Before the United States of America
Federal Energy Regulatory Commission

ROOSEVELT ISLAND TIDAL ENERGY PROJECT

FERC No. 12611

Final Kinetic Hydropower Pilot License Application

Volume 2 of 4
December 2010

Verdant Power, LLC
New York, NY

PILOT LICENSE APPLICATION

ROOSEVELT ISLAND TIDAL ENERGY PROJECT

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Submitted by:

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EXHIBIT E
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LIST OF ACRONYMS

USACE	United States Army Corps of Engineers
ADCP	Acoustic Doppler Current Profiler
BA	Biological Assessment
BO	Biological Opinion
CEII	Critical Energy Infrastructure Information
CEQ	Council on Environmental Quality
Commission	Federal Energy Regulatory Commission
CO-OPS	Center for Operational Oceanographic Products and Services
CORE	Cornwall Ontario River Energy
CR	Control Room
CZMA	Coastal Zone Management Act
D	diameter
DOE	Department of Energy
DTI	UK Department of Trade & Industry
EFH	Essential Fish Habitat
EPA	Environmental Protection Agency
EPB	Environmental Policy Board
EPRI	Electric Power Research Institute
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FMPP	Fish Monitoring and Protection Plan
ft	feet/foot
GHG	Greenhouse Gases
GHT	Gorlov Helical Turbine
ICD	Initial Consultation Document
IHA	Incidental Harassment Authorization
ILP	Integrated Licensing Process
INEEL	Idaho National Engineering and Environmental Laboratory
KHPS	Kinetic Hydropower System
LOA	Incidental Harassment Authorization
LPC	Landmarks Preservation Commission
m	meter
MMPA	Marine Mammal Protection Act
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NYC	New York City
NYCLPC	New York City Landmark Preservation Commission
NYDOS	New York State Department of State

LIST OF ACRONYMS *(continued)*

NHPA	National Historic Preservation Act
NYSDEC	New York State Department of Environmental Conservation
NYSEP	New York State Energy Plan
NYSERDA	New York State Energy Research and Development Authority
NYU	New York University
PATONS	Public Aids to Navigation
ppt	parts per thousand
RIBS	Rotating Intensive Basin Studies
RIOC	Roosevelt Island Operating Company
RITE	Roosevelt Island Tidal Energy
RTE	Rare, Threatened and Endangered
s	second
SFMP	Seasonal Fishery Monitoring Plan
SHPO	State Historic Preservation Office
TEV	Test Evaluation Vessel
TLP	Traditional Licensing Process
TMDL	Total Maximum Daily Load
UNFCCC	United Nations Framework Convention on Climate Change
USCG	United States Coast Guard
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USNSRDC	United States Navy's David Taylor Model Basin
Verdant Power	Verdant Power, LLC
WI/PWL	Waterbody Inventory and Priority Waterbody List

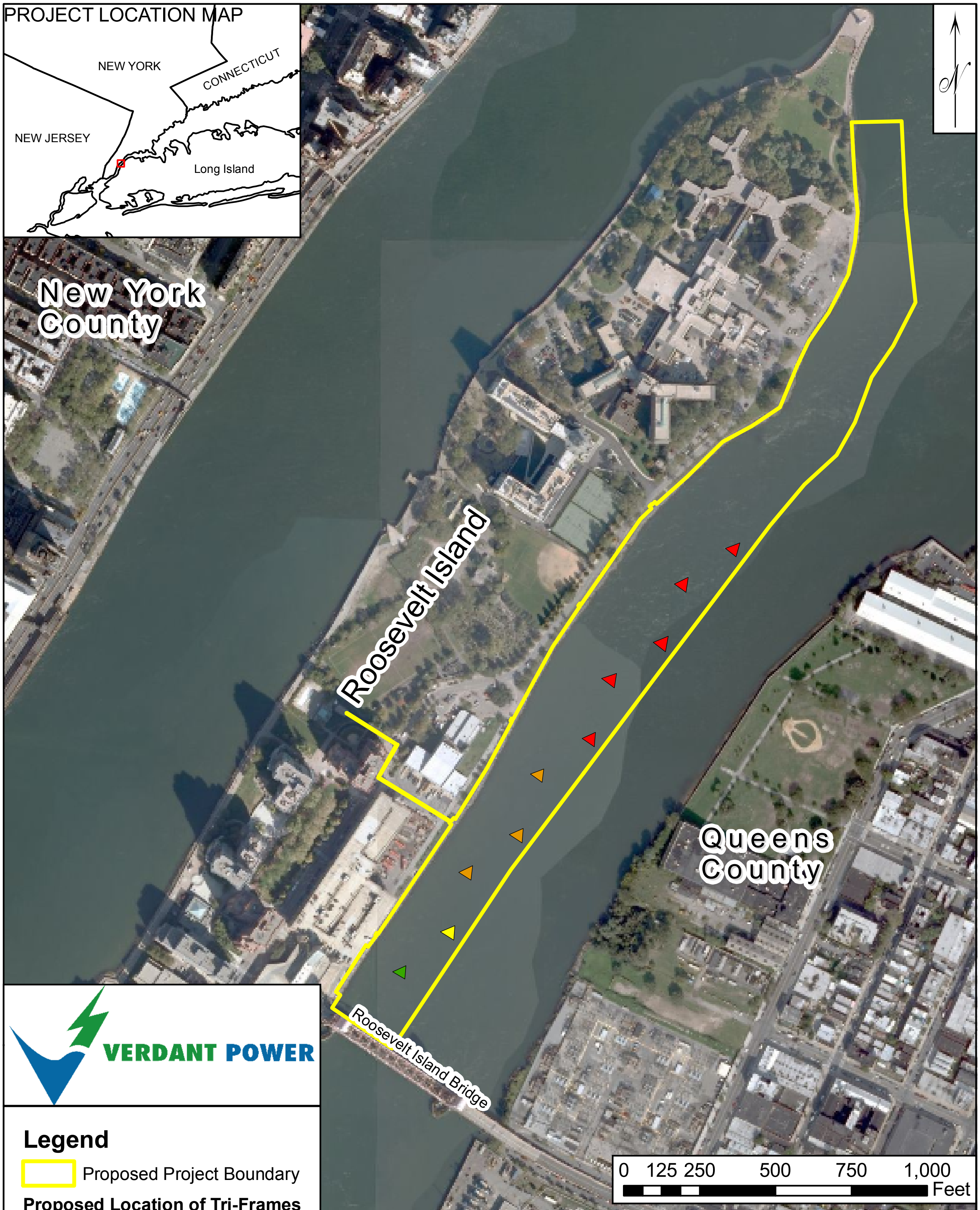
PILOT LICENSE APPLICATION
ROOSEVELT ISLAND TIDAL ENERGY PROJECT
FERC NO. 12611

EXHIBIT E
ENVIRONMENTAL REPORT

1.0 APPLICATION

Verdant Power, LLC ("Verdant Power" or "Applicant") is filing with the Federal Energy Regulatory Commission (FERC or Commission) a Final Application for an Original Hydrokinetic Pilot License (FERC No. 12611) for the Roosevelt Island Tidal Energy (RITE) Pilot Project ("Project" or "Pilot Project") to include the staged deployment[1] of up to 30 kinetic hydropower turbines with an estimated installed capacity of 1 MW, and additional project components as described herein. This Project would be located in the East Channel of the East River in New York City. This development builds on a successful demonstration project conducted by Verdant Power during 2006 to 2008 (Figure 1.0-1).

[1] Install A: 2 KHPS units executed under existing permits is not covered under the FERC Pilot License, but it is necessary to provide a continuum of technology development and environmental monitoring for subsequent stages. FERC Pilot License action includes: (1) Install B-1: 3 KHPS units total (105kW); (2) Install B-2: up to 12 KHPS units total (420kW); and (3) Install C: up to 30 KHPS units total (1,050kW).



VERDANT POWER

Legend

Proposed Project Boundary

Proposed Location of Tri-Frames

Install

- Intall A
- Install B1
- Install B2
- Install C

Scale: AS SHOWN	VERDANT POWER, LLC NEW YORK, NEW YORK	CHECK PRINT
Project No: 1642-003	RITE PROJECT PILOT LICENSE APPLICATION	
Filename: Project_Location.mxd	PROJECT LOCATION	
Drawn By: LJC	Kleinschmidt Energy & Water Resource Consultants 2 E. Main St. Strasburg, PA 17579 Telephone: (717) 687-7211 Fax: (717) 687-7266 www.KleinschmidtUSA.com	1.0-1
Date Drawn: 12-10-10		

1.1 PURPOSE AND NEED FOR ACTION

1.1.1 Purpose of Action

The purpose of the Roosevelt Island Tidal Energy (RITE) Project is to install, operate, monitor, and deliver clean renewable energy in New York City from the Kinetic Hydropower System (KHPS). The KHPS unit is Verdant Power's patented[2] renewable energy system that converts the kinetic energy of tidal and river currents into electricity for distributed generation or grid connection. The proposed Project will utilize the fifth generation ("Gen 5") of the KHPS, developed in 2009-2010. Through support from NYSERDA, the City of New York, FERC, the U.S. Navy, the Department of Energy, and other public and private sources, the RITE Project has become a world leader and model for the advancement of kinetic hydropower as a new and viable renewable energy resource.

1.1.2 Need for Power

The RITE Project meets many needs on both a local and global scale. First, the commercialization of the KHPS through the RITE Project will help advance kinetic hydropower as a cost-effective source of clean and renewable energy for the United States and world. According to the U.S. Energy Information Administration (EIA), electricity generation is expected to nearly double between 2004 and 2030 (EIA, 2007). In the United States as well as the rest of the world, fossil fuels are currently expected to be relied upon to meet much of this demand. Not only do fossil fuels represent a finite and depleting source of energy, but they are also known to emit large amounts of greenhouse gases (GHG), especially carbon dioxide, which has been linked to climate change and other environmental issues. As a newly tapped source of energy, kinetic hydropower will help meet both the nation and the world's growing demand for energy.

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[2] Intellectual property coverage for the Verdant KHPS unit and related technologies includes nine filed patent applications, two provisional applications, 17 patent disclosures, and 11 technical concepts in patent development. A detailed list is available upon request.

Also, as a clean and renewable energy source, kinetic hydropower will help displace the use of fossil fuels, thus diminishing GHG levels locally and abroad.

The RITE Project also meets New York's needs for indigenous sources of energy. Historically and today, New York has faced enormous challenges in terms of local energy use compared to production. A 2009 New York State Energy Plan (NYSEP) issued by the New York State Energy Planning Board (NYSEP, 2009) projected that between 2009 and 2018, electricity demand according to the Starting Point Case, which is based on the electricity demand forecast used by NYISO in its 2009 Reliability Needs Assessment, will increase at an average rate of 0.8 percent per year, or a total increase of 7.3 percent. According to the Energy Price and Demand Annual Long-Term Forecast for 2009 to 2028 of the Plan, it identified a need for 180,488 GW of additional supply and demand reduction resources for New York by the year 2028, the highest estimated need to date. To help fill this gap, New York has had to import a huge amount of energy from outside state lines. In fact, the New York State Energy Research and Development Authority (NYSERDA), a key partner in the RITE Project, found that 85% of energy used in New York in 2005 was imported from outside its borders (NYSERDA, 2006). The NYSERDA report goes on to state that this scenario makes New York State "vulnerable to energy supply disruptions and price volatility," while also supporting "economic development in other parts of the world at the State's expense." Generating power from the tidal currents of the East River, located in the heart of Manhattan, the Project will offset the need for New York to import energy, provide a more cost-and energy-efficient source of power through lower transmission losses, and help spark economic development locally rather than in other parts of the country. Also, by advancing the technology of kinetic hydropower generation, the Project will open the door for New York to harness the estimated 50-500 MW of tidal kinetic hydropower resources of the state.

Finally, the Project will also help the New York and U.S. economies by establishing a new market for jobs and commerce through the commercialization of the KHPS units and the advancement of kinetic hydropower overall. Already, through its demonstration phase conducted under the "Verdant Orders," the Project has sparked local commerce, led to new local hires, and begun to provide opportunities for local businesses to gain expertise on this emerging technology and energy source. By advancing kinetic hydropower in the United States, the Project will expand this type of commerce, job creation, and business knowledge, helping U.S. businesses lead the world in the development, global exportation, installation, and servicing of kinetic hydropower technologies.

1.1.3 AVOIDANCE OF GREENHOUSE GAS EMISSIONS

As with national and global entities, New York has also identified greenhouse gas (GHG) emissions as a growing energy-related crisis locally. According to scientific evidence, the 2009 Energy Plan suggests that limiting the global average temperature increase to approximately 3.6°F (2°C) above pre-industrial temperatures may minimize the likelihood of the most severe climate impacts, which is consistent with the United Nations Framework Convention on Climate Change (UNFCCC) goal of avoiding dangerous climate change. To keep warming within these limits, the UNFCCC concludes that emissions of GHGs from developed nations must be reduced by 80 to 95 percent from year 1990 levels by the year 2050. As a result of this requirement, the State of New York established a goal to reduce GHG emissions in New York 80 percent below 1990 levels by the year 2050. The Plan stated that distributed generation facilities would provide the state with great benefits by reducing electricity prices and GHG emissions, while also improving energy source diversity and flexibility. The Project, and Verdant Power's KHPS overall, precisely meets this need for distributed generation sources of clean renewable energy.

2.0 PROPOSED ACTION AND ALTERNATIVES

2.1 PROJECT DESCRIPTION

As summarized in Attachment A to Volume 1 and described in detail in Exhibit A of the Pilot License Application, the RITE Demonstration Project was installed and operated in the East Channel of the East River in New York from 2006-2008. The demonstration turbines have been removed from the water, but the permitted[3] demonstration site currently consists of a defined exclusion area delineated by 3 navigational buoys and two onshore warning signs, as shown in the cover photo. A control room with existing interconnection, storage containers, and an informational sign about the Project are located adjacent to the site on the shore. Other existing site infrastructure includes cabling to in-water instrumentation (ADCEPs) and five fish monitoring frame mounting blocks. There are also 6 in-water monopiles with pile tops that provided mounting for the RITE Demonstration turbines, which can be used to mount instrumentation. These pile tops are approximately 5.5 feet (1.7 m) above the riverbed and are within the established demonstration, navigation-restricted zone (See Exhibit F-1).

2.2 PROPOSED ACTION

The proposed action for which the Applicant seeks a pilot license is the development, testing, and environmental monitoring of a 1-MW field of 30 kinetic hydropower turbines in the East Channel of the East River in New York City[4]. This Pilot Project would consist of a phased build out of turbines with accompanying environmental monitoring. The sequences of the buildout would be:

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[3] The RITE demonstration area is covered under the joint NYSDEC Permit No. 2-6204-01510/00001 and 00002 and USACE Permit NAN-2003-00402-EHA, both which expire May 2012.

[4] Prior applications by Verdant Power for the RITE Project have included plans for up to 400 turbines in the East River, in both the East and the West Channel. Verdant categorically states that no more than 30 KHPS units are contemplated for this site.

- Install A: Two, 5-meter-diameter Gen 5 (KHPS) axial flow turbines mounted on two existing monopiles from the RITE Demonstration phase. This effort would be conducted under a proposed modification and extension to the existing NYSDEC/USACE permit (expires May 2012) and the FERC Verdant Power Order; it would not be under a FERC Pilot License. The continuing demonstration of the longevity and reliability of the Gen 5 KHPS, as well as environmental monitoring associated with Install A are important to the continuity of the subsequent pilot license installations.
- Install B-1: Install three Gen 5 turbines on a triframe mount (105kW), with associated cabling to shoreline, and interconnection with existing infrastructure.
- Install B-2: Install up to three additional triframes of three KHPS turbines each, with associated cabling and shoreline infrastructure (Vaults A and B) and underground interconnection to substation.
- Install C: Install up to six additional triframes (no more than 30 Gen 5 KHPS total for a total capacity of 1,050 MW (35 kW each)), with additional cabling to shoreline, and shoreline (Vaults C, D, E) conduit to Vault B, and underground interconnection to substation.

The phased installation approach is described further in Section 3.2.5. Additional project components would include instrumentation (water current and temperature measurement devices) and environmental monitoring equipment required under the RITE Monitoring of Environmental Effects (RMEE) plans; underwater cables from each unit to five shoreline switchgear vaults; onshore conduit to the control room and interconnection points; and appurtenant facilities for navigation safety, operation, and maintenance.

Based on the resource analysis of the temporal and spatial variation of tidal current velocities in the pilot field, the total proposed Project (Install C) would have an average annual generation of 1,680 to 2,400 MWh.

2.2.1 Location and Layout

The location of the Project is as depicted on Figure 1.0-1 and in Exhibits F and G. It extends from the Roosevelt Island Bridge northward to the tip of Roosevelt Island on the east side of Roosevelt Island in the east channel of the East River.

The envisioned full buildout layout (Install C) of the Pilot Project would follow a regular pattern of 10 rows of triframes, each containing three KHPS turbines for a total of 30 turbines. The triframes are spaced longitudinally at 12D, where D refers to the diameter of the turbine (5 meters). Therefore, the row-to-row spacing is 60 meters or 197 feet. The triframes are offset in alternate rows so that the effective streamwise spacing (Row 1 to Row 3) is 24D (120 meters or 394 feet). This spacing is based on hydrodynamic issues related to optimal array operation, as verified by Verdant Power during the RITE Demonstration Project.

The Pilot Project of 30 KHPS units would encompass a project boundary of approximately 21.6 acres, which includes 21.2 acres of underwater land lease and 0.4 acres of shoreline right-of-way for the control room, cable vaults, and underground transmission lines. The incremental buildouts of Install A, B-1, and B-2 will encompass small subset areas of the total project boundary as noted on the Exhibit F and G drawings.

2.2.2 KHPS Technology

The Verdant Power Gen 5 KHPS unit consists of four major components:

- Rotor with three fixed composite blades;
- Nacelle (watertight), pylon and yaw mechanism;
- Drivetrain generator and brake (within nacelle); and

- Riverbed mounting system, (three KHPS turbines on one triframe mount).

A 5-meter diameter, three-bladed turbine rotor will be used (See Figure 2.2.2-1). The blades are fixed-pitch, with varying thickness, chord length, and twist. The three blades are mounted on a cast ductile iron hub with a fairing diameter of 1 meter. The blades have an improved design for strength and are fabricated from composite materials for increased reliability over the previous versions of the blades used in the RITE Gen4 demonstration.

The nacelle (horizontal body of the turbine) is the central 0.8-meter-diameter cylindrical equipment. It is made of cast iron, with a stainless steel bulkhead at the upstream end and a unitized gearbox with shaft-bearing and sealing housing at the downstream (rotor) end. Static sealing is by redundant O-rings. The total axial length of the turbine body from nosecone to tailcone (rotor) is 4.3 meters. The fixed-blade rotors rotate at a relatively slow and constant speed of approximately 40 revolutions per minute (rpm), with tip-speeds in the order of 35 feet per second. This is well below normal water vessel propeller speeds and conventional hydropower turbine blade speeds.

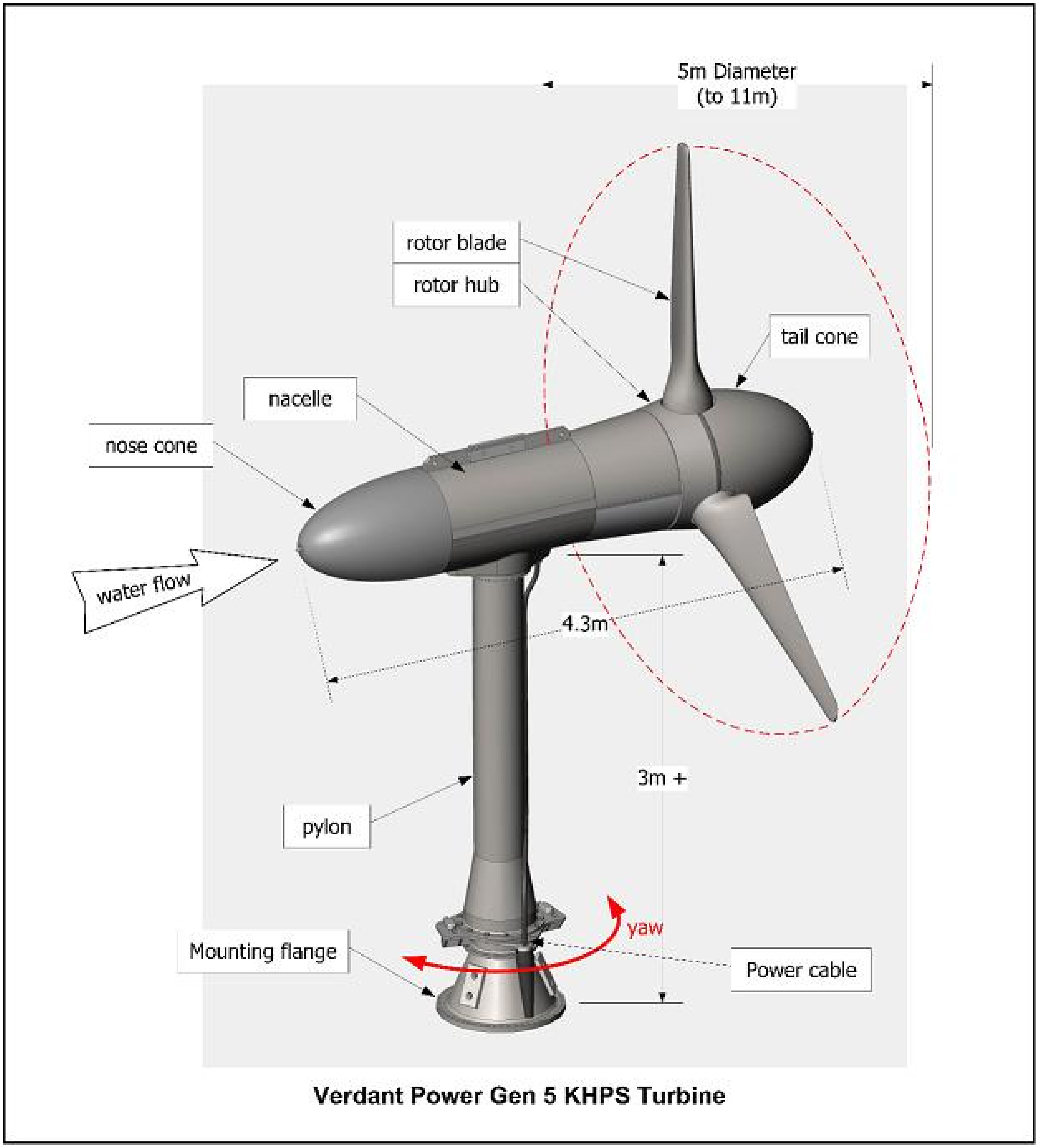
The turbines self-rotate into the prevailing current flow so that the blades are optimally aligned to generate energy on both the ebb and flow tides. The yaw bearing allows passive rotation of the entire turbine assembly up to 170 degrees during slack tide. Watertight electrical connectors are located within the area of the nacelle/pylon flange. Electrical cables travel along the exterior of the pylon assembly, down to the mounting system to the riverbed, and then to the shore.

Unlike the Gen4 demonstration, the Gen 5 turbine includes an automatic, spring-applied braking system that stops rotor rotation in all but specified operating circumstances. The brake operates in a fail-safe mode whereby if a system fault is detected or grid connection lost, the brake is de-energized and automatically applied to prevent rotation.

Because of the power characteristics of the KHPS turbine rotor, it is possible to load it near-optimally with a quasi-fixed speed generator, even as the water current speed varies. While the nameplate capacity of the Gen 5 5-meter-class machine is 56kW, the power output of each turbine depends upon the actual water velocity at a given location. Based on Verdant Power's operating experience at the RITE Demonstration, the nominal rated capacity of each KHPS turbine to be used in the RITE East Channel Pilot is 35 kW. Additionally, because spatial and temporal variations in velocities can vary widely within the array and on ebb and flood currents, at any given time all turbines in the array may not be generating power, or some turbines may be producing significantly more or less than the nominal 35 kW. All drivetrain components are designed to operate conservatively, well below any speed and stress ratings, in order to provide very long maintenance cycles and long life.

Install A will mount two of the Gen 5 turbines on existing monopoles to test the KHPS for longevity and reliability, as well as performance. Beginning with Install B-1, the triframe, foundation structure is used. The triframe is a triangular, steel space-frame structure that can support three turbines. The design relies on shape and weight for restraining the system from the water current forces. One advantage to this approach is that multiple turbines are installed with one deployment operation. The design also does not require major pile drilling or explosives for installation. The components of the KHPS technology are discussed in more detail in Exhibit A of this License Application.

Figure 2.2.2-1. Gen5 KHPS Rotor



2.2.3 Underwater Cabling, Shoreline Vaults and Interconnection

The Verdant Power KHPS is designed to have limited above-water facilities. The RITE East Channel Pilot will include 480V electrical cables (no hydraulic oil systems) from each of the 30 KHPS turbines. Cables will travel through the pylon assembly of each turbine to the triframe mount. For each triframe mount, the three turbine cables will be bundled together into a set, which will then be routed from the field, weighted along the riverbed, to five shoreline switchgear vaults, where it will join another set of three cables. The individual turbine cable lengths from the base of the turbine to their respective vaults would range from approximately 200 to 245 feet.

The existing RITE Demonstration Project control room will be retrofitted to serve as the RITE pilot project control room. The control room will house a SCADA system for array electrical and turbine performance monitoring, communication equipment for surveillance, and water velocity instrumentation by way of stationary Acoustic Doppler Current Profilers (ADCPs) on the river bottom. The control room will also house the shoreline portion of the environmental and surveillance instrumentation required under the RMEE and Safeguard Plans.

2.2.4 Appurtenant Facilities

In order to comply with navigation and safety requirements, Verdant Power would install a safety system consisting of six (6) lighted buoys and two lighted danger signs as Private Aids to Navigation (PATONS) on the periphery of the array area. For public education, Verdant Power would provide an informational project board at the control room and an information kiosk near the north end of the RITE field.

2.2.5 Project Design, Manufacturing and Construction

Verdant Power has built, assembled, tested and deployed an operating grid-connected KHPS made up of six full-scale turbines (five generators and one dynamometer) in New York City's East River. Based on the experience with the manufacturing of these six Gen4 units, Verdant Power has been developing a manufacturing/scale-up plan to provide the 30 KHPS (plus 6 spares) for the Pilot Project.

To support the manufacturing scale-up of the KHPS Verdant Power has completed two awards from the New York State Energy Research and Development Authority (NYSERDA), focused on "KHPS Technology Manufacturing Cost Reduction, Scale-up and Commercialization." This 2-year, 1.17 million-dollar project with a $500,000 NYSERDA funding commitment provided the framework for the scale-up manufacturing and delivery of the RITE Pilot machines. This ongoing NYSERDA work will support the development of a framework for monitoring and evaluating the fabrication process and ensuring final acceptance testing of the components to be installed at the Pilot Project.

Verdant Power's staged installation procedure is designed to ensure ongoing design validation and is described below.

<u>Install A</u>: Install Two Gen 5 Turbines on Existing Monopiles

- Installation would be accomplished in the 4th quarter of 2011 on existing foundation mountings.
- This installation would be conducted within the boundaries of the established RITE Demonstration Project.
- This effort would be conducted under a proposed modification and extension to the existing NYSDEC/USACE permit (currently expires May 2012) and the FERC Verdant Power Order and would not be under a FERC Pilot License.
- This stage of the Project would last a minimum operational period of up to 180 days and would include environmental monitoring as described in the environmental monitoring plan accompanying the license.
- The performance and lessons learned from these two turbines will be incorporated into the subsequent Gen 5 turbines.
- Verdant Power will propose an extension of the existing permit term of 1.5 years to November 2013 to allow for flexibility in the schedule; and incorporation of the agreed to "Install A" monitoring plan.

<u>Install B-1</u>: Install Three Gen 5 Turbines on a Triframe

- Install B-1 would be governed by the terms of a FERC Pilot License, a new NYSDEC/USACE joint permit, and other requisite permits.
- The initial purpose would be to demonstrate the new triframe mount component of the technology and prove installation, operation, and maintenance techniques.
- The environmental monitoring from Install A would continue, adding two additional elements in the RMEE plan.

