Appendix F

Estuarine assessment

Settlement City Shopping Centre – Port Macquarie
Environmental Assessment proposed Stage 1

ING REAL ESTATE

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gpb:gpb/09-2/lr831

12 March, 2009

Manidis Roberts
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Attention: Ms Rachel Haden

Dear Rachel

SETTLEMENT CITY SHOPPING CENTRE
COASTAL AND ESTUARINE PROCESSES, HAZARDS AND IMPACTS

We refer to recent discussions between Mr Gary Blumberg of gbaCOASTAL *(GBAC)* and Ms Rachael Haden of Manidis Roberts *(MR)* regarding the above. MR has retained GBAC to update the coastal estuarine stability statement prepared by Gary Blumberg & Associates *(GBA)* for Planning Workshop Australia in November 2005. Note that GBA changed its name to GBAC on 1 November 2008.

We are pleased to report in this matter, set out below under the following main headings:

- Introduction
- Site Inspection
- Coastal and Estuarine Processes, Hazards and Impacts
- Summary
- References

All reference to Relative Level *(RL)* in this report is to Australian Height Datum *(AHD)*. AHD is approximately Mean Sea Level on the open coast.

Principal Gary Blumberg BSc(Eng)Civil MSc(Eng) MIEAust NPER3

1 INTRODUCTION

1.1 Background

A proposal is being prepared by ING Real Estate to expand and partially redevelop the Settlement City Shopping Centre at Port Macquarie. The redevelopment will extend the gross floor area by up to approximately 9,200 m^2. Additional car spaces will also be provided. The project falls under Part 3A of the NSW Environmental Planning and Assessment Act 1979.

Manidis Roberts *(MR)* is currently retained by ING to lead and coordinate the approvals investigations for the development. GBAC has been engaged by MR to provide specialist coastal and estuary subconsultancy input to update and complete additional investigations and reports in relation to the required EA.

1.2 Study Area and Site Description

The study area includes the Settlement City precinct between Settlement Shores and Back Channel on the Lower Hastings River at Port Macquarie, NSW North Coast (**Figure 1**).

Settlement City Shopping Centre is located 1.3km to the east of the Port Macquarie central business area. Together with the adjoining Panthers Club they occupy a site area of 6.4 hectares, with water frontage to the north and west and road frontage to the east *(Park Street)* and south *(Bay Street)*.

1.3 Scope of Work

GBAC's Scope of Work comprised the following main tasks:

(i) Update work previously undertaken for the preliminary EA in view of legislative and planning context and on-site changes *(if any)*.

(ii) Update reports and prepare new reports in response to the current DGR's.

(iii) Review and assess revised plans for the expansion and partial redevelopment.

Project plan drawings have been provided by MR, a relevant selection of which is attached in **Appendix A**. These have been reviewed and assessed within the context of the design coastal and estuary hazards.

2 SITE INSPECTION

A site inspection was carried out by Mr Gary Blumberg on 21/1/09, between 3.50 pm and 5.30 pm. Weather during the inspection was overcast with winds moderate to fresh from the NE. The predicted tide at Settlement Point was rising over the course of the inspection, from approximately RL-0.2 to RL-0.1 (see **Table 2**). Selected photographs taken during the inspection are attached below and in **Appendix B**.

Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

Photo 6

Photo 7

Photo 8

Photo 9

Photo 10

Our inspection commenced at 3.50 pm at the SE end of drainage reserve DP263340, understood to be named Dolphin Key (**Figure 1**). The inspection progressed northwards along the western shoreline to the NW corner of the site, and then eastwards towards Park Street.

Along the western edge of the site (**Photos 1** and **3**) and around to the weir on the northern canal (**Photo 8**), we observed in general a canal edge treatment comparable to an "intertidal beach" cross-section as described in the NSW canal subdivision guidelines *(PWD, 1992).* The structural edge treatment at the site comprises a corrugated sheetpile, possibly asbestos-cement, with concrete capping beam along the crest (**Photos 3** and **4**). The treatment type changes east of the weir where a failed concrete walkway occurs.

Field notes from our inspection *(including selected photos covering damage detail)* are attached in **Appendix B.** A brief summary is attached in **Table 1**. We include in the table our assessment of shoreline condition. While the majority of the shoreline appeared in stable condition, we did encounter sections of damage and instability. It is our opinion that the sections in "poor" condition should be repaired as soon as possible to avoid immediate increased damage and destabilisation. The sections of "moderate" condition should also be repaired in due course, with the timing of this repair best informed by monitoring.

