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# APPENDIX 'L'

# Fish Survey & Biomonitoring Report

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| **To** | Nathan Crook, Scientific Officer |
| **From** | Bart Jansma, Scientific Officer |
| **Report No** | BJ301 |
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# Fish Survey of the Haehanga Stream in relation to discharges from the Remediation (NZ) Limited composting site at Uruti, December 2016

## Introduction

Remediation (NZ) Ltd operates a composting facility in the Haehanga Valley, Uruti (previously owned by Perry Environmental Ltd who was preceded by Global Vermiculture Ltd). Raw materials are trucked to the site for composting, on a purpose built composting pad for a period of 35-40 days. Synthetic hydrocarbon contaminated drilling muds and cuttings are also received on site. They are piled up and the liquids are allowed to drain, then blended with green waste and other organic matter. Composted material is transported off site by trucks to Remediation (NZ) Ltd's worm farming operations at Waitara Road and Pennington Road.

This survey is the fourth fish survey undertaken in the Haehanga Stream, in relation to this site. It was included for the first time in the 13-14 monitoring period as a replacement for the late summer macroinvertebrate programme, as flow rates have been slowly reducing over time, inhibiting macroinvertebrate sample collection. On this occasion, the fish survey was undertaken concurrent with the spring/early summer macroinvertebrate survey. Results from previous surveys are detailed in the references.

Fish surveys are useful long-term indicators of ecosystem health, as most fish live longer than a year, and as such may reflect chronic impacts from the composting site, should there be any. The first few surveys will provide results, which can be compared to those from subsequent surveys. This will allow the fish community to be assessed at that point in time, and over time it will also allow an assessment of any change in community health. Fish communities can be influenced by operations at the composting site, principally related to the discharge of wastewater from the site (and the quality thereof), but also by changes in instream habitat. The banks of the Haehanga Stream are highly unstable and support little in the way of riparian vegetation (with the exception of rank grass). As a result, there is significant bank slumping in areas. Should the stream be fenced and planted in a way that adequately protects the banks and stream channel, it is likely that the fish community would improve.

## Methods

In this survey, three sites were surveyed in the Haehanga Stream. Site 1 was located upstream of all composting and waste disposal activities, site 2 was located immediately downstream of the lower irrigation area, while site 3 was located just upstream of State Highway 3. Details of the sites surveyed are given in Table 1 and the locations of the sites surveyed in relation to the site are shown in Figure 1.

The fish populations were sampled using fyke nets (Photo 1) and gee minnow traps. At each site, five gee minnow traps were set, and baited with Marmite. They were set overnight, among macrophytes or alongside woody debris. Two fyke nets were also set at each site, a standard mesh (25mm) net and a fine mesh (13mm). The standard mesh was set downstream, in attempt to intercept any large eels moving up from downstream. Both fyke nets were baited with fish food pellets. These nets were also set overnight. All fish caught were identified, counted and measured, and any eels longer than 300mm were weighed, using electronic scales that measured to the nearest 20 grams. All nets and traps were deployed on the afternoon of 14 December 2016, and retrieved midmorning on 15 December 2016.

In addition the nets and traps set in the Haehanga Stream, two gee minnow traps were also set in the unnamed tributary, upstream of the wetland discharge. This is the first time this tributary was surveyed, and was done to gain some understanding of what may inhabit this area of the catchment.

Table 1 Sampling sites surveyed in the Haehanga Stream in relation to the Remediation NZ composting operations

| Site | Site code | Location |
|---|---|---|
| 1 | HHG000093 | Upstream of all composting and waste water irrigation areas |
| 2 | HHG000150 | 30 meters downstream of Remediation NZ irrigation area |
| 3 | HHG000190 | 50 metres upstream of State Highway 3 bridge |


Figure 1 Location of the three sampling sites in relation to composting and waste water irrigation areas.

Photo 1 A fyke net, set at site 2, Haehanga Stream.

## Results and Discussion

On the day that the nets were set, a localised rain event caused flows to increase in the Haehanga Stream. This also resulted in the discharge of sediment-contaminated stormwater into the Haehanga Stream, resulting in discolouration. Although discolouration is frequently noted in this catchment, the degree of discolouration at sites 2 and 3 was particularly severe, where it was described as brown and dirty. However, at site 1 (upstream of the site), which had only slightly elevated flows, there was no obvious discolouration. The change in water clarity is shown in Photo 2. All sites contained moderate fish habitat, with deep pools, and macrophyte beds, although site 2 only had macrophytes on the edge. The substrate of the surveyed pools comprised primarily of thick silt, with some large logs present at site 3. All sites had at least some undercut banks, but there was no overhanging vegetation at any site, other than long grass.

Water temperatures recorded during the macroinvertebrate survey, conducted on the same day, ranged from 15.3 to 17.2 ˚C. It should be noted that water temperatures have been recorded as high as 28.3˚C in this stream, well above the thermal preference, and near to the maximum thermal tolerance of a number of native fish species (Richardson, Boubee and West, 1994)), but the rain event that preceded the current survey resulted in much lower temperatures.

The previous (December 2015) survey observed seven dead eels at, and downstream of site 2. In addition, a macroinvertebrate sample collected upstream of site 2 on the same day smelt of hydrocarbons, and that there was a hydrocarbon sheen noted on the surface. This follows on from the observations made during the December 2014, when hydrocarbons were released from the sediment at site 3. No such observations were made during the current survey.

It is worth noting that the macroinvertebrate survey undertaken on the first day of the fish survey found that macroinvertebrate communities of seven mainstem sites and two unnamed tributary sites were of average to above average health, with significant recovery noted downstream of the site and irrigation area.

The full results of the fish survey are shown in Table 2.

Photo 2 Water clarity at site 1 (top) and at the culvert near the composting pads (bottom). Photos taken about 30 minutes apart.

Table 2 Results of the current fish survey and a summary of previous surveys undertaken in the Haehanga Stream in relation to Remediation NZ's composting operations.

| | Site: | Site 1 | | | Site 2 | | | Site 3 | | | Unnamed Tributary |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Net/Trap type:** | **Previous results (3 surveys)** | **Fyke net** | **Gee minnow trap** | **Previous results (3 surveys)** | **Fyke net** | **Gee minnow trap** | **Previous results (3 surveys)** | **Fyke net** | **Gee minnow trap** | **Gee minnow trap** |
| **Number of minutes fished:** | | | **2550** | **6375** | | **2220** | **5550** | | **1980** | **4950** | **2250** |
| Longfin eel (*Anguilla dieffenbachii*) | Number | 3-4 | 7 | - | 1-12 | 17 | - | 1-2 | 8 | - | - |
| | Length range (mm) | 478-1045 | 490-840 | - | 365-802 | 530-1050 | - | 431-870 | 565-930 | - | - |
| | Weight range (kg) | 0.24-3.31 | 0.39-1.91 | - | 0.10-1.04 | 0.5-3.425 | - | 0.18-2.61 | 0.48-2.17 | - | - |
| Shortfin eel (*Anguilla australis*) | Number | 0-1 | 1 | - | 4-17 | 1 | - | 2-3 | 2 | - | - |
| | Length range (mm) | 195 | 600 | - | 196-850 | 700 | - | 510-790 | 690-780 | - | - |
| | Weight range (kg) | - | 0.44 | - | 0.02-0.98 | 0.85 | - | 0.26-1.57 | 1.05-1.33 | - | - |
| Inanga (*Galaxias maculatus*) | Number | - | - | - | 1-11 | 1 | - | 0-6 | - | - | - |
| | Length range (mm) | - | - | - | 86-123 | 112 | - | - | - | - | - |
| Redfin bully (*Gobiomorphus huttoni*) | Number | - | - | - | - | - | - | 0-1 | - | - | - |
| | Length range (mm) | - | - | - | - | - | - | 70 | - | - | - |
| Banded Kokopu (*Galaxias fasciatus*) | Number | - | - | - | - | - | - | - | - | - | 1 |
| | Length range (mm) | - | - | - | - | - | - | - | - | - | 130 |
| Total number of species | | 2 | 2 | | 3 | 3 | | 4 | 2 | | 1 |
| Total number of fish | | - | 8 | | - | 19 | | - | 10 | | 1 |

## Site 1

This site recorded just two species, being longfin and shortfin eel. This is consistent with that recorded in previous surveys. It is likely that this is related in part to the reduced flow that can occur at this site, resulting in reduced habitat. Previous surveys have recorded little to know flow at this site, although this was not the case during the current survey. Fish passage may also be influencing the number of species present at this site, as the barriers to fish passage observed downstream may have prevented fish migrating upstream to this site. This has serious implications for inanga, as this species is a short-lived species, and migrates downstream annually to spawn, with juveniles migrating upstream during the whitebait season.

Overall, eight fish were recorded at this site, which is an increase on that recorded previously. This is likely a reflection of the higher flows carrying the bait odour further downstream, attracting more fish into the nets.

This site is intended as a control site with which to compare the downstream results. Due to the lack of fish passage, it cannot be considered a true control site. In addition, if a culvert does not provide for the passage of fish, it is non-compliant and must be remediated. Some remedial works have been undertaken since the previous survey was completed. However, further remedial work is requited, so it is once again recommended that the site operator is made aware of these barriers to fish passage, which are discussed in more detail below, and required to take steps to remediate them.

## Site 2

This site, located immediately downstream of the lowest irrigation area, contained the highest species richness (3) and the highest abundance (19) of the three sites surveyed. A single inanga was recorded at this site, with this species recorded in three of the four surveys completed. Natural variation will occur in inanga populations from year to year, as they recruit annually, and are therefore subject to numerous other factors. That only one inanga was recorded (compared with a maximum of eleven in 2014) is not necessarily cause for concern, as there may have been predation within the nets, especially with the number of large eels caught also.

Eighteen eels were captured, of which seventeen were longfin eels, one being relatively large at 1050mm and 3.425kg and two were shortfin eels. This is similar to the number of eels recorded in the previous survey, which recorded sixteen eels. However, there was a clear difference in size class distribution in the current survey, with the results dominated by larger (>700mm) eels, while earlier surveys were dominated by eels smaller than 700mm (Figure 2). Although the nets included a means of shelter for the smaller eels, including either a tube shelter and/or an eel excluder, the number of large longfins captured increased the risk of predation. Three eels were observed to have eaten relatively large eels, as the consumed eel was discernible when handling and viewing the consuming eel (Photo 3). It is likely smaller eels were also consumed, but they were not discernible in the large eels stomach. Therefore, it is likely to the number of eels recorded at site 2 was an under-representation of the actual number of eels captured.

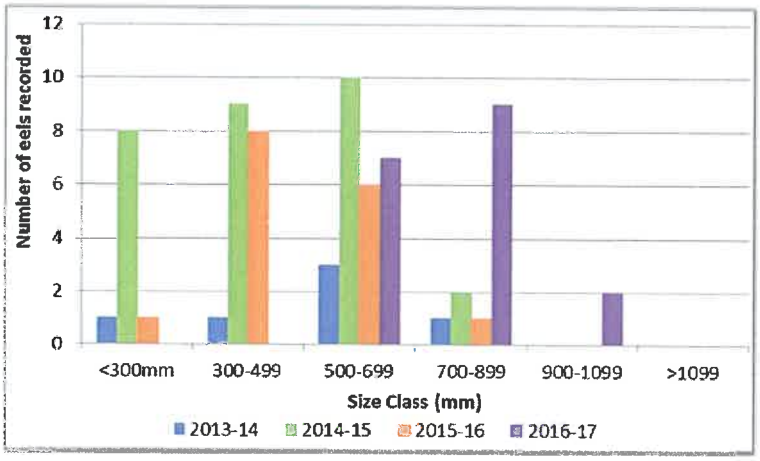


Figure 2 Size class distribution of all eels recorded at site 2 over the four surveys completed to date

Photo 3 A large longfin eel recorded at site 2, with a consumed eel evident through the deformation of the eel's underside.

