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Mr Chris Randle
Frasers Property Australia
PO Box 4148
SHELLHARBOUR NSW 2529

17th October 2019

Dear Chris,

SHELL COVE PRECINCT B2 AND C2
FLOOD ASSESSMENT

I refer to your request for supporting documentation to be prepared for the Precinct B2 and C2 Development Application (DA) to address the requirements of the Concept Approval for the Shell Cove Boat Harbour Precinct and the associated Statement of Commitments, as applicable for this DA. The purpose of this letter report is to identify how these requirements and conditions have been addressed in the context of floodplain management.

Flood modelling was previously completed and approved as part of the Part 3A concept plan approval for the boat harbour precinct. Advisian is currently undertaking an updated Flood Impact Assessment for the equivalent and total boat harbour precinct area. In the interim, this report includes relevant background information on the associated flood modelling for the wider catchment including model geometries and adopted parameters. It also includes relevant comparisons with the previous flood modelling completed and approved as part of the Part 3A approval for areas within the vicinity of Precinct B2 and C2.

1. REQUIREMENTS / COMMITMENTS FOR THE BOAT HARBOUR PRECINCT

Refer to **Table 1** below for reference to the specific sections of this report that address each of the Concept Approval Requirements, including Schedule 3 (*further environmental assessments*) and Schedule 4 (*statement of commitments*).

Table 1 Concept Approval Requirements Reference List

Concept Approval Requirement	Report Section
Concept Approval Schedule 3, Part D – Further Environmental Assessment Requirements, Clause 7. Flood Assessment	
A detailed Flood Assessment, prepared by a suitably qualified person identifying flood affected parts of the land and showing how the proposed project at each stage will comply with Shellharbour City Council Floodplain Risk Management Development Control Plan (2013), (except where it is inconsistent with NSW State Government policy and guidelines), and comply with and the government's sea level rise and climate change benchmarks, current at the time of preparation of the Flood Assessment. The findings of the Flood Assessment must inform the ultimate layout and design of each stage of the project. The assessment must include a Flood Planning Levels map, details of Flood Planning Levels adjacent to	All Sections

the boat harbour and for the major overland flow paths and mitigation measures to reduce impacts on flood levels in the vicinity of Ron Costello oval.	
Concept Approval Schedule 4, Statement of Commitments, Clause 4.7 Hazard Management and Mitigation	
The Proponent undertakes to provide waterway corridors to be used as floodways – using Water Sensitive Urban Design principles and incorporating wetlands, natural creeklines and open space areas - to manage and contain flood hazards.	Section 5 and 7
The Proponent undertakes to implement a Flood Emergency Response which includes remaining on site during PMF events and maintaining safe pedestrian and vehicular access routes out of the Boat Harbour Precinct for events up to the 100yr ARI flood.	Section 6
The Proponent undertakes to respond to sea level rise by adopting Flood Planning Levels based upon the 100 year ARI flood level plus 0.90 m sea level rise (for the year 2100) plus 0.50 m (to comply with Council's freeboard requirement).	Section 8
The Proponent undertakes to prepare a FPL map in accordance with Figure 5 of the NSW Coastal Planning Guideline Adapting to Sea Level Rise for each Project Application when more detailed definition of final design levels is available. This will include localised flood modelling for each stage of the Boat Harbour Precinct to demonstrate compliance with the NSW Coastal Planning Guideline Adapting to Sea Level Rise.	Section 8
The Proponent undertakes to prepare an assessment of the impact of 0.9m sea level rise on the 5 year and 100 year ARI and PMF storm events during detailed design phases of the Boat Harbour Precinct associated with each Project Application.	Section 10
The Proponent undertakes to ensure that the development does not result in any significant increase in flood levels on adjacent properties. Flood impacts will not exceed those identified in Appendix F of the Environmental Assessment.	Sections 5 and 8
The Proponent undertakes to ensure that flood risk will be assessed in each Project Application for consistency and compliance with the Concept Plan and compliance with the NSW Flood Plain Development Manual 2005 and Council's Flood Plain Risk Management DCP (except where inconsistent with NSW State Government Policies and Guidelines).	All Sections

2. FLOOD MODELLING OVERVIEW

Hydrologic and hydrodynamic computer models were developed and used to simulate the behaviour of flooding within the Shell Cove Boat Harbour catchment. The hydrologic modelling software package XP-RAFTS was used to model the hydrologic processes of the catchment draining to the harbour. The hydrologic model was used to provide inputs for a 2-Dimensional TUFLOW hydrodynamic model, which was then used to determine key flooding characteristics such as flood levels, flow velocities, floodwater depths and flood hazard throughout the study area. The TUFLOW model also incorporates a rainfall-on-the-grid approach to capture the hydrologic processes within the TUFLOW model domain.

3. HYDROLOGIC MODELLING

The XP-RAFTS hydrologic model of the Shell Cove Boat Harbour catchment was developed using information such as a Digital Terrain Model (DTM) and land-use zoning maps. This information was used to identify the extent of the overall catchment, the delineation of sub-catchments and the connectivity of watercourses within the catchment.

The hydrologic model consists of 26 sub-catchment nodes located upstream of the TUFLOW model extent (*refer* **Figure 3.1**). Each sub-catchment was assigned initial and continuing rainfall loss rates to simulate rainfall that would be lost from the system; for example, when rainfall is absorbed by pervious surfaces (*refer* **Table 2**).

Table 2 XP-RAFTS Hydrologic Model Parameters

Subcatchment Identifier (*refer* Figure 3.1)	Area (ha)	% Impervious	Catchment Roughness (n)	Initial Loss (mm)	Continuing Loss Rate (mm/hr)
N1	5.21	70	0.025	5	0.5
N2	4.03	70	0.025	5	0.5
N7	2.39	70	0.025	5	0.5
N11	7.88	70	0.025	5	0.5
S1_FIRST	3.15	5	0.025	10	2.5
S1_SECOND	1.22	90	0.025	1.5	0
S1_A	0.73	90	0.025	1.5	0
S2 (Pervious Sub-catchment)	9.33	50	0.025	10	2.5
S2 (Impervious Sub-catchment)	3.54	100	0.025	1.5	0
S2_A	1.26	0	0.025	15	2.5
W0	8.80	50	0.025	5	0.5
W1	9.98	70	0.025	5	0.5
W2	11.66	50	0.025	5	0.5
W3	9.16	70	0.025	5	0.5
W4	7.06	70	0.025	5	0.5
W5	10.40	50	0.025	5	0.5
W6A	8.12	70	0.025	5	0.5
W7A	4.32	70	0.025	5	0.5
W7B	2.66	70	0.025	5	0.5
W8	14.50	70	0.025	5	0.5
W10	15.26	70	0.025	5	0.5
W11	3.57	70	0.025	5	0.5
W11A	3.27	70	0.025	5	0.5
W12	4.73	70	0.025	5	0.5
W13	3.05	50	0.025	5	0.5
W14	8.46	70	0.025	5	0.5
W17	9.27	70	0.025	5	0.5
W19	6.19	70	0.025	5	0.5

In accordance with the methodology outlined in the *'Shell Cove Boat Harbour Catchment Flood Study'* (Cardno, 2005), the adopted loss rates for urban areas in **Table 2** (*i.e., most subcatchments*) are the result of applying the following standard losses weighted according to the impervious fraction of the subcatchment:

- Impervious areas: Initial Loss = 1.5 mm, Continuing Loss = 0 mm/hr
- Pervious areas: Initial Loss = 10 mm, Continuing Loss = 2.5 mm/hr

With a typical impervious fraction of urban subcatchments averaging at 60%, the result is an initial loss of 5 mm and continuing loss rate of 1 mm/hr. However, a conservative approach assuming a continuing loss rate of 0.5 mm/hr has been adopted. Guidance from *Australian Rainfall and Runoff (1987 and 1998)* has also been used to estimate loss rates. These loss parameters have been applied across all upstream urban subcatchments.

The major detention basin situated between Hayman Crescent and Norfolk Crescent has been incorporated into the XP-RAFTS model as a detention node. Stage-storage and stage-discharge relationships were developed according to the geometry of the basin and spillway contained in detailed design drawings by BMD Consulting (*Shell Cove Major Detention Basin No.1 – Dam Wall, Spillway and Wetland, dated June 2003*). These relationships are shown graphically in **Appendix A**.

For areas downstream of the XP-RAFTS catchments, the TUFLOW hydrodynamic model incorporates hydrologic modelling over a majority of the TUFLOW model domain by way of Direct Rainfall (*or rainfall-on-the-grid*). Further information on the associated hydrologic parameters is contained in the following section.

4. HYDRODYNAMIC MODELLING

4.1 TUFLOW Model Setup

A 2D TUFLOW direct rainfall hydrodynamic model was developed according to a 2-metre grid size to appropriately capture the proposed topography across the Shell Cove Boat Harbour Precinct. The extent of the TUFLOW model is shown in **Figure 4.1**.

The post-development model terrain is also shown in **Figure 4.1**, which has been developed according to a combination of available LiDAR data for previously developed areas and design drawings or Work-As-Executed survey information for more recently completed development precincts in areas south-west of Precinct A.

The civil works for Precinct B2 and C2 have been designed by Arcadis. The design terrain for each of these areas was incorporated into the TUFLOW model.

Within Precinct B2 a "block-out" is included in the TUFLOW model for the apartments site and the medium density lot alongside MC03 to the south of the apartments site is included. This is a conservative approach and represents the fact that walls and structures will largely keep floodwaters out of these lots, thus potentially increasing the impacts of flooding in the surrounding roads and lots. This method was employed primarily to confirm that other lots within Precinct B2 and Precinct A will not be affected by high hazard conditions in the PMF.

Material types, which simulate the surface roughness (*and rainfall losses*) of the land, were assigned in accordance with roughness values used in previous flood impact assessments for the precinct (*refer* **Figure 4.2**). For comparison, the equivalent roughness map for the SOBEK model used in the 2009 Part 3A assessment is included in **Appendix B**.

The roughness values have been assigned according to the land use types listed in **Table 3**.

Table 3 Adopted Roughness Parameters in TUFLOW Model

TUFLOW Material Type Identifier ^	Land Use Description	Roughness (Manning's 'n')
1	Roads*	0.015
2	Beach and bay areas / harbour, ocean*	0.02
3	Well cut grass*	0.035
4	Waterway areas, Wetlands	0.06
5	Vegetated Areas, Dune Areas*	0.06
6	Residential Areas (low density)*	0.10
7	*Not used*	-
8	Residential Areas (medium density)	0.15
9	Residential Areas (high density)	0.18
10	Commercial Properties	0.20

** Adopted from Cardno Lawson Treloar (2005), where applicable*
^ Refer Figure 4.2

The initial and continuing rainfall losses applied to the direct rainfall modelling in TUFLOW are outlined in **Table 4**, and have been applied according to the same material type distribution for floodplain roughness (*refer* **Figure 4.2**).

Table 4 Adopted Loss Rates Applied in TUFLOW Direct Rainfall Modelling

TUFLOW Material Type Identifier ^	Land Use Description	Initial Loss (mm)	Continuing Loss Rate (mm/hr)
1	Roads*	1.0	0
2	Beach and bay areas / harbour, ocean	0	0
3	Well cut grass*	10.0	2.5
4	Waterway areas, Wetland	0	0
5	Vegetated Areas, Dune Areas	10.0	2.5
6	Residential Areas (low density)	5.0	0.5
7	*Not used*	-	-
8	Residential Areas (medium density)	3.0	0
9	Residential Areas (high density)	1.0	0
10	Commercial Properties	1.0	0

** Adopted from Cardno Lawson Treloar (2005), where applicable*
^ Refer Figure 4.2

4.2 TUFLOW Stormwater Drainage Networks

Refer to **Figure 4.3** for a schematic layout of the TUFLOW model structures showing the bridges, culverts and local drainage lines included in the model. Relevant details for each component have been sourced from design drawings.

The concept pit and pipe drainage network modelled in TUFLOW at Precinct B2 and C2 is based on concept designs by Arcadis (*refer* **Figure 4.3**).

In other areas, the large box culverts beneath Harbour Boulevarde conveying flow into the proposed Wetland 6 have been modelled according to the detailed design drawings prepared by Cardno. The concept for the proposed bridge downstream of Wetland 6 incorporates two clear spans of 9 metres (*with one pier*) totalling a flow width of 18 metres. In TUFLOW, it has been modelled as two box culvert cells each with a 9 m width.

The hydrodynamic model was run initially with no blockage factor applied to major culverts and bridge structures. Sensitivity testing, which involved the application of blockage factors at major culvert and bridge structures, has been carried out for other precincts within Shell Cove, but is not relevant for Precinct B2 and C2 (*refer* **Section 9**).

4.3 TUFLOW Inflows & Boundary Conditions

Hydrographs were extracted from the XP-RAFTS hydrologic model and applied at the inflow polygons at the upstream limits of the TUFLOW model domain (*refer* **Figure 3.1**). A direct-rainfall approach was applied across the majority of the TUFLOW model grid for downstream areas, as shown in **Figure 3.1**.

The hydrodynamic model was used to simulate the following design events:

- 5 year Average Recurrence Interval (*ARI*) flood;
- 100 year ARI flood; and,
- Probable Maximum Flood (PMF).

The tailwater conditions used in the hydrodynamic model were derived from Cardno's '*Shell Cove Boat Harbour Post Development Flood Analysis*' (*July, 2009*) and *Elliot Lake – Little Lake Flood Study* (*January, 2006*). The method of deriving the tailwater level involved taking into account a 1% exceedance tide level, the effects of sea level rise (*0.55 metres by the Year 2050*), wave-setup and also the reduction in wave-setup height caused by the presence of the harbour in the post-development scenario.

The tailwater conditions used in the hydrodynamic model are listed in **Table 5**. In order to address the Statement of Commitments, a sea level rise of 0.9 metres for Year 2100 was incorporated into the harbour tailwater level for simulations to determine Flood Planning Levels and for the sea level rise sensitivity testing (*refer Section 10 below*). This effectively increases the adopted 100 year ARI harbour level by 0.35 metres.

Table 5 Adopted Harbour Tailwater Conditions in the TUFLOW Model

Scenario	Tailwater Level (mAHD)
5 Year ARI	1.55
100 Year ARI (for non-blockage and blockage scenarios)	1.95
100 Year ARI (for determining Flood Planning Levels)	2.30
PMF	2.05

5. FLOOD MODELLING RESULTS

The TUFLOW flood modelling results were used to assess the flood affectation (*or lack thereof*) at Precincts B2 and C2. Peak flood level and depth mapping was prepared for the post-development scenario and is shown in **Figures 5.1** to **5.6**. Flood hazard mapping prepared in accordance with the *NSW Floodplain Development Manual* (2005) is shown in **Figures 5.7** to **5.9**. As per consultation with Council, depths of less than 150 mm are filtered from the direct rainfall flood mapping results.

During the 5 and 100 year ARI events, local flow from Precinct B2 and C2 will be conveyed to the harbour via local drainage pipes and flood depths will be generally less than 150 mm.

During the PMF, the majority of overland flows are expected to be conveyed into the boat harbour via Road MC03. Some properties along the western edge of Precinct A are expected to be inundated during the PMF (*refer* **Figure 5.6**). Depths of inundation are generally less than 300 mm other than in the roadway and small sections of the properties that front MC03. There is also a small area of depths up to 300 mm in the laneway south of road MC24 which is the result of modelling the lots fronting to MC03 as a block-out and local PMF runoff collecting down this laneway against the block-out. The corresponding PMF flood hazard at residential lots is classified as low (*refer* **Figure 5.9**).

6. FLOOD EMERGENCY RESPONSE

The flood hazard mapping in **Figures 5.7** to **5.9** shows that for the 5 and 100 year ARI events, nothing greater than low flood hazard is expected at any part of Precinct B2 and C2.

During the 100 year ARI storm there will be clear vehicle access along internal roads leading to Harbour Boulevarde, which will allow for safe evacuation from all areas within Precinct B2 and C2.

In the PMF, high hazard conditions are expected along Road MC03 (*refer* **Figure 5.9**). This means that any off-site evacuation from the apartments would need to avoid this road; i.e. evacuation could be along Road MC24 and MC02. Alternatively, a suitable emergency response would be for residents within Precinct B2 and C2 to shelter-in-place during extreme events greater than the 100 year ARI storm, because the duration of inundation of MC03 and surrounding roadways is expected to be less than 1 hour.

7. HYDRAULIC CATEGORY MAPPING

Hydraulic category mapping for Precinct B2 and C2 has been developed according to the hydraulic criteria outlined in Cardno's report titled, *Shell Cove Boat Harbour Post Development Flood Analysis (2009)* and is provided in **Figures 7.1** to **7.3**.

The mapping shows that during the 5 year and 100 year ARI storms there are no areas that would be identified as a Floodway, despite small isolated areas meeting the hydraulic criteria on Road MC03 and other internal roads. These would not manifest as a proper connected Floodway.

During the PMF, Road MC03 would be classified as a Floodway, in addition to a small foreshore area as stormwater overflows into the harbour. There is not expected to be any Floodways across development areas (*i.e. across proposed lots*).

