BEFORE THE OTAGO REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of an application for resource consents for Project Next Generation
BY	**PORT OTAGO LIMITED**
	Applicant

STATEMENT OF EVIDENCE OF CHRISTOPHER WAYNE HICKEY ON BEHALF OF PORT OTAGO LIMITED 6 April 2011

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INTRODUCTION, QUALIFICATIONS & EXPERIENCE

1. My name is Christopher Wayne Hickey. I am a research scientist with the National Institute of Water and Atmospheric Research Limited ("NIWA") based in Hamilton. I am a Principal Scientist with NIWA and Director of NIWA USA (Inc).

2. I hold the degree of Doctor of Philosophy in biochemistry/microbiology from the University of Waikato. I have worked for 30 years in environmental research and consulting in the area of contaminant impacts in fresh and marine waters. My specialist areas are in water quality guidelines and environmental toxicology.

3. My research experience includes characterisation of wastewater oxidation lagoons and potential effects on receiving waters, characterisation of factors affecting river macroinvertebrate communities, including ammonia toxicity and chemical contaminant studies on native fish and invertebrate species. I was a contributing author to the ANZECC (2000) water quality guidelines; the New Zealand Municipal Wastewater Monitoring Guidelines (NZWWMG 2002); and Guidelines for Drinking-water Quality Management for New Zealand (2005). My ongoing studies include: routine monitoring for permit compliance, contaminant biomonitoring and sediment toxicity testing, literature reviews and government policy advice. I have authored or co-authored over 90 published scientific papers on a range of freshwater and marine environmental toxicology topics, including toxicity of chemicals to organisms, pollution impacts on benthic communities, the use of freshwater and marine organisms for biomonitoring, and the chemical contamination of freshwater and marine sediments.

4. Acting as a consultant I have been involved with the design and implementation of aquatic toxicity assessment and biomonitoring programmes, monitoring of pollution impacts, environmental impact reports and discharge consenting applications.

5. I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Consolidated Practice Note 2006 and I agree to comply with it. I have complied with in the preparation of this evidence. In particular, unless I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider

material facts known to me that might alter or detract from the opinions I express.

BACKGROUND INFORMATION

6. In this matter, I have been engaged by Port Otago Limited (POL) to prepare evidence on chemical contaminants and the potential for toxicity-related adverse effects in relation to their proposed dredging and disposal of material from the Lower Otago Harbour for their "Project Next Generation".

7. I am familiar with Otago Harbour from my involvement with Ravensdown Ltd's Ravensbourne Works re-consenting (in 2004) and various harbour effects assessments relating to potential water column and sediment-associated effects from that site. I have been involved with the design and implementation of both harbour monitoring and effects assessment programmes, and with on-site implementation of an integrated stormwater management and treatment programme. These assessments have included: chemical contaminants, wastewater toxicity monitoring, biological effects assessment (macroinvertebrates, macroalgae, mussels), diffuser mixing, thermal effects, harbour water clarity and nutrient effects. These studies have involved both near-site and reference site (distant) monitoring of background conditions. I was most recently on Otago Harbour in February 2011 as part of the compliance monitoring programme. I was also involved with the chemical and ecotoxicity effects assessment for the consenting of the Dunedin City Tahuna wastewater ocean discharge in 2003.

8. My evidence is based on my extensive experience in marine toxicity effects assessment, water and sediment quality guidelines derivation, published and unpublished reports, and work specifically undertaken for POL as presented in the Assessment of Environmental Effects.

9. I provided design guidance for the collection of sediment samples and the suite of chemical contaminant and other analyses to characterise these sites. The sediment sampling was undertaken by GHD Ltd, Christchurch, in conjunction with Benthic Science Ltd, Dunedin, and the chemical analyses by a certified and recognised analytical laboratory (Hill Laboratories Ltd, Hamilton). Subsequent to that I designed and supervised further detailed work involving sampling (by

Benthic Science Ltd) and sediment elutriate testing from a selection of sites for chemical contaminants (Hill Laboratories) and biological toxicity testing using sensitive locally relevant marine species (NIWA, Hamilton).

10. I am also reliant on the statements of evidence of other experts giving evidence. These include: Dr Rob Bell, for sediment particle size distributions and predictions of near-field contaminant dilutions; Dr Mark James, for marine ecology and sediment-deposition related effects; and Associate Professor Keith Probert on the Harbour environment.

SCOPE OF EVIDENCE

11. I have been asked by Port Otago Limited (POL) to prepare evidence on chemical contaminants and the potential for toxicity-related adverse effects in relation to their proposed dredging and disposal of material from the Lower Otago Harbour for their "Project Next Generation". In my evidence I discuss:

    a. Ecotoxicological review – contaminants of concern;

    b. Information in relation to POL chemical contaminants and external sources;

    c. POL chemical monitoring and ecotoxicity testing;

    d. Biological effects assessment;

    e. Human health assessment;

    f. Issues raised by submitters; and

    g. Conclusions.

EXECUTIVE SUMMARY

12. The sediment sampling undertaken in 2010 for chemical contaminant assessment and sediment elutriate chemical and toxicity measurements provides a robust basis for assessing the potential for contaminant-related effects from the deposited dredge material and on the water column during dredging and disposal operations.

13. I conclude that there is a very low concern for chemical contaminant related adverse effects associated with the proposed dredging and disposal operation.

THE PROPOSAL

14. My evidence relates to the Project Next Generation proposal to:

    a. deepen and widen the Otago Harbour channel, swinging areas and berths by dredging,

    b. disposal of dredged material at sea in designated disposal areas.

15. As discussed by previous witnesses, the POL proposal relates to dredging and disposal operations solely in the Lower Otago Harbour, with disposal of material off shore. Contaminant related issues in the Lower Harbour must therefore include consideration of those generated in the local area of Port Chalmers, and those transported from sources in the Upper Harbour and its catchment.

THE SITE AND ITS CONTEXT

16. Otago Harbour is a long tidal inlet situated on the east coast of the South Island of New Zealand at latitude 45° 50' south. The Harbour is ecologically, hydrologically and sedimentologically divisible into three sections:

    a. the Lower Harbour, extending from Taiaroa Head to the halfway islands, is rapidly flushed, has a short residence time and therefore has a composition similar to the open ocean;

    b. the Middle Harbour is characterised by a dredged shipping channel and a barrier wall which hydrologically separates the northern and southern regions; and

    c. the Upper Harbour which may have periods of decreased salinity but increases in residence time towards the upper harbour basin adjacent to Dunedin City, where the Water of Leith is the major freshwater inflow.

17. Extensive areas of the Upper, Middle and Lower Harbour are relatively shallow (<5 m) and supports large beds of a variety of species of

macroalgae (<0.2 m height). These more sheltered quiescent areas naturally retain fine sediment material. A tidal range of >1 m combined with relatively common moderate wind events parallel to the Harbour axis, may result in significant wave height and fine sediment resuspension from the shallower harbour areas. Thus fine sediment deposited in the Upper Harbour, which would be expected to have elevated levels of adsorbed chemical contaminants, could then be exported from the Upper to the Lower Harbour. Thus the deeper depositional areas of the Harbour, such as the swinging basin adjacent to the Port Chalmers wharves, could become enriched with both locally-sourced contaminants and those exported from the Upper Harbour environments.

18. Chemical contaminants are potentially derived from a number of sources in Otago Harbour. Attachment 1 shows the location of the dredging area (adjacent to Port Chalmers) and the location of known ongoing and legacy contaminant sources in the Harbour. Attachment 2 summarises the nature of the contaminant discharges to the Harbour. This provides the basis for deciding the types of contaminants which should be analysed in the assessment of potential effects of the Harbour dredging and offshore disposal operations. These are briefly described below:

19. The City of Dunedin has a number of stormwater discharges to the Upper Harbour. These will discharge sediments, “heavy metals” (normally expected to include copper (Cu), lead (Pb) and zinc (Zn); however a more comprehensive assessment includes: cadmium (Cd), chromium (Cr), mercury (Hg), nickel (Ni) and the metalloid, arsenic (As)), petroleum hydrocarbons (determined by measuring total petroleum hydrocarbons (TPHs) and specific components such as polycyclic aromatic hydrocarbons (PAHs)), and possibly polychlorinated biphenyls (PCBs, historically used in electrical transformers).

