Introduction

The Pownal Hydroelectric Project (Project) is located in North Pownal, Vermont on the Hoosic River. The project includes a single vertical turbine which produces a maximum output of 491 kW. Significant project features include a concrete overflow spillway with flashboards, an intake canal, forebay, penstock, powerhouse and tailrace. The Project operates in instantaneous run-of-river mode.

The Project received a FERC exemption on April 1st, 1983 and a Water Quality Certificate (WQC) for the project on March 4th, 1983. Following issuance of these documents, the project was constructed; however, in 1988 operations ceased due to a catastrophic equipment failure. The Town of Pownal, Vermont (Town) acquired the rights and FERC exemption for the site through involuntary acquisition due to non-payment of taxes. In 2013, Hoosic River Hydro (HRH) entered an agreement with the Town to revitalize the hydropower. On March 6th, 2014 FERC recognized HRH as acting agent for the Exemptee under an Option Agreement with the Town. HRH has since exercised that Option to lease and operate the Plant and, effective March 29, 2018, is now the Exemptee for the Plant.

On December 10th, 2016 HRH filed with the FERC a Project Update with a notice of a proposed non-material change to the capacity to 500 kW as part of replacing the non-operable Rodney Hunt Type 80 which had a nameplate capacity of 400 kW. The proposed change in capacity would not change the environmental requirements or operating conditions of the Exemption or the Water Quality Certificate (WQC). The Vermont Agency of Natural Resources (VTANR) and US Fish and Wildlife (USF&W) were copied on the filing.

After consultation with the FERC and on January 14th, 2016 VTANR, USF&W and VTSHPO were solicited for a concurrence specifically as to whether the change would cause the Project to violate the terms and conditions imposed by the Agencies in response to the 1982 Exemption application and public notice. Agency response concurred that the proposed change would keep the Project in compliance. In its memorandum dated February 1st, 2016, VTANR requested that an Operation and Flow Management Plan be drafted prior to the Project being operated with the new turbine.

In three Orders from the FERC issued April 15th, 2016, April 22nd, 2016 and June 16th, 2016, the Exemption was modified to accommodate a non-material amendment allowing for the change to the capacity from 400kW to 500 kW. Work began on August 1st, 2016 to rehabilitating the Plant and construction and commissioning was completed in early 2018. After the June 16, 2018 Order D Post-Installation Hydraulic Capacity Test was made available, the Exemptee requested the Exhibit A be amended to reflect the tested capacity of 491 kW. By Order issued April 4, 2018, the FERC amended the station capacity to 491 kW.

The site is enrolled in both the EPA Superfund Program and the EPA Brownfields Program; whereas the Superfund program focused on land-based contamination and the Brownfields program focused on wetlands-based contamination at the Project. Note: all contamination at the site was present prior to HRH involvement at the site. The primary remediation efforts related to the hydropower development were brownfields and focused on PCB contaminated sediment upstream of the dam. As of 2017, all contaminated sediment that would be mobilized by the operation of the Project has been properly removed from the site or mitigated with close oversite from VTDEC and EPA.

Project Location

The Project is located at the former Pownal Tannery Plant on the Hoosic River in Bennington County, Town of Pownal, Village of North Pownal, Vermont along State Route 346. The Town of Pownal is located in the southwestern most region of the State of Vermont approximately 30 miles from the New York State boarder and the watershed extends into Massachusetts. The Project is located on river mile 38.6 and there appear to be four hydropower projects located downstream of the Project with the next project downstream located at river mile 24.6. Upstream of the Project, four dams which appear to be non-powered, were identified on the main stem of the Hoosic River.

Figure 1. Project Location

Project Description

Figure 2. Overview Site Features

Dam

The Pownal dam is located at coordinates 42 47.72134 North by 73 15.8232 West and a Vermont State Dam Identification Number of 159.07. The dam is classified by the FERC as a low hazard structure.

The dam consists primarily of an ogee gravity overflow structure built in 1955. The dam is 153 feet long, has a maximum height of 18 feet and a crest elevation of 513.91 feet MSL. The dam operates with 2.5

feet of flashboards and crest gate combination with a normal water surface elevation of 516.60 feet MSL (516.41 plus 56 cfs or 0.19 feet). The dam is founded on bedrock. It is both keyed and dowelled into the bedrock.

The impounded area extends approximately 2.5 miles upstream of the dam creating a reservoir with a normal storage capacity of 490 acre-feet and a surface area of 77 acres.

Forebay

At the right abutment of the dam, there is an intake canal (40-foot-long concrete overflow section) with the same crest elevation as the dam which lead to the forebay. The canal is 20 feet wide and approximately 18 feet deep relative to the crest of the dam. At the upstream end the canal, there is a horizontal steel I-beam spanning the channel between the upstream face of the dam and the right abutment. This beam, with secondary vertical steel members, prevents large debris such as tree stumps and logs from entering the forebay area and jamming the trash racks.

The canal feeds into the forebay at the downstream end. Where the canal meets the forebay there is an I-beam gate structure with 3 white oak and steel gates. When lowered, these gates effectively dewater the downstream end of the forebay. The gates are controlled by use of cranes fixed to an overhead I-beam.

Near the middle of the forebay there is a trash rack. The racks have 1.25 inch openings and their condition is new. The racks are cleaned with use of an automatic, hydraulic trash rake controlled with use of pressure transducers and the Plant's Programmable Logic Controller (PLC).

The top of the forebay is a combination of steel grating and concrete. The deck provides access and working space for operation and maintenance and operation of the gates. The deck is at elevation 521 feet MSL or 5.8 feet above the crest of the dam. At the downstream end of the forebay, there is a wooden gate structure with one gate which controls the flow into the 8-foot diameter steel penstock. The gate is approximately 9.5 feet square and is of wood and steel construction with a small pressure release. There is a 16-inch by 16- inch stainless steel gate in the riverward wall which allows for dewatering the downstream end of the forebay after the headgates are closed. The gates are mechanically operated through a system of reduction gears located above the gates.

Penstock

The 8-foot diameter concrete encased, epoxy coated, steel penstock leads from the forebay to the powerhouse. It is 93 feet in length. The penstock, which feeds the turbine, leads to a concrete deceleration section, then to the spiral case and wicket gates. The penstock has a hydraulic capacity of 350 cfs at a velocity of 7 feet/second. The current Qmax Plant design of 350 cfs, within the design threshold of the penstock.

Powerhouse

The wood frame powerhouse is located approximately 120 feet downstream of the intake gates and sits on a foundation wall higher than the 100-year flood mark. The approximate floor space of the powerhouse area is 1,100 square feet. The floor slab is at elevation 509.6 MSL. The turbine foundation ring, runner shaft, etc. protrude up through the floor of the powerhouse. The generator sits on a concrete and steel base section on the floor slab. At the termination of the penstock, a spiral case leads up to and surrounds the wickets gates. The concrete wicket gate pedestal encases a steel lined, conical draft tube.

The Wasserkraft turbine and Hitzinger induction generator pair have a capacity of 491 kW at 20.5 feet of gross head. The power at the turbine shaft is 700 HP. The Qmax of the unit is 350 cfs.

The turbine flow ranges from 66 to 350 cfs, but the current environmental requirements stipulate a low-end flow of 110 cfs.

Tailrace

The Project essentially has no tailrace. Water from the steel lined draft tube enters a channel which conveys water directly to the Hoosic River.

Hydrology

The site drainage area is approximately 224 square miles; about 2/3 of which is located in northern Massachusetts with the remainder primarily in Vermont. The Hoosic River flows in the north-western direction and ultimately flows into the Hudson River near Stillwater, NY. The mean annual flow at the Project is estimated at 463 cfs and the 7Q10 flow at 56 cfs. The USGS gauges used to make flow estimations is gauge number 13325 on the Hoosic River (dr. area 132 sq. miles) near Williamstown, Massachusetts.

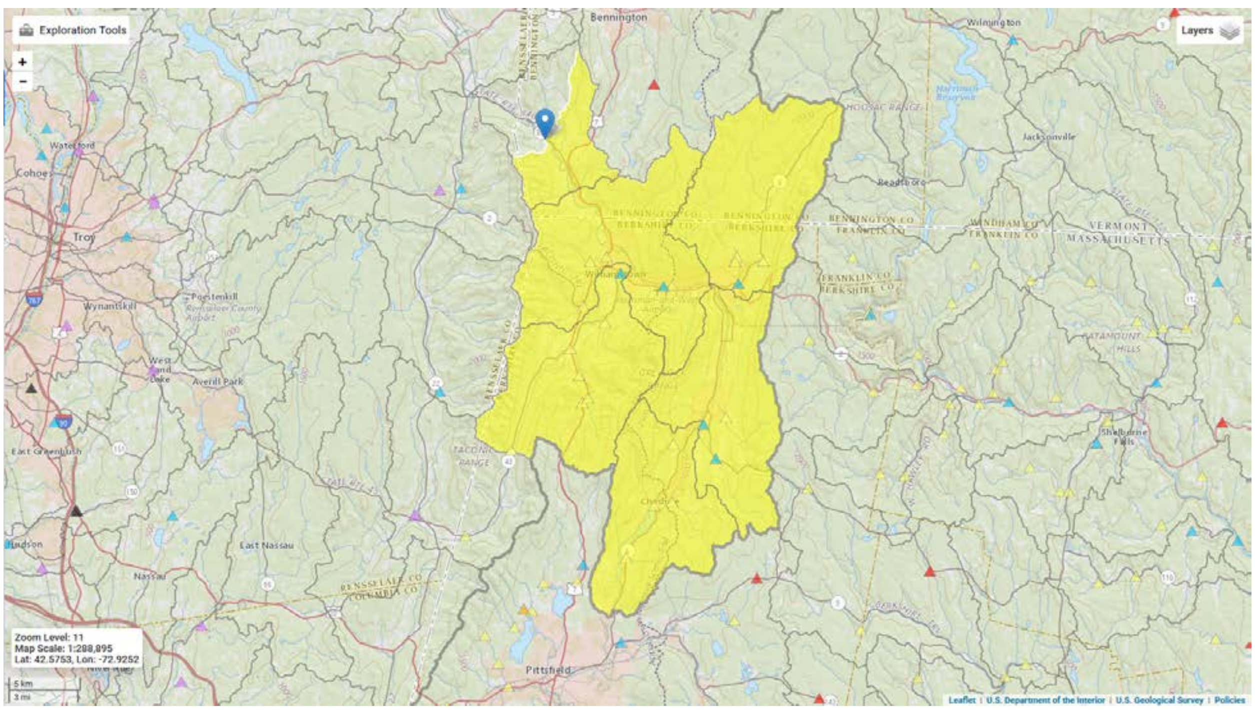


Figure 3. Site drainage basin overview

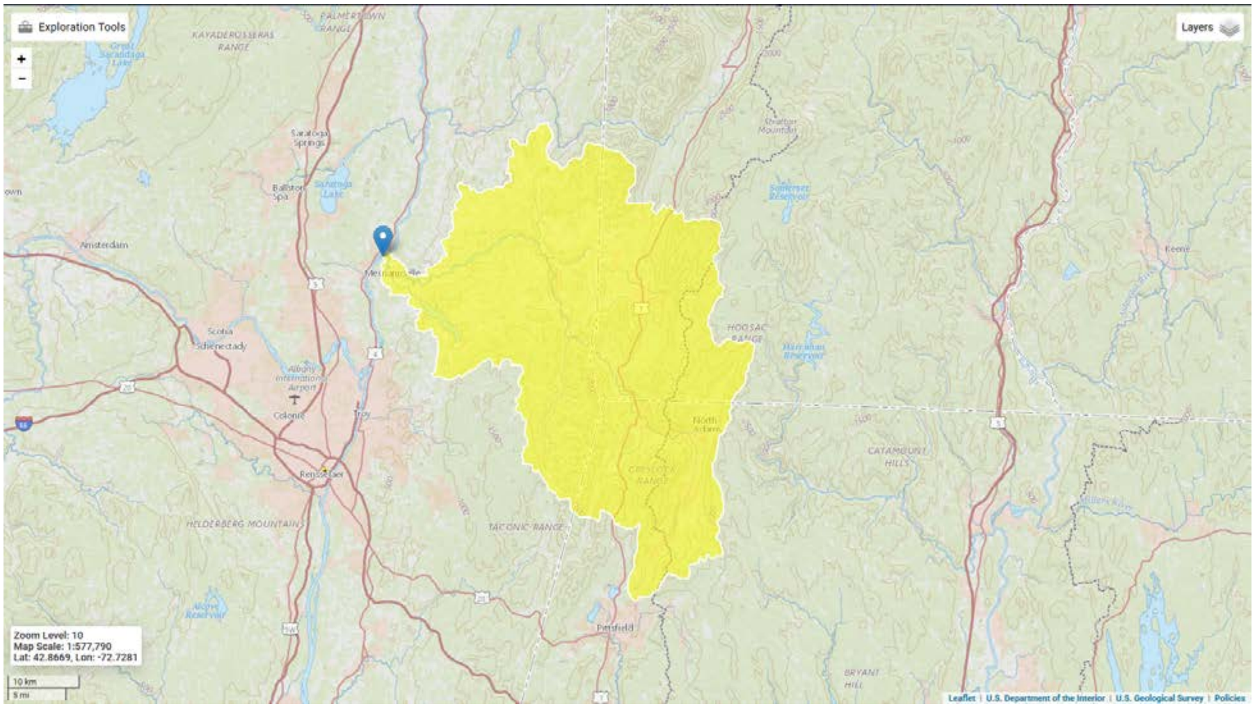
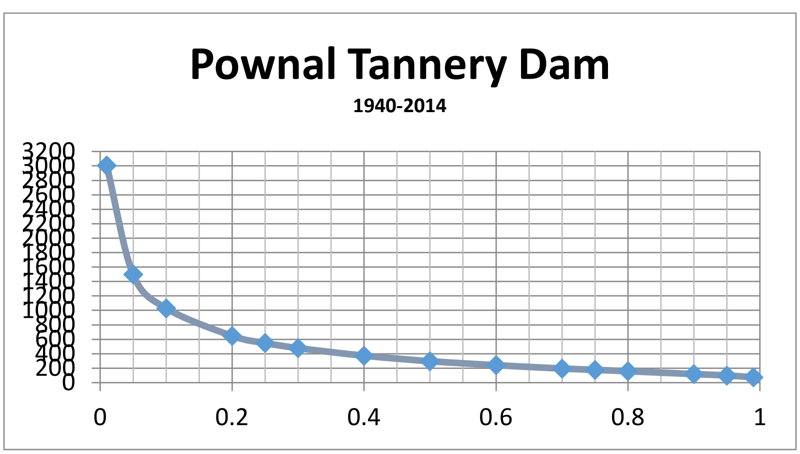


Figure 4. Hoosic River total drainage basin overview

The tabulated flow duration values and their graph are presented below:

Percent Exceedance	River Flow (cfs)
10	1008
20	615
30	482
40	396
50	297
60	223
70	199
80	192
90	121
100	85



The average monthly flows are:

January	435 cfs
February	410
March	740
April	994
May	559
June	325
July	208
August	171
September	184
October	258
November	398
December	462

Project Operations

The operation is instantaneous run of river mode, with no ponding or storage. As prescribed in the WQC and Exemption, a minimum flow of 56 cfs must be maintained in the bypass reach, between the spillway and the draft tube.

Minimum flows required to be discharged into the bypass reach will be sent over the crest of the spillway.

Conservation Flows	
Bypass Reach	Inflow ≥ 407 = Inflow minus 350 cfs
	Inflow 166 to 406 cfs = 56 cfs
	Inflow ≤ 165 cfs = Inflow

To maintain adequate aquatic flow in the bypass reach, the WQC prescribes a minimum bypass reach flow of 56 cfs. This flow discharges over the spillway. If the river inflow is zero, there is no water and all values are zero. Up to the minimum flow of the Plant (110 cfs) plus the minimum bypass reach flow (56 cfs), the river inflow will be discharged over the spillway. When the total site flow reaches 166 cfs, 110 cfs of the flow will be transferred to run the turbine at the minimum setting. The remaining flow (56 cfs) will be discharged over the spillway. This flow to the turbine will increase until the site flow reaches 406 cfs at which time the maximum authorized hydraulic capacity for the site (350 cfs) will have been reached. For all inflows over 406 cfs, the remaining flows beyond the turbine capacity will be discharged over the spillway. This process will be repeated as the river inflow cycles up and down. The following is a tabular representation of the above described plan.

Flow Regime Summary	
River Inflow (cfs)	**Description of Operations**
0-165	Inflow is less than the Plant's minimum operating capacity. All flows release over the spillway.
166-406	Minimum capacity of the Plant has been met. The turbine comes online and runs from Qmin to Qmax. A continuous 56 cfs spills over the dam.

407+	Maximum capacity for the Plant has been met. All remaining flows spill over the dam.	
Flow Distribution		
River Inflow (cfs)	**Primary Spillway**	**Turbine**
0 - 165	0 - 165	0
166-406	56	110-350
407+	56+	350

Ramping rates

The ramping rates of 0.1% per second will be implemented. The rate is equal to 21 cfs/minute. Ramping rates apply to both planned and unplanned unit startups and shutdowns and will be managed by the PLC. Ramping rates do not apply to emergency shutdowns.

Impoundment refill rates

Ninety percent of instantaneous flow will be released downstream during impoundment refills following inspections or maintenance such as flashboard replacement or crest gate raising or any event that serves to draw down the impoundment level below 516.60 MSL.

Reservoir set point

The PLC has a series of logic set points such that flows above and below the 517.91 elevation set point call for an appropriate increase or decrease to flows through the turbine so that the prescribed pond level maintained during plant operation.

Station Control and Monitoring

The PLC has been programmed with and implements the environmental flow regime. Using the manufacturer tested flows relative to gate position, the system can calculate continuous, real time flow data through the turbines as well as total station flow.

System calibration

Please see the attached report of the calibration and testing of the installed equipment and its monitors.

Table B-1. Facility Description Information for Hoosic

Information Type	*Variable Description*	*Response (and reference to further details)*
Name of the Facility	Facility name (use FERC project name if possible)	Pownal Hydroelectric Project (Pownal) FERC Project No. P-6795
Location	River name (USGS proper name)	Hoosic River
	River basin name	Hudson River Basin
	Nearest town, county, and state	Pownal, Bennington County, Vermont
	River mile of dam above next major river	38.6 miles to Hudson River at Stillwater, New York
	Geographic latitude	42°47’45” N
	Geographic longitude	73°15’49” W
Facility Owner	Application contact names (IMPORTANT: you must also complete the Facilities Contact Form):	Applicant/Facility Owner/Operator- William F. Scully Hoosic River Hydro, LLC P.O. Box 338 North Bennington, VT 05257 wfscully@gmail.com (802) 379-2469 Applicant Preparer- William K. Fay Fay Engineering Services 189 River Road Ware, Massachusetts 01082 frenchriverland@gmail.com Cell-(413) 427-2665 See facilities Contact Form for additional information.
	- Facility owner (individual and company names)	Facility Owner William F. Scully Hoosic River Hydro, LLC P.O. Box 338 North Bennington, VT 05257 wfscully@gmail.com (802) 379-2469 See facilities Contact Form for additional information.
	- Operating affiliate (if different from owner)	Operator- William F. Scully Hoosic River Hydro, LLC P.O. Box 338 North Bennington, VT 05257

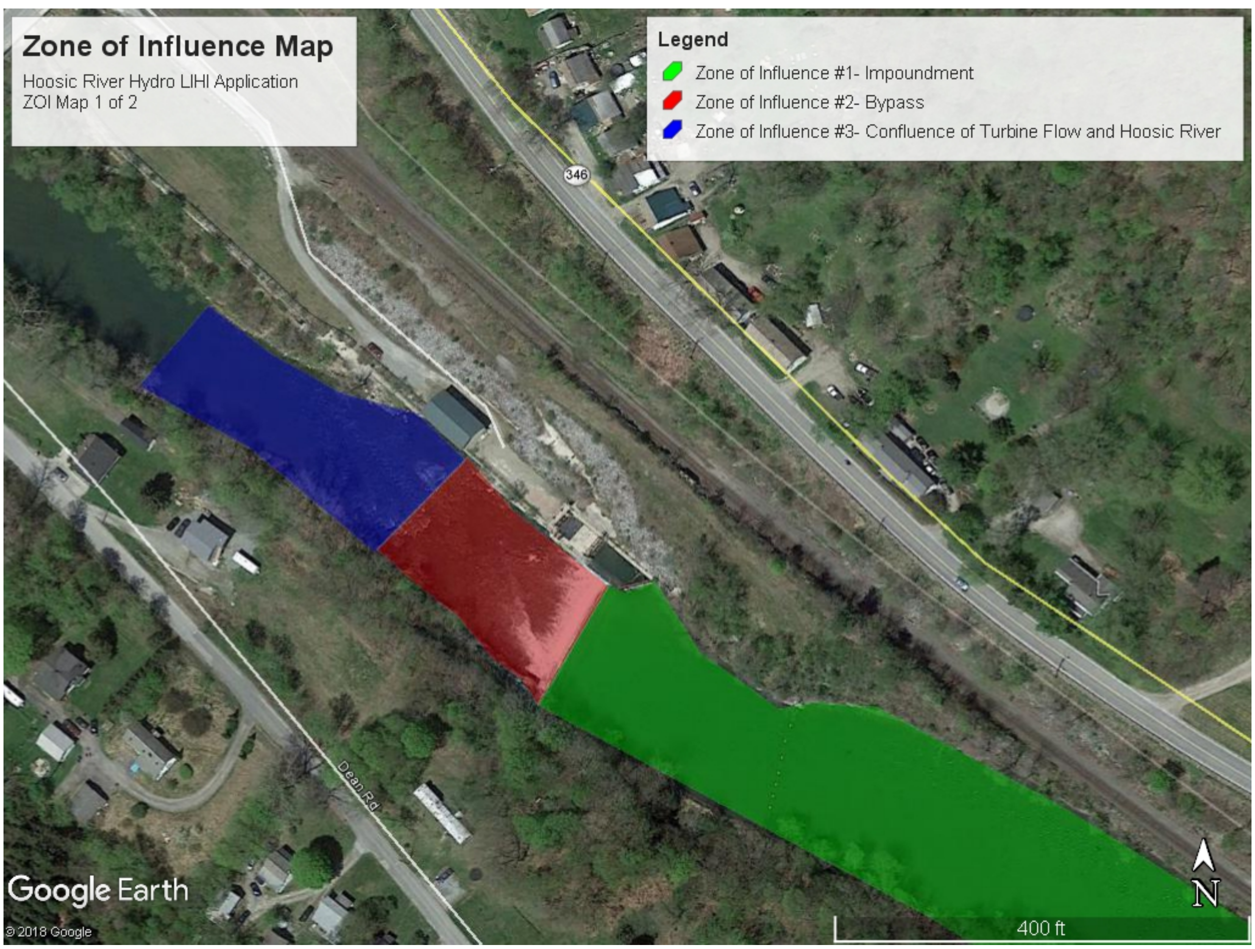
Information Type	*Variable Description*	*Response (and reference to further details)*
		wfscully@gmail.com (802) 379-2469 See facilities Contact Form for additional information.
	- Representative in LIHI certification	Applicant/Facility Owner/Operator- William F. Scully Hoosic River Hydro, LLC P.O. Box 338 North Bennington, VT 05257 wfscully@gmail.com (802) 379-2469 Applicant Preparer- William K. Fay Fay Engineering Services 189 River Road Ware, Massachusetts 01082 frenchriverland@gmail.com Cell-(413) 427-2665 See facilities Contact Form for additional information.
Regulatory Status	FERC Project Number (e.g., P-xxxxx), issuance and expiration dates	FERC License Exemption P-6795 Issued: April 1, 1983 Expiration: Indefinite
	FERC license type or special classification (e.g., "qualified conduit")	FERC Exemption from Licensing of a Small Hydroelectric Project of 5 Megawatts or Less
	Water Quality Certificate identifier and issuance date, plus source agency name	WQC P.L. 92-500, March 4, 1983, Vermont Department of Water Resources and Environmental Planning.
	Hyperlinks to key electronic records on FERC e-library website (e.g., most recent Commission Orders, WQC, ESA documents, etc.)	See attached link sheet of FERC filings and the associated document zip folder for documents not contained in the e-library.
Power Plant Character-istics	Date of initial operation (past or future for operational applications)	The Pownal Tannery operated from the 1930s to the 1988. The current dam and hydroelectric intake was constructed in 1955.
	Total name-plate capacity (MW)	0.491 MW
	Average annual generation (MWh)	3,200 MWh/year
	Number, type, and size of turbines, including maximum and minimum hydraulic capacity of each unit	(1) Wasserkraft vertical double regulated Kaplan, 20.5 ft gross head, Qmax=350 cfs, Qmin=110 cfs (turbine may operate down to 66 cfs but is limited to 110 cfs through control settings)