<u>Install B-2</u>: Install up to Three Additional Triframes of Three Turbines Each

- Install B-2 would be done under the FERC Pilot License proposed herein and additional authorizations and expand the Project to up to 12 operating KHPS units in 2013.
- This stage would include an additional element of environmental monitoring within an array of multiple Gen 5 units to increase the understanding of environmental effects.
- The experience and lessons learned from the execution of previous RMEE elements will be incorporated into this stage.

<u>Install C</u>: Install up to Six Additional Triframes (no more than 30 Gen 5 KHPS units total)

- This phase completes the buildout of the full Pilot Project, incorporating the results of technology and environmental testing in previous stages.
- This would also be done under the FERC Pilot License and additional authorizations and will likely be completed in 2014. −RMEE plans will continue through this installation, building on prior observations.

Based on Verdant Power's experience with the six turbines through the three deployments of the RITE Demonstration Project, Verdant Power expects a short construction period at the RITE East Channel field. The in-water production rates are estimated to be greater than 1 triframe per week (3 KHPS units). Therefore, with contingency, a 3-month construction period is expected.

It is anticipated that many of the component parts will be manufactured and assembled at a lay-down area in the surrounding Greater New York City area and floated by barge to the project site. The details of the on-water installation of the triangle frame structures with three KHPS turbines are currently under final design by Verdant Power.

Other key points of the construction process:

- Shoreline vaults are likely of prefab construction and brought to site minimizing any local disturbances to the existing area.
- Aggregate ground disturbance is expected to be <1 acre.
- Diver intervention is minimal, but is still needed (during slack periods) for shoreline cable weighting and connections.
- The use of four semi-permanent piles (as shown on Exhibit G-1) to assist in construction deployment and potentially maintenance is under consideration and may or may not be required.
- This system may require some riverbed pinning of the triframes but will likely not require major drilling or explosives for deployment.

2.2.6 Proposed Project Operations

The RITE Pilot Project will operate using the natural tidal currents of the East River. The Verdant Power KHPS turbines capture energy efficiently from the flow in all directions by yawing, using a completely passive yaw system with a downstream rotor as described in more detail in Exhibit A. At the RITE Pilot Project, the kinetic hydropower turbine-generators are unique in operation in many distinct areas:

- The operation of the kinetic hydropower turbines follows a very predictable tidal cycle quite dissimilar to the hydrologic cycle of conventional hydropower. This predictive cycle follows four, daily, on-off cycles with slack tides of no generation, and lunar monthly periods of high spring tides, and lower neap tides with corresponding higher and lower generation periods. While this cycle permits extreme predictability for generation (and O&M activities) it allows no flexibility in terms of hourly or seasonal alternative operation.

- Once deployed, installed, and cabled, the turbine-generator units are commissioned. The turbines will operate under an individual data acquisition and control system (DACS) that allows for startup and shutdown (with braking) on both ebb and flood cycles. When the water velocity is too low or too high, or any electrical parameter is out of specification, the rotor is stopped by the break. A supervisory control and data acquisition (SCADA) system monitors all the turbines in the array, measures water conditions, the electrical grid, and controls the system as a whole.
- The operating experience to date of the RITE Demonstration Project is encouraging and the pilot field of 30 KHPS units will provide additional challenges. In an operating field, Verdant Power KHPS units will likely operate for periods when some percentage of the turbine-generators are not generating due to various mechanical or electrical issues. Verdant Power is optimistic that this percentage will be low due to the simple yet robust design concept. However, since this is a first-ever installation, flexibility in maintenance decisions is the only alternative for operating the KHPS array.

As fully demonstrated during the RITE Demonstration Project, the operation of a full field buildout of 30 KHPS units at the RITE East Channel Project will be by automatic and (after commission and approval) unattended control. Each Gen 5 KHPS turbine will passively yaw with the new flood or ebb tide. At a water velocity of approximately 0.8 to 1 m/s, the turbine will be independently connected to the line, releasing the break, and the rotor will rotate at about 40 rpm, and the turbine will generate power. As the water velocity decreases as slack tide approaches the KHPS will trip off line, and the break will apply, stopping the rotor. On the rise of the next tidal current, the turbine will passively yaw to the new flood position, ready to begin generating again, when the velocity is adequate. Table 2.2.6-1 below summarizes this repetitive cycle.

Table 2.2.6-1. KHPS operation during typical tidal cycle.

Tide	Turbine Orientation	Rotor (rpm)	Generating?	Duration (hrs)
Slack tide		0	No	~1/2
Ebb Flow <1m/s	Transitioning (yaw) from flood to ebb	0	No	~1/2
Ebb Flow >1 m/s	Unit fully in ebb position	40	Yes	~4
Ebb Flow <1m/s	Unit in ebb position	0	No	~1/2
Slack Tide	Transitioning (yaw) from ebb to flood	0	No	~1/2
Flood Flow <1m/s	Unit fully in flood position	0	Yes	~4
Flood Flow >1m/s	Unit fully in flood position	40	No	~1/2
Flood Flow <1 m/s	Unit in flood position	0	No	~1/2

2.2.7 Proposed Project Maintenance

The design philosophy of the Verdant Power KHPS units includes an imperative for simplicity and ruggedness so that operating and maintenance costs are minimized. This is necessary due to the mobilization and time-on-site costs for deployment equipment and personnel. The turbines are designed to be installed, commissioned, and then operate unattended. The minimum target service period is 3-5 years; one of the primary objectives of the Pilot Project is to demonstrate this service period.

Verdant Power's plan for maintenance as demonstrated in Deployment #3 is a remove-and-replace strategy that should have minimal environmental impact. On-site service involves only a switch-out (remove and replace) operation. Both for construction and maintenance in a tidal current, the 1-1.5-hour, useful duration of slack tides is the only period for activity. During Deployment #3, Verdant Power executed removal and replacement of one KHPS unit in less than 7 hours (during two tidal cycles) and this is the model for servicing a larger array. No turbine servicing is performed on site, but a local service shop is expected to be established to refurbish KHPS units for the array.

With 30 KHPS units in the RITE East Channel Field Array (and 6 planned spares), depending on the attrition rate and location, the turbines may be serviced on a regular schedule or on an as-needed basis. For this size array, the DACS system monitors various parameters of turbine performance and can give notice of a turbine failure or advance notice of an incipient failure. A detailed service cost model, which can be continuously updated, is under development and will determine at which point a mobilization is warranted for turbines in each project.

2.2.8 Proposed Project Plans under Pilot License

In accordance with the Commission's Hydrokinetic Pilot Licensing whitepaper guidance, Verdant Power outlines the specific monitoring plans during the course of the Pilot Project Term that have been negotiated since the filing of the Draft License Application in November 2008. These are contained in the section titled "Proposed Monitoring Plans" in Volume 4 of this Pilot License Application, which embodies six elements of the RITE Monitoring of Environmental Effects (RMEE); the document continuously provides additional information on the staged installation of the Pilot Project.

2.3 NO-ACTION ALTERNATIVE

The no-action alternative would be to remove the remaining components of the demonstration project and not go forward with a staged development of a commercial tidal energy project in the East River.

2.4 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM FURTHER ANALYSIS

Verdant Power has undergone a 9-year process that included assessing alternative sites and technologies, addressing concerns of various agencies and stakeholders, and refining the project concept and technology to arrive at the currently proposed project and phased construction approach. Verdant Power also considered and developed a variety of technologies and technological solutions to the challenges of this new waterpower industry.

2.4.1 Alternative Sites Considered

Verdant Power considered a number of alternative sites in developing this proposed project boundary. The primary criteria for siting Verdant Power's kinetic hydropower systems is the availability of adequate water velocities and depths and the acceptability of areas for co-location of other water uses such as commercial and recreational navigation and non-interference with sensitive environmental areas. Another important factor in considering siting is the need and desire by New York City (NYC) and the State of New York to encourage renewable electricity development.

Additional sites were analyzed by Verdant Power as part of developing the RITE East Channel Pilot License Project Boundary. In May 2002, Verdant Power filed for its initial preliminary permit in the East River (P-12178). The initial preliminary permit application considered a site that encompassed the entire eastern shore of Roosevelt Island, described as "the East Channel of the East River approximately 37.5 acres extending from the southern tip of Roosevelt Island to the northern tip of Roosevelt Island." This site was anticipated to be a 10-MW site (494 KHPS turbines) and of a size that would provide significant renewable energy to NYC and New York State. The preliminary permit was renewed in November 2005 (P-12611) with the same site considered. During the course of initial consultations, the initial project boundary was modified for the following reasons:

- The southern tip of Roosevelt Island to the 59th Street Bridge: Verdant Power decided against this site because of insufficient water velocities for kinetic power development;
- The area between the 59th Street Bridge and the Roosevelt Island Bridge: Verdant Power decided against this site due to conflicts with commercial barge traffic making deliveries to the Ravenswood generating facility; and
- From the Roosevelt Island Bridge to the northern tip of Roosevelt Island: Verdant Power found this to be an ideal site, and a portion of this area was developed as the location of the RITE Demonstration Project.

In August 2006, in order to achieve the stated goal of producing 10 MW of energy in the East River, Verdant Power began to consider a different project area, north of the Roosevelt Island site in an area extending from the Triborough Bridge (Hell Gate) north to Lawrence Point in the general area of Astoria, Queens. Verdant Power applied to amend its preliminary permit (P-12611) to include this continuous project boundary extending to the Astoria area. This project boundary was the boundary considered by agencies during a March 2007 FERC scoping meeting.

In March 2007, Verdant Power met with the Navigation and Security Study Group in Verdant Power’s offices on Roosevelt Island. At that meeting, representatives of the U.S. Coast Guard and active commercial and recreational vessel operators as part of the Harbor Operations Committee voiced compelling objections to development in the area extending north in the Astoria, Queens area. In the spirit of cooperation and in support of Verdant Power, the U.S. Coast Guard provided supplementary maps of five areas where, through consideration of the federal navigation channel and polling of commercial and recreational interest groups, they believe that kinetic hydropower turbines can be co-located within the waters of the East Channel. Verdant Power considered all five sites;

however, only two sites were considered to have adequate velocities to support kinetic hydropower development.

In April 2007, Verdant Power again applied to amend its preliminary permit. FERC approved this amendment in June 2007 to include two areas. After hearing a number of objections from navigation interests and reevaluating technology issues, Verdant Power has now decided against trying to develop in the West Channel of Roosevelt Island and is focused only on a 30-KHPS development in the East Channel as described in this Pilot License Application where there appears to be a great deal of acceptance for the Project.

2.4.2 Alternative Facility Designs, Processes, and Operations Considered

Verdant Power has hands-on experience with alternative turbine designs and has also conducted industry-wide research on alternative approaches to kinetic hydropower energy generation. Verdant Power conducted technology assessments for the Electric Power Research Institute (EPRI) Renewable Energy Technical Assessment Guide reports from 2002 to 2004. The Company's Canadian subsidiary, Verdant Power Canada, was also retained by Natural Resources Canada in 2006 to assess tidal power technologies as they might be applied to Canada's rivers. Through these studies, Verdant Power has conducted in-depth desktop analysis of over 40 different kinetic hydropower energy generation technologies from around the world.

Based on the hands-on and desktop analysis of alternative systems described above, Verdant Power determined the axial flow KHPS units to be the most viable kinetic hydropower energy generation technology available for Verdant Power development at the RITE Project. The work leading up to and including the Demonstration Project of the Gen4 KHPS technology (described in Appendix A) has formed the basis for this Pilot License Application, which utilizes the Gen5 KHPS units and includes significant improvements over the overall design and function of the Gen4 turbine, including but not limited to:

- Composite (FRP) Blades, tested by the National Renewable Energy Lab
- Ductile Iron Hub Casting
- Ductile Iron Casting for pylon/nacelle connection
- Custom Integrated Gearbox incorporating/shaft housing/bearings/seals and long-life lubrication system
- Redundant dynamic (shaft) and static sealing to retain lubricant and exclude seawater
- Customized generator
- Failsafe brake
- Non-toxic fouling-release coating system
- Improved commercial quality control and assurance manufacturing process

3.0 CONSULTATION AND COMPLIANCE

3.1 AGENCY CONSULTATION AND COORDINATION OF REVIEW AND COMMENTS

Verdant Power has a long and ongoing history of working with regulatory agencies and stakeholders in a cooperative spirit to understand and address concerns associated with this new and revolutionary method of power generation. Throughout the preliminary permit period, Verdant Power conducted consultation with federal agencies and New York State and local regulators to develop a template for the key permitting and consultations required for kinetic hydropower licenses. In addition, Verdant Power voluntarily convened on two separate occasions (January and May 2007) a separate Environmental Policy Board (EPB) of federal agencies to assist in understanding the various applicable laws and policies to allow for full permitting of a commercial project.

For the RITE Demonstration Project, Verdant Power received a joint permit from U.S. Army Corps of Engineers (USACE) and the New York State Department of Environmental Conservation (NYSDEC) under Section 10 of the Rivers and Harbors Act, Section 401 and 404 of the Clean Water Act and ECL Article 15, Title 5 in September 2005 (DEC Permit No. 2-6204-01510/00001 and 00002 and NAN-2003-402-EHA). In accordance with the permits, Verdant Power developed a Fish Movement and Protection Plan with the USACE, NYSDEC, NOAA, USFWS, EPA, NYCDEP, version 6.0 (October 2005), which was subsequently amended to version 7.5 in September 2008. These permits are currently in effect for the RITE Demonstration project area and Verdant Power is currently seeking to modify and extend these permits to support the first phase of the overall proposed project (Installation A). More recently, Verdant Power has worked with agencies to develop a complete monitoring plan (RMEE) to assess the various phases of the pilot license installation and address the questions that remain about potential environmental impacts of the proposed Project.

Also, during the RITE Demonstration Project, Verdant Power submitted and installed approved Private Aids to Navigation (PATON) in accordance with the U.S. Coast Guard (USCG) First District office directives, for approved buoys and signs that marked the exclusion zone in the East Channel of the East River. During the course of the preliminary permit, Verdant Power convened a Navigation and Security work group to examine issues and concerns related to commercial and navigational safety in and near the proposed Pilot Project. As a result, the proposed draft Safeguard Plans, provided in Volume 3, contain those recommendations. Verdant Power continued to work with the USCG during the period between the draft and final Pilot License Application to arrive at suitable navigation safety plans.

In addition to the plans for compliance with the applicable statutes identified in 18 CFR §5.18(b)(3), as well as the Marine Mammals Protection Act, as discussed below, Verdant Power has researched statutes of the State of New York and City of New York that may require compliance prior to implementation of the final license and buildout. Verdant Power has supplemented its research with consultation with appropriate regulatory bodies about the applicability and permitting requirements under these statutes and will continue with such consultation under the term of the Pilot License.

3.2 COMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS

3.2.1 Clean Water Act - Section 401 and 404

Pursuant to Section 401 of the Clean Water Act, as amended, any activity requiring a federal license or permit that may result in discharge into navigable waterways requires certification from the state that confirms that any such discharge will comply with applicable state water quality standards. This requires Verdant Power to obtain Section 401 Water Quality certification prior to issuance of the Pilot License and a subsequent USACE permit under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act.

Verdant Compliance and Consultation:

As discussed above Verdant Power is currently in compliance with requirements of Section 401 for the RITE Demonstration Project as evidenced by the existing joint 401/404 permit. Verdant Power is concurrently applying for an extension and modification of this permit to cover the Install A phase of this Project. Verdant Power is concurrently filing for a new Section 401 certification for the activities proposed under this Pilot License Application for Installs B and C. Discussions to date have indicated that this certification will be granted in a timely manner.

3.2.2 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act established exclusive United States authority over all fishing within the exclusive economic zone (200 nautical miles from shore) and is the primary law governing fisheries management in the United States. Before any federal agency can authorize a project that will impact Essential Fish Habitat (EFH), it must be reviewed by the NMFS, who will then respond with recommended steps to avoid or minimize any adverse impacts. The authorizing federal agency must develop an EFH Assessment, and NMFS will review the EFH Assessment and provide conservation recommendations.

Verdant Compliance and Consultation:

In conjunction with this Final License Application, Verdant Power has developed a draft EFH Assessment document for review. This is included as Attachment 2 in Volume 4 of this License Application.

3.2.3 Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) of 1972 is administered at the federal level by the Coastal Programs Division within NOAA’s Office of Ocean and Coastal Resource Management. In New York State the NYS Department of State (NYSDOS), Office of Coastal Resources administers the CZMA. The enforceable policies of any Local Waterfront Revitalization Program for New York City, the New Waterfront Revitalization Program, is administered by the Department of City Planning. For federal and state actions within the city's coastal zone, the Department of City Planning will forward consistency determination comments to the Department of State. NYSDOS is responsible for the consistency determination, which is necessary for the FERC license and USACE permits.

Verdant Compliance and Consultation:

During the course of the preliminary permit, Verdant Power consulted with both New York State and New York City to determine consistency and applicability of the proposed project with these requirements for the RITE Demonstration Project. In conjunction with the filing of the Final License Application, Verdant Power is submitting the NYC Local Waterfront Revitalization Plan (LWRP) Consistency Assessment form (and associated application materials) to the Department of State.

3.2.4 Endangered Species Act

Section 7 of the Endangered Species Act (ESA) requires an authorizing or acting federal agency to consult with USFWS/National Marine Fisheries Service (NMFS) on any actions that might affect listed species or their habitats. If the authorizing/acting agency or USFWS/NMFS determines an action is likely to adversely affect a species, formal consultation is required with USFWS or NMFS depending on their jurisdiction over the listed species. Formal consultation consists of submittal by the authorizing/acting of a Biological Assessment (BA) for review by USFWS or NMFS. Upon review of the BA, USFWS/NMFS would each prepare a Biological Opinion (BO) which assesses whether the action is likely to impact the existence of the listed species. The BO may include binding and/or discretionary recommendations to reduce potential impact. An Incidental Take Statement may be attached to the BO if there is potential impact to the species.

Verdant Compliance and Consultation:

As part of the draft Pilot License Application, Verdant Power requested and was designated FERC's non-federal representative to initiate consultation pursuant to Section 7 of the ESA. Verdant Power has been consulting with NMFS and has prepared a Draft Biological Assessments (BA) for shortnose and Atlantic sturgeon, as well as for sea turtles that could potentially traverse through the project area. These are attached as Attachment 1 to Volume 4 of this Final Pilot License Application.

3.2.5 Section 106 Consultation

Section 106 of the National Historic Preservation Act requires federal agencies to consider the effect of federally permitted projects on historic and cultural resources and requires consultation with the State Historic Preservation Officer (SHPO) prior to authorizing a project. Compliance with Section 106 of the Act also requires consultation with tribes in the region. SHPO consultation also satisfies New York State Historic Preservation Act of 1980. FERC typically satisfies Section 106 requirements for a license term through a Historic Properties Management Plans (developed by the applicant in consultation with the SHPO) or a Programmatic Agreement to which FERC, the SHPO and ACHP are typically the signatories. Environmental review by New York City Landmark Preservation Commission (NYCLPC) is required for projects that require in-ground disturbance and that may affect landmark properties (or historic districts).

Verdant Compliance and Consultation:

As part of the draft Pilot License Application, Verdant Power requested and was designated as FERC's non-federal representative pursuant to Section 106 of the NHPA. During the course of the preliminary permit, Verdant Power had several consultations regarding the NHPA and designated properties in and around the pilot project site. On land, there are no Nationally Registered historic places, archaeological sites, or landmarks near the immediate project area. In April 2007, Verdant Power conducted a side-scan sonar survey to look for underwater wreckages in the project buildout area. There were no wreckages found in the project footprint (see Section 5.3.9).

In April 2007, FERC initiated Tribal consultation for the proposed Project with three tribal entities in the New York City area, inviting tribal consultation on the Project. The Delaware Nation submitted a letter in January 6, 2008 stating that the location of the project does not endanger known sites of interest to the Delaware Nation though they requested that they be notified if any archeological sites or objects were inadvertently uncovered. The New York State SHPO sent a letter, dated December 22, 2008, stating that “the project will have No Adverse Effect on cultural and historical resources eligible for or listed on the National Register of Historic Places.”

3.2.6 Marine Mammal Protection Act (MMPA)

For marine mammals that are not endangered but are still protected under the MMPA, two types of permits can be issued: (1) Incidental Harassment Authorization (IHA) issued by NOAA for non-lethal takes only for a period of 1 year with annual renewals; or, (2) Letter of Authorization (LOA or Incidental Take Authorization) issued by FERC, for a period of 5 years.

Verdant Compliance and Consultation:

Anecdotal evidence has preliminarily indicated that the only marine mammals likely to be in the vicinity of the project area are harbor seals. Verdant Power has prepared a draft Biological Assessment (BA) on potential impacts to harbor seals and this is included in Attachment 3 of Volume 4 of the Final License Application.

3.2.7 Wild and Scenic Rivers and Wilderness Act

This statute is not applicable to the RITE Pilot Project.

3.2.8 Pacific Northwest Power Planning and Conservation Act (Act)

This statute is not applicable to the RITE Pilot Project.

4.0 ENVIRONMENTAL ANALYSIS

4.1 DESCRIPTION OF PROJECT AREA

The East River is a 17-mile-long tidal strait connecting the waters of the Long Island Sound with those of the Atlantic Ocean in New York Harbor. The East River separates the New York City boroughs of Manhattan and the Bronx from Brooklyn and Queens. The Harlem River flows from the Hudson River and connects with the East River at Hell Gate. The East River is not a freshwater river normally described in a FERC application, but a saltwater conveyance passage for tidal flow. There is some freshwater influence from the Harlem River and some direct drainage area from the surrounding metropolis, but the river is predominantly controlled by tidal influence. Figure 1.0-1 provides the project location. In 2003, Verdant Power submitted an Initial Consultation Document (ICD) to the Commission which summarized the available environmental information in the project area.

4.2 SCOPE OF THE PROJECT SPECIFIC AND CUMULATIVE EFFECTS ANALYSIS

According to the Council on Environmental Quality's (CEQ) regulations for implementing National Environmental Policy Act (NEPA) (40 CFR §1508.7), an action may cause cumulative effects on the environment if its effects overlap in time and/or space with the effects of other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes the actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time, including hydropower and other land and water development activities.

Aquatic resources are the primary resource area having the potential to be cumulatively affected by the Project. The geographic and temporal scope for both project-specific and cumulative effects is discussed below.

4.2.1 Geographic Scope

The geographic scope of the analysis defines the physical limits or boundaries of the proposed action's effect on the resources. Because the proposed action would affect resources differently, the geographic scope for each resource may vary. The geographic scope of the effects analysis broadly includes the East River in the area of the proposed Project.

4.2.2 Temporal Scope

The temporal scope of analysis includes a discussion of the past, present, and reasonably foreseeable future actions and their effects on cumulative affected resources. This Pilot License Application is for a 10-year term which would expire in 2021. This document looks to the future, to the duration of the amended license, concentrating on the effects on the resources from reasonably foreseeable future actions. The historical discussion is limited, by necessity, to the amount of available information.

4.3 PROPOSED ACTION AND ACTION ALTERNATIVES

The scope of the Proposed Action is analyzed below by resource area in standard FERC NEPA assessment format. Consideration has been given to all relevant resource areas identified for analysis in the Commission's whitepaper on hydrokinetic projects in (Appendix B of whitepaper §5.18(b)(5)(ii)(B)). As stated earlier, this plan has been developed in cooperation with resource agencies and stakeholders and has been based on detailed environmental information collected. The plan has been designed to avoid and/or minimize all environmental impacts.

4.3.1 Geology and Soils

4.3.1.1 Affected Environment

The geology, bedrock lithology, stratigraphy, glacial features, unconsolidated deposits and mineral resources of the RITE project area were extensively described in the ICD developed by Verdant Power in 2003.

Geology

The Urban Core of the New York Bight[5] is situated along the boundaries of three distinct physiographic provinces: the Piedmont Province; the New England Province; and the Atlantic Coastal Plains. The convergence of these provinces provides a diversity of landforms, soils, botanical communities, and habitats within the Urban Core (USFWS, 1997).

The bedrock of New York City and the East River include the Middle Proterozoic Fordham Gneiss, the Cambrian Manhattan Formation (schist), and of the Cambrian and Ordovician Inwood Marble. Outcrops of these formations display the northeast-trending known to New York statigraphy. The Manhattan skyline owes its existence to the durability of its bedrock. Riprap, made up of Manhattan bedrock (schist, gneiss) lines the East River's shores, helping to prevent erosion with its durability (USGS, 2003).

Soils

Based on the scoping and comments provided in response to the ICD and in consultation with the NYSDEC, NMFS, the USFWS, USACE, the New York Department of State, and the New York City Department of Environmental Protection, Verdant Power developed a study plan for two separate characterizations of the seabed substrate. These field surveys (conducted by contractors to Verdant Power) included the seabed and substrate composition of both the Demonstration area in February 2005 and the larger RITE East Channel buildout covered by this pilot license application in

[5] A "bight" is a mariner's term for a bend or curve in the shoreline of an open coast; in the New York region it refers to the ocean between Long Island (to the north and east) and the New Jersey Coast (to the south and west). The East River is a tidal strait that links Long Island Sound and the New York Bight.

April 2007. Verdant Power conducted these field surveys with the following objectives:

- Provide baseline information on bathymetry and channel substrates in the vicinity of the Project;
- Evaluate through side-scan sonar and video grab samples the presence and location of any seabed or other significant bottom features indicating possible historic properties (wrecks);
- Evaluate the presence of shallow littoral zone and vegetative cover in the project area that may provide valuable aquatic habitat; and
- Provide information to assist in project layout and development of the Essential Fish Habitat (EFH) Assessment.

RITE East Channel Field

In February 2005 and April 2007, Verdant Power conducted geophysical surveys to document surficial and subsurface riverbed features in the East Channel. The surveys were titled "Acoustic Remote Sensing Survey for Roosevelt Island Tidal Energy Project," published in March 2005 (Verdant Power, 2005) and "2007 Expanded Geophysical Survey Roosevelt Island Tidal Energy Project" (Verdant Power, 2007). The focus of the 2005 survey was in the area of the demonstration project. The 2007 survey extended along the eastern edge of Roosevelt Island from the Roosevelt Island Bridge and north, to include the RITE Pilot Project field. The geologically relevant parts of both investigations included a side-scan sonar survey, sub-bottom profiling, and a bathymetric survey. The 2005 survey also included a substrate inspection using a custom-designed video-grab system.

Both surveys used a high-resolution side-scan sonar device at frequencies of 500kHz and 100-kHz respectively. Detailed images of the riverbed features were generated from data collected and included in the reports. The sub-bottom sonar surveys were conducted using a fixed boom-mounted 10-kHz SyQwest Stratabox system with transects spaced 25 feet apart; the bathymetric surveys were single-beam.

The video-grab inspection was conducted using a custom-designed Ted Young benthic grab samplers equipped with brackets for two Deep Sea Power and Light 250-watt video lights and a Deep Sea Power color video camera.

While these studies were conducted to characterize sediment and substrate for engineering purposes, investigate the river bottom for archeological sites, and aid in the design of the fish movement and protection study, these studies also support the basic understanding of the geology in the vicinity of the Project.

The 2005 study confirmed the presence of boulders and cobbles depicted on the side-scan sonar video and sub-bottom records.

The video coverage did not show any evidence of fine grain soft sediments, thereby precluding any further requirement to obtain sediment samples for grain size and chemical analyses. This was also later confirmed when Verdant Power drilled the 6 piles into the bedrock for the demonstration project.

The April 2007 "Expanded Geophysical Survey Roosevelt Island Tidal Energy Project" (Verdant Power, 2007), extended along the entire eastern edge of Roosevelt Island from the Roosevelt Island Bridge and north to include the RITE East Channel field buildout and detailed images of riverbed features generated from the data collected.

Figure 4.3.1.1-1 is a bathymetric contour map of the East Channel of the East River from the 2007 survey using a 1.0 ft contour interval. The mean elevation within the survey area was -28.7 feet Mean Lower Low Water (MLLW). The minimum and maximum surveyed elevations were -74.7 feet MLLW and -1.6 feet MLLW, respectively.

