El Vado Dam Rehabilitation Case Study: Coatings & Cathodic Protection

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- El Vado Dam is located on the Chama River in north central New Mexico
- Construction completed in 1935 by Middle Rio Grande Conservancy District
- Transferred to BOR in the 1950s
- Cathodic Protection added in the 1980's.
- Faceplate is steel lined and needs new Cathodic Protection system.
- Radial Gate will be newly installed and needs Cathodic Protection.

Recap

Not the best location for a dam. Geological instability with seepage and erosion issues.

The location is right in the middle of a landslide zone.

A major contributing factor for the rehabilitation work

Recap

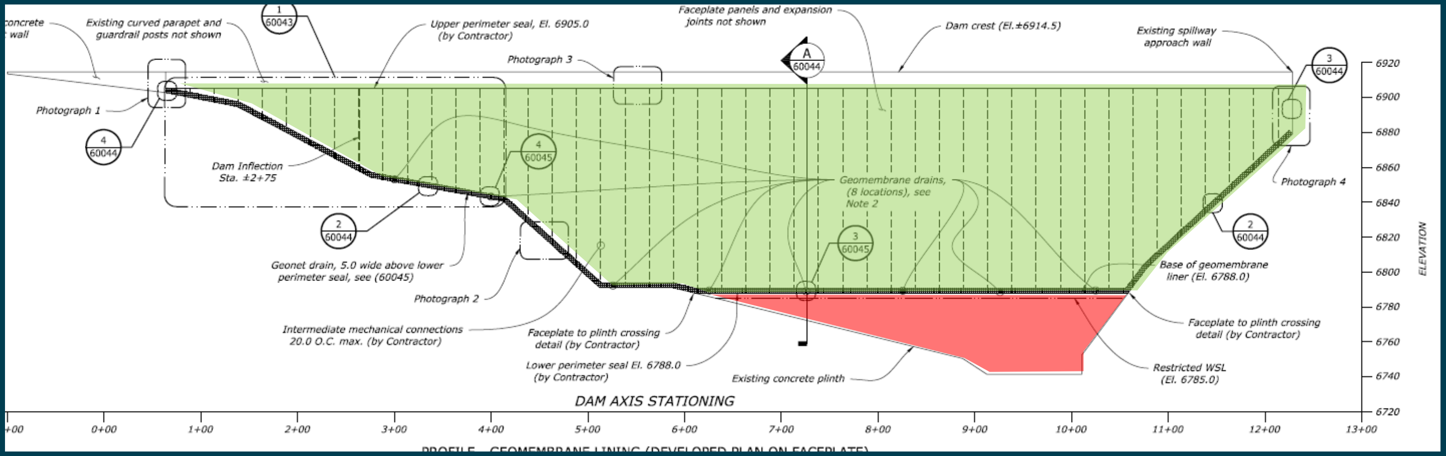
One of the few steel faced rockfill dams in the country.

- Substantial settlement along the dam.
- Expansion joints of faceplate are cracked and allow water to seep through.
- Voids underneath the faceplate.
- Deformations and distress are occurring on the faceplate.

Recap

- The steel plating hasn't lost much thickness, via ultrasonic testing.

- To reduce the seepage issues a <u>PVC geomembrane </u>was selected. The top 88% of the Dam will be lined.



- The geomembrane will tie into the Cathodic Protection work that will be shared with you in this webinar. CP will be protecting the area that is not lined with the geomembrane.

Coatings Replacement (~1950s)

Not re-coating the faceplate.
For Cathodic Protection design we will treat the faceplate as bare!

Cathodic Protection

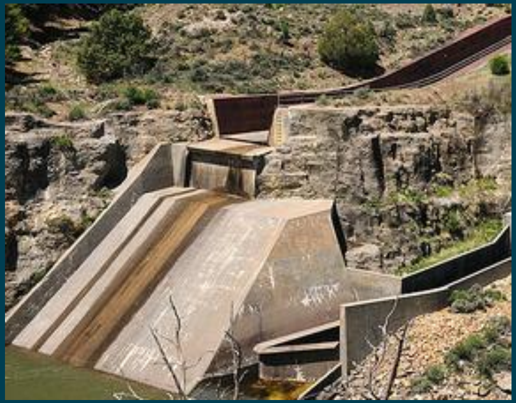
CP system was not installed until the 80’s
El Vado went about 50 yrs without CP.

Being replaced.

