Concept Design for Cone Screens at M & T Ranch Diversion on the Sacramento River

Prepared August 8, 2013 by:

Steve Thomas, Hydraulic Engineer, National Marine Fisheries Service (NMFS), Southwest Region

George Heise, Senior Hydraulic Engineer, California Department of Fish and Wildlife (CDFW).

Dan Meier, Fishery Biologist, Anadromous Fish Screen Program, United States Fish and Wildlife Service (USFWS), Pacific Southwest Division.

Introduction

In 1997, the M & T Ranch diversion was relocated from Big Chico Creek to the east bank of the Sacramento River downstream of the confluence with Big Chico Creek, and a 150 cubic feet per second (cfs) fixed cylindrical fish screen was installed. Subsequently, an encroaching upstream gravel bar has threatened operation of the pumping plant and proper functioning on the fish screen. Current efforts are underway to identify all feasible long-term solutions to this problem, which would then be evaluated further through a required NEPA/CEQA environmental analysis.

Because initial development of potential long-term solutions involving the M & T Ranch diversion were developed over ten years ago, several fish screen experts were recently requested to look at the previously identified alternatives and to determine if there are additional options that could warrant further consideration. On June 12, 2013, a fish screen team consisting of Steve Thomas (NMFS), George Heise (CDFW) and Dan Meier (USFWS) met at the project site with Kelly Moroney of the USFWS and Les Heringer of M & T Ranch to obtain background information on the project, diversion operations, and site characteristics. As a result of this effort, the fish screen team identified one additional project alternative using a cone screen design that they believe warrants further consideration.

Cone screens were first used in Suisun Bay in 1996. Ever since, the manufacturer has been improving the design, upgrading existing screens, and providing options for screen material and screen cleaner drive systems. The fish screen team believes that cone screens would be well suited to the M & T diversion site using a design customized for the site specific characteristics. This report provides background information on cone screens, along with a proposed concept design for cone screens at the M & T Ranch diversion.

Background on Cone Screens

Positive barrier screens provide a physical barrier that prevents fish from being entrained into a diversion and are widely used and accepted by fishery resource agencies. Cone screens are positive barrier screens with a conical shape that typically are mounted on or near the channel bottom (Figure 1). The diversion pipe passes out the base of the cone screen and is plumbed to a pump or passed through a headwall. The most common screen materials for cone screens are stainless steel in the form of a perforated plate or wedge-wire. Screen bases are typically five to fourteen feet in diameter to accommodate up to 50 cfs for each cone screen. The screens are adaptable to a concrete or steel base structure and can be used singly or in groupings.

Screens are typically cleaned with external wiper brushes. Use of external brushes has proven to be an effective cleaning system for cone screens that prevents bio-fouling and debris plugging and minimizes head loss. The brushes rotate in both directions using an automated cleaning cycle. Cone screens perform well in high silt environments, with the brush arms preventing silt build-up at the screen base. Available information on cone screens indicates that debris problems have been generally minimal. If needed, debris deflectors can be installed at locations where the screens may be damaged by floating or submerged debris.

Cone screens work well in shallow water applications because the conical shape provides a large submerged screen area even with shallow water depths. The cone design is hydraulically efficient and provides a relatively large screen area for a relatively small footprint.

Although cone screens were originally designed for use in backwater or slough areas, they have also been used in flowing water applications. Ten cone screens were installed at the Tehama-Colusa Canal Authority diversion in Red Bluff for four years. Some of the screen units were located in a high velocity environment. Those screens held up well to the wear and tear of a harsh environment but they did not meet current standards for approach and sweeping velocities. A modified internal baffling system was recently developed for cone screens to improve uniformity of fish screen approach velocities used in a riverine environment (Hanna, June 2011).

Cone screens have been used in California with increasing frequency in recent years. Applications have included tidal areas within the Sacramento-San Joaquin Delta (e.g. Grizzly Island, Empire Tract and Quimby Island) and backwater areas or impoundments (e.g., Williams Ranch, Napa Ranch and Greco Ranch), and within rivers (e.g., Lake California and Red Bluff Interim Pumping Plant on the Sacramento River, and NSJWCD and CALFED pumps on the Mokelumne River). Several cone screen installations are proposed in 2013 (i.e., 40 and 70 cfs FWD screens on the Feather River, 22 cfs CICC Compton screen on the Sacramento River, and 80 cfs SSID #1 screens on Auburn Ravine).

