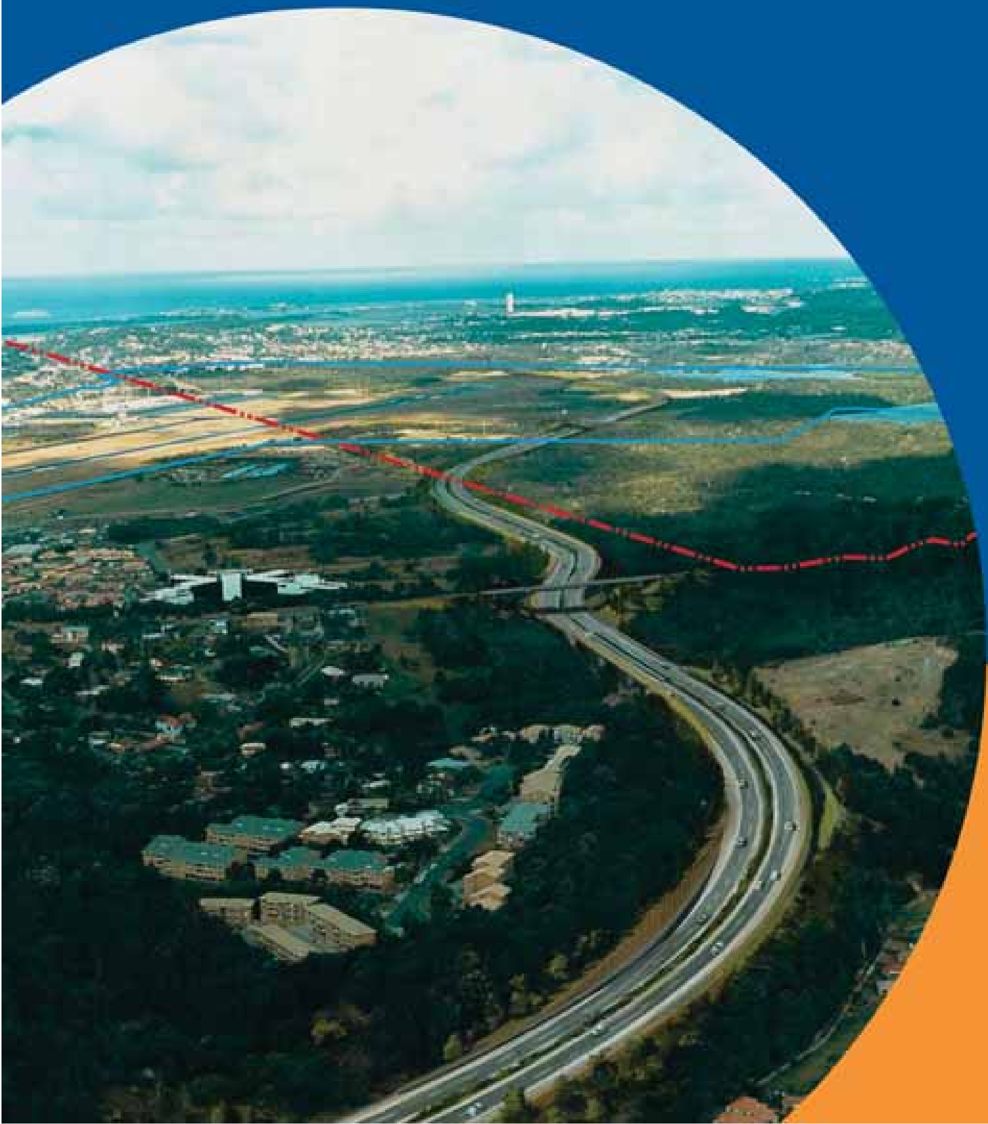
Australian Government
Department of Transport and Regional Services

RTA

Queensland Government
Department of Main Roads

TUGUN BYPASS

stewart road to kennedy drive



Technical Papers

December 2004

Tugun Bypass Environmental Impact Statement

Technical Paper Number 7
Flooding and Hydrological Assessment

Tugun Bypass Alliance

Client:	Queensland Department of Main Roads
Prepared By:	WBM Oceanics Australia
Prepared For:	Parsons Brinckerhoff (formerly PPK Environment & Infrastructure)
July, 2003	

Offices

Brisbane
Denver
Karratha
Melbourne
Morwell
Newcastle
Sydney
Vancouver

November 2004
2134070A-PR049Car- R.B13010.001.05

Contents

Contents (continued)

Page Number

List of Tables

List of Figures

List of Appendices

Glossary

Term	Meaning
Afflux	The difference in water levels across a waterway structure (e.g. bridge or culvert).
Attenuation	Reduction of flood peak due to storage effects of the floodplain.
Australian Height Datum (AHD)	A common national plane of level corresponding approximately to mean sea level. This report generally refers to levels relative to AHD.
Average Recurrence Interval (ARI)	A means of defining the probability / size of a flood event by ascribing the average period (usually in years) between exceedances of a given flood magnitude.
Barometric Setup	The increase in mean sea level caused by a drop in barometric pressure.
Bathymetry	The measurement of depths of water, also information derived from such measurements.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow which is a measure of how fast the water is moving rather than how much is moving.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream or river.
Floodplain	The portion of a river valley, adjacent to the river channel, which is covered with water when the river overflows during floods.
Greenhouse Effect	A term used to describe the likely global warming predicted to accompany the increasing levels of carbon dioxide and other "greenhouse" gases in the atmosphere.
Peak discharge	The maximum discharge occurring during a flood event.
Run-off	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Storm Surge	The increase in coastal water level caused by the effects of storms. Storm surge consists of two components: the increase in water level caused by the reduction in barometric pressure (barometric setup) and the increase in water level caused by the action of wind blowing over the sea surface (wind setup).
Time of Inundation	Period of time a given area is under water due to flooding.
Wave Set-up	The increase in water level within the surf zone above mean still water level caused by the breaking action of waves.

1. Introduction

1.1 Summary of the Technical Paper

This technical paper examines the potential flooding and drainage issues associated with the proposed Tugun transport corridor.

The proposed transport corridor crosses Coolangatta Creek and a number of local/minor catchments. Existing flooding and drainage characteristics are provided for each of these. In addition, the proposal is located within the floodplain of the Tweed River. Flooding characteristics of this system are identified including peak flood levels, the influence of elevated ocean levels, peak flood levels for rare flood events, frequency of inundation of the study area and inundation times.

Flood impacts on Coolangatta Creek, the local/minor catchments crossed by the proposed route and the Tweed River floodplain have been considered on an individual basis. Impacts were assessed on construction of the transport corridor with immunity from inundation during a 1 in 100 year ARI (Average Recurrence Interval) flood event.

The proposal would have a negligible impact on the nature and behaviour of flooding in Coolangatta Creek as there would be little, if any, change to the conveyance characteristics of the overflow channel from Coolangatta Creek to the Cobaki Broadwater. This channel would pass over the proposed road route and be re-instated as an open channel. The channel would be sized to ensure that it has the same flood capacity as in its present state.

The primary impact of the proposal on the Tweed River floodplain is the loss of floodplain storage resulting from the filling required for the road embankment. This loss of storage has the potential to result in increased flood levels. The loss of floodplain storage was quantified using the 1D flood model of the entire Tweed River floodplain. The results of the this modelling showed that filling for the proposal would result in increases in flood level of less than 3 mm for the 100, 20 and 5 year ARI flood events.

The proposal would have a negligible impact on the time that flood prone land is inundated and the rates of flood rise and recession during Tweed River flood events. This is due largely to the loss of floodplain storage being only a very small proportion of the total floodplain storage on the Tweed River floodplain and to the slow rising behaviour of Tweed River flood events at the downstream end of the floodplain.

Flooding assessments for the road embankment were extended to consider the cumulative impacts resulting from filling associated with other development proposals in the vicinity of the bypass, namely the possible developments at the Gold Coast Airport and the proposed construction of the embankment for the rail extension to Gold Coast Airport. The results indicated that the maximum impact from this cumulative filling scenario is 13 mm in the 100 year ARI flood event.

Tweed Shire Council have indicated that impacts of these magnitudes are likely to be accepted under the Murwillumbah Floodplain Management Plan.

1.2 Reporting of Study Findings in the EIS

The studies for the Tugun Bypass environmental impact assessment commenced in 2000. In the subsequent four years the results of the various studies have been used to refine the concept design of the proposal. Further studies were also commissioned to ensure that all aspects of the various environmental issues were fully understood.

The long time period of the assessment has meant that the content of some of the earlier reports has been superseded by newer work. Changes to the design of the bypass have also been introduced to take account of these studies.

In the event that there is a contradiction between the technical papers and the text of the EIS, the EIS takes precedence as it reports the current understanding of issues, impacts and the concept design.

2. Purpose and Approach

2.1 General

This technical paper examines the potential flooding issues associated with the proposed Tugun transport corridor. Potential flooding impacts are identified and discussed in relation to the sizes of waterway openings required to ensure the impacts are acceptable.

2.2 Design Criteria and Required Flood Immunity

It is proposed to construct the bypass to be immune from inundation during a 1 in 100 year ARI (Average Recurrence Interval) flood event. In most parts of the route, this has resulted in a vertical elevation dictated by Tweed River flood levels.

The criteria for limiting afflux and increases in flood levels resulting from the proposal vary along the route depending on the area expected to be affected. Based on previous Tweed Shire Council considerations (e.g. urban developments involving filling of floodplain and the Pacific Highway Upgrades at Chinderah), increases in flood level of up to 50 mm on the Tweed River floodplain would be acceptable. This upper limit of acceptable impact recognises the relative accuracy of the modelling used for these predictions and the expected increase in flood damages resulting from an increase of this magnitude.

For other drainage systems crossed by the proposal, a range of waterway openings (i.e. culverts) and their resulting flood affluxes have been presented.

3. Existing Flooding Conditions

3.1 Local/Minor Catchments

The route is crossed by a number of minor watercourses draining the western portion of the airport area as well as the catchment to the north including the Pacific Beach Estate and John Flynn Hospital and Medical Centre. The minor watercourses crossed by the proposal are shown in Figures 3.1 to 3.4.

The existing flooding and drainage characteristics for the local/minor catchments crossed by the route are discussed below.

3.1.1 Chainage 00 to 2,300

There are a number of small steep catchments crossed by the route between chainages 00 and 2,300. Peak flows for these catchments have been assessed using the Rational Method of peak flow estimation. The 100 year ARI peak flows derived for these catchments are presented in Table 3.1.

Table 3.1: Peak Flows for Minor Catchments

Chainage (m)	Catchment Area (ha)	Peak Flow (m^3/s)
700	4.0	2.0
1,000	4.7	2.2
1,200	8.6	4.1
1,500	1.8	1.0
2,300	2.5	1.2

3.1.2 Chainage 2,800

The waterway crossed by the proposal at chainage 2,800 drains from a recent residential development area (the Pacific Beach Estate) and the John Flynn Hospital and Medical Centre (refer to Figure 3.2). The area of this catchment is 50.5 ha and contains a mix of residential and vegetated areas.

Peak flood levels and flows were based on the flood modelling carried out for the sizing of the waterway elements for the Pacific Beach Estate. This assessment involved the use of a RAFTS-XP hydrological model of the catchment and a EXTRAN-XP hydraulic model of the waterway elements (e.g. pipes, open channels, proposed wetlands, weirs). The assessment was based on the assumption of the full development of the Pacific Beach Estate.

The critical duration for this catchment is the 60 minute storm. The 60 minute duration 100 year ARI peak flows for this catchment is 6.5 m^3/s. The peak flood levels for the proposed Pacific Beach Estate are presented in Figure 3.5.

Ground levels in the vicinity are in the order of 3.5 mAHD. Hence, Tweed River flooding and back-up for this area is considered unlikely as the 100 year ARI peak flood level for the Tweed River is 2.7 mAHD.

