A LONG FLUME FISH FACILITY TO PROVIDE TECHNOLOGY DEVELOPMENT FOR UPGRADING SOUTH DELTA FISH SALVAGE FACILITIES IN CALIFORNIA

SUBMITTED BY

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TO

CALIFORNIA SOUTH DELTA FISH FACILITIES FORUM (SDFF)

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INTRODUCTION AND BACKGROUND

This proposal provides the concept for a Long Flume Fish Facility (LFFF) to be constructed at UCD J. Amorocho Hydraulics Laboratory. The LFFF represents an alternative to the Tracy Demonstration Fish Facility (TDFF) proposed by USBR for developing technologies for fish salvage upgrades in the South Delta.

UCD J. Amorocho (UCDJA) Hydraulics Laboratory was built by the California Department of Water Resources to perform hydraulics modeling studies for the California state water project in 1960's. Since then, UCDJA Hydraulics Laboratory has had a long history of applying hydraulics modeling expertise to solve water resources, hydraulics, and fluid mechanics problems. For over forty years, UCDJA Hydraulics Laboratory has been conducting hydraulic investigations through scaled and prototype models to provide modeling service to the state and local water agencies of California. UCDJA Hydraulics Laboratory has been actively participating in the development of solutions to fish protection technologies for the Bay Delta river system since 1970s.

The present and future research interests of the Hydraulics Laboratory are focused towards meeting the needs for solution of the ecological, environmental and hydraulic engineering problems existing in California, especially in the overall Delta region. The Laboratory has a fully equipped machine shop with experienced technicians who can construct and modify a test facility with a high level of accuracy. The Laboratory has a source of unchlorinated well water that is suitable for environmental and biological studies. The Laboratory also has a heating/cooling system that is capable of controlling the temperature of the water. Engineers in the UC Davis J. Amorocho Hydraulics Laboratory have the experience to design and construct large-scale flumes and to conduct flow experiments in large-scale flumes. Fish Biologists in the UC Davis J. Amorocho Hydraulics Laboratory have had many years of experience of handling, transporting, holding and testing various Delta fish species that were captured in the Sacramento River or collected in the Delta fish facilities and in a size range of centimeters to meters. UCD researchers in the lab not only have rich experience to handle flow and fish in large-scale flumes, but also have extensive experience in handling debris that occurs in the Delta fish facilities. UCD researchers with the help of the state and federal agencies have been pursuing the application of new fish facility technologies, and developing a better understanding of the hydraulic and biological issues at the existing facilities. These investigations have been conducted primarily at the UCDJA Hydraulics Laboratory in Davis. Using a large scale flume 8 ft high, 5 ft wide with a capacity of 100 cfs that they have designed and built in the laboratory, they have been conducting studies in the flume with prototype debris racks and fresh debris that are collected at the Delta fish facilities for debris capture efficiency and fish behaviors near the debris racks for several years.

Recognizing the need to integrate with near field biological investigations to assess project impacts, and the need to continue time consuming tasks of technology development, a field scale testing facility that will be an alternative to USBR's proposed Tracy Demonstration Fish Facility (TDFF), is being proposed by UCDJA Hydraulics Laboratory (UCDJAHL).

From the observations of fish survival at the State and Federal fish salvage facilities it became clear that these facilities need significant upgrading in order to improve the fish survival rates at these facilities. The LFFF, that is being proposed for testing the possible improvements to the State and Federal salvage facilities, will be of sufficient scale to test long screens and agency fish screening criteria. In addition, further capabilities for testing novel approaches to fish salvage structures, hydraulics and general operations are attainable. LFFF shall be flexible due to its accessible modular design. It is expected that TTAT will refine the LFFF as necessary in order to meet the technology development objectives.

Once the LFFF is built, it will be open to all State and Federal agencies for any investigation of fish salvage technologies. Locating the facility near an existing hydraulics and fish testing laboratory, utilizing the existing infrastructure in UCDJAHL, is enabling UCDJAHL staff to reduce the construction costs of the proposed long flume significantly. The availability of university students to participate in the future investigations will also reduce the costs of the future investigations. Participation of the students will render qualified individuals for the future fish protection investigations in the State of California.

The location of the LFFF will also benefit the State and Federal agencies for easy accessibility due to the proximity of the LFFF site to Sacramento where most of the state and federal agencies are located.

