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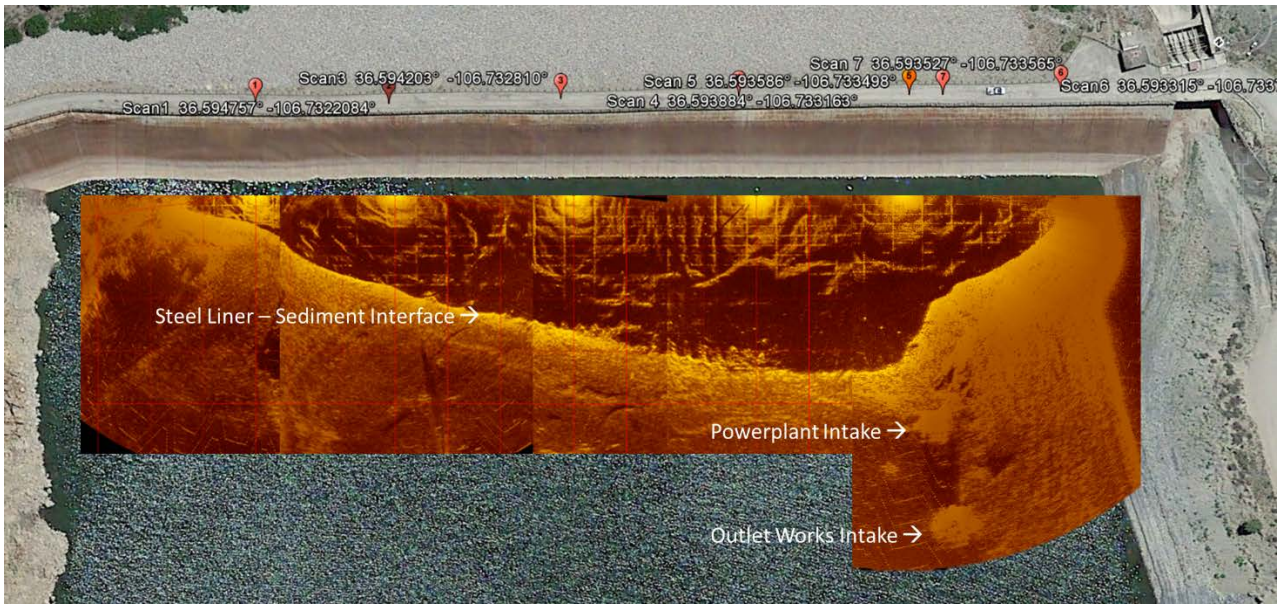
Hydraulic Laboratory Technical Memorandum PAP-1169

Scanning Sonar Survey Report for El Vado Dam

Middle Rio Grande Project – New Mexico



U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Hydraulics Investigations and Laboratory Services Group
Denver, Colorado

May 2018

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Purpose

The purpose of this sonar imaging project was to map the sediment/steel liner interface along the upstream face of El Vado Dam near Chama, New Mexico.

Introduction

El Vado Dam is located on Rio Chama about 80 miles northwest from Santa Fe, New Mexico. The dam was built by the Middle Rio Grande Conservancy District from 1933-1935 and was rehabilitated by Reclamation between 1954-1955. An enlarged outlet works was added by Reclamation from 1965-1966 to accommodate the increased water releases associated with Heron Dam which is a feature of the San Juan-Chama Project. The dam embankment is constructed from rolled gravel fill with a steel liner (membrane) covering the upstream face, see figure 1. The dam is 230 feet high and has a crest length of 1,326 feet. The reservoir has a total storage capacity of 196,500 acre-feet.

Figure 1. Photograph El Vado Dam's upstream face while the reservoir is drawn down for repairs to the steel liner.

There are two intake structures located near the right abutment and the local bathymetry along the steel liner and the intakes were the primary interest for this sonar imaging project.

Methods and Instrumentation

On April 25, 2018, staff from the TSC's Hydraulic Investigations & Laboratory Services Group (86-68560) collected sonar images along the upstream face of El Vado Dam.

