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Grange Resources

Report for Cape Riche Seawater Desalination Plant

Cheyne Bay Marine Habitat Assessment

August 2011

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The services undertaken by GHD in connection with preparing this Report:

- *were limited to those specifically detailed in section 1.2 of this Report;*
- *did not include detailed benthic habitat assessment of the proposed Southern Ocean Brine Discharge location because of safety considerations regarding the highly energetic ocean environment, but was limited to the region of the proposed seawater intake channel.*

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report ("Assumptions"), including (but not limited to):

- *Though brine discharge impacts are expected to be minimal to the benthic habitat of the Project Area in general and Cheyne Bay in particular, any potential impacts are likely to be in the western portion of the Bay, hence the focus of the assessment was in this region; and*
- *Any impacts associated with the development of the proposed seawater intake open channel will be limited to the western portion of the Bay.*

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Executive Summary

A 12 GL/y desalinisation plant is proposed by Grange Resources to provide water for their proposed 'Southdown' mine near Wellstead, Western Australia. The proposed location for the brine discharge is along the exposed southern shore of Cape Riche while the seawater intake will be an open channel along the southern shoreline of Cheyne Bay. Given the presence of known benthic primary producer habitat in Cheyne Bay (e.g. seagrass, macroalgae), several field surveys were carried out to characterise the benthic habitat of the study area.

Three marine habitat field surveys were carried out, the first was from the 14th to the-16th of February 2011, the second on the 6th of April 2011 and the final on the 14th of July 2011. These field investigations included ground truth surveys of areal seagrass distribution estimates from photographic aerial imagery, subtidal SCUBA and snorkel transects, and intertidal and shoreline assessments. Most of these studies focused primarily in the southern extent of Cheyne Bay, but also considered the brine discharge location along the southern shore of Cape Riche.

Seagrass was the dominant benthic primary producer habitat in the study area. The dominant seagrass types were *Posidonia* and *Amphibolis*, with lower percentage coverage of *Halophila*. Within the Cheyne Bay study area of 135.5 ha, 15.9 ha was high density (>80% coverage) seagrass and 27 ha was moderate density (10-80% coverage) seagrass. Most of the estimated 'sand' habitat of the 92.6 ha was typically bare or low density (<10%) seagrass. Fish were abundant in the dense seagrass meadows and sparse (if any) in the sand habitat.

Parallel to the southern shoreline of Cheyne Bay two habitat types were surveyed between the intertidal zone and sand habitat. Healthy hard corals were identified from the families Dendrophyllidae (plate coral) and Faviidae. An outcrop of several large boulders was densely covered in plate coral in the south eastern extent of the study area in relative proximity to the shoreline. Generally, coral habitat was associated with many fish species. A decrease in hard coral density and size was observed along a westerly transect from the hard coral outcrop to the interface with the second dominant habitat type, namely a boulder-reef-macroalgae mosaic. Between the low water mark and the sand habitat to the west of the hard coral habitat, the boulder-reef-macroalgae habitat was primarily characterised by brown macroalgae species with some occasional red and green macroalgae.

The intertidal zone of the bay was rocky for nearly the entire length of the southern shoreline and was approximately 10-15 m wide. The intertidal zone was mostly barren of colonial organisms (e.g. oysters) though occasional boulders contained large congregations of a marine snail (*Turbo undulates*). Several shore crab species were observed. Rock pools had various green and brown macroalgae.

The rocky coastline in the vicinity of the proposed brine discharge was observed to transition to a mosaic of reef, sand and macroalgae habitat several metres from the shoreline and then to sand. No seagrass were observed.

The pumping station will be located near to the seawater intake and will be constructed to have minimal (if any) noise impacts on marine fauna. The brine discharge will be a passive gravity driven system in the proximity of the marine receiving environment and will not have any noise impacts on marine fauna.

Hydrodynamic modelling predicts that the dilution of brine along the seabed will be over 90-fold prior to transport to the tip of Cape Riche, so no impact from the brine discharge on the benthic primary producer habitat (seagrass, macroalgae, hard coral) in Cheyne Bay is predicted.

1. Introduction

Grange Resources are proposing a 12 gigalitre per year (GL/y) desalinisation plant to provide water for the Southdown mine near Wellstead, Western Australia. The proposed brine discharge location (hereafter referred to as 'brine discharge') is on the exposed south side of Cape Riche (Figure 1). An open channel seawater intake (hereafter referred to as 'seawater intake') is proposed to be sited along the southern shoreline of Cheyne Bay on the north side of Cape Riche, approximately 500 m east of Cheyne Inlet (Figure 2). The location of the proposed seawater intake was selected in part to minimise direct impacts to subtidal benthic habitat and to take advantage of the relatively minimal ocean swell energy exposure. The proposed brine discharge on the southern side of Cape Riche was selected because it is a highly energetic receiving water environment that is predicted to rapidly mix and disperse the brine discharge. Further, the location of the brine discharge was sited sufficiently distant (>1 km to the west of Cape Riche point) to not impact benthic primary producer habitat (BPPH) in Cheyne Bay.

1.1 Study Area

The study area is approximately 100 km east of Albany, Western Australia. The two (2) regions of interest are:

- The most southerly extent of Cheyne Bay on the north side of Cape Riche. The study area of this region is roughly bounded by Cheyne Island to the north, Cape Riche to the South and Cheyne Inlet to the west (Figure 1). The proposed seawater intake will consist of a short, narrow, channel cut through the rocky shoreline, leading to a below ground pump station. The shoreline of Cheyne Bay in the study area generally faces northeast (Figure 1), and is typically well protected from the prevailing Southern Ocean swell; and
- The south side of Cape Riche in the vicinity of the proposed brine discharge location. This area is directly exposed to large Southern Ocean swell (Figure 2).

1.2 Objective

Other than very limited direct impacts to intertidal and shoreline habitats from the proposed seawater intake, no impacts to the marine environment are predicted from the proposed infrastructure for the desalination plant. Nonetheless, given the presence of known substantial BPPH habitat in Cheyne Bay (e.g. seagrass, macroalgae), GHD Pty Ltd (GHD) undertook several field surveys to characterise the benthic habitat of the study area to serve as baseline conditions.

2. Desktop Review

2.1 Regional Setting

This region has 3 distinctive coastal types (Colman 1998) that also occur in the study area around Cape Riche:

- Type 1: Long, wide bay and beach with shallow shelving shore, often with perched limestone cliffs and exposed limestone rock platforms at sea level;
- Type 2: High granite or gneissic headland exposed to the open ocean swells with wave-swept slopes, steep to shores, cliff and small lunate bays between projecting elements of headland; and
- Type 3: Eastward-facing, semi-exposed shore with granite or gneissic boulders and tide pools.

