Project Title: **VIVACE Hydrokinetic Power Generator System: The Solution for Fish Protection and Debris Avoidance in Alaskan Rivers.**

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Total project cost: $900,000
Grant funds requested: $750,000
Match committed: $150,000
Previous projects/applications: N/A
Previous abstracts: N/A

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# 1. Project Summary

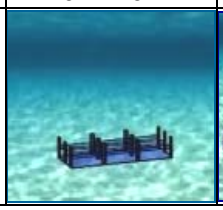
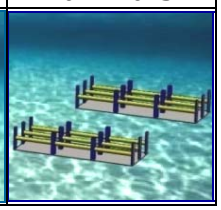
## 1.A. Project Description

This project proposes to install and monitor an innovative hydrokinetic power generation device in the Tanana River. The test site is located at the Hydrokinetic Energy Test Center (AHERC) in Nenana, Alaska. The technology is called VIVACE (Vortex Induced Vibration for Aquatic Clean Energy), owned by Vortex Hydro Energy (VHE). The proposed 24-month project will involve the design and fabrication of a new VIVACE unit specifically designed for deployment in Alaskan rivers. This new VIVACE unit will be tested at the Physical Modeling Basin at the University of Michigan for functionality and baseline performance prior to being deployed in the Tanana River.This demonstration will assess the VIVACE's energy extraction effectiveness, its ability to resist debris, fish safety, reliability, maintenance requirements, and economic viability.

VIVACE is a novel technology that uses flow induced motion phenomena of vortex induced vibrations and galloping to generate energy from water currents (river or tidal). The technology has been well proven through laboratory testing and deployment in the St. Claire River at Port Huron, MI. Project partners include VHE, The Yukon River Inter-tribal Watershed Council (YRITWC), and the University of Alaska Fairbanks (UAF). Physical Modeling Basin tests and design and construction of the VIVACE will occur during 2012 and the early part of 2013 with in-river testing at Nenana occurring during the ice free season of 2013. Analysis of results will occur during the fall and winter of 2013 and final reports prepared and delivered in 2014.

## 1.B. Project Eligibility

VHE has established a development process to take the VIVACE technology from a prototype to commercial demonstration. This process, summarized in the table below, addresses the needs to systematically advance the development of the VIVACE converter through clearly defined stages that have minimum threshold values of performance. This method closely follows the Department of Energy's TRL Stage platform. Vortex Hydro Energy (VHE) is currently at DOE TRL 6, and plans to install a full size commercial demonstrator unit in 2015.

| | **TRL 1-3** | **TRL 4/5** | **TRL 6** | **TRL 7/8** | **TRL 9** |
|---|---|---|---|---|---|
| Name | Alpha 1&2 | Alpha 3,4,5 | Beta 1 / Beta 1B | Beta 2 | VIVACE 1 |
| Scale | 1:15 | 1:3 | 1:3 | 1:1 | 1:1 |
| Timeline | 2005 to 2009 | 2009 to 2010 | 2010-2012 | 2012-2014 | 2014-2015 |
| Picture / Sketch | | | |  |  |

Vortex Hydro Energy has an exclusive license to commercialize patent number US7493759, which is intellectual property of the Regents of the University of Michigan.

## 1.C. Project Innovation

**VIVACE Technology -** VIVACE uses the physical phenomenon of vortex induced vibrations (VIV) to move its cylinder and generate power. VIV sounds somewhat foreign to most people, but it is a naturally occurring phenomenon. VIV is the mechanism by which fish are propelled forward, see Figure 1.

To date, most scientific effort has been spent on minimizing the effects of VIV's incredible power, most often in civil engineering applications. However, VIVACE generates electricity by exploiting the power of VIV, not counteracting it. With VIVACE, the water currents pass by horizontal cylinders, and just as airplane wings are caused to lift by the flow of air across them, the VIVACE cylinder is lifted by the flow of water traveling passed it. Once the cylinder reaches the top of its stroke, the direction of movement is reversed, and the same hydrodynamic forces propel the cylinder downward. The process repeats itself as in Figure 2. The cylinders move up and down slowly and fish can navigate around them. No dams are needed.