Areas of Flood Fringe are defined as depths less than 200mm and therefore, cover a relatively small extent given the map filtering method to trim any depths less than 150mm.

Overall, the hydraulic category mapping is consistent with the mapping presented in the Part 3A assessment, while allowing for minor differences due to changes in design terrain and features.

8. FLOOD PLANNING AREA

A Flood Planning Level (FPL) map has been prepared for Precinct B2 and C2 and is shown in **Figure 8.1**, which is consistent with the approach outlined in Figure 5 of the *NSW Coastal Planning Guideline: Adapting to Sea Level Rise*. The Flood Planning Levels used to derive the FPA was assigned by taking the greater of:

- The peak 100 year ARI flood level (with a 2.3 mAHD tailwater level, including an allowance of 0.9m for sea level rise) plus 500 mm freeboard; and,

- The peak 100 year ARI flood level (with a 1.95 mAHD tailwater level) in the culvert/bridge blockage scenario (*refer* **Section 9**), albeit such a scenario is not relevant for Precinct B2 and C2.

As shown in **Figure 5.2**, the majority of overland flows within Precinct B2 and C2 during the 100 year ARI storm will be largely captured into the street drainage system. The 100 year ARI flooding shown along Road MC03 and in adjacent intersections is reflective of local runoff from Precinct B2 and is not the result of flows from the southern catchment upstream of Harbour Boulevarde, which will be accommodated in the proposed twin 1800 mm pipes beneath the Road MC03 median.

Management of local runoff will be addressed as part of further detailed design of the Precinct B2 and C2 local drainage systems and therefore, the assessment of Flood Planning Levels is not required for Road MC03. This is consistent with the requirements outlined in Schedule 3 Part D of the Concept Approval, which states that the mapping of Flood Planning Levels is to apply to areas adjacent to the boat harbour and for major overland flow paths.

Accordingly, other than along the boat harbour foreshore the application of Flood Planning Levels is not required (*refer* **Figure 8.1**). The Flood Planning Level at the boat harbour is 2.8 mAHD.

9. CULVERT AND BRIDGE BLOCKAGE

Blockage sensitivity testing has been completed for other harbour precincts which include major flood conveyance systems, such as the overland flow channels at Precinct E, F, and G. No such systems are proposed as part of Precinct B2 and C2 and therefore, no further simulation of culvert or bridge blockage was required. Notwithstanding this, it is assumed that the road and urban drainage networks are suitably designed to convey local runoff (*i.e. no blockage factor was applied in TUFLOW to urban drainage pipes*), and that the design of all inlet pits has incorporated suitable allowance for inlet blockage (*e.g. doubling of the inlet size at sag pits*). It is understood that this approach has been applied in the design of the street drainage at Precinct B2 and C2.

10. SEA LEVEL RISE SENSITIVITY TESTING

Sea level rise sensitivity testing has been completed by allowing for 0.9 m sea level rise by the year 2100. The adopted tailwater levels are shown in **Table 6**.

Peak flood level and depth mapping was prepared for the post-development scenario and is shown in **Figures 10.1** to **10.6**. Flood hazard mapping prepared in accordance with the *NSW Floodplain Development Manual* (2005) is shown in **Figures 10.7** to **10.9**.

Table 6 Adopted Harbour Tailwater Conditions in the TUFLOW Model for the Year 2100 Sea Level Rise Sensitivity Tests

Scenario	Tailwater Level (mAHD)
5 Year ARI with Sea Level Rise	1.90
100 Year ARI with Sea Level Rise	2.30
PMF with Sea Level Rise	2.40

The mapping shows that during events up to and including the 100 year ARI storm, there will be no impact on flood levels within Precinct B2 and C2, other than along the harbour edge.

During the PMF, there is expected to be some minor flood level increases at the northern end of Road MC03, but these will be less than 10 mm and do not cause a change in the flood hazard classification at any roads or properties within Precinct B2 and C2.

11. CONCLUSIONS

In reference to **Table 1** and relevant sections of the above report, it has been shown that the proposed Precinct B2 and C2 development is consistent with the Part 3A Concept Approval Requirements.

It has also been shown that the proposed development of Precinct B2 and C2 will not cause any properties to be affected by the Flood Planning Area.

A sensitivity test of the effects of sea level rise by Year 2100 has been which shows that a heightened tailwater will not cause an increase in flood levels at Precinct B2 and C2 or its access routes during events up to and including the 100 year ARI storm. An impact of less than 10 mm increase in flood levels is expected during the PMF sea level rise scenario, which will not manifest as any material change in flood conditions.

The above assessment has demonstrated that the post-development flood mapping is consistent with a flood emergency response strategy consisting of evacuation during events up to the 100 year ARI storm and shelter-in-place during more extreme events.

12. REFERENCES

- Advisian (May 2018), '*Shell Cove Precinct B2 and C2 – Flood Assessment* ', prepared for Frasers Property.
- Advisian (October 2017), '*Shell Cove Boat Harbour Development – Updated Southern Catchment Drainage Concept* ', prepared for Frasers Property.
- Cardno (July 2009), '*Shell Cove Boat Harbour Post Development Flood Analysis*'.
- Cardno (January 2006), '*Elliot Lake – Little Lake Flood Study*'.
- Cardno Lawson Treloar (November 2005), '*Shell Cove Boat Harbour Catchment Flood Study*'.
- NSW Government (August 2010), *'NSW Coastal Planning Guideline: Adapting to Sea Level Rise'*.
- NSW Government (April 2005), '*Floodplain Development Manual: The Management of Flood Liable Land*'.
- Shellharbour City Council (November 2004), '*Development Design Specifications D5 – Subdivision Drainage Design'*.
- WorleyParsons (July 2009), '*Shell Cove Boat Harbour Precinct Flood Management Assessment*'.

If you have any queries on the above report please do not hesitate to contact the undersigned.

Yours sincerely,
ADVISIAN

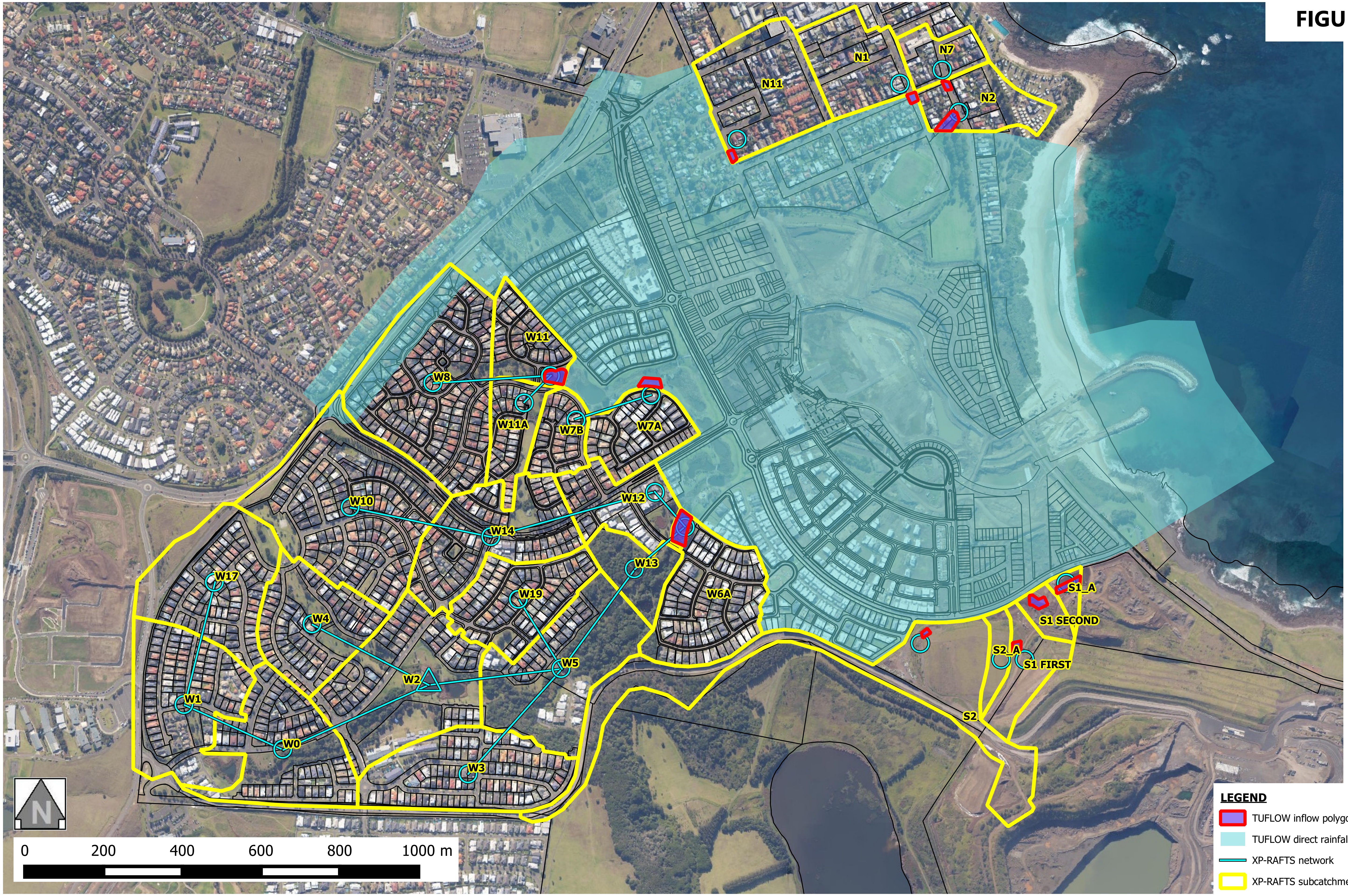
Reviewed by

Declan Bird
Water Resources Engineer

Warick Honour
Principal Engineer

Report Figures

FIGURE 3.1



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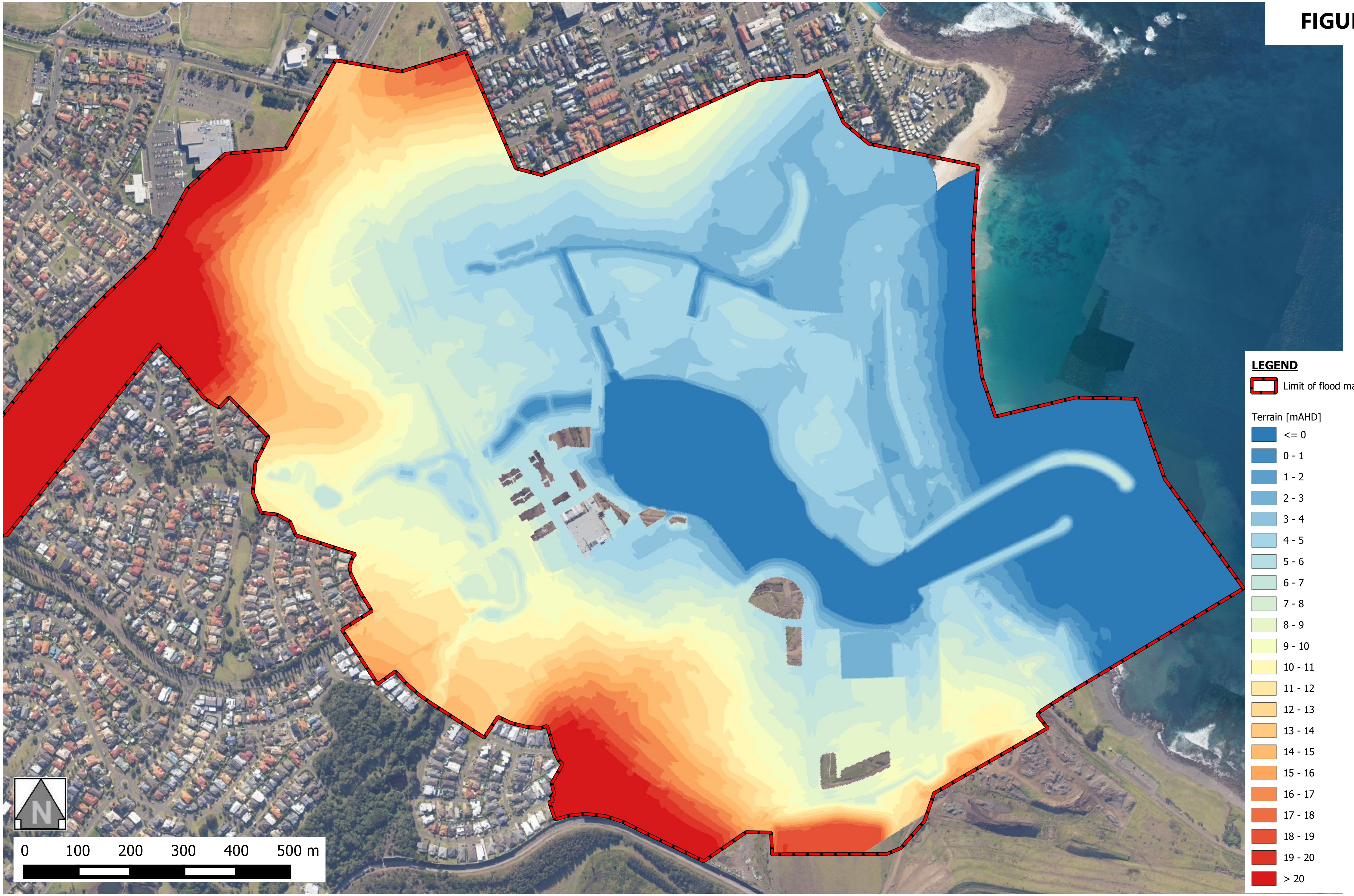
PrecADA 2017-11-07 Figure 3.1 - RAFTS and Inflows
2017-03-03_ShellCove_Section75W.qgs

SHELL COVE BOAT HARBOUR XP-RAFTS CATCHMENT DELINEATION AND TUFLOW INFLOW POLYGONS



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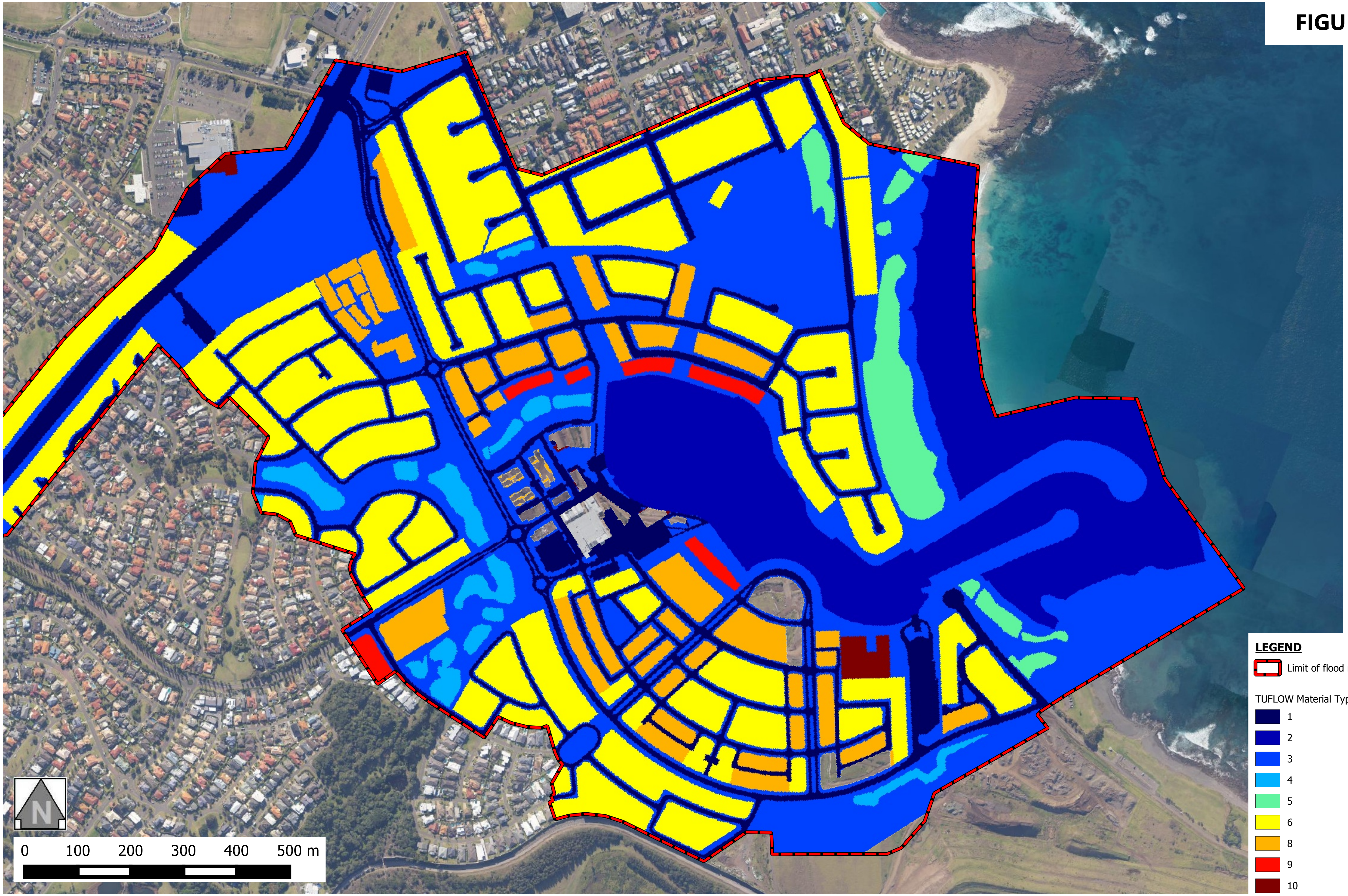
SHELL COVE BOAT HARBOUR TUFLOW MODEL TERRAIN [POST-DEVELOPMENT SCENARIO]