It may also be that shortfin eels were the species predated upon by the large longfin eels, and this would explain the reduction in shortfin eel numbers at this site. Longfin eel have been observed to predate upon shortfin eels when in aquariums (pers. obs.). Unlike in the previous survey, no dead eels were observed around this site.

It is apparent that site 2 still had a much higher abundance than that recorded upstream at site 1. This suggests that the access culvert immediately upstream of this site may still be posing a barrier to fish passage (Photo 4). Some remedial works had been undertaken, with gravel being used to build up the bed level at the outlet of the first pool downstream of the culvert. While this is an appropriate approach, as it will lift the water level and resolve the perched nature of the culverts, the material used was too fine and had already begun scouring away (Photo 5). During the current survey, the culverts were not perched, although this may have been partly because flows were high.

Photo 4 The access culvert immediately upstream of site 2, December 2015 (left) and December 2016 (right).

Photo 5
The outlet of the pool, directly below the main track access culverts, showing deposited gravels that are beginning to scour away

## Site 3

Located just upstream of State Highway 3, this site provides some perspective, providing an indication as to the extent of influence from the upstream composting activities. This site contained some of the best habitat, with large logs, deep water and undercut banks. These three habitat features are frequently used by nocturnal fish as cover.

Ten fish were recorded at this site, up from the five recorded in the previous survey. Inanga and redfin bully were absent despite being recorded in one or more previous surveys. Eight longfin eels and two shortfin eels were recorded, although there was a lack of small individuals, which seems typical for this site (Table 2). This site recorded the same species richness (two) as site 1, with a similar ratio of longfin to shortfin eels. Again, due to the number of large eels recorded, the possibility that other fish (including inanga) were caught but then predated upon while in the net cannot be discounted. Overall, these results represented improvement from that recorded in the previous survey, a result consistent with the results from the macroinvertebrate survey undertaken on the same day (Jansma, 2017).

## Unnamed tributary

This tributary was surveyed for the first time in this survey, although previous macroinvertebrate surveys have incidentally recorded fish, including banded kokopu and longfin eel, with larger unidentified eels observed below the wetland discharge. The two gee-minnow traps were set upstream of the wetland discharge, where there was some deeper water immediately downstream of an access culvert. One banded kokopu was captured (Photo 6), being an individual 130mm in length, likely to be between two and three years old (Hopkins, 1979). Banded kokopu are considered a regionally distinctive species in Taranaki, and as such, their presence in this unnamed tributary shows the significant values such small streams can have.

Due to significant differences in habitat between the sites upstream and downstream of the discharge, it is likely that there is a natural difference between the fish communities at these sites. However, consideration should be given to expanding fish monitoring in this tributary.

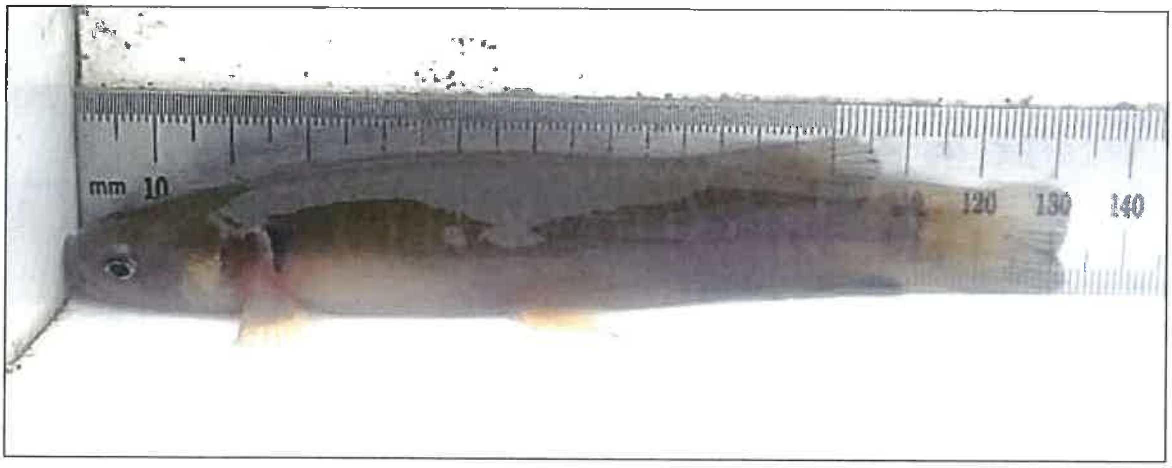


Photo 6 Banded kokopu (*Galaxias fasciatus*) captured in the unnamed tributary upstream of the wetland discharge.

## Size class distribution

Assessing the size class distribution of fish populations can provide a useful perspective on fish recruitment, and the long-term health of the community. For example, if recruitment were restricted, then there would be a lack of young fish. However, it can be influenced by other activities such as people feeding eels, or commercial eeling operations. It is therefore recommended that no such activities take place on the consent holder's property. It should also be noted that good numbers of fish are needed to support strong conclusions, and therefore only the size class distribution of eels (as opposed to other species) is discussed.

Figure 3 shows that a similar number of eels were recorded in the current survey as in the 2014-15 survey, higher than that recorded in the 2013-14 and 2015-16 surveys. The size class distribution was quite different however. In the first three surveys, the eel community was dominated by fish smaller than 700mm, while in the current survey, the community was dominated by fish larger than 500mm. However, all surveys recorded the most eels in the 500 to 700 mm size class.

This difference in size class distribution can be attributed to the improved flow conditions during the current survey. This higher flow meant that the bait scent was carried further downstream, and can have attracted fish from well downstream. The likelihood that predation occurred in the nets means that it was likely that the current size class distribution was an underrepresentation of smaller eels.

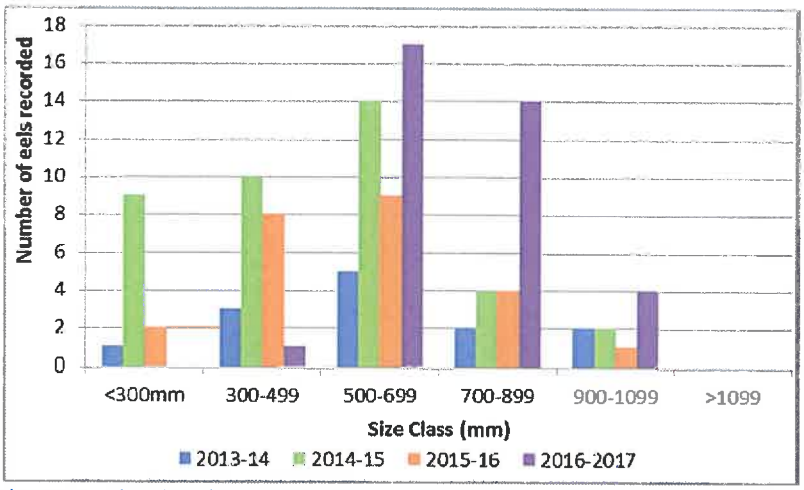


Figure 3 The size class distribution of all eels captured at all sites over the three surveys undertaken to date.

This higher number so large eels is a positive result, as it suggests some recovery from the impacts of commercial eeling, which is understood to have occurred just prior to the 2013-14 survey. However, this recovery will not yet be complete. The community will take some time to recover from the impacts of commercial eeling, as commercial eeling methods (fyke netting) are so efficient that 75% of the eels in a fished area can be caught in a single night. As a result, it can take a decade or more for the eel's population at such a site to recover (PCE, 2013). It should be noted that the sampling methodology is less likely to record eels smaller than 150mm, compared with larger eels.

## Fish condition

The composting activities undertaken alongside the Haehanga Stream have the potential to release a range of substances to the stream, including some that have toxic effects on the fauna of the stream. The degree of toxicity can range from acute, resulting in quick death, to chronic, where repeated exposure over time may result in the fauna becoming unwell, and/or leaving the area. Eels captured in this survey were measured and weighed. Using this data it is possible to gauge the physical condition of the fish, which can be a useful indication of fish health. If fish at one site were in poorer condition than others in the same stream, then it would be expected that the sick fish of the same length would be lighter.

Figure 4 shows that most of the longfin eels recorded in the current survey were in better condition than would be expected, with some fish being significantly heavier than would be expected. Shortfin eel showed a similar result, with the two eels captured at site 3 being well in excess of the expected weight, while the individual eels captured at sites 1 and 2 being similar to the expected weight. This is indicates that the eel communities were in better physical condition than would be expected, and this is likely a reflection of the high flows that preceded this survey, and probably predation within the nets. The high flows will have resulted in improved invertebrate habitat in the Haehanga Stream, improving the food supply for these eels. This better than average condition is similar to that that recorded in the previous surveys, but better than that recorded in the 2013-14 and 2014-15 surveys, when no site had fish that differed markedly from that predicted by Jellyman *et al* (2013). The trend lines in Figure 4 used the equation from table 1 for longfin eel and table 3 for shortfin eel found in Jellyman *et al* (2013).

Overall, these fish condition results suggest that fish condition is better in early summer than late summer, including at site 2. This is consistent with higher and cooler flow conditions providing for improved habitat and food supply. The results from site 2 suggest that the eel community was in better health than the previous survey, which recorded eels in poorer condition than would be expected. This suggests that the activities at the composting facility had not affected this community.

In addition to length and weight measurements, each fish was inspected for obvious physical damage or abnormalities. Other than the predation of eels in the nets, there were, no such features were noted.

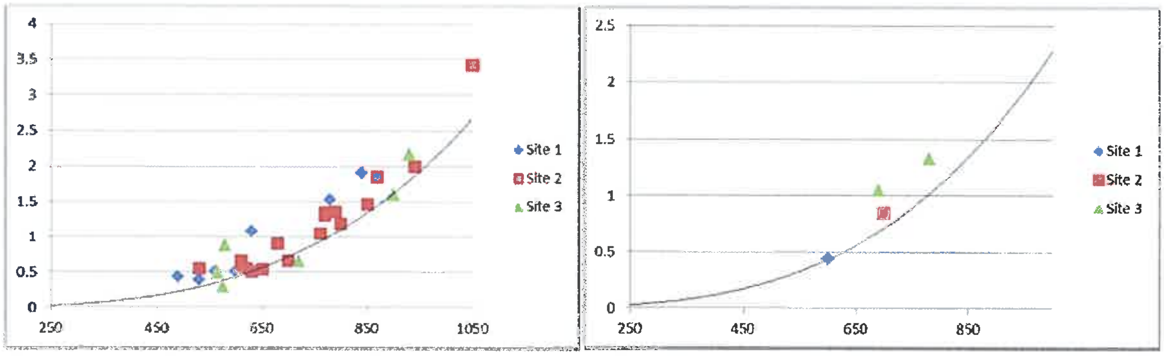


Figure 4 Longfin eel condition (left) and shortfin eel condition (right) in the Haehanga Stream, 14/15 December 2016. Weight (Kg) is on the y-axis, length (mm) on the x-axis. The trend line is the predicted weight, using equations from Jellyman *et al* 2013.