20. The Water of Leith is a small sized river (mean flow 0.82 m^3/s) which rises between Mount Cargill and Swampy Hill and flows about 11.6 km (about 7 km of farmland) and draining a catchment of 42.1 km^2 before entering the Upper Otago Harbour at Dunedin. In the upper catchments indigenous hardwoods, harvested forest, manuka, kanuka, grassland and pine forest dominate, while in the lower

catchment the bottom and side slopes of the valley are occupied to a large degree by streets and buildings, parks and open spaces and a large surface mine (ORC 2008). Thus the expected contaminants discharged from the Water of Leith include nutrients, sediments, agriculture and forestry related chemicals and urban stormwater-associated heavy metals and organics (Reid 1990). Some run off of persistent organic pesticides, such as the now disused dieldrin and DDT, would be expected to occur from an agricultural catchment.

21. Upper and Lower Harbour port operations at Dunedin and Port Chalmers may result in general stormwater contaminants (i.e., heavy metals, hydrocarbons), spillage of cargo materials and ships antifoulants (e.g., organo-tins (TBT, historically used on shipping); copper, diuron).

22. Ravensdown Fertiliser Co-operative discharges at Ravensbourne near the Upper Harbour. The contaminants associated with the fertiliser operations are Cd, fluoride and nutrient (phosphate). Harbour monitoring has shown no significant contaminant wastewater discharge-associated increase in sediment contaminants beyond the designated mixing zones (NIWA 2008).

23. Two legacy contaminated sites are present in Otago Harbour[1]. The sediments adjacent to the disused gas works site, located in Andersons Bay in the Upper Harbour, have very high PAH concentrations. However, this site is located about 11 km away from the area to be dredged and the contaminated material is in an area unlikely to be affected by significant wave and tidal disturbance. A now disused tannery operated for over a century in Sawyers Bay, just south of Port Chalmers, and is a potential local Cr source. A 1984 study identified significant chromium concentrations in Sawyers Bay (Aislabie & Loutit 1984).

24. There are also septic tank soakage, the wastewater treatment plant at Portobello, the Otago salmon hatchery and waste from the Otago Peninsula visitors centre which may contribute a range of chemical contaminants. These sources would largely contribute nutrients

[1] http://www.odt.co.nz/news/dunedin/77996/dcc-reveals-contaminated-hotspots

(nitrogen + phosphorus) to the Harbour but may also add to the background metals which accumulate in the sediments.

25. Integrated contaminant assessment. The range of contaminants identified in relation to both local and upper harbour sources are consistent with the suite of contaminants recommended for analysis in the marine dredge disposal guidelines (NZGSDW 1999). The presence of ammonia and sulphides may also be present in the harbour sediments associated with decaying organic matter. While these are not persistent contaminants in the aquatic environment, with both rapidly decaying by oxidising to non-toxic breakdown products, they each have the potential for localised toxic effects during dredging and disposal operations. Thus a comprehensive analytical suite was used to characterise the material from the area to be dredged.

EVIDENCE

Design of the assessment programme

26. The contaminant assessment programme was designed to provide a comprehensive suite of chemical data for the potentially most contaminated sites. The effects assessment considered three major components:

    a. ecological effects of chemical contaminant associated deposited dredge material (i.e. whole sediments); and

    b. ecological effects on water column species of disturbed dredge material (measured on sediment elutriates with chemical and toxicity testing bioassays); and

    c. potential human health effects of contaminant-affected food chains.

27. The design of this assessment programme is consistent with the tiered approach recommended for the dredging material "waste characterisation process" (NZGSDW 1999). The New Zealand assessment approach largely follows Australian guidance published in 2002 (Environment Australia 2002), which was recently revised (NAGD 2009). The toxicity decision-making component for all of these guidance documents is based on the ANZECC (2000) water quality guidelines. The ANZECC guidelines are currently in review, however,

no documents have been finalised which are relevant to this assessment.

28. This assessment includes several tiers of the New Zealand marine disposal guidelines. This includes reviewing existing information (Level 1), sampling and analysis of waste materials (Level 2) and undertaking elutriate testing with chemical and toxicity testing (Levels 3 & 4 components). The flow chart from the New Zealand marine disposal guidelines is shown in Attachment 3.

Site selection

29. Only limited background contaminant information was available for the Lower Harbour area proposed for dredging. Analysis of five composited samples from this area was undertaken by Opus in 2008 for a limited range of chemical contaminants. This showed no exceedance of the NZGSDW (1999) assessment guidelines for those contaminants. This material and other previous studies for other Otago Harbour areas has been reviewed by GHD Ltd (draft report, 2011). The 2010 sediment sampling was designed to give a comprehensive spatial assessment of the proposed dredging area.

30. The contaminant assessment monitoring was focussed on characterising the surficial sediments in the depositional areas (i.e., low velocity areas where fine suspended solids will settle), predominantly in the swinging basin adjacent to the Port Chalmers wharves. This area consists of predominantly silt particle size, compared with the sand classification for the majority of the area to be dredged. Only surficial (0-5 cm) sediments were analysed, since there was no information to suggest that deeper buried sediments would have higher concentrations of contaminants. A stratified sampling programme was undertaken with fewer samples in the predominantly sandy areas (Attachment 4). The location of the 18 sediment sampling sites for contaminant analysis are shown in Attachment 5.

31. I am confident that these sediment sampling sites provide a representative basis for determining sediment contaminant concentrations in the area to be dredged. One additional local reference site was selected for the sediment elutriate testing. The potential sites were selected on the basis of being within Otago Harbour and depositional environments, but distant from the Port

Chalmers wharves. A site with similar particle size composition was the primary selector for the reference site (site R2; Attachment 6).

Chemical and toxicological analyses

32. Chemical characterisation included:

    a. basic characteristics (moisture content, total organic carbon (TOC), total nitrogen (TN), total recoverable phosphorus, and particle size distribution);

    b. heavy metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn);

    c. organochlorine pesticides (aldrin, total chlordane, dieldrin, heptachlor, heptachlor epoxide, methoxychlor, endrin, DDD, DDE, DDT, alpha and beta BHC, lindane, endosulfan (total alpha, beta and sulphate), hexachlorobenzene);

    d. polycyclic aromatic hydrocarbons (PAHs) (napthalene, acenapthalene, acenapthene, fluorene, phenanthene, anthracene, fluoranthene total, benz[b]fluoranthene, benzo[k]fluoranthene, indeno[1,2,3-cd]pyrene, dibenz[ah]anthracene, chrysene, pyrene, benzo[a]pyrene);

    e. polychlorinated biphenyls (PCBs);

    f. tributyl tins (TBT); and

    g. total petroleum hydrocarbons (TPH).

    This is the recommended analytical list from NZGSDW (1999) and was undertaken on the 18 sediment samples (with the exception of TPH which was just analysed on the three elutriate sediments), with methods and results detailed in GHD Ltd (draft report, 2011).

33. Elutriate testing included chemical and toxicity testing bioassays. The chemical tests included the suite of heavy metals listed above, together with total ammoniacal-nitrogen (termed “ammonia” for this evidence) and total sulphide.

34. Human health assessment. The potential for human health and seafood predator (e.g., birds, seal) effects from chemical contaminants is largely restricted to two contaminant classes: (i) carcinogenic chemicals (e.g., certain PAHs); and (ii) biomagnifying chemicals (e.g., mercury, DDT, PCBs). The nature of the food-chain contamination is

that the base of the food-chain (e.g., sediment-dwelling organisms) must take up the chemical contaminant from the sediment (i.e., it is bioavailable) and that it is then transferred up the food-chain by predators consuming food species from the contaminated area of the Harbour. Thus key components of this analysis are: (i) the presence of sediment contaminants; (ii) that contaminants are bioavailable to aquatic organisms; and (iii) that a food-chain exists to top level ecosystem predators, including humans.

