Taihoro Nukurangi

Biological monitoring of rivers in Gisborne District

Benefits, costs and recommendations

Prepared for Gisborne District Council

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Contents

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Executive summary

Gisborne District Council currently monitors the physico-chemical water quality at 44 sites on 28 rivers across the district. It is considering whether to enhance this monitoring programme by adding biological monitoring of rivers. This report describes the benefits of monitoring the four main groups of riverine biota plus physical habitat quality in addition to physico-chemical water quality. It outlines the context for monitoring the ecological health of rivers, describes the practicalities and costs of a biological monitoring programme and makes recommendations for beginning a biomonitoring programme.

Four groups of organisms are commonly monitored as indicators of river ecological health. These are benthic macro-invertebrates, periphyton (attached algae), macrophytes (rooted aquatic plants) and fish. These organisms are often monitored in addition to physico-chemical water quality (water temperature, oxygen, visual clarity, pH, nutrients, etc.,) for several reasons: a) they integrate a range of environmental stressors including various aspects of habitat and flow regime as well as water quality; b) they reflect long-term conditions including critical extremes that may be missed by water sampling; c) for most of the organism groups, indices can be compared with guideline values that define excellent, good, fair or poor ecological health; d) some of the organism groups (particularly fish and some invertebrates) are valued in themselves by the community; e) some of the organism groups relate directly to other community values such as aesthetics, fishing or swimming; and f) they provide direct information on the state and trends of aquatic biodiversity. Therefore, monitoring the organisms that inhabit streams and rivers provides a much more complete picture of ecological health than monitoring physico-chemical water quality alone. The picture is enhanced further by monitoring the physical habitat of the river channel and riparian zone.

Currently all regional councils and unitary authorities except Gisborne District Council conduct regular biological monitoring of rivers for State of Environment reporting. Establishing biological monitoring in Gisborne would complete the national data set that Ministry for the Environment uses to assess the state and trends of New Zealand's fresh waters.

Gisborne District Council is currently preparing a regional plan for freshwater management that includes both water quality and water quantity. Because river biota are affected by flow regimes as well as water quality, monitoring the effectiveness of policies in the freshwater management plan (as required under the Resource Management Act 1991) is best achieved by monitoring biota in tandem with water quality. The National Policy Statement on Freshwater Management provides additional reason to monitor biological indicators, as Objectives A1 and B1 refer to "safeguarding the life-supporting capacity, ecosystem processes and indigenous species…. of fresh water". Biological monitoring is the most direct way of assessing life-supporting capacity and indigenous species.

The field protocols for sampling benthic macro-invertebrates and assessing periphyton and aquatic macrophytes are not difficult, and can be learned by any competent environmental science field technician with some additional training. Field assessments of physical habitat also are relatively simple and could be performed by environmental science technicians with general experience and competence. Benthic macro-invertebrates require additional laboratory processing that can be done by an external consultant at a modest cost. Methods

for monitoring fish in a scientifically robust way are more time-consuming and require specialist training. Therefore, it is anticipated that fish monitoring may be beyond the resources of Gisborne District Council at present. Fish monitoring could be added in future if resources permit.

Determining the number and locations of monitoring sites, and the amount of integration with the current water quality network would require an additional consultation involving desktop analyses, discussions with key individuals and visits to potential field sites.

1 Scope of this report

This report outlines the benefits, costs, opportunities and constraints for biological monitoring of streams and rivers in Gisborne District. The terms “stream” and “river” are used interchangeably.

Biological monitoring (often abbreviated to biomonitoring) refers to the regular assessment of aquatic biota, including benthic macro-invertebrates, periphyton (attached algae), macrophytes (rooted aquatic plants) and fish. This report considers all four of these biological components. Because the physical habitat so strongly affects the stream biota, and is often omitted from water quality monitoring, comments on physical habitat are also included. Biomonitoring typically is conducted in conjunction with water quality monitoring because these two aspects support each other in assessing ecological health and suitability for different human uses. Gisborne District Council currently monitors water quality in 30 rivers, and the comments in this report are to be understood in the context of that monitoring programme.

