandy substrate and features areas of standing water sustained by groundwater.

Upstream of the pond, natural flow paths have been modified as a result of urbanisation. Of note are the following modified main tributaries:

- From the south-west: Two engineered open channels convey runoff from the steep urbanised areas of the catchment. One of the channels runs under the Agnes Water Visitor's Centre, whilst the second runs under the Agnes shopping centre. Both channels join upstream of the pond.
- From the south-east: Flows are conveyed through Jeffrey Court (one of the older areas of Agnes Water) via a 1050mm Reinforced Concrete Pipe (RCP). This pipe also discharges to the Beach Houses Estate ornamental pond.

Source:Client Supplied Aerial Photo (2006)

Client	Project	Title
GLADSTONE REGIONAL COUNCIL	AGNES WATER FLOOD STORAGE AND CONVEYANCE IMPROVEMENT OPTIONS	**FLOOD STORAGE AND CONVEYANCE IMPROVEMENT LOCATIONS**
URS	Drawn: EK · Approved: TMcC · Date: 11-04-2008 Job No: **4262 6179** · File No: 42626179-g-001.wor	Figure: **1-1** · Rev: A · **A4**

Section 2 Flood Storage Assessment

Cadastral Information

Cadastral information for Agnes Water was provided by GRC, as part of the Agnes Water Flood Mitigation Project.

2.1.2 Design Outcomes

A brief description of each concept flood storage basin is outlined below.

Flood Storage Basin 1

Crest shape: Straight due to well defined gully

Crest RL (m): 24.5

Size constraints: Property boundaries adjacent to Starfish Street

Approximate maximum crest height above ground surface (m AHD): 3.2

Embankment slopes (V:H): 1:2

Embankment crest width (m): 3

Contributing catchment size (ha): 7.6

Storage Volume (m3): 830

Diameter of outlet discharge pipe (mm): 450

Flood Storage Basin 2

Crest shape: L-shape due to topography and no defined gully

Crest RL (m AHD): 10

Size constraints: Sunlover Avenue (south) and stormwater drain (north)

Approximate maximum crest height above ground surface (m AHD): 1.4

Embankment slopes (V:H): 1:2

Embankment crest width (m): 3

Contributing catchment size (ha): 17.3

Storage Volume (m3): 560

Diameter of outlet discharge pipe (mm): 450

Section 2 Flood Storage Assessment

Flood Storage Basin 3

Crest shape: Straight due to well defined gully

Crest RL (m): 15

Size constraints: Property boundaries to the north of Sunlover Avenue

Approximate maximum crest height above ground surface (m AHD): 1.5

Embankment slopes (V:H): 1:2

Embankment crest width (m): 3

Contributing catchment size (ha): 8.9

Storage Volume (m3): 320

Diameter of outlet discharge pipe (mm): 450

Flood Storage Basin 4

Crest shape: U-shaped due topography and no defined gully

Crest RL (m): 16

Size constraints: Land acquisition

Approximate maximum crest height above ground surface (m AHD): 3.9

Embankment slopes (V:H): 1:2

Embankment crest width (m): 3

Contributing catchment size (ha): 5.2

Storage Volume (m3): 12,100

Diameter of outlet discharge pipe (mm): 600

Flood Storage Basin 5

Crest shape: L-shaped due topography

Crest RL (m): 7

Size constraints: Jeffery Court and Springs Road

Approximate maximum crest height above ground surface (m AHD): 2.8

Embankment slopes (V:H): 1:2

Embankment crest width (m): 3

Contributing catchment size (ha): 14.2

Storage Volume (m3): 6,150

Diameter of outlet discharge pipe (mm): 600

2.2 Concept Flood Storage Basin Hydrological Modelling

An XP-RAFTS hydrological model was developed as part of URS' current commission with GRC for design and project management of Flood Mitigation Works at Agnes Water. This model was modified to assess the effectiveness of the concept flood storage basins.

The effectiveness of the concept flood storage basins correlates to their ability to reduce peak flows i.e. controlling the volume and timing of flows entering the downstream environment with the aim of reducing downstream flood levels.

The XP-RAFTS hydrologic computer package was used for the estimation of peak flows for the 100yr ARI event modelled over 0.25, 0.5, 1, 2, 3, 6, 9, 12 and 18hr storm durations for the following scenarios:

- Existing development;
- Existing development with concept flood storage basins;
- Future development; and
- Future development with concept flood storage basins.

The volume versus height relationships for each of the concept flood storage basins were calculated in 12d and input into the XP-RAFTS models.

For a summary of XP-RAFTS input parameters refer to Appendix A.

2.2.1 Concept Flood Storage Basin Hydrology Modelling Results

Table 2-1 and Table 2-2 present the reduction in peak flows for the existing and future scenarios respectively.

Table 2-1 Peak Flow Reduction of Concept Flood Storage Basins - Existing Development

Storm Duration (hr)	Reduction Peak Flow (m^3/s)				
	Node A2 (Downstream of Basin 1)	Node 29 (Downstream of Basin 3)	Node 28 (Downstream of Basin 2)	Node 25 (Downstream of Basin 4)	Node 9 (Downstream of Basin 5)
0.25	0	3.14	12.02	1.73	1.52
0.5	0	2.62	10.37	2.2	3.85
1	-0.03	2.49	9.82	2.15	5.21
2	1.24	2.58	9.79	2.74	6.88
3	0.29	0.73	4.37	1.24	4.15
6	0.8	0.33	2.64	0.69	2.91
9	0.87	0.37	2.68	0.71	2.96
12	1.08	0.51	3.12	0.83	3.3
18	0.37	0.2	1.75	0.38	1.95

Section 2 Flood Storage Assessment

Table 2-2 Peak Flow Reduction of Concept Flood Storage Basins - Future Development

Storm Duration (hrs)	Reduction Peak Flow (m^3/s)				
	Node A2 (Downstream of Basin 1)	Node 29 (Downstream of Basin 3)	Node 28 (Downstream of Basin 2)	Node 25 (Downstream of Basin 4)	Node 9 (Downstream of Basin 5)
0.25	0	3.13	12.12	2.25	5.15
0.5	0	2.63	10.5	2.67	7.71
1	0.04	2.5	10.18	2.3	6.12
2	0.34	1.76	7.78	1.48	3.93
3	0.19	0.75	4.43	1.25	4.41
6	0.85	0.33	2.8	0.68	2.92
9	0.92	0.37	2.9	0.71	2.98
12	1.15	0.51	3.46	0.85	3.31
18	0.55	0.25	2.03	0.38	1.97

Review of Table 2-1 and Table 2-2, combined with the summary information presented in Section 2.1.2 for each concept flood storage basin, indicates the following:

- Concept Flood Storage Basin 1
  - Small contributing catchment area and storage volume result in minimal reduction in peak flows for both existing and future scenarios.
  - No further analysis is recommended for this basin.
- Concept Flood Storage Basin 2
  - Large reduction in peak flows for the existing and future scenarios.
  - Recommended for further analysis.
- Concept Flood Storage Basin 3
  - Small contributing catchment area and storage volume result in moderate reduction in peak flows for both existing and future scenarios.
  - No further analysis is recommended for this basin.
- Concept Flood Storage Basin 4
  - Small contributing catchment area, however large storage volume, resulting in moderate reduction in peak flows for both existing and future scenarios. Swales or bunds could be implemented to direct additional catchment into this basin and further reduce peak flows.
  - Recommended for further analysis.
- Concept Flood Storage Basin 5
  - Large reduction in peak flows for the existing and future scenarios.
  - Recommended for further analysis.

