APPENDIX 4: WATER QUALITY
PIRINGA 4: ORANGA PŪMAU O TE WAI

EXPLAINING SEDIMENT OBJECTIVES

Sedimentation Rate

Why: Estuaries and coastal embayments with a sedimentation rate that is high compared to the "baseline rate" (when the catchment was naturally forested) are sediment stressed, and suffer a wide range of adverse sediment-related effects. They are also rapidly shallowing and infilling with sediments.

Aim: Limit the sedimentation rate to reduce sediment stress and related adverse effects, and to slow down infilling with sediment.

- Objective WQ1: Sedimentation rate across the Gulf to be no more than 2mm per year above the baseline rate by 2050.

Explanation:

- Sedimentation rate is the rate at which the seabed is vertically accreting, or rising, due to deposition of sediment. It is typically expressed in millimetres per year.
- < 2mm per year above the baseline rate is an ecological adverse-effects threshold.
- The baseline rate is the rate when the catchment was fully forested.
- The baseline sedimentation rate (when the catchment was fully forested) varies from location to location within any given estuary or embayment, for example, 1mm per year on exposed intertidal flats, 2 to 4mm per year in tidal creeks.
- The 30-year timeframe recognises that sedimentation changes slowly in response to changes in catchment sediment runoff, and will also allow time for yearly variation in sedimentation to average out.
- The 30-year timeframe may be aspirational, but it is appropriate to set an ambitious target. The improved monitoring will inform future goals.

Where the objective applies: The objective applies across the Gulf.

Assessing achievement: achievement can only be assessed at representative monitoring sites, which need to be selected in consultation with agencies and mana whenua. monitoring sites will cover a range of estuaries and coastal embayments, and different habitats within those systems. auckland council, waikato regional council and mana whenua need to standardise measurement methods for sedimentation rate (in consultation with other regional councils and the Ministry for the Environment). Issues to consider include natural spatial and temporal variability of sedimentation rate, determining trends from limited datasets, acquiring baseline information, accuracy and cost of different measurement methods, representativeness of monitoring sites.

How the objective will be achieved: Reducing catchment sediment runoff to the coastal marine area.

Outcome: Reduced sediment stress with corresponding healthier estuarine ecosystems. Prolonged lifespan of estuarine and coastal systems.

Seabed Muddiness

Why: The amount of mud in the seabed has a profound effect on the types of animals and plants that are able to live and thrive within the sediment. For example, the muddier the seabed, the less suitable it is for a range of shellfish and other invertebrates. Seagrass that grows on intertidal flats also prefers a less muddy seabed. With less mud in the seabed, the water also tends to be clearer.

Aim: Prevent sandy seabeds from becoming muddy, and help already-affected seabeds return to their naturally sandy state.

- Objective WQ2: Proportion of intertidal area with seabed mud content greater than 25% not to expand in all estuaries of the Hauraki Gulf Marine Park.

Explanation:

- Seabeds with a mud content of 25% support a distinctly impoverished fauna compared to sandier seabeds.

- Some parts of estuaries are naturally very muddy, but encroachment of mud over previously sandy seabeds reduces biodiversity and impacts seagrass.

Where the objective applies: All estuaries of the Hauraki Gulf.

- Objective WQ3: Seabed muddiness to be less than 10% at 95% of intertidal flats that are exposed to winds and waves by 2050.

Explanation:

- “Mud” refers to sediment particle size less than 63 microns.
- “Exposed” means exposed to winds and waves, which naturally act to keep the seabed scoured of excessive mud buildup. Exposed intertidal flats are typically sandy, but increased fine-sediment runoff from the catchment encroaches on those areas turning them from sandy to muddy..
- Seabed muddiness of 10% (that is, seabed composed of 10% mud and 90% sand) is recognised as an “ecological threshold” above which shifts in benthic community composition and functioning begin to occur.
- Sandy seabeds that are already affected by mud may be cleansed of that mud by wave action once sediment inputs from the catchment are reduced.
- The 2050 timeframe recognises that the seabed changes slowly in response to changes in catchment sediment runoff.

Where the objective applies: Intertidal flats that are exposed to winds and waves. The objective may be expanded to subtidal areas if deemed appropriate.

Where the objective does not apply: This objective does not apply where the seabed is naturally muddy. This includes tidal creeks (e.g., Henderson Creek), sheltered upper arms of estuaries (e.g., landward of Okura Township, Okura estuary), subtidal channels (e.g., entrance channel to the Central Waitemata Harbour), subtidal embayments (e.g., inner Firth of Thames).

How the objectives relate to each other: Objective WQ2 seeks to prevent further expansion of mud over currently sandy seabeds. Objective WQ3 seeks to limit the amount of mud to a specific percentage on exposed intertidal flats.

Assessing achievement: Achievement can only be assessed at representative monitoring sites, which need to be selected in consultation with agencies. Additional monitoring sites will need to be established where the existing monitoring network is too sparse to assess the achievement of this objective. This may include subtidal monitoring if deemed to be appropriate. Auckland Council and Waikato Regional Council need to determine protocols and methods for monitoring seabed muddiness. Issues to consider include cost, the merits of different measurement methods (e.g., wet sieving, laser), representativeness of sites, avoiding bias in site selection, natural spatial and temporal variability of seabed muddiness.

How the objectives will be achieved: Reducing catchment sediment runoff to the coastal marine area.

Outcome: Sandy habitats where they are meant to be, supporting seagrass and a diverse and productive benthic ecology. Clearer water.

1. **Integrated harbour and catchment management plans**

The Whangapoua Harbour and Catchment Plan (HCMP)[1] is one of 3 plans[2] prepared by Waikato Regional Council for estuaries on the Coromandel Peninsula as part of delivering on the Coromandel Zone Plan. The HCMP, which has been developed with the local community and which draws on local and scientific knowledge, lays a foundation for integrated harbour and catchment management.

The Whangapoua HCMP provides a baseline (current) assessment of the harbour and catchment. Erosion and sedimentation are recognised as key issues, with sometimes inappropriate landuse practices and declining biodiversity also being of concern. Environmental priorities are identified, and practical and realistic actions are laid out that will make a difference to the state of the harbour and catchment. Actions are divided into themes (The People, Land, Water, Coast and Harbour, Biodiversity), and at the end of each of these theme sections are many excellent suggestions on “What can you do?” Actions are designed to be undertaken over a 10-year period, with regular review of priorities. Although the plan is nonstatutory, it nevertheless has the capacity to inform and support statutory documents.

1 http://www.waikatoregion.govt.nz/PageFiles/40291/TR201503.pdf
2 One other plan is currently being prepared.

Importantly, actions are budgeted for consideration by agencies in their respective annual planning processes.

Whangapoua Harbour and Catchment Management Plan

Sea Change endorses the Whangapoua HCMP as the top priority of the HCMPs developed by Waikato Regional Council to date due to the size of the harbour, the issues it faces, the good prospects of working productively with local communities, Mana Whenua and forestry operators, and the potential for multiple benefits as the plan is executed.

Auckland Council has previously identified priority catchments through their Sustainable Catchments programme for developing integrated catchment management plans and corresponding implementation plans. The priority catchments have been identified using a number of criteria including level of community engagement, perceived ability to make a difference and urgency of threats. The programme promotes and supports a wide range of on-the-ground actions; a summary of achievements over the life of the programme to 2015 is presented on the Environment Foundation's website[3].

Auckland Council is presently developing a new programme – the Wai Ora Healthy Waterways programme – which is being designed to implement the National Policy Statement for Freshwater Management and to align council activities around water. The Auckland region is being divided into catchments based on marine receiving environments such as the Waitemata Harbour and it is anticipated that limit setting under the National Policy Statement for Freshwater Management will be based on freshwater as well as marine receiving environment objectives.

Integrated harbour and catchment plans

Sea Change endorses the concept of the integrated harbour and catchment plan as a basis for communicating with communities, identifying issues, developing actions, achieving outcomes though community engagement, and feeding into local-government planning and budgeting processes.

2. **Prioritisation of spending**

Where regional council resources are required to help bring about change, obviously not everything can be done all at once. Prioritisation of spending requires careful consideration of ability to make a difference, cost, and capability and capacity of Mana Whenua and landowners to work with council. Co-funding of research and science with industry good body's is an important way to share the cost and access the technical expertise required. This will also increase the "buy in" of industry groups and their recognition of changes required.