The brine discharge location is categorised as coastal type 2. This is a typical feature of the southwest coast and is a high energy environment with steep slopes, particularly around the headlands. Within these environments the benthic community primarily consists of macrophytes (marine plants) to depths of 20 m which then transitions in deeper waters into sponges, ascidians and coelenterates dominated communities on rocky substrate (Colman 1998). The benthos is primarily barren sand at greater than 40 m depth, while on the shoreline the rock crabs and barnacles are the dominant species with anemones in the rock pools (Colman 1998). Fauna along the shoreline typically includes barnacles, bivalves and crustaceans, which can tolerate this high energy environment.

Marine studies in the region indicate that the Leeuwin Current and Cresswell Current have a large influence on the biological communities creating biodiversity hotspots and species endemism (DEWHA 2007, Colman 1998).

2.2 Marine Flora and Fauna

Generally marine surveys have focused on key commercial fish species (abalone, herring, salmon and pilchards) (Kendrick et al 2001). Kendrick et al (2001) identified 172 fish species of which 28% are endemic to the region. DEWHA (2007) listed the following recreational, commercial or protected species:

- Western Blue Grouper;
- Queen Snapper (Blue Morwong);
- Herring;
- Sardine;
- Scaly Mackerel;
- Jack Mackerel;
- Yellow Tail ;
- Blue Mackerel;
- Anchovy;
- Blue Sprat;
- Mulloway;

- Harlequin Cod;
- Nannygai;
- Southern Rock Lobster;
- Roei Abalone; and
- Leafy Seadragon.

Within the region there are ten (10) species of pinnipeds (seals, sea lions), 27 species of cetaceans (whales and dolphins) and 43 shorebird species that are known or reasonably expected to occur (Colman 1998). Protected species in the region include; sharks, bony fish (seahorse, sea dragon), turtles, pinnipeds, sea birds and cetaceans (Coleman 1998, DEWHA 2007). Some species are migratory and use the region for breeding or calving (e.g. Southern Right Whale) (DEWHA 2007).

The regional benthic habitat is ecologically important in terms of benthic primary producer habitat (macroalgae and seagrass), which also provide a food source, refuge and nursery habitats for other marine species (Colman 1998).

2.3 Marine Conservation Areas

Marine reserve areas in the region include Waychinicup Reserve, Mount Manypeaks Nature Reserve and Two Peoples Bay Nature Reserve to the east and Fitzgerald River National Park to the west.

3. Methods

A summary of the sites and data collection methods is provided in Figure 1 and Figure 2 for Cheyne Bay and southern Cape Riche (brine outlet region), respectively. The methodology used for the benthic habitat assessment is provided in this section. Dates in which field activities were undertaken are summarised in Table 1.

Table 1 Dates of field activities during field surveys 1 (14-16 February 2011) and 2 (6 April 2011).

	Date	Activity
Field Trip 1	13-Feb	Arrive at Cape Riche
		Shoreline, intertidal and macroalgae (nearshore) surveys (snorkel and land-based)
	14-Feb	Spot surveys at Cheyne Bay sites
		Drift snorkel
	15-Feb	SCUBA survey of coral outcrop
		Seagrass video transects in Cheyne Bay
	16-Feb	Brine discharge survey
	17-Feb	Depart Cape Riche
Field Trip 2	5-Apr	Arrive at Cape Riche
	6-Apr	Coral transect manta tow
	7-Apr	Depart Cape Riche
Field Trip 3	17-Jul	Arrived at Cape Riche and conducted ground truth snorkelling survey at brine discharge location. Departed Cape Riche in afternoon.

3.1 Initial Seagrass Habitat Delineation with Aerial Photographs

Aerial photography of the study area within Cheyne Bay at 20 cm resolution was commissioned by Grange Resources on 1 September 2010 (Figure 1 and Figure 2). High water clarity when the image was captured allowed delineation between areas of seagrass and sand. These two (2) categories were utilised to initially identify habitat types and their areal extent. Twelve sites were selected from each of these habitat types for subsequent ground truth field surveys.

3.2 Subtidal Field Surveys

During the field surveys, good water clarity and minimal wave swell allowed the benthic habitat to be readily observed via snorkel, SCUBA and vessel-based methods. These conditions allowed observations of habitat type and estimates of habitat characteristics (i.e. seagrass shoot density, percentage cover).

3.2.1 Ground Truth Surveys of Sand and Seagrass Habitat

Dominant sand and seagrass areas from the initial aerial photo delineation were ground truthed through snorkelling observations at monitoring sites 1-12 during the first field survey on 14 February 2011 (Figure 1). The percentage substrate cover on the seabed was independently quantified by two (2) snorkelers

simultaneously, which was followed by comparisons of the respective assessments to minimise potential bias in observations.

Video transects were also carried out during the first field survey on 15 February 2011 at three (3) of the ground truth sites (sites 2, 8 and 10, Figure 1). At each of these three (3) sites a weighted reference shotline was deployed to mark the start of the transect. A 50 m transect tape was secured to the shotline and the other end of the tape was weighted to hold its position. A diver on SCUBA deployed the tape and a second diver with a VC HD handy cam filmed along the transect. The video footage was acquired at an average height of 1.5 m above the seabed with the camera approximately 90° to the seabed. This video height above the seabed resulted in approximately a 2 m swath along each transect, which yielded approximately 100 m^2 of habitat footage per transect. A second transect was then captured from the shotline at a 90° bearing offset to the first transect.

Video images were analysed for presence of seagrass species and seagrass density, as well as observations of sand patches, fish and other marine flora and fauna. The seagrass density was categorised as:

- High: seagrass cover >80% of visible area;
- Moderate: seagrass cover between 10-80% of visible area; and
- Low: seagrass covers <10% of visible area.

This information and the spot surveys at sites 1-12 was used to update the seagrass areal estimates and to determine a characteristic seagrass density to derive a percentage cover over the study area.

3.2.2 Hard Coral Habitat Survey

During the first field trip in mid-February 2011, field staff became aware of hard coral habitat through discussions with the vessel skipper, who has a local knowledge of the area. Hard coral habitat was not originally discerned from the aerial photographs, which is an important habitat type, so field surveys were carried out. Hard coral habitat primarily occurs adjacent to the southern shoreline of Cheyne Bay. Two (2) divers on SCUBA made observations and took photos of the hard coral colonies at an outcrop (Figure 1) and their associated fauna on 15 February 2011.

