Recommendations on State of the Environment Monitoring for Hawke's Bay Urban Streams

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Executive Summary

Hawke's Bay Regional Council (HBRC) has sought advice from NIWA on how to successfully integrate sampling of urban streams within their State of the Environment (SoE) monitoring programme.

In this report we briefly review water quality issues associated with urban streams and why they should be included in SoE monitoring. The main point arising from this review is that changes in hydrology associated with urbanisation (e.g., increasing impervious surfaces and channel engineering) have a much greater impact on in-stream habitat and ecology than increases in contaminant concentrations from diffuse urban sources (chemical spills excepted). It is, therefore, important not to weight an urban SoE monitoring programme too heavily in favour of chemical contaminants, which while of interest, may have little bearing on in-stream values.

Exceptions to the above are the heavy metals zinc and copper which are known contaminants in urban runoff from tyres and iron roofs (Zn) and from brake linings and vehicle wear and tear (Cu). Historically high levels of lead (Pb) were recorded in urban streams (particularly sediments), however concentrations have decreased since lead was removed from petrol. Nevertheless concentrations of these three contaminants in urban streams can often exceed criteria for long-term exposure, and it for this reason that we recommend including them in the list of existing parameters for SoE monitoring; at least until it can be established that the concentrations in Hawke's Bay urban streams are within or below nationally established ranges. Polyaromatic hydrocarbons (PAH) from engine oil and industrial spills have also been implicated in urban stream degradation. However, PAH is nearly always associated with sediment contamination, and thus more relevant to sampling stormflows. Hence we do not recommend its inclusion in SoE monitoring.

Measuring flow in Hawke's Bay urban streams presents particular problems; especially in Napier where urban streams are pumped to the sea. HBRC's current SoE monitoring is on a quarterly fixed cycle, which reduces the probability of sampling during storm flows. We also examined the use HBRC is making of current SoE data and note that it is mainly used to compare concentration data with and between REC classes. There does not appear to be a need for continuous flow monitoring but nevertheless there would be some value in having instantaneous flow measurements at the time of sampling in order to determine the importance of 'flow-weighting' the concentration data. We therefore recommend gauging flow at the time of sampling, but only if it is hydrologically meaningful to do so.

We recommend that sampling frequency should be as for the existing SoE programme (i.e., quarterly) as we cannot see any justification for increasing the sampling frequency of water quality parameters

while biological monitoring is only annual[1]. Similarly there is no justification for increasing the frequency of biological monitoring of urban streams unless the frequency is also increased in the other 55 streams in the SoE monitoring programme. Justification for this may include looking at seasonal differences, but this is beyond the scope of this report. There may be justification for winter and summer sampling, as ecological values may be enhanced in winter due to lower temps and higher flows (dilution). Sampling in summer provides a “worst case” scenario only, whereas winter sampling may show some natural values that help HBRC convince the community that the system needs protection.

Current SoE monitoring by HBRC uses MCI and other metrics of organic pollution to compare macroinvertebrate populations within and between REC classes. We recommend that HBRC continue to use these metrics for urban streams in order to compare with the other 55 sites in the SoE programme. However if HBRC wishes to compare macroinvertebrate populations with other urban streams in New Zealand, then it may wish to consider using the Urban community Index (UCI) recommended by NIWA as being more suitable metric for comparing urban streams.

Following a one day visit of candidate streams with HBRC staff, we recommend the following sites be included in SoE monitoring to represent urban stream in Hawke’s Bay:

Taipo at Church Rd (Taradale – mature urban catchment**-** good background supporting data available)

Ruahapia Stream at Hawkes Bay Showgrounds, Hastings – ‘industrial’ (agricultural and horticultural processing) catchment with history of industrial spills.

Maungarau at Te Aute Rd Havelock North – a mature residential catchment with good number of iron roofs.

Maungarau at Toops Rd Havelock North – at upstream edge of urban development. A good site from which to separate urban and rural influences

Herehere at Te Aute Rd Havelock North – currently mainly rural, but urbanisation forecast in near future in lower part of the catchment. This is a good site from which to monitor the effects of developing urbanisation.

[1] We note that there is a separate project in progress examining the frequency of sampling needed for trend detection, and that the sampling frequency for all sites in the SoE monitoring programme may change as a result of this study.