PROJECT GOAL AND OBJECTIVES

In order to have a sound evaluation of new fish salvage facilities in the South Delta that will significantly improve fish survival while transferring the necessary water supply to Southern California, it is necessary to develop a testing facility which would test various fish salvage facility designs economically before the actual facilities are constructed and placed into operation. Within this framework, the LFFF will be constructed at UCDJAHL in order to evaluate technologies that will minimize fish loss during large diversions of water. Since all the studies that will be performed at the LFFF will be physical model studies of fish behavior in interaction with proposed hydraulic structure designs, the LFFF will provide scientifically-based guidance on ecologically, technically and financially feasible design alternatives for the future fish salvage facilities at South Delta.

The overall goal of the LFFF is the same as USBR's TDFF: "to develop improved fish protection technologies for South Delta fish salvage facilities to support environmentally and economically sound water diversions", and to ensure that the new salvage facilities are user friendly, reliable and economical to operate.

This overall goal will be reached by the following objectives:

1. To test and evaluate new designs and handling procedures that will minimize the negative impact of debris and sediment on the operation of the components of a fish salvage facility, while minimizing fish injury and fatality; accordingly, the new trashrack designs and handling procedures that are being developed currently at UCDJAHL, will be tested in the new LFFF where their interaction with louvers, fish screens, fish separation systems, and fish holding tanks, in the presence of various delta fishes will be evaluated;
2. To test and evaluate new designs that will minimize fish predation at the fish salvage facilities; accordingly,
   - to evaluate designs for "sieving fish" by size through a sequence of trashrack, leaky louver and positive screen in the main channel;
   - to evaluate fish crowder designs with respect to moving the fish rapidly through fish sorters toward bypasses in the channels and holding facilities;
   - to evaluate fish sorting systems at bypasses under gravity flow or lift-pump options;
   - to evaluate fish sorting class sizes with respect to fish survival by studying behavior of different size fish in different holding tanks;
3. To evaluate the feasibility and efficiency of positive barrier screens in moving fish toward fish holding tanks with respect to fish survival;
4. To evaluate the feasibility and efficiency of gravity-flow and lift-pump bypass systems in transferring fish from the main channel to the sorting apparatus and holding tanks with respect to fish survival;
5. To evaluate systems to transfer fish from the holding tanks to the transport tanks at vehicles with respect to fish injury and fatality;
6. To evaluate various fish salvage facility operation procedure options with respect to cost, reliability, ease of operation, and fish survival.

LFFF Proposal Specifics

LFFF will be sited on the east side of UCDJAHL's experimental field and close to the in-house fish holding facility in UCDJAHL, and will draw test water from the existing pond near the Putah Creek. The LFFF will be over 300 feet long, with the main flume being 10 feet wide and 8 feet deep, while the bypass channel will be 2 feet wide. Up to 260 cfs of water could be delivered to the flume for tests.

In order to evaluate their efficiencies for the separation of prey from predator, various trashrack-louver-screen combinations would be tested in the LFFF under various hydraulic conditions in the presence of various Delta fish species and of naturally entrained debris (transported to LFFF from current fish salvage facilities). Hydraulic conditions would range from 2.0 to 4.0 ft/s flume velocities and 0.1 to 0.4 ft/s screen approach velocities. Exposure times of fish moving along the screens would range from about 30 to 113 seconds. The new trashrack designs and handling procedures that are

being developed currently at UCDJAHL, will be tested in the new LFFF where their interaction with louvers, fish screens, fish separation systems, and fish holding tanks, in the presence of various delta fishes will be evaluated. The knowledge being gained from the current fish experiments in the presence of debris at the UCDJAHL large flume, will be utilized in the development of new designs for fish sorting and holding facilities downstream of flume bypasses in order to improve fish survival by reducing predator exposure in the presence of debris.

Since UCDJAHL has a longstanding collaboration with CADWR and CA Department of Fish and Game (CADFG), the LFFF will incorporate the findings of the fish holding, transportation and fish release research, conducted concurrently by CADFG and CADWR, into the future experiments at LFFF.

Once the LFFF is built, it will be open to all State and Federal agencies for any investigation of fish salvage technologies. By locating the facility near an existing hydraulics and fish testing laboratory, utilizing the existing infrastructure in UCDJAHL is enabling UCDJAHL staff to reduce the construction costs of the proposed long flume significantly.