From the above summary, it is recommended that concept flood storage basins 2, 4 and 5 be further analysed within the hydraulic model.

2.3 Concept Flood Storage Hydraulics

A TUFLOW hydraulic model was developed as part of URS' current commission with GRC for design and project management of Flood Mitigation Works at Agnes Water. This model was modified to further assess the effectiveness of the concept flood storage basins 2, 4 and 5 in reducing floods levels within Agnes Water.

The TUFLOW model was used for the estimation of peak flood levels for the 100yr ARI event (1 hour and 12 hour storm durations) for the following scenarios:

- Existing development;
- Existing development with concept flood storage basins;
- Future development; and
- Future development with concept flood storage basins.

XP-RAFTS hydrograph outputs for these scenarios were entered into the TUFLOW hydraulic model. A comparison between the with flood storage basins and without flood storage basins flood levels for the existing and future scenarios was undertaken to estimate the reduction in flood levels.

For further explanation of the TUFLOW model and inputs refer to Appendix B.

2.3.1 Concept Flood Storage Hydraulic Results

Figure 2-1 presents the reduction in flood levels for the existing scenario during the 100yr 1 hour storm, achieved by constructing flood storage basins 2, 4 and 5.

Flood Storage Assessment

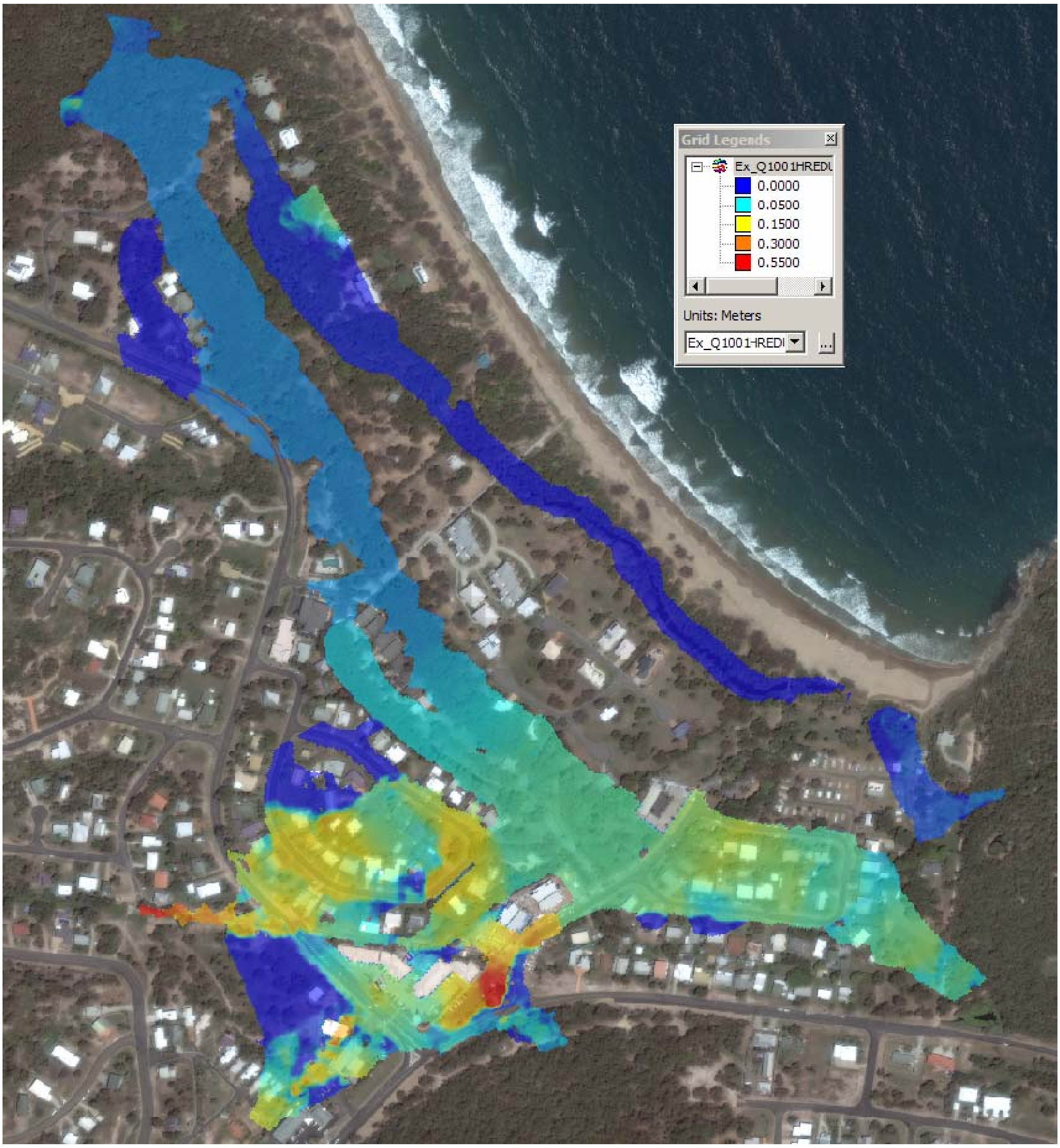


Figure 2-1 Existing Development 100 year ARI, 1 hr storm duration - Estimated flood level reduction

Review of Figure 2-1, indicates a reduction in existing flood levels during the 100 yr ARI, 1 hour storm event, as follows:

- 0.1m-0.25m in Graham Colyer Court; and
- 0.1-0.2m in Jeffery Court.

These reductions are considered significant and if swales or bunds were constructed to direct upper catchment flows into concept flood storage basin 4 it is possible that greater peak flow reduction could be achieved. The addition of conveyance improvement options could also drain flood waters out to sea more efficiently, thus reducing the flood inundation duration. The following sections report on the combination of conveyance improvement and concept flood storage basins.

