Potential Effect of Boat Wakes on the Willamette River Margins

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Potential Effect of Boat Wakes on the Willamette River Margins

Outline

- Introduction
- Boat Wake Generation and Propagation
- River Margin Morphodynamics
- Problem Assessment

Newberg Pool

Wilsonville

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Introduction

- Erosion has been observed along the Willamette River margins, and it has been generally associated with the navigation (leisure) activity.
- Erosion has been observed for several years, and apparently it has increased recently, since the introduction of wakeboarding and wakesurfing.
- Other sources of erosion, including the natural evolution of the river morphology, have been also proposed as responsible of the problem.
- We will first address the characteristics and description of water surface boat wakes

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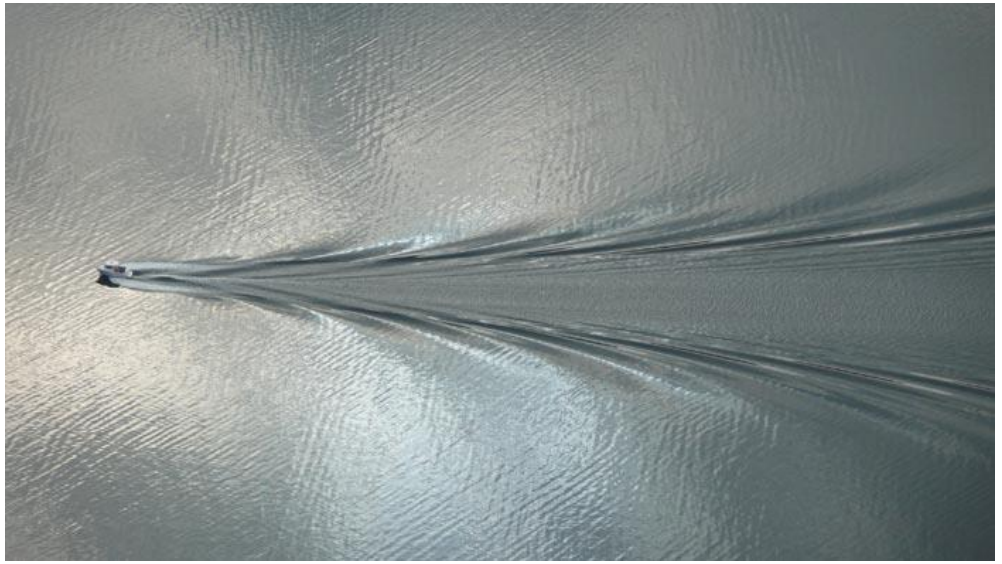
Boat Wake Generation and Propagation

Wakes are the wave pattern on the water surface downstream of an object in a flow, or produced by a moving object.



Boat Wakes can be described by:

Height, Period, Energy Flux, Direction

Boat Wakes are affected by:

Boat speed, length, draft, shape, propulsion method

Water depth, current, dispersion, dissipation

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Observations along the Willamette River Margins

Natural and built environment

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Observations along the Willamette River Margins

Bed material (mud, sand, gravel, pebbles, cobbles, rock)

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Observations along the Willamette River Margins

Margin vegetation and trees

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Observations along the Willamette River Margins

Debris

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Observations along the Willamette River Margins

Shoreline protection (wooden piles, rock, armor stones)

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Observations along the Willamette River Margins

Development (docks, piers, pontoons, ramps, houses, buildings, bridges, abutments, dams)

