CLIVE RIVER DREDGING

RESOURCE CONSENT APPLICATION

AN APPLICATION TO THE HAWKE'S BAY REGIONAL COUNCIL

FROM

REGIONAL ASSET MANAGER
(HAWKE'S BAY REGIONAL COUNCIL)

December 2020

Prepared by
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P.O. Box 554, Napier

APPLICATION FOR RESOURCE CONSENT UNDER SECTION 88 OF THE RESOURCE MANAGEMENT ACT 1991

To the Hawke's Bay Regional Council.

1. **The Regional Asset Manager (Hawke's Bay Regional Council)** applies for the following types of resource consent:

(A) In the Clive River (upstream of the Clive Bridge)

- A Land Use consent to ***disturb the bed of the Clive River by dredging***. This is a Discretionary Activity under **Rule 69** (via Rule 75) of the Hawke's Bay Regional Resource Management Plan. The activity defaults to Rule 69 by exceeding the 5m2 maximum area for a Permitted activity under Rule 75.

(B) In the 'Coastal Margin' (between Clive Bridge & CMA Boundary, also on the Clive Beach)

- A Land Use consent to ***disturb the foreshore and seabed by dredging* in the Coastal *Margin***. This is a Discretionary Activity under **Rule 46** (via Rule 47) of the Coastal Environment Plan. The activity defaults to Rule 46 by exceeding the 5m2 maximum area for a Permitted activity under Rule 47.

- A Discharge Permit for the ***discharge of dredged material onto the shore*** above mean high water springs, on or near the river mouth groyne, whereby the dredge sediments, in slurry form, will flow down the beach and into the sea. This activity will occur in the 'Coastal Margin' and will be a Discretionary Activity under **Rule 9**, via Rule 19 of the Coastal Environment Plan as a '*Discharge of contaminants to land that may enter water*'. The activity defaults to Rule 9 by exceeding the 50m3/day maximum volume for a Permitted activity under Rule 19.

- A Water Permit to ***take surface water*** from within the 'Coastal Margin'. This is a Discretionary Activity under **Rule 35** (via Rule 38) of the Coastal Environment Plan. The water will be 'taken' to the extent that a cutter-suction dredge will be used for the dredging operation and the uptake of water along with sediment is incidental to that operation. The activity defaults to Rule 35 by exceeding the 20m3/day maximum volume for a Permitted activity under Rule 38.

(C) In the Coastal Marine Area

- A Coastal Permit to ***disturb the foreshore and seabed by dredging***. This is a Discretionary Activity under **Rule 130** of the Hawke's Bay Coastal Environment Plan. The dredged material will be predominantly silt that has deposited in the channel since the previous dredging in 2009, combined with water.

- A Coastal Permit to ***deposit more than 50,000m3 of dredged material on the foreshore and seabed***. This is a Discretionary Activity under **Rule 151** of the Coastal Environment Plan. The total estimated volume for the dredging operation will be 55,000m3.

- A Coastal Permit to ***deposit dredged sediment in the Coastal Hazard 1 (CHZ1) Zone.*** The CHZ1 extends over the area between the shoreline and a line 200m off-shore at Clive. This is a Discretionary Activity under **Rule 160** (via Rule 104) of the Coastal Environment Plan. The activity defaults to Rule 160 by exceeding the 5m3 maximum volume for a Restricted Discretionary activity under Rule 104.

- A Coastal Permit to ***take surface water*** within SCA11 (*Significant Conservation Area 11 – 'Waitangi Estuary'*). The water will be 'taken' to the extent that a cutter-suction dredge will be used for the dredging operation and the uptake of water along with sediment is incidental to that operation. This is a Discretionary Activity under **Rule 154** (via Rule 156). The activity defaults to Rule 154 because the activity of taking water from within SCA11 means that it cannot qualify as a Permitted activity under Rule 156.

- A Coastal Permit for ***placement of a structure (the cutter-suction dredge discharge pipeline)*** in the coastal marine area. This is a Discretionary Activity under **Rule 117** of the Coastal Environment Plan. The pipeline floats, and will run from the dredge to a discharge point on or beside the river mouth groyne. The activity defaults to Rule 117 by potentially occupying more than 5m2 in the CMA and/or remaining for longer than 28 days, which are Permitted activity requirements under Rule 122.

2. The activity to which the application relates (the proposed activity) is as follows:

   "Dredging of the bed of the lower Clive River (including that part of the river defined as coastal marine area). The dredged area will be approximately 1,500m long by 60m wide, starting from a point approximately 300m upstream of the Clive Bridge and extending to approximately 1,200m downstream of the bridge.

   The depth, extent and method of dredging will be similar to that in the previous dredging of the river in 2009. The dredgings will be predominantly silt and will be pumped from the cutter-suction dredge to a discharge point on or near the sea groyne on the southern side of the river mouth. The dredgings will be discharged on the beach at this point, above high tide level, and will flow from there into the sea".

3. The site of the proposed activity is the Clive River upstream and downstream of the state highway bridge, as shown in Figure 1, below. The area to be dredged extends over approximately 1,500 metres length by 60m width of river and coastal marine area. Of the 1,500 metres, approximately 200m is "river" (upstream of the bridge); 740m is "coastal margin" (between the bridge and the CMA boundary); and the remaining 560m is "coastal marine area".

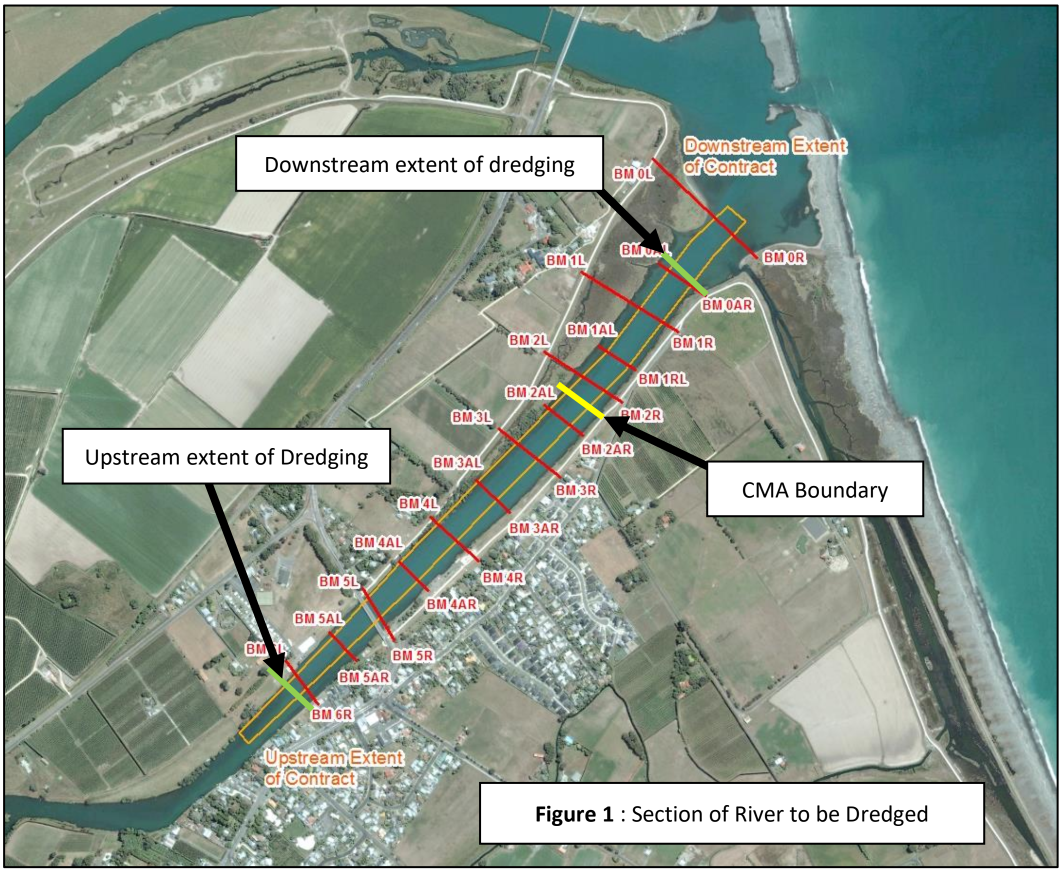


Figure 1 : Section of River to be Dredged

4. The land is Crown land. The Clive River is also subject to Statutory Acknowledgement under the Heretaunga Tamatea Claims Settlement Act 2018.

5. There are no other activities that are part of the proposal to which this application relates.

6. No other resource consents are needed for the proposal to which this application relates.

7. I attach an assessment of the proposed activity's effects on the environment that –
   (a) includes the information required by clause 6 of Schedule 4 of the RMA 1991; and
   (b) addresses the matters specified in clause 6 of Schedule 4 of the RMA 1991; and
   (c) includes such details as corresponds with the scale and significance of the effects that the activity may have on the environment.

8. I attach an assessment of the proposed activity against the matters set out in Part 2 of the RMA 1991.

9. I attach an assessment of the proposed activity against any relevant provisions of a document referred to in section 104(1)(b) of the RMA 1991, including the information required by clause 2(2) of Schedule 4 of that Act.

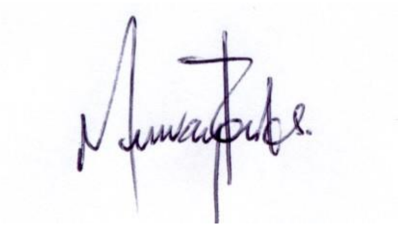
10. N/A

11. Applicants for protected customary rights and customary marine title (namely *Heretaunga Tamatea Settlement Trust and He Toa Takitini* [MAC-0109-01]; and *Ngai Tamahaua hapu (Herewini)* [MAC-01-07-09]) have been notified of the proposed application in accordance with s.62 of the Marine and Coastal Area (Takutai Moana) Act 2011.

12. N/A

13. N/A

13. N/A



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For Regional Assets Manager, HBRC

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Assessment of Effects on the Environment

(based on the format of the 4th Schedule to the RMA)

1. *Background*

In 1969 the Ngaruroro River, which used to pass through Clive, was diverted to a new channel in order to reduce the incidence of flooding in the area. Since then, the 'old' channel of the Ngaruroro (now known as the Clive River) only carries water from the Karamu and Raupare catchments. The diversion has been successful in reducing flood risk but, because the old channel now carries less water than pre-1969, and because of significant changes in bed gradient as a result of the 1931 earthquake (specifically, a 'flattening' of gradient over the last 1.8km)[1], the lower reaches of the Clive River have a tendency to silt up over time.

The majority of the sediment is believed to come up into the Clive River from the Waitangi estuary when the Ngaruroro and Tutaekuri are in flood. The slower flow in the Clive River allows sediment to drop out and settle on the bed. It is likely that there is also a tendency for sediment to be carried up into the Clive River and deposited there when the two major rivers are simply running 'dirty' and there is an incoming tide. In addition, sediment will be coming down the Clive River itself, from the Karamu and Raupare catchments, and settling as it arrives in the more sluggish, shallow-graded and saline waters of the lower Clive.

Adding to the problem within the last 10 years has been the arrival of invasive Australian tube-worm in the lower Clive River. Tube-worms form dense coral-like masses. These are now well-established on and around the piers of the state highway bridge and are already obstructing the movement of rowing boats and other vessels at lower tides. The rowing club have occasionally attempted to cut back the worst of the clumps, when boats start to collide with them, but with limited success, and the problem is liable to get worse and remain on-going without other intervention. Reefs of tubeworm are most visible between the northern river bank and the first pier of the bridge and now effectively block most boat passage through that space.

As sediment (and tube-worm) builds up it hinders the use of the river for the various water sports and other water-based activities that happen there.

The river is used not only for rowing – as the base for the Hawke's Bay Rowing Club – but also for waka-ama, waka excursions (including for the annual Waitangi Day festivities), water-skiing, wake-boarding, jet-skiing, surf lifesaver training and other water sports. As the river gets shallower, these activities become difficult (and for some – notably the waka excursions – impossible) around low tide.

[1] Clode, G. (August 2018) *Clive River Sediment* (a report to HB Regional Council). The shallow gradients resulting from the 1931 earthquake also explain why gravel is no longer carried to the sea from either the Ngaruroro or Tutaekuri rivers and why the Waitangi Estuary now has a silty (rather than gravelly) base.

The shallow depth also leads to a build-up of floating weed mats in the river which get snagged as they drift downstream. As the weed decays it causes odour problems in the summer months.

In order to relieve the situation it is proposed to dredge the lower Clive River to restore the 1997 and 2009 level of the bed (these being the years when the river was previously dredged).

Specifically, the Applicant proposes to dredge sediment from the bed of the river to achieve a minimum water depth of approximately 0.70 metres at low tide (8.3m R.L.), over a 1,500 metre length by 60 metre width of river, using a cutter-suction dredge, and to discharge this sediment onto the foreshore and seabed near the river mouth (Refer Figure 2, below). From there the sediment will be carried away by waves and currents and by the outward flow of the rivers (in the same way that river sediment normally is dispersed).

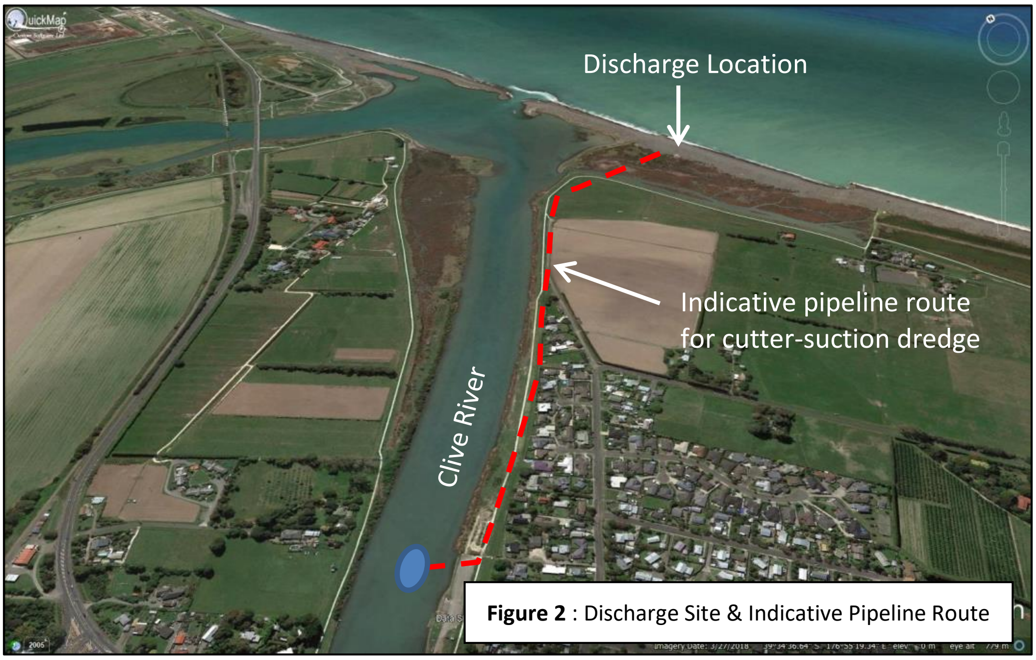

Figure 2 : Discharge Site & Indicative Pipeline Route

The dredge material is, itself, river sediment, and the volume of material will equate to about 2.5% of what may come down the Ngaruroro River in a single flood event[2].

The proposed dredging operation will be the same as that carried out on the Clive River in 1997 and 2009, including the use of a cutter-suction dredge and discharge of dredged sediment onto the foreshore and seabed near the river mouth.

[2] The Ngaruroro can discharge up to 2,000,000 cubic metres of sediment into the sea in a single large scale event. The dredging will involve the discharge of approximately 48,000 cubic metres, which is 2.5% of that volume.

2. *Description of the Proposal*

The proposal is to dredge a length of 1,500 metres by 60m width of the bed of the lower Clive River, from about 200 metres upstream of the Clive Bridge to 1,300 metres downstream of the bridge (as shown in Figure 1). The dredge will cut to a sufficient level to provide a minimum water depth of approximately 0.70 metres at low tide (design depth 8.3m R.L.).

3. *If it is likely that the activity will result in significant adverse effects on the environment, a description of any possible alternative locations and methods for undertaking the activity:*

Other alternative methods and locations have been considered. These are as follow:

3.1 Alternative Locations

In a review conducted in 2013 the Regional Council assessed various alternative locations for the open water recreation activities currently occurring on the Clive River to see if there would be other ways to provide for these activities that would not require on-going maintenance dredging[3]. A number of sites were examined, including sections of the lower Ngaruroro and Tutaekuri Rivers and Ahuriri Estuary, but none of these other sites were found to be feasible and/or likely to provide any significant advantage over continuing at Clive.

Problems with the alternative sites included safety of access; flood-risk; wind and cross-current exposure and (for the Ahuriri Estuary) the likelihood of conflict with the status of that area as a wildlife refuge.

3.2 Alternative Methods

(a) Do Nothing

If nothing is done to re-dredge the river then recreational activities (rowing; waka excursions; waka-ama; wake-boarding, etc) will continue to run into difficulty with shallow water, including groundings, and odour and obstruction from stranded weed-rafts, at low tide.

Tubeworm in particular will be an ever-growing problem in the river and, unless removed, will progressively block off the channel to the movement of water craft. It may also begin to impact on flood passage in the Clive River – especially in the vicinity of the state highway bridge.

[3] Environmental Management Services Ltd (February 2013) *Clive River Dredging Review (Draft Report). A Report to Hawke's Bay Regional Council.*

The rate of sedimentation more generally is probably now slowing and approaching an equilibrium point. But even at the current water depth it is already a significant constraint on boat movement around low tide.

(b) Narrowing of the Clive River Channel

A solution that has been considered in the past is to narrow down the width of the river channel to increase the velocity of water coming down the Clive River, especially at high flows, so that there will be a greater flushing effect to move the sediment along and out to sea. An increased flushing force would also help to keep the weed mats moving and reduce the amount that strands in the downstream area.

The problem with this solution is that by narrowing the river it would also significantly impact on the amount of space available for existing recreational activity. To have any chance of being effective, the river would probably need to be narrowed down from the existing 90 – 100 metres to a width of about 30 – 40 metres (possibly even narrower). This would impinge on many of the existing river activities, causing congestion and conflict between existing users and eliminate those that need a greater amount of amount of manoeuvring space, such as wake-boarding.

Furthermore, even if this narrowing was done, there would still be no guarantee that it would actually work. The situation on the lower Clive River is complicated by the fact that the river has a naturally flat gradient (since the 1931 earthquake) and the rate of sedimentation is highly influenced by back-flow from the Ngaruroro and Tutaekuri rivers in times of flood. This means that even narrowing the channel still might not be enough to prevent a similar amount of sedimentation as occurs today.

The narrowing of the river would also have potential ecological risks, given that portions of the channel are effectively an extension of the estuary, and that some of the existing reedy banks are likely to be habitat for inanga and other species. These existing tidal reed areas would be lost – including within portions of the river currently designated 'Significant Conservation Area'.

(c) Installation of a weir

A further option would be to install a weir at the downstream end of the river, with only a relatively narrow opening (of, say, 8 metres) between the river and the main estuary. An effect of this weir would be to reduce the amount of back-flow from the Ngaruroro and Tutaekuri Rivers, via the Waitangi Estuary, into the Clive River, as it would concentrate the force of water coming out of the Clive River to counter the pressure of water coming in. That in turn would reduce the amount of sediment coming up in to the Clive River from the larger and more silt-laden rivers.

There are, however, potential issues with this solution as well. It is uncertain, for example, what effect a structure of this kind would have on flood flows in the Clive River and whether the weir (even when over-topped) would be likely to obstruct that flow and potentially increase the risk of flooding in the township of Clive. Flood modelling would be required to better assess these risks.

It is also uncertain if the weir would have the potential to create an obstruction to floating weed mats and other debris. Weed mats would probably pass through the opening, but might get snagged on the outer flanks of the weir.

Another potential risk is the effect that a weir would have on extent of the so-called 'salt water wedge' within the river and the effect that a movement of the location of upstream end of the wedge might have on existing whitebait spawning areas. It is possible that the whitebait would simply adjust and if necessary spawn in new locations, but this remains unknown.

Finally, even if a weir was to be installed, there would still need to be a dredging of the river anyway. A weir, if it works at all, will only serve to reduce the rate of re-sedimentation of the river once the river has already been dredged. It will not do anything to shift the sediment that has accumulated to date.

(d) Disposal of dredge material to Land

An alternative to disposing of dredge sediment from the Clive River into the sea would be to land-fill the material somewhere in the vicinity of the river. Although there would be no obvious ecological advantages in doing so, and in fact potentially greater significant adverse effects overall, it would at least satisfy broader community perceptions that intuitively favour land disposal over disposal to sea.

Various landfill sites were considered as part of the review of options for the previous dredgings in 1997 and 2009 and this option has again been assessed for the current dredging proposal.

The recent investigations have mainly focused on the possibility of disposing of dredge material onto land at the Hohepa Homes site between the river and state highway north of Clive. This site is on the left bank, downstream of the bridge, and the Trust that operates the farm has indicated that they are willing to at least consider the option. The site is near enough to the river to be within reach for pumping from a cutter-suction dredge.

This option is 'technically possible' but would also be substantially more expensive than the method of ocean discharge that has been used in the past, and that is again proposed for this current application. As an indication: The budget for the sea discharge option is approximately $1M. The cost of disposal to the Hohepa site (if indeed that site was available), exclusive of land acquisition costs, would be a minimum of $1.7M – $2.3M and potentially $3M to $4M when allowance is made for associated cost-escalation risks due the specific nature of the work.

These cost impacts are ‘real’ impacts insofar as the additional funding required for land disposal would not then be available for other environmental works undertaken by the Regional Council, to the value of $1M or more. That is $1M that would not then be available for use on, for example, a more intensive control of tubeworm, additional dredging, or riparian planting in the Clive River, or for any number of other projects across the Region. The funds would be used instead for putting the dredged river sediment onto land.

There would also be significant logistical difficulties with this option including, most obviously, the requirement to purchase or lease, on a willing-seller/ willing-buyer basis, approximately 6 hectares of land at the Hohepa farm. There have been discussions with the Hohepa Trust but it still remains to be seen if an agreement can be reached.

This land, if purchased or leased and then used for a dredge disposal site, would no longer be readily available for the use of the farming operation and would potentially lose organic certification status as a result of the dredge material that is placed on it.

In order to get the sediment onto the land (delivered in slurry form directly from the cutter-suction dredge) the 6 hectares would need to be stripped of top-soil and both surrounded and sub-divided by approximately 1.5m high earth bunds. The division into at least two separate bunded areas would be necessary to create a settling and de-watering system for the recovery and containment of sediment. However, even with settling ponds a significant portion of finer suspended sediment (clays in particular) would be expected to pass through the settling process and go back into the river with the returning dredge water. This would form a visible plume in the river at the point of discharge. The plume would mostly flow down-river, toward the sea and estuary, but would also be carried up-river at times on the in-coming tide (where some would re-settle on the bed).

Once the sediment has been stored and dried-out on the land at Hohepa the intention is for the resulting (predominantly silt) material to then be available for contractors to take away and use as fill. River silt is a material commonly used as fill on construction projects. Sediment grain-size testing shows that the material will be around 60% silt; 35% sand and 5% clay, so should be acceptable for this purpose. However, in order for contractors to uplift the material it would be necessary for trucks to be able to drive into and out of the Hohepa property from the highway on an irregular as-needed basis and for loaders to be allowed to operate on site. This may present safety issues both within the site and on the highway.

The material could alternatively be capped with topsoil and left permanently on the Hohepa site but, if so, this would prevent the same area from being re-used for the receipt of dredge material in future dredgings, which would then most likely eliminate land disposal as a future option due to the lack of other suitable alternative sites.

Odour would also be an issue – although this effect is likely to be only temporary as the dredge material dries out. The sediments, which have been tested, are mostly anoxic, with a slight odour of hydrogen sulphide[4].

These various issues, combined, make land disposal a less-preferred option than the proposed method of ocean discharge at the present time. As discussed above, the reasons include the substantially higher cost of land disposal for minimal (if any) ecological benefits compared with disposal to sea, as well as lost opportunity costs associated with $1M or more of additional expenditure. The land disposal option also presents uncertainty in terms of the ability to acquire the necessary amount of land and would have its own impacts on the utility of existing productive organic farmland. It would result in a visible plume of sediment in the river (due to the return of dredge-water from the de-watering site); safety issues on the highway and within the receiving property; and potential odour nuisance. None of these issues occur with the proposed option of disposal to sea.

4. An assessment of actual or potential effects on the environment:

4.1 <u>Beneficial Effects</u>

The proposed dredging will improve the recreational potential of the Lower Clive River for rowing, waka-ama, canoe-paddling, water-skiing, casual boating, swimming and fishing; allow a potential return of the waka excursions, with resulting social and economic benefits (specifically, the promotion of community sporting and cultural activity and the economic value of such activities including, for example, the hosting of national and regional regattas and the commercial activity of waka excursions).

The dredging will also help to overcome the problems of stagnant weed during the summer. Reduction in weed stranding and increased water circulation will enhance water quality in the channel and the deepening of the channel will slightly improve flood capacity for the Karamu and Raupare catchments (mainly by reducing bed friction).

An associated benefit will be the removal of a considerable amount of invasive Australian tubeworm (*Ficopomatus enigmaticus*) from the bed of the river, which is particularly evident in the vicinity of the state highway bridge. Although the dredging on its own can not be expected to eliminate tubeworm, the dredge work will at least succeed in pushing the growth back. It may also present an opportunity for other manual clearing of tubeworm to take place and further improve flood passage.

[4] eCoast (Oct 2019) *Lower Clive River Sediment Sampling and Depth Probing, and Entrance Bathymetry and Ecological Assessment* (p.6).

These benefits will be enjoyed for the lifetime of the project (expected to be about 10 years). Re-dredging will be required at the end of this period if the benefits are to be maintained.

4.2 Adverse Effects

All of the potential adverse effects associated with the dredging will be of a relatively minor and temporary nature. The relevant issues are:

(a) Water turbidity in the River

While dredging is underway there could be a small loss of sediment around the dredge and into the water column as the dredge works the bed of the river. However, because this will be a cutter-suction dredge, which effectively vacuums as it cuts, the amount of sediment that is lost from this process will be minimal. Certainly, in previous dredgings, around the dredge no obvious plume was apparent.

If any such plume occurs it will have only a localised, transitory and no more than minor effect on water quality and aquatic life.

(b) Water turbidity off-shore

The proposed discharge point for the dredge sediments from the cutter-suction pipeline will be above the high tide line on the shore to the south of the rivermouth groyne. From here the sediment, combined with conveyance water, will run down the beach and into the sea. This will cause a visible plume in the wave zone which will then be carried along the shore with the north-trending long-shore drift.

This direction of drift will soon take the plume into the path of the outflow from the river mouth which will cause it to be pushed outward and dispersed off-shore. Heavier material (i.e. river stones) will drop out early and settle in the river delta-fan, where it will be later re-distributed and/or moved further along the coastline by wave action or by the force of water exiting the rivermouth in times of higher flow. The finer sediments (sands, silt, and ultimately clay) will successively deposit further off-shore. This is similar to what happens to sediment that comes out of the rivers by natural processes.

Within this immediate off-shore area there are very few benthic species. Almost mothing survives in the wave-zone because of the constant abrasive effects of movement of the shingle in this zone and the recent (July 2019) eCoast benthic survey found no live organisms in any of the 10 ponar grab samples collected beyond the rivermouth, within about 300m of the shore.

These findings strongly suggest that any dredge sediment that settles in the river delta, or that passes along the wave zone with the long-shore drift, will have a negligible adverse effect on any existing benthic species. That is because there is very little there. Furthermore, because this area around the rivermouth is a naturally high-sediment environment anyway, due to the continual input of sediment from the rivers, it is almost certain that any such benthic species living in the area will already be well adapted to cope with far higher levels of sediment than are likely to be seen as a result of discharge from the dredge.

The area is nevertheless frequented by fish (presumably feeding on prey and materials washed out of the rivers) and the dredge plume may cross over with areas where fish are to be found. The turbidity of the water may cause some of these fish to avoid the plume. On the other hand it may have the effect of actually drawing fish in to the shore in search of marine worms, shrimps and snails brought up with the river sediment by the dredge. Anecdotal reports from previous dredgings suggest that this may have in fact resulted in an overall improvement in fish-catches at the river mouth during the time that the dredge was at work[5].

(c) Contaminants

Sediment samples were collected by eCoast marine scientists in August 2019 from eleven sampling sites on 4 cross-sections along the length of river where the proposed dredging will occur. The sampling sites are as shown in Figure 3 (see following page). The samples were tested at a certified laboratory for potential contaminants. The results of the sampling are reported in eCoast report[6] attached to this assessment as Appendix 1.

The eCoast report finds that contaminant concentrations were mostly below the guidelines threshold, and in some cases undetectable, but that nutrients (specifically total nitrogen and total phosphorus) were found to be in the upper-range of recorded values for reference sites in Hawke's Bay and other estuaries in New Zealand. Zinc levels were also found to be slightly elevated, above the ANZEEC ISQC-Low effect threshold level[7], at three of the eleven sites – with the higher-concentration sites located near to the state highway bridge. The zinc level in all other samples, and the average across all samples combined (approximately 150 mg/kg) was, however, below the ANZECC ISQC-Low effects threshold of 200 mg/kg for zinc.

These results are similar to the sampling results from sediment testing undertaken prior to the 1997 dredging. At that time the highest concentration of zinc was also in

[5] *Pers comm*. (June 2019) Marei Apatu (Te Taiwhenua O Heretaunga), reporting on comment relayed to him from a well-known local fisherman (Mick Unahi).
[6] eCoast (August 2019) *Lower Clive River Sediment Sampling and Depth Probing.*
[7] ANZECC is the Australia and New Zealand Environment and Conservation Council. ISQC is the International Standard on Quality Control. The 'Low' effects threshold for contaminants is the concentration at which a contaminant may begin to affect some species. The default guideline 'Low' effect threshold for zinc is currently 200mg/kg. The 'High' guideline value is 410mg/kg.

samples taken from the vicinity of the state highway bridge and is likely to have been due to road run-off, with the zinc originating as a component in tyres, and is typical of the run-off from most highways.

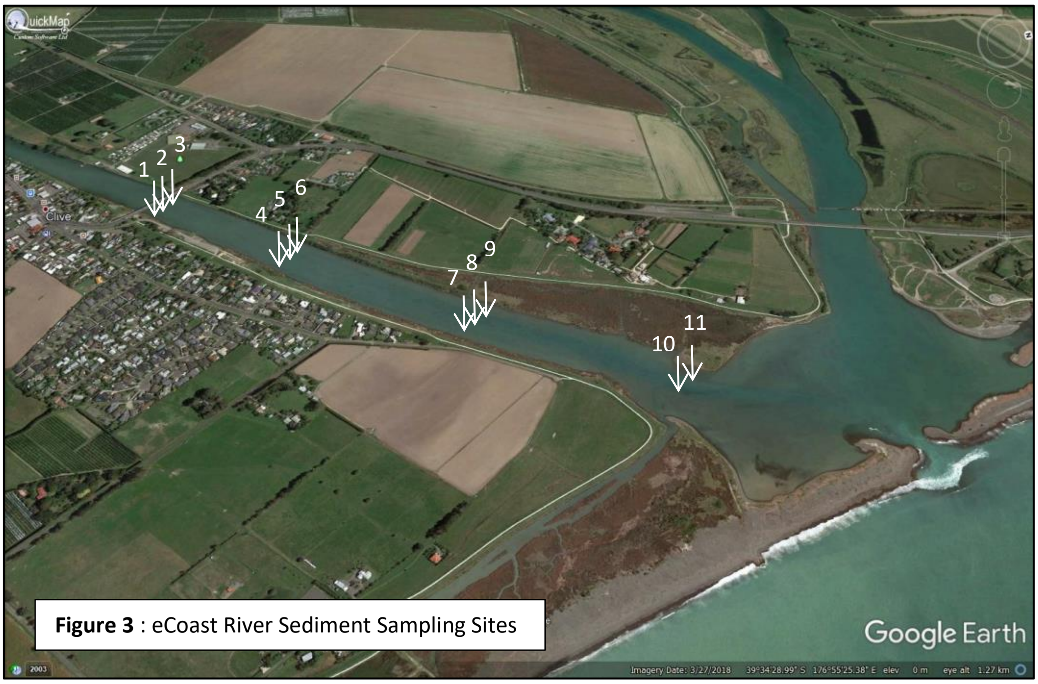

Figure 3 : eCoast River Sediment Sampling Sites

In 1997 there were also slightly elevated lead concentrations found in this same area near the road bridge and probably originating from lead in petrol. The relatively low concentrations of lead in the latest (2019) results will be a reflection of the fact that lead is no longer a petrol additive in New Zealand, having been removed from all regular petrols in 1996.

The results for zinc concentration indicate that sediments in the vicinity of the bridge, on their own, would potentially have a minor effect on zinc-sensitive species, based on the ANZECC default guideline values for 'Low' environmental effect. These particular samples are not, however, representative of the entire volume of dredged material and the mixing and dilution with other lower-concentration sediments from across the remainder of the dredge area needs to be taken into account. Allowing for this, the average zinc concentration falls below the default 200mg/kg 'Low' effects threshold to approximately 150mg/kg. At this concentration, and allowing also for dispersal in the receiving environment, there will be a less than minor effect.

Similarly, because of the well-aerated and highly mobile nature of the open-water environment at the river mouth, the effect of elevated nutrient concentrations (nitrogen and phosphorus) will be no more than minor. These inputs will be dwarfed by the quantities of nutrient, combined with sediment, that is discharged naturally from the Tutaekuri and Ngaruroro Rivers in times of high flow. To put this into perspective: the amount of sediment that will be discharged from the entire dredging operation (55,000m^3) will be the equivalent of that discharged from the Tukituki

River, along with associated nutrients, over a period of 4 hours during a typical 1-in-5 year flow event[8].

For further information and expert analysis of sediment contaminant loadings, refer to the accompanying eCoast reports in Appendix 1.

(d) Risk of Spread of Australian Tubeworm (*Ficopomatus enigmaticus*)

The proposed dredging operation will remove not only sediment from the river but also most of the existing larger infestations of Australian tubeworm. The tubeworm mounds will be cut up by the dredge and the resulting fragments will join the other sediments that are piped down-river in the floating pipeline and discharged to the coast.

The process of cutting and fragmenting the tubeworm masses, along with abrasion within the pipeline, can be expected to destroy most of them. Any that come through this process and that are discharged to the open ocean will be unable to survive in an active wave environment. The natural habitat for Australian tubeworm is confined to the sheltered waters of estuaries and lagoons.

This will explain why tubeworm do not already occupy any of the open coastal waters of Hawke's Bay, despite ample opportunity for the existing colonies in the Clive River to spawn into the river and have their larvae carried down-current and out to sea. That is to say: if it was possible for tubeworm to colonise areas of active open coastline, they would have done so by now. They have not, and this is consistent with available information on the tubeworm ecology.

Note: Further expert opinion is now being sought on this matter, which is expected to confirm the above conclusion. That further information will be supplied separately, when it arrives.

(e) Dredge Noise

Noise will be generated from the dredge and associated booster pumps while the plant is in operation. This will be during daylight hours only.

The sound made by the cutter suction dredge is a low humming engine noise, comparable to that of an idling train. There may also be sound caused by the rattle of stones in the pipeline – although the majority of sediment to be removed from the Clive River will be silt, sand and clay.

The noise will not be especially loud or intrusive.

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[8] HBRC Land Scientist Tim Norrie, quoted in *Hawke's Bay Today* (28 June 2018)

(f) Whitebait

On the advice of the Department of Conservation, the previous dredgings of the Clive River in 1997 and 2009 were timed to avoid the whitebait spawning and upstream migration periods (March to mid-May, and mid-August to November).

Recent discussions with the Department of Conservation (August 2019[9]) have reconfirmed that it is appropriate to avoid the main upstream migration period but from observation of the previous dredging the DOC staff now advise that also avoiding the spawning period is likely to be an unnecessary precaution.

It is therefore not proposed to place any restriction on timing of dredging around the March to mid-May spawning season but the restriction on dredging in the period of August to November will remain. The official whitebait season runs from the 15th of August to 30th November. The Department of Conservation have accordingly asked that the period 1st August to 30th November be avoided.

The dredge itself will generally work no closer than about 10 metres (averaging more than 20 metres) from the banks of the river. This means that whitebait spawning areas along the banks of the river will not be damaged or disturbed.

(g) Birds

The previous dredgings of the Clive River were also timed to avoid the period of arrival of migratory birds in the Waitangi Estuary (September to March). However, from on-site observation during the dredging in 1997 and 2009, Department of Conservation staff have indicated that they now believe this to be an unnecessary precaution and that dredging can be carried out at any time without significant adverse effect on the birds.

(h) River Benthos

Benthic species in the Clive River (shrimps, worms, snails etc that live in the mud) will be almost completely removed from the section of river where the dredging will occur, along with the sediment. It is likely to take a few months for these species to re-colonise the area once dredging has been completed.

This will have a short-term effect on flat-fish and possibly other species of fish that currently feed in the Clive River on these invertebrates, although there will still be the remainder of the Waitangi Estuary and Ngaruroro / Tutaekuri Rivers for these species to feed while natural re-stocking occurs. The benthos will return, however. Full colonisation can be expected to occur within the course of a year.

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[9] In attendance: Matt Brady; Neil Grant, from DoC. Also present, Jessie Friedlander (NZ Fish & Game).

(i) Boat Passage

Boat passage on the river is likely to be slightly disrupted while the dredge is there. The dredge, if not anchored, may be tethered to the river bank by cables, which will temporarily obstruct some boat movement. There will also be some obstruction from the discharge pipeline – which will be partly a floating line – although most of the pipeline will be laid along the banks of the river. This is, however, considered to be a relatively minor inconvenience for boat-users in the interests of a longer term improvement for boating in the river.

(j) Power Boat Noise

An indirect effect will be longer periods of motor-boat noise. At present the state of the river allows boating to occur only around high tide. It is acknowledged that the dredging will allow that use (and associated noise) to be extended. Motor boating is, however, a permitted activity on the lower Clive River.

5. Where the activity includes the use of hazardous substances and installations, an assessment of any risks to the environment which are likely to arise from such use:

There will be no hazardous substances or installations associated with the dredging operation other than the normal use of fuel for powering the dredge.

6. Where the activity includes the discharge of any contaminant, a description of:

(i) The nature of the discharge and the sensitivity of the proposed receiving environment to adverse effects:

(ii) Any possible alternative methods of discharge, including discharge into any other receiving environment.

The nature of the proposed activity has been described in preceding sections. It is intended to dredge the bed of the Clive River over a 1,500 metre length, from the about 200 metres upstream of the road bridge to 1,300 metres below the bridge. The sediment from this dredging exercise will be discharged from the cutter-suction dredge pipeline onto the foreshore and in to the surf zone beyond the Clive / Ngaruroro/Tutaekuri river mouth. This sediment may be considered a "contaminant" in terms of the definition of Section 2 of the Resource Management Act[10].

[10] "Contaminant" includes … *any substance (including gases, liquids, solids and micro-organisms) … that … when discharged into water, changes or is likely to change the physical, chemical, or biological condition of the water.*

The sediment will mainly be comprised of silt, clay and mud, but with small amounts of shingle possibly present in some of the deeper sediment layers.

The sediments of the Clive River have been tested (in August 2019) and found to be generally below the guideline threshold for all contaminants except for slightly elevated zinc concentrations from the two sampling points near the state highway bridge. The mixing of these near-bridge sediments with other sediments will result in concentrations below the guidelines and a negligible adverse effect on the receiving environment, after reasonable mixing.

The sediments are anoxic, with elevated nutrient levels (total nitrogen and total phosphorus). This will not materially affect the open receiving waters where there is abundant oxygen and a high potential for assimilation of nutrients.

The receiving environment for the sediment will be the beach and surf zone of the coastal marine area. The sediment will be discharged above high tide level (to keep the pipeline safe from wave damage) and will flow from there down the beach and into the water where it will be transported by long-shore drift into the outflow from the rivers and dispersed. A recent survey found no living benthic species in this receiving area and any benthic species as may exist will be pre-adapted to high sediment environments. A single large flood on the Ngaruroro / Tutaekuri will carry down in to this area many times the amount of sediment proposed to be discharged from the dredge.

