Ecological Effects of Wakesports

Implications for shallow lakes,

including Lake Windermere and Columbia Lake

An applied literature review to support lake stewardship and decision-making





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wildsight

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Contact

info@wildsight.ca

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Limitations and permitted use

This report is an applied review of scientific and technical literature available at the time of preparation. It does not present the results of a site-specific experimental assessment of wakesports on Lake Windermere or Columbia Lake. Findings from other waterbodies were evaluated for their relevance to the physical and ecological characteristics of these lakes, but local responses may vary with water depth, substrate, shoreline condition, weather, boating intensity, and other factors.

The report is intended to support stewardship, planning, policy development, and further investigation.

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Executive Summary

Wakesports, particularly wakesurfing, use boats configured with ballast systems, specialized hull designs, and wave-shaping devices to generate enhanced wakes. These wakes are generally higher, have longer wave periods, and carry more energy than those produced by conventional recreational boats. Where lake depth or operating space is limited, they reach shorelines and interact with shallow lakebeds and associated habitats before fully dissipating.

> This report reviews scientific and technical evidence on the ecological effects of wakesports and evaluates its relevance to shallow freshwater lakes, focusing on Lake Windermere and Columbia Lake in the Columbia River headwaters region of British Columbia.

Wakesports suitability depends on two factors: a lake's overall susceptibility to boating-related effects, and whether it contains enough operating space away from shorelines and shallow water. This review applies a wakesports suitability framework to each lake, assessing both factors and interpreting the results together. Lake-wide susceptibility reflects factors such as mean depth, the extent of shallow littoral habitat, fine sediments, shoreline condition, sensitive habitats and species at risk, water quality, and boating density. Operating space depends on whether any area meets minimum requirements for depth, distance from shore, area, width, and operating length.

What the literature shows

The reviewed literature documents physical effects of wakesports and identifies how they can affect lake ecosystems. When enhanced wakes reach shorelines, their energy increases erosion potential where shoreline materials are erodible and natural buffers are limited. In shallow water, wake-induced near-bed movement and propeller wash can resuspend fine sediments and reduce water clarity. Resuspension can also mobilize sediment-bound phosphorus, potentially increasing its availability for algal growth. Repeated physical disturbance can damage or uproot aquatic plants. Because these plants stabilize sediments, support clear-water conditions, and provide habitat, their loss can reinforce sediment resuspension and turbidity, further reducing vegetation and habitat quality.

Shallow vegetated areas provide spawning, rearing, and refuge habitat for fish, as well as nesting, feeding, brood-rearing, and staging habitat for waterbirds. Repeated wave exposure and vessel passage can disturb these habitats, while close approaches can alter animal behaviour and habitat use. Ballast systems create an additional transport risk because they can retain residual water and viable organisms in components that are difficult to drain fully or inspect. Moving ballast-equipped boats between waterbodies therefore increases the risk of transporting aquatic invasive species relative to boats without ballast systems.

The strength of evidence varies among these effects and processes. The evidence base is strongest for wake characteristics and directly measured physical processes. Wave height, period, energy, power, and attenuation with distance have been directly measured, as have near-bed water movement, propeller wash, sediment resuspension, and the retention of residual water and viable organisms in ballast systems. The general relationship between wave energy and shoreline erosion potential is also well established, whether waves are generated by wind or vessels. So are the relationships between sediment resuspension, turbidity, and nutrient mobilization, although site-specific outcomes depend on local conditions.

Direct wakesport-specific evidence for shoreline erosion, aquatic-vegetation loss, and effects on fish and waterbirds is more limited. Evidence of vessel-caused shoreline erosion comes mainly from river studies and does not isolate wakeboats. Aquatic vegetation findings draw partly from conventional powerboat and other physical-disturbance studies, although field video has documented wakeboats operated for wakesurfing uprooting sparse submerged vegetation in shallow water; fish and waterbird evidence more often documents habitat disturbance and behavioural responses than long-term population-level change. These limitations require cautious interpretation but do not negate the documented physical effects or the basis for managing risk where lake conditions increase susceptibility.

Why Lake Windermere and Columbia Lake warrant particular attention

The potential for ecological effects is greater in shallow lakes with extensive littoral zones because there is little vertical separation between boating activity and the lakebed, and a large proportion of the lake supports shallow aquatic habitat. Lake Windermere and Columbia Lake both have these characteristics. Lake Windermere has a mean depth of approximately 3.4 m and a maximum depth of approximately 6.4 m, and about 95% of its area is littoral. Columbia Lake has a mean depth of approximately 2.9 m and a maximum depth of approximately 5.2 m. Aquatic vegetation occurs along about 84% of its shoreline, and littoral shelves extend more than 50 m from shore along 59% of the shoreline.

Both lakes are long and narrow. Boats travelling along the length of each lake send wakes toward the side shorelines, where the short cross-lake fetch limits wind-wave development. On these shorelines, wakes can make up a larger share of the wave energy, increasing their potential to contribute to erosion. Wind-driven waves also affect both lakes, but enhanced wakes add a human-generated source of erosive wave energy, including during calm periods when natural wave action is limited. Shoreline modification is extensive in both lakes, although its form and distribution differ. Consequently, the remaining natural shoreline segments are especially important for maintaining shoreline stability and habitat.

Warm summer temperatures can stress cold-water fish, while seasonally lower water levels decrease the water depth beneath boats. Both lakes also have documented concerns related to rising phosphorus concentrations, making additional sediment disturbance and nutrient mobilization particularly relevant.

Recreational-use surveys found that boating pressure on Lake Windermere is concentrated during peak summer periods. High-use areas, particularly at the north end, regularly exceeded a safe-boating-density

benchmark of one powerboat per 8 ha on weekends and long weekends. Wakesurf boats were the most frequently observed boat type (Larratt et al., 2024).

From evidence to a wakesports suitability framework

The framework pairs two assessments. The lake-wide assessment uses the Lake Suitability Index, developed by Larratt Aquatic Consulting to assess lake suitability for powerboating (Larratt et al., 2024). A qualified professional interprets the index rating and its indicators to determine which set of spatial criteria applies. The spatial assessment then maps whether any area of the lake meets those criteria. The two results are interpreted together; neither establishes wakesports suitability on its own.

The minimum spatial criteria draw largely from Vermont's 2026 wakesports-zone eligibility criteria, converted to rounded metric values. They retain Vermont's minimum depth, area, width, and operating-length requirements but replace its 152 m shoreline setback with a more protective, evidence-informed setback of 200 m.

> **Minimum spatial criteria.** These criteria require a depth of at least 6.1 m at the seasonally low operating water level and a distance of at least 200 m from all shorelines, including islands. They also require at least 40.5 ha of contiguous area, a width of at least 61 m, and a continuous operating length of at least 914 m.
>
> **Precautionary spatial criteria.** These criteria increase the minimum operating depth to 9 m and the shoreline setback to 250 m while retaining the same minimum area, width, and operating-length requirements. They provide an additional margin where the lake-wide assessment indicates elevated susceptibility, including extensive littoral shallows, fine sediments, erodible shorelines, sensitive habitats, water-quality concerns, seasonal water-level variability, or uncertainty in bathymetry or sediment conditions.

A *Negligible Risk* or *Very Low Risk* rating indicates lower lake-wide concern and supports proceeding to the spatial assessment using the minimum spatial criteria. For a *Low Risk* or *Moderate Risk* rating, the indicators behind the index score are reviewed for their relevance to wakesports, along with any important information gaps. This review determines whether the minimum or precautionary spatial criteria apply. Greater wakesport-relevant susceptibility supports use of the precautionary spatial criteria and may weigh against considering a wakesports operating area. A *High Risk* or *Extreme Risk* rating indicates substantial lake-wide concern and weighs strongly against considering a wakesports operating area. A lake-wide restriction would generally be proposed, unless a qualified professional determines that a spatial assessment is warranted, in which case the precautionary spatial criteria apply.

An area meeting all five applicable spatial criteria is identified as a candidate zone and would be proposed as a wakesports operating area. It would become a designated operating area only if Transport Canada approves the restriction. Together, the two assessments inform whether a lake-wide wakesurfing restriction or a restriction outside a candidate zone should be considered under the current *Vessel Operation Restriction*

Regulations (VORR). The framework could also support a standardized, criteria-based process for Transport Canada's consideration.

Application of the framework identifies different limitations in the two lakes. Lake Windermere received an index score of 53/60, corresponding to an *Extreme Risk* index rating, so a lake-wide restriction would generally be proposed. Even if a spatial assessment were warranted, the precautionary spatial criteria would apply. The lake contains no candidate zone under the precautionary criteria because its maximum depth of approximately 6.4 m is less than the 9 m depth criterion. For comparison, approximately 63 ha met the minimum spatial criteria. This result demonstrates that adequate physical space alone does not establish wakesports suitability or support designation of a wakesports operating area.

Columbia Lake contains no candidate zone under either set of spatial criteria because its maximum depth of approximately 5.2 m is less than the 6.1 m depth criterion. The Lake Suitability Index has not been applied to Columbia Lake, but this spatial result does not depend on an index rating.

A coordinated regional application

Transport Canada's current *Local Authorities' Guide* requires an eligible local authority to submit a separate restriction request for each waterbody. This report proposes that Transport Canada consider an alternative: one coordinated regional application that includes all lakes in a regional district with road access for trailered boats. Lakes already subject to a restriction prohibiting wakesurfing would be excluded.

Where a candidate zone is identified, the proposed restriction would apply outside that zone. All other lakes, including those smaller than 40.5 ha, would be proposed for a lake-wide Schedule 7 wakesurfing restriction. The application would draw on substantial existing evidence, including peer-reviewed studies, technical reports, and local monitoring. It would apply the wakesports suitability framework to each lake, providing assessment results and a distinct proposed restriction for each waterbody.

Preliminary mapping shows how this would work in practice. The north and south basins of Moyie Lake contain areas meeting both sets of spatial criteria, subject to their lake-wide assessments. St. Mary Lake likely contains such areas as well, although updated bathymetry is needed to confirm this.

Lake Windermere meets the minimum spatial criteria, but its *Extreme Risk* rating means a lake-wide restriction would generally be proposed. Columbia Lake does not meet them because no part of it is at least 6.1 m deep. Premier Lake also does not, because only 34.1 ha beyond 200 m from shore lies outside its already-restricted southern waters. Tie, Rosen, and Wasa lakes, where wakesurfing has raised local concern, do not meet the area criterion beyond 200 m from shore.

The initiative could verify the list of lakes to be included and coordinate information gathering and consultation. This would include addressing data gaps, such as missing or inconsistent bathymetry, and collaborating with Indigenous Nations as well as other eligible local authorities. Coordinating this work regionally could reduce duplication among communities addressing similar concerns. Transport Canada staff have indicated that regional coordination may be possible (Transport Canada, personal communication, May 28, 2026). However, implementing a multi-lake application would still require Transport Canada's agreement because it differs from the current process.

This model is consistent with resolutions sponsored by the Regional District of East Kootenay (RDEK) to the Union of British Columbia Municipalities (UBCM) and the Federation of Canadian Municipalities (FCM). These resolutions call for objective, science-based waterbody criteria and a standardized federal approach to wakesurfing restrictions (FCM, 2025; UBCM, 2025a, 2025b). The UBCM Executive endorsed the resolution in 2025, and the FCM resolution remains active until March 2028. Vermont provides a regulatory precedent for linking wakesports-zone eligibility to measurable waterbody criteria, including depth, area, width, operating length, and distance from shore. Its approach provides an example of how standardized criteria can retain wakesports access on lakes containing a wakesports zone while excluding the activity from lakes that do not.

Conclusion

The physical and ecological characteristics of Lake Windermere and Columbia Lake indicate that both are susceptible to wakesport-related effects. Repeated wake exposure and lakebed disturbance may contribute to cumulative effects in shallow habitats and along sensitive shorelines. This disturbance would add to existing pressures, including other boating activity, shoreline modification, and rising phosphorus concentrations. Projected climate changes, including warmer water and lower late-summer flows, could further reduce depth beneath boats and increase the sensitivity of shallow habitats. The transport of aquatic invasive species in retained ballast water presents a separate concern.

> This review's findings support consideration of lake-wide wakesurfing restrictions for both lakes. For Lake Windermere, the *Extreme Risk* index rating indicates substantial lake-wide concern, and the lake contains no candidate zone. Columbia Lake is too shallow to contain a candidate zone under either set of spatial criteria.

The existing evidence is sufficient to support a VORR application for both lakes; further local research is not a prerequisite. Targeted local research, such as measuring wake energy, near-bed water movement, and sediment resuspension, could still help refine the depth and setback criteria over time. Monitoring that begins before a restriction takes effect would also provide a baseline for assessing its effectiveness and support adaptive management.

The evidence indicates that lakes differ in their suitability for wakesports. Regional lakes provide valued opportunities for recreational boating, and some can accommodate wakesports. Sustaining these uses over time depends on matching each activity to what a lake can support, which also helps maintain the ecological condition that recreation relies on. Applied regionally, the wakesports suitability framework could support consistent and defensible decisions by maintaining wakesports access where lakes can accommodate it and supporting restrictions where they cannot.

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Glossary of Terms

AIS. Aquatic invasive species. Non-native aquatic plants, animals, or pathogens (bacteria/viruses) that thrive in water bodies outside their natural range, causing significant ecological, cultural, recreational, or economic harm.

Ballast system. Onboard tanks, pumps, and plumbing in wakeboats that take in, retain, and discharge lake water to increase boat weight and produce larger, surfable wakes (Campbell et al., 2016; Ruprecht et al., 2015).

Bathymetry. The measurement and mapping of underwater depth and lakebed contours; bathymetric data are used in this report to identify shallow zones where wake energy is more likely to reach sediments and habitat.

Benthic. Refers to the bottom of a lake, river, or other waterbody, including the sediments, lakebed surface, and organisms that live on or within those bottom habitats.

Candidate zone. An area that meets all five applicable spatial criteria and would be proposed as a wakesports operating area. The applicable criteria, minimum or precautionary, are determined through the lake-wide assessment, so a candidate zone reflects both assessments. It becomes a designated wakesports operating area only if Transport Canada approves the proposed restriction.

Carrying capacity (recreational). An estimate of the level of recreational use a waterbody can support before ecological, social, or experiential thresholds are exceeded; applied here to boating intensity on Lake Windermere (Larratt et al., 2024).

Clean, Drain, Dry. A standard prevention protocol for aquatic invasive species in which watercraft and gear are cleaned of plant, animal, and mud debris; all water is drained from compartments including ballast and live wells; and equipment is dried before reuse on another waterbody (Government of British Columbia, 2025a).

CLSS. Columbia Lake Stewardship Society. Local stewardship organization that conducts water quality and water quantity monitoring, ecological monitoring, education, and outreach on Columbia Lake.

Displacement. An operating mode in which a boat travels slowly enough that the hull remains supported by buoyancy, pushing water aside rather than rising onto the surface; produces a relatively small wake. See Figure 1.

Dreissenid mussels. A group of small freshwater mussels including zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena rostriformis bugensis*); high-impact aquatic invasive species not yet established in British Columbia at the time of writing.

Ecological reserve. A designation under British Columbia's *Ecological Reserve Act* protecting representative or rare ecosystems for research, education, and conservation purposes.

EKILMP. East Kootenay Integrated Lake Management Partnership. Multi-agency partnership formed in 2006 to coordinate lake stewardship and planning in the region.

Euphotic zone. The upper, light-penetrated layer of the water column where photosynthesis can occur; relevant to discussions of nutrient cycling and primary production in shallow lakes.

FCM. Federation of Canadian Municipalities. National association of local governments. An

RDEK-sponsored resolution calling for objective, science-based waterbody criteria and a standardized federal approach to wakesurfing restrictions is active until March 2028 (FCM, 2025).

FDG. Foreshore Development Guide. A guidance document developed through the FIMP process that identifies shoreline sensitivity, Zones of Sensitivity, activity risk ratings, and recommended planning or permitting considerations for shoreline works.

Fetch. The uninterrupted distance over open water that wind can travel in one direction and build waves. Longer fetch generally allows larger wind-generated waves to develop.

FIM. Foreshore Inventory and Mapping. A standardized British Columbia methodology for documenting lake shoreline condition, habitat features, land use, and shoreline modifications.

FIMP. Foreshore Integrated Management Planning. A planning framework that uses FIM data to identify foreshore habitat sensitivity and inform shoreline development, conservation, and stewardship decisions.

Foreshore. The shoreline transition zone between the high-water mark and the lakebed, including nearshore aquatic habitat; a focal area for both ecological assessment and regulatory authority in British Columbia. In FIMP, it generally extends from the deeper edge of the littoral zone to an area up to 50 m inland from the high-water mark.

Internal nutrient loading. The release of sediment-stored nutrients, especially phosphorus, back into the water column when bottom sediments are resuspended or when chemical conditions at the sediment-water interface change; can amplify algal growth in shallow lakes.

Interstitial. Refers to the small spaces between sediment particles, such as gravel, cobble, or coarse lakebed material. In aquatic habitats, interstitial spaces allow water to move through the substrate, supporting oxygen exchange and providing habitat for fish eggs, larvae, invertebrates, and other bottom-associated organisms. In this report, interstitial habitat is relevant where fine sediment fills these spaces and reduces water flow, oxygen availability, or habitat suitability for spawning and juvenile rearing.

Lake Suitability Index. A screening index developed by Larratt Aquatic Consulting to assess lake suitability for powerboating (Larratt et al., 2024). It scores 12 indicators across four domains (limnology, recreational safety, habitat, and water quality) from 1 to 5, producing an index score of 12 to 60. Higher scores indicate greater assessed susceptibility, and each score corresponds to a published index rating from *Negligible Risk* to *Extreme Risk*. See Table 3.

Lake-wide assessment. The component of the wakesports suitability framework that evaluates a lake's overall susceptibility to boating-related effects using the Lake Suitability Index, interpreted by a qualified professional. It determines which set of spatial criteria applies. See Section 4.3.

Littoral zone. The shallow, nearshore portion of a lake where sunlight reaches the bottom and can support rooted aquatic plants. The depth of the littoral zone varies with water clarity, lakebed slope, and substrate, and it is often a primary area of ecological productivity and disturbance sensitivity.

LWA. Lake Windermere Ambassadors. Local stewardship organization that conducts water quality monitoring, aquatic invasive species and aquatic plant monitoring, education, and outreach on Lake Windermere, and that commissioned the lake's recreational impacts assessment.

Macrophyte. Rooted or floating aquatic plants visible to the naked eye; macrophytes stabilize

sediments, support fish and invertebrate habitat, and contribute to clear-water conditions in shallow lakes.

Mesotrophic. A lake trophic classification describing moderate nutrient concentrations and moderate biological productivity, intermediate between oligotrophic and eutrophic conditions.

Minimum spatial criteria. Proposed spatial criteria used in the spatial assessment: at least 40.5 ha of contiguous area, an operating depth of at least 6.1 m at the seasonally low operating water level, a shoreline setback of at least 200 m, a minimum width of 61 m, and a minimum operating length of 914 m.

Ministerial order. A regulatory instrument that allows the Minister of Transport, under subsection 136(3) of the *Canada Shipping Act, 2001*, to suspend or modify the operation of regulations such as the *Vessel Operation Restriction Regulations* (VORR).

Nearshore zone. The shallow water and shoreline area extending from the water's edge to depths typically supporting aquatic vegetation and juvenile fish habitat; often overlapping the foreshore and littoral zones.

No-wake zone. A legally designated or formally marked area where vessels must operate at a speed slow enough to produce minimal wake, typically idle speed or below planing speed. These zones are often used to reduce shoreline erosion, improve safety, and limit disturbance in nearshore or otherwise sensitive areas.

Oligotrophic. A lake trophic classification describing low nutrient concentrations, low biological productivity, and generally high water clarity. Lake Windermere and Columbia Lake are naturally oligotrophic systems.

Planing. An operating mode in which a boat travels fast enough for hydrodynamic lift to raise the hull so that it skims across the water surface, supported mainly by lift rather than by buoyancy. Conventional recreational boats typically cruise in this mode. See Figure 1.

Precautionary spatial criteria. Proposed, more protective spatial criteria that increase the operating depth to at least 9 m and the shoreline setback to at least 250 m while retaining the same minimum area, width, and operating-length requirements. They apply to lakes with a *High Risk* or *Extreme Risk* index rating and may apply to lakes rated *Low Risk* or *Moderate Risk*.

PWC. Personal watercraft. Small, jet-propelled vessels designed to carry one to three riders (for example, jet skis).

RDEK. Regional District of East Kootenay. Regional government whose jurisdiction includes Lake Windermere and Columbia Lake; a partner in both lake management plans and responsible for shoreline land-use direction through official community plans.

Riparian. The land-water interface zone adjacent to lakes, rivers, and wetlands; supports vegetation and wildlife that depend on the moisture, microclimate, and structural connectivity of shoreline habitats.

SARA. Species at Risk Act. Federal Canadian legislation that lists and protects species at risk of extinction or extirpation, including the Bank Swallow referenced in this report.

Schedules (VORR). Categories within the *Vessel Operation Restriction Regulations* that specify types of restrictions applicable to a defined waterbody (for example, Schedule 5 speed limits, Schedule 7 wakesurfing time restrictions); see Section 3.2.

Sediment resuspension. The lifting of fine bottom sediments back into the water column by wave energy, propeller wash, or other turbulence; reduces

water clarity and can release sediment-bound nutrients and contaminants.

Semi-displacement. An intermediate operating mode in which the hull is partly supported by buoyancy and partly by hydrodynamic lift, without fully planing. Wakesurfing typically occurs in this mode, with the wakeboat weighted and trimmed to maximize wave production (Riesgraf et al., 2025). See Figure 1.

Shoreline armouring (hardening). Modification of natural shorelines using hard materials such as riprap or retaining walls; reduces habitat complexity and can alter wave reflection and erosion patterns (Jennings et al., 1999).

Spatial assessment. The component of the wakesports suitability framework that maps whether any area of a lake meets the applicable spatial criteria for contiguous area, operating depth, shoreline setback, width, and operating length. See Section 4.3 and Table 2.

Substrate. The physical material making up the lakebed (for example, sand, silt, cobble); substrate composition influences erosion potential, vegetation establishment, and fish spawning suitability.

Turbidity. A measure of water cloudiness caused by suspended particles such as sediment, organic matter, or algae; reduces light penetration and is a common indicator of nearshore disturbance.

UBCM. Union of British Columbia Municipalities. Provincial association of local governments. In 2025, its Executive endorsed an RDEK-sponsored resolution calling for objective waterbody criteria and a standardized federal approach to wakesurfing restrictions.

Veliger. The free-swimming, microscopic larval stage of dreissenid mussels and other bivalves. Veligers can be transported between waterbodies in residual water held in ballast tanks, live wells, bilges, engines, and other watercraft compartments (Doll, 2018).

VORR. *Vessel Operation Restriction Regulations*. Federal regulations under the *Canada Shipping Act, 2001* that allow a local authority to request restrictions on vessel operation in specified waters (Transport Canada, 2025; Vessel Operation Restriction Regulations, 2008).

Wakeboat. A wakeboat is a motorized boat built or operated to create large, surfable wakes, often by using ballast tanks, hull design, and wake-shaping devices to displace more water than a typical powerboat.

