FISH CULTURE SYSTEM PLANNING REPORT

BLUE RIVER FISH HATCHERY
BLUE, AZ

AUGUST 2009

PREPARED BY:
THE CONSERVATION FUND
FRESHWATER INSTITUTE

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Project Summary

The U.S. Fish & Wildlife Service (USFWS) and Arizona Game and Fish Department (AZGFD) are interested in utilizing the existing privately-owned Blue River Fish Hatchery for the following:

- Temporary holding and grow-out for translocated native fish for distribution in the Blue River Basin;
- Short-term (1 year) or long-term (>1 year) holding of rare stocks of Gila River Basin native fishes;
- Captive propagation of native fish;
- Intense production for native trout species using a conservative rainbow trout model.

In the past, Blue River Fish Hatchery produced rainbow trout for sale to the state of Arizona who stocked the trout for recreational fishing in their urban fishing program. Trout are raised on surface water in a small hatchery building and then outdoors in raceways and ponds. This report details the existing conditions at the hatchery and makes recommendations for facility improvements to accommodate the new objectives.

Existing Conditions

Source Water

Blue River Fish Hatchery has a single surface water source, the Blue River, as well as two wells for rearing fish. Upstream of the hatchery the Blue River has a small dam that diverts water into an open channel for hatchery use (Figure 1). Water in the diversion channel flows to the hatchery to supply the raceways and ponds. The hatchery's water right from the Blue River is 365 acre-feet per year, or 225 gallons per minute (gpm).

The dam was re-constructed in the 1980s using pre-cast concrete barriers. Visual inspection of the dam indicates multiple breaks in the dam structure and significant sediment buildup behind the dam wall.

Water in the diversion channel can also be diverted to an infiltration pond to provide water for the hatchery building. The infiltration pond is approximately one eighth of an acre with a network of perforated drain piping six feet below the pond bottom (Figure 2). Water that flows to the pond infiltrates through the soil and into the perforated pipes to supply the hatchery building 1,100-ft away. The supply line from the filter pond is 12-inch diameter PVC. When originally installed in 1989 the flow from the infiltration pond was approximately 150–200 gpm. Currently the flow is estimated to be approximately 30 gpm due to siltation and plugging of the buried perforated piping network.

Figure 1. Blue River Water Supply Diversion Dam.

Figure 2. Hatchery Infiltration Pond.

The surface water flow has been estimated to supply 250–1,000 gpm with temperatures ranging from 55–72ºF (13–22ºC). Dissolved gas concentrations in the surface water are not regularly monitored; however, no dissolved gas problems have been observed at the hatchery. Dissolved oxygen concentrations of the surface water have been reported to be 8 mg/L, approximately saturation for the elevation (5,450 ft) and water temperature.

Blue River Fish Hatchery also has two wells that are used to supply water to the raceways and the ponds. Well #1 is 50-ft deep with an 8 horsepower well pump (Figure 3). Well #1 produces approximately 125 gpm at 56ºF and provides water directly to the raceways. Well #2 is 100-ft deep with a 10 horsepower well pump. Well #2 produces approximately 200 gpm and provides water into the diversion ditch as it supplies the ponds. Typically the wells are used to lower the temperature of the water supply for two months during the summer each year.

Figure 3. Well #1 Wellhead and Electrical Service.

Source Water Quality

The in-depth water quality of the Blue River has not been measured. The Blue River water quality is suitable for fish culture; however, there are some water quality parameters that might be of concern and others for which there is no data. It is recommended that additional water quality sampling be completed at levels that will provide the certainty required to ensure compliance with published fish culture standards.

It has been noted that the surface water quality is significantly impacted during rainfall events. Rainfall events increase the flow, sediment, and turbidity of the water supplied to the hatchery by the diversion channel. The significant increase in flows during rainfall events has washed out two different channel linings over the years (metal, plastic). High flow events cause the water in the diversion channel to become "muddy" and the hatchery to stop using the surface water and switch entirely to well water.

Hatchery Building

Blue River Fish Hatchery's hatchery building was constructed in 1989 (Figure 4). The hatchery building has four fry rearing troughs; each trough has a large hatching jar on the influent end. Troughs are approximately 10-ft long sections of 12-inch diameter pipe that are cut in half. Water is supplied to each jar/trough combination from the 12-inch diameter supply line from the infiltration pond. The flow to the hatchery building is estimated to be 30 gpm.

