Southern Reclamation Area – Hydrodynamic Changes Monitoring Plan

Reference: R.A10422.007.02.WBE_SRC_Hydrodynamic_Changes_Monitoring_Plan.docx
Date: 9 May 2024
Confidential

Document Control Sheet

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Document:	R.A10422.007.03.WBE_SRC_Hydrodynamic_Changes_Monitoring_Plan.docx
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Synopsis: **An estimate of the hydrodynamic changes due to construction of the Northern Land Expansion Project Southern Reclamation Area and a description of the proposed monitoring plan.**

REVISION/CHECKING HISTORY

Revision Number	Date	Checked by	Issued by
0	29/10/2021	IAT	PAG
1	24/11/2021		
2	26/04/2022		
3	14/11/2023		
4	9/05/2024		

DISTRIBUTION

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Signed

Full name (please print)

RICHARD HAWARD

Organisation (please print)

GLADSTONE PORTS CORPORATION LIMITED

Date 08/07/2024

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1 Introduction

1.1 Background

In 2020 Gladstone Ports Corporation Limited (GPC) received Coordinator-General (CG) and Federal Environmental Protection and Biodiversity Act 1999 (EPBC Act) approval to commence the Gatcombe and Golding Channel Duplication Project. The latter will commence with the development of a new trade area, the Northern Trade Precinct located north of Fisherman's Landing (FL). The project, named Northern Land Expansion Project (NLEP), was previously referred to as the Western Basin Expansion (WBE) Project. It will commence with the construction of the Southern Reclamation Area (SRA) which will be located north of the existing Western Basin Reclamation Area (WBRA) (see Figure 1-1). This stage of the NLEP (formerly WBE Project) does not include any dredging, placement of dredging material or tailwater discharge. Those activities will be subject to a separate future approval and monitoring plan. A glossary of project terminology is provided in Table 1-1.

Table 1-1 Glossary

Terminology in the EPBC Approval (2012/6558)	Terminology in This Report
Western Basin Expansion (WBE) Reclamation Area	Northern Land Expansion Project (NLEP)
WBE Southern Reclamation Area	Southern Reclamation Area (SRA)

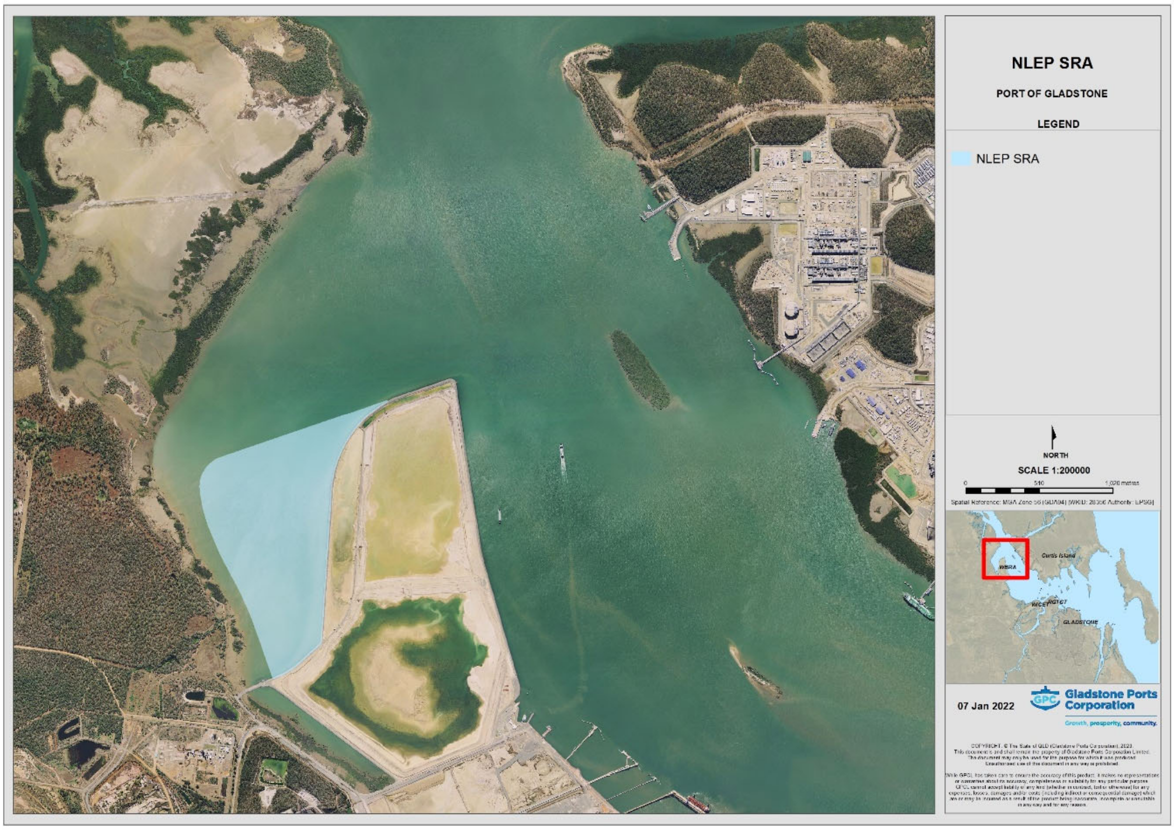

Figure 1-1 Northern Land Expansion Project Southern Reclamation Area (Blue)