Section 3 Conveyance Improvement Assessment

This section reports on the methodology undertaken in the concept design of conveyance improvement options and summarises the hydraulic analysis of their effectiveness in reducing flood levels within Agnes Water.

3.1 Concept Conveyance Improvement Design

3.1.1 Design Input

The concept conveyance improvement works were designed to fit within the cadastral constraints, whilst maintaining a suitable longitudinal slope. The analysis was conceptual and most of the attention was devoted to creating a flow path (typically of trapezoidal shape) for runoff to drain from flood affected areas rather than determining the actual dimensions or structure type of the conveyance improvement work. The following describes QUDM design criteria for open channels and design outcomes of conveyance options used in the flood study.

Design Criteria

The following design criteria were adopted:

- Longitudinal slope
    - For steep channels employ drop structures to reduce flows
        - This should be adopted for the Tucker Property conveyance
            - Hand rails and warning signs are an alternative
- Side slopes no steeper than 1V:2H
    - For channels with ground covers
- Minimum base width of 2.0m
    - Largest possible base width with 1V:2H side slopes adopted
- Minimum depth of 0.45m
    - Excavations up to a depth of 2.0m adopted
        - Possible barrier fencing and warning sign installation for deep channels
- Access and maintenance
    - Minimum side berm of 4.5m required
- Safety
    - Minimum 1.5m side access strip

Topographical & Cadastral Information

Refer Section 2.1.1 for details.

3.1.2 Design Outcomes

A brief description of each concept conveyance improvement is outlined below.

Endeavour Plaza (cnr Captain Cook Drive and Round Hill Road)

The aim of this conveyance improvement is to drain flood waters from Endeavour Plaza towards Agnes Street and tie in with the Tucker property conveyance improvement option.

Conveyance Length (m):	Approximately 60
Size constraints:	Endeavour Plaza and Jeffery Court
Longitudinal slope (V:H):	1.5:100
Side slopes (V:H)	1:2
Base width (m):	10
Maximum depth (m):	Approximately 0.4

Easements behind Endeavour Plaza and Beach Club

Concept design was not undertaken for this option, due to limiting topography.

Graham Colyer Drive

The Graham Colyer Drive conveyance improvement is designed to drain water from Graham Colyer Drive to the ornamental lake within the Beach Houses estate (head of Agnes Creek).

Conveyance Length (m):	83
Size constraints:	Property boundaries off Graham Colyer Drive
Longitudinal slope (V:H):	1:100
Side slopes (V:H)	1:2
Base width (m):	5
Maximum depth (m):	0.5

Tucker property (1/RP856970)

This conveyance improvement collects runoff from Jeffery Court and Agnes Street and directs this through the Tucker property and out to Agnes Creek (adjacent to the Agnes Water Flood Mitigation Works outlet).

Conveyance Length (m):	220
Size constraints:	Agnes Street, Tucker property and Jeffery Court
Longitudinal slope (V:H):	1:9
Side slopes (V:H)	1:2
Base width (m):	10
Maximum depth (m):	2

3.2 Concept Conveyance Improvement Hydraulic Modelling

The modified TUFLOW hydraulic model used to assess the concept flood storage basins, was further modified to assess the effectiveness of the conveyance improvement options.

The TUFLOW model was used for the estimation of peak flood levels for the 100yr ARI event (1 hour and 12 hour storm durations) for the following scenarios:

- Existing development;
- Existing development with concept flood storage basins and conveyance improvement options;
- Future development; and
- Future development with concept flood storage basins and conveyance improvement options.

The conveyance improvement options were designed in 12d and modified ground surface in the areas of the conveyance improvements were incorporated into the TUFLOW model, as a patch over the existing digital ground data.

For further explanation of the TUFLOW model and inputs refer to Appendix B.

3.2.1 Concept Conveyance Improvement Hydraulic Results

Figure 3-3 presents the reduction in flood levels for the existing scenario during the 100 yr 1 hour storm, achieved by constructing flood storage basins 2, 4 and 5 as well as the conveyance improvement options.