1. Introduction

Hawke's Bay Regional Council (HBRC) requested NIWA to provide advice[2] on appropriate sites, sampling frequency, and parameters to include within an existing State of the Environment (SoE) monitoring programme for the region.

This report firstly reviews water quality issues associated with urban streams and the reasons why they should be included in a SoE monitoring programme. Secondly we make specific recommendations on sites, parameters, sampling frequency and issues associated with the special nature of streams and how they are currently managed. Finally we review candidate streams in Hawke's Bay and assess their suitability for inclusion in such a programme.

[2] Funded through the Envirolink Small Advice Fund by the Foundation for Research Science and Technology

2. Water quality and environmental issues associated with urban streams

Urban streams are the primary receiving waters for runoff generated within their urban catchments. There are some unique characteristics of urban runoff that have implications for SoE monitoring; both in terms of the parameters chosen and sampling strategy. These are discussed briefly below.

2.1 Flow regime

Because urban catchments have a large proportion of impervious areas (roads, driveways, roofs etc.) runoff waters are conveyed more efficiently and rapidly to the stream channel than is the case in rural catchments. This rapid concentration of flow results in higher peak flows and lower baseflows than in natural systems.. Even in unmodified urban streams, the increase in the frequency and magnitude of storm flows leads to stream bank erosion and channel scouring which reduces or eliminates benthic habitat. Because of the risk of flood damage in high-value urban areas, local authorities frequently modify the channel by straightening or lining it in order to get rid of the flood waters more quickly. This has the effect of further reducing or eliminating aquatic habitat to the extent that perceptions change from it being a stream to a drain, or floodway.

Increased impervious area also reduces groundwater recharge in urban catchments. Thus dry weather baseflows tend to be lower and non-sustainable in smaller streams (i.e., streams may become intermittent). This has significant effects on aquatic habitat availability (completely if the stream dries up) and habitat quality (e.g., through deposition of eroded fines and higher stream temperatures).

2.2 Suspended sediment

Exposure of urban soils during development of urban areas can lead to very high concentrations of suspended sediment (SS) in runoff with concentrations typically increasing 100 to 1000 fold (Williamson, 1993). While an area is being infilled with houses, SS in the drainage networks remains high until mobilised sediment can re-equilibrate to the new flow regime. When urban areas are fully mature, the SS concentrations and loads gradually decrease to levels that are lower than predevelopment pasture loads. A typical consequence of urban development is complete smothering of benthic habitat by SS, with stony-bottomed streams being the most susceptible.

2.3 Riparian effects

Urban development may also change the riparian vegetation of streams. In common with all streams such changes can affect the shade and climate at the waters edge, and hence water temperature and the dissolved oxygen. However riparian vegetation can also change particulate and dissolved organic inputs to streams which can have particular value in urban streams in reducing the bioavailability of potentially toxic metals (Timperley, 2004). Grassed riparian areas are common in urban areas, but this practice has been found to limit ecological values. For example, Taylor (1996) found mowing of grass verges of streams transiting parks in Christchurch causes significant damage to inanga spawning areas .

2.4 Toxic substances

Urban streams nearly always have high concentrations of zinc (Zn) and polyaromatic hydrocarbons (PAH) in their sediments. This is because of the high concentrations of these substance in urban stormwater originating from tyres and galvanised iron roofs (Zn) , and fuel combustion products and leaked oil (PAH), respectively (Timperley and Kuschell, 1999). Streams sediments may also contain moderately high concentrations of copper (Cu) from brake linings and vehicle wear and tear. Lead (Pb) concentrations in urban stormwater have decreased markedly since the removal of Pb from petrol. A variety of other toxic substances are found in urban stormwater (and hence in urban streams) but these are usually associated with spills from specific industries or inappropriate disposal of herbicides rather than any ubiquitous input from the urban catchment as a whole. We consider spills to fall outside the scope of SOE monitoring.

Although concentrations of Zn, Cu, and PAH in urban storm water can be high compared with water quality guidelines, these concentrations are usually associated with particulate material and hence the compounds are not readily available. While concentrations of Cu and Zn in urban streams at low flow often exceed <u>chronic</u> water quality guidelines, the results of laboratory toxicity tests can be inconclusive with toxicity apparent in some test animals on some occasions (Williamson, 1993). PAH are highly toxic to animals and some are known human carcinogens. However most are insoluble in water and are associated with the particulate component of runoff. The problems associated with PAH in urban runoff are likely to be manifest in sediment feeders and there is evidence that high incidences of carcinomas in bottom-dwelling fish are caused by these substances. However the relative contribution of urban runoff compared with industrial discharges to PAH accumulation in sediments is uncertain.