PrecB2 C2 2017-11-07 Figure 4.1 - Post-Dev Terrain
2017-03-03_ShellCove_Section75W.qgs

FIGURE 4.2



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Prec B2 C2 2017-11-07 Figure 4.2 - Post-Dev Material Types
2017-03-03_ShellCove_Section75W.qgs

SHELL COVE BOAT HARBOUR TUFLOW MATERIAL TYPES [POST-DEVELOPMENT SCENARIO]

FIGURE 4.3

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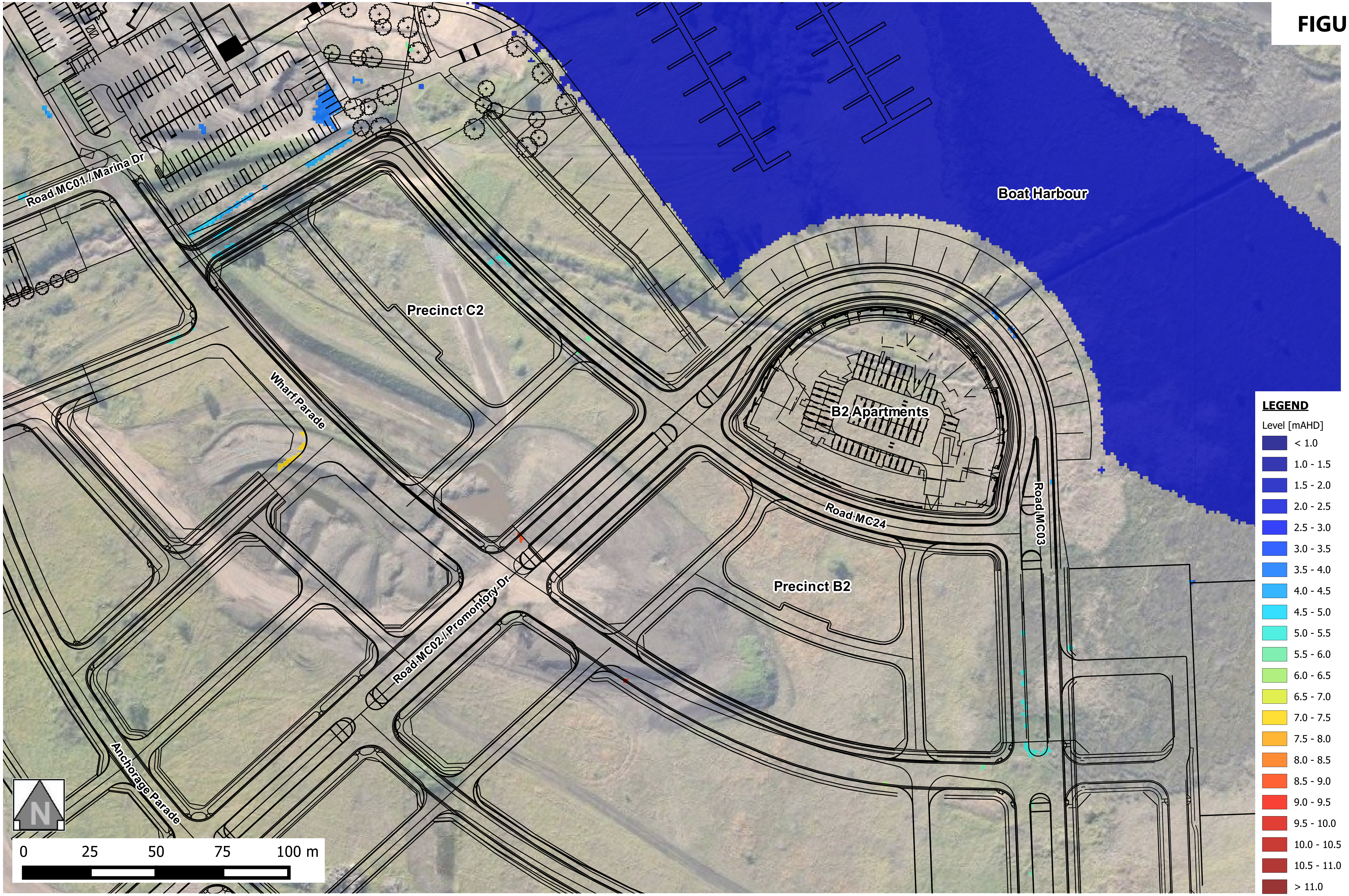
SHELL COVE BOAT HARBOUR TUFLOW MODEL CULVERT NETWORK [POST-DEVELOPMENT SCENARIO]

Prec B2 C2A 2017-11-07 Figure 4.3 - Post-Dev Culverts
2017-03-03_ShellCove_Section75W.qgs

FIGURE 5.1



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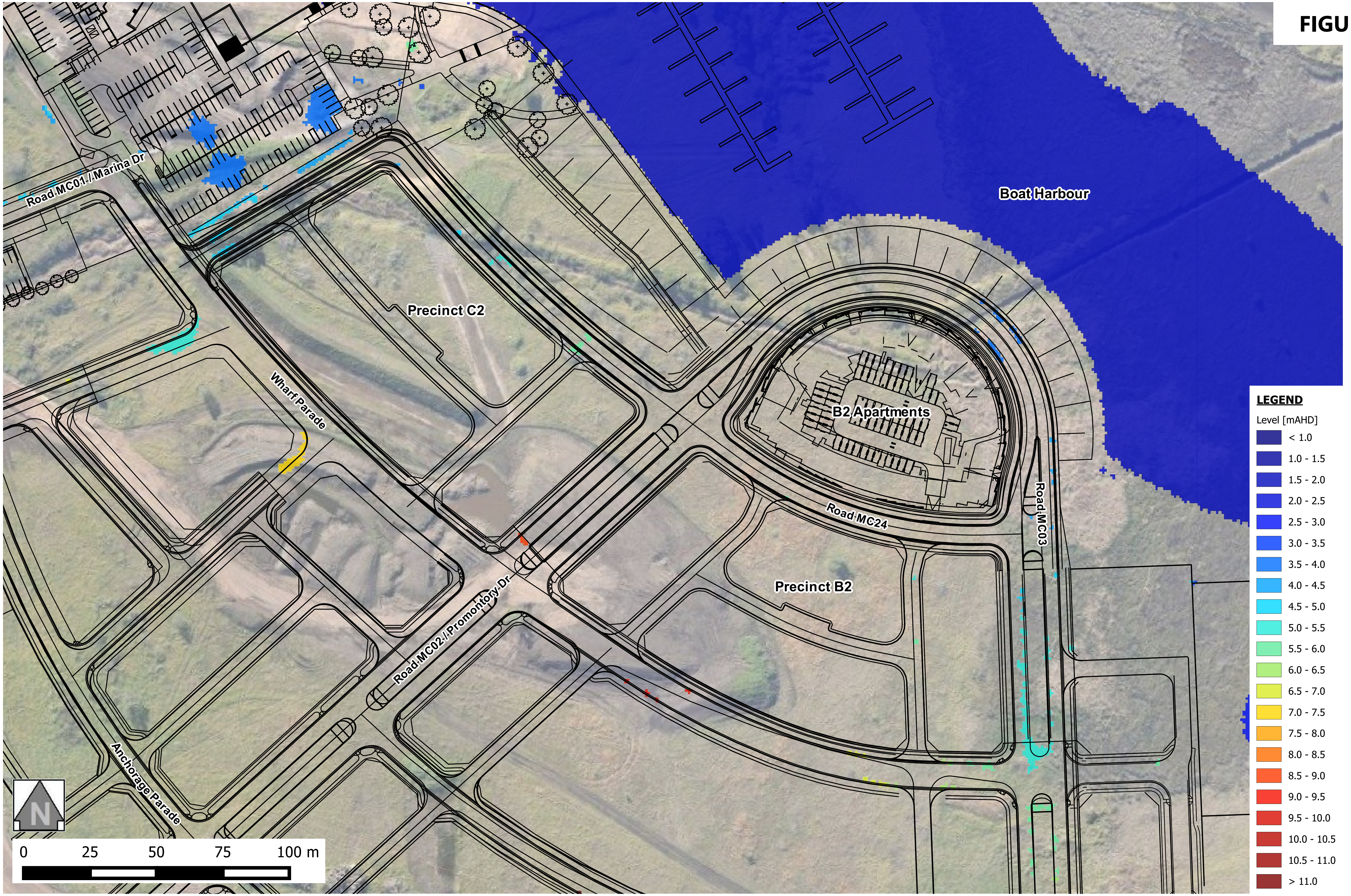
PEAK FLOOD LEVELS FOR THE 5 YEAR ARI EVENT [POST-DEVELOPMENT SCENARIO]

190924 - Bullnose updates Fig 5.1 5yr Levels
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 5.2



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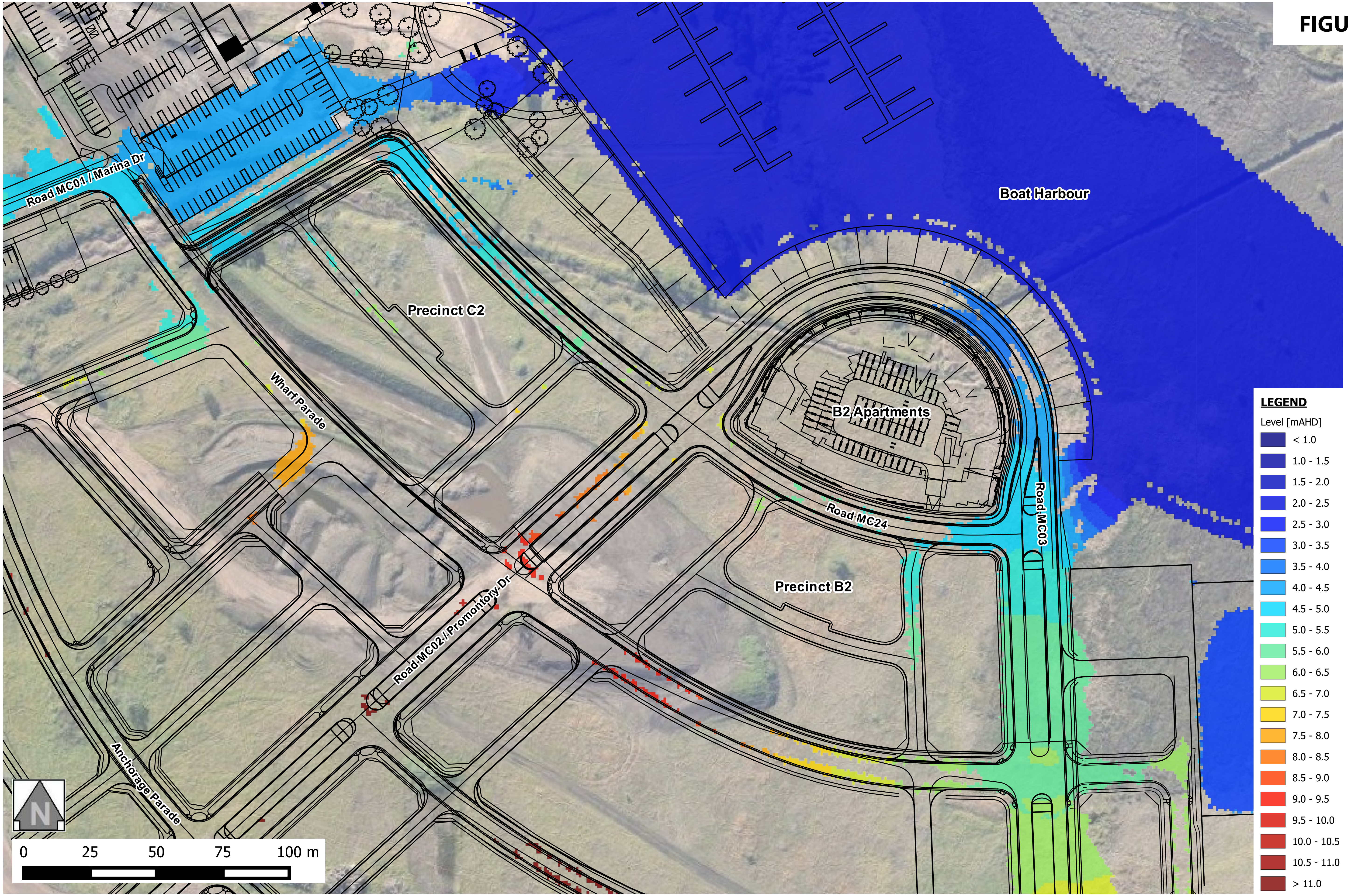
190924 - Bullnose updates Fig 5.2 100yr Levels
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

PEAK FLOOD LEVELS FOR THE 100 YEAR ARI EVENT
[POST-DEVELOPMENT SCENARIO]

FIGURE 5.3



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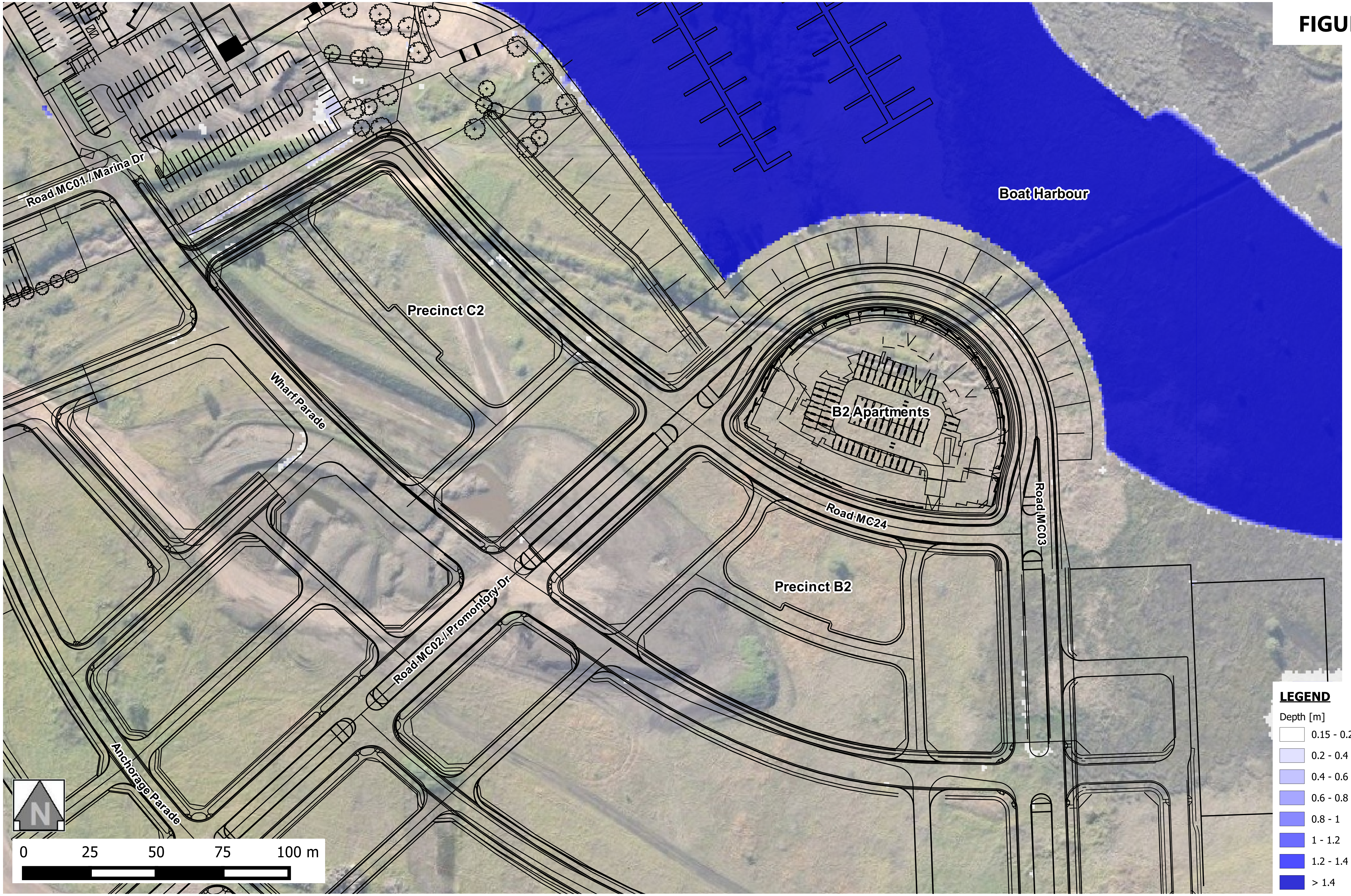
PEAK FLOOD LEVELS FOR THE PROBABLE MAXIMUM FLOOD [POST-DEVELOPMENT SCENARIO]