Various species of fish (snapper, kahawai) are also present in the receiving environment, with fishing being a popular activity at the mouth and in the Ngaruroro River. Fish are sufficiently mobile to avoid the sediment plume and may tend to avoid the turbid water carried north of the pipe outlet toward the river mouth. On the other hand fish may be attracted to the discharge plume to catch the various worms, shrimps and marine snails that will be mixed in with the dredgings. Fishing in the vicinity of the dredge outlet therefore may actually improve while the dredge is operating. Anecdotal reports from previous dredging support this.

Overall, the discharge will have a short-term effect on water clarity in the near-shore area and may discourage fish from coming close inshore because of the plume but also draw them in because of the feeding opportunities at the point of discharge.

An alternative method for discharging the sediment would be to pump the material on to land immediately adjacent to the Clive River. There is limited space available but sufficient land could theoretically be found at Hohepa Farm. The sediment would arrive on the land as a slurry and would be bunded, dewatered, and allowed to dry before being re-spread and surfaced with original top-soil. This would be possible, but expensive and logistically difficult to carry out, and would provide no obvious environmental benefit when compared with the impacts of discharging to sea.

7. A description of the mitigation measures (safeguards and contingency plans where relevant) to be undertaken to help prevent or reduce the actual or potential effects:

(a) Timing limitations

In order to minimise disturbance of the migration of whitebait (15th of August to the 30th November) it is proposed that dredging will not be carried out in the period 1st August to 30th November.

Note that the Department of Conservation have advised that no special precautions are required with respect to timing of the operation as regards effects on birds.

(b) Avoidance of whitebait spawning areas

The dredge will generally work no closer than about 10 metres (averaging more than 20 metres) from the banks of the river. This means that whitebait spawning areas along the banks of the river will not be damaged or disturbed.

The only proposed exception to this rule is where Australian tubeworm is found and needs to be removed within 10m of the bank.

(c) Hours of Operation

Dredging will take place only during daylight hours, so that there will be a minimal noise disturbance for adjacent residents associated with the dredging activity. The dredge itself does not produce a particularly loud or intrusive noise during operation.

8. An identification of those persons interested in or affected by the proposal, the consultation undertaken, and any response to the views of those consulted:

In the course of this assessment and preparation for the proposed dredging, meetings and/or discussions have been had with:

a) Representatives of Kohupatiki Marae
b) Te Taiwhenua O Heretaunga
c) Department of Conservation
d) NZ Fish & Game
e) Hawke's Bay Rowing Club
f) Hawke's Bay Canoe Club
g) Heretaunga Ararau O Ngati Kahungunu Waka-ama
h) Operators of the Clive waka excursions (Nga Tukemata o Kahungunu)

Other parties known to use the river for recreational purposes but not individually consulted include the Clive Waterski Club; Wakeboarders; Jet-skiers; and Waimarama surf life-saving Club.

All of the consulted recreational groups, along with the operators of the Nga Tukemata o Kahungunu waka excursions, are strongly supportive of the proposed dredging and have been advocating for the work to commence. The lack of dredging has particularly impacted the waka excursions, which can no longer operate on the river due to the risk of stranding, and with the result that the waka has now been removed from the river.

Te Taiwhenua O Heretaunga have not expressed any firm opinion (deferring instead to Kohupatiki Marae) but have equally not indicated any opposition to the proposed dredging.

HBRC staff have met with representatives of Kohupatiki Marae to discuss the dredging proposal on various occasions in 2019 and 2020, with a final meeting on 24th November 2020. At this meeting the marae representatives repeated a previously-stated preference for the dredging to be extended to include not only the proposed area but also much further up the river to at least as far as the marae (another 3 km), or to the rail bridge (600m beyond the marae). The representatives stated that they were disappointed that this will not be done and have said that they will not actively 'support' the proposal for this reason, but equally that they can see the value of the work for recreational users of the river, and will not object to the proposal.

The marae representatives have also indicated that they would also have preferred to see the dredge material discharged to land, rather than to sea, but likewise accept that this would be a far higher-cost option and that there is not currently any guarantee that land (the Hohepa site) would be available. They acknowledge that the extra money required for land disposal would be better directed to other environmental works such as addressing the problem of tubeworm infestation in the Clive River.

Other persons who may potentially have an interest in the proposed dredging but have not been individually consulted are those residents of Clive that live alongside the section of river where the dredging will occur. The dredging of the river will result in a reduction in odour for these residents, from the weed rafts that currently get caught in the shallow water and rot during the summer, but also result in extended use of the river by recreational craft during periods of lower tide.

9. Where the scale and significance of the activity's effect are such that monitoring is required, a description of how, once the proposal is approved, effects will be monitored and by whom:

Cross-sectional surveys are carried out every 3 years on the river to monitor silt build-up in the dredged channel. These surveys will continue.

The applicant also proposes to commit to follow-up benthic sampling in the area off the river mouth, on completion of the dredging operation, to test for effects.

10. Assessment against matters in Part 2 of the Act

(a) Regarding the Purpose of the Act

The proposed dredging is intended to enable the on-going unimpeded use of the lower Clive River for recreational and cultural activities including rowing, waka-ama, canoeing, wakeboarding and waka excursions – which in turn includes use of the waka (Nga Tukemata o Kahungunu) for the annual Waitangi Day festivities. In so doing, the dredging will better enable the people and communities in the Heretaunga Plains area to provide for their social and cultural well-being.

The dredging will at the same time have no enduring adverse effect on the environment. This is illustrated by the two previous dredgings of the river, which used identical methods. The activity will not, therefore, compromise the potential of the relevant natural and physical resources for meeting the needs of future generations.

(b) Regarding Matters of National Importance

(a) The proposed dredging will not adversely affect the natural character of the coastal environment or wetlands. It will merely deepen the water in the existing channel.
(b) The dredging will not impact upon an Outstanding Natural Landscape;
(c) No areas of significant indigenous vegetation will be affected. The dredging will include work in an area of significant habitat (a branch of the Waitangi Estuary) but will not significantly adversely affect this habitat.
(d) The dredging will enhance public access to and along the coast by making the river more navigable, especially at low tide.
(e) The work will facilitate waka-ama and waka excursions on the river. These activities have an association with Maori culture and traditions, although it is also separately acknowledged that Kohupatiki marae have mixed opinions on the proposal and would prefer to see the dredge work extended another 3km up-river to the marae, as well as dredge material discharged to land, for them to fully support it. They have, however, also indicated that they will not object to what is now proposed.
(f) No heritage sites will be materially affected.
(g) There will be no impact on any protected customary rights.
(h) The proposed dredging will not present any significant risk from natural hazards.

(c) Regarding 'Other Matters'

(a) The kaitiakitanga of the people of Kohupatiki Marae is acknowledged. The marae have been consulted and will be formally notified of the proposal through the Statutory Acknowledgement process. The representatives of the marae have indicated that they won’t actively ‘support’ a proposal that does not include dredged another 3km up to the marae, and that does not include discharge to land, but will equally not oppose the application.

(aa) The stewardship of the people of Kohupatiki in respect of the river is also recognised.

(b) N/A

(ba) N/A

(c) The amenity values of the Clive River will be enhanced by the proposed dredging. The dredging will allow better boat movement; remove invasive tubeworm and improve water quality in the river and estuary (mainly be reducing the stranding of rafts of weed and allowing more water movement).

(d) The dredging will enhance the intrinsic value of the river ecosystem.

(f) Removal of tubeworm and deepening the river will enhance the quality of the river environment – especially for recreational users.

(g) N/A

(h) N/A

(i) N/A

(j) N/A

(d) Regarding the Treaty of Waitangi

As discussed above: there have been various consultations with Te Taiwhenua o Heretaunga and more particularly with the people of Kohupatiki Marae (for whom the lower Clive River has special significance). These consultations have been undertaken in good faith and the Regional Council Asset Management Group have made every attempt to come up with a solution that is affordable, achievable, and agreeable to Kohupatiki. The proposal put forward with this application is considered by the Asset Management Group to be the best compromise.

11. Assessment against the provisions of relevant Plans

(a) New Zealand Coastal Policy Statement (2010)

The relevant Objectives of the New Zealand Coastal Policy Statement (NZCS) include **Objective 1**, which seeks to safeguard the integrity of the coastal environment and sustaining its ecosystems, by maintaining or enhancing natural biological and physical processes; protecting significant natural ecosystems and maintaining coastal water quality. Accompanying this Objective is **Policy 11**, which seeks to avoid significant adverse effects on coastal ecosystems.

Assessment

As explained in the preceding assessment of effects: the proposed dredging will not compromise existing ecosystems. The deepening of the river will improve water circulation (and therefore water quality) and will have only a temporary effect on existing river benthos, which will re-populate the area once the dredging is complete. The site where the dredge material is to be disposed of is already adapted to high rates of sediment input from natural sources (of far greater volume than will occur as a result of the dredging).

Vulnerable habitats within the Clive River include the estuarine marshes on the northern bank of the river, beside the Waitangi Estuary, and the whitebait spawning areas elsewhere along the bank. None of these areas will be impacted by the dredging and the dredge work will be timed to avoid the whitebait upstream migration.

Objective 3 requires that account should be taken of the principles of the Treaty of Waitangi, including recognising the on-going relationship of tangata whenua over their lands, rohe and resources; promoting meaningful relationships with tangata whenua; and recognising and protecting characteristics of the coastal environment that are of special value to them. **Policy 2** correspondingly requires the recognition of the traditional and on-going relationship of tangata whenua with the coastal environment.

Assessment

The consultation with tangata whenua that the Applicant has undertaken – in particular with the people of Kohupatiki marae – recognises these values and responsibilities.

Objective 4 is also relevant and seeks to maintain and enhance the public open space qualities and recreation opportunities of the coastal environment (including in the coastal marine area). Objective 4 may be read in conjunction with **Objective 6**, which seeks to 'enable people and communities to provide for their social, economic and cultural well-being; as well as **Policy 9**, which requires a recognition of the need for open space in the coastal marine area, including for active and passive recreation. Also **Policy 18**, which requires a recognition of the need for public open space in the coastal marine area, where this can be done in a way that is compatible with the natural character of the coastal environment, and requires that account should be taken of the need for public open space in the coastal marine area that is close to cities and other settlements.

Assessment

The proposed dredging is primarily for the benefit of recreational users of the Clive River and is intended to enhance that use. In so doing, the dredging will serve to enable people and communities to provide for their social and cultural well-being through the various recreational activities (rowing, waka-ama, canoeing, waka excursions) that occur on the river. The dredging will merely deepen the river and therefore have no impact on the river's natural character.

(b) Hawke's Bay Regional Policy Statement

The Regional Policy Statement (RPS) is incorporated into the Regional Plan. There are no coastal-related policies in the RPS (these are reserved for the Coastal Plan) but there are a number of Objectives (Obj 4 – 10).

Those of relevance to the current application include **OBJ 5**, which sets the objective of maintaining and where practical and in the public interest, the enhancement of public access to and along the coast, and **OBJ 6** which seeks to manage coastal water quality to achieve appropriate standards, taking into account spatial variations in existing water quality, actual public uses and the sensitivity of the receiving environment.

Assessment

The proposed dredging will enhance public access within the coastal marine part of the Clive River, which is currently impassable (or difficult to navigate) for a number of vessels at low tide.

The place of discharge for the dredged material, next to the river mouth, is an environment that is already adapted to far greater inputs of river sediment than proposed by the current consent application.

Also relevant are RPS Objectives relating to water quality, including **OBJ 27**, which seeks to maintain and improve surface water quality in rivers, lakes and wetlands, and **OBJ 27A** which aims to protect riparian vegetation.

Assessment

The proposed dredging will improve summer water quality in the lower Clive River by providing better water circulation and reducing the incidence of water-weed strandings (where rafts of weed, cut upstream for flood protection purposes, get snagged in the shallow water). The dredging activity itself will have no significant adverse effect on water quality within the river due to the use of a cutter-suction dredge.

In regard to riparian vegetation: there will be no effect on existing bank vegetation as the dredging will occur in the mid-channel of the river, no closer than about 10m from the bank. The only exception to this will be if the dredge is used to target specific areas of tubeworm infestation that is nearer to the river bank, such as in the vicinity of the bridge.

Objectives **OBJ 34 – OBJ 37** and policies **POL 57 – POL 66** in the RPS also need to be considered. These recognise the role of tikanga and the role of tangata whenua as kaitiaki and seek to ensure that consultation occurs with Maori on relevant resource management issues as well as ensuring that waahi tapu and tauranga waka (landings for waka) are protected and preserved.

Assessment

The proposed dredging project has involved consultations with local hapu and marae (particularly Kohupatiki Marae) and the dredging itself will protect and enable waka launching sites on the lower Clive River. This includes the waka-ama and waka excursions – both of whom are active supporters of the proposed dredging. The operators of the waka excursions are currently unable to use the river because of the build-up of sediment that has occurred.

(c) Hawke's Bay Regional Resource Management Plan

The main policy in the RRMP of relevance to this application, as this relates to activities on the beds of Rivers and Lakes (Section 5.8 of the RRMP), is **Policy 79**, which requires that the effects of activities affecting the beds of rivers should be in accordance with the Environmental Guidelines set out in Table 12.

Assessment

The proposed dredging will comply with all of the guidelines in Table 12 and therefore Policy 79. This is in large part because a cutter-suction dredge will be used in the river, which means that there will be a minimal amount of 'stray' sediment, within the river, during the operation.

On completion of the dredging there will be an overall improvement in water quality due to the reduced amount of weed strandings; enhanced water circulation; and improved temperature buffering from deeper water. There will also be a minor improvement in flood capacity – mainly due to the reduction in bed friction resulting from increased depth. These will be positive factors in respect of the Guidelines in Table 12.

The same applies in respect of objectives and policies in Section 5.4 of the RRMP (Surface Water Quality). **OBJ 40** seeks to ensure that river water quality is maintained and policy **POL 71** sets environmental guidelines for surface water quality. These guidelines are as set out in Tables 7 & 8 in Section 5.4.

Assessment

The proposed dredging will comply with the guidelines in Tables 7 & 8. This is, again, largely due to the use of a cutter-suction dredge for the proposed dredging operation.

(d) Hawke's Bay Coastal Environment Plan

Part D : Use and Development : Coastal Marine Area

16. Discharge of Contaminants into the CMA

The principal policy of this section of the Plan (**Policy 16.1**) seeks to manage discharges of contaminants in the coastal marine area in accordance with the environmental guidelines set out in the accompanying table (Table 16-1). This includes guidelines for (5) 'water quality'.

Assessment

The proposed dredging will not comply with the AE(HB) and CR(HB) to the extent that the discharge of dredge material to the shoreline at the river mouth, and which will then flow into the sea, will "result in the deposition of matter on the foreshore or seabed" and involve a "discharge of contaminant into water". The Water Quality guideline (5(b)(ii)) goes on to say, however, that despite such exceedance, a permit may be granted for the discharge if the discharge is "of a temporary nature". That will be the situation in this case and means that the Council would be entitled to grant the application due to the temporary nature of the activity.

Exception can also be made for discharges associated with necessary maintenance works, under 5(b)(iii) and for "exceptional circumstances" under 5(b)(i).

17. Disturbances, Depositions and Extractions in the CMA

The principal policy in section 17 (**Policy 17.1**) is for the deposition and extraction of material within the CMA to be managed in accordance with guidelines in Table 17-1.

This includes, under Issue 2 in Table 17-1, the 'removal of material' within the CMA, for which the guidelines require that adverse effects on indigenous flora, fauna, benthic organisms and their habitats within a Significant Conservation Area (which would include the Clive River branch of the Waitangi Estuary) should be avoided.

Assessment

The preceding environmental impact analysis (accompanying this application) confirms that there will be no significant adverse effects on indigenous flora or fauna, including benthic organisms.

The guidelines for Issue 6 also allow (under (a)) that the disturbance of the foreshore and seabed shall be provided for where it is necessary for the "maintenance of safe access for marine vessels". This will be the primary purpose of the dredging.

(e) Overall Conclusion of Policy Analysis

From the preceding analysis it is concluded that the proposed dredging operation will be generally compatible with relevant national and regional policy documents (the NZCPS, RPS, RRMP and Coastal Plan).

Key factors in this analysis include:

1. That the proposed dredging will generally improve overall water quality in the lower Clive River (by reducing weed strandings; increasing water circulation; and providing greater temperature buffering due to the increased depth.

2. The nature of the existing benthic environment at the combined Clive / Ngaruroro / Tutaekuri river mouth, which is regularly affected by naturally high river-sediment inputs and therefore ecologically adapted to this effect.

3. Local hapu / marae representatives have been consulted about the proposed dredging operation (as has, to a secondary extent, Te Taiwhenua O Heretaunga). This consultation has occurred over a number of meetings and conversations.

4. The dredging will clearly enhance public access to and recreational use of the lower Clive River, which is the primary sheltered open-water recreational resource of its kind in the Heretaunga Plains. It will also enhance the use of the river for waka ama and waka excursions, and as a site for tauranga waka, with associated Maori cultural significance.

5. The discharge of the dredge material will result in a '*deposition of matter on the foreshore and seabed*' and in a '*discharge of contaminant to water'* in the coastal marine area beyond the river mouth but will not result in any material adverse effect on benthic species within this area (where the rate of natural river sedimentation from a single flood event far exceeds the 55,000m3 proposed to be dredged from the Clive River). There will be an acknowledged temporary impact on water turbidity but (under Regional Coastal Plan) discharges of a “temporary nature” may be granted by HBRC. Exceptions can also be made where the activity is a necessary maintenance work.

12. Recommendation & Conditions

It is recommended that consent be granted to this application, and that the terms and conditions of consent should be essentially the same as those applied to the dredging consents issued in 1996, except that:

- The period over which the consent may be exercised (which, in the 1996 consents was limited to the period 15 May to 8 September), should this time be changed to read:

  *"**The consent may only be exercised between 30 November and 1 August of the following year**".*

APPENDIX 1

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eCOAST SEDIMENT SAMPLING &
DEPTH PROBING REPORT
(August 2019)

AND

eCOAST SEDIMENT SAMPLING, DEPTH PROBING &
ENTRANCE BATHYMETRY AND ECOLOGICAL ASSESSMENT
(October 2019)

Lower Clive River Sediment Sampling and Depth Probing

Prepared for:

HAWKE'S BAY REGIONAL COUNCIL

eCoast
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Lower Clive River Sediment Sampling and Depth Probing

Report Status

Version	Date	Status	Approved by
V.1	12 August 2019	Final Draft	STM
V.2	15 August 2019	Rev. 1	STM

It is the responsibility of the reader to verify the version number of this report.

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1 Introduction

The Hawke's Bay Regional Council (HBRC) commissioned eCoast marine consulting and research to undertake a sampling programme in the lower Clive River (Figure 1.1) to determine the characteristics of the sediment in the area, which is to be dredged and disposed of in order to deepen this section of the river. The characterisation of the sediments to be discharged includes discharge volume, type (grain size) and contaminants (nutrients, PAH's, trace metals, TOC, level of hypoxia, SVOC's). In addition, probing was undertaken to determine the depth of the soft sediment that has accumulated above the original gravel riverbed.

Figure 1.1. Location plan of area to be dredged (delineated by the elongated yellow box). The potential disposal site is shown in yellow on the southern side of the estuary entrance.

2 Methodology

Sediment samples were collected at 11 sites (Figure 2.1) using a 100 mm diameter PVC corer, and sediment was placed into 3 different collection jars for the various contaminant laboratory tests (Figure 2.2). A YSI multi-meter was also used to measure the dissolved oxygen level in the upper layer of sediment. In addition, an extendable 10 mm diameter steel probe was pushed until resistance prevented further penetration to determine the thickness of fine sediment above the original gravel riverbed at each of the sample sites. Table 2.1 Includes the coordinates of the sample sites.

Figure 2.1. The 11 sediment and probe sampling sites are indicated by the yellow markers (the coordinates are presented in Table 2.1), and the digitised transects for dredging volume calculations are shown by the red lines.

Figure 2.2. A sediment core (left) and sample jar (right). Note, the ~5 mm of surficial sediment above the anoxic material.

Table 2.1: Sediment and probe sampling locations (WGS84) refer Figure 2.1.

Site	Latitude	Longitude
1	39°34'53.29"S	176°54'58.05"E
2	39°34'52.87"S	176°54'57.60"E
3	39°34'52.29"S	176°54'57.14"E
4	39°34'44.01"S	176°55'9.56"E
5	39°34'43.61"S	176°55'9.03"E
6	39°34'43.18"S	176°55'8.27"E
7	39°34'31.19"S	176°55'23.54"E
8	39°34'30.90"S	176°55'22.78"E
9	39°34'30.54"S	176°55'22.06"E
10	39°34'18.99"S	176°55'32.74"E
11	39°34'20.06"S	176°55'34.93"E

In order to estimate the total volume of fine sediment to be dredged from the lower Clive River (as delineated by the elongated yellow box in Figure 1.1), the 13 cross-sections surveyed by the HBRC (Figure 2.3) were digitised and the cross-sectional area in each was measured using AutoCAD. The distances between each cross-section and to the extents of the proposed dredging area were then digitised in Google Earth. An estimation of the volume of dredge material was calculated by averaging the volume of dredge material between transects and multiplying by the distance between each, and then summing all to generate a total estimated dredge volume.

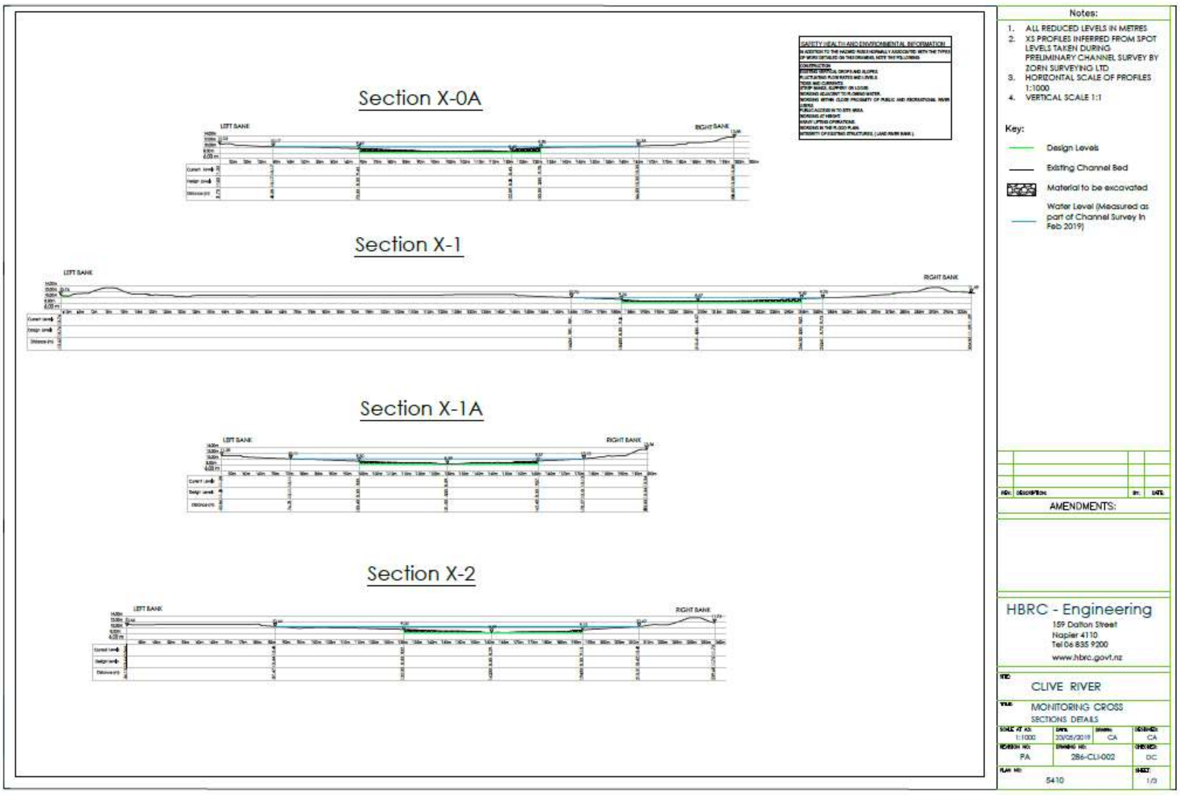

Figure 2.3. Cross-sections 0A to 2 along the lower Clive River shown the areas to be dredged and the depths that they will be dredged to (RL 8.3 m).

3 Results

3.1 Sediment Grain Size and Contaminants

3.1.1 Dissolved Oxygen

Sediment samples were found to be anoxic (i.e., black with an odour of hydrogen sulphide) with a small layer (~5 mm) of aerated surficial sediment (Figure 2.2), except for samples 10 and 11 located in the lower/northern part of the river closest to the entrance to the sea (Figure 2.1). At sample sites 10 and 11, a thick surficial layer of living pipi (*Paphies australis*) and cockles (*Astrovenus stutchburyi*), many with barnacles and small anemones attached, and a mix of small gravel and dead bivalve shells was present (Figure 3.1).

Figure 3.1. The surface layer at sites 10 and 11 (Figure 2.1) included living pipis and cockles, and a mix of small gravel and dead bivalve shells.

Dissolved oxygen was found to be relatively high in the water column (>12 mg/l). However, dissolved oxygen in the surficial sediment was found to be <2 mg/l at sites 1 to 6 (i.e. hypoxic), and ~3-4 mg/l at sites 7 to 9; there was no surficial sediment layer at sites 10 and 11 (Figure 3.1). That is, oxygen levels in the surficial sediment increase towards the mouth of the river, which was supported by the presence of small gastropods at sample sites 7 to 9 (Figure 3.2) and bivalves at sites 10 and 11 (Figure 3.1).

Figure 3.2. Small gastropods in the oxygenated surface layer of sediment at sample site 7 (Figure 2.1).

3.1.2 Sediment Grainsize

The laboratory results of the sediment analyses are including in Appendix a. Sediment grainsize analysis results are summarised in Table 3.1.

Table 3.1. Broad classification of sediment grainsize fractions in the samples (Figure 2.1).

Site	Clay	Silt	Fine-Med Sand
1	18%	72%	11%
2	12%	71%	18%
3	14%	69%	18%
4	19%	70%	11%
5	17%	73%	10%
6	15%	71%	14%
7	18%	72%	11%
8	16%	65%	20%
9	16%	69%	15%
10	6%	25%	69%
11	3%	13%	84%

3.1.3 Sediment Organic Carbon

Because levels of organic carbon in sediments tend to be higher in samples with higher silt fractions, results have been normalised to 100% of the silt/clay fraction for each site in order to more accurately compare between sites. Herein, 'normalised' results are referring to this adjustment. Table 3.2 below details the total and normalised total organic carbon content in each sample.

Table 3.2. Total and normalised organic carbon content results.

Site	Organic Carbon (g/100g)	Normalised Organic Carbon (g/100g)
1	2.5	2.8
2	2.8	3.4
3	1.66	2.01
4	2.1	2.36
5	1.6	1.78
6	2.6	3.04
7	1.29	1.45
8	1.16	1.45
9	1.42	1.67
10	0.31	0.99
11	0.28	1.75

3.1.4 Sediment Nutrients

Table 3.3 below details the total and normalised total nitrogen and phosphorus content in each sample. When compared to other Hawkes Bay and reference estuaries throughout New Zealand, total nitrogen and total phosphorus concentrations at Sites 1-9 are elevated, and lie in the upper-range of recorded values (Table 3.3). Sites 10 and 11 returned nitrogen levels that were below the detection limit and mid-range phosphorus levels when compared to other recorded sites around New Zealand.

The Normalised phosphorus results at Sites 10 and 11 are relatively high at 1058 mg/kg and 2249 mg/kg, respectively, which is largely due to the low silt/clay content in the sediments at these locations.

Table 3.3. Total and normalised nitrogen and phosphorus content results. Note: BDL = Below Detection Limit of 0.05 g/100g.

Site	Total Nitrogen (g/100g)	Normalised Total Nitrogen (g/100g)	Total Phosphorus (mg/kg)	Normalised Total Phosphorus (mg/kg)
1	0.25	0.28	680	762
2	0.26	0.32	640	777
3	0.16	0.19	560	679
4	0.23	0.26	650	731
5	0.16	0.18	660	733
6	0.25	0.29	580	677
7	0.11	0.12	650	728
8	0.1	0.12	610	761
9	0.14	0.17	690	814
10	BDL	-	330	1058
11	BDL	-	360	2249
Reference Sites				
Otamatea/Kaipara[1]	0.08 – 0.24	-	443 – 619	-
Ohiwa[1]	0.025 – 0.1	-	212 – 350	-
Ruataniwha[1]	0.025 – 0.07	-	330 – 580	-
Waimea[1]	0.025 – 0.1	-	243 – 562	-
Havelock[1]	0.007 – 0.09	-	241 – 433	-
Kaikorai[1]	0.15 – 0.21	-	728 – 913	-
Avon-Heathcote[1]	0.025 – 0.06	-	298 – 355	-
Ahuriri[2]	0.079 – 0.084	-	320 – 810	-

1. Robertson *et al.* (2002) **2.** Bennet (2006)

3.1.5 Sediment Trace Metals

Table 3.4and Table 3.5 below shows the trace metal content results, as well as the ANZECC (2000) Interim Sediment Quality Guidelines low threshold values (ISQG-Low), above which biological effects can be expected. Samples 1 and 2 (adjacent to the Clive River Bridge) have elevated zinc levels above the ISQG-Low threshold. All other levels are below the ISQG-Low threshold values.

Table 3.4. Trace metal results and ANZECC (2000) ISQG-Low guidelines (mg/kg dry weight). Yellow shaded cells indicate an ISQG-Low exceedance.

Site	Cadmium	Chromium	Copper	Nickel	Lead	Zinc	Arsenic	Mercury
1	0.137	19.2	19.4	13.1	22	230	4.9	0.08
2	0.175	21	22	14.2	24	260	6.4	0.09
3	0.16	18.6	18.2	13.2	23	189	7.2	0.09
4	0.125	18.8	17.1	13.9	18.5	183	4.5	0.08
5	0.098	17.8	15.8	13.2	17	157	4.2	0.07
6	0.175	19.9	22	14.1	23	270	8.6	0.09
7	0.061	15.8	11.7	12.9	14.4	82	3.8	0.07
8	0.049	15.9	10.2	13.2	12.5	74	3.4	0.07
9	0.081	17.1	12.8	14.3	15.1	112	4.3	0.07
10	0.019	9.6	4.7	7.8	6.6	41	2.4	0.04
11	0.024	9.6	5	7.5	6.5	42	2.4	0.05
ISQG-Low	1.5	80	65	21	50	200	20	0.15

Trace metals have been shown to preferentially adhere to fine sediments in the silt/clay fraction that have reactive surface properties. Therefore, differences in trace metal concentrations between sites may simply reflect differences in the proportion of sediments in this fraction. Normalising sediment contaminant data allows standardisation of sediment contaminants to sediment composition. Table 3.5 below shows the normalised trace metal concentrations at all 11 sites, which due to the small fraction of silt/clay in the lower river sites (i.e., 10 and 11) imply higher concentrations in this samples for nickel, zinc and mercury. Site 3 and 4 are also above the ISQG-Low threshold for zinc when the samples are normalised for silt/clay sediment fractions.

Table 3.5. Normalised trace metal results (mg/kg dry weight).

Site	Cadmium	Chromium	Copper	Nickel	Lead	Zinc	Arsenic	Mercury
1	0.154	21.5	21.7	14.7	24.7	258	5.5	0.09
2	0.212	25.5	26.7	17.2	29.1	316	7.8	0.11
3	0.194	22.6	22.1	16.0	27.9	229	8.7	0.11
4	0.141	21.1	19.2	15.6	20.8	206	5.1	0.09
5	0.109	19.8	17.6	14.7	18.9	174	4.7	0.08
6	0.204	23.2	25.7	16.5	26.9	315	10.0	0.11
7	0.068	17.7	13.1	14.5	16.1	92	4.3	0.08
8	0.061	19.8	12.7	16.5	15.6	92	4.2	0.09
9	0.096	20.2	15.1	16.9	17.8	132	5.1	0.08
10	0.061	30.8	15.1	25.0	21.2	131	7.7	0.13
11	0.150	60.0	31.2	46.8	40.6	262	15.0	0.31

3.1.6 Sediment Total Petroleum Hydrocarbons

Hydrocarbons C7 – C20 (number of carbon atoms in the hydrocarbon) were all found to be below detection limit and so only C21 – C44 are considered. Table 3.6 below details the total petroleum hydrocarbon results for each sample. These values are all extremely low when compared to the Ministry for the Environment (MfE, 1999) low threshold guidelines for all sediment types (20,000 mg/kg).

Table 3.6. Total petroleum hydrocarbon results (C21 – C44). Note: BDL = Below Detection Limit of 14 mg/kg.

Site	Total Petroleum Hydrocarbons (mg/kg dry weight)
1	109
2	136
3	39
4	69
5	BDL
6	39
7	BDL
8	BDL
9	BDL
10	23
11	BDL

3.2 Sediment Volume to be Dredged

Table 3.7 presents the results from the digital volumetric analysis of the proposed dredge material. It is estimated that approximately 60,500 m^3 of find sediment material in the lower Clive River will require dredging and disposal.

Table 3.7. Estimated volumes of fine sediment to be dredged from the lower Clive River (Figure 2.1).

Profile	Volume (m^3)	Distance	Ave volume	Volume/segment
Start	29.4	0	0	0
0A	29.4	200	29.4	5880
1	42.8	126	36.1	4548.6
1A	34.8	140	38.8	5432
2	29.9	106	32.35	3429.1
2A	29.4	127	29.65	3765.55
3	23.9	117	26.65	3118.05
3A	28.2	150	26.05	3907.5
4	35.4	154	31.8	4897.2
4A	37.6	140	36.5	5110
5	26.2	141	31.9	4497.9
5A	35.4	119	30.8	3665.2
6	39.9	157	37.65	5911.05
End	21	208	30.45	6333.6
			Total Volume	**60495.75**

By applying the percentages of each fraction to the volume calculations (with the assumption that only the lower river has high sand content), the estimated volumes of each of the 3 main sediment fractions to be dredged and discharged are[1]:

- Clay (<3.9 µm) 8,888 m^3 (14.7%)
- Silt (3.9 to 63 µm) 39,390 m^3 (65.1%)
- Fine to Medium grain sand (63-500 µm) 12,205 m^3 (20.2%)

3.3 Sediment Depth Above Gravel Riverbed

Table 3.8 presents the results of the sediment depth probing at each sample site. Cross-checking the mud depths estimated with the probe (Table 3.8) and the depths to be dredged to as shown on the HBRC cross-sections (Figure 2.3) indicates that there is general agreement with the probe depths and the proposed depth to be dredged to. This provides

[1] This estimate assumes that the sediment grade is similar throughout the depth of sediment above the river gravel layer.

additional confidence that the removal of ~60,500 m^3 of accumulated soft sediment from the lower Clive River is in line with the location of the original gravel riverbed.

Table 3.8. Probing results.

Site	Water depth (m)	Mud depth (m)	Water + Mud (m)
1	1.3	0.3	1.6
2	1.4	0.5	1.9
3	1.4	0.35	1.75
4	0.9	0.8	1.7
5	1.4	0.5	1.9
6	1.3	0.35	1.65
7	1.5	0.7	2.2
8	1.1	0.65	1.75
9	0.8	0.85	1.65
10	1.1	0.9	2
11	0.8	0.9	1.7

4 Tubeworms Infesting the Clive River Bridge

At the completion of the survey, the piles on the Clive River Bridge (SH2) were investigated for the Australian tubeworm (*Ficopomatus enigmaticus*), an invasive marine pest. The tubeworms were found on every pile from the low water mark to close to the riverbed, and in some places >30 cm thick (Figure 4.1 and Figure 4.2). Tubeworms were also present in clumps beside the bridge piles (Figure 4.3), presumably attached to pieces of rock or concrete.

Figure 4.1. Clumps of the invasive marine pest, the Australian tubeworm (*Ficopomatus enigmaticus*), that infest the Clive River Bridge piles.

Figure 4.2. Australian tubeworms (*Ficopomatus enigmaticus*) are present from the low water mark to near the riverbed on every pile of the bridge that is in the water.

Figure 4.3. Tubeworms are also present in clumps beside the bridge piles.

5 Summary

1. The lower Clive River area is to be dredged to removed sediment that have accumulated in the area.
2. Sediment samples (11) were collected in the lower Clive River to determine the characteristics of the sediments to be discharged; i.e., type (grain size) and contaminants (nutrients, PAH's, trace metals, TOC, level of hypoxia, SVOC's).
3. In addition, probing was undertaken to determine the depth of the soft sediment that has accumulated above the original gravel riverbed, and the dredge/discharge volume was calculated from river cross-sections.
4. Samples were found to be anoxic, with a thin aerated layer – oxygen levels increased towards the river mouth, with small gastropods present at sites 7 to 9 and a thick surficial layer of living pipi (*Paphies australis*) and cockles (*Astrovenus stutchburyi*), many with barnacles and small anemones attached, at sites 10 and 11.
5. Dissolved oxygen was found to be relatively high in the water column (>12 mg/l). However, dissolved oxygen in the surficial sediment was found to be <2 mg/l at sites 1 to 6 (i.e. hypoxic), and ~3-4 mg/l at sites 7 to 9; there was no surficial sediment layer at sites 10 and 11. That is, oxygen levels in the surficial sediment increase towards the mouth of the river, which was supported by the presence of small gastropods at sample sites 7 to 9 and bivalves at sites 10 and 11.
6. Sediment contaminants were found to be mostly below guideline thresholds, and in some cases undetectable. However, sediment nutrients (i.e. total nitrogen and total phosphorous were found to be in the upper-range of recorded values for reference sites in the Hawke's Bay and other estuaries in New Zealand. Zinc levels were also found to be elevated above the ISQG-Low threshold level at sites 1 and 2 (i.e. adjacent to the Clive River Bridge).
7. The total sediment volume to be dredged is estimated at 60,500 m^3. Sediment depths determined with a probe were found to support the cross-sections that were used to estimate the volume of sediment to be dredged.
8. Based on the sediment grainsize analysis, and assuming that similar grades of sediment are present throughout the depth of sediment above the river gravel layer, the estimated volumes to be dredged and discharged are:
    - Clay (<3.9 µm) 8,888 m^3 (14.7%)
    - Silt (3.9 to 63 µm) 39,390 m^3 (65.1%)
    - Fine to Medium grain sand (63-500 µm) 12,205 m^3 (20.2%)
9. The Australian tubeworm (*Ficopomatus enigmaticus*), an invasive marine pest, is present between the low water mark and the riverbed (~1.0 m deep) encrusting all of

the Clive River Bridge piles that are in the water, as well as in clumps adjacent to the piles.

References

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Bennett, C. (2006). Ahuriri Storm water Discharge Compliance Monitoring. Napier, Cawthron Report 1146.

Ministry for the Environment (1999). Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand. Module 4 - Tier 1 Soil Screening Criteria.

Robertson B, Gillespie P, Asher R, Frisk S, Keeley N, Hopkins G, Thompson S, Tuckey B (2002). Estuarine environmental assessment and monitoring: a national protocol. Report prepared for the Supporting Councils and Ministry for the Environment, Sustainable Management Fund, Contract No. 5096. 93 p.