Criteria for effects assessment

35. The criteria for whole sediment effects was based on the New Zealand guidelines for sea disposal of waste (NZGSDW 1999), the ANZECC (2000) guidelines and updated Australian dredging and disposal guidance (Environment Australia 2002 & NAGD 2009).

36. The elutriate toxicity and chemical assessments were based on quantitative effect measurements on multispecies chronic toxicity tests (blue mussel larvae and algae) and ANZECC (2000) chronic marine water quality guidelines. The toxicity testing measured chronic effects using the two test species (blue mussel embryo/larvae, *Mytilus galloprovincialis*, 48 h larval development, Williams & Hall 1999; marine alga, *Minutocellus polymorphus*, 48 h cell growth, US EPA (1987)). Sediments were elutriated with addition of clean oceanic water and tumbling in glass jars for 24 h at room temperature (500 g wet sediment added to 1L of seawater; equivalent to approximately 5x dilution of pore water). This elutriate was used as the basis for a dilution series (mussels 5 concentrations; algae 8 concentrations) to provide quantitative toxicity measurements.

37. Human health assessments were based on biomagnifying and carcinogenic contaminants. Assessments of potential levels of bioaccumulation are made after consideration of source material contamination and dilution/dispersal after dredging and disposal. For this assessment, the concentrations of these contaminants of concern were so low as to preclude the necessity for this level of analysis.

Chemical contaminant monitoring results

38. The sediment chemical characterisation results are given in Attachment 7 for Port Chalmers to Pulling Point and Attachment 8 for Pulling Point to Taiaroa Head. The chemical characterisation showed

the silty sands of the swinging basin area were uniformly low in total organic carbon (TOC, <1.0%) and total nitrogen (TN, <0.15%), indicating low organic matter enrichment and a low potential for contaminant accumulation. Generally very low contaminant accumulations were supported by the chemical analyses, with the majority of heavy metal contaminants being below the guideline low effect “trigger level”, and all organic contaminants being below guideline low effect and most below the analytical detection limit. Trace concentrations of a DDT breakdown product (DDD) and various PAHs were detected at the swinging basin site closest to the wharves (Site A01) (Attachment 7 & Attachment 8).

39. The New Zealand guidelines for sea disposal of waste (NZGSDW 1999) contaminant effect threshold for sediment arsenic was exceeded at two sites (ER-L guideline (Effects Range-Low) As = 8.2 mg/kg). However, the NZGSDW (1999) value for the As ER-L was derived from an early draft of the ANZECC guidelines (ANZECC 1998, referenced in Table 5). The final version of the ANZECC (2000) guidelines has a sediment As threshold effect value of 20 mg/kg. This slightly increased guideline value reflects the high natural background mineralogy of West Australian and New Zealand sediments. Subsequent revision of the Australian dredge disposal guidelines use the revised As value (Environment Australia 2002 & NAGD 2009).

40. I consider that the ANZECC (2000) low effect threshold for As of 20 mg/kg is the most appropriate screening guideline for assessing potential chemical-associated effects on subtidal communities.

41. Detail of the distribution of the sediment As, TOC and TN in the swinging basin area is shown in Attachment 9. This shows a similar sediment composition throughout the area, with no potential “hot-spots” for contaminant accumulation.

42. Using the ANZECC (2000) guideline value for As, and the suite of other NZGSDW (1999) guideline values, there are no exceedances of chemical thresholds relating to the suitability of the dredging material at the proposed offshore disposal site and Lower Harbour subtidal sites. This does not consider the potential for physical and physiological effects associated with deposition of fine sediment, which have been covered in the evidence of Dr Mark James.

Elutriate toxicity and chemical assessment

43. The elutriate testing was designed to assess the potential for toxicity effects on the water column associated with the localised disturbance and dumping of the dredged material. The three sites selected for testing were in the swinging basin (A01 & A05, Attachment 5) and near Pulling Point in a nominal "silty" area. The reference site choseen for the elutriate testing was R2, based on similarity of silty-sand composition, with R3 being fine mud with hydrogen sulphide odour (Attachment 6). There was no hydrogen sulphide odour with any of the main-channel test sediments.

44. There were no significant adverse effects for either the blue mussel embryos, or the marine algae, when exposed to any of the three sediment elutriates (maximum concentration about 5-fold dilution of sediment). The mussels showed a significant effect (-23% c.f. Control) only for the local reference site (R2) – a response probably attributable to unmeasured natural organics. The algae showed growth stimulation for all test sediments relative to the test controls (which reflects the low nutrient conditions in the standard test media, rather than a site-specific effect), with a 2-fold growth stimulation occurring at Site 18 compared to the local reference site (R2) (Attachment 10).

45. Chemical analyses were also undertaken on the elutriate waters obtained from the sediments. Each of the test sediments showed slight exceedance of the chronic (i.e., long-term) ANZECC (2000) marine water quality guideline for only one contaminant, which differed between test sediments (Cu for Site 18; Ammonia for Site 5; and Sulphide for Site 1; Attachment 11). The maximum additional dilution required (Site 1 for sulphide) to meet the chronic guideline would be 5-fold, corresponding to a total dilution of 25-fold.

46. Together, these analyses indicate a negligible risk relating to chemical contaminants associated with the dredging and disposal operations. Firstly, no toxicity was measured for the locally-relevant blue mussel larval species; secondly any exceedance of chronic water quality guidelines requires less than 25-fold dilution – which will be accomplished after allowing for reasonable mixing within a short distance (several 10s of metres) of the dredging and disposal discharges.

47. Given the nature of the contaminants (i.e., two non-persistent contaminants, ammonia and sulphide) and the short-term nature of these contaminant exposures, I do not consider that there is a significant toxic contaminant risk to water column species associated with the proposed dredging or disposal operations.

Human health issues

48. As noted earlier, few chemical contaminants are of concern to humans or other seafood consumers through food-chain accumulation. The major organochlorine biomagnifying contaminants (i.e., DDTs, PCB) and mercury were less than the analytical detection limit at all sites. The only potential carcinogenic contaminants are some of the PAHs (e.g., benzo[a]pyrene, BAP), and PAHs were detected at only one site (Site 1). The BAP at Site 1 was at a trace concentration (37% of the trigger level, Attachment 7).

49. I do not consider that the trace levels of BAP detected at only one site would pose any significant risk to piscivorous species or human consumers.

Harbour biological monitoring for contaminants

50. The presence of chemical contaminants in aquatic systems is often most efficiently monitored by tissue analysis of biological tissue. Analysis of shellfish tissue (e.g., “Mussel-watch”) provides the additional advantage of measuring only bioavailable contaminants and in determining exposure to potentially highly time-variable contaminant concentrations.

51. Some baseline research has been done in Otago Harbour to measure metal bioaccumulation using cockle species (Peake et. al. 2006) and using both blue mussels and fish (spotties) for contaminant measurement associated with the Ravensdown discharges (NIWA 2008). The metal concentrations in cockles which was measured at multiple Harbour sites, showed elevated concentrations at some sites, but there was marked variability between both sites and seasons. This indicates that detection of changes associated with other Harbour activities, such as dredging, would be difficult.

52. Given that the channel area to be dredged is largely sandy, with the swinging basin and some other sections from Pulling Point to Taylor

Point containing sandy-silts, and contaminant concentrations are low and minimally elevated, I do not consider that a biomonitoring programme for contaminants would be warranted in this case.

RESPONSE TO SUBMISSIONS

A. Hall, Aramoana (Submission 185)

53. Concerns are raised regarding “toxins”, “lead usage, and DDT in farm-drainage, assorted anti-fouling compounds to mention a few”.