Section 3 Conveyance Improvement Assessment

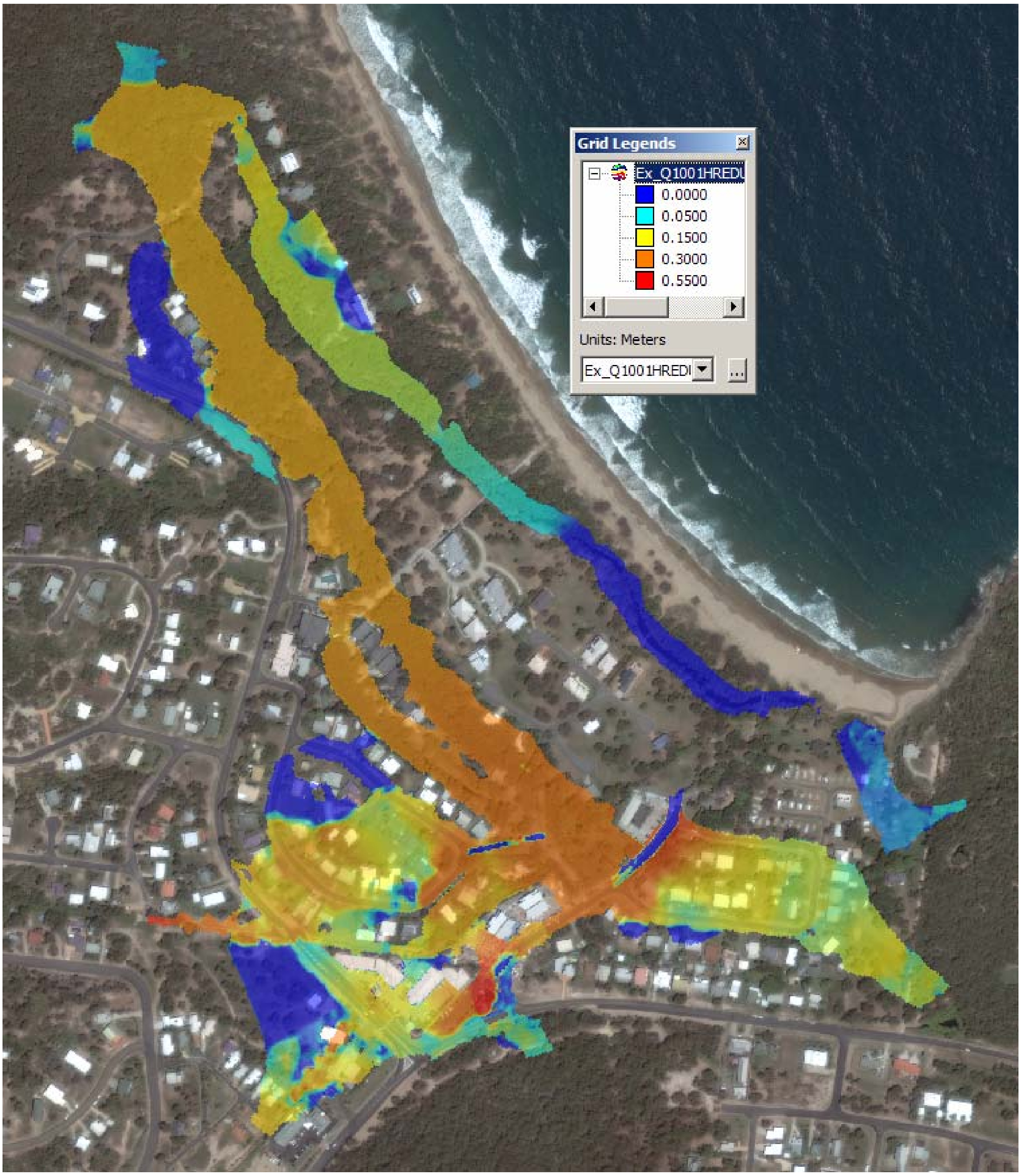


Figure 3-1 Existing Development 100yr ARI 1 hr storm duration – flood level reduction

Review of Figure 3-1, indicates a reduction in existing flood levels during the 100 yr ARI, 1 hour storm event, as follows:

- 0.0-0.3m in Graham Colyer Drive; and
- 0.1-0.4m in Jeffery Court.

Section 3 Conveyance Improvement Assessment

Figure 3-2 presents the reduction in flood levels for the existing scenario during the 100 yr 12 hour storm, achieved by constructing flood storage basins 2, 4 and 5 as well as the conveyance improvement options.

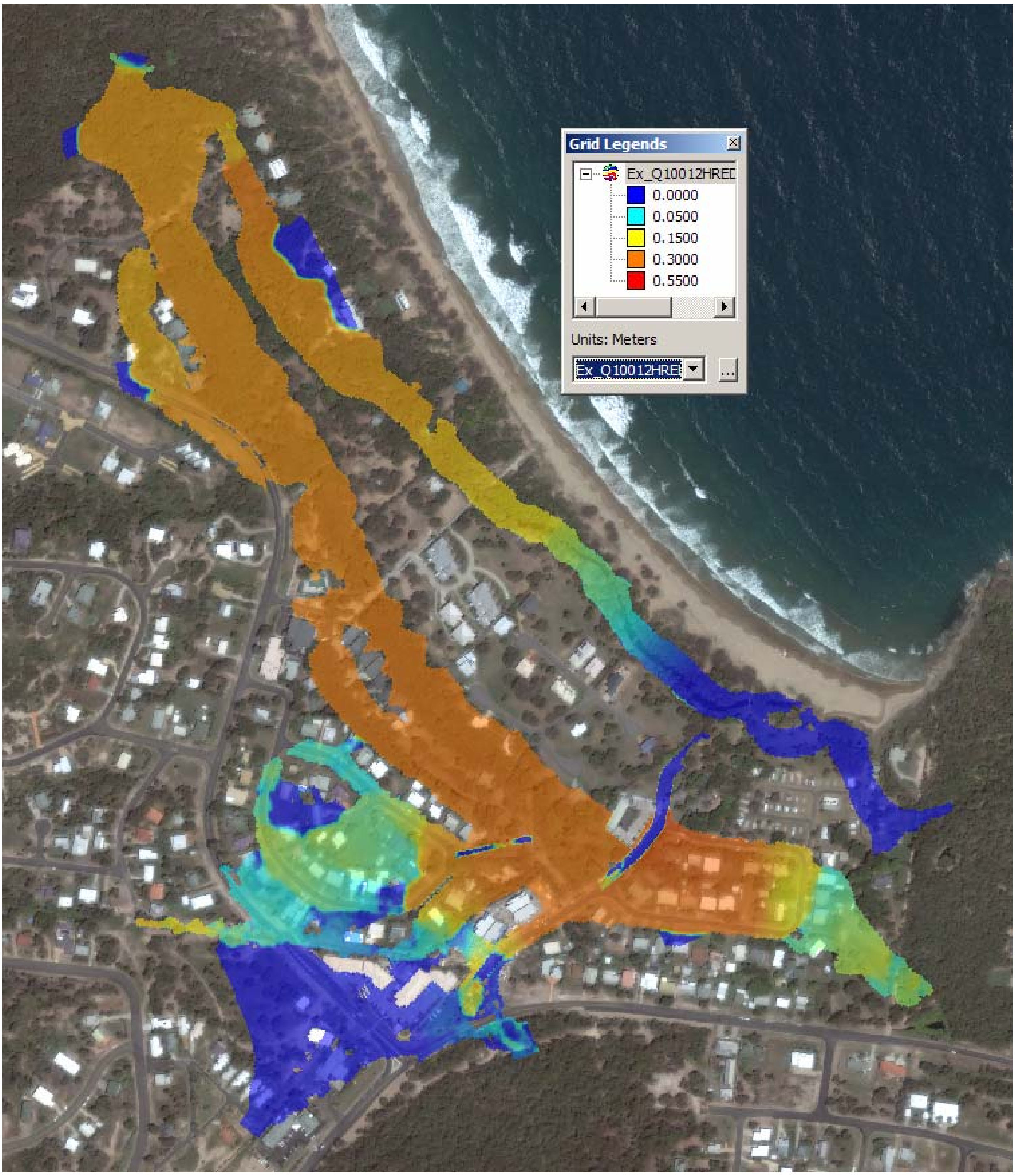


Figure 3-2 Existing Development 100yr ARI 12hr storm duration - flood level reduction

Review of Figure 3-2, indicates a reduction in existing flood levels during the 100 yr ARI, 12 hour storm event, as follows:

- 0-0.3m in Graham Colyer Drive; and
- 0.2-0.4m in Jeffery Court.

Figure 3-3 presents the reduction in flood levels for the future scenario during the 100 yr 1 hour storm, achieved by constructing flood storage basins 2, 4 and 5 as well as the conveyance improvement options.

