Pershing County Water Conservation District System Master Plan

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Prepared for:

Pershing County Water Conservation District
P.O. Box 218
Lovelock, NV 89419
(775) 273-2293

Prepared by:

Farr West Engineering
1310 Dalwood Court
Reno, Nevada 89521
(775) 851-4788

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Chapter 1
EXECUTIVE SUMMARY

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1.1 INTRODUCTION

Purpose of the Plan

The objective of the Master Plan is to provide a long range strategy to implement necessary improvements. The intent of the improvements is to conserve water, maximize use available water, increase conservation, improve operation and maintenance, and ensure efficient and safe delivery to water users in the Pershing County Water Conservation District (PCWCD). The plan assesses the condition of facilities and makes recommendations for proposed improvements

Chronological History of PCWCD

- First irrigation ditches dug circa 1862
- By about 1892 75% of water rights had been established
- In 1900 14,000 acres were being irrigated, mostly producing alfalfa
- In 1913 the Humboldt-Lovelock Power and Irrigation Company (HLPIC) built the Pitt-Taylor Diversion Dam, Diversion Structure, Diversion Canal and the Upper and Lower Pitt-Taylor Reservoirs. The reservoirs hold 20,000 and 15,000 acre-feet respectively
- In 1915 Pitt Dam was constructed
- In 1923 the Nevada State Engineer ordered a general adjudication of the Humboldt River system designating the Sixth Judicial Court in Winnemucca as the decree court.
- In 1931 Hon. George A. Bartlett issued a decree establishing water rights for the Humboldt Basin
- In 1934 Judge H.W. Edwards issued a decree correcting the errors and omissions in the Bartlett Decree. The Bartlett and Edwards decrees together became known as the Humboldt River Decree
- In 1938 the Nevada Supreme Court finalized and affirmed the Humboldt River Decree, halting all future challenges
- In 1926 the Lovelock Irrigation District was formed
- By 1930 the Lovelock Irrigation District was reorganized under the Nevada Irrigation District Act and became the Pershing County Water Conservation District (PCWCD)
- The Bureau of Reclamation begins construction of Rye Patch reservoir in January 1935 and completes construction in January 1936
- In the early 1940's the PCWCD assumed the operation and maintenance of the Humboldt Project, which includes Rye Patch Dam, Reservoir, and lands purchased in Lander County
- In 1996 modifications to Rye Patch Reservoir were completed, increasing the capacity to 213,000 acre-feet

PCWCD Operation and Maintenance Concerns

Most of the diversion structures in the PCWCD system were built before 1935 and many of these structures have exceeded their useful life. The Pitt-Taylor Diversion Dam, Diversion Structure and Canal were constructed in 1913 and need to be replaced. Replacement of these structures would allow for improved conservation and greater delivery efficiency.

The control structures on both the Upper and Lower Pitt-Taylor Dams need to be replaced. These structures were also built in 1913 and are in an advanced state of deterioration. Two of the three outlet gates on the Upper Pitt-Taylor structure are non-operational and beyond repair. The concrete on both the Upper and Lower structures is in poor condition and the structures leak. Additionally, seepage has been detected in both dams.

The Humboldt Plug at the end of the system functions inadequately as a back up structure and needs to be replaced with an engineered structure. The Plug has failed three times in the last 19 years.

The Pitt Dam is the main control structure in the Upper Valley and the Rodgers Dam is its Lower Valley counterpart. These dams are old but could be improved with the addition of slide gates. The existing stop logs leak and are difficult to remove and replace.

The diversion structure at the junction of the Old Channel and Union Canals is old and deteriorating. Much of the water used in the Upper and Lower Valleys is delivered directly or indirectly by these canals. Accurate measurement and control at this point in the system would contribute to improved water management.

Most of the canals in the system are in need of improvement. The last system wide flow studies were performed in 1969 (Upper Valley) and 1970 (Lower Valley) and those studies revealed losses due to seepage and management. Since that time there have been physical and managerial changes in the system as well as improvements in flow measurement techniques that would justify a new survey of system losses.

Anker Pond is also a control junction that is in need of improvement. It is a simple structure with an average flow rate of 90 cfs passing through it during the irrigation season. The pond leaks and could fail. Automated monitoring and flow control would also be useful at this location.