54. The additional, more comprehensive sediment sampling and chemical analyses provides high confidence in the low concentrations of contaminants in the area to be dredged. In addition, the toxicity testing with sensitive locally relevant species (such as the blue mussel larvae) will integrate the potential adverse effects of all of the contaminants present (i.e., not just those chemically measured). The toxicity results have indicated no measurable toxicity to either the blue mussel larvae or the algal test species.

Marine Sciences Society (Submission 141)

55. The Society raises concerns that “Insufficient information has been provided about the nature and levels of contaminants occurring in harbour sediments”. Additionally, they have referenced studies undertaken to assess the toxicity of Auckland Harbour sediments in 1991 for dredge disposal.

56. I consider that the more comprehensive sampling at 18 channel sites, together with the comprehensive chemical analysis and elutriate toxicity testing will address the concerns raised by the Society. As stated in my evidence, this chemical contaminant data indicates that the concentrations are low in the area to be dredged.

WWF-NZ Hector’s Dolphin Community Co-ordinator (Ms Gemma McGrath, Submission 193)

57. WWF raises concerns that the “Information provided and investigations on the nature of contaminants occurring in harbour sediments are highly inadequate”. Additional concerns are raised about potential long term effects from “bioaccumulation” of contaminants.

58. As noted above in my response to other submitters, the more comprehensive sediment contaminant assessment has shown sediment chemical concentrations to be low. Additionally, in my evidence I have specifically addressed chemicals which biomagnify in food-chains. These contaminants are also largely below detection and therefore I would conclude that no additional exposure would be experienced by marine mammals or humans consuming seafood as a result of the chemical contaminants associated with the dredging and disposal operations.

OFFICERS REPORT

Peter Christophers, Suzanne Watt (16 March 2011)

59. In relation to sediment-associated chemical contaminants the officers' conclude: "Because of the low levels of major contaminants at the dredging sites, the effect from release of contaminants is likely to be less than minor" (s. 7.2.9).

60. This supports my conclusion regarding the concentrations and potential effects of the sediment chemical contaminants.

CONCLUSIONS

61. The sediment sampling undertaken in 2010 for chemical contaminant assessment and sediment elutriate chemical and toxicity measurements provides a robust basis for assessing the potential for contaminant-related effects from the deposited dredge material and on the water column during dredging and disposal operations.

62. I conclude that there is a very low concern for chemical contaminant related adverse effects associated with the proposed dredging and disposal operations.

Dr Christopher Wayne Hickey

References

Aislabie, J.; Loutit, M.W. (1984). The effect of effluent high in chromium on marine sediment aerobic heterotrophic bacteria. Marine Environmental Research 13: 69-79.

ANZECC (2000). Australian and New Zealand guidelines for fresh and marine water quality. National Water Quality Management Strategy Paper No. 4, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, Australia.

Environment Australia (2002). National Ocean Disposal Guidelines for Dredged Material. Commonwealth of Australia, Canberra. pp. 182.

GHD Ltd (2011). Report for Project Next Generation: Desktop review and preliminary sediment quality assessment (Draft). Report by Wijnand Udema, GHD Ltd, Christchurch for Port Otago Ltd, Christchurch. pp. 90.

NAGD (2009). National Assessment Guidelines for Dredging. Commonwealth of Australia, Canberra, Australia. pp. 92.

NIWA (2008). Ravensdown Fertiliser Co-operative Ltd: Ravensbourne Works: Benthic monitoring report 2006. No. RDF06202; HAM2007-055. NIWA report for Ravensdown Fertiliser Co-operative Limited, Dunedin. pp. 75.

NZGSDW (1999). New Zealand Guidelines for Sea Disposal of Waste. No. 180-1. Maritime Safety Authority of New Zealand, Wellington. pp. 88.

NZWWMG, (2002). New Zealand Municipal Wastewater Monitoring Guidelines. Ray, D.E. (Ed.). New Zealand Water and Waste Association, Wellington. 272 p.

ORC (2008). Surface water quality: The Water of Leith and Lindsay's Creek Kaikorai Stream Waitati River and Carey's Creek. No. Otago Regional Council report, Dunedin. pp. 82.

Peake, B.M.; Marsden, I.D.; Bryan, A.M. (2006). Spatial and temporal variations in trace metal concentrations in the cockle, *Austrovenus stutchburyi* from Otago, New Zealand. Environmental Monitoring and Assessment 115: 119-144.

Reid, M. R.: (1990), 'The Marine Geochemistry of Lead in an Urban Catchment', PhD Thesis (unpublished). Dunedin, New Zealand: Chemistry Department, University of Otago.

USEPA (1987). Methods for toxicity tests of single substances and liquid complex wastes with marine unicellular algae. EPA-600-8/87/043. US Environmental Protection Agency Cincinnati, Ohio. 65p.

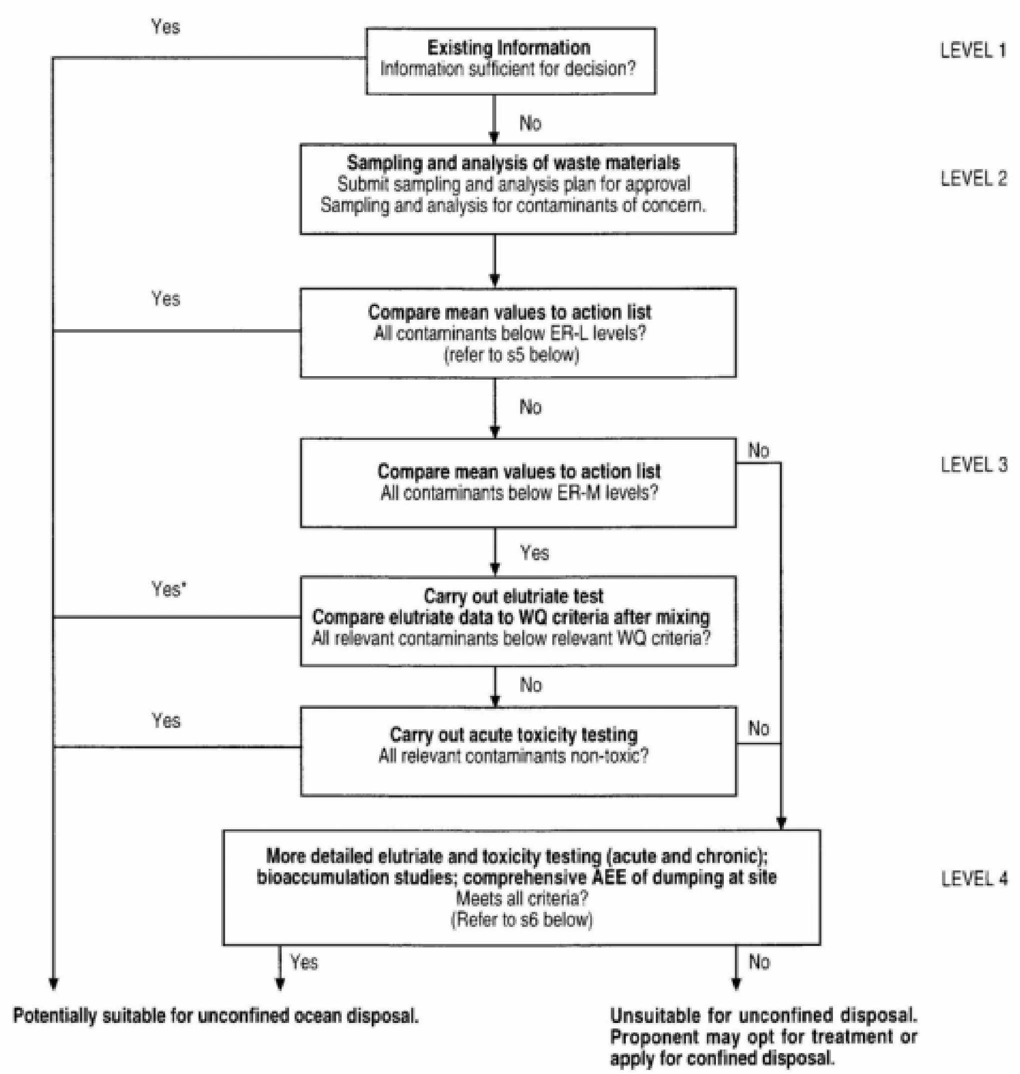
Williams, E.K.; Hall, J.A. (1999). Seasonal and geographic variability in toxicant sensitivity of *Mytilus galloprovincialis* larvae. Australasian Journal of Ecotoxicology 5: 1-10.