A mosaic was created from combined, side-scan sonar files composed of gray shaded information, with the shading determined by the intensity of the returning sonar signal. In general, weak signal returns correspond to smooth riverbed substrates (*e.g.*, fine sediments with little micro-topography), soft materials that absorb the signal, or riverbed sloping away from the signal source (towfish). These features appear lighter gray in the conventional gray scale. Strong signal returns correspond to rough riverbed substrates (*e.g.*, gravel, cobble), highly reflective materials, or to a riverbed sloping towards the signal source. These features appear dark gray to black in the conventional gray scale. The data evaluation was based on careful inspection of raw and projected sonar imagery for individual transects and close inspection of the sonar mosaic. Five substrate classes were identified in the survey area: ledge or exposed rock; boulders; cobbles; gravels; and sands.

Figure 4.3.1.1-2 depicts the distribution of dominant substrate classes. The vast majority of the channel appears to be dominated by boulder/cobble substrates. Exposed ledge or rock appears to be present along the western shoreline. Sands and gravels are present in Hallet's Cove and along the slopes of the northernmost channels. Note that debris was widespread throughout the survey area, with the highest density of debris along the eastern shoreline and in Hallet's Cove likely representing a sediment deposit (the cove at the northeastern extent of the survey area). A linear depression is approximately co-located with a former river crossing parallel to 35th Avenue. Shoreward evidence of this crossing is easily observed on the eastern shore, but no obvious relic structures were noted on the island shore.

Figure 4.3.1.1-1. Bathymetric contour map of the East Channel of the East River New York.

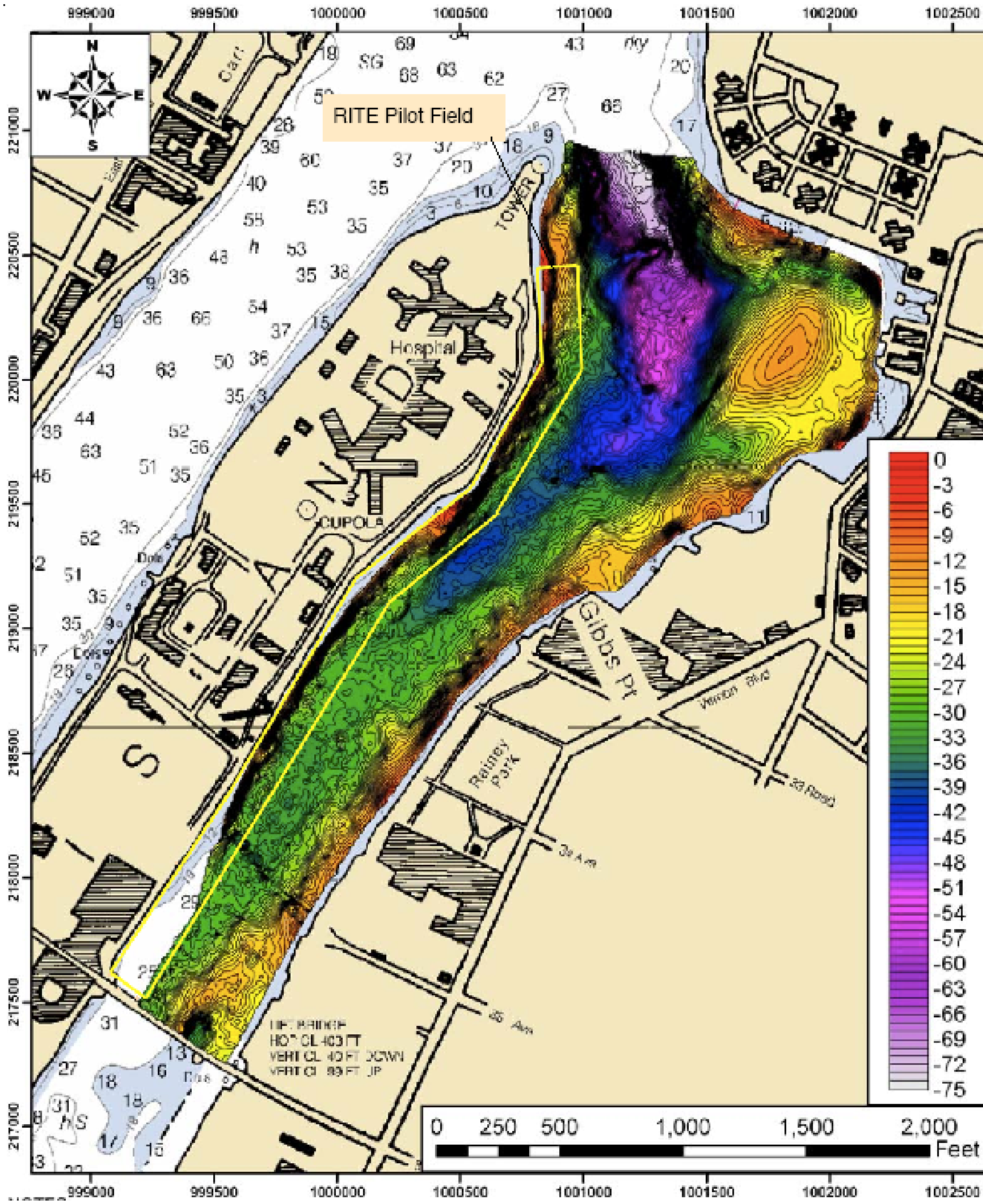
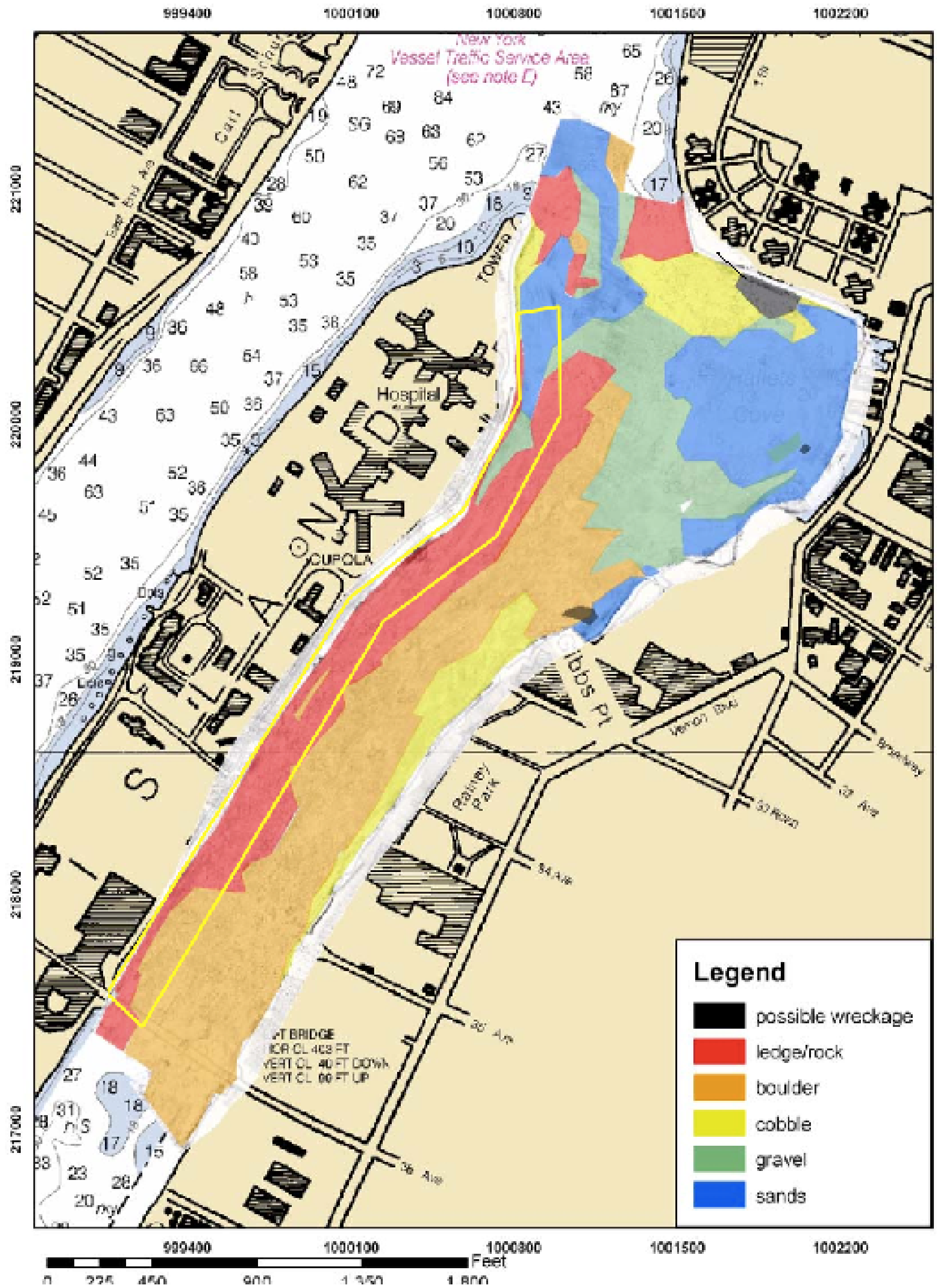


Figure 4.3.1.1-2. Distribution of dominant surficial substrate classes based on side scan sonar data East Channel of the East River New York.



4.3.1.2 Environmental Effects

Proposed Action

The project likely will have little effect on the geology and soils. The urban and developed setting including developed riprap and shoreline bulkhead in the vicinity of the project boundary pose no concern for shoreline erosion.

Geology

Based on the 2003, 2005, and 2007 reviews of the surficial geology, the proposed action does not pose any potential geologic hazards, including scouring action, slope failure, faulting, fluid and gas expulsion, or irregular topography in and around the proposed project area.

Soils

In 2005, the agencies reviewed the "Sediment Sampling Plan for the Roosevelt Island Tidal Energy Project" (DTA, 2005a) and the "Sediment Sampling and Contour Mapping Results for the Roosevelt Island Tidal Energy Project" (DTA, 2005b). The report concluded that the river substrate, including the types, occurrence, physical characteristics, and chemical characteristics, has little chance for erosion and potential for mass sediment movement.

Based on the surficial substrate data developed in the detailed surveys conducted during the preliminary permit term, Verdant Power concludes that no further studies or monitoring is required to determine potential environmental effects.

4.3.1.3 Unavoidable Adverse Effects

None Identified.

4.3.1.4 No Action Alternative

Under the No-Action Alternative, the geology and soils would remain unaffected.

4.3.1.5 Sources

DTA. 2005a. Sediment Sampling Plan for the Roosevelt Island Tidal Energy Project. January 21, 2005.

DTA. 2005b. Sediment Sampling and Contour Mapping Results for the Roosevelt Island Tidal Energy Project. March 2005.

U.S. Fish and Wildlife Service (USFWS). 1997. Significant Habitats and Habitat Complexes of the New York Bight Watershed. USFWS. Charlestown, RI.

USGS. 2003. Geology of New York City Region: A Preliminary Regional Field-Trip Guidebook. Website: http://3dparks.wr.usgs.gov/nyc/index.html.

Verdant Power, Inc. 2003. Initial Consultation Document for the Roosevelt Island Tidal Energy Project (ICD), FERC Project Number 12178. October 2003. Prepared by Devine Tarbell and Associates.

Verdant Power, Inc. 2005. Acoustic Remote Sensing Survey Roosevelt Island Tidal Energy Project. October 2005. Prepared by CR Environmental, Inc.

Verdant Power, Inc. 2007. 2007 Expanded Geophysical Survey Roosevelt Island Tidal Energy Project. April 2007. Prepared by CR Environmental, Inc.

4.3.2 Water Resources

4.3.2.1 Affected Environment - Water Quantity

Verdant described the reported water uses and existing water quality in the East River in the ICD (Verdant, 2003). A summary of these sections and additional information developed over the course of the preliminary permit is presented below.

Water Uses

Water withdrawals in the project vicinity include both industrial and commercial facilities, including thermoelectric power plants (fossil fuel), which utilize water from the East River for process/cooling water purposes. There are also several sources of water discharges from large industrial and municipal wastewater treatment plants that discharge to the East River. Table 4.3.2.1-1 below summarizes these licensed dischargers and the maximum licensed volume for each.

Table 4.3.2.1-1. Licensed dischargers to the East River.

Plant	Type	Volume
NYC Hunt's Point Sewer Treatment Plant	Municipal	200 mgd
NYC Newtown Creek Sewer Treatment Plant	Municipal	310 mgd
NYC Tallman's Island Sewer Treatment Plant	Municipal	80 mgd
NYC Red Hook Water Pollution Control Plant	Municipal	60 mgd
NYC Wards Island Sewer Treatment Plant	Municipal	250 mgd
Consolidated Edison 60th Street Stream Gathering Station	Electric	N/A
Consolidated Edison East River Facility	Electric	541 mgd
Ravenswood Generating Station	Electric	N/A
New York Plaza Building	Cooling	26 mgd
866 UN Plaza Associates	Cooling	6 mgd
Astoria Wastewater Treatment Facility	Combined	N/A

mgd = million gallons per day
N/A: Not Available
Source: NYSDEC, 1999; EPA, 2003.

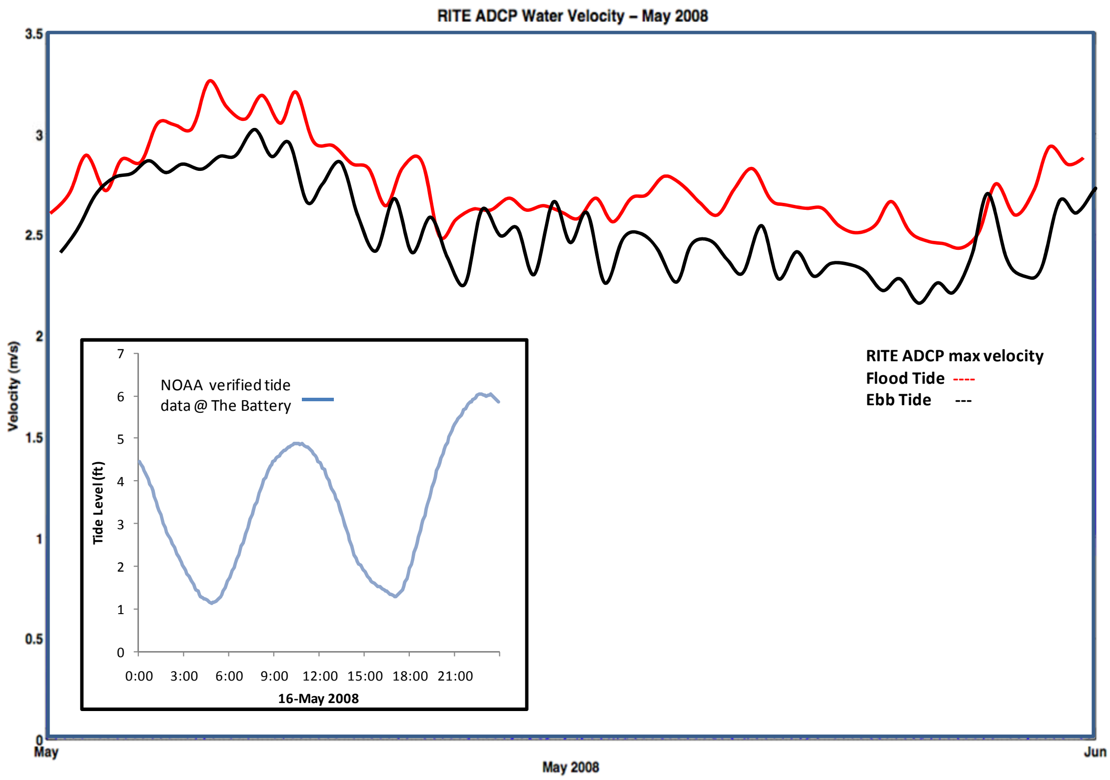
Water Quantity

Tides are formed as a result of the moon, sun and to some extent the rotation of the earth. As the moon orbits around the earth, its gravitational attraction upon the earth causes an increase in sea level in the area directly below and as a result, directly opposite. This results in an elliptical distribution of water with the major axis aligned to the moon will result in the maximum tidal depth (high tide) and the minor axis will result in the minimum tidal depth (low tide). The gravitational influence of the sun will also have a (lesser) effect but will reinforce and counteract the forces exerted by the moon, depending upon the celestial arrangement, to produce spring and neap tides. Importantly, the range of tidal elevation change can be altered significantly through geographical or coastline features such as estuaries.

Depending upon the geography, most locations on earth will experience a semidiurnal tide, which describes two high and two low tides each day. This includes the RITE location. Rising and falling tides will produce oscillating flows of water known as tidal streams. At the point of high or low tide, any tidal flow will be zero and this point is known as slack tide. At the RITE site a typical monthly tidal stage cycle as recorded by actual Acoustic Doppler Current Profiler (ADCP) instrumentation is represented by Figure 4.3.2.1-1.

Using NOAA Center for Operational, Oceanographic Products and Services (CO-OPS) data, the diurnal tidal elevation variations (Mean Higher High Water to Mean Lower Low Water) at the RITE site was taken to be 1.6 m (5.2 ft). The mean water level variations (Mean High Water to Mean Low Water) were estimated at 1.4 m (4.7 ft), and the maximum water level variation (Extreme High Water to Extreme Low Water) was estimated to be 2.1 m (7 ft).

Figure 4.3.2.1-1. RITE Project typical monthly tidal cycle, May 2008, showing maximum flow velocities. Inset illustrates tidal variation over a single day



Tidal Gages

NOAA has two active tidal gages (stations) near the project site, as noted on Figure 4.3.2.1-2. One station is at the southern tip of Manhattan in Battery Park, and the other to the north on Kings Point in Long Island Sound. The Battery NOAA station (8518750) has been in service since 1920. The Kings Point NOAA Station (8516945) has been in service since October 1998.

The mean tide range at the Battery is reported as 4.5 feet (NOAA), and represents the difference between mean high water and mean low water. The mean tide range for the station at Kings Point is reported as 7.2 feet within Long Island Sound (NOAA, 2003c). This information is only a generalization for the RITE Project, since the primary stations are located too far away from the actual RITE site to be meaningful.

Secondary stations are those which have operated for less than 18.6 years and oftentimes for less than a month. Their primary role is to provide data metrics in bays and estuaries where the primary station is not enough to determine local tidal effects. Secondary station data is not usually sufficient to precisely determine tidal currents but can be used through comparison to monthly measurements at a primary station to obtain satisfactory predictions.

Two secondary tidal current charts are used for tidal current prediction at the RITE site. These are located at the NOAA Hell Gate tidal current prediction station north of the site and at the Queensboro Bridge tidal prediction station. In addition, Verdant Power maintained a permanent velocity reference instrument (an ADCP) at the RITE demonstration site from December 2006 until they removed it in September 2009. These tidal gages are shown on Figure 4.3.2.1-2 in relation to the RITE project boundary.

Legend

- Verdant ADCP Location
- NOAA Primary Tidal Station
- NOAA Secondary Tidal Stations
- Proposed Project Boundary

Scale: AS SHOWN	VERDANT POWER, LLC NEW YORK, NEW YORK		CHECK PRINT
Project No: 1642-003	RITE PROJECT PILOT LICENSE APPLICATION		
Filename: 5.3.2.1.2-2.mxd	LOCATION OF TIDAL GAUGES		
Drawn By: LJC			
Date Drawn: 12-10-10	Kleinschmidt Energy & Water Resource Consultants	2 E. Main St. Strasburg, PA 17579 Telephone: (717) 687-7211 Fax: (717) 687-7266 www.KleinschmidtUSA.com	4.3.2.1-2

Data Sources: NOAA: Tides and Currents;

Water Velocity Prediction

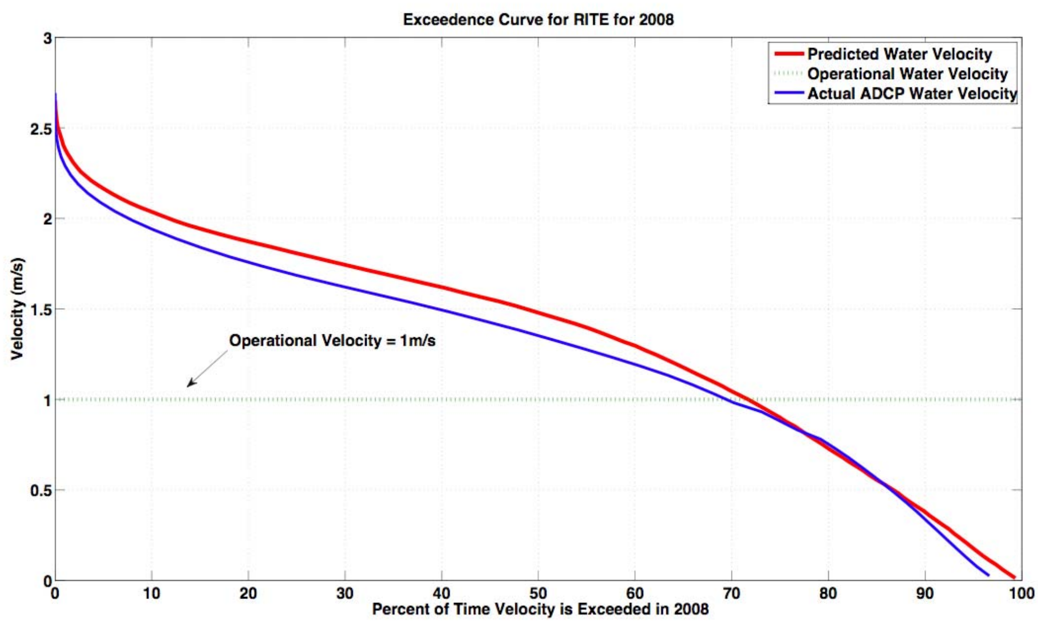
The complex interaction of the tides between the New York Harbor and Long Island Sound create tidal currents coincident with changes in the tidal stage. The tidal currents in the East River are semidiurnal, having two flood periods and two ebb periods per tidal day (24.84 hours). The reversing flood and ebb currents are of opposite direction, but with similar current velocity profiles. The tidal velocities are at a maximum when the tide stage is near the mean level, and are at a minimum when the tides are at high and low stages.

Tidal current data is available from NOAA (2003c) at two sites distant to the RITE project as described above. These predictions of tidal ranges were empirically transferred from the NOAA tidal station to the actual RITE project site, using harmonic constituent analysis. For several years, Verdant Power has maintained a stationary recording Acoustic Doppler Current Profiler (ADCP) instrument within the RITE field to record the instantaneous current velocity (in m/s). This instrumentation allows Verdant Power to accurately quantify and calibrate the currents and tidal current data, facilitates the transfer of actual tidal measurements and predictions at a distant site to the project site, and also is a necessary instrument for understanding operational data from the KHPS units.

In order to fully understand and predict the velocity patterns within the proposed RITE project field array, Verdant Power integrated mobile ADCP and stationary ADCP data. While the mobile data is a “snap shot” of velocity at the time of the field survey (both temporally and spatially), the stationary ADCP provides a continuous record of velocity but only at one location in the array. The stationary ADCP data set was analyzed to determine the harmonic constituents of the tidal prediction specifically for the RITE field array. Once the harmonic constituents of the tidal cycle at RITE are known, through empirical integration with the mobile data; it is possible to predict the water velocity at the RITE field for any date in the past or future with good accuracy.

Twenty-one harmonic constituents were used to predict the water velocity at RITE for the entire 2008 year, in 30 minutes intervals. This yearly tidal dataset was used to calculate the Tidal Velocity Exceedance Curve, which is presented as Figure 4.3.2.1-3. The maximum predicted tidal current velocity at the RITE site during this period is approximately 2.7 m/s, with the KHPS turn-on velocity of 1 m/s exceeded 72% of the time.

Figure 4.3.2.1-3. Tidal velocity exceedance curve - RITE East Channel Field (2008 data).



Hydrodynamics

Resource agencies have expressed concern about the installation of the proposed field of submerged tidal turbines potentially affecting flow patterns in the vicinity of the RITE Project and possibly beyond. In particular, two separate concerns were raised by resource agencies during consultation and study scoping meetings. One issue is related to near-field effect of the rotating blades on flow patterns in regards to increased turbulence or creation of small flow disturbances (eddies) which may affect aquatic life predator-prey relationships. The second issue of concern is in regards to a possible modification of flow through the East River (*i.e.*, if the turbines are removing kinetic energy from the system and if so, how that might affect transport flows).

4.3.2.2 Environmental Effects - Water Quantity/Hydrodynamics

Verdant Power conducted both numerical and in-water hydrodynamic evaluations over the last several years (2005 – Present) to better understand these issues. Verdant Power has used a combination of in-house computational tools, advanced external computational resources, and on-water surveys to understand and predict these complex hydrodynamic occurrences.

In brief, the discussions that follow are focused on three levels of hydrodynamic modeling and analysis: Micro-Scale; Meso-Scale; and Macro-Scale. In these three cases, the scale -an important factor to the accuracy and applicability of any model -is non-dimensional, related to the Diameter (D) of a kinetic hydropower rotor. For example, at the RITE Project, the rotor diameter is 5 meters; accordingly, the spatial applicability of results will vary from less than 0.1D (0.5 m) to 700D (3,500 m) and greater.

Micro-Scale Hydrodynamics: ~0.1D to ~2D (D is the Rotor Diameter)

This level of hydrodynamic modeling describes the hydrodynamics in and around an individual turbine, rotor, nacelle, pylon or mounting structure that may affect the structural performance of the machine or the energy extraction performance of the rotor. Commercial modeling software can be generally used for this type of analysis, as well as simplified in-house written codes for these complex problems. Simplifications can be made based on system symmetry, single blade approximations, and/or 2-dimensional (2-d) assumptions.

Verdant Power used ANSYS CFX to model the micro-scale hydrodynamics of a single Gen4 turbine with Gen 5 rotor at the RITE site. This work centered on structural integrity and blade hydrodynamics, but information about the near field wake was also obtained, both from the rotating blades and the stationary structures. This work focused on the proprietary design and technology development of the Verdant Power KHPS™ and is only discussed generally here.

Meso-Scale Hydrodynamics: ~2D to 200D

This level of hydrodynamic analysis includes the interactions (downstream, laterally, and vertically) between two or more turbines in an array. These interactions include kinetic energy extraction, structural requirements, and potentially fish behavior in and around an operating turbine. Specifically, these interactions relate to the recovery and interaction of the 3-dimensional (3-d) wake generated as a result of the turbine (rotating or stationary) in the water body and the vortex generation associated with blade rotation and energy extraction. To examine the effects at this scale, there are various approaches to field data collection and modeling that can be taken. These include commercially available software and in-house written code that either models the interaction in 2-d or solves the 3-d interactions directly.

In consultation with the resource agencies, Verdant Power developed and executed the East River Hydrodynamic Survey (Study Plans, 2006). This comprised a series of on-water data collection operations to measure the meso-scale hydrodynamics in the RITE array. These measurements were made before deployment of demonstration KHPS units November 15, 2005 and repeated during Deployment #2 with 4 KHPS units operational simultaneously, May 17, 2007, on both ebb and flood tides. The objective of this study was to determine how the turbines affect the flow patterns in the East River, both near-field and far-field, and to develop some information on the comparison of velocity and circulation patterns in the deployment area prior to and after installation of the turbines. The results of this work are described below.

Macro-Scale Hydrodynamics: ~200D to the Largest River/Estuary/Channel Dimension

This level of hydrodynamic analysis describes the effect of the placement of a field (assume 30 or more) of KHPS units in a natural water body and provides estimates of the far field effects related to energy extraction and also potential changes in natural water conditions with the operation of kinetic hydropower turbines. These models often are developed to examine macro-scale effects of large projects, such as dredging, contaminant dispersal, and sediment transport on large reaches of water bodies (>100 acres or >1 mile). Models in this category typically include 1-dimensional (1-d) and 2-d riverine models adapted to tidal conditions. More complex 3-d calibrated models are available, but these require significant investment of time in data collection and modeling expertise to produce relevant results.

