Southern Reclamation Area Construction Fine-Grained Sediment Monitoring Plan

Customer	GPC
Project	A10422
Deliverable	006
Version	09
	11 April 2024

Document Control

Document Identification

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Classification	BMT (OFFICIAL)
Synopsis	An estimate of the likely release of fine sediment during construction of the Southern Reclamation Area and details of the proposed fine-grained sediment monitoring plan

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Reviewed By	Dr Ian Teakle
Project Manager	Dr Paul Guard

Amendment Record

The Amendment Record below records the history and issue status of this document.

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03	25 July 2022	GPC	Monitoring Plan
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Version	Version Date	Distribution	Record
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09	11 April 2024	GPC	Monitoring Plan

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In making this declaration, I am aware that section 491 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) makes it an offence in certain circumstances to knowingly provide false or misleading information or documents to specified persons who are known to be performing a duty or carrying out a function under the EPBC Act or the *Environment Protection and Biodiversity Conservation Regulations 2000* (Cth). The offence is punishable on conviction by imprisonment or a fine, or both. I am authorised to bind the approval holder to this declaration and tat I have no knowledge of that authorisation being revoked at the time of making this declaration.

Signed

RHaward

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 The Northern Land Expansion Project Southern Reclamation Area (Western Basin Expansion Southern Reclamation Area)

The approval conditions issued by the Department of Agriculture, Water and Environment (DAWE) require GPC to provide an estimate of the total amount of fine-grained sediment (FGS) that will be released to the marine environment due to construction, that was not previously available for resuspension. FGS is defined as sediment particles that are less than 15.6 micron in diameter. Specifically, the condition 14f of the EPBC Approval (2012/6558) must be satisfied:

14f. a Fine-grained Sediment Validation Monitoring Plan (FSVMP):
i. capable of accurately quantifying the amount of fine-grained sediment released or returned to the marine environment including from tailwater discharge and erosion as a result of each of Project Stage 1 and Project Stage 3 that was not available for resuspension before the commencement of each of Project Stage 1 and Project Stage 3;

ii. capable of accurately quantifying the amount of fine-grained sediment released or returned to the marine environment that was available for resuspension before the commencement of each of Project Stage 1 and Project Stage 3;

iii. which includes an assessment of the effectiveness of the methods specified in the FSVMP for monitoring and measuring fine-grained sediment releases and for validating the fine-grained sediment release and return modelling; and

iv. which includes the findings of a review undertaken by the Dredge Technical Reference Panel (DTRP) or other suitably qualified person prior to the FSVMP's submission to the Department, accompanied by details of how any recommendations from this review have been addressed in the FSVMP.

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 fine-grained sediment monitoring plan for that stage of construction will be conducted prior to commencement of that phase. Stage 3 will not commence until a revised Fine-grained Sediment Validation Monitoring Plan (FSVMP) 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:

- Provide an estimate of the likely amount of FGS not previously available for resuspension that will be released into the water column due to the construction of the SRA;
- Provide an estimate of the likely amount of FGS that is presently available for resuspension that will be released into the water column due to the construction of the SRA;
- Outline the proposed monitoring program which will be undertaken to measure and quantify the amount of FGS that is released due to the construction activities.

2 Fine-Grained Sediment Release Estimate

2.1 Seabed Sediment Characteristics

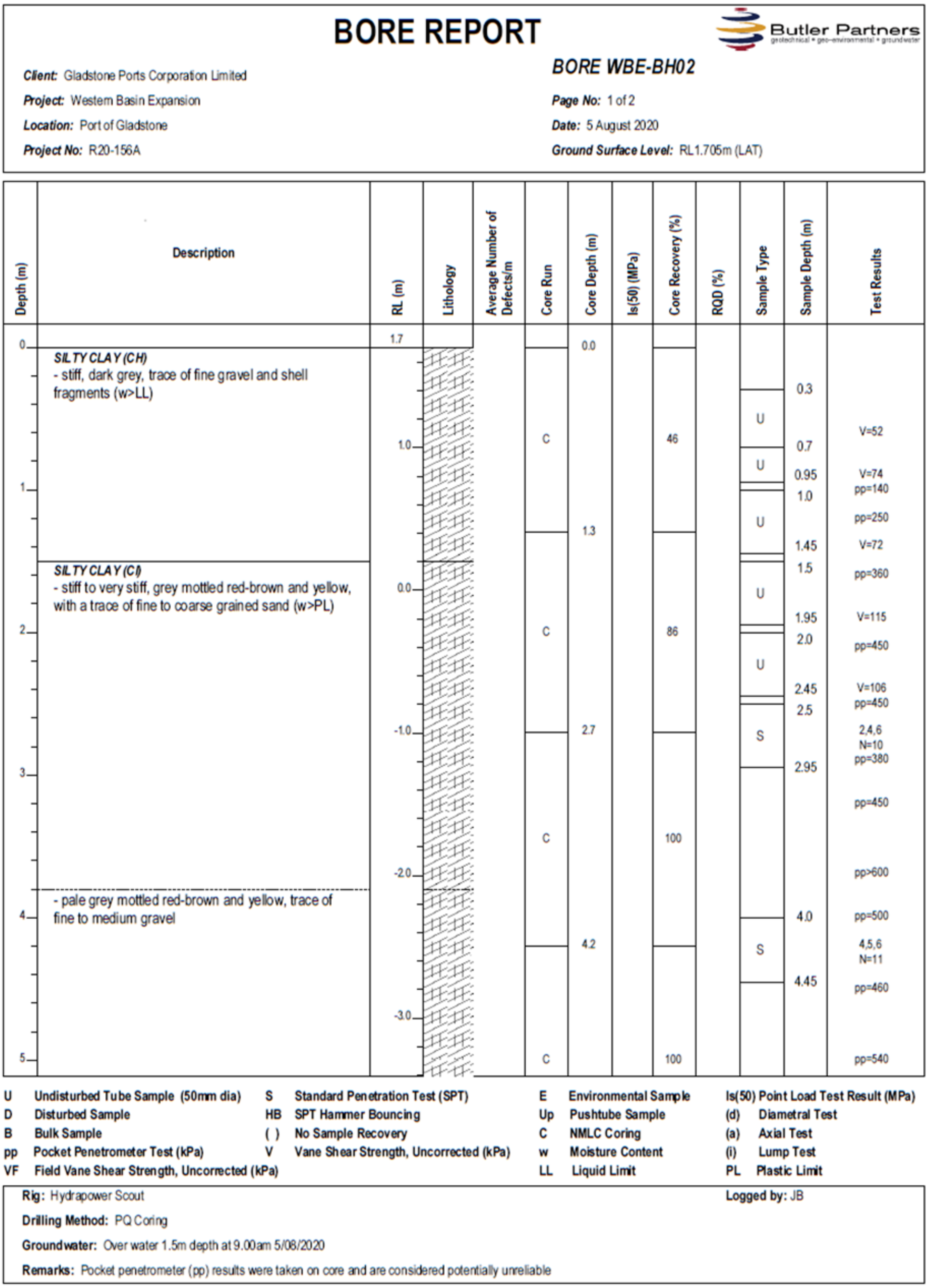
Borehole data was collected within the footprint of the SRA (boreholes WBE-BH02, WBE-BH04, WBE-BH10 and WBE-BH12 in Figure 2.1). The borehole reports for each of these locations are provided in Figure 2.2 to Figure 2.5.

Samples from as close as possible to the top of the sediment profile from each borehole were analysed to determine the particle size distribution (except WBE-BH04, because no material was available from the top 1 metre of the profile).

- WBE-BH02 – 0.7-1.0m depth
- WBE-BH10 – 0.9-1.1m depth
- WBE-BH12 – 1.0-1.5m depth

The particle size distribution data from each of those samples is provided in Figure 2.6, Figure 2.7 and Figure 2.8.

Figure 2.1 Borehole Locations



BORE REPORT

Butler Partners

BORE WBE-BH02

Client: Gladstone Ports Corporation Limited
Project: Western Basin Expansion
Location: Port of Gladstone
Project No: R20-156A

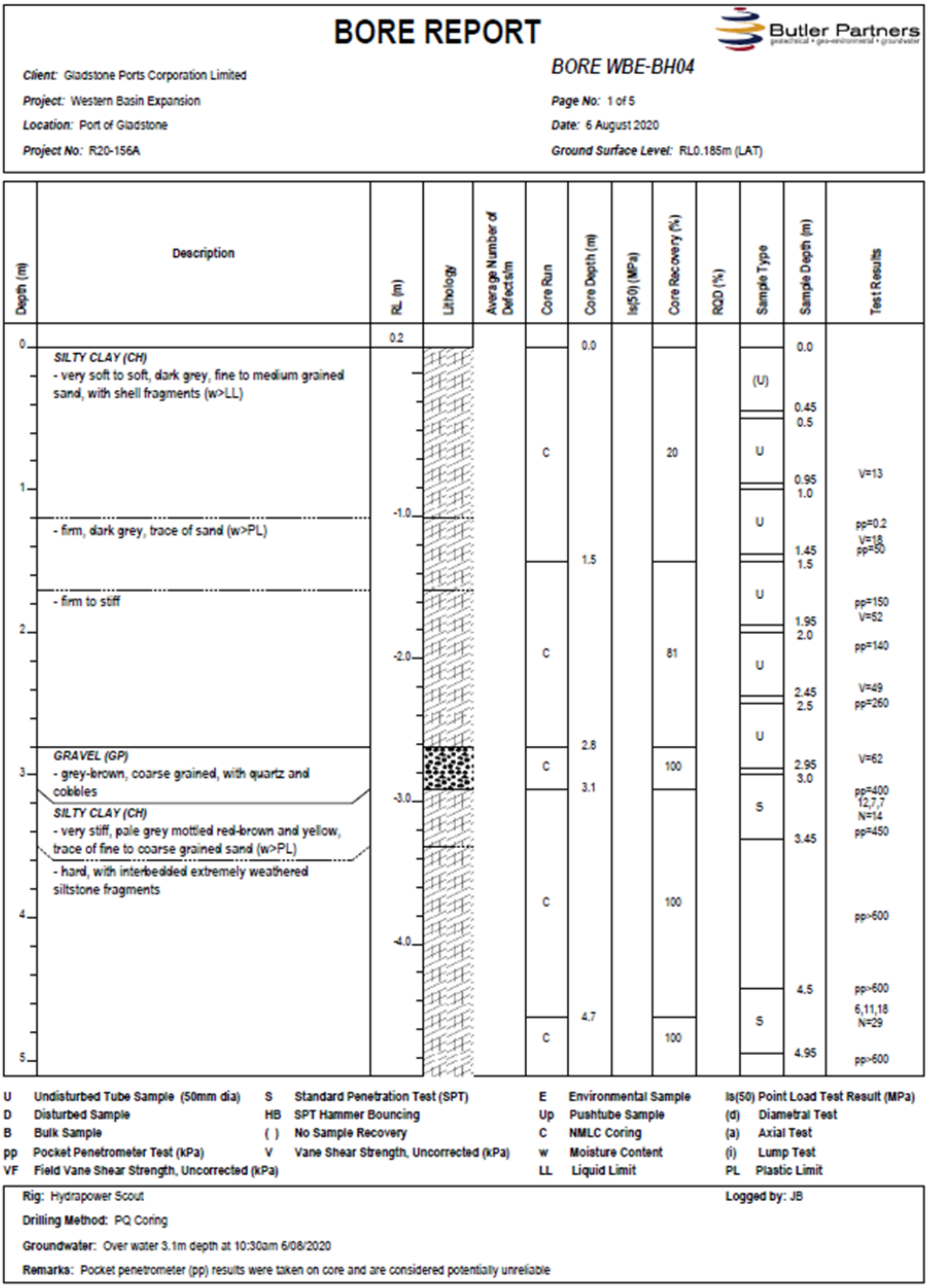
Page No: 1 of 2
Date: 5 August 2020
Ground Surface Level: RL1.705m (LAT)

Depth (m)	Description	RL (m)	Lithology	Average Number of Defects/m	Core Run	Core Depth (m)	Is(50) (MPa)	Core Recovery (%)	RQD (%)	Sample Type	Sample Depth (m)	Test Results
0		1.7				0.0						
	SILTY CLAY (CH) - stiff, dark grey, trace of fine gravel and shell fragments (w>LL)				C			46		U	0.3	V=52
		1.0								U	0.7	
1											0.95	V=74 pp=140
										U	1.0	pp=250
						1.3					1.45	V=72
	SILTY CLAY (CI) - stiff to very stiff, grey mottled red-brown and yellow, with a trace of fine to coarse grained sand (w>PL)	0.0			C			86		U	1.5	pp=360
2											1.95	V=115
										U	2.0	pp=450
											2.45	V=106 pp=450
		-1.0				2.7				S	2.5	2,4,6 N=10 pp=380
3											2.95	pp=450
					C			100				
		-2.0										pp>600
4	- pale grey mottled red-brown and yellow, trace of fine to medium gravel									S	4.0	pp=500
						4.2						4,5,6 N=11
		-3.0									4.45	pp=460
5					C			100				pp=540

U	**Undisturbed Tube Sample (50mm dia)**	**S**	**Standard Penetration Test (SPT)**	**E**	**Environmental Sample**	**Is(50)**	**Point Load Test Result (MPa)**
D	**Disturbed Sample**	**HB**	**SPT Hammer Bouncing**	**Up**	**Pushtube Sample**	**(d)**	**Diametral Test**
B	**Bulk Sample**	**( )**	**No Sample Recovery**	**C**	**NMLC Coring**	**(a)**	**Axial Test**
pp	**Pocket Penetrometer Test (kPa)**	**V**	**Vane Shear Strength, Uncorrected (kPa)**	**w**	**Moisture Content**	**(i)**	**Lump Test**
VF	**Field Vane Shear Strength, Uncorrected (kPa)**			**LL**	**Liquid Limit**	**PL**	**Plastic Limit**

Rig: Hydrapower Scout
Logged by: JB
Drilling Method: PQ Coring
Groundwater: Over water 1.5m depth at 9.00am 5/08/2020
Remarks: Pocket penetrometer (pp) results were taken on core and are considered potentially unreliable

Figure 2.2 Borehole Report WBE-BH02



BORE REPORT

Butler Partners
geotechnical • geo-environmental • groundwater

BORE WBE-BH04

Client: Gladstone Ports Corporation Limited
Project: Western Basin Expansion
Location: Port of Gladstone
Project No: R20-156A

Page No: 1 of 5
Date: 6 August 2020
Ground Surface Level: RL0.185m (LAT)

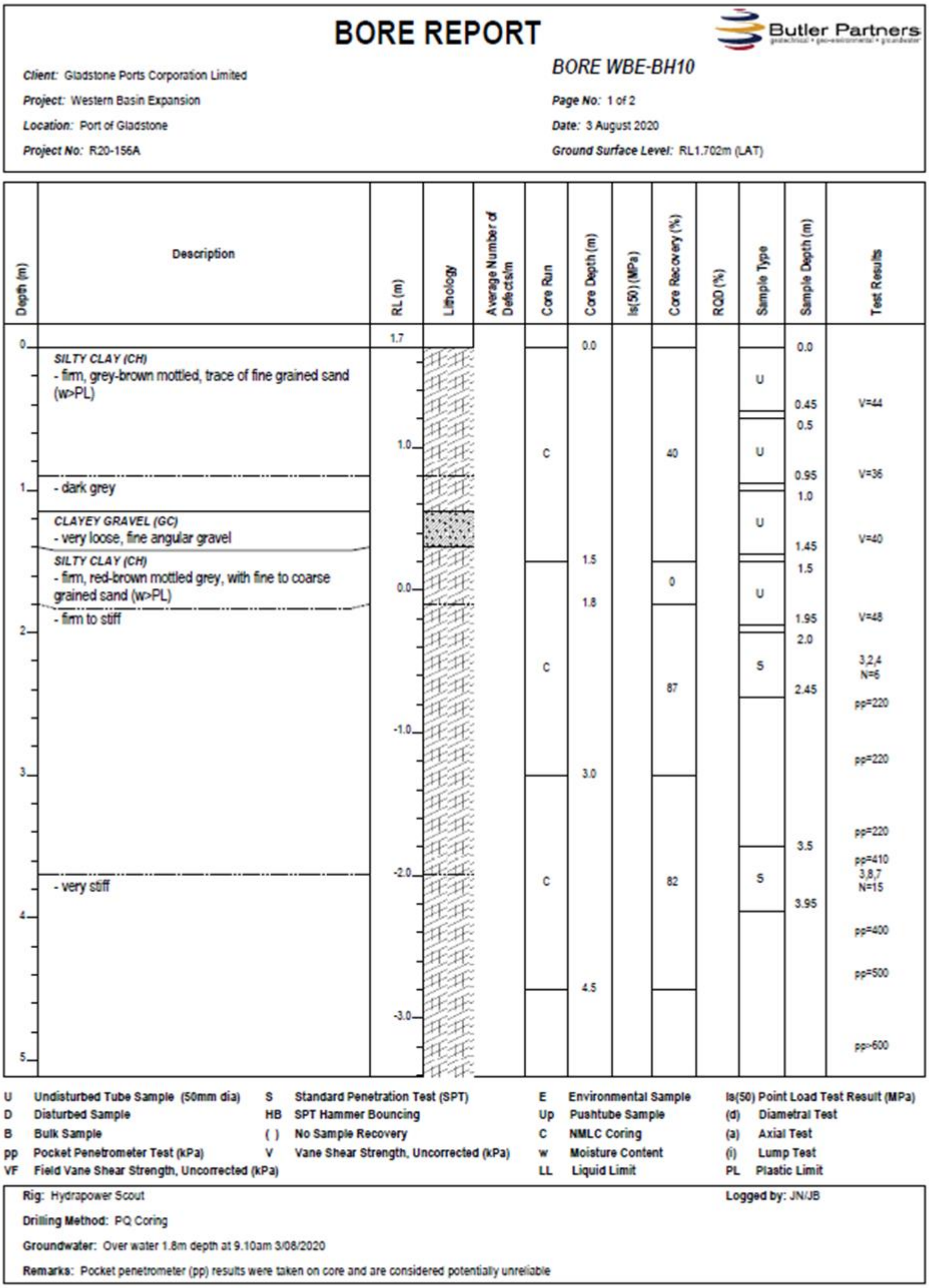
Depth (m)	Description	RL (m)	Lithology	Average Number of Defects/m	Core Run	Core Depth (m)	Is(50) (MPa)	Core Recovery (%)	RQD (%)	Sample Type	Sample Depth (m)	Test Results
0		0.2				0.0					0.0	
	SILTY CLAY (CH) - very soft to soft, dark grey, fine to medium grained sand, with shell fragments (w>LL)				C			20		(U)	0.45 0.5	
										U	0.95 1.0	V=13
1	- firm, dark grey, trace of sand (w>PL)	-1.0								U	1.45 1.5	pp=0.2 V=18 pp=50
	- firm to stiff				C	1.5		81		U	1.95 2.0	pp=150 V=52
2		-2.0								U	2.45 2.5	pp=140 V=49 pp=260
										U	2.95 3.0	V=62
3	***GRAVEL (GP)*** - grey-brown, coarse grained, with quartz and cobbles				C	2.8		100				
	SILTY CLAY (CH) - very stiff, pale grey mottled red-brown and yellow, trace of fine to coarse grained sand (w>PL)	-3.0			C	3.1		100		S	3.45	pp=400 12,7,7 N=14 pp=450
4	- hard, with interbedded extremely weathered siltstone fragments	-4.0									4.5	pp>600 pp>600
					C	4.7		100		S	4.95	6,11,18 N=29 pp>600
5												

U	Undisturbed Tube Sample (50mm dia)	S	Standard Penetration Test (SPT)	E	Environmental Sample	Is(50)	Point Load Test Result (MPa)
D	Disturbed Sample	HB	SPT Hammer Bouncing	Up	Pushtube Sample	(d)	Diametral Test
B	Bulk Sample	( )	No Sample Recovery	C	NMLC Coring	(a)	Axial Test
pp	Pocket Penetrometer Test (kPa)	V	Vane Shear Strength, Uncorrected (kPa)	w	Moisture Content	(i)	Lump Test
VF	Field Vane Shear Strength, Uncorrected (kPa)			LL	Liquid Limit	PL	Plastic Limit

Rig: Hydrapower Scout
Drilling Method: PQ Coring
Groundwater: Over water 3.1m depth at 10:30am 6/08/2020
Remarks: Pocket penetrometer (pp) results were taken on core and are considered potentially unreliable

Logged by: JB

Figure 2.3 Borehole Report WBE-BH04



BORE REPORT

Butler Partners

BORE WBE-BH10

Client: Gladstone Ports Corporation Limited
Project: Western Basin Expansion
Location: Port of Gladstone
Project No: R20-156A

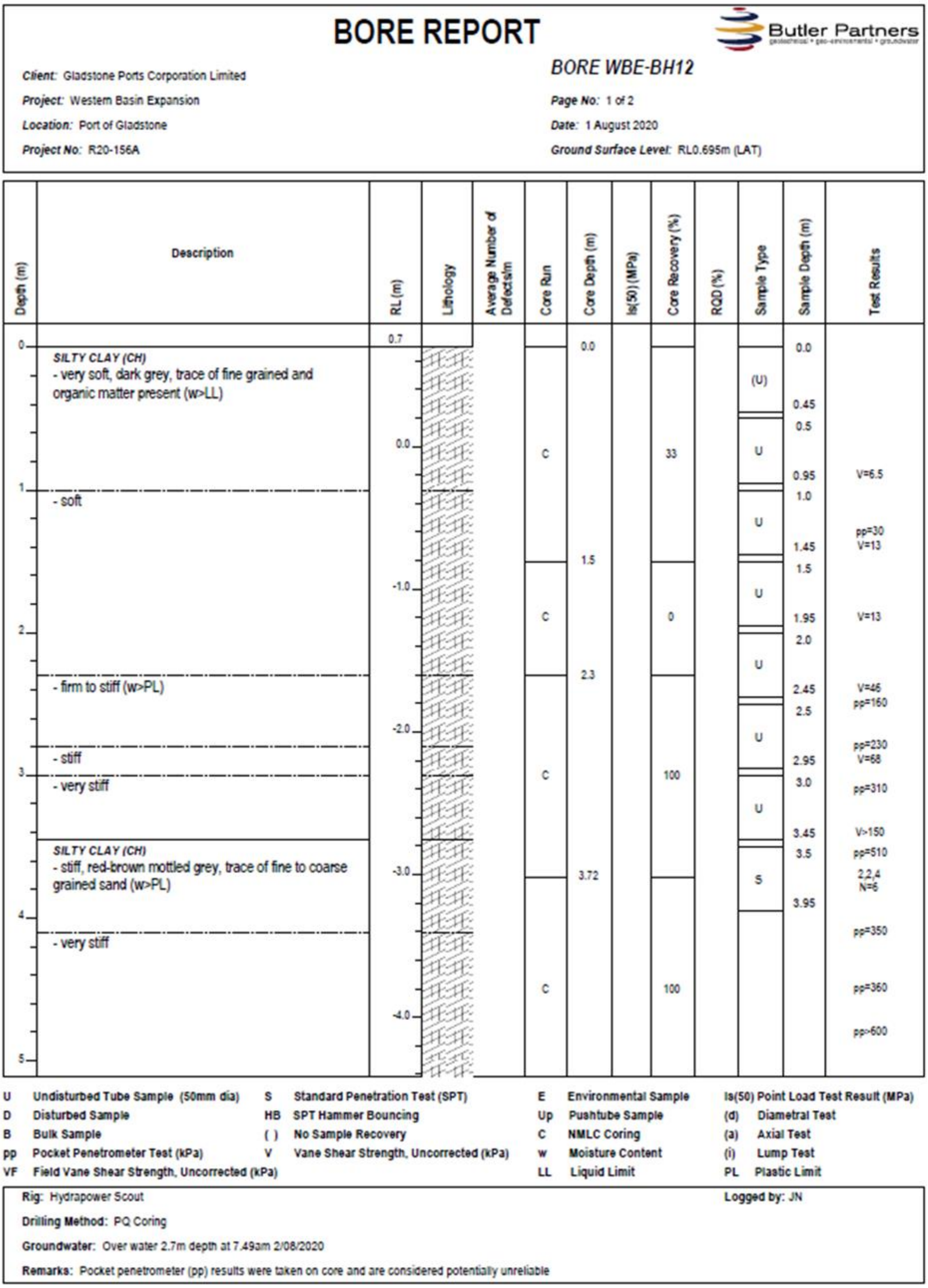
Page No: 1 of 2
Date: 3 August 2020
Ground Surface Level: RL1.702m (LAT)

Depth (m)	Description	RL (m)	Lithology	Average Number of Defects/m	Core Run	Core Depth (m)	Is(50) (MPa)	Core Recovery (%)	RQD (%)	Sample Type	Sample Depth (m)	Test Results
0		1.7				0.0					0.0	
	SILTY CLAY (CH) - firm, grey-brown mottled, trace of fine grained sand (w>PL)									U		
											0.45 0.5	V=44
		1.0			C			40		U		
											0.95	V=36
1	- dark grey										1.0	
	CLAYEY GRAVEL (GC) - very loose, fine angular gravel									U		
											1.45	V=40
	SILTY CLAY (CH) - firm, red-brown mottled grey, with fine to coarse grained sand (w>PL)					1.5		0			1.5	
		0.0								U		
	- firm to stiff					1.8						
											1.95	V=48
2											2.0	
					C					S		3,2,4 N=6
								87			2.45	pp=220
		-1.0										pp=220
3						3.0						
												pp=220
											3.5	
	- very stiff	-2.0			C			82		S		pp=410 3,8,7 N=15
											3.95	
4												pp=400
												pp=500
						4.5						
		-3.0										
5												pp>600

U	Undisturbed Tube Sample (50mm dia)	S	Standard Penetration Test (SPT)	E	Environmental Sample	Is(50)	Point Load Test Result (MPa)
D	Disturbed Sample	HB	SPT Hammer Bouncing	Up	Pushtube Sample	(d)	Diametral Test
B	Bulk Sample	( )	No Sample Recovery	C	NMLC Coring	(a)	Axial Test
pp	Pocket Penetrometer Test (kPa)	V	Vane Shear Strength, Uncorrected (kPa)	w	Moisture Content	(i)	Lump Test
VF	Field Vane Shear Strength, Uncorrected (kPa)			LL	Liquid Limit	PL	Plastic Limit