Attachment 1: Location of Port Chalmers dredging area and potential contaminant sources in Otago Harbour

Attachment 2: Sources of chemical contaminants of potential concern to Otago Harbour

Discharge	Contaminants / stressor of concern	Sources	Potential effects
City of Dunedin	“heavy” metals (copper (Cu), lead (Pb) and zinc (Zn)) petroleum hydrocarbons polychlorinated biphenyls (PCBs) suspended sediments	stormwater inputs contaminated sites industrial run off	toxicity from contaminants sediment smothering
Water of Leith	nutrients (nitrogen + phosphorus) stormwater contaminants (see above) pesticides (including dieldrin, DDT) suspended sediments	as above agricultural chemicals forestry chemicals	toxicity from contaminants nutrient enhancement of algal growths reduced clarity
Port Operations (to upper and lower harbour area)	stormwater contaminants petroleum hydrocarbons spillage of cargo materials antifoulants (e.g., TBT, copper, diuron) suspended sediments	wharves and operations areas bilge discharges propeller and wave wash from shipping operations	toxicity from contaminants reduced clarity
Ravensdown Fertilizer Co-operative, Ravensbourne	Cd, fluoride, rock phosphate suspended sediments	consented discharges site stormwater wharf operations	toxicity from contaminants reduced clarity
Contaminated sites in Otago Harbour	PAHs cadmium	harbour material from old gas-works tannery inputs to Sawyers Bay	toxicity from contaminants
Sewage discharges	heavy metals ammonia nutrients	various	nutrient enhancement of algal growths
Harbour macroalgae	decaying organic matter produces ammonia, sulphides, nutrients	subtidal sand flats	algal blooms (sea lettuce) settling and decay

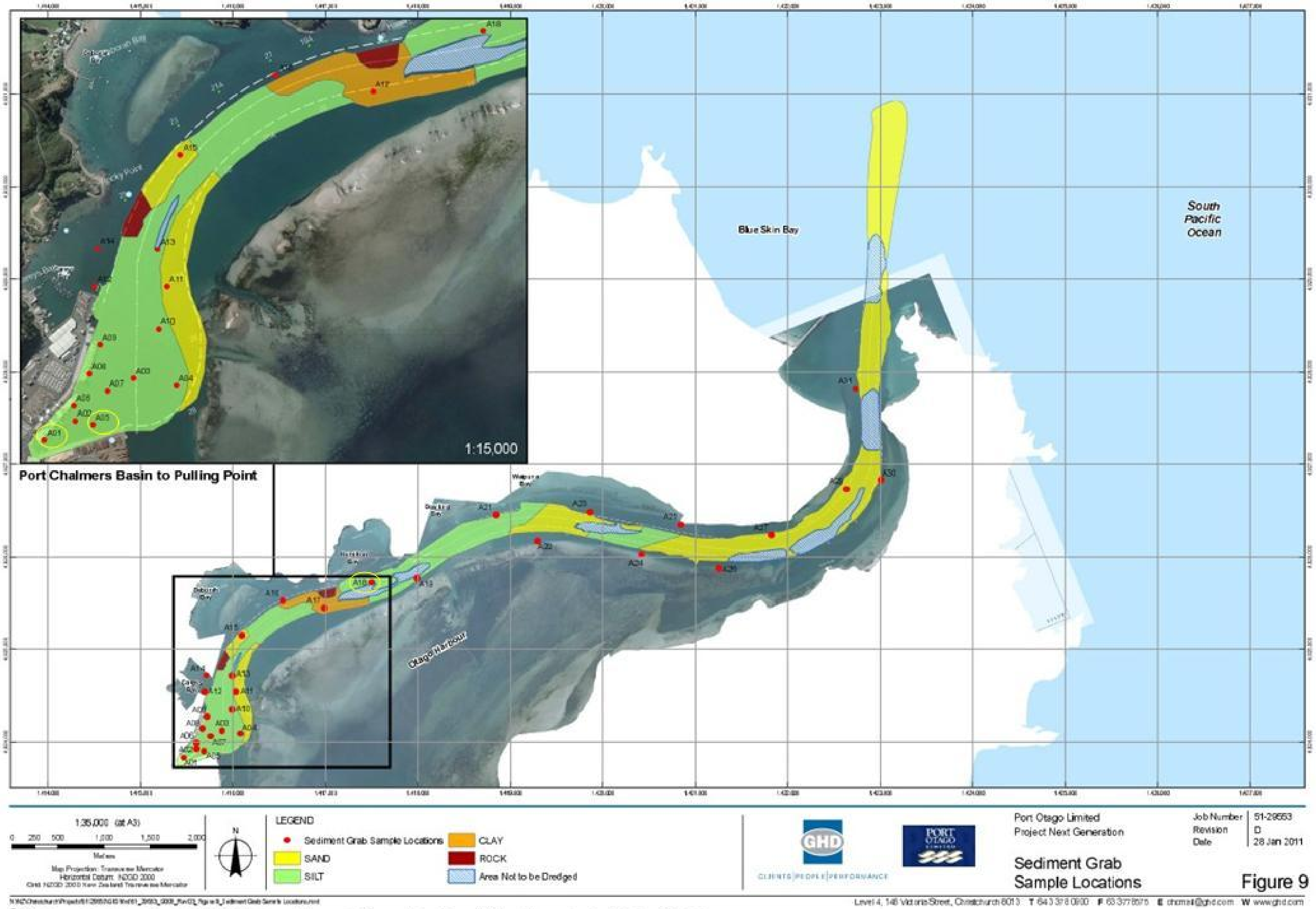
Attachment 3: Dredging material "waste characterisation process" (NZGSDW 1999, Fig. 4). Note section references refer to the original document.



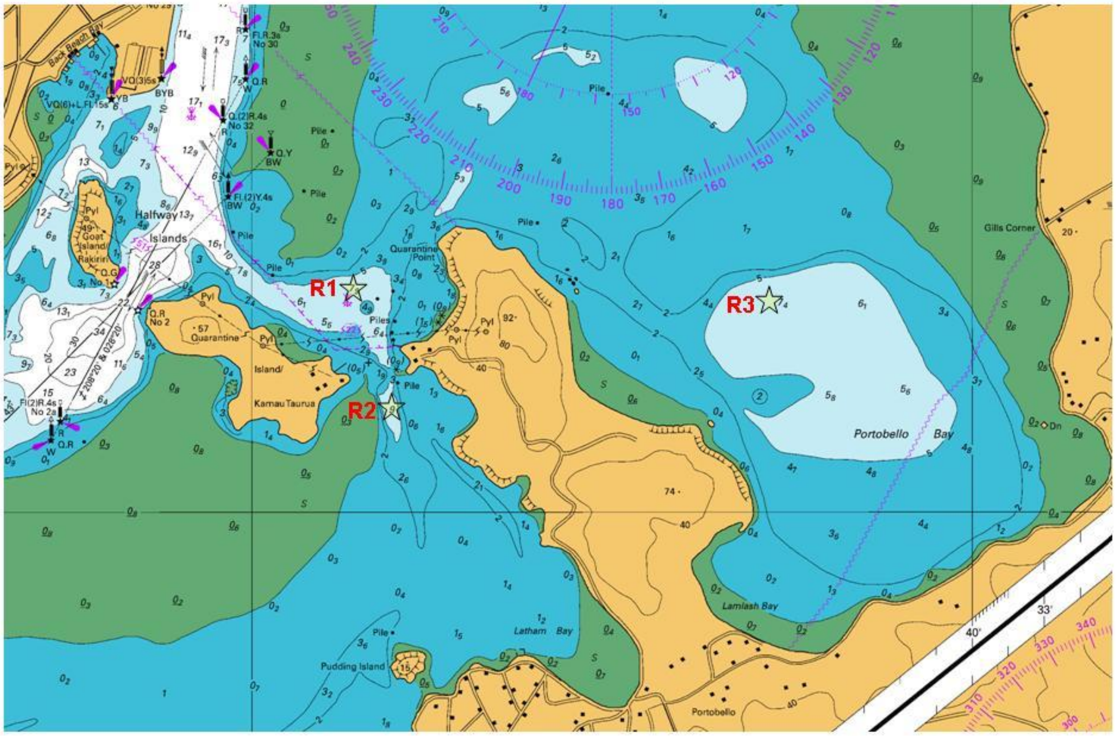
Attachment 4: Sampling zones and numbers of samples (Table 3 from GHD Ltd (draft report) 2011)