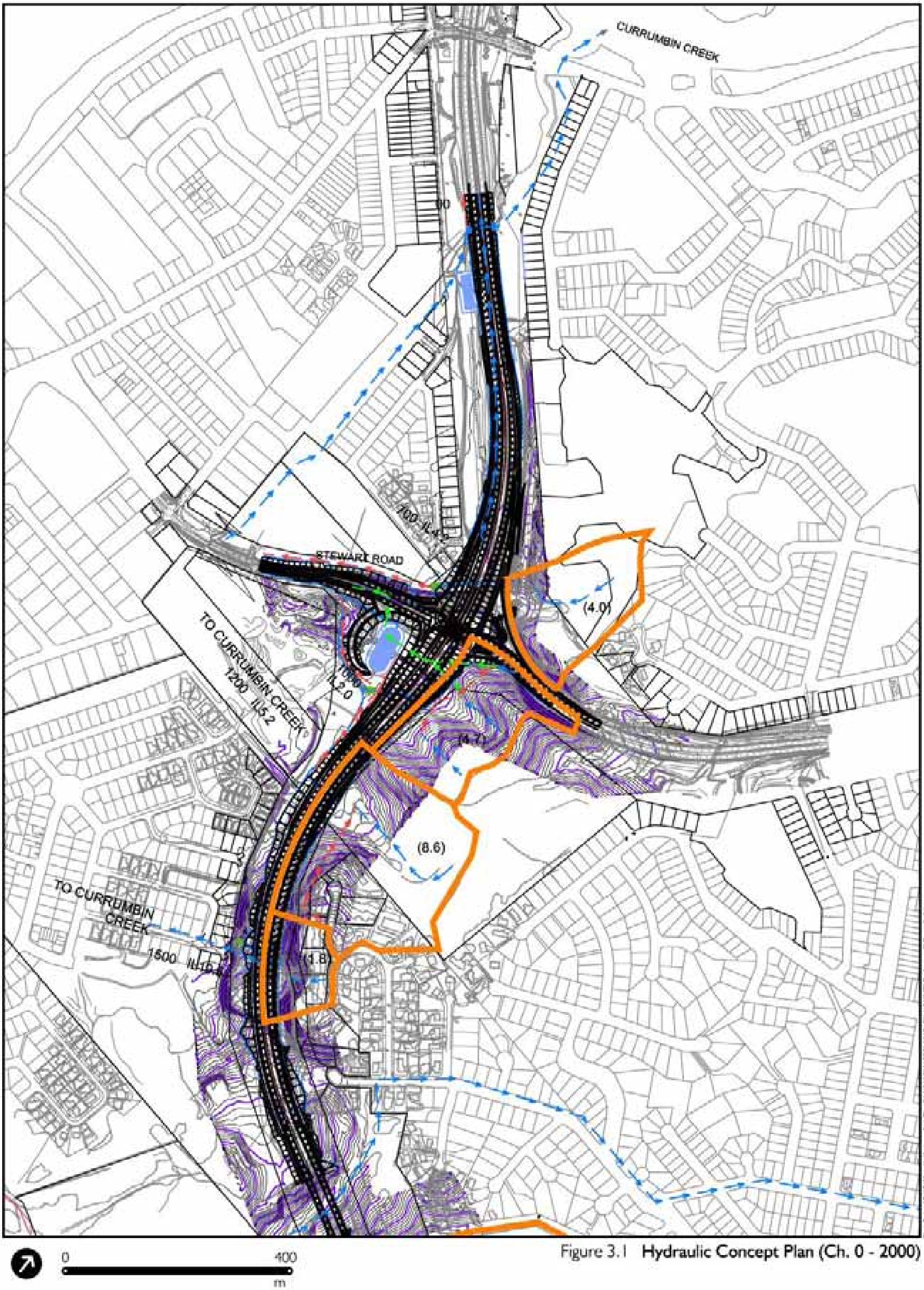
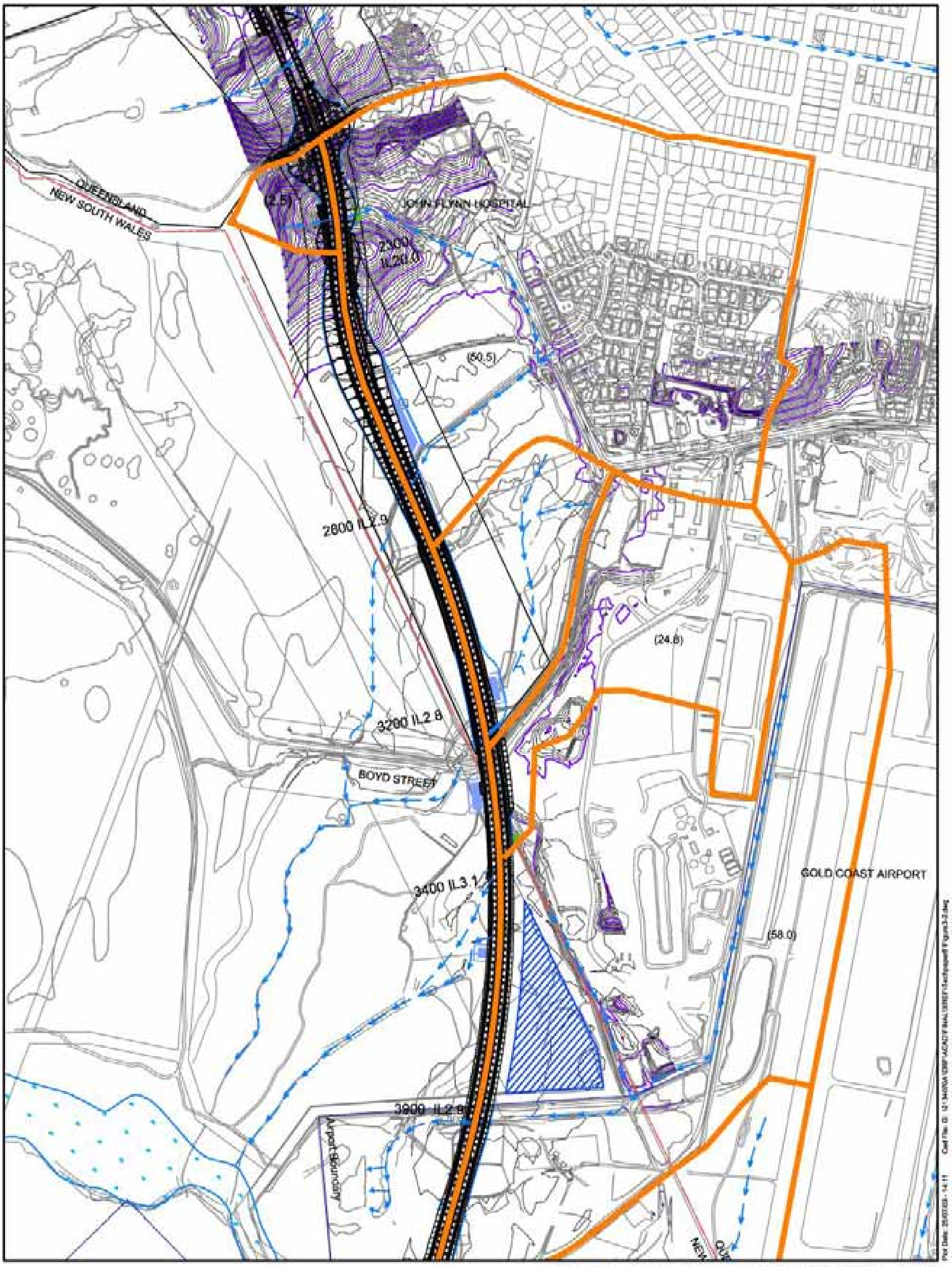


Figure 3.1 **Hydraulic Concept Plan (Ch. 0 - 2000)**

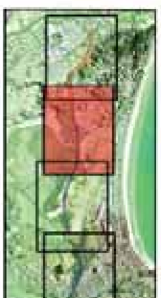
LEGEND

EXISTING WATERCOURSE	SEPP 14 WETLANDS
EXISTING WATERCOURSE TO BE ABANDONED	CATCHMENT BOUNDARY
PROPOSED WATERCOURSE	(23.1) CATCHMENT AREA (Hectares)
PROPOSED SEDIMENTATION BASINS/ WATER QUALITY CONTROL PONDS	PROPOSED OPEN CHANNEL (APPROXIMATE CHAINAGE)
PROPOSED ROAD	PROPOSED CULVERT (APPROXIMATE CHAINAGE)
QUEENSLAND / NSW BORDER	IL20.0 INVERT LEVEL OF CULVERT
	2300 CHAINAGE OF CROSSING



0 400
m

Figure 3.2 **Hydraulic Concept Plan (Ch. 2000 - 4000)**



LEGEND

- EXISTING WATERCOURSE
- EXISTING WATERCOURSE TO BE ABANDONED
- PROPOSED WATERCOURSE
- PROPOSED SEDIMENTATION BASINS/ WATER QUALITY CONTROL PONDS
- PROPOSED ROAD
- QUEENSLAND / NSW BORDER
- SEPP 14 WETLANDS
- CATCHMENT BOUNDARY
- (23.1) CATCHMENT AREA (Hectares)
- PROPOSED OPEN CHANNEL (APPROXIMATE CHAINAGE)
- PROPOSED CULVERT (APPROXIMATE CHAINAGE)
- IL20.0 INVERT LEVEL OF CULVERT
- 2300 CHAINAGE OF CROSSING

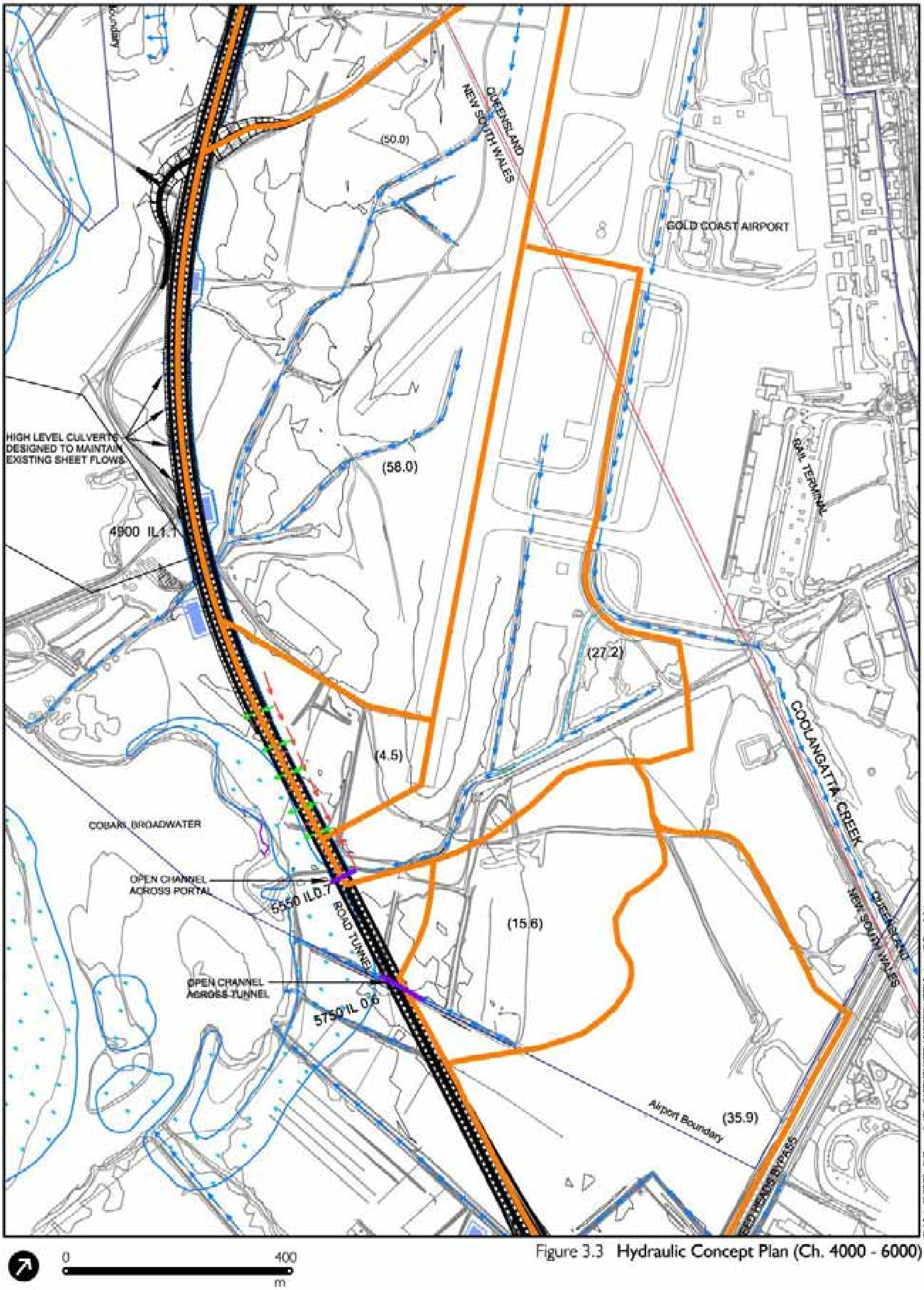
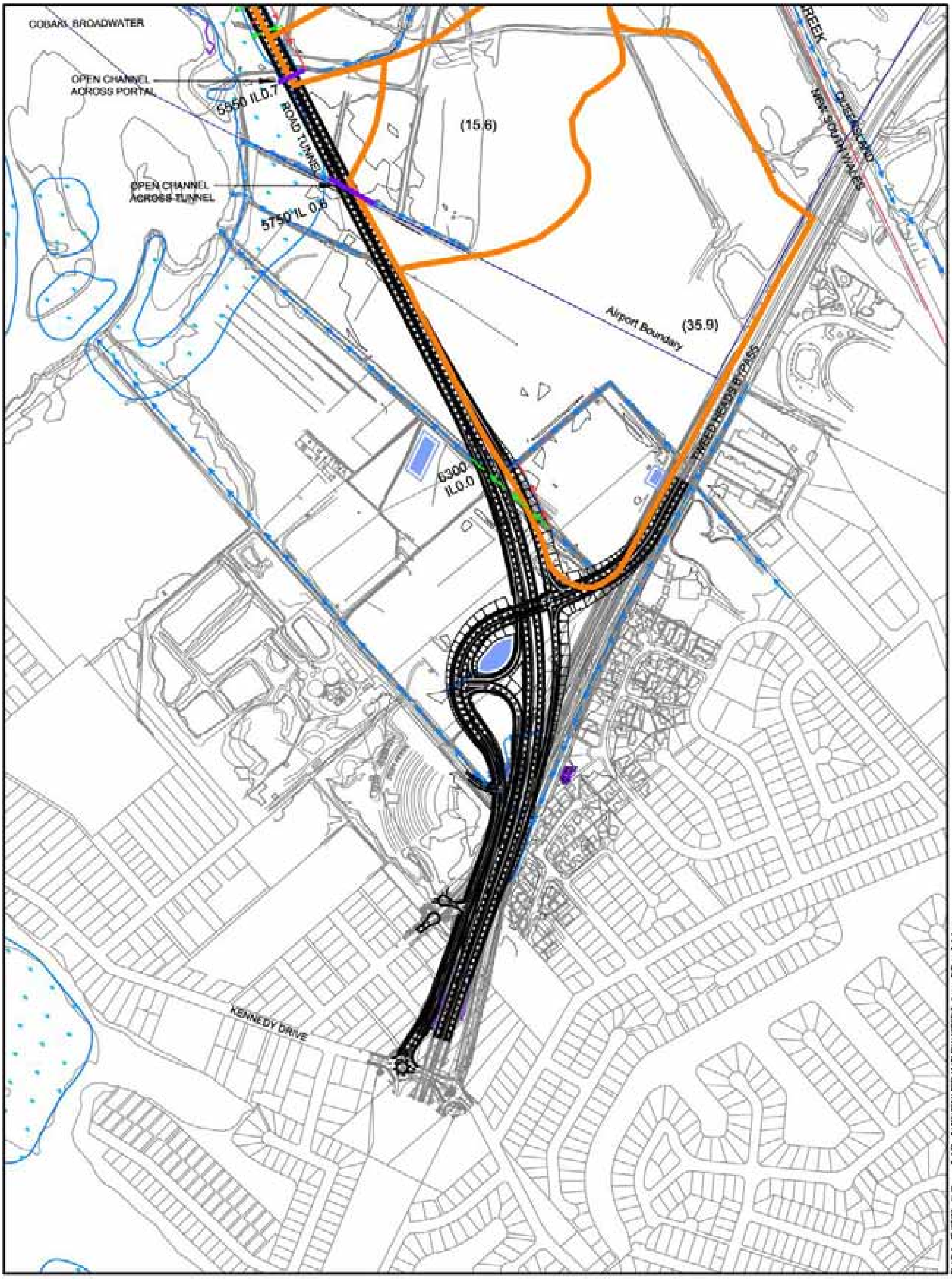