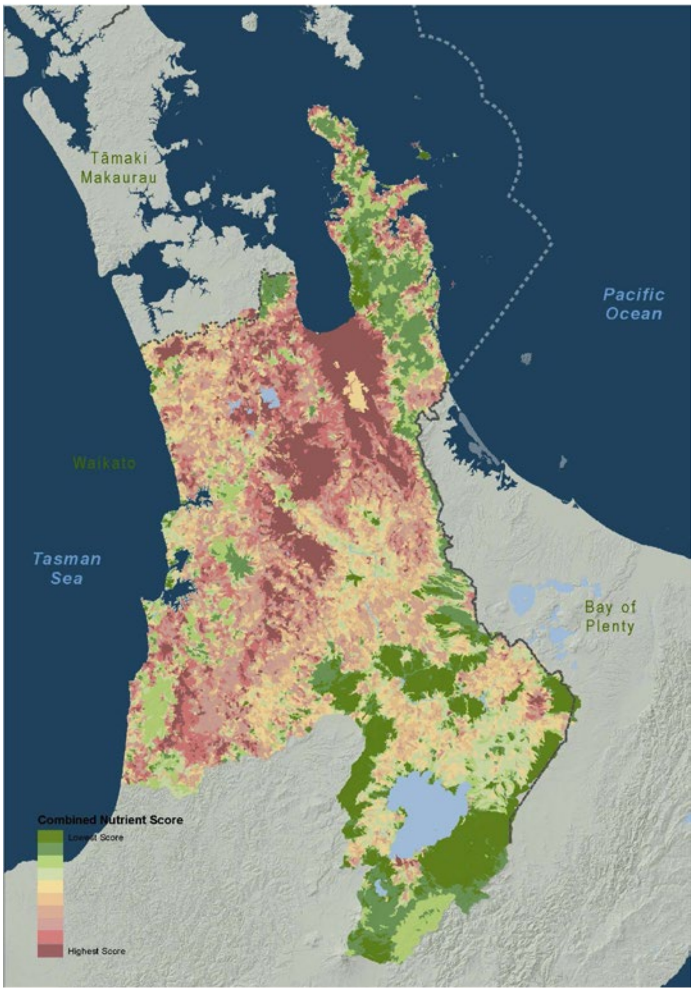
Models can be used to identify critical source areas in the catchment – areas where, for instance, sediment erosion or nutrient loss is greatest – and where these areas are connected by transport pathways to vulnerable aquatic receiving environments, they should receive priority attention. Models can also be used to estimate cost of applying mitigation, and likely improvements (reduction in sediment runoff or nutrient loss, for instance) following mitigation.

Waikato Regional Council's Regional Prioritisation Project aims to inform priorities for on-the-ground works designed to protect and enhance soil, biodiversity and water quality, which it does by identifying locations of highest risk and greatest opportunity. Spatial models are used to develop information that can be used – with other types of information, including expert knowledge of issues – to decide priorities for spending. Models used in the analysis include CLUES (sediment, nitrogen, phosphorus and E. coli generation) and SedNetNZ (sediment generation), which are linked to a number of spatial databases that describe various aspects of terrain, landcover and landuse to make predictions.

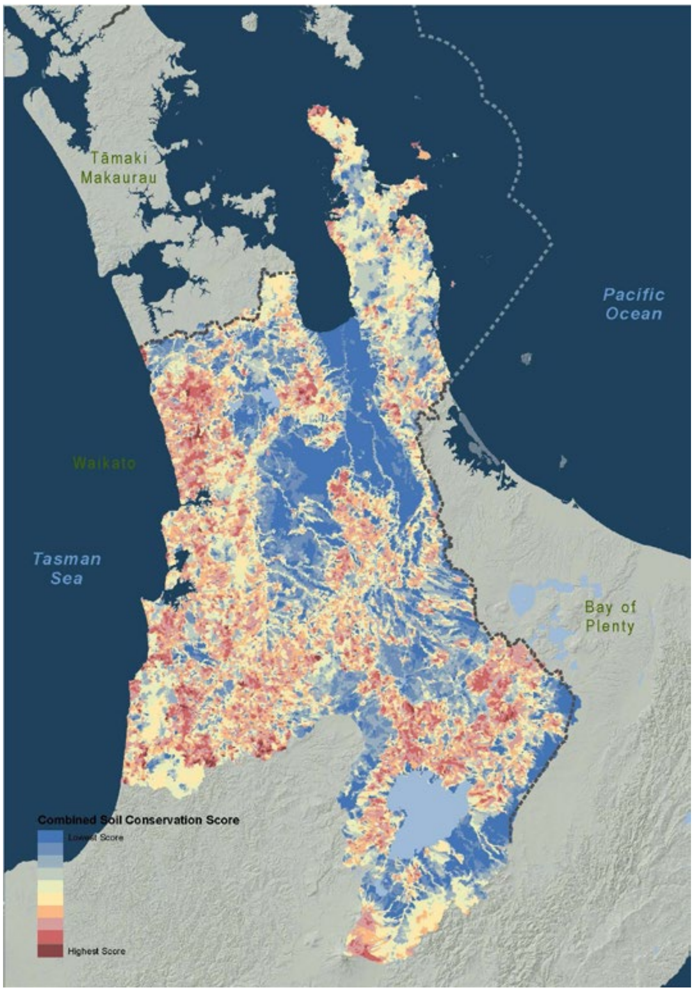
- An example of the project output is shown in the figure below, which is a spatial map of the "water quality combined score", which in turn is a weighted combination of "E. coli generation", "nitrogen generation" and "phosphorus generation" factor scores. (The weightings reflect the relative importance placed on each of the factors and are based on expert opinion.) The factor scores may be similarly mapped. The information shown in the figure potentially provides a basis for ranking the implementation of farm plans within Freshwater Management Units (defined for the purpose of implementing the National Policy Statement for Freshwater Management).

3 http://www.environmentguide.org.nz/issues/marine/catchment-based-activities/im:2133/

The “soil conservation combined score” (shown in Map A4.2) is a weighted combination of the “sediment”, “erosion”, “streambank erosion”, “vegetation protection”, “stock pressure” and “WRC works” factor scores.



Map A4.1 Combined nutrient scores



Map A4.2 Combined soil conservation scores

As before, the factor scores may be similarly mapped. Costs of sediment mitigation and associated reductions in sediment have also been estimated, with certain assumptions being made about “realistic implementation”. An annual-average reduction in sediment generation as a result of mitigation has been estimated, and this has been broken down into reduction due to hillslope soil conservation and reduction due to streambank mitigations. Factor scores, mitigation costs and sediment-reduction estimates have been used elsewhere in the Waikato Region, and could be used in the Hauraki Gulf catchments. Factor score maps were initially used to identify priority catchments for management. Mitigation and sediment-reduction estimates were used to further rank catchment work priorities and for basic cost–benefit assessment. Data gathered through these processes are ultimately intended to assist with developing priorities for inclusion in a restoration strategy, which is being done elsewhere in the Waikato using the INFFER (Investment Framework for Environmental Resources) process to assess cost–benefit assessment of potential restoration projects.

Contaminant-generation models such as those used in the Waikato Regional Prioritisation Project need to be linked to models that predict transport, dispersal, fate and effects of contaminants in the coastal marine area receiving environment. Where contaminants that originate on the land accumulate in or otherwise pass through sensitive or valuable habitats in the CMA causing adverse effects on the ecosystem, health or loss of human amenity, this information needs to be brought into any analysis of priorities for spending on mitigation in the catchment. For instance, nutrients lost to waterways in lowland areas may be more readily transported into the marine receiving environment, where they add to the nutrient burden, than nutrients lost from upland areas. In that case, even if the nutrient loss from the upland areas is greater, the lowland areas should receive priority for mitigation.

3. **Setting Sediment Load Limits**

The Resource Management Act is widely acknowledged as having provided the tools necessary for effectively managing the effects of point-source contaminants on aquatic ecosystems. However, the Act has been less successful at dealing with the effects of diffuse-source contaminants, which now are regarded as the major cause of degradation.

The central difficulty is managing the cumulative effects of diffuse-source contaminants. Cumulative effects, by definition, arise from many individual activities added together over time and throughout the catchment. To manage them requires a catchment-wide approach, which can be difficult to achieve by piecemeal granting or declining of individual applications for resource consent under the RMA which, individually, are expected to have “no more than minor” effects.

In their first report back in 2010, the Land and Water Forum established a link between cumulative effects and the need to set limits: “without limits it is hard to manage diffuse discharges… and impossible to deal with the cumulative effects on water bodies of water takes on the one hand and diffuse and direct discharges to water on the other”. In response, government embarked on a programme of reforming freshwater management based on setting limits.