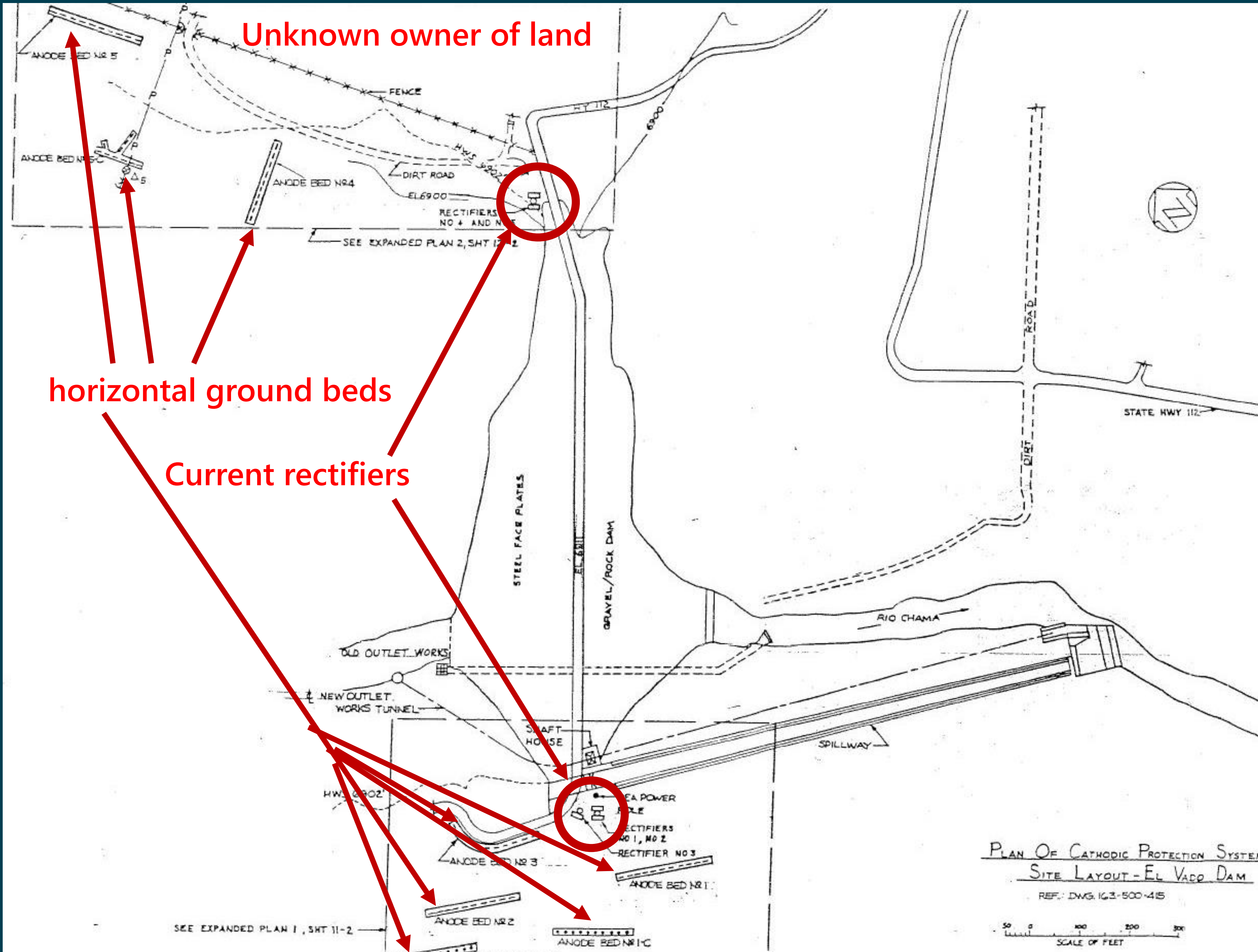
El Vado Dam
Cathodic Protection

Current Cathodic Protection System:

Faceplate, Steel Spillway, Spillway Radial Gate

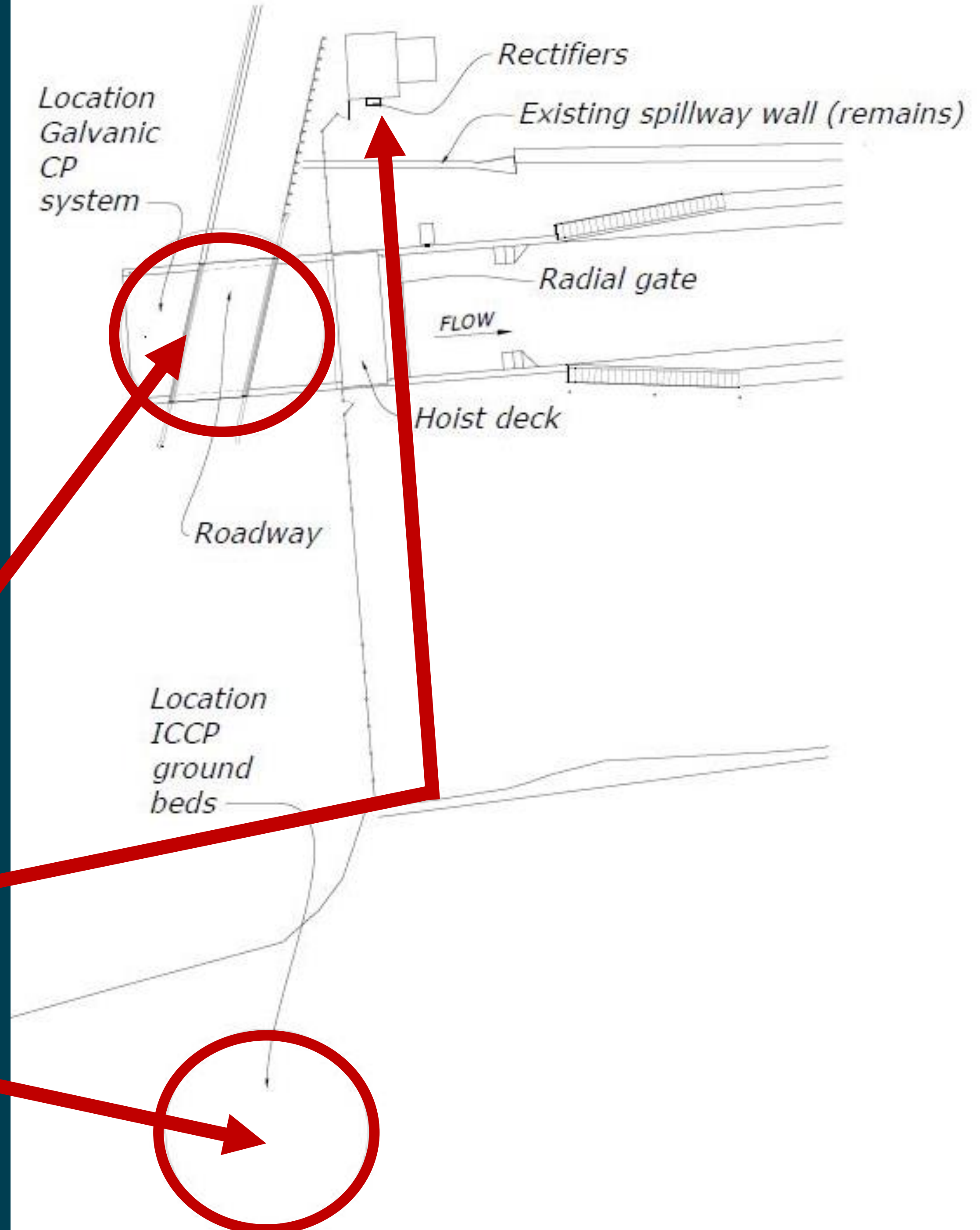


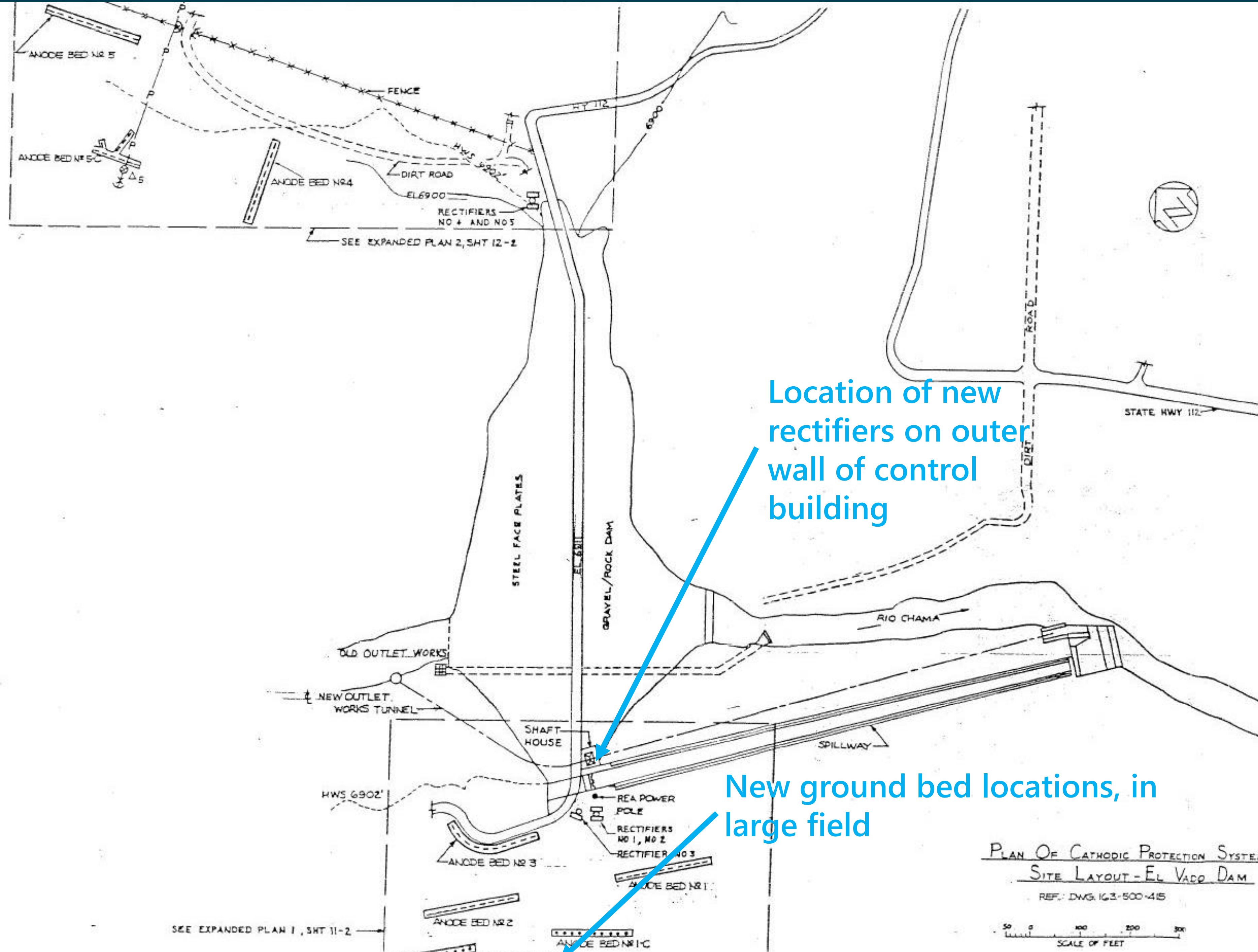
- Impressed current cathodic protection (rectifier).
- 2 rectifiers with multiple horizontal anode beds per rectifier on left abutment.
- 3 rectifiers with multiple horizontal anode beds per rectifier on right abutment.
- 8 total horizontal groundbeds


