Baird.

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Mr. Mike Priestly

Status: Correspondence
20/9/2024

Dear Mike,

Reference # 12979.406.M2.RevA

RE: Mardie Dredge Plume Modelling - Model Results Summary

Background

Baird have been requested by BCI Minerals (BCIM) to assess the impacts from sediment plumes associated with the proposed disposal of dredge spoil at an offshore location in the vicinity of the Mardie site. A specialist marine environmental consultant for the Mardie project will commence benthic studies at the preferred offshore disposal location mid-September. This modelling work has been undertaken to determine the preferred location for the dredged material placement area (DMPA) to be surveyed for benthic species. Investigation has been undertaken for DMPA4 (see Figure 1).

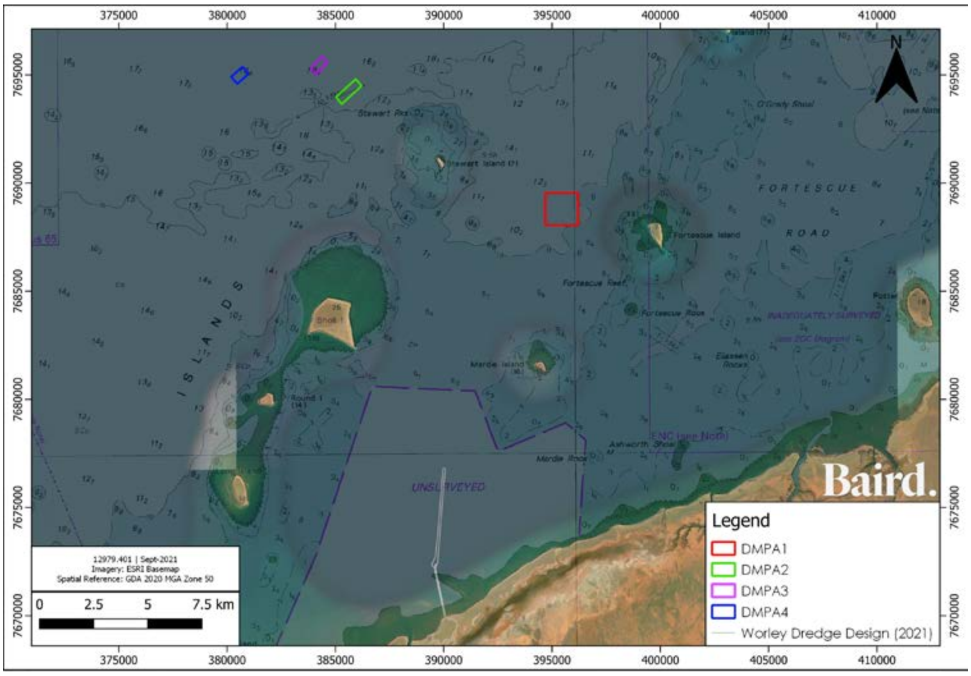

Figure 1: Dredge Material Placement Areas (DMPAs) previously investigated via Baird modelling.

Baird have been requested to model the full dredge program prior to the requirement to carry out survey of the benthic habitat at the DMPA4 location. This campaign follows the modelling of a representative period of the dredge program, with disposal of sediment occurring at DMPA1, completed by Baird in August 2024.

Model Inputs – Schedule

Baird have an established and validated a 3D hydrodynamic model and dredge plume model that has been updated with the current dredge method and schedule to complete this assessment. The model has been reviewed and accepted by the EPA as part of the previous submissions (most recently in Baird, 2022), and was used to model the predicted impacts of plumes generated during the capital dredging works of the channel and basin areas.

Baird have been provided with a dredging schedule by BCIM, with relevant expected duration, quantity of deposited materials, and expected start and finish dates (Figure 2). This schedule does not account for the need to dredge deeper than the design depth (i.e., over dredging) and additionally does not capture the potential schedule acceleration should soil conditions allow. In line with this and direction given by BCIM, the assumed volume of sediment to be placed at the DMPA each day is set at 3,600m^3, delivered via 3 hopper loads of 1,200m^3 each.

