Real-Time Fish Image Collection of Bonneville AFF Bypassed Fish via Chute Slide Through the Whooshh Scanning System

**Background**

Accurate, autonomous fish counts and selective fish passage are desired features which are not available in many fish passage settings. Whooshh Innovations has designed a scanning system which images partially dewatered fish as they slide individually through a chute passing through the Whooshh scanning hood without delay, handling or confinement. Images are taken in real-time from three set angles by six cameras, three utilizing visible light and three utilizing infrared spectra. Rapid image capture software computationally processes the images within fractions of a second. Algorithms have been developed to computationally calculate the size of the fish enabling real-time sorting decisions. The utility potential for fisheries management to increase efficiencies in distinguishing hatchery verses native origin fish based upon the scanned-determined presence or absence of the adipose fin is terrific. In addition, species identification based upon morphologic indicators is possible. Algorithms can be written to computationally evaluate images to recognize adipose fin and species-specific features, however, to ensure the algorithms can accurately distinguish such features, a very large number of fish images are required. The fish images needed will include a range of species that represent the scope of morphological life stage changes. The images collected from this project will be used to create a database that represents the breadth of possible fish positions and morphologic variations of a given feature for a given a species. Once images have been manually identified and classified they will be used to computationally derive rapid, accurate identification algorithms. Such algorithms will be incorporated into the Whooshh scanning software to facilitate real-time species identification and wild verse hatchery distinctions autonomously.

The USACE (the Corp), local tribes and various government agencies have invested considerable time, effort and millions of dollars to monitor, track and provide fish the means for safe passage past Bonneville dam. As the first dam encountered by ocean return migrating fish species in the Columbia River, the fish counts collected at Bonneville dam form a critical foundation of actual numbers on which all other upstream fish number estimates are evaluated and validated. Accurately and effectively counting the diversity of species and sheer numbers of fish at Bonneville requires substantial, specialty-trained resources. The Whooshh scanner logs each fish that passes through the scanner recording in real time both fish count number and multiple images of the fish as described above. Fish size can be calculated in real time from the images. For the proposed project, the images taken will be subsequently evaluated by a biologist and catalogued with respect to species, adipose fin, pinniped injury and overall condition. The data set of the compiled information gathered on the fish that are images in the Whooshh system will be shared with Bonneville Fisheries Research Coordinators and/or Project Biologists, CRITFC and written up as a study report to be shared on-line on the studies page of the Whooshh website (www.whooshh.com).

The prototype Whooshh scanning system was installed at Cle Elum dam in the summer of 2017 capturing sockeye images and at Ringold Springs Hatchery in the fall of 2017 capturing Chinook and steelhead images. These studies provided invaluable development and operational insight which lead to a number of optimizations and enhancements which have been incorporated into the current Whooshh scanner system. In mid-October of 2018, the current Whooshh scanning system will be put in operation at the Feather River fish barrier dam in California. Fall Chinook and the occasional late spring Chinook and steelhead swimming up the hatchery fish ladder, will be guided on a longer step to enter a short steeppass, to pass over a false weir and slide through the Whooshh scanning system without handling, containment or delay, exiting back into the fish ladder for continued migration to the hatchery. We anticipate about 7000 fish will pass through the Whooshh scanning system over the course of several weeks. Additional scanning systems are in production. One will be mounted to a trailer and used as a mobile scanner, collecting images of various fish species at hatcheries around Washington and Oregon with the support of WDFW, Bellingham Technical College, the Spokane Tribe of Indians, ODFW and others.