Rig: Hydrapower Scout
Logged by: JN/JB
Drilling Method: PQ Coring
Groundwater: Over water 1.8m depth at 9.10am 3/08/2020
Remarks: Pocket penetrometer (pp) results were taken on core and are considered potentially unreliable

Figure 2.4 Borehole Report WBE-BH10



BORE REPORT

Butler Partners

BORE WBE-BH12

Client: Gladstone Ports Corporation Limited
Project: Western Basin Expansion
Location: Port of Gladstone
Project No: R20-156A

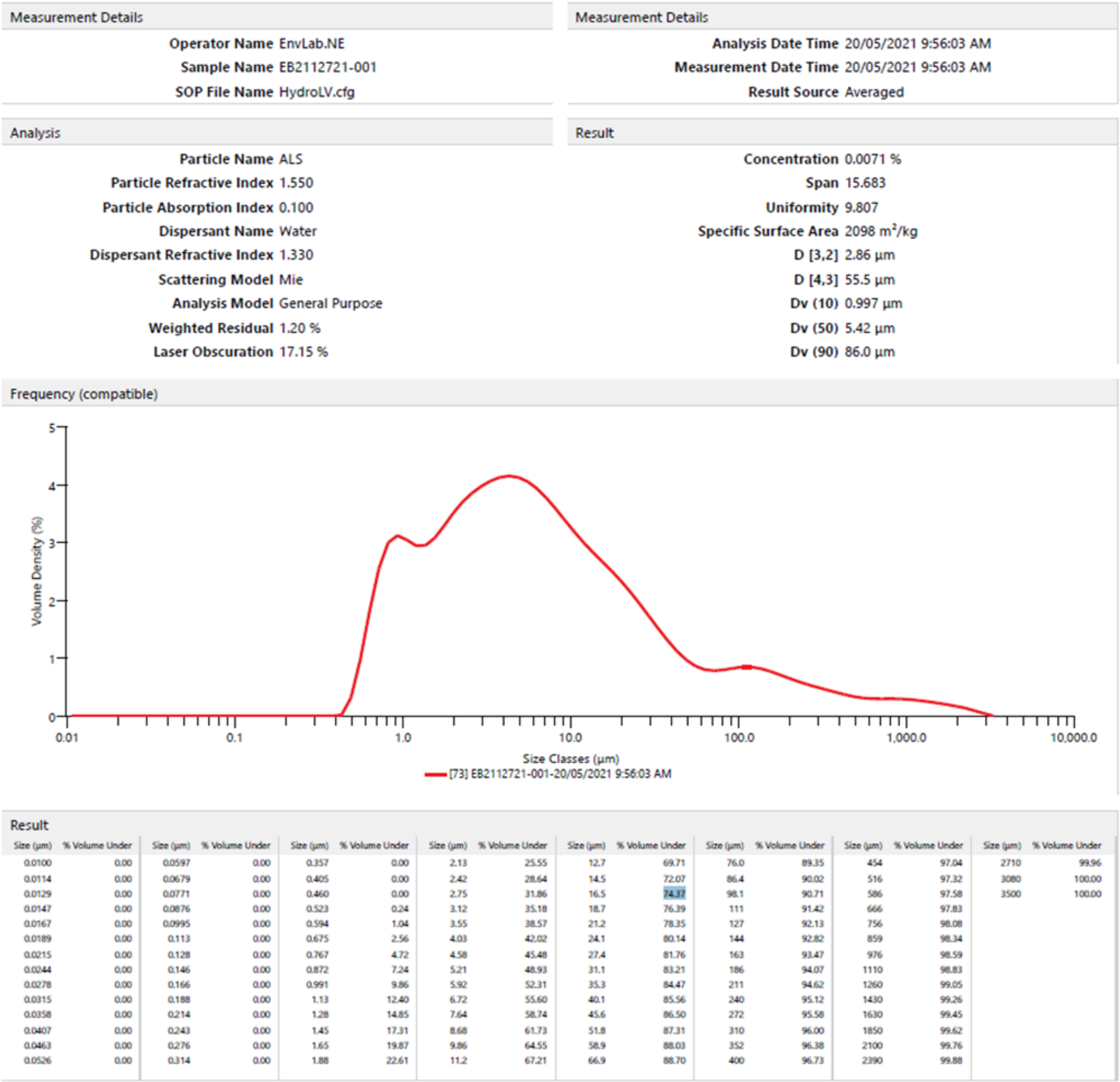
Page No: 1 of 2
Date: 1 August 2020
Ground Surface Level: RL0.695m (LAT)

Depth (m)	Description	RL (m)	Lithology	Average Number of Defects/m	Core Run	Core Depth (m)	Is(50) (MPa)	Core Recovery (%)	RQD (%)	Sample Type	Sample Depth (m)	Test Results
0	***SILTY CLAY (CH)*** - very soft, dark grey, trace of fine grained and organic matter present (w>LL)	0.7			C	0.0		33		(U)	0.0 0.45	
		0.0								U	0.5 0.95	V=6.5
1	- soft									U	1.0 1.45	pp=30 V=13
		-1.0			C	1.5		0		U	1.5 1.95	V=13
2										U	2.0 2.45	V=46 pp=160
	- firm to stiff (w>PL)	-2.0			C	2.3		100		U	2.5 2.95	pp=230 V=68
	- stiff											
3	- very stiff									U	3.0 3.45	pp=310 V>150
	SILTY CLAY (CH) - stiff, red-brown mottled grey, trace of fine to coarse grained sand (w>PL)	-3.0								S	3.5 3.95	pp=510 2,2,4 N=6
4	- very stiff	-4.0			C	3.72		100				pp=350 pp=360 pp>600
5												

U	**Undisturbed Tube Sample (50mm dia)**	**S**	**Standard Penetration Test (SPT)**	**E**	**Environmental Sample**	**Is(50)**	**Point Load Test Result (MPa)**
D	**Disturbed Sample**	**HB**	**SPT Hammer Bouncing**	**Up**	**Pushtube Sample**	**(d)**	**Diametral Test**
B	**Bulk Sample**	**( )**	**No Sample Recovery**	**C**	**NMLC Coring**	**(a)**	**Axial Test**
pp	**Pocket Penetrometer Test (kPa)**	**V**	**Vane Shear Strength, Uncorrected (kPa)**	**w**	**Moisture Content**	**(i)**	**Lump Test**
VF	**Field Vane Shear Strength, Uncorrected (kPa)**			**LL**	**Liquid Limit**	**PL**	**Plastic Limit**

Rig: Hydrapower Scout
Logged by: JN
Drilling Method: PQ Coring
Groundwater: Over water 2.7m depth at 7.49am 2/08/2020
Remarks: Pocket penetrometer (pp) results were taken on core and are considered potentially unreliable

Figure 2.5 Borehole Report WBE-BH12



Measurement Details

Operator Name	EnvLab.NE
Sample Name	EB2112721-001
SOP File Name	HydroLV.cfg

Measurement Details

Analysis Date Time	20/05/2021 9:56:03 AM
Measurement Date Time	20/05/2021 9:56:03 AM
Result Source	Averaged

Analysis

Particle Name	ALS
Particle Refractive Index	1.550
Particle Absorption Index	0.100
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	1.20 %
Laser Obscuration	17.15 %

Result

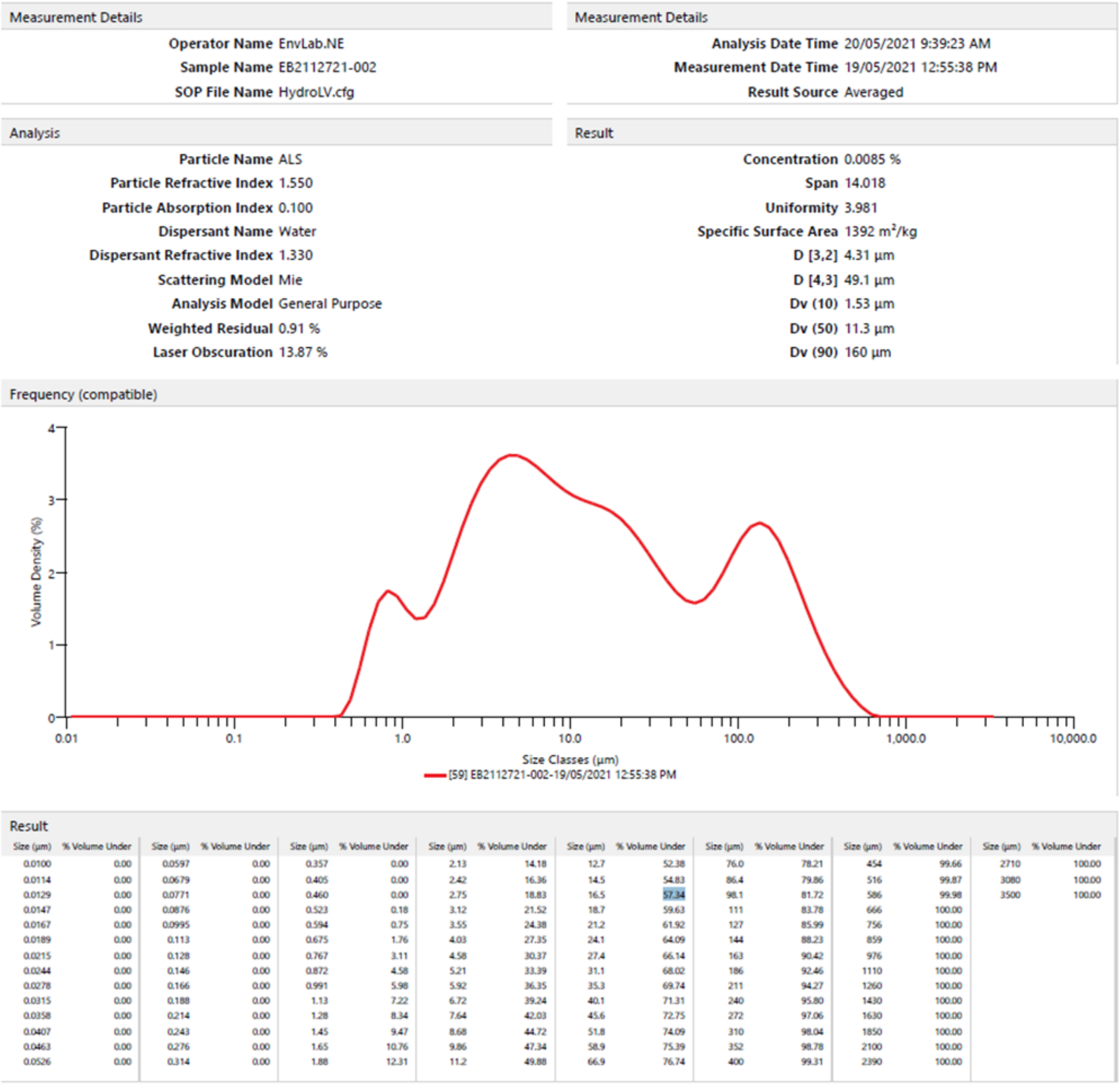
Concentration	0.0071 %
Span	15.683
Uniformity	9.807
Specific Surface Area	2098 m²/kg
D [3,2]	2.86 µm
D [4,3]	55.5 µm
Dv (10)	0.997 µm
Dv (50)	5.42 µm
Dv (90)	86.0 µm

Frequency (compatible)

Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0100	0.00	0.0597	0.00	0.357	0.00	2.13	25.55	12.7	69.71	76.0	89.35	454	97.04	2710	99.96
0.0114	0.00	0.0679	0.00	0.405	0.00	2.42	28.64	14.5	72.07	86.4	90.02	516	97.32	3080	100.00
0.0129	0.00	0.0771	0.00	0.460	0.00	2.75	31.86	16.5	74.37	98.1	90.71	586	97.58	3500	100.00
0.0147	0.00	0.0876	0.00	0.523	0.24	3.12	35.18	18.7	76.39	111	91.42	666	97.83		
0.0167	0.00	0.0995	0.00	0.594	1.04	3.55	38.57	21.2	78.35	127	92.13	756	98.08		
0.0189	0.00	0.113	0.00	0.675	2.56	4.03	42.02	24.1	80.14	144	92.82	859	98.34		
0.0215	0.00	0.128	0.00	0.767	4.72	4.58	45.48	27.4	81.76	163	93.47	976	98.59		
0.0244	0.00	0.146	0.00	0.872	7.24	5.21	48.93	31.1	83.21	186	94.07	1110	98.83		
0.0278	0.00	0.166	0.00	0.991	9.86	5.92	52.31	35.3	84.47	211	94.62	1260	99.05		
0.0315	0.00	0.188	0.00	1.13	12.40	6.72	55.60	40.1	85.56	240	95.12	1430	99.26		
0.0358	0.00	0.214	0.00	1.28	14.85	7.64	58.74	45.6	86.50	272	95.58	1630	99.45		
0.0407	0.00	0.243	0.00	1.45	17.31	8.68	61.73	51.8	87.31	310	96.00	1850	99.62		
0.0463	0.00	0.276	0.00	1.65	19.87	9.86	64.55	58.9	88.03	352	96.38	2100	99.76		
0.0526	0.00	0.314	0.00	1.88	22.61	11.2	67.21	66.9	88.70	400	96.73	2390	99.88		

Figure 2.6 PSD Analysis for Borehole WBE-BH02 (Depth of Sample 0.7-1.0m)



Measurement Details

Operator Name EnvLab.NE
Sample Name EB2112721-002
SOP File Name HydroLV.cfg

Measurement Details

Analysis Date Time 20/05/2021 9:39:23 AM
Measurement Date Time 19/05/2021 12:55:38 PM
Result Source Averaged

Analysis

Particle Name ALS
Particle Refractive Index 1.550
Particle Absorption Index 0.100
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.91 %
Laser Obscuration 13.87 %

Result

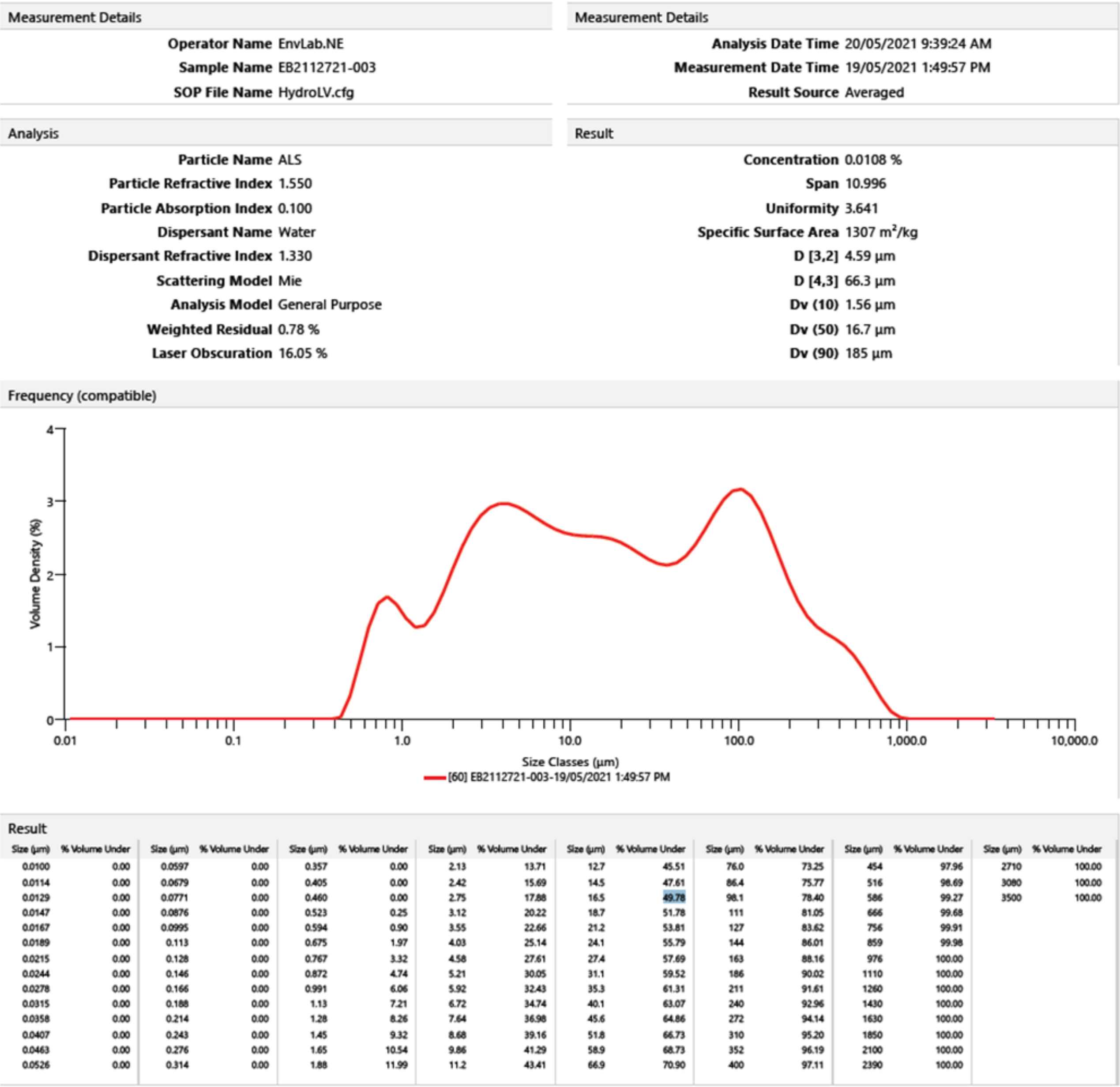
Concentration 0.0085 %
Span 14.018
Uniformity 3.981
Specific Surface Area 1392 m²/kg
D [3,2] 4.31 µm
D [4,3] 49.1 µm
Dv (10) 1.53 µm
Dv (50) 11.3 µm
Dv (90) 160 µm

Frequency (compatible)

Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0100	0.00	0.0597	0.00	0.357	0.00	2.13	14.18	12.7	52.38	76.0	78.21	454	99.66	2710	100.00
0.0114	0.00	0.0679	0.00	0.405	0.00	2.42	16.36	14.5	54.83	86.4	79.86	516	99.87	3080	100.00
0.0129	0.00	0.0771	0.00	0.460	0.00	2.75	18.83	16.5	57.34	98.1	81.72	586	99.98	3500	100.00
0.0147	0.00	0.0876	0.00	0.523	0.18	3.12	21.52	18.7	59.63	111	83.78	666	100.00		
0.0167	0.00	0.0995	0.00	0.594	0.75	3.55	24.38	21.2	61.92	127	85.99	756	100.00		
0.0189	0.00	0.113	0.00	0.675	1.76	4.03	27.35	24.1	64.09	144	88.23	859	100.00		
0.0215	0.00	0.128	0.00	0.767	3.11	4.58	30.37	27.4	66.14	163	90.42	976	100.00		
0.0244	0.00	0.146	0.00	0.872	4.58	5.21	33.39	31.1	68.02	186	92.46	1110	100.00		
0.0278	0.00	0.166	0.00	0.991	5.98	5.92	36.35	35.3	69.74	211	94.27	1260	100.00		
0.0315	0.00	0.188	0.00	1.13	7.22	6.72	39.24	40.1	71.31	240	95.80	1430	100.00		
0.0358	0.00	0.214	0.00	1.28	8.34	7.64	42.03	45.6	72.75	272	97.06	1630	100.00		
0.0407	0.00	0.243	0.00	1.45	9.47	8.68	44.72	51.8	74.09	310	98.04	1850	100.00		
0.0463	0.00	0.276	0.00	1.65	10.76	9.86	47.34	58.9	75.39	352	98.78	2100	100.00		
0.0526	0.00	0.314	0.00	1.88	12.31	11.2	49.88	66.9	76.74	400	99.31	2390	100.00		

Figure 2.7 PSD Analysis for Borehole WBE-BH10 (Depth of Sample 0.9-1.1m)



Measurement Details

Operator Name EnvLab.NE
Sample Name EB2112721-003
SOP File Name HydroLV.cfg

Measurement Details

Analysis Date Time 20/05/2021 9:39:24 AM
Measurement Date Time 19/05/2021 1:49:57 PM
Result Source Averaged

Analysis

Particle Name ALS
Particle Refractive Index 1.550
Particle Absorption Index 0.100
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.78 %
Laser Obscuration 16.05 %

Result

Concentration 0.0108 %
Span 10.996
Uniformity 3.641
Specific Surface Area 1307 m^2/kg
D [3,2] 4.59 µm
D [4,3] 66.3 µm
Dv (10) 1.56 µm
Dv (50) 16.7 µm
Dv (90) 185 µm

Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0100	0.00	0.0597	0.00	0.357	0.00	2.13	13.71	12.7	45.51	76.0	73.25	454	97.96	2710	100.00
0.0114	0.00	0.0679	0.00	0.405	0.00	2.42	15.69	14.5	47.61	86.4	75.77	516	98.69	3080	100.00
0.0129	0.00	0.0771	0.00	0.460	0.00	2.75	17.88	16.5	49.78	98.1	78.40	586	99.27	3500	100.00
0.0147	0.00	0.0876	0.00	0.523	0.25	3.12	20.22	18.7	51.78	111	81.05	666	99.68		
0.0167	0.00	0.0995	0.00	0.594	0.90	3.55	22.66	21.2	53.81	127	83.62	756	99.91		
0.0189	0.00	0.113	0.00	0.675	1.97	4.03	25.14	24.1	55.79	144	86.01	859	99.98		
0.0215	0.00	0.128	0.00	0.767	3.32	4.58	27.61	27.4	57.69	163	88.16	976	100.00		
0.0244	0.00	0.146	0.00	0.872	4.74	5.21	30.05	31.1	59.52	186	90.02	1110	100.00		
0.0278	0.00	0.166	0.00	0.991	6.06	5.92	32.43	35.3	61.31	211	91.61	1260	100.00		
0.0315	0.00	0.188	0.00	1.13	7.21	6.72	34.74	40.1	63.07	240	92.96	1430	100.00		
0.0358	0.00	0.214	0.00	1.28	8.26	7.64	36.98	45.6	64.86	272	94.14	1630	100.00		
0.0407	0.00	0.243	0.00	1.45	9.32	8.68	39.16	51.8	66.73	310	95.20	1850	100.00		
0.0463	0.00	0.276	0.00	1.65	10.54	9.86	41.29	58.9	68.73	352	96.19	2100	100.00		
0.0526	0.00	0.314	0.00	1.88	11.99	11.2	43.41	66.9	70.90	400	97.11	2390	100.00		

Figure 2.8 PSD Analysis for Borehole WBE-BH12 (Depth of Sample 1.0-1.5m)

The percentage of each borehole sample that was finer than 15.6 micron is provided in Table 2.1.

Table 2.1 Percentage of Fine-Grained Sediment in SRA Boreholes

Borehole	Percentage of sample less than 15.6 micron
WBE-BH02	74
WBE-BH10	57
WBE-BH12	50

2.2 Overall Impact of the SRA on Sediment Resuspension

The completion of the SRA will result in the reclamation of approximately 108 hectares of intertidal seabed that is presently exposed to tidal currents and wave action. The sediment that comprises the seabed in this area is presently available for resuspension, and will not be available for resuspension following completion of the SRA, since the constructed bund will include two geotextile fabric layers which will prevent the transport of sediment from the SRA to the estuary. Therefore, the construction of the SRA will have the net effect of reducing the overall amount of sediment available for resuspension in the sedimentary system.

The borehole data at location WBE-BH04 and also at WBE-BH12 within the SRA footprint (see Figure 2.5) shows that the top one metre of the sedimentary profile is very soft material, and therefore could possibly be resuspended in the event of cyclonic wind and wave conditions combined with spring tidal currents. If it is assumed that the top one metre of sediment is currently available for resuspension, the total amount of sediment currently available for resuspension that will be removed from the active system would be approximately 1,080,000 tonnes (area 1,080,000m^2 x 1 metre depth x 1 tonne/m^3 dry density). The material in the top one metre of the profiles at WBE-BH02 and WBE-BH10 is described as firm/stiff clay, but since these boreholes are closer to the shoreline and outside the reclamation footprint they are less representative of the typical material near the surface within the reclamation footprint than the other two boreholes. In any case, if conditions were extreme it is expected that the top one metre of material in those locations could still be subject to erosion.

2.3 The Amount of Fine-Grained Sediment Released to the Marine Environment Due to Construction of the SRA.

2.3.1 Fine-Grained Sediment Not Previously Available for Resuspension

No material with particles finer than 15.6 micron in diameter will be used in the construction of the new SRA perimeter bund wall. The finest-grained component of the construction material is fine sand, which will be composed of sediment grains larger than 75 microns in diameter.

Any existing seabed material that is displaced or relocated during construction will be soft surface material that is already available for resuspension (see Figure 2.5– surface layers are very soft material).

Therefore, construction of the SRA will not result in the release of any fine-grained sediment (less than 15.6 micron) that was not already available for resuspension.

2.3.2 Fine-Grained Sediment Previously Available for Resuspension

The proposed construction methodology for the new bund along the perimeter of the SRA involves placement of rock on the existing seabed, with displacement of overlying soft sediment so that the rock foundation sits on a stiff clay foundation. No sediment will be removed prior to placement of rock. In areas affected by paleo channels, it is anticipated that the foundation of the placed rock may sit at between -1 m and -3.5 m LAT (see Figure 2.9).

The placement of the rock and the displacement of the underlying soft sediment is expected to release fine sediment into the water column at the following rates during the placement of rock material (Aurecon, 2020):

- Rock placement on marine sediment source rate: 0.48 kg/s
- Mud wave source rate: 0.3 kg/s

The rock placement generation term is an estimate of the amount of sediment immediately released into the water column due to placement of rock, while the mud wave source term refers to subsequent release of sediment from the 'mud wave', which is sediment that is displaced by the rock and forms a mound next to the bund. These estimated plume generation rates were based on values used in an environmental impact assessment for a similar rock wall construction at the Port of Townsville (BMT, 2012, page 6-3). The construction method will maximise the placement of rock on tidally exposed seabed during low tide conditions wherever possible, which will have the effect of reducing the release of fine sediment plumes. An independent review of these sources rates found that they are the best available estimates (attached to this report as Annex B).