Scanning Sonar

A Kongsberg Mesotech Ltd (KML) a Kongsberg-Mesotech 1171 scanning sonar (see appendix 1) and the MS1000 software package was used for this investigation. The MS1000 system, with a high-resolution geared fan/cone sonar head, was used to collect two-dimensional images of underwater structural features. This sonar has a range of 1.5 to 450 ft with a resolution of about 0.06 ft. A detailed specification sheet for the sonar system is included as appendix 1.

Trimble Pathfinder ProXT GPS

Prior to the bathymetric survey, a Trimble Pathfinder ProXT GPS was set up at the sonar imaging location to provide real-time differentially corrected GPS position data to the sonar imaging software package (MS1000 by Kongsberg-Mesotech). The uncertainty of dGPS horizontal positions for this application are less than ± 1 meter. All GPS coordinates are referenced to the WGS-84 datum. All elevations referenced in this report and figures are in Reclamation's project vertical datum. No attempt was made to convert GPS-measured coordinates to Reclamation's project datum.

Motion Reference Unit

A Think Sensor Research motion reference unit (TSR-100 MRU) was integrated into the data acquisition system to allow correction of sensor motion (pitch and roll). The MRU also has a digital compass, pressure and water temperature sensors. The MRU was used for the sonar imaging of the dam face and intakes to provide temperature, heading and pitch and roll of the sonar transducer. Heading, pitch and roll data can be useful when creating mosaics of adjacent sonar images.

Dam Face and Intake Structure Imaging

El Vado dam face and intake structures were imaged on April 25, 2018 from 9:00 a.m. to 1:00 p.m. The scanning sonar was positioned in an orientation perpendicular to the steel liner. Detailed notes were taken regarding sonar location and orientation to assist with image interpretation. Several 180° sonar image scans were recorded for

sonar ranges varying from 45 to 450 ft. The reservoir elevation was 6860.53 ft and the river outlet works was releasing 621 CFS during the sonar imaging. The reservoir surface water temperature was 61.0 °F at the time of the imaging. For sonar images collected at scan locations 1-6 the sonar was 3 ft below the water surface – at El. 6857.53 ft. The sonar images at location 7 were collected at depths of 30 and 50 ft in an effort to capture more detail on the intake structures. Image locations 1-5 were sufficient to provide full coverage of the dam face and abutments. Figure 1 shows the scan locations and corresponding GPS coordinates on an aerial image of El Vado Dam. The sonar imaging locations were spaced approximately 150 ft apart. Stationing along the dam crest (in feet, starting at the left abutment) for scans 1 through 7 are as follows: Scan 1 @ Sta 4+02, Scan 2 @ Sta 5+20, Scan 3 @ Sta 6+71, Scan 4 @ Sta 8+26, Scan 5 @ Sta 9+65, Scan 6 @ Sta 10+94, and @ Scan 7 Sta 9+94. Note: Dam crest stationing was based on a station value marked on a concrete post at the Scan 1 location. The origin (0+00) of the stationing was not determined. Sonar scans were started near the left abutment and proceeded toward the right abutment. Future sonar scans should be collected at the same locations and elevation to obtain images that will directly compare to the April 25, 2018 images.

