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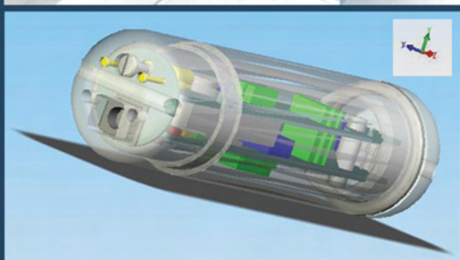

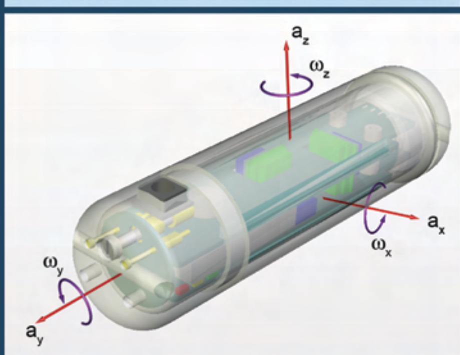

Data Overview for Sensor Fish Samples Acquired at Ice Harbor, John Day, and Bonneville II Dams in 2005, 2006, and 2007

T. J. Carlson
J. P. Duncan
Z. Deng

Final Report

March 2008

Prepared for
the U.S. Army Corps of Engineers,
Portland District,
under an Interagency Agreement
with the U.S. Department of Energy
Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

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Summary

The purpose of this work was to acquire data using Sensor Fish at Bonneville II, John Day, and Ice Harbor dams to meet anticipated future needs for turbine passage condition information. The project scope of work did not include analysis of acquired data. The original data sets have been entered into a database and are being maintained by Pacific Northwest National Laboratory pending delivery to the U.S. Army Corps of Engineers when requested. This report provides documentation for the data sets acquired and details about the operation of the Sensor Fish and interpretation of Sensor Fish data that will be necessary for later use of the acquired data. A limited review of the acquired data was conducted to assess its quality and to extract information that might prove useful to its later use.

The data sets acquired are representative of flow conditions within operating turbines at the conditions tested and are sufficient for the applications identified that motivated their acquisition. However, the sample size for any one set of conditions is too small to properly describe some factors such as the distribution of nadir pressures.

Contents

Figures

Tables

1.0 Introduction

Operating guidelines for turbine units at Snake and Columbia River dams in the Pacific Northwest require that turbines be operated within 1% of peak relative efficiency during the juvenile fish migration season (Bell 1991). This turbine operating range was specified by Columbia River fish managers based on limited historical data relating fish survival to relative turbine efficiency. A more recent investigation using a much larger data set has rejected the hypothesis that the survival of juvenile fish through turbines is a function of turbine operating efficiency (Skalski et al. 2002). As an element of its Turbine Survival Program, the North Pacific Division of the U.S. Army Corps of Engineers (USACE) is now investigating the physical conditions within mainstem Kaplan turbines to identify the turbine operations that are safest for passage of juvenile salmonid migrants.

1.1 Purpose and Scope

To support the ongoing USACE investigations, Pacific Northwest National Laboratory (PNNL)[1] used Sensor Fish devices to acquire turbine passage data at Ice Harbor, John Day, and Bonneville hydroelectric dams in 2005, 2006, and 2007 to attain Sensor Fish data for later use. This report presents the results of a limited data review that are intended to serve as a guide to the data but are not an analysis of the acquired data. The data were acquired by releasing Sensor Fish devices from locations in turbine intakes and recovering the sensors in the dam tailraces following turbine passage.

The data acquired during this project will be used to

- identify elements of treatments to assess the response of juvenile salmonids to rapid decompression
- assist with evaluation of computational fluid dynamic (CFD) models of the turbine environment
- serve as a source of data to verify aspects of turbine environment information acquired using physical turbine modes
- assess the differences in passage conditions for turbines that more safely pass fish and those that do not
- broaden investigations as to the large differences frequently observed between total direct turbine passage mortality and the rates of direct turbine mortality observed resulting from mechanical injury as measured using balloon-tag methods (USACE 2004).

1.2 Report Contents and Organization

The ensuing chapters of this report describe the Sensor Fish device and how it is used to derive data (Chapter 2.0) and the specific methods used to review the acquired data (Chapter 3.0). It contains

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[1] Pacific Northwest National Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC05-76RL01830.

selected data review results (Chapter 4.0) and concluding remarks (Chapter 5.0). Appendix A contains data for the Ice Harbor Dam releases, including the following:

- field log data sheets showing dam operating conditions, targeted turbine intake release elevations, and deployment and recovery times for each Sensor Fish release
- estimated turbine intake release elevations
- pressure rate of change during runner passage
- pressure nadir observations
- quality of flow assessment data
- significant event observations
- other data summary tables.

Appendixes B and C contain similar data for releases at John Day Dam, and Bonneville Powerhouse II, respectively.

2.0 Sensor Fish Overview

Juvenile salmon (smolts) passing through hydroelectric turbines are subjected to conditions that can potentially injure or kill them. The responses of Sensor Fish devices to flow conditions and interaction with structures as they are carried by flow through operating turbines provides unique information about the conditions fish may experience during passage through turbines. Analysis of Sensor Fish data can help identify the location and details of exposure conditions—hydraulic or structural in nature—that may be responsible for injuries and deaths of turbine passed fish. The resulting information can help identify locations and conditions that endanger fish so that they can be addressed by changes in the operation and/or design of turbines.

The Sensor Fish device and its internal sensors and associated data acquisition capabilities described in this chapter set the stage for understanding the methods used to sample the turbine environment as described in Chapter 3.0.

2.1 Sensor Fish Device

The Sensor Fish device contains accelerometers, rotation sensors, a microprocessor, a pressure sensor, an analog-to-digital converter amplifier, digital memory, and computer communication capability, all encased in a clear polycarbonate plastic cylinder. It is 24.5 mm in diameter, 90 mm long, and has a dry weight of 43 g (Figure 2.1, Figure 2.2). These measurements roughly match the dimensions of a yearling salmon smolt. The current Sensor Fish design is nearly neutrally buoyant in fresh water. The Sensor Fish measures 6-degrees-of-freedom (6DOF)—the three components of linear acceleration and the three components of rotation—as well as pressure and temperature, at a sampling frequency of 2,000 Hz for each sensor data stream over a selectable recording time with a maximum duration of 4 minutes (Deng et al. 2007).

2.2 Sensor Fish Calibration

Use of the Sensor Fish requires calibration of several internal sensors. The acceleration and rotation sensors are calibrated using an acceleration test track and rotational test fixture, respectively. High-speed videography is used to provide an independent measure of sensor motion for comparison with the output of the sensor under test conditions. The pressure sensor is calibrated in a hyperbaric chamber that is programmed to simulate the rapid pressure changes fish encounter when passing through a hydroturbine or spillway.

2.2.1 Acceleration

Three accelerometers (Motorola MMA1210D) are orthogonally placed near the geometric center of the Sensor Fish housing to measure three-dimensional acceleration. The accelerometers are silicon capacitive, surface-micro-machined, and feature integral signal conditioning, a 4-pole low pass filter, and linear output. The sensors have an operating acceleration range of ±112.5 g and high-powered shock survivability with a 1,500-g overload rating. Before assembly, all sensors are tested for linear acceleration and transverse sensitivity.

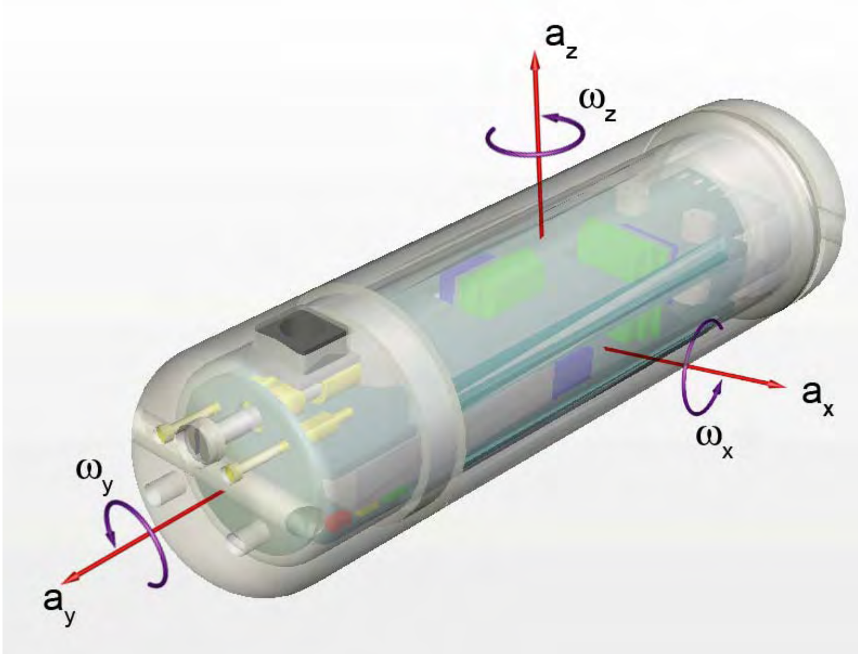


Figure 2.1. Sensor Fish device showing the location of the measurement axes for the three rate gyros (that measure angular velocity, ω), three linear accelerometers (that measure linear acceleration, a), and pressure and temperature transducers

Figure 2.2. Six degrees-of-freedom Sensor Fish device

After assembly, Sensor Fish acceleration measurements are calibrated using a linear acceleration test track (Figure 2.3) in conjunction with high-speed videography. The test track also has a built-in potentiometer, which gives the displacement of the sensor along the test track as a function of time. Sensor Fish displacement along the test track is simultaneously observed using a digital high-speed camera (Photron PCI FastCAM 1280; Photron USA, Inc., San Diego, California) equipped with a 50-mm lens. The

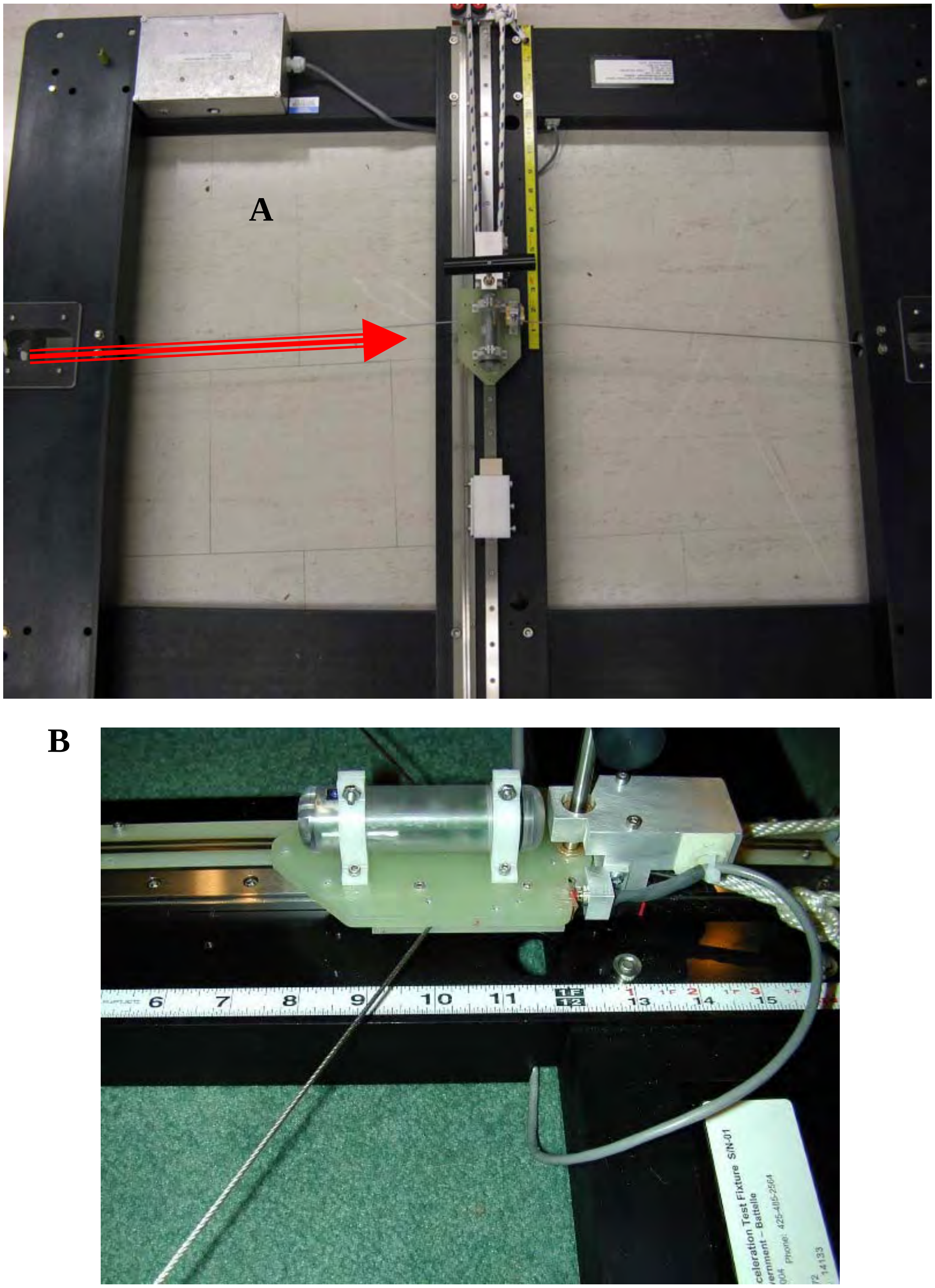


Figure 2.3. (A) Accelerometer test track used to check the calibration of the Sensor Fish's tri-axial accelerometer and (B) detail of the Sensor Fish attachment sled and release mechanism indicated by the red arrow in the top photograph

camera is capable of a 500-frame-per-second frame rate at a resolution of 1,280 x 1,024 pixels and up to 16,000 frames-per-second at reduced resolution (smaller number of pixels). Trajectories of the sensor are obtained using a motion-tracking software package (Visual Fusion 4.2; Boeing-SVS Inc., Albuquerque, New Mexico). Velocity is then computed by numerical differentiation of the measured position trajectories. Acceleration is computed by numerical differentiation of the velocity time histories (see the article by Deng et al. 2005 for additional detail). Each axis of the tri-axial accelerometer set is individually checked under two different accelerating mechanisms: an unforced spring-mass-damper system and a collision system. For the unforced spring-mass-damper system, the Sensor Fish mounting plate is pulled to a preset displacement to achieve a desired peak acceleration. After the Sensor Fish accelerometers are activated, the test track sensor mounting plate is released and set in motion. It moves sinusoidally with a progressively decreasing amplitude and eventually stops moving due to dampening (Figure 2.4a). The measurements obtained by the accelerometers are almost identical to those obtained by motion analysis of high-speed video records, both in wave form (dampening of motion with time) and acceleration magnitude (Figure 2.4b).

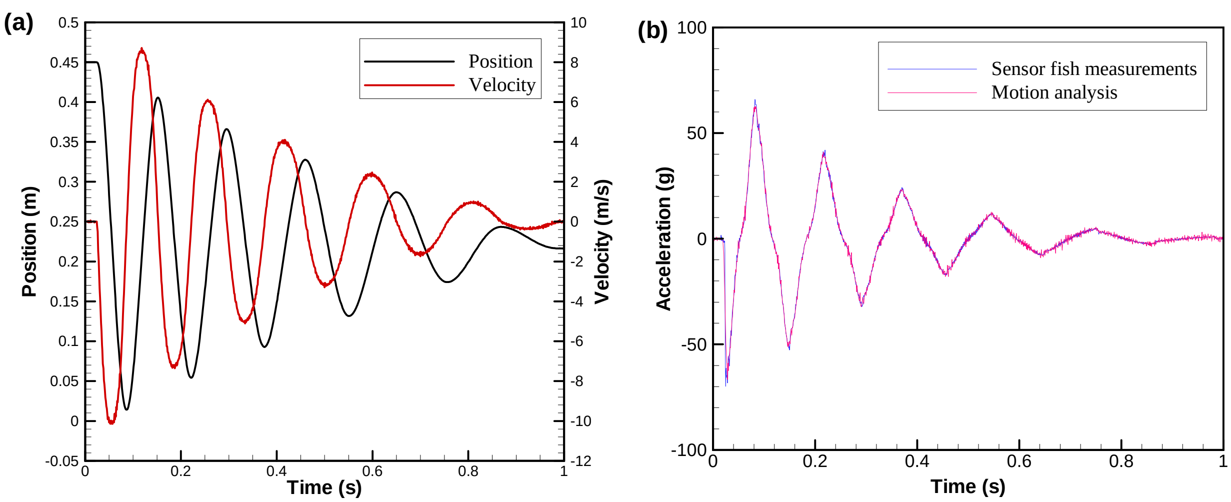


Figure 2.4. Example of linear acceleration calibration in the x-direction comparing the Sensor Fish measurements and motion analysis results

The collision system is set up by installing a stopper on the test track. The procedure for release of the sensor is the same as that for the acceleration test but with less initial mounting plate displacement. The mounting plate collides with the stopper after release of the Sensor Fish, which simulates a collision between the Sensor Fish and hydraulic structures very similar to those observed in the field. Because of the collision impact, the Sensor Fish experience a sudden change of velocity (Figure 2.5a), leading to a large acceleration magnitude (impulse). Again, motion analysis of high-speed video records shows that the collision process is captured accurately by the Sensor Fish (Figure 2.5b). The relative errors of linear acceleration measurements are determined to be less than 5%.

2.2.2 Rotation

Three surface micro-machined angular rate sensors ADXRS300 (Analog Devices, Inc., Norwood, Massachusetts) are added to the sensor package of the 6DOF Sensor Fish. They are installed orthogonally at the center of the Sensor Fish housing. These sensors are based on the Coriolis effect, under which an extra force, termed Coriolis force, is added to the equations of motion in a rotating reference frame. An electrical signal is produced by sensing the Coriolis force. The resulting signal is then amplified and demodulated to produce the voltage signal output. The ADXRS300 sensors have an original full-scale dynamic range of ±300 degrees/second and an increased full-scale measurement range of ±1500 degrees/second with the addition of an external resistor. The sensor weighs about 1 g, has a size of 7.0 x 7.0 x 3.0 mm, and a powered shock survivability of 2,000 g load.

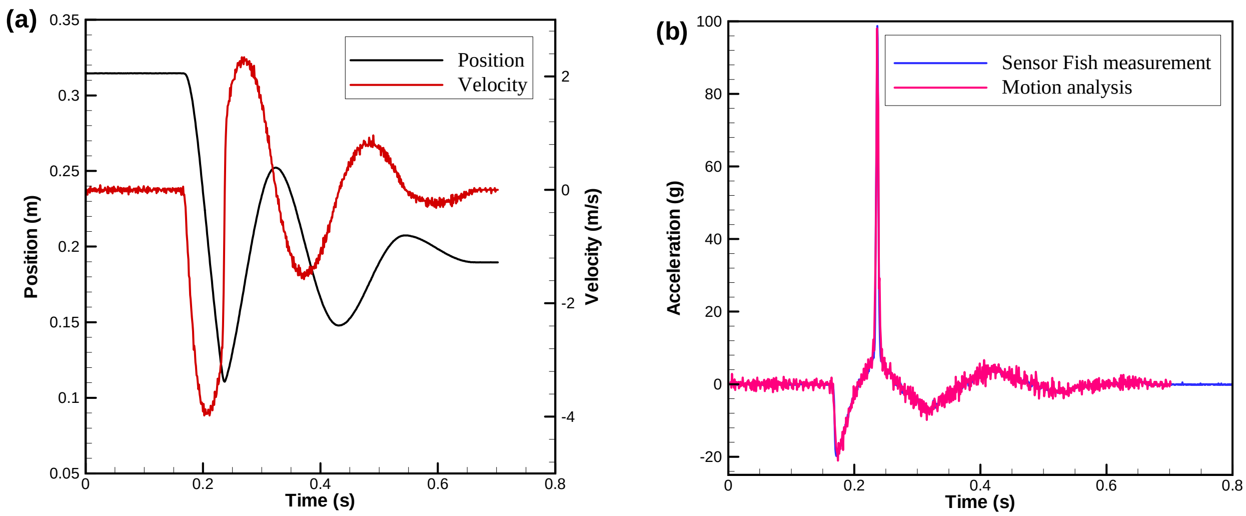


Figure 2.5. Comparison of Sensor Fish acceleration magnitude measurements during a collision process with concurrently measured motion analysis results

All of the sensors are calibrated in a rotational test fixture (Figure 2.6), which is programmable and controlled by a computer. All three axes are calibrated individually by mounting the sensor in the fixture with one axis at a time parallel to the rotational axis of the fixture. The rotating motions and trajectories of the sensors are obtained using the motion analysis of high-speed video records that are acquired simultaneously with the Sensor Fish response data. The motion analysis data are used to verify the operation of the rotation sensors. A time history of sensor angle relative to the rotating axis is computed from the observed rotational trajectory. The angular velocity is then obtained by numerically differentiating the time history of the angle relative to the rotating axis. The calibration is conducted in two modes: constant rotation mode and variable rotation mode. In the constant rotation mode, the fixture is programmed to rotate at a constant velocity of 1080 degrees/second (Figure 2.7); while in variable rotation mode, the rotational velocity of the fixture is controlled to alternate between 1080 and 720 degrees/second (Figure 2.8). The error of Sensor Fish measurements is determined to be less than 5% when comparing the sensor measurements with the results of the motion analysis and the fixture readings.

2.2.3 Pressure

A pressure sensor (MSI 1451 or 1471) is embedded flush in the Sensor Fish housing. The MSI sensor is a piezoresistive silicon pressure sensor packaged in a surface-mounted configuration. Before they are mounted in the Sensor Fish housings, all sensors are calibrated using a Fluke model 717 100G Pressure Calibrator and Fluke model 700PA6 Absolute Pressure Module (Fluke Corporation, Everett, Washington). The pressure sensor has a measurement range of 0–100 psia and a resolution of 0.1 psi with the use of a 10-bit A/D converter, which is built into the Sensor Fish's microcontroller chip.

Figure 2.6. Angular test instrument used to check the calibration of the Sensor Fish's tri-axial rotation sensor

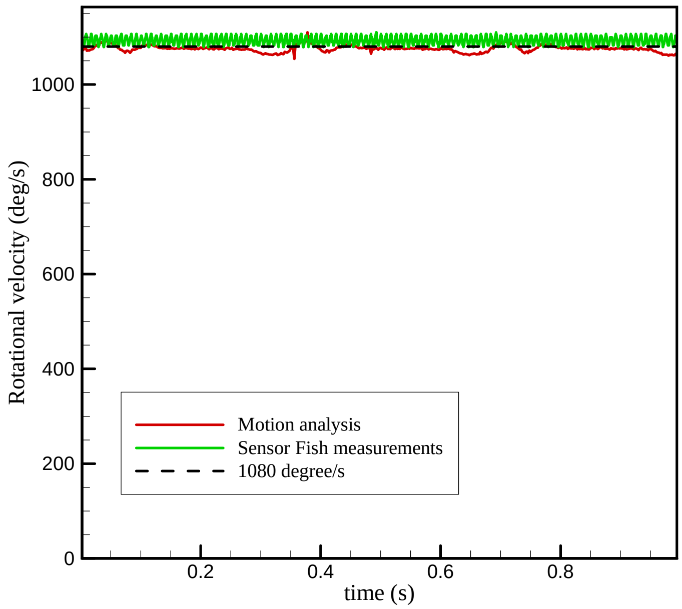


Figure 2.7. Comparison of data from a Sensor Fish mounted in the rotation fixture with its x-axis parallel to the rotational axis of the fixture, which is rotating at a constant velocity of 1080 degrees/second, with motion analysis results

After the complete Sensor Fish device is built, its pressure sensor measurement is evaluated by placing the device in a Rapid Decompression Testing Chamber (hyperbaric chamber) in the laboratory (Figure 2.9). The chamber is programmed to simulate pressure time history with the pressure range and rate of change similar to those in the turbine or spill passage. The pressure data acquired by the Sensor Fish during the exposure are compared to the pressure data file that controls the chamber pressure exciter and to another set of pressure observations obtained using another, independent, pressure sensor located in the chamber (Figure 2.10). Multiple tests with different pressure-time exposure histories and temperatures are conducted to confirm that there is no effect of the assembly process or drift from different pressure exposures that might bias pressure measurements. A small pressure offset for individual Sensor Fish is common, but it is a constant and temperature independent. By subtracting the offset during the data conversion process, the accuracy of the pressure sensor was determined to be within ±0.2 psi.

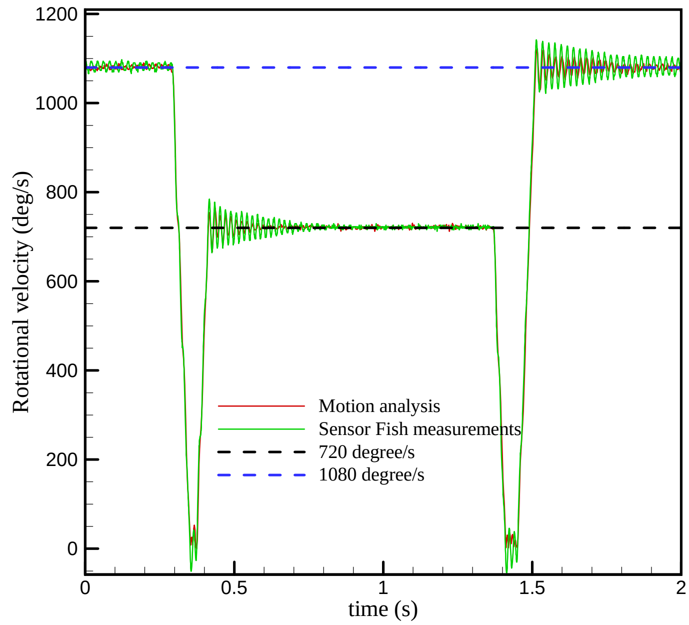


Figure 2.8. Comparison of data from a Sensor Fish mounted in the rotation fixture with its x-axis parallel to the rotational axis of the fixture with motion analysis results. The rotational velocity of the fixture is alternating between 1080 and 720 degrees/second.

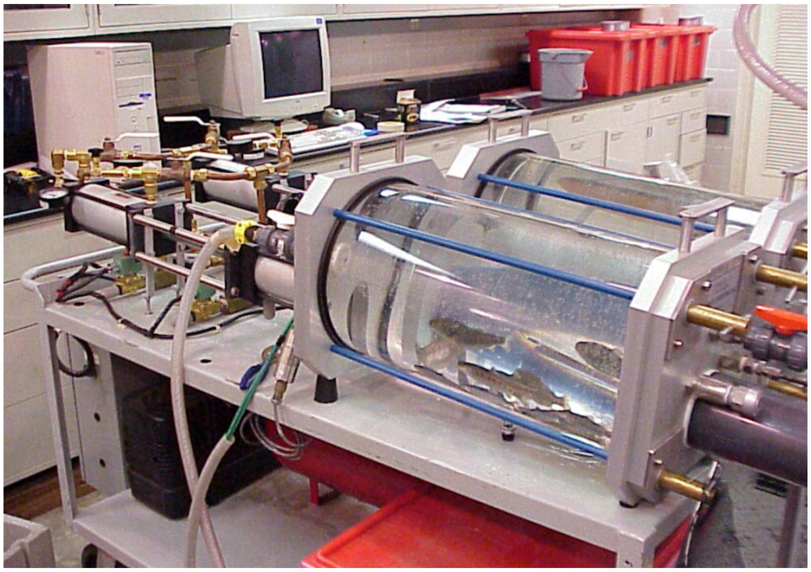


Figure 2.9. Hyperbaric chambers used to verify the performance of Sensor Fish pressure sensors

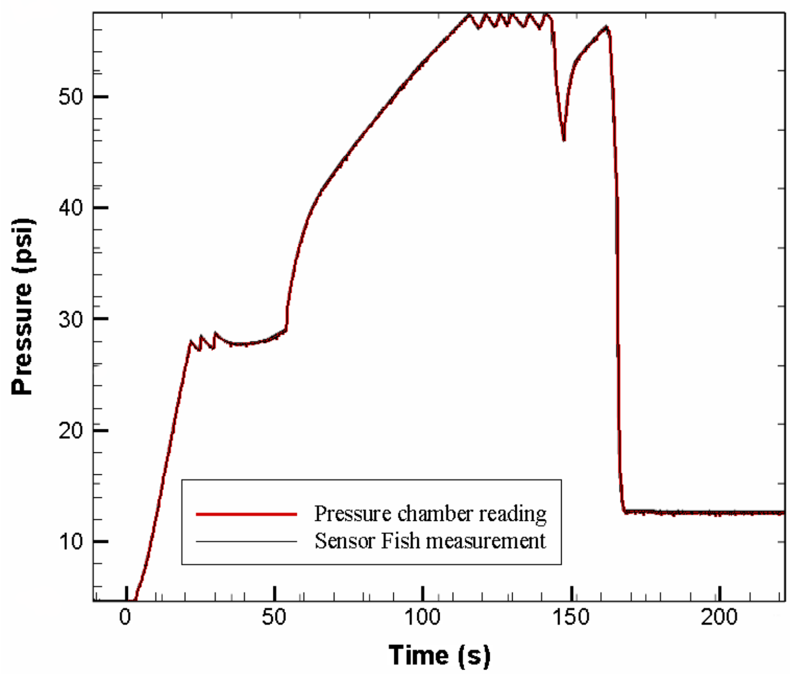


Figure 2.10. Comparison of Sensor Fish pressure sensor output with the output of a pressure sensor in the hyperbaric chamber. The pressure sensor in the Sensor Fish was calibrated in a pressure chamber at variable pressure settings and different temperatures.

2.3 Data Acquisition

In actual use, the Sensor Fish is only one part of a "system" necessary to acquire data about the response of the sensor to hydraulic conditions and interaction with structures. Other requirements relate to deploying and retrieving the Sensor Fish, downloading the acquired data, and analyzing and interpreting the data. The data acquisition system consists of modules that charge the internal battery, program the sensor settings, acquire data, convert signals from analog to digital form, download and analyze the data, and interpret the results. The acquired data are stored in an internal memory card and transferred to computers via a wireless infrared link with an external infrared link modem.

For retrieval after passage during field studies, the Sensor Fish is equipped with a micro-radio transmitter (Advanced Telemetry Systems, Isanti, Minnesota) and HI-Z balloon tags (Normandeau Associates Inc., Bedford, New Hampshire) identical to those used for live test fish (Heisey et al. 1992). The balloon tags contain a capsule filled with a chemical that produces gas when activated with water. Initiation of gas production is inhibited until the capsule material surrounding the gas-producing chemical dissolves, a process that takes approximately 3 minutes. The balloon inflates sufficiently within a few minutes of release to bring the Sensor Fish to the surface for recovery. A directional radio receiver antenna is used to home in on the radio transmitter attached to the Sensor Fish (Figure 2.11) so that scientists in boats can find and recover the Sensor Fish in the dam tailrace downstream from the turbine exit.

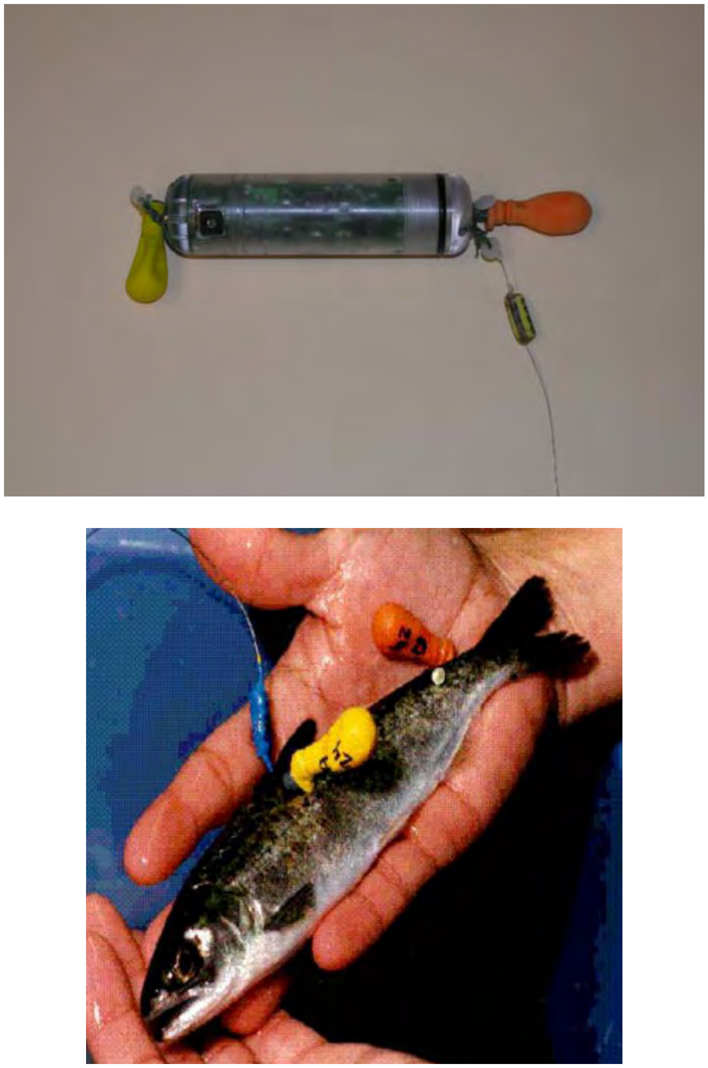


Figure 2.11. Comparison of the Sensor Fish device with balloon-tagged live fish. The top photo shows a Sensor Fish ready for deployment and bottom photo shows a live yearling Chinook salmon smolt also ready for deployment.

2.4 Understanding Sensor Fish Pressure Measurements

The pressure time history acquired by the Sensor Fish during transit through a fish passage environment helps identify the location of events of interest and, in particular, the depth of the Sensor Fish. Pressure exposure also may have physiological consequences or otherwise factor into the injury or death of passing fish. Correct analysis and interpretation of the absolute pressure observations acquired using Sensor Fish devices is essential.

Three different types of pressure measures are each measured using a specially designed sensor: differential pressure, absolute pressure, and gauge pressure sensors. Differential pressure sensors are often used in the measurement of flow velocity. Using the Bernoulli equation, flow velocity is estimated from the difference in pressure observed between two locations in the water flow path. Absolute pressure is defined as the absolute value of the force per unit area exerted on a surface by a fluid and is equal to the gauge pressure plus local atmospheric pressure. Gauge pressure is the pressure at a point in a fluid resulting from static plus dynamic pressure components. Gauge pressure is a differential pressure measurement where gauge pressure is the difference between the total pressure at a point in the fluid and atmospheric pressure. Local atmospheric pressure varies depending on ambient temperature, altitude, and local weather.

The Sensor Fish measures absolute pressure. Because of the relative motion between the Sensor Fish and flow, the pressure measured by the Sensor Fish is a combination of static pressure (gauge), local atmospheric pressure, and correction due to the relative motion (commonly termed “slip velocity;” i.e., the velocity difference between the Sensor Fish pressure transducer and water velocity). Static pressure is the actual thermodynamic pressure of the fluid as it flows. Its name came from the fact that one could measure it by moving along with the fluid; i.e., being static relative to the moving fluid. The Sensor Fish was designed to operate exactly the same way, that being to be passively transported by the fluid; therefore,

$$P_{SF} = P + P_{atm} + P_{cr}(V_{slip}, \theta) \tag{2.1}$$

where P_{SF} = Sensor Fish pressure measurement
P = static pressure (gauge)
P_{atm} = atmospheric pressure
P_{cr} = correction function of slip velocity V_{slip} and orientation θ.

When V_{slip} is small and the pressure sensor aligns well with flow velocity, P_{cr} is then negligible and $P_{SF} = P + P_{atm}$; i.e., the Sensor Fish measures static pressure (absolute).

Applying the Bernoulli equation following a streamline from the water free surface to the measurement point,

$$P_{total} = 0 + rZ_0 + \frac{1}{2}\rho V_0^{\,2} = P + \gamma Z + \frac{1}{2}\rho V^2 \tag{2.2}$$

where P = local static pressure (gauge)
$\gamma = \rho g$ = specific weight of water
ρ = density of water
Z_0 = elevation of the free surface of the streamline
V_0 = water velocity at the free surface of the streamline
Z = local elevation
V = local water velocity
$\frac{1}{2}\rho V^2$ = normally termed dynamic pressure.

By combining Equations (2.1) and (2.2), we get

$$rZ_0 + \frac{1}{2}\rho V_0^{\,2} = (P_{SF} - P_{atm} - P_{cr}(V_{slip}, \theta)) + \gamma Z + \frac{1}{2}\rho V^2 \tag{2.3}$$

and obtain the most general form

$$Z = Z_0 - \frac{(P_{SF} - P_{atm} - P_{cr}(V_{slip}, \theta)) + \frac{1}{2}\rho(V^2 - V_0^2)}{\gamma} \tag{2.4}$$

If the Sensor Fish follows flow relatively well (small slip velocity and rotation), then Equation (2.4) can be simplified to

$$Z = Z_0 - \frac{(P_{SF} - P_{atm}) + \frac{1}{2}\rho(V^2 - V_0^2)}{\gamma} \tag{2.5}$$

Please note that Equations (2.4) and (2.5) only apply along a streamline unless the flow is irrotational.

Pressure measurement varies depending on location: in the turbine intake or spillway before gate passing, in uniform open channel flow, or in spillway after gate passage. This variation and the associated data analysis are described in the following sections.

2.4.1 In Turbine Intake or Spillway Before Gate Passage

At the free surface in a turbine intake or spillway before gate passage (Figure 2.12), Z_0 is the forebay elevation and $V_0 \approx 0$, Equation (2.5) becomes

$$Z = Z_0 - \frac{(P_{SF} - P_{atm}) + \frac{1}{2}\rho V^2}{\gamma} \tag{2.6}$$

In these regions, usually dynamic pressure ($\frac{1}{2}\rho V^2$) is small compared with static pressure, then Equation (2.6) is further simplified to

$$Z = Z_0 - \frac{P_{SF} - P_{atm}}{\gamma} \tag{2.7}$$

However, in nonuniform flow regions, because of the difficulty of determining the local fluid velocity and the effect of the dynamic pressure, Equation (2.7) may not yield reliable estimates. For example, in the region immediately above the runner, suppose V = 20 m/s, $P_{SF} - P_{atm} = 30$ psi, $\frac{1}{2}\rho V^2$ = 29 psi, then dynamic pressure is not negligible compared with static pressure (gauge), so any attempt to convert pressure to elevation using Equation (2.7) would result in considerable errors.

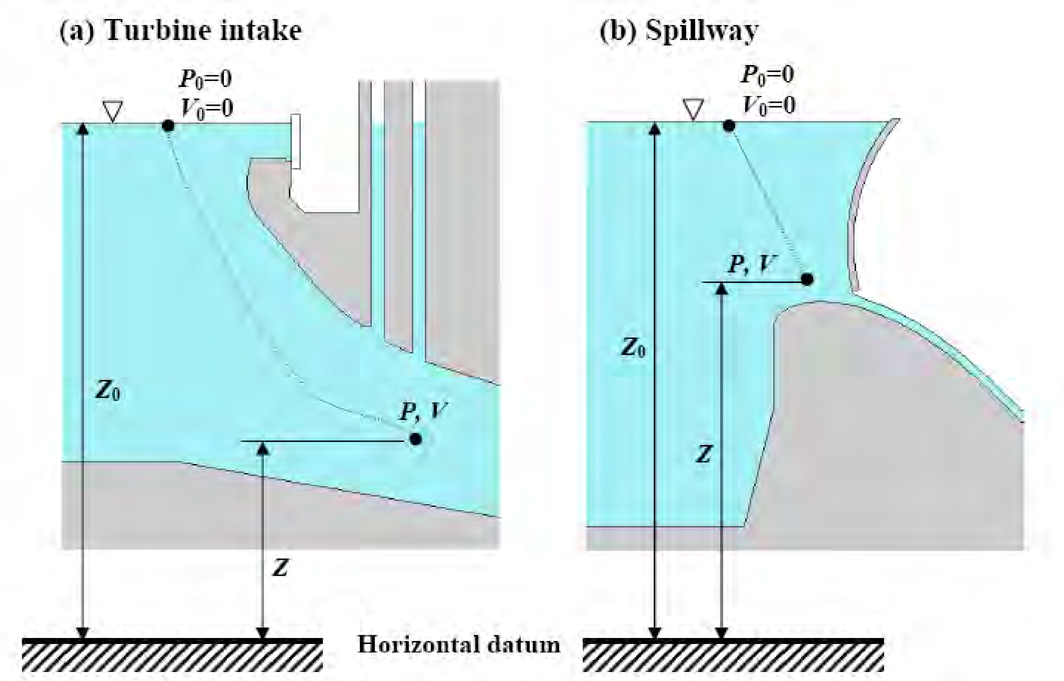


Figure 2.12. Calculation of elevation from Sensor Fish pressure measurement in enclosed flows: (a) turbine intake and (b) spillway before gate passage

2.4.2 In Uniform Open Channel Flow

Because uniform open channel flows are irrotational (Figure 2.13), Equation (2.5) can be applied across streamlines, that is, the use of the Bernoulli equation is valid for any two points in the flow. At the surface, $P_0 = 0$ and because of the uniformity of the flow, Equation (2.5) becomes

$$Z = Z_0 - \frac{P_{SF} - P_{atm}}{\gamma} \tag{2.8}$$

which is the same as Equation (2.7), except that Equation (2.8) does not require the negligibility of the dynamic pressure; i.e., the flow velocity itself has no effect on the accuracy of estimating sensor elevation in flow from Sensor Fish pressure measurements.

However, in the stilling basin immediately downstream from the spillways or in the turbine discharge, Equation (2.8) may not be used because the flow is unsteady, rotational, and Equation (2.8) is only for uniform or quasi-uniform flows.

2.4.3 In a Spillway After Gate Passage

In a curved open channel flow with a steep slope such as the spillway chute, because of the large vertical velocity acceleration and pronounced curvature of the streamlines, the flows are not irrotational, even if we can assume that the flow is uniform over a local region (Figure 2.14) and apply the same approach used in the uniform open channel example. In this case, the reference free surface point should be in the plane, which is perpendicular to the flow and contains the Sensor Fish's location. However, due to the uncertainties in determining the elevation (Z_0) of the reference free surface, there is no direct precise way to convert measured pressure to elevation.

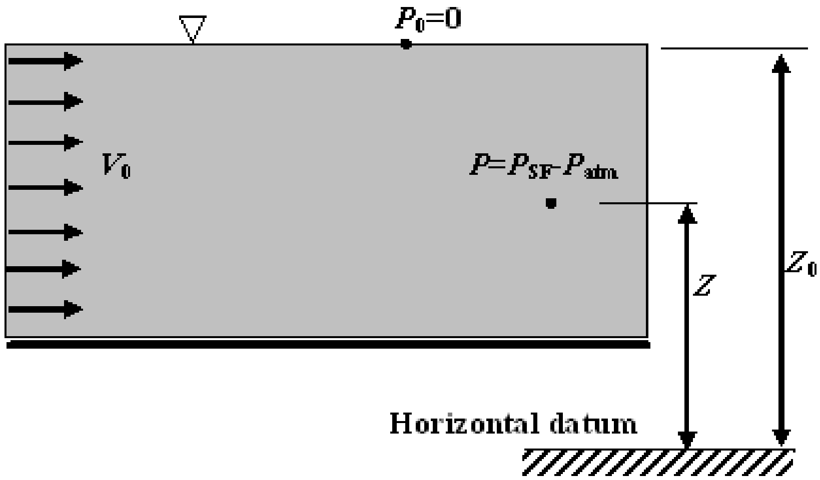


Figure 2.13. Uniform open channel flow where the Bernoulli equation can be applied across streamlines

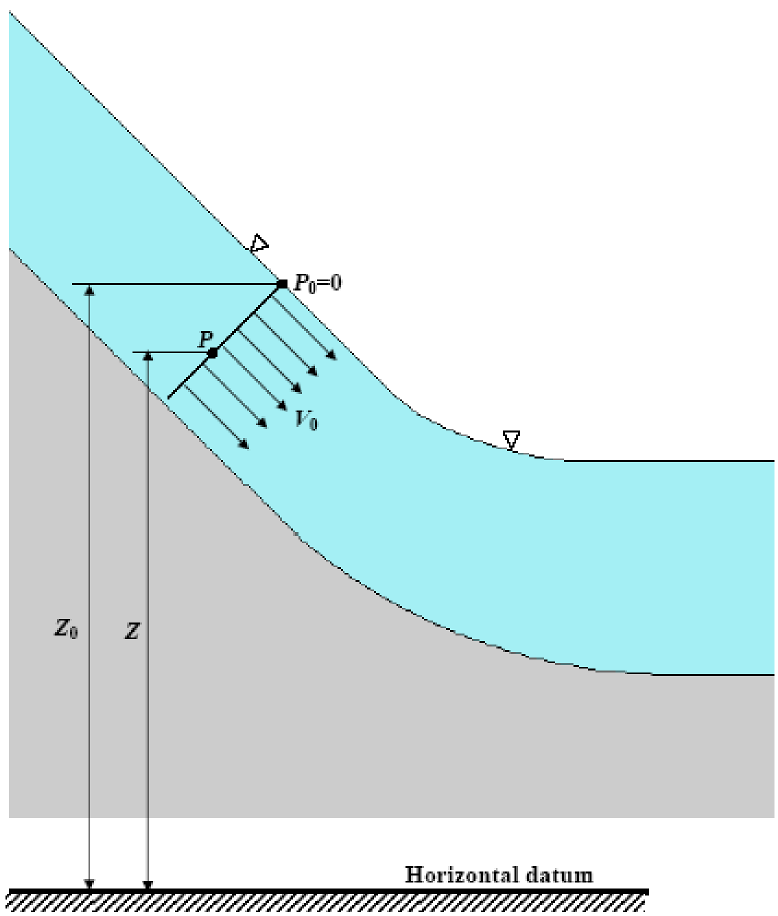


Figure 2.14. Application of the Bernoulli equation in a spillway chute

2.4.4 Summary of Sensor Fish Pressure Measurement

The Sensor Fish pressure transducer measures absolute pressure. If a Sensor Fish follows fluid flow faithfully (little or no difference in the velocity of the sensor and that of the surrounding fluid) and orients well with the flow direction, it measures static pressure (absolute). For enclosed flows, such as turbine intakes or spillways before gate passage, if fluid velocity can be determined accurately or dynamic pressure due to fluid velocity is negligible compared with static pressure, elevation can then be estimated using Equation (2.6) or (2.7), respectively. For uniform open channel flows, elevation can be converted accurately from Sensor Fish pressure measurements using Equation (2.8) without the restriction of the dynamic pressure being negligible. However, for curved steep open channel flows, such as flow in a spillway chute, there is no direct way of relating Sensor Fish pressure measurements to local elevation because of the uncertainties in determining the elevation of the reference-free surface. In such cases, the approximate location of the Sensor Fish with time can be obtained by comparing the pressure history of Sensor Fish with those of Lagrangian numerical particles tracked through a simulated flow field that have a mass and density equivalent to the Sensor Fish.

2.4.5 Data Analysis

Sensor Fish data sets obtained with the 6DOF Sensor Fish consist of time histories that include angular motion (pitch, roll, and yaw) as well as the measurements of pressure, acceleration (x, y, and z axes), temperature, and battery status extending from the time of release through the period of data acquisition programmed prior to release of the Sensor Fish. The period of data acquisition was 120 seconds for all releases reported in this study. The data time histories contain a data point for each transducer for every 0.0005 second, corresponding to a 2,000-Hz sampling rate for each of the analog outputs from the tri-axial acceleration, rotation, and pressure sensors. Sampling of all analog data streams occurs nearly simultaneously within each sampling interval.

Water depth in feet is estimated, when appropriate, from absolute pressure at various points along the Sensor Fish's route by subtracting atmospheric pressure, determined at the time of the release of each Sensor Fish, and dividing the resulting gauge pressure by 0.4335, which is the pressure in pounds per square inch of 12 in. of fresh (distilled) water at a temperature of 39.2ºF (4ºC). The raw output of the tri-axial accelerometers is processed to detect and quantify Sensor Fish response to turbulence, contact with structure (collision), and shear. Acceleration vector magnitude is computed during each sampling interval using tri-axial accelerometer output, and it is one of the variables analyzed and reported to characterize passage conditions and the occurrence of collision and shear events. Tri-axial angle rate-of-change data are processed similarly to tri-axial acceleration data to provide further information about the response of the Sensor Fish to flow conditions.

Analysis of the raw data from the Sensor Fish begins with preparation of graphs showing absolute pressure, tri-axial acceleration, and tri-axial rotation. These records are visually inspected to identify collision and shear events and to obtain a general overview of the passage conditions present for each test treatment. Changes in pressure during passage include consistently present features that result from the design of passageway structures and the dynamics of water flow through the passageway. These features in the pressure time history permit acceleration and rotation data to be divided into segments corresponding to particular locations (zones) that extend from Sensor Fish injection to its exit from the stilling basin. Each region is identified by characteristic features in the Sensor Fish pressure time history and characteristics in tri-axial acceleration and rotation data. For each Sensor Fish data set, events of interest, such as rapid pressure changes, collisions, shear, and severe turbulence, are identified and quantified. Quantification of events includes the time of occurrence, location by zone, the extraction of information describing severity, and information to separate collisions from shear exposure.

3.0 Methods

Fish passage data were collected at the three study sites using the data acquisition, sensor fish release and recovery, and data review methods described here.

3.1 Study Sites

Sensor Fish were used to sample the turbine environment at the following three USACE hydroelectric projects (Figure 3.1):

- Ice Harbor Dam, which began operation in 1961, is the first dam on the Snake River upstream from its confluence with the Columbia River in south-central Washington State. Ice Harbor Dam is 2,822 ft long and 100 ft tall and has six turbine units, a 10-bay spillway, a navigation lock, two fish ladders, an earth-fill section, and a generating capacity of 603 MW.

- John Day Dam, completed in 1971, is located 216 miles from the mouth of the Columbia River. It is 7,365 ft long and 183 ft tall and has 16 turbine units, a 20-bay spillway, a navigation lock, two fish ladders, and a generating capacity of 2,160 MW.

- Bonneville Dam Powerhouse One was completed in 1937 and is 1,027 ft long with 10 turbine units and a generating capacity of 527 megawatts. The Bonneville Dam spillway, also completed in 1937, is 1,450 ft long and has 18 spillbays. Powerhouse II, constructed in 1981, is located 146 miles from the mouth of the Columbia River. It is 986 ft long and has eight turbine units with a generating capacity of 532 MW. Each of two fishway units (ladders) located at the second powerhouse has a turbine unit, adding 26.2 MW of capacity.

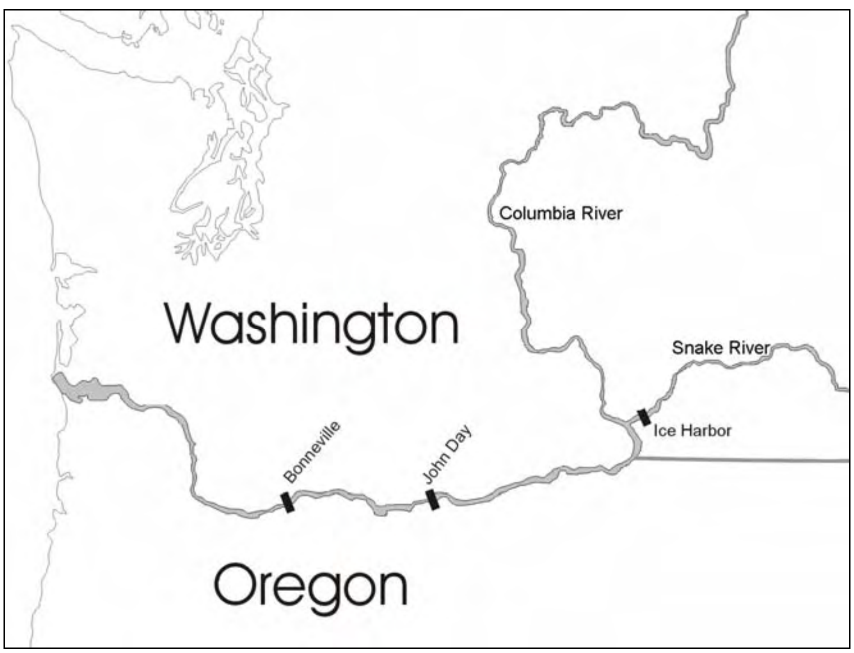


Figure 3.1. Locations of Bonneville, John Day, and Ice Harbor dams

3.2 Data Acquisition Design

Bead trajectories from turbine intake release elevations to turbine distributor entry were observed using turbine physical models located at the USACE Environmental Research and Development Center (ERDC) in Vicksburg, Mississippi. These observations were used to determine the turbine intake elevations from which Sensor Fish were released. Turbine intake release elevations that satisfied desired runner passage routes were determined to be a function of turbine operations and the resulting turbine flow conditions that differed between dams. Generator limit and upper and lower 1% turbine efficiency operation levels were selected by USACE for sampling at Ice Harbor, upper and lower 1% operating efficiencies were selected for Bonneville II, and lower 1% generator limit and peak operating efficiencies were selected for investigation at John Day. Turbine intake release elevations were identified that maximized the likelihood that Sensor Fish would pass through turbine runners by blade tip and mid-blade/hub runner passage routes. Sample sizes (the number of successful Sensor Fish releases) varied between 30 and 60 Sensor Fish releases per dam per release elevation (runner passage route).

3.3 Sensor Fish Release and Recovery

Seven hundred nineteen Sensor Fish successful releases were made during September 2005, March 2006, and March 2007. Figure 3.2, Figure 3.3, and Figure 3.4 are cross sections of Ice Harbor, John Day, and Bonneville turbines, respectively, showing the targeted release elevations.

Sensor Fish were released using an induction system consisting of a wire cable held taut by hydro-dynamic sounding weights. A 2-in. flexible hose, which extended from the forebay deck to the required release elevation, was attached to the wire cable (Figure 3.5). The system was portable and was deployed and adjusted as needed using a winch. Pressure readings using a sensor attached to the terminus of the flexible hose were taken to confirm that the hose terminus was at the targeted release elevations. Sensor Fish were released using this induction system, which was routed through the test turbine gatewell slot and behind the submersible traveling screens at Ice Harbor and Bonneville dam turbine units. The Sensor Fish were released through the induction system, which was routed through the head gate slot at John Day Dam. The upper end of the induction system was connected to the dam water supply via a 2-in. fire hose to provide water needed to push the sensors through the induction hose into the turbine intake. Releases at Ice Harbor Dam in March 2007 were deployed through a fixed-pipe induction system being used for live-fish direct injury testing.

Sensor Fish were equipped with HI-Z balloon tags and a micro-radio transmitter to enable their recovery. Chemicals in the balloon tags were activated by injection of a small amount of water immediately before they were placed into the induction system so that they would rise to the surface where they could be recovered. After passing through the turbines, the Sensor Fish were recovered by boat crews in the tailrace, who were guided to the location of the Sensor Fish by transmissions from the attached micro-radio transmitters. Following their recovery in the dam tailrace and return to the dam forebay deck, data were downloaded from the Sensor Fish memory and backed up, the Sensor Fish's memory was reset, and new deflated recovery balloons were attached for redeployment.

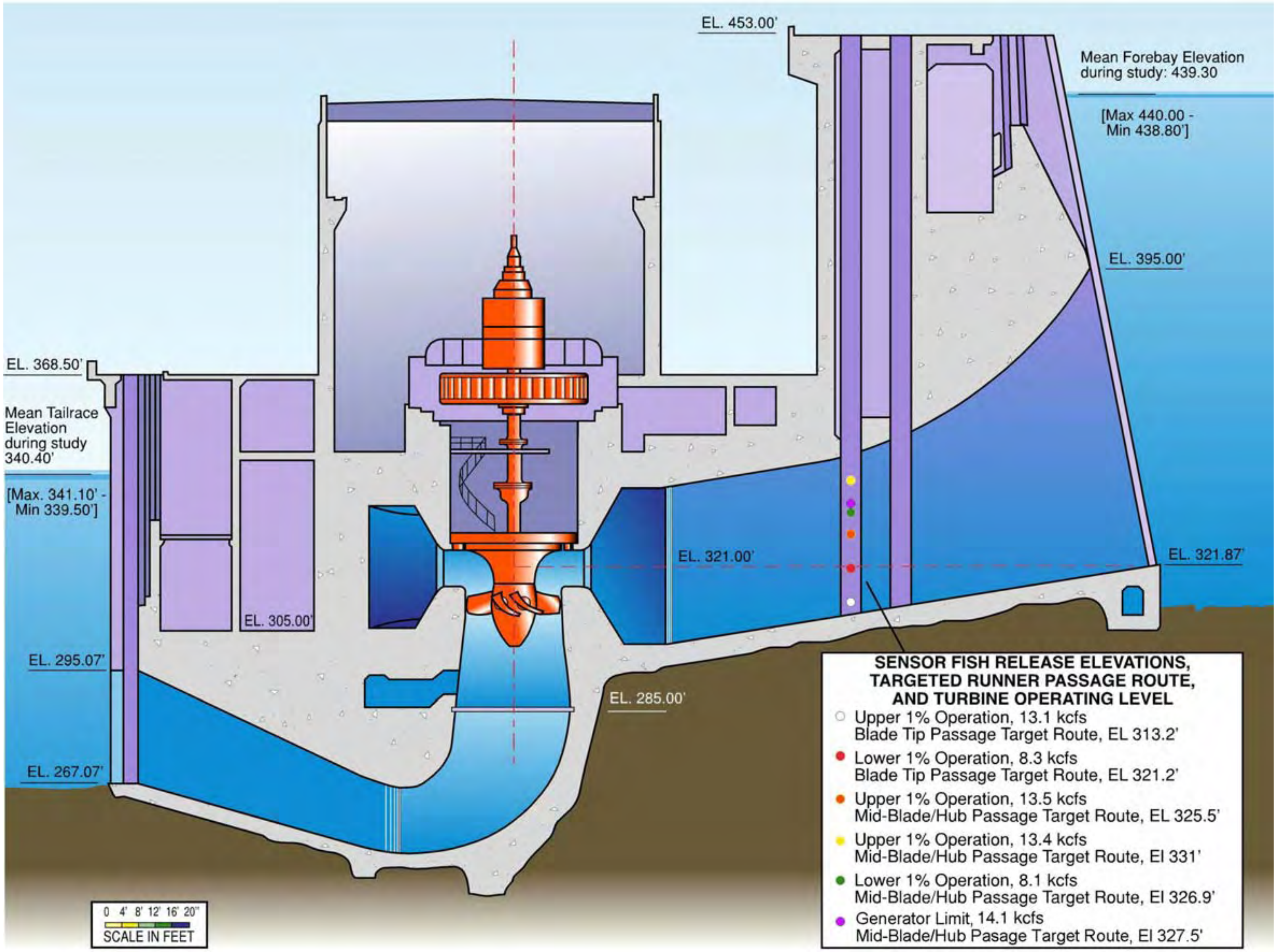


Figure 3.2. Cross section of Ice Harbor Dam Turbine Unit 2 showing Sensor Fish release elevations by turbine relative efficiency operation and runner passage route

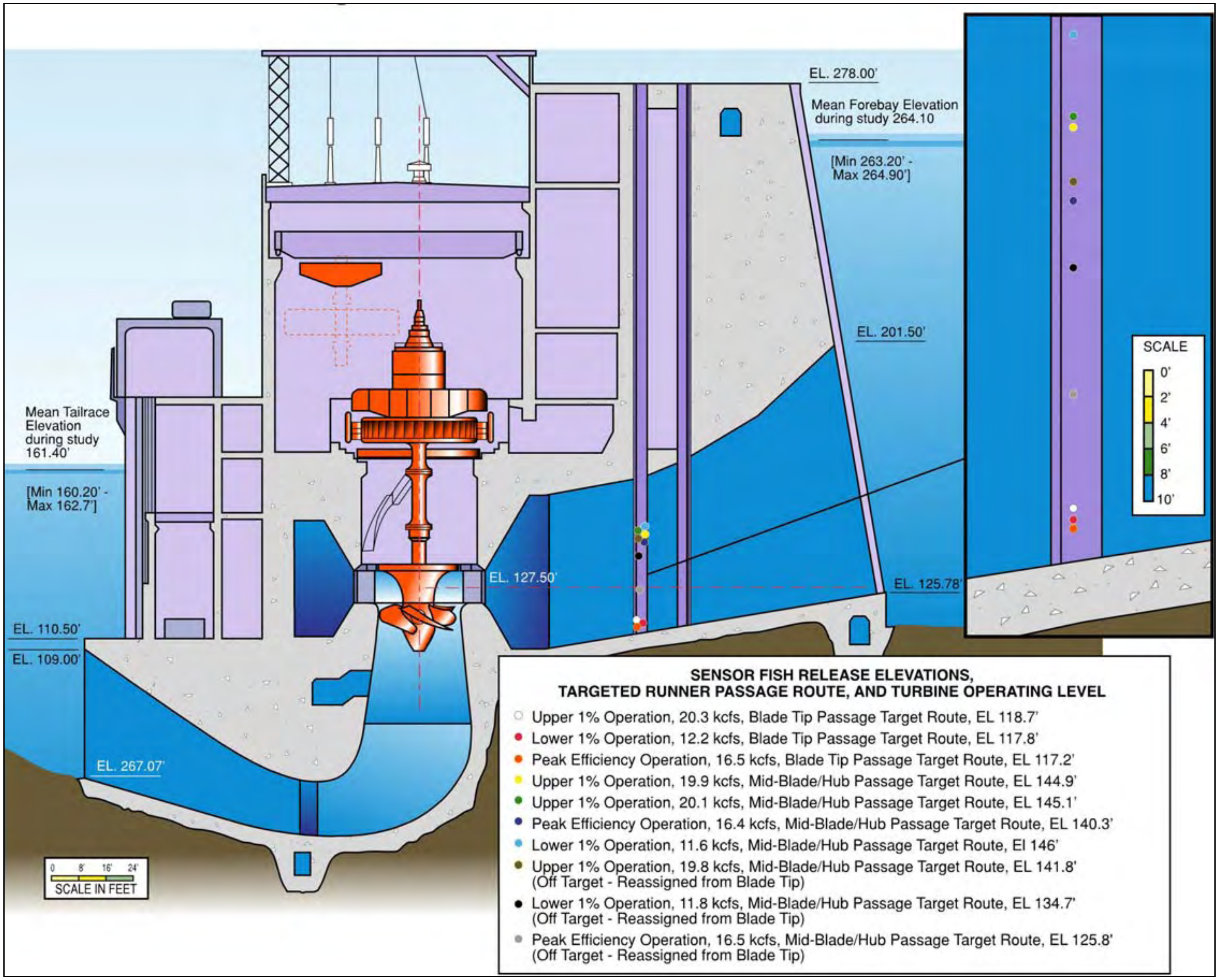


Figure 3.3. Cross section of John Day Dam Turbine Unit 9 showing Sensor Fish release elevations by turbine relative efficiency operation and runner passage route

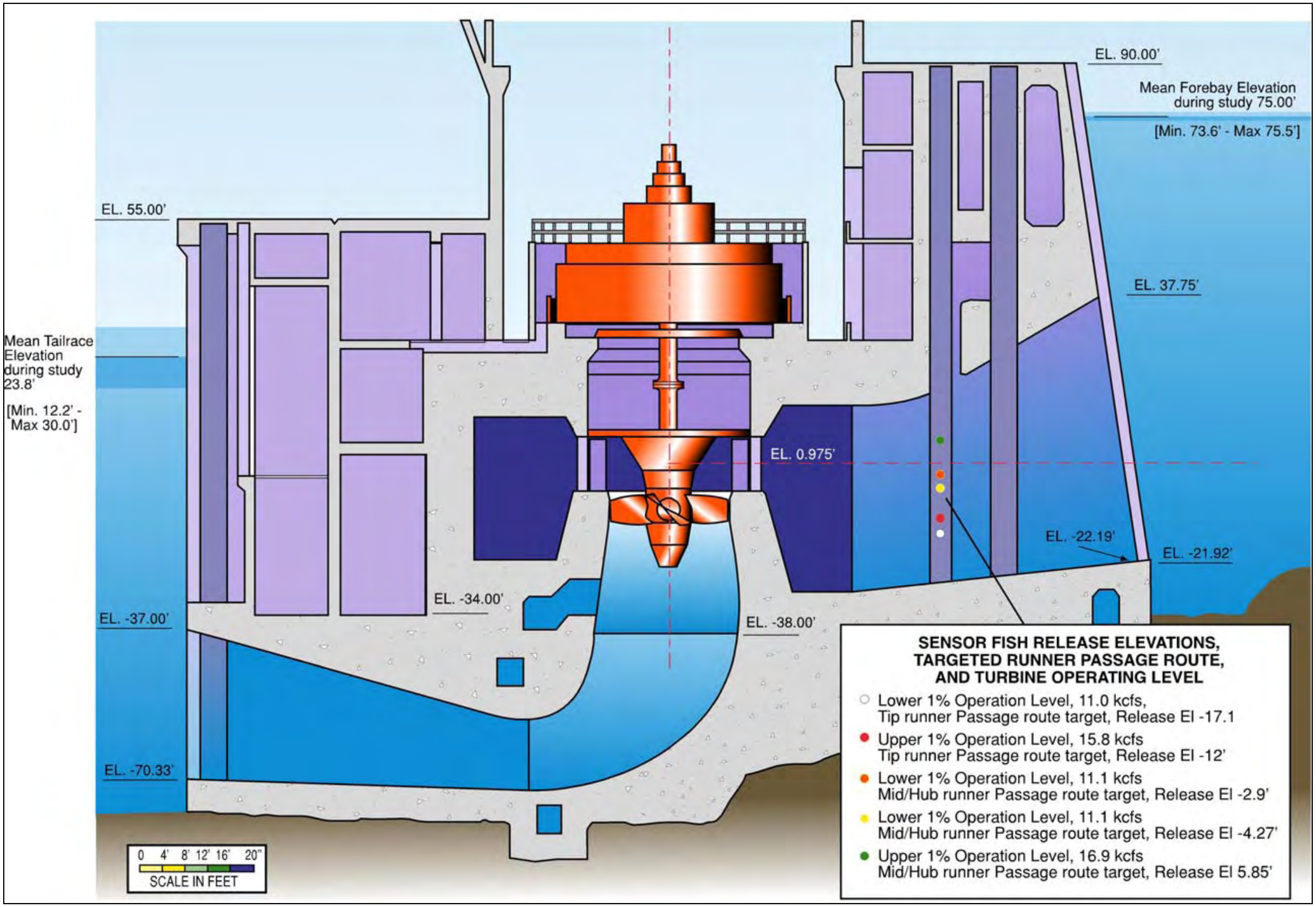


Figure 3.4. Cross section of Bonneville Powerhouse II Turbine Unit 16 showing Sensor Fish release elevations by turbine relative efficiency operation and runner passage route

Figure 3.5. Sensor Fish induction system. Left photograph shows the winching system with sounding weights attached; right top photograph shows the induction hose routing down into the turbine gate slot; right bottom photograph is the ball valve, which controls the supply of water to the Sensor Fish induction system.