The damaged sections of shoreline treatment, particularly those with cracked corrugated sheeting and washout *(Ch 140W, 155W and 298W)*, should be repaired as soon as possible. For this repair, we would suggest replacement of the damaged sheet(s), followed by filling of the wash out with a stone filter *(eg blue metal)* wrapped in geotextile. It seems that once the sheeting is cracked at the underside of the capping and a section of sheet breaks away, deterioration is inevitable. At high tide, waves and currents would swirl through the crack and scour out the backfill. The Casuarina root mat behind the wall assists to reinforce the soil, but is not sufficient to prevent the washout. A quick repair is also necessary at Ch 98-111W and Ch 70-140E.

Where the wall is not damaged but erosion is observed under the capping, remedial action may prove cost-beneficial. Such work could involve minor excavation, placement of geotextile, and placement of stone and cobble filling *(say 50 to 100∅, subject to slope, design etc).*

Council has released the Port Macquarie Foreshore Masterplan which includes a public walkway along the shoreline from the new marina located to the SE of the site, extending northwards along the eastern side of Park Street. This footpath is to join with a new footpath on the northern side of the Panthers Club (**Section 3.6**).

Figure 2 shows the site layout and adopted chainage system used for location during the site inspection. Typical canal edge treatment profiles encountered are also shown.

We observed a 20' cruiser passing through the canal. It was travelling at low speed, complying with the signposted 4 knot speed limit (**Photo 6**). Estimated boat generated wave height at the shore 30 mm with period less than 0.5 s. A second boat movement was also at low speed.

Table 1 Summary of Damaged and Unstable Shoreline

Approx Ch East (E) and (W) of Weir (m)	Description	Condition Guide
490W	Cobbled shore, flat profile. Casuarina to 8 high behind beach	Good
420W	Cobbles covered with marine sand from here to N. No sign of erosion. Retaining wall at roadway in good condition	Good
350W	Canal edge capping (450 high x 250 wide) starts to become exposed in back of beach. Corrugated sheeting below capping	Good
330-340W	250 mm erosion under base of concrete capping. Damaged wall. Horizontal crack, possibly construction joint. Poor construction suspected.	Poor
315W	Good age spread Casuarina in upper bank. Retaining wall at roadway in good condition. Canal wall good.	Good
298W	Broken corrugated sheet 150 long. 280 erosion between underside capping and beach	Poor
285W	450 erosion, beach to underside capping	Moderate
230W	Canal wall construction substandard. Poor edge under concrete capping. Capping height varies from 400 to 300 over 0.5 m wall length. Nevertheless, wall alignment still true, no settlement or rotation. Estimated canal wall crest level RL 1.1	Moderate
185W	Beach and vegetated profile above canal wall, and roadway retaining wall all good. 300 mm erosion between capping and beach	Good
170-190W	Oysters on beach. Stones on beach to 50Ø, estimated beach slope 1:10	Good
155W	Damaged section of corrugated sheeting. Broken length 1.5 m. Washout 0.6 m x 3.0 m behind capping.	Poor
150W	Corrugated sheeting close to front of capping – poor construction. Erosion under capping to 350 mm.	Moderate
140W	100x150 hole in sheeting, another 100x30 hole close by. 2.2 m x 0.4 m washout behind. Significant washout for relatively small hole	Poor
98-111W	Keyed concrete block wall *(repair?)* in poor condition. 600 wide x 800 long blocks in plan, 700 high. Ten blocks keyed into one another. These have all slid into the canal by 75 approx, and rotated. Suspect poor foundation. Concrete fill behind blocks provides an inflexible design	Poor
70 – 95W	Canal wall turns around corner to E, and subducts into foreshore. 50-200Ø basalt riprap and cobbles with stones, spread over beach at approx 1:8. Appears stable	Good
0 - 50W	Canal wall re-emerges, then failed in sections to weir. Rotated 5 to 250 mm with washout behind, unsightly.	Moderate to poor
Weir and adjoining structure (0-40E)	Substantial structure. No cracking and no settlement. Substantial apron immediately to W and then 20 m long riprap beach; 400-500Ø basalt at 1:6 approx	Good
70-140E	1.2 m wide concrete footpath forms edge to waterway. The entire structure has failed. The footpath rotated towards the canal with lip dropped up to 100 mm. Void to 300 deep observed under the footpath *(50% of fill under footpath lost over the approx 70 m length)*. Seems scour protection at the edge of the footpath has failed and the subgrade washed out –suspect a combination of poor design, construction and/or high currents. Shoreline here barricaded with parrawebbing	Poor

3 COASTAL AND ESTUARINE PROCESSES, HAZARDS AND IMPACTS

To support the revised EA, coastal and estuarine processes, hazards and impacts relevant to the site have been considered. These comprise:

- Physical estuarine setting
- Water levels *(including sea level rise)*
- Currents
- Wave action
- Sediments and sediment transport
- Bank stability

In accordance with Clause 3 of General Requirements, DGR Attachment 1, we have included a site analysis with constraints mapping in respect of the above. Our appraisal of potential impacts and mitigation measures is suitable for MR's review and incorporation as required into the environmental assessment for the project.