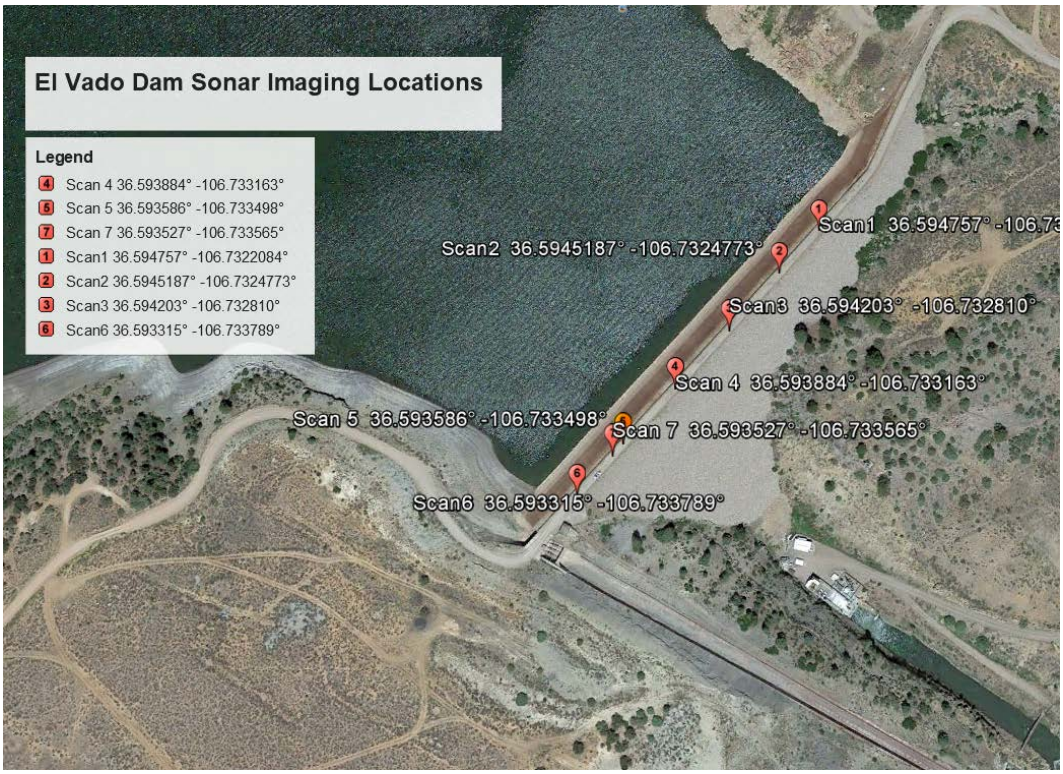


Figure 2. Aerial view of El Vado Dam and sonar scan locations and their GPS coordinates.

Results

Scanning Sonar Imaging

For this imaging project, the scanning sonar was deployed from a wheeled cart so that the sonar was oriented perpendicular to the upstream dam face slope. The scanning sonar produced 2-D images in the same plane as the dam face. Sonar images are useful for defining the sediment profile along the base of the dam face and detecting major defects on steel liner. It is important to note that sonar images are oriented parallel to the 1.5H:1V slope of the dam face slope. As a result, sonar ranges are slope distances and had to be corrected for slope to compute elevations of the steel liner-sediment interface.

El Vado Dam Face Images

A series of acoustic images were captured at 7 adjacent locations along the dam crest road. Figure 3 is a composite image of 5 sonar images of the El Vado Dam face. This image was created using five adjacent sonar images collected with a 225 ft acoustic range. The composite sonar image was overlaid on an aerial image of El Vado Dam to provide spatial perspective. The composite image is a front view from an upstream position (looking downstream). The image clearly shows the powerplant intake trashrack structure located near the right abutment. The image also shows the joints and seams of the steel panels. There appears to be debris accumulation on the steel liner which created acoustic shadows that prevented imaging of panels on the lower portion of the dam face.

Figure 4 contains images from locations 5 and 7 that were collected with a 300 ft acoustic range. The sonar images were collected at different elevations to produce different “views” of the two intake structures and what appears to be a small slide or slip of the right abutment slope. These images provide two different perspectives of the area, but the presence of a slide should be confirmed with bathymetric data that were collected in April 2018 by the TSC’s River Hydraulics and Sedimentation Group.

Figure 5 contains a sonar image from location 4 that was collected with a 30 ft acoustic range. This image shows the high resolution that can be obtained with a short acoustic range. Figure 5 includes a photograph of a section of the steel liner’s expansion joint. Both images show features such as the expansion joint, horizontal seam with bolts (or rivets). The steel liner is made up of 8.33 ft high by 24.41 ft long plates, which agrees closely with the dimensions measured using the MS1000 tape measure utility.