190924 - Bullnose updates Fig 5.3 PMF Levels
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 5.4



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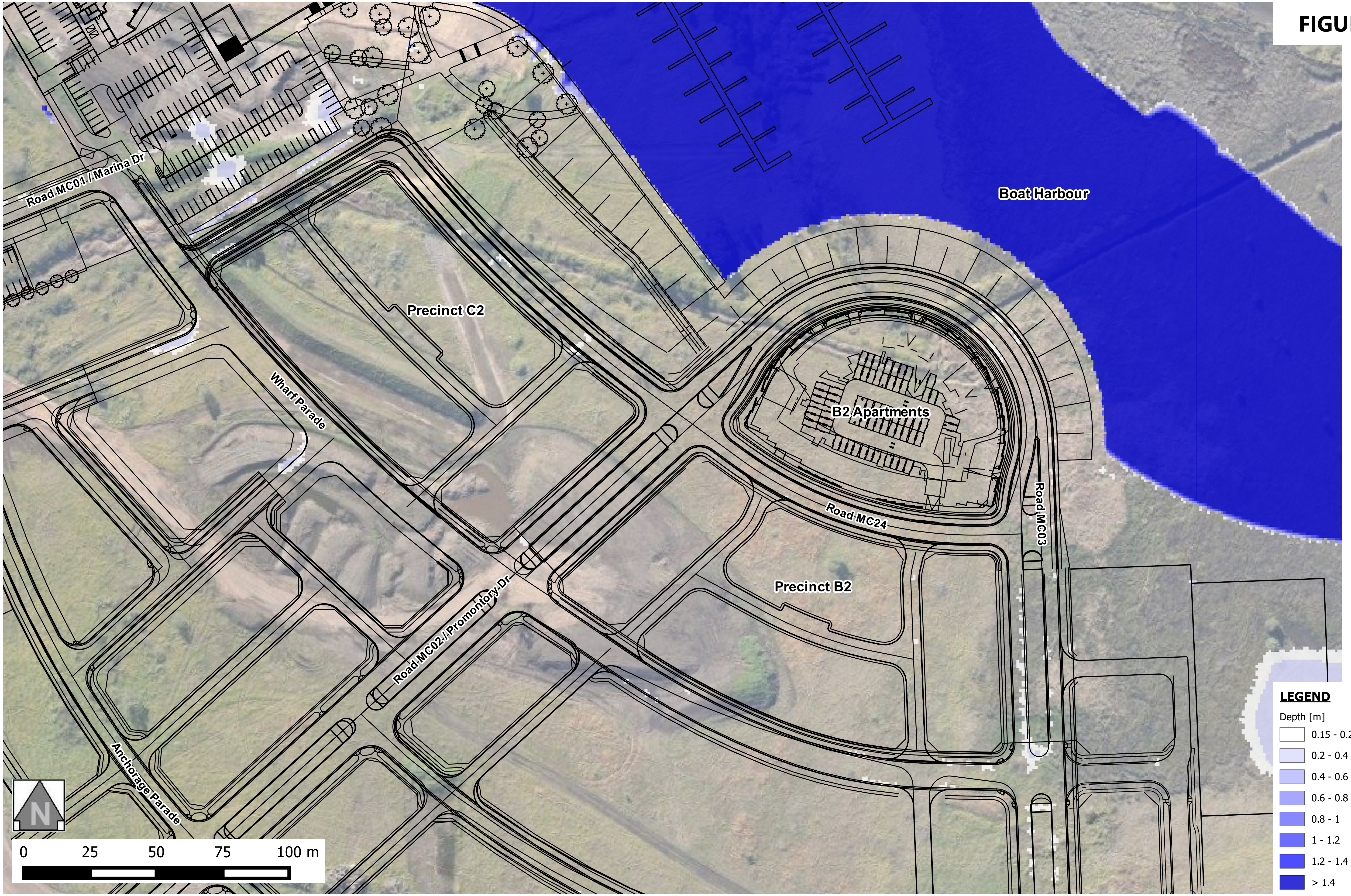
PEAK FLOOD DEPTHS FOR THE 5 YEAR ARI EVENT [POST-DEVELOPMENT SCENARIO]

190924 - Bullnose updates Fig 5.4 5yr Depths
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 5.5



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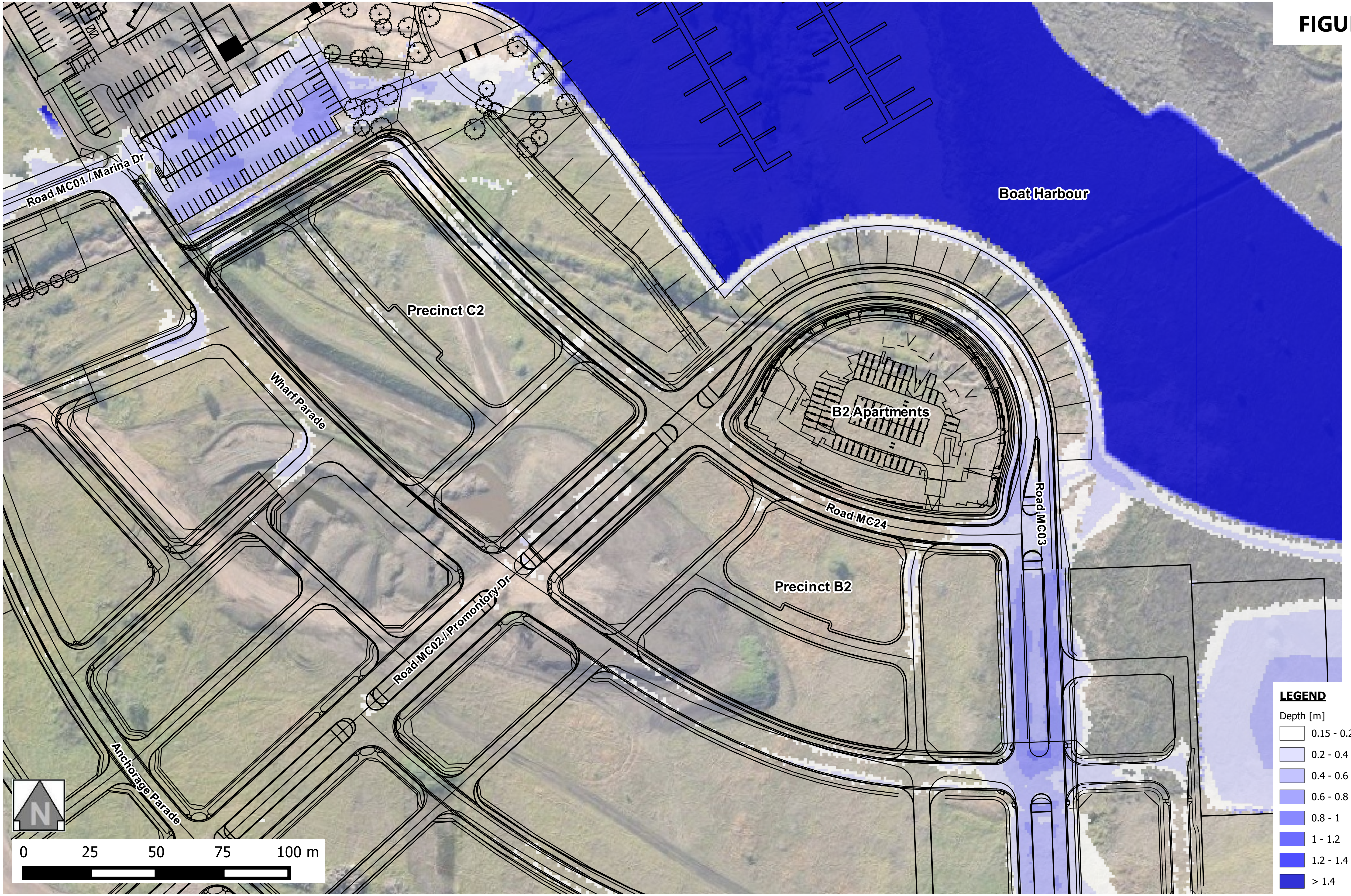
PEAK FLOOD DEPTHS FOR THE 100 YEAR ARI EVENT [POST-DEVELOPMENT SCENARIO]

190924 - Bullnose updates Fig 5.5 100yr Depths
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 5.6



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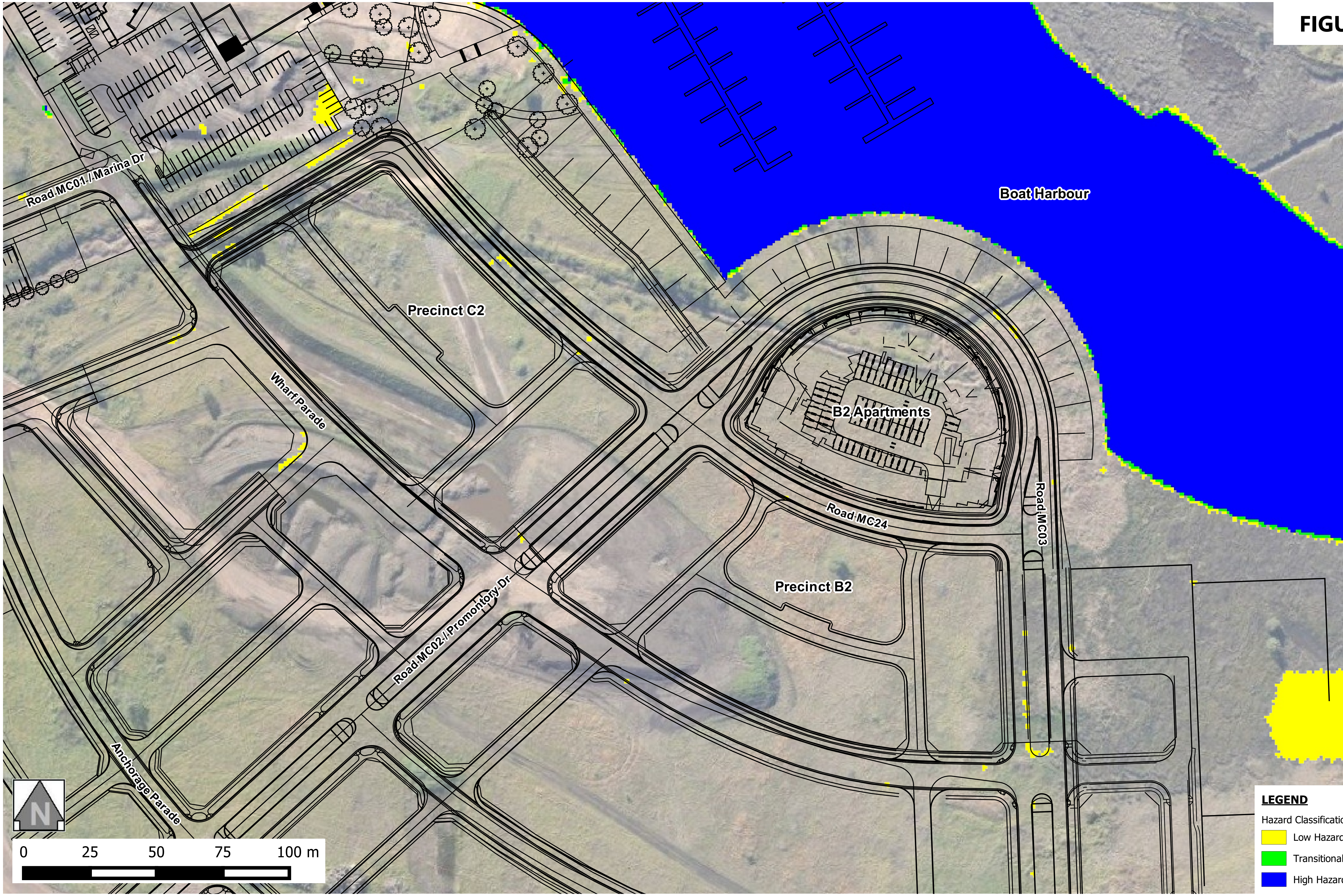
PEAK FLOOD DEPTHS FOR THE PROBABLE MAXIMUM FLOOD [POST-DEVELOPMENT SCENARIO]

190924 - Bullnose updates Fig 5.6 PMF Depths
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 5.7



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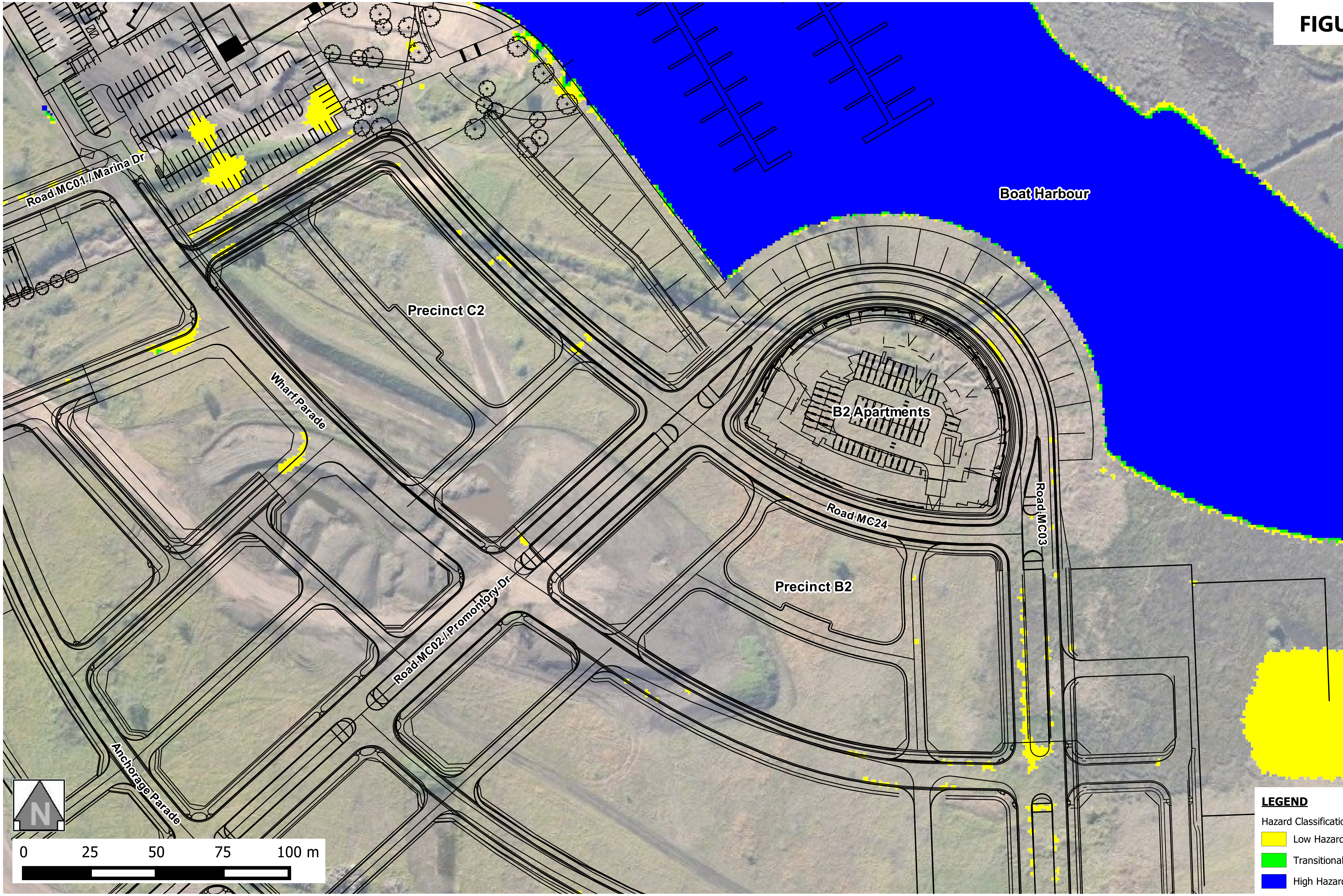
PROVISIONAL FLOOD HAZARD FOR THE 5 YEAR ARI EVENT [POST-DEVELOPMENT SCENARIO]

190924 - Bullnose updates Fig 5.7 5yr Hazard
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 5.8



