23 November 2020

Measuring the benefits of management actions

Monitoring Design Working Group –

Scenarios for Decision Support Tool development

# Scope and Aim

This document summarises catchment and land management mitigation scenarios used by WG1 for the development of conceptual Decision Support Tools to guide monitoring design recommendations.

These scenarios may be used by WG2 to identify technologies available to undertake the monitoring programme.

# Format

For each scenario, the following is described:

* Nature of catchment and receiving environment, including key contaminant pathways, and lag/transport times where applicable
* Key Values
* Key issues (i.e. what values are degraded and why)
* Basic description and aims of the land mitigation/management programme

The intent is to develop scenarios that cover a wide enough range of catchment characteristics and mitigation action types to test our thinking with regards to the development of the conceptual DST(s).

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| **Scenario 3 – Lake mitigation – Glacial lakes (oligotrophic)** | | | |
| **Current state** | | | |
| Catchment characteristics | Large freshwater lake. Monomictic, naturally oligotrophic, low phytoplankton, very high visual clarity  Surface and groundwater inputs /pathways into the lake  Naturally low P from glacial origin  Mainly natural catchments, some pressures from local urban expansion and intensification of pastoral land use in headwater catchments (close to streams and lake) |  |
| Key Values | Ecological health: Naturally oligotrophic, low TLI, high clarity. Naturally supports healthy macrophytes, shellfish (kakahi) and fish.  Public health: Primary contact, swimming, waterskiing etc. in lake  Recreational fishing: internationally valued trout fishery, supported by natural spawning in tributaries  Mahinga Kai: Eeling, koura and kakahi in stream network and lake but often disconnected due to dams |
| Key issues | Invasive macrophytes (*Lagarosiphon major* and *Elodea canadensis*)  Invasive algae (lake snot, *Cyclotella*)  Danger of increased eutrophication |
| Objectives of mitigation action | Status quo; no increase in catchment nutrient loads, maintain status quo of trophic state, avoid long-term deterioration |
| Mitigations | Control of invasives – long-term weed removal by NIWA  Riparian restoration - protection and restoration of riparian land around streams and lakes  Best management practices for pastoral catchment  Localised pressures from urban settlements: education |
| Monitoring Plan | |
| Key questions | **Invasives:** Status monitoring **Water quality:** Avoid long-term deterioration  **Time scales of response**: long-term monitoring |
| Attributes | High bottom-water DO, low chlorophyll, low cyanobacteria, high clarity, may have high reflectance (enhanced blue colour) from glacial flour |
| Site location | Throughout water column, sediments |
| Frequency | Monthly monitoring (water column), 5-yearly bottom sediments |
|  | Issues: monitoring very low levels of PO4, TP for detection of change (clarity and chlorophyll *a* may be more reliable |
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| Methods/  technologies | Annual minimum bottom DO critical indicator. Consider development of methods for low-level phosphorus monitoring |
| Success | Desire to maintain current trophic status, i.e., no further deterioration  Reduce existing invasive weedbeds |  |

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| **Scenario 3 – Lake mitigation - Smaller glacial lakes** | | | |
| **Current state** | | | |
| Catchment characteristics | Mid-size freshwater lake. Monomictic, high phytoplankton, blooms (cyanobacteria, dinofagellates like *Ceratium*), reduced visual clarity  May be multiple surface and groundwater inputs /pathways into the lake which had been modified in various ways, physically and chemically  Pastoral grazing is extensive in catchment; long-term pressure  Emerging pressure of increased human settlement, vineyards in some instances |  |
| Key Values | Ecological health: Naturally oligo-meso-trophic, elevated TLI, reduced clarity. Naturally supports healthy macrophytes, shellfish (kakahi) and fish.  Public health: Primary contact, swimming, waterskiing, etc. in lake  Recreational fishing: valued trout fishery, may be stocked by F&G  Mahinga Kai: Eeling, koura and kakahi in stream network and lake but often disconnected due to dams |
| Key issues | * Elevated TLI, reduced visual clarity over last 30 years, sustained anoxia (>50 years) in bottom waters during stratification * Elevated or rising N and P concentrations in both lake water column and inflow streams. * Cyanobacteria and other algae blooms and associated effects/concerns on primary contact recreation * Invasive zooplankton (although may be associated with reduction in trophic state) |
| Mitigations | * In-lake: Phosphorus inactivation * In catchment: Regional plan/ limit-setting process led to FEP/compulsory development of FEPs and implementation of BMPs. Full implementation over 10 year period (started 5 years ago) * Stated objectives, e.g., a 40% reduction in N inputs into lake from both groundwater and surface water. Relatively detailed information is available re. baseline and future N reductions at farm/enterprise scale. |
| Monitoring Plan | |
| Key questions | **Restoration monitoring: post restoration activities** |
| Attributes | P, N, DO, macrophytes |
| Site location | Throughout water column, sediments |
| Frequency | **Nutrients**  Medium term (monthly) – measurements in the water column  Shorter term (days) – monitoring of flocculation (sediment traps + visual survey + phosphorus + clarity)  Long term (every 5 years) – monitoring of P trends in sediment – is P re-released?  **Biota**  LakeSPI and zooplankton monitoring (e.g., rotifer TLI) – once a year |
| Methods/  technologies | Monitoring negative effects: short term acute effects, long-term chemical legacies in biota and sediments |
| Success | Reduced sustainable trophic level, reduced incidence of blooms, recovery of DO in bottom waters throughout year |  |