3.4 Data Review

Sensor Fish data sets consist of pressure, linear acceleration (x, y, and z axes), rotation (pitch, roll, and yaw), temperature, time, and battery status time histories for each release. All sensor data sets are obtained by digital sampling at a 2-kHz rate of the various sensor analog outputs. The results are 10 time-synchronized data series, each consisting of 2,000 data points per second. The period of data acquisition was 120 seconds for all releases made during the turbine studies. The data sets acquired during this study are currently being maintained by PNNL pending transfer to USACE.

Among other uses, Sensor Fish pressure and acceleration data are used to identify the location, occurrence, and severity of collision, strike, and shear events that may occur during turbine passage. Collision and/or shear events appear as high-amplitude impulses in acceleration magnitude. To qualify as a “significant event,” a high-amplitude acceleration impulse must have a peak value ≥95 g. The criterion for classification of a collision, strike, or shear exposure as a “significant event” is based on information relating the magnitude of such events to the onset of injury to fish. This information was obtained from various laboratory studies (Deng et al. 2005).

Pressure time histories are also used to identify the approximate location of a Sensor Fish during turbine passage. Using characteristic features of pressure time histories that are present in each Sensor Fish release, the time of passage from injection pipe exit into the turbine intake, through the turbine stay vane-wicket gate cascade, the time upstream of the runner, through the runner, the runner wake, and through the draft tube are easily identified (Figure 3.6). A characteristic rapid pressure decrease is present during passage through the runner region; the pressure nadir occurs under the runner blade prior to draft tube entry. The time axis for pressure, acceleration, and rotation time histories is determined by setting the nadir in the pressure time history as time zero. Using this convention, the time history data from the same turbine at different operating conditions and release elevations or from different turbines can be directly compared.

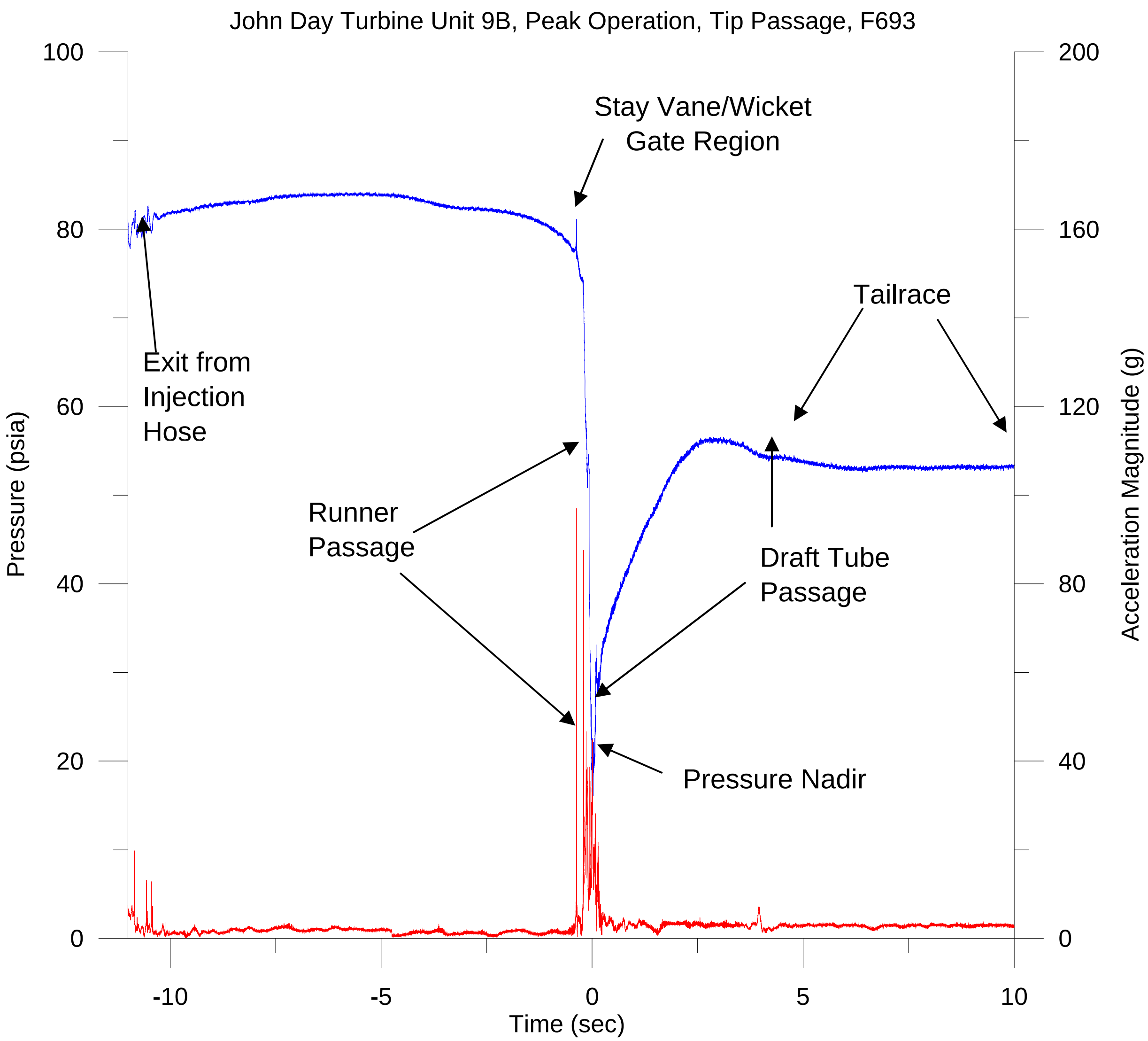


Figure 3.6. Sample of pressure and acceleration magnitude time histories acquired using a Sensor Fish device at John Day Turbine Unit 9, Intake Slot B, for peak efficiency operation and runner tip passage route. A collision event that occurred during passage through the vane/wicket gate region is shown.

4.0 Data Review Findings

A total of 764 Sensor Fish releases were made and 719 data sets were acquired (Table 4.1). Nine Sensor Fish were not recovered and 41 Sensor Fish were damaged during passage.

Table 4.1. Study design matrix showing the targeted runner passage route, turbine relative efficiency operation level, turbine discharge, number of Sensor Fish releases (sample size), and the targeted turbine intake Sensor Fish release elevations

Location	Operation	Target Turbine Runner Passage Route	Intake	Release Elevation (ft)	Discharge (kcfs)	Releases	Datasets Acquired
Ice Harbor	Lower 1%	Blade Tip	2B	321.2	8.3	30	29
Ice Harbor	Upper 1%	Blade Tip	2B	313.2	13.1	30	30
Ice Harbor	Upper 1%	Mid-Blade/Hub	2B	325.5	13.5	30	27
Ice Harbor	Upper 1%	Mid-Blade/Hub	2B	331	13.4	60	55
Ice Harbor	Lower 1%	Mid-Blade/Hub	2B	326.9	8.1	60	58
Ice Harbor	Generator Limit	Mid-Blade/Hub	3B	327.5	14.1	30	30
					Total Ice Harbor Releases	**240**	**229**
John Day	Upper 1%	Blade Tip	9B	118.7	20.3	23	23
John Day	Lower 1%	Blade Tip	9B	117.8	12.2	23	23
John Day	Peak Efficiency	Blade Tip	9B	117.2	16.5	23	19
John Day	Upper 1%	Mid-Blade/Hub	9A	144.9	19.9	27	26
John Day	Upper 1%	Mid-Blade/Hub	9A	145.1	20.1	40	35
John Day	Peak Efficiency	Mid-Blade/Hub	9A	140.3	16.4	68	66
John Day	Lower 1%	Mid-Blade/Hub	9A	146	11.6	67	60
John Day	Upper 1%	Blade Tip (off target release elevation by 22.4 ft) - Re-Assigned to Mid-Blade Passage Route for Analysis	9B	141.8	19.8	23	22
John Day	Lower 1%	Blade Tip (off target release elevation by 15.3 ft) - Re-Assigned to Mid-Blade Passage Route for Analysis	9B	134.7	11.8	23	22
John Day	Peak Efficiency	Blade Tip (off target release elevation by 7.7 ft) - Re-Assigned to Mid-Blade Passage Route for Analysis	9B	125.8	16.5	23	20
					Total John Day Releases	**340**	**316**
Bonneville 2	Upper 1%	Blade Tip	16B	-12	15.8	23	21
Bonneville 2	Lower 1%	Blade Tip	16B	-17.1	11	23	23
Bonneville 2	Lower 1%	Mid-Blade/Hub	16A	-2.9	11.1	54	51
Bonneville 2	Lower 1%	Mid-Blade/Hub	16A	-4.27	11.1	17	13
Bonneville 2	Upper 1%	Mid-Blade/Hub	16A	5.85	16.9	67	66
					Total Bonneville 2 Releases	**184**	**174**
					Total	**764**	**719**

Unforeseen problems with the injection apparatus while at John Day Dam resulted in early termination of the study in September 2005; work resumed in March 2006. The elevation of release into turbine flow from the injection hose was estimated for each Sensor Fish release using Sensor Fish pressure data under the assumption that there was no slip velocity contribution to the pressure measured by the Sensor Fish. Such release elevation estimates identified discrepancies between targeted release elevations and those realized. Supplementary releases were made at targeted release elevations to acquire the number of data sets required to achieve the sample sizes of successful Sensor Fish releases set for the study. Data obtained from off-target releases were retained and are included in archived study data. The identification information for off-target releases indicates the probable turbine runner passage route for these releases.

4.1 Pressure Time Histories

Decreases in pressure during turbine passage (rapid decompression), particularly during passage through the turbine runner, may injure or kill exposed fish. Hemorrhages caused by vein rupture, gas bubble formation in tissues and organs, and rupture of the swim bladder are a few of the potential consequences of rapid decompression that may result in temporary impairment, physical injury, or immediate or delayed mortality. Research shows that a fish's depth of acclimation when accompanied by achievement of neutral buoyancy prior to rapid decompression is a significant factor for risk of injury or death (Brown et al. 2007).

The nadir in pressure occurs during passage through the turbine runner. Figure 4.1 is a plot of nadir values for all Sensor Fish releases by dam, turbine operating point, and runner passage route. Figure 4.2 is another plot of nadir pressure data showing the median, maximum, and minimum absolute pressures.

The lowest nadir pressure values were observed at upper 1% turbine relative efficiency operations at all dams. The highest nadir pressures were observed at lower 1% relative efficiency operation at all dams. Sensor Fish observations met expectations; for any one turbine, lower nadir pressures were more common for higher discharges through blade-tip runner passage routes. It was also expected that there would be differences observed between dams, with Bonneville turbines being more different than turbines at mainstem dams. These trends were also seen in the Sensor Fish data.

Cumulative nadir pressure distributions were calculated for each dam, operating condition, and runner passage route. For each dam, Figure 4.3 shows the cumulative nadir pressure distributions for the lower 1% turbine operation. Figure 4.4 shows the nadir pressure distributions for the upper 1% turbine operational level for each dam. Turbine runner passage nadir pressures do not appear to be normally distributed. The distribution appears to be more noncentral in nature, such as seen in a chi-squared distribution, with a small but finite probability for values in the decreasing, low nadir, end of the distribution. However, the sample sizes used to generate these cumulative distributions are too small to enable any final conclusion about the nature of nadir pressure distributions.

The pressure rate of change during turbine runner passage was calculated for each Sensor Fish run using a consistent 0.05-second time segment during sensor passage through the turbine runner immediately before the nadir in pressure was reached. Figure 4.5 shows the median, maximum, and minimum turbine runner passage pressure rate of change by dam, turbine operation, and runner passage route. Observed pressure rates of change did not show the same trends with respect to runner passage route and turbine operations as do nadir pressures. However, as was the case for nadir pressure, pressure rates of change for the Bonneville test turbine were noticeably lower for all tested conditions than those observed for Ice Harbor and John Day dams.

The complex relationship between the pressure rates of change and nadir pressures during passage through the turbine runner is a reflection of the complex three dimensional, time-dependent distribution of pressure within a turbine runner. The distribution of pressure within a turbine runner has been simulated using CFD (Figure 4.6). The pressure data represented in Figure 4.6 are for a generic Kaplan turbine and are not representative of the exact turbine conditions observed in the Ice Harbor, John Day, or Bonneville Powerhouse II turbines.

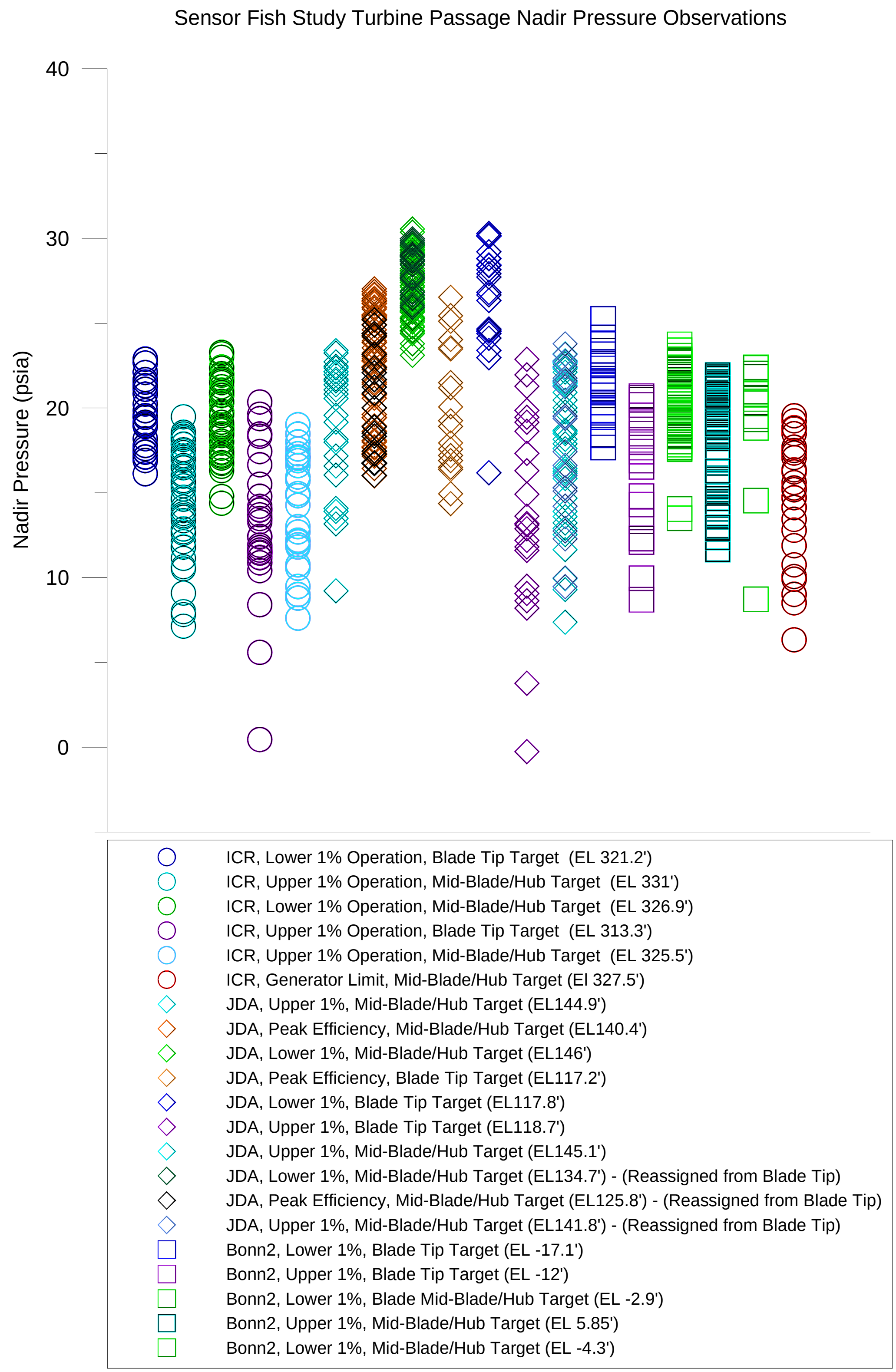


Figure 4.1. Nadir pressures (psia) observed for each Sensor Fish release by turbine relative efficiency operation and runner passage route

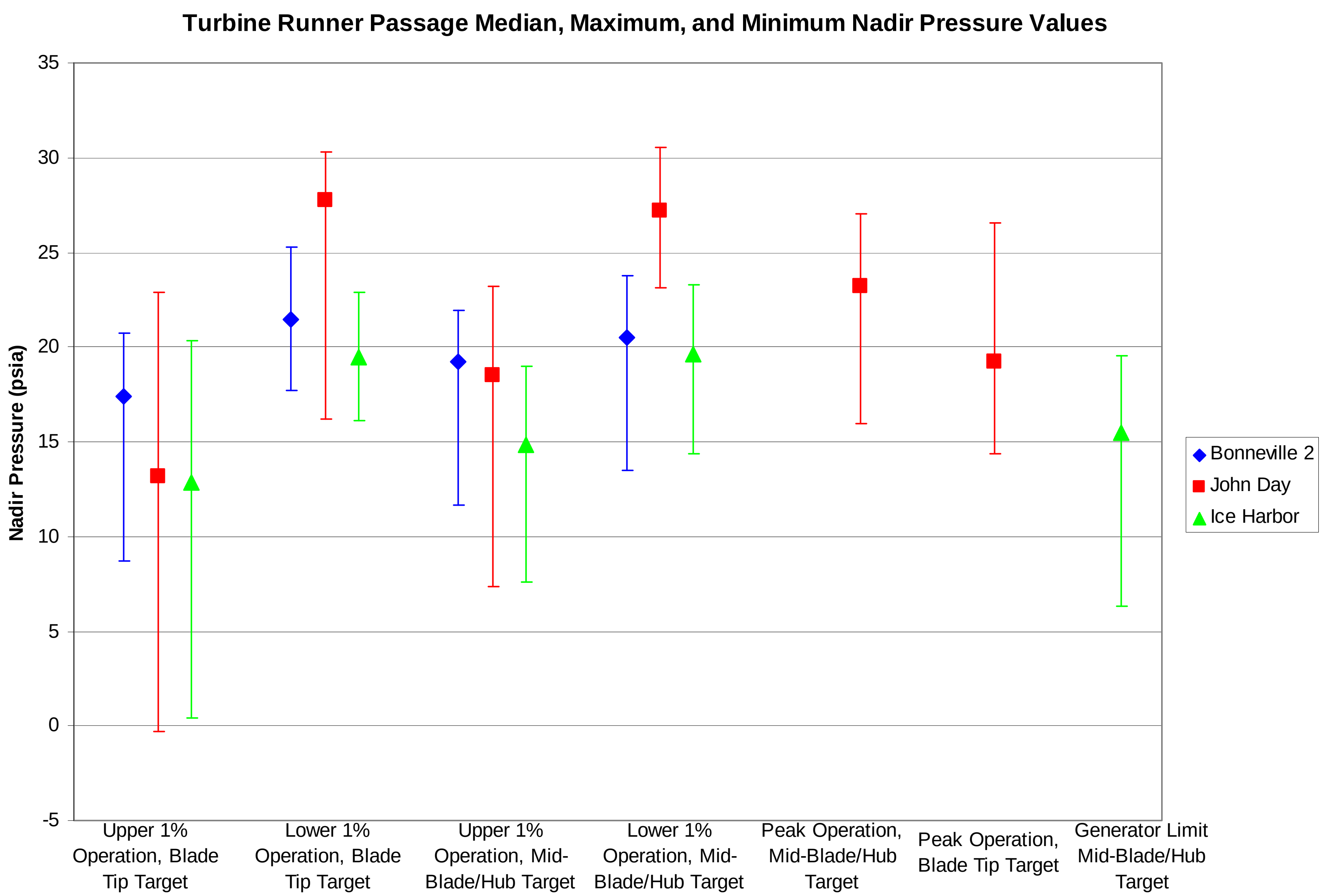
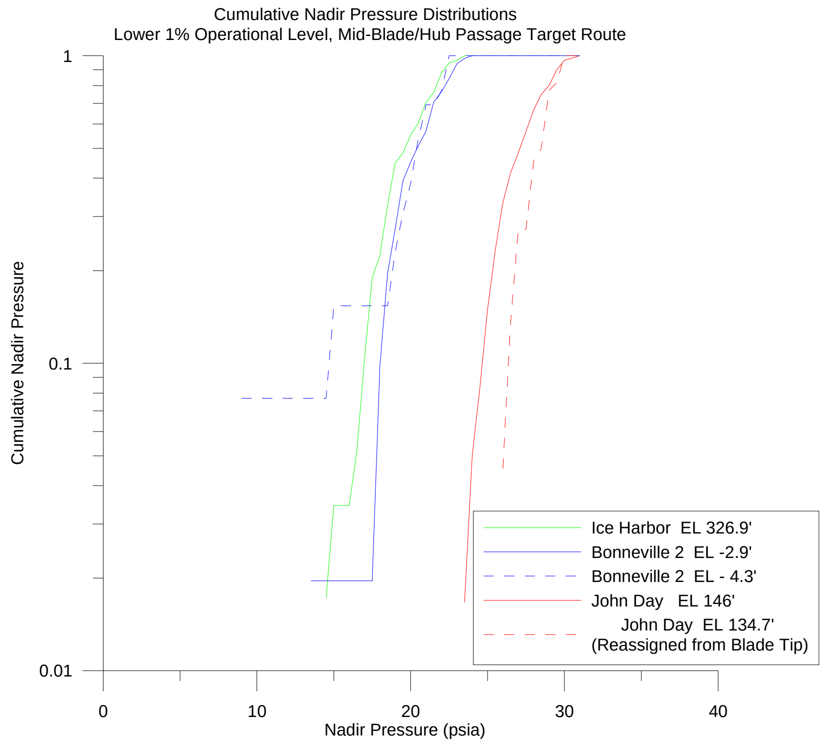


Figure 4.2. Median, maximum, and minimum nadir pressures observed for Sensor Fish releases by turbine relative efficiency operation and runner passage route



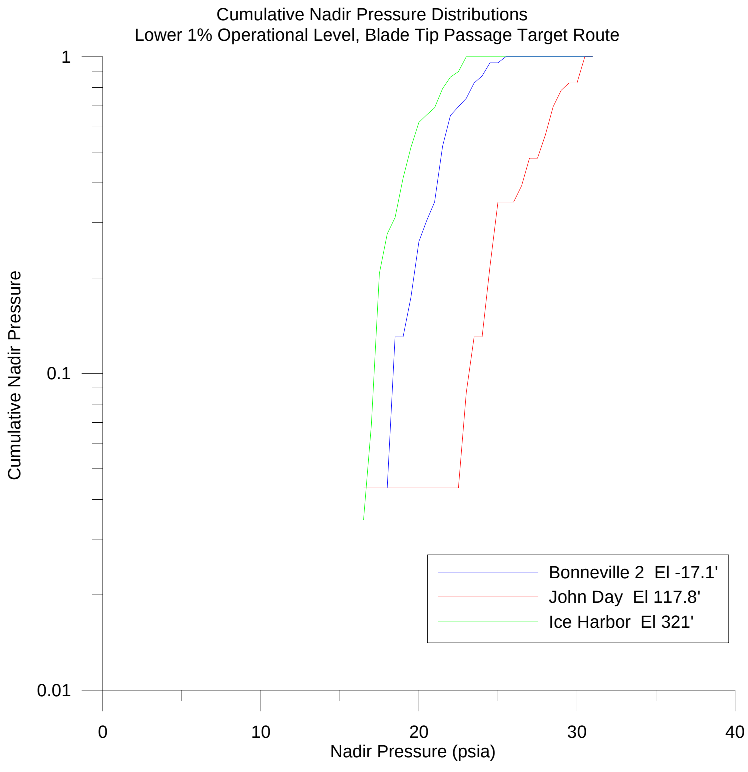
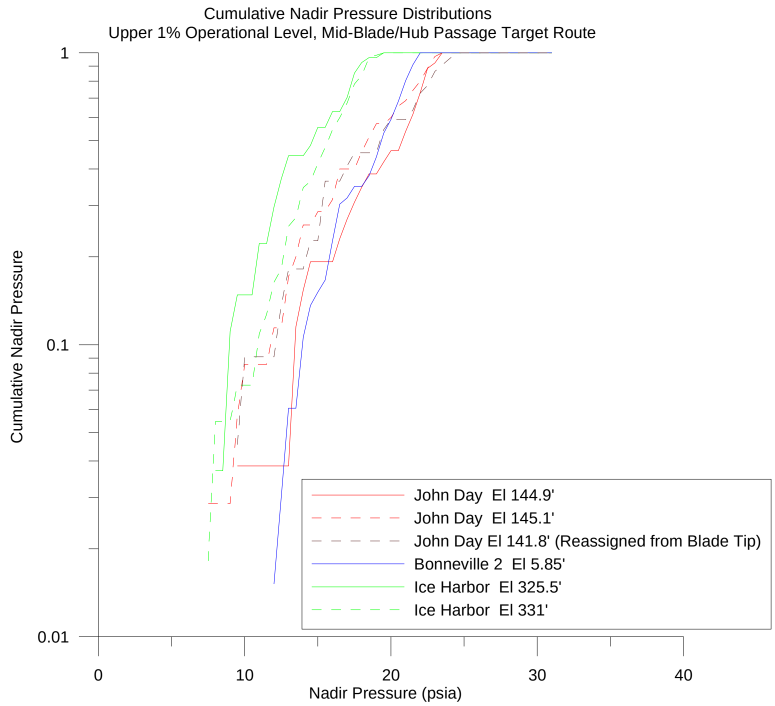


Figure 4.3. Cumulative nadir pressure distributions for lower 1% relative efficiency turbine operation level by dam. The top graphic shows the nadir cumulative distribution for the mid-blade/hub runner passage route. The bottom graphic shows nadir the cumulative distribution for the runner blade tip passage route.



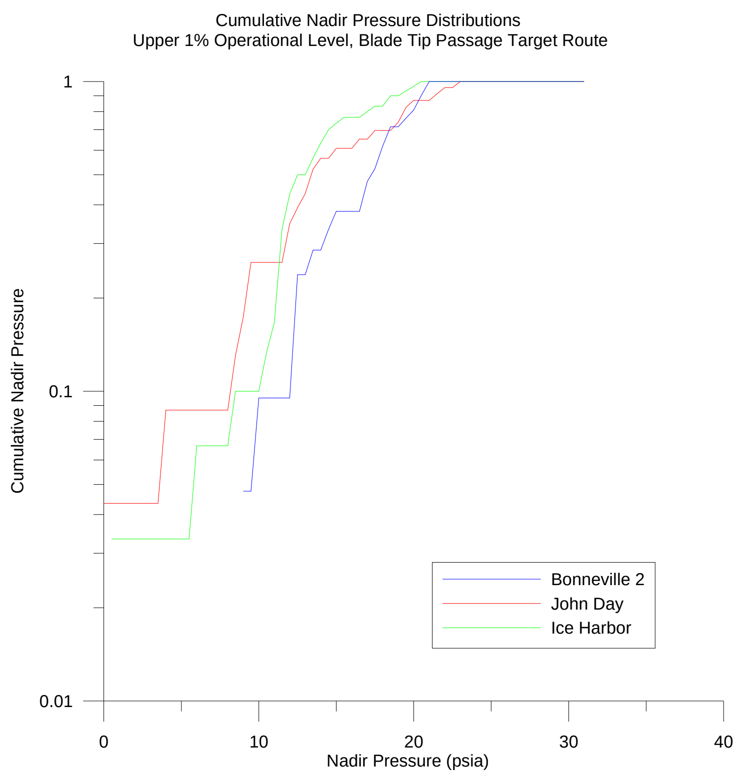


Figure 4.4. Cumulative nadir pressure distributions for upper 1% relative efficiency turbine operation by dam. The top graphic shows the nadir cumulative distribution for the mid-blade/hub runner passage route. The bottom graphic shows the nadir cumulative distribution for the runner blade tip passage route.

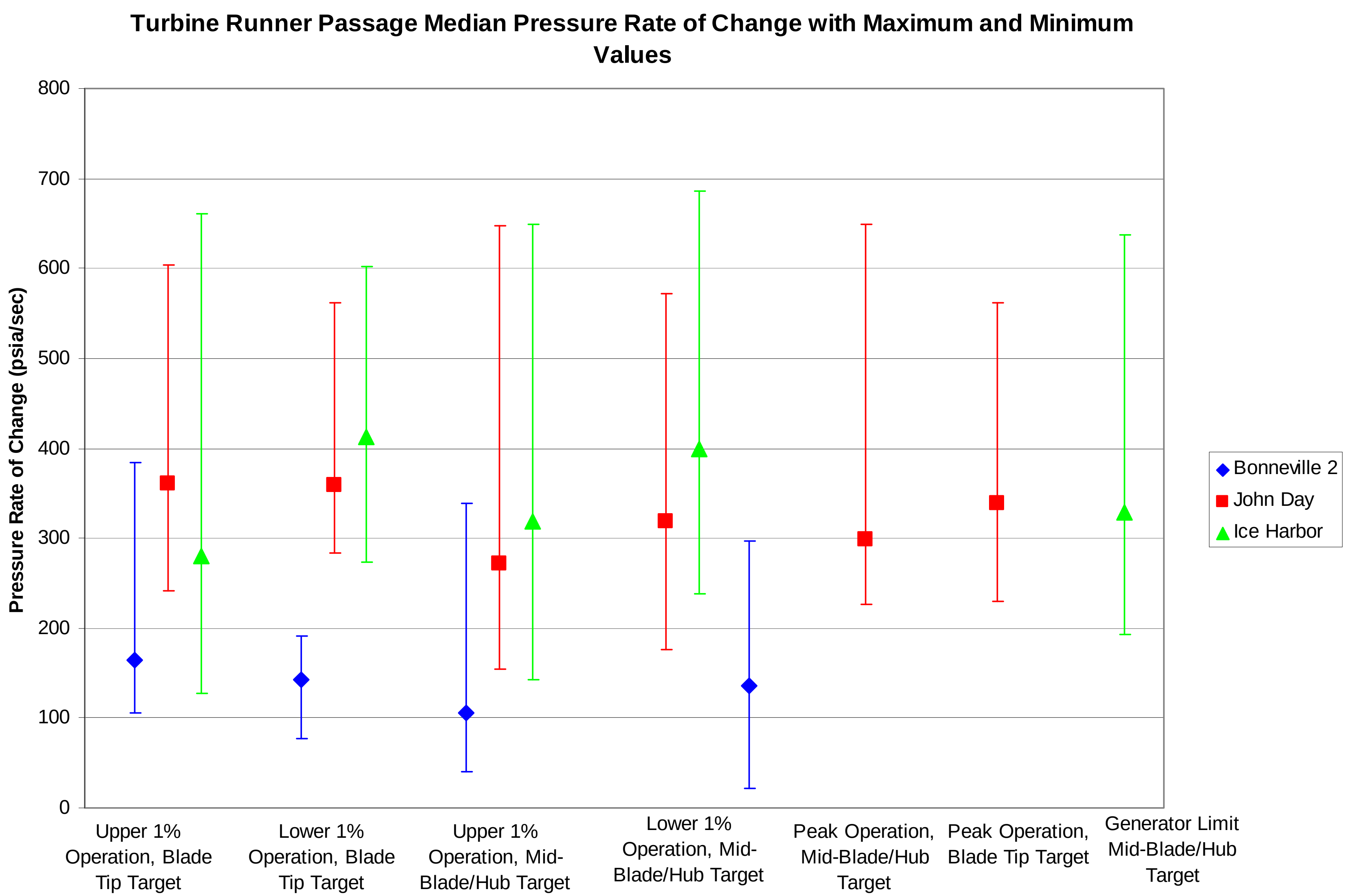


Figure 4.5. Median, maximum, and minimum turbine runner pressure rates of change for all dams by turbine relative efficiency operation and runner passage route

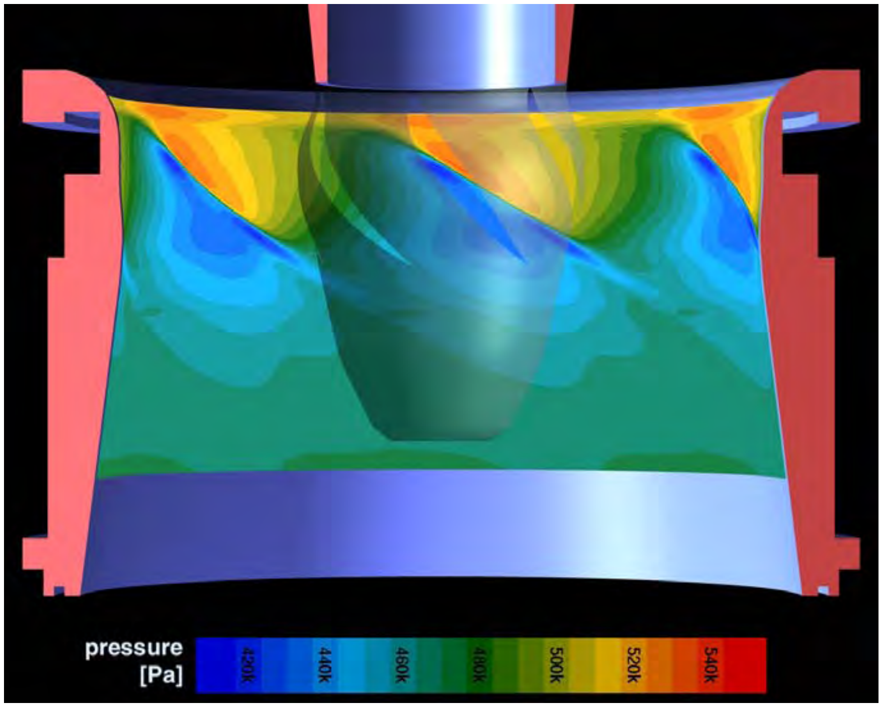


Figure 4.6. Simulated pressure distributions in the runner region of a Kaplan turbine showing the decrease in pressure from the leading edge to the trailing edge of the blade on the upper face of the runner blades and the low pressure region below the blade (101,325 Pa = 1 atmosphere = 14.7 psi) (Simulation and data copyright by Sulzer Hydro, Ltd. [Escher Wyss]; visualizations and images copyright by ETH Zurich, SCSC.)

The highest pressures in a turbine runner are observed on the upper faces of the turbine blades where water passing through the turbine distributor initially comes in contact with the turbine runner. This is called the pressure side of the runner blades. The lower surface of the turbine blades is called the suction side. The differential in pressure between the pressure and suction sides provides the force differential required to rotate the turbine runner and generator parts required to generate electricity. Fish passing through the turbine runner experience a rapid decrease in pressure, where the lowest pressure experienced depends on their route. Fish that pass closest to the suction side of the runner blades experience the lowest nadir pressures.

A scatter plot of the pressure rate of change versus the nadir for all dams, turbine operations, and runner passage routes is shown in Figure 4.7. These data show that the pressure environment within turbine runners at Bonneville is different than that at John Day and Ice Harbor. In particular, pressure rates of change are lower and the range of nadir values is less for Bonneville II turbines than those for the other two dams.

Figure 4.8, Figure 4.9, Figure 4.10, Figure 4.11, and Figure 4.12 are scatter plots of the pressure rate of change versus the pressure nadir by dam, turbine operation, and runner passage route. With the exception of a couple of cases for Bonneville, there is a trend of lower nadir pressures being associated with higher rates of change in pressure. This trend is likely the result of a steeper gradient in pressure when a sensor passes closer to the suction side of a runner blade. The statistics for the linear fits to the data shown in the figures are given in Table 4.2.

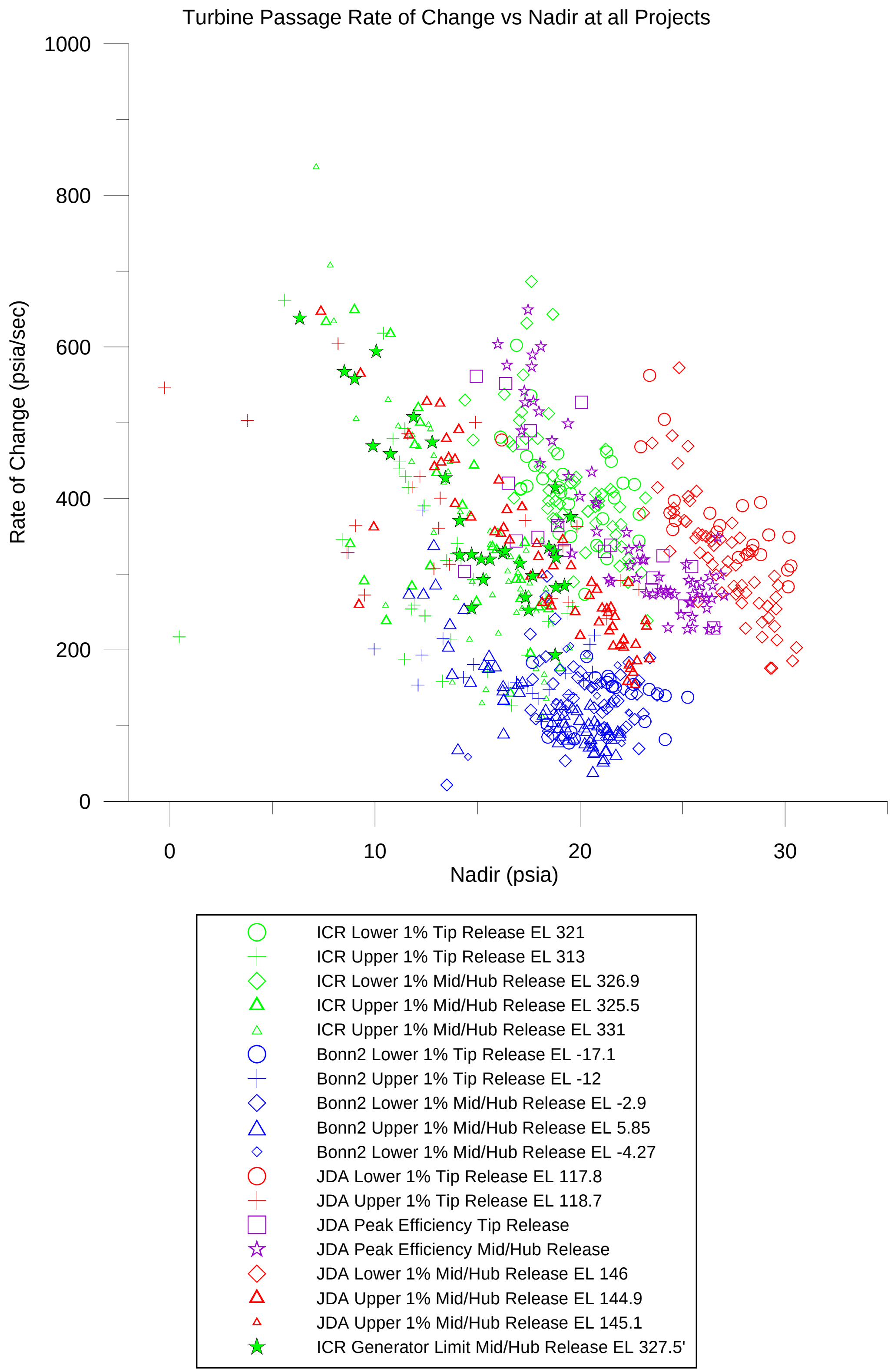


Figure 4.7. Turbine runner passage pressure rate of change by nadir pressure for all dams, turbine relative efficiency operations, and runner passage routes

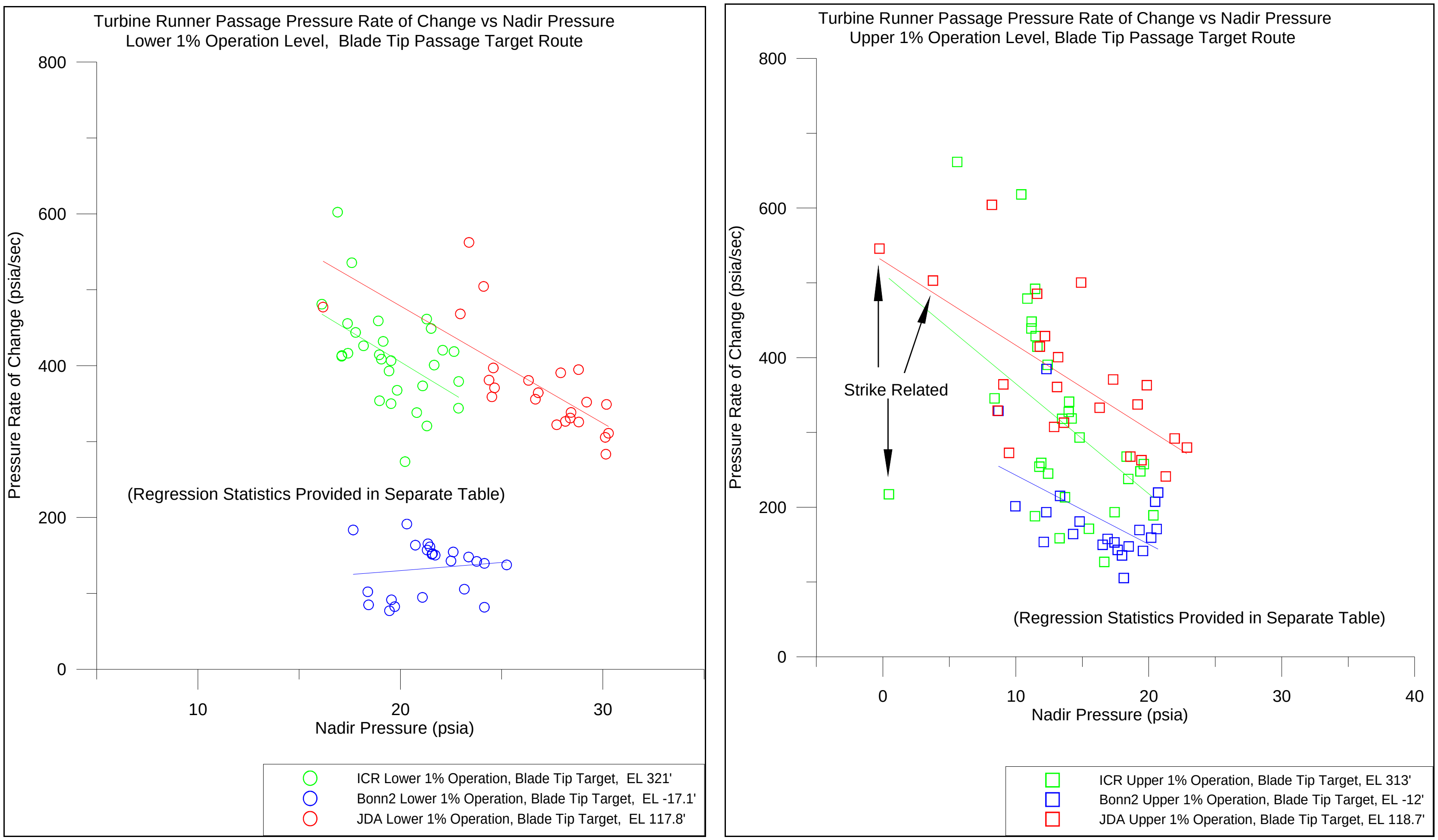


Figure 4.8. The turbine runner passage rate of change by nadir pressure for all dams. Results for the lower 1% relative efficiency turbine operation and runner blade tip passage route are on the left and those for upper 1% relative efficiency turbine operation and runner blade tip passage route are on the right.

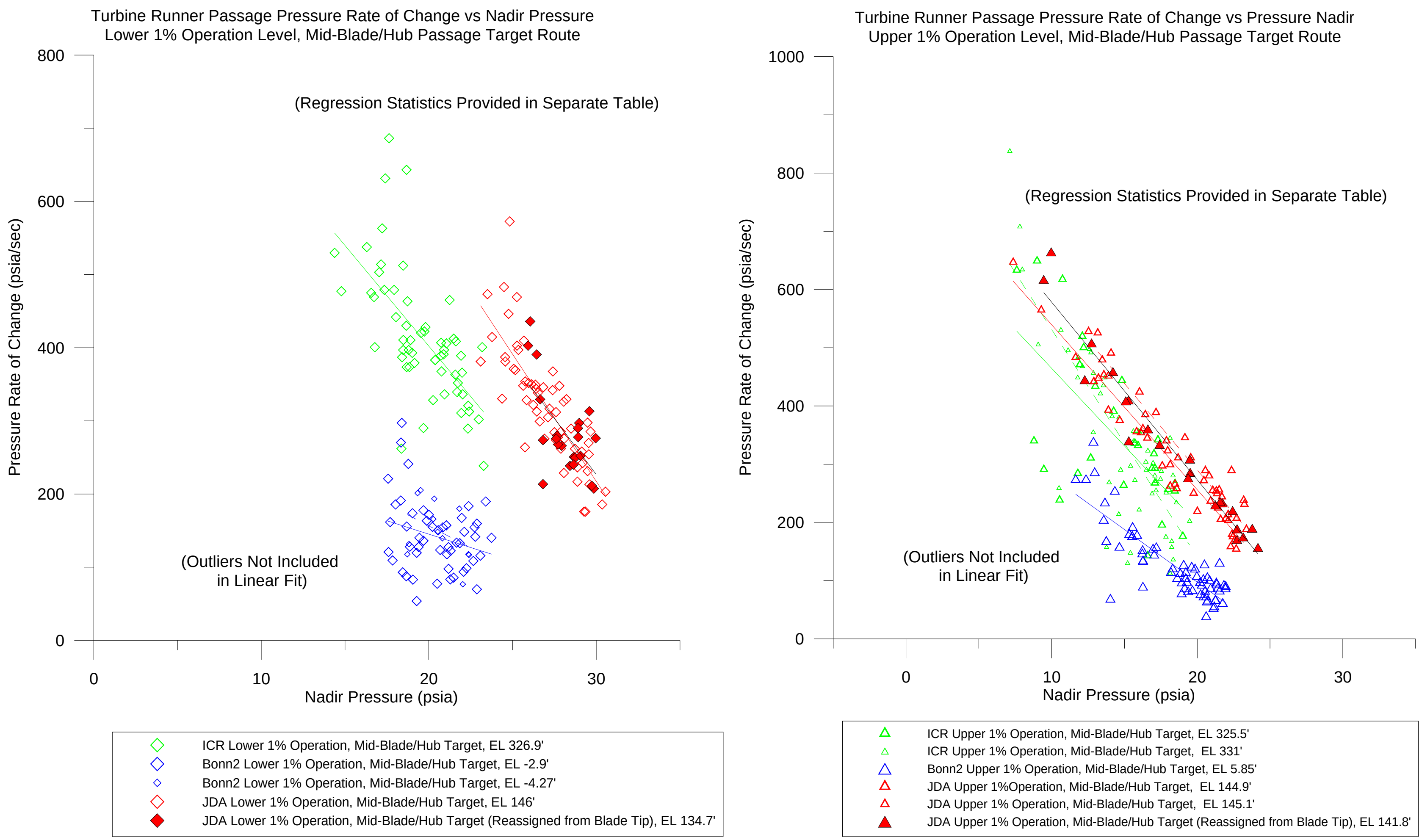


Figure 4.9. The turbine runner passage rate of change by nadir pressure for all dams. Results for the lower 1% relative efficiency turbine operation and runner mid-blade/hub passage route are on the left and those for upper 1% relative efficiency turbine operation and runner mid-blade/hub passage route are on the right.

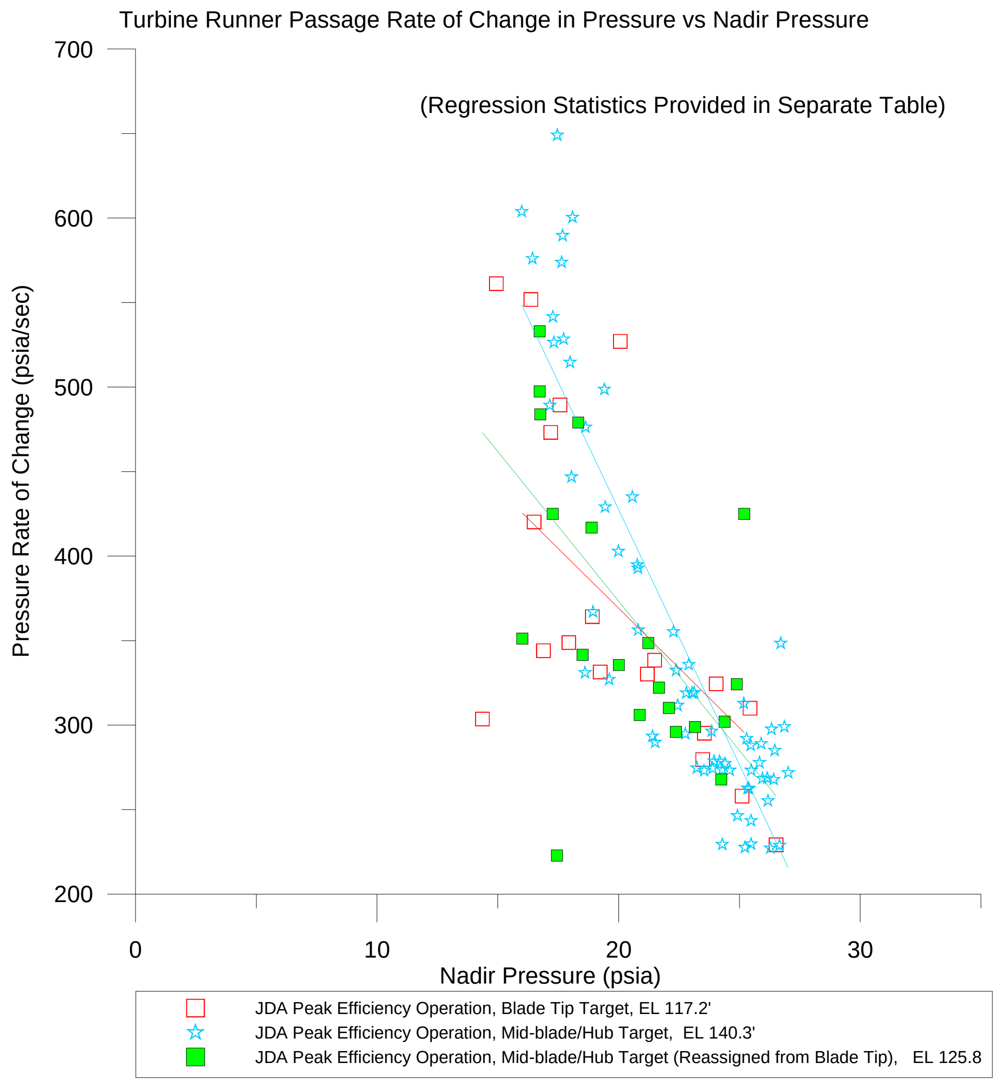


Figure 4.10. The turbine runner passage rate of change by nadir pressures for John Day Dam, targeted mid-blade/hub and blade tip passage routes, and peak efficiency operational levels

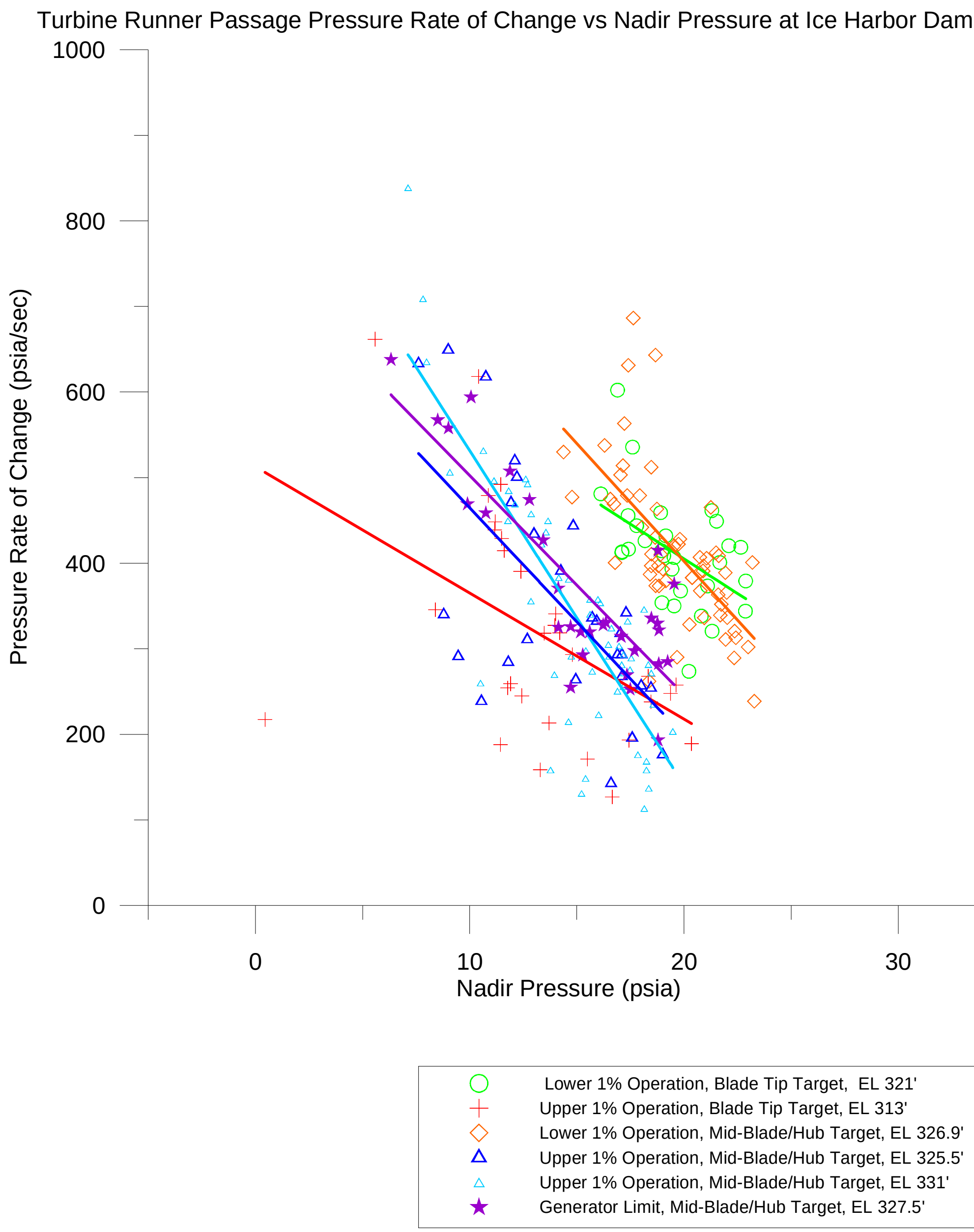


Figure 4.11. The turbine runner passage rate of change by nadir pressures for targeted mid-blade/hub and blade tip passage routes and generator limit operational levels at Ice Harbor Dam

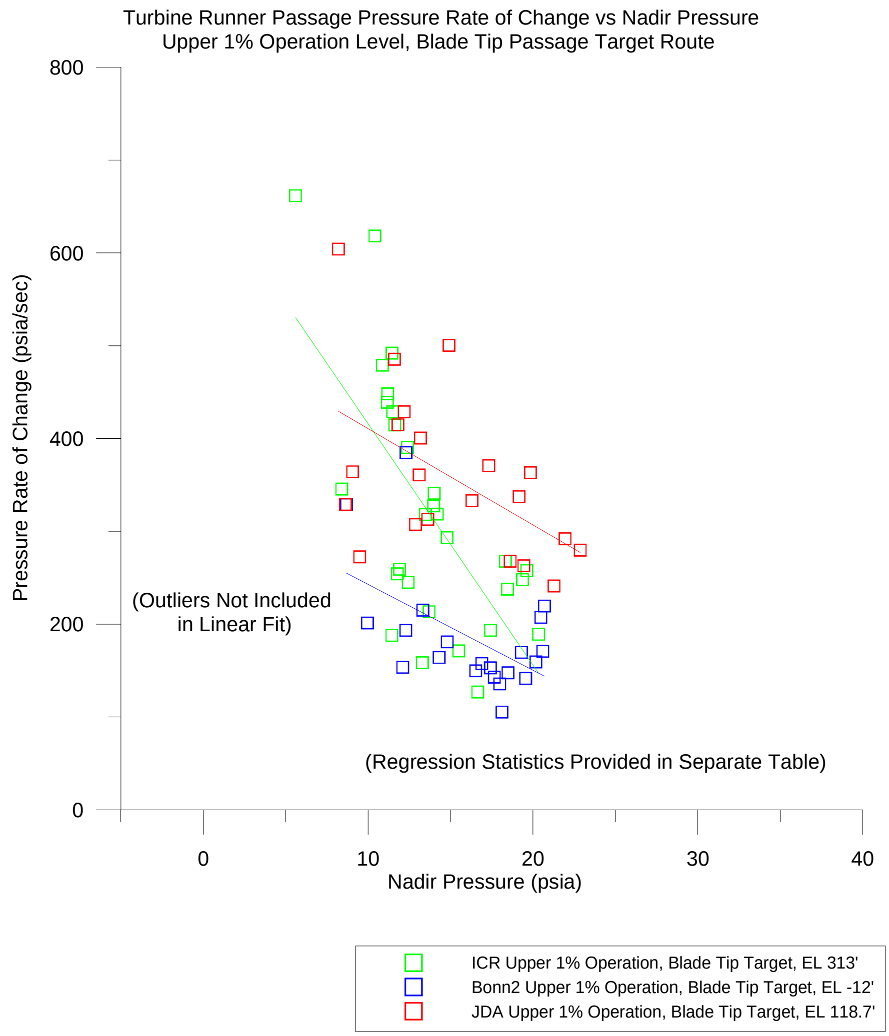


Figure 4.12. The turbine runner passage rate of change by nadir pressure for all dams, runner blade tip passage route, and upper 1% relative efficiency turbine operation

Table 4.2. Slope, intercept, and R^2 values for all linear fits to pressure rate of change by nadir shown in Figures 4.8 through 4.12

Location	Operation	Target Turbine Runner Passage Route	Elevation (ft)	Discharge (kcfs)	# of Samples	Slope	Intercept	R^2, Coefficient of Determination	
Ice Harbor	Lower 1%	Blade Tip	321.2	8.3	29	-16.229	729.646	0.2446	
Ice Harbor	Upper 1%	Blade Tip	313.2	13.1	30	-14.741	512.582	0.2162	
Ice Harbor*	Upper 1%	Blade Tip	313.2	13.1	29	-25.987	675.82	0.4585	without outlier
Ice Harbor	Upper 1%	Mid-Blade/Hub	325.5	13.5	27	-26.646	731.168	0.4275	
Ice Harbor	Upper 1%	Mid-Blade/Hub	331	13.4	55	-39.069	922.141	0.6629	
Ice Harbor	Lower 1%	Mid-Blade/Hub	326.9	8.1	58	-27.499	952.237	0.4286	
Ice Harbor	Generator Limit	Mid-Blade/Hub	327.5	14.1	30	-25.65	758.978	0.7064	
John Day	Upper 1%	Blade Tip	118.7	20.3	23	-11.278	529.382	0.4499	
John Day	Lower 1%	Blade Tip	117.8	12.2	23	-15.438	787.415	0.5485	
John Day	Peak Efficiency	Blade Tip	117.2	16.5	19	-17.694	727.249	0.4365	
John Day	Upper 1%	Mid-Blade/Hub	144.9	19.9	26	-20.2	689.447	0.5874	
John Day	Upper 1%	Mid-Blade/Hub	144.9	19.9	25	-29.735	884.804	0.9255	without outlier
John Day	Upper 1%	Mid-Blade/Hub	145.1	20.1	35	-26.211	780.304	0.8875	
John Day	Upper 1%	Mid-Blade/Hub	145.1	20.1	34	-28.344	823.11	0.9435	without outlier
John Day	Peak Efficiency	Mid-Blade/Hub	140.3	16.4	66	-30.169	1030.925	0.7768	
John Day	Lower 1%	Mid-Blade/Hub	146	11.6	60	-34.806	1261.577	0.6742	
John Day	Upper 1%	Mid-Blade/Hub*	141.8	19.8	22	-30.511	883.48	0.9501	
John Day	Lower 1%	Mid-Blade/Hub*	134.7	11.8	22	-30.582	1144.349	0.4088	
John Day	Peak Efficiency	Mid-Blade/Hub*	125.8	16.5	20	-14.133	651.801	0.2602	
Bonneville 2	Upper 1%	Blade Tip	-12	15.8	21	-9.245	335.32	0.2756	
Bonneville 2	Lower 1%	Blade Tip	-17.1	11	23	2.138	87.301	0.0152	
Bonneville 2	Lower 1%	Mid-Blade/Hub	-2.9	11.1	51	-1.493	169.963	0.0034	
Bonneville 2*	Lower 1%	Mid-Blade/Hub	-2.9	11.1	50	-7.303	291.253	0.0703	without outlier
Bonneville 2	Lower 1%	Mid-Blade/Hub	-4.27	11.1	13	5.059	40.837	0.0539	
Bonneville 2*	Lower 1%	Mid-Blade/Hub	-4.27	11.1	12	-11.975	396.029	0.1587	without outlier
Bonneville 2	Upper 1%	Mid-Blade/Hub	5.85	16.9	66	-18.092	459.192	0.7055	
		* Reassigned							

4.2 Significant Events

Collision and/or shear events appear as high-amplitude impulses in acceleration magnitude time histories. To qualify as a "significant event," a high-amplitude acceleration impulse must have a peak value ≥95 g. The location of a significant event during turbine passage is determined by the location of the event's impulse relative to distinctive, consistent features in pressure time histories that are associated with the physical conditions of turbine flow at specific locations. An important "timing mark" is the turbine runner pressure nadir, which is present in every pressure time history. The pressure nadir is used to standardize the time line for Sensor Fish time history data. It is set at zero with time between injection of the sensor into turbine intake flow to the nadir in runner passage having negative time and that from the nadir to the tailrace having positive time. Figure 4.13 shows an example of Sensor Fish passage through Turbine Unit 2 at Ice Harbor Dam for a 4-second time period around the pressure nadir, showing pressure and acceleration magnitude time histories. Several significant events are evident; the first is contact between the Sensor Fish and a wicket gate, followed by several events, either structural contact or shear immediately before, during, and immediately after runner passage. All significant events detected during the data review are reported in the appendixes of this report.

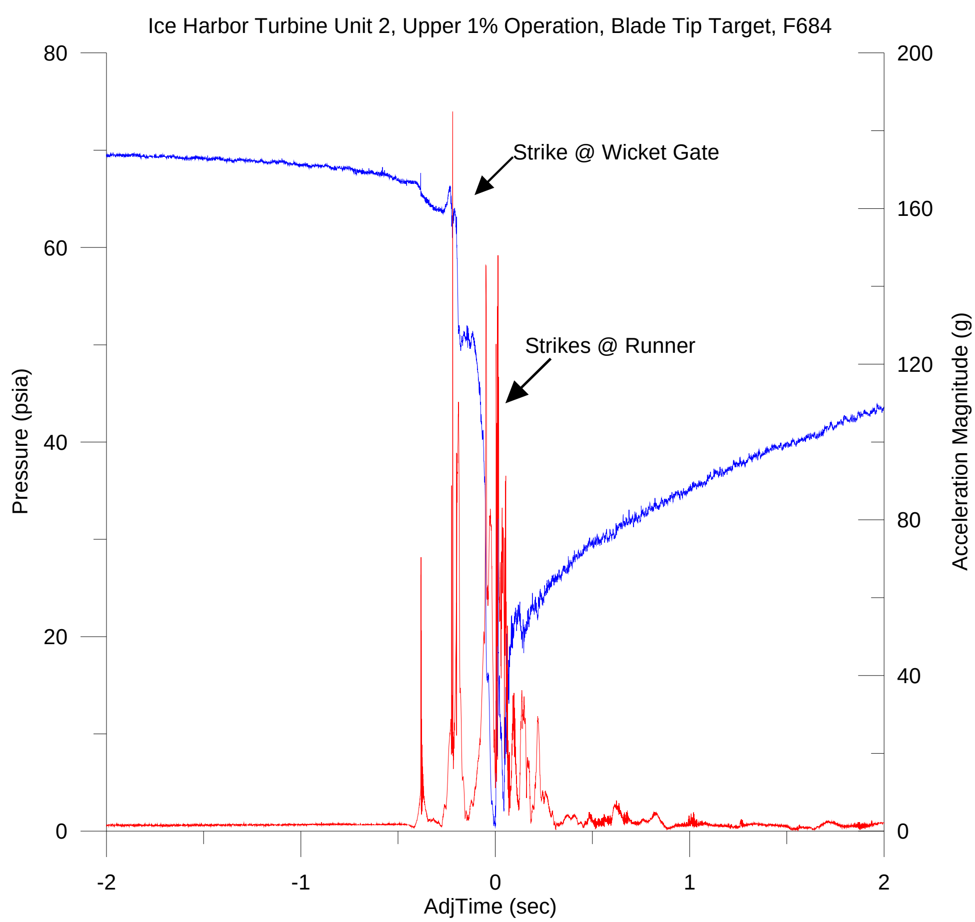


Figure 4.13. Example of Sensor Fish pressure and acceleration magnitude time histories for passage through Ice Harbor Turbine Unit 2 at a turbine relative efficiency upper 1% operations and blade tip runner passage route. Significant events are observed in the wicket gate and runner regions.