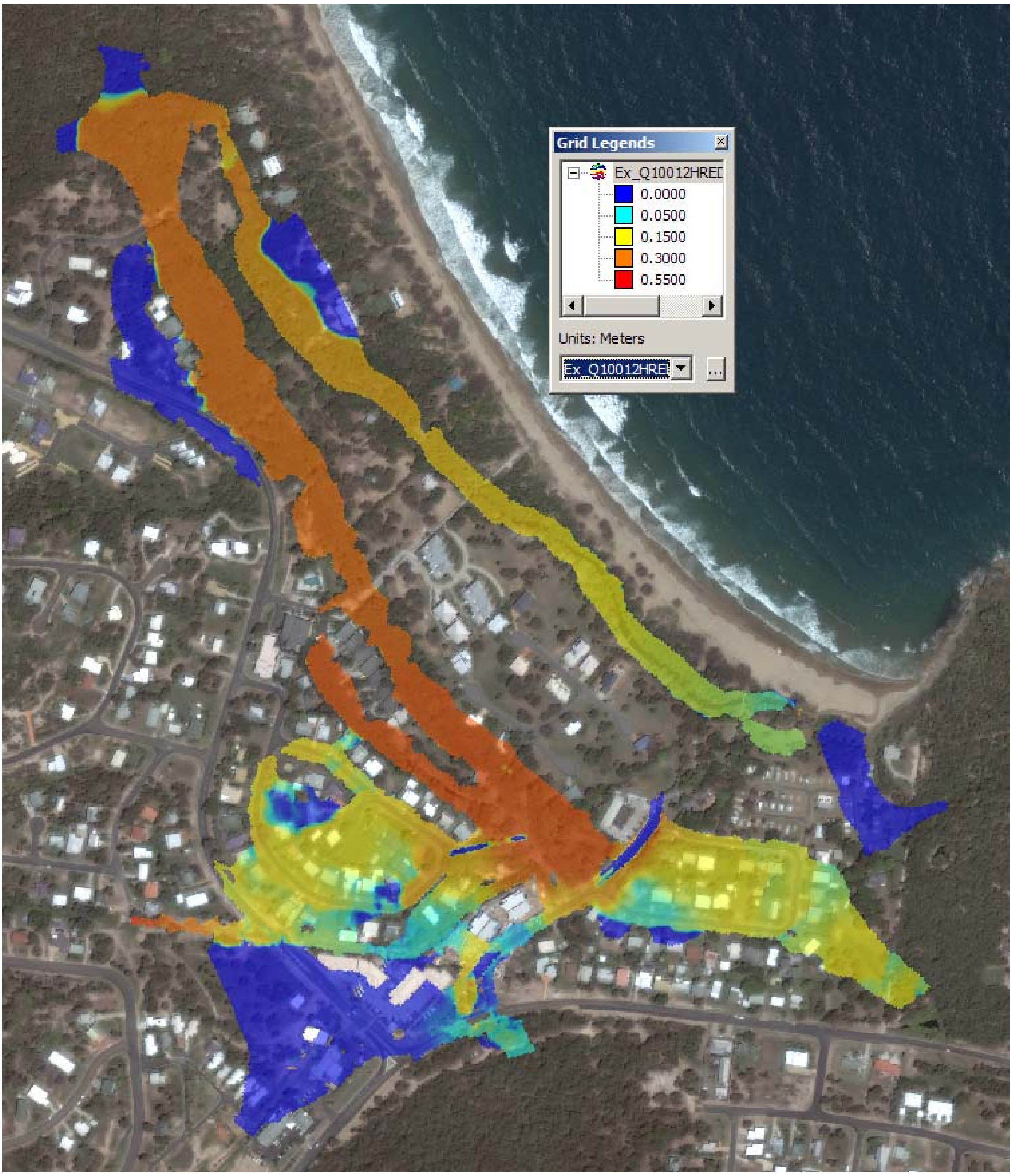


Figure 3-3 Future Development 100yr ARI 1hr storm duration - flood level reduction

Review of Figure 3-3, indicates a reduction in future flood levels during the 100 yr ARI, 1 hour storm event, as follows:

- 0-0.3m in Graham Colyer Court; and
- 0.1-0.4m in Jeffery Court.

Section 3 Conveyance Improvement Assessment

Figure 3-4 presents the reduction in flood levels for the future scenario during the 100 yr 12 hour storm, achieved by constructing flood storage basins 2, 4 and 5 as well as the conveyance improvement options.