The construction period is expected to be 18 months, with 12 hours of rock placement per day. Construction will take place on two work fronts, starting at each end of the planned bund, with the two arms meeting together in the middle to form the completed bund. Therefore, the total amount of sediment release due to rock placement and displacement of soft underlying material is:

2 x (0.48 + 0.3) kg/s x 43,200 s/day x 547 days x 0.001 tonnes/kg = 37,000 tonnes

Of this quantity, the data presented in Table 2.1 indicates that between 50% and 74% of the material could comprise sediment particles less than 15.6 micron. As an upper-bound estimate, if 75% of the material was composed of particles less than 15.6 micron in diameter, an estimate of the amount of fine-grained sediment that could be released during construction due to rock placement and mud wave generation is 27,750 tonnes. The accuracy of this estimate is not able to be quantified, since there is no data available from monitoring of comparable construction activities and the design and physical setting of the bund and the potential plume generation mechanisms are unique to this project. It is expected that the actual amount of sediment released due to rock placement and mud wave generation could certainly be a factor of two higher or lower than the central estimate (between 14,000-55,000 tonnes).

Another potential source of sediment release to the marine environment is scour and erosion of the seabed due to stronger currents around the end of the bund during construction and through the gap that remains prior to final closure of the bund. Numerical modelling of these processes was undertaken to determine the potential rate of scour (BMT, 2021, refer to Annex A), at three different stages of the construction process. The results are only indicative since the erosion rate will vary throughout the construction period, and the parameterisation of the model requires certain assumptions. The results indicate that during most of the campaign (the first two scenarios modelled), there may be an average erosion rate of approximately 10 mm/day in areas near the ends of the bund under construction. When the final closure approaches (during the final month or so of construction, which was the third scenario modelled), this rate could increase to an average of approximately 75 mm/day. The model indicates that the area subject to such erosion is approximately 1.5 hectares (15,000 m^2). Therefore, an indicative amount of erosion that may be generated due to elevated currents during construction is:

518 days x 0.01 m/day x 15,000 m^2 + 30 days x 0.075 m/day x 15,000 m^2 = 111,450 m^3

The erosion rates derived from the modelling results were derived by assuming that the seabed dry density was 1 tonne/m^3, so this volume of material would have a mass of 111,450 tonnes (this is an upper-bound estimate, the dry density may be closer to 0.5 tonne/m^3).

The data presented in Table 2.1 indicates that the percentage of material less than 15.6 micron ranges between 50% and 74%. If we assume that 75% of this material is composed of particles less than 15.6 micron, an estimate of the amount of fine-grained sediment that could be released during construction due to seabed erosion is 83,500 tonnes. All of this sediment was already subject to resuspension.

This is a simplified calculation, but additional complexity in the formula is unlikely to provide a more accurate estimate due to the inherent uncertainty in the modelling assumptions. An estimate within a factor two of the measured sediment transport rate is considered a reasonable level of accuracy for sediment transport models (Camenen and Larroudé, 2003, p. 9). It is therefore expected that the total release quantity due to seabed erosion could be between 41,000 and 167,000 tonnes (a factor of two lower or higher than the central estimate).

In the long term, the channel to the west of the new SRA reclamation area may deepen over time as an adjustment to the change in the tidal hydrodynamics (BMT, 2020). However, since this is a long-term process it is not expected that any significant plumes of fine sediment will be generated and therefore the quantity of fine-grained sediment released is not included in the estimate presented here. The long-term changes will be measured as part of a separate monitoring program (BMT, 2022a).

Therefore, the total amount of fine-grained sediment (diameter less than 15.6 micron) released or returned to the marine environment that was already available for resuspension before the commencement of the SRA construction is estimated to be 111,250 tonnes (27,750 tonnes due to rock placement and 83,500 tonnes due to bed erosion, see Table 2.2). Due to the approximate nature of the plume generation rate estimates and the inherent limitations in the accuracy of the sediment transport modelling, the total amount of fine-grained sediment released during construction could be expected to be between 55,000-222,000 tonnes (a factor of two higher or lower than the central estimate). This amount of sediment would be released very gradually over 18 months, and there is expected to be only small increases in the turbidity and deposition rate due to these releases. The 95th percentile of the turbidity may increase by approximately 10 NTU close to the rock placement location, and by up to 20 NTU as final bund closure approaches during the final month of construction (see Annex A for a description of turbidity impacts).

Potential sources of uncertainty in these estimates include:

- The erosion rate of the seabed in response to the elevated flow velocity and bed shear stress at the ends of the bund during construction may by over- or under-estimated;
- The plume source rates do not account for any potential pressure gradient induced mobilisation of in-situ sediments underlying (or adjacent to) the bund wall;
- The plume source rates associated with rock placement and entrainment from the mud wave may be over- or under-estimated; and
- The amount of fine sediment eroded during the final stages of bund closure may be larger or smaller than expected.

The completion of the SRA reduces the overall volume of sediment available for resuspension, since areas of seabed that were previously exposed to waves and tidal currents will be removed from the active sedimentary system following completion of the bund. If it is assumed that the top one metre of sediment is currently available for resuspension, the amount of sediment removed from the active system would be approximately 1,080,000 tonnes (area 1,080,000m^2 x 1 metre depth x 1 tonne/m^3 dry density). Therefore the reduction in the amount of sediment available for resuspension could be approximately ten times larger than the estimated mass released into the marine environment during construction.

Table 2.2 Total Amount of Fine-Grained Sediment Release During Construction of the SRA that was Already Available for Resuspension

Source	Estimated Amount of Release
Rock Placement	27,750 tonnes (range: 14,000-55,000 tonnes)
Bed Erosion	83,500 tonnes (range: 41,000-167,000 tonnes)
Total	111,250 tonnes (range: 55,000-222,000 tonnes)

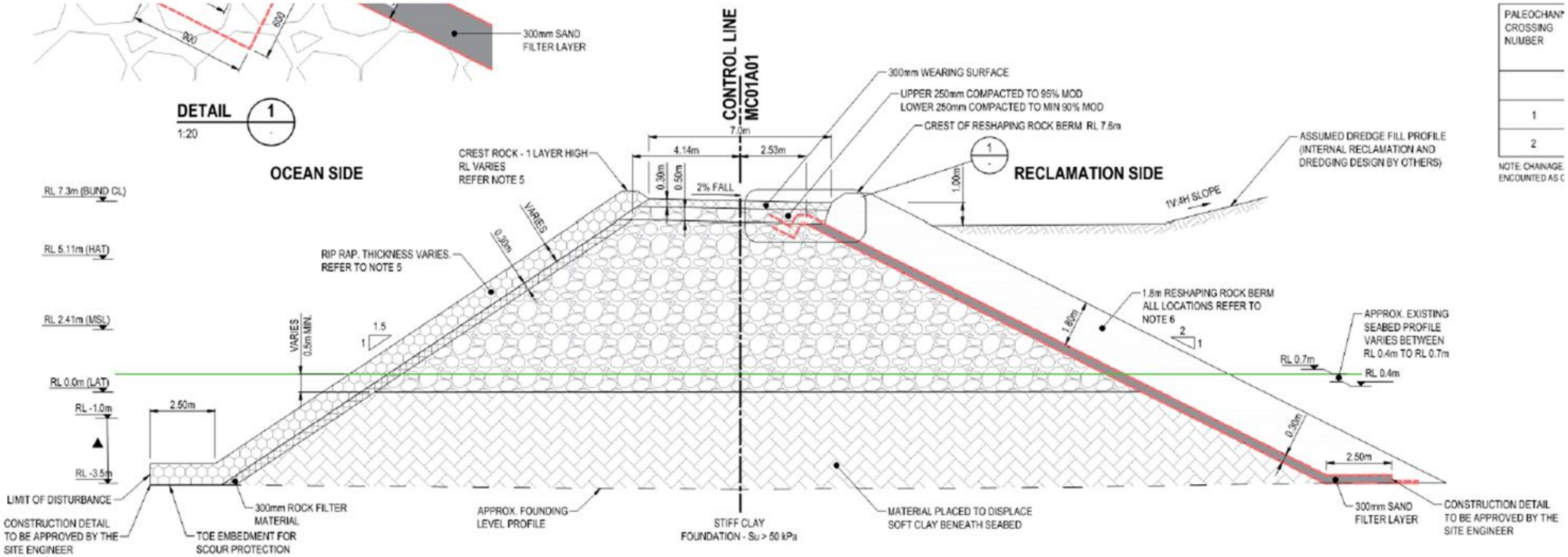


Figure 2.9 Proposed Bund Cross Section in Paleo-Channel Areas

3 Monitoring Plan

3.1 Fine-Grained Sediment Not Previously Available for Resuspension

As noted in Section 2.3.1, the construction of the bund for the SRA does not involve the use of any material with grains smaller than 15.6 micron in diameter. Therefore, there is no fine-grained sediment not previously available for resuspension that will be released to the marine environment, and no monitoring or measurement is proposed.

3.2 Fine-Grained Sediment Not Previously Available for Resuspension

3.2.1 Overall Methodology

The rate of release of sediment into the marine environment during construction is expected to be very low relative to the levels of ambient suspended sediment. It is therefore expected that sediment released to the environment as a result of construction will not be distinguishable from baseline sediment levels, despite accurate monitoring techniques. This is because the instruments that are used to measure turbidity cannot distinguish between turbidity that is generated by the construction activity and the natural ambient (background) turbidity. The ambient turbidity is naturally high during spring tidal periods due to the high-energy tidal environment, so the additional turbidity generated by the construction activity will comprise only a small proportion of the total turbidity. For example, the modelled turbidity for the existing situation (no construction) is compared to the modelled construction case turbidity in Figure 3.1. The additional turbidity generated during construction is expected to cause only a modest increase in the peak turbidity at locations near the bund. In this example, the model estimates that the turbidity at the peak would be approximately 43 NTU if construction is taking place, compared to 36 NTU if it is not. The difference between these values is small (7 NTU) relative to the variability in the ambient background turbidity (see Figure 3.2 for an illustration of the natural variability of the background turbidity in the Port of Gladstone, both between individual tides and between neap-spring tidal periods). Therefore it is unlikely that any instrumentation could reliably detect the influence of construction on the turbidity level if the actual construction effects are similar to those that have been modelled. During neap tides, the construction-related signal is much smaller, so it would be even harder to detect.

The validation of the overall sediment release estimate will therefore involve analysing the data that is collected as part of the Receiving Environment Monitoring Program (REMP) (GPC, 2021) to confirm that the measured turbidity during bund construction was in line with expectations given the estimated quantity of fine sediment release (see Section 2.3.2). Measurements of turbidity and particle size distribution will also be undertaken at an additional site close to the edge of the mudflat to provide additional data for the analysis. Baseline measurements of the flux of sediment entering the estuary from the mudflats to the north of the WBE will be undertaken using a boat-mounted Acoustic Doppler Current Profiler (ADCP), and additional measurements will be undertaken during similar tidal and weather conditions during construction to allow a comparison of the sediment fluxes.

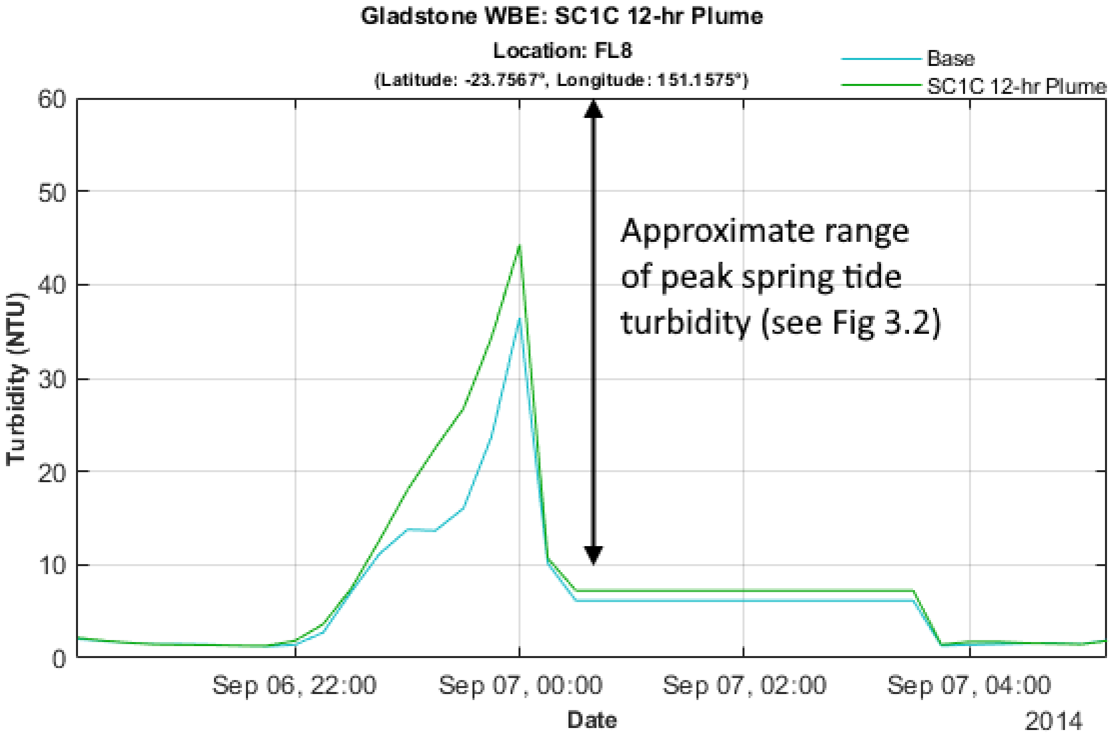


Figure 3.1 Comparison of Modelled Base Case and Construction Case Turbidity

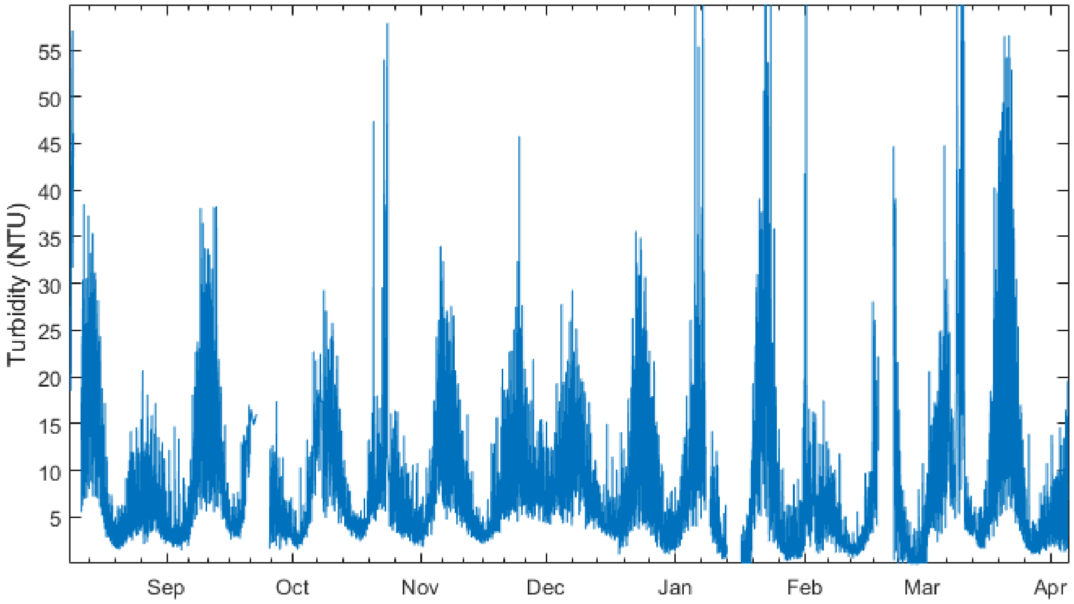


Figure 3.2 Example of Natural Variation in Measured Ambient Turbidity

3.2.2 REMP Data and Additional Monitoring

The plan for water quality monitoring before and during construction of the SRA is outlined in the REMP that will be submitted. Water quality monitoring will be undertaken continuously at three sites (see Table 3.1). The locations of these sites are shown in Figure 3.3. Dual instruments at each site measure standard physico-chemical parameters and turbidity.

Additional measurements of turbidity will be undertaken at the site ‘FSM01’ for a one-month period prior to commencement of construction and for two additional one-month periods during construction (one at the start of the construction activity, and another towards the end of the bund construction as the gap in the bund approaches final closure). This location was chosen because aerial photography indicates that sediment plumes generated along the edge of the reclamation tend to advect past this location. A Laser In Situ Scattering and Transmissometry (LISST) instrument will also be deployed to will measure the volumetric sediment concentration directly and also measure the particle size distribution of the suspended sediment. This instrument will be deployed at the same time as the turbidity sensors at ‘FSM01’ but will only be deployed for two weeks each time to reduce the risk of sensor fouling affecting the measurements. This data will be helpful for determining the proportion of the suspended sediment that is smaller than 15.6 micron in diameter. In order to calibrate the turbidity and LISST measurements, water samples will be collected adjacent to the monitoring site FSM01 for a range of turbidity conditions (both pre and during construction) and will be analysed for both Total Suspended Solids (TSS) and PSD. The monitoring at site FSM01 is not proposed to be continuous, since any change in turbidity dynamics will be detected and measured at the other three water quality measurement sites.

Once the data has been collated, it will be analysed to confirm that the measured turbidity during construction was consistent with expectations (i.e., within the usual limits of variability observed in the Port of Gladstone, as observed in the long term data). A statistical comparison of the baseline data and construction-period data will be undertaken. This will involve calculating the 20th, 50th and 80th percentiles of the turbidity time series within 14-day windows during the construction period, and seeing where they lie within the statistical distribution of those same percentiles over a large number of 14-day windows in the baseline data. Any significant statistical anomaly that cannot be reasonably explained by a difference in the meteorological conditions will be identified. The estimated quantity of sediment release will be revised accordingly, if necessary.

Table 3.1 Turbidity Measurement Locations

Site name	GPS coordinates	Location/zone
Turbidity Monitoring Sites in the REMP:		
WB50 (P2)	-23.80483, 151.2079	Outside Calliope River mouth. Western Basin
WB20 (P14)	-23.765406, 151.18112	Passage Island, Western Basin
NW60 (QE4)	-23.74775, 151.1620	The Narrows
Additional Turbidity and Particle Size Distribution Measurement Site:		
FSM01	-23.762978, 151.16556	Near the NW corner of the Western Basin Reclamation

▬ ADCP Transect
● WQ Monitoring Locations
▨ Southern Reclamation Cell

Title:

WQ Monitoring Locations and Proposed ADCP Transect Measurement Location

Figure: 3.3

Rev: A

N 0 1,000 2,000 m

BMT
www.bmt.org

Filepath: L:\A10422.pag.Gladstone_Western_Basin_Reclamation\03_GIS\QGIS\A10422_Gladstone_Western_Basin.qgz

3.2.3 ADCP Transect Measurements

A set of baseline ADCP transect measurements will be undertaken over a full tidal cycle (12.5 hours) along a transect to the north of the existing WBE reclamation (refer to the red line on Figure 3.2 for location). The measurements will be undertaken during spring tidal conditions, since the largest increases in turbidity associated with construction are expected to occur during spring tidal periods. This is because most of the construction-related increases in turbidity will be generated by spring tide currents eroding the seabed when water goes in and out of the partially-closed SRA bund. Within Gladstone Harbour, the spring-neap tidal cycle is the dominant driver of sediment dynamics, and seasonal influences are much less significant. It is therefore not necessary to undertake baseline measurements in different seasonal conditions.

The vessel-based transecting will include a number of monitoring techniques, including collection of water samples and subsequent laboratory analysis, water column profiling with optical backscatter instrument/s and continuous acoustic profiling with an ADCP. The vessel-based transecting will seek to measure the total flux of sediment across the transect over a full tidal cycle. The primary measurement technique will be conversion of the measured ADCP backscatter into equivalent TSS, using a detailed calibration technique.

LISST and Optical Back Scatter (OBS) profiling of the water column will be carried out from the vessel at various times and at discrete depths water samples would be collected using a co-located pump sampler. The LISST profiling instrument measures the volumetric concentration of suspended solids along with the associated in-situ Particle Size Distribution (PSD). The OBS provides a measurement of the turbidity in Nephelometric Turbidity Units (NTU). Laboratory analysis of the water samples will measure the dry weight concentration of Total Suspended Solids (in mg/L) as well as the PSD of select samples. The laboratory TSS would be used to convert the OBS turbidity measurements into equivalent TSS, and provide calibration data for the LISST. The converted LISST and OBS profile datasets would subsequently be used to convert the measured ADCP backscatter into equivalent TSS. Since the water velocity across the transect is also measured by the ADCP, the total flux across the transect at the time of each transect can be calculated.

These measurements will form a baseline dataset which will establish the ‘typical’ flux of sediment on and off the mudflats to the north of the Western Basin reclamation during spring tides. An additional set of ADCP transect measurements will be undertaken at the same location during construction, during similar tidal and weather conditions, in order to provide a comparison with the baseline sediment flux.

3.2.4 Drone Photography

Baseline aerial photography will be undertaken using a drone to establish the typical pattern of visually significant ambient suspended sediment prior to the commencement of construction. The photography will be undertaken during spring tides, at approximately mid-tide water level on both a flood tide and an ebb tide. The photography will be taken from a fixed height, and with the camera facing directly downwards to allow the image to be accurately georeferenced. Additional drone photography will be undertaken during similar-sized spring tides and during the same stages of the tide during construction to identify the extent of any construction-related plumes.

3.2.5 Satellite Photography Analysis

High-resolution satellite imagery (converted into an approximate TSS concentration) will be obtained for the pre- and during-construction periods when other measurements at FSM01 are being undertaken. Although the 10-metre spatial resolution of the imagery will mean that any small scale plumes will not be visible, it will allow any changes on a larger scale to be observed. The imagery is only available at certain times of capture, and its usefulness will depend on how much cloud-free imagery is available over the periods of interest.

3.2.6 Hindcast Modelling

Numerical modelling will be undertaken to assist in the determination of the possible magnitude of the construction-related source rate. This will involve running the model for the period of construction when measurements were undertaken and adjusting the source rate of excess sediment in the model to obtain the best agreement between the measured turbidity and the modelled turbidity (converted from TSS). If this analysis indicates that the quantity of suspended sediment released needs to be revised upwards, a revised estimate of the total mass of fine sediment released to the environment will be calculated based on the revised source term estimates.

3.3 Summary of Proposed Monitoring Methods

A summary of the proposed monitoring methods is provided in Table 3.2

Table 3.2 Monitoring Methods

Measurement Method	Method of Implementation	Comment on Data Obtained
Turbidity Measurement as per the REMP	The data collected during implementation of the REMP will be analysed to confirm turbidity levels were in line with expectations and below turbidity triggers	This will serve to confirm the adequacy of the estimate of the quantity of fine sediment release due to bund construction
ADCP	Sediment concentration and sediment flux will be measured across a transect both before and during construction	The transect TSS and flux measurements, once properly calibrated, provide a very good description of the sediment flux at the edge of the mudflat
Optical Sensor	Optical sensor profile measurements will be undertaken during ADCP transecting using LISST and OBS instruments. A LISST instrument will also be deployed at FSM01	The optical sensor profile measurements are used to calibrate the conversion of ADCP backscatter into equivalent TSS The LISST PSD measurements are used to characterise suspended sediment particle sizing
Water Sampling	A number of water samples will be collected during ADCP transecting measurements using a pump sampler, as well as at site FSM01	These water samples will be analysed for TSS and PSD. The TSS measurements are used to calibrate the optical sensor measurements (NTU to TSS) and ADCP backscatter
Drone Photography	Drone photography will be undertaken at a known state of tide, elevation and orientation both before and during construction	This photography will help to identify the extent of any construction-related plumes
Satellite Photography	Photography will be obtained for snapshots at times available both before and during construction	This photography may help to identify the extent of any construction-related plumes
Numerical Hindcast Modelling	The numerical modelling will be used to assess the likely construction plume source rates by comparing modelled and measured TSS	The numerical modelling will be useful since it accounts differences in tidal conditions and allows for plume advection, dispersion and settling between the point of discharge and the measurement transect.

3.1 Assessment of the Effectiveness of Monitoring Methods

The methods outlined in Section 3.2 will be assessed for their effectiveness at the conclusion of the monitoring campaign. This will include assessment of:

- The adequacy of data collected as part of the REMP, including spatial and temporal coverage;
- The effectiveness of each of the targeted measurement campaigns, including the ADCP transecting and the optical sensor measurements at FSM01 (and commenting on the appropriateness of the chosen locations, durations and frequency of the measurements);
- The usefulness of the drone and satellite photography in identifying any unexpected turbidity generation; and
- The utility of the numerical modelling hindcast analysis.

Any shortcomings or potential improvements to each element of the methodology will be identified and reported as part of this process. The assessment of the effectiveness of each component will be similar to that presented in the Fine Sediment Management Plan for the Clinton Vessel Interaction Project (BMT, 2022b).

3.2 Reporting

At the conclusion of the construction of the SRA, a final report will be developed that uses the results of the monitoring program to confirm whether the estimate of the amount of fine sediment released was accurate. If the monitoring program has not detected turbidity levels that are outside the expected natural variability (refer to the analysis described in Section 3.2.2), the original estimate of the quantity of fine sediment released presented in Section 2 will be confirmed. If the data indicates that the existing estimate needs to be revised (if investigations as part of the REMP determine that measured excess turbidity is due to SRA construction activities), the data will be used together with hindcast modelling reuslts to refine the estimate.

The report will address the requirements of the EPBC conditions by reporting:

- The amount of fine-grained sediment returned to the marine environment that was not previously available for resuspension before commencement of SRA construction activities, calculated and validated in accordance with the FSVMP (expected to be zero);
- The amount of fine-grained sediment returned to the marine environment that was previously available for resuspension before commencement of SRA construction activities, calculated and validated in accordance with the FSVMP;
- An assessment of the effectiveness of the methods of monitoring and measuring during Stage 1 construction activities, as described in the FSVMP for validating the fine-sediment release modelling.

The requirements of condition 17 of the EPBC approval will also be met, by carrying out the actions identified in Table 3.3.

Table 3.3 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 and reviewed by Dr Andy Symonds. Both Paul and Andy are suitably qualified specialists for preparing and reviewing the fine Sediment 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 Fine Sediment 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 ofthe monitoring in respect of the particular **Project Stage** which is the subject of the monitoring plan or program);	The Fine Sediment Monitoring Report will be submitted to DCCEEW within six months of completion of monitoring.
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 report from this monitoring plan will provide better indication of sedimentation and erosion rates from 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 Fine Sediment Monitoring Report will provide details of any fine sediment offset that needs to be provided.

