Shingle Extraction and By-product Disposal in Wellington Harbour

Environmental Effects Assessment in relation to a Resource Consent Application

Prepared for

Wellington Regional Council

by

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EXECUTIVE SUMMARY

1. Greater Wellington Regional Council is seeking approval to renew three consents, two of which are addressed in this report as follows: WGN 950154(01) Permit to extract an average of 50,000 cubic metres of sand and shingle annually with a maximum of 65,000 cubic metres annually, from the bed of the Hutt River mouth for the purposes of flood mitigation, and WGN 990012(01) Permit to spread an average of 5,200 cubic metres of by-product being a mixture of stones, shell and waterlogged wood dredged from the bed of the Hutt River mouth over a designated disposal zone in Wellington Harbour up to a maximum of 6,700 cubic metres per year. These consents are due to expire on 17 May, 2001.

2. Extraction of sediment is by way of a mobile hydraulic excavator mounted on a barge and positioned by a tug. The excavator digs the seabed level to a maximum depth of about 4 m below the water level. When the barge has a full load of about 60 m^3 it is pushed to the shore where the sediment is unloaded for processing. By-product is barged to a designated 6 hectare disposal zone located about 700 m south of the Hutt River mouth and discharged serially over one or more 50 m X 50 m cells accurately located by GPS.

3. Sediments of the extraction zone are essentially anoxic and the benthic biota is depauperate and of low ecological value. It was concluded that the shingle extraction operation has had very little impact on the local commercial or recreational fishery and is unlikely to impede the passage of migratory fish. The intertidal biota inhabiting the southeastern flood protection wall was typical of that occurring elsewhere in Wellington Harbour. There was no evidence that shingle extraction has had a deleterious effect on the hard substrate intertidal biota or on the ecology of the western embayment mudflat which is a “no extraction zone”.

4. Annual or biennial monitoring and sonar surveys were carried out to determine if the relocated by-product had remained within the disposal zone, whether or not material had remained on the surface of the sediments, or had created significant mounding, or had sunk beneath the surface. The effects of by-product accumulation on the sediment composition and bottom biota of the site and over adjacent areas, and the degree to which the bottom biota survived disturbance or had re-colonised in the individual cells following disposal were also determined.

5. Eleven studies have now been completed in and around the disposal zone. The most recent full sediment and biological survey (2009) confirmed earlier evidence of mounding to the extent that after a further 7-10 years, and at the present rate of disposal there was some risk of by-product material, especially wood, sticks and other organic matter less dense than stones and rubble, shifting inshore.

6. Continued sediment deposition has changed the nature of the substrate within the top 10-20 cm of the disposal zone from homogeneous muddy sand to pebbles, cobbles and waterlogged timber and sticks giving it the consistency of sloppy concrete. This change resulted in a general absence of larger mobile animals, dominance of small primary colonisers and considerable reduction in the number of species present per unit area. No such trend was

evident outside the disposal zone and no by-product had spread 100 m beyond the site on any side. It was estimated that if by-product disposal ceased, at the current natural sedimentation rate of about 5-6 cm per year, it would take the site about 10 years to recover its original pre-1999 state with respect to the physical and ecological character of the surface 50-100 mm.

7. A brief survey involving sediment sampling and a sonar bottom profile was carried out on 01 July, 2010. Winstone Aggregates disposal records indicated that that since 1999 and up to 30 June, 2010, 36,190 cubic metres of spoil had been consigned to the 400 m X 150 m disposal zone. No biological samples could be taken successfully within the zone because coarse material prevented the grab from closing thereby allowing any soft sediment and associated biota to winnow out during retrieval of the grab.

8. Undisturbed sediments of the disposal zone (the receiving environment) have the consistency of sandy mud with a median Phi value of 4.0 to 4.5. Over 90% of this comprises grain sizes less than 0.063 mm. This is typical of the great majority of the Wellington Harbour Basin at depths greater than 10.0 m. Once introduced, the by-product material accumulates on or only just within the muddy bottom sediments, significantly changing the nature of the substrate – a change which if disposal ceases may persist for a decade at least, or until natural sediment fall-out and accretion covers the coarser material with soft sediment. If disposal over any part of the site ceases, then at the natural sedimentation rate of conservatively 5-6 mm per year, it would take about 10 years to recover its original pre-1999 state with respect to the physical and ecological nature of the surface 50-60 mm.

9. To be consistent with targeted spreading of 36,190 m^3 of material evenly over a 60,000 m^2 area, with the material building up on the surface rather than sinking below it, there is likely to be a further general depth decrease of about 0.6 m over the next 10 year period if the whole of the present site is used. This would result in a depth decrease of 2.1 m over any requested consent duration of 35 years, with mounding bringing deposited by-product close to the depth where there is a significant risk of it moving inshore during major southerly storms. This is especially the case for less dense material such as timber, wood and sticks. It is clear from the accumulated results there is some risk that parts of the northern half of the zone may not sustain a 35 year consent period.

10. Between 41 and 124 species or morphospecies were found over the study area with considerable year to year variation, and the number of species present inside the zone generally matched the number outside. The data show that over the approximately 9 year period covered by the six full; biological surveys 2000 to 2009 there was a stable number of species present inside the designated disposal zone up to 2007, but a sharp decrease in 2009. The mean number of individuals per cell varied widely over both locations because huge numbers of primary recolonising species with typically patchy distribution sometimes occurred. Qualitatively, the benthic community could be termed "infauna" as all but a few surface predatory and scavenging species lived below the surface of the sediment. In all samples from all years polychaete worms dominated the biota, followed by crustaceans and molluscs with sipunculid worms, nemerteans and echinoderms also present.

11. The overall pattern of abundance seen in 2009 differs from that characterizing the animal assemblages of previous years, with fewer species (and individuals) present within the disposal zone (due to repeated disturbance and substrate change) and fewer species shared with the outside-zone stations. The conclusion is that disposal of by-product at the present (2007-2009) rates reduced the number of animals present within the cells receiving most by-product, and there had been insufficient time for effective recolonisation at the time of sampling.

12. The homogeneous fine silt and clay environment of Wellington Harbour, including the disposal zone, naturally supports low species richness and diversity, and relatively low biomass. As such, the disposal zone and its surrounding area can be considered to have comparatively low ecological significance.

13. There is no evidence that established inshore pipi and cockle beds are being affected by mechanical introduction of by-product into the disposal zone, and no rare or endangered species were found during any of the monitoring surveys.

14. Dendrograms derived from Bray-Curtis cluster analyses showed that there was at least a 50% similarity between the benthic community of Station HO3 (the reference site) in 2000 and the composite within-zone samples in 2009. The remaining 4 outside zone samples (HO1, HO2, HO4, HS4) were themselves between 57% and 72% similar in species composition. Essentially the undisturbed level of similarity in community structure between stations within the disposal zone, and those outside, had been maintained over a 9-year period.

15. In the event that by-product disposal ceases over any part of the disposal zone, the process of recolonisation will start almost immediately mainly by way of the plankton rather than by inward migration, and should be complete after 4-5 years.

16. In application for a new consent effective after 17 May, 2011, it is recommended that consideration be given to sliding the northern half of the present disposal zone southward over deeper water (12-14 m) effectively moving the site 200 m to the south thus avoiding any chance of mounding over the shallower parts of the northern half of the existing disposal zone reaching depths which risk the possibility of less dense components of by-product being dislodged during severe southerly gales during the later years of the consent period, if granted. The present northern half should be retired and allowed to recolonise its sof sediment biota through planktonic larval recruitments. This area not form part of any new consent.

17. This redefinition of the southern boundary should not add significantly to the costs of disposal. It is unlikely to interfere with shipping operations at the Point Howard Oil Wharf, and gives the opportunity for a consent period of 35 years to be applied for and granted with minimal risk. The bottom sediments, depth profile and community composition of such a new area are known and are confirmed by past and present data from Stations HO2 and the reference site HO3,

18. There are no new adverse or deleterious environmental effects likely to arise as a result of continued shingle extraction. The bottom sediments of the extraction zone are currently anoxic and faunistically depauperate. Continued extraction is unlikely to have any effect on existing amenity values, or recreational or commercial fishing in the area. A 35-year term of consent is therefore defensible on the grounds that the sediments of the extraction zone are already degraded ecologically.

19. The current disposal technology involving a barge, a small mechanical digger and accurate differential GPS location of individual cells within the disposal zone remains appropriate for the future. The present conditions specifying maximum and average disposal rates and strict record-keeping requirements are also appropriate and should continue as at present.

20. It is my opinion that biological monitoring need not be required as a condition of a new consent because there are now sufficient data from the 10 years of biological monitoring associated with the current consent to predict any environmental effect, deleterious or otherwise, likely to occur in the event that a new consent is granted for a period of 35 years. At the present rate of disposal over the proposed new 3 ha southern section, over the first 2-3 years there is likely to be a rise in species richness and diversity due to increased substrate heterogeneity, followed by about 5 years of relative stability in biological indicators. Thereafter biological indicators will probably decline due to a reduction in the availability of soft muddy substrate.

21. Use of the van-Veen grab, while able to detect the presence of coarse by-product, is not a repeatable method of taking quantitative biological samples beyond about 7 years of by-product accumulation. Additionally, the ABC method of biological analysis is very time-consuming in relation to the efficacy and usefulness of the results obtained. Overall, There appears to be little point in requiring continuation of the current intensive biological monitoring programme over the proposed new disposal zone and immediately surrounding area as this would most likely reveal no trends or environmental effects beyond those which are already evident or predictable.

22. The three most important considerations for a new consent valid for 35 years are:

1. Sliding the disposal zone 200 meters to the south and retiring the northern half of the existing site.
2: To ensure that over the proposed 35-year consent period the by-product is spread as evenly as possible by way of targeted rotational distribution designed also to minimise the possibility of mounding.
3. To ensure that the introduced by-product remains within the designated disposal zone for the duration of the consent and preferably thereafter.

These considerations should be addressed through conditions of consent requiring sonar bottom profiling of the entire site, and by grab sampling for coarse grain sediment analysis immediately outside (about 10 - 15m) each of the four perimeter boundaries of the disposal zone. It is recommended that this baseline is established within three months of the new consent becoming effective, and subsequently repeated at 5-yearly intervals. Review options should be at the discretion of the Manager, Consents Management, GW Regional

Council.

The Existing Consent Applications

(1) WGN 950154(01) Permit to extract an average of 50,000 cubic metres of sand and shingle annually with a maximum of 65,000 cubic metres annually, from the bed of the Hutt River mouth for the purposes of flood mitigation. This consent is due to expire on 17 May, 2001.

(2) WGN 990012(01) Permit to spread an average of 5,200 cubic metres of by-product being a mixture of stones, shell and waterlogged wood dredged from the bed of the Hutt River mouth over a designated disposal zone in Wellington Harbour up to a maximum of 6,700 cubic metres per year. This consent is also due to expire on 17 May, 2001.

1. The Current Shingle Extraction Consent

Winstone Aggregates Ltd and its predecessors have extracted up to 65,000 cubic metres of sand and gravel annually from the bed of the Hutt River mouth with an annual average of 50,000 m^3 for many years. A resource consent for this activity exists as Coastal Permit WGN 950154(01) which is due to expire on 17 May, 2011, and an application for new consent need to be lodged by 17 November, 2010. An associated consent for marine offshore disposal of processed by-product (WGN 990012(01) is due to expire at the same time. A Permit to deposit fine sand on the Petone Beach eastern shoreline (WGN 990012(2)) is not covered by this paper.

Extraction of sediment from the dredged area is by way of a mobile hydraulic excavator mounted on a barge and positioned by a tug. The excavator digs the seabed level to a maximum depth of about 4 m below the water level. When the barge has a full load of about 60 m^3 it is pushed to the shore where the sediment is unloaded for processing. Extraction is required mainly for river flood management purposes as it is important that the river mouth be kept free of excessive sedimentation and the formation of a sand bar which would restrict

flood flows.

This would have the effect of increasing upstream water levels and increasing the risk of flooding in the lower part of the Hutt Valley. Sand and gravel recovered from the river mouth by Winstone Aggregates Ltd supplies the building industry with a valuable fine, rounded aggregate. The combination of these two functions may be considered an efficient use of the resource.

Shingle extraction has been operational for almost 100 years, but there is no baseline information or data describing the local benthic environment prior to sediment extraction. However some mainly unpublished studies have been carried out since about 1980 which by inference give a useful guide to the past ecological status of the area and its significance as a marine habitat. To fill this gap in our knowledge, a recent assessment of the ecological status of the extraction zone (Figure 1) was completed in July, 2010, so that the present ecological status of this area of river mouth is now known in broad terms. Results are incorporated into this Environmental Effect Assessment (EEA).

2. Summary Results of 2010 Survey of Hutt River Mouth

2.1. The Extraction Area - Sediments and Benthic Biota

The Hutt River mouth extraction area south of the river hydraulic line can be divided into 3 ecological areas. These are the western embayment mudflat, the intertidal protection wall along the true left bank (Figure 1 & Map points SO 35431 to SL 0090) and the water column and sediments of the extraction zone located between the true left bank and the eastern hydraulic line (Figure 1). Extraction operations are restricted to the extraction zone.

No previous ecological study has targeted the extraction zone. To provide at least some information, Dr Bob Wear who is widely experienced in the ecology of Wellington Harbour, was contracted to carry out a brief survey of the sediments in the main channel. This was carried out on 01 July, 2010.

Grab samples were taken in 2.3 m water depth or about 1.0 m Chart Datum.