Wakeboarding. A towed water sport in which a rider on a board uses the boat's wake for jumps and manoeuvres. Wakeboarding is typically performed at higher planing speeds than wakesurfing, around 20 to 24 mph (32 to 39 km/h) compared with 10 to 13 mph (16 to 21 km/h), with ballast use varying by boat and operator, and correspondingly produces smaller wakes, though wakeboarding behind a ballast-engaged wakeboat produces an enhanced wake.

Wakesports. In this report, an umbrella term for operating a wakeboat to produce an enhanced wake, or for using a surfboard, wakeboard, hydrofoil, or similar device to ride that wake. The report focuses primarily on wakesurfing. Wakeboarding and related activities are included only when conducted under enhanced-wake conditions. Operation of a wakeboat without producing an enhanced wake is not considered wakesports for the purposes of this report.

Wakesports operating area. A formally approved or designated area where wakesports may occur subject to applicable regulatory and operating requirements. A candidate zone is a proposed

operating area until Transport Canada approves the restriction.

Wakesports suitability framework. The framework proposed in this report for evaluating whether a lake can accommodate wakesports, and under what conditions. It pairs a lake-wide assessment with a spatial assessment and interprets the two results together. See Section 4.3 and Appendix B.

Wakesurfing[1]. A water sport in which a rider is initially towed and then releases the rope to surf continuously on a large, sustained wave generated behind a wakeboat operating at low speed. In this report, wakesurfing refers specifically to operation with the wake deliberately enhanced, typically through ballast, wake-shaping devices, hull design, or a combination of these features. This enhanced-wake operating condition is sometimes referred to informally as "surf mode."

Water skiing. A towed water sport in which a rider is pulled across the water surface on skis; typically performed at higher speeds than wakesurfing and producing different wake characteristics.

WCT. Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*). Native salmonid of the Columbia Basin, sensitive to nearshore habitat disturbance and substrate degradation.

Whirling disease. A fish disease caused by the parasite *Myxobolus cerebralis* that affects salmonids and can be transported in mud, water, and on watercraft; first detected in British Columbia in Emerald Lake, Yoho National Park.

[1] Transport Canada writes this term as two words ("wake surfing") in the *Vessel Operation Restriction Regulations*. This report uses the closed form "wakesurfing," for consistency with "wakeboat" and "wakesports," except when quoting the Regulations directly.

1. Introduction

Wake-based recreation has evolved considerably over the past few decades. In wakeboarding, an earlier and more established form of the sport, a boat tows a rider on a board using a rope, with the boat's wake serving as a launch point for aerial jumps and tricks (Brown, 2021; Francis et al., 2023). In wakesurfing, the rider is initially towed and then releases the rope to surf continuously on the boat-generated wave (Francis et al., 2023). Wakesurfing became increasingly prominent during the 2010s alongside the expanded availability of purpose-built wakeboats. In the United States, retail sales of wakesport boats nearly doubled from 8,204 units in 2016 to 16,164 units in 2021, an increase of approximately 97% (National Marine Manufacturers Association, 2025).

Wakeboats are specifically engineered to support these activities by generating more surfable wakes than conventional recreational motorboats (Figure 1). Ballast increases vessel displacement and lowers the stern, while hull design and wake-shaping devices such as plates, wedges, and surf gates modify wave height, steepness, and length (Francis et al., 2023; Ortiz et al., 2026; Ruprecht et al., 2015). As shown in Figure 1, wakesurfing typically occurs in a semi-displacement operating mode, where the boat is not fully planing and is intentionally weighted and trimmed to maximize wave production (Riesgraf et al., 2025). Compared with ordinary cruising and many wakeboarding conditions, this operating mode is associated with fuller ballast, lower speeds, and larger, longer-lasting waves (Brown, 2021; Macfarlane, 2025; Ruprecht et al., 2015).

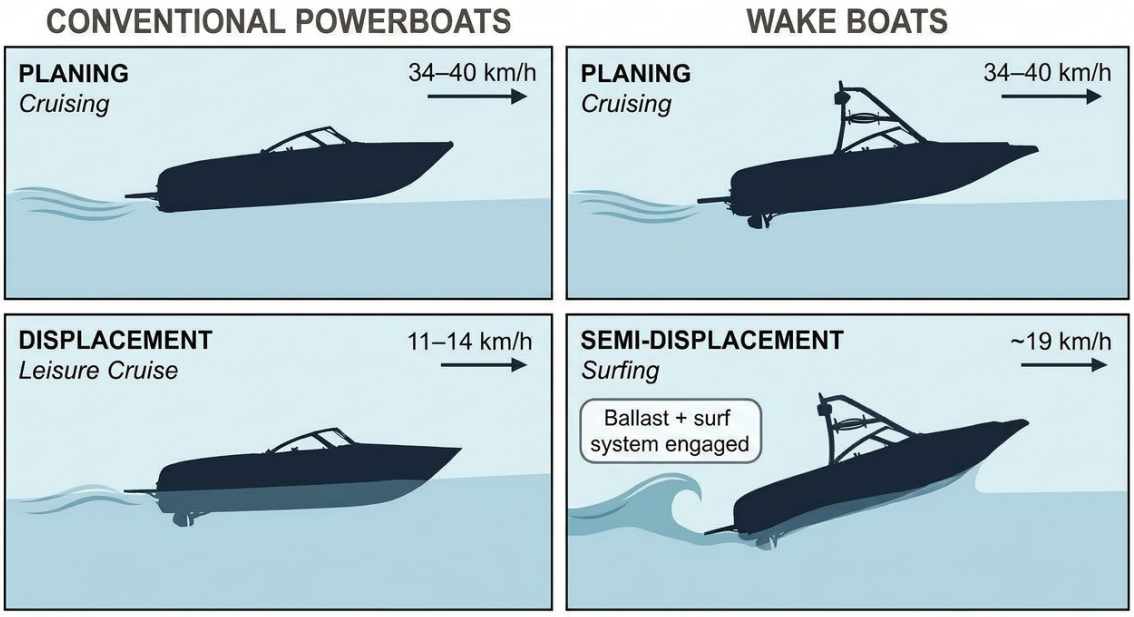


Figure 1. Conceptual comparison of planing, displacement, and semi-displacement operating modes for conventional recreational boats and wakeboats. Adapted from Riesgraf et al. (2025).

These operational differences are important because wakes produced by ballast-equipped wakeboats can differ substantially from those generated by conventional powerboats. Recent studies and technical reviews indicate that wakeboats can produce larger, longer-period, and more energetic waves (Houser & George, 2026; Macfarlane, 2025; Marr et al., 2022; Riesgraf et al., 2025). Although vessel-generated wakes are episodic relative to wind-generated waves, their greater height and longer period can make them a substantial component of nearshore wave energy under low-wind conditions or where effective wind fetch is limited (Houser et al., 2021; Houser et al., 2024). In shallow freshwater lakes, these characteristics increase the potential for wake-induced water movement to interact with the lakebed and for wave energy to reach shorelines and nearshore habitats before dissipating (Francis et al., 2023; Marr et al., 2022; Riesgraf et al., 2025).

This review focuses primarily on wakesurfing and the operation of wakeboats with ballast or other wake-enhancing systems engaged. Wakeboarding is included where it is conducted in this enhanced-wake mode. Some of the literature concerns conventional powerboats or other sources of repeated physical disturbance rather than wakeboats specifically; where this evidence is used, its applicability and limitations are identified.

The review synthesizes ecological literature, focusing on shallow freshwater lake systems, and considers its relevance to Lake Windermere and Columbia Lake, located in southeastern British Columbia. It evaluates six principal areas of environmental concern: shoreline and foreshore stability; sediment resuspension and related water-quality effects; aquatic vegetation and littoral habitat; fish and nearshore habitat; bird disturbance and habitat sensitivity; and aquatic invasive species risk associated with ballast systems.

1.1. Lake Windermere and Columbia Lake context

Lake Windermere and Columbia Lake are an important focus of this review because they are shallow, ecologically sensitive lakes in the Columbia River headwaters region that are highly valued for recreation. Both lakes are located in the Rocky Mountain Trench along the Highway 93/95 corridor and are connected by the Columbia River within the broader Columbia Wetlands system. Columbia Lake is located just north of Canal Flats and forms the headwaters of the Columbia River. From there, the river flows north toward Lake Windermere, which lies approximately 15 km downstream and functions as a widening of the Columbia River within the same wetland-river corridor (Urban Systems Ltd., 2001; Wood Canada Ltd., 2022).

Both lakes also support ecological, cultural, recreational, and economic values. Lake Windermere is used extensively for recreation and supports multiple designated water uses, including aquatic life, public water supply, recreation, irrigation, and livestock watering (Neufeld et al., 2010). Living Lakes Canada (n.d.) has described it as the most heavily used waterbody in the Columbia Valley. Columbia Lake's relatively undeveloped east side, wetland areas, and conservation lands contribute to its high habitat value and have been identified as important to preserve for ecological and cultural reasons (Regional District of East Kootenay [RDEK] & Village of Canal Flats, 2022; Wood Canada Ltd., 2022).

Lake Windermere has a mean depth of approximately 3.4 m, a maximum depth of 6.4 m, and an estimated littoral area of about 15.3 km², representing roughly 95% of its 16.1 km² surface area (Schleppe & McPherson, 2021b). This shallow, riverine setting distinguishes it from a typical deep interior lake and helps explain its sensitivity to nearshore disturbance (Larratt et al., 2024; Neufeld et al., 2010). Columbia Lake is similarly shallow, with a surface area of 25.74 km², a mean depth of 2.9 m, and a maximum depth of 5.2 m (Wood Canada Ltd., 2022). Although a directly comparable lake-wide littoral-area estimate was not identified for Columbia Lake, foreshore mapping indicates extensive nearshore habitat: aquatic vegetation was observed along 84% of the shoreline, littoral zones were classified as wide (more than 50 m) along 59% of the shoreline and medium (10 to 50 m) along the remaining 41%, and littoral widths ranged from 22 m to 1,500 m (Wood Canada Ltd., 2022). Both lakes are relatively long and narrow. Lake Windermere extends for approximately 17.7 km and ranges from 0.7 to 2.0 km wide (Schleppe & McPherson, 2021b; Urban Systems Ltd., 2001) while Columbia Lake is approximately 13.6 km long with a reported average width of 1.9 km (Wood Canada Ltd., 2022). These characteristics mean that boating activity on both lakes occurs largely over shallow-water habitat.

Table 1. Physical lake characteristics of Lake Windermere and Columbia Lake.

Lake	Elevation	Surface area	Mean depth	Max. depth	Lake length	Shoreline perimeter	Average width
Lake Windermere	798 m	16.1 km²	3.4 m	6.4 m	17.7 km	36.3 km	1.1 km
Columbia Lake	809 m	25.74 km²	2.9 m	5.2 m	13.6 km	42.9 km	1.9 km

Sources: Schleppe & McPherson, 2021b (Lake Windermere); Wood Canada Ltd., 2022 (Columbia Lake).

Both lakes are naturally low-productivity (oligotrophic) systems, but recent monitoring on each has raised concern about a possible shift toward mesotrophic conditions associated with elevated total phosphorus (Columbia Lake Stewardship Society [CLSS], 2026a; Saunders, 2025). On Columbia Lake, average total phosphorus in 2025 was the highest since monitoring began in 2014, although chlorophyll-a concentrations remained low (CLSS, 2026a). Potential wake-related effects on shallow-water habitat and water quality are therefore relevant to broader stewardship priorities across this connected headwater landscape.

Projected climate changes may intensify these sensitivities. In the Columbia River headwaters, warming is projected to shift peak streamflow from July to June and reduce late-summer flows (Bürger et al., 2011; Werner et al., 2013). Lower late-summer inflows could reduce water levels during the peak boating season, when seasonal declines already decrease the depth beneath boats (CLSS, 2026a). Columbia Lake's seasonal levels depend largely on high-elevation snowpack draining through Dutch Creek (CLSS, 2026b). Lake summer surface water temperatures have also risen globally, by an average of 0.34 °C per decade between 1985 and 2009 (O'Reilly et al., 2015). Warming also increases evaporation, which can

lower lake levels (Woolway et al., 2020). Low water during drought often raises total nutrient concentrations and favours algal blooms (Mosley, 2015).

The Columbia Valley has an established history of lake stewardship, monitoring, and integrated planning. Foreshore assessments and management plans for both lakes provide local information on shoreline condition, habitat values, and management priorities, while the Lake Windermere recreational impacts assessment adds a lake-specific evaluation of boating pressure and powerboating suitability (Catherine Berris & Associates Ltd., 2011; Larratt et al., 2024; RDEK & Village of Canal Flats, 2022; Schleppe & McPherson, 2021b; Wood Canada Ltd., 2022). Together, this work provides a local foundation for evaluating wakesports suitability on each lake. Appendix C summarizes the principal stewardship, monitoring, and planning initiatives.

This review is intended for Indigenous Nations; federal and provincial governments and agencies; regional districts and municipalities; stewardship organizations; researchers; and recreational users. It evaluates wakesports suitability on Lake Windermere and Columbia Lake and presents a wakesports suitability framework to inform education, monitoring, development guidance, and boating-management decisions for these and other lakes in the Regional District of East Kootenay (RDEK). This includes a proposed coordinated regional application under the *Vessel Operation Restriction Regulations* (VORR). Recognizing boating as a valued use of lakes throughout the region, this review aims to support consistent, evidence-based decisions that protect ecological, cultural, community, and recreational values over time.

1.2. Scope and approach of the literature review

This review draws on peer-reviewed studies, review articles, technical reports, and locally relevant grey literature. The broader literature was used to identify the principal environmental effects associated with wakesports, while local reports were used to assess the susceptibility of Lake Windermere and Columbia Lake based on characteristics such as shallow depth, extensive littoral habitat, shoreline modification, and high recreational pressure (Larratt et al., 2024; Schleppe & McPherson, 2021b; Wood Canada Ltd., 2022). Because direct experimental evidence on wakeboat effects in the Columbia Valley is limited, findings from other jurisdictions were evaluated against local lake conditions rather than assumed to apply directly. This approach identifies the effects most consistently supported in the literature and considers whether similar effects may occur locally, while recognizing that not all have been directly measured in these lakes. The review also develops a wakesports suitability framework and applies it using spatial analyses prepared for this review (Holden Ecological, 2026), as described in Section 4.

2. Ecological effects of wakesports

The sections below review documented and potential environmental effects associated with wakesports in shallow freshwater lakes, including shoreline erosion, sediment disturbance, changes in water quality and aquatic habitat, wildlife disturbance, and the potential for aquatic invasive species transport. The likelihood and magnitude of these effects in a given lake depend on its physical and ecological characteristics, including water depth, littoral extent, shoreline and substrate conditions, sensitive habitat, and boating intensity. Each section therefore relates the broader evidence to conditions in Lake Windermere and Columbia Lake, providing the evidence base for the wakesports suitability framework in Section 4.

2.1. Shoreline and foreshore stability

Shoreline erosion is a natural component of sediment transport in lake systems (e.g., Håkanson & Jansson, 2002; Wetzel, 2001). Human activities can increase erosion or its ecological consequences by adding wave energy, removing stabilizing vegetation, or modifying the shoreline (e.g., Gittman et al., 2016; Jennings et al., 1999). Wind-generated waves remain an important source of shoreline energy in most lakes, but vessel-generated wakes can contribute substantially where boating is frequent, fetch is short, shorelines are sheltered, or vessels operate close to shore (Allen & Tingle, 1993; Houser et al., 2024). The size and energy of these wakes also vary with vessel type and operation (Macfarlane, 2018; Marr et al., 2022).

When operated with ballast engaged at approximately 10 to 13 mph (16 to 21 km/h), wakeboats displace more water and generate enhanced wakes with greater wave height and energy than wakes produced during typical cruising or waterskiing. Measured 30 m (100 ft) from the boat under typical operating conditions, wakeboats produced approximately 3 to 9 times the total wave energy and 6 to 12 times the maximum wave power of non-wakeboats operated at planing speed (Marr et al., 2022). Field studies have measured differences in wave characteristics among wakesurfing, wakeboarding, and conventional boating, with results varying by vessel design, loading, speed, water depth, operating conditions, and distance from the sailing line (Macfarlane, 2018, 2025; Marr et al., 2022). A recent lake-focused review concluded that wakeboats produce the same broad categories of physical effects as conventional motorboats, but at greater magnitude because of their ballast, hull configuration, and sustained low-speed operation (Ortiz et al., 2026). This greater wave energy can increase erosion risk where enhanced wakes reach susceptible shorelines, although the response also depends on fetch, nearshore depth, and shoreline characteristics (Houser et al., 2024; Ortiz et al., 2026).

Freshwater studies show that frequent vessel traffic can contribute to bank erosion, but most evidence comes from rivers, not wakeboats on lakes (Dorava & Moore, 1997; McConchie & Toleman, 2003; Nanson et al., 1994). Wind waves grow with fetch, whereas wakes weaken with distance from the sailing line regardless of wind (Houser, 2010; Houser et al., 2024). Across 32 sites on Ontario lakes, recreational boat wakes contributed 69–94% of summer wave energy, with the largest share where fetch was shortest

(Houser et al., 2024). On one Ontario cottage lake, boat wakes over a single long weekend produced about three times the wave energy of a frontal storm earlier the same summer (Houser et al., 2021).

These results reflect recreational boats collectively, on cottage lakes with limited public access, and the authors caution against extending them to lakes with more day-use boating. They nevertheless show that wakes can dominate nearshore wave energy where fetch is limited.

Whether this added energy translates into erosion is less certain. Public surveys and other anecdotal reports document shoreline erosion and property damage that respondents attributed to boat wakes, including those from wakeboats, but cannot establish causation (Houser et al., 2024; Houser & George, 2026; Water Environment Consultants, 2021). Erosion-pin monitoring across five southern Quebec lakes detected no significant shoreline erosion from general recreational boating, although this does not rule out localized, episodic, or cumulative erosion (Lemieux et al., 2024).



Figure 2. Wakesurfing observed on Lake Windermere during recreational boat-count surveys. Photograph courtesy of Lake Windermere Ambassadors.

On BC's Lower Shuswap River, initial erosion-pin monitoring could not separate boat-wake effects from spring freshet flows (Laderoute & Bauer, 2013). A follow-up study found that freshet flows were too weak to erode the banks. Most measured bank retreat, up to about 8 cm, occurred in late July as water levels fell and boat traffic peaked, and the author attributed it largely to boat wakes, based on one season of monitoring (Cameron, 2015). Field research directly comparing wind- and boat-generated waves and their effects on lake shorelines remains limited. A third phase of the University of Minnesota research program is examining these effects on several Minnesota lakes, but its results were not available at the time of writing (St. Anthony Falls Laboratory, n.d.).

Fine, unconsolidated materials are generally more readily mobilized than coarse or cohesive substrates (Håkanson & Jansson, 2002; Houser & George, 2026). Aquatic and riparian vegetation can reduce nearshore wave energy, stabilize sediment, and maintain habitat structure (Dahanayake et al., 2024; Madsen et al., 2001). Vegetation loss may create a reinforcing cycle: reduced vegetation allows more wave energy to reach exposed sediment, increasing sediment movement and erosion and further weakening shoreline habitat, even where shoreline retreat is gradual or difficult to detect (Houser & George, 2026; Ortiz et al., 2026; Wehrly et al., 2012). Shoreline response also varies with bank and

foreshore slope and with the frequency and direction of wave exposure (Dahanayake et al., 2024; Johnson & Johnston, 1995; Walter et al., 2005).

Shoreline modification can further alter how wave energy is distributed. Shoreline armouring can protect infrastructure locally, but it replaces natural shoreline habitat and can alter wave reflection and sediment movement. In some settings, reflected wave energy may shift erosion pressure toward neighbouring shoreline segments (Chhor et al., 2020; Gittman et al., 2016; Jennings et al., 1999; Wehrly et al., 2012).

These shoreline effects are locally relevant because Lake Windermere includes gravel and sand beaches, cliff and bluff shorelines, wetlands, and stream mouths, with varying levels of natural cover and shoreline modification (McPherson & Hlushak, 2008; Schleppe & McPherson, 2021b). The 2020 Foreshore Inventory and Mapping assessment classified approximately 43% of its shoreline as natural and 57% as disturbed. Between 2006 and 2020, disturbed shoreline increased by approximately 1%, representing an estimated loss of about 369 m of natural habitat (Schleppe & McPherson, 2021b). Much of this change was associated with small, incremental shoreline alterations rather than measured wake erosion. These losses often involved clearing small patches of natural vegetation on private property, particularly during new construction or rebuilding (Schleppe & McPherson, 2021b). Over the same period, the number of docks rose by 35% and the estimated length of retaining walls roughly doubled, although part of that increase may reflect differences between surveys.

Columbia Lake retains a larger proportion of natural shoreline, with approximately 59% classified as natural and 41% as disturbed. It also contains mobile foreshore material: fine substrates account for approximately 57% of the mapped foreshore and gravel for 36% (Wood Canada Ltd., 2022). Erosion-protection structures were mapped along approximately 16.4 km, or 41%, of the shoreline. Railway infrastructure was mapped separately along approximately 15.2 km, or 38%, of the western shoreline, while retaining walls were mapped along approximately 1.1 km, or 3%. These categories describe different and potentially overlapping shoreline attributes and should not be added together to estimate total disturbance (Wood Canada Ltd., 2022). Between 2009 and 2021, mapped disturbed shoreline increased by approximately 75 m, or 0.2% of the total shoreline, primarily in one segment near the southeast end of the lake.

Lake Windermere and Columbia Lake are long and narrow, so fetch is long along each lake's main axis but short across it. Wakes are likely to form a larger share of wave energy along shorelines near main boating routes that are sheltered from the dominant wind direction (Houser et al., 2021; Houser et al., 2024). Repeated enhanced wakes could add physical stress to susceptible shoreline and foreshore areas, particularly where fine sediments, reduced vegetation, or existing modification reduce shoreline stability (Houser & George, 2026; Ortiz et al., 2026; Schleppe & McPherson, 2021b; Wood Canada Ltd., 2022). Wake-related shoreline retreat has not been directly quantified on either lake, and foreshore inventories map shoreline condition and modifications rather than measuring erosion (Schleppe et al., 2020).

2.2. Sediment resuspension, water clarity, and nutrient release

Bow and stern pressure waves, transverse waves, and propeller wash generated by recreational powerboats can disturb the lakebed and resuspend fine sediment, increasing turbidity and reducing light penetration (Asplund, 2000; Mosisch & Arthington, 1998; Ortiz et al., 2026; Riesgraf et al., 2025). Wakeboats can intensify these effects when configured to produce an enhanced wake for wakesurfing because their ballasted, stern-down orientation strengthens these hydrodynamic effects and directs propeller wash downward (Ortiz et al., 2026; Riesgraf et al., 2025). These effects are most likely to occur in shallow water over fine, unconsolidated sediment, where the resulting reduction in light can affect submerged vegetation and benthic habitat conditions (Madsen et al., 2001; Mosisch & Arthington, 1998). The magnitude and duration of disturbance depend on water depth, substrate, vegetation, vessel design, operating mode, speed, passage frequency, wind, and background wave conditions (Lemieux et al., 2024; Ortiz et al., 2026; Riesgraf et al., 2025).