Project Benefits

Details for the benefits of constructing and testing a LFFF are as follows:

- LFFF can be constructed and tested with a much smaller cost than that of TDFF;
- Available infrastructure in UCDJAHL expedites the construction of the flume and the associated facility – the complete LFFF will be constructed in 13 months;
- LFFF at the UCDJAHL allows the use of existing fish sources and holding capabilities at UCD;
- LFFF at the UCDJAHL would employ the university's experienced fisheries researchers, engineering faculty and staff in order to further reduce the cost and duration of planned investigations;
- In experiments LFFF can utilize south Delta's natural water that is of the same condition as of the South Delta fish collection facilities (water quality, debris, sediment, biological organisms);
- LFFF can also utilize clear well water conditions that would enable the researchers to observe the fish behaviors visually;
- LFFF at the UCDJAHL allows easy access to all researchers and staff of the State and Federal agencies; UCDJAHL is just 15 miles from Sacramento;

- Due to the modular design of LFFF operational changes can be performed expediently in order to minimize the duration of a sequence of tests;

- Placement of the LFFF away from the TFCF eliminates the influence of listed species on TFCF operations;

- LFFF will not impact existing Tracy Pumping Plant operations since it is completely removed from the Tracy Pumping Plant;

- Siting on UCD property minimizes environmental impacts.

CONCEPTUAL DESIGNS FOR THE LFFF

Two different layouts of the flume are being considered as design options for the LFFF.

The option #1 (Layout 1, see figure 1) is to build a new flume 12 feet wide (10ft for main channel plus 2ft for bypass channel), 8 feet high, and 300 feet long, located on the east side of the UCDJAHL experimental field. A fish separator with a gravity bypass structure near the new flume can be built on the dry creek immediately downstream of an existing pond at UCDJAHL.

The option #2 (Layout 2, see figure 2) is to build a new flume with the same configuration as that option #1, which is 12 feet wide, 8 feet high, and 300 feet long, located on the east side of the UCDJAHL experimental field. A fish separator with a pumped bypass structure will be built on an existing concrete pad near the new flume.

Anticipated construction costs of the proposed facilities are estimated at around $2,500,000.

Differences between options and costs are related primarily to the type of bypass structure for the fish separator which delivers bypass water from the experimental channel to the fish separator and holding tanks downstream, and the types of pumps chosen for circulating the water in the flume.

The LFFF would be constructed and evaluated in several phases. Phase 1 would include all components required for testing a basic layout, and additional items would be constructed as needs arise. Main components for a **Phase 1** would be:

1. **Long Test Flume** (see figures 3 and 4 for both option #1 and option #2 in detail)
    - A long concrete pad as the flume foundation at ground level;
    - In-flume facilities accommodating future trashrack installation;
    - In-flume facilities accommodating future leaky louvers in a “V” shape with central bypass;
    - Positive fish screen in straight line with bypass;
    - Sweep cleaner (brush) apparatus to clean screen;
    - Side bypass from screen to fish separator/holding facilities;
    - Flow regulating weir in return flow from flume to pump station.

2. **Pumps providing up to 260 cfs to the main flume**

    A pump station with 4 new 60 cfs pumps, plus one 20 cfs pump, and a head tank control (see figures 3 and 4 for both option #1 and option #2).

3. Return flow channel with flow control and measurement devices to send 260 cfs from the pump station to the upstream of the main testing flume.

4. Separator/holding tank facility for fish screen bypass

a. Option #1 – Gravity flow with active/passive separator just downstream from the bypass (see figure 3), or
b. Option #2 – Pumped flow with fish lift just downstream from the bypass; flow goes to elevated active/passive fish separator and into tanks (see figure 4), and
c. Flow to separator/holding facility is 12 cfs for each option;
d. Two circular holding tanks and one elliptical tank for each option
    - Elliptical tank receives small fish from passive separator
    - One circular tank receives small fish from active separator; Other circular tank receives large fish from active separator.

5. Water supplies

a. Storage pond which could be filled with the natural Delta water or be filled with well groundwater;
b. Temperature controlled and treated groundwater for fish;
c. Non-temperature controlled and treated groundwater for fish;
d. Untreated well water to large fish circular tank;
e. Campus tap water for other purposes.