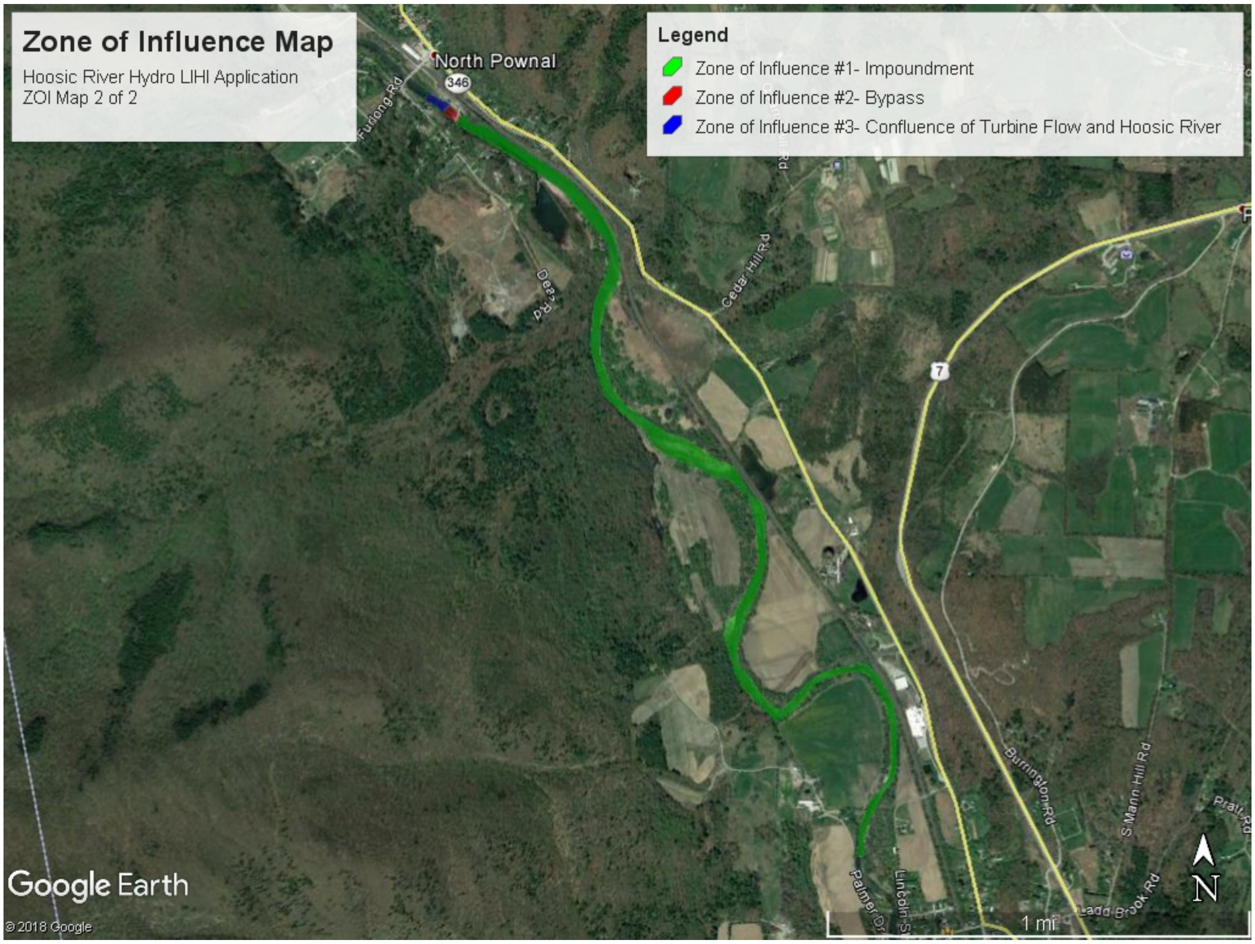
Information Type	*Variable Description*	*Response (and reference to further details)*
	Modes of operation (run-of-river, peaking, pulsing, seasonal storage, etc.)	Instantaneous run of river operation
	Dates and types of major equipment upgrades	Current equipment installed in 2016 and 2017
	Dates, purpose, and type of any recent operational changes	Site hydraulic and electrical equipment completely replaced in 2016 and 2017. Original equipment had not run since the late 1980's. Changes in project operations were made from FERC exemption including Ramping rates, decreased trash rack spacing, and added crest gates.
	Plans, authorization, and regulatory activities for any facility upgrades	Please see attached FERC correspondence
Character-istics of Dam, Diversion, or Conduit	Date of construction	Original construction 1955, new powerhouse constructed 2001, major renovations 2016/2017
	Dam height	18 feet
	Spillway elevation and hydraulic capacity	Crest spillway-513.91 ft (MSL) Top of 2.5 ft high flash boards 516.41 ft (MSL) Normal Operating level with 56 cfs crest bypass flow 516.60 ft (MSL)
	Tailwater elevation	496.10 ft (MSL)
	Length and type of all penstocks and water conveyance structures between reservoir and powerhouse	20 ft wide by 40 ft long intake canal feeding a, 20 ft by 34 ft long forebay, leading to (1) one-8 ft diameter steel penstock 93 ft long.
	Dates and types of major, generation-related infrastructure improvements	1955 original construction, 2016/2017 major renovations
	Designated facility purposes (e.g., power, navigation, flood control, water supply, etc.)	Energy generation
	Water source	Project impoundment on Hoosic River
	Water discharge location or facility	Project powerhouse
Characte-ristics of Reservoir and Watershed	Gross volume and surface area at full pool	490 acre-ft and 77 acres
	Maximum water surface elevation (ft. MSL)	516.60 ft (MSL) during normal operations
	Maximum and minimum volume and water surface elevations for designated power pool, if available	Run-of-river project, no impoundment storage utilized.
	Upstream dam(s) by name, ownership, FERC number (if applicable), and river mile	RM 49.5 – Nonpowered Dam RM 51 – Nonpowered Dam RM 51.2 – Nonpowered Dam RM 52 – Nonpowered Dam

Information Type	*Variable Description*	*Response (and reference to further details)*
	Downstream dam(s) by name, ownership, FERC number (if applicable), and river mile	RM 24.6 – Hoosic Falls Hydroelectric Project, Hydro Power, Inc. P=2487 RM 13.4 – Johnsonville Hydroelectric Project, Brookfield Renewable Energy Group, P-2616 (co licensed with Schaghticoke) RM 9.1 – James Thompson Hydroelectric Project, Valley Falls Associates, P-6411 RM 7.1 – Schaghticoke Project, Brookfield Renewable Energy Group, P-2616 (co licensed with Johnsonville)
	Operating agreements with upstream or downstream reservoirs that affect water availability, if any, and facility operation	None
	Area inside FERC project boundary, where appropriate	N/A
Hydrologic Setting	Average annual flow at the dam	495 cfs
	Average monthly flows	January – 464 cfs February – 438 cfs March – 792 cfs April – 1165 cfs May – 635 cfs June – 408 cfs July – 254 cfs August – 231 cfs September – 237 cfs October – 345 cfs November – 464 cfs December 516 cfs
	Location and name of relevant stream gauging stations above and below the facility	There are two USGS gaging stations upstream of the Project on the Hoosic River as follows: 1 – Gage No. 01332500 Hoosic River near Williamstown, MA DA=126 SM **This is the gage utilized for Project analysis.** 2 – Gage No. 01331500 Hoosic River near Adams, MA DA=46.7 There are two USGS gaging stations downstream of the Project 1 – Gage No. 01334500 Hoosic River near Eagle Bridge, NY DA= 510 SM 2 – Gage No. 01335000 Hoosic River at Buskirk, NY DA= 577 SM
	Watershed area at the dam	224 mi^2
Designated	Number of zones of effect	3

Information Type	***Variable Description***	***Response (and reference to further details)***
Zones of Effect	Upstream and downstream locations by river miles	Downstream extent of Zone of Effect #1 (dam) – RM 38.6 Downstream extent of Zone of Effect #2 (draft tube) – RM 38.64 Downstream extent of Zone of Effect #3 (DS extent of project boundary) – RM 38.7
	Type of waterbody (river, impoundment, by-passed reach, etc.)	Zone of Effect #1 – Impoundment Zone of Effect #2 – Bypass reach Zone of Effect #3 - Confluence Downstream of Turbine Flow and Hoosic River
	Delimiting structures	Zone of Effect #1: Impoundment The project has a 77-acre impoundment at elevation 516.60 ft (MSL) created during normal project operations by the project dam. The FERC project boundary extends approximately 2.5 miles upstream to the upstream limit of the impoundment. Zone of Effect #2: Bypass Reach The project has an approximately 190 ft long bypass reach between the project overflow spillway and the confluence of the turbine outflow with the Hoosic River where turbine flows are bypassed for hydropower generation. Zone of Effect #3: Confluence Downstream of Turbine Flow and Hoosic River The FERC project boundary extends approximately 300 ft downstream of the confluence of the turbine outflow and Hoosic River. No tailrace is included as a zone of influence since there is no separate tailrace, the project turbine outflow enters the Hoosic River with no separate tailrace structure.
	Designated uses by state water quality agency	WQC Specifies that river is Class C waters suitable for recreational boating, irrigation of crops not used for consumption without cooking, habitat for wildlife and for common food and game fishes indigenous to the

Information Type	*Variable Description*	*Response (and reference to further details)*
		region. River has significant industrial and agricultural pollution that limits use in Massachusetts, Vermont, and New York.
Additional Contact Information	Names, addresses, phone numbers, and e-mail for local state and federal resource agencies	See attached contact form
	Names, addresses, phone numbers, and e-mail for local non-governmental stakeholders	See attached contact form
Photographs and Maps	Photographs of key features of the facility and each of the designated zones of effect	See photos attachment
	Maps, aerial photos, and/or plan view diagrams of facility area and river basin	See project description.





Zone of Influence Map
Hoosic River Hydro LIHI Application
ZOI Map 2 of 2
Legend
Zone of Influence #1- Impoundment
Zone of Influence #2- Bypass
Zone of Influence #3- Confluence of Turbine Flow and Hoosic River
North Pownal
346
Furlong Rd
Dean Rd
Cedar Hill Rd
7
Burrington Rd
S Mann Hill Rd
Pratt Rd
Ladd Brook Rd
Palmer Dr
Lincoln St
1 mi
N
Google Earth
© 2018 Google

Zone of Effect # 1: Impoundment

	Criterion	*Alternative Standards*				
		1	*2*	*3*	*4*	*Plus*
A	Ecological Flow Regimes	X				X
B	Water Quality		X			X
C	Upstream Fish Passage	X				
D	Downstream Fish Passage	X				X
E	Watershed and Shoreline Protection	X				
F	Threatened and Endangered Species Protection	X				
G	Cultural and Historic Resources Protection	X				
H	Recreational Resources	X				

Zone of Effect # 2: Bypass Reach

	Criterion	*Alternative Standards*				
		1	*2*	*3*	*4*	*Plus*
A	Ecological Flow Regimes		X			X
B	Water Quality		X			
C	Upstream Fish Passage	X				
D	Downstream Fish Passage	X				
E	Watershed and Shoreline Protection	X				
F	Threatened and Endangered Species Protection	X				
G	Cultural and Historic Resources Protection	X				
H	Recreational Resources	X				

Zone of Effect # 3: Confluence of Turbine Flow and Hoosic River

	Criterion	*Alternative Standards*				
		1	*2*	*3*	*4*	*Plus*
A	Ecological Flow Regimes	X				
B	Water Quality	X				
C	Upstream Fish Passage	X				
D	Downstream Fish Passage	X				
E	Watershed and Shoreline Protection	X				
F	Threatened and Endangered Species Protection	X				
G	Cultural and Historic Resources Protection	X				
H	Recreational Resources	X				

B.2.1 Ecological Flow Standards

Zone of Influence #1-Impoundment Ecological Flow Standards

Table B-1 ZOE #1. Information Required to Support Ecological Flows Standards.

Criterion	*Standard*	*Instructions*
A	PLUS	Bonus Activities: • If an adaptive management program is in place, provide sufficient information to understand. • If non-flow habitat enhancements have been applied, explain what they are, how their benefits are being monitored, and how they are achieving a positive net benefit to fish and wildlife resources.
A	1	Not Applicable / De Minimis Effect: • Confirm the location of the powerhouse relative to other dam/diversion structures to establish that there are no bypassed reaches at the facility. • If Run-of-River operation, provide details on how flows, water levels, and operation are monitored to ensure such an operational mode is maintained. • In a conduit project, identify the water source and discharge points for the conduit system within which the hydropower plant is located. • For impoundment zones only, explain how fish and wildlife habitat within the zone is evaluated and managed – ***NOTE:*** this is required information, but it will not be used to determine whether the Ecological Flows criterion has been satisfied. All impoundment zones can apply Criterion A-1 to pass this criterion.

Bonus Activities-Installation of a movable crest gate to minimize flow entrainment of contaminated sediment and/or dewatering of upstream shallow bays. This was a voluntary measure enacted by the project applicant to reduce environmental contamination through better regulation of impoundment water surface elevation and project flows.

Introduction

The incorporation of automatically adjustable crest gates at The Hoosic Dam has benefitted the riverine environment in two crucial ways. They prevent the migration of PCB laden sediments during classic pin & board crest control failures. They prevent long term dewatering of upstream shallow bays that were created by the installation of classic pin & board crest control and dried up after their failure.

PCB Sediment Transport

Originally, the project proponents hired and paid Fay Engineering Services (FES) to design a set of inexpensive crest control consisting of pins and boards. During subsequent discussions, between FES and the project proponents, the subject of PCB migration during failure of the pins and boards came up.

FES explained that failure of the pins and boards occurs during extreme flood events with an elevated river flow. Failure of the boards drops the upstream water surface elevation (WSE). The flowrate is constrained to a smaller cross-sectional area. This creates an acceleration of the water and a tractive force on the PCB laden sediments. The sediments break free, become suspended in the water column and are transported over the dam to the downstream river reaches. Installation of automatically adjustable crest gates prevent this detrimental downstream transport of PCBs by allowing a very gradual modulation of the velocities through the impoundment. The sudden acceleration of the water column in the impoundment and resultant tractive force on the PCB laden sediments is prevented.

Dewatering of Upstream Shallow Bays

The failure of the classic pin and board crest control causes a lowering of the impoundment. This depressed WSE can last for many months until the river flow drops to an acceptable level that allows workmen to replace the failed components. Once the pins and boards have been replaced, the impoundment elevation is restored to the pre-failure elevation. Unfortunately, the higher WSE floods and covers over upstream areas creating additional riverine habitat. Riverine species enter and populate these shallow bays and create additional ecosystem. When the boards subsequently fail, this newly created habitat is completely dried up and destroyed. Installation of automatically adjustable crest gates prevents this recurrent, detrimental and tragic upstream destruction of riverine habitat. During and after the flood, the automatically adjustable crest gates maintain the WSE constant.

The project proponents decided to protect the environment and prevent these two detrimental conditions occurring by abandoning the much less expensive use of pins and boards crest control by opting to purchase much more expensive automatically adjustable crest gates.

Main B.2.1 Narrative

Zone of Influence #1 focuses on the reservoir and does not include a bypass reach. The site is operated in an instantaneous run-of-river mode with a PLC controller to maintain the project impoundment at 516.60 ft (MSL) during normal project operation. Requirements for these project operations are specified in the FERC Order Granting Exemption from Licensing of a Small Hydroelectric Project of 5 Megawatts or Less (Issued April 1, 1983) and the Vermont Agency of Environmental Protection (Vermont AEC is now part of Vermont Agency of Natural Resources) Water Quality Certificate (Issued March 4, 1983). These requirements were reviewed by VTDEC and US Fish and Wildlife Service (USFWS) and their comments incorporated into the ORDER AMENDING EXEMPTION AND REVISING PROJECT DESCRIPTION (April 15, 2016).

The 2016/2017 project upgrades included installing a movable crest gate on the dam crest. The use of crest gates reduces future reservoir draw-downs, reduces fluctuations in the reservoir water surface level, reduces debris buildup in the impoundment, and is aesthetically neutral compared to standard flashboards. This provides many benefits, some listed above and the applicant considers them an adaptive management technique that should be considered as a bonus activity. The use of this flashboard system is an innovative site upgrade that provides for habitat enhancement through superior maintenance of true run-of-river operation, instantaneous bypass flows and impoundment water surface control.

No requirements for evaluating and managing wildlife habitat within the impoundment zone of influence have been requested by VTDEC, USFWS, or any other agency in either 1983 or 2016. VTDEC and USFWS reserved the right during the initial 1983 exemption to require fish passage and other fisheries methods when requested by the resource agencies. Currently, due to organic chemical contamination in the Hoosic River and downstream conditions, fish passage is not currently recommended. This was confirmed in a July 31, 2018 correspondence with VTDEC.

As described in the Operation and Flow Management Plan HRH uses a SEAMTEC SCADA Enterprise System programmable logic controller to handle continuous monitoring and reporting. The PLC has an 8-hour battery back-up. The PLC controls the system with the use of two pond sensors.

The PLC has a series of logic set points such that flows above and below the 516.60 ft (MSL) elevation set point call for an appropriate increase or decrease to flows through the turbine so that the prescribed pond level maintained during Plant operation.

The PLC has been programmed with and implements the environmental flow regime. Using the manufacturer tested flows relative to gate position, the system can calculate continuous, real time flow data through the turbines as well as total station flow.

The station records any deviation from normal operations as an alarm. All alarms are sent out via email instantaneously to plant staff and owners. Alarms are also immediately displayed on the PLC, displayed in the daily reports and can be accessed in the PLC memory. The PLC is programmed with a series of responses to varying circumstances. Depending on the nature of the concern, these responses range from simple alarms to full and immediate shut down. Additionally, all functions within the PLC are available remotely, including the station cameras.

Ramping rates of 0.1% per second or 21 cfs/minute were proposed by the applicant. Ramping rates apply to both planned and unplanned unit startups and shutdowns and will be managed by the PLC.

Ramping rates do not apply to emergency shutdowns.

In addition, a reduction in the original trashrack spacing to 1” and the installation of an automatic trashrake was proposed by the applicant and implemented to reduce entrainment of fish and aquatic life.

Zone of Influence #2-Bypass Ecological Flow Standards

Table B-2 ZOE #2. Information Required to Support Ecological Flows Standards.

Criterion	*Standard*	*Instructions*
A	2	Agency Recommendation (see Appendix A for definitions): • Identify the proceeding and source, date, and specifics of the agency recommendation applied (NOTE: there may be more than one; identify and explain which is most environmentally stringent). • Explain the scientific or technical basis for the agency recommendation, including methods and data used. This is required regardless of whether the recommendation is or is not part of a Settlement Agreement. • Explain how the recommendation relates to agency management goals and objectives for fish and wildlife. • Explain how the recommendation provides fish and wildlife protection, mitigation and enhancement (including in-stream flows, ramping and peaking rate conditions, and seasonal and episodic instream flow variations).
A	PLUS	Bonus Activities: • If an adaptive management program is in place, provide sufficient information to understand. • If non-flow habitat enhancements have been applied, explain what they are, how their benefits are being monitored, and how they are achieving a positive net benefit to fish and wildlife resources.

Bonus Activities- The 2016/2017 project upgrades included installing a movable crest gate on the dam crest. Through use of the moveable crest gate, site water control is significantly improved over the previous pin and board flashboard system. As such, the flows to the bypass reach can be controlled more precisely and the applicant considers them an adaptive management technique that should be considered as a bonus activity. This is another voluntary project improvement by the applicant to decrease the project's impact. It should be considered adaptive and unique in that very few operating hydroelectric projects voluntarily replace standard pin style flashboards with movable crest gates AND combine the system with PLC controls.

The project bypass is a bypassed reach of the Hoosic River with agency recommended prescriptions for flow. The site is operated in an instantaneous run-of-river mode with a PLC controller to maintain the project impoundment at 516.60 ft (MSL) during normal project operation. These requirements are specified in the FERC Order Granting Exemption from Licensing of a Small Hydroelectric Project of 5 Megawatts or Less (Issued April 1, 1983) and the Vermont Agency of Environmental Protection (Vermont AEC is now part of Vermont Agency of Natural Resources) Water Quality Certificate (Issued March 4, 1983). These requirements were reviewed by VTDEC and US Fish and Wildlife Service (USFWS) and their comments incorporated into the ORDER AMENDING EXEMPTION AND REVISING PROJECT DESCRIPTION (April 15, 2016).

To maintain adequate aquatic flow in the bypass reach, the WQC prescribes a minimum bypass reach flow of 56 cfs. This flow discharges over the spillway. Up to the minimum flow of the Plant (110 cfs) plus the minimum bypass reach flow (56 cfs), the river inflow will be discharged over the spillway. When the total site flow reaches 166 cfs, 110 cfs of the flow will be transferred to run the turbine at the minimum setting. The remaining flow (56 cfs) will be discharged over the spillway. This flow to the turbine will increase until the site flow reaches 406 cfs at which time the maximum flow for the turbine (350 cfs) will have been reached. For all inflows over 406 cfs, the remaining flows beyond the turbine capacity will be discharged over the spillway. This process will be repeated as the river inflow cycles up and down. The following is a tabular representation of the above described plan. These were voluntarily proposed and implemented by the applicant to protect the project bypass reach.

The wetted width doesn't change noticeably at the low flows between off and minimum operation. There are no dewatered areas to trap fish. As such, there are no opportunities for stranding.

Flow Regime Summary		
River Inflow (cfs)	**Description of Operations**	
0-165	Inflow is less than the Plant's minimum operating capacity. All flows release over the spillway.	
166-406	Minimum capacity of the Plant has been met. The turbine comes online and runs from Qmin to Qmax. A continuous 56 cfs spills over the dam.	
407+	Maximum capacity for the Plant has been met. All remaining flows spill over the dam.	
Flow Distribution		
River Inflow (cfs)	**Primary Spillway**	**Turbine**
0 - 165	0 - 165	0
166-406	56	110-350
407+	56+	350

The 2016/2017 project upgrades included installing a movable crest gate on the dam crest. Through use of the moveable crest gate, site water control is significantly improved over the previous pin and board flashboard system. As such, the flows to the bypass reach can be controlled more precisely and the applicant considers them an adaptive management technique that should be considered as a bonus activity. This is another voluntary project improvement by the applicant to decrease the project's impact.

Zone of Influence #3- Confluence Downstream of Turbine Flow and Hoosic River Ecological Flow Standards

Table B-3 ZOE #3. Information Required to Support Ecological Flows Standards.

Criterion	*Standard*	*Instructions*
A	1	Not Applicable / De Minimis Effect: • Confirm the location of the powerhouse relative to other dam/diversion structures to establish that there are no bypassed reaches at the facility. • If Run-of-River operation, provide details on how flows, water levels, and operation are monitored to ensure such an operational mode is maintained. • In a conduit project, identify the water source and discharge points for the conduit system within which the hydropower plant is located. • For impoundment zones only, explain how fish and wildlife habitat within the zone is evaluated and managed – ***NOTE:*** this is required information, but it will not be used to determine whether the Ecological Flows criterion has been satisfied. All impoundment zones can apply Criterion A-1 to pass this criterion.

Zone of Effect #3 does not include a bypass reach. Since the project is operated in instantaneous run-of-river mode with all inflows equaling outflows, Zone of Effect #3 is not affected in any way by the Project since it is downstream of the influence of the project. This was not true before the 2016/2017 upgrade work. Certain provisions such as crest gates, automatic controls, and better turbine operations have enabled the site to operate in a much more precise form of run-of-river operation. These improvements were voluntarily proposed and implemented by the project applicant. See discussions above in Zone of Effect #1 and #2 for additional details on run-of-river operations.

B.2.2 Water Quality Standards

Zone of Influence #1- <u>Impoundment</u> Water Quality Standards

Table B-4. Information Required to Support Water Quality Standards.

Criterion	*Standard*	*Instructions*
B	2	<u>Agency Recommendation:</u> • If facility is located on a Water Quality Limited river reach, provide an agency letter stating that the facility is not a cause of such limitation. • Provide a copy of the most recent Water Quality Certificate, including the date of issuance. • Identify any other agency recommendations related to water quality and explain their scientific or technical basis. • Describe all compliance activities related to the water quality related agency recommendations for the facility, including on-going monitoring, and how those are integrated into facility operations.
B	PLUS	<u>Bonus Activities:</u> • Describe any advance technologies that have been deployed at the facility to enhance ambient water quality and how its performance is being monitored. • If adaptive management is being applied, describe the management objectives, the monitoring program pursuant to evaluating performance against those objectives, and the management actions that will be taken in response to monitoring results.

Please see an excerpt from the State of Vermont's 2014, 303(d) List of Impaired Waters. The impoundment, the bypass reach and the downstream reach are polluted by PCBs. The waters of the Hoosic River in the vicinity of the project are not suitable for fishing. Since PCBs can be absorbed through the skin, even handling fish during "catch and release" fishing poses a health issue.

Part A. Waters appearing below have documentation and data indicating impairment and do not meet VT Water Quality Standards according to the methodology described in the Vermont Surface Water Assessment and Listing Methodology. Required or needed pollution controls have yet to be fully implemented and further pollutant loading determinations (i.e. TMDLs) are necessary - unless remediation will be completed prior to the scheduled TMDL.

Waterbody ID	ADB Code(s)	Segment Name/ Description	Pollutant(s)	Use(s) Impaired	Surface Water Quality Problem(s)	TMDL Priority
VT01-02	01	HOOSIC RIVER, ENTIRE 7 MILE LENGTH IN VERMONT	PCBs	FC	ELEVATED LEVELS OF TOXIC CONTAMINANT IN BROWN TROUT	L

Bonus Activity- HRH considers the contaminated sediment dredging work to be an adaptive management technique that undoubtedly improved the water quality of the Hoosic River. Voluntary removal of the PCB contaminated soils upstream of the dam required a significant allocation of labor-hours and financial resources. However, it is an important step for long-term remediation of the river from prior industrial pollution. HRH is proud to have completed this task and improved water quality at the Project as compared to its prior condition. More information is presented at the end of B.2.2 and in the project narrative. This should be considered separately from the installation of crest gates to decrease sediment transport and drying of upstream shallows (bonus activity 2.1.1) since they were implemented with different measures and they tackled two distinctly separate issues.