Station 1. Near the Waione St Road bridge at 41^0 14.100' S X 1740 53.999' E

Station 2. Mid-way along the extraction zone a 41^0 14.489' S X 1740 53 948' E

Station 3. Near the southern end of the zone close to a line drawn between point HL6 and the southern end of the true left bank at 41^0 14.669' S X 174^0 53.756' E. (Figure 1). Sediment samples were sieved to 1.0 mm and the biota noted. Sediments comprised compacted black anoxic mud to muddy sand containing little animal life. Biota identified were pipi *Paphies australis*, juvenile mud crabs *Macrophthalmus hirtipes*, very small tube worms *Pectinaria australis* and thread-like spionids, a nut shell *Nucula nitidula* and one cockle Austrovenus *stutchburyi.* This sparse biotic assemblage mainly comprised animals feeding from the water column. It was concluded that the sediments of the extraction zone are essentially anoxic and the biota is depauperate and of very low ecological value.

2.1. Extraction Zone - The Water Column

Indigenous freshwater fish species rely on the extraction zone to provide unimpeded access through it to move from the open Harbour waters and the upper reaches of the river (or vice verca) for the purposes of spawning. These include whitebait species, bullies, sea-run brown trout and eels. Additionally a number of marine species venture into the estuarine area to breed or feed and have been observed between the estuary and the Melling Bridge. These are *Aldrichetta forsteri* (yellow-eyed mullet), *Rhombosolea plebia* (sand flounder) and *Arripis trutta* (kahawai). Species recorded are listed in a recent report by this author (Wear, 2010a)


Legend
GRAB SAMPLES TAKEN 1 JULY 2010
GWRC SURVEY CONTROL
DESIGN CHANNEL
RIVER CORRIDOR
GWRC CROSS SECTION ALIGNMENTS
GREEN OUTLINE INDICATES PROPOSED MARINE DISPOSAL AREA
HATCHED AREA DENOTES EXISTING MARINE DISPOSAL AREA
YELLOW LINE DENOTES HYDRAULIC LINE (Indicated on site by White marker posts HL1 to HL4 & Red Buoys for HL5 & HL6)
RED LINE DENOTES SAND PLANT DEPOSITION LINE. (Indicated on site by Yellow marker posts DL1 to DL3)
Approx. location of Remnant of Hikoikoi Pa (Submerged)
WESTERN MUDFLAT EMBAYMENT NO EXTRACTION
HIKOIKOI PA NO EXTRACTION AREA
STATION 3
STATION 2
STATION 1
ORANGE FILL AREA INDICATES LIMIT OF EXTRACTION AREA
WAIWHETU STREAM MOUTH NO EXTRACTION AREA
Specific conditions apply to this area to protect the bridge
Waione Street Bridge
Figure 1.
0 100 200 400 Meters
A3 Scale 1 : 5,000
HUTT RIVER MOUTH AERIAL SITE LAYOUT INDICATING : MARINE DISPOSAL SITE, NO EXTRACTION AREAS, SAND PLANT DEPOSITION & HYDRAULIC LINE
GRAB SAMPLES TAKEN 1 JULY 2010
File Ref : Maritime - 2010 - Grab Samples 1 July 2010.mxd

The 1995 EEA (CER Ltd, 1995) states (p.20) that approximately 30% of the river bed within the extraction zone is dredged each year and this would imply a commensurate loss of habitat and food species for fish. However, this present sampling of the extraction zone benthos showed that food species for fish are virtually absent or very sparsely represented. The 1995 EEA photograph 2 also shows that at no time is the river mouth even partially blocked off by shingle extraction activities and contends that there is at no time any barrier to fish migration. Accordingly, it was concluded that the shingle extraction operation has had very little impact on the local fishery.

2.3. The Southeastern Flood Protection Sea Wall.

This ecological area consists mainly of man-made materials positioned along the true left bank as protection from flooding and erosion. The material includes masonry blocks, concrete slabs, demolition materials and natural rock and is positioned in a hap-hazard manner. The habitat is essentially intertidal. As no directly applicable data are available, the habitat was visited by Dr Wear on 02 July, 2010 and briefly studied as a qualitative exercise.

The intertidal biota grades from fully marine (tidally) at point ORMVI S035431 (Figure 1) on the true left bank through estuarine upriver to the Waione Street bridge. Details of the biota are given on the ecological report on the area (Wear, 2010a). At the seaward end of the area the lower intertidal was dominated by green algae *Ulva lactuca* and *Enteromorpha intestinalis* and blue mussels *Mylilus galloprovincialis* with patches of the necklace seaweed *Hormosira banksii.* (Algal greening becomes more prolific in the summer months). The biotic assemblage both on top of the rocks and slabs, and beneath them, was fully comparable with earlier studies on adjacent areas within the Seaview Marina precincts which are now reclaimed. (Haddon et al, 1988; Wear et al, 1990; Wear & Haddon, 1988). In an intertidal survey of Seaview (Wear & Haddon, 1988), 31 species were recorded.

Mid-way along the extraction zone (Point SL0010, Figure 1) algal greening was less evident (probably due to the fact that this present observation was made during mid-winter when

photosynthetic processes are at low levels). Several species were not present or were less abundant due to their inability to tolerate desiccation (at low tides) or lowered salinity during flood conditions. Mainly soft-bodied animals fell into this category.
Opposite the western mudflat at or about the point SL0080 (Figure 1) algal greening was not evident, but occasional cryptic patches of barnacles and blue mussels were still present as were amphipods and the isopod *Ligia sp* under rocks and masonry. Qualitative observations made during summer in previous years are that significant algal greening occurs at this level of the extraction zone, but due to reduced winter sunlight at the time of observation (July 2001) this is not presently apparent,

In summary, the biota inhabiting the southeastern flood protection wall (and by inference any patches of hard substrate on the western or true right bank of the river) was typical of that occurring elsewhere in Wellington Harbour except for the dominance of summer seasonal algal greening by *Ulva lactuca* and *Enteromorpha* spp resulting from high nutrient loadings and warm temperatures. There was no evidence that dredging has had a deleterious effect on the intertidal biota of this man-made substrate or its species composition.

2.4. The Western Embayment mudflat (Hutt River Mouth Estuary).

The Hutt River estuary is considered to be an important ecological area in the Wellington district, although the proposed Regional Coastal Plan does not list it as an area of significant conservation value. It is the only significant area of tidal mudflat and shallow brackish water in Wellington Harbour. Further, it is a true estuary – no comparable system exists on the east coast north to Lake Ferry or on the west coast north to Waikanae (Dalziell & Wear, 1986; Wear, 1988). The estuary is an important area for juvenile flatfish and a significant feeding\ refuge area for wading and non-wading birds.

Biota living on or near the surface of the mud has been recorded by Dalziell & Wear, 1986. The marine invertebrate fauna is of low diversity but high in numbers of individuals and in biomass and is therefore typically estuarine. The most common macrofauna are the burrowing crabs *Helice crassa* (upper shoreline) and *Macrophthalmus hirtipes* (lower shore), the mud snail *Amphibola crenata* and juvenile flatfish. Patches of pipis (*Paphies*

australis), cockles (*Austrovenus stutchburyi*), the deposit-feeding bivalve *Tellina liliana* and a variety of polychaete worm species are common in the upper 10 cm of soft substrate.

The ecology of the mudflat area is strongly influenced by river flood events, especially during high tides and when turbidity is high. Fall-out of fine sediments is greatest at these times. Relative to this, and also because no extraction occurs in the Western mudflat embayment, anecdotal observations and available evidence support the conclusion that the benthic biota and birdlife have not been affected by shingle extraction in any way, and that any impact on the mudflat area has been no more than minor compared with natural events. Any such activity between the Waiwhetu Stream mouth exclusion area and the mudflat is likely to have downstream rather than upstream impacts.

2.5. Concluding Comments

At the previous Hearing, submitters raised a number of issues or concerns with respect to the extraction processes. These included the possibility of contaminants from the Waiwhetu stream sometimes being present in the retrieved material, the issue of stability of the bund, concerns over the frequency of monitoring and the possibility of adverse effects not being manifested until after a considerable period of time had passed. There is no evidence that any of the concerns implicit in these issues have come to fruition.

The initial ecological effect of shingle extraction in the Hutt River mouth would have been one of high impact in the extraction zone, especially with respect to the benthic environment and benthic organisms, but it is not known precisely when this occurred, or over what time period. In this sense, renewal of the permit for dredging to continue will have no new or additional environmental effects.

In summary and with respect to the extraction area, bottom sediments are anoxic or near anoxic and support a depauperate biota of low ecological value. There is no pre-extraction baseline, but it is likely that the seaward sediments and the intertidal flood protection bund supported a biota similar to that of the Seaview area in these early days. Shingle extraction has to date had little or no identifiable impact on the local fishery or the passage of

freshwater indigenous or marine fish species. As the extraction zone is already degraded ecologically, there appears to be little point in devising a monitoring programme for the area as it would most likely reveal nothing beyond that which is already evident. It is recommended that Resource Consent to enable continued shingle extraction within the designated zone should be renewed. The benefits of this activity appear to outweigh any ecologically deleterious effects which may arise over a renewed consent period.

3. Offshore Disposal of By-product

From 1999 to the present there have been a number of offshore benthic sediment and biological surveys commissioned in relation to the set-up and monitoring of Coastal Permit 990012 (01) issued to the Flood Protection Group of the Greater Wellington Regional Council (GWRC) to dispose of by-product from shingle extraction and processing on the sea floor over an area of some 6 ha in Wellington Harbour. The by-product material consists of cobbles, pebbles, shells and wood-fragments with the permit allowing for the relocation of an average volume of 5,200 m^3 per year with a maximum of up to 6,700 m^3 per year. The permit was issued pursuant to sections 105 and 108, and subject to all the provisions of the Resource Management Act 1991 and any regulations made thereunder. The permit is due to expire on 17 May, 2011.

The location of this present disposal zone is about 700 m south of the Hutt River mouth at or about map reference NZMS 260:R27; 685.942. over depths of about 10 m to 15 m Chart Datum. The 60,000 $m^{2\ rectangular}$ area (400 m X 150 m) is bounded by the following coordinates (Figures 2 & 3).

A	41^0 14.710’ S, 174^0 53.404’E (northwest corner)
B	41^0 14.710’ S, 174^0 53.512’E (northeast corner)
C	41^0 14.930’ S, 174^0 53.404’E (southwest corner
D	41^0 14.930’ S, 174^0 53.512’E (southeast corner)
A-C	41^0 14.820’ S, 1 74^0 53.404’E (mid-way along the line A – C)
B-D	41^0 14.820’ S, 174^0 53.512’E (mid-way along the line B – D)

The rectangular area was further divided into 24, 50 m X 50 m cells to facilitate rotational introduction and even distribution of the deposited material. (Figure 4) into which by-product is dumped systematically so as to avoid excessive mounding and to ensure that the recolonising bottom biota is not repeatedly disturbed. By-product material is spread from a barge using a small mechanical loader about twice per week or as weather permits. The material is spread as evenly as possible within and between designated cells.

3.1. Current Conditions of Consent (Sediments and Ecology)

Relevant to ecological considerations are conditions 18, 19, 20 and 21 which read as follows:

(18) "The permit holder shall during years 4 and 11 after commencement date of this permit survey seafloor levels within and in the vicinity of the marine disposal site to the satisfaction of the Manager, Consents Management, Greater Wellington Regional Council. Using the data obtained the permit holder shall determine the height and lateral extent of the build-up. The survey results shall be supplied to the Manager within 3 months of the completion of the survey."

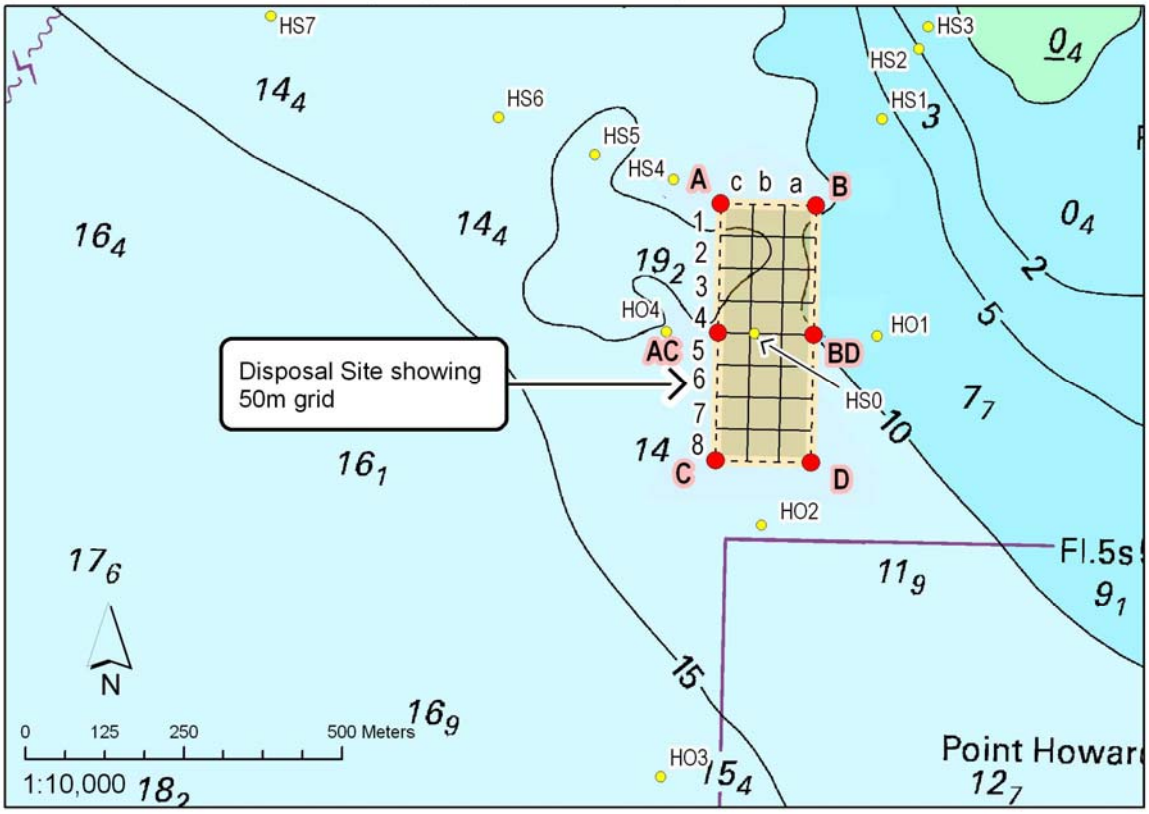
(19) "The permit holder shall collect and undertake a coarse grain size evaluation on seabed sediment samples. These samples shall be collected annually for the first four years of the life of this permit, and thereafter at intervals, to the satisfaction of the Manager, Consents Management, GWRC. The sediment samples shall be taken as follows:

- Samples from within the marine disposal area and also samples westwards, parallel to the shore at about 10 m below sea level as distances of 100 m, 200 m, 400 m, and 800 m away from the margin of the marine disposal area. One sample run shall be undertaken before any dumping of coarse material commences.
- Samples from at least 3 locations to be determined to the satisfaction of the Manager, Consents Management GWRC along a transect taken at 20 degrees east from the centre of the disposal site to the shoreline (MHWS), to conform with the expected direction of the sediment transport mechanism. One sample run shall be undertaken before any dumping of coarse material

commences.

