The Scientific Evidence Regarding Enhanced Boat Wakes is Compelling

Executive Summary

1. Other jurisdictions have taken definitive, technically defensible actions to regulate large wakes (*Attachment A*)
2. Wake energy/power is directly related to wake height and goes up exponentially. Wake/surf boats can generate wakes that are 10-25 times more powerful than wakes from boats operated on a plane. (*Slide 3*)
3. The results of scientific studies and recommendations from numerous sources and jurisdictions generally point to a distance of 500 feet or more from shore to reduce safety and erosion risks from wake/surf boats. Distances of 200-250 feet are clearly not effective. (*Slide 4*)
4. The best correlation to wake energy and erosion potential is not boat length but rather "boat size", which is analogous to displacement. Displacement is the key factor in 2018 performance tests of surf boats.
5. Boats operating at transition speed* generate the most damaging wakes. Boats operating below planing speeds include surf boats (8-13 mph), wakeboarding (typically 15-20 mph), and those towing inflatables (15-20 mph). Waterski boats typically operate at high speeds (about 30 mph), on a plane. (*Slide 6*)
6. Despite their growing popularity, wake/surf boats are a small percentage of watercraft on Kootenai County waterways. Yet they make it nearly impossible for the majority to safely recreate on rivers, smaller lakes and narrower bays on Coeur d'Alene Lake.

**Transition speed is any speed between slow-no-wake speed and the speed required for a boat to operate on a plane*

What Would be a Technically Based, Enforceable Regulatory Approach?

There is a straightforward, easy to measure, enforceable approach to regulating excessive boat wakes. Consensus on the best approach is a combination of wake height and distance from shore for boats generating excessive wakes. Well-established no-wake regulations across the US are already based on wake height and distance from shore, including those in Kootenai County. Numerous technical references, including those cited in the following pages, support such an approach. This approach could readily be expanded to include a provision to "avoid traveling at sustained transition speed".

How to implement:

- Wake height for excessive wakes can be determined with a combination of documented visual references (*see examples on Slide 8*) and speed measurements. Kootenai County senior marine staff indicate their deputies can be trained to judge wake height, just as they are now trained to judge distance from shore.
- Distance from shore is an accepted and enforceable regulatory factor, even though some comment that it can be difficult to judge 500 feet from shore, or 200 feet or 100 feet. Kootenai County's waterways code already incorporates 200- and 100-feet from shore provisions and is routinely enforced. A 500-feet from shore provision would be even clearer to boaters for the waterways most vulnerable to excessive wakes– the Spokane River and the narrower bays on Lake Coeur d'Alene.
- Kootenai County marine staff commented at January Waterways Workshop that a combination of wake height and distance from shore would be readily enforceable.

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Wave Height and Energy

- **The energy in a boat wake goes up exponentially with wave height** (US Army Corps of Engineers)
  That means a 2-foot wave is 4 times as powerful as a 1-foot wave, and a 3-foot wave is 9 times as powerful. The corresponding safety risks and damage potential increase accordingly. Wake/surf boats can generate wakes that are 10-25 times more powerful than that of a boat operated on a plane.

- **Wave height provides a reasonable proxy for erosive force** (Bilkovic et at)
  Wave energy increases with wave height squared.
  Wave height is more easily estimated by the observer than wave energy
  Traditionally, the highest wave has been the principal measure of wake intensity (G. Cox). Studies have shown it may not be the sole measure of erosion potential. When considered properly as one of several parameters (e.g., water depth, slope and composition of shore materials), it does have a primary role.

- **Studies show that boat wakes contained more energy than the top wind-generated waves** (Fonseca and Malhorta, for US Army Corps of Engineers)

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Wave Attenuation (how a wave loses energy with distance) and Protective Distances

- **A distance of 500 feet is needed to attenuate wave energies** (Zabawa and Ostrom, CEDS)

- **A minimum distance of 150 m (500 feet) is needed to reduce erosion caused by wakeboats** (Mercier-Blais and Prairie)
  The very short and intense wave train created by a wake/surf boat has the most impact when it reaches the shore because it contains much more energy than other boat- or wind-generated waves.
  The passage of "wakeboat" type vessels causes considerable impact on the shore when they pass 100 m (330 ft) from shore

- **A distance of 200 feet for wake/surf boats is not adequate based on studies on the Willamette River. Distances of at least 300-400 feet or more are required** (G. MacFarlane)

- **Based on extensive boat wake studies, a feasible management option is to restrict wake surfing to wider water bodies** (Ruprecht et al)

A multitude of well-crafted and reviewed scientific studies from around the world refute the Water Sports Industry Association's (WSIA) recommended 200 ft from shore for wake surfing, as has data from the Spokane River. The WSIA conclusion regarding surf boat vs wind generated waves is not technically applicable to the Spokane River and conflicts with well-developed and reviewed research studies. The Spokane River lacks the fetch to create sizable wind-generated waves.

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<u>Wake/Wave Attenuation</u>

- **In general, the maximum height of waves decreases in proportion to the cube root of distance from the boat (JJ Stoker)**

  So, for instance, a fully-developed wake/surf boat wake of 4 feet (typically fully developed 72 feet from the boat) would still be over 2-feet high 430 feet from the boat's line of travel, and still much more powerful than wakes from a boat on a plane.

- Note, however, that other factors influence wave attenuation, including water depth and the slope of the subsurface, as well as interactions between boats wakes.