Water quality requirements for the project are based on the FERC Order Granting Exemption from Licensing of a Small Hydroelectric Project of 5 Megawatts or Less (Issued April 1, 1983) and the Vermont Agency of Environmental Protection (Vermont AEC is now part of Vermont Agency of Natural Resources) Water Quality Certificate (Issued March 4, 1983). These requirements were reviewed by VTDEC and US Fish and Wildlife Service (USFWS) and their comments incorporated into the ORDER AMENDING EXEMPTION AND REVISING PROJECT DESCRIPTION (April 15, 2016). The project is in compliance with all requirements of the WQC and FERC exemption as discussed below.

The following is a summary of Project conditions from the 1983 WQC:

- The Project shall be operated in a strict run-of-the-river manner, with instantaneous flows downstream of the tailrace maintained equivalent to the instantaneous inflows to the impoundment. A minimum flow of 56 cfs, or instantaneous inflow, if less, shall be spilled at the dam. When the facility is not operating, all inflows shall be spilled at the dam on an instantons basis.
- When flashboards are installed and the storage deficit behind the boards must be filled, a minimum instantaneous flow of 155 cfs (the estimated August median flow) must be spilled while the pool fills.
- Any desilting shall be done in accordance with the Agency of Environmental Conservation's Desilting Policy.
- The applicant shall insure that every reasonable precaution is taken to prevent the discharge of petro chemicals and debris to the state waters.
- Any debris removed from the dam in trashracks shall be disposed of properly.
- Any significant changes to the project, including the operational scheme, shall be submitted to the Department of Water Resources and Environmental Engineering for review an approval prior to effecting the change.

The reservoir is operated in instantaneous run-of-river mode. For details on the PLC control and operations see discussion in Zone of Effect #1 Ecological Flow Regimes and Zone of Effect #2 Ecological Flow Regimes. Ninety percent of instantaneous flow will be released downstream during impoundment refills following inspections or maintenance such as flashboard replacement or crest gate raising or any event (other than low flows or reservoir drawdowns) that serves to draw down the impoundment level below 516.60 msl. Desilting is discussed separately below.

HRH has an emergency spill prevention and action plan in place at the Project to prevent the discharge of oil into the river and provide guidance on remedial measures in the event of a discharge. Debris is sorted to remove non-organic debris to the extent possible.

Since the project had not operated since 1988, HRH completed outreach to Agencies. On February 1, 2016 HRH received comments from VTDEC as follows:

- As proposed the replacement of the turbine and generator does not modifying the design, the location of the discharge or intake relative to the Projects original water quality certification. Additionally, HRH has not proposed to modify the existing terms and conditions of the

Certification. However, HRH has indicated that the manufacture specifications on the new turbine show that it may be capable of operating at a lower hydraulic capacity of 66 cfs, as compared to the 110 cfs. HRH has not proposed to operate the unit at the lower capacity, but to continue to operate the project only when inflow is 166 ccs or greater (56 cfs plus 110 cfs lower hydraulic capacity of the certification and exemption). HRH has proposed to conduct a test of the turbine capacity once the unit is operational to confirm the configuration and settings for the turbine are within the terms and conditions of the water quality certification and original exemption.

- In subsequent discussions with the Agency, HRH has agreed to develop an Operations and Flow Management Plan subject to Agency approval, before the Project is operated with the new turbine. The Operations and Flow Management plan will describe how the Project will operate to be in compliance with the terms and conditions of the Certification. Additionally, the HRH will coordinate the hydraulic capacity test with the Agency and Service once the unit is installed and the Project is operational. This will provide the necessary information for the Agency to determine whether the new unit would result in a violation of existing terms and conditions of the Certification.

As required by VTDEC, HRH has completed the hydraulic capacity tests of the unit and developed an Operations and Flow Management Plan which has been accepted by Agencies.

The former Pownal Tannery is listed on the EPA's National Priorities List. A Phase I environmental site assessment (ESA) conducted by the Johnson Company in 2009 identified Polychlorinated biphenyls, polynuclear aromatic hydrocarbons, and metals to be the contaminants of concern for the surficial river sediments located upstream of the dam. In support of reactivating the hydro project, Lincoln Applied Geology conducted a Phase II ESA to evaluate sediment quality conditions along the Pownal Dam and upstream of the dam to develop a remedial plan for handling and disposing sediment that would be mobilized by the redevelopment of the hydroelectric facility. The Phase II report, which was reviewed and approved by the Agency, recommends 1,159 cubic yards of sediment be removed to specific dimensions in the impoundment to avoid mobilization of sediment when the new turbine is operating at its maximum hydraulic capacity.

The Department issued a Section 401 Water Quality Certification (Certification) for operation of the Pownal Tannery hydroelectric project on March 4th, 1983. Condition C of the certification specifically addresses maintenance of the impoundment and states, "any desilting shall be done in accordance with the Agency of Environmental Conservation's Desilting Policy". The VTDEC no longer maintains a desilting policy, rather desilting and dredging activities are reviewed on a case by case basis due the potential adverse effects on downstream water quality and aquatic habitat. On August 24, 2016 VTDEC provided the following conditions to ensure that maintenance of the impoundment in preparation for reactivating the hydroelectric works will proceed in a manner that will not violate Vermont Water Quality Standards, consistent with the intent of condition C of the 1983 water quality certification.

- Excavation of sediment shall proceed in accordance with the Agency approval CAP prepared by Lincoln Applied Geology dated June 21, 2016
- The excavation of sediment shall conform to the specifications recommended by the H.L. Turner group dated February 11, 2016 to ensure operation of the turbine will not mobilize sediment.
- Following installation of the cofferdam, all instream work shall take place in the dry.

- All machinery shall be clean, well maintained, and free of fuel, hydraulic and gear oil leaks.
- Streambank disturbance shall be minimized, and all disturbed areas shall be regraded, seeded and mulched at the conclusion of the operation.
- Work should be suspended if a release of sediment, debris, or waste to State waters occurs or appears likely to occur, and the Department shall be notified as soon as possible of the circumstances.
- Sediment control measures, including those enclosing the temporary stockpile area, shall comply with the Vermont DEC 2006 Standard Specifications for Erosion Prevention and Sediment Control and be properly installed (e.g., silt fence should be staked and trenched).
- Turbid water shall not be allowed to drain to the river from the staging area.
- Sediment and debris that is removed from the intake area shall be managed in accordance with Vermont Solid Waste Management Rules.
- All temporary erosion and sediment control measures, as well as construction material, shall be removed from the area when no longer needed.
- All instream work shall be completed before October 1, 2016.
- The as-built completion report described in the CAP shall also be submitted to the Department's Rivers program.

HRH worked very closely with VTDEC and EPA during this sensitive dredging program and work was completed in 2017 and both Agencies are satisfied.

HRH considers this dredging work to be an adaptive management technique that undoubtedly improved the water quality of the Hoosic River. Removal of the PCB contaminated soils upstream of the dam required a significant allocation of labor-hours and financial resources. However, it is an important step for long-term remediation of the river from prior industrial pollution. HRH is proud to have completed this task and improved water quality at the Project as compared to its prior condition.

Figure 3. Pownal Dam dredging program to remove contaminated soil.

Zone of Influence #2- Bypass Water Quality Standards

Table B-5. Information Required to Support Water Quality Standards.

Criterion	*Standard*	*Instructions*
B	2	Agency Recommendation: • If facility is located on a Water Quality Limited river reach, provide an agency letter stating that the facility is not a cause of such limitation. • Provide a copy of the most recent Water Quality Certificate, including the date of issuance. • Identify any other agency recommendations related to water quality and explain their scientific or technical basis. • Describe all compliance activities related to the water quality related agency recommendations for the facility, including on-going monitoring, and how those are integrated into facility operations.

The instructions in Table B-3 identify information needed to meet the Water Quality criterion and to satisfy its goal. The applicant should provide only the information associated with the standard selected for a designated zone of effect. If the PLUS standard is also selected for this criterion, the information associate with that standard must also be provided. If more than one ZoE is designated for an application, this process should be repeated for other zones.

Water quality requirements for the project are based on the FERC Order Granting Exemption from Licensing of a Small Hydroelectric Project of 5 Megawatts or Less (Issued April 1, 1983) and the Vermont Agency of Environmental Protection (Vermont AEC is now part of Vermont Agency of Natural Resources) Water Quality Certificate (Issued March 4, 1983). These requirements were reviewed by VTDEC and US Fish and Wildlife Service (USFWS) and their comments incorporated into the ORDER AMENDING EXEMPTION AND REVISING PROJECT DESCRIPTION (April 15, 2016). The project is in compliance with all requirements of the WQC and FERC exemption. More details of the WQC requirements are discussed in Zone of Influence #1 Water Quality Standards above.

Relative to the bypass reach, the primary Project requirements are instantaneous run-of-river operations and the minimum bypass flow. The Project operates in instantaneous run-of-river mode and is controlled by a PLC. Additional details can be found in Zone of Effect #1 Ecological Flow Regimes and Zone of Effect #2 Ecological Flow Regimes. The PLC is programmed to provide the minimum bypass flow of 56 cfs (or inflow if less) at all times.

HRH is in compliance with all water quality standards required by the QWC and FERC exemption. In addition, voluntary measures proposed and implemented by the applicant have a beneficial effect on water quality in the bypass. More accurate run-of-river operation realized because of the crest gates, computer controls, and new generation equipment will provide an improvement in flow stability and most likely water quality.

Zone of Influence #3- Confluence Downstream of Turbine Flow and Hoosic River Water Quality Standards

Table B-6. Information Required to Support Water Quality Standards.

Criterion	***Standard***	***Instructions***
B	1	Not Applicable / De Minimis Effect: • If facility is located on a Water Quality Limited river reach, provide an agency letter stating that the facility is not a cause of such limitation. • Explain rationale for why facility does not alter water quality characteristics below, around, and above the facility.

The instructions in Table B-3 identify information needed to meet the Water Quality criterion and to satisfy its goal. The applicant should provide only the information associated with the standard selected for a designated zone of effect. If the PLUS standard is also selected for this criterion, the information associate with that standard must also be provided. If more than one ZoE is designated for an application, this process should be repeated for other zones.

Since the project is operated in instantaneous run-of-river mode with all inflows equaling outflows, Zone of Effect #3 is not affected in any way by the Project since it is downstream of the influence of the project. This was not true before the 2016/2017 upgrade work. Certain provisions such as crest gates, automatic controls, and better turbine operations have enabled the site to operate in a much more precise form of run-of-river operation. See discussions above in Zone of Effect #1 and #2 Ecological Flow Standards for additional details on run-of-river operations.

B.2.3 Upstream Fish Passage Standards

Zone of Influence #1, #2 & #3- Impoundment, Bypass Reach & Confluence Downstream of Turbine Flow and Hoosic River Upstream Fish Passage Standards

Table B-7. Information Required to Support Upstream Fish Passage Standards.

Criterion	*Standard*	*Instructions*
C	1	Not Applicable / De Minimis Effect: • Explain why the facility does not impose a barrier to upstream fish passage in the designated zone. • Document available fish distribution data and the lack of migratory fish species in the vicinity. If migratory fish species have been extirpated from the area, explain why the facility is or was not the cause of this.

There is no upstream fish passage facilities at the project. The WQC does not include any discussion of the need for upstream fish passage. The FERC exemption includes a stipulation from US Fish and Wildlife Services that fish passage facilities be provided when prescribed by US Fish and Wildlife Services. HRH has committed to install upstream fish passage facilities at such a time as required by US Fish and Wildlife Services. This primarily applies to the dam which is the interface between Zone #1 and Zone #2. Fish passage does not apply to Zone #3. Since there are no migratory fish species currently at the Project, the Project has no effect on upstream fish passage. Multiple literature searches for historic species information for the Hoosic River yielded no information.

An email consultation with VTDEC and USF&WS regarding fish passage is in the project document folder.

The following table published by the Vermont Fish & Game Department lists the fish species living in the Hoosic River:

Species	Season	Length	Daily Limit	Legal Method
Anadromous Atlantic Salmon	No open season	NA	0	NA
Lake Sturgeon	No open season	NA	0	NA
Brook Trout and Brown Trout and Rainbow Trout	2nd Sat. in April to Oct. 31	None	Total of brook + brown + rainbow = no more than 12 Total of brown + rainbows = no more than 6	Open-water fishing
Lake Trout	2nd Sat. in April to Oct. 31	18	Total of lake trout + landlocked salmon = no more than 2	Open-water fishing
Landlocked Salmon	2nd Sat. in April to Oct. 31	15	Total of lake trout + landlocked salmon = no more than 2	Open-water fishing
American Shad	2nd Sat. in April to Oct. 31		0	Catch & Release angling
Largemouth and Smallmouth Bass	1st Sat. in May to Oct. 31	None	Total of largemouth + smallmouth = no more than 5	Open-water fishing
Walleye	2nd Sat. in April to Oct. 31	15	3	Open-water fishing
Northern Pike	2nd Sat. in April to Oct. 31	20	5	Open-water fishing
Muskellunge	2nd Sat. in April to Oct. 31	NA	0	Open-water fishing
Rainbow Smelt	2nd Sat. in April to Oct. 31	None	None	Open-water fishing
Yellow Perch	2nd Sat. in April to Oct. 31	None	50	Open-water fishing
Crappie	2nd Sat. in April to Oct. 31	8	25	Open-water fishing
All Other Species	2nd Sat. in April to Oct. 31	None	None	Open-water fishing
Sauger	No open season		0	NA

B.2.4 Downstream Fish Passage and Protection Standards

Zone of Influence #1 Impoundment Downstream Fish Passage Standards

Table B-8. Information Required to Support Downstream Fish Passage Standards.

Criterion	*Standard*	*Instructions*
D	1	Not Applicable / De Minimis Effect: • Explain why the facility does not impose a barrier to downstream fish passage in the designated zone, considering both physical obstruction and increased mortality relative to natural downstream movement (e.g., entrainment into hydropower turbines). • For riverine fish populations that are known to move downstream, explain why the facility does not contribute adversely to the sustainability of these populations or to their access to habitat necessary for successful completion of their life cycles. • Document available fish distribution data and the lack of migratory fish species in the vicinity. • If migratory fish species have been extirpated from the area, explain why the facility is or was not the cause of this.
D	PLUS	Bonus Activities: • If advanced technology has been or will be deployed, explain how it will increase fish passage success relative to other options. • If a basin-scale redevelopment strategy is being pursued, explain how it will increase the abundance and sustainability of migratory fish species in the river system. • If adaptive management is being applied, describe the management objectives, the monitoring program pursuant to evaluating performance against those objectives, and the management actions that will be taken in response to monitoring results.

Bonus Activities- Even though fish passage and screening was not required by any resource agency, the applicant voluntarily proposed and installed 1.25” trashrack spacing and an automatic trashrack to prevent downstream entrainment of fish and aquatic life.

There are no known migratory fisheries at the Project and concern for resident species was not identified at the Project by Agencies. Zone of Influence #1 includes the entrance to the forebay and trashrack. It is estimated that the approach velocity at the entrance to the forebay is about 1 ft/s or less and the approach velocity at the trashrack is calculated as 1.1 ft/s. Although there were no requirements specified in the QWC or FERC Exemption regarding intake velocities, the Project velocities are significantly less than the typical Agency guidelines of 2 ft/s or less. Furthermore, the velocities at the forebay and trashrack are generally sufficiently low to as to prevent impingement or entrainment. Even though fish passage and screening was not required by any resource agency, the applicant voluntarily proposed and installed 1.25” trashrack spacing and an automatic trashrack to prevent downstream entrainment of fish and aquatic life. The Project has no effect on downstream fish passage.

The FERC exemption includes a stipulation from US Fish and Wildlife Services that fish passage facilities be provided when prescribed by US Fish and Wildlife Services. HRH has committed to install upstream fish passage facilities at such a time as required by US Fish and Wildlife Services.

An email consultation with VTDEC and USF&WS regarding fish passage is in the project document folder.

Zone of Influence #2 & #3- Bypass Reach & Confluence Downstream of Turbine Flow and Hoosic River Downstream Fish Passage Standards

Table B-9. Information Required to Support Downstream Fish Passage Standards.

Criterion	***Standard***	***Instructions***
D	1	Not Applicable / De Minimis Effect: • Explain why the facility does not impose a barrier to downstream fish passage in the designated zone, considering both physical obstruction and increased mortality relative to natural downstream movement (e.g., entrainment into hydropower turbines). • For riverine fish populations that are known to move downstream, explain why the facility does not contribute adversely to the sustainability of these populations or to their access to habitat necessary for successful completion of their life cycles. • Document available fish distribution data and the lack of migratory fish species in the vicinity. • If migratory fish species have been extirpated from the area, explain why the facility is or was not the cause of this.

There are no known migratory species within this area of the Hoosic River. Zone #2 and Zone #3 do not have any influence on downstream fish. Zone #2 has a minimum bypass flow equal to the 7Q10 which would be observed naturally and Zone #3 is downstream of the influence of the Project.

The FERC exemption includes a stipulation from US Fish and Wildlife Services that fish passage facilities be provided when prescribed by US Fish and Wildlife Services. HRH has committed to install upstream fish passage facilities at such a time as required by US Fish and Wildlife Services.

An email consultation with VTDEC and USF&WS regarding fish passage is in the project document folder.

B.2.5 Shoreline and Watershed Protection Standards

Zone of Influence #1, #2 & #3- Impoundment, Bypass Reach & Confluence Downstream of Turbine Flow and Hoosic River Shoreline and Watershed Protection Standards

Table B-10. Information Required to Support Shoreline and Watershed Protection Standards.

Criterion	*Standard*	*Instructions*
E	1	Not Applicable / De Minimis Effect: • If there are no lands with significant ecological value associated with the facility, document and justify this (e.g., describe the land use and land cover within the project boundary). • Document that there have been no Shoreline Management Plans or similar protection requirements for the facility.

There are no specific Agency recommendations for shoreline protection or watershed protection nor any mention of these protections in the WQC or FERC license. Zone of Influence #1, #2 and #3 have no effect on the shoreline or watershed. Rather, removal of contaminated PCB material from the impoundment has a beneficial effect on the watershed.

The project does not have, nor is it required to have, a watershed enhancement fund or specific watershed land protection plan. The project is in compliance with all State and Federal resource Agency recommendations in the exemption.

The project operates in an instantaneous run-of-river mode which minimizes any shoreline effects. See discussion in Zone of Effect #1 Ecological Flow Regimes and Zone of Effect #2 Ecological Flow Regimes.

B.2.6 Threatened and Endangered Species Standards

Zone of Influence #1, #2 & #3- Impoundment, Bypass Reach & Confluence Downstream of Turbine Flow and Hoosic River Threatened and Endangered Species

The instructions in Table B-7 identify information needed to meet the Threatened and Endangered Species criterion and to satisfy its goal. The applicant should provide only the information associated with the standard selected for a designated zone of effect. If the PLUS standard is also selected for this criterion, the information associate with that standard must also be provided. If more than one ZoE is designated for an application, this process should be repeated for other zones.

In all cases, the applicant shall identify all listed species in the facility area based on current data from the appropriate state and federal natural resource management agencies.

Table B-11. Information Required to Support Threatened and Endangered Species Standards.

Criterion	***Standard***	***Instructions***
F	1	Not Applicable / De Minimis Effect: • Document that there are no listed species in the facility area or affected riverine zones downstream of the facility. • If listed species are known to have existed in the facility area in the past but are not currently present, explain why the facility was not the cause of the extirpation of such species. • If the facility is making significant efforts to reintroduce an extirpated species, describe the actions that are being taken.

There are no known state or federally listed threatened or endangered species onsite. Consultation with VTDEC and the Department of the Interior during the original exemption process identified no threatened or endangered species at the project.

Please see the species list below from USF&WS for the project.

The following is a description of the animal and plant species found in the project vicinity.

Ornithological Species:

The Hoosic River Valley features very good breeding populations of a wide variety of neotropical migrants. Common breeding warbler species include: Blue-winged Warbler (locally around the periphery), Chestnut-sided Warbler, Magnolia Warbler, Black-throated Blue Warbler, Yellow-rumped Warbler, Black-throated Green Warbler, Blackburnian Warbler, Black-and-white Warbler, American Redstart, Ovenbird, Northern and Louisiana waterthrushes, and Common Yellowthroat. Mourning Warblers breed in very small numbers locally in Savoy Mountain State Forest and have been recently found in Dubuque State Forest. Other regular breeding birds include Wood Ducks, Black Ducks, Red-shouldered and Red-tailed hawks, Northern Goshawks, American Woodcocks, Barred Owls, Northern Saw-whet Owls (one of the best areas in the state to find this species during the breeding season), Ruby-throated Hummingbirds, Yellow-bellied Sapsuckers, Pileated Woodpeckers, Eastern Wood-Pewee, Alder Flycatcher, Least Flycatcher, Winter Wren, Golden-crowned Kinglet, Veery, Hermit Thrush, Wood Thrush, Blue-headed Vireo, Evening Grosbeak, and Scarlet Tanager. Common Ravens and Turkey Vultures are commonly seen in and flying over the IBA and may breed in the parcel. Rusty Blackbird was first documented as a breeding bird in the state at Tyler Swamp in the Savoy Mountain State Forest in 1977 and has been noted breeding in this parcel in 1978 on Borden Mountain. Likely, this species is a very local and rare but regular breeder in the parcel. Summering reports of a Sharp-shinned Hawk also suggest the site nominators; young have been documented in the area. Historically, Olive-sided Flycatchers bred in several locations throughout this IBA area (example: Busby Swamp, Hawley Bog, Hell Huddle Road) but have not been found breeding recently though the bird still occurs as a migrant, and future nesting might certainly occur. Lincoln's sparrows were documented breeding at Busby Swamp (summer of 1981) and summering/breeding birds are still found there some years. There were several summering records of Yellow-bellied flycatchers at Busby Swamp (e.g., summer 1981), and nesting was suspected at that time. Summer records of a Swainson's thrush may also suggest breeding. Ruby-Crowned kinglets were documented as breeding on Borden Mountain in this IBA area (3 July 1932, see Petersen & Veit, and singing male birds during the breeding season have been more recently reported at least up to 1976 (see Petersen & Veit) and into the 1990s.

Flora and Fauna of Significance:

The entire parcel has good populations of large mammals including Bobcats, Black Bears, and Fishers. Moose have been spotted on several occasions. Spring Salamanders are found along the many streams. Butterflies of many species are also found here including good populations of the Atlantis Fritillary.

Plants are of special interest in this area. The Hawley Bog alone has good numbers of Calopogon, Rose Pogonia, White-fringed and Purple-fringed orchis, as well as Sundew, Northern Pitcher-plant and Horned Bladderwort. The entire parcel supports a wide variety of flowers and plants special to the northern Berkshires.

Operations of the project will not have a detrimental effect on any of these species.

Endangered Species Act Species

The following is an appendix from a letter sent to the project owner by US F&WS regarding endangered species. The project does not have an effect on northern long-eared bat.

Endangered Species Act Species

There is a total of 1 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

Mammals

NAME	STATUS
Northern Long-eared Bat *Myotis septentrionalis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9045	Threatened

Critical habitats

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

B.2.7 Cultural and Historic Resources Standards

Zone of Influence #1, #2 & #3- Impoundment, Bypass Reach & Confluence Downstream of Turbine Flow and Hoosic River Cultural and Historic Resources

The instructions in Table B-8 identify information needed to meet the Cultural and Historic Resources criterion and to satisfy its goal. The applicant should provide only the information associated with the standard selected for a designated zone of effect. If the PLUS standard is also selected for this criterion, the information associate with that standard must also be provided. If more than one ZoE is designated for an application, this process should be repeated for other zones.

In all cases, the applicant shall identify all cultural and historic resources that are on facility owned property or that may be affected by facility operations.

Table B-12. Information Required to Support Cultural and Historic Resources Standards.

Criterion	*Standard*	*Instructions*
G	1	Not Applicable / De Minimis Effect: • Document that there are no cultural or historic resources located on facility lands that can be affected by construction or operations of the facility. • Document that the facility construction and operation have not in the past adversely affected any cultural or historic resources that are present on facility lands.

There are no specific Agency recommendations for Cultural and Historic resources in the FERC license. Zone of influence #1, #2, and #3 have no effect on cultural and historic resources. The Project does not have, nor is it required to have, a Cultural Resources Management Plan or Historic Properties Management Plan. The FERC license includes the following guidance for all zones:

- If any cultural resources are discovered during the work approved in this order, the exemptee must immediately cease all work at the site. The exemptee must consult with Vermont State Historic Preservation Officer (Vermont SHPO) and any tribes that might attach religious or cultural significance to the cultural resource to determine what steps need to be taken to evaluate the discovered cultural resource. If the resource is found to be eligible for the National Register of Historic Places, the exemptee, in consultation with Vermont SHPO and tribes, if applicable, must develop measures to mitigate or to avoid any adverse effects. The licensee must file with the Commission, for approval, a report on the historic property and the effects of the undertaking. If the property would be adversely affected, the report should contain the proposed mitigation measures along with any comments received from the SHIPO and tribes on the report. The licensee must allow 30 days for an agency to comment. If there are no comments, the licensee must include its request for comments in the filing to the Commission. The licensee must not resume work it the vicinity of the discovered site until instructed by the Commission.