Appendix A. Sediment Analysis Results

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Certificate of Analysis

Client:	eCoast Limited	**Lab No:**	2211219 SPv2
Contact:	Shaw Mead	**Date Received:**	19-Jul-2019
	C/- eCoast Limited	**Date Reported:**	08-Aug-2019
	PO Box 151	**Quote No:**	99757
	Raglan 3225	**Order No:**	
		Client Reference:	Clive River
		Submitted By:	Shaw Mead

Sample Type: Sediment

Sample Name:		Clive 1 18-Jul-2019 12:53 pm	Clive 2 18-Jul-2019 1:01 pm	Clive 3 18-Jul-2019 1:07 pm	Clive 4 18-Jul-2019 1:16 pm	Clive 5 18-Jul-2019 1:24 pm
Lab Number:		2211219.1	2211219.2	2211219.3	2211219.4	2211219.5
Individual Tests						
Dry Matter	g/100g as rcvd	45	43	59	43	53
Particle size analysis*		See attached report	See attached report	See attached report	See attached report	See attached report
Total Recoverable Beryllium*	mg/kg dry wt	0.8	0.8	0.8	0.8	0.7
Total Recoverable Boron	mg/kg dry wt	25	26	20	24	19
Chromium (hexavalent)*	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total Recoverable Cobalt	mg/kg dry wt	7.3	7.8	7.4	7.5	7.1
Total Recoverable Manganese	mg/kg dry wt	390	350	350	410	330
Total Recoverable Phosphorus	mg/kg dry wt	680	640	560	650	660
Total Recoverable Selenium	mg/kg dry wt	< 2	< 2	< 2	< 2	< 2
Total Nitrogen*	g/100g dry wt	0.25	0.26	0.16	0.23	0.16
Ammonium-N*	mg/kg dry wt	< 5	< 5	< 5	47	< 5
Nitrite-N*	mg/kg dry wt	< 1.1	< 1.1	< 1.0	< 1.1	< 1.0
Nitrate-N*	mg/kg dry wt	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
Nitrate-N + Nitrite-N*	mg/kg dry wt	< 1.1	< 1.1	< 1.0	< 1.1	< 1.0
Total Organic Carbon*	g/100g dry wt	2.5	2.8	1.66	2.1	1.60
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	4.9	6.4	7.2	4.5	4.2
Total Recoverable Cadmium	mg/kg dry wt	0.137	0.175	0.160	0.125	0.098
Total Recoverable Chromium	mg/kg dry wt	19.2	21	18.6	18.8	17.8
Total Recoverable Copper	mg/kg dry wt	19.4	22	18.2	17.1	15.8
Total Recoverable Lead	mg/kg dry wt	22	24	23	18.5	17.0
Total Recoverable Mercury	mg/kg dry wt	0.08	0.09	0.09	0.08	0.07
Total Recoverable Nickel	mg/kg dry wt	13.1	14.2	13.2	13.9	13.2
Total Recoverable Zinc	mg/kg dry wt	230	260	189	183	157
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.3	< 0.3	< 0.19	< 0.3	< 0.3
2,4-Dinitrotoluene	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.3	< 0.3
2,6-Dinitrotoluene	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.3	< 0.3
Nitrobenzene	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.3	< 0.3	< 0.19	< 0.3	< 0.3

Sample Type: Sediment						
Sample Name:		Clive 1 18-Jul-2019 12:53 pm	Clive 2 18-Jul-2019 1:01 pm	Clive 3 18-Jul-2019 1:07 pm	Clive 4 18-Jul-2019 1:16 pm	Clive 5 18-Jul-2019 1:24 pm
Lab Number:		2211219.1	2211219.2	2211219.3	2211219.4	2211219.5
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
alpha-BHC	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
beta-BHC	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
delta-BHC	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
gamma-BHC (Lindane)	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
4,4'-DDD	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
4,4'-DDE	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
4,4'-DDT	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.3	< 0.3
Dieldrin	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Endosulfan I	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.3	< 0.3
Endosulfan II	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Endosulfan sulphate	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.3	< 0.3
Endrin	mg/kg dry wt	< 0.3	< 0.3	< 0.19	< 0.3	< 0.3
Endrin ketone	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.3	< 0.3
Heptachlor	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Heptachlor epoxide	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Hexachlorobenzene	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples						
Acenaphthene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Anthracene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Benzo[k]fluoranthene	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
1&2-Chloronaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Chrysene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Fluoranthene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
2-Methylnaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Naphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Pyrene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2-Chlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2,4-Dichlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2-Nitrophenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	< 6	< 6	< 6	< 6
Phenol	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.3	< 0.3
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.3	< 0.3
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.3	< 0.3

Sample Type: Sediment						
Sample Name:		Clive 1 18-Jul-2019 12:53 pm	Clive 2 18-Jul-2019 1:01 pm	Clive 3 18-Jul-2019 1:07 pm	Clive 4 18-Jul-2019 1:16 pm	Clive 5 18-Jul-2019 1:24 pm
Lab Number:		2211219.1	2211219.2	2211219.3	2211219.4	2211219.5
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Butylbenzylphthalate	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.3	< 0.3
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Diethylphthalate	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.3	< 0.3
Dimethylphthalate	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.3	< 0.3
Di-n-butylphthalate	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.3	< 0.3
Di-n-octylphthalate	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.3	< 0.3
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.3	< 0.19	< 0.3	< 0.3
1,3-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.3	< 0.19	< 0.3	< 0.3
1,4-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.3	< 0.19	< 0.3	< 0.3
Hexachlorobutadiene	mg/kg dry wt	< 0.3	< 0.3	< 0.19	< 0.3	< 0.3
Hexachloroethane	mg/kg dry wt	< 0.3	< 0.3	< 0.19	< 0.3	< 0.3
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 1.2	< 1.3	< 1.0	< 1.3	< 1.1
Carbazole	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Dibenzofuran	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Isophorone	mg/kg dry wt	< 0.12	< 0.13	< 0.10	< 0.13	< 0.11
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 14	< 14	< 10	< 14	< 11
C10 - C11	mg/kg dry wt	< 14	< 14	< 10	< 14	< 11
C12 - C14	mg/kg dry wt	< 14	< 14	< 10	< 14	< 11
C15 - C20	mg/kg dry wt	< 14	14	< 10	< 14	< 11
C21 - C25	mg/kg dry wt	15	25	< 10	< 14	< 11
C26 - C29	mg/kg dry wt	17	22	< 10	< 14	< 11
C30 - C44	mg/kg dry wt	77	74	39	69	< 20
Total hydrocarbons (C7 - C44)	mg/kg dry wt	109	136	< 80	< 110	< 90

Sample Name:		Clive 6 18-Jul-2019 1:28 pm	Clive 7 18-Jul-2019 1:34 pm	Clive 8 18-Jul-2019 1:40 pm	Clive 9 18-Jul-2019 1:43 pm	Clive 10 18-Jul-2019 1:50 pm
Lab Number:		2211219.6	2211219.7	2211219.8	2211219.9	2211219.10
Individual Tests						
Dry Matter	g/100g as rcvd	42	55	58	49	74
Particle size analysis*		See attached report	See attached report	See attached report	See attached report	See attached report
Total Recoverable Beryllium*	mg/kg dry wt	0.8	0.7	0.7	0.7	0.4
Total Recoverable Boron	mg/kg dry wt	31	19	18	18	5
Chromium (hexavalent)*	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total Recoverable Cobalt	mg/kg dry wt	8.0	7.0	6.7	7.4	4.3
Total Recoverable Manganese	mg/kg dry wt	470	300	280	350	240
Total Recoverable Phosphorus	mg/kg dry wt	580	650	610	690	330
Total Recoverable Selenium	mg/kg dry wt	< 2	< 2	< 2	< 2	< 2
Total Nitrogen*	g/100g dry wt	0.25	0.11	0.10	0.14	< 0.05
Ammonium-N*	mg/kg dry wt	< 5	< 5	< 5	13	< 5
Nitrite-N*	mg/kg dry wt	< 1.1	< 1.0	< 1.0	< 1.0	< 1.0
Nitrate-N*	mg/kg dry wt	< 1.6	< 1.5	< 1.5	< 1.5	2.4
Nitrate-N + Nitrite-N*	mg/kg dry wt	< 1.1	< 1.0	< 1.0	< 1.0	2.5
Total Organic Carbon*	g/100g dry wt	2.6	1.29	1.16	1.42	0.31
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	8.6	3.8	3.4	4.3	2.4
Total Recoverable Cadmium	mg/kg dry wt	0.175	0.061	0.049	0.081	0.019
Total Recoverable Chromium	mg/kg dry wt	19.9	15.8	15.9	17.1	9.6
Total Recoverable Copper	mg/kg dry wt	22	11.7	10.2	12.8	4.7

Sample Type: Sediment						
Sample Name:		Clive 6 18-Jul-2019 1:28 pm	Clive 7 18-Jul-2019 1:34 pm	Clive 8 18-Jul-2019 1:40 pm	Clive 9 18-Jul-2019 1:43 pm	Clive 10 18-Jul-2019 1:50 pm
Lab Number:		2211219.6	2211219.7	2211219.8	2211219.9	2211219.10
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Lead	mg/kg dry wt	23	14.4	12.5	15.1	6.6
Total Recoverable Mercury	mg/kg dry wt	0.09	0.07	0.07	0.07	0.04
Total Recoverable Nickel	mg/kg dry wt	14.1	12.9	13.2	14.3	7.8
Total Recoverable Zinc	mg/kg dry wt	270	82	74	112	41
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.3	< 0.2	< 0.19	< 0.3	< 0.15
2,4-Dinitrotoluene	mg/kg dry wt	< 0.3	< 0.2	< 0.2	< 0.3	< 0.2
2,6-Dinitrotoluene	mg/kg dry wt	< 0.3	< 0.2	< 0.2	< 0.3	< 0.2
Nitrobenzene	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.3	< 0.2	< 0.19	< 0.3	< 0.15
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
alpha-BHC	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
beta-BHC	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
delta-BHC	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
gamma-BHC (Lindane)	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
4,4'-DDD	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
4,4'-DDE	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
4,4'-DDT	mg/kg dry wt	< 0.3	< 0.2	< 0.2	< 0.3	< 0.2
Dieldrin	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Endosulfan I	mg/kg dry wt	< 0.3	< 0.2	< 0.2	< 0.3	< 0.2
Endosulfan II	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Endosulfan sulphate	mg/kg dry wt	< 0.3	< 0.2	< 0.2	< 0.3	< 0.2
Endrin	mg/kg dry wt	< 0.3	< 0.2	< 0.19	< 0.3	< 0.15
Endrin ketone	mg/kg dry wt	< 0.3	< 0.2	< 0.2	< 0.3	< 0.2
Heptachlor	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Heptachlor epoxide	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Hexachlorobenzene	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples						
Acenaphthene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Anthracene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Benzo[k]fluoranthene	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
1&2-Chloronaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Chrysene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Fluoranthene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
2-Methylnaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Naphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10

Sample Type: Sediment						
Sample Name:		Clive 6 18-Jul-2019 1:28 pm	Clive 7 18-Jul-2019 1:34 pm	Clive 8 18-Jul-2019 1:40 pm	Clive 9 18-Jul-2019 1:43 pm	Clive 10 18-Jul-2019 1:50 pm
Lab Number:		2211219.6	2211219.7	2211219.8	2211219.9	2211219.10
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples						
Pyrene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2-Chlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2,4-Dichlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2-Nitrophenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	< 6	< 6	< 6	< 6
Phenol	mg/kg dry wt	< 0.3	< 0.2	< 0.2	< 0.3	< 0.2
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.3	< 0.2	< 0.2	< 0.3	< 0.2
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.3	< 0.2	< 0.2	< 0.3	< 0.2
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	< 0.6	< 0.5	< 0.5	< 0.5	< 0.5
Butylbenzylphthalate	mg/kg dry wt	< 0.3	< 0.2	< 0.2	< 0.3	< 0.2
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Diethylphthalate	mg/kg dry wt	< 0.3	< 0.2	< 0.2	< 0.3	< 0.2
Dimethylphthalate	mg/kg dry wt	< 0.3	< 0.2	< 0.2	< 0.3	< 0.2
Di-n-butylphthalate	mg/kg dry wt	< 0.3	< 0.2	< 0.2	< 0.3	< 0.2
Di-n-octylphthalate	mg/kg dry wt	< 0.3	< 0.2	< 0.2	< 0.3	< 0.2
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.2	< 0.19	< 0.3	< 0.15
1,3-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.2	< 0.19	< 0.3	< 0.15
1,4-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.2	< 0.19	< 0.3	< 0.15
Hexachlorobutadiene	mg/kg dry wt	< 0.3	< 0.2	< 0.19	< 0.3	< 0.15
Hexachloroethane	mg/kg dry wt	< 0.3	< 0.2	< 0.19	< 0.3	< 0.15
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 1.3	< 1.0	< 1.0	< 1.1	< 1.0
Carbazole	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Dibenzofuran	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Isophorone	mg/kg dry wt	< 0.13	< 0.10	< 0.10	< 0.11	< 0.10
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 14	< 11	< 11	< 12	< 9
C10 - C11	mg/kg dry wt	< 14	< 11	< 11	< 12	< 9
C12 - C14	mg/kg dry wt	< 14	< 11	< 11	< 12	< 9
C15 - C20	mg/kg dry wt	< 14	< 11	< 11	< 12	< 9
C21 - C25	mg/kg dry wt	< 14	< 11	< 11	< 12	< 9
C26 - C29	mg/kg dry wt	< 14	< 11	< 11	< 12	< 9
C30 - C44	mg/kg dry wt	39	< 20	< 20	< 20	23
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 110	< 90	< 90	< 100	< 70

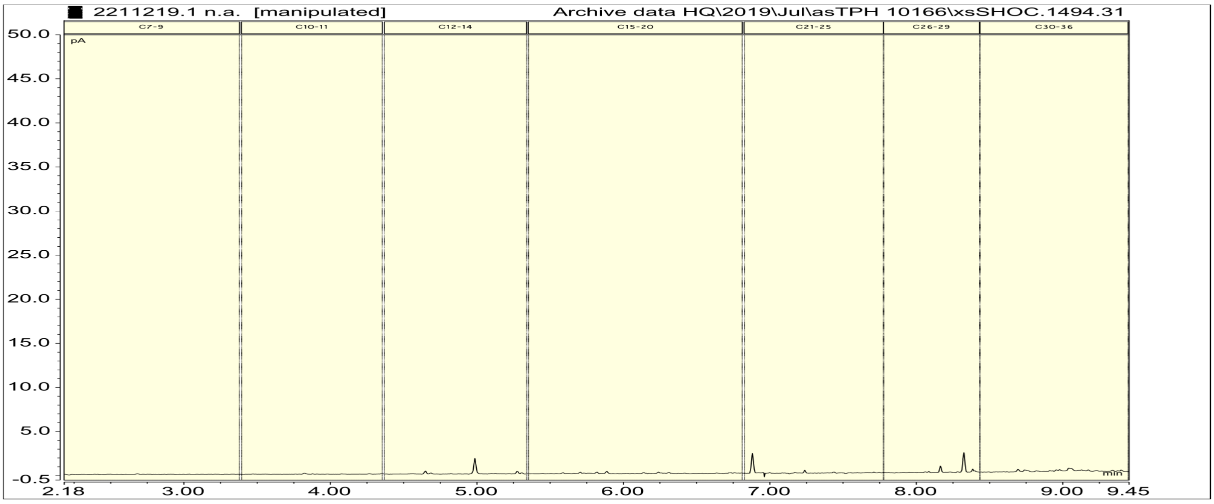
Sample Name:		Clive 11 18-Jul-2019 1:58 pm				
Lab Number:		2211219.11				
Individual Tests						
Dry Matter	g/100g as rcvd	85	-	-	-	-
Particle size analysis*		See attached report	-	-	-	-

Sample Type: Sediment						
	Sample Name:	Clive 11 18-Jul-2019 1:58 pm				
	Lab Number:	2211219.11				
Individual Tests						
Total Recoverable Beryllium*	mg/kg dry wt	0.4	-	-	-	-
Total Recoverable Boron	mg/kg dry wt	7	-	-	-	-
Chromium (hexavalent)*	mg/kg dry wt	< 0.4	-	-	-	-
Total Recoverable Cobalt	mg/kg dry wt	4.4	-	-	-	-
Total Recoverable Manganese	mg/kg dry wt	220	-	-	-	-
Total Recoverable Phosphorus	mg/kg dry wt	360	-	-	-	-
Total Recoverable Selenium	mg/kg dry wt	< 2	-	-	-	-
Total Nitrogen*	g/100g dry wt	< 0.05	-	-	-	-
Ammonium-N*	mg/kg dry wt	< 5	-	-	-	-
Nitrite-N*	mg/kg dry wt	< 1.0	-	-	-	-
Nitrate-N*	mg/kg dry wt	< 1.5	-	-	-	-
Nitrate-N + Nitrite-N*	mg/kg dry wt	< 1.0	-	-	-	-
Total Organic Carbon*	g/100g dry wt	0.28	-	-	-	-
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	2.4	-	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	0.024	-	-	-	-
Total Recoverable Chromium	mg/kg dry wt	9.6	-	-	-	-
Total Recoverable Copper	mg/kg dry wt	5.0	-	-	-	-
Total Recoverable Lead	mg/kg dry wt	6.5	-	-	-	-
Total Recoverable Mercury	mg/kg dry wt	0.05	-	-	-	-
Total Recoverable Nickel	mg/kg dry wt	7.5	-	-	-	-
Total Recoverable Zinc	mg/kg dry wt	42	-	-	-	-
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.10	-	-	-	-
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.10	-	-	-	-
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.10	-	-	-	-
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.10	-	-	-	-
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.10	-	-	-	-
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.13	-	-	-	-
2,4-Dinitrotoluene	mg/kg dry wt	< 0.2	-	-	-	-
2,6-Dinitrotoluene	mg/kg dry wt	< 0.2	-	-	-	-
Nitrobenzene	mg/kg dry wt	< 0.10	-	-	-	-
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.13	-	-	-	-
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.10	-	-	-	-
alpha-BHC	mg/kg dry wt	< 0.10	-	-	-	-
beta-BHC	mg/kg dry wt	< 0.10	-	-	-	-
delta-BHC	mg/kg dry wt	< 0.10	-	-	-	-
gamma-BHC (Lindane)	mg/kg dry wt	< 0.10	-	-	-	-
4,4'-DDD	mg/kg dry wt	< 0.10	-	-	-	-
4,4'-DDE	mg/kg dry wt	< 0.10	-	-	-	-
4,4'-DDT	mg/kg dry wt	< 0.2	-	-	-	-
Dieldrin	mg/kg dry wt	< 0.10	-	-	-	-
Endosulfan I	mg/kg dry wt	< 0.2	-	-	-	-
Endosulfan II	mg/kg dry wt	< 0.5	-	-	-	-
Endosulfan sulphate	mg/kg dry wt	< 0.2	-	-	-	-
Endrin	mg/kg dry wt	< 0.13	-	-	-	-
Endrin ketone	mg/kg dry wt	< 0.2	-	-	-	-
Heptachlor	mg/kg dry wt	< 0.10	-	-	-	-
Heptachlor epoxide	mg/kg dry wt	< 0.10	-	-	-	-
Hexachlorobenzene	mg/kg dry wt	< 0.10	-	-	-	-

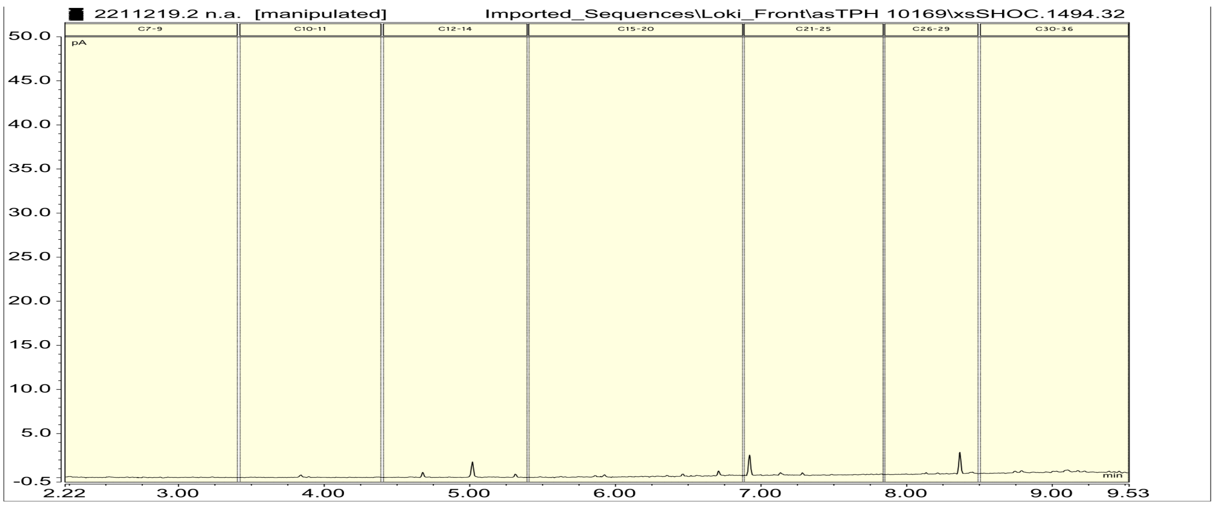
Sample Type: Sediment						
Sample Name:		Clive 11 18-Jul-2019 1:58 pm				
Lab Number:		2211219.11				
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples						
Acenaphthene	mg/kg dry wt	< 0.10	-	-	-	-
Acenaphthylene	mg/kg dry wt	< 0.10	-	-	-	-
Anthracene	mg/kg dry wt	< 0.10	-	-	-	-
Benzo[a]anthracene	mg/kg dry wt	< 0.10	-	-	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.10	-	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.10	-	-	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.10	-	-	-	-
Benzo[k]fluoranthene	mg/kg dry wt	< 0.10	-	-	-	-
1&2-Chloronaphthalene	mg/kg dry wt	< 0.10	-	-	-	-
Chrysene	mg/kg dry wt	< 0.10	-	-	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.10	-	-	-	-
Fluoranthene	mg/kg dry wt	< 0.10	-	-	-	-
Fluorene	mg/kg dry wt	< 0.10	-	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.10	-	-	-	-
2-Methylnaphthalene	mg/kg dry wt	< 0.10	-	-	-	-
Naphthalene	mg/kg dry wt	< 0.10	-	-	-	-
Phenanthrene	mg/kg dry wt	< 0.10	-	-	-	-
Pyrene	mg/kg dry wt	< 0.10	-	-	-	-
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	< 0.3	-	-	-	-
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	< 0.3	-	-	-	-
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	-	-	-	-
2-Chlorophenol	mg/kg dry wt	< 0.2	-	-	-	-
2,4-Dichlorophenol	mg/kg dry wt	< 0.2	-	-	-	-
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	-	-	-	-
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.4	-	-	-	-
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.2	-	-	-	-
2-Nitrophenol	mg/kg dry wt	< 0.4	-	-	-	-
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	-	-	-	-
Phenol	mg/kg dry wt	< 0.2	-	-	-	-
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.2	-	-	-	-
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.2	-	-	-	-
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	< 0.5	-	-	-	-
Butylbenzylphthalate	mg/kg dry wt	< 0.2	-	-	-	-
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.2	-	-	-	-
Diethylphthalate	mg/kg dry wt	< 0.2	-	-	-	-
Dimethylphthalate	mg/kg dry wt	< 0.2	-	-	-	-
Di-n-butylphthalate	mg/kg dry wt	< 0.2	-	-	-	-
Di-n-octylphthalate	mg/kg dry wt	< 0.2	-	-	-	-
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.13	-	-	-	-
1,3-Dichlorobenzene	mg/kg dry wt	< 0.13	-	-	-	-
1,4-Dichlorobenzene	mg/kg dry wt	< 0.13	-	-	-	-
Hexachlorobutadiene	mg/kg dry wt	< 0.13	-	-	-	-
Hexachloroethane	mg/kg dry wt	< 0.13	-	-	-	-
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.10	-	-	-	-
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 1.0	-	-	-	-
Carbazole	mg/kg dry wt	< 0.10	-	-	-	-
Dibenzofuran	mg/kg dry wt	< 0.10	-	-	-	-

Sample Type: Sediment						
	Sample Name:	Clive 11 18-Jul-2019 1:58 pm				
	Lab Number:	2211219.11				
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Isophorone	mg/kg dry wt	< 0.10	-	-	-	-
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 8	-	-	-	-
C10 - C11	mg/kg dry wt	< 8	-	-	-	-
C12 - C14	mg/kg dry wt	< 8	-	-	-	-
C15 - C20	mg/kg dry wt	< 8	-	-	-	-
C21 - C25	mg/kg dry wt	< 8	-	-	-	-
C26 - C29	mg/kg dry wt	< 8	-	-	-	-
C30 - C44	mg/kg dry wt	< 20	-	-	-	-
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 70	-	-	-	-

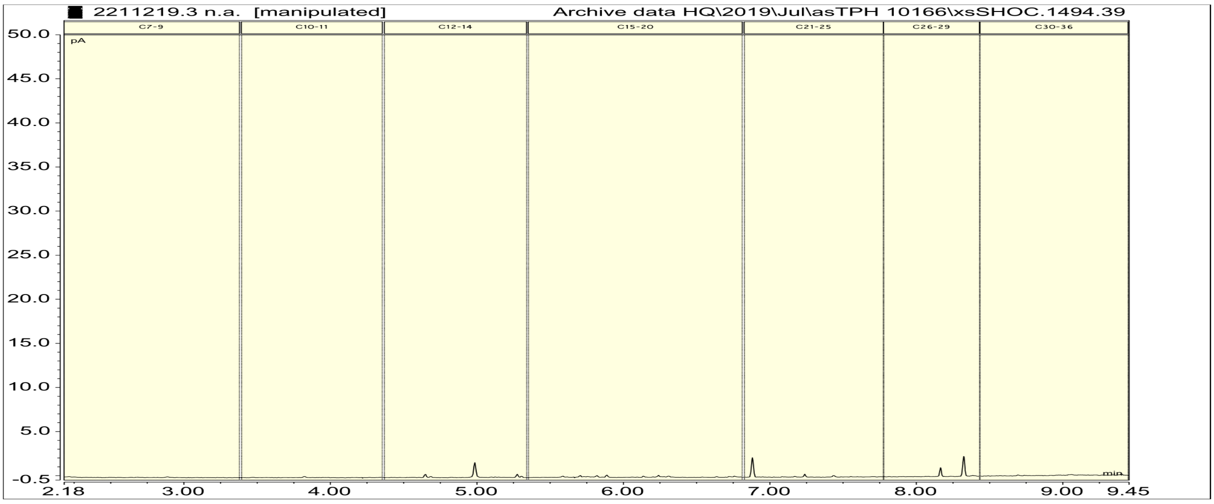
2211219.1
Clive 1 18-Jul-2019 12:53 pm
Client Chromatogram for TPH by FID



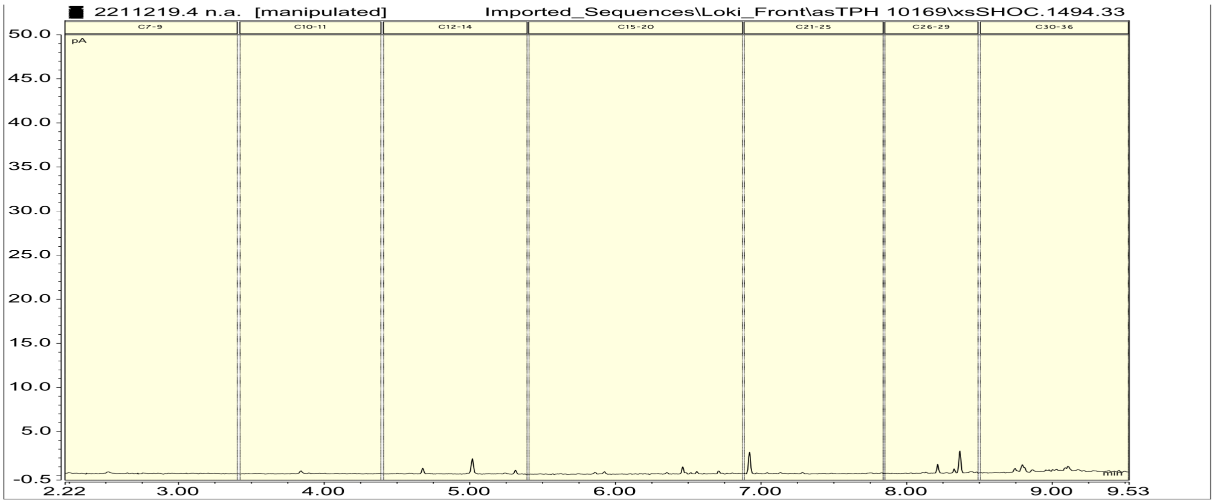
2211219.2
Clive 2 18-Jul-2019 1:01 pm
Client Chromatogram for TPH by FID



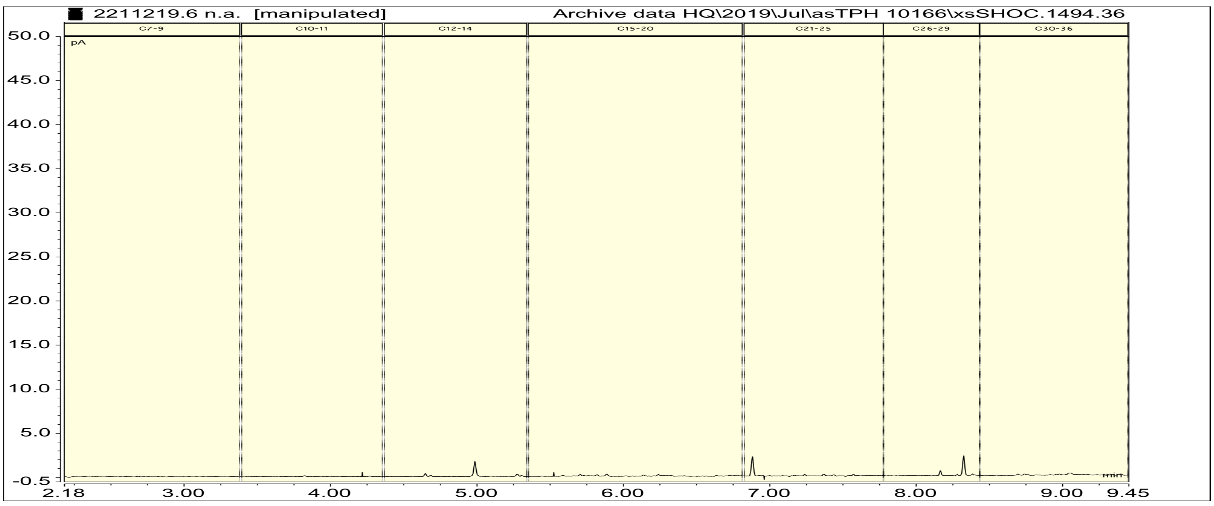
2211219.3
Clive 3 18-Jul-2019 1:07 pm
Client Chromatogram for TPH by FID



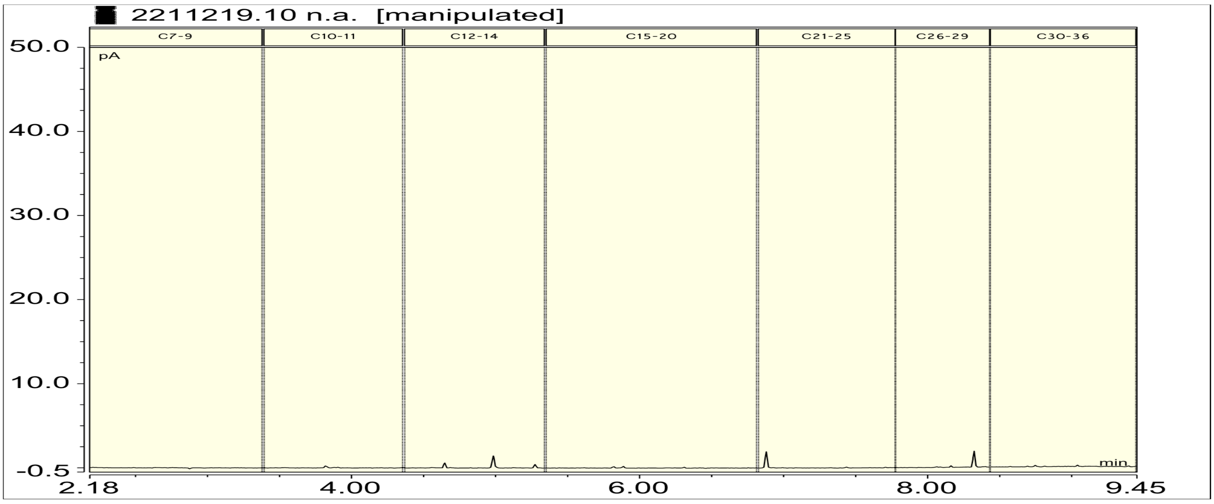
2211219.4
Clive 4 18-Jul-2019 1:16 pm
Client Chromatogram for TPH by FID



2211219.6
Clive 6 18-Jul-2019 1:28 pm
Client Chromatogram for TPH by FID



2211219.10
Clive 10 18-Jul-2019 1:50 pm
Client Chromatogram for TPH by FID



Analyst's Comments

Appendix No.1 - Waikato University report

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Sample No
Environmental Solids Sample Drying*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-11
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-11
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, trace level.	0.010 - 0.4 mg/kg dry wt	1-11
Semivolatile Organic Compounds Trace in Soil by GC-MS	Sonication extraction, GPC cleanup, GC-MS FS analysis. Tested on as received sample	0.002 - 6 mg/kg dry wt	1-11
Total Petroleum Hydrocarbons in Soil, GC*	Sonication extraction, Silica cleanup, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines. Tested on as received sample [KBIs:5786,2805,10734]	8 - 70 mg/kg dry wt	1-11
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. (Free water removed before analysis, non-soil objects such as sticks, leaves, grass and stones also removed). US EPA 3550.	0.10 g/100g as rcvd	1-11
2M KCl Extraction*	2M potassium chloride extraction of as received fraction for analysis of NH4N, NO2N and NO3N. Analyst, 109, 549, (1984).	-	1-11
Extraction of Exchangeable Hexavalent Chromium*	0.01M KH_2PO_4 Extraction.	-	1-11
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-11
Particle size analysis*	Malvern Laser Sizer particle size analysis from 0.05 microns to 3.4 mm. Samples are measured in volume %. Subcontracted to Earth Sciences Department, Waikato University, Hamilton.	-	1-11
Total Recoverable Beryllium*	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.2 mg/kg dry wt	1-11
Total Recoverable Boron	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	2 mg/kg dry wt	1-11
Hexavalent Chromium in Environmental Solids*	Phosphate buffer extraction, colorimetry.	0.4 mg/kg dry wt	1-11
Total Recoverable Cobalt	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.04 mg/kg dry wt	1-11

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Recoverable Manganese	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	1.0 mg/kg dry wt	1-11
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-11
Total Recoverable Selenium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	2 mg/kg dry wt	1-11
Total Nitrogen*	Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-11
Ammonium-N*	2M potassium chloride extraction on as received fraction. Phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-NH_3 F (modified) 23rd ed. 2017.	5 mg/kg dry wt	1-11
Nitrite-N*	FIA determination of 2M potassium chloride extraction on as received fraction. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	1.0 mg/kg dry wt	1-11
Nitrate-N*	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N.	1.5 mg/kg dry wt	1-11
Nitrate-N + Nitrite-N*	Automated cadmium reduction, FIA determination of 2M potassium chloride extraction on as received fraction. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	1.0 mg/kg dry wt	1-11
Total Organic Carbon*	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-11

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Analysis - Under

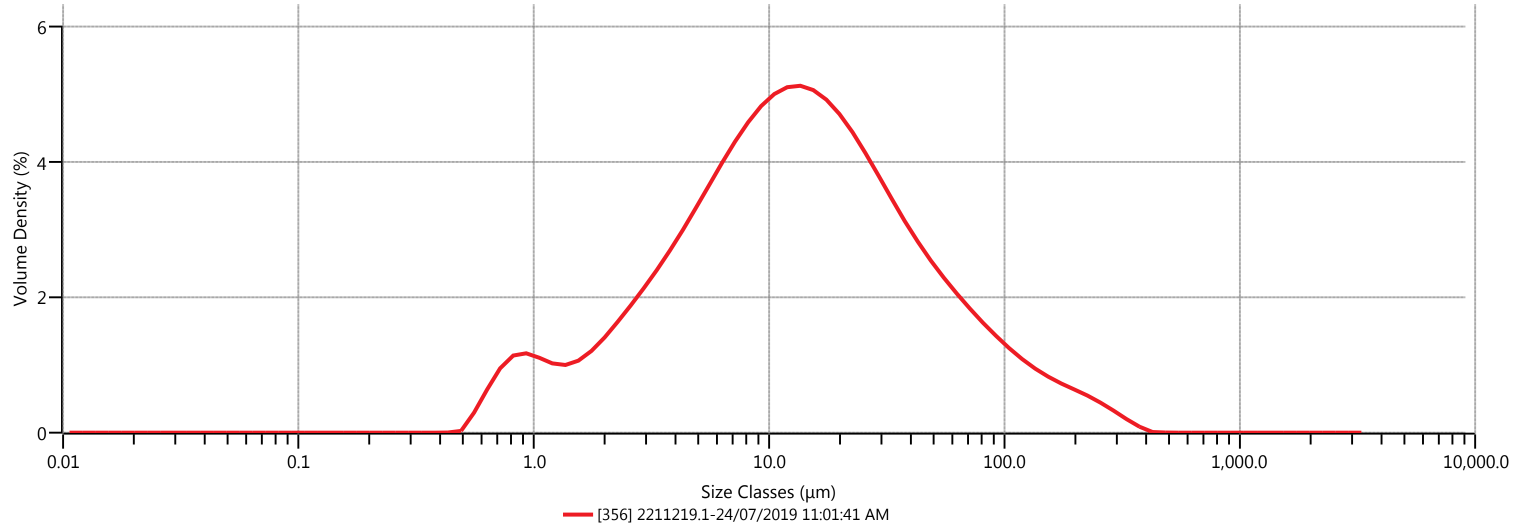
Measurement Details	
Sample Name	2211219.1
SOP File Name	Marine Sediment.msop
Lab Number	2019126/1
Operator Name	instrument

Measurement Details	
Analysis Date Time	24/07/2019 11:01:41 AM
Measurement Date Time	24/07/2019 11:01:41 AM
Result Source	Measurement

Analysis	
Particle Name	Marine Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.64 %
Laser Obscuration	14.13 %

Result	
Concentration	0.0115 %
Span	5.003
Uniformity	1.688
Specific Surface Area	1065 m^2/kg
D [3,2]	5.63 μm
D [4,3]	27.6 μm
Dv (10)	2.30 μm
Dv (50)	12.9 μm
Dv (90)	66.7 μm

Frequency (compatible)



Result

Size (μm)	% Volume Under	Size (μm)	% Volume Under	Size (μm)	% Volume Under	Size (μm)	% Volume Under	Size (μm)	% Volume Under
0.0500	0.00	7.80	33.96	88.0	93.09	350	99.92	1410	100.00
0.0600	0.00	15.6	56.41	105	94.66	420	100.00	1680	100.00
0.120	0.00	31.0	76.39	125	95.96	500	100.00	2000	100.00
0.240	0.00	37.0	80.29	149	97.03	590	100.00	2380	100.00
0.490	0.00	44.0	83.64	177	97.90	710	100.00	2830	100.00
0.980	3.44	53.0	86.75	210	98.64	840	100.00	3360	100.00
2.00	8.59	63.0	89.23	250	99.24	1000	100.00		
3.90	17.52	74.0	91.24	300	99.70	1190	100.00		