During the second field trip on 6 April 2011 the extent of the hard coral habitat region to the west of the large coral outcrop was surveyed (Figure 1). During a manta tow, marine scientists on snorkel took notes on the density, size and health of the hard coral. Further, photographs of the hard corals at different densities and sizes, as well as the associated marine life, were captured by the marine scientists. In parallel, video footage over the same transect was collected as a visual record of the presence and health of hard corals. All photos, notes and video footage have been stored for later analysis of baseline conditions if required.

This survey information was then used to delineate hard coral habitat, a characteristic hard coral density and a percentage cover in the study area.

3.2.3 Macroalgae Habitat Survey

During the first field trip on 13 February 2011, a snorkel transect by marine scientists along the intertidal-subtidal interface along the western portion of the southern Cheyne Bay shoreline was carried out (Figure 1). During the snorkel transect marine scientists took notes on the density, size and health of the

predominately macroalgae habitat. Further, photographs were captured of representative macroalgae types, as well as the associated marine life.

This survey information was then used to delineate the region dominated by macroalgal habitat.

3.2.4 Sand Habitat Survey

During the first field trip on 14 February 2011, a drift snorkel by marine scientists along a transect through primarily sand habitat near sites 13 and 15 was carried out (Figure 1). During the drift snorkel marine scientists took notes on the density, size and health of the predominately low density seagrass habitat.

This survey information was then used to delineate the region dominated by low density seagrass and sand habitats.

3.3 Shoreline and Intertidal Field Survey

During the first survey on 13 February 2011 areas in the vicinity of the proposed seawater intake along the southern shoreline of Cheyne Bay were surveyed through snorkelling (intertidal) and land-based (shoreline) observations that were roughly parallel to the subtidal snorkel transect (Figure 1). Dominant habitat types and species were noted along representative sections of both the shoreline and intertidal zone.

3.4 Field Survey of Brine Discharge Region

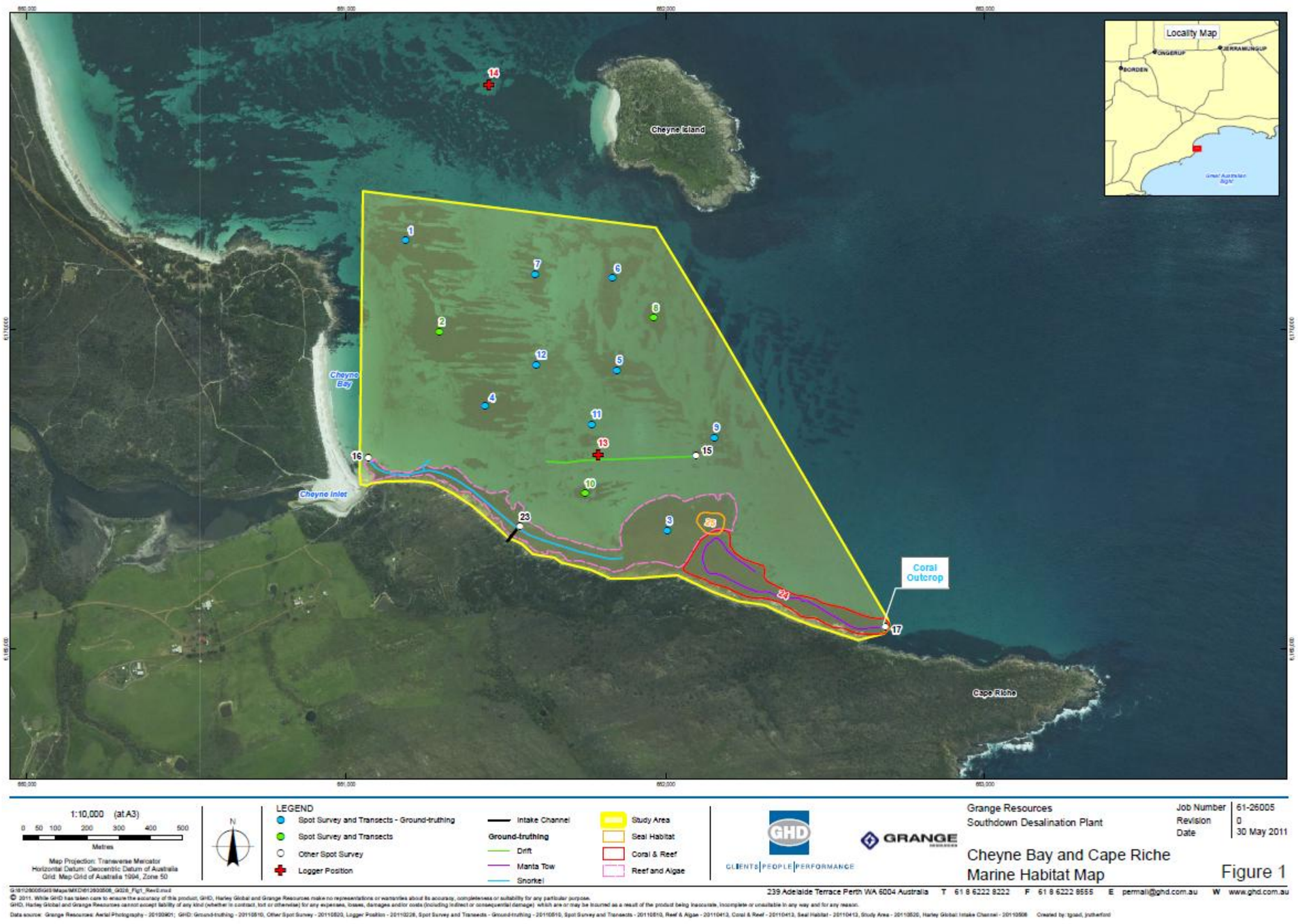
3.4.1 Vessel-based Survey

Because of the high energy wave environment during the first field study (and generally so), it was unsafe for marine scientists to carry out observations away from the vessel. Instead snorkel observations while marine scientists were secured to the vessel were made at five (5) locations in relative proximity to the proposed brine discharge location on 16 February 2011. An additional twenty two (22) snorkelling observations were made during the third field investigation on 14 July 2011. Measurements included water depth and snorkel observations of benthic habitat types. Hence, data from this component of study can be considered a qualitative measure of habitat type and composition. Figure 2 shows the locations of the snorkelling observations.