During the original 1983 exemption application and during the recent rehabilitation work and sediment removal work, no cultural resources were identified within any of the Project zones. Letters stating that the proposed project development would not impact cultural and historic resources was received from the Vermont State Historic Preservation in 1983 and 2017.

B.2.8 Recreational Resources Standards

Zone of Influence #1, #2 & #3- <u>Impoundment, Bypass Reach & Confluence Downstream of Turbine Flow and Hoosic River</u> Recreational Resources

Table B-13. Information Required to Support Recreational Resources Standards.

Criterion	*Standard*	*Instructions*
H	1	<u>Not Applicable / De Minimis Effect:</u> • Document that the facility does not occupy lands or waters to which public access can be granted and that the facility does not otherwise impact recreational opportunities in the facility area.

There are no specific Agency recommendations for recreation other than allowing for general fishing access nor any mention of this resource in the QWC or FERC license. Zone of influence #1, #2 and #3 have no effect on recreation. Within 200 feet of the dam turbine discharges re-enter the main Hoosic River channel and do not influence downstream recreational resources.

The project is in compliance with all State and Federal resource Agency recommendations in the exemption.

06/13/2018	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14945417	Order Approving Operation and Flow Management Plan re Hoosic River Hydro, LLC under P-6795.	
05/31/2018	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14934655 This is only cover letter, main document was considered CEII. Final post consultation flow management plan is in document folder.	Supplemental Information / Request of Hoosic River Hydro, LLC under P-6795. Compliance filing: Operation and Flow Management Plan for the Pownal Hydroelectric Project on the Hoosic River in Pownal, Vermont (FERC Project No. P-6795)	Just cover letter. Main document is CEII and is included in the document zip folder sent with application. As DOC1-Draft Operation and Flow Management Plan with Consultation.pdf
04/27/2018	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14899909	The H.L. Turner Group Inc. submits the Exhibit G drawings for the Hoosic River Hydro Project under P-6795.	Final Exhibit G Boundary Drawings
04/04/2018	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14863988	Order Approving As-Built Exhibits A and G and Revising Project Description re Hoosic River Hydro, LLC under P-6795.	Approval of as built project description and boundary
03/29/2018	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14856001	Notice of Transfer of Exemption re Town of Pownal et al under P-6795	Transfer of exemption to Hoosic River Hydro, LLC
03/29/2018	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14857675	Supplemental Information / Request of Hoosic River Hydro, LLC under P-6795. Exhibit A, Exhibit B, and Exhibit G, as requested. Thank you	As built exhibits A, B, and G
01/30/2018	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14809738	Draft Exhibit F drawings as specified under Exemption Order I of Hoosic River Hydro, LLC under P-6795.	As filed exhibit F drawings
01/19/2017	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14806686	Dam Safety Inspection Report by NYRO for Hoosic River for the Pownal Project under P-6795.	FERC project inspection
06/16/2016	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14277669	Order Amending Exemption re Town of Pownal under P-6795.	
05/28/2016	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14260735	Supplemental Information of Hoosic River Hydro, LLC under P-6795. Supplemental filing_VTANR concurrence with May 20th, 2016 Exemptee filing on Order Paragraphs D and E.	VTANR support of flow management plan and hydraulic capacity test
05/20/2016	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14252736	Hoosic River Hydro, LLC submits Comments by stakeholders and recommendations by Hoosic River Hydro pertaining to Paragraphs (D) & (E) in the FERC Order dated April 16th, 2016 under P-	Stakeholder support of flow management plan and

		6795.	hydraulic capacity test
04/22/2016	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14213457	Order Amending Exemption re Town of Pownal under P-6795.	Amendment to conduct hydraulic capacity test and flow management plan until after commercial operation
04/15/2016	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14238903	Order Amending Exemption and Revising Project Description re Town of Pownal under P-6795.	First FERC exemption amendment to new project configuration
04/15/16	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14206786	Supplemental Information of Hoosic River Hydro, LLC under P-6795. Refiling of February 15th, 2016 submission with CEII information removed.	Stakeholder support of FERC exemption amendment to repower project
03/23/2016	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14178269	Supplemental Information of Hoosic River Hydro, LLC under P-6795. HRH Response to Intervention Requests regarding request to replace equipment.	Applicant response to NGO stakeholder request to intervene concerning FERC exemption amendment
03/17/2016	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14172474	Motion to Intervene of Vermont Natural Resources Council under P-6795.	
03/17/2016	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14173183	Motion to Intervene and Comments of Vermont Council of Trout Unlimited under P-6795.	
03/14/2016	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14170029	Motion to Intervene of Vermont Agency of Natural Resources under P-6795	
03/02/2016	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14162168	Correspondence from U.S. Fish and Wildlife Service to Hoosic River Hydro LLC re the Pownal Tannery Dam Project under P-6795.	
02/15/2016	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14146084	Supplemental Information of Hoosic River Hydro, LLC under P-6795. Information pertaining to the proposed equipment change filed in response to a request from Commission staff.	
02/03/2016	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14137459	Hoosic River Hydro, LLC Project update and notice of implementation of turbine and generator replacement under P-6795.	Contains initial consultation with USFW, VTDEC, and SHPO

12/10/2015	https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14069196	Supplemental Information of Hoosic River Hydro, LLC under P-6795. Project update and notification of turbine and generator operating characteristics for the replacement units.	Initial notice to FERC and stakeholders of FERC exemption amendment
02/09/2001	https://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=156594	State of Vermont submits excerpts from draft Remedial Investigation Report for Pownal Tannery dated January 2001 under P-6795.Volume I-Sections 1.0 through 6.0.	Initial report describing sediment contamination in vicinity of project
02/01/2000	https://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=8088721	US Environmental Protection Agency submits Engineer's Field Report re Pownal Hydropower Proj-6795.	Field report describing environmental contamination in vicinity of project
03/04/1983	In folders not available on elibrary or other electronic source	Water quality certificate	
04/01/1983	https://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=14123848	Order granting exemption from licensing of small hydro proj of 5 MW or less re Pownal Hydro Corp under P-6795.	Original exemption
02/04/1983	https://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=14117170	Comments re review of proposal for exemption from licensing re appl of Pownal Hydropower Corp.	VTDEC (Was VTDEC in 1983) comments
01/27/1983	https://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=14117168	Comments re review of proposal for exemption from licensing. Requests for conditions listed.	VT public service board certification
01/12/1983	https://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=14034948	Comments in response to 821222 notice of Pownal Hydro Corp appl for exemption.Finds no objections to appl.	USACE comments
10/25/1982	https://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=14022281	Appl for exemption from licensing for Pownal Hydro Proj.	Page 32-51 contains the original stakeholder correspondence for the project

FACILITY CONTACTS FORM

1. **All applications for LIHI Certification must include complete contact information to be reviewed.**

Project Owner:	
Name and Title	William F. Scully, Owner
Company	Hoosic River Hydro, LLC
Phone	(802) 379-2469
Email Address	wfscully@gmail.com
Mailing Address	P.O. Box 338 North Bennington, VT 05257
Project Operator (if different from Owner):	
Name and Title	Same as Project Owner
Company	
Phone	
Email Address	
Mailing Address	
Agent for LIHI Program (if different from above):	
Name and Title	Same as Project Owner
Company	
Phone	
Email Address	
Mailing Address	
Consulting Firm / Applicant Preparer:	
Name and Title	William K. Fay, P.E., President
Company	Fay Engineering Services
Phone	(413) 427-2665
Email Address	frenchriverland@gmail.com
Mailing Address	189 River Road Ware, MA 01082
Compliance Contact (responsible for LIHI Program and FERC requirements):	
Name and Title	Same as Project Owner
Company	
Phone	
Email Address	
Mailing Address	
Party responsible for accounts payable:	
Name and Title	Same as Project Owner
Company	
Phone	
Email Address	
Mailing Address	

2. **Applicant must identify the most current and relevant state, federal, provincial, and tribal resource agency contacts (copy and repeat the following table as needed).**

Agency Contact – General Recreation and Project Lead on Federal Compliance	
Agency Name	FERC (Recreation access is monitored during FERC project inspections)
Name and Title	John Spain, Regional Engineer, New York Regional Office
Phone	212-273-5954
Email address	john.spain@ferc.gov
Mailing Address	Division of Dam Safety and Inspections - New York Regional Office 19 West 34th Street, Suite 400 New York, NY 10001-3006

Agency Contact Vermont Flows, Water Quality, Fish/Wildlife Resources and Watershed	
Agency Name	Agency of Natural Resources, Department of Environmental Conservation, Streamflow Protection
Name and Title	Jeff Crocker - Streamflow Protection Coordinator
Phone	802-490-6151
Email address	jeff.crocker@vermont.gov
Mailing Address	Vermont Department of Environmental Conservation Watershed Management Division Main Building - 2nd Floor 1 National Life Drive Montpelier, VT 05620-3522

Agency Contact Federal Flows, Water Quality, and Fish/Wildlife Resources	
Agency Name	US Department of Interior, Fish and Wildlife Service, New England Ecological Services Field Office
Name and Title	Melissa Grader, Fish and Wildlife Biologist
Phone	413-548-8002 x8124
Email address	melissa_grader@fws.gov
Mailing Address	U.S. Fish and Wildlife Service - New England Field Office 103 East Plumtree Road Sunderland, MA 01375

Agency Contact –Federal Threatened and Endangered Species	
Agency Name	US Department of Interior, Fish and Wildlife Service, New England Ecological Services Field Office
Name and Title	David Simmons, Assistant Supervisor Endangered Species
Phone	603-227-6425
Email address	David_Simmons@fws.gov
Mailing Address	U.S. Fish and Wildlife Service New England Field Office 70 Commercial Street, Suite 300 Concord, NH 03301

Agency Contact – Vermont Cultural/Historic Resources	
Agency Name	Vermont Agency for Commerce and Community Development, Division for Historic Preservation
Name and Title	Laura V. Trieschmann, Vermont State Historic Preservation Officer
Phone	802-828-3222
Email address	laura.trieschmann@vermont.gov
Mailing Address	Laura V. Trieschmann One National Life Drive Deane C. Davis Building, 6th Floor Montpelier, VT 05620-0501

Sworn Statement and Waiver Form

All applications for LIHI Certification must include the following sworn statement before they can be reviewed by LIHI:

SWORN STATEMENT

As an Authorized Representative of Hoosic River Hydro LLC, the Undersigned attests that the material presented in the application is true and complete.

The Undersigned acknowledges that the primary goal of the Low Impact Hydropower Institute's Certification Program is public benefit, and that the LIHI Governing Board and its agents are not responsible for financial or other private consequences of its certification decisions.

The undersigned further acknowledges that if certification of the applying facility is issued, the LIHI Certification Mark License Agreement must be executed prior to marketing the electricity product as LIHI Certified.

The undersigned Applicant further agrees to hold the Low Impact Hydropower Institute, the Governing Board and its agents harmless for any decision rendered on this or other applications, from any consequences of disclosing or publishing any submitted certification application materials to the public, or on any other action pursuant to the Low Impact Hydropower Institute's Certification Program.

PLEASE INSERT ONLY FOR PRE-OPERATIONAL CERTIFICATIONS (See Section 4.5.3)**:**

For applications for pre-operational certification of a "new" facility the applicant must also acknowledge that the Institute may suspend or revoke the certification should the impacts of the project, once operational, fail to comply with the certification criteria.

Company Name: Hoosic River Hydro LLC

Authorize Representative Name: William F. Scully

Title: Operating Manager

Authorized Signature: ____________________

Date: August 28, 2018

PHOTO APPENDIX

View of dam, powerhouse, tailrace, and bypass from right bank (note picture before new flashboard system was installed).

View of tailrace and bypass confluence from right bank

View of the Project Dam and new flashboard system

View of the powerhouse from the intake area

View of the dam and bypass with new flashboards

View of the new forebay, automatic trash rake, and trashrack

View inside the powerhouse showing the new turbine and generator

Project PLC automation controls and switchgear

View of the dam and entrance to the canal pool

Turbine and scroll case

Field measurement
HPP Hoosic River

Version: 05.12.2017

Contractor:

Institut für Hydraulische Strömungsmaschinen
der Technischen Universität Graz
Kopernikusgasse 24/IV
A-8010 Graz

WWS Wasserkraft GmbH & Co KG
Oberfeuchtenbach 11
A-4120 Neufelden

Principal:

William F. Scully
PO Box 338
North Bennington, Vermont 05257
(802) 379-2469

Contact names (alphabetical)

Paul M. Becht,	Turner Group, pbecht@hlturner.com
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Helmut Jaberg,	TU Graz, helmut.jaberg@tugraz.at, Tel.: +43 664 3224642 (mobile)
William F. Scully,	Operator, wfscully@gmail.com
Christoph Wagner,	WWS, c.wagner@wws-wasserkraft.at, Tel.: +43 664 44 30 513 (mobile)

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1 Initial Situation

1.1 Description of the Power Plant

The Hydro Power Plant (HPP) Hoosic River is located in the town Pownal 225 km away from Boston in the southwestern part of Vermont (USA) (Location of the power plant: N42° 47' 44.83" W73° 15' 50.591"). The commissioning of the power plant took place in the second half of 2017. One Kaplan turbine is operated in the HPP to gain energy of the water from the Hoosic River. The manufacturer of the hydraulic turbine is WWS Wasserkraft GmbH & Co KG, the manufacturer of the hydrogenerator is Hitzinger. The turbine with a concrete intake is positioned at the end of a steel penstock with a length of about 28 m and a nominal diameter of 2.43 m. Figure 1 and Figure 2 show the location of the HPP, the power house and machine hall with the machine unit.

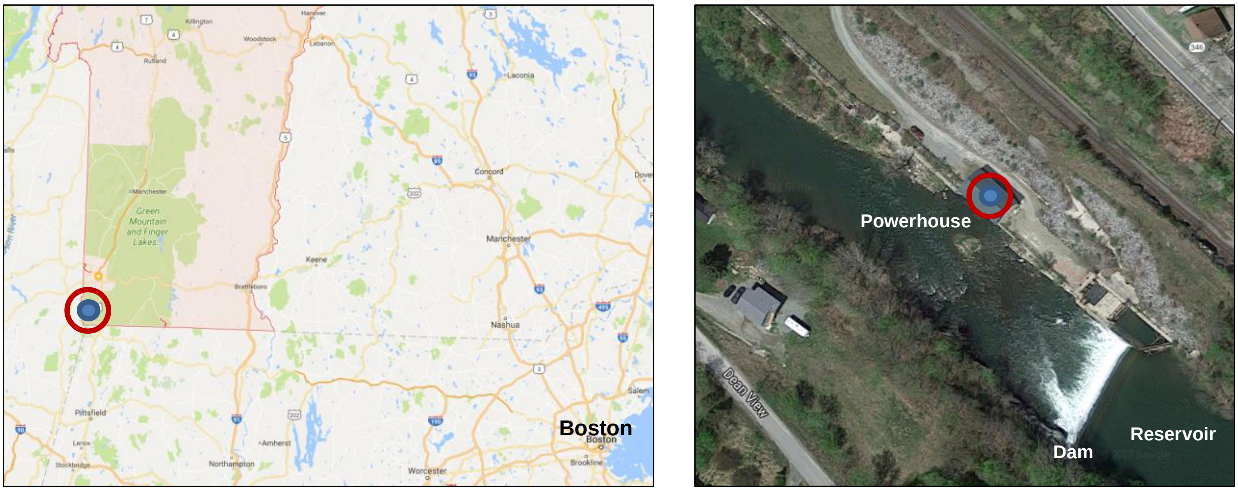


Figure 1: Location of the HPP Hoosic River

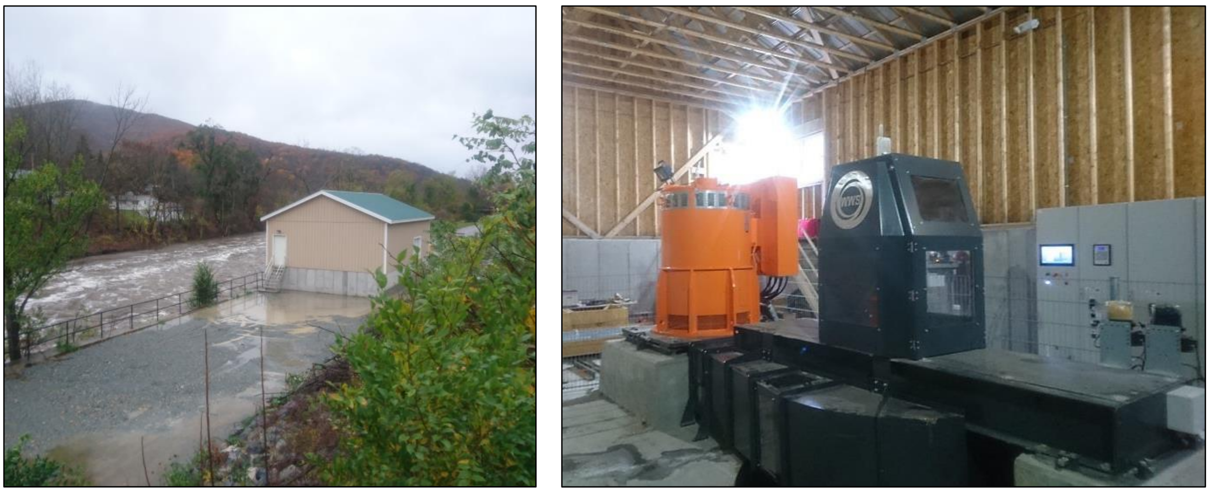


Figure 2: Left – Power house, right – machine hall

The nominal specific speed of the machine is n_{q_BEP}=170 rpm (Table 1). Figure 3 shows a sketch of the machine in side view and a top view of the penstock including the turbine can be seen in Figure 4. The main technical data are summarized with Table 1.

Table 1: Main technical data [5]

Turbine type	**Kaplan-turbine**
Manufacturer	WWS
Nominal Head H_n	6,25 m / 20,5 ft
Nominal Discharge Q_n	9,4 m³/s / 332 ft³/s
Rotational speed n	220 rpm
Build date	2017
Runner diameter	1500 mm
Runner blades	4
Generator	**3-phase-generator**
Manufacturer	Hitzinger
Nominal load	570 kVA
Frequency	60 Hz
Nominal voltage	480 V
Rotational speed n	720 rpm
Belt transmission	Yes

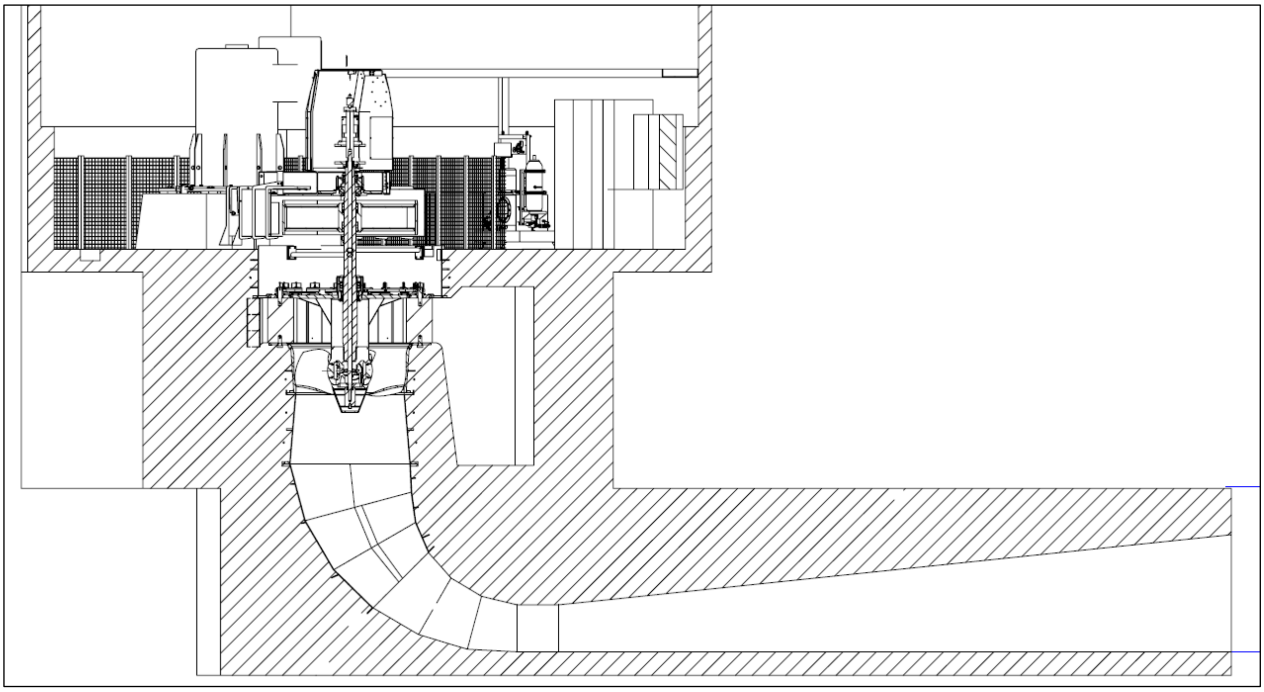


Figure 3: Side view of the turbine [5]

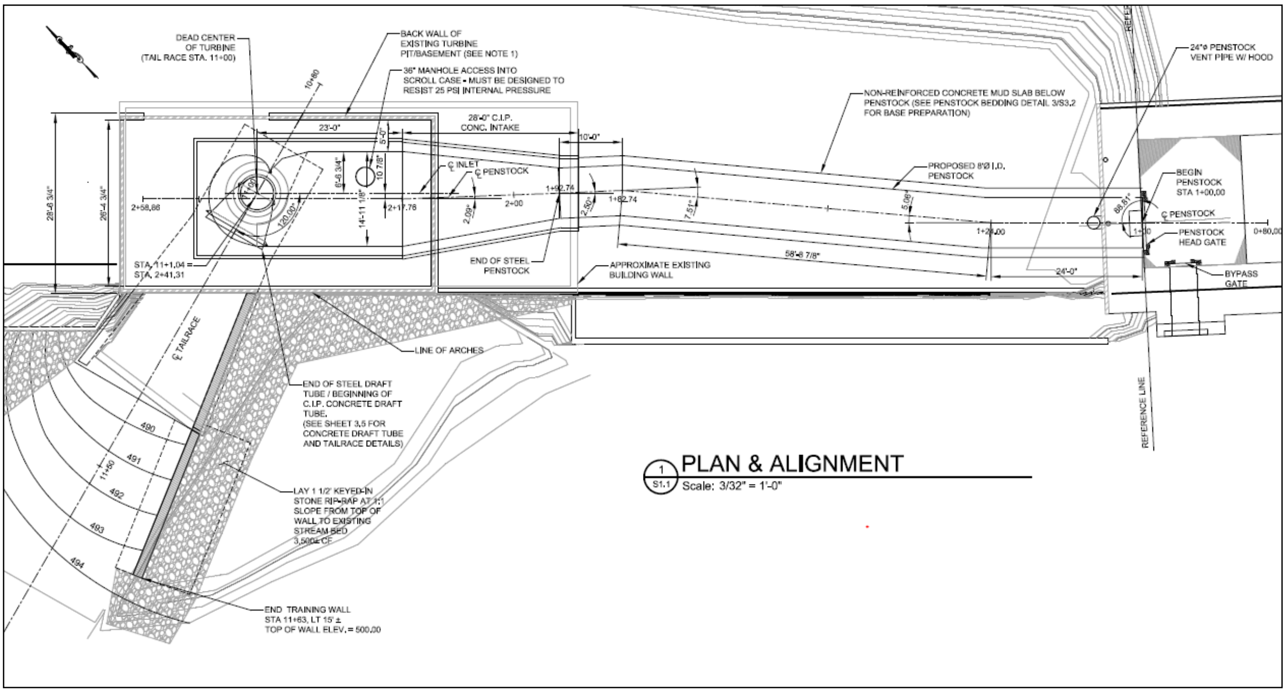


Figure 4: Top view of the penstock and power house [4]

1.2 Field Measurement

The field measurement was assigned by the company WWS Wasserkraft GmbH & Co KG and conducted following the standards IEC 60041 [1], ASME PTC 18-2011 [2] and ISO 3354 [3], respectively.

The following boundary conditions are agreed with the client:

- Efficiency measurement basing on current meter method and level probe measurement of three different operating points (runner/guide vane openings) and one reproducibility point.
- Measurement of the discharge with current meter method (42 measurement points), regarding to the IEC 60041-standard.
  - Area of the measurement section A_M = 1600 m².
  - Consideration of the sediment by measuring the profile.
  - Minimum Flow velocity c_{Mmin}=1.3 m/s at Q=2.6 m³/s.
  - Maximum Flow velocity c_{Mmax}=3.5 m/s at Q =7.0 m³/s.
- In addition the current-meter measurement is used to calibrate the relative Winter-Kennedy method.
- The gross head is calculated with level probes measuring the head and tailwater level. As there is no other possibility the net head is calculated in an analytical way (head loss-calculation to the turbine spiral inlet according to IEC60041).
- A Fluke power analyzer is used to measure the generator active power.
- The turbine efficiency is calculated by referring the unit efficiency to the generator efficiency and the belt efficiency.

