APPENDIX O11.4

Final Modelling Assessments: Scenarios for a Desalination Plant at Point Lowly (report by BMT WBM, 2008)

See overleaf for report.

A part of BMT in Energy and Environment

Final Modelling Assessments: Scenarios for a Desalination Plant at Point Lowly

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Final Modelling Assessments: Scenarios for a Desalination Plant at Point Lowly

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1 INTRODUCTION

BMT WBM and the Centre for Water Research (CWR) have undertaken hydrodynamic and dispersion numerical modelling of Spencer Gulf. This has been executed as a consultancy to BHP Billiton (BHPB) to assist with production of the EIS for the Olympic Dam Expansion (ODX) project.

The numerical modelling involved the setup, calibration and validation of a suite of models, including two three-dimensional models, and a single steady state near field model. In particular, these models have been used to assess the likely dispersion and dilution behaviour of brine discharged from a proposed desalination plant at Port Bonython, where the plant is to provide fresh water to assist with ODX operations. Full details of these models and their execution are provided in the BMT WBM/CWR reports:

- R.B15583.004.04.Calibration, and
- R.B15583.005.04.ModellingAssessments.

The models encompass different spatial and temporal scales, as described below. All have been externally peer reviewed by Australian and international experts.

1.1 Far Field Model

A three dimensional model of the entire Spencer Gulf was constructed to assess potential impacts of the desalination discharge on global circulation patterns in the Gulf. This is known as the far field model. The model was built using the package ELCOM, which has been developed by CWR (details provided in previous reports as above). The model bathymetry is shown in Figure 1-1, and was run at a timestep of 50 minutes. For the purposes of efficiently executing the model, the domain was rotated by 36 degrees, pivoted at the northern end of the domain. The lateral model grid resolution was 2km, with 2 metre vertical layers.

1.2 Mid Field Model

A three dimensional model of the northern portion of Spencer Gulf was constructed to assess finer details of any potential impacts of the desalination discharge on local areas of interest. This is known as the mid field model. The model was also built using ELCOM. The model bathymetry is shown in Figure 1-2, and was run at an 8 minute timestep. It was also rotated as per the far field model domain. The lateral model grid resolution was 200 m, with 2 metre vertical layers.

1.3 Near Field Model

A quasi-one dimensional steady state model of the proposed diffuser was also constructed. This model examines centreline brine concentrations with downstream distance for a given water depth condition, and is known as the near field model. It was used to assess the specifics of the discharged brine plume dynamics, and associated dilutions. The standard proprietary USEPA supported package CORMIX was used (www.cormix.info/).

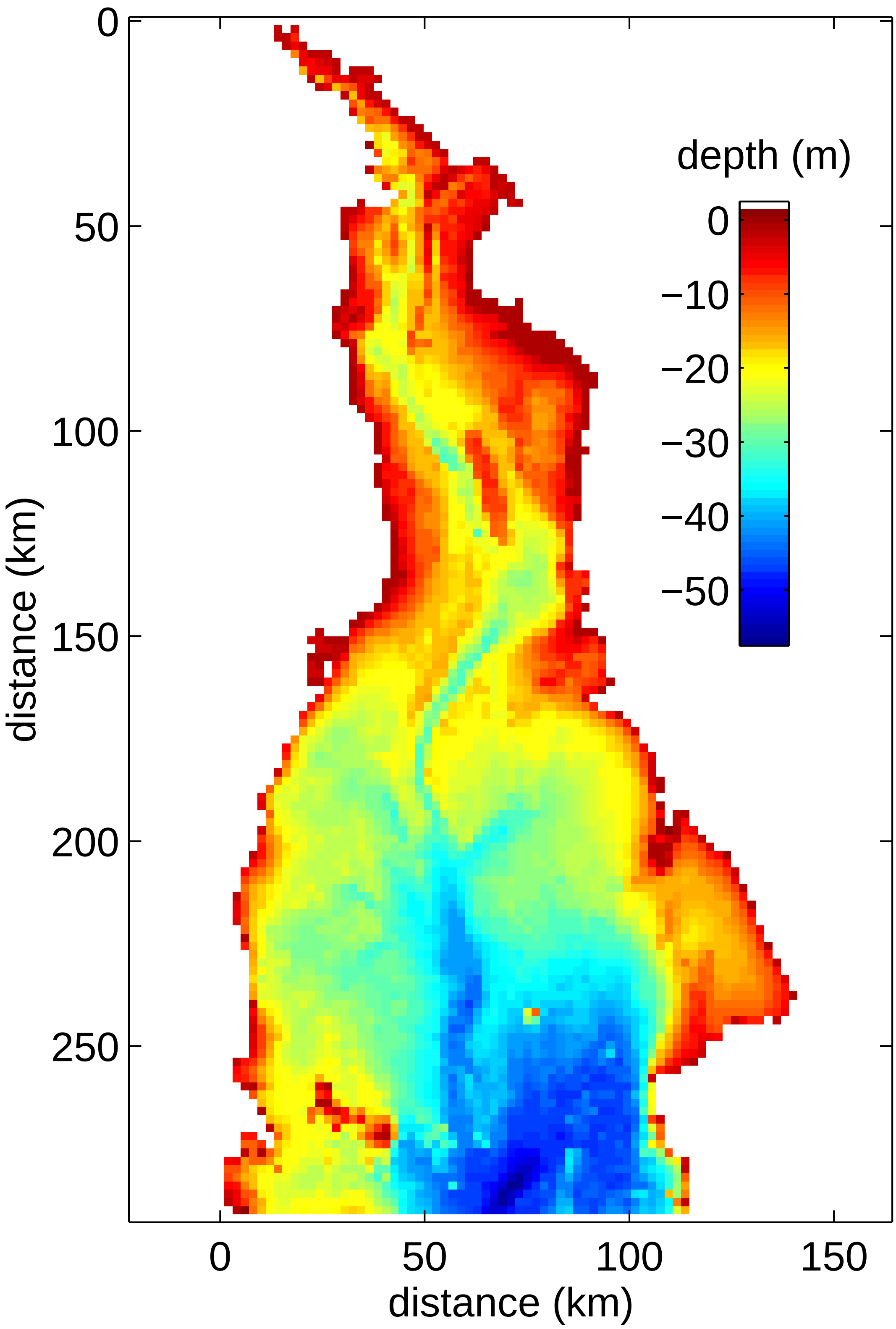


Figure 1-1 Far Field Bathymetry Grid Rotated 36 Degrees Anticlockwise Pivoted at Northern End of Model Domain

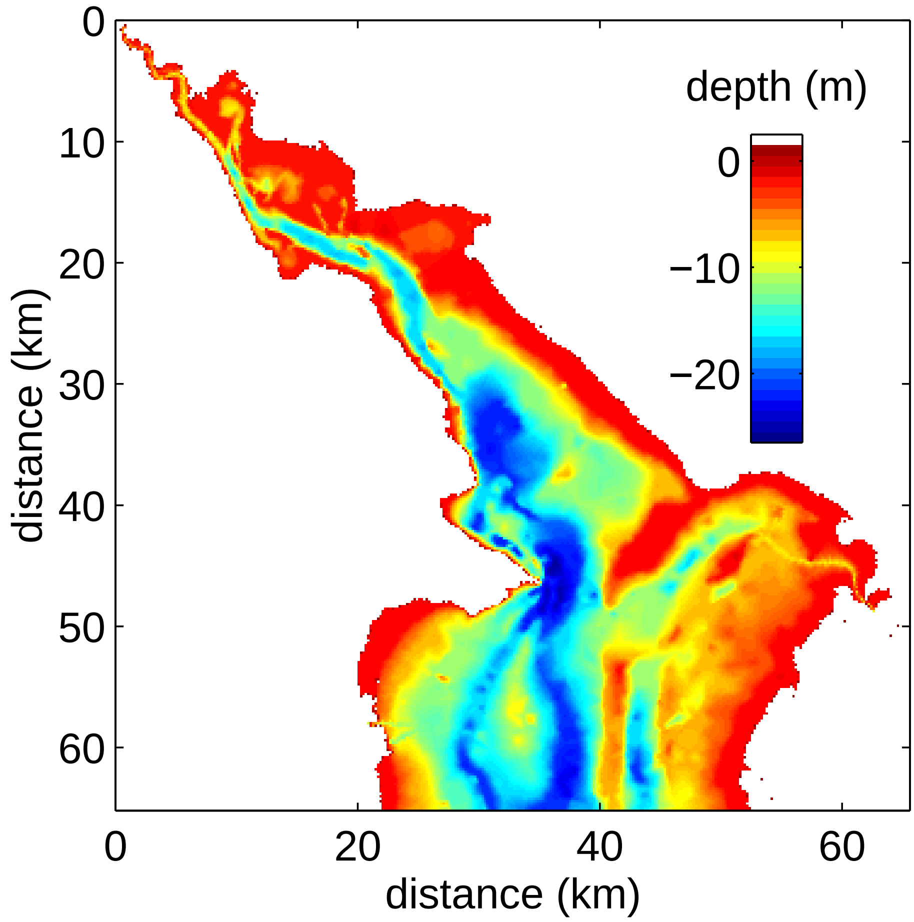


Figure 1-2 Mid Field Bathymetry Grid Rotated 36 Degrees Anticlockwise Pivoted at Northern End of Model Domain

These models were used to provide initial assessments of the likely plume dispersal from an outfall located in the vicinity of Port Bonython. BMT WBM has been subsequently commissioned to further these investigations via a series of additional simulations. These are described and reported here.

1.4 Model Results Combination

A considerable volume of data was derived from the above models at different spatial and temporal scales, with no single model providing an estimate of the overall impact of the discharge. As such, model results required combination, and the method to do so is described below.

In combining model results, it was noted that the three models were developed for three separate purposes:

1 Far Field model: To capture any long-term average increase in Gulf wide salinity due to the desalination plant operation;

2 Mid Field model: To provide spatial (xyz) and temporal information around Point Lowly as to assess mid-term salinity build-ups and evacuations; and

3 Near Field model: To provide detail about the acute salinity spikes associated with the detailed dynamics of the plume discharge.

As such, there are spatial (and associated temporal) components to consider with each, and these are intimately linked to the spatial distribution of organisms within Spencer Gulf. These are as follows:

a. Organisms living in Spencer Gulf at any location away from Point Lowly;

b. Organisms living in and around Point Lowly (but not in the core of the discharge plume); and

c. Organisms living in and around Point Lowly and being directly impacted by the plume core leaving the diffuser.

These distributions are akin to the spatial scale of the far, mid and near field models. Given this, the models were combined as follows:

- The long term average salinity increase (if any) predicted by the far field model was used to assess impacts at locations away from Point Lowly, outside the designated mid field plume extents (see figures in subsequent sections for this mid field zone). This represents the long term increase in background salinity levels due to the brine outfall, i.e. is related to the potential for chronic toxicity;
- The summation of this long term average increase at a representative location in the vicinity of Point Lowly and the 0th percentile salinity increase from the mid field model was used to assess likely worst case impacts at locations within the mid field plume extents. This addition represents a situation that would occur for no more than a few days a month when more extreme dodge tide conditions occur; and
- The summation of the long term average far field, and quasi-dynamic mid field and near field results, based on respective dilution percentile distributions. This applies only for the zone encompassed by the mid field model cell into which the brine discharge is delivered (i.e. +/- 100m) and was used to assess impacts in the immediate zone of the proposed outfall. This approach assumes a quasi-dynamic relationship between ambient tidal velocity and brine dilution in the near field model, with the former being extracted as percentiles from the mid field model. A corresponding relationship was derived between dilution and velocity percentile in the mid field model to support this analysis. The fundamental premise of this multi-model combination technique is that the near field plume discharges into an environmental already influenced by brine discharge in a mid and far field sense. That is, long and mid term salt accumulation and evacuation has been assumed to already have occurred in the discharge setting and hence to be influencing the ability of the near field outfall configuration to dilute brine. In other words, the background salinity to which discharge occurs has been assumed to be raised relative to base case (no discharge) conditions to reflect ambient mid and far field conditions. Thus, this summation is essentially related to the potential for acute toxicity, as it includes the cumulative temporal variation of the near field plume core dynamics, i.e. the potential impact of short term brine spike concentrations.

This approach is approximately aligned with the assessment of chronic through to acute impacts on receiving organisms due to the proposed brine discharge. This combination is shown diagrammatically in Figure 1-3.

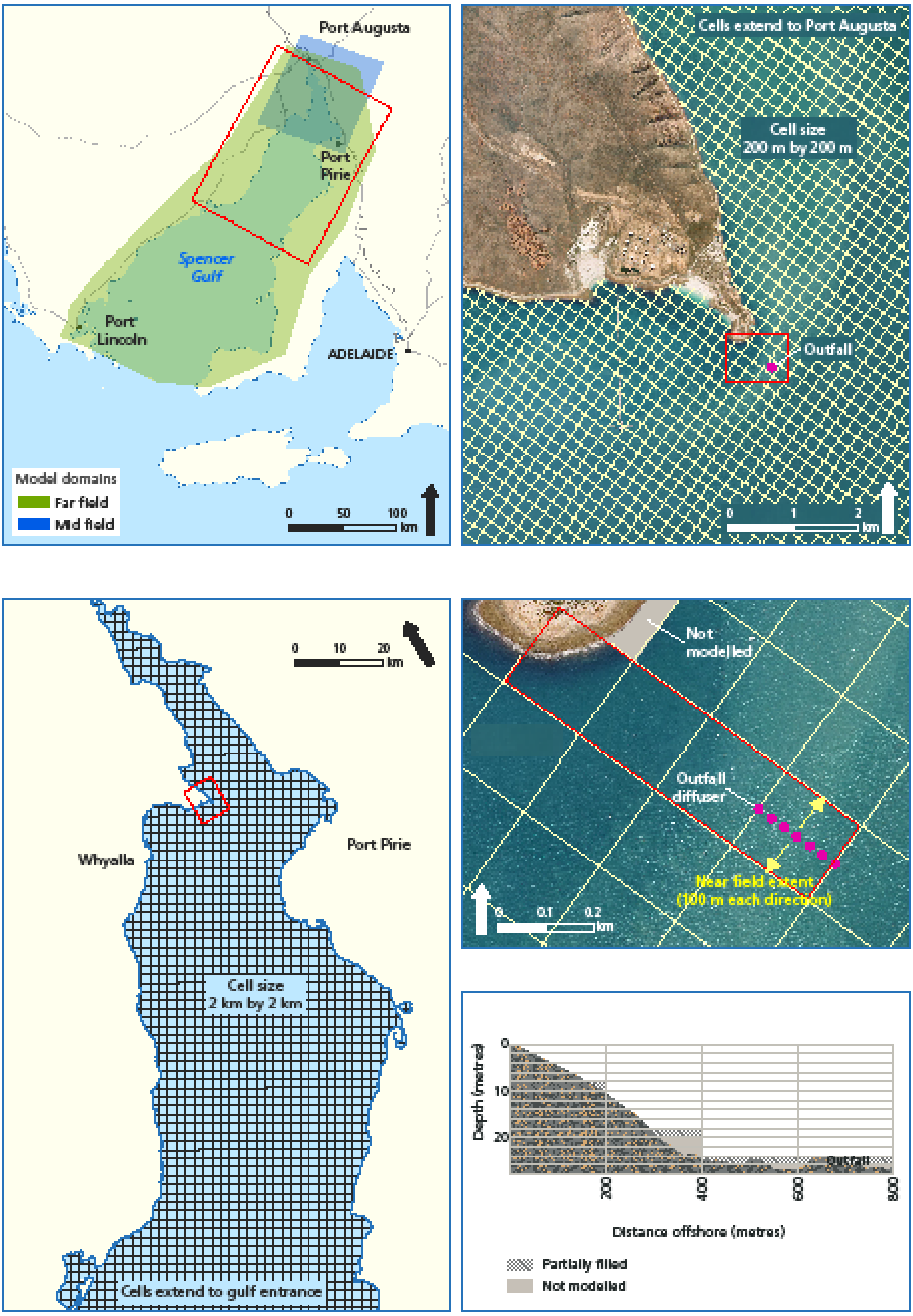


Figure 1-3 Schematic Representation of Model Result Combination

1.5 Plant Configuration

The outfall locations and discharge flow regimes for the current scope of works have been amended from previous simulations. The amendments include a higher discharge rate and a lower brine concentration.

Peak monthly discharge parameters for the desalination plant are presented in Table 1-1. It has been requested to set brine salinity to a constant 75 g/L in all cases.

Table 1-1 Summary of Discharge Parameters

Operating Parameters	Value
Raw Water Intake (ML/d)	650
Desalinated Water (ML/d)	280
Return Water Discharge (ML/d)	370
Return Water salinity (mg/L TDS)	75,000
Return Water Discharge (L/s)	**4282**

2 SIMULATIONS

A suite of additional numerical model simulations has been requested by BHPB to advance assessment of the near field, mid field and far field dispersion of the desalination plant effluent, based on the data Table 1-1. The details and simulation reference codes are described below.

2.1 Far Field Model

One additional far field run was required to provide information on far field dispersion of the effluent for the currently proposed discharge flow regimes shown in Table 1-1. The details of this simulation are provided in Table 2-1.

Table 2-1 Summary of Required Far Field Simulation

Simulation Code	Outlet Site Name	Brine Flow (ML/d)	Simulation Period	Data Extraction Cells
07-12	B3	370	5 years	2-10, 9-15, 24-22, 69-35

All forcing conditions from the original suite of far field simulations were retained. The simulations were run from 12th August 2000 for five years.

The locations of the above data extraction cells and outfall B3 are provided in Figure 2-1.

2.2 Mid Field Model

Five additional mid field runs were required to provide more detailed information on dispersion of the effluent as related to the currently proposed discharge flow regimes shown in Table 1-1. The details of these simulations are provided in Table 2-2.

Table 2-2 Summary of Required Mid Field Simulations

Simulation Code	Outlet Site Name	Brine Flow (ML/d)	Tidal Conditions	Wind Conditions
07-6	B3	370	S, T, D	No wind during dodge
07-7	B3	370	S, T, D	Strong SE wind during dodge
07-8	B7	370	S, T, D	No wind during dodge
07-9	B8	370	S, T, D	No wind during dodge
07-10	B9	370	S, T, D	No wind during dodge

S, T, D: Spring, Typical, Dodge – see below for actual time periods and plots
Strong SE wind = 10 m/s constant South East wind through dodge period

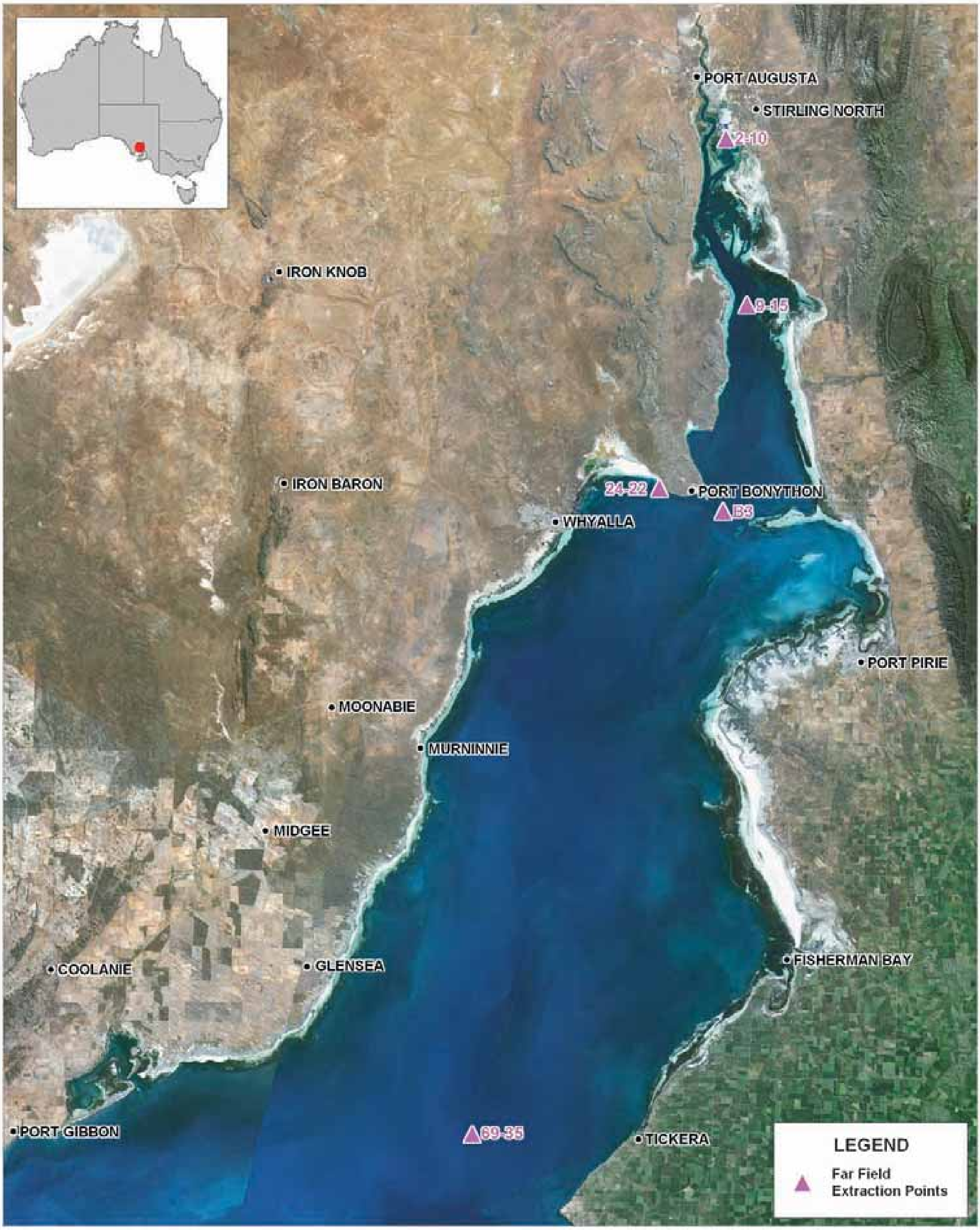
The locations of the above outfalls are provided in Figure 2-2.

A revised Base Case (no outfall) simulation was also executed, where the 'No wind during dodge' condition was implemented to allow direct comparison with simulation results.

The simulations (complete with respective discharges, depending on scenario) were commenced on 6th December 2001, and were run until 15th January 2002. The tidal periods chosen for Spring, Typical and Dodge analysis are all of a two day duration, and had been agreed previously with BHPB. These same periods were adopted for this study, and were as follows:

- Spring: 1st January 2002 at 12:00am to 3rd January 2002 at 12:00 am;
- Typical: 4th January 2002 at 12:00am to 6th January 2002 at 12:00am; and
- Dodge: 7th January 2002 at 12:00am to 9th January 2002 at 12:00am.

The tidal record during this period, with the above extraction periods shaded, is shown in Figure 2-3. The tidal range for the Dodge tide is approximately half the difference between the mean high and low water marks over a six year period. Extraction and analysis was also performed over the entire 40 day period.



Title:

Far Field Model Outfall and Results Extraction Points

Figure: **2-1**

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0 15 30km

Approx. Scale

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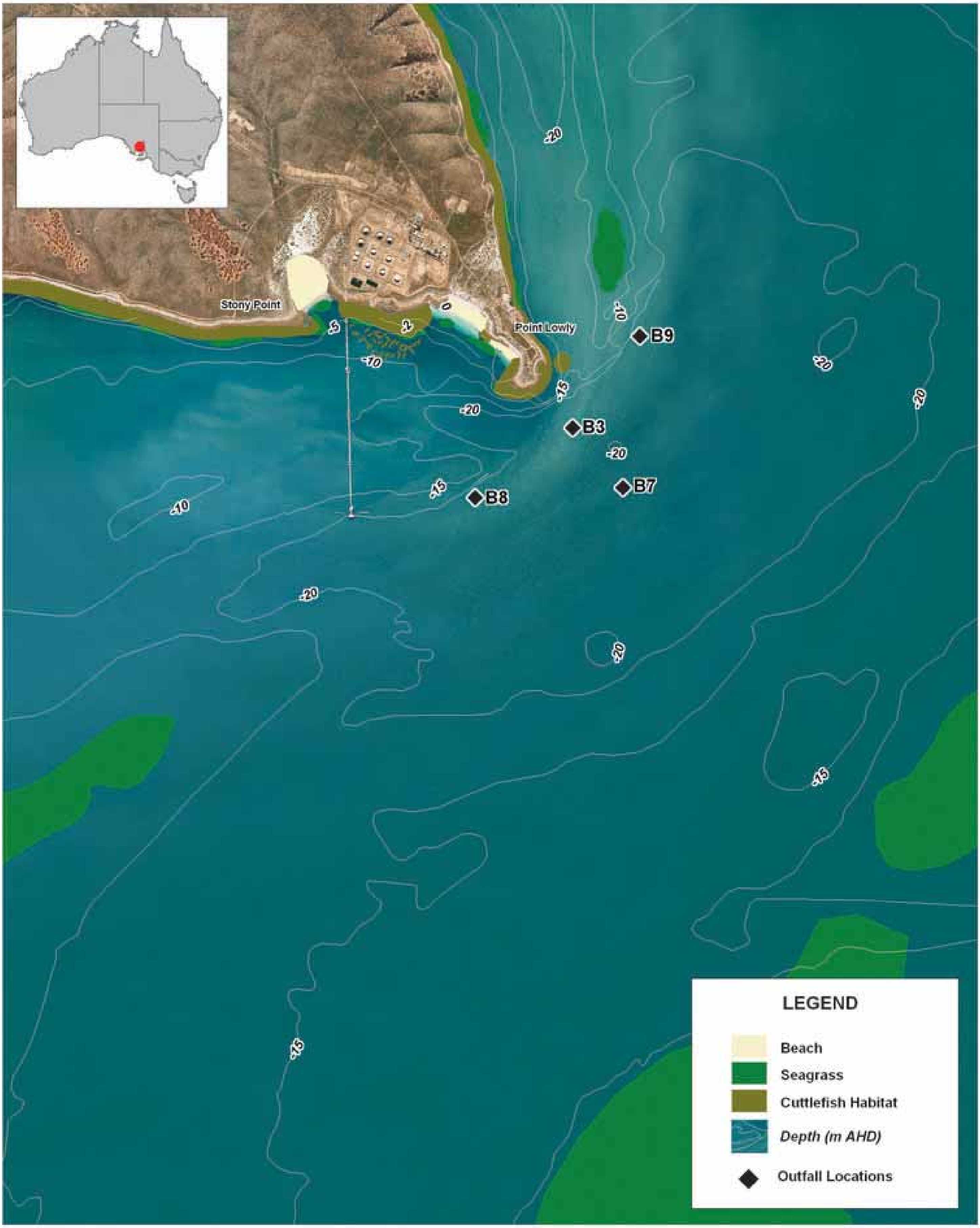

Title:
Mid Field Model Outfall Locations

Figure: 2-2

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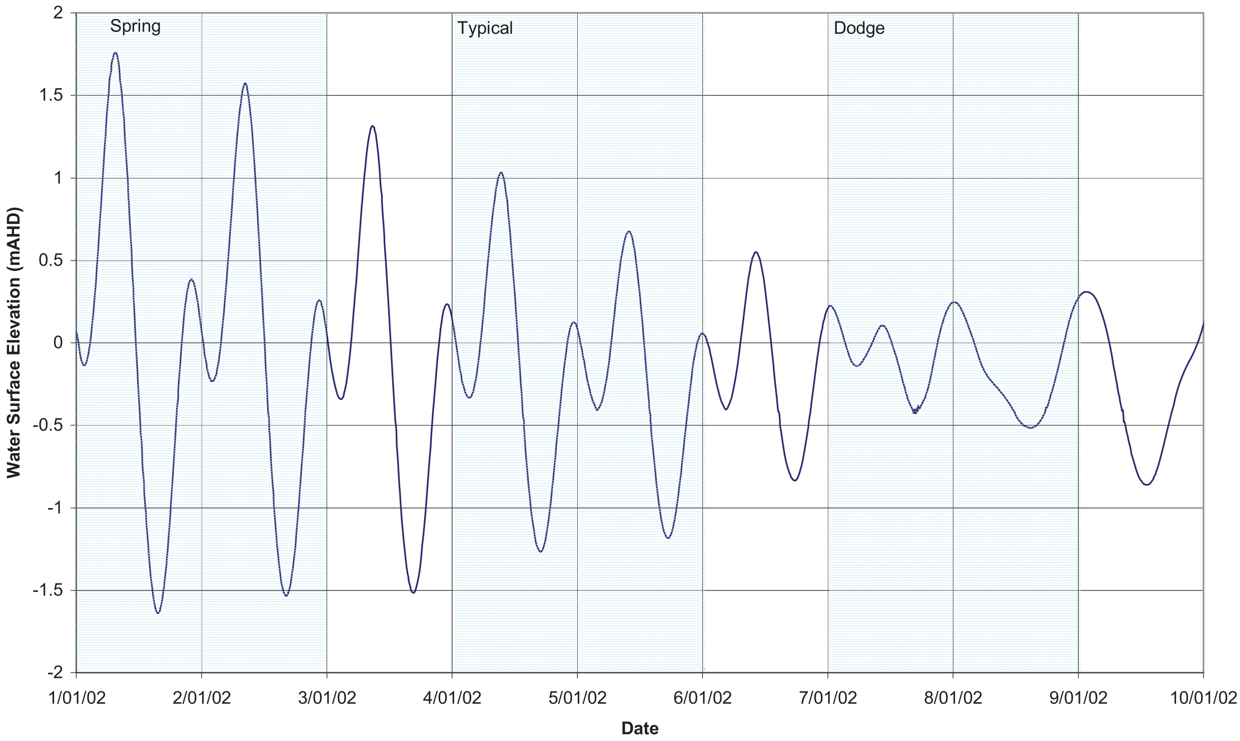


Figure 2-3 Tidal Record at Point Bonython During Data Extraction Periods. Extraction Periods are Shaded.

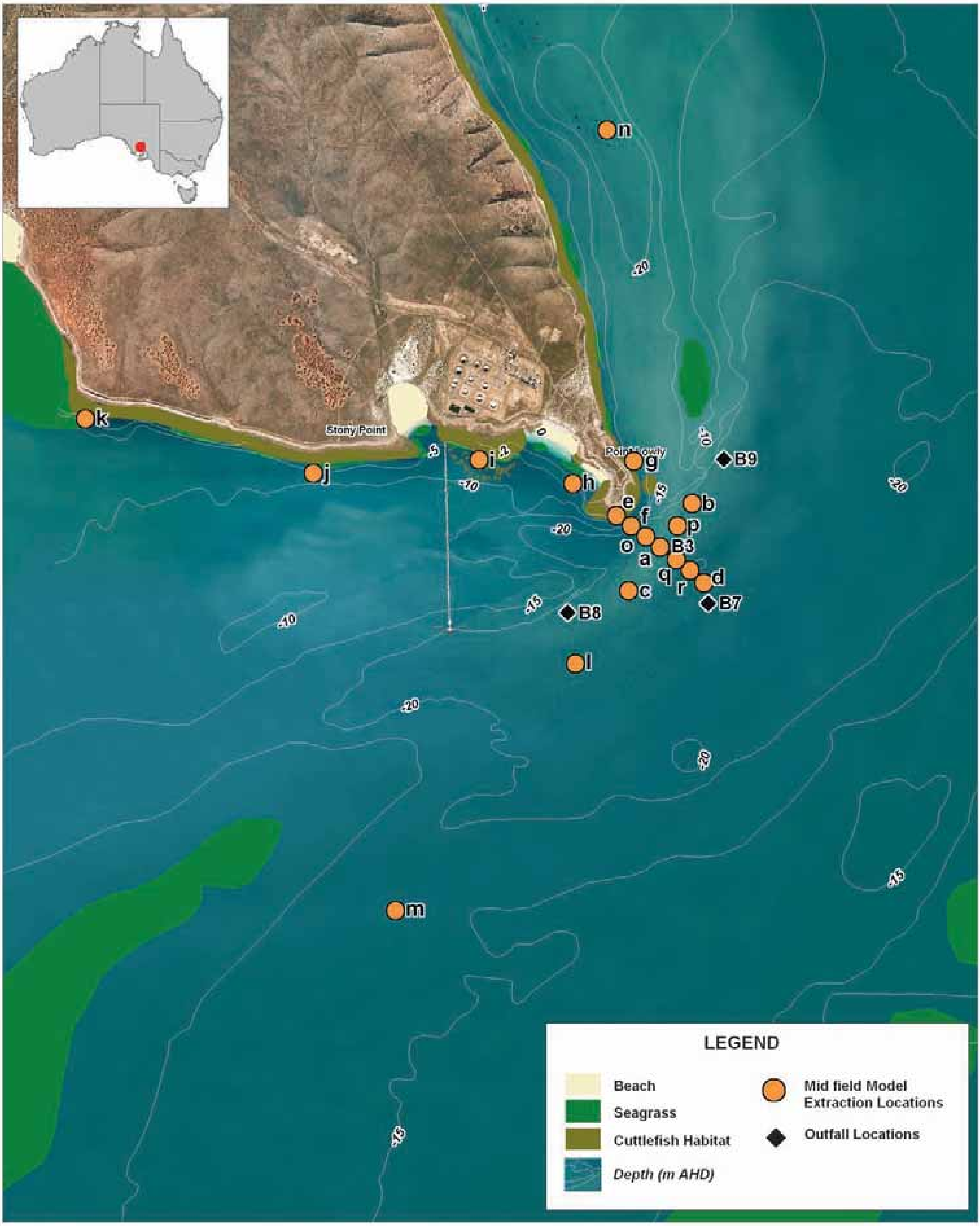
For each simulation involving an outfall, an inert (i.e. without hydrodynamic influence) numerical tracer was introduced with the brine discharge at the same rate and location. The tracer was set to a nominal concentration of 1.0 at introduction, and was used as a direct tracker of both the brine dispersion and dilution. Tracer concentrations were used to compute dilutions of brine across the model domain, either as timeseries, percentiles or model output maps, as required. Dilutions have been related to ecotoxicity by others, with the varying dilution levels corresponding to different responses of different marine species. BMT WBM was advised by BHPB to use dilutions of 1:45 and 1:85 for extractions over the entire 40 day period, but to use indicative dilutions of 1:50, 1:100 and 1:200 for the maps illustrating the different two-day tide periods.

Results from each mid field simulation were extracted in a variety of ways.

Firstly, salinity timeseries data from the model layer directly above the bed were extracted at a series of representative locations defined by BHPB, as shown in Figure 2-4. These timeseries were extracted and plotted for simulation 07-6 only, and co-plotted with the Base Case (no outfall) data. Salinity data at the three computational cells above the bed were also plotted for a selection of three extraction locations.

Tracer concentrations were also used to produce tabular data for each of the simulations. Tracer timeseries data (from which dilutions were computed) for the entire simulation period, and all of the extraction locations (shown in Figure 2-4), were submitted to percentile analysis for all runs. The 1st, 5th, 10th, 25th, 50th, 75th 90th and 95th percentiles of dilution were reported, together with respective simulation minimums. Counts of all dilutions in the ranges <50, <100, and <200 were also reported in the tables, together with the corresponding percentage of simulation time (although not necessarily contiguous) that each these dilutions were not exceeded. A vertical profile of minimum tracer dilutions through the discharge zone was also produced.

Finally, maps of tracer dilution (in the model layer immediately above the bed) were produced for the entire 40 day period for minimum, 1st, 10th and 50th percentile dilutions. That is, the timeseries of dilution was examined at every computational bottom cell, and a percentile analysis undertaken. The 0th (minimum), 1st 10th and 50th percentile dilutions were then stored for each bottom computational cell, and four separate maps (one for each percentile) produced, for each scenario. As such, these percentile maps are not snapshots of brine dilutions, but rather, percentile distributions of dilution over the 40 day model period. The same analysis was applied to each tidal regime period (spring, typical and dodge), over two days, as shown in Figure 2-3. This reporting technique had been agreed with BHPB in preceding works.



Title:
Mid Field Model Timeseries Extraction Locations. Outfall Locations Included for Reference

Figure: 2-4

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2.3 Near Field Model

A suite of near field runs were required to provide detailed information on plume dispersion characteristics. These simulations were performed for the discharge configurations shown in Table 2-3.

Table 2-3 Summary of Required Near Field Simulations

Configuration Item	Value
Concentrate Discharge (L/s)	
Peak Monthly Flow	4282
Diffuser angle	60^{o} to horizontal, alternating directions
Port diameter (mm)	175
N^{o} of ports	50
Port spacing (m)	4.0
Diffuser length (m)	200

A range of background velocities (extracted from the mid field model) was considered for the flow rate above, namely the 1^{st}, 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th} 95^{th} and 99^{th} percentiles. Brine dilutions (calculated at the edge of the near field mixing zone, this being effectively when the centreline of the plume first contacts the sea bed and at 100m), extents of the near field mixing zone (the distance from the outfall to where the centreline of the plume contacts the sea bed) and the maximum height of the plume above the diffuser have been extracted from the model and reported.

3 RESULTS

The presentation of results is consistent with previous studies, and conforms to that specified by BHPB in its work scope memorandum of 28th August, 2007.

3.1 Far Field Model

3.1.1 Timeseries

Timeseries of bottom layer salinities at the locations shown in Figure 2-1 follow. Each figure presents two timeseries: Base Case and simulation salinity at a single extraction location.

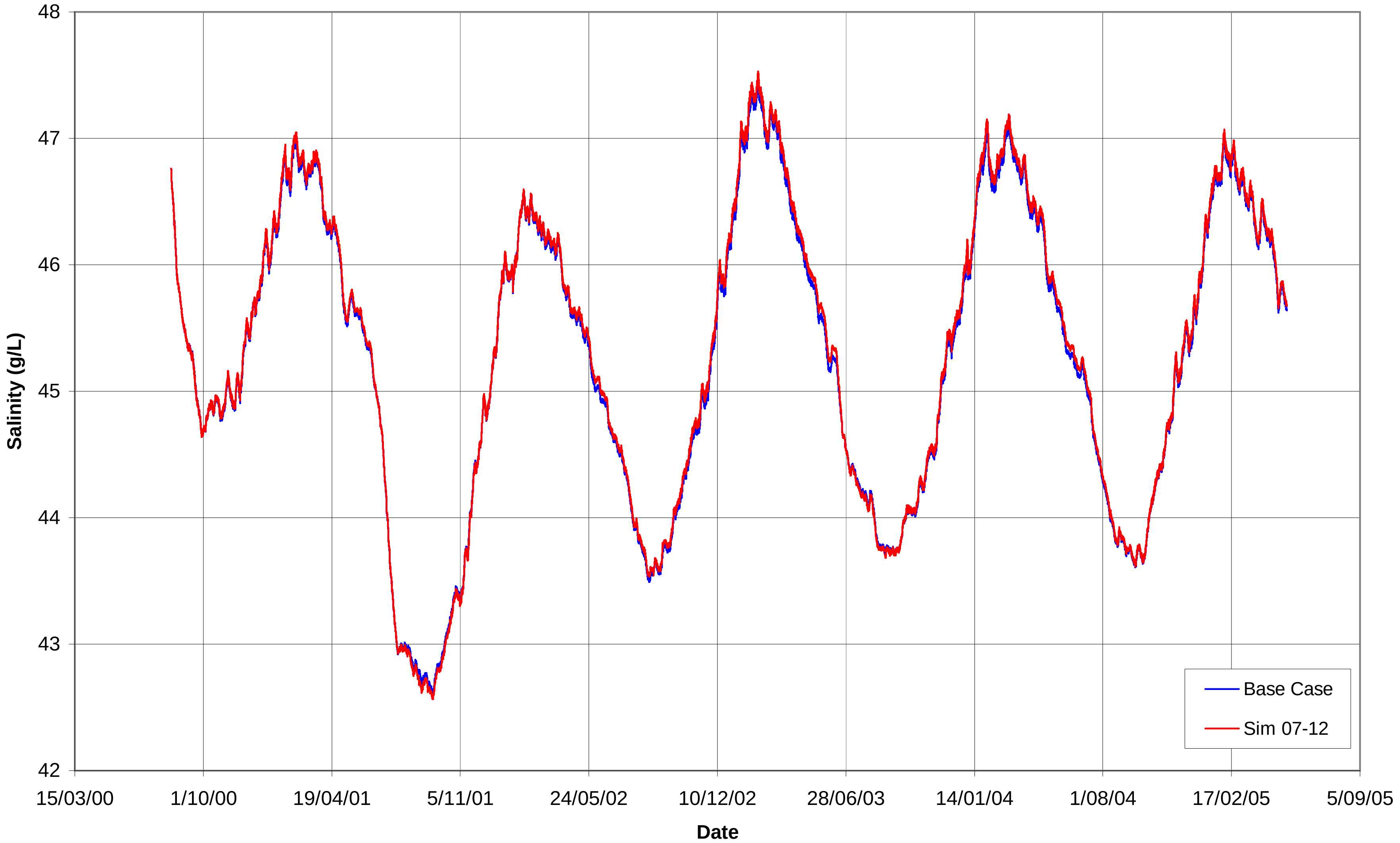


Figure 3-1 Far Field Results: Simulation 07-12 Location 2-10

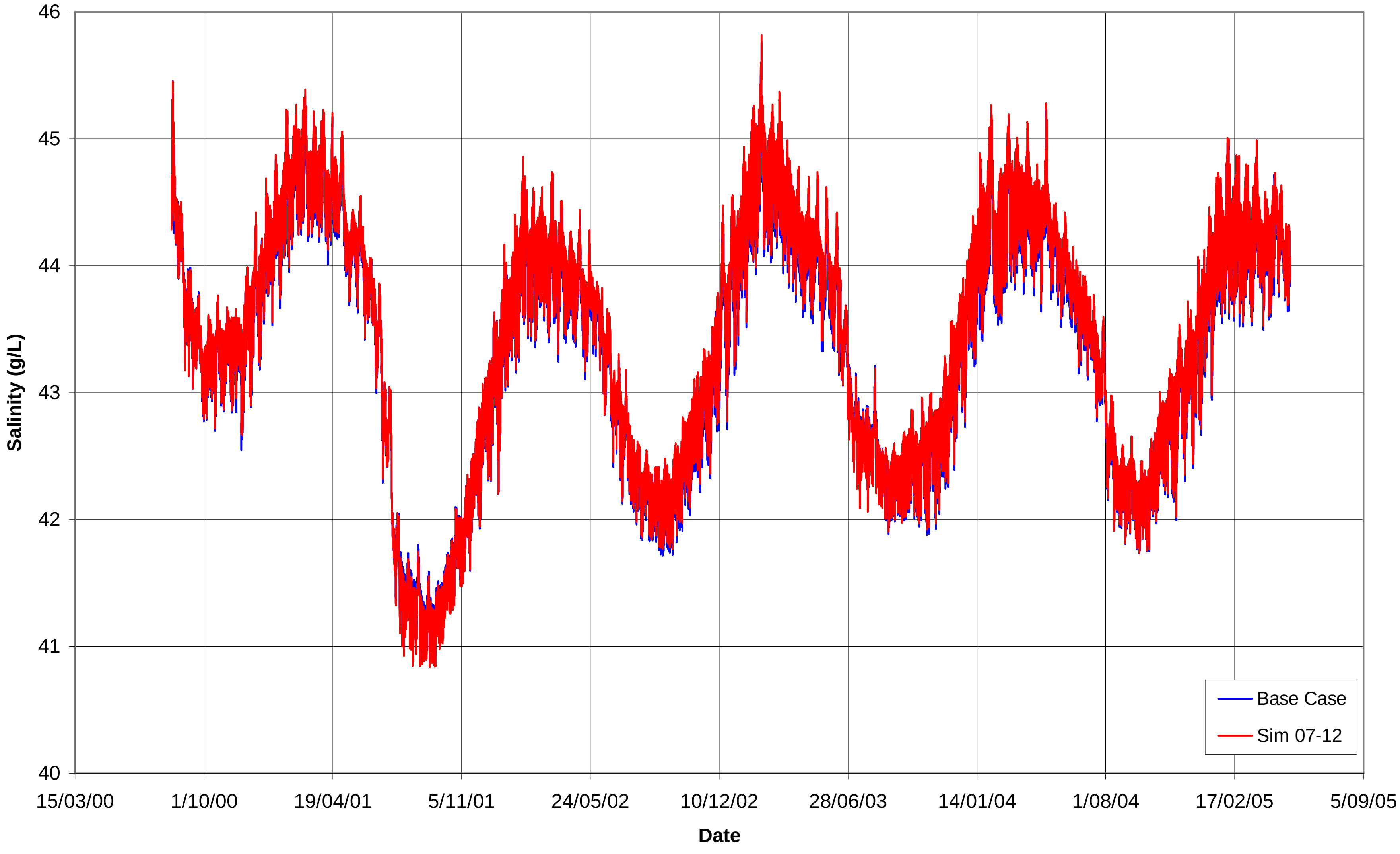


Figure 3-2 Far Field Results: Simulation 07-12 Location 9-15

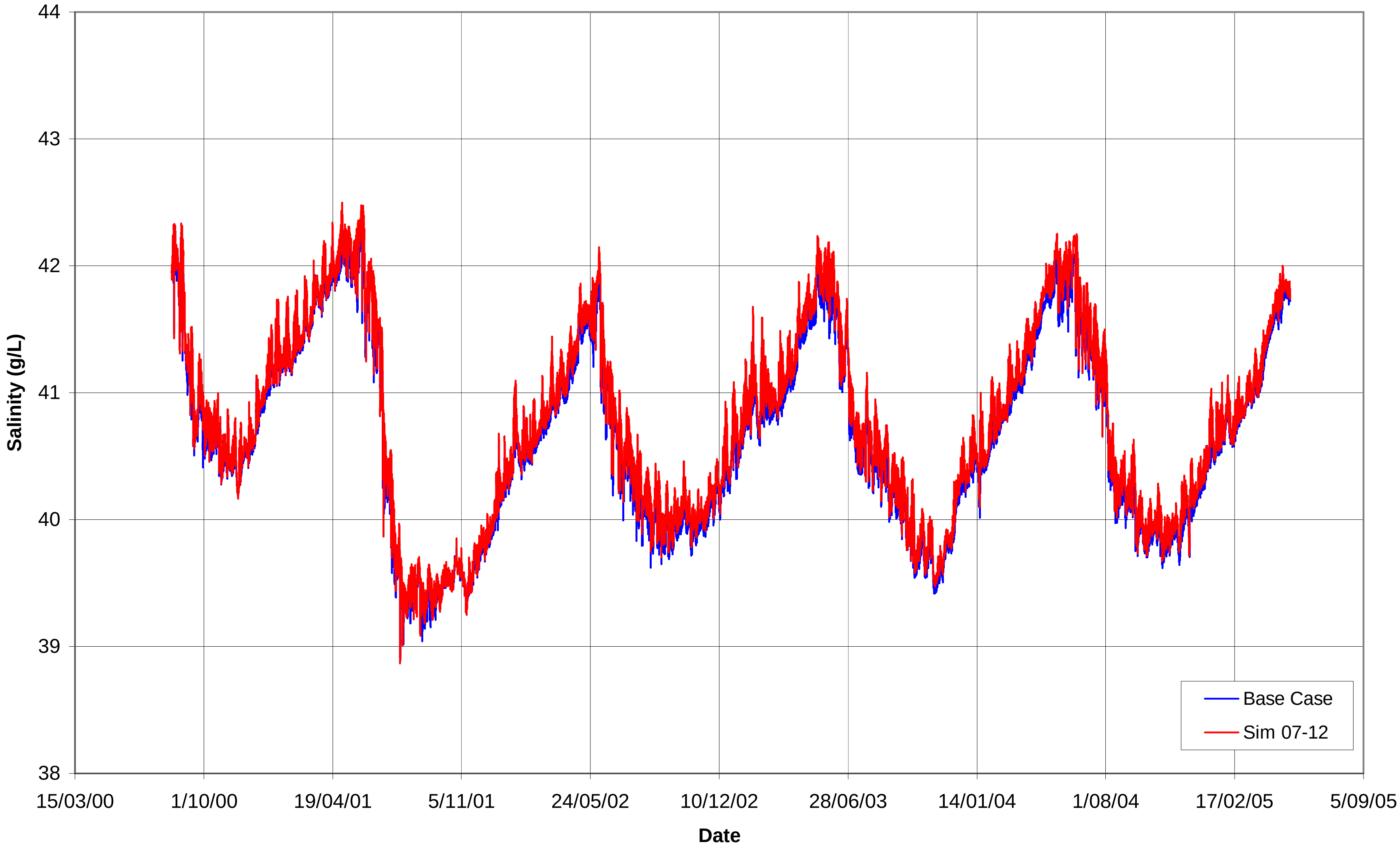


Figure 3-3 Far Field Results: Simulation 07-12 Location 24-22

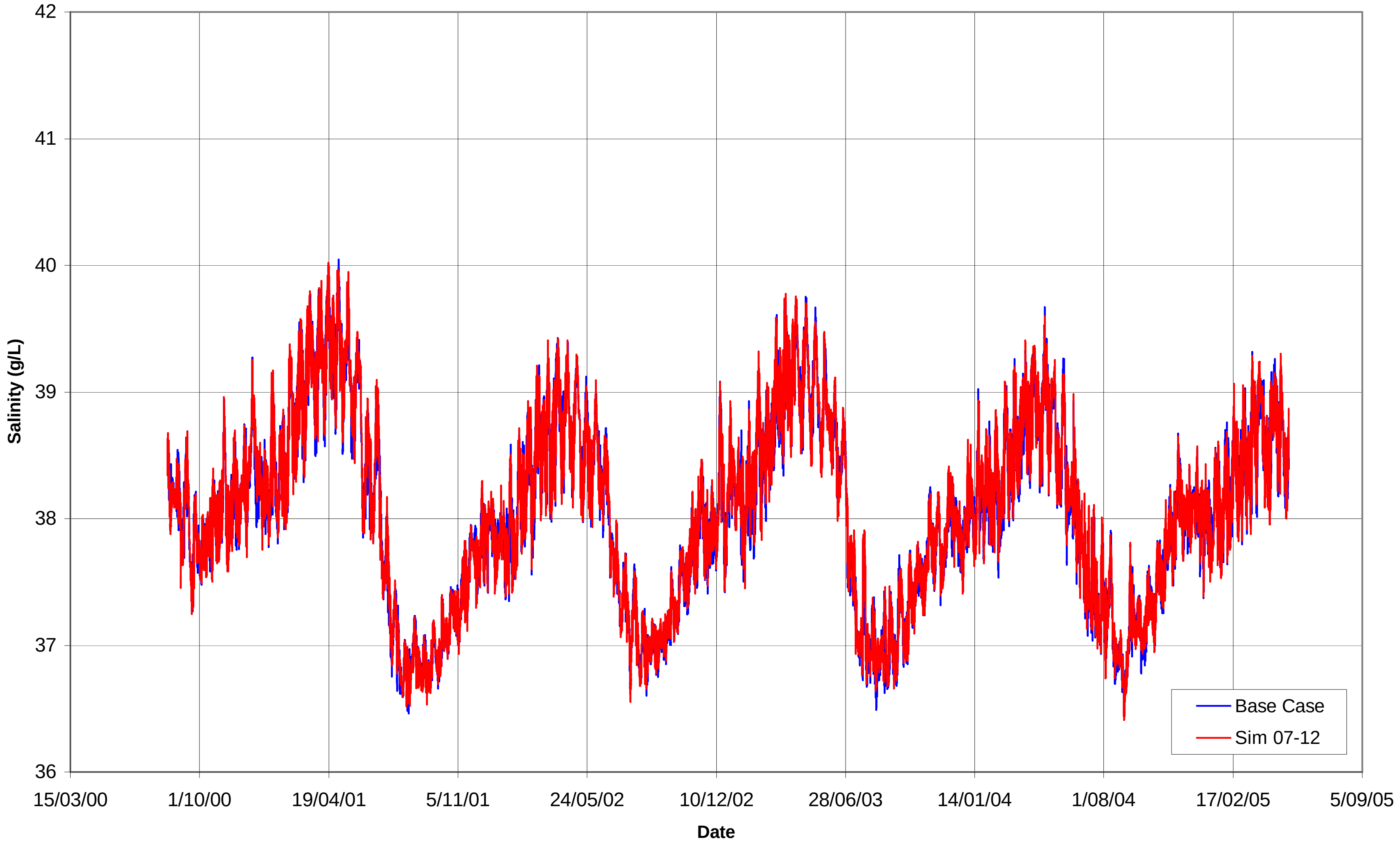


Figure 3-4 Far Field Results: Simulation 07-12 Location 69-35

3.1.2 Tabulated Salinity Differences

The differences between Base Case and individual simulation salinities at the nominated extraction locations were computed on a 30-day moving average basis. Long term average differences are presented in Table 3-1 for Simulation 07-12. Examination of long term average changes to salinity has been undertaken in accordance with discussion provided in Section 1.4.

Table 3-1 Salinity Difference Statistics – Absolute

Location	Long Term Average Salinity Difference (g/L)
2-10	0.03
9-15	0.03
24-22	0.07
69-35	0.01

These are expressed as percentages of the long term average ambient salinity (Base Case) at each location in Table 3-2.

Table 3-2 Salinity Difference Statistics – Percentage

Location	Long Term Average Salinity Difference (%)
2-10	0.06
9-15	0.07
24-22	0.17
69-35	0.03

3.2 Mid Field Model

3.2.1 Timeseries

Timeseries of bottom layer salinities at the locations shown in Figure 2-4 follow, for simulation 07_6. Two figures have been prepared for clarity of presentation. Each plot within each figure displays two lines: Base Case (no outfall) and simulation dependent bottom layer salinities (blue and red lines, respectively) at the corresponding extraction location (as marked at the top of each subplot). Tidal timeseries is also presented for the simulation period in the first figure.

