PORT of TOWNSVILLE
Nexus North Queensland

Appendix G
Report on Construction Method for Dredging, Reclamation and Breakwater Construction

Townsville Marine Precinct Project
Environmental Impact Statement

GHD

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1. Introduction

1.1 Background

With increasing trade, commercial and residential growth in Townsville, strategic planning activities for the city have focused on providing opportunities to relocate existing old commercial marine facilities spread around Ross Creek, Ross River and South Townsville into a new, purpose-built precinct on Ross River.

The Port of Townsville Limited (POTL) is the preparing an EIS for the development of a commercial marine precinct project (known as the Townsville Marine Precinct Project). POTL, a government owned corporation and a port authority, is responsible for managing and developing the Port of Townsville.

The development of the EIS is being undertaken in conjunction with a commercial process to engage a third party to develop the Marine Precinct under long term lease. The third party will be responsible for the final design configuration of the Marina Precinct within the guidelines established by the Approvals. As a result the final configuration of the precinct and particularly the topside infrastructure and reclamation configuration is yet to be finalised.

1.2 Brief Description of the Project

The proposed Marine Precinct Project will be situated at the mouth of Ross River. The project will require the reclamation of land on Lot 773. The project also incorporates dredging of channel and basin areas as well as the construction of a breakwater on the eastern side of the mouth of Ross River to protect the marine precinct from the action of waves.

1.3 Purpose of this Report

The purpose of this report is to present the extent and nature of the project construction phases for dredging and reclamation, as well as describe the associated type and methods of construction to be employed and the construction equipment to be used.

Construction methods associated with the implementation of other marine precinct infrastructure and topside construction has been deferred pending the identification of a suitable developer and finalisation of a configuration.

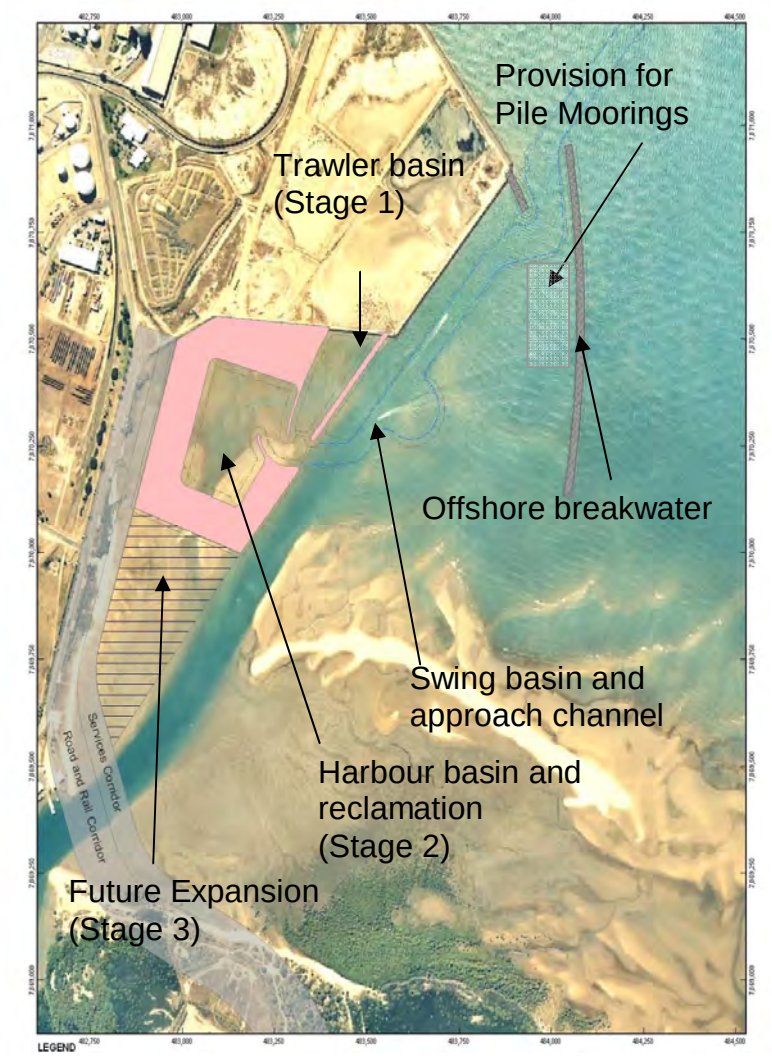
2. Main Construction Activities

2.1 Summary of Works Areas

The reference design for the proposed Townsville Marine Precinct Project incorporates onshore and offshore elements, which can be divided into six distinct areas. These are listed below and shown in Figure 1.

- Trawler basin and associated revetment (Stage 1).
- Offshore breakwater.
- Swing basin and approach channel.
- Harbour basin and associated revetment and reclamation (Stage 2).
- Future revetment and reclamation (Stage 3)
- Provision for Pile Moorings in lee of offshore breakwater

Figure 1 Plan Showing Works Areas



2.2 Ground Conditions

2.2.1 Ground Investigations

A number of intrusive investigations for the marine precinct have been carried out since 2007. These include:

- Preliminary Geotechnical and Acid Sulfate Soils Investigation, by Golder Associates (report dated July 2008) comprising 23 cone penetration tests (CPT's) and boreholes;
- Acid Sulfate Soils Investigation, by GHD (report dated January 2009) comprising 72 vibrocores (23 vibrocores in Lot 773, and 49 vibrocores in the Harbour Area).

Relevant investigation locations within the proposed marine precinct area are shown in Appendix B.

2.2.2 Inferred Ground Conditions

The various investigations indicate that the near surface marine ground conditions comprise relatively recent marine deposits overlying an older firm to stiff silty clay. The near surface marine deposits are mostly loose sandy deposits in the proposed precinct area (Lot 773), although soft marine clay was encountered in a number of places, notably in the outer section of the development, under the breakwater footprint and the northernmost area of Lot 773.

Geological cross-sections through the various areas of proposed work are shown in Appendix B. The ground conditions are briefly summarised below.

Stage 1 Trawler Basin

Subsurface conditions at the proposed trawler basin area comprise up to 2m of loose sand (with zones of silty clay) over firm to stiff clay. A zone of soft silty clay is present at the north-east end, adjacent to the existing revetment.

Offshore Breakwaters

Investigation at the breakwater has shown subsurface conditions below the breakwaters comprise very soft clay overlying firm clay. The thickness of soft clay varies between 1m and 7m.

Swing Basin and Approach Channel

The inferred subsurface conditions at the swing basin comprise between 1m and 2m of loose sand (with zones of silty clay) over firm to stiff silty clay.

Stage 2 Harbour Basin, Revetment and Reclamation

Investigation at the breakwater has shown subsurface conditions below the proposed Stage 2 area comprise up to 2m of loose sand (with zones of silty clay) over firm to stiff clay.

Stage 3 Future Reclamation

The inferred subsurface conditions at the proposed Stage 3 area are similar to those determined for Stage 2.

Pile Moorings

Material similar to that identified for the Offshore Breakwaters is expected, consisting of soft clay over firm clay. The thickness of soft clay is expected to extend to full dredging depths.

2.2.3 Geotechnical Laboratory Testing Results

Geotechnical laboratory testing was carried out on various samples retrieved from the geotechnical and acid sulfate soil investigations. Important to the dredge assessment is the material particle size, which affects suspended solid concentrations at the dredge and ocean disposal sites. Particle size distribution (PSD) plots of samples above -6mLAT (i.e. just below the planned dredge limit) are included in Appendix C. These suggest the upper (1-2m) sand layer is likely to have a percentage of fines (< 0.075 mm) in the order of 20%, whilst the underlying clay layer is likely to have a relatively high 70% of fines.

2.2.4 Brief Summary of Acid Sulfate Soils Testing

The results of acid sulfate soil testing are reported separately, along with soil management options. This suggests that all of the material disturbed as part of the development should be assumed to be potential acid sulfate soils (PASS) and, subject to detailed assessment, managed accordingly, either pre- or post-dredging and placement.

Without the benefit of detailed ASS assessment it is necessary for this construction methodology report to assume that the most cost-effective and practical management option for reusable materials is strategic reburial of materials beneath the permanent water table and capping with non ASS material of sufficient thickness to ensure the underlying PASS is not disturbed during construction or in the future.

2.3 Scope of Dredging and Filling

POTL currently undertakes an approved program of maintenance dredging to maintain the navigability of channels within the port and Ross River areas and it is not anticipated that development of the marine precinct project will significantly increase the requirement for maintenance dredging.

Capital dredging will be required to obtain the necessary depth for vessel movements and also to remove soft clay materials below revetment and breakwater footprints. In terms of dredging and filling, the proposed marine precinct development involves:

- deepening of the existing levels to channels, berth pockets and a swing basin;
- provision of a navigable area to accommodate pile moorings;
- removal of any soft sediments below rock revetment and breakwater footprints;
- placement of sand fill below breakwater footprints to replace dredged soft sediments;
- placement of rock materials to form rock revetments and breakwaters; and
- sand filling behind rock revetments to form reclaimed land.

Dredge levels for channels and harbour basins have been determined separately based on vessel sizes and maintenance dredge requirements. The following scope of dredging and/or filling works is required at each works area.

Table 1 Anticipated scope of dredging and filling works

Location	Summary of dredging and filling work
Trawler basin (Stage 1)	Dredge soft clay from below north side of revetment footprint. Construct revetment (using imported land based source of rock armour and rock core). Dredge trawler basin area to -3.5mLAT.
Offshore breakwaters	Dredge soft clay from below the breakwater footprint. Refill dredged trench to seabed level using imported non-cohesive fill (from marine or land based source). Construct revetment (using land based source of rock armour and rock core).
Swing basin and approach channel	Dredge approach channel and basin area to -3.0mLAT.
Harbour basin (Stage 2)	Construct revetment (using land based source of rock armour and rock core). Dredge harbour basin area to -4.5mLAT. Filling to form precinct reclamation area using imported non-cohesive fill (from marine or land based source).
Future Reclamation (Stage 3)	Construct revetment (using land based source of rock armour and rock core). Filling to form precinct reclamation area using imported non-cohesive fill (from marine or land based source).
Pile Moorings	Dredge navigable area to -3.0mLAT.

A sketch showing the finished reclaim, dredged levels and typical cross sections of the protective rock works relevant to the construction assessment is included as Appendix A of this report.

2.4 Dredge and Fill Volumes

In-situ dredge and fill volumes have been calculated using proprietary software package '12D'. The calculated volumes are shown in Appendix D and summarised in Table 2 and Table 3. The volumes in Appendix D are in-situ volumes to design levels and include an overdredging provision to establish clear navigable depths.

There is potential for some dredged material to be re-used within the project. This potential will be affected by the composition of the material and it's suitability for re-use as engineering fill, staging of the works and the availability of reclaim areas for onshore disposal concurrent with dredging activities coupled with successful management of potential acid sulfate soils.

Due to the presence of Potential Acid Sulfate Soils and geotechnical unsuitability of the material, it is anticipated that a significant volume of material will need to be disposed of to spoil and is likely to include ocean disposal pending approval of an Ocean Disposal Permit.

For transport and handling assessment a provisional allowance has been made to account for material bulking, settlement and consolidation, construction procedures and control, and natural changes which may occur to the surveyed seabed levels.

Table 2 Summary of Dredge Volumes

	Dredge (in-situ)	Reuse	Dispose to spoil	Comments
Trawler Basin (Stage 1)	95,000* m^3	0 m^3	95,000 m^3	Approx. 15,000 m^3 of soft silty clay below northern part of the revetment. Elsewhere, sand over silty clay. Estimated approx. 30% will be reusable sand. However, sand is potential acid sulfate soil and there is limited opportunity to reuse within the project (Stage 1 is constructed in advance of filling in other areas).
Offshore breakwaters	262,000 m^3	0 m^3	262,000 m^3	Soft silty clay below breakwaters.
Swing Basin & Channel	185,000* m^3	0 m^3	185,000 m^3	Mixed sand, silt and mud. Separation of materials not likely to be feasible.
Harbour Basin (Stage 2)	340,000* m^3	85,000 m^3	255,000 m^3	Sand (1-2m thick) overlying silty clay. Estimated approx. 25% will be sand and reusable within the Project provided it is placed below water or managed for PASS.
Future Reclamation (Stage 3)	0 m^3	0 m^3	0 m^3	No dredging required for this stage of works
Pile Moorings	70,000* m^3	0 m^3	70,000 m^3	Soft silty clay
Totals	**952,000 m^3**	**85,000 m^3**	**867,000 m^3**	

* includes overdredging provision

It is assumed that all the soil types found in the areas to be excavated are potential acid sulfate soils and have to be treated accordingly.

Table 3 Summary of Fill Volumes

	Non-Cohesive fill	Rockfill (core + armour)	Comments
Trawler Basin (Stage 1)	0 m^3	39,000 m^3	Stage 1 Breakwater
Offshore breakwaters	262,000 m^3	147,000 m^3	Backfilling dredged trench refilled using 262,000m^3 of imported non cohesive fill. Offshore Breakwater construction.
Swing Basin & Channel	0 m^3	0 m^3	
Harbour Basin (Stage 2)	394,000 m^3	118,000 m^3	85,000 m^3 sand fill available for reuse from Stage 2 dredge operations reducing total amount of imported sand required from 394,000 m^3 to 309,000 m^3
Future Reclamation (Stage 3)	351,000 m^3	44,000 m^3	
Pile Moorings	0 m^3	0 m^3	
Totals	**1,007,000 m^3**	**348,000 m^3**	Import requirements 922,000 m^3 sand fill and 348,000 m^3 rock fill.

Volumes are insitu volumes – a bulking factor has been included for transportation and handling assessment.