Figure 4. Inside of Hatchery Building.

Raceways

Blue River Fish Hatchery has 4 concrete raceways which were constructed in 1989 (Figure 5). The raceways are configured in serial reuse flow, i.e., two of the raceways discharge into the inlet of two raceways downstream. Raceways are 4-ft by 50-ft by 3-ft deep. Approximate rearing volume is 4,300 gallons each. The raceway pairs are covered with a hoop-structure that can be fitted with a covering of wire mesh or shade cloth. The hoop-structure is heavily rusted and in need of repair or refurbishment.

Water is supplied to the raceways by three different sources: the diversion channel, Well #1, and the 12-inch diameter supply pipe from the infiltration pond. Well water that is supplied to the raceways is first treated with an open packed column for aeration. The packed column is approximately 4-ft tall filled with standard plastic media.

Figure 5. Outdoor Concrete Raceways.

Rearing Ponds

Blue River Fish Hatchery has 6 earthen ponds which were constructed in 1989 (Figure 6). Five of the earthen ponds are 30-ft by 125-ft by 8-ft deep; pond depth increases from the head of the pond (3-ft) to the end of the pond (12-ft). Pond one is 75-ft by 150-ft by 15-ft deep. The ponds have a clay bottom. Ponds are supplied with water from the diversion channel after it has passed through the fee-fishing pond and also collected the effluent from the hatchery building and the raceways. The diversion channel water is also supplemented by Well #2 before it enters the ponds (Figure 7).

It has been noted that the rearing ponds require maintenance every five years to remove sediment buildup. Sediment is removed with a backhoe when the ponds are dewatered.

Figure 6. Rearing Ponds #1 new and #2 new.

Figure 7. Well #2 Supply to the Diversion Channel Before the Rearing Ponds.

Fish Production

Since 1989, the Blue River Fish Hatchery has produced approximately 60,000 half-pound rainbow trout per year (20,000–30,000 pounds/year). Trout were primarily sold to the state of Arizona who stocked the trout for recreational fishing in their urban fishing program. Trout were also sold to fee fishing operations in the area (e.g., Greer, Pinetop, Mountain Meadows). The hatchery is permitted to grow rainbow trout, Kamloops trout, and brown trout by the Arizona Department of Agriculture.

The typical bioplan for the hatchery is to incubate and hatch 50,000 trout eggs inside the hatchery building. Eggs are incubated and hatched in the large jars and the fry swim out into the troughs. The fry are brought onto dry feed and grown to 1–2 inches in length. When the trout reach 1–2 inches in size they are stocked into the outside raceways. Once the trout reach 4-inches they are moved out of the raceways and into the ponds. The hatchery is able to complete this bioplan cycle twice each year.

Fish Health and Biosecurity

The hatchery has had ongoing issues with protozoan and arthropodan parasites. Other than parasites, there have not been any reports of major fish health problems, although the fish culture is distributed in an extensive environment, making surveillance difficult. The hatchery has successfully passed its annual fish health certification covering reportable pathogens for the last three years.

The hatchery ponds are subject to bird predation from kingfishers, mergansers, and osprey; there is no real biosecurity at the facility.

Proposed Improvements

The U.S. Fish and Wildlife Service and the Arizona Game and Fish Department would like to install circular, dual-drain tanks at Blue River Fish Hatchery for native fish, ideally in a gravity flow configuration. When designed and operated appropriately, solids can be removed from the bottom of dual-drain fish culture tanks within 10–15 minutes utilizing a center drain at the bottom of the tank. The majority of solids produced in the tank are concentrated in this bottom center drain and discharged from each tank in a relatively small flow. In a Cornell-style dual drain tank, the cleaner flow is collected in a sidewall box that is located approximately halfway up the tank wall. The cleaner flow, which typically represents 75–85% of the tank flow, exits the tank through the sidewall box and can be reused. The self-cleaning action of the dual-drain tank and quick removal of solids from the fish culture volume improves the water quality in the tank and also reduces labor requirements associated with tank cleaning.

Recommendations for implementing circular dual-drain tanks at the hatchery are dependent on the site topography and hydraulic gradeline. Elevations are not currently available for the Blue River Fish Hatchery site. Based on site observation, incorporating circular, dual-drain tanks into the existing gradeline may be possible but must include supply pipe headloss, influent dissolved gas conditioning, tank nozzle headloss, the depth of the tank, bottom drain pipelines, and receiving water elevation changes.