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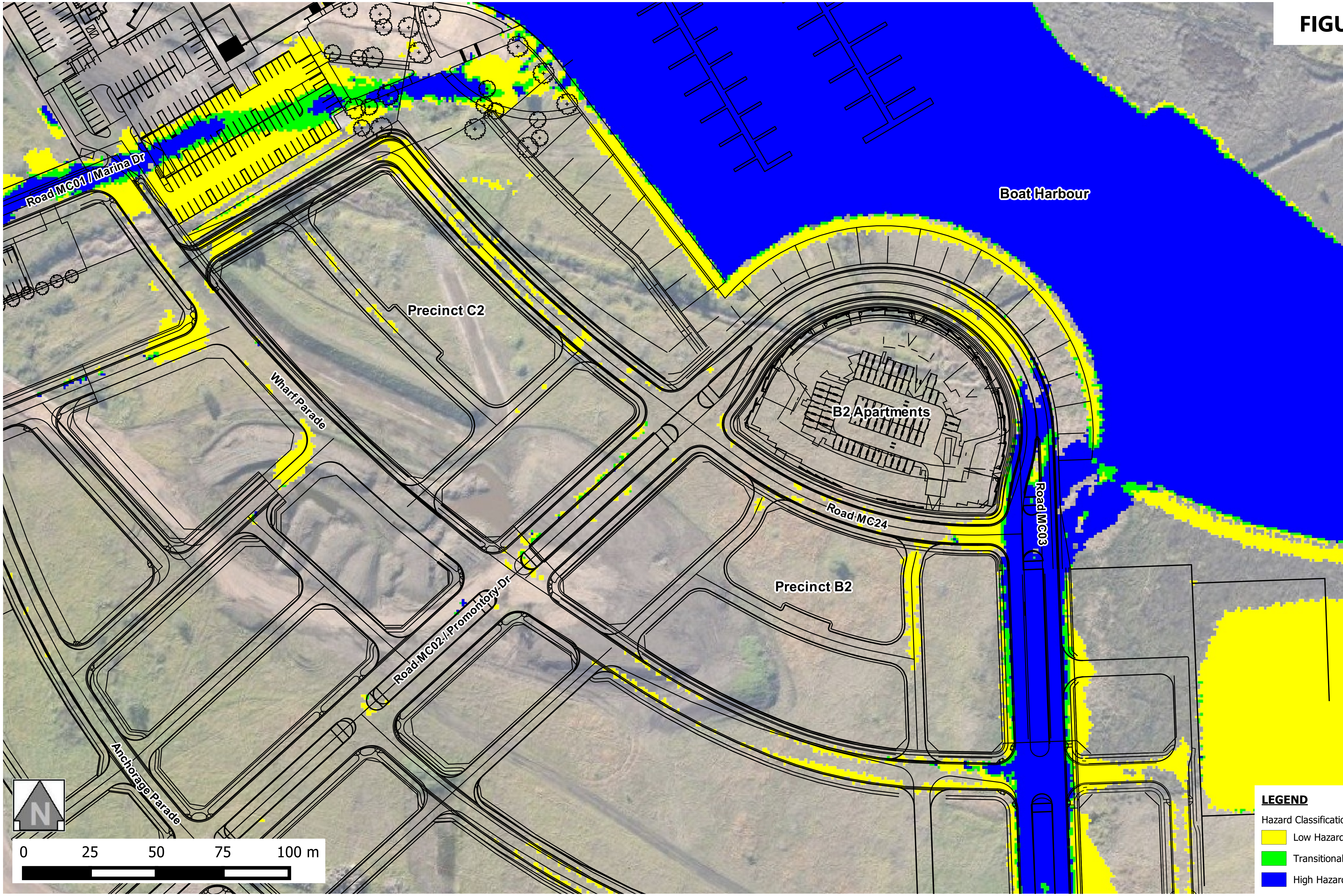
PROVISIONAL FLOOD HAZARD FOR THE 100 YEAR ARI EVENT [POST-DEVELOPMENT SCENARIO]

190924 - Bullnose updates Fig 5.8 100yr Hazard
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 5.9



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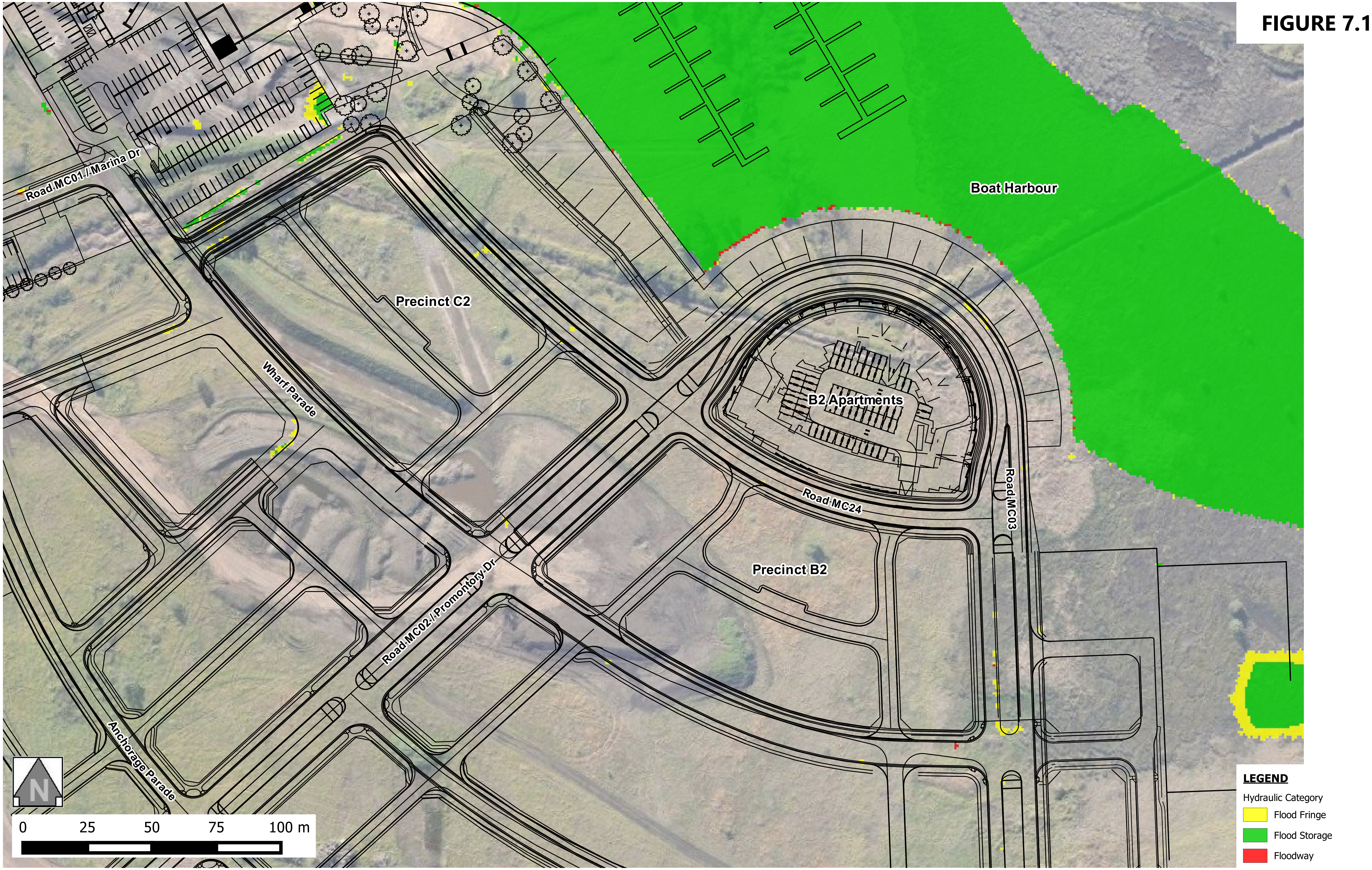
PROVISIONAL FLOOD HAZARD FOR THE PROBABLE MAXIMUM FLOOD [POST-DEVELOPMENT SCENARIO]

190924 - Bullnose updates Fig 5.9 PMF Hazard
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 7.1



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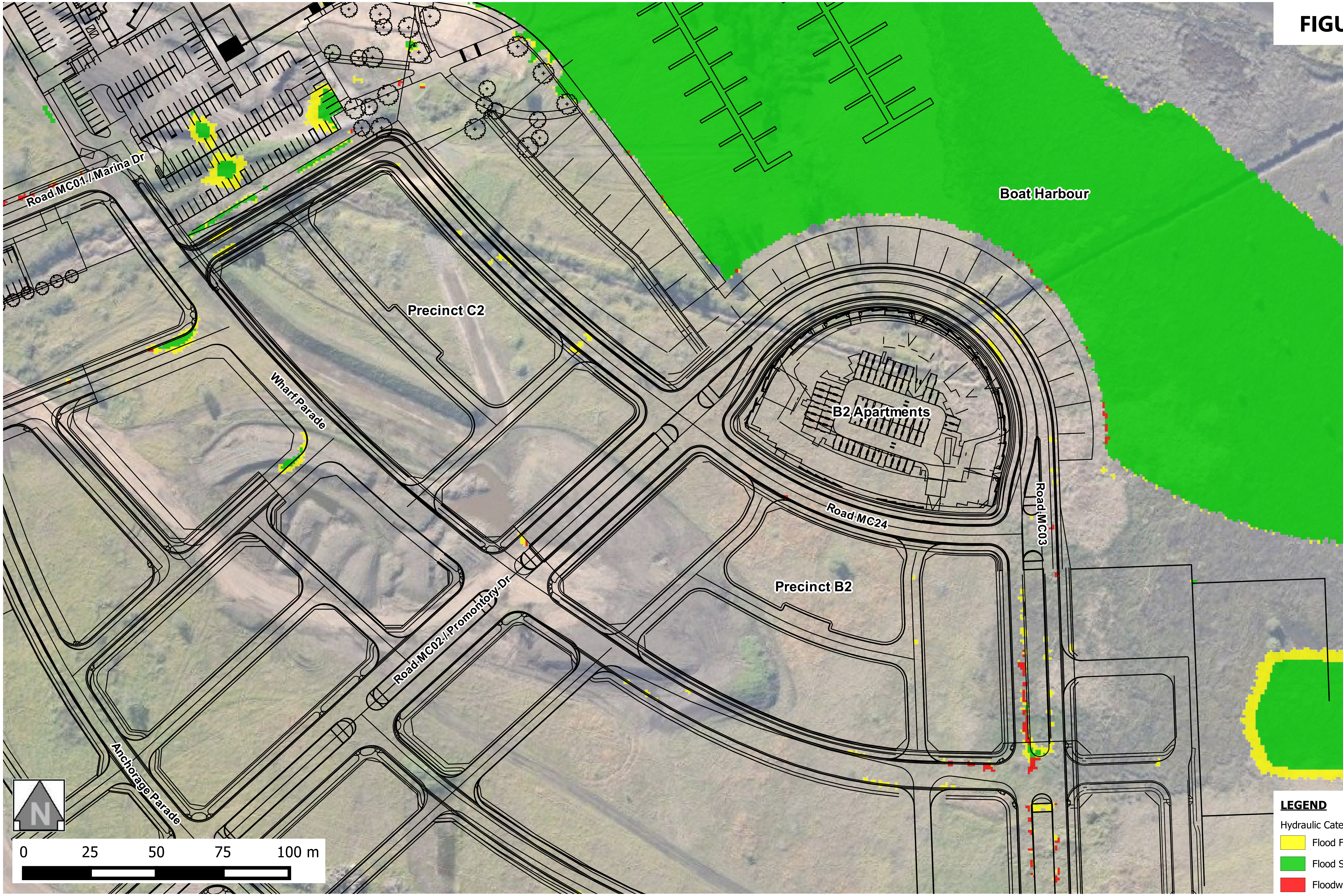
HYDRAULIC CATEGORY MAPPING FOR THE 5 YEAR ARI EVENT [POST-DEVELOPMENT SCENARIO]

190924 - Bullnose updates Fig 7.1 5yr Hyd Cat
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 7.2



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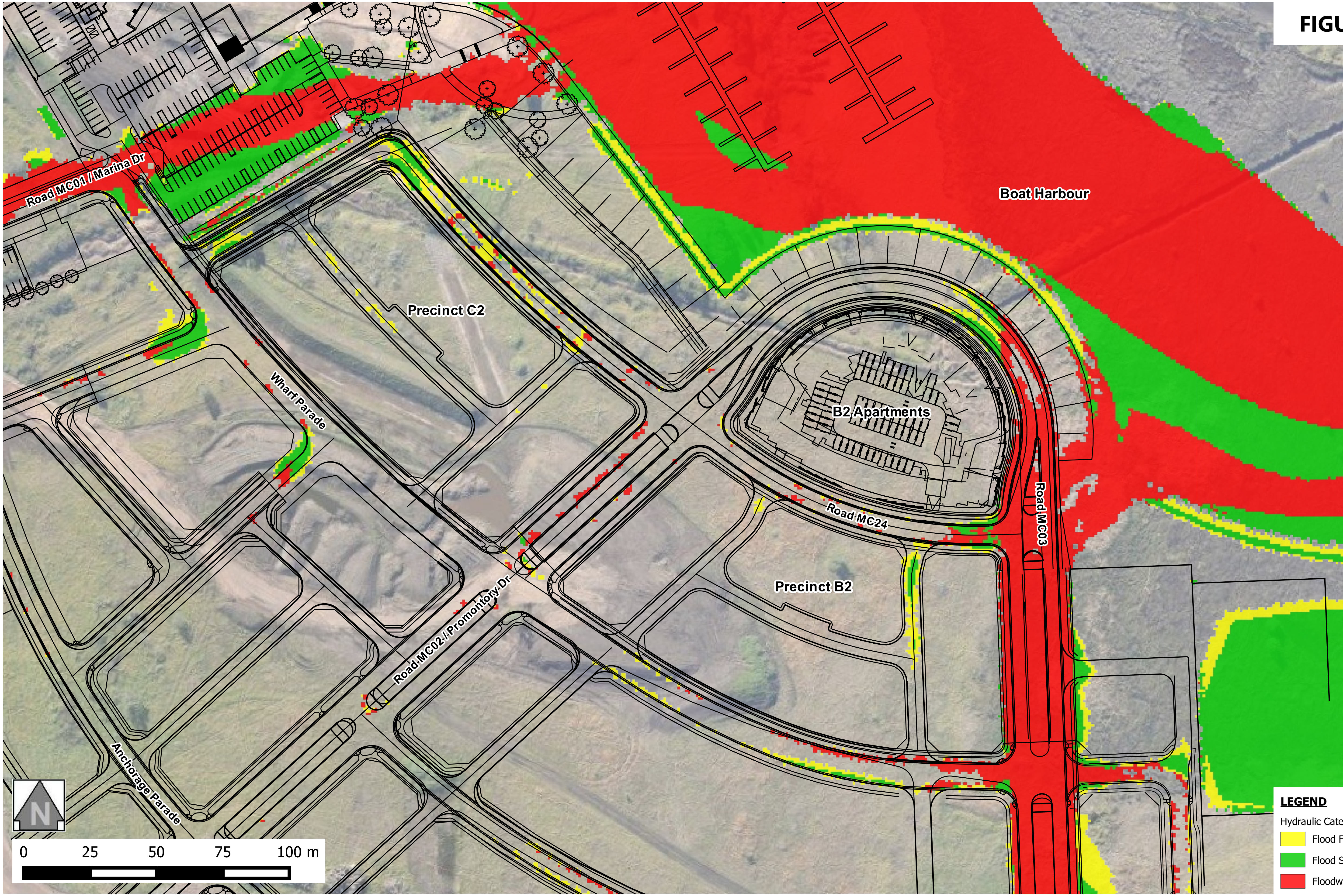
HYDRAULIC CATEGORY MAPPING FOR THE 100 YEAR ARI EVENT [POST-DEVELOPMENT SCENARIO]

190924 - Bullnose updates Fig 7.2 100yr Hyd Cat
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 7.3