4.3 Quality of Flow

Quality of flow is a quantitative assessment of a Sensor Fish's response to turbulence as measured by acceleration and rotation sensors. Thresholds to classify flow quality as good or poor are indexes only because they are not directly related to factors that might impact fish health. However, quality of flow assessment is a summary of the physical conditions within turbine flow and provides another factor that is helpful in ranking turbine operations for fish passage safety. When acceleration magnitude values exceed 50 g or angular rate of change (rotation) magnitude values are greater than 1500 degrees/second, the quality of flow is regarded as poor or less than optimal for juvenile fish passage. Quality of flow was determined for the following turbine passage regions: stay vanes to runner entrance, runner entrance to draft tube entrance, draft tube entrance to draft tube exit, draft tube exit through the tailrace backroll, and the total turbine passage environment (i.e., all regions previously mentioned).

Figure 4.14 presents the exceedance of quality of flow acceleration and rotation thresholds by dam, turbine operation, and runner passage route. Exceedance, as it is used here, is the percent of Sensor Fish releases where the acceleration and rotation values exceeded the quality of flow thresholds. Overall, John Day and Ice Harbor turbines appear to have a higher exceedance of poor quality of flow than do Bonneville turbines.

Figure 4.15, Figure 4.16, Figure 4.17, and Figure 4.18 show quality of flow exceedance for all dams by turbine operation and runner passage route. Figure 4.15 shows the lower 1% operation, targeted blade tip region, where the runner portion of the passage route shows the lowest quality of flow, for all dams. Figure 4.16 shows the upper 1% operation, targeted blade tip region where Bonneville Powerhouse II passage has the best quality of flow and flow conditions in the John Day turbine exceed quality of flow thresholds most often. For the lower 1% relative efficiency operation, targeted mid-blade/hub runner passage route (Figure 4.17), quality of flow is generally good, with some variation within turbine regions. Figure 4.18 shows the quality of flow exceedance for the upper 1% relative efficiency operating condition and the mid-blade/hub runner passage route. At these conditions, exceedances are similar to conditions at lower 1% relative efficiency turbine operation with each turbine region exhibiting a quality of flow exceedance of less than 70%. In general, quality of flow was better for the hub/mid-blade runner passage route at all dams and at Bonneville for all turbine operations and runner passage routes.

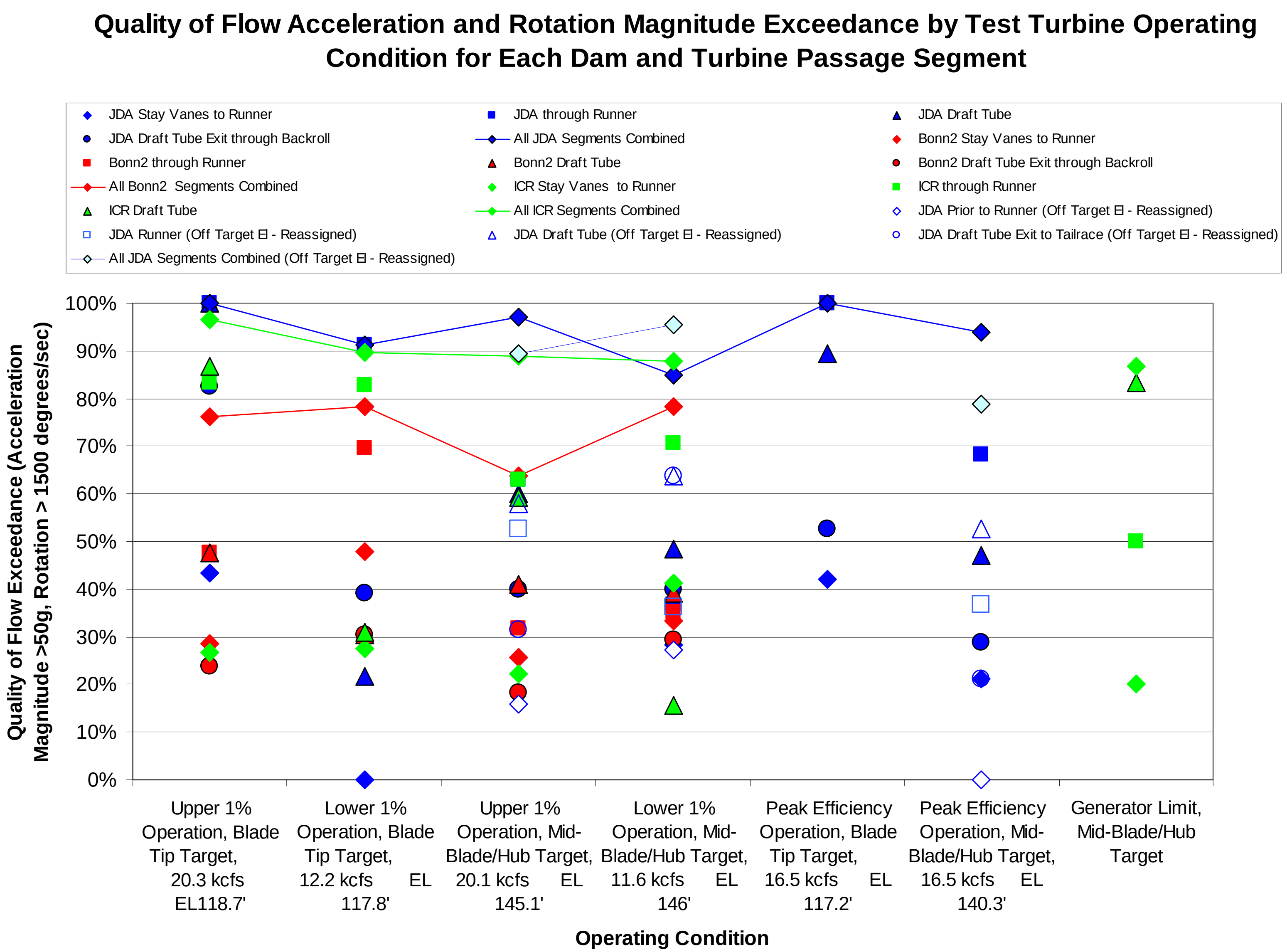


Figure 4.14. Percent (exceedance) of Sensor Fish releases by dam, turbine relative efficiency operation, and runner passage route of quality of flow thresholds (i.e., acceleration magnitudes >50 g or rotations >1500 degrees/second)

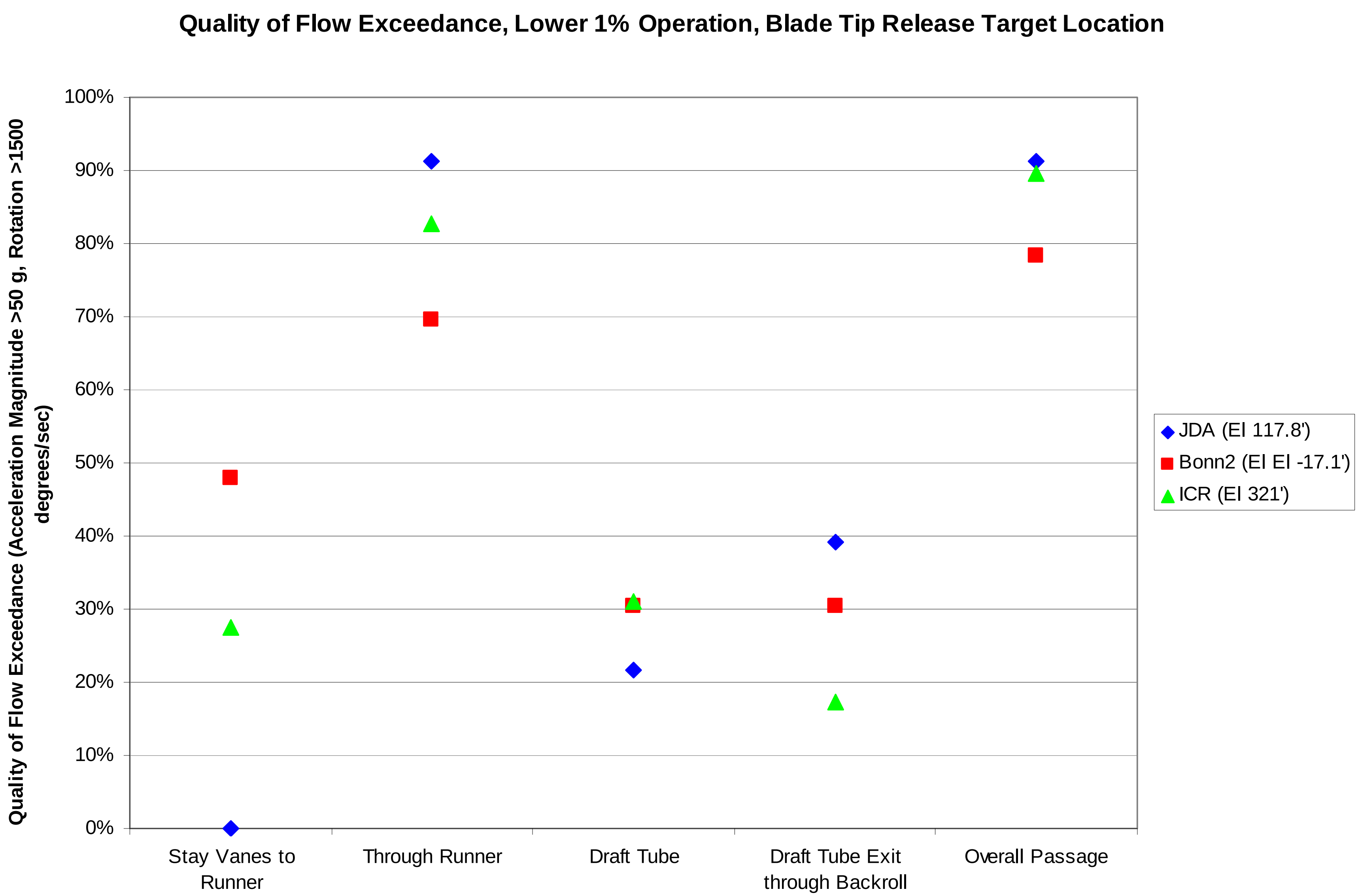


Figure 4.15. Percent (exceedance) of Sensor Fish releases by dam for turbine relative efficiency lower 1% operation and runner blade tip passage route that exceeded quality of flow thresholds (i.e., acceleration magnitudes >50 g or rotations >1500 degrees/second)

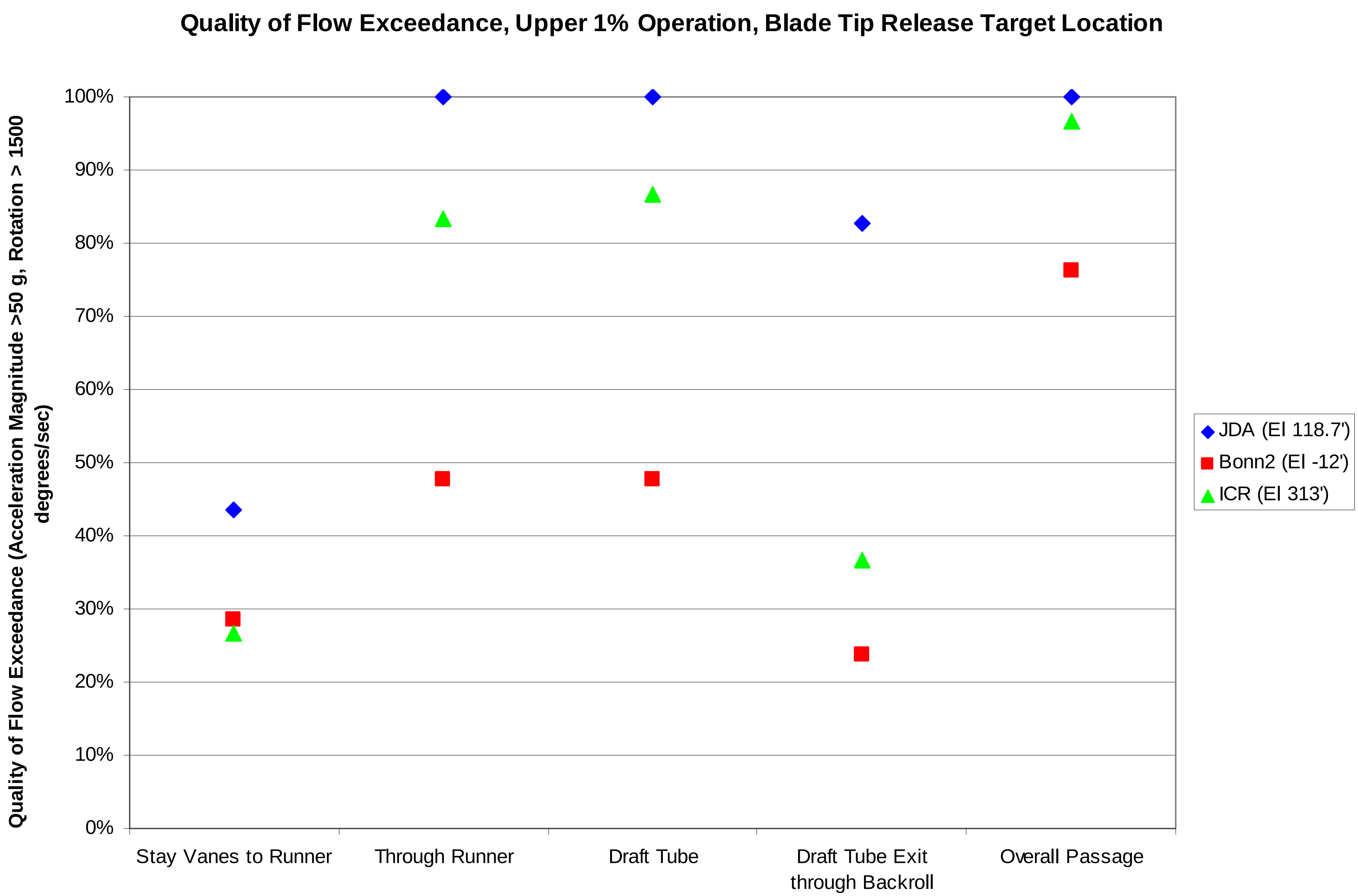


Figure 4.16. Percent (exceedance) of Sensor Fish releases by dam for turbine relative efficiency upper 1% operation and runner blade tip passage route that exceeded quality of flow thresholds (i.e., acceleration magnitudes >50 g or rotations >1500 degrees/second)

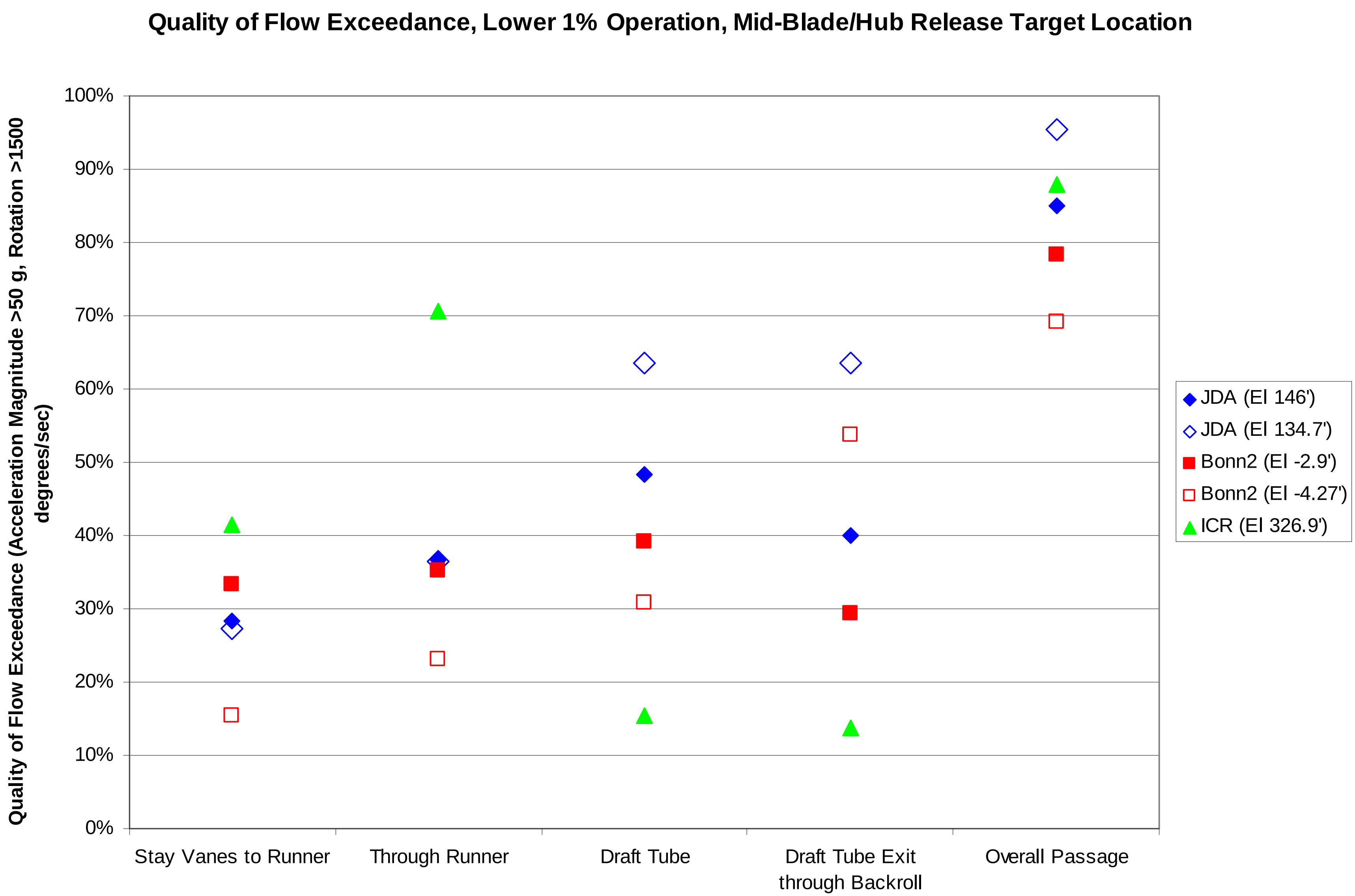


Figure 4.17. Percent (exceedance) of Sensor Fish releases by dam for turbine relative efficiency lower 1% operation and runner mid-blade/hub passage route that exceeded quality of flow thresholds (i.e., acceleration magnitudes >50 g or rotations >1500 degrees/second)

Figure 4.18. Percent (exceedance) of Sensor Fish releases by dam for turbine relative efficiency upper 1% operation and runner mid-blade/hub passage route that exceeded quality of flow thresholds (i.e., acceleration magnitudes >50 g or rotations >1500 degrees/second)

5.0 Conclusion

The purpose of this work was to acquire Sensor Fish data at Bonneville II, John Day, and Ice Harbor dams for later analysis and use. The original data sets have been entered into a database and are being maintained by PNNL pending delivery to USACE when requested. This report provides documentation for the data sets acquired and details about the operations of the Sensor Fish and interpretation of Sensor Fish data that will be necessary for later use of the acquired data. A limited review of the acquired data was conducted to assess its quality and to extract information that might prove useful to its later use.

The data sets acquired are representative of flow conditions within operating turbines at the conditions tested and are sufficient for the applications identified that motivated their acquisition. However, the sample sizes for any one set of conditions were too few to properly describe some factors such as the distribution of nadir pressures.

6.0 References

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Appendix A

Ice Harbor Dam Turbine Data

Table A.1. Field data sheets for Ice Harbor turbine testing

Test Date	Location	Test Condition	Fish ID	Tag Number	Deployment Time	Recovery Time	File Name	Barometer reading	Barometer (psi)	Notes	Forebay	Tailwater	Total Discharge (kcfs)	PH	Spill	T1	T2	T3	T4	T5	T6	S1	S2
9/13/2005	U2-B	8200 -	620	8 771	9:36	9:45	L_mid_620_1	29.54	14.51		439.64	340.37	19.8	18.0	1.8	9.7	8.3	0	0	0	0	0	1.8
			675	8 871	9:40	9:49	L_mid_675_2	29.54	14.51		439.56	340.37	19.8	18.0	1.8	9.7	8.3	0	0	0	0	0	1.8
		mid/hub	665	8 291	9:47			29.54	14.51	yellow balloon recovered	439.58	340.39	19.8	18.0	1.8	9.7	8.3	0	0	0	0	0	1.8
		326.5 EL	674	8 890	9:49	10:00	L_mid_674_3	29.54	14.51		439.68	340.41	19.7	17.9	1.8	9.6	8.3	0	0	0	0	0	1.8
			666	8 700	10:00	10:07	L_mid_666_4	29.54	14.51		439.52	340.38	19.6	17.8	1.8	9.6	8.2	0	0	0	0	0	1.8
			640	8 211	10:43	10:52	L_mid_640_5	29.54	14.51		439.57	340.36	20.9	19.1	1.8	10.8	8.3	0	0	0	0	0	1.8
			679	8 101	10:48	10:57	L_mid_679_6	29.54	14.51		439.6	340.34	20.9	19.1	1.8	10.8	8.3	0	0	0	0	0	1.8
			668	8 280	10:47	10:51	L_mid_668_7	29.54	14.51		439.6	340.34	20.9	19.1	1.8	10.8	8.3	0	0	0	0	0	1.8
			673	8 140	10:45	10:50	L_mid_673_8	29.54	14.51		439.6	340.34	20.9	19.1	1.8	10.8	8.3	0	0	0	0	0	1.8
			667	8 960	10:49	10:56	L_mid_667_9	29.54	14.51		439.6	340.34	20.9	19.1	1.8	10.8	8.3	0	0	0	0	0	1.8
			648	8 581	11:18	11:24	L_mid_648_10	29.54	14.51		439.72	340.45	20.9	19.1	1.8	10.8	8.3	0	0	0	0	0	1.8
			630	8 640	11:17	11:22	L_mid_630_11	29.54	14.51		439.72	340.45	20.9	19.1	1.8	10.8	8.3	0	0	0	0	0	1.8
			669	8 950	11:19	11:23	L_mid_669_12	29.54	14.51		439.72	340.45	20.9	19.1	1.8	10.8	8.3	0	0	0	0	0	1.8
			670	8 741	11:20	11:25	L_mid_670_13	29.54	14.51		439.68	340.35	20.9	19.1	1.8	10.8	8.3	0	0	0	0	0	1.8
			660	8 200	11:21	11:25	L_mid_660_14	29.53	14.5		439.68	340.35	20.9	19.1	1.8	10.8	8.3	0	0	0	0	0	1.8
			664	8 160	11:47	11:54	L_mid_664_15	29.52	14.5		439.98	340.99	30.5	28.7	1.8	8.7	8.3	0	0	0	12	0	1.8
			639	8 250	11:48	11:53	L_mid_639_16	29.52	14.5		439.98	340.99	30.5	28.7	1.8	8.7	8.3	0	0	0	12	0	1.8
			678	8 780	11:49	11:53	L_mid_678_17	29.52	14.5		439.98	340.99	30.5	28.7	1.8	8.7	8.3	0	0	0	12	0	1.8
			671	8 191	11:50	11:56	L_mid_671_18	29.52	14.5		439.96	341	30.4	28.6	1.8	8.6	8.3	0	0	0	12	0	1.8
			661	8 860	11:51	11:54	L_mid_661_19	29.52	14.5		439.96	341	30.4	28.6	1.8	8.6	8.3	0	0	0	12	0	1.8
			672	8 331	12:18	12:23	L_mid_672_20	29.60	14.54		439.75	341.07	31.8	30	1.8	8.7	8.3	0	0	0	13	0	1.8
			620	8 771	12:19	12:24	L_mid_620_21	29.60	14.54		439.75	341.07	31.8	30	1.8	8.7	8.3	0	0	0	13	0	1.8
			675	8 871	12:20	12:24	L_mid_675_22	29.60	14.54		439.68	341.03	31.8	30	1.8	8.6	8.4	0	0	0	13	0	1.8
			674	8 890	12:21	12:34	L_mid_674_23	29.60	14.54		439.68	341.03	31.8	30	1.8	8.6	8.4	0	0	0	13	0	1.8
			666	8 700	12:22	12:32	L_mid_666_24	29.51	14.49		439.68	341.03	31.8	30	1.8	8.6	8.4	0	0	0	13	0	1.8
			640	8 211	12:49	13:01	L_mid_640_25	29.51	14.49		439.71	341.04	31.8	30	1.8	8.6	8.3	0	0	0	13	0	1.8
			679	8 101	12:50	12:54	L_mid_679_26	29.51	14.49		439.76	341.02	32.0	30.2	1.8	8.7	8.4	0	0	0	13	0	1.8
			668	8 280	12:51	12:55	L_mid_668_27	29.50	14.49		439.76	341.02	32.0	30.2	1.8	8.7	8.4	0	0	0	13	0	1.8
			673	8 140	12:52	12:59	L_mid_673_28	29.50	14.49		439.76	341.02	32.0	30.2	1.8	8.7	8.4	0	0	0	13	0	1.8
			667	8 960	12:53	13:01	L_mid_667_29	29.50	14.49		439.76	341.02	32.0	30.2	1.8	8.7	8.4	0	0	0	13	0	1.8
			648	8 581	13:22	13:31		29.50	14.49	hard hit tags ripped, dead	439.68	341.01	32.0	30.2	1.8	8.6	8.3	0	0	0	13	0	1.8
			630	8 640	13:23	13:44	L_mid_630_30	29.50	14.49		439.68	341.01	32.0	30.2	1.8	8.6	8.3	0	0	0	13	0	1.8
			669	8 950	13:24	13:37	L_mid_669_31	29.50	14.49		439.68	341.01	32.0	30.2	1.8	8.6	8.3	0	0	0	13	0	1.8
			670	8 741	13:25	13:41	L_mid_670_32	29.50	14.49		439.75	341.01	32.8	31	1.8	11.1	8.3	0	0	0	12	0	1.8
			660	8 200	13:20	13:38	L_mid_660_33	29.60	14.54		439.68	341.01	32.0	30.2	1.8	8.6	8.3	0	0	0	13	0	1.8

Table A.1. (contd)

Test Date	Location	Test Condi	Fish ID	Tag Number	Deployment Time	Recovery Time	File Name	Barometer reading	Barometer (psi)	Notes	Forebay	Tailwater	Total Discharge (kcfs)	PH	Spill	T1	T2	T3	T4	T5	T6	S1	S2
9/13/2005	U2-B	8200 -	664	8 160	13:59	14:05	L_mid_664_34	29.49	14.48		439.79	341.08	33.0	31.2	1.8	11.2	8.4	0	0	0	12	0	1.8
			639	8 250	14:00	14:22	L_mid_639_35	29.48	14.48		439.79	341.11	32.9	31.1	1.8	11.2	8.3	0	0	0	12	0	1.8
		mid/hub	678	8 780	14:01	14:06	L_mid_678_36	29.48	14.48		439.79	341.11	32.9	31.1	1.8	11.2	8.3	0	0	0	12	0	1.8
		326.5 EL	671	8 191	14:02	14:08	L_mid_671_37	29.48	14.48		439.79	341.11	32.9	31.1	1.8	11.2	8.3	0	0	0	12	0	1.8
			661	8 860	14:03	14:06	L_mid_661_38	29.48	14.48		439.79	341.11	32.9	31.1	1.8	11.2	8.3	0	0	0	12	0	1.8
			672	8 331	14:32	14:41	L_mid_672_39	29.57	14.52		439.87	341.1	33.1	31.3	1.8	11.4	8.3	0	0	0	12	0	1.8
			620	8 771	14:33	14:38	L_mid_620_40	29.57	14.52		439.87	341.1	33.1	31.3	1.8	11.4	8.3	0	0	0	12	0	1.8
			675	8 871	14:34	14:40	L_mid_675_41	29.57	14.52		439.87	341.1	33.1	31.3	1.8	11.4	8.3	0	0	0	12	0	1.8
			674	8 890	14:35	14:41	L_mid_674_42	29.57	14.52		439.77	341.11	33.3	31.5	1.8	11.4	8.4	0	0	0	12	0	1.8
			666	8 700	14:35	14:39	L_mid_666_43	29.57	14.52		439.77	341.11	33.3	31.5	1.8	11.4	8.4	0	0	0	12	0	1.8
			640	8 211	15:02	15:12	L_mid_640_44	29.46	14.47		439.68	341.09	33.0	31.2	1.8	11.2	8.4	0	0	0	12	0	1.8
			679	8 101	15:02	15:05	L_mid_679_45	29.46	14.47		439.68	341.09	33.0	31.2	1.8	11.2	8.4	0	0	0	12	0	1.8
			668	8 280	15:03	15:07	L_mid_668_46	29.46	14.47		439.68	341.09	33.0	31.2	1.8	11.2	8.4	0	0	0	12	0	1.8
			673	8 140	15:04	15:08	L_mid_673_47	29.46	14.47		439.68	341.09	33.0	31.2	1.8	11.2	8.4	0	0	0	12	0	1.8
			667	8 960	15:05	15:14	L_mid_667_48	29.46	14.47		439.71	341.09	33.1	31.3	1.8	11.3	8.4	0	0	0	12	0	1.8
			630	8 640	15:29	15:41	L_mid_630_49	29.45	14.46		439.71	341.08	26.4	24.6	1.8	11.3	8.3	0	0	0	5	0	1.8
			669	8 950	15:31	15:41	L_mid_669_50	29.45	14.46		439.71	341.09	16.8	15	1.8	5	5	0	0	0	5	0	1.8
			670	8 741	15:31	15:34	L_mid_670_51	29.45	14.46		439.71	341.09	16.8	15	1.8	5	5	0	0	0	5	0	1.8
			660	8 200	15:32	15:41	L_mid_660_52	29.45	14.46		439.71	341.09	16.8	15	1.8	5	5	0	0	0	5	0	1.8
			664	8 160	15:33	15:37	L_mid_664_53	29.45	14.46		439.71	341.09	16.8	15	1.8	5	5	0	0	0	5	0	1.8
			678	8 780	16:04	16:12	L_mid_678_54	29.44	14.46		439.73	341.1	33.3	31.5	1.8	11.4	8.4	0	0	0	12	0	1.8
			671	8 191	16:06	16:11	L_mid_671_55	29.44	14.46		439.76	341.09	33.2	31.4	1.8	11.4	8.4	0	0	0	12	0	1.8
			661	8 860	16:07	16:11	L_mid_661_56	29.44	14.46		439.76	341.09	33.2	31.4	1.8	11.4	8.4	0	0	0	12	0	1.8
			672	8 331	16:08	16:12	L_mid_672_57	29.44	14.46		439.76	341.09	33.2	31.4	1.8	11.4	8.4	0	0	0	12	0	1.8
			620	8 771	16:08	16:17	L_mid_620_58	29.44	14.46		439.76	341.09	33.2	31.4	1.8	11.4	8.4	0	0	0	12	0	1.8

Table A.1. (contd)

Test Date	Location	Test Condi	Fish ID	Tag Number	Deployment Time	Recovery Time	File Name	Barometer reading	Barometer (psi)	Notes	Forebay	Tailwater	Total Discharge (kcfs)	PH	Spill	T1	T2	T3	T4	T5	T6	S1	S2
9/14/2005	U2-B	8200cfs	678	8 780	7:38	7:44	l_678_1	29.45	14.46	wrong elevation - 327.8	439.42	340.23	19.9	18.1	1.8	9.8	8.3	0	0	0	0	0	1.8
			671	8 191	7:39	7:46	L_671_2	29.45	14.46	wrong elevation - 327.8	439.42	340.23	19.9	18.1	1.8	9.8	8.3	0	0	0	0	0	1.8
		tip	661	8 860	7:40	7:44	L_661_3	29.45	14.46	wrong elevation - 327.8	439.41	340.24	19.9	18.1	1.8	9.8	8.3	0	0	0	0	0	1.8
		317' EL	672	8 331	7:40	7:43	L_672_4	29.45	14.46	wrong elevation - 327.8	439.41	340.24	19.9	18.1	1.8	9.8	8.3	0	0	0	0	0	1.8
			620	8 771	7:41	7:49	L_620_5	29.45	14.46	wrong elevation - 327.8	439.41	340.24	19.9	18.1	1.8	9.8	8.3	0	0	0	0	0	1.8
			630	8 640	8:06	8:09	L_T_630_1	29.44	14.46		439.41	340.18	20.0	18.2	1.8	10	8.2	0	0	0	0	0	1.8
			669	8 950	8:07	8:11	L_T_669_2	29.46	14.47		439.41	340.18	20.0	18.2	1.8	10	8.2	0	0	0	0	0	1.8
			670	8 741	8:07	8:13	L_T_670_3	29.46	14.47		439.41	340.18	20.0	18.2	1.8	10	8.2	0	0	0	0	0	1.8
			660	8 200	8:08	8:15	L_T_660_4	29.46	14.47		439.41	340.18	20.0	18.2	1.8	10	8.2	0	0	0	0	0	1.8
			664	8 160	8:09	8:13	L_T_664_5	29.46	14.47		439.41	340.18	20.0	18.2	1.8	10	8.2	0	0	0	0	0	1.8
			640	8 211	8:33	8:40	L_T_640_6	29.46	14.47		439.35	340.1	19.7	17.9	1.8	9.7	8.2	0	0	0	0	0	1.8
			679	8 101	8:34	8:36		29.46	14.47		439.35	340.1	19.7	17.9	1.8	9.7	8.2	0	0	0	0	0	1.8
			668	8 280	8:35	8:39	L_T_668_7	29.46	14.47		439.34	340.09	19.7	17.9	1.8	9.7	8.2	0	0	0	0	0	1.8
			673	8 140	8:35	8:42	L_T_673_8	29.46	14.47		439.34	340.09	19.7	17.9	1.8	9.7	8.2	0	0	0	0	0	1.8
			667	8 960	8:36	8:43	L_T_667_9	29.46	14.47		439.34	340.09	19.7	17.9	1.8	9.7	8.2	0	0	0	0	0	1.8
			639	8 250	8:53	8:56	L_T_639_10	29.45	14.46		439.32	340.12	20.1	18.3	1.8	10	8.3	0	0	0	0	0	1.8
			675	8 871	8:54	9:01	L_T_675_11	29.45	14.46		439.32	340.12	20.1	18.3	1.8	10	8.3	0	0	0	0	0	1.8
			674	8 890	8:54	8:58	L_T_674_12	29.45	14.46		439.32	340.12	20.1	18.3	1.8	10	8.3	0	0	0	0	0	1.8
			666	8 700	8:55	9:01	L_T_666_13	29.45	14.46		439.26	340.14	20.0	18.2	1.8	9.9	8.3	0	0	0	0	0	1.8
			678	8 780	8:56	9:00	L_T_678_14	29.45	14.46		439.26	340.14	20.0	18.2	1.8	9.9	8.3	0	0	0	0	0	1.8
			671	8 191	9:09	9:14	L_T_671_15	29.45	14.46		439.28	340.16	19.9	18.1	1.8	9.9	8.2	0	0	0	0	0	1.8
			661	8 860	9:10	9:15	L_T_661_16	29.45	14.46		439.3	340.16	20.0	18.2	1.8	9.9	8.3	0	0	0	0	0	1.8
			672	8 331	9:11	9:16	L_T_672_17	29.45	14.46		439.3	340.16	20.0	18.2	1.8	9.9	8.3	0	0	0	0	0	1.8
			620	8 771	9:12	9:32	L_T_620_18	29.45	14.46		439.3	340.16	20.0	18.2	1.8	9.9	8.3	0	0	0	0	0	1.8
			630	8 640	9:12	9:17	L_T_630_19	29.45	14.46		439.3	340.16	20.0	18.2	1.8	9.9	8.3	0	0	0	0	0	1.8
			669	8 950	9:41	9:45	L_T_669_20	29.45	14.46		439.18	340.18	19.9	18.1	1.8	9.8	8.3	0	0	0	0	0	1.8
			670	8 741	9:41	9:49	L_T_670_21	29.45	14.46		439.18	340.18	19.9	18.1	1.8	9.8	8.3	0	0	0	0	0	1.8
			660	8 200	9:42	9:47	L_T_660_22	29.45	14.46		439.18	340.18	19.9	18.1	1.8	9.8	8.3	0	0	0	0	0	1.8
			664	8 160	9:43	9:47	L_T_664_23	29.45	14.46		439.18	340.18	19.9	18.1	1.8	9.8	8.3	0	0	0	0	0	1.8
			640	8 211	9:44	9:51	L_T_640_24	29.45	14.46		439.18	340.18	19.9	18.1	1.8	9.8	8.3	0	0	0	0	0	1.8
			668	8 280	10:01	10:04	L_T_668_25	29.44	14.46		439.22	340.14	19.9	18.1	1.8	0	8.3	9.8	0	0	0	0	1.8
			673	8 140	10:01	10:09	L_T_673_26	29.44	14.46		439.22	340.14	19.9	18.1	1.8	0	8.3	9.8	0	0	0	0	1.8
			667	8 960	10:02	10:14	L_T_667_27	29.44	14.46		439.22	340.14	19.9	18.1	1.8	0	8.3	9.8	0	0	0	0	1.8
			639	8 250	10:03	10:10	L_T_639_28	29.44	14.46		439.22	340.14	19.9	18.1	1.8	0	8.3	9.8	0	0	0	0	1.8
			675	8 871	10:04	10:07	L_T_675_29	29.44	14.46		439.22	340.14	19.9	18.1	1.8	0	8.3	9.8	0	0	0	0	1.8

Table A.1. (contd)

Test Date	Location	Test Condi	Fish ID	Tag Number	Deployment Time	Recovery Time	File Name	Barometer reading	Barometer (psi)	Notes	Forebay	Tailwater	Total Discharge (kcfs)	PH	Spill	T1	T2	T3	T4	T5	T6	S1	S2
	U2-B	13,900cfs	674	8 890	10:32	10:35	H_m_674_1	29.44	14.46		439.22	340.18	23.9	22.1	1.8	0	13.6	8.5	0	0	0	0	1.8
9/14/2005			666	8 700	10:33	10:41	H_m_666_2	29.44	14.46		439.22	340.18	23.9	22.1	1.8	0	13.6	8.5	0	0	0	0	1.8
		mid/hub	678	8 780	10:33	10:44	H_m_678_3	29.44	14.46		439.22	340.18	23.9	22.1	1.8	0	13.6	8.5	0	0	0	0	1.8
		327.8 EL	671	8 191	10:35	10:40	H_m_671_4	29.44	14.46		439.19	340.22	23.8	22	1.8	0	13.6	8.4	0	0	0	0	1.8
			661	8 860	10:35	10:39	H_m_661_5	29.44	14.46		439.19	340.22	23.8	22	1.8	0	13.6	8.4	0	0	0	0	1.8
			672	8 331	10:56	11:03	H_m_672_6	29.44	14.46		439.21	340.25	23.7	21.9	1.8	0	13.5	8.4	0	0	0	0	1.8
			620	8 771	10:57	11:00	H_m_620_7	29.44	14.46		439.21	340.25	23.7	21.9	1.8	0	13.5	8.4	0	0	0	0	1.8
			630	8 640	10:58	11:10	H_m_630_8	29.44	14.46		439.21	340.25	23.7	21.9	1.8	0	13.5	8.4	0	0	0	0	1.8
			669	8 950	10:59	11:08	H_m_669_9	29.44	14.46		439.21	340.25	23.7	21.9	1.8	0	13.5	8.4	0	0	0	0	1.8
			670	8 741	11:00	11:06	H_m_670_10	29.44	14.46		439.1	340.27	23.7	21.9	1.8	0	13.5	8.4	0	0	0	0	1.8
			660	8 200	11:24	11:36	H_m_660_11	29.43	14.45		439.12	340.28	23.8	22	1.8	0	13.5	8.5	0	0	0	0	1.8
			664	8 160	11:25		H_m_664_55	29.43	14.45	recovered	439.07	340.27	23.9	22.1	1.8	0	13.7	8.4	0	0	0	0	1.8
			640	8 211	11:26	11:38	H_m_640_12	29.43	14.45		439.07	340.27	23.9	22.1	1.8	0	13.7	8.4	0	0	0	0	1.8
			668	8 280	11:26	11:32	H_m_668_13	29.43	14.45		439.07	340.27	23.9	22.1	1.8	0	13.7	8.4	0	0	0	0	1.8
			673	8 140	11:27	11:35	H_m_673_14	29.43	14.45		439.07	340.27	23.9	22.1	1.8	0	13.7	8.4	0	0	0	0	1.8
			667	8 960	12:02	12:21	H_m_667_15	29.42	14.45		439.08	339.93	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			639	8 250	12:02	12:15	H_m_639_16	29.42	14.45		439.08	339.93	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			675	8 871	12:03	12:18	H_m_675_17	29.42	14.45		439.08	339.93	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			674	8 890	12:04	12:19	H_m_674_18	29.42	14.45		439.08	339.93	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			666	8 700	12:05	12:08	H_m_666_19	29.42	14.45		439.09	339.76	15.1	13.3	1.8	0	13.3	0	0	0	0	0	1.8
			678	8 780	12:32	12:44	H_m_678_20	29.42	14.45		439.09	339.6	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			671	8 191	12:33	12:37	H_m_671_21	29.42	14.45		439.09	339.6	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			661	8 860	12:34	12:41	H_m_661_22	29.42	14.45		439.09	339.6	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			672	8 331	12:34	12:48	H_m_672_23	29.42	14.45		439.09	339.6	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			620	8 771	12:36	12:39	H_m_620_24	29.42	14.45		439.08	339.58	15.1	13.3	1.8	0	13.3	0	0	0	0	0	1.8
			630	8 640	13:02	13:10	H_m_630_25	29.41	14.44		439.15	339.54	15.1	13.3	1.8	0	13.3	0	0	0	0	0	1.8
			669	8 950	13:03	13:18	H_m_669_26	29.41	14.44		439.15	339.54	15.1	13.3	1.8	0	13.3	0	0	0	0	0	1.8
			670	8 741	13:04	13:15	H_m_670_27	29.41	14.44		439.15	339.54	15.1	13.3	1.8	0	13.3	0	0	0	0	0	1.8
			660	8 200	13:05	13:12	H_m_660_28	29.41	14.44		439.08	339.54	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			640	8 211	13:06	13:14	H_m_640_29	29.40	14.44		439.08	339.54	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8

Table A.1. (contd)

Test Date	Location	Test Condi	Fish ID	Tag Number	Deployment Time	Recovery Time	File Name	Barometer reading	Barometer (psi)	Notes	Forebay	Tailwater	Total Discharge (kcfs)	PH	Spill	T1	T2	T3	T4	T5	T6	S1	S2
	U2-B	13,900cfs	668	8 280	13:29	13:39	H_m_668_30	29.40	14.44		438.89	339.73	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
9/14/2005			673	8 140	13:30	13:36	H_m_673_31	29.40	14.44		438.99	339.99	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
		mid/hub	667	8 960	13:30	13:43	H_m_667_32	29.40	14.44		438.99	339.99	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
		327.8 EL	639	8 250	13:31	13:39	H_m_639_33	29.40	14.44		438.99	339.99	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			675	8 871	13:32	13:38	H_m_675_34	29.40	14.44		438.99	339.99	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			674	8 890	14:03	14:15		29.39	14.43	broken in 2, cylinder w/ tag	438.9	339.84	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			666	8 700	14:04	14:15	H_m_666_35	29.39	14.43		438.9	339.84	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			678	8 780	14:05	14:08	H_m_678_36	29.39	14.43		438.94	339.81	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			671	8 191	14:06	14:13	H_m_671_37	29.39	14.43		438.94	339.81	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			661	8 860	14:07		H_M_661_55	29.39	14.43	no signal, lost _Recovered January 2007	438.94	339.81	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			672	8 331	14:56	15:13	H_m_672_38	29.37	14.43		439.1	339.57	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			620	8 771	14:57	15:01		29.37	14.43	bad data!	439.1	339.57	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			630	8 640	14:58	15:07	H_m_630_39	29.37	14.43		439.1	339.57	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			669	8 950	14:59	15:10	H_m_669_40	29.37	14.43		439.1	339.57	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			670	8 741	15:00	15:03	H_m_670_41	29.37	14.43		439.02	339.6	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			660	8 200	15:26	15:31	H_m_660_42	29.37	14.43		439.02	339.65	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			640	8 211	15:27	15:31	H_m_640_43	29.37	14.43		439.02	339.65	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			668	8 280	15:28	15:33	H_m_668_44	29.37	14.43		439.02	339.65	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			673	8 140	15:29	15:35	H_m_673_45	29.37	14.43		439.02	339.65	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			667	8 960	15:30			29.37	14.43	weak signal,	439.07	339.62	15.1	13.3	1.8	0	13.3	0	0	0	0	0	1.8
			639	8 250	15:59	16:11	H_m_639_46	29.35	14.42		438.94	340.21	15.0	13.2	1.8	0	13.2	0	0	0	0	0	1.8
			675	8 871	16:01	16:04	H_m_675_47	29.35	14.42		438.93	340.1	15.1	13.3	1.8	0	13.3	0	0	0	0	0	1.8
			666	8 700	16:03	16:09	H_m_666_48	29.35	14.42		438.93	340.1	15.1	13.3	1.8	0	13.3	0	0	0	0	0	1.8
			678	8 780	16:04	16:10	H_m_678_49	29.35	14.42		438.93	340.1	15.1	13.3	1.8	0	13.3	0	0	0	0	0	1.8
			671	8 191	16:05	16:08	H_m_671_50	29.35	14.42		439.02	339.81	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			672	8 331	16:24	16:29	H_m_672_51	29.35	14.42		438.93	339.67	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8
			620	8 771	16:25	16:32		29.35	14.42	bad data! Fish no good	438.85	339.74	20.2	18.4	1.8	0	13.4	0	0	5	0	0	1.8
			630	8 640	16:26	16:33	H_m_630_52	29.35	14.42		438.85	339.74	20.2	18.4	1.8	0	13.4	0	0	5	0	0	1.8
			669	8 950	16:28	16:29	H_m_669_53	29.35	14.42		438.85	339.74	20.2	18.4	1.8	0	13.4	0	0	5	0	0	1.8
			670	8 741	16:30	16:34	H_m_670_54	29.35	14.42		438.79	339.67	15.2	13.4	1.8	0	13.4	0	0	0	0	0	1.8

Table A.1. (contd)

Test Date	Location	Test Condi	Fish ID	Tag Number	Deployment Time	Recovery Time	File Name	Barometer reading	Barometer (psi)	Notes	Forebay	Tailwater	Total Discharge (kcfs)	PH	Spill	T1	T2	T3	T4	T5	T6	S1	S2
9/15/2005	U2-B	13,900 cfs	639	8 250	7:51	8:02	H_t_639_1	29.46	14.47		439.31	340.02	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			660	8 200	7:52			29.46	14.47	MIA	439.31	340.02	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
		tip	668	8 280	7:53	8:01	H_t_668_2	29.46	14.47		439.31	340.02	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
		313.4 ft EL	640	8 211	7:53	7:57	H_t_640_3	29.46	14.47		439.31	340.02	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			673	8 140	7:54	8:04	H_t_673_4	29.45	14.46		439.31	340.02	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			678	8 780	8:21	8:28	H_t_678_5	29.45	14.46		439.34	340	15.4	13.6	1.8	0	13.6	0	0	0	0	0	1.8
			666	8 700	8:22	8:29	H_t_666_6	29.45	14.46		439.34	340	15.4	13.6	1.8	0	13.6	0	0	0	0	0	1.8
			672	8 331	8:23	8:39	H_t_672_7	29.45	14.46		439.34	340	15.4	13.6	1.8	0	13.6	0	0	0	0	0	1.8
			671	8 191	8:24	8:33	H_t_671_8	29.45	14.46		439.34	340	15.4	13.6	1.8	0	13.6	0	0	0	0	0	1.8
			630	8 640	8:25	8:32	H_t_630_9	29.45	14.46		439.35	339.99	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			670	8 741	8:55	8:59	H_t_670_10	29.46	14.46		439.33	339.96	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			675	8 871	8:56	9:03	H_t_675_11	29.46	14.46		439.33	339.96	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			669	8 950	8:58	9:04	H_t_669_13	29.46	14.46		439.33	339.96	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			639	8 250	8:59	9:06	H_t_639_12	29.46	14.46		439.33	339.96	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			668	8 280	9:00			29.46	14.46	MIA	439.34	339.94	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			640	8 211	9:41	9:48	H_t_640_14	29.44	14.46		439.18	339.98	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			673	8 140	9:42	9:53	H_t_673_15	29.44	14.46		439.18	339.98	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			678	8 780	9:43	9:51	H_t_678_16	29.44	14.46		439.18	339.98	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			666	8 700	9:45	9:52		29.44	14.46	bad data! Fish no good	439.21	339.99	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			672	8 331	9:46	9:50	H_t_672_17	29.44	14.46		439.21	339.99	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			671	8 191	10:07	10:12	H_t_671_21	29.44	14.46		439.27	340.34	15.4	13.6	1.8	0	13.6	0	0	0	0	0	1.8
			630	8 640	10:08	10:14	H_t_630_18	29.43	14.45		439.27	340.34	15.4	13.6	1.8	0	13.6	0	0	0	0	0	1.8
			664	8 160	10:09	10:18	H_t_664_19	29.43	14.45		439.27	340.34	15.4	13.6	1.8	0	13.6	0	0	0	0	0	1.8
			670	8 741	10:10	10:16	H_t_670_22	29.43	14.45		439.3	340.16	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			675	8 871	10:12	10:18	H_t_675_20	29.43	14.45		439.3	340.16	15.3	13.5	1.8	0	13.5	0	0	0	0	0	1.8
			669	8 950	10:58	11:02	H_t_669_23	29.43	14.45		439.3	340.34	15.4	13.6	1.8	0	13.6	0	0	0	0	0	1.8
			639	8 250	10:59	11:07	H_t_639_24	29.43	14.45		439.3	340.34	15.4	13.6	1.8	0	13.6	0	0	0	0	0	1.8
			640	8 211	10:59	11:06	H_t_640_25	29.43	14.45		439.3	340.34	15.4	13.6	1.8	0	13.6	0	0	0	0	0	1.8
			673	8 140	11:00	11:04	H_t_673_26	29.43	14.45		439.33	340.14	15.4	13.6	1.8	0	13.6	0	0	0	0	0	1.8
			678	8 780	11:01	11:04	H_t_678_27	29.43	14.45		439.33	340.14	15.4	13.6	1.8	0	13.6	0	0	0	0	0	1.8

Table A.1. (contd)

Date	Location	Test Condition	Fish ID	Tag #	Deployment Time	Recovery Time	File Name	Barometric Pressure	FB EL	TW EL	# units on	PH Q	Spill Q	Total Q	T1 Q	T3Q	T4 Q
3/19/2006	Unit 3B	Tip Release	691	8 081	1010	1015	F691_tip_high_1	29.54	438.8	340.36	3	40.3	0	40.3	12.1	13.3	14.9
		Target EL313.4	682	8 251	1013	1020	f682_tip_high_2	29.54	438.8	340.36	3	40.3	0	40.3	12.1	13.3	14.9
		Upper 1%	701	8 221	1015	1021	f701_tip_high_3	29.54	438.8	340.39	3	40.2	0	40.2	12.1	13.2	14.9
			686	8 411	1019	1023	f686_tip_high_4	29.54	438.8	340.39	3	40.2	0	40.2	12.1	13.2	14.9
			699	8 371	1042	1046	f699_tip_high_5	29.52	438.99	340.55	3	41	0	41	12.9	13.2	14.9
			692	8 211	1043	1050	f692_tip_high_6	29.52	438.99	340.55	3	41	0	41	12.9	13.2	14.9
			635	8 711	1045	1051	f635_tip_high_7	29.52	439	340.58	3	41	0	41	12.9	13.2	14.9
			689	8 191	1047	1054	f689_tip_high_8	29.52	439	340.58	3	41	0	41	12.9	13.2	14.9
			672	8 311	1051	1058	f672_tip_high_9	29.52	438.99	340.59	3	40.7	0	40.7	12.9	13	14.8
			700	8 331	1053	1058	f700_tip_high_10	29.52	438.99	340.59	3	40.7	0	40.7	12.9	13	14.8
			640	8 091	1056	1102	f640_tip_high_11	29.52	439	340.61	3	41.3	0	41.3	13.1	13.2	15
			694	8 111	1059	1104	f694_tip_high_12	29.52	439	340.61	3	41.3	0	41.3	13.1	13.2	15
			693	8 501	1100	1105	f693_tip_high_13	29.52	439.11	340.62	3	40.9	0	40.9	12.9	13.2	14.8
			703	8 240	1102	1107	f703_tip_high_14	29.52	439.11	340.62	3	40.9	0	40.9	12.9	13.2	14.8
			684	8 831	1104	1109	f684_tip_high_15	29.52	439.11	340.62	3	40.9	0	40.9	12.9	13.2	14.8
			664	8 671	1113	1131	f664_tip_high_16	29.52	439.1	340.59	3	40.6	0	40.6	12.8	13.1	14.7
			656	8 201	1114	1117	f656_tip_high_17	29.52	439.1	340.59	3	40.6	0	40.6	12.8	13.1	14.7
			633	8 151	1115	1118	f633_tip_high_18	29.52	439.11	340.56	3	40.6	0	40.6	12.8	13.1	14.7
			675	8 121	1116	1119	f675_tip_high_19	29.52	439.11	340.56	3	40.6	0	40.6	12.8	13.1	14.7
			687	8 561	1118	1121	f687_tip_high_20	29.52	439.11	340.56	3	40.6	0	40.6	12.8	13.1	14.7
			695	8 101	1119	1131	f695_tip_high_21	29.52	439.11	340.56	3	40.6	0	40.6	12.8	13.1	14.7
			698	8 891	1120	1124	f698_tip_high_22	29.52	439.18	340.58	3	40.6	0	40.6	12.8	13.1	14.7
			678	8 131	1122	1125	f678_tip_high_23	29.52	439.18	340.58	3	40.6	0	40.6	12.8	13.1	14.7
			673	8 281	1123	1125	f673_tip_high_24	29.52	439.18	340.58	3	40.6	0	40.6	12.8	13.1	14.7
			691	8 081	1125	1130	f691_tip_high_25	29.52	439.18	340.58	3	40.5	0	40.5	12.8	13	14.7
			682	8 251	1132	1150	f682_tip_high_26	29.51	439.15	340.58	3	40.6	0	40.6	12.8	13.1	14.7
			701	8 221	1133	1136	f701_tip_high_27	29.51	439.15	340.58	3	40.6	0	40.6	12.8	13.1	14.7
			686	8 411	1134	1137	f686_tip_high_28	29.51	439.15	340.58	3	40.6	0	40.6	12.8	13.1	14.7
			699	8 371	1135	1138	f699_tip_high_29	29.51	439.15	340.57	3	40.7	0	40.7	12.8	13.1	14.8
			692	8 211	1136	1211	f692_tip_high_30	29.51	439.15	340.57	3	40.7	0	40.7	12.8	13.1	14.8

Table A.1. (contd)

Date	Location	Test Condition	Fish ID	Tag #	Deployment Time	Recovery Time	File Name	Barometric Pressure (in/Hg)	Barometric Pressure (psi)	Notes	Forebay Elevation (ft)
3/21/2007	Unit 3B	Generator Limit	724	9 211	1422	1428	gen_1_724	29.78	14.63		439.77
			722	9 034	1420	1428	gen_2_722	29.78	14.63		439.77
			719	9 075	1420	1426	gen_3_719	29.78	14.63		439.77
			709	9 104	1419	1426	gen_4_709	29.78	14.63		439.77
			725	9 064	1419	1425	gen_5_725	29.79	14.63		439.77
			711	9 024	1419	1424	gen_6_711	29.79	14.63		439.77
			718	9 055	1418	1425	gen_7_718	29.79	14.63		439.77
			635	9 081	1417	1426	gen_8_635	29.79	14.63		439.77
			723	9 271	1421	1426	gen_9_723	29.79	14.63		439.77
	Unit 3C	Generator Limit	713	9 144	1529	1537	gen_slotC_1_713	29.77	14.62		439.61
			705	9 004	1529	1537	gen_slotC_2_705	29.77	14.62		439.61
	Unit 3A	Generator Limit	707	9 184	1605	1611	gen_slotA_1_707	29.75	14.61		439.52
			714	9 014	1605	1611	gen_slotA_2_714	29.75	14.61		439.52
3/23/2007	Unit 3C	Generator Limit	635	9 081	750	758	gen_slotC_3_635	29.64	14.56		437.89
			711	9 024	750	801	gen_slotC_4_711	29.64	14.56		437.89
	Unit 3B	Generator Limit	709	9 104	830	838	gen_11_709	29.64	14.56		438.1
			724	9 211	831	843	gen_12_724	29.64	14.56		438.1
			714	9 014	831	842	gen_13_714	29.64	14.56		438.1
			661	9 144	832	840	gen_19_661	29.64	14.56		438.1
			718	9 055	833	842	gen_14_718	29.64	14.56		438.1
			705	9 004	839	849	gen_18_705	29.64	14.56		438.1
			722	9 034	840	842	gen_10_722	29.64	14.56		438.1
			707	9 184	840	846	gen_20_707	29.64	14.56		438.1
			723	9 271	841	852	gen_15_723	29.64	14.56		438.1
			725	9 064	841	848	gen_16_725	29.64	14.56		438.1
			713	9 144	844	849	gen_17_713	29.64	14.56		438.1
			711	9 024	1024	1032	gen_21_711	29.64	14.56		438.43
			635	9 081	1024	~1700	gen_30_635	29.64	14.56	Recovered PM	438.43
			722	9 034	1025	1030	gen_22_722	29.64	14.56		438.43
			709	9 104	1025	1039	gen_23_709	29.64	14.56		438.43
			724	9 211	1026	1034	gen_24_724	29.64	14.56		438.43
			714	9 014	1026	1036	gen_25_714	29.64	14.56		438.43
			718	9 055	1027	1032	gen_26_718	29.64	14.56		438.43
			723	9 271	1027	1034	gen_27_723	29.64	14.56		438.43
			725	9 064	1027	1038	gen_28_725	29.64	14.56		438.43
			713	9 144	1028	1037	gen_29_713	29.64	14.56		438.43

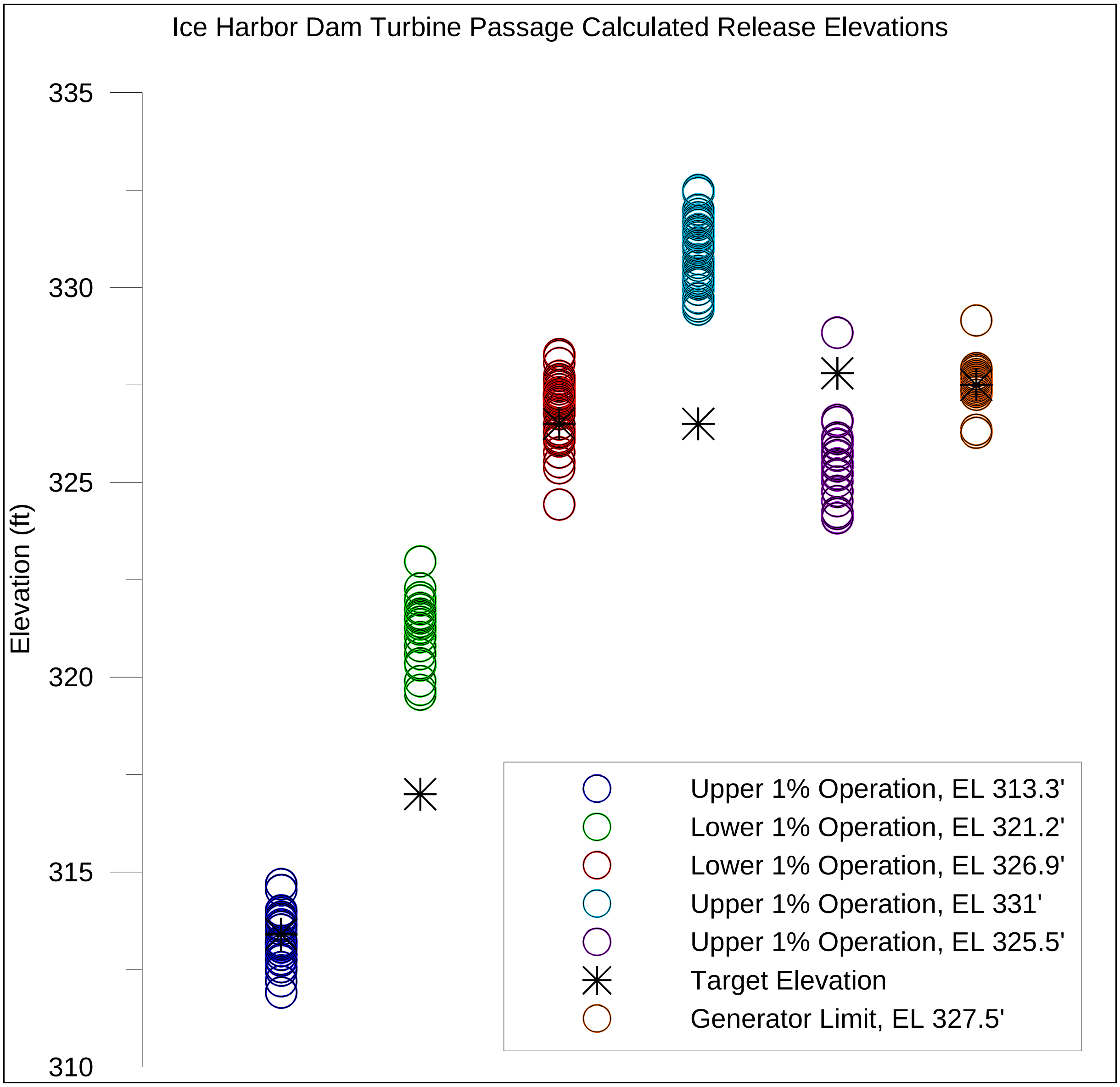

Figure A.1. Release elevations and targeted elevations calculated by the Sensor Fish