As part of the East River Hydrodynamic Study discussed above, two hydrodynamic field surveys (pre-and post-Deployment #2) were conducted to collect flow velocity and direction (as a measure of turbulence) measurements in and around the operating KHPS units in the RITE Demonstration Project.

These surveys included two transects bounding the buildout site in the East Channel that were selected for replicate flow measurements. A level logger was deployed near each site to measure the changes in the water surface elevation throughout the study. Velocity data was collected and linked to a Trimble XRS GPS. After deployment of the study units, a second survey was performed on the same two bounding transects over a range of tidal flows that best represent the pre-deployment conditions. This data was collected in November 2005, the results of which were provided in a 60-day report (Verdant Power, 2007) and May 2007 (DTA, 2008), respectively, by Verdant Power's contractor and is discussed below.

To evaluate a larger pilot field area and evaluate potential changes associated with operation of a large number of tidal energy turbines, the study plan proposed the development of an empirical model to better understand possible effects on the total flow through the East River. Verdant Power developed and calibrated a 1-d model based on standard open channel flow equations and total energy flux to model the macro-scale hydrodynamics of the 30 turbine (1 MW) buildout proposed in this Pilot License Application.

Modeling, In-Field Methods, and Results

Micro-Scale Hydrodynamic Modeling

To investigate the micro-scale hydrodynamics in and around the turbine rotor, nacelle, and pylon, Verdant Power engaged a consultant to provide ANSYS CFX modeling of the Gen 5 KHPS turbine rotors. ANSYS CFX is a commercial software package designed to solve computational fluid dynamics problems. This package was chosen due to the ease of importing CAD drawings of the KHPS units into the solution domain. Further, the ANSYS CFX package offers a wide range of modeling tools, including advanced turbulence models and can provide 3-d, time-dependent solutions.

Figures 5.3.3.2-1 and 5.3.3.2-3 show the interactions between stationary and rotating turbines and the natural channel flow. Figure 4.3.2.2-1 shows the mean axial velocity around a stationary turbine in a flow with VW = 2.5 m/s. The bluff body wake downstream of the tail cone and the pile are apparent, with velocities below 1.25 m/s. It can be noted that the stationary turbine produces almost no flow acceleration, except for a small increase in velocity around the blade tips. This increased velocity is a localized phenomenon, well above the river bed. Some additional acceleration must occur around the turbine pile; however, the natural turbulent boundary layer just above the river bed reduces this impact significantly.

The pressure distribution on the stationary turbine, not shown, is directly related to the velocity distribution shown in Figure 4.3.2.2-1. The largest pressures on the stationary turbine occur at the nose cone, pylon leading edge, and blade faces. Low pressure regions behind these stationary objects lead to the wake regions which can be seen as areas of turbulent kinetic energy in Figure 4.3.2.2-2. The larger the pressure difference, the stronger the wake. As such, the largest pressure drop across the turbine can be seen behind the tail cone and with a smaller drop behind the turbine pile. Importantly, the lowest pressures predicted for the non-rotating turbines are well above the ambient vapor pressure, and therefore, cavitation is not a concern.

Figure 4.3.2.2-2 below shows the inherent 3-d nature of the turbulent wake and confirms the need for advanced computational resources to accurately model the turbulent mixing in and around a single KHPS unit. This figure shows the Turbulent Kinetic Energy, a common measure of the "strength" of the turbulence. It is clear that the most turbulent mixing occurs behind the stationary objects, in the wake region described above. It can be seen that the base of the faired pylon shows enhanced turbulent mixing, which is approximately 2 meters from the river bottom.

The micro-scale hydrodynamic modeling of a single, non-rotating KHPS unit confirms the bluff-body behavior. Regions of relatively high and low pressure are created across the pile, pylon, nacelle, and cones. These small differences in pressure lead to the wake regions seen, with reduced water velocity downstream, but do not lead to cavitation. Some local flow acceleration is seen, specifically at the blade tip and around the pile/pylon. Turbulent mixing is increased near the stationary blades and the base of the faired pylon, both f which are well above the river bottom. Additional mixing is seen around the pile; however, the naturally turbulent boundary layer along the river bed is expected to dampen any flow disturbances, significantly reducing any impact.

A rotating turbine unit is shown in Figure 4.3.2.2-3 below. This presents an instantaneous snapshot of the streamlines around a single rotating KHPS unit. Flow is from bottom-left to top-right, and the 3-d, twisting nature of the flow is clearly visible beyond the rotor. This behavior is as expected, given the tip vortex that is generated as a result of blade rotation. This tip vortex is shed continuously from the trailing edge tip of each blade and is helical in nature, which necessitates a 3-d solution. Furthermore, the decay rate of this vortex, as well as any vortex merging that may occur, is mainly a function of the turbulent properties of the flow and as such, any model must include 3-d, time-dependent turbulence modeling to accurately capture the near field wake behavior.

Figure 4.3.2.2-3 highlights some of complexity inherent in hydrodynamic modeling. The model requires a solution to be found at a discrete number of points provided by a mesh, the resolution of which will define the accuracy of the model. The solving of the equations of motion at each of these points is computationally very demanding, therefore it is common practice to apply a variable mesh to a problem, whereby areas of the most interest will have the closest mesh spacing and hence the highest accuracy and reliability; therefore, it was not practical to apply a close spaced mesh in the far field (>2D) behind the rotor and it is thus likely that this area is not modeled accurately. For example, it can be seen that the streamlines in Figure 4.3.2.2-3 appear to straighten immediately downstream of the first and only “twist,” which is likely inaccurate. As a result, meso-scale hydrodynamic analysis is essential to understand the vortex/wake behavior beyond a single KHPS unit.

Figure 4.3.2.2-1. ANSYS CFX Results – Velocity field (m/s) around non-rotating Gen 5 KHPS (Micro-Scale Hydrodynamics).

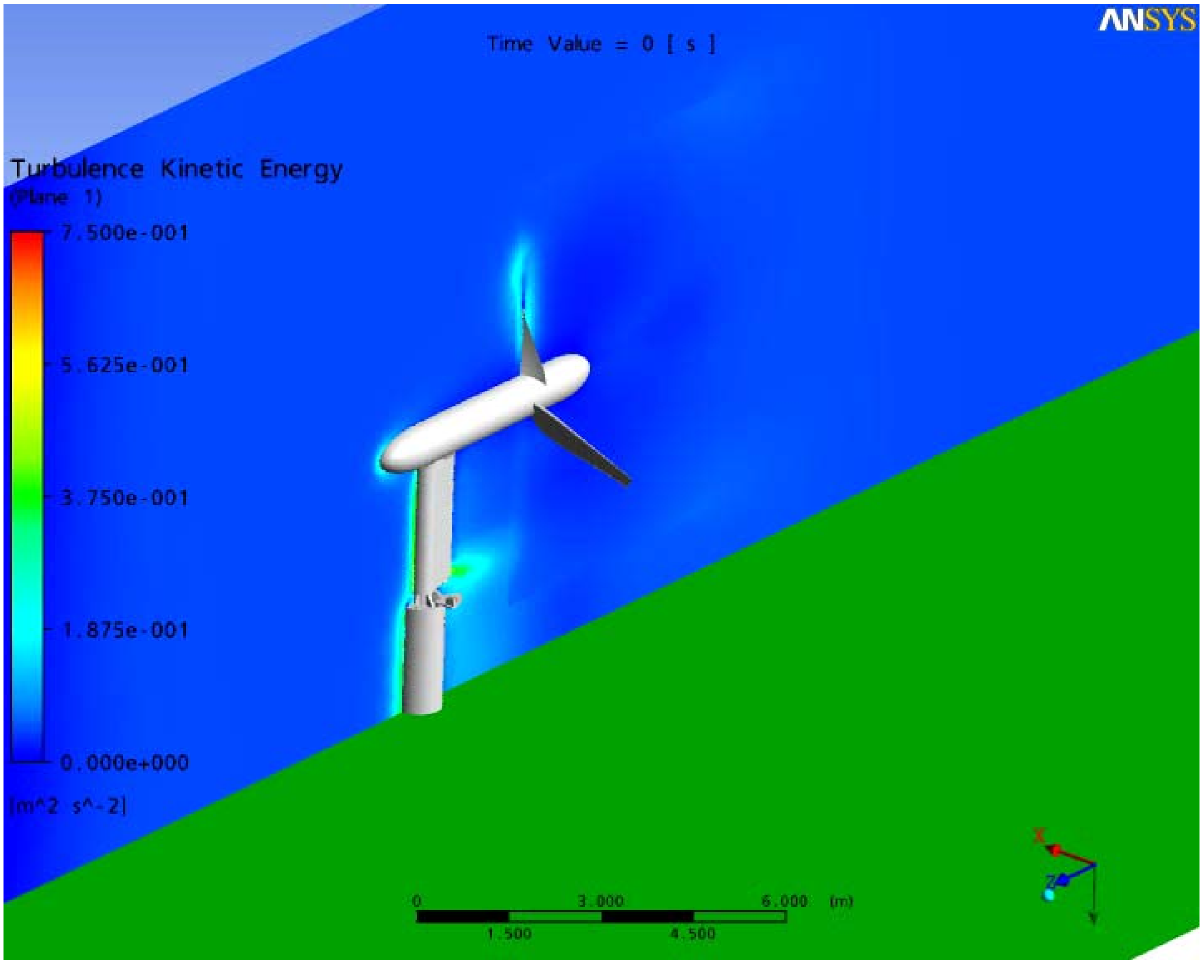


Figure 4.3.2.2-2. ANSYS CFX Results – Turbulent kinetic energy (m^2/s^2) around Non-Rotating Gen 5 KHPS (Micro-Scale Hydrodynamics).

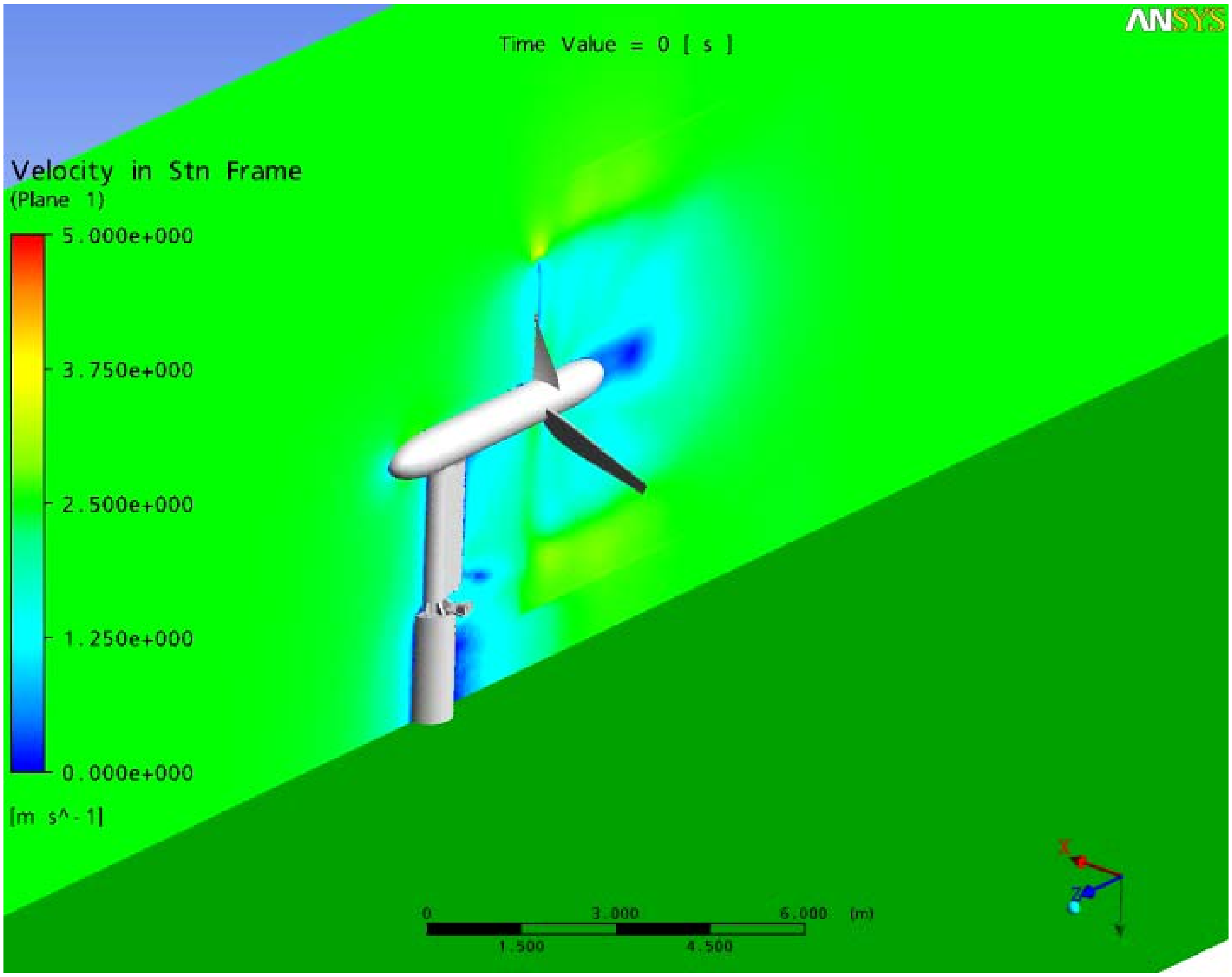
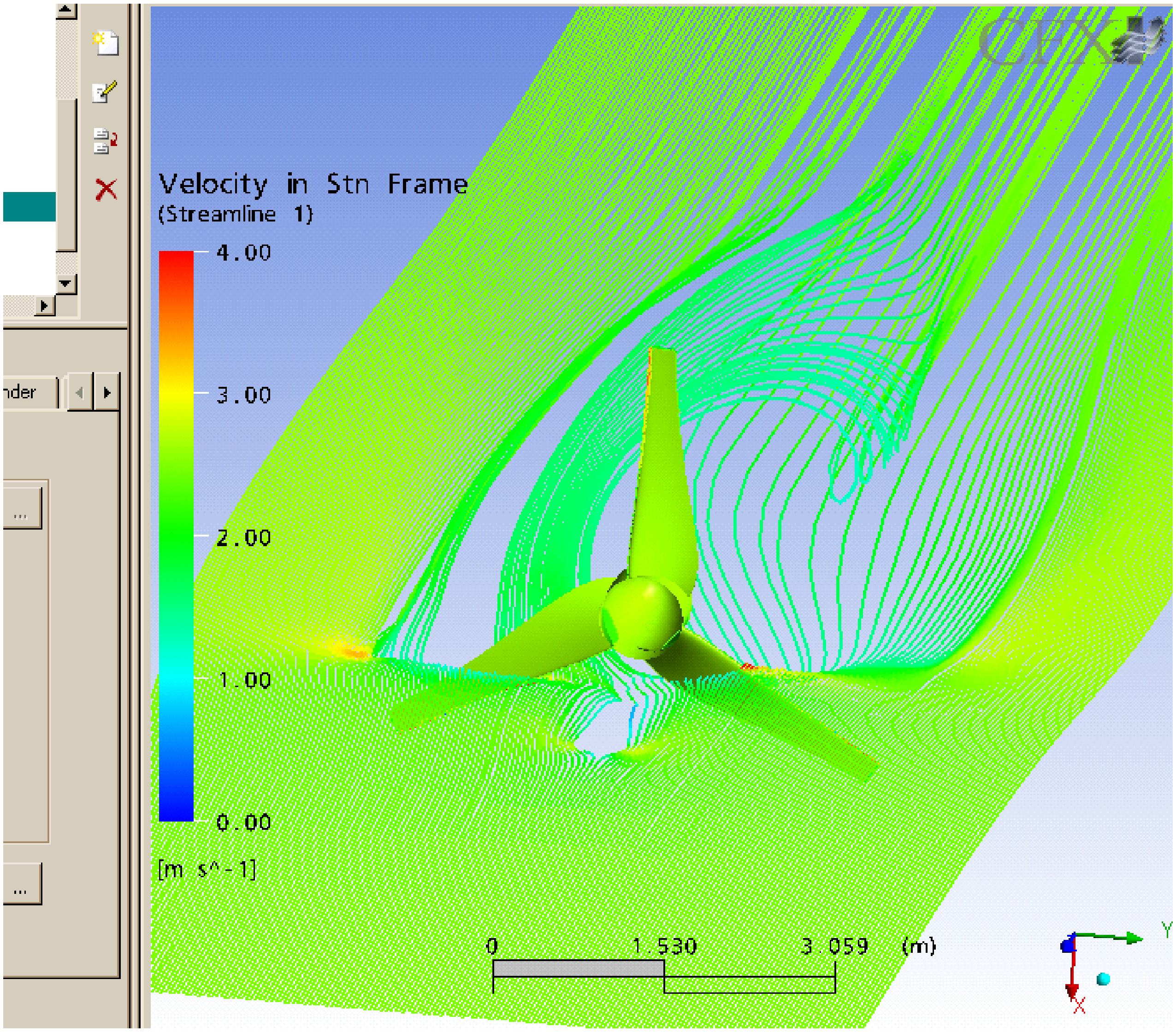


Figure 4.3.2.2-3. ANSYS CFX Results – Velocity streamlines (m/s) around rotating Gen 5 KHPS (Micro-Scale Hydrodynamics).



Meso-Scale Hydrodynamic Studies

In accordance with the NYSDEC and USACE permits, Verdant Power completed, through its contractor, the hydrodynamic survey outlined by the “East River Hydrodynamic Survey” Study Plan (revised October 25, 2006) in November 2005 and then again in May 2007. The following is a discussion of the general methodology, and a discussion of the pertinent results.

Methodology for Pre-and post Deployment Surveys (Verdant Power, 2007)

- **Navigation:** In order to collect data consistent with the transects depicted in the study plan, a laptop computer containing Hypack Navigation software and receiving DGPS signals was placed in the view of the boat skipper to aid in following the pre-planned transects. Hypack displayed a visual location of the boat relative to the individual transects and also showed the continuous coverage. A total of approximately 58 transects were performed. Figures 4.3.2.2-4 and 4.3.2.2-5 below provide definition of the pre-planned transects, flood and ebb respectively.
- **Measured Currents:** Optimum data collection times were selected from current data (in knots) using NobleTec’s Tides and Currents software for the East River. Several days were identified as ideal for the purposes of this study. Based on the statistical analysis, the East River currents exceed 1.5ms^{-1} more than 33.2 percent of the time. Ideal days, therefore, consist of a tidal range where the flood strength is greater than 1.5ms^{-1} and the ebb strength is greater than 1.5ms^{-1}. Data collection took approximately 3 hours per tidal period.
- **Equipment:** Velocity data was collected with a RDI 1200kh Rio Grande Acoustic Doppler Current Profiler (ADCP) and was displayed onboard with a laptop computer. The ADCP was attached to the port gunnel, mid-ship, using a specialized mounting clamp. The face of the transducer was placed

approximately 1 foot below the water surface. Data was recorded with WinRiver software from RDI which also interfaced with a Trimble Pro XRS GPS for sub-meter tracking.

- **Data Management and Analysis:** Initially, data was analyzed onboard with RDI's Win River software to ensure quality. Subsequent to data collection, utilities were used to further analyze, error check, and format the data for final post processing. The data was then imported into Tecplot, a 3-d visualization software. Each data point incorporated into Tecplot contained velocity magnitude for X, Y, and Z (Vertical), as well as coordinates in Easting and Northing. Tecplot employs an industry standard method of data interpolation to develop a complete velocity field for the study area. Each measured point is then placed onto a grid where the results show each point equally spaced. A 3-d bed profile was also developed using the bed elevations collected by the ADCP.

Figure 4.3.2.2-4. Hydrodynamic survey transect definitions – Flood tide (Verdant and DTA, 2006).

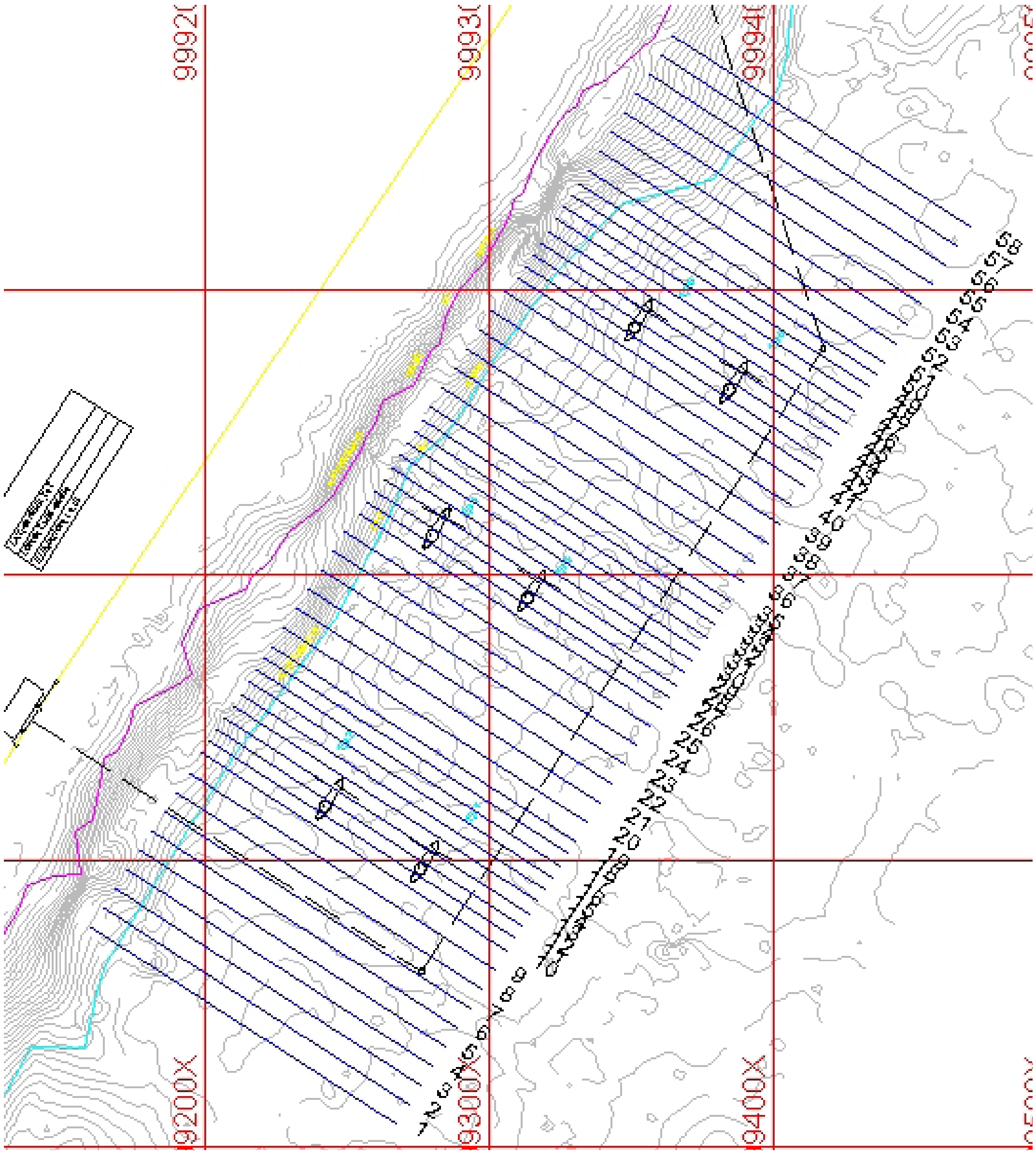
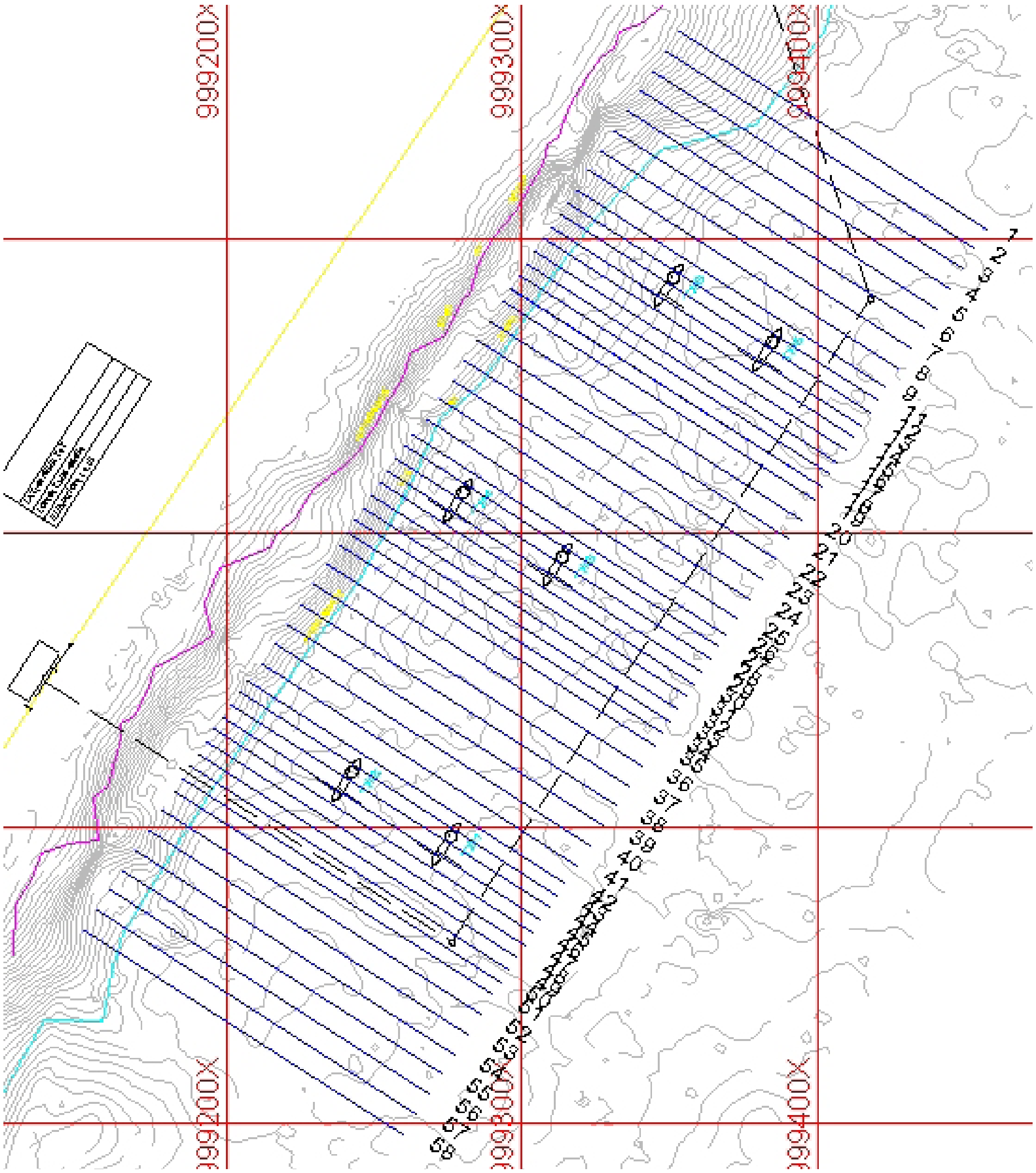


Figure 4.3.2.2-5. Hydrodynamic survey transect definitions – Ebb tides (Verdant and DTA, 2006)



Results and Discussion for Pre-Deploy Survey (2005)

The pre-deployment hydrodynamic survey was conducted between November 14 and 16, 2005 in the RITE demonstration area adjacent to Roosevelt Island in the East River. While an attempt was made to equally cover all predetermined transects, the ebb survey was shortened slightly due to time constraints. As a result, there is little data beyond the locations of Turbines 1 and 2; therefore, the total area of coverage is not quite equal for the ebb and flood data sets.

For visual clarity, slices of information have been extracted from the velocity field in 5-foot increments from MLLW to the channel bed. All results are shown in a New York State Plane-Feet coordinate system. Velocity magnitudes described by the legend are in ft/sec. Vectors displayed on each slice describe the direction (angle) and the magnitude (length) of the water velocity at that point.