The National Policy Statement for Freshwater Management (NPSFM) (2014) establishes a legal and policy framework for building a national limits-based scheme for freshwater management. The Policy requires maintaining or improving overall water quality in a region, and safeguarding of the life-supporting capacity, ecosystem processes and indigenous species (including their associated ecosystems) of freshwater. Regional councils are required to have set freshwater objectives by 2030 that reflect national and local values; set flow, allocation and water quality limits to ensure freshwater objectives are achieved; address over-allocation; manage landuse and water in an integrated way; and involve iwi and hapū in freshwater decision-making. Councils and communities can choose the timeframes to meet freshwater objectives and limits.

The management process prescribed by the NPSFM centres on limiting resource use in “freshwater management units” in order to achieve specific, agreed values. The steps involved are:

- Agree on desired values, which are the intrinsic qualities that people appreciate or benefit from, or the uses to which people put freshwater. Examples are mahinga kai (Māori traditional food and other natural resources, including the places they are obtained and the practices around their acquisition) and swimming.
- Identify “attributes”, which are the characteristics or properties of freshwater that have to be managed to provide for the value at hand. Examples are E. coli contamination, which is reflective of a health risk, or the concentration of nitrogen dissolved in the water, which has a bearing on aesthetics (e.g., by stimulating periphyton blooms).
- Decide on the “state” of each attribute. For instance, to provide for safe swimming, E. coli will need to be maintained at a lower level compared to providing for just wading.
- Convert the attribute states into “SMART” objectives, which are specific, measurable, achievable, realistic and time-bound.
- Formulate limits to resource use that will result in the achievement the objectives. These are of two types: limits to extraction (e.g., the amount of water taken for irrigation), and limits to disposal of contaminants (e.g., a catchment nutrient load limit).
- Develop a suite of management actions that, when implemented, will achieve the limits accordingly.

A critical element of the process is the involvement of stakeholders, which begins with agreement on values, and includes understanding the consequences of agreeing to the limits and the management actions that are needed to meet limits.

Estuaries and coastal systems are specifically excluded from consideration in the NPSFM, but they must be “given regard to” when setting limits for freshwater. This means that limits that are set to achieve freshwater objectives should also result in the achievement of objectives at the coast.

Map A4.3 Auckland Council's Consolidated Receiving Environments

In some cases, the coastal objectives may actually take precedence over the freshwater objectives. For instance, an estuary ecosystem may be far more sensitive than the streams in the surrounding catchment to sediment runoff from the land, which might mean that catchment sediment load limits are set with the estuary objectives – not the freshwater objectives – in mind.

When setting limits, it is therefore crucial that the entire system – all the streams in the catchment and the coastal receiving environment at the base of the catchment – be analysed as one unit. What we need to avoid is the situation in which limits are set separately for, say, freshwater, and then these are found later on to be lacking when the coast is eventually looked at.

Recognising this, Auckland Council has defined Consolidated Receiving Environments (CREs) for implementing the NPSFM. Each CRE is centred on an either an estuary or a part of the coast, and will be used to set objectives and limits that are fully integrated across freshwater and the coastal marine area.

4. **Integrated Wetlands**

Map A4.4 Wetland complex on the Kauaeranga River near Thames

The design shown above (designed by Boffa Miskell for Waikato Regional Council) is for a wetland complex in a bend of the Kauaeranga River, near Thames, to serve multiple purposes. This is a bold, innovative design, which potentially will deliver multiple benefits.

Areas of open water, mangroves, saltmarshes, rushes, sedges and lowland swamp forest, including kahikatea and cabbage tree, would provide habitat for a wide range of wildlife, including fish and birds. An interesting feature of the design is the mix of freshwater and saline water habitats. Public amenity is provided for in the design through a range of features, including trails, observation points, a bird hide shelter, a kayak launching ramp, and educational information. Being close to a centre of population (Thames), the wetland complex would be expected to provide a substantial point of contact and engagement with the tidal river, which is otherwise difficult due to current limited public access.

There is a very wide range of wetlands type, including bogs, fens, peatlands, marshes, lowland swamp forests, flax swamps, saltmarsh and mangroves[4]. Wetlands occur where the water table is at or near the surface of the land, or where land is permanently or temporarily inundated (by tides or floods, for example). According to DOC, in New Zealand, wetlands “support the greatest concentration of wildlife out of any other habitat[5]”. Some endangered plant species depend totally on wetlands, as do many threatened bird species. Native fish also rely on wetlands, including short-finned eels, kokopu and bullies, and the whitebait fishery depends on spawning habitat provided by wetlands. By absorbing heavy rain and releasing flood waters gradually, impacts of flooding are reduced, and groundwater levels are maintained during periods of low rainfall. Wetlands offer a wider range of recreation opportunities including boating, fishing, swimming, bird watching, whitebaiting and hunting. Wetlands have always been important to Māori, providing food, weaving material, medicines and dyes. Wetlands have also been used as places to store taonga and as access for canoes.

Wetlands have been likened to kidneys in that they clean inflowing water, and subsequently release the “polished” water on its onward journey to downstream receiving environments, including in the coastal marine area. This is achieved by stilling the flow of water, which facilitates the removal of fine sediments from the water by settling and by sticking of sediment particles to leaves and stems of plants.

4 Johnson, P. and Gerbeaux, P. 2004. Wetland Types in New Zealand. Department of Conservation, Wellington.
5 http://www.doc.govt.nz/nature/habitats/wetlands/

Plants help to oxygenate the water, and take dissolved nutrients out of the water to build plant tissue, leaving outflows relatively depleted of nutrients. Wetlands also provide the anoxic conditions and abundant supply of organic matter needed for a certain class of bacteria to perform denitrification, which results in the nitrogen bound up in nitrates being released to the atmosphere as nitrogen gas. Furthermore, since denitrification is accompanied by the oxidation of organic matter, runoff is also scrubbed of excessive organic matter. Thus, wetlands naturally mitigate nutrient enrichment of freshwater runoff, which can reduce the eutrophication risk in the coastal marine area.

It has been estimated[6] that only about 10% of the New Zealand's original wetlands remain, although with great regional variation, and some particular wetland types have been lost forever; only very few examples of others remain (for example, kahikatea swamp forest and some kinds of flax swamp and salt marsh). In the Waikato, around 15% of unmodified wetlands remain.

There is a wealth of information and expertise around restoring wetlands. For example, Wetland Restoration: A Handbook for New Zealand Freshwater Systems, is an authoritative and practical guide that brings together information from specialists and groups that are actively engaged in restoration[7]. Mana whenua have substantial experience in wetland restoration using traditional knowledge, and both Waikato Regional Council and Auckland Council provide resources on wetland restoration[8].

The design shown above for the Kauaeranga River is on land already owned by Waikato Regional Council as part of the Waihou Valley Scheme (albeit presently leased in part for stock grazing), and makes use of borrow pits within the curve of the river and inside stopbanks. The potential benefits of a scheme of this size are many and varied, including for water quality, and not the least of which is the opportunity for the relationship of Mana Whenua with the location to be strengthened and for the public to re-engage with the river.

Pastoral, exotic and native forestry land

A need exists for universal adoption of good practice for all pastoral, exotic and native forestry land, including smaller landowners. Increasing areas of land are being used for "lifestyle" purposes with owners who may have less understanding of the need for good soil husbandry, riparian management and erosion protection.