This report does not consider monitoring of lakes, wetlands or coastal waters. Only one lake of significant size exists in Gisborne District – Lake Repongaere near the Poverty Bay flats. This lake has significant values, including a commercial eel fishery (Dennis Crone, Gisborne District Council, pers. comm.), thus the Council may wish to consider monitoring it in future. Guidelines for lake monitoring are available (Davies-Colley et al. 2012), but lake monitoring involves different protocols than river monitoring, and is outside the scope of this report. A small number of wetlands also occur in Gisborne District, including ox-bows of the lower Waipaoa River in the Poverty Bay flats. Protocols for monitoring wetlands are not well standardised among regional councils in New Zealand. The Council may wish to consider monitoring wetlands in future, but wetland monitoring is outside the scope of this report.

2 Benefits of biomonitoring

In most developed countries, and in all other regions of New Zealand, river monitoring programmes include biota in conjunction with water quality. There are several reasons for this. First, many river organisms are valued in themselves. Typically fish are the organisms most valued by the public, but many people also value “biodiversity” in general, which would include all native species. Second, biological communities integrate the effects of a variety of environmental stressors and any interactions among stressors, thus provide a broad measure of their combined impact (Barbour et al. 1999). In this way, the abundance and diversity of aquatic organisms indicate the “ecological integrity” or the (closely related) “life-supporting capacity” of a river ecosystem. Alongside protecting waters for human health and human use, most river monitoring programmes aim to protect ecological integrity or life-supporting capacity, whether or not they state this explicitly. The importance of these two concepts has been strengthened by two recent documents. The National Environmental Monitoring and Reporting (NEMaR) project (Davies-Colley et al. 2011) identifies assessing ecological integrity as the primary goal of monitoring, while the National Policy Statement on Freshwaters identifies “safeguarding the life-supporting capacity of fresh waters” as Objective A1 (see Section 3.2 below). Monitoring biota assesses ecological integrity and life-supporting capacity directly.

In addition to these general benefits, each group of organisms provides specific benefits for assessing river ecological health.

2.1 Macroinvertebrates

Macro-invertebrates are the group most commonly used for assessing river ecological condition (Rosenberg and Resh 1993). This is because:

- Macro-invertebrates are sensitive to many forms of habitat and water quality degradation.
- The different sensitivities of different taxa are reasonably well known so that robust indices of stream health can be calculated from the presence and/or abundance of different taxa.
- They have limited mobility so they tend to reflect environmental conditions within a specific area, usually metres to tens of metres, which makes them suitable for assessing site-specific impacts.
- They integrate the effects of short-term environmental variations over longer periods. Because each animal lives in water for weeks or months, its presence indicates that environmental conditions must have been suitable during that entire period. In contrast, water quality monitoring typically involves “spot” measurements that are likely to miss critical extremes, for example daily peaks in temperature, daily minima in dissolved oxygen, short-term discharges of pollutants or stresses associated with storm flows.
- They are relatively easy to collect and identify without expensive equipment, and protocols for sample collection and processing are well established (Stark et al. 2001).

For these reasons, benthic macro-invertebrates continue to be recommended for providing the core of river bio-monitoring programmes, both in New Zealand (e.g., Collier and Hamer 2010, Moore and Neale 2008, Schallenberg et al. 2011) and internationally (e.g., Barbour et al. 1999, Hering et al. 2004).

2.2 Fish

Fish are generally the most highly-valued organisms of our native instream fauna, and for this reason should be considered for inclusion in a biomonitoring programme. Fish are sensitive to many of the same aspects of river environments as benthic macroinvertebrates, and because they are high in the food chain, they are affected indirectly by the impacts on other aquatic biota (Barbour et al. 1999). In addition, fish are severely affected by two other common human impacts that do not greatly affect macro-invertebrates. Artificial barriers, such as culverts weirs or low water clarity, that block migration between rivers and the sea, may reduce the presence and abundance of migratory fish species in upstream river reaches (Boubée et al. 1997, Rowe and Dean 1998). Native fish survival is also affected by the presence of introduced fish species, particularly salmonids such as trout, which prey on some native species and compete with them for food (McDowall 2003). Monitoring fish richness and abundance shows the presence and severity of each of these human impacts.