For reference, the top of the rotor blades are 5 feet below MLLW, the rotor centerline is approximately 13 feet below MLLW, and the bottom of the rotor is 21 feet below MLLW. Pre-deploy survey data was not extracted at 13 feet below MLLW, so results from the 10 foot below MLLW slice are presented in Figures 4.3.2.2-6 and 4.3.2.2-7 below, flood and ebb tides, respectively. It is felt that this 3ft vertical discrepancy in the pre-survey data plot is negligible and still provides a good indication of the current profile at the hub height, and was evidenced by a visual comparison of data.

These two figures illustrate the tidal nature of the East River, as well as confirm the quality of the channel as a resource for tidal energy production. The flow in both the ebb and flood tide is very unidirectional, with the natural slowing of the channel velocity near the west shore. At the 10 foot depth shown, velocities near the channel center are in the region of 2.5ms^{-1} on a flood and 2.1ms^{-1} on an ebb tide. This data matches energy generation results quite well, with higher peak power on a flood tide compared with an ebb tide. Further confirmations are also seen, for example in Figure 4.3.2.2-6, which reveals that the fastest velocities are clearly in the NE corner of the survey while energy generation during the RITE 6-pack buildout confirmed that the turbine in the NE position outperformed other turbines. The presence of the Roosevelt Island west caisson is clearly visible in the figures below and as a result shows reduced velocities in the SW corner of the survey on both ebb and flood tides.

Figure 4.3.2.2-6. Pre-deploy survey results – Flood Flow (Meso-Scale Hydro) (Verdant, 2007)

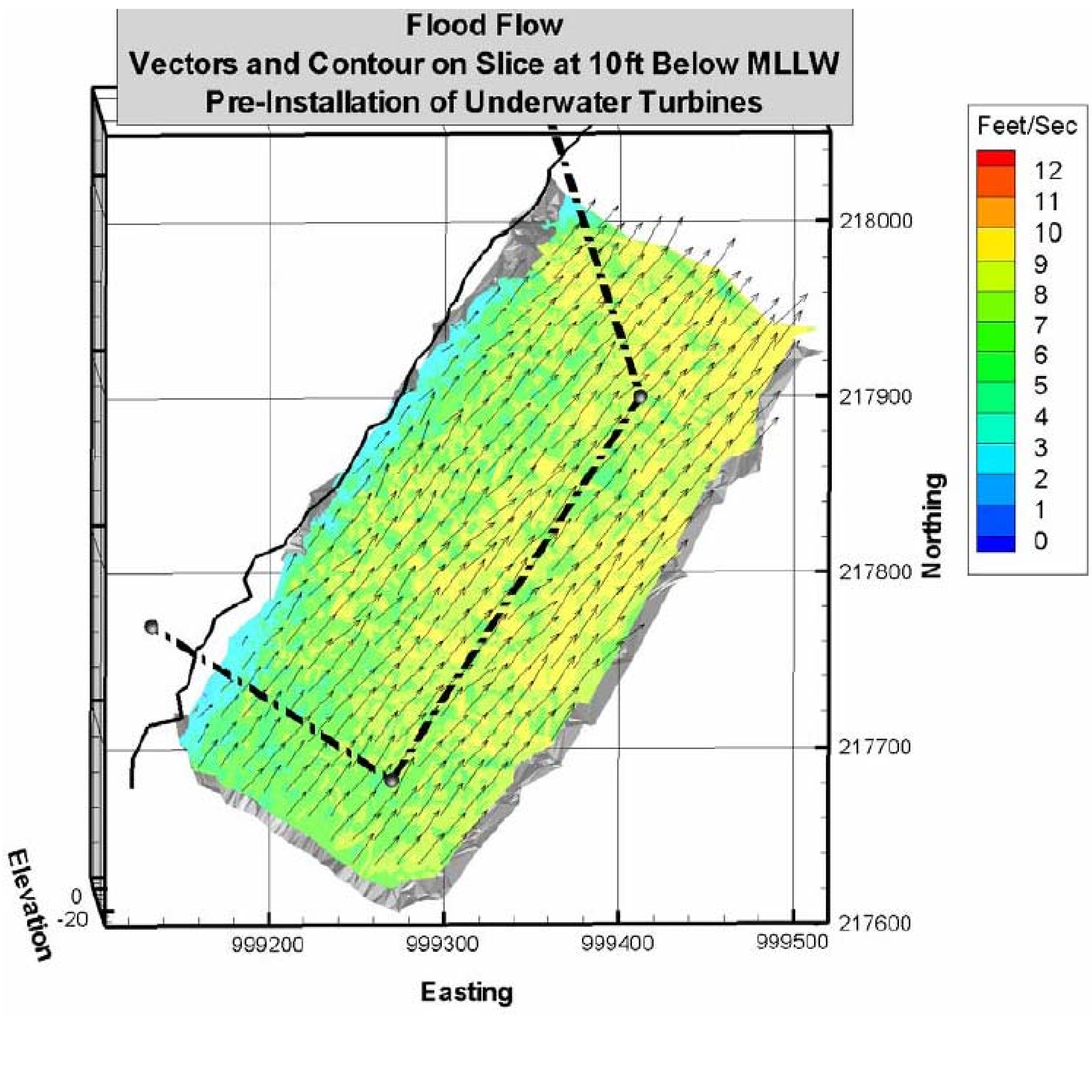
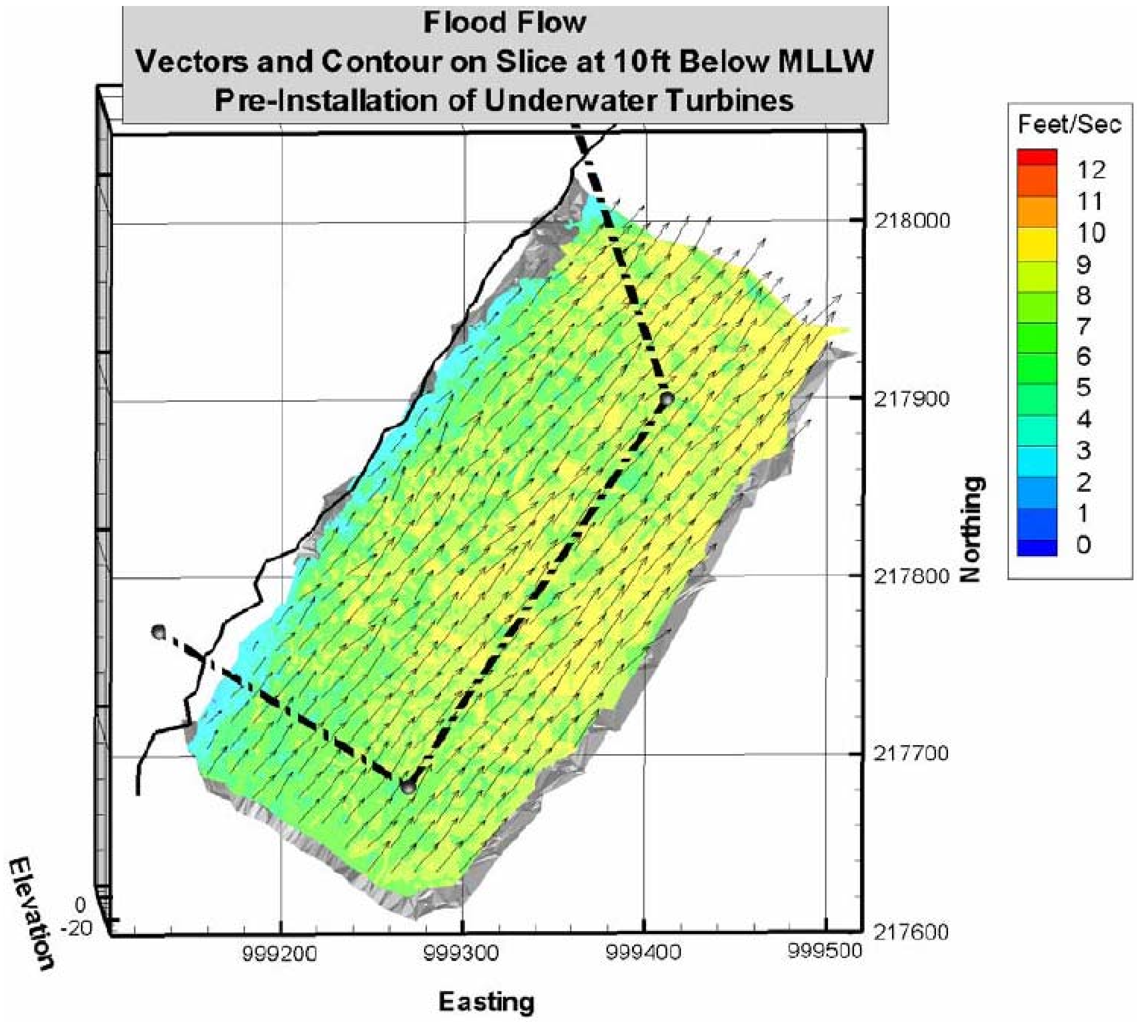


Figure 4.3.2.2-7. Pre-deploy survey results – Ebb tide (Meso-Scale Hydro) (Verdant, 2007)



Provisional Results and Discussion for Post-Deployment Survey (May 2007)

As planned in the East River Hydrodynamic Survey Plan, a post-Deployment #2 survey was executed by Verdant Power's contractor and documented in provisional results of June 2007 (DTA, 2008). At the time of this survey, May 17, 2007, both Turbines 1 and 2 had failed. However, Turbines 3, 4, 5, and 6 were still rotating and generating. This behavior is clearly visible in both Figures 4.3.2.2-8 and 5.3.3.2-9 below. Figure 4.3.2.2-8 below shows the Tecplot interpolation of ADCP data collected during the post-deployment survey on a flood tide, while Figure 4.3.2.2-9 shows similar data on an ebb tide, both along the rotor centerline, 13 feet below MLLW. Both the reduction in flow velocity and change in flow direction downstream of an operating KHPS unit are apparent. Velocity magnitudes approach zero immediately behind the rotating rotors, evidence of the significant wake behind a generating turbine.

The velocity direction is clearly modified, with velocities up to 90° out of phase with the natural channel velocity. The 3-d nature of the helical vortex wake requires some portion of the flow to be traveling at 180° to the natural channel. However, given the limited resolution, sampling biases, and necessary interpolation to generate Figures 4.3.2.2-8 and 5.3.2.2-9, this behavior is not visible. Within the obvious wake regions seen, it is certain that parts of the flow are traveling against the natural flow direction.

Further, each turbine wake clearly propagates downstream and potentially interacts with the subsequent turbine. Not only does this introduce structural concerns, but energy extraction may be compromised downstream. This behavior is clearly evident in both flood and ebb tides, with some asymmetry between wake strength from turbines placed further from the river bank as opposed to those nearer. As expected, this wake propagation was not captured in the micro-scale modeling above and confirms the need for further analysis based on the corresponding flow scales of interest.

The on-water surveys presented above provide an excellent visualization of the impact of operating and non-operating KHPS units on the meso-scale hydrodynamics. From the results above, it is apparent that ample wake recovery distance between turbines is essential and both vertical and lateral spacing of turbine rotors may improve individual performance.

Figure 4.3.2.2-8. Post-deploy survey results – Flood tide (Meso-Scale Hydro) (DTA, 2008)

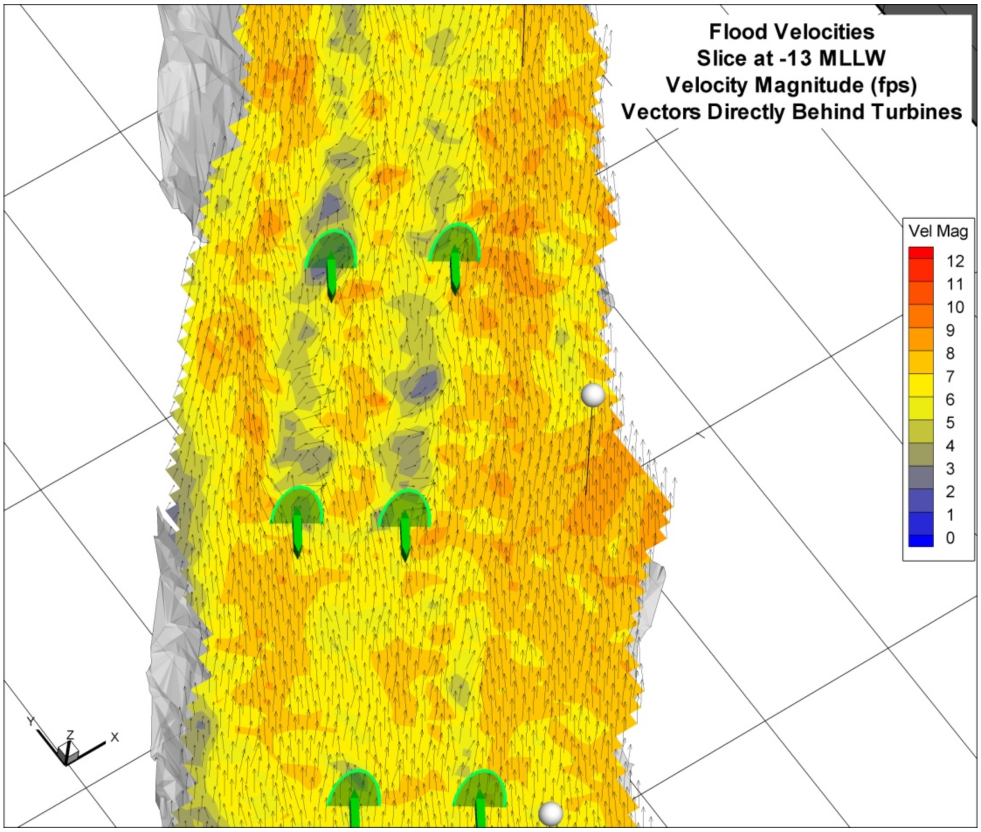
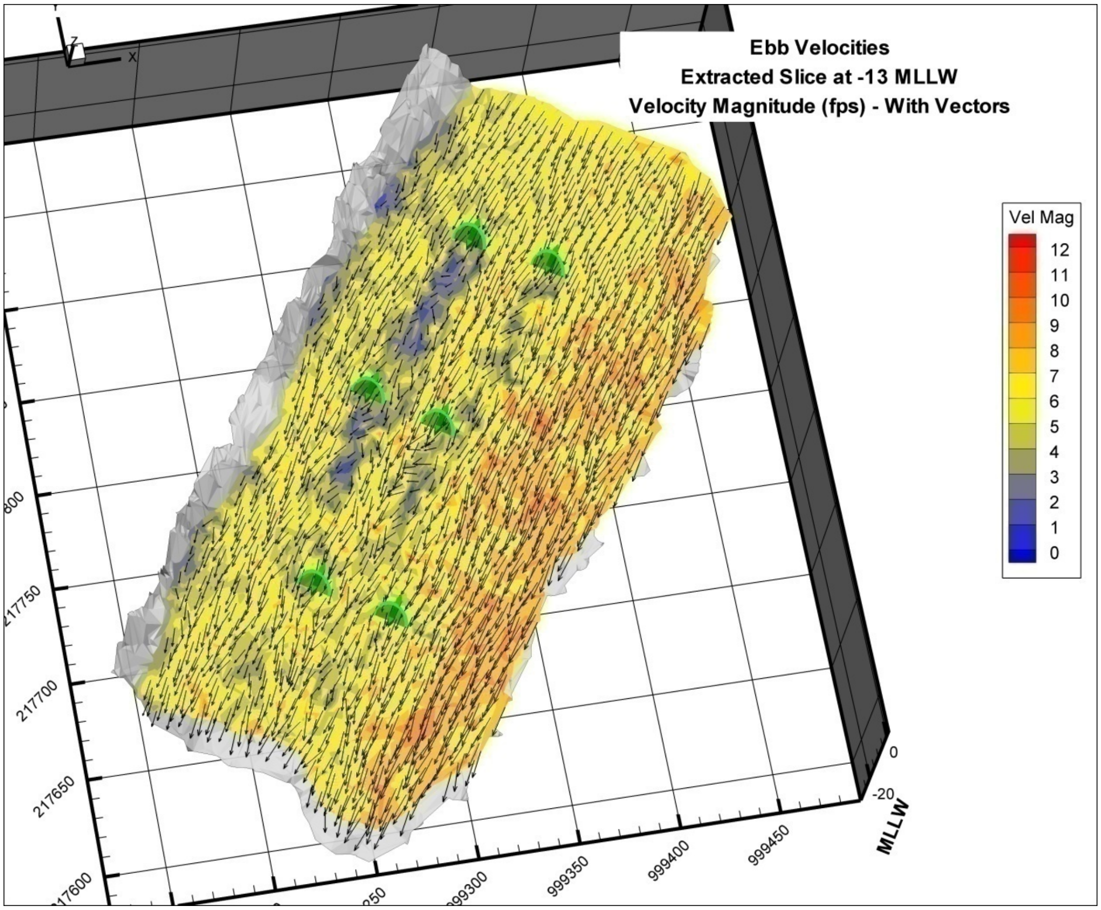


Figure 4.3.2.2-9. Post-deploy survey results – Ebb tide (Meso-Scale Hydro) (DTA, 2008)



Due to the experimental limitations addressed above, these survey results do not provide calibration or validation data for subsequent modeling of the complex, 3-d, and time-dependent meso-scale hydrodynamic phenomena.

Macro-Scale Hydrodynamic Modeling

Given the in-water field results discussed above, to model the influence of the RITE Pilot Project East Channel buildout of 30 KHPS units (1 MW), a 1-d hydrodynamic model was developed internally by Verdant Power based on the work of Ian Bryden *et al.* (4) (5) (6) (2004). Before presenting the results of this model, a brief outline of the methodology is discussed.

The 1-d model used to examine the influence of kinetic energy extraction on the macro-scale hydrodynamics is based on a simple channel linking oceans (or water bodies) of infinite size, shown schematically in Figure 4.3.2.2-10 below.

Figure 4.3.2.2-10. Reprint of Figure 4 from Bryden and Couch.

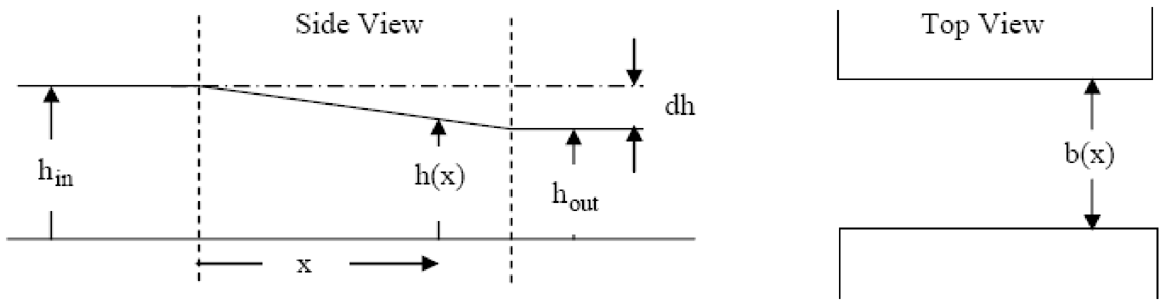


Fig. 4. Schematic diagram of a hypothetical channel linking two oceans.

In this schematic, the variation in channel width is assumed to be a function of the downstream location (x) only. The driving force for this flow is the head difference, dh = $h_{out} – h_{in}$, seen above, where the elevation of both oceans is assumed known. The governing hydraulic equations can be solved for the water elevation, h(x), and velocity, V_W, along the length of the channel given the inlet height, h_{in}, and outlet height, h_{out}, are known.

The following open channel flow equation was used, along with additional equations given in (4) (5) and (6):

<u>Equation 1</u>. General Hydraulic Equation for Open Channel Flow

$Q^2 \partial h$ 1

$[1-_{32}] = -P_W \tau_{eff} h\ b\ g\ \partial x\ \rho gbh$ (eqn 1) b = channel width h = water depth Q = volumetric flow rate g = acceleration due to gravity ρ = fluid density P_W = wetted perimeter = 2h + b τ_{eff} = effective shear stress (eqn 2 below)

Equation 2. Definition of Effective Shear Stress

$$\tau_{eff} = \tau_O + \tau_{ext}(f) \quad \text{(eqn 2)}$$

τ_{eff} = effective shear stress τ_o = natural shear stress $\tau_{ext}(f)$ = extraction stress

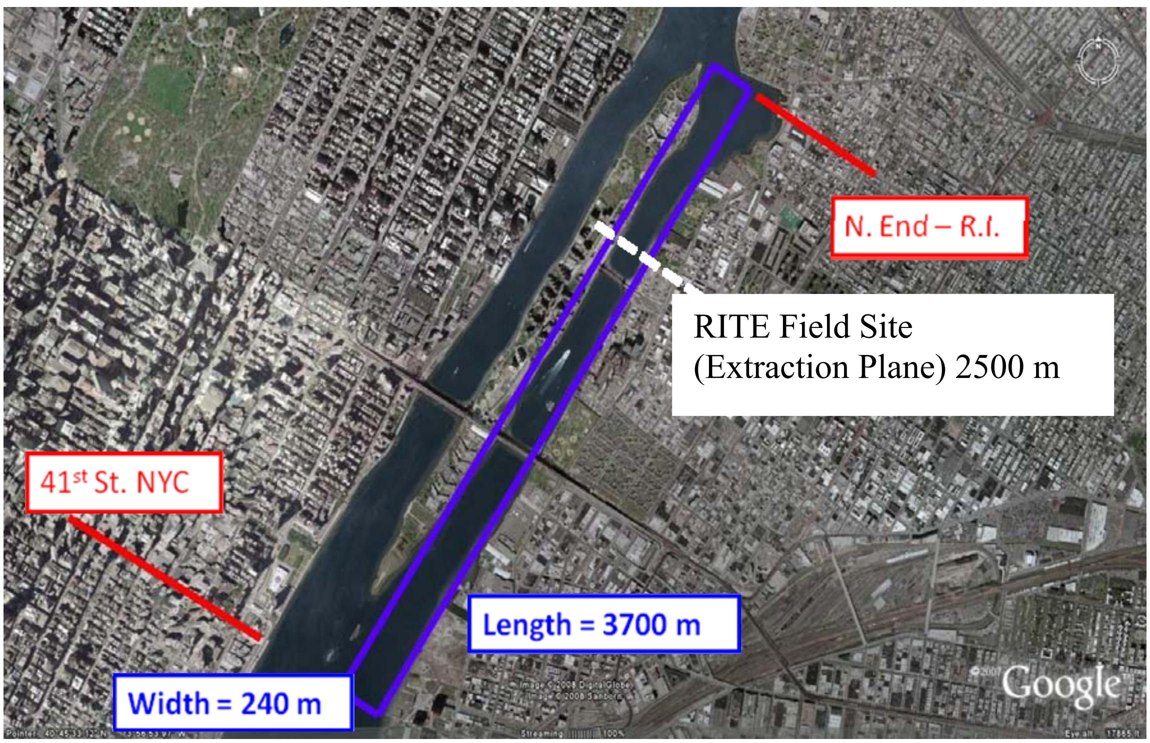
The effective shear stress (τ_{eff}) represents frictional losses, and the extraction term (τ_{ext}) can be represented by f, the fraction of energy extracted, seen in Eq. 2 above. When f = 0, the effective shear stress is equal to the natural shear stress and the channel is considered undisturbed. The extraction of energy, *i.e.* increasing f, is modeled as an increase in effective shear stress at the extraction plane along the channel.

Given these definitions for the governing equations and the model for energy extraction, an iterative solution can be found for Q, the volumetric flow rate through the channel, if h_{in} and h_{out} are known. Once Q is known, the water elevation and velocity profiles at each location along the channel can be determined. Initially, undisturbed channel profiles were determined with f = 0, followed by disturbed channel profiles with f > 0. Since these solutions are iterative, the influence of energy extraction at a single plane, or multiple planes, is felt throughout the model domain – true in a river or tidal application as well.

Simulations were run using MATLAB 7.6.0 R2010b and solved these equations for the specific application at the RITE Project. For the specific application of this model, a number of parameters and assumptions must be defined, as seen below. Following the discussion of model parameters, results for 30 turbines, each delivering 35 kW of usable energy, for a 1 MW buildout, are presented with discussion.

To accurately model the full field effects, known water level differences at the north and south end of the island were required. In addition, water velocity measurements at the turbine location were essential to calibrate the model to ensure an accurate solution. To determine the water level difference between the north and south ends of Roosevelt Island, the University of South Carolina tide predictor, T-Bone was used[6]. The "*East 41st Street, New York City, East River, New York, New York*" and the "*Roosevelt Island, north end, East River, New York, New York*" were used for the south and north, respectively. These can be seen in Figure 4.3.2.2-11, highlighting the modeling extent used in this work and the RITE Field Site.

Figure 4.3.2.2-11. Modeling extent for the East Channel of the East River, NY, NY.



Given the known elevation above the mean lower low-water (MLLW) datum at every high and low tide at each station, the intermediate water levels could be found by interpolation. The elevation at the northern end was then subtracted from the elevation at the southern end to compute the elevation difference across the modeling extent for any given Flood (dh >0) or Ebb (dh<0).

[6] http://tbone.biol.sc.edu/tide/index.html

Over the period of a week in March 2008, the maximum "instantaneous" elevation difference on a flood tide between the south and north end of Roosevelt Island was determined to be equal to 0.224 meters (22.4 cm). Further, based on NOAA Survey-H11353, a water elevation of 15.24 meters was determined to be the datum for MLLW at 41st Street, NYC. At the time of the maximum difference, (flood tide; March 21, 2008 19:00 EST) the measured water velocity from the ADCP at the turbine site was recorded as, $V_W = 2.1$ m/s. This information provided the baseline data necessary to create and calibrate the model. A flood tide was chosen based on Verdant Power's experience with systematically elevated velocity values on the flood tide.

The model results are shown on Table 4.3.2.2-1 below and graphically on Figure 4.3.2.2-12 at a greatly expanded scale to show detail. Without this zoom in, the differences in elevation and velocity are difficult to discern.

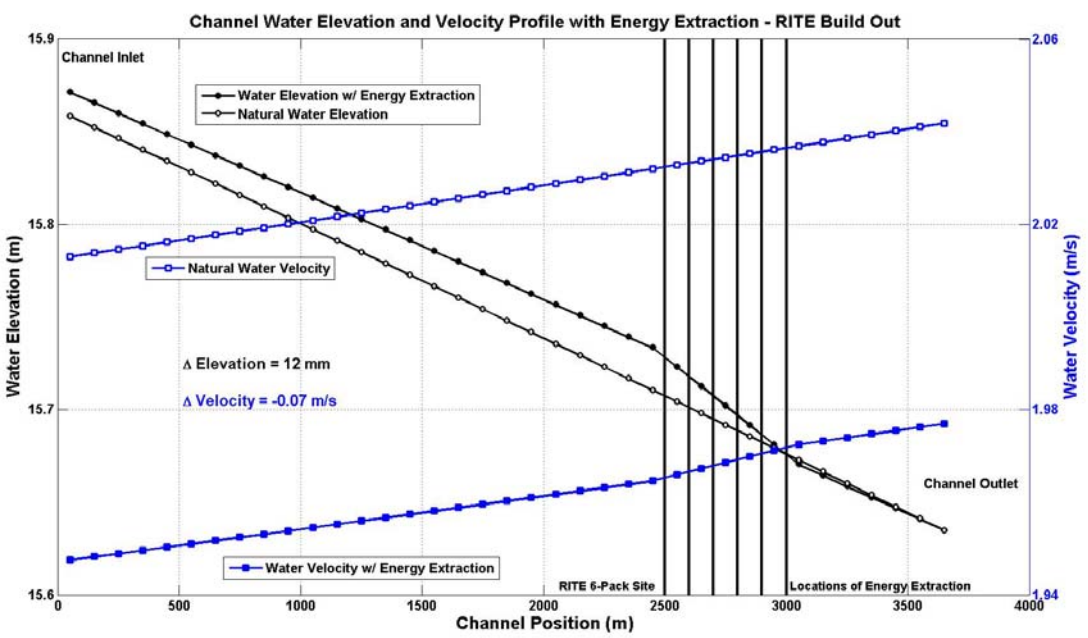
Table 4.3.2.2-1. East Channel conditions with 1-D model results: Natural Channel and extraction.