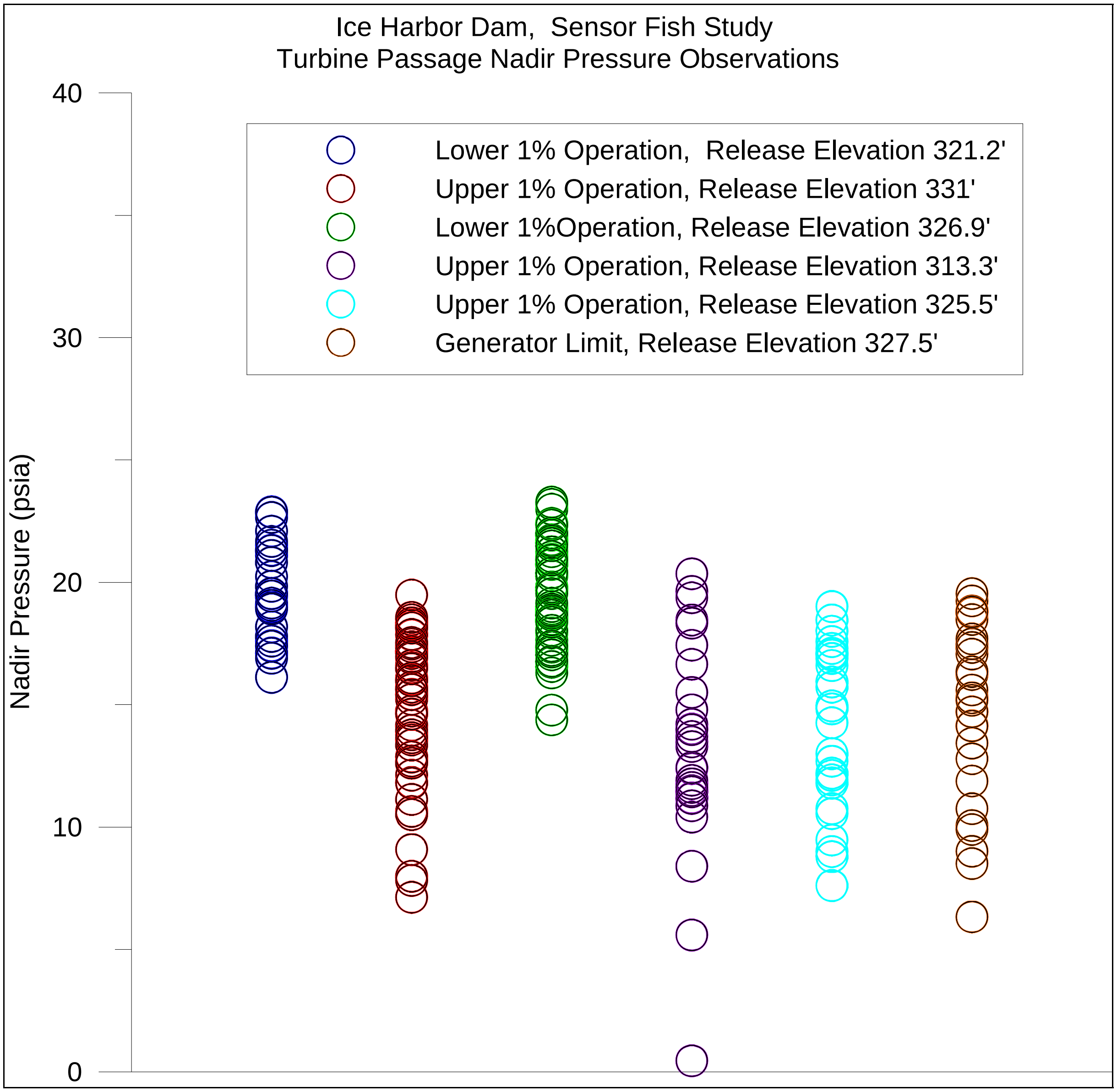

Figure A.2. Nadir pressure values as determined from Sensor Fish turbine passage

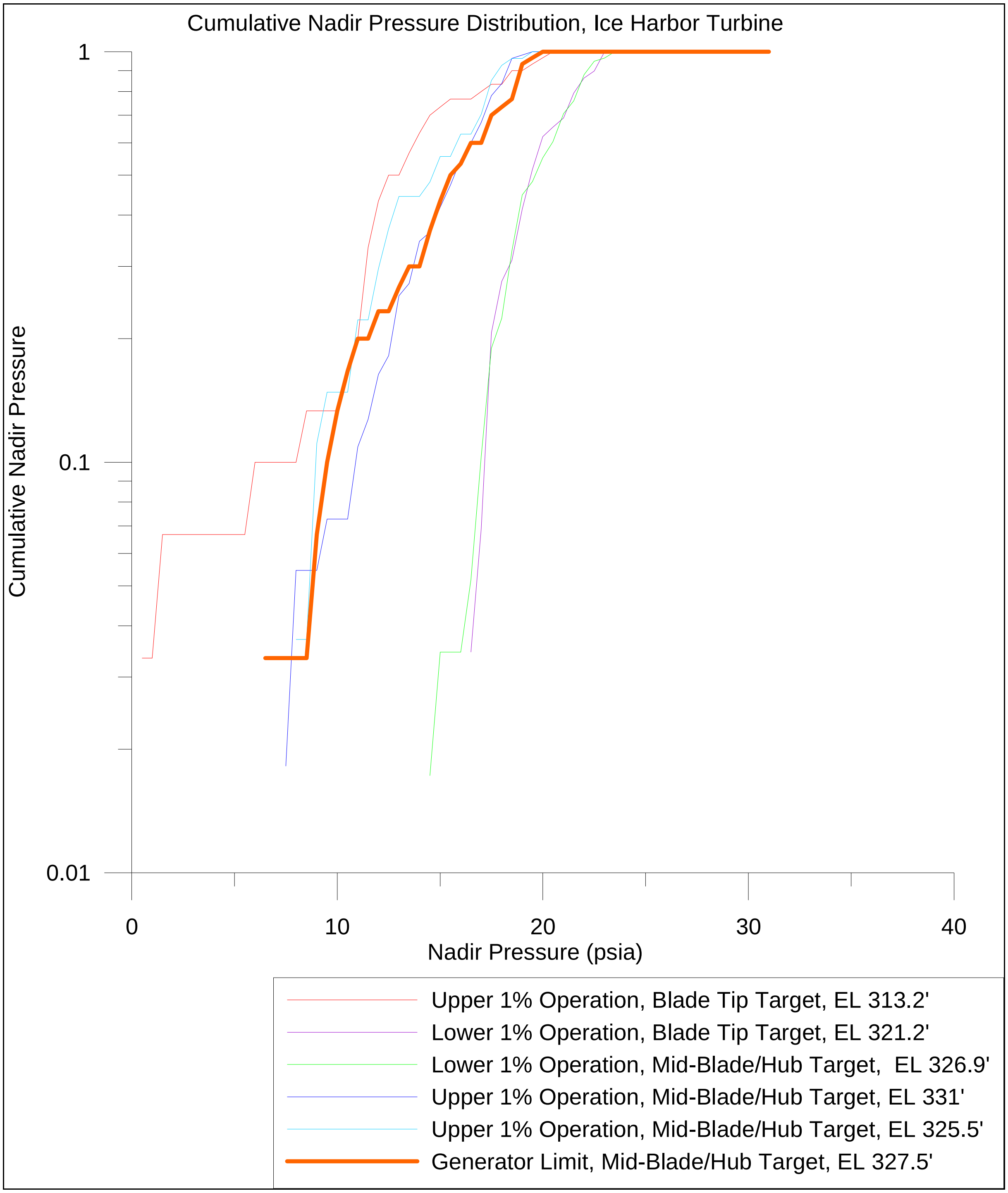

Figure A.3. Cumulative nadir pressure distributions from Sensor Fish

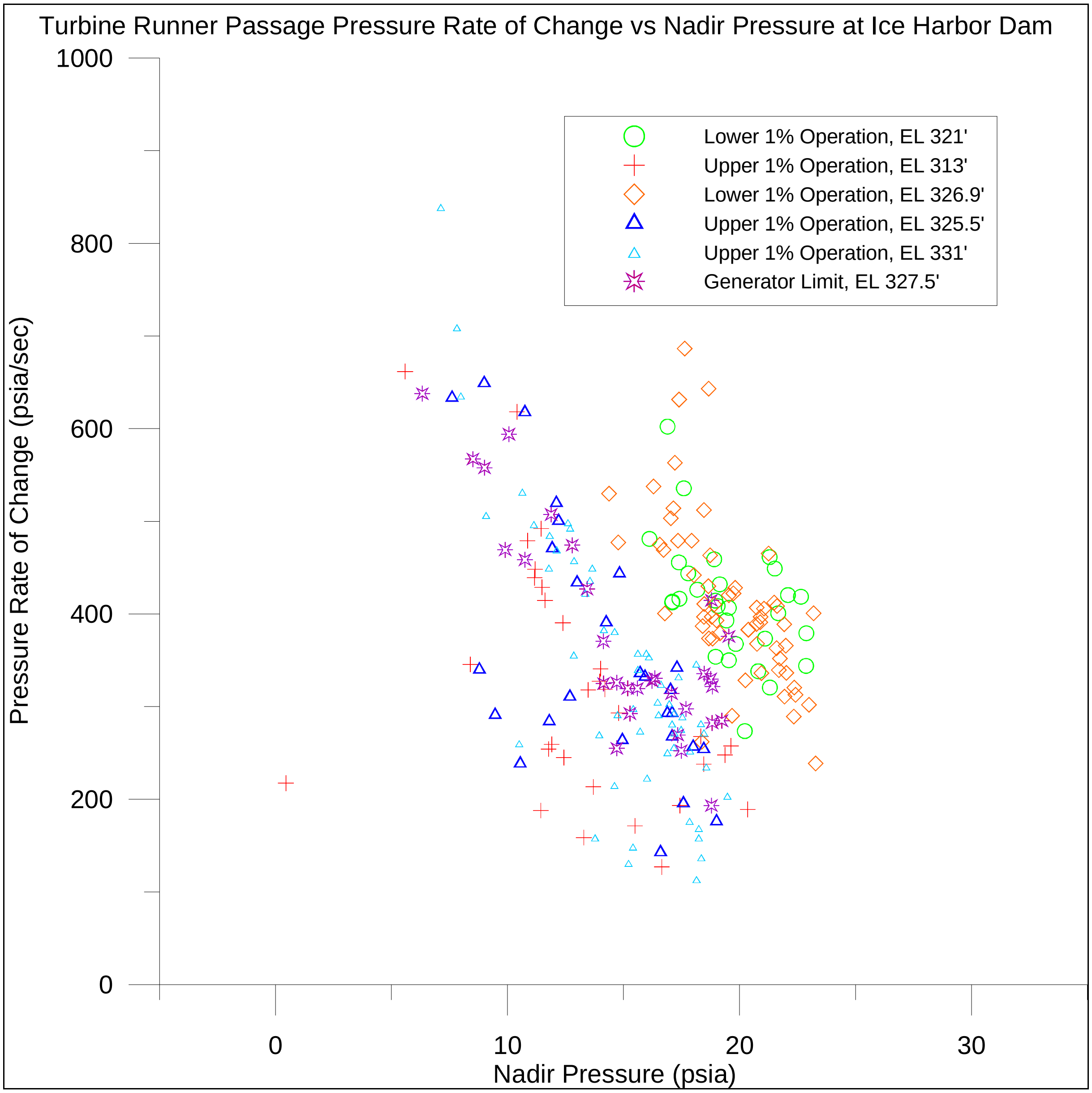

Figure A.4. Turbine runner passage rate of change by nadir pressure for all operations and routes

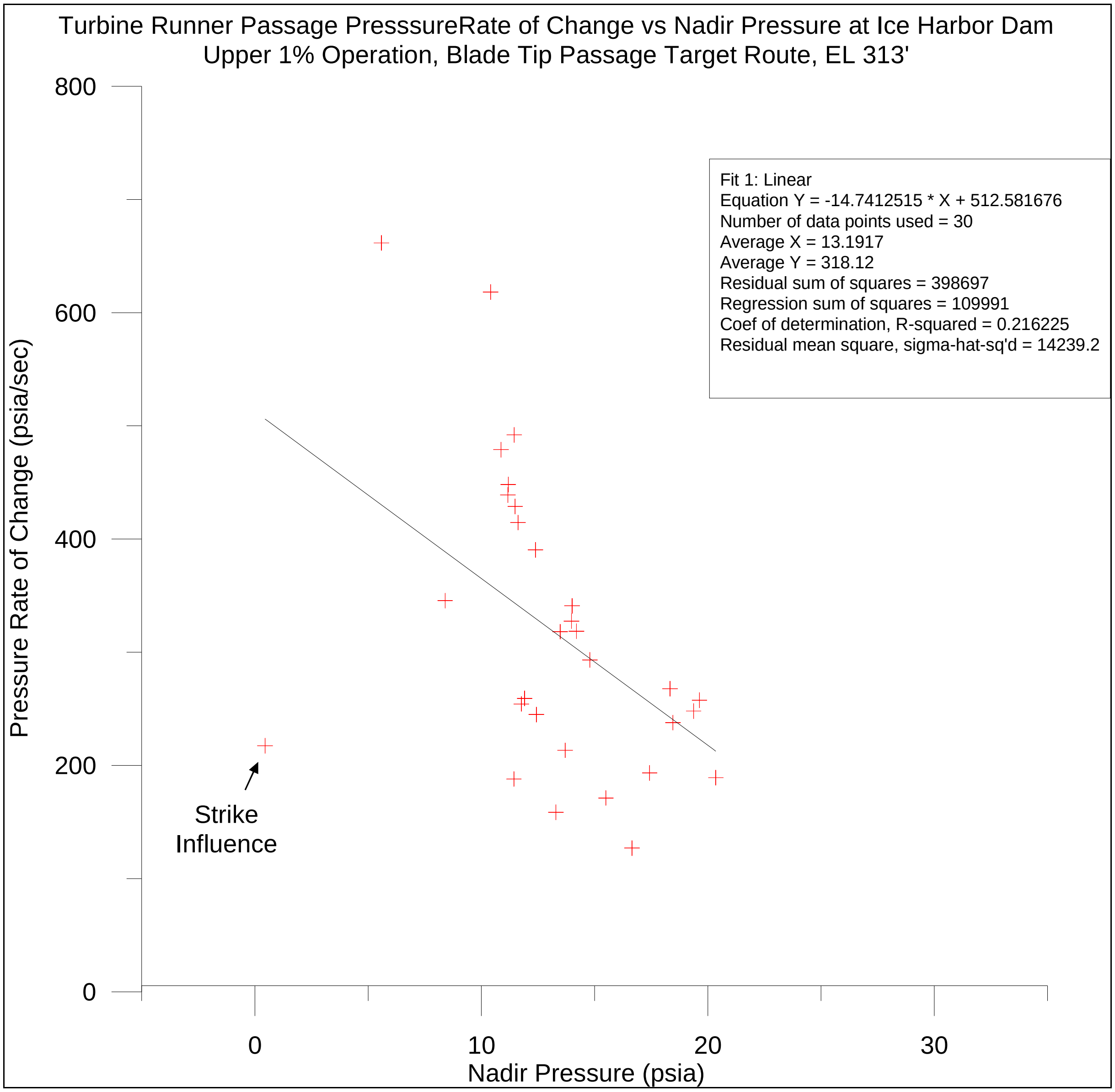

Figure A.5. Turbine runner passage rate of change by nadir pressure for upper 1% operation and the targeted blade tip passage route

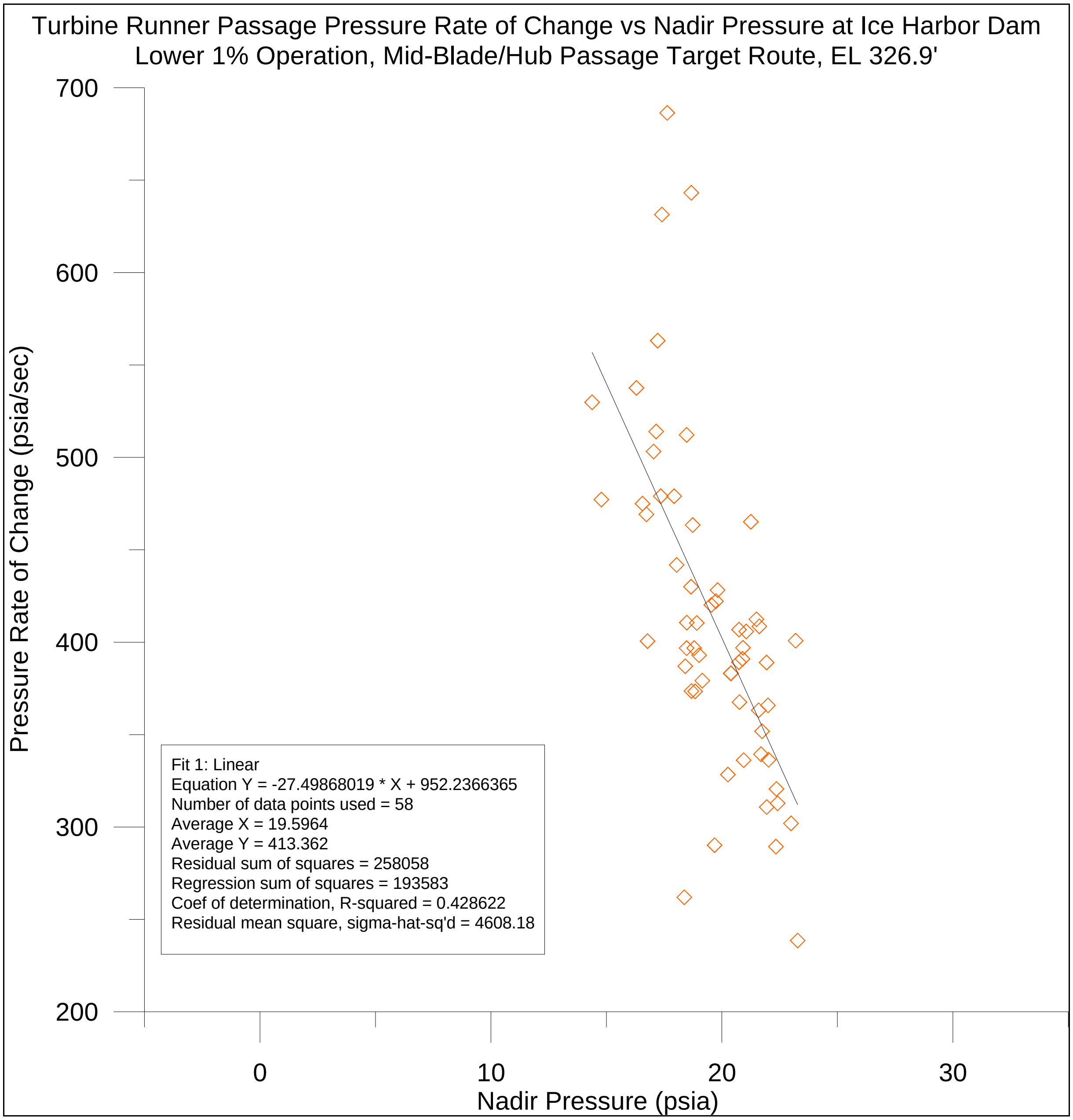

Figure A.6. Turbine runner passage rate of change by nadir pressure for lower 1% operation in the targeted mid-blade/hub passage route

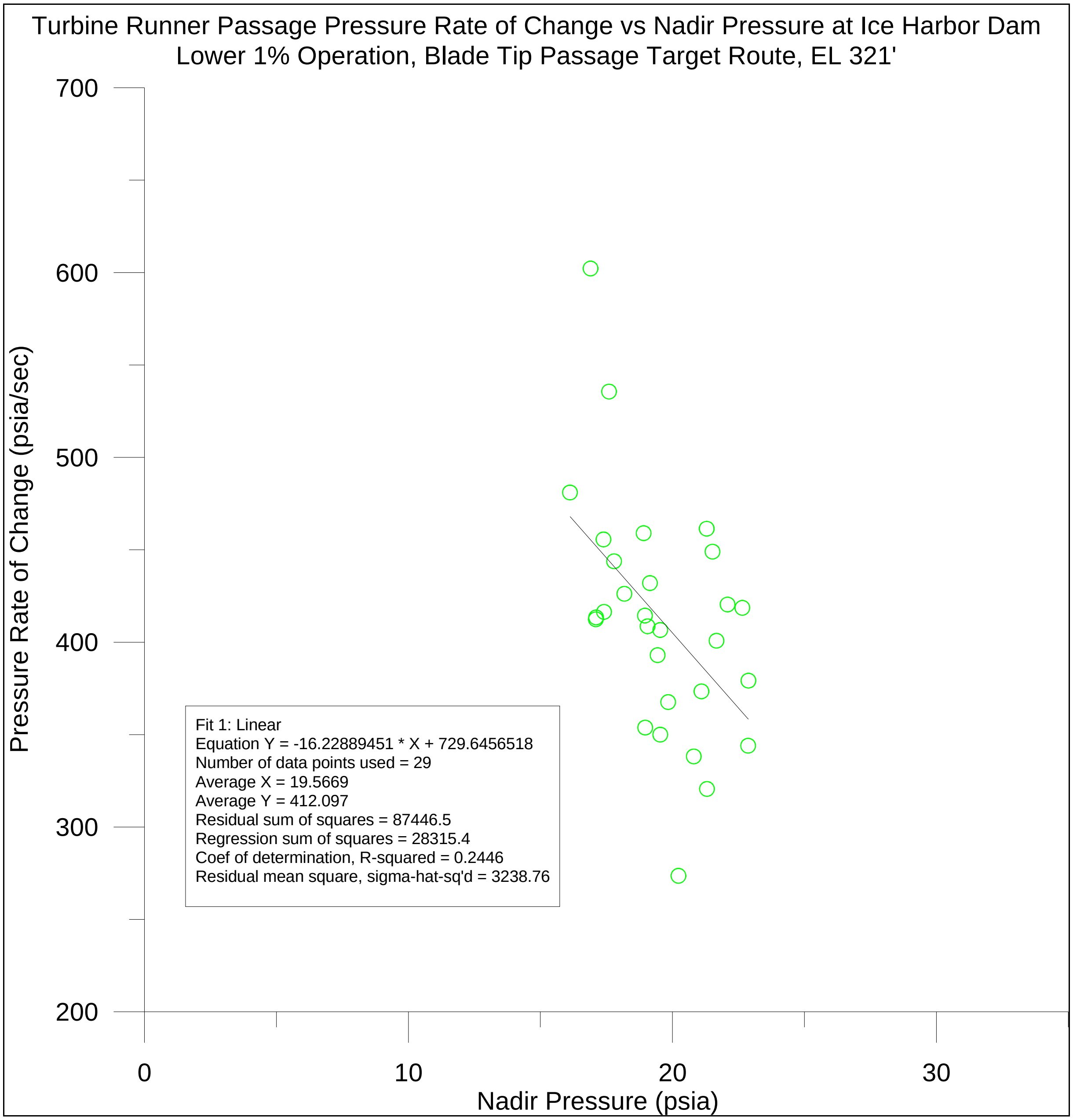

Figure A.7. Turbine runner passage rate of change by nadir pressure for lower 1% operation in the targeted blade tip passage route

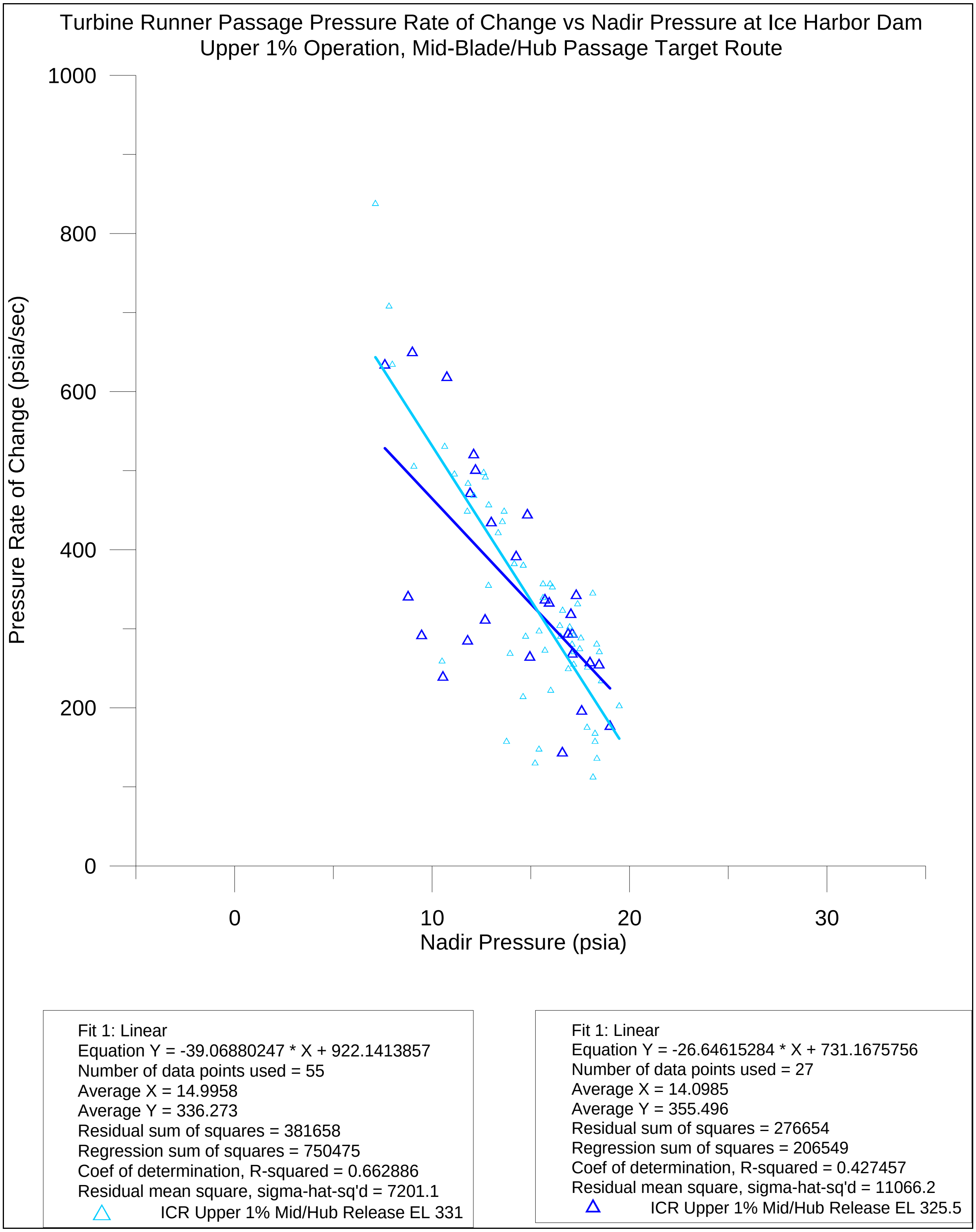

Figure A.8. Turbine runner passage rate of change by nadir pressure for the targeted upper 1% mid-blade/hub passage route

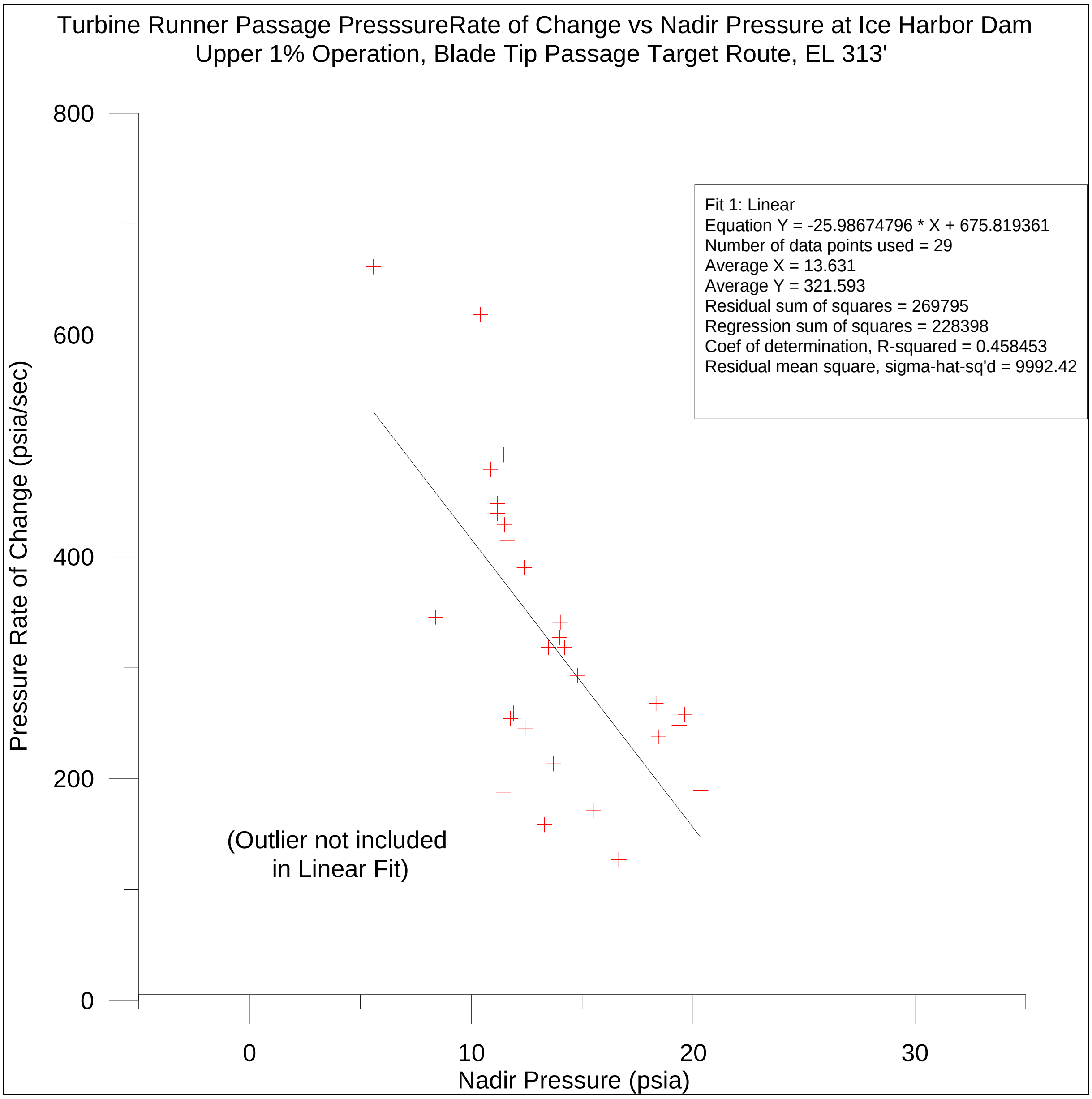

Figure A.9. Turbine runner passage rate of change by nadir pressure for upper 1% operation in the targeted blade tip passage route

Table A.2. Summary statistics for nadir pressure values

ICR Tip Upper 1% 13.1 kcfs - EL 313.2	
Nadir	
Mean	13.1917
Standard Error	0.7628
Median	12.86
Standard Deviation	4.1778
Sample Variance	17.4538
Kurtosis	1.9759
Skewness	-0.7124
Range	19.9
Minimum	0.45
Maximum	20.35
Count	30
Confidence Level (95.0%)	1.5600

ICR Tip Lower 1% 8.3 kcfs - EL 321.2	
Nadir	
Mean	19.5669
Standard Error	0.3639
Median	19.44
Standard Deviation	1.9595
Sample Variance	3.8396
Kurtosis	-1.0405
Skewness	0.1221
Range	6.76
Minimum	16.12
Maximum	22.88
Count	29
Confidence Level (95.0%)	0.7454

ICR Mid/Hub Release Upper 1% - 13.45 kcfs EL 331	
Nadir	
Mean	14.9958
Standard Error	0.4069
Median	15.62
Standard Deviation	3.0175
Sample Variance	9.1050
Kurtosis	0.1377
Skewness	-0.8662
Range	12.35
Minimum	7.13
Maximum	19.48
Count	55
Confidence Level (95.0%)	0.8157

ICR Mid/Hub Release Lower 1% - 8.3 kcfs EL 326.9	
Nadir	
Mean	19.5964
Standard Error	0.2783
Median	19.61
Standard Deviation	2.1193
Sample Variance	4.4913
Kurtosis	-0.5422
Skewness	-0.2732
Range	8.9
Minimum	14.38
Maximum	23.28
Count	58
Confidence Level (95.0%)	0.5572

ICR Mid/Hub Release Upper 1% - 13.5 kcfs EL 325.5	
Nadir	
Mean	14.0985
Standard Error	0.6437
Median	14.83
Standard Deviation	3.3450
Sample Variance	11.1887
Kurtosis	-1.1146
Skewness	-0.3484
Range	11.4
Minimum	7.61
Maximum	19.01
Count	27
Confidence Level (95.0%)	1.3232

ICR Mid/Hub Release Generator Limit - 14.1 kcfs EL 327.5	
Nadir	
Mean	14.9900
Standard Error	0.6697
Median	15.44
Standard Deviation	3.6680
Sample Variance	13.4560
Kurtosis	-0.4100
Skewness	-0.7210
Range	13.21
Minimum	6.33
Maximum	19.54
Count	30
Confidence Level (95.0%)	1.3696

Table A.3. Summary statistics for pressure rate-of-change values

ICR Tip Upper 1% 13.1 kcfs - EL 313.2	
Rate of Change	
Mean	318.1200
Standard Error	24.1805
Median	280.5
Standard Deviation	132.4423
Sample Variance	17540.9644
Kurtosis	0.5223
Skewness	0.9359
Range	534.6
Minimum	127
Maximum	661.6
Count	30
Confidence Level (95.0%)	49.4548

ICR Tip Lower 1% 8.3 kcfs - EL 321.2	
Rate of Change	
Mean	412.0966
Standard Error	11.9400
Median	413.4
Standard Deviation	64.2989
Sample Variance	4134.3503
Kurtosis	2.0923
Skewness	0.6797
Range	328.6
Minimum	273.6
Maximum	602.2
Count	29
Confidence Level (95.0%)	24.4580

ICR Mid/Hub Release Upper 1% - 13.45 kcfs EL 331	
Rate of Change	
Mean	336.2727
Standard Error	19.5241
Median	298
Standard Deviation	144.7944
Sample Variance	20965.4302
Kurtosis	1.9319
Skewness	1.1206
Range	725.4
Minimum	113.4
Maximum	838.8
Count	55
Confidence Level (95.0%)	39.1434

ICR Mid/Hub Release Lower 1% - 8.3 kcfs EL 326.9	
Rate of Change	
Mean	413.3621
Standard Error	11.6881
Median	398.8
Standard Deviation	89.0142
Sample Variance	7923.5333
Kurtosis	1.3208
Skewness	0.8838
Range	447.8
Minimum	238.6
Maximum	686.4
Count	58
Confidence Level (95.0%)	23.4051

ICR Mid/Hub Release Upper 1% - 13.5 kcfs EL 325.5	
Rate of Change	
Mean	355.4963
Standard Error	26.2359
Median	318
Standard Deviation	136.3258
Sample Variance	18584.7304
Kurtosis	-0.0244
Skewness	0.8087
Range	506.4
Minimum	142.8
Maximum	649.2
Count	27
Confidence Level (95.0%)	53.9287

ICR Mid/Hub Release Generator Limit - 14.1 kcfs EL 327.5	
Rate of Change	
Mean	374.3900
Standard Error	20.4380
Median	328.8
Standard Deviation	111.9400
Sample Variance	12532.0000
Kurtosis	-0.0660
Skewness	0.8650
Range	444.6
Minimum	193.2
Maximum	637.8
Count	30
Confidence Level (95.0%)	41.7960

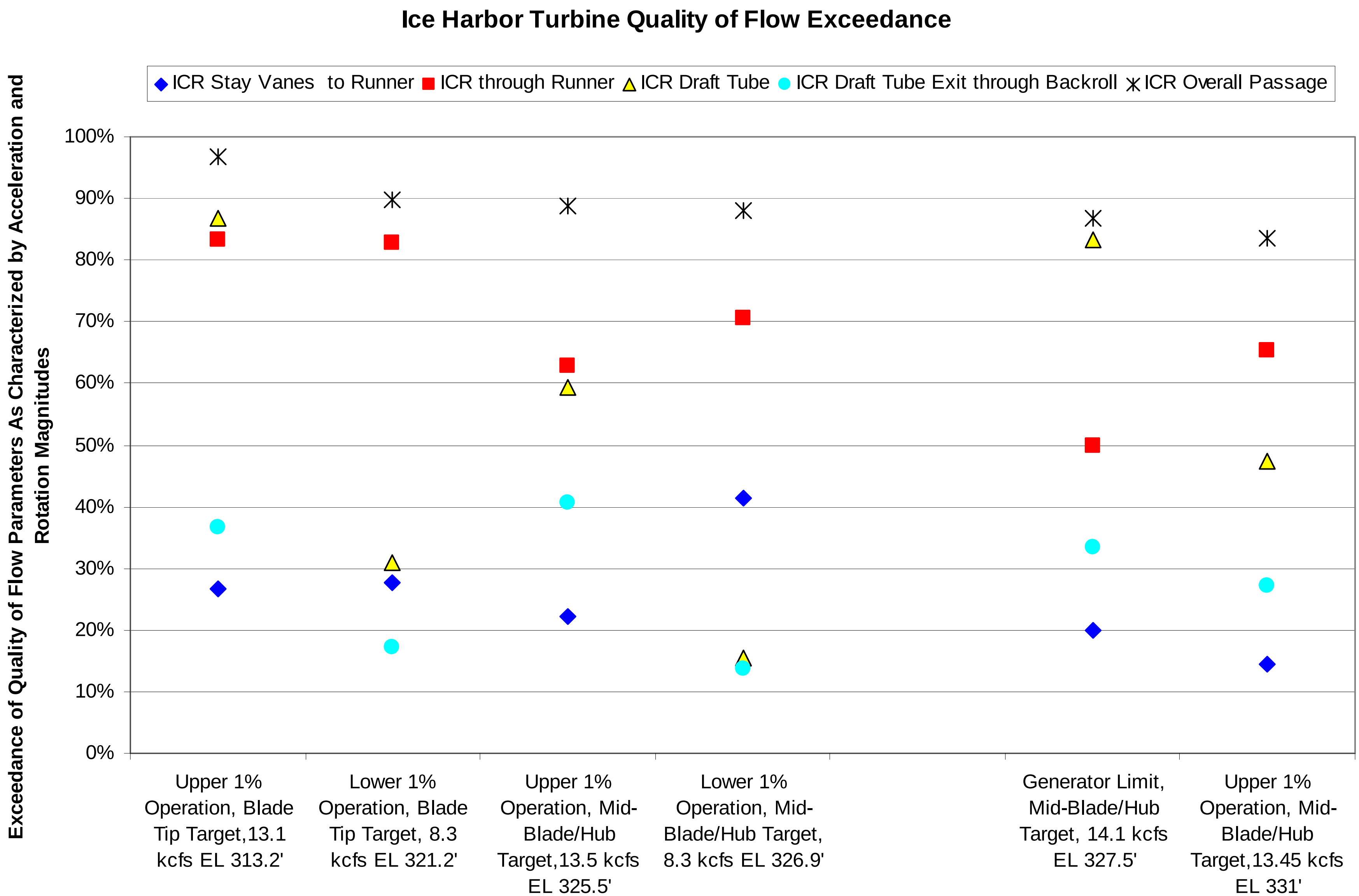

Figure A.10. Ice Harbor quality of flow exceedance based on turbine operation and location

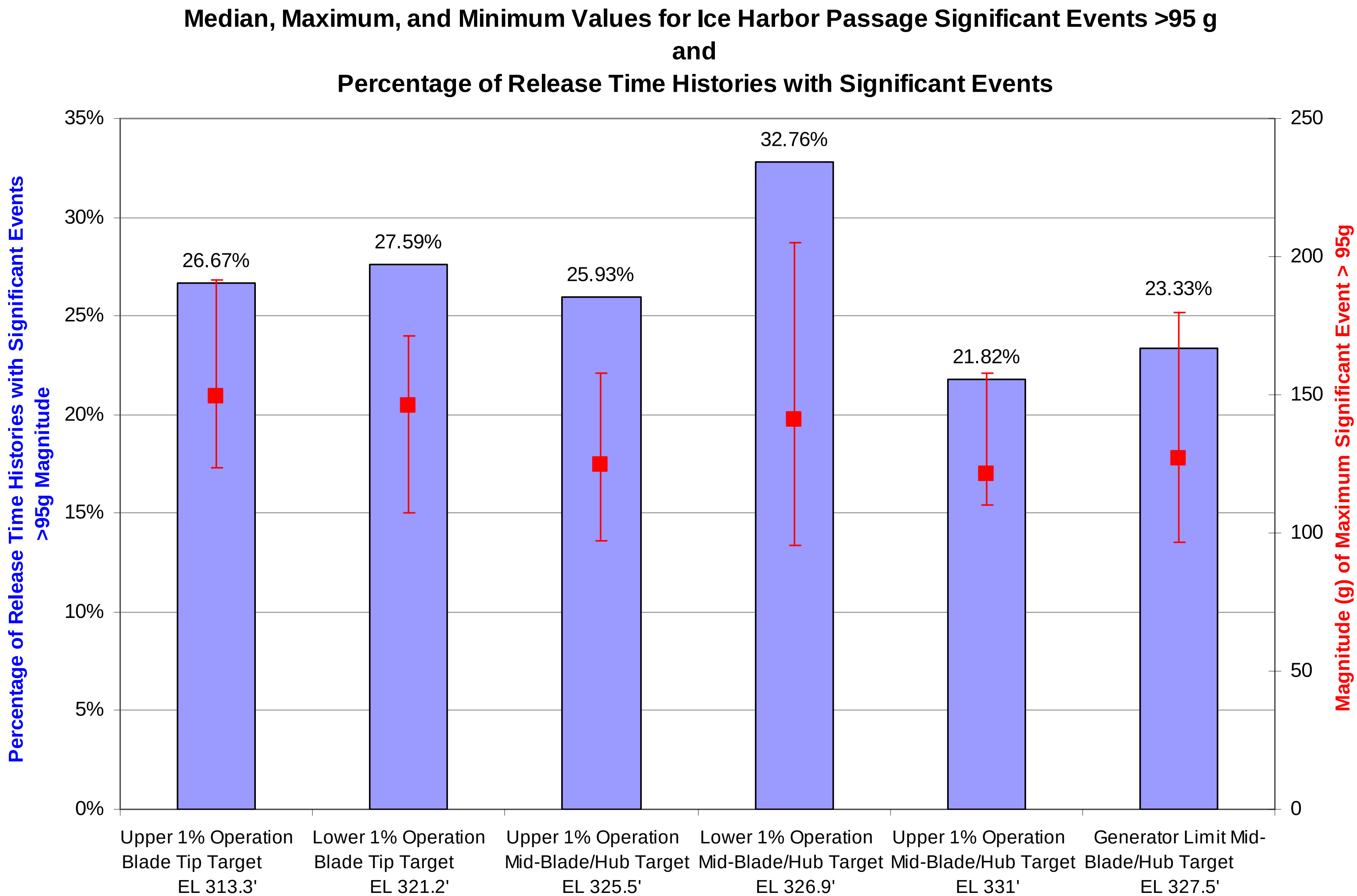

Figure A.11. Median, maximum, and minimum significant event magnitudes with percentage of releases having at least one event

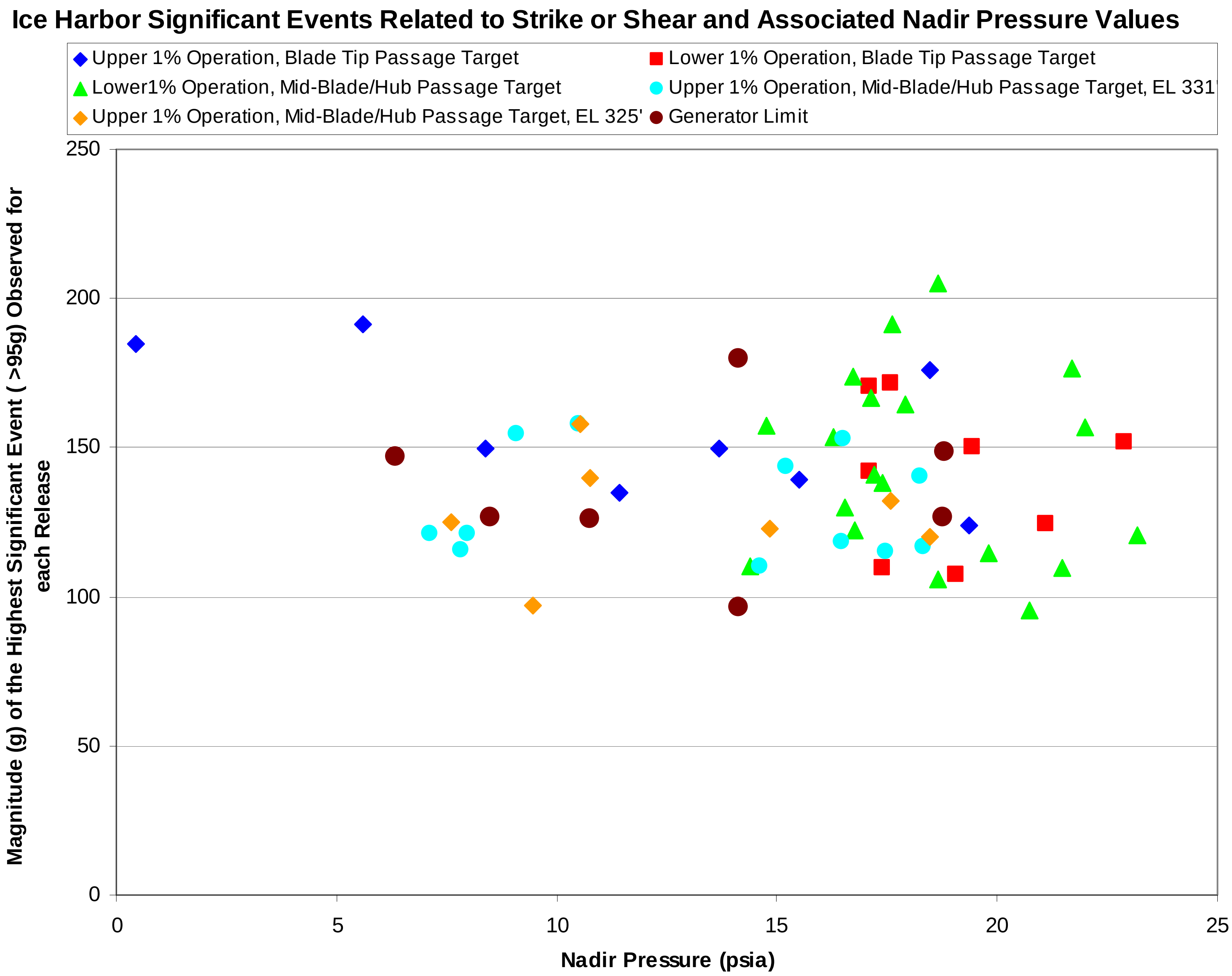

Figure A.12. Ice Harbor significant events related to strike or shear and associated pressure nadir values

Table A.4. Summary data for turbine significant events with related dam operations at Ice Harbor

Test Condition	*File Name*	*Baro Psi*	*FB ele*	*TW ele*	*Head (ft)*	*Release Pt -psia*	*Release El*	*Rate of Change Psi/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
Upper 1%	F691_tip_high_1	14.51	438.8	340.36	98.44	68.38	314.5381	189.20	20.35		
Tip	f682_tip_high_2	14.51	438.8	340.36	98.44	69.15	312.7619	390.40	12.39		
Target El 313.4'	f701_tip_high_3	14.51	438.8	340.39	98.41	69.1	312.8772	254.20	11.77		
	f686_tip_high_4	14.51	438.8	340.39	98.41	69.1	312.8772	158.60	13.29		
Unit 3B	f699_tip_high_5	14.5	438.99	340.55	98.44	68.75	313.8515	127.00	16.65		
	f692_tip_high_6	14.5	438.99	340.55	98.44	69.04	313.1826	259.20	11.91		
	f635_tip_high_7	14.5	439	340.58	98.42	68.84	313.6539	341.00	14.01		
	f689_tip_high_8	14.5	439	340.58	98.42	69.07	313.1234	257.60	19.63		
	f672_tip_high_9	14.5	438.99	340.59	98.4	69.31	312.5598	318.60	14.2		
	f700_tip_high_10	14.5	438.99	340.59	98.4	69.09	313.0672	492.00	11.45		
	f640_tip_high_11	14.5	439	340.61	98.39	69.24	312.7312	448.20	11.19		
	f694_tip_high_12	14.5	439	340.61	98.39	69.47	312.2007	171.20	15.5	y	139.3
	f693_tip_high_13	14.5	439.11	340.62	98.49	69.29	312.7259	345.60	8.4	y	149.7
	f703_tip_high_14	14.5	439.11	340.62	98.49	68.9	313.6255	318.20	13.48		
	f684_tip_high_15	14.5	439.11	340.62	98.49	69.14	313.0719	217.40	0.45	y	184.9
	f664_tip_high_16	14.5	439.1	340.59	98.51	69.64	311.9086	618.20	10.41		
	f656_tip_high_17	14.5	439.1	340.59	98.51	68.94	313.5233	193.40	17.43		
	f633_tip_high_18	14.5	439.11	340.56	98.55	68.76	313.9485	439.00	11.17		
	f675_tip_high_19	14.5	439.11	340.56	98.55	69.11	313.1411	428.80	11.49		
	f687_tip_high_20	14.5	439.11	340.56	98.55	69.09	313.1872	237.80	18.46	y	176
	f695_tip_high_21	14.5	439.11	340.56	98.55	68.74	313.9946	188.00	11.44	y	134.8
	f698_tip_high_22	14.5	439.18	340.58	98.6	69.1	313.2342	245.00	12.43		
	f678_tip_high_23	14.5	439.18	340.58	98.6	69.43	312.473	213.40	13.7	y	149.7
	f673_tip_high_24	14.5	439.18	340.58	98.6	68.87	313.7647	414.60	11.62		
	f691_tip_high_25	14.5	439.18	340.58	98.6	68.47	314.6874	267.80	18.33		
	f682_tip_high_26	14.49	439.15	340.58	98.57	68.92	313.5963	661.60	5.59	y	191.3
	f701_tip_high_27	14.49	439.15	340.58	98.57	69.08	313.2272	327.40	13.98		
	f686_tip_high_28	14.49	439.15	340.58	98.57	69.19	312.9735	248.00	19.37	y	123.7
	f699_tip_high_29	14.49	439.15	340.57	98.58	68.74	314.0115	479.00	10.87		
	f692_tip_high_30	14.49	439.15	340.57	98.58	68.83	313.8039	293.20	14.79		
						Mean	**313.28**	**318.12**	**13.19167**	26.67%	**156.175**
						Median	**313.18**	**280.5**	**12.86**		**149.70**
						Min	**311.91**	**127**	**0.45**		**123.70**
						Max	**314.69**	**661.6**	**20.35**		**191.30**
						STDEV	**0.643**	**132.442**	**4.178**		**24.877**

Table A.4. (contd)

Test Condition	*File Name*	*Baro Psi*	*FB ele*	*TW ele*	*Head (ft)*	*Release Pt -psia*	*Release El*	*Rate of Change Psi/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
Lower 1%	L_T_630_1	14.46	439.41	340.18	99.23	66.42	319.5539	413.40	17.11	y	170.5
Tip	L_T_669_2	14.47	439.41	340.18	99.23	65.89	320.7995	535.60	17.6	y	171.4
Target El 317'	L_T_670_3	14.47	439.41	340.18	99.23	65.69	321.2608	379.20	22.88		
	L_T_660_4	14.47	439.41	340.18	99.23	65.69	321.2608	443.80	17.79		
Unit 2B	L_T_664_5	14.47	439.41	340.18	99.23	65.79	321.0302	426.20	18.18		
	L_T_640_6	14.47	439.35	340.1	99.25	66.08	320.3012	353.80	18.97		
	L_T_668_7	14.47	439.34	340.09	99.25	65.59	321.4215	273.60	20.23		
	L_T_673_8	14.47	439.34	340.09	99.25	65.5	321.6291	416.40	17.41	y	109.4
	L_T_667_9	14.47	439.34	340.09	99.25	65.59	321.4215	408.60	19.06	y DT	107.2
	L_T_639_10	14.46	439.32	340.12	99.2	65.6	321.3554	418.60	22.65		
	L_T_675_11	14.46	439.32	340.12	99.2	64.9	322.9701	373.40	21.1	y	124.2
	L_T_674_12	14.46	439.32	340.12	99.2	65.2	322.278	414.40	18.96		
	L_T_666_13	14.46	439.26	340.14	99.12	65.49	321.5491	320.60	21.31		
	L_T_678_14	14.46	439.26	340.14	99.12	65.39	321.7798	420.40	22.09		
	L_T_671_15	14.46	439.28	340.16	99.12	65.58	321.3615	432.00	19.15		
	L_T_661_16	14.46	439.3	340.16	99.14	65.49	321.5891	455.60	17.39		
	L_T_672_17	14.46	439.3	340.16	99.14	65.29	322.0504	406.60	19.54		
	L_T_620_18	14.46	439.3	340.16	99.14	65.65	321.22	449.00	21.52		
	L_T_630_19	14.46	439.3	340.16	99.14	66.32	319.6745	459.00	18.91		
	L_T_669_20	14.46	439.18	340.18	99	65.68	321.0308	412.40	17.1	y	141.8
	L_T_670_21	14.46	439.18	340.18	99	65.58	321.2615	481.00	16.12		
	L_T_660_22	14.46	439.18	340.18	99	65.87	320.5926	461.40	21.3		
	L_T_664_23	14.46	439.18	340.18	99	65.58	321.2615	338.20	20.81		
	L_T_640_24	14.46	439.18	340.18	99	66.17	319.9005	393.00	19.44	y	150.2
	L_T_668_25	14.46	439.22	340.14	99.08	65.39	321.7398	602.20	16.9		
	L_T_673_26	14.46	439.22	340.14	99.08	65.49	321.5091	350.00	19.54		
	L_T_667_27	14.46	439.22	340.14	99.08	65.29	321.9704	367.60	19.84		
	L_T_639_28	14.46	439.22	340.14	99.08	65.99	320.3557	400.80	21.67		
	L_T_675_29	14.46	439.22	340.14	99.08	65.29	321.9704	344.00	22.87	y	152
						Mean	**321.24**	**412.1**	**19.6**	27.59%	**140.8**
						Median	**321.36**	**413.4**	**19.4**		**146.00**
						Min	**319.55**	**273.6**	**16.1**		**107.20**
						Max	**322.97**	**602.2**	**22.9**		**171.40**
						STDEV	**0.764**	**64.299**	**1.959**		**25.139**

Table A.4. (contd)

Test Condition	***File Name***	***Baro Psi***	***FB ele***	***TW ele***	***Head (ft)***	***Release Pt -psia***	***Release El***	***Rate of Change Psi/sec***	***Nadir***	***Significant Event***	***Significant Event Magnitude***
Lower 1%	L_mid_620_1	14.51	439.64	340.37	99.27	63.29	327.1192	373.60	18.68		
Mid/Hub	L_mid_675_2	14.51	439.56	340.37	99.19	63.09	327.5005	351.80	21.74		
Target El 326.5'	L_mid_674_3	14.51	439.68	340.41	99.27	62.8	328.2895	310.80	21.94		
Unit 2B	L_mid_666_4	14.51	439.52	340.38	99.14	63.39	326.7685	393.00	19.01		
	L_mid_640_5	14.51	439.57	340.36	99.21	63.38	326.8416	465.20	21.25		
	L_mid_679_6	14.51	439.6	340.34	99.26	63.19	327.3098	479.00	17.35		
	L_mid_668_7	14.51	439.6	340.34	99.26	63.19	327.3098	475.00	16.56	y	130.1
	L_mid_673_8	14.51	439.6	340.34	99.26	63.38	326.8716	514.00	17.15	y	166.8
	L_mid_667_9	14.51	439.6	340.34	99.26	63.2	327.2868	383.20	20.38		
	L_mid_648_10	14.51	439.72	340.45	99.27	64.49	324.4311	428.20	19.81	y	114.6
	L_mid_630_11	14.51	439.72	340.45	99.27	63.91	325.769	405.80	21.05		
	L_mid_669_12	14.51	439.72	340.45	99.27	63.48	326.7609	410.40	18.91		
	L_mid_670_13	14.51	439.68	340.35	99.33	63.19	327.3898	367.60	20.76		
	L_mid_660_14	14.5	439.68	340.35	99.33	63.67	326.2596	686.40	17.63	y	191.1
	L_mid_664_15	14.5	439.98	340.99	98.99	63.76	326.352	396.80	18.8		
	L_mid_639_16	14.5	439.98	340.99	98.99	63.37	327.2516	302.00	22.99		
	L_mid_678_17	14.5	439.98	340.99	98.99	63.38	327.2285	479.00	17.93	y	164.6
	L_mid_671_18	14.5	439.96	341	98.96	63.77	326.3089	387.00	18.41		
	L_mid_661_19	14.5	439.96	341	98.96	63.57	326.7702	389.00	21.93		
	L_mid_672_20	14.54	439.75	341.07	98.68	63.22	327.4598	373.40	18.84		
	L_mid_620_21	14.54	439.75	341.07	98.68	63.32	327.2292	365.80	21.99	y	156.8
	L_mid_675_22	14.54	439.68	341.03	98.65	63.12	327.6205	391.00	20.89		
	L_mid_674_23	14.54	439.68	341.03	98.65	62.93	328.0588	537.60	16.3	y	153.6
	L_mid_666_24	14.49	439.68	341.03	98.65	63.27	327.1592	477.20	14.78	y	157.2
	L_mid_640_25	14.49	439.71	341.04	98.67	63.75	326.082	469.20	16.73	y	173.8
	L_mid_679_26	14.49	439.76	341.02	98.74	63.36	327.0316	336.20	20.94		
	L_mid_668_27	14.49	439.76	341.02	98.74	63.27	327.2392	400.80	23.19	y	120.4
	L_mid_673_28	14.49	439.76	341.02	98.74	63.27	327.2392	312.80	22.41		

Table A.4. (contd)

Test Condition	*File Name*	*Baro Psi*	*FB ele*	*TW ele*	*Head (ft)*	*Release Pt -psia*	*Release El*	*Rate of Change Psi/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
Lower 1%	L_mid_667_29	14.49	439.76	341.02	98.74	63.37	327.0085	328.40	20.26		
Mid/Hub	L_mid_630_30	14.49	439.68	341.01	98.67	63.98	325.5214	339.40	21.69	y	176.8
Target El 326.5'	L_mid_669_31	14.49	439.68	341.01	98.67	63.36	326.9516	408.60	21.62		
Unit 2B	L_mid_670_32	14.49	439.75	341.01	98.74	63.76	326.0989	336.40	22.02		
	L_mid_660_33	14.54	439.68	341.01	98.67	63.8	326.052	320.60	22.36		
	L_mid_664_34	14.48	439.79	341.08	98.71	63.06	327.7305	389.20	20.73	y	95.3
	L_mid_639_35	14.48	439.79	341.11	98.68	63.74	326.162	363.20	21.59		
	L_mid_678_36	14.48	439.79	341.11	98.68	63.26	327.2692	563.20	17.22	y	140.9
	L_mid_671_37	14.48	439.79	341.11	98.68	63.45	326.8309	406.80	20.74		
	L_mid_661_38	14.48	439.79	341.11	98.68	63.35	327.0616	238.60	23.28		
	L_mid_672_39	14.52	439.87	341.1	98.77	63.2	327.5798	289.40	22.34		
	L_mid_620_40	14.52	439.87	341.1	98.77	62.91	328.2488	503.20	17.04		
	L_mid_675_41	14.52	439.87	341.1	98.77	63.4	327.1185	463.40	18.73		
	L_mid_674_42	14.52	439.77	341.11	98.66	63.79	326.1189	383.20	20.39		
	L_mid_666_43	14.52	439.77	341.11	98.66	63.4	327.0185	441.80	18.04		
	L_mid_640_44	14.47	439.68	341.09	98.59	64.03	325.3599	410.60	18.48		
	L_mid_679_45	14.47	439.68	341.09	98.59	63.25	327.1592	529.80	14.38	y	110.1
	L_mid_668_46	14.47	439.68	341.09	98.59	63.54	326.4902	643.20	18.67	y	205.3
	L_mid_673_47	14.47	439.68	341.09	98.59	63.24	327.1822	422.20	19.74		
	L_mid_667_48	14.47	439.71	341.09	98.62	63.25	327.1892	512.20	18.47		
	L_mid_630_49	14.46	439.71	341.08	98.63	63.2	327.2814	290.20	19.68		
	L_mid_669_50	14.46	439.71	341.09	98.62	63.63	326.2896	396.80	18.47		
	L_mid_670_51	14.46	439.71	341.09	98.62	63.24	327.1892	430.00	18.66	y	105.6
	L_mid_660_52	14.46	439.71	341.09	98.62	63.72	326.082	420.20	19.54		
	L_mid_664_53	14.46	439.71	341.09	98.62	63.43	326.7509	262.00	18.37		
	L_mid_678_54	14.46	439.73	341.1	98.63	63.05	327.6474	631.40	17.4	y	137.9
	L_mid_671_55	14.46	439.76	341.09	98.67	63.23	327.2622	412.40	21.49	y	109.5
	L_mid_661_56	14.46	439.76	341.09	98.67	63.24	327.2392	397.00	20.91		
	L_mid_672_57	14.46	439.76	341.09	98.67	63.24	327.2392	379.20	19.15		
	L_mid_620_58	14.46	439.76	341.09	***98.67***	63.23	327.2622	400.60	16.78	y	122.3
						Mean	**326.92**	**413.36**	**19.60**	32.76%	**143.83**
						Median	**327.1392**	**398.8**	**19.61**		**140.9**
						Min	**324.4311**	**238.6**	**14.38**		**95.3**
						Max	**328.2895**	**686.4**	**23.28**		**205.3**
						STDEV	**0.698**	**89.014**	**2.119**		**31.298**

Table A.4. (contd)

Test Condition	File Name	Baro Psi	FB ele	TW ele	Head (ft)	Release Pt -psia	Release El	Rate of Change Psi/sec	Nadir	Significant Event	Significant Event Magnitude
Upper 1%	H_m_674_1	14.46	439.22	340.18	99.04	61.09	331.6586	496.60	11.13		
Mid/Hub	H_m_666_2	14.46	439.22	340.18	99.04	61.19	331.4279	492.80	12.7		
Target El 327.8	H_m_678_3	14.46	439.22	340.18	99.04	61.09	331.6586	469.20	12.12		
Unit 2B	H_m_671_4	14.46	439.19	340.22	98.97	61.48	330.729	506.40	9.08	y	154.4
	H_m_661_5	14.46	439.19	340.22	98.97	61.67	330.2907	838.80	7.13	y	121.3
	H_m_672_6	14.46	439.21	340.25	98.96	61.18	331.441	158.40	13.77		
	H_m_620_7	14.46	439.21	340.25	98.96	61.3	331.1642	176.20	17.85		
	H_m_630_8	14.46	439.21	340.25	98.96	62.05	329.4341	168.60	18.25	y	140.1
	H_m_669_9	14.46	439.21	340.25	98.96	61.77	330.08	484.80	11.82		
	H_m_670_10	14.46	439.1	340.27	98.83	61.28	331.1003	271.80	18.47		
	H_m_660_11	14.45	439.12	340.28	98.84	61.57	330.4283	223.00	16.01		
	H_m_640_12	14.45	439.07	340.27	98.8	61.76	329.94	252.20	17.87		
	H_m_668_13	14.45	439.07	340.27	98.8	61.16	331.324	256.00	17.17		
	H_m_673_14	14.45	439.07	340.27	98.8	60.98	331.7392	531.60	10.64		
	H_m_667_15	14.45	439.08	339.93	99.15	61.18	331.2879	273.80	15.72		
	H_m_639_16	14.45	439.08	339.93	99.15	61.25	331.1264	436.40	13.56		
	H_m_675_17	14.45	439.08	339.93	99.15	60.88	331.9799	275.60	17.48	y	115.1
	H_m_674_18	14.45	439.08	339.93	99.15	60.68	332.4413	291.40	14.74		
	H_m_666_19	14.45	439.09	339.76	99.33	60.69	332.4282	291.40	16.51	y	152.8
	H_m_678_20	14.45	439.09	339.6	99.49	60.69	332.4282	383.20	14.16		
	H_m_671_21	14.45	439.09	339.6	99.49	61.47	330.629	271.80	17.19		
	H_m_661_22	14.45	439.09	339.6	99.49	61.66	330.1907	281.40	17.09		
	H_m_672_23	14.45	439.09	339.6	99.49	61.27	331.0903	293.20	17.18		
	H_m_620_24	14.45	439.08	339.58	99.5	61.29	331.0342	298.00	15.42		
	H_m_630_25	14.44	439.15	339.54	99.61	61.94	329.5818	250.40	16.9		
	H_m_669_26	14.44	439.15	339.54	99.61	61.66	330.2276	357.80	15.62		
	H_m_670_27	14.44	439.15	339.54	99.61	61.26	331.1503	158.40	18.25		
	H_m_660_28	14.44	439.08	339.54	99.54	61.26	331.0803	635.40	7.99	y	121.1

Table A.4. (contd)

Test Condition	*File Name*	*Baro Psi*	*FB ele*	*TW ele*	*Head (ft)*	*Release Pt -psia*	*Release El*	*Rate of Change Psi/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
Upper 1%	H_m_640_29	14.44	439.08	339.54	99.54	61.94	329.5118	269.80	13.95		
Mid/Hub	H_m_668_30	14.44	438.89	339.73	99.16	61.16	331.121	113.40	18.15		
Target El 327.8	H_m_673_31	14.44	438.99	339.99	99.00	61.26	330.9903	332.40	17.37		
Unit 2B	H_m_667_32	14.44	438.99	339.99	99.00	60.97	331.6592	131.00	15.22	y	143.4
	H_m_639_33	14.44	438.99	339.99	99.00	61.04	331.4978	709.00	7.82	y	115.9
	H_m_675_34	14.44	438.99	339.99	99.00	60.87	331.8899	137.00	18.35		
	H_m_666_35	14.43	438.9	339.84	99.06	60.86	331.7999	457.60	12.87		
	H_m_678_36	14.43	438.94	339.81	99.13	60.96	331.6092	449.60	13.65		
	H_m_671_37	14.43	438.94	339.81	99.13	61.06	331.3786	353.80	16.09		
	H_m_672_38	14.43	439.1	339.57	99.53	60.86	331.9999	355.80	12.86		
	H_m_630_39	14.43	439.1	339.57	99.53	61.84	329.7394	324.20	16.61		
	H_m_669_40	14.43	439.1	339.57	99.53	61.65	330.1776	281.60	18.34	y DT	116.7
	H_m_670_41	14.43	439.02	339.6	99.42	60.96	331.6892	303.20	16.97		
	H_m_660_42	14.43	439.02	339.65	99.37	61.54	330.3514	346.00	18.14		
	H_m_640_43	14.43	439.02	339.65	99.37	61.64	330.1207	449.60	11.79		
	H_m_668_44	14.43	439.02	339.65	99.37	60.96	331.6892	148.60	15.41		
	H_m_673_45	14.43	439.02	339.65	99.37	61.05	331.4816	422.40	13.35		
	H_m_639_46	14.42	438.94	340.21	98.73	61.23	330.9634	235.00	18.57		
	H_m_675_47	14.42	438.93	340.1	98.83	60.56	332.4989	215.00	14.61	y	110.2
	H_m_666_48	14.42	438.93	340.1	98.83	60.56	332.4989	305.00	16.47	y	118.6
	H_m_678_49	14.42	438.93	340.1	98.83	61.04	331.3916	357.80	15.98		
	H_m_671_50	14.42	439.02	339.81	99.21	61.61	330.1668	203.40	19.48		
	H_m_672_51	14.42	438.93	339.67	99.26	61.04	331.3916	289.20	17.54		
	H_m_630_52	14.42	438.85	339.74	99.11	61.82	329.5124	498.60	12.61		
	H_m_669_53	14.42	438.85	339.74	99.11	61.73	329.72	260.00	10.51	y	157.7
	H_m_670_54	14.42	438.79	339.67	99.12	61.34	330.5596	381.20	14.62		
	H_M_664_55	14.45	439.07	340.27	**98.80**	61.27	331.0703	340.20	15.62		
						Mean	**331.05**	**336.27**	**15.00**	21.82%	**130.61**
						Median	**331.1264**	**298**	**15.62**		**121.2**
						Min	**329.4341**	**113.4**	**7.13**		**110.2**
						Max	**332.4989**	**838.8**	**19.48**		**157.7**
						STDEV	**0.837**	**144.794**	**3.017**		**17.669**

