M E M O R A N D U M

MWH
MONTGOMERY WATSON HARZA

To: Jim Well, Ducks Unlimited **Date:** December 12, 2013

From: Dennis Dorratcague
Neil Schild **Reference:**

Subject: M&T Intake, West Bank Intake, Engineering Analysis

Introduction

Background

The M & T Ranch/Llano Seco Rancho intake on the Sacramento River near Chico was built in 1997. Soon after the intake was built, the west bank of the river has eroded just upstream of the intake, and a gravel bar has moved downstream and threatens to isolate the intake's cylindrical fish screens. As short-term protection of the intake, several measures have been undertaken. These include: twice dredging the gravel of a total of 300,000 tons of material and installation of 1500 feet of toe rock on the west bank to prevent future erosion. In addition, since 2000, studies have been undertaken to seek a long-term solution. These studies addressed many alternatives and finally recommended feasible improvements to permanently provide a reliable water intake. These included rock groins on the west bank of the river, and moving the intake 2,000 and 3,500 feet downstream. Presently, an environmental review process is underway to evaluate the recommended alternatives for a reliable water withdrawal system, while protecting fish and the function of the river. Recently, another alternative has been suggested. This alternative involves moving the intake to the west bank of the river and pumping the water to the east bank and into the M & T canal. A geomorphic analysis of this alternative was performed (Tetra Tech, October 14, 2013).

Purpose

The purpose of this memorandum is to provide engineering feasibility analysis to the level of the other alternatives in support of the environmental analysis. Another purpose is to answer questions posed by Yantao Cui in his comments made in reviewing the Tetra Tech memo (October 14, 2013).

Intake Description and Cost Analysis

Since 2000 three types of fish screens were analyzed during the course of studies to remedy the existing M&T intake problems. These included vertical flat plate screens on the east bank 2,000 and 3,500 feet downstream of the existing intake, cylindrical screens (similar to the existing intake), and cone screens to replace the cylindrical screens at the existing intake location. The analyses of these screens form the basis for the engineering analyses of the west bank screens described below. From data presented in Tetra Tech (October 14, 2013), the best location for an intake giving the best depth and sweeping velocity is at cross section XS4. The size of screens required are the same and the river depth and bank configuration is similar to the west bank location at XS4 in Tetra Tech (October 14, 2013).

Flat Plate Fish Screen Intake

Fish Screen Intake Structure

Cross Section XS4 in Tetra Tech (October 14, 2013) is very similar to that at the location of the 2,000-foot downstream intake in MWH (September, 2008). The channel bottom at the toe of the bank is 105.0 at XS4 and 101.5.0 at the 2,000-foot downstream intake location. The top of bank is 133.0 at XS4 and 128.0.0 at the 2,000 foot downstream intake location. Therefore, the structure would be essentially the same as that described in Section 4 in MWH (September, 2008). The description below repeats the screen structure information from MWH (September, 2008) except the elevations have been changed to reflect the structure at XS4. The intake structure will have a footprint that is 76 feet long and 27 feet wide and will have six vertical flat-plate screens, each 10 feet long by 8 feet high, along the front face that will provide fish screening that meets state and federal agency criteria. The screens will have a maximum approach velocity of 0.31 fps. From data presented in Tetra Tech (October 14, 2013), there is sufficient sweeping velocity to meet fishery agency criteria. The top of the screens will be at elevation 114.5 feet, or approximately 0.5 feet below the estimated minimum water surface elevation of 5,000 cfs in the Sacramento River. The screens will be kept clean by a water jet system that will also act to re-suspend sediment at the intake structure. It is assumed that the natural sweeping velocity of the river combined with the minimal approach velocity will be able to keep the screens clear of large debris. However, a log boom floated a few feet out from the screens and supported by pilings could be included in the design. Concrete wing walls will extend from the back side of the structure to support the access road and retain fill.

The intake structure will have a sediment re-suspension system using the same pumps as the back-spray screen cleaning system. The structure will need to be accessed at times to remove excess sediment, clean fish screens, or repair the screen cleaning system.