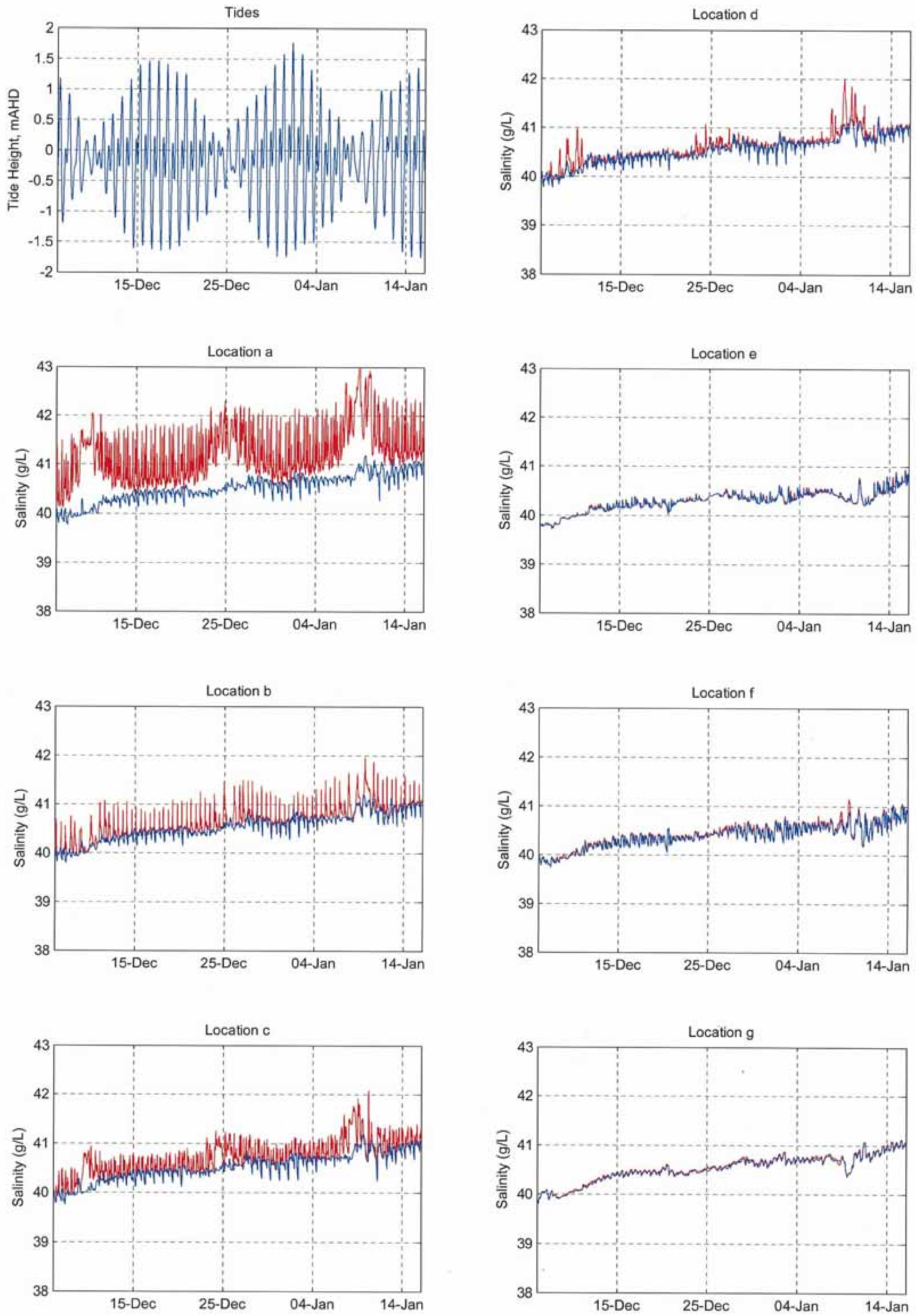


Figure 3-5 Bottom Salinity Timeseries, Locations 'a' to 'g', Simulation 07_6. Red Line is with Brine Discharge, Blue Line is without Brine Discharge

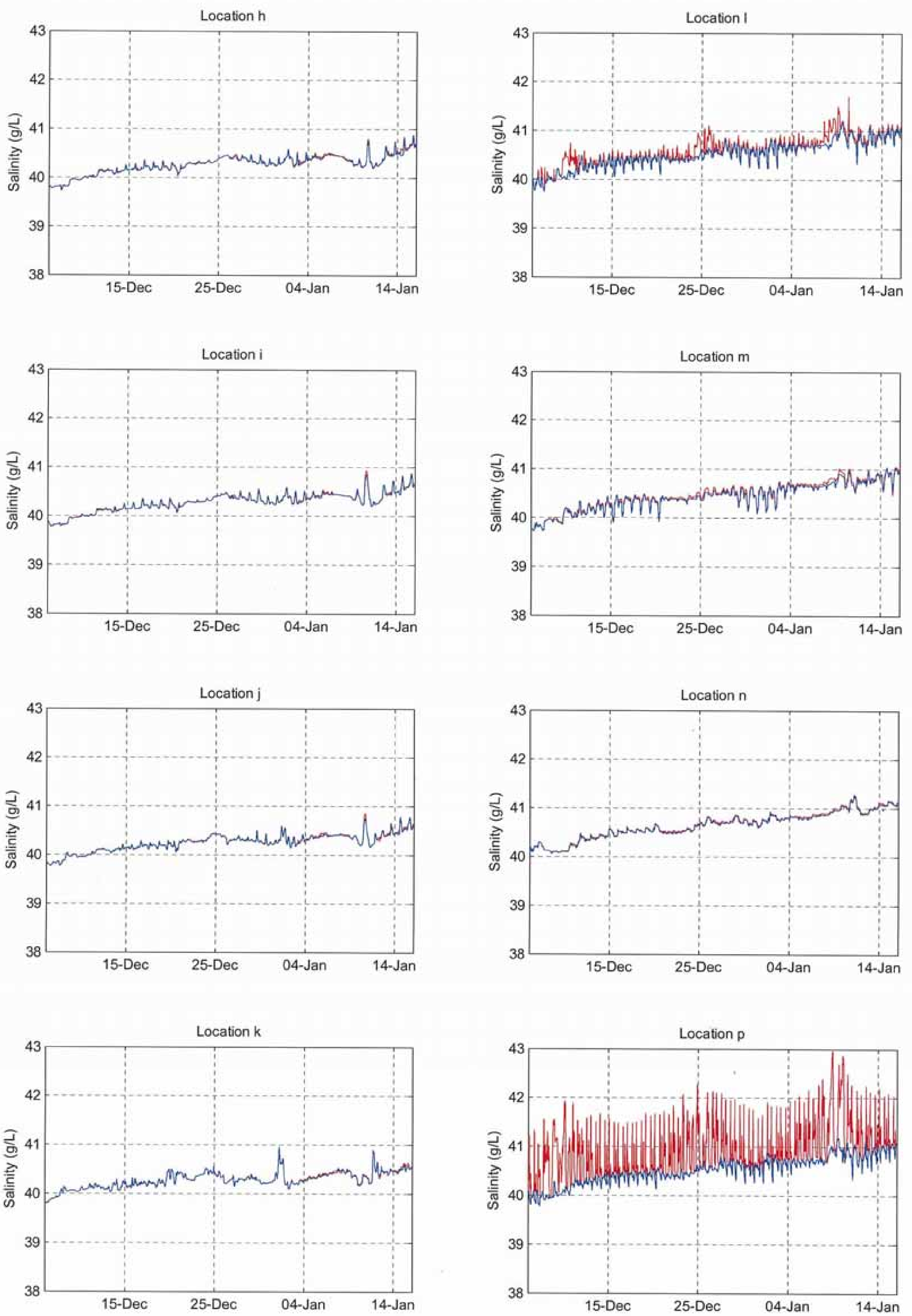


Figure 3-6 Bottom Salinity Timeseries, Locations 'h' to 'n' and 'p', Simulation 07_6. Red Line is with Brine Discharge, Blue Line is without Brine Discharge

In addition to the above, timeseries of salinity for the bottom three computational layers is provided below for cells ‘a’, ‘p’ and ‘c’.

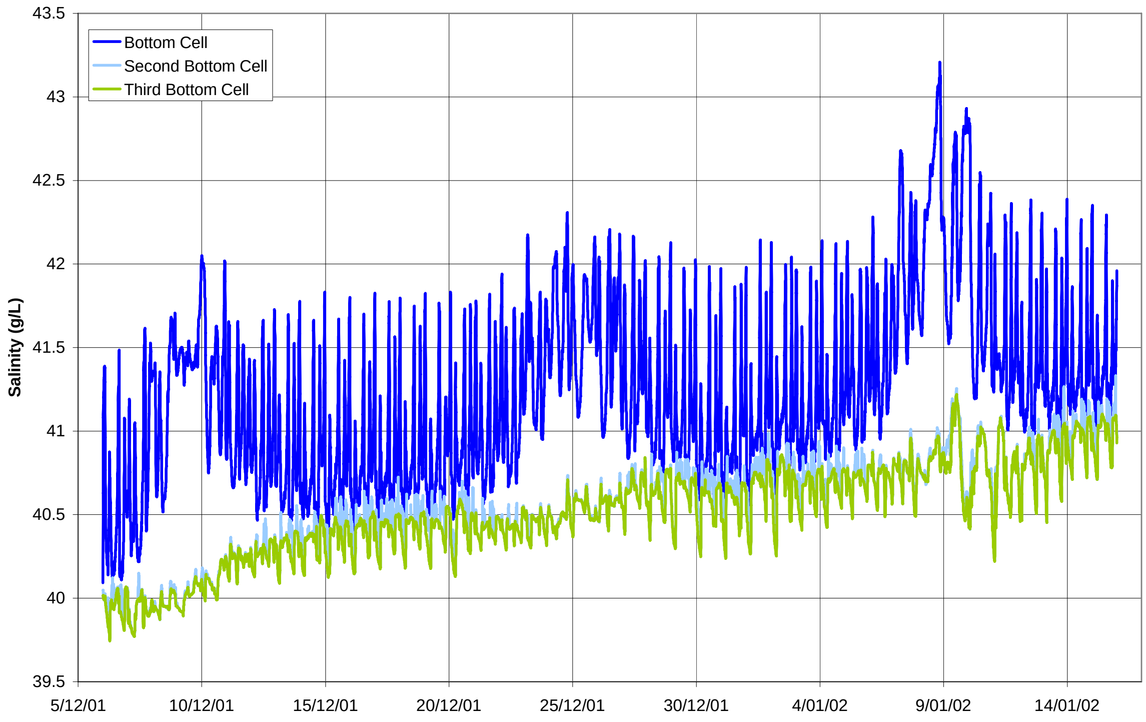


Figure 3-7 Location ‘a’ Salinity Timeseries

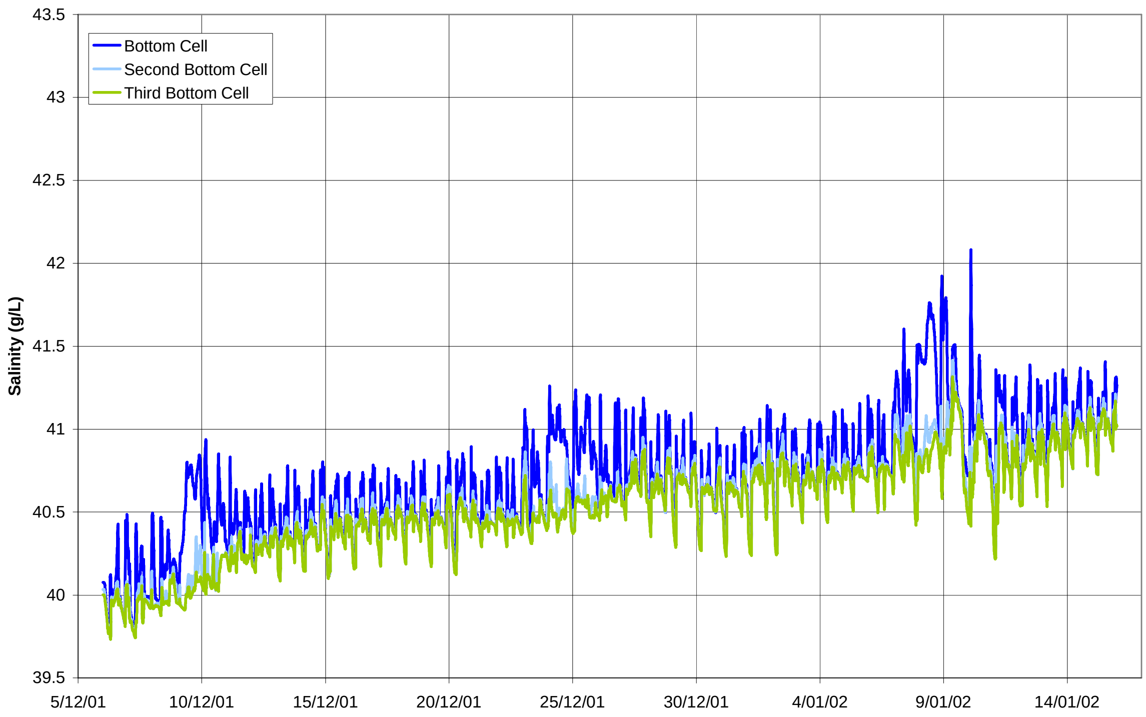


Figure 3-8 Location ‘c’ Salinity Timeseries

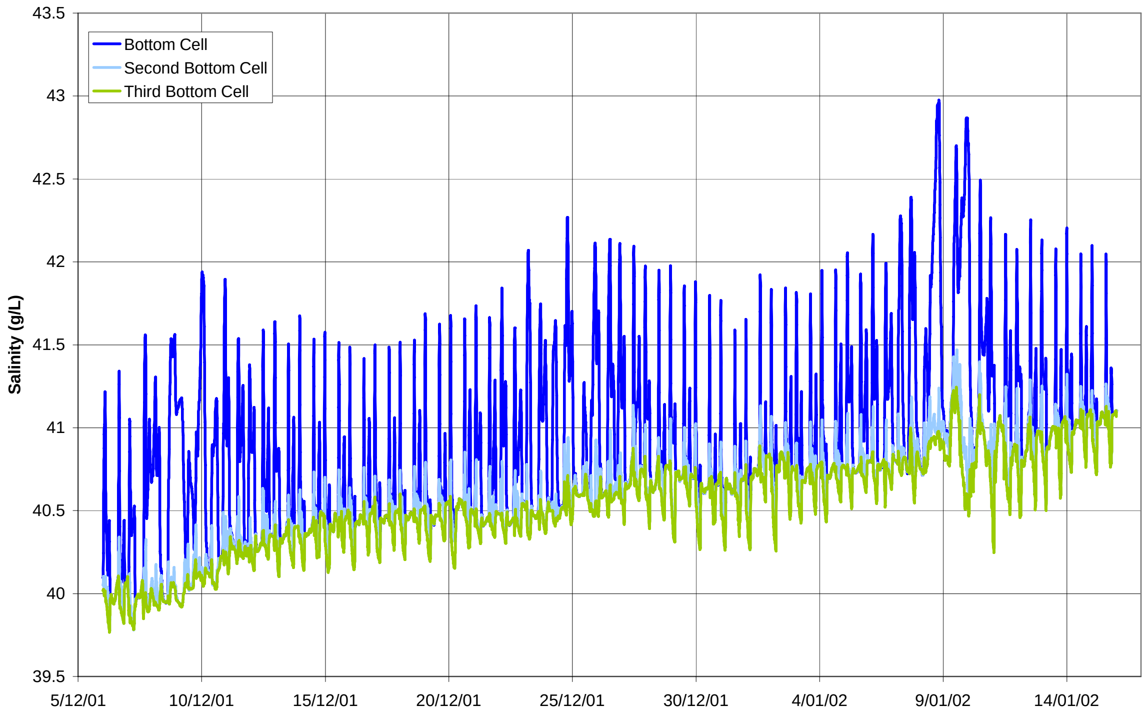


Figure 3-9 Location 'p' Salinity Timeseries

With regards to the above figures, a difference in salinity between the layers implies reduced vertical mixing, although horizontal mixing may still be taking place (with a balance being maintained between additional return water being entrained with fresh ambient water).

For sites beyond the outfall (sites p and c), there are periods of less than two days around dodge tides where the bottom salinity is distinctly different from the cells above. For the outfall (site a), these periods can be up to six days. This may be largely due to an artefact of the model, whereby the brine is introduced to the bottom cell only at the outfall.

3.2.2 Tables

Tabular data reporting percentile distributions of brine dilutions for the entire simulation period (for simulation 07-6 to 07-10) at the selected extraction points has also been produced as per previous description. These follow.

Table 3-3 Statistical Analysis of Dilutions, Simulation 07_6

	Percentile									Count	Pcnt	Count	Pcnt	Count	Pcnt
Site	1	5	10	25	50	75	90	95	Min	<50	<50	<100	<100	<200	<200
a	20	25	29	39	75	137	182	203	16	2519	34	4584	62	6968	94
b	52	77	105	231	681	1258	1789	2519	40	54	0	650	8	1618	21
c	45	65	86	157	345	880	1346	1716	28	129	1	921	12	2443	33
d	50	99	198	501	936	1296	1833	3411	38	74	1	370	5	749	10
e	838	1064	1236	1557	2249	3447	5643	10901	490	0	0	0	0	0	0
f	256	543	734	971	1290	1859	2653	3903	151	0	0	0	0	48	0
g	633	738	841	1025	1272	1812	2766	3312	365	0	0	0	0	0	0
h	888	1349	1528	1842	2775	4424	7082	21486	426	0	0	0	0	0	0
i	468	1085	1441	1856	2867	4618	7527	30811	292	0	0	0	0	0	0
j	635	1645	1899	2554	4370	8683	24605	146938	293	0	0	0	0	0	0
k	2379	3271	4074	7599	15735	45305	1495021	291262444	1839	0	0	0	0	0	0
l	72	104	154	382	927	1299	1821	3329	41	4	0	341	4	904	12
m	268	371	487	902	1143	1490	2540	5052	220	0	0	0	0	0	0
n	1025	1112	1142	1283	1671	2424	6260	20248	888	0	0	0	0	0	0
o	24	35	45	86	313	738	1261	1655	19	901	12	2032	27	2959	40
p	23	32	39	69	217	1119	1642	2165	18	1160	15	2487	33	3498	47
B7	85	183	270	635	1029	1429	2270	5168	55	0	0	157	2	478	6
B8	82	105	142	293	574	1053	1462	1962	68	0	0	311	4	1185	16
B9	83	143	229	431	880	1341	2024	3888	59	0	0	158	2	625	8

Table 3-4 Statistical Analysis of Dilutions, Simulation 07_7

	Percentile									Count	Pcnt	Count	Pcnt	Count	Pcnt
Site	1	5	10	25	50	75	90	95	Min	<50	<50	<100	<100	<200	<200
a	23	27	30	39	76	137	184	203	19	2502	33	4575	61	6960	94
b	55	82	111	246	774	1286	1789	2519	40	37	0	571	7	1489	20
c	54	76	95	162	378	918	1345	1708	45	37	0	807	10	2379	32
d	55	104	192	524	963	1309	1833	3411	43	35	0	347	4	762	10
e	617	828	981	1419	1962	2948	4986	10901	519	0	0	0	0	0	0
f	447	629	756	963	1272	1796	2627	3721	244	0	0	0	0	0	0
g	645	763	846	1018	1272	1781	2766	3312	365	0	0	0	0	0	0
h	598	833	1096	1667	2390	3727	6451	21486	547	0	0	0	0	0	0
i	586	781	1058	1654	2508	4214	7527	30811	445	0	0	0	0	0	0
j	687	886	1392	2087	3560	8525	24605	146938	663	0	0	0	0	0	0
k	794	959	1389	3862	15253	45305	1495021	291262444	669	0	0	0	0	0	0
l	82	117	177	471	953	1301	1821	3329	57	0	0	256	3	821	11
m	268	505	713	956	1156	1516	2540	5052	220	0	0	0	0	0	0
n	1016	1077	1141	1333	1682	2424	6260	20248	979	0	0	0	0	0	0
B7	89	179	296	652	1038	1433	2270	5168	62	0	0	112	1	465	6
B8	94	121	179	348	628	1073	1460	1962	82	0	0	139	1	927	12
B9	85	165	257	450	942	1370	2024	3888	63	0	0	129	1	533	7

Table 3-5 Statistical Analysis of Dilutions, Simulation 07_8

	Percentile									Count	Pcnt	Count	Pcnt	Count	Pcnt
Site	1	5	10	25	50	75	90	95	Min	<50	<50	<100	<100	<200	<200
a	132	238	410	930	1308	1783	2894	4605	93	0	0	19	0	244	3
b	136	260	527	954	1338	1838	3131	5747	94	0	0	16	0	223	3
c	115	190	265	725	1181	1612	2525	3589	90	0	0	41	0	437	5
d	45	72	102	389	1027	1471	2188	3922	37	118	1	717	9	1376	18
e	1017	1388	1531	1922	2834	4152	6984	22404	535	0	0	0	0	0	0
f	334	762	996	1323	1777	2540	3848	7979	226	0	0	0	0	0	0
g	873	1092	1184	1383	1753	2801	4269	13997	712	0	0	0	0	0	0
h	1116	1602	1732	2185	3373	5253	9034	33581	483	0	0	0	0	0	0
i	533	1382	1701	2180	3294	5615	10216	49851	361	0	0	0	0	0	0
j	851	1935	2112	3038	5021	10777	28853	293793	416	0	0	0	0	0	0
k	2750	3578	4434	8383	18065	55463	1716238	626811653	2365	0	0	0	0	0	0
l	104	173	232	436	788	1212	1883	2753	88	0	0	53	0	541	7
m	196	284	410	821	1090	1466	2646	5377	152	0	0	0	0	104	1
n	1165	1236	1305	1471	1887	2982	8924	29151	1074	0	0	0	0	0	0
B7	26	29	32	38	57	91	133	164	20	3147	42	5926	80	7274	98
B8	122	181	241	564	1043	1441	2175	3118	96	0	0	6	0	494	6
B9	167	372	585	921	1282	1787	3627	6775	129	0	0	0	0	125	1

Table 3-6 Statistical Analysis of Dilutions, Simulation 07_9

	Percentile									Count	Pcnt	Count	Pcnt	Count	Pcnt
Site	1	5	10	25	50	75	90	95	Min	<50	<50	<100	<100	<200	<200
a	94	193	348	680	1130	1582	2600	4362	65	0	0	101	1	386	5
b	115	255	456	799	1208	1660	2874	5117	84	0	0	41	0	250	3
c	84	126	178	319	809	1381	2159	3238	53	0	0	166	2	898	12
d	85	139	197	420	905	1435	2394	5028	65	0	0	130	1	752	10
e	895	1173	1354	1700	2364	3551	5691	12453	515	0	0	0	0	0	0
f	407	633	873	1176	1580	2265	3488	4821	240	0	0	0	0	0	0
g	865	1032	1118	1335	1649	2486	4235	10151	735	0	0	0	0	0	0
h	990	1356	1572	1926	2959	4529	7418	24436	435	0	0	0	0	0	0
i	533	1109	1418	1861	2973	4587	7704	34523	325	0	0	0	0	0	0
j	641	1660	1894	2570	4351	8718	24853	178102	348	0	0	0	0	0	0
k	2445	3076	3808	6949	15352	44372	1164450	39661514	2270	0	0	0	0	0	0
l	55	74	88	142	789	1280	1861	2803	50	0	0	943	12	2304	31
m	171	257	368	790	1096	1466	2459	6413	149	0	0	0	0	145	1
n	1113	1221	1261	1440	1807	3021	8504	31169	1005	0	0	0	0	0	0
B7	100	138	191	418	868	1479	2608	6418	78	0	0	71	0	793	10
B8	15	17	18	21	24	32	50	89	13	6626	89	7070	95	7315	99
B9	196	357	472	772	1164	1656	3469	6777	130	0	0	0	0	77	1

Table 3-7 Statistical Analysis of Dilutions, Simulation 07_10

	Percentile									Count	Pcnt	Count	Pcnt	Count	Pcnt
Site	1	5	10	25	50	75	90	95	Min	<50	<50	<100	<100	<200	<200
a	89	134	169	257	471	1042	1525	2131	73	0	0	136	1	1148	15
b	75	94	111	153	267	857	1357	1730	47	3	0	476	6	2846	38
c	128	181	227	384	690	1099	1554	2293	89	0	0	12	0	531	7
d	147	195	279	550	907	1297	1856	2795	89	0	0	6	0	384	5
e	846	1137	1293	1624	2369	3556	6296	15813	453	0	0	0	0	0	0
f	250	593	760	1003	1302	1873	3023	4710	145	0	0	0	0	54	0
g	608	804	879	1046	1279	1789	2886	4184	373	0	0	0	0	0	0
h	928	1405	1543	1896	2955	4693	7861	28725	388	0	0	0	0	0	0
i	474	1154	1486	1936	2904	4872	8078	40025	267	0	0	0	0	0	0
j	636	1748	1914	2734	4513	9255	23329	283290	297	0	0	0	0	0	0
k	2593	3452	4329	7911	16500	48859	1724675	315738645	2159	0	0	0	0	0	0
l	180	260	319	591	923	1284	1916	2850	115	0	0	0	0	163	2
m	322	406	561	870	1097	1470	2603	4381	232	0	0	0	0	0	0
n	958	1078	1133	1270	1654	2317	6893	21900	785	0	0	0	0	0	0
B7	126	181	261	584	983	1397	2158	4147	82	0	0	16	0	440	5
B8	155	196	274	454	795	1155	1648	2611	109	0	0	0	0	405	5
B9	15	18	20	25	33	52	80	95	13	5336	72	7065	95	7378	99

In addition, the following table presents the minimum dilution simulated in each vertical computational cell above extraction points (in order) 'e', 'f', 'o', 'a', 'q', 'r' and 'd', over the 40 day 07-6 simulation. Hatched cells are land cells.

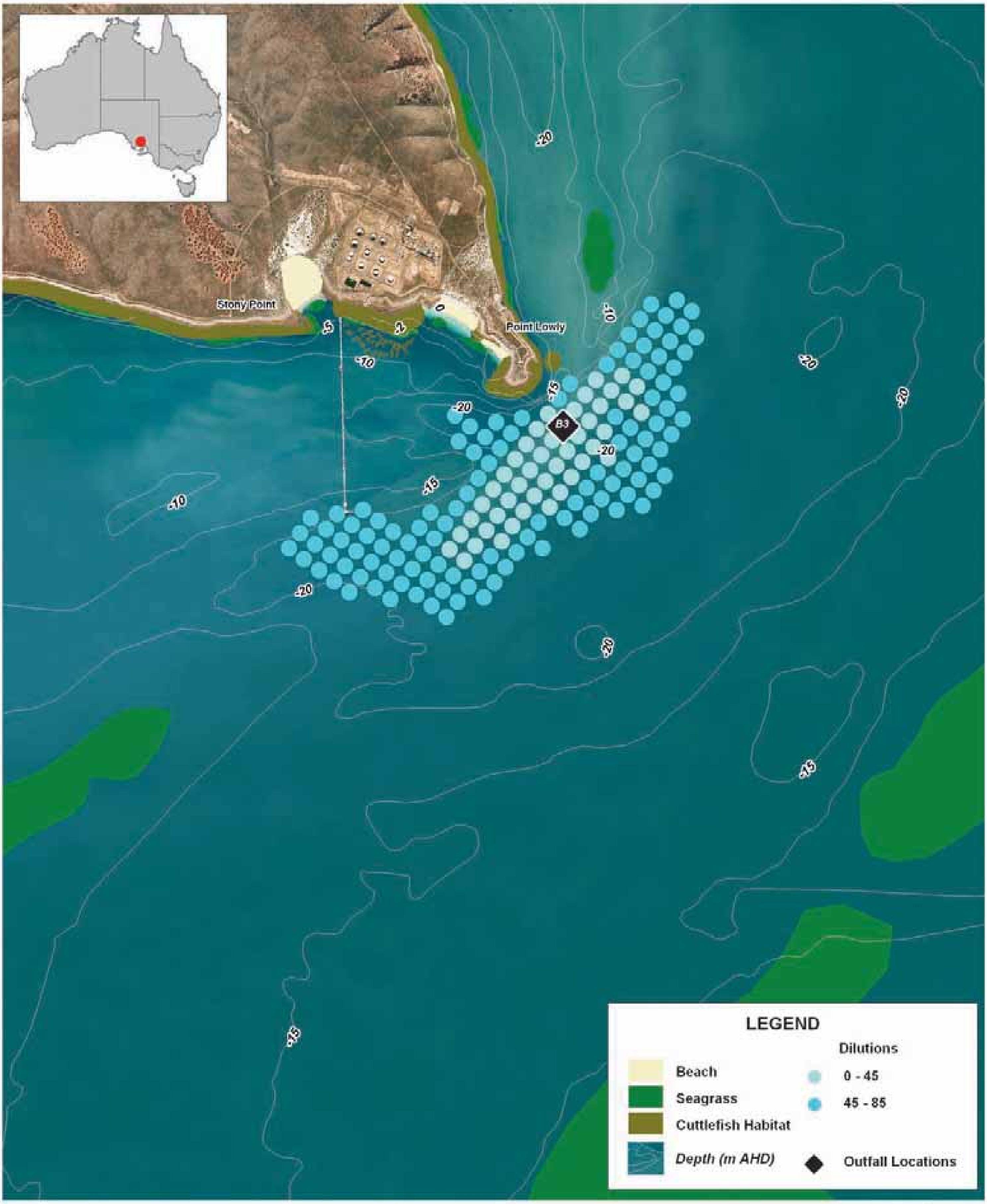
Table 3-8 Minimum Dilutions Across Cells 'e' to 'd'. Mid Field Model 07-6 Only.

Vertical Computational Layer	e	f	o	a	q	r	d
14	5000	5000	3333	2000	1667	2000	2500
13	556	667	588	500	400	345	417
12	476	500	500	500	400	345	417
11	476	526	476	476	400	345	417
10	500	435	417	435	400	345	417
9		417	417	417	370	345	345
8		294	357	385	333	323	313
7		233	270	263	263	238	217
6		169	179	189	217	179	192
5		152	147	169	179	154	179
4			78	156	120	145	145
3			48	133	74	95	105
2			19	16	24	33	38

3.2.3 Maps

Finally, maps of dilution have also been produced, as previously described. A figure for each 40 day analysis dilution percentile (0^{th}, 1^{st}, 10^{th} and 50^{th}) is presented, for simulation 07-6. Dilution contours are set to 1:45 and 1:85 for these figures.

In addition to the above, the same percentile dilutions were also computed for simulation 07-6 to 07-10 for each tidal regime (spring, typical and dodge). These dilutions have been contoured at 1:50, 1:100 and 1:200 dilutions. All figures follow.



Title:

Simulation 07_6: 40 Day 0th Percentile

Figure: 3-10

Rev: A

N

0 1 2km

Approx. Scale

BMT WBM

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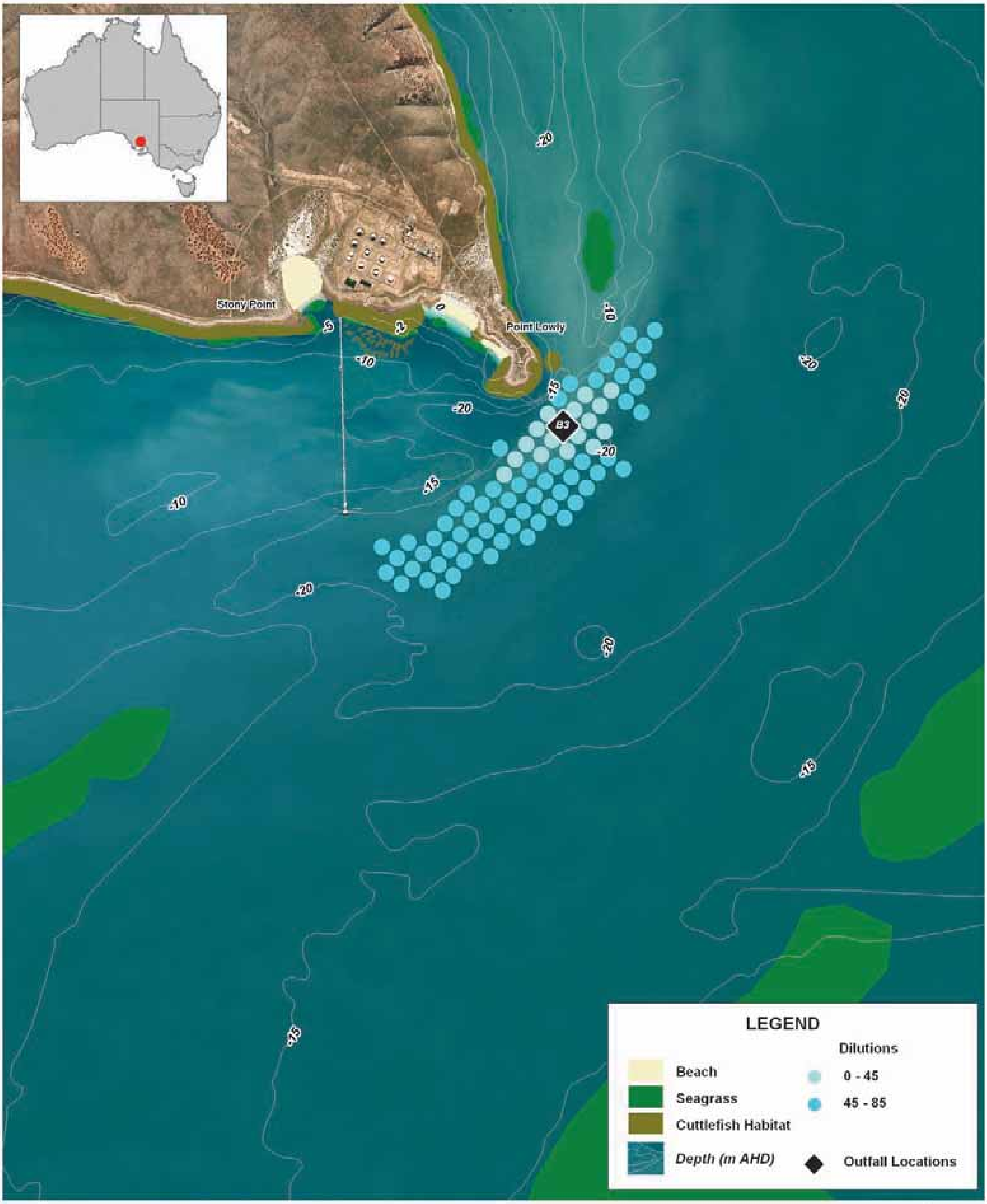
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_235_080114_07_6_0.WOR



Title:

Simulation 07_6: 40 Day 1st Percentile

Figure: 3-11

Rev: A

Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

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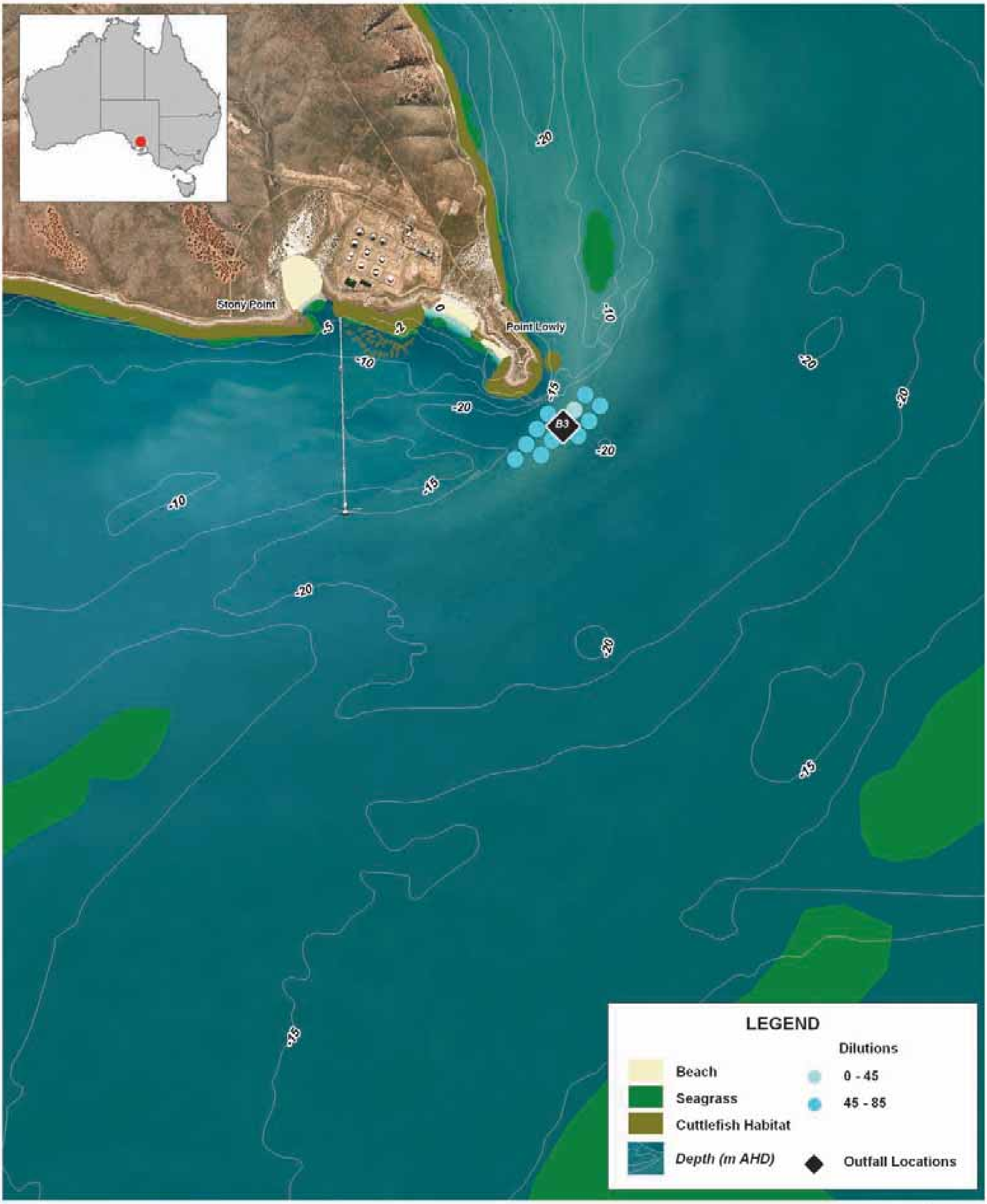

Title:
Simulation 07_6: 40 Day 10th Percentile

Figure: 3-12

Rev: A

Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
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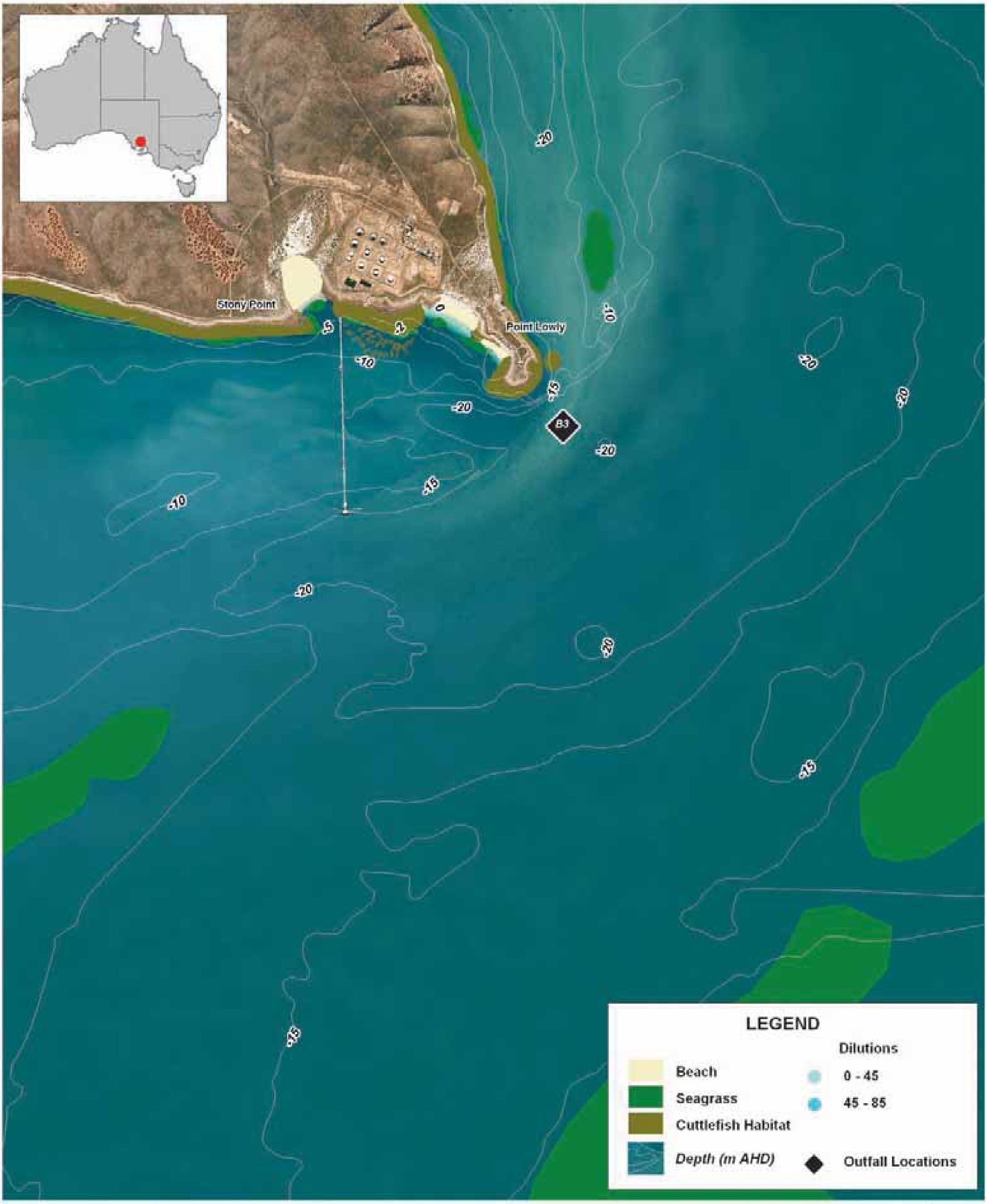
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_237_080114_07_6_10.WOR



Title:
Simulation 07_6: 40 Day 50th Percentile

Figure: 3-13

Rev: A

Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
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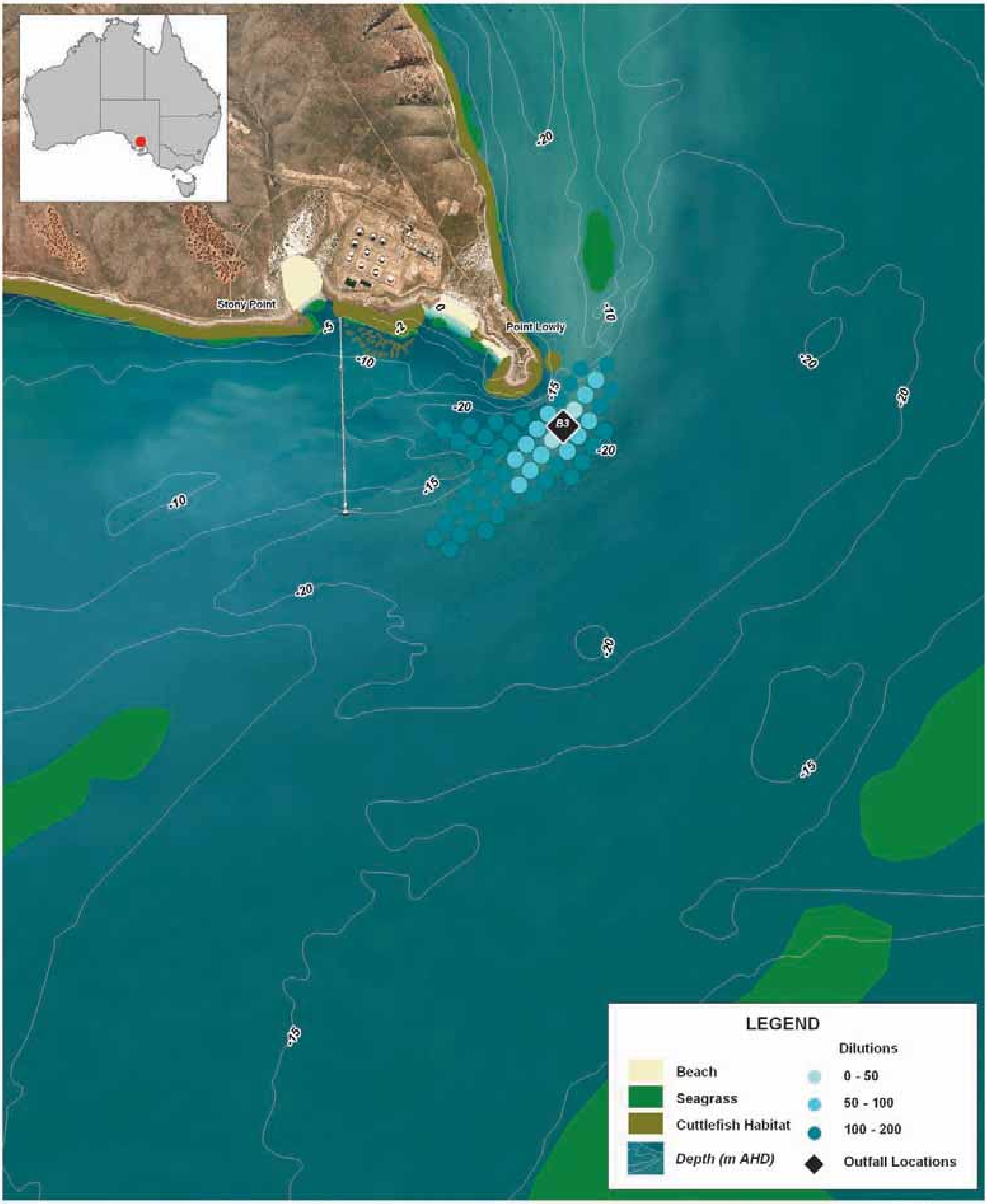

Title:

Simulation 07_6: Spring Tide 0th Percentile

Figure: 3-14

Rev: A

Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

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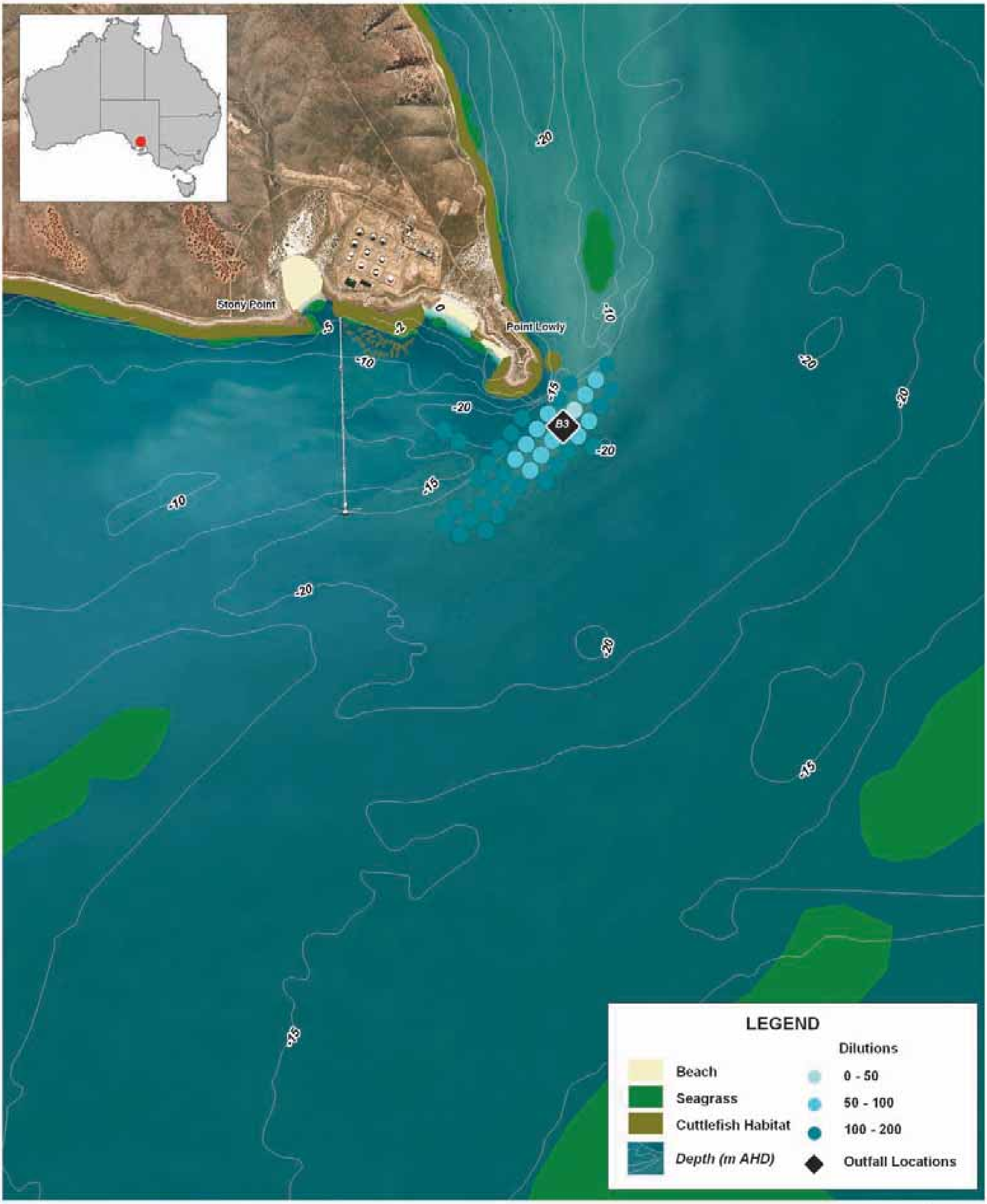

Title:

Simulation 07_6: Spring Tide 1st Percentile

Figure: 3-15

Rev: A

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N

0 1 2km

Approx. Scale

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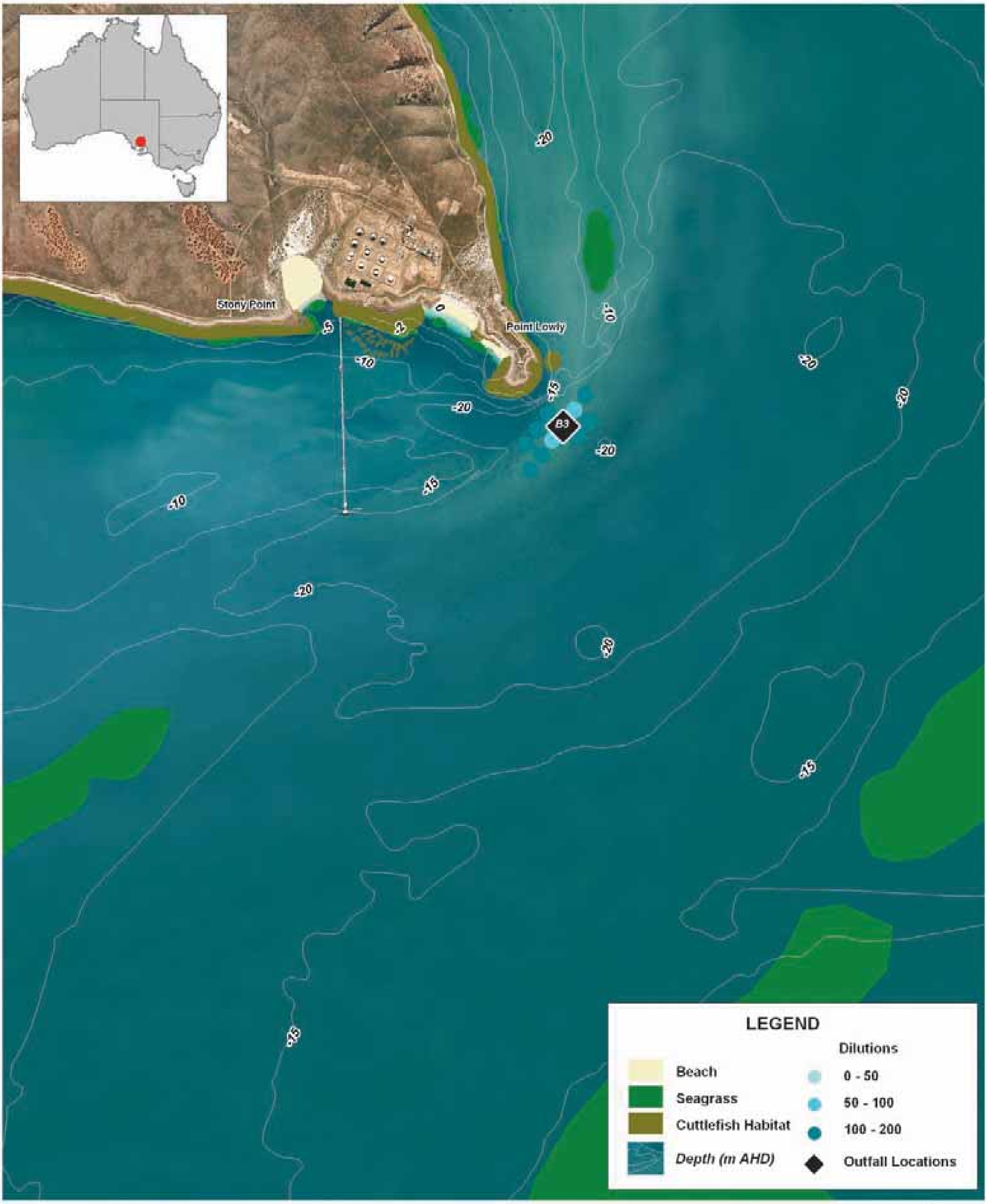
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_068_071015_07_6_Spring_1.WOR



Title:

Simulation 07_6: Spring Tide 10th Percentile

Figure: 3-16

Rev: A

N

0 1 2km

Approx. Scale

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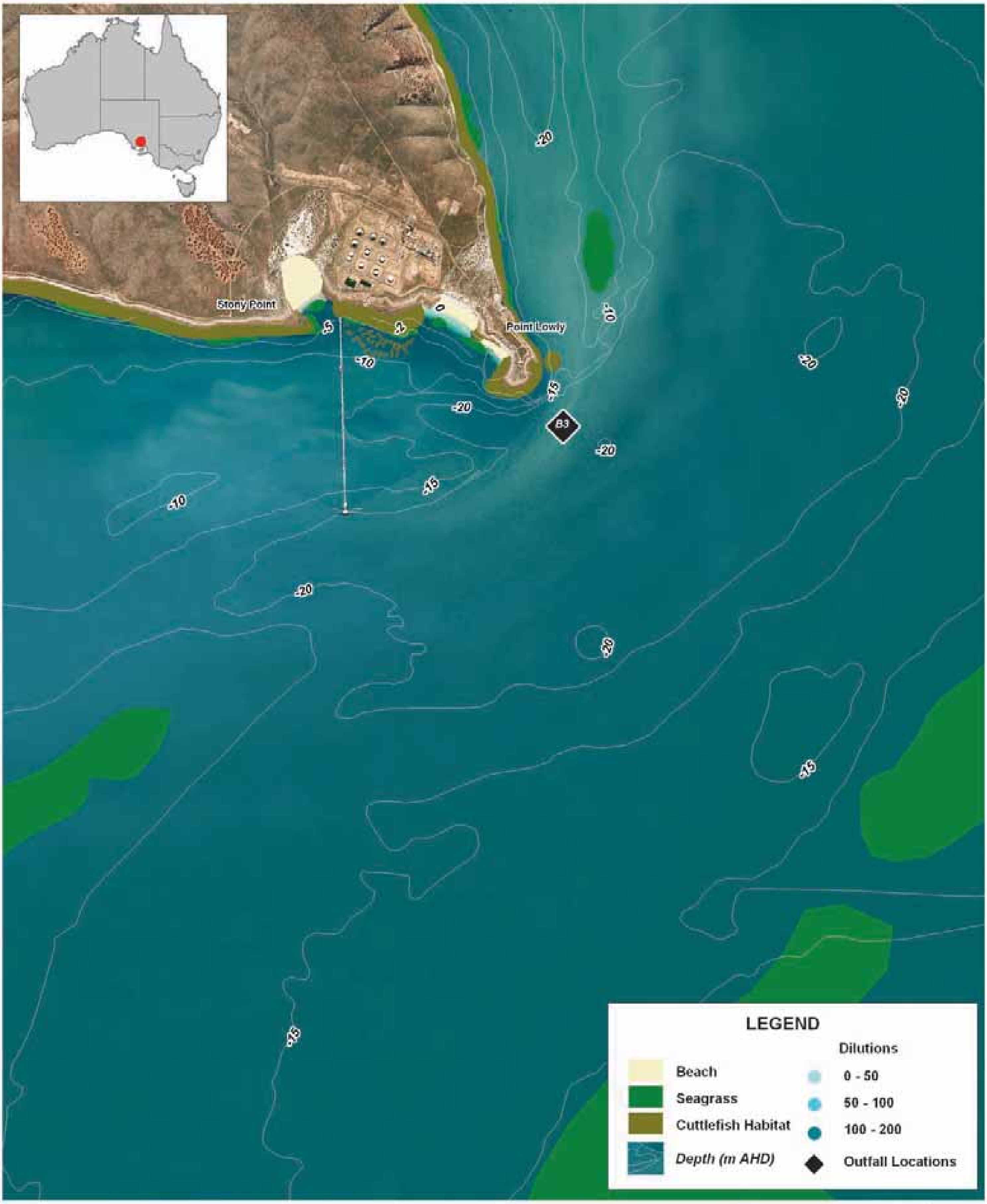