The following assumptions have been made in establishing the volumes:

- Very soft and/ or soft clay subsoils below revetment/ reclamation footprints must be removed to minimise long-term instability and differential settlement below rock wall structures. (An alternative to displace the soft material by dumping rock exists but the rock volumes required, mudwaves potentially formed and settlement response is more unpredictable and has not been considered under this preliminary assessment);
- The dredge excavation gradient is adopted as 1V:5H (i.e. 11º) in accordance with guidance given in BS6349 and consistent with natural slopes derived from bathymetric section;
- Sandy materials below revetments will undergo immediate settlement and will not compromise rock wall stability or integrity. Revetment rock material and granular fill can therefore be placed directly on sea bed without any ground improvement to the foundation level;
- Soft sediments below offshore breakwaters will be removed and replaced with non-cohesive fill to minimise the volume of imported rock;
- Revetment and breakwaters will comprise sloping walls, with a slope of 1V:2H on the seaward side and 1V:1.5H on the leeward side;
- A provision for overdredging has been adopted appropriate to the dredging plant for establishment of navigable depths. Vertical dredging tolerances of 400mm (average) for backhoe type dredgers and 300mm (average) for small cutter suction dredgers has been adopted for volumetric calculations where indicated;
- A bulking factor of 1.1 has been applied to dredge materials (Bray, 1979), which are essentially marine/ alluvial sediments for transportation and operational estimates; and
- A bulking factor of approximately 1.1 has been applied to imported fill materials to address uncertainties due to bulking of terrestrial fill, consolidation and settlement and survey accuracy for transportation and operational duration estimates.
- Appropriate capacity of spoil ground exists and appropriate permits to facilitate disposal of unsuitable spoil to sea will be obtained.

3. Construction Methods

3.1 Broad Alternatives

In general terms, there are two broad alternatives to construction, namely 'wet construction' or 'dry construction'.

Wet construction involves dredging and filling within the existing marine environment. Dredging is undertaken using specialist marine based equipment such as cutter suction dredge or backhoe dredge in conjunction with barges to transport material. Rock revetments are formed by end filling from dump trucks or from barges, and reclamation is formed by end filling from dump trucks or pumping directly via pipeline from suction dredge.

Dry construction involves forming a perimeter cut-off system and pumping to maintain dry conditions during excavation and filling works. Once dry, excavation can be undertaken by conventional excavator and fill placed using conventional earthworks equipment. Dewatering of the excavation will be required thoughout the construction period.

Key advantages and disadvantages of the two methods are summarised in Table 4.

Table 4 Comparison of wet and dry construction methods

	Wet construction	Dry construction
Advantages	◗ Allows dredging and filling works to commence immediately. ◗ Seabed materials not exposed to atmosphere, minimising risk of acid sulfate soil generation.	◗ Conventional backhoe and dump truck plant and construction techniques can be utilised. ◗ May be possible to reuse greater volume of excavated materials and reduce disposal / import volumes with successful management or treatment of ASS. ◗ Allows compaction during placement and completion / development of fill areas in short timeframes.
Disadvantages	◗ Marine based plant and construction techniques required until construction is above the water level. ◗ Selective earthworks material required below sea level (e.g. rock and sand fill with low fines content) ◗ Consideration must be given to tailwater management if hydraulic dredging methods are used to source marine fill.	◗ Creation of a dry works areas presents a significant challenge (rock revetment walls are naturally highly permeable and sea levels cannot be drawn down without some form of near impermeable cut-off system). ◗ Impractical for construction of offshore breakwater, which is relatively isolated and requires marine plant to transport materials and equipment. ◗ Seabed materials exposed to

	atmosphere, creating risk of acid sulfate soil generation. ◗ Low traffickability of surface materials after dewatering – requires use of construction platform.

Although dry construction is technically possible, the need to form a dry works area presents a significant challenge due to potential acid sulfate soil generation issues and effectiveness of seawater cut-off. Specifically, formation of a seawater cut-off may be problematic as the near surface subsoil comprises sandy marine deposits over firm to stiff silty clay, which may be expected to contain more permeable sand and silt layers. In addition, the north side of the Stage 2 Harbour Basin directly abuts a previous reclamation area, which is almost certainly hydraulically connected to the sea (ie subject to substantial seepage flows into the excavation).

The wet method provides more certainty in terms of constructability. For the purpose of this report and in the context of supporting non constraining approvals, the wet construction method will be adopted as the most viable.

3.2 Method of Dredging

Dredging is typically conducted by two basic methods - mechanical or hydraulic - depending on the volume to be removed, disposal location, the nature of the sediments and sea conditions at the site.

Mechanical Dredge

Mechanical dredgers excavate material using some form of bucket to carry dredged material up through the water column and to a barge for off-site transport. They are typically used in areas where hydraulic dredges cannot work because of the proximity of piers, docks, etc., or where the disposal area is too far from the dredge site for it to be feasible to pump the dredged material.

A **backhoe dredge (BHD)** is in principle a mechanical excavator on a pontoon equipped with hydraulically operated spuds. It is one of the most commonly used mechanical dredging techniques for smaller projects. Systems are available to seal off the bucket and significantly reduce dredged material entering the water column and creating turbidity. It is also possible to equip the excavator with an 'environmental bucket', which closes with a near horizontal movement and thus facilitates shallow dredge depth tolerances. This type of bucket can also be sealed off to minimize turbidity.

Movement of the barge is carried out by the arm of the excavator whilst the spuds are in a raised position. When the spuds are down the barge is fixed in position and the excavator can excavate the material within reach and deposit the material to a barge for disposal.

Split hopper barges are commonly used to transport spoil and range in capacity from 100 m^3 to 1,000 m^3 and operate by splitting the hull to dispose of the dispose of their material by bottom dumping. For the marine precinct project, it is estimated that two 500 m^3 capacity barges will be required. Based on 5 hours to fill the barge and a 5 hour return trip to the offshore disposal site (15 – 20 km), two barges and 100 m^3 per hour filling rate will allow continual 24 hours operations.

Figure 2 Typical backhoe dredge with split hopper barge being loaded

Dredging production is dependent upon bucket size and the hardness of the material. For the marine precinct project, it is envisaged that a bucket capacity of $2m^3$ will provide sufficient capacity to achieve a 100 m^3 per hour filling rate. Cycle times of the bucket depend on the dredging depth and soil type, but are typically in the order of 40 seconds.

Hydraulic Dredge

Hydraulically operated dredgers are self-contained units that handle both the dredge and disposal phases of dredging operations. The dredge material is first loosened and mixed with water and then pumped as a fluid either through a floating pipeline to the placement area, or into a hopper that is subsequently emptied over the placement area. Hydraulic dredgers are of two principal types; Cutter Suction dredgers and Trailer Suction Hopper Dredgers. Trailer Suction hopper dredgers are not appropriate for the type of works required for this project.

A **Cutter Suction Dredger (CSD)** is a stationary hydraulic dredger which makes use of a “cutter head” to loosen the material to be dredged and pumps the dredged materials to the disposal area via a sunken or floating pipeline. A key feature of a CSD is a rotating cutter which is mounted at the lower end of the ladder used to support the cutter drive and suction pipe. The loosened material enters the suction mouth, passes through the suction pipe and pumps and then into the delivery line.

Cutter suction dredgers operate by swinging around a central working spud by means of steel cables leading via deck mounted winches and the lower end of the ladder to anchors. By pulling on alternate sides the dredger clears an arc of cut and then moves forward by pushing against the working spud using a spud carriage. Modern instrumentation allows profiles and side slopes to be dredged accurately.

Figure 3 Typical cutter suction dredgers

Small sized cutter suction dredge

Medium sized cutter suction dredge

The size of a cutter suction dredger is measured by the diameter of the discharge pipe (from 100 to 1,500 mm) and the installed machinery power from (50 to 37,200 HP).

Backhoe and Cutter Suction dredgers are the most appropriate dredger plant for the project and both of the above dredge methods will be utilised, depending on the location of works. These are summarised in Table 5 along with relevant plant and personnel for each component of the dredging.

Table 5 Summary of Dredge Areas and Dredge Methods

Location	Material type	Work method	Typical Site Personnel
Trawler basin (Stage 1)	Approx. 15,000 m^3 (in-situ) of soft clay from northern part of the revetment. 32,000 m^3 (in-situ) of sand (1-2m thick) over silty clay. The sand will be difficult to separate successfully and is also a potential acid sulfate soil. Materials with high percentage of fines are unsuitable for reuse due to time for consolidation and also potential for acid sulfate soil generation. Total 95,000 m^3 (in-situ) of clay and mixed sand/ clay. All material disposed offshore.	Utilise mechanical backhoe dredge method. Equipment spread: ◗ Floating excavator with clamshell or grab dredge. ◗ 2 No. 500 m^3 split hopper barges. ◗ Tug and workboat. ◗ Survey boat. ◗ Support boat (fuel, etc). Production rates of 100m^3/hr (~15,000m^3 / wk). Approx. 7 weeks dredge period.	◗ Office: 3 persons ◗ Dredger: 10 persons ◗ Barge: 5 persons per barge ◗ Work boat: 2 persons ◗ Tug: 2 persons ◗ Survey boat: 2 persons ◗ General support: 2 persons
Offshore breakwaters	262,000 m^3 (in-situ) of soft silty clay below breakwaters. Clay is soft and unsuitable for fill. Also, potential acid sulfate soils. All material disposed offshore.	Mechanical backhoe dredge method as above. Approx. 22 weeks dredge period. (Allowing some provision for a more exposed site and consequent weather delays)	As above.
Swing basin and approach channel	185,000 m^3 (in-situ) of mixed sand, silt and mud. Separation of materials not likely to be feasible and is also a potential acid sulfate soil. Assume all disposed offshore.	Mechanical backhoe dredge method as above. Approx. 14 weeks dredge period.	As above.

Location	Material type	Work method	Typical Site Personnel
Harbour basin (Stage 2)	340,000 m^3 (in-situ) of sand (1-2m thick) overlying silty clay. Estimated sand (approx. 25%) (85,000 m^3) will be reusable. Sand can be reused to form precinct reclamation, provided revetments are constructed in advance and sand is placed below water level (or treated for PASS). Remainder (255,000 m^3) of material disposed offshore.	<u>Upper layers - Sand</u> Small cutter suction can be used to dredge the upper sand layer and pump into the Stage 2 reclamation area. Small CSD equipment spread: ◗ Small cutter suction dredge. ◗ Tug and workboat. ◗ Support boat ◗ Floating and bolted steel pipeline ◗ Dozer / wheel loader for pipe handling Production rate of 100m^3/hr (cut and fill) (~15,000m^3/wk) allowing for restricted hours during low tides. Approx. 7 weeks period for CSD of sand. <u>Lower Layers – mixed Silt, Sand, Clay</u> Mechanical backhoe dredge method as above to dredge silty clay and dispose offshore. Approx. 19 weeks dredge period for backhoe dredge and disposal of silty clay.	As above for backhoe dredge and disposal offshore. For Small CSD: ◗ Office: 3 persons ◗ Dredger: 5 persons ◗ Work boat: 2 persons ◗ Tug: 2 persons ◗ Discharge area: 5 persons ◗ Support boat: 3 persons ◗ General support: 2 persons
Pile Moorings	70,000 m^3 (in-situ) of soft silty clay	Mechanical backhoe dredge method as above. Approx. 6 weeks dredge period	As above.

3.3 Method of Filling

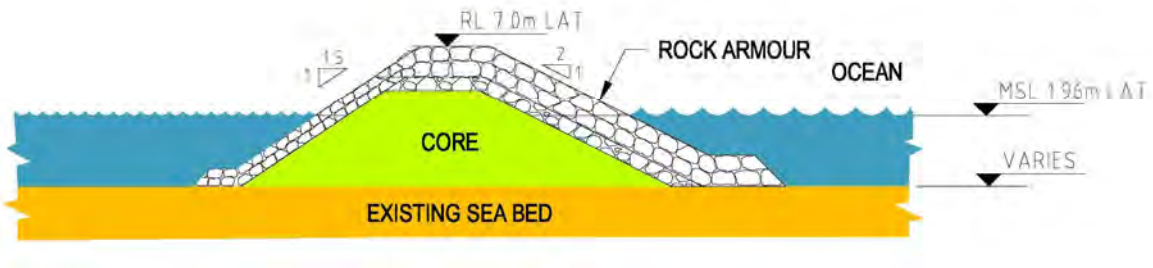
Various filling operations are required as part of the marine precinct project, including:

- Rock works to construct the offshore breakwaters
- Rock works to provide protection to the Stage 1, 2 and 3 precinct revetments.
- Filling to replace soft clay removed from below the offshore breakwaters.
- Filling to form the Stage 2 and 3 reclamation area.

Rock Works

The breakwaters and revetments are required to protect the precinct from waves, particularly during storm events. The walls typically consist of a rock armour layer over a core of run of quarry material. The width of the bund crest is usually dictated by requirements to allow the passage of trucks to build the bund while maintaining working room for plant to place the armour layers.

Figure 4 Typical breakwater / revetment arrangement



A total of 348,000 m^3 imported rock fill (Table 3) is required for the project. It is understood that sufficient quantity/ quality of rock armour (typically 2 -5 tonne size offshore) and rock core material (typically quarry run size) can be sourced from local quarries located within 60km from the marine precinct site.

This material will be delivered from the quarry to the site by road in a fleet of road-registered haulage trucks, which typically have capacities of 20 - 40 tonnes (~ 13 - 25m^3). The trucks will haul the material from the quarry to the bund site and continue out to the bund and end tip material into place allowing progressive bund construction nearest-shore to furthest from shore. For the offshore breakwaters, the trucks will dump the rock fill directly into barges, which transport the rock to the breakwater location, where it would be placed by barge mounted grab crane (the use of a temporary causeway to the outer breakwater is not feasible as it would obstruct the Ross River Channel). Alternately, the road-registered fleet could dump fill at a stockpile and the material can be rehandled and placed by dedicated on site plant. Photographs of the indicative method are attached as Figure 5.