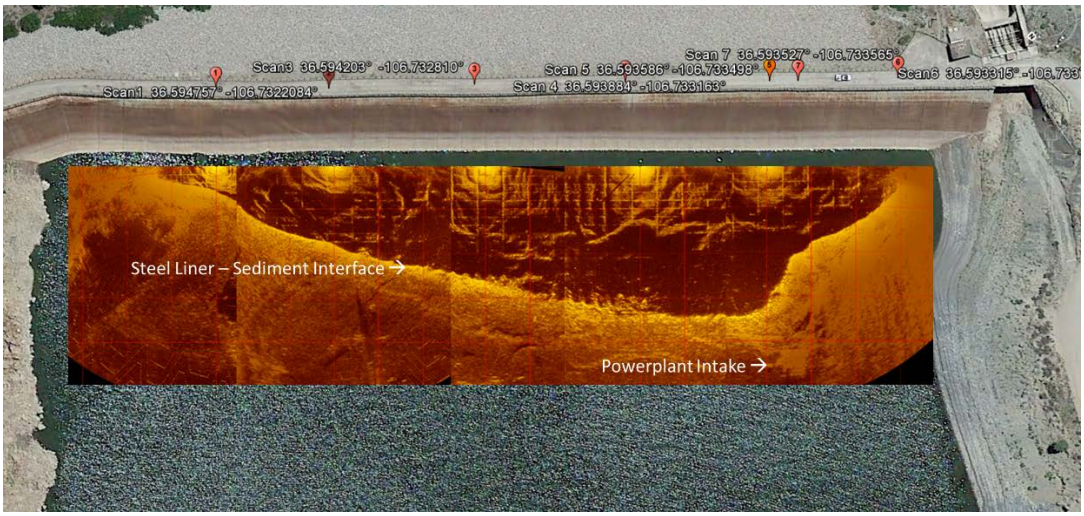


Figure 3. Composite sonar image of the El Vado dam face using 5 images collected with a 225 ft acoustic range. Note: the dam face image is a front view of the steel liner looking downstream. The reservoir bottom and powerplant intake appear in the image, but they are a skewed plan view.

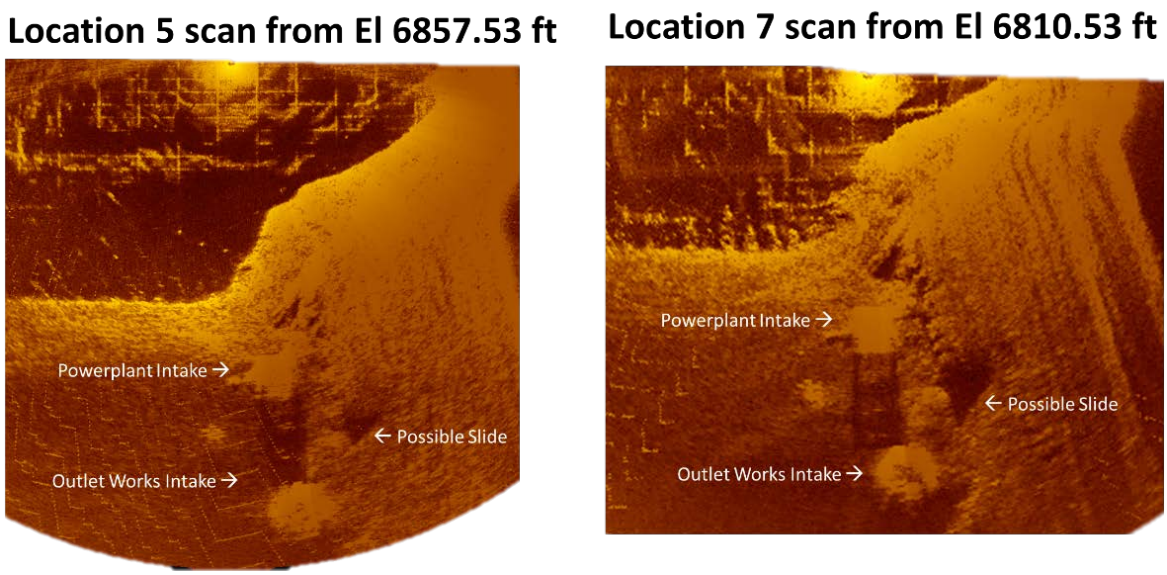
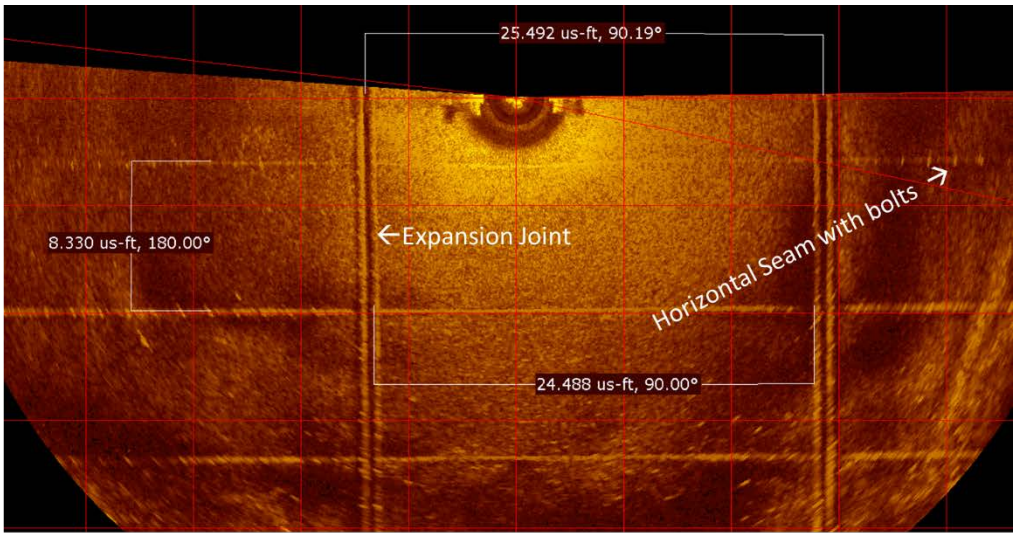