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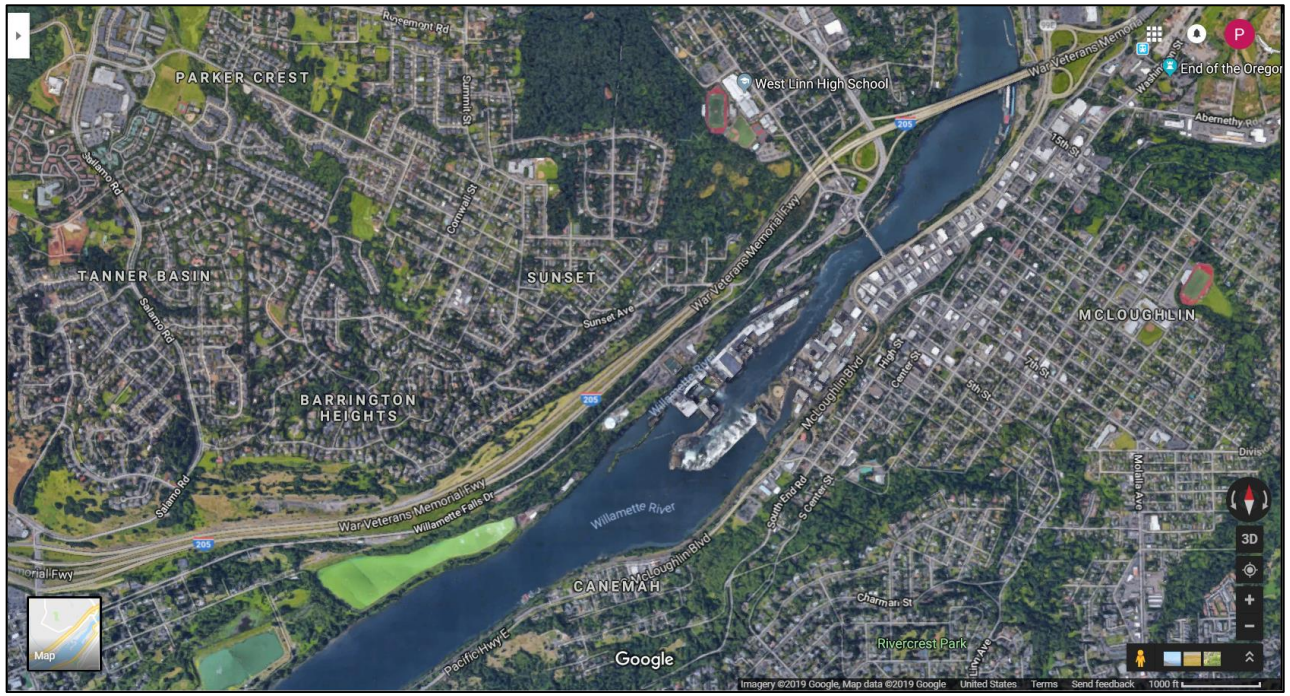

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Observations along the Willamette River Margins

Eroded Margins

Potential Effect of Boat Wakes on the Willamette River Margins

Observations along the Willamette River Margins

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Potential Effect of Boat Wakes on the Willamette River Margins

Observations along the Willamette River Margins

Eroded Margins

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Problem Assessment

- Erosion has been observed along the Willamette River margins, and it has been generally associated with the navigation (leisure) activity.
- Any object interfering with the water flow, or moving in the fluid will generate wakes. Boat wakes are one of the forms of the waves produced by this interaction.
- Displacement (transport) of lose material (sediment, rocks, or any object) in rivers is function of the water particle velocities and pore pressures.
- Different time and length scales are observed in sediment transport processes. Natural processes at mid-scales (order of hundreds of yards to few miles) are associated to relatively long-term scales (order of several years), with the exception of episodic extreme events.
- It can be said that, within the corresponding time scale, a sedimentary system will tend, naturally, to a dynamic equilibrium as long as the hydrodynamic conditions are not changed significantly.
- These (natural) conditions have not changed (significantly) since the end of the last ice age (~15,000 years).

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Problem Assessment

- Intensive anthropogenic activity have changed the morphodynamic conditions along the Willamette River (since ~1850?):
  - Agriculture
  - Construction
  - Excavation
  - Dams
  - Reclamation
  - Dredging
  - Water intakes
  - Industrial Discharges
  - Tourism and Leisure Activities
  - Watersports
  - Climate change
  - …

- Each of the different activities have varying intensities and time responses.

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Problem Assessment

- Erosion will occur, only, if there is an imbalance of the sediment budget.