The Corp and the BPA have been progressive in supporting studies that address fish monitoring, fish passage and other environmental challenges. The Bonneville AFF is a well-designed and maintained facility, with high fish traffic numbers; an ideal environment to advance the development of technologies considering innovative and economical ways of monitoring and addressing fish passage and other environmental concerns. The aim of the proposed project is to collect scanning images, data to be used in new development efforts with a focus of selective, autonomous, effective, and efficient fish monitoring and extended applications. The proposed scanning image collection project has been designed with the goal of no impact on the fish, AFF use or on-going studies. Unsampled fish that pass through the AFF exit back into the fish ladder via a bypass pipe. The proposed Whooshh scanner will image the fish as they slide through the bypass path and exit the AFF. From the fish perspective, the bypass path will be unchanged; no delay, no handling, exiting the bypass path into the same calm channel. Th opportunity to image the diversity of fish species and the range of morphological maturation states that bypass through the AFF is of unmatched value and paramount to achieving cutting-edge advances in algorithm development of fish and feature recognition. The access contributions of the Corp, to the advancement of fish monitoring sciences, will be actively acknowledged and recognized. With a positive outcome of development efforts made possible through the proposed image collection project, it will be possible to autonomously collect fish counts, identify fish species and categorize individual wild vs hatchery fish without incurring migration delay, detainment, or handling. It is the goal for the system to provide image verifiable accurate, real-time, autonomous fish count and characterization data.

**Study Objectives**

* Install the Whooshh scanning system temporarily replacing the terminal end of the eastern-most AFF chute bypass pipe. Installation plan and location designed to have zero impact on normal AFF operations.
* Collect thousands of partially dewatered fish images representing the diversity of fish species migrating up the Columbia River. Image collection will occur as fish slide through the bypass path requiring no handling, fish delay, capture or containment.
* Collect fish counts on all fish that pass through the Whooshh scanning system. Fish count data will be shared with Bonneville Fisheries Research Coordinators and/or Project Biologists and CRITFC as a source of additional data to augment run estimates and provide validation of AFF fish bypass estimates.

**Outline of Study Design**

*NOTE: Terminology to reference features in the AFF. Left/Right in reference to fish point of view.*

**Lane 1**: Left of 3 lanes, bypass directly to exit channel.

**Work-up Lane**: Trough routed from lanes 1 or 2 over to the workup area.

**Lane 2**: Center of 3 lanes, bypass into scanner, then to exit channel

**Lane 3**: Right of 3 lanes, unused.

**Exit Channel:** 2-3ft deep waterway that exits AFF; location where scanner will be mounted

1. Install the Whooshh scanning system.

1. Remove 14” pipes on Lanes 1 & 2 and supporting beam to provide installation access.
2. Remove last 10ft section of trough from unused lane 3 for access to Maintenance Walkway
3. Install mounting strut for scanner in channel wall.
4. Install Scanner
5. Install new 14” sweep on Lane 2 (lane feeding scanner)
6. Reinstall original 14” straight section on Lane 1 (bypass lane not feeding scanner)
7. Install Maintenance Access Walkway
8. Install Control Enclosure

 (See detailed Installation Plan in Appendix)

2. Operate the Whooshh scanning system during all hours that the AFF bypass is in operational use.

 A. Collect images of all fish that slide through the Whooshh scanning system chute.

 B. Collect fish counts of all fish that slide through the Whooshh scanning system chute.

3. Data storage and distribution

 A. Collected images will be stored on a local computer and uploaded to Whooshh servers on a scheduled routine basis.

 B. Fish counts will be stored on a local computer and uploaded to Whooshh servers on a scheduled routine basis. Fish counts will be shared with Bonneville Fisheries Research Coordinators and/or Project Biologists and AFF facility users in a format and via a pre-established schedule convenient for all parties.

4. Site Access

 A. Whooshh personnel and Sub Contractor will request access during installation.

 B. Whooshh personnel will request access to be present during the initiation of the project. i. Calibration and operational optimization adjustments are anticipated as the system will have been installed during the AFF dry period restricting the ability to run full operation quality checks at installation.

C. Whooshh personnel will request access to perform quarterly on-site PM quality checks in additional to anticipated weekly data uploads.

 D. Whooshh personnel and Sub Contractor will request access during removal of the scanning system.

5. Redundancy: Ensured Operational Bypass Option

A. The integrity of the LANE 1 (second, westerly, bypass pipe) will be maintained. It is possible that during scanner installation LANE 1 (the second bypass pipe) may be repositioned slightly while the AFF is in the dry period to ensure a clear, unencumbered bypass path is maintained adjacent to the Whooshh scanning system bypass installation.