An earlier Canadian case study comparing two shallow lakes, one with motorboat activity and one without, found evidence that motorboat disturbance released sediment-stored phosphorus into the water column (Nedohin & Elefsiniotis, 1997). Even shallow sediment disturbance may be sufficient to influence nutrient cycling because loosely bound (labile) phosphorus is often concentrated within the upper 1 to 2 cm of lake sediments (Doig et al., 2017, as cited in Ortiz et al., 2026). Whether resuspended phosphorus becomes biologically available depends on oxygen conditions, pH, temperature, sediment chemistry, which together control whether phosphorus stays bound to sediment particles or is released into the water (James, 2017; Orihel et al., 2017).

Recent field testing provides direct evidence of the depths at which wakeboat operation can interact with lakebed material. Riesgraf et al. (2025) tested seven recreational powerboats, including two wakeboats, at depths of approximately 2.7, 4.3, 4.9, and 8.2 m. Wakeboats configured to produce an enhanced wake for wakesurfing produced the strongest measured near-bed motions. At 2.7 m, they resuspended sediment, shells, and vegetation, uprooting some plants, and material remained suspended for more than 15 minutes. At 4.3 m, they resuspended organic sediment (detritus), which took 5 to 8 minutes to resettle. Transverse-wave velocities persisted to about 4.6 to 4.9 m and had decreased to near zero by 6.1 m. Bow and stern pressure-wave velocities remained large enough to disturb lakebed sediment to depths of approximately 6.1 m, although these brief pulses initiated sediment movement rather than causing sustained resuspension (Riesgraf et al., 2025). The authors recommended a minimum operating depth of 6.1 m for wakeboats operated in this configuration, although that recommendation reflects the vessels, substrates, and operating conditions tested rather than a universal ecological threshold.

Earlier Quebec field studies reported wakeboat-generated water movement at similar depths. At Lake Masson and Sand Lake, wakesurfing velocities of at least 0.1 m/s were measured to approximately 4.5 m and inferred to extend to about 5 m. These velocities could theoretically mobilize very fine sediment, although no significant turbidity response or visible sediment resuspension was observed over the relatively coarse test substrate (Raymond & Galvez-Cloutier, 2015). At Lac Noir, instrumented testing indicated wakesurfing-related water-column disturbance to approximately 6 m. Based on the measured

water movement and sediment characteristics, the authors recommended a minimum operating depth of 7 m (Raymond & Galvez, 2016).

Regional field observations from southern British Columbia provide complementary evidence. During a 2019 wakesurfing trial in the shallow south bay of Kalamalka Lake, vertical wake turbulence caused major sediment disturbance in water 3 m deep or shallower, and sediment resuspension remained visible at 4 m. No sediment resuspension was observed at depths of 5 m or greater, although the wake was reported to produce a visible response at the lake bottom at the deepest monitoring station, 8 m (Self & Larratt, 2020). In subsequent correspondence, the study author clarified that, at the 8 m monitoring station, wake-generated water movement visibly moved macrophytes and benthic algae, but did not cause substantial sediment resuspension (H. Larratt, personal communication, July 15, 2026). The authors recommended low-power, minimal-wake operation in water shallower than 5 m, where resuspension was directly observed (Self & Larratt, 2020).

Broader field monitoring indicates an association between recreational boating intensity and short-term changes in nearshore water clarity. During summer 2012, researchers compared morning and evening turbidity measurements from two piers in South Lake Tahoe. On days classified as having high boating intensity, nearshore turbidity increased by an average of 1.19 NTU over the day, compared with 0.10 NTU on low-intensity days, an approximately twelvefold difference (Alexander & Wigart, 2013). That study grouped all motorized watercraft together and therefore did not isolate wakeboats or individual operating modes (Alexander & Wigart, 2013).

In three years of shallow-water monitoring at Lake Massawippi, turbidity was higher when boat traffic and wind speed were greater and at sites with more gently sloping nearshore areas (Lemieux et al., 2024). These patterns occurred even though a 10 km/h speed limit applied within 100 m of shore. Total phosphorus was positively correlated with turbidity, which the authors interpreted as increased phosphorus availability from resuspended sediment (Lemieux et al., 2024). Because total phosphorus includes particle-bound forms, however, this correlation does not show how much phosphorus became biologically available (James, 2017; Orihel et al., 2017).

A 2021 field trial on North Lake, Wisconsin, reported in a consultant report, provides preliminary evidence that enhanced-wake operation can affect water-column phosphorus concentrations. After a fully ballasted wakeboat completed two wakesurfing course runs at approximately 10 mph (16 km/h), total phosphorus concentrations at three nearshore sampling sites were 17% to 33% higher than pre-run concentrations, averaging 25%, within 30 minutes of the initial disturbance (Terra Vigilis Environmental Services Group, 2022). Because the trial involved two passes on one lake, the result should be interpreted with caution until further replicated.

These sediment and water-quality effects are relevant to Lake Windermere. The lake has a mean depth of approximately 3.4 m, a maximum depth of approximately 6.4 m, and littoral habitat covering about 95% of its area; fine organic and silty sediments occur in shallow areas susceptible to physical disturbance (Larratt et al., 2024). Existing local studies include historical sediment records, lake monitoring, and recent nearshore observations.

Sediment-core evidence identified changes in water quality, benthic community composition, and sedimentation beginning around 1950 (McDonald, 2000). Provincial monitoring at three main-lake stations from 2006 to 2009 found no substantial change in measured water-column conditions relative to the available historical data, while noting that localized nearshore effects, such as those from runoff and shoreline development, might not be detected at main-lake stations (Neufeld et al., 2010). These studies provide historical and main-lake context, but neither addresses short-term nearshore sediment or phosphorus mobilization by enhanced wakes or conditions after 2009.

More recent local monitoring illustrates why additional phosphorus mobilization warrants attention. In September 2022, very high cyanobacteria densities dominated by potentially toxic *Anacystis* sp. were recorded at sites at the north end of Lake Windermere, including 21,410 cells/mL at Main Beach. Although the study did not attribute this occurrence to boating or sediment resuspension, it noted that additional phosphorus could make summer cyanobacteria blooms more problematic (Larratt et al., 2024). Field teams observed sediment plumes emanating from a marina for hours during peak boating activity, and aerial imagery documented a sediment plume behind a wakeboat operated for wakesurfing in shallow water, together with tracks and scouring from other boat passages near the marina (Larratt et al., 2024). Only two of eight sediment traps were recovered after one year, preventing the study from quantifying the effects of powerboating on sedimentation rates (Larratt et al., 2024). The overlap among Lake Windermere's shallow morphology, fine sediments, locally observed disturbance, and the effect depths documented in field studies indicates that the lake is susceptible to wake-related sediment disturbance (Larratt et al., 2024; Riesgraf et al., 2025).

Resuspension may also mobilize contaminants where they have accumulated in fine depositional sediments (Cantwell et al., 2008; Kalnejais et al., 2007). Lake Windermere sampling found manganese, arsenic, and nickel concentrations above applicable provincial interim sediment-quality guidelines at some sites. Copper and lead remained below their applicable guidelines but were flagged because some concentrations exceeded the report's 80% warning-level screening threshold (Larratt et al., 2024). However, arsenic and nickel concentrations were near the lower end of the ranges reported for sediments from lakes in the southern Rocky Mountain tectonic region that were considered relatively unaffected by human activity (Larratt et al., 2024; Rieberger, 1992).

Hydrocarbon results were more equivocal. Extractable petroleum hydrocarbons in the C19–C32 range were initially detected at several sites, and field crews reported a hydrocarbon odour while collecting marina sediment cores. However, silica-gel-cleaned quality-assurance samples contained no detectable C19–C32 hydrocarbons, and polycyclic aromatic hydrocarbons were below detection at all sites. The study therefore did not identify hydrocarbons as a lake-wide concern, although localized marina contamination could not be excluded (Larratt et al., 2024).

Columbia Lake is similarly susceptible because it has a mean depth of approximately 2.9 m and a maximum depth of approximately 5.2 m (Wood Canada Ltd., 2022). Fine material accounts for approximately 57% of its mapped foreshore, littoral areas extend more than 50 m from shore along approximately 59% of the shoreline, and foreshore mapping documented propeller-drag and anchor-scour disturbance in shallow areas (Wood Canada Ltd., 2022). During 2025 monitoring, the deepest

recorded water depth declined from 5.1 m in early June to 4.5 m by late August as seasonal water levels fell. Surface temperatures remained above 20 °C through July and August, monitoring described soft bottom sediments, and average total phosphorus was the highest recorded since monitoring began in 2014 (CLSS, 2026a). Field studies have directly observed sediment or detritus resuspension at depths of approximately 4.0 to 4.3 m and measured near-bed water movement capable of disturbing sufficiently fine sediment at depths approaching 6.1 m (Riesgraf et al., 2025; Self & Larratt, 2020). Lake Windermere and Columbia Lake are shallow and contain fine or soft sediments across extensive littoral areas, meaning that much of both lakes falls within the depths at which resuspension or potentially sediment-mobilizing water movement has been documented (Larratt et al., 2024; Wood Canada Ltd., 2022). Although local sediment disturbance has been documented on Lake Windermere, the magnitude and spatial extent of wakeboat-attributable changes in turbidity and nutrient concentrations have not been quantified on either lake (Larratt et al., 2024). The evidence therefore establishes that both lakes have conditions associated with greater susceptibility to lakebed disturbance but does not provide a lake-wide estimate of effect magnitude.



Figure 3. Sediment plumes in shallow water. Left: aerial photograph near a Lake Windermere marina in August 2022. Larratt et al. (2024) attributed the plume to a wakeboat operated for wakesurfing; tracks from other boat passages are also visible. Photo: Lake Windermere Ambassadors. Right: sediment plume during a 2019 wakesurfing trial on Kalamalka Lake (Self & Larratt, 2020).

2.3. Aquatic vegetation and littoral habitat

Freshwater shore zones can support highly diverse biological communities and are considered among the most ecologically valuable habitats (Strayer & Findlay, 2010). Vegetation in and around the littoral zone includes several distinct functional groups: submerged macrophytes grow largely below the water surface; floating-leaved macrophytes have leaves at the water surface; emergent vegetation, including bulrush and cattail communities, is rooted in shallow sediment but extends above the water; and riparian vegetation grows along the shoreline (Chambers et al., 1999; Madsen et al., 2001). Together, these plant communities slow water movement, bind and trap sediment, support clear-water conditions, and provide cover, nursery, and foraging habitat (Coops et al., 1996; Madsen et al., 2001; Ortiz et al., 2026). Their stabilizing capacity and susceptibility to disturbance vary among species, seasons, substrates, and exposure conditions (Chambers et al., 1999; Coops et al., 1996; Houser & George, 2026).

Recreational boating can affect these communities directly through hull and propeller contact, anchor drag, and mooring-chain scour, and indirectly through waves, propeller wash, and turbulence that disturb sediment and vegetation (Asplund & Cook, 1997; Houser & George, 2026; Madsen et al., 2001; Wood Canada Ltd., 2022). Wakeboats can increase these pressures when configured to produce an enhanced wake. Added ballast lowers the stern and places the propeller deeper in the water, with propellers up to about 1 m below the surface during wake creation, increasing the potential for direct contact with vegetation and the lakebed (Ortiz et al., 2026). In wakesurfing mode, full ballast and a stern-down hull pitch of about 13° to 16° produced stronger near-bed water movement than any other boat or operating mode tested, and propeller wash reached the lakebed in 2.7 m of water. Underwater video from the same study recorded stem stripping, stem breaking, and uprooting of sparse submerged vegetation, with uprooting at the 2.7 m site, although vegetation effects were not measured directly (Riesgraf et al., 2025). The magnitude of this disturbance depends on vessel design, loading, operating mode, and water depth (Ortiz et al., 2026; Riesgraf et al., 2025).

Submerged vegetation can be impaired even without visible uprooting. Boating-related sediment resuspension can reduce light penetration, compress the depth range in which submerged plants can persist, and deposit fine material on plant surfaces and substrates (Chambers et al., 1999; Madsen et al., 2001). Together, reduced light and sediment coating can suppress photosynthesis and plant growth. If plant cover declines, the associated loss of sediment stabilization and wave attenuation can increase sediment mobility and turbidity, further limiting recovery and reinforcing habitat degradation (Houser & George, 2026; Ortiz et al., 2026; Scheffer et al., 1993). Repeated disturbance can also favour disturbance-tolerant plants and simplify littoral habitat structure (Asplund, 2000).

Freshwater experiments demonstrate that wave exposure can affect plant growth, establishment, and sediment-stabilizing functions before complete vegetation loss becomes visible. In a three-year wave-tank experiment using 1.9 s waves representative of vessel-generated waves, vegetated banks experienced less net erosion than unvegetated banks, but exposure to 23 cm waves uprooted rhizomes of lakeshore bulrush (*Scirpus lacustris*), whereas common reed (*Phragmites australis*) was more resistant under the conditions tested (Coops et al., 1996). In a separate experiment, young wild celery (*Vallisneria americana*) exposed to simulated 15 cm boat waves five or six times per day for 67 days survived but accumulated

approximately half the biomass of control plants and produced shorter leaves and fewer daughter plants (Doyle, 2001). Although these experiments did not test modern wakeboats, they show that vegetation responses differ among species and that repeated wave exposure can reduce plant growth or stability without causing immediate plant mortality.

On Lake Windermere, the Foreshore Integrated Management Planning assessment documented localized losses of riparian and emergent vegetation near boat launches, buoys, and shoreline moorage (Schleppe & McPherson, 2021b). The assessment anticipated that continued intensive recreation and moorage could contribute to further incremental losses, although annual variation in emergent vegetation limited the accuracy with which vegetation change could be mapped (Schleppe & McPherson, 2021b). The 2024 aquatic plant inventory found the most abundant and diverse native submerged plant beds at Ruault Road, while several other stations had lower plant abundance or diversity (Darvill, 2025a). Thick sediment coatings were observed on plants at Tretheway Docks and Baltac Beach, and the report suggested that propeller action and boat-generated wakes could contribute to sediment resuspension and redeposition (Darvill, 2025a). Because the inventory was designed primarily for aquatic invasive plant surveillance rather than a controlled assessment of boating effects, these observations identify local conditions warranting further investigation but do not establish what caused the sediment deposits or quantify the contribution of individual vessel types.

Foreshore assessments confirm that extensive emergent and submerged vegetation occupies Columbia Lake's shallow littoral zone (McPherson et al., 2010; Wood Canada Ltd., 2022). The 2009 assessment recorded emergent vegetation, primarily bulrush species, along approximately 75% of the shoreline and covering about 3 km² (McPherson et al., 2010). In 2021, aquatic vegetation was recorded along 84% of the shoreline, including emergent vegetation along 78% and submerged vegetation along 56%, with bulrush and cattail marsh communities identified at several locations (Wood Canada Ltd., 2022). The 2009 vegetation mapping closely matched the 2021 field and aerial observations, but the assessment did not quantify lake-wide changes in vegetation area or condition.

Local stability or expansion of vegetation at some locations can occur alongside disturbance elsewhere. The 2021 assessment documented localized removal of emergent vegetation for shoreline access, propeller-drag lines through aquatic vegetation and marl, and mooring-anchor and chain scour affecting submerged plant growth (Wood Canada Ltd., 2022). These observations establish localized boating-related disturbance but do not demonstrate a lake-wide vegetation decline or attribute the disturbance to individual vessel types. Enhanced-wake operation could add to these pressures where stronger waves and near-bed water movement overlap shallow vegetated habitat (Ortiz et al., 2026; Riesgraf et al., 2025).

Experiments show that repeated wave exposure can reduce plant growth and stability (Coops et al., 1996; Doyle, 2001), while field studies document stronger waves, near-bed water movement, and vegetation damage during enhanced-wake operation (Marr et al., 2022; Riesgraf et al., 2025). Local assessments confirm that both lakes contain extensive shallow vegetation and areas of localized boating-related disturbance (Schleppe & McPherson, 2021b; Wood Canada Ltd., 2022). However, lake-wide vegetation change has not been attributed specifically to wakeboats on either lake. The evidence

therefore identifies shallow plant communities as susceptible where enhanced-wake operation overlaps them but does not demonstrate a wakeboat-caused lake-wide decline.

2.4. Fish and nearshore habitat

Littoral zones provide spawning, juvenile rearing, feeding, and refuge habitat for fish (Ortiz et al., 2026; Schleppe & McPherson, 2021b; Wood Canada Ltd., 2022). Their ecological value is closely linked to aquatic vegetation, coarse substrates, woody material, and other physical structures that provide cover and support aquatic food webs (Ortiz et al., 2026; Whitfield & Becker, 2014). Disturbance that removes vegetation, mobilizes sediment, or alters nearshore wave conditions can therefore affect fish both directly and through changes to habitat and prey availability (Houser & George, 2026; Ortiz et al., 2026).

Freshwater studies document several direct and indirect effects of vessel-generated waves on early fish life stages. On the Danube River, navigation-induced wave wash temporarily altered the shallow nursery habitat available to larval and juvenile fish, produced water velocities that frequently exceeded the swimming capacity of larval and juvenile fish, and increased suspended sediment concentrations (Kucera-Hirzinger et al., 2009). In freshwater mesocosms, pulse waves resembling ship-generated waves resuspended benthic prey and altered fish foraging success, with responses differing among the fish groups tested (Gabel et al., 2011). These river and experimental studies are not direct simulations of wakesurfing on a lake, but they demonstrate that repeated vessel waves can displace small fish and alter feeding conditions in shallow habitats.

Sediment mobilization is an additional concern for fish. Increased turbidity can interfere with visual foraging, while settling sediment can cover nests or eggs and reduce hatching success in susceptible species (Ortiz et al., 2026; Whitfield & Becker, 2014). In a Wisconsin lake, wind-generated nearshore waves produced water velocities that were frequently sufficient to move nonadhesive walleye eggs and fine sand during incubation, and field surveys documented movement of eggs toward and onto shore (Raabe & Bozek, 2015). Although the study examined natural waves rather than vessel wakes, it demonstrates that eggs deposited in shallow habitat can be displaced or buried when wave-driven water movement is sufficient. Fish responses to sediment disturbance appear to be species-specific (Ortiz et al., 2026), and potential effects are greatest when repeated disturbance occurs where and when fish are spawning or eggs are incubating.

Vessels may also affect fish through their presence and underwater sound. Behavioural and physiological responses vary among species, partly because of differences in auditory adaptations, and available evidence does not establish general sound thresholds for behavioural change or physical harm (Barbeau et al., 2024; Popper & Hawkins, 2019; Whitfield & Becker, 2014). These studies concern motorboats generally. Wakeboats are likely to produce comparable underwater sound, but whether enhanced-wake operation differs in sound level, frequency, or duration of exposure has not been examined in the studies reviewed.

These effects are locally relevant because both lakes contain extensive shallow habitat and several fish species that depend on nearshore vegetation or coarse substrates. On Lake Windermere, kokanee

spawning has been documented in gravel and cobble habitat around the lake outlet, including areas upstream and downstream of the Athalmer Bridge. The Windermere FIMP identifies the outlet as the lake's most important kokanee staging and spawning area, notes that the main public boat launch is located within this area, and reports visible boat scour in the spawning gravels (McPherson & Hlushak, 2008; Schleppe & McPherson, 2021b). Burbot historically spawned in macrophyte beds near the mouths of Windermere and Goldie creeks, while juveniles are strongly associated with interstitial spaces in gravel, cobble, and boulder substrates and with structurally complex aquatic vegetation (Schleppe & McPherson, 2021b; Taylor, 2001, 2002). These habitats are susceptible to propeller disturbance, sediment deposition, vegetation damage, and repeated wave exposure.

The 2021 Lake Windermere shoreline fisheries assessment provides additional local context on nearshore fish assemblages (Hildebrand, 2022). Northern pikeminnow and largemouth bass accounted for most fish recorded. In beach-seine samples, total catch per unit effort across all species was similar among disturbance classes, but descriptive differences occurred in species composition. Northern pikeminnow catch per unit effort was higher at highly disturbed sites, while mountain whitefish, redside shiner, peamouth chub, and largescale sucker were captured mainly or exclusively at low-disturbance sites. The sampling design did not provide sufficient replication for statistical analysis, and the report recommends sampling across multiple seasons and years before drawing conclusions about differences in fish use among disturbance levels.

Columbia Lake contains similarly concentrated areas of sensitive fish habitat. Productive wetlands at its north and south ends, tributary mouths, and broad shallow littoral areas provide spawning, rearing, and refuge habitat (McPherson et al., 2010; Wood Canada Ltd., 2022). Burbot spawning has been documented in a shallow spring-fed tributary at the south end and under the ice near the north end, and juveniles occur in littoral areas (McPherson et al., 2010; Wood Canada Ltd., 2022). The 2021 foreshore assessment also documented propeller-drag lines and mooring-related scour within shallow vegetation and marl substrate, confirming that boating-related physical disturbance already overlaps nearshore habitat on Columbia Lake (Wood Canada Ltd., 2022).

Native freshwater mussels are another sensitive component of nearshore habitat on both lakes. Mussels contribute to filtration, nutrient cycling, food webs, and physical habitat structure, while suspended sediment, deposition, and substrate instability can interfere with feeding, respiration, reproduction, or persistence (Goldsmith et al., 2021; Vaughn, 2018). The Windermere FIMP recorded native mussels across a broader portion of the lake than earlier mapping had indicated, although densities were not measured (Schleppe & McPherson, 2021b). Mussel beds have also been documented at several Columbia Lake locations, but poor underwater visibility has limited mapping of their extent (McPherson et al., 2010; Wood Canada Ltd., 2022). Their distribution therefore remains an important local data gap.

Physical disturbance associated with enhanced-wake operation could affect fish and nearshore habitat where it overlaps shallow spawning or juvenile-rearing areas, aquatic vegetation, coarse substrates used for cover, or native mussel beds. The strongest local evidence is the documented overlap between boating-related physical disturbance and sensitive habitats, including kokanee spawning gravels and burbot rearing habitat (Schleppe & McPherson, 2021b; Wood Canada Ltd., 2022). However, wakeboat-

specific effects on egg survival, recruitment, fish abundance, or native mussel condition have not been measured on either lake, so the risk to fish populations remains unquantified.

2.5. Birds and sensitive habitat

Boating can affect waterbirds through behavioural disturbance and through waves that alter nesting, brood-rearing, feeding, and resting habitat. Close approaches may cause birds to flush, interrupt feeding or incubation, or move away from preferred habitat, with responses varying by species, season, life stage, boating behaviour, and the frequency of disturbance (Hockin et al., 1992; Korschgen & Dahlgren, 1992; Schafft et al., 2021). Federal guidance does not specify a universal setback distance for boats. Instead, it directs boaters to maintain a "sufficient distance" from nesting birds and identifies erect posture, increased vocalization, or adults leaving their nests as signs that they are too close. It also recommends maintaining appropriate buffers around colonies and avoiding concentrations of waterbirds (Environment and Climate Change Canada, 2024).