Figure 2

Location of Standardised Sample Stations in relation to Disposal Site in Wellington Harbour
(Generated on New Zealand Hydrographic Chart, Wellington Harbour No. 4633



The permit holder shall supply the results of the aforesaid monitoring to the Manager, Consents Management GWRC, in the annual report required by condition 25, or on request".

(20) **(see Note 1 below)** "Throughout the duration of this permit, the permit holder shall undertake ecological monitoring of the marine disposal site in Wellington Harbour. The primary objectives of the monitoring shall be to:

- Assess the ecological consequences of gravel dumping at and immediately beyond the marine disposal site.
- Outline measures to mitigate any potential deleterious effects of the dumping
- The monitoring shall be to the satisfaction of the Manager, Consents management, GWRC and shall be in accordance with the following methodology:
- At least one grab sample ***and SCUBA diving observations (including video recording) undertaken annually*** at each of five sample stations ***randomly located*** **(see Note 2)** within the marine disposal site, these samples shall be collected biennially until 2011. A review of the monitoring internal by the Manager, Consents Management, GWRC will follow the monitoring in 2007. This review would consider whether there are any significant adverse effects within the disposal site and would consider eliminating the 2009 monitoring, reinstating annual monitoring, or retain the biennial monitoring.
- At least one grab **sample** ***and SCUBA diving observations (including video recording) undertaken annually*** at each of the five sample stations acting as controls located outside the marine disposal site. At lease one of the control stations shall be Victoria University's nearest harbour-wide continuing biota monitoring site (reference Wear & Gardner's 1998 ecological survey report site OF4 or HO3 located 400 m due south of the disposal area.
- All grab samples ***and SCUBA diving observations*** shall be undertaken during February or March each year following spring and summer breeding and growth periods. The permit hold shall supply the results of the aforesaid monitoring to the Manager, Consents Management, GWRC in the annual report required by condition 25, or on request.

- All grab samples shall be analysed for species richness, species diversity, evenness and abundance biomass comparison. The species analysed shall be to the satisfaction of the Manager, Consents Management, GWRC and may include macrofaunal species greater than 0.5 mm.
- Mounding of the marine disposal site shall be assessed by way of sonar survey; these surveys shall be collected biennially until 2011. A review of the monitoring interval by the Manager, Consents Management, GWRC will follow the monitoring in 2007. This review would consider whether there are any significant adverse effects within the disposal site, and would consider whether there are any significant adverse effects within the disposal site, and would consider eliminating the 2009 monitoring, reinstating annual monitoring or retaining biennial monitoring **(see note 3).**

(21) All methods and procedures for monitoring shall be to the satisfaction of the Manager, Consents Management, Greater Wellington Regional Council."

Notes

Note 1: Italicised and bolded sections of Condition 20 were deleted from the original consent conditions pursuant to section 127 of the Resource management Act 1991, and granted in February,2004. The reason for this change is that visibility over the site was almost always too low to permit either video or to meaningfully survey the site visually by SCUBA diving.

Note 2: For the 2005 survey this provision was modified by removing the word "random" so that the within-site cells would remain as the centre cell HSO plus the

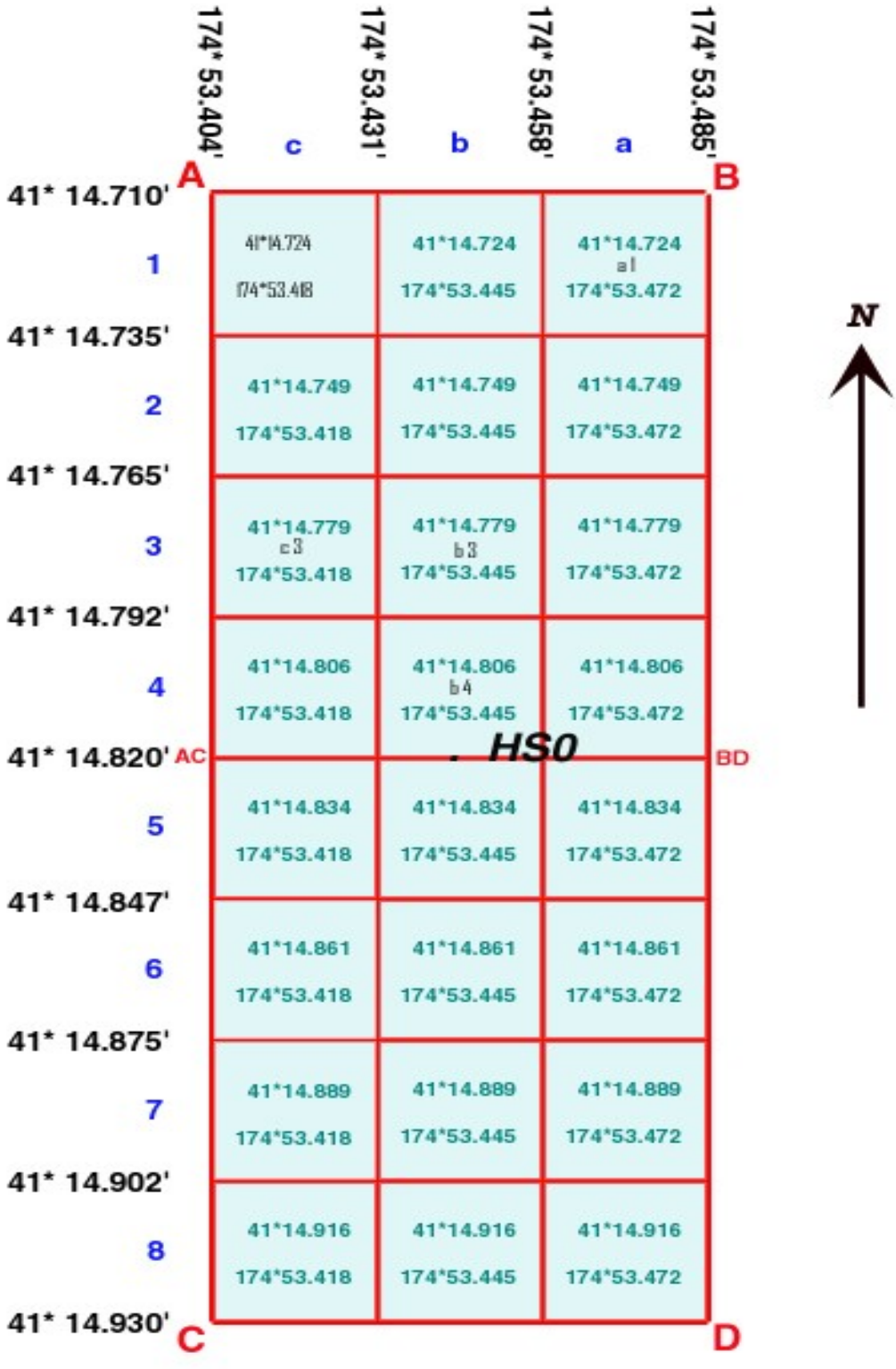


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Figure 3 Grid Diagram of the Offshore Coarse By-product Disposal zone showing the 50 m X 50 m Cells and coordinates for the centre of each Cell.

our within-site cells which had received the greatest volume of by-product since the last sampling.

Note 3: The decision to reduce the programme to a biennial framework was made by the Consents Manager, GWRC during 2004 following the 2004 sediment survey so that there was no sediment or biological survey scheduled for either 2006 or 2008. The 2005 survey covered ecological monitoring requirements and a sonar survey of the disposal site in addition to bottom sediment analysis. This was repeated in 2007 and 2009.

3.2. Duration of Current and Future Consents

The permit WGN 990012(01) expires on 17 May 2011, and application for a new consent is required to be lodged 6 months in advance (17 November, 2010). Application to rescind the requirement for the scheduled February-March 2011 full biological survey has been made.

The 2009 survey and the 2010 interim survey suggest that at the present rate of dumping the longevity of the north-eastern part of the zone is likely to be about 7 years, more or less, beyond the term of the present consent, whereas a new consent effective for up to 35 years is likely to be sought. As there is evidence of some degree of build-up and mounding in the northern half of the presently utilised zone, it is desirable that this half be slid southward to extend the southern half by 200 m to the south and over deeper water so as to ensure the full life of any new consent (Figure 4).

3.3. Monitoring Objectives 2000 - 2010

Periodic monitoring surveys were to determine:

1. If the relocated by-product had remained within the disposal zone. Any spread beyond the zone/grids was to be noted.

2. Whether or not the by-product had remained on the surface of the sediments, or had created significant build-up of material or mounding, or had sunk beneath

the surface.

3. The effects of by-product accumulation on the bottom biota of the site and over adjacent areas, and the degree to which the bottom biota survived disturbance or had re-colonised in the individual cells following disposal.

4. Considerations relating to renewal of the resource consent or application for a new consent prior to the current consent expiring on 17 May, 2011.

To achieve these objectives, the monitoring studies gave particular attention to the following parameters in accordance with provisions of the Permit:

(a) Coarse grain sediment analyses.

(b) Biological analyses of grab samples to determine the number of species present or species richness (s) including a full species list, number of individuals of each species (n), species diversity (H'), species evenness (E), biomass (B), abundance - biomass comparisons and community structure.

(c) Sonar survey of the disposal zone and immediately surrounding sea bed, and qualitative evaluation of grab sample contents to determine if by-product continues to be built up on the surface.

(d) General observations

3.4. Summary Chronological Results of Monitoring Studies

Eleven studies have now been completed in ad around the disposal zone.

1. Wear & Gardner (1998) completed an ecological survey of the gravel disposal site to establish a baseline prior to any by-product disposal from shingle extraction. The biological results of this survey were somewhat compromised because of the impact of the toxic algal bloom in March, 1998. Samples were taken 5 and 6 May, 1998 when very few species were present and were represented by only a few individuals, and as a consequence biomass was much lower than expected.

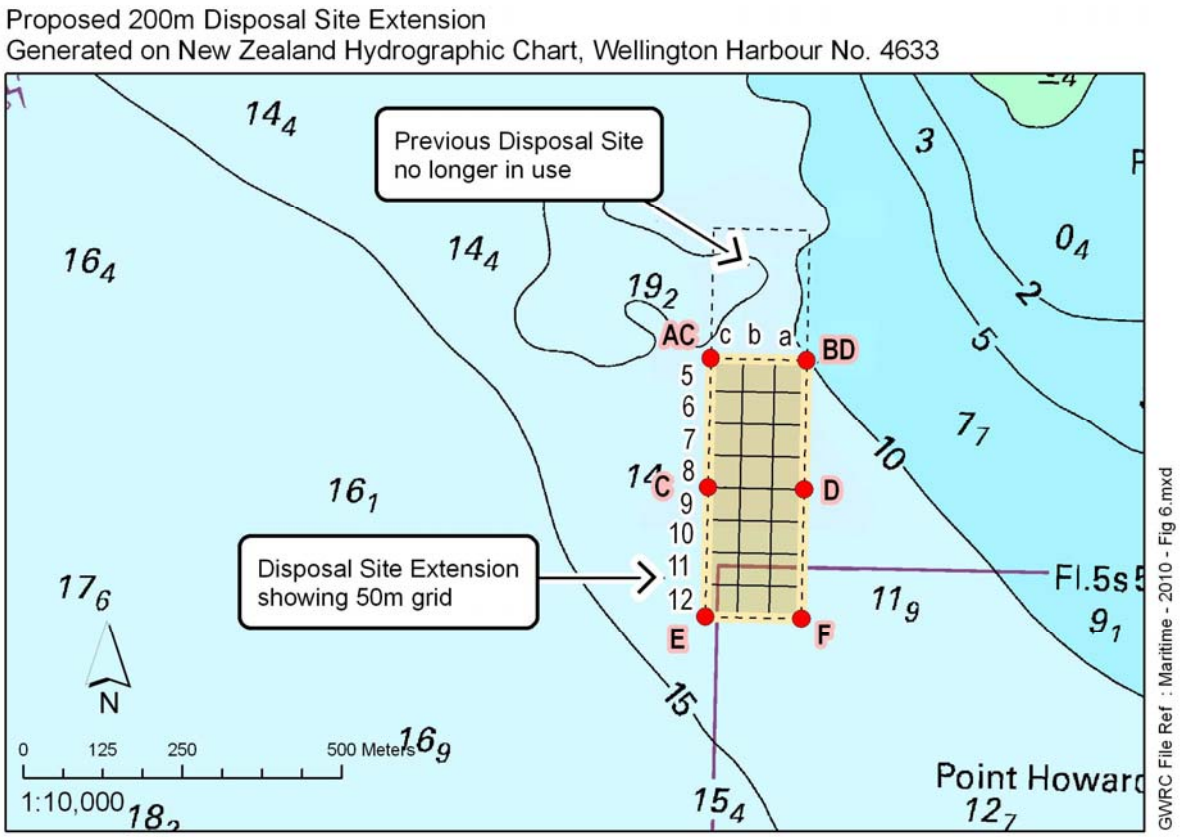
2. Wear (1999) carried out a sediment analysis of 8 stations to serve as a baseline upon which to determine whether by-product remained *in situ* following spreading over the

sea floor, or whether it migrates shoreward or alongshore after disposal. In this survey, one station was established in the centre of the disposal zone, 3 stations were located along a transect bearing northeast toward the Hutt River mouth, and 4 stations were sampled 100 m, 200 m, 400 m and 800 m from the northwest corner of the zone, more or less parallel to Petone Beach. These stations served as a basis for all future monitoring possible changes in the composition of sediments in the area (Figure 2).