3.4.2 Shoreline Survey

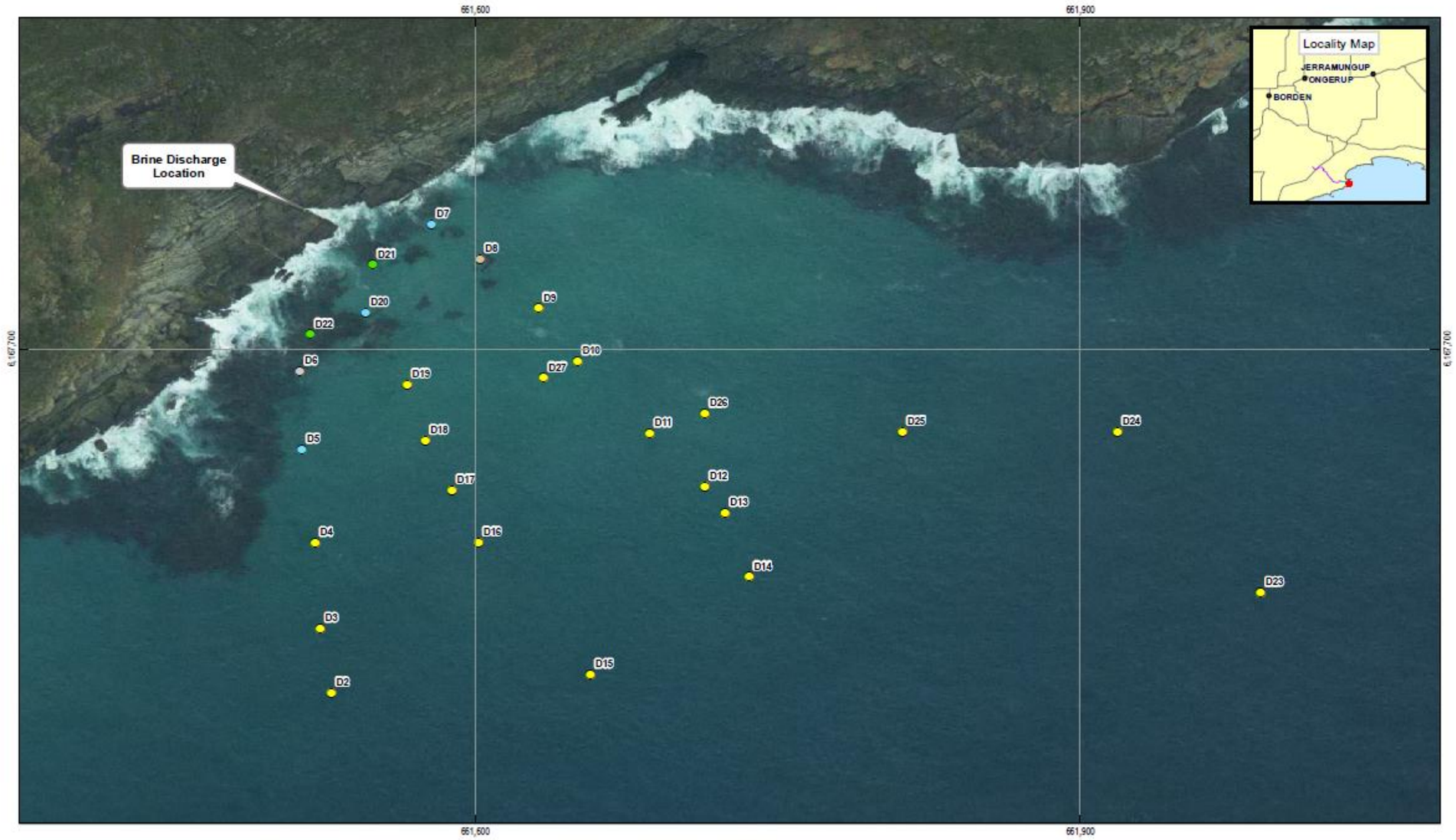
The shore-based survey on 16 February 2011 included visual observations and photos on the rock plateau and upper intertidal zone. Again, the proximity to the intertidal area that staff could make these observations from was limited due to safety considerations in the vicinity of the high energy environment, as well as the associated wet and slippery surfaces. Hence, findings from this shoreline survey are qualitative and indicative only..

Figure 1 Survey sites and field activities in the Cheyne Bay portion of the study area.



Data source: Grange Resources: Aerial Photography - 20100901; GHD: Ground-truthing - 20110510, Other Spot Survey - 20110520, Logger Position - 20110228, Spot Survey and Transects - Ground-truthing - 20110510, Spot Survey and Transects - 20110510, Reef & Algae - 20110413, Coral & Reef - 20110413, Seal Habitat - 20110413, Study Area - 20110520, Harley Global: Intake Channel - 20110508 Created by: tgoad, jrutherford

Figure 2 Survey sites near the brine discharge region of the study area.



4. Results

4.1 Initial Seagrass and Sand Habitat Delineation in Cheyne Bay

Initial habitat delineation from the aerial photo imagery at twelve sites is shown in Table 2. These twelve sites were used for the subsequent spot checks for the ground truth survey**.**

Table 2 Location and initial delineation of seagrass habitats for subsequent ground truth survey (Datum – MGA50).

Site	Easting	Northing	Predicted Habitat
1	661184.8	6170279.7	Seagrass
2	661291.5	6169993.4	Seagrass
3	662099.4	6169372.1	Seagrass
4	661433.9	6169760.6	Seagrass
5	661847.3	6169872.9	Seagrass
6	661833.4	6170161.1	Seagrass
7	661591.1	6170172.9	Seagrass
8	661962.2	6170037.1	Seagrass
9	662152.8	6169662.1	Seagrass
10	661788.9	6169609.0	Seagrass
11	661743.9	6169590.3	Sand
12	661595.0	6169889.4	Seagrass

4.2 Ground Truth of Seagrass and Sand Habitats in Cheyne Bay

4.2.1 Spot Ground Truth Survey at Sites 1-12

The majority of the predicted habitats from the aerial photo delineation corresponded to the ground truth data at sites 1-12 (Table 3). However, site 3 was initially delineated as seagrass habitat, but was field surveyed as rocky reef substrate and macroalgae habitat. Lastly, at site 11, low density seagrass habitat was observed instead of barren sand. Table 3 also provides estimates of seagrass density and the number of seagrass species observed at each of the sites. Four (4) sites (1, 2, 6 and 7) had high seagrass densities (>80%). Two (2) sites (10 and 11) had low seagrass density (<10%). Five (5) sites (4, 5, 8, 9 and 12) had moderate seagrass densities (10-80%).

