Lake Kowhai

Baseline Assessment Summary Report

AOTEAROA LAKES

CITIZEN SCIENCE FOR OUR LAKES

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Introduction

Lake Kowhai, also known as Emerald Lake and Green Lake, is a small shallow lake in South Head adjacent to 90 Trig Road. This lake has never been formally assessed or studied and has limited to no historic information on it. Aotearoa Lakes has undertaken a bassline assessment of Lake Kowhai with a focus on understanding the current ecological values, identifying key impacts/pressures and drafting a long-term management plan.

The baseline assessment was conducted over three separate surveys across two years (2020 - 2021), a reconnaissance trip and two seasonal in-lake surveys (spring and autumn respectively). Various terrestrial and in-lake surveys were done during these site visits including a comprehensive assessment of in lake biodiversity (fauna & flora), habitat mapping and lake zone delimitation. A catchment and in-lake impacts assessment was also completed. The combination of these assessments will inform the final long term management plan.

This report summarises the key results from the baseline and impacts assessments as well as the initial management plans proposed. Please contact Aotearoa Lakes for further information if required.

Lake Kowhai Metadata

This lake is part of the Kaipara South Head Dune Lake Complex and has a total area of 0.98 ha and a perimeter of 0.51 km. The maximum depth recorded was 5.8 m and the mean depth is approximately 3.5 m, majority of the lake is between 1 to 3 m deep.

Figure 1: Map indicating the total lake area and perimeter.

The catchment consists of three dominant land use types; forestry, deer farming and native bush. The lake is located within a steep sided valley which forms a small sub catchment composed largely of native bush and wetland.

The immediate lake margin (0 – 5 m) consists of dense riparian vegetation largely composed of common reed/rush/sedge assemblages. There is a high degree of shading along the lake margins from overhanging vegetation and the steep slopes that surround majority of the lake. There is an established wetland along the north east bank that extends into a gully stretching north east along the adjacent property boundary.

The surrounding native bush has a mature canopy and almost 100% cover however, the understory is heavily damaged and poorly developed as a result of grazing pressure from feral deer.

It is assumed that the lake is feed via precipitation, overland flow, and groundwater incursion. The exact contribution of each of these sources to the total lake volume is unknown. The lake residence time is also unknown but considering the shallow depth and relatively small volume it is assumed that the residence time would be short.

In-lake Biodiversity

The lake is a good representation of a shallow upper North Island dune lake. The macrophyte assemblage is not as diverse as the neighbouring Lake Rototoa which is significantly larger and deeper however, Lake Kowhai remains one of the best examples of shallow dune lake macrophyte assemblages in the region and is likely the most intact on the South Head peninsula.

The dominant macrophyte species are charophytes and native pond weeds. *Chara australis* is the most abundant species and accounts for majority of the macrophyte cover. *Chara fibrosa* and *Chara globularis* are also present amongst the extensive charophyte beds but in a far smaller biomass than *Chara australis*. Various Nitella species (likely *Nitella Hookeri, Nitella sp. aff. Cristata, Nitella leonhardii* and *Nitella pseudoflabellata*) were found throughout the shallow sections of the lake. Native pondweeds (*Potamogeton ochreatus*) were found along the deeper sections of the lake.