2.5 Human pathogens

Pathogens are frequently detected in urban streams, but compared with sewage, the occurrence of enteric pathogenic bacteria and viruses is low (Williamson, 1993). Pathogenic organisms that may cause skin, ear and eye infections are also found in moderate levels, however there is little epidemiological evidence for these types of infections occurring after contact recreation in urban streams. This is probably because stormwater runoff tends to occur at times when water recreation is not attractive. Consumption of shellfish gathered near the mouth of urban streams is a more likely risk to human health.

2.6 Implications for state of environment monitoring

The above discussion illustrates that there are potentially major differences between urban streams and the current set of rural streams and rivers and rivers that form the basis for current SoE monitoring in Hawke's Bay. These differences relate mainly to hydrological response and source characteristics. While the differences in sources of contaminants do have implications to the selection of parameters to be monitored, contemporary thought on the health of urban streams (e.g., Suren and Elliott, 2004) suggest that reductions in habitat quantity and quality due to hydrological characteristics and exacerbated by bank and channel engineering will usually have a far more significant effect on stream 'health' than contaminants. It is only when stream habitat is not limiting, that contaminant inputs may become important drivers of stream health. A critical question that needs to be addressed if a selection of urban streams is to be included in the SoE monitoring is, "to what extent does the current list of parameters and sampling strategy need to be modified".

3. Consideration of specific issues for HBRC SoE monitoring

3.1 The existing programme/network

The Hawke's Bay Regional Council has an extensive water quality monitoring network that serves as the backbone of SoE reporting comprised of 55 sites (A subset of these sites (42) are also monitored for biological variables). The stated purpose of the network (HBRC, 2004) is to provide council with information that:

1. provides an overall assessment of water quality in the Hawke's Bay region so that areas suitable for aquatic life and other uses may be assessed;

2. identifies trends in water quality across the region and through time; and

3. identifies water quality related issues.

HBRC uses the River Environment classification (Snelder et al. 2003) as the framework from which similar river sites can be compared with each other and subsequently detect anthropogenic effects. These effects include 'stormwater impacts – runoff from urban areas of the region'. However it would appear that rivers/streams that might be recipients of urban runoff are not represented within the current 55 sites; hence the need to add additional sites that provides this representation.

Using the existing surface water quality variables and sampling frequencies (see Table 1 in HBRC, 2004) with additional urban streams would largely satisfy 1 and 2 above, but not 3. i.e., it would not necessarily identify water quality related issues (such as for example high concentrations of a toxic contaminant, the source of which could be identified and the problem dealt with). While this is not strictly a function of a SoE programme, it would nevertheless be an added benefit provided it didn't entail significant additional cost. There would also be benefit in comparing the water quality of Hawke's Bay urban streams in relation to larger NZ datasets in a similar way to that already done with the bulk SoE dataset.

3.2 Flow and stormflow measurements

For any water quality monitoring programme it is highly desirable to have accompanying flow measurements. If the monitoring programme is sufficiently comprehensive (including storm events) such measurements enable the computation of loads (annual or seasonal). Even where stormflows are not sampled systematically, it is not possible to remove flow as a source of variability without appropriate measurements. There are, however, some major problems with measuring flow in Hawke's Bay urban streams. Firstly, most streams flowing through the Napier urban area do not drain naturally to the sea, but rather are pumped over stop banks. Secondly, even where this does not happen (such as on the periphery of Napier) urban streams tend to have very low gradients and are clogged with macrophytes making flow measurements very difficult.

It is also important to make the distinction between the inclusion of urban streams in SoE monitoring (where samples are taken on a regular basis for a long time period, with project-specific urban water quality monitoring carried out for consenting purposes such as discharge to a highly valued receiving environment (e.g., Macaskill et al. 2003 (urban streams discharging into Lake Rotorua), Timperley and Reed, 2005 (discharge to Waitemata harbour). In the latter case it is important to know the quantities of contaminants ending up in the receiving environment and hence measuring loads generated by stormflow is essential. In the former case it is the overall 'State' (concentrations, numbers, quality) of the Environment that is of primary interest and hence it is not necessary to measure stormflows specifically.