2 Measured Values

2.1 Discharge Measurement

A velocity field was measured in a predefined section in the forebay channel, in front of the trash rake (see Figure 5). The velocity component perpendicular to the cross section is relevant for the discharge. The velocity is measured by an OTT C31 current meter. The discharge measurement section was divided in a grid of 42 measurement points. With seven current meters in a horizontal position six different heights were measured (see Figure 6 and Figure 7).

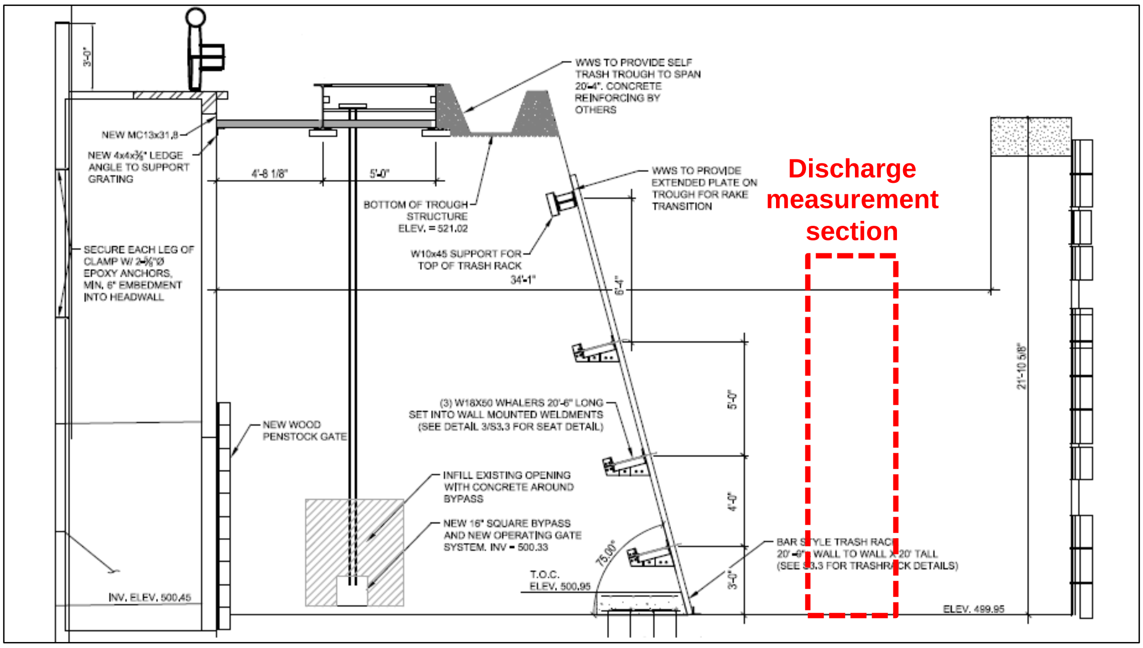


Figure 5: Chosen measurement section [4]

Figure 6: Mounting of the current meters on the trash rack cleaner

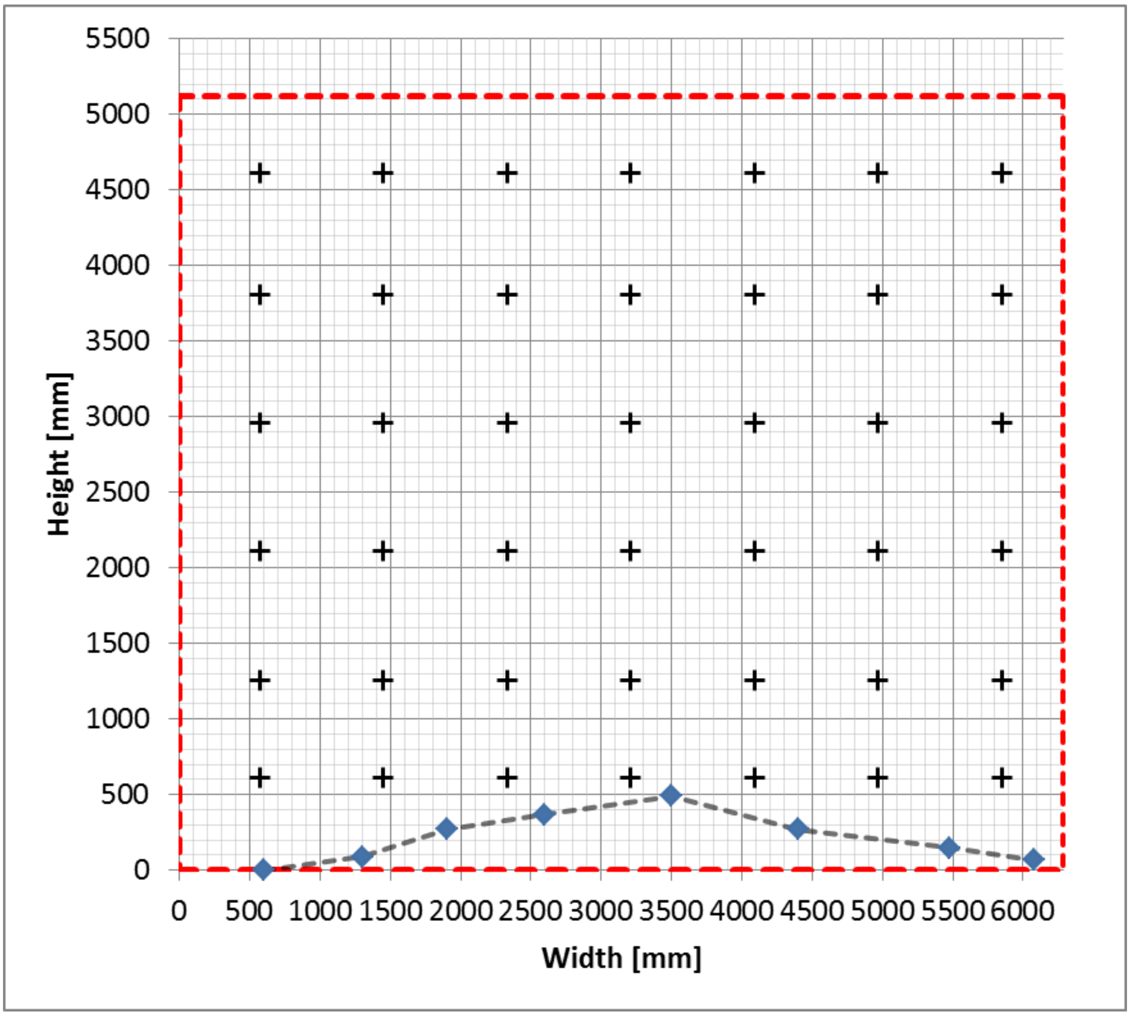


Figure 7: Current meter position in the forebay channel

Because of sedimentation the area of the measurement section was not rectangular. To consider the profile of the ground depth measurements at different positions were performed. The distances from the current meter position to the walls, the ground and the air was reduced. The discharge measurement was performed according to the standard IEC60041 [1]: Discharge measurement in open channels. Additional the ISO 3354 standard [4]: Rectangular cross-sections was used to calculate the discharge. As stated in the standard the discharge was calculated with equations which are derived from interpolations between successive pairs of measuring points and additional measured with the help of 3D-CAD software.

The measurement device to record the flow velocity was an OTT C31 current meter in combination with an OTT Z400 counterset (see Figure 8). By counting the impulses it automatically records the number of propeller revolutions. The OTT C31 Universal Current Meter is designed for flow velocity measurements in combination with wading rods or cable suspended from a bridge or boat.

The used current meters are calibrated within a range of 0-5 m/s. The calibration certificates were handed out during the measurement and can be provided if needed. The used current meter types comply with the requirements of the standard.

Table 2: Discharge measurement device

Type	OTT Z400
Measurement range	50 Hz (680 Ohm), 100 Hz
Accuracy	± 0,01 s / ± 0,5 Impulse
Type	OTT C31
Propeller type	6 x Type 1, 1 x Type 2
Measurement range	0.025 ... 10 m/s
Accuracy	± 2%

Figure 8: Measurement equipment for discharge measurement: OTT C31 current meter and OTT Z400 counterset

2.2 Head Measurement

The gross head was measured with level probes measuring the head and tailwater level (see Figure 9). The gross head was defined as difference between the head water level in the forebay before the fine trash rack and the tailwater level. The outlet pressure was measured as the pressure height of tail water level right after the draft tube outlet by means of a level probe. The determination of the gross head was checked with a Leica NA324 levelling instrument on both points. As there was no other possibility the net head was calculated analytically. The losses were calculated as described in chapter Evaluation. The calibration certificate is attached to the report.

Figure 9: Head and tail water measurement probe

2.3 Power Measurement

The active power was recorded with the power measurement device Fluke 435 Power Quality Analyzer (Figure 10). A three phase power measurement was performed and the values were compared with the values of the Scada control system. The calibration protocol of the Fluke 435 is available at WWS.

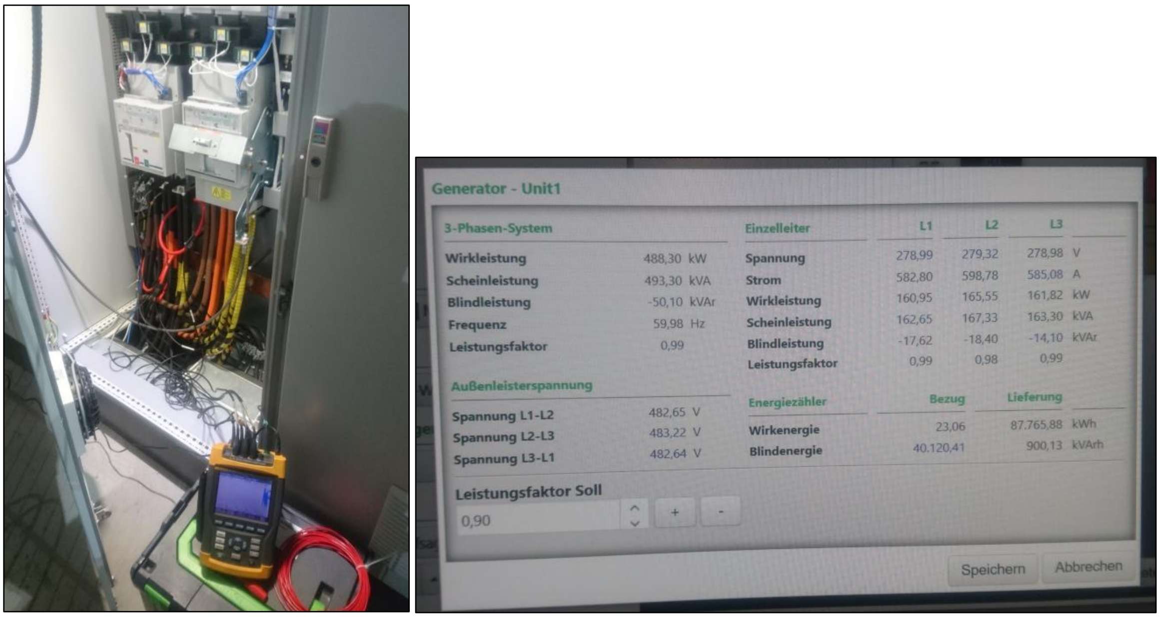


Figure 10: Control system Scada power measurement

2.4 Guide Vane Opening

The guide vane opening was measured by the control system. The measured values were recorded and compared with the values of the mechanical angle disc and the scale (Figure 11).

Figure 11: Guide vane opening

2.5 Rotational Speed

The fluctuations of the rotational speed were checked with the Fluke 435 Power Analyzer.

2.6 Temperature Measurement

The temperature of the water was measured upstream with a thermocouple.

2.7 Winter-Kennedy Measurement

A differential pressure measurement was performed at the spiral casing of the turbine. The pressure measurement taps are located according to the standard. The pressure measurement tubes were flushed and checked before the measurement.

Figure 12: Winter-Kennedy differential pressure measurement device

3 Execution of the Measurements

The setup of the measurement equipment took place on Monday, the 30th of November 2017, the measurements on Wednesday (1st of November 2017, see Table 3). All measured values were recorded simultaneously and checked independently of each other.
It was not possible to open and check the turbine in the course of the measurement programme.

3.1 Participants and Witnesses

Below the witnesses and involved persons (without academic title):

<u>H.L. Turner Group</u>
Paul M. Becht
Bob Carter

<u>TU Graz</u>
Mark Guggenberger
Helmut Benigni (measurement report)
Helmut Jaberg (measurement report)

<u>Vermont Watershed Management</u>
Jeff Crocker

<u>WWS</u>
Christoph Wagner

3.2 Measuring Procedure

The measurement programme included three predefined operation points from 77 to 350 ft³/s. To check the reproducibility one operation point was set and measured a second time. Before and after the measurement a zero-measurement of the gross head was performed.

Table 3: Procedure of the measurement programme

Monday 30th October 2017	Setup equipment
Tuesday 31th October 2017	Test measurement
Wednesday 1st November 2017	Q=77 ft³/s
	Q=110 ft³/s
	Q=350 ft³/s and Reproducibility measurement
	Removal of equipment

4 Generator

The information of the generator efficiency was provided by WWS [6]. During the measurement programme different generator loads were set. Therefore it was necessary to determine the efficiency values at different power factors. The function of the efficiency was calculated by interpolation of the known values with polynomic approximations (third order polynomial) (Table 4, Figure 13).

Table 4: Generator efficiency values [6]

Generator data				
Load [%]	100	75	50	25
cos(phi) 0,9	95,50	95,80	95,20	91,20
cos(phi) 0,99	96,04	96,34	96,01	92,10
cos(phi) 1,0	96,10	96,40	96,10	92,20
Nominal Last	570	[kVA]		

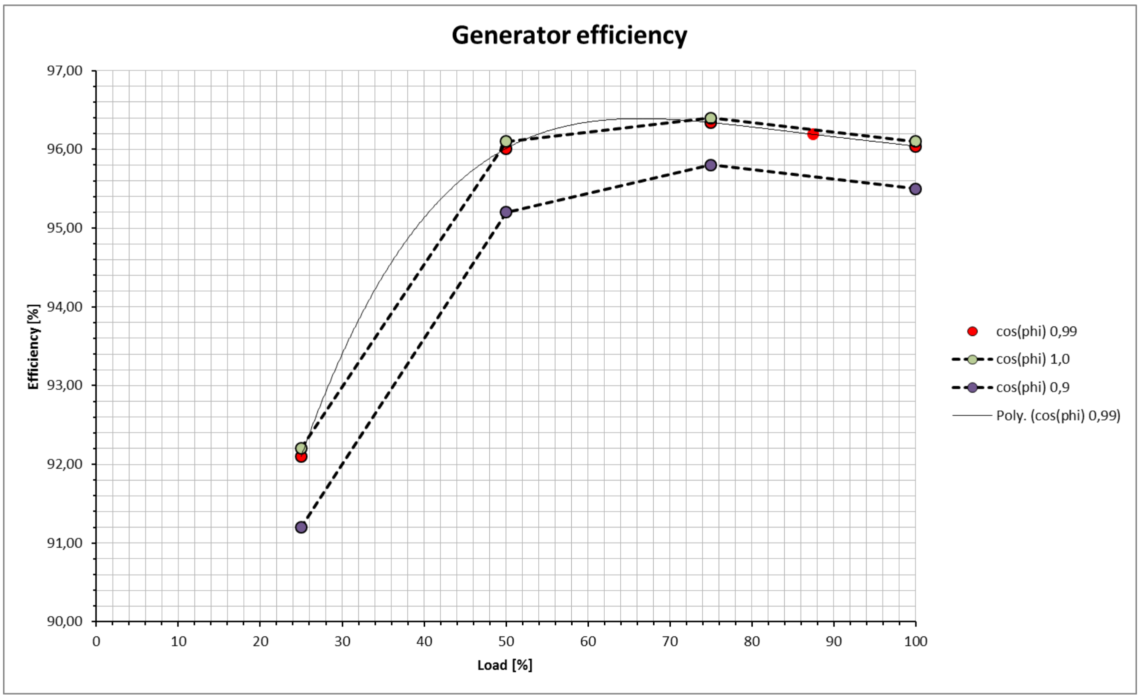


Figure 13: Generator efficiency

5 Evaluation

5.1 Calculation Formulas

<u>Head [m]:</u>

As already mentioned the gross head is calculated with level probes measuring the head and tail water level. As there is no other possibility the net head is calculated in an analytical way.

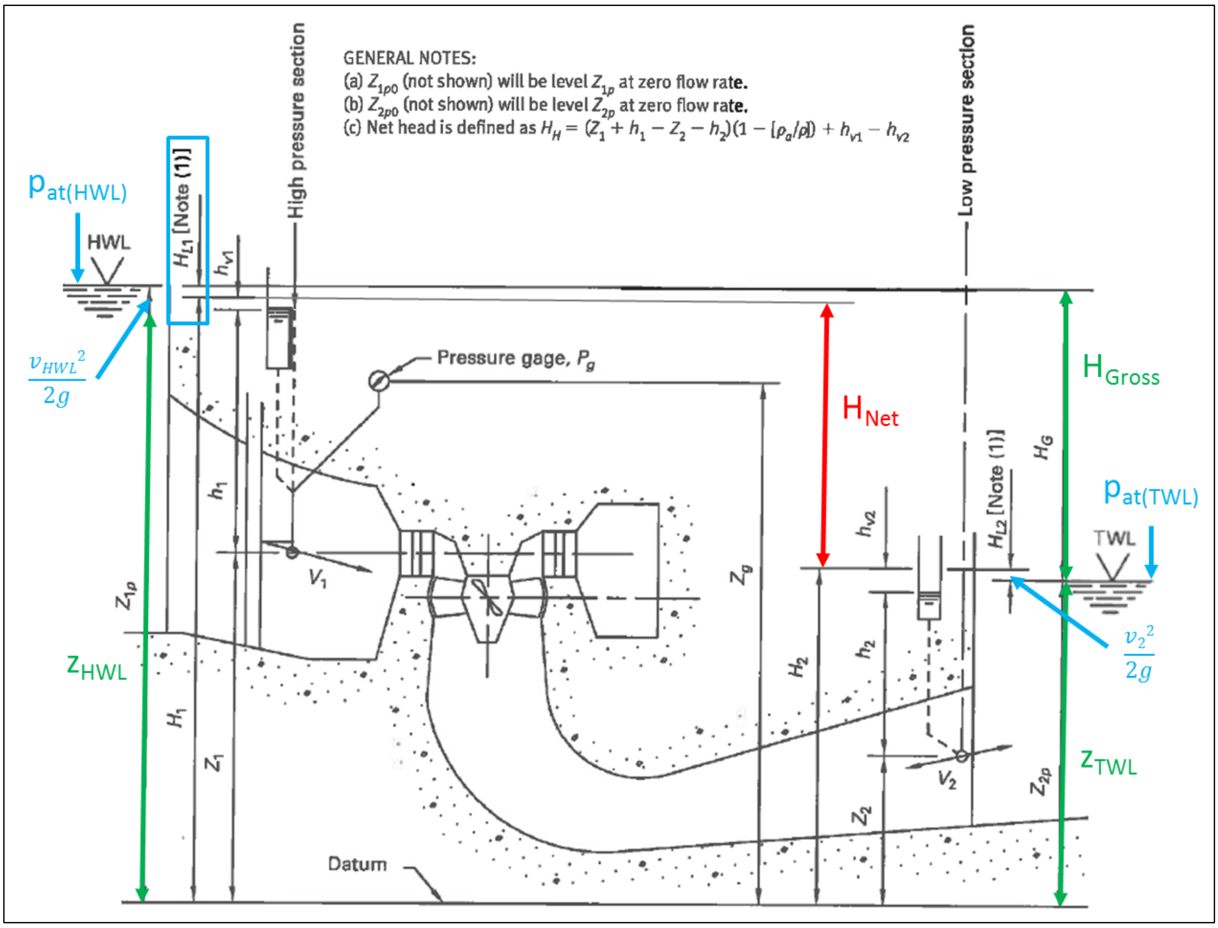


Figure 14: Sketch of the calculation process for the head [2]

To calculate the gross head H_{Gross} the levels of the head water ($z_{1p}=z_{HWL}$) and tail water ($z_{2p}=z_{TWL}$) are needed. The difference of the air pressure is taken in account according to the standard [2].

$$H_{Gross} = \frac{p_{at}(HWL)}{\rho g} + z_{HWL} - \frac{p_{at}(TWL)}{\rho g} - z_{TWL}$$

$$p_{at}(TWL) = p_{at}(HWL) + \rho_a g (z_{HWL} - z_{TWL})$$

$$H_{Gross} = (z_{HWL} - z_{TWL}) \cdot (1 - \frac{\rho_a}{\rho})$$

The net head is calculated as the gross head reduced by the losses.

$$H_{Net} = H_{Gross} - \sum h_{L\,HWL\to 1} + (\frac{v_{HWL}^2 - v_2^2}{2g})$$

$$H_{Net} = (z_{HWL} - z_{TWL}) \cdot \left(1 - \frac{\rho_a}{\rho}\right) - \sum h_{L\,HWL\to 1} + (\frac{v_{HWL}^2 - v_2^2}{2g})$$

The sum of the losses from head water level to the intake of the turbine is calculated analytically.

Losses [m] [6]:

The sum of the losses (see Figure 15) is defined by:

$$\sum h_{L\,HWL\to 1} = hv1 + hv2 + hv3 + hv4$$

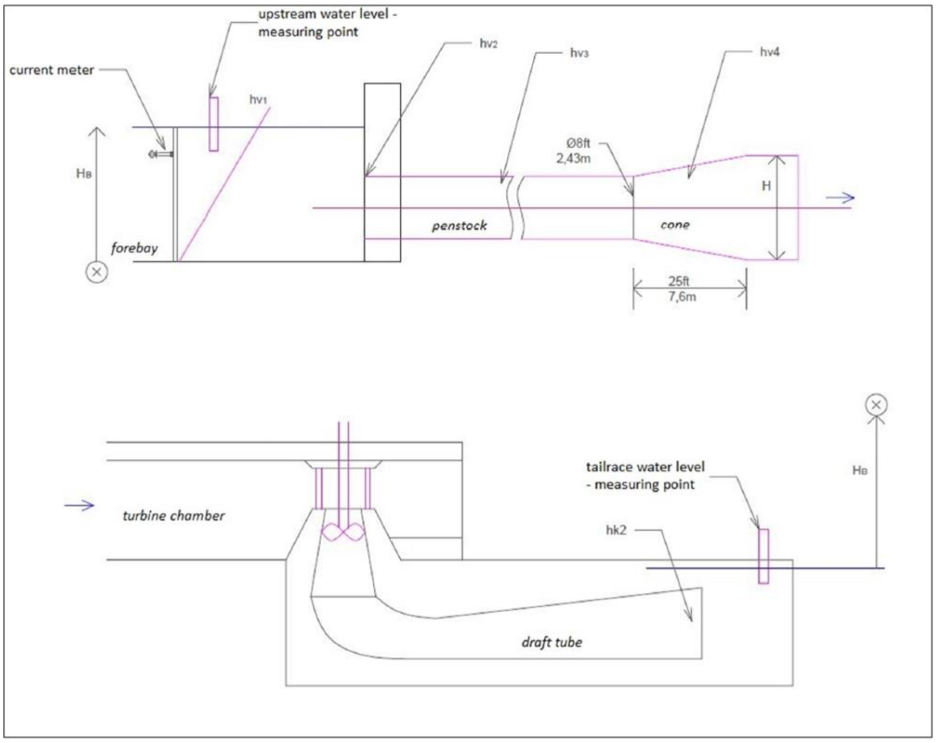


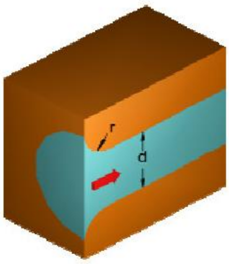
Figure 15: Calculation of the losses [6]

hv1: Fine trash rake losses
Determined by a level measurement before and after the fine trash rake.

hv2: Pipe entry losses
For the determination of the penstock entry losses, the sketch below is used according to Idelchick [8]: Penstock inlet with radius. The guide rails are not included in the calculation. The

losses of the pipe entry are based on assumptions due to the fact that no inspection of the piping system was possible out during the field measurement.

