Evaluation Plan

USBR Flat Plate Screen
at
Coleman National Fish Hatchery Intake No. 3
(Contract No. 14-48-0001-96044)

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BACKGROUND

The existing fish screen that is installed and recently modified at Intake No. 3 at the Coleman National Fish Hatchery (CNFH) does not meet existing criteria for screening fish, and a new interim screen is needed as soon as possible. The U. S. Fish and Wildlife Service (Service) has decided to use the U.S. Bureau of Reclamation's Underwater Submersible Bottom Retrievable (USBR) fish screen as an interim fish protection measure. The USBR fish screen will be placed into an excavation on the bottom of the creek and connected to the new ports on the existing screened water intake line number 3. The USBR screen is under development and is scheduled for installation at Intake No. 3 in fall 1998. Since this is a new type of screening technology, and it will be buried in the substrate of Battle Creek rather than resting on the bottom, it is imperative that it be evaluated to insure that it is effectively protecting fish. This evaluation plan provides the direction by which the USBR screen will be evaluated.

The work for this evaluation plan was performed under a contract between Jones and Stokes Associates (JSA) and the Service (Contract 14-48-001-96004). Montgomery Watson, a subcontractor to JSA, wrote Sections 1, 2, 3, 5, 6, and the Appendix, and JSA prepared Section 4 and contributed to Section 6.

GOAL AND OBJECTIVES

Goal

The goal of the fish screen evaluation is to test the USBR fish screen to determine if it is working according to specifications, meeting agency criteria, and protecting fish in the creek.

Objectives

To achieve this goal, the following specific objectives must be met:

- Measure and describe the physical performance of the screen as constructed and installed
- Measure and describe the physical performance of the screen under operations (hydraulic testing)
- Measure and describe the biological performance of the screen
- Identify any need for modifications as installed
- Provide a written record of the evaluation

CONTENTS

This evaluation plan is divided into sections based on the above listed objectives. This section, Introduction, gives the reason for the evaluation, its goals and objectives, and a description of the USBR fish screen. Section 2, Screen Installation Testing, describes the USBR fish screen, how it works, and how the physical performance of the fish screen at installation will be evaluated. Section 3, Hydraulic Testing, describes how the installed screen modules are operating hydraulically and are evaluated for hydraulic performance. This includes measuring approach velocities to the screen panels, flow velocities near the modules, and sediment deposition in and near the modules. Section 4, Biological Testing, describes the testing procedures to determine if fish become entrained in the intake, impinged on the screens, or injured in the vicinity of the screen modules. It will also outline procedures for documenting the reaction of fish near the modules. Section 5, Report, describes the content of the report which will document the tests, give test results, and provide conclusions and recommendations for improvement in the screen and its operation. Section 6 presents the estimated costs to perform the evaluation plan.

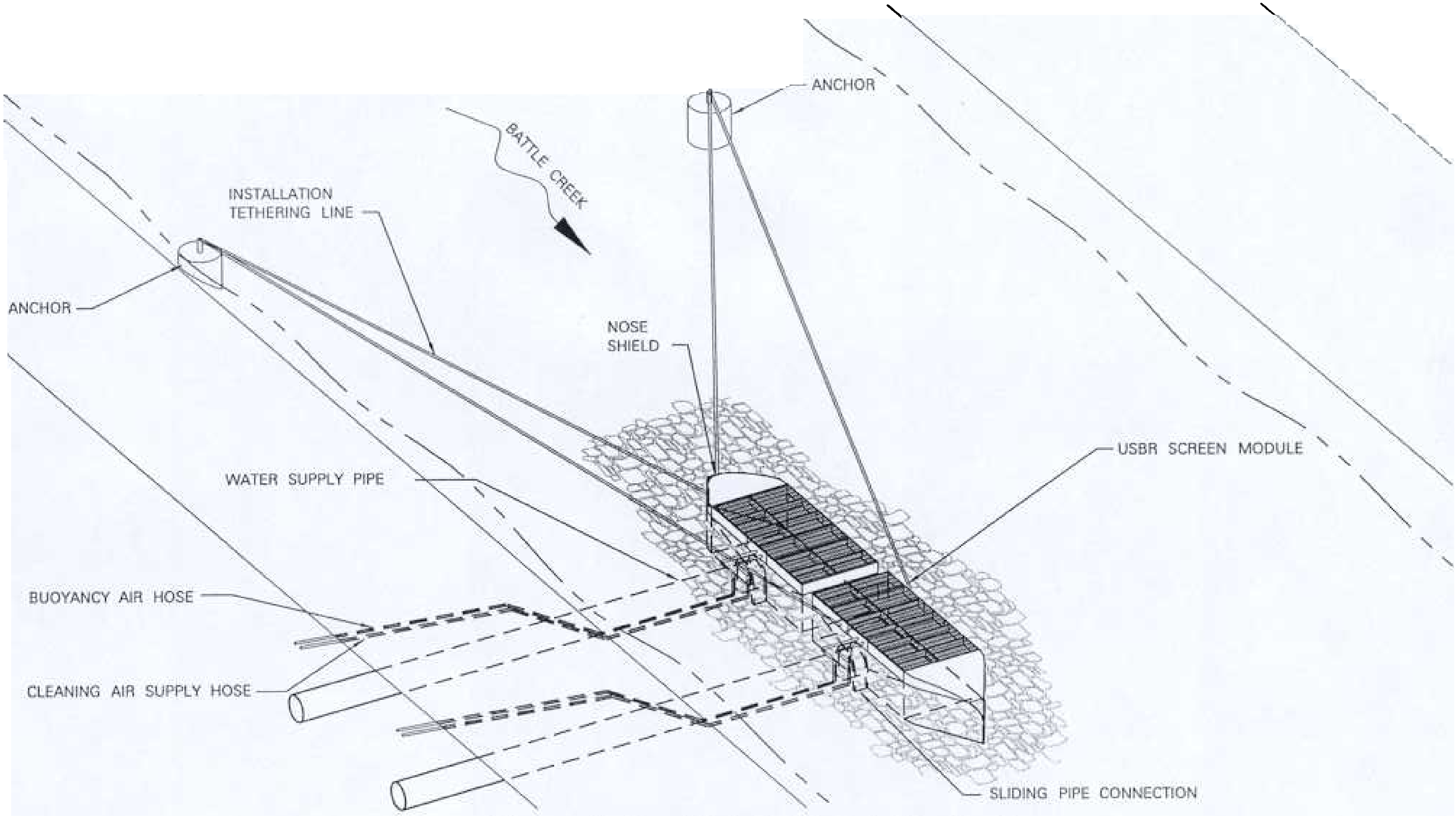
USBR FISH SCREEN DESCRIPTION

The USBR fish screen was developed principally by Greg O'Haver in the U.S. Bureau of Reclamation's Northern California Area Office. It is meant to serve water withdrawals on large rivers. The screen would be installed in the river and connected to an existing pipe in the spring and removed in the fall after the irrigation season. In some diversions, the screen will be left in place all year.

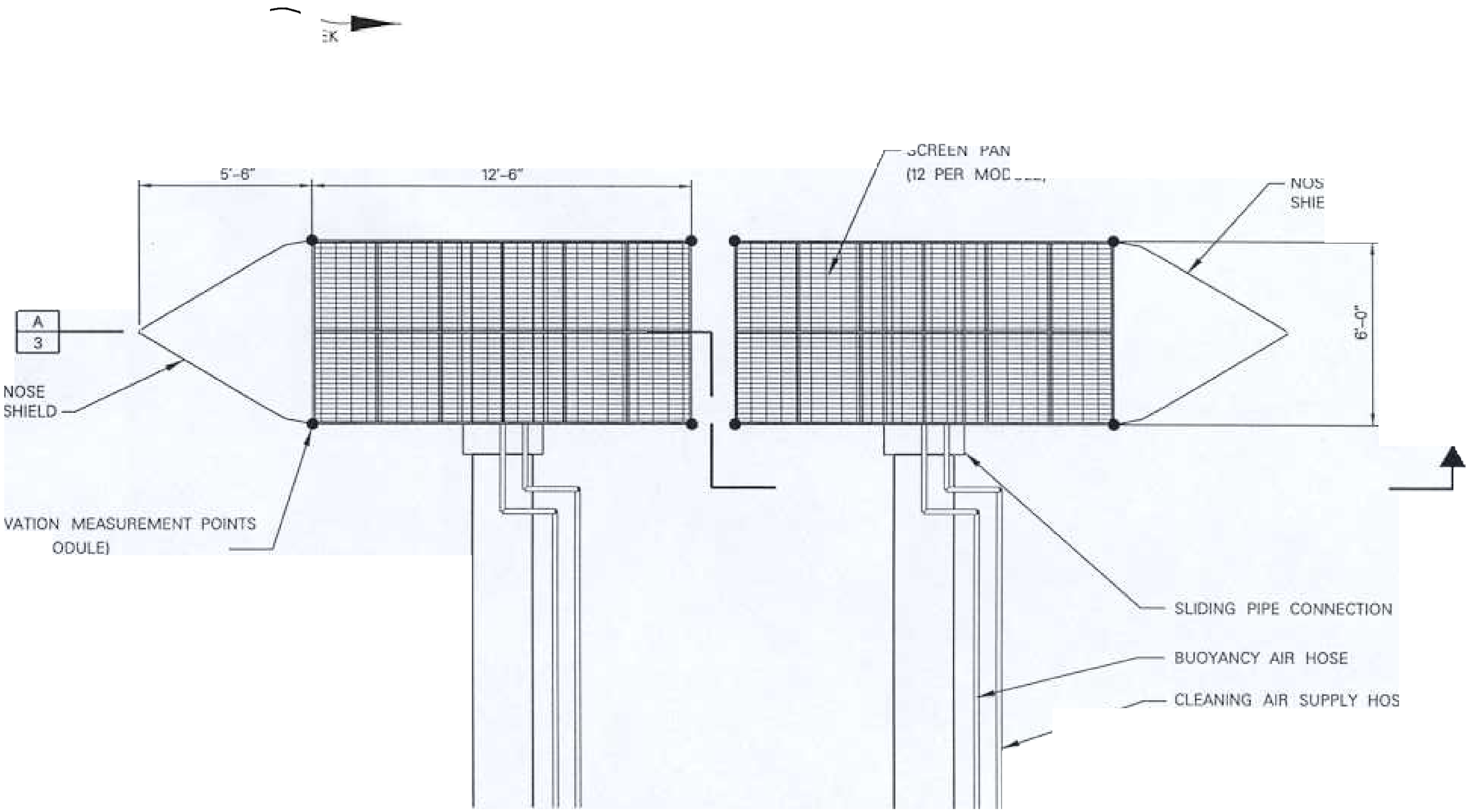
The USBR screen was designed to be installed in large rivers for a variety of pumped or gravity diversions. It is made in modules to standardize its manufacture. The standard module sizes constructed to date are for 5 and 25 cfs screening capacity. The following is a description of the standard 25-cfs module. Each module contains tanks, which can be filled with air to allow it to float. The air can be replaced with water to sink it in the desired location for installation. Each module would be launched from a trailer or lowered to the water by crane. It would be floated into position, and sunk onto the end of the supply pipe. There would be a separate supply pipe for each module to carry water from the screen module to the delivery canal or pump intake. Air supply pipes to carry air for screen cleaning and module floatation would be run adjacent to the water supply pipes. A compressor station on shore would supply air to the module.

Two 25-cfs modules are scheduled for installation at Intake No. 3 at CNFH. The modules are of the same design. However, at Intake No. 3 they will be permanently buried so that the creek bed will be approximately 6 inches below the top of each module. Two supply pipes, one from each module, would connect to a new 48-inch pipe, which would be connected to an existing 46-inch pipe running from the existing Intake No. 3 located in the diversion dam's right abutment. The air pipes would run to the existing compressor house adjacent to the diversion dam. Figure 1 shows a schematic representation of the installation of the two modules at Intake No. 3.