In the options presented, tanks should be installed in a location and at an elevation that allows for connection to a new water supply line and a discharge line to the creek. Tank process supply and drain piping should allow for isolation and bypass of tanks as needed during chemical treatments administered to control external parasites. Covering and enclosing the fish culture area is recommended for all options in order to minimize predation and potential sun stress, while providing a more controlled environment. An enclosure similar to that surrounding the raceways at the AZGFD Page Springs Hatchery would be suitable.

Since the fish rearing plan for any improvements to Blue River Fish Hatchery are not specifically identified, the proposed options assume that Gila Trout will be raised similar to Apache Trout at Silver Creek SFH. It is assumed that Gila Trout will be grown to 9.5 inches (24 cm) long and 0.357 lbs (162 g) in weight. Since Gila Trout are known to be difficult to culture intensively a wide range of rearing densities is evaluated, starting at a low rearing density of 15 kg/m^3. Also, to accommodate other uses of any improvements, the fish culture tanks are sized relatively small and manageable at 12-ft in diameter. The small tank size should provide the flexibility for raising other native fish species.

Influent Treatment

The existing diversion channel requires maintenance to maintain good flow of the surface water to the hatchery. Maintenance involves using a backhoe to widen and clear the channel of debris. Clearing the diversion channel of debris and silt is completed after each heavy rainfall event and every summer. The open diversion channel also allows heat gain by the water in the summer. If this hatchery is to be used in the future, it is recommended that a pipeline be installed to replace the existing diversion ditch. The pipeline would eliminate the maintenance required to clear the channel of tree debris and eliminate the heat gain in the summer.

The pipeline required would be approximately 1,500 lineal feet of 8 or 10-inch diameter pipe. The pipe does not need to be larger to accommodate the higher flows since the hatchery water right is only 225 gpm. Pipe sizing should result in water velocities of at least 1.5 feet per sec to ensure that sedimentation does not occur within the pipe.

The proposed options also require that the two well water sources be utilized. Well #1 is to be employed on a constant basis, whereas Well #2 is employed as a backup or replacement for the surface water supply. If both wells pumping together are shown to consistently produce water (325–350 gpm) over the course of an entire year then the surface water supply could be eliminated and full biosecurity could be achieved. However, for planning purposes here, Well #2 is assumed to provide backup should the surface water become unusable due to water quality concerns. Disinfection of the surface water supply is likely problematic due to the large increases in turbidity that are reported to occur after rainfall events. This type of turbidity is typically due to colloidal solids. Filtration and UV treatment in this case requires large safety factors resulting in increased capital and operating cost. It is recommended that additional data be collected to determine the nature of the solids after rainfall events and feasibility of treatment.

Option A: Single-pass gravity system with five circular, dual-drain tanks

Option A is the installation of a single row of circular, dual-drain fish culture tanks and is a simple, gravity flow option. The installation of five 12-ft diameter circular, Cornell-style, dual-drain tanks operated with 3.75 feet of water depth is recommended in this option. The process flow diagram for Option A is shown in Figure 8 and basic design characteristics for the 12-ft diameter tanks are summarized in Table 1. The hydraulic gradeline for Option A is shown in Figure 9. A water supply flowrate of 70 gpm is required for each tank to maintain a hydraulic retention time of 45 minutes. Fish rearing densities proposed will require supplemental oxygen (Table 2). Of the 70 gpm supplied to each tank, approximately 17 gpm will be discharged from the tank bottom drain with the majority of the waste solids, while 53 gpm of the cleaner flow will be discharged in the sidewall box drain. Installation of five 12-ft diameter tanks in a single pass, flow-through design results in a total water supply requirement of 350 gpm; the water supply is intended to be a combination of water from the diversion channel (225 gpm) and Well #1 (125 gpm).