## Fish Passage

During this and previous surveys, three access culverts were inspected, and assessed for fish passage. The locations of these culverts are summarised in Table 3. It was noted that one of the three culverts impeded fish passage in some way, with the remaining two culverts providing some passage, but may be a greater impediment to passage during low flows.

Culvert 1, on the Haehanga Stream near the composting pads, had a deep but swift flow (Photo 7), which would inhibit poorer swimmers such as inanga. The outlet of this culvert is usually too steep and water speeds too swift, and only suitable for climbing species. The higher flows during the current survey improved it slightly, but it is likely that passage will deteriorate as flows reduced.

Culvert 2 was perched, and not suitable for swimming species (Photo 7). However, while kokopu and eels have been recorded upstream of this culvert, these species are good climbing species and highly adept at negotiating barriers that swimming species cannot pass. This culvert will still reduce the passage of climbing species, while completely preventing the passage of swimming species. It was noted during the current survey that the lower of the two culverts might have been partially blocked.

Culvert 3, a double culvert under the main access track, had experienced some remedial works since the previous survey, with the bed level built up in an effort to resolve the perched nature of the culvert. During the current survey, neither of the two culverts was perched, due to the remedial works and higher water levels caused by recent rain (Photo 4). It was noted that the remedial works were beginning to scour away, and it is likely that the culverts will again be perched once flows recede (Photo 5). This will need to be assessed during lower flows, with remedial works required should this be confirmed.

Table 3 Culverts assessed for fish passage during the current fish survey

| Culvert number | Location | GPS reference |
|---|---|---|
| 1 | Haehanga Stream, near composting pads | 1732285-5685087 |
| 2 | Unnamed tributary, immediately upstream of Haehanga Stream | 1732291-5685098 |
| 3 | Haehanga Stream, at downstream extent of irrigation area | 1731707-5685778 |

Photo 7
Top left: Culvert 1 December 2015
Top Right: Culvert 1 December 2016
Bottom Left: Culvert 2 December 2015
Bottom Right: Culvert 2 December 2016

## Summary and conclusions

On 14 and 15 December 2016, three sites were surveyed for freshwater fish in the Haehanga Stream in relation to the composting activities undertaken by Remediation NZ Ltd. Site 1 was located upstream of the site, site 2 located immediately downstream of the lowest extent of the irrigation area, and site 3 was located just upstream of State Highway 3. The survey method involved deploying baited fine and coarse mesh fyke nets and gee minnow traps at each site overnight. This survey also including trapping of the unnamed tributary that receives the wetland discharge, with two gee minnow traps set upstream of the discharge. All nets and traps were recovered the following morning, with all fish identified, counted and measured, with eels greater than 300mm weighed.

Earlier in the day prior to the survey commencing, the Haehanga Stream catchment experienced a rain event. As a result, the Haehanga Stream had a moderate to high flow at all sites. The timing of this survey has been brought forward, in an effort to target periods when stream flow is higher. This follows the initial survey, completed in March 2014, which found that the stream was not flowing at site 1 due to extremely low flows. The higher flows in the current survey will have carried the bait scent further downstream than that which occurred in previous surveys. All sites contained moderate fish habitat, with deep pools, and good cover. It should be noted that water temperatures in this stream may occasionally exceed the thermal preference, and maximum thermal tolerance of a number of native fish species, with a water temperature of 28.3˚C recorded at site 3 during the December 2014 survey. Due to the improved flow conditions, which should have resulted in more flow past the nets and traps, and conceivably more fish captured, fish abundance and number of species recorded were higher than that recorded in the previous survey. Over all sites, twenty-eight fish were recorded across four species. This included the capture of a banded kokopu in the unnamed tributary.

Unlike in the previous survey, which observed seven dead eels at and downstream of site 2, there were no observations made that posed particular concern. There was significant discolouration observed downstream of the wormfarm and quarry access road, but no obvious hydrocarbon contamination of the Haehanga Stream like that recorded in the previous two surveys. The degree of discolouration, although not present upstream, was severe, but was considered primarily an aesthetic effect rather than deleterious to the biological communities. This is because it is likely to be a relatively frequent event, and the biological communities will have adjusted to it.

It is worth noting that the macroinvertebrate survey undertaken on the first day of the fish survey found that macroinvertebrate communities of seven mainstem sites and two unnamed tributary sites were of average to above average health, with significant recovery noted downstream of the site and irrigation area.

The site that would be expected to experience the greatest impacts should there be any is site 2. At this site, three species were recorded, as was the highest abundance (19 fish) of the survey. Inanga were again present after being absent in the previous survey, representing some recovery in the fish communities. Although only one individual inanga was recorded, natural variation will occur in inanga populations from year to year, as they recruit annually, and are therefore subject to numerous other factors. It should also be noted that there had been predation within the nets, with some eels having clearly ingested another eel. It is very possible that smaller fish such as inanga has also been predated upon, but this was not obvious when handling the eels.

Site 3, further downstream recorded two species, which is equal to that recorded in the previous survey. Inanga were absent, but have been recorded at this site previously.

Eels were recorded at all three sites, with the largest longfin eel being recorded at site 2. This individual was 1050 mm long, and weighed 3.425 kg. The size class distribution of the eels was quite different to that recorded in the previous surveys, with the community dominated by large eels. This is probably a reflection of improved effectiveness of the bait, resulting in more large eels being captured. This may have also caused increased predation of the smaller eels in the nets, resulting in an under-representation in the smaller size classes. It is likely that the community is still impacted by the commercial eeling that is understood to have occurred just prior to the 2013-14 survey. It is expected it will take over decade for the community to recover from this. The physical condition of the eels showed that most of the eels captured at all three sites were in much better condition than would be expected. This is likely due to the increased flows that preceded this survey resulting in an improved food supply for these eels, with more macroinvertebrate habitat present. This is a good result, especially at site 2, where the eels were more similar to their expected weight during the previous survey. Overall, these fish condition results suggest that fish condition is better in early summer than late summer, as indicated by the results from sites 1 and 3. This is consistent with higher and cooler flow conditions providing for improved habitat and food supply. The results from site 2 suggest that the eel community is in better health than that recorded in the previous survey, which found that the activities at the composting facility had likely negatively affected this community. No observed fish exhibited any obvious physical damage or abnormalities during the current survey.

Three access culverts were assessed for fish passage during this survey, and one was found to present a barrier to fish passage at all flows, while the remaining two culverts were considered likely to restrict fish passage during lower flows. Even in the higher flows of the current survey, it is likely that all culverts severely restricted the passage of swimming species such as inanga. The culvert located immediately above site 2 had experienced some remedial works since the previous survey, but this was already being scoured away. It is likely that this culvert will still be perched during lower flows, and this would preclude the passage of a number of species, included inanga. If this is confirmed, then remedial works will be required. Remedial works are still to be undertaken on the remaining two culverts, which have been identified as a barrier for a number of years.

In summary, the results of the current survey do not indicate that the composting activities and wastewater irrigation undertaken by Remediation NZ Ltd, alongside the Haehanga Stream, have had a deleterious impact on the fish communities of this stream. This is consistent with the findings of the macroinvertebrate survey, completed on the same day. However, the impact on fish passage caused by the three access culverts is likely to have contributed to the reduced species richness at site 1.

The current survey was undertaken in early summer, in an effort to target the higher flows present at this time. It is recommended that this is continued, and that surveys continue on an annual basis. In addition, it is recommended consideration be given to installing continuous water temperature monitoring equipment over the summer months, to improve our understanding of how the water temperature changes in the Haehanga Stream. Finally, it is recommended that the company be reminded of their responsibilities regarding the provision for fish passage.

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| **To** | Nathan Crook, Job Manager |
| **From** | Bart Jansma; Scientific Officer |
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| **Document No** | 1926776 |
| **Date** | 5 August 2017 |

# Biomonitoring of the Haehanga Stream in relation to discharges from the Remediation (NZ) Limited composting site at Uruti, December 2016

## Introduction

Remediation (NZ) Ltd operates a composting facility in the Haehanga Valley, Uruti (previously owned by Perry Environmental Ltd who was preceded by Global Vermiculture Ltd). Raw materials are trucked to the site for composting, on a purpose built composting pad for a period of 35-40 days. Synthetic hydrocarbon contaminated drilling muds and cuttings are also received on site. They are piled up and the liquids are allowed to drain, then blended with green waste and other organic matter. Composted material is transported off site by trucks to Remediation (NZ) Ltd's worm farming operations at Waitara Road and Pennington Road.

This survey was the only survey scheduled for the 2016-2017 monitoring year. At the time of this survey, there were two composting pads. The south-west pad (referred to as composting pad 1 in this report) has been established and operating for some years, and is where the synthetic muds are blended with green waste and other organic matter. A second pad northeast of the original composting pad, which became operational in the summer of 2005, is referred to as composting pad 2.

Both composting pads are bunded, with all surface stormwater and leachate contained and directed to treatment ponds. Water from the settling pond is recycled back to the composting material if and when required to maintain a moist composting environment. The runoff from composting pad 1 is treated in the series of ponds. Between each pond, there is a baffle that skims off any floating hydrocarbons as the leachate passes through. The treated liquid in the final pond, located just upstream of site 5 (HHG000115), is then irrigated to pasture. This irrigation system was installed prior to the November 2005 biological survey.

Prior to February 2008, no discharges of stormwater or leachate directly entered the Haehanga Stream or its tributaries. However, after that date, the site has been permitted to discharge treated stormwater and compost leachate to the unnamed tributary of the Haehanga Stream. This comes from composting pad 2, where leachate is pumped up to the top of a seven-tier wetland, which was constructed in late 2007. Under dry conditions, the wetland water from the bottom pond of the wetland is reticulated back to the upper tier of the wetland. Under high flow conditions the wetland discharges to a tributary of the Haehanga Stream.

In addition to this discharge from the wetland, there is some potential for seepage from the composting pads and irrigation area to enter groundwater, and for stormwater runoff to escape the collection system, and thus gravitate toward the surface watercourses at the site.

A baseline survey of five sites was conducted in October 2002 in relation to the composting operation (Dunning, 2003). At the time of this earlier survey, only composting pad 1 was operational, and sites were established for both the existing and proposed composting pads. Unnamed tributaries of the Haehanga Stream flow adjacent to (and down gradient of) both composting pads and flow into the Haehanga Stream downstream of the composting areas (Figure 1). Since this baseline survey, significant changes have occurred on site, leading to sampling sites being moved, or sampling at some sites to be discontinued. Any changes to sampling sites made prior to the current survey have been discussed in previous reports, referenced below

The current biological survey was conducted to monitor the effects of discharges from the composting site to the Haehanga Stream and tributaries in relation to composting areas (pads 1 & 2), the irrigation of treated liquid to land, and the discharge of treated stormwater and leachate to the unnamed tributary. During the May 2012 survey an additional site was included (HHG000150), at the downstream extent of the irrigation area. This site is now referred to as site 6, with HHG000112 now referred to as site 5. This constitutes a change, as HHG000112 was previously referred to as site 6.