Title:
Simulation 07_6: Spring Tide 50th Percentile

Figure: 3-17

Rev: A

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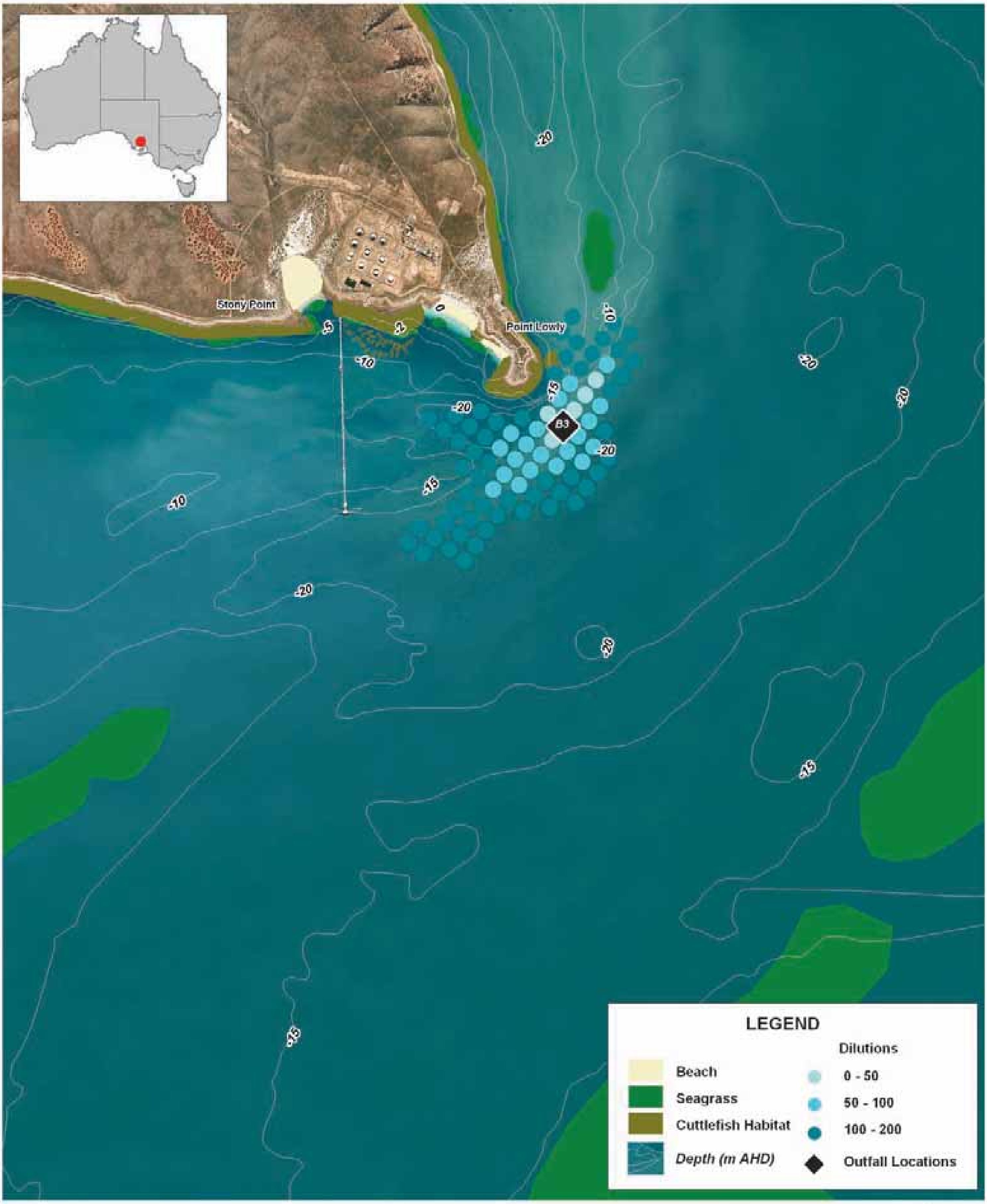

Title:

Simulation 07_6: Typical Tide 0th Percentile

Figure: 3-18

Rev: A

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0 1 2km

Approx. Scale

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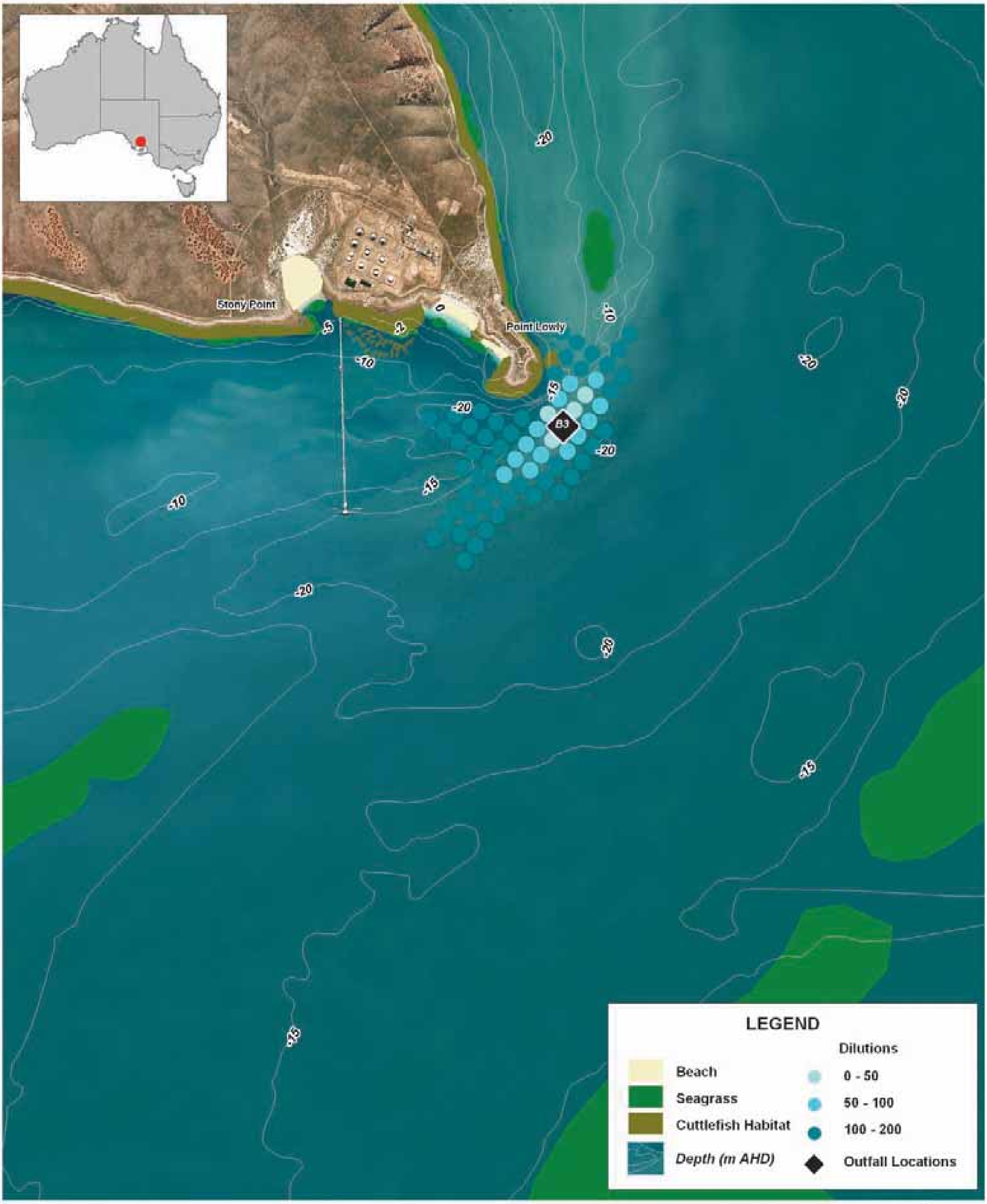

Title:
Simulation 07_6: Typical Tide 1st Percentile

Figure: 3-19

Rev: A

Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

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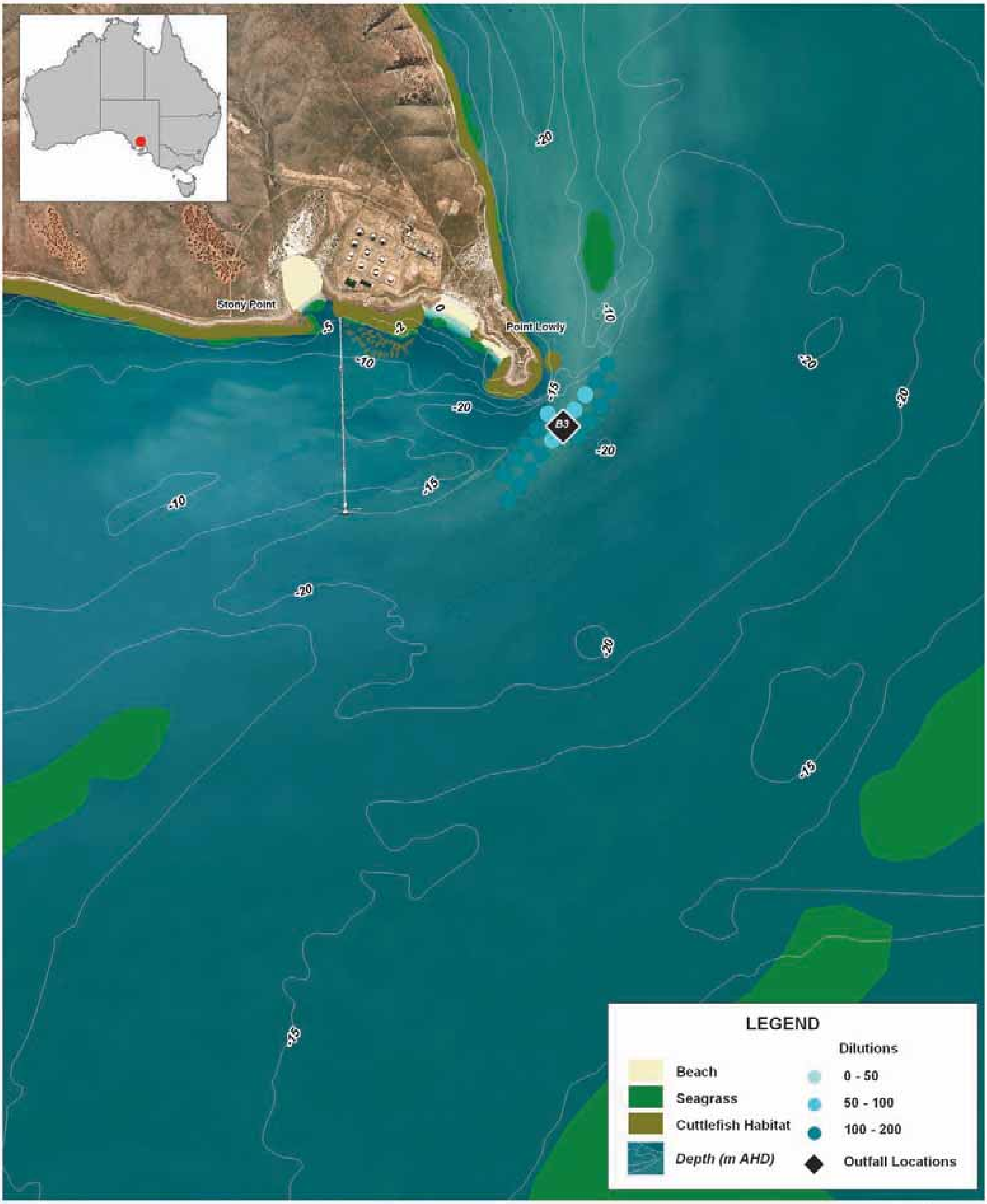
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_072_071015_07_6_Typical_1.WOR



Title:

Simulation 07_6: Typical Tide 10th Percentile

Figure: 3-20

Rev: A

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Air photo from Google Earth.

N

0 1 2km

Approx. Scale

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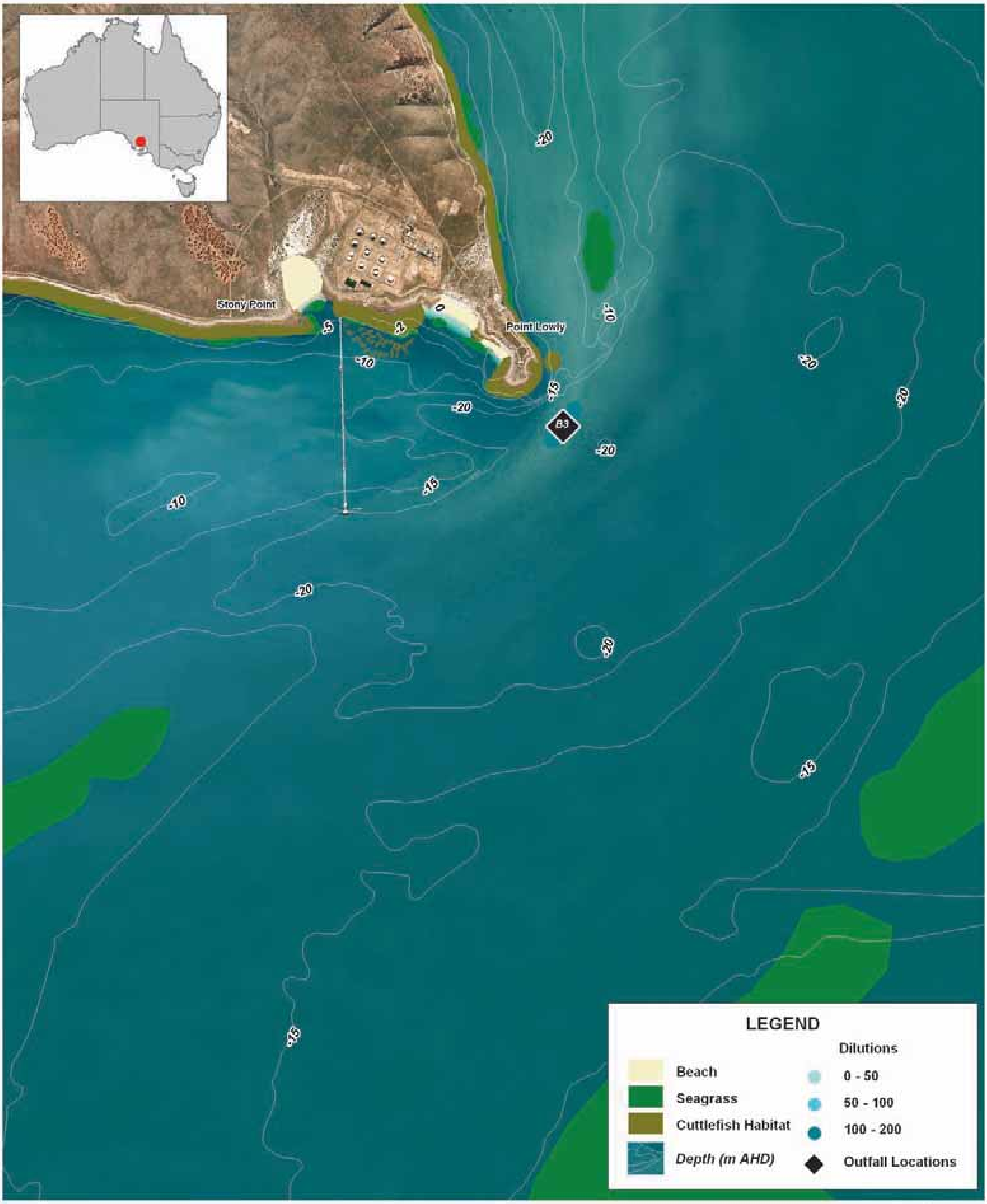
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_073_071015_07_6_Typical_10.WOR



Title:
Simulation 07_6: Typical Tide 50th Percentile

Figure: 3-21

Rev: A

Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

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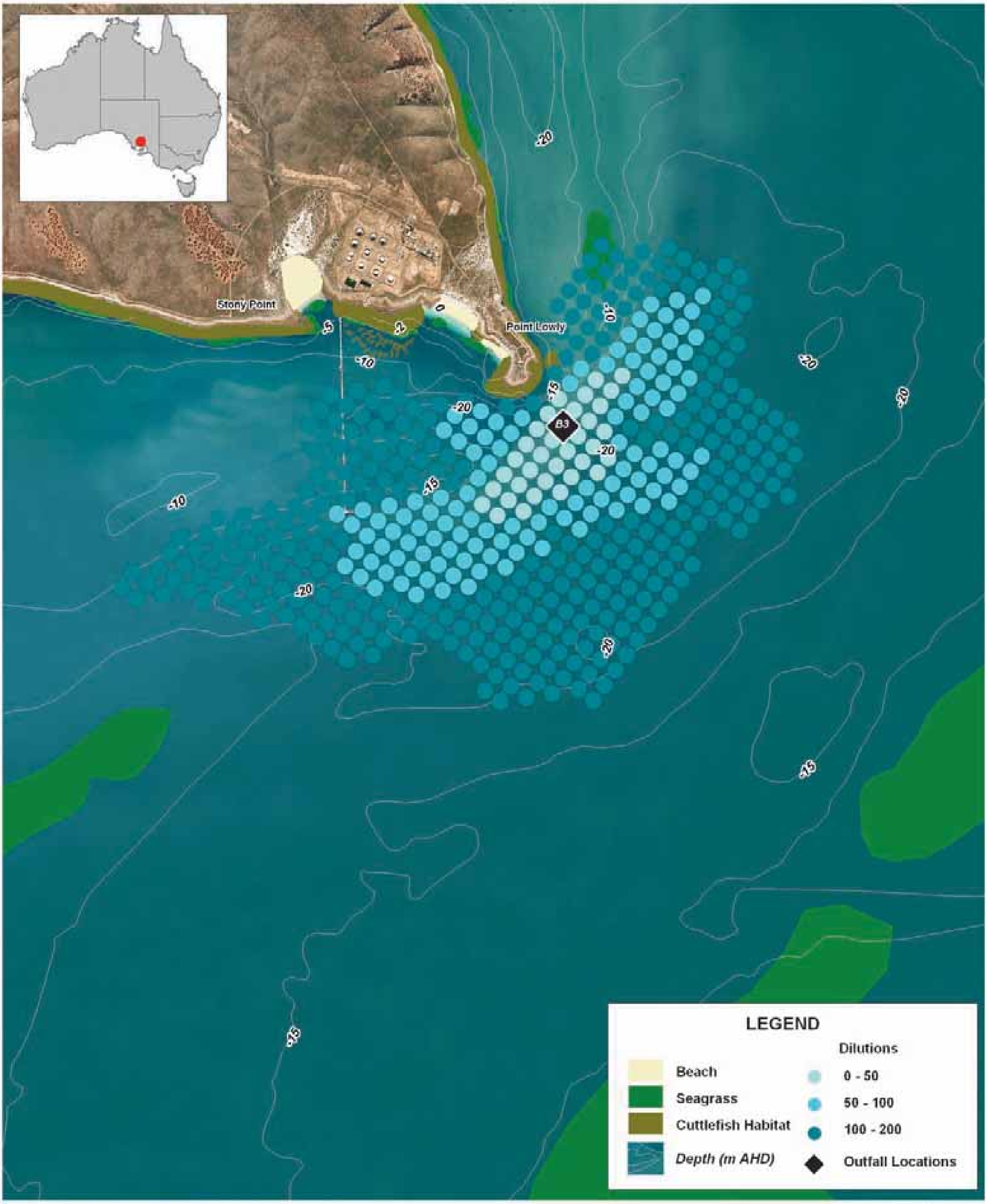

Title:

Simulation 07_6: Dodge Tide 0th Percentile

Figure: **3-22**

Rev: **A**

Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

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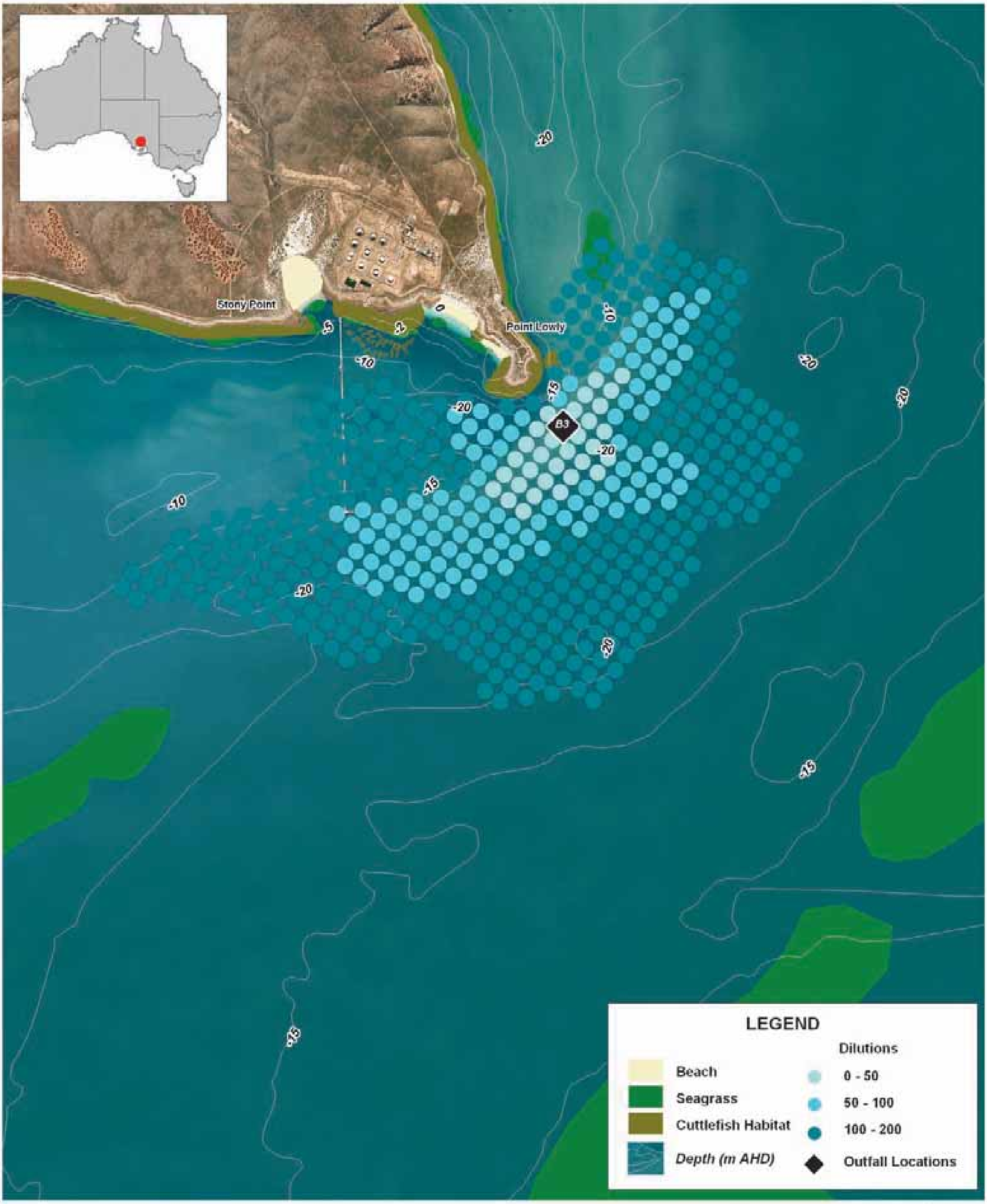

Title:
Simulation 07_6: Dodge Tide 1st Percentile

Figure: 3-23

Rev: A

Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
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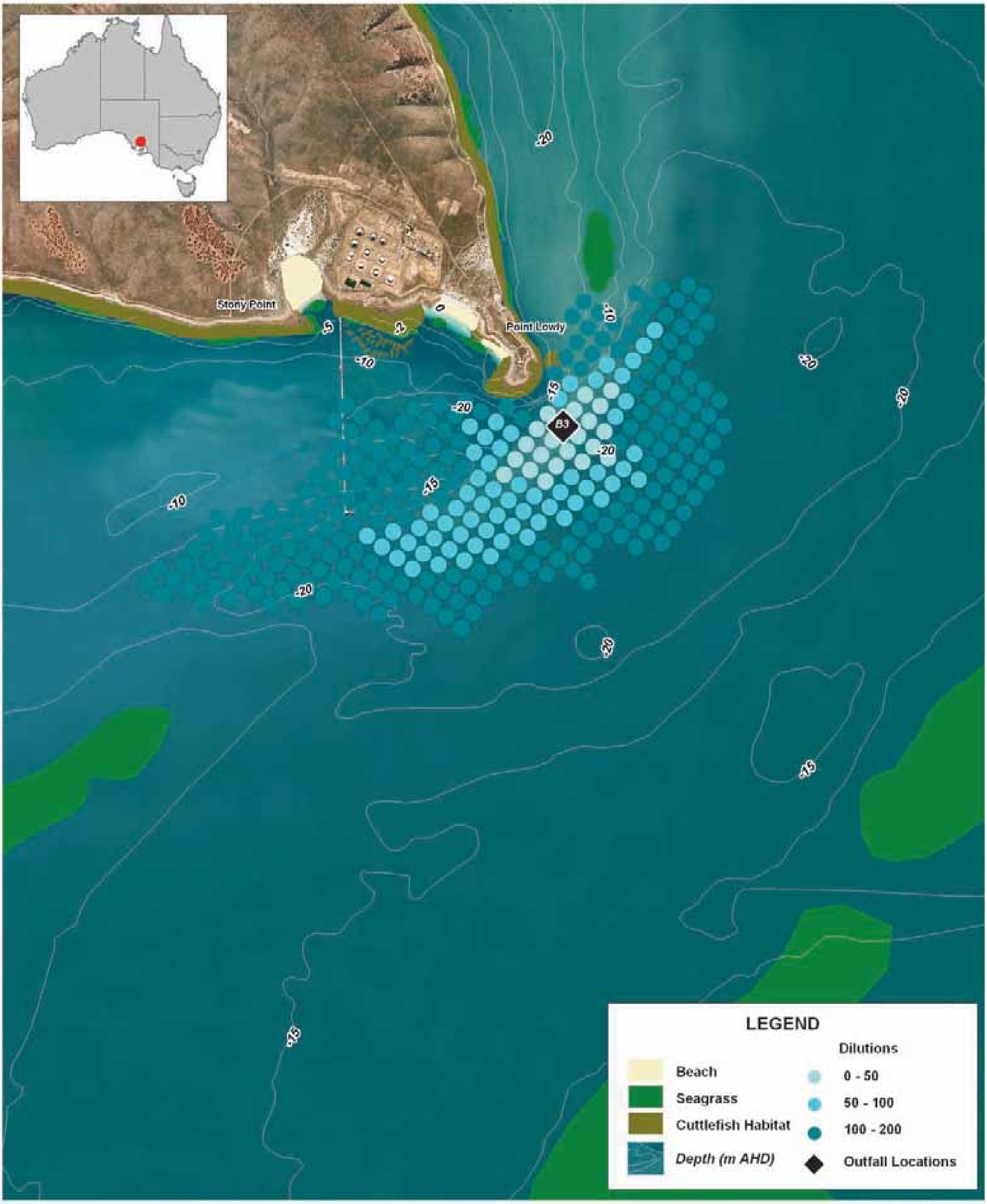
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_076_071015_07_6_Dodge_1.WOR



Title:

Simulation 07_6: Dodge Tide 10th Percentile

Figure: 3-24

Rev: A

Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

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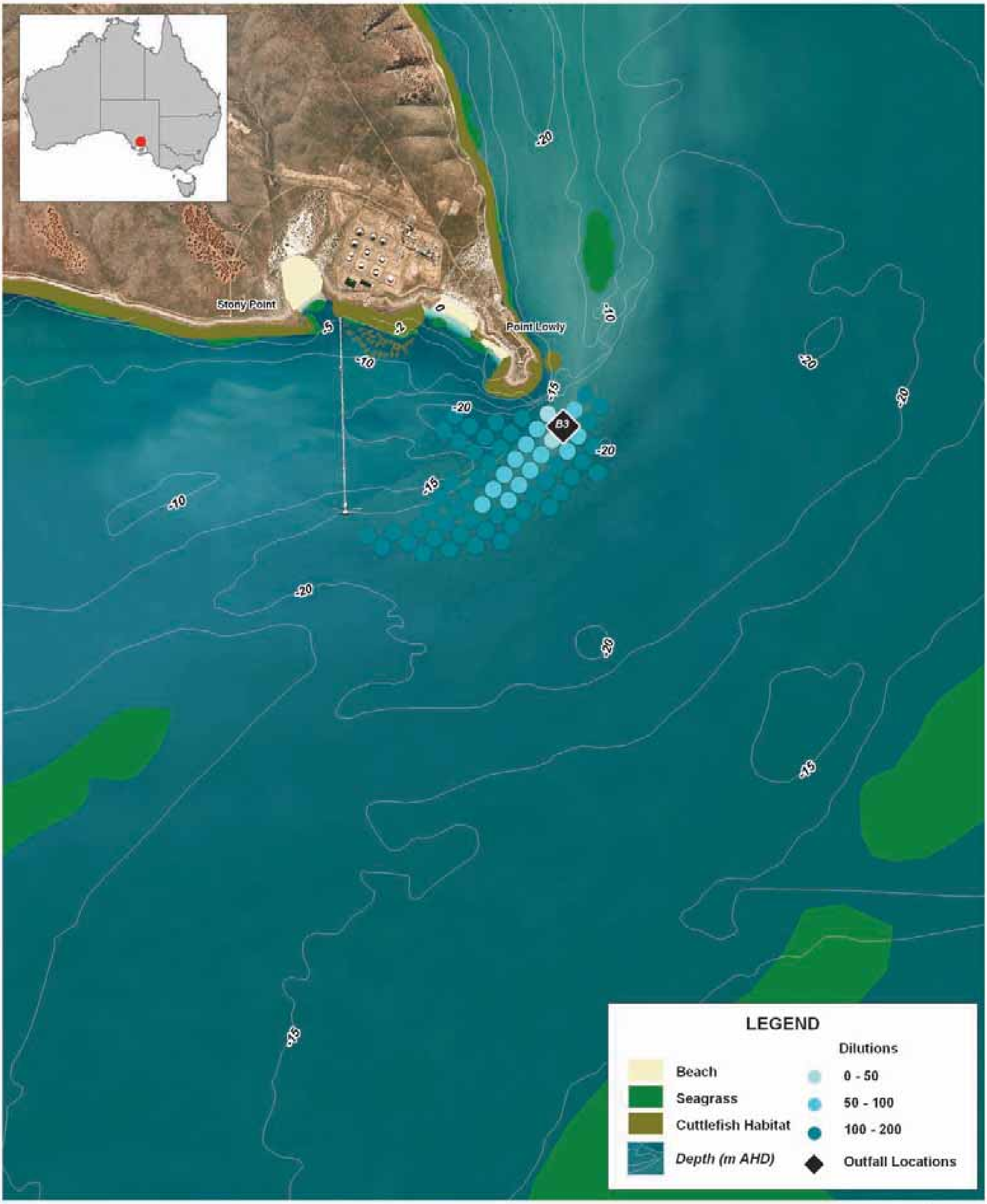

Title:

Simulation 07_6: Dodge Tide 50th Percentile

Figure: 3-25

Rev: A

N

0 1 2km

Approx. Scale

BMT WBM

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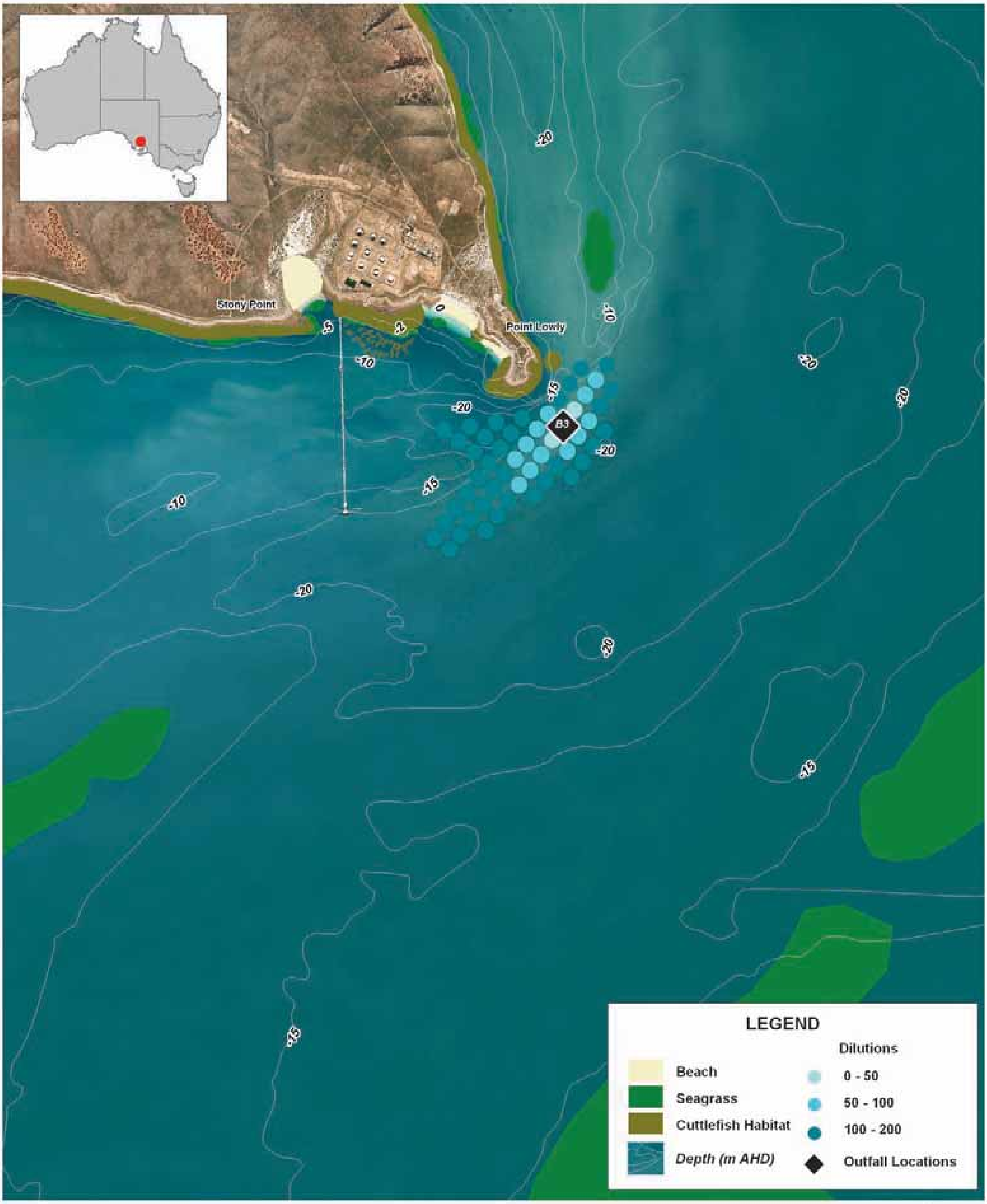

Title:
Simulation 07_7: Spring Tide 0th Percentile

Figure: 3-26

Rev: A

Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
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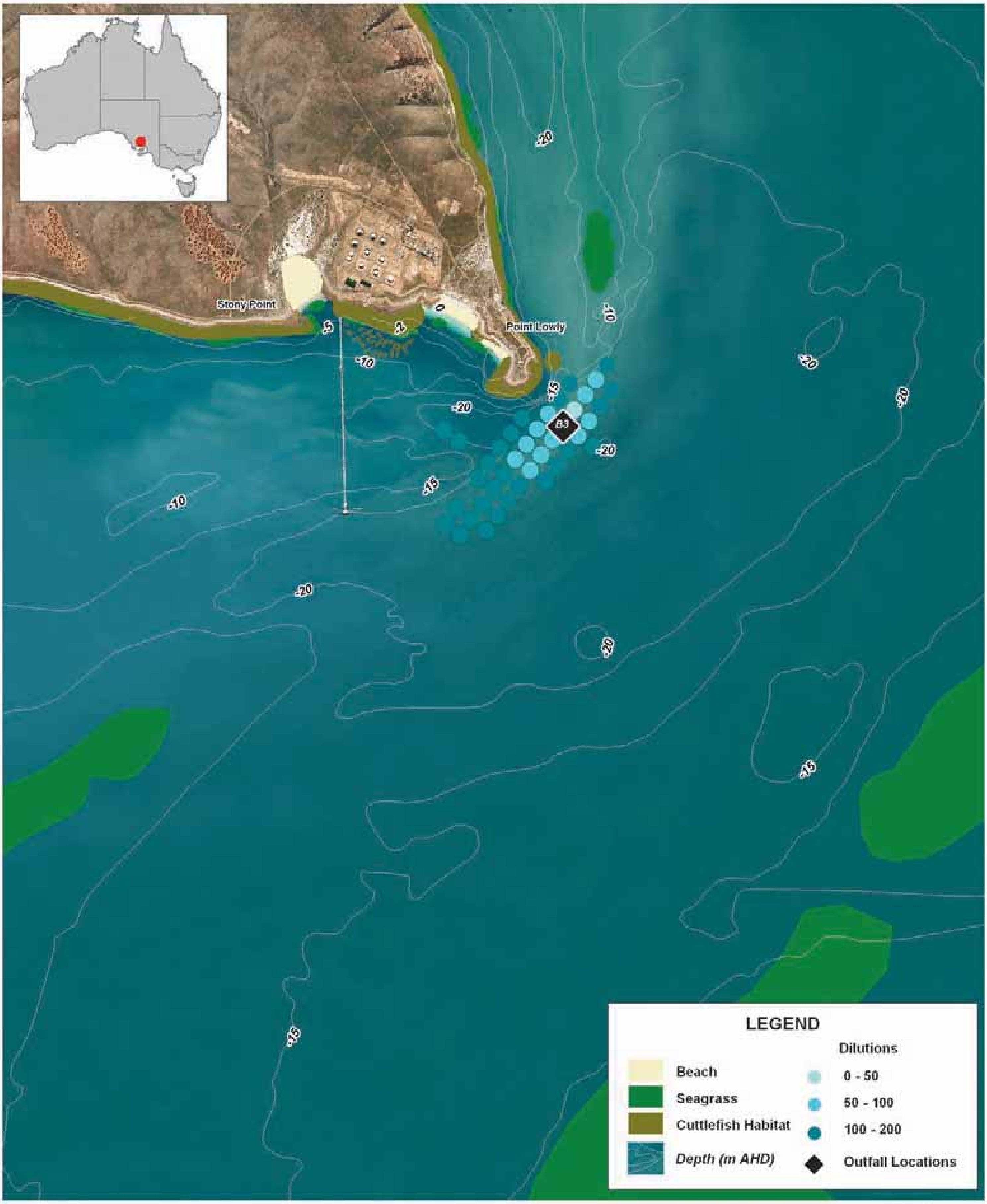
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_079_071015_07_7_Spring_0.WOR



Title:
Simulation 07_7: Spring Tide 1st Percentile

Figure: 3-27

Rev: A

Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

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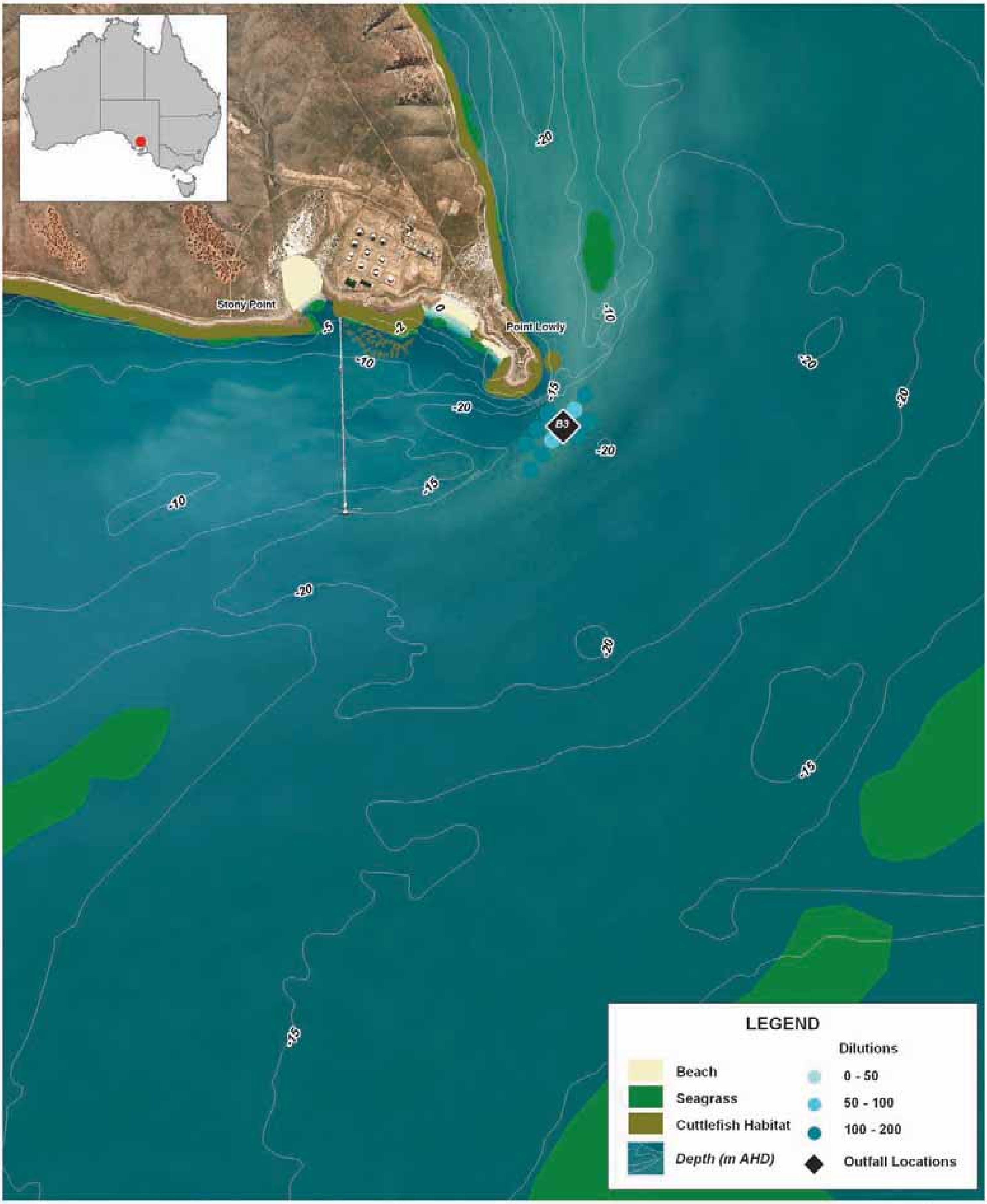
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_080_071015_07_7_Spring_1.WOR



Title:
Simulation 07_7: Spring Tide 10th Percentile

Figure: 3-28

Rev: A

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Air photo from Google Earth.

N

0 1 2km

Approx. Scale

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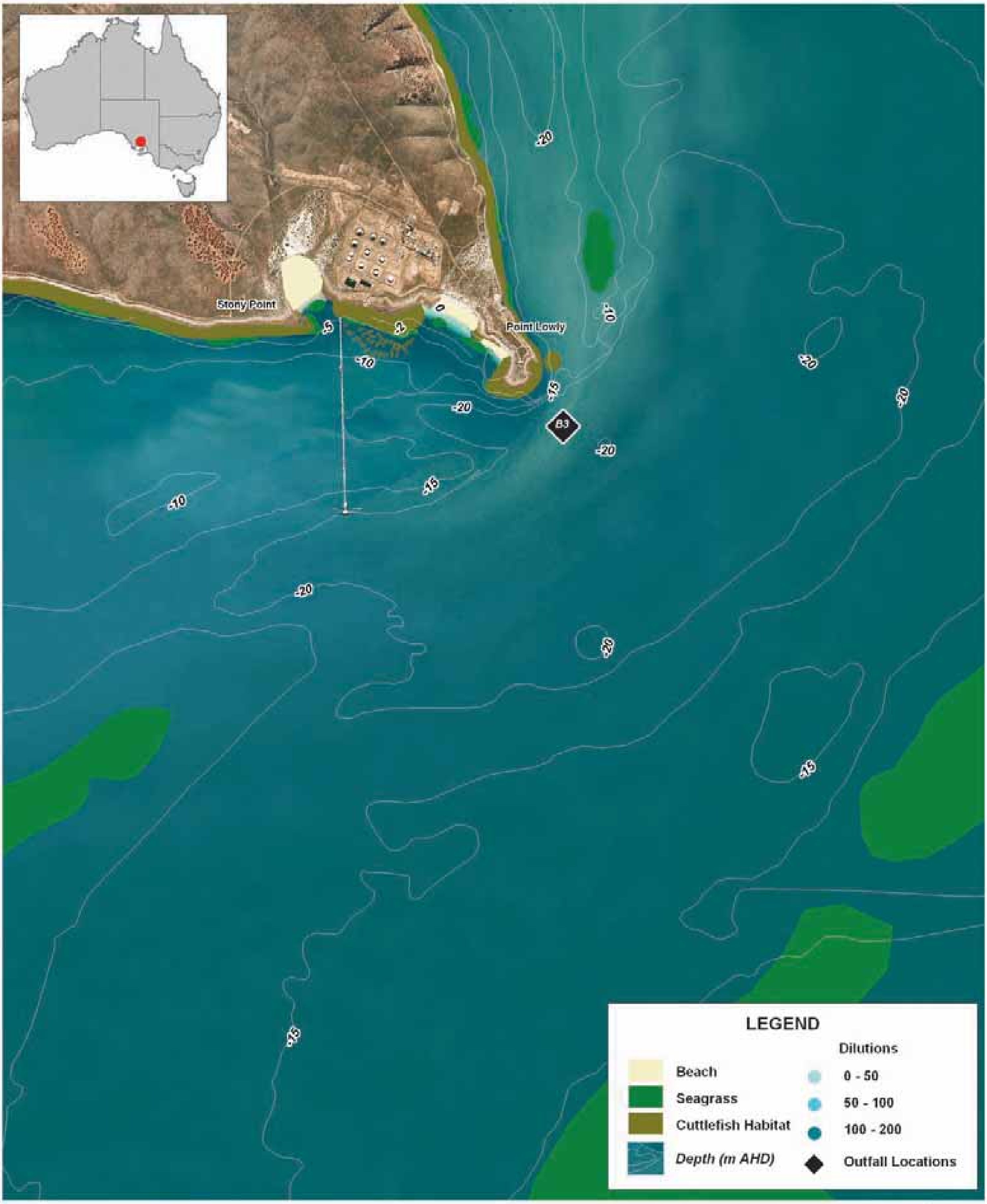
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_081_071015_07_7_Spring_10.WOR



Title:
Simulation 07_7: Spring Tide 50th Percentile

Figure: 3-29

Rev: A

Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
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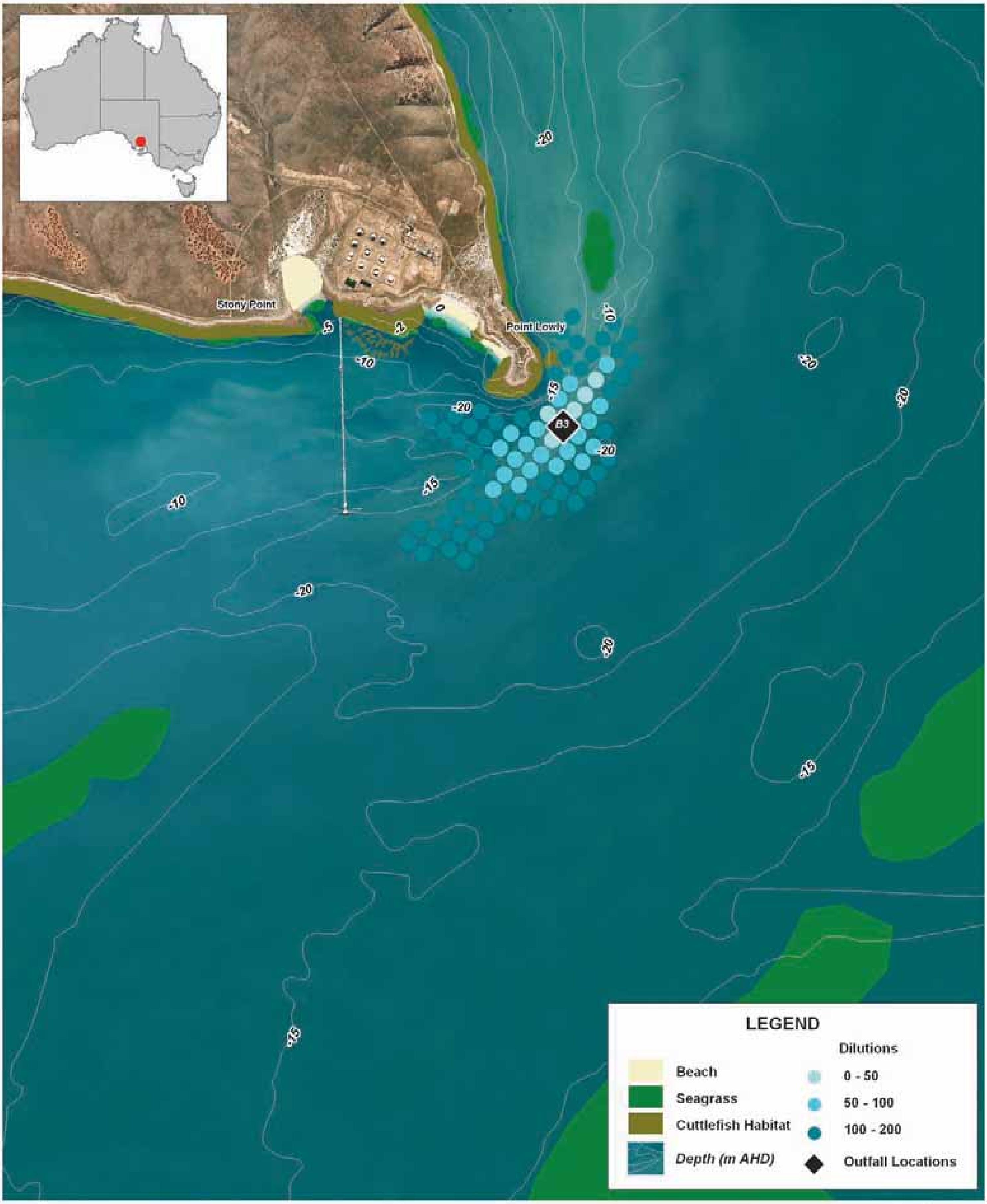
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_082_071015_07_7_Spring_50.WOR



Title:
Simulation 07_7: Typical Tide 0th Percentile

Figure: 3-30

Rev: A

Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
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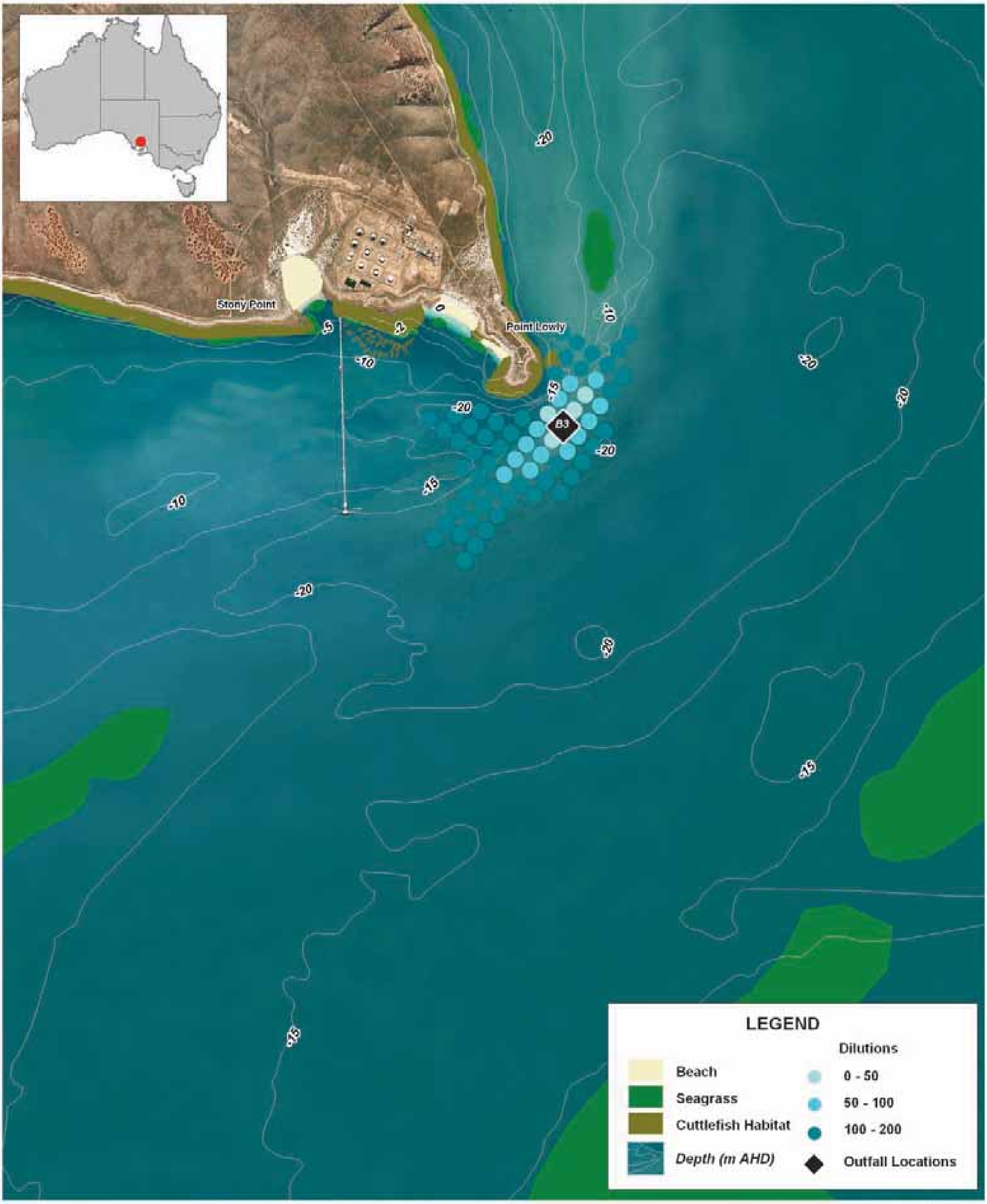
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_083_071015_07_7_Typical_0.WOR



Title:

Simulation 07_7: Typical Tide 1st Percentile

Figure: 3-31

Rev: A

Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

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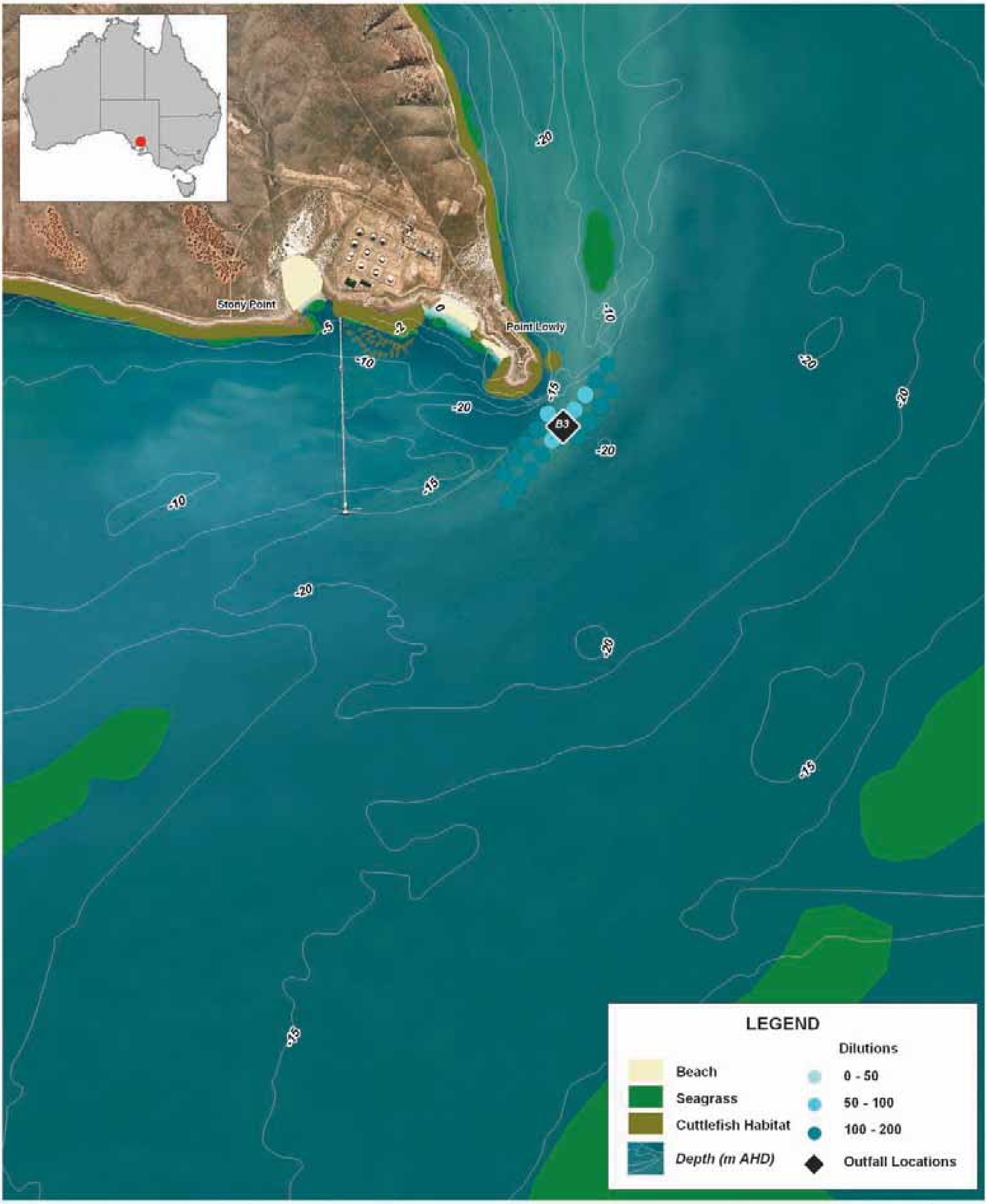
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_084_071015_07_7_Typical_1.WOR



Title:
Simulation 07_7: Typical Tide 10th Percentile

Figure: 3-32

Rev: A

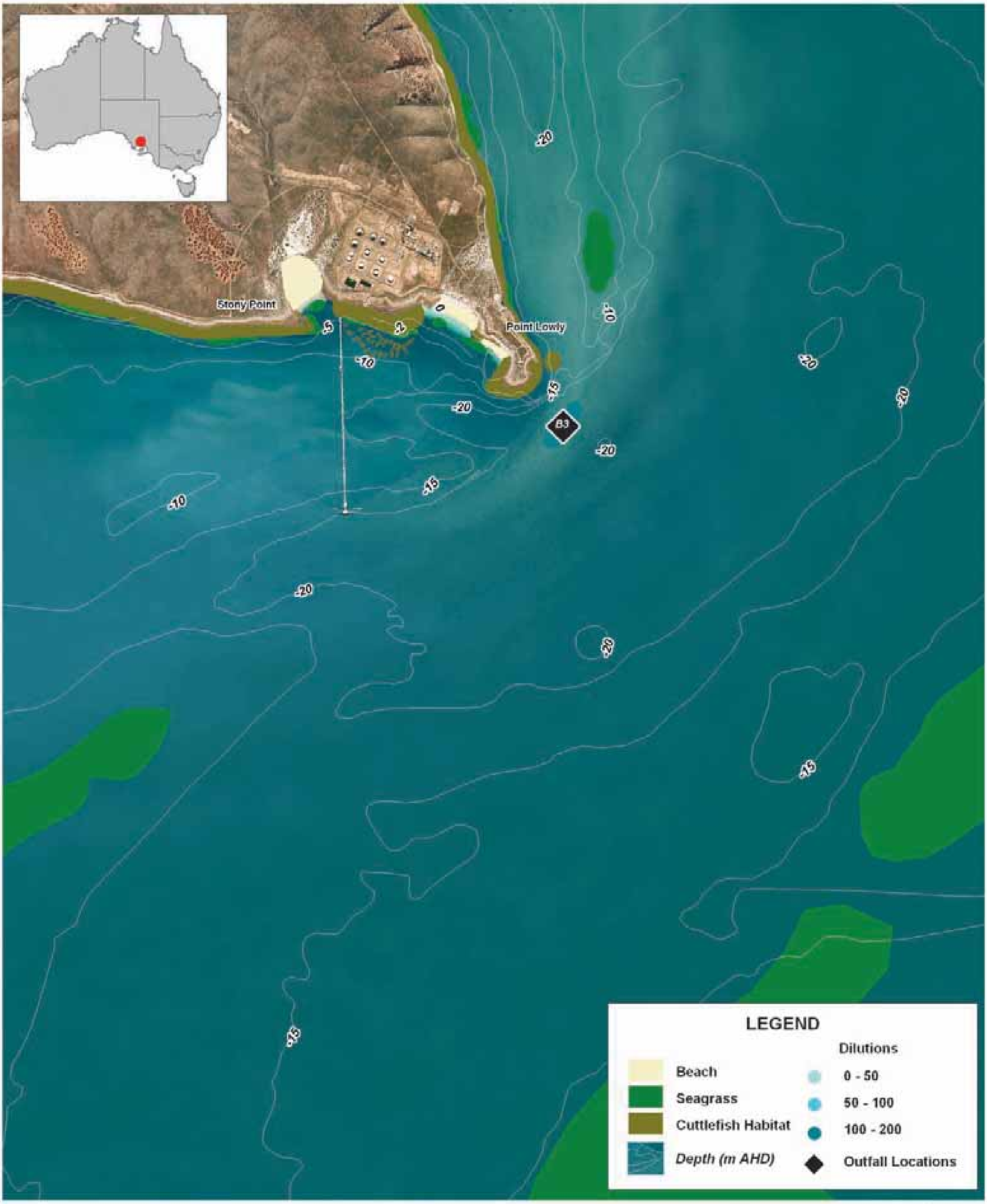
Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_085_071015_07_7_Typical_10.WOR



Title:
Simulation 07_7: Typical Tide 50th Percentile

Figure: 3-33

Rev: A

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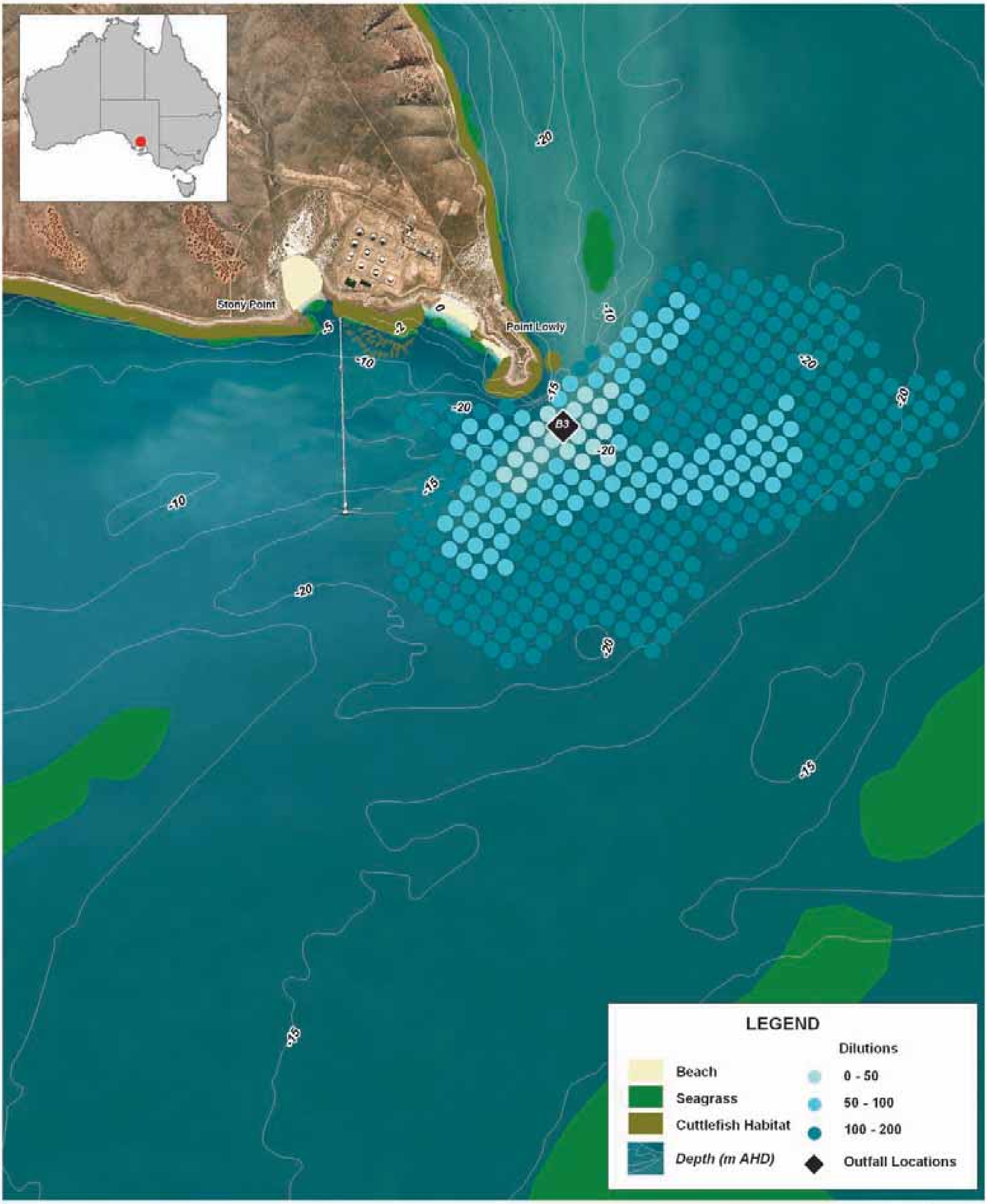
Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_086_071015_07_7_Typical_50.WOR



Title:
Simulation 07_7: Dodge Tide 0th Percentile

Figure: 3-34

Rev: A

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Air photo from Google Earth.