4 Conclusion

During the construction of the Southern Reclamation Area in the Western Basin of the Port of Gladstone it is expected that:

- The amount of fine-grained sediment returned to the marine environment that was not previously available for resuspension before commencement of SRA construction activities will be zero, since no sediment grains finer than 15.6 micron will be used in the bund design and any seabed erosion that occurs will involve sediment that is already available for resuspension;
- The amount of fine-grained sediment returned to the marine environment that was previously available for resuspension before commencement of SRA construction activities is estimated to be approximately 111,000 tonnes (due to uncertainty in underlying assumptions, a range between 55,000 and 222,000 tonnes is expected);
- The sediment that comprises the seabed to be covered by the SRA is presently available for resuspension, and will not be available for resuspension following completion of the SRA, since the constructed bund will form an effective barrier preventing the transport of sediment from the SRA to the estuary. Therefore, the construction of the SRA will have the net effect of reducing the overall amount of sediment available for resuspension in the sedimentary system. If it is assumed that the top one metre of sediment is currently available for resuspension, the amount of sediment removed from the active system would be approximately 1,080,000 tonnes. Therefore the reduction in the amount of sediment that is available for resuspension may be approximately ten times larger than the estimated mass released into the marine environment during construction.

The results of the monitoring campaign and numerical modelling hindcasts will be used to validate the estimate of the amount of fine-grained sediment released to the marine environment. The monitoring methods to be adopted include turbidity measurements, ADCP transect sediment flux measurements, LISST measurements for TSS and PSD, and drone photography.

At the conclusion of the monitoring program, if the measured data is consistent with expectations, the estimate of the amount of fine-grained sediment release will be confirmed. If analysis of the measured data and numerical modelling hindcasts indicate that the fine sediment release source terms were larger than expected, the fine sediment release estimate will be revised.

No fine-grained sediment will be returned to the marine environment that was not already available for resuspension as part of bund wall construction.

5 References

Aurecon (2020). Memorandum: CA19000217 – WBE reclamation area (southern area) and BUF detailed design – construction water quality impact modelling – BMT WBM scope of works. Prepared for Gladstone Ports Corporation.

BMT (2012). Townsville Port Expansion EIS. Appendix H1: Hydrodynamic and Advection-Dispersion Modelling Technical Report.

BMT (2020). Technical memorandum: Gladstone WBE Reclamation Long Term Impacts - Southern Cell Modelling Results. Prepared for Gladstone Ports Corporation.

BMT (2021). Technical Memorandum: Gladstone WBE Reclamation Construction Impacts - Southern Cell Modelling Results. Prepared for Gladstone Ports Corporation.

BMT (2022a). Southern Reclamation Area Construction: Long Term Changes Monitoring Plan. Prepared for Gladstone Ports Corporation.

BMT (2022b). Clinton Vessel Interaction Project Dredge Plume Monitoring and Fine Sediment Assessment. Australasian Coasts & Ports 2021 Conference. https://www.coastsandports.org/papers/2021/076_guard_finalpaper.pdf Retrieved 01/03/2023.

Camenen, B., Larroudé, P. (2003). Comparison of sediment transport formulae for a coastal environment. Coastal Engineering 48, pp.111-132. 10.1016/S0378-3839(03)00002-4. https://hal.science/hal-00259797/file/Camenen2003.pdf Retrieved 01/03/2023.

GPC (2021). Northern Land Expansion Project - Southern Reclamation Area Bund Wall Construction Receiving Environment Monitoring Program.

Annex A Technical Memorandum on Turbidity and Deposition Rate Impacts

Technical Memorandum

From:	Dr Mitchell Baum and Dr Paul Guard	To:	Freddie Pastorelli (GPC)
Date:	22 September 2021	CC:	
Subject:	Gladstone WBE Reclamation Construction Impacts - Southern Cell Modelling Results		

Background

BMT was commissioned to undertake construction associated impact assessment modelling on behalf of Gladstone Ports Corporation (GPC) to support design development and monitoring campaigns for the Western Basin Expansion (WBE) reclamation.

As part of this work, two development scenarios are considered in this study:

- Scenario 1 – Southern Reclamation Area
- Scenario 2 – Southern + Northern Reclamation Areas, with channel

This memorandum presents modelled construction impact results for Scenario 1.

Modelled Scenarios

The Port of Gladstone TUFLOW FV hydrodynamic model and SWAN wave model were updated to represent the proposed geometry of each of the scenario configurations. 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). Model bathymetry was updated to include the March 2020 Western Basin Flats survey and the Clinton Vessel Interaction Project (CVIP) post-dredge survey.

A total of three configurations were modelled for Scenario 1 construction-related impact assessment:

1. Scenario 1A. Start of bund construction. Placement of rock on two fronts at the start of rock placement. Existing configuration.
2. Scenario 1B. Mid-bund construction. Placement of rock on two fronts (approximately 900 m from the start of rock placement).
3. Scenario 1C. Prior to bund closure. Placement of rock on two fronts (approximately 70 m from completion of the Southern Reclamation Area.

Two construction modes have been modelled for each configuration (12 hour / 24 hour operations), comprising a total of six modelled scenarios.

Each simulation was run for a 30-day duration with a nominal period of 01/09/2014 – 01/10/2014, targeting a large tidal range.

Sediment source rates are defined for the construction impact as follows (Aurecon, 2020):

- Rock placement on marine sediment source rate: 0.48 kg/s
- Mud wave source rate (long arm excavator): 0.30 kg/s

Sediment releases were applied as static sources at locations presented in Figure 1. The sediment releases were assumed to be composed of 50% fines (silts and clays), with the breakdown of fines as follows (Aurecon, 2020):

- 40% clay particles
- 60% silt particles.

The constructed bund was modelled as an impermeable barrier (no flow through the bund). In reality, the bund will be permeable and will allow some water to flow through. However, in terms of the potential for turbid plume generation the assumption that the bund is impermeable is conservative, since the flow velocity and bed shear stress through the remaining gap will be higher in the model than in reality and will therefore lead to a higher estimate for the plume concentration.

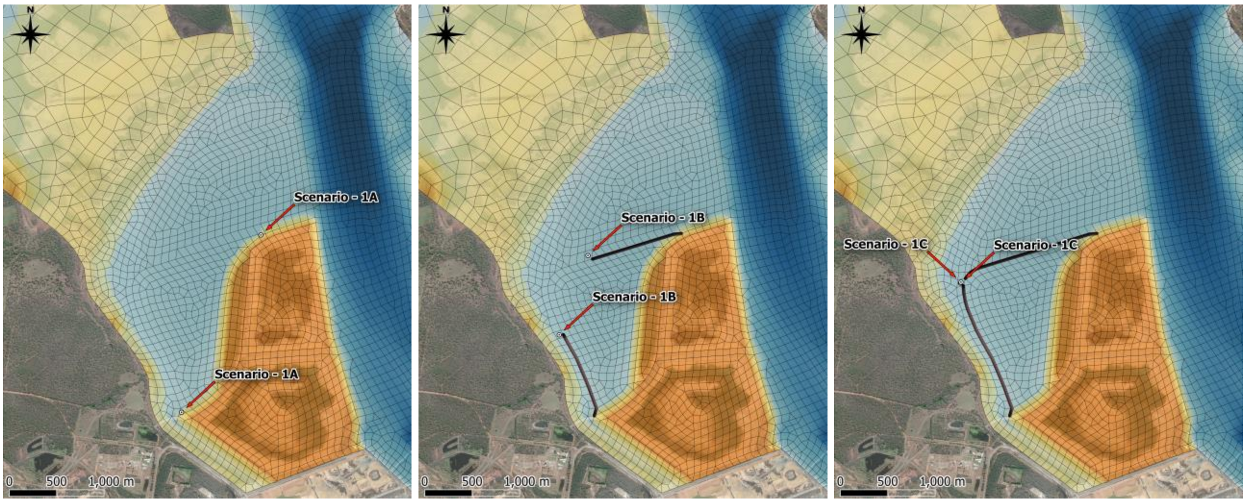


Figure 1 Modelled Scenario 1 Cases with Bund Treatments and Annotated Plume Source Locations. Left: Scenario 1A, Middle: Scenario 1B, Right: Scenario 1C.

A fish passage connection will be constructed between the WBE reclamation area and the existing polishing pond at the north east corner of the WBE reclamation (refer to Figure 2). This connection will remain open for the period of construction and will not cause a major impact to hydrodynamics due to the small relative tidal volume. Furthermore, there will be very limited plume generation during construction of the passage since the majority of the material to be excavated can be removed above the waterline (during low tides where necessary). Any plumes generated during construction of the passage will be significantly smaller than those generated during bund construction and are not likely to cause adverse water quality impacts.

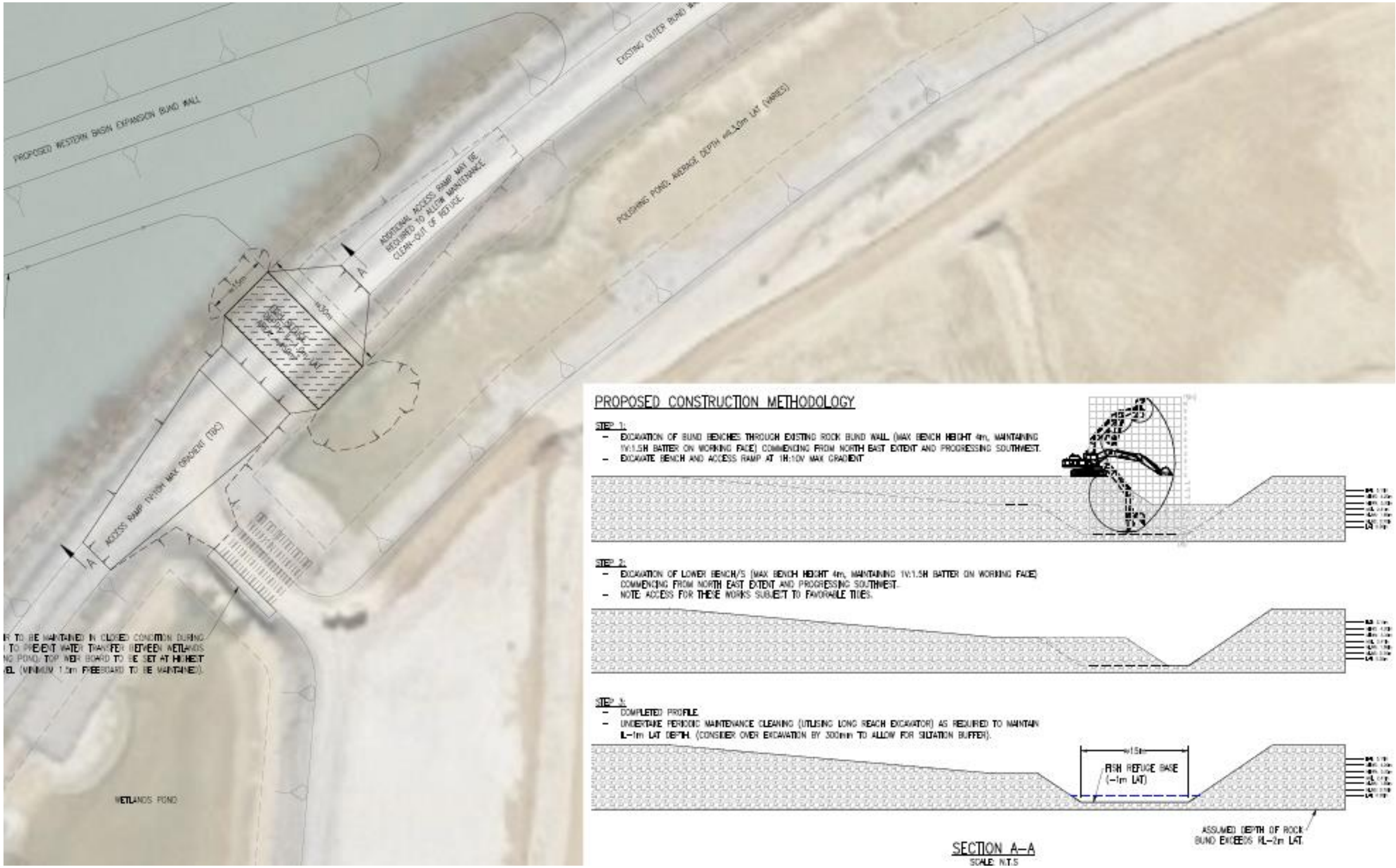


Figure 2 Proposed Fish Passage at the North East Corner of the WBE Reclamation

Methodology

The effects of construction were assessed based on modelled increases in suspended sediment concentration and sedimentation above natural or ambient levels, consistent with the methodology used for the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project EIS (BMT, 2019). Both ambient and construction-related signals were resolved in the predictive model, which allows for an understanding of how significant the construction-related contribution is in relation to ambient conditions.

Depth-averaged turbidity values are presented here since they are most relevant to assessing ecological impacts due to the reduction in seabed Photosynthetically Active Radiation (PAR). Sedimentation impacts were derived from the daily rate of change in bed sediment mass. The adopted sedimentation rate units are mg/cm^2/day.

The anticipated effects of construction have been assessed using two different presentation techniques:

- Time series at sensitive receptor sites; and
- Spatial plots based on percentile analysis.

Time Series Analysis

Time series provide a simple way to present turbidity increases due to construction at predetermined points of interest. Having simulated both the construction-related plumes and ambient sediment, the time series show both these contributions to the total signal and in doing so provide important information on the relative magnitude of the construction-related signal.

Percentile Analysis

Spatial representations of the construction impacts were based on percentile analysis of the model results and were derived by applying a moving 14-day analysis window over the 30-day simulation period. The 14-day window is somewhat arbitrary but in a physical hydrodynamic context represents the approximate duration of one spring-neap tidal cycle, while in an ecological context it is a meaningful timescale for assessing impacts to some key sensitive receptors in the area (e.g. intertidal seagrass meadow). The 14-day analysis window was moved forward by 5-day increments from the start to the finish of the simulation period, to ensure full coverage of the simulation.

The percentile impact plots correspond to the predicted increase in turbidity and sedimentation rate above ambient conditions that are attributable to the construction activities. Impacts at each percentile level were calculated for every 14-day window during the simulation, and the maximum increase for any window at each location in the model domain is presented. Different locations within the model will have experienced their worst period at different times during the simulation and the different percentile statistics may also have occurred during different 14-day windows.

Percentile values considered in this report are 95th and 50th, which correspond to exceedance durations of 17hrs (5%) and 7 days (50%), respectively for the 14-day window. The highest percentiles correspond to relatively short-lived increases in turbidity/sedimentation while the lower percentiles correspond to sustained (but temporary) increases.

Key features of the moving window percentile analysis include:

- Consideration of a range of impact durations from short to long term;
- Can be applied to a long term program and capture periods of high intensity versus low intensity impacts; and

- A similar analysis applied to the baseline data can quantify the ambient conditions, including natural variability across different periods. This can be used to derive meaningful thresholds for the potential impacts.

It is important to note that the percentile plots presented in this report are not ‘snapshots’ of the levels of turbidity in the Port, and the impact plots do not represent what the visible plume might look like at any one time. They are representations of turbidity statistics over long periods of time, and the impact plots show the potential changes to those statistics.

1.1.1 Impact Zone Derivation

The modelled impacts to the turbidity were compared to threshold values derived from measured data to assess the potential impacts to marine water quality and ecologically sensitive areas. These are presented as ‘Zones of Impact’ as required by the Commonwealth EIS Guidelines. The Zones of Impact, which are generally based on dredging environmental assessment guidelines produced by the WA EPA (2011), include the following:

- Zone of High Impact = Excess turbidity from construction activities most likely to cause water quality to deteriorate beyond natural variation;
- Zone of Moderate Impact = Excess turbidity from construction activities likely to cause water quality to deteriorate beyond natural variation;
- Zone of Low Impact = Excess turbidity from construction activities may cause water quality to deteriorate beyond natural variation; and
- Zone of Influence = Extent of detectable plume (as measured by instrumentation) but no predicted ecological impacts.

To determine the threshold values to delineate the Zones of Impact, a combination of referential and biological tolerances methods was used. This entailed using baseline water quality monitoring data to set initial threshold values (referential method). These values were then compared to biological tolerances from literature values as a ‘reality check’ to see if the threshold values are biologically meaningful. For full details of the derivation of the impact zone threshold values, refer to the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project EIS, Appendix D (BMT, 2019). The threshold values for each zone of impact at each monitoring site are provided in Table 1.

The threshold values at each site in Table 1 for each percentile were used to derive an interpolated grid of threshold values for the entire Port. The modelled increases in the 20th, 50th and 80th percentiles of the turbidity in each cell of the model were then compared to the local threshold values, and the cell was included in an impact zone if any of the threshold values for that zone at that location were exceeded.

The continuous releases associated with the 24-hr construction operation scenario produce more significant plumes than 12-hr construction scenario. Therefore, the 24-hr construction scenarios are described in the body of this memorandum and the 12-hr construction scenario results are appended to this report.

Table 1 Impact Threshold Values (Above Background) for each Monitoring Site

Impact Zone	Description	Method	Percentile	Descriptor	CD1	CD2	CD3	CD4	CD5	P2B	P5	QE3
					Turbidity Threshold Values (NTU) - *above background*							
Zone of High Impact	Excess turbidity *most likely* pushes total turbidity beyond natural variation	3 x standard deviations from 20%ile mean	20%ile	Exceeded 80% of the time	4	5	6	4	2	8	3	12
		3 x standard deviations from 50%ile mean	50%ile	Exceeded 50% of the time	7	7	9	5	4	10	5	13
		3 x standard deviations from 80%ile mean	80%ile	Exceeded 20% of the time	12	12	16	8	8	20	13	20
Zone of Moderate Impact	Excess turbidity *likely* pushes total turbidity beyond natural variation	2 x standard deviations from 20%ile mean	20%ile	Exceeded 80% of the time	3	3	4	3	2	5	2	8
		2 x standard deviations from 50%ile mean	50%ile	Exceeded 50% of the time	5	5	6	4	3	7	4	9
		2 x standard deviations from 80%ile mean	80%ile	Exceeded 20% of the time	8	8	10	5	6	13	8	13
Zone of Low Impact	Excess turbidity *may* push total turbidity beyond natural variation	One standard deviation from 20%ile mean	20%ile	Exceeded 80% of the time	1	2	2	1	1	3	1	4
		One standard deviation from 50%ile mean	50%ile	Exceeded 50% of the time	2	2	3	2	1	3	2	4
		One standard deviation from 80%ile mean	80%ile	Exceeded 20% of the time	4	4	5	3	3	7	4	7
Zone of Influence	Full extent of detectable plumes (including resuspension)	Construction-related turbidity exceeds 0.5 NTU	50%ile	Exceeded 50% of the time	0.5							
		Construction-related turbidity exceeds 2 NTU	80%ile	Exceeded 20% of the time	2							
		Construction-related turbidity exceeds 5 NTU	95%ile	Exceeded 5% of the time	5							
		Construction-related turbidity exceeds 10 NTU	99%ile	Exceeded 1% of the time	10							

Results

Scenario 1A, 24-hr Construction Operations

The modelled increases in the turbidity percentiles due to the bund construction activity under 24-hr construction operations are shown in Figure 3 and Figure 4.

Figure 3 shows the highest 95th percentile turbidity during any 14-day period during the simulation in the Base Case, the 'With Construction' Case, and the difference. This provides an indication of the transient impact of the bund-construction activity (the increase in turbidity due to construction which occurs for approximately 17 hours over the 14-day period). The plot indicates that the bund construction activity causes some minor increases to the 95th percentile turbidity within close proximity of the sediment source in the south-western part of the WBE. The most-eastern source location shows a lower increase in turbidity due to the higher ambient flow velocity at this location.

Figure 4 shows the highest 50th percentile turbidity during any 14-day period during the simulation in the Base Case, the 'With Construction' Case, and the difference. This is an indication of the persistent (but temporary) impact of the bund-construction activity (the increase in turbidity due to construction which occurs for approximately 7 days over a 14-day period). The plot shows that the persistent influence of the bund construction activity is minor due to the low rate of plume release in this scenario. Note that the colour bar scale limits are different in Figure 3 and Figure 4.

The effect of bund construction on rates of sediment deposition is minor across the study area. The modelled increase in the 95th and 50th percentiles of the deposition rate (bottom panels of Figure 5 and Figure 6) shows that the modelled increased to the deposition rate is low, and limited to an area in close proximity to the source locations.

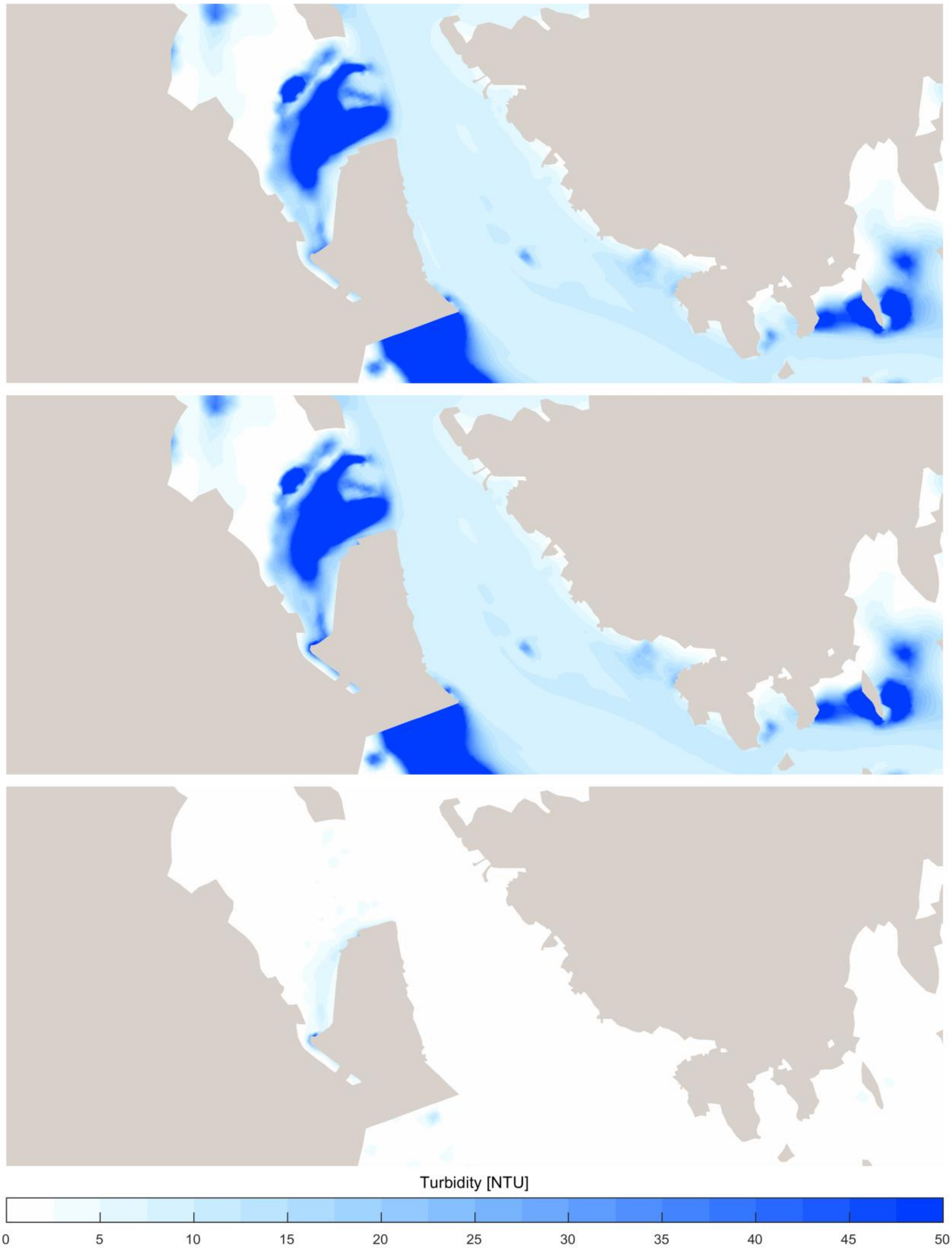


Figure 3 Scenario 1A (24-hr Construction Operations). 95th Percentile Turbidity Base Case (Top), With Construction (Middle) and Difference (Bottom)

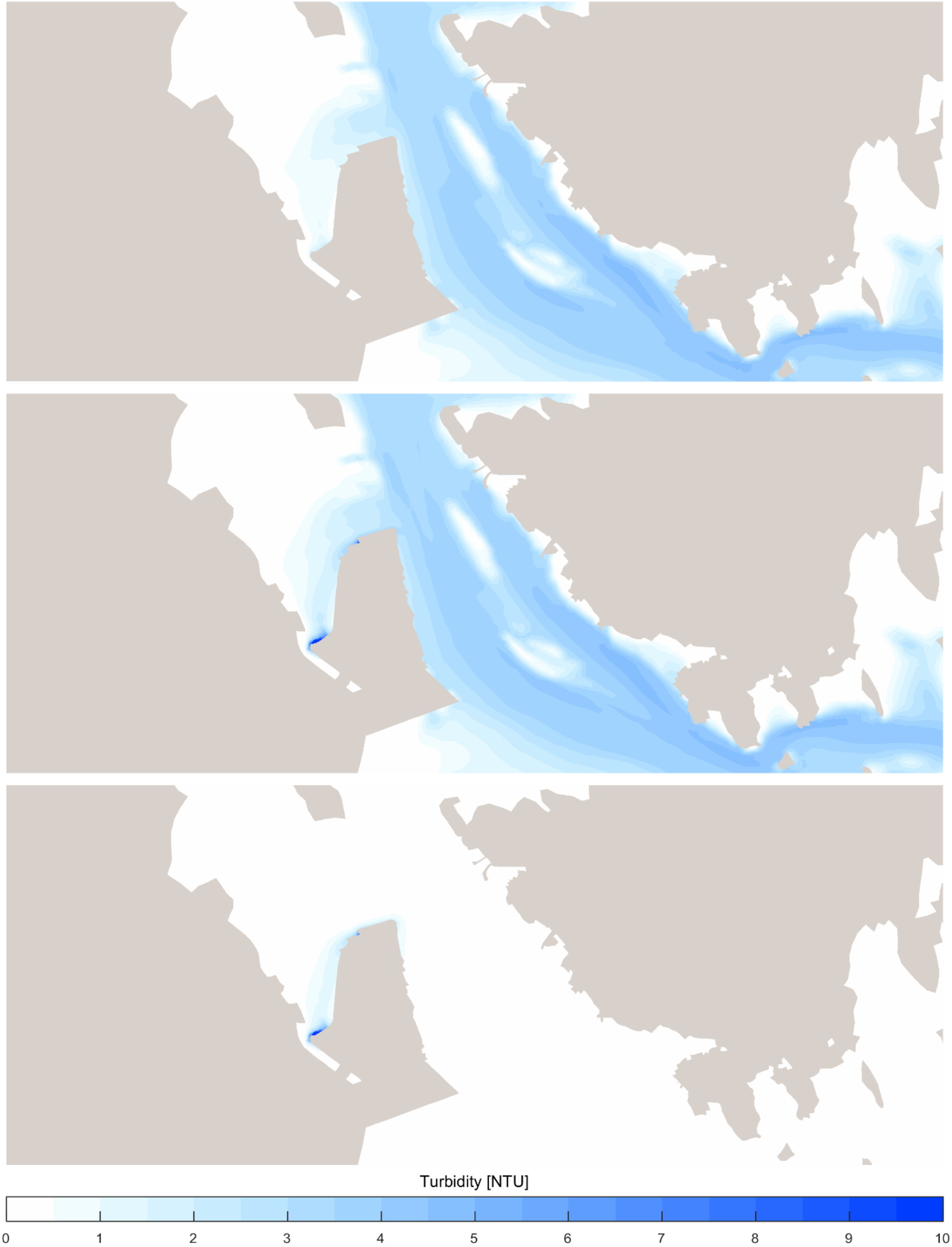


Figure 4 Scenario 1A (24-hr Construction Operations). 50th Percentile Turbidity Base Case (Top), With Construction (Middle) and Difference (Bottom)