4.2.2 Video Transects at Sites 2, 8 and 10

The 50 m video transects were collected over three (3) separate distinct seagrass habitat areas, namely, areas of high (site 2), moderate (site 8) and low (site 10) densities. A brief description of each transect inclusive of identified seagrass species is summarised in Table 4.

4.2.3 Seagrass Identification

In addition to the video transects, several qualitative surveys were undertaken in the vicinity of the transects to catalogue the presence of seagrass species within the study area. Potentially six (6) species of seagrass were identified within Cheyne Bay: *Amphibolis antarctica and Amphibolis griffithii,* one (1) species of *Halophila* and possibly three (3) species of *Posidonia*. Observations at each of the twelve seagrass ground truth sites were also made and reported in Table 3. Further, potential morphs of the same species were also observed in the bay. For example, the blade width was noticeably different between several of the *Posidonia* beds. Several large seagrass areas contained mixtures of both *Amphibolis* species, though these were generally isolated from the dominant *Posidonia* meadows. Example photographs of marine fauna, sponges and seagrass species observed along the video transects are shown in Figure 3. Generally, *Posidonia* was the dominant genus throughout the bay with the greatest total coverage and highest density in the seagrass meadows. Small patches of *Halophila* were present, although rarely encountered.

Figure 3 Examples of marine fauna and seagrass species observed in Cheyne Bay: (a) green turtle (*Chelonia mydas*), (b) sponges and ascidians, (c) *Posidonia* sp., (d) *Amphibolis antarctica* bed, (e) *Halophila* sp., and (f) *Amphibolis griffithii*.

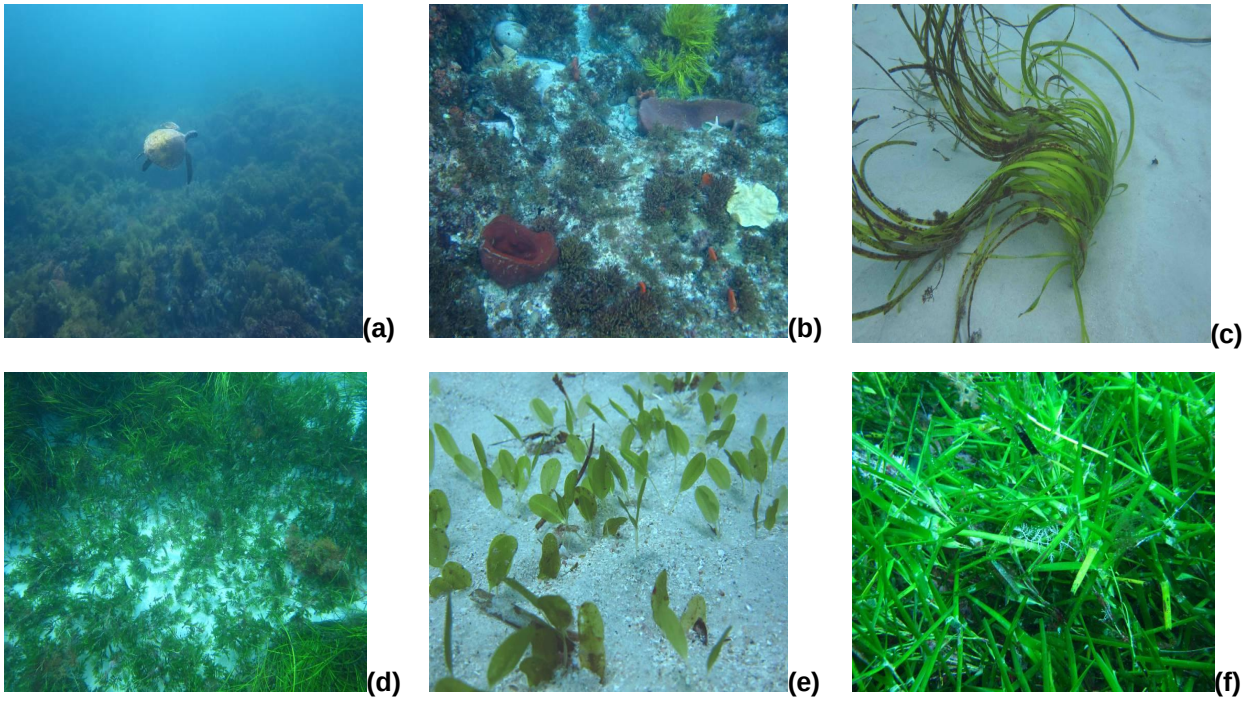


Table 3 Location and characterisation of seagrass habitats from ground truth survey (sites 1-12) (Datum – MGA50).

Site	Easting	Northing	Predicted Habitat (Table 2)	Ground Truth Habitat	Seagrass Density	Dominant Seagrass Genus	# of Seagrass Species
1	661184.8	6170279.7	Seagrass	Seagrass	High	*Posidonia, Amphibolis*	2
2	661291.5	6169993.4	Seagrass	Seagrass	High	*Posidonia, Amphibolis, Halophila*	4
3	662099.4	6169372.1	Seagrass	Reef and Macroalgae	NA[1]	NA	NA
4	661433.9	6169760.6	Seagrass	Seagrass	Moderate	*Posidonia, Halophila*	3
5	661847.3	6169872.9	Seagrass	Seagrass	Moderate	*Posidonia, Amphibolis, Halophila*	3
6	661833.4	6170161.1	Seagrass	Seagrass	High	*Posidonia, Amphibolis*	2
7	661591.1	6170172.9	Seagrass	Seagrass	High	*Posidonia*	1
8	661962.2	6170037.1	Seagrass	Seagrass	Moderate	*Posidonia, Amphibolis*	5
9	662152.8	6169662.1	Seagrass	Seagrass	Moderate	*Posidonia, Amphibolis, Halophila*	2
10	661788.9	6169609.0	Seagrass	Reef/Macroalgae/Seagrass	Low	*Posidonia*	3
11	661743.9	6169590.3	Sand	Seagrass	Low	*Posidonia, Amphibolis*	2
12	661595.0	6169889.4	Seagrass	Seagrass	Moderate	*Posidonia*	2

[1] Not applicable.