5. **Much of the Auckland Region is rural**

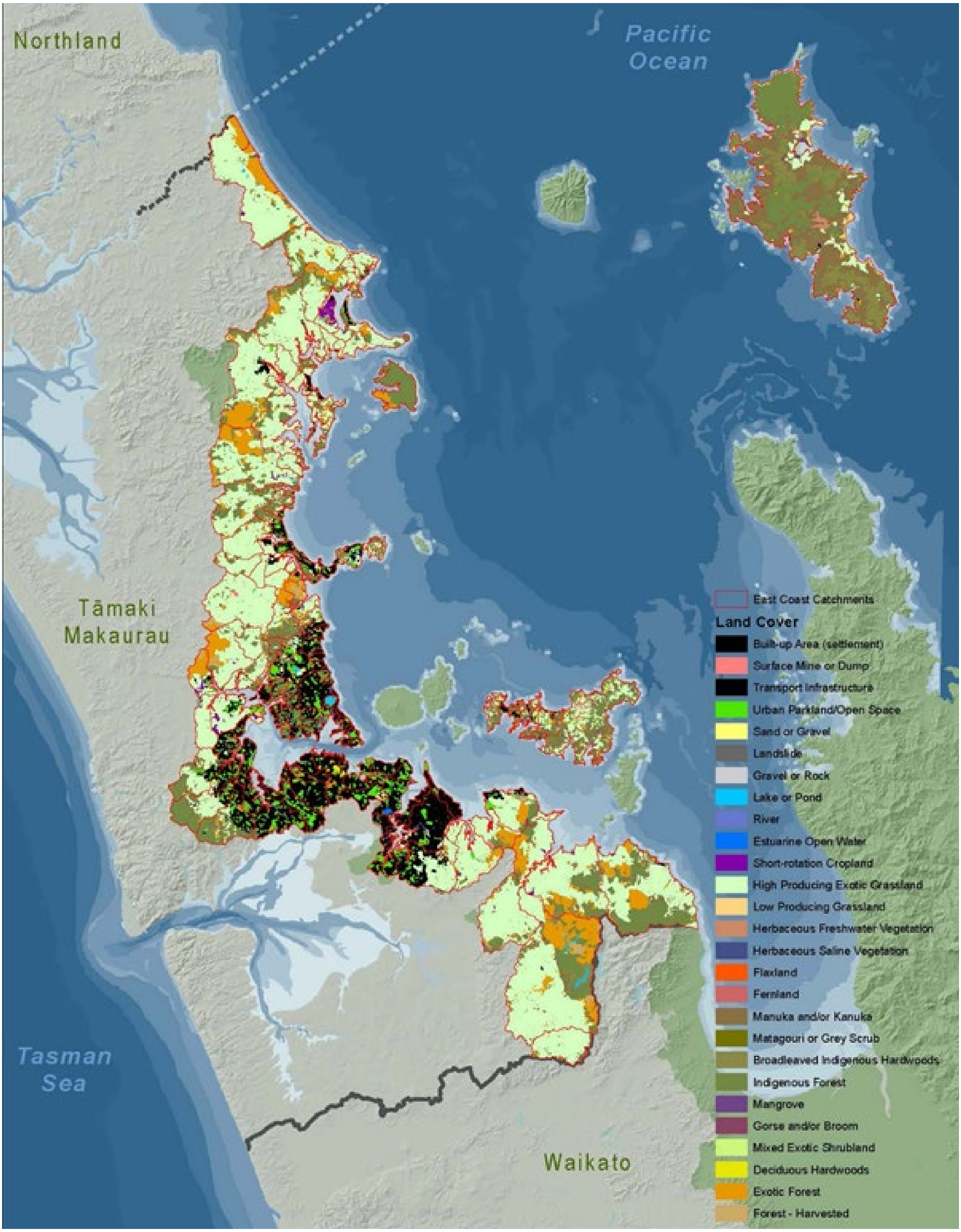
In the Auckland Region, the largest use of land that drains to the Hauraki Gulf Marine Park is "grassland" (that is, pasture) (37%). The next largest use of land is native forest.

Hence, sediment mitigations applied to pasture and improving the health of native forest in the Auckland Region stand to be effective at reducing sediment loss, even in this perceived "urban" area, to the coastal marine environment.

6 Cromarty, P. and Scott, D.A. (Eds), 1995. A Directory of Wetlands in New Zealand. Department of Conservation, Wellington. Available for download from http://www.doc.govt.nz/Documents/science-and-technical/nzwetlands00.pdf

7 Available for purchase under hardcover and as free download at http://www.landcareresearch.co.nz/publications/books/wetlands-handbook.

8 Waikato Regional Council – http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Freshwater-wetlands/Restoring-a-wetland/Create-your-own-wetland-plan/
Auckland Council – http://www.aucklandcouncil.govt.nz/en/environmentwaste/biodiversity/pages/biodiversityonyourproperty.aspx



Map A4.5 Auckland East coast catchment landcover

6. Chemical Flocculants

Erosion and sediment control practices and methods[9] can be highly effective at reducing sediment loss from earthworking sites to streams and, ultimately, the coastal marine area. Nevertheless, as noted by Basher et al. (in prep.), even with a sediment removal efficiency in excess of 90%, levels of sediments in effluent and runoff discharged from construction sites can still be "markedly higher than environmental guidelines and/or background concentrations in receiving aquatic environments". Furthermore, typical practices are more effective at managing coarse particles than they are fine particles, which tend to cause a wider range of and more severe adverse effects in downstream receiving environments.

Various chemical treatments may be used to reduce sediment loss from earthworks. For example, chemical treatments are used to bind sediments at source, and they also are used to flocculate fine sediments, which enhances their capture in sediment retention ponds, thereby improving effluent quality.

Basher et al. (in prep.) reviewed the use of chemical treatment applied to enhance erosion control practices, and found that it did not significantly improve the performance of traditional physical practices such as mulching and grass seeding; furthermore, the effectiveness of chemical treatment was found to reduce with time since application. In contrast, chemical flocculation applied in retention ponds was found to significantly lower turbidity and total suspended sediment in effluent. Studies of the use of the chemical flocculant PAC[10] in New Zealand showed good performance and, very importantly, a greater difference to effluent quality discharged during larger events, when the performance of non-treated ponds is relatively poor. PAC was also found to be of benefit during winter, when the performance of untreated ponds tends to be poor. Basher et al. (in prep.) found that concentrations of residual aluminium from PAC treatment are generally, but not always, below relevant water quality guidelines.

Water-sensitive urban design

Sea Change endorses the concept of water-sensitive urban design espoused in the Proposed Auckland Unitary Plan. The principles, tools and technologies of WSD need to be used wherever possible in all municipalities that discharge into the Hauraki Gulf.

Chemical flocculants are more-or-less routinely used in sediment retention ponds on large earthworks sites in the Auckland region to increase pond efficiency at removing fine sediment from overland runoff from the site before it reaches streams and the coastal marine area.

7. Guidelines for controlling sediment loss from earthworks sites.

Detailed guidelines for controlling sediment runoff from earthworking sites have been produced for both the Auckland region[11]and the Waikato region[12], which are supplemented with training and education programmes for contractors, and regular newsletters to keep abreast of developments and changes in rules. Waikato Regional Council note that, since their Guidelines for Soil Disturbing Activities were published in 2009, there have been many significant changes and new innovations that are now being considered for inclusion in a revision to the Guidelines. In the meantime, WRC has updated sections of their Guidelines that deal with sediment control practices, sediment retention ponds, silt fences, hay bale barriers and decanting earth bunds as best practice has evolved. Auckland Council is also currently updating their Erosion and Sediment Control Guidelines for Land Disturbing Activities in the Auckland Region. Auckland Council requires that earthworking be done in the driest season, that appropriate sediment retention devices be used, and that earthworks be co-ordinated with the provision of infrastructure to put in place erosion and sediment control measures. In both regions, resource consents may be required in certain situations to disturb the ground.

9 Erosion control practices seek to manage sediment generation at source; examples include the use of mulches and geotextiles to protect bare land, and stabilisation by hydroseeding. Sediment control practices, which include sediment retention ponds and silt fences, seek to manage sediments in effluent or runoff discharged from a site.

10 Polyaluminium chloride (PAC) is an aluminium-based liquid flocculant.

11 Technical Publication 90, available at http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/reports/technicalpublications/Pages/technicalpublications51-100.aspx

12 http://www.waikatoregion.govt.nz/earthworks/

DISCUSSION OF NUTRIENT OBJECTIVES ACTIONS AND PRIORITIES

Explaining Nutrient Objectives

Water-Column Nutrients

Why: High levels of dissolved nutrients in the water column can increase phytoplankton growth, resulting in blooms at certain times of the year when growing conditions are favourable. Phytoplankton is an essential component of the marine food web, but too much phytoplankton can cause problems such as discoloured and murky water, smothering of the seabed, depleted dissolved oxygen and acidification of the water. Some phytoplankton blooms can be toxic to humans.

Aim: Maintain nutrients to provide optimum phytoplankton levels.

- Objective WQ4: 80% of subtidal areas and coastal embayments with increasing trends in water-column ammonia-N, nitrate+nitrite-N, soluble reactive phosphorus and total phosphorus have the trend reversed within 15 years.

Explanation:

- High levels of nitrogen and phosphorus in different chemical forms dissolved in the water column fuel phytoplankton growth.
- Dissolved nitrogen and phosphorus are routinely monitored, and trends can be assessed from repeated measurements over time.
- Turning around (or reversing) trends that are currently increasing indicates a reduction in nutrients that can fuel phytoplankton growth.

Where the objective applies: The objective applies to coastal embayments (e.g., the Firth of Thames, Tamaki Strait) and subtidal parts of estuaries (e.g., in the middle of the Central Waitemata Harbour, around the entrance to Mahurangi Harbour).

Assessing achievement: Achievement can only be assessed at representative monitoring sites, which need to be selected in consultation with agencies. Additional monitoring sites will need to be established where the existing monitoring network is too sparse to assess the achievement of this objective. Waikato Regional Council, working from an understanding of regional issues and a review of Auckland Council's water-column nutrient monitoring programme, needs to assess the case for a monitoring programme to be able to identify trends in water-column nutrients. Issues to consider include cost, representativeness of sites, determining trends given seasonal and climate variability, and adapting monitoring to address issues that might arise in the future without compromising continuity of data.