BCI MINERALS LIMITED- MARDIE SALT AND POTASH PROJECT- PORT - Dredging Schedule

Table Item	Description	Unit Qty (excl overdredge)m3	Average Weekly Production Rate-Hall (m3/week)	Duration (weeks)	Duration (days)	Start Date	End Date
SN	Dredging Works						
1	Separable Portion 12 - by BHD	12264.94	13766.80	0.89	7.00	1/04/2025	8/04/2025
2	Separable Portion 11 - by BHD	121241.14	13766.80	8.81	62.00	8/04/2025	9/06/2025
3	Separable Portion 1- by BHD	15594.84	13766.80	1.13	8.00	9/06/2025	17/06/2025
4	Separable Portion 2- by BHD	15813.52	13766.80	1.15	9.00	17/06/2025	26/06/2025
5	Separable Portion 3-by BHD	24798.97	13766.80	1.80	13.00	26/06/2025	9/07/2025
6	Separable Portion 4- BHD	32248.20	13766.80	2.34	17.00	9/07/2025	26/07/2025
7	Separable Portion 5 - by BHD	29844.22	13766.80	2.17	16.00	26/07/2025	11/08/2025
8	Separable Portion 6 - by BHD	22613.68	13766.80	1.64	12.00	11/08/2025	23/08/2025
9	Separable Portion 7 - by BHD	14639.45	13766.80	1.06	8.00	23/08/2025	31/08/2025
10	Separable Portion 8 - by BHD	14927.15	13766.80	1.08	8.00	31/08/2025	8/09/2025
11	Separable Portion 9 - by BHD	9722.93	13766.80	0.71	5.00	8/09/2025	13/09/2025
12	Separable Portion 10 - by BHD	6565.96	13766.80	0.48	4.00	13/09/2025	17/09/2025
	Total	320275.00		23.26	169.00		

Figure 2: Dredging Schedule Outline.

The dredging, and accompanying offshore disposal program, is due to be undertaken across the period April to September (inclusive), over the dry season months at the project location. This period is outside of the cyclone season and is a time of year where metocean conditions are most favourable with generally calm wave conditions. Table 1 displays the offshore disposal schedule based solely on the Hall dredging schedule. It has been broken into six separate sequences, each approximately one month long, starting from April 1st and operating until September 17th, a total of 169 days.

Table 1: Start and End times of each Sequence, for dry season 2019 (as proxy for 2024) based solely on Hall Schedule.

		Dry Season		
	Areas included in SEQ (BHD)	Start	End	No. Days
SEQ0	SP12 (7 days) 22 days in SP11	1/4/2019	30/4/2019	29
SEQ1	31 days in SP11	30/4/2019	31/5/2019	31
SEQ2	9 days in SP11 SP1 (8 days) SP2 (9 days) 5 days in SP3	31/5/2019	1/7/2019	31
SEQ3	8 days in SP3 SP4 (17 days) 6 days in SP5	1/7/2019	1/8/2019	31
SEQ4	10 days in SP5 SP6 (12 days) SP7 (8 days) 1 day in SP8	1/8/2019	1/9/2020	31
SEQ5	7 days in SP8 SP9 SP10	1/9/2019	16/9/2019	16
			TOTAL	169

If the dredging schedule presented in Table 1 is followed and 3,600m^3 of sediment is placed at the DMPA4 per day, a total of 608,400m^3 would be disposed of throughout the campaign. This volume of sediment is approximately 1.73 times the scheduled disposal amount (320,275m^3, without consideration of over dredging and bulking factors).

Table 2 details the adjustments made to the days in the schedule, to ensure the model represents offshore disposal of the required sediment volume of 352,302.5 m^3 (including 10% over dredge). Table 3 shows the adjustments made to the number of days in each Separable Portion (SP) to account for the adjusted volumes shown in Table 2. The adjusted schedule has been broken into four separate sequences, starting from April 1st and operating until July 8th, a total of 98 days.

Table 2: Adjusted days per Separable Portion of the Dredging Footprint.

Separable Portion (SP)	Days in Schedule	Volume to Dispose per SP (at 3,600m3/day)	Days in Schedule (plus 10% over dredge)	Volume to Dispose per SP based on adjusted scheduled days
SP12	7	25200.0	4	14592.41
SP11	62	223200.0	36	129247.07
SP1	8	28800.0	5	16677.04
SP2	9	32400.0	5	18761.67
SP3	13	46800.0	8	27100.19
SP4	17	61200.0	10	35438.7
SP5	16	57600.0.	9	33354.1
SP6	12	43200.0	7	25015.6
SP7	8	28800.0	5	16677.0
SP8	8	28800.0	5	16677.0
SP9	5	18000.0	3	10423.2
SP10	4	14400.0	2	8338.5
Total Dredge Volume		608,400.0		352,302.5

Table 3: Start and End times of each Sequence, for dry season 2019 (as proxy for 2024) based on adjusted dredging schedule.