6. Tanks for holding fish prior to testing (In-house)

TRASHRACK/LOUVER/POSITIVE BARRIER FISH SCREEN LFFF FLUME

The trashrack/louver/screen flume will be built above ground inside the experimental field of UCDJHAL. A maximum of 260 cfs of water will be pumped into the upstream end of the flume from a pump station that is located immediately below the downstream end of the main channel of the flume. An existing pond at J. Amorocho Hydraulics Lab is located near the pump station, and the water in the main flume can be easily drained to or supplied from the pond. The main channel of the flume will be 10 feet wide with flow depth in the range of 5 to 7 feet, depending on the nature of the experiment. The trashrack and leaky louvers would not be installed in the first phase of studies. When installed, the trashrack would be at the most upstream end of the flume, followed by the leaky louvers, and flow would proceed in two directions: 1) main flows would go through the trashrack and the leaky louvers to the screen; and, 2) louvered flows would proceed to a side holding tank.

After passing the louvers (if there are any existing louvers for the particular experiment) the flow would enter the main flume section which would include a wedge-wire screen at a maximum length of 195 feet. Flow that would go through the wedge-wire screen would be returned to the pump station at the end of the flume. The screen bypass channel at 2 ft width and 45 ft length would have a variable flow depth due to a ramp channel bed. By means of this ramp bed and dewatering screens the bypass flow would be reduced before reaching the separator/holding facilities.

The following hydraulic conditions will be considered in the LFFF during the first phase of studies:

	Condition 1	Condition 2	Condition 3	Condition 4
Channel Velocity (ft/s) at Upstream End of Flume	4	2	4	2
Channel Water Depth (ft) at Upstream End of Flume	5	5	5	5
Active Screen Length (ft)	195	195	97.5	97.5
Flow (cfs) Upstream of Fish Screen	200	100	200	100
Main Screen Approach Velocity (ft/s)	0.2	0.1	0.4	0.2
Exposure Time (Seconds)	60	113	30	50
Bypass Entrance Flow vs. Velocity (cfs vs. ft/s)	40 vs. 4	20 vs. 2	40 vs. 4	20 vs. 2
Bypass Exit Flow vs. Velocity (cfs vs. ft/s)	12 vs. 4	12 vs. 4	12 vs. 4	12 vs. 4

PROJECT COST

Construction costs for LFFF for Phase 1 of studies are estimated at around $2,500,000. The details of the budget for the construction are shown below:

Budget for Phase 1

	Option #1	Option #2
Equipment and construction	$1,682,000	$1,827,000
Supplies	$211,000	$211,000
Personnel salary and benefits	$350,000	$350,000
Overhead (10% of non-equipment items)	$103,300	$110,100
Total	$2,346,300	$2,498,100

Potential Additions to LFFF that will follow Phase 1

The following items may be added to the LFFF for the future studies, following Phase 1: a) addition of trashracks, traveling screens etc. for the efficient removal of debris; b) addition of leaky louvers with center bypass, and addition of side holding tanks to receive bypass flows from the leaky louvers; c) addition of fish crowders; and d) any promising fish salvage equipment that may emerge during the first phase of the study.

DESIGN AND CONSTRUCTION SCHEDULE

PROPOSED SCHEDULE FOR LFFF DESIGN AND CONSTRUCTION

Event	Date
Cost Estimates and Initial Concept Drawings	February 6, 2004
LFFF Design Meetings with TTAT	March, 2004
Second Updated Draft LFFF Report	May, 2004
Decision to Proceed with Final Design of Option	June 15, 2004
Drawings out for final spec reviews	August 15, 2004
Review (final spec review)	September 15, 2004
Specifications published and Bidding	October 15, 2004
Award	November 15, 2004
Notice to Proceed	November 15, 2004
Complete Construction	December 15, 2005
LFFF Evaluations and Demonstrations	January 06 – Dec 08

INITIAL LFFF EVALUATION PLAN

Once the LFFF is built, it will be open to all State and Federal agencies for any investigation of fish salvage technologies. Since LFFF is designed as an alternative to USBR's proposed Tracy Demonstration Fish Facility (TDFF), the initial LFFF evaluation plan will be the same as the one proposed for TDFF. The past fish salvage studies and on-going studies at the existing TFCF facilities and USBR Technical Center in Denver, and future facilities can be integrated with the LFFF.