Table A.4. (contd)

Test Condition	File Name	Baro Psi	FB ele	TW ele	Head (ft)	Release Pt -psia	Release El	Rate of Change Psi/sec	Nadir	Significant Event	Significant Event Magnitude
High 1%	H_t_639_1	14.47	439.31	340.02	99.29	63.93	325.2206	284.40	11.8		
Tip	H_t_668_2	14.47	439.31	340.02	99.29	63.73	325.682	471.00	11.93		
Target El 313.4'	H_t_640_3	14.47	439.31	340.02	99.29	64.42	324.0903	649.20	9		
INCORRECT EL	H_t_673_4	14.46	439.31	340.02	99.29	63.92	325.2206	340.20	8.79		
Unit 2B	H_t_678_5	14.46	439.34	340	99.34	63.53	326.1502	434.00	13		
	H_t_666_6	14.46	439.34	340	99.34	64.02	325.0199	633.40	7.61	y	125
Mid/Hub Elevation	H_t_672_7	14.46	439.34	340	99.34	63.82	325.4813	254.20	18.46	y	120
	H_t_671_8	14.46	439.34	340	99.34	63.82	325.4813	293.20	17.1		
	H_t_630_9	14.46	439.35	339.99	99.36	64.14	324.7531	176.40	19.01		
	H_t_670_10	14.46	439.33	339.96	99.37	63.83	325.4482	264.00	14.95		
	H_t_675_11	14.46	439.33	339.96	99.37	63.33	326.6016	267.80	17.1		
	H_t_639_12	14.46	439.33	339.96	99.37	64.12	324.7793	318.00	17.03		
	H_t_669_13	14.46	439.33	339.96	99.37	62.36	328.8391	238.60	10.55	y -SV/WG/Blade	157.7
	H_t_640_14	14.46	439.18	339.98	99.2	64.31	324.191	520.00	12.11		
	H_t_673_15	14.46	439.18	339.98	99.2	63.53	325.9902	342.00	17.3		
	H_t_678_16	14.46	439.18	339.98	99.2	63.54	325.9672	332.40	15.93		
	H_t_672_17	14.46	439.21	339.99	99.22	63.63	325.7896	391.00	14.26		
	H_t_630_18	14.45	439.27	340.34	98.93	64.32	324.2349	443.80	14.83	y	122.9
	H_t_664_19	14.45	439.27	340.34	98.93	63.81	325.4113	310.80	12.69		
	H_t_675_20	14.45	439.3	340.16	99.14	63.33	326.5485	291.20	9.47	y	97.1
	H_t_671_21	14.46	439.27	340.34	98.93	63.92	325.1806	617.80	10.75	y	139.8
	H_t_670_22	14.45	439.3	340.16	99.14	63.91	325.2106	500.40	12.2		
	H_t_669_23	14.45	439.3	340.34	98.96	64.21	324.5186	293.20	16.89		
	H_t_639_24	14.45	439.3	340.34	98.96	63.52	326.1102	256.80	18		
	H_t_640_25	14.45	439.3	340.34	98.96	64.4	324.0803	142.80	16.6		
	H_t_673_26	14.45	439.33	340.14	99.19	63.71	325.702	336.20	15.72		
	H_t_678_27	14.45	439.33	340.14	99.19	63.81	325.4713	195.60	17.58	y	132.4
						Mean	**325.45**	**355.50**	**14.10**	25.93%	**127.84**
						Median	**325.45**	**318.00**	**14.83**		**125.00**
						Min	**324.08**	**142.80**	**7.61**		**97.10**
						Max	**328.84**	**649.20**	**19.01**		**157.70**
						STDEV	**0.976**	**136.326**	**3.345**		**18.683**

Table A.4. (contd)

Test Condition	File Name	Baro psi	Forebay Elevation (ft)	Tailwater Elevation (ft)	Head (ft)	Release Pt - psia	Release El (ft)	Rate of Change (psia/sec)	Nadir (psia)	Significant Event (y/n)	Significant Event Magnitude (g)
Generator Limit	gen_1_724	14.63	439.77			63.8	326.35	474.2	12.79	n	
14.1 kcfs	gen_2_722	14.63	439.77			63.27	327.57	284.8	19.24	n	
Unit 3B	gen_3_719	14.63	439.77			63.3	327.50	637.8	6.33	y	146.7
	gen_4_709	14.63	439.77			63.27	327.57	327.8	16.23	n	
	gen_5_725	14.63	439.77			63.32	327.46	335.6	18.48	n	
Mid-Blade/Hub	gen_6_711	14.63	439.77			63.27	327.57	282.4	18.82	n	
	gen_7_718	14.63	439.77			63.24	327.64	319.6	15.6	n	
	gen_8_635	14.63	439.77			63.29	327.53	325	14.14	y	96.7
	gen_9_723	14.63	439.77			63.15	327.85	314.2	17.07	n	
	gen_11_709	14.56	438.1			62.46	327.61	325.8	14.71	n	
	gen_12_724	14.56	438.1			63.04	326.27	329.8	18.76	y	126.8
	gen_13_714	14.56	438.1			62.47	327.59	292.6	15.28	n	
	gen_19_661	14.56	438.1			62.33	327.91	507.4	11.88	n	
	gen_14_718	14.56	438.1			62.52	327.47	427	13.43	n	
	gen_18_705	14.56	438.1			62.34	327.89	330.6	16.35	n	
	gen_10_722	14.56	438.1			62.45	327.63	321.8	18.83	n	
	gen_20_707	14.56	438.1			62.55	327.40	375.8	19.54	n	
	gen_15_723	14.56	438.1			62.32	327.93	557.8	9.01	n	
	gen_16_725	14.56	438.1			61.79	329.15	193.2	18.79	n	
	gen_17_713	14.56	438.1			62.51	327.49	370.6	14.13	y	179.8
	gen_21_711	14.56	438.43			62.55	327.73	567.2	8.51	y	126.4
	gen_30_635	14.56	438.43			62.59	327.64	458.6	10.75	y	126.2
	gen_22_722	14.56	438.43			62.66	327.48	594	10.06	n	
	gen_23_709	14.56	438.43			62.57	327.69	255	14.71	n	
	gen_24_724	14.56	438.43			62.76	327.25	269.4	17.34	n	
	gen_25_714	14.56	438.43			62.67	327.45	252.4	17.49	n	
	gen_26_718	14.56	438.43			62.73	327.32	319.6	15.18	n	
	gen_27_723	14.56	438.43			62.53	327.78	297.6	17.69	n	
	gen_28_725	14.56	438.43			62.71	327.36	414.8	18.79	y	148.4
	gen_29_713	14.56	438.43			62.71	327.36	469.2	9.9	n	
						Mean	327.55	374.39	14.99	23.33%	135.86
						Median	327.57	328.80	15.44		126.80
						Min	326.27	193.20	6.33		96.70
						Max	329.15	637.80	19.54		179.80
						STDev	0.4747	111.945	3.668		25.832

Appendix B

John Day Dam Turbine Data

Table B.1. Field data sheets for John Day Dam turbine testing

Test Date	Location	Test Condition	Fish ID	Tag #	Deployment Time	Recovery Time	File Name	Barometer	Notes	Forebay	Tailwater	Total Discharge (kcfs)	PH	Spill	T1	T2	T3	T4	T5	T9	S2
9/16/2005	U9A	11,680 cfs	630	8 640	15:22	15:28	L_M_630_1	29.55		263.41	160.26	81.8	80.3	1.5	12.7	13.8	14.2	14.3	13.8	11.5	1.5
		141.2 elevation	670	8 741	15:32	15:37	L_M_670_2	29.55		263.41	160.44	81.4	79.9	1.5	13.1	13.8	14.3	13.4	13.8	11.5	1.5
		90 mW	639	8 250	15:38	15:44	L_M_639_3	29.55		263.41	160.34	80.5	79	1.5	13.1	13.7	13.6	13.4	13.7	11.5	1.5
		Mid/Hub	671	8 191	15:45	15:48	L_M_671_4	29.56		263.41	160.43	80.8	79.3	1.5	13.1	13.6	14.5	13.4	13.2	11.5	1.5
			675	8 871	15:49	15:52	L_M_675_5	29.55		263.41	160.43	80.8	79.3	1.5	13.1	13.6	14.5	13.4	13.2	11.5	1.5
		actual 11679 cfs	664	8 160	15:58	16:02	L_M_664_6	29.56		263.41	160.35	79.8	78.3	1.5	13.1	13.6	13.4	13.4	13.3	11.5	1.5
		89 mw	669	8 950	16:04	16:10	L_M_669_7	29.54		263.41	160.32	79.4	77.9	1.5	13	13.6	13.3	13.3	13.2	11.5	1.5
			678	8 771	16:12	16:15	L_M_678_8	29.55		263.41	160.48	79.7	78.2	1.5	13.1	13.5	13.2	13.6	13.3	11.5	1.5
			672	8 331	16:16	16:20	L_M_672_9	29.54		263.41	160.46	79.3	77.8	1.5	13.1	13.6	13.3	13.1	13.2	11.5	1.5
			673	8 140	16:21	16:24	L_M_673_10	29.55		263.31	160.39	79.6	78.1	1.5	13	13.6	13.2	13.2	13.6	11.5	1.5
			640	8 211	16:25	16:30	L_M_640_11	29.55		263.31	160.65	79.9	78.4	1.5	13.1	13.6	13.3	13.2	13.7	11.5	1.5
			630	8 640	16:31	16:36	L_M_630_12	29.54		263.34	160.64	80.0	78.5	1.5	13.1	13.6	13.3	13.2	13.7	11.6	1.5
			670	8 741	16:36	16:40	L_M_670_13	29.54		263.31	160.45	79.9	78.4	1.5	13.1	13.6	13.3	13.2	13.7	11.5	1.5
			639	8 250	16:38	16:40	L_M_639_14	29.54		263.31	160.45	79.9	78.4	1.5	13.1	13.6	13.3	13.2	13.7	11.5	1.5
			671	8 191	16:42	16:44	L_M_671_15	29.55		263.31	160.5	79.8	78.3	1.5	13.1	13.6	13.3	13.1	13.7	11.5	1.5
			675	8 871	16:43	16:50	L_M_675_16	29.55		263.31	160.5	79.8	78.3	1.5	13.1	13.6	13.3	13.1	13.7	11.5	1.5
			664	8 160	16:47	16:51	L_M_664_17	29.55		263.31	160.54	79.8	78.3	1.5	13.1	13.6	13.3	13.2	13.6	11.5	1.5
			669	8 950	16:58	17:01	L_M_669_18	29.56		263.31	160.66	80.2	78.7	1.5	13.1	13.6	13.3	13.5	13.7	11.5	1.5
			678	8 771	17:00	17:03	L_M_678_19	29.57		263.31	160.44	80.3	78.8	1.5	13	13.5	13.5	13.6	13.7	11.5	1.5
			672	8 331	17:05	17:09	L_M_672_20	29.56		263.31	160.55	79.6	78.1	1.5	13	13.3	13.7	13.4	13.2	11.5	1.5
			673	8 140	17:10	17:13	L_M_673_21	29.56		263.31	160.44	79.4	77.9	1.5	13	13.3	13.5	13.5	13.1	11.5	1.5
			640	8 211	17:17	17:22	L_M_640_22	29.56		263.31	160.51	79.7	78.2	1.5	13.1	13.3	13.6	13.5	13.2	11.5	1.5
			630	8 640	17:23	17:28	L_M_630_23	29.55		263.31	160.55	80.7	79.2	1.5	13.1	13.3	14.6	13.5	13.2	11.5	1.5
			670	8 741	17:29	17:36	L_M_670_24	29.56		263.31	160.55	80.7	79.2	1.5	13.1	13.3	14.6	13.5	13.2	11.5	1.5
			639	8 250	17:34	17:37	L_M_639_25	29.56		263.21	160.65	80.7	79.2	1.5	13.1	13.3	14.6	13.5	13.2	11.5	1.5
			671	8 191	17:40		L_M_671_49	29.56		263.21	160.55	79.5	78	1.5	13.1	13.3	13.3	13.5	13.3	11.5	1.5
			675	8 131	17:45	17:48	L_M_675_26	29.57		263.21	160.55	79.9	78.4	1.5	13.1	13.4	13.3	13.6	13.5	11.5	1.5

Table B.1. (contd)

Test Date	Location	Test Condition	Fish ID	Tag #	Deployment Time	Recovery Time	File Name	Barometer	Notes	Forebay	Tailwater	Total Discharge (kcfs)	PH	Spill	T1	T2	T3	T4	T5	T9	S2
9/17/2005	U9A	11,680 cfs	630	8 640	7:52	7:54	L_M_630_28	29.70		263.31	160.34	90.5	89	1.5	14.4	16.1	16.1	15.4	15.3	11.7	1.5
		141.2 elevation	670	8 741	7:53	7:58	L_M_670_29	29.70		263.31	160.34	90.5	89	1.5	14.4	16.1	16.1	15.4	15.3	11.7	1.5
			639	8 250	7:56	7:59	L_M_639_30	29.70		263.31	160.34	91.4	89.9	1.5	14.3	16.2	16.1	15.9	15.7	11.7	1.5
		Mid/Hub	675	8 131	8:00	8:06	L_M_675_31	29.69		263.31	160.24	88.3	86.8	1.5	14.2	15.1	14.9	15.2	15.7	11.7	1.5
			664	8 160	8:04	8:06	L_M_664_32	29.70		263.31	160.24	88.3	86.8	1.5	14.2	15.1	14.9	15.2	15.7	11.7	1.5
			669	8 950	8:08	8:11		29.69	no yellow balloon - lea	263.41	160.55	90.6	89.1	1.5	14.3	15.8	15.8	15.5	15.9	11.8	1.5
			678	8 771	8:10	8:16	L_M_678_33	29.70		263.41	160.31	90.4	88.9	1.5	14.2	16.1	15.5	15.8	15.6	11.7	1.5
			672	8 331	8:12	8:19	L_M_672_34	29.69		263.41	160.31	90.4	88.9	1.5	14.2	16.1	15.5	15.8	15.6	11.7	1.5
			673	8 910	8:17	8:23		29.69	dead	263.41	160.54	90.0	88.5	1.5	14.3	16	15	15.9	15.6	11.7	1.5
			640	8 211	8:20	8:29	L_M_640_35	29.69		263.41	160.45	91.0	89.5	1.5	14.2	15.9	16.2	15.9	15.6	11.7	1.5
			630	8 640	8:30	8:33	L_M_630_36	29.71		263.41	160.27	91.1	89.6	1.5	14.3	15.9	16.4	16	15.3	11.7	1.5
			670	8 741	8:35	8:43		29.68	no orange balloon, no radio tag	263.41	160.44	91.2	89.7	1.5	14.3	16	16.4	16	15.3	11.7	1.5
			639	8 250	8:40	8:48	L_M_639_37	29.66		263.31	160.34	91.3	89.8	1.5	14.3	16	16.5	16	15.3	11.7	1.5
			675	8 131	8:45	8:49	L_M_675_38	29.72		263.31	160.26	91.5	90	1.5	14.3	15.9	16.5	16.3	15.3	11.7	1.5
			664	8 160	8:52	9:00		29.72	NO Data leaked	263.31	160.32	91.7	90.2	1.5	14.3	15.9	16.4	16.6	15.3	11.7	1.5
			678	8 771	9:01	9:11	L_M_678_39	29.72		263.38	160.24	92.0	90.5	1.5	14.3	16.3	16	16.7	15.5	11.7	1.5
			672	8 331	9:04	9:08	L_M_672_40	29.73		263.38	160.24	92.0	90.5	1.5	14.3	16.3	16	16.7	15.5	11.7	1.5
			640	8 211	9:11	9:15	L_M_640_41	29.74		263.31	160.34	90.6	89.1	1.5	14.4	15.8	16	15.8	15.4	11.7	1.5
			630	8 640	9:21	9:26	L_M_630_42	29.73		263.31	160.34	90.8	89.3	1.5	14.4	15.7	16	15.9	15.5	11.8	1.5
			670	8 341	9:30	9:34	L_M_670_43	29.73		263.31	160.39	90.9	89.4	1.5	14.4	16.4	15.4	15.9	15.5	11.8	1.5
			639	8 250	9:34	9:39	L_M_639_44	29.73		263.31	160.39	90.9	89.4	1.5	14.4	16.4	15.4	15.9	15.5	11.8	1.5
			675	8 131	9:40	9:45	L_M_675_45	29.73		263.31	160.34	92	90.5	1.5	14.4	16	16.8	16.3	15.3	11.7	1.5
			678	8 771	9:50	9:55	L_M_678_46	29.73		263.31	160.31	90.8	89.3	1.5	14.4	15.5	16.1	16.3	15.3	11.7	1.5
			672	8 331	9:57	10:02	L_M_672_47	29.73		263.41	160.34	91.3	89.8	1.5	14.3	16.2	16	15.9	15.7	11.7	1.5
			640	8 211	10:01	10:15		29.73	no data	263.41	160.34	90.8	89.3	1.5	14.3	15.8	15.7	15.9	15.9	11.7	1.5
			630	8 640	10:07	10:13	L_M_630_48	29.73		263.41	160.38	90.1	88.6	1.5	14.3	15.5	15.4	15.9	15.8	11.7	1.5
			670	8 341	10:16	10:20	L_M_670_50	29.72		263.51	160.44	88.8	87.3	1.5	14.3	15.4	14.8	15.2	15.9	11.7	1.5
			639	8 250	10:19	10:27	L_M_639_51	29.72		263.51	160.44	88.8	87.3	1.5	14.3	15.4	14.8	15.2	15.9	11.7	1.5
			675	8 131	10:30	10:33	L_M_675_52	29.73		263.51	160.41	88.2	86.7	1.5	14.4	15.4	14.8	15.1	15.2	11.8	1.5
			678	8 771	10:33	10:39	L_M_678_53	29.73		263.51	160.41	88.2	86.7	1.5	14.4	15.4	14.8	15.1	15.2	11.8	1.5
			672	8 331	10:42	10:45	L_M_672_54	29.72		263.51	160.26	87.9	86.4	1.5	14.3	15.4	14.8	15.1	15.1	11.7	1.5
			671	8 681	10:57	11:07	L_M_671_55	29.72		263.61	160.46	87.8	86.3	1.5	14.3	15.3	14.8	15	15.2	11.7	1.5
			630	8 640	10:52	11:11		29.72	no data	263.52	160.34	87.8	86.3	1.5	14.3	15.3	14.7	15.1	15.2	11.7	1.5
			670	8 341	11:08	11:13	L_M_670_56	29.72		263.61	160.55	91.5	90	1.5	14.3	15.9	16.2	15.9	16	11.7	1.5
			639	8 250	11:13	11:18	L_M_639_57	29.72		263.61	160.55	92.2	90.7	1.5	14.4	16.3	16.3	16	16	11.7	1.5
			675	8 131	11:34	11:38	L_M_675_58	29.72		263.61	160.75	92.1	90.6	1.5	14.3	16.3	16.3	15.9	16.1	11.7	1.5
			678	8 771	11:39	11:44	L_M_678_59	29.72		263.61	160.57	91.8	90.3	1.5	14.2	16.2	16.2	15.9	16.1	11.7	1.5
			672	8 331	11:44	11:49		29.72	no data	263.61	160.77	91.7	90.2	1.5	14.3	15.9	16.3	15.9	16.1	11.7	1.5
			640	8 211	11:50	11:59	L_M_640_60	29.72		263.61	160.75	91.2	89.7	1.5	14.3	15.3	16.3	15.9	16.2	11.7	1.5
			671	8 681	11:51	11:56	L_M_671_61	29.72		263.61	160.75	91.2	89.7	1.5	14.3	15.3	16.3	15.9	16.2	11.7	1.5

Table B.1. (contd)

Test Date	Location	Test Condition	Fish ID	Tag #	Deployment Time	Recovery Time	File Name	Barometer	Notes	Forebay	Tailwater	Total Discharge (kcfs)	PH	Spill	T1	T2	T3	T4	T5	T9	S2
9/17/2005	U9A	145.2' elevation	670	8 341	12:08	12:10	H_M_670_1	29.71		263.61	160.44	90.1	88.6	1.5	14.2	13	13.9	14	13.7	19.8	1.5
		20,510 cfs	639	8 250	12:10	12:14	H_M_639_2	29.72		263.61	160.55	85.1	83.6	1.5	13.1	12.4	12.5	12.8	12.4	20.4	1.5
		mid hub	630	8 640	12:13	12:16	H_M_630_3	29.71		263.61	160.55	85.1	83.6	1.5	13.1	12.4	12.5	12.8	12.4	20.4	1.5
			673	8 910	12:14	12:18		29.71	DEAD pulled	263.61	160.55	85.1	83.6	1.5	13.1	12.4	12.5	12.8	12.4	20.4	1.5
			675	8 131	12:20	12:25	H_M_675_4	29.71		263.61	160.33	83.7	82.2	1.5	12.4	12.3	12.1	12.4	12.4	20.6	1.5
			678	8 771	12:25	12:35	H_M_678_5	29.71		263.62	160.44	83.6	82.1	1.5	12.4	12.5	12.2	12.4	12.5	20.1	1.5
			672	8 331	12:29	12:36		29.71	no Data pulled	263.62	160.44	83.6	82.1	1.5	12.4	12.5	12.2	12.4	12.5	20.1	1.5
			640	8 211	12:38	12:46	H_M_640_6	29.71		263.71	160.44	83.3	81.8	1.5	12.3	12.6	12.1	12.3	12.4	20.1	1.5
			671	8 681	12:41	12:45	H_M_671_7	29.70		263.71	160.33	83.1	81.6	1.5	12.3	12.4	12.1	12.3	12.4	20.1	1.5
			670	8 341	12:47	12:50	H_M_670_8	29.70		263.71	160.44	83.4	81.9	1.5	12.4	12.3	12.1	12.4	12.5	20.2	1.5
			639	8 250	12:57	13:01	H_M_639_9	29.71		263.71	160.44	84.3	82.8	1.5	12.6	12.3	12.8	12.4	12.5	20.2	1.5
			630	8 640	13:01	13:06	H_M_630_10	29.71		263.71	160.53	88.5	87	1.5	13	13.4	13.7	13.3	13.5	20.1	1.5
			675	8 131	13:12	13:18	H_M_675_11	29.70		263.71	160.85	95.7	94.2	1.5	14.5	14.9	15.1	14.8	14.8	20.1	1.5
			678	8 771	13:19	13:26	H_M_678_12	29.70		263.71	160.96	97.2	95.7	1.5	15.2	15.1	14.4	15.3	15.5	20.2	1.5
			671	8 681	13:36	13:47	H_M_671_13	29.69		263.71	161.06	95.9	94.4	1.5	14.3	15.1	15.5	14.8	14.6	20.1	1.5
			640	8 211	13:27	13:32	H_M_640_14	29.69		263.71	160.96	96.4	94.9	1.5	14.2	15.1	15.4	14.8	15.3	20.1	1.5
			670	8 341	13:43	13:49	H_M_670_15	29.69		263.71	161.04	95.3	93.8	1.5	14.3	15.1	14.9	14.8	14.5	20.2	1.5
			664	8 160	13:48	13:54	H_M_664_16	29.69		263.61	161.01	94.8	93.3	1.5	14.3	15.2	14.4	14.8	14.5	20.1	1.5
			639	8 250	13:55	14:03	H_M_639_17	29.69		263.61	161.16	97.1	95.6	1.5	14.4	15.2	15.7	15.1	15.1	20.1	1.5
			630	8 640	13:58	14:02		29.69	pieces recovered	263.61	161.16	97.1	95.6	1.5	14.4	15.2	15.7	15.1	15.1	20.1	1.5
			675	8 131	14:06	14:10	H_M_675_18	29.69		263.61	161.09	89.9	88.4	1.5	14.4	13.6	13.7	13.2	13.5	20	1.5
			678	8 771	14:18	14:23	H_M_678_19	29.68		263.61	160.98	94.8	93.3	1.5	14.3	14.6	15.1	14.4	14.9	20	1.5
			671	8 681	14:23	14:30	H_M_671_20	29.68		263.61	161.06	95.1	93.6	1.5	14.4	14.7	15.1	14.4	15	20	1.5
			640	8 211	14:30	14:33	H_M_640_21	29.67		263.61	161.12	94.3	92.8	1.5	14.4	14.7	14.7	14.5	14.4	20.1	1.5
			670	8 341	14:38	14:41	H_M_670_22	29.67		263.61	161	94.2	92.7	1.5	14.4	14.7	14.7	14.5	14.4	20	1.5
			664	8 160	14:41	14:50	H_M_664_23	29.67		263.61	161.17	94.1	92.6	1.5	14.4	14.7	14.6	14.5	14.3	20.1	1.5
			639	8 250	14:58	15:11		29.67	full of water	263.61	161.06	95.1	93.6	1.5	14.4	14.7	15.1	14.5	15	19.9	1.5
			675	8 131	15:01	15:11	H_M_675_24	29.67		263.51	161.1	95.8	94.3	1.5	14.3	14.8	15.1	15	15.1	20	1.5
			678	8 771	15:09	15:14	H_M_678_25	29.67		263.51	161.27	98.1	96.6	1.5	14.4	15.9	15.1	15.3	15.9	20	1.5
			671	8 681	15:17			29.66	STATIONARY SIGNAI	263.41	161.27	100.5	99	1.5	14.4	16.1	16.5	16.1	16	19.9	1.5
			640	8 211	15:23	15:30	H_M_640_26	29.67		263.41	161.27	100.4	98.9	1.5	14.3	15.9	16.5	16.1	16.1	20	1.5
			670	8 341	15:31	15:45	H_M_670_27	29.67		263.41	161.37	100.4	98.9	1.5	14.4	15.9	16.3	16.2	16.1	20	1.5
			664	8 160	15:37	15:45	H_M_664_28	29.66		263.51	161.46	99.5	98	1.5	14.4	15.9	15.5	16.2	16.1	19.9	1.5
			675	8 131	15:42	15:47	H_M_675_29	29.66		263.51	161.4	101	99.5	1.5	14.4	15.9	16.7	16.2	16.2	20.1	1.5
			678	8 771	15:48	15:52	H_M_678_30	29.66		263.51	161.48	100.9	99.4	1.5	14.4	15.9	16.7	16.2	16.2	20	1.5
			640	8 211	16:07	16:12	H_M_640_31	29.67		263.41	161.43	101	99.5	1.5	14.3	16.1	16.7	16.1	16.1	20.2	1.5
			670	8 341	16:13	16:19	H_M_670_32	29.67		263.41	161.58	100.8	99.3	1.5	14.4	16.1	16.2	16.2	16.2	20.2	1.5
			664	8 160	16:17	16:21	H_M_664_33	29.66		263.41	161.39	100.4	98.9	1.5	14.3	16.1	16	16.1	16.1	20.3	1.5
			675	8 131	16:23	16:27	H_M_675_34	29.66		263.41	161.57	100.7	99.2	1.5	14.4	16.1	16	16.2	16.2	20.3	1.5
			678	8 771	16:30	16:33	H_M_678_35	29.66		263.51	161.54	100.1	98.6	1.5	14.3	16	16	16.1	16.1	20.1	1.5

Table B.1. (contd)

Date	*Location*	*Test Condition*	*Fish ID*	*Tag #*	*Deployment Time*	*Recovery Time*	*File Name*	*Barometric Pressure*	*Notes*	*FB EL*	*TW EL*	*# units on*	*PH Q*	*Spill Q*	*Total Q*	*T8 Q*	*T9 Q*	*T10 Q*
3/26/2006	9A	Normandeau pipe	689	8 191	808	812	norm_689_ELTest	29.88										
		El 130.5																
3/26/2006	9A	Upper 1%	633	8 151	924	927	mid_U_633_1	29.89		264.31	161.37	12	188.2	0	188.2	15	19.9	15.6
		~20.5 kcfs	694	8 111	925	929	mid_U_694_2	29.89		264.31	161.37	12	188.2	0	188.2	15	19.9	15.6
		Mid/Hub	691	8 081	926	931	mid_U_691_3	29.89		264.31	161.37	12	188.2	0	188.2	15	19.9	15.6
		EL 145.2	635	8 711	927	931	mid_U_635_4	29.89		264.31	161.37	12	188.2	0	188.2	15	19.9	15.6
			673	8 091	928	939	Accidently erased	29.89		264.31	161.37	12	188.2	0	188.2	15	19.9	15.6
			684	9 661	929	933	mid_U_684_5	29.89		264.31	161.37	12	188.2	0	188.2	15	19.9	15.6
			700	9 130	930	933	mid_U_700_6	29.89		264.31	161.27	12	187.5	0	187.5	15	19.9	15.7
			672	9 180	931	934	mid_U_672_7	29.89		264.31	161.27	12	187.5	0	187.5	15	19.9	15.7
			692	8 211	932	945	mid_U_692_8	29.89		264.31	161.27	12	187.5	0	187.5	15	19.9	15.7
			682	8 251	933	936	mid_U_682_9	29.89		264.31	161.27	12	187.5	0	187.5	15	19.9	15.7
			678	9 931	934	937	mid_U_678_10	29.89		264.31	161.27	12	187.5	0	187.5	15	19.9	15.7
			693	8 501	935	938	mid_U_693_11	29.89		264.31	161.27	12	190.6	0	190.6	15	19.9	15.5
			664	9 300	936	940	mid_U_664_12	29.89		264.31	161.27	12	190.6	0	190.6	15	19.9	15.5
			701	8 221	937	943	mid_U_701_13	29.89		264.31	161.27	12	190.6	0	190.6	15	19.9	15.5
			689	8 191	937	940	mid_U_689_14	29.89		264.31	161.27	12	190.6	0	190.6	15	19.9	15.5
			633	8 151	1050	1054	mid_U_633_15	29.88		264.21	161.17	12	184	0	184	15.3	19.9	14.8
			694	8 111	1051	1055	mid_U_694_16	29.88		264.21	161.17	12	184	0	184	15.3	19.9	14.8
			691	8 081	1052			29.88	lost-orange balloon found, radiotag at bottom of river	264.21	161.17	12	184	0	184	15.3	19.9	14.8
			635	8 711	1053	1057	mid_U_635_17	29.88		264.21	161.17	12	184	0	184	15.3	19.9	14.8
			673	8 091	1054	1058	mid_U_673_18	29.88		264.21	161.17	12	184	0	184	15.3	19.9	14.8
			684	9 661	1055	1058	mid_U_684_19	29.88		264.21	161.06	12	179.4	0	179.4	14	20	14.7
			700	9 130	1056	1104	mid_U_700_20	29.88		264.21	161.06	12	179.4	0	179.4	14	20	14.7
			672	9 180	1057	1101	mid_U_672_21	29.88		264.21	161.06	12	179.4	0	179.4	14	20	14.7
			692	8 211	1058	1102	mid_U_692_22	29.88		264.21	161.06	12	179.4	0	179.4	14	20	14.7
			682	8 251	1059	1102	mid_U_682_23	29.88		264.21	161.06	12	179.4	0	179.4	14	20	14.7
			678	9 931	1100	1105	mid_U_678_24	29.88		264.21	160.96	12	175.8	0	175.8	13.7	20	14.3
			693	8 501	1101	1105	mid_U_693_25	29.88		264.21	160.96	12	175.8	0	175.8	13.7	20	14.3
			664	9 300	1102	1109	mid_U_664_26	29.88		264.21	160.96	12	175.8	0	175.8	13.7	20	14.3

Table B.1. (contd)

Date	*Location*	*Test Condition*	*Fish ID*	*Tag #*	*Deployment Time*	*Recovery Time*	*File Name*	*Barometric Pressure*	*Notes*	*FB EL*	*TW EL*	*# units on*	*PH Q*	*Spill Q*	*Total Q*	*T8 Q*	*T9 Q*	*T10 Q*
3/27/2006	9A	Normandeau pipe	689	8 191	820	823	normandeau_ck_3-2	29.63										
		El 130.5																
		Lower 1%																
3/27/2006	9A	PEAK	700	9 130	942	946	mid_p_700_1	29.59		264.81	161.48	12	186.9	0	186.9	15.4	16.5	15.4
		~16.6 kcfs	692	8 211	943	946	mid_p_692_2	29.59		264.81	161.48	12	186.9	0	186.9	15.4	16.5	15.4
		Mid/Hub	672	9 180	944	950	mid_p_672_3	29.59		264.81	161.48	12	186.9	0	186.9	15.4	16.5	15.4
		141.7	673	8 411	945	948	mid_p_673_4	29.59		264.81	161.48	12	185.3	0	185.3	15.3	16.5	15.5
			684	9 661	946	945	mid_p_684_5	29.59		264.81	161.48	12	185.3	0	185.3	15.3	16.5	15.5
			682	8 251	947	1001	mid_p_682_6	29.59		264.81	161.48	12	185.3	0	185.3	15.3	16.5	15.5
			678	9 931	948	951	mid_p_678_7	29.59		264.81	161.48	12	185.3	0	185.3	15.3	16.5	15.5
			701	8 221	949	953	mid_p_701_8	29.59		264.81	161.48	12	185.3	0	185.3	15.3	16.5	15.5
			664	9 300	951	954	mid_p_664_9	29.59		264.71	161.48	12	184.5	0	184.5	15.3	16.5	15.4
			693	8 501	950	956	mid_p_693_10	29.59		264.71	161.48	12	184.5	0	184.5	15.3	16.5	15.4
			633	8 151	951	954	mid_p_633_11	29.59		264.71	161.48	12	184.5	0	184.5	15.3	16.5	15.4
			694	8 111	952	955	mid_p_694_12	29.59		264.71	161.48	12	184.5	0	184.5	15.3	16.5	15.4
			635	8 711	953	957	mid_p_635_13	29.59		264.71	161.48	12	184.5	0	184.5	15.3	16.5	15.4
			689	8 191	954	956	mid_p_689_14	29.59		264.71	161.48	12	184.5	0	184.5	15.3	16.5	15.4
			700	9 130	1137	1140	mid_p_700_15	29.52		264.51	161.48	12	178.8	0	178.8	15.1	16.5	14.8
			672	9 180	1137	1142	mid_p_672_16	29.52		264.51	161.48	12	178.8	0	178.8	15.1	16.5	14.8
			684	9 661	1138	1142	mid_p_684_17	29.52		264.51	161.48	12	178.8	0	178.8	15.1	16.5	14.8
			678	9 931	1139	1144	mid_p_678_18	29.52		264.51	161.48	12	178.8	0	178.8	15.1	16.5	14.8
			664	9 300	1140	1147		29.52	download problem	264.51	161.48	12	178.6	0	178.6	15.6	16.5	14.8
			692	8 211	1141	1144	mid_p_692_19	29.52		264.51	161.48	12	178.6	0	178.6	15.6	16.5	14.8
			673	8 411	1142	1145	mid_p_673_20	29.52		264.51	161.48	12	178.6	0	178.6	15.6	16.5	14.8
			682	8 251	1143	1146	mid_p_682_21	29.52		264.51	161.48	12	178.6	0	178.6	15.6	16.5	14.8
			701	8 221	1144	1147	mid_p_701_22	29.52		264.51	161.48	12	178.6	0	178.6	15.6	16.5	14.8
			693	8 501	1145	1148	mid_p_693_23	29.52		264.51	161.48	12	178.7	0	178.7	14.9	16.5	14.7
			633	8 151	1145	1148	mid_p_633_24	29.52		264.51	161.48	12	178.7	0	178.7	14.9	16.5	14.7
			694	8 111	1146	1149	mid_p_694_25	29.52		264.51	161.48	12	178.7	0	178.7	14.9	16.5	14.7
			635	8 711	1147	1150	mid_p_635_26	29.52		264.51	161.48	12	178.7	0	178.7	14.9	16.5	14.7
			689	8 191	1148	1152	mid_p_689_27	29.52		264.51	161.48	12	178.7	0	178.7	14.9	16.5	14.7

Table B.1. (contd)

Date	Location	Test Condition	Fish ID	Tag #	Deployment Time	Recovery Time	File Name	Barometric Pressure	Notes	FB EL	TW EL	# units on	PH Q	Spill Q	Total Q	T8 Q	T9 Q	T10 Q
3/27/2006	9A	PEAK	700	9 130	1324	1328	mid_p_700_28	29.44		264.71	161.27	11	162.2	0	162.2	14.2	16.3	14.5
		~16.6 kcfs	672	9 180	1325	1332	mid_p_672_29	29.44		264.71	161.27	11	162.2	0	162.2	14.2	16.3	14.5
		Mid/Hub	684	9 661	1326	1330	mid_p_684_30	29.44		264.71	161.27	11	162.2	0	162.2	14.2	16.3	14.5
		141.7	678	9 931	1327	1331	mid_p_678_31	29.44		264.71	161.27	11	162.2	0	162.2	14.2	16.3	14.5
			692	8 211	1328	1331	dead	29.44		264.71	161.27	11	162.2	0	162.2	14.2	16.3	14.5
			673	8 411	1328	1334	mid_p_673_32	29.44		264.71	161.27	11	162.2	0	162.2	14.2	16.3	14.5
			682	8 251	1329	1334	mid_p_682_33	29.44		264.71	161.27	11	162.2	0	162.2	14.2	16.3	14.5
			701	8 221	1330	1334	mid_p_701_34	29.44		264.71	161.17	11	162.2	0	162.2	14.2	16.3	14.5
			693	8 501	1331	1334	mid_p_693_35	29.44		264.71	161.17	11	162.2	0	162.2	14.2	16.3	14.5
			633	8 151	1332	1335	mid_p_633_36	29.44		264.71	161.17	11	162.2	0	162.2	14.2	16.3	14.5
			694	8 111	1333	1335	mid_p_694_37	29.44		264.71	161.17	11	162.2	0	162.2	14.2	16.3	14.5
			635	8 711	1333	1339	mid_p_635_38	29.44		264.71	161.17	11	162.2	0	162.2	14.2	16.3	14.5
			689	8 191	1334	1337	mid_p_689_39	29.44		264.71	161.17	11	162.2	0	162.2	14.2	16.3	14.5
			664	9 300	1334	1341	mid_p_664_40	29.44		264.71	161.17	11	162.2	0	162.2	14.2	16.3	14.5
			700	9 130	1524	1537	mid_p_700_41	29.36		264.91	161.58	11	166.1	0	166.1	14.8	16.3	14.6
			672	9 180	1525	1528	mid_p_672_42	29.36		264.91	161.58	11	166.1	0	166.1	14.8	16.3	14.6
			684	9 661	1525	1537	mid_p_684_43	29.36		264.91	161.58	11	166.1	0	166.1	14.8	16.3	14.6
			678	9 931	1526	1530	mid_p_678_44	29.36		264.91	161.58	11	166.1	0	166.1	14.8	16.3	14.6
			673	8 411	1527	1531	mid_p_673_45	29.36		264.91	161.58	11	166.1	0	166.1	14.8	16.3	14.6
			682	8 251	1528	1533	mid_p_682_46	29.36		264.91	161.58	11	166.1	0	166.1	14.8	16.3	14.6
			693	8 501	1529	1534	mid_p_693_47	29.36		264.91	161.58	11	166.1	0	166.1	14.8	16.3	14.6
			633	8 151	1530	1540	mid_p_633_48	29.36		264.88	161.58	11	167.2	0	167.2	14.9	16.3	15.4
			694	8 111	1531	1535	mid_p_694_49	29.36		264.88	161.58	11	167.2	0	167.2	14.9	16.3	15.4
			635	8 711	1532	1536	mid_p_635_50	29.36		264.88	161.58	11	167.2	0	167.2	14.9	16.3	15.4
			689	8 191	1534	1539	mid_p_689_51	29.36		264.88	161.58	11	167.2	0	167.2	14.9	16.3	15.4
			664	9 300	1535	1539	mid_p_664_52	29.36		264.81	161.58	11	167.9	0	167.9	14.8	16.3	15.4
3/28/2006	9A	Normandeau pipe	689	8 221	828	833	normandeau_ck_3-2	29.36	FB 264.7									
		El 130.5																
		Upper 1% ~20.5 kcfs																
3/28/2006	9A	PEAK	689	8 221	951	1005	mid_P_689_53	29.38		264.91	162.2	12	202	0	202	17.1	16.4	17.1
		~16.6 kcfs	693	8 501	952	955	mid_P_693_54	29.38		264.91	162.2	12	202	0	202	17.1	16.4	17.1
		Mid/Hub	694	8 111	953	956	mid_P_694_55	29.38		264.91	162.2	12	202	0	202	17.1	16.4	17.1
		EL 141.7	682	8 251	954	958	mid_p_682_56	29.38		264.91	162.2	12	202	0	202	17.1	16.4	17.1
			678	8 211	954	957	mid_P_678_57	29.38		264.91	162.2	12	202	0	202	17.1	16.4	17.1
			633	8 151	956	1000	mid_P_633_58	29.38		264.81	162.29	12	206.4	0	206.4	17.2	16.4	17.3
			635	8 711	956	1000	mid_p_635_59	29.38		264.81	162.29	12	206.4	0	206.4	17.2	16.4	17.3
			673	8 411	957	1005	mid_P_673_60	29.38		264.81	162.29	12	206.4	0	206.4	17.2	16.4	17.3
			664	9 300	958	1001	mid_p_664_61	29.38		264.81	162.29	12	206.4	0	206.4	17.2	16.4	17.3
			684	9 661	959	1005	mid_P_684_62	29.38		264.81	162.29	12	206.4	0	206.4	17.2	16.4	17.3
			700	9 130	1000	1004	mid_p_700_63	29.38		264.91	162.2	12	205.7	0	205.7	17.2	16.3	17.3
			672	9 180	1001	1006	mid_P_672_64	29.38		264.91	162.2	12	205.7	0	205.7	17.2	16.3	17.3
			689	8 221	1125	1129	mid_p_689_65	29.35		264.71	162.2	12	204.5	0	204.5	17.2	16.4	17.4
			694	8 111	1126	1130	mid_p_694_66	29.35		264.71	162.2	12	204.5	0	204.5	17.2	16.4	17.4

Table B.1. (contd)

Date	Location	Test Condition	Fish ID	Tag #	Deployment Time	Recovery Time	File Name	Barometric Pressure	Notes	FB EL	TW EL	# units on	PH Q	Spill Q	Total Q	T8 Q	T9 Q	T10 Q
3/30/2006	9B	Peak	700	9 130	751	755	tip_p_700_1	29.64		264.21	162.1	12	202	0	202	16.4	16.5	16.8
		~16.6 kcfs	672	9 180	752	755	tip_p_672_2	29.64		264.21	162.1	12	202	0	202	16.4	16.5	16.8
		Tip	684	9 661	753	756	tip_p_684_3	29.64		264.21	162.1	12	202	0	202	16.4	16.5	16.8
		EL 118.1	693	9 581	754	758	tip_p_693_4	29.64		264.21	162.1	12	202	0	202	16.4	16.5	16.8
			664	9 300	754	805	no download	29.64		264.21	162.1	12	202	0	202	16.4	16.5	16.8
			678	8 211	755	759	tip_p_678_5	29.64		264.21	162.2	12	202.1	0	202.1	16.4	16.4	16.8
			694	8 111	807	811	tip_p_694_6	29.64		264.21	162.1	12	200.1	0	200.1	16.6	16.5	16.8
			689	8 221	809	826	tip_p_689_7	29.64		264.21	162.1	12	200.1	0	200.1	16.6	16.5	16.8
			673	8 411	810	838	tip_p_673_8	29.64		264.31	161.99	12	199.5	0	199.5	17.1	16.5	16.8
			682	8 251	811	828	tip_p_682_9	29.64		264.31	161.99	12	199.5	0	199.5	17.1	16.5	16.8
			633	8 151	812			29.64	LOST	264.31	161.99	12	199.5	0	199.5	17.1	16.5	16.8
			635	8 711	813	816	tip_p_635_10	29.64		264.31	161.99	12	199.5	0	199.5	17.1	16.5	16.8
			700	9 130	848	851	leaked	29.63		264.51	161.9	12	195.3	0	195.3	16.3	16.4	16.4
			672	9 180	849	853	tip_p_672_11	29.63		264.51	161.9	12	195.3	0	195.3	16.3	16.4	16.4
			684	9 661	850	853	tip_p_684_12	29.63		264.51	161.9	12	195.3	0	195.3	16.3	16.4	16.4
			693	9 581	851	854	tip_p_693_13	29.63		264.51	161.9	12	195.3	0	195.3	16.3	16.4	16.4
			664	9 300	852	855	dead	29.63		264.51	161.9	12	195.3	0	195.3	16.3	16.4	16.4
			678	8 211	853	856	tip_p_678_14	29.63		264.51	161.9	12	195.3	0	195.3	16.3	16.4	16.4
			694	8 111	939	948	tip_p_694_15	29.62		264.71	162.1	12	194.5	0	194.5	16.2	16.4	16.3
			689	8 221	940	945	tip_p_689_16	29.62		264.71	162.1	12	194.5	0	194.5	16.2	16.4	16.3
			673	8 411	941	944	tip_p_673_17	29.62		264.71	162.1	12	194.5	0	194.5	16.2	16.4	16.3
			682	8 251	942	951	tip_p_682_18	29.62		264.71	162.1	12	194.5	0	194.5	16.2	16.4	16.3
			635	8 711	943	947	tip_p_635_19	29.62		264.71	162.1	12	194.5	0	194.5	16.2	16.4	16.3
3/30/2006	9B	Lower 1%	672	9 180	1002	1007	tip_L_672_1	29.62		264.71	162.2	12	202.4	0	202.4	17.9	12.1	17.4
		~11.7 kcfs	684	9 661	1003	1007	tip_L_684_2	29.62		264.71	162.2	12	202.4	0	202.4	17.9	12.1	17.4
		tip	693	9 581	1004	1009	tip_L_693_3	29.62		264.71	162.2	12	202.4	0	202.4	17.9	12.1	17.4
		EL 119.4	678	8 211	1005	1007	tip_L_678_4	29.62		264.61	162.3	12	209.1	0	209.1	17.7	12.1	18.3
			694	8 111	1025	1036	tip_L_694_5	29.61		264.61	162.57	12	216.2	0	216.2	18.4	12.2	18.4
			673	8 411	1026	1030	tip_L_673_6	29.61		264.61	162.57	12	216.2	0	216.2	18.4	12.2	18.4
			682	8 251	1028	1031	tip_L_682_7	29.61		264.61	162.57	12	216.2	0	216.2	18.4	12.2	18.4
			689	8 221	1029	1038	tip_L_689_8	29.61		264.61	162.57	12	216.2	0	216.2	18.4	12.2	18.4
			635	8 711	1030	1033	tip_L_635_9	29.59		264.61	162.61	12	216.4	0	216.4	18.4	12.2	18.5
			672	9 180	1051	1055	tip_L_672_10	29.59		264.61	162.61	12	216.4	0	216.4	18.4	12.2	18.5
			684	9 661	1052	1056	tip_L_684_11	29.59		264.61	162.61	12	216.4	0	216.4	18.4	12.2	18.5
			693	9 581	1053	1102	tip_L_693_12	29.59		264.61	162.61	12	216.4	0	216.4	18.4	12.2	18.5
			678	8 211	1054	1058	tip_L_678_13	29.59		264.61	162.61	12	216.4	0	216.4	18.4	12.2	18.5
			694	8 111	1113	1121	tip_L_694_14	29.59		264.41	162.51	12	214.4	0	214.4	18.3	12.1	18.3
			673	8 411	1114	1120	tip_L_673_15	29.59		264.41	162.51	12	214.4	0	214.4	18.3	12.1	18.3
			682	8 251	1115	1123	tip_L_682_16	29.59		264.41	162.61	12	214.3	0	214.3	18.3	12.2	18
			689	8 221	1115	1119	tip_L_689_17	29.59		264.41	162.61	12	214.3	0	214.3	18.3	12.2	18
			635	8 711	1116	1136	tip_L_635_18	29.59		264.41	162.61	12	214.3	0	214.3	18.3	12.2	18
			672	9 180	1155	1158	tip_L_672_19	29.57		264.41	162.41	11	210.8	0	210.8	20	12.1	19.5
			684	9 661	1156	1201	tip_L_684_20	29.57		264.41	162.41	11	210.8	0	210.8	20	12.1	19.5
			693	9 581	1157	1205	tip_L_693_21	29.57	x axis	264.41	162.41	11	210.8	0	210.8	20	12.1	19.5
			678	8 211	1158	1202	tip_L_678_22	29.57		264.41	162.41	11	210.8	0	210.8	20	12.1	19.5
			694	8 111	1159	1204	tip_L_694_23	29.57		264.41	162.41	11	210.8	0	210.8	20	12.1	19.5

Table B.1. (contd)

Date	Location	Test Condition	Fish ID	Tag #	Deployment Time	Recovery Time	File Name	Barometric Pressure	Notes	FB EL	TW EL	# units on	PH Q	Spill Q	Total Q	T8 Q	T9 Q	T10 Q
3/30/2006	9B	higher 1%	673	8 411	1214	1230	tip_U_673_1	29.56		264.31	162.51	11	210.7	0	210.7	19.1	20.3	18.5
		~20 kcfs	682	8 251	1215	1218	tip_U_682_2	29.56		264.31	162.51	11	210.7	0	210.7	19.1	20.3	18.5
		tip EL 119.4	689	8 221	1216	1219	tip_U_689_3	29.56		264.31	162.51	11	210.7	0	210.7	19.1	20.3	18.5
			635	8 711	1217	1220	tip_U_635_4	29.56		264.31	162.51	11	210.7	0	210.7	19.1	20.3	18.5
			672	9 180	1241	1244	tip_U_672_5	29.54		264.31	162.41	11	209.2	0	209.2	19.1	20.3	18.4
			684	9 661	1242	1245	tip_U_684_6	29.54		264.31	162.41	11	209.2	0	209.2	19.1	20.3	18.4
			694	8 111	1242	1245	tip_U_694_7	29.54		264.31	162.41	11	209.2	0	209.2	19.1	20.3	18.4
			678	8 211	1243	1246	tip_U_678_8	29.54		264.31	162.41	11	209.2	0	209.2	19.1	20.3	18.4
			673	8 411	1302	1307	tip_U_673_9	29.53		264.31	162.41	11	211	0	211	19	20.3	19.1
			682	8 251	1303	1311	tip_U_682_10	29.53		264.31	162.41	11	211	0	211	19	20.3	19.1
			689	8 221	1304	1311	tip_U_689_11	29.53		264.31	162.41	11	211	0	211	19	20.3	19.1
			635	8 711	1305	1310	tip_U_635_12	29.54		264.31	162.51	11	213.9	0	213.9	19.1	20.3	19.5
			672	9 180	1321	1325	tip_U_672_13	29.52		264.31	162.62	11	218.1	0	218.1	19.2	20.4	19.5
			684	9 661	1322	1328	tip_U_684_14	29.52		264.31	162.62	11	218.1	0	218.1	19.2	20.4	19.5
			694	8 111	1323	1330	tip_U_694_15	29.52		264.31	162.62	11	218.1	0	218.1	19.2	20.4	19.5
			678	8 211	1324	1340	tip_U_678_16	29.52		264.31	162.62	11	218.1	0	218.1	19.2	20.4	19.5
			673	8 411	1345	1348	tip_U_673_20	29.51		264.41	162.64	11	216.3	0	216.3	19.4	20.3	19.4
			682	8 251	1346	1401	tip_U_682_21	29.51		264.41	162.61	11	215.7	0	215.7	19.4	20.3	19.5
			689	8 221	1347	1353	tip_U_689_22	29.51		264.41	162.64	11	216.3	0	216.3	19.4	20.3	19.4
			635	8 711	1348	1350	tip_U_635_23	29.51		264.41	162.72	11	216.7	0	216.7	19.4	20.4	19.5
			672	9 180	1403	1408	tip_U_672_17	29.51		264.41	162.72	11	216.7	0	216.7	19.4	20.4	19.5
			684	9 661	1405	1407	tip_U_684_18	29.51		264.41	162.72	11	216.7	0	216.7	19.4	20.4	19.5
			694	8 111	1404	1408	tip_U_694_19	29.51		264.41	162.72	11	216.7	0	216.7	19.4	20.4	19.5

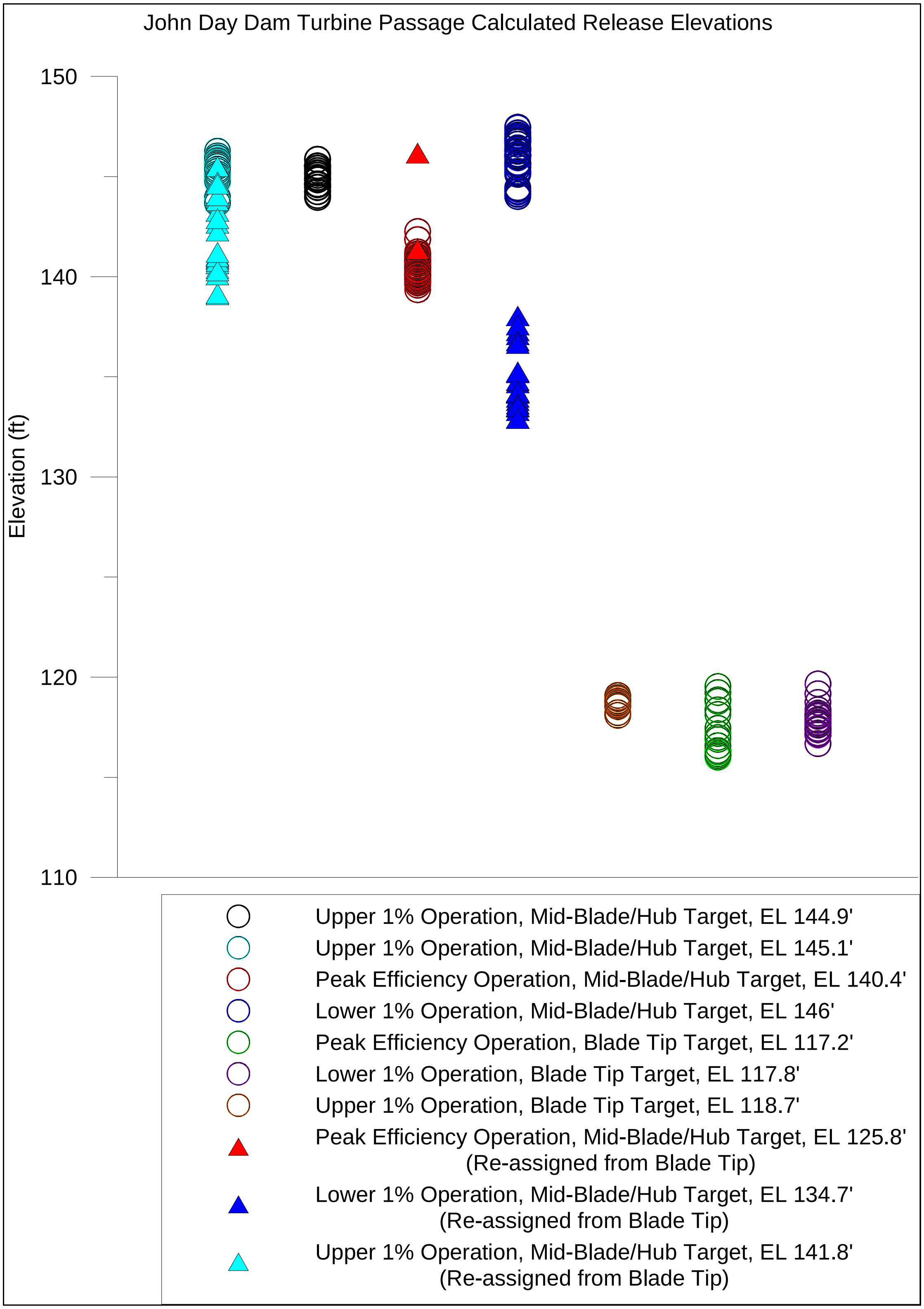

Figure B.1. Release elevations and targeted elevations calculated by the Sensor Fish

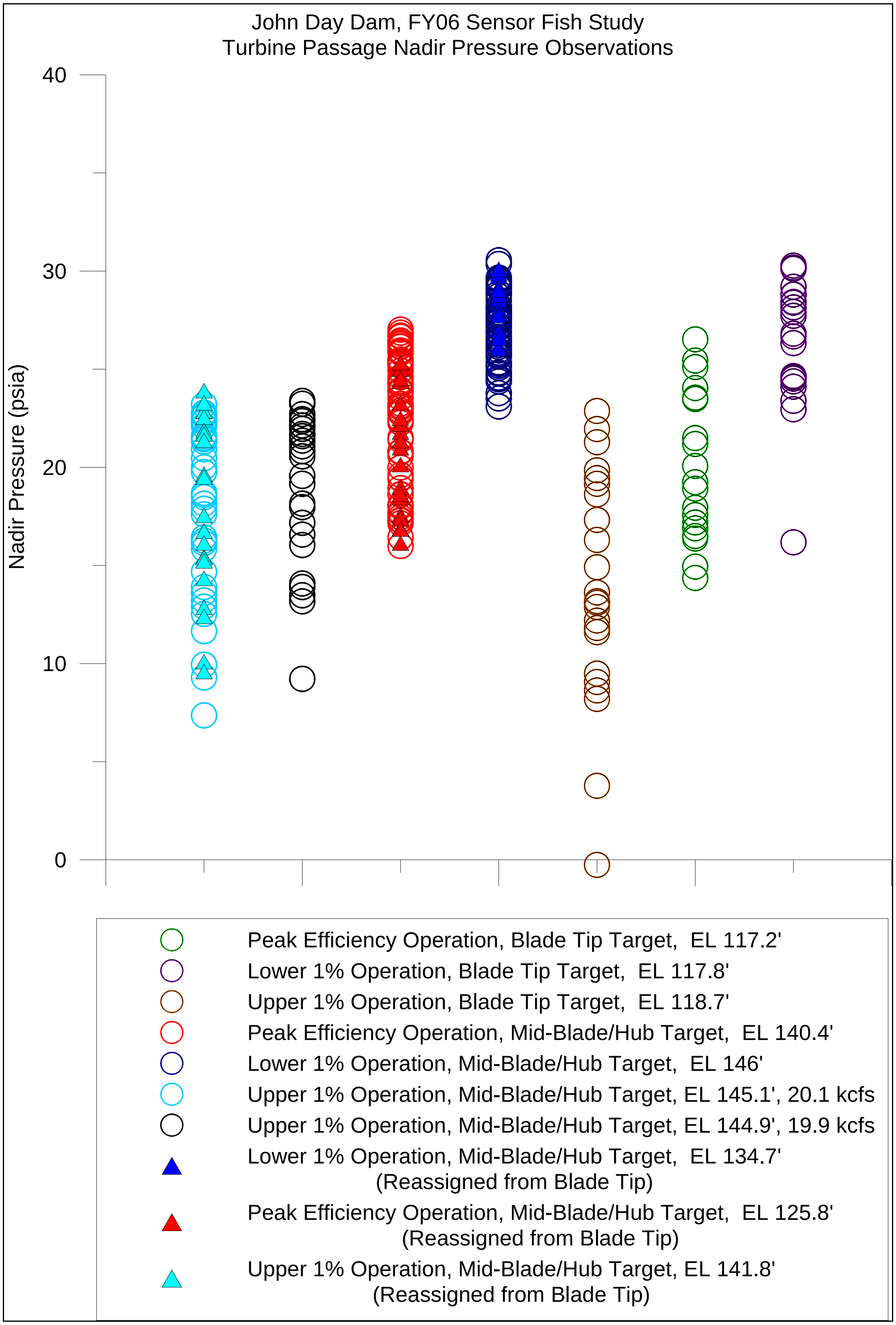

Figure B.2. Nadir pressure values as determined from Sensor Fish turbine passage

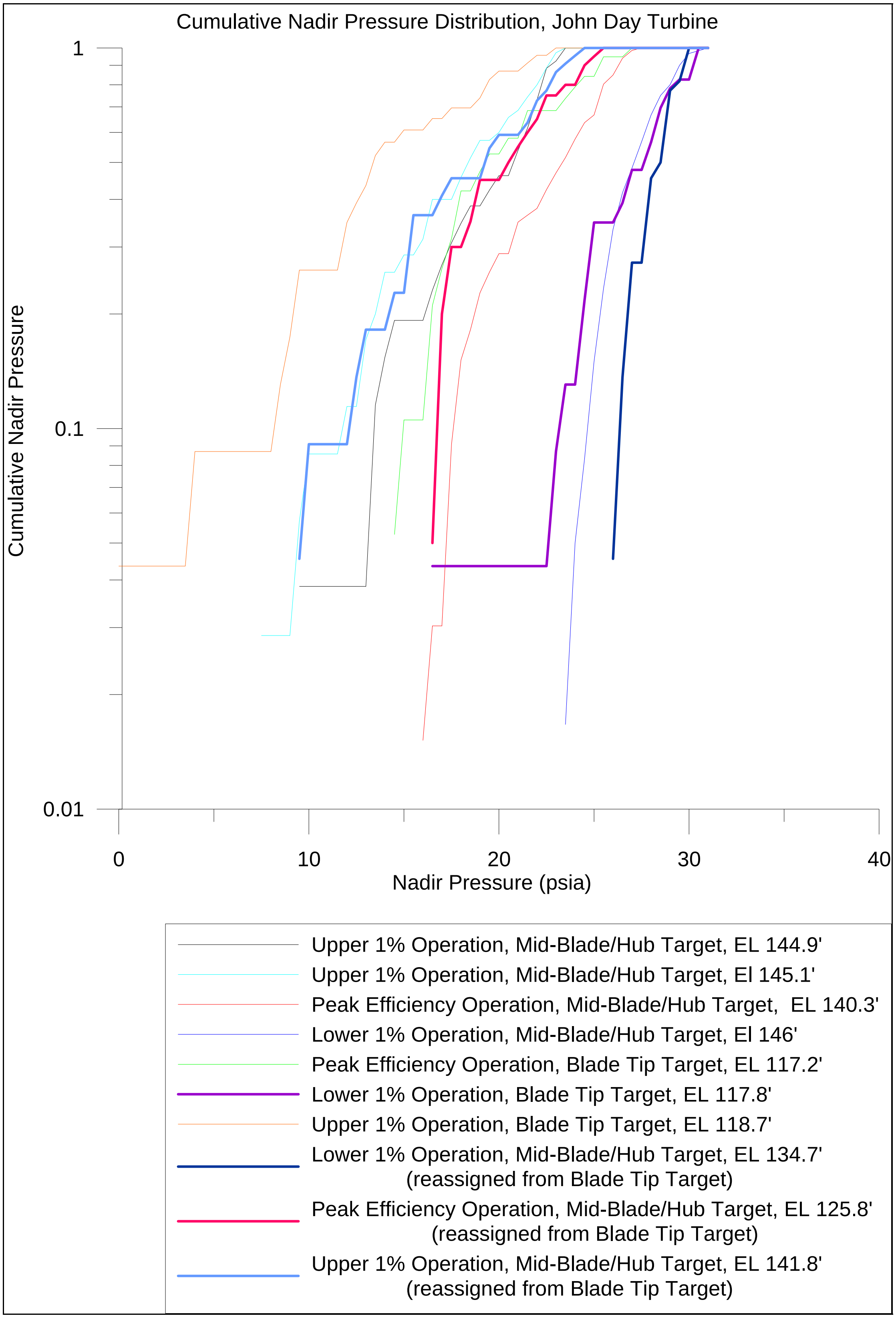

Figure B.3. Cumulative nadir pressure distributions from Sensor Fish

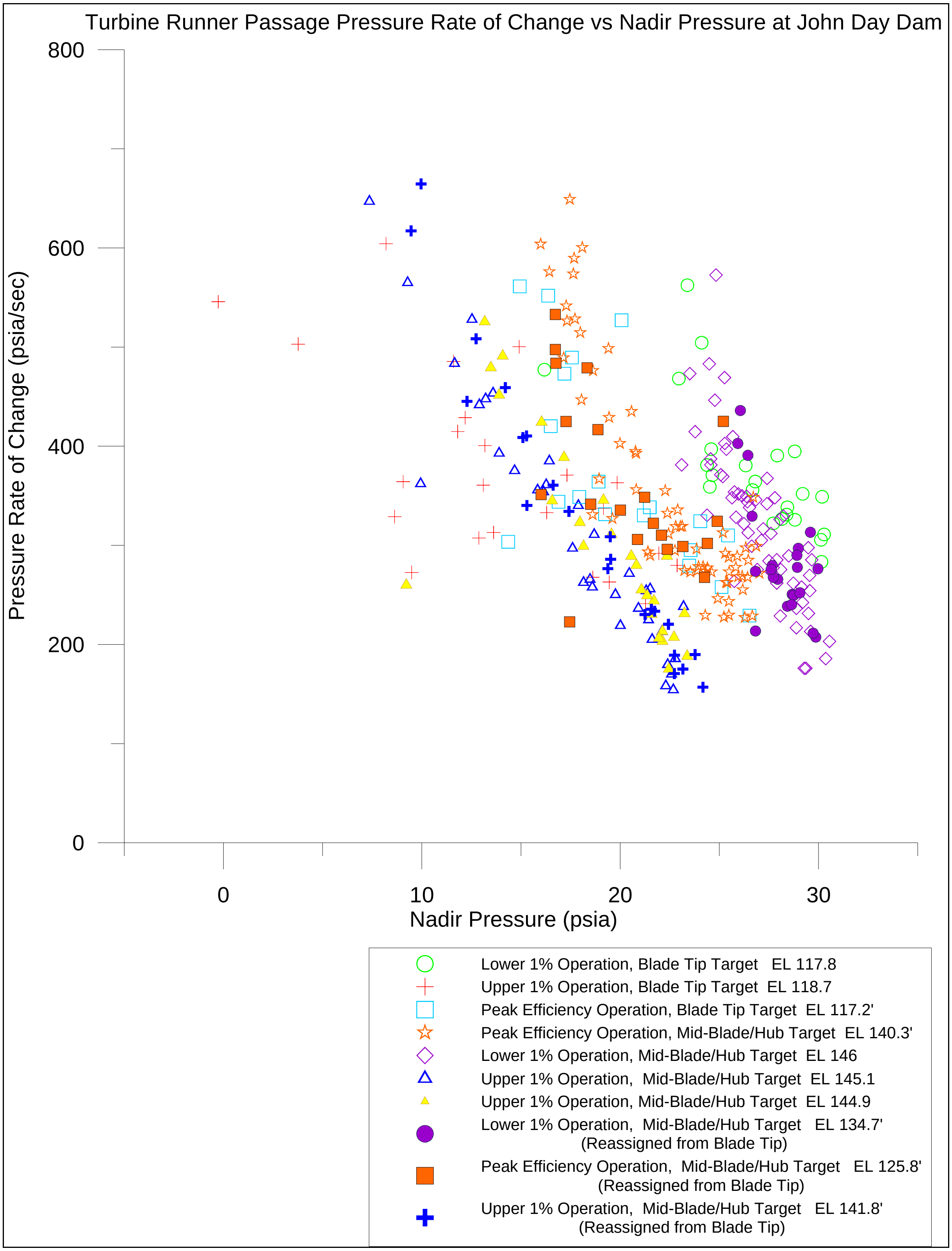

Figure B.4. Turbine runner passage rate of change by nadir pressure for all operations and routes