Figure 3.3 Hydraulic Concept Plan (Ch. 4000 - 6000)

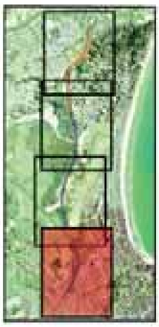
LEGEND

- EXISTING WATERCOURSE
- EXISTING WATERCOURSE TO BE ABANDONED
- PROPOSED WATERCOURSE
- PROPOSED SEDIMENTATION BASINS/ WATER QUALITY CONTROL PONDS
- PROPOSED ROAD
- QUEENSLAND / NSW BORDER
- SEPP 14 WETLANDS
- CATCHMENT BOUNDARY
- (23.1) CATCHMENT AREA (Hectares)
- PROPOSED OPEN CHANNEL (APPROXIMATE CHAINAGE)
- PROPOSED CULVERT (APPROXIMATE CHAINAGE)
- IL20.0 INVERT LEVEL OF CULVERT
- 2300 CHAINAGE OF CROSSING



0 400
m

Figure 3.4 **Hydraulic Concept Plan (Ch.6000 - 7700)**



LEGEND

- EXISTING WATERCOURSE
- EXISTING WATERCOURSE TO BE ABANDONED
- PROPOSED WATERCOURSE
- PROPOSED SEDIMENTATION BASINS/ WATER QUALITY CONTROL PONDS
- PROPOSED ROAD
- QUEENSLAND / NSW BORDER
- SEPP 14 WETLANDS
- CATCHMENT BOUNDARY
- (23.1) CATCHMENT AREA (Hectares)
- PROPOSED OPEN CHANNEL (APPROXIMATE CHAINAGE)
- PROPOSED CULVERT (APPROXIMATE CHAINAGE)
- IL20.0 INVERT LEVEL OF CULVERT
- 2300 CHAINAGE OF CROSSING

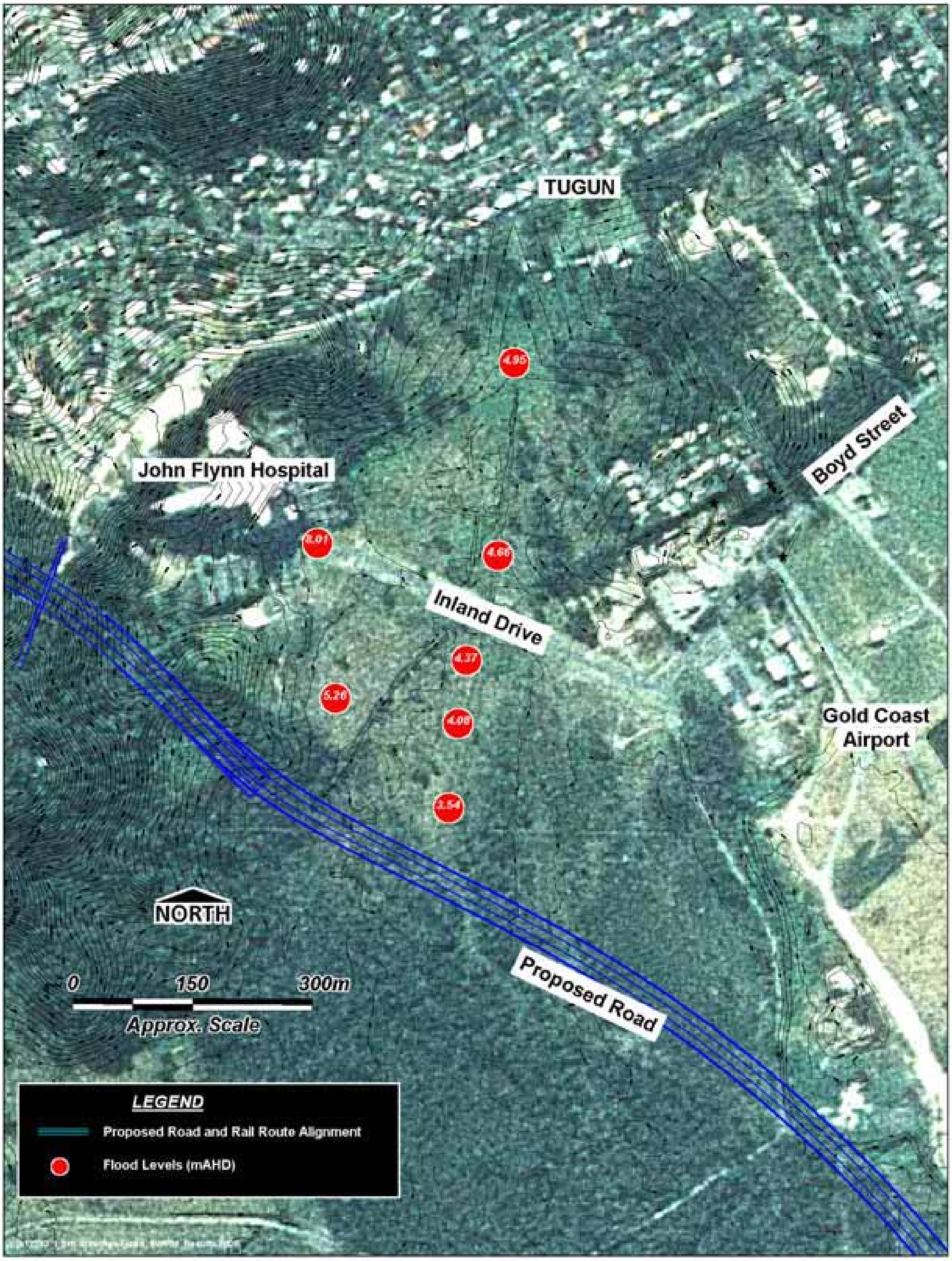


Figure 3.5: Existing 100 Year ARI Flood Levels - Pacific Beach Catchment (Chainage 2,800)

3.1.3 Chainage 3,200

The run-off from the catchment at chainage 3,200 (area of 24.8 ha – refer to Figure 3.2) was assessed using a RAFTS-XP model of the catchment with a B coefficient (i.e. the storage delay time coefficient) of 1.0. The peak 100 year ARI flow was estimated to be 6.8 m^3/s. This analysis assumed future development in this catchment for a railway station and other associated development.

The run-off derived from the RAFTS-XP model was then used as inflows into a 1D hydrodynamic model developed using the ESTRY modelling software. The resulting peak 100 year ARI flood levels for the 30 minute storm (the critical duration) are shown in Figure 3.6.

3.1.4 Chainage 3,900

The run-off from the catchment at chainage 3,900 (area of 50.0 ha – refer to Figure 3.2) was assessed using a RAFTS-XP model of the catchment with a B coefficient (i.e. the storage delay time coefficient) of 1.0. The peak flow from the model was verified against the Rational Method to ensure consistency. The peak 100 year ARI flow was estimated to be 11.1 m^3/s.

The run-off derived from the RAFTS-XP model was then used as inflows into a 1D hydrodynamic model developed using the ESTRY modelling software. The resulting peak 100 year ARI flood levels for the 30 minute storm (the critical duration) are shown in Figure 3.6.

3.1.5 Chainage 4,900

The run-off from the catchment at chainage 4,900 (area of 58.0 ha – refer to Figure 3.3) was assessed using a RAFTS-XP model of the catchment with a B coefficient (i.e. the storage delay time coefficient) of 1.0. The peak flow from the model was verified against the Rational Method to ensure consistency. The peak 100 year ARI flow was estimated to be 10.0 m^3/s.

The run-off derived from the RAFTS-XP model was then used as inflows into a 1D hydrodynamic model developed using the ESTRY modelling software. The resulting peak 100 year ARI flood levels for the 30 minute storm (the critical duration) are shown in Figure 3.6.

3.1.6 Chainage 5,450 to 6,000

From chainages 5,450 to 6,000 (refer to Figures 3.3 and 3.4), there are three minor catchments that discharge across the area where the proposed road tunnel is located. This section also includes the overflow channel from Coolangatta Creek which is discussed separately in Section 3.3.

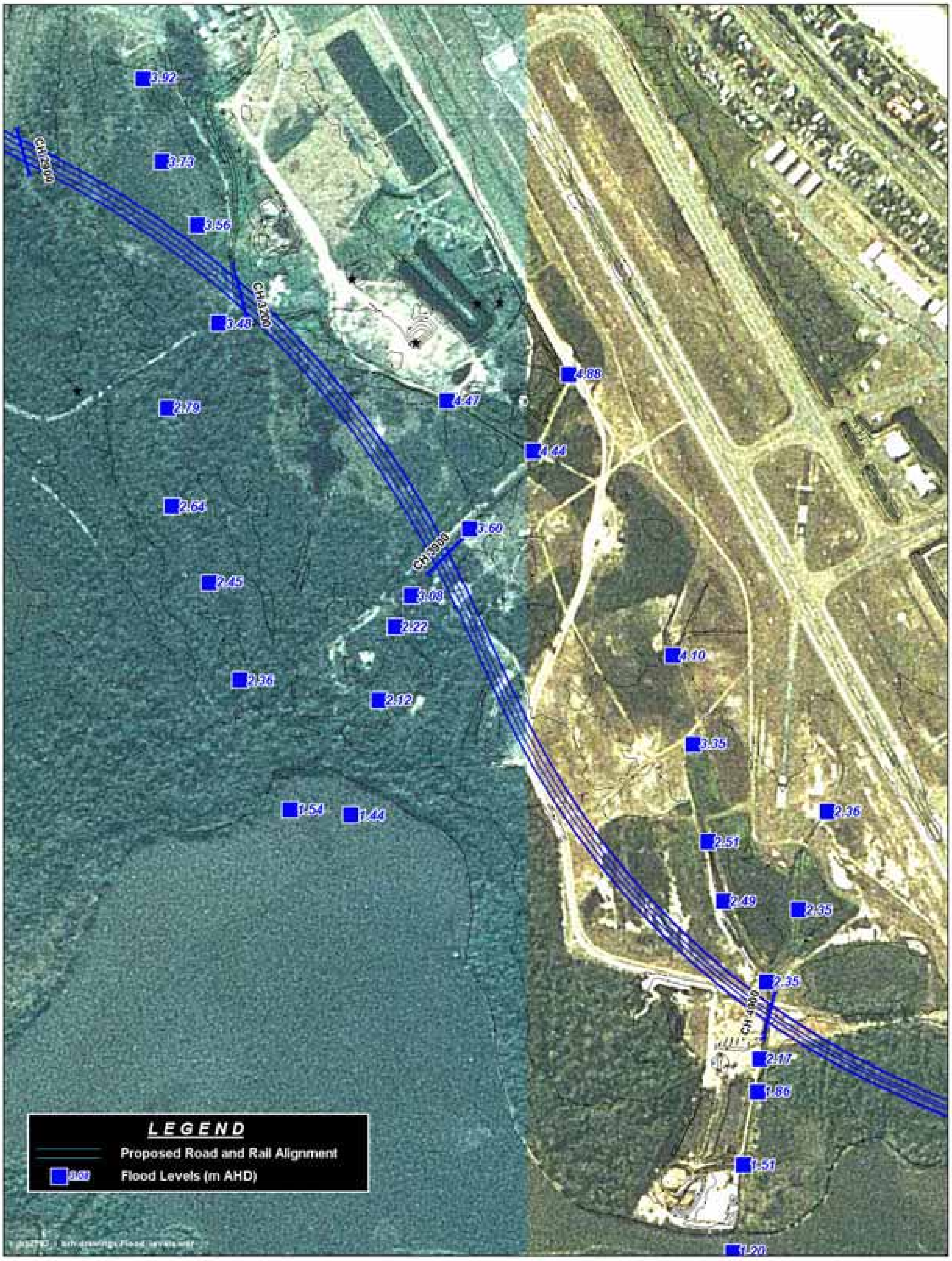


Figure 3.6: Existing 100 Year ARI Flood Levels - Catchments at Chainages 3,200, 3,900 and 4,900

3.2 Tweed River Floodplain

3.2.1 Previous Studies by WBM on Tweed River

WBM Oceanics Australia have undertaken extensive flooding investigations on all the river and creek systems affected by the proposal. These investigations have been performed for a variety of clients, including State Government (NSW Roads and Traffic Authority, NSW Public Works Department), Local Government (Tweed Shire Council), other consulting firms, industry and developers. This significant degree of involvement has enabled the development of a particularly good understanding of flooding in the area.

3.2.2 Tweed River Flood Model

The hydrodynamic ESTRY model of flooding processes on the Tweed River used in this study is the culmination of more than 15 years development, refinement, calibration, verification and rigorous utilisation. The model is recognised by the NSW Public Works Department (PWD) for flood prediction and impact assessment purposes and has been used in many studies for both NSW Public Works Department and Tweed Shire Council. In particular, the most relevant recent applications have been for the Upper and Lower Tweed River Management Plans performed by WBM Oceanics Australia for NSW Public Works Department (WBM Oceanics Australia 1991, 1992).

The latest revision of the model used for this study has been calibrated to the April 1989 flood, and verified (with appropriate channel bathymetry modifications) for the March 1974 and March 1978 floods. The performance of the model for these calibration and verification events is shown in Figures 3.7 to 3.9.

The model was further refined for the flood impact assessments associated with upgrades to the Pacific Highway south of the river. The existing model includes the representation of the Chinderah Bypass and the northern section of the Yelgun to Chinderah Upgrade.