Analysis - Under

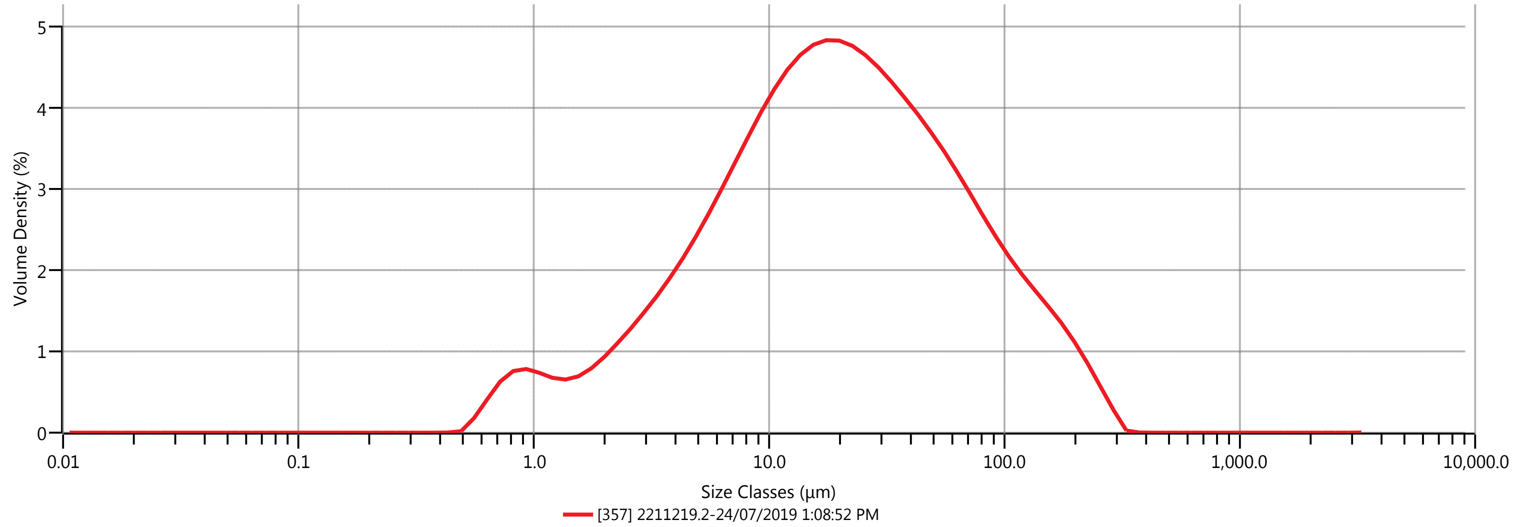
Measurement Details	
Sample Name	2211219.2
SOP File Name	Marine Sediment.msop
Lab Number	2019126/2
Operator Name	instrument

Measurement Details	
Analysis Date Time	24/07/2019 1:08:52 PM
Measurement Date Time	24/07/2019 1:08:52 PM
Result Source	Measurement

Analysis	
Particle Name	Marine Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.72 %
Laser Obscuration	14.37 %

Result	
Concentration	0.0158 %
Span	4.819
Uniformity	1.479
Specific Surface Area	785.7 m^2/kg
D [3,2]	7.64 µm
D [4,3]	37.1 µm
Dv (10)	3.35 µm
Dv (50)	19.2 µm
Dv (90)	96.0 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	24.07	88.0	88.62	350	100.00	1410	100.00
0.0600	0.00	15.6	43.40	105	91.29	420	100.00	1680	100.00
0.120	0.00	31.0	64.58	125	93.59	500	100.00	2000	100.00
0.240	0.00	37.0	69.51	149	95.57	590	100.00	2380	100.00
0.490	0.00	44.0	74.06	177	97.21	710	100.00	2830	100.00
0.980	2.26	53.0	78.58	210	98.54	840	100.00	3360	100.00
2.00	5.65	63.0	82.38	250	99.45	1000	100.00		
3.90	11.82	74.0	85.59	300	99.94	1190	100.00		

Analysis - Under

Measurement Details

Sample Name 2211219.3
SOP File Name Marine Sediment.msop
Lab Number 2019126/3
Operator Name instrument

Measurement Details

Analysis Date Time 24/07/2019 1:16:43 PM
Measurement Date Time 24/07/2019 1:16:43 PM
Result Source Measurement

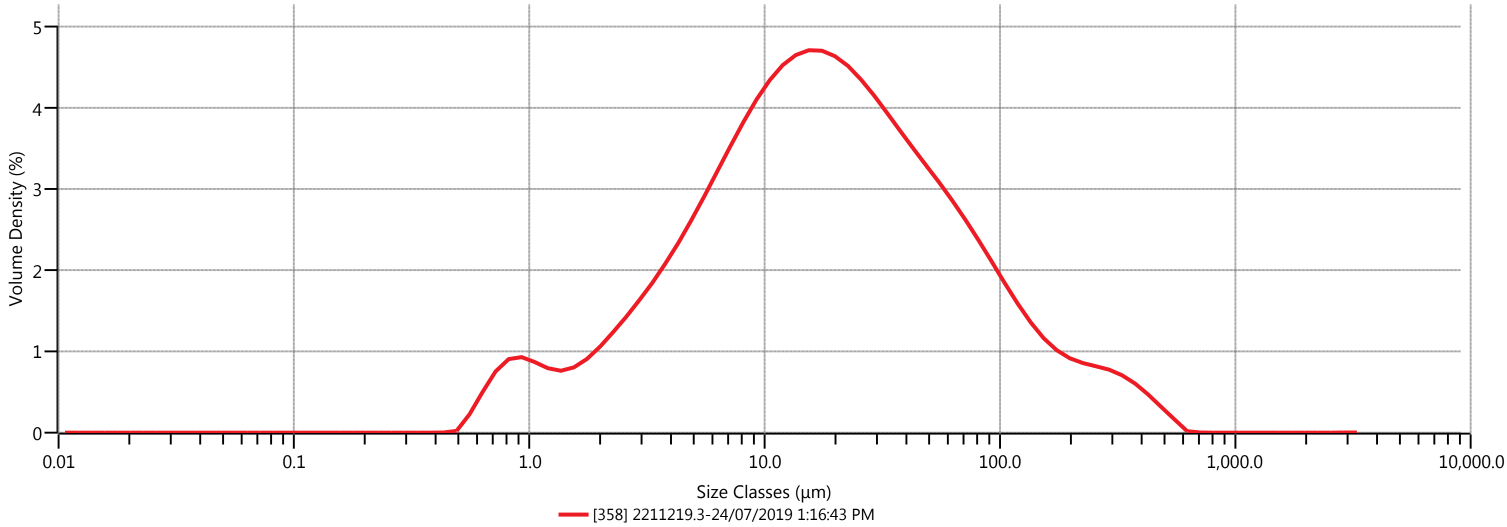
Analysis

Particle Name Marine Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.56 %
Laser Obscuration 17.61 %

Result

Concentration 0.0180 %
Span 5.654
Uniformity 1.963
Specific Surface Area 867.2 m^2/kg
D [3,2] 6.92 µm
D [4,3] 42.3 µm
Dv (10) 2.93 µm
Dv (50) 17.6 µm
Dv (90) 102 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	26.65	88.0	88.01	350	98.67	1410	100.00
0.0600	0.00	15.6	46.36	105	90.32	420	99.36	1680	100.00
0.120	0.00	31.0	66.51	125	92.23	500	99.79	2000	100.00
0.240	0.00	37.0	71.00	149	93.76	590	100.00	2380	100.00
0.490	0.00	44.0	75.07	177	94.98	710	100.00	2830	100.00
0.980	2.72	53.0	79.09	210	96.03	840	100.00	3360	100.00
2.00	6.66	63.0	82.46	250	97.00	1000	100.00		
3.90	13.48	74.0	85.31	300	97.95	1190	100.00		

Analysis - Under

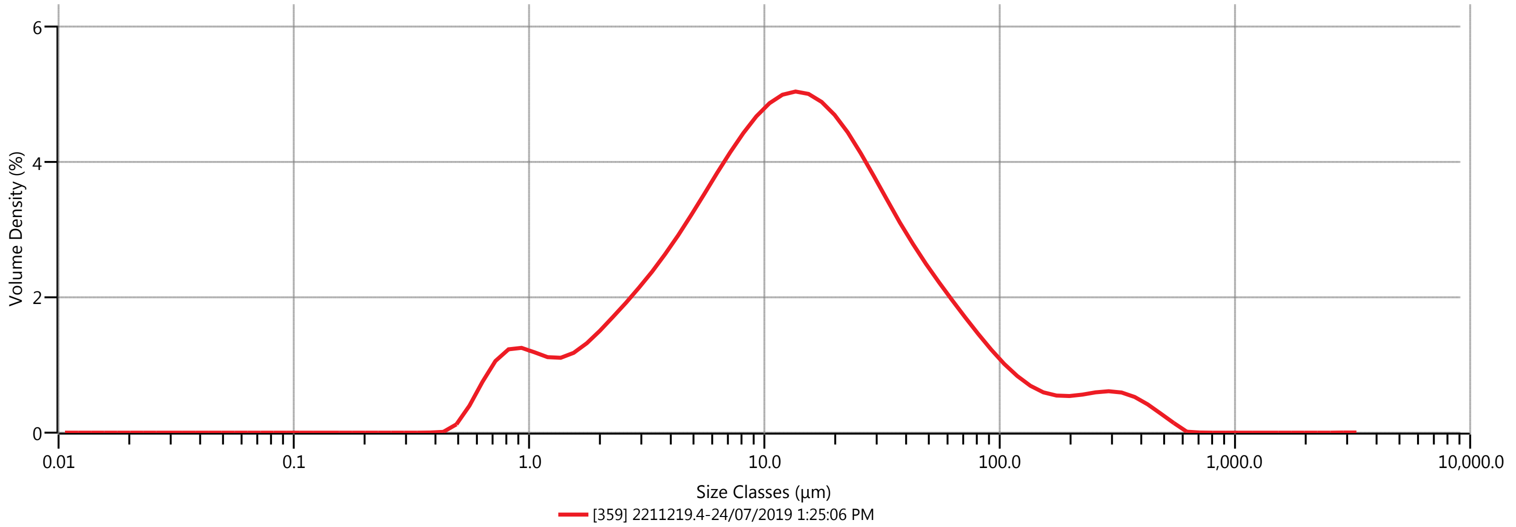
Measurement Details	
Sample Name	2211219.4
SOP File Name	Marine Sediment.msop
Lab Number	2019126/4
Operator Name	instrument

Measurement Details	
Analysis Date Time	24/07/2019 1:25:06 PM
Measurement Date Time	24/07/2019 1:25:06 PM
Result Source	Measurement

Analysis	
Particle Name	Marine Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.60 %
Laser Obscuration	22.62 %

Result	
Concentration	0.0186 %
Span	5.178
Uniformity	2.074
Specific Surface Area	1125 m^2/kg
D [3,2]	5.34 µm
D [4,3]	32.4 µm
Dv (10)	2.09 µm
Dv (50)	12.8 µm
Dv (90)	68.6 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	34.48	88.0	92.51	350	98.84	1410	100.00
0.0600	0.00	15.6	56.39	105	93.83	420	99.43	1680	100.00
0.120	0.00	31.0	76.30	125	94.84	500	99.82	2000	100.00
0.240	0.00	37.0	80.19	149	95.62	590	100.00	2380	100.00
0.490	0.04	44.0	83.51	177	96.27	710	100.00	2830	100.00
0.980	3.94	53.0	86.56	210	96.87	840	100.00	3360	100.00
2.00	9.56	63.0	88.95	250	97.51	1000	100.00		
3.90	18.58	74.0	90.84	300	98.23	1190	100.00		

Analysis - Under

Measurement Details

Sample Name 2211219.5
SOP File Name Marine Sediment.msop
Lab Number 2019126/5
Operator Name instrument

Measurement Details

Analysis Date Time 24/07/2019 1:51:17 PM
Measurement Date Time 24/07/2019 1:51:17 PM
Result Source Measurement

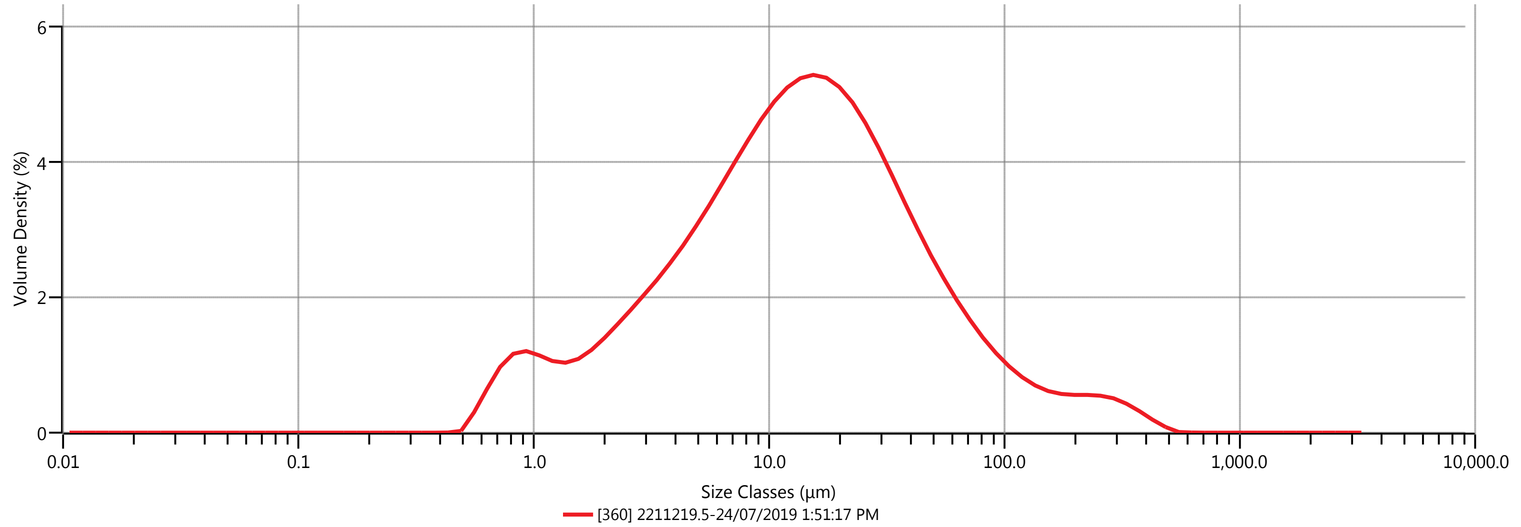
Analysis

Particle Name Marine Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.66 %
Laser Obscuration 16.39 %

Result

Concentration 0.0137 %
Span 4.467
Uniformity 1.702
Specific Surface Area 1059 m^2/kg
D [3,2] 5.67 µm
D [4,3] 29.3 µm
Dv (10) 2.26 µm
Dv (50) 13.6 µm
Dv (90) 63.1 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	32.50	88.0	93.45	350	99.50	1410	100.00
0.0600	0.00	15.6	54.70	105	94.72	420	99.84	1680	100.00
0.120	0.00	31.0	76.44	125	95.71	500	99.98	2000	100.00
0.240	0.00	37.0	80.73	149	96.50	590	100.00	2380	100.00
0.490	0.00	44.0	84.34	177	97.16	710	100.00	2830	100.00
0.980	3.52	53.0	87.56	210	97.79	840	100.00	3360	100.00
2.00	8.79	63.0	89.99	250	98.42	1000	100.00		
3.90	17.32	74.0	91.85	300	99.05	1190	100.00		

Analysis - Under

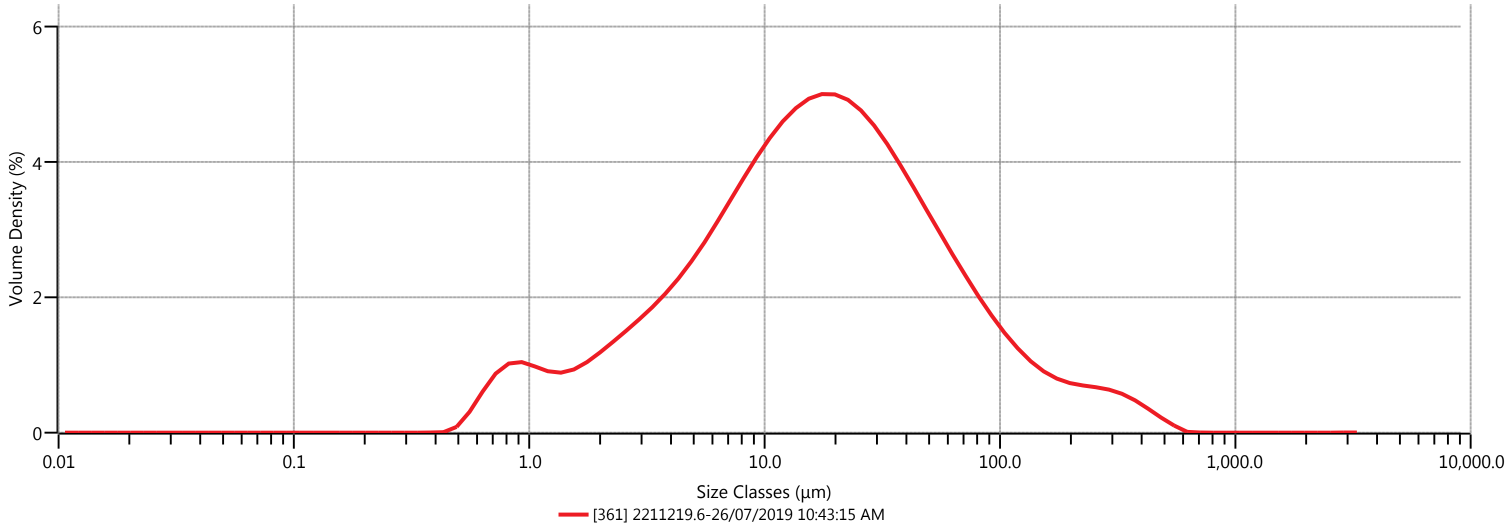
Measurement Details	
Sample Name	2211219.6
SOP File Name	Marine Sediment.msop
Lab Number	2019126/6
Operator Name	instrument

Measurement Details	
Analysis Date Time	26/07/2019 10:43:15 AM
Measurement Date Time	26/07/2019 10:43:15 AM
Result Source	Measurement

Analysis	
Particle Name	Marine Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.55 %
Laser Obscuration	24.82 %

Result	
Concentration	0.0246 %
Span	4.859
Uniformity	1.767
Specific Surface Area	941.5 m^2/kg
D [3,2]	6.37 µm
D [4,3]	37.2 µm
Dv (10)	2.59 µm
Dv (50)	16.9 µm
Dv (90)	84.5 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	27.56	88.0	90.50	350	99.02	1410	100.00
0.0600	0.00	15.6	47.49	105	92.38	420	99.55	1680	100.00
0.120	0.00	31.0	69.27	125	93.89	500	99.87	2000	100.00
0.240	0.00	37.0	74.12	149	95.07	590	100.00	2380	100.00
0.490	0.03	44.0	78.40	177	96.03	710	100.00	2830	100.00
0.980	3.21	53.0	82.44	210	96.87	840	100.00	3360	100.00
2.00	7.72	63.0	85.64	250	97.65	1000	100.00		
3.90	14.78	74.0	88.20	300	98.43	1190	100.00		

Analysis - Under

Measurement Details

Sample Name 2211219.7
SOP File Name Marine Sediment.msop
Lab Number 2019126/7
Operator Name instrument

Measurement Details

Analysis Date Time 26/07/2019 10:51:07 AM
Measurement Date Time 26/07/2019 10:51:07 AM
Result Source Measurement

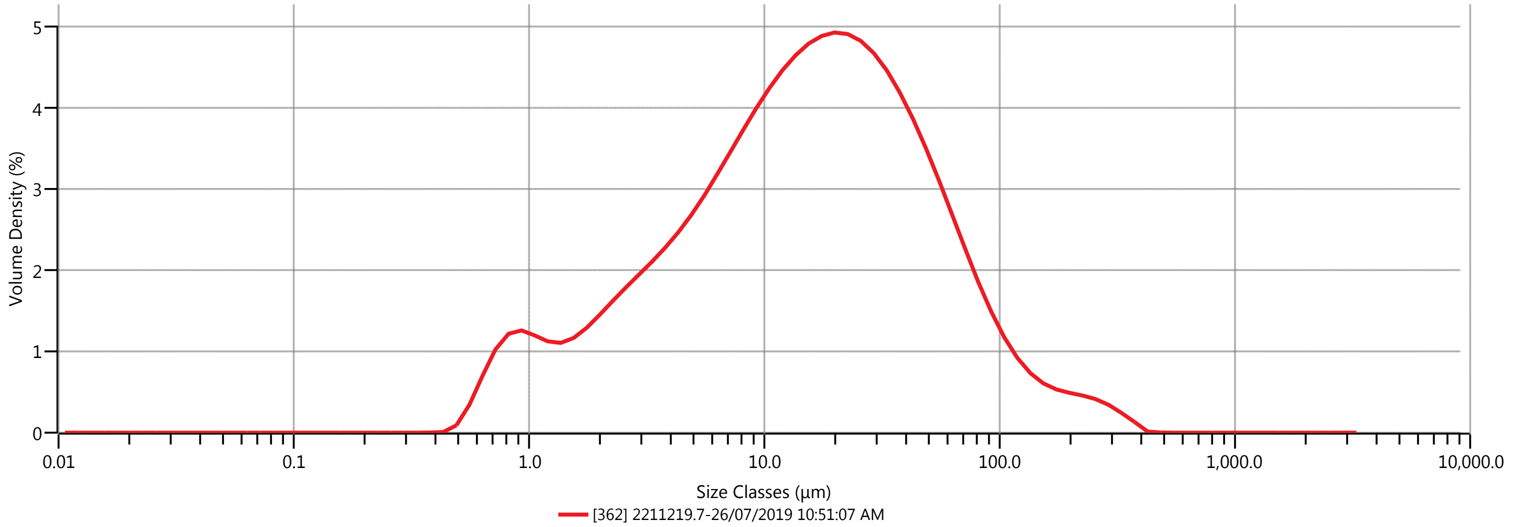
Analysis

Particle Name Marine Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.66 %
Laser Obscuration 16.30 %

Result

Concentration 0.0137 %
Span 4.116
Uniformity 1.443
Specific Surface Area 1061 m^2/kg
D [3,2] 5.66 µm
D [4,3] 28.9 µm
Dv (10) 2.14 µm
Dv (50) 15.5 µm
Dv (90) 65.7 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	30.84	88.0	93.92	350	99.88	1410	100.00
0.0600	0.00	15.6	50.29	105	95.50	420	100.00	1680	100.00
0.120	0.00	31.0	72.02	125	96.64	500	100.00	2000	100.00
0.240	0.00	37.0	77.10	149	97.46	590	100.00	2380	100.00
0.490	0.03	44.0	81.65	177	98.10	710	100.00	2830	100.00
0.980	3.78	53.0	85.93	210	98.66	840	100.00	3360	100.00
2.00	9.37	63.0	89.25	250	99.17	1000	100.00		
3.90	17.58	74.0	91.80	300	99.62	1190	100.00		

Analysis - Under

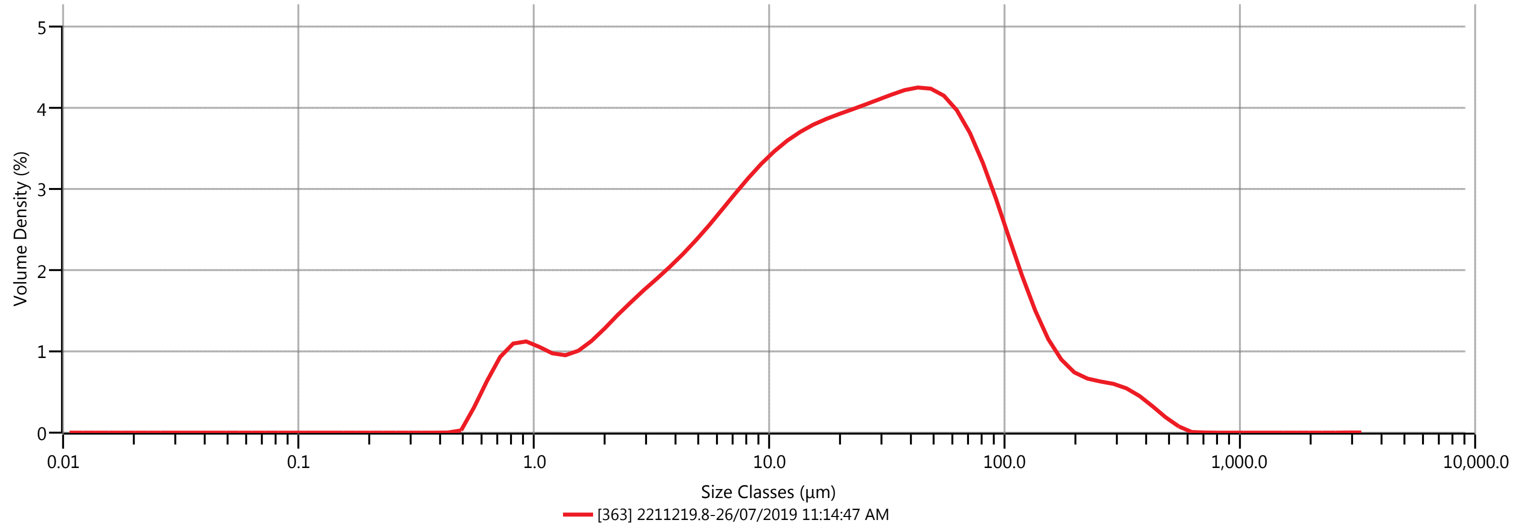
Measurement Details	
Sample Name	2211219.8
SOP File Name	Marine Sediment.msop
Lab Number	2019126/8
Operator Name	instrument

Measurement Details	
Analysis Date Time	26/07/2019 11:14:47 AM
Measurement Date Time	26/07/2019 11:14:47 AM
Result Source	Measurement

Analysis	
Particle Name	Marine Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.63 %
Laser Obscuration	18.84 %

Result	
Concentration	0.0182 %
Span	4.661
Uniformity	1.646
Specific Surface Area	935.1 m^2/kg
D [3,2]	6.42 µm
D [4,3]	42.0 µm
Dv (10)	2.43 µm
Dv (50)	20.6 µm
Dv (90)	98.5 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	27.15	88.0	87.89	350	99.12	1410	100.00
0.0600	0.00	15.6	42.95	105	91.00	420	99.62	1680	100.00
0.120	0.00	31.0	60.74	125	93.38	500	99.90	2000	100.00
0.240	0.00	37.0	65.57	149	95.05	590	100.00	2380	100.00
0.490	0.00	44.0	70.36	177	96.21	710	100.00	2830	100.00
0.980	3.36	53.0	75.51	210	97.08	840	100.00	3360	100.00
2.00	8.24	63.0	80.12	250	97.82	1000	100.00		
3.90	15.60	74.0	84.12	300	98.55	1190	100.00		

Analysis - Under

Measurement Details

Sample Name 2211219.9
SOP File Name Marine Sediment.msop
Lab Number 2019126/9
Operator Name instrument

Measurement Details

Analysis Date Time 26/07/2019 11:22:55 AM
Measurement Date Time 26/07/2019 11:22:55 AM
Result Source Measurement

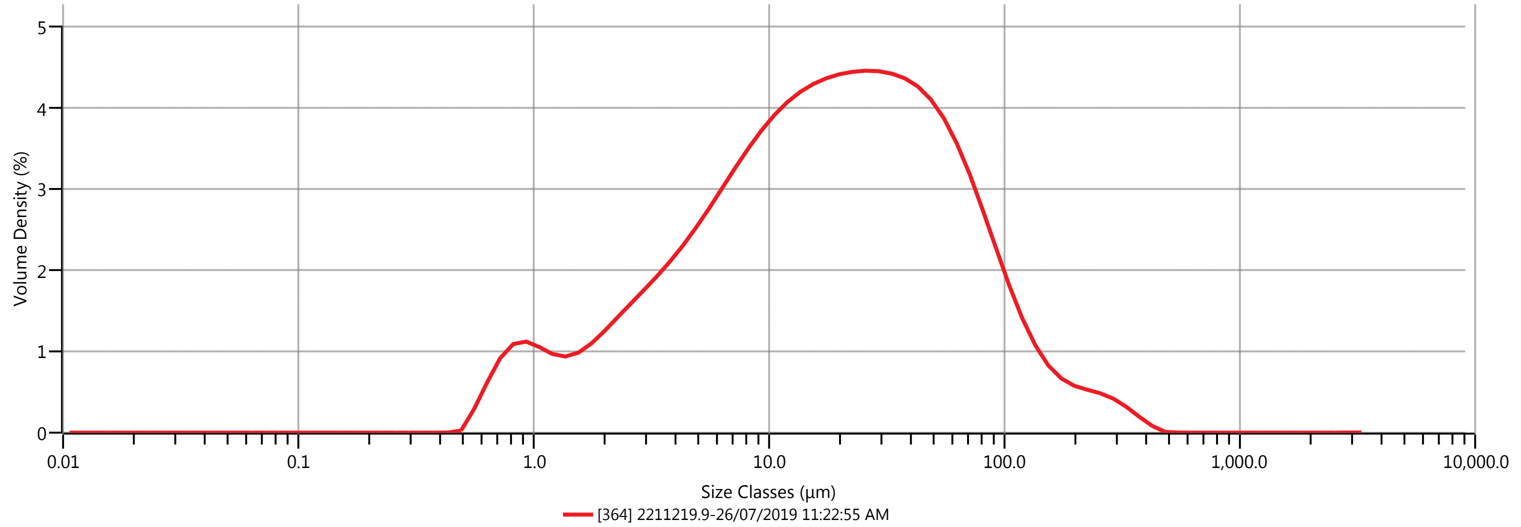
Analysis

Particle Name Marine Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.67 %
Laser Obscuration 19.16 %

Result

Concentration 0.0181 %
Span 4.341
Uniformity 1.482
Specific Surface Area 950.5 m^2/kg
D [3,2] 6.31 µm
D [4,3] 34.4 µm
Dv (10) 2.47 µm
Dv (50) 18.1 µm
Dv (90) 81.1 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	27.96	88.0	91.41	350	99.77	1410	100.00
0.0600	0.00	15.6	45.78	105	93.83	420	99.96	1680	100.00
0.120	0.00	31.0	65.59	125	95.59	500	100.00	2000	100.00
0.240	0.00	37.0	70.69	149	96.79	590	100.00	2380	100.00
0.490	0.00	44.0	75.57	177	97.63	710	100.00	2830	100.00
0.980	3.31	53.0	80.57	210	98.30	840	100.00	3360	100.00
2.00	8.10	63.0	84.81	250	98.89	1000	100.00		
3.90	15.48	74.0	88.30	300	99.43	1190	100.00		

Analysis - Under

Measurement Details

Sample Name 2211219.10
SOP File Name Marine Sediment.msop
Lab Number 2019126/10
Operator Name instrument

Measurement Details

Analysis Date Time 26/07/2019 11:31:42 AM
Measurement Date Time 26/07/2019 11:31:42 AM
Result Source Measurement

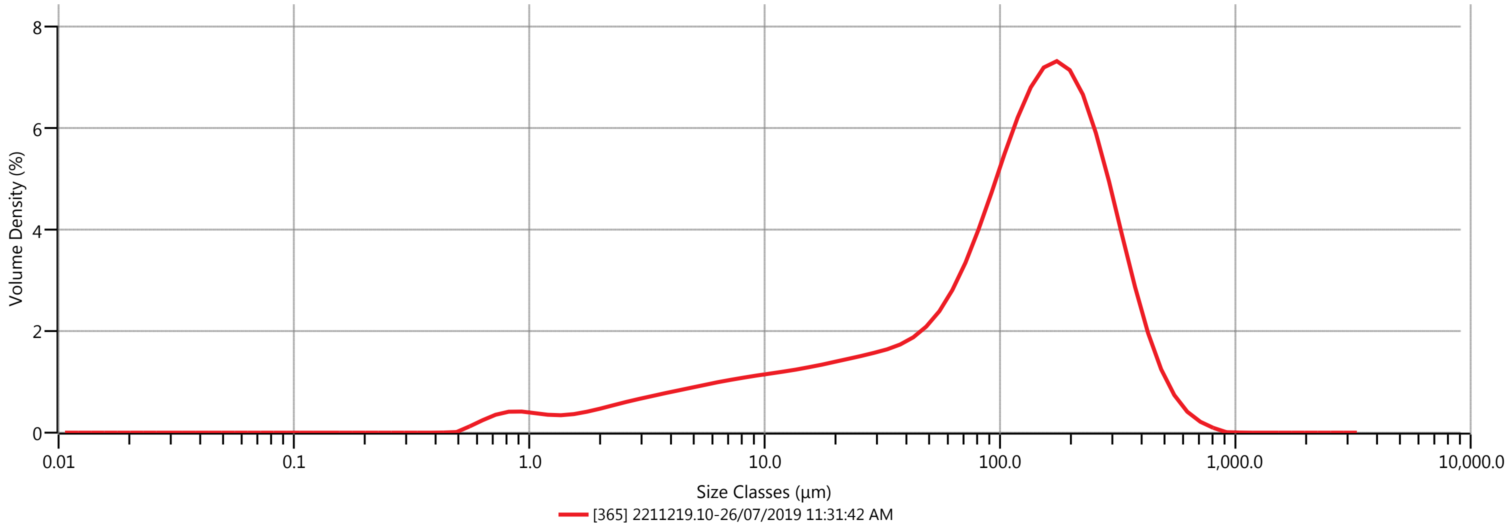
Analysis

Particle Name Marine Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.29 %
Laser Obscuration 17.57 %

Result

Concentration 0.0425 %
Span 2.467
Uniformity 0.778
Specific Surface Area 369.9 m^2/kg
D [3,2] 16.2 μm
D [4,3] 142 μm
Dv (10) 7.75 μm
Dv (50) 120 μm
Dv (90) 304 μm

Frequency (compatible)



Result

Size (μm)	% Volume Under	Size (μm)	% Volume Under	Size (μm)	% Volume Under	Size (μm)	% Volume Under	Size (μm)	% Volume Under
0.0500	0.00	7.80	10.04	88.0	38.97	350	93.66	1410	100.00
0.0600	0.00	15.6	15.37	105	44.76	420	96.80	1680	100.00
0.120	0.00	31.0	21.83	125	51.56	500	98.56	2000	100.00
0.240	0.00	37.0	23.75	149	59.42	590	99.44	2380	100.00
0.490	0.00	44.0	25.79	177	67.60	710	99.84	2830	100.00
0.980	1.27	53.0	28.31	210	75.66	840	99.98	3360	100.00
2.00	3.04	63.0	31.19	250	83.08	1000	100.00		
3.90	5.81	74.0	34.48	300	89.52	1190	100.00		

Analysis - Under

Measurement Details

Sample Name 2211219.11
SOP File Name Marine Sediment.msop
Lab Number 2019126/11
Operator Name instrument

Measurement Details

Analysis Date Time 26/07/2019 12:07:11 PM
Measurement Date Time 26/07/2019 12:07:11 PM
Result Source Measurement

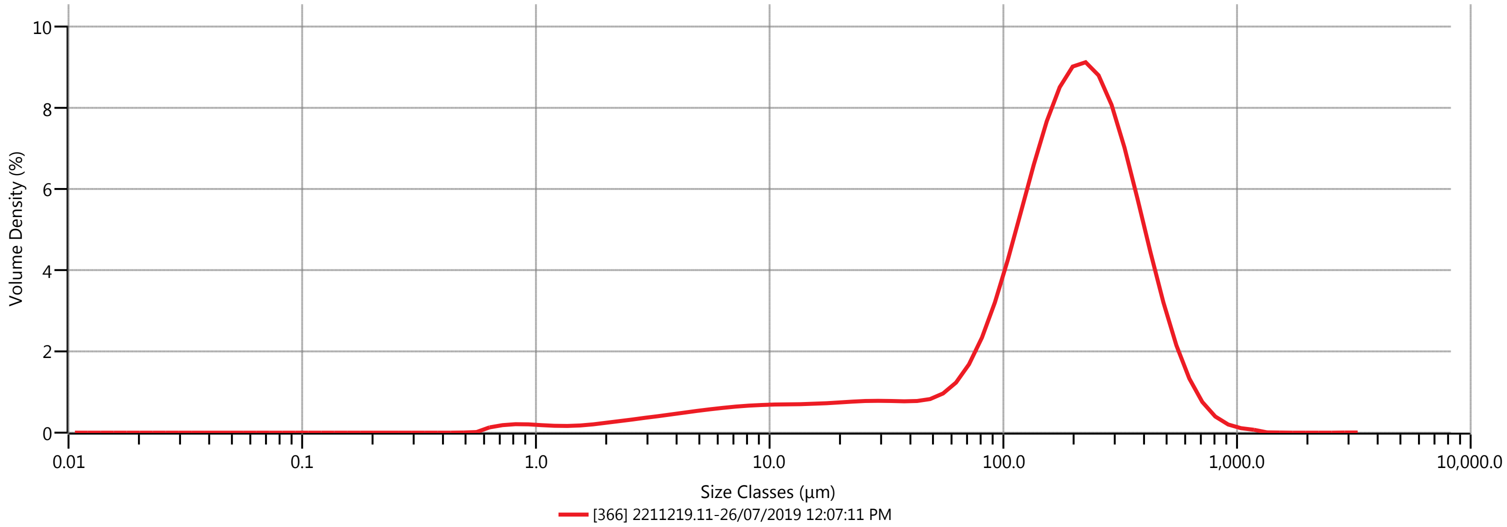
Analysis

Particle Name Marine Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.20 %
Laser Obscuration 16.10 %

Result

Concentration 0.0695 %
Span 2.059
Uniformity 0.611
Specific Surface Area 202.3 m^2/kg
D [3,2] 29.7 µm
D [4,3] 210 µm
Dv (10) 20.7 µm
Dv (50) 187 µm
Dv (90) 406 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	5.54	88.0	20.20	350	84.51	1410	100.00
0.0600	0.00	15.6	8.66	105	24.35	420	90.98	1680	100.00
0.120	0.00	31.0	12.05	125	30.07	500	95.25	2000	100.00
0.240	0.00	37.0	12.94	149	37.79	590	97.73	2380	100.00
0.490	0.00	44.0	13.82	177	46.88	710	99.07	2830	100.00
0.980	0.60	53.0	14.82	210	56.82	840	99.64	3360	100.00
2.00	1.45	63.0	16.01	250	67.16	1000	99.87		
3.90	2.97	74.0	17.59	300	77.21	1190	99.97		

Lower Clive River Sediment Sampling and Depth Probing, and Entrance Bathymetry and Ecological Assessment.

Prepared for:

HAWKE'S BAY REGIONAL COUNCIL

eCoast eTakutai

MOHIO - AUAHA - TAUTOKO
UNDERSTAND - INNOVATE - SUSTAIN

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Lower Clive River Sediment Sampling and Depth Probing, and Entrance Bathymetry and Ecological Assessment.

Report Status

Version	Date	Status	Approved by
V.1	7 October 2019	Final Draft	STM

It is the responsibility of the reader to verify the version number of this report.

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Contents

Figures

Tables

1 Introduction

This report follows on from the “Lower Clive River Sediment Sampling and Depth Probing” undertaken in July 2019 (eCoast, 2019), which focussed on the characteristics of the sediment in the lower Clive river area, which is to be dredged and disposed of in order to deepen this section of the river (red box shown in Figure 1.1). This report describes the findings of sediment sampling to characterise the sediments upriver of the dredge location and in the potential disposal area (river entrance), including type (grain size) and contaminants (nutrients, PAH’s, trace metals, TOC, level of hypoxia, SVOC’s) (Figure 1.1). Probing was undertaken to determine the depth of the soft sediment that has accumulated above the original gravel riverbed at sites 1A to 4C (Figure 1.1). Bathymetry survey and ecological assessment was carried out for the lower Clive River (Waitangi Estuary) and the immediate offshore area where the dredged material from the lower Clive could potentially be disposed of (Figure 1.1).