			Dry Season	
	Areas included in SEQ (BHD)	Start	End	No. Days
SEQ1	SP12 (4 days) 25 days in SP11	1/4/2019	30/4/2019	29
SEQ2	11 days in SP11 SP1 (5 days) SP2 (5 days) SP3 (8 days) 2 days in SP4	30/4/2019	31/5/2019	31
SEQ3	8 days in SP4 SP5 (8 days) SP6 (7 days) SP7 (5 days) 3 days in SP8	31/5/2019	1/7/2019	31
SEQ4	2 days in SP8 SP9 (3 days) SP10 (2 days)	1/7/2019	8/7/2019	7
			TOTAL	98

The model has been run using the representative year identified by Baird during previously reported dredge plume modelling campaigns (Baird 2022, Baird 2023) with the following dredging assumptions based on the BCIM dredging schedule:

- Disposal rate at the site by split hull hopper barges of three hopper loads a day, each hopper load holding 1,200 m^3 (3,600m^3 total per day).

The schedule has been broken into four separate sequences. The first three sequences are each approximately one month long, starting from April 1st through until July 1st, followed by sequence four which is approximately one week long and concludes on the 8th of July. It can be seen in the *Days in Schedule (plus 10% over dredge)* column of

If the dredging schedule presented in Table 1 is followed and 3,600m^3 of sediment is placed at the DMPA4 per day, a total of 608,400m^3 would be disposed of throughout the campaign. This volume of sediment is approximately 1.73 times the scheduled disposal amount (320,275m^3, without consideration of over dredging and bulking factors).

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Table 2, that the sequence of areas nominated in the adjusted BCIM dredging schedule (Table 3) has been maintained in the schedule of sequences in Baird's dredge plume modelling.

- An overview of the dredge areas (SPs) can be seen in Figure 3, including the entire dredge footprint shown to the left, and the areas closest to the shore to the right (i.e., areas covered by SP1 to SP10).
- An overview of the hydrodynamic modelling grids and position of the DMPA4 relative to these grids can be seen in Figure 4 and Figure 5.