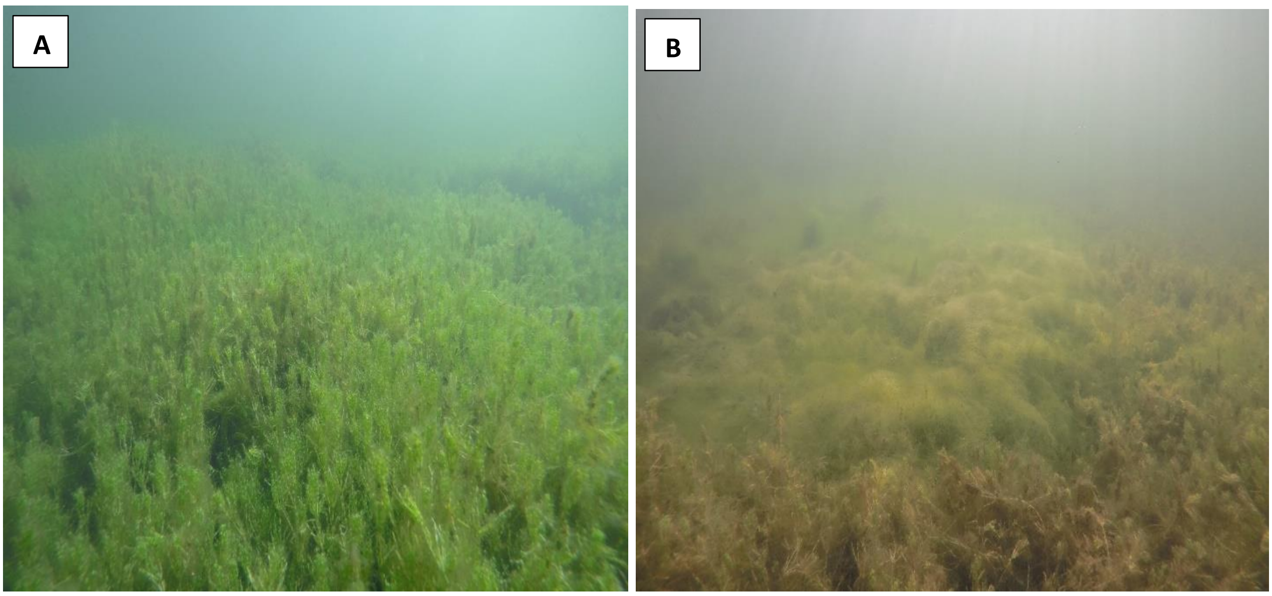

Figure 2: (A) *Chara australis* meadow; (B) Charophyte meadow with *Nitella spp* draped over it

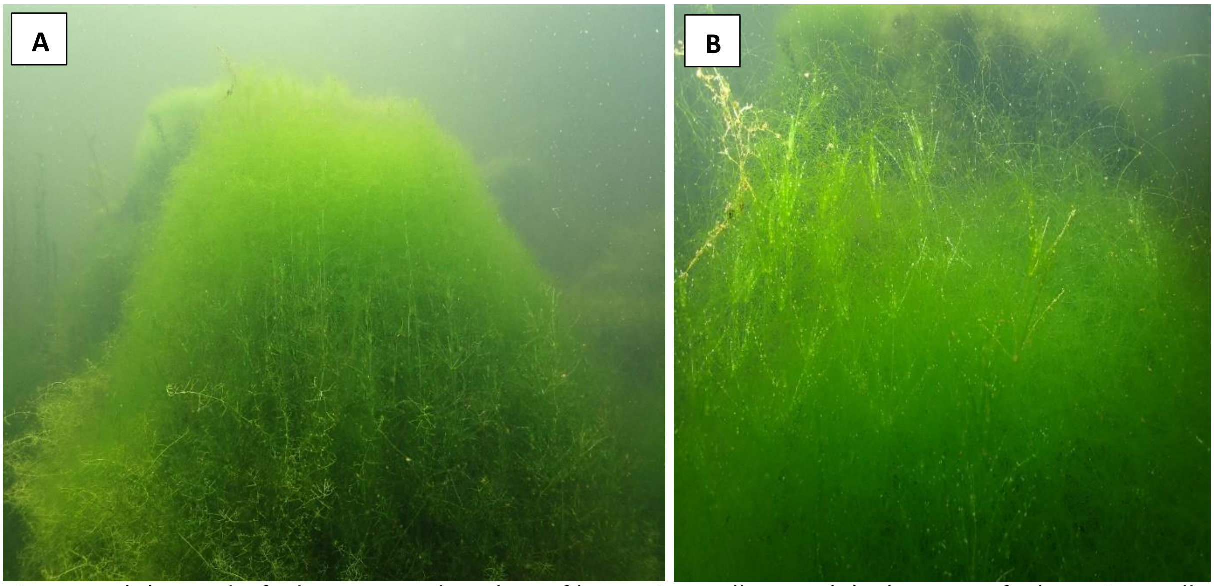

Figure 3: (A) Stand of *Chara australis, Chara fibrosa* & *Nitella spp*; (B) Close up of *Chara* & *Nitella* complex