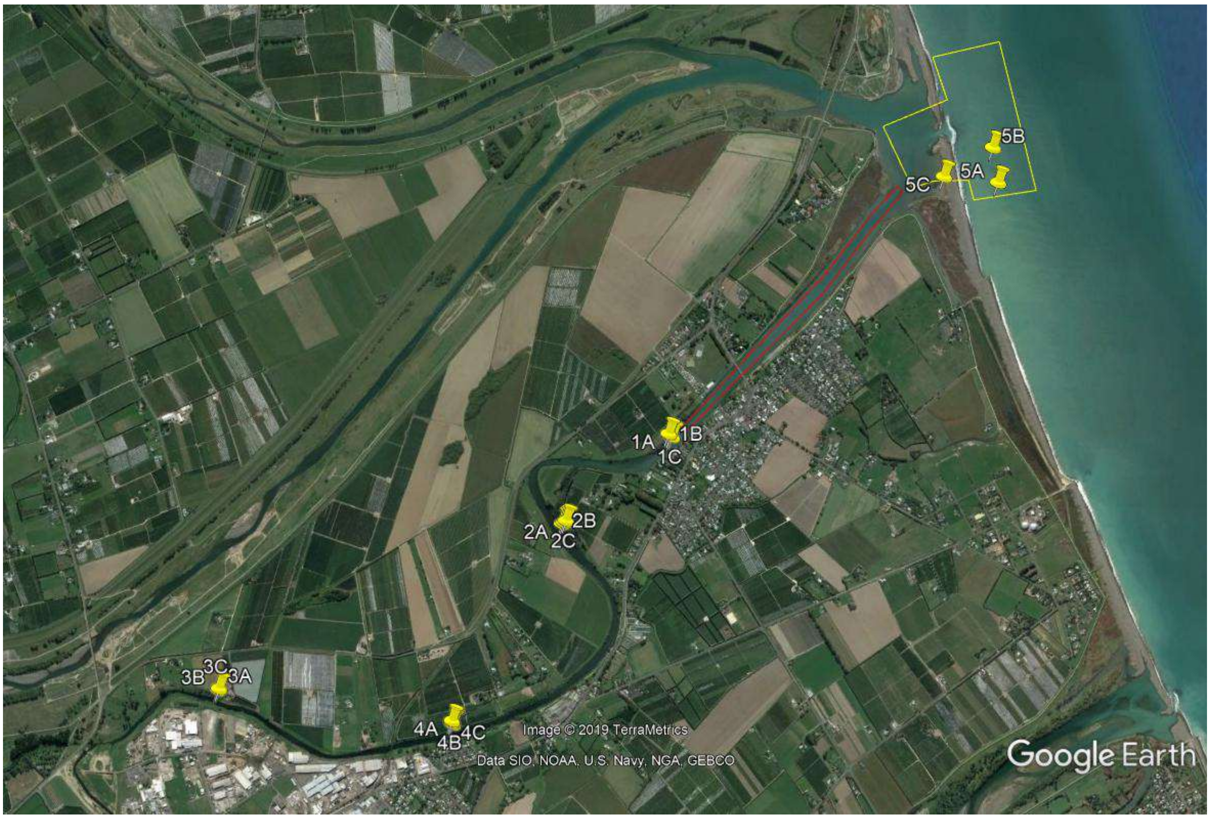

Figure 1.1. Location plan of the survey sites. Sediment sampling was undertaken at sites 1A through to 5C. Depth probing was undertaken at sites 1A to 4C. The bathymetry survey covered the area in the yellow box (the area delineated by the elongated red box is the area to be dredged (eCoast, 2019)). The ecological assessment was undertaken in the area of the 5C marker near the entrance.

2 Methodology

2.1 Sediment Sampling

A 2-person personal water vehicle (PWC) was used to collect sediment samples at 15 sites (Figure 1.1) using a 100 mm diameter PVC corer at the riverine sites (1A to 5A), and a ponar grab sampler for the 2 open coast sites on 23 August 2019. Sediment was placed into 3 different collection jars for the various contaminant laboratory tests (Figure 2.1). A YSI multi-meter was also used to measure the dissolved oxygen level in the upper layer of sediment at the riverine sites. In addition, an extendable 10 mm diameter steel probe was pushed until resistance prevented further penetration to determine the thickness of fine sediment above the original gravel riverbed at each of the riverine sample sites. Table 2.1 provides the coordinates of the sample sites (also Figure 1.1).

Figure 2.1. A sediment core (left) and sample jar (right).

Table 2.1: Sediment and probe sampling locations (WGS84) refer Figure 1.1.

Site	Lat	Long
1A	39°35'7.67"S	176°54'39.66"E
1B	39°35'7.95"S	176°54'40.10"E
1C	39°35'8.20"S	176°54'40.50"E

2A	39°35'24.98"S	176°54'14.69"E
2B	39°35'24.67"S	176°54'15.20"E
2C	39°35'24.39"S	176°54'15.68"E
3A	39°35'57.35"S	176°52'53.57"E
3B	39°35'57.60"S	176°52'53.43"E
3C	39°35'57.84"S	176°52'53.30"E
4A	39°36'2.17"S	176°53'49.76"E
4B	39°36'2.49"S	176°53'49.86"E
4C	39°36'2.84"S	176°53'49.97"E
5A	39°34'19.09"S	176°55'56.97"E
5B	39°34'12.64"S	176°55'55.42"E
5C	39°34'18.33"S	176°55'43.89"E

2.2 Bathymetry Survey

Appendix A provides a full description of the equipment used to carry out the RTK-GPS bathymetry survey, as well as the methods of data reduction and correction. Figure 2.2 presents the survey run-lines; these data were supplemented with additional spot depths collected in the shallower areas of the lower estuary and digitised data from satellite images to develop a bathymetry chart.

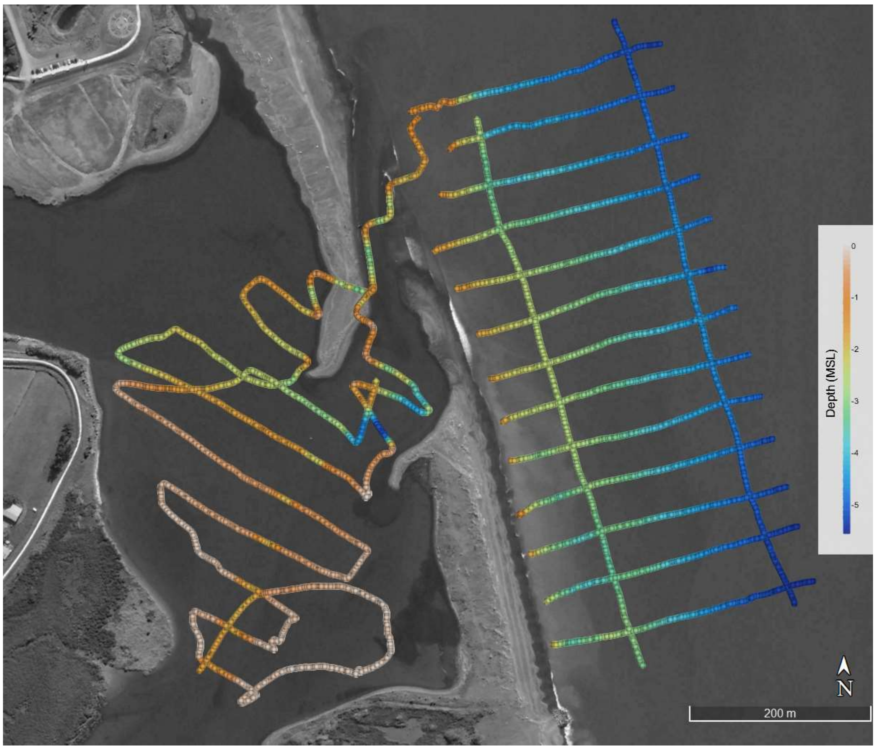

Figure 2.2. Survey data points adjusted to Napier Vertical Datum 2000 overlaid on a satellite image from 22nd May 2019 (Google Earth). Note, the river entrance was located north of this image on 23rd August 2019.

2.3 Ecological Assessment

An ecological assessment was undertaken in the lower estuary and on the open coast adjacent to the river entrance. A ponar grab sampler was used to collect sediment samples at 10 locations on the open coast, and a 100 mm diameter core sampler was used to collect 10 in the shallow lower estuary (Figure 2.3 and Table 2.2).

Figure 2.3. Sample locations for ecological assessment (Table 2.2).

Table 2.2. Sample locations for ecological assessment (Figure 2.3).

Open Coast			Lower Estuary		
Site	Lat	Long	Site	Lat	Long
1	39°33'55.67"S	176°55'47.82"E	I	39°34'12.40"S	176°55'39.77"E
2	39°33'55.72"S	176°55'55.18"E	II	39°34'12.66"S	176°55'42.72"E
3	39°33'58.92"S	176°55'52.13"E	III	39°34'13.52"S	176°55'43.48"E
4	39°34'3.15"S	176°55'48.94"E	IV	39°34'13.76"S	176°55'41.50"E
5	39°34'1.96"S	176°55'56.73"E	V	176°55'41.50"E	176°55'40.48"E
6	39°34'6.38"S	176°55'59.67"E	VI	39°34'15.14"S	176°55'43.05"E
7	39°34'6.56"S	176°55'54.23"E	VII	39°34'16.79"S	176°55'43.78"E
8	39°34'12.32"S	176°55'50.49"E	VIII	39°34'17.85"S	176°55'44.39"E
9	39°34'15.37"S	176°55'56.99"E	IX	39°34'18.69"S	176°55'43.58"E
10	39°34'11.10"S	176°56'1.52"E	X	39°34'18.00"S	176°55'40.62"E

Samples were sieved through 500 µm mesh and 70% isopropyl alcohol and with rose Bengal was on hand to preserve species that could not be identified in the field for later identification at Leigh Marine Laboratory. However, in all the samples only 4 species were found, which could be identified on site.

In addition to grab sampling, a drop-camera was used to record the state of the seabed and any epifauna present. However, visibility was basically zero, which meant this method (or SCUBA diving) could not collect any useful data.

2.3.1 Statistical Analysis

Following taxa identification, data from grab/core sampling were compiled, graphed, and formally analysed to provide a description of the abundance, community structure and diversity (species richness and evenness).

To evaluate diversity, species richness (i.e. the total number of different organisms present), and the Shannon-Wiener diversity index were used which takes into account the proportion of each species within the survey area.

The Shannon-Wiener index (H^I) is based on the number of different species per sample (species richness) and the 'relative abundance' of the different organisms present defined as:

$$H^I = -\sum(p_i \log(p_i))$$

Where p_i is the abundance of an individual taxon (n_i) divided by the total number of individuals observed in all species (N). Relatively higher values of H^I imply relatively higher levels of biodiversity. H^I values can range from 0-4.6 (when using the natural log, as in this case), with a value near to 0 indicating that every species in the sample is the same and a number near 4.6 indicating that there are similar numbers of individuals present for each species present.

Species evenness is a measure of how similar the abundance of different species is over the survey area. Species richness (S - the total number of different species) and the Shannon-Weaver index (H^I) are used to calculate the evenness (E), defined as,

$$E=H/\log(S)$$

When there are similar proportions of all species within the survey area, then the evenness tends towards 1.

3 Sediment Grain Size and Contaminants

3.1 Dissolved Oxygen

Similar to the results of the July survey of the lower Clive River, sediment samples were mostly found to be anoxic (i.e., black with a slight odour of hydrogen sulphide), often with a small layer (~5-10 mm) of aerated surficial sediment. However, unlike the uniform estuary bed of the lower reaches, there are channels that result in faster flowing areas with little deposition in comparison to other parts of the riverbed and dense patches of weed (), which are shallower and have higher deposition.

Figure 3.1. The mix of dense weed in the Clive River.

Dissolved oxygen was found to be relatively high in the water column (>12 mg/l). Dissolved oxygen in the surficial sediment was found to be 2-4 mg/l at sites 1A-C (i.e. hypoxic), and >4 mg/l at sites 2A to 4C; dissolved oxygen in the surficial sediment layer was not measured for sites 5A-C. This is an opposite trend to what was found in the lower Clive River, where dissolved oxygen increased towards to river entrance (eCoast, 2019).

3.2 Sediment Grainsize

The laboratory results of the sediment analyses are included in Appendix B. Sediment grainsize analysis results are summarised in Table 3.1. These results indicate that the sediment composition at sites 1A to 4C are mostly similar with silt content >50% (with the exception of 2A) and clay content of 4-10%. Sediment composition was also in this category for site 5C, which is inside the river entrance (Figure 1.1), while the 2 open coast samples (5A and B) were comprised of fine-medium sand with only a very small fraction of silt (Table 3.1).

Table 3.1. Broad classification of sediment grainsize fractions in the samples (Figure 2.1).

Site	Clay%	Silt%	Fine-Med Sand%
1A	10	66	24
1B	6	54	40
1C	6	52	42
2A	4	38	58
2B	7	53	40
2C	7	59	34
3A	6	60	34
3B	5	50	45
3C	6	52	42
4A	5	56	39
4B	5	66	29
4C	5	52	43
5A	0	3	97
5B	0	2	98
5C	5	54	41

3.3 Sediment Organic Carbon

Because levels of organic carbon in sediments tend to be higher in samples with higher silt fractions, results have also been normalised to 100% of the silt/clay fraction for each site in order to provide further comparison between sites. Herein, 'normalised' results are referring to this adjustment. Table 3.2 below details the total and normalised total organic carbon content in each sample. There is no obvious trend in organic carbon content with respect to sample location.

Table 3.2. Total and normalised organic carbon content results.

Site	Organic Carbon (g/100g)	Normalised Organic Carbon (g/100g)
1A	3.9	5.10
1B	2.8	4.67
1C	3.6	6.24
2A	1.81	4.31
2B	2.5	4.18
2C	1.09	1.65
3A	0.62	0.94
3B	2.4	4.38
3C	3.3	5.68
4A	3.6	5.89
4B	2.8	3.93
4C	2.9	5.02
5A	0.08	2.90
5B	0.07	4.58
5C	0.51	0.86

3.4 Sediment Nutrients

Table 3.3 below details the total and normalised total nitrogen and phosphorus content in each sample. Similar to the results of the lower Clive River (eCoast, 2019), when compared to other Hawkes Bay and reference estuaries throughout New Zealand, total nitrogen and total phosphorus concentrations at Sites 1A, 1B, 1C, 2A, 2B, 3B, 3C, 4A, 4B, 4C and 5C are elevated, and lie in the upper-range and in exceedance of recorded values (Table 3.3). Sites 5A and 5B (open coast) returned nitrogen levels that were below the detection limit and mid-range phosphorus levels when compared to other recorded sites around New Zealand.

The normalised nitrogen and phosphorus results at Sites 1A, 1B, 1C, 2A, 2B, 3B, 3C, 4A, 4B and 4C are relatively high also. In particular, Sites 5A and 5B show very high normalised nitrogen and phosphorus levels at 10,145 mg/kg and 18,301 mg/kg respectively, which is largely due to the very low silt/clay content in the sediments at these locations; these are the 2 open coast samples.

Table 3.3. Total and normalised nitrogen and phosphorus content results. Note: BDL = Below Detection Limit of 0.05 g/100g.

Site	Total Nitrogen (g/100g)	Normalised Total Nitrogen (g/100g)	Total Phosphorus (mg/kg)	Normalised Total Phosphorus (mg/kg)
1A	0.4	0.52	830	1085
1B	0.29	0.48	660	1100
1C	0.35	0.61	730	1265
2A	0.18	0.43	560	1333
2B	0.24	0.40	840	1403
2C	0.11	0.17	540	815
3A	0.07	0.11	430	650
3B	0.24	0.44	1160	2118
3C	0.36	0.62	1230	2117
4A	0.39	0.64	1450	2374
4B	0.31	0.43	1090	1529
4C	0.3	0.52	1280	2216
5A	BDL	-	280	10145
5B	BDL	-	280	18301
5C	0.06	0.10	470	796
Reference Sites				
Otamatea/Kaipara[1]	0.08 – 0.24	-	443 – 619	-
Ohiwa[1]	0.025 – 0.1	-	212 – 350	-
Ruataniwha[1]	0.025 – 0.07	-	330 – 580	-
Waimea[1]	0.025 – 0.1	-	243 – 562	-
Havelock[1]	0.007 – 0.09	-	241 – 433	-
Kaikorai[1]	0.15 – 0.21	-	728 – 913	-
Avon-Heathcote[1]	0.025 – 0.06	-	298 – 355	-
Ahuriri[2]	0.079 – 0.084	-	320 – 810	-

1. Robertson *et al.* (2002) **2.** Bennet (2006)

3.5 Sediment Trace Metals

Table 3.4 and Table 3.5 below presents the trace metal content results, as well as the ANZECC (2000) Interim Sediment Quality Guidelines low threshold values (ISQG-Low), above which biological effects can be expected. Samples 1A, 1B, 1C, 2A, 2B, 3B, 3C, 4A, 4B and 4C have elevated zinc levels above the ISQG-Low threshold, although are below the ISQG-High threshold for zinc of 410 mg/kg. All other levels are below the ISQG-Low threshold values.

Table 3.4. Trace metal results and ANZECC (2000) ISQG-Low guidelines (mg/kg dry weight). Yellow shaded cells indicate an ISQG-Low exceedance.

Site	Cadmium	Chromium	Copper	Nickel	Lead	Zinc	Arsenic	Mercury
1A	0.33	21	26	12.6	33	360	7.3	0.08
1B	0.2	15.5	15.8	10	20	260	4.9	0.08
1C	0.21	16.8	12.4	10.6	21	270	5.5	0.08
2A	0.21	13.5	12.4	8.9	19.1	260	4.9	0.05
2B	0.23	14.2	14.3	9.1	20	280	5.2	0.06
2C	0.09	11.1	8.9	8.1	12.8	155	3.2	0.05
3A	0.059	10.4	7.5	8	9.7	108	3.3	0.05
3B	0.143	15.3	18	10.4	18.5	240	4	0.06
3C	0.23	18.1	22	11.1	26	370	7.6	0.07
4A	0.23	18.4	23	11	27	380	7.6	0.08
4B	0.185	17.3	19.5	10.6	25	330	7.1	0.07
4C	0.21	17.4	21	10.7	25	380	8.1	0.08
5A	0.017	8.4	4	5.7	6	30	2.6	0.05
5B	0.017	8	3.8	5.7	5.9	30	2.6	0.05
5C	0.03	11.3	5.7	9.1	7.9	44	2.9	0.05
ISQG-Low	1.5	80	65	21	50	200	20	0.15

Trace metals have been shown to preferentially adhere to fine sediments in the silt/clay fraction that have reactive surface properties. Therefore, differences in trace metal concentrations between sites may simply reflect differences in the proportion of sediments in this fraction. Normalising sediment contaminant data allows standardisation of sediment contaminants to sediment composition.

Table 3.5 below shows the normalised trace metal concentrations at all 15 sites, which due to the small fraction of silt/clay in the lower river sites (i.e., 5A and 5B) imply higher concentrations in these samples. Site 2A shows elevated normalised nickel levels and all sites, with the exception of Site 3A, are also above the ISQG-High threshold for zinc when the samples are normalised for silt/clay sediment fractions.

Table 3.5. Normalised trace metal results (mg/kg dry weight). Yellow shaded cells indicate an ISQG-Low exceedance.

Site	Cadmium	Chromium	Copper	Nickel	Lead	Zinc	Arsenic	Mercury
1A	0.431	27.4	34	16.5	43.1	470	9.5	0.1
1B	0.333	25.8	26.3	16.7	33.3	433	8.2	0.13
1C	0.364	29.1	21.5	18.4	36.4	468	9.5	0.14
2A	0.5	32.1	29.5	21.2	45.5	619	11.7	0.12
2B	0.384	23.7	23.9	15.2	33.4	468	8.7	0.1
2C	0.136	16.8	13.4	12.2	19.3	234	4.8	0.08
3A	0.089	15.7	11.3	12.1	14.7	163	5	0.08
3B	0.261	27.9	32.9	19	33.8	438	7.3	0.11
3C	0.396	31.2	37.9	19.1	44.8	637	13.1	0.12
4A	0.377	30.1	37.7	18	44.2	622	12.4	0.13
4B	0.26	24.3	27.4	14.9	35.1	463	10	0.1
4C	0.364	30.1	36.4	18.5	43.3	658	14	0.14
5A	0.616	304.3	144.9	206.5	217.4	1087	94.2	1.81
5B	1.111	522.9	248.4	372.5	385.6	1961	169.9	3.27
5C	0.051	19.1	9.7	15.4	13.4	75	4.9	0.08

3.6 Sediment Total Petroleum Hydrocarbons

Hydrocarbons C7 – C14 (number of carbon atoms in the hydrocarbon) were all found to be below detection limit and so only C15 – C44 are considered. Table 3.6 below details the total petroleum hydrocarbon results for each sample. Similar to the findings in the lower Clive River (eCoast, 2019), these values are all extremely low (and below detection limits for the entrance and open ocean sites) when compared to the Ministry for the Environment (MfE, 1999) low threshold guidelines for all sediment types (20,000 mg/kg).

Table 3.6. Total petroleum hydrocarbon results (C15 – C44). Note: BDL = Below Detection Limit.

Site	Total Petroleum Hydrocarbons (mg/kg dry weight)
1A	360
1B	310
1C	550
2A	290
2B	250
2C	121
3A	135
3B	124
3C	490
4A	105
4B	330
4C	440
5A	BDL
5B	BDL
5C	BDL

3.7 Sediment Depth Above Gravel Riverbed

Table 3.7 presents the results of the sediment depth probing at each sample site, which represents a transect across the river at locations 1-4 (Figure 1.1). These results indicate increasing deposition down the river (note, transect 3 is higher up the river then transect 4 (Figure 1.1)).

Table 3.7. Probing results.

Site	Mud depth (m)
1A	0.1
1B	0.8
1C	0.5
2A	0.4
2B	0.45
2C	0.7
3A	0.1
3B	0.15
3C	0.3
4A	0.1
4B	0.4
4C	0.3

4 Bathymetry Chart

Appendix B provides the technical specifications for the bathymetry survey, which was undertaken on a PWC (Figure 4.1) and covered the area well (Figure 2.2). Figure 4.2 presents the bathymetry chart created from the bathymetry survey data, spot depths collected in the shallower areas of the lower estuary and digitised data from satellite images.

The main channel of the Clive River can be seen aligned SSW to NNE through the centre of the lower southern estuary, with much of the lower southern estuary being intertidal (Figure 4.2); the spring tidal range in Hawke's Bay is 1.8 m (Table 4.1). This morphology can be seen in the October 2018 satellite image (Figure 4.3). A remnant channel with a maximum depth of 5.3 m and an isolated shingle bank/island are also distinct features – the remnant channel was the entrance channel to the open sea and the island was part of the northern spit in late May 2019 (Figure 2.2), which demonstrates the dynamic nature of the barrier spits and entrance channel, which can sometimes be closed to the sea.

On the open coast, the seabed is shallow around the area where the entrance regularly migrates, and grades steeply to ~3.0 m deep at the toes of the subtidal beach south of the influence of the river entrance (Figure 4.2).

Figure 4.1. Bathymetry surveying on the open coast side of the Clive River entrance.

Table 4.1. Spring and neap tidal heights in Hawke's Bay (m).

Tide	MHWS	MHWN	MLWN	MLWS	MSL
To MSL	0.84	0.44	-0.56	-0.96	0
To Neap tide	1.8	1.4	0.4	0	0.96

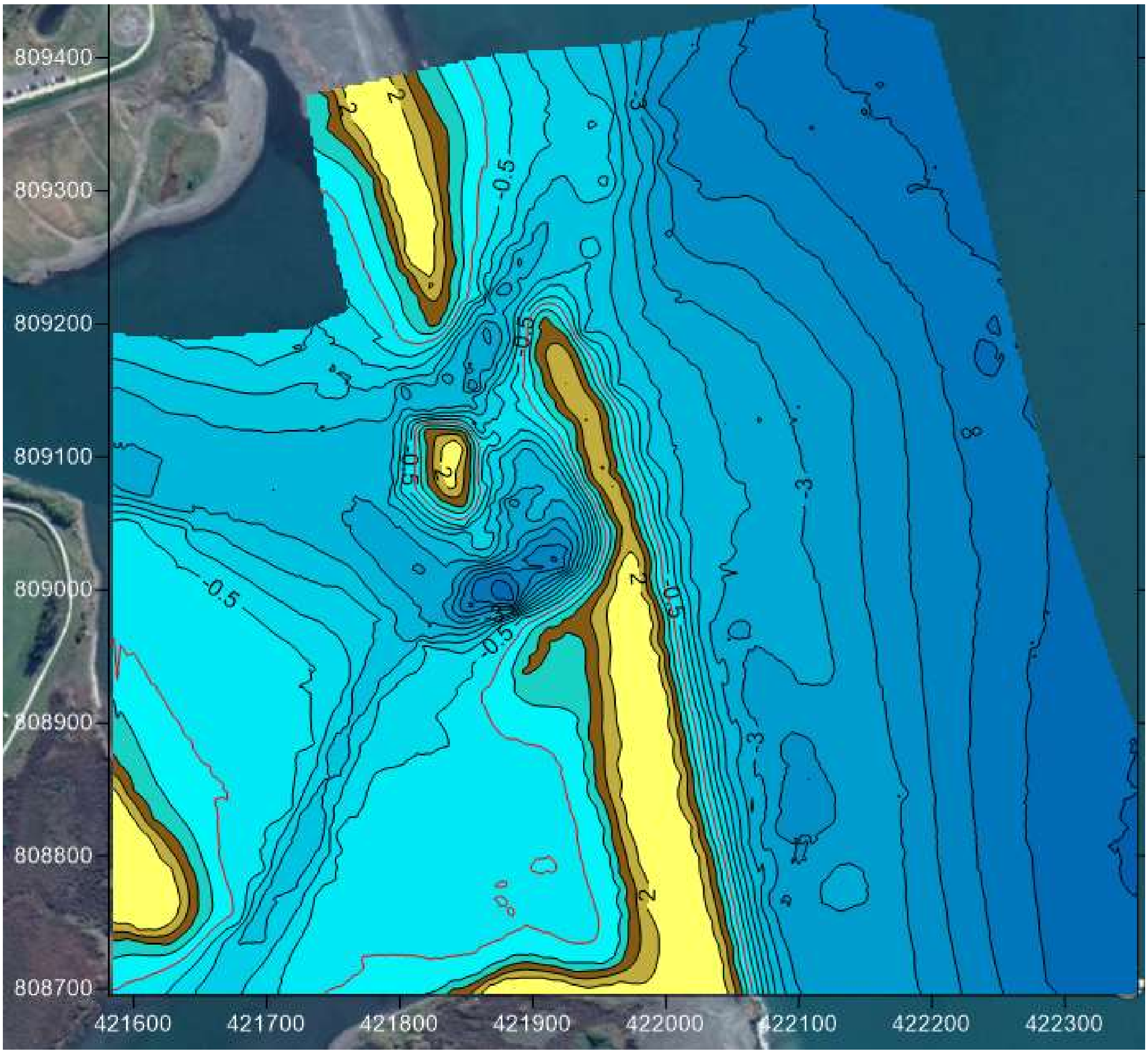

Figure 4.2. The bathymetry chart compiled from the bathymetry survey data, spot depths collected in the shallower areas of the lower estuary and digitised data from satellite images. Contour intervals are 0.5 m, and the depths are relative to the Napier Vertical Datum 2000, which is approximately mean sea level (MSL).

When the southern side of the lower estuary (i.e. on the south-eastern side of the main channel – Figure 4.4) is considered as a potential location to dispose of the dredge material from the lower Clive River (~60,500 m^3), it would be filled to ~1.4 m above MSL (i.e. partway up the shingle spit).

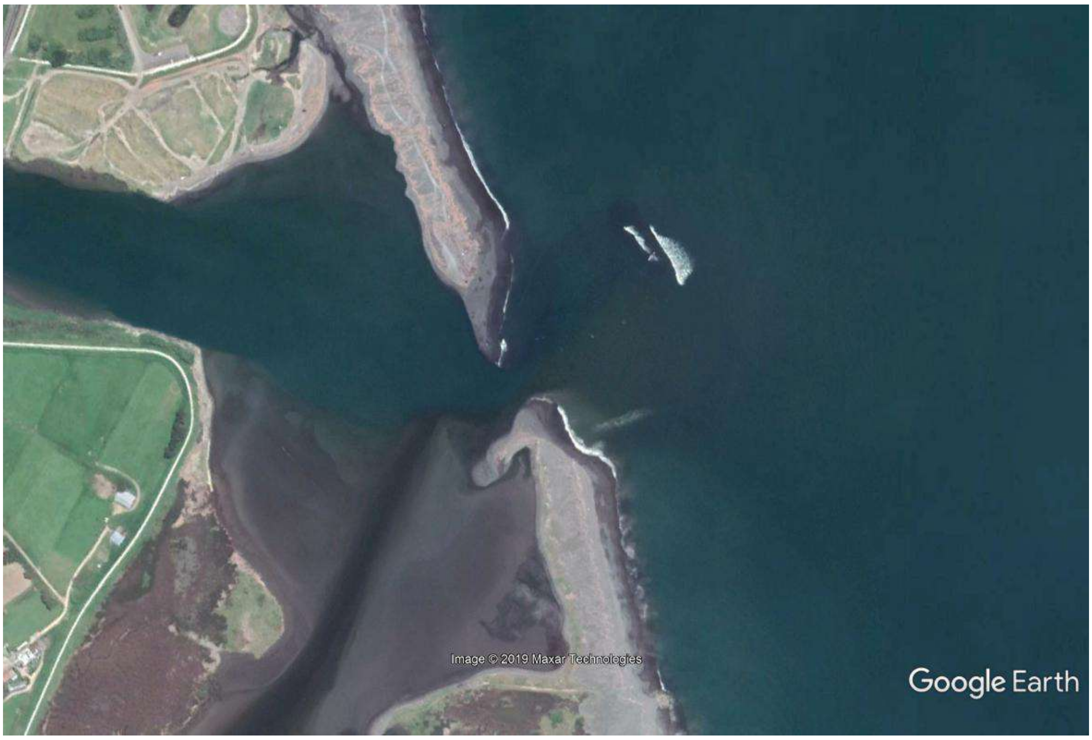

Figure 4.3. Satellite image from October 2018 showing the main channel of the Clive River and the shallow intertidal areas to either side (Google Earth 2019).

Figure 4.4. The southern estuary would be filled to ~1.4 m above MSL if the ~60,500 m^3 of dredged material from the lower Clive River was deposited here.

5 Ecological Assessment of Lower Clive Estuary and Coast

5.1 General Setting and Literature Review

The Clive/Karamu River mouth forms part of the Waitangi Estuary, the area of which is ~30 ha. The catchment mainly comprises sheep and beef pasture (42%), indigenous forest (16.5%) and manuka/kanuka scrub (13%) (HBRC, unpublished data 2016; cited in Haggitt., 2016). The Waitangi Estuary is regarded as providing exceptional habitat for wetland bird species, which include several rare and iconic species, such as the godwit, golden plover, black-billed gull, gannet and kotuku. The brackish swamps near the mouth provide habitat for the spotless crake and bitten. Haggitt (2016) describes the gravel beach ridge and bar system at the entrance as providing important nesting and roosting habitat for birds, such as dotterels, stilts, and terns. Walls (2005) reports that the estuary is also home to a significant number of native flora species including shore ribbonwood, marsh clubrush, and the threatened turf plant *Mimulus repens* (cited in Haggitt, 2016). The Karamu riverbanks provide important Inanga spawning habitat. Fish that frequent the Waitangi Estuary include Inanga, kahawai, eels, mullet, warehou (rarely) and flatfish.

Section 5.3 of the “State of the Hawke’s Bay Coastal Environment report (2004 – 2013)” (Wade *et al.,* 2016) describes the infaunal assemblages within Waitangi for a 5-year period between 2009 and 2013. Various community metric and indices were used to interpret the state and health of the Waitangi Estuary, among others within the region. In general, the Waitangi Estuary had the highest number of individuals per core (333 individuals), which was dominated by the amphipod *Paracorophium excavatum* (average of 227 individuals in each core) and the estuarine snail *Potamopurgus estuarinus* (average of 97 individuals per core). With respect to the various indices indicating species diversity and richness (Shannon’s diversity, Simpson’s diversity, Margalef’s richness, and Peilou’s eveness) Waitangi Estuary scored lowest amongst all the sampled estuaries.

The SOE concluded that the infauna associated with individual estuary sites is responding to mud concentrations. As such, species reported as intolerant of higher mud fractions *(*e.g. *Aonides trifida and Macomona Liliana)* are largely absent from sites where concentrations are >25% (as found at site 5C with approximately 60% silt and clay – Table 3.1). Further, a Traits Based Index (TBI) applied to the estuaries sampled corresponded closely to concentrations of mud (silt/clay), which indicates a reduction in the resilience of sites as mud concentrations increases. Waitangi Estuary scored ‘poorly’ in the TBI.

The Hawke’s Bay Regional Council does not monitor the shingle beaches within its region (HBRC website), in turn there is a paucity of data pertaining to the local ecology of these beaches. In general, shingle beaches provide habitat for an array of macro invertebrates, particularly macro invertebrates and associated predators. Species richness typically increases on shingle beaches where wrack accumulates, which provides additional invertebrate habitat and source of energy flow to higher order trophic levels (Menge, 1992, Dugan *et al.*, 2003). However, down the beach and into the surf zone, very few species are present due to the continual abrasive movement of the shingle (which becomes a sand/shingle mix moving into the subtidal zone) driven by almost constant wave action (Figure 5.1).

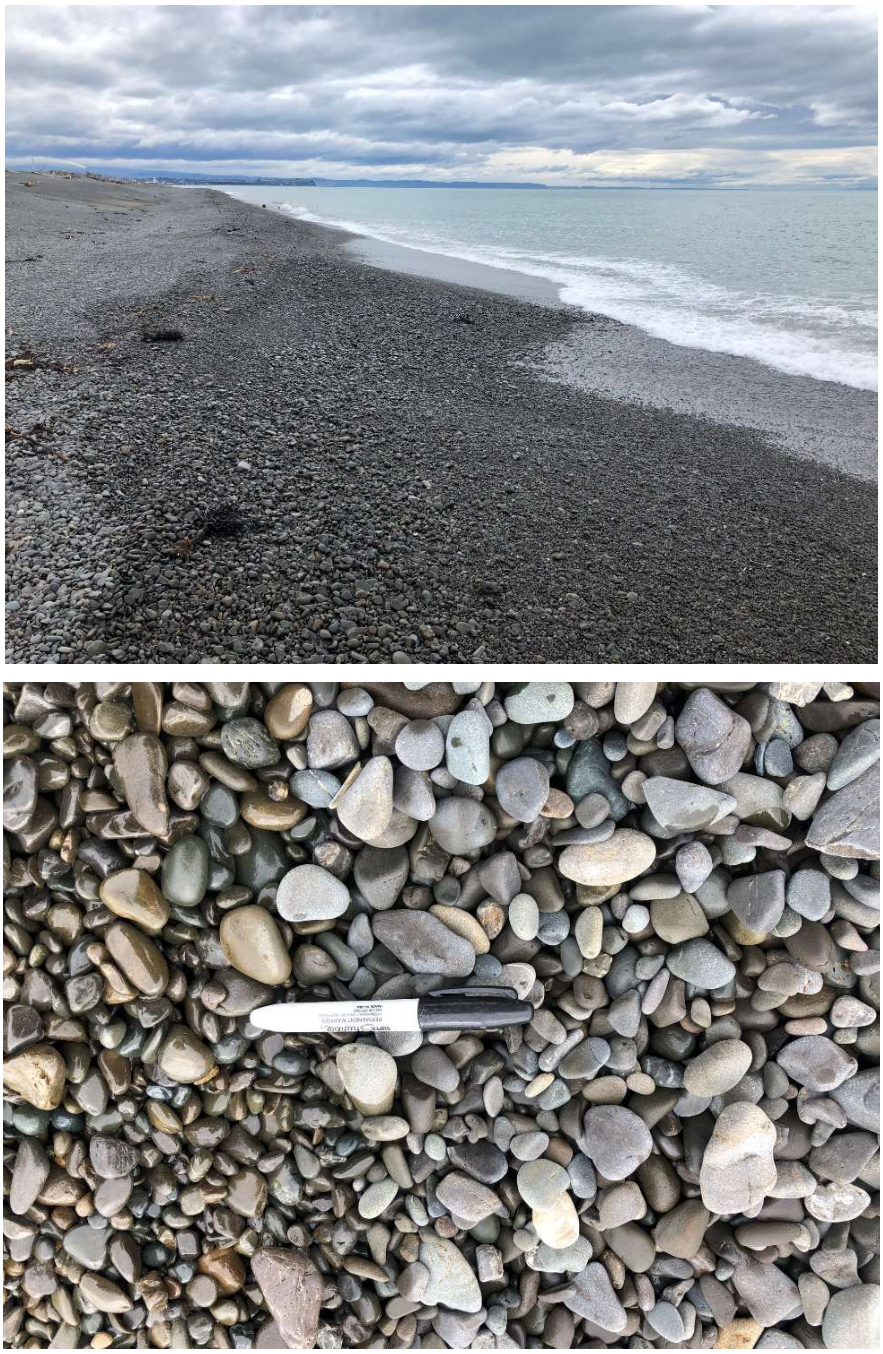

Figure 5.1. Even during very low wave conditions, wave action drives the continual abrasive movement of the shingle resulting in an inhospitable habitat.

The lower estuary site is very shallow and mostly intertidal in the small embayment on the southern side of the estuary entrance (Figure 4.2). This area is also very dynamic due to the migration of the entrance channel through the shingle barrier spit (Figure 5.2) and the interactions between the spit and the lower Clive River. For example, in October 2003, the small embayment in the southern part of the Waitangi Estuary had a distinctly different morphology in comparison to today (Figure 5.3 – it appears to have been stable since ~2013); even the location of the river entrance through the barrier spit had migrated significantly northward between 22 May and the date of the survey (23 August). An additional feature of the southern estuary is the mobile shingle banks (Figure 5.4), which can be seen as dark patches at sample locations V and VI in 2003, and between VII and X in 2019 (Figure 5.4).

Figure 5.2. The shingle spit between the lower estuary and the open coast, which is an important habitat for birds and native plants.

Figure 5.3. The southern part of the Waitangi Estuary has changed since 2003 (top) to 2019 (bottom), which is due to the dynamic nature of both the entrance channel and the shingle barrier spit. It has been relatively stable since around 2013. The dark patches at sample locations V and VI in 2003 (top), and between VII and X in 2019 (bottom) are mobile shingle banks (Figure 5.4).

Figure 5.4. The mobile shingle of the current banks in the southern part of the estuary.

5.2 Results of Field Data Collection

No living organisms were found in the 10 ponar grab samples on the open coast; sampling at sites 1, 4 and 8 (Figure 2.3) resulted in acquiring no sediment for sieving, which was due to the extension of the shingle layer offshore into the intertidal zone.

Three species were found in the core samples in the southern embayment area of the lower estuary – a common amphipod *Paracorophium excavatum*, the estuarine snail *Potamopurgus estuarinus* (Figure 5.5), which was also found in core samples of the lower Clive River in the previous study (Mead, 2019), and tiny red polychaetes (*Opheliid* sp.). Sea lettuce (*Ulva lactuca*) was also present on the occasional boulder (Figure 5.6).

The numbers of individual\s in each sample was very varied and ranged between 0 and 44, with the latter being dominated by amphipods (Figure 5.7). Given the low number of species present and with 4 sites having zero individuals (Figure 5.7), the Shannon-Wiener biodiversity index and species evenness were both found to be very low (0.60 and 0.55, respectively), as would be expected.

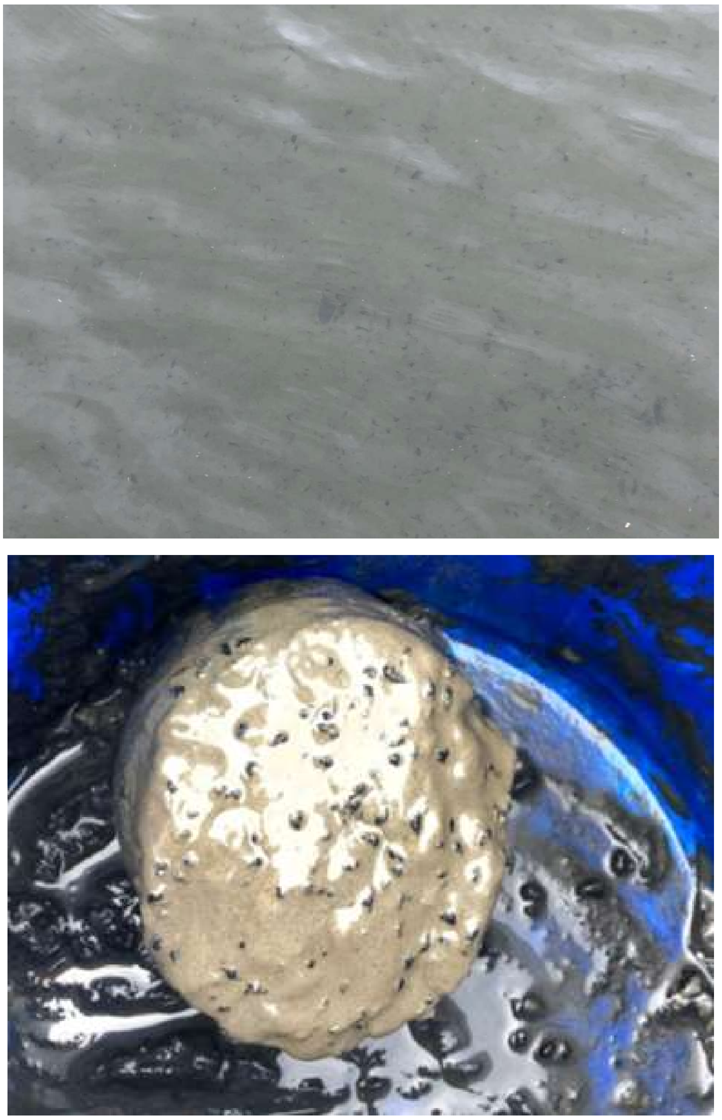

Figure 5.5. The estuarine snail *Potamopurgus estuarinus* in low density in the intertidal zone at the southern estuary (top) and in a core sample some 500 m further up the Clive River (eCoast, 2019) (bottom).