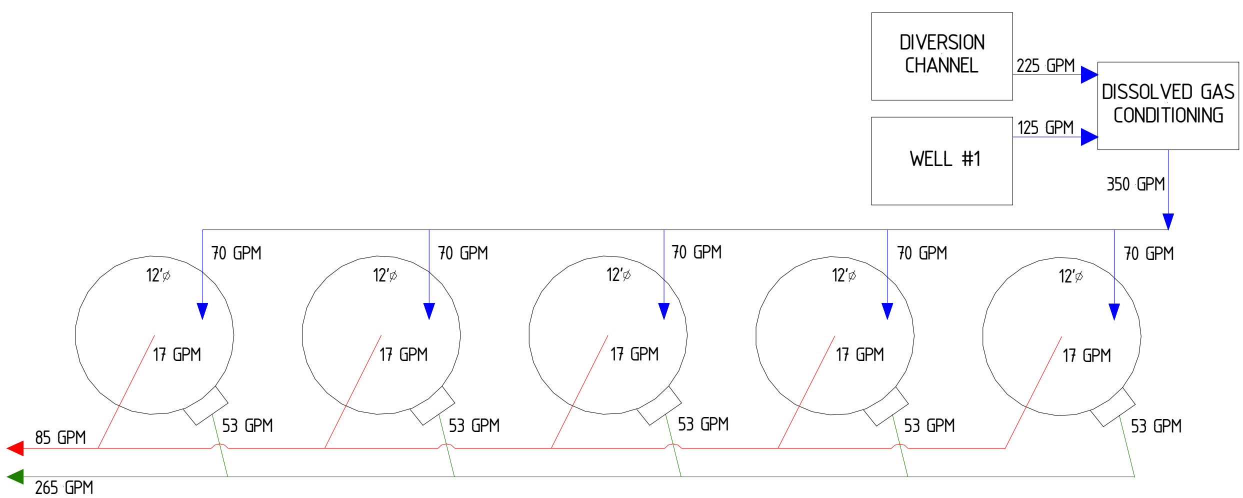
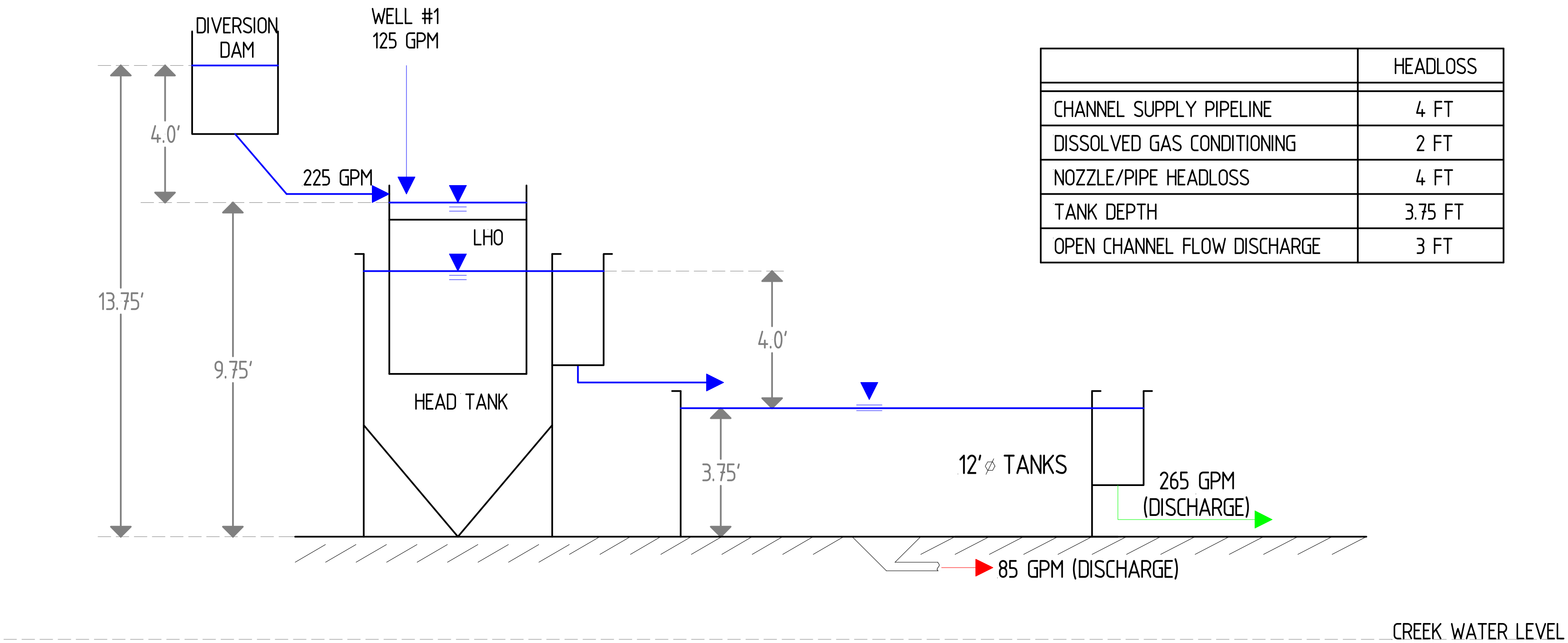