The intake structure will be accessed by a road built at the approximate level of the ground across the USFWS property. The access road will be below the 100 year flood elevation. Therefore, during high water with flows over bank, access to the fish screen and pump station will not be possible.

This option of an intake on the west bank of the river is of concern to the current Ranch Manager and may be acceptable only if sufficient remote controls and monitoring are provided in the ranch office building. This will include monitoring of pump status, including flow measurements on each pump, flow conditions into the pipeline east side of the river, head loss across screen, adjustment of screen cleaning cycle and sediment re-suspension system.

Under flooding conditions the pumping plant on the west side of the river can’t be accessed via roads through the refuge lands, so, if power goes out, the entire service area on the east side of the river could be out of a water supply.

The power alternatives for powering the motors on the pumps have been discussed with the Ranch Manager. Natural gas isn't available on the west side of the river and electric power will likely have to be provided from the nearest main road where sufficient power is available for the operation of the pump motors.

Access under normal conditions consists of a 34 mile round trip for an employee and the Ranch Manager feels the pumping plant should be inspected three times per day when operating. Each round trip and inspection would likely take a minimum of two hours. This means a total of more than 100 miles would have to be traveled daily and require about six hours of time.

The number of trips may be reduced after a period of time operating a pumping plant on the west bank. This will vary on the amount of water being used and timing during the year. When river flow conditions are above normal and possibly during lower river flows, the monitoring will be increased.

Pump Station

The pump station and wet well are assumed to be similar to the existing pump station and would be located 50 feet to the west of the intake. The screen structure and pump station are designed to withdraw water from the Sacramento River at the XS4 location and deliver it to the discharge pipe from the existing pump station on the east side of the river and then to the head works of the Phelan Canal. The station will have 3 pumps, each designed with a maximum capacity of approximately 50 cfs. Water surface elevations in the Sacramento River can vary up to about 21.5 feet. The minimum estimated water surface elevation is 115.0 feet, and the maximum design water elevation is 137.5 feet at the 100-year event. Water discharged from the pumps will be conveyed through approximately 2,950 feet of 72-inch diameter concrete pipe to the connection with the existing pump discharge pipe immediately north of the existing pump station. From this connection to the canal the flow will be conveyed in the existing 72-inch diameter pipe.

To facilitate operations, an interconnect with the existing wet well may be considered to allow for some water to be delivered to the canal should the pumps on the west side for some reason stop operating. If the existing pumping plant is maintained for standby operation, the costs of obtaining water supply will increase. Water from either of the sources will be measured.

In total, there is 7,650 feet of pipe from the river to the canal. The 72" pipe is turned up at 90 degrees and flow out of the pipe goes into the main canal.

At minimum water elevation in the Sacramento River and maximum diversion flow, the pumps will be required to produce about 42 feet of head to deliver water to the canal outlet structure. This is about 11% more head loss than in the 2,000-foot downstream pump station alternative. The head loss in this system is too great to deliver the flow by gravity from the west bank intake to the gravity side of the existing pump station intake.

The west bank pump station building and pumps would be the same size as in the existing pump station. The pumps would be driven by electric motors instead of natural gas powered motors. The west bank pump station is described below. .

The 72-inch pipe from the west bank fish screen structure will expand into a 120-inch pipe. The 35 feet of 120-inch pipe will enter a manifold structure at an invert elevation at 102.25 feet. The manifold structure will consist of four branches to the three pumps and a spare pump bay. An above-ground building will house the pump motors and electrical equipment.

Three single-stage, variable speed, vertical turbine pumps similar to the those used in the existing pump station will be installed at the new pump station. The impeller diameter will be about 19.5 inches. The pump will be operated at 675 rpm to achieve a flow rate of 50 cfs at 42 feet total discharge head. The pumps will have variable frequency drives and will be operable at progressively lower rpm to achieve the desired flow rate at the water level in the Sacramento River.

Each pump will require a 300 hp electric motor and will draw approximately 300 kW at the maximum flow and head combination. This system will require about 14% more energy to pump the same amount of flow than in the existing pump station.

