IF IT’S NOT BROKEN… OR: COST-EFFECTIVE SOLUTIONS TO CATCHMENT MANAGEMENT

Jane Groves, Tauranga City Council
Keith Frentz, Beca, Tauranga
Dr Sharon De Luca, Boffa Miskell, Tauranga

ABSTRACT

In stormwater management, there are few questions more likely to raise multiple answers than “*What’s the problem?*”.

To answer the question, do you start with flooding and spend time and money on modelling the “problem”; or with the network upgrading pipes that may just move the “problem” to another area; or building treatment devices in the hope of improving receiving environment quality; or with identifying the real effect the stormwater runoff is having on the environment?

This last approach was taken by Tauranga City Council in preparing its application for comprehensive stormwater discharge and related consents for their stormwater network, with some surprising results.

- Firstly it showed that there wasn’t a widespread contamination problem;
- Secondly it allowed the Project Team of Tauranga City, Beca, Boffa Miskell, and Cathy Bebelman to target specific contaminant issues, locations and management approaches; and
- Thirdly it saved time and money in preparing the consent application and in the future capital works programme.

By knowing what needs to be treated, and where, allows a much more focussed programme of works and the ability for a targeted “top of the cliff” pollution prevention approach – on-site management – rather than expensive end-of-pipe solutions at a cost to all ratepayers.

KEYWORDS

Catchment Management

State of Environment Reporting

Multi-Criteria Analysis

Geo-targeted Solutions

Comprehensive Consents

PRESENTER PROFILE

Jane Groves: Jane is an Environmental Scientist with over eleven years experience in Consulting and Local Government. She has particular expertise in urban stormwater pollution prevention, stormwater and water quality management, and catchment management planning. More recently, she has focussed on stormwater management of high risk industrial sites and policy development.

Keith Frentz: Keith is a Technical Director – Planning with Beca in the Tauranga office. He has over thirty years' experience in Resource Management, Master Planning and Planning for infrastructure and has spent time working in Africa and the Middle East as well as New Zealand and the Pacific.

Dr Sharon De Luca: Sharon has 10 years experience in a variety of aquatic and broader environmental science area. She has significant experience in assessment of effects on coastal/marine and freshwater ecological values, preparation of aquatic monitoring programmes, habitat surveys, contaminant analyses and restoration plans, and preparation and presentation of expert witness evidence.

1 INTRODUCTION

By knowing what needs to be treated, and where, allows a much more focused programme of works to manage the quality of stormwater discharge to the receiving environment. It provides the regulatory authority the opportunity to target "top of the cliff" solutions within the stormwater system and sub-systems while ensuring the collective responsibility of what is discharged to the public drains, to land and to the receiving environment.

The aim of this project is to obtain comprehensive stormwater consents for the discharge of stormwater from the land to water. Tauranga City was in a position where approximately 80% of the City by area, and 90% by population, needed a stormwater discharge consent, or consents, to allow the lawful discharge of stormwater to the three main receiving environments around the City – the Pacific Ocean, the Tauranga Harbour and the Wairoa River.

The areas contributing stormwater to these environments were each considered as a separate "catchment" area that affected the receiving environment differently. The Wairoa River, for example, is a freshwater or intertidal environment with only a very small proportion of its physical catchment within the City boundary. The vast majority of the catchment land-use, including that within the City, is of a rural nature and has the potential for elevated nutrient and faecal contaminants in the stormwater draining to it.

The Pacific Ocean receives only a small proportion of the City's runoff originating wholly from the residential areas of coastal Mount Maunganui. The Ocean is a large high energy environment that provided rapid mixing for the fresh, and relatively clean, stormwater runoff.

By far the majority of the discharges are to the Tauranga Harbour. The Harbour comprises a range of hydrodynamic environments from the low-energy areas in the upper reaches of Waipu Bay, and the Waimapu and Waikareao Estuaries to the rapid tidal-flows experienced nearer the Harbour entrance and around the Port of Tauranga.

There is also a wide range of land-uses contributing to the characteristics of the stormwater that enters the Harbour, ranging from rural and open space through to residential and, most critically when considering the potential for contamination, commercial and industrial.

It is clear, to even the casual observer, that the Industrial area at Mount Maunganui and Sulphur Point serving the Port of Tauranga poses the greatest potential risk to stormwater quality discharging to the Harbour.

Because of this the "Harbour Catchment" was divided into two areas for consenting purposes – the Mount Maunganui and Sulphur Point Industrial Area and the remainder of the city.

The outline of these main "catchments" and the constituent land-uses is shown in Figure 1.