Although there are clear benefits to monitoring native fish, monitoring at the level required for State of Environment (SoE) reporting is time-consuming, can be expensive, and requires special expertise. Current protocols (David et al. 2010) recommend the electric fishing method (EFM) for most stream conditions. EFM requires relatively expensive equipment (currently $8250, plus an annual service and recertification fee of $470), and two operators must be trained in handling the equipment and identifying the fish. Sampling typically involves 1-8 hours per site. Alternative methods such as spotlighting or minnow traps, are simpler, but are still time-consuming. For these reasons, although fish monitoring has been recommend for regional council SoE monitoring programmes (Davies-Colley et al. 2011, Schallenberg et al. 2011) annual monitoring may be beyond the current resources of Gisborne District Council.

2.3 Periphyton

Periphyton is a valuable component of biomonitoring programmes for several reasons. In hard-bottomed (gravel-bed) streams lacking riparian shade, periphyton typically forms the base of the stream food web, but excessive growth can lead to reduced richness of macro-invertebrates as it significantly modifies the physical habitat. Furthermore, excessive growth may become an aesthetic nuisance. Periphyton is particularly sensitive to certain human modifications of river systems associated with agricultural and urban development of catchments. Periphyton growth responds more rapidly than macro-invertebrates to increases in nutrients, decreases in stream shading and decreases in flood flows (e.g., through water impoundments or abstractions). Therefore, it may be better than macro-invertebrates at showing short-term impacts. For these reasons, periphyton has been recommended for inclusion in regional council SoE monitoring programmes (Davies-Colley et al. 2011).

Standard protocols for visually assessing periphyton growth (Kilroy, 2011; Matheson et al. 2012) are rapid and are easily incorporated into water quality monitoring routines. Visual assessments require only simple inexpensive equipment and involve no processing costs.

Quantitative methods are more costly and time-consuming, but can be done periodically to calibrate visual assessments, if desired.

The only disadvantage of periphyton is that it is not a major feature of soft-bottomed streams. Thus monitoring periphyton may not provide much useful information for such streams, which are common particularly across the Poverty Bay Flats. There, macrophytes, which grow best in soft sediments, may be monitored instead of periphyton, though macrophytes cannot be compared directly with periphyton as environmental indicators.

2.4 Macrophytes

Submerged, emergent and floating plants (together known as macrophytes) are useful to monitor because they are indicators of modified conditions and themselves influence stream hydrology, water quality and physical habitat. Macrophytes increase water retention in stream channels during the dry season (Champion and Tanner 2000), take up nutrients and dissolved oxygen, settle suspended sediment from the water column, and provide refuge and living surfaces for fish, invertebrates and periphyton. Macrophytes proliferate under conditions of low shading, slow currents (less than about 0.5 m/s) and low frequency of scouring floods (Matheson et al. 2012), conditions that typically occur in low-gradient or spring-fed streams where agricultural or urban development has removed riparian forest. Thus, if aquatic macrophytes occur in Gisborne District, they are likely to be confined to lowland, low-gradient areas where silty stream beds limit periphyton growth.

3 The context for biological monitoring of streams and rivers

3.1 The monitoring context

Of New Zealand's 16 regional councils and unitary authorities, all except Gisborne District Council regularly monitor biological components of streams and rivers for State of Environment (SoE) reporting (Davies-Colley et al. 2012). All 15 of these councils monitor benthic macro-invertebrates, 13 monitor periphyton, eight monitor native fish, 10 monitor macrophytes and 13 assess physical habitat. In all, there are about 930 SoE biomonitoring sites across New Zealand (Davies-Colley et al. 2011).