The upstream module has a nose shield section at its upstream end, and the downstream module has a nose shield on its downstream end (Figure 1). The main section contains the floatation tanks, fish screen panels, flow control baffles, air burst cleaning pipes, and the water supply pipe connection (Figures 2 and 3). The fish screens, baffles, and air burst piping are located on the top of the main section. There are 12 fish screen panels placed in recesses on the top of the main component. Each panel is approximately two feet by three feet and consists of wedgewire fabricated by the Hendrix Company. Floatation tanks are located at the bottom of the upstream and downstream ends of the main section. Water flows downward through the screens past the baffles and toward the collection chamber. The water is then drawn from the collection chamber to the supply pipe. The spacing of the baffles has been preset to evenly distribute the flow through all the screens. The baffle spacing was obtained from laboratory experiments with a 5-



Coleman National Fish Hatchery Intake No. 3
USBR Fish Screen Evaluation Plan
General Installation Schematic
Figure 1



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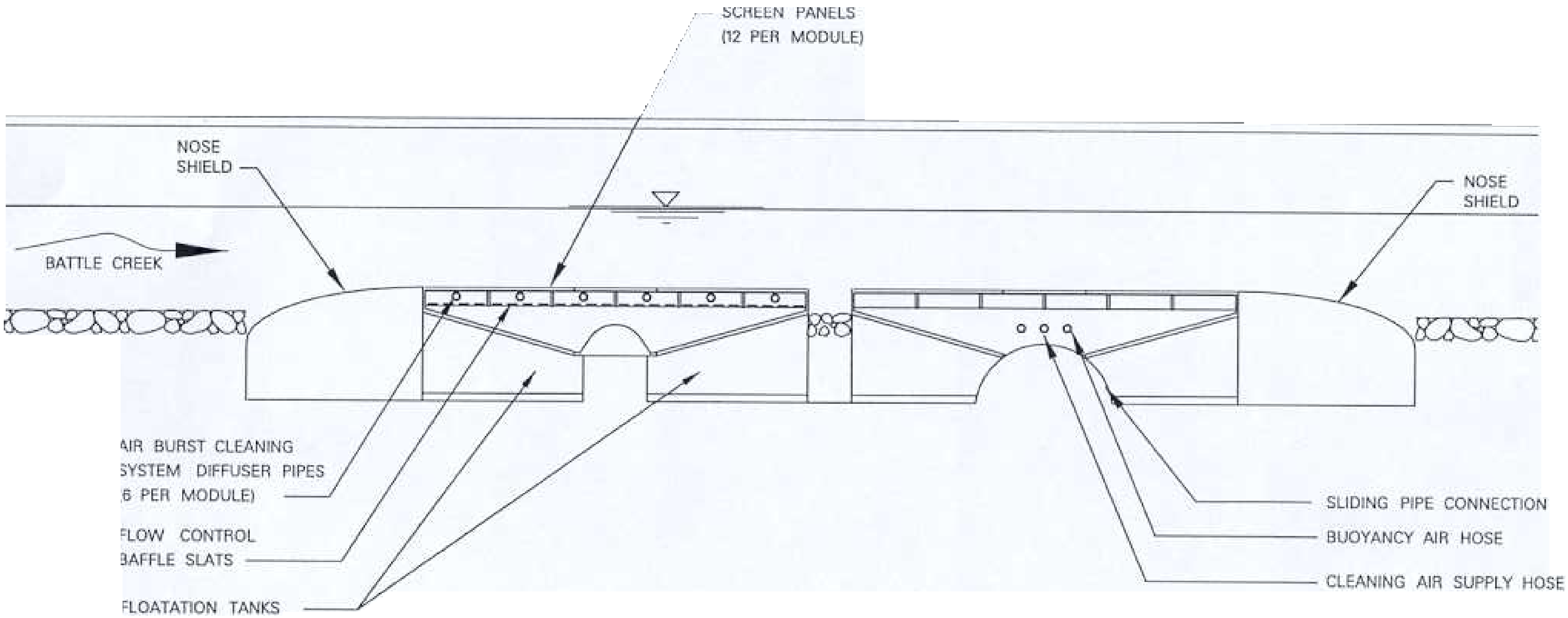


Coleman National Fish Hatchery Intake No. 3
USBR Fish Screen Evaluation Plan
Section A – USBR Screen Module
Figure 3

cfs module. Further adjustments may be required after installation at Intake No. 3. Horizontal PVC pipes are located between the screens and baffles. These pipes are fitted with small holes to distribute the air bursts for cleaning the screens. These holes must be spaced properly to distribute the air to lift debris from all parts of the screen panels.

INTAKE NO. 3 FISH SCREEN INSTALLATION

Slightly over half of the contract cost for the fish screens and installation was for installing the water and air pipes and replacing the bank of the creek. The remainder of the contract cost was for the modules.

After the water supply and air pipes were installed and the creek bottom excavated, the modules were installed. The installation occurred in the following steps:

1. Two 1500-pound anchors were installed upstream of the modules – one on the right bank and one in the creek near the left bank.
2. The modules were lifted into place in their holes in the creek bottom using a large excavator.
3. Cables were fixed from the two anchors to the nose of the upstream module and another two cables were fixed from the anchors to a connection point about one third of the way down from the upstream end of the downstream module.
4. The air hoses were hooked up. These hoses were for air supply to the floatation compartments and the air cleaning system. Subsequently, smaller air hoses were connected for the bubbler gages. Presently, the air hoses are buried except near the modules where they are exposed for a short distance. When installation is complete, the air hoses and water supply pipe will be buried.

It took about two weeks to install the modules including the connections and clean gravel backfill.

Some work is still required to complete the installation. Permission has been obtained for the contractor to work in the creek in March, 1999. The work left to complete the installation is listed below:

Repair damage in the nose of the upstream module. The damage appears to be a partial puncture about 4 inches in diameter caused by vandals.

Attach bands to complete the connection between the modules and their water supply pipes. The bands will be located at the half-round pipe connection about a foot out from the module.

Complete the backfill around the modules.

The installation work should be completed in March or April of 1999 if the water becomes clear enough to complete the installation. After the installation is complete, the contractor plans to measure the approach and sweeping velocities again and to adjust intake valves and baffles, if necessary. This work should be completed in June.

The contractor plans on preparing an operations and maintenance manual for the installation. The manual would be prepared based on information obtained from the installation and the screen evaluation.

EVALUATION PLAN SCHEDULE

This evaluation plan must be conducted at a range of flow conditions and when juvenile chinook salmon and steelhead are present in relatively high densities in Battle Creek. It can be assumed that approximately one year will be needed to complete the evaluation. Assuming work begins immediately the general proposed work schedule is as follows:

• screen installation evaluation	April-June 1999
hydraulic testing:	May-June 1999 (high flows and post high flow inspection)
	September 1999 (low flows)
• biological testing	May-July 1999 (high and moderate flows, fry and smolt)
	September 1999 (low flows, parr)
	January 2000 (moderate flows, fry)
	March-April 2000 (high flows, fingerling)

Hydraulic testing could be conducted entirely independent of biological testing, but data integration will be optimized if the tests are conducted concurrently. It is recognized that hydraulic testing (dependent on flows only) will be completed prior to biological testing (dependent on both flows and seasonality of important salmon and steelhead lifestages); however, hydraulic testing will be timed to coincide with early biological testing events.

Sampling could be continued for another year but is deemed to be unnecessary. This evaluation is designed to evaluate efforts under a wide range of flow and seasonal conditions. While a second year of data would add some marginal value, particularly with respect to biological testing, it is not considered to be cost effective. It is assumed that a wide range of flows will be available to facilitate sampling over a one year period.

Section 2
Screen Installation Testing

INTRODUCTION

In this portion of the evaluation effort the fish screen and its installation will be described. All measurements will be made of the completely installed modules. The location and size of the screen modules will be measured including their elevations. The surrounding streambed conditions will also be measured and described. A general measurement of substrate type and size will be made by diving. The diver will note the type of substrate (gravel, sand, algal cover, etc.) and take photographs of the substrate. The on-shore support facilities will be described including the size and type of air compressors and the type and number of water level gages. The various sections of each module will be measured and described including screen panels, baffling, and screen cleaning system. This will generate physical data and set the stage for the hydraulic and biological testing to follow.

Hatchery staff will be notified immediately of any cases of noncompliance with screening criteria and provided with suggested recommendations to repair them.

Module Installation

Various measurements to accurately locate the modules and describe their location and support equipment will be made. All elevation measurements will be accurate to plus or minus 0.05 feet. The required measurements are tabulated below:

1 Module Location – Survey in the modules and reference their horizontal location to the equipment building on the right bank adjacent to the dam. The accuracy should be plus or minus 0.1 feet.
2. Module Elevation –Obtain the elevation of each module at the four corners of the fish screen area located at the top of each module. See Figure 2.
3. Foundation and Substrate – Obtain the elevation of the creek bottom around the modules. The location can be measured by survey methods or by measuring with tape horizontally off the modules. Observe the substrate and describe its composition. Make a rough contour map of the stream bottom and include the general location and the crest elevation of the downstream diversion dam.
4. Connection to Water Supply Pipes – If the connection between the module and the end of the water supply pipe is exposed, inspect it by diving or video camera. Check for a good seal or any misalignment.
5. Support Facilities – Inspect the support facilities on the creek bank. Note the size of the compressor and air accumulators used for screen cleaning. Note the size of any pumps and describe any flow measurement devices.

FISH SCREEN MODULES

Module Screen Panels – Measure the size of the screen panels at the top of each module and compute the total screen area for each module. Make several spot measurements of the spacing between wedgewires and around the perimeter of each panel. This will confirm that no apparent "fish leaks" exist.

2. Module Condition – Visually inspect the screen modules for any cracks, holes, or dents on all exposed surfaces. Inspect the screen panels for damage.
3. Screen Cleaning System – Visually inspect the screen cleaning system, including the supply pipes to see that they are properly attached. Observe operation of the screen cleaner and note the coverage of the air bubbles. The cleaning performance will be inspected as described in the next section.
4. Screen Baffle System – Visually check the position of the baffles, if possible. If they cannot be seen, obtain the location and spacing of the baffle slats for each screen panel from the manufacturer.

BACKGROUND DATA

During the evaluation, data will be collected concerning the physical characteristics of the screen modules and their hydraulic performance. In developing the design of the USBR fish screen module, velocity measurements were made in the laboratory on a 5-cfs module and in a canal on a 25-cfs module. In the evaluation report, it would be useful to compare the data collected at the Intake No. 3 screens with design parameters, drawings, and the hydraulic measurements made in the laboratory and Tehama Colusa Canal. In preparation for this comparison, the following existing data should be collected:

- Design drawings used to fabricate the Intake No. 3 modules. Be sure to include any shop or field changes made after the drawings were completed. Of particular interest are any changes to the cleaning system and baffle settings. It is important that the baffle settings be known and documented in the evaluation report.

  Laboratory velocity data. The U.S. Bureau of Reclamation hydraulic laboratory in Denver evaluated a 5-cfs model and a report was written. Obtain this report and the velocity data as required.
- Canal velocity data. A 25-cfs module prototype was built and tested in the Tehama Colusa Canal and in the Sacramento River. Much of this testing was to evaluate the installation procedures; however, approach and sweeping velocity measurements were taken. Obtain records of these velocity data for comparison to the data collected as described in Section 3.

Section 3
Hydraulic Testing

INTRODUCTION

This section lists the procedures for performing the hydraulic testing on the USBR fish screen installation at the CNFH Intake No. 3. The tests have been divided into four parts: 1. Sediment Deposition; 2. Near-field Velocities; 3. Approach and Sweeping Velocities; and 4. Screen Cleaning Performance. In each of these parts three items are described. These items provide the directions needed to perform the hydraulic tests and are listed below:

- Equipment – This item provides a list of equipment required to carry out this part of the hydraulic testing.
- Procedures –This item describes the steps required to perform the tests. It also shows the locations at which the velocity and other measurements will be taken.
- Results – This item describes what data to include in the report and how to display the data.

TESTING SETUP

In order to properly test the fish screens, the flow into Intake No. 3 and the head loss through the screens must be measured to provide data for all the hydraulic tests described below.

Intake No. 3 Flow Measurement

Ideally the flows from each module should be measured separately. To install a meter on each pipe would require removing rip rap and the creek bank and dewatering the area. In addition, a straight length of pipe, 10 pipe diameters long is required. The pipes between the modules and the 48-inch main pipe do not contain a straight section of sufficient length to accommodate a meter. Therefore, any meter would have to be installed in the 48-inch pipe downstream.

Water taken into Intake No. 3 is transported to the hatchery through a 48-inch pipe, which trifurcates into three smaller pipes and discharges into a sediment basin. A strap-on sonic meter cannot be used to measure the flow in the 48-inch pipe because it is mortar lined. Installation of other types of meters would require digging up the pipe and tapping it to install a venturi meter or sonic meter probes. This was judged to be too expensive for just the evaluation testing. The flows will be measured with a portable velocity meter at the settling basin where the flow discharges from the three pipes. Measurements will be taken here at the same time as the approach and sweeping velocities are being taken at the screens.

Screen Head Loss Measurement

According to Greg O'Haver, designer of the USBR screen and the installation at Intake No. 3, there are three taps at the two-module installation for measuring the head. These taps are located as follows:

- Tap 1 - Inside upstream module located below the screens and near and above the outlet to the water supply pipe.
- Tap 2 - Inside downstream module located in the same place as Tap 1.
- Tap 3 - On the outside of the downstream module.

Taps 1 and 3 will be connected to the two inputs of a differential bubbler gage located in the compressor house near the intake. This gage will measure the difference in head between the outside water surface near the modules and the inside of the upstream module. This measures the head differential across the screen-baffle arrangement. Taps 2 and 3 will be connected to a second differential bubbler to measure the head across the downstream module screens. Costs to rent two differential bubbler meters have been included in the cost estimate. Two Computer Instruments Corporation Model 7700 bubbler gages could be used for this application. To provide an automatic cleaning feature for the intake, these could be purchased and installed permanently in the compressor house.

1. SEDIMENT DEPOSITION

Sediment, both suspended and bed load, can affect the operation of a fish screen. In the vicinity of a fish screen, the flow velocity is usually much lower than the velocity in the channel. This can cause sediment carried by the flow in the creek to be deposited near or inside a fish screen structure. In the case of the USBR screen installation at Intake No. 3, the screens will be oriented horizontally about six inches above the stream bed. During high flows when sediment is in motion, bed load might run up onto the screen and remain there. It is also possible that suspended load could enter the module through the fish screen and be deposited inside the module in areas of lower velocity. This part of the hydraulic testing program is meant to determine the propensity of sediment to degrade the operation of the USBR screens located at Intake No. 3. It will also locate sediment deposits and record their locations and depths.

Timing

Two tests will be conducted. The first will be performed after the first high flow event after module installation. If the testing program begins after the screens have encountered a high flow event, this test will be performed at the beginning of the testing program. The second test will be conducted after flows recede in the summer. This test will show the effects of sedimentation after a full high flow season. In addition, any algal growth on the screen would be noted.

Equipment

The following equipment is required:

- Underwater light
- Underwater camera or video
- Surveying level & survey rod

Procedures

Sediment deposition will be measured in and around the module. The turbidity in the water tower will be observed before and during the tests and will be measured in NTU's.