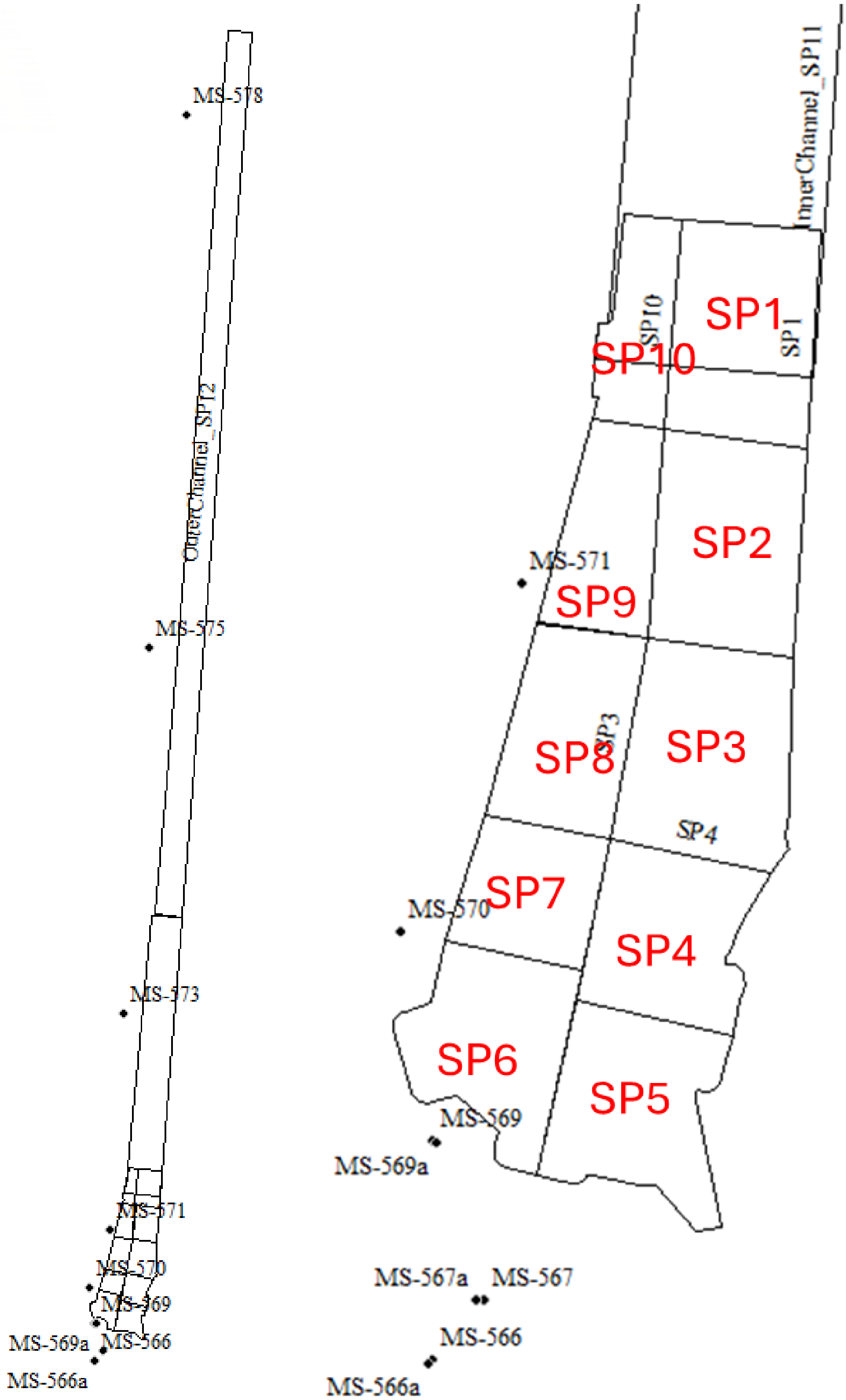

Figure 3: Dredge footprint showing the dredge areas nominated in the offshore disposal schedule (left) with an overview of the areas included in each phase of the offshore disposal program.

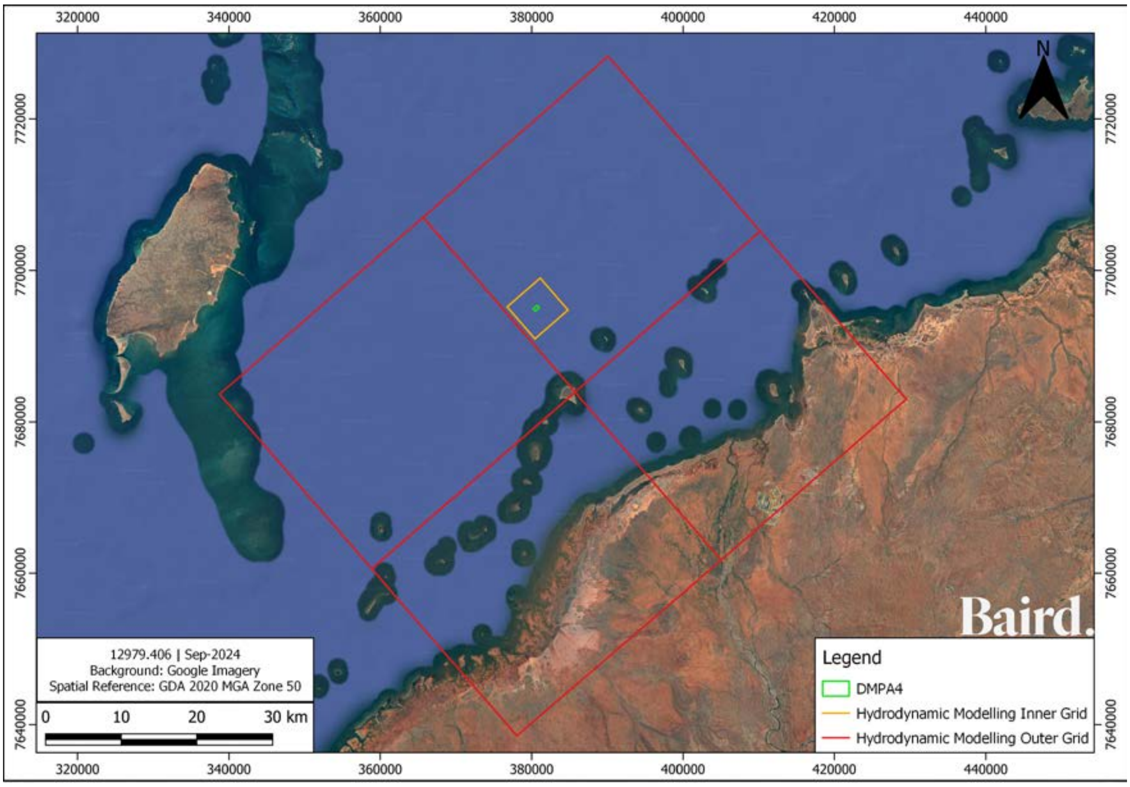

Figure 4: DMPA4 locations within the hydrodynamic modelling grids used in this modelling campaign.