The approval conditions issued by the Department of Climate Change, Energy, the Environment and Water (DCCEEW) require GPC to monitor and quantify impacts of hydrodynamic changes associated with the construction of Stage 1 of the project. Specifically, the condition 14.c. of the EPBC Approval (2012/6558) must be satisfied:

A program capable of accurately monitoring and quantifying the impact of hydrodynamic changes including erosion, sedimentation, and channelisation which occur as a result of either Project Stage 1, Project Stage 3, or the combined effects of both, and any resulting impacts on protected matters;

This monitoring plan covers only Stage 1 of the project referred to in the EPBC Approval. Stage 3 of the Project involved construction of another reclamation area north of the proposed Southern Reclamation Area. This construction is not likely to happen in the next five years. Impact assessment and development of a monitoring plan for that stage of construction will be conducted prior to commencement of that phase. Stage 3 will not commence until a revised Hydrodynamic Changes Monitoring Plan for Stage 3 has been approved by the Minister of the Environment and Water in writing.

1.2 Study Objectives

The specific objectives of the report are:

- Summarise the expected hydrodynamic changes associated with the construction of the NLEP SRA;
- Outline the proposed monitoring program which will be undertaken to measure and quantify the hydrodynamic and erosion/sedimentation that occurs after completion of construction.

2 Estimated Hydrodynamic Changes

2.1 Previous Investigations

BMT prepared a technical memorandum (BMT, 2020) which provided estimates of the extent of hydrodynamic changes that are likely to occur following completion of construction of the NLEP SRA over an extended period. The memorandum is provided in Appendix A. The model was only run for 1-month periods for the existing case and developed case, which is long enough to characterise the resulting hydrodynamic regime for each configuration and therefore estimate changes that will occur over a long period of time.

Numerical modelling results indicated that construction of the NLEP SRA will cause the following changes:

- No changes to water levels throughout most of the Port are expected, and changes to current velocities will occur only in areas immediately adjacent to the reclamation area. These are minor changes in the context of the Port as a whole.
- Some deepening of the channel to the west of the NLEP SRA is likely, consistent with an empirical analysis based on the relationship between channel cross section and tidal prism.
- The construction of the NLEP SRA will have no effect on extreme water levels in the Port, and the effect on wave processes at the shoreline is minor because the incident wave energy is already very low.
- The construction of the NLEP SRA will have no effect on the long term water quality, since the changes to the overall hydrodynamics are not large enough to have any significant impact on turbidity levels or salinity or tidal flushing capactity.
- Analysis of aerial photography indicates that the construction of the existing Western Basin reclamation area has had no significant influence on the mainland shoreline alignment or vegetation, and since the alignment of the the NLEP SRA to the mainland is similar, its construction is also expected to have no significant impact on the shoreline.

The main morphological impact that is expected following completion of the NLEP SRA is therefore the potential gradual deepening of the channel to the west of the NLEP SRA.

Stable tidal channels, unless otherwise geologically restricted or subject to strong external influences such as input of sediments by other processes, have been shown to exhibit a well-defined relationship between the volume of tidal flow (tidal prism) and the cross-section area of the flow; a consequence of the fact that they tend to adjust their geometry until a certain equilibrium is achieved. A great many river entrance channels have been studied throughout the world and a number of stability expressions have been developed. The best known of these is that of O'Brien (1969), which is commonly adopted as follows:

$A = 0.91 \times 10^{-3} P^{0.85}$ [Equation 1]

Where A is the channel cross-section area below mid-tide level and P is the tidal prism volume between Mean High High Water and Mean Low Low Water (approximately Mean Spring Tide range).

Similar types of regime equilibrium expressions have been found to apply along the tidal reaches of estuaries. Using numerical models of various tidal streams in Eastern Australia, BMT has developed a clear equilibrium relationship that applies to a wide range of channel sizes. This relationship is given as:

$$A = 3.1 \times 10^{-3} P^{0.81} \quad \text{[Equation 2]}$$

The TUFLOW FV model results were used to determine the likely regime status of the channel to the west of the completed NLEP SRA, with a view to assessing the stability of the channel cross-section and its likely morphological development. The existing cross-section area below mean sea level at that transect was estimated to be 73 m^2 using the Digital Elevation Model that was developed for the Port of Gladstone model. The calibrated TUFLOW FV model indicates that the tidal prism for a Mean Spring Tide range (3.2 m) at a transect at the northern end of the channel will be approximately 724 x 10^3 m^3 following completion of Stage 1 construction. Inserting these values into the empirical stream equilibrium relationship provided (equation 2), the channel to the west of the proposed NLEP SRA is likely increase in cross-sectional area at its northern end, from approximately 73 m^2 to 173 m^2. It is not possible to use the empirical stream equilibrium relationship to determine whether the channel area will increase or decrease by widening or deepening, except where hard structures are expected to restrict the ability of the channel to widen. The NLEP SRA bund cross section has been designed with riprap protection on the outer side and toe embedment for scour protection. Since the deepest part of the channel will be adjacent to the new bund it is expected that if erosion does occur it is most likely to involve deepening of the channel adjacent to the bund.

