Tanana River Hydrokinetic Test Site

More than 200 communities in Alaska are located on or near rivers or ocean coastlines. Using the rivers that flow past these communities to produce power has been a dream for many years. That dream is closer to becoming a reality, in large part thanks to pioneering work made possible by the success of the Tanana River Hydrokinetic Test Site and the products being tested there.

In 2010, the Alaska Hydrokinetic Energy Research Center established the test site in Nenana, about 60 miles (95 km) south of Fairbanks. We are pleased to bring our knowledge and expertise in hydrokinetics to the world by offering the Tanana River Hydrokinetic Test Site as a fully characterized, fully permitted facility for testing power-generating devices and related technologies under realistic conditions.

Conclusions

Overall, the RDDP and buoy system, developed as part of prior work directed by Alaska Power and Telephone and refined under this project, has proved to be an effective platform for protecting surface-mounted RECs from floating debris. Despite progress, however, many questions about subsurface debris remain. Future research topics include the potential of the RDDP to disrupt subsurface RECs and how to best bring hydrokinetic power to shore in debris-infested river waters.

The RDDP/buoy/pontoon barge protection scheme has been successful, but cost-effective and practical installations of RECs in remote communities will require refinements in the converters and the debris protection systems. The tools developed during this study will aid evaluation of future hydrokinetic projects, both within and outside Alaska.

As additional steps are taken toward employing hydrokinetic energy systems in Alaska's waterways, it is important to consider the effects of new hydrokinetic infrastructure on aquatic habitat, such as fisheries. All will require continuing cooperation between state and federal agencies, the university, and the private sector.

> *"The Tanana River Hydrokinetic Test Site provides what no other location in the world can deliver for the hydrokinetic industry — a permitted river location for turbine testing that is well-characterized with frequent measurements for turbulence and sediment transport, fish interactions, bathymetry and river velocity."*
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> *— Jeremy Kasper, Alaska Hydrokinetic Energy Research Center*

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For more information, contact:
Jeremy L. Kasper, Ph.D., Director
Alaska Hydrokinetic Energy Research Center
jlkasper@alaska.edu

Alaska Center for Energy and Power
acep.uaf.edu • 907-474-5402

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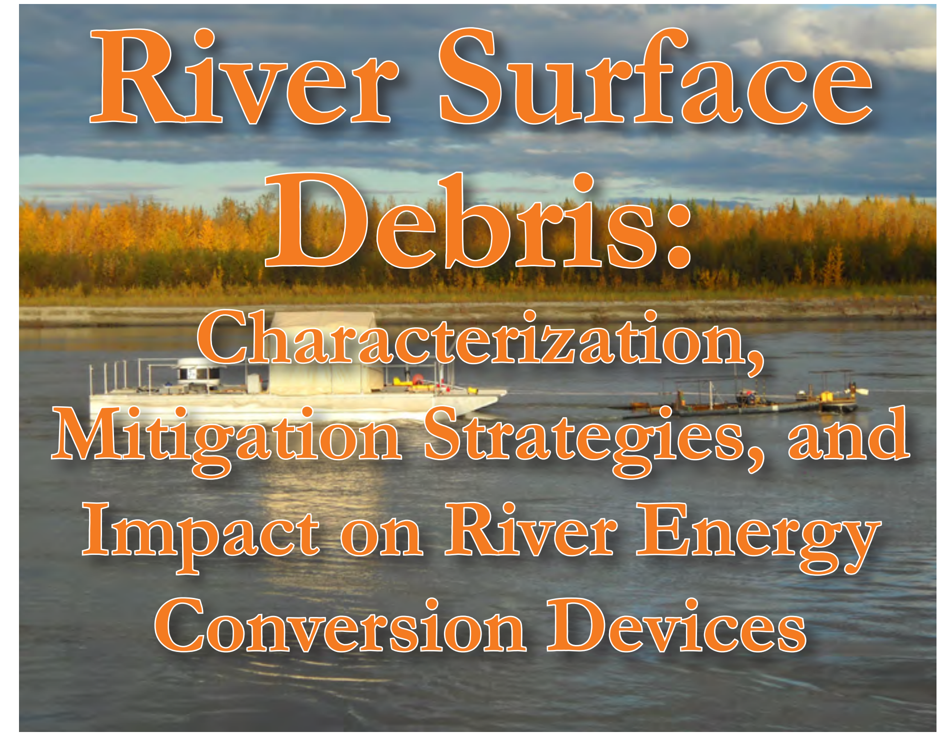
River Surface Debris: Characterization, Mitigation Strategies, and Impact on River Energy Conversion Devices



Platform and debris diverter. Photo by Paul Duvoy

This project improved the design of the research debris diversion platform on the Tanana River at Nenana, Alaska, and enhanced researchers' ability to understand its use with river energy converters. The project also led to the development of new techniques and technologies for analyzing debris and its effect on river energy converters in Alaska.