Ministry for the Environment is currently attempting to rationalise SoE freshwater monitoring nationally so that it can use SoE data to report on the state and trend of New Zealand's fresh waters. An important aspect of this initiative is improving the coverage of monitoring sites to better capture the range and variability of New Zealand's streams and rivers and to reduce bias. To complete the national picture of New Zealand's fresh waters, data from Gisborne District is essential.

In addition to SoE reporting, scientific studies often draw on national-scale river data (e.g., Scarsbrook et al. 2000, Larned et al. 2004, Matheson et al. 2012). Regional council data have been used for several of these studies, thus completing the coverage of council monitoring would help greatly to advance the scientific understanding of New Zealand's streams and rivers.

3.2 The policy context

Several documents, including the Resource Management Act (1991), the National Policy Statement for Freshwater Management (2011) and the reports of the Land and Water Forum (2012), provide a policy framework that encourages biological monitoring of rivers.

The Resource Management Act (1991) requires councils to report on the state of the environment in order to assess the effectiveness of their regional policy statement or regional plan. To date, Gisborne District Council does not have a regional plan for fresh water, but it is currently developing one, and will need to monitor its effectiveness. The plan includes policies for maintaining flow regimes as well as water quality, and a key element of its effectiveness will be the biological responses to the water allocation limits set. These responses cannot be inferred from water quality monitoring alone.

The National Policy Statement for Freshwater Management (2011) makes a number of statements with relevance to biological monitoring. With respect to both water quality (Objective A1) and water quantity (Objective B1), the objectives of the NPS are "To safeguard the life-supporting capacity, ecosystem processes and indigenous species including their associated ecosystems of fresh water". As explained in Section 2 above, biological monitoring is the most direct way to assess the life-supporting capacity and indigenous species of rivers. In addition, the NPS requires councils "To provide for the involvement of iwi and hapū, and to ensure that tāngata whenua values and interests are identified and reflected in the management of fresh water including associated ecosystems…" Since tāngata whenua values and interests typically relate to the animals and plants living in rivers, and some iwi and hapū in Gisborne District are already involved in monitoring macro-invertebrates (Murray Palmer, pers. comm.), biomonitoring appears to be an effective way to fulfil this requirement of the NPS.

The three reports of the Land and Water Forum (LAWF) (2010-2012) emphasise the importance of collaboration among stakeholders in making decisions on freshwater management. In Gisborne, the Fresh Water Advisory Group currently guiding GDC through the development of its Freshwater Plan is an example of such a group. Collaboration requires that all parties have access to information that is understandable to them and relevant to their values. The third LAWF report (2012) also emphasises the importance of monitoring progress towards the objectives and limits set for particular rivers, and recommends that “iwi and wider community values, objectives and data are included in monitoring and review processes”. The LAWF recommendations raise the question of what monitoring variables are relevant to the values of iwi and the wider community?

3.3 Community values

No single source of information describes the key values that the Gisborne community ascribes to streams and rivers in the district. However, recent surveys and current activities give some indication of community values.

Recent surveys using the RiVAS framework (Hughey and Booth 2012) have shown that community values in Gisborne District include trout fishing, native fish, native birdlife, natural character, swimming, domestic use and irrigation. The surveys do not compare the importance of these values, and do not imply that no other values exist, but show that all of these are important to at least some people in the district. Water quality variables are clearly relevant to all of the values identified by the RiVAS surveys. In addition, biological variables are relevant to at least some of the values. For example, periphyton is relevant to trout fishing, natural character and swimming, and benthic macro-invertebrates are relevant to trout fishing, native fish and native birdlife. Native fish themselves represent a potential biomonitoring variable. Assessing physical habitat is the most direct way of monitoring natural character, and is relevant to native birds, native fish, trout fishing and swimming.

Maori values typically focus on food sources, which include tuna (eels) and koura (freshwater crayfish). Te Aitanga a Mahaki Trust has identified tuna as “environmental sentinels” in the Waipaoa River catchment. In addition, iwi groups and predominantly-Maori secondary and tertiary (Wananga) student groups are currently monitoring benthic macro-invertebrates at 20-25 sites between East Cape and Gisborne (Murray Palmer, pers. comm.). These are indications that biological variables are relevant to Maori values regarding rivers.