Outside Module – Using the level, take elevations around the modules from the sides of the module to 3 feet away from the module all the way around it. This will be done at a minimum of three different times: 1) at the beginning of the evaluation, 2) after a high flow event of at least 2,000 cfs or greater, and 3) in the spring after the first full high flow season. Create contour maps for comparison.

Inside the Module – Visually check for deposition inside the module. Remove some screen panels and baffles in order to see into the interior of the module. During this inspection, water will have to be taken into the hatchery through the old water intake. Sediment deposition within the module will be recorded on a drawing.

Results

Outside Module – Create contour maps showing the substrate around the module and the elevation of the module. Compare the two maps to determine the effect of the high water event on deposition. The magnitude of the event or events which might have caused the deposition will be noted.

Inside the Module – Deposition within the module will be recorded on a drawing. An estimate of the volume of sediment deposited inside the module will be recorded.

2. NEAR-FIELD VELOCITIES

Velocities will be taken in the vicinity of the module to see how the module affects the ambient velocities in the creek. These data will help determine how the modules affect the flow in the creek. These ambient flows determine flows approaching the screen and the sweeping velocities across the screen. Coupled with data from Part 1, Sediment Deposition, the scour and bed load effects on the screen can be determined.

Equipment

1. Acoustic doppler velocity meter attached to a top setting wading rod. This meter will provide velocities in the x, y, & z directions, which can be resolved to a resultant velocity for definition of the flow field. Alternatively, an

electromagnetic current meter or pygmy meter can be used. However, if either of these two meters are used the angle of the velocity must be measured and recorded.

2. Tape and/or survey equipment to locate the velocity measurement points.

Procedures

The velocity data will be taken at the full diversion rate and at two different flows in Battle Creek:

At a low flow of 300 cfs or less in Battle Creek. This will provide data when the water depth over the screens is at a minimum.

2. At a higher flow in Battle Creek. The flow must be as high as possible; however, since the velocity data must be collected by means of wading in the stream, the flow must be low enough to not endanger the field personnel collecting the data. This will have to be decided upon in the field by the field personnel. Refer to Appendix A for data on Battle Creek flows near the Intake No. 3 site.

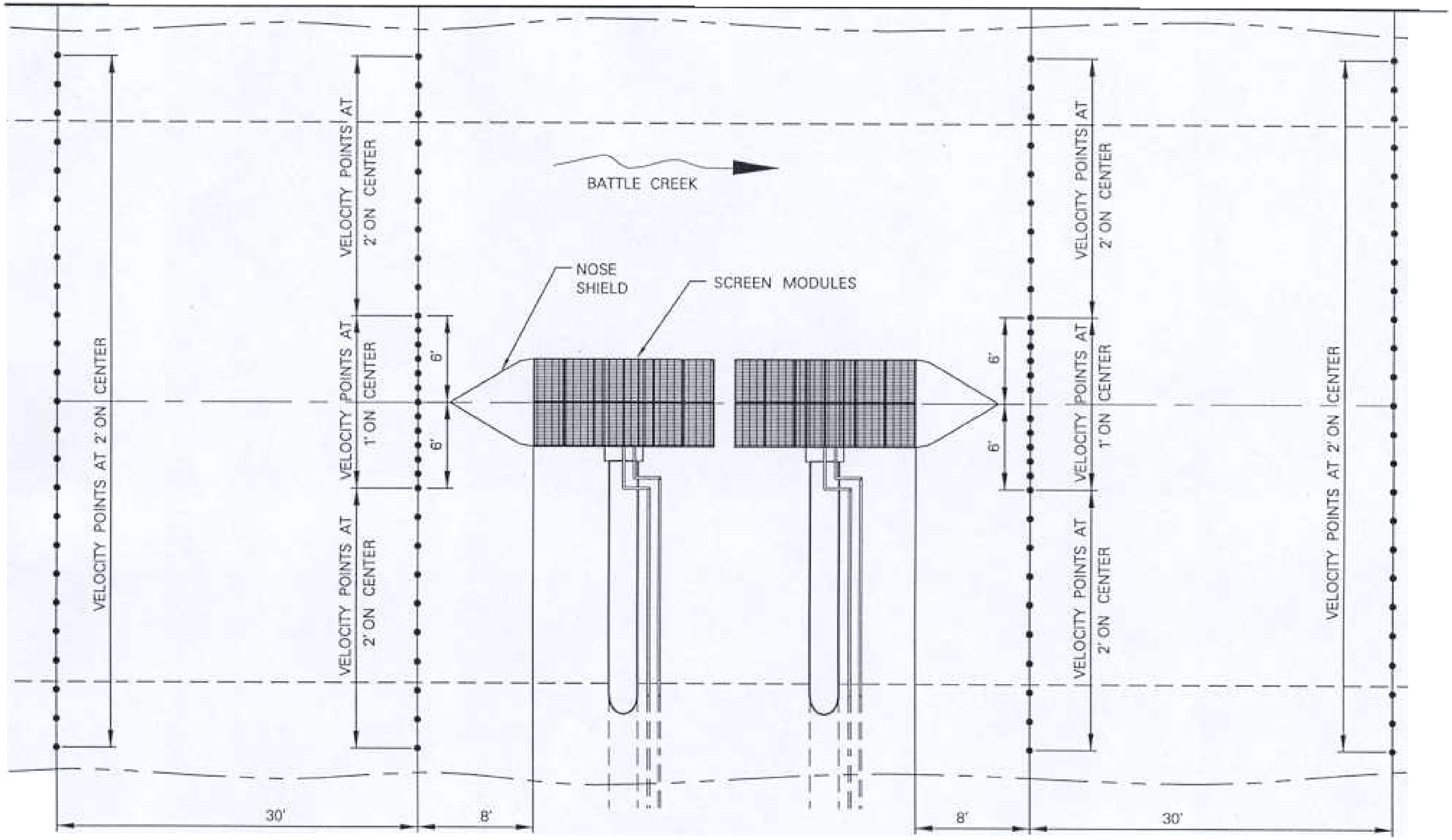
The velocities taken in Part 2, Near-field Velocities, and Part 3, Approach and Sweeping Velocities, should be taken at the same time, so that the low and high flows are the same for both sets of data.

Velocities will be measured in cross sections across the creek and at a series of points around the modules. These two sets of velocity measurements will define the flow fields upstream, around, and downstream of the screen modules. The flow field over the screens is defined in the Part 3, Approach and Sweeping Velocities, described below. The velocity measurement locations are shown on Figures 4 and 5 and are described below.

In addition, the ability of the diversion to deliver water in flood flows should be observed by visits to the intake and measurement of the flow from the pipe if possible.

Velocity Transects – Four velocity transects will be taken at the locations shown on Figure 4. The velocities will be taken while wading in the creek. Velocities will be taken at the intervals along the transect as shown on Figure 4. At each measurement point the velocity will be taken at 0.6 depth (0.6 of the way from the water surface to the creek bottom) when the water depth is less that 1 foot. For depths greater than one foot, the velocity will be measured at the 0.2 and 0.8 depth points.

Spot Velocities – Spot velocities will be taken around the modules and on the Nose Shields to define the flow field near the modules. Velocities on the screens will be measured in another part of the hydraulic testing effort. See Figure 5 for the locations of these spot velocity measurements. At each measurement point, the velocity will be taken at 0.6 depth (0.6 of the way from the water surface to the creek bottom) when the water depth is less that 1 foot. For depths greater than one foot the velocity will be measured at the 0.2 and 0.8 depth points.



Coleman National Fish Hatchery Intake No. 3
USBR Fish Screen Evaluation Plan
Velocity Transect Locations
Figure 4

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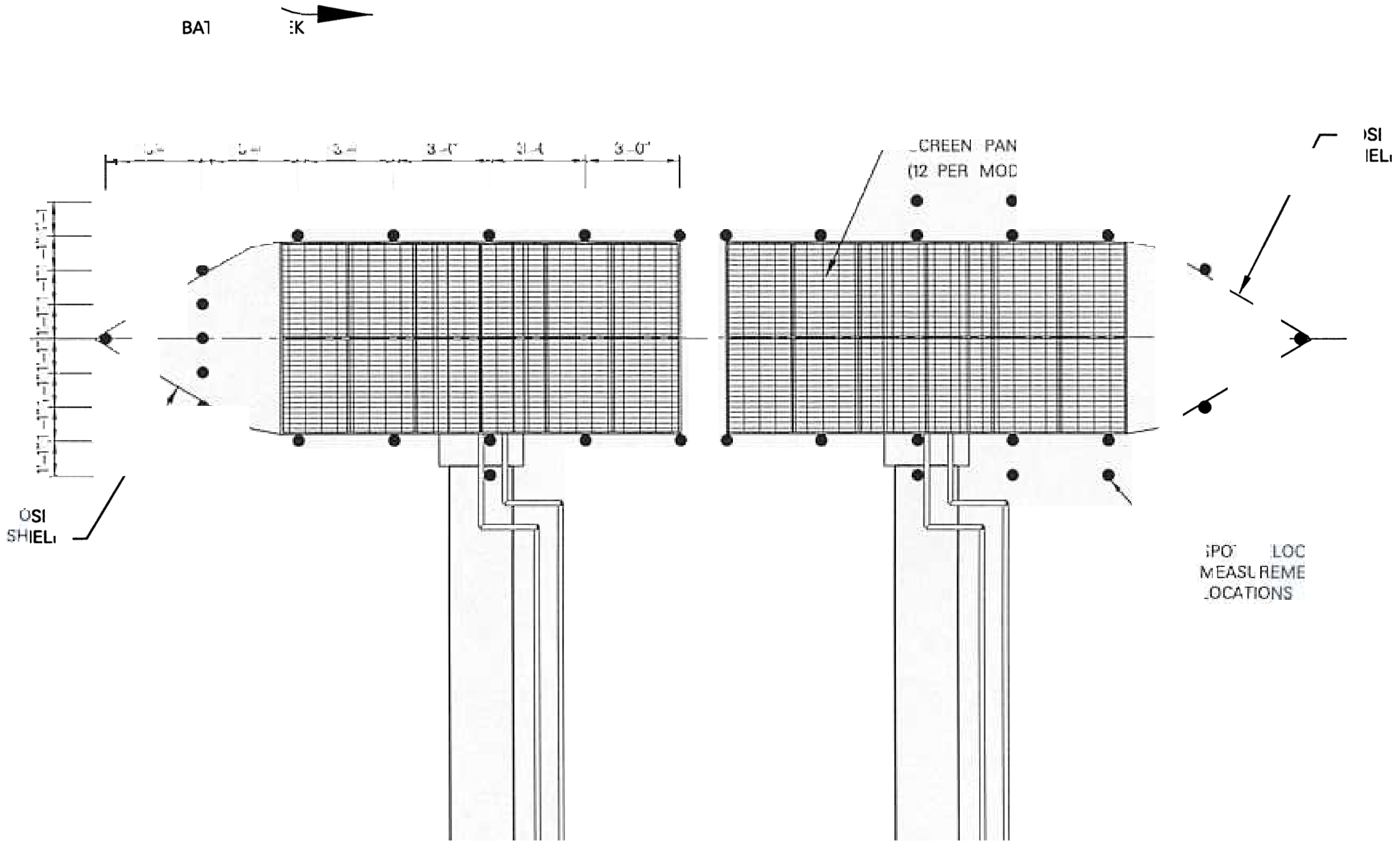

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Results

The following results, tabulations, and graphics will be made for each flow

- Horizontal velocity profiles at the four transects.
- Computations of flow using the velocity data at the transects.
- Table of spot velocities.
- Graphic presentation of velocity data as velocity vectors located at their measurement points. Use the sweeping velocities obtained in Part 3 below in this graphic.

3. APPROACH AND SWEEPING VELOCITIES

In this test, velocities will be taken above the screens in each module. These data will show how the fish screens are meeting agency criteria for approach and sweeping velocities. These data will also be added to the near-field velocities to complete the flow field picture around the modules at Intake No. 3.

Equipment

1 Acoustic doppler velocity meter attached to a top setting wading rod. This meter will provide velocities in the x, y, & z directions. With proper instrument orientation the z velocity is the approach velocity and the x and y velocities form the sweeping flow. The component velocities will be resolved to a resultant velocity for definition of the flow field.
2. Tape and/or survey gear to locate the velocity measurement points.

Procedures

The velocity data will be taken at two Battle Creek flows. These are to be as close as possible to the flows in which the near-field data are taken. All data will be taken at the full diversion rate to test the maximum expected approach velocities.

1. At a low flow in Battle Creek. This will provide data when the water depth over the screens is at a minimum.
2. At a higher flow in Battle Creek. The flow must be as high as possible; however, since the velocity data must be collected by means of wading in the stream, the flow must be low enough to not endanger the field personnel collecting the data. Refer to Appendix A for data on the Battle Creek flows near the Intake No. 3 site.

The velocities taken in Parts 2 and 3 should be taken at the same time, so that the low and high flows are the same for both sets of data. The data will also be collected before and after debris cleaning to determine any changes.

The velocities will be measured at the same places on both modules. The measurement points will be from 3 to 4 inches above the screens at the points indicated on Figure 6.

Results

The following results, tabulations, and graphics will be made for each flow

- Table of approach and sweeping velocities.
- Graphic presentation of approach velocity data as a velocity contour plot.

4. SCREEN CLEANING PERFORMANCE

The ability of the screen to clean itself is important in maintaining proper approach velocities. Screens that are partially blocked cause increased head loss across the screens or cause a reduction in the amount flow through the screens. In this test, the ability of the screens to clean themselves will be assessed.