Scope of the Plan

The plan includes the following elements:

1. A description of the PCWCD including personnel, equipment and facilities;
2. A description of water rights, storage facility capacities and system demands;
3. An assessment of possible conservation measures that could be implemented within the District;
4. An assessment of the condition of each facility;
5. Proposed improvements based on the condition assessments;
6. Estimates for 8 of the 28 proposed projects;
7. A prioritization of projects based on their condition and role in PCWCD system;
8. An analysis of funding alternatives;
9. An implementation plan for the first projects and instructions on when to schedule subsequent projects.

1.2 DESCRIPTION OF THE PERSHING COUNTY WATER CONSERVATION DISTRICT

Description of the PCWCD Management Structure and Staff

The PCWCD is governed by a seven member Board of Directors representing the District constituency. Elections are held every 4 years to elect board members and any constituent of the PCWCD is eligible to run for a Board position. The PCWCD General Manager serves as Secretary to the Board and the District Secretary serves as Treasurer. The General Manager oversees a seven member staff.

Description of the PCWCD Buildings and Equipment

The PCWCD shop and administrative office are housed in a 4000 sq. foot building situated on a three acre parcel. The administrative portion of the facility includes an office for the District General Manager, a reception area and a conference room. The remainder of the building is used as a fabrication and

maintenance equipment shop. The property is fenced and has space for storing the Districts heavy equipment and construction materials.

The following equipment is owned and operated by the PCWCD for the purpose of maintaining canals and structures within the District.

1. 3, International 10 wheel dump trucks.
2. 1, 1982 Peterbilt Tractor with low-boy trailer.
3. 1, 1992 Peterbilt Tractor with belly dump trailer.
4. 1, John Deere 690 Excavator with standard reach boom (also has a 50' auxiliary boom).
5. 1, John Deere 790 Excavator with 60' boom.
6. 1, John Deere 710 Backhoe.
7. 1, Caterpiller 950 Wheel Loader
8. Motor Grader

In addition to the above equipment the PCWCD rents a dozer.

Description of PCWCD Water System Facilities

The facilities owned, operated, and maintained by PCWCD are:

- Pitt-Taylor Diversion Dam
- Upper Pitt-Taylor Reservoir/Dam
- Lower Pitt-Taylor Reservoir/Dam
- Young Dam
- Pitt Dam
- Irish-American Dam
- Rodgers Dam
- Sommers Dam
- Big Five Dam
- Humboldt River Plug
- Pitt-Taylor Canal
- Young Canal
- Old Channel Canal (including 12 laterals)
- Union Canal (supplies the Big Meadow, Irish-American, and Arobio Ditches)
- Rodgers Canal
- Union-Rodgers Canal (supplies the Rodgers, Seven, Tule, Lakeshore and Reed laterals).
- Union Lateral (supplies the Upper Lakeshore, West, East, and Reed laterals)
- Anker Pond (supplies the West Lakeshore, East Lakeshore, and Anker laterals)

Per State Dam inspection reports there are two different drainage areas in the PCWCD system. The Upper and Lower Pitt Taylor Dams share one watershed and the Young, Pitt, Irish-American, Rodgers, Sommers and Big Five Dams share the other. The following descriptions of these watersheds are taken from inspection reports prepared for the State of Nevada by GA Engineering and Planning:

Pitt-Taylor Reservoirs
"The drainage area for the Humboldt River at Imlay, Nevada is 15,500 square miles (per the USGS). The average annual precipitation in the vicinity of the reservoir ranges from 4 inches on the valley floor to 20 inches on the adjoining mountain tops. The average annual runoff is less then one inch and annual evaporation is 51 inches. The soil in and around the reservoir consists of unconsolidated alluvial silt and sand. Vegetation in the vicinity of the reservoir includes sagebrush and saltcedar (a member of the Tamarisk family)."

Young, Pitt, Irish-American, Rodgers, Sommers, and Big Five Dams
"The drainage area for the Young, Pitt, Irish-American, Rodgers, Sommers and Big Five Dams and Humboldt River is north of Lovelock and includes approximately 16,300 square miles. The Young, Rodgers, Pitt, Irish-American, Sommers, and Big Fives Dam are downstream of the Rye Patch Reservoir and the Humboldt River flows into the Dams are regulated by Rye Patch Reservoir."

Pitt-Taylor Diversion Dam and Diversion Structure

The Pitt-Taylor Diversion Structure is located on the Humboldt River and can be found on the Mill City, Nevada 7.5 minute map.

A preliminary engineering report summarizing the condition and replacement options for the Pitt-Taylor diversion structure prepared by Dyer Engineering Consultants Inc. is included in Appendix A of this plan.