The design criteria for fish screens include values for approach velocities (water velocities perpendicular to the screen face) and sweeping velocities (water velocities parallel to the screen face). Cone screens often do not meet sweeping velocity criteria for intakes with capacities greater than 40 cfs. Regulatory agencies evaluate the acceptability of sweeping flow and approach velocities for cone screens on a case by case basis based on site specific characteristics. Although cone screens were not designed to be used in riverine environments, the modified internal baffle system improves the distribution of flow through all screen area and creates acceptable sweeping flow patterns around cone screen units. Based on that research and the proven history of cone screens to operate well in areas where sedimentation has been a challenge for other screening alternatives, fish screen experts from the resource agencies who are responsible for reviewing proposed screening alternatives developed the concept described below.

Figure 1. Installation of a cone screen and its base at Lake California diversion on the Sacramento River. (Photos courtesy of CDFW)

M & T Ranch Cone Screen Concept Design

The existing four cylindrical Tee screens would be replaced with four, twelve-foot-diameter cone screens. Each cone screen has a capacity of 43.2 cfs; four screen units will have a capacity of 172.8 cfs, sufficient for the needs of the M & T Ranch pumping plant. Cone screens are shorter than the existing cylindrical screens so the bottoms of the screens can be higher in the water column than the bottoms of the existing cylindrical screens while maintaining screen submergence. The cone screens would sit on a platform approximately three feet higher than the river bottom. This will reduce the chances of the screens being buried in river sediment. A conceptual drawing is shown in Figure 2.

The screen units would be attached to the existing flanges to which the cylindrical screens are attached with risers to raise the invert elevation of the screen units. The screen platform would be supported on new steel piles. (Figures 3 and 4). A sheet pile perimeter wall will protect the screens from scour and debris accumulation under the screen units. The sheet pile wall will also redirect flows at the river bed elevation causing river flows to accelerate around the structure and keep gravels moving downstream. Gravel and fine sediment may accumulate in the area immediately downstream of the structure, depending on the layout of the sheet pile cutoff wall. The area inside the sheet pile wall and around the screen support structure will be filled with rip-rap and gravel, and may be capped with grout.

The existing air burst cleaning system would not be needed with the cone screen alternative. The cone screens could use hydraulically-driven brushes to clean the outer screen surfaces. The cleaning systems may be controlled with an adjustable timer and manually. Controls for the cleaning system would be installed within the secured area at the existing M & T Ranch pumping plant, or in a secured structure on the river side of the levee above the 100 year flood elevation. Hydraulic pumps for driving the cleaning system would also be located at the pumping plant. Alternatively, the cleaning system could be driven by a solar electric system.

The cone screen units would use the modified internal baffle system developed for riverine environments. The modified baffle system consists of vertical partitions that divide the internal space into four chambers, and an internal, perforated cylinder that regulates flows through each chamber and thus each quadrant of screen area. The perforations in the flow regulation cylinder will need to be customized for each screen unit based on ambient water velocities in that area of the river.

Debris deflectors may be added if desired. Deflectors similar to what exists now, and a floating log boom, a commonly used debris deflector concept used on the largest fish screens, are shown in Figure 5. The existing deflectors are designed to prevent large trees from striking or crushing the cylinder screens. They add to the complexity of the structure which could allow small and moderate sizes of debris to accumulation around the screen and may reduce water velocities around the screens. The reduced water velocities could encourage sediment deposition near the screens, although that has not been a problem thus far. Annual removal of debris caught in the deflector barrier similar to current O&M requirements would remain in place.

A floating log boom would require driving three or four large steel piles in the river. The floating log boom would be designed to guide debris away from the intake structure, but large debris could become entangled on the piles. Depending on the design, the boom could also divert flow away from the intake at lower flows, possibly leading to an eddy forming near the screens. The floating log boom would have the added benefit of preventing boaters from dropping anchor on the screens. If no deflector is used, the screens could be vulnerable to damage from debris and boaters. At a minimum, seasonally installed buoys should be deployed to direct boaters away from the site to lessen the likelihood that boaters will strike the screens.