How the objective will be achieved: Monitoring nutrient inputs to the coastal marine area and reducing where necessary.

Outcome: Phytoplankton at appropriate levels for supporting a diverse and productive marine food web.

Water-Column Chlorophyll a

Why: High levels of chlorophyll a in the water column are indicative of high levels of phytoplankton, which can result from excessive nutrients dissolved in the water, and which can cause a wide range of problems, including discoloured and murky water, smothering of the seabed, depleted dissolved oxygen and acidification of the water. Some phytoplankton blooms can be toxic to humans. Phytoplankton blooms in late spring and summer as the water warms up and the sun moves down over the southern hemisphere, exacerbating problems.

Aim: Limit phytoplankton at the height of the summer growing season.

- Objective WQ5: Within 10 years, chlorophyll a in the surface water (i.e., above the thermocline) of subtidal areas and coastal embayments does not exceed 5 mg m-3 during the summer when primary production is greatest.

Explanation:

- 5 mg m^{-3} of chlorophyll a is recognised as a threshold above which adverse effects associated with excessive primary production begin to be manifest.

Where the objective applies: The objective applies to coastal embayments (e.g., the Firth of Thames, Tamaki Strait) and subtidal parts of estuaries (e.g., in the middle of the Central Waitemata Harbour, around the entrance to Mahurangi Harbour).

The chlorophyll a threshold may be exceeded locally at some sites, for example, fish farms, which should be given special consideration and not be included in performance monitoring for this objective.

Assessing achievement: Achievement can only be assessed at representative monitoring sites, which need to be selected in consultation with agencies. Additional monitoring sites will need to be established where the existing monitoring network is too sparse to assess the achievement of this objective. Auckland Council and Waikato Regional need to determine rational and robust criteria for assessing achievement of the water-column chlorophyll a objective. Issues to consider include seasonal variation in primary production and oceanic upwelling, short-lived and infrequent exceedances, representativeness of sites, cost, and accounting for climate variability.

How the objective will be achieved: By achieving the Water-Column Nutrients Objective WQ4.

Outcome: Fewer and less extensive and prolonged phytoplankton blooms during times of the year when growing conditions are favourable.

Water-Column Dissolved Oxygen

Why: When phytoplankton levels are high due to excessive nutrients in the water column, dissolved oxygen can be reduced, which is life-threatening to marine animals, including shellfish and fish.

Aim: Ensure dissolved oxygen is maintained at a life-sustaining level.

- Objective WQ6: Within 20 years, dissolved oxygen concentration in subtidal areas and coastal embayments is no lower than 5 mg L-1.

Explanation:

- 5 mg L-1 of dissolved oxygen is internationally recognised as a “precautionary limit to avoid catastrophic mortality events, except for the most sensitive crab species, and effectively conserve marine biodiversity”.

Where the objective applies: The objective applies to coastal embayments (e.g., the Firth of Thames, Tamaki Strait) and subtidal parts of estuaries (e.g., in the middle of the Central Waitemata Harbour, around the entrance to Mahurangi Harbour).

The dissolved-oxygen threshold may be failed locally at some sites, for example, fish farms, which should be given special consideration and not be included in performance monitoring for this objective.

Assessing achievement: Achievement can only be assessed at representative monitoring sites, which need to be selected in consultation with agencies. Additional monitoring sites will need to be established where the existing monitoring network is too sparse to assess the achievement of this objective. Auckland Council and Waikato Regional Council need to determine rational and robust criteria for assessing achievement of the water-column dissolved oxygen objective. Issues to consider include seasonal variation in primary production and upwelling, short-lived and infrequent exceedances, representativeness of sites, cost, and accounting for climate variability (e.g., ENSO cycles).

How the objective will be achieved: By achieving the Water-Column Nutrients Objective WQ4 and the Water-Column Chlorophyll a Objective WQ5.

Outcome: Water-column dissolved oxygen at all times of the year that is protective of marine life.

1. Firth of Thames

The Firth of Thames is central to the identity of Hauraki Mana Whenua. It contains important customary, commercial and recreational fisheries, includes a globally significant RAMSAR site, and is an aquaculture focus area. At the same time, the Firth ecosystem has been profoundly changed by green-lipped mussel dredging that ceased 50 years ago, and it is presently stressed by excessive nutrients and sediments.

The Firth is an example of a coastal embayment that has features that enhance susceptibility to eutrophication. It has a long residence time compared to the growth cycle of phytoplankton, and the upper water column is typically clear, which means primary production is not light limited. Furthermore, the water column becomes (thermally) stratified in the autumn, which enhances the depletion of oxygen from the water column caused by rotting organic matter at the end of the growth season. The problem is exacerbated in the lower water column below the thermocline, where contact with the atmosphere is shut off, which prevents re-aeration of the water.

A recent assessment has concluded that dissolved nitrogen and the proportion of small phytoplankton have increased in the outer Firth over the past 20 years, although they have been stable or slightly decreasing over the last 13 years of that 20 year period. Nitrogen from the land is one possible factor responsible for the higher phytoplankton levels. Other factors are oceanic sources of nitrogen and physical processes such as mixing and water-column stratification that enhance phytoplankton production through effects on nutrient and light availability. The available data show that the Firth of Thames is generally well oxygenated, but there are seasonal (autumnal) low-oxygen (60–70% saturation) events in the bottom waters in some parts of the Firth. Although there is no evidence that oxygen depletion has increased under the higher nitrogen and phytoplankton burdens, it is nevertheless prudent to manage nutrients to prevent it worsening in the future.

While total nitrogen loads in rivers draining to the Firth of Thames are significantly higher than in pre human times, they have been stable or increased only slowly for the past 20 years (Vant 2011).

DISCUSSION OF HEAVY METALS OBJECTIVES, ACTIONS AND PRIORITIES

Explaining Heavy Metals Objectives

Seabed Heavy Metals

Why: Heavy metals (primarily zinc, copper and lead) can build up in seabed sediments and become toxic to seabed-dwelling animals (shellfish, worms and crabs).

Aim: Limit the buildup of heavy metals in seabed sediments.

- Objective WQ7: 95% of intertidal and subtidal seabed with an increasing trend in heavy metals have trend arrested within 15 years.
- Objective WQ8: 95% of intertidal and subtidal seabed with heavy-metal concentration above threshold effects level (TEL) have concentration below the TEL within 30 years, and 95% of intertidal and subtidal seabed with heavy-metal concentration above probable effects level (PEL) have concentration below the PEL within 30 years.
- Objective WQ9: All intertidal and subtidal seabed with heavy-metal concentration below the threshold effects level (TEL) remain below the TEL.

Explanation:

Heavy metals in seabed sediments are routinely monitored, and trends can be assessed from repeated measurements over time.

"Arresting" an increasing trend means flattening or reversing the increase.

The 15-year timeframe recognises that seabed heavy-metal concentrations change slowly in response to changes in heavy metals from the catchment.

Explanation:

Seabed heavy-metal concentrations above the TEL and PEL pose a threat to seabed animals.

Where the objectives apply: The objectives apply to both intertidal and subtidal seabed.

How the objectives relate to each other: Objective WQ7 seeks to arrest increasing trends in seabed heavy metals within 15 years. Objective WQ8 seeks to reduce seabed heavy metals to specific levels within 30 years, and objective WQ9 seeks to prevent sites currently below the TEL exceeding that level.

Assessing achievement: Achievement can only be assessed at representative monitoring sites, which need to be selected in consultation with agencies. Waikato Regional Council, working from an understanding of regional issues and a review of Auckland Council's seabed heavy-metal monitoring programme, needs to assess the case for expanding their regional monitoring of heavy metals to be able to identify trends and to be alert to exceedance of guideline concentrations. Issues to consider include cost and representativeness of sites. Additional monitoring sites in both regions will need to be established where the existing monitoring network is too sparse to assess the achievement of this objective. Additional monitoring sites may be established for assessing achievement of this objective in order to protect special values or particular locations, including locations that will be vulnerable to heavy-metal runoff from areas in the catchment designated for future urbanisation.

How the objectives will be achieved: Reducing heavy metals in urban stormwater runoff; reducing discharges such as antifouling contaminants from ports and marinas; reducing stormwater discharges directly into the coastal marine area.

Outcome: Seabed habitat that is not compromised by excessive levels of heavy metals.

Benthic Ecological Health

Why: Animals that live in and on the seabed (shellfish, crabs, worms and so on) underpin the proper functioning of the wider estuarine and marine ecosystems and the benefits derived from those ecosystems by people.