There is clearly a need for targeted studies to identify monitoring variables that most appropriately reflect community values. In the meantime, however, I suggest that widening the range of variables to include biological as well as water quality variables increases the chances that monitoring will be relevant to community values.

3.4 Current and future pressures on streams and rivers

This section provides a very brief commentary on the current and future pressures on rivers. The pressures described here were identified from brief readings and conversations rather than on a thorough analysis.

Pastoral farming, the most extensive land use in Gisborne District, puts pressure on rivers in several ways. The main effects are addition of fine sediment, runoff of nutrients, increases in sunlight and peak water temperatures, and addition of faecal bacteria. Most of these effects are detected in water quality monitoring. However, fine sediment affects river ecosystems both in suspension, where it reduces water clarity, and deposited on the stream bed, where it may reduce habitat quality for invertebrates and fish and may smother invertebrates. The latter impact is not detected by water quality monitoring, though it represents a major ecological impact. Increased sunlight also is not detected in water quality monitoring, other than indirectly via water temperature, but it may significantly affect river ecosystems by promoting growth of aquatic macrophytes and algae. Therefore biological monitoring is required in addition to water quality monitoring to detect all of the potential impacts of farming. The ecological impacts of farming on river ecosystems may increase in Gisborne District as dairy farming, which typically has greater impacts than sheep and beef farming, is beginning to expand (GDC 2010), particularly in the upper Motu River catchment (Ballantine and Davies-Colley 2009).

Plantation forestry is another large-scale land use in Gisborne District. Current clear-felling of commercial forests is causing community concern about erosion and transport of “slash” to downstream reaches of some rivers (Anne Salmond, pers. comm.). As with farming, water quality monitoring will detect some but not all of the ecological impacts of clear-felling. Deposition of fine sediment, changes to stream morphology and river flow regimes (Fahey et al. 2004), and the consequent impacts on fish and macroinvertebrates, may be undetected by water sampling. These effects are best measured directly, as has been done elsewhere in New Zealand (e.g., Rowe et al. 2002, Quinn et al. 2004).

Water extraction for irrigation is high on the Poverty Bay Flats, an intensive horticultural area. Water is extracted both from aquifers underlying the flats and also from surface waters such as the two main rivers Waipaoa and Te Arai. Because groundwater and surface water are typically connected to some extent, it is likely that water abstraction from either source will affect river flows. Water extraction may increase in future, with increases in the land area used for “thirsty” crops such as kiwifruit, and with climate change expected to result in greater demand for and less availability of water during dry summer months (GDC 2011). For this reason, GDC is considering limits to water allocations in its proposed regional water plan, and commissioned a report by NIWA to determine the appropriate flow regimes for the Waipaoa and Te Arai Rivers (Booker et al. 2010). This report recommended flow regimes based on maintaining healthy communities of fish, invertebrates and algae (periphyton). Therefore, if GDC bases its water allocation policy on these recommendations, it will need to monitor fish, invertebrates and periphyton in order to assess the effectiveness of the policy. Water quality data clearly cannot be used to infer the biological responses to altered flows.

Shingle was extracted from 17 rivers in Gisborne District in 2010 (GDC 2010). Present rates of shingle extraction are believed to be sustainable as these rivers are thought to be aggrading (GDC 2010). Nevertheless, monitoring of downstream impacts is advised, since in other parts of New Zealand where shingle extraction has exceeded supply, severe morphological and ecological impacts to downstream reaches have occurred (Kelly et al. 2005). These impacts will not be detected by water quality monitoring alone, but require direct monitoring of the physical habitat and macroinvertebrate community.