## Methods

Two different sampling techniques were used to collect streambed macroinvertebrates in this survey. The 'vegetation sweep' sampling technique was used at site 1, and the Council's standard 'streambed kick' sampling technique was used at sites 2, 6 and T2. A combination of the 'streambed kick' and 'vegetation sweep' sampling techniques was used at sites T3, 5 and 7 (Table 1). The 'streambed kick' and 'vegetation sweep' techniques are very similar to Protocol C1 (hard-bottomed, semi-quantitative) and C2 (soft-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

Two of the sites surveyed were previously established in the baseline survey (sites 1 and 2) (Dunning, 2003). Site T2 and T3 were sampled for the ninth time during the current survey, while site 5 has been sampled since January 2005 and site 7 since February 2007. Site 6 was sampled for the sixth time in the current survey.

**Table 1** Biomonitoring sites in the Haehanga Stream catchment

| Site | Site Code | Location | Sampling Method |
|---|---|---|---|
| 1 | HHG000093 | Upstream of extended irrigation area | Vegetation sweep |
| 2 | HHG000100 | Downstream of extended irrigation area | Streambed Kick |
| T2 | HHG000098 | Upstream of wetland discharge point | Streambed Kick |
| T3 | HHG000103 | Downstream of wetland discharge point | Kick-sweep |
| 5 | HHG000115 | 25 m downstream of last pond and swale collection area | Kick-sweep |
| 6 | HHG000150 | 30 m downstream of lower irrigation area | Streambed Kick |
| 7 | HHG000190 | 50 metres upstream of State Highway 3 bridge | Kick-sweep |

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al. 2001).

Macroinvertebrate taxa found in each sample were recorded as:

| | |
|---|---|
| R (rare) | = less than 5 individuals; |
| C (common) | = 5-19 individuals; |
| A (abundant) | = estimated 20-99 individuals; |
| VA (very abundant) | = estimated 100-499 individuals; |
| XA (extremely abundant) | = estimated 500 individuals or more. |

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams (MCI). Recently, a similar scoring system has been developed for macroinvertebrate taxa found in soft bottomed streams (Stark and Maxted, 2004, 2007) (SBMCI). The SBMCI has been used in a number of biomonitoring reports since its inception, and results to date suggest that it is not as effective at assessing the impacts of organic pollution as the MCI. For example, results from the February 2008 Mangati survey found a relatively unchanged SBMCI score at a site that had thick growths of sewage fungus (Jansma, 2008c). Therefore, this index is considered less appropriate for the assessment of macroinvertebrate communities possibly affected by industrial discharges. Any subsequent reference to MCI refers to the MCI.

Highly 'sensitive' taxa were assigned the highest scores of 9 or 10, while the most 'tolerant' forms scored 1 and 0.1 in hard bottomed and soft bottomed streams respectively. The sensitivity scores for certain taxa found in hard bottomed streams have been modified in accordance with Taranaki experience. By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. Communities that are more 'sensitive' inhabit less polluted waterways.

A semi-quantitative MCI value ($SQMCI_S$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

**HHG000190 ~1900m DS**

**HHG000150 ~ 675m DS**

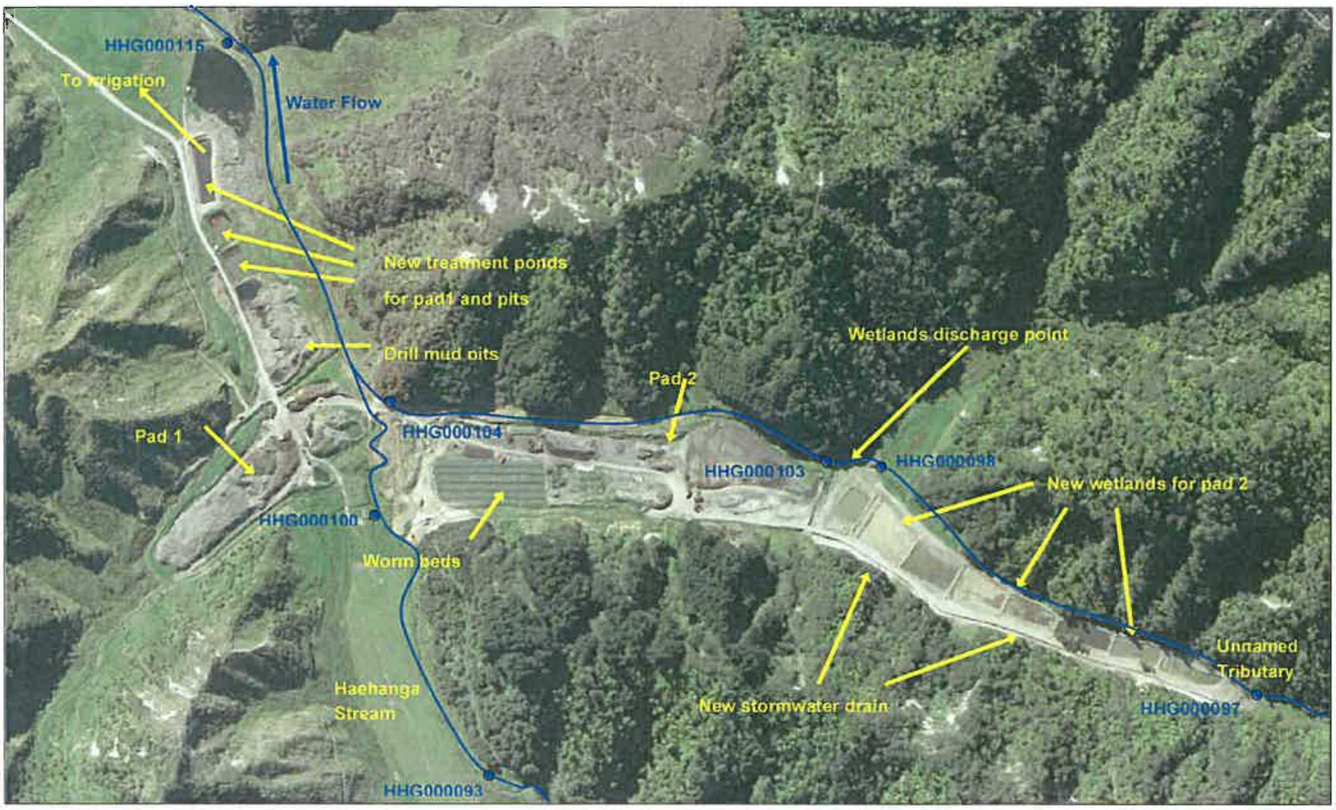


Figure 1 Location of biomonitoring sites in the Haehanga Stream catchment

Sub-samples of algal and detrital material taken from the macroinvertebrate samples, were scanned under 40-400x magnification to determine the presence or absence of any mats, plumes or dense growths of bacteria, fungi or protozoa ("undesirable biological growths") at a microscopic level. The presence of masses of these organisms is an indicator of organic enrichment within a stream.

## Results and Discussion

During the present survey, water temperatures in the Haehanga Stream catchment ranged from 15.5°C to 17.2°C. It should be noted that the January 2015 survey recorded a temperature of 28.3°C, which is outside the upper thermal tolerances of some macroinvertebrate taxa, including some occasionally recorded in the Haehanga Stream catchment (Quinn et al, 1994)). The current survey was undertaken earlier in the year, in an effort to survey at a time of higher flow in the Haehanga Stream. Due to a rain event in the area shortly before the survey commenced, flows in the Haehanga Stream were quite high. This also resulted in the discharge of sediment-contaminated stormwater into the Haehanga Stream, resulting in discolouration. Although the Haehanga Stream is frequently observed to be cloudy, with associated yellow to brown discolouration, the degree of discolouration at sites 2, 5, 6 and 7 was particularly severe, where it was described as brown and dirty. However, at site 1 (upstream of the site), which had only slightly elevated flows, there was no obvious discolouration. The flow in the unnamed tributary was described as brown and cloudy.

Usually the cloudiness and discolouration is primarily caused through tannins and suspended solids entering via groundwater and tributary inflows, rather than a point source discharge from the wormfarm. However, at times tannins are also provided through the wetland discharge, which can also result in some discolouration. During the current survey, a moderate discharge, estimated at approximately 1 l/sec was leaving the wetland. This discharge was not recorded in the discharge log kept by the consent holder, with this log indicating that no discharge had occurred since 9 December 2016.

With the exception of site 1, the substrate at all sites was generally a mix of silt, sand and gravels, with some wood. The streambed at site 1 was covered in macrophytes, with an underlying bed of silt. All mainstem sites supported aquatic vegetation, with such growth observed at the edges of the stream at sites 2, 5, 6 and 7, and throughout the stream at site 1. Only site T3 in the tributary supported aquatic vegetation, with small beds growing on the streambed, some of which were sampled. Site T2 did not support any aquatic vegetation. Due to the discolouration it was difficult to discern the degree of algal growth present, with thin films recorded at all sites, and site 1 also supporting patchy growths of filaments.

No undesirable heterotrophic growths were recorded at any of the seven sites in this survey.

Unlike the previous (December 2015) survey, which noted dead eels on the stream bed and the January 2015 survey, which observed hydrocarbons being released from the streambed at site 7, no concerning observations were made while completing the current survey.

## Macroinvertebrate communities

A moderate number of macroinvertebrate surveys have been conducted at these sites. Monitoring has been conducted in other small lowland hill country streams in Taranaki surveyed at similar altitudes (TRC, 1999 (statistics updated 2016)) and these have been compared with the current results in Table 2. Table 2 gives summary statistics for the sites, while Table 3 provides a complete taxa list for the current survey.

Table 2 Number of taxa, MCI and SQMCI$_s$ values recorded in the Haehanga Stream catchment together with a summary of results from control sites in other small lowland hill country streams (LOWL) between 25-49 MASL, in Taranaki (TRC, 1999) (Updated to October 2016).

| Site | Number of previous surveys | Numbers of taxa | | | MCI values | | | SQMCIs values | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Median | Range | Current | Median | Range | Current | Median | Range | Current |
| LOWL* | 23 | 22 | 17-30 | - | 80 | 68-109 | - | 4.0 | 2.7-6.2 | - |
| 1 | 12 | 22 | 17-27 | 17 | 71 | 68-78 | 69 | 3.6 | 2.7-4.2 | 3.9 |
| 2 | 20 | 19 | 17-23 | 17 | 74 | 62-99 | 99 | 4.0 | 2.7-4.4 | 4.3 |
| 5 | 19 | 19 | 6-28 | 26 | 73 | 53-83 | 88 | 2.8 | 1.1-4.1 | 3.2 |
| 6 | 6 | 20 | 6-24 | 16 | 72 | 60-79 | 88 | 2.9 | 1.0-3.1 | 2.6 |
| 7 | 15 | 20 | 12-30 | 21 | 70 | 59-82 | 78 | 3.2 | 1.3-4.3 | 3.5 |
| T2 | 9 | 23 | 20-30 | 18 | 86 | 79-94 | 104 | 5.1 | 4.6-6.2 | 7.2 |
| T3 | 9 | 27 | 24-32 | 23 | 83 | 78-93 | 90 | 4.4 | 3.5-5.4 | 5.3 |

*SQMCI$_s$ median and range based on only 22

The current survey results for the Haehanga mainstem are also presented in Figure 2 and Figure 3, with these figures providing a catchment perspective.