Aim: Maintain and improve the health and functioning of the seabed – or "benthic" – fauna.

- Objective WQ10: No decline in benthic ecological health from present day and improvement in benthic ecological health at 25% of monitoring sites within 15 years.

Explanation:

"Benthic ecological health" is assessed from measurements of seabed fauna. Assessments focus on species abundance and diversity, and the resilience of benthic communities to withstand disturbances such as excessive sediments and heavy metals. There are different indicators or metrics available for assessing benthic ecological health from monitoring data; some apply to intertidal flats only, others are more generally applicable.

Good benthic ecological health means that things are right with the habitat and that stressor levels (e.g., sediments, heavy metals) are low.

Conversely, a poor or declining benthic ecological health signifies that something is going wrong, for example, buildup of heavy metals in the seabed.

Any assessment of change (for example, a decline in benthic ecological health in a given monitoring year), will need to be judged against natural variability, which cannot be managed.

Where the objective applies: The objective applies to both intertidal and subtidal areas.

Assessing achievement: Achievement can only be assessed at representative monitoring sites, which need to be selected in consultation with agencies. Additional monitoring sites will need to be established where the existing monitoring network is too sparse to assess the achievement of this objective. Auckland Regional Council and Waikato Regional Council need to agree on metrics and indicators for assessing benthic ecological health in intertidal and subtidal habitats, and develop methods for assessing natural variability against which change can be assessed.

How the objective will be achieved: (1) Protecting seabed habitats from loss and physical disturbance. (2) Reducing sediment and heavy-metal runoff to the coastal marine area. (3) Achieving the Sedimentation Rate Objective WQ1, the Seabed Muddiness Objectives WQ2 and WQ3, and the Seabed Heavy Metals Objectives WQ7, WQ8 and WQ9.

Outcome: Abundant and diverse seabed fauna supported by appropriate habitat, underpinning the functioning of the wider estuarine and marine ecosystems and providing a range of benefits to people.

1. Benthic ecological health

Animals that live in and on the seabed (shellfish, crabs, worms and so on) underpin the proper functioning of the wider estuary and marine ecosystems and the benefits derived from those ecosystems by people. "Benthic ecological health" is assessed from routine measurements of seabed fauna. Assessments focus on species abundance and diversity, and the resilience of benthic communities to withstand disturbances such as excessive sediments and heavy metals. There are different indicators or metrics available for assessing benthic ecological health from monitoring data; some apply to intertidal flats only, others are more generally applicable.

Good benthic ecological health means that things are right with the habitat and that stressor levels (e.g., sediments, heavy metals) are low. Conversely, a poor or declining benthic ecological health signifies that something is going wrong, for example, buildup of heavy metals in the seabed.

Auckland Council assesses the benthic ecological health grade from seabed monitoring data. The grade combines information on seabed mud content and metal concentration and the types and abundances of animals in the seabed. Sites are scored from 1 (healthy) to 5 (unhealthy). In 2015, all harbours and estuaries had monitoring sites that were scored as only moderately healthy and most had sites scored as unhealthy. Most sites near the older urban centres scored as unhealthy (scores of 4 to 5), particularly within the Waitemata Harbour and Tamaki Inlet, where the issue is elevated concentrations of at least one heavy metal.

However, sites further away from urban Auckland were also rated as unhealthy, which was attributed to sediment runoff from rural land.

2. **Urban water design**

The Proposed Auckland Unitary Plan intends moving away from a focus on infrastructure and end-of-pipe management and towards an integrated approach to management of landuse and stormwater discharges, including emphasis on water-sensitive design (WSD), all intended to result in achievement of a wide range of environmental outcomes.

Provisions in the Unitary Plan designed to achieve a more integrated approach to land development and stormwater management include:

- overarching objectives and policies in respect of integrated management, WSD, water quality/flow, freshwater systems and hazards;
- controls on development, landuse and discharges for water quality, hydrology and flooding;
- controls on subdivision, including the application of WSD, management of development within flood hazard areas and water quality/quantity; stormwater management requirements for integrated planning processes such as structure plans, and within-precinct plans

Water-sensitive design is central to minimising the adverse effects of stormwater runoff on freshwater and coastal ecosystems. To achieve this, WSD seeks to, amongst other things: minimise impervious area on individual sites by site design, clustering of houses, use of pervious paving and provision of open or vegetated spaces; minimise the generation of contaminants, including by the use of building materials that have a low contaminant yield; and mitigating stormwater contaminants and runoff at or close to source.

Retention ponds

Sea Change endorses the use of innovative technologies to improve the performance of wastewater treatment plants, and encourages small- and medium-sized communities to seriously consider new technologies when existing WWTPs are due for upgrade or re-consenting.

3. **Boat Anti-Fouling**

Boat anti-fouling paints contain toxic substances – typically copper – that slowly leach out into the water over time, killing organisms that attempt to attach to the boat. A recent NIWA study found that antifouling paint is primarily responsible for copper accumulation in sediments around marinas at concentrations that are above the guidelines for protection of marine life. Furthermore, as much copper is exported from the four marinas in the Waitemata Harbour as from inputs of stormwater from the entire catchment of the Waitemata Harbour. Alternatives to copper-based antifouling paints do exist. For instance, Rentunder Drive-in BoatwashTM scrubs off fouling using brushes applied to the boat while it is contained in a pen, which contains all of the debris. Other innovations include ultrasonic cleaning systems, and coating hulls with materials that mimic the skin of sharks.

DISCUSSION OF MICROBIAL PATHOGENS OBJECTIVES, ACTIONS AND PRIORITIES

Explaining Microbial Pathogen Objectives

Enterococci

Why: Microbial pathogens (bacteria, viruses, protozoa) in human and animal faeces are capable of causing illness and disease in humans that swim in polluted water.

Aim: Provide safe swimming for people.

- Objective WQ11: All popular swimming spots in the Hauraki Gulf to be in Microbial Assessment Category A by 2030.

Explanation:

- Enterococci are bacteria that are an indicator of faecal contamination. They are generally not harmful themselves, but they indicate the possible presence of pathogenic bacteria, viruses and protozoans that are associated with human and animal faeces.
- Microbial Assessment Category A is designated when the Hazen 95-percentile of the previous 5 years of monitoring data is ≤40 enterococci per 100mL of water (MfE, 2003[13]). This is the highest level of water quality for bathing.

Where the objective applies: The objective applies to all popular swimming spots in the Hauraki Gulf.

Assessing achievement: Waikato Regional Council, working from an understanding of regional issues, needs to assess the case for a beach-monitoring programme to be able to assess and report swimming safety. Issues to consider include cost and representativeness of sites.

How the objective will be achieved: Different actions depending on source of contamination, for instance, reducing wastewater overflows and eliminating stormwater cross-connections, maintaining septic tanks, excluding stock from streams, controlling discharges from boats.

Outcome: Safe and enjoyable swimming experience at all popular swimming spots in the Hauraki Gulf.

13 Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas, MfE 2003, http://www.mfe.govt.nz/publications/fresh-water/microbiological-water-quality-guidelines-marine-and-freshwater-recreatio-13#twod4

1. **Innovative technologies for municipal wastewater treatment.**

For many decades, oxidation ponds have been used to treat wastewater in most small and medium-sized communities. The conventional ponds work well at removing suspended solids and reducing biochemical oxygen demand. They are cost effective and require little maintenance. However, when it comes to removing pathogens and nutrients, they are highly inconsistent[14]. As an alternative to a costly upgrade to a mechanical system, it now possible to upgrade conventional systems with an Enhanced Pond System (EPS), which uses natural physical, chemical and microbiological process to treat wastewater more effectively and cost-efficiently[15]. The EPS consists of a series of ponds that work together: covered anaerobic ponds, high rate algal ponds, algal harvest ponds, a covered digester pond, maturation ponds and rock filters.

EPS provide significant benefits and advantages compared to traditional pond systems, including improved natural disinfection and nutrient removal, with nutrients being recoverable in the form of algal biomass, which in turn may be used for fertiliser, feed or biofuel feedstock; recovery of wastewater energy (by anaerobic digestion of wastewater solids and harvested algae) as biogas; the ability to reuse the treated effluent; and reduction in greenhouse gas emissions. In addition, EPS take up about the same amount of land area, virtually eliminate sludge disposal, and produce less odour.

NIWA is currently collaborating with Waipa District Council to demonstrate, over a three-year period, the use and benefits of a full-scale EPS at the Cambridge Wastewater Treatment Plant[16].