Location Description	Chainage Descriptor	Rationale for Sampling Locations	Approximate Number of Samples	Approximate Dredge Volume (m^3)
Port Chalmers Basin and lower harbour	Swinging Basin through to Pulling Point	Likely to have highest contaminant concentrations due to intensive use on shore and with ship movements	18	2,539,728
Pulling Point to Taiaroa Head	Pulling Point through to Harrington Bend / Kaik Rock	Large proportion of area dominated clay and silt sediments, with the balance comprising sand. Contaminants likely to preferentially sorb to finer grained sediments.	4	2,604,608
	Kaik Rock through to Landfall Tower	Likely to have lower concentrations of contaminants as sediments appear to be coarser grained (sand). Required to assess contaminant concentrations in coarser grained sediments.	4	1,992,540
QA/QC Samples			3	
Total			26 + 3 QA/QC	7,136,876

Attachment 5: Sediment sampling sites for chemical contaminant characterisation. Elutriate chemistry and toxicity sites circled.



Attachment 6: Sites sampled for use as elutriate testing reference sediment



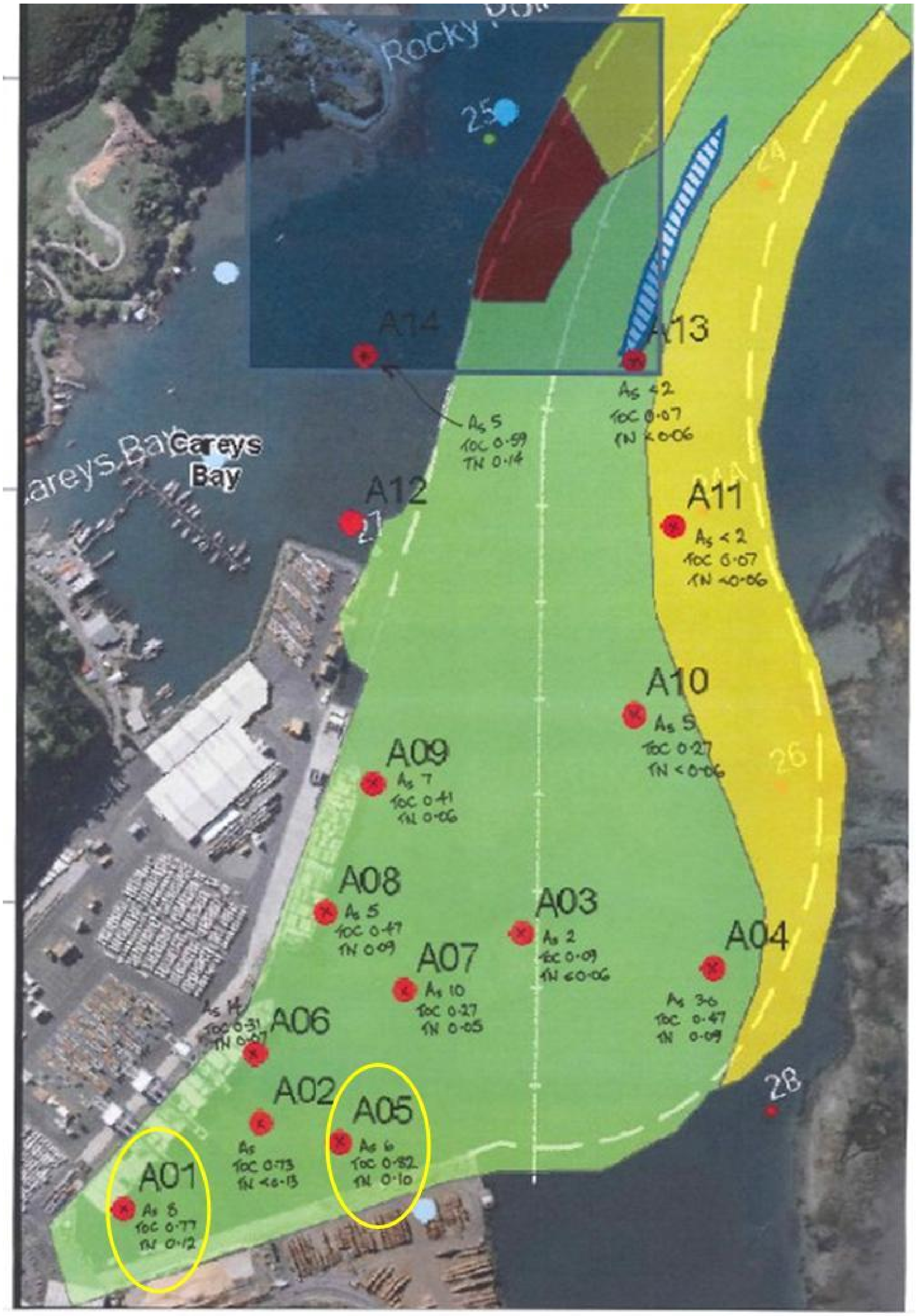
Attachment 7: Chemical contaminant monitoring results – sediments Port Chalmers to Pulling Point (Table 6 from GHD (draft report) 2011)