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| **Scenario 3 – Lake mitigation – Volcanic lakes** | | | |
| **Current state** | | | |
| Catchment characteristics | Medium/large freshwater lakes. Polymictic and monomictic, range of trophic states, cyanobacteria blooms in several lakes. Loss of DO in bottom waters of monomictic lakes over ~50 years  Surface and groundwater inputs /pathways into the lake  Natural/ geologically-derived elevated P levels, aquifers progressively enriched in N  Intensively grazed in many catchments (>50% in some catchments)  Effects of plantation forestry may not be benign, especially at harvest |  |
| Key Values | Ecological health: Variable, impacted by eutrophication, invasive macrophytes, catfish incursion (Rotorua/Rotoiti)  Public health: Cyanobacteria health warnings  Recreational fishing: Internationally recognised trout fishery in some lakes  Mahinga Kai: Reactivation of interest in cultural havests (koura), also relevant: kakahi, kokopu |
| Key issues | * Rising N and P concentrations in both lake water column and inflow streams. * Rising N trend in groundwater * Cyanobacteria blooms and associated effects/concerns on public health /swimming and fish/shellfish suitability for consumption |
| Mitigations | * In-Lake: Phosphorus inactivation, inflow diversion * In catchment: Regional plan/ limit-setting process led to FEP/compulsory development of FEPs and implementation of BMPs. Full implementation over 10-year period (started 5 years ago). Rule 11 (Rotorua); implementation of rules in regional Water and Land plans * Stated objectives are a 40% reduction in N inputs into lake from both groundwater and surface water. Relatively detailed information is available re. baseline and future N loss at farm/enterprise scale. * Bubble plume destratification |
| Monitoring Plan | |
| Key questions | * Establish full nutrient balance and quantify fluxes * Evaluate effects of inflow diversions * Link cultural health monitoring to restoration actions * Duration of effectiveness of actions designed to be temporary |
| Attributes | Loads in and out of the lake/including   * P/N * Water quantity * Sediment |
| Site location | Throughout water column, sediments |
| Frequency | **Nutrients**  Medium term (monthly) – measurements in the water column  Shorter term (days) – monitoring of flocculation (sediment traps + visual survey + phosphorus + clarity)  Long term (every 5 years) – monitoring of P trends in sediment – is P re-released?  **Biota**  LakeSPI and zooplankton monitoring (e.g., rotifer TLI) – once a year  **Cultural health monitoring** |
| Methods/  technologies | Issues with Si and Hg interference with nutrients, some inconsistencies  Existing extensive network of real-time monitoring in many of the lakes |
| Success | Reduced nutrient levels, recovery of taonga biota, restoring DO to bottom waters, reduced algal blooms |  |

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| **Scenario 3 – Lake mitigation – Riverine lakes** | | | | |
| **Current state** | | | | |
| Catchment characteristics | Medium/large freshwater lakes. Polymictic, highly eutropic/supertrophic, high phytoplankton, cyanobacteria blooms  Surface and groundwater inputs /pathways into the lake  N and P loads highly elevated  In some cases, wastewater inputs into lakes | |  |
| Key Values | Ecological health: Generally poor  Public health: Not advised for primary contact recreation  Recreational fishing: Some recreation fishing for exotic species (e.g., koi carp)  Mahinga Kai: Taonga species: longfin and shortfin eel. Kakahi. | |
| Key issues | * Disconnection from river * Cyanobacterial blooms * Deoxygenation despite shallowness * Pest fish, invasive plants (if present - most of now devegetated) * Historical loss of wetlands * Wind induced resuspension of sediment * Lakes become very shallow from very high rates of sedimentation | |
| Mitigations | * **Main option:** Flushing flows (get residence time below 30 days, resuspend and flush sediment) * Reduce external load by 50% or more for effectiveness of in-lake remediation options * Restore macrophyte beds decimated by pest fish, wind resuspension and loss of clarity * Mitigate stock access * Control invasive plants during remediation * Remove large biomass of benthivorous pest fish | |
| Monitoring Plan | | |
| Key questions | 1. Baseline monitoring 2. Modeling/monitoring of flushing flows 3. Inflow diversion monitoring. 4. Ability to achieve effective pest fish removals | |
| Attributes | To establish regime flushing regime: Loads in and out of the lake/including   * P/N * Water quantity * Sediment | To monitor post restoration:   * Macrophyte recovery * Benthos * Pest fish |
| Site location | Throughout water column, sediments | |
| Frequency | **Establishment:** High frequency year long P/N, water quality, sediment  **Post restoration**: Annual/twice a year | |
| Methods/  technologies | Real-time monitoring to capture variability from polymictic and eutrophic character of lake. Effective assessment tools for pest fish biomass | |
| Success | Reduced nutrients and sediments, macrophyte cover return, taong species recovery | |  |