Measured flight-initiation distances illustrate the spatial scale over which waterbirds may respond to approaching vessels. In a study on three freshwater lakes and three rivers, 215 controlled approaches by a small motorboat to 10 waterbird species produced a mean flight-initiation distance of 145 m (Mayer et al., 2019). Mean distances were greater on lakes than on rivers and increased with group size. These results do not establish a universal wakeboat setback because the study involved European waterbirds, a small outboard motorboat, and winter and spring observations. They nevertheless show that disturbance can occur well before a vessel closely approaches birds and that responses vary with waterbody setting and flock size.

Wave exposure creates a separate risk for birds that nest close to the water or on floating vegetation. Western Grebes build floating nests that can be swamped or detached by wave action. Field observations found that nests located farther within bulrush stands were more likely to survive storms, while experiments showed that hardstem bulrush reduced the height and energy of both natural waves and boat wakes. Nests on the sheltered side of vegetation stands were at least three times more likely to hatch eggs than nests exposed to greater wave action (Allen et al., 2008a, 2008b).

Common Loons typically nest within about 0.3 m of the water's edge. Chicks often use shallow water within 150 m of shore during their first eight weeks, extending their potential exposure to wakes beyond the nesting period (Ortiz et al., 2026). Fuirst et al. (2026) analyzed 45,591 breeding attempts on 3,421 lakes from 1975 to 2023. The number of chicks surviving to six weeks declined significantly in seven of the 12 monitored regions. British Columbia showed a smaller decline (14%), while chick production fell by 65% in the Prairie provinces and 74% in the Atlantic provinces between 1992 and 2023. Proposed causes include shoreline development, disturbance during nesting, nest flooding from water-level changes, and reduced water clarity, possibly acting together. In northern Wisconsin, chicks weighed about 80 g more, on average, for each additional metre of July water clarity, consistent with clearer water helping adults locate fish to feed their young (Piper et al., 2024). The study did not examine boating, but enhanced wakes could add to several of these pressures where loons nest or rear chicks near shore. Local foreshore mapping also identifies emergent and floating vegetation as potential nesting habitat and notes

that large wind events and boat-generated waves can submerge floating nests (Schleppe & McPherson, 2021b).

Lake Windermere supports breeding, staging, feeding, and migration habitat for a diverse waterbird community. The south end consistently supports large concentrations of staging waterfowl and has been identified as the most important staging area within the surveyed Columbia Wetlands for at-risk grebes and American Coot. Creek mouths also provide important habitat for migrating shorebirds (Darvill, 2019). Western, Horned, and Eared Grebes have been documented during migration; Red-necked Grebes breed at the south end; and Common Loons have also been recorded on the lake (Darvill, 2019). Fall surveys conducted from 2019 to 2022 and again in 2024 continued to record at-risk grebes and Common Loons, confirming repeated fall use of the lake, although annual counts varied with weather, visibility, and migration conditions (Darvill, 2024).

Columbia Lake provides similarly extensive waterbird habitat. Its north and south wetlands, broad littoral zone, aquatic vegetation, and relatively natural eastern shoreline provide nesting, staging, and feeding opportunities (McPherson et al., 2010; Wood Canada Ltd., 2022). Earlier Columbia Wetlands surveys recorded Western Grebes throughout Columbia Lake and identified its middle reaches, along with Lake Windermere, as important grebe stopover and staging habitat (Wood Canada Ltd., 2022). Foreshore assessments also recorded swallow nesting burrows, loons, grebes, mergansers, and other waterbirds (McPherson et al., 2010; Wood Canada Ltd., 2022).

The Bank Swallow requires particular consideration because it is federally listed as Threatened and nests colonially in steep, erodible banks. At least 29 colony sites have been identified along the Lake Windermere foreshore, and nesting habitat is also documented along Columbia Lake (Darvill, 2025b; Wood Canada Ltd., 2022). Bank Swallows excavate their nesting burrows directly into steep, exposed banks of sand or silt. Periodic erosion can expose fresh nesting faces, but rapid bank slumping or flooding while burrows are occupied can destroy nests, eggs, or nestlings (Environment and Climate Change Canada, 2022). Monitoring from 2021 to 2025 documented boating and shoreline access close to active colonies on both lakes (Darvill, 2026). Boats can provide access to colonies that may otherwise be difficult to reach; close approaches may cause adults to flush, while people landing, walking, or climbing on the banks can destabilize the bank face and collapse occupied burrows (Darvill, 2026; Environment and Climate Change Canada, 2022). Boat-generated waves could also contribute to undercutting or abrupt bank failure while burrows are occupied, although wake-related nest loss has not been documented on either lake (Darvill, 2026; Environment and Climate Change Canada, 2022; Houser & George, 2026). The Lake Windermere Foreshore Development Guide recommends a 200 m buffer around Bank Swallow nesting areas during the nesting period because adults generally forage within 200 m of their colonies, although distances of up to 1 km have been reported (Schleppe & McPherson, 2021a). This recommendation was developed for shoreline planning rather than as a measured vessel-disturbance threshold.

The risk to birds is greatest where vessels closely approach nesting, brood-rearing, or staging areas, or where enhanced wakes reach floating nests, nearshore vegetation, or banks containing active Bank Swallow colonies. Local surveys and foreshore assessments confirm waterbird use and extensive habitat

on both lakes (Darvill, 2019, 2024, 2026; Schleppe & McPherson, 2021b; Wood Canada Ltd., 2022). Wakeboat-specific effects on waterbird behaviour, nest success, or Bank Swallow colonies have not been measured locally, so these findings identify habitat at risk rather than observed effects on bird populations. This is consistent with the broader literature, where wakeboat-specific evidence for wildlife remains limited (Ortiz et al., 2026).

2.6. Aquatic invasive species (AIS)

Aquatic invasive species can alter food webs, habitat, water quality, fisheries, infrastructure, and recreational use. Because eradication is rarely feasible once an invasive species becomes established in a waterbody, prevention and early detection are central to aquatic invasive species management (IPBES, 2023; Ortiz et al., 2026; Vander Zanden et al., 2010). Recreational watercraft can transport aquatic organisms and other viable biological material between waterbodies in residual water or mud; entangled in vegetation; attached to anchors, ropes, trailers, or motors; or retained in live wells, bilges, and other compartments (Drake, 2017; Johnson et al., 2001; Rothlisberger et al., 2010).

Ballast-equipped wakeboats present an additional transport risk because their ballast systems take in and discharge large volumes of lake water. Water can remain in tanks, pumps, hoses, and other low or inaccessible parts of the system that are difficult to inspect or drain completely (Campbell et al., 2016; Doll, 2018; Ortiz et al., 2026). Campbell et al. (2016) examined 23 wakeboats, of which 13 had removable ballast bags that could be sampled. The sampled systems retained an average of 31.7 L of water after the pumps ran dry, with volumes ranging from 1.0 to 86.8 L. Small numbers of dreissenid mussel veligers were detected in samples from two boats, and live invertebrates were found in residual water for at least one week. Boats with inaccessible hard ballast tanks were not sampled, so the measured volumes do not characterize every ballast-system design. Subsequent research found that ballast tanks contained the highest median number of zebra mussel veligers among the watercraft compartments tested and that veligers survived longer in ballast tanks than in live wells under the experimental conditions (Doll, 2018).

These studies show that running a ballast pump until it stops discharging does not ensure complete drainage or decontamination. Decontamination effectiveness depends on the organism, water temperature, exposure time, drying period, and accessibility of the treated area (Mohit et al., 2021, 2023). Brief exposure of less than 10 seconds to water at or above 60 °C produced nearly complete mortality for all six species tested except banded mystery snails, while hot-water treatment followed by drying was generally more effective than either method alone (Mohit et al., 2023). These experiments tested organisms and surfaces rather than installed ballast systems and therefore do not establish a validated ballast-system treatment protocol. Field trials also found considerable variation in the effectiveness and execution of boater cleaning, watercraft inspection, and hot-water decontamination. Decontaminators sometimes modified established protocols, and equipment often failed to reach the minimum temperature required for lethal exposure (Angell et al., 2024). These findings show that treatment effectiveness depends on both an appropriate protocol and its consistent execution.

No live zebra or quagga mussels have been confirmed in British Columbia waterways, and the Province continues to treat prevention as a priority (Government of British Columbia, 2026b). They are not established in Alberta either, but they have spread in Manitoba, Ontario, Quebec, and New Brunswick. Quagga mussels were also confirmed in Idaho's Snake River in 2023 (Government of British Columbia, 2026c). Transported watercraft must stop at every open provincial inspection station along their route, where inspectors assess recent travel history, cleanliness, drainage, and drying and can require decontamination or quarantine (Government of British Columbia, 2026a). The 2026 inspection network includes permanent, part-time, and roving operations, so coverage varies by route and operating period (Government of British Columbia, 2026a). Provincial estimates indicate that establishment of zebra or quagga mussels could cost British Columbia approximately $64 million to $129 million annually through effects on water infrastructure, hydroelectric facilities, irrigation, marinas, tourism, and property values (Government of British Columbia, 2023).

From 2016 through 2022, when the Radium station operated seven days per week for approximately 10 hours per day or from dawn to dusk, it conducted 3,061 to 6,277 inspections per season. In 2016–2018, 143 to 253 inspections per year, representing 3.1% to 4.1% of annual inspections, were classified as high risk. In 2019, the Invasive Mussel Defence Program refined this classification so that watercraft arriving from a high-risk jurisdiction could be classified as low risk when they met Clean, Drain, Dry conditions. High-risk counts before and after this change are therefore not directly comparable. The station recorded 100 high-risk inspections in 2019, five in 2020, 15 in 2021, and none in 2022. Across the 2016–2022 period, inspectors performed 143 decontaminations. The station did not operate in 2023 or 2024 and operated part time in 2025, when staff conducted 1,170 inspections, identified four as high risk, and performed no decontaminations. The four high-risk inspections involved watercraft from British Columbia and Ontario, two from each province (Ministry of Water, Land and Resource Stewardship, 2026).

During its permanent operating years, the station also inspected 153 to 980 watercraft annually in the program's "very complex" category; 131 were inspected during part-time operations in 2025. This category includes wakeboard boats with ballast tanks, as well as houseboats and other watercraft with complex internal water systems. Inspection totals reflect only watercraft encountered during operating hours and do not represent all trailered watercraft traffic on the route (Ministry of Water, Land and Resource Stewardship, 2026). These records confirm that high-risk watercraft and vessels in the "very complex" category, which includes boats with ballast systems, travel through the Radium corridor. Because both the classification system and inspection coverage changed over time, lower recent interception counts do not demonstrate that transport risk declined and partly reflect fewer opportunities for inspection and decontamination.

At Lake Windermere, annual aquatic plant monitoring supports early detection but cannot prevent introductions. Annual monitoring since 2014 has found no aquatic invasive plants at Lake Windermere's long-term sampling sites. In 2024, the program surveyed five shoreline and 11 offshore stations, including launches, marinas, and other locations selected because of their higher exposure to trailered watercraft (Darvill, 2025a). The absence of target invasive plant detections is encouraging, but the program provides targeted early-warning coverage rather than a complete lake-wide inventory.

Whirling disease demonstrates the regional importance of preventing the movement of water, mud, fish material, and contaminated equipment. British Columbia's first confirmed occurrence was reported in Yoho National Park in December 2023, followed by detection in Kootenay Lake in December 2024 (Government of British Columbia, 2024, 2025b). Because there is no treatment once the disease is present in a natural waterbody, containment and prevention are the principal responses (Government of British Columbia, 2024). Subject to limited exceptions for authorized operations, all waterbodies in Yoho and Kootenay national parks remain closed to watercraft and angling until March 31, 2027 (Parks Canada, n.d.). Banff National Park requires motorized watercraft entering Lake Minnewanka to pass a mandatory inspection and prohibits boats with ballast tanks, ballast bags, or similar systems (Parks Canada, 2026). These measures illustrate Parks Canada's use of waterbody closures, mandatory inspection, and ballast prohibitions to address aquatic biosecurity risk.

The evidence shows that ballast systems can retain water and viable organisms after pumps stop discharging, while inspection and treatment effectiveness depend on the method and its consistent execution (Angell et al., 2024; Campbell et al., 2016; Doll, 2018). A recent review concluded that, given their larger retained volumes, wakeboats pose a greater risk of transporting aquatic invasive species between waterbodies than other motorboats (Ortiz et al., 2026). Radium records confirm that high-risk and "very complex" watercraft, a category that includes ballast-equipped vessels, travel through the regional corridor (Ministry of Water, Land and Resource Stewardship, 2026). Lake Windermere monitoring supports early detection but cannot prevent introductions; ballast systems therefore warrant added attention during screening and inspection (Darvill, 2025a). Given the potential ecological and economic consequences of establishment, prevention should remain the priority (Government of British Columbia, 2023; Vander Zanden et al., 2010).

3. Management and governance options

3.1. The *Vessel Operation Restriction Regulations* (VORR) framework

The *Vessel Operation Restriction Regulations* (VORR), SOR/2008-120, provide a federal regulatory process under the *Canada Shipping Act, 2001* through which a local authority can request boating restrictions for a specific waterbody. Only a local authority may submit a request; local associations, citizens' groups, and community groups cannot apply directly and are directed instead to seek the support of a local authority (Transport Canada, 2026b). The VORR define a local authority as a government of a municipality, township, parish, county, or regional district; another government constituted under provincial or territorial law; or a provincial, territorial, or federal government department (Vessel Operation Restriction Regulations, 2008, s. 1). Transport Canada's current guidance also includes the government of an Indigenous community, uses the broader term Indigenous governing bodies in the application instructions, and describes the process as open to municipal and Indigenous governments (Transport Canada, 2026a, 2026b).

Restrictions may be established to improve navigation safety, protect the environment, or serve the public interest. Available measures include prohibitions on certain vessels, limits on propulsion or engine power, speed limits, restrictions on towing and wakesurfing, and controls on sporting, recreational, or public events and activities (Transport Canada, 2026a, 2026b). Restrictions can apply at all times or during specified parts of the day, week, month, or year. Once approved, they are listed in Transport Canada's schedules publication, TP 15587E, which provides the public record of the restrictions in force and the waters to which they apply (Transport Canada, 2026a).

In 2023, the VORR were amended to remove wakesurfing from the general towing restriction and establish a wakesurfing-specific schedule, allowing a local authority to seek a wakesurfing prohibition without also restricting activities such as waterskiing or tubing. The restriction targets the activity rather than the vessel and does not prohibit the use of wakeboats (Government of Canada, 2023). Following the 2025 relocation of the schedules into TP 15587E, this restriction is now Schedule 7 (Transport Canada, 2026a). As a result, a Schedule 6 towing restriction does not restrict wakesurfing.

The subsections below summarize the restriction types available under the VORR and the practical requirements for requesting, implementing, and enforcing them.

3.2. Available VORR restriction types

Under the current VORR framework, a local authority must identify the waters to which the proposed restriction would apply, select one or more existing schedule types, and submit a complete application supported by site-specific evidence, public consultation, consideration of alternative measures, assessment of potential impacts, and a cost-benefit analysis (Transport Canada, 2025, 2026b). Approved

restrictions are listed in TP 15587E, with permitted hours, engine-power limits, or speed limits where applicable. The current schedules provide the following restriction types (Vessel Operation Restriction Regulations, 2008, ss. 2(1)–(6.1), 11(2); Transport Canada, 2026a):

> **Schedule 1:** Waters on Which All Vessels Are Prohibited
>
> **Schedule 2:** Waters on Which Vessels Driven by Electrical Propulsion and Power-driven Vessels Are Prohibited
>
> **Schedule 3:** Waters on Which Vessels Driven by Electrical Propulsion That Have an Aggregate Maximum Power Greater Than 7.5 kW and Power-driven Vessels Are Prohibited
>
> **Schedule 4:** Waters on Which Vessels Driven by Electrical Propulsion and Power-driven Vessels Are Subject to an Engine Power Limit
>
> **Schedule 5:** Waters on Which Vessels Driven by Electrical Propulsion and Power-driven Vessels Are Subject to a Speed Limit
>
> **Schedule 6:** Waters in Which Towing a Person on Any Sporting or Recreational Equipment Is Prohibited Except During the Permitted Hours
>
> **Schedule 7:** Waters in Which Allowing a Person to Wake Surf Is Prohibited Except During the Permitted Hours
>
> **Schedule 8:** Waters in Which a Sporting, Recreational or Public Event or Activity Is Prohibited

Schedules 6 and 7 may specify permitted hours during which the activity is allowed; where no permitted hours are listed, the restriction applies at all times (Vessel Operation Restriction Regulations, 2008, ss. 2(6)–(6.1)). In addition to the schedule-based restrictions, the Regulations impose a default speed limit of 10 km/h within 30 m of shore in rivers and lakes in British Columbia. The limit is subject to exceptions for vessels towing a person on a course away from and perpendicular to shore, vessels operating in rivers less than 100 m wide or in canals or buoyed channels, and waters for which a speed limit is listed in Schedule 5 (Vessel Operation Restriction Regulations, 2008, ss. 2(7)–(8)).

A request may be submitted at any time of year, but must reach the regional Office of Boating Safety by November 15 to be considered for implementation in the following year's boating season (Transport Canada, 2025, 2026b).

3.3. Implementation and enforceability

Transport Canada administers the VORR process, reviews applications, and maintains the published schedules, while the requesting local authority conducts public consultation, submits the application, implements any approved restriction, and ensures that an enforcement regime is in place (Transport Canada, 2025, 2026b).

Any proposed restriction must be expressed in clear geographic, activity-based, or temporal terms and be practical to communicate and enforce (Transport Canada, 2026a, 2026b). Effective implementation also requires public information, appropriate signage, and an enforcement regime. Any sign placed to indicate

a scheduled VORR restriction must be authorized in writing by the Minister and meet Transport Canada's signage standard. The person placing the sign is responsible for the costs of its construction, placement, maintenance, and removal (Vessel Operation Restriction Regulations, 2008, ss. 5–6). Restrictions based on observable activities and clearly described locations or permitted hours avoid some of the enforcement difficulties associated with internal vessel configuration or subjective judgments about wake size.

Under the VORR, a wakesurfing restriction applies when a power-driven vessel or vessel driven by electrical propulsion is operated in designated waters "for the purpose of allowing a person to wake surf" (Vessel Operation Restriction Regulations, 2008, s. 2(6.1)). The restriction is therefore defined by the activity rather than by ballast use, vessel design, operating mode, or wake size. During consultation on the 2023 amendments, Transport Canada considered suggestions to regulate ballast use or excessive wake but concluded that both approaches would be impractical to enforce (Government of Canada, 2023). Consequently, a Schedule 7 restriction addresses wakesurfing without prohibiting other towing activities, but it does not regulate other boating activities that may also contribute to nearshore disturbance (Francis et al., 2023; Mosisch & Arthington, 2004). It also does not apply to wakeboarding behind a ballasted wakeboat, which can produce enhanced wakes, although these are typically smaller than wakes generated for wakesurfing (Macfarlane, 2025).

4. Assessing wakesports suitability

Section 3 described the restriction types and implementation requirements available under the current VORR. This section considers whether a standardized wakesports suitability framework could support more consistent decisions across waterbodies. It reviews recent VORR modernization and Vermont's criteria-based rule, presents the proposed framework, and applies it through initial regional and lake-specific analyses.

4.1. Regulatory context for a standardized approach

The 2024–2025 modernization of the VORR moved the local restriction schedules into the incorporated-by-reference Transport Canada publication TP 15587E. This allows approved restrictions to be added more efficiently than under the previous process, which required a full regulatory amendment. The modernization was administrative in scope, however, and did not introduce new restriction types or establish national waterbody criteria. During consultation, Transport Canada indicated that proposals for restrictions tied to waterbody characteristics such as length, width, and depth would require additional research and comparative analysis (Government of Canada, 2024, 2025).

Transport Canada's current *Local Authorities' Guide* states that a separate restriction request is required for each waterbody (Transport Canada, 2026b). This report proposes that Transport Canada consider accepting one coordinated regional application covering all lakes in a regional district with road access for trailered boats. Waters already subject to a restriction that prohibits wakesurfing would be excluded (Section 4.4). The application would use a shared evidence base and consultation process, while each lake would be assessed using the wakesports suitability framework and retain its own evidence, proposed boundaries, and restriction details. Where a candidate zone is identified, a Schedule 7 restriction would apply outside that zone; all other lakes would be proposed for a lake-wide Schedule 7 restriction (Section 4.3).

Transport Canada staff have indicated that regional coordination of evidence development, consultation, and aligned applications may be possible (Transport Canada, personal communication, May 28, 2026). However, a single multi-lake application would still require Transport Canada's agreement because it differs from the current process, so the proposed approach would require early confirmation from the regional Office of Boating Safety.

This approach is consistent with existing municipal policy direction. In 2025, the RDEK sponsored UBCM Resolution NR70, Standardized Wake Surfing Regulation, which calls for objective, science-based waterbody criteria and a standardized process for applying VORR restrictions where wakesurfing could affect lake and ecosystem health. The UBCM Executive endorsed the resolution in 2025 (UBCM, 2025a, 2025b). A parallel RDEK-sponsored resolution was considered by the FCM Board of Directors in March 2025 and remains active until March 2028 (FCM, 2025). It urges Transport Canada to establish "objective, science-based, lake and water body characteristics and criteria" and to restrict wakesurfing on waters with those characteristics through a standardized federal approach. These resolutions do not

establish specific thresholds or alter current application requirements, but they demonstrate municipal support for a standardized, multi-waterbody approach.

The evidence reviewed in this report indicates that wakesports suitability depends strongly on physical characteristics, including depth, littoral coverage, available operating space, shoreline configuration, and the capacity for wakes to dissipate. A shared assessment framework could reduce duplication and support more consistent decisions while preserving the site-specific evidence required for each lake.

Waterbody criteria are not currently established as a distinct restriction type under the VORR. Subsection 136(3) of the *Canada Shipping Act, 2001* authorizes the Minister of Transport to temporarily suspend or modify the operation of certain regulations for up to two years, but Transport Canada has described this authority as a means of responding to new or emerging issues where existing processes are not adequate (Government of Canada, 2024, 2025). Transport Canada would therefore need to determine whether a standardized wakesports suitability process could be implemented through existing VORR schedules, a new regulatory approach, or another mechanism. In the near term, the proposed framework could support a coordinated regional application seeking lake-specific restrictions under the current schedules. The longer-term objective would be a standardized process for assessing wakesports suitability across multiple waterbodies.

4.2. Vermont precedent and proposed spatial criteria

Vermont's current wakesports rule, effective June 11, 2026, provides a recent North American example of waterbody eligibility criteria combined with operating requirements. The rule regulates enhanced-wake activity rather than wakeboats as a vessel class. A wakeboat operating without ballast or other wake-enhancing features engaged remains subject to the general boating rules for that waterbody (Vermont Department of Environmental Conservation, 2026).

An inland lake can contain a wakesports zone only where one contiguous area meets five eligibility criteria: at least 100 acres (40.5 ha), a minimum depth of 20 ft (6.1 m), a minimum width of 200 ft (61 m), a minimum operating length of 3,000 ft (914 m), and a shoreline setback of at least 500 ft (152 m). All five criteria must be met together. Where no wakesports zone is defined, wakesports using a wakeboat are not permitted (Vermont Department of Environmental Conservation, 2026).