N

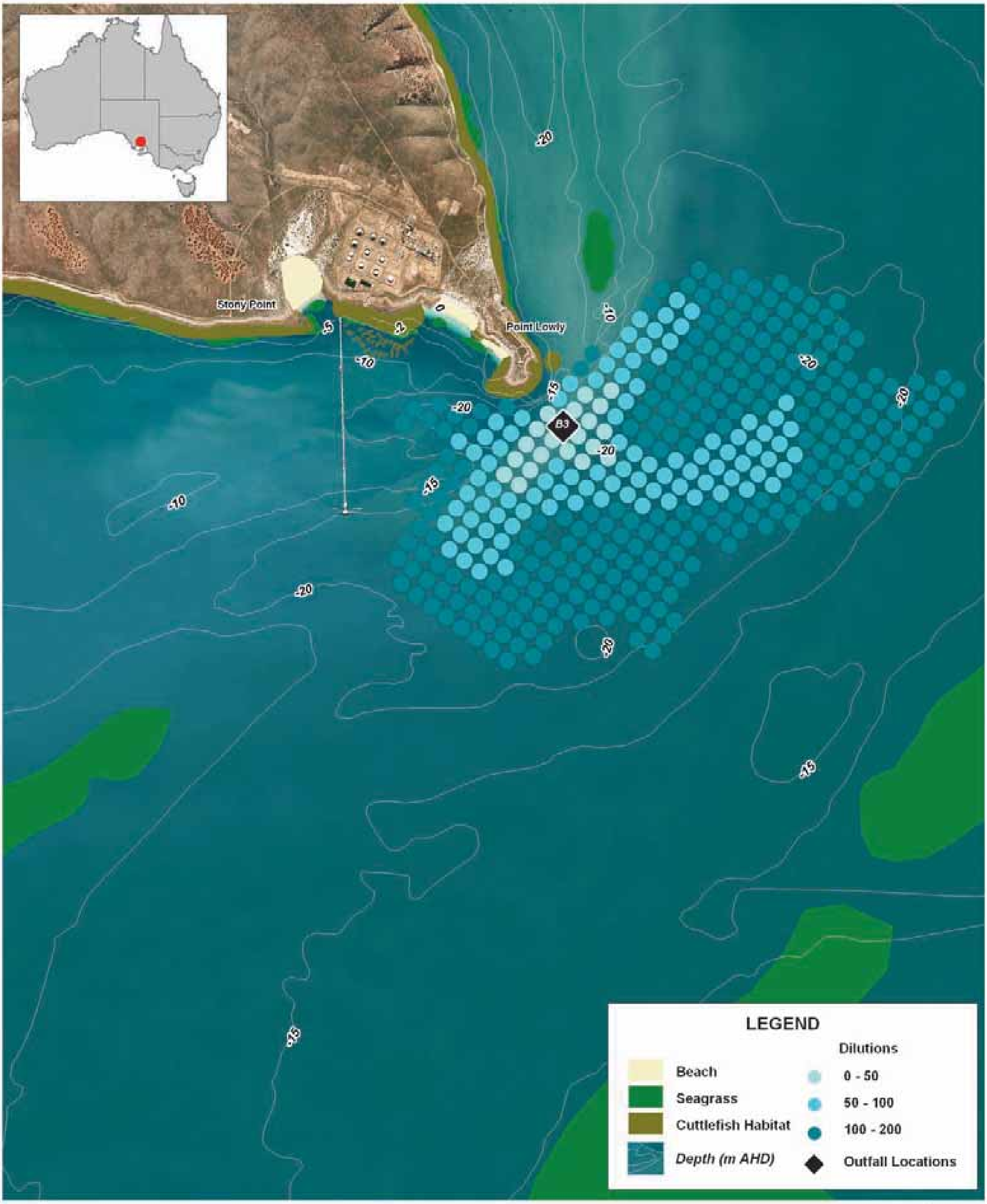
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_087_071015_07_7_Dodge_0.WOR



Title:
Simulation 07_7: Dodge Tide 1st Percentile

Figure:
3-35

Rev:
A

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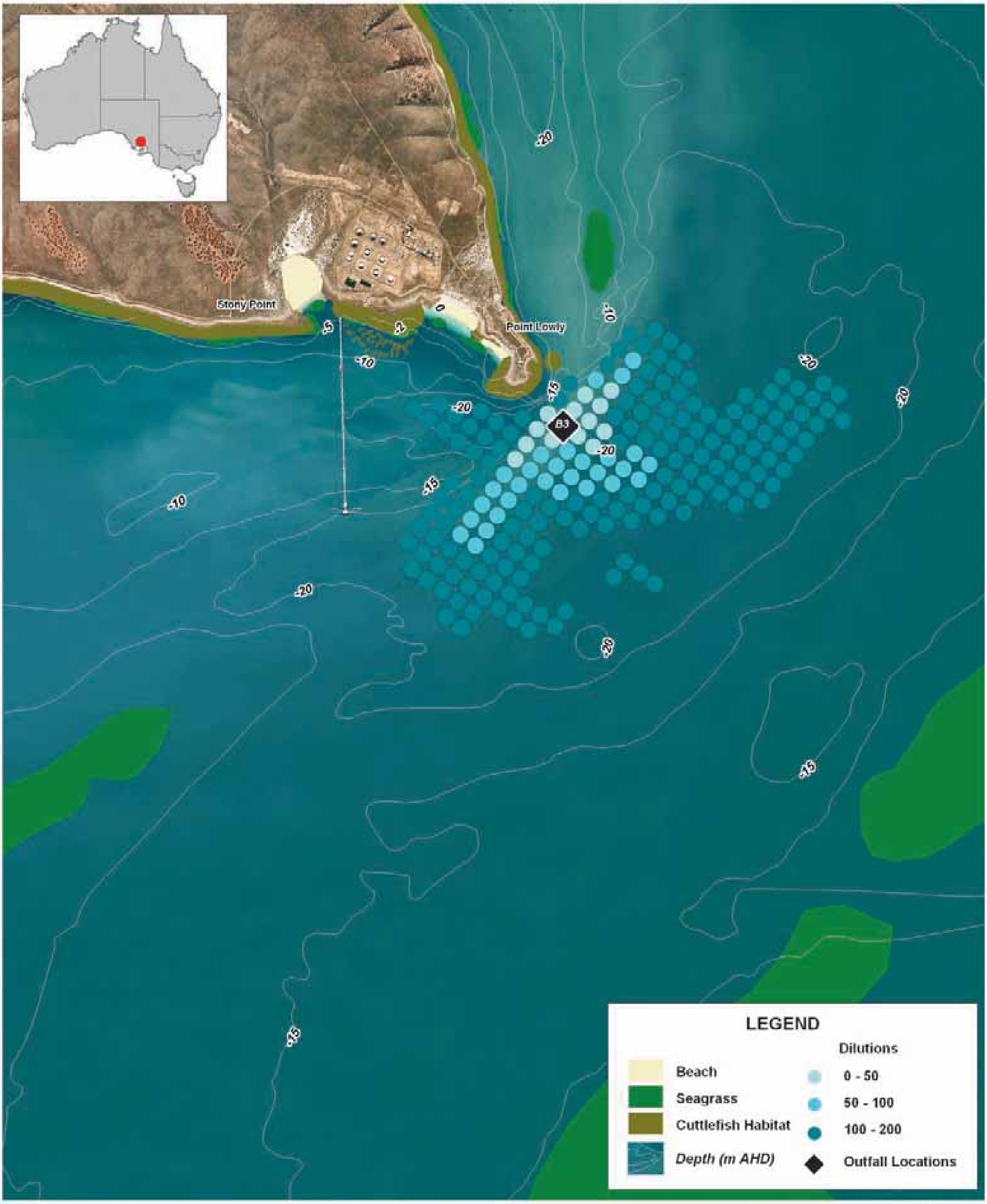
Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_088_071015_07_7_Dodge_1.WOR



Title:
Simulation 07_7: Dodge Tide 10th Percentile

Figure: 3-36

Rev: A

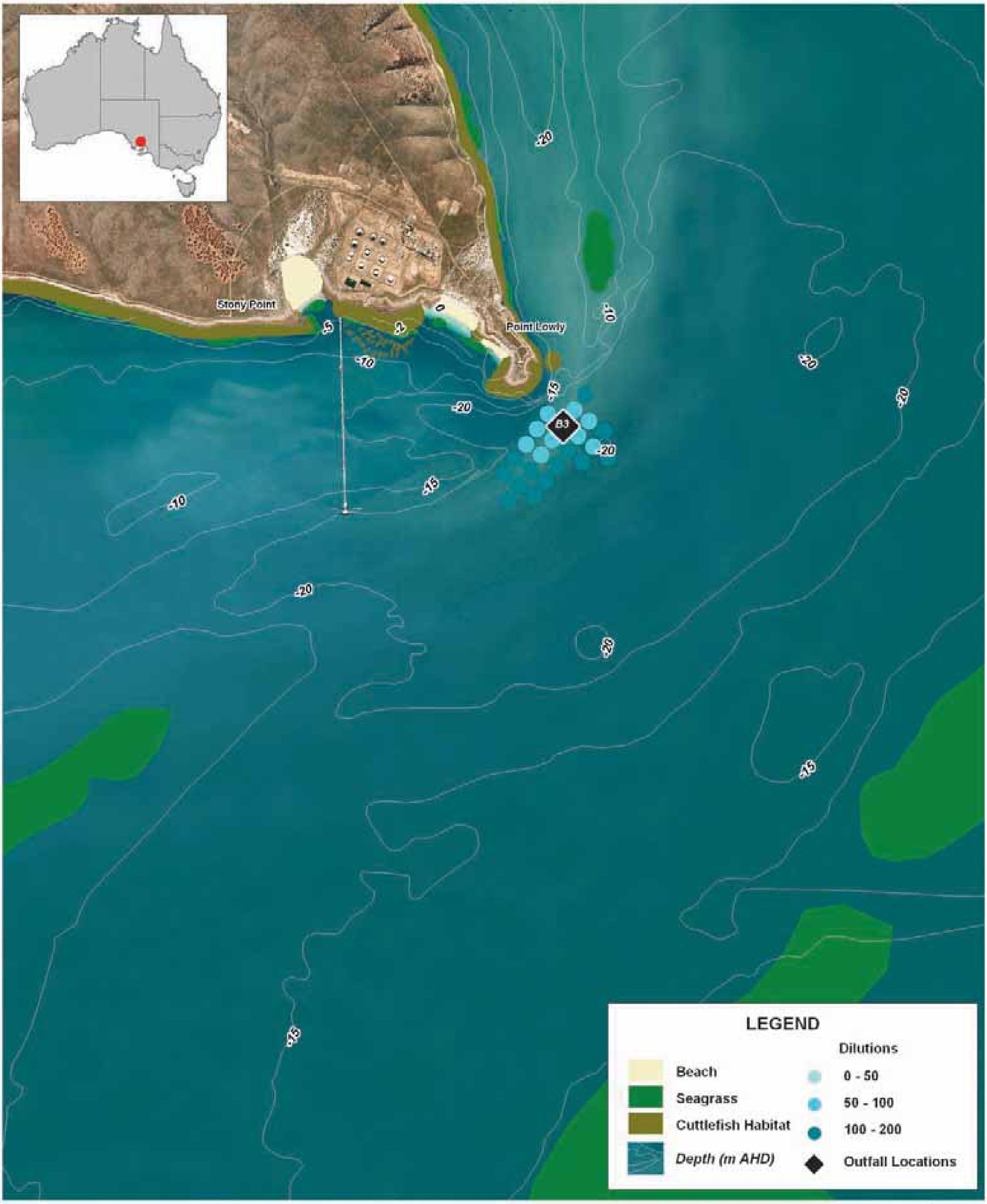
Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_089_071015_07_7_Dodge_10.WOR



Title:
Simulation 07_7: Dodge Tide 50th Percentile

Figure: 3-37

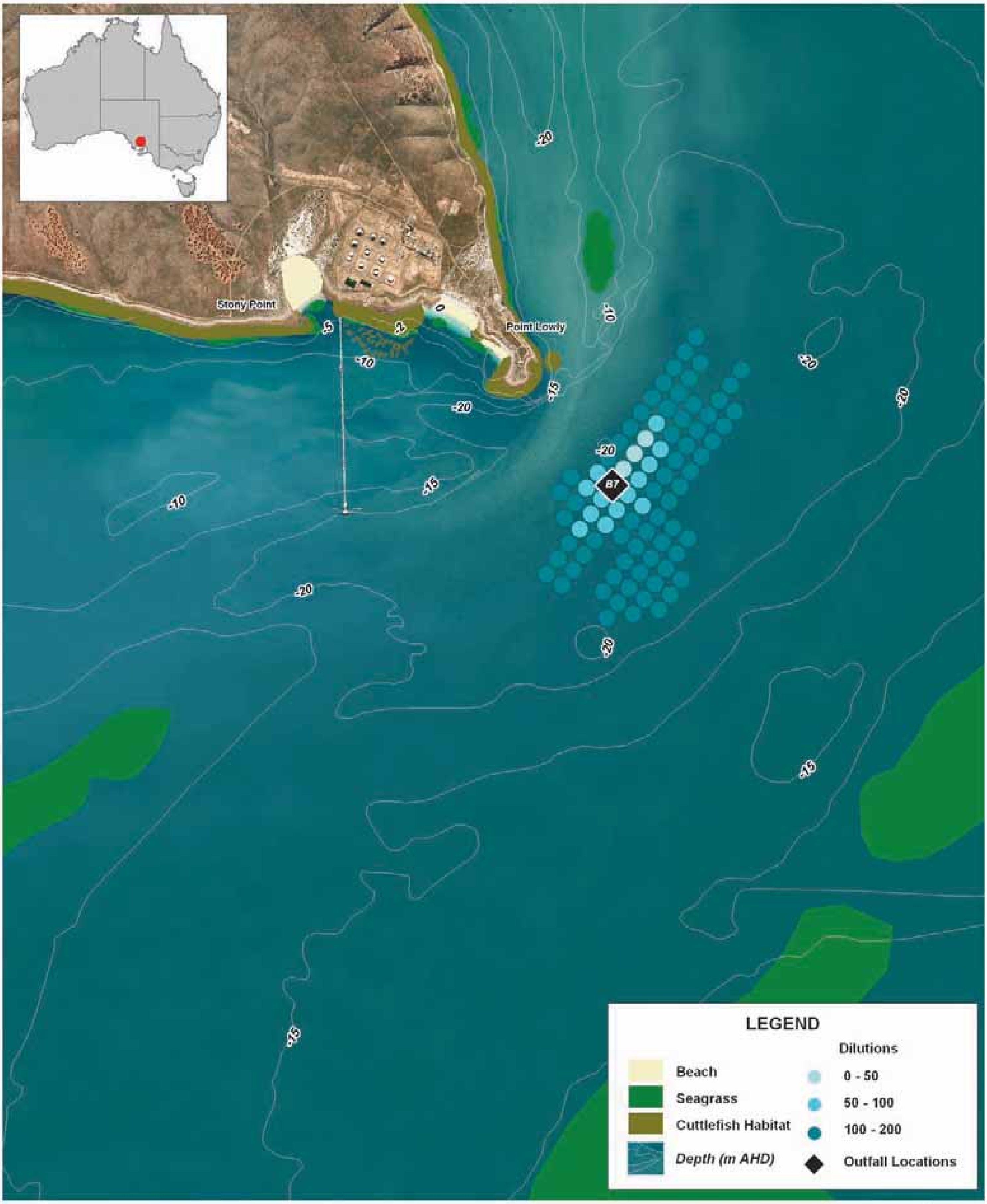
Rev: A

Air photo from Google Earth.

BMT WBM

www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_090_071015_07_7_Dodge_50.WOR



Title:

Simulation 07_8: Spring Tide 0th Percentile

Figure: 3-38

Rev: A

Air photo from Google Earth.

N

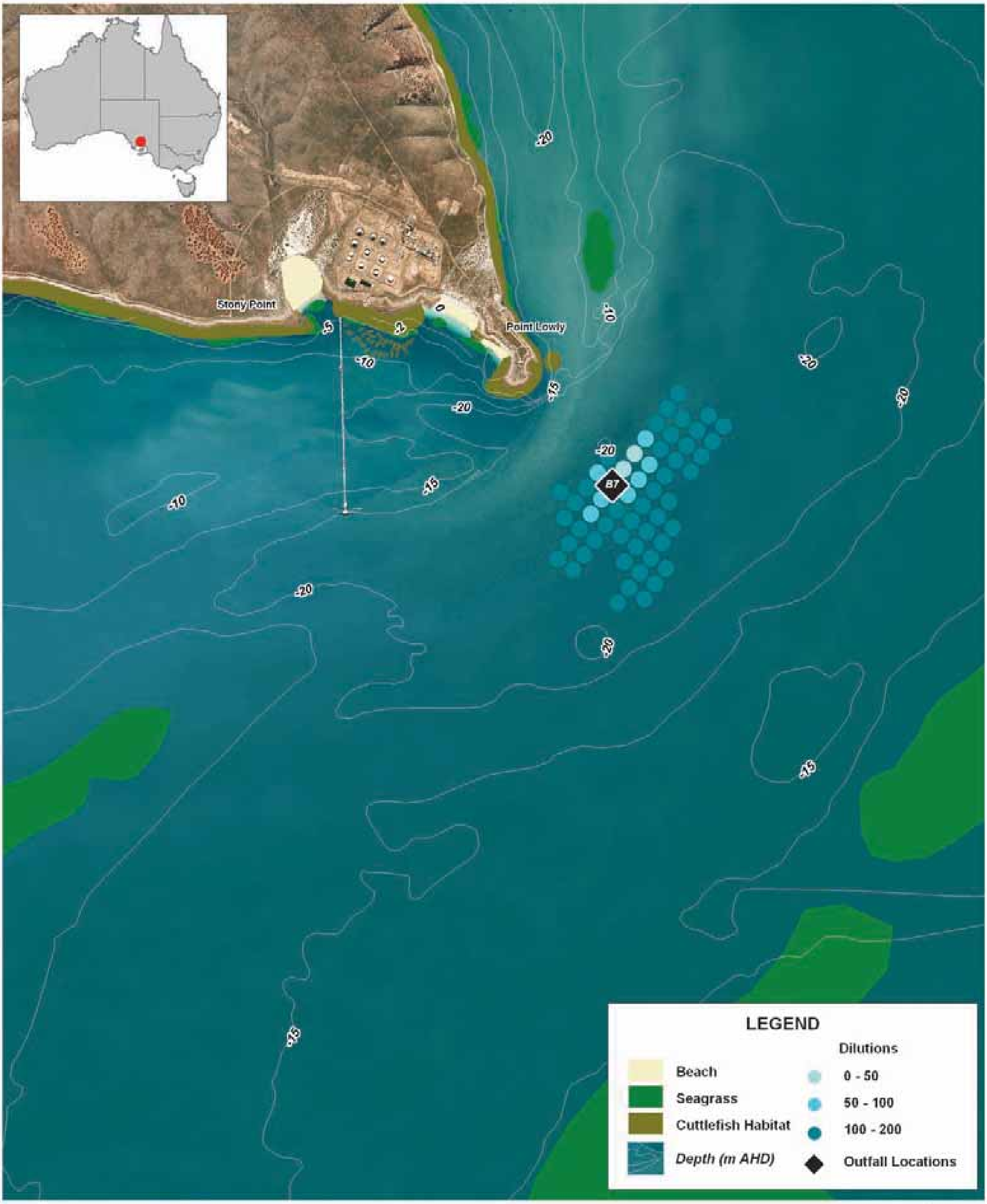
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_091_071015_07_8_Spring_0.WOR



Title:
Simulation 07_8: Spring Tide 1st Percentile

Figure: 3-39

Rev: A

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Air photo from Google Earth.

N

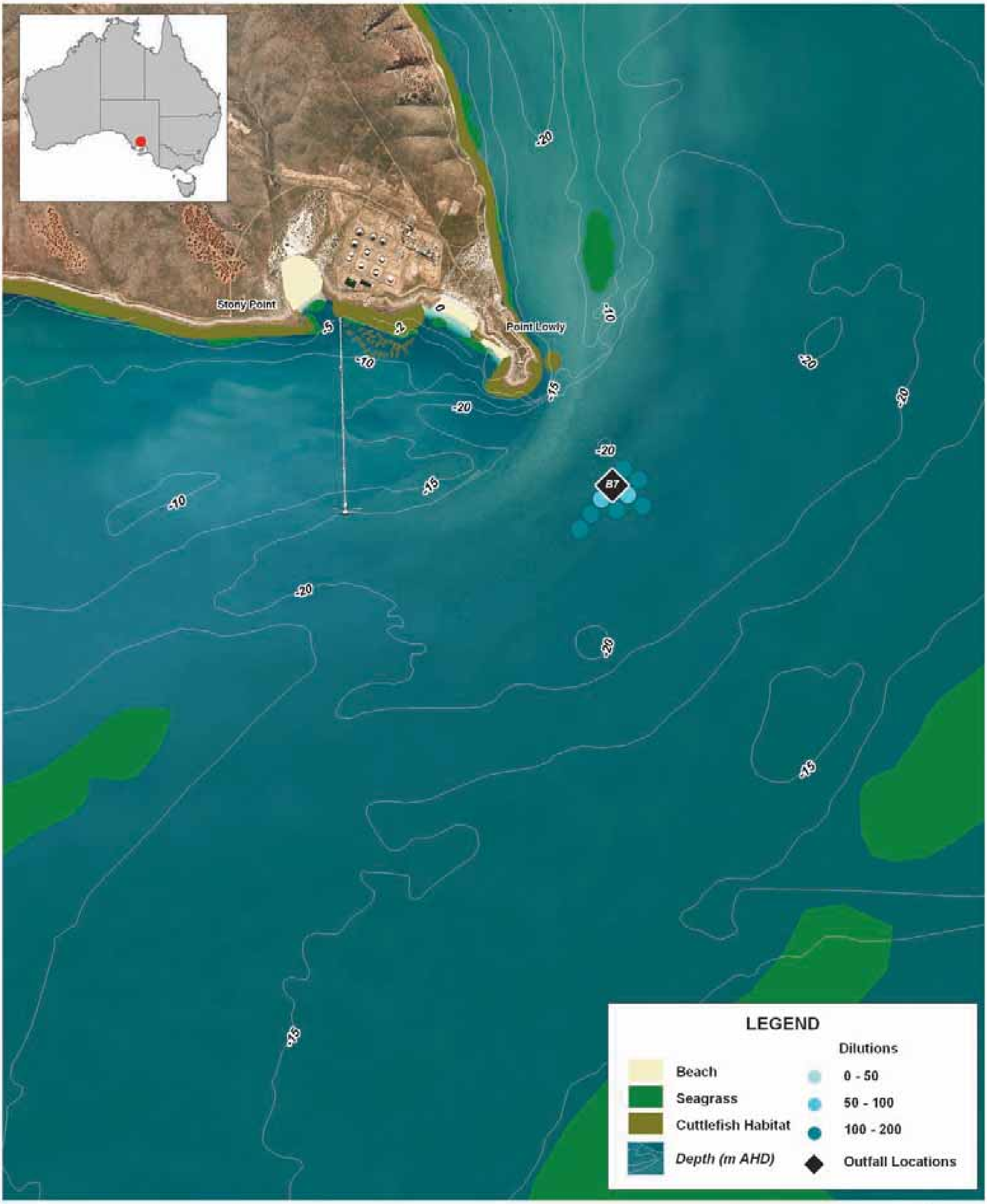
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_092_071015_07_8_Spring_1.WOR



Title:
Simulation 07_8: Spring Tide 10th Percentile

Figure: 3-40

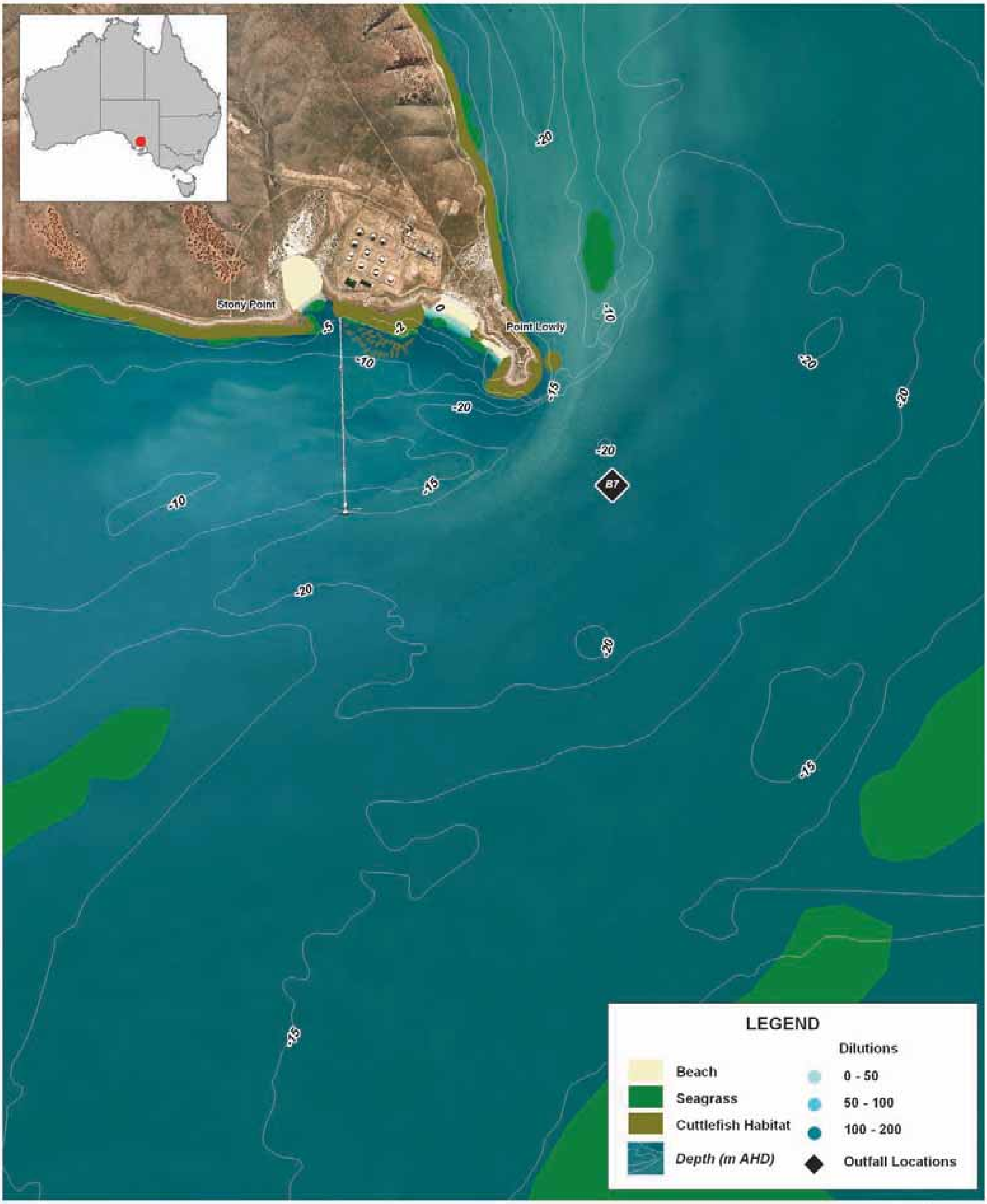
Rev: A

N

0 1 2km
Approx. Scale

BMT WBM
www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_093_071015_07_8_Spring_10.WOR



Title:
Simulation 07_8: Spring Tide 50th Percentile

Figure:
3-41

Rev:
A

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Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
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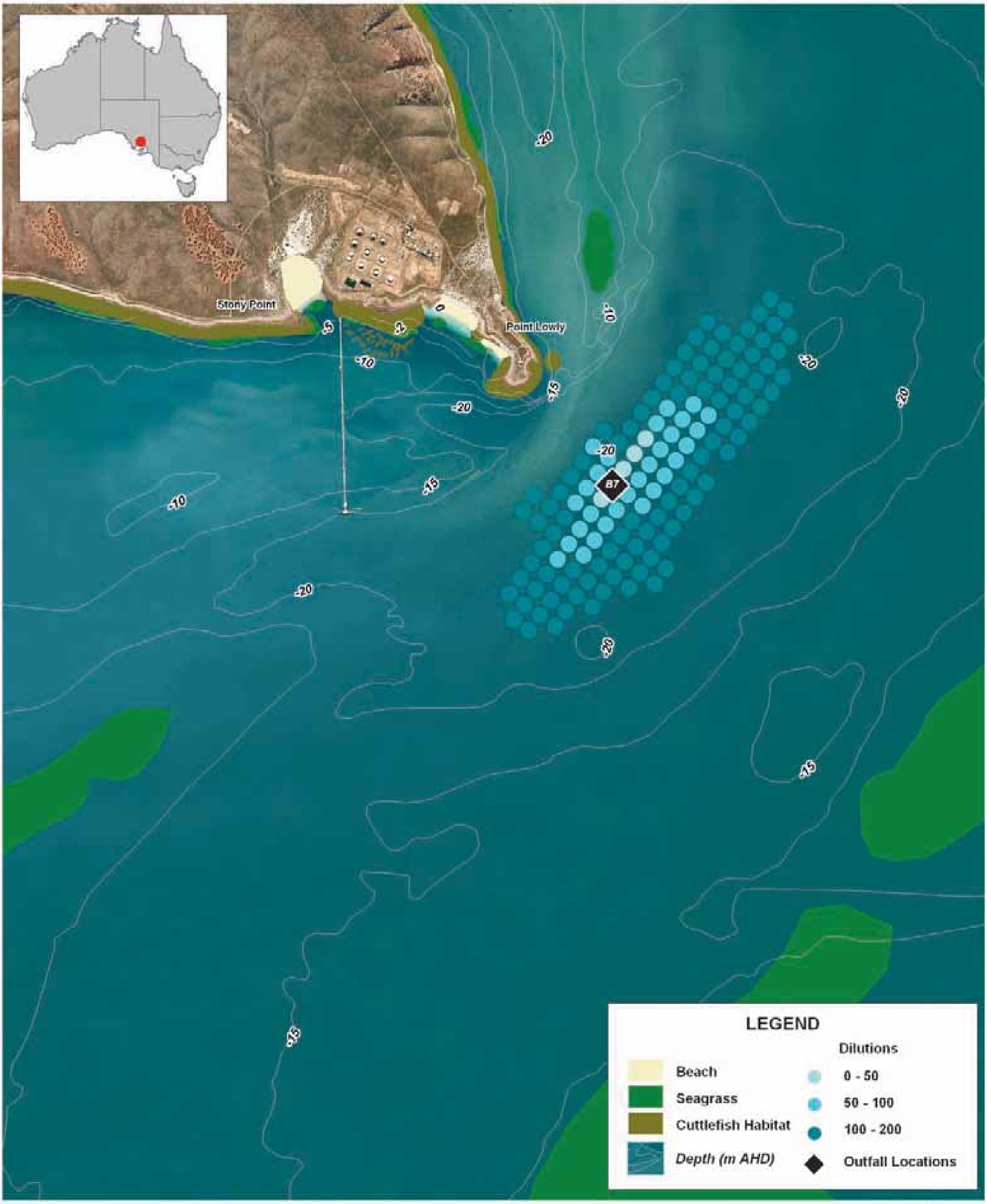
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_094_071015_07_8_Spring_50.WOR



Title:
Simulation 07_8: Typical Tide 0th Percentile

Figure: 3-42

Rev: A

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Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

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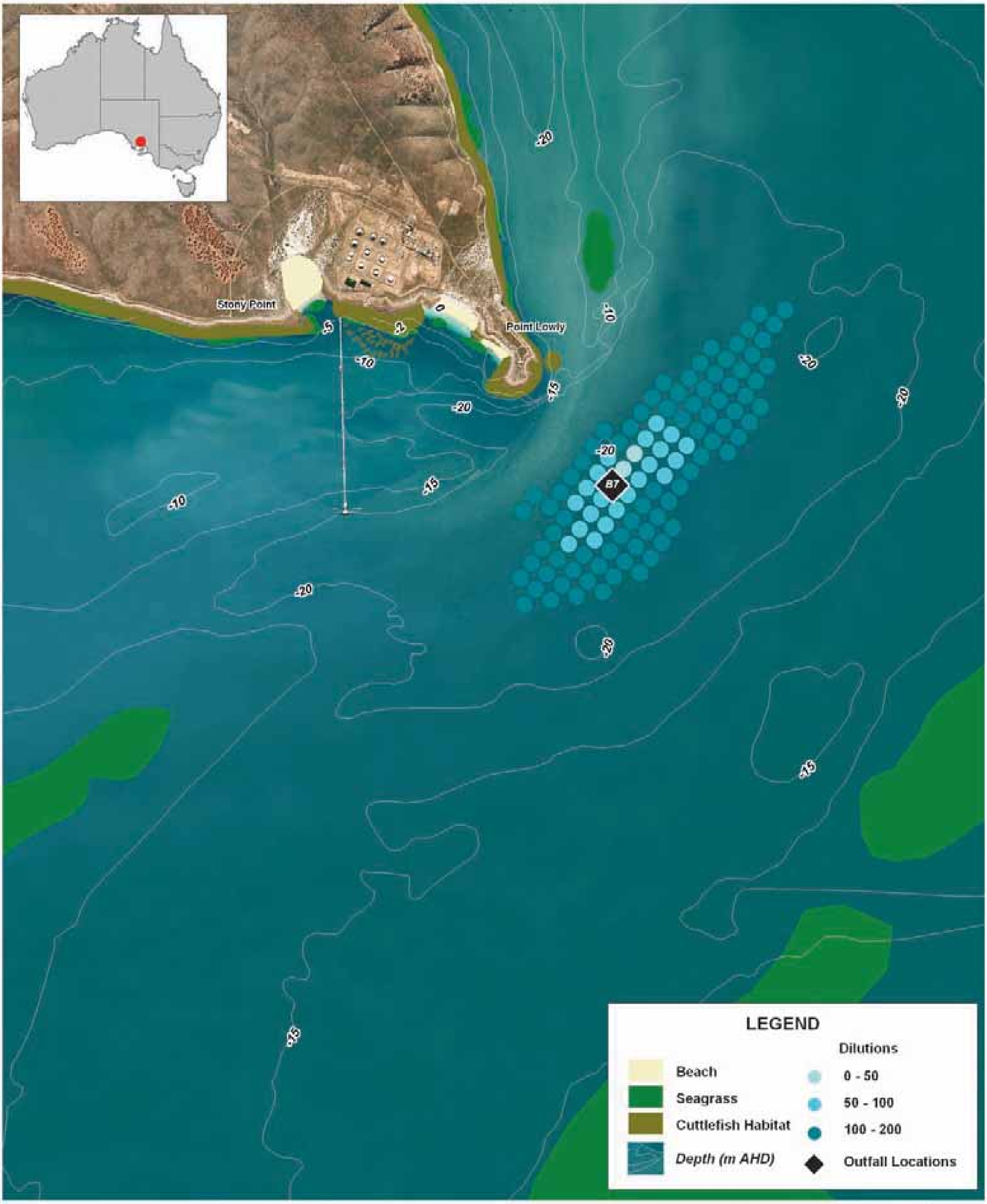
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_095_071015_07_8_Typical_0.WOR



Title:
Simulation 07_8: Typical Tide 1st Percentile

Figure: 3-43

Rev: A

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Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

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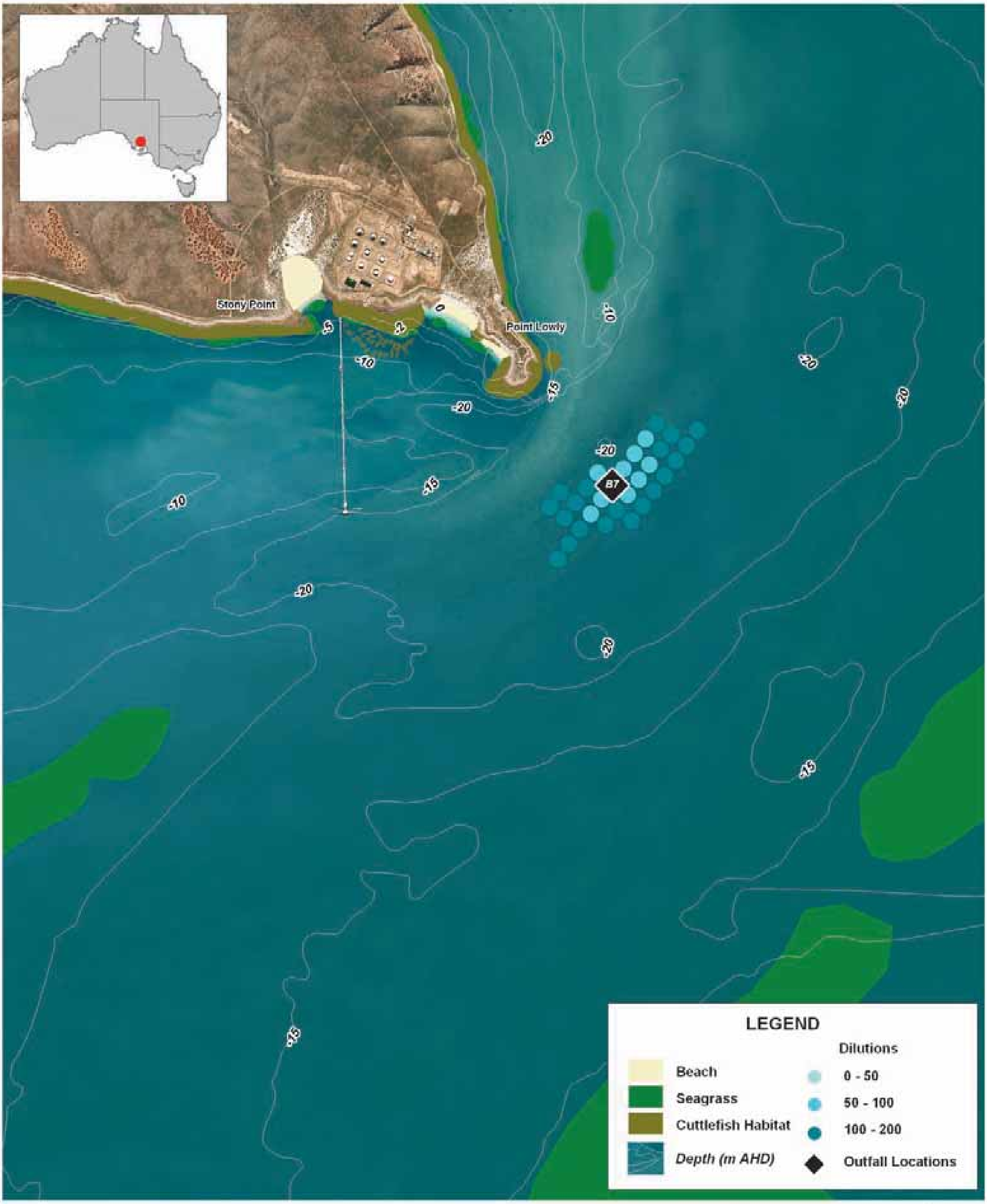
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_096_071015_07_8_Typical_1.WOR



Title:

Simulation 07_8: Typical Tide 10th Percentile

Figure: 3-44

Rev: A

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Air photo from Google Earth.

N

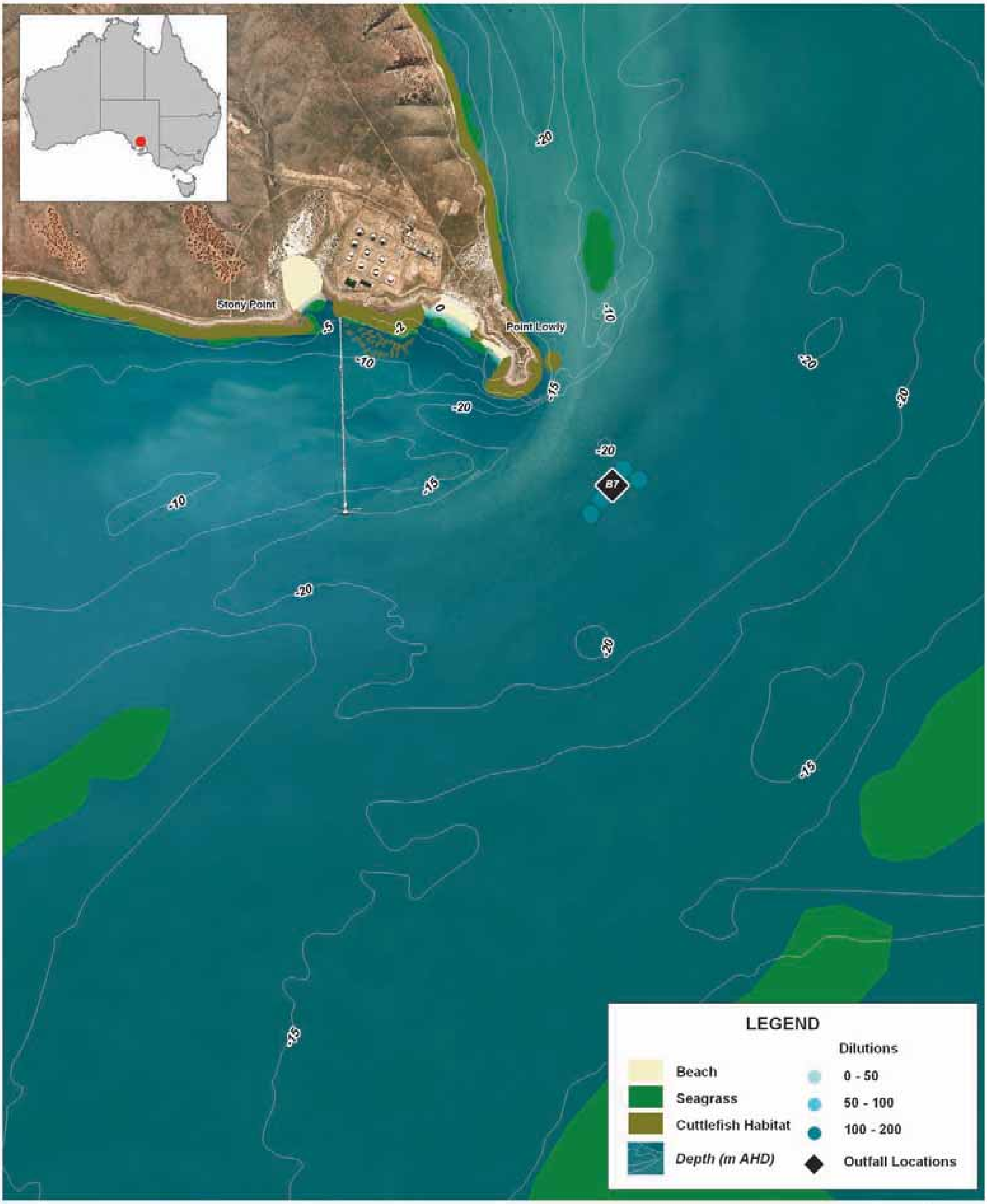
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_097_071015_07_8_Typical_10.WOR



Title:
Simulation 07_8: Typical Tide 50th Percentile

Figure: 3-45

Rev: A

Air photo from Google Earth.

N

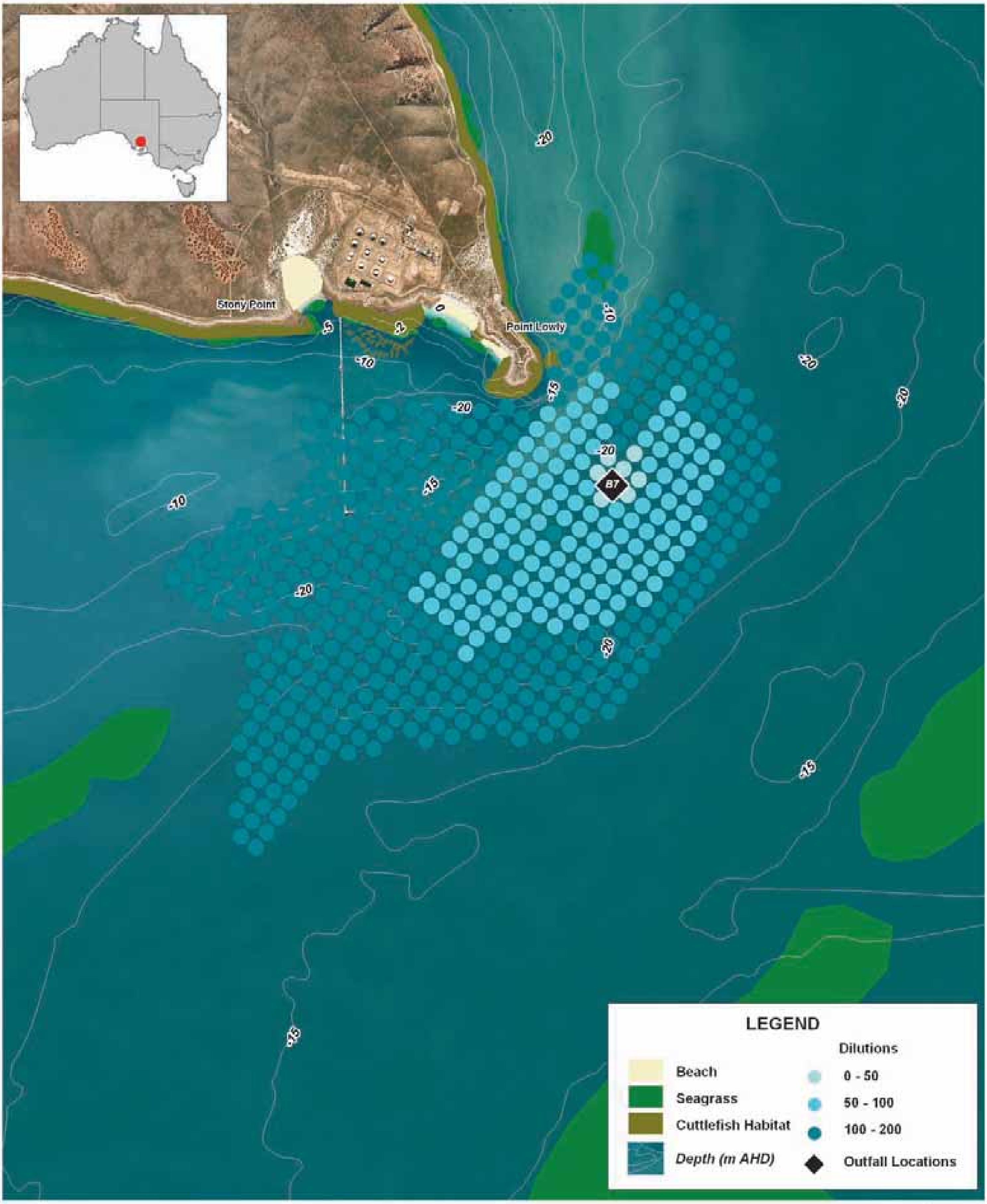
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_098_071015_07_8_Typical_50.WOR



Title:
Simulation 07_8: Dodge Tide 0th Percentile

Figure: 3-46

Rev: A

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Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
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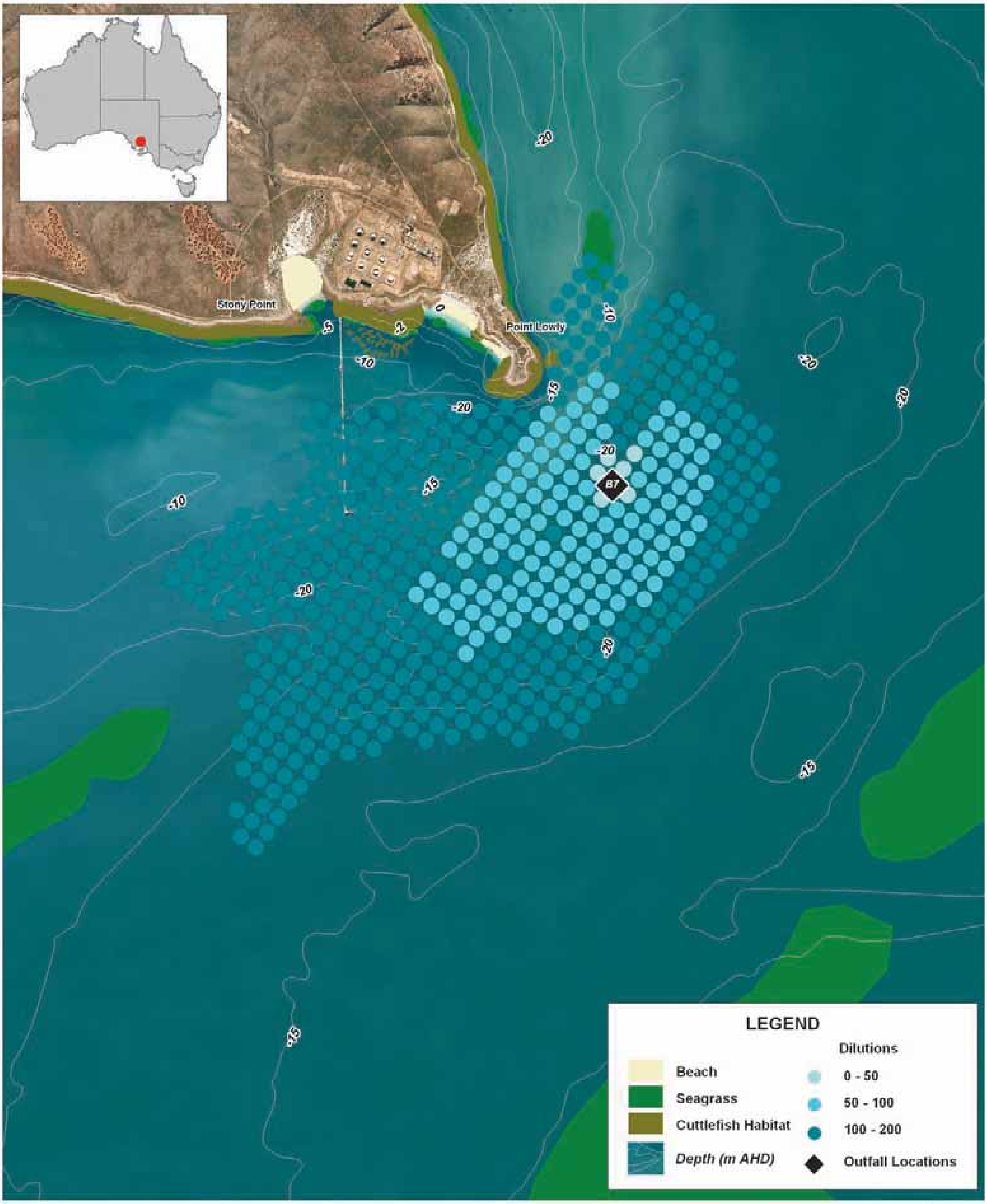
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_099_071015_07_8_Dodge_0.WOR



Title:
Simulation 07_8: Dodge Tide 1st Percentile

Figure: 3-47

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. It does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

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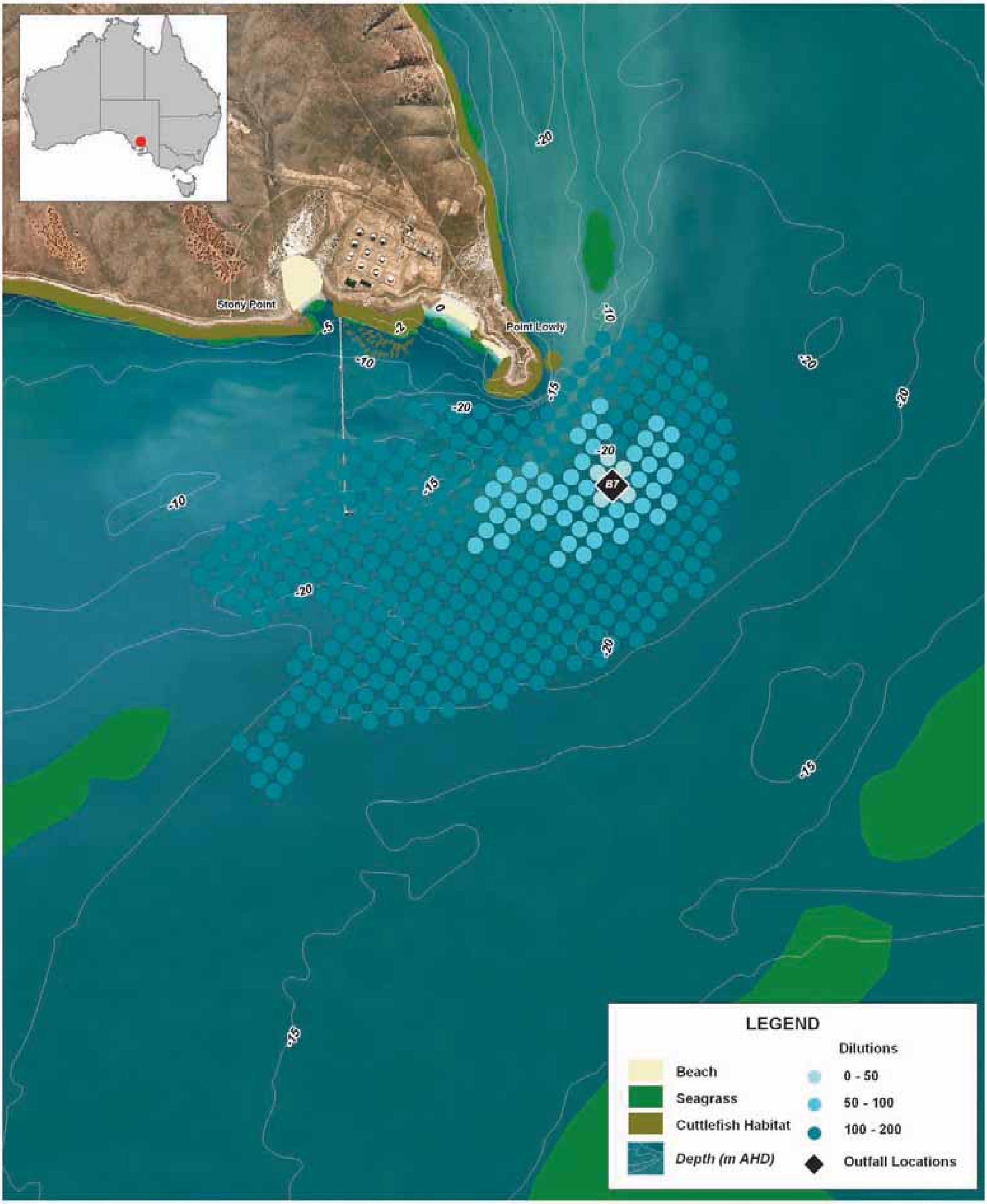
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_100_071015_07_8_Dodge_1.WOR



Title:

Simulation 07_8: Dodge Tide 10th Percentile

Figure: 3-48

Rev: A

Air photo from Google Earth.