3.2.3 Tweed River Flooding Characteristics

The main arm of the Tweed River is approximately 40 km in length and has a catchment of approximately 1,100 km^2. The major tributaries include the Oxley River and the Rous River. These tributaries rise to their headwaters in mountainous terrain at elevations between 600 m and 1,100 m. Most of the upper catchment is heavily timbered with natural vegetation. Some areas of land in the lower areas have been cleared for banana plantations. The floodplains are dominated by sugar cane.

The catchment experiences high annual rainfall. The average annual rainfall at Murwillumbah is 1,600 mm. Major flood events in the Tweed River system are typically the result of rainfall associated with the southerly track of decaying cyclonic depressions. In conjunction with the relatively small size of the catchment and the steepness of the terrain, this results in a rapid onset of major flooding on the floodplain.

The mathematical flood model described above was used to define the existing flooding characteristics of the floodplain. The critical duration rainfall event for this catchment has been determined to be 36 hours (NSW Public Works Department 1989).

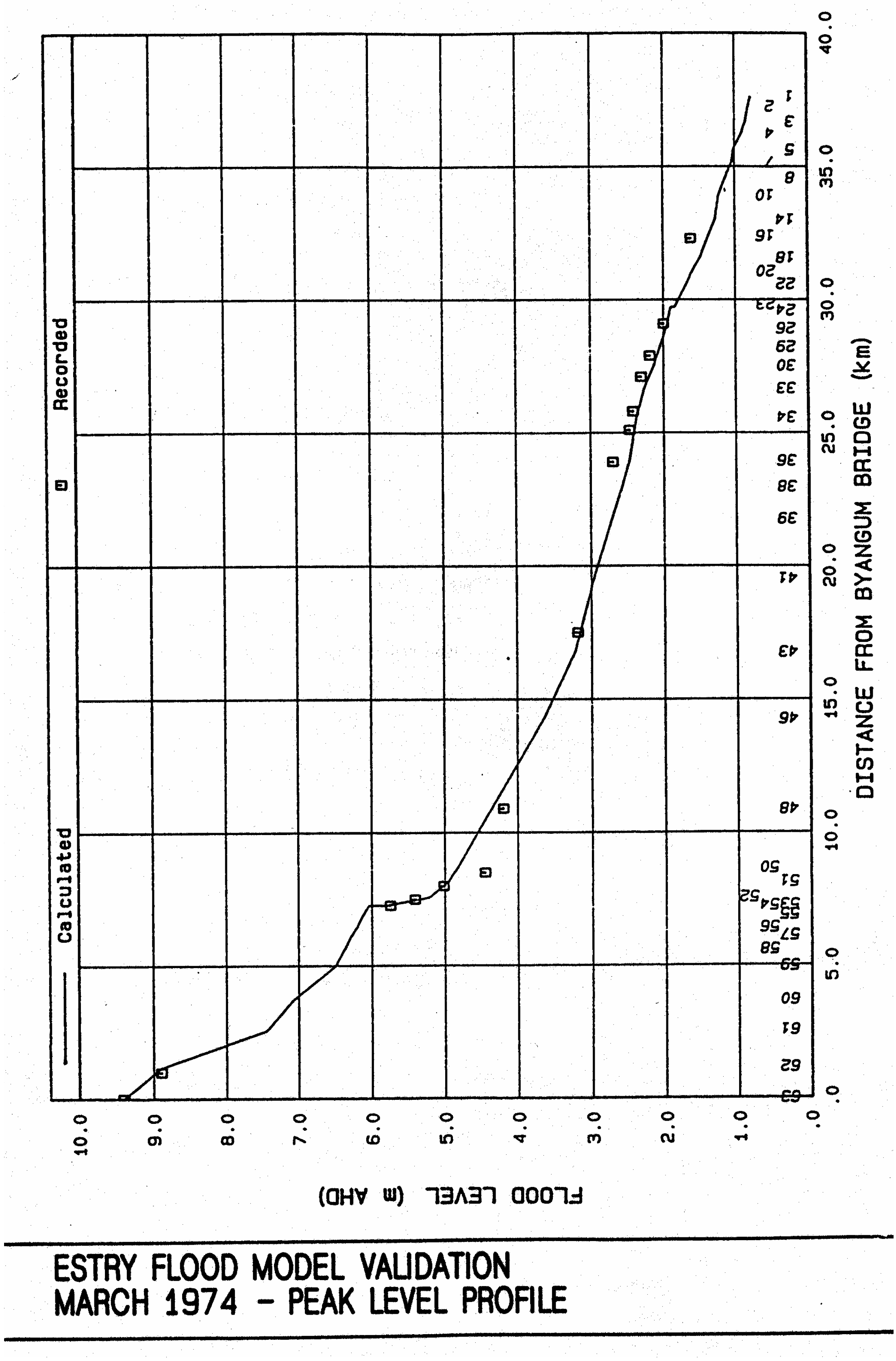


Figure 3.7: Tweed River 1D Model Verification for March 1974 Flood Event

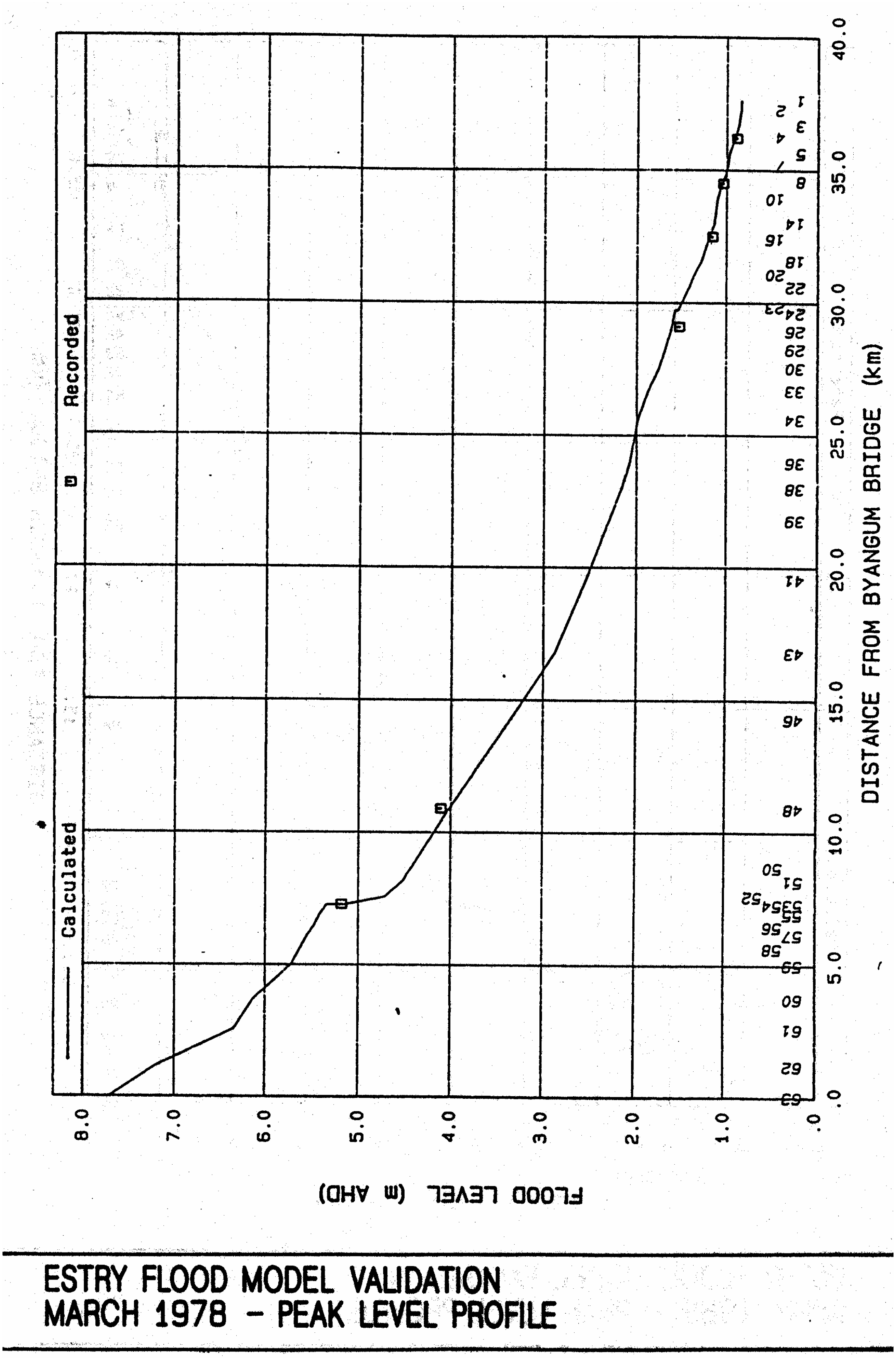


Figure 3.8: Tweed River 1D Model Verification for March 1978 Flood Event

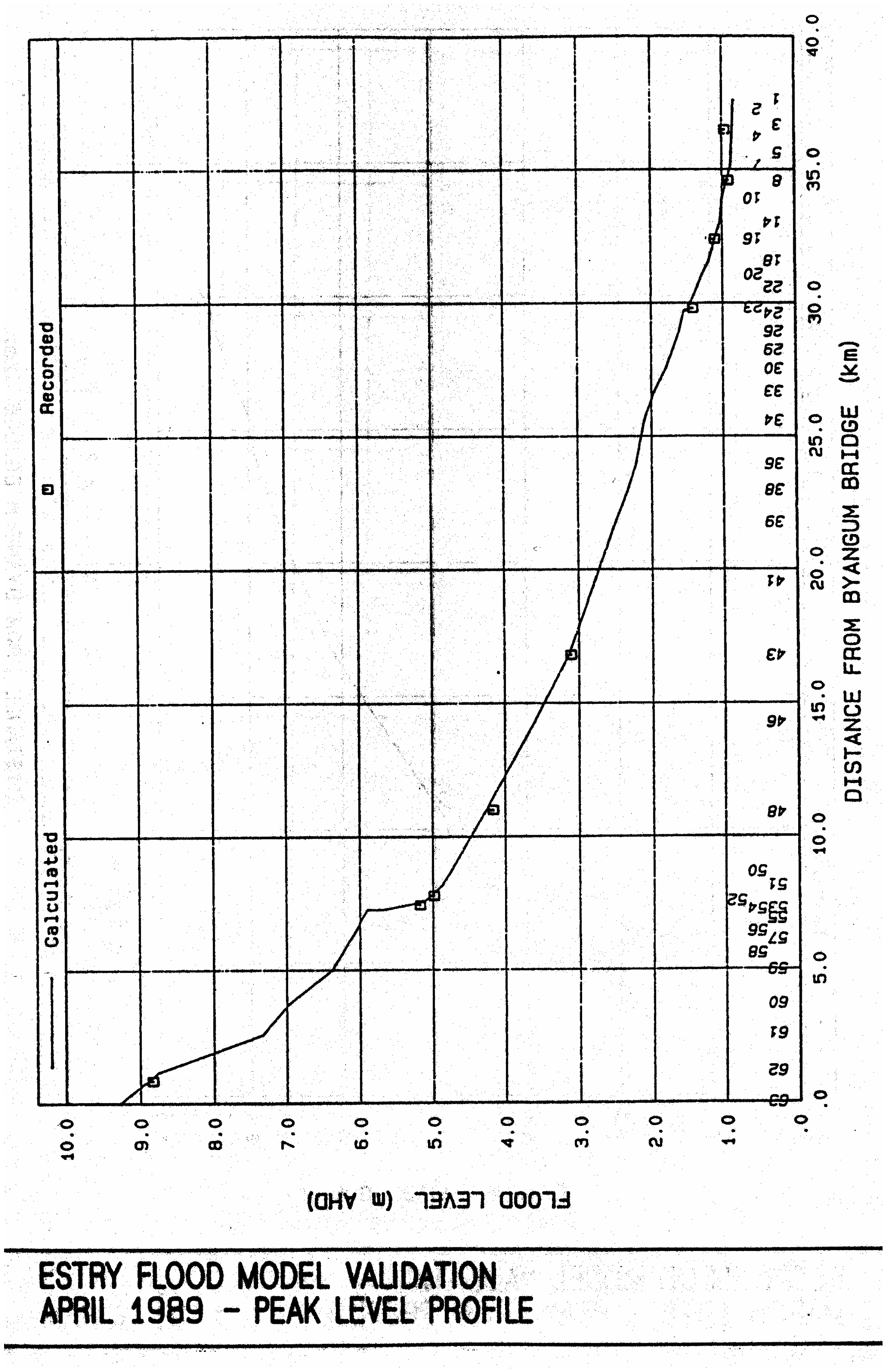


Figure 3.9: Tweed River 1D Model Verification for April 1989 Flood Event

3.2.4 Peak Flood Levels

Peak flood levels in the vicinity of the proposal are shown in Figure 3.10 for the 100 and 20 year ARI flood events. At the downstream end of the floodplain, near the site of the proposal, the flood gradient is dominated by the influence of the ocean levels during a major flood event.

The largest recorded flood in the study area was the February 1954 event which had a peak level of approximately 2.1 mAHD. The March 1974 flood event was also one of the largest flood events in the Tweed River. However, the ocean levels occurring during the February 1954 were significantly higher than those for the March 1974 flood event. Consequently, the levels in the lower parts of the floodplain (i.e. the study area) were not as high for the March 1974 flood event. The peak flood level for the March 1974 flood event in the study area was approximately 1.3 mAHD (Oceanics Australia 1980).

A comparison between design and historical Tweed River peak flood levels for the areas of floodplain adjacent to the route is presented below:

- 100 year ARI flood level = 2.70 mAHD
- 20 year ARI flood level = 2.25 mAHD
- 5 year ARI flood level = 1.10 mAHD
- 1954 flood level = 2.1 mAHD
- 1974 flood level = 1.3 mAHD

In comparing the design flood levels with the historical flood levels, the design flood levels are relatively high due to the conservative assumptions relating to ocean storm surge levels. A storm surge occurs as a result of a low pressure system. It was assumed that the storm surge in the ocean would be coincident with a Tweed River flood and a mean spring tide level of 0.6 mAHD.