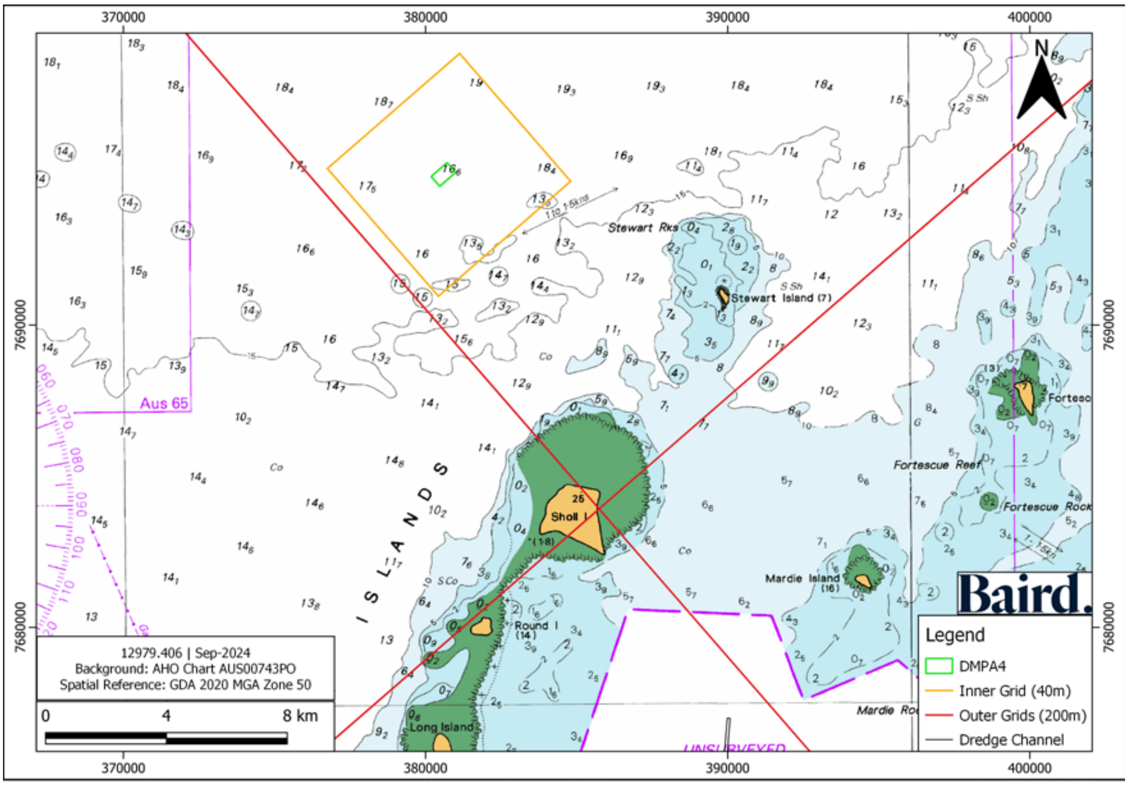

Figure 5: Zoom to DMPA4 within the hydrodynamic modelling grids used in this modelling campaign.

Source Term Assumptions

The model run was based on source terms used in previous modelling campaigns undertaken for BCIM as reported in Baird (2023), based on recommendations from in2Dredging in their Turbidity Source Terms Prediction Technical Note (In2Dredging, 2023):

- 0.94% by mass of total fine sediments lost from the Backhoe Dredge (BHD) bucket, with
- 2.81% by mass of total fine sediments lost from overflow of the hopper barges input at the surface layer.

These sediment losses at the dredging site were factored into the final volume of each sediment fraction that would be present in the 1,200m^3 hopper load to be released at the DMPA4 site. These assumptions have resulted in the following volumes of the sediment being input to the model per hour (Figure 6), split into four sequences as outlined in Table 3.