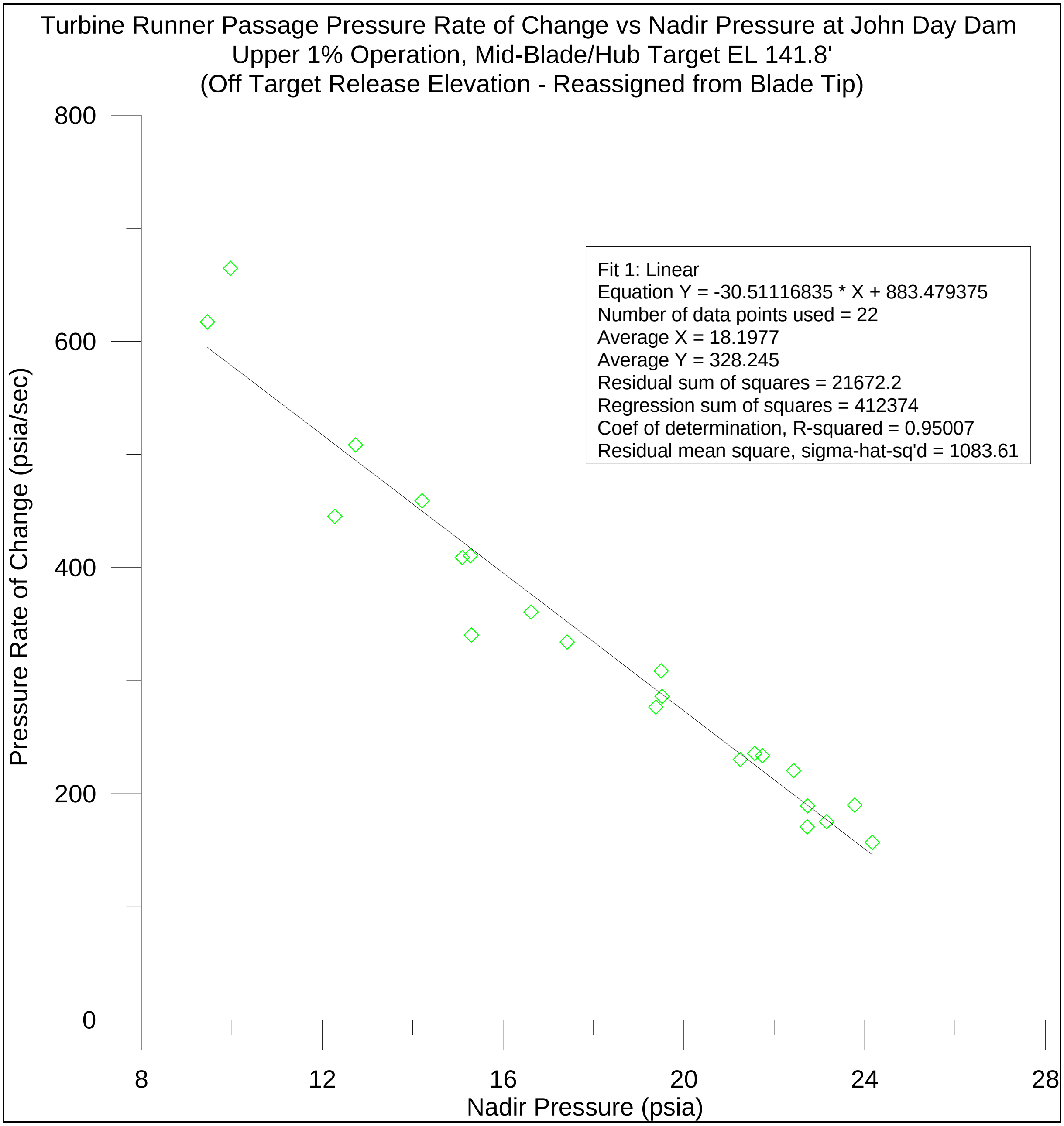

Figure B.5. Turbine runner passage rate of change by nadir pressure for the targeted upper 1% mid-blade/hub passage route at a release elevation of 141.8 ft (reassigned from targeted blade tip route)

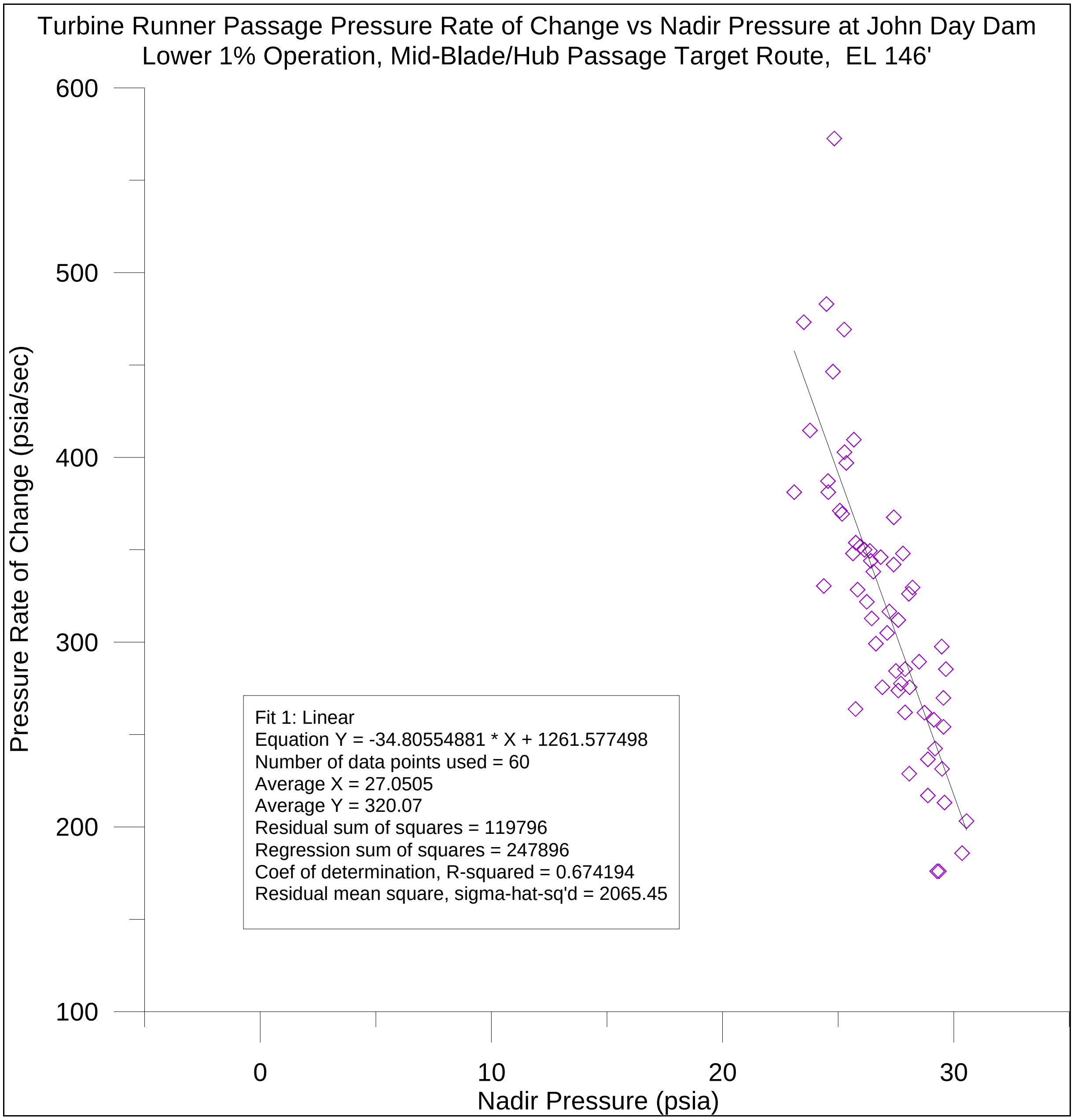

Figure B.6. Turbine runner passage rate of change by nadir pressure for lower 1% operation in the targeted mid-blade/hub passage route at a release elevation of 146 ft

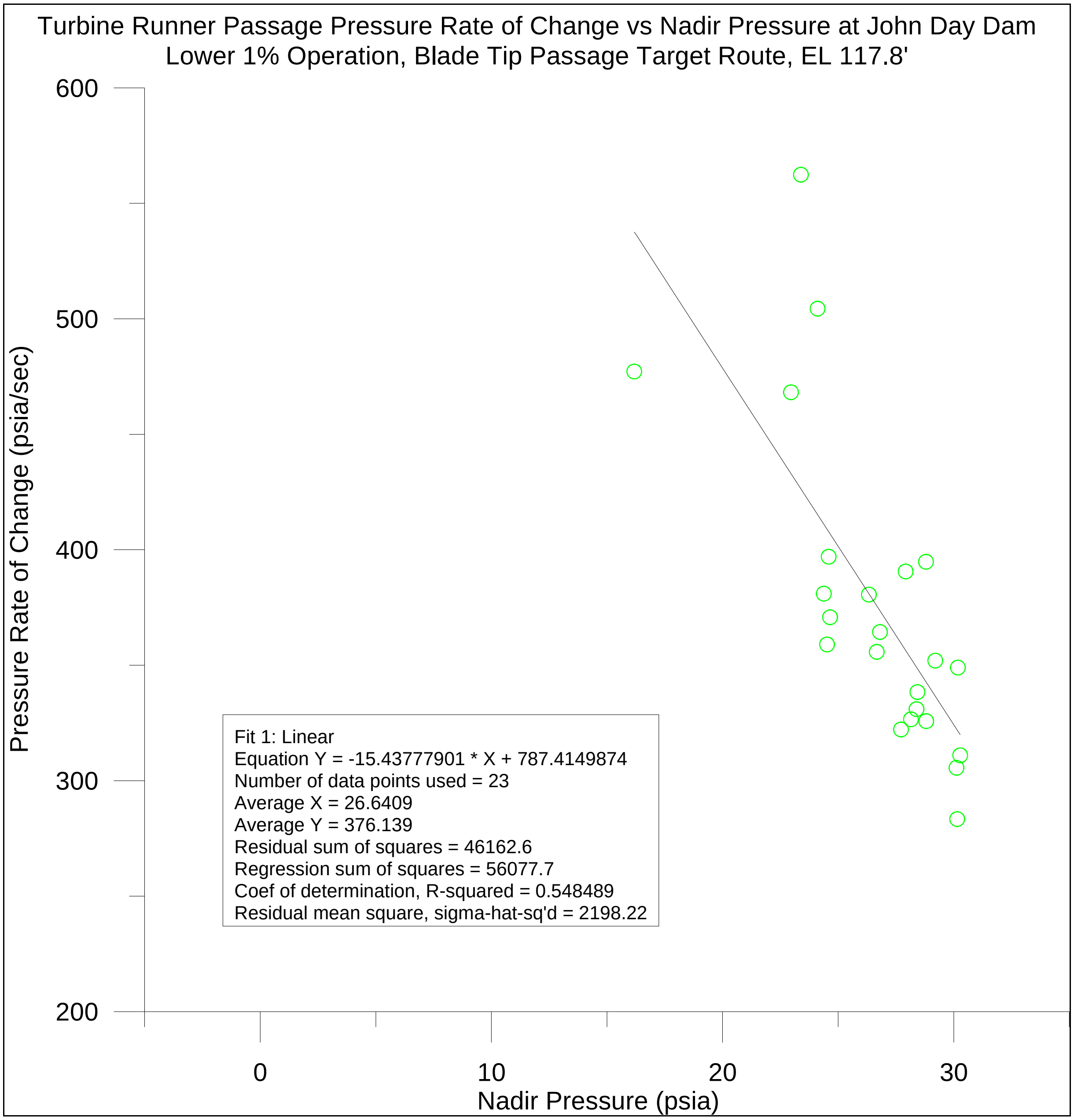

Figure B.7. Turbine runner passage rate of change by nadir pressure for lower 1% operation in the targeted blade tip passage route at a release elevation of 117.8 ft

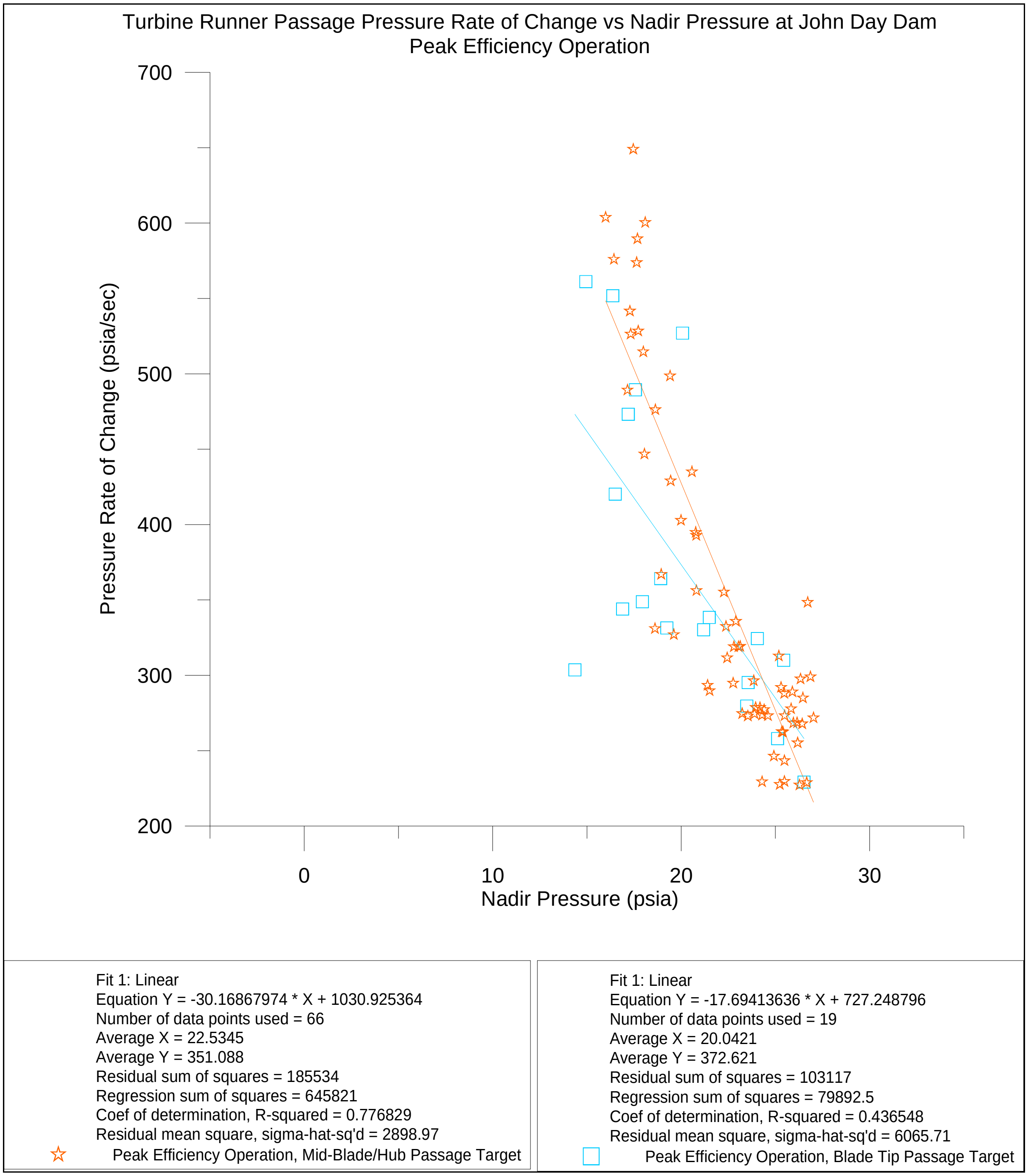

Figure B.8. Turbine runner passage rate of change by nadir pressure for peak efficiency operation

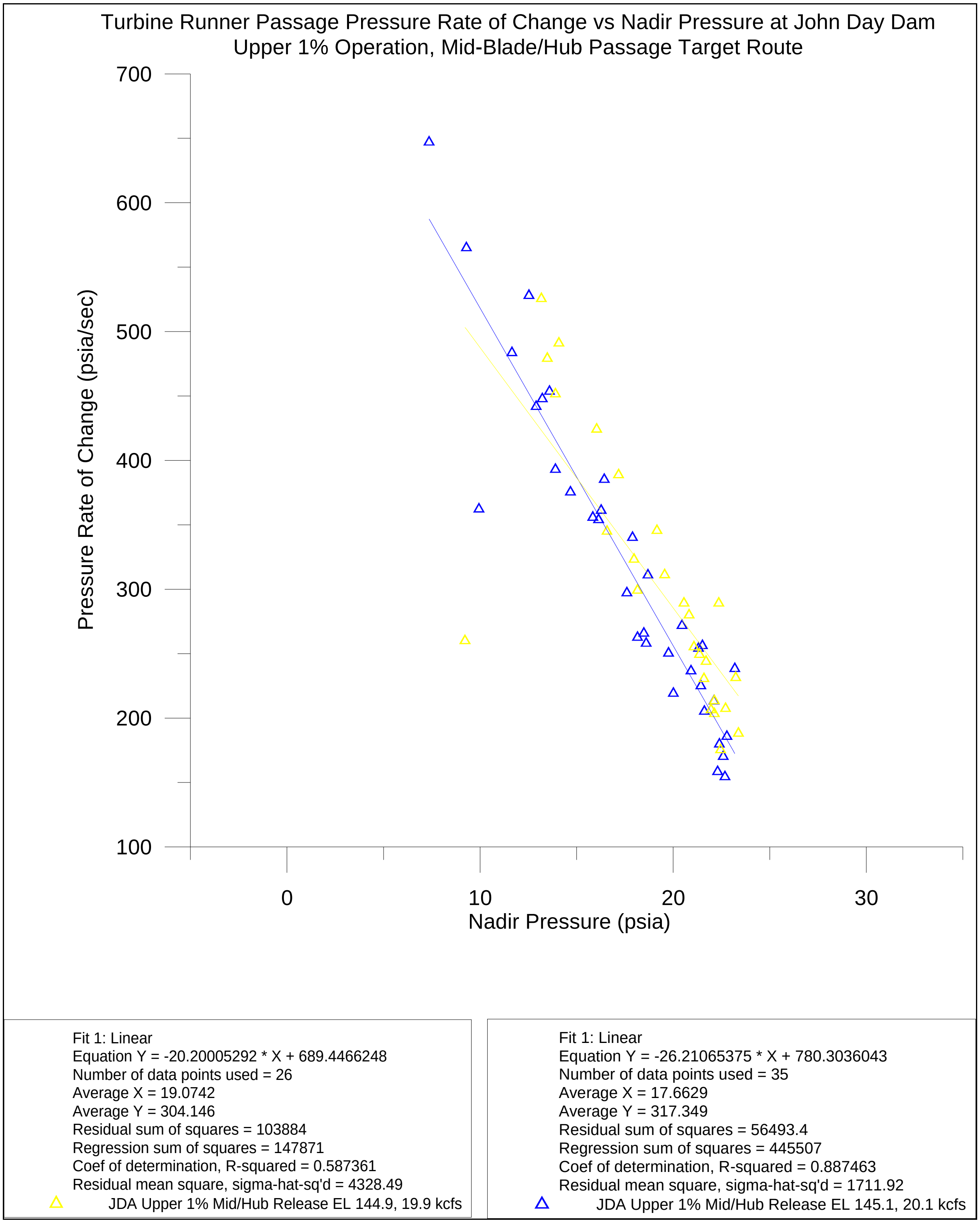

Figure B.9. Turbine runner passage rate of change by nadir pressure in the targeted upper 1% mid-blade/hub passage route

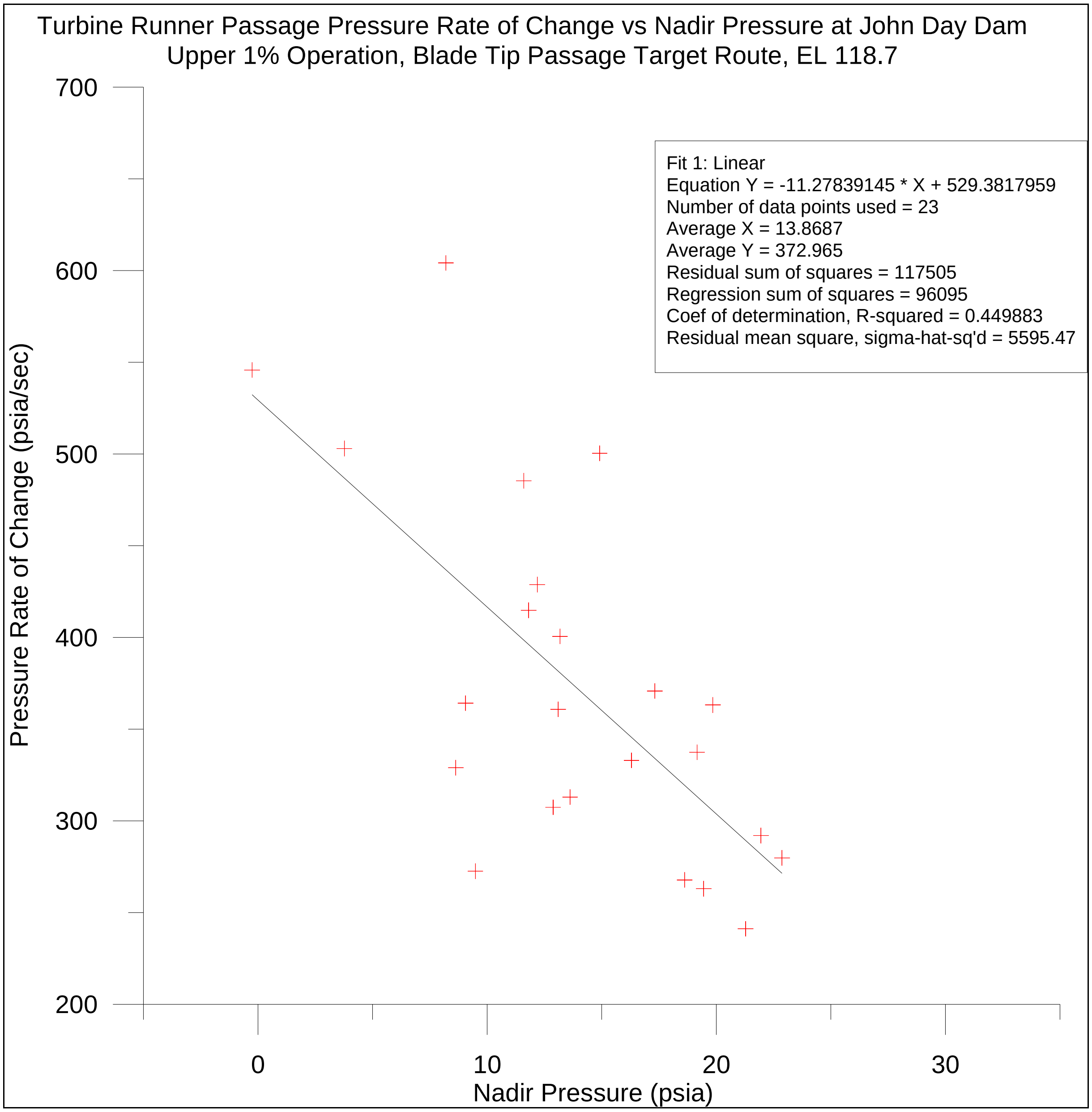

Figure B.10. Turbine runner passage rate of change by nadir pressure for upper 1% operation in the targeted blade tip passage route at a release elevation of 118.7 ft

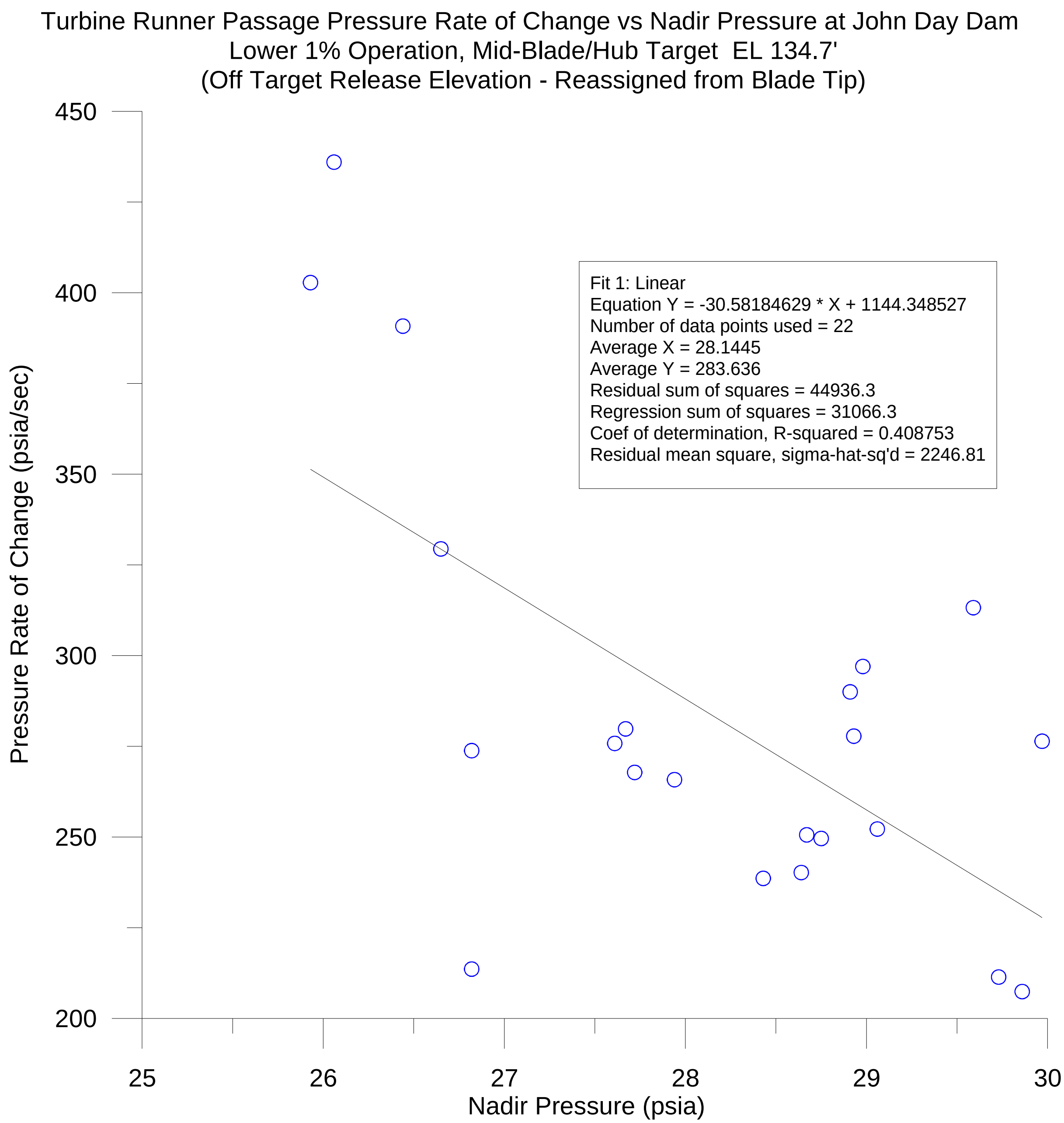

Figure B.11. Turbine runner passage rate of change by nadir pressure for lower 1% operation in the targeted mid-blade/hub passage route at a release elevation of 134.7 ft (reassigned from the targeted blade tip route)

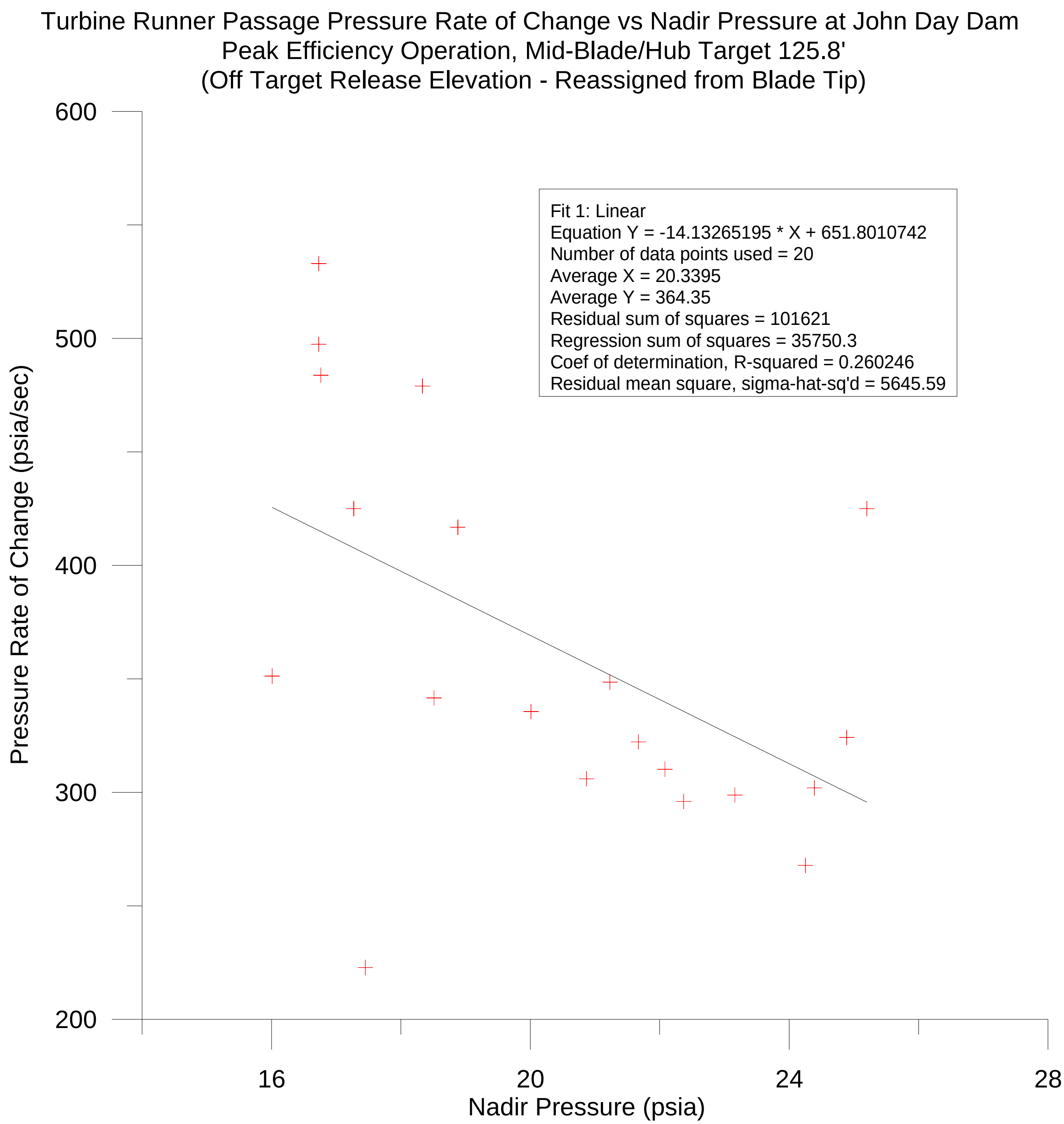

Figure B.12. Turbine runner passage rate of change by nadir pressure for peak efficiency operation in the targeted mid-blade/hub passage route at a release elevation of 125.8 ft (reassigned from the targeted blade tip route)

Table B.2. Summary statistics for nadir pressure values

JDA Mid/Hub Upper 1% (max) 19.9 kcfs - EL 144.9	
Nadir Pressure	
Mean	19.0742
Standard Error	0.7467
Median	20.6900
Standard Deviation	3.8073
Sample Variance	14.4956
Kurtosis	0.1275
Skewness	-0.9703
Range	14.1600
Minimum	9.2200
Maximum	23.3800
Count	26
Confidence Level (95.0%)	1.5378

JDA Tip Lower 1% 12.2 kcfs - EL 117.8	
Nadir Pressure	
Mean	26.6409
Standard Error	0.6819
Median	27.7200
Standard Deviation	3.2704
Sample Variance	10.6954
Kurtosis	3.4035
Skewness	-1.4945
Range	14.1000
Minimum	16.1800
Maximum	30.2800
Count	23
Confidence Level (95.0%)	1.4142

JDA Mid/Hub Peak Efficiency 16.5 kcfs - EL 140.3	
Nadir Pressure	
Mean	22.5345
Standard Error	0.4067
Median	23.1850
Standard Deviation	3.3040
Sample Variance	10.9166
Kurtosis	-1.1983
Skewness	-0.4311
Range	11.0300
Minimum	15.9900
Maximum	27.0200
Count	66
Confidence Level (95.0%)	0.8122

JDA Mid/Hub Lower 1% (max) 11.6 kcfs - El 146	
Nadir Pressure	
Mean	27.0505
Standard Error	0.2404
Median	27.1650
Standard Deviation	1.8623
Sample Variance	3.4683
Kurtosis	-0.8908
Skewness	-0.0893
Range	7.4500
Minimum	23.1000
Maximum	30.5500
Count	60
Confidence Level (95.0%)	0.4811

JDA Tip Upper 1% 20.3 kcfs - EL 118.7	
Nadir Pressure	
Mean	13.8687
Standard Error	1.2219
Median	13.1800
Standard Deviation	5.8599
Sample Variance	34.3387
Kurtosis	0.1177
Skewness	-0.5033
Range	23.1300
Minimum	-0.2600
Maximum	22.8700
Count	23
Confidence Level (95.0%)	2.5340

JDA Tip Peak Efficiency 16.5 kcfs - EL 117.2	
Nadir Pressure	
Mean	20.0421
Standard Error	0.8638
Median	19.24
Standard Deviation	3.7652
Sample Variance	14.1767
Kurtosis	-1.2158
Skewness	0.2564
Range	12.16
Minimum	14.36
Maximum	26.52
Count	19
Confidence Level (95.0%)	1.8148

Table B.2. (contd)

JDA Mid/Hub Upper 1% (max) 20.1 kcfs - El 145.1	
Nadir Pressure	
Mean	17.6629
Standard Error	0.7382
Median	18.4800
Standard Deviation	4.3673
Sample Variance	19.0730
Kurtosis	-0.5364
Skewness	-0.6395
Range	15.8300
Minimum	7.3600
Maximum	23.1900
Count	35
Confidence Level (95.0%)	1.5002

JDA Mid-Blade/Hub (Re-assigned from Blade Tip), Lower 1%, 11.8 kcfs - EL 134.7'	
Nadir Pressure	
Mean	28.1445
Standard Error	0.2681
Median	28.535
Standard Deviation	1.2577
Sample Variance	1.5818
Kurtosis	-1.0657
Skewness	-0.3231
Range	4.04
Minimum	25.93
Maximum	29.97
Count	22
Confidence Level (95.0%)	0.5576

JDA Mid-Blade/Hub (Re-assigned from Blade Tip), Peak Efficiency, 16.5 kcfs - EL 125.8'	
Nadir Pressure	
Mean	20.3395
Standard Error	0.6863
Median	20.44
Standard Deviation	3.0693
Sample Variance	9.4206
Kurtosis	-1.3994
Skewness	0.1681
Range	9.19
Minimum	16.01
Maximum	25.2
Count	20
Confidence Level(95.0%)	1.4365

JDA Mid-Blade/Hub (Re-assigned from Blade Tip), Upper 1%, 19.8 kcfs - EL 141.8'	
Nadir Pressure	
Mean	18.1977
Standard Error	0.9792
Median	19.44
Standard Deviation	4.5928
Sample Variance	21.0938
Kurtosis	-0.9992
Skewness	-0.4603
Range	14.71
Minimum	9.46
Maximum	24.17
Count	22
Confidence Level(95.0%)	2.0363

Table B.3. Summary statistics for pressure rate-of-change values

JDA Mid/Hub Upper 1% (max) 19.9 kcfs - EL 144.9	
Pressure Rate of Change	
Mean	304.1462
Standard Error	19.6803
Median	284.6
Standard Deviation	100.3503
Sample Variance	10070.1842
Kurtosis	-0.2890
Skewness	0.8468
Range	350.2
Minimum	175.4
Maximum	525.6
Count	26
Confidence Level (95.0%)	40.5324

JDA Tip Lower 1% 12.2 kcfs - EL 117.8	
Pressure Rate of Change	
Mean	376.1391
Standard Error	14.2146
Median	359
Standard Deviation	68.1710
Sample Variance	4647.2852
Kurtosis	1.5100
Skewness	1.3164
Range	279
Minimum	283.4
Maximum	562.4
Count	23
Confidence Level (95.0%)	29.4794

JDA Mid/Hub Peak Efficiency 16.5 kcfs - EL 140.3	
Pressure Rate of Change	
Mean	351.0879
Standard Error	13.9208
Median	298.3
Standard Deviation	113.0932
Sample Variance	12790.0765
Kurtosis	0.1093
Skewness	1.1368
Range	421.8
Minimum	227.2
Maximum	649
Count	66
Confidence Level (95.0%)	27.8018

JDA Mid/Hub Lower 1% (max) 11.6 kcfs - El 146	
Pressure Rate of Change	
Mean	320.0700
Standard Error	10.1916
Median	319.2
Standard Deviation	78.9435
Sample Variance	6232.0771
Kurtosis	0.8493
Skewness	0.5950
Range	396.6
Minimum	176
Maximum	572.6
Count	60
Confidence Level (95.0%)	20.3933

JDA Tip Upper 1% 20.3 kcfs - EL 118.7	
Pressure Rate of Change	
Mean	372.9652
Standard Error	20.5459
Median	360.8
Standard Deviation	98.5347
Sample Variance	9709.0896
Kurtosis	-0.0963
Skewness	0.8149
Range	363
Minimum	241.2
Maximum	604.2
Count	23
Confidence Level (95.0%)	42.6096

JDA Tip Peak Efficiency 16.5 kcfs - EL 117.2	
Pressure Rate of Change	
Mean	372.6211
Standard Error	23.1326
Median	338.4
Standard Deviation	100.8325
Sample Variance	10167.1995
Kurtosis	-0.6338
Skewness	0.7401
Range	332
Minimum	229.2
Maximum	561.2
Count	19
Confidence Level (95.0%)	48.5997

Table B.3. (contd)

JDA Mid/Hub Upper 1% (max) 20.1 kcfs - El 145.1	
Pressure Rate of Change	
Mean	317.3486
Standard Error	20.5390
Median	271.8
Standard Deviation	121.5102
Sample Variance	14764.7208
Kurtosis	0.3107
Skewness	0.8654
Range	492.6
Minimum	154.4
Maximum	647
Count	35
Confidence Level (95.0%)	41.7402

JDA Mid-Blade/Hub (Re-assigned from Blade Tip), Lower 1%, 11.8 kcfs - EL 134.7'	
Pressure Rate of Change	
Mean	283.6364
Standard Error	12.8261
Median	274.8
Standard Deviation	60.1596
Sample Variance	3619.1719
Kurtosis	1.2338
Skewness	1.2340
Range	228.6
Minimum	207.4
Maximum	436
Count	22
Confidence Level(95.0%)	26.6733

JDA Mid-Blade/Hub (Re-assigned from Blade Tip), Peak Efficiency, 16.5 kcfs - EL 125.8'	
Pressure Rate of Change	
Mean	364.3500
Standard Error	19.0132
Median	338.6
Standard Deviation	85.0297
Sample Variance	7230.0500
Kurtosis	-0.6315
Skewness	0.5551
Range	310.2
Minimum	222.8
Maximum	533
Count	20
Confidence Level(95.0%)	39.7951

JDA Mid-Blade/Hub (Re-assigned from Blade Tip), Upper 1%, 19.8 kcfs - EL 141.8'	
Pressure Rate of Change	
Mean	328.2455
Standard Error	30.6512
Median	297.3
Standard Deviation	143.7668
Sample Variance	20668.8874
Kurtosis	0.1626
Skewness	0.8999
Range	507.6
Minimum	157
Maximum	664.6
Count	22
Confidence Level(95.0%)	63.7426

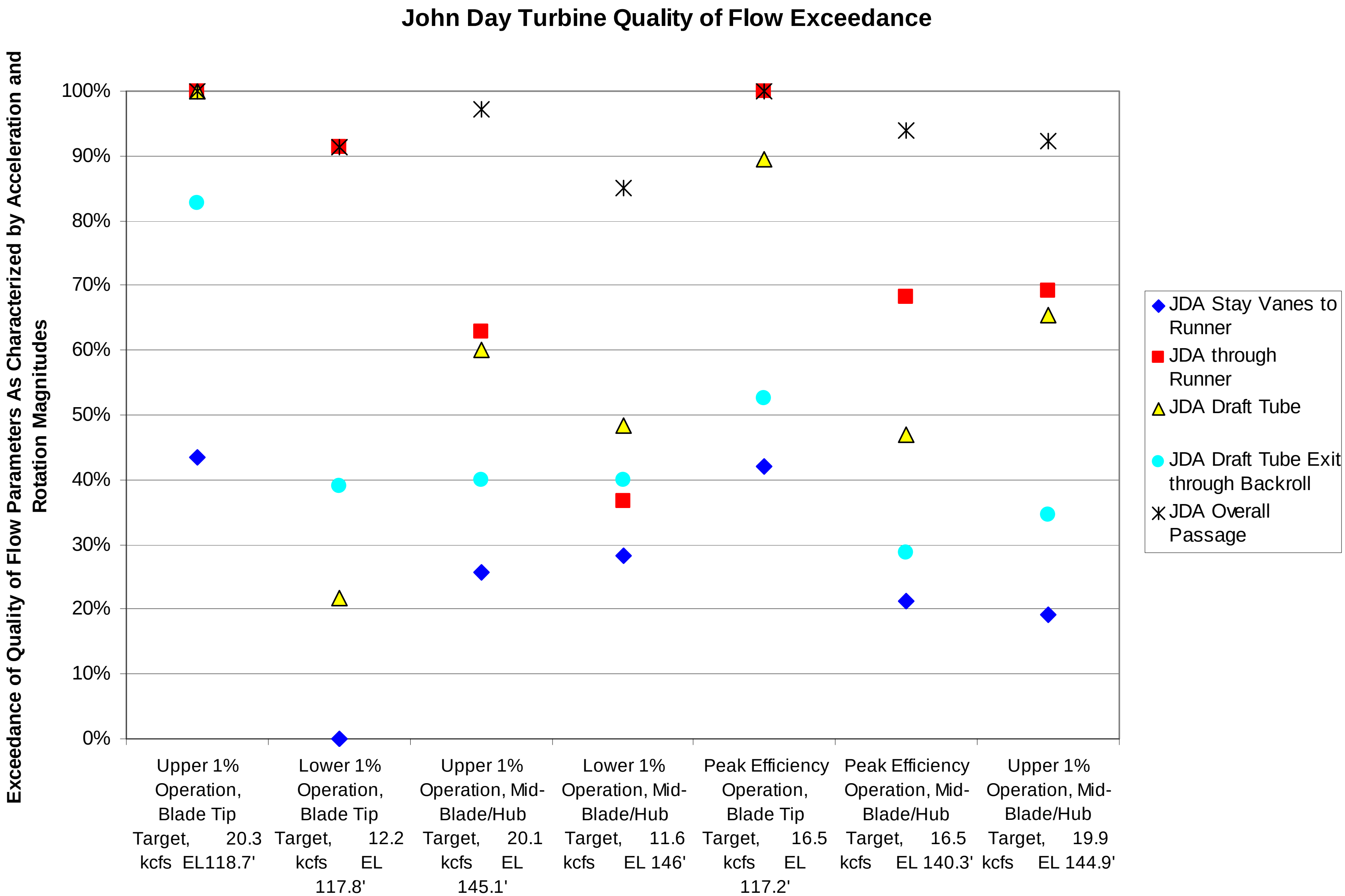

Figure B.13. John Day quality of flow exceedance based on turbine operation and location

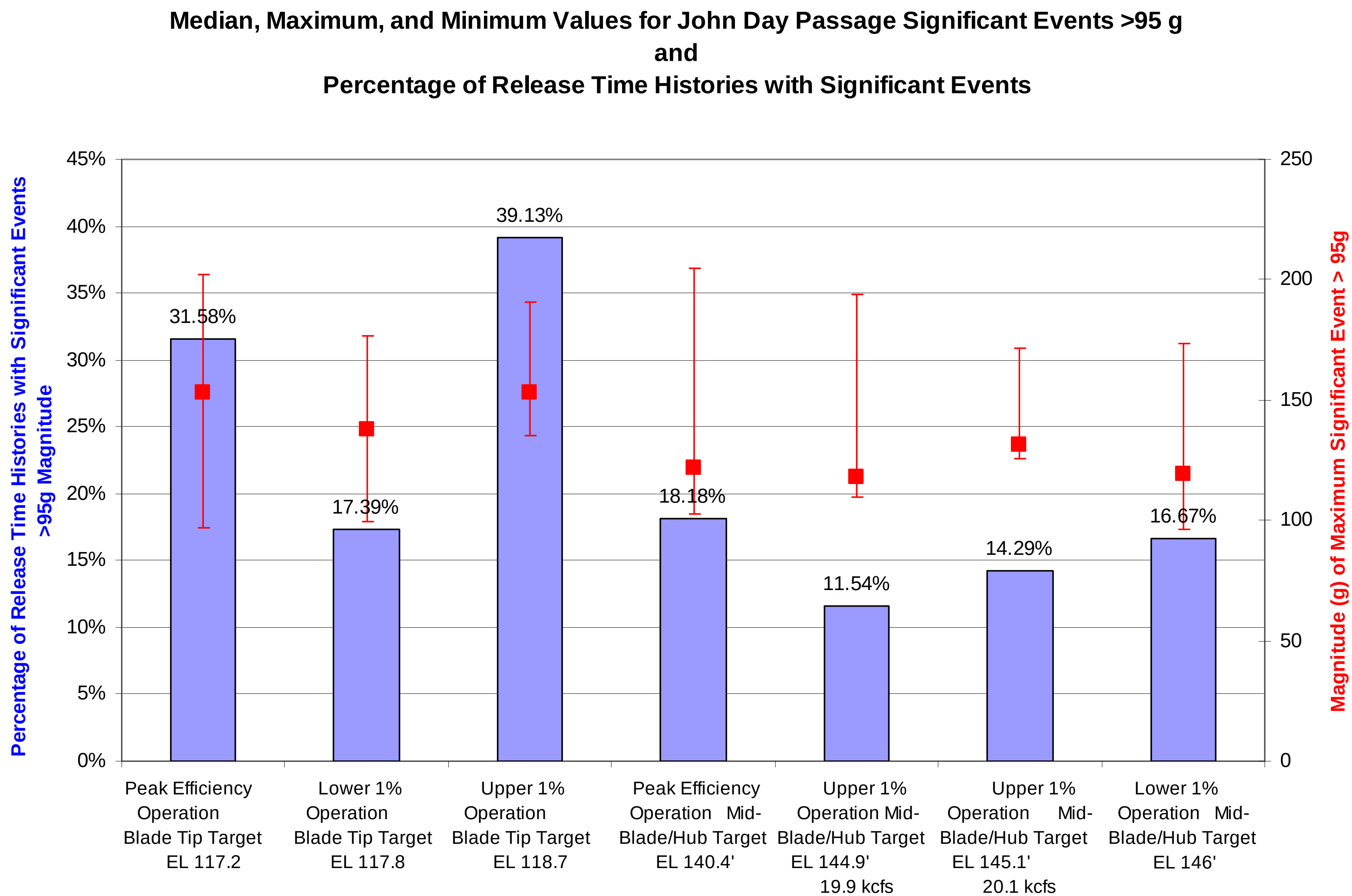

Figure B.14. Median, maximum, and minimum significant event magnitudes with percentage of releases having at least one event

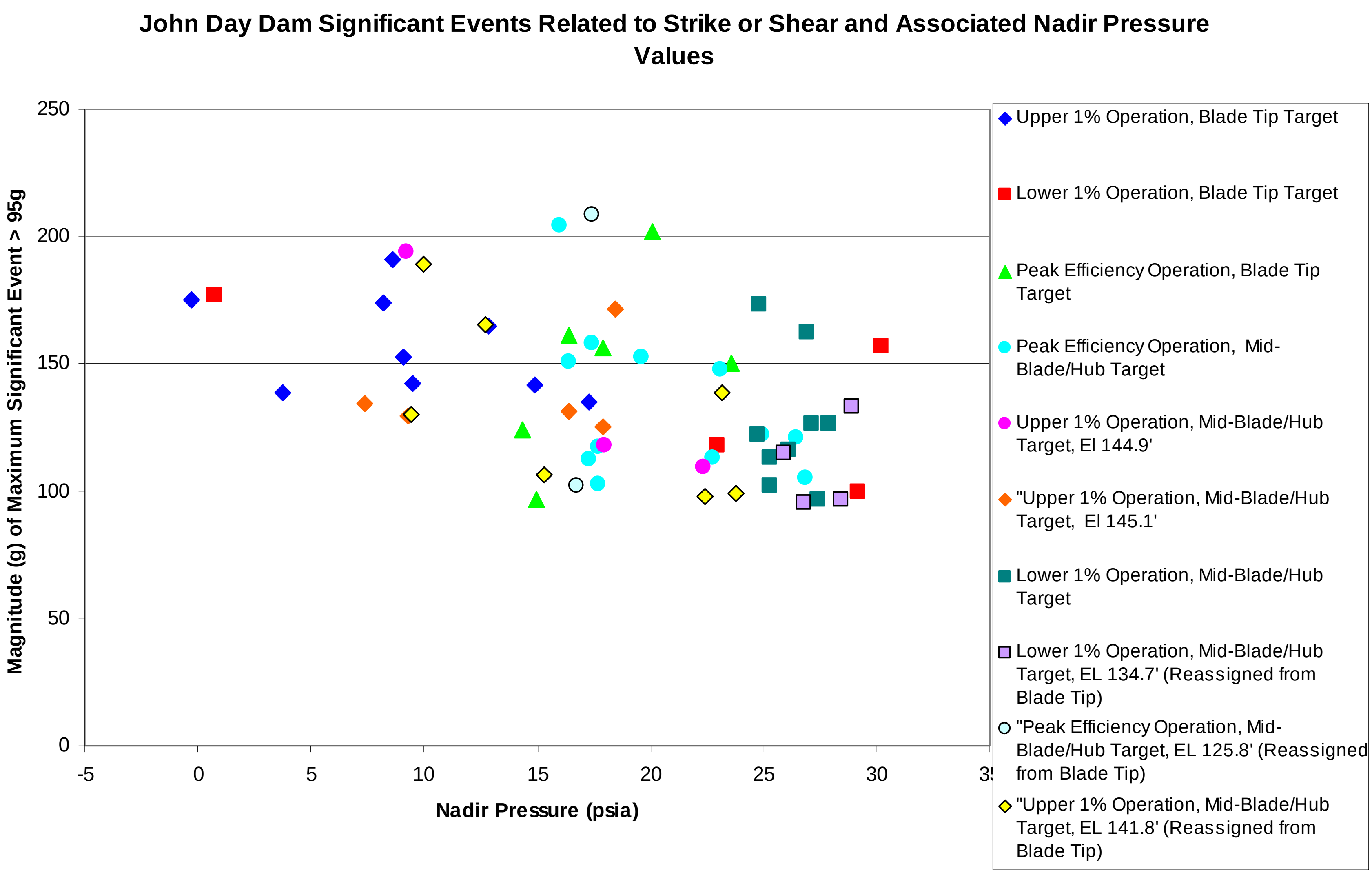

Figure B.15. John Day significant events related to strike or shear and associated pressure nadir values

Table B.4. Summary data tables for turbine significant events with related dam operations at John Day Dam

Test Condition	*File Name*	*Baro Psi*	*FB ele*	*TW ele*	*PH Q*	*T9 Q*	*Release Pt -psia*	*Release El*	*Rate of Change Psi/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
Upper 1%	mid_U_633_1	14.68	264.31	161.37	188.2	19.9	66.64	144.45	525.60	13.17		
Mid/Hub	mid_U_694_2	14.68	264.31	161.37	188.2	19.9	66.44	144.92	231.40	23.24		
145.2	mid_U_691_3	14.68	264.31	161.37	188.2	19.9	66.33	145.17	213.40	22.13		
	mid_U_635_4	14.68	264.31	161.37	188.2	19.9	66.03	145.86	255.20	21.07		
	mid_U_684_5	14.68	264.31	161.37	188.2	19.9	66.32	145.19	388.80	17.17		
	mid_U_700_6	14.68	264.31	161.27	187.5	19.9	66.73	144.25	345.60	19.16		
	mid_U_672_7	14.68	264.31	161.27	187.5	19.9	66.18	145.51	230.60	21.59		
	mid_U_692_8	14.68	264.31	161.27	187.5	19.9	66.03	145.86	289.20	20.56		
	mid_U_682_9	14.68	264.31	161.27	187.5	19.9	66.58	144.59	188.20	23.38		
	mid_U_678_10	14.68	264.31	161.27	187.5	19.9	66.42	144.96	311.20	19.56		
	mid_U_693_11	14.68	264.31	161.27	190.6	19.9	66.58	144.59	424.20	16.04		
	mid_U_664_12	14.68	264.31	161.27	190.6	19.9	66.73	144.25	323.20	17.97	y	118
	mid_U_701_13	14.68	264.31	161.27	190.6	19.9	66.73	144.25	207.40	22.71		
	mid_U_689_14	14.68	264.31	161.27	190.6	19.9	66.33	145.17	280.00	20.82		
	mid_U_633_15	14.68	264.21	161.17	184	19.9	66.33	145.07	203.40	22.13		
	mid_U_694_16	14.68	264.21	161.17	184	19.9	66.13	145.53	479.20	13.48		
	mid_U_635_17	14.68	264.21	161.17	184	19.9	66.23	145.30	289.20	22.36	y	109.6
	mid_U_673_18	14.68	264.21	161.17	184	19.9	66.77	144.05	260.00	9.22	y	193.8
	mid_U_684_19	14.68	264.21	161.06	179.4	20	66.52	144.63	175.40	22.45		
	mid_U_700_20	14.68	264.21	161.06	179.4	20	66.43	144.84	244.00	21.7		
	mid_U_672_21	14.68	264.21	161.06	179.4	20	66.18	145.41	491.00	14.08		
	mid_U_692_22	14.68	264.21	161.06	179.4	20	66.43	144.84	249.40	21.36		
	mid_U_682_23	14.68	264.21	161.06	179.4	20	66.18	145.41	206.40	21.96		
	mid_U_678_24	14.68	264.21	160.96	175.8	20	66.13	145.53	345.00	16.57		
	mid_U_693_25	14.68	264.21	160.96	175.8	20	66.59	144.47	451.60	13.9		
	mid_U_664_26	14.68	264.21	160.96	175.8	20	66.81	143.96	299.20	18.15		
						19.93	**Mean**	**144.93**	**304.15**	**19.07**	11.54%	**140.47**
						19.90	**Median**	**144.94**	**284.60**	**20.69**		**118.00**
							Min	**143.96**	**175.40**	**9.22**		**109.60**
							Max	**145.86**	**525.60**	**23.38**		**193.80**
							STDev	**0.55**	**100.35**	**3.81**		**46.38**

Table B.4. (contd)

Test Condition	File Name	Baro Psi	FB ele	TW ele	PH Q	T9 Q	Release Pt -psia	Release El	Rate of Change Psi/sec	Nadir	Significant Event	Significant Event Magnitude
Upper 1%	H_M_670_1	14.59	263.61	160.44		19.8	66.01	145.01	393.00	13.9		
Mid/Hub	H_M_639_2	14.60	263.61	160.55		20.4	66.03	144.97	262.60	18.15		
145.2	H_M_630_3	14.59	263.61	160.55		20.4	65.98	145.08	483.60	11.65		
	H_M_675_4	14.59	263.61	160.33		20.6	65.62	145.91	647.00	7.36	y	134.6
	H_M_678_5	14.59	263.62	160.44		20.1	65.71	145.71	258.00	18.6		
	H_M_640_6	14.59	263.71	160.44		20.1	66.59	143.77	225.00	21.43		
	H_M_671_7	14.59	263.71	160.33		20.1	66	145.13	311.00	18.69		
	H_M_670_8	14.59	263.71	160.44		20.2	66.01	145.11	447.80	13.22		
	H_M_639_9	14.59	263.71	160.44		20.2	66.12	144.85	361.20	16.27		
	H_M_630_10	14.59	263.71	160.53		20.1	66.08	144.95	362.20	9.94		
	H_M_675_11	14.59	263.71	160.85		20.1	65.72	145.77	271.80	20.46		
	H_M_678_12	14.59	263.71	160.96		20.2	65.81	145.56	238.40	23.19		
	H_M_671_13	14.58	263.71	161.06		20.1	66	145.11	375.40	14.68		
	H_M_640_14	14.58	263.71	160.96		20.1	66.49	143.98	385.20	16.43	y	131.3
	H_M_670_15	14.58	263.71	161.04		20.2	66	145.11	354.00	16.14		
	H_M_664_16	14.58	263.61	161.01		20.1	65.99	145.03	158.40	22.3		
	H_M_639_17	14.58	263.61	161.16		20.1	66.11	144.75	219.20	20.01		
	H_M_675_18	14.58	263.61	161.09		20	65.71	145.68	528.00	12.53		
	H_M_678_19	14.58	263.61	160.98		20	65.71	145.67	213.20	22.11		
	H_M_671_20	14.58	263.61	161.06		20	66.09	144.79	250.40	19.76		
	H_M_640_21	14.57	263.61	161.12		20.1	66.57	143.67	179.80	22.39		
	H_M_670_22	14.57	263.61	161		20	65.99	145.01	236.60	20.92		
	H_M_664_23	14.57	263.61	161.17		20.1	66.08	144.80	565.00	9.29	y	129.7
	H_M_675_24	14.57	263.51	161.1		20	65.5	146.04	205.20	21.61		
	H_M_678_25	14.57	263.51	161.27		20	65.6	145.81	170.20	22.59		
	H_M_640_26	14.57	263.41	161.27		20	66.47	143.70	256.20	21.51		
	H_M_670_27	14.57	263.41	161.37		20	65.89	145.04	453.60	13.59		
	H_M_664_28	14.57	263.51	161.46		19.9	65.89	145.14	441.80	12.9		
	H_M_675_29	14.57	263.51	161.4		20.1	65.4	146.27	340.20	17.89	y	125.6
	H_M_678_30	14.57	263.51	161.48		20	65.69	145.60	154.40	22.68		
	H_M_640_31	14.57	263.41	161.43		20.2	66.48	143.68	265.80	18.48	y	171.6
	H_M_670_32	14.57	263.41	161.58		20.2	65.69	145.50	254.20	21.31		
	H_M_664_33	14.57	263.41	161.39		20.3	65.79	145.27	185.80	22.78		
	H_M_675_34	14.57	263.41	161.57		20.3	65.5	145.94	297.20	17.6		
	H_M_678_35	14.57	263.51	161.54		20.1	65.79	145.37	355.80	15.84		
						20.12	**Mean**	**145.11**	**317.35**	**17.66**	14.29%	**138.56**
						20.10	**Median**	**145.11**	**271.80**	**18.48**		**131.30**
							Min	**143.67**	**154.40**	**7.36**		**125.60**
							Max	**146.27**	**647.00**	**23.19**		**171.60**
							StDev	**0.68**	**121.51**	**4.37**		**18.75**

Table B.4. (contd)

Test Condition	File Name	Baro Psi	FB ele	TW ele	PH Q	T9 Q	Release Pt -psia	Release El	Rate of Change Psi/sec	Nadir	Significant Event	Significant Event Magnitude
PEAK	mid_p_700_1	14.53	264.81	161.48	186.9	16.5	68.92	139.35	294.80	22.76	y	113.1
Mid/Hub	mid_p_692_2	14.53	264.81	161.48	186.9	16.5	68.77	139.69	289.00	25.9		
141.7	mid_p_672_3	14.53	264.81	161.48	186.9	16.5	68.74	139.76	268.60	26.15		
	mid_p_673_4	14.53	264.81	161.48	185.3	16.5	68.7	139.86	402.80	19.99		
	mid_p_684_5	14.53	264.81	161.48	185.3	16.5	68.57	140.16	331.00	18.61		
	mid_p_682_6	14.53	264.81	161.48	185.3	16.5	68.56	140.18	356.20	20.81		
	mid_p_678_7	14.53	264.81	161.48	185.3	16.5	68.47	140.39	273.20	24.6		
	mid_p_701_8	14.53	264.81	161.48	185.3	16.5	68.62	140.04	274.40	23.89		
	mid_p_664_9	14.53	264.71	161.48	184.5	16.5	68.57	140.06	528.40	17.72	y	102.8
	mid_p_693_10	14.53	264.71	161.48	184.5	16.5	68.58	140.03	312.80	25.18		
	mid_p_633_11	14.53	264.71	161.48	184.5	16.5	68.5	140.22	489.20	17.15		
	mid_p_694_12	14.53	264.71	161.48	184.5	16.5	67.79	141.86	394.80	20.77		
	mid_p_635_13	14.53	264.71	161.48	184.5	16.5	68.27	140.75	526.40	17.32	y	112.8
	mid_p_689_14	14.53	264.71	161.48	184.5	16.5	68.59	140.01	435.00	20.57		
	mid_p_700_15	14.50	264.51	161.48	178.8	16.5	68.28	140.46	278.60	23.95		
	mid_p_672_16	14.50	264.51	161.48	178.8	16.5	68.61	139.69	246.40	24.92	y	122.3
	mid_p_684_17	14.50	264.51	161.48	178.8	16.5	68.34	140.32	285.00	26.46	y	120.8
	mid_p_678_18	14.50	264.51	161.48	178.8	16.5	68.04	141.01	600.40	18.09		
	mid_p_692_19	14.50	264.51	161.48	178.6	16.5	68.54	139.86	299.00	26.86	y	105
	mid_p_673_20	14.50	264.51	161.48	178.6	16.5	68.38	140.23	311.60	22.44		
	mid_p_682_21	14.50	264.51	161.48	178.6	16.5	68.43	140.11	335.80	22.9		
	mid_p_701_22	14.50	264.51	161.48	178.6	16.5	68.38	140.23	274.60	23.24		
	mid_p_693_23	14.50	264.51	161.48	178.7	16.5	68.45	140.06	267.80	26.42		
	mid_p_633_24	14.50	264.51	161.48	178.7	16.5	68.27	140.48	429.00	19.44		
	mid_p_694_25	14.50	264.51	161.48	178.7	16.5	68.17	140.71	229.60	25.48		
	mid_p_635_26	14.50	264.51	161.48	178.7	16.5	67.94	141.24	514.60	17.99		
	mid_p_689_27	14.50	264.51	161.48	178.7	16.5	68.66	139.58	288.00	25.47		
	mid_p_700_28	14.46	264.71	161.27	162.2	16.3	68.34	140.43	268.40	25.95		
	mid_p_672_29	14.46	264.71	161.27	162.2	16.3	68.47	140.13	278.60	24.18		
	mid_p_684_30	14.46	264.71	161.27	162.2	16.3	68.4	140.29	446.80	18.05		
	mid_p_678_31	14.46	264.71	161.27	162.2	16.3	68.1	140.98	319.20	23.13	y	147.9

Table B.4. (contd)