Upper Pitt-Taylor Dam

The Upper Pitt-Taylor Dam is located approximately 115 miles northeast of Reno, Nevada, and about 40 miles north of Lovelock, Nevada. The reservoir is on the east shore of the Ryepatch Reservoir and the Humboldt River. The dam and the reservoir can be found on the Rye Patch Reservoir North, Nevada Pershing County 7.5 minute topographic map. The following description comes from the Dam Safety Inspection Report prepared by GA Engineering and Planning for the State of Nevada;

"Upper Pitt Taylor Dam is an earthen dike, approximately 6,500 feet in length. The dam's height (measured from the toe to the crest on the downstream side of the dam at the outlet structure) is 16 feet. The dam runs generally southeast to northwest for 4,000 feet then turns to the west for 2,500 feet. Top width of the dam is 22 feet. The dam's crest is used as a road. The downstream side slope of the dam is 2 feet horizontal to 1.5 feet vertical on the upper 8 feet and 8 feet horizontal to 1 foot vertical for the lower 8 feet."

Construction on the Upper Pitt-Taylor Reservoir began in 1909 and water was turned into the reservoir for the first time in November of 1912. In 1915 the dam and the levees were raised to 19 feet in order to increase storage. The Upper and Lower Pitt-Taylor Reservoirs were the main storage facilities prior to the construction of the Ryepatch Reservoir in 1935 however their capacities were insufficient to meet water storage needs.

Lower Pitt-Taylor Dam

The Lower Pitt-Taylor Dam is located approximately 110 miles northeast of Reno,Nevada, and about 35 miles north of Lovelock, Nevada. The reservoir is on the east shore of the Ryepatch Reservoir and the Humboldt River. The dam and the reservoir can be found on the Rye Patch Reservoir South, Nevada Pershing County 7.5 minute topographic map.

The dam is an earthen structure, approximately 3000 feet long and was constructed of native soils borrowed from both sides of the embankment. The height of the dam measured at the outlet from the toe to the crest on the upstream side is 36 feet. The dam runs southeast to northwest. The dam is 22 feet wide at the crest and is used as a road. The slope on the downstream side of the dam is 4:1.5 and the slope on the reservoir side is 2:1.5 on the upper 12 feet and 8:1 on the lower 24 feet. The upper 12 feet of the dam has rip-rap and there is a spillway southeast of the dam.

The Pitt-Taylor Reservoirs were intended for irrigation storage. Construction on the Lower Pitt-Taylor Reservoir began in 1909. Water was turned into the reservoir for the first time in November of 1912. In 1915 the dam and the levees were raised to 38 feet to increase storage. The Upper and Lower Pitt-Taylor Reservoirs were the primary storage facilities prior to the construction of the Ryepatch Reservoir in 1935 however their capacities were insufficient to meet water storage needs.

Young Dam

The Young Dam can be found on the Arabia, Nevada 7.5 minute topographic map.

The Dam consists of three large steel reinforced buttresses and concrete abutments that form four bays. Three of the four bays have integrated keyways for flash boards that back up and control the height of the water behind the dam. The fourth bay has a jack operated slide gate used to control the flow though the dam. The height of the dam from toe to crest is 4 feet (approximate) and the length of the crest is approximately 30 feet.

Pitt Dam

The Pitt Dam can be found on the Lovelock, Nevada 7.5 minute topographic map and it is an eight-buttress dam constructed of steel reinforced concrete. The banks on both sides downstream of the dam are armored with rip-rap and the dam has a steel reinforced concrete toe and erosion control slab. The height of the dam from toe to crest is 15 feet and the length of the crest is approximately 85 feet. The dam has two railcar chassis placed end to end that provide the structure for a vehicular bridge that runs the length of the crest. Steel reinforced wooden flash boards in seven of the eight bays control the height of the water behind the dam and a manually operated rack and pinion operated slide gate in the eighth bay controls the release of water from the dam. The dam is used to back up water for diversion to the Old Channel and Union Canals. The Pitt Dam was constructed in 1915.

Irish American Dam

The Irish-American Dam can be found on the Lovelock, Nevada 7.5 minute topographic map and is nothing more than a drop structure. There are no control features on or near the dam and no water is diverted at that location.

Rodgers Dam

The Rodgers Dam is situated just northeast of Lovelock on the Humboldt River and can be found on the Lovelock, Nevada 7.5 minute series topographic map. It is constructed of eight steel reinforced buttresses and abutments. The height of the dam from toe to crest is 10 feet and the length of the crest is 80 feet. There is a steel grate foot bridge on the crest of the dam and an erosion control slab on the downstream side. The height of the water on the upstream side is controlled by flash boards in nine bays that average ten feet in width.