SEQ1		Sand	Fine Sand	Silt	Clay	Total Fines	
Assumed PSD	**SEQ1_SP12**	19%	10%	36%	35%	81%	100%
	SEQ1_SP11	50%	25%	14%	11%	50%	100%
Volume in Hopper (m^3) out of 1,200m^3 hopper load	**SEQ1_SP12**	233	115	432	420	852	1200
	SEQ1_SP11	603	297	168	132	300	1200
Final Volume Released at Spoil Ground	**SEQ1_SP12**	231	114	416	404	820	1165
	SEQ1_SP11	597	294	162	127	289	1180

SEQ2		Sand	Fine Sand	Silt	Clay	Total Fines	
Assumed PSD	**SEQ2_SP11**	50%	25%	14%	7%	46%	100%
	SEQ2_SP1	42%	20%	20%	10%	50%	100%
	SEQ2_SP2	33%	16%	26%	13%	54%	100%
	SEQ2_SP3	29%	14%	29%	14%	58%	100%
	SEQ2_SP4	27%	14%	30%	15%	59%	100%
Volume in Hopper (m^3) out of 1,200m^3 hopper load	**SEQ2_SP11**	603	297	168	132	597	1200
	SEQ2_SP1	498	246	237	219	702	1200
	SEQ2_SP2	394	194	306	306	806	1200
	SEQ2_SP3	346	170	347	338	854	1200
	SEQ2_SP4	330	162	360	348	870	1200
Final Volume Released at Spoil Ground	**SEQ2_SP11**	597	294	162	127	583	1180
	SEQ2_SP1	494	243	228	211	682	1176
	SEQ2_SP2	390	192	295	295	781	1172
	SEQ2_SP3	342	169	334	325	827	1170
	SEQ2_SP4	327	161	347	335	842	1169

SEQ3		Sand	Fine Sand	Silt	Clay	Total Fines	
Assumed PSD	**SEQ3_SP4**	27%	14%	30%	29%	73%	100%
	SEQ3_SP5	21%	11%	25%	43%	79%	100%
	SEQ3_SP6	24%	12%	28%	36%	76%	100%
	SEQ3_SP7	27%	14%	30%	29%	73%	100%
	SEQ3_SP8	30%	15%	28%	27%	70%	100%
Volume in Hopper (m^3) out of 1,200m^3 hopper load	**SEQ3_SP4**	330	162	360	348	870	1200
	SEQ3_SP5	257	127	300	516	943	1200
	SEQ3_SP6	293	145	330	432	907	1200
	SEQ3_SP7	330	162	360	348	870	1200
	SEQ3_SP8	362	178	333	327	838	1200
Final Volume Released at Spoil Ground	**SEQ3_SP4**	327	161	347	335	842	1169
	SEQ3_SP5	255	126	289	497	911	1166
	SEQ3_SP6	291	143	318	416	877	1168
	SEQ3_SP7	327	161	347	335	842	1169
	SEQ3_SP8	358	177	321	315	812	1170

SEQ4		Sand	Fine Sand	Silt	Clay	Total Fines	
Assumed PSD	**SEQ4_SP8**	30%	15%	28%	14%	56%	100%
	SEQ4_SP9	33%	16%	26%	13%	54%	100%
	SEQ4_SP10	33%	16%	26%	13%	54%	100%
Volume in Hopper (m^3) out of 1,200m^3 hopper load	**SEQ4_SP8**	362	178	333	327	838	1200
	SEQ4_SP9	394	194	306	306	806	1200
	SEQ4_SP10	394	194	306	306	806	1200
Final Volume Released at Spoil Ground	**SEQ4_SP8**	358	177	321	315	812	1170
	SEQ4_SP9	390	192	295	295	781	1172
	SEQ4_SP10	390	192	295	295	781	1172

Figure 6: Sources of sediment discharged in the model runs based on In2Dredging source term advice, broken down per model sequence.

Spatial Mapping

The overall map of the dredge spoil plume impact area that exceeds the WAMSI thresholds, as defined in Baird (2023), is shown using an 80th percentile (P80) background suspended sediment concentration (SSC) in Figure 7 for the DMPA4 location. This presents the Zone of High Impact (ZoHI) and Zone of Moderate Impact (ZoMI) for the representative model run period based on the release of dredge spoil from a 1,200m^3 capacity split hull hopper barge.

The results in Figure 7 show that the plume generated by disposal of sediments at the DMPA4 site result in both the ZOMI and ZOHI plumes confined to deep waters (>16m). It can be noted the plumes extend from the DMPA4 in a general northeast-southwest direction, which mimics the movement of the tidal flow, averaging a 1-1.5 knot velocity, in this area. The plumes do not pass through any of the sensitive marine areas shown in the AHO chart.