Based on an average 3 hour haulage cycle (fill, haul, dump, haul, refill) a fleet of 6 trucks will be required to provide a truck load every 30 minutes (pre TPAR restricted transport rate) with greater frequency acceptable after opening the Port Access Road.

Figure 5 Breakwater Construction

Excavator and grab barge placing rock offshore

Loader rehandling armour to offroad dump truck

General Filling

A total of **922,000** m^3 imported non cohesive fill (Table 3) is required for the project.

If a land based source, e.g. an area (or areas) of weathered rock, is adopted, the material would be delivered to site using a fleet of haulage trucks and spread on site using conventional swamp dozers and earthmoving plant.

If a marine based source, e.g. a near-shore sand bar, could be identified, the construction method would utilise a CSD located in the borrow area. A submerged pipeline would be laid from the borrow area to the precinct site, with the section of pipeline crossing the Ross River Channel and buried to avoid obstructing vessels using the channel. The borrow area would ideally be located within 1 - 2km of the precinct site to minimise pumping requirements. The Stage 2 Harbour perimeter revetments must be constructed prior to dredging and placement of sand. The revetments will contain the placed sand and also control tailwater by directing the discharge water from the dredging.

A key constraint associated with securing a near shore sand source is that material will form part of the littoral environment and securing approvals to win this material is problematic. A viable and proximate marine based source has not been identified and the terrestrial source is the most feasible option. However, details of the construction procedure associated with marine based material sourcing have been included for completeness.

Some ground improvement or consolidation / compaction works will be required before construction on reclaimed land, this may include; dynamic compaction, vertical drains or surcharging. The actual method adopted will depend on the ground conditions, required speed of construction and the contractor's plant.

Filling methods are summarised in Table 6, along with associated required plant and personnel.

Table 6 Summary of Filling Areas and Filling Methods

Location	Material type	Work method	Typical Site Personnel
Trawler basin revetment (Stage 1)	39,000 m^3 rock fill comprising mix of 400 – 700 kg size armour rock and quarry run core material. Material to be sourced from local quarry (approx. 60km from precinct site).	Road haulage from local quarry and end tipping on site or stockpiling and rehandling. Equipment spread: ◗ Fleet (6No.) of haulage trucks. ◗ Hydraulic excavator and dozer for handling/ placing rock fill. ◗ Loader and offroad dump truck for rehandling. ◗ Small equipment (generators, compressors, 4WD vehicles, etc). Filling rates of 30m^3/hr (~2,200m^3/ wk for 12 hour + 6 day week). Approx. 18 weeks filling period. (before TPAR opening)	◗ Office: 3 persons ◗ Haulage fleet: 6 persons ◗ Excavator: 1 person ◗ Dozer: 1 person ◗ Loader: 1 person ◗ Offroad dump truck: 1 person ◗ General support: 10 persons *Daylight operations pre TPAR*

Location	Material type	Work method	Typical Site Personnel
Filling dredged trench below offshore breakwaters	262,000 m^3 non-cohesive fill. Material to be obtained from either land based source (e.g. local rock quarry) or marine based source (e.g. near shore sand bar). Material to be loaded onto barge over a temporary barge wharf for land based source material.	<u>Land based sand source:</u> Road haulage from local quarry. Split bottom barge to transport and place offshore. Equipment spread: ◗ Fleet (18No.) of haulage trucks. ◗ Loader for rehandling / barge loading. ◗ 2No. split hopper barges or transport barge with spreader barge. ◗ Bed levelling / sweep bar for levelling / profiling fill. ◗ Hydrographic survey spread. ◗ Small equipment (generators, compressors, 4WD vehicles, etc). Filling rates of 75m^3 / hour (~12,000 m^3 / wk for 24 hour + 7 day week, i.e. after bridge open). Approx. 24 weeks filling period. <u>Alternative - Marine based sand source:</u> Medium cutter suction dredge method. Equipment spread: ◗ Medium CSD with floating and bolted steel pipeline. ◗ Tug and workboat. ◗ Spreader barge. ◗ Support boat. ◗ Dozer / loader for pipe handling. Filling rates of 600m^3/hr (~100,000 m^3/wk). Approx. 3 weeks filling period.	◗ Office: 3 persons ◗ Haulage fleet: 18 persons ◗ Loader: 1 person ◗ Barge: 5 persons per barge ◗ Survey boat: 2 persons ◗ Bed Levelling spread: 3 persons ◗ General support: 10 persons *24 hr operations post TPAR*

Location	Material type	Work method	Typical Site Personnel
Offshore breakwaters	147,000 m^3 rock armour comprising mix of 2 – 5 tonne size armour rock and quarry run core material. Material to be loaded onto barge over a temporary barge wharf.	Road haulage from local quarry. Barge + barge mounted grab to transport and place offshore. Equipment spread: ◗ as Stage 1 revetment + ◗ Loader for rehandling / barge loading. ◗ 2No. transport barges with bobcat / small loader. ◗ Large barge mounted grab for handling armour. ◗ Survey boat. Filling rates of 75m^3 / hour (~12,000 m^3 / wk for 24 hour + 7 day week, i.e. after bridge opening). Approx. 14 weeks filling period.	◗ Office: 3 persons ◗ Haulage fleet: 18 persons ◗ Excavator: 1 person ◗ Dozer: 1 person ◗ Loader: 1 person ◗ Barge: 5 persons per barge ◗ Bobcat: 1 person per barge ◗ Barge grab: 3 persons ◗ Survey boat: 2 persons ◗ General support: 10 persons *24 hr operations post TPAR*
Harbour basin (Stage 2) revetments	118,000 m^3 rock armour and rock core fill from local quarry.	Method and equipment as Stage 1 revetment except with greater haulage rate / fleet. Filling rates of 75m^3 / hour (~12,000 m^3 / wk for 24 hour + 7 day week, i.e. after bridge opening). Approx. 10 weeks filling period.	◗ Office: 3 persons ◗ Haulage fleet: 18 persons ◗ Loader: 2 person ◗ Excavator: 3 person ◗ Dozer: 3 person ◗ Offroad dump truck: 3 person ◗ General support: 10 persons *24 hr operations post TPAR*

Location	Material type	Work method	Typical Site Personnel
Harbour basin (Stage 2) reclamation	394,000 m^3 sand fill, comprising 309,000 m^3 imported fill and 85,000 m^3 fill reused from Stage 2 dredging (ie. dredging of navigable depths in the basin). Ground improvement / surcharging required.	<u>Land based sand source:</u> Method and equipment spread as Stage 2 Harbour Basin revetment above. Filling rates of 75m^3 / hour (~12,000 m^3 / wk for 24 hour + 7 day week, i.e. after bridge open). Approx. 33 weeks filling period. <u>Alternative - Marine based sand source:</u> Medium cutter suction dredge. Equipment spread as offshore breakwater trench above. Filling rates of 600m^3 / hour (~100,000 m^3 / wk) can be expected. Approx. 4 weeks filling period.	◗ Office: 3 persons ◗ Haulage fleet: 18 persons ◗ Loader: 2 person ◗ Excavator: 3 person ◗ Dozer: 3 person ◗ Offroad dump truck: 3 person ◗ General support: 10 persons *24 hr operations post TPAR*
Future Reclamation (Stage 3) revetments	44,000 m^3 rock armour and rock core fill from local quarry.	Method and equipment as Stage 2 Harbour Basin revetment. Filling rates of 75m^3 / hour (~12,000 m^3 / wk for 24 hour + 7 day week, i.e. after bridge opening). Approx. 4 week filling period.	Personnel as Stage 2 revetment.
Future Reclamation (Stage 3)	351,000 m^3 sand fill. Ground improvement / surcharging required.	Method and equipment as Stage 2 reclamation. Filling rates of 75m^3 / hour (~12,000 m^3 / wk for 24 hour + 7 day week, i.e. after bridge opening). Approx. 30 weeks filling period.	Personnel as Stage 2 reclamation.

3.4 Phasing and Timing of the Works

A phasing programme for the marine precinct project has been developed on the basis of the foregoing construction methodology and is included in Appendix E.

Construction of the Townsville Port Access Road (TPAR) demands that the Stage 1 precinct works be implemented prior to completion of the bridge linking the Port Access Road to Townsville Port, such that the existing trawler fleet can be relocated. The TPAR project therefore serves as a primary driver for construction of the Stage 1 Trawler Basin.

The following assumptions have been made in establishing the phasing programme:

- Development of the Stage 1 precinct works have been based on a completion date of August 2010, some 4.5 months ahead of completion of the Port Access Road bridge substructure in January 2011. This allows 3 months for relocation of existing upstream facilities.
- Remaining elements of the precinct project excluding Stage 3 (offshore breakwater, turning basin/ approach channel and Stage 2 harbour basin) may commence in February 2011 and can be carried out concurrently.
- Stage 3 is notionally programmed to commence in Jan 2013.
- Marine operations (dredging and/ or filling) on the project will be carried out 24 hours per day, 7 days per week, without need to observe a 'dredge window'.
- Rock fill will generally be hauled over a 12 hour daytime period 6 days per week through South Townsville, reverting to a 24 hour period, 7 days per week after opening of the Port Access Road Bridge in September 2011. Haulage limitations of 1 truck per 30 minutes through South Townsville have been adopted with greater rates allowable upon completion of the Port Access road (TPAR).
- Stage 2 revetment walls will be constructed in advance of filling operations to minimise environmental impacts from filling and tailwater discharge.
- Dredge rate of 100 m^3 per hour by backhoe dredge.
- Sand dredge and filling rate of 100 m^3 per hour by small size cutter suction dredge.
- Rock filling rate of 75 m^3 per hour by road haulage from local rock quarry.
- Marine sand dredge and filling rate of 600 m^3 per hour by medium size cutter suction dredge.
- All necessary designs, materials sourcing, approvals and permits can be implemented to meet the required timelines for commencement of construction.

3.5 Execution of the works

3.5.1 Contractors Works Area

The construction contractors will require an area to accommodate their operations during the works. Some of the principal activities that would occur within the construction works area may include:

- Office, staff amenities and administrative functions;
- Vehicle parking for construction vehicles and contractors staff;
- Workshops and maintenance area;

- Stockpiling and handling of rock and fill for revetment and reclamation purposes;
- Temporary Barge loading facility.

It is expected that the Contractor would construct an area within either Lot 773 or the temporary hardstand area as appropriate to accommodate these operations and that an additional area outside the project footprint will not be required.

3.5.2 Suspended Sediment

The background water quality determined for the Port has been measured at relatively high levels with values of 23-35 NTU (80-120 mg/L) measured as 3 month median and mean values respectively during the course of the EIS. Consequently, the receiving waters are expected to be relatively tolerant of dredging and reclamation activities and the resultant dredge plumes are not expected to be extensive.

Further, filling of the excavated section under the breakwater and placement of core and armour rock is not anticipated to cause significant concentrations of suspended sediment.

The proposed dredge methodology provides the following sources of potential turbidity:

- at dredge Siltation (Backhoe and Cutter Suction Dredge);
- reclamation tailwater decant; and
- offshore spoil dumping.

Of these sources the Backhoe dredge operation is considered to have the most significant effect.

Considerations influencing this determination include;

- the proposed Cutter Suction Dredger will generally be working coarser sediments, suitable for reclaim, working within the Stage 2 harbour basin and is relatively easy to contain if required. Tailwater decant water quality at levels less than the measured background values should be achievable.
- In the event that additional reclaim / shore disposal opportunities are realised through construction phasing (ie long lead times supporting consolidation of poor fill), hydraulic dredging methods (Cutter Suction Dredge) may be used to reclaim poorer material. Design of dredge spoil settlement ponds would be required to be undertaken with tailwater decant water quality levels consistent with the measured background values.
- Offshore dumping operations have been undertaken by the POTL at the existing offshore spoil ground periodically for many years. It is understood that during the course of these works significant monitoring has demonstrated no significant impact to sensitive receptors in the adjacent environment (Cruz, 2000 and Benson, 1993).

The following design sediment concentration from dredging operations for assessment through modelling has been adopted as a representation of the sediment generation for hydrodynamic modelling;

At source backhoe dredger

Adopt a conservative 2% loss of material (US Army Corps of Engineers, 2008)

Likely dredge equipment = $2m^3$ bucket on 40 sec cycle, for 1600 kg/m^3 density of material

= 1.7 kg/sec solids discharge rate.

3.5.3 Impacts on Navigation

Construction of the Stage 1, Stage 2 and Stage 3 reclamation, protective rockworks and inner harbour navigation dredging will be conducted adjacent to but off the line of existing navigation channels and are not expected to cause interference to other operations.

The majority of the works associated with bed preparation and construction of the offshore breakwater will be conducted remotely from the main navigational access except for the northerly section of the offshore breakwater and the dredging for re-alignment of the Ross River channel. The latter two operations will be conducted within and in close proximity to the existing navigation channel. However, the works will be conducted using relatively small dredging plant, and only minor constraint to the operation of existing commercial, defence or recreational users is envisaged. In the event that marine construction operations do lead to partial blockage of the channel the plant will be able to be periodically pulled aside to allow access to other traffic. Provision can be made within the construction contracts to manage potential navigation constraint.

3.5.4 Construction hours

Dredging and reclamation works are proposed to be conducted 24 hours a day, 7 days a week.

Other construction activities would be limited to daylight hours, 6 days a week prior to the opening of the Port Access Road (June 2011). Following the opening of the port access road filling and reclamation works may also be able to progress on a 24 hours a day, 7 days a week basis.

3.6 Summary of Construction Equipment

The actual equipment adopted will depend on the final configuration of the development, plant availability and the Contractors preferred working method. An indicative list of equipment is provided below based on the identified construction method above.