Figure 8. Process Flow Diagram for Option A.



	HEADLOSS
CHANNEL SUPPLY PIPELINE	4 FT
DISSOLVED GAS CONDITIONING	2 FT
NOZZLE/PIPE HEADLOSS	4 FT
TANK DEPTH	3.75 FT
OPEN CHANNEL FLOW DISCHARGE	3 FT

Figure 9. Elevation View of the Process Flow Diagram for Option A.

Design Parameter	**Option A**
Tank diameter	12 ft
Number of tanks	5
Tank water depth	3.75 ft
Tank diameter to depth ratio	3.2:1
Tank volume	3,200 gal
Tank water supply	70 gpm
Tank hydraulic residence time	45 min
Tank bottom drain hydraulic loading	0.155 gpm/ft^2
Tank bottom drain flowrate	17 gpm
Tank sidewall box flowrate	53 gpm

Table 1. Design characteristics of dual-drain tanks for Option A.

Fish Density (kg/m^3)	**Fish Density (lb/gal)**	**Fish Weight (lb/fish)**	**Fish Per Tank (#/tank)**	**Biomass Per Tank (lb/tank)**	**Max Feeding Per Tank* (lb/tank)**	**5-Tank Water Flow (gpm/tank)**	**Delta DO** (mg/L)**
15	0.125	0.357	1,113	397	4.0	70	1.7
30	0.250	0.357	2,225	794	8.0	70	3.3
45	0.375	0.357	3,339	1,191	11.9	70	5.0
60	0.500	0.357	4,451	1,589	15.9	70	6.6

*Assumes a 1% bodyweight per day feeding rate
**Assumes oxygen consumption is 0.35 kg per kg of feed fed

Table 2. Supplemental oxygen required to maintain outlet dissolved oxygen at saturation at varying final densities.

Installing the pipeline, dissolved gas conditioning equipment and circular rearing tanks as outlined in Option A results in a preliminary cost estimate of $555,000. A breakdown of these costs is provided in Table 3.

Item	**Quantity**	**Unit Cost**	**Cost**[1]
Mobilization[2]	—	15%	$43,000
Site Preparation	2,500 ft^2	$\$6/ft^2$	$15,000
Influent Pipeline Installation (10-inch HDPE)	1,500 ft	$60/ft	$90,000
Tank Enclosure and Covering (50-ft by 40-ft)	2,000 ft^2	$\$30/ft^2$	$60,000
12-ft diameter, 4-ft deep, Circular, Dual-drain Tanks[3]	5	$9,000	$45,000
Dissolved Gas Conditioning Equipment for 500 gpm[3]	1	$12,000	$12,000
Effluent Pipeline Installation (10-inch HDPE)	200 ft	$50/ft	$10,000
Process Piping Allowance	Lump Sum	—	$30,000
Electrical Allowance	Lump Sum	—	$10,000
Miscellaneous Labor Allowance	Lump Sum	—	$10,000
Subtotal			$325,000
Design	Lump Sum	—	$50,000
Construction Administration	5%	$325,000	$17,000
Contractor Overhead/Profit	20%	$325,000	$65,000
Contingency	30%	$325,000	$98,000
		TOTAL	**$555,000**

[1]All costs rounded up to the nearest $1,000
[2]Remote Site
[3]Includes Shipping

Table 3. Summary of preliminary costs for Option A.

Fish culture in the proposed dual-drain tanks in a gravity flow configuration requires daily maintenance for fish feeding, tank cleaning, and other basic fish culture tasks. It is estimated that fish culture tasks for this system will take two hours each day. The resulting full-time employee (FTE) equivalent is 0.25. In addition to daily manpower there is also a cost associated with running the pump for Well #1 continuously. Although the pump motor has been indicated to be 8 horsepower, it is likely 7.5 horsepower, a standard motor size. Assuming an electricity cost of $0.10 per kilowatt-hour, operating Well #1 is estimated to cost $4,900 per year.