N

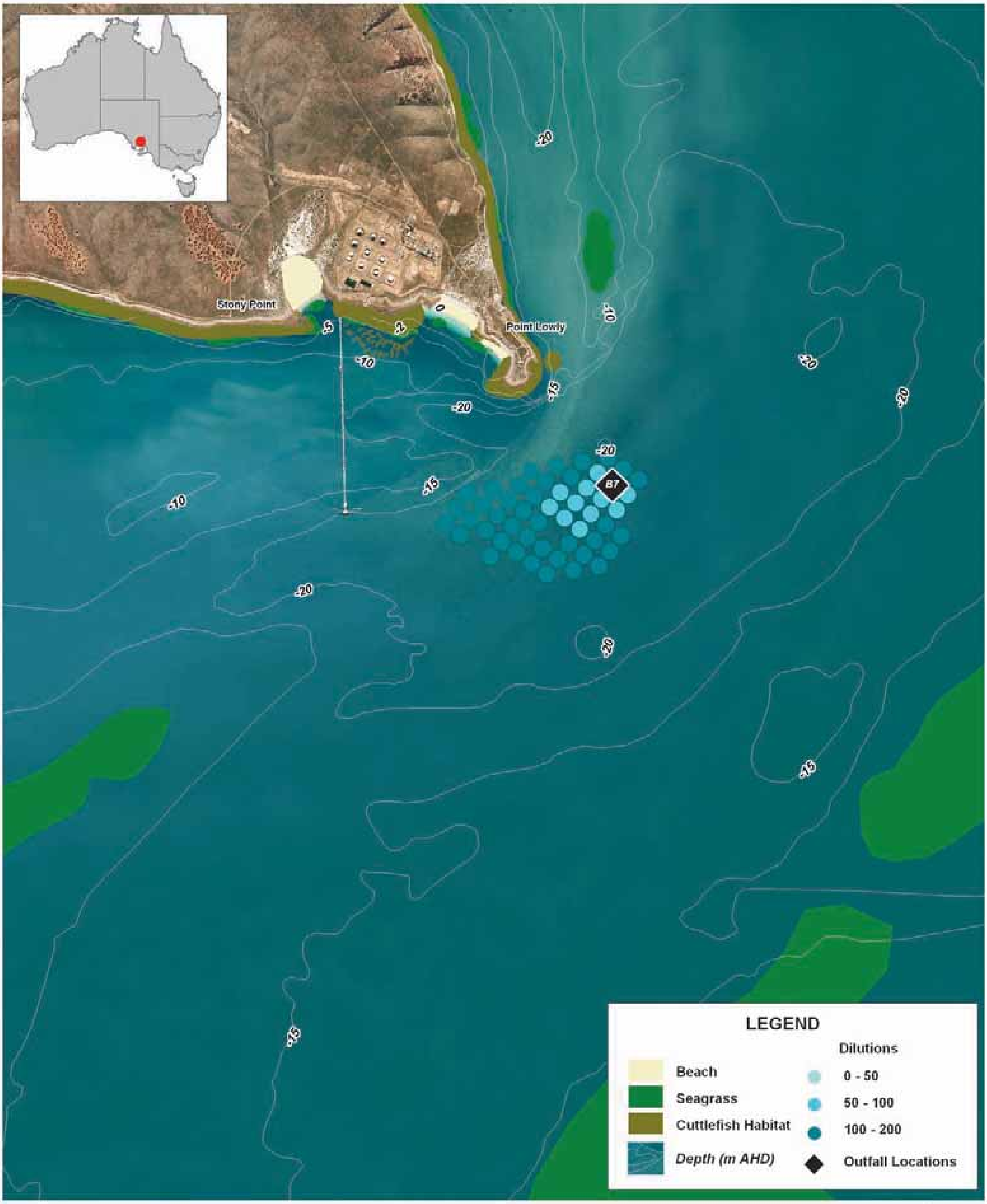
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_101_071015_07_8_Dodge_10.WOR



Title:
Simulation 07_8: Dodge Tide 50th Percentile

Figure: 3-49

Rev: A

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Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
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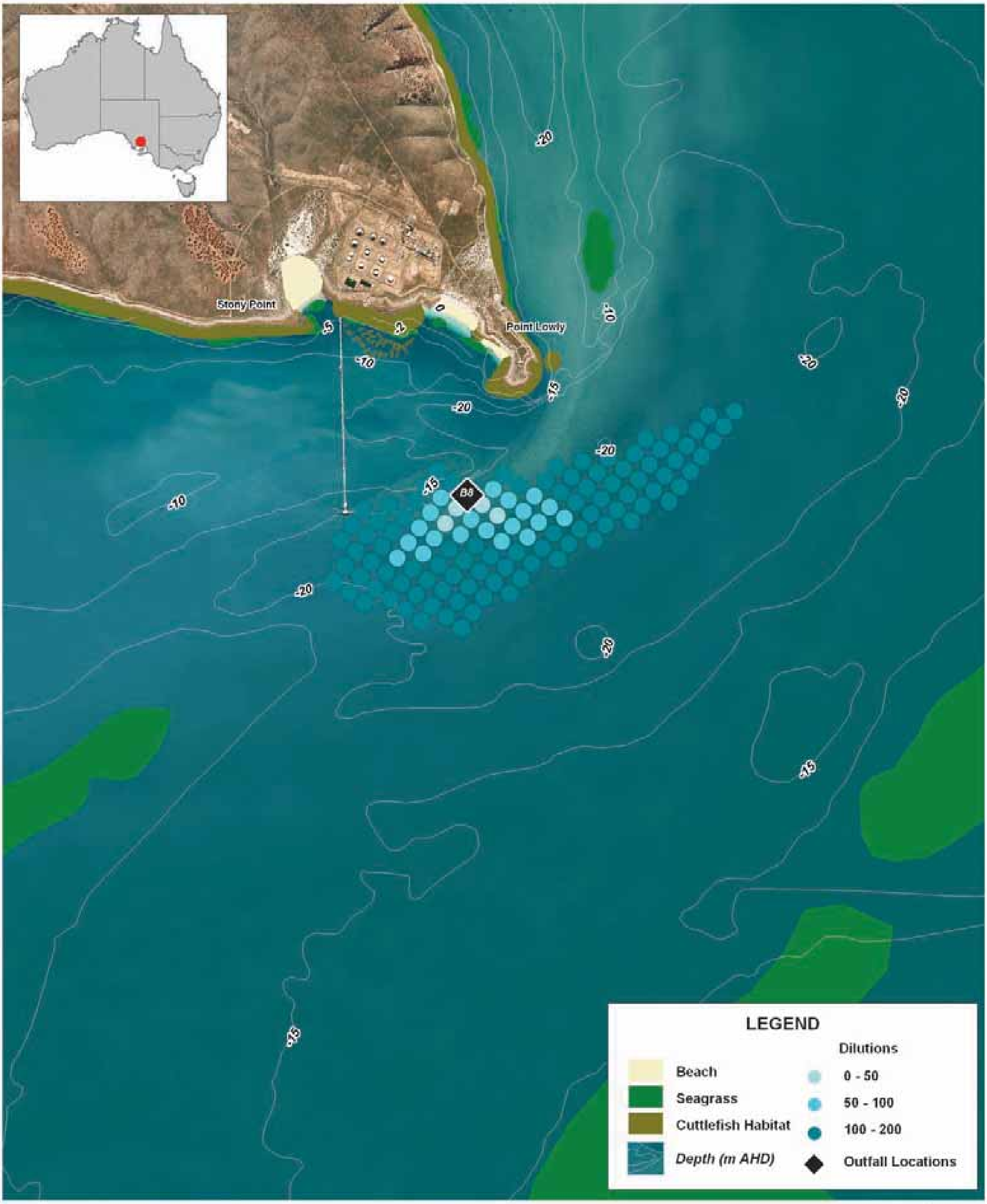
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_102_071015_07_8_Dodge_50.WOR



Title:
Simulation 07_9: Spring Tide 0th Percentile

Figure: 3-50

Rev: A

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Air photo from Google Earth.

N

0 1 2km
Approx. Scale

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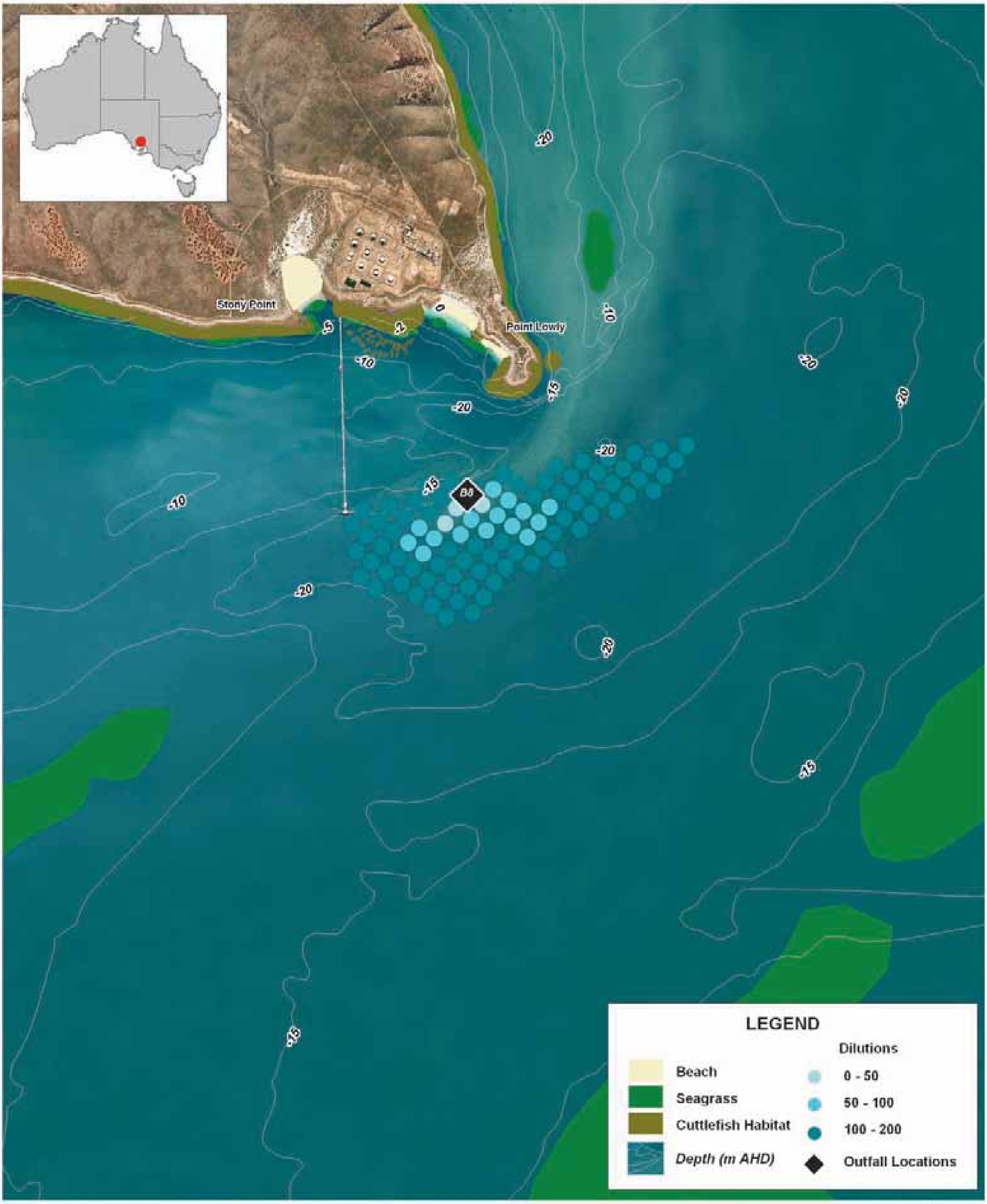


Title:
Simulation 07_9: Spring Tide 1st Percentile

Figure: 3-51

Rev: A

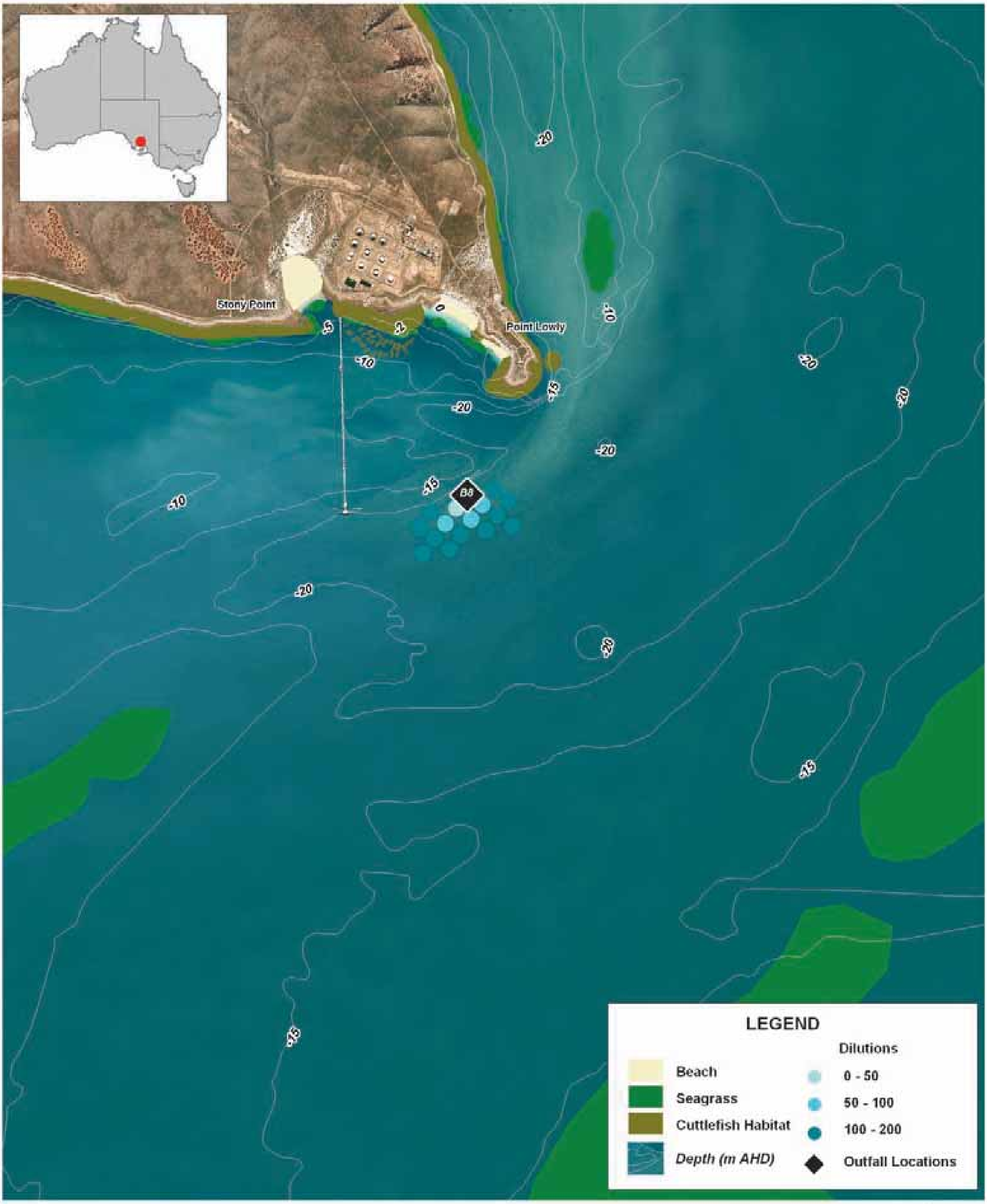
Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_104_071015_07_9_Spring_1.WOR



Title:
Simulation 07_9: Spring Tide 10th Percentile

Figure: 3-52

Rev: A

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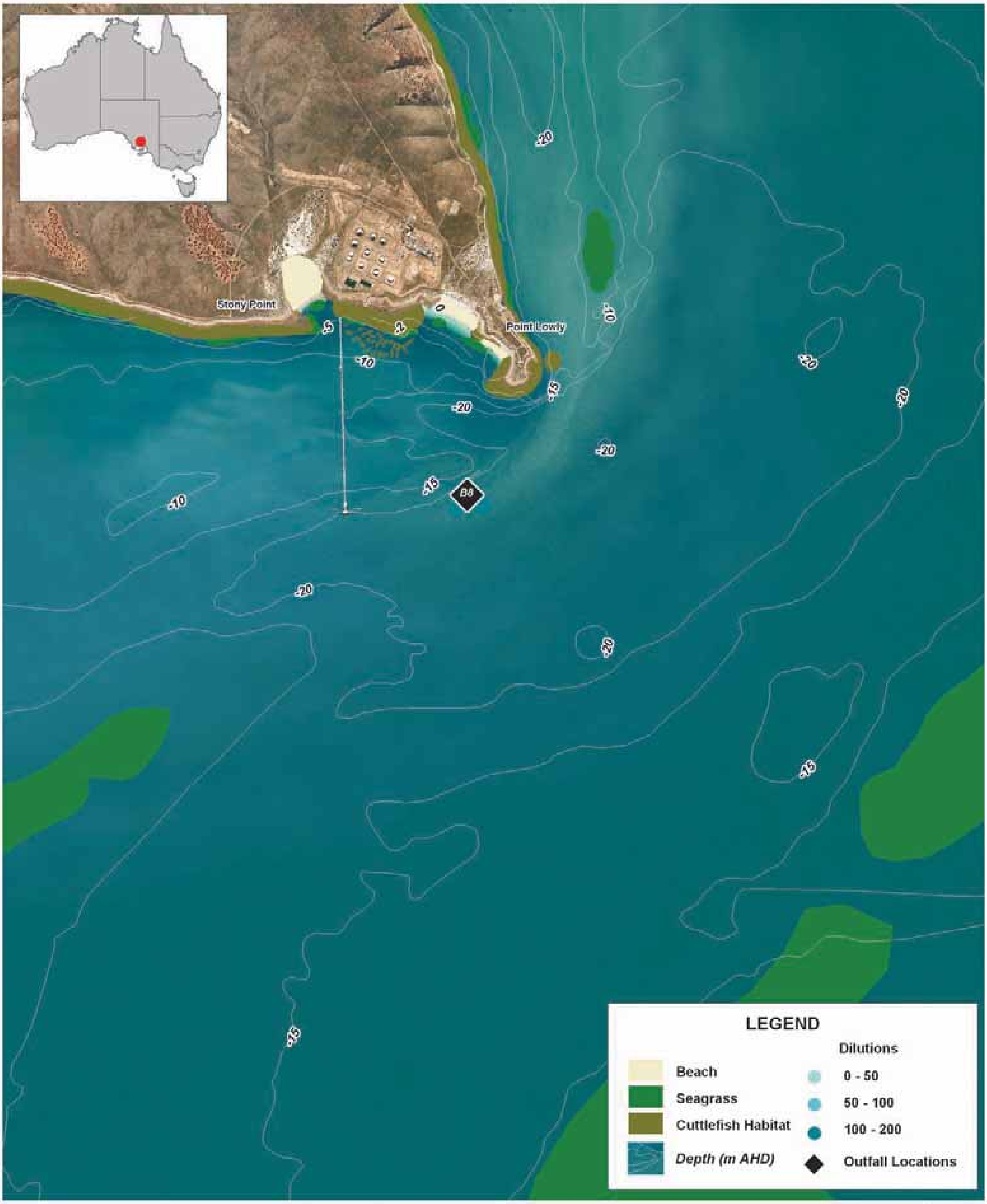
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_105_071015_07_9_Spring_10.WOR



Title:
Simulation 07_9: Spring Tide 50th Percentile

Figure:
3-53

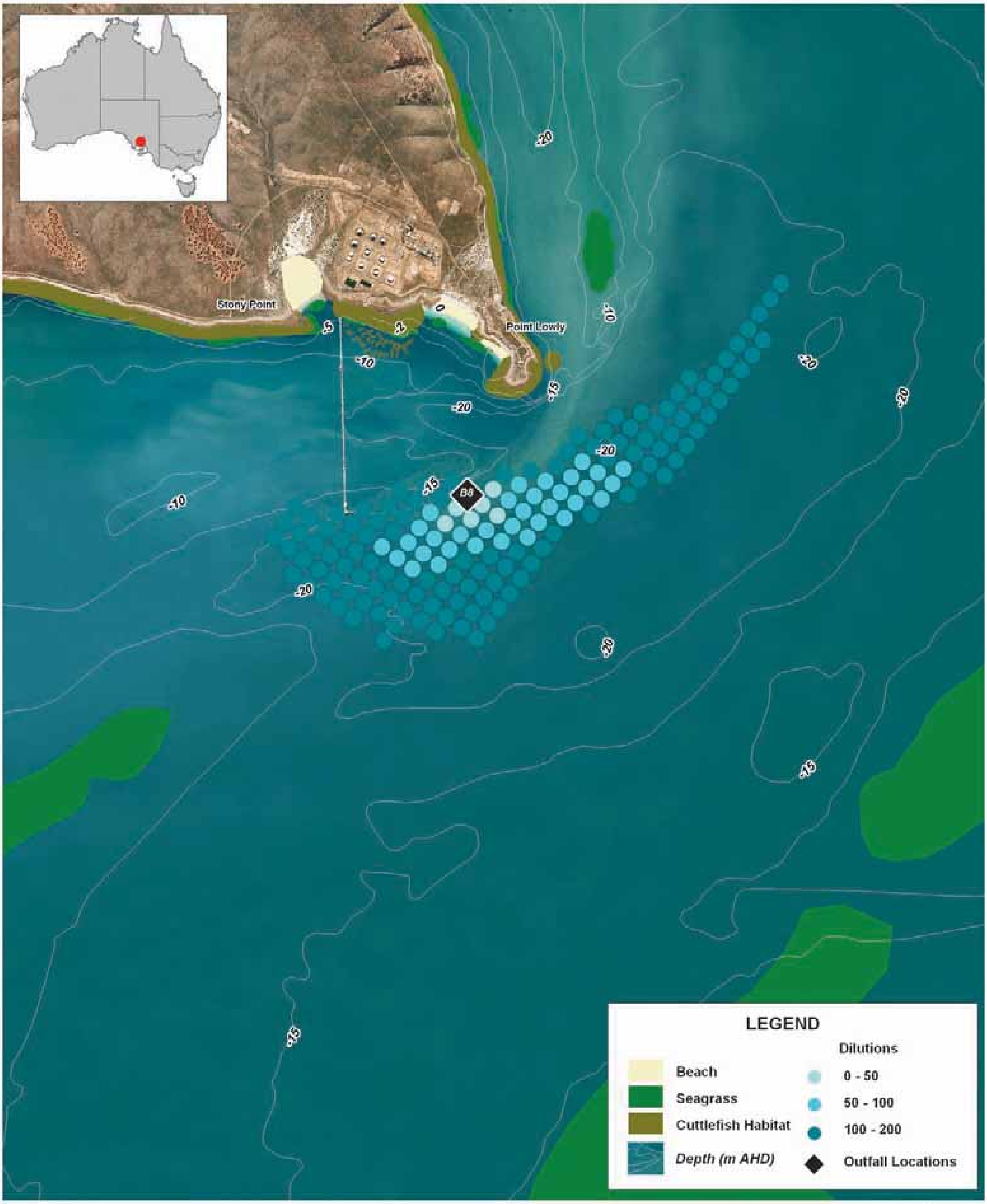
Rev:
A

Air photo from Google Earth.

0 1 2km
Approx. Scale

BMT WBM
www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_106_071015_07_9_Spring_50.WOR



Title:
Simulation 07_9: Typical Tide 0th Percentile

Figure: 3-54

Rev: A

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Air photo from Google Earth.

N

0 1 2km

Approx. Scale

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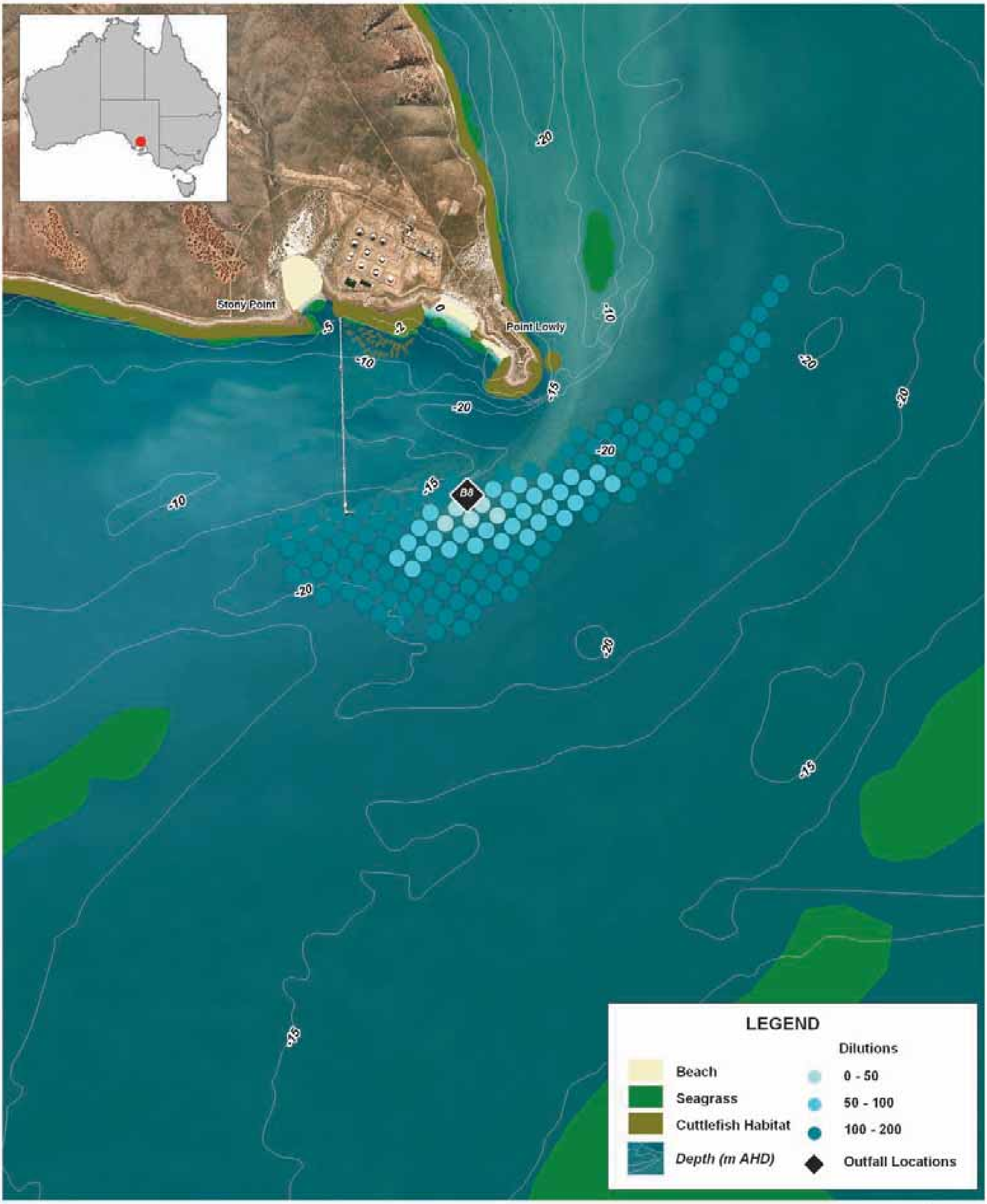
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_107_071015_07_9_Typical_0.WOR



Title:

Simulation 07_9: Typical Tide 1st Percentile

Figure:

3-55

Rev:

A

Air photo from Google Earth.

BMT WBM

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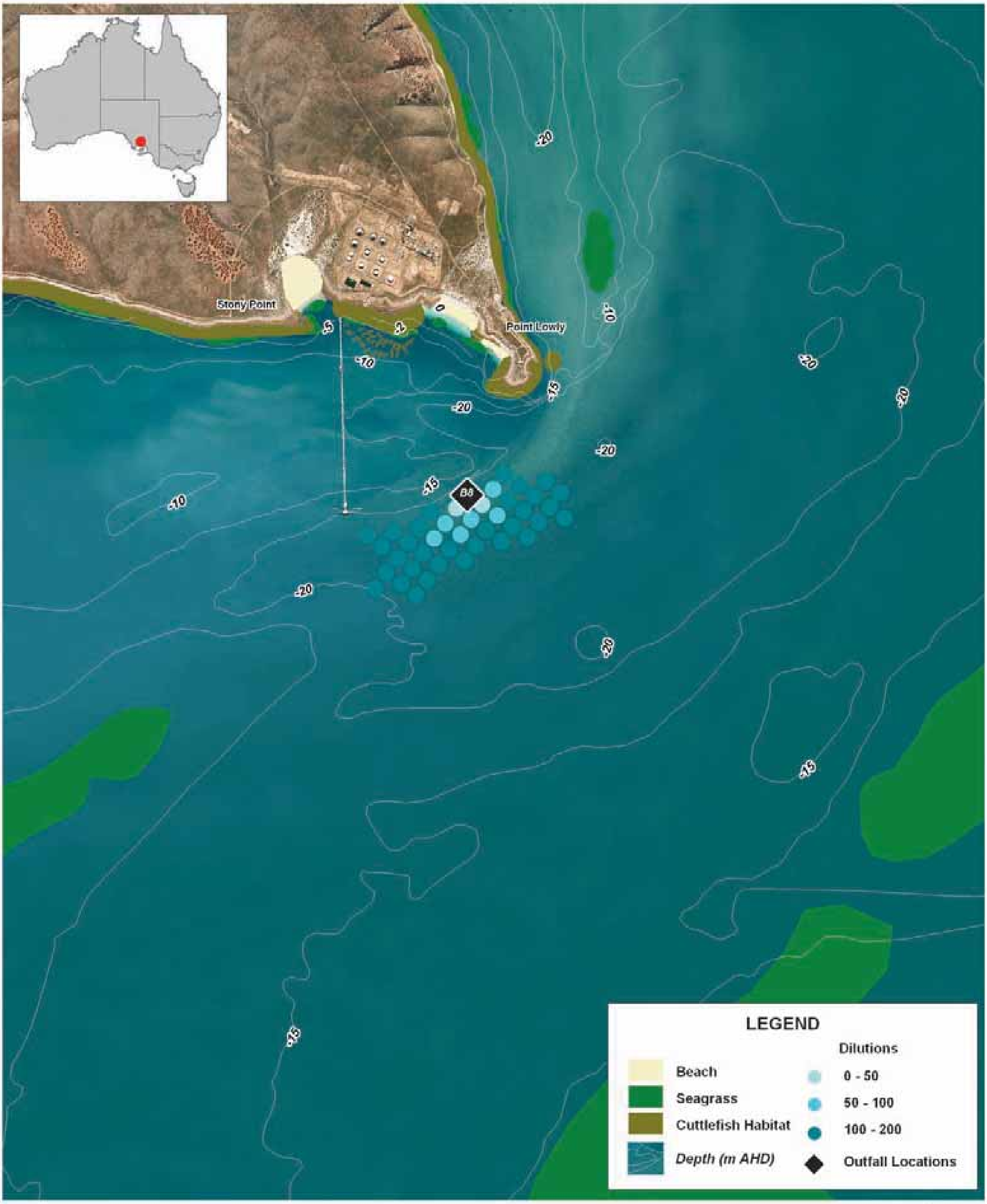
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_108_071015_07_9_Typical_1.WOR



Title:
Simulation 07_9: Typical Tide 10th Percentile

Figure: 3-56

Rev: A

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Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
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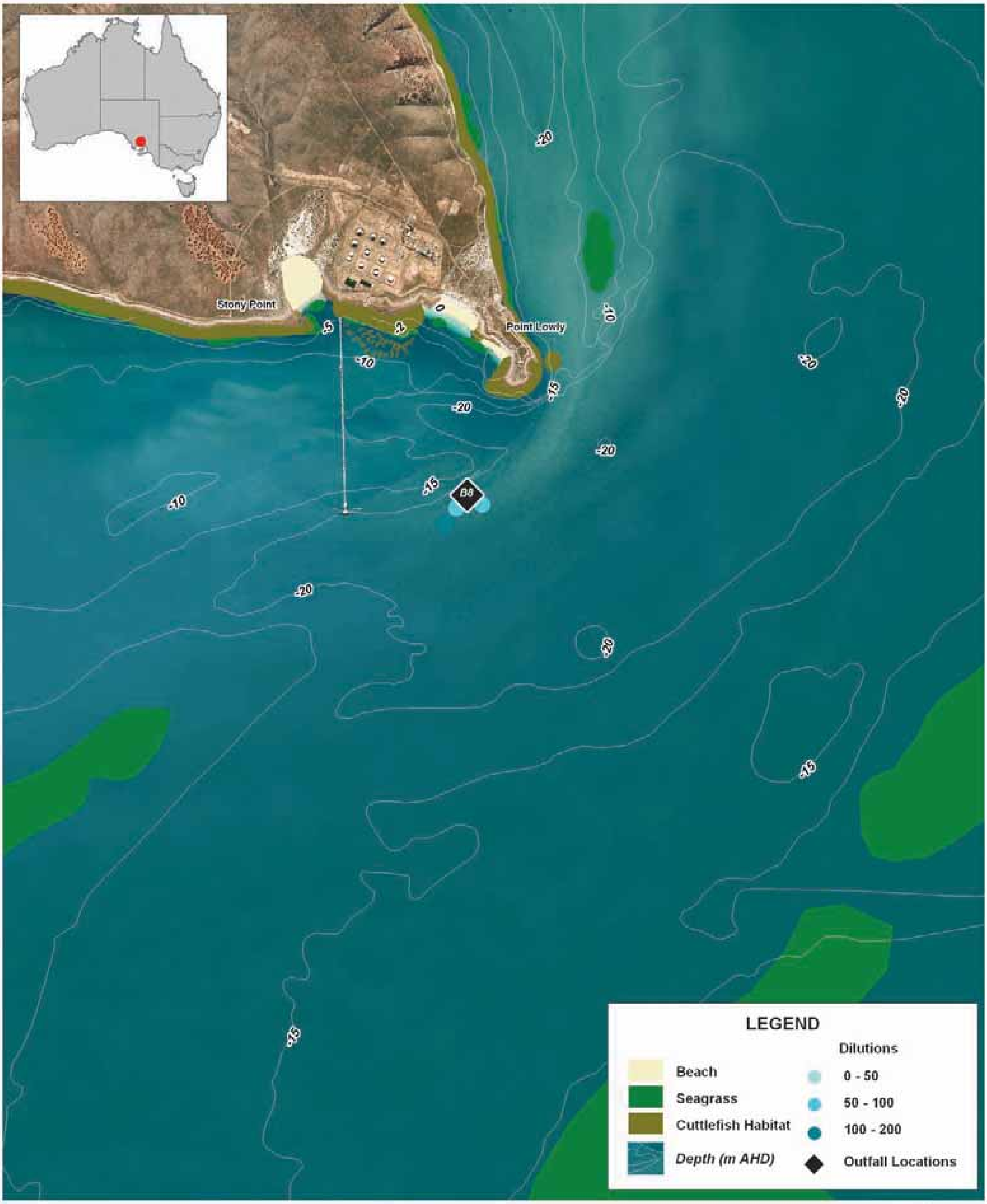
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_109_071015_07_9_Typical_10.WOR



Title:
Simulation 07_9: Typical Tide 50th Percentile

Figure: 3-57

Rev: A

Air photo from Google Earth.

N

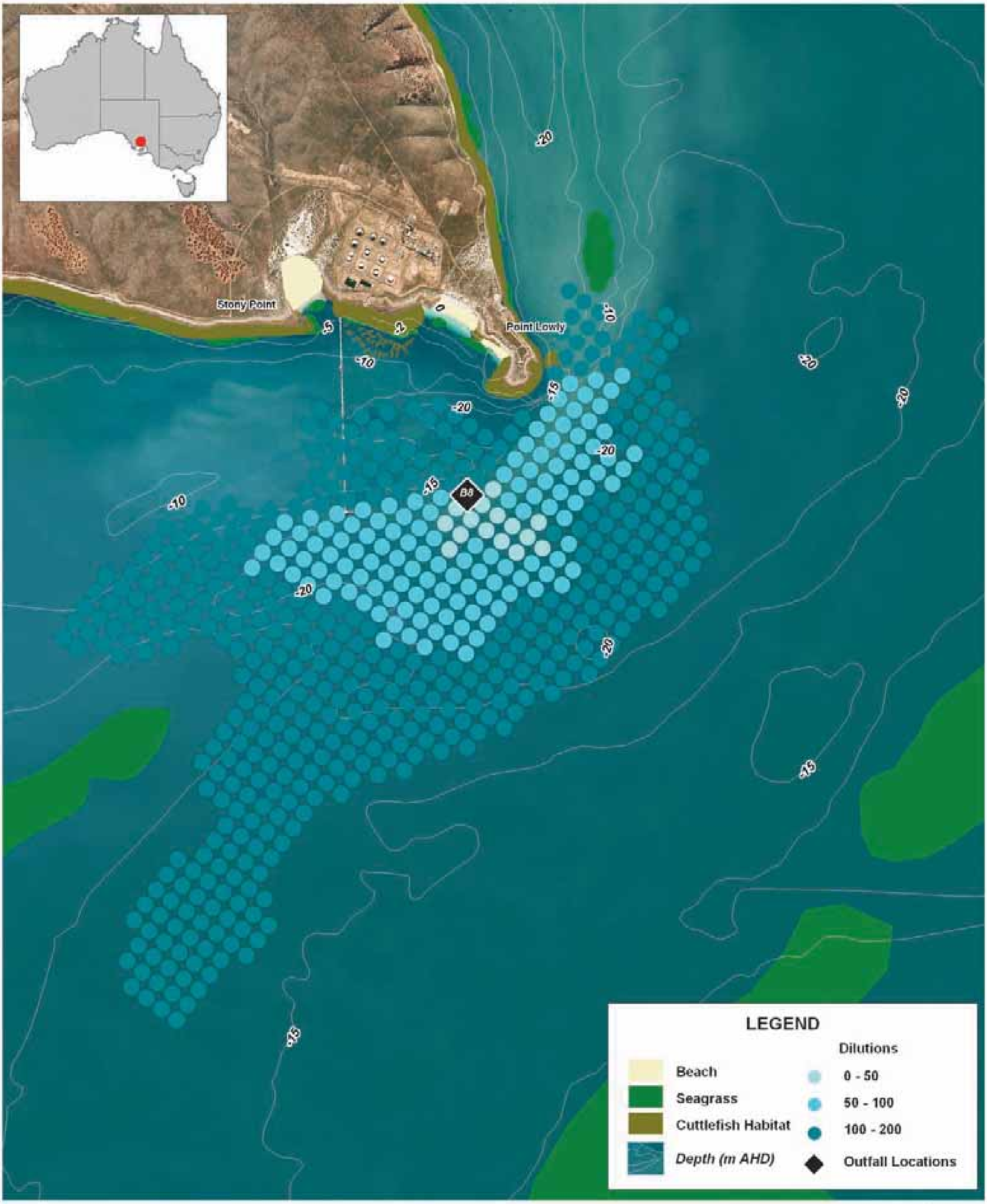
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_110_071015_07_9_Typical_50.WOR



Title:
Simulation 07_9: Dodge Tide 0th Percentile

Figure: 3-58

Rev: A

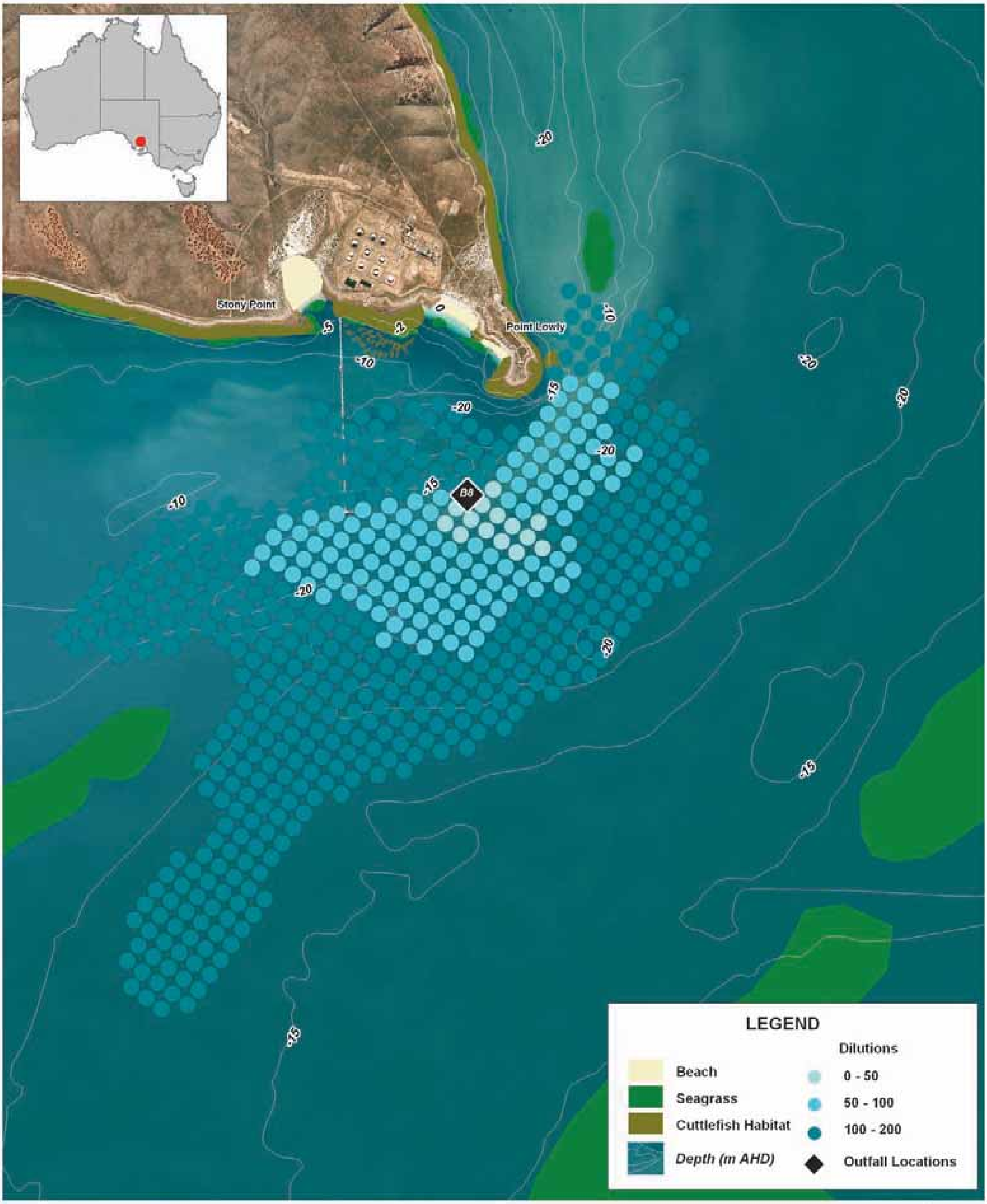
Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_111_071015_07_9_Dodge_0.WOR



Title:

Simulation 07_9: Dodge Tide 1st Percentile

Figure: 3-59

Rev: A

Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

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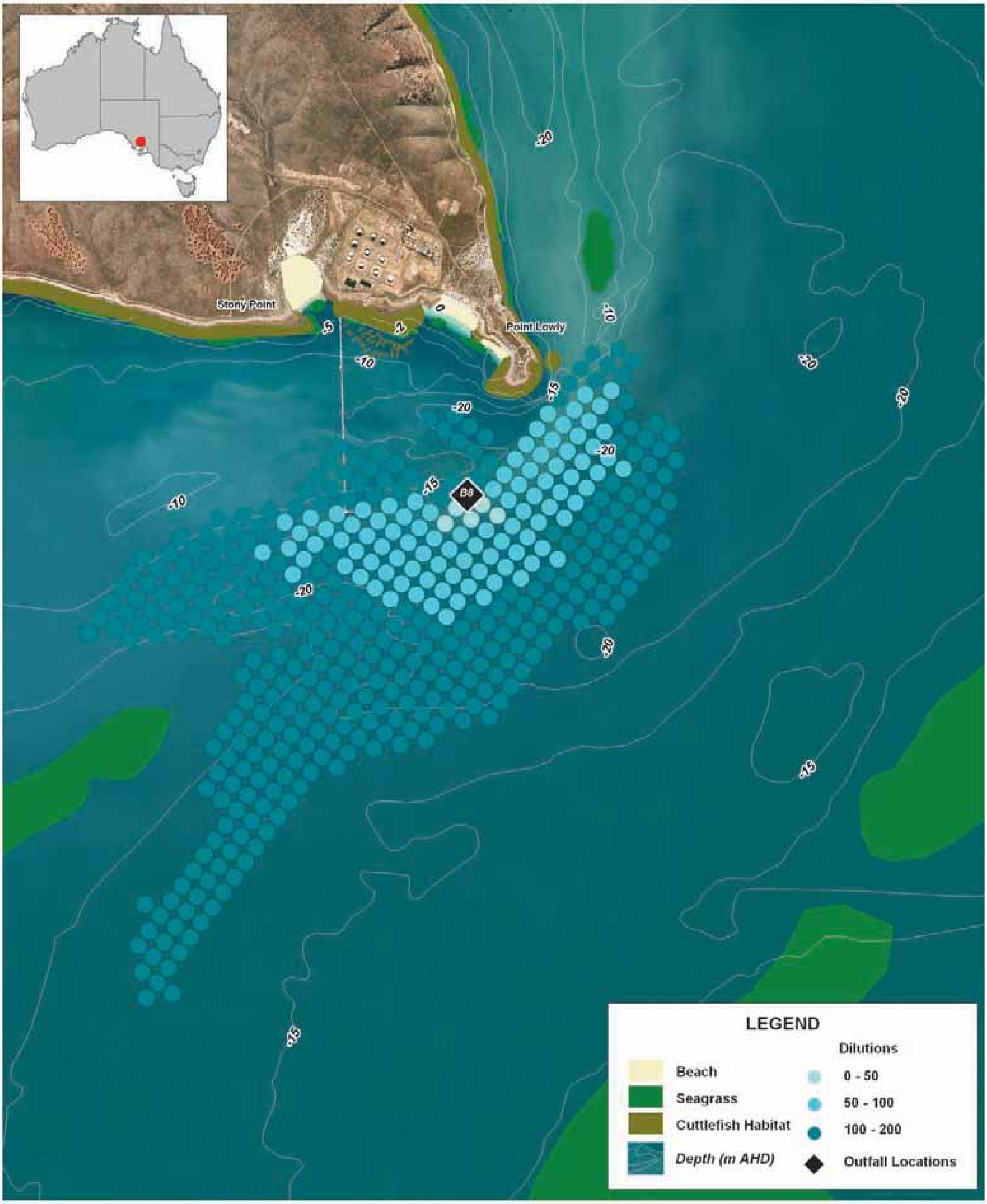
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_112_071015_07_9_Dodge_1.WOR



Title:

Simulation 07_9: Dodge Tide 10th Percentile

Figure: 3-60

Rev: A

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Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

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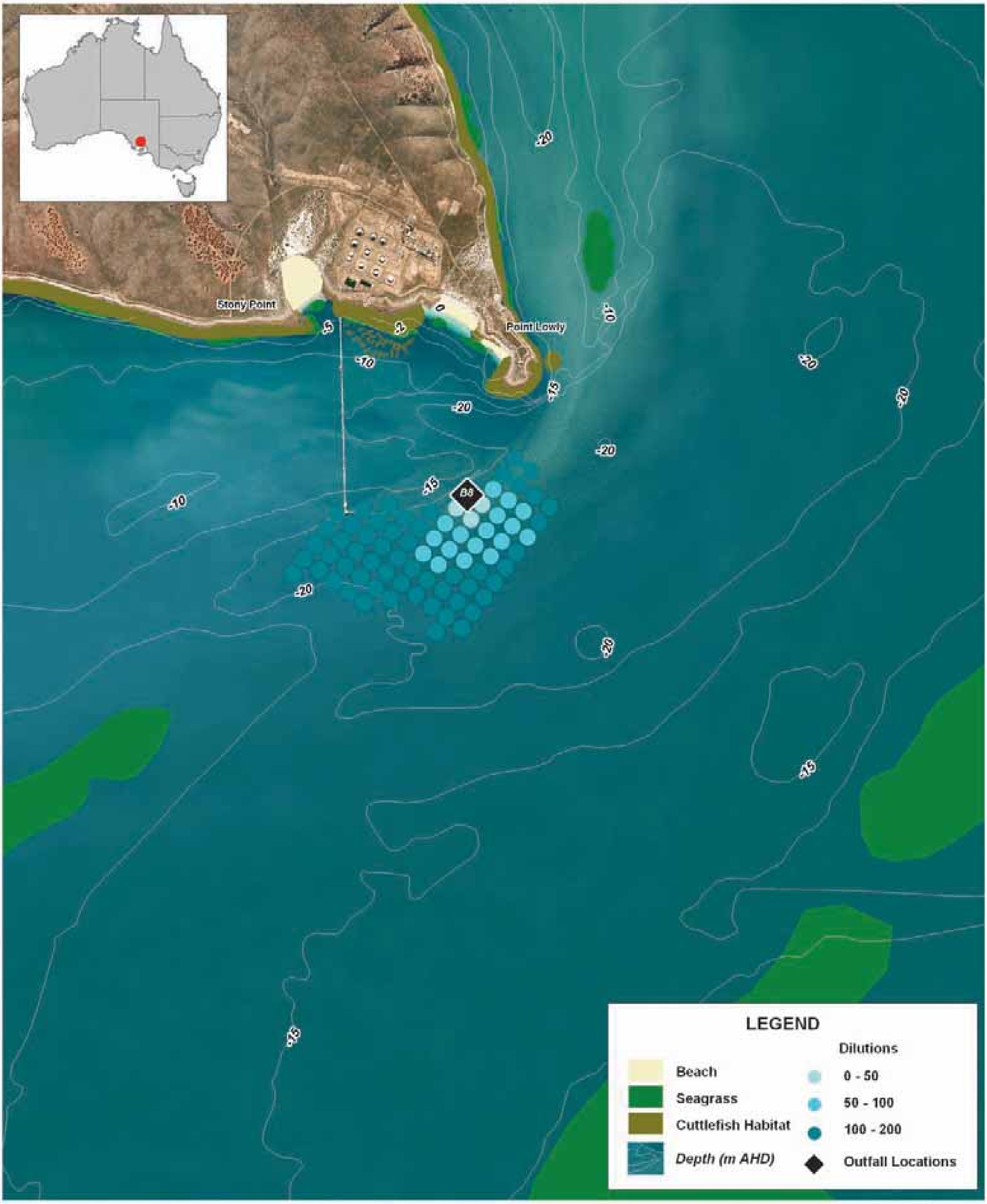
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_113_071015_07_9_Dodge_10.WOR



Title:
Simulation 07_9: Dodge Tide 50th Percentile

Figure: 3-61

Rev: A

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Air photo from Google Earth.