Our recommendation is that where urban streams are included in SoE monitoring, they should be gauged at the time of sampling, providing it is meaningful hydrologically to do so. This will at least allow flow-weighting of any subsequent analysis of concentrations.

While current SoE monitoring may include the influence of stormflow events (by chance during regular monitoring) it is not designed to sample complete events, or enable the computation of loads. Our recommendation is that the urban streams should be treated in the same way and any stormflow monitoring treated as a specific project, rather than as part of SoE monitoring.

3.3 Parameters and sampling frequency

With the preceding discussion in mind we recommend inclusion of the following parameters not currently measured in HBRC SoE monitoring for urban streams only.

Zn, Cu, and Pb (as total dissolved metals – filtered and acidified to pH 3)

However metals are usually analysed by ICPMS and it is possible to obtain concentrations of a whole spectrum of metals for little extra cost. HBRC may wish to consider some initial 'screening' for this whole spectrum, as it may detect the effects of a particular industrial discharge (as discussed above).

We have also considered the possibility of including PAH in the monitoring suite since it the main organic toxicant of interest in urban runoff. However given that it is mainly associated with particulate material and therefore unlikely to be detected in water samples under base flow conditions, we do not think it would a cost-effective parameter to include in SoE monitoring. While total hydrocarbons (which includes PAH) are much cheaper to analyse, they similarly will be mainly associated with the particulate phase. It is therefore debateable as to whether it is of value to include this parameter. We suggest including it in he first year of monitoring if results show hydrocarbons in excess of an expected maxima (see section 3.4) then include PAH in further sampling. If it is within, or below, the expected range then cease monitoring hydrocarbons completely unless it is part of more detailed monitoring of organics in Hawke's Bays rivers and streams generally (we note that there is no measure of organic contaminants in the current SoE monitoring; including a surrogate measure such as BOD_5 or COD).

Sampling frequencies should be as for the existing SoE monitoring programme (i.e., quarterly for water quality variables and faecal indicators, and annually (summer) algae, chlorophyll a and macroinvertebrates. There is no advantage in increasing sampling frequency to monthly for a short period, as opposed to making a commitment to quarterly sampling for a long period. Also the argument has been advanced that most of the 'effects' will be detected in the biological monitoring. Therefore there is no advantage in increasing the number of water quality samples whilst keeping biological monitoring to an annual event. There may be justification for winter and summer sampling, as ecological values may be enhanced in winter due to lower temps and higher flows (dilution). Sampling in summer provides a "worst case" scenario only, whereas winter sampling may show some natural values that help HBRC convince the community that the system needs protection. For comparison with existing streams and rivers it would be more sensible to continue with existing metrics for macroinvertebrates (MCI, EPT or taxa richness). However if HBRC wish to compare results with other urban streams around NZ then consideration should be given to using the Urban Community Index (UCI) metric developed as part of the USHA (urban stream health assessment) programme (Suren et al. 1998).

3.4 Expected concentration ranges: Putting HBRC data into perspective

There has been a great deal of data collected on the water quality of urban runoff (and urban streams) in New Zealand; most of it in either Hamilton or Auckland.

Williamson (1993) summarised the data collected up to that time in an "Urban Runoff Handbook". We recommend that HBRC use the ranges of concentrations reported by Williamson (1993) in order to put Hawke's Bay data into perspective. This would provide a basis for decision making. If for example the median concentration of Cu for a particular stream was greatly in excess of the data reported by Williamson, then this might provide a trigger for more detailed investigation. If on the other hand, the median concentrations of metals were within or below the range reported by Williamson (1993) then this information may be sufficient for HBRC's needs and provide a basis for dropping these metals from the parameters analysed. For convenience we have compiled a table (from Williamson, 1993) of expected concentrations in urban streams during dry weather flow. Williamson (1993) contains more detailed histograms and cumulative frequency distributions for event mean concentrations and loads.

4. Site selection

The author visited a number of 'candidate' urban streams within Napier, Hastings and Havelock North on 24th April 2006 guided by HBRC staff (Brett Stansfield and Lisa McGlinchey. A map of the streams/sites visited is given in Figure 1.