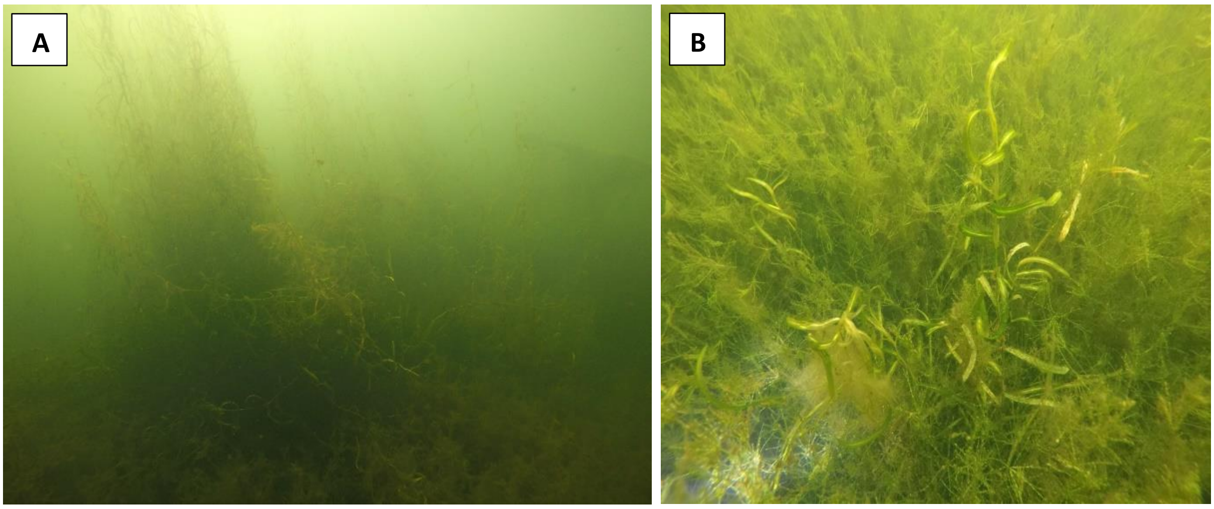

Figure 4: (A) Tall stands of *Potamogeton ochreatus*; (B) *Potamogeton ochreatus* amongst charophyte meadow

No fish were sighted on any of the dive surveys indicating that the overall fish biomass is low. Various habitats were sampled for eDNA to detect any fauna that were missed during the dive surveys. Shortfin eels (*Anguilla australis*) and mosquitofish (*Gambusia affinis*) were the only fish species detected. Low traces of invasive *Gambusia* were detected at a single site along the northwest bank and all sampling locations were positive for shortfin eels. The highest concentration of eels were detected along the northern sections of the lake closest to the wetland. This section of the lake has dense submerged vegetation and large sunken trees/branches with deep undercut banks which explains why eels were not sighted by the divers.

No kākahi or koura were detected by the divers or the eDNA analysis and there were no signs of their previous existence in the lake. There were a lot of sponges sited on submerged tree debris throughout the entire lake. The eDNA analysis confirmed that these sponges are *Ephydatia fluviatilis* and *Eunapius subterraneus.* An invasive jellyfish (*Craspedacusta sowerbii*) was also detected in low concentrations along the northern section of the lake.

A relatively high concentration of *Simocephalus vetulus* was detected throughout the lake. This water flea species actively grazes on suspended phytoplankton (up to 70% of the daily phytoplankton biomass) and is commonly associated with high water clarity. Various macroinvertebrates were sighted throughout the lake and dragonfly larvae were common. The macroinvertebrates were not identified or surveyed in detail.

Several cormorants/shags were sighted perched upon the emergent tree debris and overhanging branches along the northeast bank. A dabchick was also sighted near the wetland margin along the northeast bank. Several common wetland and garden birds were observed throughout the wetland margin and surrounding riparian vegetation.

The in-lake biodiversity value of Lake Kowhai is considered high despite the lack of aquatic fauna. The lake has intact native macrophyte assemblages and vast charophyte meadows that span almost the entire lake. Charophyte meadows of this scale and condition are increasingly rare and Lake Kowhai arguably has the best example of these in the region. The in-lake habitat and surrounding riparian margin is capable of supporting a diverse assemblage on native biodiversity.