The LFFF aims to address eventually all objectives outlined earlier under the section "Project Goal and Objectives". The study priorities require a multiagency input from all interested parties dealing with both State and Federal South Delta fish salvage facilities. Accordingly, the priorities will be determined by consultations with TFRED (Tracy Facility Research and Evaluation Document Team) and with all concerned State and Federal Agencies.

Some of the priority topics for the early studies may be stated as follows:

- Evaluation of new designs that will minimize fish predation at the fish salvage facilities;

- Evaluation of the feasibility and efficiency of positive barrier screens in moving fish toward fish holding tanks with respect to fish survival. (A variety of hydraulic conditions, fish species and fish sizes need to be examined);

- Evaluation of the feasibility and efficiency of gravity-flow and lift-pump bypass systems in transferring fish from the main channel to the sorting apparatus and holding tanks with respect to fish survival;

- Evaluation of new designs and handling procedures that will minimize the negative impact of debris and sediment on the operation of the components of a fish salvage facility.

The general approaches to the LFFF evaluations will follow the strict hydraulic/biological/statistical scientific experimental procedures that have been established at UCDJAHL in the last four decades. These approaches will be based upon observation and statistical evaluation of the performance of planned facilities in the presence of fish and debris that are entrained from the Delta waters, under controlled experimental scenarios.

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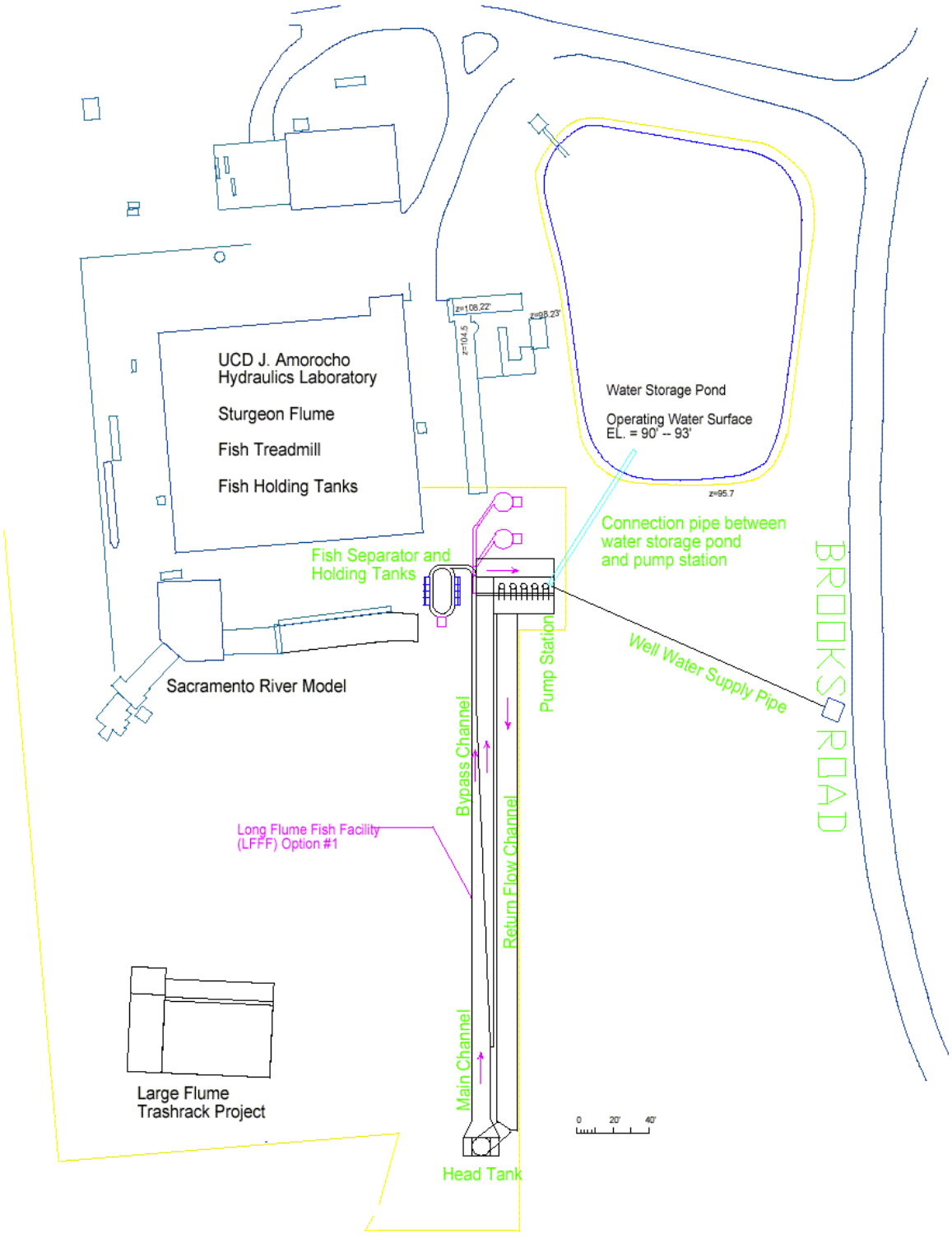