Streams within Napier City (e.g., Georges Drain) were not considered good candidates for SoE monitoring because they are intensively managed as a drainage system and are pumped (rather than drain naturally) to the sea. In addition another project run jointly between Napier city and HBRC (Napier-Meeanee CMP) will undertake a baseline survey (water chemistry, sediment chemistry, macroinvertebrates, fish, macrophytes, and riparian vegetation) of a number of these urban streams. While the CMP programme aims to address specific questions concerning the condition of the catchment and areas for targeted enhancement and/or protection, it may also reveal some stream types that HBRC wishes to capture in their SoE monitoring. The question will however, remain; "Is this really a stream?"

Other streams that were not considered after inspection were:

1. The Irongate (Hastings) – too rural.

2. Karitawhenua (Havelock North) –extremely modified and ephemeral.

3. Tekahika (Havelock North) – mature – similar to Maungarau but with less features of interest.

Those streams deemed suitable for inclusion in SoE monitoring were:

1. The Taipo stream arises in rural hill country at the back of Taradale. If flows through a fully developed urban landscape before passing through a mixed rural/urban landscape along Church Road. At Park Island Rd, low gradient together with copious amounts of azolla and hornwort result in no discernable flow velocity. The stream discharges to the Ahuriri lagoon approximately 2 km downstream of Park Island Rd.

   While the stream is not 'ideal' in terms of being able to differentiate urban influences completely, we noted that there was little flow at the point where the upper pastoral catchment meets the urban fringe (Trigg Cres), whereas a short distance downstream (Puketapu Rd) there was quite a significant increase in flow. This indicates that the urban reach is largely sustained by groundwater inflows through the alluvial gravels. Therefore a sampling site downstream of the main residential areas should provide a good indication of the surface water quality /ecology that may be expected of a fully urbanised catchment. Although the channel has been modified, it has mainly planted and/or grassed banks, flows through reserve areas, and is obviously valued as a recreational amenity. There is also data available from an urban stream study conducted in 1995 that would provide a useful comparison with the surface water quality / ecology of today. We recommend the Church Road site as the most suitable to integrate all urban influences and also to be able to gauge flow (Plate 1).

Plate 1: Taipo Stream at Church Rd crossing.

2. Ruahapia Stream (Hastings). This stream is 100% industrial and has a history of many pollution incidents. The data generated from this stream will provide a baseline of what surface water quality / ecology conditions are expected in this 'industrial' (mainly agricultural/horticultural processing) part of the region. We recommend that further investigation be done on this stream

(possibly a dye release) to ensure that the industrial catchment will be 'captured' by sampling at the showgrounds (site 2) which has a good control structure (Plate 2).

Plate 2: Ruahapia Stream at Hawke's Bay Showgrounds.

3. Maungarau Stream Havelock North

This stream flows off Te Mata peak through Havelock North. Keirunga Gardens partially drain into the upper reach which then flows through a mature residential suburb with many iron roofs. The lower part of the catchment contains more modern housing. A site at Te Aute Road (Plate 3) would integrate all the effects of rural and urban catchments whilst an additional site at Toops Rd would act as a rural 'control' form which the urban influences could be separated.

Table 1: "Recommended" low, high, and average concentrations of contaminants reported in NZ Urban Streams under low flow conditions (from Williamson, 1993).

Contaminant	Low	Average	High
SS (g m^{-3})	7	14	23
BOD_5 (g m^{-3})	0.9	Not given	2.8
COD	11	15	19
TP (mg m^{-3})	30	55	90
DRP (mg m^{-3})	4	8	20
NH_3-N (mg m^{-3})	30	55	130
NO3-N (mg m^{-3})	265	450	3600
TKN (mg m^{-3})	460	570	830
Pb total (mg m^{-3})	0.3	2.8	75
Zn total (mg m^{-3})	20	60	225
Cu total (mg m^{-3})	0.9	2.9	21
Pb sol.[3] (mg m^{-3})	Not given	0.41	Not given
Zn sol[2] (mg m^{-3})	Not given	25	Not given
Cu sol[2] (mg m^{-3})	Not given	1.0	Not given
Total hydrocarbon[4] (g m^{-3})	1	Not given	5
PAH[3]		0.007	

[3] Filtered, acidified to pH 3, chelex extracted
[4] Few data available – not specifically low flow – event mean concentration and indicative only