 B. Approximately 50% of the AFF bypassed fish will pass through LANE 1 (the second bypass pipe.) The redundancy of the current AFF bypass exit system is ideally designed to ensure an alternative means of AFF fish bypass exit should a problem arise. This redundancy will be maintained mitigating risk to fish that could be impacted if a situation were to arise in the AFF that would temporarily require restricting use of one of the upstream chutes or one of the bypass exit options; LANE 1 (the second bypass pipe) or LANE 2 (the Whooshh scanning system chute).

6. Timeline

 A. Installation February 2019.

 B. Fish image collection will occur across a full season of AFF use (Spring – Fall 2019).

 C. Removal or Extension requested Winter 2019/2020.

**Justification for the Proposed Study Area/Impact to facility and facility users**

The proposed study area was identified in July 2018 during a site visit to the AFF. Fish that enter the AFF volitionally pass over one of two false weirs and slide down a chute partially dewatered and are either manually directed to a center chute (WORK UP LANE) for other studies (capture and work-up) or directed by default into one of two bypass pipes (LANES 1 OR 2) which exit back into a calm water channel connected to the fish ladder. The bypass pipes terminate just above water level with a walkway overhead. The proposed area of use is off to the side, removed from the area of normal AFF operations, downstream of the AFF study sorting gates and would entail imaging only bypassed fish, those not directed for use in other AFF studies.

The proposed study installation would involve temporarily routing the LANE 2 bypass through the Whooshh Scanning System. A new custom fabricated fiberglass sweep would be required to transition from the end of the aluminum trough of Lane 2 directly into the entrance of the Whooshh Scanning System, replacing the existing fiberglass sweep and PVC straight section.

Based on the best available information (from coarse survey dimensions performed by Whooshh personnel), there will likely be a small, but unavoidable interference between the scanner and the end of the Lane 1 bypass pipe. However, this interference should be small enough that it can be eliminated by shifting the end of the Lane 1 bypass pipe by a few inches. However, it would be prudent to provide an option for a back-up solution if the interference is not able to be eliminated only by moving the end of the Lane 1 bypass pipe. This alternate solution would involve inserting a 4-6” long flanged spacer pipe between the end of the Lane 1 Aluminum Trough and the beginning of the Lane 1 sweep that would shift the straight section of the Lane 1 Bypass Pipe down and to the left. The second bypass outlet pipe (Lane 1) may be repositioned slightly but otherwise maintained and will remain functional.

The Whooshh scanner has a bottom chute and a top hood section. The new fabricated fiberglass sweep on Lane 2 will be inserted into the scanner chute to provide a clean entry into the scanner. Fish will exit the Whooshh scanning system directly into the exit channel water that leads back to the fish ladder. The complete Whooshh scanning system will be installed above the exit channel, between the cement walls and within open space currently not in use. The system will require access to a small volume of water to maintain slide lubrication through the scanner bottom chute. A water stream is currently injected into the exit flange on Lanes 1 and 2, upstream of the proposed scanner installation and thus the water stream will continue to flow through the scanner down the bypass path along with the fish. To provide maintenance access to the scanner when the facility is watered up, a self-contained walkway unit will be placed just upstream of the scanner, supported above the pipes by existing horizontal C-channel beams. The last section of trough on the unused Lane 3 in the facility will be unbolted and removed to provide personnel access from the concrete floor under the troughs up onto the maintenance walkway.