3.1 Physical Estuarine Setting

The main arm of the Hastings River is approximately 120 km long, draining a catchment area of some 2,800 km^2. In catchment terms, the Hastings is the ninth largest coastal river in NSW. The river is under tidal influence for some 32 km from the entrance to upstream of Bains Bridge, about 8 km above Wauchope. The Maria River forms the major tidal tributary.

Sedimentation, flooding and bank erosion are key management issues for the lower estuary. The Settlement City site interfaces with the Hastings Estuary within Stage A of the Settlement Shores Canal Estate, developed in the 1970's.

3.2 Water Levels (including Sea Level Rise)

Water levels in the lower estuary are controlled by tide, ocean storms and fresh water flooding. Sea level rise *(SLR)* due to climate change must also be considered.

Tides

The estuary experiences a semi-diurnal tide, namely two highs and two lows per day. Tidal planes for the site are as presented in **Table 2**.

Table 2 Tidal Planes for Canals surrounding Settlement City Site

Tidal Plane		**RL (m AHD)**
Mean High Water Solstice Springs	MHWSS	0.808
Mean High Water Springs	MHWS	0.487
Mean High Water	MHW	0.393
Mean Sea Level	MSL	-0.001
Mean Low Water	MLW	-0.396
Mean Low Water Springs	MLWS	-0.489
Indian Spring Low Water	ISLW	-0.719
Source	MHL (1995)	

Effects of Ocean Storms

Ocean storms can cause water levels to rise above predicted astronomical tide levels. This is attributed to barometric setup, wind setup and wave setup. Webb McKeown (1998) reports that elevated ocean levels at the entrance to the Hasting River will be up to RL 1.9 and RL 2.1 for 5% and 1% Annual Exceedance Probability *(AEP)* events respectively. Levels of this order could be expected to represent extreme "tailwater levels" in the assessment of freshwater flooding in the lower estuary.

Freshwater Flooding

Freshwater flooding in the lower Hastings River will increase the water level above the tide. This increment will increase with distance upstream.

Council's Interim Flood Policy *(PMHC, 2007)* applies pending completion and adoption of their flood Development Control Plan. For flood prone development east of the Pacific Highway, the policy adopts a Flood Planning Level *(FPL)* based on the 100 year Average Recurrence Interval *(ARI)* flood plus a freeboard of 800 mm. For commercial development, Council may accept a lower FPL *(20 year ARI flood level absolute minimum)* where special circumstances are required to achieve mobility access standards and compatibility with existing street frontages.

The flood study for the Hastings River predicts 100 year ARI flood levels *(PBP, 2006)*. For the canals adjoining the site, GBAC interprets the 100 year flood level at RL 2.7. We note this is the same level specified for Settlement Shores in Hastings Council DCP 50. The computation of this flood level incorporates a tailwater level at the entrance of RL 2.2, approximately a 20 year coastal water level event according to PBP . Because freshwater flooding and coastal storm processes are not necessarily interdependent, PBP makes the comment that their adopted tailwater level can be considered to provide conservative conditions *(100 year ARI flood predictions)* in the lower reaches of the river, "eg downstream of the Settlement City Shopping Centre" *(PBP, 2006)*.

Existing minimum ground levels across the shopping centre site vary from RL 3.1 to RL 4.6 in the SW carpark, and from RL 3.2 to RL 3.4 along the internal roadway running along the western side of the site and around to the north *(1982 survey,* **Figure 2***)*. These levels may exclude localised depressions related to drainage intake structures. For the proposed redeveloped shopping centre, minimum ground floor levels are shown at RL 3.5 in elevations presented in Buchan Dwg ATP 400 6/2/09 (**Appendix A**). Thus the minimum ground floor level in the proposed shopping centre is the same as the FPL, namely RL 2.7 plus 800 mm.

PMHC (2007) permits carparks below the FPL where it can be demonstrated that the potential damage to motor vehicles from flooding is minimised, where vehicles will not become moving debris, and where risk to life from inundation is minimised *(Clause 10)*. Excluding local drainage depressions, the freeboard on the 100 year flood level available at the carparks and internal roadways varies from 400 mm to 1,900 mm.

Mapping in PBP (2006) shows the full Settlement City Shopping Centre site to reside within an area for which the hazard category is designated as less than "low". The proposed ground floor level within the shopping centre is the same as the FPL. It is GBAC's submission that these two outcomes, together with the available minimum freeboard of 400 mm to the 100 year ARI flood at the carparks and internal roadways, would satisfy Council's flood policy requirements for the site.