Option B: Partial water reuse systems with ten circular, dual-drain tanks

Option B is the installation of two partial water reuse systems each with five circular, dual-drain fish culture tanks and associated water treatment equipment. The process flow diagram for Option B is shown in Figure 10 and basic design characteristics for each reuse system are summarized in Table 4. A water reuse flowrate of 625 gpm is required; each tank will maintain a hydraulic retention time of 25 minutes. Densities proposed will require supplemental oxygen (Table 5). Of the 125 gpm supplied to each tank, approximately 35 gpm will be discharged from the tank bottom drain with the majority of the waste solids, while 90 gpm of the cleaner flow will be discharged in the sidewall box drain and reused after treatment.

Water requirements for the partial water reuse systems are based on maintaining safe levels of unionized ammonia for fish culture. Because there is no biofiltration process in a partial water reuse system to oxidize the ammonia produced by the fish, makeup water must be used to dilute the levels of ammonia from becoming toxic. However, the water pH also factors into ammonia toxicity and the carbon dioxide produced by the fish during respiration will depress the pH and reduce the fraction of total ammonia that is unionized or toxic. The minimum pH that the fish can tolerate is based on the level of total alkalinity in the system water. High levels of alkalinity will result in higher equilibrium values of carbon dioxide for a given pH and temperature. Therefore, a balance must be maintained between the lower pH, ammonia toxicity, and safe levels of carbon dioxide.

The unit processes required in a partial water reuse system ensure high quality water is returned to the fish tanks. Solids filtration of the sidewall drain flow ensures low levels of suspended solids in the culture water. Solids filtration is typically achieved through screen filtration utilizing screens with openings of 60–90 microns. Carbon dioxide removal maintains low levels of carbon dioxide for the fish; typical threshold levels for coldwater fish culture are 10–20 mg/L. Carbon dioxide removal requires large quantities of fresh air for stripping of dissolved carbon dioxide, which is very soluble in water. Packed columns coupled with high volume, low pressure air blowers are typically used for carbon dioxide removal. Finally, oxygenation of the process water achieves high levels of dissolved oxygen for fish culture.

The water supply requirement for both partial water reuse systems together is 350 gpm (175 gpm per system) which results in a water reuse rate of 72%.

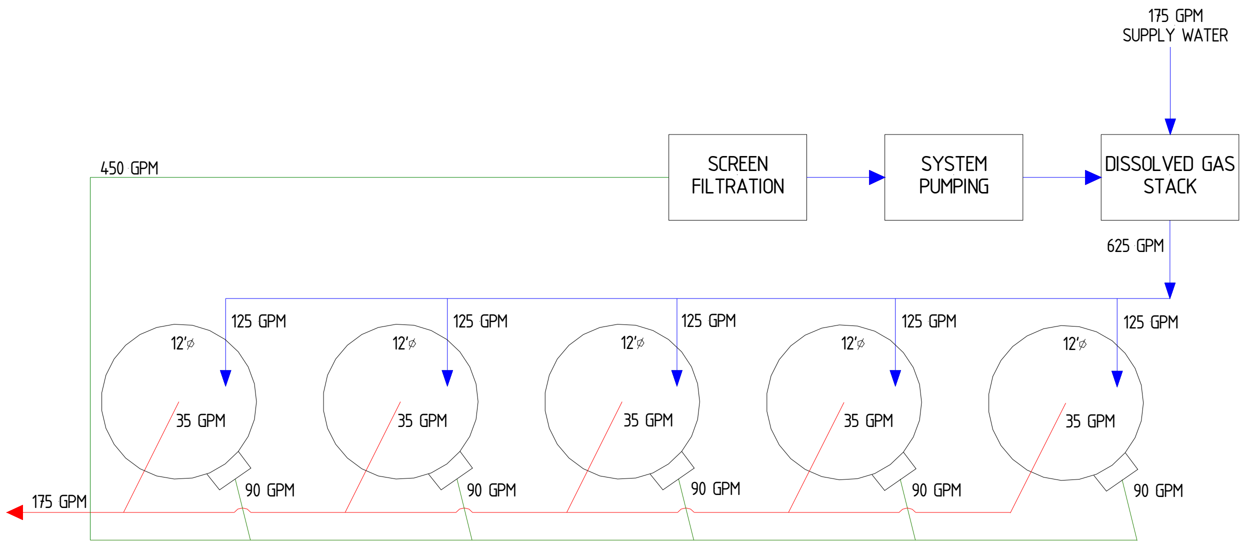


Figure 10. Process Flow Diagram for a Single Partial Water Reuse System in Option B.