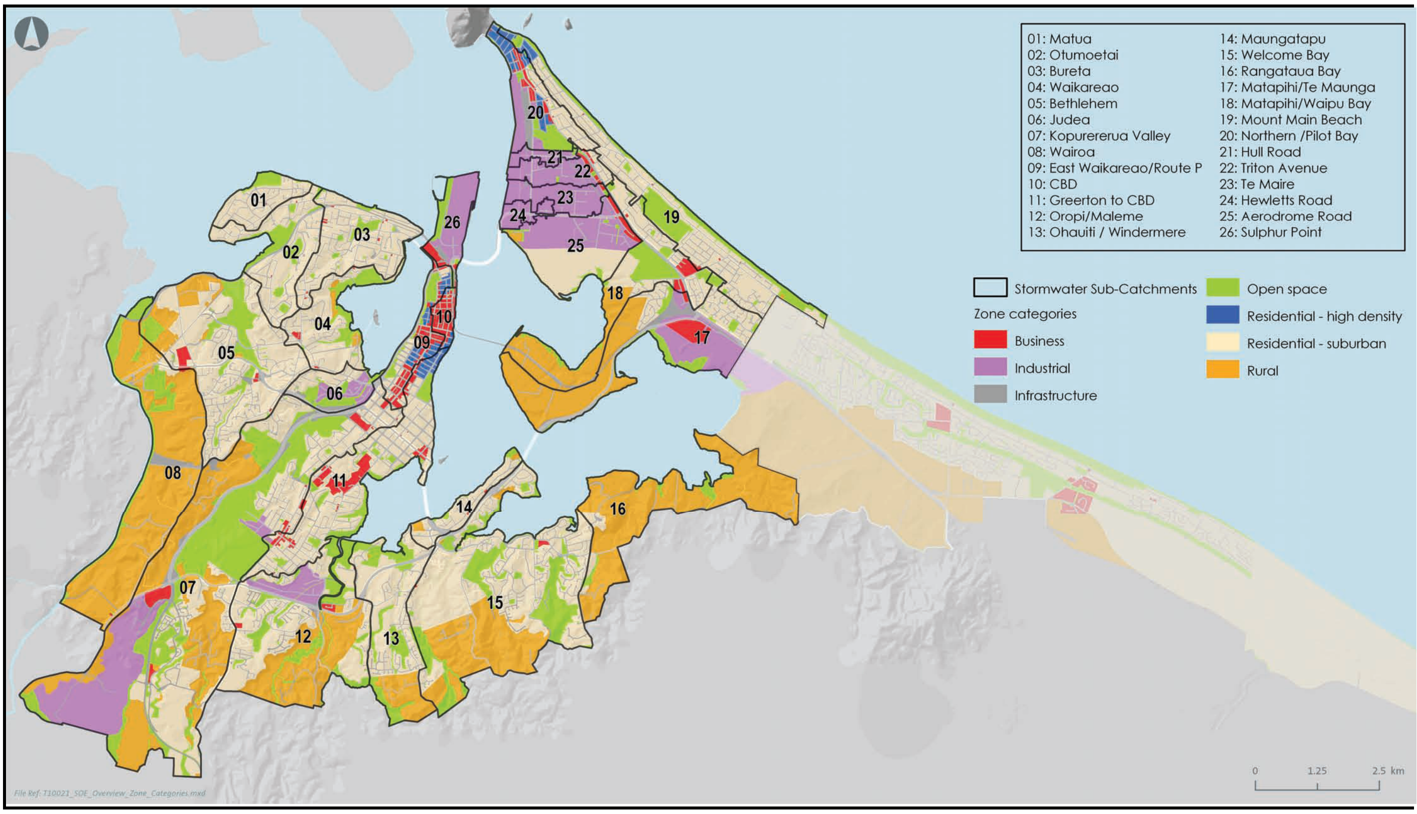

Figure 1: Tauranga City Project Catchment Areas by Land-use

In general, issues of stormwater management can be related to either quantity (flooding) or quality. These Comprehensive Stormwater Consent Applications (one for each of the major catchments) provide for the existing stormwater system and the discharge of stormwater from the Maximum Probable Development of the area but they do not address areas subject to flooding in detail. Areas potentially subject to flooding are well known to Council and there are a number of projects currently programmed to address specific areas. More detailed analysis, possibly including flood modeling, will be undertaken on a locational basis when the more detailed Catchment Management Plans are prepared. This, more general approach, results in a more targeted use of resources and better programming over the period of Council's Ten-year Plan. Once areas are programmed as requiring a Catchment Management Plan the necessary modeling, assessment and implementation works can then be provided for as a continuous project or package of works saving time and costs, reducing the need for rework that would most likely occur if the assessment work was done now.

In order to achieve this targeted approach to managing the stormwater, the City determined that the first task that needed to be done in preparing the documentation for the consents was to know what the state of the receiving environment really was. In other words, have the historic and present day discharges had an adverse effect on the receiving environments. Only once the problems had been identified, could solutions be proposed and actions taken to resolve those problems.

In other words; if there wasn't a problem there was no need to provide a physical solution to mitigate the effects on the environment – If it's not broken, don't fix it.

This paper describes the process of preparing and presenting the State of the Receiving Environment Report, identifying targeted areas for action, assessing the non-structural and structural options for implementation and provides a conclusion on the cost-effectiveness of the process in achieving a better environmental outcome.

2 THE STATE OF RECEIVING ENVIRONMENT REPORT

2.1 METHODOLOGY

The State of Receiving Environment (SoRE) Report provides for the first time a repository of all the known environmental data available to the Tauranga City Council and the Bay of Plenty Regional Council for the Tauranga Harbour, the Ocean Beach area and the main streams and rivers flowing through the City to the Harbour.

The initial task was to undertake a desktop analysis of the known data and plot it using GIS in order to identify where there were gaps, spatially, in the study area. The gaps were then filled by undertaking field surveys to sample and analyse the existing environment.