D	8 ft	...diameter of penstock
D	2438,4 mm	
A	4,67 m²	...cross section of penstock
Q	350 cfs	...flow rate / discharge
Q	9,91 m³/s	
v_{max}	2,12 m/s	...maximum stream velocity
g	9,81 m/s²	...gravitational constant
H_N	6,25 m	...net height



r / D_h	0	0,01	0,02	0,03	0,04	0,05	0,06	0,08	0,12	0,16	...quotient of radius and penstock diameter
ζ	0,5	0,44	0,37	0,31	0,26	0,22	0,2	0,15	0,09	0,06	...pressure loss coefficient
r [mm]	0	24,4	48,8	73,2	97,5	121,9	146,3	195,1	292,6	390,1	...radius
r [ft]	0	0,08	0,16	0,24	0,32	0,40	0,48	0,64	0,96	1,28	
h_V [m]	0,115	0,101	0,085	0,071	0,060	0,050	0,046	0,034	0,021	0,014	...loss of height
h_V [ft]	0,377	0,331	0,279	0,233	0,196	0,166	0,151	0,113	0,068	0,045	
h_V [%]	1,84%	1,62%	1,36%	1,14%	0,95%	0,81%	0,73%	0,55%	0,33%	0,22%	

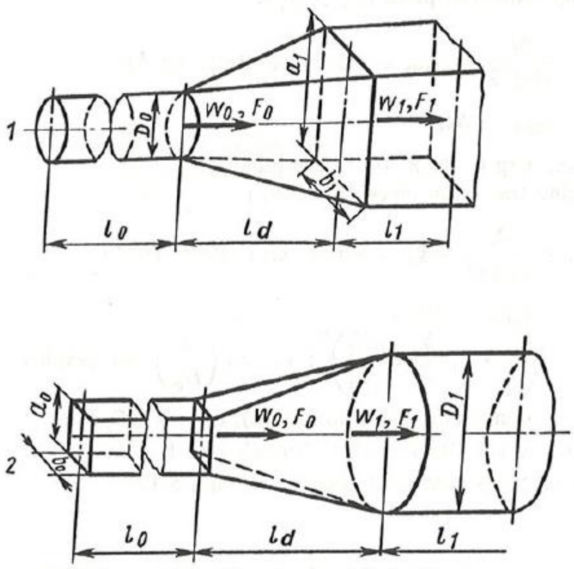
Figure 16: Pipe entry losses [8]

hv3: Pipe friction losses

Length: ~92ft = 28m, Diameter 8 ft = 2,43m, Pipe roughness ~0,02mm (estimation), calculation according to Prandtl-Colebrook, including the losses for the bends (5° and 7.5°). The losses of the pipe friction are based on assumptions.

hv4: Outlet losses in the cone

For the determination of the outlet losses in the cone, the sketch below is used according to Idelchick [8]: Pyramidal diffusor of rectangular cross section, for transition from a circle into a rectangle.



$$\zeta = \frac{\Delta p}{\rho w_0^2/2}$$

see Diagram 5-4 for a pyramidal diffuser of rectangular cross section with an equivalent divergence angle which is determined from the relations:

for transition from a circle into a rectangle

$$\tan\frac{\alpha}{2} = \frac{2\sqrt{a_1 b_1/\pi} - D_0}{2l_d}$$

for transition from a square into a circle

$$\tan\frac{\alpha}{2} = \frac{D_1 - 2\sqrt{a_0 b_0/\pi}}{2l_d}$$

Figure 17: Pipe entry losses [6]

Discharge [m³/s]:

The calculation of the discharge was done with two different methods: On the one hand a determination of the mean axial fluid velocity by numerical integration of the velocity area was performed. On the other hand the discharge was determined of the mean axial fluid velocity by graphical integration of the velocity area.
The graphical integration was carried out with the software package Catia V5. The measured values were imported with regard to their a- and y-coordinates. The single points were then interpolated with vertical and horizontal splines (3rd order splines). The values at the wall were set to zero. Additional at the wall area zone the tangent of the profile was set parallel to the wall. The mesh of curves was connected to a closed surface. In combination with the back side a volume was merged considering the sedimentation on the ground of the forebay. The resulting volume is equal to the discharge in m³/s. The 3D-profiles of the determined discharge are shown in the attachment.
The calculation of the discharge by numerical integration according to ISO 3354 is described in the attachment.

Hydraulic power [kW]:

$$P_H = \rho \cdot g \cdot Q \cdot H$$

The hydraulic energy results from the product of the discharge, the head, the density and the gravity.

Gravity [m/s²] and density of water [kg/m³]:

A gravity constant of g = 9.8032m/s² is given for the geographical location N42° 47' 44.83" W73° 15' 50.591" of the power plant according to [7]. The mean density of water at 7,.3°C and the different inlet and outlet pressures ρ=999.9156 kg/m³ was used according to [1].

Discharge transposed to the specific head [m³/s]:

$$Q_{Ref} = Q \cdot \left(\frac{H_{Ref}}{H}\right)^{0.5}$$

To transpose the discharge at the measured head to that at the specific head the formula above is used. This is provided for a head in between the given limits: $0.97 \leq (H_{Ref}/H)^{0.5} \leq 1.03$.

Power transposed to the specific head [kW]:

$$P_{Ref} = P \cdot \left(\frac{H_{Ref}}{H}\right)^{1.5}$$

To transpose the hydraulic power at the measured head to that at the specific head the formula above is used. This is provided for a head in between the given limits: $0.97 \leq (H_{Ref}/H)^{0.5} \leq 1.03$.

Unit efficiency [%]:

$$\eta_U = \frac{P_A}{P_H}$$

The unit efficiency is calculated by dividing the active power with the hydraulic power.

Turbine efficiency [%]:

$$\eta_T = \frac{\eta_U}{\eta_G \cdot \eta_B}$$

By dividing the unit efficiency with the generator efficiency and the belt efficiency finally the turbine efficiency can be calculated.

The specific parameters of the plant are listed in Table 5.

Table 5: HPP Parameters [6]

Parameter and substance data				
Net Head	H		6,25	m
Discharge	Q		9,4	m³/s
Power	P		521	kW
Rotational speed	n		220	rpm
Specific speed	nq		171	
Pipe length	L_Pipe		28,00	m
Pipe diameter	D_Pipe		2,44	m
Pipe friction coefficient	λ		0,020	
Pipe cross section	A_Pipe		4,67	m²
Resistance Pipe-Cone	ζ_P_C		0,13	
Outlet area suction pipe	A_o		9,00	m²
Level probe difference	Δz_Probe		5,99	m
Reference Head 1	Current-meter H_Ref1		6,00	m
Average water density	ρ		999,9156	kg/m³
Air density	ρa		1,2466	kg/m³
Gravity	g		9,8032	m/s²

Raw data of the measurement is listed in Table 6.

Table 6: Raw data of the measurement

Operation Point	Date of measurement	Duration of measurement		Guide vane opening actual value	Runner opening actual value	Discharge	Discharge	Head water level	Head water level after trash rake	Tail water level	Winter Kennedy Pressure	Generator active power Fluke	Generator active power CS	Generator reactive power	Generator apparent power	Power factor	Water temperature	Note
OP	-	Start	End	GVO_%	RNO_%	Q	ft³/s	HWL	HWL	TWL	p_WK	P_A	P_A	P_Q	P_S	cos(phi)	T_W	-
#	dd.mm.	hh:mm	hh:mm	%	%	m³/s	m³/s	cm	cm	cm	Pa	kW	kW	kVAr	kVA	-	°C	-
1	01.11.	13:30	14:20	24,0	-	2,457	86,781	169,68	166,54	150,79	2,4	97,58	97,58	8,67	97,97	1,00	7,3	Current-meter
2	01.11.	14:30	15:10	28,0	22,4	3,365	118,852	167,83	163,25	149,79	3,8	157,90	155,50	15,38	156,26	1,00	7,3	Current-meter
3	01.11.	15:20	15:55	62,0	70,0	10,554	372,719	157,44	152,64	155,05	33,9	494,54	489,23	61,01	493,02	0,99	7,3	Current-meter
4	01.11.	16:00	16:35	62,0	70,0	10,713	378,323	154,46	149,47	151,52	35,7	493,10	488,36	67,33	492,98	0,99	7,2	C-m: Reproducibility
4	30.10.			20,0	10,0	1,923	67,894				1,2		53,67					Winter-Kennedy
9	30.10.			23,0	15,0	2,450	86,519				1,9		77,97					Winter-Kennedy
10	30.10.			28,0	15,0	2,507	88,545				2,0		80,09					Winter-Kennedy
14	30.10.			27,0	20,0	3,011	106,335				2,9		117,12					Winter-Kennedy
19	30.10.			30,0	25,0	3,647	128,788				4,2		159,64					Winter-Kennedy
24	30.10.			34,0	30,0	4,266	150,642				5,8		199,35					Winter-Kennedy
31	30.10.			47,0	35,0	5,394	190,487				9,2		256,52					Winter-Kennedy
34	30.10.			41,0	40,0	5,629	198,786				10,0		276,14					Winter-Kennedy
35	30.10.			46,0	40,0	5,852	206,657				10,8		286,91					Winter-Kennedy
39	30.10.			44,0	45,0	6,319	223,156				12,6		310,48					Winter-Kennedy
40	30.10.			49,0	45,0	6,581	232,410				13,7		323,84					Winter-Kennedy
44	30.10.			48,0	50,0	7,034	248,388				15,7		343,54					Winter-Kennedy
50	30.10.			51,0	55,0	7,766	274,245				19,1		379,36					Winter-Kennedy
55	30.10.			55,0	60,0	8,803	310,874				24,5		413,63					Winter-Kennedy
60	30.10.			58,0	65,0	9,542	336,963				28,8		441,73					Winter-Kennedy
65	30.10.			62,0	70,0	10,374	366,371				34,1		464,78					Winter-Kennedy
69	30.10.			60,0	75,0	10,732	379,004				36,5		477,57					Winter-Kennedy

5.2 Calculation Table

The results of the measurements are presented in Table 7.

Table 7: Results of the measurements

Pipe velocity	HWL velocity	Outlet velocity	HWL velocity losses	Gross Head	Fine trash rake losses	Pipe entry losses	Pipe friction losses	Outled losses in the cone	Outlet losses	Net head	Head losses	Hydraulic power	Generator output active power	Unit efficiency	Turbine efficiency	Generator load	Generator efficiency	Belt efficiency	Turbine shaft power	Reference discharge	Reference hydraulic power	Reference active power	Reference turbine shaft power
c_{Pipe}	c_{HWL}	c_{out}	hk1	H_G	hv1	hv2	hv3	hv4	hk2	H	H_L	P_H	P_A	η_U	η_T	G_L	η_G	η_B	P_T	Q_{Ref}	P_{H_Ref}	P_{A_Ref}	P_{T_Ref}
m/s	m/s	m/s	m	m	m	m	m	m	m	m	m	kW	kW	%	%	%	%	%	kW	m^3/s	kW	kW	kW
0,53	0,08	0,27	0,000	6,175	0,031	0,0062	0,003	0,002	0,004	6,128	0,05	147,61	97,58	66,11	75,54	17,12	89,29	98,00	111,51	2,43	143,01	94,54	108,03
0,72	0,11	0,37	0,001	6,166	0,046	0,0117	0,006	0,003	0,007	6,092	0,07	200,98	157,90	78,57	86,35	27,70	92,84	98,00	173,54	3,34	196,43	154,33	169,62
2,26	0,36	1,17	0,006	6,016	0,048	0,1146	0,060	0,034	0,070	5,689	0,33	588,60	494,54	84,02	89,12	86,76	96,20	98,00	524,57	10,84	637,46	535,59	568,12
2,29	0,36	1,19	0,007	6,022	0,050	0,1181	0,062	0,035	0,072	5,685	0,34	596,97	493,10	82,60	87,61	86,51	96,20	98,00	523,03	11,01	647,30	534,67	567,12
0,41		0,21		6,257	0,050	0,0038	0,002	0,001	0,002	6,198	0,06	116,80	53,67	45,95	54,87	9,42	85,46	98,00	64,08	1,89	111,25	51,12	61,04
0,52		0,27		6,238	0,050	0,0062	0,003	0,002	0,004	6,173	0,06	148,24	77,97	52,60	61,18	13,68	87,73	98,00	90,69	2,42	142,06	74,72	86,91
0,54		0,28		6,236	0,050	0,0065	0,003	0,002	0,004	6,170	0,07	151,65	80,09	52,81	61,30	14,05	87,91	98,00	92,97	2,47	145,41	76,80	89,14
0,64		0,33		6,207	0,050	0,0093	0,005	0,003	0,006	6,134	0,07	181,05	117,12	64,69	72,83	20,55	90,64	98,00	131,86	2,98	175,15	113,31	127,56
0,78		0,41		6,173	0,050	0,0137	0,007	0,004	0,008	6,090	0,08	217,69	159,64	73,33	80,53	28,01	92,92	98,00	175,30	3,62	212,90	156,12	171,44
0,91		0,47		6,141	0,050	0,0187	0,010	0,006	0,011	6,046	0,10	252,80	199,35	78,86	85,25	34,97	94,39	98,00	215,51	4,25	249,93	197,10	213,07
1,16		0,60		6,095	0,050	0,0299	0,016	0,009	0,018	5,973	0,12	315,80	256,52	81,23	86,65	45,00	95,66	98,00	273,64	5,41	317,96	258,27	275,51
1,21		0,63		6,080	0,050	0,0326	0,017	0,010	0,020	5,951	0,13	328,34	276,14	84,10	89,47	48,45	95,92	98,00	293,77	5,65	332,43	279,59	297,44
1,25		0,65		6,071	0,050	0,0352	0,018	0,010	0,022	5,936	0,14	340,47	286,91	84,27	89,54	50,34	96,03	98,00	304,87	5,88	346,04	291,60	309,85
1,35		0,70		6,052	0,050	0,0411	0,021	0,012	0,025	5,902	0,15	365,60	310,48	84,92	90,07	54,47	96,21	98,00	329,30	6,37	374,71	318,22	337,50
1,41		0,73		6,041	0,050	0,0446	0,023	0,013	0,027	5,883	0,16	379,53	323,84	85,33	90,43	56,81	96,28	98,00	343,21	6,65	390,88	333,53	353,48
1,51		0,78		6,025	0,050	0,0509	0,027	0,015	0,031	5,852	0,17	403,46	343,54	85,15	90,18	60,27	96,35	98,00	363,84	7,12	418,87	356,67	377,73
1,66		0,86		5,997	0,050	0,0621	0,032	0,018	0,038	5,796	0,20	441,20	379,36	85,98	91,03	66,55	96,39	98,00	401,60	7,90	464,71	399,57	423,00
1,89		0,98		5,969	0,050	0,0797	0,042	0,024	0,049	5,725	0,24	494,03	413,63	83,73	88,66	72,57	96,36	98,00	438,00	9,01	530,01	443,76	469,91
2,04		1,06		5,946	0,050	0,0937	0,049	0,028	0,057	5,669	0,28	530,19	441,73	83,32	88,27	77,50	96,31	98,00	468,00	9,82	577,36	481,03	509,64
2,22		1,15		5,927	0,050	0,1108	0,058	0,033	0,068	5,608	0,32	570,34	464,78	81,49	86,38	81,54	96,26	98,00	492,67	10,73	631,11	514,31	545,17
2,30		1,19		5,917	0,050	0,1185	0,062	0,035	0,073	5,579	0,34	586,92	477,57	81,37	86,28	83,78	96,24	98,00	506,38	11,13	654,58	532,62	564,75

The evaluation of the measured current-meter data shows a good reproducibility of 1.51% in the turbine efficiency.

6 Results

Hereinafter the results of the measurements of the Guide vane opening, the discharge, the active power, the Winter-Kennedy-measurement and the turbine efficiency are presented.

6.1 Guide Vane Opening

Figure 18 and Figure 19 show the discharge and the generator active power as function of the guide vane opening in [%]. The measured values are interpolated with a polynomial function.

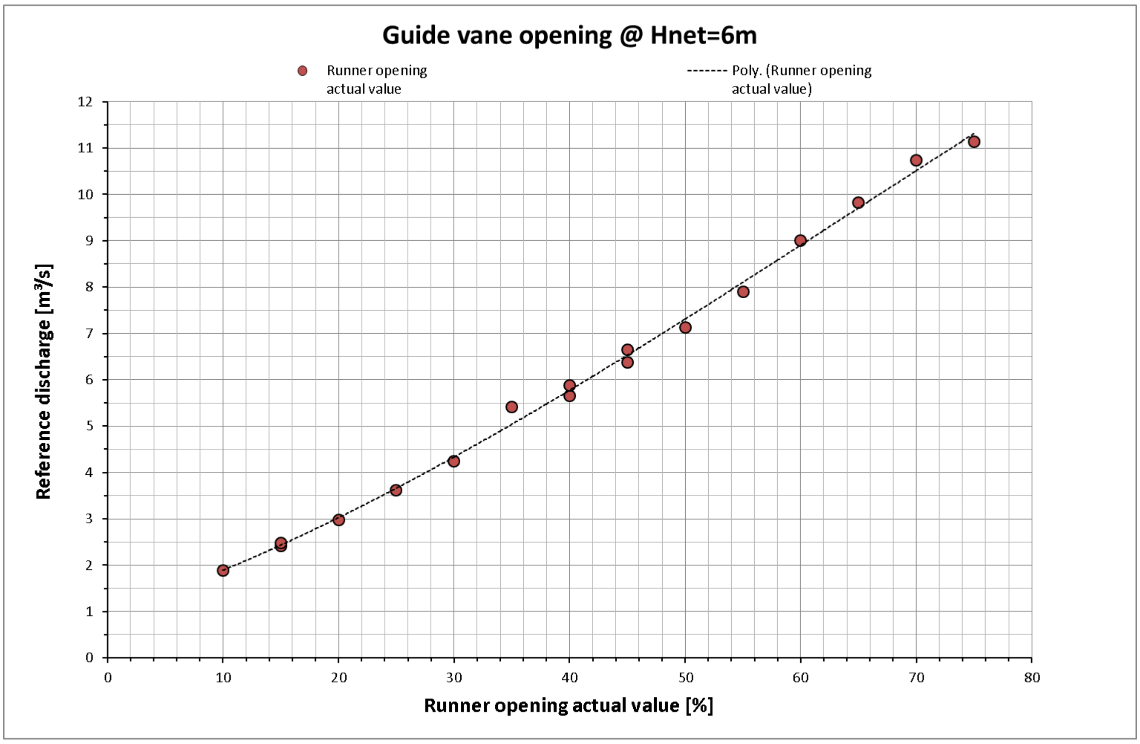


Figure 18: Discharge as function of the guide vane opening [%]

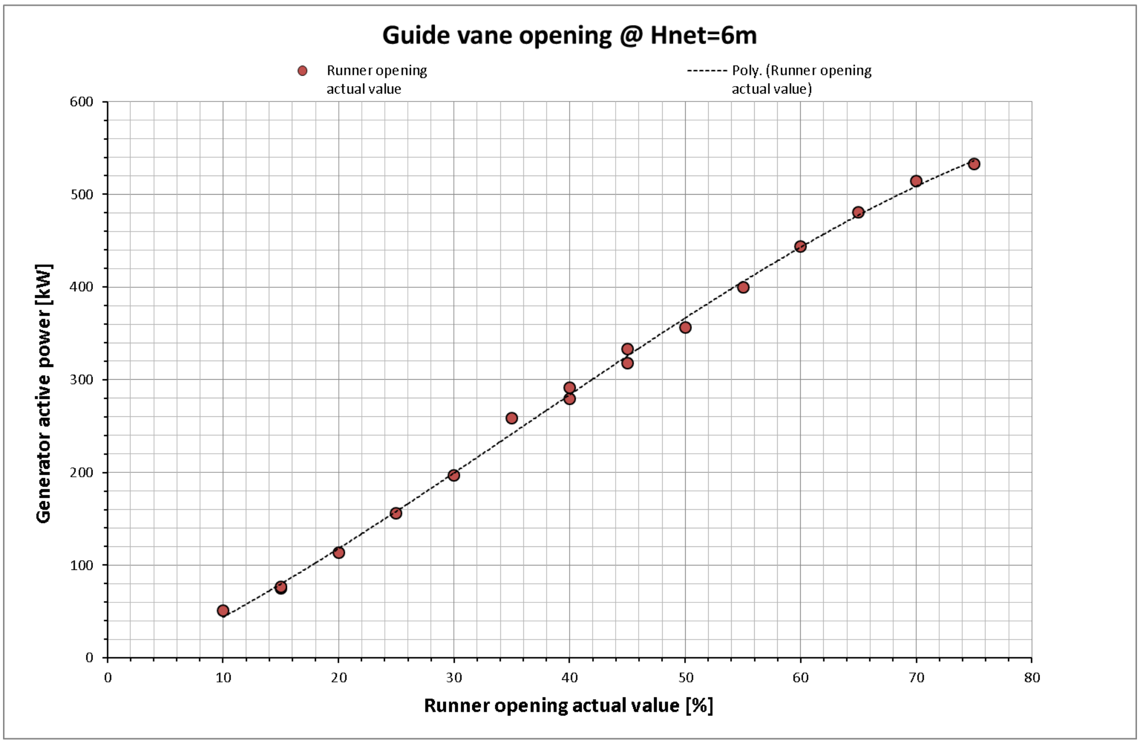


Figure 19: Generator active power as function of the guide vane opening [%]

6.2 Winter-Kennedy-Measurement

The Winter-Kennedy differential pressure is plotted against the discharge measured with the current-meter-method (see Figure 20). The mean value of the absolute method is used to calibrate the relative method.

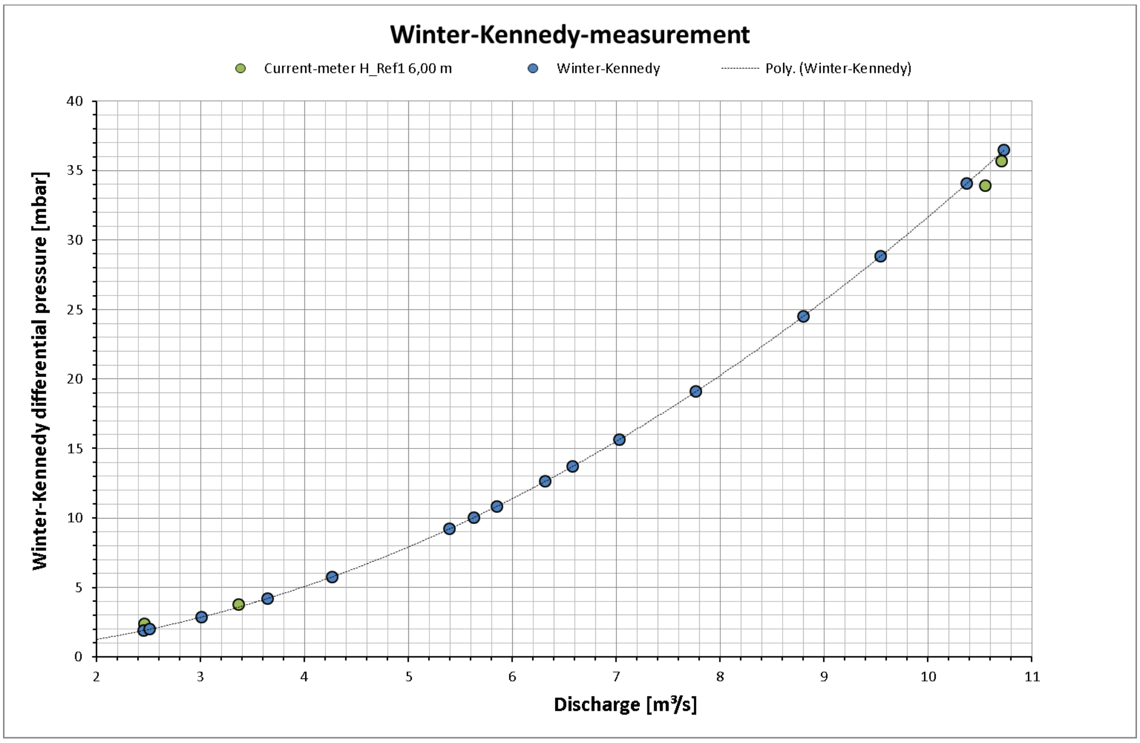


Figure 20: Winter-Kennedy differential pressure as a function of the discharge

6.3 Turbine Efficiency

The turbine efficiency is shown in Figure 21 and Figure 22 without the error bands. A presentation of the efficiency curves including the error bands is shown in the appendix. The best efficiency of the Kaplan turbine measured with the current meters was 89.12 % at 10.84 m³/s transposed to the specific head of 6 m. For flow rates below 5.6 m³/s the values of the Winter-Kennedy-measurement are not feasible and the current meter measurements have to be used to validate the turbine efficiency.