14 https://www.niwa.co.nz/freshwater-and-estuaries/freshwater-and-estuaries-update/freshwater-update-62-september-2014/niwa-advances-wastewater-treatment

15 NIWA estimates capital costs of EPS to be only a quarter those of electromechanical treatment systems removing both BOD5 and nutrients, while operating costs of EPS are less than half.

16 Craggs, R., Park, J., Sutherland, D. and Heubeck, S., 2015. Economic construction and operation of hectare-scale wastewater treatment enhanced pond systems. Journal of Applied Phycology, 27: 1913–1922.

A key component of the system is the two 1-hectare high rate algal ponds, augmented with carbon dioxide addition during the day to promote algal growth when it is often carbon-limited[17]. The high rate algal ponds aerobically treat and remove nutrients from the anaerobic pond effluent through the production of algal biomass, and algal harvest ponds settle and concentrate the algal biomass which is then pumped into a covered digester pond to recover energy as biogas and nutrients as a concentrated digestate.

Further effluent polishing is provided by maturation ponds and rock filters. With the enhanced pond system, the WWTP is expected to exceed current performance and meet future consent conditions. Actual performance will be verified during the demonstration period, and will vary seasonally.

The main objectives of the Cambridge project are to showcase the technology by demonstrating efficiency and consent compliance; algal production and harvest; biogas production; and the use of algal digestate as a soil fertiliser. The expected benefits are many: cost savings (capital and operating); reduced environmental impact; and future cultural benefits, including a final habitat pond providing habitat and a nursery for native fish (e.g., eels, bullies, whitebait) and invertebrates (e.g., koura).

On-site wastewater treatment systems

Sea Change recognises that there is a strong need for ongoing proactive planning to manage the key risk areas associated with proper design, maintenance and operation of on-site wastewater treatment systems. Councils need a system to ensure good maintaenance of septic tanks; either a requirement for a regular pump out and compliance inspections, or incorporating it in the rates and the council doing it.

17 Craggs, R., Park, J., Heubeck, S. and Sutherland, D., 2014. High rate algal pond systems for low-energy wastewater treatment, nutrient recovery and energy production. New Zealand Journal of Botany, 52(1): 60–73.

2. **Use of habitat wetlands in municipal wastewater treatment.**

A project between Ngāti Koroki Kahukura, Ngāti Haua, Raukawa, Waikato Tainui, Waipa District Council and NIWA seeks to showcase a more culturally appropriate treatment of wastewater using habitat wetlands[18]. A demonstration habitat wetland is being developed at the Cambridge WWTP, being installed as the final stage of the Enhanced Pond System.

The habitat wetland will further cleanse effluent by contact with the land, and will provide habitat for native plants, fish and invertebrates, some which could have economic value.

3. **On-site wastewater treatment systems.**

On-site wastewater treatment systems, which are typically used on properties in rural or coastal areas which are not serviced by sewerage systems, are used for the treatment of domestic wastewater, which includes water from the toilet, bathroom, kitchen and laundry[19].

There are two parts to the systems: treatment and disposal. Treatment is primary (for example, by septic tanks) and secondary (for example, by aerated wastewater treatment systems). Treated wastewater is discharged to land, where physical filtering, chemical reactions and biological processes in the soil provide further treatment and removal of contaminants. In addition, plants growing in the disposal field take up water and nutrients. The disposal field needs to be properly sized so that it does not become overloaded, and there must be the means for distributing wastewater evenly over the field. In addition, the disposal field must meet minimum separation distances from surface water, drains and property boundaries.

Under-designed, faulty and poorly maintained on-site wastewater treatment and disposal systems can pollute groundwater and streams – and eventually the coastal marine area – with nitrogen and phosphorus, and create public health risks due to escape of pathogenic microbes.

Rules in the regional plan are the main vehicle for managing on-site wastewater discharges.

18 Funded by the Waikato River Authority. For more information, go to http://makearipple.co.nz/Action-groups/ripples/Habitat-wetland-wastewater-treatment/

19 http://www.aucklandcouncil.govt.nz/EN/ratesbuildingproperty/consents/buildingstructures/Documents/onsitewastewatermanagementintro.pdf

In the Auckland region, a building consent is required to install or alter a septic tank or other on-site wastewater management system. A resource consent may also be needed for discharging the treated wastewater onto or into the land. Resource consents are typically issued for periods of 10 to 15 years, and will have conditions which must be complied with, including limits to the volume of wastewater discharged each day and standards for quality of the wastewater. The latter may include total suspended solids, biochemical oxygen demand and faecal coliforms. Typically, council officers will monitor compliance every five years, and there is a charge for this monitoring.

The Waikato Regional Plan has permitted activity rules for existing on-site wastewater discharges, new septic tank systems and new improved systems with secondary treatment. The conditions that must be satisfied relate to a number of design considerations, discharge volume, and discharge quality.

A review by Trebilco et al. (2012)[20] concluded that Waikato's permitted-activity conditions are "at least as rigorous as most other regions, and which adequately manage the effects of on-site wastewater discharges". Nonetheless, they also identified some conditions that may not be stringent enough, and recommended that some review was required. Trebilco et al. (2012) noted that "The single biggest outstanding issue with on-site systems is wide-spread lack of maintenance. Few councils in New Zealand have monitoring programmes in place. It is suggested that where adverse effects do occur from on-site systems, lack of maintenance is generally the primary cause (assuming of course that the system was correctly installed in the first place).

Lack of maintenance has been the message conveyed by the on-site industry in recent conferences in NZ and Australia, and is nearly always a central theme in studies about management of on-site systems". Furthermore, they noted "it is evident that the risk of adverse effects increases as on-site systems become more numerous and older.

20 http://www.waikatoregion.govt.nz/PageFiles/23921/TR201209.pdf

Sea Change recognises that there is a strong need for ongoing proactive planning to manage the key risk areas associated with proper design, maintenance and operation of on-site wastewater treatment systems. Councils need a system to ensure good maintaenance of septic tanks; either a requirement for a regular pump out and compliance inspections, or incorporating it in the rates and the council doing it.

4. **Discharge of sewage from vessels.**

The Proposed Auckland Unitary Plan (PAUP) recognises that the direct discharge of untreated human sewage from vessels reduces water quality and can have localised adverse effects on the values and uses of coastal waters. Sewage discharge is culturally offensive to Māori, who value the coastal marine area as taonga, and who recognise that the degradation of water quality as a result of sewage discharge adversely affects the Mauri or life force of the water. Furthermore, there is a wide range of potential adverse effects on food gathering, swimming, tourism and aquaculture. The PAUP recognises that boats can be a problem in this regard, especially where they congregate in anchorage areas with poor tidal circulation and limited capacity to flush contaminants, and seeks to safeguard activities in coastal waters from the effects of untreated sewage discharge from vessels.

Three policies are proposed in the PAUP to give effect to two objectives relating to protecting the values of the coastal marine area and activities that rely on high water quality, and maintaining recreational and amenity values of the Inner Hauraki Gulf:

1. Avoid the discharge of untreated sewage from vessels within areas that have been identified as inappropriate due to the proximity to shore, marine farms, marine reserves, or shallow water depth while providing for the health and safety of vessels and their occupants.
2. Require provision of sewage collection and disposal facilities for vessels at ports, marinas and other allied facilities, or at the time of significant upgrading of these facilities (3) Promote the installation of public toilet facilities at high use boat ramps and boating destinations, at construction, or during significant upgrades of such facilities.

In the rules, standard F2.21.8.2 establishes that the discharge of untreated sewage from a vessel or offshore installation will be permitted only where it complies with the following:

1. The discharge must be in water depths greater than 5m.
2. The discharge must be more than 500m (0.27 nautical miles) from mean high water springs.
3. The discharge must be more than 500 m (0.27 nautical miles) from an aquaculture activity.
4. The discharge must be more than 500 m (0.27 nautical miles) from a mātaitai reserve.
5. The discharge must be more than 200 m (0.108 nautical miles) from a marine reserve.
6. Notwithstanding F2.21.8.2 (1) to (5) the discharge must not be inside two headlands (point to point) of the following specific locations:
   a) Waitemata Harbour from North Head to Orakei Wharf;
   b) Mahurangi Harbour from Pudding Island to Sadler Point;
   c) Bostaquet Bay Kawau Island, from Brownrigg Point to Challenger Island;
   d) Port Fitzroy Great Barrier Island, inside Paget rock in Man O War Passage to a line between the NE tip of Kaikoura Island and Kotutu point;
   e) Nagle Cove Great Barrier Island from Tortoise Head and Wood island; or
   f) Tryphena Harbour Great Barrier Island from Tryphena Point to Bird Islet.
7. Notwithstanding in harbours, bays and embayments listed in F2.21.8.2(6), during rough weather conditions when wind conditions at the mouth of the harbour, bay or embayment exceed 15-18 knots untreated sewage may be discharged as necessary for health and safety reasons.