In order to achieve a workable dataset within the catchments draining to the Tauranga Harbour, the Tauranga City and Mount Maunganui/Sulphur Point catchments were further divided into 24 sub-catchments generally representative of the particular part of the harbour that they drained into. These sub-catchments are shown in Figure 2.

The completed data-set was then analysed to determine how the sampled data compared to current environmental guidelines including ANZECC and the ARC ERC guidelines. Each contaminant measured was then ranked as being good, fair or poor in relation to the guidelines and depicted on the plans prepared and within the tables as green, amber or red respectively. This allowed an easy visual recognition of where the problems (if any) were and what form of contamination was of most concern (see Table 1).

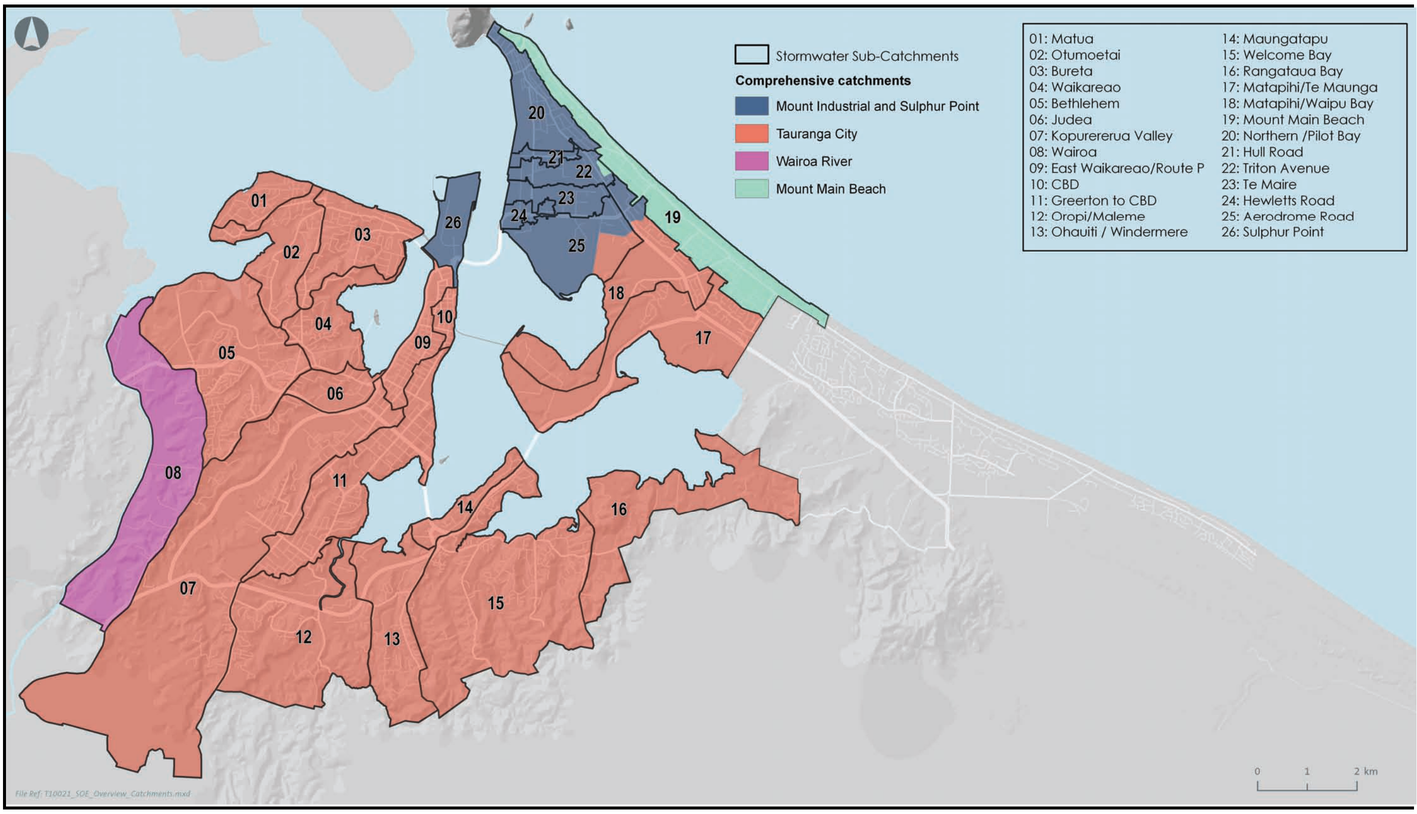

Figure 2: Tauranga City Project Sub-Catchment Areas

Finally the comparison for each contaminant and metric measured was aggregated so that the sub-catchment as a whole could be ranked on the same traffic light system. In order to be conservative, it was determined that if >20% of the data within each category (e.g. marine sediment quality) was within the amber or red range then that category would be classified as amber or red (depending on whichever was numerically dominant) even though 80% of the data may be within the green range. The overall outcome showed that the state of the receiving environment for the study area was generally good with only 1 sub-catchment ranked poor across an average of all characteristics, 6 ranked fair indicating that further monitoring should be carried out to determine the specific cause and spatial extent of the identified issues (whether they were historic or current, for example) and 19 were ranked good. These overall results are shown in Table 1. The rankings are used to determine the frequency of monitoring so that future trends can be determined i.e. Those areas that rank poorly warrant more intensive further investigation. They do not indicate that the environment has reached a state that is unsafe or dangerous.