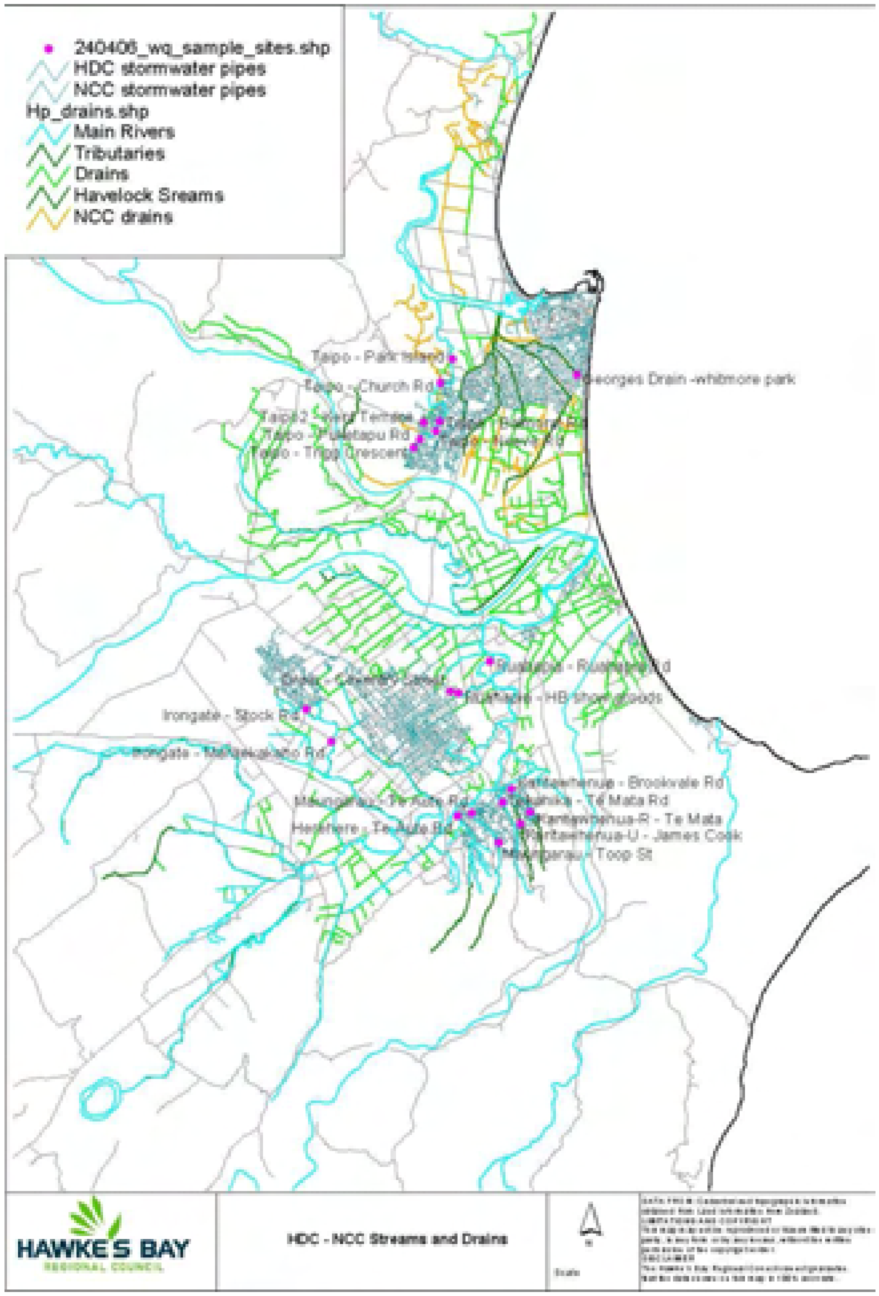

Figure 1: Urban streams and sites visited within Napier, Hastings and Havelock North.

Plate 3 : Maungarau at Te Aute Rd.

4. Herehere Stream – Havelock North

   This stream has only a small part of its catchment currently urbanised. However it is designated for future urban subdivision on the outskirts of Havelock North and the Herehere at Te Aute (Plate 5) would be a useful site from which to obtain long-term monitoring data on the effects of changing landuse from rural to urban and its subsequent maturity.

Plate 5: Herehere Stream at Te Aute Road.

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