- **Because of this, direct observation of boat wakes and their travel on waterways can provide more useful data than the general formulas for wave attenuation** *(see Stiger Report for the Spokane River, for example. Update based on more data taken in 2019 is in process*).
- **This photo is one of many examples that clearly illustrate that 200 feet is not sufficient to address excessive wakes on Kootenai County waterways. Nor is the current 200-foot no wake zone on Lake Coeur d'Alene.**

Excessive wake generated more than 300 feet from shore on the Spokane River, easily topping seawall (more than 32-inch wave).

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<u>Boat Type, Speed, Size and Wake Height</u>

- Studies on the Sacramento River show **the best correlation to wake energy and erosion potential is not boat length, but rather "boat size", which is analogous to displacement (Shuster et al). Displacement has been shown to be the key factor in tests of the best performing surf boats on Lake Oroville in 2018**.
- **There is a reverse correlation between wake height and boat speed** (Shuster et al). Numerous studies show that wake height decreases as speed increases for most powerboats. **The smallest wakes are associated with boats operating on a plane or at no-wake speeds.**
- **The largest possible waves are generated when a boat is in transition mode (plowing)** (State of Oregon). When a boat is on a plane, less hull is in the water to make wakes and total energy of the wake is less.
    - Boats on a plane and water ski boats typically operate at speeds of 25-35 mph or more
    - Optimal speed for surf boats is 8-13 mph, well below planing speed, with wake enhanced by ballast, or mechanical means
    - Wakeboarding is typically at speeds between 15-20 mph, also not on a plane
    - Tubing manufacturers recommend not exceeding speeds of 15 mph for children
- Wake heights 72 feet from the boat (wakes fully developed) show **wakes from wake/surf boats with ballast to be 3 times the height of wakes from a water ski boat and other boats operating on a plane** (Ruprecht et al)
- Recent full-scale experiments on ten typical craft, including the latest water skiing and wake boats, has confirmed that **the energy of the maximum wave created by a modern wake boat at optimal speed (9-12 mph) can be an order of magnitude (nominally 10x) greater than those from water-skiing**

Kootenai County has already taken one action driven by boat wake and plowing issues -- increasing the night-time speed limit for boats from 20 to 25 mph (Nick Snyder, Kootenai County)**, even though some have observed that an increased speed at night is less safe**

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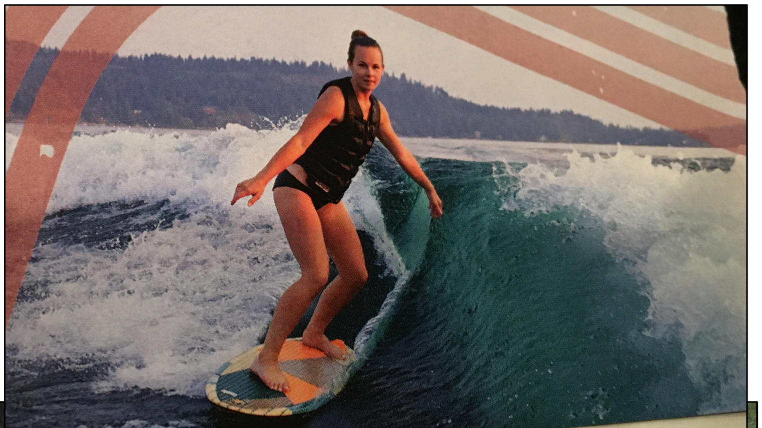
Boating Guidance

- **When producing 24-inch wakes or larger, stay 500 feet or more from the shoreline**. Respect private property and other boaters too (State of Oregon)
- You cannot see what your wake's doing at the shore from the boat**. Even when you are fairly close to the bank, say 150 feet, the peak wake impact will hit when you are about 1000 feet away. This is why regulations based on waves lapping onto docks or observed impacts are not enforceable.**
- **"Avoid traveling at transition speed, with the stern dug in and the bow high—you're making the most damaging wake"** (Tasmania)
- Producing a large wake near other boats, boating facilities and personal property is an error in judgement made by many boat operators**. If your wake is rocking boats or crashing against the shoreline, you are creating too much wake** (State of Washington)
- Most boat-wake waves generated by recreational boat traffic are of short period and short wavelength and don't have any impact in deep water. But **as they migrate toward the bank and interact with the sloping bottom, they can be quite erosive** (Regional District of North Okanagan Fisheries and Oceans Canada)
- Oregon marine accident data for 2010-2017 show that on the average 12% of all accidents were related to the force of wakes. **3 people died from wake-related accidents** in that period (Oregon Staff Report)
- Small craft advisories are issued on waterways in much of the US for waves the size that can be generated by wake/surf boats (4 feet or more) (US Coast Guard)

The height of a boat wake is not currently as easily measured as boat speed. However, **there are numerous observations that can readily be used to demonstrate that a boat is making an excessive wake (e.g.,** top of wake compared to surfer and boat transom, attitude of the boat, etc) **coupled with direct measurements of boat speed** (is the boat operating in sustained transition mode/speed between no-wake speed and on a plane?)



Spokane River 2019

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Suggestions that damage along Spokane River is due more to boat traffic than excessive wakes are not supported by evidence from the Spokane River nor from numerous research studies.

Spokane River late August 2019. Peak wave from 4 boats close to one another, mostly on a plane. Wake duration about 20 seconds.

Excessive wakes on Spokane River (Aug 2019). Numerous wave crests lasting at least 40 seconds.

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(Additional references upon request)