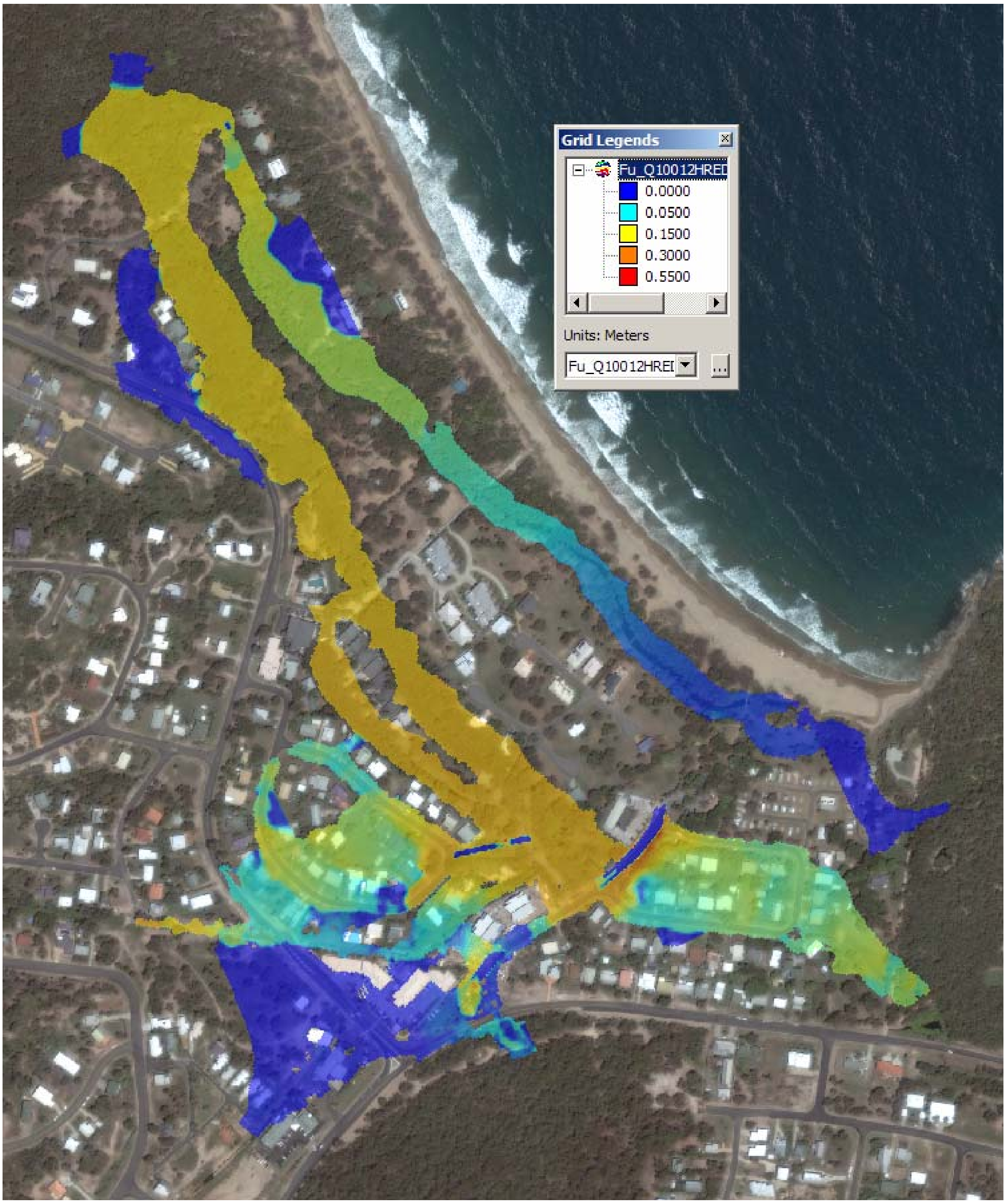


Figure 3-4 Future Development 100yr ARI 12hr storm duration - flood level reduction

Review of Figure 3-4, indicates a reduction in future flood levels during the 100 yr ARI, 12 hour storm event, as follows:

- 0-0.2m in Graham Colyer Drive; and
- 0-0.4m in Jeffery Court.

Section 2 Flood Storage Assessment

This section reports on the methodology undertaken in the concept design of flood storage basins and summarises the hydrological and hydraulic analysis of their effectiveness in reducing flood levels within Agnes Water.

2.1 Concept Flood Storage Design

2.1.1 Design Input

The concept flood storage basins were designed to maximise storage volumes whilst meeting design criteria and fitting within the cadastral and topographical constraints.

Design Criteria

The following design criteria were adopted as per the Queensland Urban Drainage Manual 1992 (QUDM). These constraints include:

- Embankment slopes no steeper than 1V:4H
  - This created embankments with large plan areas and therefore embankment slopes of 1V:2H were adopted. As the design progresses, the following measures are recommended to be investigated:
    - Handrails and steps; and/or
    - In storage excavation to increase storage volume and reduce slope of embankments.
- 1.2m max embankment height
  - To increase to storage capacity of the basins, the embankment height was increased up to 3.2m. As the design progresses, the following measures are recommended to be investigated:
    - Handrails and steps;
    - In storage excavation to increase storage volume and reduce height of embankments; and
    - Warning signs, refuge mounds, fencing or excavations to increase storage and reduce embankment height.
- Minimum 3m crest width
  - 3m crest width was adopted.

Topographical Information

Existing digital ground data was used to create the concept flood storage basins using the Civil Design software 12d (version 8) (12d). The digital ground data used was a combined terrain model formulated by URS from the following sources:

- Ground survey undertaken by McNee Surveys in late 2005 and early 2006;
- Field survey undertaken by McNee Surveys in 2003; and
- 5m contours from 2003 aerial survey, provided by GRC.

Section 4 Summary of Results

These investigations have assessed the effectiveness of flood storage basins and conveyance improvements within Agnes Water.

Key conclusions from this assessment include:

- Concept flood storage basins 2, 4 and 5 provide the greatest potential to reduce flood levels within Agnes Water and should be considered for further design and construction analyses;
- The conveyance improvement options assessed result in localised reduction in flood levels, however they result in minimal flood level reduction (extent and time) at a regional level.

The estimated cost of the favourable concept flood storage basins is approximately $ 2.0 Million (excluding land acquisition costs), refer Section 4.1 below for further details. Flood conveyance options have not been costed given their minimal benefit in flood level reduction.

4.1 Concept Flood Storage Cost Estimate

The concept flood storage basins cost estimate was derived in accordance to rates specified in Rawlinsons 2007 Australian Construction Handbook and provided for the construction and design of concept flood storage basins 2, 4 and 5. Quantities for excavation, filling, basin storage area, sediment fence length and pipe length were derived from 12d designs of the concept flood storage basins. Table 4-1 provides a summary of estimated cost the project will incur. For a full version of the cost estimate refer to Appendix C.

Table 4-1 Flood Storage Construction and Design Cost Estimate

Description	Cost ($, Excluding GST)	Comments
Preliminaries	157,356	10% of construction cost
Design cost	180,000	$60,000 per basin
Site Preparation	123,053	Clearing, stripping and sediment control
Basin 2 Embankment	122,153	Embankment filling, liners and erosion control
Basin 4 Embankment	807,704	Embankment filling, liners and erosion control
Basin 5 Embankment	323,136	Embankment filling, liners and erosion control
Piping	14,352	Excavation, backfilling, spoil, bedding and pipe jointing
Inlet/Outlet structures	3,159	Culvert precast plus preparation/installation
Contingency	314,711	Additional 20% of total construction and design cost
TOTAL	**2,045,624**	Total basin construction cost minus land acquisition cost

Section 5 References

Rawlinsons (ed.) 2007, *Australian Construction Handbook*, Edition 26, Rawlinsons Publishing, Perth, Western Australia.

Neville Jones and Associates and Australian Water Engineering (ed.) 1992, *Queensland Urban Drainage Manual*, Ed. 1-2, Water Resources, Brisbane.

Pilgrim, DH (ed.) 1987, *Australian Rainfall and Runoff – A Guide to Flood Estimation*, Volume 1, The Institution of Engineers Australia, Barton, ACT.

Section 6 Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Miriam Vale Shire Council and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 24th January 2008.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between 25th January and 11th April 2008 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Appendix A Hydrology

Appendix A Hydrology

XP-RAFTS Input Data

In XP-RAFTS parameters such as slope, catchment area, percentage impervious area, surface roughness and rainfall loss are used to simulate the catchment response to a specific storm and to generate design hydrographs where required.

The model structure consists of nodes which represent each sub-catchment area. Links provide a connection between nodes and simulate channel routing effects. The sub-catchments are differentiated by drainage sub-division, topography, and land use or soil type. Discharges are computed at the outlet of each sub-catchment.

Catchment boundaries and major flow paths were delineated from digital topographic information supplied by GRC. Sub-catchments were chosen for their homogeneity in terms of size, slope, land use and surface roughness and to provide flows at flood storage basin locations.

Aerial photography was used to delineate surface roughness. A combination of the Agnes Water Zoning Plan and aerial photography was used to delineate the percentage impervious area parameters. XP-RAFTS sub-catchment boundaries, basin locations and channel routing are illustrated in Figure A-1 and key sub-catchment parameters summarised in Table A-1.