3. Wear (2000) reported on the first monitoring survey after 1,200 m^2 had been distributed over 3 of the 24 boxes within the disposal zone by the end of February, 2000. Samples were taken at all stations noted in para 2 above on March 17, 2000. Data from this first monitoring exercise indicated that deposited material had not moved beyond the perimeter boundaries of the disposal zone, that some of the cobbles, pebbles, wood and shell debris remained on the surface of the substrate, and that the limited amount of by-product deposition up to that time caused no deleterious effects on the bottom biota. There was some evidence that the effects of increased substrate heterogeneity had been beneficial.

4. Wear (2001) carried out a second monitoring survey following disposal of a further 3,350 m^3 of by-product distributed within 5 boxes a7, b7, c6, c7 and c8 – all crowded to the southern end of the disposal site. There was again no evidence of mounding, or that the by-product material had spread beyond the disposal zone even though some had remained near the surface of the sediments. Compared with the first survey, 80 species (cf 78) were identified, 64 of which were in the disposal zone (cf 60). Mean species diversity (H') and species evenness (E) within the disposal zone showed little effect from sediment disposal, but immediately outside its boundaries there was much more instability and low species diversity – due to natural pulses of settlement among opportunistic colonisers of small size. Mean biomass within the zone was similar to the results obtained in 2000 (Wear, 2000). The general conclusion was that there had been no deleterious effects on the biota within or outside the disposal zone, which could be attributed to the introduction of by-product.

Figure 4


Proposed 200m Disposal Site Extension
Generated on New Zealand Hydrographic Chart, Wellington Harbour No. 4633
Previous Disposal Site no longer in use
Disposal Site Extension showing 50m grid
AC
c b a
BD
D
E
F
5
6
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9
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11
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N
0 125 250 500 Meters
1:10,000
Fl.5s
Point Howard
GWRC File Ref : Maritime - 2010 - Fig 6.mxd

5 Wear (2002) carried the third survey following the distribution of 3050 m^3 of by-product over the 5 grid boxes b6, c2,c5, c6 and c8, all located in the southern half of the disposal site. Again there was no evidence of mounding, or that the by-product material had spread beyond the disposal zone, although a significant quantity of waterlogged wood, cobbles and shell debris remained on or near the surface. Compared with the first and second surveys 124 animal species were found (cf 78 and 80), 92 species within the disposal zone, 95 outside it, and 63 species were common to both. The distribution of species within major invertebrate groups was similar to that of 2001 and 2002, the only change being the presence of more species in all three major groups (polychaetes, molluscs & crustaceans). Mean species diversity (H') was 2.77 inside and 2.57 outside the disposal zone, and these values, associated evenness values, benthic animal biomass data, and K-dominance curves arising from abundance/ biomass comparisons over the whole area were all within the range usually occurring in the muddy sediments of the Wellington Harbour basin. The general conclusion was that there had been no deleterious effects on the biota within or outside the disposal zone, which could be attributed to the introduction of by-product from shingle extraction.

6. The 4th full survey (ecological and sediments) was carried out during April, 2003. Data supplied by Winstone Aggregates Ltd indicate that between 01 April, 2002 and 31 March, 2003, 2600 m^3 were distributed within the 5 boxes a4 (1150), a5 (850), b5 (350), b6 (250). A total of 82 animal species were found overall, 65 species within the disposal zone, 62 outside it, and 44 species were common to both sites. Small polychaete worms numerically dominated at all stations within the disposal zone, with bivalve molluscs and crustaceans being the next most abundant groups. This pattern of abundance seen in 2003 was very similar to that characterizing the 2000 and 2001 samples, but in all three comparable years there were fewer species and individuals present than in 2002. Biological results from the four years of monitoring appeared to fall within a range of natural year to year

variation, and such variation cannot be attributed to the presence of by-product since the same trend was apparent in the reference station 400 m to the south of the disposal zone. Mean species diversity (H') was 2.80 inside and 2.65 outside the disposal zone, and these values, associated E values, benthic animal biomass data, and K-dominance curves arising from Abundance/ Biomass Comparisons over the area were all within the range usually occurring in muddy sediments of the Wellington Harbour Basin. The benthic community appears to be relatively stable and well balanced. Results from this survey indicated that there had been no movement of by-product northeast or northwest from the disposal zone. Based on the analyses applied in the 2003 report, by-product disposal had not resulted in deleterious effects on the biota within or outside the designated zone.

7 In accordance with changes approved to the conditions 19 and 20 of consent WGN 990012 (01) granted 17 February, 2004, the fifth (no 5) 2004 survey was restricted to coarse grain analysis of sediments within and immediately outside the disposal zone (Wear, 2004). There was no evidence that by-product material (small and large pebbles, waterlogged sticks etc) had spread beyond the disposal zone. As in 2001 to 2003, fine river-borne organic detritus was present in samples within the disposal zone and at stations close to its perimeter boundaries. Sediment grain size analysis data showed little change from the general situation that existed from the 2000 to 2003 surveys, either within or outside the disposal zone. As the mechanical disposal process and barge positioning appeared satisfactory up to March, 2004, the method of disposal statement was amended to one based on volume rather than a temporal sequence of targeting specific cells, with each cell receiving no more than 1000 m^3 in any given year.

8. The 2005 survey (Wear, 2005) once more confirmed that there had been no movement of by-product northeast or northwest from the disposal zone, and that although a considerable amount of by-product was mixed in with the muddy surface sediments, mounding appeared to be insignificant up to January 2005. The introduction of by-product resulted in no deleterious effects on the biota either within or outside the

disposal zone. A total of 83 animal species were found, 61 species within the zone and 59 outside, with 39 species common to both. The marine benthic community appeared to be in a state of relative stability. Mean species diversity within the disposal zone was 2.42 inside and 2.35 outside it, and these values, associated evenness values, benthic biomass data and k-dominance curves arising from abundance\biomass comparisons over the study area were all within the range normally occurring in muddy sediments of the Wellington Harbour basin.

9 The 2007 survey was carried out on 13 February, 2007 and reported in May, 2007 following disposal of 5,780 m^3 of by-product over the previous two years. Results and general conclusions indicated that although there was no evidence that by-product had moved beyond the perimeter boundaries of the designated site, there was clear evidence of surface mounding and the depth profile over these mounds had decreased by up to 1.0 +\- 0.1 m. It was recommended that more emphasis be placed on targeted tipping over specific cells to alleviate the mounding problem. Overall, the previously homogeneous muddy sand substrate within the zone had changed to a mixture of pebbles, cobbles and water-logged sticks having a general consistency of sloppy concrete. A total of 62 animal species were found within the disposal zone, 54 species outside it, with 32 species common to both areas. Primary colonising polychaetes, molluscs and crustaceans dominated the within-zone biota, and there appeared to be no serious deleterious effects on this assemblage which could be attributed to the introduction of by-product or the consequential change in sediment structure (Wear, 2007).

10. The most recent full survey (2009) confirmed evidence for mounding to the extent that after a further 7-10 years and at the present rate of disposal there was some risk of by-product material, especially wood, sticks and other organic matter less dense than stones and rubble, shifting inshore. It was suggested that retiring the northern half of the disposal zone and attaching an equivalent area to the southern boundary of the southern half of the site and over deeper water could be a satisfactory way for a proposed 35-year consent period to be a realistic option Sediment deposition has

changed the nature of the substrate within the top 10-20 cm of the disposal zone from homogeneous muddy sand to pebbles, cobbles and waterlogged timber and sticks giving it the consistency of sloppy concrete. This change resulted in a general absence of larger mobile animals, dominance of small primary colonisers and considerable reduction in the number of species present per unit area. No such trend was evident outside the disposal zone and none of the by-product had spread 100 m beyond the site on any side. It was estimated that if by-product disposal ceased, at the current natural sedimentation rate of about 5-6 cm per year, it would take the site about 10 years to recover to its original pre-1999 state with respect to the physical and ecological character of the surface 50-100 mm.

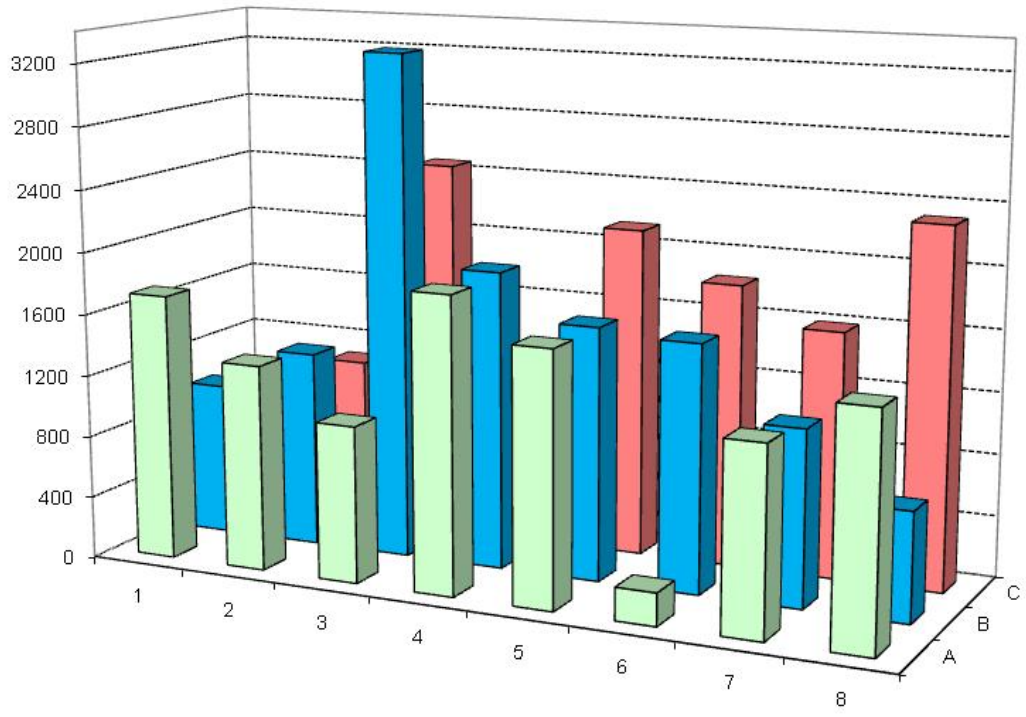
11. An interim survey (Wear, 2010b) involving sediment sampling and a sonar bottom profile was carried out on 01 July, 2010 after a further 4,620 m^3 of material had been introduced over a 17-month period. No biological samples could be taken within the zone successfully due to winnowing (see methods below), and three random grab samples were little different from those taken in 2009. It was not considered necessary to devote time to biological analyses outside the zone since the results were predictable and likely to mirror the results of the 2009 sampling. Sediment samples taken 100 m from the perimeter boundaries of the disposal zone showed little change from 2009 (Wear, 2010b).

Further and more detailed information for consideration is contained in formal reports to the consent holders (Winstone Aggregate Ltd and the Greater Wellington Regional Council Flood Protection Division) which are fully referenced at the end of this paper. The scope of the 11 studies carried out in and around the disposal zone and the most significant sedimentological and biological results of each are outlined in the 2009 and 2010 reports (Wear, 2009, 2010b).

Additionally, a number of other benthic surveys carried out within Wellington Harbour provide valuable information on benthic community structure of the harbour basin sediments, its resilience, and how the biota potentially or actually responds to, or recovers

from disturbance. Reference to these EEA's is also provided in the reference section. Copies will be in the WCC or GWRC libraries, in the Hutt City Council Library, or in the Wellington Port Company (Centerport Ltd) or Wellington Harbour Board archives. Alternatively, the writer has access to hard copies of all reports and computer records of most data on disk.