Figure 4. Sonar images collected at scan locations 5 and 7 at different elevations which produced different views of the two intake structures and a possible slide on the right abutment slope between the intakes. Both images were collected using a 300 ft acoustic range.



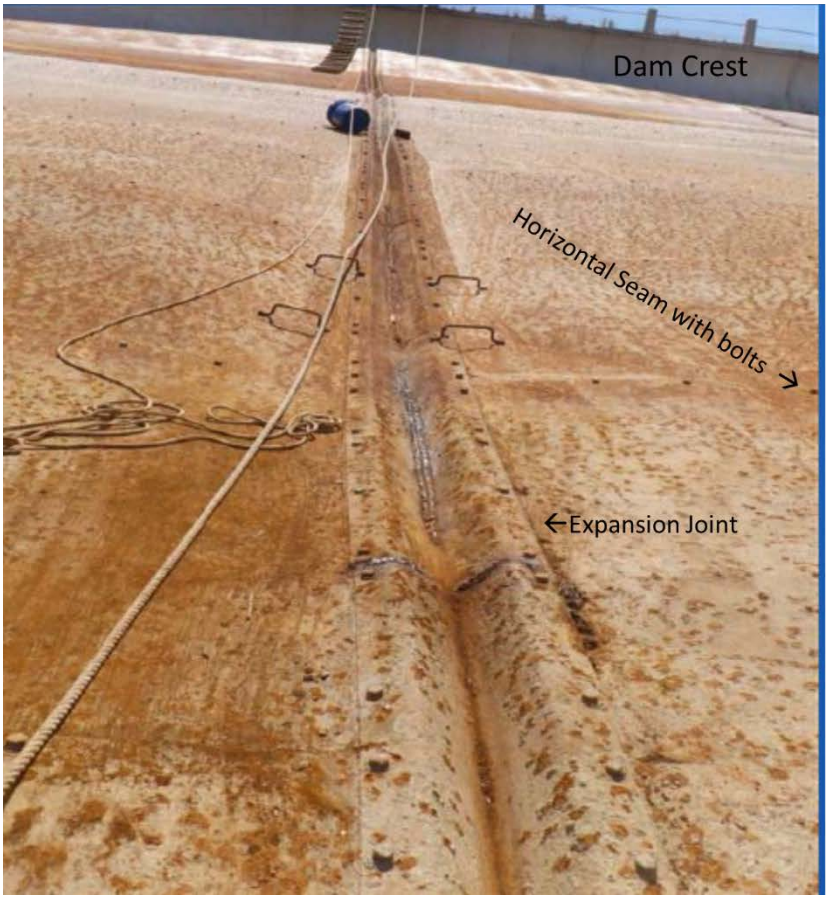


Figure 5. Sonar Image and photograph of steel liner expansion joints and horizontal seams. The high-resolution sonar image was obtained using a 30-ft acoustic range. The photograph was taken during welding repairs to the steel liner (Source: Art Valverde 2013).