Operations and maintenance of the cone screens would be similar to that needed for the existing cylindrical screens. The existing pneumatic cleaning system would be removed, thus there would be no O&M associated with that system. The hydraulically powered (with non-toxic food grade hydraulic fluid) cleaning system would require maintenance of the hydraulic motors contained within each screen unit, the hydraulic pumps and hoses, and the electronic systems. The nylon brush bristles would also need to be replaced periodically, likely every 5 to 10 years. Each screen unit could be removed relatively easily for maintenance and repairs as needed. The manufacturer can provide more detailed information on O&M requirements for these screens.

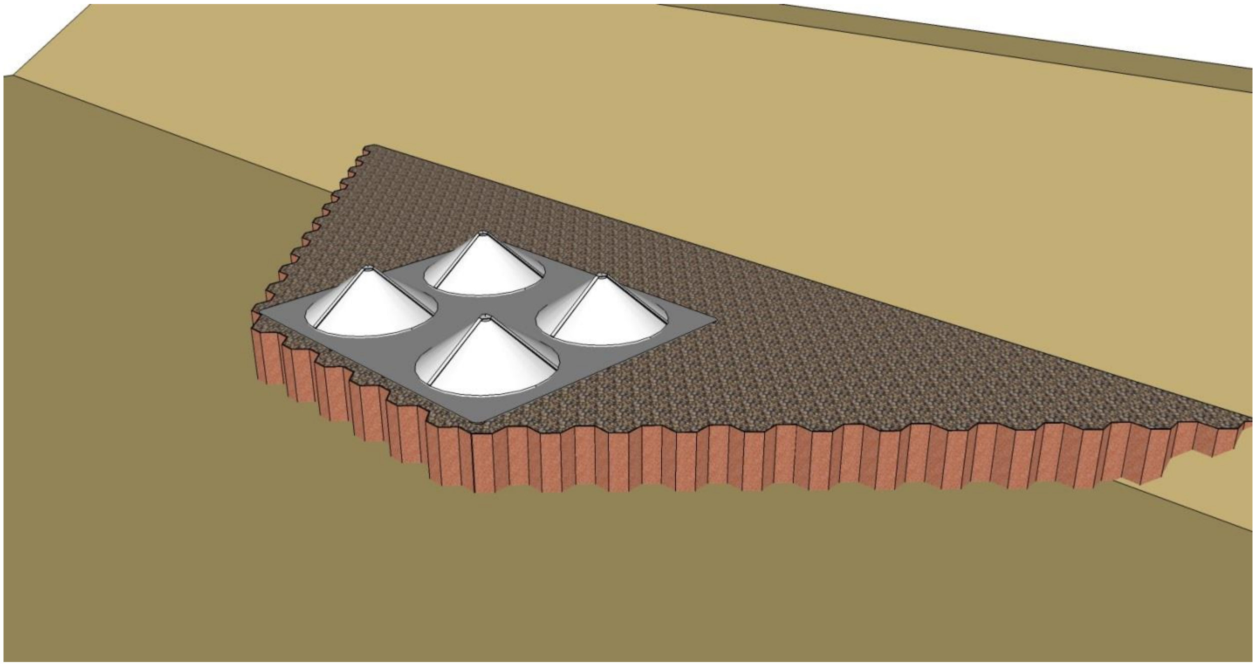

Figure 2. Isometric view of the cone screen design concept. (Drawing is not to scale.)