		Freshwater			
ID	Subcatchment	Sediment	Water	Invertebrates	Fish
1	Matua	*no data*	*no data*	*no data*	*no data*
2	Otumoetai	*no data*	*no data*	[green]	[green]
3	Bureta	[red]	[orange]	[orange]	*no data*
4	Waikareao	*no data*	*no data*	*no data*	*no data*
5	Bethlehem	[green]	[orange]	[red]	[orange]
6	Judea	[green]	[green]	[orange]	[green]
7	Kopurererua Valley	[green]	[orange]	[orange]	[orange]
8	Wairoa	[green]	[green]	[orange]	[green]
9	East Waikareao/Route P	*no data*	*no data*	*no data*	*no data*
10	CBD	*no data*	*no data*	*no data*	*no data*
11	Greerton to CBD	[green]	[orange]	[orange]	[green]
12	Oropi/Maleme	[green]	[orange]	[green]	[green]
13	Ohauiti/Windermere	[green]	[orange]	[red]	[green]
14	Maungatapu	*no data*	*no data*	*no data*	*no data*
15	Welcome Bay	[green]	[green]	[orange]	[green]
16	Rangataua Bay	*no data*	[orange]	*no data*	*no data*
17	Matapihi/Te Maunga	[green]	[red]	[red]	*no data*
18	Matapihi/Waipu Bay	[green]	[orange]	[orange]	[green]
19	Mount Main Beach	*no data*	*no data*	*no data*	*no data*
20	Northern/Pilot Bay	*no data*	*no data*	*no data*	*no data*
21	Hull Road	*no data*	*no data*	*no data*	*no data*
22	Triton Avenue	*no data*	[red]	*no data*	*no data*
23	Te Maire	[red]	[orange]	[red]	[red]
24	Hewletts Road	*no data*	[orange]	*no data*	*no data*
25	Aerodrome Road	[green]	[orange]	[orange]	[red]
26	Sulphur Point	*no data*	*no data*	*no data*	*no data*

		Marine		
ID	Subcatchment	Sediment	Water	Invertebrates
1	Matua	[green]	[green]	[red]
2	Otumoetai	[green]	[orange]	[green]
3	Bureta	[red]	[orange]	[orange]
4	Waikareao	[red]	[orange]	[orange]
5	Bethlehem	[green]	[orange]	[orange]
6	Judea	[green]	[orange]	[orange]
7	Kopurererua Valley	*no data*	*no data*	*no data*
8	Wairoa	[green]	[orange]	[orange]
9	East Waikareao/Route P	[green]	[orange]	[green]
10	CBD	[red]	*no data*	[green]
11	Greerton to CBD	[red]	[orange]	[orange]
12	Oropi/Maleme	*no data*	*no data*	*no data*
13	Ohauiti/Windermere	[green]	[orange]	[orange]
14	Maungatapu	[green]	[orange]	[red]
15	Welcome Bay	[red]	[orange]	[orange]
16	Rangataua Bay	[green]	*no data*	[green]
17	Matapihi/Te Maunga	[green]	[orange]	[orange]
18	Matapihi/Waipu Bay	[green]	[orange]	[orange]
19	Mount Main Beach	[green]	[green]	[orange]
20	Northern/Pilot Bay	[green]	[red]	[red]
21	Hull Road	*no data*	*no data*	[green]
22	Triton Avenue	*no data*	*no data*	*no data*
23	Te Maire	*no data*	*no data*	*no data*
24	Hewletts Road	*no data*	[orange]	*no data*
25	Aerodrome Road	[green]	[orange]	[green]
26	Sulphur Point	[red]	[orange]	[green]

Table 1: Overall Assessment of the State of the Sub-Catchment Receiving Environment

2.2 DATA COLLECTION

Data Collection was undertaken in two parts. The first was to review all the available reports related to the state of the receiving environment held by the Tauranga City Council and the Bay of Plenty Regional Council, while the second was to undertake new sampling to complete a representative spatial spread of data.

2.2.1 DESK-TOP ANALYSIS

The desk-top analysis involved review of over 130 reports that had been prepared for a range of purposes over the past 30 years.

The data collated included fresh and marine-water quality, fresh sediment and marine sediment quality, fresh-water and marine invertebrates and fish. Contaminants and physico-chemical parameters analysed included lead, copper and zinc, both in total and in fine (<63um) fractions, and NH_4N, pH, DO, DRP, E.coli, Total PAH and HMW PAH concentrations were also recorded. Sediment grain size was also recorded in order to determine the proportion of silts and clays.

This analysis provided a significant quantity of data but it also highlighted a number of gaps and differences in data particularly in the older datasets. Most earlier reports had been prepared in response to a particular question or problem and as a result had only sampled for the particular contaminants or aspects of interest at that time. This led to a realisation that not only were there spatial gaps in the data but that not all datasets were complete or representative of the existing environment. This is effectively shown in Figure 3 which provides an example of how the collated data is presented in the SoRE.