Biosecurity

Two species of invasive macrophytes and one species of invasive fish were found during the surveys. *Utricularia gibba* was found amongst the reeds that border the lake. This invasive macrophyte does not pose a significant risk and has a minimal impact on the native biodiversity. It was found in low quantities and was confined to the submerged portions of the surrounding reeds. *Egeria densa* was detected along the northeastern bank of the lake, this species is extremely destructive and can cause significant impacts on lake health. *Egeria* is commonly associated declining water quality and can quickly overrun an entire lake, displacing native species.

Egeria densa forms dense beds that grow taller than native charophytes. This dense growth shades out native species and prevents them from establishing. Large *Egeria* beds also cause water stagnation which leads to localised anoxia, this anoxia prevents native species from occupying these areas and contributes to internal nutrient remobilisation. *Egeria* dies back seasonally and contributes significant amounts of organic material, this organic input coupled with anoxic conditions promote internal nutrient loading. If there is a high enough biomass of *Egeria* this cycling of organic matter, formation of anoxia and displacement of native species can accelerate eutrophication leading to an overall decline in lake health.

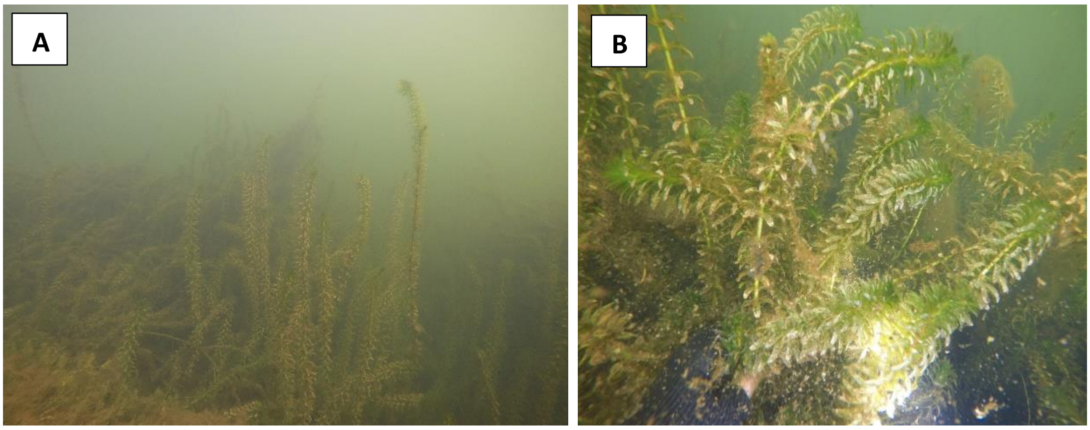

Figure 5: (A) *Egeria densa* bed; (B) close up of dense *Egeria* stand

Mosquitofish (*Gambusia affinis*) was the only pest fish species detected. The population is likely to be low considering only a single fish was sighted on the surface near the southern end of the lake, no fish were seen during the diver surveys. This observation was validated by the eDNA analysis which showed low traces of *Gambusia* along the north western bank, all other sampling locations were negative for *Gambusia*. This species is near impossible to eradicate and can cause significant damage to native biodiversity. The population in this lake has not grown to the extent one would expect and the exact reasons for this are unknown. One theory is that the lake does not have an abundance of their preferred habitat type, majority of the littoral zone is shaded by overhanging vegetation and steep slopes. This shading moderates the water temperature and creates less suitable conditions for these fish.

There were no signs of grazing damage on the macrophytes and no sediment feeding pits which indicate other pest species like Rudd, Carp and Tench are absent from the lake. This observation was validated by the eDNA analysis which did not detect any other pest fish species aside from *Gambusia.*

Craspedacusta sowerbii is an invasive freshwater jellyfish that was detected along the norther section of the lake. This species was detected in low concentrations and is likely limited by the shading and relatively low water temperature. This species feeds on zooplankton and is unlikely to have a significant effect on overall lake health.