Separate requirements govern wakesports within a designated zone. Operators must remain at least 500 ft (152 m) from other recreational users and signed loon nesting sites during the nesting season. Ballasted vessels moved between waterbodies must also undergo prescribed hot-water decontamination, addressing the aquatic invasive species risk discussed in Section 2.6. These requirements do not determine whether a zone is physically eligible (Vermont Department of Environmental Conservation, 2026).

Vermont does not impose a numerical carrying capacity within designated zones. The user-separation requirement limits concurrent wakesports activity as a zone becomes crowded, but does not restrict total daily or seasonal use or repeated passes. The rule also allows zones and lake eligibility to be reviewed annually where water levels or other conditions alter eligibility or create concerns for lake management,

research, or water quality. Lake-specific maps, access-area signs, offline GPS-enabled maps, and reporting procedures support implementation (Vermont Department of Environmental Conservation, 2026).

The Vermont model is relevant to British Columbia because it applies common, activity-specific criteria across multiple lakes. Depth and shoreline setback relate most directly to lakebed disturbance and wake attenuation, while area, width, and operating length determine whether enough open water is available for a physically usable zone. User separation addresses interactions with other recreational users. Vermont therefore provides a regulatory and administrative precedent, but its adoption of these criteria does not independently validate their application in British Columbia (Francis et al., 2023; Larratt et al., 2024; Marr et al., 2022).

The proposed minimum spatial criteria retain Vermont's minimum area, depth, width, and operating-length values but increase the shoreline setback from 152 m to 200 m. The 152 m separation from other recreational users is kept as a proposed operating requirement within any wakesports operating area and is not used to identify a candidate zone.

The proposed 200 m shoreline setback is informed by the wave-equivalence distances reported by Marr et al. (2022) and adds a margin beyond the farthest distance measured in that study (183 m). The proposed 6.1 m depth criterion, evaluated at the seasonally low operating water level, is consistent with Riesgraf et al. (2025), who recommended that wakeboats operating in wakesurfing mode use water at least 6.1 m deep under the conditions tested. Additional lake-specific testing at Lac Noir indicated disturbance to approximately 6 m and supported a 7 m operating-depth recommendation (Raymond & Galvez, 2016).

At the lower end, a numerical modelling study concluded that a 61 m setback and a 3 m operating depth were sufficient (Fay et al., 2022), but reviews have criticized its reliance on an uncalibrated, unvalidated model and its extrapolation beyond the model's scope (Macfarlane, 2025; Ortiz et al., 2026). By contrast, other evidence syntheses and management recommendations support consideration of additional margins but do not establish a universal threshold. Drawing on recent wave studies, including Macfarlane (2025), Ortiz et al. (2026) conclude that shoreline protection likely requires setbacks of 100 to 150 m. As mitigation measures, they propose setbacks greater than 180 m and operating depths greater than 10 m. Wisconsin Lakes and Last Wilderness Alliance recommend a 213 m shoreline setback and a minimum operating depth of 9.1 m. These values are precautionary recommendations rather than thresholds demonstrated by a single field study (Wisconsin Lakes & Last Wilderness Alliance, 2025).

The proposed precautionary spatial criteria use a 250 m shoreline setback and a 9 m operating depth, consistent with Safe Quiet Lakes' Better Wake Zones guidance (Safe Quiet Lakes, n.d.). The 9 m depth also falls within the range of scientific recommendations: Larratt et al. (2024) applied a depth greater than 8 m in its ecological scenario for Lake Windermere, Raymond and Galvez (2016) recommended 7 m at Lac Noir, and Ortiz et al. (2026) propose operating depths greater than 10 m. These values are proposed for management purposes rather than as universal ecological-effect thresholds.

Table 2 presents the proposed minimum and precautionary spatial criteria and separately identifies the operating-separation requirement. The role of these criteria within the wakesports suitability framework is described in Section 4.3.

Table 2. Proposed spatial criteria for candidate zones and operating separation within a wakesports operating area.

Criterion	Minimum spatial criteria	Precautionary spatial criteria
Contiguous area	≥ 40.5 ha	
Operating depth (at the seasonally low operating water level)	**≥ 6.1 m**	**≥ 9 m**
Shoreline setback (from all shorelines, including islands)	**≥ 200 m**	**≥ 250 m**
Minimum zone width	≥ 61 m	
Minimum zone length	≥ 914 m	
Proposed operating separation within a wakesports operating area (from people, other motorized or unmotorized vessels)	≥ 152 m	

Note. The minimum area, depth, width, and operating-length criteria are adapted from Vermont's wakesports rule. The metric values are rounded conversions of 100 acres, 20 ft, 200 ft, and 3,000 ft. The proposed 200 m shoreline setback replaces Vermont's 500 ft (152 m) setback. The precautionary criteria draw on Safe Quiet Lakes' Better Wake Zones guidance (Safe Quiet Lakes, n.d.) and are consistent with depth recommendations by Larratt et al. (2024), Raymond and Galvez (2016), and Ortiz et al. (2026). Vermont's separate 152 m (500 ft) operating separation from people in the water and other vessels is proposed as an operating requirement within a wakesports operating area and is not used to identify a candidate zone. The precautionary spatial criteria apply to lakes with a *High Risk* or *Extreme Risk* index rating and may apply to lakes rated *Low Risk* or *Moderate Risk* (Section 4.3).

4.3. Proposed wakesports suitability framework

Appendix B presents the proposed wakesports suitability framework. The framework pairs two assessments. The lake-wide assessment evaluates a lake's overall susceptibility to boating-related effects and determines which set of spatial criteria applies. The spatial assessment then maps whether any part of the lake meets the applicable criteria in Table 2. The two results are interpreted together, so an area meeting the spatial criteria is not treated as sufficient evidence of wakesports suitability on its own.

Lake-wide assessment

The lake-wide assessment uses the Lake Suitability Index, developed by Larratt Aquatic Consulting to distinguish lakes that may be able to accommodate powerboating, particularly wakesurfing, from lakes that are more susceptible to adverse effects (Larratt et al., 2024). The index scores 12 indicators across

four domains: limnology, recreational safety, habitat, and water quality (Table 3). Each indicator is scored from 1 to 5, producing an index score of 12 to 60, with higher scores indicating greater assessed susceptibility. Under the published index, ratings from *Negligible Risk* through *Moderate Risk* are classified as suitable for powerboating, subject to increasingly protective management responses, while *High Risk* and *Extreme Risk* ratings are classified as unsuitable. Because these categories address powerboating generally, the index rating informs the lake-wide assessment but does not, by itself, determine wakesports suitability.

A qualified professional interprets the index rating and its indicators, considering their relevance to wakesports, to determine which set of spatial criteria applies. A *Negligible Risk* or *Very Low Risk* rating supports proceeding to the spatial assessment using the minimum spatial criteria. For a *Low Risk* or *Moderate Risk* rating, the indicators behind the index score are reviewed along with any important information gaps to determine whether the minimum or precautionary spatial criteria apply. Greater wakesport-relevant susceptibility supports applying the precautionary spatial criteria and may weigh against considering a wakesports operating area. A *High Risk* or *Extreme Risk* rating weighs strongly against considering a wakesports operating area. A lake-wide restriction would generally be proposed, unless the qualified professional determines that a spatial assessment is warranted, in which case the precautionary spatial criteria apply.

The index is needed only for lakes that pass the initial lake screening (Section 4.4). To pass, a lake must have a contiguous area of at least 40.5 ha beyond 200 m from all shorelines. Where bathymetry exists, that area must also be at least 6.1 m deep. Lakes that do not pass cannot contain a candidate zone, so a lake-wide Schedule 7 wakesurfing restriction would be proposed without an index rating.

Table 3. Lake Suitability Index domains, indicators, and supporting information.

Domain	Indicators included	Principal supporting information
Limnology: five indicators	Mean depth; trophic condition; percentage of littoral shallows under 8 m; distribution of fine littoral sediments; shoreline erosion/riparian condition	Bathymetry, sediment surveys and foreshore mapping
Recreational safety: two indicators	Swimmer/paddlecraft safety; powerboat safety and density in key summer-use areas	Boat counts, carrying-capacity analysis and lake-user information
Habitat: three indicators	Vulnerable riparian-littoral habitat; aquatic/riparian species at risk; vulnerability to invasive mussels	FIM/FHSI information, species records, water chemistry
Water quality: two indicators	Degraded water-quality potential; harmful algal-bloom potential	Water-quality monitoring, trends, objectives and lake studies

Note. Adapted from Larratt et al. (2024, pp. 38–40). Each of the 12 indicators is scored from 1 to 5, producing an index score of 12 to 60. Higher scores indicate greater assessed susceptibility under the index. The index informs

the lake-wide assessment; whether any area meets the applicable spatial criteria is determined separately through the spatial assessment.

Spatial assessment

The spatial assessment applies the minimum or precautionary spatial criteria identified through the lake-wide assessment. It requires bathymetry referenced to the seasonally low operating water level and mapped shorelines, including islands. An area meeting all five applicable spatial criteria is identified as a candidate zone, which would be proposed as a wakesports operating area. Because the applicable criteria come from the lake-wide assessment, a candidate zone reflects both assessments. It becomes a designated operating area only if Transport Canada approves the proposed restriction. Areas meeting a criteria set that does not apply to the lake, such as the minimum spatial criteria on a lake with an *Extreme Risk* rating, may be reported for comparison but are not candidate zones.

Information gaps

Where information needed for either assessment is incomplete, a qualified professional may make the determination using the best available information. Examples include a lake that lacks the boat-count data needed to score the index's powerboat density indicator, and a reservoir whose large and variable drawdown prevents bathymetry from being referenced to a stable low water level. In the first case, launch and moorage capacity, aerial imagery, or local observations could inform the score. The determination should document the data used and uncertainty, and should apply the precautionary spatial criteria where that uncertainty could affect the outcome.

Interpreting the results

The lake-wide and spatial assessment results are then interpreted together. Where a candidate zone is identified, it would be proposed as a wakesports operating area, and a Schedule 7 wakesurfing restriction would be proposed for the waters outside it. If Transport Canada approves the restriction, wakesurfing would remain permitted within the designated operating area, subject to any operating requirements. Where the lake-wide assessment does not support proceeding to the spatial assessment, or no candidate zone is identified, a lake-wide Schedule 7 wakesurfing restriction would instead be proposed. These outcomes address wakesurfing specifically. Other boating activities and broader nearshore pressures, including wakeboarding behind ballasted wakeboats, would require separate or complementary measures.

4.4. Initial lake screening and spatial analyses

An initial B.C.-wide GIS analysis prepared for this review used the B.C. Freshwater Atlas to identify lake features warranting further bathymetric analysis. The Freshwater Atlas contains 386,025 mapped lake features, including many small open-water wetlands. Of these, 3,848 were larger than 40.5 ha, the minimum contiguous area required by both sets of spatial criteria. After a 200 m shoreline setback was applied, 839 lake features retained a contiguous area of at least 40.5 ha. Of these, 427 were within 250 m of a road in the B.C. Digital Road Atlas and were treated as reasonably accessible to boaters. Of the accessible features, 323 had bathymetry available through the provincial database, while 104 lacked it

(Holden Ecological, 2026). These counts identify lake features warranting further mapping; they do not indicate how many meet all five proposed minimum spatial criteria.

The RDEK portion of the analysis screened the 36 mapped lake features in the regional district larger than 40.5 ha. After a 200 m shoreline setback was applied, nine retained at least 40.5 ha of contiguous area, and eight of these were within 250 m of a road (Holden Ecological, 2026). The remaining 28 features did not meet one or both preliminary screening conditions. Three of the eight were then excluded from further assessment. Whiteswan Lake is already subject to a lake-wide Schedule 7 restriction with no permitted hours (Transport Canada, 2026a), and such waters are excluded before screening (Section 4.3). Columbia Lake does not pass the initial lake screening because its maximum depth of 5.2 m is less than 6.1 m. The southern portion of Premier Lake is already subject to a Schedule 7 wakesurfing restriction with no permitted hours, a towing restriction, and a 16 km/h speed limit (Transport Canada, 2026a). In the northern portion of Premier Lake, only 34.1 ha of contiguous area lies beyond 200 m from shore, below the 40.5 ha minimum; therefore, does not pass the initial area screening. A Schedule 7 restriction would be proposed for both Columbia Lake and the northern portion of Premier Lake.

Five lake features were therefore retained for further assessment: Lake Koocanusa, the north and south basins of Moyie Lake, St. Mary Lake, and Lake Windermere. Spatial mapping applied both sets of spatial criteria to these features (Table 4; Holden Ecological, 2026). Both basins of Moyie Lake contain areas meeting all five minimum and all five precautionary spatial criteria. Each would therefore contain a candidate zone under either set, unless its lake-wide assessment does not support proceeding to the spatial assessment. Preliminary mapping indicates that St. Mary Lake likely also contains such areas (Table 4), although updated bathymetry is needed to confirm their extent. Lake Suitability Index ratings have not been completed for these lakes. Results for Lake Windermere are discussed below.

These results are preliminary, and several of the provincial bathymetric maps used were surveyed between 1958 and 1974. The south basin of Moyie Lake only narrowly meets the precautionary area and width criteria (41.7 ha; 62 m at its narrowest). Confirming each result would require bathymetry referenced to the seasonally low operating water level (Section 4.3).

St. Mary Lake's result is less certain because its 1959 bathymetric map conflicts with air photos taken between 1975 and 2026. Those photos show parts of the surveyed lake as dry or wetland, including a northwest-arm pool mapped at 6.1 m deep. The lake's 6.1 m and 9 m depth lines were therefore estimated from distance to a shoreline adjusted manually from the Freshwater Atlas polygon (Holden Ecological, 2026). Updated bathymetry would be needed to confirm the location and extent of a candidate zone on St. Mary Lake.

Lake Koocanusa could not be assessed because no bathymetry is available in the provincial database. Its size suggests it could contain a candidate zone, but confirming this would require further investigation, including depth data. Its status as a reservoir does not, by itself, justify its removal from regional consideration. Because its large and variable drawdown also prevents bathymetry from being referenced to a stable low water level, its spatial assessment would require a qualified professional's determination using the best available information, which could include reservoir operating levels (Section 4.3).

Table 4. Preliminary spatial assessment results for the five lake features retained for further assessment.

Lake feature	Minimum spatial criteria	Precautionary spatial criteria	Notes
Moyie Lake, north basin	324 ha	264 ha	Meets both sets
Moyie Lake, south basin	70 ha	41.7 ha	Narrowly meets precautionary area and width (41.7 ha; 62 m at narrowest)
St. Mary Lake	Possible (about 140 ha)	Possible (about 60 ha)	Approximate only; 1959 bathymetry conflicts with recent air photos; updated bathymetry required
Lake Windermere	63 ha (comparison only)	None	*Extreme Risk* index rating; maximum depth 6.4 m
Lake Koocanusa	Not assessed	Not assessed	No bathymetry in the provincial database

Note. Area of the largest contiguous zone meeting all five applicable criteria (Holden Ecological, 2026). Results are spatial only and do not reflect a lake-wide assessment.

For the proposed regional application, the screening would start from every road-accessible lake in the regional district, regardless of size, so that lakes too small to contain a candidate zone can be proposed for a lake-wide Schedule 7 restriction. Lakes within 250 m of a road would form a first-pass list, confirmed using known boat launches, observed motorized use, or local knowledge; lakes farther from a road with a known launch could be added. Waters already subject to a restriction that prohibits wakesurfing at all times would be excluded: Schedules 1, 2, or 3, or a Schedule 7 restriction without permitted hours. Lakes subject to a Schedule 4 engine-power limit or a Schedule 5 speed limit would be excluded only where that limit clearly prevents wakesurfing, such as a speed limit below typical wakesurfing speeds of about 16 to 21 km/h.

Any remaining lake with no contiguous area of at least 40.5 ha beyond 200 m from shore, which includes every lake smaller than 40.5 ha, would be proposed for a lake-wide Schedule 7 restriction. This group includes lakes where wakesurfing has raised local concern. Residents have reported conflicts over wakesurfing on Tie Lake, Rosen Lake, and Wasa Lake. These lakes each lack a contiguous area of at least 40.5 ha even with a 150 m setback (Holden Ecological, 2026). A recent assessment of Wasa Lake gave it a *High Risk* index rating and found it unsuitable for unrestricted powerboating and wakesurfing (Knezevic & Self, 2026). The RDEK screening did not assess road access for the 3,863 lake features smaller than 40.5 ha, so this list would be compiled for the application. Transport Canada has not indicated whether a spatial screening result alone would be sufficient evidence for these smaller lakes.

Framework results for Lake Windermere and Columbia Lake

Spatial mapping prepared for this review applied the minimum spatial criteria to Lake Windermere and Columbia Lake (Figures 4 and 5), including a minimum operating depth of 6.1 m and a 200 m setback

from all shorelines. Columbia Lake cannot meet the minimum spatial criteria because its reported maximum depth is approximately 5.2 m, so it contains no candidate zone and its outcome does not depend on an index rating. Lake Windermere's *Extreme Risk* index rating means a lake-wide restriction would generally be proposed. If a spatial assessment were warranted, the precautionary spatial criteria would apply, and no part of the lake meets the 9 m precautionary depth criterion (Holden Ecological, 2026; Larratt et al., 2024; Wood Canada Ltd., 2022). Lake Windermere therefore also contains no candidate zone. For comparison, approximately 63 ha met all five minimum spatial criteria.

The Lake Windermere comparison result should be interpreted alongside the recreational-use surveys and Lake Suitability Index assessment reported by Larratt et al. (2024). Popular portions of the lake exceeded the study's boating-density benchmark of one powerboat per 8 ha (20 acres) during summer weekend and long-weekend survey events. Motorized activity was greatest on weekend afternoons, and wakeboats were the most frequently observed boat type. During some weekend survey events, areas exceeding the benchmark collectively accounted for up to 28% of the lake surface. Paddlecraft counts were lower during peak powerboating periods and on long weekends than on weekdays.

Larratt et al. (2024) also examined how the lake's available operating space could be distributed among recreational uses. Under the study's proposed play-area analysis, approximately 705 ha, or 43% of the lake, was classified as deeper than 4 m and potentially available for general powerboat use. Approximately 926 ha, or 57%, was identified for paddlecraft and swimming under the study's depth and shoreline-buffer assumptions. The report also identified the shallow southern end as a factor concentrating motorized boating in other portions of the lake.

Together, these findings demonstrate that an area meeting the minimum spatial criteria must be interpreted in relation to the amount and distribution of usable operating space and the intensity and spatial concentration of existing use. The Lake Suitability Index placed Lake Windermere in its published *Extreme Risk* category, and Larratt et al. (2024) concluded that the lake was not suited to wakesurfing. Under the proposed framework, that lake-wide result weighs strongly against considering a wakesports operating area, and the 63 ha comparison result does not override it. Comparable recreation-focused carrying-capacity data were not identified for Columbia Lake, leaving boating pressure and recreational capacity as local data gaps. Earlier foreshore planning similarly recommended that recreational and environmental carrying capacity be assessed together (Schleppe & McPherson, 2021b).

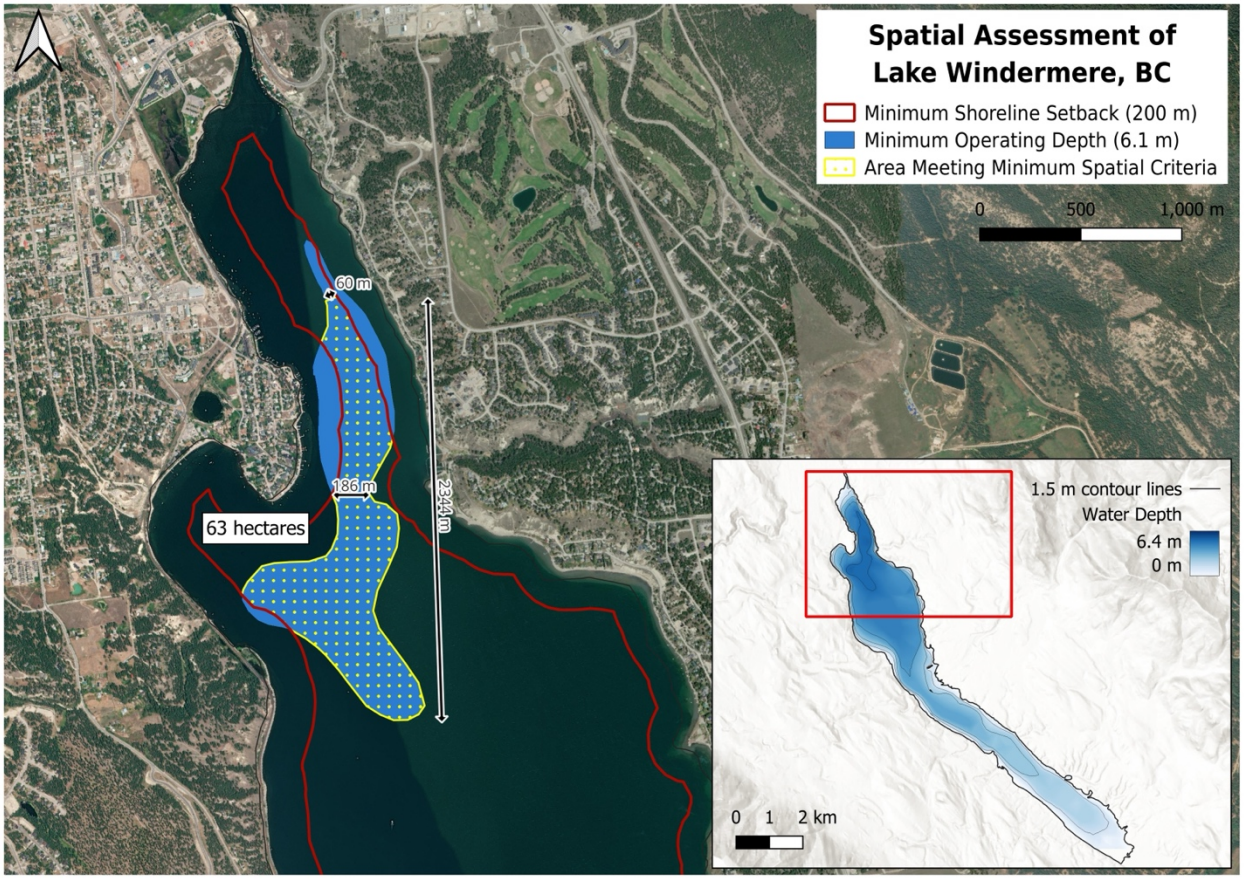


Figure 4. Area of Lake Windermere (about 63 ha) that meets the five minimum spatial criteria, shown for comparison only. This area is not a candidate zone. The lake's Extreme Risk index rating means a lake-wide restriction would generally be proposed. Even under the precautionary criteria, no part of the lake reaches the required 9 m depth (maximum 6.4 m; Holden Ecological, 2026).