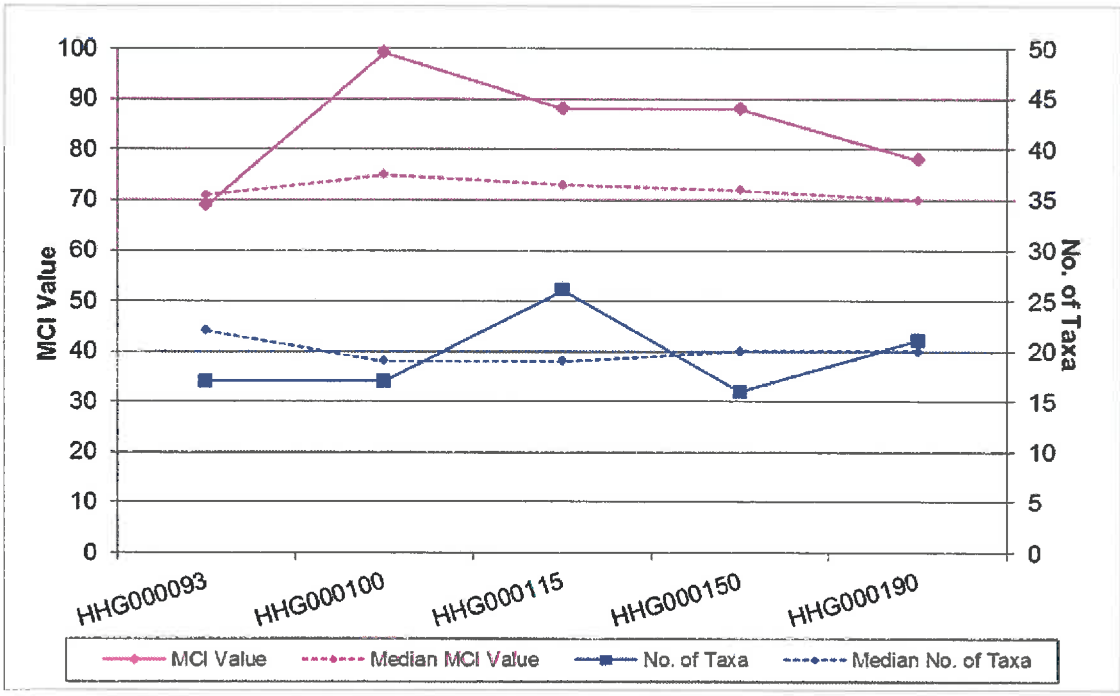


Figure 2 Number of taxa and MCI scores recorded at each Haehanga Stream sites during the current survey, compared with the respective medians for these sites.

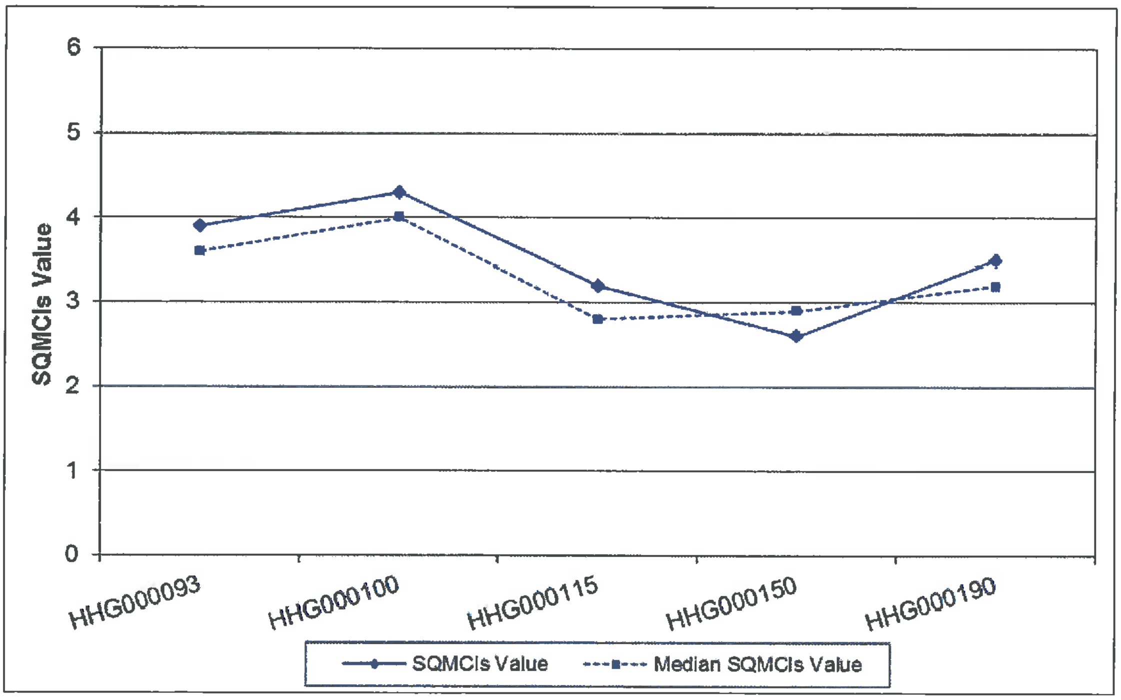


Figure 3 SQMCI$_S$ scores recorded at each Haehanga Stream sites during the current survey, compared with the respective medians for these sites.

## Site 1 – Upstream of expanded irrigation area

This site, sampled intermittently since 2002, was re-introduced to the monitoring programme in 2010, prior to the irrigation of wastewater onto land between sites 1 and 2. Irrigation on this land has since occurred, consequently site 1 becomes the upstream control site, and site 2 becomes an impact site.

A relatively low taxa richness was recorded at this site (17), which was five taxa less than the median, and the lowest richness recorded at this site to date, equal to that recorded in the previous survey. This is quite a drop (ten taxa) from the summer 2014 survey, which recorded the highest richness for this site to date (Figure 4), and may reflect the earlier timing of the last two surveys. This survey was undertaken only thirteen days after the last fresh in this stream, and preceding flow conditions may have flushed out a number of taxa from this stream.

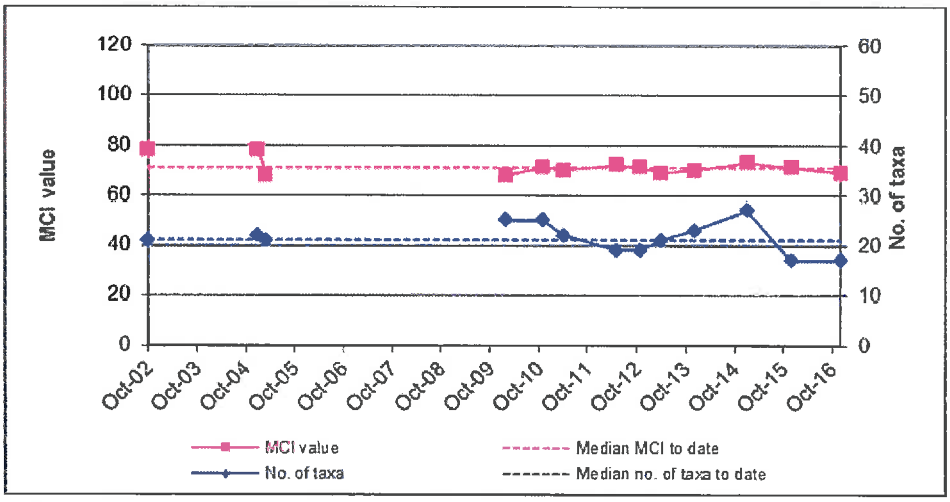


**Figure 4** Taxa numbers and MCI recorded to date at site 1

**Table 3** Macroinvertebrate fauna of the Haehanga Stream catchment, sampled in relation to Remediation (NZ) Ltd on 14 December 2016.

| Taxa List | Site Number | MCI score | 1 | 2 | 5 | 6 | 7 | T2 | T3 |
|---|---|---|---|---|---|---|---|---|---|
| | Site Code HHG000: | | 093 | 100 | 115 | 150 | 190 | 098 | 103 |
| | Sample Number FWB16: | | 294 | 295 | 296 | 297 | 298 | 299 | 300 |
| ANNELIDA | Oligochaeta | 1 | R | A | VA | XA | VA | C | A |
| | Lumbricidae | 5 | - | C | R | C | R | C | C |
| HIRUDINEA | Hirudinea | 3 | C | - | - | - | R | - | - |
| MOLLUSCA | *Gyraulus* | 3 | - | - | - | - | R | - | - |
| | *Physa* | 3 | C | R | R | R | C | - | R |
| | *Potamopyrgus* | 4 | XA | VA | VA | VA | XA | A | VA |
| CRUSTACEA | Ostracoda | 1 | A | - | R | - | A | - | R |
| | *Paracalliope* | 5 | A | VA | C | R | - | VA | VA |
| | Paraleptamphopidae | 5 | - | - | - | - | - | R | - |
| | Talitridae | 5 | - | - | - | - | - | - | R |
| EPHEMEROPTERA | *Austroclima* | 7 | - | R | R | - | - | - | - |
| | *Deleatidium* | 8 | - | C | A | VA | C | XA | VA |
| | *Zephlebia group* | 7 | R | C | R | - | R | A | A |
| PLECOPTERA | *Acroperla* | 5 | - | R | - | R | - | R | C |
| | *Austroperla* | 9 | - | R | - | - | - | R | - |
| ODONATA | *Xanthocnemis* | 4 | A | - | C | - | C | - | - |
| | *Aeshna* | 5 | R | - | - | - | - | - | - |
| | *Hemicordulia* | 5 | R | - | - | - | - | - | - |
| HEMIPTERA | *Anisops* | 5 | - | - | - | - | C | - | R |
| | *Sigara* | 3 | - | - | - | - | A | - | - |
| COLEOPTERA | Elmidae | 6 | - | - | R | R | - | - | - |
| | Dytiscidae | 5 | - | - | R | - | R | - | R |
| | Hydrophilidae | 5 | - | - | - | R | - | - | - |
| | Ptilodactylidae | 8 | - | - | - | - | - | R | R |
| TRICHOPTERA | *Hydrobiosis* | 5 | - | R | R | A | R | C | C |
| | *Polyplectropus* | 6 | - | - | R | - | - | - | - |
| | *Psilochorema* | 6 | - | - | R | R | C | R | C |
| | *Oxyethira* | 2 | C | - | - | R | - | - | - |
| | *Paroxyethira* | 2 | R | - | - | - | - | - | - |
| | *Triplectides* | 5 | R | - | C | - | C | - | R |
| LEPIDOPTERA | *Hygraula* | 4 | R | - | - | - | - | - | - |
| DIPTERA | *Aphrophila* | 5 | - | - | - | R | - | - | - |
| | Eriopterini | 5 | - | R | R | - | - | R | - |
| | *Paralimnophila* | 6 | - | C | R | C | - | R | C |
| | *Zelandotipula* | 6 | - | R | - | - | - | R | - |
| | *Chironomus* | 1 | - | - | R | R | R | - | R |
| | Orthocladiinae | 2 | R | R | C | - | C | C | - |
| | *Polypedilum* | 3 | - | R | R | - | C | - | C |
| | Tanypodinae | 5 | - | - | R | - | - | - | R |
| | Culicidae | 3 | - | - | R | - | - | - | - |
| | Dolichopodidae | 3 | - | - | R | - | - | - | - |
| | *Paradixa* | 4 | - | - | - | - | R | R | R |
| | Empididae | 3 | R | - | - | - | - | - | R |
| | *Austrosimulium* | 3 | R | A | - | R | - | C | A |
| | Tanyderidae | 4 | - | - | R | - | R | - | - |
| ACARINA | Acarina | 5 | - | - | R | - | - | - | - |
| | | No of taxa | 17 | 17 | 26 | 16 | 21 | 18 | 23 |
| | | MCI | 69 | 99 | 88 | 88 | 78 | 104 | 90 |
| | | SQMCIs | 3.9 | 4.3 | 3.2 | 2.6 | 3.5 | 7.2 | 5.3 |
| | | EPT (taxa) | 2 | 6 | 7 | 4 | 5 | 6 | 6 |
| | | %EPT (taxa) | 12 | 35 | 27 | 25 | 24 | 33 | 26 |