Figure 1 – Long Flume Fish Facility at UCD J. Amorocho Hydraulics Laboratory (Option #1)

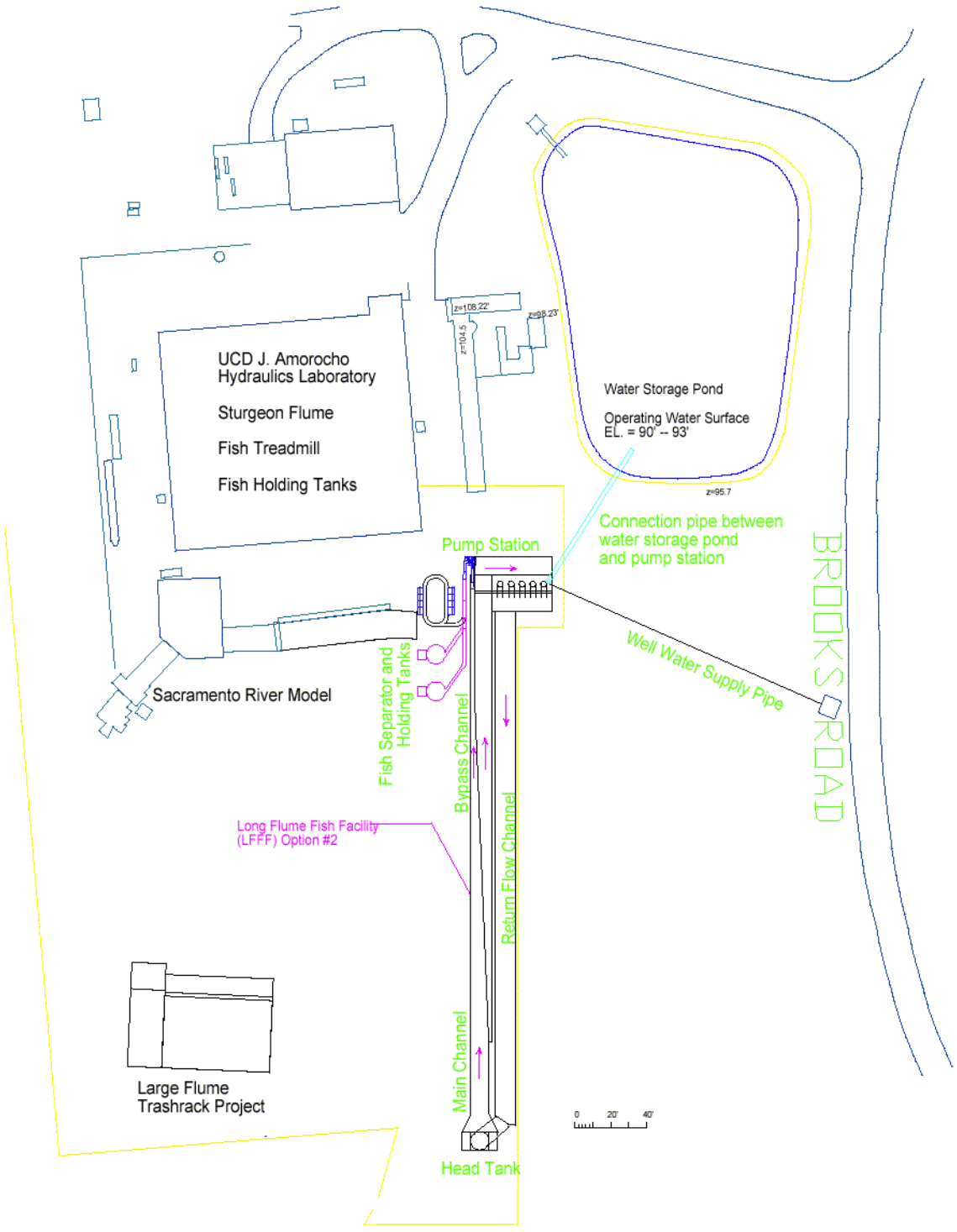

Figure 2 – Long Flume Fish Facility at UCD J. Amorocho Hydraulics Laboratory (Option #2)