Test Condition	File Name	Baro Psi	FB ele	TW ele	PH Q	T9 Q	Release Pt -psia	Release El	Rate of Change Psi/sec	Nadir	Significant Event	Significant Event Magnitude
	mid_p_673_32	14.46	264.71	161.27	162.2	16.3	68.04	141.12	476.20	18.63		
PEAK	mid_p_682_33	14.46	264.71	161.27	162.2	16.3	68.29	140.54	273.20	25.49		
Mid/Hub	mid_p_701_34	14.46	264.71	161.17	162.2	16.3	68.34	140.43	603.80	15.99	y	204.5
141.7	mid_p_693_35	14.46	264.71	161.17	162.2	16.3	68.52	140.01	293.40	21.4		
	mid_p_633_36	14.46	264.71	161.17	162.2	16.3	68.13	140.91	541.60	17.28		
	mid_p_694_37	14.46	264.71	161.17	162.2	16.3	67.72	141.86	289.80	21.51		
	mid_p_635_38	14.46	264.71	161.17	162.2	16.3	68.4	140.29	367.00	18.94		
	mid_p_689_39	14.46	264.71	161.17	162.2	16.3	68.52	140.01	227.60	25.23		
	mid_p_664_40	14.46	264.71	161.17	162.2	16.3	68.5	140.06	319.00	23.04		
	mid_p_700_41	14.42	264.91	161.58	166.1	16.3	68.61	139.91	262.40	25.4		
	mid_p_672_42	14.42	264.91	161.58	166.1	16.3	68.53	140.09	262.60	25.34		
	mid_p_684_43	14.42	264.91	161.58	166.1	16.3	68.26	140.72	255.20	26.18		
	mid_p_678_44	14.42	264.91	161.58	166.1	16.3	68.46	140.26	227.20	26.28		
	mid_p_673_45	14.42	264.91	161.58	166.1	16.3	68.49	140.19	297.60	26.33		
	mid_p_682_46	14.42	264.91	161.58	166.1	16.3	68.45	140.28	228.80	26.66		
	mid_p_693_47	14.42	264.91	161.58	166.1	16.3	68.67	139.77	273.60	24.29		
	mid_p_633_48	14.42	264.88	161.58	167.2	16.3	68.49	140.16	576.00	16.43	y	150.8
	mid_p_694_49	14.42	264.88	161.58	167.2	16.3	67.58	142.26	292.00	25.3		
	mid_p_635_50	14.42	264.88	161.58	167.2	16.3	68.26	140.69	243.40	25.48		
	mid_p_689_51	14.42	264.88	161.58	167.2	16.3	68.28	140.64	573.80	17.64		
	mid_p_664_52	14.42	264.81	161.58	167.9	16.3	68.56	139.93	392.80	20.8		
	mid_P_689_53	14.43	264.91	162.2	202	16.4	68.59	139.98	348.40	26.71		
	mid_P_693_54	14.43	264.91	162.2	202	16.4	68.39	140.44	649.00	17.46	y	158.1
	mid_P_694_55	14.43	264.91	162.2	202	16.4	68.3	140.65	271.80	27.02		
	mid_p_682_56	14.43	264.91	162.2	202	16.4	68.46	140.28	273.00	23.54		
	mid_P_678_57	14.43	264.91	162.2	202	16.4	68.37	140.49	498.60	19.41		
	mid_P_633_58	14.43	264.81	162.29	206.4	16.4	68.42	140.27	277.80	25.83		
	mid_p_635_59	14.43	264.81	162.29	206.4	16.4	68.17	140.85	327.00	19.61	y	152.4
	mid_P_673_60	14.43	264.81	162.29	206.4	16.4	68.21	140.76	355.20	22.27		
	mid_p_664_61	14.43	264.81	162.29	206.4	16.4	68.57	139.93	277.20	24.4		
	mid_P_684_62	14.43	264.81	162.29	206.4	16.4	68.17	140.85	319.00	22.8		
	mid_p_700_63	14.43	264.91	162.2	205.7	16.3	68.61	139.93	589.60	17.68	y	117.1
	mid_P_672_64	14.43	264.91	162.2	205.7	16.3	68.54	140.09	296.40	23.85		
	mid_p_689_65	14.42	264.71	162.2	204.5	16.4	67.99	141.14	229.40	24.29		
	mid_p_694_66	14.42	264.71	162.2	204.5	16.4	68.29	140.45	332.40	22.38		
						16.40	**Mean**	**140.37**	**351.09**	**22.53**	18.18%	**133.97**
						16.40	**Median**	**140.26**	**298.30**	**23.19**		**121.55**
							Min	**139.35**	**227.20**	**15.99**		**102.80**
							Max	**142.26**	**649.00**	**27.02**		**204.50**
							StDev	**0.53**	**113.09**	**3.30**		**29.64**

Table B.4. (contd)

Test Condition	***File Name***	***Baro Psi***	***FB ele***	***TW ele***	***PH Q***	***T9 Q***	***Release Pt -psia***	***Release El***	***Rate of Change Psi/sec***	***Nadir***	***Significant Event***	***Significant Event Magnitude***
Lower 1%	L_M_630_1	14.51	263.41	160.26		11.5	66.28	144.00	261.80	28.73		
Mid/Hub	L_M_670_2	14.51	263.41	160.44		11.5	65.44	145.94	236.60	28.88		
141.2	L_M_639_3	14.51	263.41	160.34		11.5	65.55	145.69	371.20	25.07		
	L_M_671_4	14.52	263.41	160.43		11.5	65.55	145.70	351.80	25.96		
	L_M_675_5	14.51	263.41	160.43		11.5	65.05	146.84	369.40	25.17		
	L_M_664_6	14.52	263.41	160.35		11.5	65.25	146.39	176.00	29.28		
	L_M_669_7	14.51	263.41	160.32		11.5	65.73	145.26	305.00	27.12	y	126.4
	L_M_678_8	14.51	263.41	160.48		11.5	65.25	146.38	483.00	24.49		
	L_M_672_9	14.51	263.41	160.46		11.5	65.14	146.62	381.20	24.57		
	L_M_673_10	14.51	263.31	160.39		11.5	65.54	145.61	285.40	29.66		
	L_M_640_11	14.51	263.31	160.65		11.5	66.12	144.27	367.60	27.41	y	96.5
	L_M_630_12	14.51	263.34	160.64		11.5	66.19	144.13	231.40	29.49		
	L_M_670_13	14.51	263.31	160.45		11.5	65.34	146.06	254.20	29.56		
	L_M_639_14	14.51	263.31	160.45		11.5	65.35	146.04	381.20	23.1		
	L_M_671_15	14.51	263.31	160.5		11.5	65.24	146.30	330.40	24.38		
	L_M_675_16	14.51	263.31	160.5		11.5	64.86	147.18	277.60	27.71		
	L_M_664_17	14.51	263.31	160.54		11.5	65.34	146.07	217.00	28.88		
	L_M_669_18	14.52	263.31	160.66		11.5	65.74	145.16	289.40	28.5		
	L_M_678_19	14.52	263.31	160.44		11.5	64.76	147.43	346.00	26.84		
	L_M_672_20	14.52	263.31	160.55		11.5	64.96	146.96	242.40	29.19		
	L_M_673_21	14.52	263.31	160.44		11.5	65.35	146.06	473.20	23.51		
	L_M_640_22	14.52	263.31	160.51		11.5	66.13	144.26	185.80	30.36		
	L_M_630_23	14.51	263.31	160.55		11.5	66.19	144.11	284.40	27.5		
	L_M_670_24	14.52	263.31	160.55		11.5	65.35	146.06	312.80	26.45		
	L_M_639_25	14.52	263.21	160.65		11.5	65.66	145.25	349.40	26.37		
	L_M_675_26	14.52	263.21	160.55		11.5	65.15	146.43	203.20	30.55		
	L_M_630_28	14.59	263.31	160.34		11.7	65.79	145.20	409.60	25.68		
	L_M_670_29	14.59	263.31	160.34		11.7	65.42	146.06	414.60	23.78		
	L_M_639_30	14.59	263.31	160.34		11.7	65.83	145.11	321.80	26.24		

Table B.4. (contd)

Test Condition	File Name	Baro Psi	FB ele	TW ele	PH Q	T9 Q	Release Pt -psia	Release El	Rate of Change Psi/sec	Nadir	Significant Event	Significant Event Magnitude
	L_M_675_31	14.58	263.31	160.24		11.7	65.12	146.74	344.00	26.41		
Lower 1%	L_M_664_32	14.59	263.31	160.24		11.7	65.32	146.29	342.00	27.4		
Mid/Hub	L_M_678_33	14.59	263.41	160.31		11.7	65.03	147.06	387.20	24.56		
141.2	L_M_672_34	14.58	263.41	160.31		11.7	65.12	146.84	228.80	28.07		
	L_M_640_35	14.58	263.41	160.45		11.7	66.19	144.37	258.00	29.14		
	L_M_630_36	14.59	263.41	160.27		11.7	66.17	144.44	572.60	24.83	y	173.6
	L_M_639_37	14.57	263.31	160.34		11.7	65.61	145.57	312.00	27.6		
	L_M_675_38	14.60	263.31	160.26		11.7	65.13	146.75	275.60	26.91	y	162.3
	L_M_678_39	14.60	263.38	160.24		11.7	65.14	146.80	469.20	25.26	y	102.4
	L_M_672_40	14.60	263.38	160.24		11.7	65.14	146.81	328.40	25.84		
	L_M_640_41	14.61	263.31	160.34		11.7	66.23	144.23	353.80	25.76		
	L_M_630_42	14.60	263.31	160.34		11.8	65.7	145.45	297.60	29.48		
	L_M_670_43	14.60	263.31	160.39		11.8	65.33	146.30	285.40	27.89	y	126.3
	L_M_639_44	14.60	263.31	160.39		11.8	65.64	145.58	329.60	28.22		
	L_M_675_45	14.60	263.31	160.34		11.7	64.95	147.18	263.80	25.75		
	L_M_678_46	14.60	263.31	160.31		11.7	65.14	146.74	350.00	26.14	y	116.3
	L_M_672_47	14.60	263.41	160.34		11.7	65.04	147.07	397.00	25.35		
	L_M_630_48	14.60	263.41	160.38		11.7	65.52	145.96	326.20	28.06		
	L_M_671_49	14.52	263.21	160.55		11.5	65.35	145.96	402.80	25.27	y	113
	L_M_670_50	14.60	263.51	160.44		11.7	65.43	146.26	275.60	28.09		
	L_M_639_51	14.60	263.51	160.44		11.7	65.54	146.00	446.40	24.77	y	122.4
	L_M_675_52	14.60	263.51	160.41		11.8	65.14	146.94	299.20	26.63		
	L_M_678_53	14.60	263.51	160.41		11.8	65.14	146.94	262.00	27.89		
	L_M_672_54	14.60	263.51	160.26		11.7	65.14	146.93	273.80	27.6		
	L_M_671_55	14.60	263.61	160.46		11.7	65.53	146.13	338.20	26.52		
	L_M_670_56	14.60	263.61	160.55		11.7	65.53	146.13	269.80	29.55		
	L_M_639_57	14.60	263.61	160.55		11.7	65.74	145.64	213.20	29.6		
	L_M_675_58	14.60	263.61	160.75		11.7	65.14	147.03	316.60	27.21		
	L_M_678_59	14.60	263.61	160.57		11.7	64.95	147.46	176.00	29.36	y	108.1
	L_M_640_60	14.60	263.61	160.75		11.7	65.82	145.46	348.00	25.64		
	L_M_671_61	14.60	263.61	160.75		11.7	65.73	145.66	348.00	27.8		
						11.62	**Mean**	**145.99**	**320.07**	**27.05**	16.67%	**124.73**
						11.70	**Median**	**146.06**	**319.20**	**27.17**		**119.35**
							Min	**144.00**	**176.00**	**23.10**		**96.50**
							Max	**147.46**	**572.60**	**30.55**		**173.60**
							StDev	**0.92**	**78.94**	**1.86**		**24.92**

Table B.4. (contd)

Test Condition	*File Name*	*Baro Psi*	*FB ele*	*TW ele*	*PH Q*	*T9 Q*	*Release Pt -psia*	*Release El*	*Rate of Change Psi/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
Peak	tip_p_700_1	14.56	264.21	162.1	202	16.5	78.81	116.00	331.40	19.24		
Tip	tip_p_672_2	14.56	264.21	162.1	202	16.5	78.79	116.05	527.00	20.07	y	202
118.1	tip_p_684_3	14.56	264.21	162.1	202	16.5	77.6	118.80	473.20	17.19		
	tip_p_693_4	14.56	264.21	162.1	202	16.5	78.3	117.18	324.40	24.04		
	tip_p_678_5	14.56	264.21	162.2	202.1	16.4	77.41	119.23	295.20	23.55	y	150.4
	tip_p_694_6	14.56	264.21	162.1	200.1	16.5	78.7	116.26	310.00	25.44		
	tip_p_689_7	14.56	264.21	162.1	200.1	16.5	78.69	116.28	551.80	16.37	y	161.4
	tip_p_673_8	14.56	264.31	161.99	199.5	16.5	78.71	116.34	279.60	23.48		
	tip_p_682_9	14.56	264.31	161.99	199.5	16.5	78.71	116.34	303.60	14.36	y	124.3
	tip_p_635_10	14.56	264.31	161.99	199.5	16.5	78.47	116.89	229.20	26.52		
	tip_p_672_11	14.55	264.51	161.9	195.3	16.4	77.69	118.86	338.40	21.49		
	tip_p_684_12	14.55	264.51	161.9	195.3	16.4	78.86	116.17	348.80	17.94	y	156.1
	tip_p_693_13	14.55	264.51	161.9	195.3	16.4	78.68	116.58	561.20	14.94	y	97
	tip_p_678_14	14.55	264.51	161.9	195.3	16.4	77.4	119.53	420.20	16.5		
	tip_p_694_15	14.55	264.71	162.1	194.5	16.4	78.59	116.99	489.40	17.57		
	tip_p_689_16	14.55	264.71	162.1	194.5	16.4	78.98	116.09	330.20	21.19		
	tip_p_673_17	14.55	264.71	162.1	194.5	16.4	78.09	118.14	258.00	25.11		
	tip_p_682_18	14.55	264.71	162.1	194.5	16.4	78.39	117.45	364.20	18.91		
	tip_p_635_19	14.55	264.71	162.1	194.5	16.4	77.99	118.37	344.00	16.89		
						16.45	**Mean**	**117.24**	**372.62**	**20.04**	31.58%	**148.53**
						16.40	**Median**	**116.89**	**338.40**	**19.24**		**153.25**
							Min	**116.00**	**229.20**	**14.36**		**97.00**
							Max	**119.53**	**561.20**	**26.52**		**202.00**
							StDev	**1.20**	**100.83**	**3.77**		**35.58**

Table B.4. (contd)

Test Condition	*File Name*	*Baro Psi*	*FB ele*	*TW ele*	*PH Q*	*T9 Q*	*Release Pt -psia*	*Release El*	*Rate of Change Psi/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
Lower 1%	tip_L_672_1	14.55	264.71	162.2	202.4	12.1	77.83	118.74	380.60	26.33		
tip	tip_L_684_2	14.55	264.71	162.2	202.4	12.1	78.26	117.75	359.00	24.52		
119.4	tip_L_693_3	14.55	264.71	162.2	202.4	12.1	78.39	117.45	355.80	26.67		
	tip_L_678_4	14.55	264.61	162.3	209.1	12.1	78.02	118.20	381.00	24.38		
	tip_L_694_5	14.54	264.61	162.57	216.2	12.2	78.48	117.12	283.40	30.15		
	tip_L_673_6	14.54	264.61	162.57	216.2	12.2	78.44	117.21	305.60	30.12		
	tip_L_682_7	14.54	264.61	162.57	216.2	12.2	78.08	118.04	325.80	28.81		
	tip_L_689_8	14.54	264.61	162.57	216.2	12.2	78.67	116.68	338.40	28.43		
	tip_L_635_9	14.53	264.61	162.61	216.4	12.2	77.58	119.17	504.40	24.11		
	tip_L_672_10	14.53	264.61	162.61	216.4	12.2	78.46	117.14	370.80	24.65		
	tip_L_684_11	14.53	264.61	162.61	216.4	12.2	78.14	117.88	331.00	28.39		
	tip_L_693_12	14.53	264.61	162.61	216.4	12.2	78.36	117.37	394.80	28.8		
	tip_L_678_13	14.53	264.61	162.61	216.4	12.2	78.24	117.65	311.00	30.28		
	tip_L_694_14	14.53	264.41	162.51	214.4	12.1	78.07	117.84	390.60	27.92		
	tip_L_673_15	14.53	264.41	162.51	214.4	12.1	78.13	117.70	468.20	22.96	y	118.2
	tip_L_682_16	14.53	264.41	162.61	214.3	12.2	78.17	117.61	352.00	29.2	y	99.5
	tip_L_689_17	14.53	264.41	162.61	214.3	12.2	78.36	117.17	364.40	26.81		
	tip_L_635_18	14.53	264.41	162.61	214.3	12.2	77.28	119.66	397.00	24.59		
	tip_L_672_19	14.52	264.41	162.41	210.8	12.1	77.94	118.12	326.60	28.15		
	tip_L_684_20	14.52	264.41	162.41	210.8	12.1	78.24	117.43	349.00	30.18	y	157.1
	tip_L_693_21	14.52	264.41	162.41	210.8	12.1	77.96	118.07	322.20	27.72		
	tip_L_678_22	14.52	264.41	162.41	210.8	12.1	77.83	118.37	562.40	23.39		
	tip_L_694_23	14.52	264.41	162.41	210.8	12.1	78.26	117.38	477.20	16.18	y	176.9
						12.15	**Mean**	**117.82**	**376.14**	**26.64**	17.39%	**137.93**
						12.20	**Median**	**117.70**	**359.00**	**27.72**		**137.65**
							Min	**116.68**	**283.40**	**16.18**		**99.50**
							Max	**119.66**	**562.40**	**30.28**		**176.90**
							StDev	**0.69**	**68.17**	**3.27**		**35.37**

Table B.4. (contd)

Test Condition	File Name	Baro Psi	FB ele	TW ele	PH Q	T9 Q	Release Pt -psia	Release El	Rate of Change Psi/sec	Nadir	Significant Event	Significant Event Magnitude
higher 1%	tip_U_673_1	14.52	264.31	162.51	210.7	20.3	77.52	118.99	545.80	-0.26	y	175.4
tip	tip_U_682_2	14.52	264.31	162.51	210.7	20.3	77.66	118.66	364.20	9.06	y	152.8
119.4	tip_U_689_3	14.52	264.31	162.51	210.7	20.3	77.85	118.23	485.40	11.6		
	tip_U_635_4	14.52	264.31	162.51	210.7	20.3	77.63	118.73	313.00	13.62		
	tip_U_672_5	14.51	264.31	162.41	209.2	20.3	77.63	118.71	370.80	17.32	y	135.1
	tip_U_684_6	14.51	264.31	162.41	209.2	20.3	77.62	118.73	333.00	16.3		
	tip_U_694_7	14.51	264.31	162.41	209.2	20.3	77.64	118.69	279.80	22.87		
	tip_U_678_8	14.51	264.31	162.41	209.2	20.3	77.62	118.73	500.40	14.91	y	141.9
	tip_U_673_9	14.5	264.31	162.41	211	20.3	77.6	118.76	337.40	19.16		
	tip_U_682_10	14.5	264.31	162.41	211	20.3	77.63	118.69	263.00	19.45		
	tip_U_689_11	14.5	264.31	162.41	211	20.3	77.53	118.92	292.00	21.95		
	tip_U_635_12	14.51	264.31	162.51	213.9	20.3	77.53	118.94	329.00	8.63	y	190.8
	tip_U_672_13	14.5	264.31	162.62	218.1	20.4	77.62	118.71	272.60	9.49	y	142.3
	tip_U_684_14	14.5	264.31	162.62	218.1	20.4	77.61	118.73	241.20	21.28		
	tip_U_694_15	14.5	264.31	162.62	218.1	20.4	77.63	118.69	428.80	12.19		
	tip_U_678_16	14.5	264.31	162.62	218.1	20.4	77.61	118.73	414.80	11.81		
	tip_U_672_17	14.49	264.41	162.64	216.3	20.3	77.71	118.58	503.00	3.77	y	138.6
	tip_U_684_18	14.49	264.41	162.61	215.7	20.3	77.7	118.60	604.20	8.2	y	174.2
	tip_U_694_19	14.49	264.41	162.64	216.3	20.3	77.62	118.79	400.60	13.18		
	tip_U_673_20	14.49	264.41	162.72	216.7	20.4	77.49	119.09	363.20	19.85		
	tip_U_682_21	14.49	264.41	162.72	216.7	20.4	77.73	118.53	307.40	12.88	y	164.8
	tip_U_689_22	14.49	264.41	162.72	216.7	20.4	77.92	118.10	267.80	18.62		
	tip_U_635_23	14.49	264.41	162.72	216.7	20.4	77.61	118.81	360.80	13.1		
						20.33	**Mean**	**118.70**	**372.97**	**13.87**	39.13%	**157.32**
						20.30	**Median**	**118.73**	**360.80**	**13.18**		**152.80**
							Min	**118.10**	**241.20**	**-0.26**		**135.10**
							Max	**119.09**	**604.20**	**22.87**		**190.80**
							StDev	**0.21**	**98.53**	**5.86**		**19.74**

Table B.4. (contd)

File Name	*Barometric Pressure*	*Barometric Pressure (psia)*	*FB EL*	*TW EL*	*# units on*	*PH Q*	*Spill Q*	*Total Q*	*T8 Q*	*T9 Q*	*T10 Q*	*Release Pt -psia*	*Release El*	*Rate of Change Psia/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
L_673_1	29.66	14.57	264.51	161.06	11	146.3	0	146.3	13.6	11.9	0	70.92	134.5275	279.8	27.67		
L_689_2	29.65	14.56	264.51	161.06	11	146.3	0	146.3	13.6	11.9	0	71.14	133.9969	207.4	29.86		
L_691_3	29.61	14.54	264.41	160.79	11	155.2	0	155.2	14.8	12	0	70.63	135.0272	277.8	28.93	y	133.5
L_672_4	29.61	14.54	264.41	160.79	11	155.2	0	155.2	14.8	12	0	71.05	134.0584	250.6	28.67		
L_693_5	29.61	14.54	264.41	160.79	11	155.2	0	155.2	14.8	12	0	71.37	133.3202	297	28.98		
L_699_6	29.62	14.55	264.41	160.86	11	154.4	0	154.4	14.7	11.9	0	71.24	133.6432	238.6	28.43	y	96.6
L_694_7	29.62	14.55	264.41	160.86	11	154.4	0	154.4	14.7	11.9	0	69.73	137.1263	249.6	28.75		
L_686_8	29.62	14.55	264.41	160.86	11	154.4	0	154.4	14.7	11.9	0	71.17	133.8046	329.4	26.65		
L_673_9	29.62	14.55	264.41	160.86	11	154.4	0	154.4	14.7	11.9	0	70.81	134.6351	240.2	28.64		
L_701_10	29.62	14.55	264.41	160.86	11	154.4	0	154.4	14.7	11.9	0	71.07	134.0353	313.2	29.59		
L_689_11	29.62	14.55	264.41	160.75	11	153.1	0	153.1	14.7	11.9	0	71.63	132.7436	265.8	27.94		
L_691_12	29.59	14.53	264.21	160.65	11	154.5	0	154.5	14.7	11.9	0	69.71	136.9263	273.8	26.82		
L_701_13	29.59	14.53	264.21	160.65	11	154.5	0	154.5	14.7	11.9	0	70.95	134.066	252.2	29.06		
L_689_14	29.59	14.53	264.21	160.65	11	154.5	0	154.5	14.7	11.9	0	71.21	133.4662	267.8	27.72		
L_694_15	29.57	14.52	264.21	160.75	11	170	0	170	16.4	11.6	0	69.29	137.872	211.4	29.73		
L_701_16	29.57	14.52	264.21	160.84	11	170.4	0	170.4	15.9	11.5	0	71.34	133.1433	276.4	29.97		
L_693_17	29.57	14.52	264.21	160.84	11	170.4	0	170.4	15.9	11.5	0	71.25	133.3509	213.6	26.82	y	95.6
L_699_18	29.57	14.52	264.21	160.84	11	170.4	0	170.4	15.9	11.5	0	71.51	132.7512	436	26.06		
L_673_19	29.57	14.52	264.21	160.84	11	170.4	0	170.4	15.9	11.5	0	69.49	137.4107	402.8	25.93	y	115.2
L_672_21	29.57	14.52	264.21	160.86	11	175.2	0	175.2	16.9	11.9	0	69.83	136.6264	390.8	26.44		
L_689_22	29.57	14.52	264.21	160.86	11	175.2	0	175.2	16.9	11.9	0	69.89	136.488	290	28.91		
L_691_23	29.57	14.52	264.21	160.86	11	175.2	0	175.2	16.9	11.9	0	70.5	135.0809	275.8	27.61		
										11.83		**Mean**	**134.73**	**283.64**	**28.14**	18.18%	**110.23**
												Median	**134.0622**	**274.8**	**28.535**		**105.9**
												Min	**132.7436**	**207.4**	**25.93**		**95.6**
												Max	**137.872**	**436**	**29.97**		**133.5**
												StDev	**1.609**	**60.160**	**1.258**		**17.944**

Table B.4. (contd)

File Name	*Barometric Pressure*	*Barometric Pressure (psia)*	*FB EL*	*TW EL*	*# units on*	*PH Q*	*Spill Q*	*Total Q*	*T8 Q*	*T9 Q*	*T10 Q*	*Release Pt -psia*	*Release El*	*Rate of Change Psia/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
P_689_1	29.57	14.52	263.01	159.92	8	110	0	110	0	16.4	13	74.32	125.0693	322.2	21.67		
P_691_2	29.56	14.52	263.01	159.92	8	110	0	110	0	16.4	13	73.52	126.9147	324.2	24.89		
P_693_3	29.57	14.52	263.01	159.93	8	110.1	0	110.1	0	16.4	13.1	75.11	123.247	483.8	16.76		
P_699_4	29.57	14.52	263.11	159.93	8	107.9	0	107.9	0	16.7	13	74.05	125.7921	222.8	17.45	y	208.8
P_694_5	29.57	14.52	263.11	159.93	8	107.9	0	107.9	0	16.7	13	73.93	126.069	425	25.2		
P_701_7	29.56	14.52	263.11	159.93	8	107.9	0	107.9	0	16.7	13	74.4	124.9848	335.6	20.01		
P_673_8	29.57	14.52	263.01	159.93	8	110.1	0	110.1	0	16.4	13.1	74.05	125.6921	351.2	16.01		
P_673_9	29.58	14.53	263.81	160.03	7	106.9	0	106.9	0	16.7	14.9	74.46	125.5695	267.8	24.25		
P_689_10	29.57	14.52	263.91	160.02	7	105.9	0	105.9	0	16.7	14.8	74.53	125.4849	497.4	16.73		
P_694_11	29.57	14.52	263.91	160.02	7	105.9	0	105.9	0	16.7	14.8	73.93	126.869	306	20.87		
P_672_12	29.57	14.52	263.91	160.02	7	105.9	0	105.9	0	16.7	14.8	74.64	125.2312	348.6	21.23		
P_701_13	29.59	14.53	263.91	160.02	7	105.9	0	105.9	0	16.7	14.8	74.41	125.7848	425	17.27		
P_673_14	29.57	14.52	263.51	159.93	7	105.7	0	105.7	0	16.3	14.5	74.35	125.5001	416.8	18.88		
P_694_16	29.57	14.52	263.51	160.03	7	105.8	0	105.8	0	16.3	14.5	73.73	126.9303	310.2	22.08		
P_672_17	29.57	14.52	263.51	160.03	7	105.8	0	105.8	0	16.3	14.5	74.44	125.2925	533	16.73	y	101.9
P_701_18	29.57	14.52	263.51	160.03	7	105.8	0	105.8	0	16.3	14.5	74.4	125.3848	298.8	23.16		
P_699_19	29.57	14.52	263.51	160.03	7	105.8	0	105.8	0	16.3	14.5	74.64	124.8312	479	18.33		
P_691_20	29.57	14.52	263.51	160.03	7	105.8	0	105.8	0	16.3	14.5	73.72	126.9534	296	22.37		
P_686_21	29.57	14.52	263.51	159.94	7	104.3	0	104.3	0	16.3	14.5	73.61	127.2071	341.6	18.51		
P_691_23	29.58	14.53	263.21	160.1	7	107.7	0	107.7	0	16.3	17	73.63	126.884	302	24.39		
										16.48		**Mean**	**125.78**	**364.35**	**20.34**	15.00%	**155.35**
										16.4		**Median**	**125.6308**	**338.6**	**20.44**		**155.35**
												Min	**123.247**	**222.8**	**16.01**		**101.9**
												Max	**127.2071**	**533**	**25.2**		**208.8**
												StDev	**0.970**	**85.030**	**3.069**		**75.590**

Table B.4. (contd)

File Name	Barometric Pressure	Barometric Pressure (psia)	FB EL	TW EL	# units on	PH Q	Spill Q	Total Q	T8 Q	T9 Q	T10 Q	Release Pt -psia	Release El	Rate of Change Psia/sec	Nadir	Significant Event	Significant Event Magnitude
u_672_1	29.51	14.49	263.51	159.92	7	107.1	0	107.1	0	19.4	15.4	68.5	138.9251	308.6	19.5		
u_701_2	29.52	14.5	263.51	159.92	7	107.1	0	107.1	0	19.4	15.4	68.48	138.9943	170.6	22.73		
u_699_3	29.52	14.5	263.51	159.92	7	107.1	0	107.1	0	19.4	15.4	66.7	143.1003	508.4	12.74	y	165.3
u_694_4	29.52	14.5	263.51	159.92	7	107.1	0	107.1	0	19.4	15.4	66.96	142.5005	664.6	9.97	y	188.9
u_689_5	29.51	14.49	263.51	159.92	7	107.1	0	107.1	0	19.4	15.4	67.65	140.8858	189.2	22.74		
u_691_7	29.51	14.49	263.61	159.82	7	106	0	106	0	19.4	14	67.75	140.7552	286	19.52		
u_693_8	29.34	14.41	263.81	160.33	7	110.7	0	110.7	0	19.9	15.5	67.88	140.4708	220.4	22.43	y	98.1
u_689_9	29.3	14.39	263.81	160.33	7	110.7	0	110.7	0	19.9	15.5	66.44	143.7463	233.6	21.74		
u_699_10	29.35	14.42	263.81	160.33	7	110.7	0	110.7	0	19.9	15.5	66.52	143.6309	340.2	15.3	y	106.4
u_701_11	29.34	14.41	263.81	160.34	7	111.9	0	111.9	0	19.9	15.5	67.78	140.7014	445.2	12.28		
u_691_12	29.34	14.41	263.81	160.34	7	111.9	0	111.9	0	19.9	15.5	67.17	142.1085	459	14.21		
u_672_13	29.34	14.41	263.81	160.34	7	111.9	0	111.9	0	19.9	15.5	68.12	139.9171	360.6	16.62		
u_694_14	29.35	14.42	263.81	160.34	7	111.9	0	111.9	0	19.9	15.5	67.99	140.2401	235.6	21.57		
u_673_15	29.35	14.42	263.81	160.34	7	111.9	0	111.9	0	19.9	15.5	66.91	142.7313	617.2	9.46	y	130
u_693_16	29.31	14.4	263.71	160.56	8	131.2	0	131.2	16.3	19.9	15.5	67.77	140.6014	189.8	23.78	y	98.9
u_689_17	29.31	14.4	263.71	160.56	8	131.2	0	131.2	16.3	19.9	15.5	67.67	140.8321	157	24.17		
u_699_18	29.31	14.4	263.71	160.44	8	131.3	0	131.3	16.4	19.9	15.5	65.72	145.3302	410.4	15.28		
u_701_19	29.31	14.4	263.71	160.56	8	131.2	0	131.2	16.3	19.9	15.5	67.98	140.117	276.6	19.38		
u_691_20	29.31	14.4	263.71	160.55	8	132	0	132	16.4	19.9	15.5	66.35	143.8769	334.2	17.42		
u_694_21	29.31	14.4	263.71	160.55	8	132	0	132	16.4	19.9	15.5	66.05	144.5689	Lower 1%	23.16	y	138.5
u_673_22	29.31	14.4	263.71	160.55	8	132	0	132	16.4	19.9	15.5	67.58	141.0397	230.2	21.25		
u_672_23	29.31	14.4	263.71	160.55	8	132	0	132	16.4	19.9	15.5	66.1	144.4536	408.8	15.1		
										19.76		**Mean**	**141.80**	**335.53**	**18.20**	31.82%	**132.30**
												Median	**140.9628**	**308.6**	**19.44**		**130**
												Min	**138.9251**	**157**	**9.46**		**98.1**
												Max	**145.3302**	**664.6**	**24.17**		**188.9**
												StDev	**1.884**	**143.092**	**4.593**		**34.862**

Appendix C

Bonneville Powerhouse II Turbine Data

Table C.1. Field data sheets for Bonneville Powerhouse II turbine testing

Date	*Location*	*Test Condition*	*Fish ID*	*Tag #*	*Deployment Time*	*Recovery Time*	*File Name*	*Barometric Pressure*	*Notes*	*USGS Barometric Pressure*	*FB*	*TW*	*Discharge*	*MW*
3/23/2006	16B	lower 1%	700	8 331	1315	1322	TIP_L_700_1t	30.56	Elevation check	14.7				
		~10.8 kcfs	698	8 891	1346	1353	TIP_L_698_2t	30.56	Elevation check	14.7				
		Tip Release	682	8 251	1412	1426	TIP_L_682_3t	30.50	Elevation check	14.68				
		EL -18.6	678	8 131	1455	1512	TIP_L_678_1	30.50	orange balloon only	14.68	74.9115	15.6868	11.0044	49.1121
			664	8 671	1456	1505	TIP_L_664_2	30.50		14.68	74.9115	15.6868	11.0044	49.1121
			692	8 211	1457	1511	TIP_L_692_3	30.50		14.68	74.9115	15.6868	11.0044	49.1121
			687	8 561	1459	1506	TIP_L_687_4	30.50		14.68	74.9115	15.6868	11.0044	49.1121
			635	8 711	1534	1543	TIP_L_635_5	30.50		14.68	74.9328	15.9737	11.0199	49.1429
			640	8 091	1536	1542	TIP_L_640_6	30.50		14.68	74.9328	15.8944	10.9884	48.3912
			656	8 201	1537	1546	TIP_L_656_7	30.50		14.68	74.9328	15.8944	10.9884	48.3912
			633	8 151	1538	1542	TIP_L_633_8	30.50		14.68	74.9328	15.8944	10.9884	48.3912
			684	8 831	1554	1618	TIP_L_684_9	30.50		14.68	74.9786	15.9707	11.1367	49.178
			695	8 101	1555	1602	TIP_L_695_11	30.50		14.68	74.9206	16.0836	11.1449	48.4352
			675	8 121	1556	1608	TIP_L_675_12	30.50		14.68	74.9206	16.0836	11.1449	48.4352
			700	8 331	1557	1602	TIP_L_700_10	30.50		14.68	74.9206	16.0836	11.1449	48.4352
			698	8 891	1620	1623	TIP_L_698_13	30.47		14.68	74.884	16.0134	10.9594	48.8308
			682	8 251	1621	1524	TIP_L_682_14	30.47		14.68	74.884	16.0134	10.9594	48.8308
			678	8 131	1623	1628	TIP_L_678_16	30.47		14.68	74.884	16.0134	10.9594	48.8308
			664	8 671	1624	1627	TIP_L_664_15	30.47		14.68	74.884	16.0134	10.9594	48.8308
			692	8 211	1633	1638	TIP_L_692_17	30.47		14.68	74.8901	16.0165	11.1343	48.9846
			687	8 561	1634	1639	TIP_L_687_18	30.47		14.68	74.8901	16.0165	11.1343	48.9846
			635	8 711	1636	1637	TIP_L_635_19	30.47		14.68	74.8535	15.8242	11.1218	48.8747
			640	8 091	1637	1640	TIP_L_640_20	30.47		14.68	74.8535	15.8242	11.1218	48.8747
			656	8 201	1650	1654	TIP_L_656_21	30.50		14.68	74.9145	16.0256	11.0255	49.3319
			633	8 151	1651	1655	TIP_L_633_22	30.50		14.68	74.9145	16.0256	11.0255	49.3319
			684	8 831	1652	1655	TIP_L_684_23	30.50		14.68	74.9145	16.0256	11.0255	49.3319

Table C.1. (contd)

Date	Location	Test Condition	Fish ID	Tag #	Deployment Time	Recovery Time	File Name	Barometric Pressure	Notes	USGS Barometric Pressure	FB	TW	Discharge	MW
3/24/2006	16B	higher 1%	635	8 711	804	811	tip_high_635_1t	30.56	Elevation check					
		~17.6 kcfs	678	8 131	827	838	tip_H_678_1	30.56		14.7	75.4151	29.9786	15.7994	75.9604
		Tip Release	656	8 201	829	834	tip_H_656_2	30.56		14.7	75.4151	29.9786	15.7994	75.9604
		EL -12	633	8 151	830	834	tip_H_633_3	30.56		14.7	75.4365	29.9786	15.8586	76.0352
			664	8 671	832	845	tip_H_664_4	30.56		14.7	75.4365	29.9786	15.8586	76.0352
			695	8 101	848	855	tip_H_695_5	30.56		14.7	75.5098	29.9786	15.7262	76.2505
			700	8 331	852	856	tip_H_700_6	30.56		14.7	75.4823	29.9786	15.8096	76.5407
			675	8 121	853	900	tip_H_675_7	30.56	radiotag ripped off	14.7	75.4823	29.9786	15.8096	76.5407
			640	8 091	850	856	tip_H_640_8	30.56		14.7	75.4823	29.9786	15.8096	76.5407
			682	8 251	903	911	tip_H_682_9	30.56		14.7	75.464	29.9786	15.8295	76.356
			698	8 891	904	919		30.56	dead - damaged no download	14.7	75.464	29.9786	15.8295	76.356
			692	8 211	906	911	tip_H_692_10	30.56		14.7	75.4731	29.9786	15.7822	76.1934
			684	8 831	908	919	tip_H_684_11	30.56		14.7	75.4731	29.9786	15.7822	76.1934
			687	8 561	923	933	tip_H_687_12	30.56		14.7	75.4823	29.9786	15.7737	76.2857
			635	8 711	924	930	tip_H_635_13	30.56		14.7	75.4823	29.9786	15.7737	76.2857
			678	8 131	927	931	tip_H_678_14	30.56		14.7	75.4823	29.9786	15.714	76.2681
			656	8 201	928	931	tip_H_656_15	30.56		14.7	75.4823	29.9786	15.714	76.2681
			633	8 151	936	941	tip_H_633_16	30.56		14.7	75.4731	29.9786	15.644	75.5912
			664	8 671	938	945	tip_H_664_17	30.56		14.7	75.4731	29.9786	15.644	75.5912
			695	8 101	940	945	tip_H_695_18	30.56		14.7	75.467	29.9786	15.754	75.8681
			700	8 331	942	947	tip_H_700_19	30.56		14.7	75.467	29.9786	15.754	75.8681
			675	8 121	953	959		30.56	no download	14.7	75.4609	29.9786	15.6961	75.767
			640	8 091	954	1000	tip_H_640_20	30.56		14.7	75.4609	29.9786	15.6961	75.767
			682	8 251	955	1002	tip_H_682_21	30.56		14.7	75.4274	29.9786	15.7616	76.4703

Table C.1. (contd)

Date	*Location*	*Test Condition*	*Fish ID*	*Tag #*	*Deployment Time*	*Recovery Time*	*File Name*	*Barometric Pressure*	*Notes*	*USGS Barometric Pressure*	*FB*	*TW*	*Discharge*	*MW*
3/24/2006	16A	lower 1%	692	8 211	1113	1120	mid_L-692_1T	30.56	Elevation check	14.7	75.3205	29.9756	11.2928	53.9516
		~10.8 kcfs	684	8 831	1139	1143	mid_L-684_1	30.56		14.7	75.4151	29.9756	11.1019	53.4945
		Mid/Hub Release	687	8 561	1140	1156	mid_L-687_2	30.56		14.7	75.4151	29.9756	10.9944	53.6
		EL -2.97	635	8 711	1141	1146	not used	30.56	adjusted pipe	14.7	75.4151	29.9756	10.9944	53.6
			678	8 131	1143	1148	not used	30.56	adjusted pipe	14.7	75.4151	29.9756	10.9944	53.6
			656	8 201	1216	1221	mid_L-656_3	30.56		14.7	75.406	29.9756	10.995	53.5209
			633	8 151	1218	1221	mid_L-633_4	30.56		14.7	75.406	29.9756	10.995	53.5209
			664	8 671	1219	1233	mid_L-664_6	30.56	radiotag ripped off, scrape on balloon	14.7	75.406	29.9756	10.995	53.5209
			695	8 101	1221	1225	mid_L-695_5	30.56		14.7	75.4335	29.9756	11.1021	52.7824
			700	8 331	1237	1247	mid_L-700_7	30.53		14.7	75.3846	29.9756	11.1776	53.2308
			640	8 091	1238	1249	mid_L-640_8	30.53		14.7	75.3846	29.9756	11.1776	53.2308
			682	8 251	1239	1245	mid_L-682_9	30.53		14.7	75.3846	29.9756	11.1776	53.2308
			692	8 211	1240	1244	mid_L-692_10	30.53		14.7	75.3968	29.9756	11.1138	52.5978
			684	8 831	1253	1257	mid_L-684_11	30.53		14.7	75.4151	29.9756	11.106	53.0198
			635	8 711	1254	1300	mid_L-635_12	30.53		14.7	75.4151	29.9756	11.106	53.0198
			678	8 131	1256	1300	mid_L-678_13	30.53		14.7	75.4457	29.9756	11.0104	53.2308
			698	8 891	1257	1300	mid_L-698_14	30.53		14.7	75.4457	29.9756	11.0104	53.2308
			687	8 561	1306	1314	mid_L-687_15	30.53		14.7	75.4609	29.9756	11.1293	53.1209
			656	8 201	1307	1312	mid_L-656_16	30.53		14.7	75.4609	29.9756	11.1293	53.1209
			633	8 151	1309	1312	mid_L-633_17	30.53		14.7	75.4609	29.9756	11.1293	53.1209
			695	8 101	1310	1314	mid_L-695_18	30.53		14.7	75.4274	29.9756	11.1057	53.4945
			664	9 300	1332	1342	mid_L-664_19	30.50		14.7	75.174	29.9756	11.0778	53.4462
			700	8 331	1329	1342	mid_L-700_20	30.50		14.7	75.4151	29.9756	11.0995	52.6637
			640	8 091	1330	1334	mid_L-640_21	30.50		14.7	75.174	29.9756	11.0778	53.4462
			682	8 251	1331	1342	mid_L-682_22	30.50		14.7	75.174	29.9756	11.0778	53.4462
			692	8 211	1349	1358	mid_L-692_23	30.50		14.7	75.5037	29.9756	11.0286	53.4813
			684	8 831	1350	1354	mid_L-684_24	30.50		14.7	75.464	29.9756	11.0372	53.3319
			635	8 711	1351	1355	mid_L-635_25	30.50		14.7	75.464	29.9756	11.0372	53.3319
			678	8 131	1353	1358	mid_L-678_26	30.50	radiotag ripped off	14.7	75.464	29.9756	11.0372	53.3319

Table C.1. (contd)

Date	Location	Test Condition	Fish ID	Tag #	Deployment Time	Recovery Time	File Name	Barometric Pressure	Notes	USGS Barometric Pressure	FB	TW	Discharge	MW
3/24/2006	16A	lower 1%	698	8 891	1415	1419	mid_L-698_27	30.50		14.68	75.3938	29.9756	11.1264	52.8659
		~10.8 kcfs	687	8 561	1416	1423	mid_L-687_28	30.50		14.68	75.3938	29.9756	11.1264	52.8659
		Mid/Hub Release	656	8 201	1417	1426	mid_L-656_29	30.50		14.68	75.3938	29.9756	11.1264	52.8659
		EL -2.97	633	8 151	1418	1424	mid_L-633_30	30.50		14.68	75.3938	29.9756	11.1264	52.8659
			695	8 101	1435			30.50	no signal -lost	14.68	75.4365	29.9756	11.107	53.411
			664	9 300	1437	1443	mid_L-664_31	30.50		14.68	75.4365	29.9756	11.107	53.411
			700	8 331	1437	1443	mid_L-700_32	30.50		14.68	75.4365	29.9756	11.107	53.411
			640	8 091	1438	1455	mid_L-640_33	30.50		14.68	75.4365	29.9756	11.107	53.411
			682	8 251	1518	1523	mid_L-682_34	30.53		14.7	75.4457	29.9756	11.1258	53.5473
			692	8 211	1520	1525	mid_L-692_35	30.56		14.7	75.4762	29.9756	11.0439	53.4681
			684	8 831	1521	1528	mid_L-684_36	30.56		14.7	75.4762	29.9756	11.0439	53.4681
			635	8 711	1522	1528	mid_L-635_37	30.56		14.7	75.4762	29.9756	11.0439	53.4681
			678	8 131	1538	1542	mid_L-678_38	30.56		14.7	75.464	29.9756	11.0285	53.7407
			698	8 891	1539	1543		30.56	wouldn't download	14.7	75.464	29.9756	11.0285	53.7407
			687	8 561	1540	1545	mid_L-687_39	30.56		14.7	75.4029	29.9756	11.0528	52.6418
			656	8 201	1542	1546	mid_L-656_40	30.56		14.7	75.4029	29.9756	11.0528	52.6418
			633	8 151	1549	1552	mid_L-633_41	30.56		14.7	75.406	29.9756	11.1249	52.4967
			640	8 091	1550	1600		30.53	wouldn't download	14.7	75.4457	29.9756	11.0262	53.4286
			664	9 300	1552	1554	mid_L-664_42	30.53		14.7	75.4457	29.9756	11.0262	53.4286
			700	8 331	1553	1557	mid_L-700_43	30.53		14.7	75.4457	29.9756	11.0262	53.4286
			682	8 251	1608	1612	mid_L_682_44	30.53		14.7	75.4151	29.9756	11.0834	52.567
			692	8 211	1609	1614	mid_L-692_45	30.53		14.7	75.4151	29.9756	11.0834	52.567
			684	8 831	1611	1617	mid_L-684_46	30.53		14.7	75.4335	29.9756	11.0132	53.6308
			635	8 711	1613	1620	mid_L-635_47	30.53		14.7	75.4335	29.9756	11.0132	53.6308
			678	8 131	1639	1641	mid_L-678_48	30.53		14.7	75.348	29.9756	11.1034	52.4835
			687	8 561	1640	1644	mid_L-687_49	30.53		14.7	75.3358	29.9756	11.0176	53.9516
			656	8 201	1641	1644	mid_L-656_50	30.53		14.7	75.3358	29.9756	11.0176	53.9516
			633	8 151	1642	1648	mid_L-633_51	30.53		14.7	75.3358	29.9756	11.0176	53.9516

Table C.1. (contd)

Date	*Location*	*Test Condition*	*Fish ID*	*Tag #*	*Deployment Time*	*Recovery Time*	*File Name*	*Barometric Pressure*	*Notes*	*USGS Barometric Pressure*	*FB*	*TW*	*Discharge*	*MW*
3/25/2006	16A	lower 1%	692	8 211	802	806	692_mid_l_t	30.24	Elevation check					
		~10.8 kcfs	700	8 331	822	828	mid_L_700_52	30.24		14.54	75.3205	29.9664	11.028	52.3517
		Mid/Hub Release	682	8 251	824	829	mid_L_682_53	30.24		14.54	75.3205	29.9664	11.028	52.3517
		EL -2.97	698	8 891	825	831	mid_L_698_53	30.24		14.54	75.3236	29.9664	11.1062	53.2176
			687	8 561	826	830	mid_L_687_54	30.24		14.54	75.3236	29.9664	11.1062	53.2176
			684	9 661	834	840	mid_L_684_56	30.24		14.54	75.3541	29.9664	11.1335	52.7341
			656	8 201	835	841		30.24	x axis bad	14.54	75.406	29.9664	11.1713	53.0901
			640	8 091	836	841	no download	30.24		14.54	75.406	29.9664	11.1713	53.0901
			664	9 300	838	845	mid_L_664_58	30.24		14.54	75.406	29.9664	11.1713	53.0901
			633	8 151	848	857	mid_L_633_57	30.24		14.54	75.406	29.9664	11.1201	53.5604
			678	9 931	850	855	mid_L_678_59	30.24		14.54	75.3968	29.9664	11.0472	53.1648
			635	8 711	852	855	mid_L_635_60	30.24		14.54	75.3968	29.9664	11.0472	53.1648
			692	8 211	853	857	mid_L_692_61	30.24		14.54	75.3968	29.9664	11.0472	53.1648
			700	8 331	900	902	mid_L_700_62	30.24		14.54	75.4365	29.9664	11.0583	52.6637
			682	8 251	901	906	mid_l_682_63	30.24		14.54	75.4365	29.9664	11.0583	52.6637
			698	8 891	902	908		30.24	dead	14.54	75.4365	29.9664	11.0583	52.6637
			687	8 561	903	908	mid_L_687_64	30.24		14.54	75.4365	29.9664	11.0583	52.6637

Table C.1. (contd)

Date	*Location*	*Test Condition*	*Fish ID*	*Tag #*	*Deployment Time*	*Recovery Time*	*File Name*	*Barometric Pressure*	*Notes*	*USGS Barometric Pressure*	*FB*	*TW*	*Discharge*	*MW*
3/25/2006	16A	Upper 1%	684	9 661	920	926	mid_H_684_T1	30.24	Elevation check	14.54	75.3633	29.9664	15.8442	75.6352
		~17.6 kcfs	664	9 300	945	957	mid_H_664_1	30.24		14.54	75.4548	29.9664	15.7386	75.8637
		Mid/Hub Release	633	8 151	946	952	mid_H_633_2	30.24		14.54	75.4548	29.9664	15.7386	75.8637
		EL 5.9	635	8 711	948	953	mid_H_635_3	30.24		14.54	75.4548	29.9664	15.7386	75.8637
			678	9 931	949	955	mid_H_678_4	30.24		14.54	75.4548	29.9664	15.7386	75.8637
			692	8 211	959	1003	mid_H_692_5	30.24		14.54	75.464	29.9664	15.7084	75.9165
			700	8 331	1001	1005	mid_H_700_6	30.24		14.54	75.3633	29.9664	15.8692	76.1582
			682	8 251	1002	1007	mid_H_682_7	30.24		14.54	75.3633	29.9664	15.8692	76.1582
			687	8 561	1004	1011	mid_H_687_8	30.24	HIT	14.54	75.3633	29.9664	15.8692	76.1582
			684	9 661	1023	1030	mid_H_684_9	30.24		14.54	74.8321	29.9664	16.3217	75.6615
			664	9 300	1025	1030	mid_H_664_10	30.24		14.54	74.9206	29.9664	16.2876	75.3758
			633	8 151	1027	1032	mid_H_633_11	30.24		14.54	74.9206	29.9664	16.2876	75.3758
			635	8 711	1028	1033	mid_H_635_12	30.24		14.54	74.9206	29.9664	16.2876	75.3758
			678	9 931	1045	1050	mid_H_678_13	30.24		14.54	74.9115	29.9664	16.5009	75.8066
			692	8 211	1047	1051	mid_H_692_14	30.24		14.54	74.9115	29.9664	16.5009	75.8066
			700	8 331	1048	1057	mid_H_700_15	30.24		14.54	74.9115	29.9664	16.5009	75.8066
			682	8 251	1050	1055	mid_H_682_16	30.24		14.54	74.9389	29.9664	16.4511	75.8813
			684	9 661	1103	1107	mid_H_684_17	30.24		14.54	74.7985	12.1459	16.0826	75.8813
			664	9 300	1104	1110	mid_H_664_18	30.24		14.54	74.7985	12.1459	16.0826	75.8813
			633	8 151	1105	1110	mid_H_633_19	30.24		14.54	74.7039	12.1459	16.0728	75.9033
			635	8 711	1106	1112	mid_H_635_20	30.24		14.54	74.7039	12.1459	16.0728	75.9033
			678	9 931	1125	1129	mid_H_678_21	30.24		14.54	74.4719	15.5128	17.0363	76.4528
			692	8 211	1126	1135	mid_H_692_22	30.24		14.54	74.4719	15.5128	17.0363	76.4528
			700	9 130	1127	1132	mid_H_700_23	30.24		14.54	74.4719	15.5128	17.0363	76.4528
			682	8 251	1128	1135	mid_H_682_24	30.24		14.54	74.4719	15.5128	17.0363	76.4528
			684	9 661	1143	1145	mid_H_684_25	30.24		14.54	74.6642	15.6532	17.0068	75.4374
			664	9 300	1144	1147	mid_H_664_26	30.24		14.54	74.6642	15.6532	17.0068	75.4374
			633	8 151	1145	1150	mid_H_633_27	30.24		14.54	74.591	15.7265	17.0079	75.5517
			635	8 711	1146	1150	mid_H_635_28	30.24		14.54	74.591	15.7265	17.0079	75.5517
			678	9 931	1203	1207	mid_H_678_29	30.24		14.56	74.4933	15.931	17.2725	76.1231
			692	8 211	1204	1207	mid_H_692_30	30.24		14.56	74.4933	15.931	17.2725	76.1231
			700	9 130	1206	1220	mid_H_700_31	30.24		14.56	74.5604	15.8913	17.22	75.8462
			682	8 251	1205	1210	mid_H_682_32	30.24		14.56	74.5604	15.8913	17.22	75.8462

Table C.1. (contd)

Date	*Location*	*Test Condition*	*Fish ID*	*Tag #*	*Deployment Time*	*Recovery Time*	*File Name*	*Barometric Pressure*	*Notes*	*USGS Barometric Pressure*	*FB*	*TW*	*Discharge*	*MW*
3/25/2006	16A	Upper 1%	684	9 661	1222	1228	mid_H_684_33	30.24		14.56	74.6123	15.5006	17.0451	76.1407
		~17.6 kcfs	664	9 300	1223	1227	mid_H_664_34	30.24		14.56	74.6123	15.5006	17.0451	76.1407
		Mid/Hub Release	633	8 151	1224	1229	mid_H_633_35	30.24		14.56	74.6123	15.5006	17.0451	76.1407
		EL 5.9	635	8 711	1226	1229	mid_H_635_36	30.24		14.56	74.5085	15.5311	17.1426	75.5165
			678	9 931	1300	1303	mid_H_678_37	30.24		14.56	74.4719	15.3999	17.1048	75.7582
			692	8 211	1301	1307	mid_H_692_38	30.24		14.56	74.4719	15.3999	17.1048	75.7582
			700	9 130	1303	1314	mid_H_700_39	30.24		14.56	74.4719	15.3999	17.1048	75.7582
			682	8 251	1304	1308	mid_H_682_40	30.27		14.56	74.4719	15.3999	17.1048	75.7582
			684	9 661	1316	1321	mid_H_684_41	30.27		14.56	74.6429	15.2289	16.911	75.7407
			664	9 300	1318	1323	mid_H_664_42	30.27		14.56	74.6429	15.2289	16.911	75.7407
			633	8 151	1319	1325	mid_H_633_43	30.27		14.56	74.6429	15.2289	16.911	75.7407
			635	8 711	1329	1325	mid_H_635_44	30.27		14.56	74.5391	14.9878	16.9531	75.6879
			689	8 191	1322	1330	mid_H_689_45	30.27		14.56	74.6154	15.1068	16.8509	75.8769
			694	8 111	1324	1330	mid_H_694_46	30.27		14.56	74.6154	15.1068	16.8509	75.8769
			673	8 281	1336	1339	mid_H_673_47	30.27		14.56	74.4933	14.9481	16.912	76.1055
			672	9 180	1337	1359	mid_H_672_51	30.27		14.56	74.4933	14.9481	16.912	76.1055
			701	8 221	1339	1345	mid_H_701_52	30.27		14.56	74.4933	14.9481	16.912	76.1055
			691	8 081	1340	1347	mid_H_691_49	30.27		14.56	74.2613	15.1679	17.0469	75.8198
			693	8 501	1342	1356	mid_H_693_48	30.27		14.56	74.2613	15.1679	17.0469	75.8198
			678	9 931	1343	1347	mid_H_678_50	30.27		14.56	74.2613	15.1679	17.0469	75.8198
			692	8 211	1402	1406	mid_H_692_53	30.27		14.56	73.9927	15.8486	17.2856	75.6527
			700	9 130	1404	1408	mid_H_700_54	30.27		14.56	73.9927	15.8486	17.2856	75.6527
			682	8 251	1406	1409	mid_H_682_55	30.27		14.56	73.9622	15.931	17.3183	75.9033
			684	9 661	1407	1411	mid_H_684_56	30.27		14.56	73.9622	15.931	17.3183	75.9033
			664	9 300	1409	1411	mid_H_664_57	30.27		14.56	73.9622	15.931	17.3183	75.9033
			633	8 151	1410	1414	mid_H_633_58	30.27		14.56	73.8889	15.9554	17.2833	75.3539
			689	8 191	1423	1427	mid_H_689_59	30.27		14.56	73.7821	16.2668	17.4582	75.1253
			694	8 111	1424	1429	mid_H_694_60	30.30		14.56	73.7821	16.2668	17.4582	75.1253
			635	8 711	1425	1429	mid_H_635_61	30.30		14.56	73.7882	16.3675	17.7155	76.4791
			673	8 281	1427	1431	mid_H_673_62	30.30	radiotag ripped off	14.56	73.7882	16.3675	17.7155	76.4791
			693	8 501	1428	1432	mid_H_693_63	30.30		14.56	73.7882	16.3675	17.7155	76.4791
			691	8 081	1437	1443	mid_H_691_64	30.30		14.56	73.7424	16.0012	17.433	76.0527
			678	9 931	1438	1443	mid_H_678_65	30.30		14.56	73.7424	16.0012	17.433	76.0527
			672	9 180	1440	1446	mid_H_672_66	30.30		14.56	73.6172	16.1722	17.4387	75.7275
			701	8 221	1441	1445	mid_H_701_67	30.30		14.56	73.6172	16.1722	17.4387	75.7275

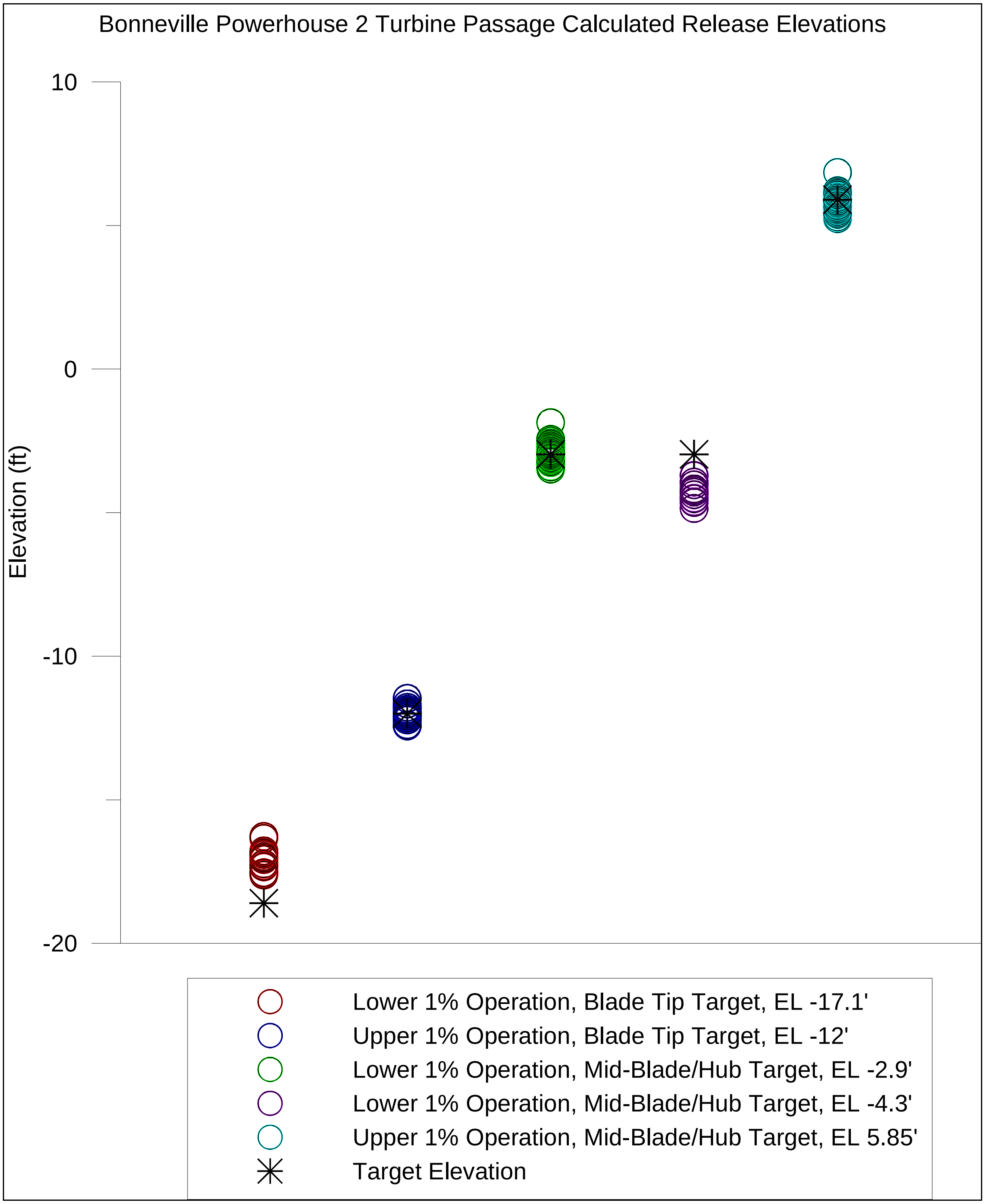

Figure C.1. Release elevations and targeted elevations calculated by Sensor Fish

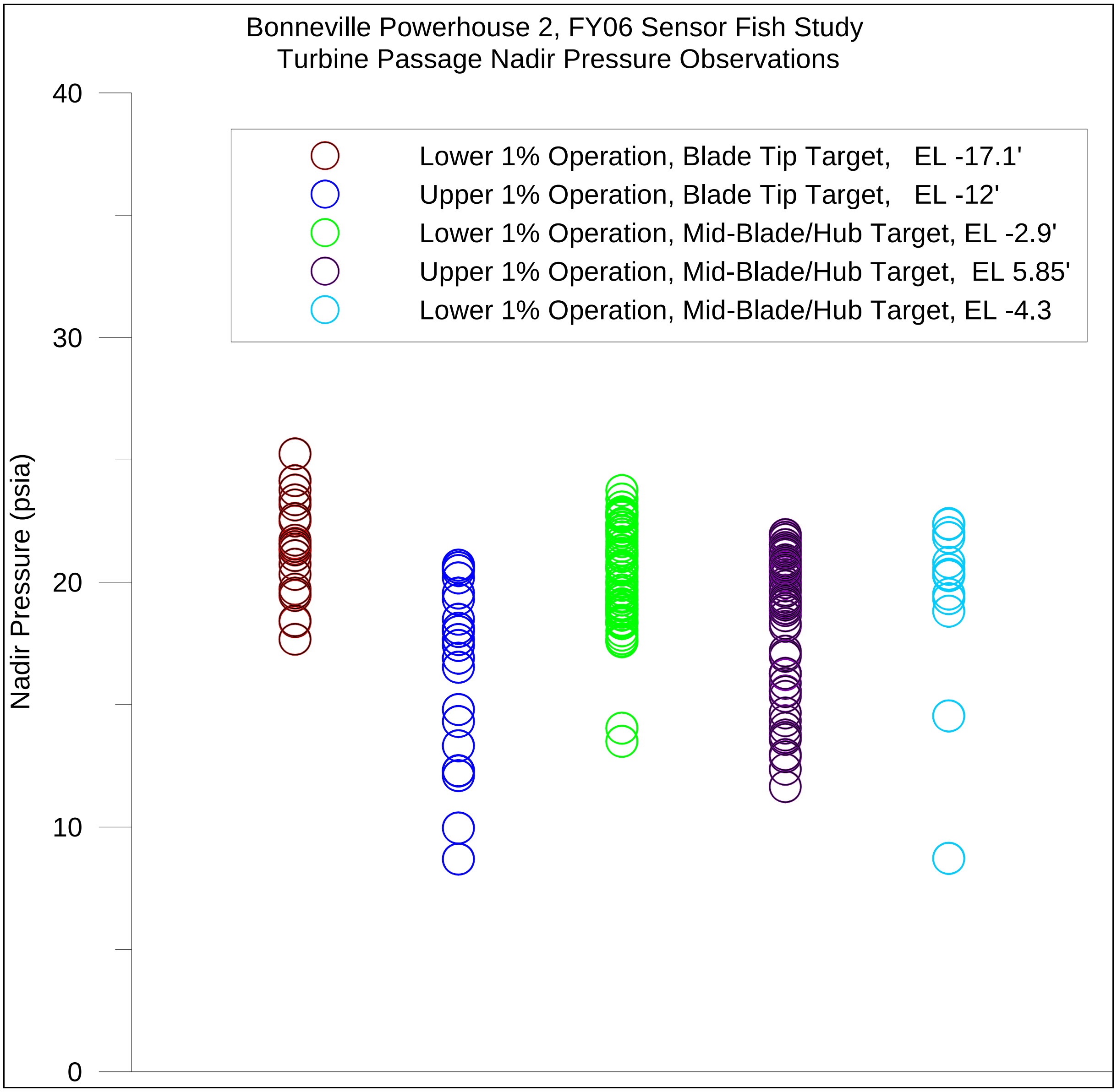

Figure C.2. Nadir pressure values as determined from Sensor Fish turbine passage

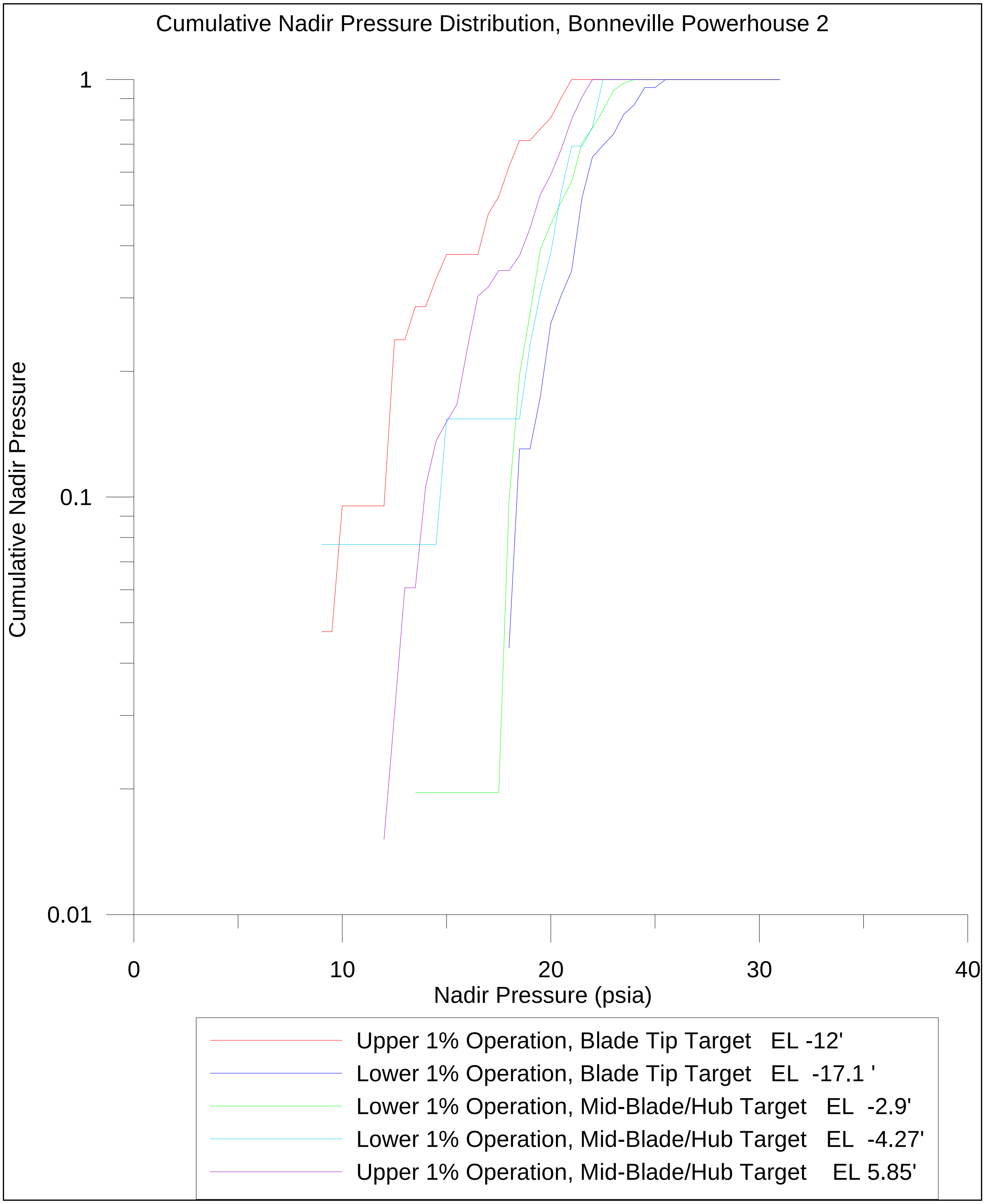

Figure C.3. Cumulative nadir pressure distributions from Sensor Fish

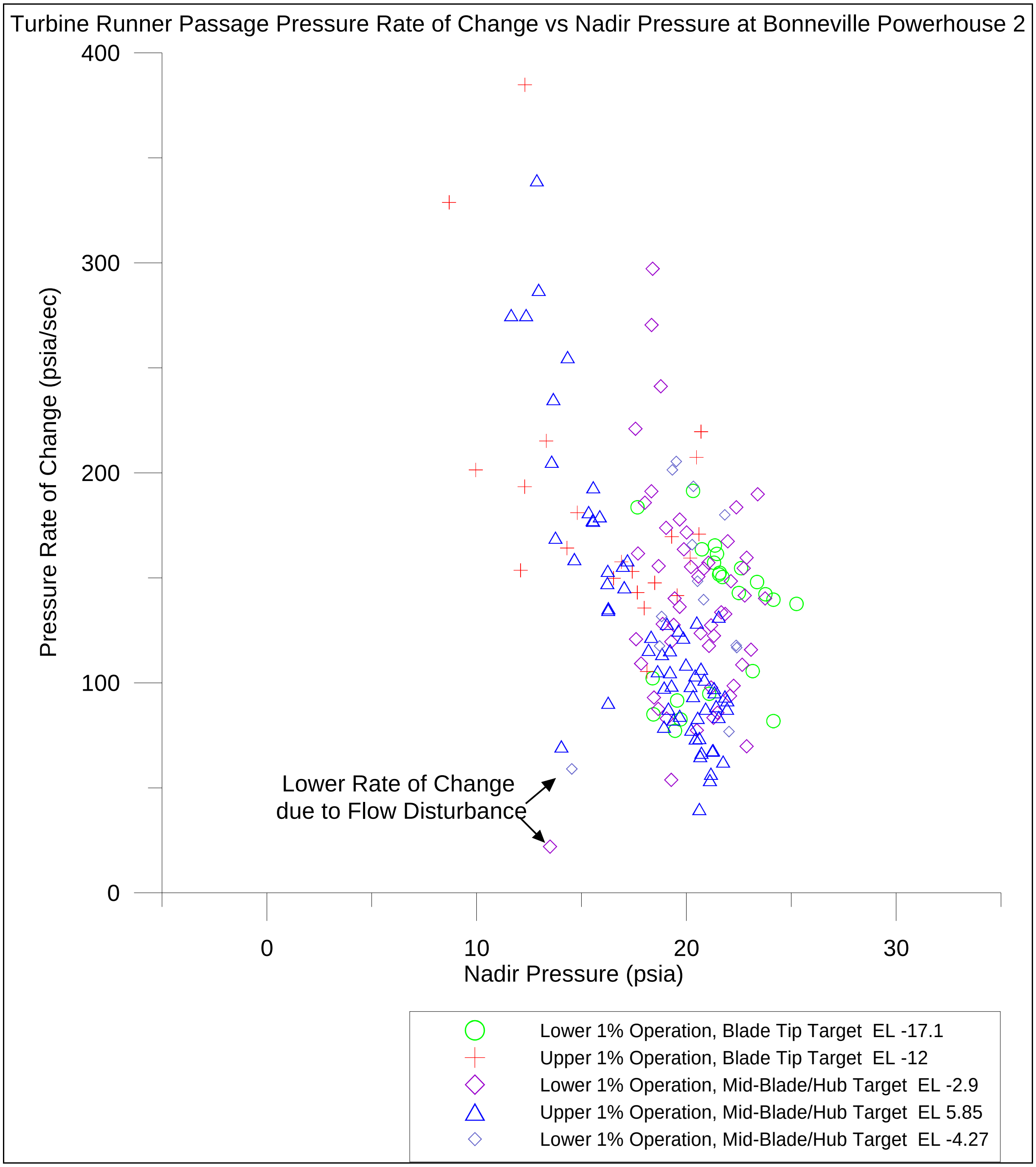

Figure C.4. Turbine runner passage rate of change by nadir pressure for all operations and routes