As well, there would be elevated ocean levels due to a phenomenon known as wave set-up which results in increased flood levels at the entrance of the river due to the force exerted by incoming waves.

3.2.5 Influence of Elevated Ocean Levels

Current concern with climate change arises from scientific research indicating that the balance of evidence suggests a discernible human influence on global climate. Increasing concentrations within the earth's atmosphere of various gases, largely derived from the burning of fossil fuels, are trapping solar radiation. The resulting global warming (enhanced Greenhouse Effect) has the potential to cause mean sea level to rise.

There are uncertainties as to the actual magnitude and rate of rise of sea level as a result of thermal expansion of the oceans and melting of glaciers and ice-sheets. This has lead to various scenarios being adopted by the Intergovernmental Panel on Climate Change (IPCC). They are based on the range of model results available and dependant upon the amount of future emissions assumed. The Institution of Engineers, Australia, National Committee on Coastal and Ocean Engineering recommends that these values be used for planning and design.

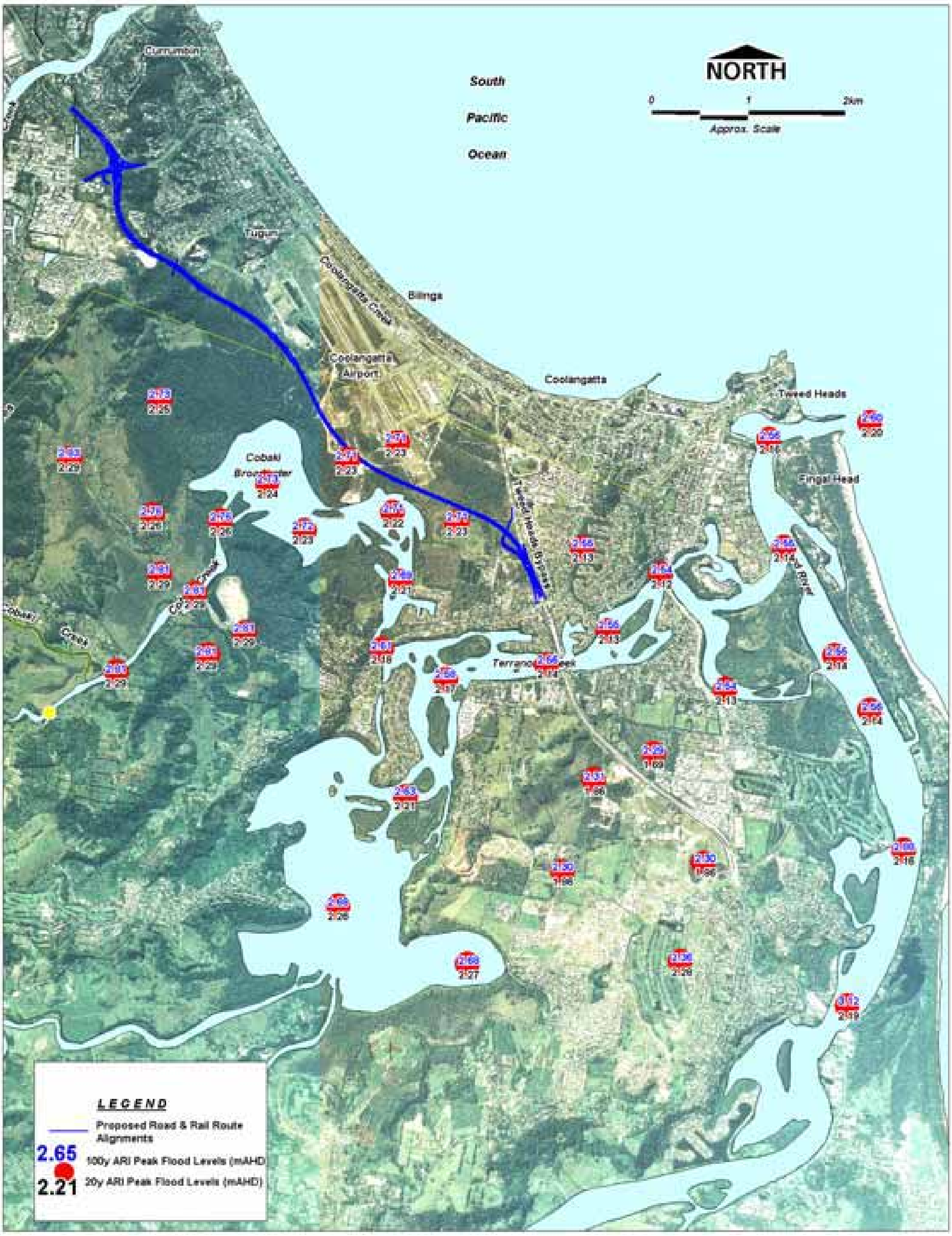


Figure 3.10: Existing Peak Flood Levels - Tweed River

Table 3.2 presents the latest low, mid (best), and high estimates of global mean sea level rise from Intergovernmental Panel on Climate Change (1996) for the years 2020, 2050 and 2100, relative to 1990.

Table 3.2: Anticipated Future Sea Level Rise (m), Relative to 1990

Year	Low	Best Estimate	High
2020	0.05	0.10	0.20
2050	0.10	0.20	0.40
2100	0.15	0.50	0.95

Gold Coast City Council has adopted an allowance of 0.3 m for future sea level rise (Betts 1999). This is based on the 'best estimate' for 2070.

Based on this estimate, an allowance of 0.3 m should be made for future sea level rise. There was no allowance for future sea level rise in the derivation of the ocean levels for the Tweed River flood assessments as it was derived prior to an understanding of the issue.

However, the peak ocean level used in the simulation of the 100 year ARI Tweed River flood is 2.6 mAHD. This level is based on the occurrence of a 100 year ARI storm surge (i.e. wind setup and barometric setup) with wave setup occurring at the peak of a mean spring tide. The peak ocean level was part of coastal assessments carried out in the 1980's. It is apparent from more recent storm surge estimations in the region that these earlier assessments were somewhat conservative. By way of comparison, the 100 year ARI ocean level used for the flood assessments of the Richmond River (some 60 km to the south of the Tweed River) was 2.0 mAHD (Lawson and Treloar 1994).

Hence, the peak ocean level used in the simulation of the 100 year ARI Tweed River flood:

- is probably over estimated by up to 0.6 m (based on other areas);
- should include an allowance of at least 0.3 m for future sea level rise.

On this basis, it is concluded that the ocean levels used in the simulation of Tweed River floods may result in an over-estimate of flood levels by approximately 0.3 m.

3.2.6 Peak Flood Levels for Rare Flood Events

In order to define peak flood levels for rare flood events (i.e. those greater than 100 years ARI), it was recognised that the peak levels resulting from Tweed River flooding of the study area are dictated by the peak ocean level. Hence, an assessment of the peak ocean levels derived for the Gold Coast area by the Queensland Beach Protection Authority was used. Based on these studies (Blain, Bremner and Williams 1985), the peak ocean levels were derived assuming:

- a storm surge resulting from a tropical cyclone (1.4 mAHD for 500 year ARI and 1.5 mAHD for 2000 year ARI);
- wave set-up of 0.7 m (refer to Figure 6.1 of Blain, Bremner and Williams 1985); and
- greenhouse sea-level rise of 0.3 m.

The peak ocean levels were then derived assuming an additional 0.1 m flood gradient for flood flow, resulting in peak flood levels at the site of:

- 2.5 mAHD for the 500 year ARI flood level; and
- 2.6 mAHD for the 2000 year ARI flood level.

Recent advice (October 2001) on peak ocean levels adopted by Gold Coast City Council, following a CSIRO study and report of May 2000, is as follows:

- 2.05 mAHD for the 100 year ARI;
- 2.3 mAHD for the 200 year ARI; and
- 2.5 mAHD for the 500 year ARI. (McInnes *et al*. 2000; Walsh *et al*. 1998)

Adding 0.3 m sea level rise due to greenhouse and 0.1 m flood gradient, flood levels at the site would be as follows:

- 2.45 mAHD for the 100 year ARI;
- 2.7 mAHD for the 200 year ARI; and
- 2.9 mAHD for the 500 year ARI.

Alternatively, adding 0.5 m sea level rise (anticipated 2100) flood levels at the site would be as follows:

- 2.65 m AHD for the 100 year ARI;
- 2.9 m AHD for the 200 year ARI; and
- 3.1 m AHD for the 500 year ARI.

3.2.7 Summary of Frequency of Inundation of Study Area

The levels for rare flood events (Section 3.2.6) are in contrast to the peak flood levels derived from the flood modelling (Section 3.2.4) which indicate that the 100 year ARI peak flood level is in the order of 2.7 mAHD. However, it was concluded in the discussion presented above that the 100 year ARI flood levels may be over-estimated by approximately 0.3 m. This conclusion is supported by the flood levels derived for higher ARI flood events. Using the adopted Gold Coast City Council peak ocean levels, a reasonable estimation for the 100 year ARI flood level would be 2.45 mAHD.

A flood frequency analysis of recorded flood levels at Murwillumbah carried out by WBM (Oceanics Australia 1979) indicated that the 1954 flood event (peak level of 2.1 mAHD at the site) had an exceedance probability of 1.6 percent or was an ARI of approximately 60 years. This result would also support a conclusion that the 100 year ARI flood level may actually be closer to 2.45 mAHD than 2.7 mAHD.

Even assuming 0.5 m sea level rise due to greenhouse effects at 2100, the 100 year ARI flood level at the time would be less than 2.7 mAHD (2.65m).

3.2.8 Inundation Times

The Tweed River is a large river system that floods relatively slowly at the downstream end near the proposal. The times of inundation for a range of flood levels for the 100 and 20 year ARI flood event are shown in Table 3.3 as well as graphically in Figure 3.11.

Table 3.3: Existing Times of Inundation for Tweed River Flooding

Flood Level (mAHD)	Time of Inundation (hrs) 100 year ARI	Time of Inundation (hrs) 20 year ARI
1.0	47	26
1.5	31	16
2.0	15	5
2.5	6	N/A

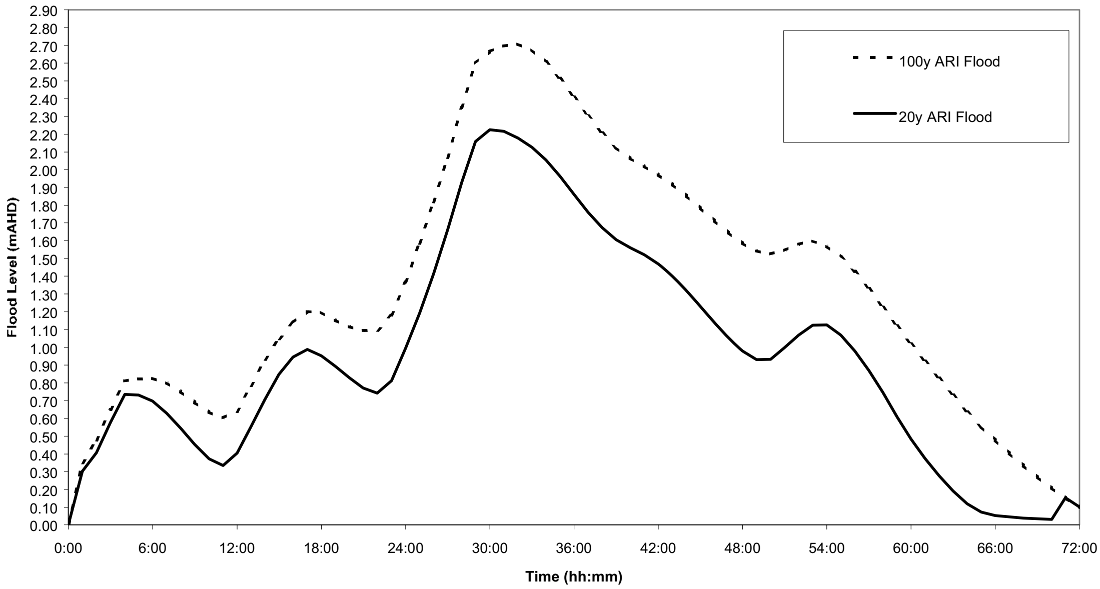


Figure 3.11: Inundation Times for Tweed River Flooding

3.3 Coolangatta Creek

Coolangatta Creek drains the areas of Tugun and Kirra. The main runway of the Gold Coast Airport forms the south-western border for majority of the creek's length. However, at the southern end of the airport, there is an overflow drain that directs high flows in large flood events (nominally larger than the 20 year ARI flood event) into Cobaki Broadwater. The route is crossed by this overflow channel.

4. Potential Impacts of the Proposal

4.1 Impacts on Local / Minor Catchments

Flood impacts on local/minor catchments crossed by the route have been considered on an individual basis and are discussed below.

4.1.1 Chainage 00 to 2,300

Waterway structures for the catchments in this part of the proposal were sized to achieve a maximum velocity of 2 m/s. The 100 year ARI peak flows and resulting waterway structures derived for these catchments are presented in Table 4.1.

Table 4.1: Peak Flows and Structures for Minor Catchments

Chainage (m)	Peak Flow (m3/s)	Waterway Structure
700	2.0	1,200 mm dia RCP
1,000	2.2	2 x 900 mm dia RCP
1,200	4.1	1,800 mm dia RCP
1,500	1.0	900 mm dia RCP
2,300	1.2	900 mm dia RCP

4.1.2 Chainage 2,800

As discussed in Section 3.1.2, the 60 minute duration 100 year ARI storm was used to size culverts under the proposed road embankments. A range of waterway openings were assessed as follows:

- Option 1: 3 barrels of 0.6 m high x 2.4 m wide box culverts;
- Option 2: 4 barrels of 0.6 m high x 2.4 m wide box culverts; and
- Option 3: 6 barrels of 0.6 m high x 2.4 m wide box culverts.

The invert level of the culvert was assumed to be 2.9 mAHD.

The impacts on the surrounding area upstream of the proposal for these three options are presented in Figure 4.1 for the 100 year ARI local flood event. The expected flood level increases range from 30 mm to 270 mm immediately upstream of the site.