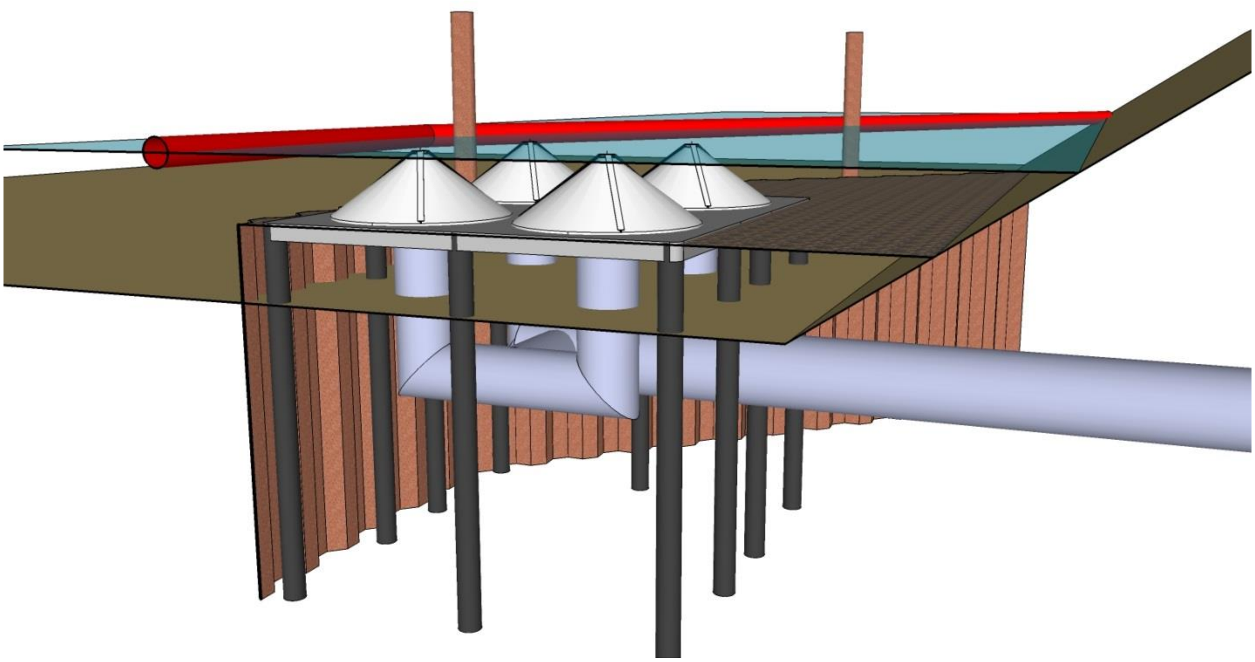

Figure 3. Section view of a cone screen alternative showing diversion pipes, steel support piles for cone screens, an optional log boom, and other elements of a possible cone screen design. The sketch shows the low summer water surface elevation just higher than the tops of the cone screens. (Drawing is not to scale.)

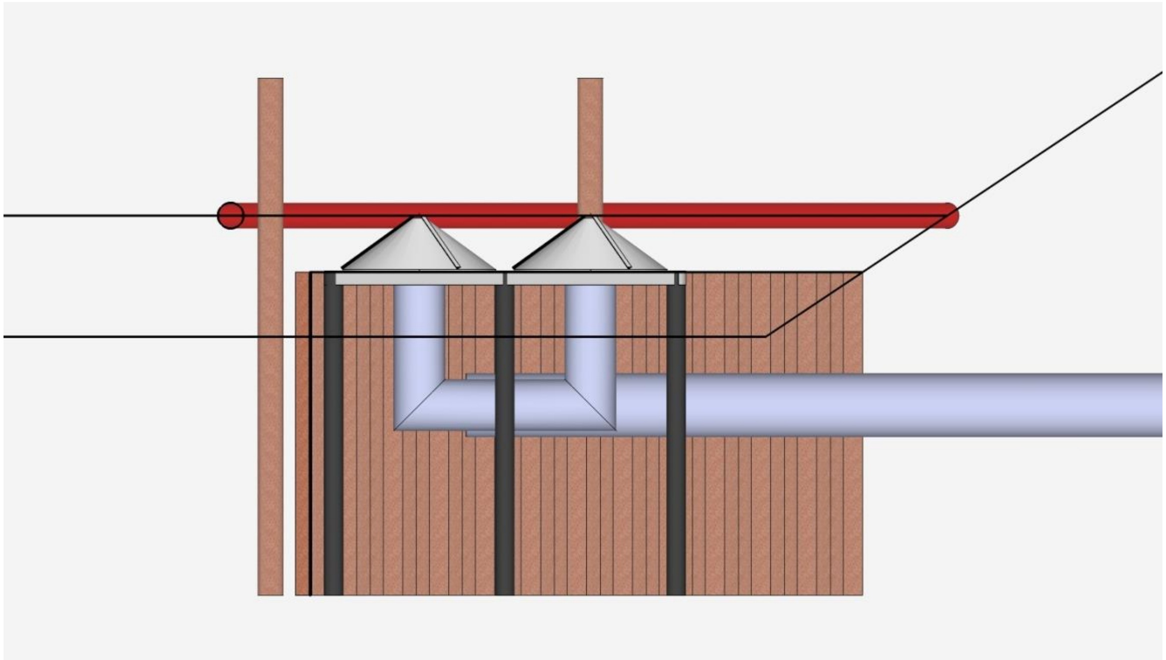

Figure 4. A section view of a possible cone screen retrofit concept. The screen units are shown resting on a platform supported by steel piles. The elevation of the platform is set to allow the screens to be submerged at low river flows. A floating log boom (red) and its support piles are also shown. The sheet pile coffer dam would be cut to the elevation of the screen support platform, as shown. (Drawing is not to scale.)