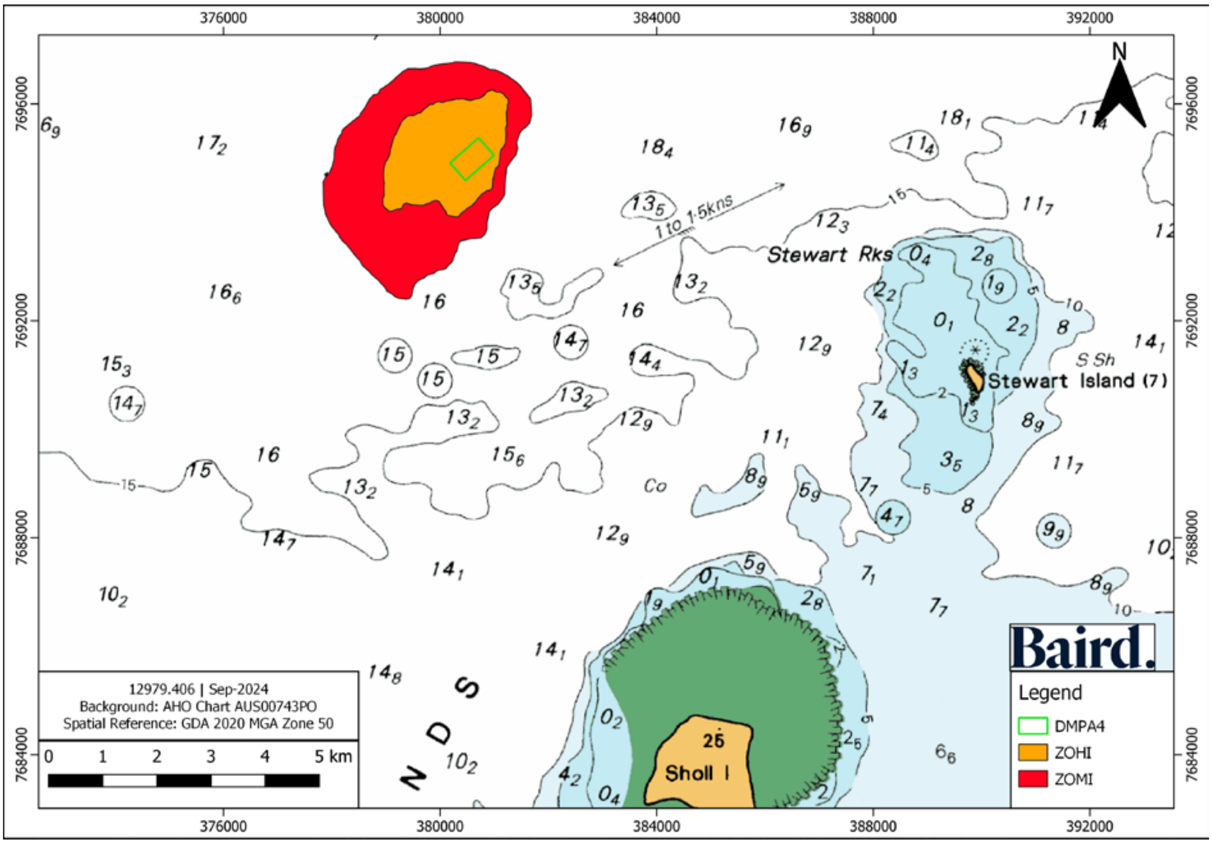

Figure 7: Calculated Zones of Impact (ZoMI and ZoHI) for the offshore disposal program based on a background SSC of P80 from the MODIS analysis at DMPA4.

A comparison of the extent of the sediment plumes resulting from Baird's offshore disposal modelling at DMPA1 (first pass and second pass) and DMPA4 is presented in Table 4. An analysis using GIS was performed and the differences in area measurements presented. In summary, the extent of the sediment plumes resulting from offshore disposal at DMPA4 have been reduced by at least 53% when compared with the areas seen at the two DMPA1 option sites.

The area of the ZOMI and ZOHI plumes at DMPA4 have been reduced by 66% and 58% respectively compared to the area of the DMPA1 (first pass) ZOMI and ZOHI plumes. Similarly, the ZOMI and ZOHI plumes were reduced by 58% and 53% respectively compared to the area of the DMPA1 (second pass).