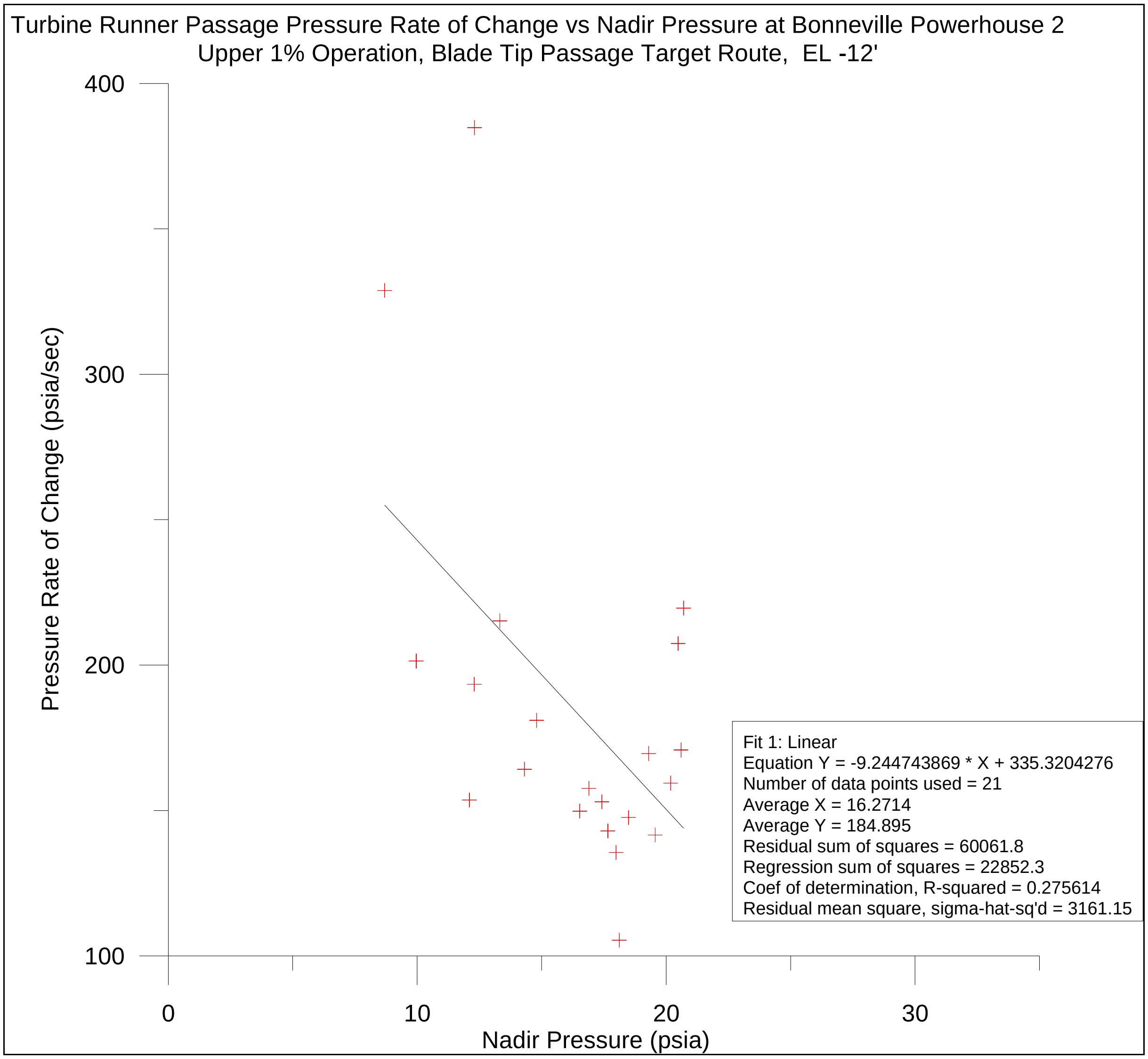

Figure C.5. Turbine runner passage rate of change by nadir pressure for upper 1% operation in the targeted blade tip passage route

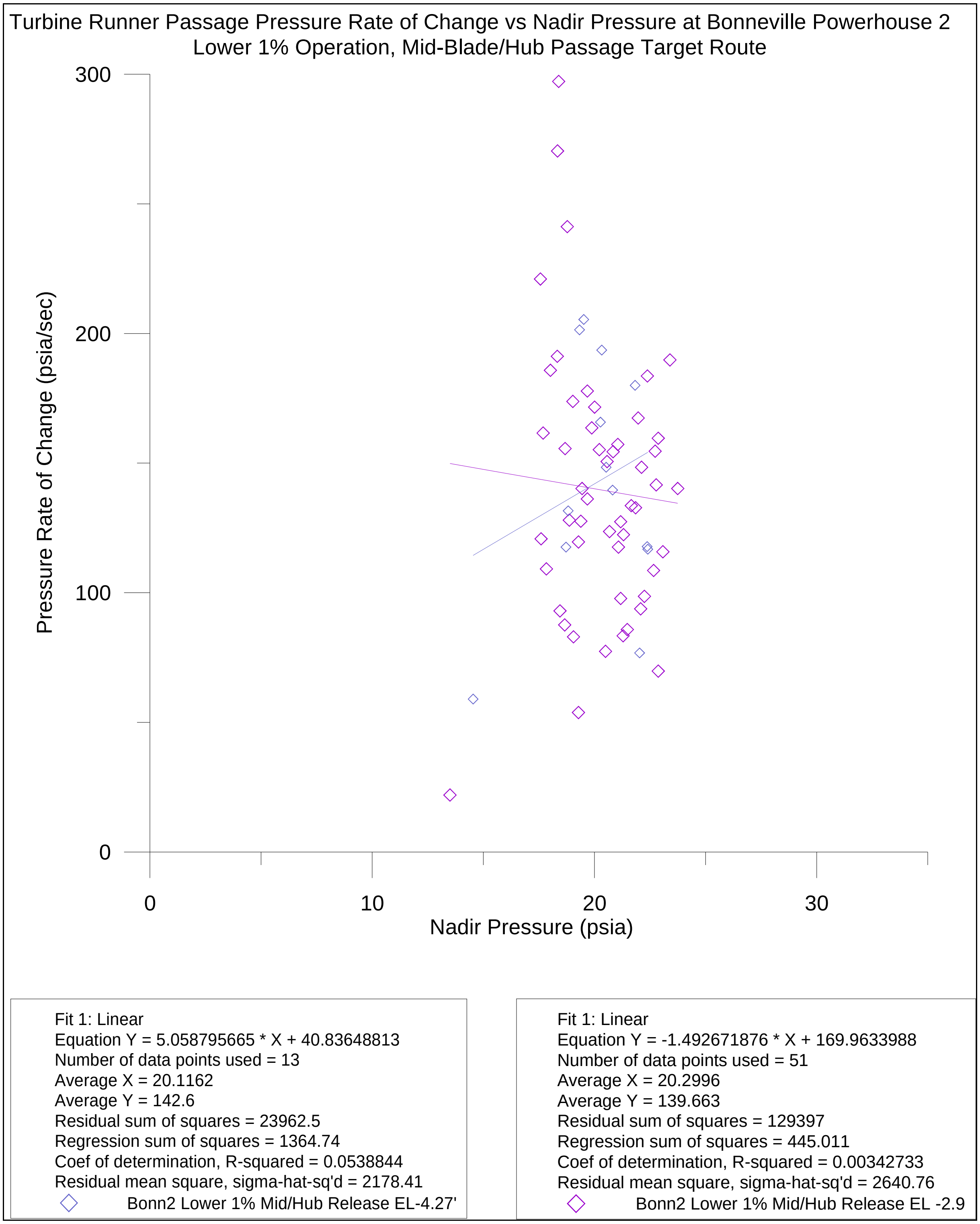

Figure C.6. Turbine runner passage rate of change by nadir pressure for lower 1% operation in the targeted mid-blade/hub passage route (with outliers)

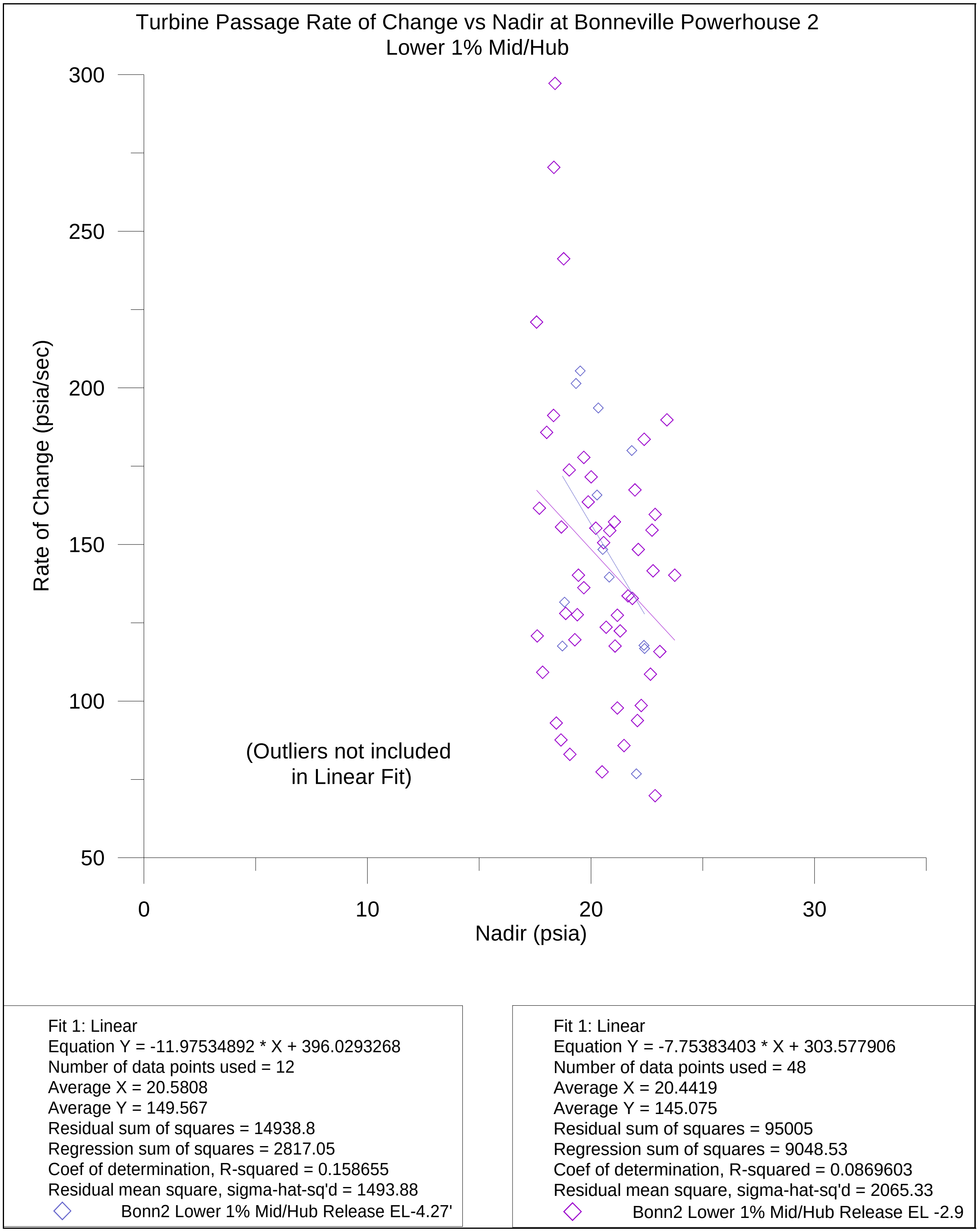

Figure C.7. Turbine runner passage rate of change by nadir pressure for lower 1% operation in the targeted mid-blade/hub passage route (without outliers)

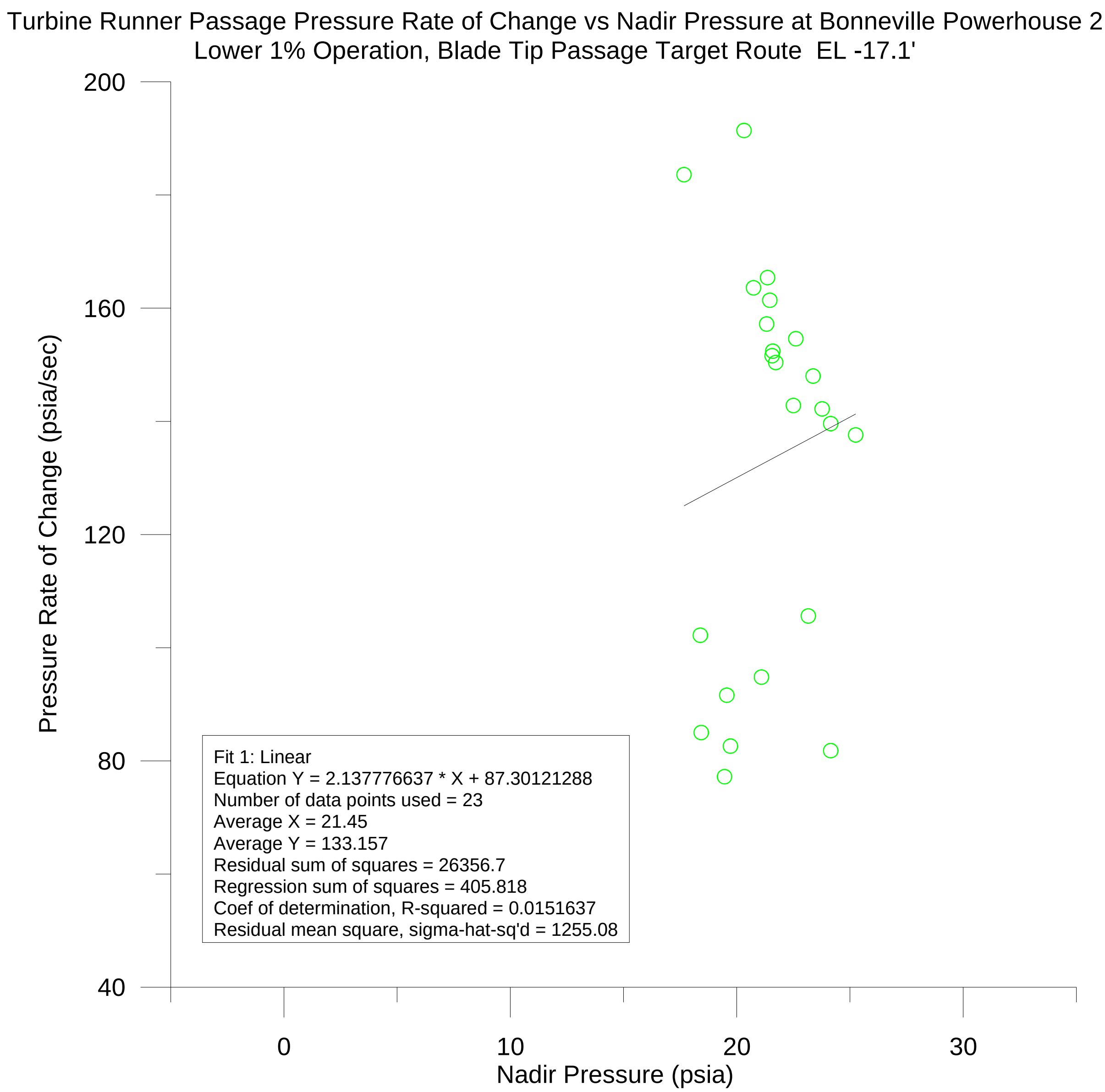

Figure C.8. Turbine runner passage rate of change by nadir pressure for lower 1% operation in the targeted blade tip passage route

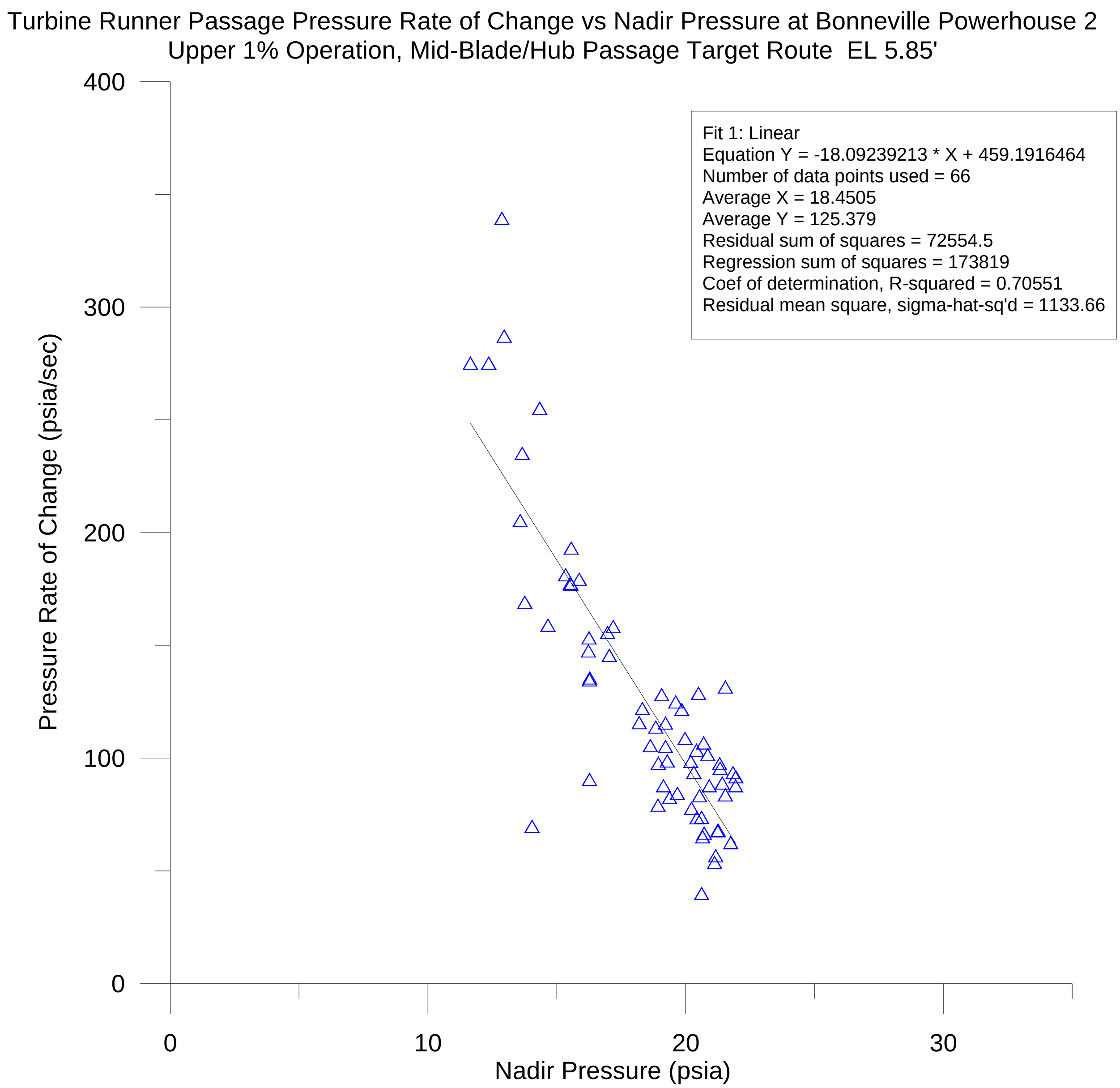

Figure C.9. Turbine runner passage rate of change by nadir pressure for the targeted upper 1% mid-blade/hub passage route

Table C.2. Summary statistics for nadir pressure values

Bonn2 Mid/Hub Release Lower 1% 11.1 kcfs EL -2.9'	
Nadir	
Mean	20.2996
Standard Error	0.2799
Median	20.5
Standard Deviation	1.9986
Sample Variance	3.9946
Kurtosis	1.0588
Skewness	-0.6159
Range	10.25
Minimum	13.5
Maximum	23.75
Count	51
Confidence Level(95.0%)	0.5621

Bonn2 Mid/Hub Release Lower 1% 11.1 kcfs EL -4.27'	
Nadir	
Mean	19.3469
Standard Error	1.0548
Median	20.33
Standard Deviation	3.8031
Sample Variance	14.4632
Kurtosis	5.0079
Skewness	-2.1737
Range	13.68
Minimum	8.72
Maximum	22.4
Count	13
Confidence Level(95.0%)	2.2982

onn2 Mid/Hub Release Upper 1% 16.9 kcfs EL 5.8	
Nadir	
Mean	18.4505
Standard Error	0.3518
Median	19.255
Standard Deviation	2.8582
Sample Variance	8.1694
Kurtosis	-0.6670
Skewness	-0.7311
Range	10.3
Minimum	11.65
Maximum	21.95
Count	66
Confidence Level(95.0%)	0.7026

Bonn2 Tip Release Upper 1% 15.8 kcfs EL -12'	
Nadir	
Mean	16.2714
Standard Error	0.7979
Median	17.42
Standard Deviation	3.6564
Sample Variance	13.3694
Kurtosis	-0.7416
Skewness	-0.5987
Range	12.01
Minimum	8.69
Maximum	20.7
Count	21
Confidence Level (95.0%)	1.6644

Bonn2 Tip Release Lower 1% 11 kcfs Elevation -17.1 '	
Nadir	
Mean	21.45
Standard Error	0.4189
Median	21.46
Standard Deviation	2.0091
Sample Variance	4.0363
Kurtosis	-0.5850
Skewness	-0.0634
Range	7.58
Minimum	17.67
Maximum	25.25
Count	23
Confidence Level (95.0%)	0.8688

Table C.3. Summary statistics for pressure rate-of-change values

Bonn2 Mid/Hub Release Lower 1% 11.1 kcfs EL -2.9'	
Rate of Change	
Mean	139.6627
Standard Error	7.1357
Median	136.2
Standard Deviation	50.9592
Sample Variance	2596.8408
Kurtosis	1.5760
Skewness	0.6958
Range	275.2
Minimum	22
Maximum	297.2
Count	51
Confidence Level (95.0%)	14.3325

Bonn2 Mid/Hub Release Lower 1% 11.1 kcfs EL -4.27'	
Rate of Change	
Mean	142.6
Standard Error	12.7418
Median	139.6
Standard Deviation	45.9413
Sample Variance	2110.6
Kurtosis	-0.6669
Skewness	-0.2742
Range	146.4
Minimum	59
Maximum	205.4
Count	13
Confidence Level (95.0%)	27.7620

Bonn2 Mid/Hub Release Upper 1% 16.9 kcfs EL 5.85'	
Rate of Change	
Mean	125.3788
Standard Error	7.5782
Median	105.4
Standard Deviation	61.5659
Sample Variance	3790.3608
Kurtosis	2.2004
Skewness	1.5047
Range	299.4
Minimum	40
Maximum	339.4
Count	66
Confidence Level(95.0%)	15.1348

Bonn2 Tip Release Upper 1% 15.8 kcfs EL -12'	
Rate of Change	
Mean	184.8952
Standard Error	14.0504
Median	164.2
Standard Deviation	64.3872
Sample Variance	4145.7065
Kurtosis	4.6953
Skewness	2.0843
Range	279.4
Minimum	105.4
Maximum	384.8
Count	21
Confidence Level (95.0%)	29.3087

Bonn2 Tip Release Lower 1% 11 kcfs Elevation -17.1 '	
Rate of Change	
Mean	133.1565
Standard Error	7.2726
Median	142.8
Standard Deviation	34.8781
Sample Variance	1216.4798
Kurtosis	-1.1631
Skewness	-0.3199
Range	114.2
Minimum	77.2
Maximum	191.4
Count	23
Confidence Level (95.0%)	15.0824

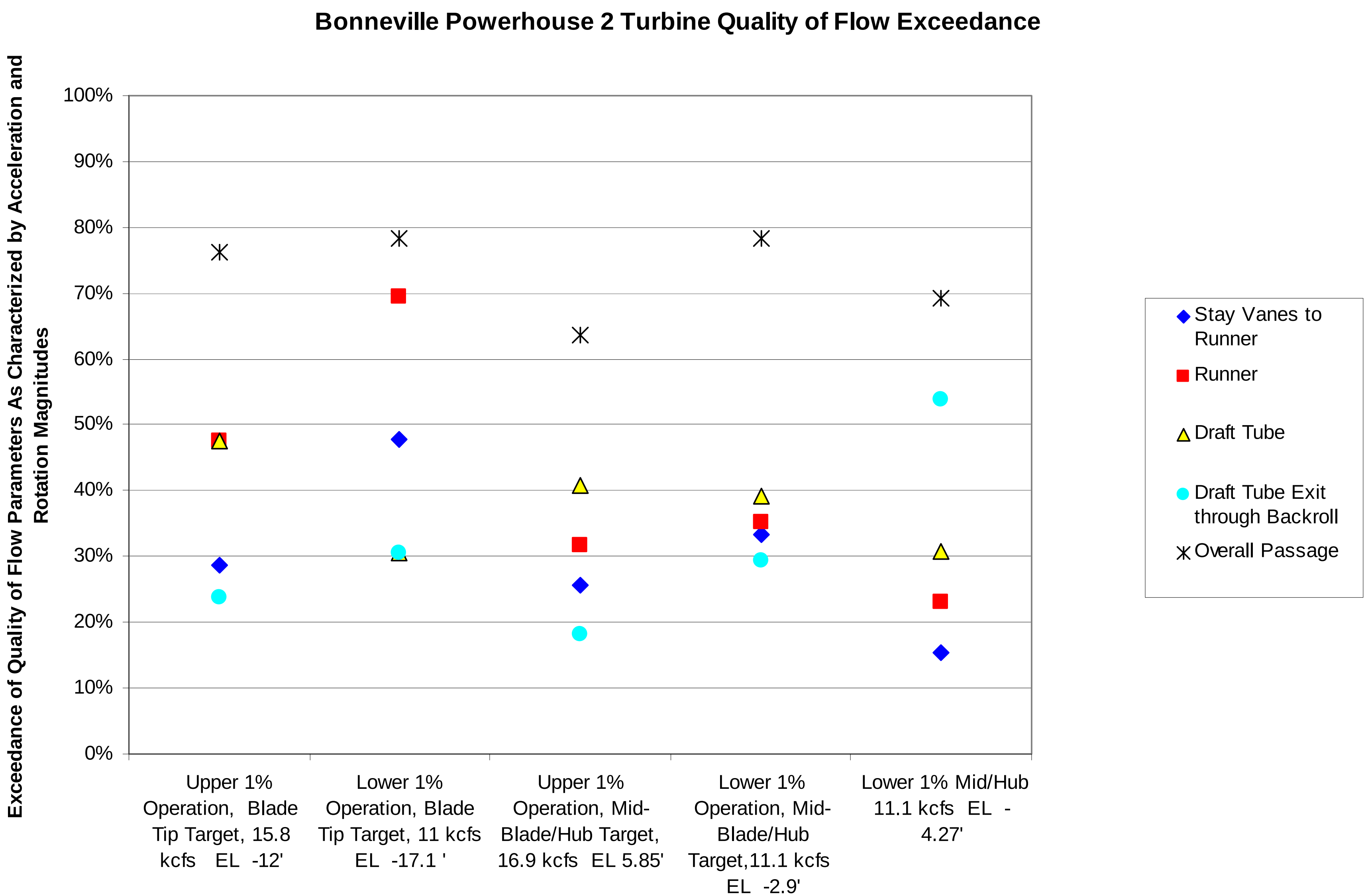

Figure C.10. Bonneville Powerhouse II quality of flow exceedance

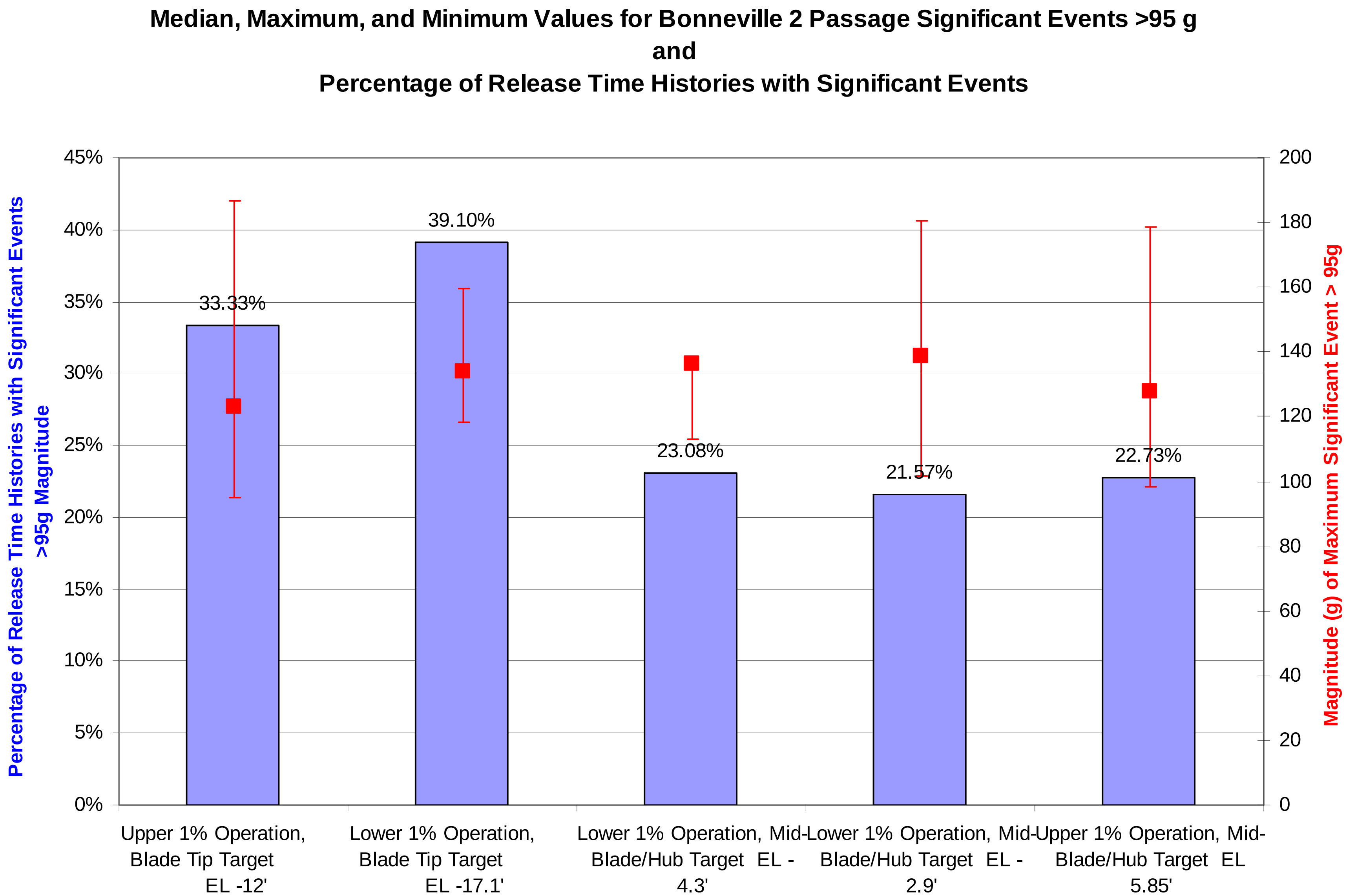

Figure C.11. Median, maximum, and minimum significant event magnitudes with percentage of releases having at least one event

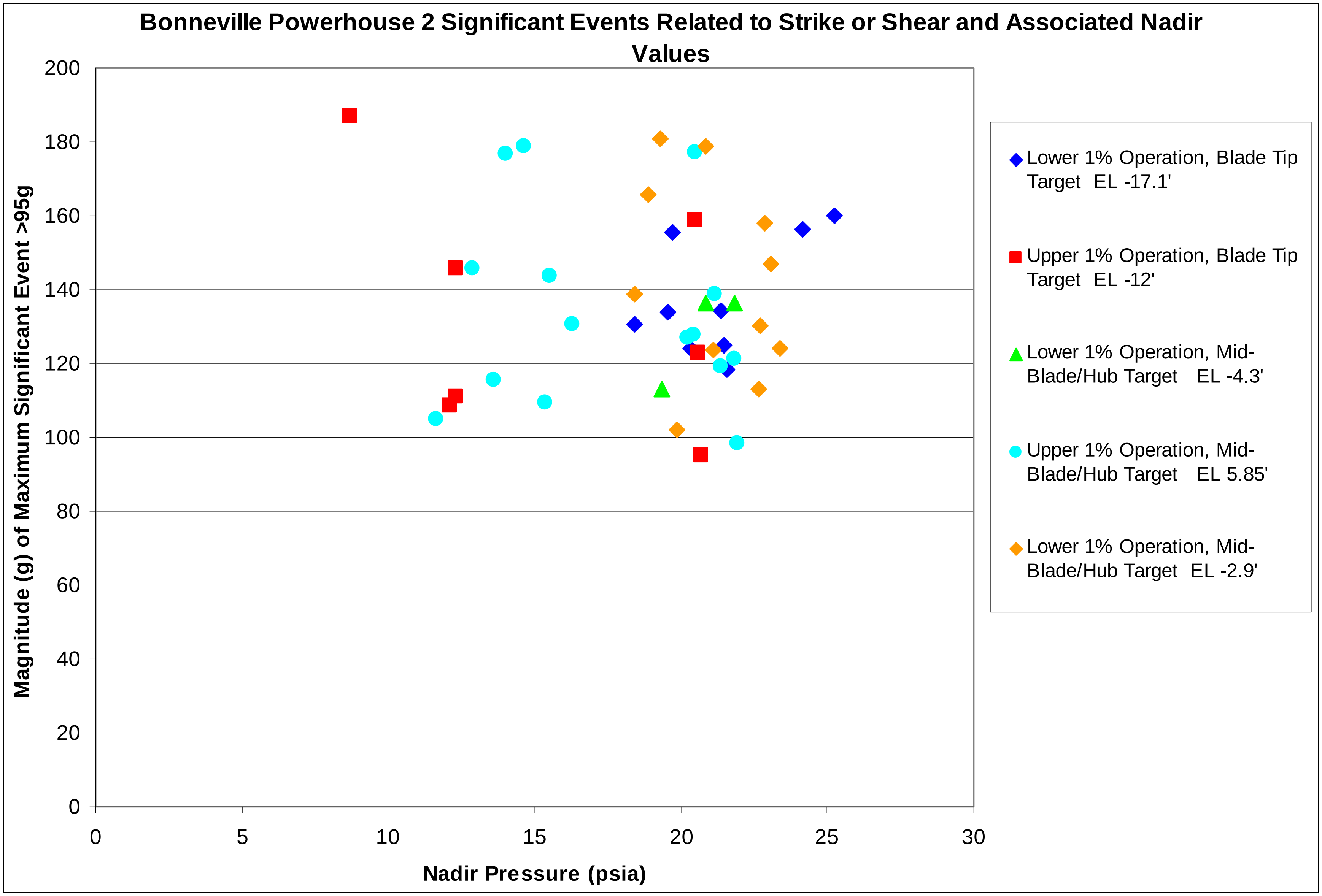

Figure C.12. Bonneville Powerhouse II significant events related to strike or shear and associated pressure nadir values

Table C.4. Summary data tables for turbine significant events with related dam operations at Bonneville Powerhouse II

Test Condition	*File Name*	*Baro Psi*	*FB ele*	*TW ele*	*Discharge*	*Release Pt -psia*	*Release El*	*Rate of Change Psi/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
Lower 1% Tip	TIP_L_678_1	14.68	74.9115	15.6868	11.0044	54.76	-17.541	137.60	25.25	y	159.8
Target Elevation -18.6'	TIP_L_664_2	14.68	74.9115	15.6868	11.0044	54.76	-17.541	165.40	21.36	y	134.4
Unit 16B	TIP_L_692_3	14.68	74.9115	15.6868	11.0044	54.56	-17.0797	139.60	24.15	y	156.5
~10.8 kcfs	TIP_L_687_4	14.68	74.9115	15.6868	11.0044	54.43	-16.7798	77.20	19.46		
	TIP_L_635_5	14.68	74.9328	15.9737	11.0199	54.47	-16.8508	105.60	23.16		
	TIP_L_640_6	14.68	74.9328	15.8944	10.9884	54.57	-17.0815	148.00	23.37		
	TIP_L_656_7	14.68	74.9328	15.8944	10.9884	54.46	-16.8277	142.80	22.5		
	TIP_L_633_8	14.68	74.9328	15.8944	10.9884	54.25	-16.3433	82.60	19.72	y	155.5
	TIP_L_684_9	14.68	74.9786	15.9707	11.1367	54.24	-16.2745	163.60	20.74		
	TIP_L_695_11	14.68	74.9206	16.0836	11.1449	54.52	-16.9783	157.20	21.32		
	TIP_L_675_12	14.68	74.9206	16.0836	11.1449	54.66	-17.3013	102.20	18.39		
	TIP_L_700_10	14.68	74.9206	16.0836	11.1449	54.63	-17.2321	154.60	22.61		
	TIP_L_698_13	14.68	74.884	16.0134	10.9594			94.80	21.09		
	TIP_L_682_14	14.68	74.884	16.0134	10.9594	54.75	-17.5455	85.00	18.43	y	130.6
	TIP_L_678_16	14.68	74.884	16.0134	10.9594	54.66	-17.3379	91.60	19.56	y	133.8
	TIP_L_664_15	14.68	74.884	16.0134	10.9594	54.76	-17.5685	183.60	17.67		
	TIP_L_692_17	14.68	74.8901	16.0165	11.1343	54.66	-17.3318	161.40	21.46	y	124.8
	TIP_L_687_18	14.68	74.8901	16.0165	11.1343	54.53	-17.0319	152.40	21.59		
	TIP_L_635_19	14.68	74.8535	15.8242	11.1218	54.46	-16.907	81.80	24.15		
	TIP_L_640_20	14.68	74.8535	15.8242	11.1218	54.77	-17.6221	142.20	23.77		
	TIP_L_656_21	14.68	74.9145	16.0256	11.0255	54.47	-16.8691	150.40	21.72		
	TIP_L_633_22	14.68	74.9145	16.0256	11.0255	54.76	-17.538	191.40	20.32	y	124.2
	TIP_L_684_23	14.68	74.9145	16.0256	11.0255	54.46	-16.846	151.60	21.56	y	118.3
					11.04	**Mean**	**-17.11**	**133.1565**	**21.45**	39.13%	**137.544**
					11.02	**Median**	**-17.08**	**142.8**	**21.46**		**133.8**
						Min	**-17.6221**	**77.2**	**17.67**		**118.3**
						Max	**-16.2745**	**191.4**	**25.25**		**159.8**
						STDev	**0.385**	**34.878**	**2.009**		**15.652**

Table C.4. (contd)

Test Condition	*File Name*	*Baro Psi*	*FB ele*	*TW ele*	*Discharge*	*Release Pt -psia*	*Release El*	*Rate of Change Psi/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
Upper 1% Tip	tip_H_678_1	14.7	75.4151	29.9786	15.7994	52.59	-11.9858	147.60	18.49		
Target Elevation -12'	tip_H_656_2	14.7	75.4151	29.9786	15.7994	52.53	-11.8474	105.40	18.12		
Unit 16B	tip_H_633_3	14.7	75.4365	29.9786	15.8586	52.56	-11.8952	153.00	17.42		
~17.6 kcfs	tip_H_664_4	14.7	75.4365	29.9786	15.8586	52.79	-12.4257	157.60	16.9		
	tip_H_695_5	14.7	75.5098	29.9786	15.7262	52.49	-11.6604	143.00	17.66		
	tip_H_700_6	14.7	75.4823	29.9786	15.8096	52.62	-11.9878	170.80	20.6	y	122.9
	tip_H_675_7	14.7	75.4823	29.9786	15.8096	52.67	-12.1031	328.80	8.69	y	186.8
	tip_H_640_8	14.7	75.4823	29.9786	15.8096	52.61	-11.9647	215.20	13.32		
	tip_H_682_9	14.7	75.464	29.9786	15.8295	52.64	-12.0522	141.60	19.56		
	tip_H_692_10	14.7	75.4731	29.9786	15.7822	52.79	-12.3891	135.60	17.99		
	tip_H_684_11	14.7	75.4731	29.9786	15.7822	52.39	-11.4664	384.80	12.3	y	145.7
	tip_H_687_12	14.7	75.4823	29.9786	15.7737	52.72	-12.2184	181.00	14.8		
	tip_H_635_13	14.7	75.4823	29.9786	15.7737	52.68	-12.1262	159.40	20.18		
	tip_H_678_14	14.7	75.4823	29.9786	15.714	52.59	-11.9186	153.60	12.1	y	108.5
	tip_H_656_15	14.7	75.4823	29.9786	15.714	52.53	-11.7802	164.20	14.31		
	tip_H_633_16	14.7	75.4731	29.9786	15.644	52.66	-12.0892	193.40	12.29	y	111
	tip_H_664_17	14.7	75.4731	29.9786	15.644	52.69	-12.1584	207.40	20.48	y	158.7
	tip_H_695_18	14.7	75.467	29.9786	15.754	52.6	-11.9569	169.60	19.3		
	tip_H_700_19	14.7	75.467	29.9786	15.754	52.62	-12.0031	219.60	20.7	y	95.1
	tip_H_640_20	14.7	75.4609	29.9786	15.6961	52.71	-12.2168	201.40	9.96		
	tip_H_682_21	14.7	75.4274	29.9786	15.7616	52.64	-12.0888	149.80	16.53		
					15.77	**Mean**	**-12.02**	**184.90**	**16.27**	33.33%	**132.67**
					15.77	**Median**	**-12.00**	**164.20**	**17.42**		**122.90**
						Min	**-12.4257**	**105.4**	**8.69**		**95.1**
						Max	**-11.4664**	**384.8**	**20.7**		**186.8**
						STDev	**0.222**	**64.387**	**3.656**		**32.502**

Table C.4. (contd)

Test Condition	*File Name*	*Baro Psi*	*FB ele*	*TW ele*	*Discharge*	*Release Pt -psia*	*Release El*	*Rate of Change Psi/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
Lower 1% Mid/Hub	mid_L-684_1	14.7	75.4151	29.9756	11.1019	48.8	-3.24337	167.40	21.97		
Target Elevation -2.97'	mid_L-687_2	14.7	75.4151	29.9756	10.9944	48.76	-3.1511	87.60	18.66		
Unit 16A	mid_L-656_3	14.7	75.406	29.9756	10.995	48.72	-3.06793	189.80	23.4	y	124
~10.8 kcfs	mid_L-633_4	14.7	75.406	29.9756	10.995	48.73	-3.091	98.60	22.25		
	mid_L-664_6	14.7	75.406	29.9756	10.995	48.8	-3.25247	115.80	23.08	y	147
	mid_L-695_5	14.7	75.4335	29.9756	11.1021	48.21	-1.86402	155.20	20.22		
	mid_L-700_7	14.7	75.3846	29.9756	11.1776	48.45	-2.46653	154.60	22.73	y	130.3
	mid_L-640_8	14.7	75.3846	29.9756	11.1776	48.76	-3.1816	140.20	19.44		
	mid_L-682_9	14.7	75.3846	29.9756	11.1776	48.7	-3.0432	109.20	17.84		
	mid_L-692_10	14.7	75.3968	29.9756	11.1138	48.6	-2.80033	117.60	21.08	y	123.6
	mid_L-684_11	14.7	75.4151	29.9756	11.106	48.7	-3.0127	297.20	18.39	y	138.6
	mid_L-635_12	14.7	75.4151	29.9756	11.106	48.79	-3.2203	155.60	18.68		
	mid_L-678_13	14.7	75.4457	29.9756	11.0104	48.7	-2.9821	53.80	19.28	y	180.7
	mid_L-698_14	14.7	75.4457	29.9756	11.0104	48.76	-3.1205	122.40	21.31		
	mid_L-687_15	14.7	75.4609	29.9756	11.1293	48.65	-2.85157	136.20	19.68		
	mid_L-656_16	14.7	75.4609	29.9756	11.1293	48.53	-2.57476	150.60	20.57		
	mid_L-633_17	14.7	75.4609	29.9756	11.1293	48.53	-2.57476	157.20	21.05		
	mid_L-695_18	14.7	75.4274	29.9756	11.1057	48.61	-2.7928	132.80	21.85		
	mid_L-664_19	14.7	75.174	29.9756	11.0778	48.8	-3.48447	183.60	22.38		
	mid_L-700_20	14.7	75.4151	29.9756	11.0995	48.55	-2.6667	77.40	20.5		
	mid_L-640_21	14.7	75.174	29.9756	11.0778	48.67	-3.1846	221.00	17.57		
	mid_L-682_22	14.7	75.174	29.9756	11.0778	48.5	-2.79246	83.00	19.06		
	mid_L-692_23	14.7	75.5037	29.9756	11.0286	48.6	-2.69343	93.80	22.08		
	mid_L-684_24	14.7	75.464	29.9756	11.0372	48.7	-2.9638	119.60	19.28		
	mid_L-635_25	14.7	75.464	29.9756	11.0372	48.5	-2.50246	123.60	20.68		
	mid_L-678_26	14.7	75.464	29.9756	11.0372	48.6	-2.73313	22.00	13.5		
	mid_L-698_27	14.68	75.3938	29.9756	11.1264	48.84	-3.40307	171.60	20.01		

Table C.4. (contd)

Test Condition	*File Name*	*Baro Psi*	*FB ele*	*TW ele*	*Discharge*	*Release Pt -psia*	*Release El*	*Rate of Change Psi/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
	mid_L-687_28	14.68	75.3938	29.9756	11.1264	48.43	-2.45733	83.40	21.29		
	mid_L-656_29	14.68	75.3938	29.9756	11.1264	48.51	-2.64186	154.40	20.84	y	178.7
	mid_L-633_30	14.68	75.3938	29.9756	11.1264	48.61	-2.87253	120.80	17.6		
	mid_L-664_31	14.68	75.4365	29.9756	11.107	48.78	-3.22197	133.60	21.66		
	mid_L-700_32	14.68	75.4365	29.9756	11.107	48.53	-2.6453	270.40	18.34		
	mid_L-640_33	14.68	75.4365	29.9756	11.107	48.55	-2.69143	173.80	19.03		
	mid_L-682_34	14.7	75.4457	29.9756	11.1258	48.6	-2.75143	127.40	21.18		
	mid_L-692_35	14.7	75.4762	29.9756	11.0439	48.7	-2.9516	127.60	19.39		
	mid_L-684_36	14.7	75.4762	29.9756	11.0439	48.9	-3.41294	85.80	21.48		
	mid_L-635_37	14.7	75.4762	29.9756	11.0439	48.6	-2.72093	97.80	21.18		
	mid_L-678_38	14.7	75.464	29.9756	11.0285	48.7	-2.9638	69.80	22.87		
	mid_L-687_39	14.7	75.4029	29.9756	11.0528	48.55	-2.6789	128.00	18.87	y	165.6
	mid_L-656_40	14.7	75.4029	29.9756	11.0528	48.52	-2.60969	185.80	18.02		
	mid_L-633_41	14.7	75.406	29.9756	11.1249	48.73	-3.091	191.20	18.33		
	mid_L-664_42	14.7	75.4457	29.9756	11.0262	48.8	-3.21277	161.60	17.69		
	mid_L-700_43	14.7	75.4457	29.9756	11.0262	48.66	-2.88983	148.40	22.12		
	mid_L_682_44	14.7	75.4151	29.9756	11.0834	48.7	-3.0127	93.00	18.45		
	mid_L-692_45	14.7	75.4151	29.9756	11.0834	48.7	-3.0127	141.60	22.78		
	mid_L-684_46	14.7	75.4335	29.9756	11.0132	48.8	-3.22497	241.20	18.78		
	mid_L-635_47	14.7	75.4335	29.9756	11.0132	48.6	-2.76363	159.60	22.87	y	157.8
	mid_L-678_48	14.7	75.348	29.9756	11.1034	48.6	-2.84913	163.60	19.88	y	101.9
	mid_L-687_49	14.7	75.3358	29.9756	11.0176	48.65	-2.97667	140.20	23.75		
	mid_L-656_50	14.7	75.3358	29.9756	11.0176	48.42	-2.44612	177.80	19.68		
	mid_L-633_51	14.7	75.3358	29.9756	11.0176	48.63	-2.93053	108.60	22.66	y	113
					11.07	**Mean**	**-2.90**	**139.66**	**20.30**	21.57%	**141.93**
					11.08	**Median**	**-2.93**	**136.20**	**20.50**		**138.60**
						Min	**-3.48447**	**22**	**13.5**		**101.9**
						Max	**-1.86402**	**297.2**	**23.75**		**180.7**
						STDev	**0.301**	**50.959**	**1.999**		**26.337**

Table C.4. (contd)

Test Condition	*File Name*	*Baro Psi*	*FB ele*	*TW ele*	*Discharge*	*Release Pt -psia*	*Release El*	*Rate of Change Psi/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
Lower 1% Mid/Hub	mid_L_700_52	14.54	75.3205	29.9664	11.028	48.8	-3.70704	59.00	14.54		
Target Elevation -2.97'	mid_L_682_53	14.54	75.3205	29.9664	11.028	48.94	-4.02998	180.00	21.83	y	136.3
Unit 16A	mid_L_687_54	14.54	75.3236	29.9664	11.1062	48.8	-3.70394	117.80	22.37		
~10.8 kcfs	mid_L_698_55	14.54	75.3236	29.9664	11.1062	48.9	-3.93461	165.80	20.27		
	mid_L_684_56	14.54	75.3541	29.9664	11.1335	49.04	-4.22705	117.60	8.72		
	mid_L_664_58	14.54	75.406	29.9664	11.1713	49.04	-4.17515	193.60	20.33		
	mid_L_633_57	14.54	75.406	29.9664	11.1201	49.18	-4.49809	116.80	22.4		
	mid_L_678_59	14.54	75.3968	29.9664	11.0472	49.33	-4.85329	131.60	18.82		
	mid_L_635_60	14.54	75.3968	29.9664	11.0472	49.23	-4.62262	139.60	20.82	y	136.4
	mid_L_692_61	14.54	75.3968	29.9664	11.0472	49.24	-4.64569	201.40	19.33	y	113.1
	mid_L_700_62	14.54	75.4365	29.9664	11.0583	49.2	-4.51372	205.40	19.52		
	mid_l_682_63	14.54	75.4365	29.9664	11.0583	49.14	-4.37532	76.80	22.03		
	mid_L_687_64	14.54	75.4365	29.9664	11.0583	49.1	-4.28305	148.40	20.53		
					11.08	**Mean**	**-4.27**	**142.60**	**19.35**	23.08%	**128.60**
					11.06	**Median**	**-4.28**	**139.60**	**20.33**		**136.30**
						Min	**-4.85329**	**59**	**8.72**		**113.1**
						Max	**-3.70394**	**205.4**	**22.4**		**136.4**
						StDev	**0.359**	**45.941**	**3.803**		**13.423**

Table C.4. (contd)

Test Condition	*File Name*	*Baro Psi*	*FB ele*	*TW ele*	*Discharge*	*Release Pt -psia*	*Release El*	*Rate of Change Psi/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
Upper 1% Mid/Hub	mid_H_664_1	14.54	75.4548	29.9664	15.7386	44.85	5.538723	145.60	17.04		
Target Elevation 5.9'	mid_H_633_2	14.54	75.4548	29.9664	15.7386	44.85	5.538723	84.40	19.68		
Unit 16A	mid_H_635_3	14.54	75.4548	29.9664	15.7386	44.65	6.000063	93.80	20.32		
~17.6 kcfs	mid_H_678_4	14.54	75.4548	29.9664	15.7386	44.75	5.769393	115.60	19.22		
	mid_H_692_5	14.54	75.464	29.9664	15.7084	44.75	5.778593	147.60	16.23		
	mid_H_700_6	14.54	75.3633	29.9664	15.8692	44.73	5.724027	83.40	20.54		
	mid_H_682_7	14.54	75.3633	29.9664	15.8692	44.69	5.816295	66.80	20.72		
	mid_H_684_9	14.54	74.8321	29.9664	16.3217	44.55	5.608033	97.60	21.32		
	mid_H_664_10	14.54	74.9206	29.9664	16.2876	44.75	5.235193	77.80	20.23	y	127.1
	mid_H_633_11	14.54	74.9206	29.9664	16.2876	44.45	5.927203	177.20	15.55		
	mid_H_635_12	14.54	74.9206	29.9664	16.2876	44.65	5.465863	53.80	21.12		
	mid_H_678_13	14.54	74.9115	29.9664	16.5009	44.45	5.918103	255.20	14.34		
	mid_H_692_14	14.54	74.9115	29.9664	16.5009	44.55	5.687433	105.60	18.63		
	mid_H_700_15	14.54	74.9115	29.9664	16.5009	44.43	5.964237	193.20	15.56		
	mid_H_682_16	14.54	74.9389	29.9664	16.4511	44.49	5.853235	155.80	16.97		
	mid_H_684_17	14.54	74.7985	12.1459	16.0826	44.45	5.805103	87.80	20.92		
	mid_H_664_18	14.54	74.7985	12.1459	16.0826	44.55	5.574433	181.40	15.34	y	109.2
	mid_H_633_19	14.54	74.7039	12.1459	16.0728	44.35	5.941173	108.80	19.98		
	mid_H_635_20	14.54	74.7039	12.1459	16.0728	44.35	5.941173	40.00	20.62		
	mid_H_678_21	14.54	74.4719	15.5128	17.0363	44.25	5.939843	275.20	11.65	y	104.9
	mid_H_692_22	14.54	74.4719	15.5128	17.0363	44.35	5.709173	69.80	14.04	y	176.9
	mid_H_700_23	14.54	74.4719	15.5128	17.0363	44.33	5.755307	115.80	18.2		
	mid_H_682_24	14.54	74.4719	15.5128	17.0363	44.39	5.616905	89.00	21.42		
	mid_H_684_25	14.54	74.6642	15.6532	17.0068	44.25	6.132143	177.60	15.53	y	143.8
	mid_H_664_26	14.54	74.6642	15.6532	17.0068	44.45	5.670803	73.80	20.62		
	mid_H_633_27	14.54	74.591	15.7265	17.0079	44.24	6.08201	82.60	19.38		
	mid_H_635_28	14.54	74.591	15.7265	17.0079	44.25	6.058943	103.60	20.42	y	127.7
	mid_H_678_29	14.56	74.4933	15.931	17.2725	44.27	5.961243	153.40	16.25		
	mid_H_692_30	14.56	74.4933	15.931	17.2725	44.37	5.730573	83.80	21.54		
	mid_H_700_31	14.56	74.5604	15.8913	17.22	44.24	6.097544	101.60	20.86		
	mid_H_682_32	14.56	74.5604	15.8913	17.22	44.21	6.166745	62.60	21.75		
	mid_H_684_33	14.56	74.6123	15.5006	17.0451	44.37	5.849573	97.80	18.94		

Table C.4. (contd)

Test Condition	*File Name*	*Baro Psi*	*FB ele*	*TW ele*	*Discharge*	*Release Pt -psia*	*Release El*	*Rate of Change Psi/sec*	*Nadir*	*Significant Event*	*Significant Event Magnitude*
	mid_H_664_34	14.56	74.6123	15.5006	17.0451	44.47	5.618903	121.60	19.85		
	mid_H_633_35	14.56	74.6123	15.5006	17.0451	44.26	6.10331	90.60	16.27		
	mid_H_635_36	14.56	74.5085	15.5311	17.1426	44.27	5.976443	235.20	13.66		
	mid_H_678_37	14.56	74.4719	15.3999	17.1048	44.37	5.709173	87.80	21.94	y	98.2
	mid_H_692_38	14.56	74.4719	15.3999	17.1048	44.47	5.478503	67.80	21.24		
	mid_H_700_39	14.56	74.4719	15.3999	17.1048	44.55	5.293967	65.20	20.66		
	mid_H_682_40	14.56	74.4719	15.3999	17.1048	44.51	5.386235	105.20	19.22		
	mid_H_684_41	14.56	74.6429	15.2289	16.911	44.37	5.880173	93.60	21.84	y	121.1
	mid_H_664_42	14.56	74.6429	15.2289	16.911	44.57	5.418833	73.60	20.44		
	mid_H_633_43	14.56	74.6429	15.2289	16.911	44.36	5.90324	179.40	15.87		
	mid_H_635_44	14.56	74.5391	14.9878	16.9531	44.37	5.776373	113.80	18.84		
	mid_H_689_45	14.56	74.6154	15.1068	16.8509	44.36	5.87574	134.80	16.27		
	mid_H_694_46	14.56	74.6154	15.1068	16.8509	44.47	5.622003	98.60	20.2		
	mid_H_673_47	14.56	74.4933	14.9481	16.912	44.33	5.822841	125.00	19.62		
	mid_H_672_51	14.56	74.4933	14.9481	16.912	44.32	5.845908	68.00	21.27		
	mid_H_701_52	14.56	74.4933	14.9481	16.912	44.25	6.007377	79.20	18.93		
	mid_H_693_48	14.56	74.2613	15.1679	17.0469	44.17	5.959913	158.40	17.19		
	mid_H_691_49	14.56	74.2613	15.1679	17.0469	44.06	6.21365	169.20	13.76		
	mid_H_678_50	14.56	74.2613	15.1679	17.0469	44.17	5.959913	87.80	19.14		
	mid_H_692_53	14.56	73.9927	15.8486	17.2856	44.07	5.921983	95.60	21.34	y	119
	mid_H_700_54	14.56	73.9927	15.8486	17.2856	44.04	5.991184	122.00	18.32		
	mid_H_682_55	14.56	73.9622	15.931	17.3183	44	6.052952	135.60	16.28	y	130.5
	mid_H_684_56	14.56	73.9622	15.931	17.3183	44.07	5.891483	275.20	12.36		
	mid_H_664_57	14.56	73.9622	15.931	17.3183	43.98	6.099086	131.60	21.54		
	mid_H_633_58	14.56	73.8889	15.9554	17.2833	43.96	6.07192	98.80	19.29		
	mid_H_689_59	14.56	73.7821	16.2668	17.4582	43.96	5.96512	159.00	14.66	y	178.7
	mid_H_694_60	14.56	73.7821	16.2668	17.4582	43.96	5.96512	128.80	20.5	y	177.2
	mid_H_635_61	14.56	73.7882	16.3675	17.7155	43.99	5.902019	91.80	21.95		
	mid_H_673_62	14.56	73.7882	16.3675	17.7155	44.03	5.809751	339.40	12.87	y	145.8
	mid_H_693_63	14.56	73.7882	16.3675	17.7155	44.08	5.694416	205.40	13.58	y	115.5
	mid_H_691_64	14.56	73.7424	16.0012	17.433	43.56	6.8481	106.80	20.7		
	mid_H_678_65	14.56	73.7424	16.0012	17.433	43.97	5.902353	287.20	12.96		
	mid_H_672_66	14.56	73.6172	16.1722	17.4387	43.82	6.123158	128.20	19.07		
	mid_H_701_67	14.56	73.6172	16.1722	17.4387	43.94	5.846354	56.80	21.17	y	138.7
					16.86	**Mean**	**5.85**	**125.38**	**18.45**	22.73%	**134.29**
					17.04	**Median**	**5.88**	**105.40**	**19.26**		**127.70**
						Min	**5.235193**	**40**	**11.65**		**98.2**
						Max	**6.8481**	**339.4**	**21.95**		**178.7**
						Stdev	**0.249**	**61.566**	**2.858**		**26.101**

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