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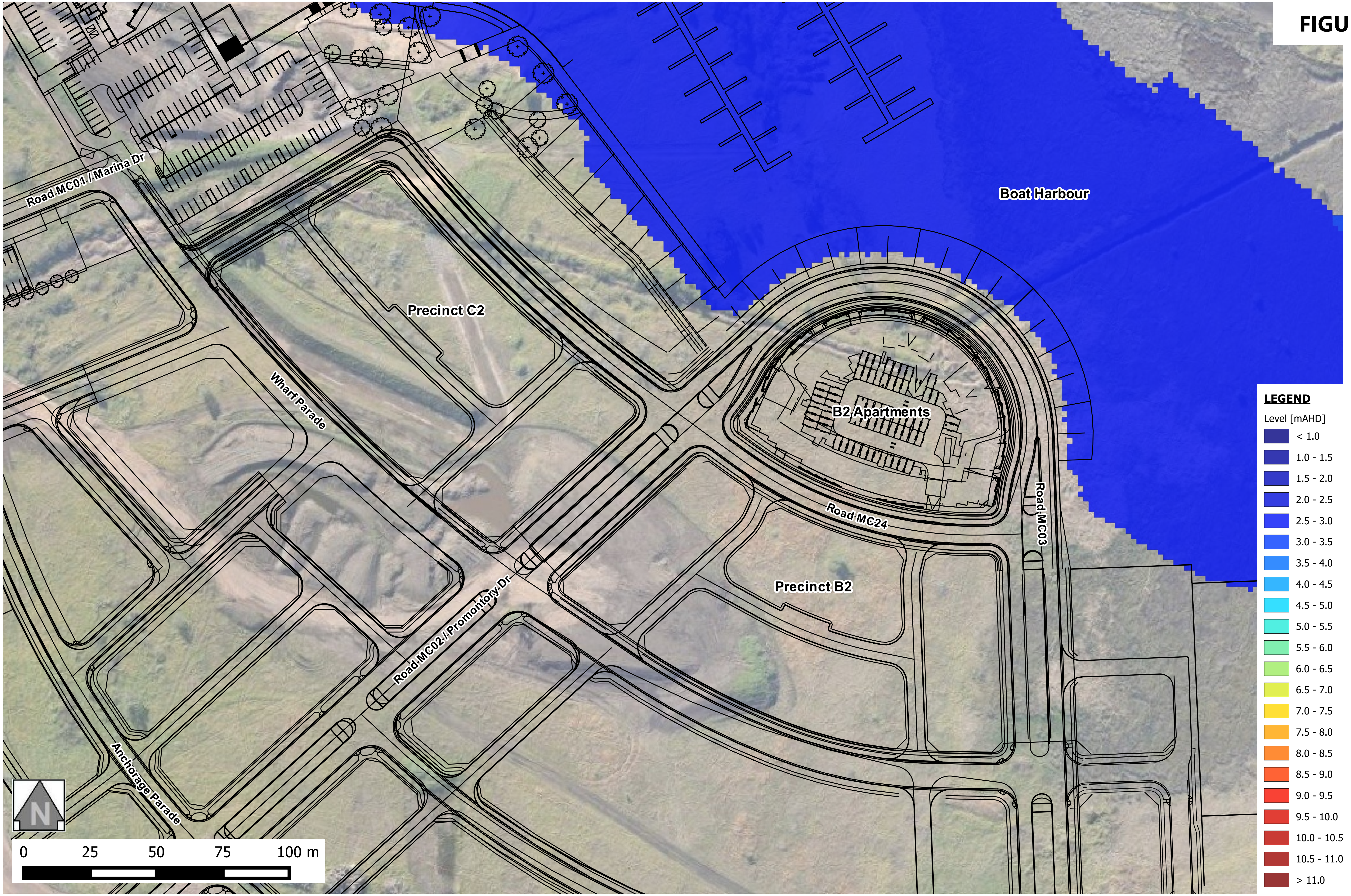
HYDRAULIC CATEGORY MAPPING FOR THE PROBABLE MAXIMUM FLOOD [POST-DEVELOPMENT SCENARIO]

190924 - Bullnose updates Fig 7.3 100yr Hyd Cat
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 8.1



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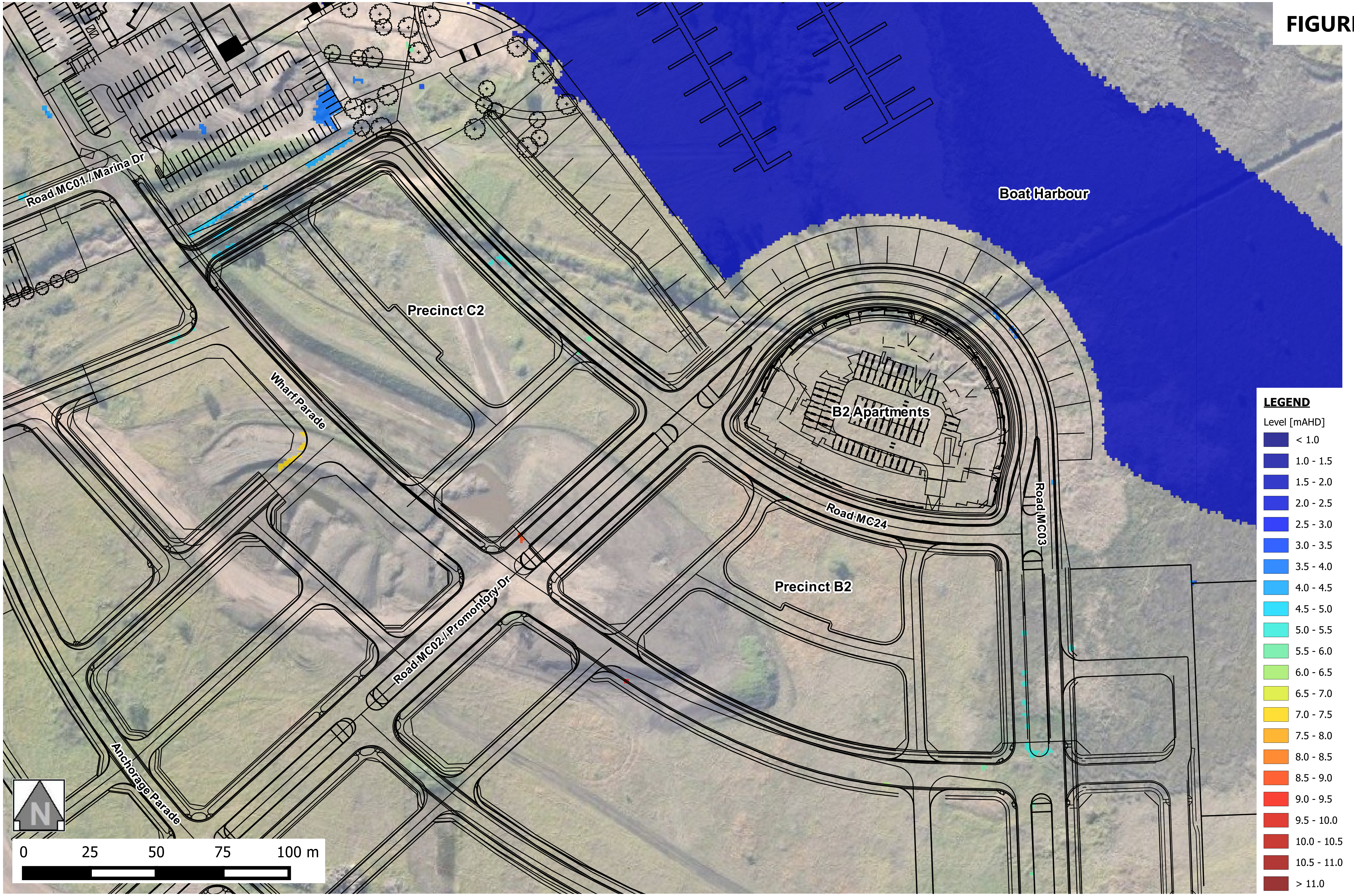
190924 - Bullnose updates Fig .1 5yr FPL
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FLOOD PLANNING LEVELS [POST-DEVELOPMENT SCENARIO]

FIGURE 10.1



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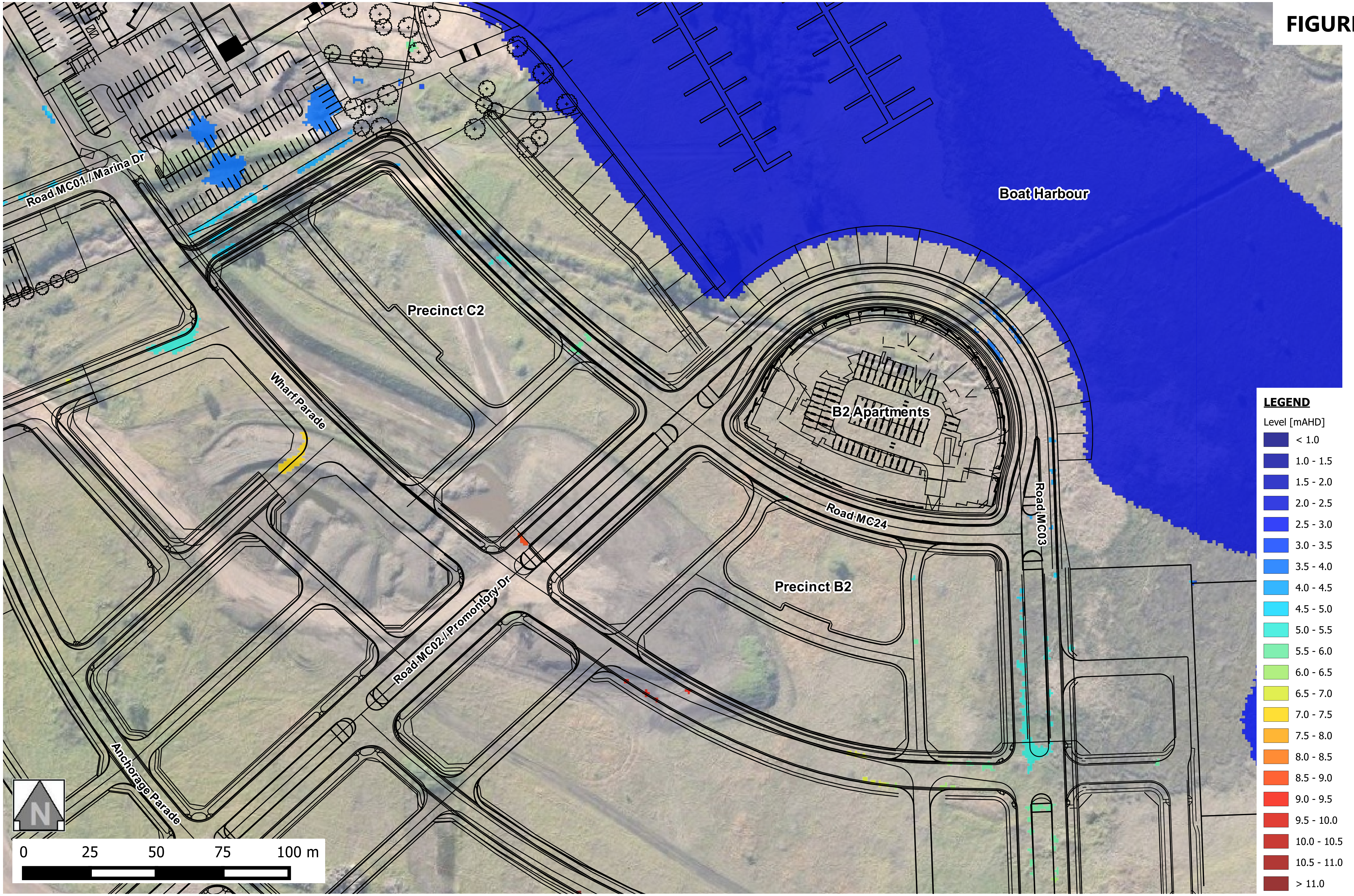
PEAK FLOOD LEVELS FOR THE 5 YEAR ARI EVENT
[POST-DEVELOPMENT YEAR 2100 SEA LEVEL RISE SCENARIO]

190924 - Bullnose updates Fig 10.1 5yr SLR Levels
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 10.2



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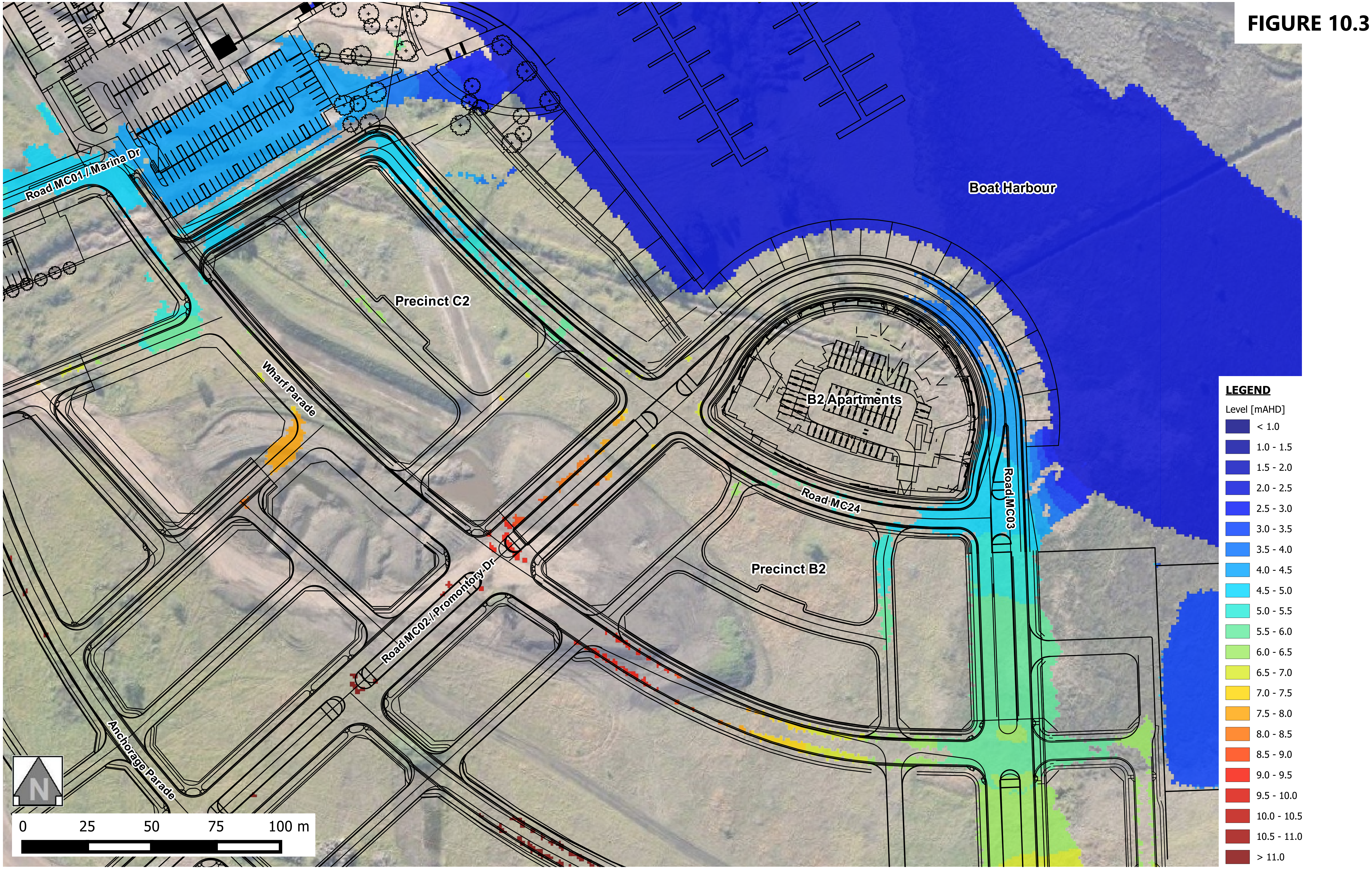
PEAK FLOOD LEVELS FOR THE 100 YEAR ARI EVENT [POST-DEVELOPMENT YEAR 2100 SEA LEVEL RISE SCENARIO]

190924 - Bullnose updates Fig 10.2 100yr SLR Levels
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs



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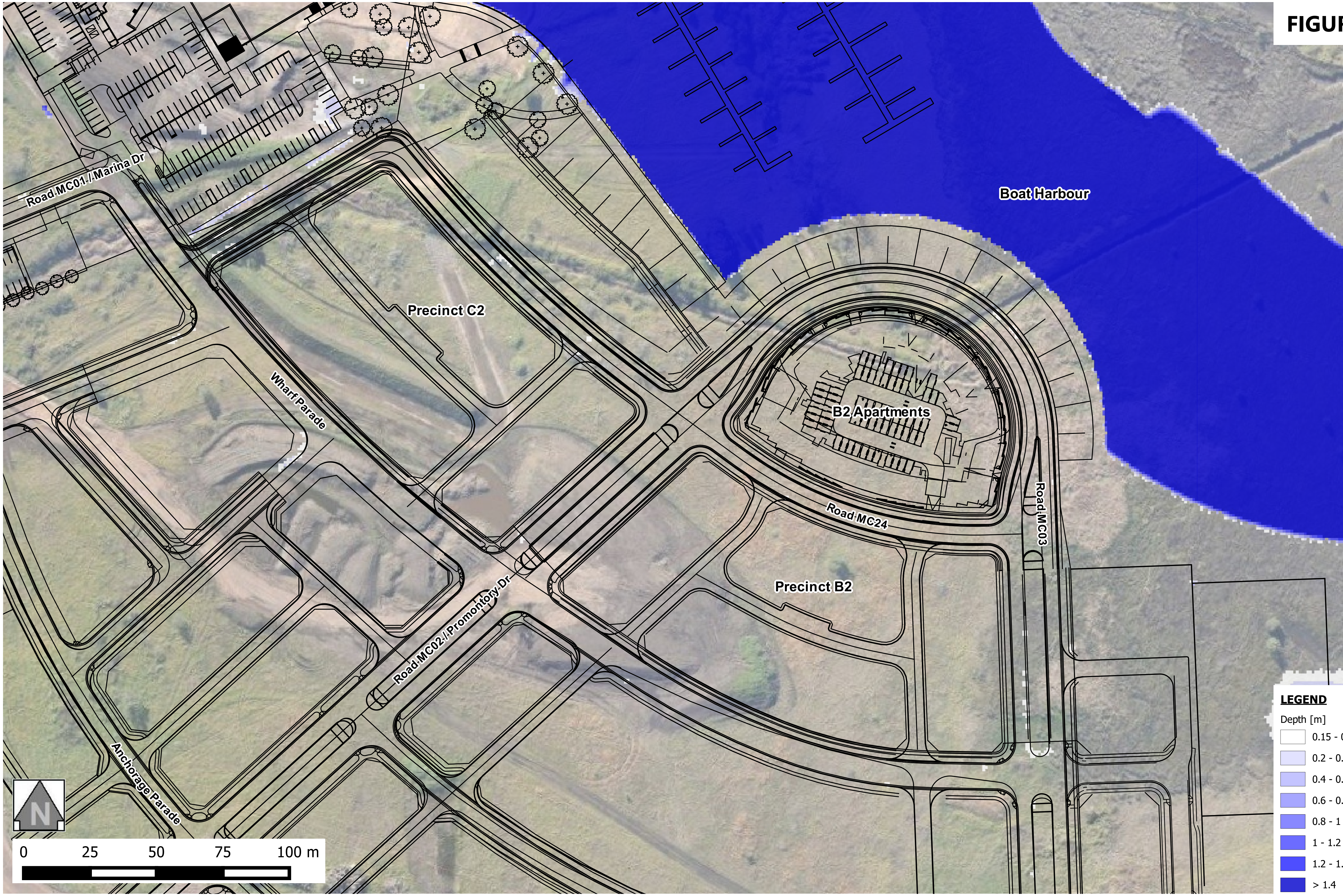
PEAK FLOOD LEVELS FOR THE PROBABLE MAXIMUM FLOOD [POST-DEVELOPMENT YEAR 2100 SEA LEVEL RISE SCENARIO]