Figure 5.6. Sea lettuce (*Ulva lactuca*) was observed on the occasional boulder.

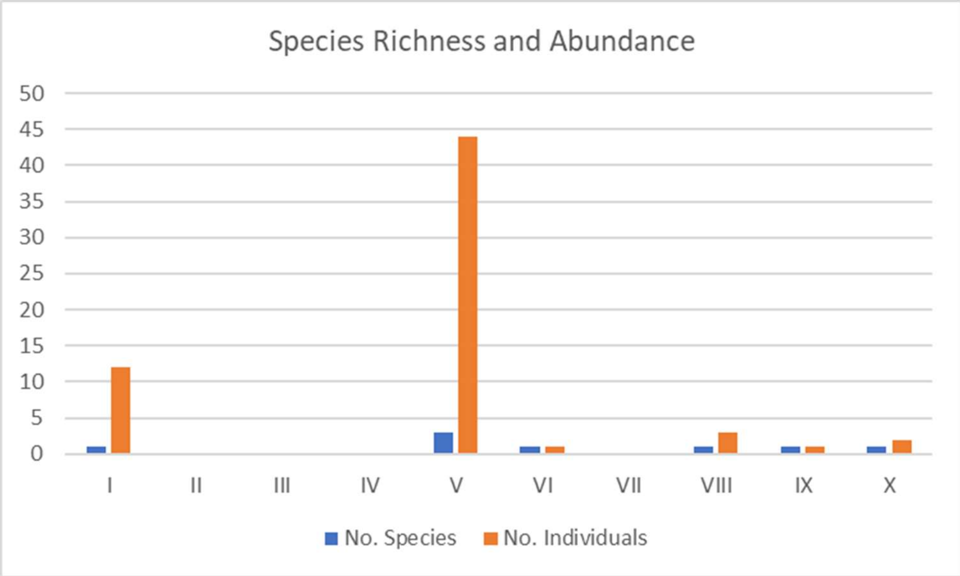

Figure 5.7. Species richness and abundance at the sample location

These results are in agreement with Wade *et al.* (2016), who found that the Waitangi Estuary scored lowest amongst all the sampled estuaries in the Hawke's Bay Region. This is likely to a large degree associated with the high mud fractions in the sediment (>25%), reducing the resilience of infauna (i.e., Waitangi Estuary scored 'poorly' in the Traits Based Index (Wade *et al.* (2016)).

6 Summary

1. Sediment samples (15) were collected in the Clive River and at the river entrance (both inside and outside) to determine the characteristics of the sediments to be discharged; i.e., type (grain size) and contaminants (nutrients, PAH's, trace metals, TOC, level of hypoxia, SVOC's).
2. In addition, probing was undertaken to determine the depth of the soft sediment that has accumulated above the original gravel riverbed.
3. Samples were found to be anoxic, with a thin aerated layer – oxygen levels increased upriver, which is the opposite trend to the prior sampling of the lower Clive River, where oxygen levels increased towards the river mouth.
4. Dissolved oxygen was found to be relatively high in the water column (>12 mg/l). Dissolved oxygen in the surficial sediment was found to be 2-4 mg/l at sites 1A-C (i.e. hypoxic), and >4 mg/l at sites 2A to 4C; dissolved oxygen in the surficial sediment layer was not measured for sites 5A-C. Similar to the anoxic layer, this was an opposite trend to what was found in the lower Clive River, where dissolved oxygen increased towards to river entrance.
5. The sediment composition at the riverine sites (1A to 4C) were found to mostly have similar with silt content >50% (with the exception of 2A) and clay content of 4-10%. Sediment composition was also in this category for site 5C (lower estuary near the river entrance), while the 2 open coast samples (5A and B) were comprised of fine-medium sand with only a very small fraction of silt.
6. Sediment contaminants were found to be mostly below guideline thresholds, and in some cases undetectable. However, sediment nutrients (i.e. total nitrogen and total phosphorous were found to be in the upper-range of recorded values for reference sites in the Hawke's Bay and other estuaries in New Zealand; similar to the results for the lower Clive River.
7. Zinc levels were found to be elevated above the ISQG-Low threshold level at all the riverine sites, except for 2C and 3A.
8. Sediment depth above the gravel riverbed was found to vary between 0.1 and 0.8 m thick, with a trend of increasing deposition down the river.
9. A relatively high resolution the bathymetry chart was created from the bathymetry survey data, spot depths collected in the shallower areas of the lower estuary and digitised data from satellite images. The bathymetry chart clearly shows the main channels into the lower estuary and the complexity of remnant channels and bars/islands due to the constantly migrating river entrance.

10. When disposal of the ~60,500 m^3 of dredge material into the south eastern side of the lower estuary is considered, it would come to a level of ~1.4 m above MSL (i.e. ~0.56 m above the MHWS tide mark).
11. Prior ecological assessment of the wider Waitangi Estuary found that it scored lowest amongst all the sampled estuaries in the Hawke's Bay, which is likely to a large part due to the high percentage of silt and clay (>60%).
12. Ecological assessment of the south eastern side of the estuary and the seabed on the open coast in the vicinity of the river entrance also found low biodiversity. No living organisms were found in grab samples on the open coast, partly due to the abrasive nature of the shingle and shingle/sand mobile substrate. Only 4 species were identified in the lower estuary, and biodiversity indices were found to be low (Shannon-Wiener biodiversity index and species evenness of 60 and 0.55, respectively), which was in agreement previous assessments of the wider estuary.

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Appendix A. Bathymetry Survey Report

Report of Survey: Clive River Entrance

MOHIO - AUAHA - TAUTOKO
UNDERSTAND - INNOVATE - SUSTAIN

1. Scope of Survey

This report of survey details the planning, methodology and results of a hydrographic and topographic survey conducted by eCoast Marine Consulting and Research at the entrance to Clive River, which is located at the south western end of Hawkes Bay, ~ 10 km south of Port Napier, New Zealand. The bathymetry survey was undertaken using a Single Beam Echo Sounder (SBES) to collect collocated depths both inside and outside of the river entrance on 23 August 2019.

2. Geodesy

2.1. Survey Datum

Horizontal Datum Parameters	
Datum	International Terrestrial Reference Frame 2008
Reference Frame	WGS 84 (G1762)
Semi-Major axis	a = 6378137.000m
Inverse flattening	1/f = 298.257223563
Vertical Datum	
Reference Datum	Ellipsoid

2.2. Control Points

The Order 4 benchmark CU5B was used as a control and reference point for survey. The equipment used for horizontal and vertical control is provided in Table 2.1.

Table 2.1: Equipment used for horizontal and vertical control

Equipment	Model	Accuracy
GNSS receiver x 2	Emlid Reach RS	Static H: 5 mm + 1 ppm Static V: 10 mm + 2 ppm
Tripod/Survey pole	Leica	N/A
Tribrach and optical plummet	Leica	±0.5mm@1.5m

3. Hydrographic Survey Equipment

Bathymetric data was collected from eCoast's PWC "*Red Rocket*". Table 3.1 provide details of the equipment used during the survey.

Table 3.1: Survey equipment used on *Red Rocket*

System	Model	Expected Accuracy
Single Bean Echo Sounder (SBES)	Ceepulse 100	See below
Transducer	Airmar SS510 200 kHz, 9°	0.01 m +/- 0.1% of depth
GNSS	Emlid Reach RS	Kinematic H: 7 mm + 1 ppm Kinematic V: 14 mm + 2 ppm
Sound Velocity Profiler (SVP)	YSI Pro DSS	±0.2°C | ±1.0% PSU | ±0.5 m/s
Lead line	NA	NA

3.1. Sound Velocity

A sound velocity profile of the water column was undertaken in the nearshore of the study site prior to survey on the morning of the 23rd August 2019. The water column was found to be homogenous. A sound velocity of 1525 m/s was applied.

3.2. Bar Check

Lead line checks were completed across a range of depths to verify the efficacy of the SBES whilst in the field. Lead line measurements (to face of transducer) and reported depth soundings were very agreeable (<0.03 m) and within the prescribed limits of the equipment.

3.3. Total Vertical Uncertainty

Total Vertical Uncertainty (TVU) is assessed by combining the sources of individual uncertainties. Table 3.2 provides sources of error and associated vertical uncertainties for the full range of depths. Note the TVU estimate has not included uncertainty values for vessel roll, pitch and yaw motions. The estimated TVU is 0.031 m (excluding vessel motion).

Table 3.2. Sources of error and vertical uncertainty

Source of Error	Expected Accuracy	Max Vertical Uncertainty (m)
SBES + transducer	0.01 m +/- 0.1%	0.026
RTK	Kinematic V: 14 mm	0.014
Sound Velocity	±0.5 m/s	0.01

4. Post-processing and Data

Data was been cleaned for outliers and bathymetric data collected throughout turns removed. A comparison of all points, some 19,000, including the cross lines was undertaken. Only pairs of points with a time difference of greater than 15 minutes were compared, and a mean offset calculated from points closer than 0.3 m. Figure 4.1 presents the data from this comparison. Figure 4.2 shows the postprocessed data overlain on a satellite image of Clive River entrance.

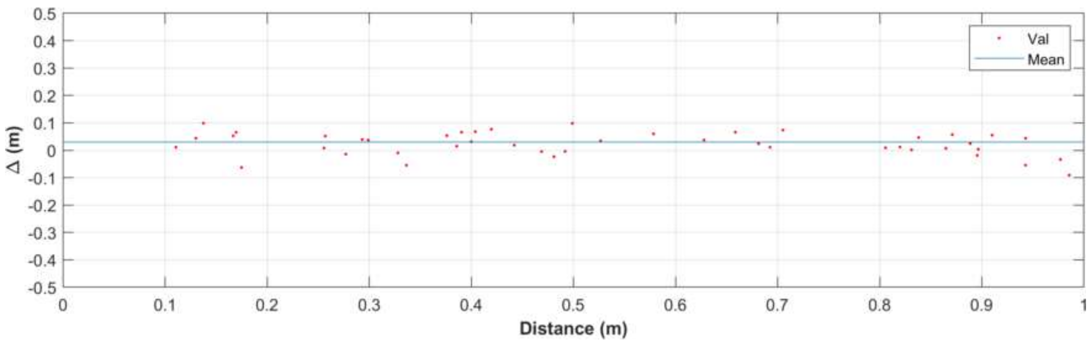

Figure 4.1: Delta values against distance between points from a comparison of points within the bathymetric survey with a time difference of no less than 15 minutes, the mean difference in calculated from points less than 0.3 m apart.

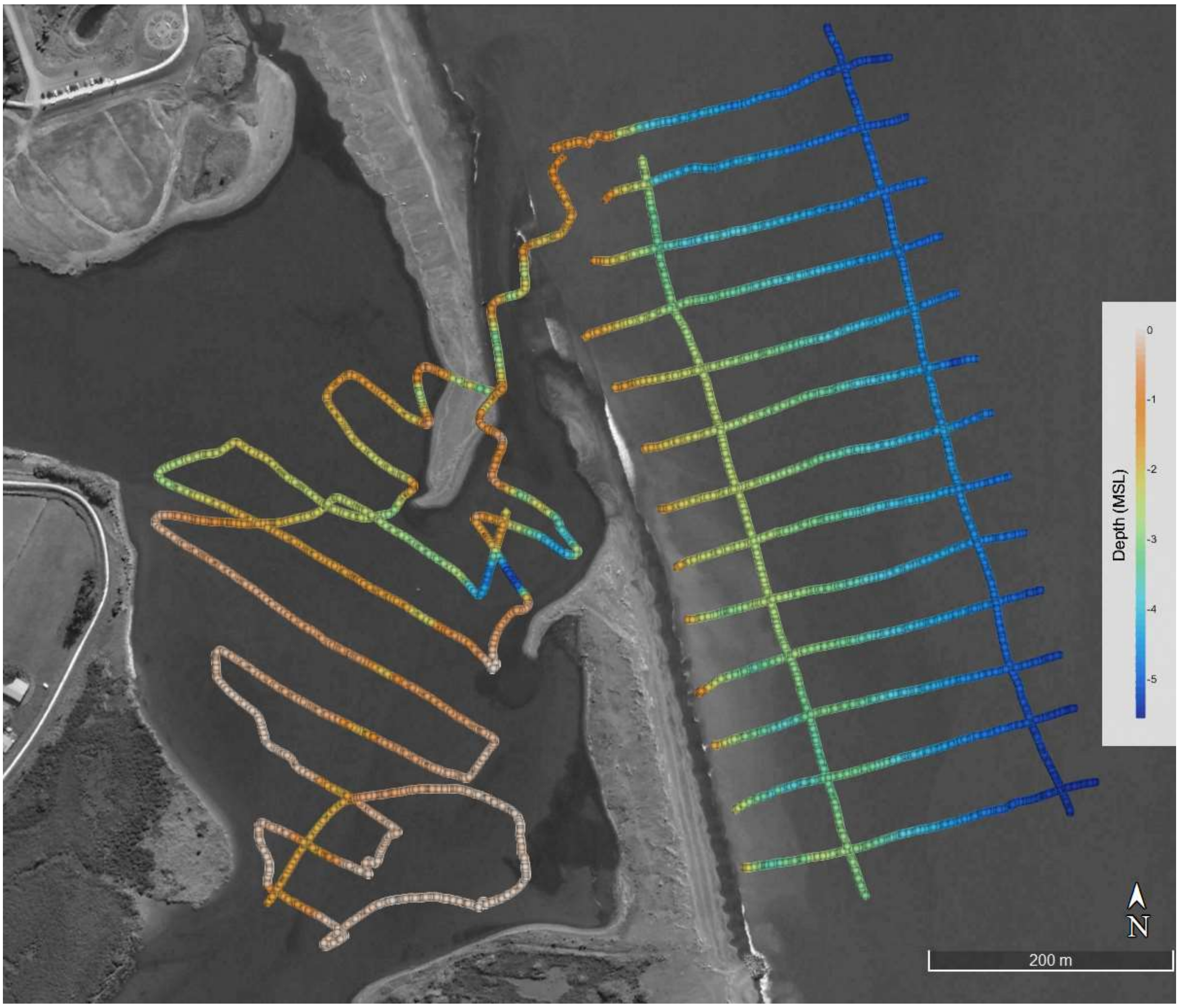

Figure 4.2: Survey data points adjusted to Napier Vertical Datum 2000 overlain on a satellite image from 22nd May 2019 (Google Earth)

Appendix B. Sediment Analysis Results

Hill Laboratories
TRIED, TESTED AND TRUSTED

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Certificate of Analysis

SPv1

Client:	eCoast Limited	**Lab No:**	2229699
Contact:	Shaw Mead C/- eCoast Limited PO Box 151 Raglan 3225	**Date Received:**	23-Aug-2019
		Date Reported:	12-Sep-2019
		Quote No:	99757
		Order No:	
		Client Reference:	Clive River
		Submitted By:	Shaw Mead

Sample Type: Sediment

Sample Name:		1A	1B	1C	2A	2B
Lab Number:		2229699.1	2229699.2	2229699.3	2229699.4	2229699.5
Individual Tests						
Dry Matter	g/100g as rcvd	34	40	37	50	45
Particle size analysis*		See attached report	See attached report	See attached report	See attached report	See attached report
Total Recoverable Beryllium*	mg/kg dry wt	0.7	0.6	0.6	0.5	0.5
Total Recoverable Boron	mg/kg dry wt	18	12	15	7	7
Chromium (hexavalent)*	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total Recoverable Cobalt	mg/kg dry wt	7.9	7.3	7.4	7.2	7.1
Total Recoverable Manganese	mg/kg dry wt	550	420	600	470	1,030
Total Recoverable Phosphorus	mg/kg dry wt	830	660	730	560	840
Total Recoverable Selenium	mg/kg dry wt	< 2	< 2	< 2	< 2	< 2
Total Nitrogen*	g/100g dry wt	0.40	0.29	0.35	0.18	0.24
Ammonium-N*	mg/kg dry wt	9	17	15	< 5	< 5
Nitrite-N*	mg/kg dry wt	< 1.4	< 1.2	< 1.3	< 1.0	< 1.1
Nitrate-N*	mg/kg dry wt	< 2.0	< 1.7	< 1.8	< 1.5	< 1.5
Nitrate-N + Nitrite-N*	mg/kg dry wt	< 1.4	< 1.2	< 1.3	< 1.0	< 1.1
Total Organic Carbon*	g/100g dry wt	3.9	2.8	3.6	1.81	2.5
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	7.3	4.9	5.5	4.9	5.2
Total Recoverable Cadmium	mg/kg dry wt	0.33	0.20	0.21	0.21	0.23
Total Recoverable Chromium	mg/kg dry wt	21	15.5	16.8	13.5	14.2
Total Recoverable Copper	mg/kg dry wt	26	15.8	17.4	12.4	14.3
Total Recoverable Lead	mg/kg dry wt	33	20	21	19.1	20
Total Recoverable Mercury	mg/kg dry wt	0.08	0.07	0.08	0.05	0.06
Total Recoverable Nickel	mg/kg dry wt	12.6	10.0	10.6	8.9	9.1
Total Recoverable Zinc	mg/kg dry wt	360	260	270	260	280
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
2,4-Dinitrotoluene	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
2,6-Dinitrotoluene	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Nitrobenzene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5

Sample Type: Sediment						
	Sample Name:	1A	1B	1C	2A	2B
	Lab Number:	2229699.1	2229699.2	2229699.3	2229699.4	2229699.5
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
alpha-BHC	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
beta-BHC	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
delta-BHC	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
gamma-BHC (Lindane)	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
4,4'-DDD	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
4,4'-DDE	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
4,4'-DDT	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Dieldrin	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Endosulfan I	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Endosulfan II	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Endosulfan sulphate	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Endrin	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Endrin ketone	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Heptachlor	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Heptachlor epoxide	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Hexachlorobenzene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples						
Acenaphthene	mg/kg dry wt	< 0.16	< 0.14	< 0.15	< 0.11	< 0.12
Acenaphthylene	mg/kg dry wt	< 0.16	< 0.14	< 0.15	< 0.11	< 0.12
Anthracene	mg/kg dry wt	< 0.16	< 0.14	< 0.15	< 0.11	< 0.12
Benzo[a]anthracene	mg/kg dry wt	< 0.16	< 0.14	< 0.15	< 0.11	< 0.12
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Benzo[k]fluoranthene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
1&2-Chloronaphthalene	mg/kg dry wt	< 0.3	< 0.2	< 0.3	< 0.15	< 0.17
Chrysene	mg/kg dry wt	< 0.16	< 0.14	< 0.15	< 0.11	< 0.12
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Fluoranthene	mg/kg dry wt	< 0.16	< 0.14	< 0.15	< 0.11	< 0.12
Fluorene	mg/kg dry wt	< 0.16	< 0.14	< 0.15	< 0.11	< 0.12
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
2-Methylnaphthalene	mg/kg dry wt	< 0.16	< 0.14	< 0.15	< 0.11	< 0.12
Naphthalene	mg/kg dry wt	< 0.16	< 0.14	< 0.15	< 0.11	< 0.12
Phenanthrene	mg/kg dry wt	< 0.16	< 0.14	< 0.15	< 0.11	< 0.12
Pyrene	mg/kg dry wt	< 0.16	< 0.14	< 0.15	< 0.11	< 0.12
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	< 0.8	< 0.7	< 0.7	< 0.6	< 0.6
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.8	< 0.7	< 0.7	< 0.5	< 0.6
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
2-Chlorophenol	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
2,4-Dichlorophenol	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
2-Nitrophenol	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Pentachlorophenol (PCP)	mg/kg dry wt	< 7	< 6	< 6	< 6	< 6
Phenol	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5

Sample Type: Sediment						
Sample Name:		1A	1B	1C	2A	2B
Lab Number:		2229699.1	2229699.2	2229699.3	2229699.4	2229699.5
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	< 1.3	< 1.1	< 1.2	< 0.9	< 1.0
Butylbenzylphthalate	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Diethylphthalate	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Dimethylphthalate	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Di-n-butylphthalate	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Di-n-octylphthalate	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
1,3-Dichlorobenzene	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
1,4-Dichlorobenzene	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Hexachlorobutadiene	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
Hexachloroethane	mg/kg dry wt	< 0.7	< 0.6	< 0.6	< 0.5	< 0.5
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 4	< 3	< 3	< 3	< 3
Carbazole	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Dibenzofuran	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Isophorone	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	< 0.3
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 17	< 15	< 16	< 12	< 14
C10 - C11	mg/kg dry wt	< 17	< 15	< 16	< 12	< 14
C12 - C14	mg/kg dry wt	< 17	< 15	< 16	< 12	< 14
C15 - C20	mg/kg dry wt	35	26	40	14	16
C21 - C25	mg/kg dry wt	41	31	55	31	28
C26 - C29	mg/kg dry wt	41	35	68	41	31
C30 - C44	mg/kg dry wt	240	210	390	200	174
Total hydrocarbons (C7 - C44)	mg/kg dry wt	360	310	550	290	250

Sample Name:		2C	3A	3B	3C	4A
Lab Number:		2229699.6	2229699.7	2229699.8	2229699.9	2229699.10
Individual Tests						
Dry Matter	g/100g as rcvd	65	71	43	33	31
Particle size analysis*		See attached report	See attached report	See attached report	See attached report	See attached report
Total Recoverable Beryllium*	mg/kg dry wt	0.5	0.4	0.6	0.7	0.7
Total Recoverable Boron	mg/kg dry wt	5	3	7	9	9
Chromium (hexavalent)*	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total Recoverable Cobalt	mg/kg dry wt	5.7	7.0	8.0	9.5	8.6
Total Recoverable Manganese	mg/kg dry wt	610	350	1,030	1,760	1,660
Total Recoverable Phosphorus	mg/kg dry wt	540	430	1,160	1,230	1,450
Total Recoverable Selenium	mg/kg dry wt	< 2	< 2	< 2	< 2	< 2
Total Nitrogen*	g/100g dry wt	0.11	0.07	0.24	0.36	0.39
Ammonium-N*	mg/kg dry wt	< 5	25	57	59	28
Nitrite-N*	mg/kg dry wt	< 1.0	< 1.0	< 1.1	< 1.5	< 1.6
Nitrate-N*	mg/kg dry wt	< 1.5	< 1.5	< 1.5	< 2.1	< 2.2
Nitrate-N + Nitrite-N*	mg/kg dry wt	< 1.0	< 1.0	< 1.1	< 1.5	< 1.6
Total Organic Carbon*	g/100g dry wt	1.09	0.62	2.4	3.3	3.6
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	3.2	3.3	4.0	7.6	7.4
Total Recoverable Cadmium	mg/kg dry wt	0.090	0.059	0.143	0.23	0.23
Total Recoverable Chromium	mg/kg dry wt	11.1	10.4	15.3	18.1	18.4
Total Recoverable Copper	mg/kg dry wt	8.9	7.5	18.0	22	23
Total Recoverable Lead	mg/kg dry wt	12.8	9.7	18.5	26	27
Total Recoverable Mercury	mg/kg dry wt	0.05	0.05	0.06	0.07	0.08
Total Recoverable Nickel	mg/kg dry wt	8.1	8.0	10.4	11.1	11.0

Sample Type: Sediment						
Sample Name:		2C	3A	3B	3C	4A
Lab Number:		2229699.6	2229699.7	2229699.8	2229699.9	2229699.10
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Zinc	mg/kg dry wt	155	108	240	370	380
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.17	< 0.3	< 0.5	< 0.7	< 0.7
2,4-Dinitrotoluene	mg/kg dry wt	< 0.2	< 0.3	< 0.5	< 0.7	< 0.7
2,6-Dinitrotoluene	mg/kg dry wt	< 0.2	< 0.3	< 0.5	< 0.7	< 0.7
Nitrobenzene	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.17	< 0.3	< 0.5	< 0.7	< 0.7
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
alpha-BHC	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
beta-BHC	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
delta-BHC	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
gamma-BHC (Lindane)	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
4,4'-DDD	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
4,4'-DDE	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
4,4'-DDT	mg/kg dry wt	< 0.2	< 0.3	< 0.5	< 0.7	< 0.7
Dieldrin	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Endosulfan I	mg/kg dry wt	< 0.2	< 0.3	< 0.5	< 0.7	< 0.7
Endosulfan II	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.7	< 0.7
Endosulfan sulphate	mg/kg dry wt	< 0.2	< 0.3	< 0.5	< 0.7	< 0.7
Endrin	mg/kg dry wt	< 0.17	< 0.3	< 0.5	< 0.7	< 0.7
Endrin ketone	mg/kg dry wt	< 0.2	< 0.3	< 0.5	< 0.7	< 0.7
Heptachlor	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Heptachlor epoxide	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Hexachlorobenzene	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples						
Acenaphthene	mg/kg dry wt	< 0.10	< 0.10	< 0.13	< 0.17	< 0.18
Acenaphthylene	mg/kg dry wt	< 0.10	< 0.10	< 0.13	< 0.17	< 0.18
Anthracene	mg/kg dry wt	< 0.10	< 0.10	< 0.13	< 0.17	< 0.18
Benzo[a]anthracene	mg/kg dry wt	< 0.10	< 0.10	< 0.13	< 0.17	< 0.18
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Benzo[k]fluoranthene	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
1&2-Chloronaphthalene	mg/kg dry wt	< 0.10	< 0.11	< 0.18	< 0.3	< 0.3
Chrysene	mg/kg dry wt	< 0.10	< 0.10	< 0.13	< 0.17	< 0.18
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Fluoranthene	mg/kg dry wt	< 0.10	< 0.10	< 0.13	< 0.17	< 0.18
Fluorene	mg/kg dry wt	< 0.10	< 0.10	< 0.13	< 0.17	< 0.18
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
2-Methylnaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.13	< 0.17	< 0.18
Naphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.13	< 0.17	< 0.18
Phenanthrene	mg/kg dry wt	< 0.10	< 0.10	< 0.13	< 0.17	< 0.18
Pyrene	mg/kg dry wt	< 0.10	< 0.10	< 0.13	< 0.17	< 0.18
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	< 0.3	< 0.4	< 0.6	< 0.8	< 0.9
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.3	< 0.4	< 0.6	< 0.8	< 0.9

Sample Type: Sediment						
Sample Name:		2C	3A	3B	3C	4A
Lab Number:		2229699.6	2229699.7	2229699.8	2229699.9	2229699.10
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.7	< 0.7
2-Chlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.3	< 0.4	< 0.4
2,4-Dichlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.3	< 0.4	< 0.4
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.4	< 0.4	< 0.5	< 0.7	< 0.7
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.2	< 0.2	< 0.3	< 0.4	< 0.4
2-Nitrophenol	mg/kg dry wt	< 0.4	< 0.4	< 0.5	< 0.7	< 0.7
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	< 6	< 6	< 7	< 7
Phenol	mg/kg dry wt	< 0.2	< 0.3	< 0.5	< 0.7	< 0.7
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.2	< 0.3	< 0.5	< 0.7	< 0.7
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.2	< 0.3	< 0.5	< 0.7	< 0.7
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	< 0.5	< 0.6	< 1.0	< 1.4	< 1.4
Butylbenzylphthalate	mg/kg dry wt	< 0.2	< 0.3	< 0.5	< 0.7	< 0.7
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.2	< 0.2	< 0.3	< 0.4	< 0.4
Diethylphthalate	mg/kg dry wt	< 0.2	< 0.3	< 0.5	< 0.7	< 0.7
Dimethylphthalate	mg/kg dry wt	< 0.2	< 0.3	< 0.5	< 0.7	< 0.7
Di-n-butylphthalate	mg/kg dry wt	< 0.2	< 0.3	< 0.5	< 0.7	< 0.7
Di-n-octylphthalate	mg/kg dry wt	< 0.2	< 0.3	< 0.5	< 0.7	< 0.7
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.17	< 0.3	< 0.5	< 0.7	< 0.7
1,3-Dichlorobenzene	mg/kg dry wt	< 0.17	< 0.3	< 0.5	< 0.7	< 0.7
1,4-Dichlorobenzene	mg/kg dry wt	< 0.17	< 0.3	< 0.5	< 0.7	< 0.7
Hexachlorobutadiene	mg/kg dry wt	< 0.17	< 0.3	< 0.5	< 0.7	< 0.7
Hexachloroethane	mg/kg dry wt	< 0.17	< 0.3	< 0.5	< 0.7	< 0.7
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 1.0	< 1.5	< 3	< 4	< 4
Carbazole	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Dibenzofuran	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Isophorone	mg/kg dry wt	< 0.10	< 0.15	< 0.3	< 0.4	< 0.4
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 9	< 9	< 30	< 18	< 20
C10 - C11	mg/kg dry wt	< 9	< 9	< 30	< 18	< 20
C12 - C14	mg/kg dry wt	< 9	< 9	< 30	< 18	< 20
C15 - C20	mg/kg dry wt	< 9	11	< 30	35	< 20
C21 - C25	mg/kg dry wt	12	12	26	48	< 20
C26 - C29	mg/kg dry wt	14	13	< 30	50	< 20
C30 - C44	mg/kg dry wt	95	98	98	350	105
Total hydrocarbons (C7 - C44)	mg/kg dry wt	121	135	< 200	490	< 150

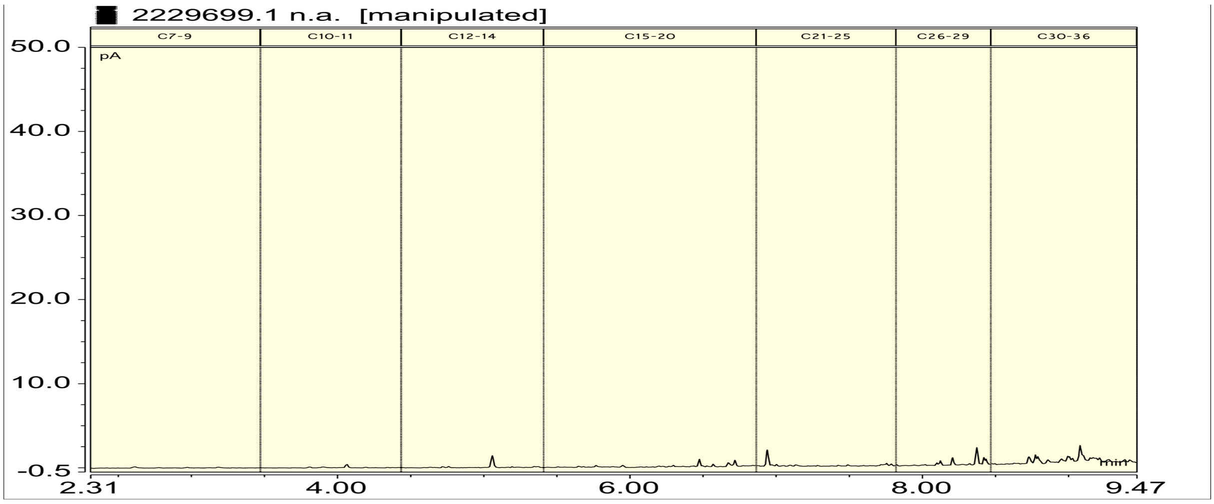
Sample Name:		4B	4C	5A	5B	5C
Lab Number:		2229699.11	2229699.12	2229699.13	2229699.14	2229699.15
Individual Tests						
Dry Matter	g/100g as rcvd	37	38	78	80	68
Particle size analysis*		See attached report	See attached report	See attached report	See attached report	See attached report
Total Recoverable Beryllium*	mg/kg dry wt	0.6	0.6	0.4	0.3	0.5
Total Recoverable Boron	mg/kg dry wt	8	9	6	5	4
Chromium (hexavalent)*	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total Recoverable Cobalt	mg/kg dry wt	8.7	9.5	3.0	2.9	5.1
Total Recoverable Manganese	mg/kg dry wt	1,370	1,490	178	180	330
Total Recoverable Phosphorus	mg/kg dry wt	1,090	1,280	280	280	470
Total Recoverable Selenium	mg/kg dry wt	< 2	< 2	< 2	< 2	< 2
Total Nitrogen*	g/100g dry wt	0.31	0.30	< 0.05	< 0.05	0.06

Sample Type: Sediment						
	Sample Name:	4B	4C	5A	5B	5C
	Lab Number:	2229699.11	2229699.12	2229699.13	2229699.14	2229699.15
Individual Tests						
Ammonium-N*	mg/kg dry wt	14	10	< 5	< 5	< 5
Nitrite-N*	mg/kg dry wt	< 1.3	< 1.3	< 1.0	< 1.0	< 1.0
Nitrate-N*	mg/kg dry wt	< 1.8	< 1.8	< 1.5	< 1.5	< 1.5
Nitrate-N + Nitrite-N*	mg/kg dry wt	< 1.3	< 1.3	< 1.0	< 1.0	< 1.0
Total Organic Carbon*	g/100g dry wt	2.8	2.9	0.08	0.07	0.51
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	7.1	8.1	2.7	2.6	2.9
Total Recoverable Cadmium	mg/kg dry wt	0.185	0.21	0.017	0.017	0.030
Total Recoverable Chromium	mg/kg dry wt	17.3	17.4	8.4	8.0	11.3
Total Recoverable Copper	mg/kg dry wt	19.5	21	4.0	3.8	5.7
Total Recoverable Lead	mg/kg dry wt	25	25	6.0	5.9	7.9
Total Recoverable Mercury	mg/kg dry wt	0.07	0.08	0.06	0.05	0.05
Total Recoverable Nickel	mg/kg dry wt	10.6	10.7	6.0	5.7	9.1
Total Recoverable Zinc	mg/kg dry wt	330	380	32	30	44
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
2,4-Dinitrotoluene	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
2,6-Dinitrotoluene	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Nitrobenzene	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
alpha-BHC	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
beta-BHC	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
delta-BHC	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
gamma-BHC (Lindane)	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
4,4'-DDD	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
4,4'-DDE	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
4,4'-DDT	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Dieldrin	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Endosulfan I	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Endosulfan II	mg/kg dry wt	< 0.6	< 0.6	< 0.5	< 0.5	< 0.5
Endosulfan sulphate	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Endrin	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Endrin ketone	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Heptachlor	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Heptachlor epoxide	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Hexachlorobenzene	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples						
Acenaphthene	mg/kg dry wt	< 0.15	< 0.14	< 0.10	< 0.10	< 0.10
Acenaphthylene	mg/kg dry wt	< 0.15	< 0.14	< 0.10	< 0.10	< 0.10
Anthracene	mg/kg dry wt	< 0.15	< 0.14	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	mg/kg dry wt	< 0.15	< 0.14	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Benzo[k]fluoranthene	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16

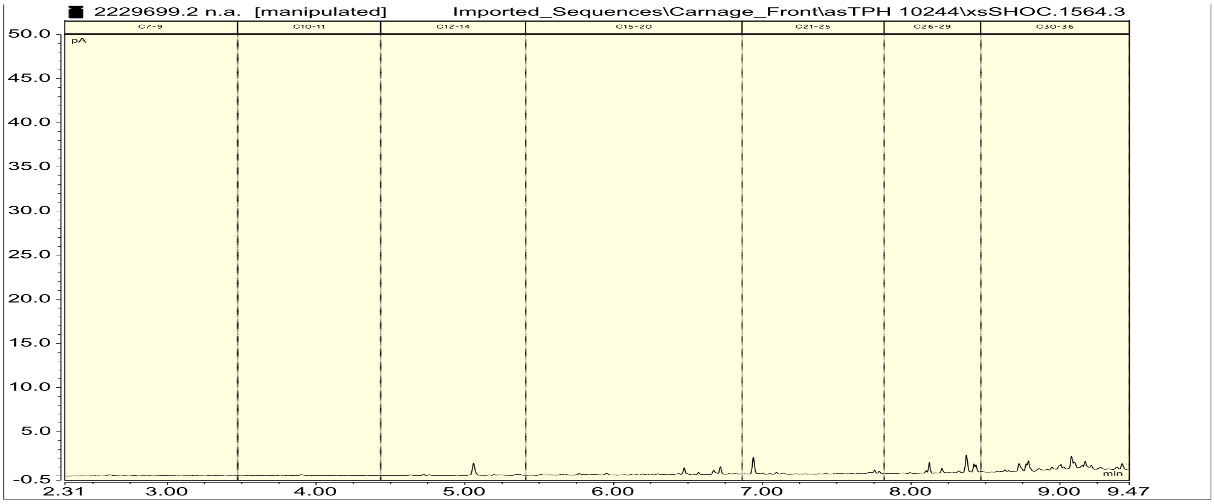
Sample Type: Sediment						
	Sample Name:	4B	4C	5A	5B	5C
	Lab Number:	2229699.11	2229699.12	2229699.13	2229699.14	2229699.15
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples						
1&2-Chloronaphthalene	mg/kg dry wt	< 0.3	< 0.2	< 0.10	< 0.10	< 0.12
Chrysene	mg/kg dry wt	< 0.15	< 0.14	< 0.10	< 0.10	< 0.10
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Fluoranthene	mg/kg dry wt	< 0.10	< 0.14	< 0.10	< 0.10	< 0.10
Fluorene	mg/kg dry wt	< 0.15	< 0.14	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
2-Methylnaphthalene	mg/kg dry wt	< 0.15	< 0.14	< 0.10	< 0.10	< 0.10
Naphthalene	mg/kg dry wt	< 0.15	< 0.14	< 0.10	< 0.10	< 0.10
Phenanthrene	mg/kg dry wt	< 0.15	< 0.14	< 0.10	< 0.10	< 0.10
Pyrene	mg/kg dry wt	< 0.10	< 0.14	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	< 0.7	< 0.7	< 0.4	< 0.4	< 0.4
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.7	< 0.7	< 0.4	< 0.4	< 0.4
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.6	< 0.6	< 0.5	< 0.5	< 0.5
2-Chlorophenol	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.2
2,4-Dichlorophenol	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.2
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.6	< 0.6	< 0.4	< 0.4	< 0.4
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.2
2-Nitrophenol	mg/kg dry wt	< 0.6	< 0.6	< 0.4	< 0.4	< 0.4
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	< 6	< 6	< 6	< 6
Phenol	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	< 1.2	< 1.2	< 0.6	< 0.6	< 0.7
Butylbenzylphthalate	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.2
Diethylphthalate	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Dimethylphthalate	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Di-n-butylphthalate	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Di-n-octylphthalate	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
1,3-Dichlorobenzene	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
1,4-Dichlorobenzene	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Hexachlorobutadiene	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
Hexachloroethane	mg/kg dry wt	< 0.6	< 0.6	< 0.3	< 0.3	< 0.4
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 3	< 3	< 1.4	< 1.4	< 1.6
Carbazole	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Dibenzofuran	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Isophorone	mg/kg dry wt	< 0.3	< 0.3	< 0.14	< 0.14	< 0.16
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 16	< 16	< 8	< 8	< 9
C10 - C11	mg/kg dry wt	< 16	< 16	< 8	< 8	< 9
C12 - C14	mg/kg dry wt	< 16	< 16	< 8	< 8	< 9
C15 - C20	mg/kg dry wt	24	24	< 8	< 8	< 9
C21 - C25	mg/kg dry wt	33	43	< 8	< 8	< 9
C26 - C29	mg/kg dry wt	32	48	< 8	< 8	< 9
C30 - C44	mg/kg dry wt	240	330	< 20	< 20	< 20
Total hydrocarbons (C7 - C44)	mg/kg dry wt	330	440	< 70	< 70	< 80