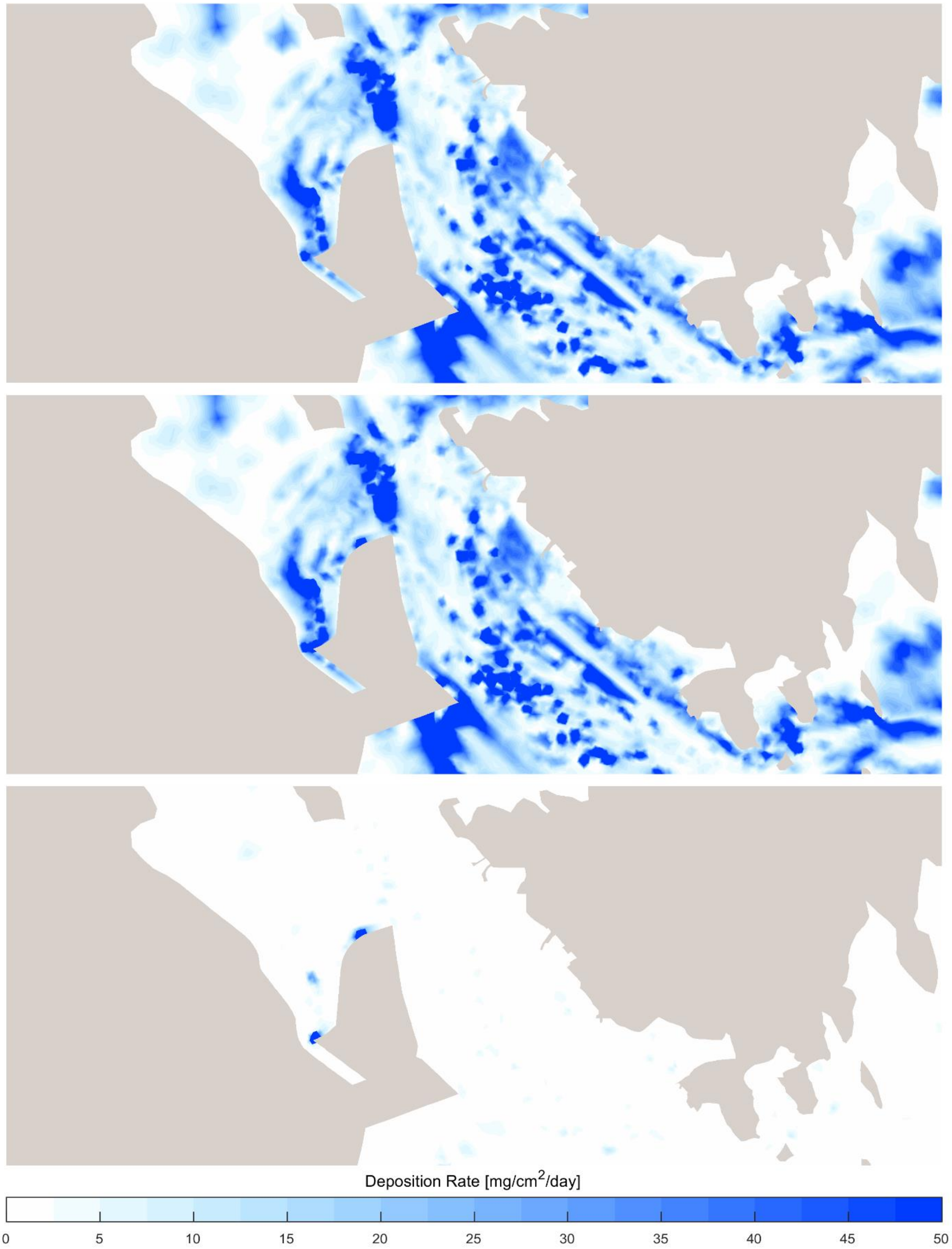


Figure 5 Scenario 1A (24-hr Construction Operations). 95th Percentile Deposition Rate Base Case (Top), With Construction (Middle) and Difference (Bottom)

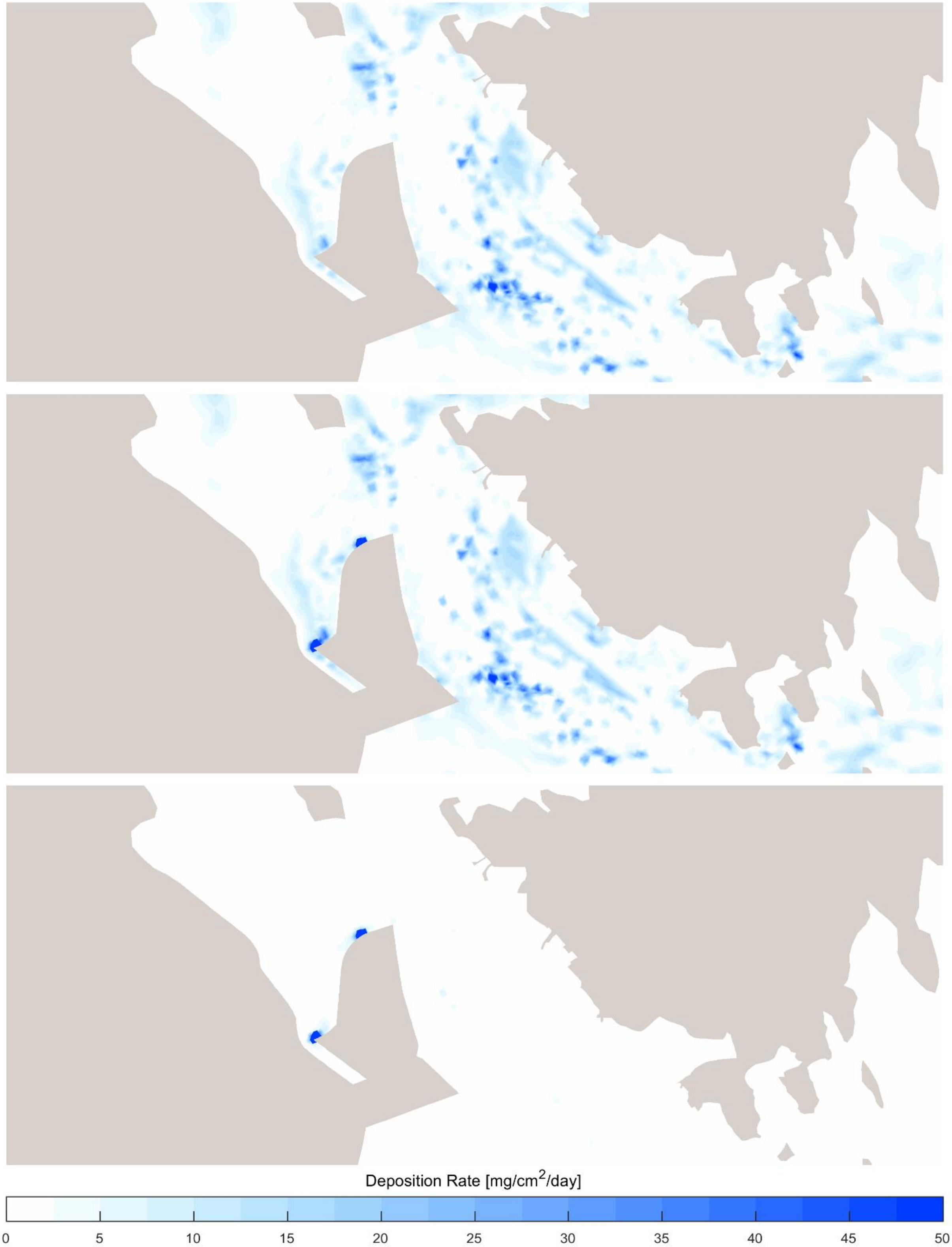


Figure 6 Scenario 1A (24-hr Construction Operations). 50th Percentile Deposition Rate Base Case (Top), With Construction (Middle) and Difference (Bottom)

The modelled increases to the turbidity percentiles during the bund-construction simulation were compared to threshold values (see Table 1 and BMT, 2019) to determine the Zones of Impact associated with the plumes generated by the bund construction activity. The results for the 24-hr Scenario 1A bund construction are presented in Figure 7. The Zones of Impact are constrained to very small areas adjacent to the source locations and the Zone of Influence is also limited to areas adjacent to the WBE reclamation area.

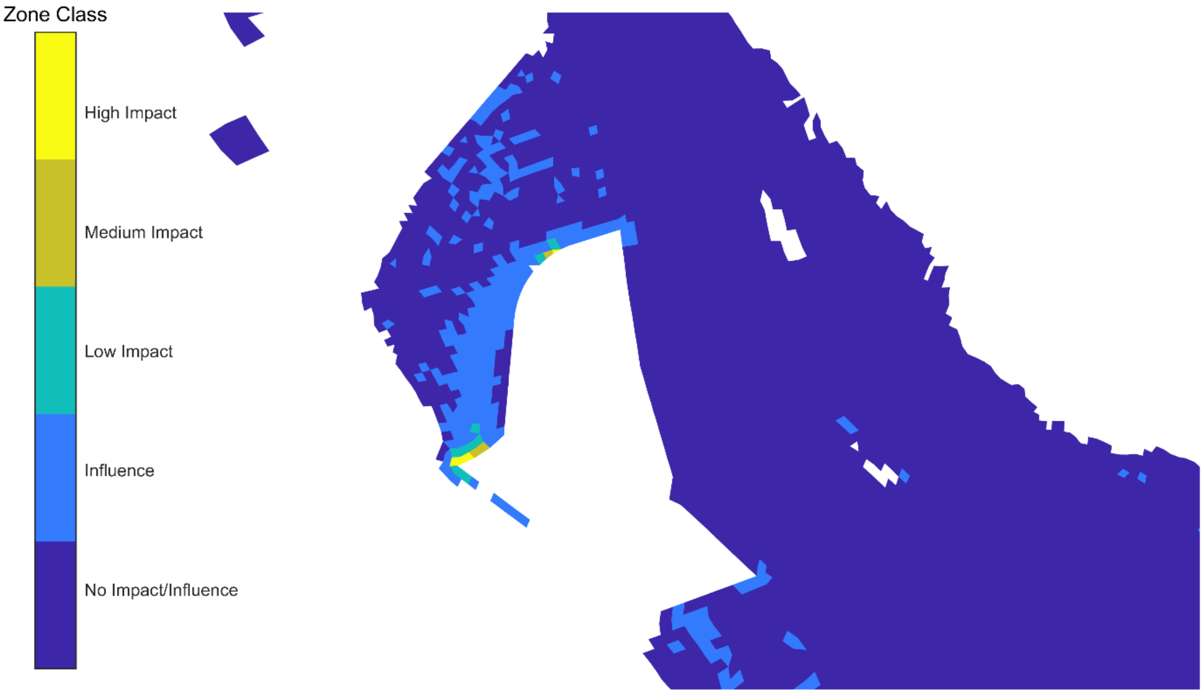


Figure 7 Scenario 1A (24-hr Construction Operations) - Zones of Impact / Influence

Scenario 1B, 24-hr Construction Operations

The modelled increases in the depth-averaged turbidity percentiles as a result of the Scenario 1B bund construction are presented in the bottom panels of Figure 8 and Figure 9, for the 95th and 50th percentiles respectively. The increases in turbidity are limited to areas adjacent to the reclamation area and the mudflat to the north of the reclamation. Note that the colour bar scale limits are different in the two plots.

Modelled increases in the Scenario 1B sediment deposition rate are presented in the bottom panels of Figure 10 and Figure 11 for the 95th and 50th percentiles respectively. Due to the constriction of the eastern bund and the subsequent changes to the distribution of flow within the Western Basin, deposition impacts are slightly more widespread than Scenario 1A, however impacts for both the 95th and 50th percentiles remain limited to the area immediately adjacent to the WBE reclamation.

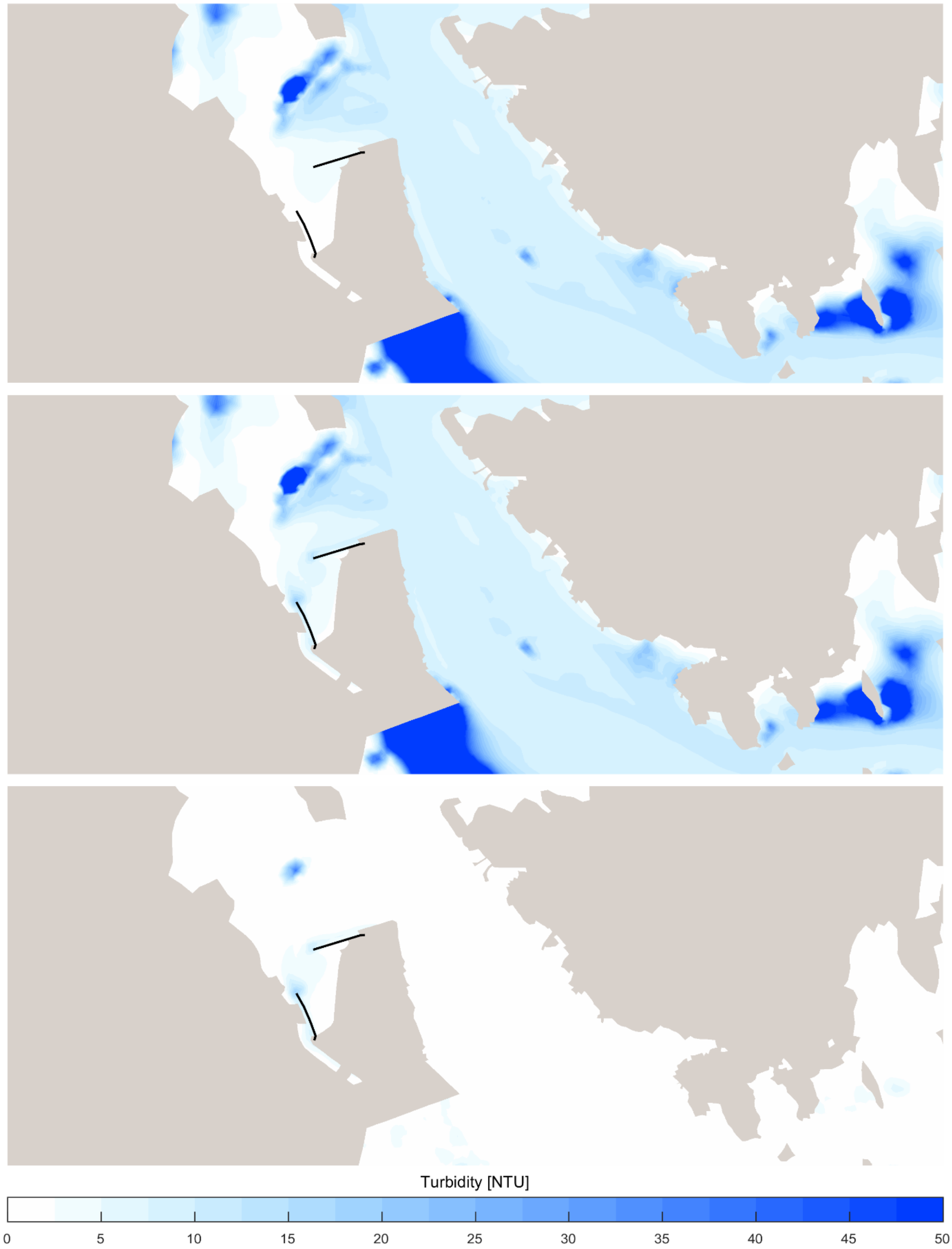


Figure 8 Scenario 1B (24-hr Construction Operations). 95th Percentile Turbidity Base Case (Top), With Construction (Middle) and Difference (Bottom)

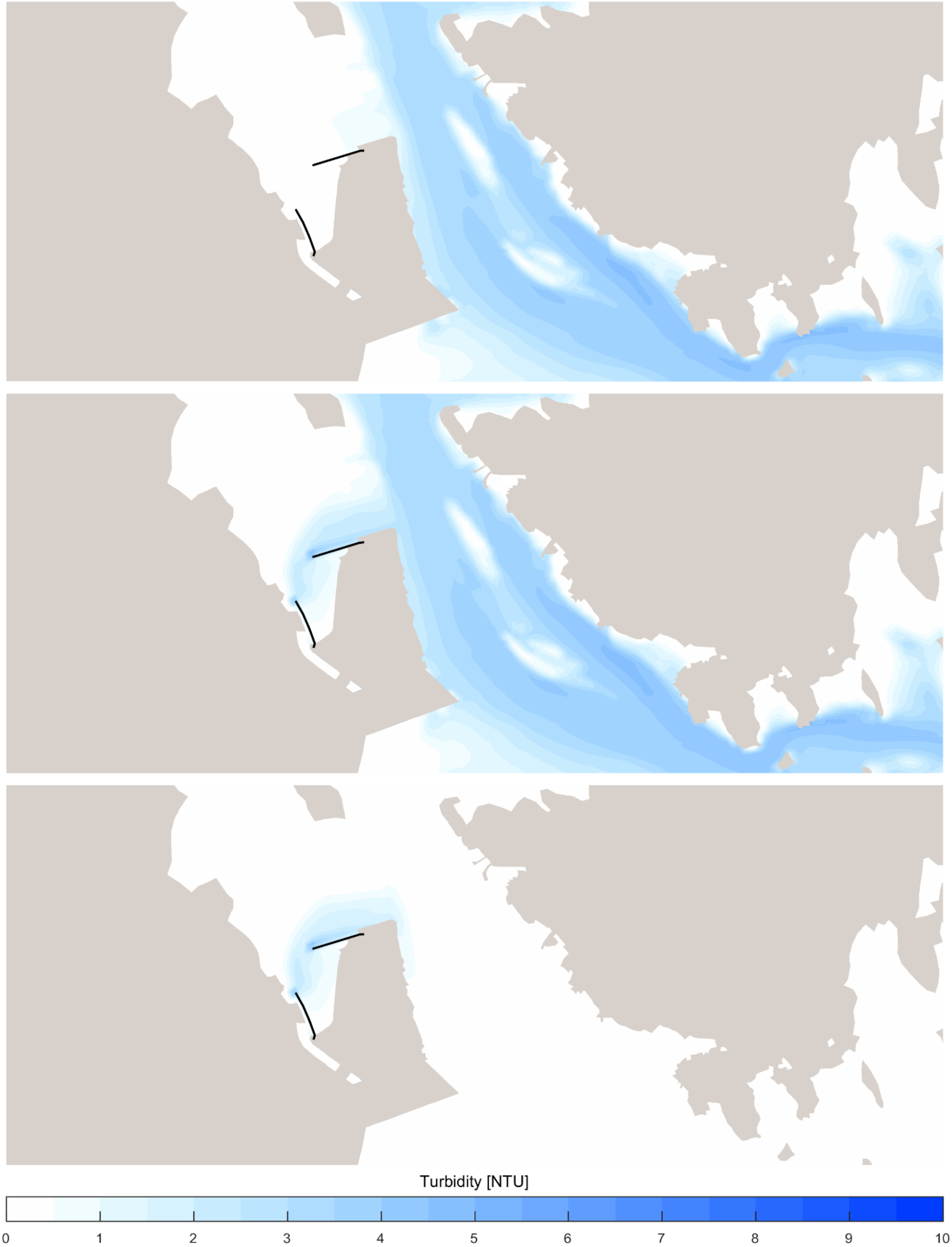


Figure 9 Scenario 1B (24-hr Construction Operations). 50th Percentile Turbidity Base Case (Top), With Construction (Middle) and Difference (Bottom)

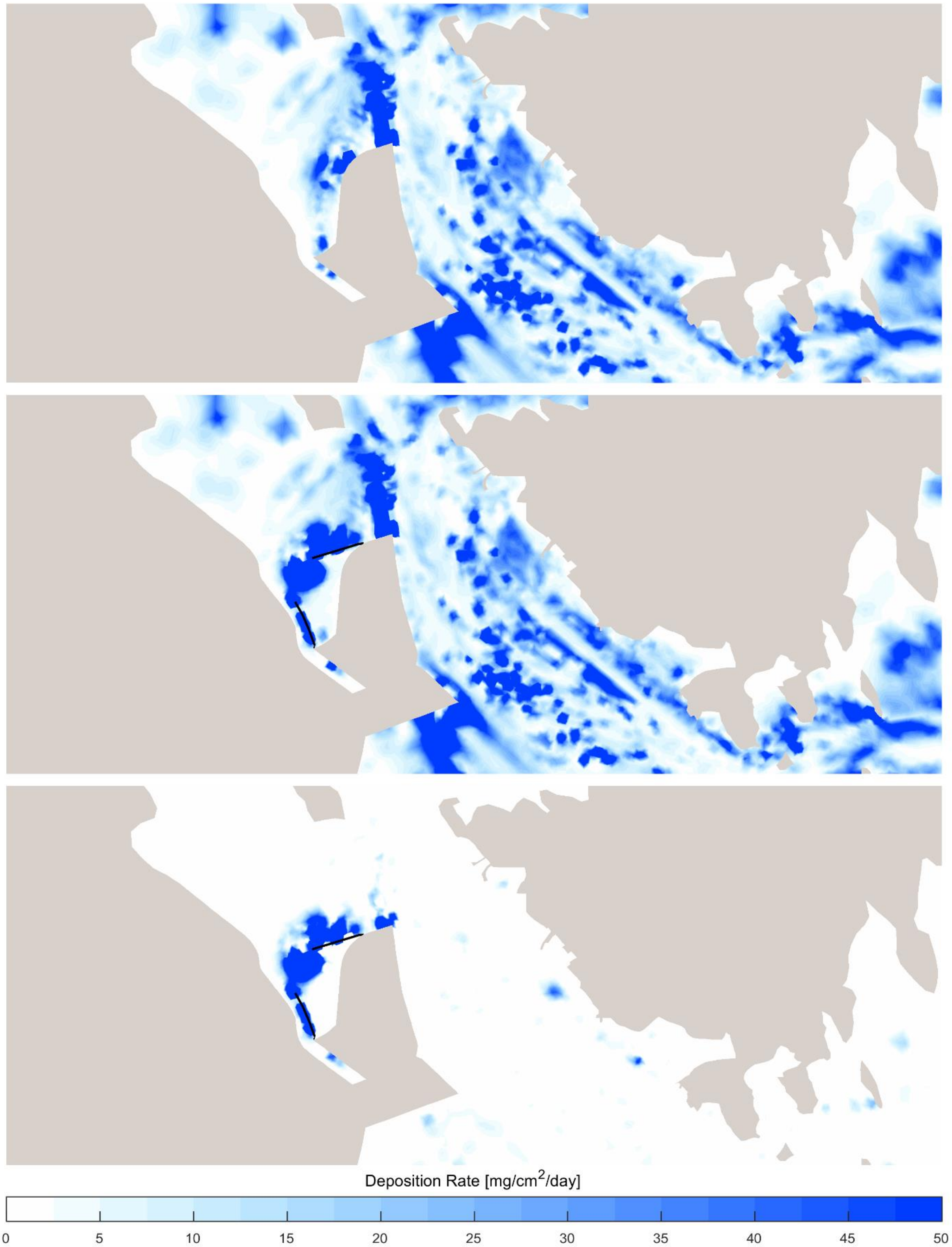


Figure 10 Scenario 1B (24-hr Construction Operations). 95th Percentile Deposition Rate Base Case (Top), With Construction (Middle) and Difference (Bottom)

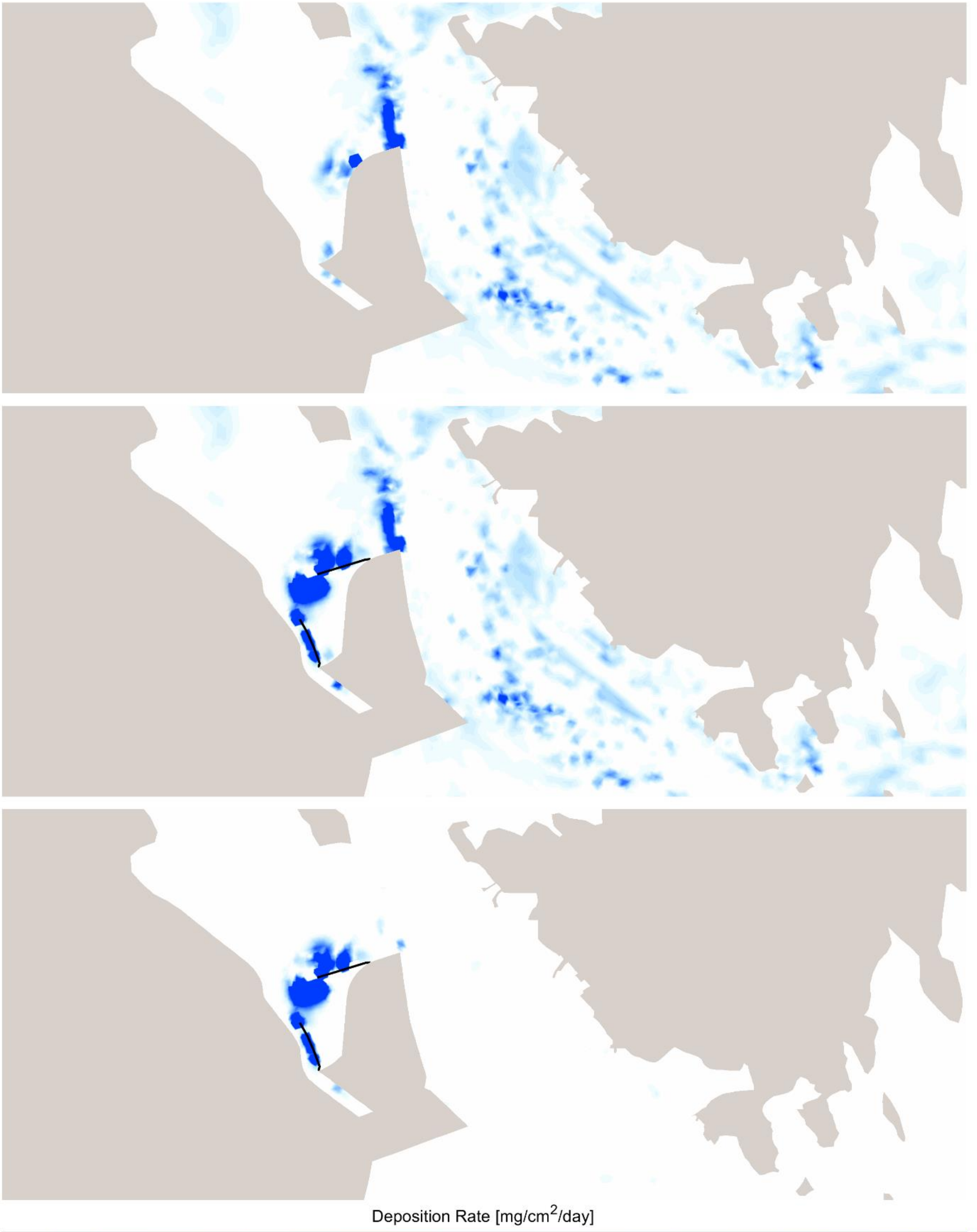


Figure 11 Scenario 1B (24-hr Construction Operations). 50th Percentile Deposition Rate Base Case (Top), With Construction (Middle) and Difference (Bottom)

The Scenario 1B Zones of Impact (Figure 12) show a small Zone of Low Impact in the immediate proximity of the eastern and western arms of the constructed bund, a very small zone of medium impact near the end of the western arm, and a Zone of Influence adjacent to the WB reclamation area.