Table 7 Construction Equipment on Site

Phase of Works	Equipment	Number	Activity
End Dumped Revetment / Breakwater construction			
Trawler Basin revetment 18 weeks *(prior to opening TPAR)*	Trucks	24/ day	Delivery of Revetment core material and armour
	Excavator:	1	Handling / placing rock fill
	Loader:	1	Rehandling / Stockpiling fill
	Offroad Dump Truck	1	Rehandling / Transporting fill
	Dozer:	1	Trimming / Level finished surface
Stage 2 revetment 10 weeks Stage 3 revetment 4 week	Trucks	140/ day	Delivery of Revetment core material and armour
	Excavator:	3	Handling / placing rock fill
	Loader	2	Rehandling / Stockpiling fill

Phase of Works	Equipment	Number	Activity
(post opening TPAR)	Offroad Dump Truck	3	Rehandling / Transporting fill
	Dozer:	3	Trimming / Level finished surface
Offshore Breakwater Construction			
Offshore Breakwater Construction 14 weeks	Trucks	140/ day	Delivery of Breakwater core material and armour
	Excavator	1	Handling / placing rock fill
	Dozer:	1	Trimming / Level finished surface
	Loader	1	Rehandling Fill / Loading barges
	Bobcat	2	Rehandling Fill onboard barges
	Transport Barge	2	Transporting core and armour
	Grab Barge	1	Placing Breakwater armour
	Survey Boat	1	Hydrographic Surveys
	Work Boat	1	General support
Backhoe Dredging			
Trawler Basin 7 weeks Stage 2 Inner Harbour 19 weeks Channel + swing basin re-alignment 14 weeks Under Offshore breakwater foundation 22 weeks Pile Moorings 6 weeks	Backhoe Dredge	1	Dredging
	Split Bottom barge	2	Transporting and dumping dredge spoil
	Tug	1	Supporting dredger and split bottom barges
	Workboat	1	Supporting dredger and tug
	Survey Boat	1	Hydrographic survey
	Support Boat	1	General support / provisioning / fuel / transport
Cutter Suction Dredging			
Dredging of Stage 2 Inner Harbour 7 weeks	Small Cutter Suction Dredge	1	Dredging to reclaim
	Floating spoil pipeline	1	Spoil transport

	Adjustable weir box	1	Tailwater management
	Dozer / loader	1	Spoil pipe handling
	Support Boat	1	General support / provisioning / fuel / transport
Reclamation using imported fill			
Stage 2 33 weeks Stage 3 30 weeks *(post opening TPAR)*	Trucks	140/ day	Delivery of sand fill material
	Excavator	3	Placing and handling fill
	Dozer:	3	Trimming, Placing and compacting fill
	Loader	2	Placing and rehandling fill
	Offroad Dump truck	3	Rehandling and transporting fill
Backfilling dredge trench			
Reinstatement of foundation under offshore breakwater 24 weeks	Trucks	140/ day	Delivery of sand / quarry run fill material
	Loader	1	Loading barges
	Survey Boat	1	Hydrographic survey
	Drag bar / bed leveller	1	Finishing / levelling
	Split bottom Barge or transport barge	2	Transporting and dumping fill
	Spreader barge	1	Placing / dumping fill

3.7 Summary of Construction Workforce

The average workforce onsite during dredging and filling construction works is envisaged to be between 30 – 50 people. Depending on the staging of the works a peak workforce in excess of 100 people may be expected for the concurrent construction of the stage 2 reclamation works and the construction of the offshore breakwater.

- Dredging operations (Stage 1, Stage 2, and Offshore Breakwater preparation) 25 – 35 ppl
- Rockworks (Stage 1 Breakwater, Stage 2 and 3 rockworks) 20 – 70 ppl
- Reclaim and filling (Stage 2 and 3 reclamation) 30 – 70 ppl
- Offshore Breakwater foundation preparation 80 – 110 ppl
- Offshore Breakwater Construction 60 – 80 ppl

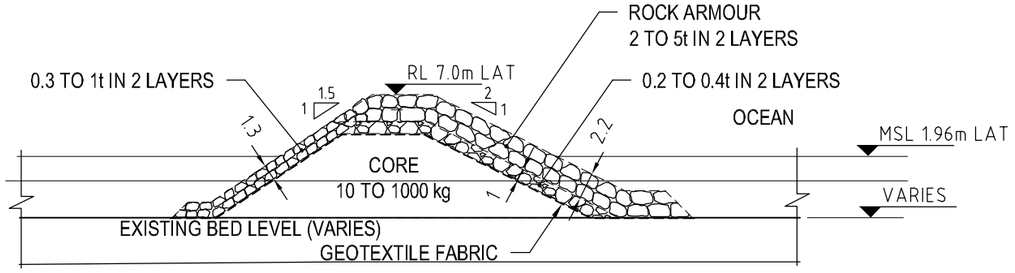
Depending on the staging of the works these workforces may be concurrently deployed.

4. References

1. BRAY, R.N., 1979. 'Dredging - a handbook for engineers'. Edward Arnold.
2. Benson et al, 1993. "Townsville Port Authority Capital Dredging Works 1993: Environmental Monitoring Program"
3. BS6349 (1991). Maritime structures - Part 5: Code of practice for dredging and land reclamation. British Standards Institution.
4. Cruz, 2000. "Effects of the Dumping of dredged material of Townsville Port on the soft-bottomed benthic community of Cleveland Bay." November 2000.
5. US Army Corps of Engineers, 2008. "Dredging Operations and Environmental Research Program, The Four R's of Environmental Dredging: Resuspension, Release, Residual, and Risk. February 2008"

Appendix A

Project Levels and Sections



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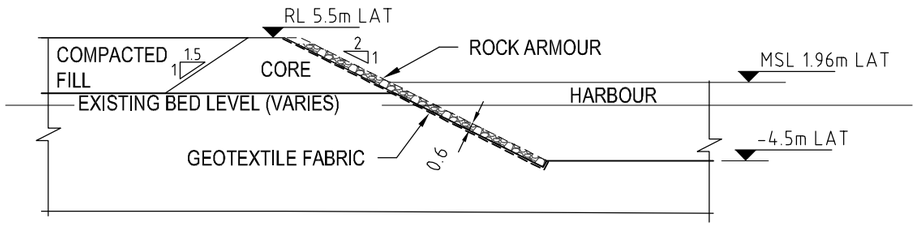

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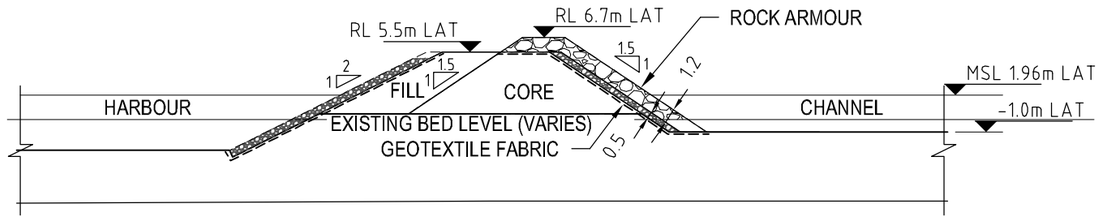

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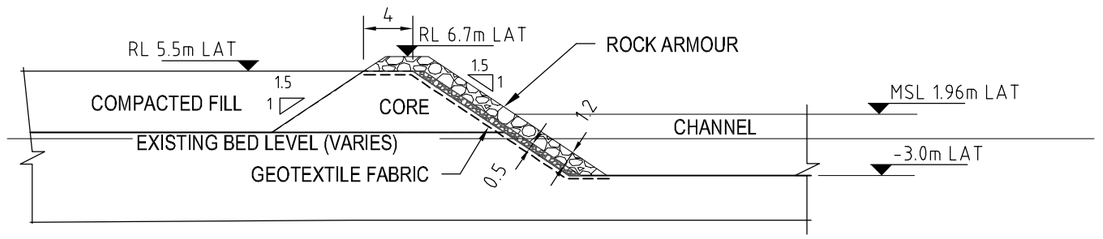

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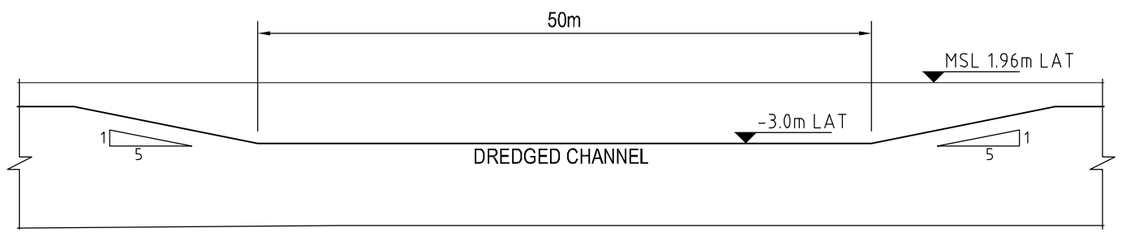

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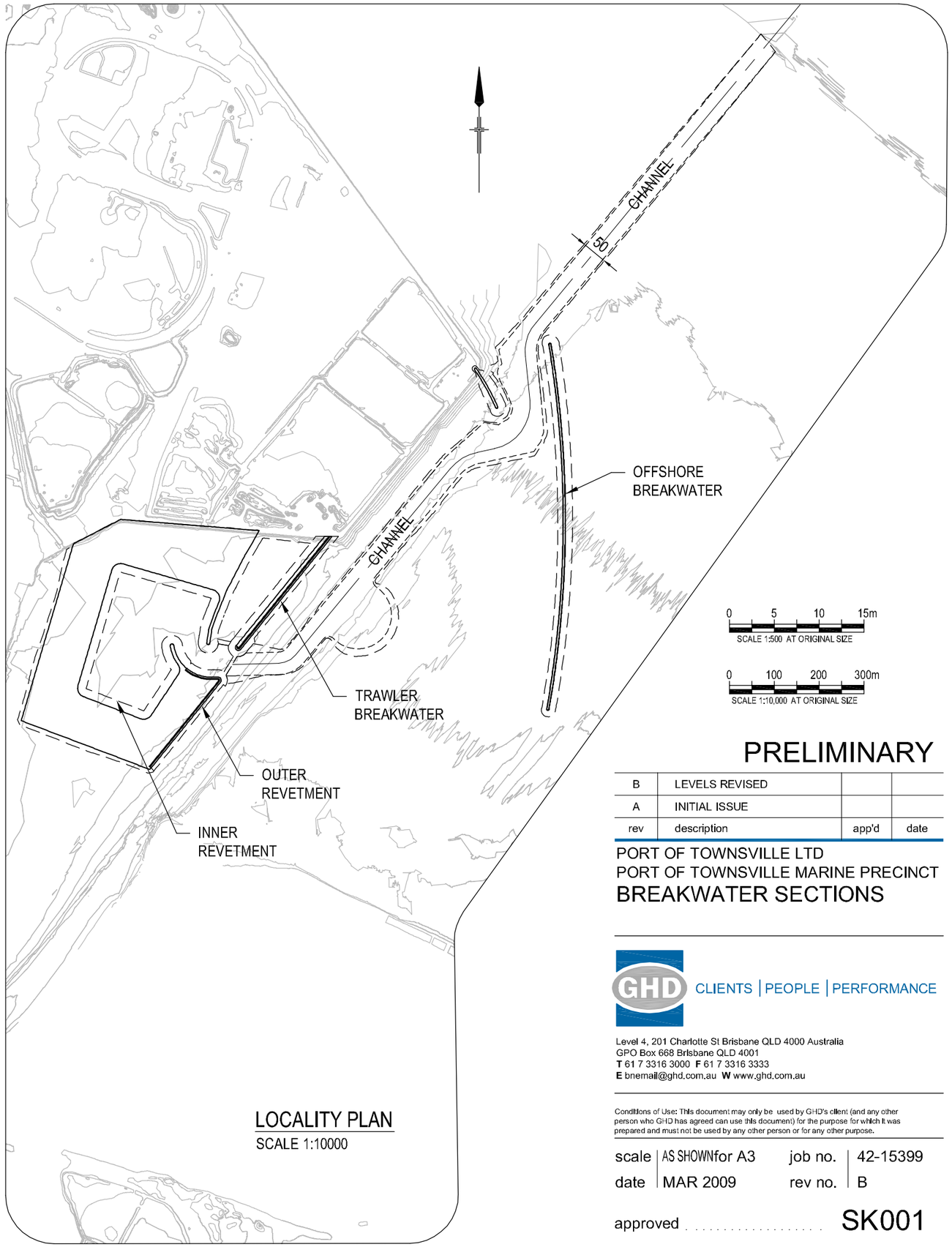

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date	MAR 2009	rev no.	B

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Appendix B

Plan of Marine Investigations and Geological Cross Sections

BOREHOLE COORDINATES

BOREHOLE	EASTING	NORTHING
BHD04	482728	7869287
BHD06	482854	7869278
BHE05	482797	7869351
BHE06	482917	7869358
BHF07	482989	7869494
BHG05	482895	7869577
BHG08	483072	7869673
BHH05	482877	7869753
BHH09	483207	7869693
BHI05	482803	7869768
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BHK17	483980	7869988
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BHL09	483169	7870165
BHL14	483703	7870100
BHL19	484206	7870100
BHM07	482955	7870243
BHM09	483122	7870209
BHM10	483258	7870204
BHM13	483902	7870601
BHM18	484082	7870204
BHN09	483183	7870297
BHN10	483301	7870306
BHN11	483393	7870319
BHN14	483705	7870300
BHN16	483885	7870294
BHN18	484102	7870301
BHO08	483073	7870413
BHO11	483308	7870419
BHO12	483519	7870448
BHO14	483661	7870417
BHO16	483904	7870400
BHP08	483107	7870490