Sample Type: Sediment					
Sample Name:	4B	4C	5A	5B	5C
Lab Number:	2229699.11	2229699.12	2229699.13	2229699.14	2229699.15

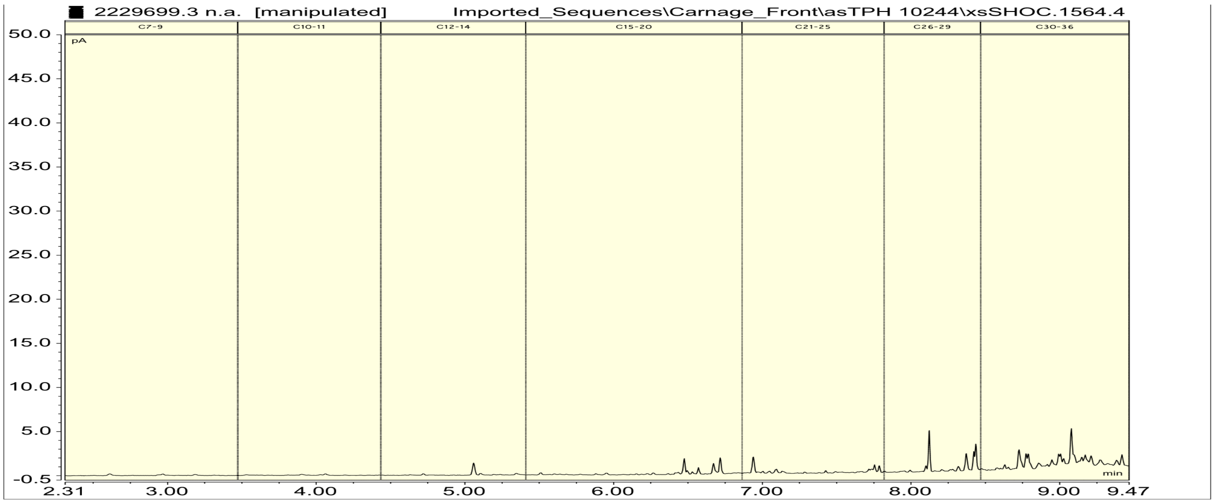
2229699.1
1A
Client Chromatogram for TPH by FID



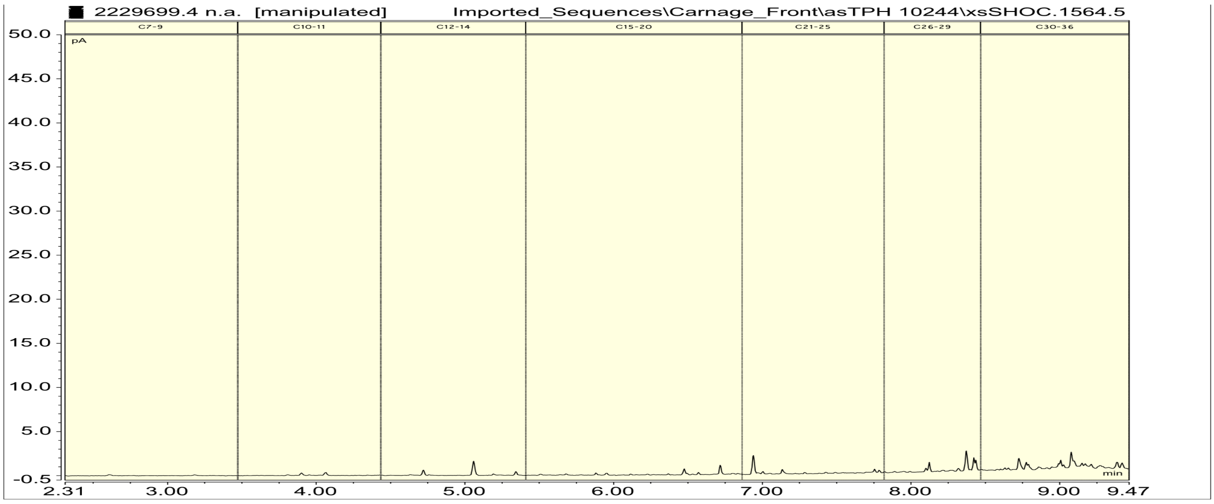
2229699.2
1B
Client Chromatogram for TPH by FID



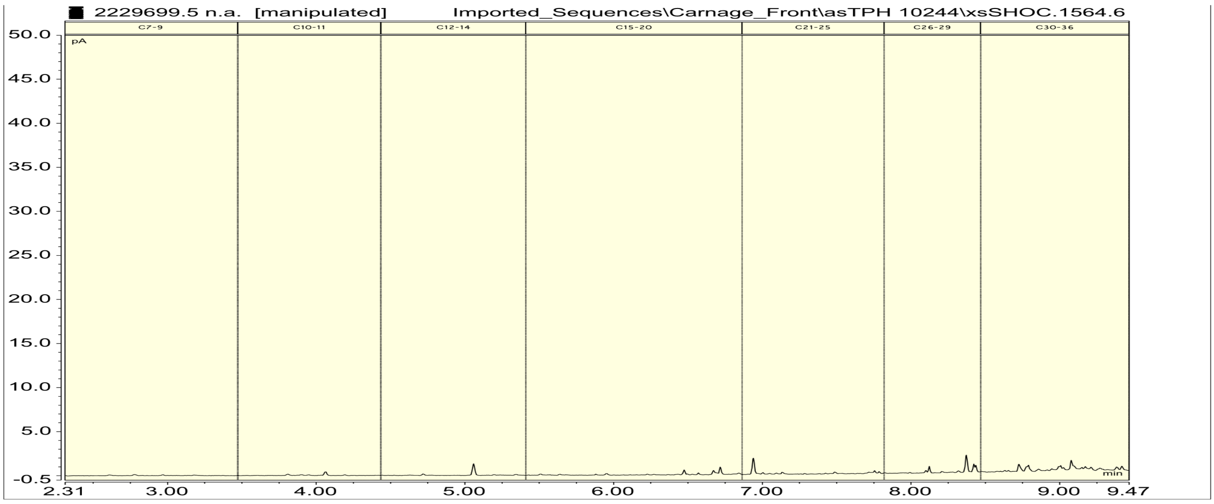
2229699.3
1C
Client Chromatogram for TPH by FID



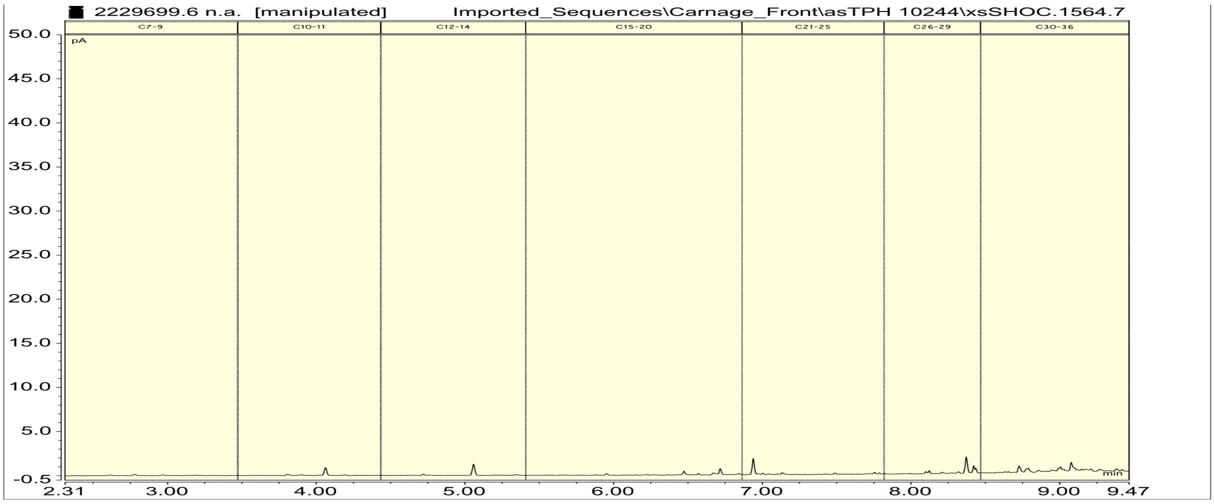
2229699.4
2A
Client Chromatogram for TPH by FID



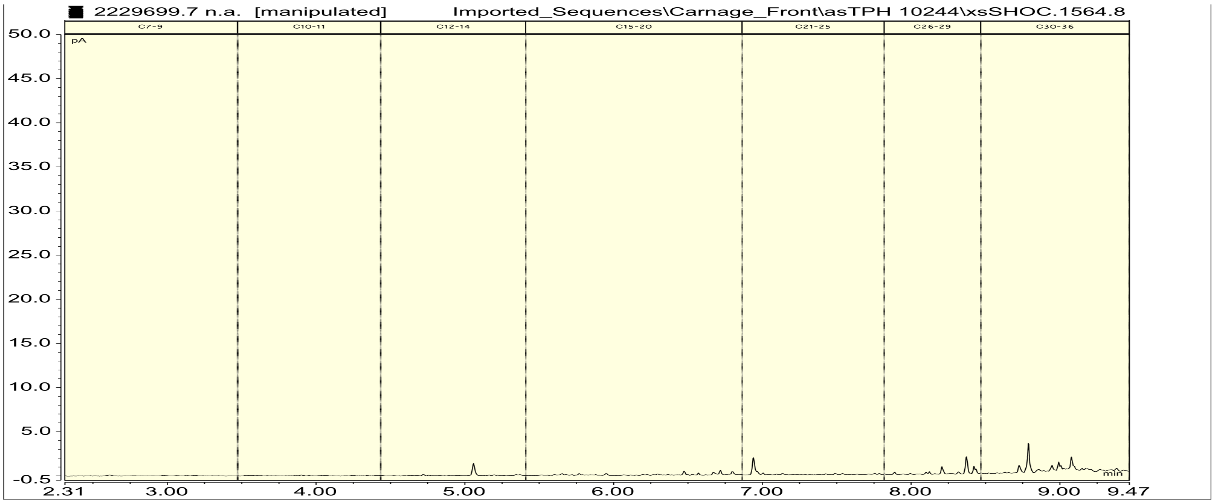
2229699.5
2B
Client Chromatogram for TPH by FID



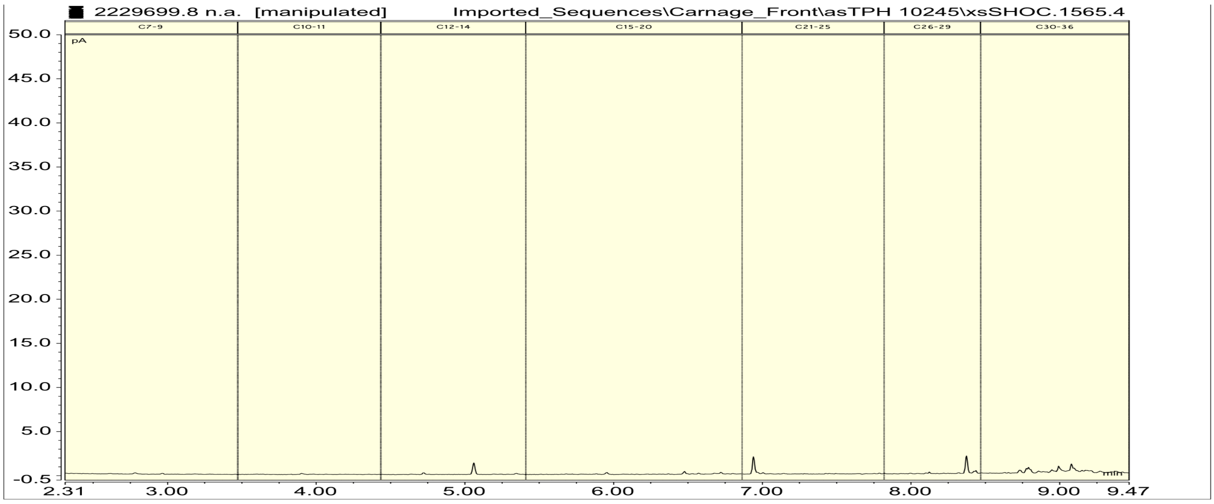
2229699.6
2C
Client Chromatogram for TPH by FID



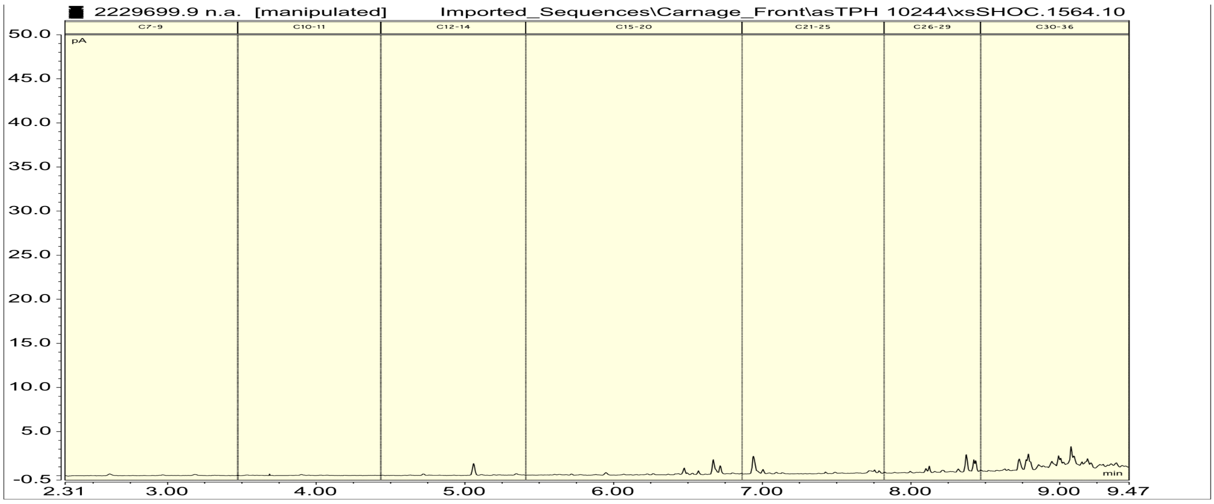
2229699.7
3A
Client Chromatogram for TPH by FID



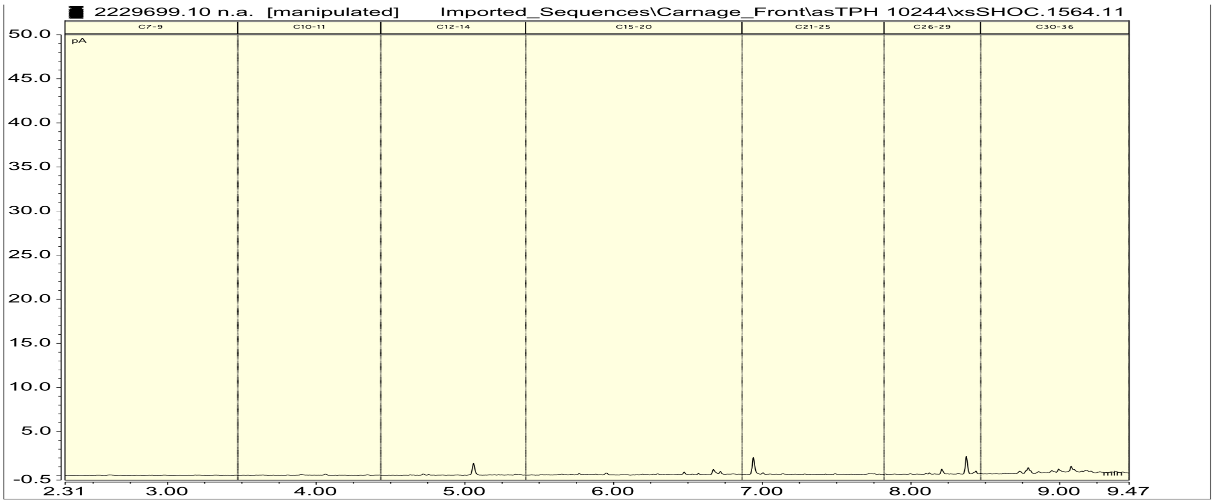
2229699.8
3B
Client Chromatogram for TPH by FID



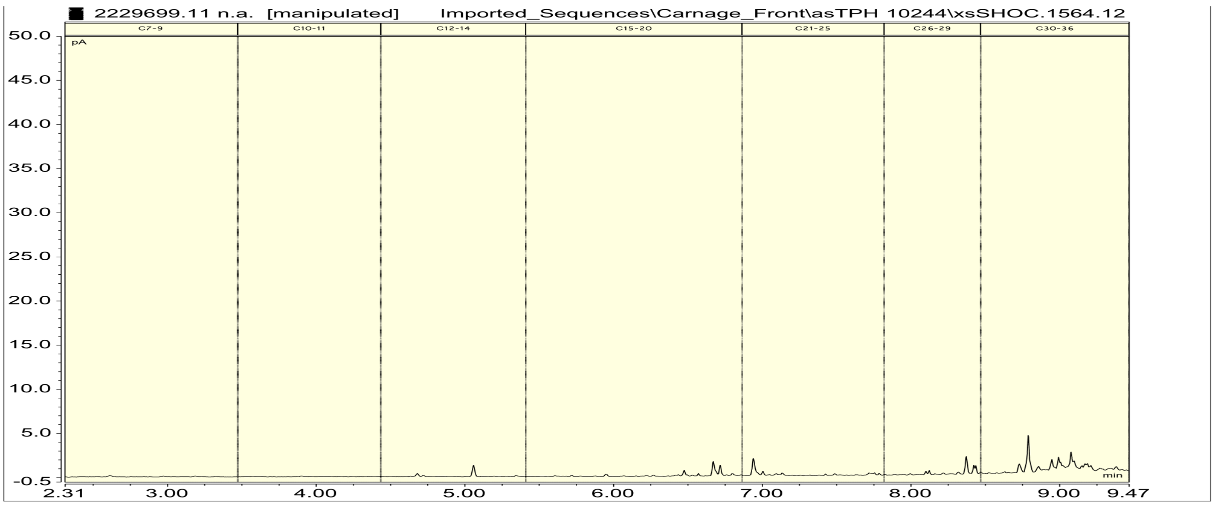
2229699.9
3C
Client Chromatogram for TPH by FID



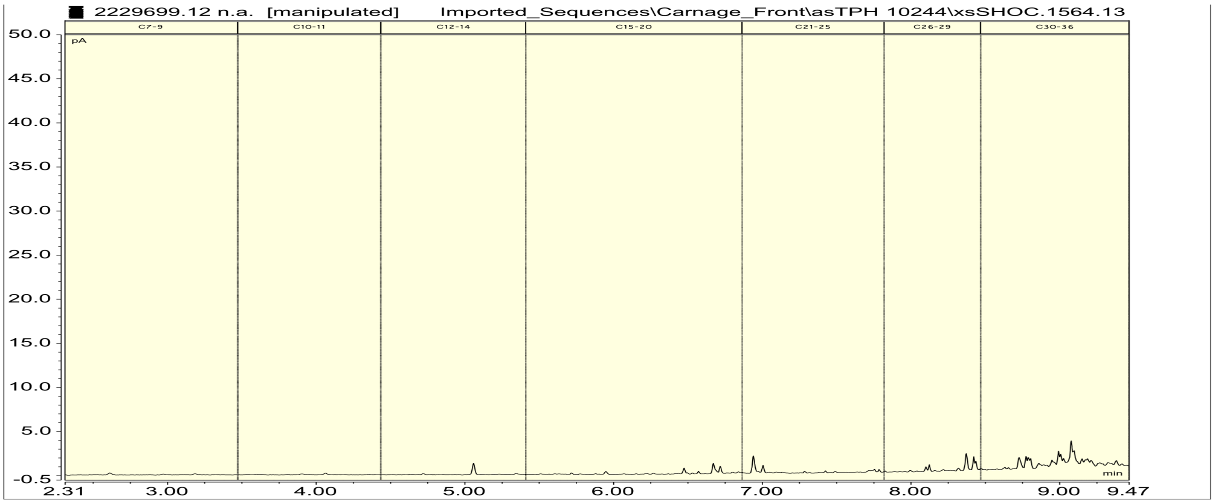
2229699.10
4A
Client Chromatogram for TPH by FID



2229699.11
4B
Client Chromatogram for TPH by FID



2229699.12
4C
Client Chromatogram for TPH by FID



Analyst's Comments

Appendix No.1 - Particle size reports

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Sample No
Environmental Solids Sample Drying*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-15
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-15
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, trace level.	0.010 - 0.4 mg/kg dry wt	1-15
Semivolatile Organic Compounds Trace in Soil by GC-MS	Sonication extraction, GPC cleanup, GC-MS FS analysis. Tested on as received sample	0.002 - 6 mg/kg dry wt	1-15
Total Petroleum Hydrocarbons in Soil, GC	Sonication extraction, Silica cleanup, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines. Tested on as received sample [KBIs:5786,2805,10734]	8 - 70 mg/kg dry wt	1-15
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. (Free water removed before analysis, non-soil objects such as sticks, leaves, grass and stones also removed). US EPA 3550.	0.10 g/100g as rcvd	1-15
2M KCl Extraction*	2M potassium chloride extraction of as received fraction for analysis of NH4N, NO2N and NO3N. Analyst, 109, 549, (1984).	-	1-15
Extraction of Exchangeable Hexavalent Chromium*	0.01M KH_2PO_4 Extraction.	-	1-15
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-15
Particle size analysis*	Malvern Laser Sizer particle size analysis from 0.05 microns to 3.4 mm. Samples are measured in volume %. Subcontracted to Earth Sciences Department, Waikato University, Hamilton.	-	1-15
Total Recoverable Beryllium*	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.2 mg/kg dry wt	1-15
Total Recoverable Boron	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	2 mg/kg dry wt	1-15
Hexavalent Chromium in Environmental Solids*	Phosphate buffer extraction, colorimetry.	0.4 mg/kg dry wt	1-15
Total Recoverable Cobalt	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.04 mg/kg dry wt	1-15

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Recoverable Manganese	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	1.0 mg/kg dry wt	1-15
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-15
Total Recoverable Selenium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	2 mg/kg dry wt	1-15
Total Nitrogen*	Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-15
Ammonium-N*	2M potassium chloride extraction on as received fraction. Phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-NH_3 F (modified) 23rd ed. 2017.	5 mg/kg dry wt	1-15
Nitrite-N*	FIA determination of 2M potassium chloride extraction on as received fraction. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	1.0 mg/kg dry wt	1-15
Nitrate-N*	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N.	1.5 mg/kg dry wt	1-15
Nitrate-N + Nitrite-N*	Automated cadmium reduction, FIA determination of 2M potassium chloride extraction on as received fraction. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	1.0 mg/kg dry wt	1-15
Total Organic Carbon*	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-15

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Analysis - Under

Measurement Details

Sample Name 2229699.1
SOP File Name Sediment.msop
Lab Number 2019158/1
Operator Name instrument

Measurement Details

Analysis Date Time 2/09/2019 1:41:28 PM
Measurement Date Time 2/09/2019 1:41:28 PM
Result Source Measurement

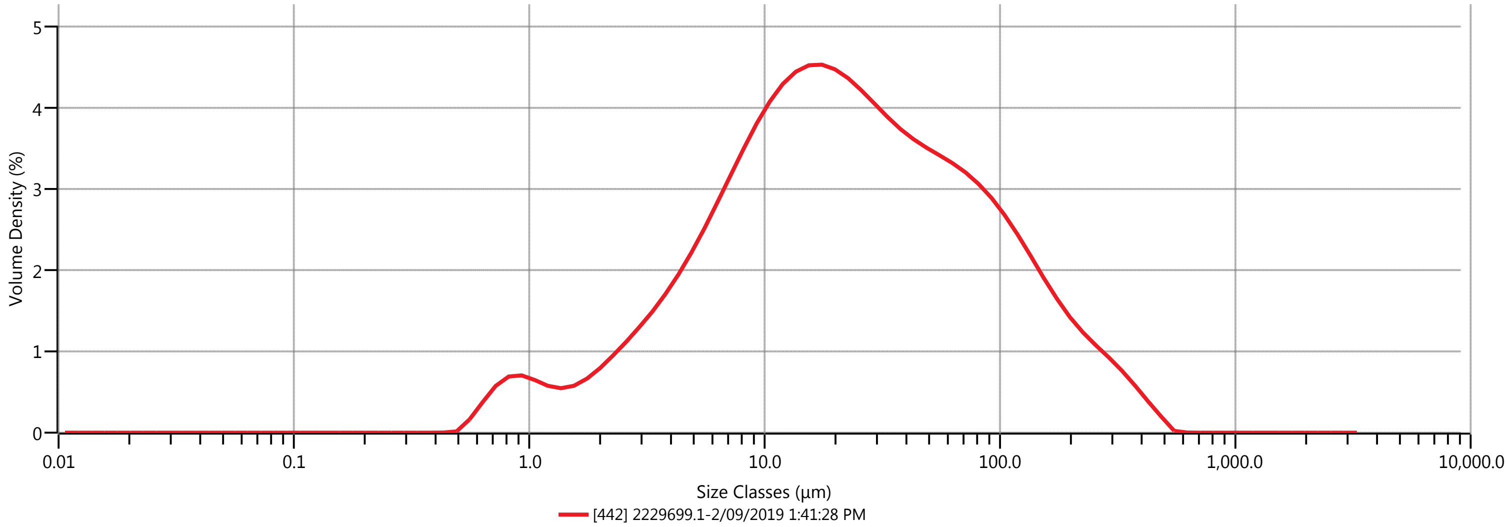
Analysis

Particle Name Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.48 %
Laser Obscuration 16.20 %

Result

Concentration 0.0198 %
Span 5.776
Uniformity 1.825
Specific Surface Area 714.3 m^2/kg
D [3,2] 8.40 µm
D [4,3] 49.1 µm
Dv (10) 3.78 µm
Dv (50) 21.7 µm
Dv (90) 129 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	21.78	88.0	83.42	350	99.00	1410	100.00
0.0600	0.00	15.6	40.33	105	86.66	420	99.64	1680	100.00
0.120	0.00	31.0	59.83	125	89.53	500	99.96	2000	100.00
0.240	0.00	37.0	64.28	149	91.99	590	100.00	2380	100.00
0.490	0.00	44.0	68.44	177	93.99	710	100.00	2830	100.00
0.980	2.06	53.0	72.72	210	95.65	840	100.00	3360	100.00
2.00	4.94	63.0	76.53	250	97.02	1000	100.00		
3.90	10.35	74.0	79.94	300	98.20	1190	100.00		

Analysis - Under

Measurement Details

Sample Name 2229699.2
SOP File Name Sediment.msop
Lab Number 2019158/2
Operator Name instrument

Measurement Details

Analysis Date Time 2/09/2019 1:49:38 PM
Measurement Date Time 2/09/2019 1:49:38 PM
Result Source Measurement

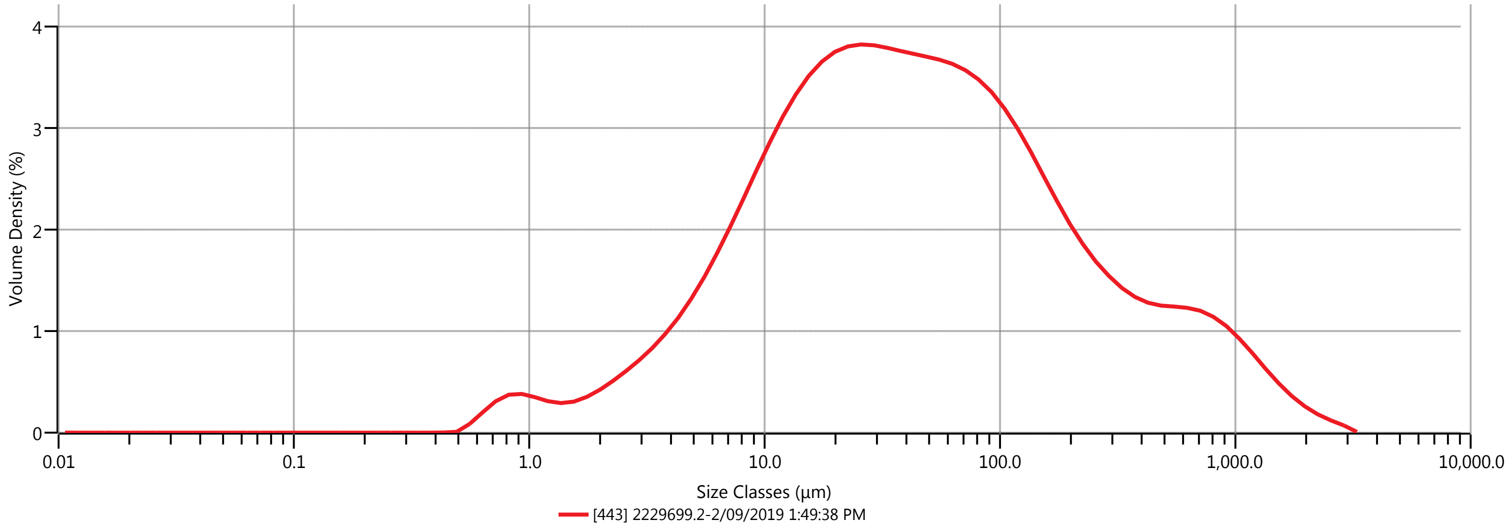
Analysis

Particle Name Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.27 %
Laser Obscuration 23.79 %

Result

Concentration 0.0480 %
Span 9.656
Uniformity 3.193
Specific Surface Area 448.6 m^2/kg
D [3,2] 13.4 μm
D [4,3] 150 μm
Dv (10) 6.36 μm
Dv (50) 41.6 μm
Dv (90) 408 μm

Frequency (compatible)



Result

Size (μm)	% Volume Under	Size (μm)	% Volume Under	Size (μm)	% Volume Under	Size (μm)	% Volume Under	Size (μm)	% Volume Under
0.0500	0.00	7.80	12.65	88.0	67.72	350	88.67	1410	98.71
0.0600	0.00	15.6	25.92	105	71.52	420	90.24	1680	99.25
0.120	0.00	31.0	42.75	125	75.01	500	91.68	2000	99.61
0.240	0.00	37.0	47.13	149	78.15	590	93.02	2380	99.84
0.490	0.00	44.0	51.37	177	80.86	710	94.50	2830	99.96
0.980	1.10	53.0	55.87	210	83.23	840	95.78	3360	100.00
2.00	2.64	63.0	60.00	250	85.30	1000	96.97		
3.90	5.63	74.0	63.78	300	87.21	1190	97.95		

Analysis - Under

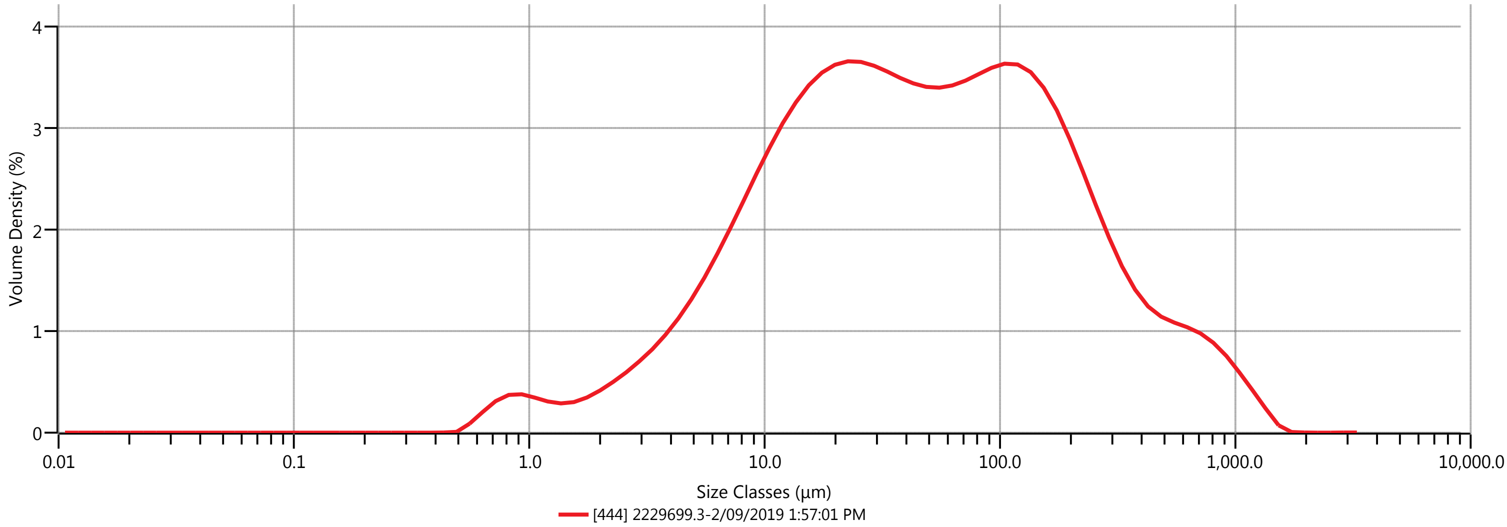
Measurement Details	
Sample Name	2229699.3
SOP File Name	Sediment.msop
Lab Number	2019158/3
Operator Name	instrument

Measurement Details	
Analysis Date Time	2/09/2019 1:57:01 PM
Measurement Date Time	2/09/2019 1:57:01 PM
Result Source	Measurement

Analysis	
Particle Name	Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.26 %
Laser Obscuration	25.43 %

Result	
Concentration	0.0525 %
Span	6.573
Uniformity	2.263
Specific Surface Area	443.4 m^2/kg
D [3,2]	13.5 µm
D [4,3]	118 µm
Dv (10)	6.42 µm
Dv (50)	44.5 µm
Dv (90)	299 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	12.53	88.0	65.34	350	91.75	1410	99.92
0.0600	0.00	15.6	25.55	105	69.51	420	93.37	1680	100.00
0.120	0.00	31.0	41.73	125	73.65	500	94.72	2000	100.00
0.240	0.00	37.0	45.82	149	77.70	590	95.90	2380	100.00
0.490	0.00	44.0	49.74	177	81.41	710	97.13	2830	100.00
0.980	1.11	53.0	53.89	210	84.73	840	98.14	3360	100.00
2.00	2.62	63.0	57.73	250	87.58	1000	99.00		
3.90	5.56	74.0	61.35	300	90.04	1190	99.59		

Analysis - Under

Measurement Details

Sample Name	2229699.4
SOP File Name	Sediment.msop
Lab Number	2019158/4
Operator Name	instrument

Measurement Details

Analysis Date Time	2/09/2019 2:20:12 PM
Measurement Date Time	2/09/2019 2:20:12 PM
Result Source	Measurement

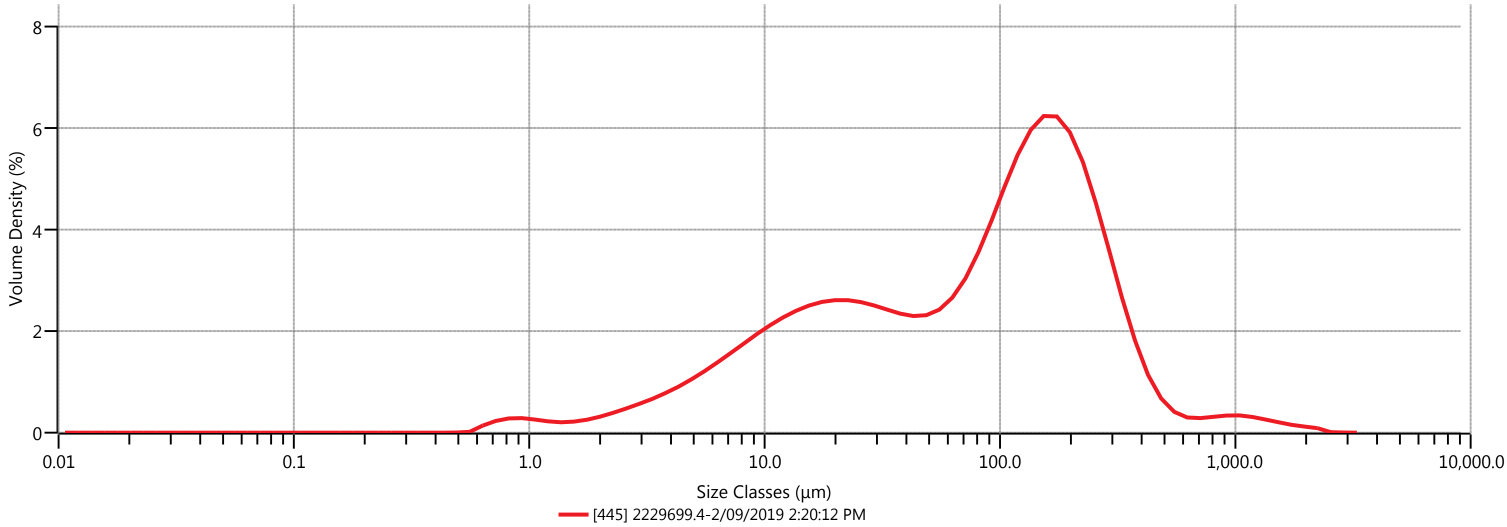
Analysis

Particle Name	Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.26 %
Laser Obscuration	14.13 %

Result

Concentration	0.0355 %
Span	3.001
Uniformity	1.150
Specific Surface Area	337.7 m^2/kg
D [3,2]	17.8 µm
D [4,3]	135 µm
Dv (10)	7.99 µm
Dv (50)	91.1 µm
Dv (90)	281 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	9.72	88.0	49.05	350	94.36	1410	99.50
0.0600	0.00	15.6	19.45	105	54.16	420	96.30	1680	99.73
0.120	0.00	31.0	30.98	125	60.15	500	97.29	2000	99.89
0.240	0.00	37.0	33.76	149	67.03	590	97.76	2380	100.00
0.490	0.00	44.0	36.38	177	74.07	710	98.11	2830	100.00
0.980	0.77	53.0	39.19	210	80.80	840	98.44	3360	100.00
2.00	1.87	63.0	42.02	250	86.69	1000	98.82		
3.90	4.22	74.0	45.05	300	91.50	1190	99.20		

Analysis - Under

Measurement Details

Sample Name 2229699.5
SOP File Name Sediment.msop
Lab Number 2019158/5
Operator Name instrument

Measurement Details

Analysis Date Time 2/09/2019 2:27:59 PM
Measurement Date Time 2/09/2019 2:27:59 PM
Result Source Measurement

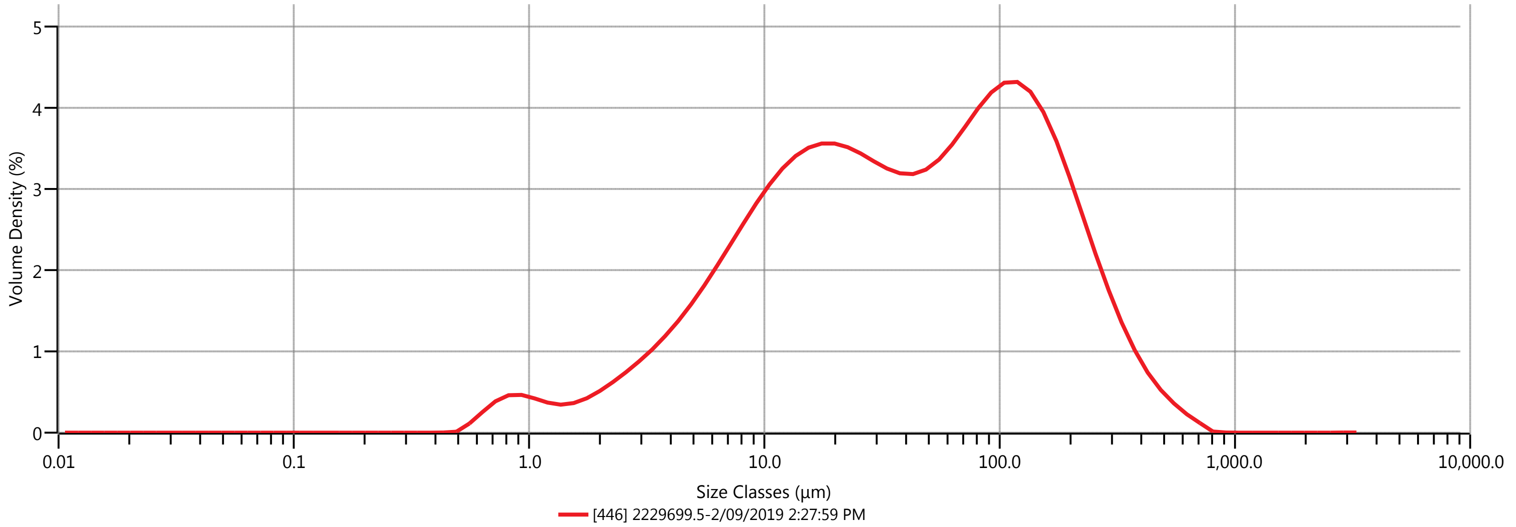
Analysis

Particle Name Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.32 %
Laser Obscuration 24.31 %