Sub-catchments were further delineated from the previous flood study undertaken by URS so concept flood storage basins could be added to the hydrologic model. Table A-1 reports these additional catchments with the catchment letter followed by a number i.e. the previous Catchment A has been split into Catchment A1 and A2 wherein a basin has been modelled. This allows for hydrographs to be outputted from the model at basin locations and the reduction in flow assessed as reduction in flood levels through the input of peak flows into a hydraulic model.

Table A-1 Agnes Creek Sub-Catchment Parameters

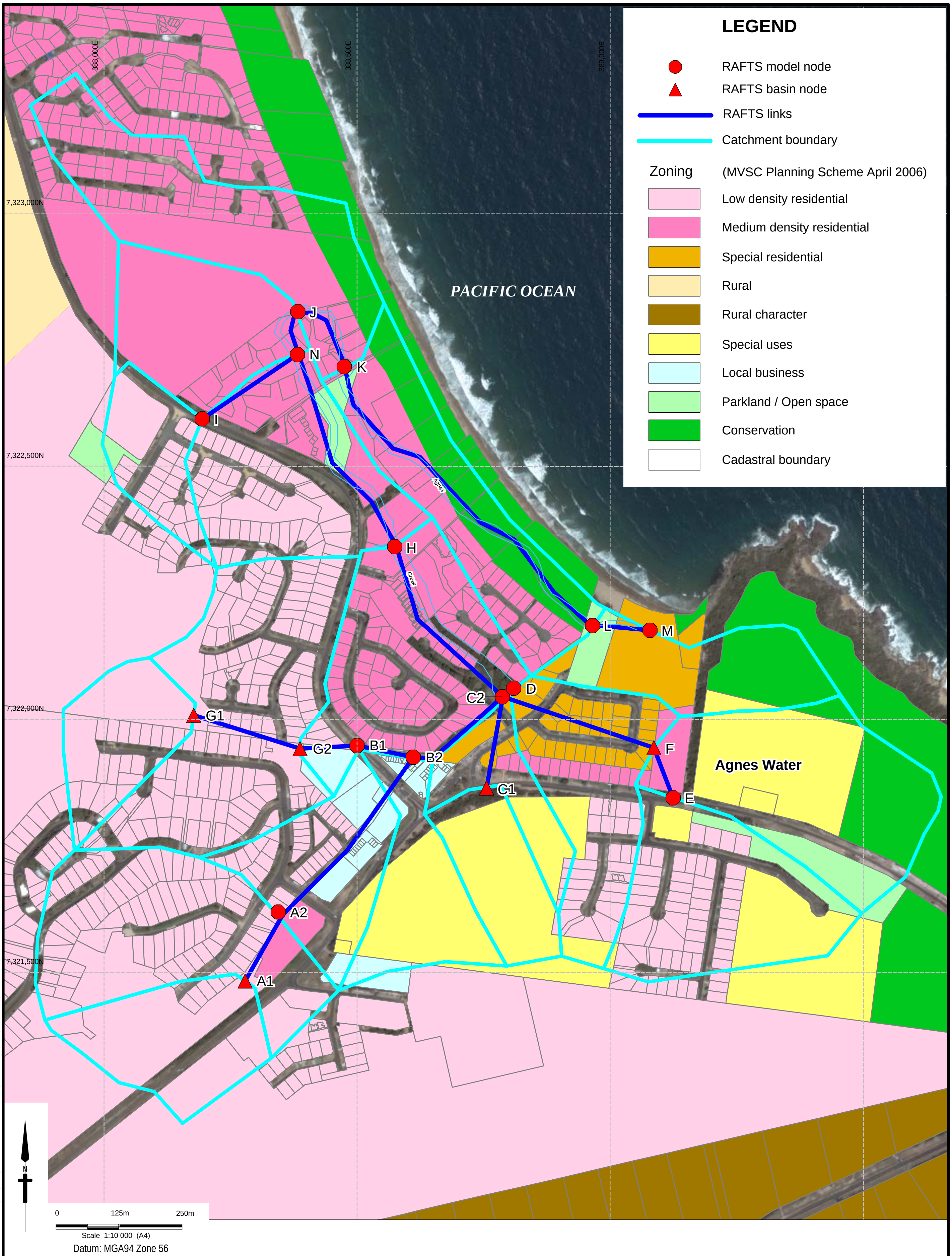
Sub-Catchment	Area (Ha)	Slope (%)	Roughness coefficient (Mannings 'n')	% Impervious Existing	% Impervious Future
A1	7.58	13.9	0.025	6	55
A2	14.1	16.3	0.025	20	56
B1	7.65	11.0	0.025	60	67
B2	6.62	7.3	0.025	6	30
C1	5.2	12.2	0.025	0	0
C2	3.99	8.4	0.025	19	30
D	10.1	9.6	0.025	44	52
E	11.9	12.7	0.025	26	37
F	14.2	6.3	0.025	5	23
G1	8.86	13.1	0.025	36	55
G2	17.3	15.5	0.025	20	55
H	13.3	1.8	0.025	41	60
I	4.57	4.0	0.025	24	55
J	8.69	2.6	0.04	0	60
K	14.2	1.4	0.025	16	48
L	11.1	0.5	0.025	7	30
M	7.36	8.7	0.025	5	30
N	12.7	11.8	0.025	25	58

Appendix A Hydrology

XP-RAFTS includes two options to account for soil losses. For the Agnes Creek catchment model, the initial loss/continuing loss approach was used. An initial loss of 10mm and a continuing loss of 2.5mm/hr (applied as a constant rate) were adopted.

Design storms for the 10, 50, and 100 ARI events were evaluated. Rainfall intensities were calculated using the maps provided in Volume 2 of AR&R (1987). Design temporal patterns for Zone 3 were used. These values are:

${}^{2}I_{1}$	47.2 mm/hr
${}^{2}I_{12}$	9.2 mm/hr
${}^{2}I_{72}$	2.9 mm/hr
${}^{50}I_{1}$	87.5 mm/hr
${}^{50}I_{12}$	22.0 mm/hr
${}^{50}I_{72}$	6.9 mm/hr
G	0.20
F2	4.30
F50	17.90



Source:Client Supplied Data

Client	Project	Title
GLADSTONE REGIONAL COUNCIL	AGNES WATER FLOOD STORAGE AND CONVEYANCE IMPROVEMENT OPTIONS	**XP-RAFTS - CATCHMENT DELINEATION AND BASIN LOCATIONS**
URS	Drawn: EK · Approved: TMcC · Date: 11-04-2008 Job No: **4262 6179** · File No: 42626179-g-002.wor	Figure: **A-1** · Rev:A · **A4**

Appendix B Hydraulics

Appendix B Hydraulics

TUFLOW Hydraulic Model

Hydraulic analyses to assess existing flooding and evaluate the performance of proposed designs were undertaken using the two-dimensional (2D) flood and tide simulation software, TUFLOW. TUFLOW was selected for this assessment for its ability to establish flow patterns in coastal water, estuaries, rivers, floodplains and urban areas where flow patterns are not confined to linear flow paths and would be difficult to represent using a one-dimensional (1D) network model.