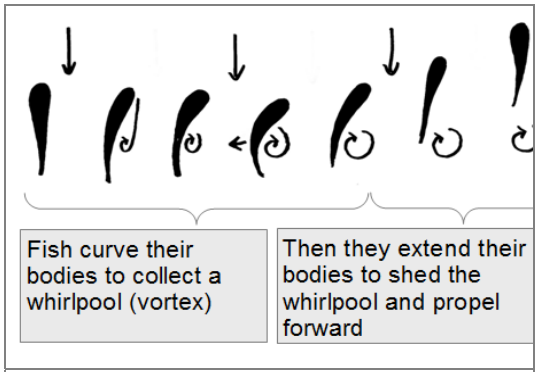


Figure 1 - Fish use VIV to swim

Advantages that VIVACE has over conventional turbines:

- Low manufacturing and maintenance costs: VIVACE uses mainly commercially available off-the-shelf components
- Fish Friendly: The round geometry of the VIVACE cylinder decreases the probability of harming fish
- Debris avoidance: The open space of the device allows for large size debris to pass through easily.

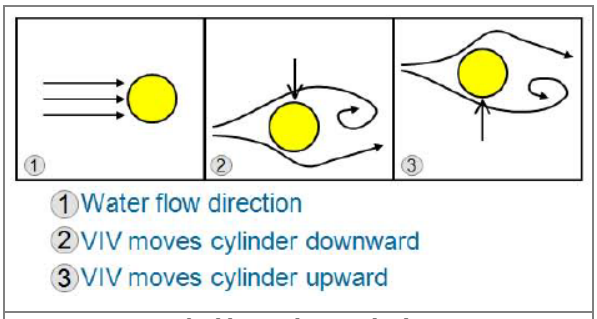


Figure 2 - Vortex shedding induces cylinder motion

**Anchor and Debris Diversion Systems** - The anchoring system will employ an industry standard self-embedment drag anchor and chain. The anchor will be connected to a permanently attached mooring buoy via a chain. The mooring buoy will act as a preliminary surface debris diversion device. The action of the buoy due to river turbulence and its smooth rounded surface prevents debris from accumulating. The buoy also facilitates the connection of the floating platforms and main debris diversion device to the anchor chain. The main surface debris diversion device consists of two ballasted low surface friction surfaced rounded float pontoons connected in a sharp angled V with the apex pointed upstream. A sweeper (a freely rotating drum with short unidirectional fins to provide slight rotation in the current) with a low friction plastic surface coating is mounted on the front of the sharp angled V. The sweeper ensures that impacting debris gets moved to the sides of the diversion pontoons rather than hanging up on the apex angle, which is a major source of debris accumulation.

**Test Site Suitability -** The test site is in the Tanana River at Nenana. The site's bathymetric and hydrodynamic conditions are well characterized. In the main channel, river velocities exceed 2 m/s, channel depths exceed 6 m, and total specific discharge exceeds 17 $m^3/s$ during summer. The test site is representative of typical rural Alaskan communities next to large rivers that represent the initial target communities.

### 1.D. Priority

(1) ABS Alaskan, Inc. is a company based in Alaska that manufacturers and sells Alternative Energy & Remote Power Products. ABS was instrumental in the introduction of hydrokinetic systems to Alaska and the both the design and installation of both the Ruby and Eagle systems. Furthermore, this project includes the participation of the Yukon River Inter-tribal Watershed Council. (2) The University of Alaska at Fairbanks is a partner in this project. (3) ABS and VHE are committing $150,000 in matching funds. (4) The VIVACE technology has the potential of widespread deployment in the state. This includes over 100 rural communities along Alaska's major rivers and communities near tidal sources or with intertie grids that can transmit power from tidal sources.

## 2. Technology Validation and Research Methodology

### 2.A. Objectives

**Objective 1: Test 3-5 kW device at Physical Modeling Basin at the University of Michigan.**
A strengthened version of the existing VIVACE converter will be designed and fabricated. It will be tested at the University of Michigan Physical Modeling Basin for basic functionality and baseline performance prior to being deployed at the Tanana River.

**Objective 2: Test 3-5 kW device in the Tanana River.**
Testing will be in a reach of the Tanana River at the Nenana Hydrokinetic Test site that has extensive bathymetry, hydrodynamic and sediment transport characterization The objective is to determine the VIVACE converter's energy extraction effectiveness, its ability to resist debris, fish safety, reliability, maintenance requirements, and economic viability under Alaskan river conditions.

**Objective 3: Measure/observe the impact on fish/environment.** During the first year, an initial characterization of the fish abundance, size, and distribution will be conducted, and methods will be developed for sampling the middle of the river channel (This will be required as part of obtaining an Alaska Department of Fish and Game Habitat Division permit, ADF&G). During the second year, a more detailed characterization of the fish community during the entire ice-free period will be conducted, as well as an assessment of direct impacts of VIVACE on these fish.