Sea Level Rise

Sea level rise *(SLR)* is a key potential hazard of the Greenhouse Effect, to be considered in coastal hazard assessments in NSW *(NSW Government 1990)*. SLR is predicted to occur in response to the thermal expansion of the upper layers of the world's oceans and melting of the polar ice sheet. SLR will contribute to flooding in the lower Hastings estuary.

As reported in DECC (2007), trends for recent SLR predictions indicate that average global SLR may be between 0.18 m and 0.59 m by between 2090 and 2100. Add to this ice flow melt uncertainty of up to 0.2 m gives an adjusted global range of 0.18 to 0.79 m *(IPCC, 2007)* . Furthermore, recent IPCC and CSIRO modelling both indicate that the mean sea level along the NSW coast is expected to rise by more than the global mean. Combining the relevant global and local information indicates that SLR on the NSW coast is expected to be in the range 0.18 to 0.91 m by between 2090 and 2100. The currently expected mid-range value is 0.55 m.

The RL 2.2 design tailwater level adopted in PBP (2006) would not appear to incorporate SLR. It follows that the design flood level of RL 2.7 would also not account for SLR. However, it is our understanding that within the context of Council's flood policy framework with its varied flood planning requirements stipulated for different land uses and scale of development, the 800 mm freeboard it requires in setting the FPL downstream of the Pacific Highway accounts for SLR *(PMHC, 2007)*.

3.3 Currents

Currents in the canals could be attributed to various processes. These are *(in order of likely recurrence)*:

(i) tides
(ii) wind-induced currents
(iii) stormwater flows
(iv) flood flows

The effects of wave induced currents and propeller wash currents are likely to be less significant than that of wind and boat-generated wave action, so are disregarded here.

Tidal flows in and out of the river entrance will give rise to tidal currents. In the main arm of the river, downstream of Settlement Point, tidal currents would not be expected to exceed 0.5 m/s. In the lee of Pelican Island and into the Settlement Shore canals, tidal currents would be much reduced, probably less than 0.2 m/s. While various detailed hydrodynamic investigations have taken place covering the lower estuary in recent years, none of these provides quantitative information on tidal currents in the vicinity of the site *(Webb McKeown 1998, PBP 2006 and CLT 2006)*.

Wind blowing across the water surface will induce a drag which generates flow. This flow is typically 2% of the wind speed up to a wind speed of approximately 7 m/s beyond which the principal forcing is oscillatory *(waves)* rather than unidirectional *(currents)*. Wind induced currents in the canals would therefore not exceed 0.15 m/s.

Localised flows at stormwater outlets discharging from the Settlement City site, could be as high as 2 to 2.5 m/s. Major stormwater outlets were not encountered along the western and northern shorelines of the site during our site inspection.

Moderate flood flows in the main arm would substantially exceed even the very highest tidal flows. In major flood events, the Settlement Shore canals are designed to receive flood flows from the Hastings River through entrances upstream of Settlement Point. These divert through the canal system before passing over the low-height weirs *(design crest level for Stage A weir adjoining the site is RL 1.5)* and discharging into the Back Channel in the lee of Pelican Island. PBP (2006) indicates 100 year ARI peak flood velocities in the canal due north of the site at approximately 0.7 m/s, concentrated along the northern bank. This velocity is shown to be little changed for the 20 year flood. Because the sectional area is throttled immediately to the east under the Park Street Bridge, we estimate flood velocities here to approximately double.

Currents in the canals would not affect any on-land works such as excavations and other civil works. All structural elements below the 100 year design flood level of RL 2.7 would be designed to withstand design maximum current pressures, estimated by GBAC at less than 700 Pa.

3.4 Wave Action

Wave action within the canals would be limited.

As wind fetches at the subject northern shoreline are restricted to less than approximately 200 m, wind wave heights in this area even in the severest of storms would not be expected to exceed 0.2 m. Boats do use Dolphin Key on the western side of the site where wash wave heights to say 0.2 m could be expected to occur. We noted during our site inspection that a 4 knot speed limit applies to this waterway, and the two craft we observed to navigate the canal kept to low speeds (**Photo 6**). The wash generated by these craft was substantially lower than 0.2 m. Other than perhaps small fishing runabouts, we would not expect boats to use the canal downstream of the weir.

Wave action in the canals would not affect any on-land works such as excavations and other civil works. All structural elements below the 100 year flood level of RL 2.7 would be designed to withstand design maximum wave pressures, estimated by GBAC at 3 to 5 kPa.