The biggest biosecurity impact/pressure in this lake is the *Egeria,* the other pest species exist in low enough numbers that they are unlikely to cause a significant effect. The *Egeria* is largely confined to an approximately 500 m^2 area along the north east bank. Again, the high degree of shading around the littoral margins has confined majority of the biomass to the north facing bank with the least amount of shading. *Egeria* prefer moderate to high light conditions and relatively warm temperatures. The shading around majority of the lake and lack of human access/recreational use has hampered the spread of *Egeria* throughout the lake. That being said the risk of lake-wide spread is high and if left untouched the *Egeria* biomass could increase exponentially and overrun the lake.

Figure 6: Map indicating *Egeria densa* incursion area

Lake Zone & Habitat Delimitation

Lakes are typically delineated into zones based on a variety of factors (light penetration, macrophyte extent etc.). Considering the maximum depth of the lake is 5.8 m and the average horizontal visual clarity is 5 – 6 m light can reach the entire lake, this means there is no distinction between photic and aphotic zones. No significant vertical temperature variations were noted, and the temperature largely remained constant at all depths. This means the lake is considered isothermal and is unlikely to stratify seasonally. As a result, the lake cannot be delimited into a well-defined epilimnion and hypolimnion.

Lake Kowhai can be delimited into two dominant zones, namely the littoral zone and the limnetic zone. The littoral zone is the shallow areas along the margins of the lake and is largely defined by the macrophyte extent which extends to an average depth of 4 m. The limnetic zone starts past this depth and extends to the maximum lake depth, this zone encompasses the deeper (4 – 5.8 m) centre portion of the lake.