'Tolerant' taxa | 'Moderately sensitive' taxa | 'Highly sensitive' taxa

R = Rare C = Common A = Abundant VA = Very Abundant XA = Extremely Abundant

The community comprised a relatively high proportion of tolerant taxa (71%) which resulted in a 'poor' MCI score of 69 units. This is only one unit higher than the minimum score recorded previously at this site and two units less than the median score (Table 2, Figure 4). Although this is a 'poor' score (TRC, 2015), it is a reflection of the low and slow flows and vegetation habitat sampled, and is consistent with that recorded at this site in recent years. This score is significantly less than the median MCI score for other similar lowland streams (Stark, 1998), indicating that the invertebrate community site is in poorer health than similar streams at this altitude.

The community was dominated by an extremely abundant 'tolerant' taxon, (snail (*Potamopyrgus*). Other dominant 'tolerant' taxa included seed shrimps (Ostracoda) and damselfly larvae (*Xanthocnemis*). One 'sensitive' taxon was also abundant, the amphipod (*Paracalliope*). The dominance of 'tolerant' taxa resulted in a low $SQMCI_S$ score of 3.9 units, equal to the previous survey and within the range of previously recorded scores (Table 2). It was also not significantly different to the median for other sites in similar small lowland streams (Stark, 1997).

Overall, this indicates that the water quality of the Haehanga Stream prior to it flowing into the Remediation NZ composting site was of average quality, and that the community was strongly influenced by the low and slow flows, and the shallow gradient of this stream.

## Site 2 – Downstream of extended irrigation area

At site 2 in the Haehanga Stream, upstream of all composting areas, 17 macroinvertebrate taxa were recorded. This was one taxon fewer than that recorded in the previous survey and two taxa less than the median for this site (Table 2). The community was dominated by three 'tolerant' taxa, (oligochaete worms, *Potamopyrgus* snails and sandfly larvae (*Austrosimulium*)), and one very abundant 'moderately sensitive' taxon, (*Paracalliope* mayfly)) (Table 3).

The MCI value of 99 units reflected a relatively high proportion of sensitive taxa in the community at this site (65%). This score is equal to that recorded in the previous survey, but significantly higher than the next highest score recorded at this site, and is twenty-four units higher than the median, also a statistically significant difference (Stark 1998)(Table 2, Figure 3). The $SQMCI_S$ value at this site (4.3) was similar to the median value, but significantly less than the previous maximum score, recorded in the previous survey. This reduction is primarily due to the reduced abundance of 'highly sensitive' *Deleatidium* mayfly.

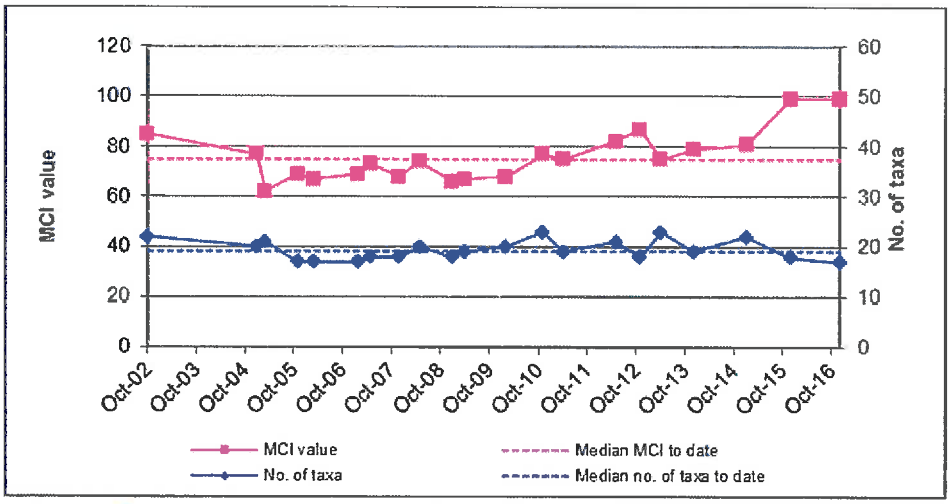


Figure 5 Taxa numbers and MCI recorded to date at site 2

Although this suggests that water quality at this site was 'fair' and well above average, it should be noted that the sampling technique differed to most previous surveys. Historically, this site was sampled using the vegetation sweep technique. Since the December 2015 survey, the kick sample technique has been used due to a lack of macrophyte habitat. The vegetation sweep technique tends to collect taxa that are more 'tolerant' and therefore produces lower MCI and $SQMCI_S$ scores. This also explains the very significant improvement in MCI score between sites 1 and 2 (30 units).

Overall, it is apparent that the primary influence on the community at this site is the variation in habitat, and the consequent change in sampling technique. The fact that one 'highly sensitive' taxon was recorded as 'common' is supportive of the conclusion of reasonable preceding water quality with no discernible impacts from the irrigation of wastewater to land between sites 1 and 2.

## Site 5 – downstream of all pond discharges

At site 5 in the Haehanga Stream, 25 m downstream of all wastewater ponds, 26 taxa were recorded, seven taxa more than the median of the nineteen previous surveys, and twelve more than that recorded in the previous survey (Table 2, Figure 3). This increased richness may be a reflection of the flushing flow that was occurring at the time of the survey, or recovery from the previous survey when hydrocarbon odour was released from the substrate during sampling. Two 'tolerant' taxa dominated the community at this downstream site (very abundant oligochaete worms and snails (*Potamopyrgus*) with the 'highly sensitive' mayfly *Deleatidium* recorded as abundant (Table 3). The numerical dominance of very abundant 'tolerant' oligochaete worms and orthoclad midge larvae resulted in a $SQMCI_S$ score of 3.2 units, a statistically insignificant 0.4 unit higher than the median for this site, but a significant 1.1 units less than that recorded at site 2 (Stark, 1998). The MCI score (88) was sixteen units greater than the median score for this site, and eleven units higher than that recorded in the previous survey, both statistically significant results (Stark, 1998) (Figure 6). It is also the highest recorded at this site to date. However, it was eleven units less than that recorded at site 2 upstream in the current survey. This is a reflection of the decreased proportion of 'sensitive' taxa in the community (58%), which was 7% lower than at the upstream site 2 (Table 2).

Some previous surveys have recorded changes in abundance of individual taxa, which can be interpreted as being an indication of organic enrichment of the stream. Such changes included *Chironomus* bloodworms becoming abundant at this site. The results from the current survey indicate that *Chironomus* bloodworms were present at the time of the survey, but only as a rarity (less than five individuals). In total, significant changes in abundance were recorded for none taxa, including an increase in three 'sensitive' taxa. Overall, this community appears to be in above average community health, indicative of 'fair' water quality.

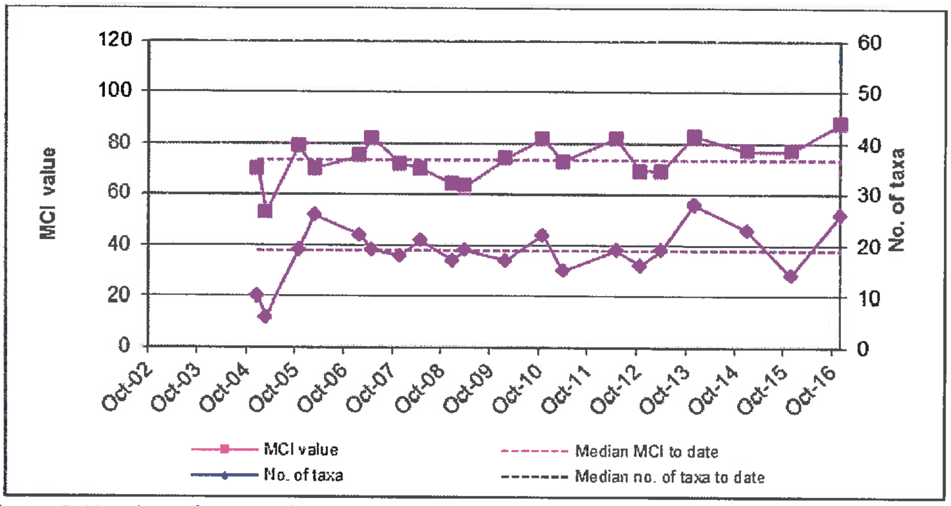


Figure 6 Number of taxa and MCI scores recorded to date at Site 5

## Site 6 – Downstream of effluent irrigation area

A richness of sixteen taxa was recorded at this site, located downstream of the effluent irrigation area (Table 2, Figure 7). This is an improvement on that recorded in the previous survey when only six taxa were recorded. The community was dominated by two 'tolerant' taxa (extremely abundant oligochaete worms and very abundant *Potamopyrgus* snails), one 'moderately sensitive' taxon (*Hydrobiosis* caddisfly larvae) and one 'highly sensitive' taxon (*Deleatidium* mayfly). This also represents an improvement from the previous survey.

The community consisted mainly of 'sensitive' taxa (62%), resulting in an MCI score of 88 units. This score is significantly higher than the median for this site, the previous maximum score recorded at this site, and 28 units higher than that recorded in the previous survey, a particularly significant result (Table 2, Figure 2). Not only does this indicate that the community during the current survey was in well above average health, it also shows how severely impacted the community was during the previous survey. The current result is indicative of 'fair' water quality (TRC, 2015).

The $SQMCI_S$ score was heavily influenced by the extremely abundant oligochaete worms, but tempered slightly by the abundance of *Deleatidium* mayfly. This resulted in a $SQMCI_S$ score of 2.6 units, slightly less than the median for this site. Although this is the lowest $SQMCI_S$ score recorded in the current survey, it does not differ from what is usually recorded at this site, and is significantly better than that recorded in the previous survey (1.0 unit).