BHP11	483385	7870480
BHP17	484004	7870500
BHP19	484202	7870500
BHQ16	483902	7870601
BHR17	484005	7870700
BHR19	484202	7870697
BHT19	484203	7870898
BHU17	484005	7871000
TPA-09	484071	7871397
TPA-10	484309	7870882
TPA-11	484487	7870652
TPA-12	483959	7870489
TPA-13	484194	7870311
TPA-14	483125	7870506
TPA15	483404	7870288
TPA-16	482847	7870066
TPA-17	483074	7869895
TPA-18	482710	7869559
B1A	482712	7869410
BHC07	482949	7869226
BHC10	483309	7869237
BHD08	483005	7869280
BHD10	483306	7869341
BHD11	483399	4869300
BHE08	483091	7869394
BHE09	483193	786371
BHE10	483305	7869406
BHE12	483500	7869385
BHF09	483185	7869563
BHF11	483391	7869505
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BHG05	482800	7869600
BHG10	483308	7869605
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BHG12	453510	7869641
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BHH11	483356	7869696
BHH13	483607	7869720
BHI14	483729	7869812
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Date	
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Project
Title

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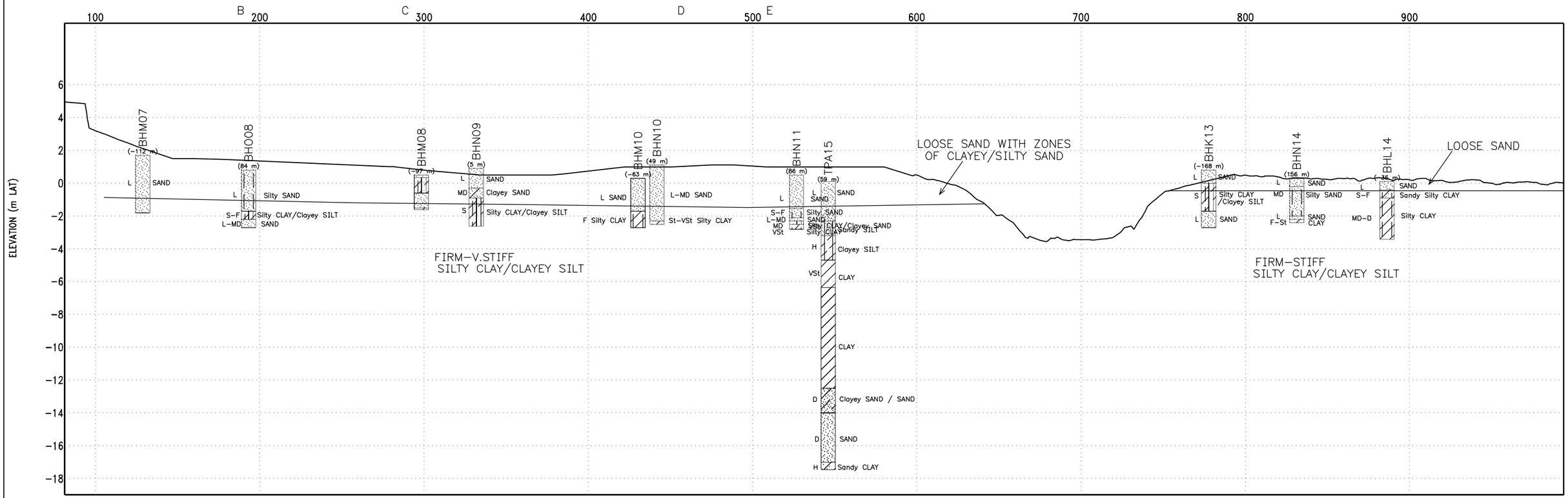

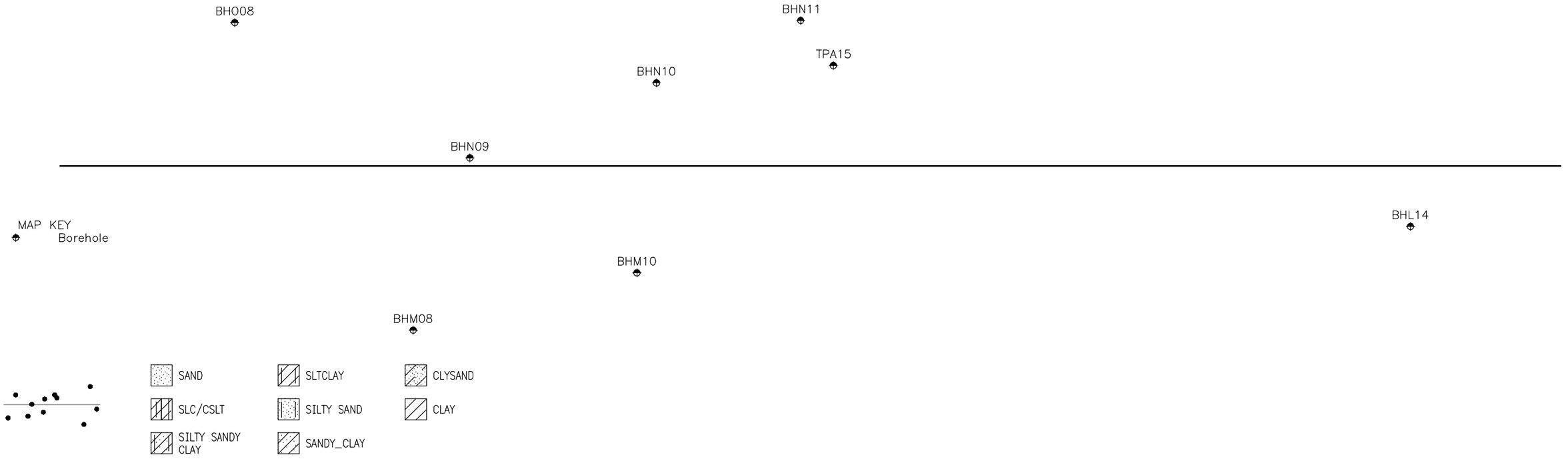

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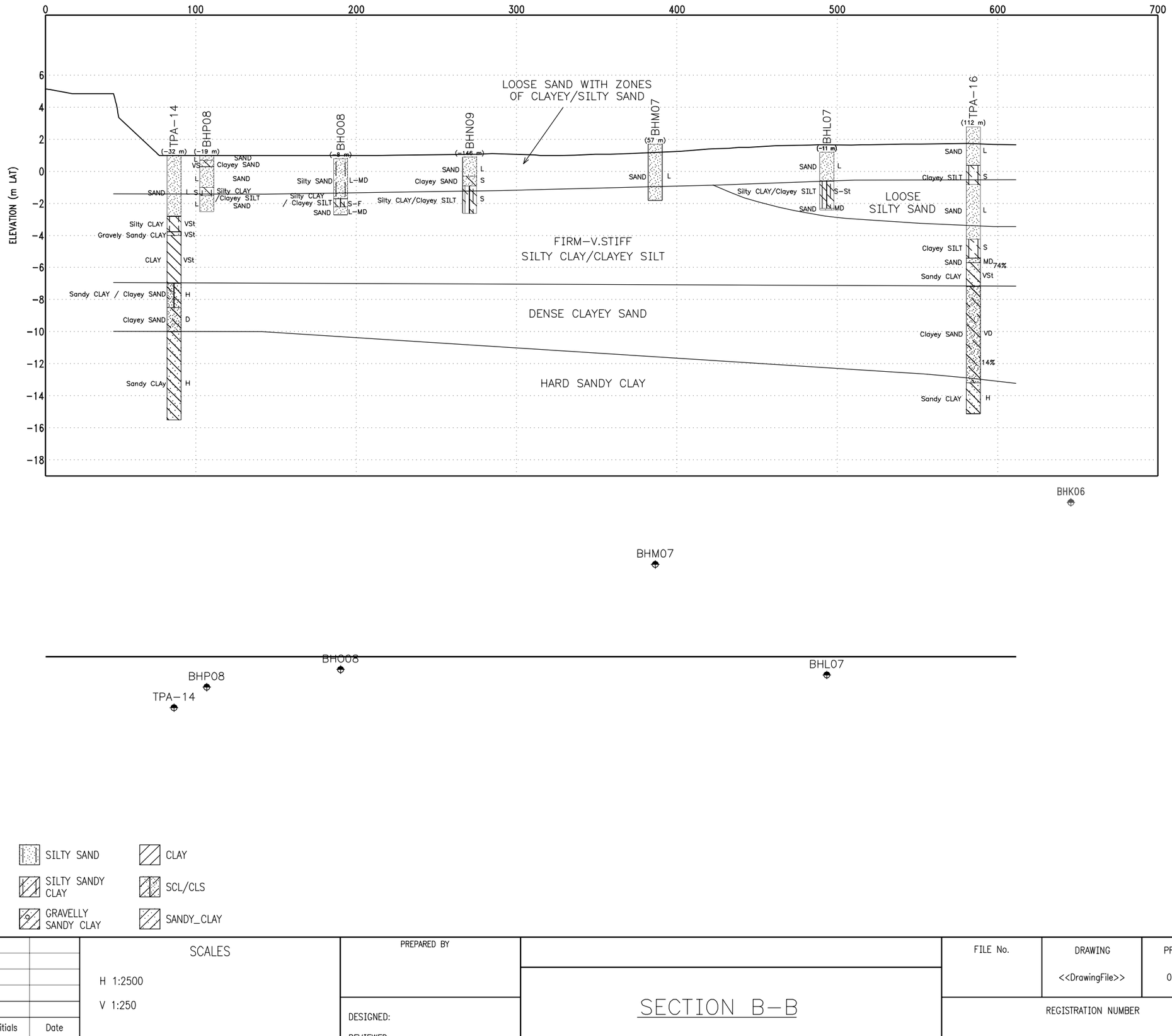

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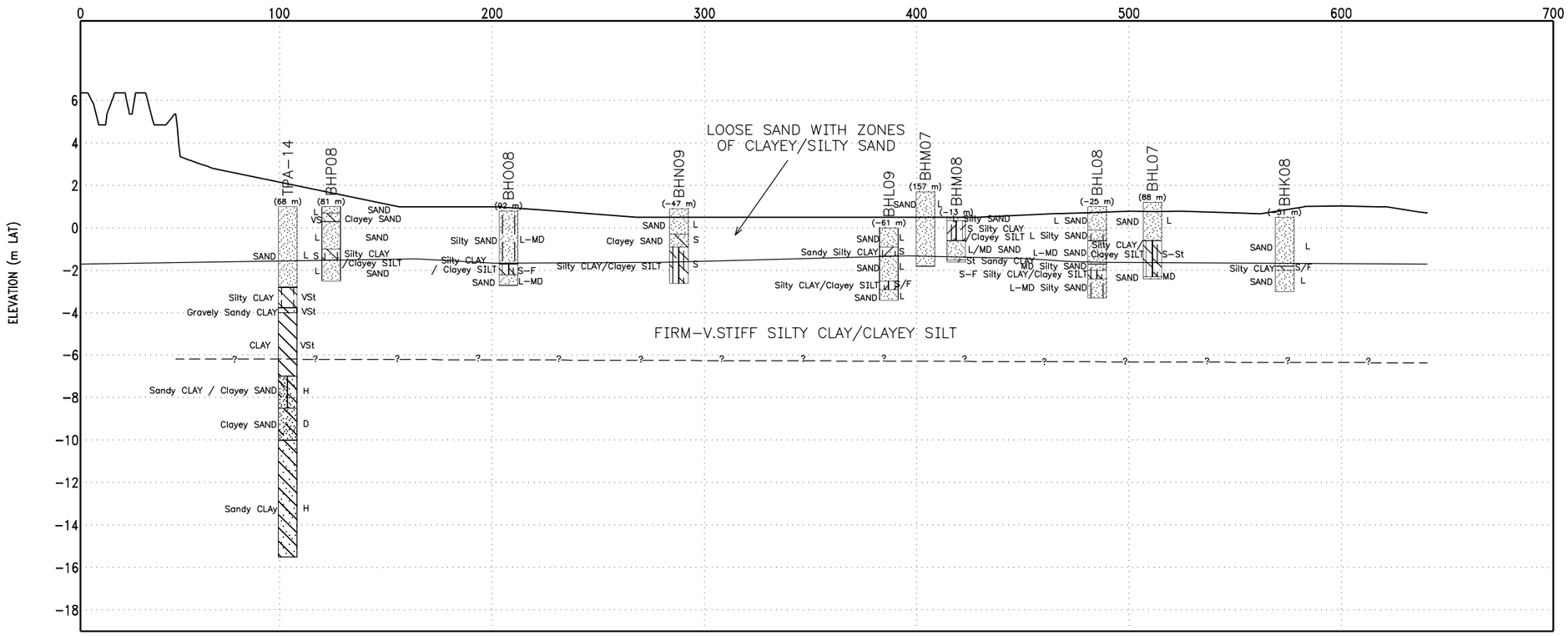