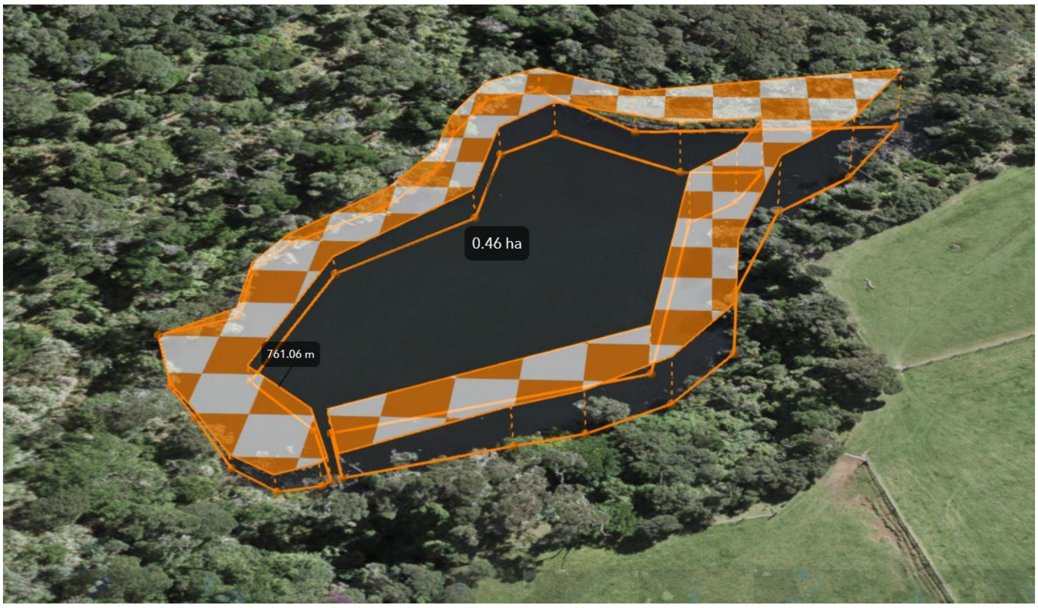

Figure 7: Map indicating the littoral zone of the lake

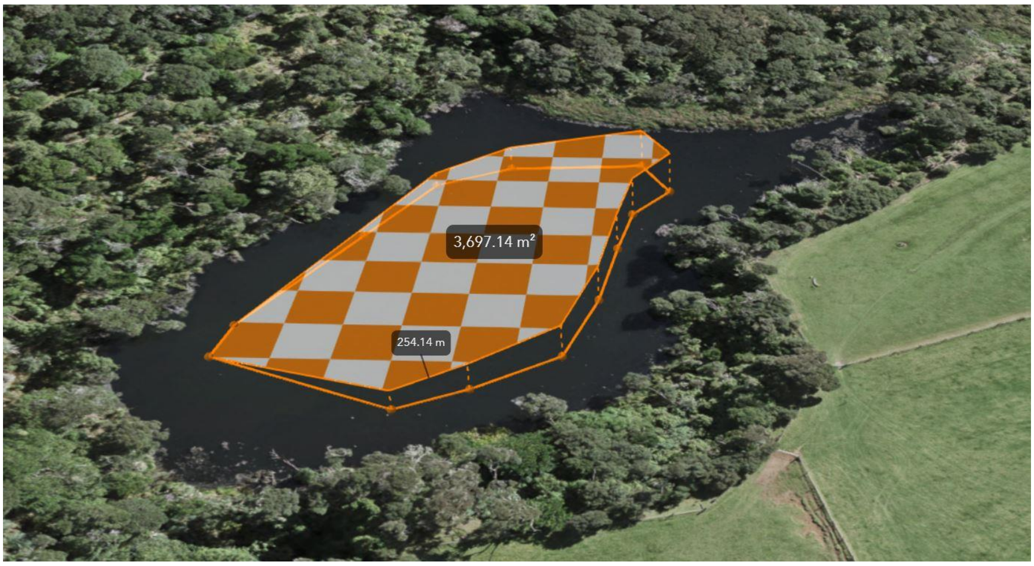

Figure 8: Map indicating the limnetic zone of the lake

Majority of the in-lake biodiversity and habitat is found within the littoral zone. The emergent riparian vegetation (reed line) marks the start of this zone. The macrophyte beds are well defined and constrained to specific depth contours. The charophytes formed dense beds from the edge of the reed line (0.5 – 1 m depth) down to a maximum extent of 4.5 m, the mean lower charophyte extent was 3 m deep. The pond weeds formed a line that mirrored the 3 – 4 m depth contour with sporadic stands down to a maximum depth of 5 m. There is a large amount of tree debris throughout the littoral zone which serves as substrate for sponges and algal growth, Nitella species are also commonly found draped over submerged tree debris.

The limnetic zone is the deepest region of the lake (5 – 5.8 m) and is largely devoid of macrophyte growth. Large areas of the sediment surface in this zone are covered by benthic algal mats. Benthic algal mats are common throughout the lake but are persistent at 5 m or deeper. There is a marked change in substrate that defines the start of this zone, the sediment changes from a fine sand to a very fine silt and mud complex. The top layer of sediment consists of a surficial layer of fine organic silt over a semi-fluid sediment layer with patches of more muddy textured sediment. This top layer is more than a meter thick in parts and consolidated sediment can be found between 1 – 1.5 m below this top layer.

In terms of habitat provision, Lake Kowhai has a diverse array of defined habitat types. Majority of the banks have deep undercuts and woody debris with overhanging or emergent vegetation that support macroinvertebrates and eels. The southern section of the lake has extensive shallow charophyte meadows that contain a diverse macrophyte assemblage. The northern and northeast banks receive the most sunlight and have a slightly different macrophyte assemblage. The submerged tree debris scattered throughout the lake provide habitat/substrate for a variety of sponges and macrophytes.

Impacts

The surveys noted were several signs of environmental degradation both above and below the water. The native bush that dominates the steep sloped sub catchment had limited to no understory as a result of grazing pressure from feral deer and pigs. The lack of understory reduces the filtration capacity of the sub catchment. This lack of filtration allows nutrients and sediment from the surrounding farm and forestry block to flow freely into the lake. The sediment laden sheet flow causes excessive sediment deposition along the littoral zone which smothers the native macrophyte beds and reduces water clarity. Excessive sedimentation and macrophyte smothering were observed across the entire lake during both surveys. The sedimentation was noticeably worse along the western margin of the lake, presumably as a result of the resent felling of the adjacent forestry block.

Nutrient rich runoff causes excessive in-lake nutrient concentrations and results in eutrophication, the effects of which were observed throughout the lake. There was a gelatinous green surface algal mass present during the October 2020 survey, this surface algal bloom was assumed to be cyanobacteria. No formal testing was done however the algal mass matched the morphological characteristics associated with cyanobacteria blooms. These blooms are a common symptom of excessive nutrient concentrations and eutrophication in general.