Previous surveys, including the most current one, had noted $SQMCI_S$ scores at this site that were lower than could be expected. It was concluded that there may be a subtle deterioration in water quality at this site, but habitat differences also needed to be taken into account. This is because this site has habitat that differed to the other Haehanga Stream sites, as it was a true riffle, in that it was shallow flow tumbling over coarse and fine gravel, as opposed to deeper flow moving over macrophyte or submerged wood. The riffle present sampled in the current survey may have also had some recent disturbance, with the placement of gravels, in an effort to resolve the perched culvert upstream. This may also explain the slightly lower than usual taxa richness. Overall, the results indicate that the community at this site was in average to above average health, and significantly better than that recorded in the previous survey, which was coincident with the discovery of a number of dead eels noted at and immediately downstream of this site.

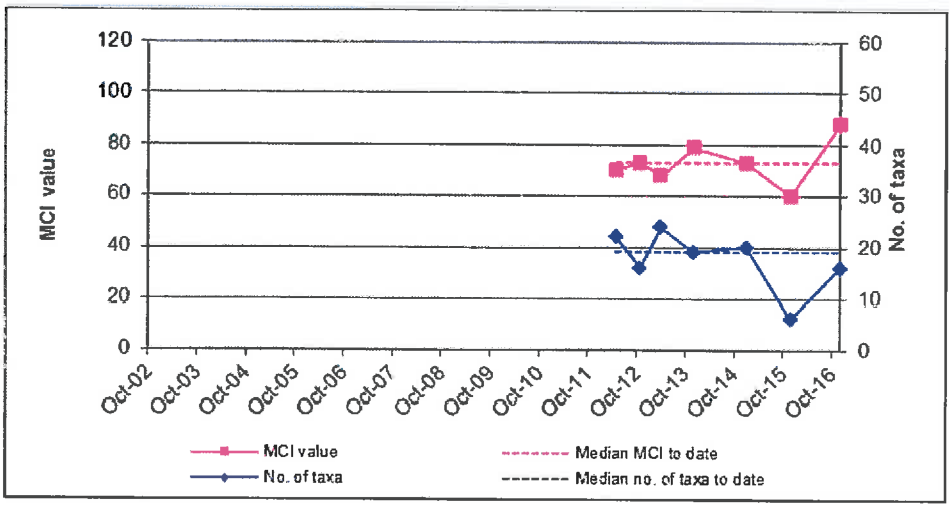


Figure 7 Number of taxa and MCI scores recorded to date at Site 6

## Site 7 – Downstream of all site activities

This site exhibited average taxa richness (21), one taxon more than the median, and seven more than the previous survey undertaken at this site. The 'poor' MCI score of 78 was due to the community comprising 62% 'tolerant' taxa, of which four were abundant (ostracod seed shrimp and water boatmen (*Sigara*), very abundant (oligochaete worms) or extremely abundant (snails (*Potamopyrgus*)). Seven 'moderately sensitive' taxa and one 'highly sensitive' taxon were recorded at this site, suggesting moderate preceding water quality.

The MCI score of 78 was nineteen units higher than that recorded in the previous survey, a statistically significant improvement (Stark, 1998) (Table 2 and Table 7). This score was statistically insignificantly higher than the median score for this site (Stark, 1998), although it was the second highest score recorded at this site to date (Figure 8). The abundance of 'tolerant' taxa, especially snails and orthoclad midge larvae, resulted in a $SQMCI_S$ of 3.5 units, 0.3 unit less than the median for this site but 0.6 unit higher than that recorded in the previous survey

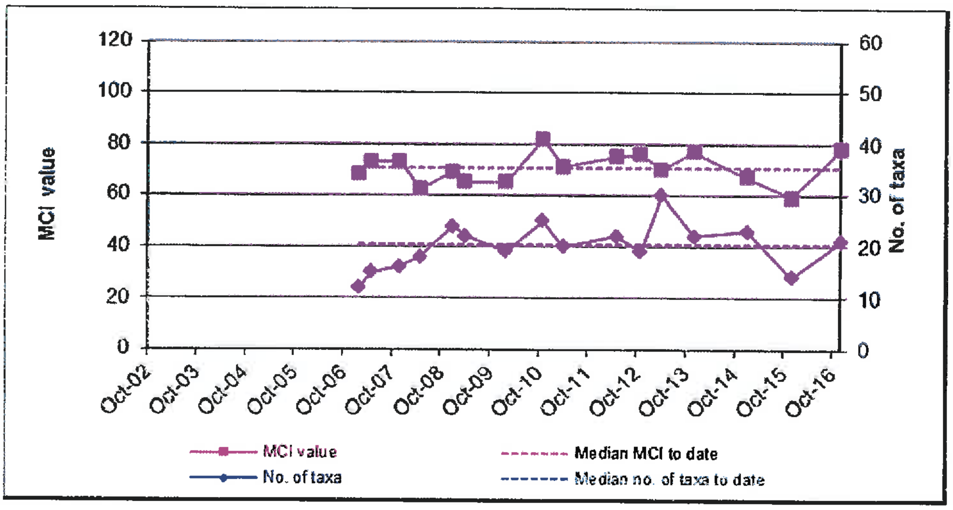


Figure 8 Number of taxa and MCI scores recorded to date at Site 7

When compared with site 6 upstream, the MCI score was lower, while the $SQMCI_S$ score improved slightly, due mainly to the reduced abundance of oligochaete worms and improved abundance of *Potamopyrgus* snails. There were ten significant differences in individual taxon abundance recorded between sites 6 and 7, with the majority of these differences reflecting the change in habitat, from a swift shallow riffle at site 6, to a deep slower run at site 7. It may also be that invertebrates were being flushed downstream in the higher flows, as a number of still or slow water taxa were recorded at site 7. The above average MCI and $SQMCI_S$ scores indicate that this community was also in above average health and reflective recovery following the previous survey.

During some previous surveys, concern was raised regarding an extreme abundance of *Chironomus* bloodworm larvae at this site. Such abundance usually only occurs where there is a significant organic discharge, which the *Chironomus* bloodworm larvae feed upon. It was noted that should this result be repeated in subsequent surveys, further investigation will be required. Dissolved oxygen readings were subsequently taken in the stream, and this found that there may be periods of low dissolved oxygen, especially when weed beds are well established, such as in summer. This is natural, and related to the shallow gradient of the stream, and can be exacerbated during low flows. It is likely that the sporadic abundance of *Chironomus* is related to the low dissolved oxygen concentrations within the stream, rather than the discharge of organic wastes upstream. *Chironomus* was recorded as rare at this site in the current survey.

## Site T2 – upstream of the wetland discharge

Sampling performed in the unnamed tributary that receives the wetland discharge has routinely found macroinvertebrate communities that are in better health than those present in the Haehanga mainstem. In the current survey, eighteen macroinvertebrate taxa were recorded at site T2, upstream of the wetland discharge point. This was slightly less than the median richness for this site and for control sites in similar streams (Table 2), and that recorded in the previous survey. Good water quality had preceded this survey, as indicated by the presence of three 'highly sensitive' taxa in the community, and the abundance of a number 'sensitive' taxa.

Extremely abundant *Deleatidium*, a 'highly sensitive' mayfly, dominated the community. Other taxa recorded in abundance included one 'tolerant' taxon (snails (*Potamopyrgus*)) and two 'moderately sensitive' taxa (*Paracalliope* amphipods and *Zephlebia* mayfly) (Table 3).

This community had a relatively high MCI score (104), reflecting the improved proportion of sensitive taxa present (72%) (Figure 9). This MCI score is 24 units higher than the median MCI score for control sites in similar streams and ten units higher than that recorded in the previous survey. This is the highest MCI score recorded in the Haehanga Stream catchment to date (Table 3). The $SQMCI_S$ value of 7.2 was particularly good for this type of stream, and significantly higher than the median for control sites in other lowland streams at a similar altitude (TRC, 1999). This is also the highest $SQMCI_S$ score recorded in the Haehanga Stream to date.

This stream typically has better MCI and $SQMCI_S$ scores than the Haehanga Stream sites, and this is a direct reflection of the difference in headwater character. Site T2 is located near to the source of this stream, which rises from a swampy spring, and flows through a short channel, which is well shaded. In contrast, sites 1 and 2 in the Haehanga Stream are located in excess of 1.5 km downstream of the source of this stream, below which the stream is relatively unshaded and unprotected.

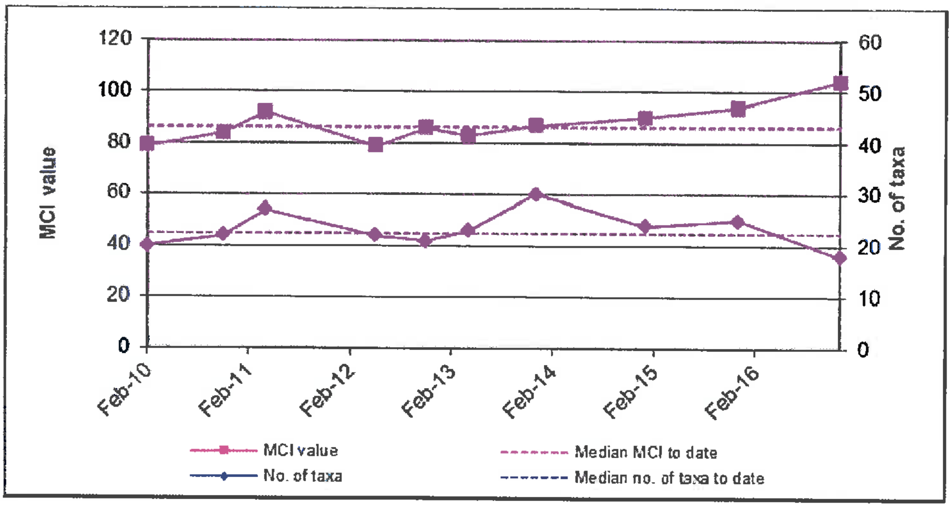


Figure 9 Taxa numbers and MCI recorded to date at site T2

## Site T3 – downstream of the wetland discharge point

This is the tenth time that macroinvertebrates have been sampled at this site, located approximately 20 metres downstream of the wetland discharge. Twenty-three taxa were recorded at this site. This is four taxa less than what was recorded in the previous survey but five more than that recorded upstream at site T2 (Table 2, Figure 10).

The community was characterised by one 'highly sensitive' taxon (*Deleatidium* mayfly), two 'moderately sensitive' taxa (*Paracalliope* amphipods and mayfly (*Zephlebia* group)), and three 'tolerant' taxa, (oligochaete worms, snails (*Potamopyrgus*) and sandfly larvae (*Austrosimulium*)) (Table 3). This site had a slightly lower proportion of sensitive taxa (61%) than site T2 upstream, resulting in a reduced MCI score (90). This is a statistically significant reduction (Stark, 1998), suggesting some impact from the wetland discharge. However, it was entirely caused by a the change in presence/absence of taxa recorded as rarities only, and as such, if there was an influence from the wetland it was only subtle. This conclusion is supported by the lack of change in communities, with only two taxa changing significantly in abundance between the sites. The significant increase in the abundance of *Chironomus* bloodworms and oligochaete worms observed in the January 2015 survey were not apparent in the current survey. The highly sensitive mayfly *Deleatidium* was recorded in abundance at both sites. The drop in MCI score was mirrored in the $SQMCI_S$ score, which dropped 1.8 units between site T2 and T3. However, the $SQMCI_S$ score of 5.3 at site T3 was a significant (Stark, 1998) 0.9 unit higher than the median for this site and a significant 1.3 units higher than the median $SQMCI_S$ score for similar streams at comparative altitudes (TRC, 1999). Overall, although the MCI and $SQMCI_S$ scores indicate deterioration in macroinvertebrate community health between sites T2 and T3, the results at site T3 were well above average, and therefore this deterioration is considered to be of a subtle nature only.