		Port Chalmers Basin to Pulling Point																		Acceptance Criteria	
GHD Sample Location ID		29553 1	29553 2	29553 3	29553 4	29553 5	29553 QA3	29553 6	29553 7	29553 8	29553 9	29553 10	29553 11	29553 13	29553 14	29553 QA2	29553 15	29553 16	29553 18	NZGSDW (1999)	
Lab Sample ID		854115.1	854115.2	854115.3	854115.4	854115.5	854115.14	854115.6	854115.7	854115.8	854115.9	854115.1	854115.11	854115.13	854127.1	854127.19	854127.2	854127.3	854127.5		
Sample Depth (m)																					
Sample Date		13/12/2010	13/12/2010	13/12/2010	13/12/2010	13/12/2010	13/12/2010	13/12/2010	13/12/2010	13/12/2010	13/12/2010	13/12/2010	13/12/2010	13/12/2010	12/12/2010	12/12/2010	12/12/2010	12/12/2010	12/12/2010		
Sample Type		Sediment	Sediment	Sediment	Sediment	Sediment	Blind Duplicate of 29553 5	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Blind Duplicate of 29553 14	Sediment	Sediment	Sediment		
Sample Description		Silty SAND	Silty SAND	SAND	SAND with trace silt	Silty SAND	Silty SAND	Silty SAND some fine gravels	Silty SAND	Sandy SILT	Sandy SILT	Silty SAND	SAND	SAND	Silty SAND	Silty SAND	SAND with trace silt	SAND with trace silt	SAND		
Analytes	**Units**																			ER-L	ER-M
Dry Matter	g/100g as rcvd	65	62	79	67	70	67	68	69	70	65	69	79	79	66	67	70	75	82		
Total Recoverable Phosphorus	mg/kg dry wt	480	500	250	300	460	440	420	390	600	530	310	152	179	570	540	220	310	450		
Nitrite-N	mg/kg dry wt	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
Nitrate-N	mg/kg dry wt	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5		
Nitrate-N + Nitrite-N	mg/kg dry wt	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.1		
Total Organic Carbon	g/100g dry wt	0.77	0.73	0.09	0.47	0.82	0.66	0.31	0.27	0.47	0.41	0.27	0.07	0.07	0.59	0.56	0.18	0.12	< 0.13		
Total Nitrogen	g/100g dry wt	0.12	< 0.13	< 0.06	0.09	0.1	0.11	0.07	0.05	0.09	0.06	< 0.06	< 0.06	< 0.06	0.14	0.13	< 0.06	< 0.06	< 0.13		
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg																					
Total Recoverable Arsenic	mg/kg dry wt	8	7	2	3	6	6	**14**	**10**	5	7	5	< 2	< 2	5	5	2	< 2	3	8.2	70
Total Recoverable Cadmium	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1.5	10
Total Recoverable Chromium	mg/kg dry wt	16	16	4	8	13	13	31	10	18	14	11	< 2	3	15	15	5	4	10	80	370
Total Recoverable Copper	mg/kg dry wt	12	8	< 2	3	7	7	12	4	7	6	4	< 2	< 2	7	7	2	< 2	3	65	270
Total Recoverable Lead	mg/kg dry wt	18.4	10.3	1.7	3.3	9.3	9.3	22	4.9	8.7	6.8	4.9	0.6	0.9	7.4	7.2	2.1	1.7	2.4	50	220
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.15	1
Total Recoverable Nickel	mg/kg dry wt	11	13	3	6	9	8	11	7	9	10	8	< 2	2	9	9	4	3	6	21	52
Total Recoverable Zinc	mg/kg dry wt	52	46	14	24	41	42	41	26	44	38	28	5	8	42	43	14	12	18	200	410
Organochlorine Pesticides Trace in Soil																					
Aldrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	0.026	0.26
alpha-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
beta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
delta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
gamma-BHC (Lindane)	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
cis-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
trans-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
2,4'-DDD	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
4,4'-DDD	mg/kg dry wt	0.0012	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0013	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
2,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
4,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
2,4'-DDT	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
4,4'-DDT	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
Dieldrin	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010	0.00002	0.008
Endosulfan I	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
Endosulfan II	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
Endosulfan sulphate	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
Endrin	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010	0.00002	0.008
Endrin Aldehyde	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
Endrin ketone	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
Heptachlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	0.0032	0.032
Heptachlor epoxide	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
Hexachlorobenzene	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0011	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	2	2.3
Methoxychlor	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
Total Chlordane [(cis+trans)*100/42]	mg/kg dry wt	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002		
Polycyclic Aromatic Hydrocarbons Screening in Soil																					
Acenaphthene	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03	0.016	0.5
Acenaphthylene	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03	0.044	0.64
Anthracene	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03	0.085	1.1
Benzo[a]anthracene	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03	0.261	1.6
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.16	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03	0.43	1.6
Benzo[b]fluoranthene + Benzo[j]fluoranthene	mg/kg dry wt	0.18	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03		
Benzo[g,h,i]perylene	mg/kg dry wt	0.17	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03		
Benzo[k]fluoranthene	mg/kg dry wt	0.07	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03		
Chrysene	mg/kg dry wt	0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03	0.384	2.8
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03	0.063	0.26
Fluoranthene	mg/kg dry wt	0.08	0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03	0.6	5.1
Fluorene	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03	0.019	0.54
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.11	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03		
Naphthalene	mg/kg dry wt	< 0.19	< 0.2	< 0.16	< 0.18	< 0.18	< 0.19	< 0.18	< 0.18	< 0.17	< 0.19	< 0.18	< 0.16	< 0.16	< 0.18	< 0.17	< 0.17	< 0.15	< 0.14		
Phenanthrene	mg/kg dry wt	< 0.04	0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03		
Pyrene	mg/kg dry wt	0.15	0.05	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.03	< 0.03	0.665	2.6
Polychlorinated Biphenyls Screening in Soil																					
Total PCB (Sum of 35 congeners)	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	23	180
Tributyl Tin Trace in Soil samples by GCMS																					
Dibutyltin (as Sn)	mg/kg dry wt	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		
Monobutyltin (as Sn)	mg/kg dry wt	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007		
Tributyltin (as Sn)	mg/kg dry wt	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	0.005	< 0.004	< 0.004	< 0.004	0.005	0.072
Triphenyltin (as Sn)	mg/kg dry wt	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003		

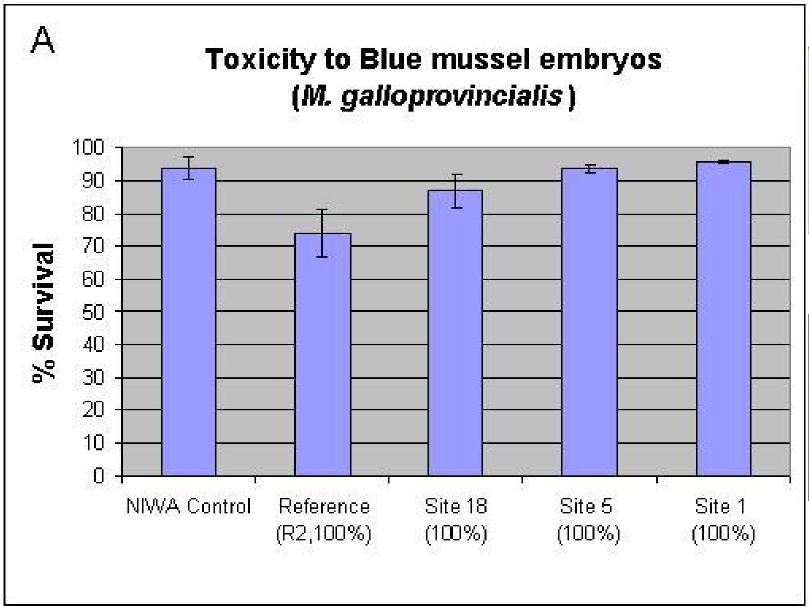
Attachment 8: Chemical contaminant monitoring results – sediments Pulling Point to Taiaroa Head (Table 7 from GHD (draft report) 2011)