Figure 5 Bottom Distribution of by-product calculated from Winstone Aggregates Records covering the 10 year period November 1999 to 30 June, 2010 (Y axis in m$^{3)}$



3.5. Disposal Records

Disposal of by-product over the designated 60,000 $m^{2\ disposal}$ zone commenced on 23 November, 1999. Records were supplied by Winstone Aggregates Ltd from that time and thereafter either annually or biennially as required for reporting purposes. Specific and historical details of cells utilised and quantities of by-product delivered on a day-by-day basis into each cell are given in each annual or biennial monitoring report from 2000 and are not repeated here. Records indicate that since 1999 and up to 30 June, 2010, 36,190 cubic metres of spoil had been consigned to the 400 m X 150 m disposal zone (Figure 5). However, significant mounding (up to about 1.0 m) was first noted in the 2007 survey, and the need to target the disposal process more accurately and selectively to ensure a more even spread of material was emphasised. At the present time the current targeting and disposal method using the barge, the small mechanical digger and GPS is being carefully monitored, and any significant mounding is being satisfactorily mitigated.

3.6 Field and Laboratory Methods

Detailed field, laboratory and analytical methods used in previous monitoring are not repeated here, but may be sourced from previous reports. The 2009 full biological and sediment report (Wear, 2009) provides the most complete account of all methods employed. Quantitative sampling and with the 0.1 m^2 Van Veen grab within the disposal zone proved difficult during the 2009 and 2010 samplings because of incomplete closing of the grab sampler (due to the presence of sticks, cobbles and other detritus) allowing fine sediments and biota to winnow away, giving unreliable non-quantitative data. Secondly, data from earlier years 2000 to 2007 are considered sufficiently robust to support the conclusions reached.

As noted above, field and laboratory methods employed in the collection and processing of biological samples, and the calculation of species diversity, species richness and evenness, and abundance/biomass comparisons are detailed in all monitoring reports. For the 2009 survey (Wear, 2009) multivariate analysis of community structure of all outside stations and the combined within-zone stations was performed with hierarchical clustering of Bray-Curtis similarities using the CLUSTER method of PRIMER software (PRIMER-E Ltd, UK).

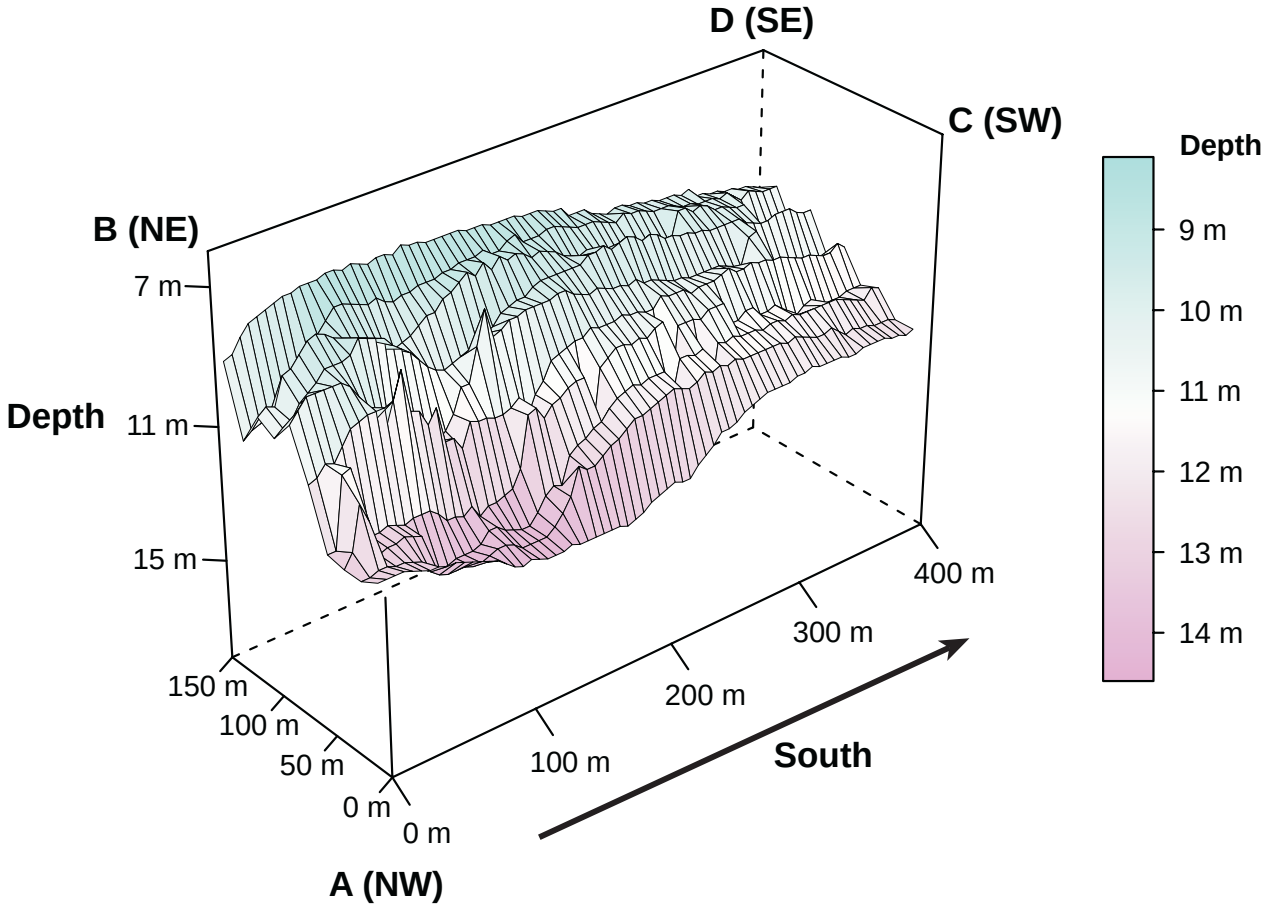
3.6.1. Bottom Profiling

The degree to which dumped waste product had mounded over the bottom within and approximately 10 m beyond all perimeter boundaries of the disposal zone was determined 01 July 2010 by way of a sonar profile (Figure 6). Before carrying out the sonar survey, it was considered appropriate to temporarily place two further locator buoys "E" 200 m due south of "C" and "F" 200 m due south of "D" at coordinates are 41^0 15.040' S X 174^0 53.404' E and 41^0 15.040' S X 174^0 53.512' E respectively. This additional 200 m X 150 m area to the south of the existing disposal zone was profiled because it is being considered in the context of an application for a future permit (Figure 9).

On 01 July, 2010, a 2-directional transect grid pattern was generated based on 10 parallel runs spaced 15 m apart with depth readings recorded on the computer every two seconds with the vessel moving at constant slow speed. A total of 700 data points were thus recorded over the disposal zone and for about 10 m outside its perimeter boundaries, and 780 were recorded over the southern half of the current zone plus the southern Corners "E" and "F" respectively (Figure 7). From each reading, 1.3 m was subtracted to adjust for Chart Datum at the time of recording. Accuracy is +/- 0.10 m.

Note: *Although all soundings were corrected to Chart Datum from the LINZ marine tide tables, determining the actual level of water lying over Chart Datum depth on the day is sometimes subject to a significant degree of error depending on barometric pressure and wind speed and direction.*

Figure 6 Bathymetry of Present (Old) Disposal Zone, 01 July, 2010



3.6.2. Sediment Sampling and AnalysisSediment

Samples were scooped from the surf of the grab samplings. In 2010, particle size analyses were carried out from Stations HO1, HO2, HO4, HS4 and the reference site HO3. Results were similar to 2009 (fine muds with no evidence of by-product) and are fully reported by Wear (2010a).

3.6.3. Biological Sample Processing

Identification of the biota was carried out to the lowest taxonomic level possible, given constraints on time available, and using a binocular microscope where necessary. Species were identified using the most recent literature available for the local fauna and direct comparisons with animals already identified and preserved in the 2005 to 2009 reference collections currently held in the School of Biological Sciences, Victoria University of Wellington. Further details concerning biological sample processing are given in the 2009 and earlier monitoring reports.

3.6.4. Biological Data Analyses

In the 2009 full monitoring report (Wear, 2009) species richness (s), species diversity (H'), evenness (E), and abundance/biomass comparisons (ABC) were calculated using the relative abundance data and the number of species present in the samples. The Abundance/Biomass Comparison (ABC) method described by Warwick (1986) and Warwick et al. (1987) was used to determine the degree of impact on biological communities arising from deposition of by-product within selected cells, and the "Beukema statistic" (Beukema (1988) was applied to determine the degree of stability or instability characterising benthic communities within and beyond the disposal zone. Multivariate analysis of community structure of all outside stations and the combined within-zone stations was performed with hierarchical clustering of Bray-Curtis similarities using the CLUSTER method of PRIMER software (PRIMER-E, Ltd., UK). Details relating to these methods are fully described in the 2009 report (Wear, 2009).

3.7 Results and Discussion

3.7.1 Sediments

Background sediments (the receiving environment) have the consistency of sandy mud with a median Phi value of 4.0 to 4.5. (Figure 7). Over 90% of this comprises grain sizes less than 0.063 mm. This is also true of the great majority of the Wellington Harbour Basin at depths greater than 10.0 m.

Most within-zone stations have now received over 1500 m^3 and up to 3260 m^3 of by-product (see Figure 5) and the substrate over the entire site is now likely to be stony with the consistency of newly-mixed sloppy concrete. Station HSO which has received no by-product directly is similarly affected through spill-over. This confirms a substantive change in the nature of the substrate from soft sandy silt to pebbles cobbles, sticks and shell debris over almost all of the disposal zone first noted in 2007. As this layer presently shows no sign of shifting or sinking further into the mud, this change will persist over the 60,000 m^2 area. However, given time (perhaps measured in terms of a decade or more) and considering the current rate of sedimentation over the area (5-6 mm per year), the introduced by-product is likely to become covered over with fine sediment if disposal ceases over all or any part of the zone.

The presence of coarse by-product material (small to large pebbles, cobbles and water-logged sticks) in grab samples from within the disposal zone, and the absence of such material from Stations HS 1 to HS7 outside the zone confirmed that the newly introduced by-product had remained near the surface of the bottom sediment, but also supported the view that none had spread beyond the disposal zone either to the north, east, south or west. This is likely to continue to be the case with continued disposal at the present rate for any new consent period (up to a maximum of 35 years). Within the disposal zone, a significant proportion of the cobbles, pebbles and water-logged wood remained within the top 150 mm of soft sediments and has clearly changed the nature of the substrate. It has become a poorly sorted mixture of fine sediments and coarse by-product with very little in the way of intermediate material, and has the consistency of sloppy concrete overlain by wood, sticks and organic debris.

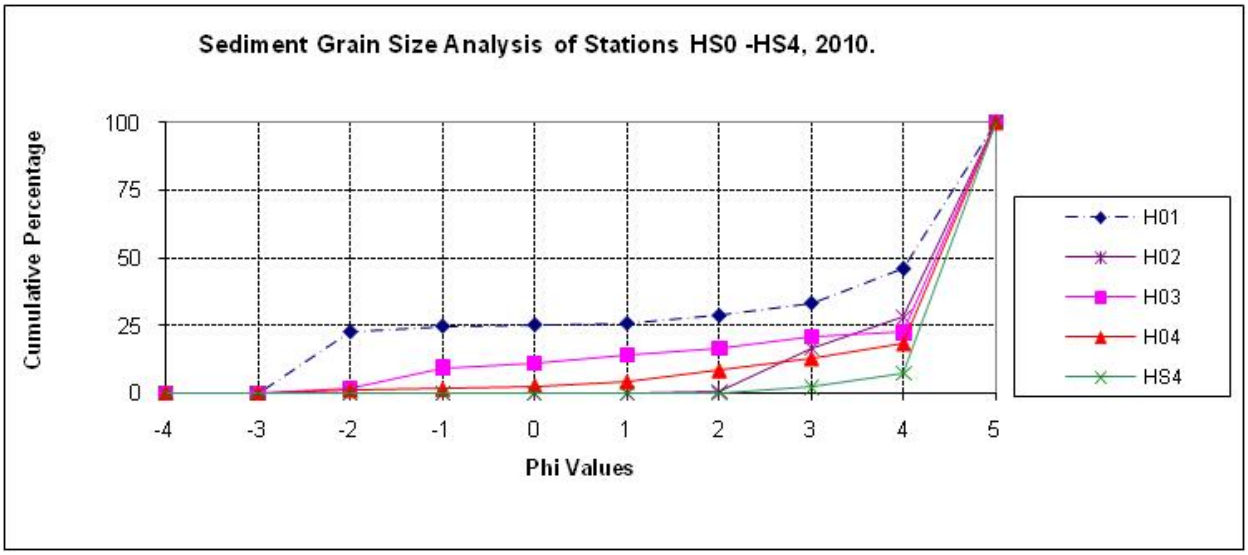


Figure 7 **Sediment Phi-size graphs for Stations 100 m beyond the Disposal Zone H01, H02, H04, HS4 and the Reference Site H03.**

Major sedimentological conclusions and recommendations are that:

1. Barge positioning and the rotational targeted spreading of by-product is a satisfactory method of disposal up to this time. This should continue for any new consent period to mitigate the possibility of mounding.

2. Once introduced, the waste material does not move away from the designated disposal zone, but accumulates on or only just within the muddy bottom sediments, significantly changing the nature of the substrate – a change which if disposal ceases may persist for a decade at least, or until natural sediment fall-out and accretion covers the coarser material with soft sediment. If disposal over any part of the site ceases (as recommended for the northern half of the present zone), then at the natural sedimentation rate of conservatively 5-6 mm per year, it would take about 10 years to recover it original pre-1999 state with respect to the physical and ecological nature of the surface 50-60 mm.