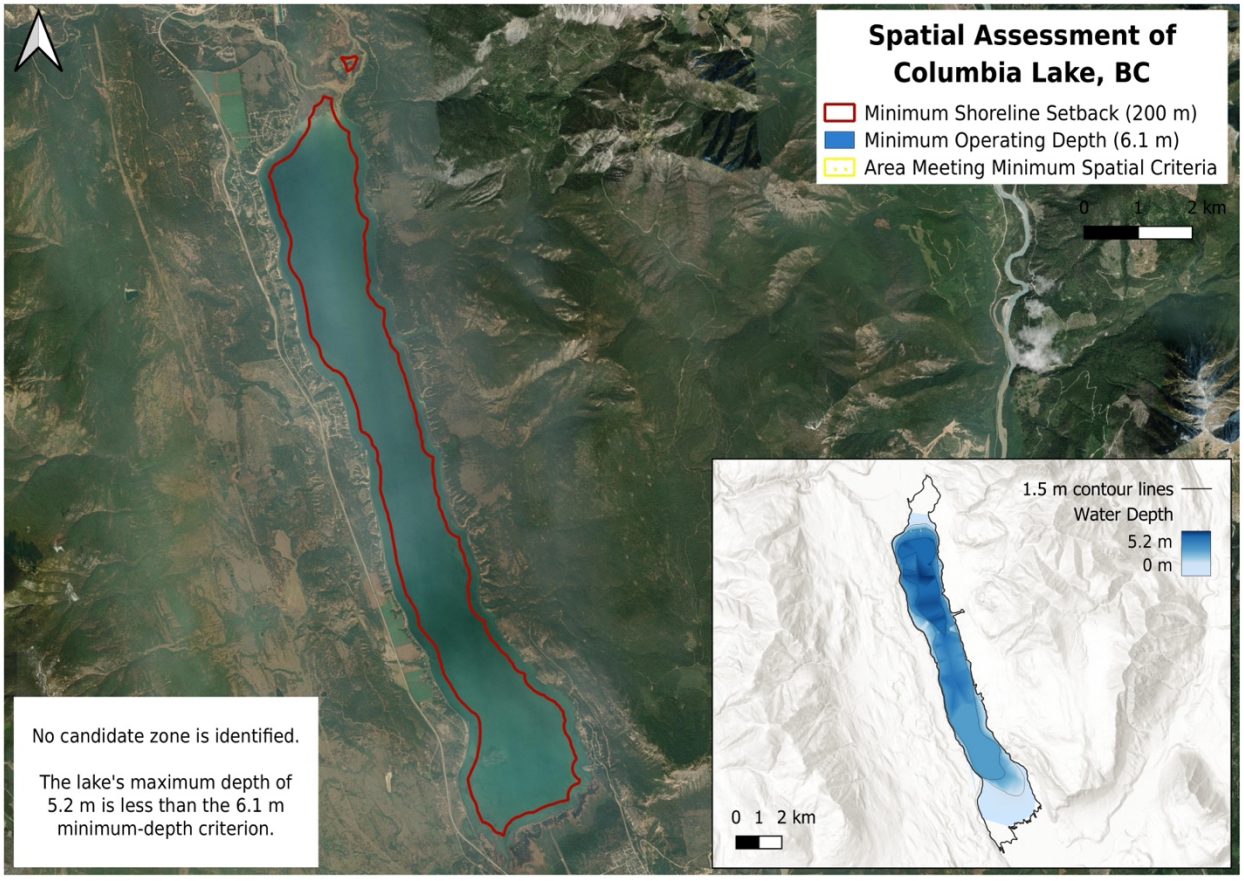


Figure 5. Spatial assessment of Columbia Lake using the proposed minimum spatial criteria. No candidate zone is identified because the lake's reported maximum depth of 5.2 m is less than the 6.1 m minimum-depth criterion (Holden Ecological, 2026).

5. Monitoring and adaptive review

5.1. Existing monitoring programs

A range of existing programs provides baseline information for Lake Windermere and Columbia Lake, including long-term water-quality and water-level monitoring, foreshore mapping, shoreline fisheries assessment, aquatic plant and invasive-species surveillance, waterbird surveys, and recreation studies. Appendix C summarizes the principal stewardship, monitoring, and planning initiatives.

Water-quality monitoring has been conducted on Columbia Lake since 2014 and on Lake Windermere through the Lake Windermere Ambassadors since 2010, building on the Lake Windermere Project initiated in 2006. The Columbia Lake Stewardship Society has also operated a water-quantity monitoring program since fall 2014 (CLSS, 2026a, 2026b; Saunders, 2025). Foreshore Integrated Management Planning assessments and the 2021 shoreline fisheries assessment provide additional baseline information on shoreline condition, habitat values, and nearshore fish assemblages, although repeated sampling would be required to distinguish natural variability from longer-term change (Hildebrand, 2022; Schleppe & McPherson, 2021b; Wood Canada Ltd., 2022).

Lake Windermere's annual aquatic plant surveys are designed primarily for the early detection of invasive plants. They provide repeated observations of native vegetation at selected high-risk stations but were not designed to assess lake-wide native macrophyte condition (Darvill, 2025a).

Existing waterbird surveys document species occurrence and seasonal habitat use (Darvill, 2019, 2024). The 2026 Columbia Headwaters Stewardship Project expands this work through a baseline native mussel survey on Lake Windermere led by Lake Windermere Ambassadors in partnership with the Columbia Lake Stewardship Society (Watershed Security Fund, 2026).

The Lake Windermere recreational impacts assessment provides the most direct local baseline for boating intensity, locations, timing, and peak-use patterns and could support future comparison if management measures are implemented (Larratt et al., 2024). A comparable recreation-focused carrying-capacity or Lake Suitability Index assessment has not been completed for Columbia Lake.

5.2. Implementation and evaluation

The monitoring components below address three distinct purposes: assessing VORR implementation and compliance, documenting optional ecological responses, and supporting aquatic invasive species prevention. Comprehensive new ecological monitoring is not required for a VORR application where adequate lake-specific evidence already exists, although Transport Canada assesses the sufficiency of that evidence case by case (Transport Canada, 2026b). Aquatic invasive species prevention and monitoring are considered separately because Schedule 7 regulates wakesurfing rather than the entry or movement of ballast-equipped vessels.

VORR implementation and effectiveness

A VORR application must describe how the effectiveness of the proposed restriction will be assessed. Transport Canada indicates that this assessment should occur one year after implementation. Practical indicators can include boating observations, complaints and public feedback, and enforcement records (Transport Canada, 2026b).

Boating activity and compliance. Where feasible, standardized boat-count surveys conducted before implementation can document boating activities, locations, timing, peak-use periods, wakesurfing frequency, and repeated passes. After implementation, repeat the surveys at the same locations and during comparable periods, recording wakesurfing observations, their locations and times, changes in where activity occurs, and observations that may indicate non-compliance. Observers should document the activity rather than determine whether an offence occurred. Compare the results with pre-implementation observations where available. The Lake Windermere boating analysis provides one example of a standardized survey approach (Larratt et al., 2024).

Complaints and public feedback. Maintain a consistent record of complaints, inquiries, and other feedback, including their date, location, and nature. A brief survey of recreational users or shoreline residents could provide additional information about awareness, compliance, and whether reported concerns have changed. Interpret complaint trends alongside changes in public awareness, outreach, and enforcement effort because reporting rates can change even where boating behaviour does not.

Enforcement information. Summarize observation or patrol effort, warnings, reported violations, and enforcement outcomes. Interpret recorded violations in relation to enforcement effort because increased patrols may produce more reports even where overall compliance is improving.

Together, these indicators provide a practical means of assessing implementation and regulatory effectiveness. Stewardship organizations could assist with standardized observations and surveys, while the local authority and enforcement partners would provide complaint and enforcement information. For a multi-lake application, effectiveness could be assessed proportionately, with standardized surveys on higher-use lakes and complaint and enforcement records for the remainder.

Optional ecological-response monitoring

Ecological-response monitoring goes beyond the VORR effectiveness assessment, and its scope should reflect available capacity, funding, and technical partnerships. Where possible, compare conditions before and after implementation of a VORR at selected higher-use sites and comparable lower-use reference sites. Record boating activity and relevant natural conditions, including wind, water level, and runoff, to support interpretation (Houser & George, 2026).

Shoreline and underwater habitat. Establish fixed shoreline photo points and repeat underwater video or snorkel transects at selected higher-use sites and comparable lower-use reference sites during similar seasonal periods. Periodic FIMP re-surveys using comparable methods would complement this targeted monitoring by improving detection of longer-term shoreline and habitat change.

Water quality and turbidity. Use established water-quality programs to evaluate seasonal and year-to-year conditions. Where equipment and technical support are available, targeted nearshore turbidity monitoring can assess responses to individual vessel passages and the time required for turbidity to return to background levels. Nutrient and chlorophyll-a sampling may be added where a study is specifically examining sediment-bound nutrient release or algal response.

Waterbirds and sensitive habitat. Use existing records, local knowledge, and preliminary surveys to identify important waterbird-use areas. During relevant breeding, brood-rearing, or migration periods, record bird numbers, boating activity, estimated vessel distance, and observable responses such as alert behaviour, displacement, or flushing. Monitoring should remain observational and should not involve deliberate approaches to birds, nests, broods, or colonies.

Specialized and longer-term studies. Qualified professionals or researchers could measure wake energy, near-bed water movement, sediment resuspension, and recovery time using pressure sensors, current measurements, turbidity instruments, or underwater video. Longer-term studies could examine changes in shoreline condition, fish habitat, aquatic vegetation, native mussels, or other biological indicators.

Where monitoring is undertaken across multiple lakes, a shared core protocol would improve consistency and support comparison among sites.

Aquatic invasive species prevention and monitoring

Aquatic invasive species prevention and monitoring should remain a separate management priority. Relevant information may include provincial inspection coverage, high-risk interceptions, watercraft travel routes, and ballast-specific decontamination outcomes. Clean, Drain, Dry outreach, launch signage, reporting of suspected invasive species, dreissenid veliger monitoring, and whirling-disease surveillance should continue through appropriate provincial, federal, or local agencies and qualified organizations. Because a Schedule 7 restriction would not prohibit ballast-equipped vessels from entering a lake, aquatic invasive species indicators should remain separate from the VORR effectiveness assessment.

Adaptive review

Following the one-year effectiveness assessment, the findings could inform adjustments to communication, enforcement, monitoring, or complementary management measures. Further review could be undertaken as appropriate. Changes to the restriction itself, including its boundaries, permitted hours, or restriction type, would require the applicable Transport Canada process (Transport Canada, 2026b).

6. Conclusion

6.1. Local susceptibility and management relevance

The available evidence shows that wakeboats operated for wakesurfing can generate larger, longer-period, and more energetic waves than conventional recreational boats. They can also produce near-bed water movement capable of disturbing susceptible sediments at depths of approximately 4 to 6 m. Ecological outcomes remain lake-specific, but risk increases where shallow water, fine sediments, extensive littoral habitat, sensitive shorelines, and concentrated boating activity overlap (Marr et al., 2022; Ortiz et al., 2026; Riesgraf et al., 2025).

Lake Windermere combines these conditions, with a mean depth of approximately 3.4 m, a maximum depth of approximately 6.4 m, and a littoral area covering about 95% of the lake. It scored 53/60 on the Lake Suitability Index, an *Extreme Risk* rating that weighs strongly against designating a wakesports operating area. No part of the lake meets the 9 m precautionary depth criterion, so the lake contains no candidate zone; the approximately 63 ha that met the minimum spatial criteria is a comparison result only. This interpretation is consistent with the assessment by Larratt et al. (2024), which concluded that Lake Windermere was unsuitable for wakesurfing.

Columbia Lake is even shallower, with a mean depth of approximately 2.9 m and a maximum depth of approximately 5.2 m. Because no part of the lake reaches 6.1 m, it does not pass the initial lake screening. It therefore has no candidate zone under either set of spatial criteria, and a lake-wide restriction would be proposed without an index rating. Its extensive vegetation, broad littoral shelves, fine or soft substrates, and seasonally lower water levels further increase the overlap between boating activity and shallow habitat (CLSS, 2026a; Wood Canada Ltd., 2022).

Both lakes support aquatic vegetation, fish spawning and juvenile-rearing habitat, native mussels, and waterbird nesting, feeding, brood-rearing, and staging areas. No population-level effects of wakesports have been documented on either lake, but these ecological values increase the potential consequences of repeated disturbance where exposure occurs. Projected climate changes, including warmer water and lower late-summer inflows and water levels, could further reduce depth beneath boats and increase the sensitivity of shallow habitats (Bürger et al., 2011; Werner et al., 2013; Woolway et al., 2020). The framework results and lake-specific evidence support consideration of lake-wide Schedule 7 wakesurfing restrictions for both lakes. Broader speed, towing, or powerboating restrictions would require separate assessment.

Ballast-mediated aquatic invasive species transport remains a separate concern. Because Schedule 7 regulates wakesurfing rather than the launching or movement of ballast-equipped vessels, invasive-species prevention requires complementary inspection, decontamination, outreach, and early-detection measures (Campbell et al., 2016; Doll, 2018).

6.2. Implications for stewardship and boating regulation

Implementation would require collaboration with Indigenous Nations, as rights holders and potential co-applicants under the VORR, and coordination among provincial agencies, local governments, stewardship organizations, and enforcement partners. Roles in consultation, stewardship, monitoring, and data governance would need to be established together, while enforceable restrictions on vessel operation would proceed through the federal VORR process.

Where existing evidence is sufficient to support a VORR application, targeted local research and ecological monitoring should not be treated as prerequisites. They could still refine understanding of lake conditions and the spatial criteria over time. Each application must, however, describe how the effectiveness of the proposed restriction will be assessed after implementation (Section 5.2). Where feasible, standardized boating observations should begin before implementation to provide a baseline and continue afterward using comparable methods.

The proposed framework is intended to support one RDEK-led regional initiative and, subject to Transport Canada's agreement, one coordinated application covering road-accessible lakes in the regional district where wakesurfing is not already prohibited (Section 4.4). Because this format differs from the current waterbody-specific process, it should be discussed early with Transport Canada. As the *Local Authorities' Guide* requires for each waterbody, each lake would retain lake-specific evidence, boundaries, and a clearly defined proposed restriction within the coordinated application (Transport Canada, 2026b).

The coordinated application would propose a Schedule 7 restriction outside each identified candidate zone and a lake-wide Schedule 7 restriction for all other lakes. Where a wakesports operating area is designated, the proposed 152 m operating separation (Table 2) could not be implemented through Schedule 7 and would need to be promoted through education or implemented through another mechanism.

6.3. Matching activities to lake conditions

Boating is a valued use of Lake Windermere and Columbia Lake. The management question is not whether people should enjoy these waters, but which activities their physical and ecological conditions can support without degrading the values that sustain recreation over time. A consistent, evidence-based approach can maintain wakesports access where lake conditions support it and support restrictions where they do not. Preliminary mapping indicates that deeper lakes, such as Moyie Lake, could accommodate a wakesports operating area, subject to their lake-wide assessments. For these two shallow, littoral-dominated lakes, the available evidence does not support designating wakesports operating areas.

7. References

Alexander, M. T., & Wigart, R. C. (2013). Effect of motorized watercraft on summer nearshore turbidity at Lake Tahoe, California–Nevada. *Lake and Reservoir Management, 29*(4), 247–256. https://doi.org/10.1080/10402381.2013.840704

Allen, H. H., & Tingle, J. L. (1993). *Proceedings of the U.S. Army Corps of Engineers workshop on reservoir shoreline erosion: A national problem*. U.S. Army Corps of Engineers.

Allen, J. H., Nuechterlein, G. L., & Buitron, D. (2008a). Bulrush mediation effects on wave action: Implications for over-water nesting birds. *Waterbirds, 31*(3), 411–416. https://doi.org/10.1675/1524-4695-31.3.411

Allen, J. H., Nuechterlein, G. L., & Buitron, D. (2008b). Weathering the storm: How wind and waves impact Western Grebe nest placement and success. *Waterbirds, 31*(3), 402–410. https://doi.org/10.1675/1524-4695-31.3.402

Angell, N. R., Campbell, T., Brady, V., Bajcz, A. W., Kinsley, A. C., Doll, A., Dumke, J., Keller, R. P., & Phelps, N. B. D. (2024). Quantifying the effectiveness of three aquatic invasive species prevention methods. *Management of Biological Invasions, 15*(3), 371–396. https://doi.org/10.3391/mbi.2024.15.3.04

Asplund, T. R. (2000). *The effects of motorized watercraft on aquatic systems*. Wisconsin Department of Natural Resources.

Asplund, T. R., & Cook, C. M. (1997). Effects of motor boats on submerged aquatic macrophytes. *Lake and Reservoir Management, 13*(1), 1–12. https://doi.org/10.1080/07438149709354290

Barbeau, J., Mazzei, R., Rodríguez, M. A., & Proulx, R. (2024). Fish responses to underwater sounds depend on auditory adaptations: An experimental test of the effect of motorboat sounds on the fish community of a large fluvial lake. *Ecology and Evolution, 14*(3), e10946. https://doi.org/10.1002/ece3.10946

Brown, W. S. (2021). *Adverse impacts attributed to the operation of wake-enhanced boats on inland lake ecosystems*. Hamburg Township. https://cms7files.revize.com/hamburgmi/Planning%20and%20Zoning/WEBSITE/adverse-impacts-attributed-to-the-operation-of-wake-enhanced-boats-on-inland-lake-ecosystems.pdf

Bürger, G., Schulla, J., & Werner, A. T. (2011). Estimates of future flow, including extremes, of the Columbia River headwaters. *Water Resources Research, 47*(10), W10520. https://doi.org/10.1029/2010WR009716

Cameron, H. (2015). *River bank erosion processes along the Lower Shuswap River, British Columbia* [Bachelor's honours thesis, University of British Columbia Okanagan]. https://a100.gov.bc.ca/pub/acat/documents/r50246/CameronThesis_2015_1460582419248_0582283256.pdf

Campbell, T., Verboomen, T., Montz, G., & Seilheimer, T. (2016). Volume and contents of residual water in recreational watercraft ballast systems. *Management of Biological Invasions, 7*(3), 281–286. https://doi.org/10.3391/mbi.2016.7.3.07

Canada Shipping Act, 2001, S.C. 2001, c. 26. https://laws-lois.justice.gc.ca/eng/acts/C-10.15/

Cantwell, M. G., Burgess, R. M., & King, J. W. (2008). Resuspension of contaminated field and formulated reference sediments Part I: Evaluation of metal release under controlled laboratory conditions. *Chemosphere, 73*(11), 1824–1831. https://doi.org/10.1016/j.chemosphere.2008.08.007

Catherine Berris & Associates Ltd. (2011). *Lake Windermere management plan*. Regional District of East Kootenay & District of Invermere. https://www.rdek.bc.ca/web/pdf/lakewindermeremanagementplan/LWMP_Final_Report_-_Text_Only.pdf

Chambers, P. A., DeWreede, R. E., Irlandi, E. A., & Vandermeulen, H. (1999). Management issues in aquatic macrophyte ecology: A Canadian perspective. *Canadian Journal of Botany, 77*(4), 471–487. https://doi.org/10.1139/b99-092

Chhor, A. D., Glassman, D. M., Smol, J. P., Vermaire, J. C., & Cooke, S. J. (2020). Ecological consequences of shoreline armoring on littoral fish and benthic macroinvertebrate communities in an eastern Ontario lake. *Aquatic Sciences, 82*(4), 73. https://doi.org/10.1007/s00027-020-00740-0

Columbia Lake Stewardship Society. (2026a). *Water quality monitoring program annual report for 2025*.

Columbia Lake Stewardship Society. (2026b). *Summary of Columbia Lake Stewardship Society's 2024–25 water quantity monitoring program*.

Coops, H., Geilen, N., Verheij, H. J., Boeters, R., & van der Velde, G. (1996). Interactions between waves, bank erosion and emergent vegetation: An experimental study in a wave tank. *Aquatic Botany, 53*(3–4), 187–198. https://doi.org/10.1016/0304-3770(96)01027-3

Dahanayake, A. C., Webb, J. A., Greet, J., & Brookes, J. D. (2024). How do plants reduce erosion? An Eco Evidence assessment. *Plant Ecology, 225*(6), 593–604. https://doi.org/10.1007/s11258-024-01414-9

Darvill, R. (2019). *Insight into the waterbirds of Lake Windermere*. Goldeneye Ecological Services.

Darvill, R. (2024). *Lake Windermere fall waterbird survey 2019–2022 and 2024* [Monitoring dataset]. Goldeneye Ecological Services.

Darvill, R. (2025a). *Lake Windermere aquatic invasive plant inventory 2024*. Lake Windermere Ambassadors.

Darvill, R. (2025b). *Upper Columbia Swallow Habitat Enhancement Project—Year 4 (2024–2025): Large Grant final report* (Project No. COL-F25-W-4010). Fish and Wildlife Compensation Program.

Darvill, R. (2026). *Kootenay Connect: Restoration of habitats and species at risk in the Columbia Valley—Year 7 (2025–2026) and summary report (2019–2026)*. Columbia Wetlands Stewardship Partners & Kootenay Connect. https://kootenayconservation.ca/wp-content/uploads/2026/04/CWSP_KC_Columbia-Wetlands_Yr-7_Restoration-of-Habitats-and-Species-at-Risk-Report_4Mar2026.pdf

Doig, L. E., North, R. L., Hudson, J. J., Hewlett, C., Lindenschmidt, K.-E., & Liber, K. (2017). Phosphorus release from sediments in a river-valley reservoir in the northern Great Plains of North America. *Hydrobiologia, 787*(1), 323–339. https://doi.org/10.1007/s10750-016-2977-2

Doll, A. C. (2018). *Occurrence and survival of zebra mussel (*Dreissena polymorpha*) veliger larvae in residual water transported by recreational watercraft* [Master's thesis, University of Minnesota]. University of Minnesota Conservancy. https://hdl.handle.net/11299/202094

Dorava, J. M., & Moore, G. W. (1997). *Effects of boatwakes on streambank erosion, Kenai River, Alaska* (Water-Resources Investigations Report 97-4105). U.S. Geological Survey. https://doi.org/10.3133/wri974105

Doyle, R. D. (2001). Effects of waves on the early growth of *Vallisneria americana. Freshwater Biology, 46*(3), 389–397. https://doi.org/10.1046/j.1365-2427.2001.00668.x

Drake, D. A. R. (2017). *Overland spread of aquatic invasive species among freshwater ecosystems due to recreational boating in Canada* (Canadian Science Advisory Secretariat Research Document 2017/031). Fisheries and Oceans Canada.

Ecological Reserve Act, R.S.B.C. 1996, c. 103. https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/96103_01

Environment and Climate Change Canada. (2022). *Recovery strategy for the Bank Swallow (*Riparia riparia*) in Canada* [Proposed]. Government of Canada. https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/recovery-strategies/bank-swallow-2022.html

Environment and Climate Change Canada. (2024, July 26). *Guidelines to avoid disturbance to seabird and waterbird colonies in Canada.* Government of Canada. https://www.canada.ca/en/environment-climate-change/services/avoiding-harm-migratory-birds/avoid-disturbance-seabird-waterbird-colonies-canada.html

Fay, E. M., Gunderson, A., & Anderson, A. (2022). Numerical study of the impact of wake surfing on inland bodies of water. *Journal of Water Resource and Protection, 14(3)*, 238–272. https://doi.org/10.4236/jwarp.2022.143012

Federation of Canadian Municipalities. (2025). *Standardized wake surfing regulation.* FCM Resolutions. Retrieved October 7, 2026, from https://fcmresolutions.powerappsportals.com/en-US/ResolutionDetails/?id=7cd969ab-ba13-f011-998a-002248b0c35e

Francis, J., Nohner, J., Bauman, J., & Gunderman, B. (2023). *A literature review of wake boat effects on aquatic habitat* (Fisheries Report 37). Michigan Department of Natural Resources, Fisheries Division.