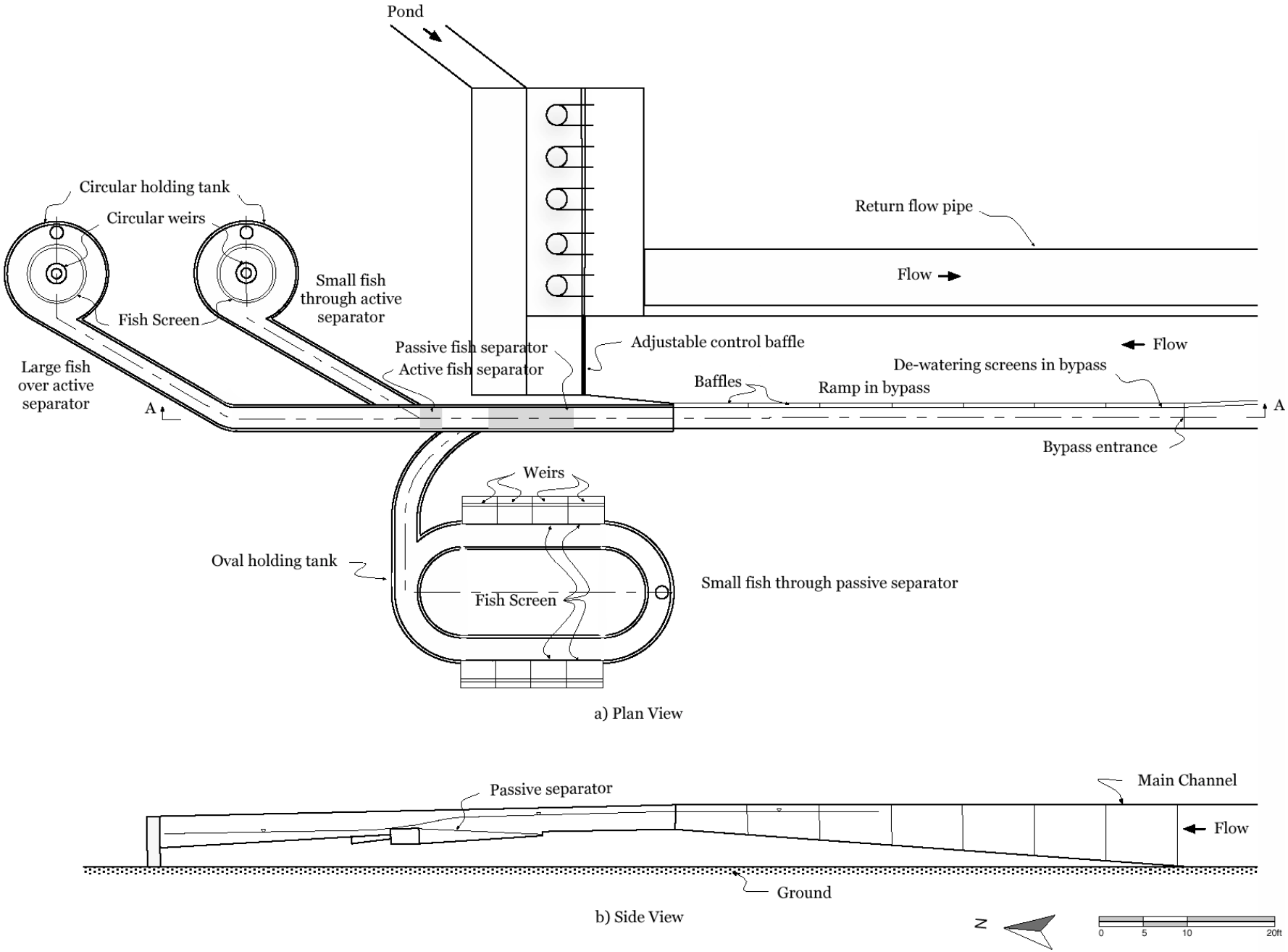

Figure 3 - Layout of the pump station, fish separator and tanks for option #1