N

0 1 2km
Approx. Scale

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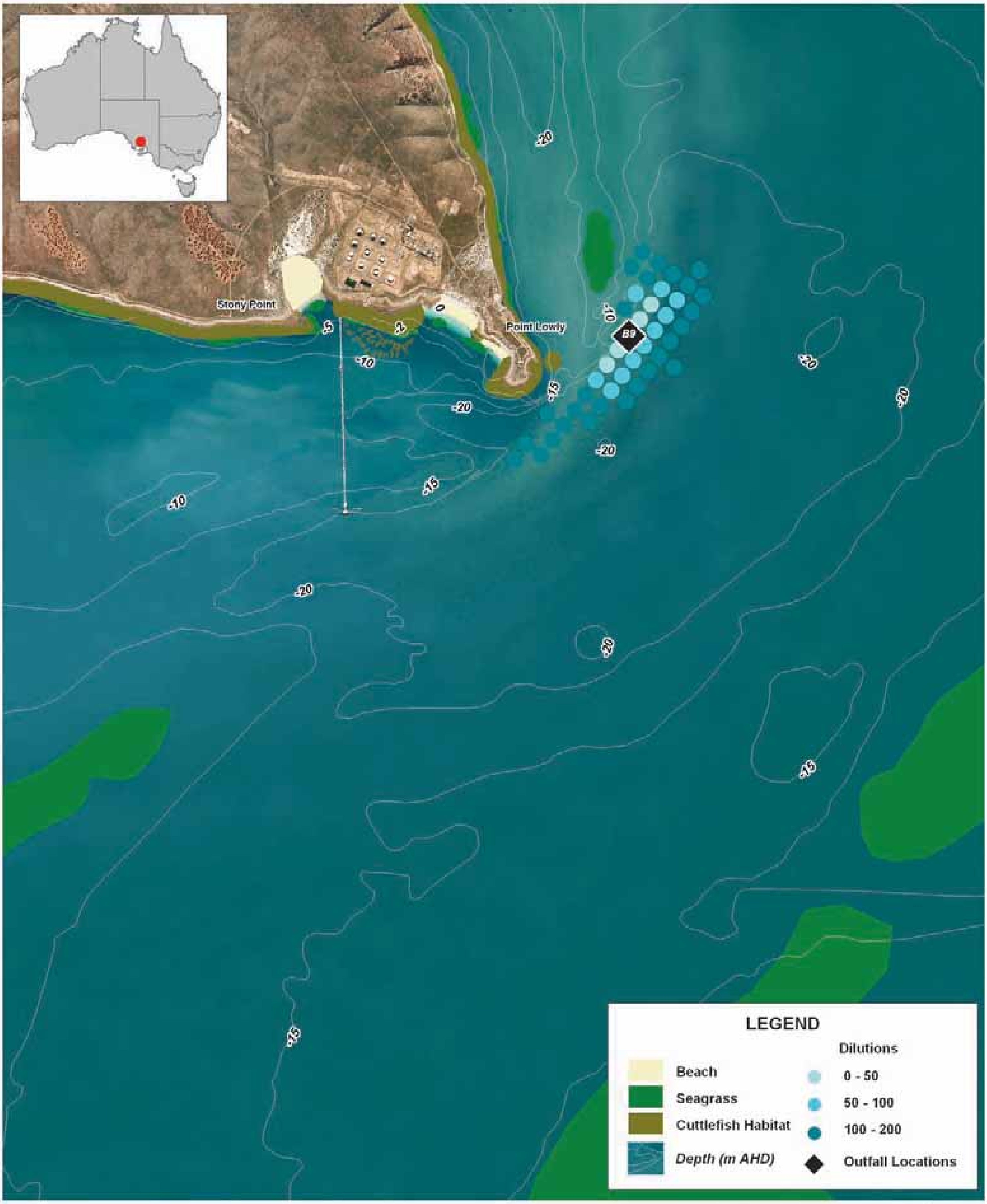
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_114_071015_07_9_Dodge_50.WOR



Title:
Simulation 07_10: Spring Tide 0th Percentile

Figure: 3-62

Rev: A

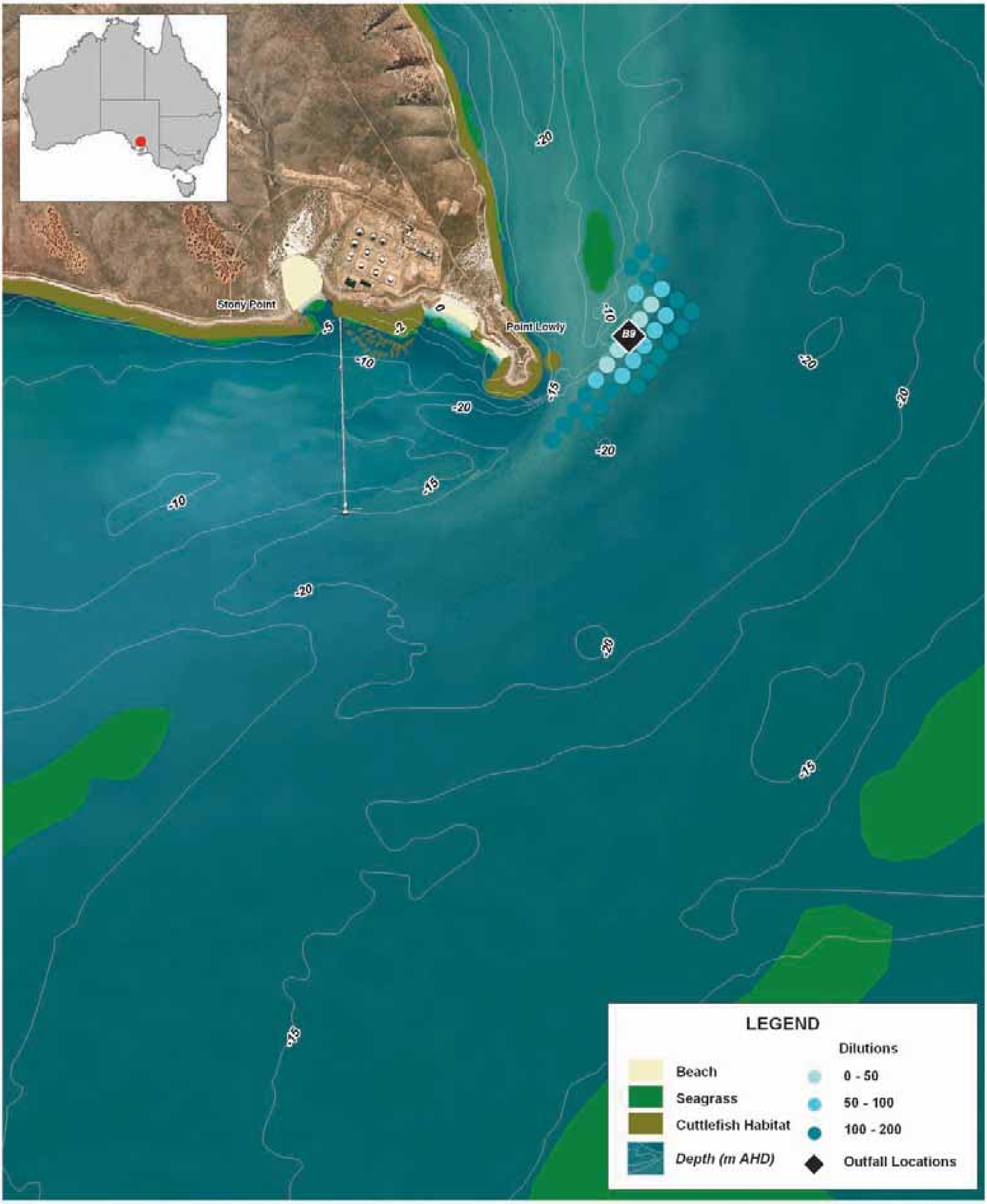
Air photo from Google Earth.

N

0 1 2km
Approx. Scale

BMT WBM
www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_115_071015_07_10_Spring_0.WOR



Title:

Simulation 07_10: Spring Tide 1st Percentile

Figure: 3-63

Rev: A

Air photo from Google Earth.

N

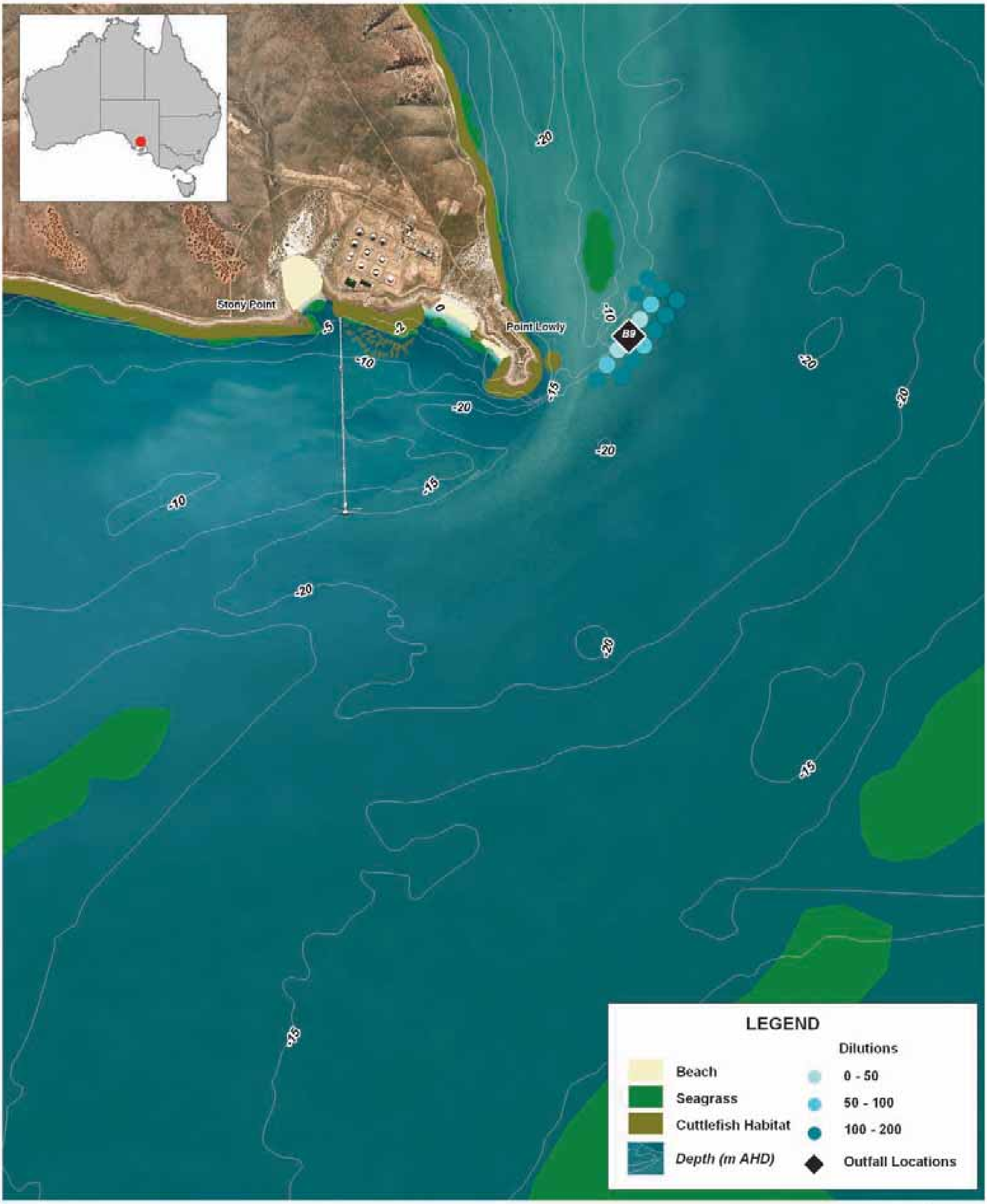
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_116_071015_07_10_Spring_1.WOR



Title:

Simulation 07_10: Spring Tide 10th Percentile

Figure:

3-64

Rev:

A

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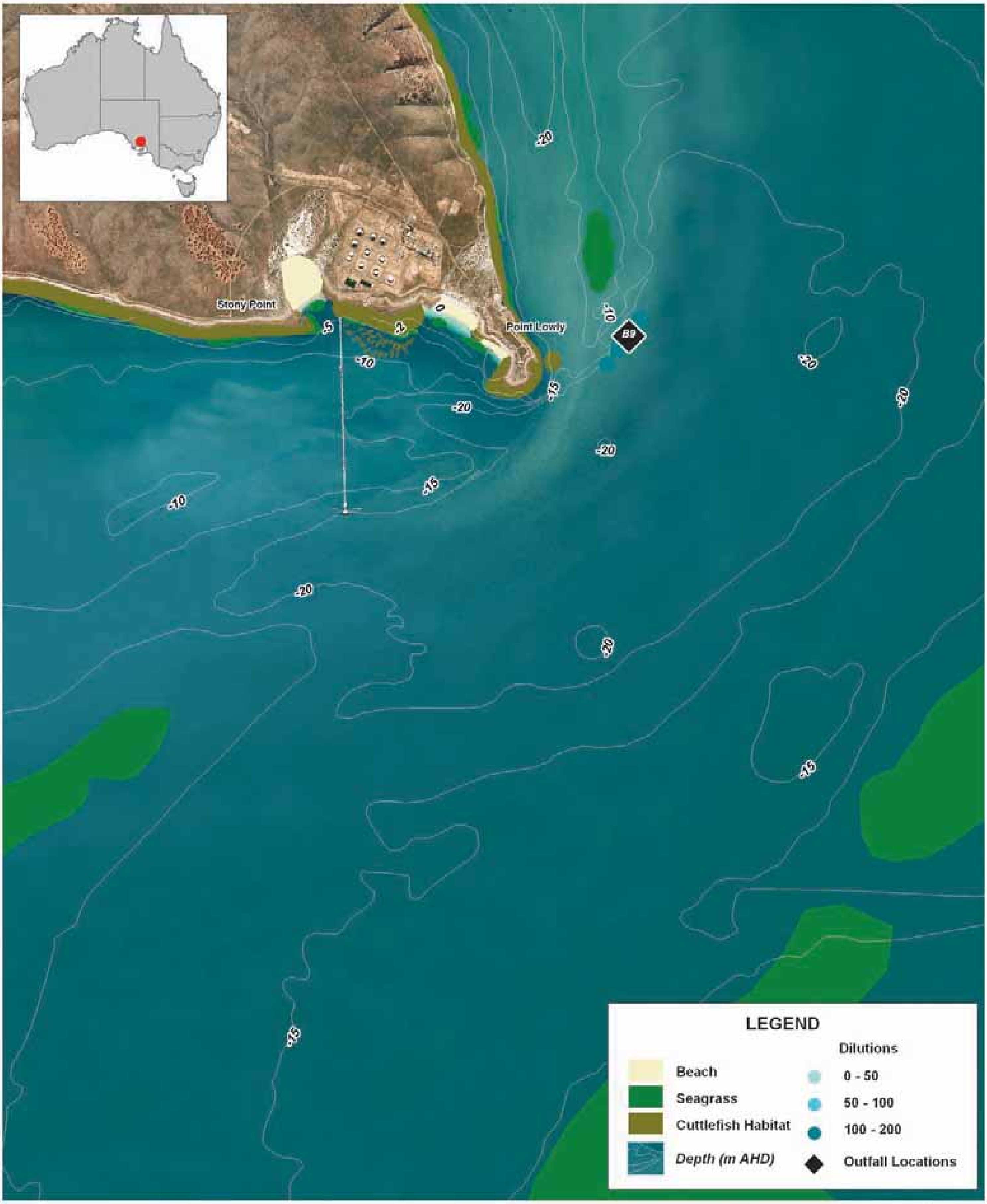

Title:
Simulation 07_10: Spring Tide 50th Percentile

Figure: 3-65

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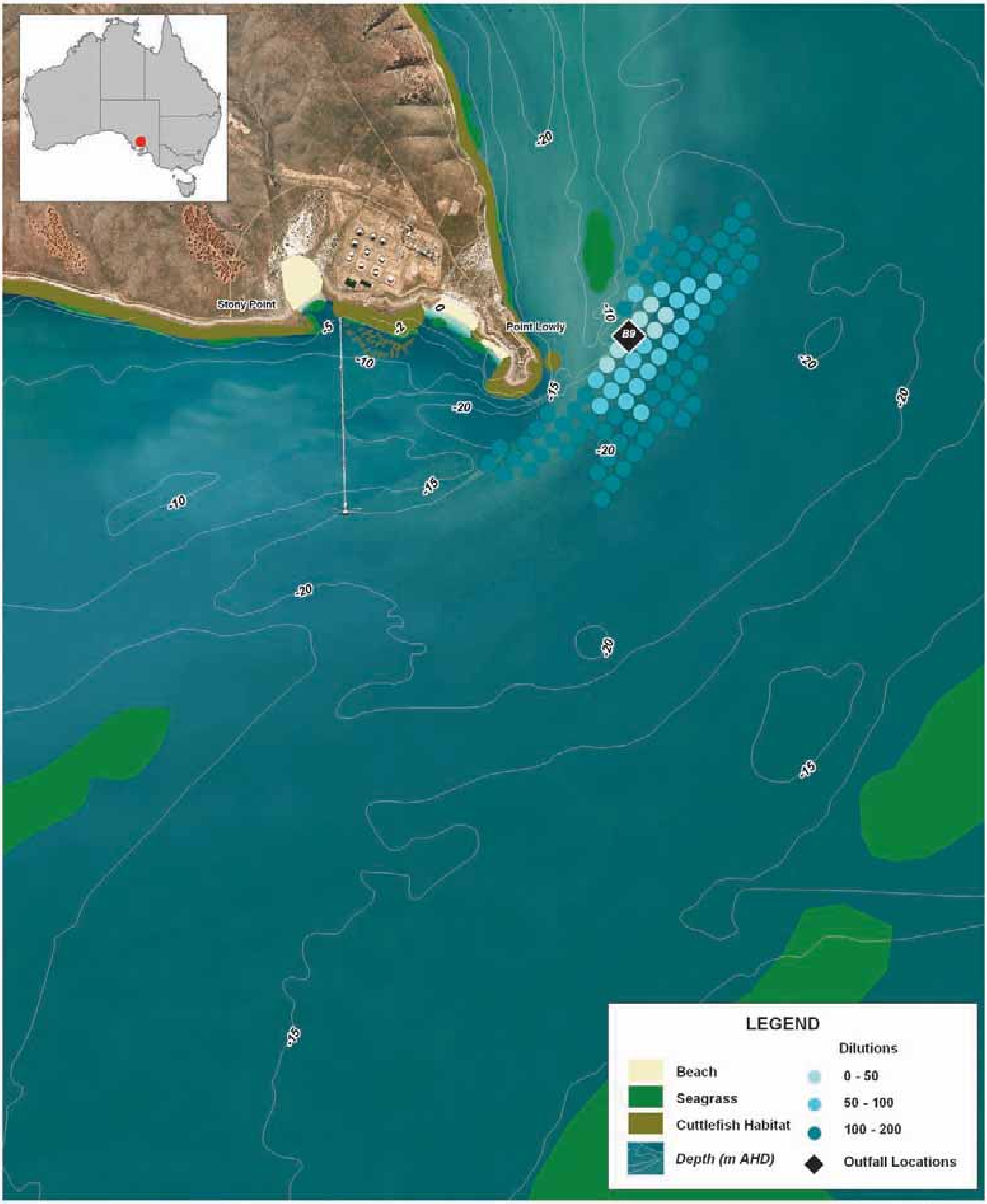

Title:
Simulation 07_10: Typical Tide 0th Percentile

Figure:
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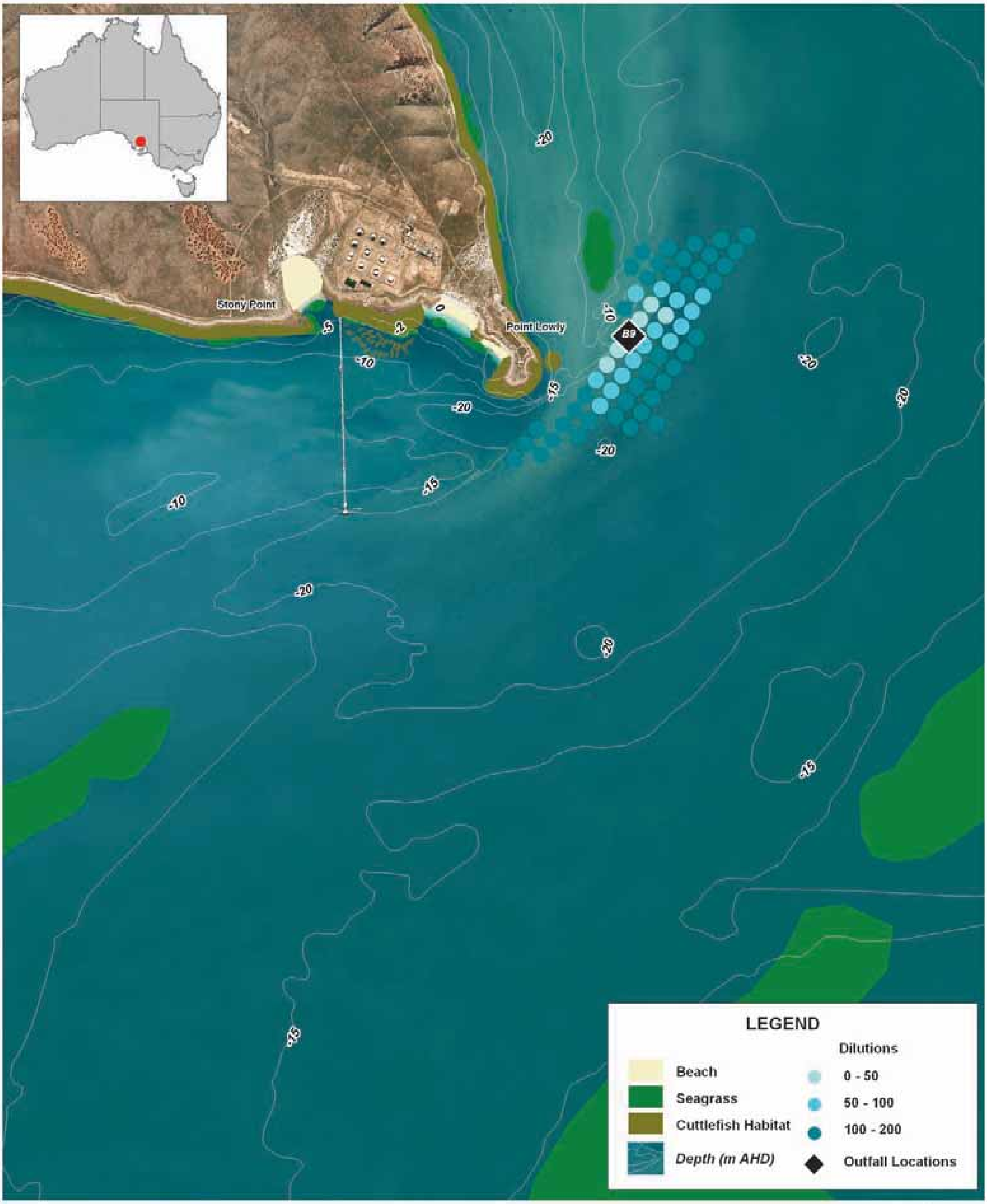

Title:

Simulation 07_10: Typical Tide 1st Percentile

Figure: 3-67

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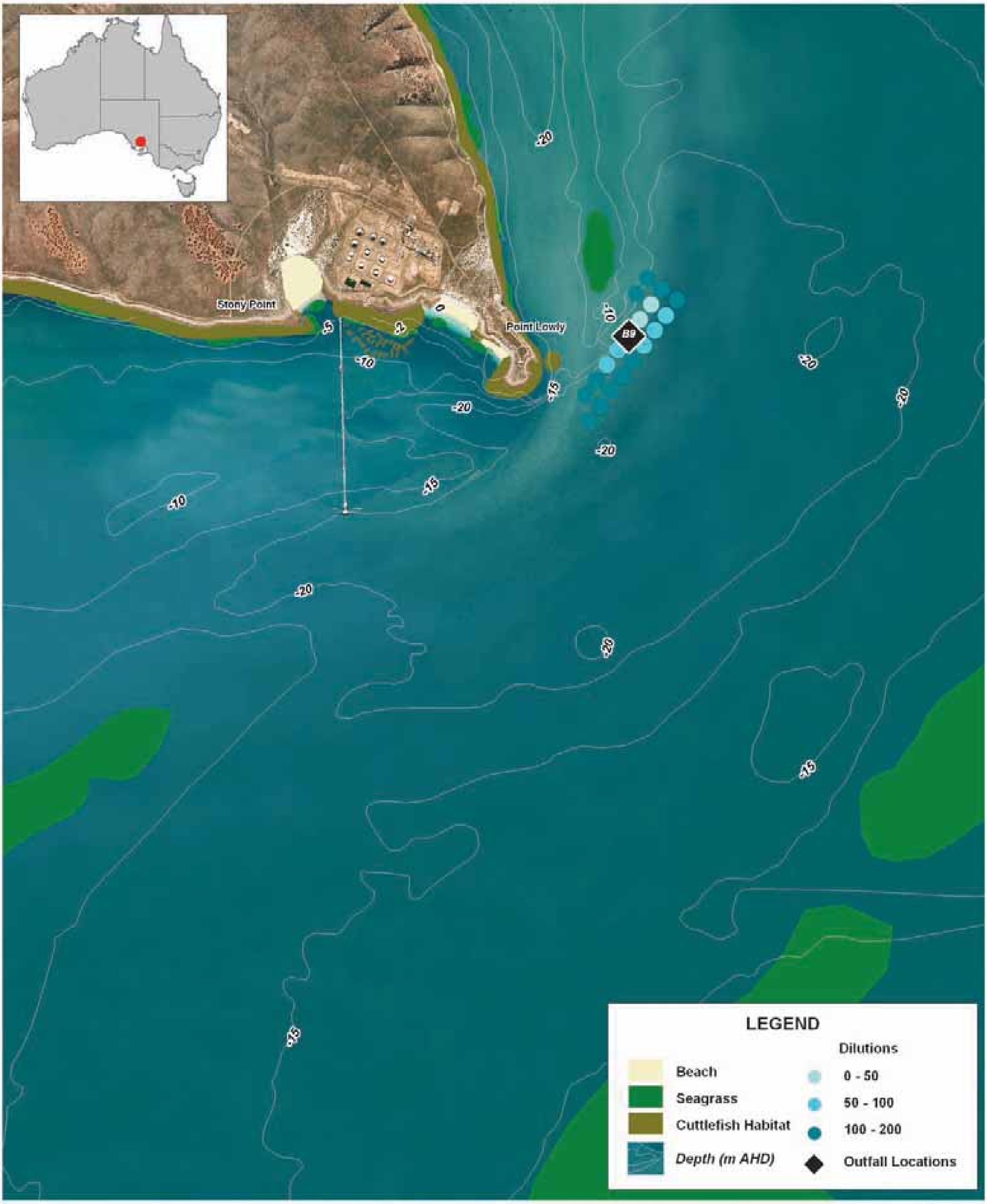

Title:

Simulation 07_10: Typical Tide 10th Percentile

Figure: 3-68

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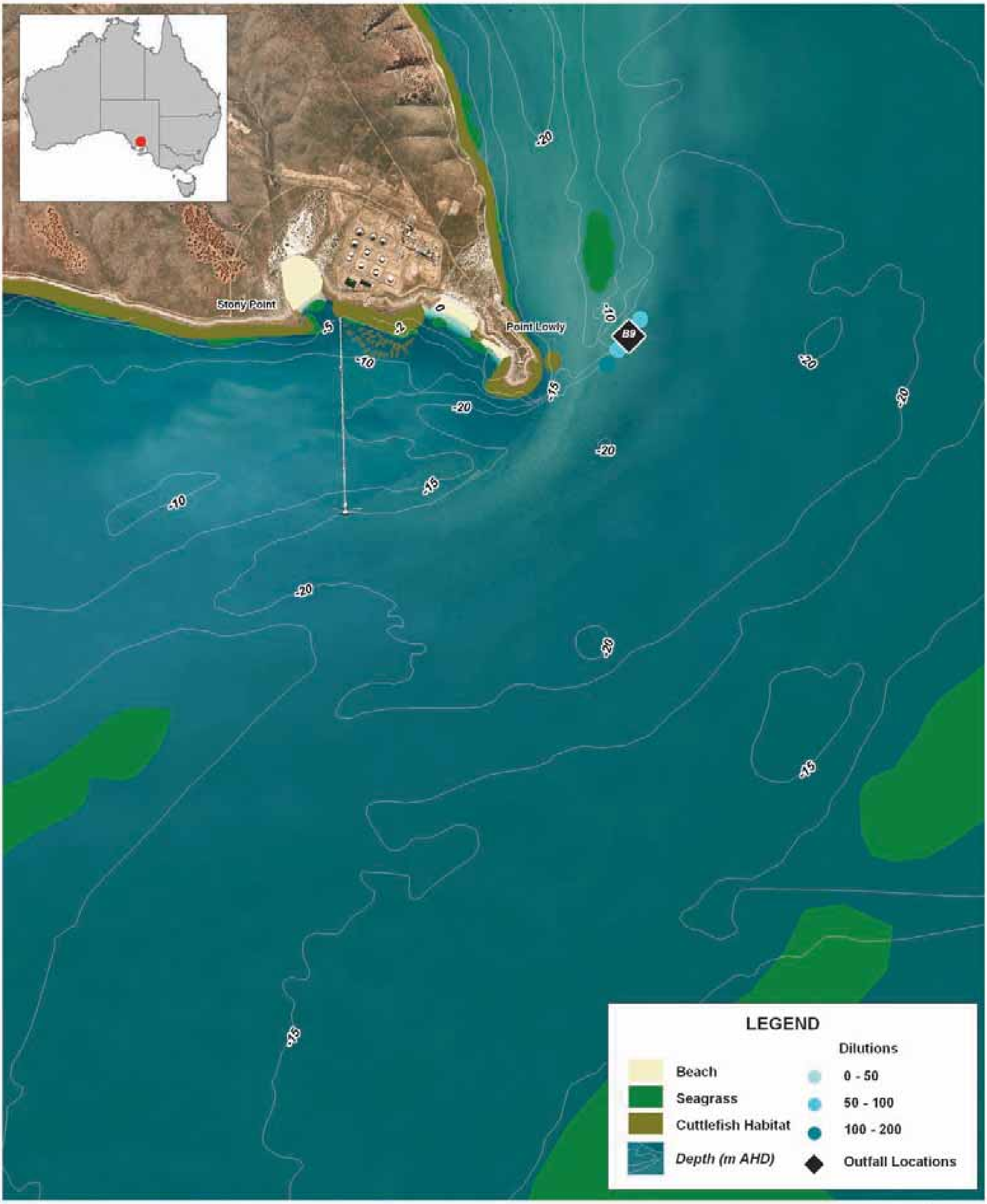

Title:

Simulation 07_10: Typical Tide 50th Percentile

Figure: 3-69

Rev: A

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Approx. Scale

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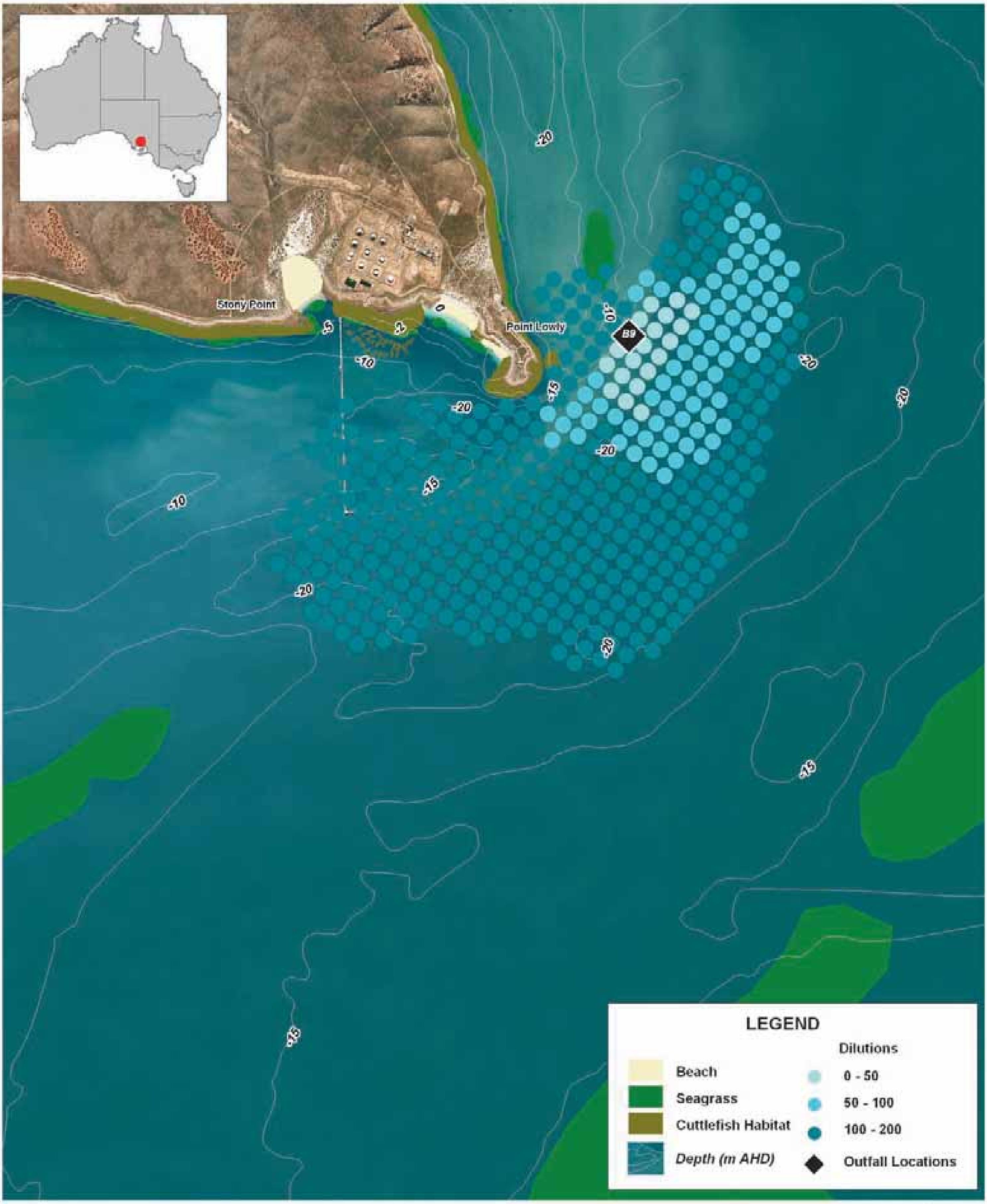
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_122_071015_07_10_Typical_50.WOR



Title:
Simulation 07_10: Dodge Tide 0th Percentile

Figure: 3-70

Rev: A

Air photo from Google Earth.

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Approx. Scale

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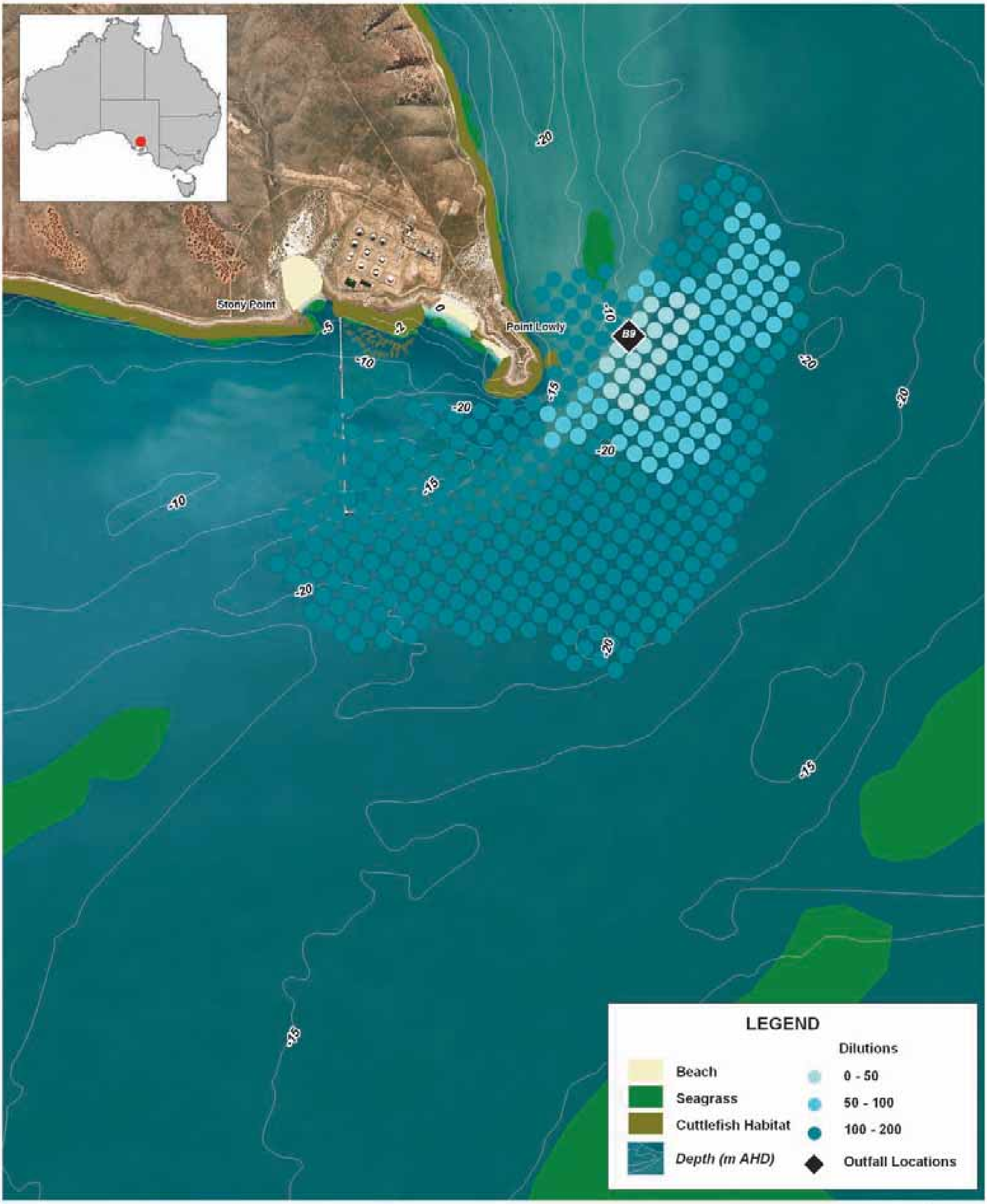

Title:

Simulation 07_10: Dodge Tide 1st Percentile

Figure: 3-71

Rev: A

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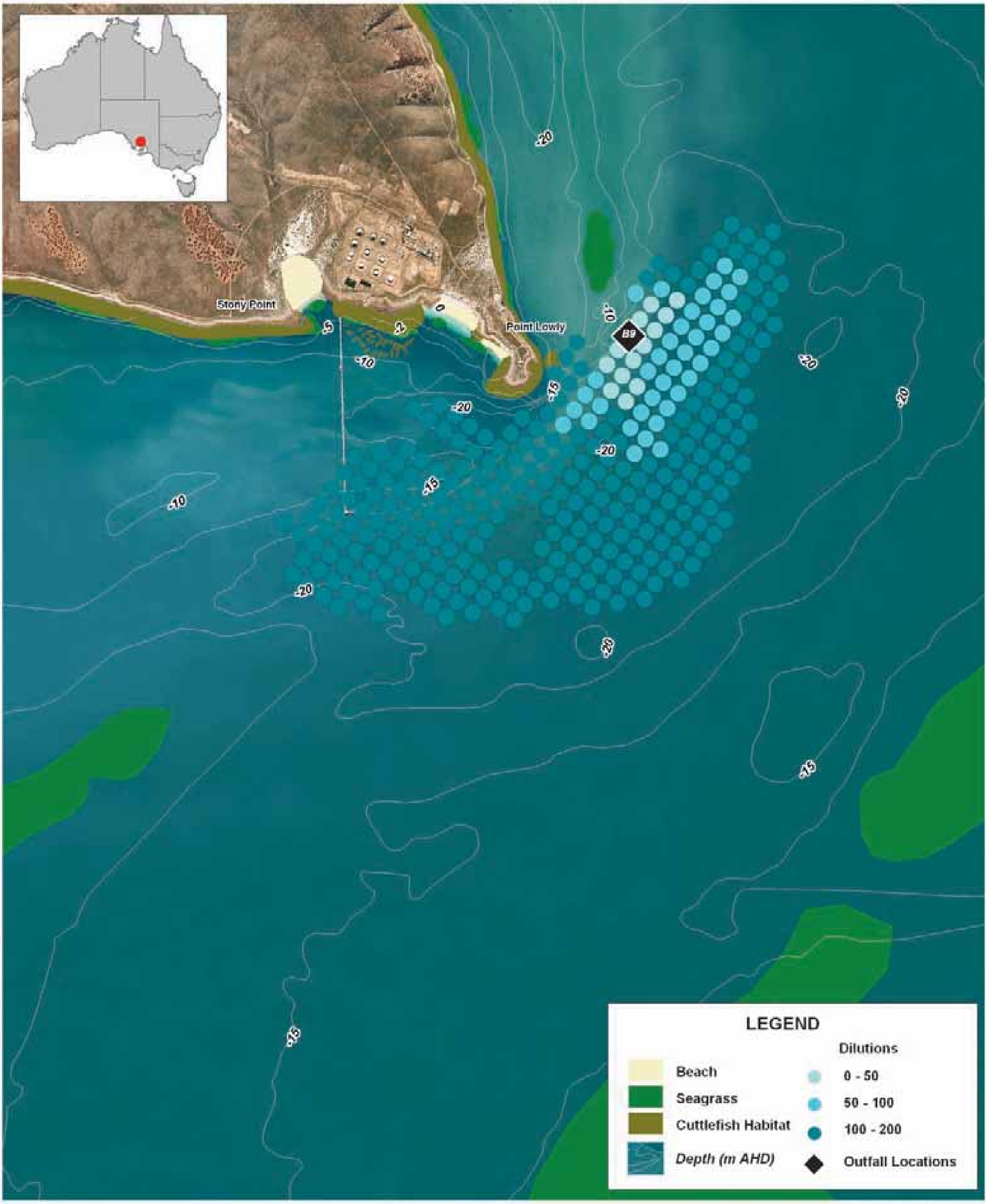

Title:
Simulation 07_10: Dodge Tide 10th Percentile

Figure: 3-72

Rev: A

Air photo from Google Earth.

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Approx. Scale

BMT WBM

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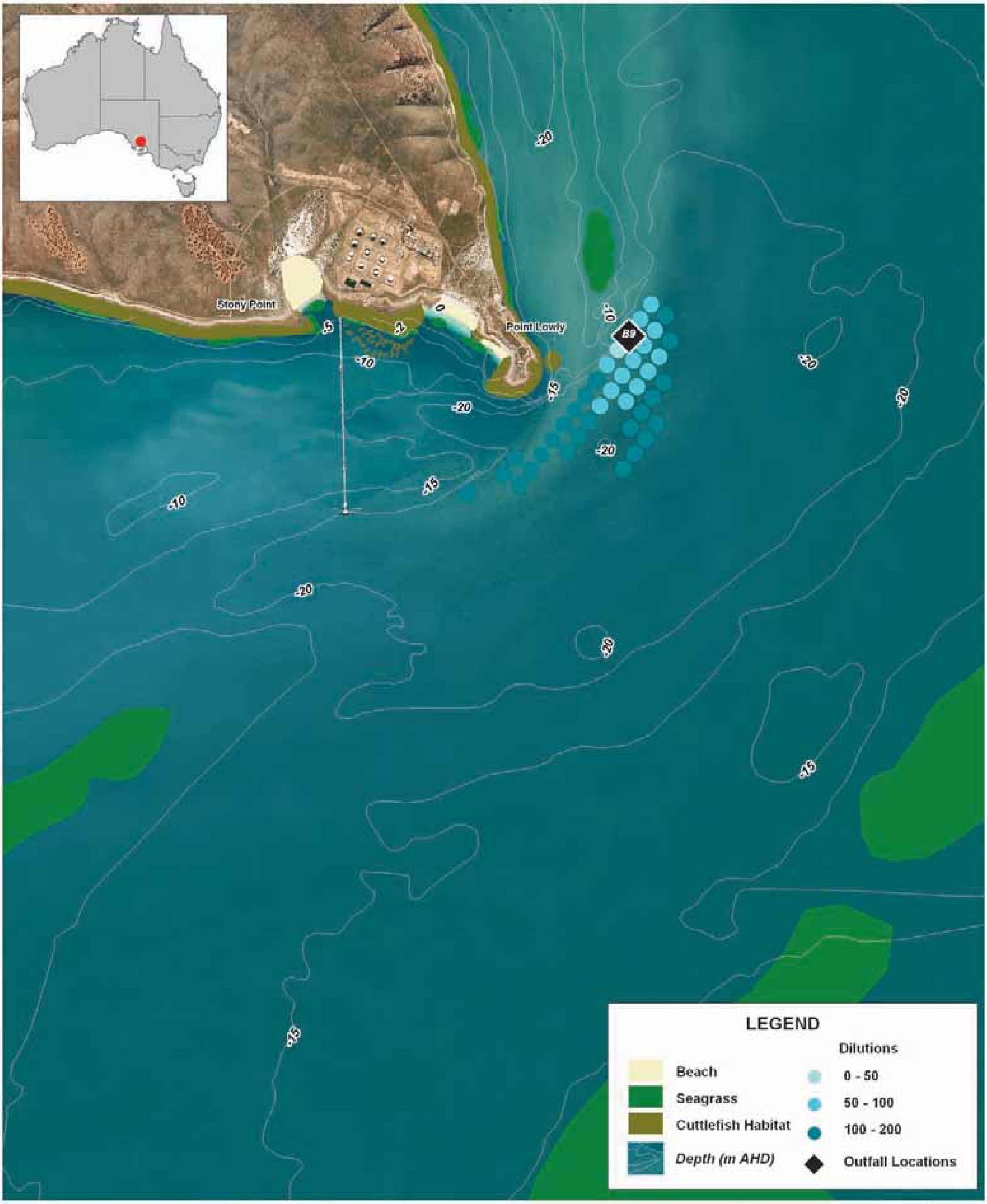
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_125_071015_07_10_Dodge_10.WOR



Title:

Simulation 07_10: Dodge Tide 50th Percentile

Figure: 3-73

Rev: A

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Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_126_071015_07_10_Dodge_50.WOR

3.3 Near Field Model

Table 3-9, 3-10 and Figure 3-74 present the results of near field model investigations.

Table 3-11 also presents model predictions of plume dilutions for still water conditions, that is the 0th percentile case. These represent the worst case conditions which would occur around slack water each day (for periods of no longer than 20-30 minutes) and for slightly longer periods under dodge tide conditions.

Table 3-9 Near Field Model Results at Plume Bottom Contact

Velocity Percentile	Dilution	Distance (m)	Maximum Height of Plume (m)
1	19.5	11.3	7.4
5	24.1	13.0	7.1
10	37.9	15.0	6.8
25	51.2	24.2	5.8
50	56.5	31.5	4.7
75	63.5	38.6	3.8
90	63.4	41.8	3.4
95	63.1	43.5	3.2
99	62.2	46.9	3.0

Table 3-10 Near Field Model Results at 100 metres

Velocity Percentile	Dilution
1	21.7
5	25.5
10	42.6
25	77.4
50	82.3
75	92.4
90	93.7
95	94.5
99	96.8

Table 3-11 Zero Velocity Near Field Model Results

Extraction Point	Dilution
At Bottom Contact	18.2
At 100 metres	20.2

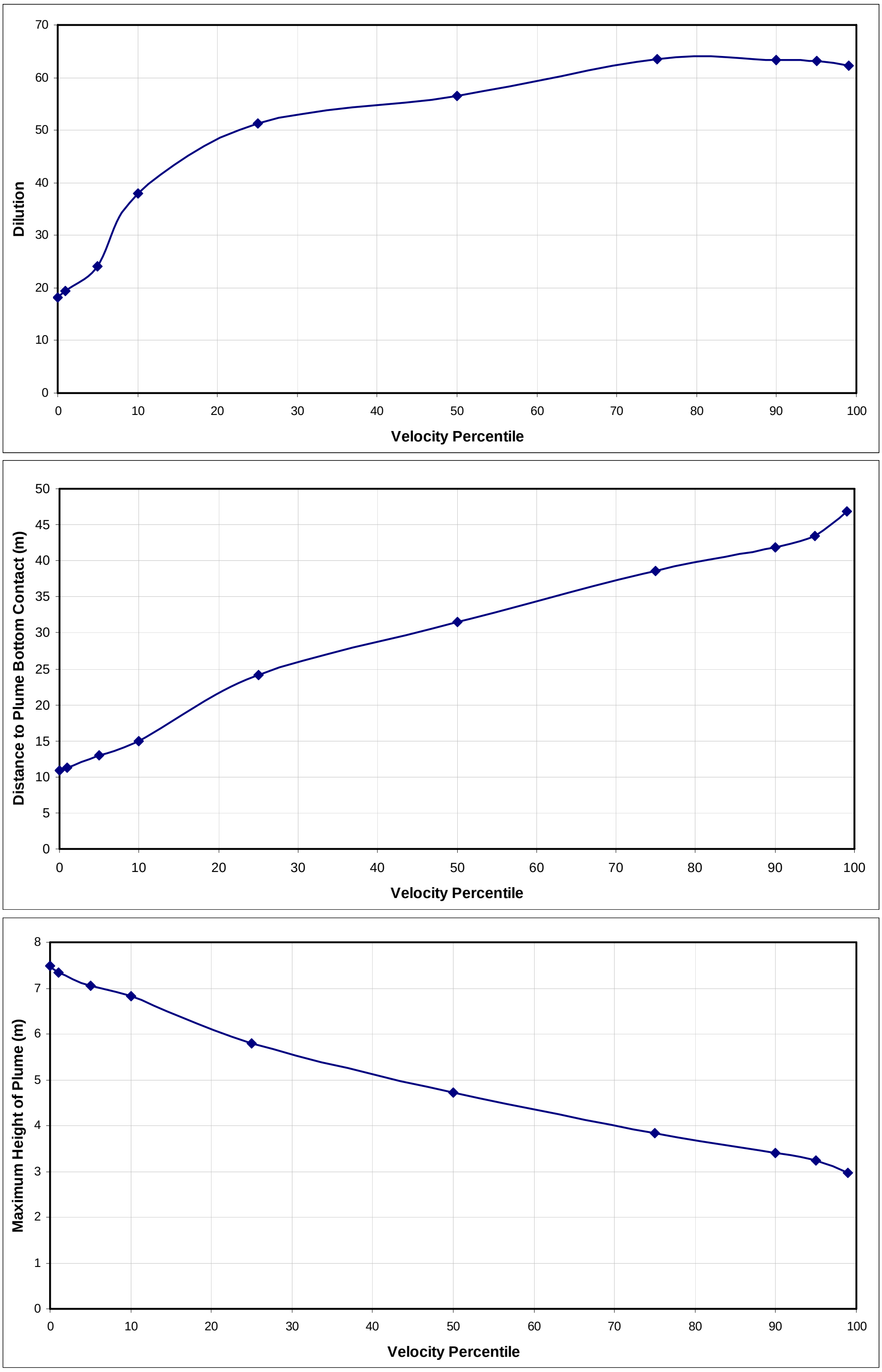


Figure 3-74 Near Field Model Results

In these tables and figures, the results for distance to plume bottom contact and maximum height of plume appear fairly straightforward as would be expected. The interplay between vertical momentum (due to the jet diffusers) and horizontal forces (due to the tide) is also interesting, with the brine discharge not being ‘allowed’ to rise as high vertically under cases with larger tidal velocities as occurs when the velocities are lower.

3.4 Combined Model Outputs

Following the approach and methodology provided in Section 1.4, we have appropriately combined the near, mid and far field model results, as presented in Table 3-12.

Table 3-12 Combined Model Results at 100 metres (Peak Monthly Flow)

Dilution Percentile	Dilution at 100m	Residual Salinity at 100m	Increase Above Ambient
0	1:8	3.7	8.9
1	1:10	3.1	7.5
5	1:12	2.	6.4
10	1:14	2.3	5.5
25	1:21	1.5	3.7
50	1:35	0.9	2.2
75	1:47	0.7	1.6
90	1:54	0.6	1.4
95	1:56	0.6	1.4
99	1:59	0.6	1.3

The worst case outcome for the combined models at 100 m is a dilution factor of 1:8, corresponding to a salinity increase of approximately 3.7 g/L and less than 9% increase above the ambient salinity at Point Lowly. Based on the model results, a dilution of 1:85 would be breached (i.e. brine would be present at that location a dilution lower than this value) at all times. The dilution of 1:45 (protecting 99% of species) would be breached 70% of the time. Almost half of the breaches would be for less than an hour (median breach duration is 1.9 hours), and more than 90% for less than six hours. Breaches of 3-4 days would occur over fortnightly dodge tides, with the maximum contiguous period of breach observed over the 40 day mid field simulation being approximately 91 hours. Figure 3-75 presents the percentile distribution of the contiguous breach periods.

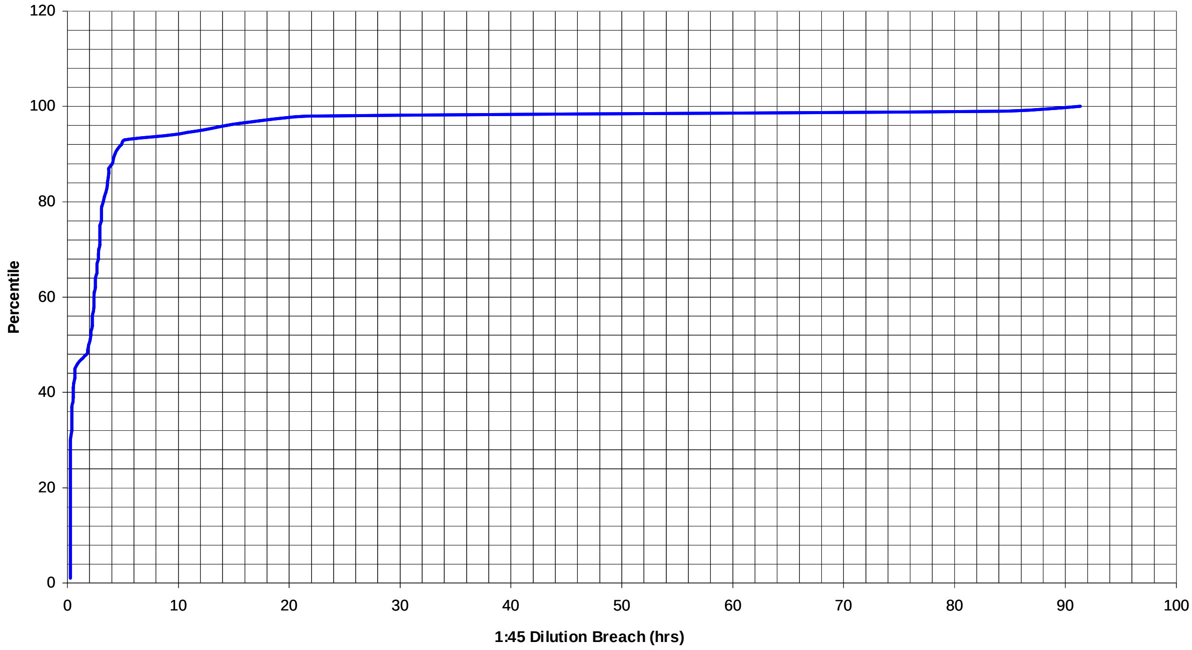


Figure 3-75 1:45 Dilution Breach (i.e. brine present at dilution less than 1:45) Duration Percentiles

In addition, the data in Table 3-3 has been recomputed to include far field effects, i.e. the long term average increase in salinity due to far field influences. The far field dilution is approximately 500:1, so this effectively places an 'upper limit' on the dilution achievable in the combined mid field results. An additional column has also been included which tabulates the longest continuous duration for which dilutions less than 1:85 are maintained at each of the locations (if at all).