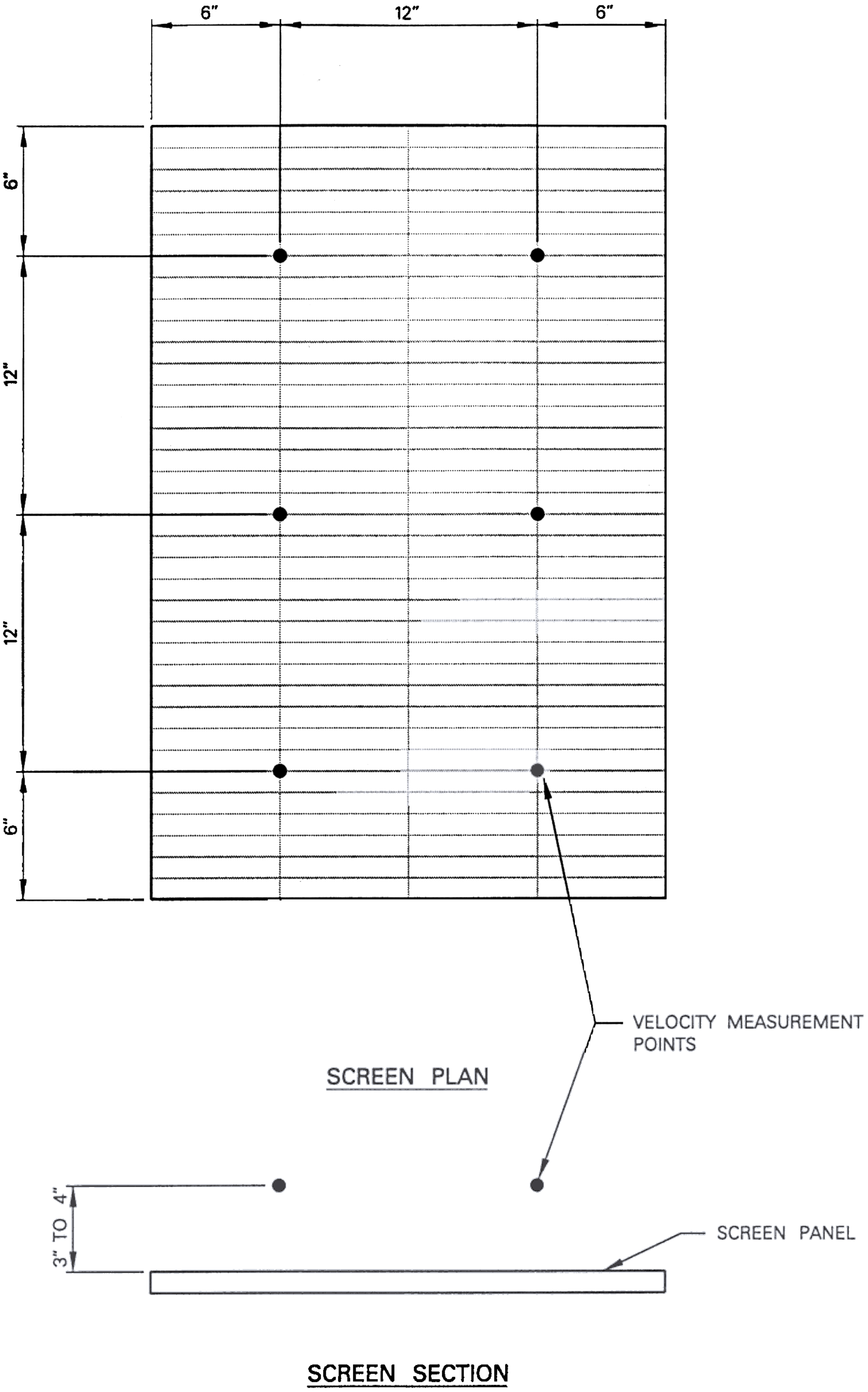
Equipment

1. Still and/or video camera
2. Differential bubbler gages. See the subsection, "Screen Head Loss Measurement" at the beginning of Section 3.

Procedures

The test involves noting the head drop across the screen panels and noting the debris cover before and after screen cleaning. The maximum debris load on the screen will occur when there is a maximum debris load in the creek and the flow is at a low value to reduce the sweeping velocity. Since a high debris load and low flows probably will not occur at the same time, multiple tests should be performed. At least five tests should be made. The following procedure will be employed:

1. Set the diversion rate at maximum.
2. Turn off the screen cleaning system and monitor the head differential across the screen as measured by the differential bubbler gages. See the subsection, "Screen Head Loss Measurement" at the beginning of Section 3. When it reaches a differential of between 3 and 6 inches, turn on the cleaning system for one complete cycle and note the head drop across the screen. Just prior to activating the screen cleaning system, visually observe, photograph, and note the amount of debris cover on the screen and note the head drop across the screen.
3. Run through one complete cleaning cycle of both modules.
4. Visually observe, photograph, and note the amount of debris, sediment cover, and periphyton growth on the screens and note the head loss across the screen by reading the differential head at the bubbler gages in the compressor building.
5. Repeat steps 2 and 3 until the screens are clean and there is no further reduction in head drop across the screens.



Coleman National Fish Hatchery Intake No. 3
USBR Fish Screen Evaluation Plan
Screen Panel Velocity Measurement Locations
Figure 6

This test will require observing the screen at a time when there is enough debris in the creek to cause some clogging of the screen. This might require that the crew to carry out this test be on call and available to perform the test when there is enough debris in the river. Observations will also be made during peak periphyton build-up on the screen, presumably in summer.

Results

The following results, tabulations, and graphics will be made :

- Table of head losses before and after the cleaning cycles.
  Graphic presentation of the debris and how it builds up on the screen. Typically debris tends to build up on the areas of the screen with high approach velocities or little sweeping velocities.
- Biological effects of semi-clogged or clogged screens.

Section 4
Biological Testing

INTRODUCTION

The purpose of the biological testing program is to ensure that no entrainment, impingement, or screen-related predation of young salmonids occurs at the test screen. The USBR flat plate fish screen will be submerged and imbedded in the streambed of Battle Creek upstream of the hatchery weir. Only the upper 2 feet of the screen will be above the streambed. The exposed surface of the screen unit will be 25-ft long, 6-ft wide, and 6 to 12-inches high (exposed). The screen surface will encompass approximately 72 square ft for a maximum capacity of about 24 cfs at an approach velocity of 0.33 fps. The slot openings in the wedge-wire screen will be 1.75 mm, which will exclude the smallest salmonid fry from entrainment. The 0.33 fps approach velocity should ensure minimal fish impingement on the screen. Testing will be performed to determine if any entrainment and impingement occurs at the screen.

Testing will also determine if screen-related predation by predatory fish occurs. Predation potential will be evaluated by direct observations of juvenile salmonid and predatory fish behavior in association with the screen, including at the gap between the two screens. Observations will be made of stream habitat associated with the screen to determine if back eddies occur that would provide predator habitat. Observations will be made of juvenile fish behavior around the screen, and in particular, when air blasts are cleaning the screen surface. Fish behavior that would prolong fish exposure to the screen or increase their susceptibility to predation will be thoroughly evaluated. Fish behavior will also be observed under various pumping regimes (i.e., 0 cfs [control] and maximum pumping) and streamflow conditions (low summer-fall, and moderate and high winter-spring).

Direct observations are proposed as compared to mark-recapture tests because direct observations offer direct rather than indirect evidence of the screen's effectiveness, and because they would be more cost effective. Direct observations are limited to waters that have excellent visibility; we expect Battle Creek in the area of the intake to have good visibility during testing periods. Furthermore, direct observations provide insights into the specific problems that may occur with the screen, so there will be greater potential to offer solutions to problems. Divers would periodically employ hand-held underwater photo and video equipment to document, as needed, the behavior of hatchery fish during planned hatchery releases and wild fish.

In addition to direct observation by divers, the periodic use of remote, fixed video cameras could be used for some of the fish observations evaluating impingement and predation. Fixed cameras would allow for impingement observations over quite a range of debris situations and flows, and could be integrated with the fish release experiments as well. Both direct observation by divers and use of video cameras would be limited when water clarity is reduced during peak storm events. Fixed cameras would need to be mounted by cable over the creek, maintained, and have staff available to monitor videos. A fixed underwater camera in a housing could also be placed at the fish screen. The installation and use of fixed video cameras add considerably to evaluation costs, were not recommended, but could be used by the Service if desired.

Radio-tracking of predators could also be used to study the behavior of fish predators near the screen. Radio-tracking could provide some additional data but at a relatively high cost. Direct observations will be able to document predator behavior more effectively than radio-tracking. Consequently, radio-tracking is not proposed or pursued further in this study design although it could be used as a supplemental or optional study design feature. As with the use of fixed video cameras, radio-tracking should not displace recommended direct observations.

The release of hatchery fish has been incorporated into the biological sampling to increase sample sizes and provide more definitive results. While not absolutely required for this evaluation, releasing hatchery fish will expedite study results, dramatically improve sample sizes, and augment observations of wild fish. Increased predation or attraction of predators to the fish screen is unlikely and would be a short-term phenomena if it occurred. Such "attraction", if it occurred, would provide valuable information on predator behavior and preferred habitats at the screen. Predators would not remain at the screen unless feeding opportunities on wild fish were enhanced. The releases of hatchery fish would be episodic (rare) events that would not result in training predators, which clearly is a problem where consistent introductions of salmon and steelhead at a specific location provide a constant food source. Such tests are minimized in this evaluation but are nonetheless a necessary component of the study design.

FISH SCREEN

Equipment

Fish screen testing will require scuba diving for evaluating impingement on the screen. Divers will periodically employ photo or video equipment to document observations. Video equipment will be particularly beneficial during hatchery fish releases. A net will be employed at the pump discharge to collect any fish that may be entrained. Hatchery fry, fingerling, and smolt salmon and steelhead will be needed for release immediately above the screen to facilitate behavior observations and entrainment assessment. Test fish will be taken from healthy hatchery lots, and will be subsampled to determine initial condition of scales, eyes, and fins, and overall condition and health. Test fish will be minimally handled to minimize stress and potential experiment bias; there are presently no plans to mark test fish for this reason. If test fish needed to be marked for other reasons, consideration for that can be addressed at a later date. Hatchery fish would be acclimated in a live well with only healthy fish being released as part of the test. A fyke net or screw trap capable of capturing fry (1/8-inch mesh) will be employed downstream of the screen to monitor fish abundance in the test area and determine the health and relative magnitude of numbers of fish moving downstream in the vicinity of the screen. Large numbers of fish, wild or hatchery, passing the screen without impingement, entrainment, or predation would be useful information to provide context to any recorded adverse impacts.

Procedures

Screen Impingement Monitoring: Three low-light chinook tests will be conducted for impingement potential on the screen: one each for fry (early winter), fingerling (late winter or spring), and smolt (spring). Two low-light steelhead tests will be conducted: one for fry (spring) and one for parr (summer). One night test will be conducted each for chinook and steelhead fry. Hatchery fish will be released immediately above the test screen for each test. A total of 5,000 fry will be released per test. A total of 1,000 fingerling, parr, and smolts will be released per test. A random sample of 30 fish from each test group will be measured for length distribution. If preliminary diving observations or hydraulic testing indicate that "hot spot" areas of potential impact exists on the screen, then the study design may be modified to focus on specific test releases into these areas.

Divers will observe potential impingement of fish on the screen (see also behavior experiments). After an adequate exposure period for the released fish, divers will make direct observations of the screen to see if any fish are contacting or being directly impinged on the screen. Night test observations will occur with lights (red light to minimize behavioral affects on test fish) after a reasonable length of acclimation of fish to the screen under darkness. All tests will be conducted under maximum diversion rates. All tests will also have a control with identical observations made with no diversions from the screens. Because observation is the experimental method, there will be no need to mark test fish; however, avoidance tests described later have the option to mark fish to differentiate results between native resident fish and the hatchery reared test fish. All test fish will be held in the creek for 24 hours before release to reduce any handling effects on the test results.

Divers will observe fish response to the screen for potential impingement (see also behavior observations in Predation and Avoidance sections). The null hypotheses being tested is that there is no impingement on the screen. Divers will record the average duration of exposure to the screen and the number of incidental contacts of fish with the screen and behavior of fish relative to the screen. Impingement is defined as non-incidental contact involving full exposure to the screen even for a brief time. Incidental contact is defined as a brief contact with part of the fish's body and the screen with an immediate avoidance response. After behavior observations, divers will scan the entire screen to look for impinged fish at the end of each test's observation period. Divers will collect impinged fish, noting condition (live or dead) and any evidence of injury (e.g., descaling).

Net samples will be examined for entrained fish. Any fish collected will be identified by species, have fork length measured, and general condition evaluated. (Any fish collected during fish impingement observations will be likewise processed.)

Response to Air Blasts: At the end of each test, an observation will be made of potential effects of screen cleaning air blasts to test fish. Observations will also be made after each test to evaluate the effectiveness of air blasts removing debris or algae build ups on screens. Observations of screens will be made prior to each test to determine initial state of debris and algae buildup. Effectiveness will be determined from direct observation of the air blast effects as well as post-test observations of the screen surface compared to pre-test conditions.

Screen Entrainment Monitoring: Entrained water from the pump discharge will be sampled after each fry test to determine if any fry were able to pass through the screen structure. Sampling will be conducted with a fine mesh net ($1/8^{th}$ inch or less in diameter or square side length) that samples the entire water flow from the test. The coupler (between the module and the intake pipe) will be assessed to quantify the percentage of time that the coupler is functioning properly and not entraining fish.