3.5 Sediments and Sediment Transport

The Hastings River estuary mainly comprises fluvial sediment, reworked coastal sand and beach and nearshore marine sand. In terms of the generalised morphology for NSW estuaries espoused by Roy, Thom and others, the lower Hastings estuary exhibits a classic twin sand barrier system with the outer barrier comprising the beach extending northwards from the river entrance, and the inner barrier extending southwards from Settlement Point. The Settlement City site is located on the inner barrier.

According to Webb McKeown (1998), median fluvial flows through the lower estuary of 9 m^3/s deposit some 5,000 m^3 of sediment annually, compared to a net marine delta supply from the ocean of 100,000 m^3. The predominantly marine sedimentary processes have resulted in the broad channel and island system that exists today.

The evolution and present-day morphology of the area would suggest that bedrock is absent from the upper stratigraphy of the site, and that sandy to muddy sediment horizons occupy the ground and below-ground material, including the bed of the adjacent canals. Such material is potentially disturbed by the redevelopment.

We understand that the weir adjoining the site ensures that floods through the upstream canals are limited to a known maximum value which will not cause erosion damage to the bed of the canals *(McIlwain and Boys, 2001)*. While this may be the case, we did observe severe undercutting of the concrete footpath downstream of the weir, along the southern bank the canal (**Table 1**, Ch 70-140E). While investigating the causes for this failure is not within the scope of this advice, we would anticipate a combination of factors including poor design, poor construction and/or high currents.

For all situations and events, sediment transport in the canals adjoining the site would be minimal and of no consequence to the redevelopment. However stability of the existing canal embankment protection structures is a separate matter, considered at **Section 3.6**.

Photo 11 shows recent civil works for Stage B of the Settlement Shores project. Here one observes the type of soil that might be expected on the adjoining Settlement City site – principally sands with washings of mud. In the same way that silt fences and curtains are shown to control sediment dispersal into the waterway for Stage B, such safeguards would be readily applied at Settlement City.

Photo 11 - Earthworks for Stage B of Settlement Shores project
(Source: McIlwain and Boys, 2001)

3.6 Bank Stability

Bank erosion is one of the more important management issues facing the Hastings estuary. Recent estuary management studies have identified nine areas as being affected by bank erosion, however Settlement Shores notably is not included *(PBP,1996)*.

The mechanism for bank erosion in the lower estuary includes a combination of wind and boat wave erosion, tidal currents and freshwater flows. Since these processes would not be affected by the land-based redevelopment of Settlement City, it follows that no impacts on bank stability could ensue. In the event of bank instability affecting the site from other influences which are beyond the control of the land owner, then numerous alternatives would be available to stabilise and reinforce the edges of canals and riverbanks.

Photo 12 – Typical riverbank along Lower Hastings estuary (Source: McIlwain and Boys, 2001)

Parts of the existing canal edge at Dolphin Key on the west side of the site, and also to the north of the site, are damaged. This was confirmed during our site inspection. The nature of this damage and our indicative advice regarding timing and substance of repairs to reinstate a stable edge treatment is outlined in **Section 2**.

However, the redevelopment of the shopping centre will not impact on the existing shoreline treatment and visa-versa. There are good buffers between the canal edges and the perimeter facilities on the site, and in our opinion failure of the shoreline treatments would not cause immediate *(or indeed short-term, say 3 to 5 years)* disruption to activities and services. The concrete walkway on the northern canal edge, fronting the Panthers Club has failed. The walkway is unserviceable and barricaded to the public. We understand from Council that the title on the Panthers Club site extends some 2 m from the shoreline into the canal, incorporating the concrete walkway. The Club is investigating the relocation of the footpath, back to the south along the crest of the foreshore embankment. It is proposed to reconstruct the canal edge treatment as a sloping rock revetment. The broad timeframe for this reconstruction is 12 months *(Mr Gordon Cameron, Hastings Council, 19/2/09 pers comm).*

3.7 Site Analysis and Constraints Map

A mapping of the site depicting the key findings of this assessment is presented in **Figure 3**. This is included to address Clause 3 of General Requirements, DGR Attachment 1.

4 SUMMARY

The Settlement City Shopping Centre is located at Settlement Point on the Lower Hastings River, Port Macquarie (**Figure 1**). The shopping centre is to expanded and partially redeveloped. This impact assessment for estuarine processes and hazards has considered the physical setting of the site as well as water levels, currents, wave action, sediments and sediment transport, and bank stability.