Sommers Dam

The Sommers Dam is situated on a diversion from the Humboldt River down stream of an earthen plug in the River south of Lovelock. It can be found on the Wildhorse Pass, Nevada 7.5 minute series topographic map. It consists of five steel reinforced concrete buttresses with integrated keyways for wooden flash boards that back up and control the height of the water behind the dam in five of the six bays and a jack operated slide gate in the sixth bay that controls the release of water from the dam. The dam has a steel reinforced toe and erosion control slab and the downstream banks on either side of the dam are armored with rip-rap. The height of the dam from toe to crest is 7’1” and the length of the crest is approximately 50 feet. The Sommers Dam was built in 2001 by PCWCD crews.

Big Five Dam

The Big Five Dam is situated on a diversion from the Humboldt River south of Lovelock. It can be found on the Wildhorse Pass, Nevada 7.5 minute series topographic map.

The Dam structure consists of five steel reinforced concrete buttresses. The Dam has integrated keyways for wooden flash boards that back up and control the height of the water behind the dam. There is a 10 foot long erosion control slab at the toe of the dam and the banks on either side of the Dam are armored with rip-rap. The height of the dam from toe to crest is 5 feet and the length of the crest is approximately

50 feet. There is a plank foot bridge across the top of the dam. The State of Nevada approved the construction of the dam in 1956 but the dam still had not been constructed by 1962. The exact year of construction is unknown.

Pitt-Taylor Diversion Canal

The Pitt-Taylor Diversion Canal originates at the Pitt-Taylor diversion dam on the Humboldt River and ends at the inlet of the Upper Pitt-Taylor Reservoir. It can be found on the Imlay, Nevada 7.5 minute series topographic map.

The original design of the canal included a base width of 25 feet, a top width of 39 feet, and a depth of 7 feet (the canal dimensions for side hill slopes was 18, 42, and 8 feet respectively).The original design flow capacity of the canal was 300 cfs. The Pitt-Taylor diversion canal is approximately 13.7 miles long and has only one diversion which supplies water to the Flying M Ranch.

Young Canal

The Young Canal originates at the Young Dam. It can be found on the Arabia, Nevada 7.5 minute topographic map. The diversion provides water to only one user.

Old Channel Canal and Diversion Structure

The Old Channel Canal originates at Holmstrom Road approximately 0.6 miles downstream of a diversion at the Pitt Dam. The head of the canal can be found on the Lovelock, Nevada Pershing County 7.5 minute topographic map. The canal flows westward for 4 miles, averages 24 feet in width and has a total of 12 laterals that serve 34 users irrigating 7,131 acres.

Union Canal and Diversion Structure

The Union Canal shares the same diversion and origin as the Old Channel Canal. The canal is 4 miles long, averages 20 feet in width and ends where it joins the Rodgers Canal to become the Union–Rodgers. The canal has 4 diversions; The Union Pump serving 8 users and 614 acres, the Irish–American Canal serving 7 users and 581 acres, the Arobio Canal serving 6 users and 1,038 acres, and the Big Meadow Canal serving 7 users and 2,739 acres.

Rodgers Canal

The Rogers Canal originates at a diversion at the Rogers Dam. The canal can be found on the Lovelock, Nevada Pershing County 7.5 minute topographic map. The canal flows to the Southwest for 1.5 miles at which point it joins the Union Canal to form the Union Rodgers. The canal averages 23 feet in width and has no diversions.

Union-Rodgers Canal

The origin of the Union-Rodgers Canal can be found on the Lovelock, Nevada Pershing County 7.5 minute topographic map. The Union-Rodgers supplies most of the irrigation water used in the lower valley. It is 10 miles long, averages 32 feet in width and has five main diversions; Rodgers Ditch and Tule, Seven, Lakeshore and Reed Laterals. In 1970 the average flow in the Union-Rodgers was 100 cfs. Since there has been little change since then that flow is probably still accurate. The canal supplies 34 users with 19,042 irrigated acres.

Rodgers Ditch

The Rodgers Ditch can be found on the Lovelock, Nevada 7.5 minute topographic map. The Rodgers Ditch serves two of the 34 users in the Union-Rodgers system, is one mile long, averages 10 feet in width and has an average flow of 22 cfs.