Table 4 Habitat observations from video transects of Cheyne Bay seagrass survey at three (3) sites.

Site	Transect Number	Description
2	T1, T2	The first transect was from site 2 heading south, while the second transect was to the west. Both transects had high densities of two (2) seagrass species, *Amphibolis antarctica* and *Posidonia* sp1 and very small, scattered patches of *Halophil*a sp1, *Amphibolis griffithii* and sand. There were no fish visible on the transect video, but divers reported 2 different schools of fish, the first school had fish less than 5 cm in length and the second school had fish less than 3 cm.
8	T3, T4	The first transect was site 8, heading west, starting with medium cover of *Amphibolois griffithii, Posidonia* sp1 and *Amphibolis Antarctica*, with very small clumps of *Posidonia* sp1 over the initial third of the transect. The middle third of the transect shows a moderate density of *Posidonia* sp1 that then increases into dense patches for a few meters then thins out to a sparse density of *Amphibolis* seagrass in a sand patch. The final third of the transect had a medium density of a mixture of *Amphibolis griffithii, Posidonia* sp1 and *Amphibolis antartica* across the transect. There were no fish visible on the video transect, but both divers recorded observations of schools of juvenile fish up to 5 cm in length. The second transect headed north from point 8, which began with a medium density of *Amphibolis griffithii* and *Posidonia* sp1 and then progressed to a sand patch with very sparse (1-5 stems) seagrass and organic matter and a sparse density of *Posidonia* sp2 and sp3. This pattern repeated four (4) times throughout the transect. There was 1 fish visible on the video transect, but both divers recorded observations of schools of juvenile fish up to 5 cm in length.
10	T5, T6	Transects 1 and 2 headed west and north, respectively from site 10. Both transects were predominantly sand with small clumps of *Posidonia* sp1 and *Posidonia* sp2 that were sparse throughout the sand patch. There were no fish visible on the first video transect, but both divers recorded observations of schools of juvenile fish up to 5 cm in length. There was a large school of small fish (less than 5 cm) recorded on the second transect that repeatedly crossed the line of transect.

4.3 Hard Coral Habitat Survey

The hard coral area had several large boulders densely covered in Dendrophyllidae plate coral, most likely *Turbinaria mesenterina* (Figure 4a), and other coral found in the area included members of the Faviidae family (Figure 4b). During the first February 2011 survey the coral outcrops were observed to range from 1-3 m in diameter and were approximately 2 m above the surrounding seabed substrate. During the second April 2011 survey a gradient in hard coral density and size was observed from east to west along the manta-tow transect. The easternmost coral outcrop that was observed included large and dense colonies (Table 5). The colonies became smaller and less dense in a westerly direction with the average coral diameter between 30-80 cm at intervals several metres apart.

All coral were noted to be in a healthy condition and provided habitat for many fish such as Tiger Cod (*Epinephelides armatus*), Blue Lined Leather Jacket (*Meuschenia galii*), Old Wife (*Enoplosus armatus*) Long-snouted Boarfish (*Pentaceropsis recurvirostris*), Maori wrasse (*Ophthalmolepis lineolata*), Banded sweep (*Scorpis georgiana*), Footballer sweep (*Neatypus obliquus*), Black-headed puller (*Chromis klunzingeri*) and Common bullseye (*Pempheris multiradiata*).

Table 5 Location and characterisation of coral habitat site (site 17) (Datum – MGA50).

Site	Easting	Northing	Observed Habitat	Qualitative Notes
17	662687.7	6169069.1	Coral	Coral Outcrop

Figure 4 Large Dendrophyllidae coral outcrops were found with Faviid corals (a) an example of one of the larger Dendrophyllidae coral outcrops and (b) small Faviid corals scattered around the vicinity of the Dendrophylliid outcrops

(a)

(b)

4.4 Macroalgae Habitat Survey

The subtidal region between the low water mark and the sand habitat along the southern shoreline of Cheyne Bay consisted primarily of a boulder-reef-macroalgae habitat. Various brown macroalgae species, including *Scaberia agardhii,* dominated this subtidal rocky substrate with occasional red and green macroalgae species also present (Figure 5a).

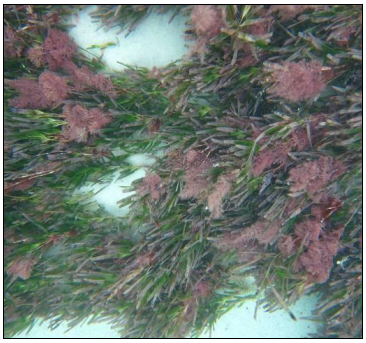
In the proximity of site 16 several small dense beds of *Amphibolis griffithii* seagrass were observed near the Cheyne Inlet beach in approximately 3-4 m of water (Table 6). The presence of epiphytic coralline algae was noted on the tips of the seagrass strands (Figure 5b).

Near point 3 a small colony of New Zealand fur seals were identified, which were observed in the same location during the February, April and July field surveys (Figure 5c).

Table 6 Location and characterisation of macroalgae habitat sites (sites 3, 16 and 23) (Datum – MGA50).

Site	Easting	Northing	Observed Habitat	Qualitative Notes
3	662099.4	6169372.1	Reef & Macroalgae	Primary habitat between intertidal and sand habitats
16	661227.1	6169511.3	Reef & Macroalgae	Primary habitat between intertidal and sand habitats
23	661178.4	6169519.9	Reef & Macroalgae	Nearshore subtidal mosaic with low density of macroalgae at intake channel

Figure 5 The dominant subtidal rocky substrate with occasional red and green macroalgae species present at Cheyne Beach: (a) mixtures of macroalgae from the subtidal area of the shoreline, (b) a bed of *Amphibolis griffithii* in close proximity to the rocky shoreline and (c) south straight on to the intertidal zone through the surf break and a colony of New Zealand fur seals.


(a)

(b)

(c)

4.5 Sand Habitat Survey

During the drift snorkel transect sand patches often were observed to be a mosaic of seagrass, macroalgae and reef / limestone substrate. The seagrass within these patches had a low density (<10% cover) and occurred only on sand substrate. Macroalgae had a similar low percentage cover as the seagrass in this region, but occurred on both the sand and reef/limestone substrate. Only one (1) site within proximity to the drift snorkel transect (site 13) and another outside of the study area (site 14) had bare sand, whereas the other site (site 15) had low density seagrass (Table 7).

Table 7 Location and characterisation of sand habitats (sites 13-15) (Datum – MGA50).