The proposed future use of the site includes the continuation of the Pacific Beach Estate. Peak flood levels have been previously derived for this part of the site (known as Precinct C in the Pacific Beach Estate). Depending on the waterway opening option chosen and the resulting afflux, the proposal may result in the need for minor increases in the required fill levels for Precinct C. If fill levels are to be maintained to the previously derived levels (within 30 mm), then the larger structures (i.e. Option 3) would be required at this location.

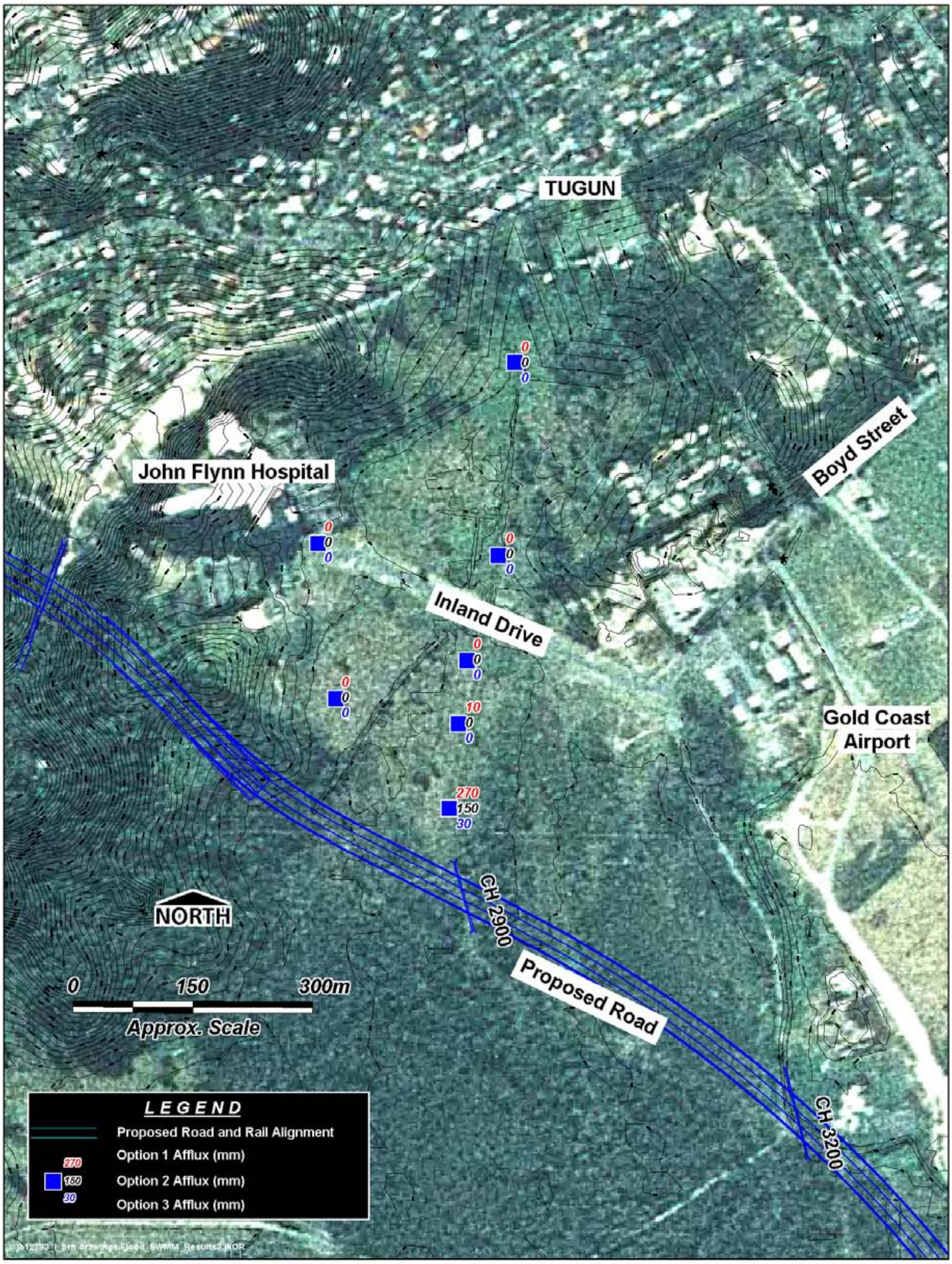


Figure 4.1: Impacts to 100 Year ARI Flood: Pacific Beach Catchment (Chainage 2,800)

The expected flood level increases in the existing urban areas upstream of Inland Drive would be negligible for all options assessed.

4.1.3 Chainage 3,200

A range of waterway openings were assessed as follows to accommodate the flows from the local catchment (i.e. not Tweed River flooding):

- Option 1: 4 barrels of 0.6 m high x 2.4 m wide box culverts;
- Option 2: 6 barrels of 0.6 m high x 2.4 m wide box culverts; and
- Option 3: 7 barrels of 0.6 m high x 2.4 m wide box culverts.

The invert level of the culvert was assumed to be 2.8 mAHD

The impacts on the surrounding area immediately upstream of the proposal for these three options are presented in Figure 4.2 for the 100 year ARI local flood event. The expected flood level increases range from 16 mm to 106 mm immediately upstream of the site.

4.1.4 Chainage 3,900

A range of waterway openings were assessed as follows to accommodate the flows from the local catchment (i.e. not Tweed River flooding):

- Option 1: 11 barrels of 0.6 m high x 2.4 m wide box culverts;
- Option 2: 14 barrels of 0.6 m high x 2.4 m wide box culverts; and
- Option 3: 17 barrels of 0.6 m high x 2.4 m wide box culverts.

The invert level of the culvert was assumed to be 2.9 mAHD.

The impacts on the surrounding area immediately upstream of the proposal for these three options are presented in Figure 4.2 for the 100 year ARI local flood event. The expected flood level increases range from 9 mm to 79 mm immediately upstream of the site.

4.1.5 Chainage 4,900

A range of waterway openings were assessed as follows to accommodate the flows from the local catchment (i.e. not Tweed River flooding):

- Option 1: 4 barrels of 0.6 m high x 2.4 m wide box culverts;
- Option 2: 8 barrels of 0.6 m high x 2.4 m wide box culverts; and
- Option 3: 20 barrels of 0.6 m high x 2.4 m wide box culverts.

The invert level of the culvert was assumed to be 1.1 mAHD.

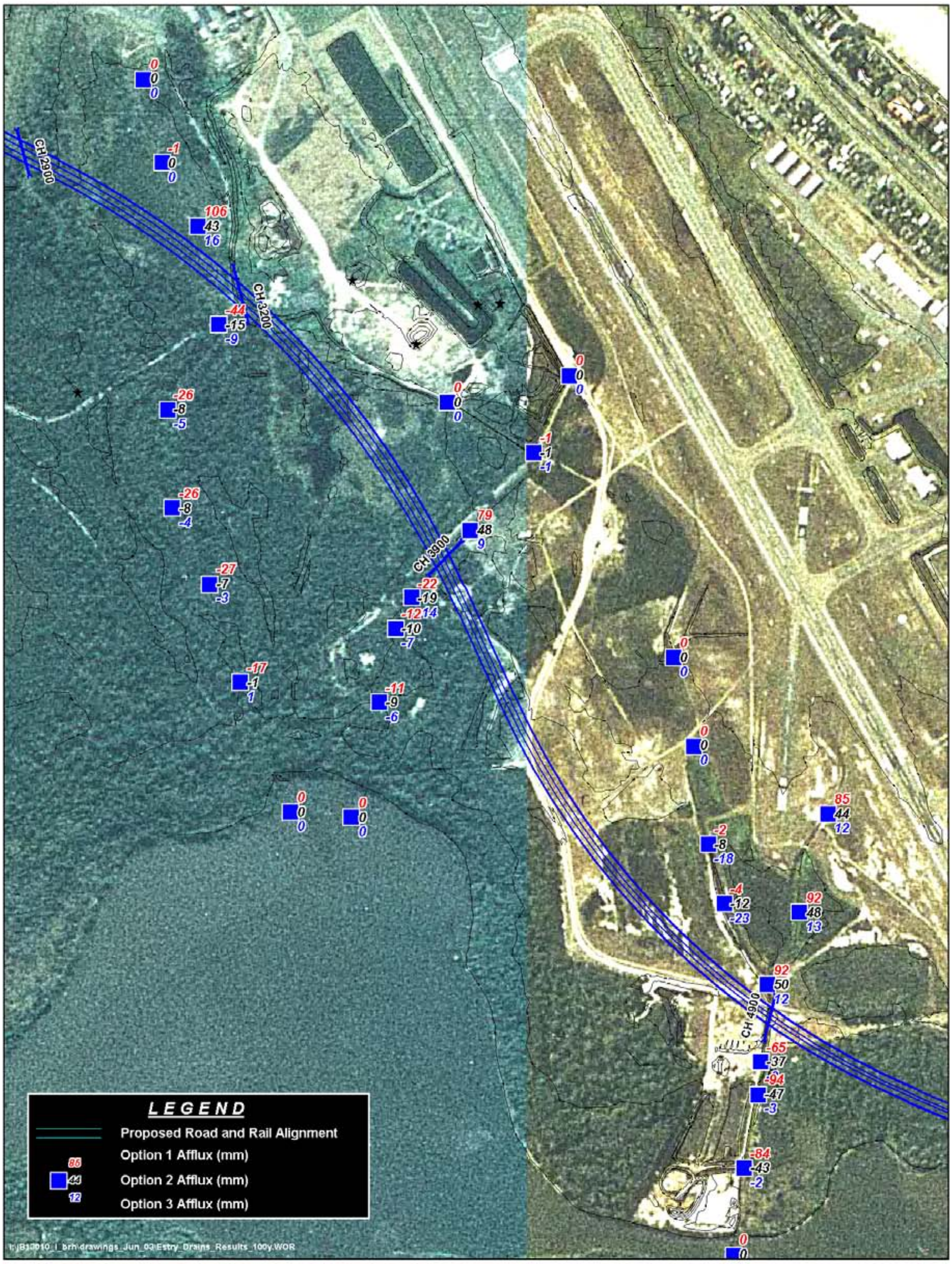


Figure 4.2: Impacts to 100 Year ARI Flood: Chainages 3,200, 3,900 and 4,900

The impacts on the surrounding area immediately upstream of the proposal for these three options are presented in Figure 4.2 for the 100 year ARI local flood event. The expected flood level increases range from 12 mm to 92 mm immediately upstream of the site. The flood level increases would be experienced in the more eastern of the two branches that comprise this drainage system as the flood gradient of this branch is very flat. The more western branch has a considerably steeper flood gradient. The more western branch would also be slightly shortened by the proposal resulting in minor decreases in flood levels.

It should be noted that the 100 year ARI flood levels resulting from local catchment run-off are less than those resulting from 100 year ARI Tweed River flooding. Hence, the Tweed River flood levels will still dictate required fill levels for any development upstream of the proposal in this catchment.

4.1.6 Chainage 5,450 to 6,000

From chainages 5,450 to 6,000, there are three minor catchments that discharge across the area where the proposed tunnels are located. This section also includes the overflow channel from Coolangatta Creek which is discussed separately above.

It is proposed to divert these catchments to discharge over the reinstated ground over the tunnels as shown in Figures 3.3 and 3.4. This would require replication of the shape, slope and invert levels of these watercourses in construction of the diverted drains.

Assuming that the general hydraulic characteristics of these drains are replicated adequately, the impacts of this re-routing of flow on flood levels is expected to be negligible.

In order to minimise the impact of the proposal, it is proposed to construct a catch drain on the eastern side of the proposal and divert this drain around the tunnel approach embankments (i.e. over the top of the road tunnels). On the western side of the proposal, the drain would allow flow over a long length of bank to ensure overland flows to continue toward the tidal drain.

One issue that will require careful management is that of ensuring the freshwater overland flow in this catch drain does not mix with the diverted tidal drain at chainage 6,000. It is proposed that these two drain would be diverted in separate drains as shown in Figures 3.3 and 3.4.

4.2 Impacts on Tweed River Floodplain

4.2.1 Impacts on Peak Flood Levels

The primary impact of the proposal on the Tweed River floodplain is the loss of floodplain storage resulting from the filling required for the road embankment. This loss of storage has the potential to result in increased flood levels.

In order to quantify these impacts, the loss of floodplain storage was simulated using the 1D flood model of the entire Tweed River floodplain. The storage available in the nodes representing the Gold Coast Airport area were reduced to simulate the filling associated with the proposal. The existing floodplain storage and the floodplain storage with the road embankment constructed are presented in Table 4.2.

Table 4.2: Loss of Floodplain Storage (Tweed River)

Level (mAHD)	Existing Storage (m^3)	Storage With Road (m^3)
0.0	0	0
1.4	94,500	87,200
2.0	325,200	283,200
2.3	534,500	464,200
2.7	872,900	755,200
3.0	1,171,100	1,007,400

The flood model was then simulated for the 100 year, 20 year and 5 year ARI flood events.

The resulting flood behaviour was compared with that for the existing situation. The comparison showed that the filling for the proposal would result in increases in flood level of less than 3 mm for the 100, 20 and 5 year ARI flood events. The spatial extent of these impacts are presented in Figures 4.3 to 4.5.

The magnitude of these impacts can be considered to be negligible. They are within the recognised accuracy of the modelling of approximately $\pm$100 mm. As well, Tweed Shire Council have indicated that impacts of this magnitude would be likely to be accepted under the Murwillumbah Floodplain Management Plan (see letter from Tweed Shire Council in Appendix A).

4.2.2 Impacts of Inundation of Houses / Property

The area of floodplain affected by the increased flood levels has been the subject of development over recent years. The majority of the filling for residential development that has taken place over the lower parts of the Tweed River floodplain has been to levels 300 mm above the 100 year ARI flood level based on Tweed Shire Council policy. Hence, the impact of the proposal on these properties would only be experienced in floods greater than the 100 year ARI flood (i.e. rare flood events) and these impacts would be negligible.