Unknown owner of land
horizontal ground beds
Current rectifiers
ANODE BED NO 5
FENCE
HY 112
6900
ANODE BED NO 5-C
ANODE BED NO 4
DIRT ROAD
EL 6900
RECTIFIERS NO 4 AND NO 5
SEE EXPANDED PLAN 2, SHT 11-2
ROAD
STATE HWY 112
DIRT
STEEL FACE PLATES
EL 6911
GRAVEL/ROCK DAM
RIO CHAMA
OLD OUTLET WORKS
NEW OUTLET WORKS TUNNEL
SHAFT HOUSE
SPILLWAY
HWS 6902'
POWER POLE
RECTIFIERS NO 1, NO 2
RECTIFIER NO 3
ANODE BED NO 3
ANODE BED NO 1
ANODE BED NO 2
ANODE BED NO 1-C
SEE EXPANDED PLAN 1, SHT 11-2
PLAN OF CATHODIC PROTECTION SYSTEM
SITE LAYOUT - EL VADO DAM
REF.: DWG. 163-500-415
SCALE OF FEET

New System

- Two separate systems instead of one.
  - Galvanic for gate
  - ICCP for faceplate
- Galvanic system for the radial gate along spillway wall.
- Rectifiers for ICCP in one location.
- Groundbeds for ICCP on hillside.




Location of new rectifiers on outer wall of control building
New ground bed locations, in large field
ANODE BED No 5
FENCE
ANODE BED No 5-C
ANODE BED No 4
DIRT ROAD
HWS 6902'
EL 6900
RECTIFIERS NO 4 AND NO 5
SEE EXPANDED PLAN 2, SHT 12-2
HY 112
6900
ROAD
DIRT
STATE HWY 112
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GRAVEL/ROCK DAM
RIO CHAMA
OLD OUTLET WORKS
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HWS 6902'
REA POWER POLE
RECTIFIERS NO 1, NO 2
RECTIFIER NO 3
ANODE BED No 3
ANODE BED No 1
ANODE BED No 2
ANODE BED No 1-C
SEE EXPANDED PLAN 1, SHT 11-2
PLAN OF CATHODIC PROTECTION SYSTEM
SITE LAYOUT - EL VADO DAM
REF.: DWG. 163-500-415
SCALE OF FEET

New Cathodic Protection Systems

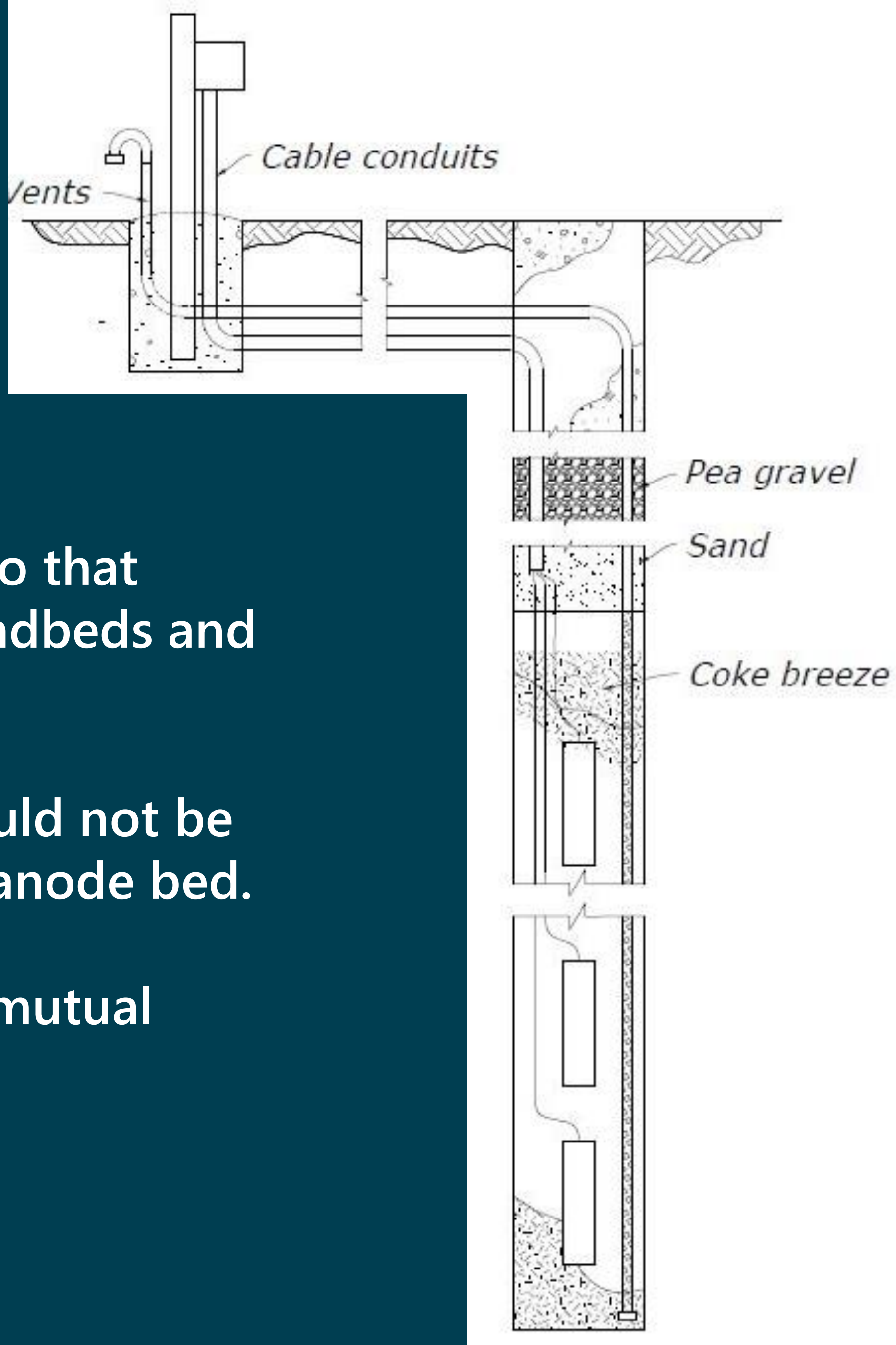
(two separate systems)