Data Analysis Methods: The numbers and proportion of fish for each test and control group entrained and impinged (and recovered by divers) will be recorded. The length frequency of fish collected in entrainment and impingement will be recorded and compared to that for pre-test group. The proportion of fish in each test group that came in contact with the screen, were impinged on the screen, or were entrained through the screen, will be calculated. A comparison will be made of the numbers of test and control fish that come in contact with the screen. A Fishers exact test or Pearson's Chi-square test (depending on the scarcity of results) will likely be used. The most appropriate statistical tests which have the most power and least bias for detecting differences between control and test conditions will be used. Factor analysis (analysis of variance) or non-parametric tests may be used given statistical assumptions can be reasonably met and reliable sample sizes can be obtained to evaluate multiple factors such as species, life stage, and test condition.

Results and Discussion

The extent of entrainment and impingement of test groups will be summarized and discussed. The extent of potential mortality of various life stages for chinook salmon and steelhead will be evaluated. Rates calculated will include proportion of test fish entrained, proportion of test fish impinged and killed or damaged, and the proportion of fish that came in contact with the screen.

PREDATION

Equipment

Diver observations will be used as for entrainment/impingement tests described above. Divers will periodically employ hand-held photo and video equipment to document observations, particularly during hatchery fish releases. If possible, video equipment could be mounted (fixed) near the screen to monitor and document experimental observations. Choice of technique could vary by season based on flows and turbidity levels. It is not recommended that fixed video equipment replace diver observations but only supplement diver observations if desired by the Service. Additional costs would be necessary to install fixed video equipment either above or underwater and are not recommended at this time.

Procedures

Review of Engineering/Hydraulic Survey Data: Hydraulic information from the screen area will be reviewed to determine the potential for back eddies or similar habitat that may favor predatory fish. Doppler current profiles will be reviewed in the area of the screen looking for low velocity or back eddies where predators and prey may locate.

Diver Observations: Divers observing entrainment/impingement will also make observations of predatory fish and test fish behavior in the area of the screen to determine if any unusual behavior occurs in either predators or test fish that would increase predation. Observations will specifically be made of areas identified from review of hydraulic information. Divers will observe whether predators are offered "ambush" habitat around the screen structure and document actual predatory attacks on test or other fish. Divers will also observe response of predators and prey to air blasts to clean screens. As for entrainment/impingement, observations will be made under test and control conditions. Electroshocking and stomach sampling are not deemed necessary.

Data Analysis Methods: The numbers of fish for each test and control group attacked and eaten will be recorded. The proportion of fish in each test group that were attacked and eaten will be calculated. A comparison will be made of the numbers of test and control fish that were attacked and eaten. Again, a Fishers exact test or Pearson's Chi-square test (depending on the scarcity of results) will likely be used. The most appropriate statistical tests which have the most power and least bias for detecting differences between control and test conditions will be used. Factor analysis (analysis of variance) or non-parametric tests may be used given statistical assumptions can be reasonably met and reliable sample sizes can be obtained to evaluate multiple factors such as species, life stage, and test condition.

Results and Discussion

The extent of predation on test fish groups will be summarized and discussed. The extent of potential mortality of various life stages for chinook salmon and steelhead will be evaluated. Rates calculated will include the proportion of test fish attacked and eaten under test and control conditions. If fish predators are finding holding habitat and subsequently feeding near the screen, modifications will be recommended where feasible to eliminate those areas. The report (see Section 5) will describe as necessary how to modify the screen or screen installation to eliminate predator holding and feeding areas identified during the study.

Section 5
Report

A report will be written which will document each test by describing the equipment, testing procedures, results, and conclusions. In addition, recommendations will be made if the testing work identifies any improvements that can be made. As tests are completed the portion of the report dealing with that test will be written and submitted. In addition, any deviation from agency criteria or major problem that might affect hatchery operations will be reported to hatchery staff immediately.

The report will be organized similar to this plan. An outline of the report is provided in Figure 7. In addition to describing the test procedures, difficulties in carrying out, the tests will be described. The results in the report are described above in the description of each test. In addition, the results of the tests will be compared to lab and field test results from previous testing reports. How well the evaluation program has met its stated goals and objectives will be described.

A draft and final report will be submitted to the fishery agencies for review.

Figure 7

Outline
Evaluation Report
USBR Flat Plate Fish Screen at Coleman National Fish Hatchery Intake No. 3

Executive Summary
Section 1 Introduction
- **Background**
- **Goals and Objectives**
- **Contents**

Section 2 Testing of Screen Installation
- **Introduction**
- **Module Installation**
- **Fish Screen Modules**
- **Auxiliary Equipment**

Section 3 Hydraulic Testing
- **Introduction**
- **Sediment Deposition**
  - Equipment
  - Procedures
  - Results
- **Near-field Velocities**
  - Equipment
  - Procedures
  - Results
- **Approach and Sweeping Velocities**
  - Equipment
  - Procedures
  - Results
- **Screen Cleaning Performance**
  - Equipment
  - Procedures
  - Results

Section 4 Biological Testing
- **Fish Screen**
  - Equipment
  - Procedures
  - Results
- **Fish Screen Entrainment**
  - Equipment
  - Procedures
  - Results
- **Predation**
  - Equipment
  - Procedures
  - Results

Section 6
Evaluation Cost Estimate

The cost to perform the evaluation described in the sections above is highly dependent on the flows in the creek, the ability to obtain the maximum diversion rate, the availability of test fish, and the presence of debris. The evaluation tasks should be scheduled for the time of year when the diversion rate is at a maximum and the desired Battle Creek flows are most likely. The estimated cost table below assumes that this is taken into account and that the proper flows are available when the test personnel are mobilized. A 20% contingency could be added to the cost estimate to account for possible false starts, such as mobilizing the evaluation crew to the site and finding that the flows in Battle Creek are not satisfactory. It is assumed that the velocity meters and video cameras required are available to the service or can be borrowed at no cost from the U.S. Bureau of Reclamation or National Marine Fisheries Service. Installing a fixed video camera, either above or underwater, and processing the additional data would likely add $10,000 to $15,000 to the cost of the study.

Estimated Cost Table

Task	Estimated Cost
DESCRIPTION OF INSTALLATION	$9,000
HYDRAULIC TESTING	
1. Sediment Deposition	$4,000
2. Near-field Velocities	$4,000
3. Approach and Sweeping Velocities	$11,000
4. Screen Cleaning Performance	$8,000
BIOLOGICAL TESTING	
1. Field Surveys	$37,000
2. Data Analysis	$12,000
REPORT PREPARATION	$19,000
TOTAL	$104,000

Appendix A
Battle Creek Flows, Hatchery Demands and Fish Releases

BATTLE CREEK FLOWS

When the hydraulic and biological testing can be performed is dependent on the flows in Battle Creek. Knowledge of the probability of obtaining certain flows in Battle Creek at Intake No. 3 is required to plan and schedule the hydraulic and biological testing. To aid the planning effort, this appendix contains flow duration curves for each month. By entering any of the twelve curves (Figures A-1 through A-12) at a given flow on the ordinate, the percent chance that the flow will be exceeded can be read on the abscissa. For example, in January (Figure A-1) 800 cfs will be exceeded about 24% of the time.

The 12 flow duration curves in this appendix were obtained by analyzing 35 years of data from 1961 through 1996 gathered at the USGS gaging station, Battle Creek below Coleman National Fish Hatchery near Cottonwood, California (Station No. 11376550).

HATCHERY DEMANDS AND FISH RELEASES

For scheduling the use of test fish, it would be beneficial to schedule the tests during the times when fish are being released from the hatchery. Figure A-13 shows the times of the year when chinook and steelhead are being released. The figure also shows the water use by the hatchery in two-week periods during the year.