There were persistent blue-green benthic algal mats noted on both in-lake surveys. During the October 2020 survey these benthic algal mats were largely confined to the deeper limnetic zone with sporadic cover in the littoral regions. During the May 2021 survey benthic algal mats were found across majority of the lake with almost 100% cover in most sections of the littoral zone. These algal mats completely covered extensive sections of charophyte beds and contributed to large areas of anoxia. During the October 2020 survey a surficial sulphide layer was observed, this layer was more prominent in the southern portion of the lake but was noticeable across the entire water body. The exact cause of this layer is not known however, its formation is likely attributed to anoxic conditions induced by the decomposition of organic matter (plant and algal material) on the sediment surface. When this anoxic water comes into contact with the overlying oxygen rich water a sulphide precipitate forms which causes the smoky appearance of the resulting layer.

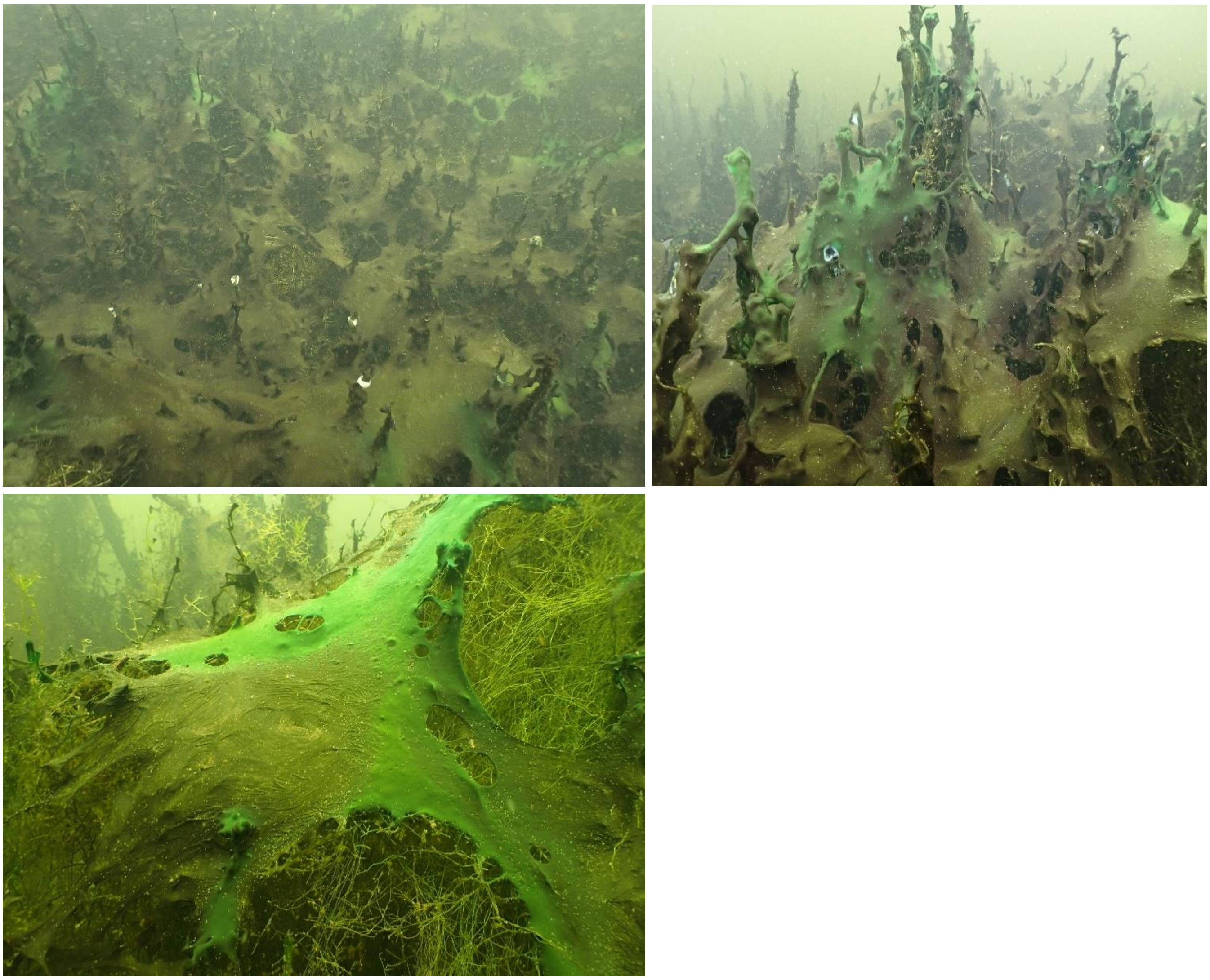

Figure 9: Blue-green algal mats smothering charophyte meadows

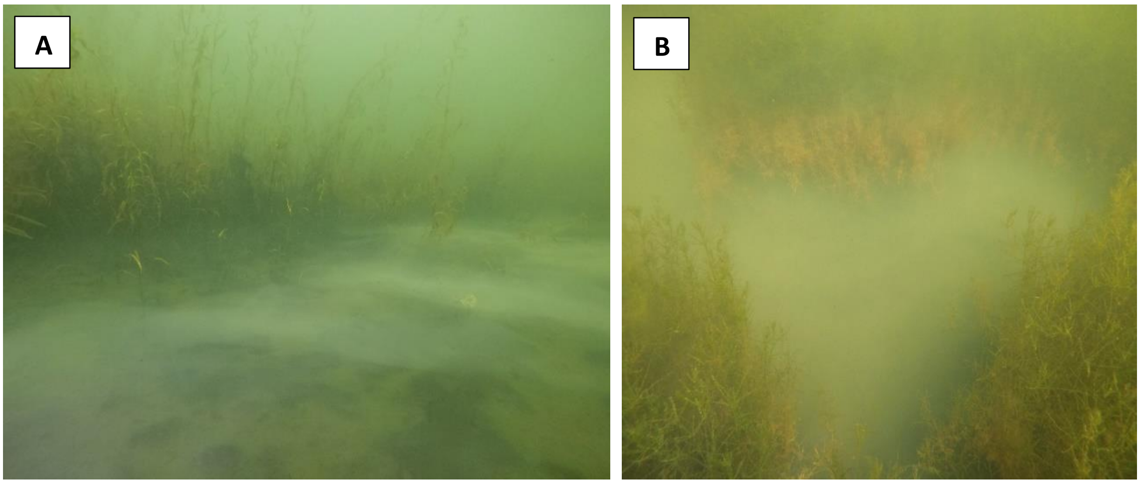

Figure 10: (A) Sulphide layer above the sediment surface with patches of benthic algal mats; (B) Sulphide precipitate accumulation with the charophyte meadows

Persistent algal mats, anoxic benthic conditions and sulphide layers are indicative of nutrient enrichment which is the principal impact to this lake. Sedimentation is considered a secondary impact. The surrounding land use (agriculture and forestry) was assessed as the primary source of nutrients and sediment entering the lake however, the effects of internal nutrient loading have not been quantified.

Management Actions