A site inspection was made on 21/1/09. Along the western edge of the site and around to the weir on the northern canal, we observed in general a canal edge treatment comparable to an "intertidal beach" cross-section as described in the NSW canal subdivision guidelines *(PWD, 1992)* The structural edge treatment at the site comprises a corrugated sheetpile, possibly asbestos-cement, with concrete capping beam along the crest. The treatment type changes east of the weir where a failed concrete walkway occurs. A summary of the canal edge treatment and a condition appraisal is provided in **Figure 2**.

Water levels in the lower estuary are controlled by tide, ocean storms and fresh water flooding. A recent flood study has confirmed the design 100 year flood level for the canals in the vicinity of the site as RL 2.7, the same level specified for Settlement Shores in Hastings Council DCP 50. While the design flood level of RL 2.7 would not appear to account for SLR, it is our understanding that the 800 mm freeboard applied by Council to set the Flood Planning Level *(FPL)* downstream of the Pacific Highway does *(PMHC, 2007)*.

Council's flood policy requirements for the site are satisfied. The proposed ground floor level for the redeveloped Settlement City is RL 3.5, equal to the FPL *(RL2.7+800 mm)*.

Currents in the canals are attributed to various processes, primarily tides, wind-induced currents and flood flows. Moderate flood flows in the main arm would substantially exceed even the very highest tidal flows. Wind induced currents in the canals are unlikely to exceed 0.15 m/s. In major floods, the canals at Settlement Shores are designed to receive flood flows from the Hastings River through entrances upstream of Settlement Point. Predicted 100 year ARI peak flood velocities in the canal due north of the subject site are 0.7 m/s, a quite manageable velocity for engineered scour protection. Wave action within the canals would be limited, with incident wave heights at the shoreline of the site unlikely to exceed 0.2 m. Currents and waves in the canals would not affect any on-land works such as excavations and other civil works. All structural elements below the design flood level would be designed to withstand design current and wave loads.

The Hastings River estuary mainly comprises fluvial sediment, reworked coastal sand and beach and nearshore marine sand. The coastal and marine sands dominate in the vicinity of the site. Bedrock does not occur in the near-surface stratigraphy. The design of the Settlement Shore canals ensures against bed erosion from freshwater flooding. All civil works associated with the redevelopment of Settlement City would employ sediment controls

in compliance with requirements set down by the Council. It is understood that such controls were successfully implemented during the recent Stage B works of the Settlement Shores canal project.

While bank erosion is an important management issues facing the Hastings estuary, Settlement Shores with its off-channel setting is relatively protected. The mechanism for bank erosion in the lower estuary includes a combination of wind and boat wave erosion, tidal currents and freshwater flows. Since these processes would not be affected by the land-based redevelopment of Settlement City, it follows that no impacts on bank stability could ensue.

Parts of the existing canal edge treatment at Dolphin Key, on the west side of the site, and also to the north of the site, are damaged. This was confirmed during our site inspection. The nature of this damage and our advice regarding timing and substance of repairs is outlined in **Section 2**. The redevelopment of the shopping centre will not impact on the existing shoreline treatment and visa-versa. There are good buffers between the canal edges and the perimeter facilities on the site, and failure of the shoreline treatments would not cause disruption in the short-term to activities and services.

The concrete walkway on the northern canal edge, fronting the Panthers Club, has failed. We understand from Council that the Panthers Club owns the land occupied by the walkway, and that walkway relocation and canal edge repair is expected within the next 12 months.

A mapping of the site depicting the key findings of this assessment is presented in **Figure 3**. This is included to address Clause 3 of General Requirements, DGR Attachment 1.

5 REFERENCES

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We trust that the above meets your immediate requirements in this matter. Should you need any further information or clarification, please do not hesitate to contact the undesigned.