Design Parameter	Option B
Tank diameter	12 ft
Number of tanks	5
Tank water depth	3.75 ft
Tank diameter to depth ratio	3.2:1
Tank volume	3,200 gal
Water Reuse Rate	72%
Reuse water flow	450 gpm
Water supply	175
Tank water supply	125 gpm
Tank hydraulic residence time	25 min
Tank bottom drain hydraulic loading	0.309 gpm/ft^2
Tank bottom drain flowrate	35 gpm
Tank sidewall box flowrate	90 gpm

Table 4. Design characteristics of a single five-tank partial water reuse system for Option B.

Fish Density (kg/m^3)	Fish Density (lb/gal)	Fish Per Tank (#/tank)	Max Feeding Per Tank* (lb/tank)	Water Flow (gpm/tank)	Delta DO** (mg/L)	Dissolved CO2 (mg/L)	Un-ionized Ammonia (mg/L)
15	0.125	1,113	4.0	125	1.9	4.1	0.0046
30	0.250	2,226	7.9	125	3.6	6.7	0.0057
45	0.375	3,339	11.9	125	5.3	9.3	0.0062
60	0.500	4,451	15.9	125	6.9	11.9	0.0064

*Assumes a 1% bodyweight per day feeding rate
**Assumes oxygen consumption is 0.46 kg per kg of feed fed

Table 5. Supplemental oxygen required to maintain outlet dissolved oxygen at saturation at varying final densities.

Implementation of partial water reuse for the five tanks installed under Option A is expected to cost approximately $236,000. A breakdown of these preliminary costs is provided in Table 6. Implementation of a second set of five tanks and the associated partial reuse equipment is expected to cost approximately $452,000 (Table 7).

Item	**Quantity**	**Unit Cost**	**Cost**[1]
Mobilization[2]	—	15%	$18,000
Microscreen Drum Filter for 450 gpm[3]	1	$13,000	$13,000
Pump Sump (8-ft diameter) [3]	1	$4,000	$4,000
Low-head Centrifugal Pumps[3]	3	$3,000	$9,000
Pump Control Panel	1	$13,000	$13,000
Instrumentation	Lump Sum	—	$10,000
Process Piping Allowance	Lump Sum	—	$30,000
Electrical Allowance	Lump Sum	—	$25,000
Miscellaneous Labor Allowance	Lump Sum	—	$10,000
Subtotal			$132,000
Design	Lump Sum	—	$30,000
Construction Administration	5%	$132,000	$7,000
Contractor Overhead/Profit	20%	$132,000	$27,000
Contingency	30%	$132,000	$40,000
		TOTAL	**$236,000**

[1]All costs rounded up to the nearest $1,000
[2]Remote Site
[3]Includes Shipping

Table 6. Summary of preliminary costs for implementing partial water reuse for the five tanks installed in Option A.

Item	**Quantity**	**Unit Cost**	**Cost**[1]
Mobilization[2]	—	15%	$37,000
Site Preparation	2,500 ft^2	$6/$ft^2$	$15,000
Tank Enclosure and Covering (50-ft by 40-ft)	2,000 ft^2	$30/$ft^2$	$60,000
12-ft diameter, 4-ft deep, Circular, Dual-drain Tanks[3]	5	$9,000	$45,000
Dissolved Gas Conditioning Equipment for 500 gpm[3]	1	$12,000	$12,000
Microscreen Drum Filter for 450 gpm[3]	1	$13,000	$13,000
Pump Sump (8-ft diameter) [3]	1	$4,000	$4,000
Low-head Centrifugal Pumps[3]	3	$3,000	$9,000
Pump Control Panel	1	$13,000	$13,000
Instrumentation	1	$5,000	$5,000
Process Piping Allowance	Lump Sum	—	$30,000
Electrical Allowance	Lump Sum	—	$25,000
Miscellaneous Labor Allowance	Lump Sum	—	$10,000
Subtotal			$278,000
Design	Lump Sum	—	$20,000
Construction Administration	5%	$278,000	$14,000
Contractor Overhead/Profit	20%	$278,000	$56,000
Contingency	30%	$278,000	$84,000
		TOTAL	**$452,000**

[1]All costs rounded up to the nearest $1,000
[2]Remote Site
[3]Includes Shipping

Table 7. Summary of preliminary costs for second partial reuse system in Option B.