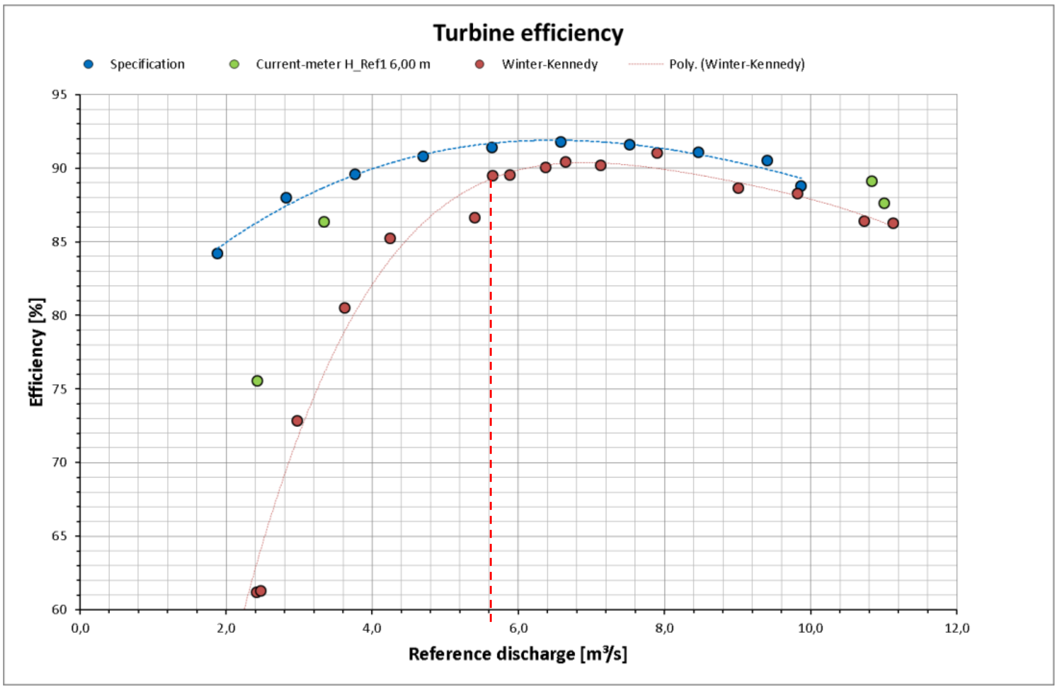


Figure 21: Turbine efficiency as function of the discharge

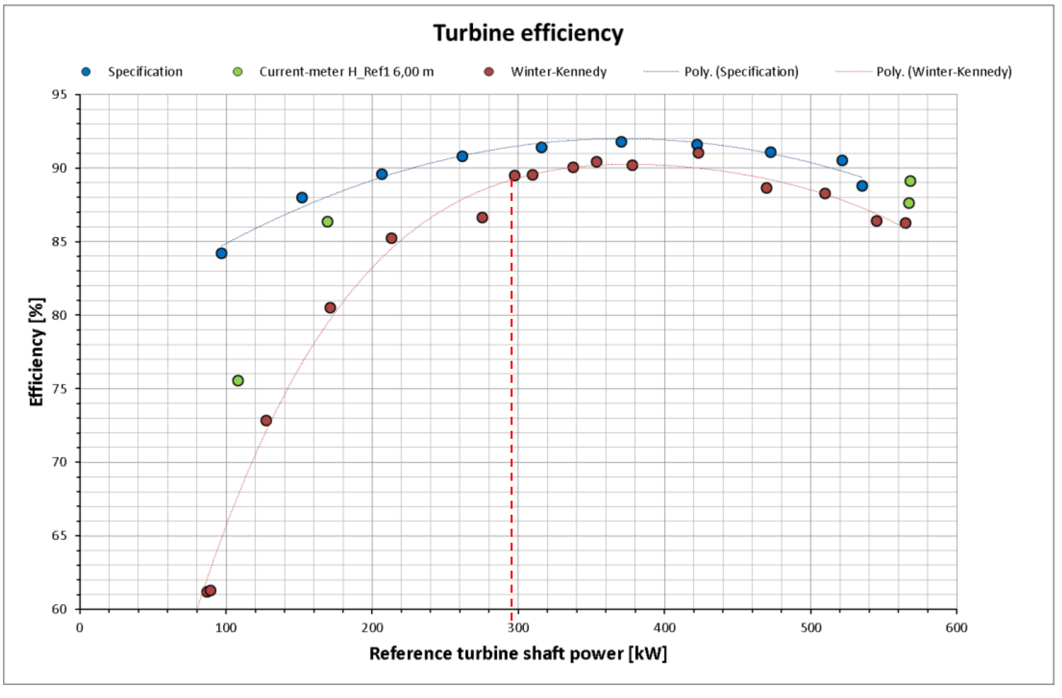


Figure 22: Turbine efficiency as function of the shaft power

6.4 Turbine Power

The generator output power is shown in Figure 23. The turbine shaft power was recalculated with the help of the generator and the belt efficiency and is presented in Figure 24.

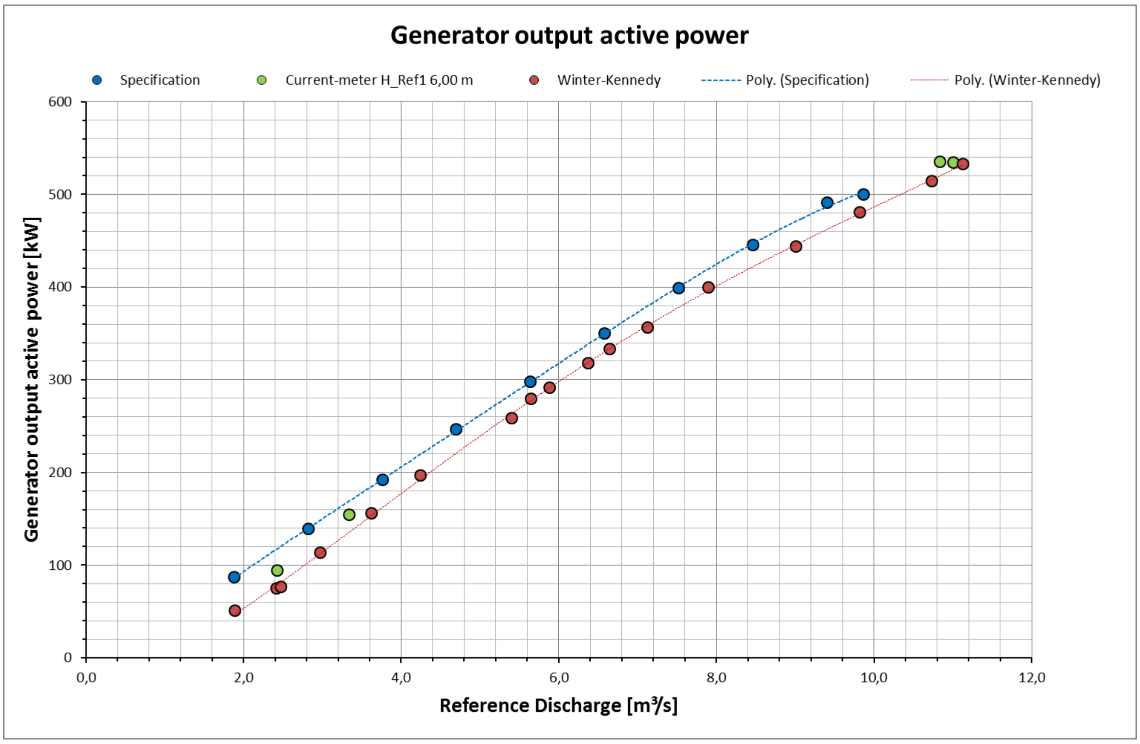


Figure 23: Generator output power as function of the discharge

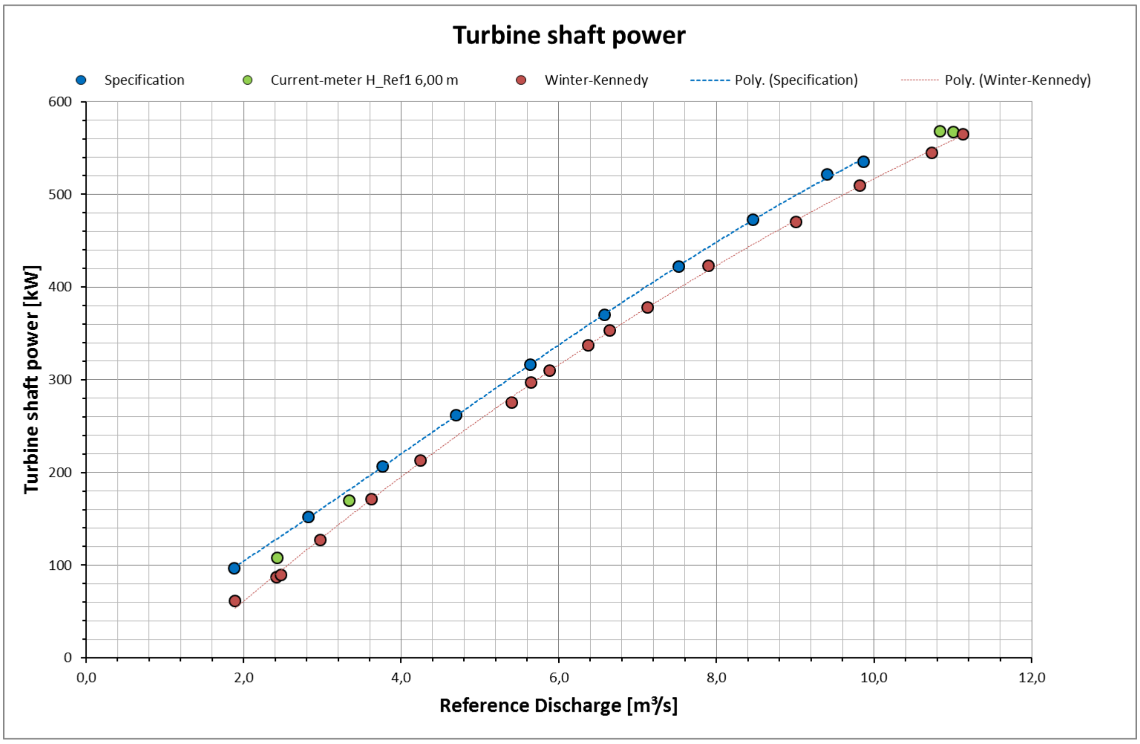


Figure 24: Turbine shaft power as function of the discharge

6.5 Measurement Error

The measurement error is calculated based on the provided information and the used measurement devices. Table 8 presents the measurement errors. The error of the discharge measurement was applied according the IEC 60041 and ISO 3354, respectively. The total measurement error is calculated of the root of the sum of the squares of the individual errors [2]. Because of the uncertainty of the area caused by the sedimentation the value of the total measurement error lies higher than in the expected range of 3%. Especially for the measurement point with the lowest velocity a higher error is expected.

To perform the measurement of an operation point under static operation conditions it was waited for at least 5 minutes until data were recorded. In this way a precise mean value with low values for the standard deviation were achieved.

To get additional information on the reproducibility the measurement of one point was repeated. The evaluation of the measured data shows a deviation of 1.51% in the turbine efficiency underlining a good reproducibility for the given conditions.

Table 8: Measurement error

	Unit efficiency	Turbine efficiency
Gravity constant	0,10%	0,10%
Density	0,10%	0,10%
Inlet diameter	0,003%	0,003%
Outled diameter	0,003%	0,003%
Discharge		
Speed measurement	2,00%	2,00%
Area measurement	3,00%	3,00%
Pressure		
Level measurement	0,25%	0,25%
Levelling error HWL +/-1cm	0,10%	0,10%
Levelling error TWL +/-1cm	0,10%	0,10%
Power		
Current transformer	0,00%	0,00%
Voltage transformer	0,00%	0,00%
Power meter	0,50%	0,50%
Generator efficiency	-	0,30%
Random error	0,50%	0,50%
Total error	3,69%	3,70%

7 Summary

On the 1st of November a field measurement of HPP Hoosic River was performed. The discharge measurement was done with a current-meter measurement. The discharge measurement was done for three different flow rates. Additionally a Winter-Kennedy measurement was performed.

- The best efficiency point of the turbine was 89.12% measured with current-meter method at a discharge of 10.84 m³/s transposed to the specific head of 6 m. The efficiency of the machine unit at this discharge was 84.02 %.

- The guide vane opening of this efficiency point is 62 % and the runner opening is 70%.

- The calculated total error of the turbine efficiency is 3.7 % because of the given conditions. The evaluation of the repeated measurement point presents a reproducibility of 1.51% in the turbine efficiency.

- At a reference discharge of 10.84 m³/s and a head of 6.0 m a turbine shaft power of 568.12 kW is achieved. With the measured head of 5.68 m the shaft power is 524.57 kW at a discharge of 10.55 m³/s.

- The values of the head water level during the measurement were in a range of 15 cm. The tail water level changed within a range of about 5 cm.

- The accuracy of the Winter-Kennedy measurement regarding the relation of discharge and differential pressure is very good. For the validation of the turbine efficiency the Winter-Kennedy measurement cannot be used because of different water levels during the measurements.

- Due to the fact that the additional installations in the forebay channel were not inspected the inflow situation and its influence on the measurement accuracy remains unknown.

Symbols and Abbreviations

Air density	ρa	kg/m³
Average water density	ρ	kg/m³
Belt efficiency	η_B	%
Discharge	Q	m³/s
Discharge	Q	m³/s
Discharge	ft³/s	m³/s
Fine trash rake losses	hv1	m
Generator apparent power	P_S	kVA
Generator efficiency	η_G	%
Generator load	G_L	%
Generator output active power	P_A	kW
Generator reactive power	P_Q	kVAr
Generator active power CS	P_A	kW
Generator active power Fluke	P_A	kW
Gravity	g	m/s²
Gross Head	H_G	m
Guide vane opening actual value	GVO_%	%
Head losses	H_L	m
Head water level	HWL	cm
Head water level after trash rake	HWL	cm
HWL velocity	c_HWL	m/s
HWL velocity losses	hk1	m
Hydraulic power	P_H	kW
Level probe difference	Δz_Probe	m
Net Head	H	m
Net head	H	m
Operation Point	OP	#
Outled losses in the cone	hv4	m
Outlet area suction pipe	A_o	m²
Outlet losses	hk2	m
Outlet velocity	c_out	m/s
Pipe cross section	A_Pipe	m²
Pipe diameter	D_Pipe	m
Pipe entry losses	hv2	m
Pipe friction coefficient	λ	
Pipe friction losses	hv3	m
Pipe length	L_Pipe	m
Pipe velocity	c_Pipe	m/s
Power	P	kW
Power factor	cos(phi)	-
Reference discharge	Q_Ref	m³/s
Reference Head 1	Current-meter H_Ref1	m
Reference active power	P_A_Ref	kW

Reference hydraulic power	P_H_Ref	kW
Reference turbine shaft power	P_T_Ref	kW
Resistance Pipe-Cone	ζ_P_C	
Rotational speed	n	rpm
Runner opening actual value	RNO_%	%
Specific speed	nq	
Tail water level	TWL	cm
Turbine efficiency	η_T	%
Turbine shaft power	P_T	kW
Unit efficiency	η_U	%
Water temperature	T_W	°C
Winter Kennedy Pressure	p_WK	Pa

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[1] IEC 60041: 1991-11, Third Edition, “Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines”

[2] ASME PTC 18-2011, “Hydraulic Turbines and Pump-Turbines – Performance Test Codes”

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[8] I. E. Idelchik: Handbook of Hydraulic Resistance, 2005

Appendix

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Tel.: +43 7282 59 22, Fax: +43 7282 59 22-21
E-Mail: office@wws-wasserkraft.at
Web: www.wws-wasserkraft.at

1|11|17
13:30 P_{el} = 97,4 kW
OP (1) H_{Gross} = 6,19 m

Pos #	CM 1	CM 2	CM 3	CM 4	CM 5	CM 6	CM 7 [m/s]
5,5	0,087	0,076	0,085	0,068	0,053	0,029	0
5	0,042	0,174	0,090	0,052	0,036	0,026	0,024
4	0,050	0,161	0,106	0,078	0,062	0,052	0,028
3	0,050	0,184	0,135	0,093	0,071	0,063	0,044
2	0,033	0,146	0,140	0,105	0,09	0,081	0,104
1	0,027	0,085	0,158	0,149	0,127	0,117	0,128

[signatures]

Figure 25: Measurement protocol 1

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wws wasserkraft GmbH & Co KG

1/11/17
14:30 Pel = 156 kW RNO 22,4 % Rechenverlust ≈ 2,7 cm
Hoben = 6,18 cm QVO 28 %
OP (2)

Pos #	CM 1	CM 2	CM 3	CM 4	CM 5	CM 6	CM 7
5,5	0,083	0,142	0,119	0,091	0,042	0,026	0,024
5	0,087	0,232	0,136	0,1	0,049	0,026	0,026
4	0,117	0,227	0,093	0,071	0,034	0,061	0,058
3	0,125	0,224	0,146	0,107	0,080	0,074	0,093
2	0,069	0,254	0,209	0,137	0,176	0,127	0,124
1	0,057	0,157	0,203	0,20	0,15	0,166	0,177

Figure 26: Measurement protocol 2

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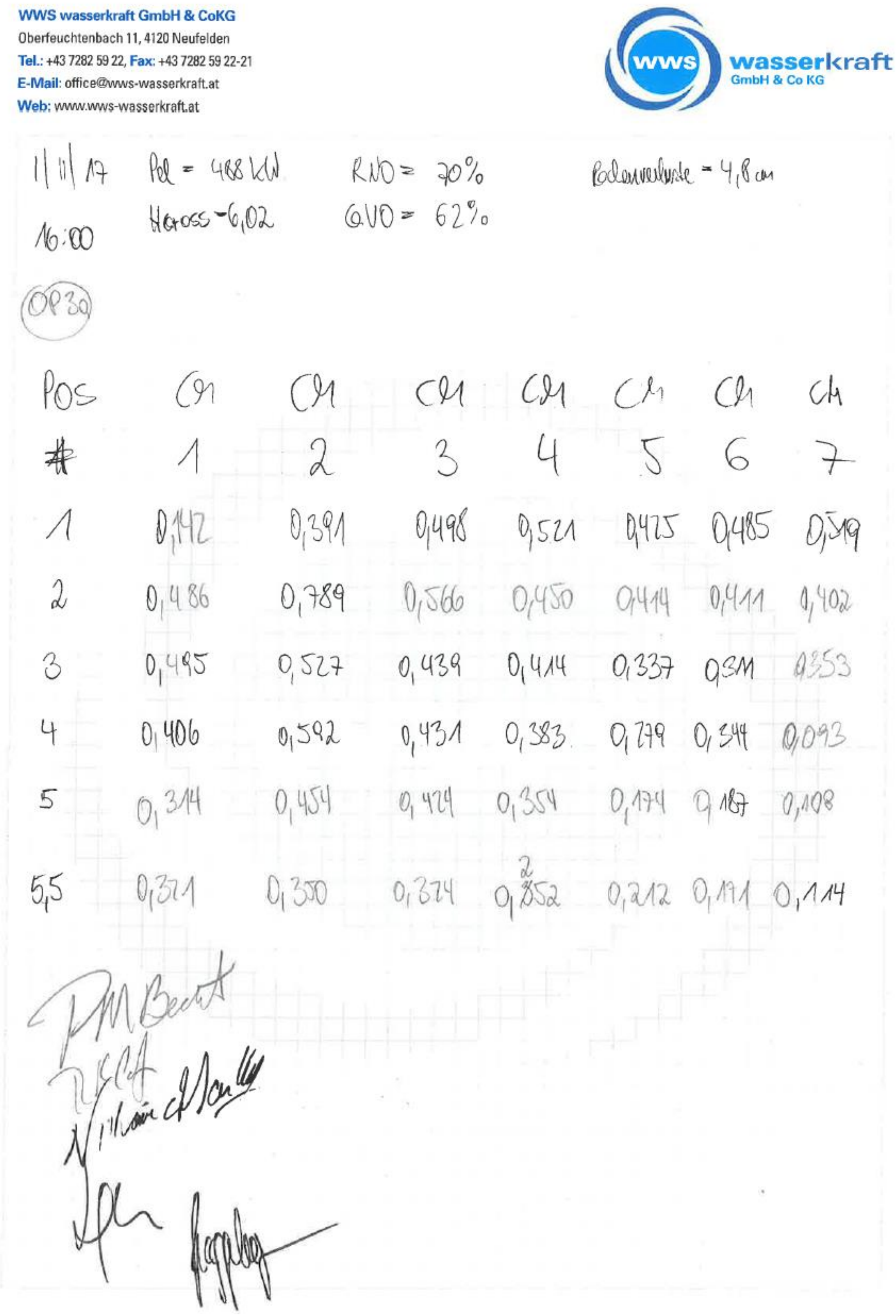
1/11/17 P_{el} = 488 kW RNO = 70% Pallenkante - 5cm
15:20 H_{Gross} = 6,07 m GVO = 62 %

OP (3)

Pos #	CH 1	CH 2	CH 3	CH 4	CH 5	CH 6	CH 7
5,5	0,262	0,411	0,288	0,241	0,181	0,158	0,1
5,0	0,301	0,443	0,422	0,363	0,207	0,188	0,097
4,0	0,415	0,551	0,446	0,363	0,292	0,244	0,077
3,0	0,48	0,496	0,465	0,429	0,333	0,318	0,302
2,0	0,467	0,756	0,589	0,488	0,478	0,402	0,375
1,0	0,136	0,389	0,497	0,507	0,446	0,477	0,524
1,0/1	0,162	0,372	0,498	0,508	0,449	0,478	0,517

1,0/2 → new set (Repeat measurement)

Figure 27: Measurement protocol 3



WWS wasserkraft GmbH & CoKG
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Tel.: +43 7282 59 22, Fax: +43 7282 59 22-21
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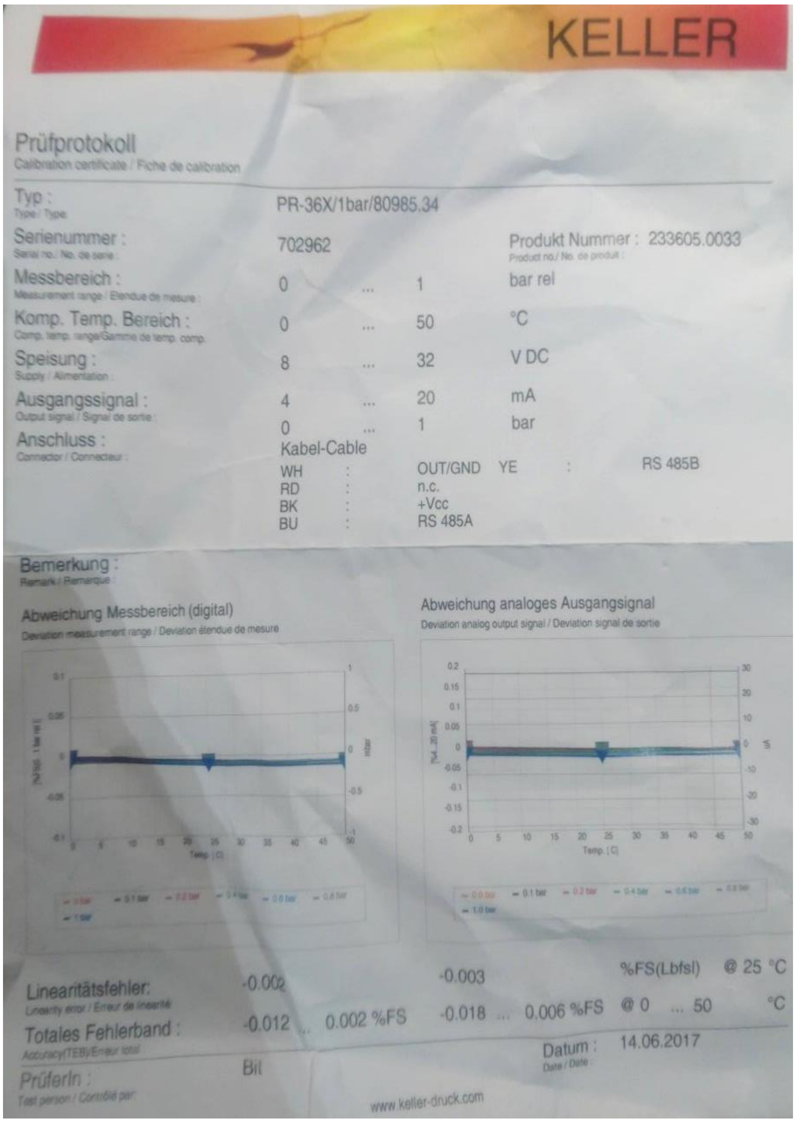
Web: www.wws-wasserkraft.at

1/11/17 Pel = 488 kW RVO = 70% Rechenverluste = 4,8 cm
16:00 Hgross = 6,02 GVO = 62%

OP30

POS	CH	CH	CH	CH	CH	CH	CH
#	1	2	3	4	5	6	7
1	0,142	0,391	0,498	0,521	0,425	0,485	0,519
2	0,486	0,789	0,566	0,450	0,414	0,411	0,402
3	0,495	0,527	0,439	0,414	0,337	0,311	0,353
4	0,406	0,592	0,431	0,383	0,279	0,344	0,093
5	0,314	0,454	0,424	0,354	0,174	0,187	0,108
5,5	0,371	0,350	0,374	0,352	0,212	0,171	0,114

Figure 28: Measurement protocol 4



KELLER

Prüfprotokoll
Calibration certificate / Fiche de calibration

Typ : Type / Type	PR-36X/1bar/80985.34			
Seriennummer : Serial no. / No. de serie	702962			Produkt Nummer : 233605.0033 Product no./ No. de produit
Messbereich : Measurement range / Etendue de mesure	0	...	1	bar rel
Komp. Temp. Bereich : Comp. temp. range/Gamme de temp. comp.	0	...	50	°C
Speisung : Supply / Alimentation	8	...	32	V DC
Ausgangssignal : Output signal / Signal de sortie	4	...	20	mA
	0	...	1	bar
Anschluss : Connector / Connecteur	Kabel-Cable			

WH	:	OUT/GND	YE	:	RS 485B
RD	:	n.c.			
BK	:	+Vcc			
BU	:	RS 485A			

Bemerkung :
Remark / Remarque

Abweichung Messbereich (digital)
Deviation measurement range / Déviation étendue de mesure

Abweichung analoges Ausgangsignal
Deviation analog output signal / Deviation signal de sortie