1. Faceplate
   - Geomembrane will cover 88% of the faceplate surface.
   - Consider structure bare for the design.
   - Coating will not be replaced.
   - Very large bare area to protect.
   - Impressed current cathodic protection (rectifier).

2. Spillway Gate
   - New spillway is concrete, not steel.
   - Cathodic protection is for the gate ONLY
   - Gate will be coated.
   - Galvanic anode cathodic protection system (sacrificial magnesium anodes)
   - Anodes are located at a distance from the gate rather than via direct mount.

El Vado Dam Faceplate Cathodic Protection

Deep Well Anode Bed



- Vertical rather than horizontal
- Groundbed resistance – designed so that resistance is low. Number of groundbeds and outputs need to be optimized.
- Groundbed discharge capacity should not be exceeded otherwise it will dry out anode bed.
- Spread out deep wells to mitigate mutual interference between them!!!

Deep well vs horizontal groundbed

- Less ground taken up, dig down vs. out.
  - Easier to get anode bed remote from structure.
  - Beneficial for limited ROW situations.

- Deep well can be treated like one very large anode with backfill dimensions.

- Can spread out easier to minimize mutual interference.

ICCP, Vertical groundbed installation

GACP, Mesa Verde National Park, 2013

Impressed Current Anodes

Option 1:

High Silicon Cast Iron
12 total anodes per deep well

Option 2:

Mixed Metal Oxide
12 total anodes per deep well

Farwest Corrosion Control website

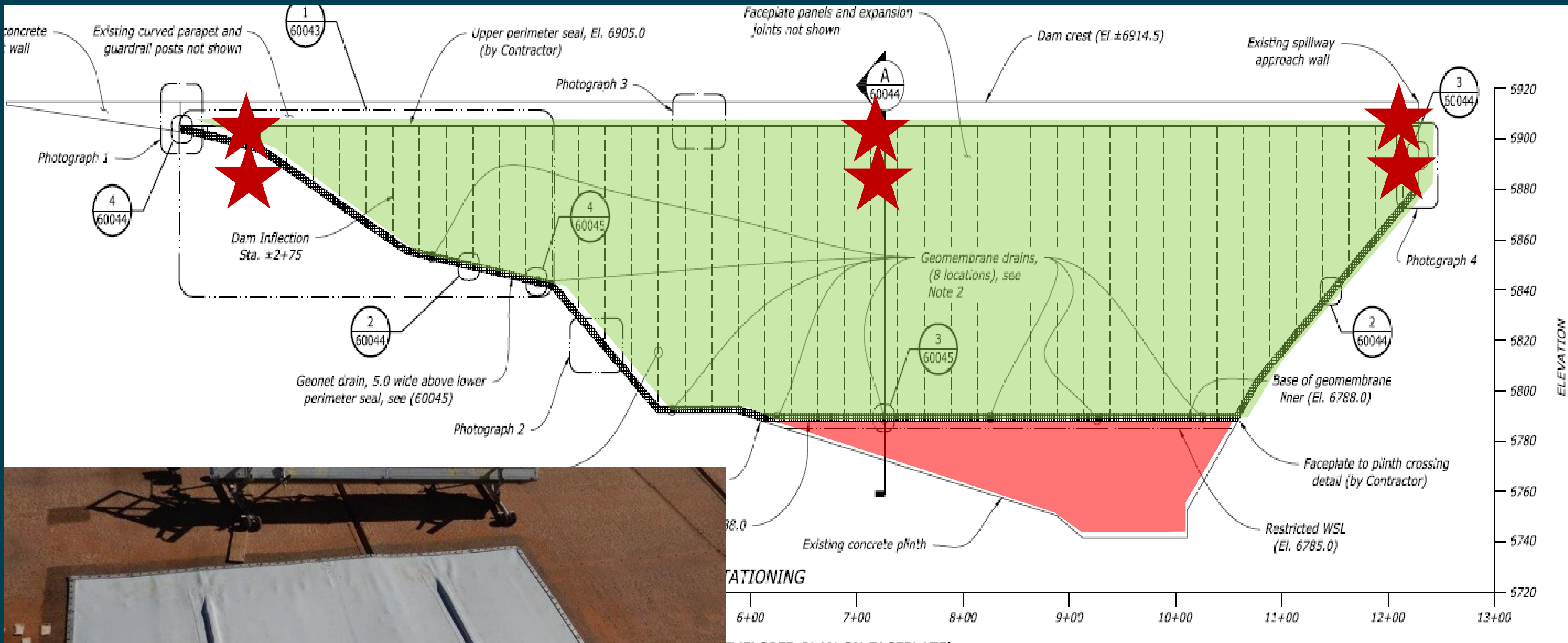
Cable attachments to faceplate

Specific molds-

- Orientation
- Material type for bonding
- Uses powder and lighter for heat source

Bonds CP cable to metallic surface

Cable attachments to faceplate



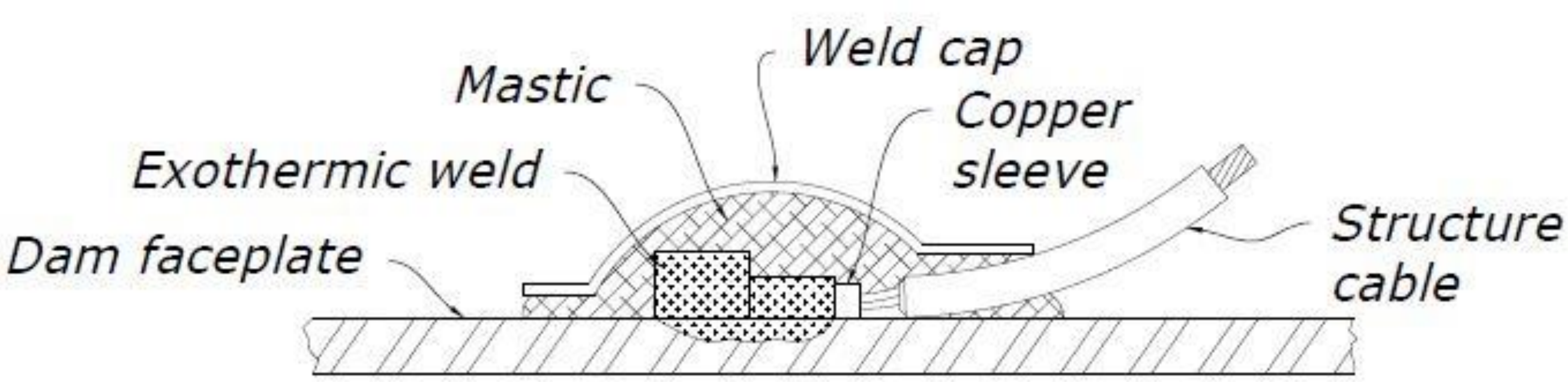
★ Exothermic weld locations
-left, middle, right
-underneath geomembrane

Cable attachments to faceplate

Multiple attachment points per location-

- Redundancy
- Minimizes attenuation of CP current
- Decreases cable resistance in the circuit

Right, Left, and center of dam faceplate at the top near the road will have exothermic welding for the CP system



Cathodic Protection Challenges

Large bare surface area-

- Need a lot of current
- Structure resistance vs. Surface area (takes more to protect less)

$$R = \frac{\rho}{2d}$$

Electrolyte resistivity-

- Voids behind faceplate can skew resistivity of soil
  - Project will involve grouting voids but unsure how effective this may be due to extent on voids and path grout may take after entering the riprap
- Higher resistance electrolyte = harder to push CP current
- Resisitivity of soil behind faceplate changes with elevation due to changes in saturation level of the soil
- Soil resistivity may change with water elevation changes