These rules correspond to the Resource Management (Marine Pollution) Regulations (1998) with an additional restriction on discharges in the bays and harbours listed in point (6). When it was notified, the Plan included a limit of 2 km from the shoreline. However, the submissions and hearing process raised several issues with that approach. There were legal challenges to the ability of a council to introduce a region-wide distance increase. Submitters also questioned the workability of the rules because it is difficult to identify instances of non-compliance, some boats cannot be retrofitted with holding tanks, it can be difficult to access pump-out facilities, there are safety issues with requiring vessels to move further offshore to discharge, and more onerous requirements may actually lead to less compliance if the control is too difficult to comply with. The council changed its approach from a blanket distance increase to identifying particular harbours and bays where the other controls leave small gaps where it was lawful to discharge but could cause adverse effects. The Independent Hearing Panel supported the revised approach.

It is expected that education about the discharge controls and promotion of holding tanks and pump-out facilities can be used to induce behavioural change among boating communities to further reduce discharges of untreated sewage.

Untreated sewage discharges from vessels

Sea Change endorses the policies and rules in the PAUP concerning untreated sewage discharges from vessels. A priority is a review of the objectives, policies, rules and methods in the Waikato Regional Plan around discharge of sewage from vessels with a view to identifying any particular bays and harbours where the Marine Pollution Regulations leave gaps and the controls should be strengthened as has occurred with the Proposed Auckland Unitary Plan.

5. The need for Integrated Catchment Modelling

The Hauraki Gulf and its wider catchment constitute a complex and dynamic structure of natural and artificial systems that interact with each other like a giant, ever-changing puzzle. When making policy and management decisions about such a system, we often think about particular pieces of the puzzle. But there is a danger that decisions aimed at outcomes for one part of the puzzle will have unintended consequences for another part. One way of trying to overcome such issues is to develop an 'integrated model' that incorporates all the key features of the catchment, and the ways in which they interact with each other.

The overall question that this type of modelling tries to answer is how do values change as a result of our policy decisions? The figure below, taken from a water quality project, illustrates the process. In step one, we gather information that characterises all the values we associate with something (in our case, this would be all those values generated by the Hauraki Gulf Marine Park). Step two is to develop with a scenario that changes the system – this could, for example, be a regulatory constraint on some activities or their effects. Step three is to work out how this might be achieved, and given this, step four is to determine how those changes affect our values. Two broad approaches to this kind of modelling are described below.

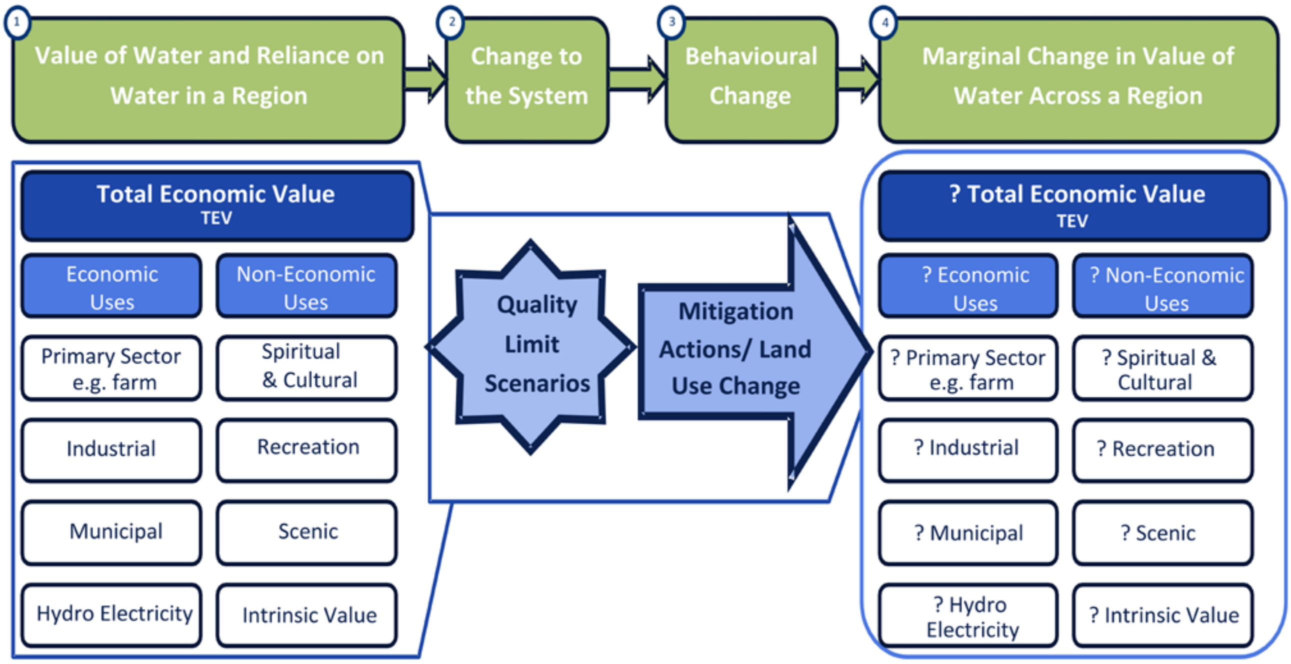


Figure A4.1 Integrated Catchment Modelling

Extended Input-Output modelling approach

An 'input-output' (or I-O) model is a method that has been used by economists to understand the changes in an economy by incorporating the way different industries interact with each other. For example, if a change happens in the dairy farming sector, this will also have flow-on effects on businesses in other sectors – including their customers (like dairy manufacturers) and their suppliers (like fertiliser companies, vets or agricultural consultants) and their communities schools, local services and shopping.

Input-output models can be extended to environmental features too. A study in 2006 developed a an I-O model for the Waikato region covering all the industries in the region, but also incorporating information on land use, delivered energy, air emissions, and solid waste21. It notes too that accounts for other natural resources and emissions (such as water use and discharges, biodiversity and soils) could, in principle, be incorporated.

The idea is to be able to model scenarios of the future and look at the implications in a wider sense.
For instance, looking at how the growth in forest planting in a catchment may impact on different industries, but also on discharges of sediment, water takes, carbon sequestration or habitat. It is noted, however, that while we have a well-established I-O model for the Waikato that covers the narrowly defined economy (and incorporates land use), we do not have these other accounts at present - and developing them is neither a straightforward nor small undertaking.

Constrained optimisation modelling – estimating the costs of policy

Another approach to catchment modelling is to develop an 'optimisation' model. This approach allows for a model that provides information about how to manage a system so as to optimise some objective variable. Generally, there are constraints imposed on this system – for example, by

21 Waikato Region Economy-Environment Futures Report, 2006. Technical Report 2006/51.

biophysical limits, or by limits imposed by policy choices. For example, we may choose to model a catchment according to the land uses and biophysical processes that exist there. We could use the model to determine the maximum profits available from land use, subject to biophysical constraints (such as the availability of water as an input) and policy choices (discharges to water must be below a certain level to achieve water quality targets).

A recent joint project involving the Waikato Regional Council, the Waikato River Authority, central government, and DairyNZ used such a modelling approach to look at the management of nutrient discharges in the Waikato-Waipa catchment. This approach was subsequently picked up and advanced by the Healthy Rivers/Wai Ora plan change process.

The models described in the previous paragraph were used to provide information about the cost (in terms of changes to the profitability of land use) of setting targets and limits for discharges to the Waikato and Waipa rivers. Such an approach might be able to be developed to consider the costs of managing discharges into the coastal marine environment. This would require models of representative land use types to be developed – including information on the profitability of land use, the discharges associated with the different types of land use, and the efficacy and cost of mitigations – and aggregated to the catchment scale. If this approach was feasible, we could use it to help inform questions such as 'if we want to reduce sediment loads in the receiving environment by X, what mitigation actions will that require on the land – and how much will that cost?'

It should be noted, however, that there are issues with this type of modelling. It is very data-intensive, and there is likely to be considerable uncertainty and debate around some of the information inputs required (for example, estimates of sediment loads from different land uses). The model also measures the cost of policy as a change in profitability of land use. In the cases of urban or conservation land, which are not managed for profit, the optimisation approach would have to be altered.

It should also be noted that this approach only considers the costs of meeting targets – and only a subset of total costs at that (albeit a very important subset!). It needs to be considered alongside other information about the benefits that are being achieved. In the Healthy Rivers/Wai Ora process, this was done through a complementary 'integrated assessment' approach, which essentially involved an expert assessment of the broader effects of meeting targets and limits.