Figure 12 Scenario 1B (24-hr Construction Operations) - Zones of Impact / Influence

Scour / Accretion Impacts

The modelled rate of scour of bed sediment is presented in Figure 13, assuming a dry density of 1000 kg/m^3. The model results indicate that the rate of scour of sediment immediately adjacent to the end of the eastern bund spur could be noticeable (approximately 20 mm/day). Note that this result is subject to considerable uncertainty, and the morphological adjustment of the seabed would lead to a reduced scour rate over time.

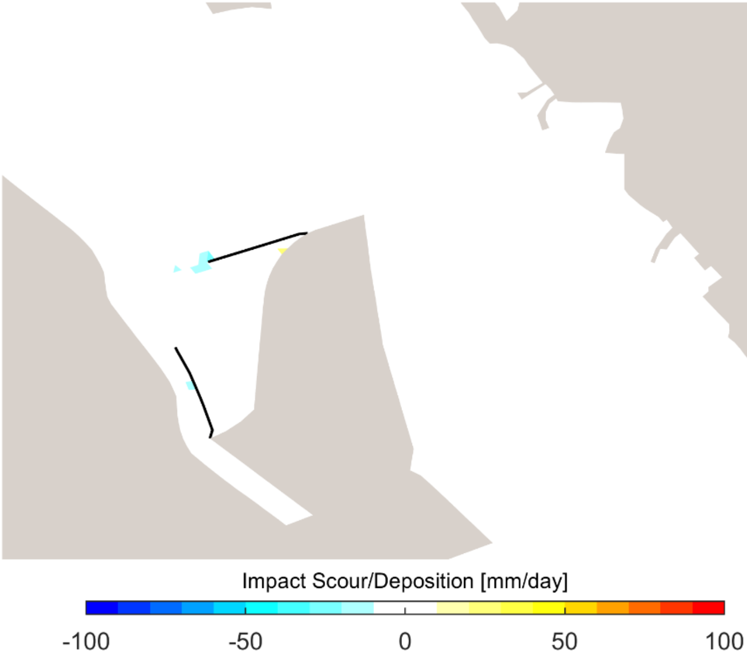


Figure 13 Scenario 1B Scour / Accretion Impacts.

Scenario 1C, 24-hr Construction Operations

Due to mesh sizing constraints, the near-closure condition for bund construction was resolved with a gap corresponding to the minimum cell width of approximately 70 m.

The modelled percentile increases in turbidity as a result of the Scenario 1C bund construction are presented in the bottom panels of Figure 14 and Figure 15 for the 95th and 50th percentiles, respectively. Short term turbidity impacts are noted along the northern extent of the constructed bund, and on the mudflat to the north of the reclamation. Minor impacts are also observed in the 50th percentile turbidity, indicating minor prolonged influence on turbidity levels. Note that the colour bar scale limits are different in the two plots.

Modelled increases in the Scenario 1C sediment deposition rate are presented in the bottom panels of Figure 16 and Figure 17 for the 95th and 50th percentiles, respectively. Both the 95th and 50th percentile deposition impacts have a similar spatial extent, and again the deposition impacts associated with the bund construction plume are limited to areas adjacent to the WBE reclamation.

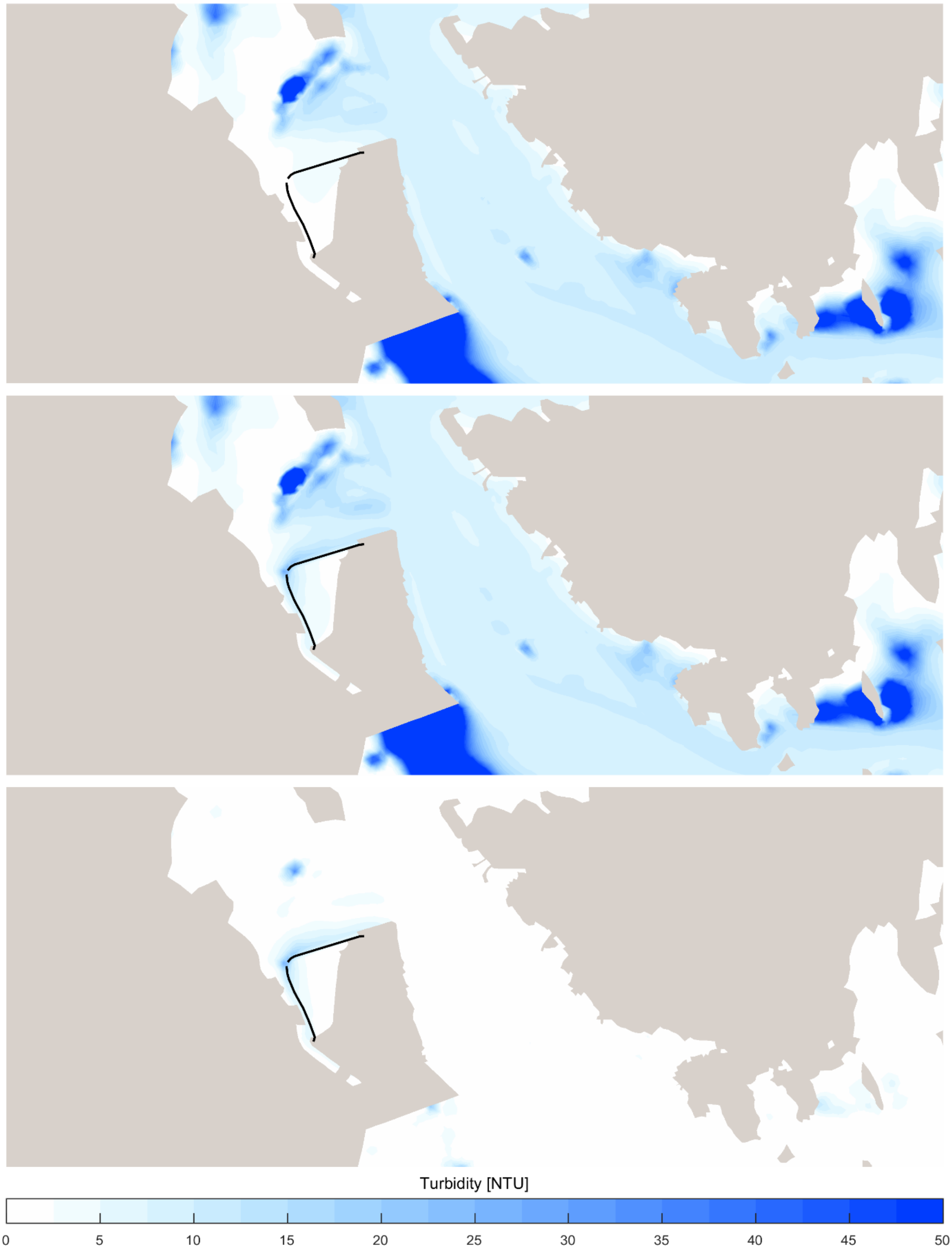


Figure 14 Scenario 1C (24-hr Construction Operations). 95th Percentile Turbidity Base Case (Top), With Construction (Middle) and Difference (Bottom)

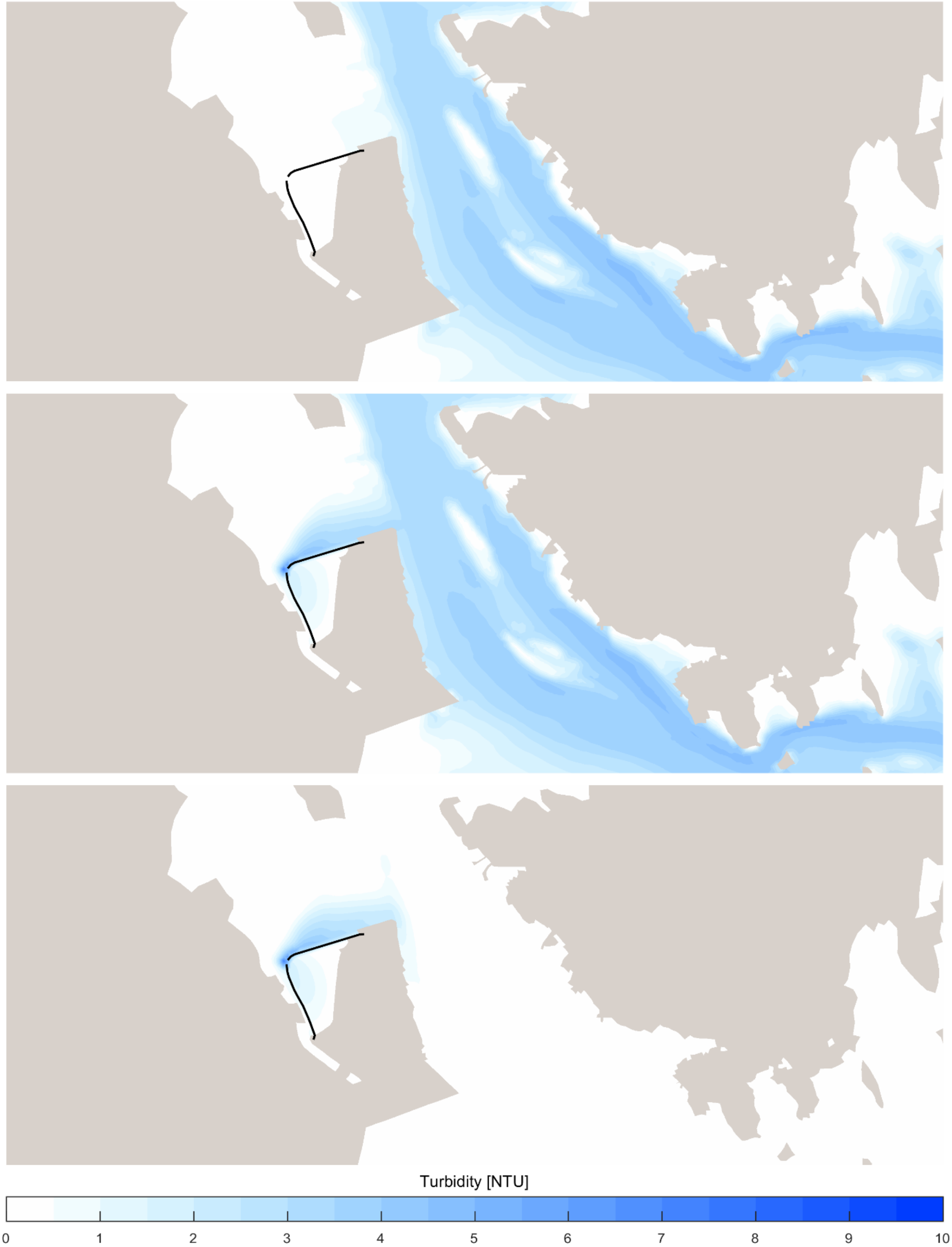


Figure 15 Scenario 1C (24-hr Construction Operations). 50th Percentile Turbidity Base Case (Top), With Construction (Middle) and Difference (Bottom)

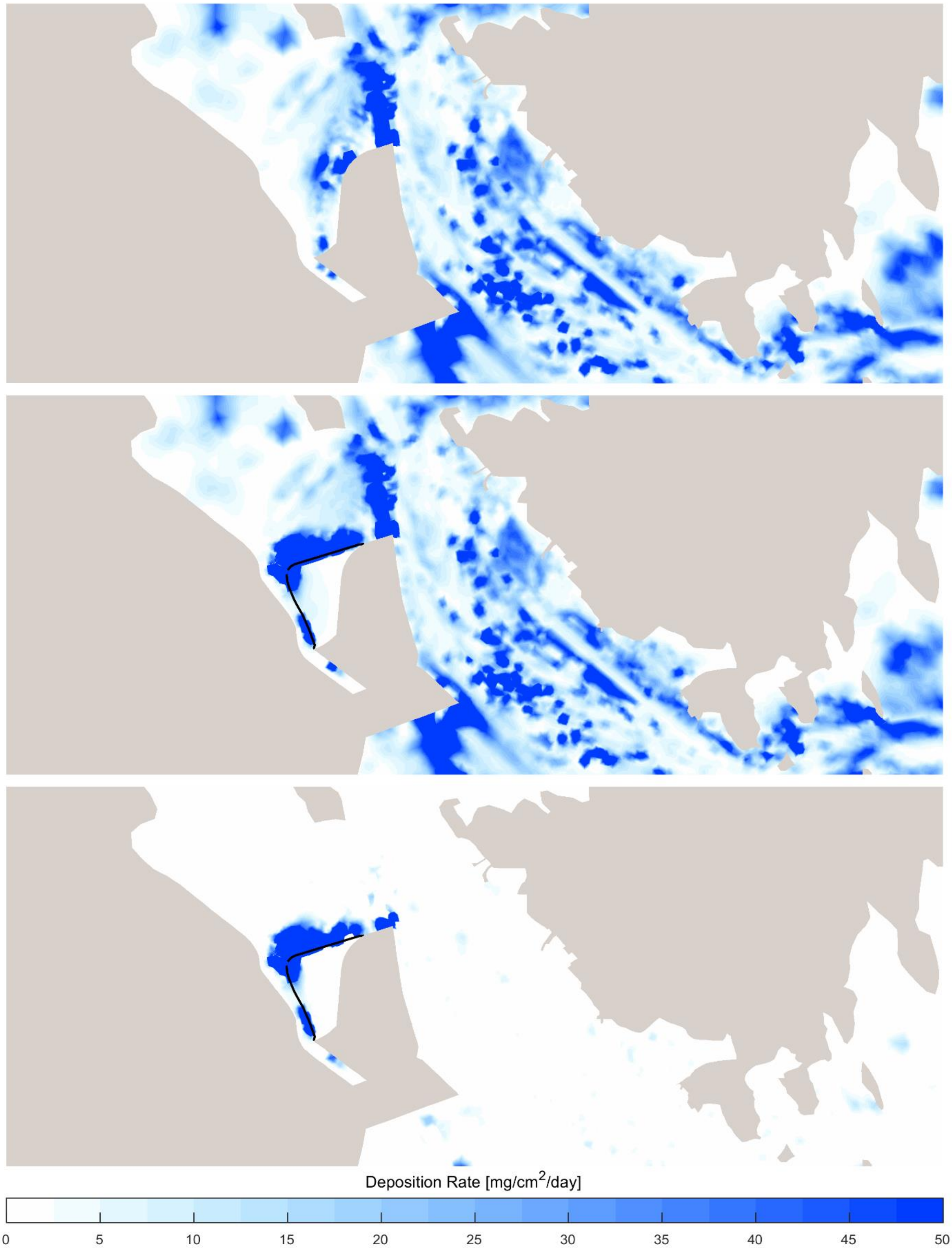


Figure 16 Scenario 1C (24-hr Construction Operations). 95th Percentile Deposition Rate Base Case (Top), With Construction (Middle) and Difference (Bottom)

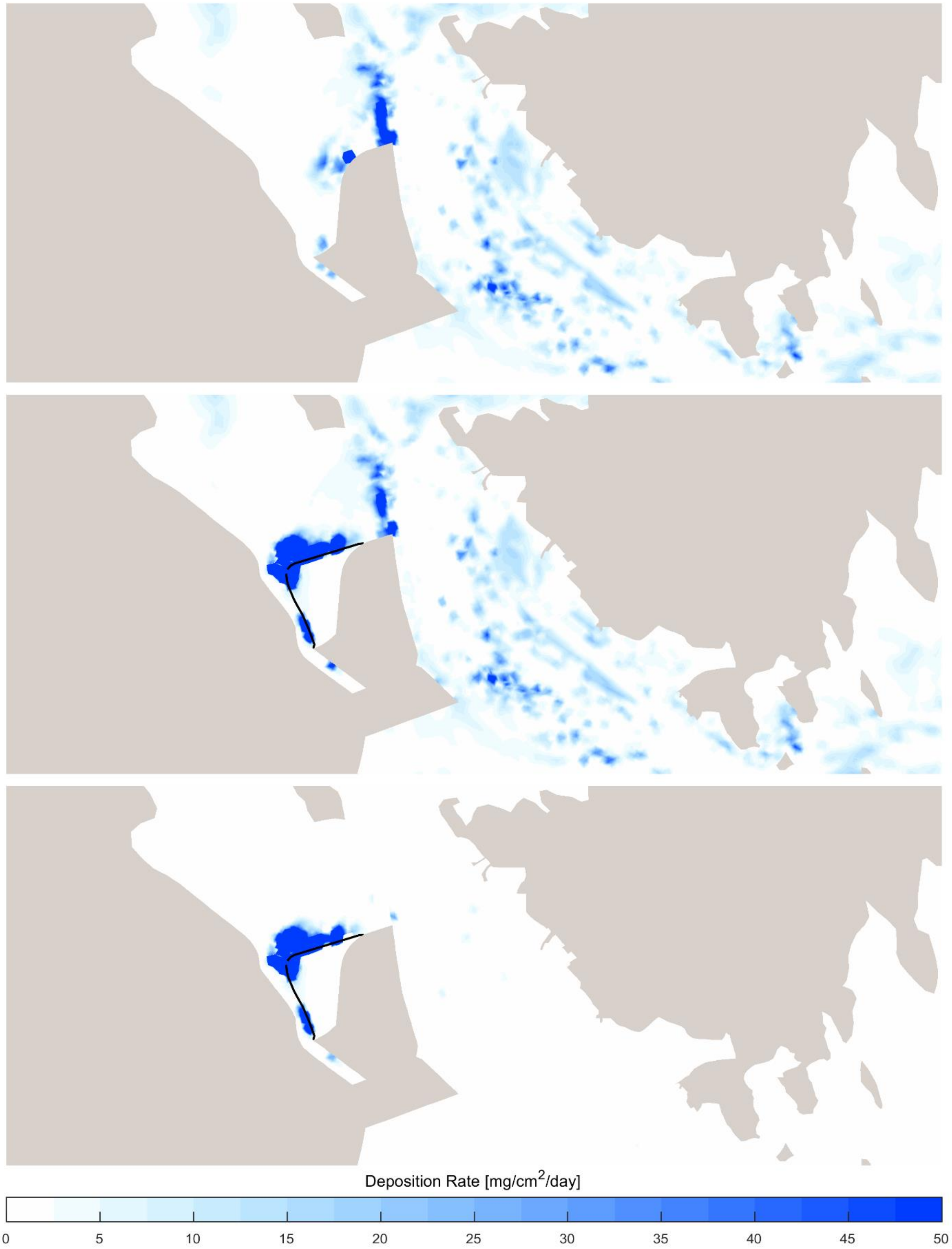


Figure 17 Scenario 1C (24-hr Construction Operations). 50th Percentile Deposition Rate Base Case (Top), With Construction (Middle) and Difference (Bottom)

The Scenario 1C Zones of Impact / Influence are presented in Figure 18. The increased velocities associated with the constricted bund opening (up to 2.5 m/s) generate suspended sediment plumes which combine with the other modelled plume sources, and therefore the Zones of Impact are larger in extent than in Scenarios 1A and 1B. However, the extent of the impact zones remains limited to the immediate vicinity of the WBE bund.

Figure 18 Scenario 1C (24-hr Construction Operations) - Zones of Impact / Influence.

Scour / Accretion Impacts

The modelled rate of scour of bed sediment is presented in Figure 19, assuming a dry density of 1000 kg/m^3. The model results indicate that the rate of scour of sediment immediately outside the opening in the bund could be significant (greater than 100 mm/day). Note that this result is subject to considerable uncertainty, and the morphological adjustment of the seabed would lead to a reduced scour rate over time. More detailed modelling of the narrow entrance during the process of bund closure may assist in estimating the likely magnitude of the scour.

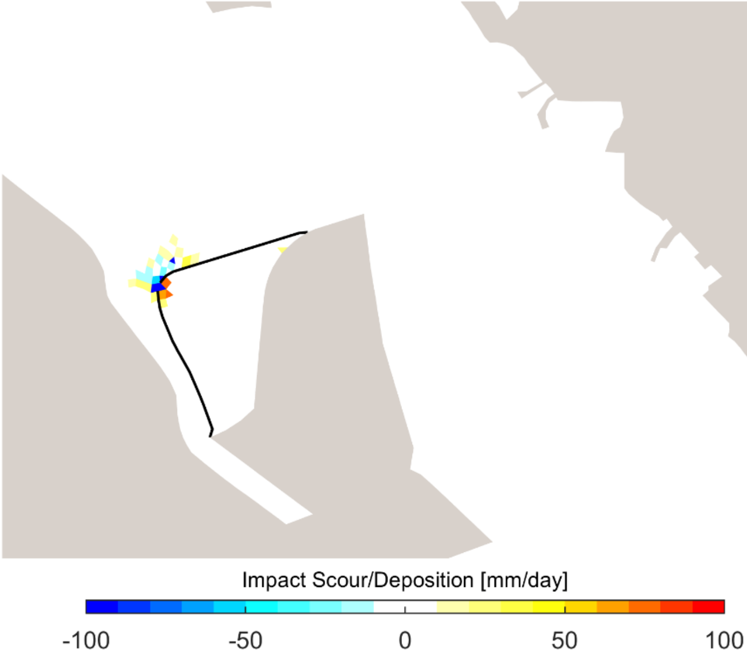


Figure 19 Scenario 1C Scour Impacts.

Conclusion

The modelling results indicate that the increases in turbidity and deposition rate associated with bund construction activities are likely to be relatively minor, and are unlikely to cause ecological impacts to seagrass or other sensitive receptors, since the Zones of Impact are limited to the immediate vicinity of the anticipated plume release locations. The model results indicate that significant erosion of bed sediment may occur as the bund nears completion when only a small gap remains to be filled.

This conclusion does depend though on the accuracy of the estimation of the suspended sediment releases associated with rock placement and 'mud wave' generation, and also on the accuracy of the model's estimate of the rate of erosion of bed sediment due to elevated flow velocities as the bund nears completion. It is recommended that the process of bund closure be investigated in more detail with a higher-resolution hydrodynamic model. The monitoring programme should be designed so that if the plume generation associated with the bund construction is higher than anticipated, the actual release rate can be accurately estimated and the modelling can be updated to produce a revised assessment of potential impacts.

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, 20/08/2020

BMT, 2019. "Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project EIS: Coastal Processes and Hydrodynamics". Report prepared for Gladstone Ports Corporation, July 2019. http://eisdocs.dsdip.qld.gov.au/Port%20of%20Gladstone%20Gatcombe%20and%20Golding%20Cutting%20Channel%20Duplication/AEIS/chapter-7-coastal-processes-and-hydrodynamics-25-september-19.pdf

Western Australia Environmental Protection Authority (WA EPA) (2011). Environmental Assessment Guideline for Marine Dredging Proposals.