Seven Lateral

The Seven Lateral serves only one of the 34 users included in the Union-Rodgers system. The canal flows for seven miles averages eight feet in width at the bottom and has an average flow of 26 cfs.

Tule Lateral

Tule Lateral originates flows for two miles, serves two of the Union-Rodgers thirty four users, has an average bottom width of fifteen feet and an average flow of 26 cfs.

Lakeshore Lateral

The Lakeshore Lateral is 2.5 miles long with an average bottom width of twenty feet and average flow of 48 cfs.
There are no users on the Lakeshore Lateral which supplies Anker Pond. Anker Pond in turn diverts water to the West and East Lakeshore and Anker ditches.

Reed Lateral

This lateral is 1.5 miles long with an average bottom width of nine feet and serves four users. It can also supply water to the Copenhagen Lateral.

Copenhagen Lateral

The Copenhagen Lateral originates at the junction of Reservation and Carpenter Roads just east of Anker Pond and can be supplied by both the Reed and East Lakeshore Laterals. The lateral runs south for three miles along Carpenter Road and serves seven users. It has an average bottom width of eight feet and average flow of 21 cfs.

Anker Pond

Anker Pond can be found next to Reservation Road on the Wildhorse Pass, Nevada Pershing County 7.5 minute topographic map.

The volume of Anker pond is approximately .25 acre feet and it is fed by the Lakeshore Lateral. Its function is to act as a distribution junction for the West Lakeshore, East Lakeshore, and Anker ditches. The pond has steel reinforced concrete only at the diversion structures. The remainder of the pond is bordered by earthen dikes. There are two 48 inch wide control gates for the West Lakeshore, one 42 inch wide gate for the Anker and two 42 inch openings with stop logs for the East Lakeshore. The current estimated combined flow out of the pond is 75 to 90 cfs.

The three ditches supplied by Anker Pond have the following characteristics;

West Lakeshore – 3.5 miles long, 4 users, 28 cfs average flow (also supplies the Harper Ditch)
East Lakeshore – 1.5 miles long, 3 users, 18 cfs average flow (also supplies the Copenhagen)
Anker – 4.5 miles long, 11 users, 29 cfs average flow

Sommers Canal

The Sommers Canal originates at the Sommers Dam and flows west for 1.5 miles supplying two users with 853 acres.

Big Five Canal

The Big Five Canal originates at the Big Five Dam and flows west for approximately 3.5 miles. The Canal serves 3 users with 2,852 acres.

Seventeen Canal

The Seventeen Canal also originates at the Big Five Dam and flows 4.3 miles to the southwest. The Canal serves 2 users with 2,079 acres.

Humboldt River Plug

The Humboldt Plug is located just beyond the diversion for the Big Five Canal. The plug is nothing more then a soil and rip rap dike that dams the river. Nevertheless the plug is important because it backs water up into the diversions for the Sommers and Big Five systems which supply 23% of the total PCWCD irrigable acreage. It also determines how much water can be released from Rye Patch Reservoir.

1.3 WATER RIGHTS, SYSTEM CAPACITIES, STORAGE AND EXISTING AND FUTURE DEMAND

Historical Origins of Humboldt River Water Rights

Settlers constructed the first irrigation ditches in the Lovelock area around 1862. By 1892 (approximate) 75 percent of the water rights had been established.

In 1904 a group of irrigators united to form the Humboldt-Lovelock Irrigation Light and Power Company. The company filed applications in 1908 and 1911 with the State for 300 cfs of water and 57,000 acre-feet of water (respectively) from the Humboldt River.

Ten years later in 1923 the State Engineer's office ordered a general adjudication of the Humboldt River system. A final decree establishing water rights was not issued until 1931 by Hon. George A. Bartlett of the Sixth Judicial District Court in Winnemucca. The Bartlett Decree adjudicated water rights along the Humboldt River and its tributaries. In addition to the adjudication of the river systems water rights, the decree recognized that the that the surface waters within the Humboldt River system were already fully appropriated, leaving no surplus water for irrigation during an average, or normal water year. The Bartlett Decree also recognized differences in growing seasons between the upper and lower Humboldt River basins and divided the river system into two districts, District No. 1 below Palisade, Nevada and District No. 2 above Palisade. Additionally the decree established three classes of lands with different irrigation requirements and periods.