3. For the remainder of the current consent period, material should be spread over the northern half of the zone if this area does not form part of an application for a new consent.

4. To be consistent with targeted spreading of 36,190 m^3 of material evenly over a 60,000 m^2 area, with the material building up on the surface rather than sinking below it, there is likely to be a further general depth decrease of about 0.6 m over the next 10 year period if the present site is used. This would result in a depth decrease of 2.1 m over any requested consent duration of 35 years, with mounding bringing deposited by-product close to the depth where there is a significant risk of it moving inshore during major southerly storms. This is especially the case for less dense material such as timber, wood and sticks. It is clear from the accumulated results there is some risk that parts of the northern half of the zone may not sustain a 35 year consent period.

3.7.2. Biology and Ecology

The homogeneous fine silt and clay environment of Wellington Harbour, including the disposal zone, naturally supports low species richness and diversity, and relatively low biomass. As such, the disposal zone and its surrounding area can be considered to have comparatively low ecological significance.

Results from the 2009 full monitoring survey are presented in Table 1. All biological data and trends apparent over a 10-year period 1998 to 2009 are summarised in Table 2 The table lists average or mean values for the biological parameters total species "s" recorded over the whole area (inside and outside the disposal zone, total "s" inside and at standard stations outside the zone, average "s"per cell inside and outside the zone, average "n" or numbers of individual animals inside and outside, and the same for "H'" (species diversity), "E" (evenness), "B" (biomass in grams per 0.1 m^2), and the statistic $\sum$n-B which is a measure of community stability. No statistical analyses of these data were carried out because there are an insufficient number of data points (see Table 2). Trends and year to year comparisons are evident from this table.

No biological data was obtained during the 2009 or July 01, 2010 surveys as it was not possible to obtain data from the 5 stations within the disposal zone (HS 0, a8, b5, c2 and c4 in 2009) because wood, sticks, stones and other debris prevented the grab from closing and the soft sediment winnowed away on retrieval of the grab, in spite of repeated efforts to obtain a quantitative sample. 2009 data are limited to a composite species list resulting from 15 grab samples combined (an area of 1.5 m^2) in efforts to obtain a representative quantity of soft sediment (Table 6). Any abundance data for these within-zone stations would be non-quantitative and were therefore not reported. However, sufficient information is available from the years 2007 and prior to complete a satisfactory assessment of the biota. An alternative method of biological sampling should be investigated should biological sampling be deemed necessary as a condition of the new consent sought.

Table 1. Summary Biological & Sediment Data for all Stations, 2009.

Station	Species Richness	Total Abundance	Species Diversity	Evenness	Biomass g/0.1m2	Σn-b	Median phi	% > 2 mm	% < 0.063mm
Composite HS0,a8, b5, c2, c4	29						2.5	44.27	43.5
HO1	24	158	3.06	0.96	57.73	-278.52		0.0	48.4
HO2	29	228	2.04	0.60	25.68	-143.71		4.4	1.9
HO3	28	181	2.84	0.85	50.11	-471.34		1.8	1.6
HO4	21	218	1.74	0.57	20.50	-87.53		0.0	65.3
HS1							4.1	0.0	57.1
HS2							1.8	2.8	2.6
HS3							1.9	0.0	1.3
HS4	24	250	2.30	0.72	54.24	-243.27	4.4	0.0	93.9
HS5							4.4	0.0	95.2
HS6							4.4	0.0	92.2
HS7							4.4	0.0	89.7

Table 2. Summary Trends (Biology and Ecology)

Report Year	1998	2000	2001	2002	2003	2004	2005	2007	2009	2010
Total S recorded	-	78	80	124	82	-	83	41	60	-
Total S inside zone	-	58	64	92	65	-	61	62	29	-
Total S outside zone	-	59	51	95	62	-	59	54	53	-
Total S in common	-	39	37	63	44	-	39	32	20	-
Mean S per cell inside	3	25	24	38	25	-	28	25	29	-
Mean S per cell outside	3	27	24	41	28	-	26	25	25	-
Mean n per cell inside	5	183	138	235	48	-	182	155	-	-
Mean n per cell outside	5	502	4057	429	131	-	257	312	209	-
Mean H' per cell inside	1.3	2.30	2.25	2.78	2.80	-	2.42	2.23	-	-
Mean H' per cell outside	1.5	1.86	1.09	2.57	2.65	-	2.35	1.93	2.40	-
Mean E per cell inside	0.91	0.72	0.72	0.76	0.88	-	0.74	1.91	-	-
Mean E per cell outside	0.87	0.56	0.34	0.69	0.80	-	0.72	1.31	0.74	-
Mean b per cell inside	1.5	16.8	80.3	115.4	55.0	-	94.4	40.4	-	-
Mean b per cell outside	5.2	11.8	25.2	18.7	39.6	-	38.2	40.6	-	-
∑n-b inside	-	-	-332	-580	-563	-	-395	-332	-	-
∑n-b outside	-	-	18	-461	-358	-	-324	-152	-245	-

3.7.2.1. Species Richness or Number of Species (S)

Between 41 and 124 species or morphospecies were found over the study area with considerable year to year variation (Table 2). However, for each year, the number of species present inside the zone more or less matched the number outside except in 2009. The number of species in common was relatively constant. The mean number of species per cell was very consistent between stations inside and those outside the disposal zone. The mean number of individuals per cell varied widely over both locations because huge numbers of primary recolonising species with typically patchy distribution sometimes occurred (eg 2001 – Table2).

In summary, the data show that over the approximately 9 year period covered by the six full; biological surveys 2000 to 2009 there was a stable number of species present inside the designated disposal zone up to 2007, but a much sharper decrease in 2009. Species richness values outside the disposal zone have fluctuated over the years but have been generally maintained. This pattern is likely to continue into the future should offshore by-product disposal continue under a new consent.

3.7.2.2. Total Abundance (n) and Species Represented

Qualitatively, the benthic community could be termed "infauna" as all but a few surface predatory and scavenging species lived below the surface of the sediment. In all samples from all years polychaete worms dominated the biota, followed by crustaceans and molluscs with sipunculid worms, nemerteans and echinoderms also present. In all years a number of adult specimens of the pipi *Paphies australis* were present in grab samples having survived the trauma of dredging, screening, stock-piling and relocating over the disposal zone. A few cockles also survived this process. No rare or endangered species were found during any of the monitoring surveys.

An extensive and dense pipi bed is present immediately west of the hydraulic line and in the area of Stations HS2 and HS3. Sieving of the 0.1 m^2 sample revealed 28 living mature pipis at Station HS2 and 67 pipis at Station HS3 in 2009. Calculated biomass equivalent was about 21 kg shellfish per m^2 which is very high. Similar results characterised both stations in previous years (Wear 2001, 2002, 2003, 2005, 2007). There is no evidence that established inshore pipi

and cockle beds are being affected by mechanical introduction of by-product into the disposal zone.

The overall pattern of abundance seen in 2009 differs from that characterizing the animal assemblages of previous years, with fewer species (and individuals) present within the disposal zone (due to repeated disturbance and substrate change) and fewer species shared with the outside-zone stations. The conclusion is that disposal of by-product at the present (2007-2009) rates reduced the number of animals present within the cells receiving most by-product, and there had been insufficient time for effective recolonisation at the time of sampling.

3.7.2.3. Species Diversity and Evenness (H' & E)

Mean species diversity (H') for stations inside the disposal zone ranged between 2.80 and 1.3. Except for the low value of 1.3 recorded in 1998 immediately following a toxic algal bloom, remaining values were generally around 2.5 which is relatively low and considered usual for the homogeneous muddy sediments of the Wellington Harbour Basin. Outside the zone mean H' ranged between 1.09 and 2.65 with the very low value of 1.09 in 2001 skewed downwards through the presence of very large numbers of polychaete worms at Station HO4 (Wear, 2001 and Table 2**.** At the reference station HO3, 400 m south of the disposal zone, the 2009 species diversity index of 2.84 was comparable with the 2007 survey (2. 37), 2.54 in 2005, 2.48 in 2001 and 1.99 in 1999, but lower than in 2002 (3.16). Species diversity can therefore be highly variable and sometimes strongly influenced by a sudden flush of recruitment involving a single very small opportunist species. All biological parameters lie within the range normally associated with Wellington Harbour soft sediments.

3.7.2.4. Biomass (B) and Abundance/Biomass Comparisons (ABC)

Results for ABC analyses with respect to stations sampled both within and outside the disposal zone in all sampling years showed that for the individual samples the cumulative percent biomass curve lies above the abundance curve over their entire length, and the two curves are widely separated. This result reflects relative stability in the benthic community (Warwick, 1986; Warwick et al, 1987). The (N-B) statistic (Beukema, 1988) is a high negative value (Table 5) with the B curve lying consistently above the N curve indicating that the community is stable. An exception is 2001 when over 18,000 individuals of a single small polychaete

species skewed the results of analysis.

3.7.2.5. Community Composition Analyses

Dendrograms derived from Bray-Curtis cluster analyses showed that there was at least a 50% similarity between the benthic community of Station HO3 (the reference site) in 2000 and the composite within-zone samples in 2009 (Wear, 2009). The remaining 4 outside zone samples (HO1, HO2, HO4, HS4) were themselves between 57% and 72% similar in species composition. Essentially the undisturbed level of similarity in community structure between stations within the disposal zone, and those outside, had been maintained over a 9-year period.

3.7.2.6 Potential for Recolonisation

In the event that by-product disposal ceases over any part of the disposal zone, the process of recolonisation will start almost immediately mainly by way of the plankton rather than by inward migration. Recolonisation success depends on six parameters, these being substrate type, substrate quality, the rate of sedimentation, wave exposure, water quality and human disturbance. Of these, the most important factors relate to substrate. Given the harbour tidal circulation (Brodie, 1958) and considering that only about 5% of the harbour water is renewed each tide, a given body of water has a residence time of at least 10 days within the harbour, meaning that almost all sedentary species have the potential to colonise almost every site in the harbour from almost any point of origin within the harbour by way of planktonic larval dispersal, providing the substrate is appropriate.

Should by-product disposal cease over any part of the disposal zone, recolonisation will be rapid and will be complete in the longer term. A formally published baseline for this effectiveness of this process has been completed by Gardner and Wear, (2006) who produced evidence to the effect that full recolonisation by all species would be complete after 4-5 years following widespread die-off of the harbour biota. The opportunity to quantify this arose from work carried out following the February-March, 1998 toxic algal bloom. Moreover, this present biological sampling programme has shown that recolonisation by small opportunist species frequently occurs over a shorter time period between one sampling and the next – as little as 1 year as shown by the 2001 data (Table 2).

An earlier study was carried out on an old sediment relocation area 14 m deep and located at 41^0 15.88' S X 1740 47.58' E about 50 m southeast of the Kaiwharawhara reclamation (Wear and Anderlini, 1995). Dumping of spoil dredged from the Overseas Passenger Terminal and Lambton Harbour wharf areas ceased in 1984. The unprocessed spoil (as determined by grab sampling in the disposal zone) was structurally similar to the Hutt River Mouth by-product. The results of this 1995 study showed sediment to be complex and varied with fines <0.63 mm comprising about 40% by weight, supporting a rich and diverse biota in a state of equilibrium with the environment. At this old disposal site location, species richness and diversity were higher than in adjacent Harbour Basin sediments, with no taxonomic group dominating. This can be attributed to the greater range of sediment particle sizes available as habitat for a greater variety of organisms. Recolonisation by way of planktonic larval dispersal has been very successful there, and this is also likely to be predictable and true for the disposal zone currently under consideration.

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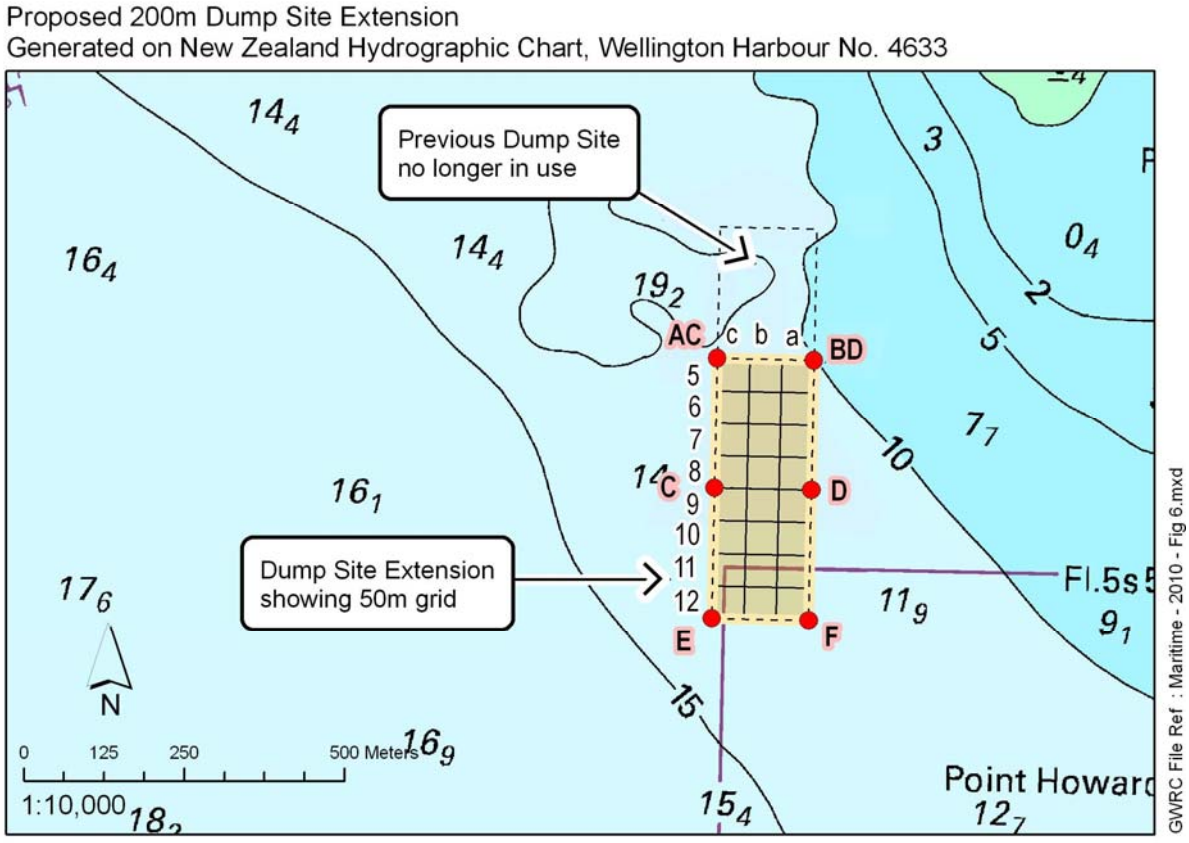
Figure 8 Location of Proposed New Southern Extension of the Disposal Zone (Generated on New Zealand Hydrographic Chart, Wellington Harbour No 4633