This desk-top analysis resulted in the collection of all available data for the Harbour and the contributing freshwater environment in one place for the first time for either the Tauranga City or the Bay of Plenty Regional Councils.

2.2.2 FIELD SAMPLES

The field sampling was undertaken between July and October 2010. It was not a survey of stormwater quality but sampling was undertaken to establish the environmental baseline in areas where no data existed or where it was considered that more data was necessary to complete a particular dataset. A minimum of three days of fine weather was needed in order to replicate conditions for sampling at all times. The field samples taken for the study are identified by the 1008 series of identifiers in the SoRE Report.

2.3 DATA PRESENTATION

The data were collated in spreadsheet form to enable direct input to GIS and flexibility in the outputs as shown in Figure 3. This also allowed a high degree of automation in the data presentation which proved to be cost-effective in preparing the SoRE Report.

The GIS base relied on network maps provided by Tauranga City Council draped over Google Earth satellite imagery. When this is downloaded in kmz file format it allows an easy to use interactive interface that can be presented with a minimal amount of technical training. This makes it suitable for public counter work within Councils and for public consultation.

The sample points displayed on the Google imagery are colour coded in the same way as the hard copy report and can be interrogated by holding the cursor over the point. When this is done the tabular data set for that point is displayed on the screen. Figure 4 provides a screen shot of the display.

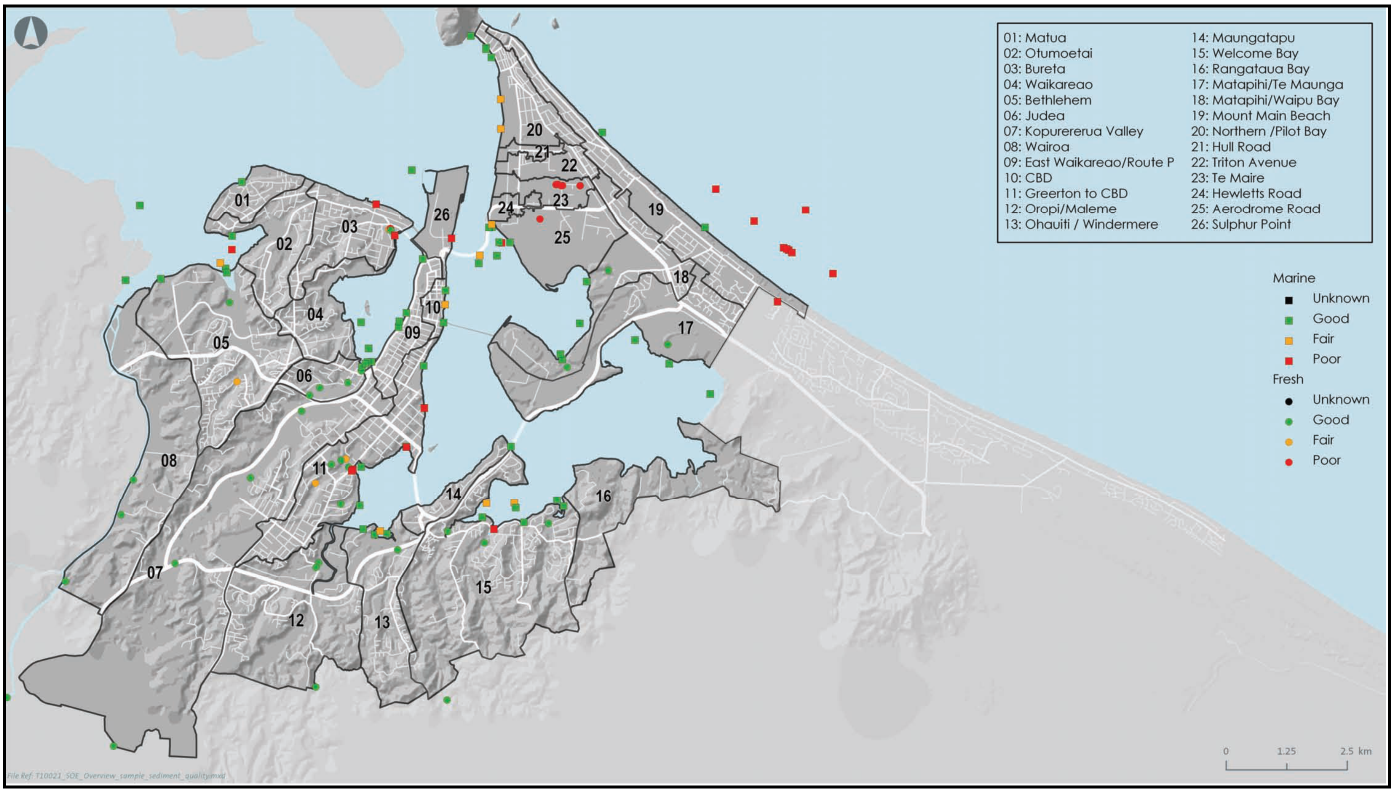

Figure 3: Presentation of Data for Sediment Quality in the SoRE Report

This form of presentation can be applied to any of the data that forms part of the comprehensive stormwater consent application and provides a simple concise format for presenting the large amount of information that is needed for the wider consent framework. For example, in this study area there are approximately 1600 outlet structures all of which are associated to some characteristic data. Approximately 800 of these require consent which includes details of type, size, construction material, structural and safety condition assessment as well as location. The GIS database can also be used as the basis for an outlet asset management tool to record and programme condition inspections and maintenance as well as a consent management tool to identify and flag monitoring inspections or sampling.