Considering eutrophication and sedimentation are the key impacts all management strategies should be focused on mitigating the effects and contributing sources. Management strategies for this lake can be broken down into two categories, catchment related and in-lakes interventions.

The key catchment related issue is the lack of filtration capacity provided by the sub catchment. It is recommended that the entire sub catchment is fenced to exclude feral deer/pigs and prevent them from grazing the understory. Deer and pig control within the newly fenced sub catchment is also advised to speed up the recovery of the native understory. If the deer and pigs are removed natural regeneration of the understory will occur however infill planting would speed up the recovery and result in better outcomes.

Mitigating eutrophication in-lake is challenging without a comprehensive understanding of sediment and water quality parameters. It is recommended that water quality and sediment samples are taken seasonally to establish a baseline understanding of the nutrient dynamics in the lake, this information will guide further in-lake interventions. The immediate actions that can be taken are the removal of *Egeria densa* from the lake, this incredibly invasive species contributes to nutrient enrichment and the formation of anoxic conditions. The *Egeria* is currently contained to the northeast section of the lake and can be removed by hand, if it is not removed soon there is a high chance it will spread throughout the lake. If *Egeria* is allowed to establish across the lake, removal/eradication will be extremely difficult and impossible in some cases.

A combination of interventions is needed to restore this lake, but the impacts are few and the required management is relatively low cost. The lake has high ecological value and can be readily enhanced using simple management strategies.