4 Requirements for biological monitoring in Gisborne District

4.1 Number and location of sites

The number and location of sites depends on the objectives of the monitoring programme. It would be helpful to align the objectives of biological monitoring in Gisborne with those of the proposed National Freshwater Monitoring Programme recommended in the NEMaR project (Schmidt 2012). In this case, the objectives would be:

1. To gain an unbiased estimate of the state and trend of the ecological health of Gisborne's rivers.
2. To make comparisons of state and trend among selected environments (i.e., land uses and/or river types).

To achieve objective 1, a sufficient number of sites would be required to represent the diversity of rivers, in terms of their natural types and the range of human impacts on them. The total number required would depend on the amount of variability in river types and human impacts. Determining this number, and the site locations, would require in-depth analysis. Achieving objective 2 would require a minimum number of sites in each selected environment so that comparisons among environments are statistically robust. Objective 2 is likely to require more sites than objective 1, but again, in-depth analysis would be required to determine the number and locations of sites.

A rough idea of the number of sites expected can be gained by comparing the density of the monitoring site network (i.e., the number of sites divided by land area) in other regions. The densest network (excluding Nelson City) is Auckland, with 0.02 sites per km^2. The least dense is West Coast, with 0.001 sites per km^2, and the median is 0.0044 sites per km^2 (Davies-Colley et al. 2011). If Gisborne had the median density, it would have 27 monitoring sites across its land area of 6127 km^2.

Should GDC aim for a higher or lower density than the median? Clearly more sites are possible and desirable in regions where humans and their impacts are more concentrated. Following this reasoning, Gisborne, could have fewer sites than the median since it has a relatively low population. However, the total number of monitoring sites is important as well as the density. If too few sites are monitored, it is difficult to make the network representative of the variety of stream types and impacts that occur in the district (Table 1). Gisborne District has a smaller land area than any other region or district except Auckland (and Nelson City). Therefore, with a median density of sites it would have a lower total number of sites than any other region or district.

A full assessment of the number of sites to achieve objectives 1 and 2 would require a separate consultation. Factors affecting the number of sites would include the total length of streams, the variety of different stream types and the variety and extent of human pressures on streams in the district.

In addition to objectives 1 and 2 above, regional councils commonly monitor the impacts of particular activities as part of their State of Environment reporting. This objective can be met in addition to 1 and 2 either by adding sites upstream and downstream of the activities of concern or, where potential impacts are more diffuse or widespread, in paired reference and potentially impacted catchments.

Table 1: Risks associated with different densities of monitoring sites.

Site density (sites per km^2)	Total no. of sites	Risks
0.001	6	Definitely too few to represent the variety of stream types and human pressures (objective 1)
0.0022	14	Probably too few to represent the variety of stream types and human pressures (objective 1)
0.0044	27	May be sufficient to meet objective 1. Unclear if sufficient for objective 2. Number of sites approximately matches that of current water quality monitoring network, so no additional sites may need to be visited. That is, all biomonitoring could be combined with water quality and flow estimation at integrated sites (refer Davies-Colley et al. 2012)
0.01	61	More sites than in the current water quality monitoring network, thus would require site visits in addition to those for water quality monitoring.

4.2 Practicalities of biological monitoring

4.2.1 Field sampling

The requirements for biological monitoring differ slightly among the different groups of biota. Benthic macro-invertebrates, being relatively long-lived, are typically monitored once per year during summer (the period of most stable river flows). Following standard protocols, taking five “Surber” or “kick” samples per site, about 30 minutes per site would be required to collect invertebrate samples.

Physical habitat could be assessed once every 1-2 years (except at sites where rapid changes are expected due to changing human activities upstream). Thus physical habitat is typically monitored at the same time as benthic macro-invertebrates. Protocol P2 in the Stream Habitat Assessment Protocols (recommended for State of Environment monitoring) is expected to take 45-60 minutes, which includes the time required for visually assessing macrophytes and periphyton. Thus, the total time required per site for annual monitoring would be about 1-1.5 hours per site for two people (i.e., 2-3 person-hours). Depending on the travel time between sites, 3-5 sites per day could be sampled. If, in addition, periphyton is sampled quantitatively (see below), another 20 minutes per site should be added, and the number of sites sampled per day may decrease.