The pump station building will have a footprint of approximately 50 ft by 65-ft. In addition to about an acre of land around the pump station, additional land of about 7 acres will be required along the USFWS property to the south for a pipeline to the micro-tunnel entrance. Additional land of about 1.5 acres will be required for construction of the intake and pipe to the pump station on USFWS land.

Pipeline

The transmission pipeline from the new pump station will run to the south about 850 feet parallel the west bank of the river. At this point at the south end of the USFWS property, it will enter a micro-tunnel bored under the river to the east southeast. The micro-tunnel will be about 1,450 feet long and end on M&T Ranch property behind the levee about 550 feet north of the existing pump station. The micro-tunnel is judged to be necessary since excavating a pipeline in the Sacramento River would not be allowed for environmental impact reasons. This route avoids any construction in the park on the east bank of the river. Then, it will continue to the south along the farm road behind the levee until reaching the existing pump station. It will tee into the existing discharge line just northeast of the present pump station. The pipe will be 72-inch diameter reinforced concrete cylinder pipe and will be buried at least 3 feet beneath the surface. The slope of the pipe will be downward to its connection with the existing discharge pipe. It is estimated that a total of 2,950 lineal feet of pipe will be required including that in the micro-tunnel under the river.

Total earth excavation for the transmission pipe is estimated to be 39,000 cubic yards not including the micro-tunnel. A clearing width of approximately 100 feet wide will be necessary along the pipe for construction and future maintenance access.

At the point of intersection between the new and existing transmission pipelines, a segment of the old pipeline will be removed and a tee connection will be installed. To block off flow back to the existing pump station, two blind flanges will be installed, one on the end of the existing pipeline and the other at the end of the tee facing the old pump station. By using blind flanges, this will allow the pipeline to be connected and re-activated more easily, if future conditions require switching operation back to the existing pump station.

Rock Revetment

It is assumed that the existing toe rock along the west bank will be added along its entire length to protect the screen structure and pipeline paralleling the river to the south end of the USFWS property. This will require full height bank protection. This is in the area of the existing rock toe.

Cylindrical Screen Intake

Since the small channel depth and river bank slope along the west bank is similar to that encountered at the 2,000-foot downstream location, cylindrical screens are not possible on the west bank as they are not on the east bank at the 2,000-foot downstream location.

Cone Screen Intake

Another type of fish screen mentioned for possible consideration is the cone screens made by Intake Screens, Inc. These screens are in the shape of a cone and are meant to be installed with flat bottom on the bottom of a body of water. They are made of stainless steel wedgewire and have been provided with baffles on the inside to produce uniform approach velocities to the screens. The water passing through the cone screen is drawn from the bottom of the cone and carried to shore through a pipe buried under the river bottom and bank. The cone screens are cleaned by a brush that rotates about a point on the top or apex of the cone. The brush is driven by a hydraulic motor. These types of screens have been installed in bays and quiet areas in rivers. Installation in the channel of the Sacramento River along the west bank would subject them to debris and bedload. Due to the large size of the bedload material and scour potential in the main channel of the Sacramento River during flood flows, these screens are not a suitable option for screening the intake on the west bank.

Answer to Questions Posed by Yantao Cui

Yantao Cui, one of the expert committee members appointed to seek a permanent solution to the M&T intake problem, reviewed the report written by Tetra Tech (October 14, 2013). At the end of his memo containing his comments, he posed 3 sets of questions of an engineering nature that go to the feasibility of west bank screens. Yantao's questions and our answers to them are provided below.

Question Set 1

> *What is the cost if the intake is to be relocated to somewhere near XS-4 in near the west bank and how does that compare with the other alternatives under consideration (i.e., Spur dikes and relocation downstream)?*

To answer this question, the cost estimate for the 2,000-foot-downstream intake alternative was used as a basis, since many of the components of this alternative are the same as those for the west bank intake alternative. The main differences are higher costs for the project access and a micro-tunnel under the Sacramento River to carry the 72-inch pump discharge pipe. The cost of the micro-tunnel was obtained using ratios applied to the costs of the North Interceptor Project built in 2006. The micro-tunnel there was for 66-inch pipes under smaller creeks.