However, since the tidal waters in the Western Basin are naturally highly turbid and the channel to the west of the NLEP SRA will be very well protected from wave activity, it is therefore possible that sediment will tend to accrete in the channel and the tidal prism will be reduced over time to restore the stream equilibrium relationship in an alternative way. It does appear that some net sediment accretion has occurred in the channel to the west of the existing reclamation area since it was constructed.

It is likely that the overall morphological response of the channel will be a combination of these two alternatives, with some deepening of the channel at the northern end and some accretion of sediment (reducing the tidal prism) at the southern end.

2.2 Impacts to Protected Matters

Protected Matters associated with the approval for this project include:

1. The following attributes of the Great Barrier Reef World Heritage Area Outstanding Universal Values:

   a. coral reefs (criteria vii, viii, ix, x)

   b. marine water quality (criteria ix, x)

   c. marine megafauna (criterion x) - Dugong, species of whales, species of dolphins, migratory whales

d. marine turtles (criteria vii and x) Green Turtle (Chelonia mydas), Flatback Turtle (Natator depressus); Loggerhead Turtle (Coretta caretta).

e. seagrass and macroalgae (criteria vii, ix and x) - seagrass meadows and beds of Halimeda algae

f. shorebirds and migratory seabirds, (criterion vii, ix, x) including threatened migratory shorebird species, shorebird habitat and important roost sites

g. flora, fauna and ecological communities (criteria vii, x, ix)

h. diversity supporting marine fauna species (criteria vii ix, x) coral reefs

i. total species diversity (criteria vii, ix, x).

2. The following listed threatened species:

a. Loggerhead Turtle (Coretta caretta) - endangered

b. Olive Ridley Turtle (Lepidochelys olivacea) - endangered

c. Flatback Turtle (Natator depressus) - vulnerable

d. Green Turtle (Chelonia mydas) -vulnerable

e. Hawksbill Turtle (Eretmochelys imbricata) - vulnerable

f. Water Mouse (Xeromys myoides) -vulnerable.

3. The following listed migratory species;

a. Eastern curlew (Numenius madagascariensis)

b. Australian humpback dolphin (Sousa sahulensis)

c. Dugong (Dugong dugon).

As discussed in Section 2.1, the changes to the hydrodynamic regime are minor in the context of the overall tidal hydrodynamics of the Port and no change in water quality or shoreline characteristics are expected. As a consequence, no impacts to Protected Matters are expected to occur.

3 Monitoring Plan

The monitoring program will be implemented to measure any observed impacts in the channel adjacent to the completed NLEP SRA and along the adjacent shoreline.

The most important method that will be used to assess morphological changes will be regular boat-based surveys of the channel to the west of the NLEP SRA and the mudflats to the north of the NLEP SRA. This will be supplemented by LiDAR or drone surveys of the shoreline to the west of the NLEP SRA. The proposed area to be surveyed is shown in Figure 3-1.

3.1 LiDAR and Boat-Based Survey Data

Bathymetric surveys of the channel to the west of the completed NLEP SRA and the mudflat to the north of the WBRA will be undertaken immediately following the completion of NLEP SRA construction, with a follow-up survey at three months post-construction, and then twice-yearly after that. The data from each survey will be analysed in a geographic information system to identify areas of accretion and areas of erosion, and to calculate the net change in seabed volume (the net amount of sediment lost or gained by the seabed). The surveys will be undertaken by a combination of shallow-draft boat-based soundings and LiDAR surveys. At the conclusion of an initial 2-year period a revised plan will be submitted as per condition 71 which will make recommendations for future monitoring based on whether morphological equilibrium has been reached or whether a consistent pattern of change is evident. Monitoring will continue on a 6-monthly basis until the revised plan is approved by the Minister in writing.

3.2 Shoreline Assessment Using LiDAR or Drone Survey

To assess the extent of any changes to the shoreline position and to the seabed elevation near the high tide mark, LiDAR or drone-based surveys will be undertaken immediately post-construction and at six-monthly intervals after that. At the conclusion of an initial 2-year period a revised plan will be submitted as per condition 71 which will make recommendations for future monitoring based on whether morphological equilibrium has been reached. Monitoring will continue on a 6-monthly basis until the revised plan is approved by the Minister in writing.

3.3 Performance Objectives and Reporting

A report outlining any initial changes observed following completion of the NLEP SRA construction will be provided within 6 months of the construction completion date and assess the likelihood and potential implications of future changes. The need for additional future reporting will be assessed at that time. Performance objectives are provided in Table 3-1.

Table 3-1 Performance Objectives

Monitoring Activity	Performance Objective
LiDAR and Boat-Based Survey	Demonstrate that the measured changes in bathymetry have not caused significant impacts to protected matters.
Shoreline Assessment Using LiDAR or Drone Survey	Demonstrate that the measured shoreline changes (if any) have not caused significant impacts to protected matters.

Proposed Survey Area

Title:

Proposed Survey Area Extent

Figure: 3-1

Rev: A

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A table summarising the actions that will be taken to ensure compliance with the requirements of the EPBC Approval (2012/6558) is provided in Table 3-2.