Steel Liner - Bottom Sediment Interface Profile

MS 1000 sonar image analysis tools were used to measure the slope distance to the steel liner - bottom sediment interface. The distances along the 1.5H:1V slope were corrected to vertical distances so that the interface elevations could be computed. The elevations were computed by subtracting the vertical distance from the sonar elevation, El 6857.53 ft (3 ft below the reservoir water surface elevation at the time of the imaging). The vertical datum is in survey feet and is tied to Reclamation's project datum which is used to report the reservoir water surface elevation. Figure 6 is a plot of the bottom sediment interface on the steel liner from station 3+42 to 11+00 as of April 25, 2018. The bottom sediment elevations near the right abutment were computed to be 1 to 2 feet lower than the river outlet works intake crest (El. 6775 ft). This elevation is 8 to 9 feet higher than intake foundation's backfill elevation of 6765.0 ft (from drawing 465-D-164, section A-A).

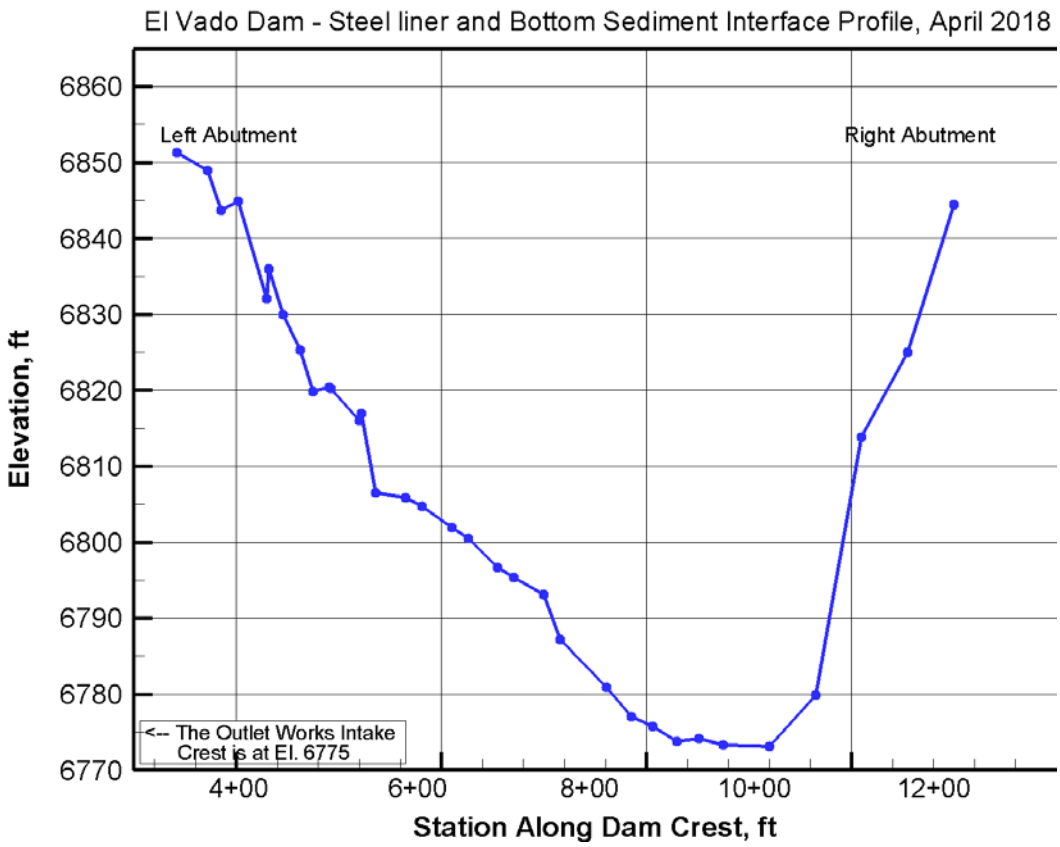


Figure 6. Profile plot of sediment interface elevation at with the dam face steel liner at El Vado Dam on April 25, 2018. The vertical datum for the elevation is the Reclamation project datum.