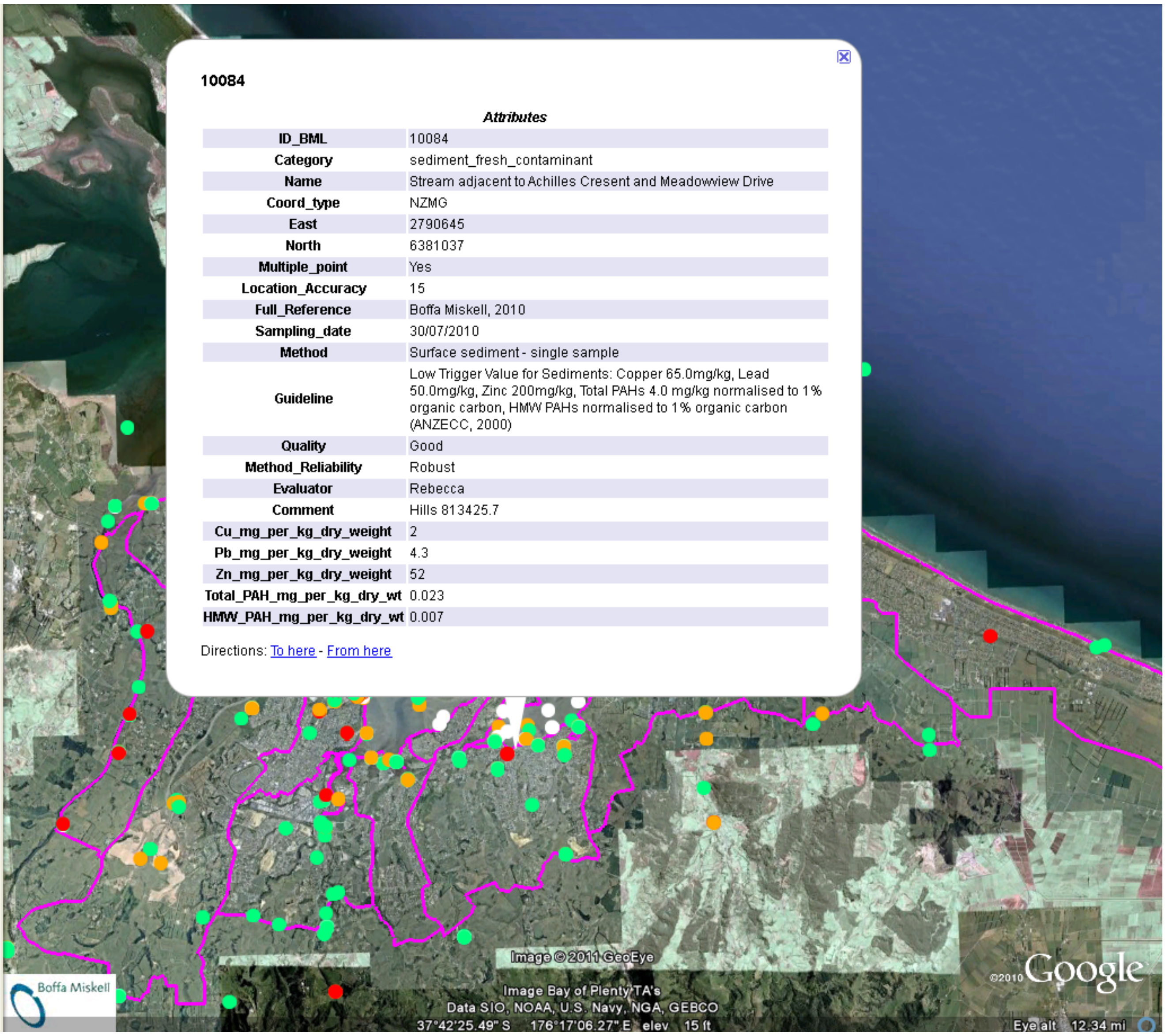

Figure 4: Screen shot of interactive display using kmz file format and Google Earth imagery

The form the data is presented in is an integral part of the consent application and it would be difficult to imagine how a paper-based system or even non-integrated electronic systems could provide for the comprehensive management of Council's stormwater system from consent documentation to asset management and maintenance in the same way.

2.4 DATA ANALYSIS

The data were analysed at the individual sample site level for each characteristic measured with reference to relevant guidelines e.g. ANZECC and ARC ERC (Environmental Response Criteria) guidelines. It was noted that the ARC ERC guidelines are more conservative than the equivalent ANZECC measures, providing an early warning of potential accumulation of contaminants in marine sediment, and a pragmatic approach to the comparison was taken depending on the extent of the differences.