Previous surveys have also noted certain changes in taxa presence/absence that indicated that there is also a significant influence from the instream habitat. For example, in a previous survey, site T3 recorded boatman (*Sigara*) and ostracod seed shrimps, which inhabit slow to still water, a habitat not typically inhabited by *Deleatidium* mayfly, which was absent at site T3 (but extremely abundant at site T2). This was less apparent in the current survey, with *Deleatidium* mayfly abundant at both sites, and fewer slow water species noted at site T3. Overall, these observations indicate that the discharge occurring at the time of this survey was having no more than a subtle impact on the communities of this stream.

Some previous water quality results indicate that unionised ammonia concentrations in the unnamed tributary have at times been toxic enough to reduce the abundance of, or eliminate entirely, some of the sensitive species usually found in this stream. Results of sampling undertaken in the year prior to this survey show that five of the six samples contained concentrations of unionised ammonia below the toxicity threshold of 0.025 $g/m^3$. This shows management of the unionised ammonia concentrations in the effluent being discharged was moderate, but could be improved. Should unionised ammonia concentrations return to high levels in the winter period, an additional macroinvertebrate survey at this time may be warranted. At the very least, the water quality monitoring will need to continue to assist with the interpretation of macroinvertebrate results.

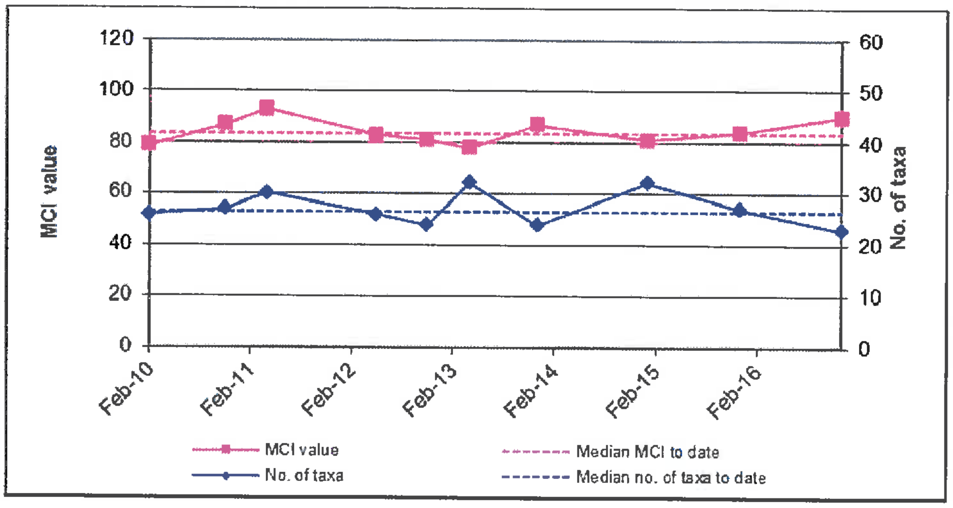

Figure 10 Taxa numbers and MCI recorded to date at site T3

## Conclusions

The Council's standard 'streambed kick' and 'vegetation sweep' techniques were used at seven established sites to collect streambed macroinvertebrates from the Haehanga Stream catchment in order to assess whether the Remediation (NZ) Ltd composting areas had had any adverse effects on the macroinvertebrate communities of these streams. Samples were processed to provide number of taxa (richness), MCI, and $SQMCI_S$ scores for each site.

The MCI is a measure of the overall sensitivity of the macroinvertebrate community to the effects of organic pollution in stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The $SQMCI_S$ takes into account taxa abundance as well as sensitivity to pollution, and may reveal more subtle changes in communities, particularly if non-organic impacts are occurring. Significant differences in either the MCI or the $SQMCI_S$ between sites indicate the degree of adverse effects (if any) of the discharges being monitored.

The macroinvertebrate survey conducted on 14 December 2016 was preceded by a rain event just hours prior, resulting in flows in the Haehanga catchment to be relatively high, with a steady to swift water speed noted at all sites. Community richnesses were slightly reduced upstream of the site, possibly due to the frequent higher flows that preceded this survey. These higher flows appear to have also led to improved invertebrate habitat, as, with the exception of site 1, all sites recorded MCI scores higher than their respective medians. Overall, this survey found that macroinvertebrate communities of the mainstem sites and two unnamed tributary sites were of average to above average health. Undesirable heterotrophic growths were not recorded at any of the seven sites in this survey.

The two sites in the unnamed tributary were sampled for the tenth time in the current survey, and exhibited a community relatively typical for this kind of habitat. However, there were some differences between these two sites. Site T2 recorded MCI and $SQMCI_S$ scores that were well above average. Site T3 also recorded MCI and $SQMCI_S$ scores higher than average, but they were significantly less than that recorded at site T2. Previous surveys have frequently recorded oligochaete worms, ostracod seed shrimps and *Chironomus* bloodworms increasing significantly in abundance downstream of the discharge. These taxa are often associated with organically enriched discharges. In the current survey all three of these taxa increased in abundance at site T3, coincident with the observation of a moderate discharge leaving the wetland.

There were only subtle changes in the community of the unnamed tributary, and although the changes in presence/absence of taxa between the sites involved only taxa recorded as rare, they were all reflective of organic enrichment of the stream. There was also little indication of a significant influence from a change in instream habitat. Previously, site T3 has recorded boatman (*Sigara*) and ostracod seed shrimps, which inhabit slow to still water, a habitat not typically inhabited by *Deleatidium* mayfly, which was absent at site T3 at that time (but extremely abundant at site T2). This was less apparent in the current survey, with *Deleatidium* mayfly abundant at both sites, and fewer slow water species noted at site T3. Overall, the unnamed tributary was in above average health, and the discharge occurring at the time of this survey was having no more than a subtle impact on the communities of this stream.

Some previous water quality results indicate that unionised ammonia concentrations in the unnamed tributary have at times been toxic enough to reduce the abundance of, or eliminate entirely, some of the sensitive species usually found in this stream. Results of sampling undertaken in the year prior to this survey show that five of the six samples contained concentrations of unionised ammonia below the toxicity threshold of 0.025 $g/m^3$. This shows management of the unionised ammonia concentrations in the effluent being discharged was moderate, but could be improved. Should unionised ammonia concentrations return to high levels in the winter period, an additional macroinvertebrate survey at this time may be warranted. At the very least, the water quality monitoring will need to continue to assist with the interpretation of macroinvertebrate results.

In general, the communities in the Haehanga Stream sites had moderate proportions of sensitive taxa. Low numbers of sensitive taxa are expected in small, silty bottomed streams such as the Haehanga Stream and the numbers of taxa were generally similar to other lowland hill country streams surveyed at similar altitude. The community richness at site 6 and 7 had recovered from that recorded in the previous survey, which recorded significant deterioration. MCI values recorded in the Haehanga Stream generally reduced in a downstream direction, although site 1 in the current survey recorded the lowest MCI score of 69 units. For second consecutive year, site 2 recorded an MCI score equal to the highest recorded in this catchment to date. Sites 1 recorded an average MCI score, with sites 2, 5, 6 and 7 recording above average scores, significantly so for sites 2, 5 and 6. This represents a significant recovery at sites 6 and 7, following the deterioration recorded in the previous survey, which was coincident with the observation of a number of dead eels at site 6.

Site 5 has exhibited poorer macroinvertebrate communities in the past compared to other sites upstream. This has suggested some level of impact from the composting operation, although the extent of adverse effects has been difficult to determine due to poor habitat quality. During the current survey, the MCI score for site 5 was fifteen units greater than the median score for this site. This is a significant improvement from the previous survey, which noted the presence of hydrocarbons in the substrate. The $SQMCI_S$ score recorded at site 5 was reduced compared with that recorded at site 2. In addition, the results from the current survey indicate that *Chironomus* bloodworms were present, but only as a rarity. This suggests some deterioration from that recorded at site 2, but overall, the communities at site 5 were in above average health.

Unlike the other sites, the sample from site 6 was collected from a riffle with coarse and fine gravels, using the 'streambed kick' sampling technique. However, this riffle had recently had additional gravels placed over the top, in an effort to resolve a perched culvert upstream. This may have influenced the invertebrate community, which recorded a relatively low taxa richness of 16 taxa. However, it recorded an MCI score of 88 units, indicative of 'fair' water quality, and the highest recorded at this site of the seven surveys conducted there. It also represents a significant improvement from the previous survey, and no change from that recorded at site 5 upstream, being higher than the median for control sites in other lowland streams at a similar altitude. This provides no indication of deterioration, a conclusion supported by the $SQMCI_S$ score of 2.6 units. Although this score is lower than that recorded upstream, it is similar to the median for this site, despite the disturbance that had recently occurred at this site.

The surveys undertaken at this site sampled habitat that differed to the other Haehanga Stream sites, as it was a true riffle, with shallow flow tumbling over coarse and fine gravel, as opposed to deeper flow moving over macrophyte or submerged wood. This habitat difference can explain some of the differences in the taxa recorded and the increased abundance of worms recorded in previous surveys. The current survey indicates that the water quality preceding this survey had been fair and better than average.

The lowest site (site 7) was sampled for the sixteenth time in this survey. There was a reduction in MCI score, but the $SQMCI_S$ score was higher than that recorded at site 6. When compared with historical data, the community at site 7 was in average health, and indicative of no deterioration in water quality. As with site 6, there was a recovery in community health from that recorded in the previous survey. The $SQMCI_S$ score for this site (3.5) and taxa richness (21) were similar to their long-term average, indicating that the community was in average health.

During certain previous surveys, *Chironomus* bloodworms have been recorded as abundant at various sites. Abundance of this taxon is usually an indication of an organic discharge, although low dissolved oxygen in the stream can also allow this taxon to dominate the community, especially when this is associated with low flows. It may be then that the sporadic appearance of *Chironomus* in abundance is at least in part related to the dissolved oxygen concentrations. Dissolved oxygen concentrations in the Haehanga have been found to be depressed at times, and during the warmer months, when there is more aquatic weed growth, dissolved oxygen may be significantly depleted at night. This is a natural occurrence in some streams that are slow flowing and weedy. Any macroinvertebrate surveys undertaken when such conditions exist could potentially record a community with fewer sensitive species, and a more abundant population of *Chironomus*. During the current survey, *Chironomus* was recorded as rare at sites 5, 6, 7 and T3. This possibly suggests a slight increase in the organic enrichment of the stream. It is understood that the issue of high chlorides at site 6 has been identified and is being addressed, and so water quality will hopefully improve with time. This would be further contributed to through any on-going works to the leachate and stormwater treatment system, and improved management of the riparian margin. Any works that improve water quality are also likely to lead to an improvement in freshwater macroinvertebrate communities below the discharges, and should continue to be encouraged.

This was the only macroinvertebrate programme scheduled for the 2016-17 period. It is recommended that this level of monitoring continue, but that a provisional macroinvertebrate survey be retained in the programme, to be implemented should water quality monitoring indicate an issue.

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