Parameter (values assessed on Flood Tide - flow moving south to north)	Actual/Measured (March 2008 at North and South End of RI	1-D Model – No Extraction - Natural Channel	1-D Model – with Extraction = to 30 KHPS RITE Pilot Project
South Inlet Elevation (m)	15.859	15.859	15.871
Extraction plane Site of RITE Field	No Extraction	No Extraction	30 KHPS units at 12D
North Outlet Elevation (m)	15.635	15.635	15.635
Site Elevation (m)	0.224	0.224	0.236
Δ Elevation (m)			0.012 m (Increase)
Inlet Velocity (m/s)	Not Known	2.013	1.948
Site Velocity (m/s)	2.10	2.04	1.97
Δ Site velocity m/s			-0.07 m/s (Decrease)
Flow Rate (m^3/s)	Not Known	7,662	7,419

As seen in the table above and Figure 4.3.2.2-12, the first energy extraction plane was 2,500 meters beyond the southern end of the model extent, just north of the Roosevelt Island bridge, *i.e*. the current location of the RITE 6-pack demonstration project. To simulate the extraction of 1 MW (equivalent to 30, 35 kW turbines) six energy extraction planes were used to simulate the presence of 30 turbines, three per row, at 12D spacing. With a 5m rotor, the total length of the array would be 600m. Since the model resolution along the channel was 100m for all work presented, six extraction planes most closely captured the real geometry, and therefore influence, of the buildout.

Given the elevation difference and MLLW datum above, a Manning Coefficient of 0.022 was chosen to describe the roughness of the channel, and therefore calibrate the model. This value was comparable to a clean earth channel discussed in (7) and produced a natural channel velocity at the extraction plane of $V_W = 2.04$ m/s with a net water level change of 0.217 meters (21.7 cm). Both of these values match the real data presented above quite well, and are shown in text along with the results below.

Figure 4.3.2.2-12. 1-d model results for RITE 1 MW buildout - Natural Channel properties



Disturbed Channel Properties for Comparison – Detailed Image

From Figure 4.3.2.2-12 above, the fraction of kinetic energy flux removed from the disturbed channel across the six extraction planes is 2.3% , which corresponds to 2 MW removed from the river and 1 MW usable to the grid, assuming a rotor efficiency equal to 50%. Given the impact of extraction on the channel velocity, the natural channel energy flux is reduced by only 2%, which is well below the suggested maximum of 10% from Bryden *et al.* (2004). With each turbine rated at a nominal 35 kW peak, this model corresponds to the simultaneous operation of 30 turbines. Based on this 1-d model, the river experiences an increase in water level of only 0.012 m at the channel inlet, and a reduction in mean water velocity at the first extraction plane of approximately 0.07 m/s. The effect of this on the overall river is highlighted in Table 4.3.2.2-1.

These calibrated, predicted changes in the East Channel properties of the order mentioned above are not within measurement capabilities of water instruments. The inlet water level changes by less than 0.08% while the inlet water velocity changes by approximately 3%. From this, it is clear that the extraction of 1 MW of usable power changes the East Channel of the East River in a subtle but insignificant manner.

In response to the FERC request for additional explanation, a 7% reduction in the flow speed would be close to the limits of effective measurement because of the difficulty in **predicting** tidal velocities to within 7%, as well as the **difficulty** in measuring tidal velocities within 7%.

To confirm a 7% reduction with energy extraction, a baseline flow condition must be measured or predicted and compared against the similar flow condition within turbines operating. Due to the nature of turbulent tidal flows, it is very difficult to predict or measure two equivalent flow conditions. A more detailed justification of why a 7% variation in tidal velocity is close to the limits of effective measurement is provided below:

1) Difficulty in **prediction** of tide height or tidal velocity to act as a baseline for comparison with measured values. From the NOAA Tides and Currents Frequently Asked Questions website: http://tidesandcurrents.noaa.gov/faq2.html#50:

   The accuracy of the tide predictions is different for each location. Periodically, we do a comparison of the predicted tides versus the observed tides for a calendar year. The information generated is compiled in a Tide Prediction Accuracy Table. We work to insure that the predictions are as accurate as possible. However, we can only predict the astronomical tides; we cannot predict the effect that wind, rain, freshwater runoff, and other short-term meteorological events will have on the tides.

   In general, predictions for stations along the outer coast are more accurate than those for stations farther inland; such as, along a river, or in a bay or other estuary. Inland stations tend to have a strong nontidal influence; that is, they are more susceptible to the effects of wind and other meteorological effects than stations along the outer coast. An example of an inland station that is difficult to predict is Baltimore, Maryland. This station is located along the length of the bay having been known to cause water levels to be 1-2 feet above or below the predicted tides.

   Stations in relatively shallow water, or with a small tidal range, are also highly susceptible to meteorological effects, and thus, difficult to accurately predict. At these stations, short-term weather events can completely mask the astronomical tides. Many of the stations along the western Gulf of Mexico fall into this category. An example is Galveston, Texas. This station is in a bay that is relatively shallow and has a small opening to the sea. At this station it is possible for meteorological events to delay or accelerate the arrival of the predicted tides by an hour or more.

2) Difficulty in measuring the tidal velocity for comparison with predicted values:

   a. While most tidal predictions provide a single number for tidal current, it is not practical to measure a single value for current. Instead, a vertical profile of tidal current is measured. This vertical profile is known to vary during a tidal cycle as the tidal boundary layer develops (VP Paper). This boundary layer development is highly site-specific, influenced from rock and boulder placement at the micro-scale up to bends in the river at the macro-scale. Further, the influence of the channel walls, including their proximity and slope, modifies the tidal velocity profile vertically and horizontally.

b. Turbulence inherent to the flow, which itself is inherently random, prevents a precise measurement of tidal velocity. At the RITE site, water velocity measurements suggest turbulent fluctuations in the water velocity up to 20% of the mean value. At a peak tide of 2.5 m/s, this implies a possible variation in velocity of ±0.5 m/s, and as such, the possibility of measuring between 2.0 m/s and 3 m/s at any given moment.

c. Measurement equipment itself introduces errors and uncertainty in the process of measurement. For an ADCP specifically, the instrument used at RITE to measure water velocity produces a measurement that is highly sensitive to instrument settings. For example, standard measurement uncertainties in a Teledyne RDI ADCP can be as high as .2 m/s, roughly 10% of the flow speed at 1.0 m/s.

Practical limits on the total energy flux that can be removed from a riverine or tidal water body have not been determined experimentally. All prior references for such a limit are based on a scientific rule of thumb. Estimates of such a limit have been given in a number of scientific reports and reference materials. The Electric Power Research Institute (EPRI) has conducted a number of feasibility studies across North America. The citation for this extraction limit was provided in the report: EPRI North American Tidal

In Stream Power Feasibility Demonstration Project; EPRI – TP – 001 NA Rev 3 by George Hagerman, Brian Polagye, Roger Bedard and Mirko Previsic; September 29, 2006. pg 32-33, quoting from this report ***[emphasis added]:***

> In contrast to atmospheric flows, tidal stream flows are constrained between the seabed and sea surface, in depths that are usually less than 100 m. Tidal stream energy is therefore more spatially constrained, and withdrawal of excessive amounts could reduce natural circulation to the point that significant environmental effects occur. Based on the limited modeling done to date, a blanket average kinetic energy extraction of 15% was been selected as the level of extraction which will not result in significant alteration to the estuary circulation.
>
> Only a few studies have been published that address this subject. In a review of tidal stream resource assessments for the Carbon Trust, Black & Veatch Consulting, Ltd., has adopted a 20% "Significant Impact Factor" as the percentage of the total available resource that can be extracted without significant environmental effect (Reference 11). ***The justification for this selection is not given.***
>
> Early numerical modeling by Ian Bryden and his colleagues led them to suggest 10% as a "rule of thumb" conservative estimate of the extractable resource in a simple channel (Reference 12). This was based on the application of open-channel flow theory to simulate a tidal channel connecting two unconstrained bodies of water (as between two islands, for example). The tidal loch filling or emptying decreases when the channel is blocked by a row of turbines. In this particular case, the authors suggest that up to 30% of the natural flux may be extractable. ***In reviewing these results, EPRI has used 15% as the environmental extraction limit.***

Conclusions

Based on the studies discussed above, Verdant Power believes the following:

Micro-Scale Hydrodynamics

Non-Rotating units create small wake regions, especially behind the pylon, pile, blades, and tail cone. Very little flow acceleration is visible and what can be seen is generally well above the river bottom. Pressure differences across the stationary and rotating structures do lead to wake regions, however pressures below the vapor pressure are not seen and cavitation is not a concern.

The turbulent wake, both bluff-body and tip-vortex, led to increased mixing and flow disturbance. However, these regions of increased mixing/scouring/sediment transport are expected to be generally well above the river bottom. The impact of the pile wake, which is near the river bottom, is reduced by the natural presence of a strong turbulent boundary layer.

Computational limitations due to blade/rotor resolution requirements prevent the accurate modeling of the far-field (meso-scale) wake behavior.

Meso-Scale Hydrodynamics

The in-water data was confirmation of the influence of KHPS units on a meso-scale and is reflected in the quality of energy production during the timeframe and largely informs Verdant Power of the correct lateral and longitudinal spacing of KHPS units.

Velocity magnitudes are greatly reduced directly downstream of a generating unit, while velocity directions are shown up to 90° out of phase with the natural channel direction. These 3-d, rotating, vortex structures convect downstream, centered on the shaft centerline. Their general influence is maintained in a slowly expanding cone downstream from the rotor, and is thought unlikely to affect the river bottom.

With regard to localized effects, the presence of the pylon and the areas of lower velocity (reductions up to 50%) behind the stationary KHPS unit pylon during ebb and flood flows do present a potential area of protection and/or habitation. However, as discussed in the Aquatic Resources sections, the fish abundance and population observations generally tend to indicate that fish (both large and small) are not present in the high current zones of the KHPS. Nor are they present in general, during the ebb and flood cycles, and so the decrease in localized velocities would not be likely to effect the predator-prey relationship within the field.

Macro-Scale Hydrodynamics

A 1-d model for the extraction of kinetic energy, as an additional source of frictional losses, from an open channel can accurately predict the depth and velocity in the East Channel of the East River. The influence of energy extraction is to slightly increase (12 mm) the overall water depth from the inlet of the channel to the extraction planes. As a result, the water velocity is decreased slightly (-0.07 m/s) throughout the channel.

These modifications to the channel properties are minimal and below the precision available for most measurement devices. As such, the generation of 1 MW from the East Channel of the East River is unlikely to modify the natural channel properties in any way. As part of the operational monitoring, Verdant Power will also continue to install and record water velocity and level data with the use of Acoustic Doppler Current Devices (ADCPs) that will inform the hydrodynamics of the machines and array, as the staged installation progresses. This data, coupled with the RMEE Plans, will continue to build and support the body of science of hydrodynamic effects of operating KHPS units in different configurations.

4.3.2.3 Affected Environment - Water Quality

According to the NYSDEC comments on the draft Pilot License Application, the reaches of the East River from the Battery to Hell's Gate are classified as Class I.

Table 4.3.2.3-1. Lists the New York State Water Quality Standards for Class I.

PARAMETER	NARRATIVE STANDARD
	Class I
Uses	Secondary contact recreation and fishing
Aquatic Habitat	Shall be suitable for fish propagation and survival
Dissolved Oxygen	4.0 mg/L

Sources: NYCDEP, 2003; NYSDEC, 2000

Based on 2003-2005 consultation with agency personnel, potential concerns associated with water quality in conjunction with the RITE Demonstration Project included:

1. Erosion and sedimentation during deployment activities;
2. An increase in suspended solids during operation activities; and
3. The presence of toxic constituents in the channel substrates within the project area.

Regional Water Quality

The NYCDEP conducts annual monitoring of the waters of New York Harbor for four indicator parameters: dissolved oxygen; fecal coliform; chlorophyll a; and turbidity. This monitoring has been conducted since 1908 and currently includes 965 water sampling stations, with 1,200 drinking water samples collected each month from up to 546 locations. The data obtained is used to monitor water quality trends and to correlate improvements with advances in wastewater treatment and other environmental protection measures. Overall, the program has documented significant improvements in all parameters due largely to the construction and upgrade of wastewater treatment plants that discharge to the harbor (NYCDEP, 2010, 2009).

In the Inner Harbor (which includes the Hudson River from the NYC-Westchester line, through the Battery to the Verrazano Narrows; the Lower East River to the Battery; and the Kill Van Kull-Arthur Kill system), bottom dissolved oxygen levels have risen from approximately 3 mg/l in the early 1970s to 6.6 mg/l presently. There is an increase between 0.4 to 1.3 mg/L for each decade. Average summer surface DO values in the Inner Harbor have risen to levels above NYSDEC standards for primary contact recreation and commercial fisheries since the late 1980s. Average dissolved oxygen values reached a record high in the Inner area in 2008. Summer DO values averaged 7.4 mg/L for surface waters and 6.6 mg/L for bottom waters, both increased more than 1.1 mg/L from 2007 values of 6.3 mg/L and 5.5 mg/L. Fecal coliform levels in the Inner Harbor have improved from summer geometric means in excess of 2,000/100 ml in the early 1970s to below 100/100ml since early 1990. The average chlorophyll *a* in the Inner Harbor in 2008 was 7.2 ug/L. Chlorophyll *a* levels throughout the inner harbor have generally been below 10 ug/l for much of the summer since 2000 and have shown no discernable trends. Turbidity in the Inner Harbor, measured as secchi transparency, has shown little variability. Average summer Secchi values have remained relatively constant (>4.0 feet) in the Inner Harbor area since measurements began in 1986, except for years 1996 and 1997. Compared with other city open waters, there have been the least variations (< 2.0 feet) over the past 22 years, which can be most likely attributed to the normal flow from the Hudson River (NYCDEP, 2008).

In the upper East River region of the harbor (which includes the East River north of Roosevelt Island, western Long Island Sound to Hart Island, and the Harlem River), bottom dissolved oxygen levels have risen from approximately 3.0 to 3.5 mg/l in the early 1970s to about 5 mg/l presently. While there was a dip in oxygen levels in the late 1990s and early 2000s, oxygen levels have been steadily increasing since 2004. The average summer levels for 2006 were approximately 5.2 mg/l at the surface and 5.0 mg/l at the bottom. Fecal coliform levels in the upper East River have improved from summer geometric means in excess of 2,000/100 ml in the early 1970s to below 50/100 ml in recent years. Chlorophyll a levels throughout the upper East River region have generally been between 10 and 15 ug/l since 1992. Turbidity in the upper East River has shown variability between areas of the region, with the Harlem River secchi depths of 3 to 4 feet and the East River at 4 to 6 feet transparency. Long-term trends show a slight increase in turbidity (NYCDEP, 2006).

305(b) and 303(d) Listing

Section 305(b) of the Clean Water Act requires states to report to the U.S. Environmental Protection Agency (EPA) on whether waters of the state are supporting the designated uses and standards of the state's water laws. The state's waterbody inventory and priority waterbody list (WI/PWL) are used to inventory the data obtained by state monitoring programs (including the New York State Rotating Intensive Basin Studies [RIBS] program) and to track known or suspect water quality problems. Waterbodies where designated uses are threatened, stressed, precluded, or impaired, are identified on the PWL and in the 305(b) Report.

The East River is included in the New York State 305(b) listing. A 3,520-acre section of the lower East River estuary and a 3,200-acre section of the upper East River estuary are listed as impaired for aquatic life due to high oxygen demand from combined sewer overflows. A 1,280-acre portion of the lower East River estuary is also listed as impaired for public bathing due to pathogens from combined sewer overflows. All three segments are listed for sediment contamination (PCBs, other toxics) that precludes or impairs fish consumption (USEPA, 2008; NYSDEC, 2010, 2002).

Pursuant to Section 303(d) of the Clean Water Act, states must develop Total Maximum Daily Loadings (TMDLs) for waterbodies identified on the State's PWL that cannot meet standards after application of best available technology. The TMDLs apportion the allowable daily loading of pollutants amongst point, non-point, and natural sources. The East River has been identified as a priority for development of TMDLs to address the impairments discussed above.

Existing Water Quality

In conjunction with the RITE Demonstration Project, Verdant Power developed a Sediment Sampling Plan for the proposed Project based on information and consultation with the New York State Department of Environmental Conservation (NYSDEC), NOAA/fisheries, the United States Fish and Wildlife Service, Army Corps of Engineers, the New York Department of State, and the New York City Department of Environmental Protection. Throughout the substrate analysis activities, Verdant Power and its contractors consulted with the NYSDEC and other applicable parties to ensure compliance with applicable water quality standards and regulations. The results of the sampling event were presented in the Sediment Sampling and Contour Mapping Results for the Roosevelt Island Tidal Energy Project (DTA, 2005b) and “Acoustic Remote Sensing Survey Roosevelt Island Tidal Energy Project” (CR Environmental, 2005). These reports were submitted to the consulting agencies in March 2005 for review and approval.

The full investigation of the demonstration field consisted of a side-scan sonar survey, using a device at frequencies of 500 kHz and 100 kHz, a sub-bottom sonar survey, using a SyQwest 10 kHz Stratabox sub-bottom profiling system and bathymetric survey, video grab samples/video inspection of riverbed, and a water column survey.

Water Column Results

The water column at the RITE demonstration site was isothermal on February 16, 2005, with a temperature of approximately 3.3 ºC. Salinity ranged from approximately 19.6 to 20 PPT (parts per thousand). Turbidity ranged from approximately 16 to 17 FTU. Dissolved oxygen was highest near the surface (approximately 11.4 mg/L) and steadily decreased with depth, to a minimum of about 7.7 mg/L.

Substrate Survey Results

Based on a review of side-scan sonar data, two stations were selected for video inspection to locate and collect fine sediment. These locations were chosen based on the absence of large boulders and the likelihood that fine sediment would be present. Both stations confirmed the presence of smaller boulders and cobbles that were depicted on the side-scan sonar and sub-bottom records. The video coverage, which was recorded directly onto VHS tapes and DVD, did not show any evidence of fine grain soft sediments, therefore precluding any further opportunity to obtain sediment samples for grain size and chemical analyses.

In the sediment survey, Verdant Power and the consulting parties agreed that no sediment or organic material exists within the initial demonstration area, and therefore, additional sampling activities, including water column monitoring was not necessary for deployment and operation of the demonstration units. In July 2006, the NYSDEC once again confirmed in a letter, listed in the consultation log, that water quality analysis was not needed at the RITE demonstration site because of the lack of sediment.

4.3.2.4 Environmental Effects – Water Quality

Since the Verdant Power KHPS design has no hydraulic components, the concern of releases or other chemicals from the underwater units is not an issue, particularly because the units will have redundant dynamic (shaft) and static sealing to retain lubricant and exclude seawater. No concerns were raised when the agencies were presented with the new design on October 14, 2010. More details regarding the design of the units is provided in Exhibit A in Volume 1.

Verdant Power determined that the East Channel of the East River is located within a larger area that has the potential for toxic contaminants to exist within the underlying substrates. However, based on site-specific information acquired during the 2005 and 2007 investigations mentioned below, it is not likely that toxic contaminants will be disrupted during deployment and/or operation of the RITE Pilot Project because no re-suspendible sediment was found at the site.

The proposed Project would not be expected to have an effect on water quality parameters, such as dissolved oxygen or oxygen demand. The Project would not affect levels of fecal coliform or pathogens.

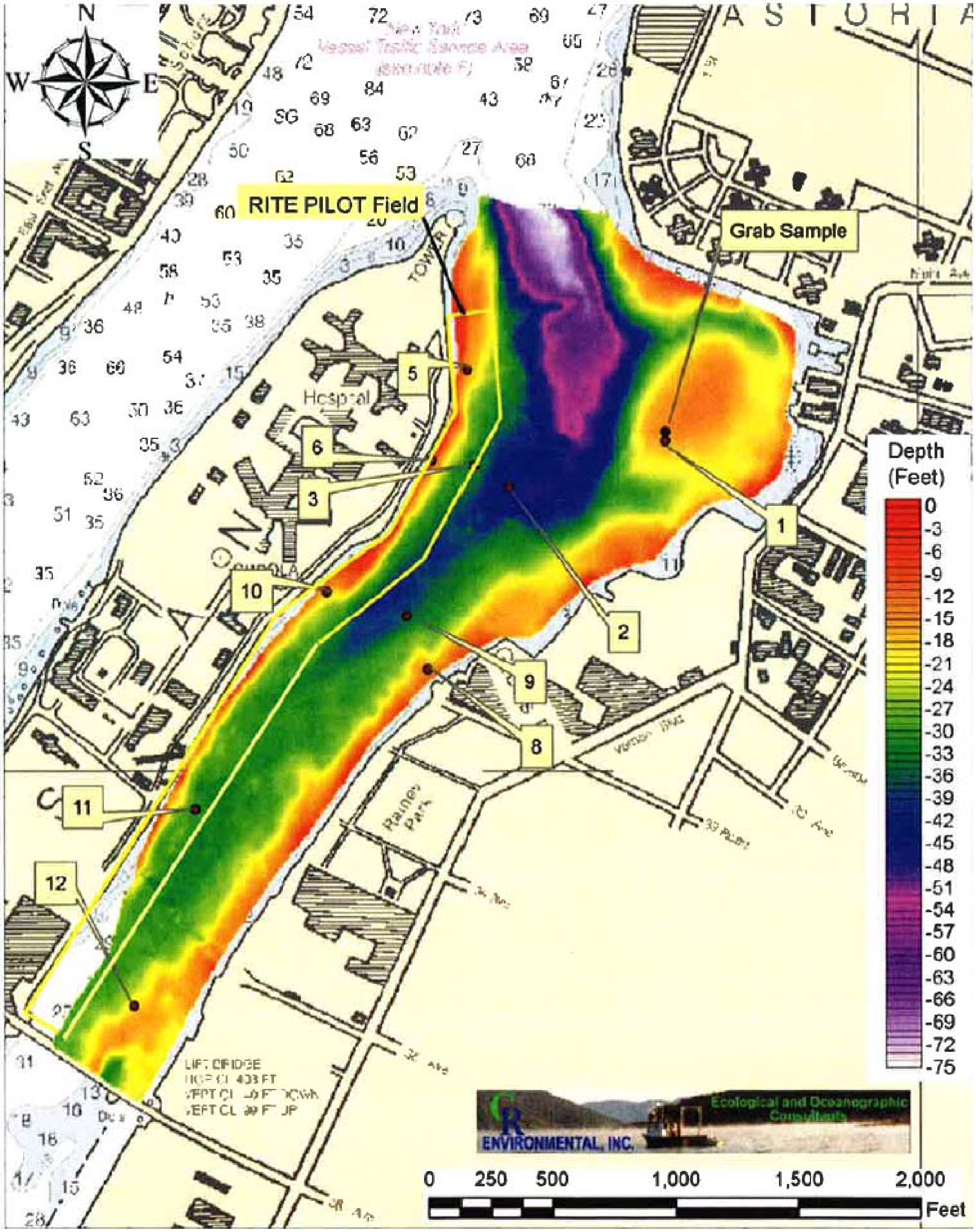
Based on agency recommendations, detailed depth and bottom substrate information were collected in April 2007 for the proposed RITE Project East Channel buildout. The survey was called "2007 Expanded Geophysical Survey Roosevelt Island Tidal Energy Project" (CR Environmental, 2007). Detailed images of the riverbed features were generated from the side-scan sonar data were collected. A mosaic was assembled from the files, which allowed accurate identification of surficial riverbed texture. The mosaic suggests that the substrate of the entire survey area is composed of cobbles, boulders, and ledge. This characterization is supported by sub-bottom sonar data, which documented a highly reflected riverbed and abundant parabolic reflections typically associated with boulders. Neither the side-scan or sub-bottom sonar surveys identified or suggested the presence of fine sediment (i.e. particles smaller than gravel) within the survey area.

Side-scan sonar data was evaluated in order to classify the composition of surface substrates. The data evaluation was based on careful inspection of raw and projected sonar imagery for individual transects and close inspection of the sonar mosaic. Five substrate classes were identified in the survey area:

1) Ledge or exposed rock
2) Boulders
3) Cobbles
4) Gravels
5) Sands

A map representing dominant substrate classes can be seen in Figure 4.3.1.1-2. Groundtruthing of the data was done using underwater video and bottom grab samples. The vast majority of the channel appeared to be dominated by boulder/cobble substrates. Exposed ledge or rock appeared to be present along the western shoreline. Sands and gravels are present in Hallet's Cove and along the slopes of the northernmost channels. Debris was widespread throughout the survey area, with the highest density of debris along the eastern shoreline and in Hallets Cove (the cove at the northeastern extent of the survey area). Sub-bottom sonar data did not suggest the presence of discernable thicknesses of sediment in any portion of the survey area other than Hallets Cove.

Figure 4.3.2.4-1. Location of video surveys.



Based on the lack of re-suspendible sediment found in the RITE Project demonstration site and the RITE East Channel buildout field, Verdant Power does not anticipate any increased turbidity. Furthermore, Verdant Power does not expect any release of chemicals into the water column because limited to no sediments would be suspended or disturbed during construction. Since the Verdant Power KHPS units have no hydraulics, there is no potential for lubricant leaching. Construction and maintenance activities could increase the potential for accidental release of gas or oil from work boats through vessel collisions. Coordinating activities with the USCG should mitigate potential for vessel collisions.

Because no impacts to water quality are expected from the operation of the East Channel Pilot Project, no further monitoring is proposed.

4.3.2.5 Unavoidable Adverse Impacts

None identified.

4.3.2.6 No Action Alternative

If the proposed buildout is not installed, there would be no increased construction or maintenance vessels that could potentially impact water quality.

4.3.2.7 Sources

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4.3.3 Aquatic Resources

4.3.3.1 Affected Environment

The East River, in the vicinity of the proposed Project, supports a variety of fish species, notably, winter flounder (Pseudopleuronectes americanus), Atlantic tomcod (Microgadus tomcod), striped bass (morone saxatilis), and grubby (Myoxocephalus aenaeus). Other fish that may be found in high numbers include the bay anchovy (Anchoa mitchilli), Atlantic silversides (Menidia menidia), blueback herring (Alosa aestivalis), northern pipefish (Syngnathus fuscus), and Atlantic menhaden (Brevoortia tyrannus). Most species are seasonal and migrate through the East River to overwintering areas offshore or spawning grounds further upriver. The two relatively common fish species found in the East River over most life stages are the Atlantic silverside and northern pipefish.

The New York Bight watershed provides important habitat for numerous migratory species, including American eel, alewife, American Shad, Atlantic menhaden, Atlantic sturgeon, Atlantic tomcod, bay anchovy, blueback herring, rainbow smelt, shortnose sturgeon and striped bass. The East River is believed to be used by migratory species as a passageway and as a temporary seasonal habitat (USFWS, 1997; Henderson, 2002).

The New York/New Jersey Bight Urban Core estuary system supports significant recreational and commercial fisheries. Recreational fishing represents approximately two million angler days annually, with primary target species including flounder, scup, American eel, bluefish, striped bass, Atlantic mackerel, black sea bass and weakfish

(USFWS, 1997). The commercial fishery includes the Hudson River fishery (American shad, striped bass, American sturgeon, herring and baitfish); the lower estuary fishery (hake, scup, flounder and tautog); and the near shore and mid-water fishery (flounder menhaden, bluefish, weakfish, and mackerel). Within the East River itself, commercial shellfishing and fishing are restricted or prohibited for most species due to contamination.