Table 3-2 Actions for Compliance with Condition 17

Condition No	Condition	Action
17	All monitoring plans and programs required under conditions 14, 15 and 16 must:	
17a	be designed and undertaken by a person suitably qualified to design and/or implement the specific plan or program and who is a suitably qualified person, such as a suitably qualified field ecologist, or a marine sediment expert.	The plan has been designed by Dr Paul Guard. Paul is a suitably qualified specialist for preparing the Hydrodynamic Changes Monitoring Plan.
17b	be submitted for the Minister's approval prior to the commencement of the relevant Project Stage;	The plan has been submitted to DCCEEW prior to commencement of Project Stage 1.
17c	include commitments for reporting to the **Department** the relevant findings and outcomes of monitoring, including performance against specified monitoring objectives, and procedures for undertaking periodic reviews of the effectiveness and appropriateness of the monitoring plan/program;	The Hydrodynamic Changes Monitoring Report will be submitted to DCCEEW post completion of all monitoring as required under Condition 17d. Updates on the progress of the monitoring will be included in the Annual Compliance Report.
17d	commit to submit completion reports to the **Department** within 6 months following the completion of each monitoring program (i.e. the completion of the monitoring in respect of the particular **Project Stage** which is the subject of the monitoring plan or program);	The Hydrodynamic Changes Monitoring Report for Project Stage 1 will be submitted to DCCEEW within six months of completion of the first two years of monitoring (which will continue until a revised plan is approved).
17e	inform relevant management plans required by this approval to adaptively manage and mitigate impacts to **protected matters;** and	This plan has been used to inform the development of the REMP, which is the relevant plan for managing and mitigating impacts. The final Hydrodynamic Changes Monitoring Report will provide better indication of hydrodynamic changes caused by bund construction activities which will inform future construction methodologies.
17f	be used to inform the development and delivery of environmental offsets for **protected matters.**	The final Hydrodynamic Changes Monitoring Report will provide details of any impacts to protected matters that would then be used to inform environmental offsets (however, such impacts are not expected to occur).

4 Conclusion

The construction of the NLEP SRA adjacent to the Western Basin Reclamation Area is not expected to cause significant changes to the hydrodynamics at the Port of Gladstone. Over time there is expected to be some morphological adjustment in the channel along the western edge of the NLEP SRA, which is likely to involve deepening of the channel at the northern end and accretion of sediment at the southern end.

A monitoring campaign will be undertaken to measure the morphological adjustment of the channel, and to check for any unexpected changes to the seabed elevation on the mudflat to the north of the NLEP SRA. In addition, the monitoring will detect any changes to shoreline position or changes near the high tide mark. The monitoring will involve regular surveys by boat and LiDAR/drone.

After two years of post-construction monitoring a revised monitoring plan will be produced as per condition 71 of the EPBC Approval (2012/6558) which will describe the observed changes with reference to the performance objectives in Section 3.3 and make recommendations for future monitoring based on whether morphological equilibrium has been reached. Monitoring will continue on a 6-monthly basis until the revised plan is approved by the Minister in writing.

5 References

BMT, 2020. Gladstone WBE Reclamation Long Term Impacts - Southern Cell Modelling Results. Technical memorandum prepared for Gladstone Ports Corporation, December 2020.

O'Brien, M. P., 1969. Equilibrium Flow Areas in Inlets on Sandy Coasts. Journal of the Waterways and Harbours Division. ASCE No. WW1, pp.43-52.

Appendix A Long Term Hydrodynamic Impact Assessment

Technical Memorandum

From:	Dr Paul Guard	To:	GPC
Date:	18 April 2024	CC:	
Subject:	NLEP SRA Long Term Impacts - Modelling Results		

Background

BMT was commissioned to undertake impact assessment modelling on behalf of Gladstone Ports Corporation (GPC) to characterise potential long-term environmental impacts of construction of the Northern Land Expansion Project Southern Reclamation Area (NLEP SRA) reclamation. In order to undertake this assessment, the model was run for a 1-month period for the existing conditions and the developed conditions, which allows characterisation of the changes in the hydrodynamics. The long-term adjustment of the seabed morphology to these changed hydrodynamic conditions can then be inferred.

Modelled Scenarios

A base case (existing conditions) and a developed case (completed NLEP SRA) were configured within the calibrated hydrodynamic model (TUFLOW FV) and wave model (SWAN). The model setup and validation results are described in the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project EIS, Appendix D (BMT, 2019)

Each simulation was run for the 30-day period 01/09/2014 – 01/10/2014, which is representative of typical conditions and includes spring tides with a large tidal range. The 30-day period is sufficiently long to characterise the change in the hydrodynamic conditions (allowing the resulting long term adjustment to the seabed morphology to be inferred). The alignment of the completed NLEP SRA bund is shown in Figure 1.

Bathymetry in the model was updated to include the March 2020 Western Basin Flats survey and the Clinton Vessel Interaction Project (CVIP) post-dredge survey.

Results and Discussion

Water Levels

The model results indicate that water levels throughout most of the Port are not affected by the construction of the additional reclamation area. Water level time series were extracted at the three locations shown in Figure 1. The time series are shown in Figure 2, and the only location showing any change in water levels after the construction of the southern cell of the NLEP SRA was Point 2, where there was a slight increase in the low tide level during spring tides (a maximum of a 40mm increase).