Introduction and Background

Alaska's hydrokinetic energy resources represent a promising source of power, but river debris poses a significant challenge to the technology. In 2010, two different efforts to demonstrate river energy converters (RECs) deployed from floating platforms were terminated because of problems with woody debris. Alaska Power and Telephone's 2010 demonstration of a 25 kW REC in the Yukon River at Eagle, Alaska, worked well until problems with both floating and submerged debris prematurely curtailed the demonstration. Subsurface debris collected on underwater power and anchoring cables, and surface debris accumulated upstream of the floating platform, posing a major hazard to operations and personnel safety.

Alaska Power and Telephone (AP&T) abandoned plans for deploying the REC and instead initiated a project with the Alaska Hydrokinetic Energy Research Center (AHERC) to examine ways to reduce the hazard of surface debris for

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REC devices deployed from floating platforms. During the study, AHERC developed a surface research debris diversion platform (RDDP) to investigate the important factors associated with diverting surface debris around REC devices.

This 2015 project extended the AP&T commission to further characterize river surface debris and examine the performance of the RDDP. Sponsored by the Alaska Energy Authority (AEA), its goals included conducting long-term deployments of the RDDP, determining the RDDP's effect on local river currents, developing a video debris observation system to monitor river surface debris, and examining the use of sonar to detect subsurface debris. Top priorities were assessing the magnitude of debris impact loads on the RDDP and improving its performance.

Challenges

Challenges to developing a commercial hydrokinetic industry in Alaska include determining the technological, operational, and economic viability of hydrokinetic turbines, meeting permitting requirements, and gaining stakeholder acceptance. The development of hydrokinetic technology can be affected by debris, sediment, and ice; river dynamics such as turbulence, current velocity, and channel stability; and the interaction of turbine operations with fish and marine mammals.

Two 2010 hydrokinetic turbine demonstrations in Alaska were significantly hindered by in-river debris. These experiences indicate that developing technology to mitigate problems caused by debris will need to be a high priority for practical hydrokinetic power production. This research briefing discusses debris problems and research developments.

Research Debris Diversion Platform

The RDDP consists of two pontoons connected at their upstream end by hinged pins that allow adjustment of the separation angle between the pontoons using a hydraulic pump. A debris sweep, consisting of a cylinder that is free to rotate in clockwise or counterclockwise directions, is placed in front of the pontoons to prevent debris from catching on the front of the RDDP. The RDDP diverts debris from its original flow path to a flow path along the edge of the wake produced by the platform.

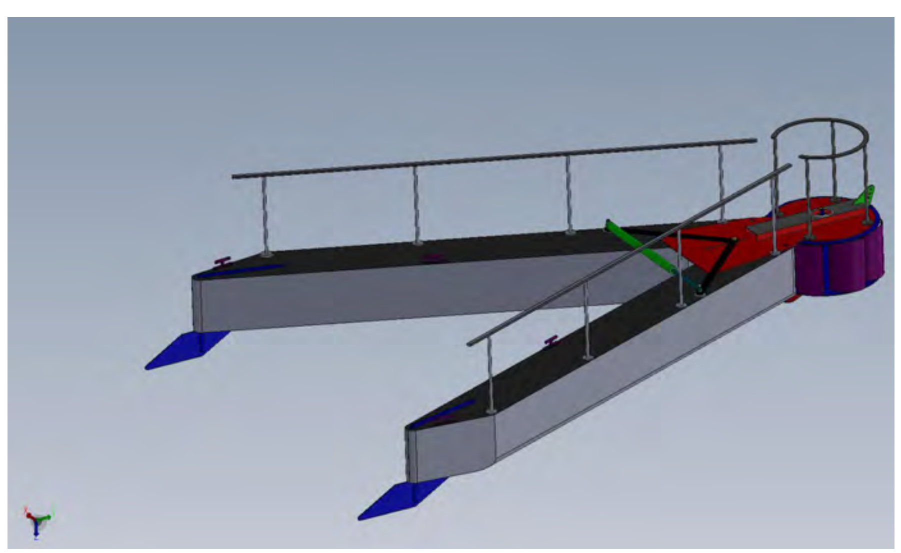
Tests and analyses of the RDDP's ability to divert debris demonstrated the debris sweep's effectiveness at preventing debris from collecting on the front of the platform. The tests also indicated that the efficiency of the RDDP to shed debris depends on the friction between debris and the pontoons and debris sweep, the inertia of the debris sweep, the opening angle of the pontoons, and the pontoons' draft.