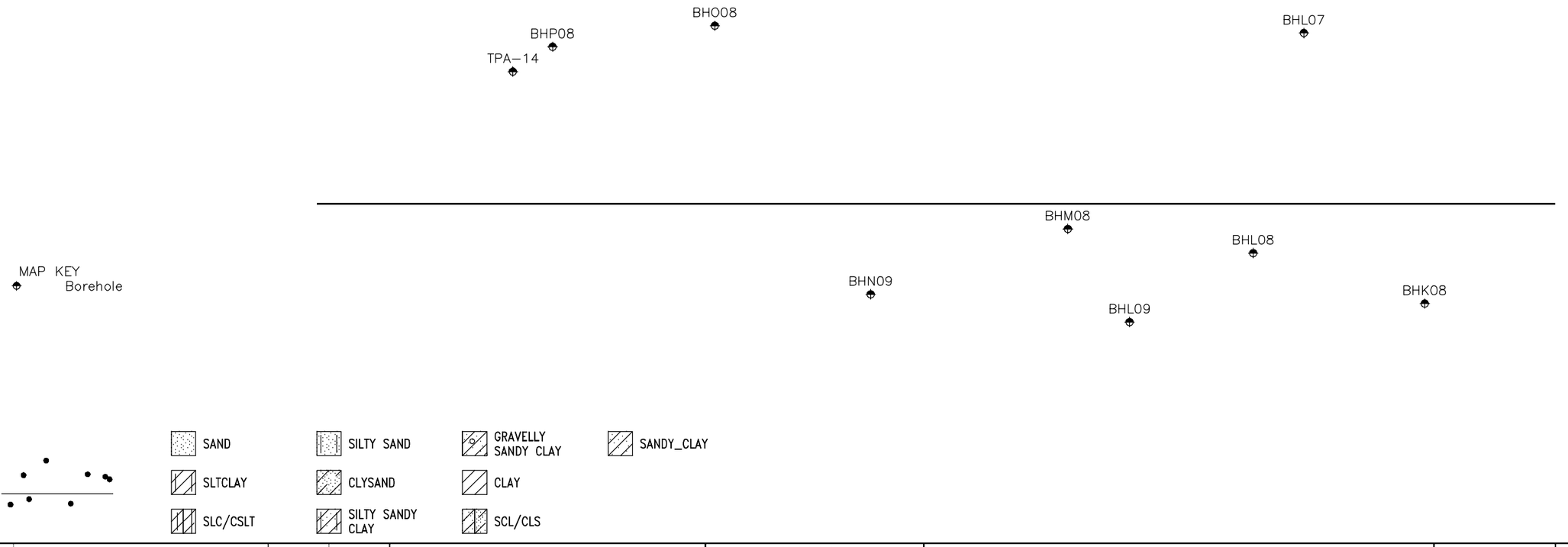

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SLTCLAY | CLYSAND | CLAY

SLC/CSLT | SILTY SANDY CLAY | SCL/CLS

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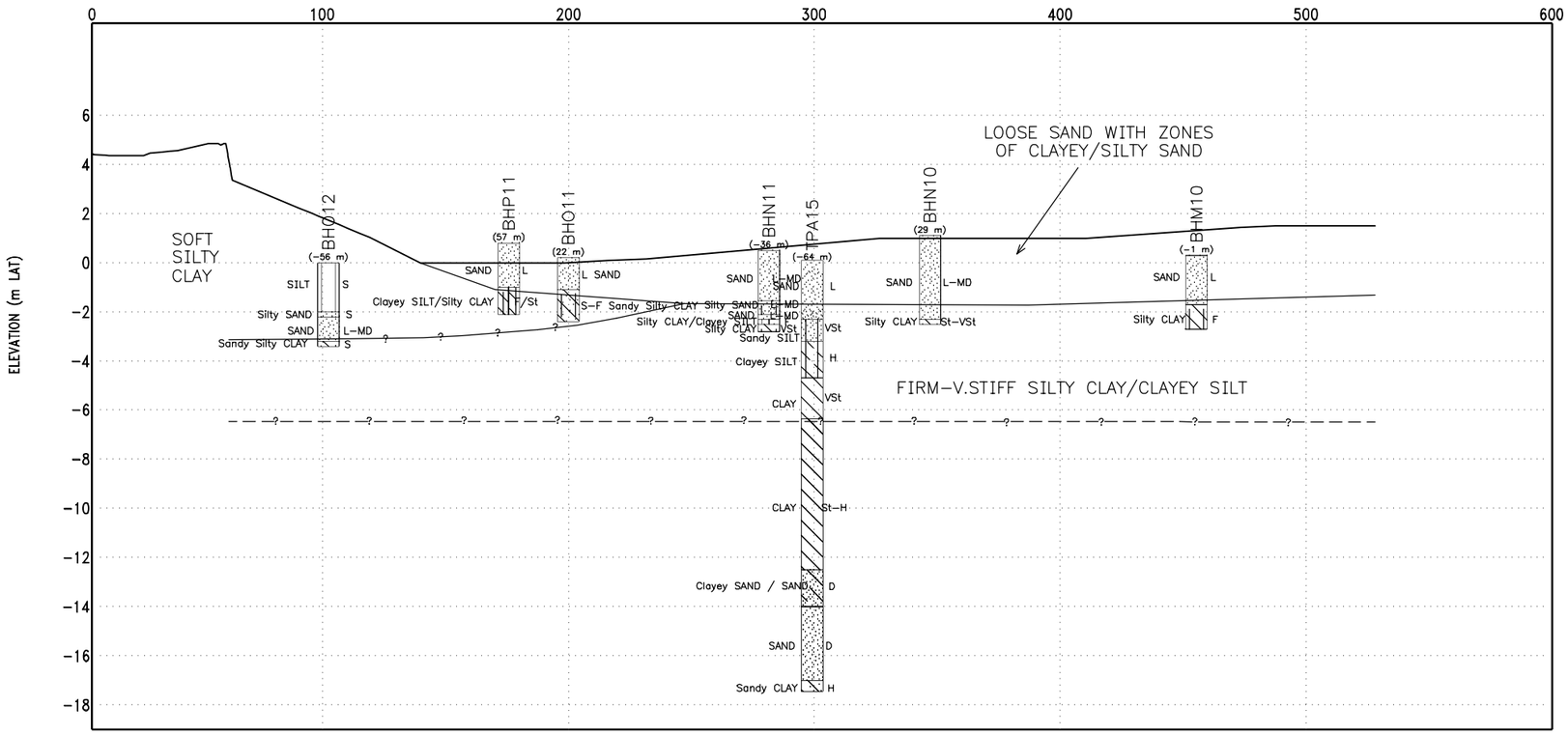

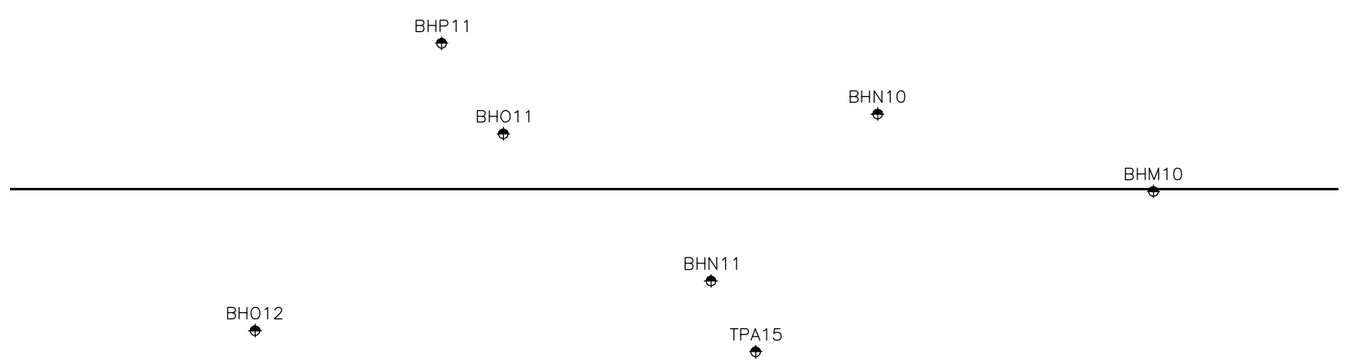

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Borehole

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SILT
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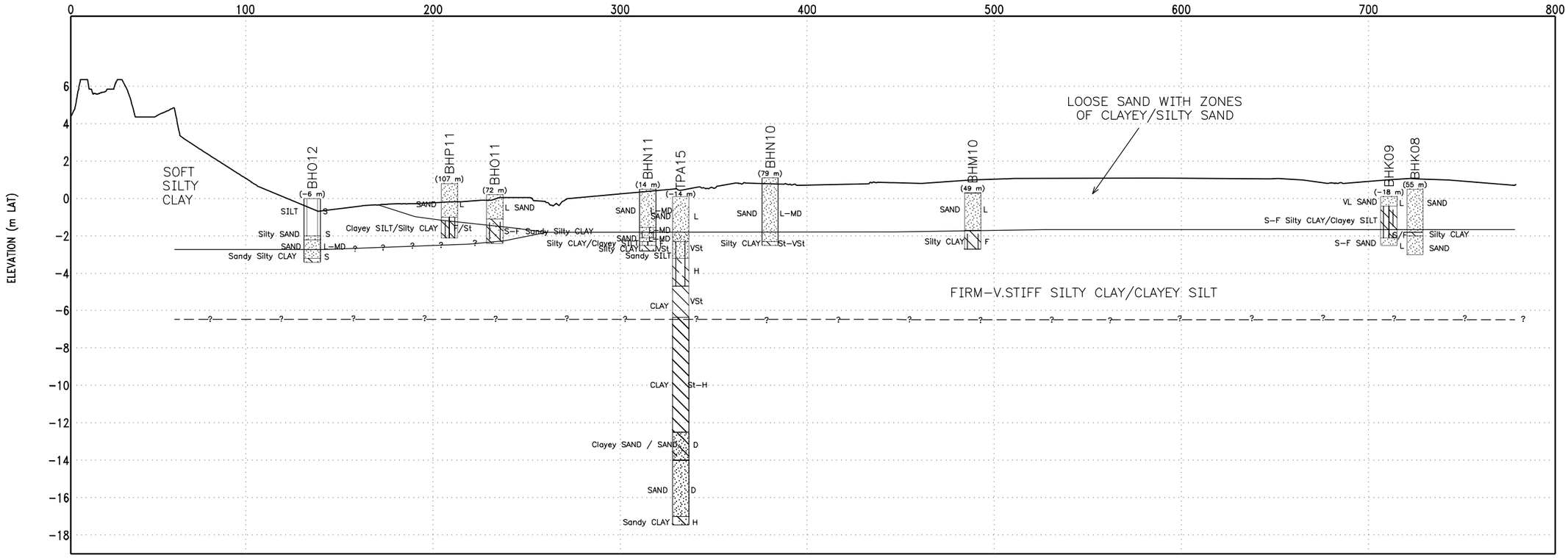
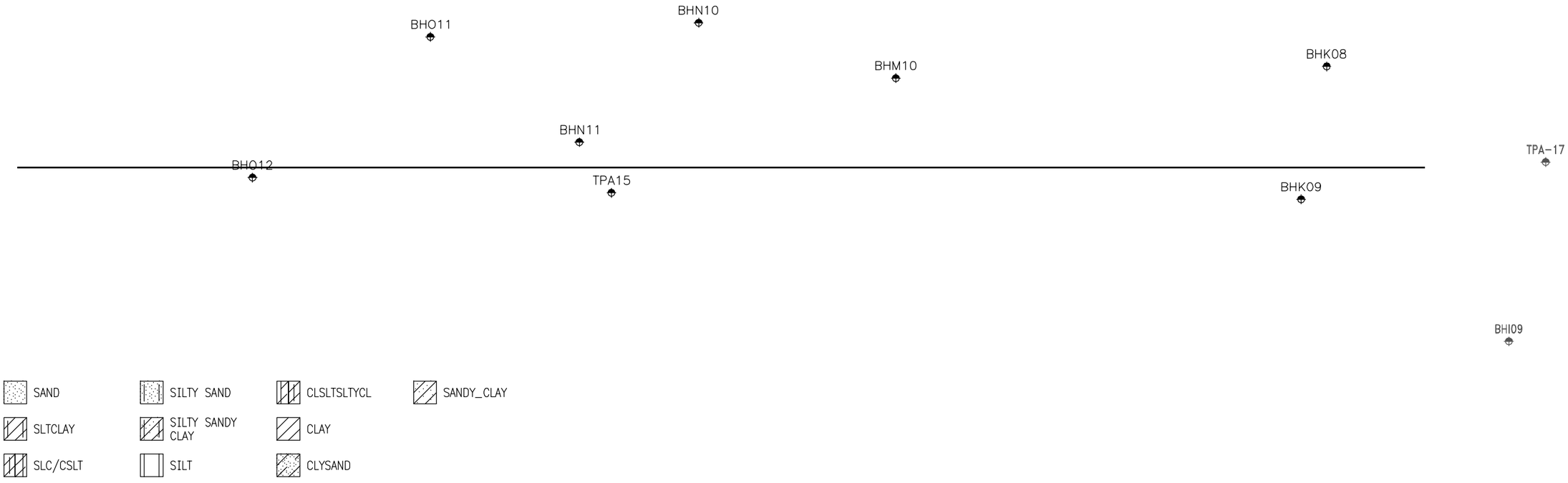




MAP KEY
Borehole

SAND
SILTY SAND
CLSLTSLTYCL
SANDY_CLAY
SLTCLAY
SILTY SANDY CLAY
CLAY
SLC/CSLT
SILT
CLYSAND

No.	Amendment Description	Initials	Date

A3 Original | This sheet may be prepared using colour and may be incomplete if copied