Yours faithfully
GARY BLUMBERG & ASSOCIATES

G P Blumberg
Principal

FIGURE 1

SOURCE: GOOGLE EARTHPRO 2/09

SHORELINE STUDY AREA

0 500 1000 m

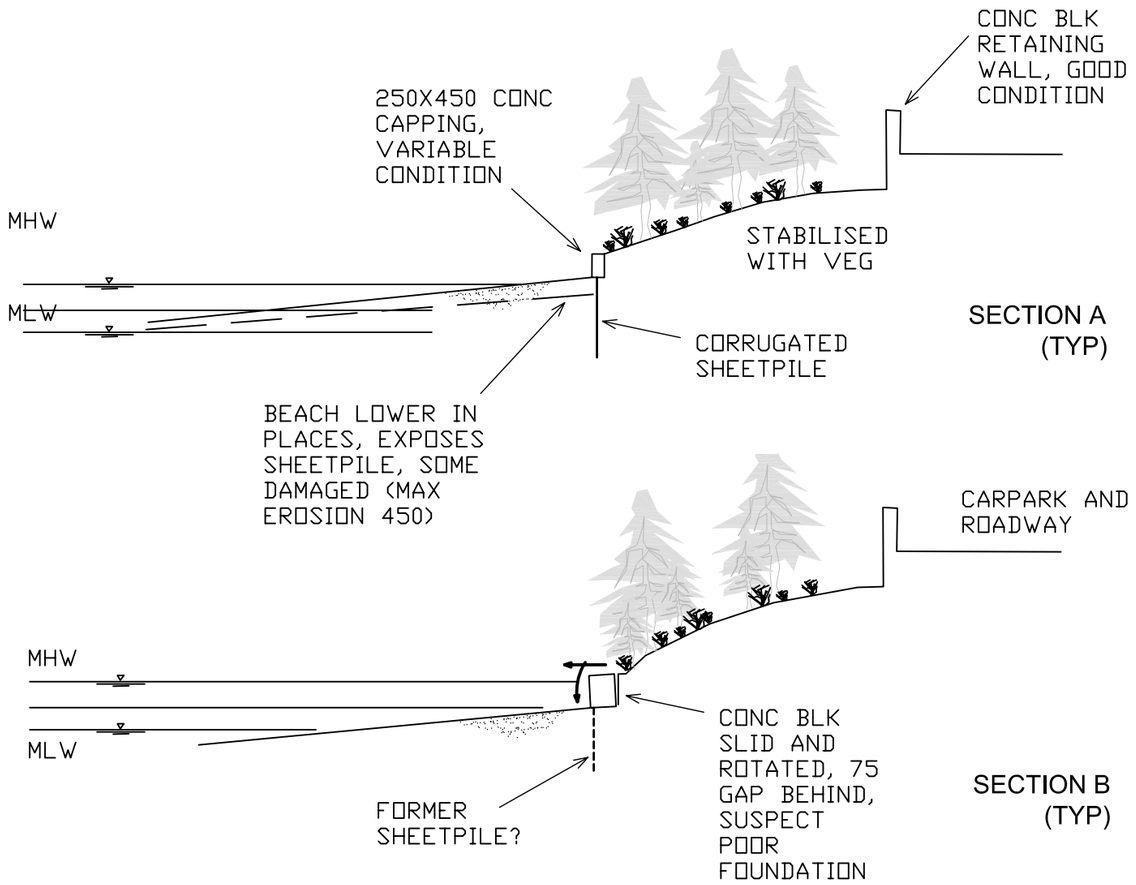
gbaCOASTAL
J09-2/lr831
Plot date 12/3/09

STUDY AREA

FIGURE 2

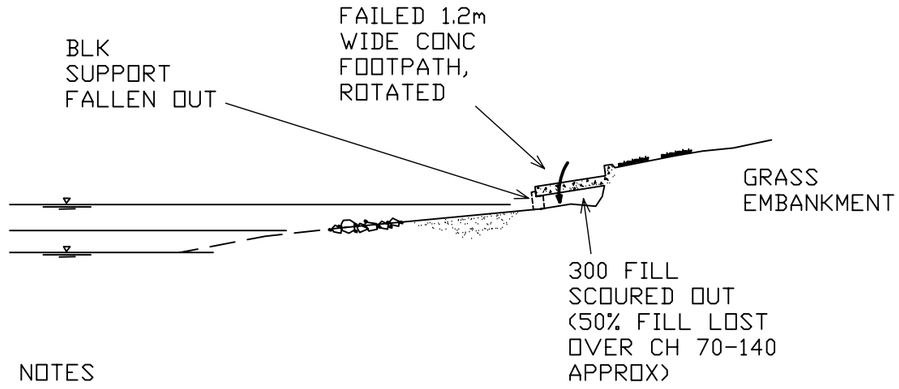
SOURCE: GOOGLE EARTHPRO 2/09, SURVEY 1982 FROM PWA

0 50 100 m



SECTION A (TYP)

SECTION B (TYP)



SECTION C (TYP)