Other guidelines used for comparison included MfE (2003) Microbiological Water Quality Guidelines for Marine and Fresh Water Recreation Areas and MfE Recreational Bathing Guidelines. Sampling of grain size was undertaken to determine the proportion of silt and clay in the sediment. This helped to determine the significance of heavy metals in the fine sediment fraction – while the concentrations of contaminant in the fine fraction may be high, if the proportion of fine material was low (as was often the case) the overall effect on total sediment quality was also considered to be low.

The data for each characteristic were then aggregated for the sub-catchment as a whole in this way determining the general state of the environment over a relatively broad area.

In order to condense all data for each subcatchment, it was determined that the trigger to allocate amber (fair) or red (poor) traffic lights to a sub-catchment would be if more than 20% of the data points were within possible (amber) or probable (red) effects thresholds. Thus the overall traffic light used, as shown in Table 1, was determined as follows: if more than 20% of the individual metrics and/or contaminants measured within a subcatchment are above the amber or red thresholds, then the summary traffic light will reflect whichever of the red or amber data points are more numerically dominant. If the same number of amber or red data points were present, then the red traffic light was used in order to be more conservative.

The analysis concluded that:

"In general, the state of Tauranga City's receiving environment, including fresh and marine water quality and sediment quality is good" *(State of Receiving Environment Report,* Beca, Boffa Miskell, November 2010).

3 GEO-TARGETING SOLUTIONS

As stated previously, the traffic lights are used as a guide to determine where further monitoring to establish spatial extents and trends should be undertaken. Options for resolving the underlying issues are not addressed through the traffic lights but through a more in-depth study of the immediate area by way of a catchment management plan tailor-made for the issue and the location.

However, the presentation of the data through the traffic light system provides a quick visual reference for areas that may be at risk currently or in the future. In this way solutions can be "geo-targeted" taking in only the land use area that has the potential to degrade the environment as well as allowing solutions that specifically target the particular contaminants identified as exceeding (and trending upwards) guidelines through ongoing monitoring.

On this basis options were considered for the seven catchments considered to be probably at risk (red - poor) or possibly at risk (amber - fair). This resulted in eight locations considered as having potential issues, with two particular areas of concern identified in Subcatchment 11. The areas considered include;

- Subcatchment 3 (Bureta)
- Subcatchment 9 (East Waikareao / Route P)
- Subcatchment 10 (CBD)
- Subcatchment 11A (Greerton to CBD – Burrow St)
- Subcatchment 11B (Greerton to CBD – Courtney Rd)
- Subcatchment 15 (Welcome Bay)
- Subcatchment 25 (Aerodrome Rd)

- Subcatchment 26 (Sulphur Pt)

Before these areas are considered in detail there remains a significant amount of catchment planning work to be done. This work, the preparation of comprehensive catchment management plans for the indicated areas, is proposed as a primary condition of the comprehensive stormwater consents for the Tauranga City Catchment, and the Mount Maunganui Industrial Area/Sulphur Point Catchment. Further consultation is necessary in that process and more detailed design and assessment would need to be done.

The key message from geo-targeting issues and solutions in this way is that, currently, and based on predictions, 19 sub-catchments or larger catchments (including the Wairoa and Mount Beach Catchments) do not need to have comprehensive catchment management plans prepared because in general the system is performing as it should be to maintain a safe and healthy environment.

4 MULTI-CRITERIA ANALYSIS AND THE ASSESSMENT OF OPTIONS

4.1 MULTI-CRITERIA ANALYSIS

The process of Multi-Criteria Analysis (MCA) provides a means of critically assessing the options proposed in any development project against each other and against a known baseline.

In this project the analysis was in the first instance to consider whether the proposed options or solutions were likely to improve or improve significantly the existing baseline characteristics or whether the option resulted in no change or even a negative change from the baseline.

The analysis takes into account the four "well-beings" of social, cultural, economic or environmental values by setting criteria for assessment that ensure that all aspects of these well-beings are taken into account.

4.1.1 MCA CRITERIA SELECTION

While MCA is a tool used in many projects the criteria used are particular to a project. For the TCC Comprehensive Stormwater Consent Project the criteria were established through a workshop process that took into account the stormwater issues and objectives evident in the three receiving environments – the Tauranga Harbour, the Wairoa River and the Pacific Ocean.

The criteria that were chosen are those shown in Table 2 below:

Table 2: Criteria used in the Multi-Criteria Analysis and Means of Assessment

Criteria	**Means of Assessment**
Treatment efficiency	How efficient is the proposed option in treating stormwater?
Groundwater	What affect the proposed option has on groundwater? Does it contribute to contamination, does it provide for recharging the groundwater?
Outfall edge	Does the proposed option create a barrier at the outfall?
Freshwater habitat	Does the option maintain or enhance the freshwater habitat?
Marine habitat	Does the option maintain or enhance the marine habitat?
Public access and opportunities for recreation	Does the option maintain, reduce or enhance opportunities for public access and recreation?
Public health	Does the option contribute to the enhancement of public health?
Safety	Is the option safe?
Public space	Does the option increase the area of available public space?
Education/community participation	Does the option include an opportunity for education and community participation?
Iwi acceptance	Is the option acceptable to iwi in terms of cultural values?
Public acceptance	Is the option acceptable to the public in terms of visual, amenity and community outcomes?
Opportunity for future development	Does the option future-proof the stormwater system?
Tourism/Industry	Does the option maintain or enhance land use opportunities, in particular, tourism or industry?