Agnes Creek was modelled in TUFLOW as a 2D/1D model, with the 1D model (Agnes Water underground stormwater network) underneath the 2D model (DTM of Agnes Creek channel and floodplain). The following information was used to perform the hydraulic simulations:

- 2D model - DTM of the channel and floodplain (refer Topographical Data Section above). A cell size of 2m was chosen to accurately model the hydraulics of Agnes Creek.
- 1D model - GIS polylines of underground stormwater network (including pipe diameters, invert levels, entry and exist losses etc), which are represented as 1D elements in the model.
- 2D – 1D Link – GIS nodes connecting the each 1D element to the 2D model.
- Upstream boundary conditions - inflow hydrograph(s) at each of the upstream boundary locations (from XP-RAFTS).
- Downstream boundary conditions - a constant water surface elevation equal to Mean High Water Springs (MHWS = 1.15mAHD, Queensland Tide Tables) was adopted as the downstream boundary condition of the Agnes Creek model. The adoption of MHWS is consistent with the Queensland Urban Drainage Manual (QUDM, 1991). No allowance was made for coincident flooding and storm surge which would be highly conservative and bias the probability of flood level results.
- Roughness coefficients - Manning's roughness, based on field inspections, refer Table B-1 (based on Chow, 1959).

Table B-1 Agnes Creek Manning's 'n' Roughness Coefficient

Category	Manning's 'n'
Main Channel (clear of vegetation)	0.045
Channel Banks (dense vegetation)	0.15
Channel Banks (unvegetated)	0.03
Dense Vegetation	0.12
Floodplain	0.12
Pavement	0.01

Model Review

In the absence of stream data and historical flood levels, the model verification was limited to examining the predicted output and addressing any model instability issues encountered.

The flood levels results predicted from the base case TUFLOW model were compared with results from previous investigations and were found to be consistent with these. The base TUFLOW model was therefore adopted to perform further simulations of the Agnes Creek system.

Flood Mechanisms

Experience shows that in coastal areas, particularly those displaying catchment morphology similar to Agnes Creek (that is a watershed bound by sand dunes with an outlet controlled by sea level), the critical

Appendix B Hydraulics

flooding envelope (maximum flood levels from a range of storm durations) is often the result of prolonged rainfall events (i.e. the storm that yields the peak instantaneous flow from the catchment may not be that which yields the maximum extent of flooding). Heavy precipitation over a long period of time is common in this area. Flooding occurs as a result of the combination of a large volume of runoff in the catchment coupled with sea levels impeding the free outlet of creek flow.

The hydraulic modelling confirms that critical flooding is the result of prolonged rainfall over the catchment. Runoff from the headwaters of the catchment effectively ponds within the low lying areas behind the sand dunes, until flood levels in the creek rise to level sufficient to flow out through the creek mouth.

The modelling shows that the capacity of the creek channel and the drainage network (open channels and major trunk drainage) are rapidly exceeded and flood waters inundate roads and built-up areas.

Appendix C Cost Estimate

URS

AGNES WATER- DETENTION BASIN WORKS					
Bill of Quantities					
	23/06/2008 8:46				
	Description	**Qty**	**Unit**	**Rate**	**Total cost**
1.0	**Design cost**	3	$	60,000	$180,000
	SUB TOTAL DESIGN				**$180,000**
1.1	**Site Preparation**				
	Cut down tree > 500mm girth, grub stump, roots and cart away	20	No.	167	$3,338
	Clear bush with bulldozer, ball and chain, grub up roots and burn on site	3,879	m^2	0.27	$1,056
	Topsoil Stripping (500 mm depth), cart > 15m, spread and level average 150mm thick	18,087	m^2	6	$110,313
	Temporary erosion control fence of geotextile, 500mm high above ground and 300mm trench below ground, fixed to steel pickets at 3000mm centres	520	m	16	$8,346
	SUB TOTAL SITE PREPARATION				**$123,053**
1.2	**Basin 2 Embankment**				
	General filling	354	m^3	57	$20,075
	Plastic impermeable liner for basin storage extents	4,823	m^2	20	$96,460
	Turfs, laid, rolled and watered for two weeks: 400mm wide roll turf	1,070	m^2	5	$5,618
	Land acquisition cost	4,823	m^2	0.00	$0
	SUB TOTAL SITE EMBANKMENT 2				**$122,153**
1.3	**Basin 4 Embankment**				
	General filling	7,912	m^3	57	$448,690
	Plastic impermeable liner for basin storage extents	14,917	m^2	20	$298,340
	Turfs, laid, rolled and watered for two weeks: 400mm wide roll turf	11,557	m^2	5	$60,674
	Land acquisition cost	14,917	m^2	0.00	$0
	SUB TOTAL SITE EMBANKMENT 4				**$807,704**

1.4	**Basin 5 Embankment**				
	General filling	1,257	m^3	57	$71,284
	Hydro mulch, sprayed grass seed compound	0	m^2	3,210	$467
	Plastic impermeable liner for basin storage extents	11,136	m^2	20	$222,720
	Turfs, laid, rolled and watered for two weeks: 400mm wide roll turf	5,460	m^2	5	$28,665
	Land acquisition cost	11,136	m^2	0.00	$0
	SUB TOTAL SITE EMBANKMENT 5				**$323,136**
1.5	**Pipelines**				
	Excavation for pipes (including inlet and outlet excavation)	22	m^3	28	$599
	Cartage and disposal of spoil material	2	m^3	6	$12
	Supply, placement and compaction of foundation bedding/haunch material	42	m	95	$3,924
	Stormwater drain - HDPE (450mm)	9	m	171	$1,541
	Stormwater drain - HDPE (600mm)	33	m	255	$8,276
	SUB TOTAL PIPELINE				**$14,352**
1.6	**Inlet/Outlet structures**				
	Culvert, precast concrete (450mm)	2	m	338	$676
	Culvert, precast concrete (600mm)	4	m	621	$2,482
	SUB TOTAL INLET/OUTLET STRUCTURE				**$3,159**
	Cumulative Sub-Total				**$1,573,557**
1.7	**Preliminary**	1	%Total	0.10	**$157,356**
1.8	**Contingency**	1	%total	0.20	**$314,711**
	Total				**$2,045,624**