190924 - Bullnose updates Fig 10.3 PMF SLR Levels
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 10.4



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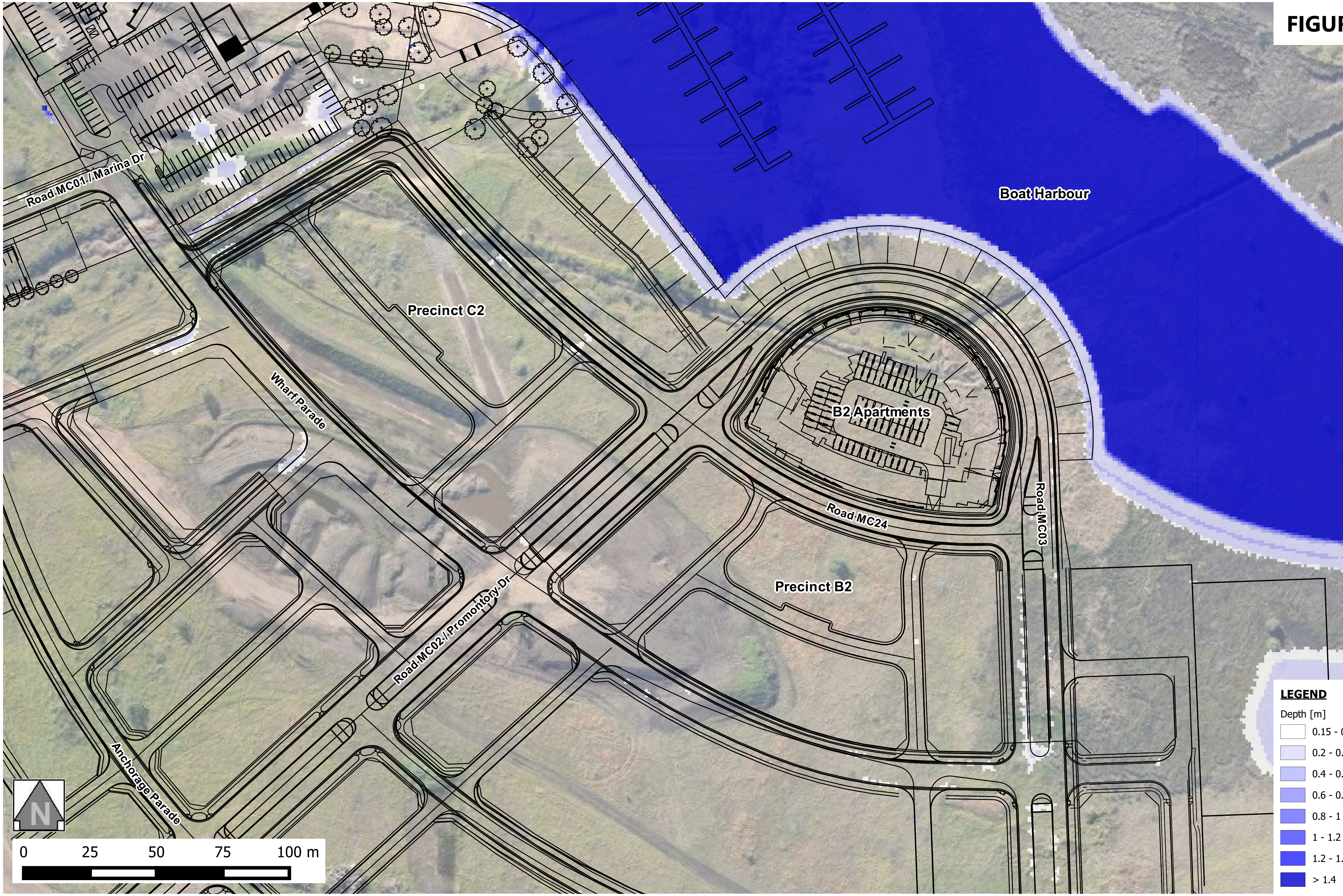
PEAK FLOOD DEPTHS FOR THE 5 YEAR ARI EVENT [POST-DEVELOPMENT YEAR 2100 SEA LEVEL RISE SCENARIO]

190924 - Bullnose updates Fig 10.4 5yr SLR Depths
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 10.5



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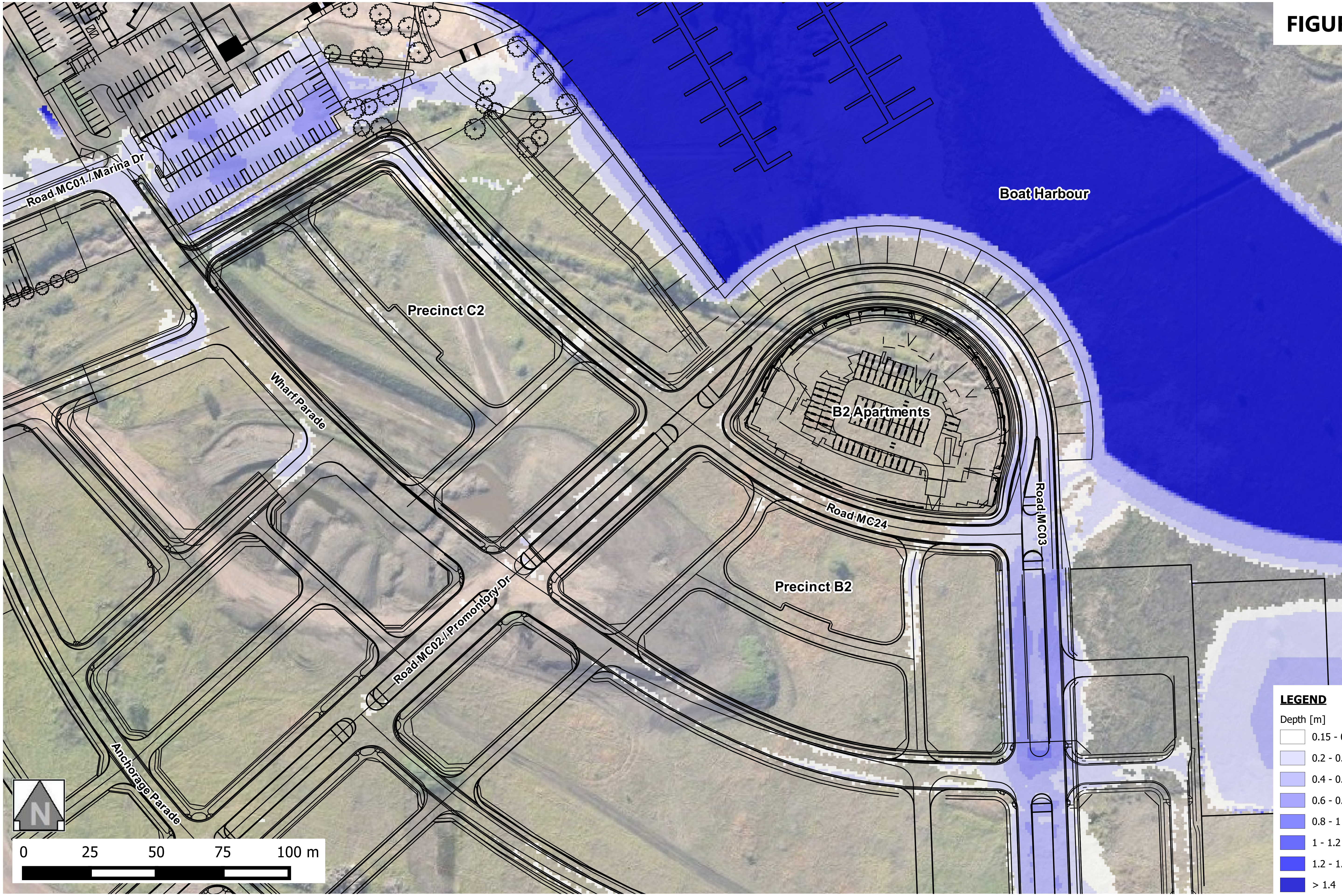
190924 - Bullnose updates Fig 10.5 100yr SLR Depths
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

PEAK FLOOD DEPTHS FOR THE 100 YEAR ARI EVENT
[POST-DEVELOPMENT YEAR 2100 SEA LEVEL RISE SCENARIO]

FIGURE 10.6



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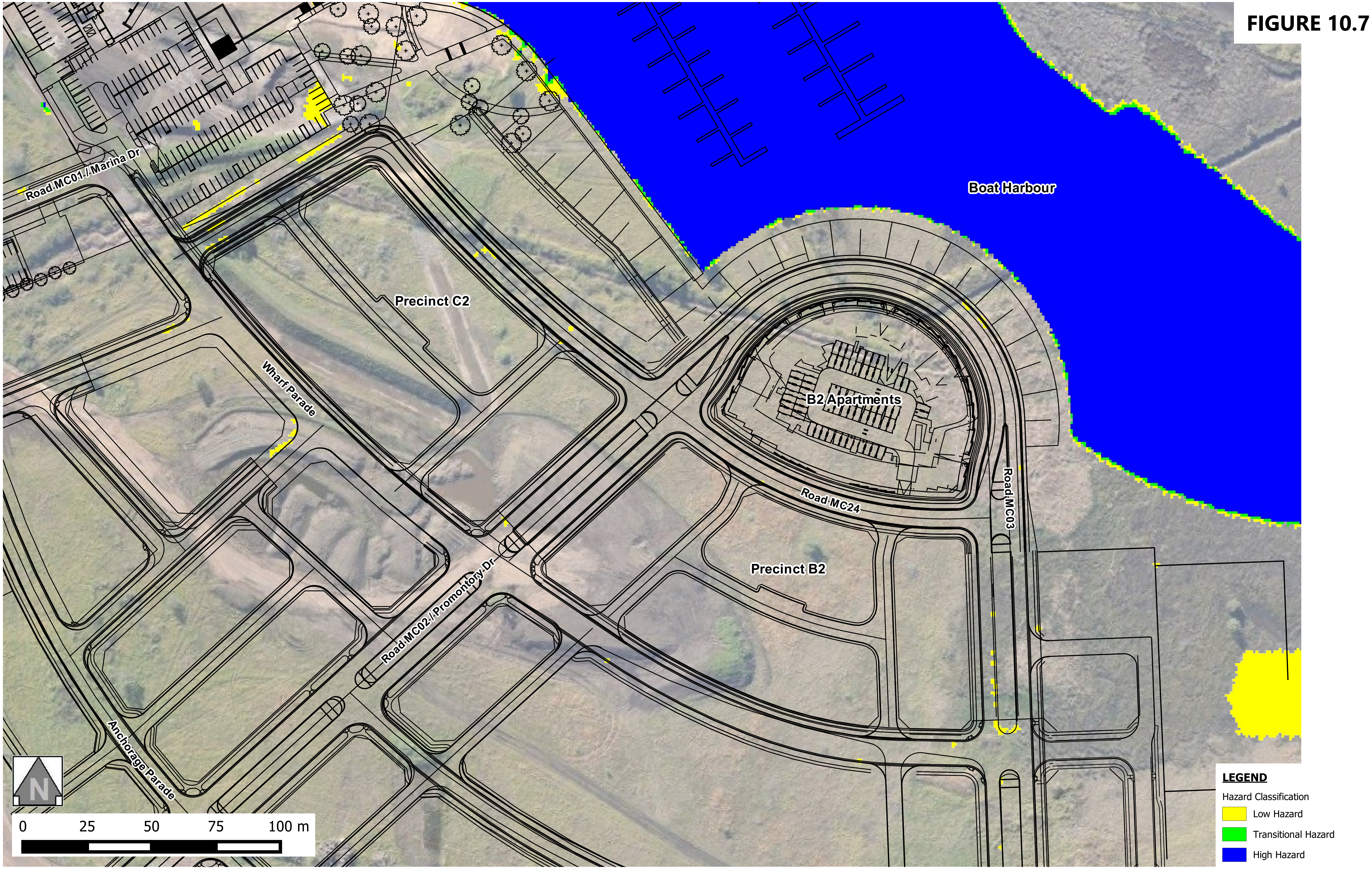
PEAK FLOOD DEPTHS FOR THE PROBABLE MAXIMUM FLOOD [POST-DEVELOPMENT YEAR 2100 SEA LEVEL RISE SCENARIO]

190924 - Bullnose updates Fig 10.6 PMF SLR Depths
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 10.7



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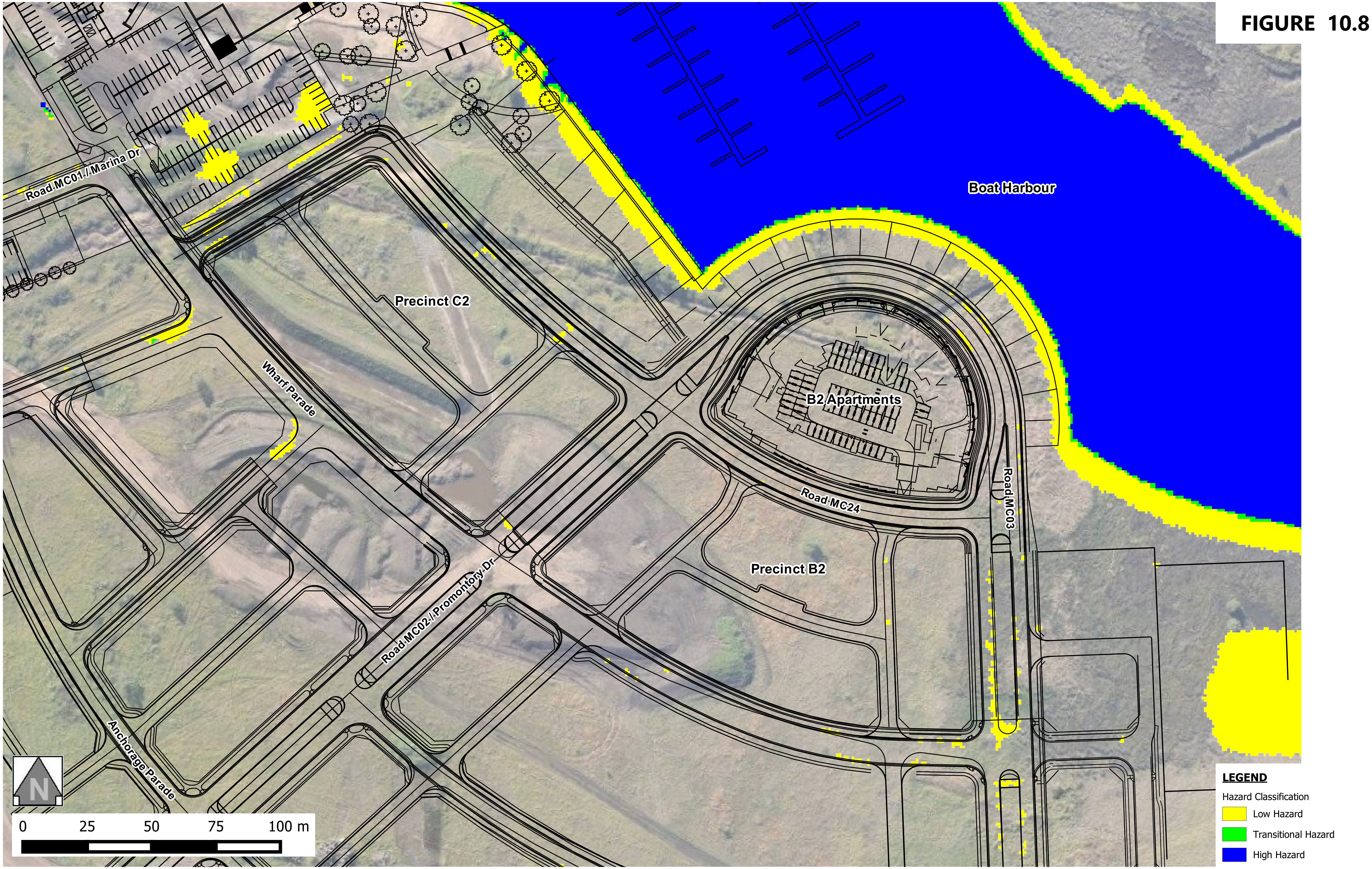
PROVISIONAL FLOOD HAZARD FOR THE 5 YEAR ARI EVENT [POST-DEVELOPMENT YEAR 2100 SEA LEVEL RISE SCENARIO]