SCALES

H 1:2500

V 1:250

Coordinate System: MGA94 | Height Datum: AHD

PREPARED BY

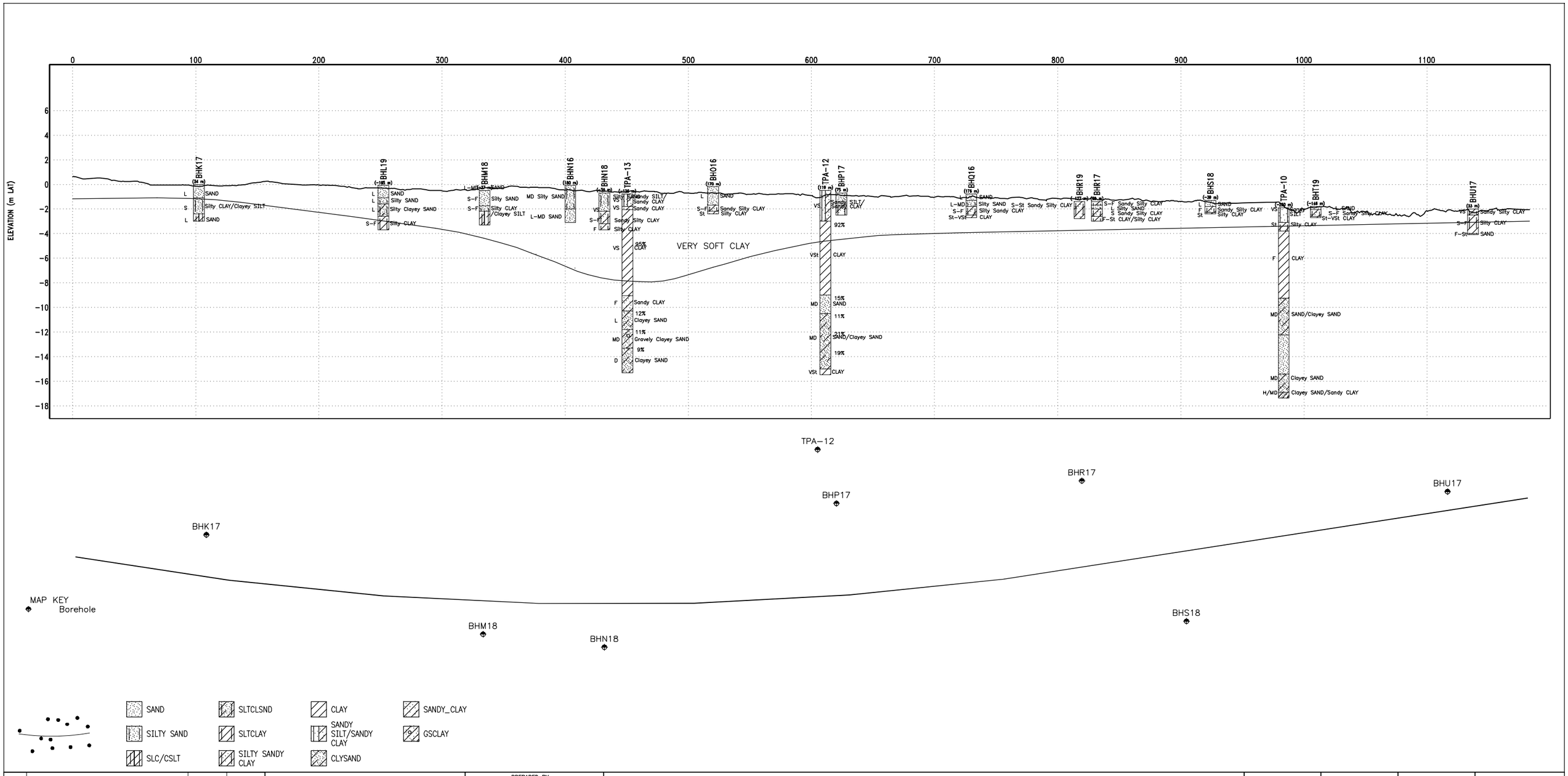
DESIGNED:

REVIEWED:

SECTION E–E

FILE No.	DRAWING	PRINTED DATE	SHEET No.
	<<DrawingFile>>	02/02/2009	

REGISTRATION NUMBER



No.	Amendment Description	Initials	Date

A3 Original | This sheet may be prepared using colour and may be incomplete if copied

SCALES

H 1:2500

V 1:250

Coordinate System: MGA94 | Height Datum: AHD

PREPARED BY

DESIGNED:

REVIEWED:

SECTION G–G

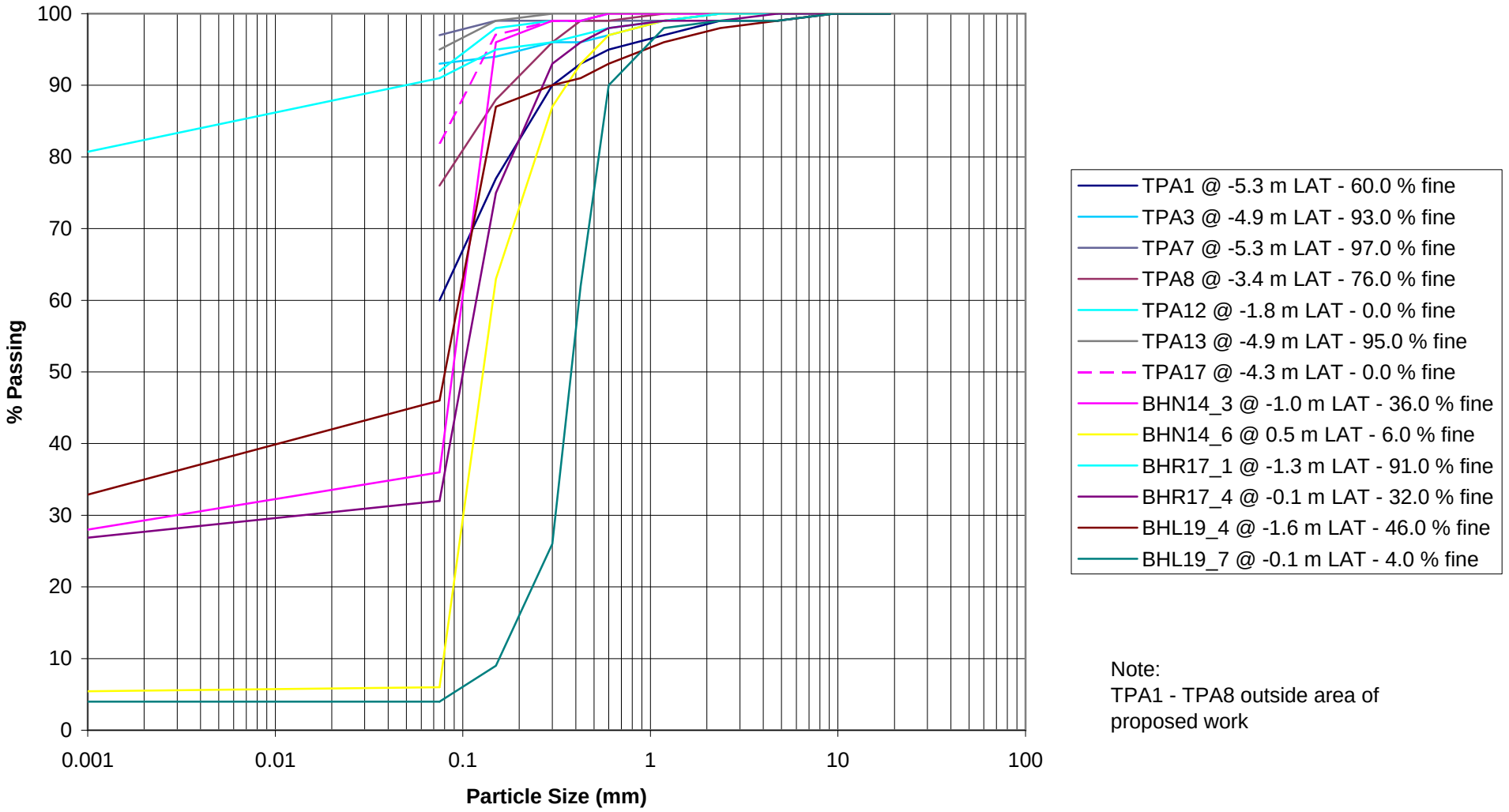
FILE No.	DRAWING	PRINTED DATE	SHEET No.
	<<DrawingFile>>	02/02/2009	