Conclusions

Sonar imaging of the upstream face of El Vado Dam was used to map the interface between the steel liner and the bottom sediments. The bottom sediment elevations near the right abutment were computed to be 1 to 2 feet lower than the river outlet works intake crest (El. 6775 ft).

Sonar images collected near the right abutment detected both intake structures and what appears to be a small slide on the right abutment between the two intakes. It is clear from the sonar images that this potential slide is closer to the outlet works intake structure. It is not clear from the sonar images if the slide reached the outlet works intake structure.

Apparent debris accumulation on the steel liner prevented the entire submerged dam face from being completed imaged from just below the water surface. If sonar images of the lower portion of the steel panels are desired, the sonar would have to be lowered below the debris piles to ensonify the lower panels.

Reference Drawings

Bureau of Reclamation, El Vado Dam, Outlet Works Intake Structure Plan and Profile drawing, 465-D-163.

Bureau of Reclamation, El Vado Dam, Outlet Works Intake Structure drawing, 465-D-164.

Appendix 1

Specification Sheet

1071-Series Sonar – Geared Fan/Cone Sonar Head

3000 m "High Resolution" Geared Fan/Cone Sonar Head Digital Telemetry

P/N 974-23050000

KONGSBERG

This version of the 1071-Series Sonar has been specifically designed to produce the highest resolution scanning sonar images possible with 675 kHz. Its design is targeted at bottom clearance, body recovery, underwater construction, pipeline inspection, cable route survey, bridge/pier inspection and applications where data clarity supercedes any other requirement.

This sonar head should also be considered in conditions where the in-water temperatures are lower than 4° C, or higher than 20° C. Domed, oil-filled heads may acoustically defocus beyond these temperature ranges. This sonar head incorporates the electronic advantages of increased sampling rates, wider receiver bandwidth, increased power output, and a very narrow horizontal beam pattern with the fan transducer. The telemetry is RS 485 and RS 232 compatible, and is automatically sensed and configured. The transducer is of a bare-shaft design, but the motor-end is oil compensated to prevent water ingress into the main electronic stack via the transducer shaft.

The sonar head is compatible with the MS1000 and MS900D Surface Processors. To take full advantage of the advanced features and high resolution this head has to be operated with the MS1000 processor.

Operating Frequency	675 kHz
Beam Width	0.9° X 30° Fan/1.7 X 1.7° Cone (nominal)
Range	0.5 - 100 Metres typical; 150 Metres obtainable
Range Resolution	≥ 19 mm (@ 1500m/sec speed of sound, 25 μs transmit pulse)
Sampling Resolution	≥ 2.5 mm
Scan Angle	360° continuous
Mechanical Step Size	≥ 0.225°
Scan Speed	nom 11 sec/360° @ 10 m and 1.8° step size (@ 230 kbits/sec.) nom 36 sec/360° @ 100m and 1.8° step size (@ 230 kbits/sec.)
Transmit Pulse Lengths	25 - 2500 μs
Transmit Power	OFF, 50 W nom, 500 W nom
Receiver Bandwidth	12/100 kHz
TVG Control	-20 to +100 dB
Telemetry	RS 485/RS 232 auto switching asynchronous serial data
Telemetry Rates	Downlink: 9600 Baud Uplink selectable: 230K, 115K, 57K, 38K, 19K, 9600 bits/sec automatic (to suit cable telemetry)
Power Requirements	33W, 22 - 60VDC
Temperature Ranges	-10 to +40° C operating -30 to +40° storage
Operating Depth	3000 meters
Connector	Seacon RMG-4-BCL (optional connectors; inquire to factory)
Materials	Aluminum 6061-T6, 300-Series SS
Dimensions	Diameter 3.5"/89 mm Length 22.4"/569 mm Transducer width 5.5"/140 mm
Weight	In air 13.5 lbs/6.1 kg, In water 6.5 lbs/2.9 kg
Options:	-7801 Built-in Security Key