The water rights adjudicated by the Bartlett Decree were modified by the Edwards Decree in 1935. The primary purpose of the Edwards Decree was to correct errors and omissions in the Bartlett Decree. The most important change made by the Edwards Decree was the removal of the formal division of the Humboldt system into the two Districts below and above Palisade (Districts No. 1 and No. 2 respectively). The Edwards Decree established specific irrigation seasons and reaffirmed the three land classes, water duty for each class, and the period over which water was to be distributed to these lands instituted in the Bartlett Decree. Since most of the corrected water rights in the Edwards Decree applied to the upper Humboldt basin (above Palisade), the Edwards Decree was used for distribution of water in the upper basin while the Bartlett Decree was applied to and used for the distribution of water in the lower basin. The Edwards Decree also allowed for a flow of 1.23 cfs per 100 acres of decreed land or at proportional rates.

Statutory and Regulatory Considerations Regarding Nevada Water Rights

The Nevada State Water Plan, Part 1, Section 3 states the following;

"All waters within the boundaries of Nevada, whether above or beneath the ground surface, belong to the public and are managed on their behalf by the State. The State Engineer is responsible for the administration of Nevada Water Law, which ensures that these waters are managed so that sufficient

quantities are available to preserve our quality of life and to protect existing water rights. Entities within the State can apply for the right to use that water. Like many of the western states, Nevada water law is founded on the doctrine of prior appropriation - "first in time, first in right." Under this doctrine, the first user of water from a watercourse acquires a priority right to the water and to the extent of its use under that right."

Summary of Water Rights

Water rights within the PCWCD consist of both direct diversion rights and storage rights. Currently water rights held in the Lovelock area are owned by individual farmers, PCWCD, the State of Nevada and the United States but PCWCD controls the allotment and distribution of water to all owners.

Table 1.1 is a summary of water rights in acre-feet held within the PCWCD.

TABLE 1.1

Summary of Water Rights

Type of Rights Held	Acre-feet
PCWCD Direct Diversion	49,667.44
Rye Patch Storage	115,152.32
PCWCD Storage	54,570.00
Nevada Division of Wildlife	31,773.00

Storage and Capacities

Table 1.2 shows the active capacities for reservoirs in the PCWCD.

TABLE 1.2

Reservoir Capacities

Reservoir	Active Storage Capacity (acre-feet)	Outlet Works Release Capacity (cfs)
Rye Patch	213,000	1,000
Upper Pitt-Taylor	19,000	50 to 150*
Lower Pitt-Taylor	13,000	50 to 150*

*Rough estimate based on outlet area times flow velocity.

Existing and Future Demands

Currently there are 37,506 irrigable acres within PCWCD, approximately 32,000 of which are irrigated annually. It is not anticipated that the amount of irrigable acres will increase in the near future.

1.4 CONSERVATION

Introduction and Overview

Currently there are 37,506 acres of irrigable land within the PCWCD with approximately 32,000 acres being irrigated annually. Pershing County as a whole is one of the foremost agricultural production regions in Nevada and presently ranks 5th in the State in cash receipts for agricultural products. Alfalfa hay, alfalfa seed, wheat, oats, and barley are the principle crops.

In Nevada perceived economic benefits and availability of financing are the primary farm-level barriers to irrigation system improvements across farm-size classes. This is consistent with the fact that larger irrigated farms generally incur greater per acre irrigation costs. According to surveys smaller farms have the additional barrier of not having investigated the merits of system improvements. This barrier could be overcome through increased education provided through the extension service or even the district where

possible. Additionally, creative public/private financing approaches should be investigated to alleviate the economic concerns associated with farm conservation improvements.

Although there has been some hesitation to implement irrigation conservation improvements, farms that have applied water conserving improvements have benefited economically in addition to saving water and energy. Employment of conservation measures can:

- Improve reliability of existing water supplies.
- Reduce overall operating costs for water users.
- Postpone the need for new or expanded water supplies, storage capacity, or drainage remediation.
- Result in higher crop yields.
- Reduce the impacts of drought.
- Under some circumstances, yield conserved water for additional agricultural or urban need.

Because of costs it is impractical to expect on-farm conservation to contribute substantially to the conservation efforts. For this reason it is important that the District make as many improvements as possible utilizing its own resources as well as funds made available through governmental sources. Also farmers should be made aware of any available financing for conservation purposes as well as any other incentives that encourage conservation.

PCWCD Base Conservation Measures

PCWCD is continually working on delivery system improvements. They include ongoing maintenance consisting of regularly scheduled ditch cleaning, construction of new gate and diversion structures, installation of rip-rap in high erosion areas, installation of water measurement devices, and sealing of canals with polymer based additives. In addition to these, the University of Nevada, in conjunction with the USDA and the Nevada Department of Agriculture, has instituted a salt cedar (Tamarisk) eradication program within the District.