12-hr Construction Operations: Turbidity and Deposition Rate Impacts

Scenario 1A

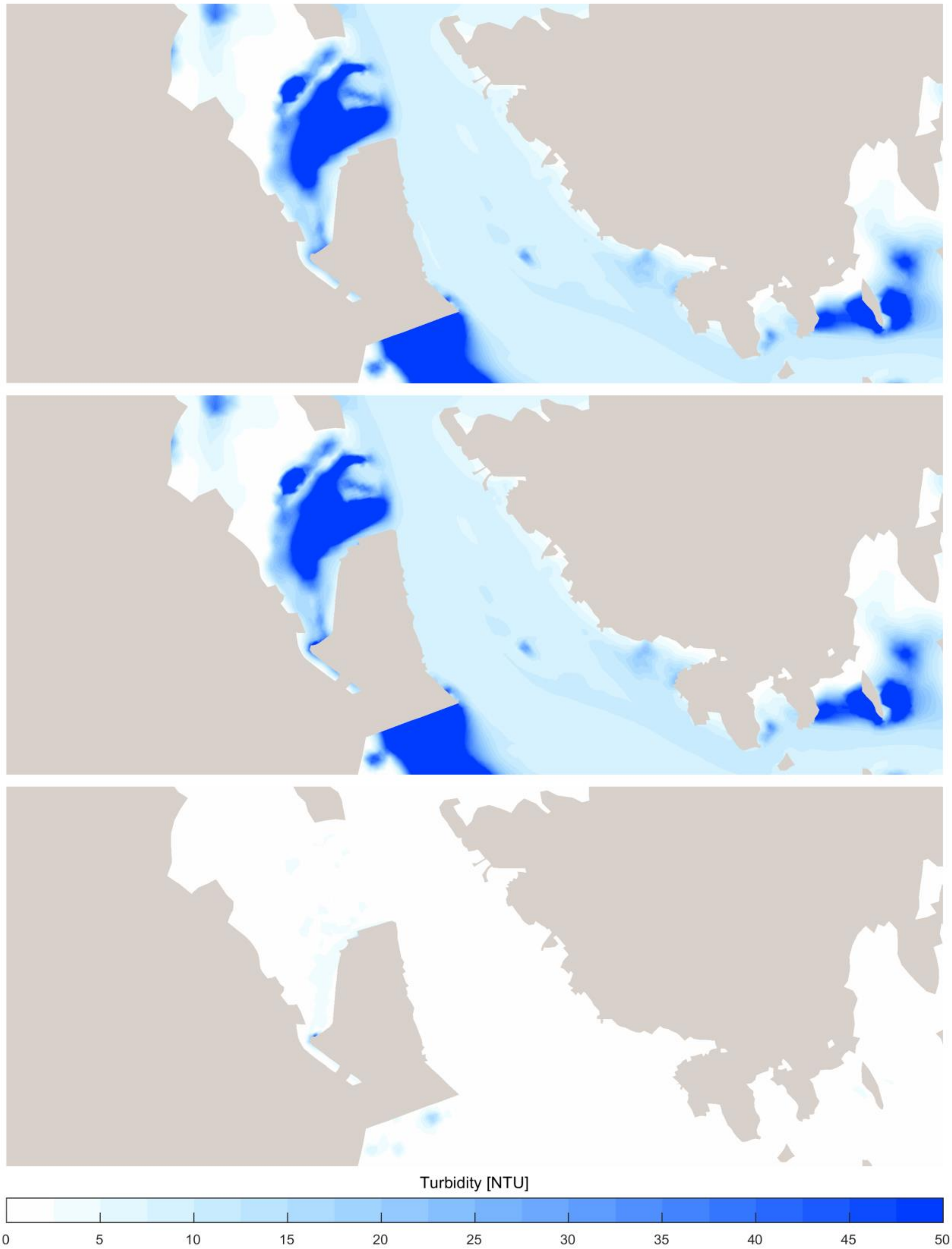


Figure 20 Scenario 1A (12-hr Construction Operations). 95th Percentile Turbidity Base Case (Top), With Construction (Middle) and Difference (Bottom)

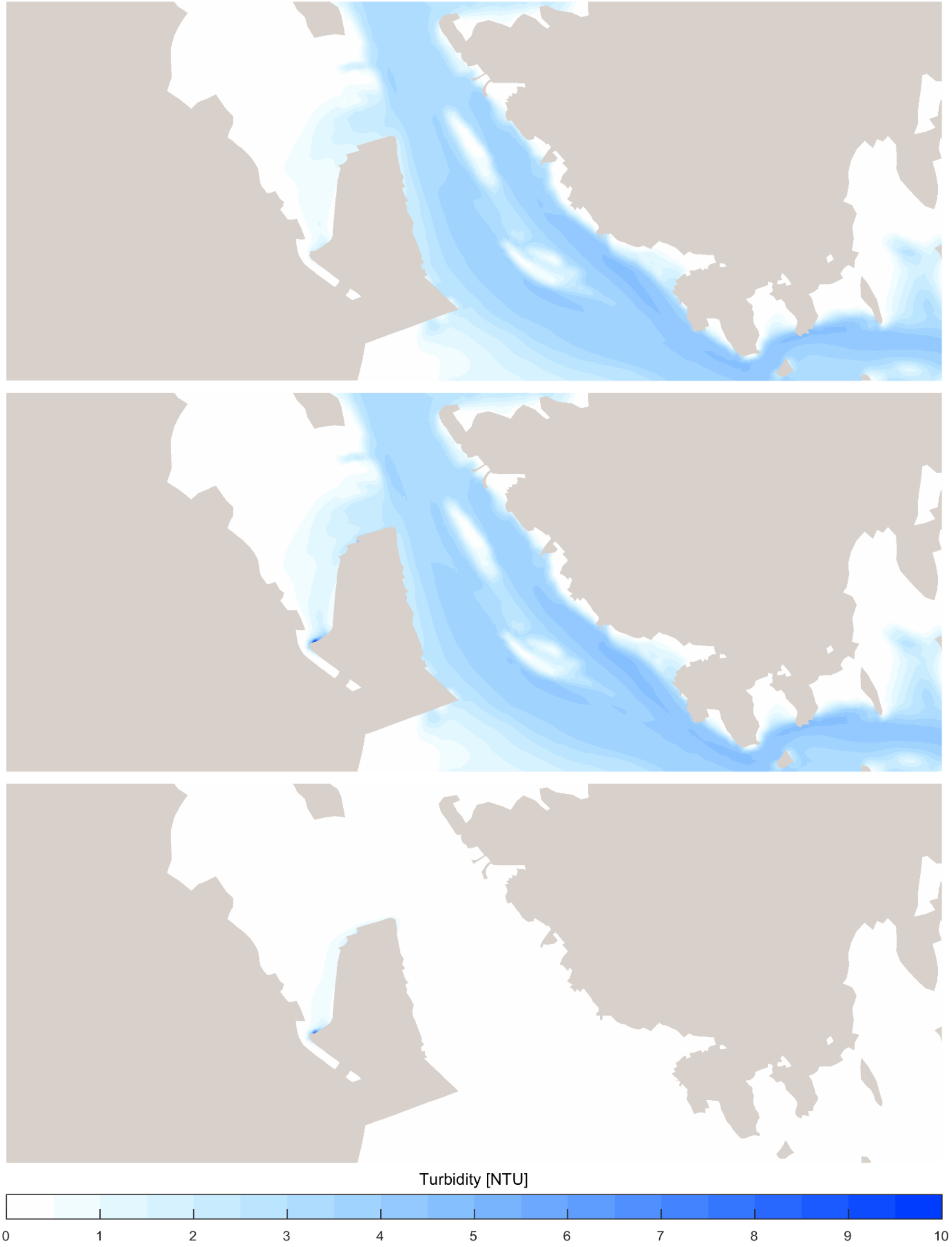


Figure 21 Scenario 1A (12-hr Construction Operations). 50th Percentile Turbidity Base Case (Top), With Construction (Middle) and Difference (Bottom)

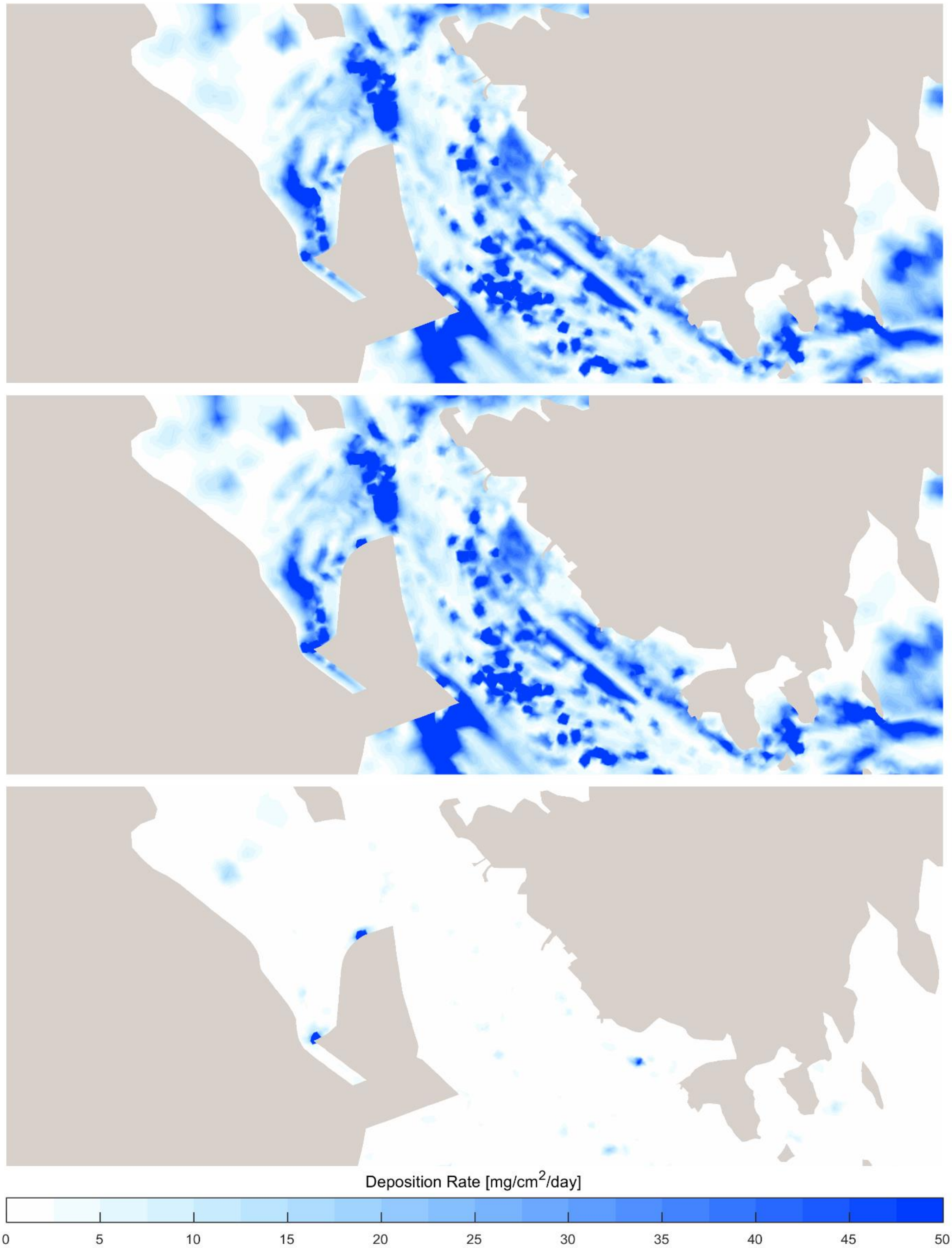


Figure 22 Scenario 1A (12-hr Construction Operations). 95th Percentile Deposition Rate Base Case (Top), With Construction (Middle) and Difference (Bottom)

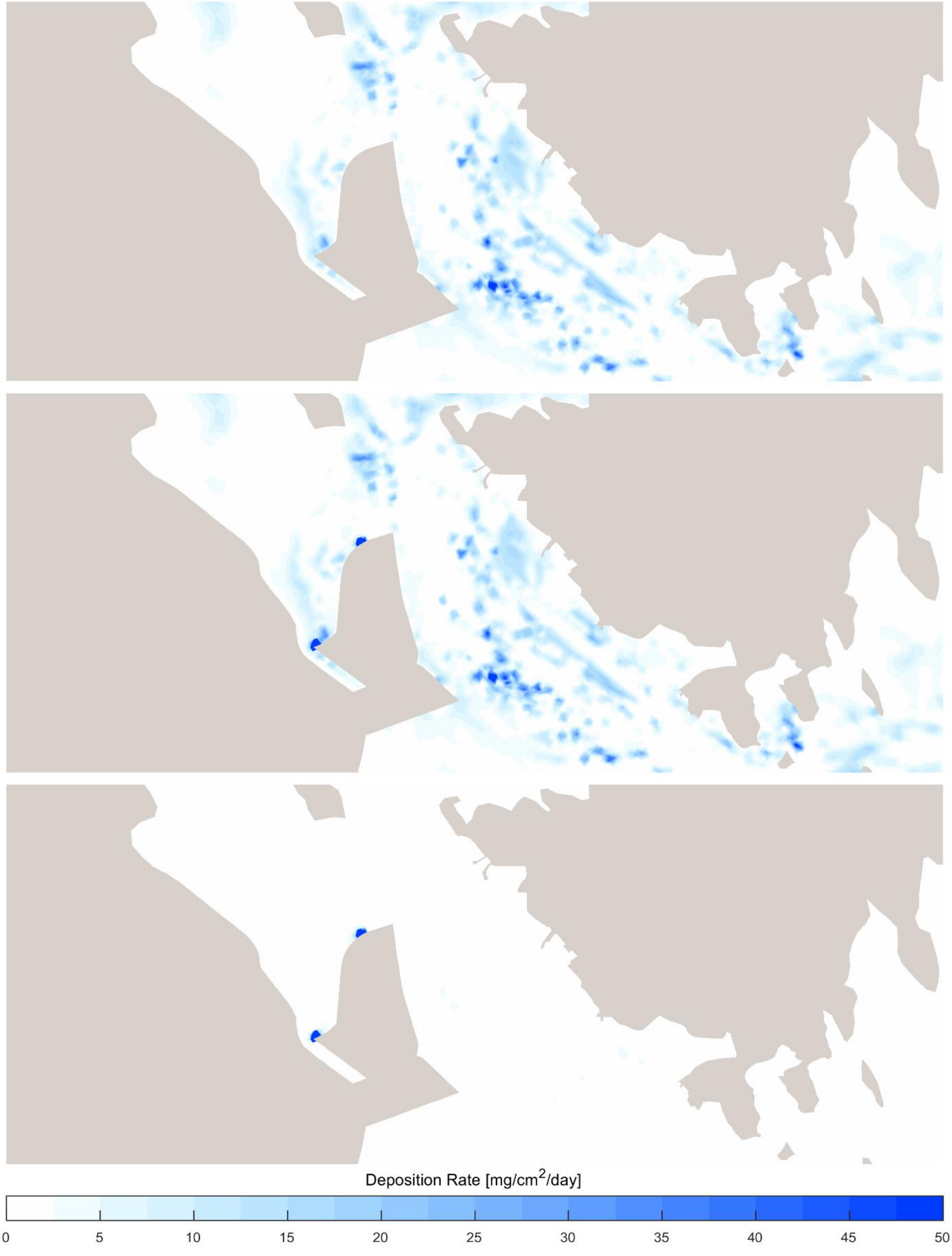


Figure 23 Scenario 1A (12-hr Construction Operations). 50th Percentile Deposition Rate Base Case (Top), With Construction (Middle) and Difference (Bottom)

Figure 24 Scenario 1A (12-hr Construction Operations) - Zones of Impact / Influence.

Scenario 1B

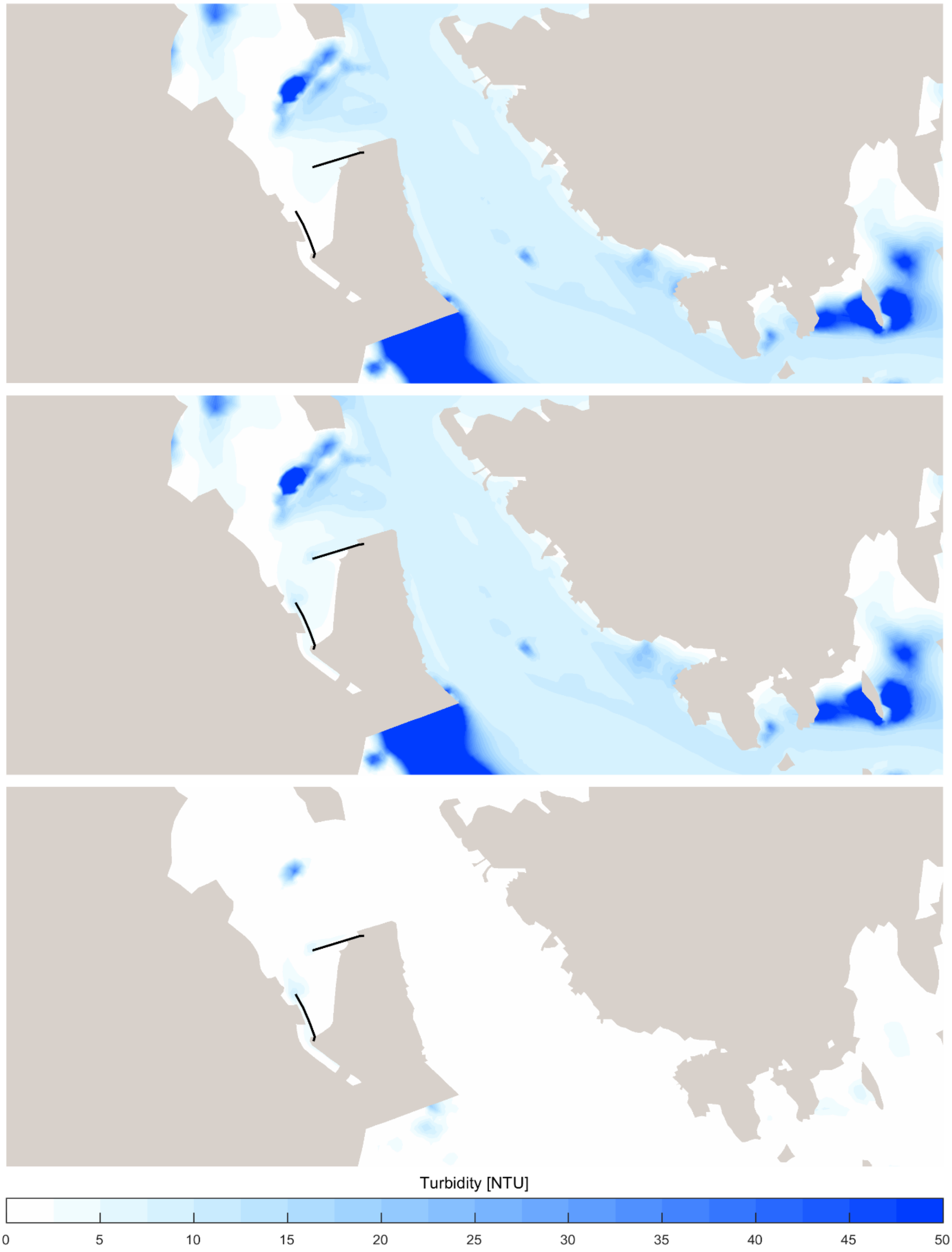


Figure 25 Scenario 1B (12-hr Construction Operations). 95th Percentile Turbidity Base Case (Top), With Construction (Middle) and Difference (Bottom)

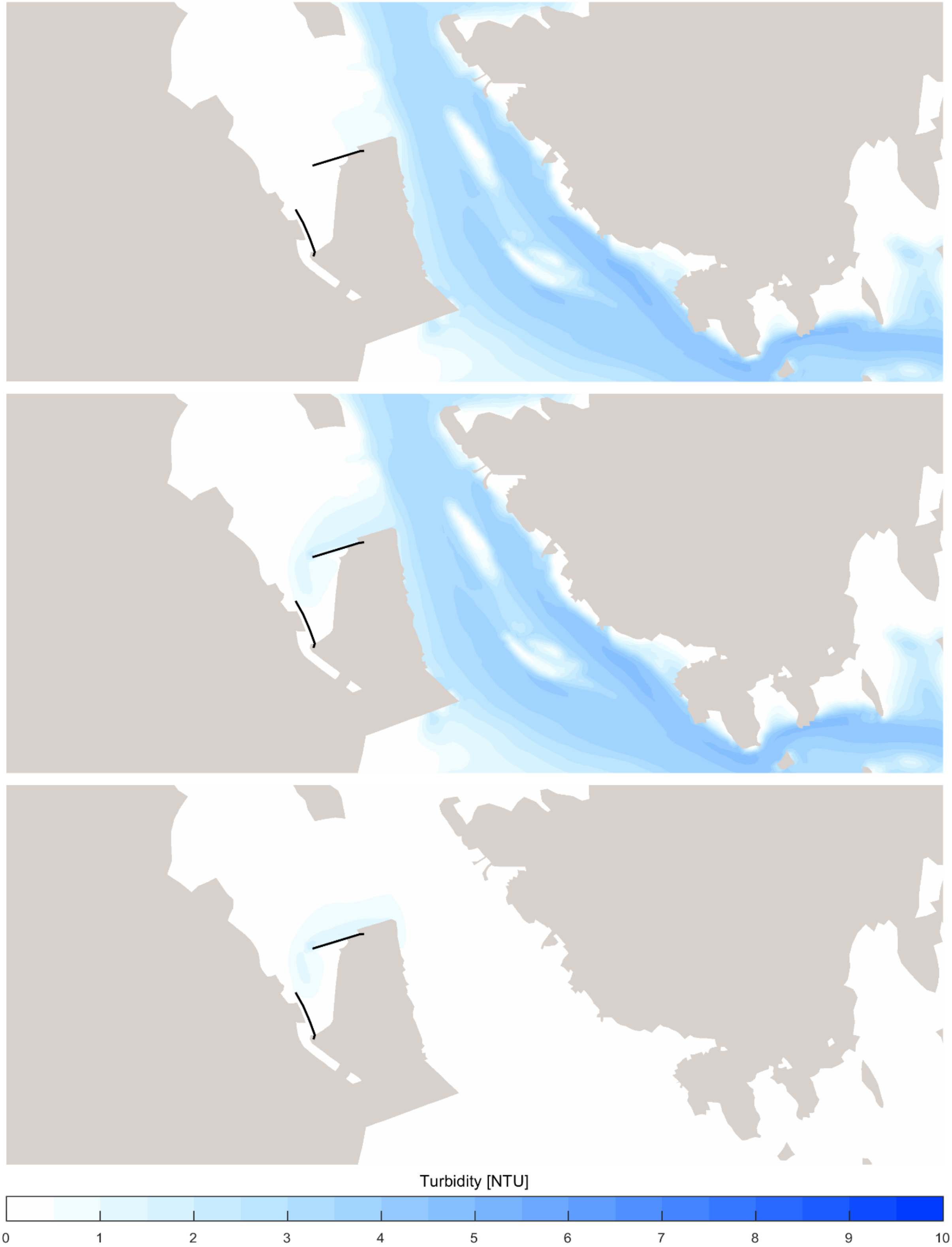


Figure 26 Scenario 1B (12-hr Construction Operations). 50th Percentile Turbidity Base Case (Top), With Construction (Middle) and Difference (Bottom)

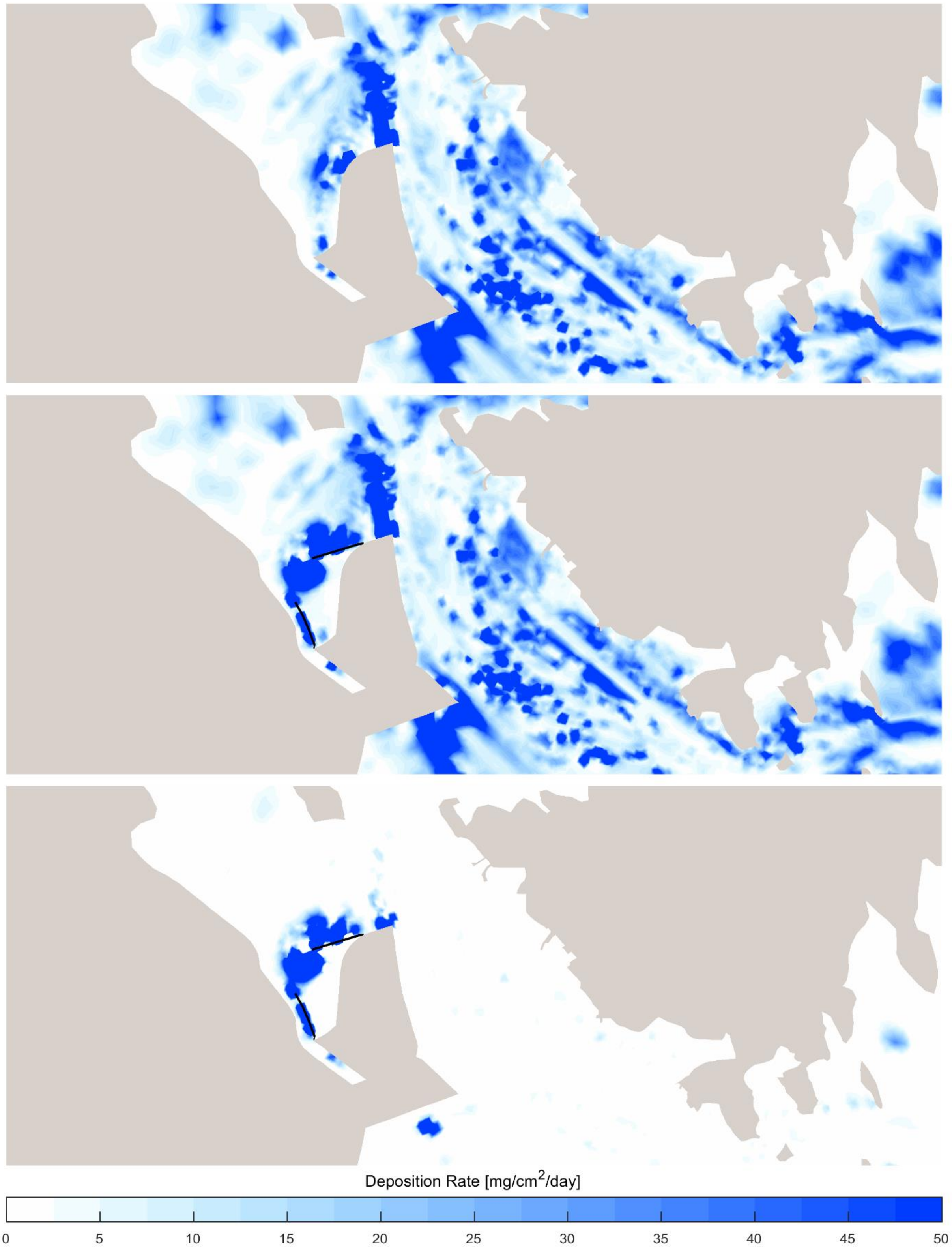


Figure 27 Scenario 1B (12-hr Construction Operations). 95th Percentile Deposition Rate Base Case (Top), With Construction (Middle) and Difference (Bottom)

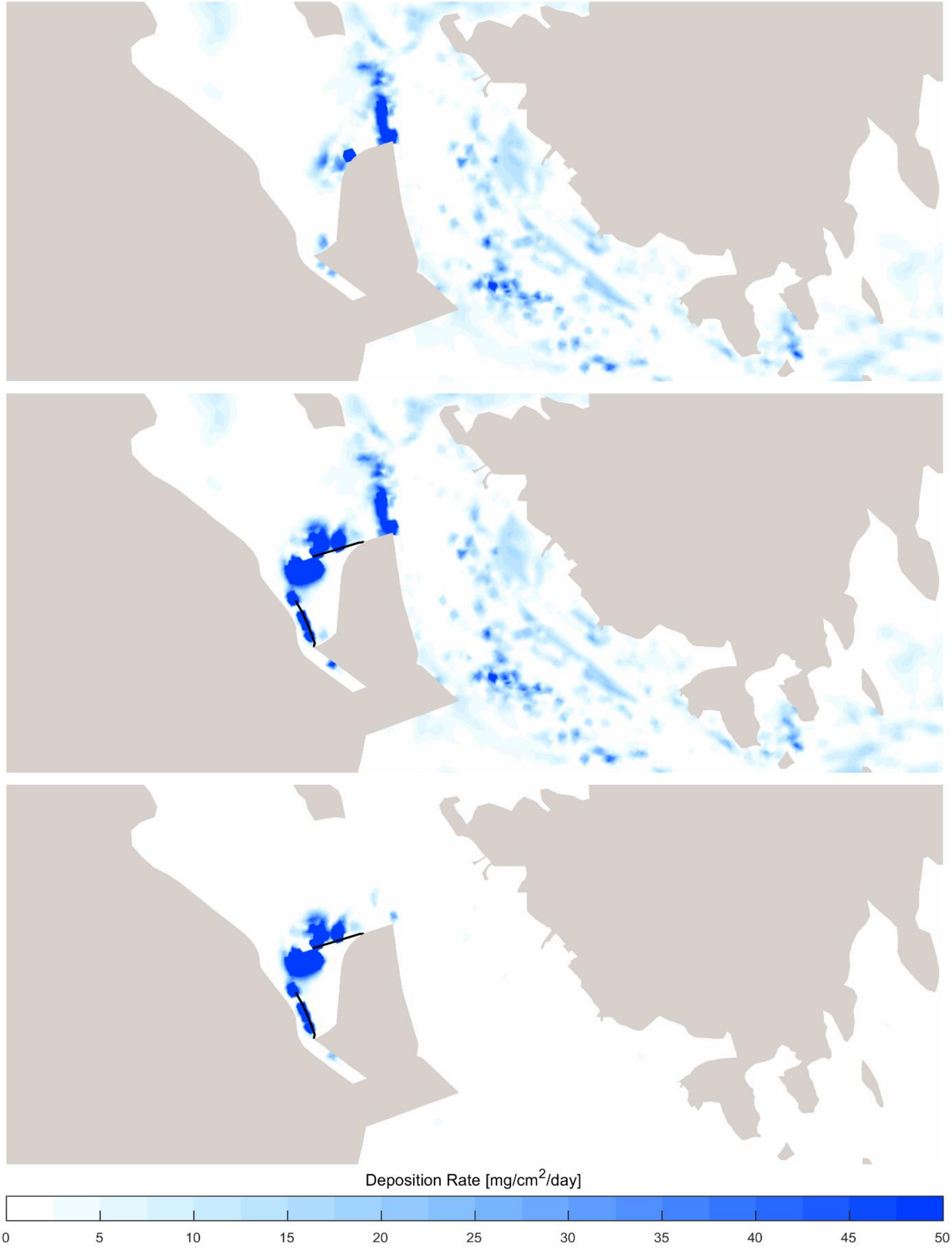


Figure 28 Scenario 1B (12-hr Construction Operations). 50th Percentile Deposition Rate Base Case (Top), With Construction (Middle) and Difference (Bottom)

Figure 29 Scenario 1B (12-hr Construction Operations) - Zones of Impact / Influence.