Verdant Power compiled a significant amount of historical fishery data that was collected in and around the RITE project site over the last thirty years. Verdant Power has also conducted a number of studies to evaluate the interaction between the fish and aquatic environment and the operating KHPS units. These studies represent the first ever in-water monitoring of operating Verdant Power design KHPS units and as such develop a unique body of information related to understanding this interaction, specific to Verdant Power's technology. NYSDEC, NYSDOS, USACE, USFWS, NOAA/NMFS, and EPA were active participants in these groundbreaking efforts and have worked with Verdant Power to develop, modify, and adapt these studies and protocols over the course of the RITE demonstration project. Studies relied on several proven methods and several new applications to examine the interaction of the fishery resource to a kinetic hydropower system. A brief summary of these methods follows:

Fixed Hydroacoustic Array

The fixed hydroacoustic studies utilized an array of 24 Biosonic split-beam acoustic transducers in fixed surveys to gather information on fish spatial distributions and abundance, as well as provide fish behavior information by tracking a fish's swimming location and direction. The split-beam technique provided estimates of individual fish target strength, a measure that roughly corresponds to the physical size of the fish. Verdant Power deployed both phases of first 12 and then 24 fixed hydroacoustic SBT transducers around the array of six hydrokinetic turbines in December 2007. There were a number of issues associated with maintenance of the equipment, but Verdant Power was able to keep a number of these running and collecting data 24 hours per day, 7 days a week, through October of 2009. A large body of information was generated about the presence, abundance and spatial placement of fish communities within the project area. This information is presented in detail in Appendices A and B to the RMEE Plans in Volume 4 of this License Application and is summarized below.

DIDSON

The split-beam acoustic technology was supplemented with an innovative but still experimental DIDSON system which uses high definition sonar to produce a near video quality graphic display. The stationary DIDSON was deployed in the tidal fluctuation zone during December 2006 and January 2007 and Vessel-Mounted Aimable DIDSON was used between October and December 2008. A detailed summary of this experience and the results obtained is included in Appendix B of Volume 4 of this License Application and a summary of this information is provided below. Generally, the experience to date strongly supports using the DIDSON for micro-scale monitoring of fish behavior around the operating KHPS units.

Mobile Hydroacoustic Transects

The mobile hydroacoustic survey study plan used the SBT mounted in a downward looking arrangement passing over multiple transects across the East River in a wide pattern in and around the RITE project area to observe fish presence, abundance, and size distributions (by virtue of signal strength). A total of four mobile surveys were conducted prior to KHPS unit deployment (September 2005 to November 2005). Post-deployment mobile surveys were conducted once a month for the first 6 months following turbine installation (January 2007 to June 2007) to assess seasonal changes in fish occurrence, distribution, and abundance. Mobile surveys were conducted for the duration of the study for a total of 10 months of mobile surveys (four pre-deployment surveys and six monthly surveys during fall 2005 and spring 2007).

The goal of the mobile surveys was to identify distribution patterns of fish abundance across the channel and within the water column prior to and after turbine installation. In general, since the data is not species definitive, the mobile survey study plans and protocols yielded very little usable information relative to pre- and post-distributions, and by mutual agency consent no further mobile surveys were executed.

Netting

Fish collections using trawl net gear is very difficult in the East Channel which has many security and navigation issues as well as hazardous sampling conditions (debris and swift currents). Some netting data was attempted by Verdant Power but was suspended due to safety considerations. As explained in Volume 4 of the License Application, Verdant Power is now proposing to conduct trawl netting during periods of slack tide in the East Channel when sampling conditions are safer and net capture is less likely to injure fish. This data will be used to confirm expected species composition in the project area.

4.3.3.2 Environmental Effects

The data collected to date provides a great deal of information about how fish are moving in and around the project area and their potential to be impacted by the proposed Project. This data shows:

- The numbers of fish moving through the area vary considerably on a seasonal basis, with the highest numbers occurring in the late fall period (October-December) in each of the three consecutive years sampled (Figure 4.3.3.2-1).
- The late fall peak consists primarily of smaller fish, based on signal strength of hydroacoustic readings (Figure 4.3.3.2-2). Verdant Power believes that outmigrating juvenile blueback herring are the species/size

class predominantly causing this spike of smaller fish based on known life history characteristics and data collected at the Ravenswood Generating Station just upriver of the proposed Project. Netting studies during the proposed Pilot License term will help confirm or refute this hypothesis.

- Daily densities of fish are relatively low during non-peak periods (Figure 4.3.3.2-1) and primarily consist of smaller fish, independent of turbines in the water (Figure 4.3.3.2-2).
- Equivalent abundance is seen day and night (Figure 4.3.3.2-3).
- Greatest movement of fish is observed in the direction of tides or during slack tides (i.e. water velocities <1.0 m/sec, when the KHPS units are non-operational), independent of turbines in the water (Figure 4.3.3.2-3).
- Fish zonal location data confirms observations that fish tend to the inshore (slower velocity, non-turbine) zones of the KHPS turbine array area (Figure 4.3.3.2-4), minimizing opportunity for harm.
- Analysis of fish location within the water column shows that fish tend to prefer swimming at the surface or bottom as opposed to the middle of the water column where the turbines would be located (Figure 4.3.3.2-5).
- The direction of swimming is strongly influenced by tidal velocity and fish were observed to swim faster than the tidal velocity, independent of turbines in the water.
- DIDSON observations showed some avoidance behavior of fish approaching turbines though this was an extremely limited data set (as explained in more detail in Appendix B of the RMEE Plans in Volume 4). The DIDSON technology has shown great promise in allowing for real-time "viewing" of turbine and fish interactions in water that is much too turbid for any type of conventional video monitoring (Figure 4.3.3.2-6).

Figure 4.3.3.2-1. RITE Hydroacoustics: June 2007 – October 2009.

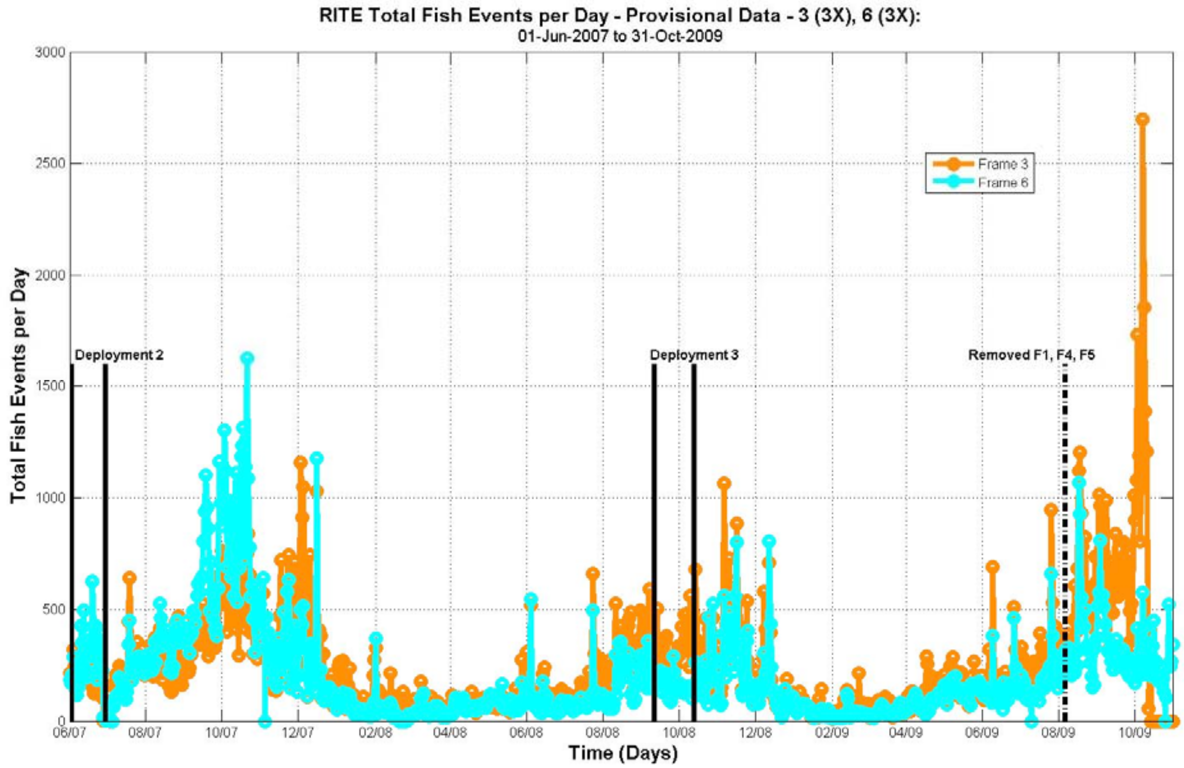


Figure 4.3.3.2-2. RITE Demonstration Project - target strength; small fish vs. large fish.

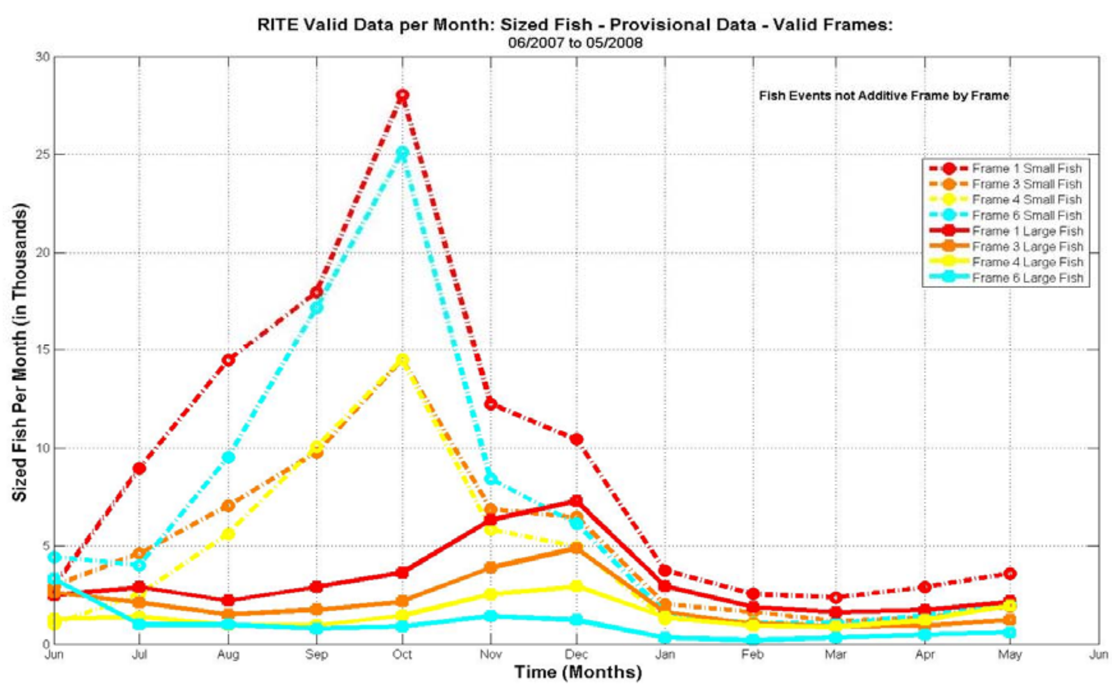


Figure 4.3.3.2-3. RITE target abundance during tidal and day/night.

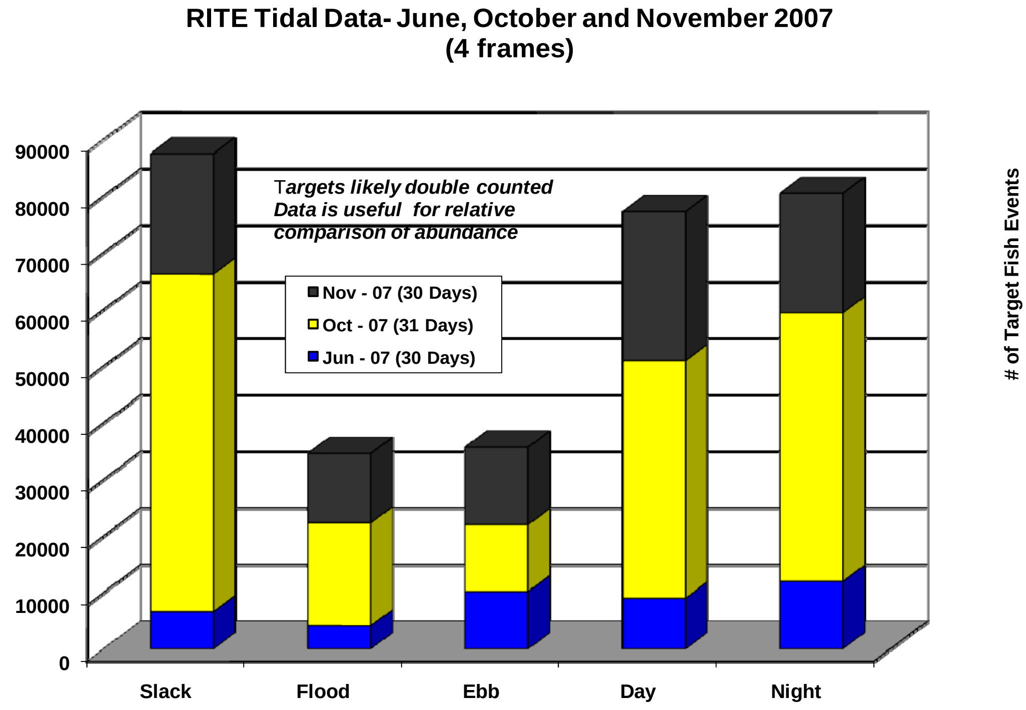


Figure 4.3.3.2-4. RITE Project Monthly Zonal Fish Distribution on an Ebb Tide – September 2007 (All Frames).

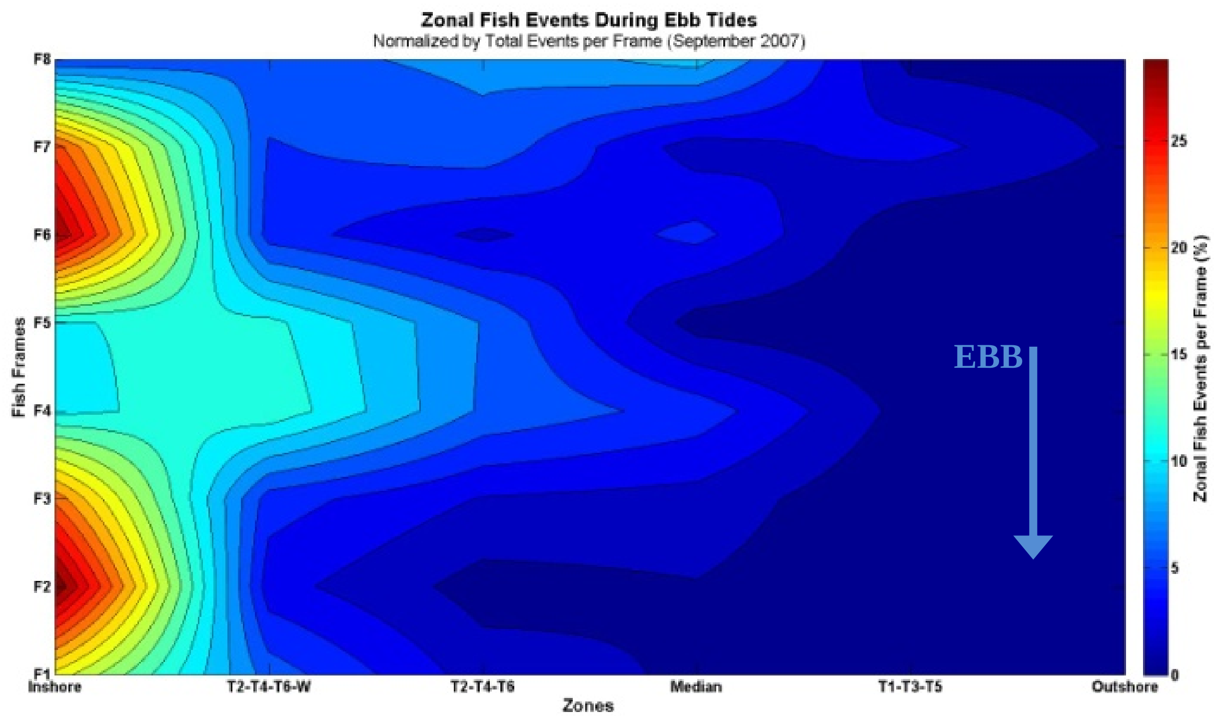


Figure 4.3.3.2-5. RITE Project Seasonal Abundance vs. Depth – 1 Day for 8 Months (4 Frames).

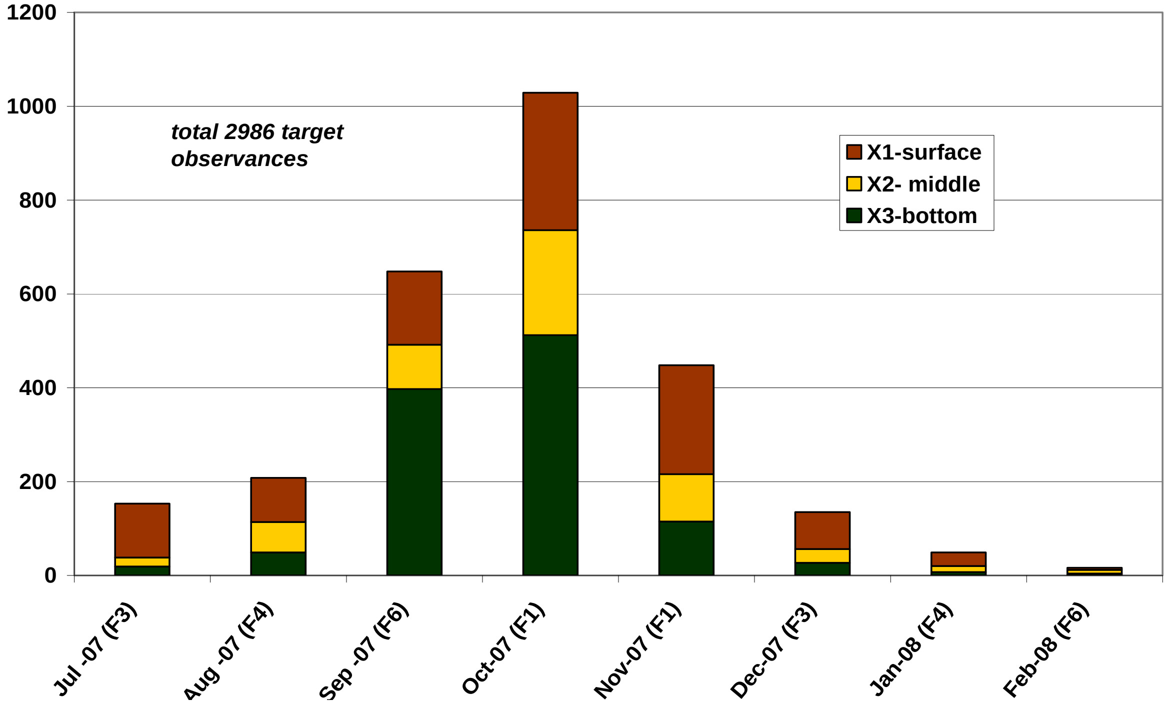
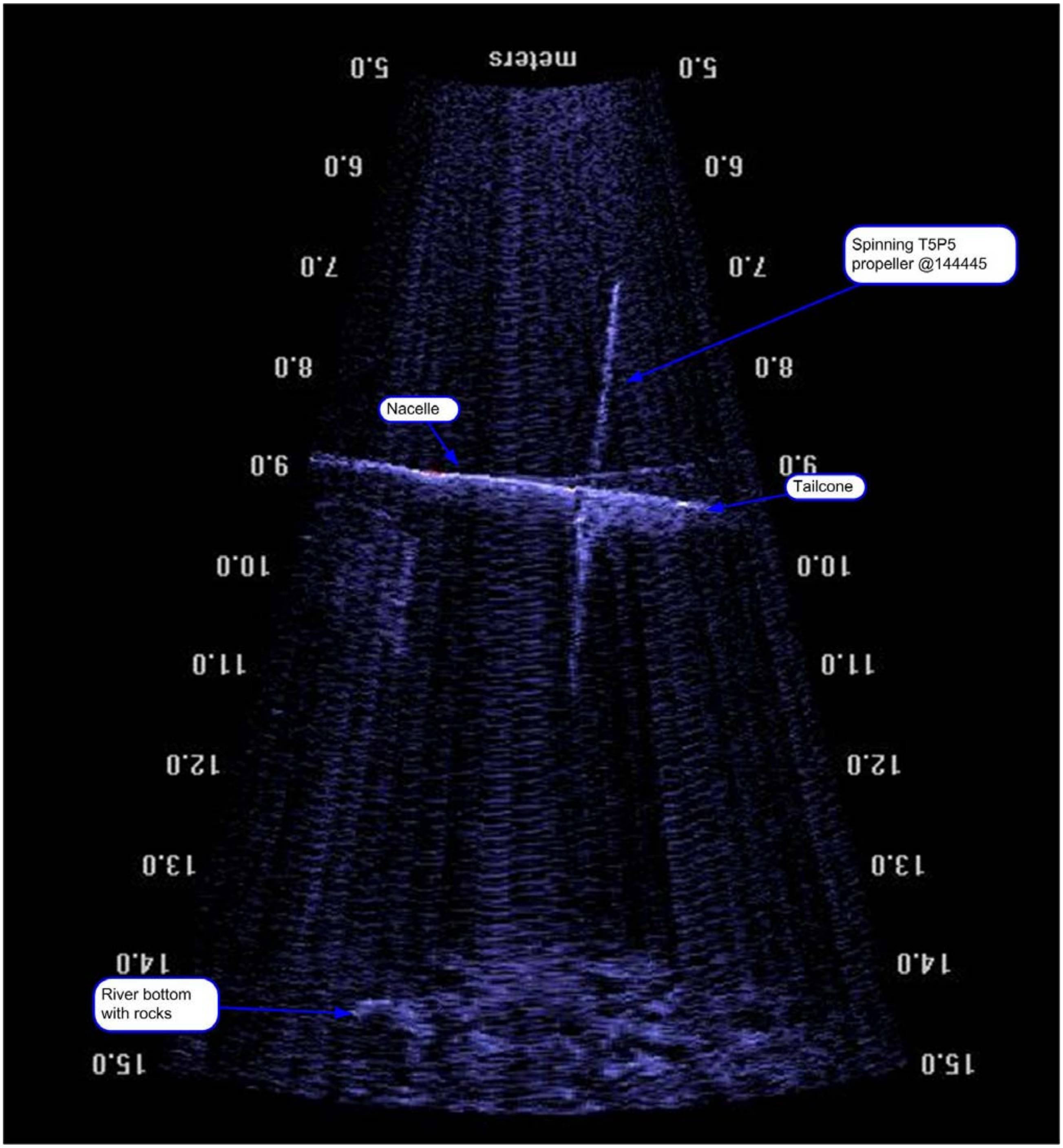


Figure 4.3.3.2-6 Imagery of a Rotating KHPS Turbine on Tide (no fish).



The data collected to date appears to indicate a limited likelihood for fish harm or mortality. The slow tip speed of KHPS units (35 rpm), lack of ducted pinch points; and ample opportunity for fish movement away from the turbine area indicates minimal opportunity for harm. During Deployment #1, #2, and #3 there was no observed evidence of increased fish mortality or injury, nor was any irregular bird activity observed.

Verdant Power has been working with resource agencies to develop a detailed approach to monitoring that includes plans for monitoring each phase of the project and modifying the approach as needed based on the results of the previous phase. The details of the proposed RITE Monitoring of Environmental Effects (RMEE) plans are included in Volume 4 of this final License Application. Continued monitoring during the phased installation of the Pilot Project will provide for an ongoing assessment of the potential impacts of the Project on aquatic resources.

4.3.3.3 Underwater Noise

Affected Environment

The nominal depth of the East Channel of the East River just north of the Roosevelt Island Bridge is approximately 30 feet or 10 meters, or a shallow water noise environment. The shore is covered with riprap extending to below the low water line. The bottom is bare solid rock with some scattered boulders. By specific examinations of bathymetry and substrate conducted by Verdant Power contractors in 2005 and again in 2007, there is no sediment, sand, or gravel covering the rock due to the fast currents in the area. Diver videos indicate that marine vegetation is minimal or non-existent as described in other sections of this Exhibit E.

The existing underwater environment has many existing sources of potential noise. In addition to the location of the noise source (above water or below water), how that sound couples is important. Anything that is in the water will couple vibration directly to the water much more efficiently than if it has to couple through the air or through rock.

Noise Sources Located Above the Water in the East Channel:

- Automotive and Truck Traffic on Roosevelt Island Bridge and Queensboro Bridge – The Roosevelt Island Bridge is the only means for automotive traffic to access Roosevelt Island and can be fairly busy during rush hours. The bridge abutments couple the traffic noise to the underwater environment.

- Roosevelt Island Bridge Bridge Lowering and Raising Operations – The Roosevelt Island Bridge is a lift-bridge which is raised when large vessels pass in the river. The bridge abutments couple the bridge operation noise to the underwater environment.

- Roosevelt Island Bridge and Queensboro Bridge Maintenance Work – The large Queensboro Bridge usually has some part of it being maintained at anytime. The Roosevelt Island Bridge does not normally have constant maintenance work but presently has a multi-year top-to-bottom renovation. The maintenance work involves trucks, jackhammers, sandblasting and other loud tools. The bridge abutments couple the bridge work noise to the underwater environment.

- Gas and Steam Turbine Operations at Ravenswood Power Plant – This power plant just across the channel and south of Roosevelt Island Bridge has many turbines which might be acoustically coupled to the underwater environment through cooling water pipes when in operation.

- Boat Propeller and Engine Noises – Most of the larger vessels in the East River use the West Channel for transit. However, the East Channel is used by recreational vessels, NYC Police, USCG, water taxis and smaller commercial traffic. Fishing charter boats use the East Channel when the striped bass are present. Large tugboats maneuver large oil barges at the

Ravenswood plant. Several times a year when the United Nations is in session, for security reasons all West Channel boat traffic is routed through the East Channel. Boat propellers spin at a much higher frequency than the KHPS units.

- Subway Traffic in Riverbed Tunnel between Roosevelt Island Bridge and Queensboro Bridge – A major subway tunnel passes under the riverbed between Roosevelt Island and Queens between the Roosevelt Island Bridge and Queensboro Bridge. During rush hours subway trains pass through as often as every 5 minutes.
- Water Intake and Output Noises at Ravenswood Power Plant – The Ravenswood Power Plant uses water taken from the East River in its operations. The noise from electric water pumps and potentially other industrial machines such as steam turbines inside the plant will pass through these pipes into the River.

Noise Sources Located Below the Water in the East Channel:

- Boat Propeller and Engine Noises - most of the larger vessels in the East River use the West Channel for transit. However the east channel is used by recreational vessels, NYC police, USCG, water taxis and smaller commercial traffic. Fishing charter boats use the east channel when the striped bass are present. Large tugboats maneuver large oil barges at the Ravenswood plant. Several times a year when the United Nations is in session, for security reasons all West Channel boat traffic is routed through the East Channel. Boat propellers spin at a much higher frequency than KHPS turbine rotors.
- Subway Traffic in Riverbed Tunnel between Roosevelt Island Bridge and Queensboro Bridge - a major subway tunnel passes under the riverbed between Roosevelt Island and Queens between the Roosevelt Island Bridge

and Queensboro Bridge. During rush hours subway trains pass through as often as every 5 minutes.