Site	Easting	Northing	Observed Habitat	Qualitative Notes
13	661788.9	6169609.0	Sand	Location of L2 logger
14	661446.5	6170767.5	Sand	Location of L1 logger outside of study area
15	662095.4	6169602.4	Sand & Seagrass	Seagrass density - Low

4.6 Shoreline and Intertidal Habitats along Southern Cheyne Bay

The intertidal zone was rocky for nearly the entire length of the transect (Figure 1) and was approximately 10-15 m wide. Boulder surfaces were mostly barren of colonial organisms (e.g. oysters) throughout the intertidal zone directly adjacent to the water's edge, although occasional boulders contained large congregations of the marine snail, *Turbo undulatus*. Several species of shore crabs were noted and rock pools in the area contained various macroalgal groups including green and brown varieties, while orange lichens coated the boulders further back from the water's edge (Figure 6).

Observations along Cheyne Inlet beach revealed a large volume of seagrass wrack within the littoral zone and the surf zone during the survey.

Figure 6 Cheyne Bay upper intertidal zone looking (a) west towards Cheyne Beach and (b) north towards Cheyne Island.


(a)

(b)

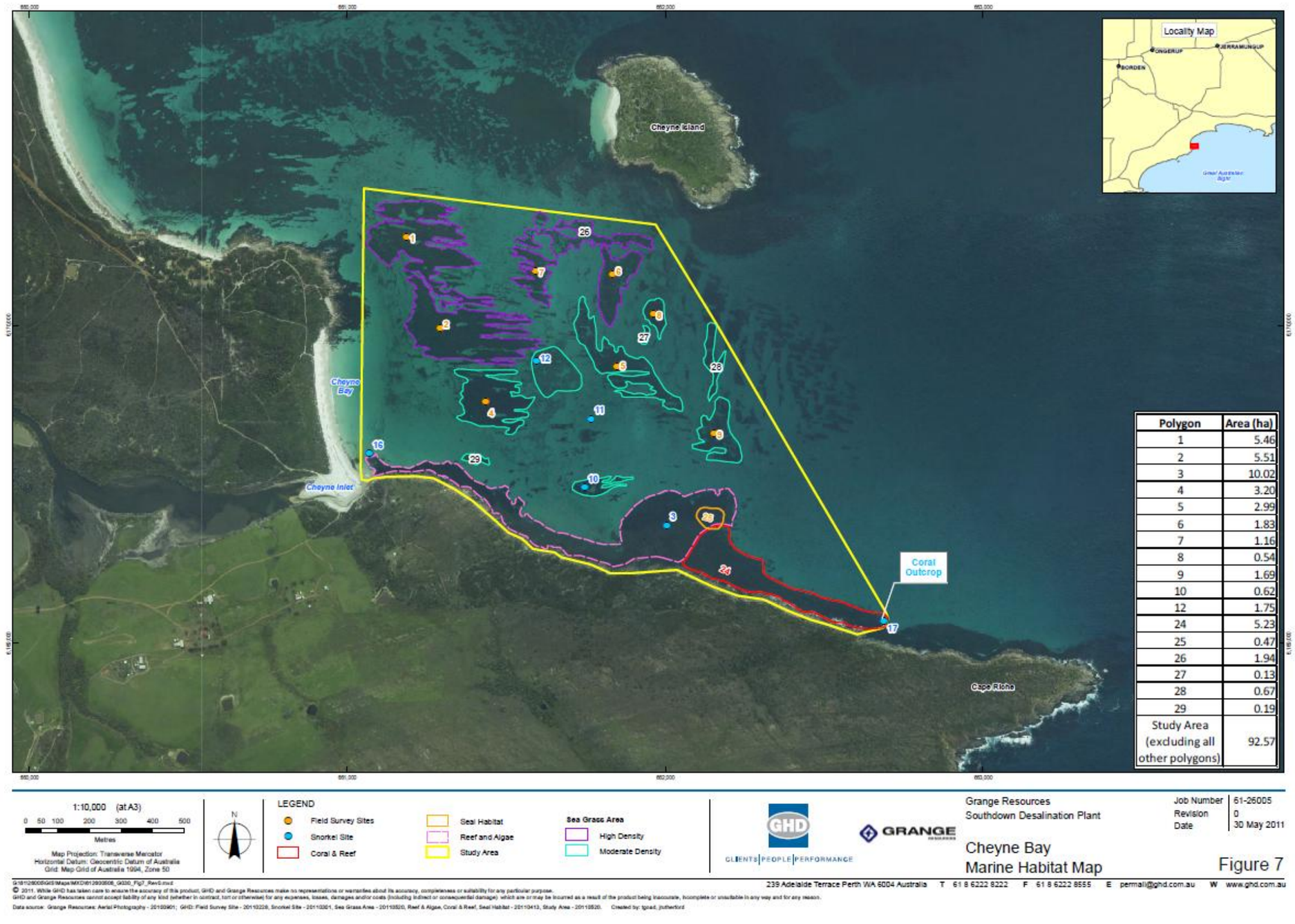
4.7 Areal Estimates of Benthic Primary Producer Habitat in Cheyne Bay

The aerial photo was then used to delineate areas of benthic primary producer habitat for hard corals, macroalgae and seagrass (Figure 7). In order to estimate the percentage cover of seagrass, low, moderate and high seagrass density were assumed to be 5%, 60% and 80% coverage, respectively, on the basis of characteristic values from the field surveys. Characteristic percentage cover for the coral and macroalgae habitats could not be reliably estimated, hence only the gross area of habitat in the study area is reported. Areas of the different habitat types for the three (3) dominant benthic primary producer habitats (hard coral, macroalgae, seagrass) in the study area are summarised in Table 8 with further delineation between estimates of low, moderate and high seagrass density habitat.

Table 8 Areal estimates of benthic primary producer habitat types.

Habitat Type	Gross Area of Habitat (ha)	Gross Area Percentage of Study Area (ha)	Characteristic Percentage Cover (%)	Actual Habitat Coverage (ha)
Study Area	135.5	100%	NA	NA
Hard Corals	5.2	3.9%	NA	NA
Macroalgae	10.0	7.4%	NA	NA
Seagrass – Low / Sand	92.6	68.3%	5%	4.6
Seagrass - Moderate	11.8	8.7%	60%	7.1
Seagrass - High	15.9	11.7%	80%	12.7

Figure 7 Areal distribution of benthic habitat in Cheyne Bay.