Periphyton and macrophytes change abundance significantly from week to week in response to water temperature, nutrient concentrations and, in particular, high flow events (which scour plants from river beds). Therefore, periphyton and macrophytes ideally should be monitored every month to obtain reliable estimates over a year (see NEMaR recommendations, Davies-Colley et al. 2012). Visual assessments are best conducted in conjunction with water quality monitoring, which is also currently conducted every 1-2 months. Visually assessing periphyton and macrophytes using standard protocols may add 20 minutes to each site visit for water quality monitoring. If possible, periphyton monitoring would be made more robust by calibrating visual estimates of periphyton growth periodically against a quantitative measure such as Chlorophyll *a* or periphyton thickness (Matheson et al. 2012). This requires scraping the algae from about seven randomly-chosen rocks per site, washing the scrapings into a vial and sending the vial to a laboratory for analysis (for Chlorophyll *a*) or measuring the volume of periphyton settled in the sample container after over-night settling. Calibrating the visual periphyton estimates with quantitative analysis could be performed annually, in conjunction with macro-invertebrate sampling.

All of the field protocols for macro-invertebrates, periphyton, macrophytes and physical habitat are relatively simple, and could be learned quickly, with a little training, by any competent field technician with experience in field ecology or water quality monitoring. No expensive equipment is required.

4.2.2 Sample analyses

The only samples requiring analysis are the benthic macro-invertebrates (and periphyton if quantified by Chlorophyll-*a* assay). Macro-invertebrate samples must be sorted (to remove animals from stream bed materials), identified and counted. This process does require specialist skills. In the case of GDC, where relatively few samples are likely to be processed per year, this laboratory processing is probably best done by an experienced environmental consultant. Several competent consultancies are available that regularly process State of Environment samples for regional councils. Periphyton samples can be analysed for Chlorophyll *a* by a commercial laboratory.

4.3 Costs of biological monitoring in Gisborne District

4.3.1 Establishing the monitoring network

As indicated above, determining the number and locations of sites required for a robust network would require consultation by an expert in biological monitoring. This would involve:

- a thorough review of the current and future human pressures on rivers
- desktop analyses to determine the distribution of land uses and river types
- statistical analysis (power analysis) of potential results
- discussions with staff of GDC and Hydrotechnologies Limited regarding the current water quality monitoring network, and
- visits to all potential field sites to determine their suitability, the logistics of access, and the appropriate sampling protocols of each site.

The total cost of establishing the network may be in the order of $40-50,000. An Envirolink Medium Advice Grant ($20,000) may be sought to help meet this cost.

4.3.2 Operating the monitoring network

The main costs for biological monitoring are staff time to conduct field work, and processing of macro-invertebrate samples. Quotes from two recognised environmental consultants for processing of macro-invertebrate samples using standard quantitative protocols are shown in Table 2.

Table 2: Expected costs for analysis of macro-invertebrate samples.

	Cost per sample	One-off cost	Total cost for 27 samples
Consultant 1	$228+GST		$6156+GST
Consultant 2	$243+GST	$640+GST	$7201+GST

It is generally recommended that for quality assurance, 10% of samples are forwarded to a second consultant for checking identifications and counts. This would add about $700 to the quote from consultant 1 and about $900 to the quote from consultant 2. Since both consultants regularly send samples for quality assurance, it may not be necessary for GDC samples to be quality assured, but it would increase confidence in the data.

If periphyton is measured quantitatively as Chlorophyll *a*, there would be an additional cost for laboratory analysis. At an estimated cost of $40 per sample, with one sample per site, 27 sites would cost $1080 per year if done annually. Quantifying periphyton by measuring thickness would be less expensive – it could be done in-house in 2-3 h per run for 27 sites.

4.4 Options for reducing the costs of biomonitoring

Due to restricted revenue, Gisborne District Council may wish to consider various ways of reducing the cost of biomonitoring.