Current Velocities

The modelled changes to the depth-averaged current velocity during peak spring tides after completion of the NLEP SRA are shown in Figure 3 (ebb tide) and Figure 4 (flood tide). The results indicate increases of up to 0.5m/s to the west of the reclamation, larger on the flood tide than the ebb.

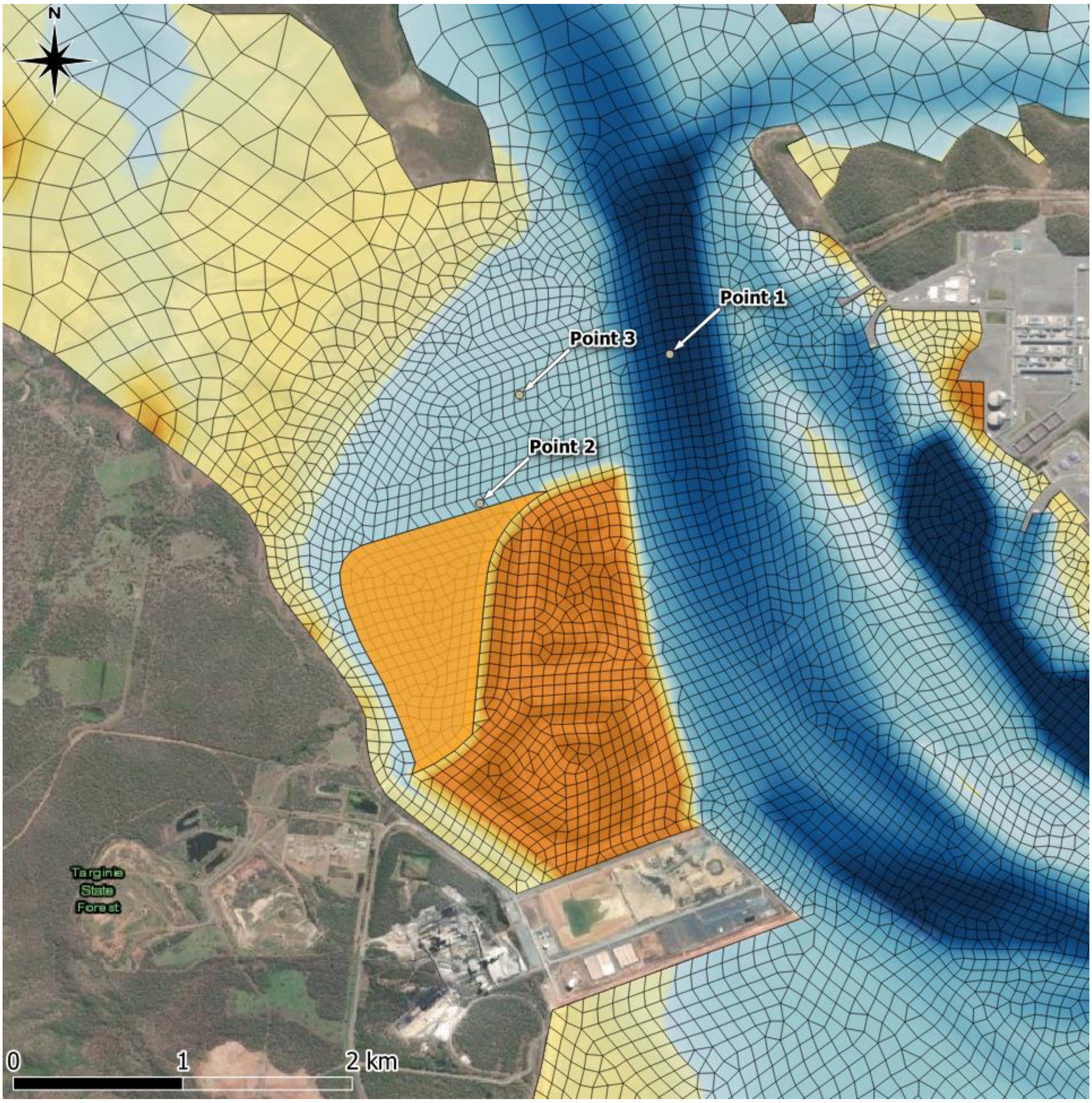

Figure 1 Modelled Scenario 1 Case and Water Level Time Series Output Locations

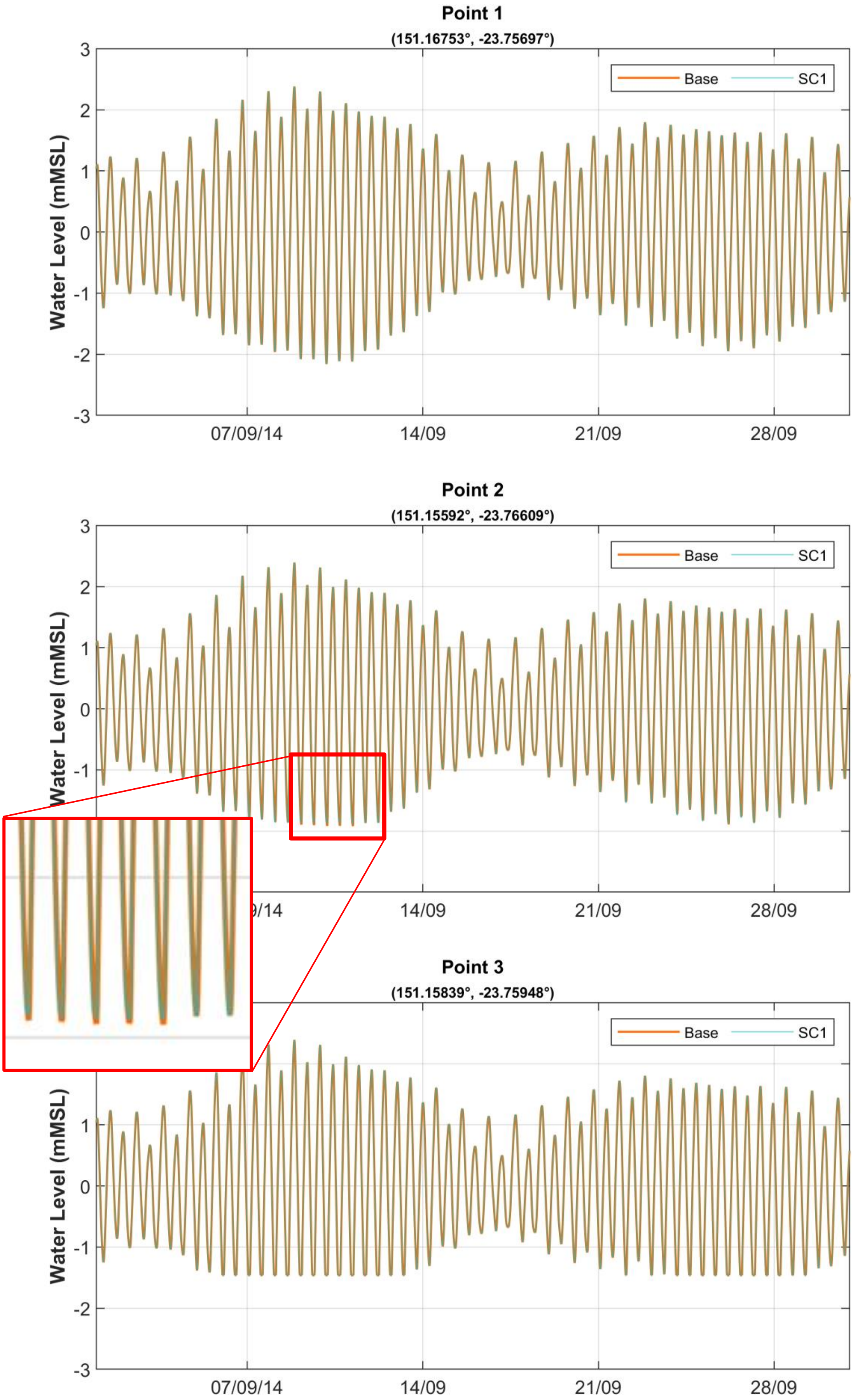

Figure 2 Water Level Time Series

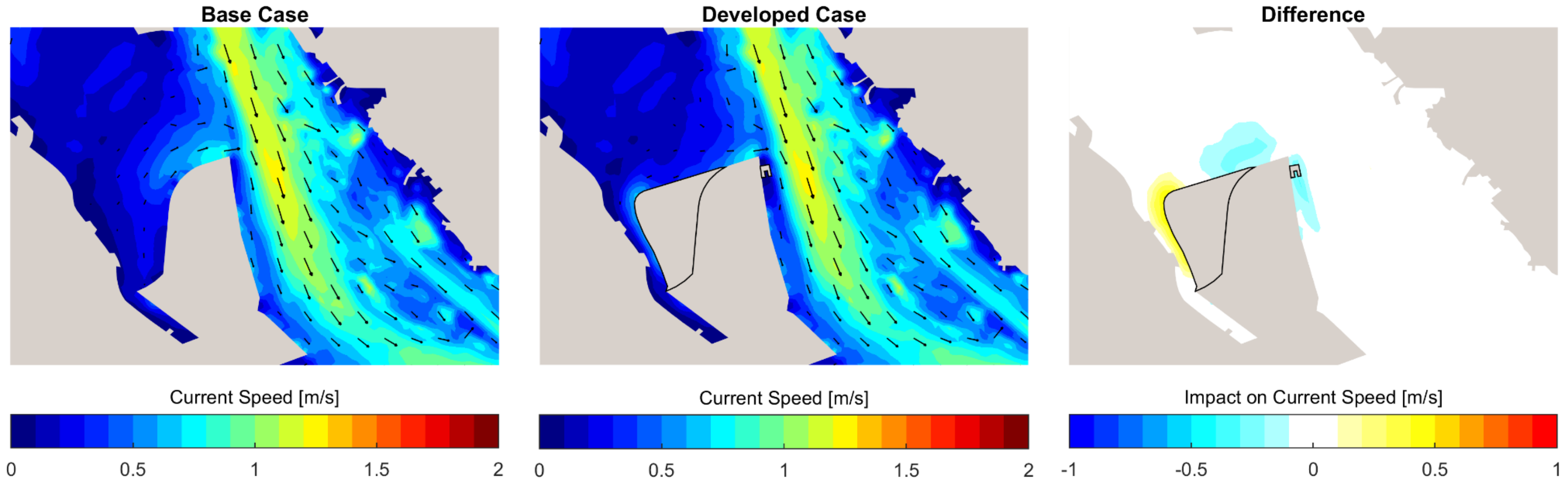

Figure 3 Ebb Tide Velocity Impacts (Spring Tidal Conditions)