PCWCD is also proposing major renovation or replacement of some of the important structures in the delivery system. These upgrades include the replacement of several of the larger structures in the system as well as the systematic improvement of various other smaller structures.

Conservation Potential Within the PCWCD

Seepage Loss

A water measurement survey was performed on the Upper Lovelock Valley PCWCD delivery system in 1969 and another was done on the Lower Valley system in 1970. Since that time none of the canals has been lined and no additional flow studies have been conducted so it will be assumed that the old data still applies. Table 1.3 summarizes the results of these surveys.

TABLE 1.3

Seepage Losses in Canals

Canal	Length (mi)	Average Flow (cfs)	Average Loss/Mile (cfs)	Average Loss (%)
Young	2.0	25.7	1.4	11.0
Old Channel	4.0	40.0	0.8	6.5
Old Channel Laterals	Variable	Variable	Variable	16.0
Union	4.0	162.0	7.0	10.0
Irish American	3.8	16.1	3.2	Up to 62.0
Arobio	5.5	17.0	Unknown	Unknown
Big Meadow	2.5	29.0	0.3	2.4
Union-Rodgers	10.0	100.0	+1.4	+7.9
Rodgers Ditch	1.0	22.0	1.0	3.8
Seven Lateral	5.0	26.0	0.3	7.0
Tule Lateral	2.0	26.0	Unknown	Unknown
Upper Lakeshore Lateral	2.5	48.0	2.5	12.9
Reed Lateral	1.5	19.0	2.0	16.4
West Lakeshore Lateral/Harper	4.5	28.0	0.4	5.6
East Lakeshore Lateral	1.5	18.0	0.0	0.0
Anker	Unknown	Unknown	Unknown	Unknown
Copenhagen	3.0	21.0	1.0	13.1
Sommers	1.5	20.0	1.0	6.4
Big Five	4.0	38.0	9.0	23.4
Seventeen	3.5	32.0	1.0	10.6

The Old Channel system loss percentage in table 1.3 for the canal and its twelve laterals is an average. The Union-Rodgers system includes all of the canals in the lower valley with the exception of the Sommers, Big Five, and Seventeen Canals. The percentage loss for the Union-Rodgers system is also an average of all the losses of the canals in that system. It should be noted that the averages used on the larger canal systems are probably well below the actual seepage losses. For example the seepage loss recorded for the Union-Rodgers and the East Lakeshore in 1970 was positive but the study also indicated that the accuracy of the measurements was questionable and that there may have been tail water reentering the canals from irrigated lands.

In addition to the above mentioned canals, the Upper and Lower Pitt-Taylor Reservoirs and the Pitt-Taylor diversion canal show evidence of seepage losses, however no flow studies have been performed on the reservoirs or the canal.

Weeds

Weeds growing in waterways can reduce flow by clogging the stream beds and trapping sediment along the banks. Uncontrolled weeds can take as much as 5 millimeters of water per day from soil, reducing the moisture available for crops and even lowering crop yields. Weeds also compete with crops for sunlight, space and vital nutrients, further jeopardizing crop vitality and yield. Because of their direct impact on water conservation within the PCWCD, a list of the most invasive weeds that grow in the riparian areas of Pershing County including in and around PCWCD facilities is included below.

Saltcedar (Tamarisk). In Pershing County the invasive plant that consumes the largest amount of water is Saltcedar. Saltcedar (*Tamarix chinensis, T. ramosissima, and T. parvifolia)* are invasive, shrubby trees that are rapidly colonizing riparian areas in Nevada. They were introduced into the United States in the early 1800's as ornamentals and to prevent soil erosion along streams. The plant grows 5 to 20 feet tall and can be identified by its pale blue green leaves and pink to white flowers. In Pershing County saltcedar occupies former croplands in the Humboldt sink and grows along many of the canals that are part of the PCWCD water delivery system.

Tall Whitetop. Tall whitetop (*Lepidium latifolium*) also known as perennial pepperweed, thrives in riparian environments. The plants consume large amounts of water and like tamarisk act as salt pumps, bringing salt to the soil surface making it difficult for native plants to grow. Tall whitetop competes with native

plants for soil moisture tends to dominate areas it has invaded. Tall whitetop also accelerates stream bank erosion.

Whitetop. Whitetop (*Cardaria draba*) also known as hoary cress has many of the same environmental impacts of tall whitetop. A large stand of the plants can use large amounts of water and will exclude beneficial native plants.