With the increasing use of modelling in ecology, it may seem possible to reduce the number of monitoring sites by using models. However, models can only produce results based on observed relationships, e.g., the relationship between land use and macro-invertebrate community index in a certain area. Using relationships observed in other parts of New Zealand would not meet the objective of determining the state of streams in Gisborne District, as there would be no evidence that those relationships apply to Gisborne in general, or to specific Gisborne streams. Also, such models would not be able to show year-to-year variation in biological variables. Models could be used to “fill in the gaps” between monitoring sites in Gisborne, thus reducing the number of sites that need to be measured directly. However, the quality of model results depends on entering sufficient input data, and it is unlikely that the number of sites could be reduced greatly below the number suggested above without compromising the reliability of the model output.

Another option is to reduce the frequency of monitoring in catchments where land use is not changing significantly. If this approach is taken, GDC must ensure that within each reporting period enough sites are monitored in total that the state of the district’s streams can be assessed with statistical robustness. If GDC wishes to report annually on the state of the district’s streams, then annual sampling of macro-invertebrates and monthly/bimonthly sampling of periphyton would be required at a certain minimum number of sites. If reports are produced every two years, biannual sampling of macro-invertebrates may be sufficient. However, across New Zealand, increasing community involvement in water management is increasing the demands on councils to provide up-to-date information on the health of streams. Therefore in deciding on the frequency of reports, GDC should consider the community’s need for current information. In addition, state of environment reporting usually includes trends in, as well as the state of, stream health. To show significant trends over time requires a certain number of data points at each site, so the less frequently measurements are made, the longer it takes to show significant trends. For these reasons all other councils in New Zealand conduct biomonitoring at least once per year.

Finally, there may be scope for reducing the costs of stream monitoring by reducing the number of sites currently monitored for water quality. If water quality and biological monitoring were combined at a slightly reduced network of key sites, the overall cost may not be much greater than the cost of the present water quality monitoring programme.

Options for reducing the number of sites and/or frequency of sampling can be explored more specifically in a follow-up consultation (see Section 5 Recommendations).

5 Recommendations

I recommend that Gisborne District Council add biological monitoring to its current programme of water quality monitoring. Biological monitoring directly measures the "life-supporting capacity" of rivers. In addition, certain human impacts on rivers in Gisborne District, particularly deposition of fine sediment and modified flow regimes, may have severe impacts on river biota that are not shown by water quality monitoring.

The biological monitoring programme should include:

- Benthic macro-invertebrates, monitored annually in summer. At each site, five Surber samples should be collected from riffle areas and combined as a single composite sample for analysis. Samples should be sent to an external consultant for processing using Protocol P2 (Stark et al. 2001). I recommend Surber samples over qualitative kick samples because the former provide quantitative information that has added value for minimal/no additional cost.

- Algae (periphyton) and aquatic macrophytes (large plants), monitored every 1-2 months in conjunction with water quality monitoring. The percent cover of different algal growth forms should be assessed visually using the methods outlined in Matheson et al. (2012). If resources permit, monthly/bimonthly visual assessments of periphyton could be augmented by annual quantitative estimates of biomass (e.g., Chlorophyll *a* and/or periphyton thickness). Quantitative measures involve additional field time and laboratory cost, but help to "anchor" visual estimates with a standard, more objective, measure.

- Physical habitat, monitored annually or once per two years in conjunction with macro-invertebrate sampling. Variables to be measured and protocols followed can be determined after further discussion. They will probably be based on Protocol P2 in the Stream Habitat Assessment Protocols (Harding et al. 2009).

Native fish may be added to the monitoring programme at a future date. At present, protocols for State of Environment monitoring of fish are under discussion. More importantly, present methods are time-consuming and require a higher level of expertise than methods for monitoring other groups of biota. Therefore, although fish are typically the most valued organisms in rivers, it is expected that robust monitoring of fish is beyond the current resources of Gisborne District Council.

Establishing the number and location of sites, and the amount of integration between biological and water quality monitoring sites, should be determined in a follow-up consultation. This consultation should also include a review of the present water quality monitoring programme to determine whether cost savings can be made.

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