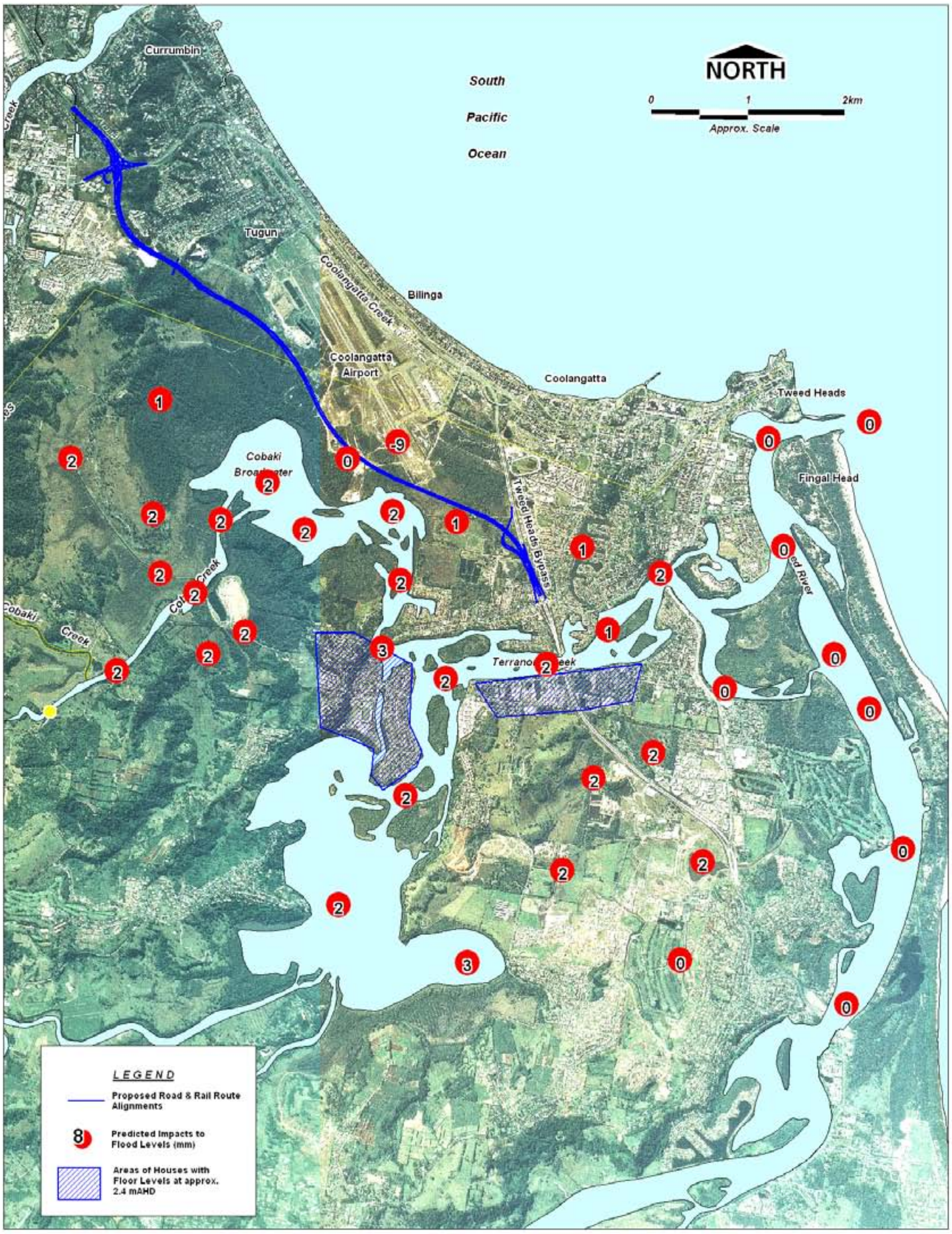


Figure 4.3: Impacts on Tweed River Flooding – 100 Year ARI Flood

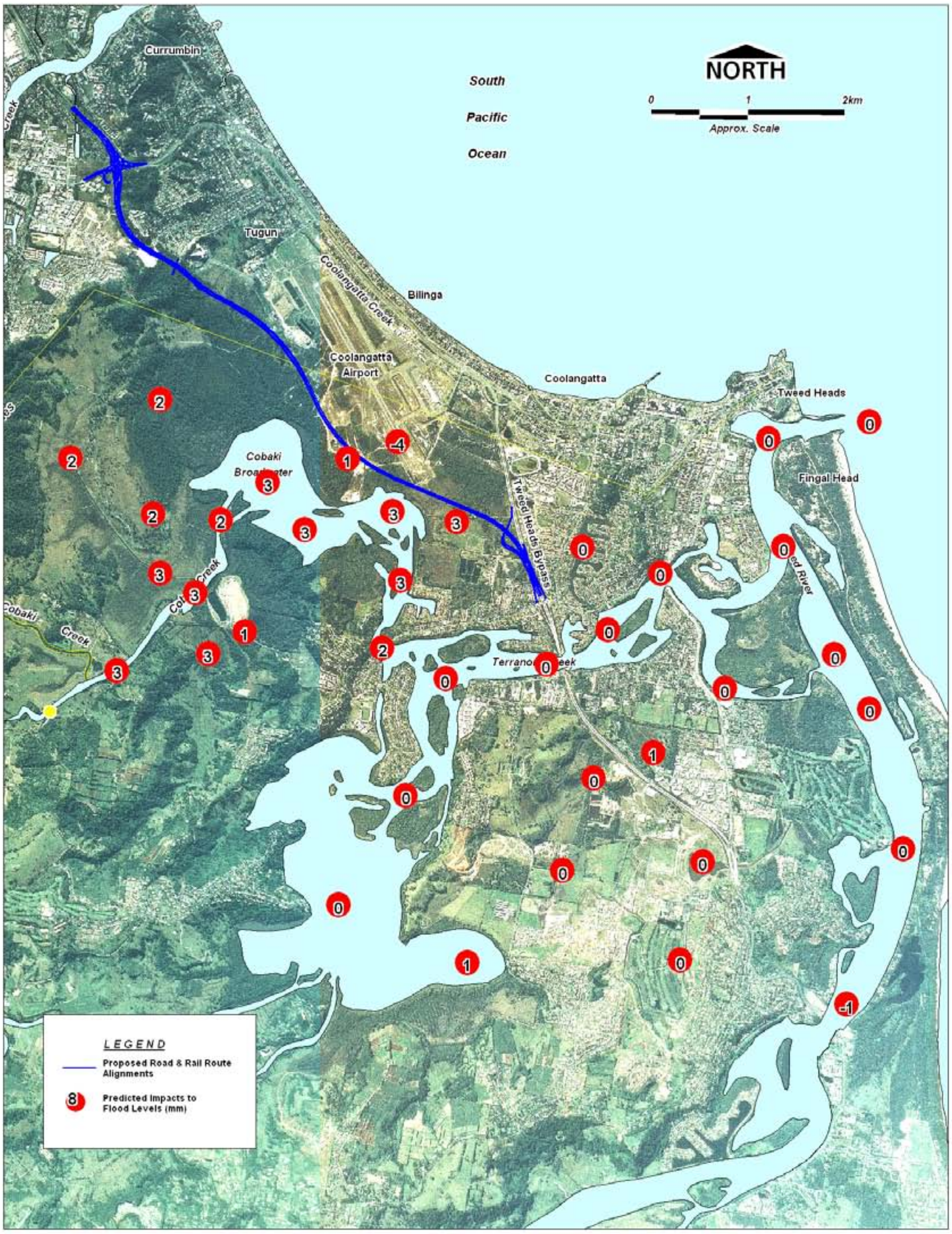


Figure 4.4: Impacts on Tweed River Flooding – 20 Year ARI Flood

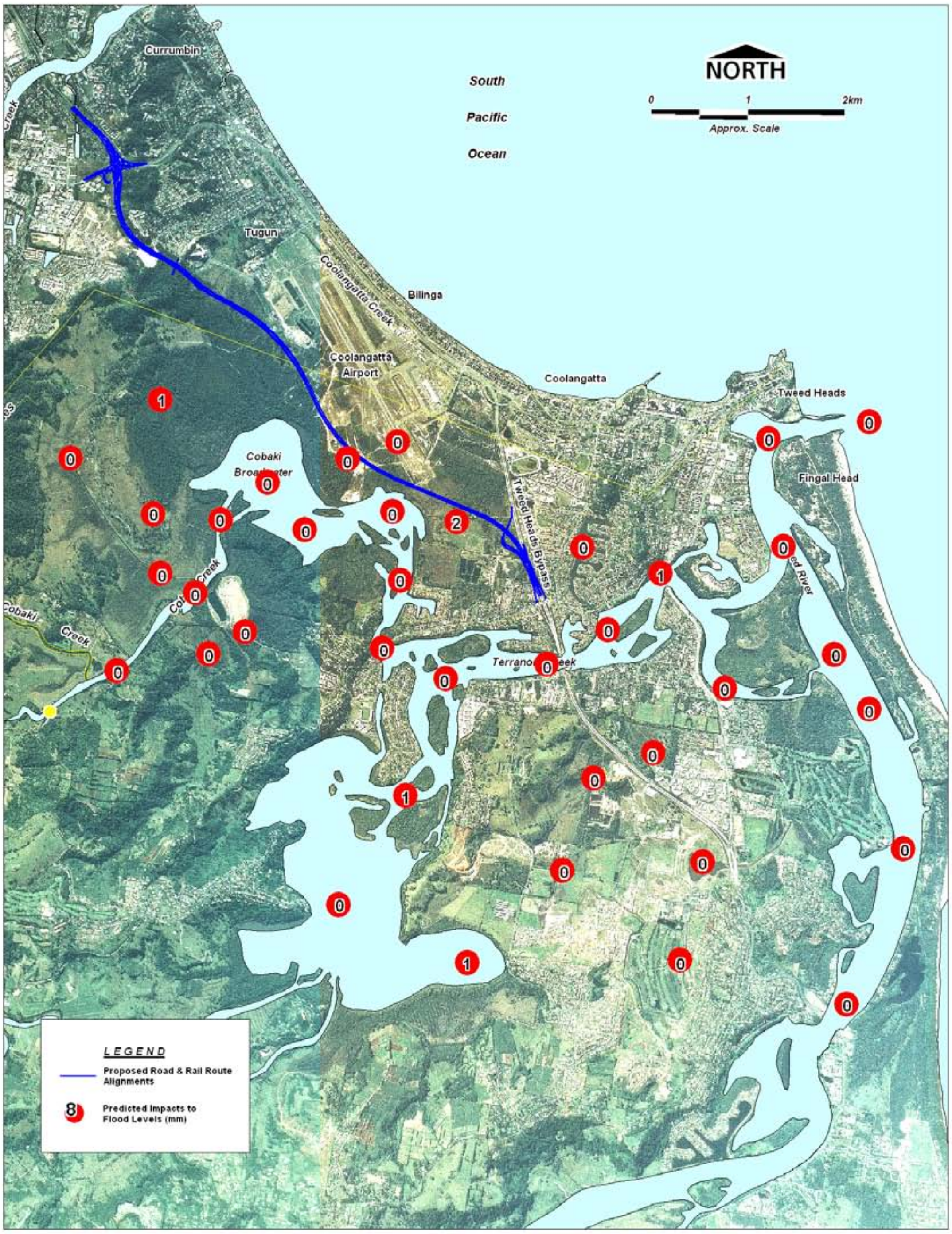


Figure 4.5: Impacts on Tweed River Flooding – 5 Year ARI Flood

However, there are some areas of the floodplain that were developed prior to the implementation of this policy. These houses have floor levels of about 2.4 mAHD based on a peak 1954 flood level of about 2.1 mAHD and 300 mm freeboard. It is estimated that there would be less than 300 houses at these lower levels and their general location is shown in Figure 4.3. The increased flood damage resulting from these increased flood levels for these lower houses would be negligible due to the magnitude of the impacts.

4.2.3 Impacts on Times of Inundation

The proposal will have a negligible impact on the time that flood-prone land is inundated during Tweed River flood events. This is largely due to the minor impact that the proposal would have on general flooding behaviour.

In order to illustrate this impact, Figure 4.6 shows the rise and fall of flood levels over time at the Cobaki Broadwater for both the existing case and that with the proposal constructed (including the road and the rail line). The two graphed lines are shown as almost coincident indicating little difference in behaviour as the difference in flood levels between the existing case and that with the road is only .009 m.

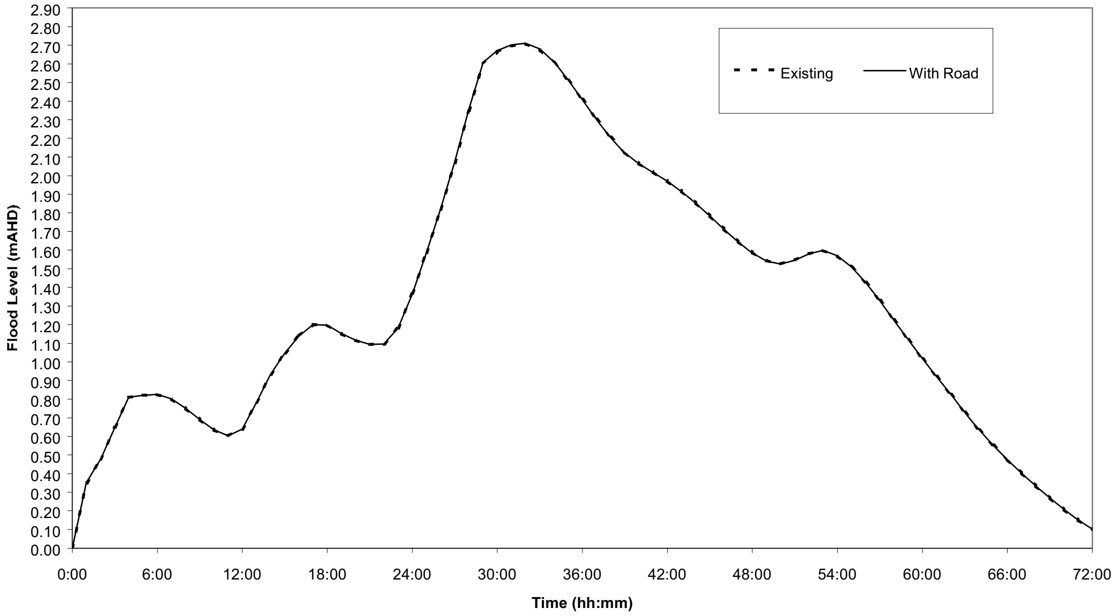


Figure 4.6: Impacts to Time of Inundation

It is apparent from this figure that the proposal would have a negligible impact on the time of flood inundation. This is largely due to the loss of floodplain storage being only a very small proportion of the total floodplain storage on the Tweed River floodplain.