The pumping head and pipe length for the west bank alternative lies between these values for the 2,000-foot and 3,500-foot alternatives. The costs for the pipe and for power for the pumps were interpolated between the values for the east bank intake alternatives. The first cost for the alternatives are compared in Table 1 below. These include construction, engineering and permitting in 2008 dollars. No land costs were assumed for the 2000-foot downstream alternative and none were assumed for this west bank alternative.

Table 1 First Cost Comparison of Alternatives

Alternative	First Cost
Rock Groins *	$6,500,000
2000 Feet DS Intake *	$9,500,000
3500 Feet DS Intake *	$13,200,000
West Bank Intake	$21,700,000

Question Set 2

Is there any operation limitation if the intake is relocated to the west bank?

If the intake is relocated to the west bank, the operational limitations include a more difficult and longer access to the site for operation and maintenance from the M&T headquarters, where the operations personnel are stationed. In addition, access to the pump station and fish screens on the west bank is not possible during high flows when water goes over bank. The fish screens and pump station can be protected from the floods, but it would be very expensive to build a flood proof access. This access would have to be a bridge across the flood plain to maintain the over-bank flood conveyance. It would also not be in keeping with the purpose of the USFWS refuge.

Is there any O&M cost change associated with such a relocation?

Since the intake and pump station on the west bank are the same as those alternatives on the left bank downstream, the only change in O&M costs is the different electrical costs for pumping the water through a different length of pipe. Table 2 below shows the increase in O&M costs over the existing pump station for the different alternatives.

Table 2 Increases in O&M Costs above the Existing Intake System

Alternative	Increased Cost above Existing
Rock Groins *	$100,000
2000 Feet DS Intake *	$50,000
3500 Feet DS Intake *	$34,000
West Bank Intake	$43,000

The main reason for the differences in O&M costs is the assumption of rock repair for the Rock Groins alternative. No rock repair was assumed for the rock revetment in the relocated intake alternatives.

Question Set 3

Are there engineering approaches that may enhance the erosion along the west bank to further reduce the risks associated with the potential sediment deposition?

Installation of the flat plate fish screen structure on the west bank creates a hard point on the bank. The face of the structure would be at the toe of the river bank. This would tend to increase scour potential at the toe of the structure and upstream and downstream of it. This might not keep the screen face from being partially blocked with sand or gravel. A series of high velocity water jets would be installed to discharge out from the bottom of the screens. This would help prevent local accumulation of bedload material from settling in front of the screens. In addition, Iowa vanes could be installed near the screen structure to further help pass bed load downstream in front of the screens.

In particular, can the interim toe be enhanced to reach the top of the bank, which will enhance the erosion along the west bank?

In addition to the screen structure itself, the existing toe rock would be supplemented adding rock up the bank to protect it from erosion upstream and downstream of the screen structure. This revetment would be extended downstream to protect the pipe running parallel to the river.

Are there any drawbacks with such an enhancement?

The possible drawback is placing rock and a structure on the river bank in refuge land owned by the USFWS.

What is the cost associated with such an enhancement if determined to be feasible?

The cost of Iowa vanes depend on the extent and size of the installation, probably from $10,000 to $100,000, assuming that they can be installed in the dry behind the cofferdam used to construct the screens. The additional rock revetment is an integral part of the fish screen structure installation.

References

MWH, *Draft Engineering Analysis Technical Memorandum*, September 2008

Tetra Tech, Memorandum to Jim Well, Ducks Unlimited, *Draft Evaluation of the Proposed M&T Intake on thje West Bank of the Sacramento River*, October 14, 2003

Cui, Yantao, Memo to Jim Well, Ducks Unlimited, *Comments on tetra Tech Draft Evaluation of the Proposed M&T Intake on thje West Bank of the Sacramento River dated 14 October, 2013, 23 October 2013.*