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| **Scenario 3 – Lake mitigation - Peat lakes** | | | |
| **Current state** | | | |
| Catchment characteristics | Small/mid sized freshwater lakes.  Polymictic, highly eutropic/supertrophic, high phytoplankton  Dairy pasture, high nutrient loading.  <https://www.waikato.ac.nz/__data/assets/pdf_file/0010/416845/ERI_Report_94_FINAL.pdf> |  |
| Key Values | Ecological health: Generally poor  Public health:  Recreational fishing:  Mahinga Kai: |
| Key issues | * very high levels of nutrients * high levels of microscopic algae (phytoplankton) * high levels of suspended sediment * Ngaroto – high degree of regulation – reversal of water levels |
| Mitigations | **Phase 1 – mitigation:**   * Catchment restoration/riparian replanting * Koi carp (pest fish) control   **Phase 2 – restoration after threat mitigation**   * Geochemical engineering to remove nutrients |
| Monitoring Plan | |
| Key questions | 1. Does mitigation work (nutrient balances, koi carp)? 2. Does restoration provide stable nutrient levels |
| Attributes | **Both phases:** Thermistor chain, bottom DO sensor to monitor anoxic sediments, remote sensing of water colour (green: pre-restoration algae, brown: return to original state)  **Additional Phase 1:** Monitoring of Koi carp control **Additional Phase 2:** Geochemical effects on macrophytes/benthos |
| Site location |  |
| Frequency | **Remote sensing and autonomous sensors:** continuous **Biological monitoring:** biannual |
| Methods/  technologies |  |
| Success | Reduced nutrients, reduced koi carp numbers |  |

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| **Scenario 3 – Lake mitigation – Shoreline lakes (Waituna, Forsythe, Onoke, Ellesmere, Wainono lagoon)** | | | |
| **Current state** | | | |
| Catchment characteristics | Small/mid sized estuarine lakes  Variable trophic status from mesotrophic to highly eutrophic.  Improving lake to national standard would  have 'severe social and economic'  consequences  Charlie Mitchell 20:16. Aug og 2017  Lake Ellesmere is one of the most polluted lakes in the country.  00000  ".LLKEA,'STJFF  Nearly every dairy farm in the Selwyn district would need to be shut down for  a polluted lake to meet national water quality standards, Environment  Canterbury (ECan) has told the Government. Improving lake to national standard would  have 'severe social and economic'  consequences  Charlie Mitchell 20:16. Aug og 2017  Lake Ellesmere is one of the most polluted lakes in the country.  00000  ".LLKEA,'STJFF  Nearly every dairy farm in the Selwyn district would need to be shut down for  a polluted lake to meet national water quality standards, Environment  Canterbury (ECan) has told the Government. |  |
| Key Values | Ecological health: Generally poor  Public health:  Recreational fishing:  Mahinga Kai: |
| Key issues | Dual threats from runoff and reduced inflows   * Intensification of agriculture * Drawdown of inflow waters for irrigation * Climate change |
| Mitigations | * Runoff mitigation * Extended riparian planting * Dredging/ICOLL * Control water extraction by users * Macrophyte restoration * Outflow management regimes |
| Monitoring Plan | |
| Key questions | 1. Does opening the outflow change water quality (yes in Waituna, no in Ellesmere - see Schallenberg et al.) 2. Can macrophytes be restored |
| Attributes | **Automated:** Salinity, temperature (detecting temporary stratification which can lead to anoxia)  **Direct effects:** Macrophyte restoration  **Additional benefits:** monitoring for eels/migratory fish |
| Site location |  |
| Frequency |  |
| Methods/  technologies |  |
| Success | Restored macrophyte beds, reduced nutrient loads |  |