Data source: Grange Resources: Aerial Photography - 20102901; GHD: Field Survey Site - 20110228, Snorkel Site - 20110301, Sea Grass Area - 20110520, Reef & Algae, Coral & Reef, Seal Habitat - 20110413, Study Area - 20110520. Created by: tgoad, jsutherford

4.8 Survey of Brine Discharge Location

The location of the proposed brine discharge was briefly inspected via vessel-based snorkel observations at five (5) sites during the February survey and twenty two (22) sites during July. The resulting indicative habitat map can be seen in Figure 2. Owing to the wave exposure experienced during the surveys, only brief observations of the marine habitat were possible. The rocky coastline was observed to transition to a mosaic of bare boulders and sand, with occasional strands of brown macroalgae, this habitat type continued for several metres before transitioning to a barren sand plane in a seaward direction. No seagrass was observed.

Land-based observations of the intertidal and shoreline included dominant flora is macroalgae (*Ecklonia radiata*) that are able to exist in this high energy environment. On the shoreline the rock crabs and barnacles are the dominant species with anemones in the rock pools.

Figure 8 Southern ocean brine discharge location as observed from the (a) vessel and (b) land-based from an easterly perspective.

(a)

(b)

Table 9 provides geographical coordinates of the survey sites and their associated water depths and habitat types.

Table 9 Survey observation sites of brine discharge location

Site Name	Easting	Northing	Depth	Habitat
D1	660,843.5	6,167,519.3	14.2	Bare Sand
D2	661,528.5	6,167,529.6	13.0	Bare Sand
D3	661,523.0	6,167,561.1	12.4	Bare Sand
D4	661,520.6	6,167,603.7	10.5	Bare Sand
D5	661,513.8	6,167,650.0	8.8	Bare Sand/Bare Boulders
D6	661,513.0	6,167,688.8	6.9	Bare Boulders
D7	661,578.4	6,167,761.7	6.1	Bare Sand/Bare Boulders
D8	661,602.6	6,167,744.6	6.8	Bare Sand/Bare Boulders with brown macroalgae
D9	661,631.2	6,167,720.1	7.4	Bare Sand
D10	661,650.6	6,167,693.8	8.3	Bare Sand
D11	661,686.7	6,167,658.1	9.2	Bare Sand
D12	661,713.7	6,167,631.7	10.3	Bare Sand
D13	661,724.2	6,167,618.6	11.3	Bare Sand
D14	661,735.9	6,167,587.0	12.4	Bare Sand
D15	661,657.1	6,167,538.4	13.2	Bare Sand
D16	661,601.7	6,167,604.1	11.0	Bare Sand
D17	661,588.4	6,167,630.2	10.0	Bare Sand
D18	661,575.0	6,167,654.5	8.9	Bare Sand
D19	661,566.3	6,167,682.4	8.2	Bare Sand
D20	661,545.6	6,167,717.9	7.7	Bare Sand/Bare Boulders
D21	661,549.0	6,167,741.8	6.4	Bare Boulders with brown macroalgae
D22	661,517.9	6,167,707.3	7.0	Bare Boulders with brown macroalgae
D23	661,989.9	6,167,578.9	18.0	Bare Sand
D24	661,918.7	6,167,659.0	14.0	Bare Sand
D25	661,811.8	6,167,659.0	11.0	Bare Sand
D26	661,713.9	6,167,667.9	8.0	Bare Sand
D27	661,633.8	6,167,685.7	8.6	Bare Sand

5. Discussion

The ground truth surveys indicate that the three (3) seagrass habitat density delineations (i.e. low <10%, moderate 10-80% and high density >80%) correlated well with the shading in the aerial photographic mapping. Generally, the darkest patches on the aerial photograph were correlated with high and medium density seagrass coverage, whereas the sandy areas were generally observed to be low density seagrass or sandy habitat. The dominant seagrass types in the study area were several species of *Amphibolis* and *Posidonia*. Juvenile fish were generally abundant within the high density seagrass meadows, but absent in the sandy regions, indicative of their reliance on seagrass habitats as refuge. Areal estimates of the ecologically significant high and moderate density seagrass meadows are 80% and 60% cover, and 15.9 ha and 11.8 ha in the western portion of Cheyne Bay.

Parallel to the southern shoreline of Cheyne Bay two (2) habitat types were delineated through the field surveys. A mosaic of reef, boulders and macroalgae occur parallel to the western portion of the shoreline to Cheyne Inlet beach. Hard coral habitat occurs parallel to the eastern portion of the shoreline of the study area with high density coral reef outcrops to the east and lower density individual corals to the west. At the interface of the coral and boulder-reef-macroalgae mosaic habitats, New Zealand fur seals and a green turtle were observed. Generally, the subtidal and intertidal zones contained typical flora and fauna of the region (Veron and Marsh 1988), with the exception of the hard coral habitat.

The benthic habitat of the brine discharge receiving environment was found to be predominantly bare sand, with boulder substrate directly adjacent the shore line. The boulder substrate had occasional strands of brown macroalgae attached, but was generally devoid of any substantial epibenthic growth; this is most likely due to the exposure of the location to constant large southern ocean swells, which may inhibit the establishment of some sessile marine invertebrates and algae.

The land-based facilities will be located 4.5 km inland with pipes extending from the seawater intake and to the brine discharge. The seawater intake will be a passive flow system that will be located approximately 300 m east of Cheyne Inlet along the southern shoreline in a naturally occurring depression. The pumping station will be located near to the seawater intake and will be constructed to have minimal (if any) noise impacts on marine fauna. The brine discharge will be a passive gravity driven system in the proximity of the marine receiving environment and will not have any noise impacts on marine fauna.

Hydrodynamic modelling of the brine discharge at a peak rate of 52 MLD[2] (0.6 m^3/s) and a salinity of 70 psu[3] predicts that the dilution of the brine along the seabed will be over 90-fold prior to transport to the tip of Cape Riche (GHD 2011). Hence, no impact from the brine discharge on the benthic primary producer habitat (seagrass, macroalgae, hard coral) in Cheyne Bay is predicted under calm and realistic simulation scenarios (GHD 2011).

[2] Note Q_{Design} is 47 MLD (GHD 2011).

[3] Based on a recovery rate of 45% and seawater salinity of 35 psu (GHD 2011).

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Draft	E. Gates	J. Romero		J. Romero		11-Apr-11
Final	E. Gates	J. Romero		J. Romero		20-May-11
Final	E. Gates	J. Romero		J. Romero		29-Aug-11