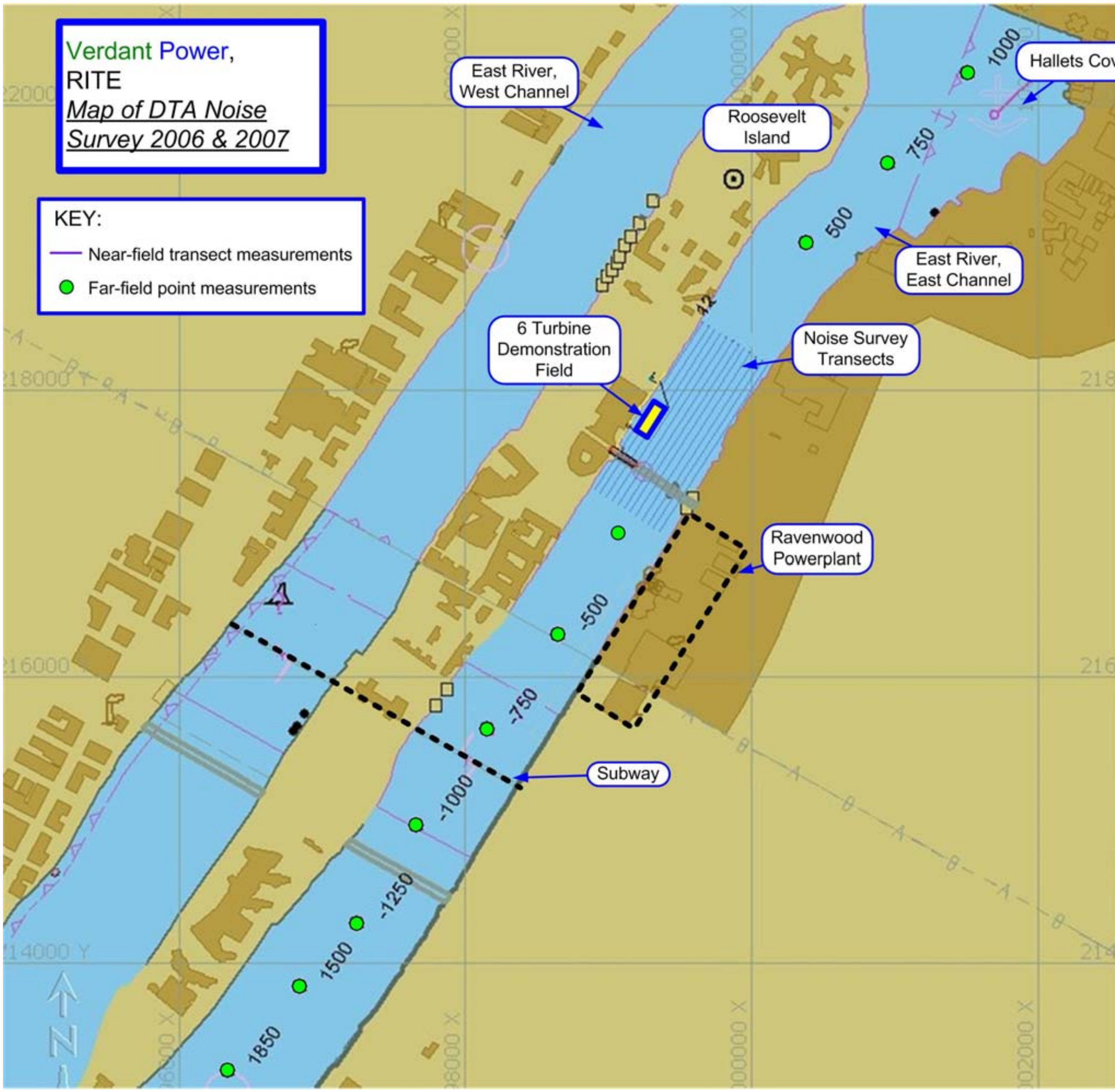
- Water Intake and Output Noises at Ravenswood Power Plant – the Ravenswood Power Plant uses water taken from the East River in its operations. The noise from electric water pumps and potentially other industrial machines such as steam turbines inside the plant will pass through these pipes into the River.

Underwater Noise Survey Methods and Analysis

Through a desktop survey, Verdant Power and its contractor had identified a substantial amount of scientific literature on aquatic sound and fish (DTA, 2004, 2005), particularly the estuarine species likely found in the East River such as American shad and river herrings. However, little was known about underwater noise generated by operating KHPS turbines. The East River Underwater Noise Survey Study Plans of 2006 were designed for both the pre-and post-deployment to establish an initial understanding of the sound signature of the operating KHPS units and the baseline of the East River in general (Verdant Power, 2006).

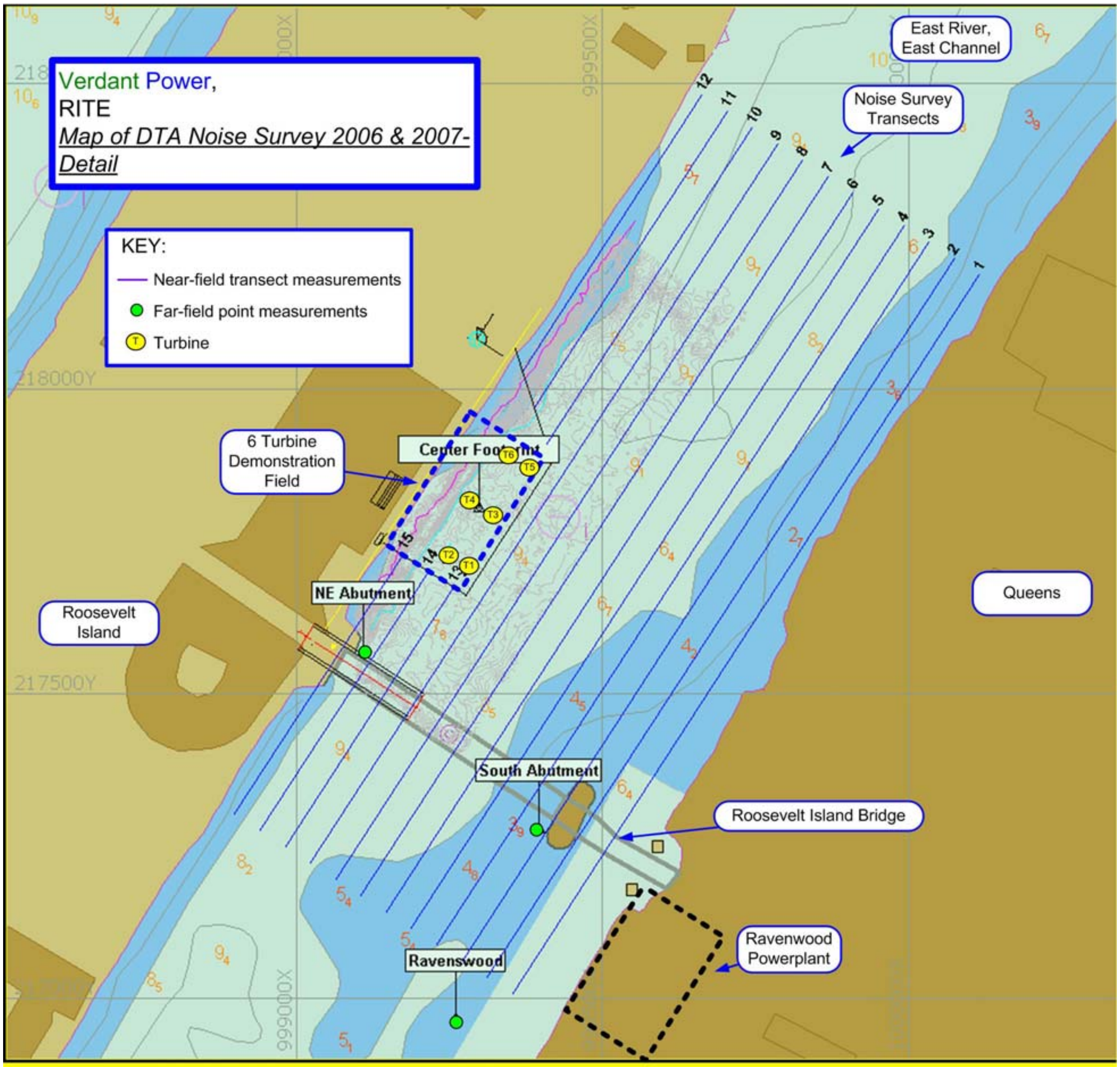
The area for the pre-and post-deployment underwater noise survey consisted of the area of the demonstration project − an area of approximately 180 wide by 365 m long, with additional long distance measurements points up to 1850 m away. See Figure 4.3.3.3-1 for the far field locations, including noise sources such as the F-train subway and Ravenswood Generating Plant, and Figure 4.3.3.3-2 for the near-field transects showing the RITE Demonstration Project and the Roosevelt Island Bridge. The study layout was designed to measure noise from the turbine array in relation to fish habitat. Therefore, transects were defined in the horizontal plane, and in the vertical plane. Measurements were made along predetermined transects parallel to the shore and surrounded the turbine array.

Figure 4.3.3.3-1. Near-field transect layout and far-field measurement locations.



Reference: DTA, Draft July 2007, as annotated by Verdant.

Figure 4.3.3.3-2. Near-field transect layout.



Reference: DTA, Draft July 2007, as annotated by Verdant.

Post Deployment Data Assessment

The post-deployment survey data was taken during Deployment #2 from May 13-16, 2007. At this time, four KHPS units were operating and the dynamometry KHPS which has a variable brake had broken blades and was rotating at 2-3 times normal speed and one KHPS unit was in failure mode, which may contribute to a noisier signature.

Sound Level and Transmission through Water

Table 4.3.3.3-1 shows received post deploy levels for sound recording samples by distance and direction from the RITE demonstration turbine array, taken at the middle depth level and at transect 9. All measurements were made at mean column depth. The right two columns compare measurements during periods of subway activity and in-activity.

Table 4.3.3.3-1. RITE Project post deployment sound levels.

Location	Distance from Mid Array	Post deploy with Inactive Subway (SPLdB re 1μPa@1m)	Post deploy with Active Subway (SPLdB re 1μPa@1m)
north (near Hallet's Cove)	+1060 m	123.6	
north (RI North)	+700 m	122.9	
north	+415 m	123.8	
north	+168 m	130.5 trans 9	
north	+84 m	136.3 trans 9	
T5-T6	+30m	N/A	
T3-T4- mid array	0	144.7 trans 9	
T1-T2	-30m	N/A	
south	-84 m	138.5 trans 9	
south	-168 m	131.9 trans 9	
Ravenswood Power Plant	-450 m	125.8	134.5
south	-700 m	125.6	134.9
south (Subway)	-735 m		148.6
south	-1200 m	124.3	133.6
south (RI south)	-1550 m	127.8	132.4

N/A = Not Available (Data could not be taken directly over the KHPS array.)

For post-deployment, the above table demonstrates that the noise concentration around the subway is equal or greater than that measured at RITE demonstration array. The subway noise appears somewhat comparable to the turbine array noise although the subway noise covers a larger area since it stretches across the entire river. In the area of the RITE demonstration project, sound levels directly at the KHPS units could not be taken because of limited clearance of the hydrophones to the active turbine rotors.

Environmental Effects

Interpreting the Effect of Measured Noises on Local Fish

With regard to biological behavioral impact analysis, there are very few audio sensitivity analyses for the fish species found in the East Channel. Comparable proxy fish species were used to relate the sensory information to the East Channel fish. These species comparisons are shown in Table 4.3.3.3-2. Results of the impact analysis on East River fish species indicate that the noise generated by the turbine array though audible to most species would not cause injury.

For all but one species analyzed (tautog), SPL rise above hearing thresholds did not reach over 30dB in any one frequency range, well below levels reported found to cause injury to fish hearing organs. Popper and Carlson 1998 cite numerous studies on the effect of noise levels on fish and offer a potential index of damage between 60dB for the most sensitive, and 100dB for least sensitive species above threshold levels. For those species that are able to detect the turbine noise in the East River, many are migratory not resident, thus further limiting their exposure potential to the period of time when they are passing the site.

Of the hearing specialist fish, none of the species studied show significant SPL levels above hearing thresholds (see Figure 4.3.3.3-3 and 4.3.3.3-4). Behavioral studies are limited for the species studied. However, studies aimed to evaluate the effectiveness of noise deterrents on the impingement of fish at water uptake structures have reported significant results for clupeid species, such as Alewife (Ross *et al*., 1993), blueback herring (Nestler *et al.,* 1992), and American shad (NEPCO, 1992). Source levels used to elicit a deterrence (or avoidance) behavior whereby fish moved away from the underwater speaker, ranged from 180 to 190 SPL x dB re 1µPa. These values are well above the source level of 145 160.75 SPL x dB re 1µPa @ 1m measured at the RITE project demonstration project array. Therefore, it is unlikely that even at very close range clupeid species will react strongly to the KHPS unit noise.

Table 4.3.3.3-2. Species used in RITE turbine noise evaluation, East River, New York.

Specialist				
Species		**Order**	**Surrogate**	
American Shad	Alosa sapidissima	Clupeiformes	(use itself)	
Alewife	Alosa pseudoharengus	Clupeiformes	American Shad	Alosa sapidissima
Atlantic Menhaden	Brevoortia tyrannus	Clupeiformes	Gulf Menhaden	Brevoortia patronus
Blueback Herring	Alosa aestivalis	Clupeiformes	American Shad	Alosa sapidissima
Generalist				
Species		**Order**	**Surrogate**	
Bay Anchovy	Anchoa mitchilli	Clupeiformes	(use itself)	
Winter Flounder	Pseudopleuronectes americanus	Pleuronectiformes	Common Dab	Limanda limanda L
Summer Flounder	Paralichthys dentatus	Pleuronectiformes	Plaice	Pleruonectes platessa
Striped Bass	Morone saxatillis	Perciformes	Euro. Sea Bass	Dicentrarchus labrax
Tautog	Tautoga onitis	Perciformes	(use itself)	
Atlantic Silverside	Menidia menidia	Atheriniformes	(use itself)	
American Eel	Anguilla rostrata	Anguilliformes	European Eel	Anguilla anguilla
Atlantic Tomcod	Microgadus tomcod	Gadiformes	(use itself)	
Shortnose Sturgeon	Acipenser brevirostrum	Acipenseriformes	Lake Sturgeon	Acipenser fulvescens
Atlantic Sturgeon	Acipenser oxirhynchus	Acipenseriformes	Lake Sturgeon	Acipenser fulvescens

Source, DTA, 2007a.

Figure 4.3.3.3-3. Audiograms for four species and five surrogate fish species (denoted by *) found in the East River, New York. Data sources are listed in Table 4.3.3.3-2 above.

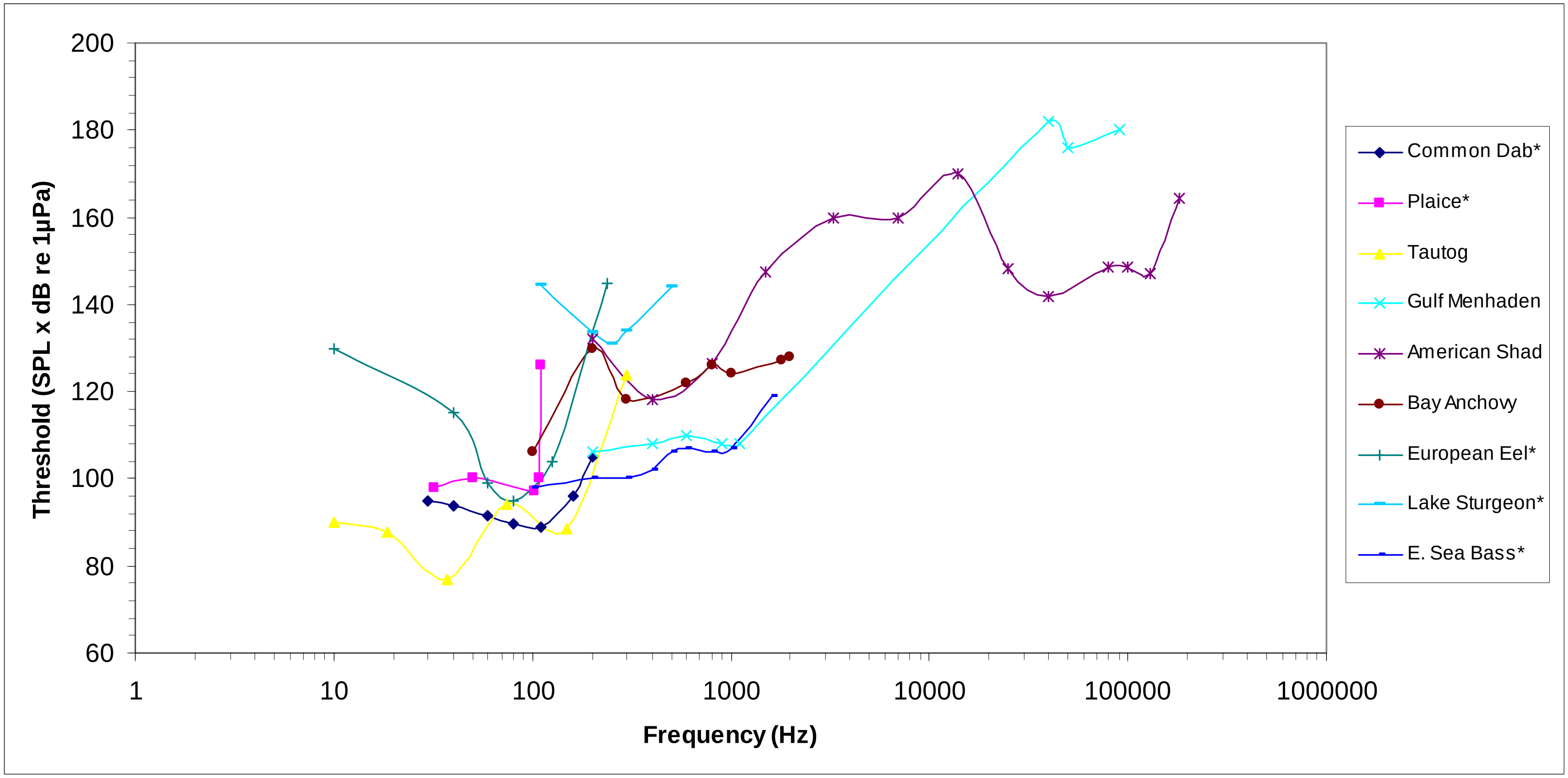


Figure 4.3.3.3-4. Species observed noise levels above hearing thresholds for five hearing generalists.

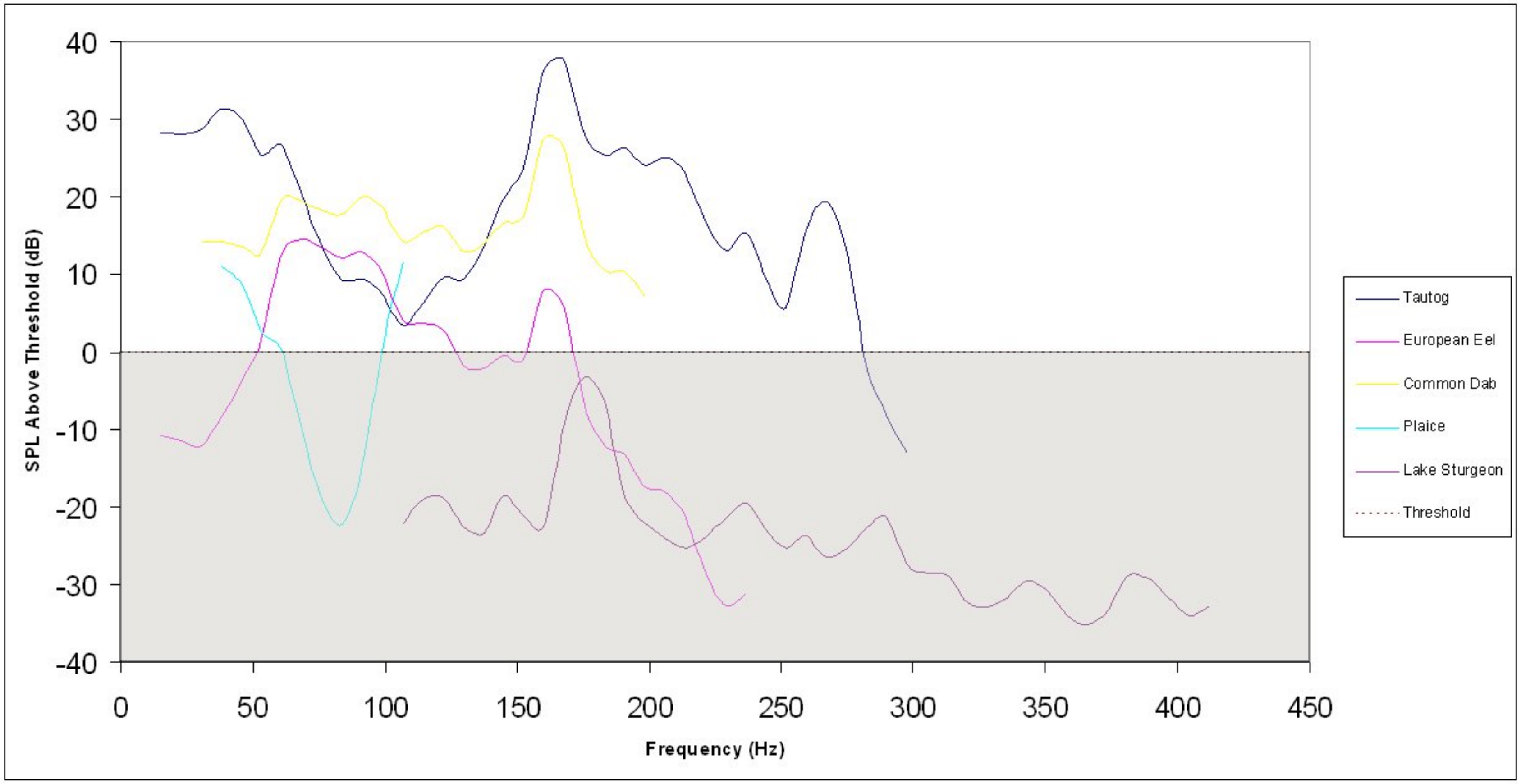


Figure represents the potential sensitivity of hearing specialist fish at a distance of 20m from the RITE turbine array from a received RMS level of 145 SPL x dB re 1µPa.

Figure 4.3.3.3-5. Species observed noise levels above hearing thresholds for two hearing specialists and two hearing generalists.

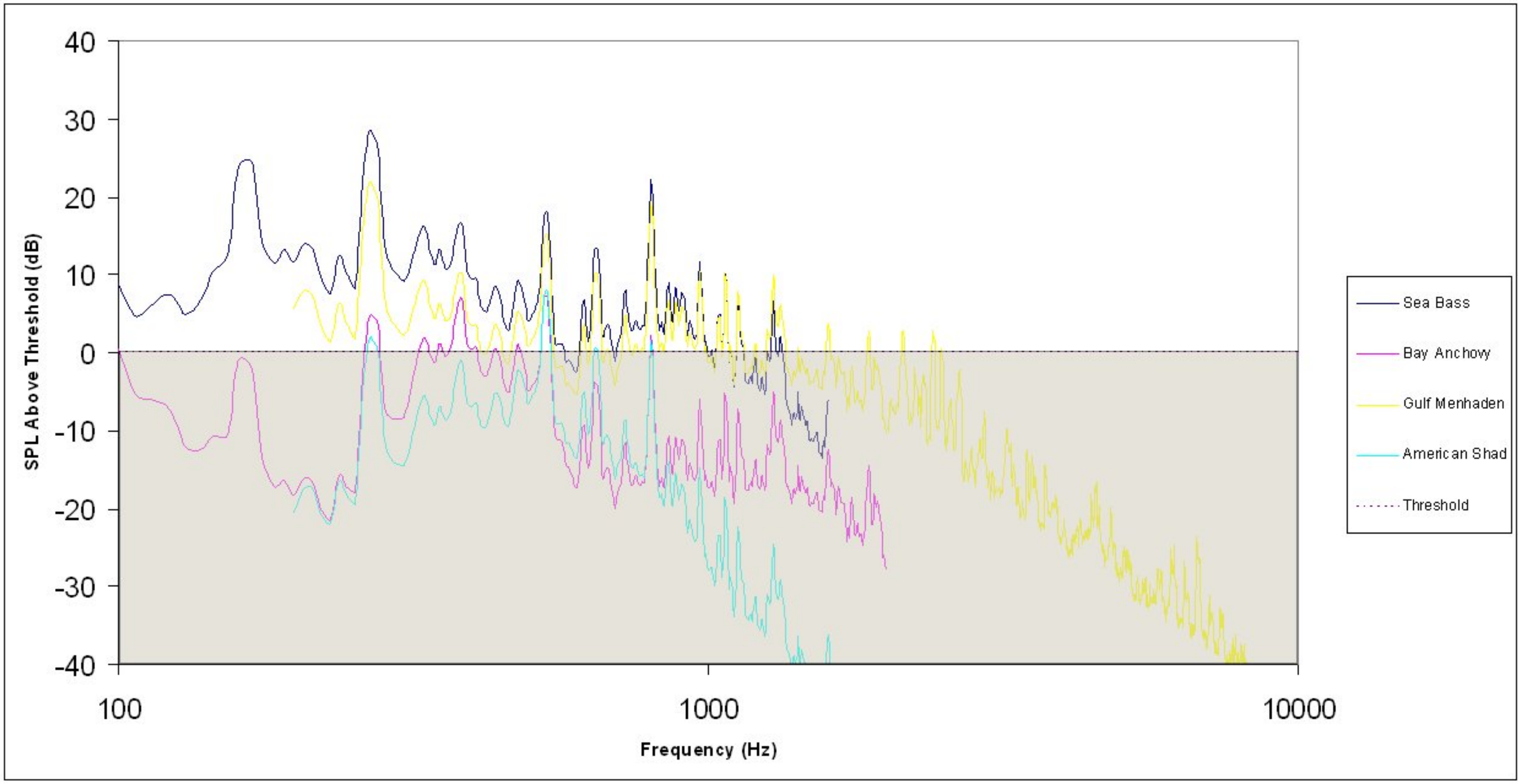


Figure represents the potential impacts from a received RMS level of 145 SPL x dB re 1µPa.

Conclusions − RITE East Channel Underwater Noise Survey

Verdant Power has reached the following conclusions from the noise studies to date:

- During the RITE Underwater Noise Survey (May 2007), for the four operating KHPS units, the survey and subsequent analysis indicates that is unlikely that the 4 KHPS units are creating noise that is harmful to fish or marine mammals in the East River. Due to difficulties with the data collection and protocols as well as the cascading failure of the KHPS machines this is likely to be true, but not well supported.
- Aquatic species are presently living with noise levels generated by the subway tunnel traffic on par with the noise levels generated by the KHPS units.

Verdant Power is confident that the incremental installation of 30 operating KHPS units at the RITE Pilot Project will not increase the background noise to levels that affect the aquatic community. To verify this prediction, Verdant Power has proposed, as part of the RITE Proposed Plans, a noise evaluation study as described below.

Proposed Underwater Noise Monitoring and Evaluation for RITE Pilot Project

The details of the proposed plan are included in RMEE-6 in Volume 4 of this License Application. Generally, Verdant Power, in consultation with the environmental regulatory agencies, will conduct a two-part underwater noise study consisting of:

- Micro-Meso (In-field) stationary underwater noise monitoring within the RITE East Channel Pilot Field; and
- Macro (far-field) stationary noise measurements at up to three established locations beyond the RITE pilot project boundary.

Verdant Power will attempt to compare the micro, meso, and macro field noise signatures when the Gen 5 machines are operating to noise signatures during the slack condition. These measurements will be made during Install B-1 and Install C as shown below.

	Install A (2 KHPS)	**Install B-1 (3 KHPS)**	**Install B-2 (9-12 KHPS)**	**Install C (30 KHPS)**
Underwater Noise Monitoring	None proposed	1 year Stationary for 1 Month 3 far-field locations (1 week)	None proposed unless B-1 indicates effect	1 year Stationary for 1 Month* 3 far-field locations (1 week)

* ***Location for B-1 at ADCP-N and at mid-field for Install C.***

4.3.3.4 Unavoidable Adverse Impacts

It is not yet clear if there are unavoidable adverse impacts to aquatic resources that would occur as a result of the proposed Pilot Project. The purpose of the proposed monitoring plans is to better understand potential impacts.

4.3.3.5 No Action Alternative

If the proposed Pilot Project is not installed, no impacts to the aquatic resource would occur.

4.3.3.6 Sources

Devine Tarbell and Associates, Inc. (DTA). 2004. Attachment I – Noise Assessment in Response to Comments Public Notice No. 2003-004402-Y3 Roosevelt Island Tidal Energy Project (FERC NO. 12178). Prepared for: Verdant Power, LLC, New York, NY.

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Verdant Power, Inc. Verdant Power, Inc. RITE Project Supplemental information for discussion; DEC Permit No. 2-6204-01510/00001 (and USACE Permit No. NAN2003-402-EHA); Submitted June 11, 2008. (Appendix A).

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