Result

Concentration 0.0433 %
Span 4.944
Uniformity 1.602
Specific Surface Area 512.1 m^2/kg
D [3,2] 11.7 µm
D [4,3] 79.0 µm
Dv (10) 5.39 µm
Dv (50) 39.8 µm
Dv (90) 202 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	15.09	88.0	68.25	350	97.48	1410	100.00
0.0600	0.00	15.6	29.09	105	73.15	420	98.61	1680	100.00
0.120	0.00	31.0	44.73	125	78.07	500	99.31	2000	100.00
0.240	0.00	37.0	48.47	149	82.85	590	99.72	2380	100.00
0.490	0.00	44.0	52.07	177	87.12	710	99.95	2830	100.00
0.980	1.37	53.0	56.01	210	90.77	840	100.00	3360	100.00
2.00	3.21	63.0	59.88	250	93.71	1000	100.00		
3.90	6.87	74.0	63.75	300	96.04	1190	100.00		

Analysis - Under

Measurement Details

Sample Name 2229699.6
SOP File Name Sediment.msop
Lab Number 2019158/6
Operator Name instrument

Measurement Details

Analysis Date Time 2/09/2019 2:37:13 PM
Measurement Date Time 2/09/2019 2:37:13 PM
Result Source Measurement

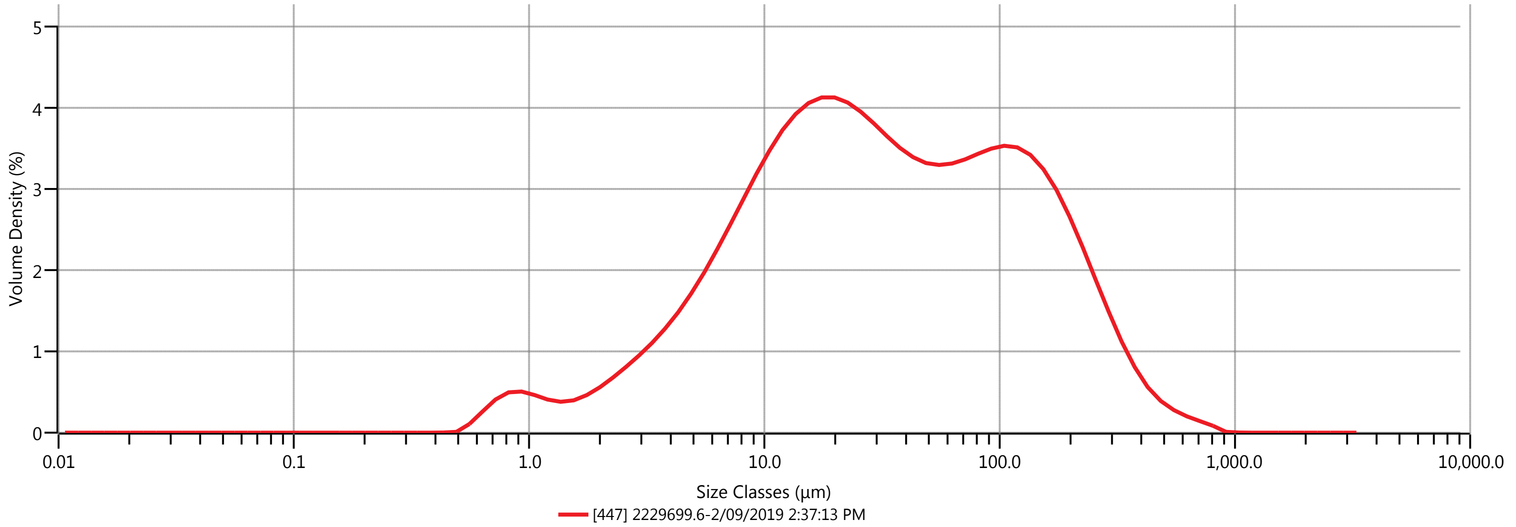
Analysis

Particle Name Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.35 %
Laser Obscuration 17.82 %

Result

Concentration 0.0281 %
Span 5.901
Uniformity 1.861
Specific Surface Area 555.4 m^2/kg
D [3,2] 10.8 µm
D [4,3] 69.5 µm
Dv (10) 5.04 µm
Dv (50) 30.5 µm
Dv (90) 185 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	16.42	88.0	73.66	350	97.93	1410	100.00
0.0600	0.00	15.6	32.38	105	77.71	420	98.82	1680	100.00
0.120	0.00	31.0	50.42	125	81.72	500	99.34	2000	100.00
0.240	0.00	37.0	54.60	149	85.62	590	99.65	2380	100.00
0.490	0.00	44.0	58.50	177	89.15	710	99.87	2830	100.00
0.980	1.45	53.0	62.54	210	92.23	840	99.99	3360	100.00
2.00	3.47	63.0	66.26	250	94.74	1000	100.00		
3.90	7.43	74.0	69.78	300	96.73	1190	100.00		

Analysis - Under

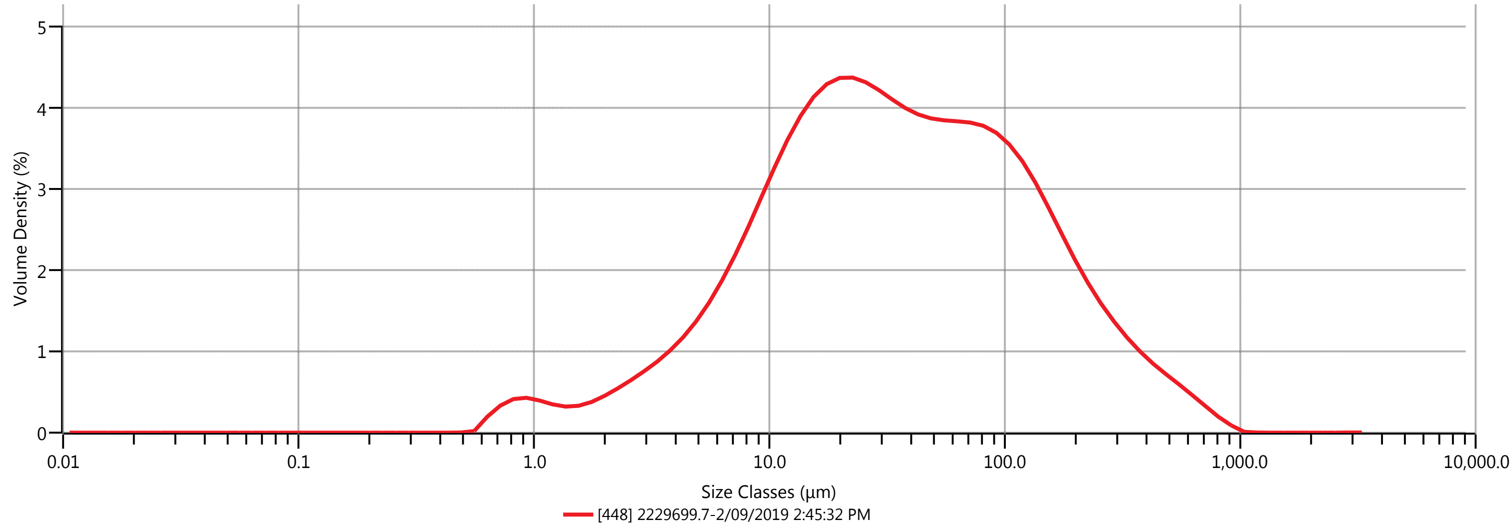
Measurement Details	
Sample Name	2229699.7
SOP File Name	Sediment.msop
Lab Number	2019158/7
Operator Name	instrument

Measurement Details	
Analysis Date Time	2/09/2019 2:45:32 PM
Measurement Date Time	2/09/2019 2:45:32 PM
Result Source	Measurement

Analysis	
Particle Name	Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.34 %
Laser Obscuration	19.25 %

Result	
Concentration	0.0350 %
Span	5.473
Uniformity	1.811
Specific Surface Area	481.4 m^2/kg
D [3,2]	12.5 µm
D [4,3]	75.4 µm
Dv (10)	6.10 µm
Dv (50)	33.5 µm
Dv (90)	190 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	13.37	88.0	74.42	350	96.44	1410	100.00
0.0600	0.00	15.6	28.59	105	78.62	420	97.58	1680	100.00
0.120	0.00	31.0	47.89	125	82.51	500	98.47	2000	100.00
0.240	0.00	37.0	52.61	149	85.99	590	99.13	2380	100.00
0.490	0.00	44.0	57.08	177	88.94	710	99.63	2830	100.00
0.980	1.13	53.0	61.79	210	91.42	840	99.90	3360	100.00
2.00	2.82	63.0	66.12	250	93.46	1000	100.00		
3.90	5.97	74.0	70.14	300	95.22	1190	100.00		

Analysis - Under

Measurement Details

Sample Name 2229699.8
SOP File Name Sediment.msop
Lab Number 2019158/8
Operator Name instrument

Measurement Details

Analysis Date Time 2/09/2019 2:53:13 PM
Measurement Date Time 2/09/2019 2:53:13 PM
Result Source Measurement

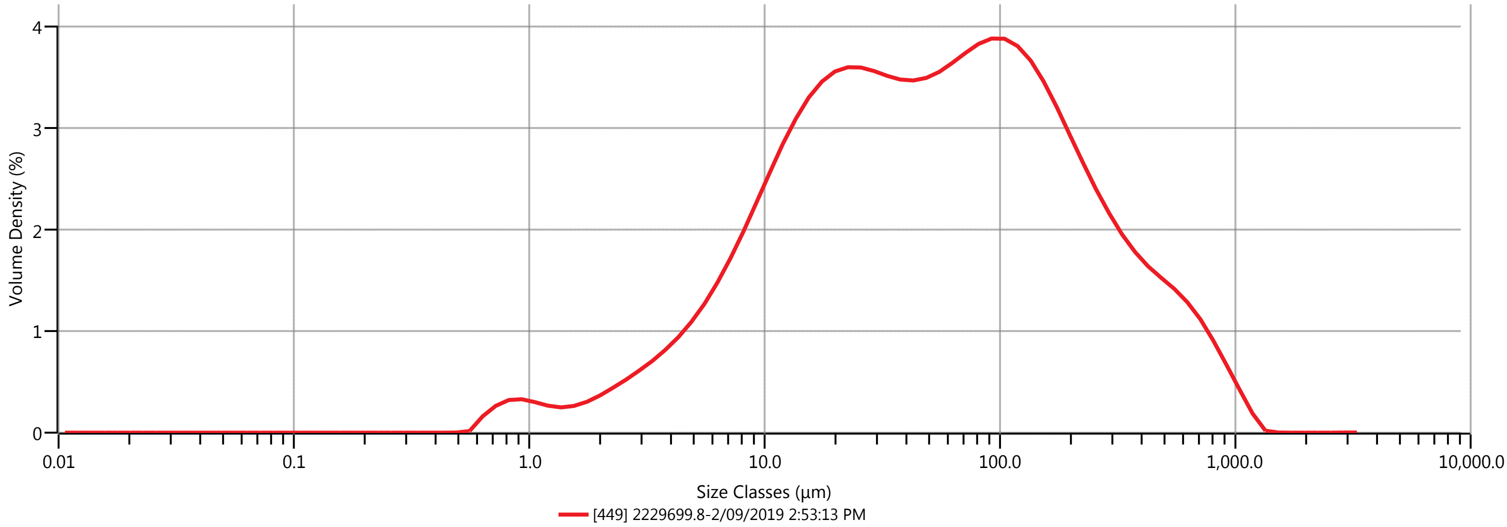
Analysis

Particle Name Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.26 %
Laser Obscuration 24.19 %

Result

Concentration 0.0558 %
Span 6.248
Uniformity 1.973
Specific Surface Area 390.4 m^2/kg
D [3,2] 15.4 µm
D [4,3] 122 µm
Dv (10) 7.41 µm
Dv (50) 51.4 µm
Dv (90) 329 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	10.61	88.0	62.98	350	90.81	1410	100.00
0.0600	0.00	15.6	22.62	105	67.46	420	92.88	1680	100.00
0.120	0.00	31.0	38.49	125	71.83	500	94.67	2000	100.00
0.240	0.00	37.0	42.54	149	76.01	590	96.22	2380	100.00
0.490	0.00	44.0	46.47	177	79.77	710	97.71	2830	100.00
0.980	0.89	53.0	50.71	210	83.13	840	98.80	3360	100.00
2.00	2.21	63.0	54.76	250	86.09	1000	99.55		
3.90	4.76	74.0	58.65	300	88.80	1190	99.93		

Analysis - Under

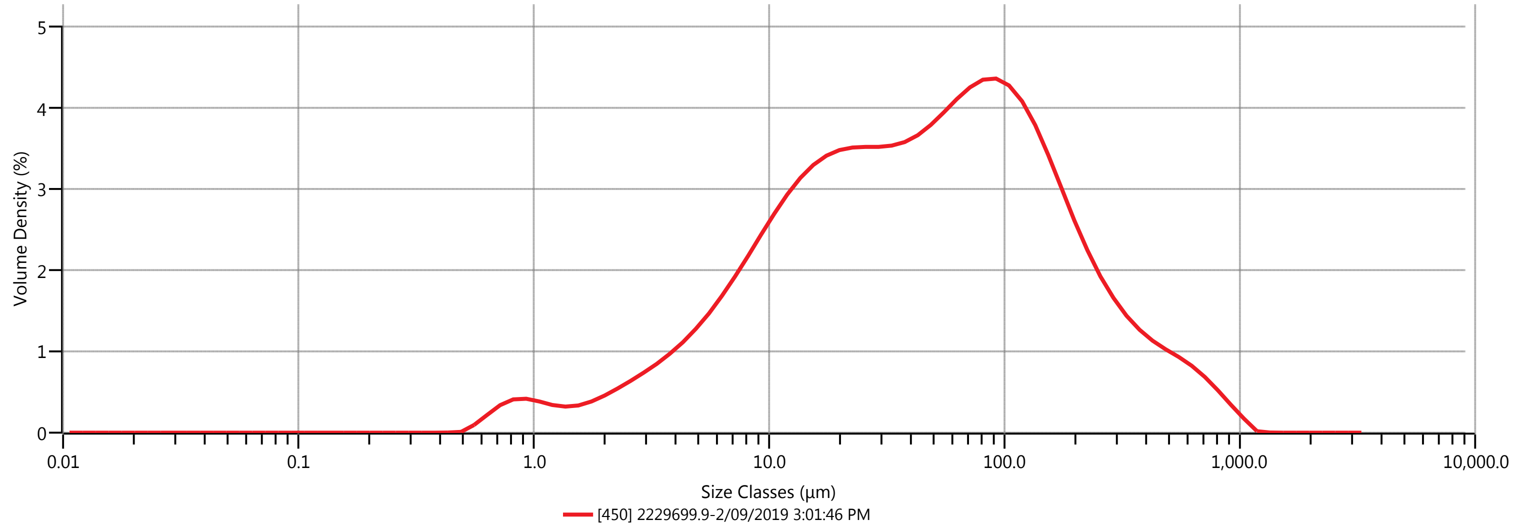
Measurement Details	
Sample Name	2229699.9
SOP File Name	Sediment.msop
Lab Number	2019158/9
Operator Name	instrument

Measurement Details	
Analysis Date Time	2/09/2019 3:01:46 PM
Measurement Date Time	2/09/2019 3:01:46 PM
Result Source	Measurement

Analysis	
Particle Name	Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.31 %
Laser Obscuration	26.70 %

Result	
Concentration	0.0539 %
Span	5.060
Uniformity	1.720
Specific Surface Area	458.5 m^2/kg
D [3,2]	13.1 µm
D [4,3]	96.9 µm
Dv (10)	6.25 µm
Dv (50)	45.9 µm
Dv (90)	239 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	12.70	88.0	67.41	350	94.20	1410	100.00
0.0600	0.00	15.6	25.20	105	72.42	420	95.67	1680	100.00
0.120	0.00	31.0	40.78	125	77.15	500	96.89	2000	100.00
0.240	0.00	37.0	44.88	149	81.44	590	97.91	2380	100.00
0.490	0.00	44.0	48.97	177	85.08	710	98.85	2830	100.00
0.980	1.21	53.0	53.56	210	88.12	840	99.49	3360	100.00
2.00	2.89	63.0	58.09	250	90.59	1000	99.88		
3.90	5.98	74.0	62.50	300	92.71	1190	100.00		

Analysis - Under

Measurement Details

Sample Name 2229699.10
SOP File Name Sediment.msop
Lab Number 2019158/10
Operator Name instrument

Measurement Details

Analysis Date Time 2/09/2019 3:55:41 PM
Measurement Date Time 2/09/2019 3:55:41 PM
Result Source Measurement

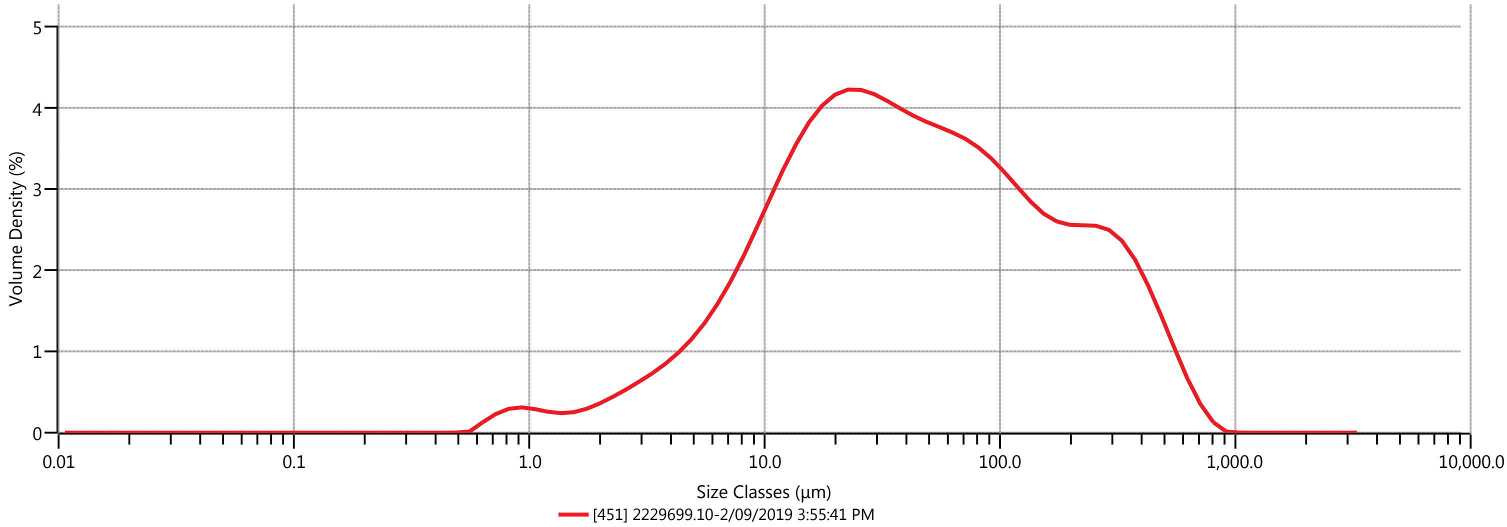
Analysis

Particle Name Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.32 %
Laser Obscuration 13.55 %

Result

Concentration 0.0283 %
Span 6.722
Uniformity 1.937
Specific Surface Area 401.5 m^2/kg
D [3,2] 14.9 µm
D [4,3] 95.6 µm
Dv (10) 7.26 µm
Dv (50) 40.4 µm
Dv (90) 279 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	10.92	88.0	68.88	350	93.62	1410	100.00
0.0600	0.00	15.6	24.48	105	72.70	420	96.07	1680	100.00
0.120	0.00	31.0	43.04	125	76.21	500	97.90	2000	100.00
0.240	0.00	37.0	47.73	149	79.45	590	99.09	2380	100.00
0.490	0.00	44.0	52.19	177	82.43	710	99.76	2830	100.00
0.980	0.79	53.0	56.85	210	85.29	840	99.98	3360	100.00
2.00	2.06	63.0	61.07	250	88.20	1000	100.00		
3.90	4.67	74.0	64.90	300	91.21	1190	100.00		

Analysis - Under

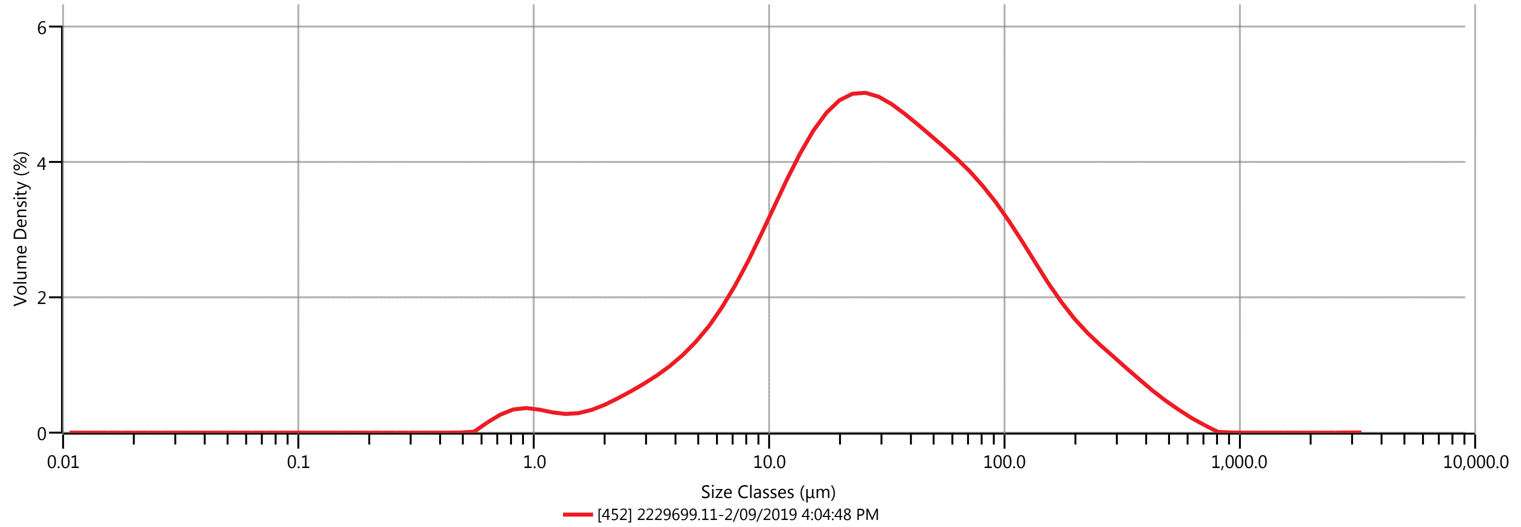
Measurement Details	
Sample Name	2229699.11
SOP File Name	Sediment.msop
Lab Number	2019158/11
Operator Name	instrument

Measurement Details	
Analysis Date Time	2/09/2019 4:04:48 PM
Measurement Date Time	2/09/2019 4:04:48 PM
Result Source	Measurement

Analysis	
Particle Name	Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.35 %
Laser Obscuration	10.80 %

Result	
Concentration	0.0193 %
Span	4.827
Uniformity	1.571
Specific Surface Area	462.4 m^2/kg
D [3,2]	13.0 µm
D [4,3]	62.5 µm
Dv (10)	6.44 µm
Dv (50)	30.6 µm
Dv (90)	154 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	12.68	88.0	79.53	350	97.86	1410	100.00
0.0600	0.00	15.6	28.46	105	83.33	420	98.74	1680	100.00
0.120	0.00	31.0	50.42	125	86.67	500	99.36	2000	100.00
0.240	0.00	37.0	55.99	149	89.51	590	99.74	2380	100.00
0.490	0.00	44.0	61.23	177	91.85	710	99.95	2830	100.00
0.980	0.92	53.0	66.58	210	93.80	840	100.00	3360	100.00
2.00	2.39	63.0	71.27	250	95.44	1000	100.00		
3.90	5.39	74.0	75.40	300	96.87	1190	100.00		

Analysis - Under

Measurement Details

Sample Name 2229699.12
SOP File Name Sediment.msop
Lab Number 2019158/12
Operator Name instrument

Measurement Details

Analysis Date Time 2/09/2019 4:12:35 PM
Measurement Date Time 2/09/2019 4:12:35 PM
Result Source Measurement

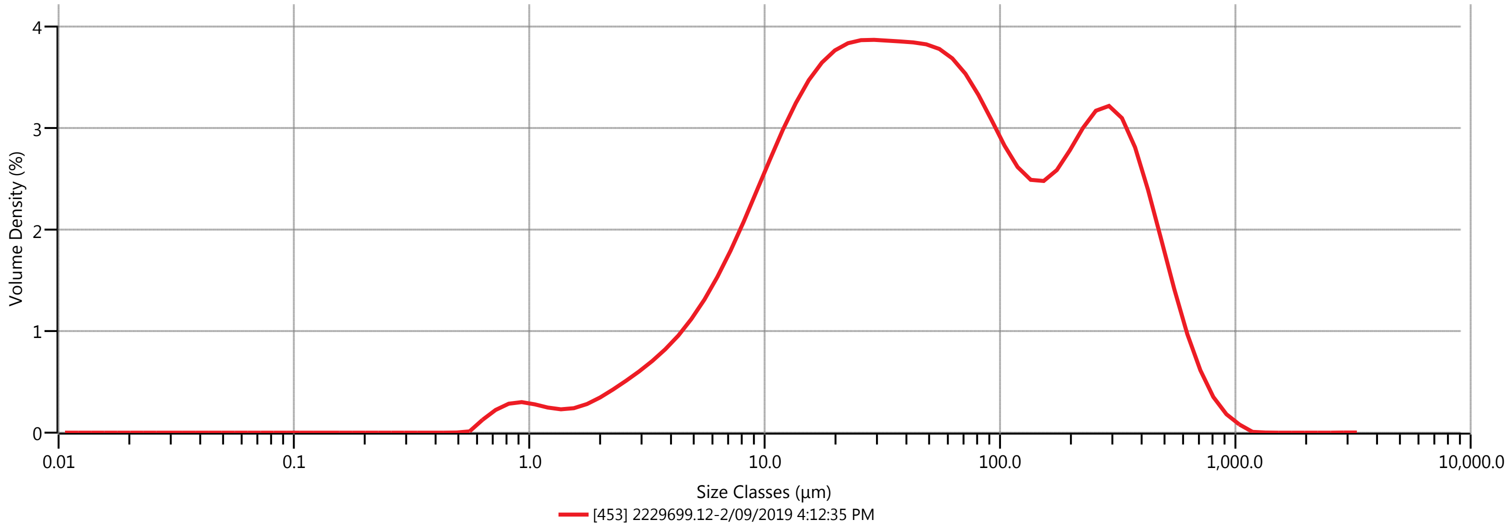
Analysis

Particle Name Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.29 %
Laser Obscuration 10.17 %

Result

Concentration 0.0218 %
Span 7.090
Uniformity 2.063
Specific Surface Area 383.9 m^2/kg
D [3,2] 15.6 µm
D [4,3] 114 µm
Dv (10) 7.46 µm
Dv (50) 46.0 µm
Dv (90) 333 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	10.56	88.0	65.33	350	90.98	1410	100.00
0.0600	0.00	15.6	23.15	105	68.77	420	94.21	1680	100.00
0.120	0.00	31.0	40.08	125	71.82	500	96.63	2000	100.00
0.240	0.00	37.0	44.54	149	74.67	590	98.24	2380	100.00
0.490	0.00	44.0	48.89	177	77.51	710	99.25	2830	100.00
0.980	0.77	53.0	53.54	210	80.54	840	99.74	3360	100.00
2.00	2.00	63.0	57.77	250	84.01	1000	99.95		
3.90	4.51	74.0	61.55	300	87.83	1190	100.00		

Analysis - Under

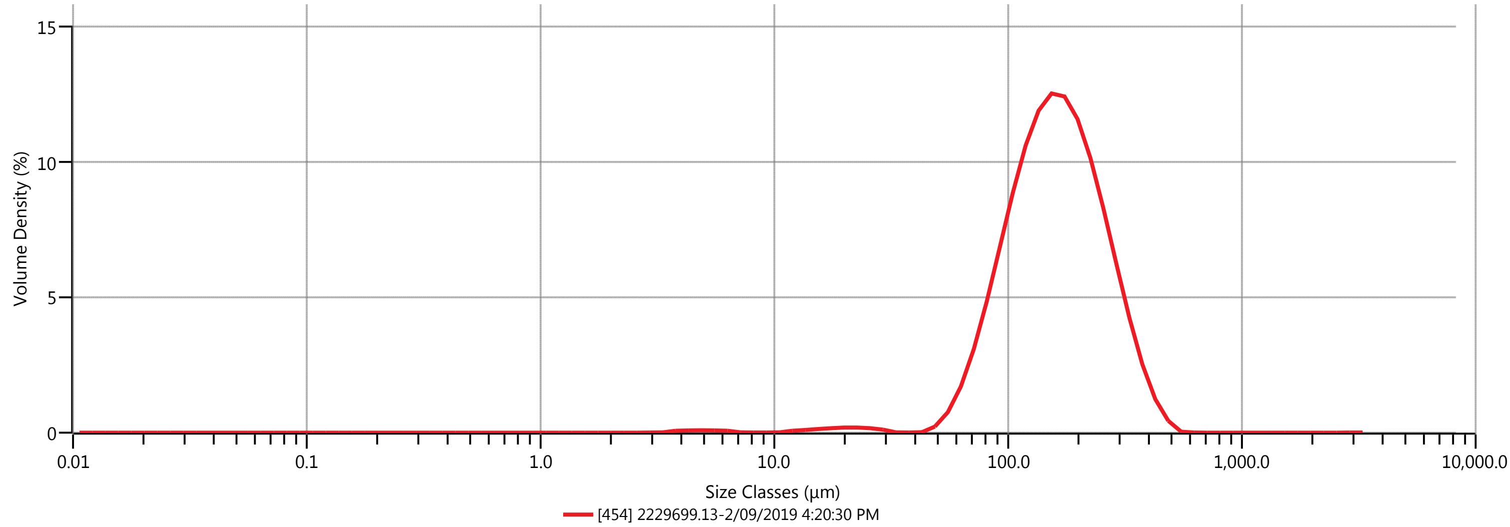
Measurement Details	
Sample Name	2229699.13
SOP File Name	Sediment.msop
Lab Number	2019158/13
Operator Name	instrument

Measurement Details	
Analysis Date Time	2/09/2019 4:20:30 PM
Measurement Date Time	2/09/2019 4:20:30 PM
Result Source	Measurement

Analysis	
Particle Name	Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.29 %
Laser Obscuration	11.76 %

Result	
Concentration	0.2010 %
Span	1.263
Uniformity	0.393
Specific Surface Area	48.03 m^2/kg
D [3,2]	125 µm
D [4,3]	174 µm
Dv (10)	86.4 µm
Dv (50)	159 µm
Dv (90)	287 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	0.33	88.0	10.82	350	96.47	1410	100.00
0.0600	0.00	15.6	0.54	105	19.60	420	99.06	1680	100.00
0.120	0.00	31.0	1.26	125	31.02	500	99.92	2000	100.00
0.240	0.00	37.0	1.27	149	44.77	590	100.00	2380	100.00
0.490	0.00	44.0	1.27	177	58.87	710	100.00	2830	100.00
0.980	0.00	53.0	1.54	210	72.13	840	100.00	3360	100.00
2.00	0.00	63.0	2.76	250	83.24	1000	100.00		
3.90	0.05	74.0	5.42	300	91.81	1190	100.00		

Analysis - Under

Measurement Details

Sample Name	2229699.14
SOP File Name	Sediment.msop
Lab Number	2019158/14
Operator Name	instrument

Measurement Details

Analysis Date Time	2/09/2019 4:31:52 PM
Measurement Date Time	2/09/2019 4:31:52 PM
Result Source	Measurement

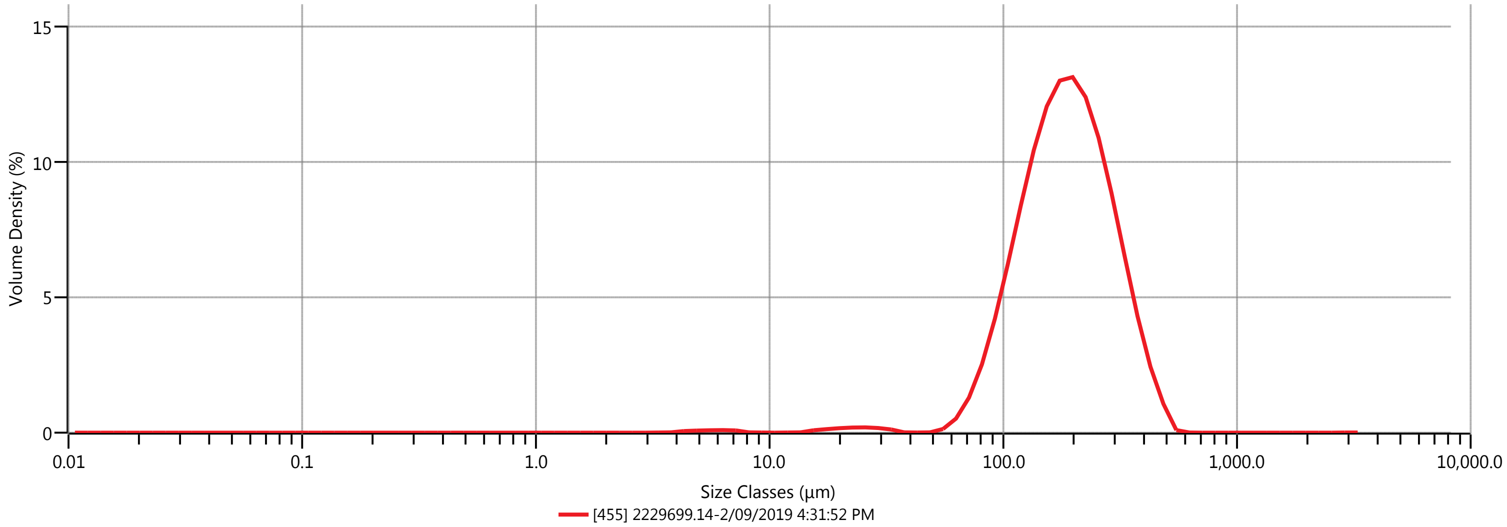
Analysis

Particle Name	Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.27 %
Laser Obscuration	12.52 %

Result

Concentration	0.2523 %
Span	1.194
Uniformity	0.370
Specific Surface Area	40.97 m^2/kg
D [3,2]	146 µm
D [4,3]	200 µm
Dv (10)	102 µm
Dv (50)	185 µm
Dv (90)	323 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	0.34	88.0	5.35	350	93.37	1410	100.00
0.0600	0.00	15.6	0.39	105	11.07	420	97.92	1680	100.00
0.120	0.00	31.0	1.11	125	19.79	500	99.79	2000	100.00
0.240	0.00	37.0	1.22	149	31.99	590	100.00	2380	100.00
0.490	0.00	44.0	1.22	177	46.10	710	100.00	2830	100.00
0.980	0.00	53.0	1.24	210	60.80	840	100.00	3360	100.00
2.00	0.00	63.0	1.53	250	74.60	1000	100.00		
3.90	0.00	74.0	2.54	300	86.32	1190	100.00		

Analysis - Under

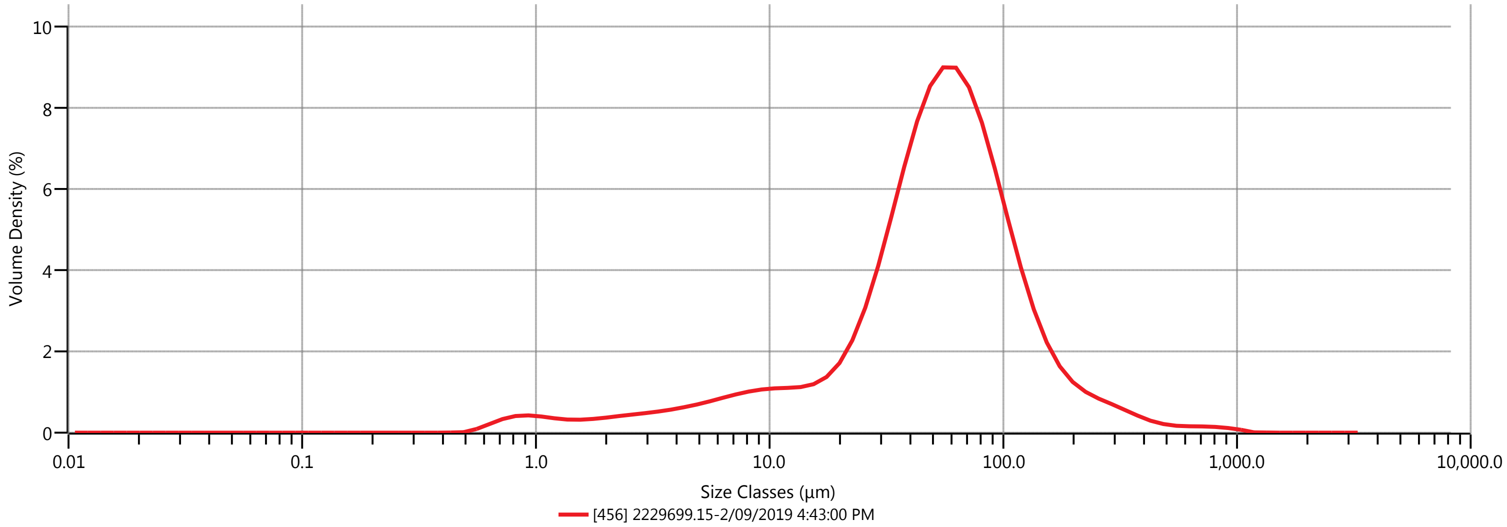
Measurement Details	
Sample Name	2229699.15
SOP File Name	Sediment.msop
Lab Number	2019158/15
Operator Name	instrument

Measurement Details	
Analysis Date Time	2/09/2019 4:43:00 PM
Measurement Date Time	2/09/2019 4:43:00 PM
Result Source	Measurement

Analysis	
Particle Name	Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.32 %
Laser Obscuration	11.04 %

Result	
Concentration	0.0253 %
Span	2.249
Uniformity	0.785
Specific Surface Area	373.7 m^2/kg
D [3,2]	16.1 µm
D [4,3]	71.5 µm
Dv (10)	9.92 µm
Dv (50)	54.1 µm
Dv (90)	131 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	8.37	88.0	76.87	350	98.55	1410	100.00
0.0600	0.00	15.6	13.30	105	83.82	420	99.01	1680	100.00
0.120	0.00	31.0	24.00	125	88.91	500	99.29	2000	100.00
0.240	0.00	37.0	30.47	149	92.28	590	99.48	2380	100.00
0.490	0.00	44.0	38.56	177	94.45	710	99.66	2830	100.00
0.980	1.20	53.0	48.84	210	95.95	840	99.82	3360	100.00
2.00	2.82	63.0	59.03	250	97.05	1000	99.95		
3.90	4.86	74.0	68.20	300	97.96	1190	100.00		