Table 4: Measurements of plume results from hydrodynamic modelling of DMPA1 and DMPA4.

Name	Zone	Area (km^2)
DMPA4	ZOMI_P80	11.11
DMPA4	ZOHI_P80	3.87
DMPA1 – first pass	ZOMI_P80	63.98
DMPA1 – first pass	ZOHI_P80	20.54
DMPA1 – second pass	ZOMI_P80	45.90
DMPA1 – second pass	ZOHI_P80	13.00

Sedimentation Map

Sedimentation maps produced from the completed modelling schedule are shown for DMPA4 in Figure 8. This is a representation of the level of sedimentation that would be expected to occur at the completion of the entire offshore dredge campaign.

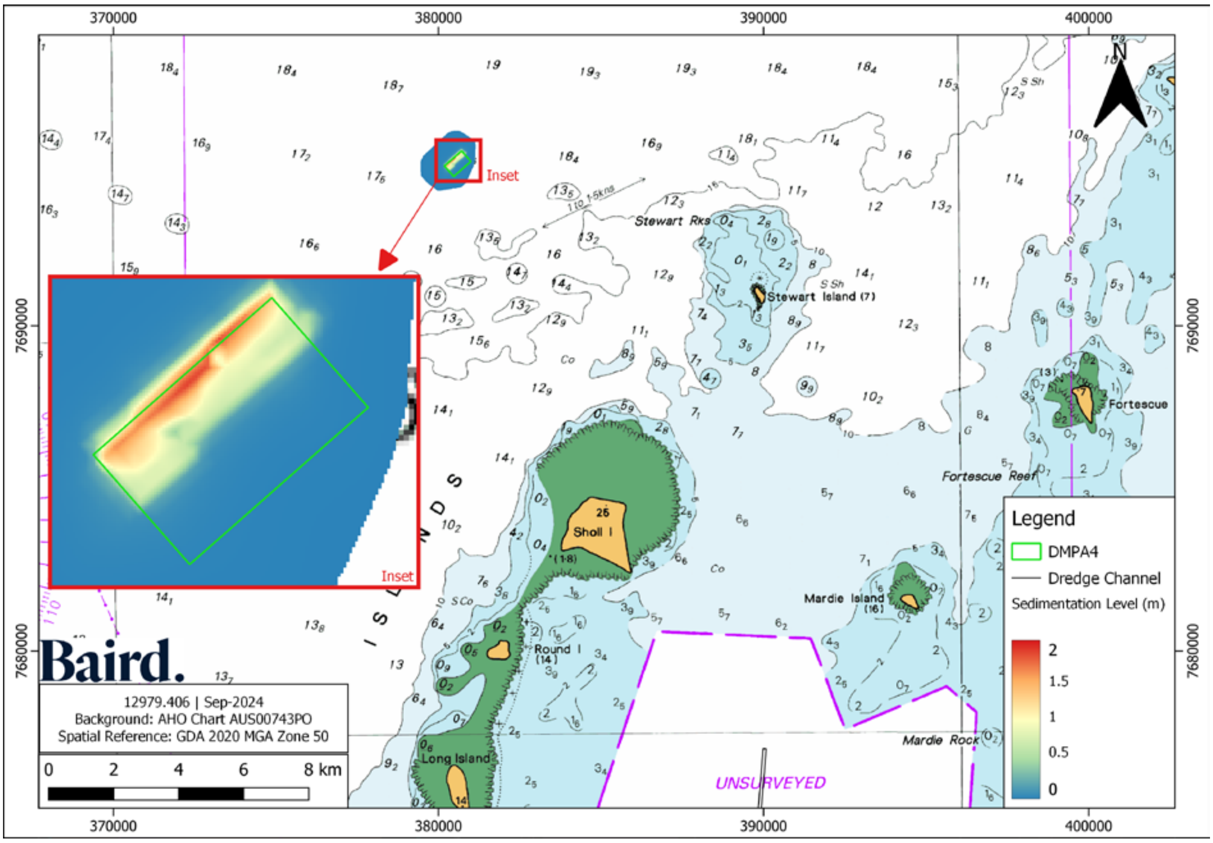

Figure 8: Seabed changes at and around DMPA4 at the end of complete modelling of the offshore disposal schedule. Sedimentation depth at DMPA4 has a maximum height of 1.85m after the 98-day run.

With thanks,

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CC: Tarek Badreldien, Karen Frehill, Snyman Van Straaten, Jim Churchill