Figure A-1
Battle Ck bl ColemanFish Hatchery
Flow Duration Curve
January

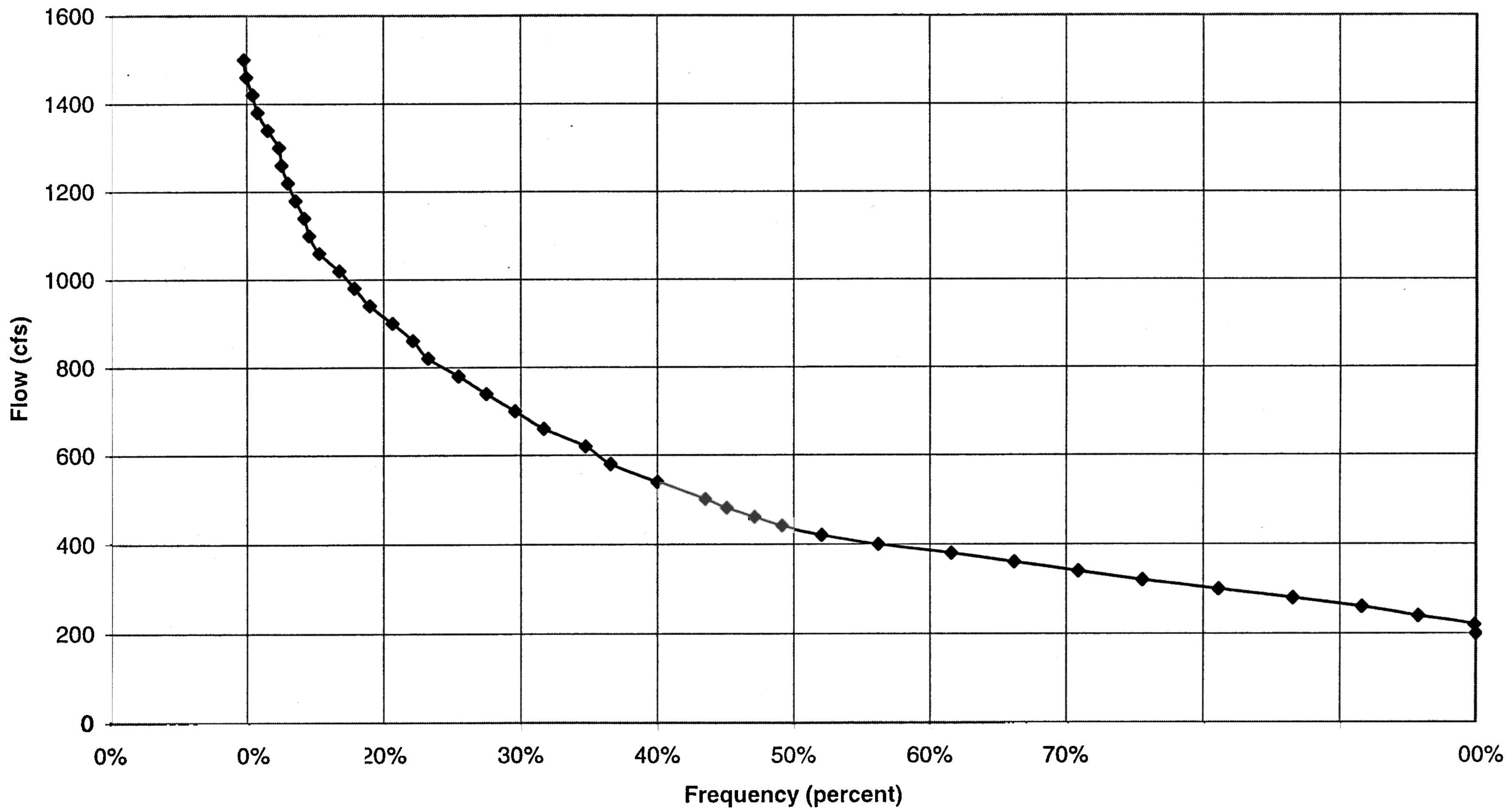


Figure A-2
Battle Ck bl ColemanFish Hatchery
Flow Duration Curve
February

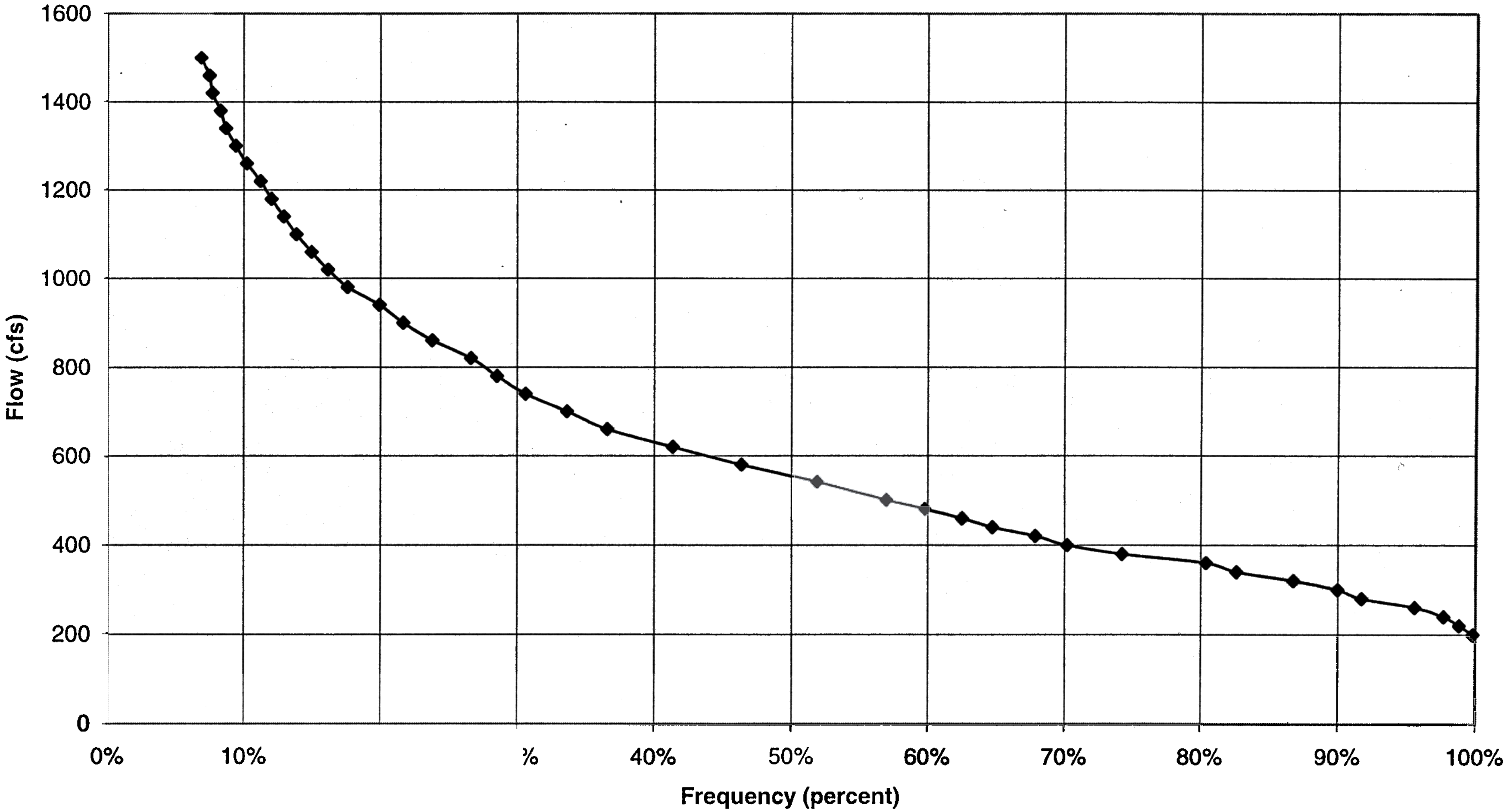
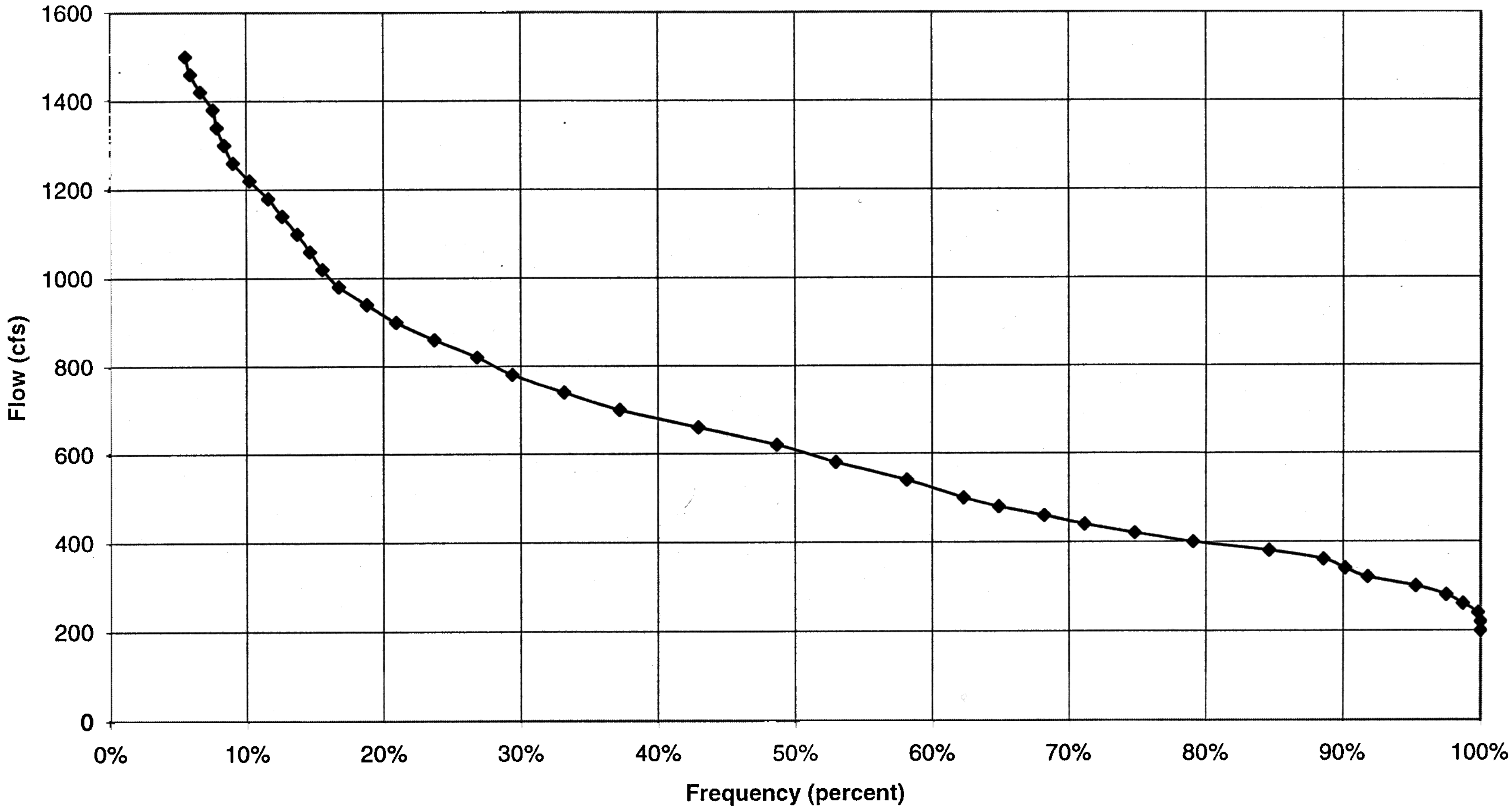