In addition to the Scanner itself, a control cabinet houses the hardware that collects, analyses and stores the scanned images. This cabinet will require connection to a standard 20A, 120VAC outlet. The cabinet will be mounted from Unistrut cross members, just upstream of the scanner. This will place the system controls in a location such that it can be operated from a safe position from the Maintenance Walkway. The system is designed to operate autonomously after start-up. Whooshh personnel will turn on the system which will run continuously over the course of the the months of AFF operation. There is no need to power-down during overnight AFF de-watering. The scanner is designed to revert to low-power mode when fish are not detected. A protocol will be developed in conjunction with Bonneville Fisheries Research Coordinators and/or Project Biologists as a backup to turn off or restart the scanning system should the need to completely power-down the AFF occur. Installation of the Whooshh scanning system will be conducted during the AFF dry period over the month of February ensuring no impact to AFF facility users during installation and reducing installation risks that would be present if the installation occurred when the calm channel described above, is filled with water. Whooshh will perform the installation in combination with sub-contractors to facilitate the lifting and placement of the various pieces of equipment. Whooshh will work with Platinum Industrial, out of Vancouver, WA. Platinum will supply Millwrights or Laborers with current rigging and boom truck certifications. The overhead gantry crane will be required for many of the steps of the installation. HECP training will be required for all personnel during installation. HECP training will not be required for Whooshh personnel accessing the system, once the installation is complete and the maintenance walkway is secured.

Detailed Installation Plan:

1. Remove components to provide installation access:
	1. Lane 2: 14” Sweep and 6ft Pipe
		1. Suspend from gantry crane with rigging
		2. Remove bolted connections to lane 2 aluminum trough flange and supporting beam in exit channel.
		3. Fly out of facility into parking lot *(Gantry crane required)*
		4. Clearly label and place into long-term storage *(Forklift required?)*
		5. Bag hardware and keep with Lane 1 Sweep
	2. Lane 1: 14” x 10ft pipe and 2x6” C-channel beam supporting pipes
		1. Suspend from gantry crane with rigging
		2. Unbolt from pipe clamp on 2x6 C-channel
		3. Remove 2” x 6” C-channel beam from concrete wall anchors.
		4. TEST: estimate range of motion at end of 10ft pipe to accommodate potential interference with Whooshh Scanning System. Record measurements for potential position of end of pipe relative to left wall and channel floor.
		5. Remove bolted connections to end of Lane 1 sweep in exit channel
		6. Fly out of facility and into parking lot. *(Gantry crane required)*
		7. place in a short-term storage location during scanner installation. *(Forklift required?)*
		8. Keep hardware for transition between end of trough and new fabricated sweep.
	3. Exit Channel: 2”x6” c-channel beam supporting pipes
		1. Manually remove from facility.
		2. Clearly label and place into long-term storage.
		3. Clearly document wall anchor locations used by C-channel beam.
	4. Lane 3: 10ft end section
		1. Unbolt trough from flanges at beginning and end of trough sections. 20-30 ½” bolts
		2. Suspend from gantry crane with rigging
		3. Fly out of facility into parking lot *(Gantry crane required)*
		4. Clearly label and place into long-term storage *(Forklift required?)*
2. Install Scanner Mounting Hardware
	1. Mount Unistrut on Wall
		1. Layout Unistrut locations on exit channel wall per drawing
		2. Mark hole locations for wall anchors per drawing
		3. Drill holes in concrete to desired depth per drawing
		4. Install anchors per manufacturer’s instructions
		5. Mount Unistrut and tighten mounting hardware
	2. Mount Scanner Mounting Plates to Unistrut
		1. Ensure that 3 u-bolts per plate are securely holding pipe and that each nut is secured with a locking nut or a jam nut
		2. Position Unistrut nuts in Unistrut at locations specified by drawing.
		3. Install mounting plate assembly in locations specified by drawing.
		4. Check clearance of threaded rod hangers into mounting plate, remove prior to installation
	3. Install mounting angle to scanner
		1. Check correct orientation of scanner brackets as specified by drawing
		2. Ensure that brackets are just loose enough to adjust position of bracket
3. Install Scanner
	1. Remove center section of walkway grating above scanner
		1. Install caution tape preventing access to grating area
		2. Provide signage indicating fall hazard open pit in floor
		3. Provide signage indicating fall protection required within restricted area
		4. Install tie-off anchor plate with concrete anchors into concrete wall
		5. Personnel within restricted area must wear fall protection
		6. Loosen grating clamps and place aside to be reinstalled later
		7. Manually flip up grating and set aside. Ensure that grating cannot fall into hole.
	2. Fly scanner into facility
		1. Consult Scanner Rigging Plan to prepare scanner for lift
		2. Position gantry crane outside over parking lot
		3. Connect Beam #1 to gantry crane
		4. Raise hook to connect Beam #2 to Beam #1 with Upstream and Inside Downstream slings / chain come-along
		5. Raise hook to connect Beam #2 to Connect Scanner with 4 corner slings
		6. Raise complete rigging assembly and check for level between scanner mounts
		7. Adjust if necessary
		8. Fly into facility
	3. Rigging Adjustment
		1. Personnel within restricted area must wear fall protection.
		2. Consult Scanner Rigging Plan for detailed description
		3. Position scanner upstream of aluminum railing over exit channel
		4. Beam #1 should be above railing, Beam #2 should be below grating.
		5. Attach additional Outside Downstream chain come-along between end of Beam #1 to end of Beam #2. This attachment is goes through hole in the walkway.
		6. Load chain come-along, release Inside Downstream chain come-along.
		7. The scanner should now be suspended partially under scanner walkway.
	4. Position Scanner
		1. Position scanner to match scanner mounting angles under scanner mounting plate assemblies.
		2. Check installation height of scanner as specified by drawing.
		3. Insert threaded rod through mounting features and tighten nuts
		4. Check all reference dimensions as specified by drawing
		5. Adjust position as needed
		6. Tighten down mounting hardware
		7. Remove rigging and return Beams #1 and Beam #2 to their original location
	5. Replace Grating Section
		1. Personnel within restricted area must wear fall protection
		2. Replace walkway grating over hole into original position
		3. Reinstall walkway hardware into original position
		4. Confirm walkway grating is secure
		5. Remove caution tape and warning signage
		6. Leave fall protection anchor in wall for future use.
4. Install 14” Outlet Pipes
	1. Install new custom 14” fabricated sweep on Lane 2
		1. Manually insert custom sweep into neoprene seal on scanner entrance
		2. Rotate custom sweep up to mate with aluminum flange on lane 2 trough
		3. Re-use previous hardware to bolt flanges together.
	2. Reinstall 10ft section of 14” pipe on Lane 1
		1. Attach wall-mounted pipe-hanger to Unistrut per drawing
		2. Use gantry crane to lift section into place.
		3. Re-use previous hardware to bolt flanges together
		4. Secure end of pipe in pipe hanger.
5. Install Maintenance Access Walkway
	1. Fly in Walkway
		1. Consult walkway rigging plan to prepare walkway for lifting
		2. Position gantry crane outside over parking lot
		3. Lift walkway and bring into position
	2. Set walkway
		1. Set walkway onto C-channel beams
		2. Do not use walkway until walkway is secured
		3. Secure walkway with hook-bolt clamping method per drawing
	3. Install Pipe Support for Custom Fabricated Sweep from Lane 2
		1. Secure Unistrut at desired height
		2. Install pipe hanger around pipe
		3. Secure pipe hanger to Unistrut
		4. Ensure pipe is centered in neoprene flange in scanner.
6. Install Auxiliary Components to Scanner
	1. Fly in Control Cabinet
		1. Install Unistrut cross bars at locations specified by drawing
		2. Fly in control cabinet into position
		3. Confirm Mounting height per drawing
		4. Secure control cabinet to Unistrut cross bars
	2. Connect cabinet
		1. Make connections to scanner
		2. Plug in scanner to 120V outlet, dress extension cord.
	3. Install air-handling enclosure on wall
		1. Connect airlines to scanner
		2. Connect airlines to compressed air tap on wall
		3. Connect low-voltage control wiring to control cabinet
	4. Install cameras on Scanning Hood
	5. Install light Curtain around exit of scanner