- The most relevant natural morphodynamic effect at the location of interest are:
  - Sedimentation, produced by reduced current intensities due to the Willamette Falls Dam, located downstream
  - Erosion on outer margins and accretion on inner margins of meanders
  - Vegetation and rocky outcrops prevent or reduce erosion
  - Vegetation induces sedimentation and produce biomass
  - Dynamics have low intensity, but are continuous and steady

- The most relevant anthropogenic effect at the location of interest are:
  - Artificial alteration and control of the river flow by the Willamette Falls Dam
  - Generation, propagation, and incidence of boat wakes along the shorelines
  - Dynamics of boat wakes have high intensity, but are discontinuous and variable.

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Problem Assessment

- Boat wakes, as any other disturbance, produce an imbalance in the sediment transport and, therefore, may induce scour and erosion.
- The intensity of the erosion produced by boat wakes can be considered as very small.
- Significant erosion due to boat wakes can be explained by the cumulative effect of large number of waves, over long time, multiannual, similar to the one observed by natural evolution.
- Differentiate the natural evolution, dynamic equilibrium, long-term anthropogenic disturbance, and short-term effects is not an easy task.
- The scale and complexity of the problem prevents to have a single, definitive answer.
- Economy, social perception, history, education, policies, and other elements play a significant role in the assessment of the potential effect of boat wakes on the Willamette River Margins.
- A long-term, monitoring program (minimum of 1 year) would provide information on the magnitude of the different agents affecting the morphological evolution of the river margins.

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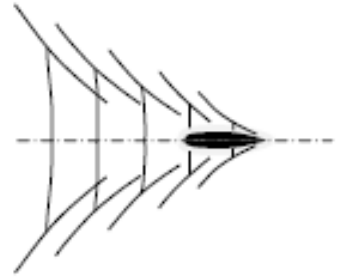
Problem Assessment

Summary of governing parameters affecting erosion along the margins

Natural parameters (steady component)	Navigation parameters (dynamic component)
Width of the river	Boat-type
Depth (water level)	Boat speed
Current speed	Displacement
Curvature of the river	Boat length
Cross-sectional variation	Propulsion system
Bed material	Hull form
Sediment input	Navigation depth
Debris	Navigation path
Vegetation	Number of boats (frequency of occurrence)
Variation in the flowrate	Time-scale
Alongshore elements (floating docks)	
Seasonal variations	
Time-scale	

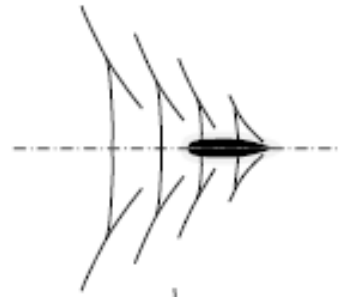
(a) Sub- Critical
$Fr_h < 0.75$

- Short-crested divergent waves
- Transverse waves present
- The well-known Kelvin deep water wave pattern



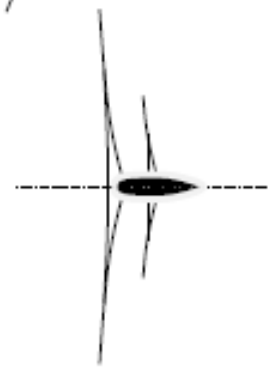
(b) Trans- Critical
$0.75 < Fr_h < 1.0$

- Divergent wave angle increases
- Period of leading waves increases



(c) Critical
$Fr_h = 1.0$

- One or more waves perpendicular to the sailing line
- Crest length grows (laterally) at a rate equal to the vessel speed



(d) Super- Critical
$Fr_h > 1.0$

- No transverse waves
- Long-crested divergent waves
- Long-period leading waves

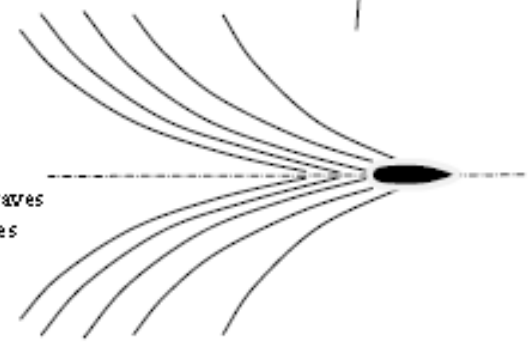


Figure 2.2 Wave wake patterns