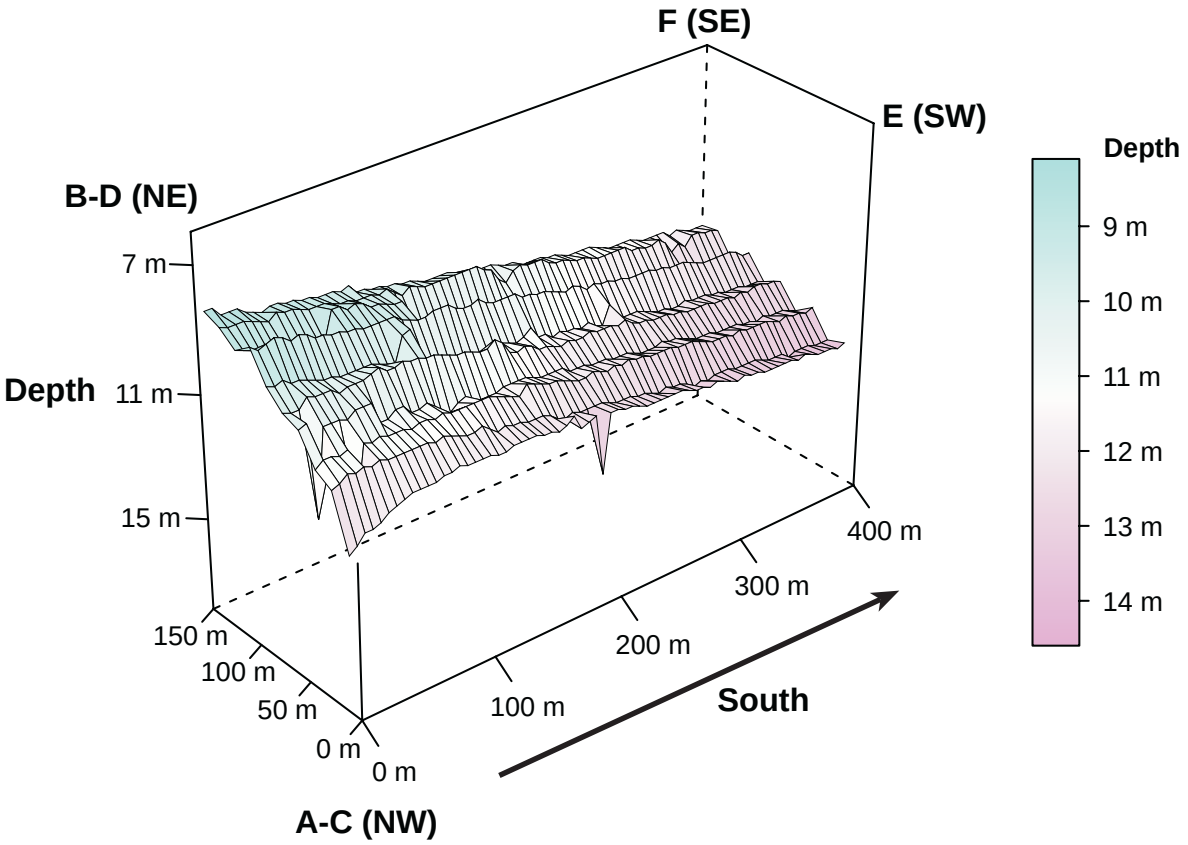


Figure 9 **Bathymetry of the Proposed New Disposal Zone (incorporating the southern half of the existing site and a new 200m X 150 m extension to its southern boundary.**

4. The Application

4.1 The Proposal

In application for a new consent effective after 17 May, 2011, it is recommended that consideration be given to sliding the northern half of the present disposal zone southward over deeper water (12-14 m) so that the northern boundary becomes the existing A-C to B-D, and that a further 200 m X 150 m area is attached to the present southern boundary C to D and designated E and F at 41^0 15.040' S X 174^0 53.404' E and 41^0 15.040' S X 174^0 53.512' E respectively (Figures 8 and 9). This re-definition of the southern boundary moves the site 200 m to the south thus avoiding any chance of mounding over the shallower parts of the northern half of the existing disposal zone reaching depths which risk the possibility of less dense components of the by-product being dislodged during severe southerly gales during the later years of the consent period, if granted.

This amendment should not add significantly to the costs of disposal, is unlikely to interfere with shipping operations at the Point Howard Oil Wharf, and gives the opportunity for a consent period of 35 years to be applied for and granted with minimal risk. The bottom sediments, depth profile and community composition of such a new area are known and are confirmed by past and present data from Stations HO2 and the reference site HO3,

4.2. Addressing Concerns

Some of the concerns raised in the EEA, by submitters and by the Hearings Committee at the previous Resource Consent Hearing in May, 1999 have been allayed as a result of the monitoring programme carried out over the last 11 years. These are italicized then addressed as following:

- *Potential shingle movement from the disposal zone.* There is no evidence that by-product has moved in any direction from the disposal zone up to this time. This agrees with the opinion of Mr O'Callaghan in his 1995 submission in support of the current consent extending over a period of 15 years.

- *Adverse effects on customary fishing rights.* There is no evidence to support this claim.
- *Potential negative effect on the local flat fishery.* The surrounding areas are still being fished and there is no evidence to support the contention that any decrease in catch per unit of effort can be attributed to spreading coarse by-product over the disposal zone.
- *Shingle accretion near Korokoro arising from dumping activity causing shingle to be "blown"westward during southerlies which is affecting water skiing.* Any accretion to the west of the disposal zone cannot be attributed to material from that source.
- *Increased turbidity.* Sediment clouds resulting from spreading by-product over the disposal zone are short-lived, localized, and no more than minor when compared with turbidity resulting from a flood or fresh in the Hutt River.
- *Potential detrimental effect on the Hutt Aquifer with shingle from the dumps moving toward or over the vents with unknown effects.* There is no evidence that this is occurring or would occur. The proposed southern extension is no nearer the aquifer than is the current disposal site.
- *Toxicity of dredged material originating from the Waiwhetu stream being present in dumped material.* There is no evidence of any toxic effects on the biota of the disposal zone, and in future this possibility is greatly ameliorated by current restoration works in the area of the stream mouth. Additionally, the area around the Waiwhetu Stream mouth is a "no Extraction" zone (Figure 1).

4.3. Term of Consent

There have been no adverse or deleterious environmental effects arising from shingle extraction or from offshore deposition of residual by-product within the designated 6 ha disposal zone over the current period of consent. The bottom sediments of the extraction zone are anoxic or near-anoxic and support a depauperate biota of low ecological value. Continued extraction is unlikely to have any effect on existing amenity values, or recreational or commercial fishing in the area. A 35-year term of consent is defensible on the grounds that the sediments of the extraction zone are already degraded ecologically, and

granting a permit of this duration is unlikely to have new or additional environmental effects.

A consent period of 35 years can also be sustained for the disposal zone provided that the northern half of the existing site is relocated southwards to become attached to the present southern boundary, thereby extending the zone southwards by 200m over deeper water. The existing northern half should be retired and allowed to recolonise its soft sediment biota by way of planktonic larval recruitment as natural sedimentation proceeds. Giving effect to this redefinition of the southern boundary will avoid the chance of mounding and by-product build-up over the existing shallower northern half reaching depths which risk the possibility of less dense components of the by-product becoming dislodged and cast ashore during severe southerly conditions during the later years of the consent period.

4.4 Possible Conditions and Monitoring.

- The current disposal technology involving a barge, a small mechanical digger and accurate differential GPS location of individual cells within the disposal zone remains appropriate for the future. The present conditions specifying maximum 5-year average disposal rates and record-keeping requirements are also appropriate and should continue as at present.

- The most expensive and time-consuming monitoring exercise is biological monitoring in which the biota is separated from the sediment by sieving, identified, counted and weighed to determine species richness (s), abundance of each species (n), abundance\biomass comparisons, species diversity (H'), evenness (E) and whether or not any rare or endangered species are present. Also, the ABC method of biological analysis is very time-consuming in relation to the efficacy and usefulness of the results achieved.

- Use of the van Veen grab is a very useful sampling tool in soft, homogeneous muddy sediments but is inefficient and non-quantitative in sediments containing waterlogged sticks, pebbles and cobbles which prevent any form of grab from closing. While grab

samples can detect the very presence of coarse by-product, the grab technology is not a repeatable method of taking quantitative samples beyond about 7 years of by-product accumulation on the bottom. As discussed in earlier reports, sampling by SCUBA diving or video recording is ineffective because of constant very poor visibility over the site. No other reliable sampling methodology springs to mind.

- There are now sufficient data from the 10 years of biological monitoring associated with the current consent to predict any environmental effect, deleterious or otherwise, likely to occur in the event that a new consent is granted for a period of 35 years. Within the 6 ha disposal zone and at the present rate of disposal, over the first 2-3 years there is likely to be a rise in s, n and H' due to increased substrate heterogeneity. An approximately 5-year period of relative stability is likely to follow with the community structure more strongly influenced by natural year to year variability and colonization by small opportunistic species, than by the rain of by-product from above. Thereafter, and after about 7 years of deposition, the biological indicators will probably decline due to a marked reduction in the availability of soft muddy substrate, frequent disturbance with insufficient time to recover, and outward migration of larger and more mobile species. At stations outside the perimeter boundaries of the disposal zone, there is no ecological or biological change which could be attributed to by-product disposal over the designated site.

- For biological monitoring the method of sampling becomes a problem over time and as by-product continues to build up. On the basis of expense, predictability and longer term effectiveness, the cost\benefit analysis with respect to intensive biological sampling is negative, and the procedure could well be excluded as a condition of consent in this present application. There appears to be little point in requiring continuation of the current intensive biological monitoring programme over the proposed new disposal zone and immediately surrounding area as this would most likely reveal no trends or environmental effects beyond those which are already evident or predictable.

- The three most important considerations for a new consent valid for 35 years are:
    1. Sliding the existing disposal zone 200 m to the south.
    2. To ensure that over the proposed consent period the by-product is spread as evenly as possible by way of targeted rotational distribution designed also to minimise the possibility of mounding.
    3. To ensure that the introduced by-product remains within the designated disposal zone for the duration of the consent and preferably thereafter.

These considerations could be addressed through conditions of consent requiring sonar bottom profiling of the entire site, and by grab sampling for coarse grain sediment analysis immediately outside (about 10 m) each of the four perimeter boundaries of the disposal zone. It is recommended that this occurs within three months of the new consent becoming effective as a baseline and subsequently repeated at 5-yearly intervals. Review options should be at the discretion of the Manager, Consents Management, Greater Wellington Regional Council.