Figure A-3
Battle Ck bl ColemanFish Hatchery
Flow Duration Curve
March



Figı re A-4
Bıttl C bl Col ema Fish Hatchery
Fl ›w D ıratio C ırve
April

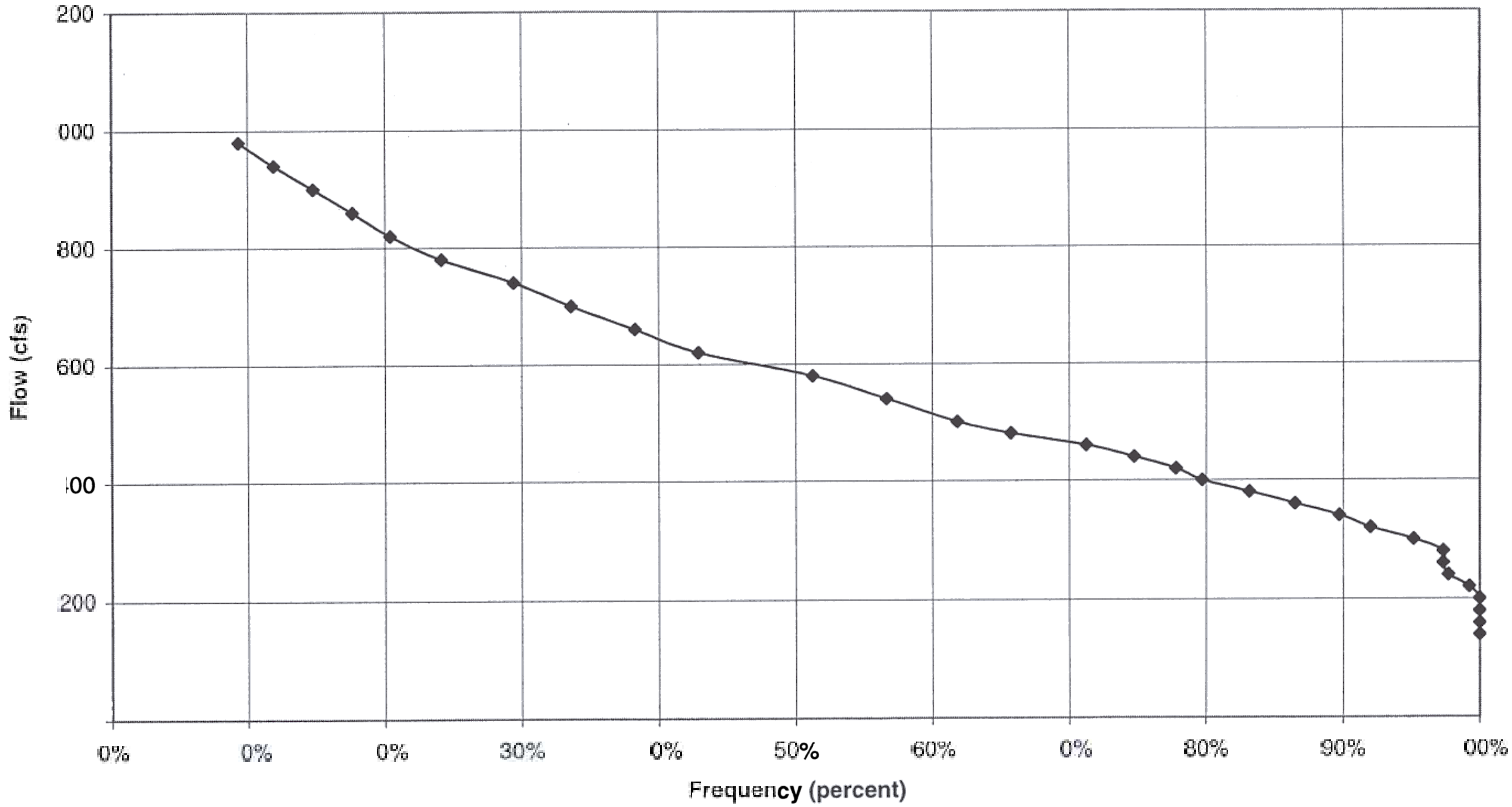


Fig A-5
B ittle Ck bl ColemanFi ;h Hatchery
Fl w Dur on C rve
May

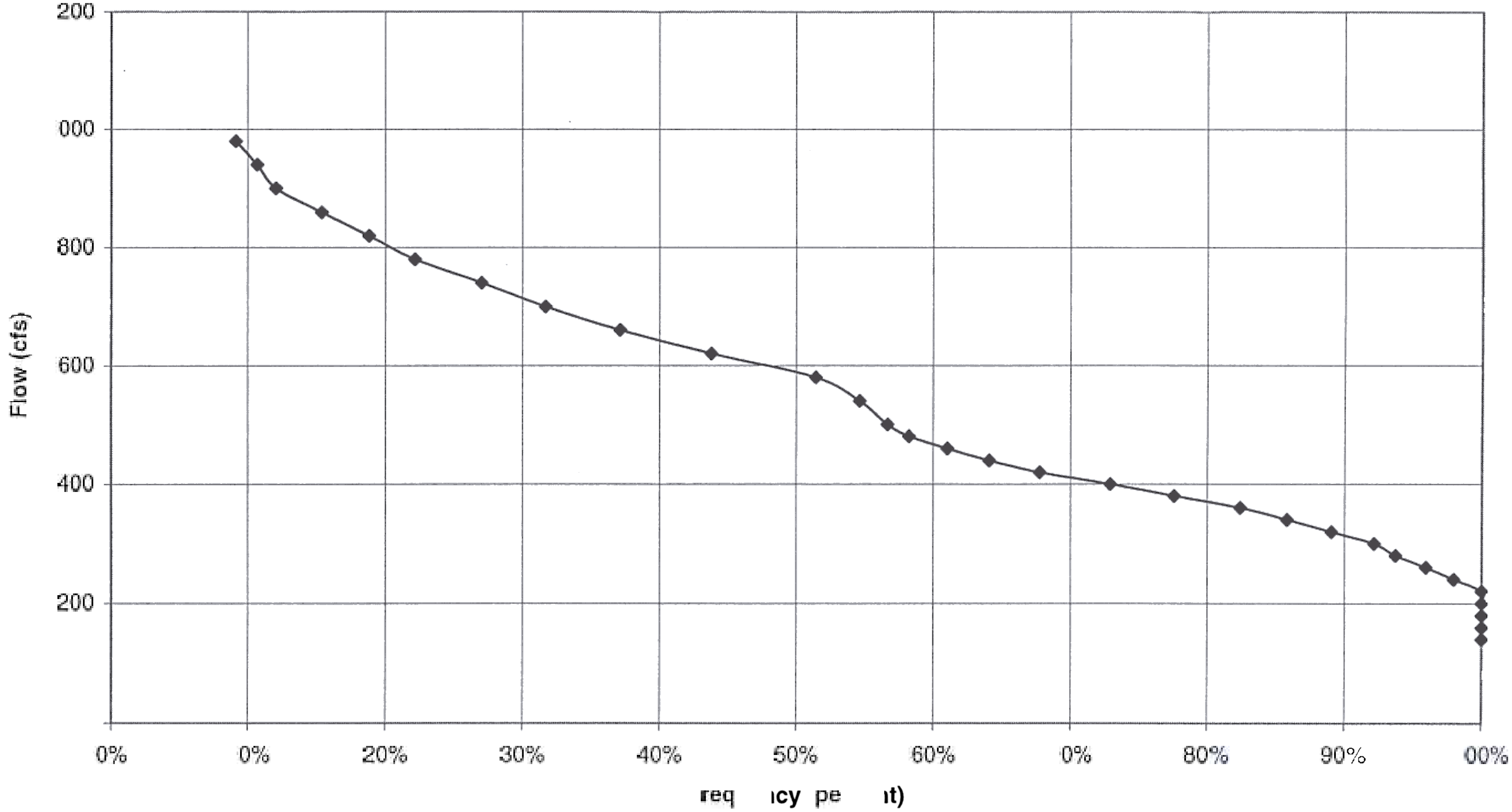


Figure A-6
Battle Ck bl ColemanFish Hatchery
Flow Duration Curve
June

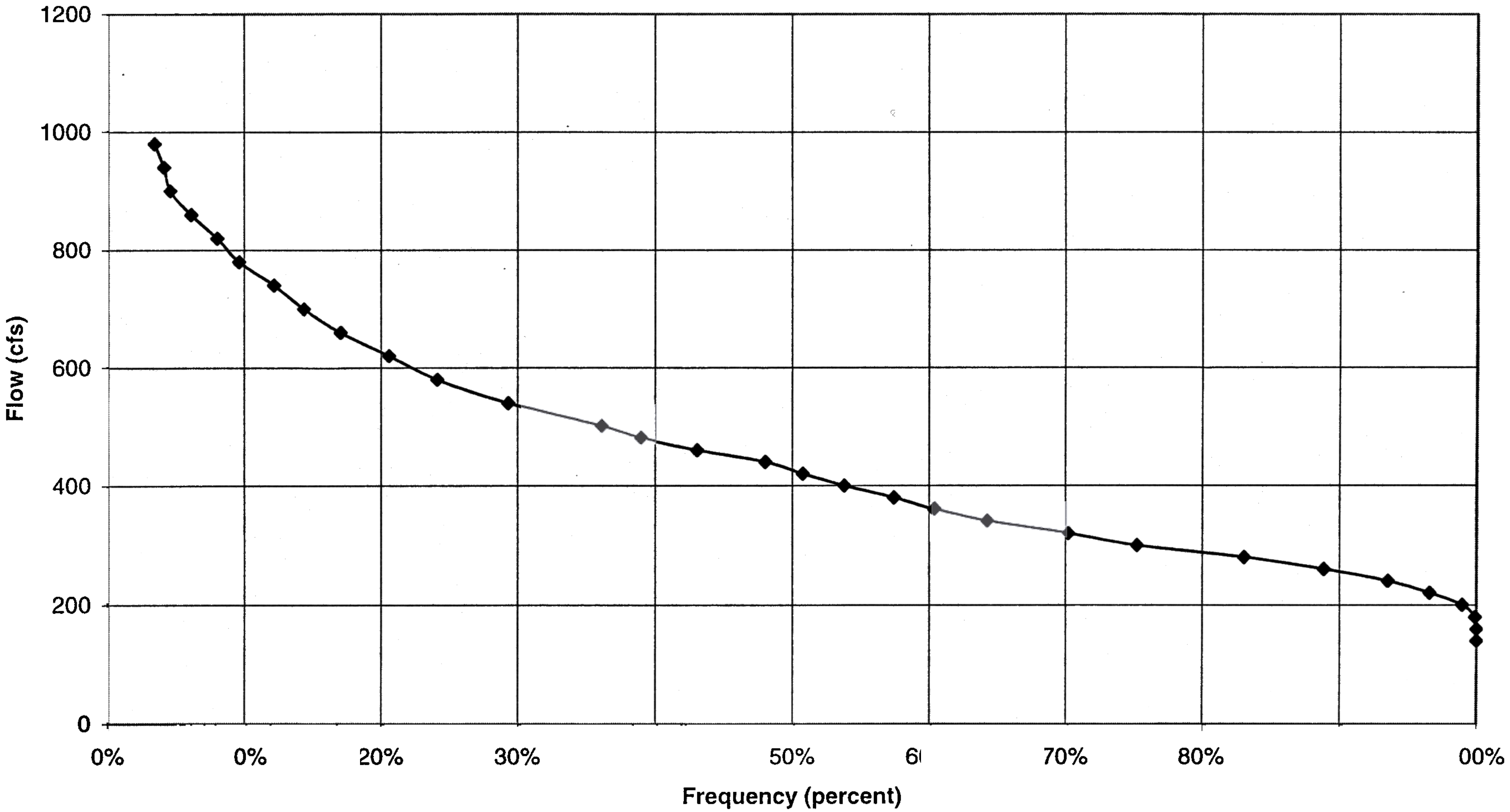


Figure A-7
Battle Ck bl ColemanFish Hatchery
Flow Duration Curve
July

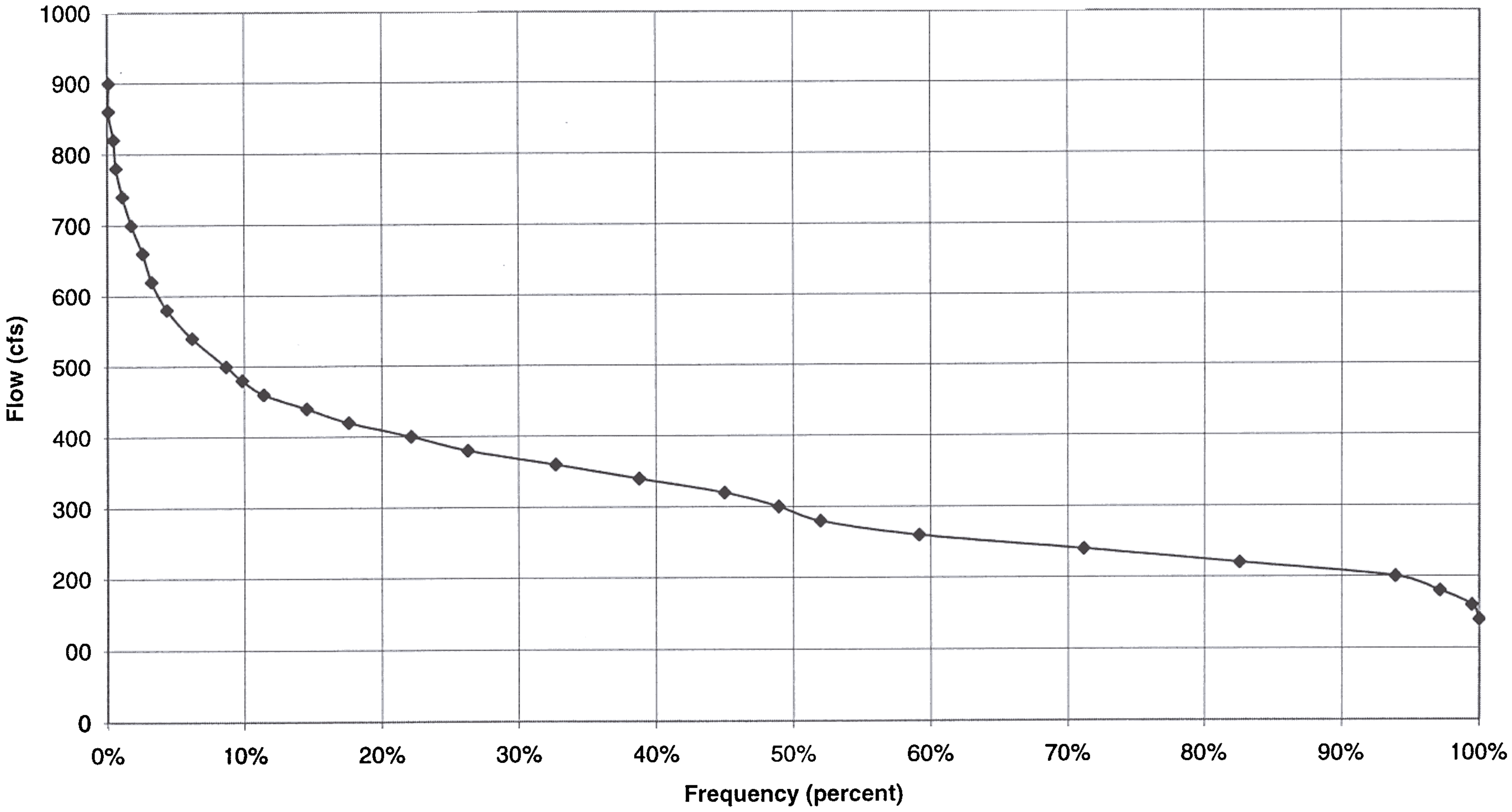


Figure A-8
B ttle Ck bl ColemanFi h H tchery
Fl D ti C
A igus