Fish culture in the proposed water reuse systems requires daily maintenance for fish feeding, tank cleaning, and other basic fish culture tasks. It is estimated that fish culture tasks for both systems will take fours hours each day. The resulting full-time employee equivalent is 0.50. In addition to daily manpower there is also the cost associated with running the reuse pumps and the pump for Well #1 continuously. Assuming an electricity cost of $0.10 per kilowatt-hour, operating Well #1 will cost $4,900 per year; operating both system's reuse pumps will cost $5,300 per year.

Final Recommendations

The number of fish that can be raised or temporarily held in the 12-ft diameter tanks operated at 3.75 feet of water depth at densities of 15, 30, 45, and 60 kg/m^3 is provided in Table 8.

Fish Density (kg/m^3)	Fish Density (lb/gal)	Fish Length (inches)	Fish Weight* (lb/fish)	Fish in 5 Tanks (#)	Fish in 10 Tanks (#)
15	0.125	9.5	0.357	5,564	11,129
30	0.250	9.5	0.357	11,129	22,257
45	0.375	9.5	0.357	16,693	33,386
60	0.500	9.5	0.357	22,257	44,514

Table 8. Number of 9.5-inch fish in 12-ft diameter tanks with 3.75-ft water depth at varying final densities.

Based on a variety of factors that includes water use, hydraulic retention time and rearing density, it is recommended that a phased approach to any improvements be pursued. Phase I would include the installation of water supply piping from the diversion dam and the implementation of Option A, the installation of a single row of circular, dual-drain fish culture tanks with a low head oxygenator in a gravity flow configuration. Implementation of this option would allow for gaining familiarity with fish culture in circular, dual-drain fish tanks and determining the optimal rearing density for the species reared. Once comfortable with fish culture in the new system, Phase II would be implemented. Phase II is the implementation of Option B, the installation of two partial water reuse systems each with five circular, dual-drain fish culture tanks and associated water treatment equipment. This option uses the five fish culture tanks installed in Phase I and adds partial water reuse treatment equipment to those tanks. Additionally, another identical five-tank water reuse system is installed. These systems could mirror each other inside a building or enclosure to allow for good stocking truck access.

Benefits

The benefits to implementing Option A and Option B include eliminating the maintenance associated with the diversion channel, reducing hatchery maintenance and labor associated with the raceways and rearing ponds, improving biosecurity by eliminating bird predation, staying within the authorized water right and increasing production or holding capacity of native fish.

Obstacles

However, there are some obstacles to implementation at this site. Obstacles include:

- Surface water supply is not biosecure and is subject to large fluctuations in water quality due to rainfall events.
- Risk associated with running Well #1 constantly. If the wells can produce water year round then there is the possibility of eliminating the use of surface water and replacing it with water from Well #2.
- Remote location and harsh landscape will increase the cost of constructing improvements.
- Remote location makes staffing the hatchery difficult.

Other Considerations

Improvements required for Gila trout culture are costly and require significant modifications to the existing hatchery site. An alternative to the culture of native coldwater fish would be to utilize the hatchery pond infrastructure for raising or holding native warm water fish. Native warm water fish that might be cultured onsite include roundtail chub. Roundtail chub could be cultured in the existing ponds with minor modifications and/or improvements. Improvements to the existing hatchery ponds for native warm water fish might include the following:

- Lining the ponds to prevent water seepage.
- Installing harvest kettles to provide a low maintenance and minimal fish stress method for harvest
- Installation of predation netting to exclude birds from the ponds
- Installation of water quality (dissolved oxygen) monitoring equipment and alarms

Both well water and surface water sources could be used for water replacement of pond water losses. Critical environmental variables that require monitoring and control would be water temperature and dissolved oxygen. The manpower associated with utilizing the ponds for culture or holding native fish would be minimal, approximately 1 hour per day (0.125 FTE).