4.2.4 Impacts to Rates of Flood Rise and Recession

The proposal would have a negligible impact on the rates of flood rise and recession during Tweed River flood events. This is largely due to the slow rising behaviour of Tweed River flood events at the downstream end of the floodplain.

In order to assess this impact, flood simulations using the Tweed River flood model were carried out for the 100 year ARI flood event. The model simulated the storage on either side of the proposal in two separate storage areas connected only by the waterway structures described above in Section 4.1. Hence, in this flood simulation, floodwaters could only fill and recede from the storage areas on the eastern side of the proposal by flowing through these waterway structures and specifically the structure at chainage 4,900 which is the only structure to be inundated in a Tweed River flood event.

Figure 4.7 shows flood levels over time for two locations in this flood simulation. One location is in the Cobaki Broadwater which is on the south-western side of the proposal. The other location is on the north-eastern side of the proposed route on Gold Coast Airport.

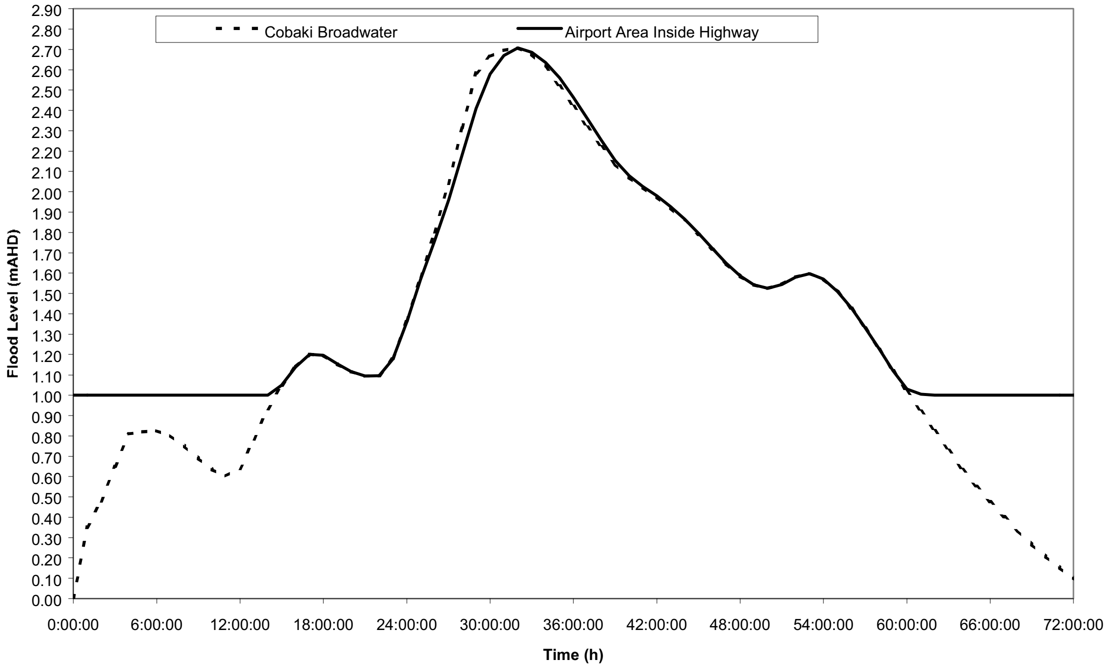


Figure 4.7: Impacts to Rate of Rise and Recession

It is apparent from this figure that the proposal would result in very similar rates of flood rise and recession for areas north-east of the proposal.

4.3 Impacts on Coolangatta Creek Flooding

The proposal would have negligible impact on the nature and behaviour of flooding in Coolangatta Creek. This lack of impact is because there would be little, if any change to the conveyance characteristics of the overflow channel from Coolangatta Creek to the Cobaki Broadwater. This channel would pass over the proposed road and rail route and be re-instated as an open channel. The channel would be sized to ensure that it has the same flood capacity as in its present state.

5. Cumulative Impacts

5.1 Development in the Immediate Area

There are a number of developments proposed in the immediate vicinity of the bypass which will have a cumulative impact on Tweed River flooding. Primarily, these are:

- the construction of a parallel rail line embankment; and
- developments at the Gold Coast Airport.

Both of these developments would result in a loss of floodplain storage.

The flooding assessments for the road embankment (described in Chapter 4) were extended to consider the cumulative impact resulting from filling for the road embankment, rail embankment and the possible airport developments.

The results (see Figure 5.1) indicated that the maximum impact resulting from this cumulative filling scenario (i.e. road, rail and possible airport developments) is 13 mm in the 100 year ARI flood event. This would be considered acceptable by Tweed Shire Council on the basis of the advice in Appendix A.

5.2 Other Developments on Tweed River Floodplain

There has been numerous urban developments on the Tweed River floodplain over the last three decades and urban development is continuing on the floodplain. These developments have resulted in an overall loss of floodplain storage over time which has the potential to raise flood levels. These proposed future developments include:

- Cobaki Lakes development;
- filling for the development of a industrial precinct on the Gold Coast Airport; and
- development of the 'Sullivan Land' at South Tweed Heads.

However, there have also been changes to the hydraulic efficiency of the Tweed River entrance that could result in lower flood levels.

It is difficult to assess the cumulative impact of all potential future developments due to the uncertainty in the proposed location and extent of filling. It is also important to note that due to the role that the elevated ocean levels play in defining flood behaviour in this area, filling of the floodplain has a relatively lesser impact of flood levels.

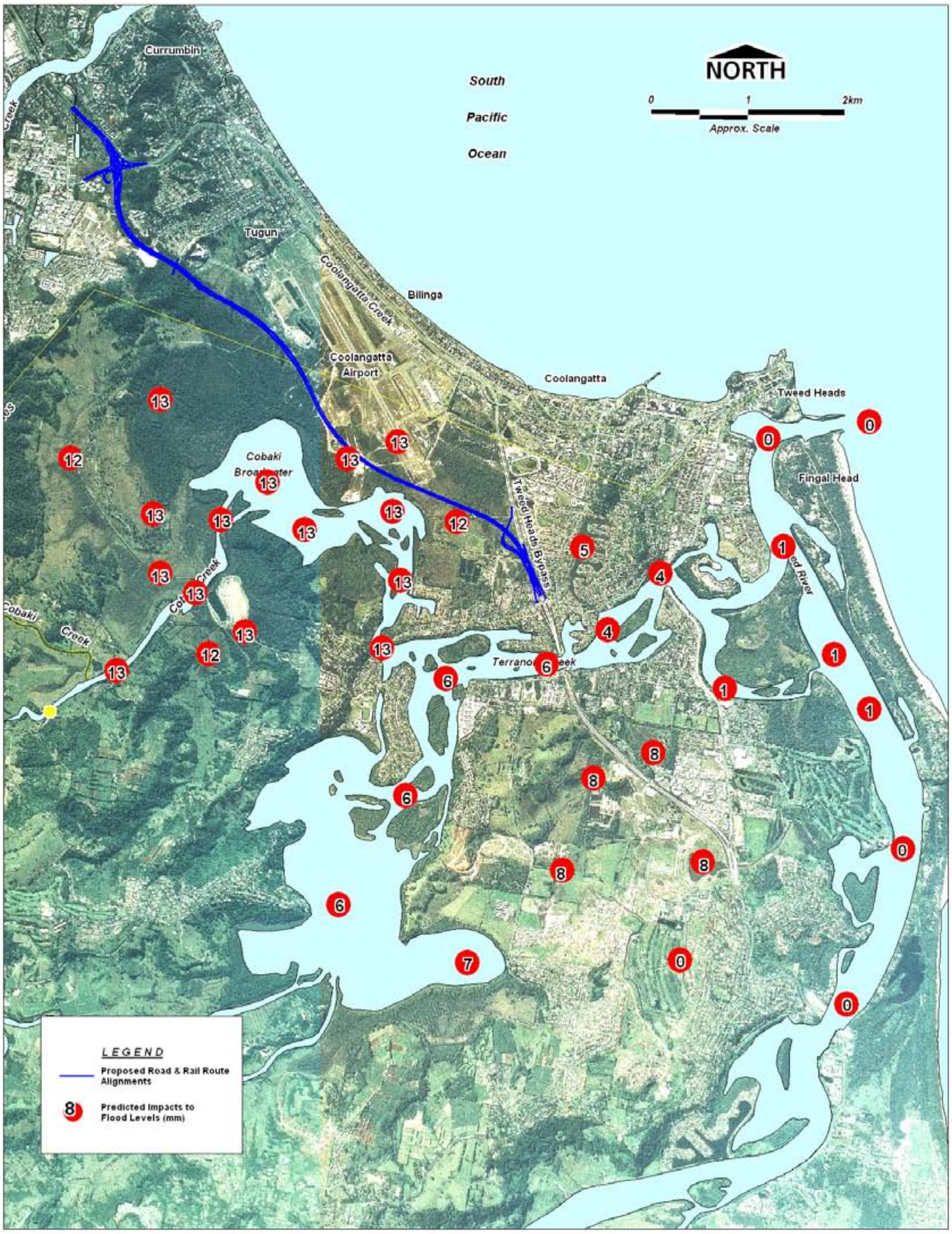


Figure 5.1: Cumulative Impacts on Tweed River Flooding with Road, Rail and Runway – 100 Year ARI Flood

6. Mitigation Measures

The primary means of mitigating the possible impacts of the proposal on flooding is to ensure the inclusion of the proposed waterway openings and drain re-routings as discussed in Chapter 4. These are summarised in Table 6.1.

Table 6.1: Summary of Waterway Structures and Drain Re-Routing

Chainage (m)	Waterway Structure
700	1,200 mm dia RCP
1,000	2 x 900 mm dia RCP
1,200	1,800 mm dia RCP
1,500	900 mm dia RCP
2,300	900 mm dia RCP
2,800	Numerous options (see Section 4.1.2)
3,200	Numerous options (see Section 4.1.3)
3,900	Numerous options (see Section 4.1.4)
4,900	Numerous options (see Section 4.1.5)
5,550	Drain re-routed over tunnel
5,750	Drain re-instated over tunnel
6,300	3 x 2,400 mm x 600 mm RCBC

It is proposed to construct a catch drain on the eastern side of the proposal and divert this drain around the tunnel approach embankments (i.e. over the top of the road and rail tunnels). On the western side of the proposal, the drain would allow flow over a long length of bank to ensure overland flows to continue toward the tidal drain.

One issue that would require careful management is that of ensuring the freshwater overland flow in this catch drain does not mix with the diverted tidal drain at chainage 6,000. It is proposed that these two drains would be diverted in separate drains.

References

Betts H. 1999, *The Implications of Future Climate Change on Floodplain Planning at Gold Coast City*, Floodplain Management Authorities Annual Conference.

Blain, Bremner and Williams 1985, *Beach Protection Authority Storm Tide Statistics (Surfers Paradise Region*).

Intergovernmental Panel on Climate Change 1996, *Climate Change 1995 - The Science of Climate Change*, Working Group 1, June.

Lawson and Treloar 1994, *Ballina Ocean Level Study,* Report Number J1238/R1520.

McInnes K.; Hubbert G.; Oliver S. and Abbs D. 2000, *Gold Coast Broadwater Study Storm Tide Return Periods and 1974 Floodwater Modelling,* (CSIRO Division of Atmospheric Research) May 2000, report prepared for Gold Coast City Council.

Oceanics Australia 1979, *Tweed River Flooding Investigation – Kingscliff / Chinderah*.

Oceanics Australia 1980, *Terranora / Tweed Heads Flooding Investigation*.

WBM Oceanics Australia 1991, Upper and Lower Tweed River Management Plan.

WBM Oceanics Australia 1992, Upper and Lower Tweed River Management Plan.

NSW Public Works Department 1989, *Tweed River Hydrology*.

Walsh K.J.E.; Jackett, D.R.; McDougall T.J. and Pittock A.B. 1998, *Global Warming and Sea Level Rise on the Gold Coast*, CSIRO Division of Atmospheric Research and Division of Marine Research, report prepared for the Gold Coast City Council, April.

Appendix A

Letter From Tweed Shire Council

29/05 '01 TUE 16:55 FAX 02 6672 7513 T.S.C. ENGINEERING ABM 001

Please Quote Council Ref: [eltr]

Your Ref No:

For Enquiries Please Contact: Mr John Henley

Telephone Direct (02) 6670 2476 128z11.doc

29 May 2001

WBM Oceanics Australia
PO Box 203
SPRING HILL QLD 4004

Dear Sir

Tugun Bypass EIS

I wish to acknowledge receipt of your facsimile letter of 23 May, 2001 and confirm verbal advice that impacts on flood levels from developments should be minimised. In the Murwillumbah Floodplain Management Plan, Council accepted affluxes of 50-60mm, without requiring any compensatory measures, on the basis of the relative accuracy of the modelling and the available flood data.

It is reasonable to assume that a similar approval will be adopted in relation to the Tugun Bypass although ~~consultative~~ cumulative impacts would need to be addressed.

Affluxes of less than 5mm, as predicted in your draft, are unlikely to be of concern to Council.

Yours faithfully

John Henley
Manager
WATER

CIVIC AND CULTURAL CENTRE, MURWILLUMBAH
P.O. BOX 816, MURWILLUMBAH. N.S.W. 2484
TELEPHONE: (02) 6672 0400 FAX: (02) 6672 0429
PLEASE ADDRESS ALL COMMUNICATIONS TO THE GENERAL MANAGER
ABN 90 178 732 496
www.tweed.nsw.gov.au

VALLEY OF CONTRASTS