Table 3-13 Statistical Analysis of Dilutions, Simulation 07_6

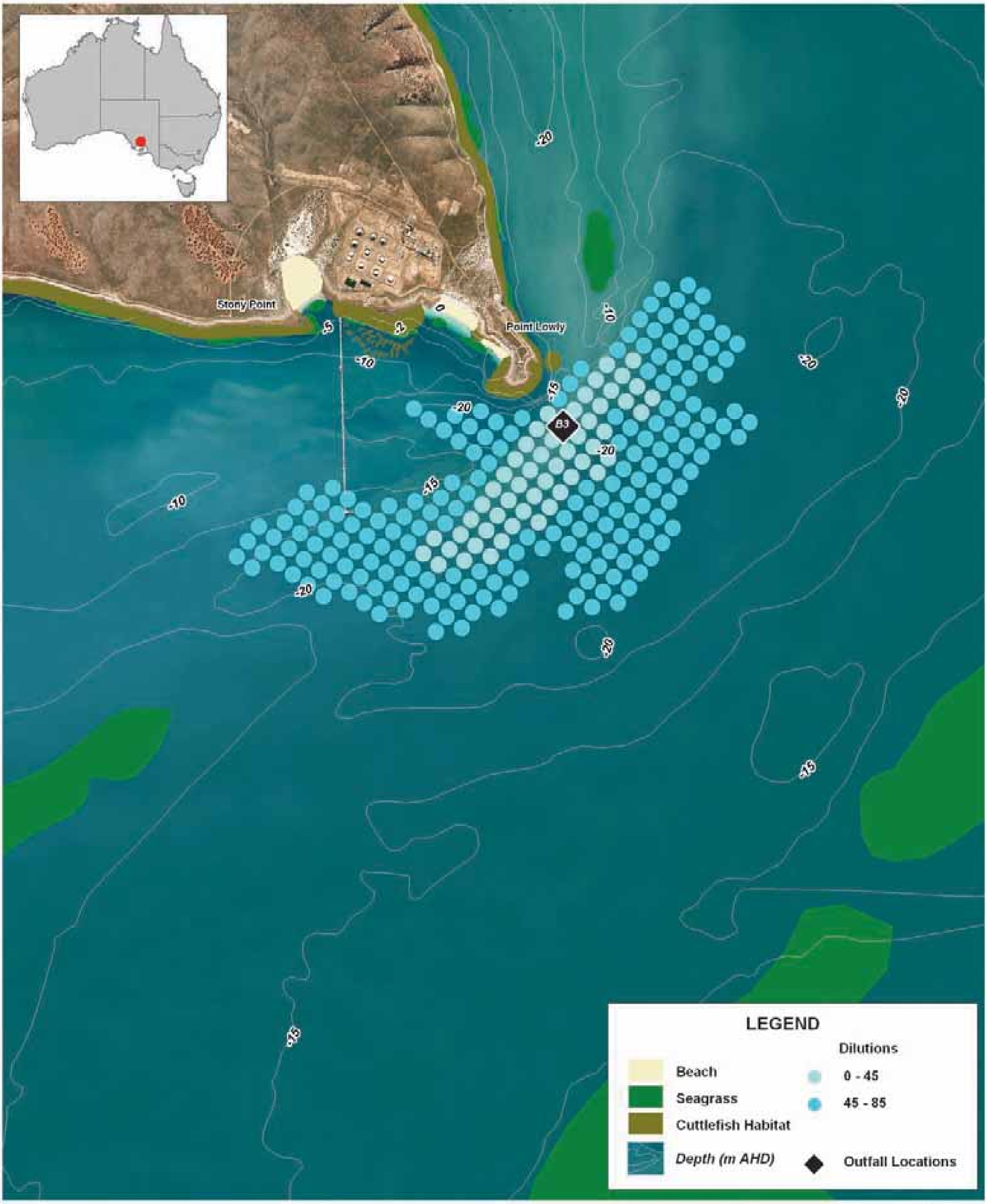
	Percentile									Count	Pcnt	Count	Pcnt	Max Duration
Site	1	5	10	25	50	75	90	95	Min	<45	<45	<85	<85	(hrs)
a	19	24	27	36	65	107	133	144	15	2494	33	4663	63	89
b	47	67	86	158	288	357	390	417	37	49	0	688	9	8
c	41	57	73	119	204	318	364	387	27	123	1	955	12	20
d	45	83	141	250	325	360	392	436	35	67	0	382	5	10
e	313	340	356	378	409	436	459	478	247	0	0	0	0	0
f	169	260	297	330	360	394	420	443	116	0	0	0	0	0
g	279	298	313	336	358	391	423	434	211	0	0	0	0	0
h	319	364	376	393	423	449	467	488	230	0	0	0	0	0
i	241	342	371	393	425	451	468	492	184	0	0	0	0	0
j	279	383	395	418	448	472	490	498	184	0	0	0	0	0
k	413	433	445	469	484	494	499	499	393	0	0	0	0	0
l	63	86	118	216	324	361	392	434	37	4	0	360	4	15
m	174	212	246	321	347	374	417	454	152	0	0	0	0	0
n	336	344	347	359	384	414	463	487	319	0	0	0	0	0
o	23	32	41	73	192	298	358	384	18	885	11	2075	28	32
p	22	30	36	60	151	345	383	406	17	1146	15	2524	34	16
B7	73	134	175	279	336	370	409	455	49	0	0	163	2	6
B8	70	86	110	185	267	339	372	398	59	0	0	335	4	17
B9	71	111	157	231	318	364	400	443	53	0	0	164	2	5

Table 3-14 provides the data presented in Table 3-8 (i.e. simulation 07-6), but with the long term far field dilutions included in the bottom cells of each profile location. The profile at ‘a’ also includes the influence of near field effects at the 0th dilution percentile (i.e. 1:8).

Table 3-14 Minimum Dilutions Across Cells ‘e’ to ‘d’. Combined Models.

Vertical Computational Layer	e	f	o	a	q	r	d
14	5000	5000	3333	2000	1667	2000	2500
13	556	667	588	500	400	345	417
12	476	500	500	500	400	345	417
11	476	526	476	476	400	345	417
10	250	435	417	435	400	345	417
9		417	417	417	370	345	345
8		294	357	385	333	323	313
7		233	270	263	263	238	217
6		169	179	189	217	179	192
5		117	147	169	179	154	179
4			78	156	120	145	145
3			48	133	74	95	105
2			18	8	23	31	35

Finally, the combined 0th, 1st, 10th and 50th percentile mid field and long term average far field results are presented in contours plot in Figure 3-76 through Figure 3-79. These figures are directly analogous to Figure 3-10 through Figure 3-13, but with the far field influence included.



Title:

Combined Far Field Long Term Average and Mid Field 0th Percentile Dilutions: 40 Day Simulation Period

Figure: 3-76

Rev: A

Air photo from Google Earth.

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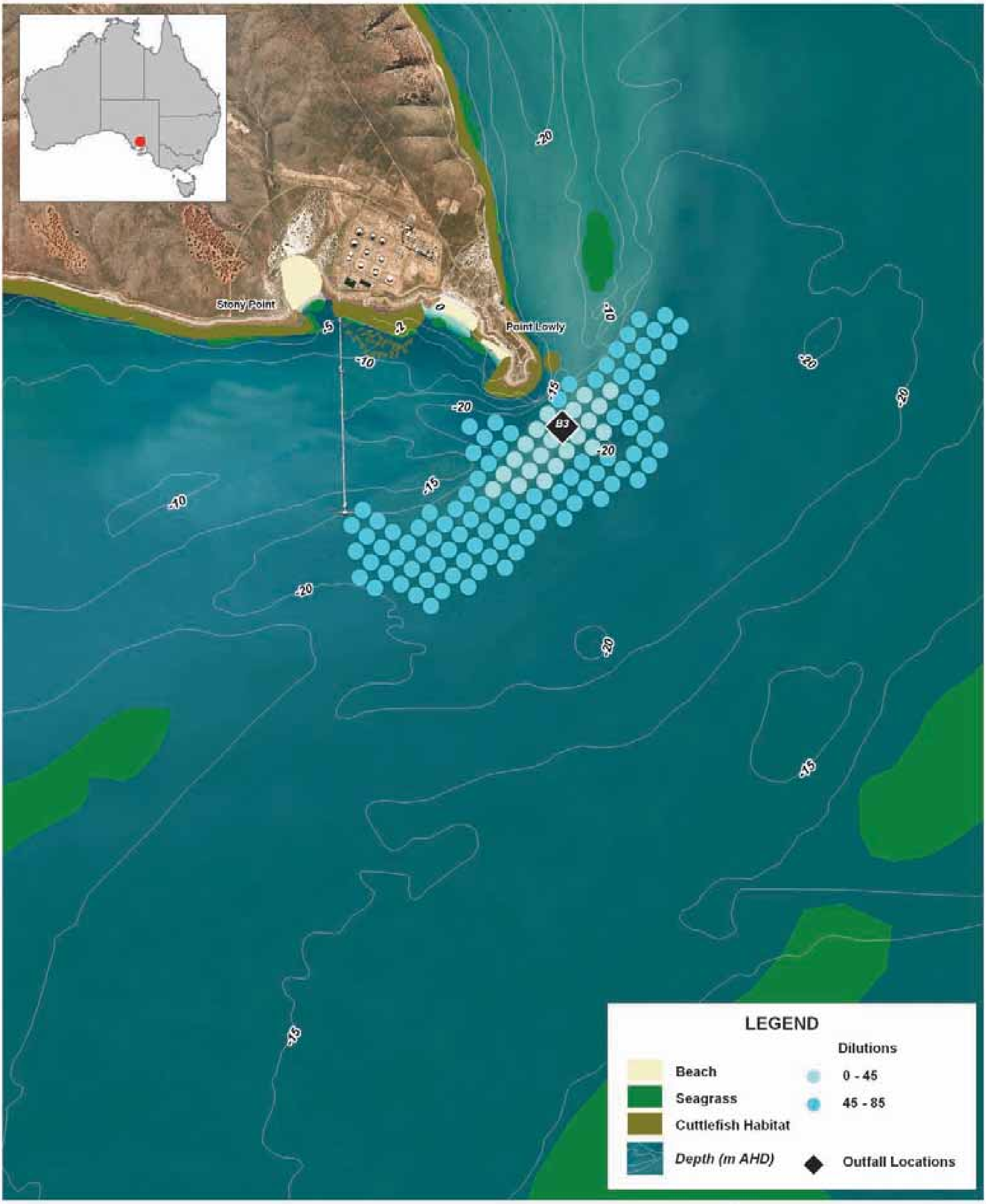

Title:

Combined Far Field Long Term Average and Mid Field 1st Percentile Dilutions: 40 Day Simulation Period

Figure: 3-77

Rev: A

Air photo from Google Earth.

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Approx. Scale

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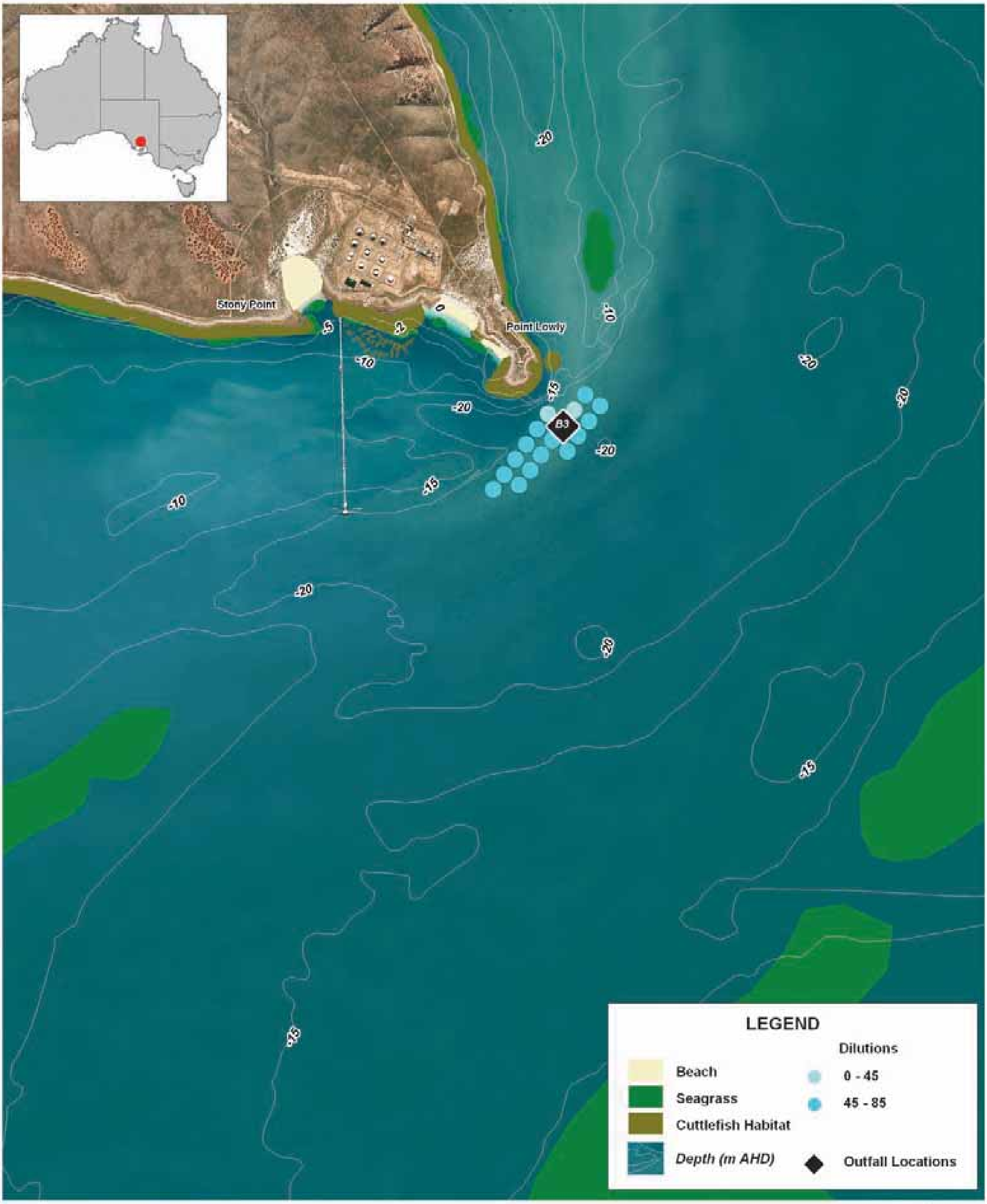

Title:
Combined Far Field Long Term Average and Mid Field 10th Percentile Dilutions: 40 Day Simulation Period

Figure: 3-78

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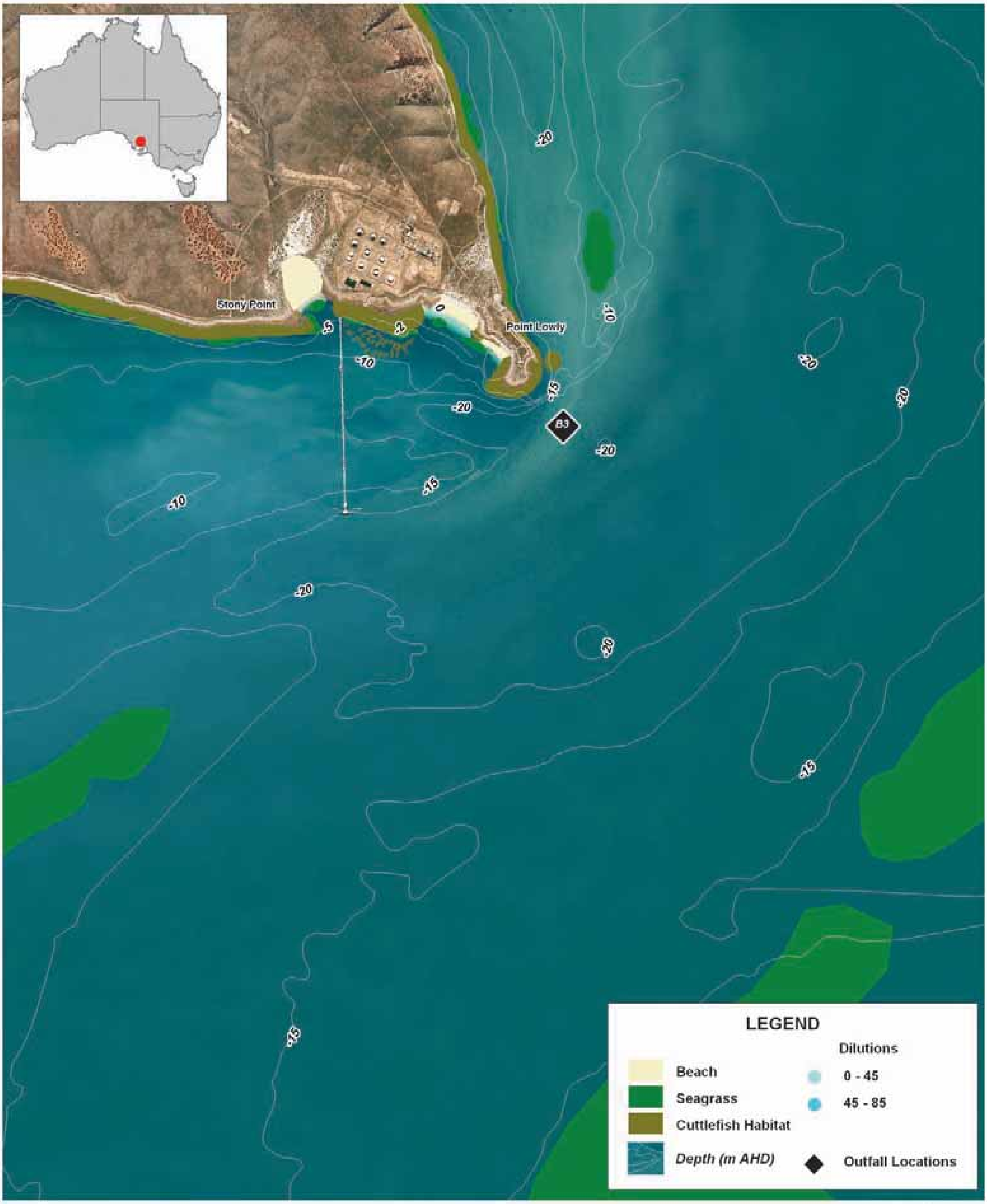

Title:

Combined Far Field Long Term Average and Mid Field 50th Percentile Dilutions: 40 Day Simulation Period

Figure: 3-79

Rev: A

Air photo from Google Earth.

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Approx. Scale

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Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_260_080730_MidFarCombined_50th.WOR

3.5 Additional Analyses

Following the main tranche of work, and partly as a result of the review process, several key additional work items arose regarding this modelling study. These included examination of the:

- Flushing timescale and 'water age' properties of Spencer Gulf;
- Water and salt balances across the entire Spencer Gulf;
- Likely mid field behaviour of discharged brine during a worst case, 'dodge' tide, condition; and
- Potential impacts of climate change on Gulf wide salinities (in a preliminary sense).

These additional investigations and results are presented in the following sections.

3.5.1 Flushing Timescale and Water Age Analyses

The far field model was used to examine the water age and flushing timescale properties of Spencer Gulf. To do so, two techniques were employed: the e-folding method and ELCOM's in-built 'retention time' capability. These are described and contrasted below, however in short, the e-folding analysis examines the rate of removal of an inert passive tracer from the system under tidal pumping, whilst the retention time analysis computes and tracks the time that water in each computational cell is retained within the model.

3.5.1.1 e-folding Analysis

This technique uses the accepted industry standard method of estimating flushing timescales via computing e-folding times (http://en.wikipedia.org/wiki/E-folding). The notation 'e' refers to the natural exponent (the inverse of the natural logarithm), where 'e' has a value of approximately 2.71. The e-folding time is the time taken for an initial concentration to reduce to 1/e of its original value (see below for details). These e-folding times are widely accepted as being representative of 'flushing' timescales. More precisely, the application of the e-folding technique involves the following:

- Setting a passive tracer to have an initially uniform and constant concentration of 1.0 throughout the region of interest at model time t = 0;
- Setting all other computational points to a concentration of 0.0 for the same tracer;
- Setting the open ocean boundary timeseries condition to also be 0.0 – i.e. all inflowing water is set to a tracer concentration of 0.0 (and all outflowing water is allowed to discharge at whatever tracer concentration it happens to have on exit, regardless of the boundary condition);
- Executing the model simulation, while recording the tracer concentration evolution with time at every model computational point. Importantly, the tracer in each computational cell is allowed to advect, disperse and mix with water in other cells, permitting interaction of the tracer with water outside the initial concentration extents. This mixing process means that waters well away from the initial tracer boundary can indirectly interact with tracer-free waters without necessarily approaching the boundary themselves. This is the core of the e-folding analysis: mixing provides a mechanism for dilution (i.e. flushing) without requiring all waters to physically 'leave' the model domain;

- Post-processing the timeseries data at each point to identify when the tracer concentration reduces below 37% (or 1/e) of its initial condition (i.e. a concentration of 0.37), following filtering to remove tidal fluctuations. This point in time is taken to be that at which sufficient interaction with the boundary (or tracer-free waters) has occurred at a particular location to allow the cell to be deemed as 'flushed'. It does not mean that all water from the cell has left the system or initial concentration extents.

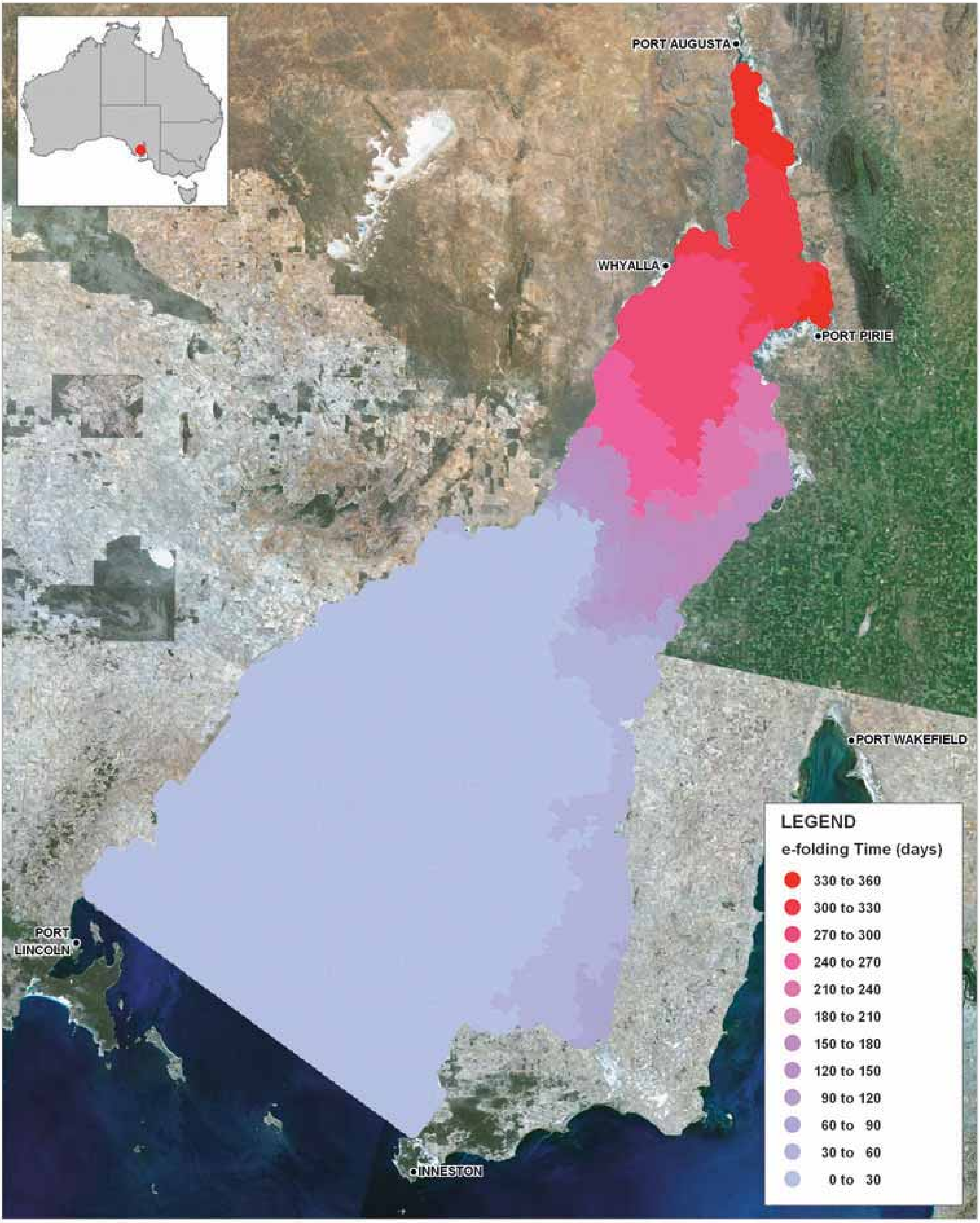
The time at which the above occurs for each point is known as the e-folding time, and it is accepted to be indicative of 'flushed' water. Undertaking this calculation at each point in the domain allows for spatial mapping of e-folding times throughout the area of interest. It is noted that running simulations to the point where tracer concentrations reach zero at all locations for use in estimating flushing times in not accepted industry practice. This is primarily because typically the temporal reduction in concentration at a point follows an exponential-style decay behaviour (i.e. conceptually similar, but still distinct from, radioactive decay half life behaviour) so the time taken to reach zero concentration can be very long, and thus not representative of real world flushing timescales.

In the case of the Spencer Gulf far field model, this technique was applied to two different initial regions of interest in order to quantify the rate of exchange of specific areas with surrounding waters. Two tracers were simulated to this end (in a single simulation), with initial condition extents set to the entire domain (tracer 1) and the area north of Point Lowly (tracer 2), respectively. In each case, tracer was set to fill the domain in a north-easterly direction from the boundary up to the northern most model extent at Port Augusta, at a concentration of 1.0. In this way, tracer 1 occupied the entire domain and tracer 2 occupied the domain north of Point Lowly at initialisation. Clearly the e-folding times reported for each tracer will be different due to the initial positioning of the tracer.

The far field model was run for a period of 5 years, and e-folding times were computed from both surface and bottom layer data. Comparison of e-folding times predicted from these two layers was undertaken for a single tracer and the results were found to be similar, so, for clarity, only e-folding times generated from surface sheet data from tracer 1 and 2 are presented here in Figure 3-80 and Figure 3-81, respectively. Colours represent e-folding times as per the legend, with colour divisions being approximately 1 month in duration.

The figures show that the longest e-folding times observed were less than approximately 1 year. These times occurred for the tracer initially set to cover the entire Gulf, and were found at the far northern extents of the model (i.e. at the furthest points from the open ocean boundary) as could be expected. Conversely, the lowest e-folding times characterise open waters near the ocean boundary. The magnitude and extents of the maximum e-folding time for the second (northern initialisation) tracer is reduced, and this is a direct result of the generally shorter travel distances required for water parcels to interact with the boundaries of the initial tracer extents.

Figure 3-80 demonstrates a significant west to east gradient in e-folding time across the lower portion of the Gulf. This is consistent with 'older' water occupying these eastern areas, and the likely origin of these waters is the northern reaches of the Gulf. These results are therefore consistent with a discharge of water from the northern Gulf leaving the system along the eastern boundary. Such a process is known to occur via salt ejection during late Autumn and early Winter, and the model's ability to capture this process has already been demonstrated in the preceding calibration report supplements.



Title:
e-folding Time Analysis: Tracer 1

Figure: 3-80

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0 30 60km
Approx. Scale

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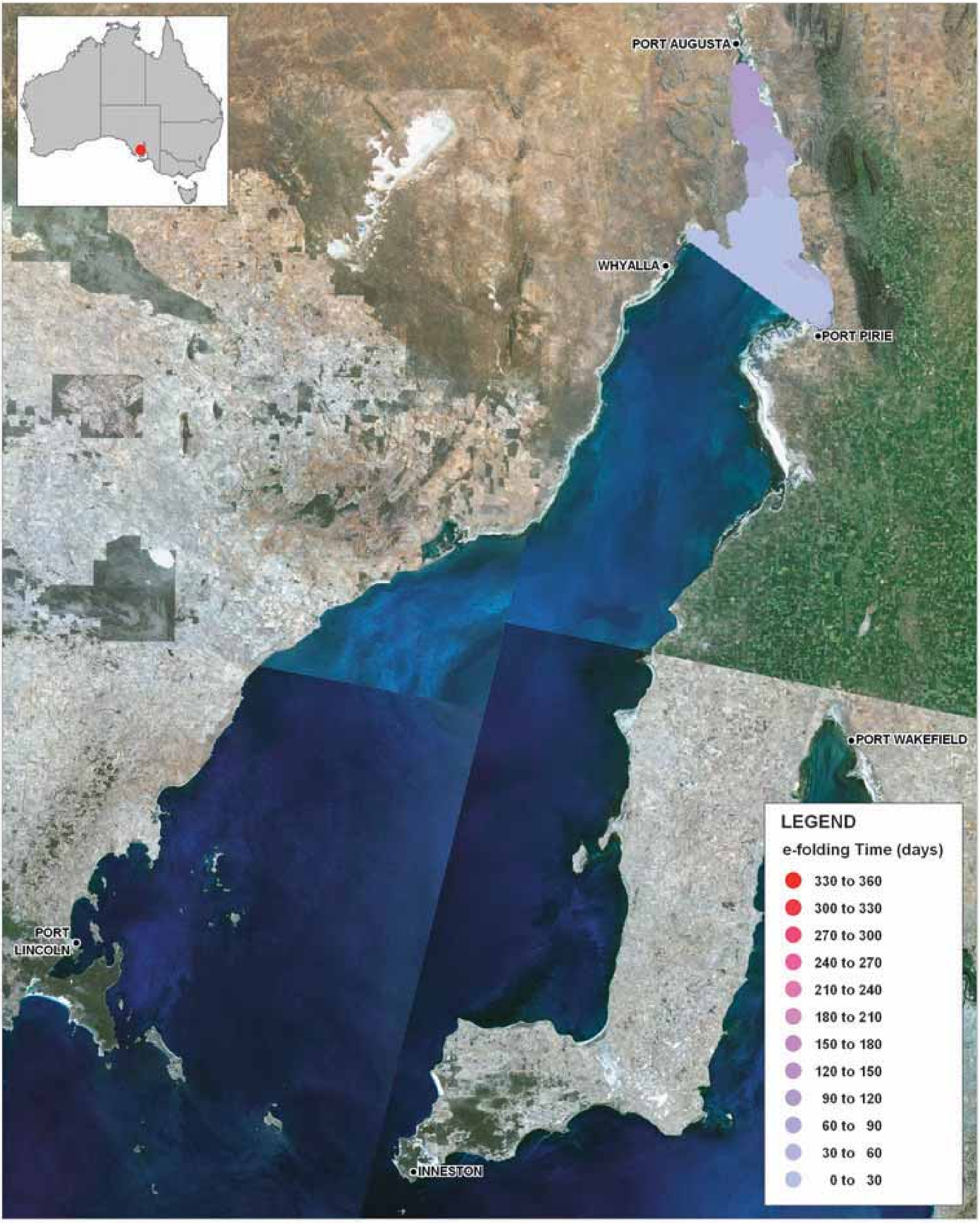

Title:

e-folding Time Analysis: Tracer 2

Figure: 3-81

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Approx. Scale

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Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_267_080812_Time Analysis Tracer 5.WOR

3.5.1.2 Retention Time Analysis

The second technique exploited ELCOM's in-built 'retention time' functionality. This functionality tracks the time each water parcel remains inside (i.e. is 'retained within) the computational domain as the simulation progresses. At each timestep, the algorithm:

- Increments the age of all cells by the model timestep; then
- Advects, disperses and mixes this 'time value' in response to hydrodynamic forcing as it would any other transportable scalar such as salt.

The retention time is then reported at each timestep. Water flowing into the model has a retention time of zero.

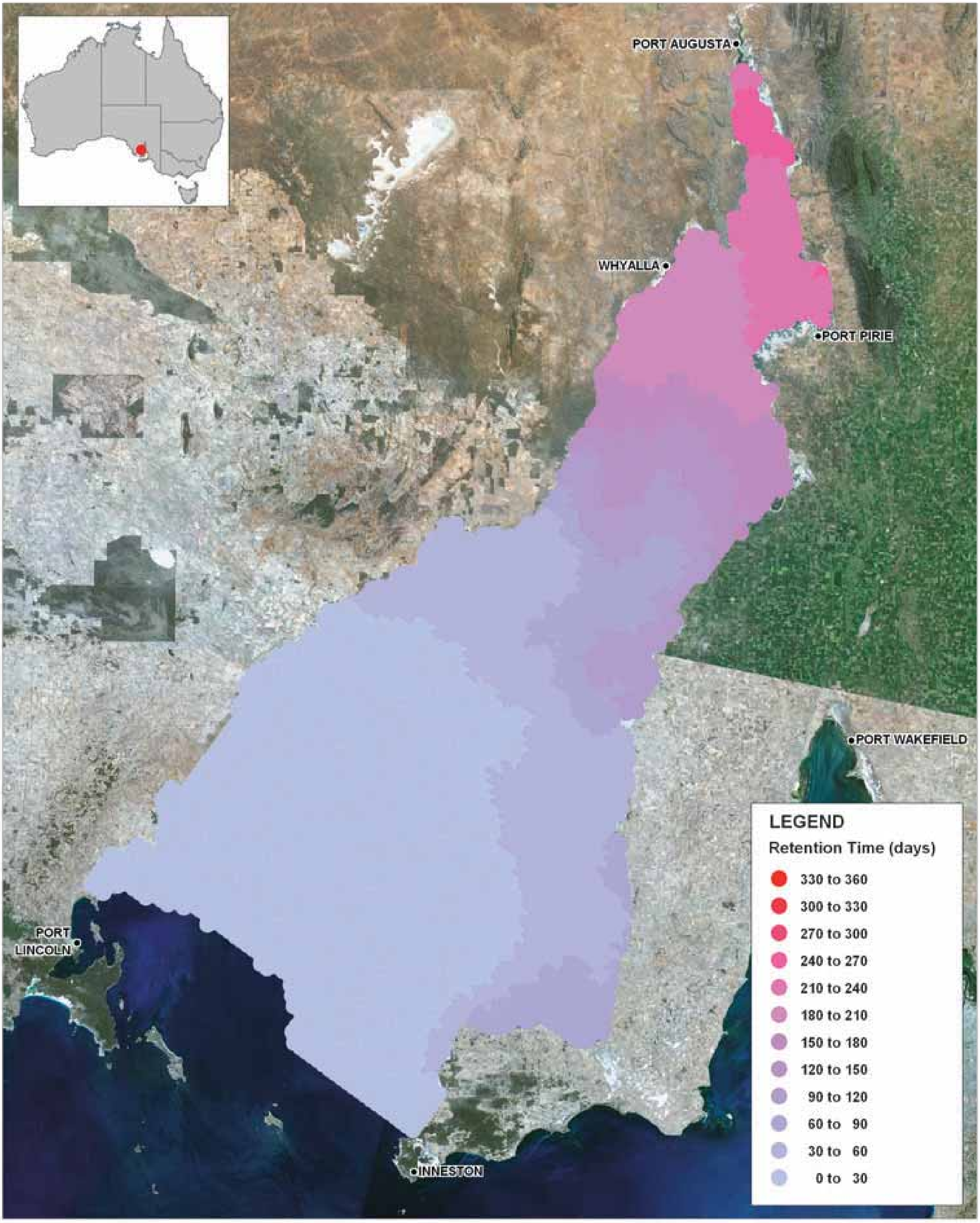
This technique was applied to the entire domain, and retention time tracked in the surface and bottom horizontal sheets. The result, in both cases, was a description of the temporal and spatial evolution of retention time within these sheets, i.e. one sheet of retention time was stored for each timestep reported.

One way to interpret retention time results is to consider a retention time map at any given time in relation to the total simulation time to that point. If the greatest retention time value within the map is less than the simulation duration to the point at which the map was produced, then by inference, all water originally within the computational domain has interacted (directly or indirectly via advection and mixing) with water originating from the model boundaries. In other words, in the case where the maximum retention time value is less than the model duration to that point in time, all water within the domain has felt the influence of the boundaries and has, at least partially, flushed from the system.

To maintain consistency with the e-folding analysis, only the surface sheet retention time map is presented in Figure 3-82 (we note that similarly to e-folding analysis, surface and bottom results were comparable), after 1 year simulation of the far field model. Colours are on the same scale as the e-folding figures to allow direct comparison.

The figure shows that the retention time within the Gulf is highest near the upper reaches, as expected, and in magnitude is consistent with the e-folding analysis. Further, a maximum retention time of approximately 250 days is predicted. This result is broadly consistent with the e-folding analysis from Tracer 1, which predicted a maximum e-folding timescale of 360 days.

Similarly to the e-folding analysis, the figures also show that, generally, waters on the eastern coast of the Gulf have greater retention times (i.e. longer flushing times) than those on the western coast. This is again consistent with these eastern waters bearing the signature of hypersaline water (with a longer retention time) having been ejected from the northern Gulf. Conversely, lower retention times on the west coast are reflective of 'newer' imported water from the open ocean having migrated northwards along the western coast of the Gulf. Both these trends are consistent with a long term 'gyre' and salt ejection operating in the Gulf, as described in the calibration report.



Title:
Retention Time Analysis: Snapshot at 1 Year

Figure: 3-82

Rev: A

N

0 30 60km
Approx. Scale

BMT WBM
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Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_269_080812_Retention Time Analysis 1 Year.WOR

3.5.2 Worst Case Dodge Tide Conditions

Previous sections have presented the 40 day 0th, 1st, 10th and 50th percentile dilution contour maps from the mid field model. This 40 day period included three neap tide periods, which were typically related to the lowest observed dilutions. In order to provide some assessment of the dilutions expected during 'extreme' neap tide conditions (i.e. extended duration low amplitude dodge tide conditions), a further mid field simulation was executed that included the application of a reductive multiplier to the tidal elevation boundary conditions used to drive the mid field model at its southern boundary. All other simulation parameters were as per run 07_6. Statistical analysis undertaken by others was used to determine the magnitude of this multiplier, and it was set at 0.476. It was applied only to the three neap tide periods, as follows:

1 07/12/2001 13:30 to 11/12/2001 08:15;

2 22/12/2001 23:15 to 28/12/2001 01:30; and

3 06/01/2002 00:00 to 09/01/2002 22:30.

The original and modified tidal elevations are shown in Figure 3-83, Figure 3-84 and Figure 3-85 for a representative section of the model boundary, for each of the three periods above, respectively.

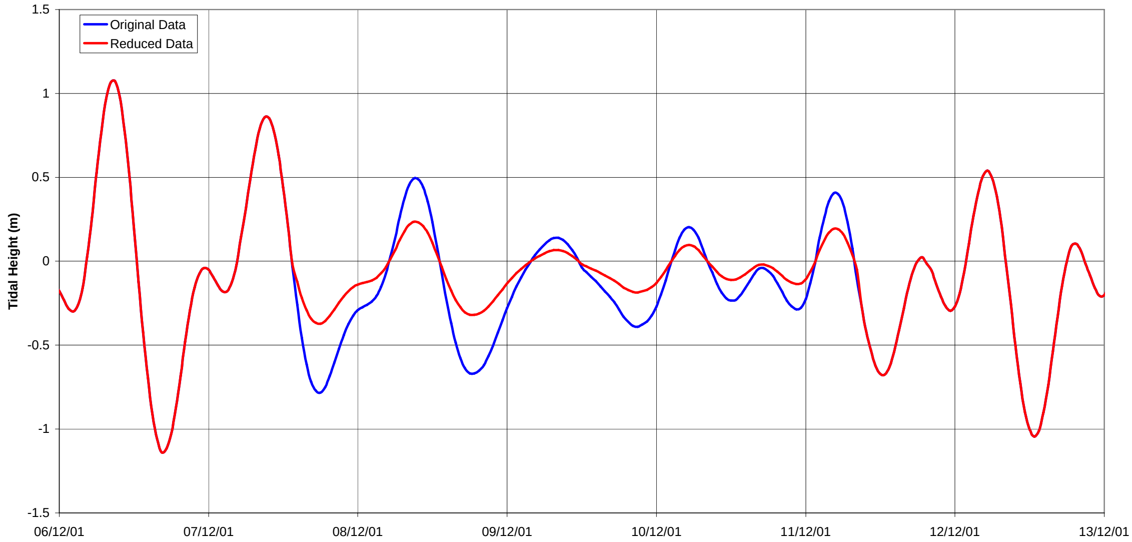


Figure 3-83 Original and Reduced Tidal Boundary Conditions – Period 1

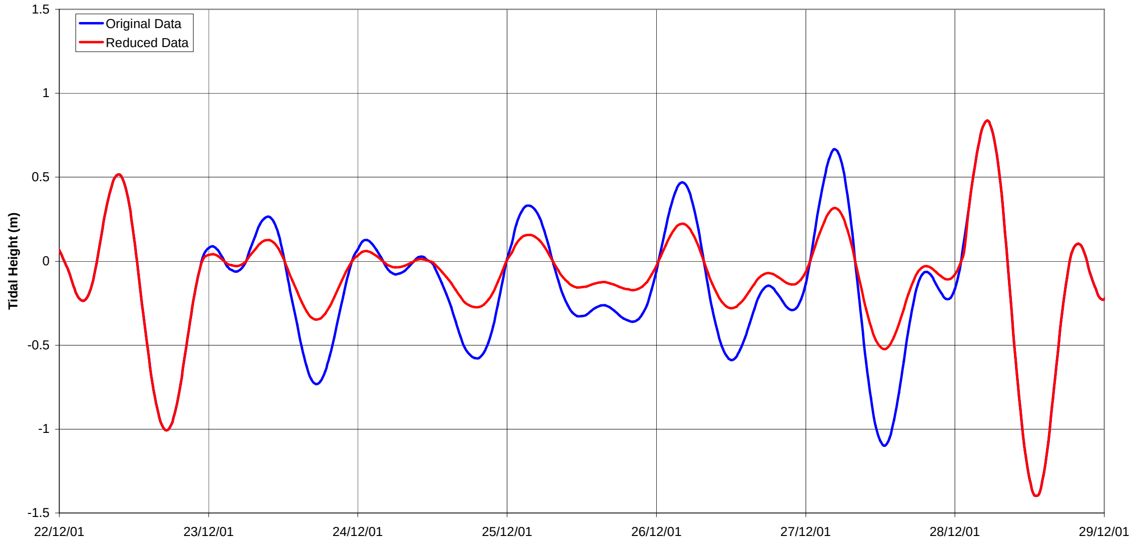


Figure 3-84 Original and Reduced Tidal Boundary Conditions – Period 2

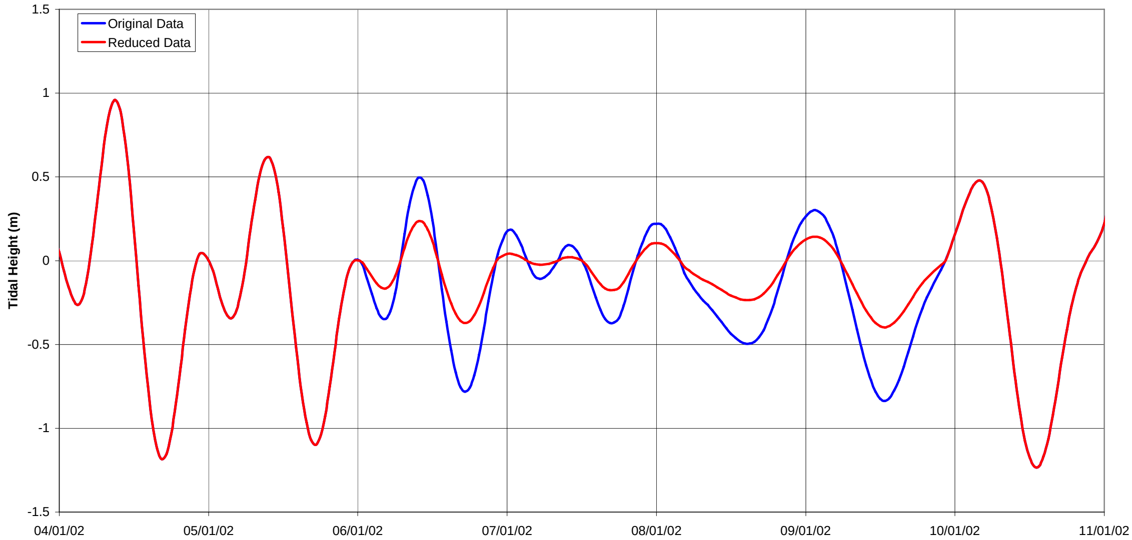


Figure 3-85 Original and Reduced Tidal Boundary Conditions – Period 3

In order to provide some context for the reductive tidal factor, the short duration of tidal timeseries that partly motivated the selection of the 0.476 factor has been plotted over the top of the timeseries presented in Figure 3-85 (note the different axes limits in Figure 3-86). This (real) tidal timeseries is from an alternative time period, so has been artificially shifted in time to best suit the tidal phase and shape of the data in Figure 3-85. All three data sets are provided in Figure 3-86, with the shifted supplementary data presented in green.

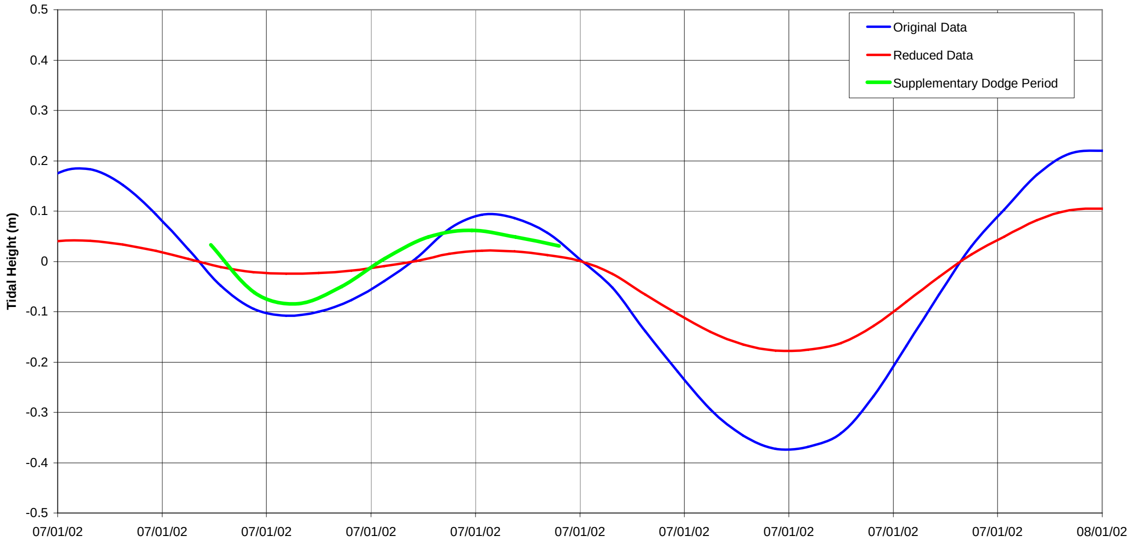
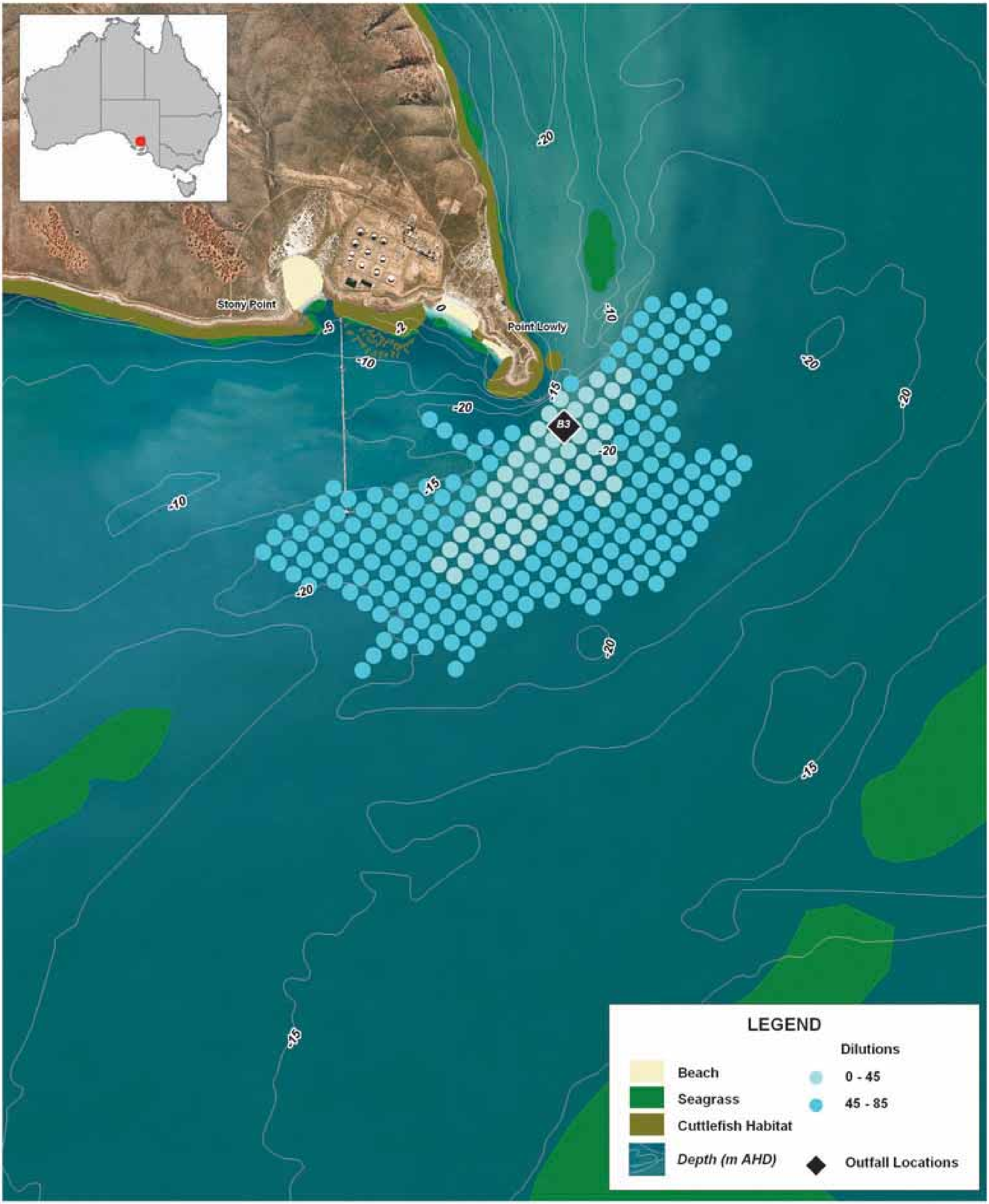


Figure 3-86 Original and Reduced Tidal Boundary Conditions with Supplementary Tidal Data (Temporally Shifted) – Period 3

The figure shows that the selected multiplier (red timeseries) provides a considerable reduction in tidal amplitude, even when compared to the supplementary dodge period, and as such the synthesized tidal boundary is likely to provide very conservative (i.e. in terms of spatial plume extents) estimates of the 'worst case' scenario.

The 0th, 1st, 10th and 50th percentile dilutions contour maps are presented in Figure 3-87 to Figure 3-90, respectively. These are mid field results only, i.e. they are not combined with the far field long term average data.



Title:

Simulation 07_6: 40 Day 0th Percentile with Reduced Neap Tidal Amplitude

Figure: 3-87

Rev: A

Air photo from Google Earth.

N

0 1 2km

Approx. Scale

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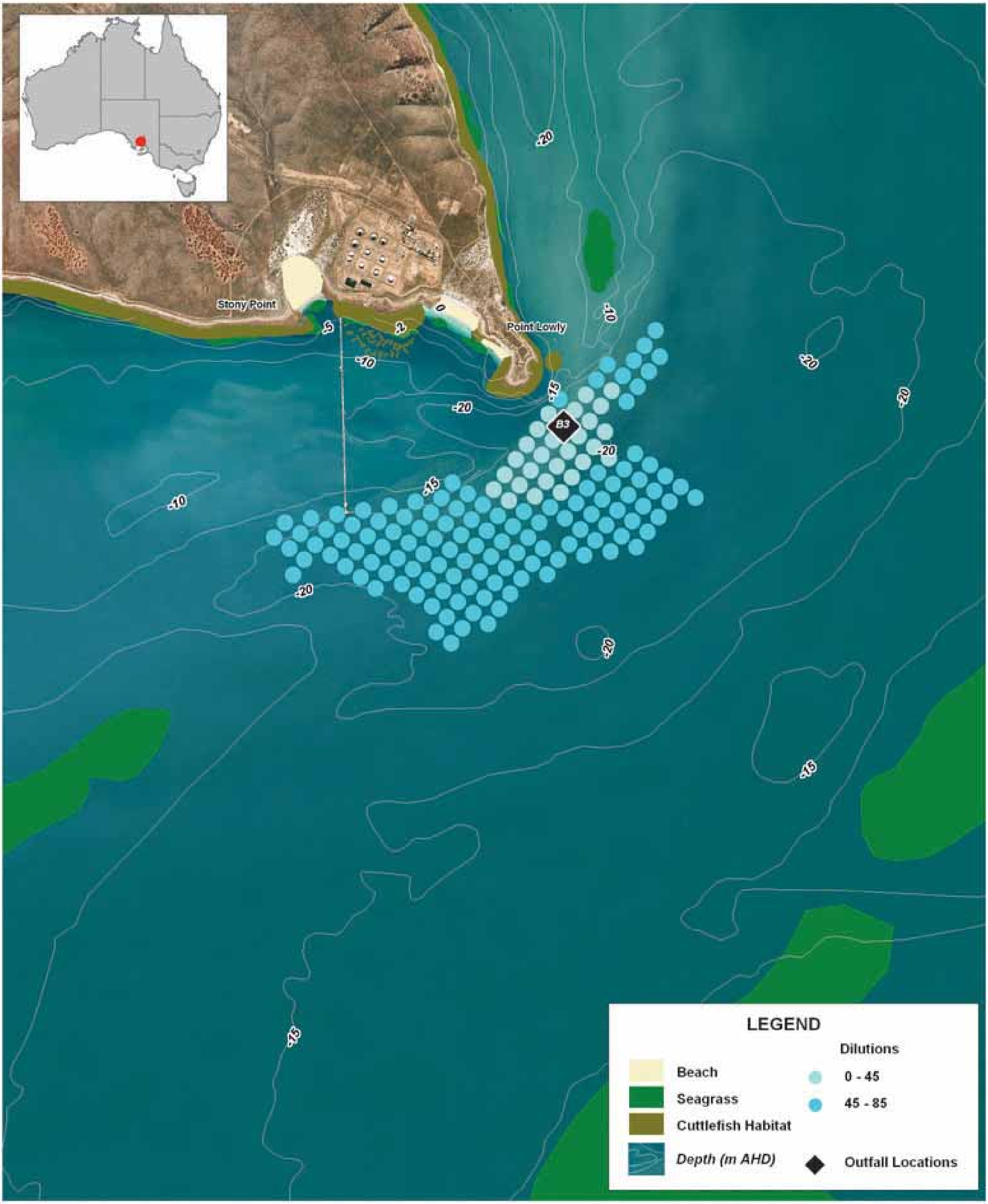
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_253_080730_07_6_40days_reduced_tide_0.WOR



Title:
Simulation 07_6: 40 Day 1st Percentile with Reduced Neap Tidal Amplitude

Figure: 3-88

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. It does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

Air photo from Google Earth.