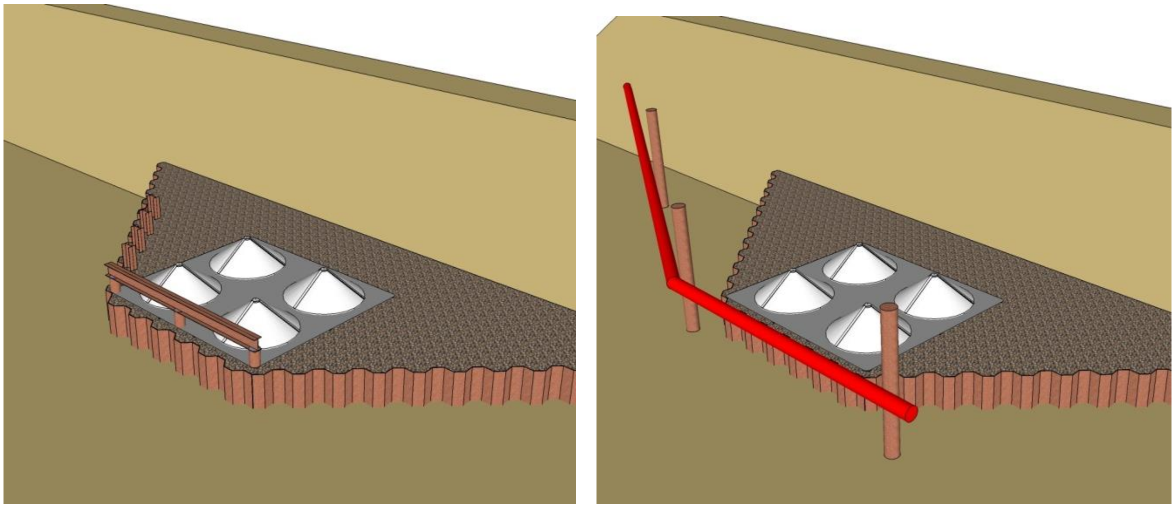

Figure 5. Alternatives for debris deflectors that may be considered for the cone screen design concept. The left drawing shows deflectors similar to those that exist currently. The right drawing shows a floating log boom. (Drawings are not to scale.)

Construction would require a sheet pile coffer dam to dewater the work area to perform the screen replacement work in a dry environment. The coffer dam would later be cut off to the elevation of the cone screen support platform forming the perimeter wall as shown in the drawings. The coffer dam would not be able to completely enclose the work site due to the existing diversion pipe that runs from the screens to the pumping plant. As a result, keeping the work area dry may require additional sealing measures.

Installing the coffer dam could take as long as one week. Approximately ten screen support piles would be required to support the weight of the screens. Driving the support piles would be done within the dry coffer dam. The pumping plant would be inoperable during the construction phase which could be six to eight weeks, and therefore options for meeting water deliveries during project construction would need to be considered.

Project Cost Estimate

A cost estimate for the project based on the concept design provided herein could best be provided by a firm with expertise in cost estimating methods and best practices, and one that has experience with design of projects using similar types of construction methods and materials. A cost estimate based on the concept design would necessarily be somewhat imprecise but would provide a general range of project costs. Cost estimation precision would improve as the project design is more fully developed.

Bibliography

Ducks Unlimited, July 2013, M & T - Llano Seco Fish Screen, project information at: *http://www.ducks.org/california/california-projects/m-t-llano-seco-fish-screen-project*

Hanna, Leslie, June 2011, ISI Cone Screen Performance in a Riverine Environment, Bureau of Reclamation, Technical Service Center, Denver Colorado, Report PAP-1037.

Intake Screens Incorporated, July 2013, list of cone screen projects and ISI Cone Screen brochure at: *Intakescreensinc.com*

Mefford, Brent, October 2012 Pocket Guide to Screening Small Water Diversions, Bureau of Reclamation, Technical Service Center, Denver Colorado, Unpublished Report.