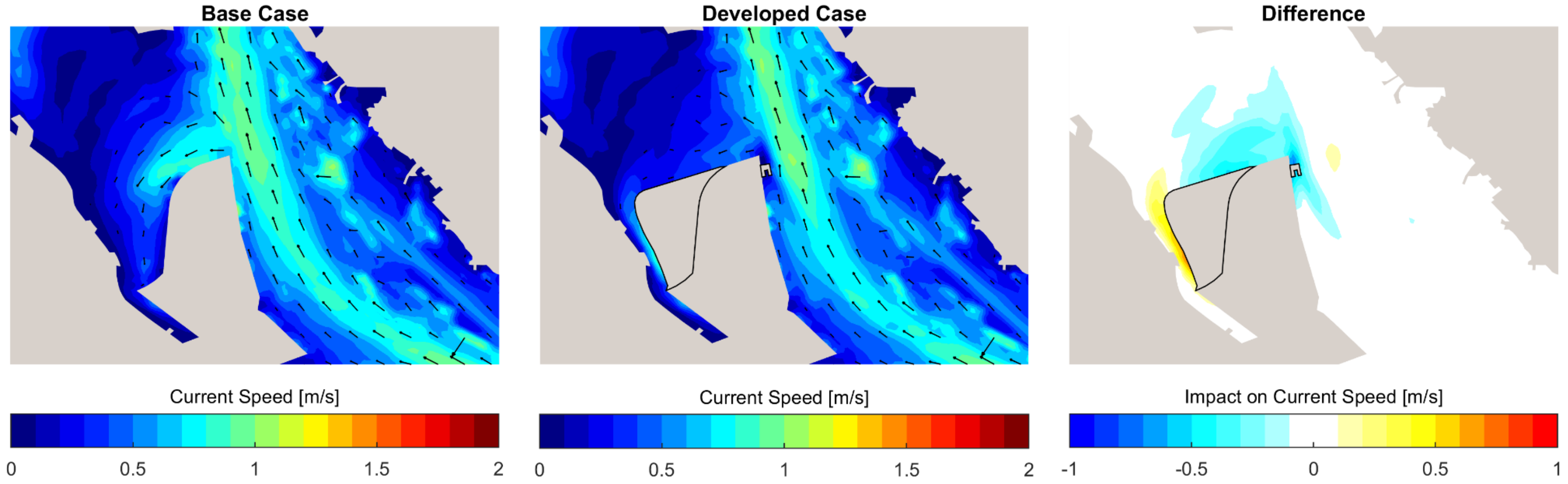

Figure 4 Flood Tide Velocity Impacts (Spring Tidal Conditions)

Potential Scour / Deposition

The model results were processed to estimate an approximate rate of change of bed elevation due to the change in hydrodynamics associated with construction of the NLEP SRA. The modelled rate of change of bed elevation (assuming an in-situ dry density of 1000kg/m^3) is provided in Figure 5. The model results indicate that scour in the channel to the west of the expanded reclamation could lead to a rate of bed elevation change of around 200mm/year. Over time, the morphology of the channel will adjust to the new hydrodynamic regime and the rate of scour/erosion will reduce (eventually reaching zero once a new equilibrium is reached). The model indicates no change in bed elevation along the mainland shoreline. The model results also indicate some accretion of sediment is likely in areas to the north of the expanded reclamation area.

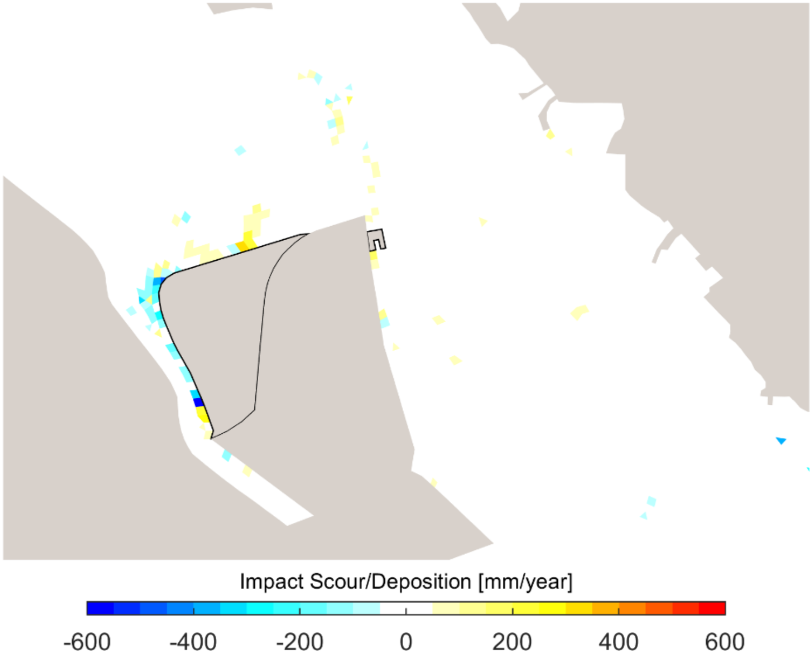

Figure 5 Modelled Rate of Bed Elevation Change (Scour / Deposition)

Extreme Water Levels

The construction of the NLEP SRA will not cause any increase in the water level during extreme events, since the geometry and bathymetry of the main port channels is unchanged.