### 2.B. Methodology

A scaled down version of the VIVACE Beta 1 (Beta 2 prototype) to withstand debris, yet light enough to be deployed from a pontoon boat will be constructed and tested in the University of Michigan Towing Tank for functionality and performance. The prototype will then be shipped to Alaska and suspended from a moored floating platform for testing in the Tanana River. Tugboat services and heavy equipment are available near the site, and the site is 60 miles from Fairbanks for support.

An improved surface debris diversion device will be constructed utilizing rounded pontoons to reduce sharp edges that can catch debris. The pontoons will be segmented into separate watertight compartments. A bow bubble creating back pressure will force water to divert, greatly reducing the likelihood of small and medium size debris from coming in contact with the diversion structure. The top surface of the diversion device will be covered to allow workers to work on the structure and remove any debris.

Monitored parameters will include river hydrodynamic conditions (current velocity, power, turbulence), force on anchor lines and lines running to the pontoon boat, debris conditions, VIVACE power output, and VIVACE interaction with fish and debris. Load cells on lines to the debris diversion device and VIVCE pontoon boat will measure debris impacts and accumulation, and VIVACE drag. A video camera will document river surface conditions. An economic analysis will be conducted using information about deployment costs, costs of maintenance an operation - to include periods of lack of availability.

Permits will be required from ADF&G, Alaska Department of Natural Resources (AK DNR). AHERC presently has in place a fish habitat permit from ADF&G Permits may or may not be required from the US Army Corps of Engineers, National Marine Fisheries Service, and the US Coast Guard.

## 3. Summary of Project Schedule and Project Budget

Sept - Dec, 2012 - Refine anchor system & debris diversion device; apply for site permits; identify & characterize specific site location for hydrodynamic, bed, and fish conditions Develop parts and equipment needs & order parts. Build mooring buoy, debris diversion device, VIVACE and related parts.

Jan. - Mar. 2013 - Test VIVACE and final review of anchor & debris diversion device systems and preliminary planning for summer deployment/ ship VIVACE.

April - May 2013 - Final preparations for deploying mooring buoy, and debris diversion device.

June – Oct 2013 - Deploy anchor, mooring buoy, debris diversion, and VIVACE device. Operate system & document performance. Remove equipment.

Nov. 2012 - May 2014 - Conduct analysis and prepare final reports.

**Budget Summary**: Total project cost: $900,000; Grant funds requested: $750,000; Match committed: $150,000 – Vortex Hydro Energy ($100,000) and ABS Alaskan, Inc. ($50,000) – all in-kind matching.

| **Category** | Budget Amount | VHE match | ABS match |
|---|---|---|---|
| Direct Labor and Benefits | 186,000 | | 28,000 |
| Travel & Per Diem | 22,000 | | |
| Equipment | 46,000 | | |
| Materials & Supplies | 74,000 | | 12,000 |
| Contractual Services | 545,000 | 100,000 | |
| Management & Administration | 27,000 | | 4,000 |
| | 900,000 | 100,000 | 50,000 |

## 4. Project Team Qualifications

Jim Norman, President ABS Alaskan, Inc. project PI responsible for overall project direction and management; Mr. Gus Simiao, VHE CEO responsible for VIVACE construction and testing; Dr. Andy Seitz, Assist. Prof. UAF-School of Fisheries and Ocean Sciences responsible for characterizing baseline fish conditions and VIVACE fish interactions; Dr. Horatio Toniolo, Assoc. Prof. UAF-College of Engineering and Mines responsible for hydrodynamic characterization; Mr. Jack Schmidt, UAF Research Engineer responsible for project design and implementation technical support.

## 5. Discussion of Commercialization of Funded Technology

The proposed project will advance the commercialization of the VIVACE technology in rivers and tidal locations in Alaska. Through monitoring performance characteristics such as debris resistance, fish safety, maintenance requirements, and power output, it will be possible to (1) determine how well the VIVACE technology performs under this harsh environment, and (2) obtain valuable information that will be used to improve the device for the follow on testing.

Potential customers for the VIVACE converter include the over 100 rural communities along Alaska's major rivers. Additional customers include communities near tidal sources or with intertie grids that can transmit power from tidal sources. Rural community power depends on diesel and is some of the highest cost power in the U. S. Hydrokinetic power would displace diesel with renewable local energy. As fossil fuel costs continue to increase and hydrokinetic technology matures the economics will favor hydrokinetic generated power. Non-economic benefits include reducing greenhouse gases, reducing the need for handling diesel, and involving more local residents.

## 6. Signed Applicant Certification

By signature on this application, I certify that we are complying and will comply with the amount of matching funds being offered.

_____ Jim Norman, President Date _____