El Vado Dam Radial Gate Cathodic Protection

New Spillway & new radial gate

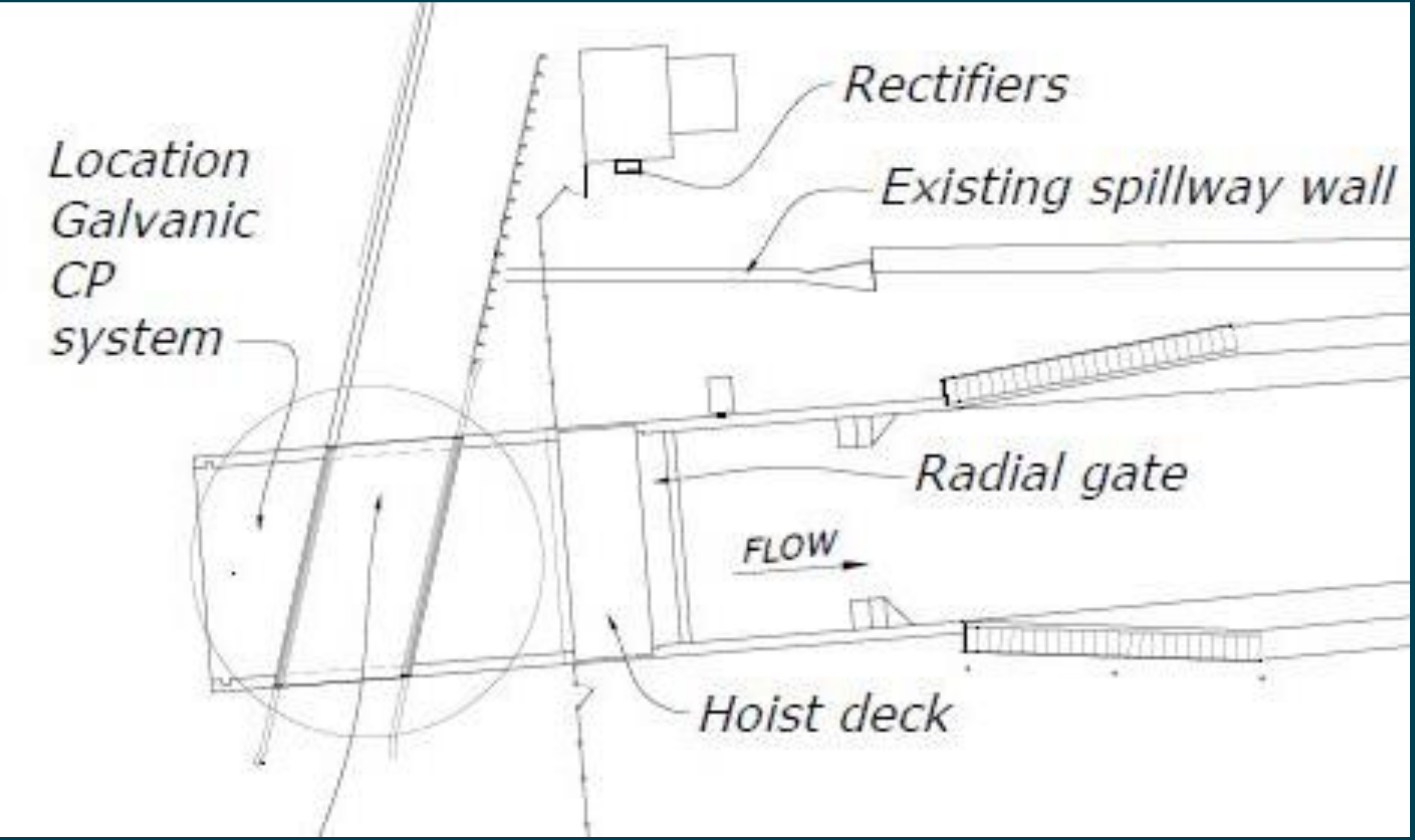
Spillway moving into hillside & widening
Spillway steel plating will be encased in concrete - no need for CP

Radial gate coating options:

- abrasion resistant epoxy, polysiloxane topcoat

Radial Gate CP System

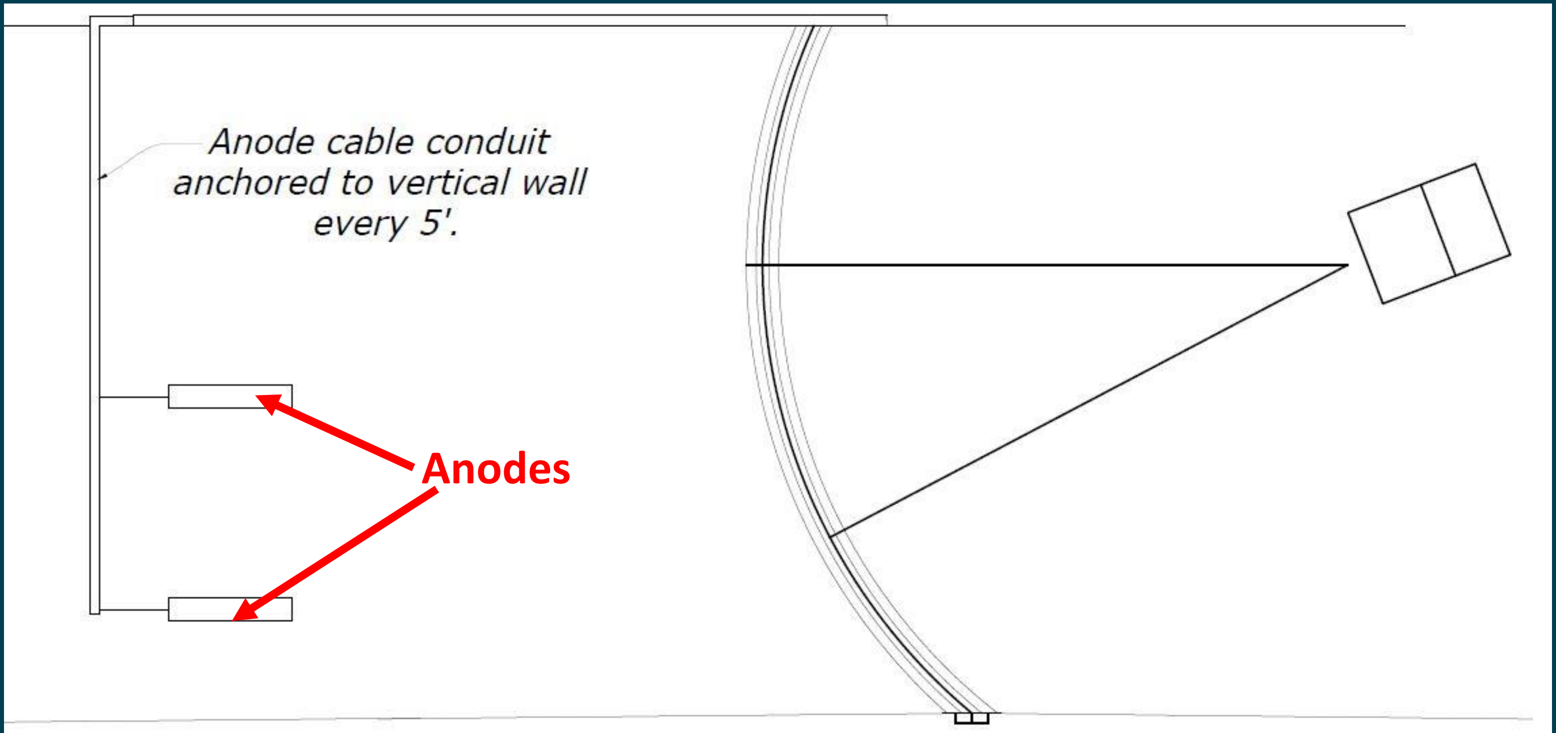
Radial Gate CP System



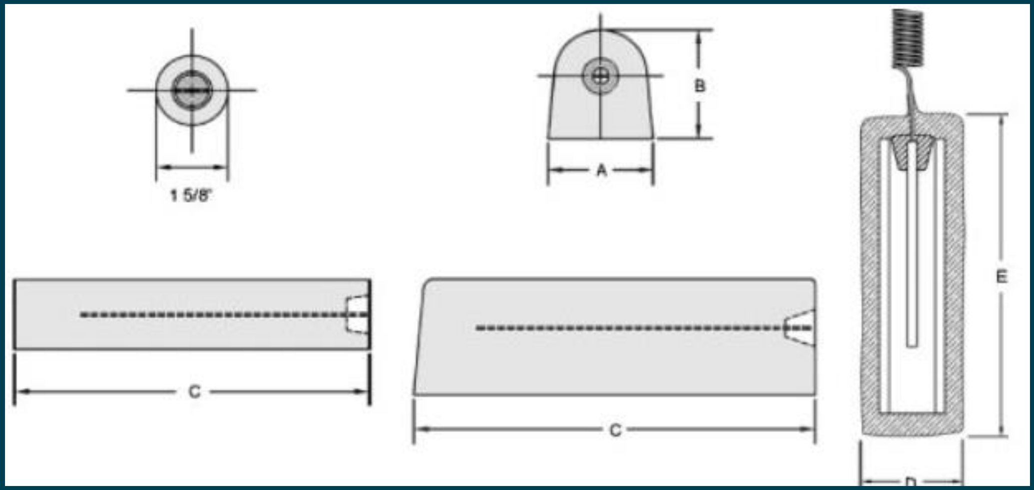
Galvanic Anode System

Galvanic anode system design-

- Anode location is close to <u>remote </u>(far enough for even current distribution)
- Coating between anode and concrete wall to limit current collection on rebar around anode
  (options: high solid epoxy or 100% solid epoxy)



Galvanic Anodes



- High potential magnesium anodes (-1750 mV)
- Size, number, dimensions chosen based on design needs for system

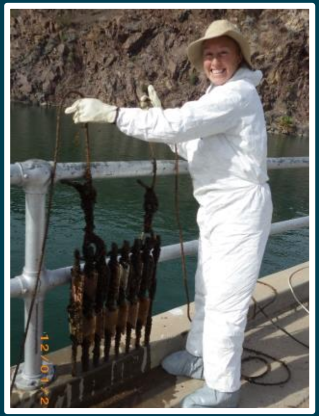
Farwest Corrosion Control website

Current Status and Construction Schedule of El Vado Rehabilitation

- Mobilization ~ March 2022
- Grouting ~ May 2022 – March 2023
- Geomembrane Installation ~ May – Sept 2023
  - Two phase plan
- Demolition intake and crest ~ Oct – Nov 2023
- Demolition spillway chute ~ Oct 2023 – March 2024
- Installation gate CP ~ Jan 2026

Materials & Corrosion Lab Capabilities: CP & Coatings

Lab & Research	Design	Fieldwork
• Standardized and specialized lab testing • Coatings evaluation • Lab-scale coating application • Coatings and CP research	• Basis of Design • Materials Selection • Specifications • Quantities • Drawings • Construction support • AE reviews	• Inspections • Condition assessment • CP system testing • Rectifier inspection • Repair/maintenance • Installation • QA/QC



Questions?