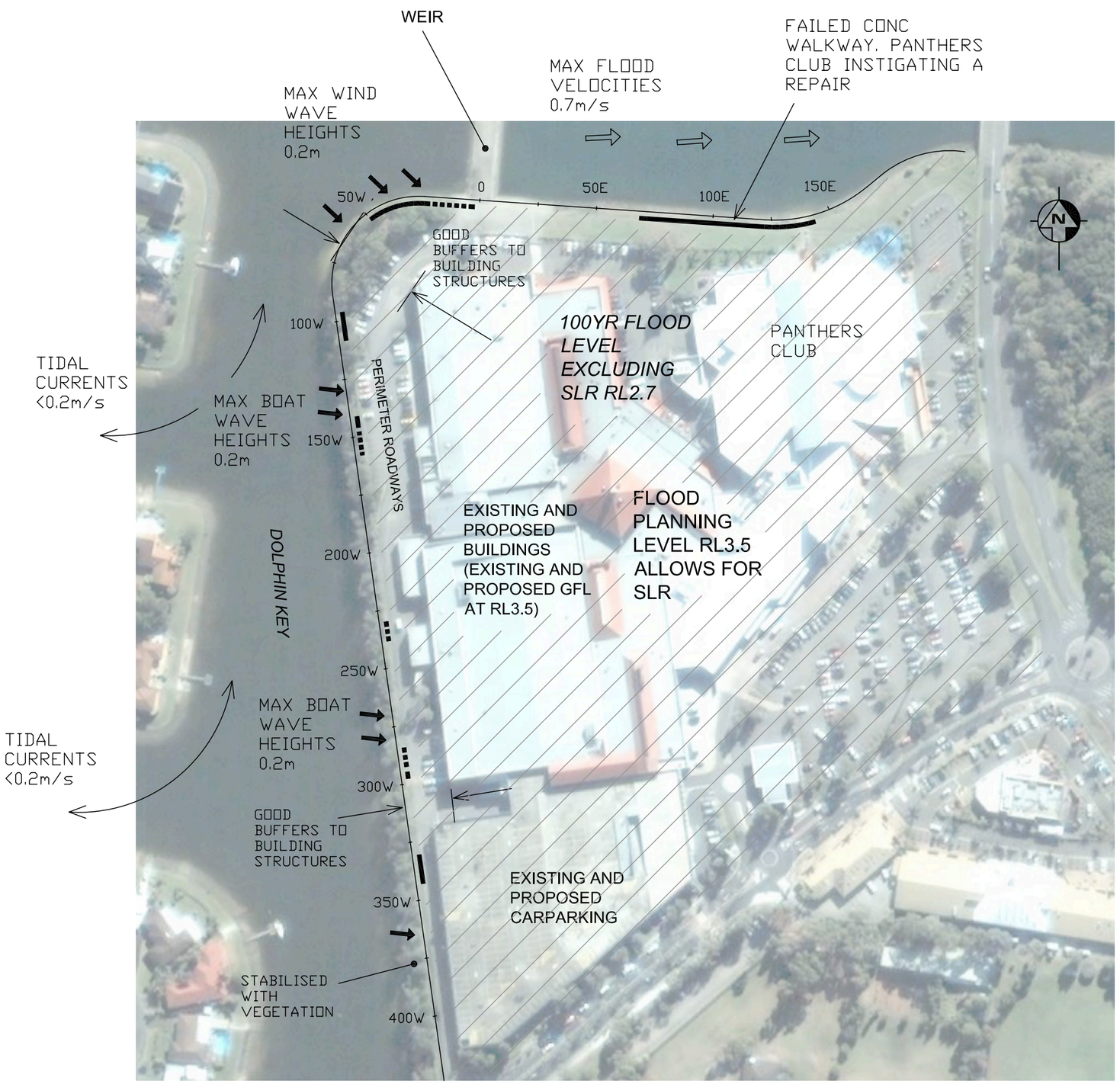
NOTES

1. APPRAISAL OF EDGE TREATMENTS FROM GBAC SITE INSPECTION 21/1/09

0 2.5 5.0 m

gbaCOASTAL
J09-2/lr831
Plot date 13/2/09

CANAL EDGE TREATMENTS AND CONDITION APPRAISAL



SOURCE: GOOGLE EARTHPRO 2/09

0 50 100 m

CHAINAGE ALONG SHORELINE EAST (E) AND WEST (W) OF WEIR IN METRES

CANAL EDGE TREATMENT CONDITION APPRAISAL: GENERALLY GOOD EXCEPT AS FOLLOWS:

"POOR" - REPAIR ASAP TO AVOID IMMEDIATE INCREASED DAMAGE AND SEATABILISATION

"MODERATE" - REPAIR IN DUE COURSE, INFORMED BY MONITORING

REFER TABLE 1 AND FIGURE 2 FOR MORE DETAIL

PRELIMINARY DESIGN ENVIRONMENTAL LOADINGS TO APPLY BELOW RL2.7:

- MAX CURRENT PRESSURES 700Pa
- MAX WAVE PRESSURES 3-5kPa

LESS THAN "LOW" FLOOD HAZARD DESIGNATED FOR FULL SITE IN HASTINGS RIVER FLOOD STUDY (PBP, 2006)

SITE ANALYSIS AND CONSTRAINTS MAP - COASTAL AND ESTUARINE PROCESSES, HAZARDS AND IMPACTS

gbaCOASTAL
J09-2/lr831
Plot date 20/2/09