Scenario 1C

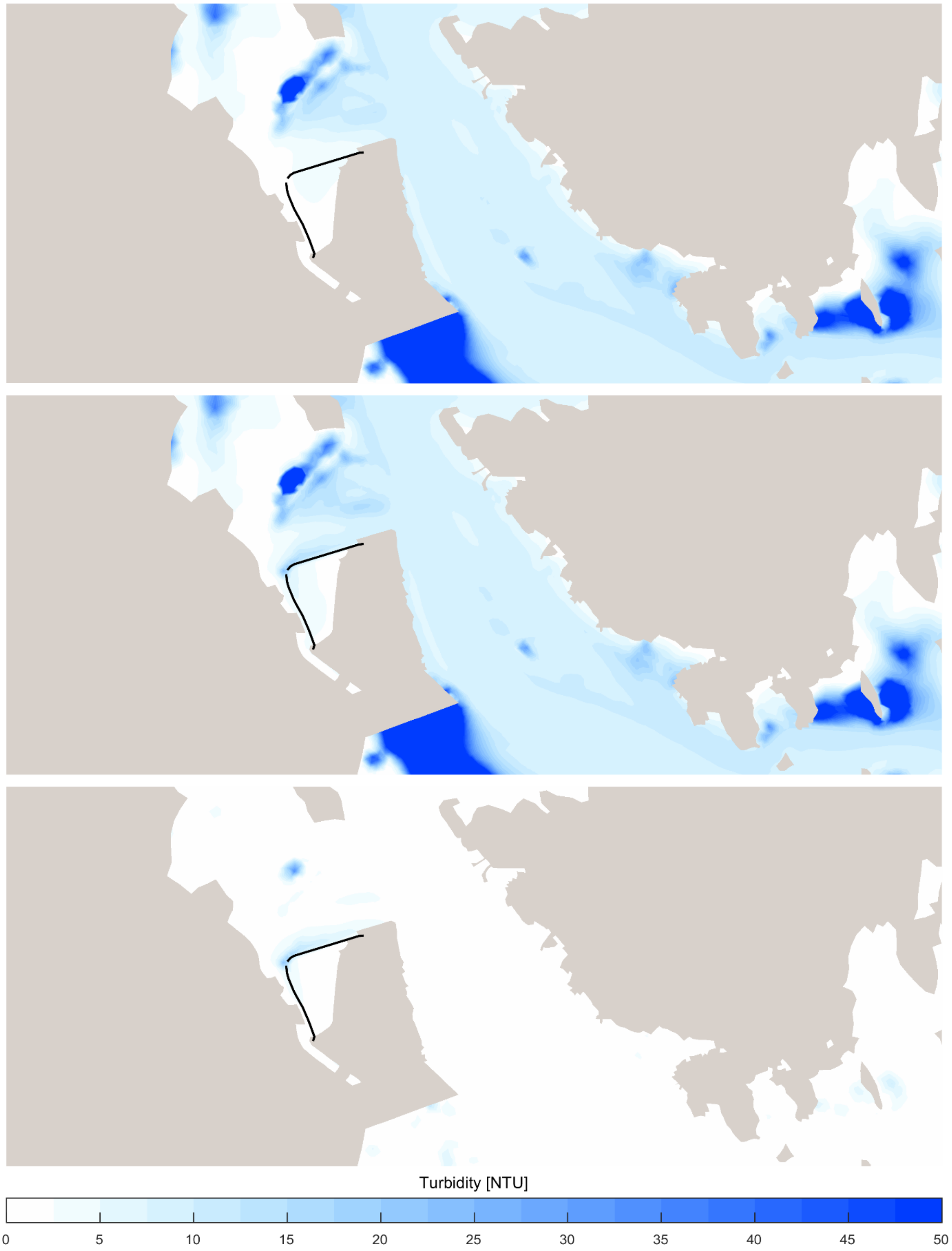


Figure 30 Scenario 1C (12-hr Construction Operations). 95th Percentile Turbidity Base Case (Top), With Construction (Middle) and Difference (Bottom)

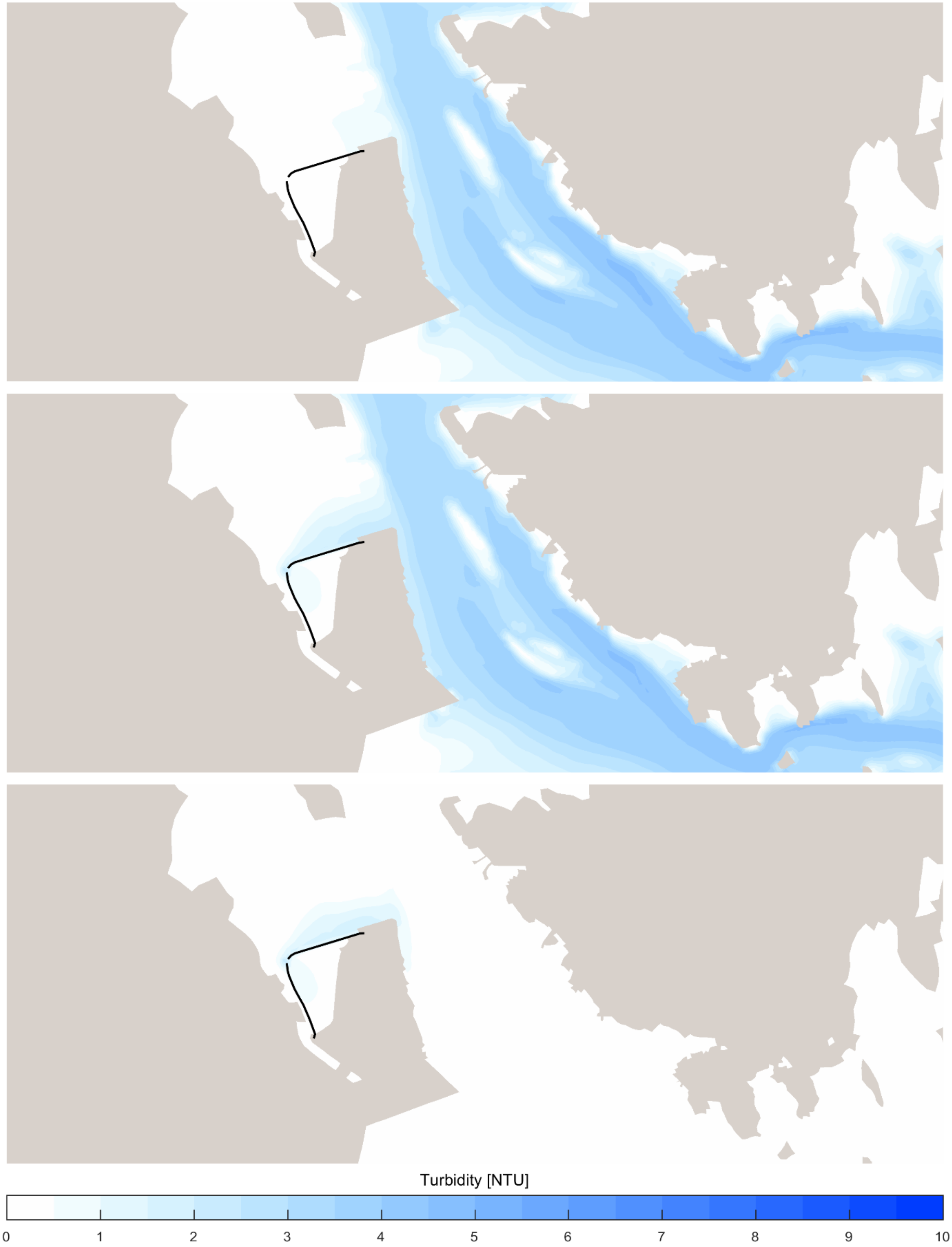


Figure 31 Scenario 1C (12-hr Construction Operations). 50th Percentile Turbidity Base Case (Top), With Construction (Middle) and Difference (Bottom)

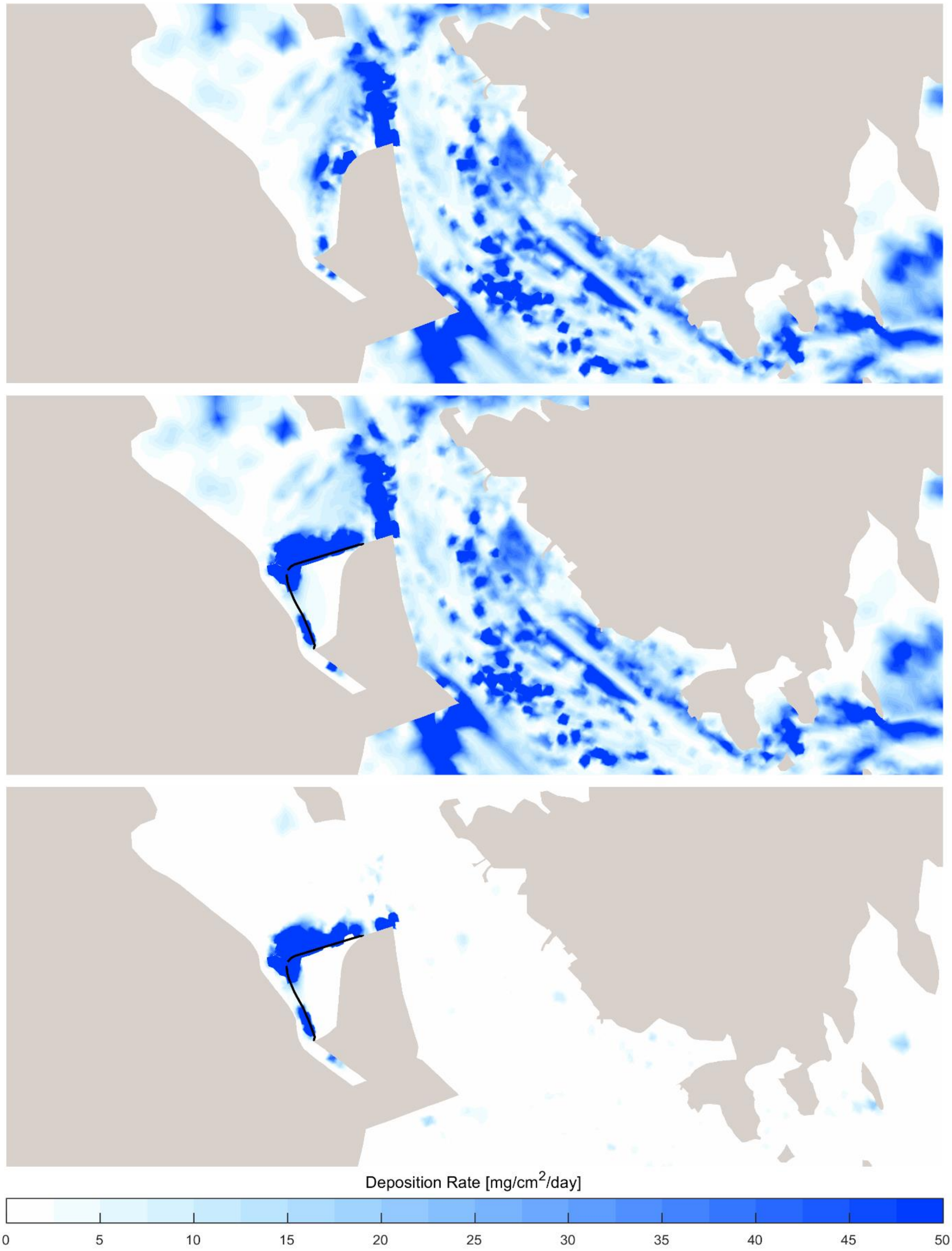


Figure 32 Scenario 1C (12-hr Construction Operations). 95th Percentile Deposition Rate Base Case (Top), With Construction (Middle) and Difference (Bottom)

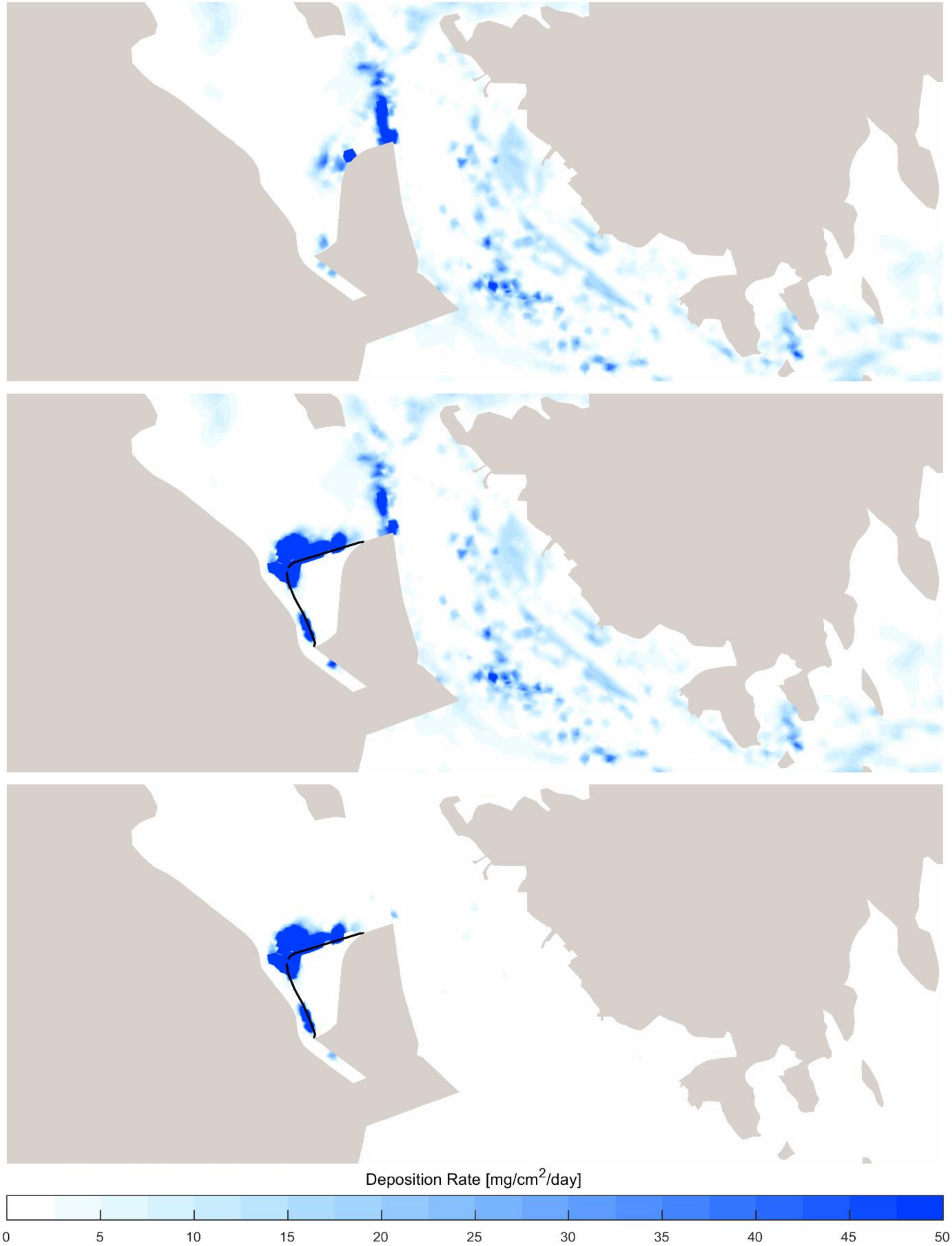


Figure 33 Scenario 1C (12-hr Construction Operations). 50th Percentile Deposition Rate Base Case (Top), With Construction (Middle) and Difference (Bottom)

Figure 34 Scenario 1C (12-hr Construction Operations) - Zones of Impact / Influence.

Annex B Technical Memorandum on Fine-Grained Sediment Source Terms

Technical Note

Date:	26/03/2024
To:	Anjana Singh, Christian Crosby
From:	Dr Andy Symonds
Subject:	Southern Reclamation Area: Source Rate Review
Classification:	Project Related
Version:	0.1

1. Introduction

Gladstone Ports Corporation (GPC) commissioned BMT to undertake an assessment into the release of fine-grained sediment (FGS) associated with the construction of the Southern Reclamation Area (SRA), located north of the existing Western Basin Reclamation Area. The aims of the assessment were:

- to provide an estimate of the FGS, which was not previously available for suspension, released into the water column due to the construction of the SRA;
- to provide an estimate of the FGS, which was presently available for suspension, released into the water column due to the construction of the SRA; and
- to detail a monitoring approach to measure and quantify the amount of FGS released due to the construction activities.

Port and Coastal Solutions (PCS) was previously commissioned by GPC to undertake a peer review of the assessment undertaken by BMT. One of the review comments by PCS suggested that further justification and discussion of the FGS source rates for the placement of rock and displacement of underlying soft sediment should be provided (PCS, 2022). Based on this comment BMT noted that the estimated source terms were based on values used in an environmental impact assessment for a similar rock wall construction at the Port of Townsville (BMT, 2023).

We understand that the Queensland Government Department of Climate Change, Energy, the Environment and Water (DCCEEW) has subsequently requested further information to improve the confidence in the source terms which have been adopted by BMT. In response to this, BMT noted to GPC that the source terms could be under- or over-estimating the sediment suspended by the activity and that a technical expert should be consulted to review and refine the source terms.

GPC has therefore requested that PCS review the source terms and provide discussion and recommendations on these, which is the focus of this technical note.

1.1. Source Term Review

The source terms which DCCEEW has requested further information on are related to the:

- rock placement on marine sediment: this is the sediment which is suspended when the rock is placed on the mud; and
- mud wave: this is the ongoing resuspension by currents of the sediment which is displaced by the rock and forms a mound next to the bund.

There is extensive literature available to inform source terms for dredging activity, with Becker *et al.* (2015) collating the available information to provide reasonable ranges of empirical source terms to adopt. The source terms are in the form of a fraction of the FGS in the material which will be suspended by the dredging, and so they are dependent on the properties of the sediment being dredged as well as the type of dredger and production rate of the dredging. Source terms are available for the main types of dredgers, which includes the trailing suction hopper dredger (TSHD), the cutter suction dredger (CSD), the backhoe dredger (BHD), the grab dredger (GD) and for placement through the bottom door of a vessel. Therefore, as long as there is sufficient information on the sediment properties and the proposed dredging approach it is possible to define realistic source terms for all the main dredging approaches.

However, we are not aware of any reliable information to inform source terms from the placement of rock on mud while creating a bund. This is likely to be due to the anticipated relatively small amount of FGS released by this activity meaning that predicting impacts from the release of FGS has not previously been a significant concern. The release of FGS from the placement of rock onto mud while creating a bund will be very dependent on the sediment properties as well as the configuration of the bund (dimensions, rock sizing etc) and so source terms from one location may not be applicable at another location. The FGS suspended by the placement of the rock onto the mud will be variable throughout the activity depending on whether the rock placement is directly onto the mud or onto previously placed rock. In addition, the erosion of any mud wave which has formed due to the rock placement will be both spatially and temporally variable depending on the sediment properties, the tidal state and the local currents.

Due to the lack of available information to inform source terms resulting from the placement of rock onto mud it is not considered to be possible to confidently derive source terms for this activity. In our opinion the source terms which result from the placement of rock onto mud for bund construction can only be defined through monitoring during the actual activity, this is discussed further in the following section.

1.2. Monitoring

A combination of monitoring approaches are proposed during the construction of the SRA. These are detailed by BMT (2023) and include fixed position monitoring, vessel-based monitoring and remote sensing.

The two years of natural background turbidity data which are available at the site to the north of the entrance to the SRA (site NW60) along with the planned short-term monitoring pre- and during construction at a site adjacent to the southern part of the entrance to the SRA (FSM01) will be used to identify if any plumes from the construction activity have resulted in an increase in turbidity in the area due to the construction and if there has been a change in the properties of the sediment in suspension (at FSM01). In addition, the ongoing monitoring at other sites in the area (WB20 and WB50) and comparison with long-term records will allow any potential increases in regional turbidity due to the construction activity to be identified.

The vessel-based monitoring will be used to determine the natural flux of suspended sediment into and out of the area adjacent to the SRA prior to construction and again during construction (both for spring tides). Therefore, any changes in the mass of suspended sediment exported from the area during the ebb stage of the tide can be used to calculate the additional mass of sediment in suspension due to the construction.

Remote sensing using drones and satellite imagery will help to identify if any visible plumes are present due to the construction work and the spatial extents of these and how they vary temporally. This will help to understand whether the plumes are local to where the construction work is being undertaken or if they can be seen to be transported away from the construction works. The drone imagery is likely to be the only monitoring approach which has the potential to differentiate between plumes resulting from the two sources (placement of rock on mud and natural erosion of the mud wave). This will allow an approximate split of the sediment suspended to be defined for the two source terms.

Comparison of the results from the monitoring with results from hindcast numerical modelling can be used to determine how the source terms assumed pre-construction represent the sediment suspended by the construction work. The source terms in the model can then be iteratively adjusted until they are considered to reliably represent the excess suspended sediment which has been identified to be due to the construction based on the measured data. These source terms can then be used to calculate the FGS released by the construction works. These values can then be adopted for the initial pre-construction source terms for any future rock bund construction work in the Port of Gladstone.

1.3. Recommendations

Based on the review of the source terms resulting from the placement of rock on mud during bund construction presented in this technical note, we have the following recommendations for the source terms:

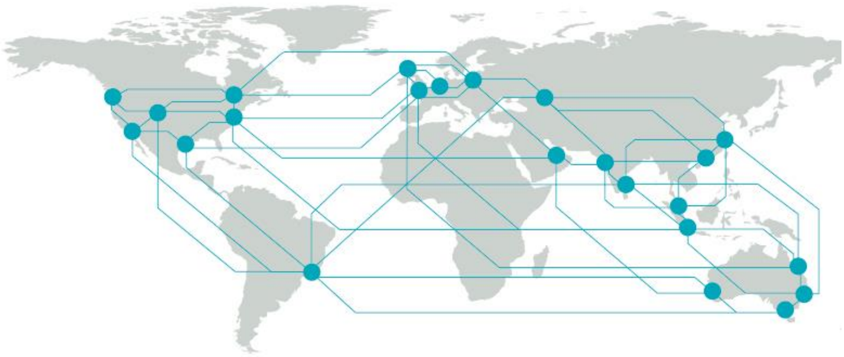
- there is insufficient available data/information to refine the existing source terms to provide additional certainty in them and so it is recommended that the existing source terms are adopted for the pre-construction FGS estimation; and
- detailed analysis of the extensive monitoring which will be undertaken pre- and during construction along with hindcast numerical modelling should be used to refine the source term estimates. These values will then be used to confirm the FGS released by the construction work.

2. References

Becker, J., van Eekelen, E., van Wiechen, J., de Lange, W., Damsma, T., Smolders, T. and van Koningsveld, M., 2015. Estimating source terms for far field dredge plume modelling. Journal of Environmental Management 149, 282-293.

BMT, 2023. Southern Reclamation Area Construction, Fine-Grained Sediment Monitoring Plan, March 2023.

PCS, 2022. Peer Review of Fine-Grained Sediment Monitoring Plan for Southern Reclamation Area Construction, June 2022.



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Final Audit Report 2024-07-07

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