Linearitätsfehler: Linearity error / Erreur de linearité	-0.002			-0.003		%FS(Lbfsl)	@ 25 °C
Totales Fehlerband : Accuracy(TEB)/Erreur total	-0.012	...	0.002 %FS	-0.018	... 0.006 %FS	@ 0 ... 50	°C
PrüferIn : Test person / Contrôlé par	Bil				Datum : Date / Date	14.06.2017	

www.keller-druck.com

Figure 29: Calibration protocol of the level probe [6]

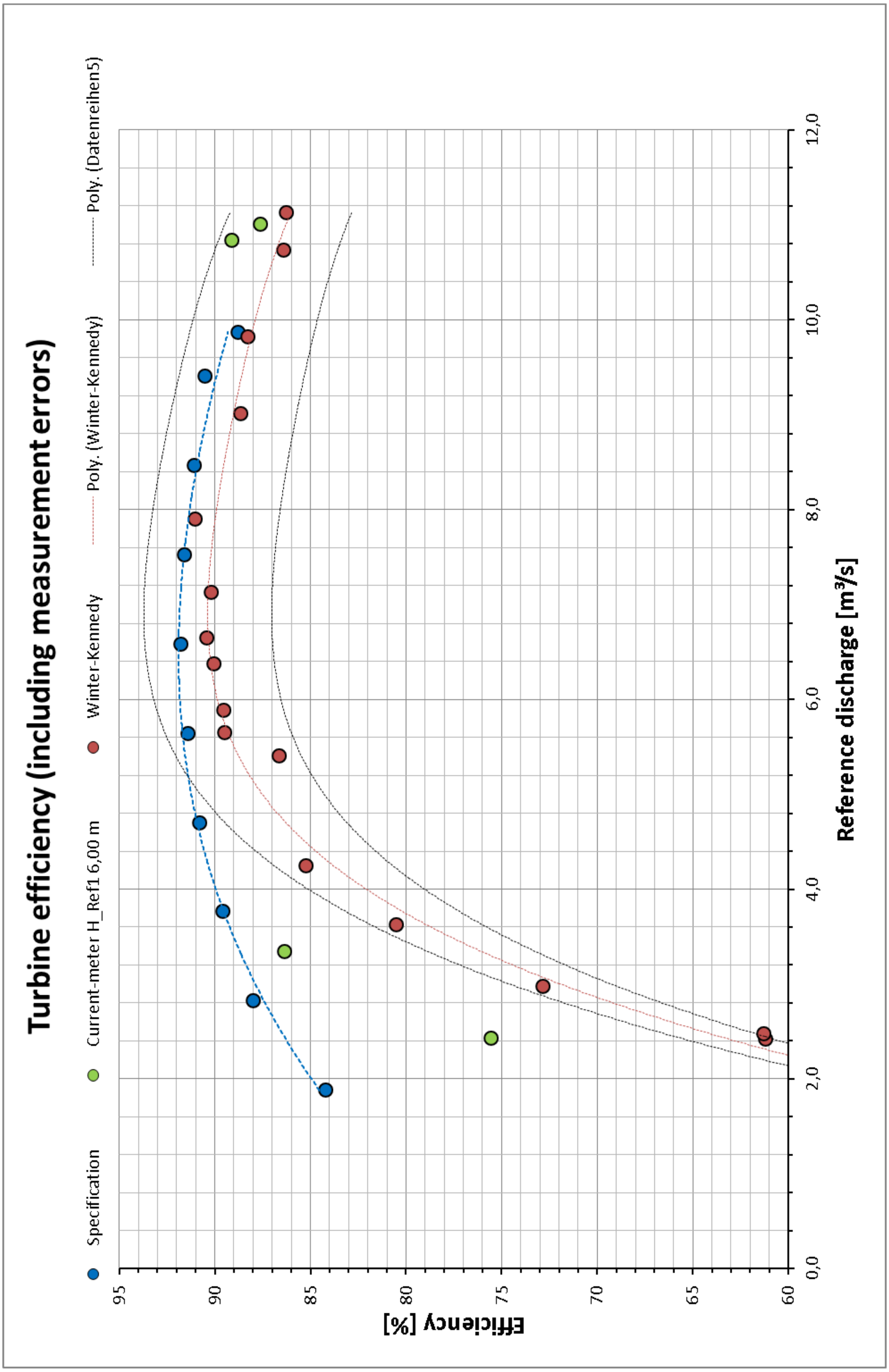


Figure 30: Turbine efficiency as function of the discharge (including error bands)

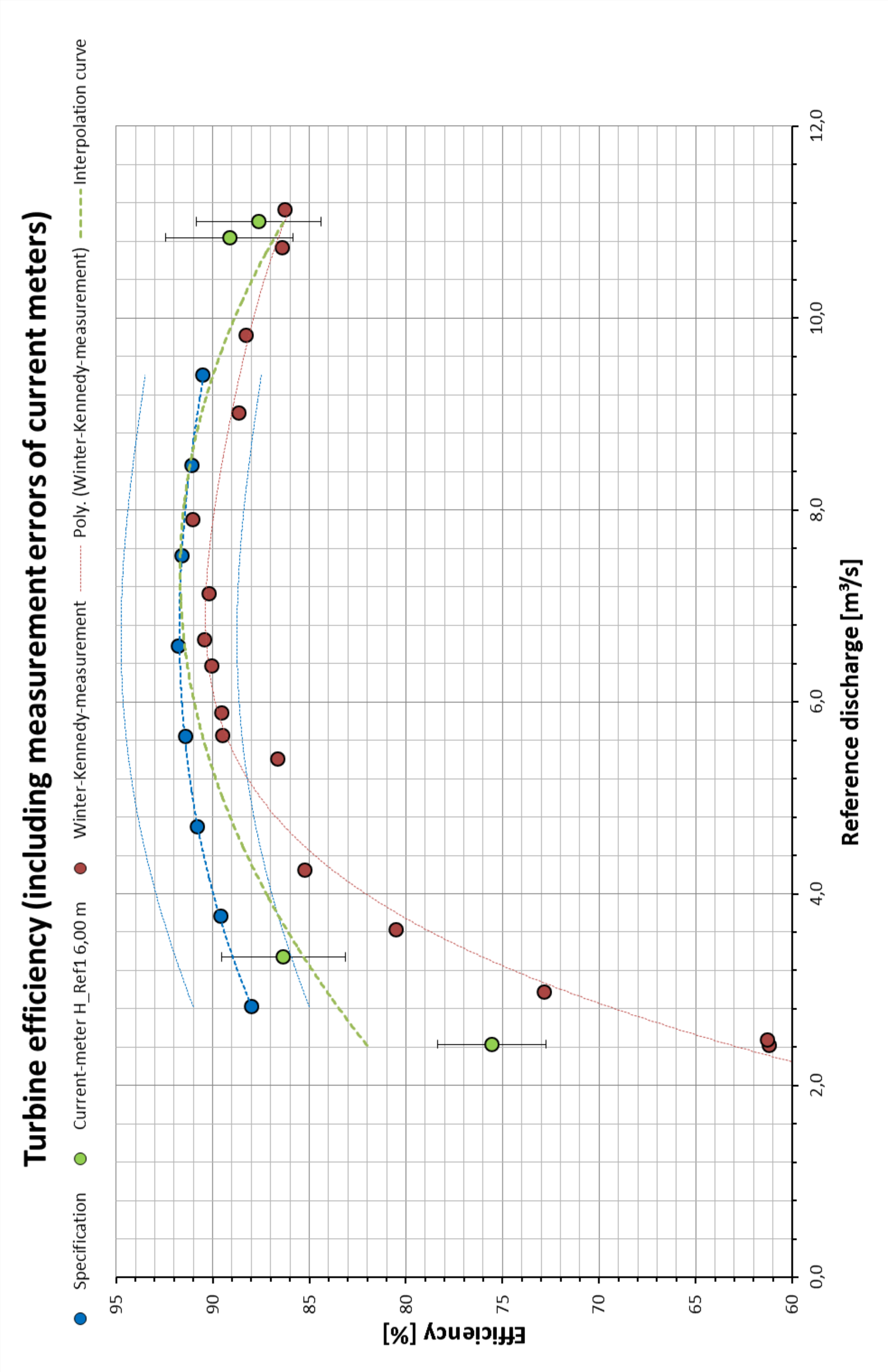


Figure 31: Turbine efficiency as function of the discharge (including error bands of current meter)

Calculation of the discharge according to ISO 3354 [4]:

1.) Determination of the mean axial fluid velocity by numerical integration of the velocity area: Rectangular cross-section [4]

$$U = \int_0^1 \int_0^1 \frac{dh}{H}\frac{dl}{L}$$

U...Mean velocity of the measurement cross section area
H...Maximum height of the cross section area
L...Maximum length of the cross section area
p...Amount of measurement points in the considered cross section area
v_i..Velocity in the measurement point
y_i^*...Dimensionless height/length

The equations proposed below are derived from interpolations between successive pairs of measuring points along third-degree curves in (r/R)2 for circular cross-section conduits, and in l/L or h/H for rectangular cross-section conduits. The different individual arcs combine to form a continuous curve with a continuous derivative.

$$\begin{aligned} U = {} & v_1\left[\frac{m}{m+1}y_1^* + \frac{1}{12m}\frac{{y_2^*}^2}{y_1^*} + \frac{7}{12}y_2^* - \frac{1}{12}y_3^*\right] + v_2\left[\frac{1}{2}y_2^* + \frac{7}{12}y_3^* - \frac{1}{12}y_4^*\right] \\ & + \sum_{i=3}^{p-2} v_i\left[\frac{7}{12}(y_{i+1}^* + y_i^*) - \frac{1}{12}(y_{i+2}^* + y_{i-1}^*)\right] \\ & + v_{p-1}\left[\frac{1}{2}y_p^* + \frac{7}{12}y_{p-1}^* - \frac{1}{12}y_{p-2}^*\right] + v_p\left[\frac{m}{m+1}y_{p+1}^* + \frac{1}{12m}\frac{{y_p^*}^2}{y_{p+1}^*} + \frac{7}{12}y_p^* - \frac{1}{12}y_{p-1}^*\right] \end{aligned}$$

The velocity U, is given by the following equation:

Horizontal averaging (7 measurement points)

$$\begin{aligned} U = {} & v_1\left[\frac{m}{m+1}y_1^* + \frac{1}{12m}\frac{{y_2^*}^2}{y_1^*} + \frac{7}{12}y_2^* - \frac{1}{12}y_3^*\right] + v_2\left[\frac{1}{2}y_2^* + \frac{7}{12}y_3^* - \frac{1}{12}y_4^*\right] \\ & + v_3\left[\frac{7}{12}(y_4^* + y_3^*) - \frac{1}{12}(y_5^* + y_2^*)\right] \\ & + v_4\left[\frac{7}{12}(y_5^* + y_4^*) - \frac{1}{12}(y_6^* + y_3^*)\right] \\ & + v_5\left[\frac{7}{12}(y_6^* + y_5^*) - \frac{1}{12}(y_7^* + y_4^*)\right] \\ & + v_6\left[\frac{1}{2}y_6^* + \frac{7}{12}y_5^* - \frac{1}{12}y_4^*\right] + v_7\left[\frac{m}{m+1}y_8^* + \frac{1}{12m}\frac{{y_7^*}^2}{y_8^*} + \frac{7}{12}y_7^* - \frac{1}{12}y_6^*\right] \end{aligned}$$

$$y_1^* = \frac{l_1}{L} \quad y_2^* = \frac{l_2 - l_1}{L} \quad \ldots \quad y_7^* = \frac{l_7 - l_6}{L} \quad y_8^* = \frac{L - l_7}{L}$$

Vertical averaging (6 measurement points)

$$U = v_1\left[\frac{m}{m+1}y_1^* + \frac{1}{12m}\frac{y_2^{*2}}{y_1^*} + \frac{7}{12}y_2^* - \frac{1}{12}y_3^*\right] + v_2\left[\frac{1}{2}y_2^* + \frac{7}{12}y_3^* - \frac{1}{12}y_4^*\right]$$
$$+v_3\left[\frac{7}{12}(y_4^* + y_3^*) - \frac{1}{12}(y_5^* + y_2^*)\right]$$
$$+v_4\left[\frac{7}{12}(y_5^* + y_4^*) - \frac{1}{12}(y_6^* + y_3^*)\right]$$
$$+v_5\left[\frac{1}{2}y_6^* + \frac{7}{12}y_5^* - \frac{1}{12}y_4^*\right] + v_6\left[\frac{m}{m+1}y_7^* + \frac{1}{12m}\frac{y_6^{*2}}{y_7^*} + \frac{7}{12}y_6^* - \frac{1}{12}y_5^*\right]$$

$$y_1^* = \frac{h_1}{H} \quad y_2^* = \frac{h_2 - h_1}{H} \quad \dots \quad y_6^* = \frac{h_6 - h_5}{H} \quad y_7^* = \frac{H - h_6}{H}$$

To calculate the mean axial fluid velocity in the peripheral zone, the coefficient, m, can be determined analytically. The value of m is dependent essentially on the surface roughness of the conduit and the flow conditions (Reynolds number, velocity distribution, etc.). The factor m and the friction coefficient are related according to Figure 32.

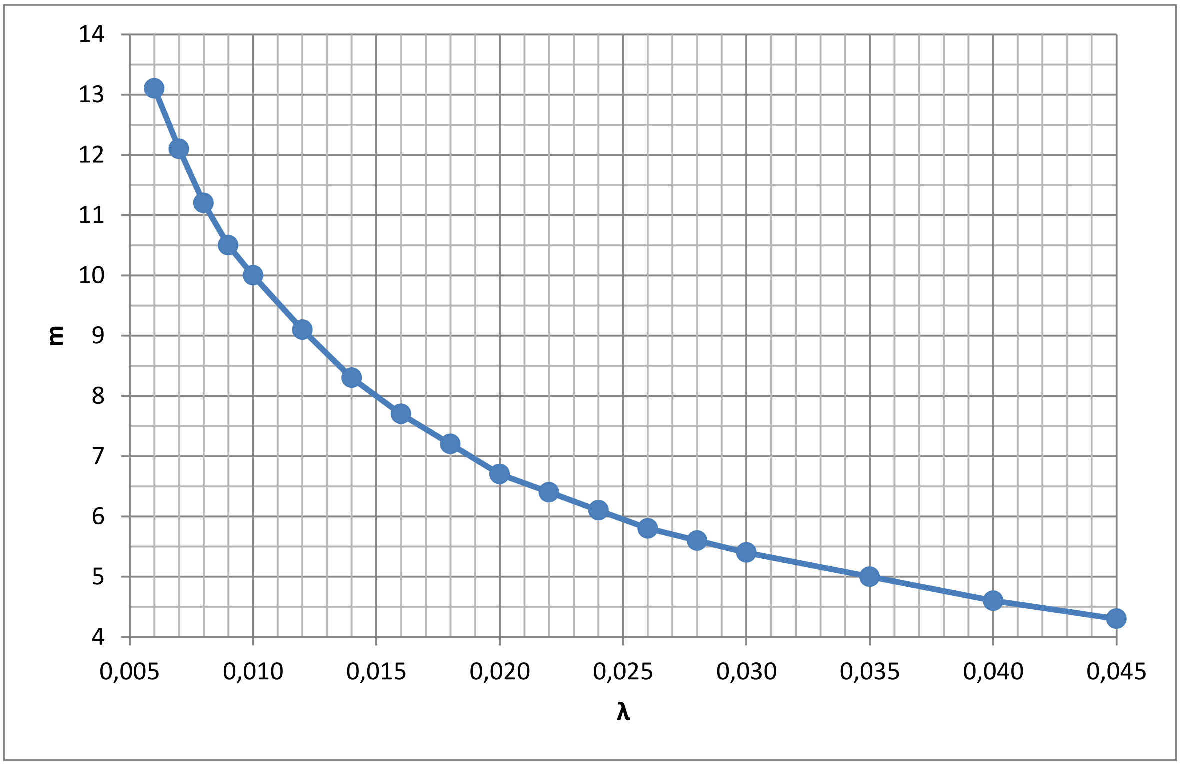


Figure 32: m-λ-relation

The total mean velocity U is calculated as followed:

Horizontal-Vertical-Averaging

The averaging is carried out for one measurement plane. To calculate the mean velocity U_i of the whole cross section area an averaging for the 6 horizontal measurement planes has to be done.

$$U_{i\_} = \sum_{j=1}^{7} f(v_{ij})$$

The result is a mean velocity referring to one height h_i. Subsequently the mean values of U_i are averaged vertical. Finally the total mean velocity is obtained by summing up the horizontal mean values of U_i.

$$U = \sum_{i=1}^{6} f(U_{i\_})$$

v_{11}	v_{12}	v_{13}	v_{14}	v_{15}	v_{16}	v_{17}	→	$U_{1\_}$
v_{21}	v_{22}	v_{23}	v_{24}	v_{25}	v_{26}	v_{27}	→	$U_{2\_}$
v_{31}	v_{32}	v_{33}	v_{34}	v_{35}	v_{36}	v_{37}	→	$U_{3\_}$
v_{41}	v_{42}	v_{43}	v_{44}	v_{45}	v_{46}	v_{47}	→	$U_{4\_}$
v_{51}	v_{52}	v_{53}	v_{54}	v_{55}	v_{56}	v_{57}	→	$U_{5\_}$
v_{61}	v_{62}	v_{63}	v_{64}	v_{65}	v_{66}	v_{67}	→	$U_{6\_}$
								⇓
								U

U...Total mean value of the cross section area
i...Line indes (Height index)
j...Row index (Length index)
v_{ij}...velocity of the measurement point (h_i,l_j)
$f(v_{ij})$...Weighting function according to standard
$f(U_{i\_})$...Weighting function according to standard
$U_{i\_}$...mean velocity of the horizontal measurement plane i

Corrections for blockage effect according to ISO 3354 [4]

The presence of current-meters and their supports in a conduit results in a reduction in the cross-sectional area of flow, and hence in a variation in the velocity distribution, particularly in the measuring plane. The calculation of the flow-rate in a conduit on the basis of calibration data obtained in a channel thus generally leads to an overestimation of the flow-rate. It appears adequate, on the basis of the present state of knowledge, to regard the error as directly proportional to the velocity over the range of velocities normally experienced. Thus, a direct percentage error correction can be used.
The investigations have shown that the main parameter influencing the magnitude of the error is the ratio of the frontal area of the support cross to the cross-sectional area of the conduit. The number of current-meters being used, their type, and the size of their propellers and hubs also have an effect but this is unlikely to exceed 0.3 % with the types of current-meter normally in use. On the basis of present knowledge, the following specifications shall apply.

If the blockage ratio, s, is less than 0.06, then the measured flow-rate will be reduced by a factor, k:

s=0.06

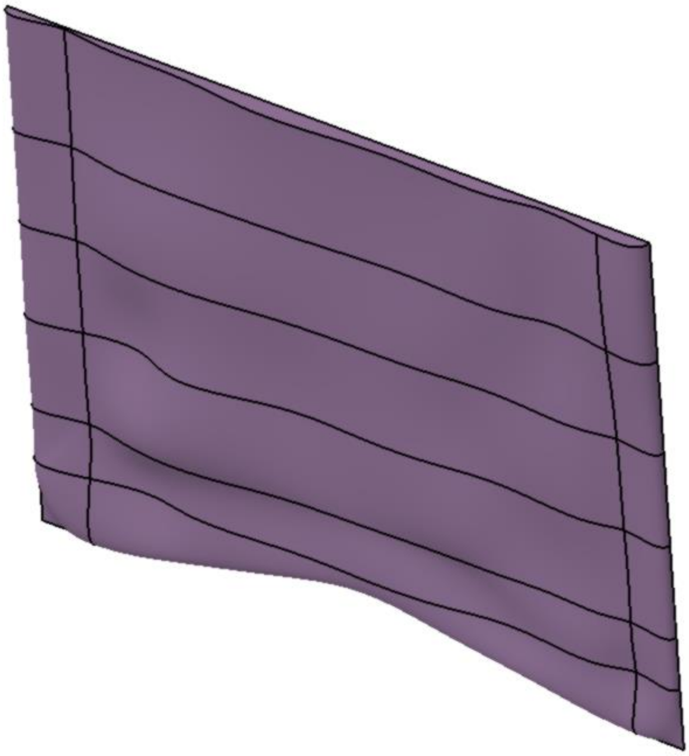
$$k = 0,12s + 0,03s_c$$

where s_c is the blockage ratio of the current-meters given by

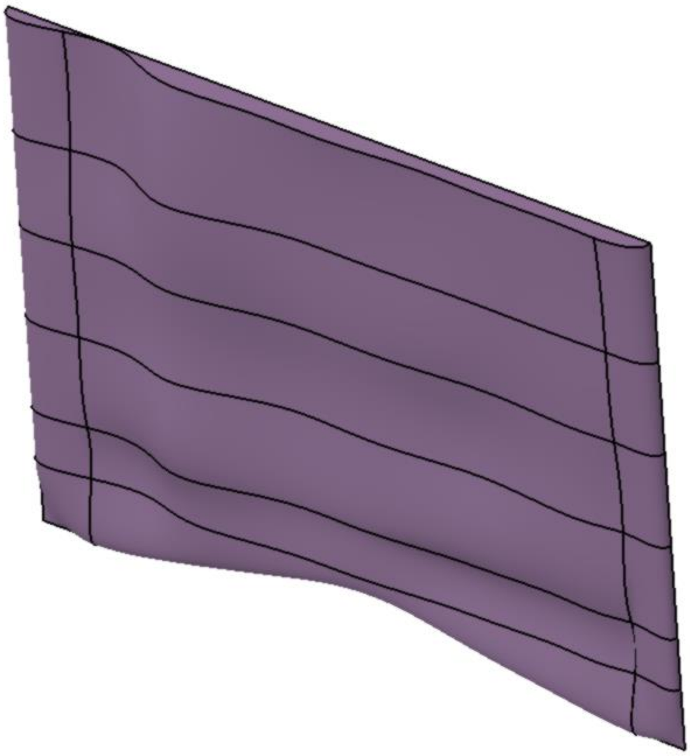
$$s_c = \frac{\pi Z d^2}{4A}$$

where
Z is the number of current-metres;
d is the propeller diameter, in metres;
A is the area, in square metres, of the measuring section.

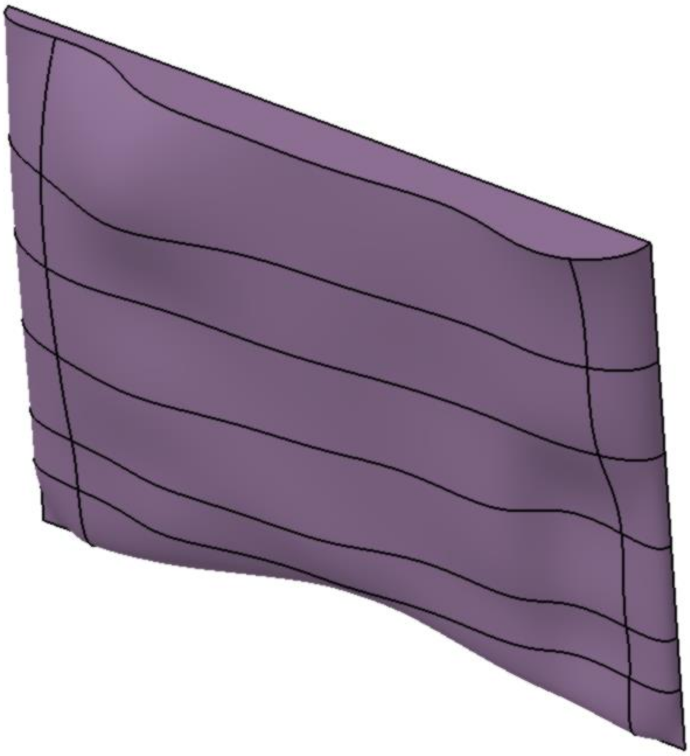
OP1:



OP2:



OP3:



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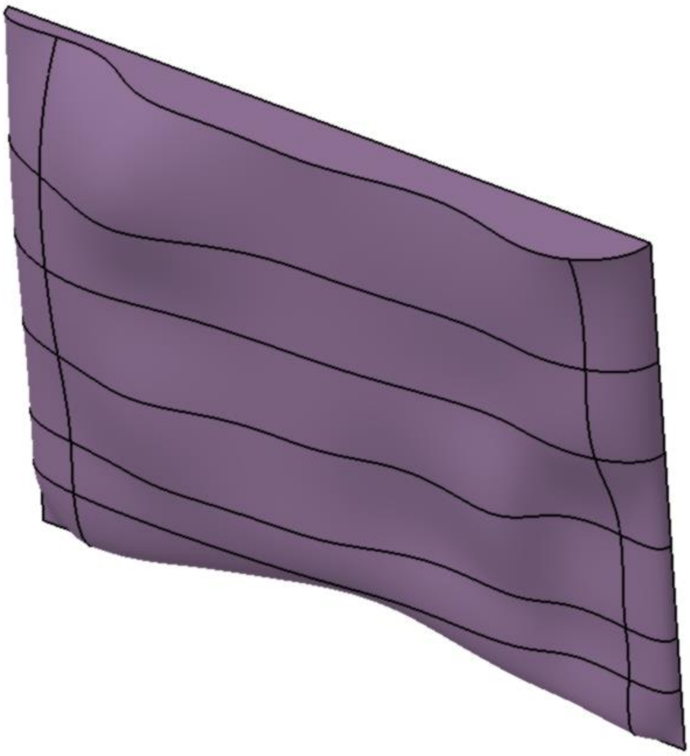

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