Fuirst, M., Mallory, M. L., Piper, W. H., Bianchini, K., Sajeev, S. K., Archambault, G., Clark, D., Cooley, J. H., Jr., Evers, D. C., Grade, T., Hanson, E. W., Hughes, C., MacKenzie, K., Poleschook, D., Jr., Poleschook, V. R., Savoy, L. J., Schoch, N., Siener, H., Vitz, A., . . . Tozer, D. C. (2026). Productivity of an iconic waterbird, the Common Loon, is decreasing across the southern portion of its breeding range. *FACETS, 11,* 1–14. https://doi.org/10.1139/facets-2025-0344

Gabel, F., Stoll, S., Fischer, P., Pusch, M. T., & Garcia, X.-F. (2011). Waves affect predator–prey interactions between fish and benthic invertebrates. *Oecologia, 165*(1), 101–109. https://doi.org/10.1007/s00442-010-1841-8

Gittman, R. K., Scyphers, S. B., Smith, C. S., Neylan, I. P., & Grabowski, J. H. (2016). Ecological consequences of shoreline hardening: A meta-analysis. *BioScience, 66*(9), 763–773. https://doi.org/10.1093/biosci/biw091

Goldsmith, A. M., Jaber, F. H., Ahmari, H., & Randklev, C. R. (2021). Clearing up cloudy waters: A review of sediment impacts to unionid freshwater mussels. *Environmental Reviews, 29*(1), 100–108. https://doi.org/10.1139/er-2020-0080

Government of British Columbia. (2023, May). *Potential economic impact of zebra and quagga mussels in B.C.* Ministry of Water, Land and Resource Stewardship. https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/invasive-species/invasive-mussels/zqm_economic_report_2023_05_26_final.pdf

Government of British Columbia. (2024, December 6). *Whirling disease detected in Kootenay Lake.* https://news.gov.bc.ca/releases/2024WLRS0043-001641

Government of British Columbia. (2025a). *2025 Invasive Mussel Defence Program summer status report.* Ministry of Water, Land and Resource Stewardship.

Government of British Columbia. (2025b). *Whirling disease.* https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/fish/aquatic-species/aquatic-invasives/whirling-disease

Government of British Columbia. (2026a). *B.C. watercraft inspection stations.* https://www2.gov.bc.ca/gov/content/invasive-mussels/bc-watercraft-inspection-stations

Government of British Columbia. (2026b). *Stop the spread of invasive mussels.* https://www2.gov.bc.ca/gov/content/invasive-mussels

Government of British Columbia. (2026c). *Zebra, quagga and golden mussel facts.* https://www2.gov.bc.ca/gov/content/invasive-mussels/zebra-and-quagga-mussel-facts

Government of Canada. (2023, December 20). Regulations amending the Vessel Operation Restriction Regulations: SOR/2023-274. *Canada Gazette, Part II, 157*(26). https://gazette.gc.ca/rp-pr/p2/2023/2023-12-20/html/sor-dors274-eng.html

Government of Canada. (2024, September 14). Regulations amending the Vessel Operation Restriction Regulations. *Canada Gazette, Part I, 158*(37). https://gazette.gc.ca/rp-pr/p1/2024/2024-09-14/html/reg2-eng.html

Government of Canada. (2025, August 13). Regulations amending the Vessel Operation Restriction Regulations: SOR/2025-158. *Canada Gazette, Part II, 159*(17). https://gazette.gc.ca/rp-pr/p2/2025/2025-08-13/html/sor-dors158-eng.html

Håkanson, L., & Jansson, M. (2002). *Principles of lake sedimentology*. Blackburn Press.

Hildebrand, M. (2022). *Lake Windermere and Columbia Lake shoreline fisheries assessment, August 2021*. Lotic Environmental Ltd.

Hockin, D., Ounsted, M., Gorman, M., Hill, D., Keller, V., & Barker, M. A. (1992). Examination of the effects of disturbance on birds with reference to its importance in ecological assessments. *Journal of Environmental Management, 36*(4), 253–286. https://doi.org/10.1016/S0301-4797(08)80002-3

Holden Ecological. (2026). *Wakesports suitability screening and mapping for British Columbia and RDEK lakes* [Unpublished GIS analysis].

Houser, C. (2010). Relative importance of vessel-generated and wind waves to salt marsh erosion in a restricted fetch environment. *Journal of Coastal Research, 26*(2), 230–240. https://doi.org/10.2112/08-1084.1

Houser, C. (2025, April 30). *Boat wakes aren't just a nuisance, they harm freshwater shorelines and wildlife*. The Conversation. https://theconversation.com/boat-wakes-arent-just-a-nuisance-they-harm-freshwater-shorelines-and-wildlife-251958

Houser, C., Carswell, A., Chittle, B., Johnson, G., Caschera, A., & Smith, A. (2024). Relative energy and perceived impact of vessel-generated waves in fetch-limited environments. *Lake and Reservoir Management, 40*(3), 285–302. https://doi.org/10.1080/10402381.2024.2370818

Houser, C., & George, E. (2026). Review of the eco-geomorphological impacts of vessel-generated wakes. *Journal of Environmental Management, 404*, Article 129298. https://doi.org/10.1016/j.jenvman.2026.129298

Houser, C., Smith, A., & Lilly, J. (2021). Relative importance of recreational boat wakes on an inland lake. *Lake and Reservoir Management, 37*(3), 227–234. https://doi.org/10.1080/10402381.2021.1879325

IPBES. (2023). *Thematic assessment report on invasive alien species and their control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* (H. E. Roy, A. Pauchard, P. Stoett, & T. Renard Truong, Eds.). IPBES Secretariat. https://doi.org/10.5281/zenodo.7430682

James, W. F. (2017). Internal phosphorus loading contributions from deposited and resuspended sediment to the Lake of the Woods. *Lake and Reservoir Management, 33*(4), 347–359. https://doi.org/10.1080/10402381.2017.1312647

Jennings, M. J., Bozek, M. A., Hatzenbeler, G. R., Emmons, E. E., & Staggs, M. D. (1999). Cumulative effects of incremental shoreline habitat modification on fish communities in north temperate lakes. *North American Journal of Fisheries Management, 19*(1), 18–27.

Johnson, B. L., & Johnston, C. A. (1995). Relationship of lithology and geomorphology to erosion of the western Lake Superior coast. *Journal of Great Lakes Research, 21*(1), 3–16.

Johnson, L. E., Ricciardi, A., & Carlton, J. T. (2001). Overland dispersal of aquatic invasive species: A risk assessment of transient recreational boating. *Ecological Applications, 11*(6), 1789–1799. https://doi.org/10.1890/1051-0761(2001)011[1789:ODOAIS]2.0.CO;2

Kalnejais, L. H., Martin, W. R., Signell, R. P., & Bothner, M. H. (2007). Role of sediment resuspension in the remobilization of particulate-phase metals from coastal sediments. *Environmental Science & Technology, 41*(7), 2282–2288. https://doi.org/10.1021/es061770z

Knezevic, S., & Self, J. (2026). *Wasa Lake recreational impacts, water quality and sediment quality assessment* [Report prepared for the Wasa Lake Land Improvement District]. Larratt Aquatic Consulting Ltd. https://wasalake.ca/wp-content/uploads/2026/05/Wasa-Lake-Water-and-Sediment-Quality-Assessment-2025-2026-1.pdf

Korschgen, C. E., & Dahlgren, R. B. (1992). *Human disturbances of waterfowl: Causes, effects, and management* (Fish and Wildlife Leaflet 13.2.15). U.S. Fish and Wildlife Service.

Kucera-Hirzinger, V., Schludermann, E., Zornig, H., Weissenbacher, A., Schabuss, M., & Schiemer, F. (2009). Potential effects of navigation-induced wave wash on the early life history stages of riverine fish. *Aquatic Sciences, 71*, 94–102. https://doi.org/10.1007/s00027-008-8110-5

Laderoute, L., & Bauer, B. (2013). *River bank erosion and boat wakes along the Lower Shuswap River, British Columbia* [Final project report prepared for the Regional District of North Okanagan and Fisheries and Oceans Canada]. University of British Columbia Okanagan.

Larratt, H., Crevier, L., Schleppe, J., & Self, J. (2024). *Lake Windermere recreational impacts 2024* (Public release version). Ecoscape Environmental Consultants Ltd. & Larratt Aquatic Consulting Ltd.

Lemieux, V., Lavoie, M., Bouffard, V., Robin, C., & Petitclerc, D. (2024). Summer recreational boating impacts on erosion, turbidity, and phosphorus levels in Canadian freshwater lakes. *Canadian Water*

Resources Journal / Revue canadienne des ressources hydriques, 49(3), 355–367. https://doi.org/10.1080/07011784.2023.2299872

Living Lakes Canada. (n.d.). *The Lake Windermere project*. https://livinglakescanada.ca/project/the-lake-windermere-project/

Macfarlane, G. J. (2018). *Wave wake study: HB4099 Motorboat Working Group* (Report No. 18WW01). Australian Maritime College, University of Tasmania.

Macfarlane, G. J. (2025). Wakesurfing, wakeboarding, and waterskiing: A comparison of wake characteristics. *River Research and Applications, 41*(6), 1189–1206. https://doi.org/10.1002/rra.4438

Madsen, J. D., Chambers, P. A., James, W. F., Koch, E. W., & Westlake, D. F. (2001). The interaction between water movement, sediment dynamics and submersed macrophytes. *Hydrobiologia, 444*(1–3), 71–84. https://doi.org/10.1023/A:1017520800568

Marr, J., Riesgraf, A., Herb, W., Lueker, M., Kozarek, J., & Hill, K. (2022). *A field study of maximum wave height, total wave energy, and maximum wave power produced by four recreational boats on a freshwater lake* (Project Report 600). St. Anthony Falls Laboratory, University of Minnesota.

Mayer, M., Natusch, D., & Frank, S. (2019). Water body type and group size affect the flight initiation distance of European waterbirds. *PLOS ONE, 14*(7), e0219845. https://doi.org/10.1371/journal.pone.0219845

McConchie, J. A., & Toleman, I. E. J. (2003). Boat wakes as a cause of riverbank erosion: A case study from the Waikato River, New Zealand. *Journal of Hydrology (New Zealand), 42*(2), 163–179.

McDonald, L. E. (2000). *Windermere Lake water quality changes over the past 300 years as determined from a bottom sediment core*. British Columbia Ministry of Environment, Lands and Parks.

McPherson, S., & Hlushak, D. (2008). *Windermere Lake foreshore fish and wildlife habitat assessment*. Interior Reforestation Co. Ltd.

McPherson, S., Hlushak, D., Adams, I., & Polzin, M. (2010). *Columbia Lake sensitive habitat inventory and mapping*. Interior Reforestation Co. Ltd.

Me. Rev. Stat. tit. 12, § 13068-A(18) (2024). https://legislature.maine.gov/statutes/12/title12sec13068-a.html

Mercier-Blais, S., & Prairie, Y. (2014). *Projet d'évaluation de l'impact des vagues créées par les bateaux de type wakeboat sur la rive des lacs Memphrémagog et Lovering*. Université du Québec à Montréal.

Ministry of Water, Land and Resource Stewardship. (2026). *Radium inspection station data, 2015–2025: Inspection totals, high-risk source jurisdictions, decontaminations, and watercraft complexity* [Unpublished dataset]. Government of British Columbia.

Mohit, S., Johnson, T. B., & Arnott, S. E. (2021). Recreational watercraft decontamination: Can current recommendations reduce aquatic invasive species spread? *Management of Biological Invasions, 12*(1), 148–164. https://doi.org/10.3391/mbi.2021.12.1.10

Mohit, S., Johnson, T. B., & Arnott, S. E. (2023). Watercraft decontamination practices to reduce the viability of aquatic invasive species implicated in overland transport. *Scientific Reports, 13*, Article 7238. https://doi.org/10.1038/s41598-023-33204-0

Mosisch, T. D., & Arthington, A. H. (1998). The impacts of power boating and water skiing on lakes and reservoirs. *Lakes & Reservoirs: Research and Management, 3*(1), 1–17. https://doi.org/10.1111/j.1440-1770.1998.tb00028.x

Mosisch, T. D., & Arthington, A. H. (2004). Impacts of recreational power-boating on freshwater ecosystems. *Biodiversity and Conservation, 13*, 211–231.

Mosley, L. M. (2015). Drought impacts on the water quality of freshwater systems; review and integration. *Earth-Science Reviews, 140*, 203–214. https://doi.org/10.1016/j.earscirev.2014.11.010

Nanson, G. C., von Krusenstierna, A., Bryant, E. A., & Renilson, M. R. (1994). Experimental measurements of river-bank erosion caused by boat-generated waves on the Gordon River, Tasmania. *Regulated Rivers: Research & Management, 9*(1), 1–14. https://doi.org/10.1002/rrr.3450090102

National Marine Manufacturers Association. (2025). *Monthly recreational boating industry data summary: Data through April 2025*. https://nmta.net/wp-content/uploads/2025/07/NMMA-Monthly-Rec-Boating-Industry-Data-Summary-April-2025.pdf

Nedohin, D. N., & Elefsiniotis, P. (1997). The effects of motor boats on water quality in shallow lakes. *Toxicological & Environmental Chemistry, 61*(1–4), 127–133. https://doi.org/10.1080/02772249709358479

Neufeld, A., Swain, L., & Rieberger, K. (2010). *Water quality assessment and objectives for Windermere Lake: Technical report* (First update). British Columbia Ministry of Environment.

O'Reilly, C. M., Sharma, S., Gray, D. K., Hampton, S. E., Read, J. S., Rowley, R. J., Schneider, P., Lenters, J. D., McIntyre, P. B., Kraemer, B. M., Weyhenmeyer, G. A., Straile, D., Dong, B., Adrian, R., Allan, M. G., Anneville, O., Arvola, L., Austin, J., Bailey, J. L., … Zhang, G. (2015). Rapid and highly variable warming of lake surface waters around the globe. *Geophysical Research Letters, 42*(24), 10773–10781. https://doi.org/10.1002/2015GL066235

Orihel, D. M., Baulch, H. M., Casson, N. J., North, R. L., Parsons, C. T., Seckar, D. C. M., & Venkiteswaran, J. J. (2017). Internal phosphorus loading in Canadian fresh waters: A critical review and data analysis. *Canadian Journal of Fisheries and Aquatic Sciences, 74*(12), 2005–2029. https://doi.org/10.1139/cjfas-2016-0500

Ortiz, D. A., Blackburn, S. R., Daulton, T., Kovar, B., Meyer, M. W., Pralle, C. E., & Stanley, E. H. (2026). Wake boats and lakes: Physical, ecological, and policy implications. *Lake and Reservoir Management, 42*(1), 15–35. https://doi.org/10.1080/10402381.2025.2578757

Ortiz, D. A., Meyer, M., Daulton, T., & Kovar, B. (2024). *The effects of wake boats on lake ecosystem health: A literature review*. Wisconsin's Green Fire.

Parks Canada. (n.d.). *Water activity rules and regulations: Kootenay National Park*. Retrieved April 1, 2026, from https://parks.canada.ca/pn-np/bc/kootenay/securite-safety/activ-aqua-regs

Parks Canada. (2026). *Water activities: Banff National Park*. https://parks.canada.ca/pn-np/ab/banff/activ/nautiques-sports

Piper, W. H., Glines, M. R., & Rose, K. C. (2024). Climate change-associated declines in water clarity impair feeding by common loons. *Ecology, 105*(5), Article e4291. https://doi.org/10.1002/ecy.4291

Popper, A. N., & Hawkins, A. D. (2019). An overview of fish bioacoustics and the impacts of anthropogenic sounds on fishes. *Journal of Fish Biology, 94*(5), 692–713. https://doi.org/10.1111/jfb.13948

Raabe, J. K., & Bozek, M. A. (2015). Influence of wind, wave, and water level dynamics on Walleye eggs in a north temperate lake. *Canadian Journal of Fisheries and Aquatic Sciences, 72*(4), 570–581. https://doi.org/10.1139/cjfas-2014-0320

Ray, A. (2020). *Analyzing threats to water quality caused by motorized recreation on Payette Lake, Idaho* [Master's thesis, Western Colorado University].

Raymond, S., & Galvez, R. (2016). *Environmental study on sediment quality in Lac Noir and the impacts of the use of power-driven vessels*. Université Laval.

Raymond, S., & Galvez-Cloutier, R. (2015). *Impact of lake navigation: Sediment suspension study, Lake Masson and Sand Lake cases*. Laval University. https://www.bclss.org/wp-content/uploads/2022/02/Laval-Wake-study1.pdf

Regional District of East Kootenay & Village of Canal Flats. (2022). *Columbia Lake management plan*. Regional District of East Kootenay.

Rieberger, K. (1992). *Metal concentrations in bottom sediments from uncontaminated B.C. lakes*. Water Quality Branch, British Columbia Ministry of Environment, Lands and Parks.

Riesgraf, A., Marr, J., Herb, W., Lueker, M., & Kozarek, J. (2025). *A field study of recreational powerboat hydrodynamics and their impacts on the water column and lakebed* (SAFL Project Report No. 611). St. Anthony Falls Laboratory, University of Minnesota. https://hdl.handle.net/11299/274184

Rothlisberger, J. D., Chadderton, W. L., McNulty, J., & Lodge, D. M. (2010). Aquatic invasive species transport via trailered boats: What is being moved, who is moving it, and what can be done. *Fisheries, 35*(3), 121–132. https://doi.org/10.1577/1548-8446-35.3.121

Ruprecht, J. E., Glamore, W. C., Coghlan, I. R., & Flocard, F. (2015, September 18–21). Wakesurfing: Some wakes are more equal than others. In *Australasian Coasts & Ports Conference 2015*. Engineers Australia and IPENZ. https://search.informit.org/doi/10.3316/informit.724770812980275

Safe Quiet Lakes. (n.d.). *Better wake zones*. https://safequiet.ca/our-initiatives/safe-wakes-coalition/better-wake-zones/

Saunders, P. (2025). *2024 Lake Windermere water quality report*. Lake Windermere Ambassadors.

Schafft, M., Wegner, B., Meyer, N., Wolter, C., & Arlinghaus, R. (2021). Ecological impacts of water-based recreational activities on freshwater ecosystems: A global meta-analysis. *Proceedings of the Royal Society B: Biological Sciences, 288*, 20211623. https://doi.org/10.1098/rspb.2021.1623

Scheffer, M., Hosper, S. H., Meijer, M.-L., Moss, B., & Jeppesen, E. (1993). Alternative equilibria in shallow lakes. *Trends in Ecology & Evolution, 8*(8), 275–279. https://doi.org/10.1016/0169-5347(93)90254-M

Schleppe, J., Larratt, H., & Plewes, R. (2017). *Kalamalka and Wood Lake boat impact study on source waters* (Project File 16-1796). Ecoscape Environmental Consultants Ltd. and Larratt Aquatic Consulting Ltd.

Schleppe, J., & McPherson, S. (2021a). *Windermere Lake foreshore development guide*. Ecoscape Environmental Consultants Ltd. & Lotic Environmental Ltd.

Schleppe, J., & McPherson, S. (2021b). *Windermere Lake foreshore integrated management planning*. Ecoscape Environmental Consultants Ltd. & Lotic Environmental Ltd.

Schleppe, J., McPherson, S., Porto, L., & Mason, B. (2020). *Foreshore Integrated Management Plan methods*. Ecoscape Environmental Consultants Ltd., Lotic Environmental Ltd., and BC Community Mapping Network & Wood Environment and Infrastructure Solutions, prepared for Living Lakes Canada.

Self, J., & Larratt, H. (2020). *2019 Kalamalka Lake Boating Impact Study*. Prepared for the Regional District of North Okanagan, Greater Vernon Water, and the District of Lake Country.

Species at Risk Act, S.C. 2002, c. 29. https://laws-lois.justice.gc.ca/eng/acts/S-15.3/

St. Anthony Falls Laboratory. (n.d.). *Phase III research*. Healthy Waters Initiative, University of Minnesota. Retrieved November 18, 2026, from https://sites.google.com/umn.edu/healthywatersinitiative/phase-iii-research

Strayer, D. L., & Findlay, S. E. G. (2010). Ecology of freshwater shore zones. *Aquatic Sciences, 72*(2), 127–163. https://doi.org/10.1007/s00027-010-0128-9

Taylor, J. L. (2001). *The early life history and ecology of Columbia Lake burbot* [Master's thesis, University of British Columbia]. UBC Open Collections. https://open.library.ubc.ca/soa/cIRcle/collections/ubctheses/831/items/1.0099526

Taylor, J. L. (2002). *Juvenile burbot sampling in Columbia and Windermere lakes, summer 2002*. Columbia Basin Fish and Wildlife Compensation Program. https://a100.gov.bc.ca/pub/acat/documents/r6592/JuvenileBurbotSamplinginColumbiaandWindermereLake_1144449206933_535c8d780f284b71b15a80bb39c4e583.pdf

Tenn. Code Ann. § 69-9-221 (2022).

Terra Vigilis Environmental Services Group. (2022, July 20). *Water quality and wave impact study: Phase 2 report*. Prepared for the North Lake Management District.

Transport Canada. (2025). *Apply for vessel operation restrictions*. Government of Canada. https://tc.canada.ca/en/marine-transportation/marine-safety/boating-safety/apply-vessel-operation-restrictions

Transport Canada. (2026a). *Schedules of the Vessel Operation Restriction Regulations: Second edition, April 2026*. Government of Canada. https://tc.canada.ca/en/marine-transportation/marine-safety/boating-safety/schedules-vessel-operation-restriction-regulations-2nd-edition-april-2026

Transport Canada. (2026b). *TP 14350E: Local Authorities' Guide, Vessel Operation Restriction Regulations*. Government of Canada. https://tc.canada.ca/en/marine-transportation/publications/tp-14350-local-authorities-guide-vessel-operation-restriction-regulations

Union of British Columbia Municipalities. (2025a). *2025 UBCM resolutions book*. https://www.ubcm.ca/sites/default/files/2025-08/2025%20UBCM%20Resolutions%20Book.pdf

Union of British Columbia Municipalities. (2025b). *Standardized wake surfing regulation* (Resolution NR70). https://www.ubcm.ca/convention-resolutions/resolutions/resolutions-database/standardized-wake-surfing-regulation

Urban Systems Ltd. (2001). *Lake Windermere management strategy*. District of Invermere.