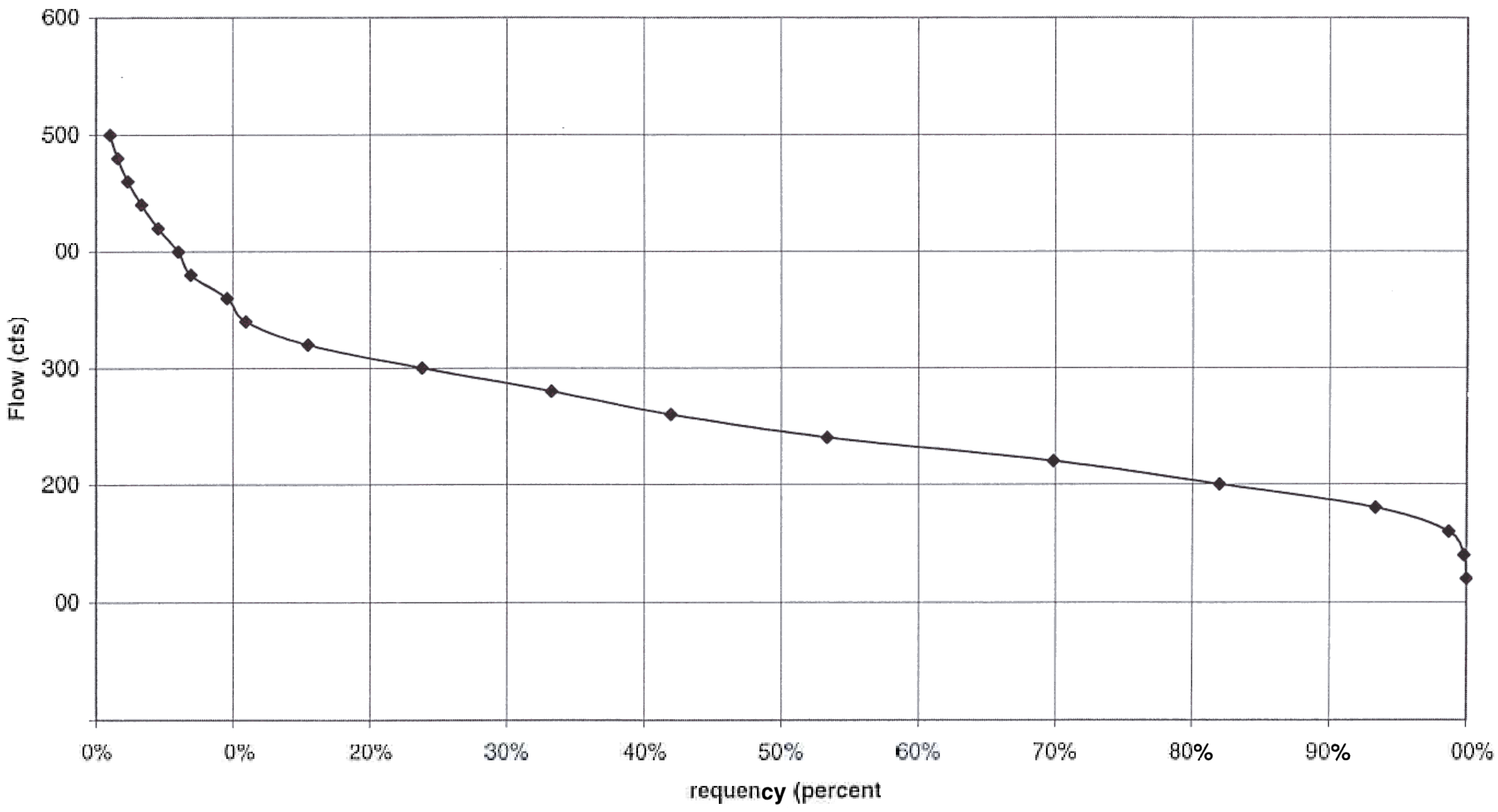


Figure A-9
Battle Ck bl ColemanFish Hatchery
Flow Duration Curve
September

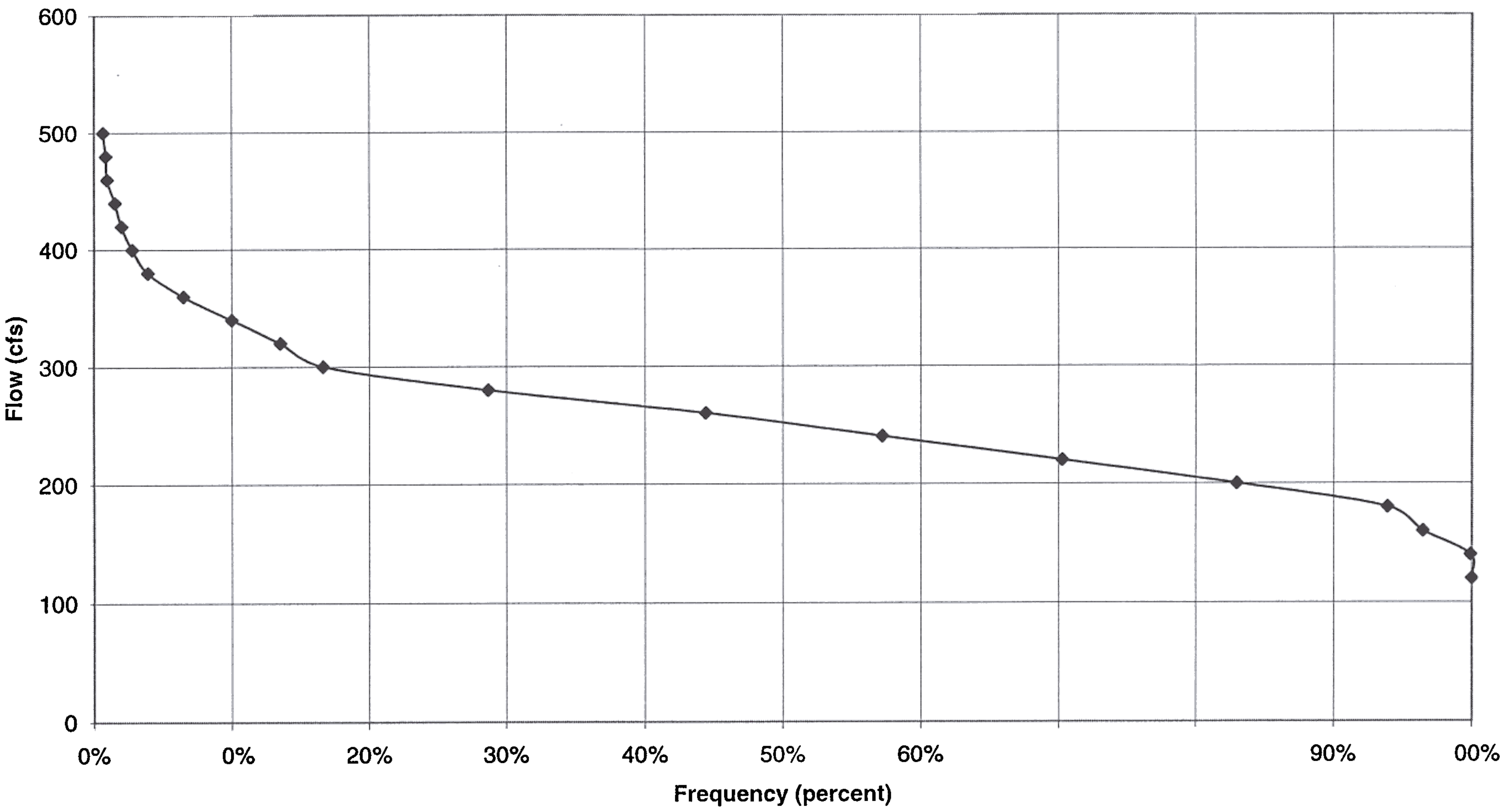


Figure A-10
Battle Ck bl ColemanFish Hatchery
Flow Duration Curve
October

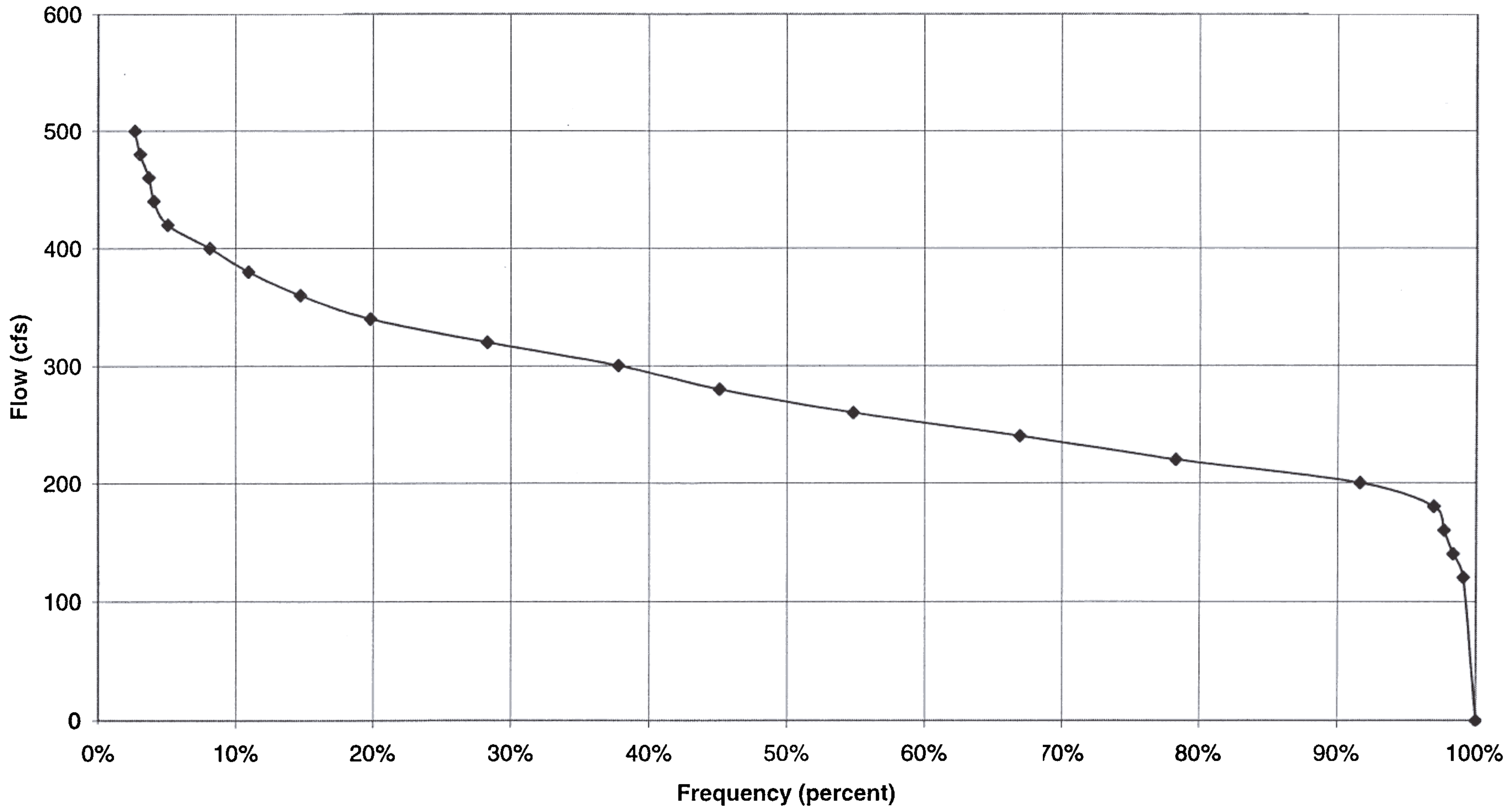


Figure A-11
Battle Ck bl ColemanFish Hatchery
Flow Duration Curve
November

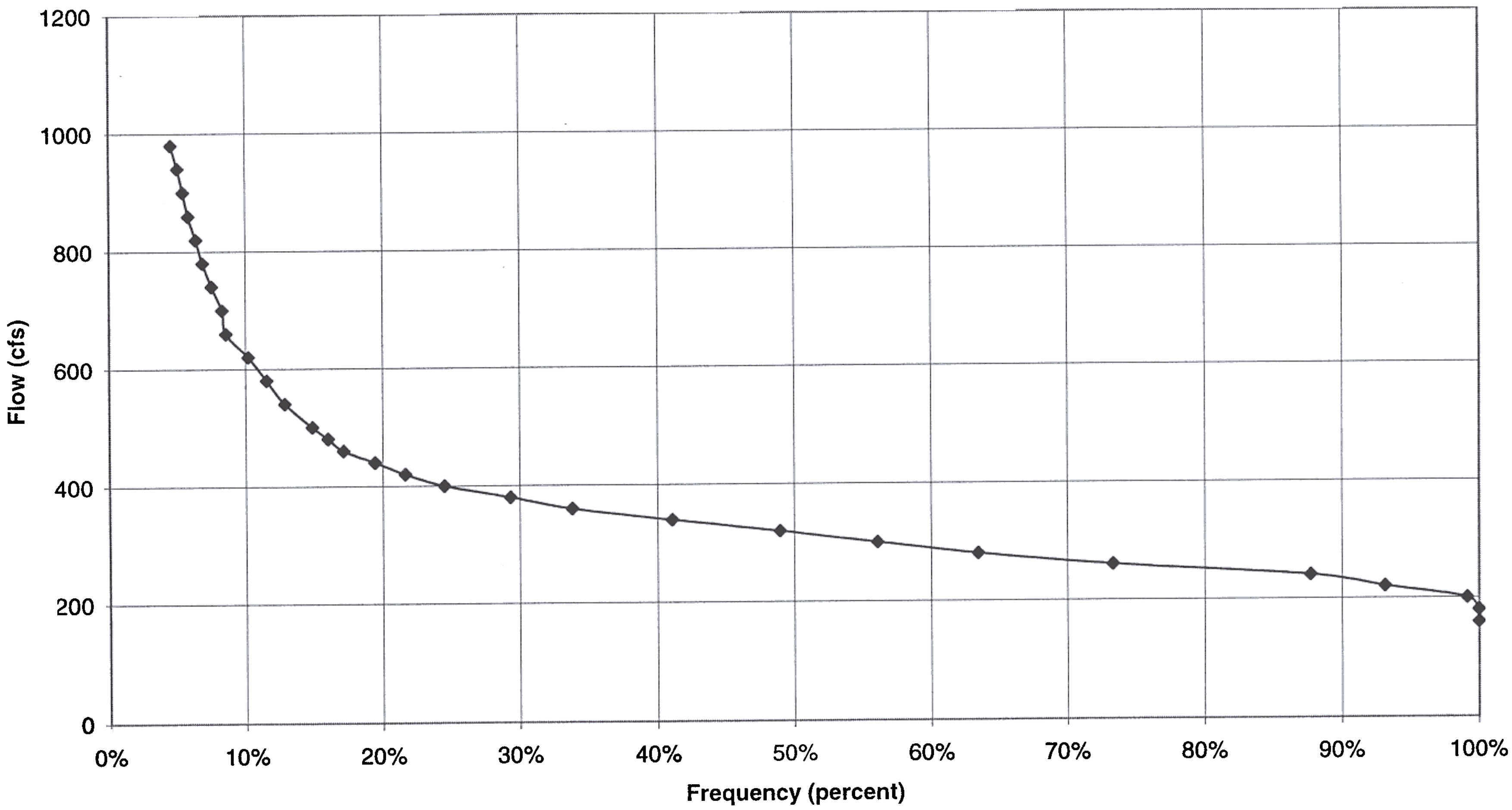


Figure A 2

B ttle Ck bl ColemanFi h H tchery

Fl D ration Curve

Decembe

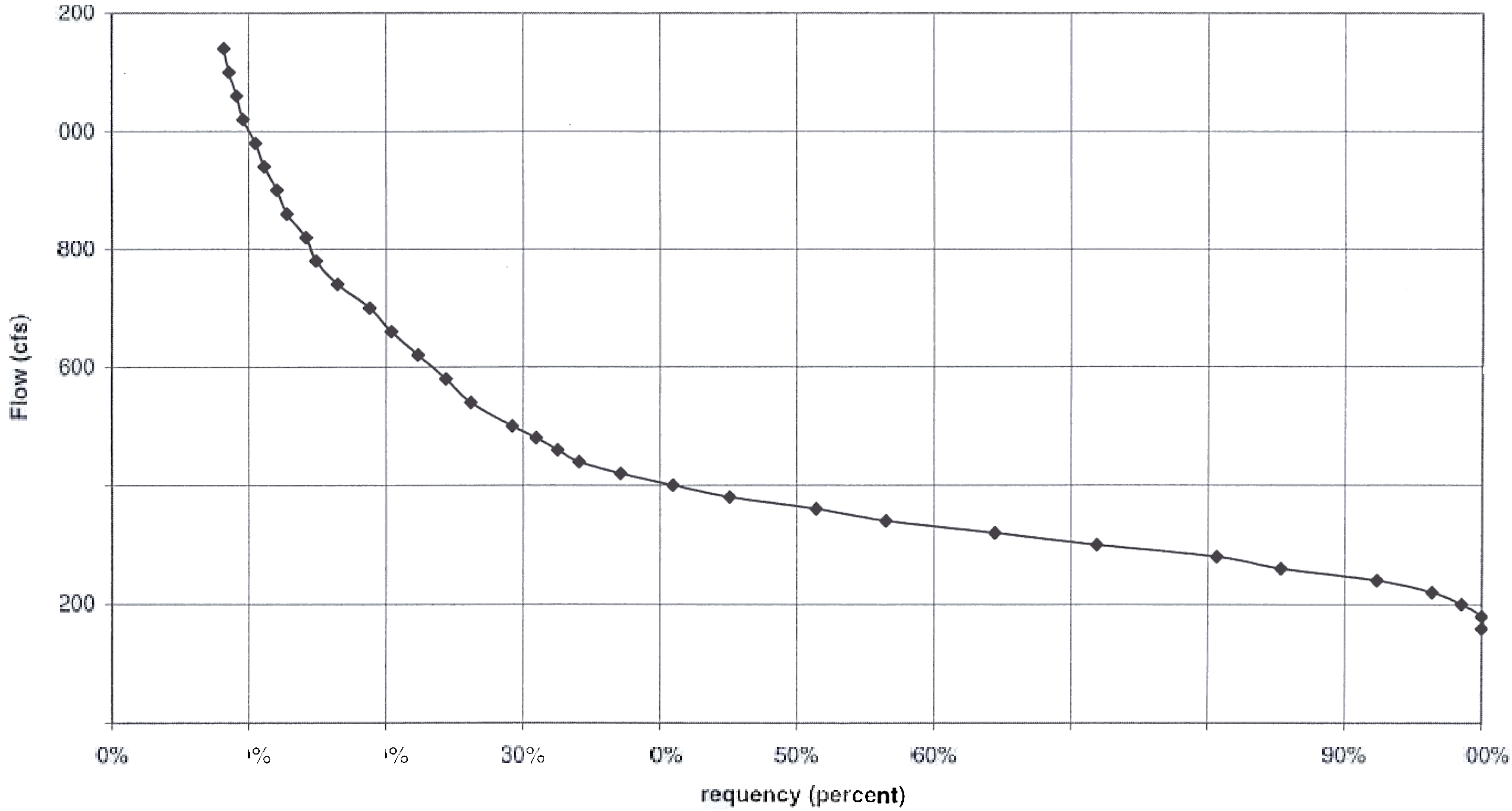


Figure A-13
Coleman National Fish Hatchery
Present Water Requirements