		Pulling Point to Taiaroa Head									Acceptance Criteria	
GHD Sample Location ID		29553 22	29553 QA1	29553 23	29553 24	29553 26	29553 27	29553 29	29553 30	29553 31	**NZGSDW (1999)**	
Lab Sample ID		854127.8	854127.18	854127.9	854127.10	854127.12	854127.13	854127.15	854127.16	854127.17		
Sample Depth (m)												
Sample Date		12/12/2010	12/12/2010	12/12/2010	12/12/2010	12/12/2010	12/12/2010	12/12/2010	12/12/2010	12/12/2010		
Sample Type		Sediment	Blind Duplicate of 29553 22	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment		
Sample Description		SAND with trace silt	SAND with trace silt	SAND	SAND with trace silt	SAND	SAND	SAND	SAND	SAND		
Analytes	**Units**										ER-L	ER-M
Dry Matter	g/100g as rcvd	76	67	77	71	76	74	76	74	76		
Total Recoverable Phosphorus	mg/kg dry wt	163	290	370	260	161	167	114	158	182		
Nitrite-N	mg/kg dry wt	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
Nitrate-N	mg/kg dry wt	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5		
Nitrate-N + Nitrite-N	mg/kg dry wt	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
Total Organic Carbon	g/100g dry wt	0.14	0.42	< 0.13	0.21	0.05	< 0.06	< 0.06	0.07	< 0.13		
Total Nitrogen	g/100g dry wt	< 0.06	0.09	< 0.13	0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.13		
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg												
Total Recoverable Arsenic	mg/kg dry wt	< 2	< 2	2	< 2	< 2	< 2	< 2	< 2	< 2	8.2	70
Total Recoverable Cadmium	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1.5	10
Total Recoverable Chromium	mg/kg dry wt	3	7	4	4	2	2	< 2	2	3	80	370
Total Recoverable Copper	mg/kg dry wt	< 2	3	< 2	< 2	< 2	< 2	< 2	< 2	< 2	65	270
Total Recoverable Lead	mg/kg dry wt	1.1	2.9	1	1.6	0.6	0.8	0.6	0.7	0.8	50	220
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.15	1
Total Recoverable Nickel	mg/kg dry wt	2	5	4	3	< 2	< 2	< 2	< 2	3	21	52
Total Recoverable Zinc	mg/kg dry wt	8	18	12	12	7	7	5	6	6	200	410
Organochlorine Pesticides Trace in Soil												
Aldrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	0.026	0.26
alpha-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
beta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
delta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
gamma-BHC (Lindane)	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
cis-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
trans-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
2,4'-DDD	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
4,4'-DDD	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
2,4'-DDE	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
4,4'-DDE	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
2,4'-DDT	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
4,4'-DDT	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
Dieldrin	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	0.00002	0.008
Endosulfan I	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
Endosulfan II	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
Endosulfan sulphate	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
Endrin	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	0.00002	0.008
Endrin Aldehyde	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
Endrin ketone	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
Heptachlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	0.0032	0.032
Heptachlor epoxide	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010		
Hexachlorobenzene	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	2	2.3
Methoxychlor	mg/kg dry wt	< 0.0011	< 0.0010	< 0.0011	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010		
Total Chlordane [(cis+trans)*100/42]	mg/kg dry wt	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002		
Polycyclic Aromatic Hydrocarbons Screening in Soil												
Acenaphthene	mg/kg dry wt	-	-	-	-	-	-	-	-	-	0.016	0.5
Acenaphthylene	mg/kg dry wt	-	-	-	-	-	-	-	-	-	0.044	0.64
Anthracene	mg/kg dry wt	-	-	-	-	-	-	-	-	-	0.085	1.1
Benzo[a]anthracene	mg/kg dry wt	-	-	-	-	-	-	-	-	-	0.261	1.6
Benzo[a]pyrene (BAP)	mg/kg dry wt	-	-	-	-	-	-	-	-	-	0.43	1.6
Benzo[b]fluoranthene + Benzo[j]fluoranthene	mg/kg dry wt	-	-	-	-	-	-	-	-	-		
Benzo[g,h,i]perylene	mg/kg dry wt	-	-	-	-	-	-	-	-	-		
Benzo[k]fluoranthene	mg/kg dry wt	-	-	-	-	-	-	-	-	-		
Chrysene	mg/kg dry wt	-	-	-	-	-	-	-	-	-	0.384	2.8
Dibenzo[a,h]anthracene	mg/kg dry wt	-	-	-	-	-	-	-	-	-	0.063	0.26
Fluoranthene	mg/kg dry wt	-	-	-	-	-	-	-	-	-	0.6	5.1
Fluorene	mg/kg dry wt	-	-	-	-	-	-	-	-	-	0.019	0.54
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	-	-	-	-	-	-	-	-	-		
Naphthalene	mg/kg dry wt	-	-	-	-	-	-	-	-	-		
Phenanthrene	mg/kg dry wt	-	-	-	-	-	-	-	-	-		
Pyrene	mg/kg dry wt	-	-	-	-	-	-	-	-	-	0.665	2.6
Polychlorinated Biphenyls Screening in Soil												
Total PCB (Sum of 35 congeners)	mg/kg dry wt	-	-	-	-	-	-	-	-	-	23	180
Tributyl Tin Trace in Soil samples by GCMS												
Dibutyltin (as Sn)	mg/kg dry wt	-	-	-	-	-	-	-	-	-		
Monobutyltin (as Sn)	mg/kg dry wt	-	-	-	-	-	-	-	-	-		
Tributyltin (as Sn)	mg/kg dry wt	-	-	-	-	-	-	-	-	-	0.005	0.072
Triphenyltin (as Sn)	mg/kg dry wt	-	-	-	-	-	-	-	-	-		

Attachment 9: Distribution of sediment carbon (TOC), nitrogen (TN) and arsenic (As) in the swinging basin. Elutriate chemistry and toxicity sites circled.

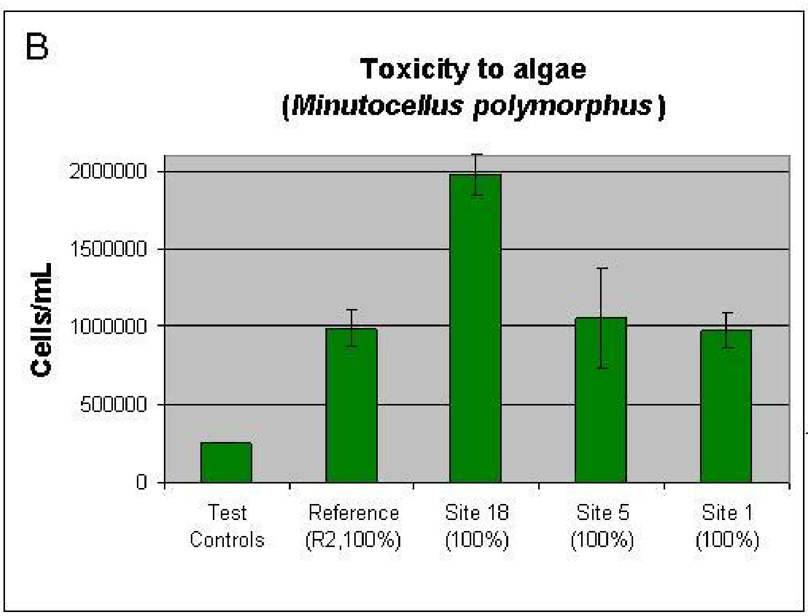


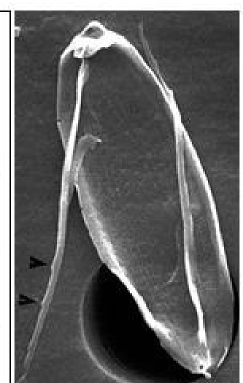
Attachment 10: Elutriate toxicity results for blue mussel larvae (A) and algae (B). Mean ± SD.



Normal

Abnormal





http://www.smhi.se/oceanografi/oce_info_data/plankton_checklist/diatoms/xminutocellus_polymorphus.htm

Attachment 11: Elutriate water quality analyses with ANZECC (2000) guidelines comparison

Elutriate tests	Site				ANZECC (2000) Guideline	Dilution required [c]
Chemical (mg/L)	Ref 2	Site 18	Site 5	Site 1		
Dissolved Arsenic	0.005	0.009	0.006	0.006	NG	
Dissolved Cadmium	0.0003	< 0.0002	< 0.0002	< 0.0002	0.0007	
Dissolved Chromium	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0077 [a]	
Dissolved Copper	< 0.0010	**0.0063**	< 0.0010	< 0.0010	0.0013	5x
Dissolved Lead	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0044	
Dissolved Mercury	< 0.00008	< 0.00008	< 0.00008	< 0.00008	0.0004	
Dissolved Nickel	0.01	0.009	0.008	0.008	0.07	
Dissolved Zinc	0.014	0.009	0.005	0.005	0.015	
Total Ammoniacal-N	0.06	0.3	**1.8**	0.032	0.91	2x
Total Sulphide	0.02	0.006	0.009	**0.117 (0.005)**	0.001 [b]	5x

[a] Chromium III; [b] Assumes freshwater guideline. Unionised H_2S at 20C, 32.5‰, pH 8 = 4.06% (bracketed in site concentration);
[c] Dilution required = Highest site concentration/Guideline concentration