Coastal Processes

The construction of the NLEP SRA will cause a reduction in wave energy to the west of the reclamation due to the shielding effect of the additional land area. However, modelling results indicate that the 95th percentile of the significant wave height is already below 0.1m in that area (see Figure 6). Therefore, further reduction in wave energy will not cause significant changes. Aerial photography of the area surrounding the existing reclamation area is shown in Figure 7.

The construction of the Western Basin reclamation area in 2011 did not lead to a major change in shoreline alignment or vegetation extent to the west of the reclamation area, as seen in Figure 7. The relationship of the SRA to the adjacent shoreline is similar because a channel of a similar width and tidal flow will be created between the new reclamation area and the mainland. Due to this similarity, it is expected that the construction of the SRA will also cause no changes to shoreline alignment and the extent of vegetation.

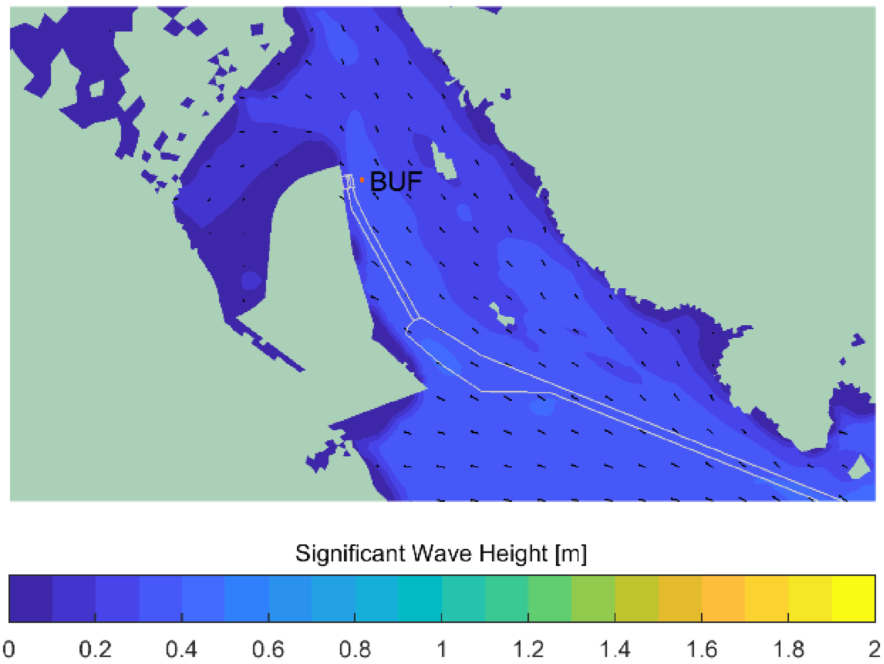

Figure 6 Modelled Typical Significant Wave Height – Existing Conditions

Figure 7 Aerial Photography – September 2003 (Top) and May 2016 (Bottom) The Western Basin Reclamation Bund was Completed in 2011

Conclusion

The numerical modelling results indicate that construction of the NLEP SRA will cause no changes to water levels throughout most of the Port and will cause changes to current velocities only in areas immediately adjacent to the reclamation area. The model results indicate that some deepening of the channel to the west of the NLEP SRA is likely. The construction of the NLEP SRA will have no effect on extreme water levels in the Port, and the effect on wave processes at the shoreline is limited because the incident wave energy is already very low. Analysis of aerial photography indicates that the construction of the existing Western Basin reclamation area has had no significant influence on the mainland shoreline alignment or vegetation, and the construction of the NLEP SRA is expected also to have no significant impact on the shoreline since it has a similar alignment relative to the shoreline. Table 1 summarises the modelling results and the expected changes.

Table 1 Summary of Modelling Results

Modelling Analysis	Expected Changes Based on Model Output
Water level changes	Up to 40mm increase in low tide levels immediately adjacent to the SRA
Current speed changes	Increases of up to 0.5m/s to the west of the reclamation, larger on the flood tide than the ebb.
Seabed morphology change	Modelled rate of bed elevation change of around 200mm/year (erosion) in parts of the channel to the west of the SRA.
Wave processes	The existing wave climate is very low energy (typical significant wave height less than 0.1m) so further reduction will not cause significant changes.

References

Aurecon, 2020. “CA19000217 – WBE reclamation area (southern area) and BUF detailed design – construction water quality impact modelling – BMT WBM scope of works”. Report prepared for Gladstone Ports Corporation, August 2020

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Final Audit Report 2024-07-07

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