Overview of Project Tasks

Project work was divided into tasks as follows:

1. Improvements to the RDDP and debris impact characterization
2. Hydrodynamic impact of the RDDP
3. Video observations of debris
4. COUPi discrete element method model (DEM), was tested for simulating the interaction of debris with hydrokinetic infrastructure.

Research Debris Diversion Platform



Project Summary

A log floats past the RDDP (upriver) while AHERC staff attend to the Oceana Energy Inc. turbine on the barge.

Task 1: Improvements to the RDDP and debris impact characterization. Tests and analyses of debris impacts on the RDDP indicated that the platform's ability to divert and clear debris improved significantly when all surfaces that came into contact with debris were covered with low-friction material, such as high-density plastic. This modification eliminated the problem of debris pinning against the RDDP pontoons as a result of river current forces and debris catching on weld beads and small protrusions at the rear of the RDDP. The RDDP profile in the water was improved by properly ballasting the platform to counterbalance the downward drag at the front of the RDDP caused by water displaced under the debris sweep. The RDDP and mooring buoy system demonstrated the capability of withstanding significant debris impact during long-term deployments.

Task 2: Hydrodynamic impact of the RDDP. A method for analyzing cross-river acoustic Doppler current profiler transects was developed to maximize information derived from such standard, widely used measurements and enable the analysis of large-scale turbulence to determine its effects on REC performance.

Task 3: Video observations of debris. Significant improvements were made to the video debris observation system (VDOS). The VDOS is now able to record images of the river and floating debris at one frame per second, from both the shore and the RDDP. The imagery can be used to categorize debris by size, location, and quantity and to observe the interaction between debris and the RDDP. Data indicated that most debris traveled in the left or middle channel of the river and that most debris was small to medium in size. The amount of debris, of all sizes, increased with river stage. Presently, the VDOS is capable of long-term autonomous operation and thus is a suitable tool for use in remote locations where hydrokinetic projects are being considered.

Task 4: COUPi Discrete Element Method (DEM) modeling. A method for simulating debris interactions with hydrokinetic infrastructure such as the RDDP was developed as a complement to the four tasks that compose the core of the project. The COUPi DEM was used for simulating the impact of debris on the RDDP to provide a qualitative way of examining the process of debris interaction with the platform and its debris sweep. Three debris impact scenarios were simulated by COUPi DEM to examine the behavior of debris interacting with the RDDP debris sweep. Simulations indicate that the ability of the RDDP to clear debris is influenced by the shape of the debris object and the contact friction between debris and the platform. Example output from the COUPi DEM is shown in Figure 1.

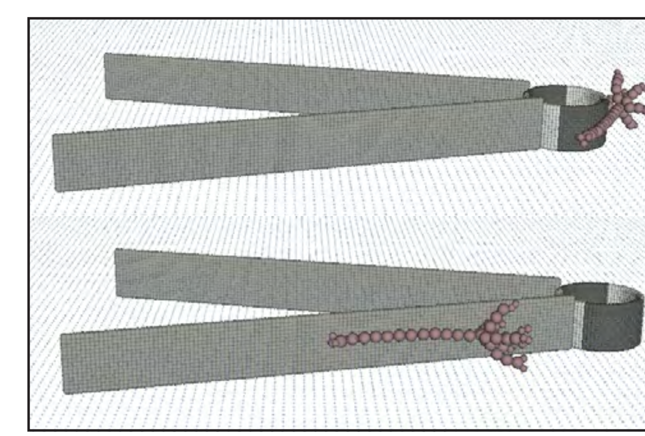


Figure 1: Example output from the COUPi DEM