Source: Bebelman Consulting, Tauranga City Council Comprehensive Stormwater Consent Application, March 2011

4.1.2 MCA ADDITIONAL INFORMATION

It also became evident that there are matters that lie outside of the MCA process that must be satisfied before any option can be considered. These are described as "Additional Information" and include such matters as:

- Statutory requirements
- Political support
- Technical effectiveness – how does the proposed solution give effect to management objectives?
- Implementation – can it be done?
- Mitigation measures – are these needed, part of the package or not required?
- Significance to iwi – such as waahi tapu sites
- Equitable level of service - Perception of level of service and funding being shared equally across community
- Affordability - Monitoring, maintenance costs, staffing levels required
- Lifecycle cost - Does the project/solution proposed require a lot or a little of on-going opex funding? This may still be considered as a criterion – to be determined later.

Clearly the fundamental questions of *"Can it be built? Is it affordable? And Does it adversely affect culturally important areas?"* must be answered before an option can be considered for ranking under the MCA.

4.2 OPTION ASSESSMENT

4.2.1 NON-STRUCTURAL OPTIONS

The next question that was raised in the workshop was *"How can this form of quantitative analysis be applied to the non-structural solutions that were proposed?"* These types of solutions included Policy change within Tauranga City Council, the implementation of a Pollution Prevention (Stormwater) bylaw and an education and awareness programme.

Measuring the effectiveness or potential for improved environmental outcomes as a result of non-structural solutions depends to a large degree on a willingness to accept a change to the present culture of stormwater management at a personal or site level.

The form the non-structural solutions may take helps to determine what assessment can be made in the MCA, for example, whether they are regulatory or non-regulatory, and how they are applied, whether regulatory methods are applied in tandem with an education and awareness programme,. What was common for all the non-structural options however, was that they may be applied across the whole of the City, regardless of land-use or the perceived risk to stormwater quality, which provides a wider benefit than just to a targeted catchment or area.

In general the MCA assessment of non-structural options assumes that the combination of regulatory and non-regulatory options will result in a positive influence on the receiving environment.

4.2.2 STRUCTURAL OPTIONS

Structural options were considered only for those geo-targeted areas identified as being potentially degraded from the SoRE Report. These included a range of hard and soft options such as the installation of Gross Pollutant Traps (hard) and constructed wetlands (soft). The options considered for MCA assessment are listed in Table 3.

Table 3: Structural Options Assessed for Geo-Targeted Solutions

Subcatchment	***Possible Options***
Subcatchment 3 (Bureta)	Wetland + Stream maintenance
Subcatchment 9 (East Waikareao / Route P)	GPT + Forebay or wetland + Painting roofs
Subcatchment 10 (CBD)	Hydrodynamic separation
Subcatchment 11A (Greerton to CBD – Burrow St)	Forebay or wetland + Hydrodynamic separation
Subcatchment 11B (Greerton to CBD – Courtney Rd)	Forebay or wetland + Rehabilitate Merivale wetland
Subcatchment 15 (Welcome Bay)	Maintenance on wetland
Subcatchment 25 (Aerodrome Rd)	Wetland
Subcatchment 26 (Sulphur Pt)	Hydrodynamic separation

Some of the options proposed, such as painting zinc roofs, also depend on implementation by private property owners and are therefore part of an ongoing education and awareness message from the two Councils.

At present none of the structural options assessed have been discarded as these may all potentially improve the receiving environment.

Selection will ultimately depend on the additional information discussed above. In particular, in the generally developed area of the four catchments, whether there is sufficient area in which to construct the wetlands proposed and whether the benefits are greater than the lifecycle costs of the options being proposed.

5 CONCLUSIONS

There is no doubt that there is a lot of positive information to be gained from catchment modeling, in particular where there are known flooding issues and also where contaminant outflows can be modeled to identify potential source locations.

However, we believe that the first task that should be undertaken is to provide a comprehensive understanding of the baseline characteristics of the receiving environment so that any issues can be identified and any change implemented can be measured and the effects of that change fully understood.

Most importantly, we believe, that an understanding of the environment will show where solutions should be targeted to address what problem. This will provide local authorities the ability to clearly plan and budget future stormwater works in a strategic and cost-effective manner.

This understanding has led the Project Team to the conclusion that:

If it's not broken … don't fix it!

ACKNOWLEDGEMENTS

We would like to acknowledge the input to this Project from the Project Team members from Tauranga City Council, in particular Kristina Hermens, Graeme Jelley, Graeme Dohnt and John Gibbons-Davies, the Bay of Plenty Regional Council, which even though it is the consenting authority has provided valuable guidance in a fully collaborative spirit, Cathy Bebelman who provided input to the MCA assessment, Boffa Miskell, in particular Garry Christofferson who provided the GIS skills and the Beca team.

We would also acknowledge the particular stakeholders consulted including the Department of Conservation, Western Bay of Plenty District Council, the Royal Forest & Bird Society, Port of Tauranga and Toi te Ora Public Health.

Finally we would like to thank the Tauranga Moana Tangata Whenua collective for their valued insight into the significance of the streams and harbour to Maori.

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