River debris: Characteristics, Impacts, and Potential Mitigation Methods

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Debris Impacts on Infrastructure

- Debris accumulation damages infrastructure, disrupts operations, and creates maintenance and safety issues, e.g.:
  - Ruby 5 kW New Energy turbine demonstration
  - Eagle 25 kW New Energy turbine demonstration
  - Ft Simpson 25 kW New Energy turbine demonstration

Bridge pier damage

Yukon at Ruby

Yukon at Eagle
Debris origins

• Primary: River bank erosion in forest regions
  – Increases with river stage

• Secondary: entrainment of stranded debris
  – Increases with river stage
Debris Extent

- Debris exists throughout the water column over a wide size scale.
Subsurface Debris On Tanana Riverbed
July 11, 2012
Debris Location

- Debris generally follows the path of maximum current or power.
- Turbulence and debris inertia can move debris out of the main channel.

Debris in the main channel

Debris forced to the left bank due to current, inertia & turbulence
Debris Location

- The probability of debris location is likely associated with power density
- Higher power density equals higher probability of debris occurrence
Debris Behavior

- Debris rotates and changes location in a river due to changes in current direction and turbulence.
- Debris tends to follow the river’s main channel aligning its length with current direction in sections of straight river reach.
- Movement of large debris is inertia dominated and follows different paths than small debris.
- Small scale debris (cm-scale) exist at all depths, but appear to be especially prevalent in the bottom quarter of the river flow.
Mitigation Methods: Debris Diversion

- Surface diversion boom
- Debris sweeper
- Debris deflector
- Debris-deflecting hydrofoil
Mitigation Methods: Debris Avoidance

- Detecting debris and removing infrastructure from the debris path
  - Lifting infrastructure from the water
  - Moving infrastructure to a safe harbor
- Placing infrastructure in a location with reduced probability of encountering debris

Log island impact of fishwheel

Power density
Mitigation Methods: Debris removal

- Manual methods of debris removal – issues:
  - Safety and effectiveness
  - Ability to keep up with debris accumulation

- Automated debris removal – issues:
  - Economic and technical viability
AHERC Debris Mitigation Technology
Diversion Boom Forces

Ratio of sweeping forces
To resistance forces

\[ Q = \frac{F_{pE} + F_{p\eta}}{F_\mu} > R \]

\[ Q = \frac{\pi V \cos \theta \left( V \cos \theta + \frac{\beta}{2} \right)}{2 \mu \beta (V \sin \theta)^2} > R \]
Diversion Boom Forces

Friction coefficient & current velocity

- $\mu = 0.3, \beta = 1, V = 2$
- $\mu = 0.3, \beta = 1, V = 1$
- $\mu = 0.6, \beta = 1, V = 1$
- $\mu = 1.0, \beta = 1, V = 1$

Debris log length to diameter ratio ($\beta$)

- $\mu = 0.3, \beta = 1, V = 1$
- $\mu = 0.3, \beta = 10, V = 1$
- $\mu = 0.3, \beta = 50, V = 1$
Debris Diversion Platform Testing
Debris on Diversion Device
Conclusions (1/2)

• Developing effective debris mitigation methods and technology is imperative if hydrokinetic power generation in Alaskan rivers is to be feasible.

• Debris exists throughout a river flow:
  – Highest probability of occurrence is correlated to power density and rising river stage.
  – Debris inertia, changes in current direction and turbulence affect debris motion.
  – Small size debris can exist near the riverbed affecting interpretation of sonar surveys.

• Debris mitigation will require multiple approaches to deal with the varied debris conditions:
  – Debris prediction; detection, diversion; avoidance; removal.
Conclusions (2/2)

- Characterization of river debris conditions should be part of hydrokinetic site assessments.
- Diversion boom performance is governed by:
  - Angle of boom pontoons (pinning; sweeping; underflow)
  - Depth in the water (underflow; submerged debris)
  - Friction of surfaces (sliding resistance)
  - Bow geometry, rotation resistance, friction (debris torque balance; debris hang up)
- Additional work is needed to adapt what has been learned and develop effective debris mitigation methods for subsurface debris and improve surface debris mitigation.
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