Vander Zanden, M. J., Hansen, G. J. A., Higgins, S. N., & Kornis, M. S. (2010). A pound of prevention, plus a pound of cure: Early detection and eradication of invasive species in the Laurentian Great Lakes. *Journal of Great Lakes Research, 36*(1), 199–205. https://doi.org/10.1016/j.jglr.2009.11.002

Vaughn, C. C. (2018). Ecosystem services provided by freshwater mussels. *Hydrobiologia, 810*, 15–27. https://doi.org/10.1007/s10750-017-3139-x

Vermont Department of Environmental Conservation. (2026). *Wakeboating and wakesports in Vermont*. Vermont Agency of Natural Resources. https://dec.vermont.gov/watershed/lakes-ponds/vermont-use-public-waters-rules/wakeboats

Vermont Use of Public Waters Rules, Code Vt. R. 12-030-027 §§ 3.8, 5.18 (2024). https://regulations.justia.com/states/vermont/agency-12/sub-agency-030/chapter-027/section-12-030-027/

Vessel Operation Restriction Regulations, SOR/2008-120 (2008). https://laws-lois.justice.gc.ca/eng/regulations/SOR-2008-120/

Wake Boats; Define and Regulate, H.B. 5532, 102nd Leg., Reg. Sess. (Mich. 2024). https://www.legislature.mi.gov/Home/GetObject?objectName=2024-HB-5532

Walter, J., Hughes, D., Moore, N., & Inoue, F. (2005). *Streambank revegetation and protection: A guide for Alaska*. Alaska Department of Fish and Game.

Water Environment Consultants. (2021). *Boat wake impact analysis: Lake Rabun and Lake Burton, Georgia*. Lake Rabun Association, Inc., & Lake Burton Civic Association.

Watershed Security Fund. (2026). *Columbia Headwaters Stewardship Project*. https://watershedsecurityfund.ca/projects/columbia-headwaters-stewardship-project/

Wehrly, K. E., Breck, J. E., Wang, L., & Szabo-Kraft, L. (2012). Assessing local and landscape patterns of residential shoreline development in Michigan lakes. *Lake and Reservoir Management, 28*(2), 158–169. https://doi.org/10.1080/07438141.2012.690824

Werner, A. T., Schnorbus, M. A., Shrestha, R. R., & Eckstrand, H. D. (2013). Spatial and temporal change in the hydro-climatology of the Canadian portion of the Columbia River Basin under multiple emissions scenarios. *Atmosphere-Ocean, 51*(4), 357–379. https://doi.org/10.1080/07055900.2013.821400

Wetzel, R. G. (2001). *Limnology: Lake and river ecosystems* (3rd ed.). Academic Press.

Whitfield, A. K., & Becker, A. (2014). Impacts of recreational motorboats on fishes: A review. *Marine Pollution Bulletin, 83*(1), 24–31. https://doi.org/10.1016/j.marpolbul.2014.03.055

Wisconsin Lakes & Last Wilderness Alliance. (2025, December 10). *Joint press release: Why 700' shoreline buffer for enhanced wakes*. https://wisconsinlakes.org/joint-press-release-why-700-shoreline-buffer-for-enhanced-wakes/

Wood Canada Ltd. (2022). *Columbia Lake foreshore integrated management planning—2021*. Living Lakes Canada.

Woolway, R. I., Kraemer, B. M., Lenters, J. D., Merchant, C. J., O'Reilly, C. M., & Sharma, S. (2020). Global lake responses to climate change. *Nature Reviews Earth & Environment, 1*(8), 388–403. https://doi.org/10.1038/s43017-020-0067-5

8. Appendices

Appendix A. Comparison of regulatory criteria, management recommendations, and research benchmarks for wakesports and recreational powerboating.

Appendix B. Proposed wakesports suitability framework (Discussion draft).

Appendix C. Lake Windermere and Columbia Lake management, planning, and stewardship timeline.

Appendix A. Comparison of regulatory criteria, management recommendations, and research benchmarks for wakesports and recreational powerboating.

Source / jurisdiction	Type	Shoreline distance criterion	Depth criterion or study finding	Area / size criterion or result	Notes
Vermont, USA (2024 wakesports rule)	Adopted regulation	152 m (500 ft)	6.1 m (20 ft)	20.2 ha (50 contiguous acres) meeting the 500 ft / 20 ft criteria; 61 m (200 ft) wide	Rule 3.8(c) required a wakeboat to have one designated home lake per calendar year and display an Agency-issued decal identifying it, with decontamination at an Agency-approved provider as the only exception (Vermont Use of Public Waters Rules, 2024).
Vermont, USA (2026 amendments)	Adopted regulation	152 m (500 ft)	6.1 m (20 ft)	40.5 ha (100 contiguous acres); 914 m (3,000 ft) zone length; 61 m (200 ft) minimum zone width	Effective June 11, 2026. The amendments raised the minimum zone to 100 contiguous acres, added a 914 m (3,000 ft) minimum length, and reduced wakesports-eligible inland lakes from 30 to 18. They require 152 m (500 ft) separation from other recreational users while an enhanced wake is being created, and 152 m (500 ft) from signed loon nesting sites May 1 to July 31. Decontamination was extended to all ballasted vessels and the 2024 home-lake and decal system removed.
Maine, USA (2024 wakesurfing law)	Adopted statute	91 m (300 ft)	4.6 m (15 ft)	Operating area must meet both setback and depth criteria	Statutory criteria effective August 2024 (Me. Rev. Stat. tit. 12, § 13068-A(18), 2024). Department report due February 1, 2027; the legislative committee may consider amendments. The statutory definition of wakesurfing activity includes wakeboarding or use of a similar device.

Source / jurisdiction	Type	Shoreline distance criterion	Depth criterion or study finding	Area / size criterion or result	Notes
Tennessee, USA (2022 law)	Adopted statute	61 m (200 ft)	Not specified	Prohibited on waterbodies <20.2 ha (50 acres) and on any portion of a waterbody <122 m (400 ft) wide	Applies to wakeboarding and wakesurfing; provides an enacted example combining setback and operating-area criteria (Tenn. Code Ann. § 69-9-221, 2022).
Michigan, USA (HB 5532)	Proposed legislation (not enacted)	152 m (500 ft)	6.1 m (20 ft)	Not specified	Introduced February 2024; did not pass.
Michigan DNR, USA (Francis et al., 2023)	Government best practice (non-binding)	152 m (500 ft)	4.6 m (15 ft)	Not specified	Voluntary operating guidance.
Australian Maritime College, University of Tasmania (Macfarlane, 2025)	Peer-reviewed comparative analysis of three field datasets	>107 m (>350 ft) based on wave height; >152 m (>500 ft) based on wave energy	Not specified	Not specified	The author noted that depending on the benchmark selected, some rational distances may need to exceed 107 m (350 ft) for wave height and 152 m (500 ft) for wave energy.
St. Anthony Falls Laboratory, University of Minnesota (Marr et al., 2022)	University field study	>152 m for wave height; >175 m for wave energy; >183 m for wave power	Not primary criterion	Not specified	Estimated distances for wakesurfing waves to attenuate to conventional-boat wave characteristics measured at 61 m (200 ft). Wakesurfing wave power still exceeded this comparison at 183 m (600 ft), the farthest distance measured. These are equivalence benchmarks, not setbacks or complete-dissipation distances.

Source / jurisdiction	Type	Shoreline distance criterion	Depth criterion or study finding	Area / size criterion or result	Notes
St. Anthony Falls Laboratory, University of Minnesota (Riesgraf et al., 2025)	University field study	Not specified	6.1 m (20 ft) for wakesurfing	Not specified	Recommends minimum operating depths of 6.1 m for wakesurfing and 3 m (10 ft) for other recreational powerboats operating under typical conditions.
Fay et al. (2022)	Journal-published numerical-modelling study (industry-funded)	61 m (200 ft)	≥3.0 m (10 ft)	Not specified	Represents the lower end of published recommendations. The study used numerical modelling rather than direct field measurements; later technical reviews disputed important assumptions and whether the 200 ft/10 ft conclusions were supported by the model (Francis et al., 2023; Macfarlane, 2025; Ortiz et al., 2026).
Lake Memphrémagog and Lake Lovering, Quebec, Canada (Mercier-Blais & Prairie, 2014)	University study (not peer-reviewed)	300 m (984 ft) proposed management distance	Not primary criterion	Not specified	Measurements at 100–200 m were extrapolated to energy-equivalence distances of approximately 268 m at Lake Memphrémagog and 312 m at Lake Lovering. The authors recommended a 300 m shoreline distance.
Lake Masson and Lac des Sables, Quebec, Canada (Raymond & Galvez-Cloutier, 2015)	Commissioned university technical report (not peer-reviewed)	Not tested in this study	≥5 m (16 ft) recommended operating depth	Approx. 600 m wide operating zone recommended	Wake-surfing velocities ≥0.1 m/s were measured to approximately 4.5 m and inferred to reach 5 m, with theoretical potential to mobilize fine particles; no significant turbidity increase or visible sediment resuspension was observed.
Lac Noir, Quebec, Canada (Raymond & Galvez, 2016; report issued 2017)	Commissioned university technical report (not peer-reviewed)	Not tested in this study	≥7 m (23 ft) recommended operating depth	Min. 600 m wide operating zone recommended	Instrumented field testing indicated wake-surfing disturbance to approximately 6 m, with potential to mobilize fine sediments. The authors recommended a minimum operating depth of 7 m.

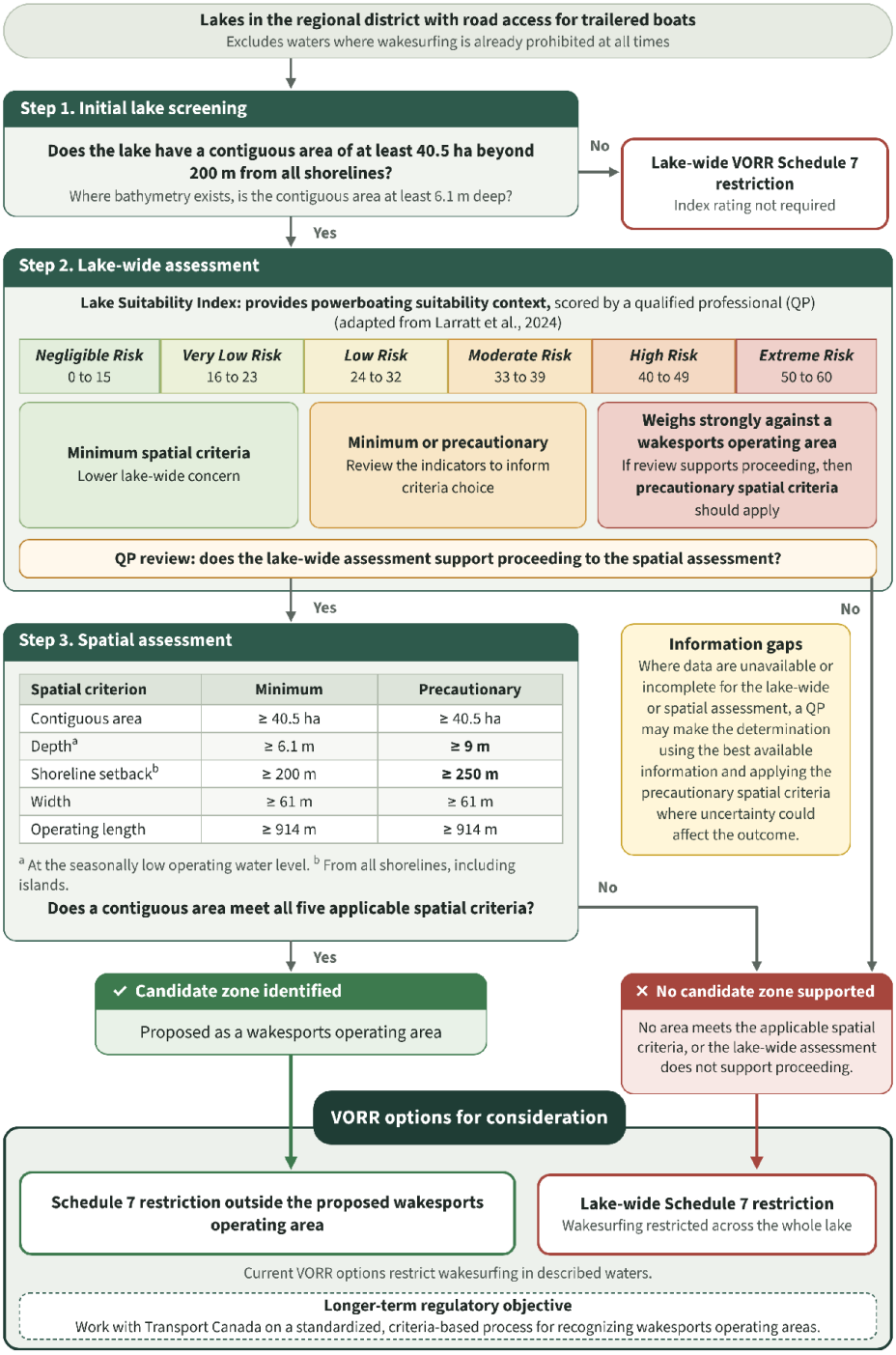
Source / jurisdiction	Type	Shoreline distance criterion	Depth criterion or study finding	Area / size criterion or result	Notes
Payette Lake, Idaho, USA (Ray, 2020)	Master's thesis; preliminary modelling	Not tested in this study	Up to 10 m (33 ft) for modelled wakeboat propeller slipstreams.	Not specified	Model indicated that susceptible sediments could be disturbed at these depths. This was not field-tested sediment resuspension. The estimate depends on vessel characteristics, operating conditions, sediment susceptibility, and model assumptions; it is not a proposed management criterion.
Wisconsin's Green Fire (Ortiz et al., 2024)	Technical literature review and professional recommendation	≥183 m (600 ft) from all shorelines, including islands	≥6.1 m (20 ft)	Not specified	Recommendations based on their literature review and professional judgment. This is an organizational policy recommendation, not a regulatory standard.
Ortiz et al. (2026)	Peer-reviewed literature search, policy review, and scenario analysis.	100–150 m (350–500 ft) based on the evidence synthesis; >180 m proposed mitigation actions	>10 m (~33 ft) proposed mitigation actions	Not specified	The review identifies 100–150 m as an evidence-synthesis range. The >180 m distance and >10 m depth are the authors' proposed mitigation actions.
Lake Windermere, BC (Larratt et al., 2024)	Lake-specific assessment	≥152 m (500 ft)	1) ≥6.5 m (21 ft), operating-area scenario; 2) >8 m (26 ft), ecological scenario	1) 75 ha (185 acres) met the 6.5 m/150 m criteria; 2) 0 ha; no area met the 8 m criteria	Using the Lake Suitability Index, Lake Windermere scored 53/60 (*Extreme Risk*) and was classified as unsuitable for large powerboats and wakeboats. The index is a lake-specific screening tool, not a regulatory standard.
Kalamalka and Wood lakes, BC (Schleppe et al., 2017)	Lake-specific carrying-capacity and source-water risk assessment	100 m nearshore assessment / sensitivity zone	Shallow-water risk areas, including waters <3 m	Boating-density criterion: 8.1 ha (20 acres) per boat	The 100 m value is a nearshore assessment zone, and 8.1 ha per boat is a boating-density criterion, not a wakesports-zone requirement.

Source / jurisdiction	Type	Shoreline distance criterion	Depth criterion or study finding	Area / size criterion or result	Notes
Kalamalka Lake, BC (Self & Larratt, 2020)	Lake-specific wakeboat field trial and technical report	Not tested in this study	Low-power/minimal-wake operation recommended in water <5 m (16 ft); hydrodynamic effects measured to 8 m (26 ft)	Not specified	Major sediment disturbance occurred at ≤3 m, visible resuspension extended to 4 m, and hydrodynamic effects were measured to 8 m. Recommends minimal wake generation in water <5 m deep.
Wasa Lake, BC (Knezevic & Self, 2026)	Lake-specific assessment	>120 m (394 ft) in the mapped assessment; the report cites a broader 120–310 m range	≥8 m (26 ft) mapped wake-surfing scenario; >4.5 m (15 ft) used for the broader powerboating and carrying-capacity assessment	13.7 ha (34 acres; 13% of the lake) met the >4.5 m depth and >120 m setback criteria at full pool	Wasa Lake received an index score of 44/60 (*High Risk*), and the report concluded that it was unsuitable for unrestricted lake-wide powerboating and wakesurfing. Area/size criterion was the broader powerboating assessment, not an independently established wakesports zone.
Wisconsin Lakes & Last Wilderness Alliance, USA (2025)	Advocacy recommendation	≥213 m (≥700 ft)	≥9.1 m (≥30 ft)	≥40.5 ha (≥100 contiguous acres)	Defines 213 m (700 ft) as 152 m (500 ft) for wake attenuation plus a 61 m (200 ft) strip for other boaters. Also recommends ballast decontamination and preservation of local control.
Safe Wakes Coalition and Safe Quiet Lakes, Ontario, Canada (Safe Quiet Lakes, n.d.)	Advocacy recommendation	250 m (820 ft)	9 m (30 ft)	≥24 ha (60 acres) for the lake or operating zone	Education and outreach guidance from an Ontario coalition formed in 2024.

Note. The Type column distinguishes enacted laws and regulations, proposed legislation, agency guidance, research findings and modelled benchmarks, lake-specific assessment criteria or results, and organizational recommendations. The relevance of each value depends on the management objective, vessel type and operating conditions, lake morphology, sediment and habitat sensitivity, other recreational uses, and the selected level of precaution. Measurements converted between metric and imperial units are approximate.

Appendix B. Proposed wakesports suitability framework (Discussion draft).

Decision pathway: from initial screening to VORR options



Appendix C. Lake Windermere and Columbia Lake management, planning, and stewardship timeline.

This table consolidates key grey literature, monitoring programs, and planning documents relevant to Lake Windermere and Columbia Lake (post-2006). Clickable links open source documents.

Lake colour coding: ■ Windermere ■ Columbia Lake ■ Both / Regional

Lake	Years	Lead / Partners	Documents & Links
FORESHORE INTEGRATED MANAGEMENT PLANNING (FIMP) | Foreshore Inventory and Mapping (FIM) · Foreshore Habitat Sensitivity Index (FHSI) · Foreshore Development Guide (FDG) / Shoreline Management Guidelines (SMG)			
Windermere	**2007–2021**	East Kootenay Integrated Lake Management Partnership (EKILMP) / Interior Reforestation Co Ltd Living Lakes Canada (LLC) / Regional District of East Kootenay (RDEK) Ecoscape / Lotic Environmental	Windermere Lake FIM Report (2007) Windermere Fish & Wildlife Habitat Assessment (2008) — fish and wildlife values; basis for SMG Windermere Lake Shoreline Mgmt Guidelines for Fish and Wildlife Habitats/FDG (2009) — first FDG for Windermere Windermere FDG (2021) Windermere Lake FIMP (2021) — umbrella term post-2020, replaces SHIM; supersedes all prior Windermere FIM/SMG
Columbia Lake	**2007–2022**	EKILMP / Interior Reforestation Co Ltd Columbia Lake Stewardship Society (CLSS) / LLC LLC / Wood Canada Ltd.	Columbia Lake FIM / SHIM Report (2007–2010) — field survey 2007; supplemented 2009 Columbia Lake Shoreline Mgmt Guidelines for Fish and Wildlife Habitats (2010) Columbia Lake FDG (2021) Columbia Lake FIMP (2022) — supersedes all prior Columbia FIM/SMG
PLANNING & POLICY | Management Plans · Official Community Plans			
Both / Regional	**2011–2022**	RDEK / District of Invermere (DOI), Village of Canal Flats	Lake Windermere Management Plan (LWMP) (2011) Columbia Lake Management Plan (2022)
	2014–2016	RDEK / DOI Village of Canal Flats	Fairmont Hot Springs & Columbia Lake Area Official Community Plan, Bylaw No.2779 (2017) — RDEK current OCP Lake Windermere OCP Bylaw No. 2929 (2019, updated 2025) — RDEK current OCP District of Invermere OCP (2015) Village of Canal Flats OCP (2016)

Lake	Years	Lead / Partners	Documents & Links
Windermere	2022	District of Invermere (DOI)	Athalmer Neighbourhood Plan (2022) — *includes planning direction for the boat launch centre and wetland interface near Pete's Marina*
WATER QUALITY & QUANTITY MONITORING | Annual Programs · Objectives · Synthesis Reports			
Windermere	2010–present	BC Ministry of Environment (objectives) Lake Windermere Ambassadors (LWA) (annual monitoring)	Water Quality Objectives for Windermere & Columbia Lakes (1985) LWA Annual Water Quality Monitoring Reports (2011–present) State of the Lake Report 2010–2019 (released 2020) — 10-year synthesis by LWA / BCLSS B.C. Lake Stewardship and Monitoring Program, Level 3 (2023–present) — LWA entering year 4 of multi-depth water-quality monitoring LWA Water Quality Report 2024 (most recent) — latest annual report
Columbia Lake	2014–present	Columbia Lake Stewardship Society (CLSS)	CLSS Annual Water Quality Reports (2014–present) — annual series — monitoring began April 2014 CLSS Annual Water Quantity Reports (2015–present) — streamflow & lake-level monitoring B.C. Lake Stewardship and Monitoring Program, Level 2 (2025–present) — provincial monitoring partnership initiated in 2025 CLSS documents library — all CLSS annual reports
ECOLOGICAL MONITORING | Aquatic Invasive Species · Aquatic Plants			
Windermere	2015–present	LWA / Goldeneye Ecological Services (Rachel Darvill) Columbia Wetlands Stewardship Partners (CWSP)	AIS Sampling 2016 — first formal AIS survey series AIS Sampling 2017 Aquatic Plant Inventory (2019) AIS Sampling 2023 Aquatic Invasive Plant Inventory 2024 AIS Sampling 2025 — monitoring completed and data retained by LWA
FISHERIES & WILDLIFE | Habitat Assessments · Waterbirds · Species at Risk			
Both / Regional	2007–2026	EKILMP / Interior Reforestation LWA & CLSS / Lotic Environmental	Fish & Wildlife Habitat Assessment — Windermere (2008) — baseline fish and wildlife assessment for Lake Windermere Insight into the Waterbirds of Lake Windermere (2019)

Lake	Years	Lead / Partners	Documents & Links
		CWSP / Kootenay Connect /Goldeneye Ecological Services (Rachel Darvill) CWSP / Goldeneye Ecological Services (Rachel Darvill)	Columbia Wetlands Waterbird Survey 2015–2019 (2019) — regional multi-year waterbird monitoring relevant to Lake Windermere and adjacent wetlands Columbia Wetlands Marsh Bird Monitoring Project (2020) — regional baseline monitoring of marsh-dependent birds and wetland habitat Lake Windermere Fall Waterbird Surveys (2019–2022 and 2024) — recurring inventory data Kootenay Connect: SAR Literature Review — Columbia Valley (2020) Windermere & Columbia Lakes Shoreline Fisheries Assessment (2021) Upper Columbia Swallow Habitat Enhancement Project — Year 4 Report, 2024–2025 (2025) Kootenay Connect: Restoration of Habitats and Species at Risk in the Columbia Valley, Year 7 and Summary Report, 2019–2026 (2026) — regional synthesis of habitat restoration, species-at-risk work, and conservation outcomes in the Columbia Valley
RECREATION & CARRYING CAPACITY | Sediment · Boat Density · Management Thresholds			
Windermere	**2022–2024**	LWA / Ecoscape / Larratt Aquatic	Lake Windermere Recreational Carrying Capacity Study (2024) — integrates boat-density, sediment-quality, habitat, and management-threshold analyses