190924 - Bullnose updates Fig 10.7 5yr SLR Hazard
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 10.8



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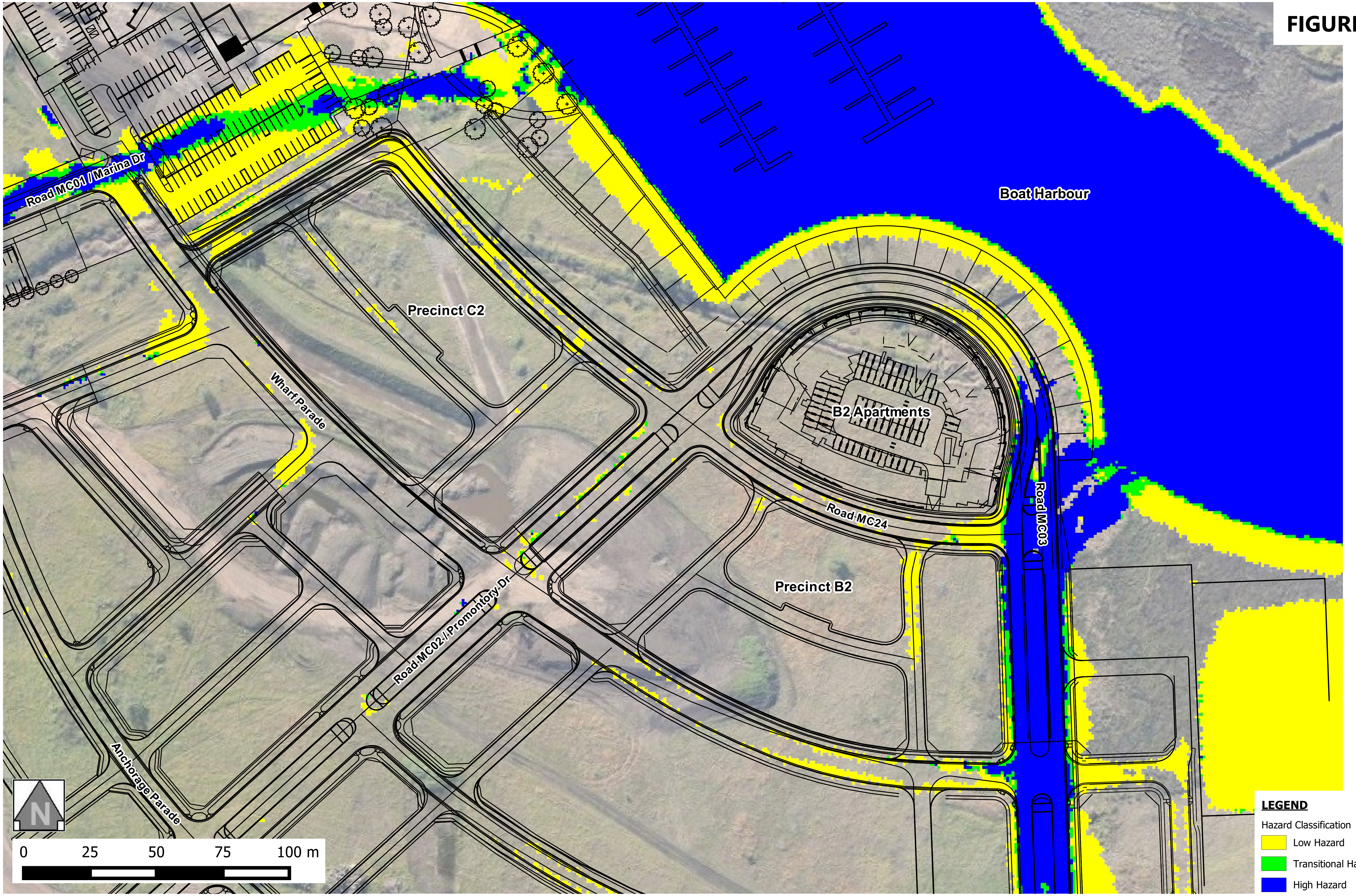
PROVISIONAL FLOOD HAZARD FOR THE 100 YEAR ARI EVENT [POST-DEVELOPMENT YEAR 2100 SEA LEVEL RISE SCENARIO]

190924 - Bullnose updates Fig 10.8 100yr SLR Hazard
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

FIGURE 10.9



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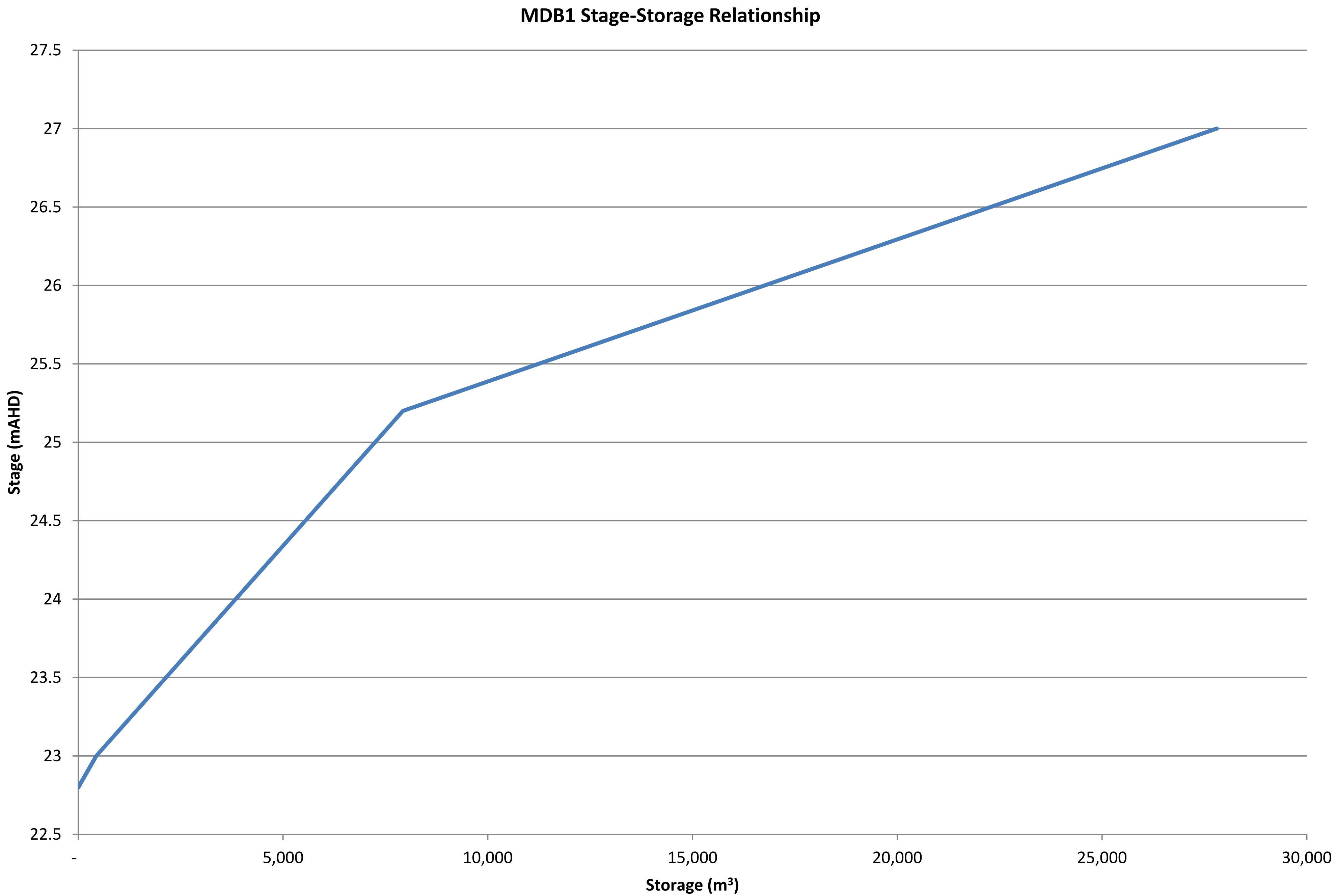
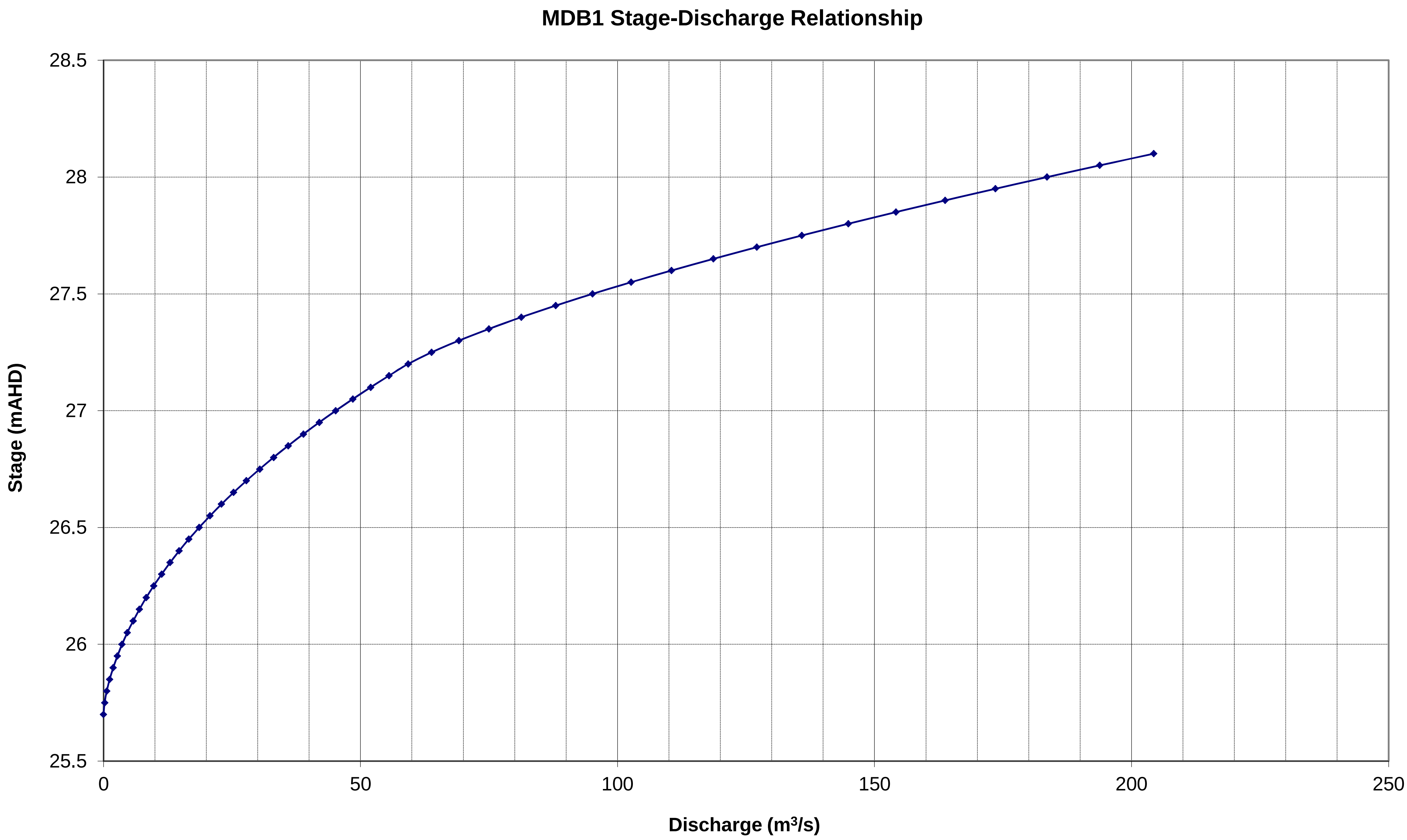
PROVISIONAL FLOOD HAZARD FOR THE PROBABLE MAXIMUM FLOOD [POST-DEVELOPMENT YEAR 2100 SEA LEVEL RISE SCENARIO]

190924 - Bullnose updates Fig 10.9 PMF SLR Hazard
2019-03-01_ShellCove_PrecB2-C2-BullnoseUpdate.qgs

Appendix A: Major Detention Basin 1 Stage-Storage & Storage-Discharge Relationships


MDB1 Stage-Storage Relationship
Stage (mAHD)
27.5
27
26.5
26
25.5
25
24.5
24
23.5
23
22.5
-
5,000
10,000
15,000
20,000
25,000
30,000
Storage (m³)


MDB1 Stage-Discharge Relationship
Stage (mAHD)
Discharge (m3/s)
28.5
28
27.5
27
26.5
26
25.5
0
50
100
150
200
250

Appendix B: SOBEK Model Roughness 2009

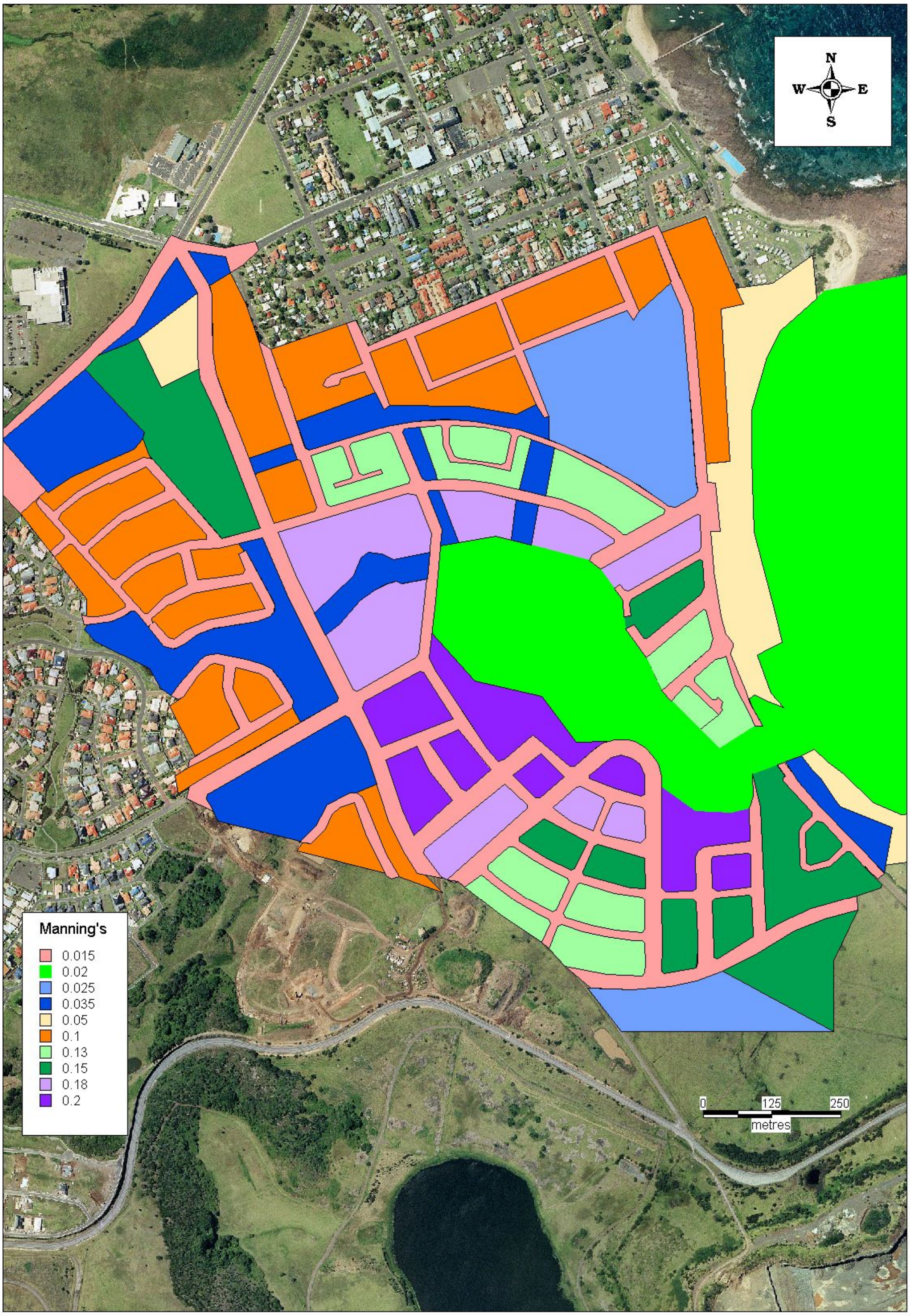


Figure 5.2 2D Roughness Values Adopted