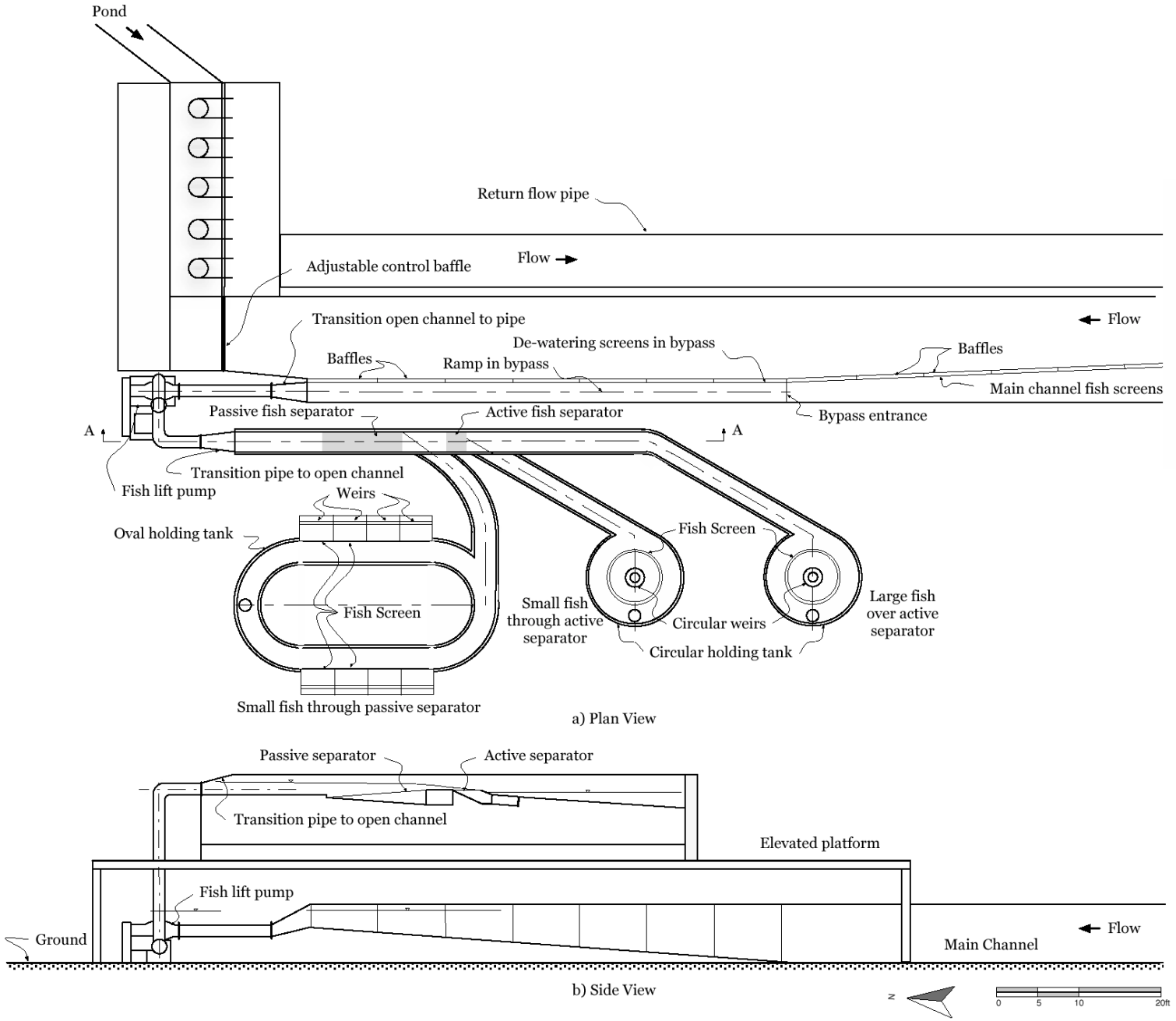

Figure 4 - Layout of the pump station, fish separator and tanks for option #2