5. Acknowledgements

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Appendix 1

Soundings for Bathymetric Survey of the Present (Old) Disposal Zone, 01 July, 2010

(700 Data Points)

		~15m	~15m	~15m	~15m	~15m	~15m	~15m	~15m	~15m	
NW corner (A)	12.7	13.0	13.0	12.9	11.2	9.8	10.5	10.2	11.2	**9.2**	**NE Corner (B)**
	12.7	13.0	12.6	12.9	11.1	9.5	10.3	10.0	11.0	9.1	
	12.7	12.9	11.3	10.8	10.8	9.2	10.2	10.1	10.9	8.7	
	12.7	12.9	11.9	10.7	10.9	9.2	9.8	9.3	10.8	8.4	
	12.8	13.0	13.0	13.1	10.5	9.2	9.6	9.2	10.6	8.3	
	12.9	13.0	12.9	129	10.1	9.2	9.4	8.9	10.5	8.2	
	13.0	13.1	2.9	12.9	10.0	9.2	9.1	8.6	10.2	8.1	
	13.0	13.2	12.8	12.8	9.9	9.4	9.1	8.5	10.2	8.0	
	13.1	13,6	12.9	12.9	9.9	9.8	9.1	8.6	9.5	8.0	
	13.1	13.8	13.0	13.0	9.9	10.2	9.0	8.8	9.0	7.9	
	13.2	13.9	14.1	12.9	9.8	10.6	8.6	8.9	8.7	7.9	
	13.3	13.9	14.2	12.9	9.0	11.0	8.7	9.0	8.4	7.9	
	13.4	13.9	14.2	12.9	10.3	12.4	8.8	9.1	8.4	7.8	
	13.5	14.0	14.1	13.1	10.4	13.0	8.9	9.2	8.5	7.8	
	13.6	14.0	14.1	13.4	10.9	12.1	9.2	9.4	8.6	7.9	
	13.8	13.9	14.1	13.4	10.5	12.1	9.4	9.7	8.7	7.8	
	14.0	13.8	14.0	13.5	11.6	12.0	9.6	9.8	8.6	7.9	
	14.1	13.8	13.7	13.3	11.6	12.0	9.9	9.7	8.8	8.0	
	14.0	13.9	13.7	13.7	12.0	11.8	10.2	9.6	8.9	7.9	
	14.1	14.1	13.9	13.5	11.3	11.4	10.4	9.4	8.8	7.9	
	14.2	14.1	14.0	13.5	11.4	10.7	10.5	9.2	8.8	8.0	
	14.2	14.1	14.1	13.4	11.4	10.7	10.4	9.2	8.7	7.8	
	14.2	14.1	14.1	13.3	11.5	9.7	10.3	8.9	8.7	7.9	
	14.1	13.9	13.8	12.8	11.5	8.7	10.2	8.8	8.7	7.9	
	14.2	13.6	13.4	11.3	11.4	9.6	10.0	8.6	8.6	8.0	
	14.2	13.2	13.2	11.2	11.2	9.5	9.9	8.4	8.6	8.0	
	14.2	12.4	13.3	11.6	11.9	9.3	9.8	8.6	8.5	8.0	
	14.2	12.6	12.5	11.3	11.3	9.3	9.5	8.3	8.5	8.0	
	14.2	12.6	12.3	11.2	11.0	9.2	9.4	8.6	8.5	8.0	
	14.2	12.4	12.2	11.0	10.5	9.2	9.3	8.3	8.4	8.1	
	14.3	12.2	12.0	10.9	10.4	9.2	9.3	8.5	8.6	8.1	
	14.2	12.1	11.9	10.9	10.3	9.2	9.1	8.4	8.6	8.1	
	14.1	11.9	11.6	12.9	10.2	9.1	9.0	8.5	8.4	8.2	
	13,9	11.7	11.4	10.8	10.2	9.1	9.0	8.7	8.3	8.2	
	13.8	11.7	11.3	10.6	10.0	9.3	9.0	8.6	8.6	8.2	
	13.7	11.6	11.2	10.4	10.1	9.4	9.0	8.7	8.6	8.2	
	13.6	11.5	11.3	10.4	10.1	9.5	9.0	8.8	8.6	8.3	
	13.7	11.4	11.2	10.5	10.1	9.4	9.0	9.0	8.5	8.3	
	13.7	11.3	11.2	10.4	10.0	9.5	8.8	9.1	8.5	8.3	

13.4	11.4	11.2	10.5	10.1	9.6	8.8	9.2	8.6	8.4
13.2	11.5	22.2	10.3	10.1	9.6	8.7	9.1	8.7	8.5
13.0	11.4	11.0	10.2	10.2	9.7	8.9	9.2	8.8	8.5
12.7	11,2	11.0	13.3	10.2	9.6	8.8	9.3	8.8	8.8
12.7	11.3	11.1	10.5	9.9	9.8	8.7	9.4	8.8	8.8
12.6	11.2	11.0	10.5	10.0	9.8	8.8	9.5	8.9	8.8
12.4	11.3	12.9	10.5	10.0	9.9	9.0	9.6	9.0	9.0
12.3	11.2	11.0	10.6	10.0	10.0	8.9	9.6	9.1	9.1
12.2	11.3	11.1	10.4	10.2	10.1	9.0	9.6	8.9	9.2
12.1	11.3	11.0	10.4	10.1	10.1	9.2	9.6	9.0	9.1
12.1	11.3	11.1	10.4	10.1	10.2	9.2	9.7	9.0	9.1
12.1	11.3	11.1	11.1	10.1	10.2	9.3	9.7	9.1	9.2
12.1	11.3	11.1	11.1	10.0	10.2	9.3	9.9	9.2	9.2
12.0	11.3	11.2	10.9	9.9	10.2	9.4	9.0	9.2	9.3
12.0	11.4	11.1	10.9	10.1	10.2	9.4	9.0	9.2	9.3
11.9	11.3	11.1	11.2	10.1	10.3	9.5	9.2	9.3	9.4
12.0	11.4	11.2	11.2	10.0	10.4	9.5	9.1	9.4	9.4
12.0	11.5	11.1	11.1	10.1	10.5	9.5	9.2	9.4	9.4
12.0	11.6	11.2	11.3	10.1	9.7	9.5	9.4	9.5	9.5
12.0	11.6	11.2	11.7	10.2	9.6	9.5	9.4	9.5	9.4
12.1	11.5	11.2	11.7	10.2	10.8	9.7	9.5	9.5	9.7
12.1	11.7	11.2	11.5	10.3	10.9	9.8	9.6	9.6	9.7
12.0	11.9	11.2	11.4	10.4	11.0	9.9	9.6	9.5	9.8
12.0	11.8	11.2	11.7	10.5	11.1	9.9	10.7	9.7	9.8
12.0	11.9	11.3	11.7	10.5	11.1	9.8	10.8	9.9	9.9
12.0	11.9	11.4	11.7	10.6	11.1	9.8	10.9	9.7	9.9
12.1	12.0	11.5	11.7	10.7	11.2	9.8	10,9	9.8	10.0
12.1	12.0	11.6	11.6	10.7	11.2	10.0	11.0	9.9	10.0
12.2	12.0	11.3	11.6	10.5	11.2	10.1	11.0	9.9	10.1
12.1	12.1	11.4	11.6	10.7	11.2	10.1	11.0	9.9	10.2

SW Corner(C) **SE Corner (D)**

Appendix 2

Soundings for Bathymetric Survey of Proposed New Disposal Zone, July, 2010 (Raw Data)

(780 Data Points)

	~15m	~15m	~15m	~15m	~15m	~15m	~15m	~15m	~15m	
NW Corner (A - C)										**NE Corner (B – D)**
13.2	11.5	11.2	10.3	10.1	9.6	8.7	9.1	8.7	8.5	
13.0	11.4	11.0	10.2	10.2	9.7	8.9	9.2	8.8	8.5	
12.7	11,2	11.0	13.3	10.2	9.6	8.8	9.3	8.8	8.8	
12.7	11.3	11.1	10.5	9.9	9.8	8.7	9.4	8.8	8.8	
12.6	11.2	11.0	10.5	10.0	9.8	8.8	9.5	8.9	8.8	
12.4	11.3	12.9	10.5	10.0	9.9	9.0	9.6	9.0	9.0	
12.3	11.2	11.0	10.6	10.0	10.0	8.9	9.6	9.1	9.1	
12.2	11.3	11.1	10.4	10.2	10.1	9.0	9.6	8.9	9.2	
12.1	11.3	11.0	10.4	10.1	10.1	9.2	9.6	9.0	9.1	
12.1	11.3	11.1	10.4	10.1	10.2	9.2	9.7	9.0	9.1	
12.1	11.3	11.1	11.1	10.1	10.2	9.3	9.7	9.1	9.2	
12.1	11.3	11.1	11.1	10.0	10.2	9.3	9.9	9.2	9.2	
12.0	11.3	11.2	10.9	9.9	10.2	9.4	9.0	9.2	9.3	
12.0	11.4	11.1	10.9	10.1	10.2	9.4	9.0	9.2	9.3	
11.9	11.3	11.1	11.2	10.1	10.3	9.5	9.2	9.3	9.4	
12.0	11.4	11.2	11.2	10.0	10.4	9.5	9.1	9.4	9.4	
12.0	11.5	11.1	11.1	10.1	10.5	9.5	9.2	9.4	9.4	
12.0	11.6	11.2	11.3	10.1	9.7	9.5	9.4	9.5	9.5	
12.0	11.6	11.2	11.7	10.2	9.6	9.5	9.4	9.5	9.4	
12.1	11.5	11.2	11.7	10.2	10.8	9.7	9.5	9.5	9.7	
12.1	11.7	11.2	11.5	10.3	10.9	9.8	9.6	9.6	9.7	
12.0	11.9	11.2	11.4	10.4	11.0	9.9	9.6	9.5	9.8	
12.0	11.8	11.2	11.7	10.5	11.1	9.9	10.7	9.7	9.8	
12.0	11.9	11.3	11.7	10.5	11.1	9.8	10.8	9.9	9.9	
12.0	11.9	11.4	11.7	10.6	11.1	9.8	10.9	9.7	9.9	
12.1	12.0	11.5	11.7	10.7	11.2	9.8	10,9	9.8	10.0	
12.1	12.0	11.6	11.6	10.7	11.2	10.0	11.0	9.9	10.0	
12.2	12.0	11.3	11.6	10.5	11.2	10.1	11.0	9.9	10.1	
12.1	12.1	11.4	11.6	10.7	11.2	10.1	11.0	9.9	10.2	
11.9	12.3	11.5	11.6	11.1	11.2	10.0	11.1	9.9	10.2	
12.4	12.4	11.6	11.7	11.2	11.2	10.2	11.2	9.9	10.2	
12.3	12.3	11.6	11.8	11.1	11.3	10.3	11.2	9.9	10.2	
12.2	12,4	11.7	11.8	11.2	11,4	10.3	11.2	9.9	10.3	
14.2	12.4	11.8	11.8	11.4	11.3	10.3	11.2	9.9	10.4	

12.3	12.4	11.9	11.8	11.4	11.1	10.3	11.2	10.1	10.5
12.3	12.4	11.9	12.0	11.5	11.5	10.5	11.3	10.2	10.5
12.4	12.5	11.8	12.0	11.6	11.5	10.5	11.3	10.6	10.5
12.4	12.6	11.9	12.0	11.5	11.7	10.6	11.3	10.8	10.5
12.5	12.6	12.0	12.1	11.6	11.6	10.6	11.3	10.5	10.6
12.6	12.6	11.9	12.1	11.6	11.7	10.7	11.4	10.4	10.7
12.6	12.7	12.0	12.1	11.5	11.7	10.8	11.4	10.5	10.7
12.6	12.7	11.9	12.2	11.6	11.8	10.9	11.5	10.5	10.9
12.6	12.8	12.0	12.2	11.6	11.7	10.8	11.6	10.5	10.9
12.6	12.9	12.0	12.2	11.6	11.9	10.9	11.6	10.7	10.9
12.6	12.8	12.1	12.3	11.7	12.0	11.1	11.6	10.8	10.9
12.7	12.9	12.1	12.4	11.6	11.4	11.0	11.8	10.8	11.0
12.8	12.9	12.1	12.4	11.8	12.0	11.1	11.8	10.9	11.0
12.8	13.0	12.1	12.4	11.9	12.0	11.1	11.9	11.0	11.1
12.9	13.2	12.2	12.3	11.9	12.0	11.2	11.9	11.0	11.2
12.8	13.1	12.2	12.4	12.0	12.0	11.2	12.0	11.1	11.2
12.9	13.2	12.2	12.4	12.0	12.1	11.3	12.1	11.2	11.2
13.0	13.1	12.3	12.5	12.0	12.2	11.3	12.1	11.2	11.2
13.1	13.1	12.4	12.6	12.1	12.3	11.3	12.2	11.2	11.3
13.0	13.1	12.5	12.7	12.1	12.3	11.3	12.2	11.2	11.4
13.1	13.2	12.5	12.7	12.2	12.4	11.4	12.2	11.2	11.5
13.1	13.2	12.5	12.7	12.2	12.4	11.4	12.2	11.4	11.5
13.2	13.2	12.6	12.8	12.2	12.3	11.5	12.2	11.4	11.5
13.2	13.2	12.5	12.8	12.2	12.4	11.5	12.3	11.5	11.5
13.2	13.3	12.6	12.8	12.3	12.4	11.5	12.4	11.5	11.6
13.2	13.4	12.6	12.8	12.3	12.4	11.6	12.4	11.4	11.7
13.2	13.4	12.6	12.9	12.3	12.5	11.7	12.5	11.6	11.7
13.3	13.4	12.6	12.9	12.4	12.5	11.8	12.5	12.0	11.7
13.2	13.6	12.7	13.0	12.3	12.6	11.8	12.6	11.8	11.7
13.3	13.5	12.8	12.9	12.4	12.6	11.8	12.6	12.0	11.9
13.4	13.5	12.7	13.0	12.3	12.6	11.8	12.6	11.7	11.8
13.4	13.5	12.8	13.0	12.3	12.7	11.8	12.6	11.7	11.9
13.4	13.6	12.8	13.0	12.4	12.7	11.9	12.6	11.8	12.0
13.5	13.6	12.9	13.1	12.4	12.7	12.1	12.6	11.8	12.0
13.4	13.6	12.8	13.2	12.5	12.8	12.1	12.7	11.9	12.0
13.6	13.6	13.0	13.2	12.6	12.8	12.2	12.7	11.8	12.1
13.6	13.7	13.0	13.2	12.5	12.9	12.2	12.7	11.9	12.2
13.7	13.7	13.1	13.2	12.6	13.0	12.2	12.7	12.0	12.2
13.8	13.7	13.0	13.3	12.7	12.9	12.2	12.7	12.0	12.2
13.8	13.8	13.1	13.3	12.6	13.0	12.2	12.8	12.1	12.2
13.8	13.8	13.1	13.3	12.6	13.0	12.2	12.3	12.1	12.3
13.8	13.8	13.2	13.3	12.6	13.0	12.2	12.3	12.1	12.3
13.8	13.6	13.2	13.4	12.6	13.1	12.2	12.3	12.2	12.4