REGISTRATION NUMBER

Appendix C

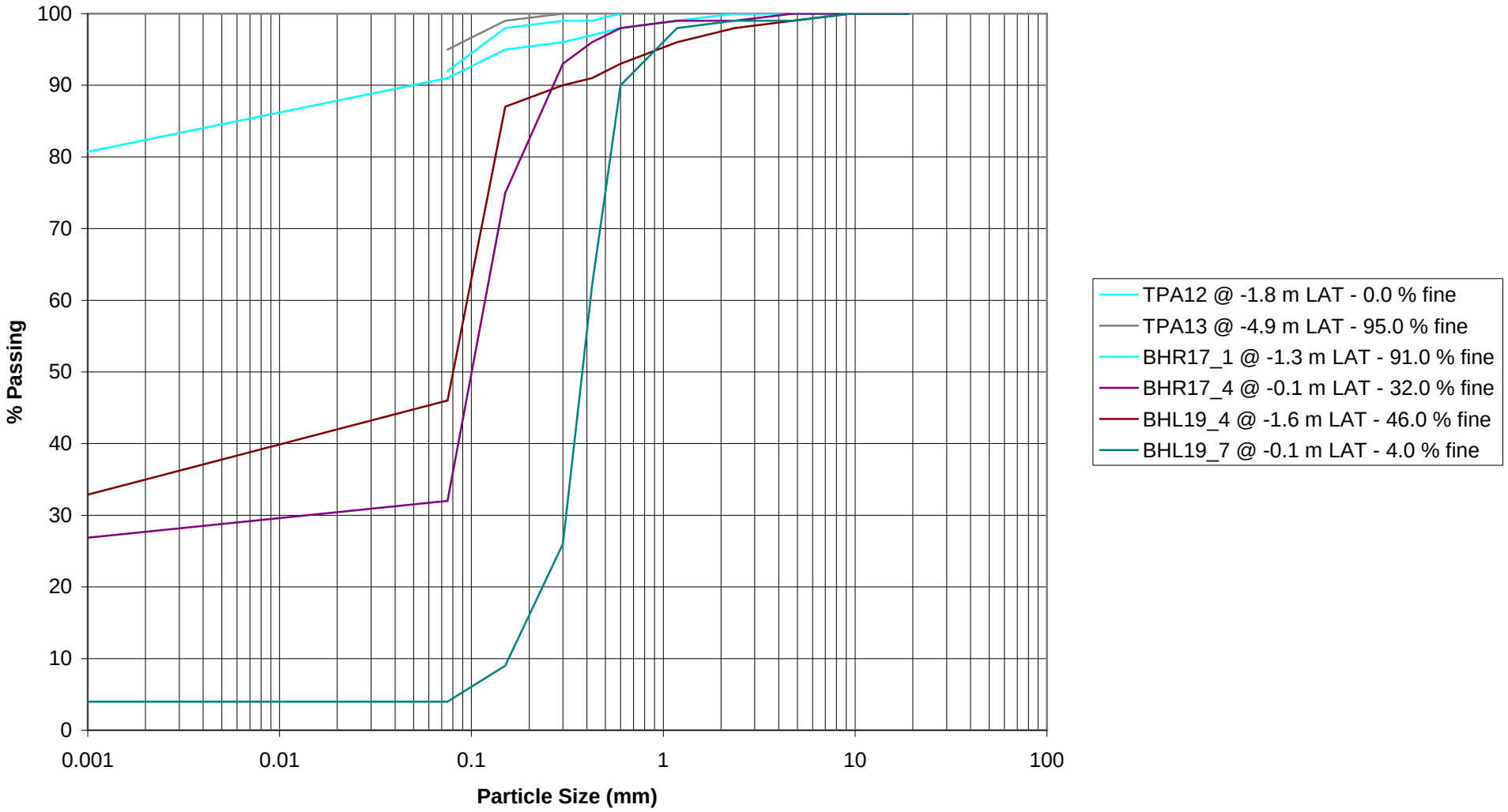
Particle Size Distribution Plots

All PSD Results Above -6m LAT

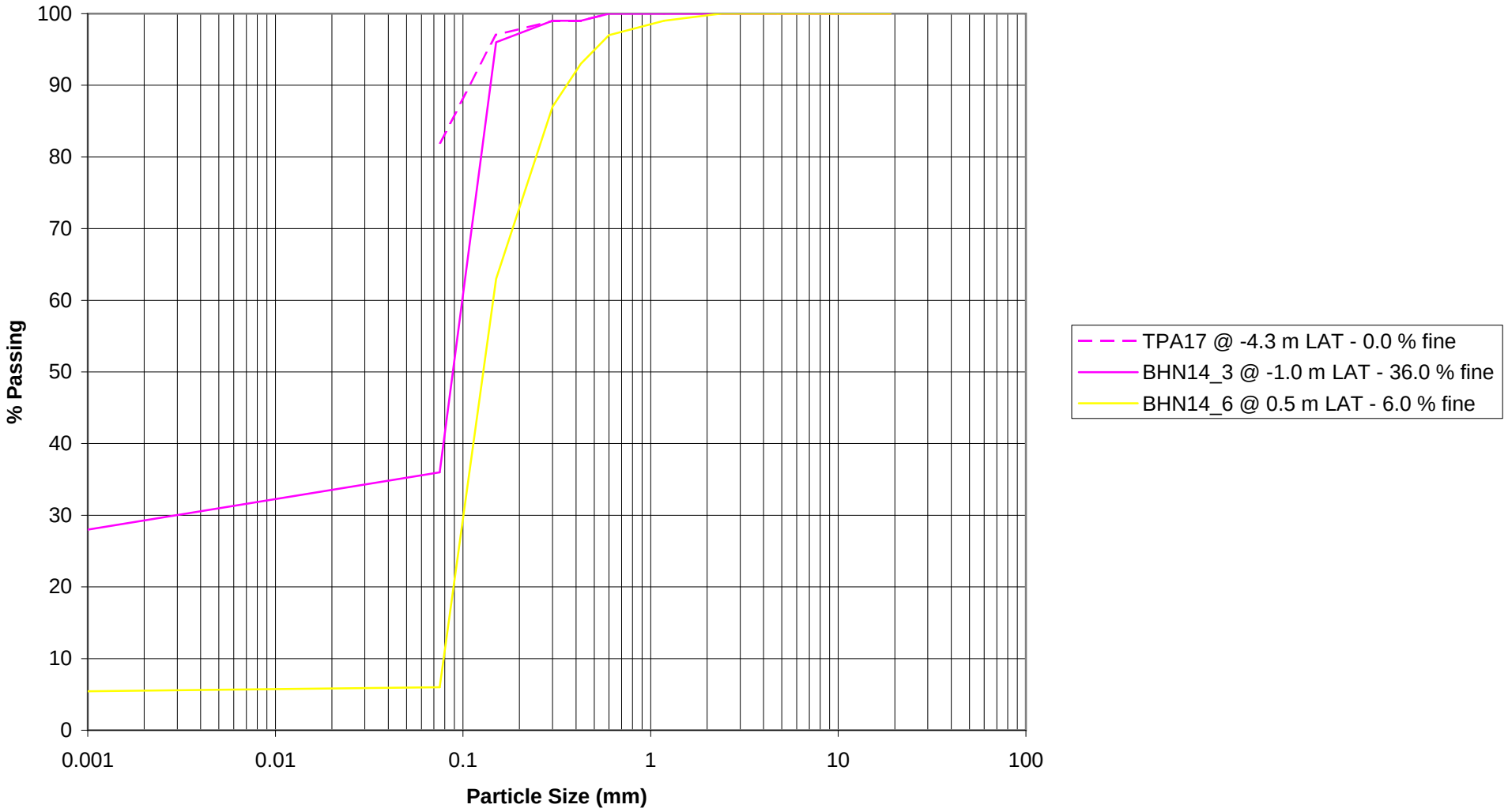


Note:
TPA1 - TPA8 outside area of proposed work

PSD Results Above -6m LAT in Offshore Breakwater Area

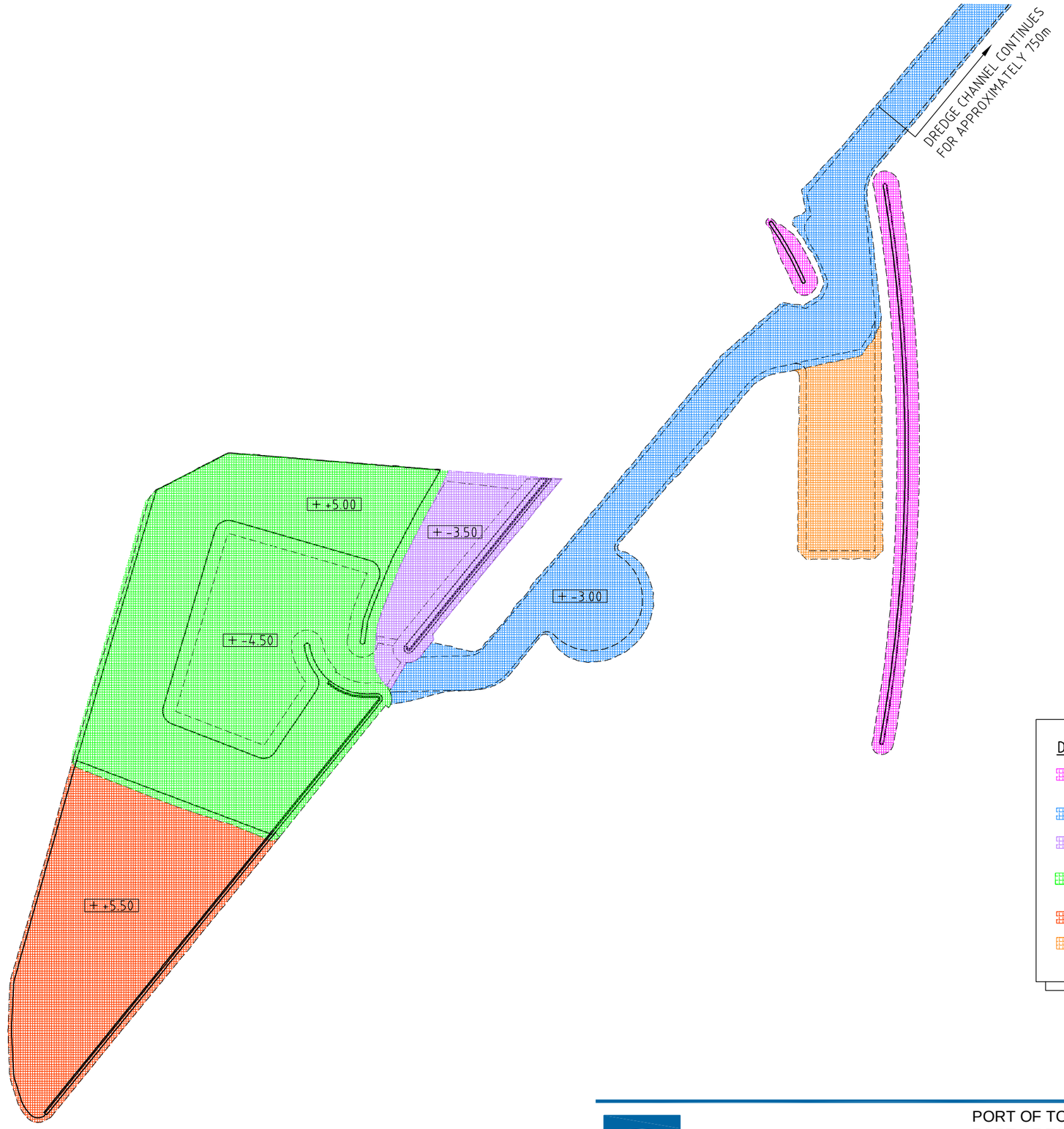


PSD Results Above -6m LAT in Precinct Area



Appendix D

Plan Showing Dredge and Fill Volumes



DREDGE VOLUMES

	BREAKWATER	FILL	= 147,000m³
		DREDGE	= 262,000m³
	DREDGE CHANNEL	DREDGE	= 185,000m³
		× INCLUDING 400mm OVER DREDGE ALLOWANCE	
	TRAWLER BASIN	FILL	= 39,000m³
		DREDGE	= 95,000m³
		× INCLUDING 400mm OVER DREDGE ALLOWANCE	
	HARBOUR BASIN	FILL	= 512,000m³
		DREDGE	= 340,000m³
		× INCLUDING 400mm OVER DREDGE ALLOWANCE	
	STAGE 3	FILL	= 395,000m³
	PILE MOORINGS	DREDGE	= 70,000m³
		× INCLUDING 400mm OVER DREDGE ALLOWANCE	

GHD CLIENTS | PEOPLE | PERFORMANCE

PORT OF TOWNSVILLE LTD
PORT OF TOWNSVILLE MARINE PRECINCT
VOLUMES

job no. | 42-15399
rev no. | B

scale | NTS for A3 date | MAR 2009

Figure 01

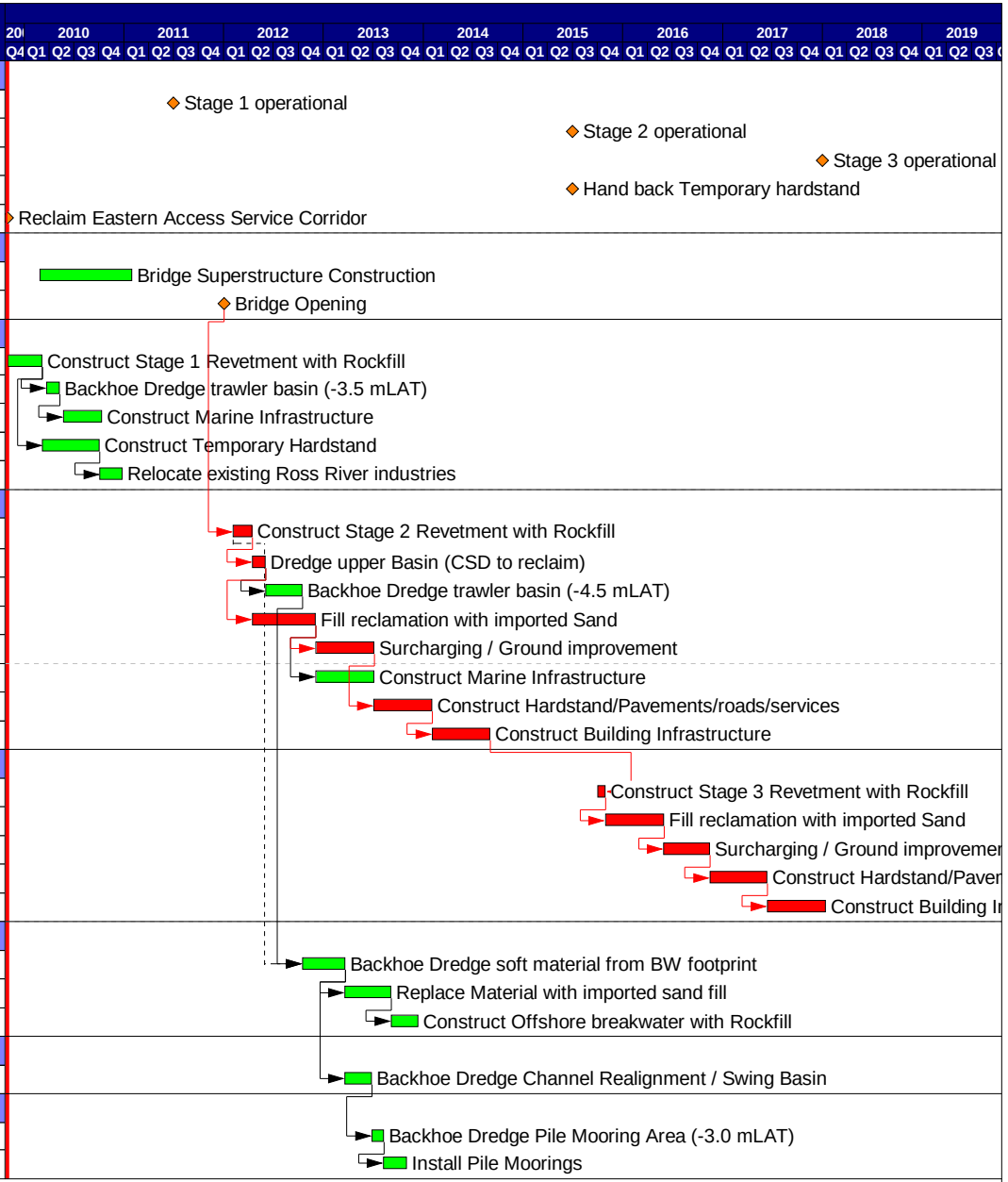
Level 4, 201 Charlotte St Brisbane QLD 4000 Australia T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com.au W www.ghd.com.au

Plot Date: 01 July, 2009 - 11:03 AM Cad File No: G:\42\15399\CADD\Drawings\42-15399-R1G01.dwg

Appendix E

Construction Phasing Programme

Act ID	Description	Orig Dur	Early Start	Early Finish	Total Float	%
PROJECT MILESTONES						
3200	Stage 1 operational	0		30JUN11 *	↓690d	0
3840	Stage 2 operational	0		30JUN15 *	657d	0
3900	Stage 3 operational	0		02JAN18 *	9d	0
3910	Hand back Temporary hardstand	0		30JUN15 *	657d	0
3920	Reclaim Eastern Access Service Corridor	0		30OCT09	?122d	0
TOWNSVILLE PORT ACCESS ROAD						
3210	Bridge Superstructure Construction	8w1d	01MAR10 *	31JAN11	↓798d	0
3220	Bridge Opening	0		02JAN12 *	0	0
STAGE 1 - TRAWLER BASIN						
3750	Construct Stage 1 Revetment with Rockfill	18w	02NOV09	09MAR10	↓822d	0
3760	Backhoe Dredge trawler basin (-3.5 mLAT)	7w	24MAR10	11MAY10	↓877d	0
3770	Construct Marine Infrastructure	20w	26MAY10	12OCT10	↓877d	0
3780	Construct Temporary Hardstand	30w	10MAR10	05OCT10	↓822d	0
3790	Relocate existing Ross River industries	12w	06OCT10	28DEC10	↓822d	0
STAGE 2 - HARBOUR BASIN AND RECLAMATION						
4000	Construct Stage 2 Revetment with Rockfill	10w	06FEB12 *	16APR12	0	0
4010	Dredge upper Basin (CSD to reclaim)	7w	16APR12	04JUN12	0	0
4020	Backhoe Dredge trawler basin (-4.5 mLAT)	19w	04JUN12	16OCT12	↓055d	0
4030	Fill reclamation with imported Sand	33w	16APR12	04DEC12	0	0
4040	Surcharging / Ground improvement	30w	04DEC12	05JUL13	0	0
4050	Construct Marine Infrastructure	30w	04DEC12	05JUL13	↓170d	0
4060	Construct Hardstand/Pavements/roads/services	30w	05JUL13	04FEB14	0	0
4070	Construct Building Infrastructure	30w	04FEB14	03SEP14	0	0
STAGE 3 - FUTURE RECLAMATION						
3740	Construct Stage 3 Revetment with Rockfill	4w	02OCT15	30OCT15	0	0
3830	Fill reclamation with imported Sand	30w	30OCT15	31MAY16	0	0
3850	Surcharging / Ground improvement	24w	31MAY16	16NOV16	0	0
4130	Construct Hardstand/Pavements/roads/services	30w	16NOV16	14JUN17	0	0
4140	Construct Building Infrastructure	30w	14JUN17	15JAN18	0	0
OFFSHORE BREAKWATER						
3440	Backhoe Dredge soft material from BW footprint	22w	16OCT12	21MAR13	↓055d	0
3450	Replace Material with imported sand fill	24w	21MAR13	06SEP13	↓055d	0
3490	Construct Offshore breakwater with Rockfill	14w	06SEP13	13DEC13	↓055d	0
SWING BASIN AND CHANNEL REALIGNMENT						
3950	Backhoe Dredge Channel Realignment / Swing	14w	21MAR13	27JUN13	↓085d	0
PILE MOORINGS						
3800	Backhoe Dredge Pile Mooring Area (-3.0 mLAT)	6w	27JUN13	09AUG13	↓085d	0
3870	Install Pile Moorings	12w	09AUG13	01NOV13	↓085d	0



Start date	01NOV09
Finish date	15JAN18
Data date	01NOV09
Run date	01JUL09
Project title	POTL Marine Precinct Project
Project name	POTL Marine Pre...

Early bar
Critical bar
Summary bar
Start milestone point
Finish milestone point

POTL Marine Precinct Project

Filename: 4116336

Date	Revision	Checked	Approved
20MAR09	Construct Report		
20JUN09	Report Rev 1		

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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1	M. McAuley	S. Vivian		S. Vivian		06.09