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Approx. Scale

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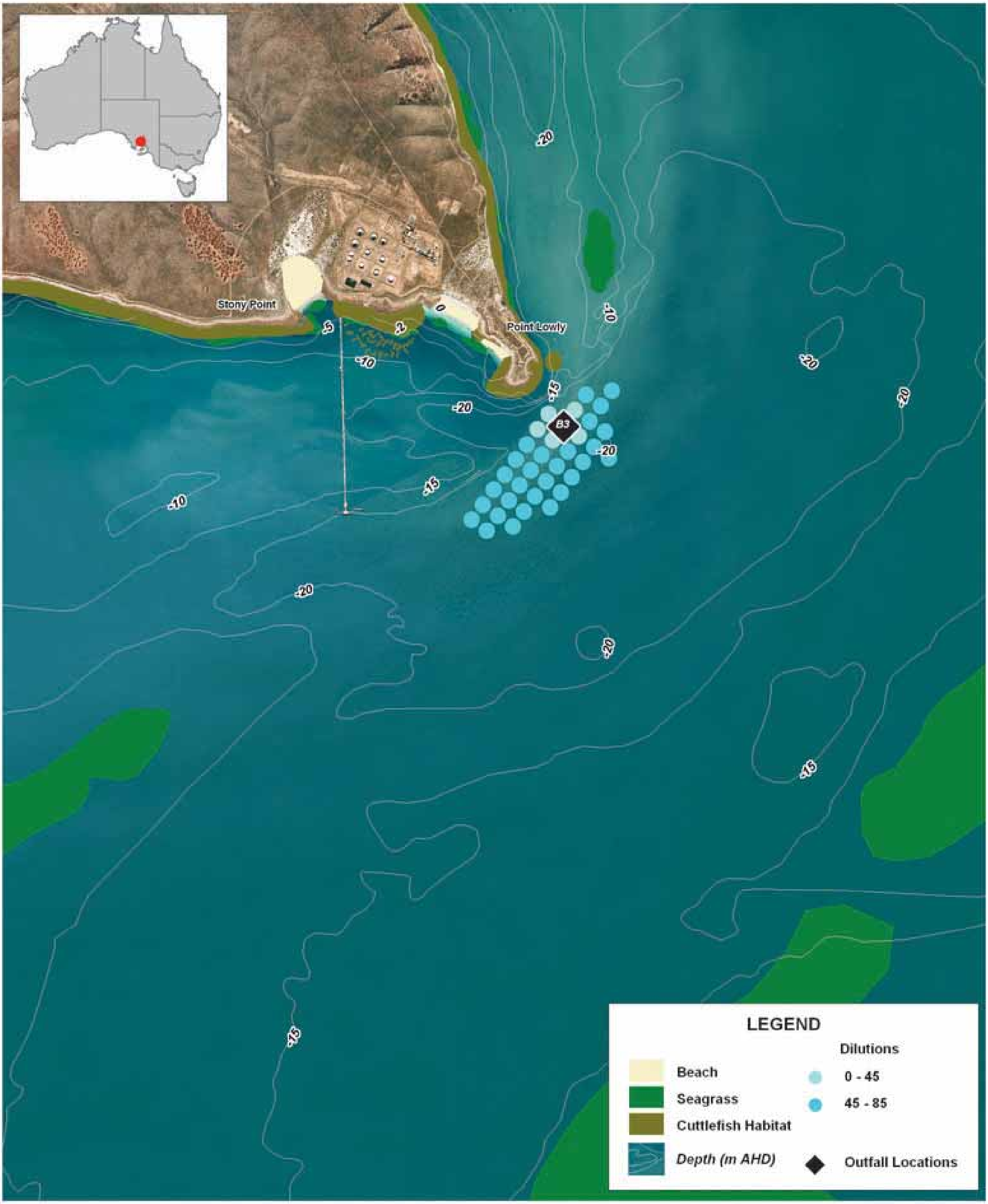
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_254_080730_07_6_40days_reduced_tide_1.WOR



Title:
Simulation 07_6: 40 Day 10th Percentile with Reduced Neap Tidal Amplitude

Figure: 3-89

Rev: A

N

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Approx. Scale

BMT WBM
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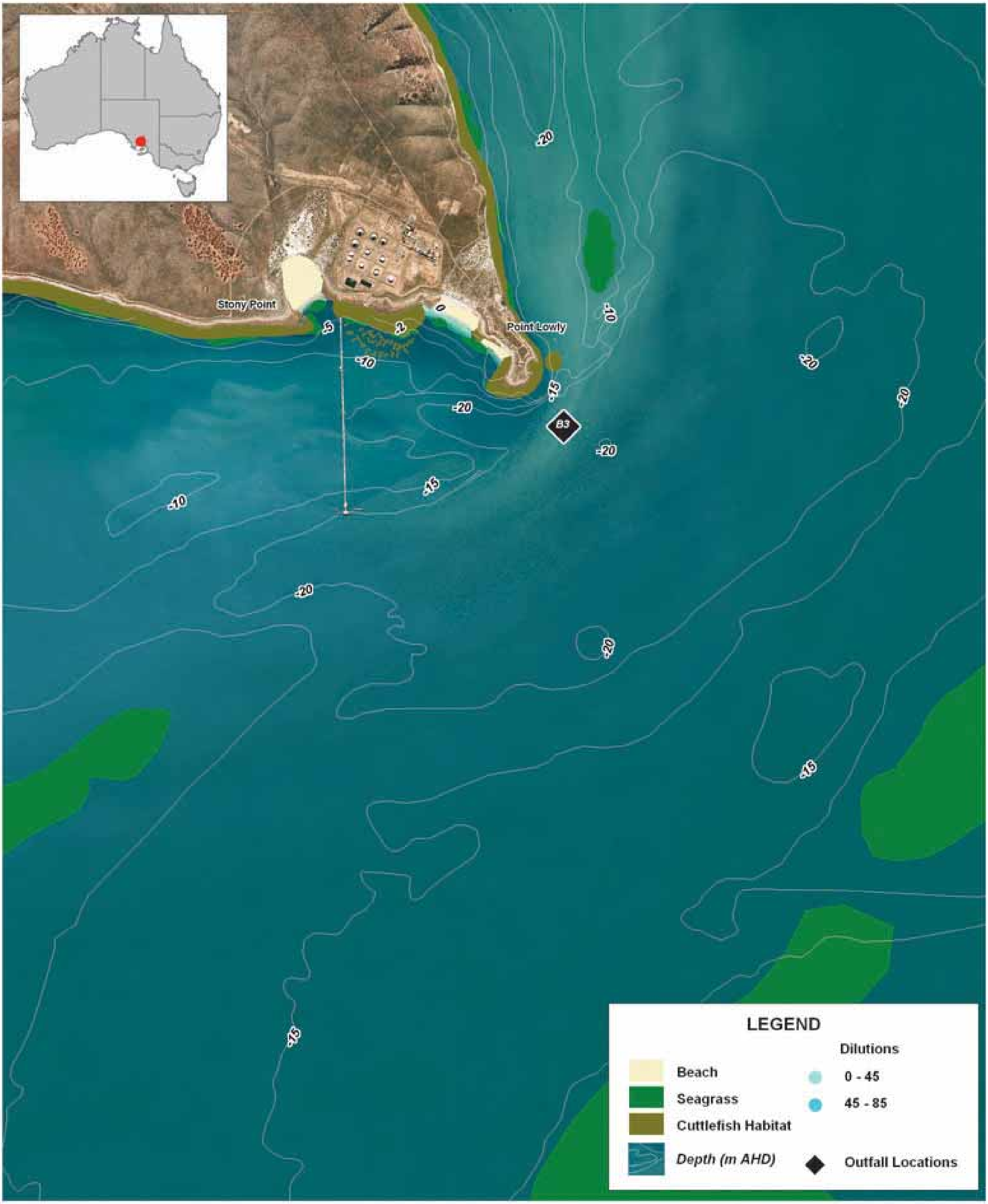
Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_255_080730_07_6_40days_reduced_tide_10.WOR



Title:
Simulation 07_6: 40 Day 50th Percentile with Reduced Neap Tidal Amplitude

Figure: 3-90

Rev: A

Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_256_080730_07_6_40days_reduced_tide_50.WOR

To provide comparison with previous simulations, the above data are re-presented in Figure 3-91, with the original 40 day results overlain. Only the 1:85 contours have been presented for clarity.

3.5.3 Gulf Wide Water and Salt Balances

The far field ELCOM model was interrogated to provide estimates of the long term water and salt fluxes through Spencer Gulf. The salt and water analyses were considered separately and are described below.

3.5.3.1 Water Balance

The far field ELCOM model was re-executed and two new parameters output at each 50 minute timestep. These were:

- Evaporative volume flux over the entire water surface; and
- Total volume of water in the Gulf.

Other fluxes of water were sourced either from model input data or data banks. These were:

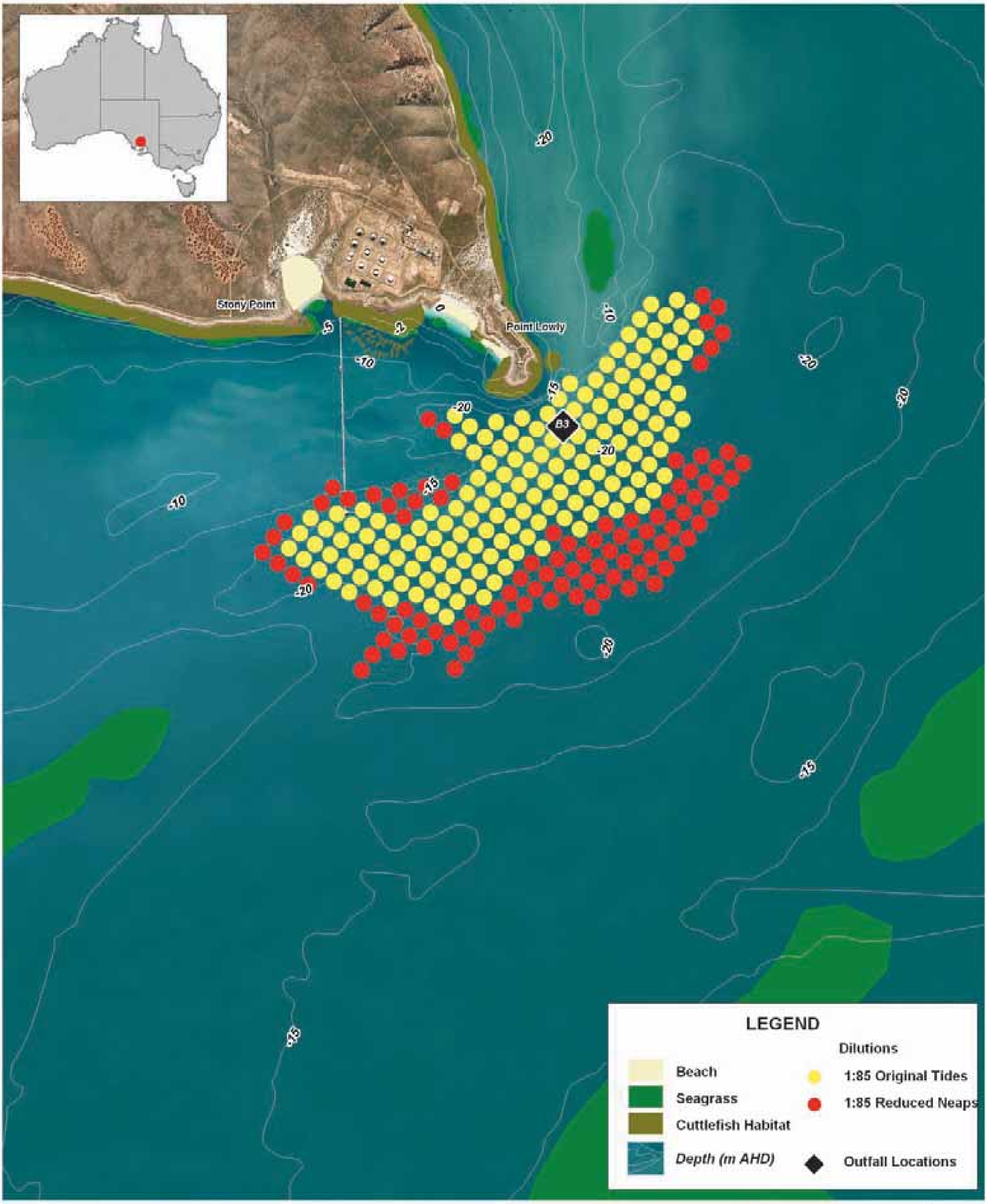
- Rainfall;
- Inflows; and
- Desalination plant extractions.

All of the above were combined in a water balance analysis to estimate the following Gulf wide volumetric fluxes on a long term average basis:

- Evaporative;
- Rainfall;
- Tidal exchange (both in and out of the Gulf);
- Catchment inflows; and
- Desalination plant extractions.

A representative two-year period was selected for this analysis. Results are presented in both timeseries and tabular format as appropriate.

Timeseries data present temporal variations of flux volumes on a model timestep by timestep basis. Negative and positive fluxes are respectively in and out of the model domain. Tabular data are presented both as total *annual* volumetric fluxes (in gigalitres, GL) and corresponding long term equivalent flow rates (m^3/s). The accuracy to which these tabular values are reported reflects the inherent uncertainty in such an analysis, and the natural variability in the system. Further, the very large difference in magnitude of these numbers (for example, the magnitude of inflow volumes is comparable to, or smaller than, the uncertainty and variability in the volumetric tidal exchange), precludes reporting to an exact balance in a numerical sense, and the data should be treated as such.



Title:

Simulation 07_6: 40 Day 0th Percentile Original and Reduced Neap Tidal Amplitude 1:85 Contours.

Figure: 3-91

Rev: A

Air photo from Google Earth.

N

0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_261_080801_07_6_40days_both_tides_0_NoFarField.WOR

Tabular data are best interpreted as order of magnitude estimates that provide a context for the overall water balance in the Gulf.

The following timeseries data are presented for the two year period:

- Volumetric evaporative flux (GL/s);
- Volumetric tidal flux (GL/s); and
- Total water volume in Spencer Gulf (GL).

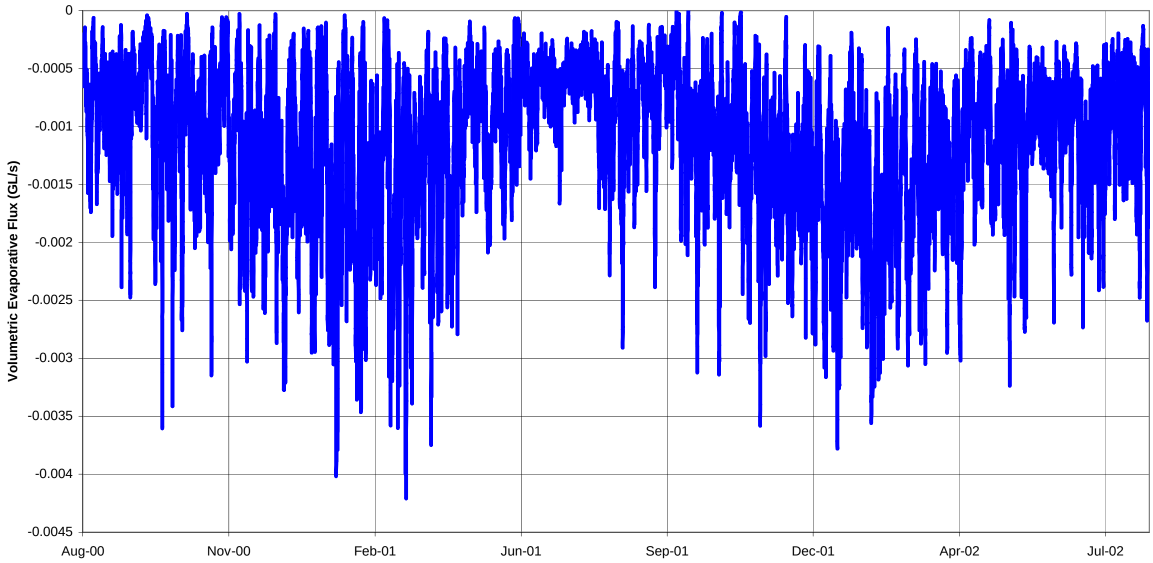


Figure 3-92 Volumetric Evaporative Flux (GL/s)

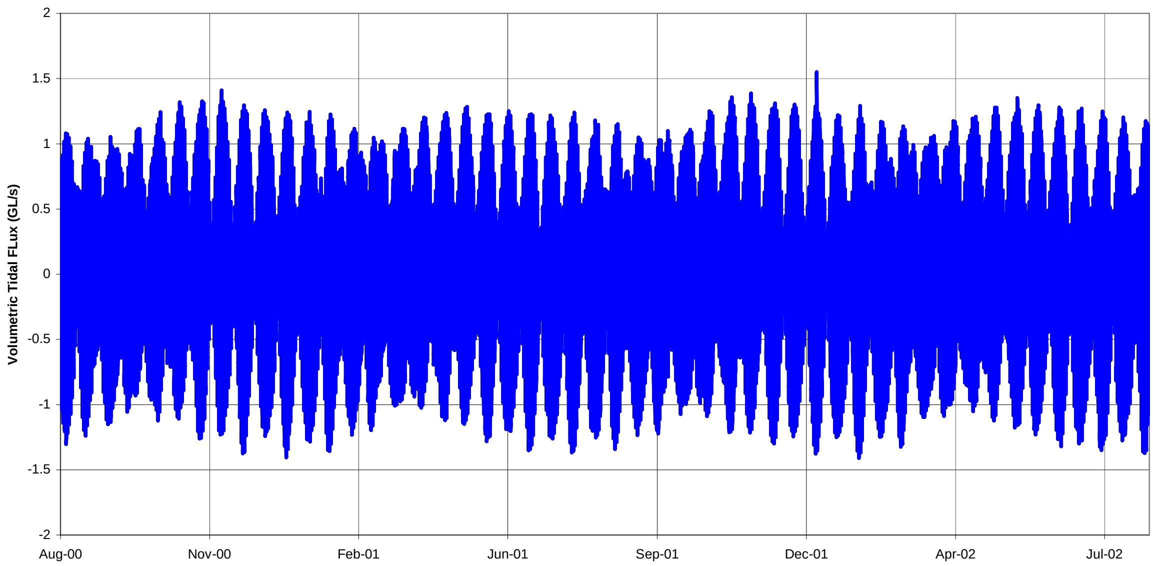


Figure 3-93 Volumetric Tidal Flux (GL/s)

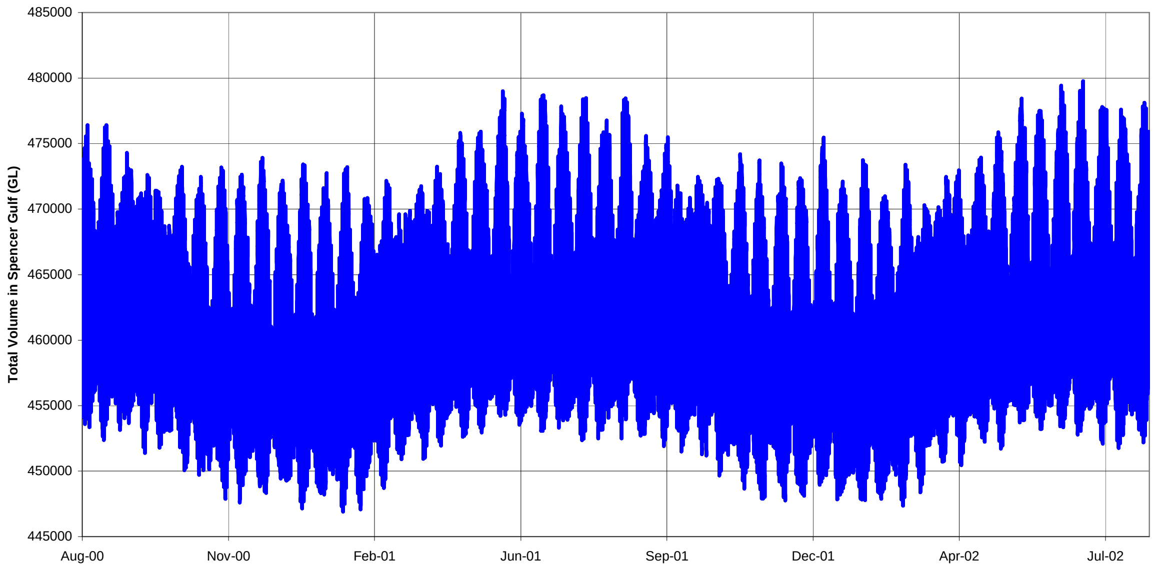


Figure 3-94 Total Water Volume in Spencer Gulf (GL)

The figures show a clear seasonal trend in evaporative losses, as expected, and an intra-annual variation in total water volume (but by 10% at most) in response to low frequency tidal boundary harmonics. Tabular data are presented below.

Table 3-15 Water Fluxes through Spencer Gulf

Flux Item	Total Annual (GL)	Equivalent Flow Rate (m^3/s)
Evaporative	-36,000	-1000
Rainfall	5,000	200
Tidal Inflow	7,092,000	225,000
Tidal Outflow	-7,053,000	-224,000
Catchment Inflows	5	0
Desalination Plant Extraction	-220	-7
Desalination Plant Return	120	4

The data are consistent with a net tidal flux of water into Spencer Gulf, and this approximately matches net evaporative losses. Clearly there is natural (and stochastic) variability in rainfall inputs. It is noted that the net tidal exchange (~1,000 m^3/s) is extremely small when compared to the range of inflows and outflows from which it is derived, with the former being some 0.2% of the latter.

3.5.3.2 Salt Balance

The same far field ELCOM model was used to assess the Gulf wide salt balance. In addition to the water balance outputs, average salinity across the model domain was output from the ELCOM model at each timestep to facilitate this assessment.

All data were combined in a salt balance analysis to estimate the following mass fluxes on a long term average basis (noting that the desalination plant operation does not result in a net salt flux in or out of the Gulf):

- Tidal exchange (both in and out of the Gulf); and
- Catchment inflows.

The same representative two-year period was selected for this analysis. Results are presented in both timeseries and tabular format as appropriate, as before, with the same restrictions on reporting accuracy.

Timeseries data present temporal variation of mass fluxes on a model timestep by timestep basis. Negative and positive fluxes are again respectively in and out of the model domain. Tabular data are presented as total *annual* mass fluxes (in gigatonnes of salt, Gt).

The following timeseries data are presented for the two year period:

- Average salinity (g/L);
- Total salt mass in Spencer Gulf (Gt); and
- Tidal mass flux (t/s).

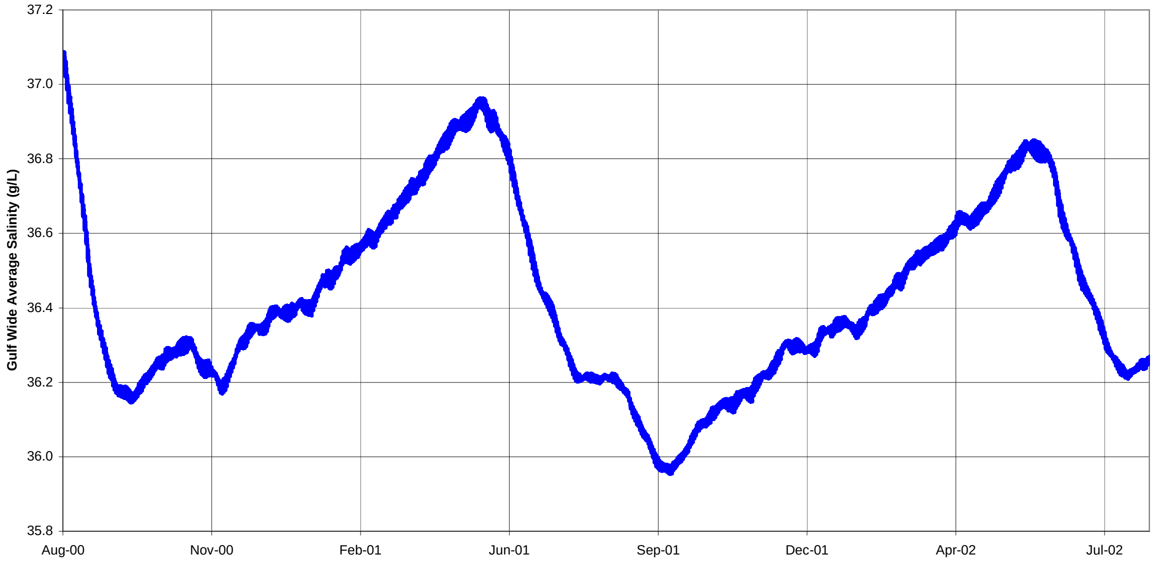


Figure 3-95 Average Salinity in Spencer Gulf (g/L)

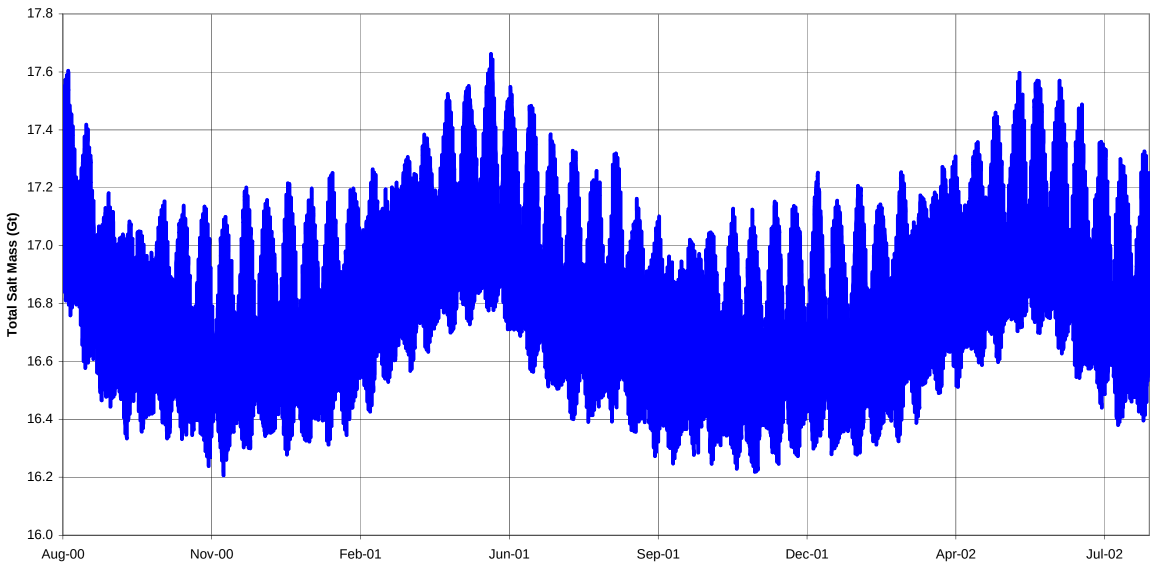


Figure 3-96 Total Salt Mass in Spencer Gulf (Gt)

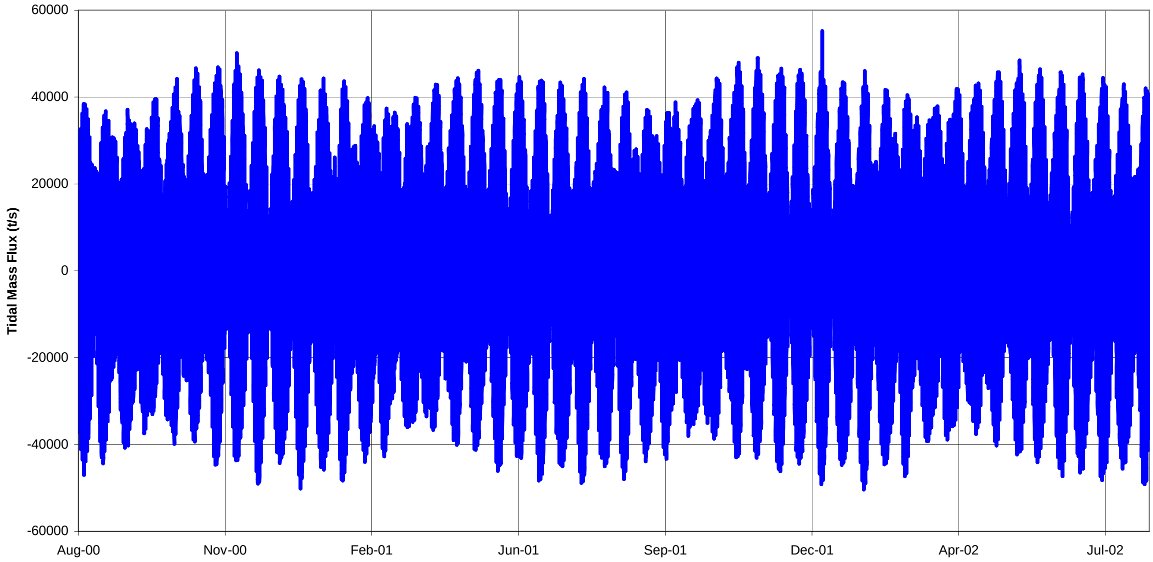


Figure 3-97 Tidal Mass Flux (t/s)

The figures show a clear seasonal trend in average salinity and total salt mass, consistent with a build up and ejection of salt, as discussed in previous sections. Notably, the relatively rapid drop off in total salt mass occurs in late autumn to early winter, which is the same time the saline ejection mechanism operates from north to south. For this mechanism to operate, seasonal variations in salt exchange across the boundary must occur. Such variations are not evident in Figure 3-97 as it is presented, primarily because tidal fluctuations mask seasonal changes. As such, the tidal exchange data were run through a 2-month window moving average (i.e. quasi-low pass filter) process. The corresponding filtered data are presented in Figure 3-98.

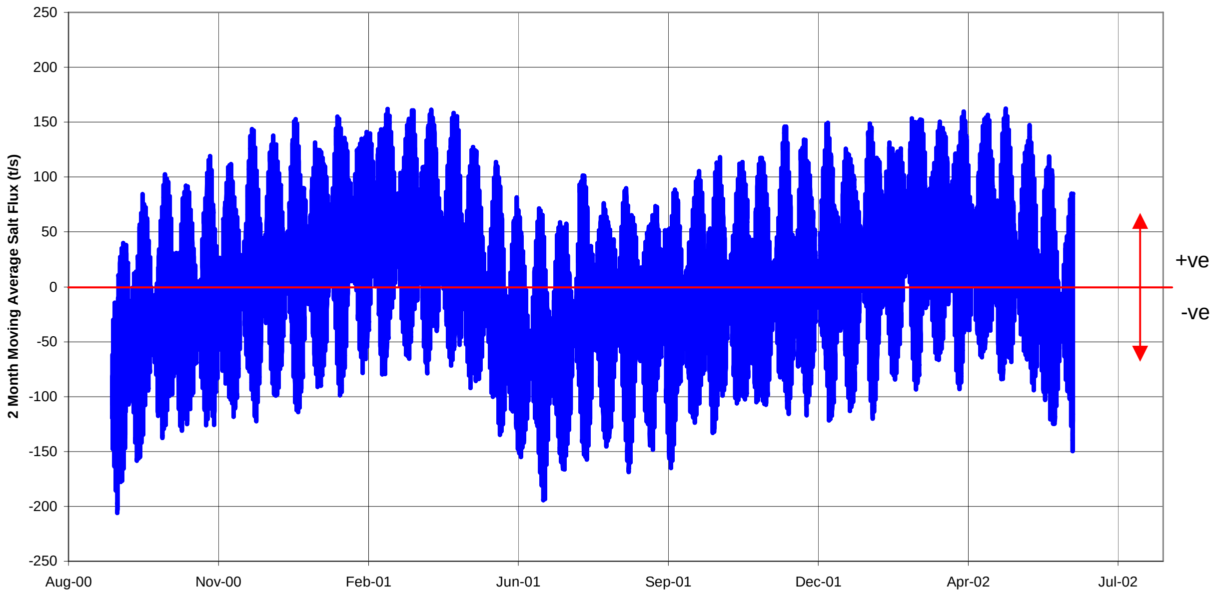


Figure 3-98 Two-Month Filtered Tidal Mass Flux (t/s)

Clearly the magnitude of the fluxes reduce relative to the unfiltered case (as is expected following low pass filtering), however the seasonal trend in flux is clear. Noting that negative fluxes are out of the system, Figure 3-98 shows strong negative fluxes developing in late autumn to early winter (i.e. ejection of salt) and a gradual return to positive fluxes (i.e. salt renewal by tidal action) by early summer, when salt buildup in the northern Gulf area generally commences.

Tabular data are presented below, with the same presentation accuracy limitations as applied to the water balance analysis.

Table 3-16 Salt Fluxes through Spencer Gulf

Flux Item	Total Annual (Gt)
Evaporative	0
Rainfall	0
Tidal Inflow	250
Tidal Outflow	-250
Catchment Inflows	0
Desalination Plant Extraction	<0.01
Desalination Plant Return	<0.01

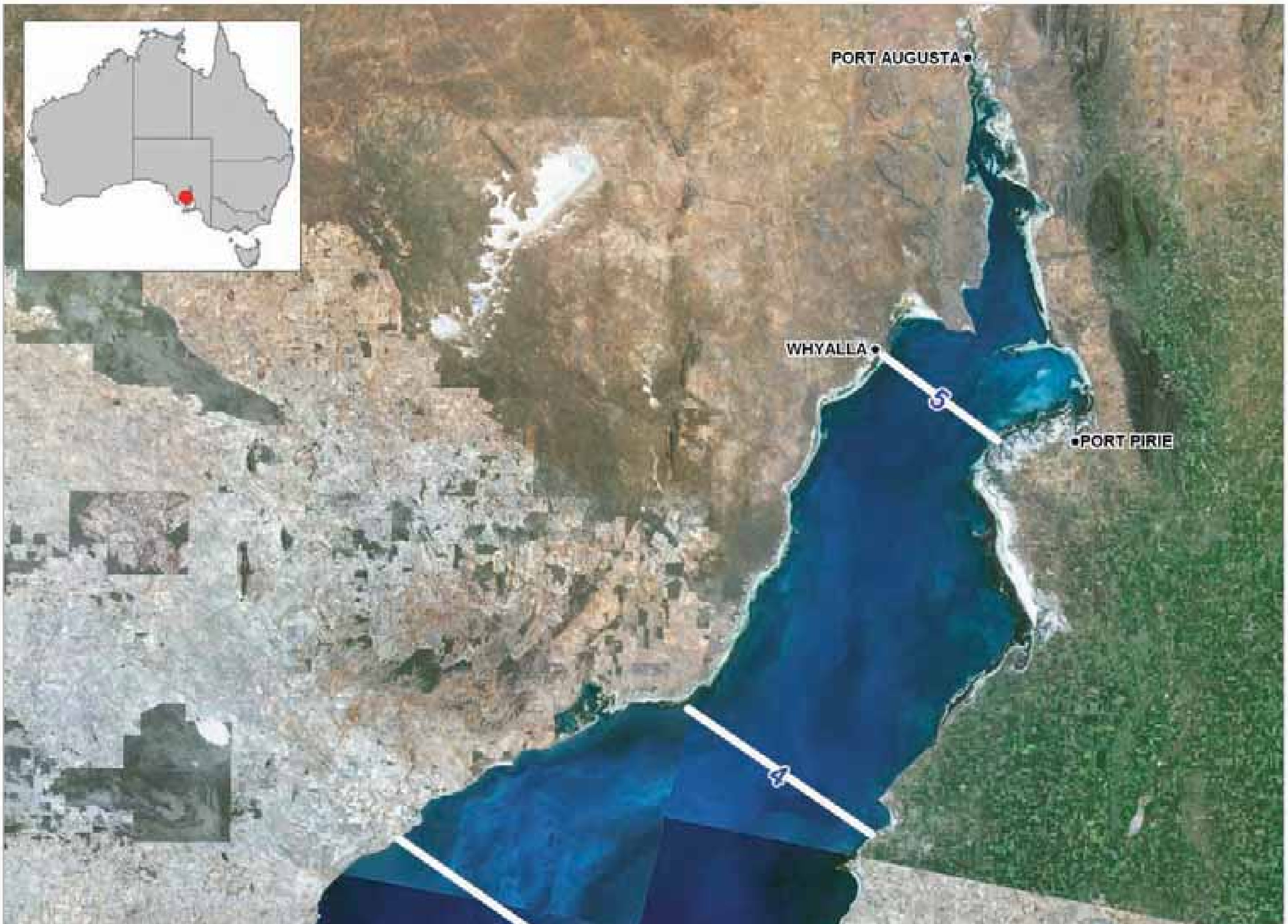
The table suggests zero net flux of salt across the tidal boundary, on an annual basis (with catchment inflows being effectively zero). This is in turn consistent with the e-folding, retention time and salt ejection analyses, which all suggest that the Gulf operates on an approximately annual cycle in terms of its' hydrodynamics. It is noted that the estimate of 250 Gt salt mass flux in and out of the system does not imply that the salt mass of Spencer Gulf (which is approximately 17 Gt) it turned over approximately 15 times a year. This is because effectively the same salt can advect back and forth across the southern tidal boundary, and each time this occurs the fluxes in each direction increase, but also cancel when combined.

Finally, the filtered data presented in Figure 3-98 was integrated in time over an annual period to estimate the nett incoming and outgoing salt masses (as opposed to total fluxes presented in Table 3-16). The analysis showed that between the start of November and the middle of May the following calendar year, approximately 500 million tonnes of salt enters Spencer Gulf at typical seawater concentrations. Throughout the remainder of the annual period (i.e. middle of May to November in the same calendar year), the same mass of salt leaves the system, generally at elevated salinities representative of Upper to Mid Gulf conditions. It is noted that this nett mass flux is consistent with the annual variation in salt mass within Spencer Gulf, as presented in Figure 3-96 (i.e. 0.5 Gt).

3.5.3.3 Internal Fluxes

The above analysis has presented the Gulf-wide water and salt balance. In order to provide some estimate of the fluxes of salt internally through the Gulf, data were extracted for several 'east-west' curtains (in rotated model space) and timeseries of water volume and salt mass fluxes computed. The locations of these curtains are shown in Figure 3-99.

Timeseries data for both volumetric water flux and total salt mass flux are shown in Figure 3-100 and Figure 3-101, respectively. In order to provide contrast with the previous section, the calendar year of 2004 was analysed to this end.



Title:

Location of Internal Flux Lines

Figure: 3-99

Rev: A

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0 30 60km

Approx. Scale

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Filepath : I:\B16750_I_GML_Olympic_Dam_Desal_Modelling_SCN_027_ABM\DRG\WQU_287_080815_Internal Flux Lines.WOR

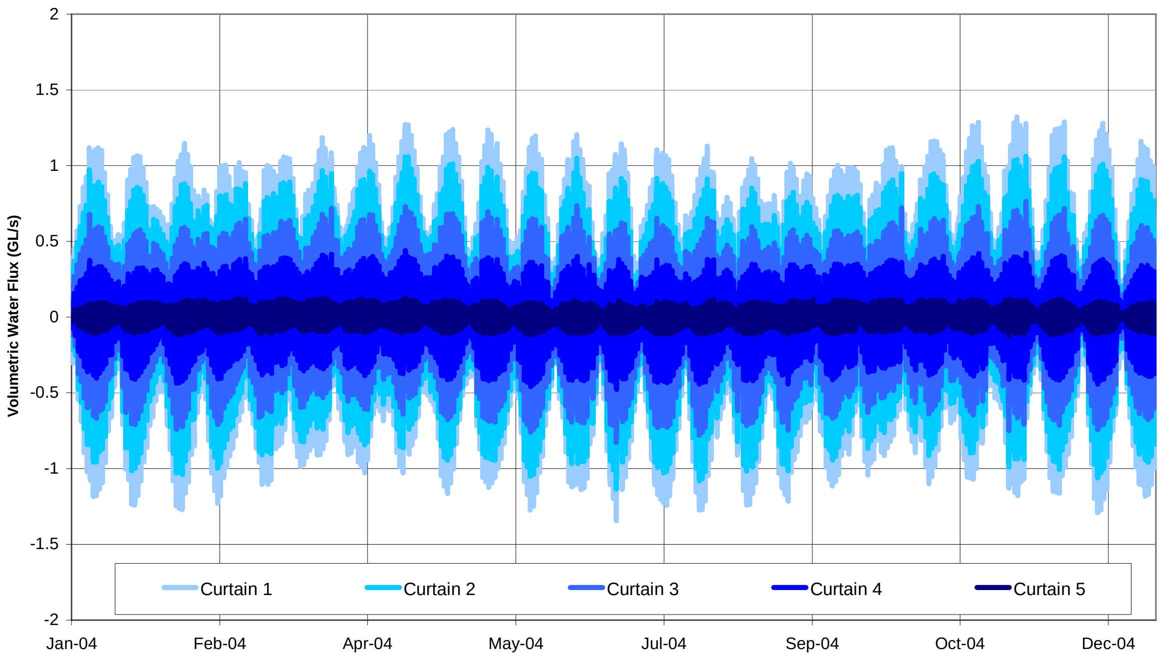

Figure 3-100 Volumetric Water Flux (GL/s)

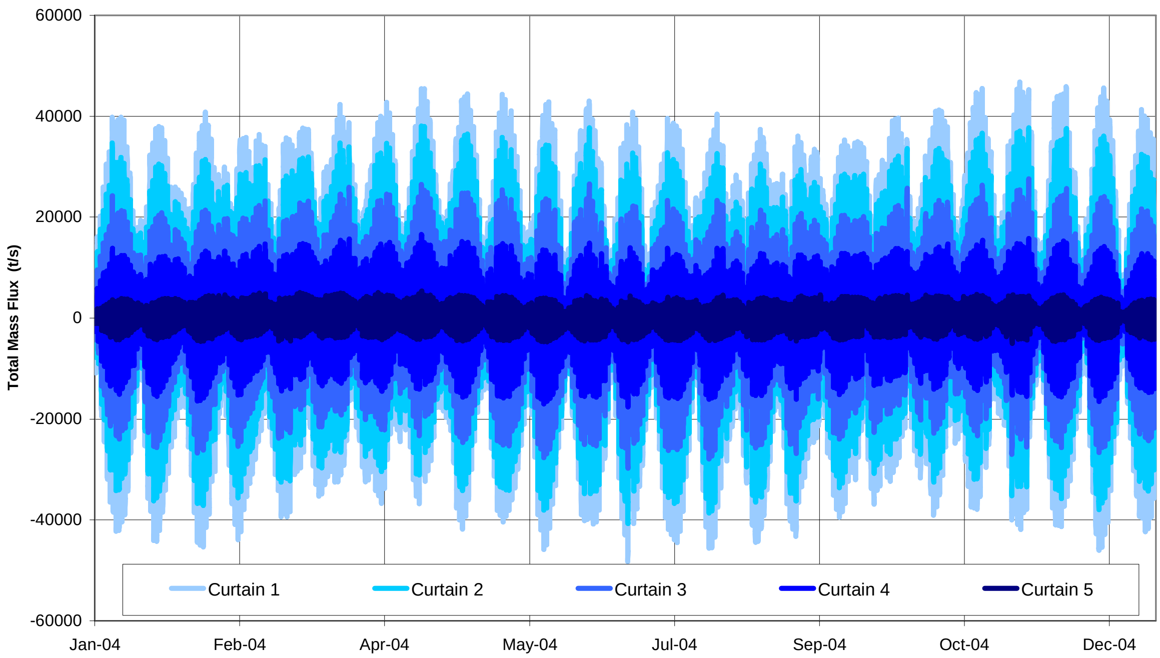

Figure 3-101 Total Salt Mass Flux (t/s)

The figures are consistent with a decrease in both water volume and salt mass fluxes with increasing distance from the open boundary, as expected. In addition, the figures indicate a reduction in the tidal influence on these fluxes, both on spring-neap and intra-annual timescales.

3.5.4 Potential Impacts of Climate Change

The base case far field model was re-run with ambient air temperature in the forcing meteorological data increased by a uniform 2 degrees Celsius for all time. This increase was selected based on Suppiah et al. (2006). Following are timeseries of salinity at four representative locations within the far field Spencer Gulf model, as shown in Figure 2-4. The timeseries are presented together with those from the base case to allow visual comparison.

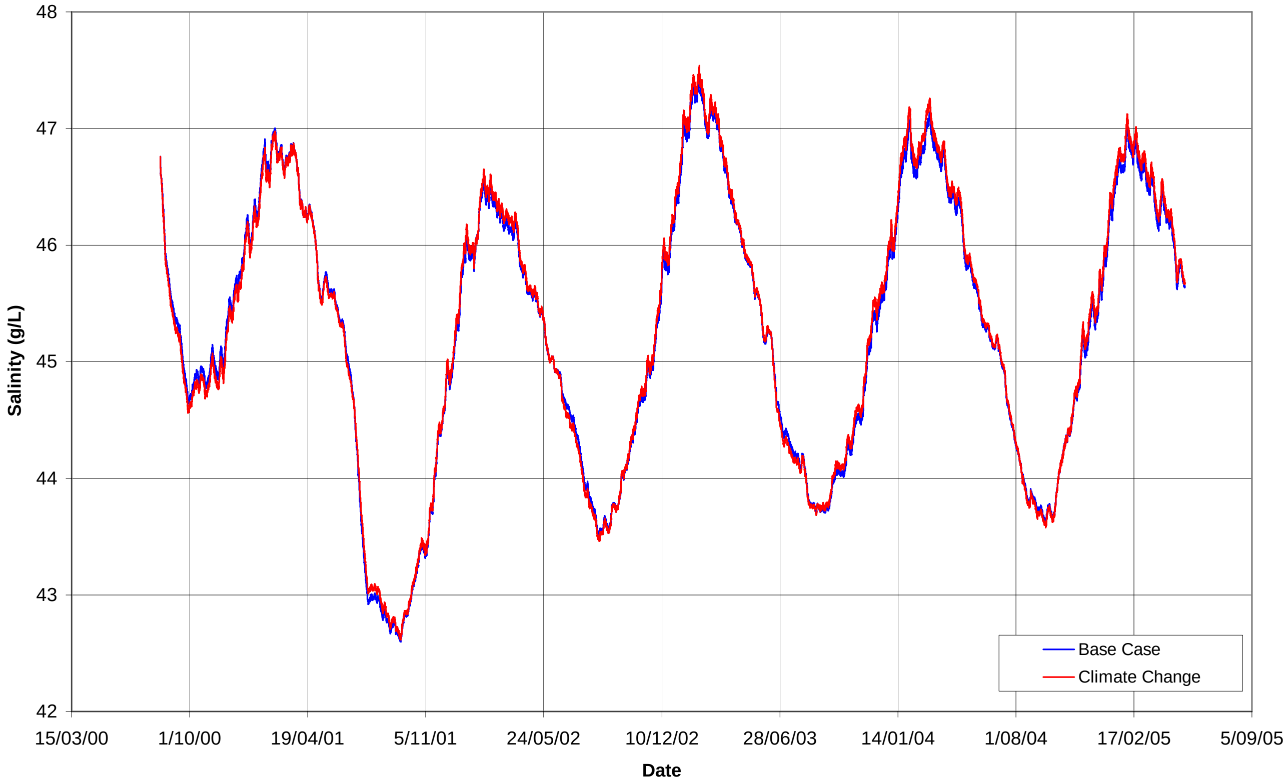

Figure 3-102Salinity at Model Location 2-10

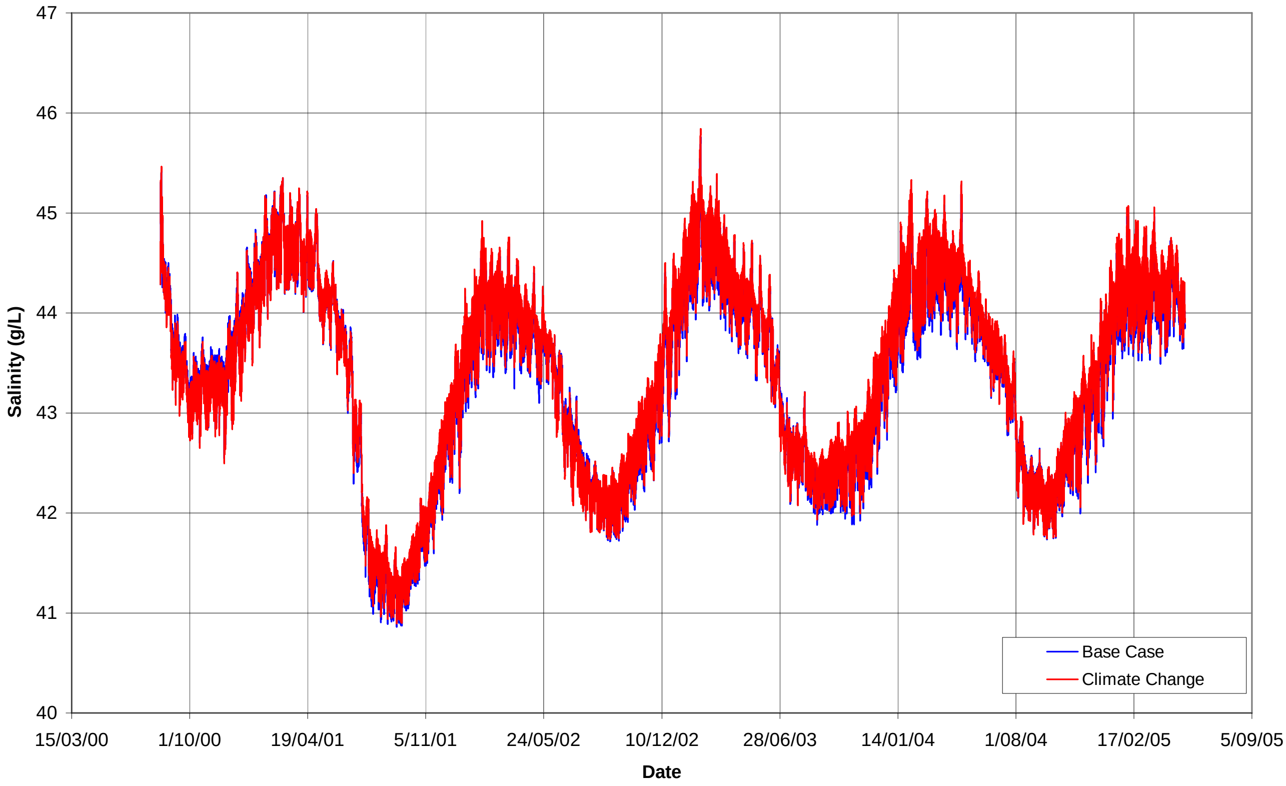

Figure 3-103 Salinity at Model Location 9-15

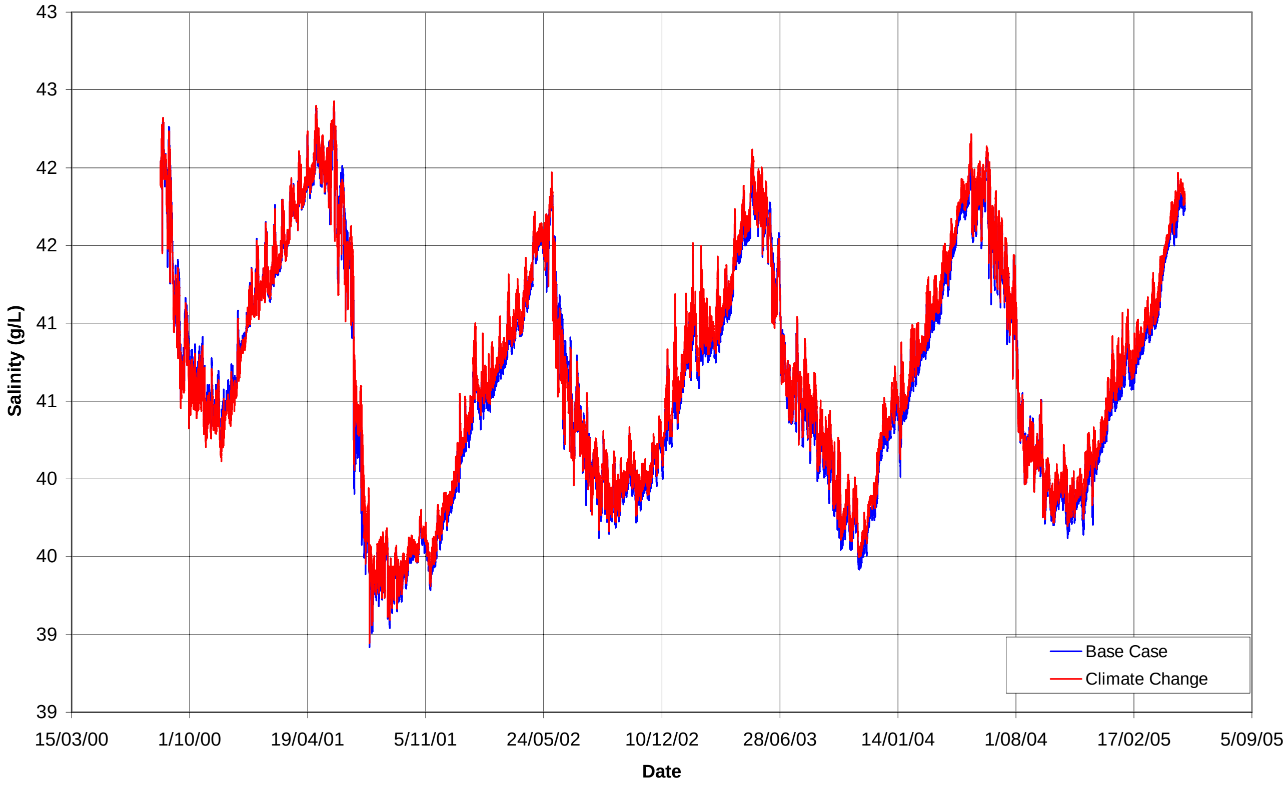

Figure 3-104 Salinity at Model Location 24-22

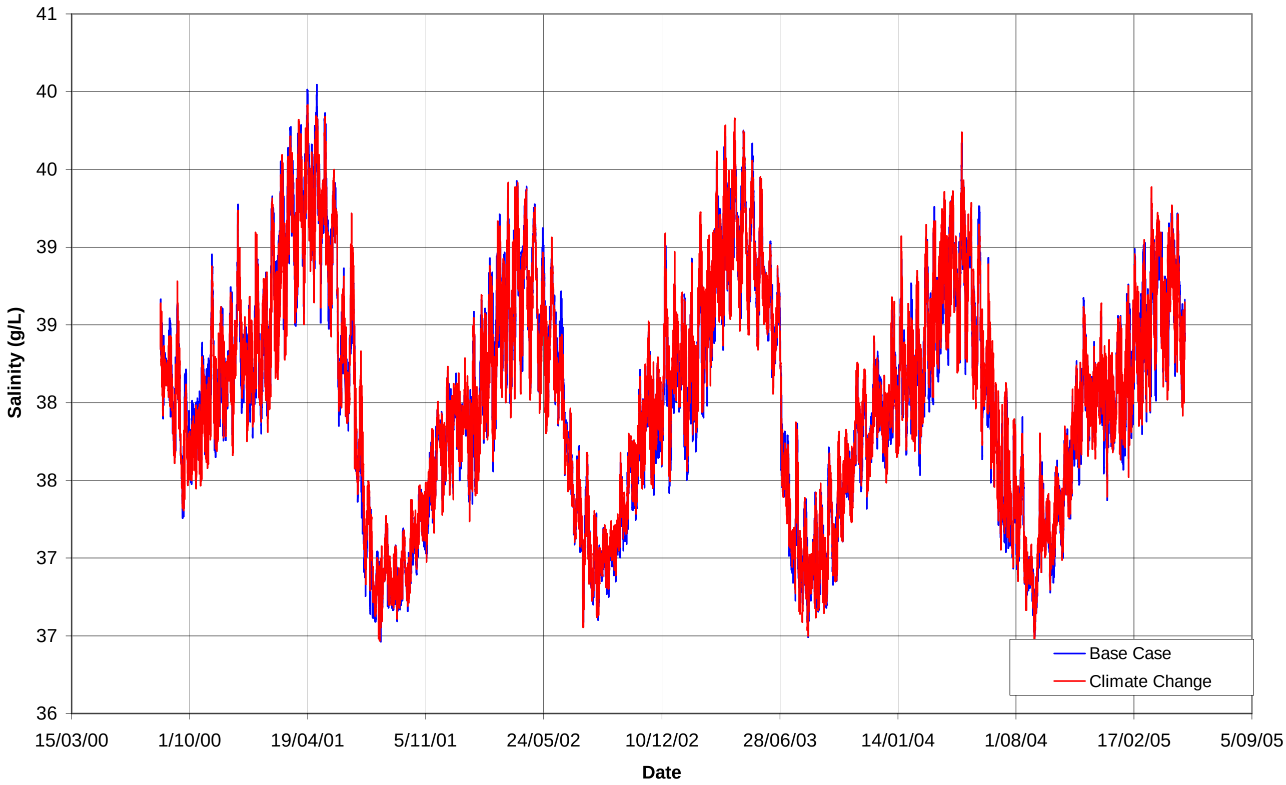

Figure 3-105 Salinity at Model Location 69-35

The figures show that in this analysis, the influence of climate change (as simulated via a 2 degree increase in ambient air temperature) is to increase ambient salinities. The absolute and percentage long-term average salinity increases for each site (compared to the base case) are presented in the following tables.

Table 3-17 Salinity Difference Statistics – Absolute

Location	Long Term Average Salinity Difference (g/L)
2-10	0.02
9-15	0.04
24-22	0.03
69-35	0.01

These are expressed as percentages of the long term average ambient salinity (Base Case) at each location in Table 3-18.

Table 3-18 Salinity Difference Statistics – Percentage

Location	Long Term Average Salinity Difference (%)
2-10	0.04
9-15	0.09
24-22	0.08
69-35	0.01

It is noted that further climate change analysis can be undertaken as higher temporal and spatial resolution meteorological data and progressively more complex and/or detailed climate alteration algorithms become available.

4 REFERENCES

Suppiah, R, Preston B., Whetton, P. H., McInnes, K. L., Jones, R. N., Macadam, I., Bathols, J. and D. Kirono. 2006. Climate change under enhanced greenhouse conditions in South Australia. *CSIRO Marine and Atmospheric Research.*

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