Purple Loosestrife. Purple Loosestrife (*Lythrum salicaria L.*) tends to form dense stands in streams, canals, and ditches. It will eventually overwhelm and exclude native plants. It will grow in the water and clog waterways.

Poison Hemlock and Western Water Hemlock. Poison hemlock (*Conium maculatum*) is generally found at lower elevations in riparian areas or at least areas with sufficient soil moisture. It grows 6 to 8 feet tall and has shiny green fern-like shaped leaves and white flowers which bloom from June to August.

Western water hemlock (*Cicuta douglasii*) is more poisonous then Poison hemlock and is considered the most violently toxic plant in North America. It grows 3 to 7 feet tall with green leaves that have a toothed margin. The white flowers grow in clusters. Western water hemlock is a wetland plant.

Eurasian or spiked watermilfoil.This plant is currently only found in Lake Tahoe and part of the upper end of the Truckee River. It is considered a threat to the Stillwater Wildlife Refuge and potentially can be spread on boating and fishing equipment to other lakes and waterways which includes Rye Patch Reservoir.

Water Measurement

During field reconnaissance by Farr West Engineering personnel it was discovered that the PCWCD system could benefit from additional water measurement devices.

Water measurements can provide the data necessary for:

- Determining irrigation efficiency.
- Improving water management.
- Completing annual water reports.

Water measurement devices can also help in the evaluation of seepage losses in unlined canals, prevent excess runoff, and help facilitate equitable distribution of water within the District. One of the primary benefits of accurate water measurement is that the use of the water can be more precisely monitored, which would help PCWCD manage available water during dry years.

Measurement devices should match the specific conditions of the waterway. The following is a list of selection criteria taken from the United States Bureau of Reclamation (USBR) Water Measurement Handbook.

1. Accuracy Requirements
2. Cost
3. Legal Constraints
4. Flow Range
5. Head Loss
6. Adaptability to Site Conditions
7. Adaptability to Variable Operating Conditions
8. Type of Measurement and Records Needed
9. Operating Requirements
10. Ability to Pass Sediment and Debris
11. Device Environment
12. Maintenance Requirements

13. Construction and Installation Requirements
14. Device Standardization and Calibration
15. Field Verification, Troubleshooting and Repair
16. User Acceptance of New Methods
17. Vandalism Potential
18. Impact on Environment

Automation

There are a number of sites in the District that would benefit from automated monitoring and gate control. The Pitt-Taylor diversion, the Old Channel/Union Canal control structures, and Anker Pond are the most likely candidates for automation. By applying the flow rates from table 1.3, table 1.4 shows the amount of water that flows through these control structures at 15, 30 and 60 minute intervals.

TABLE 1.4

Flow through selected control structures

		FLOW THROUGH STRUCTURE (AF)		
Structure	**Flow (cfs)**	**15 min**	**30 min**	**60 min**
Pitt-Taylor Diversion Structure	300	6	12	25
Old Channel Structure	40	1	2	3
Union Structure	162	3	7	13
Anker Pond	90	2	4	7

The table above can be used to estimate the amount of water that could be conserved at structures with high flows. Manual control limits the precision of the release and retention of water at these sites. Automated monitoring and control can insure accurate deliveries in regard to timing and volume.

The USBR has had success with a number of canal automation projects in the United States, China, and Malaysia. According to the USBR the basic components of a simple canal automation set-up include the following:

- Datalogger/Controller
- Water level sensor
- Cellular phone, telephone or radio
- Modem
- Solar energy system
- Enclosures
- Gate actuators

Automation equipment can be installed in existing structures or included in new construction.

Replacement of Aging Control Structures

Currently a number of important control structures within the District are operating at a low level of efficiency. The Pitt-Taylor diversion dam and diversion structure leak and the channel upstream is in poor condition. Considering the importance of these structures, the existing method of releasing of water from the dam and the diversion is crude. The replacement of these facilities would definitely improve the accuracy of delivery of water to the Pitt-Taylor Reservoirs as well as the amount that continues downstream to the Rye Patch Reservoir.

The control structures on the Upper and Lower Pitt-Taylor Dams are also in poor condition. Both structures leak and could be seriously damaged in a moderate seismic event. If either of these structures became inoperable, it would be useless to store water in either one.

Conservation measures down stream of Rye Patch Dam would include the installation of slide gates on the Pitt and Rodgers Dams, the installation of a back up structure at the Humboldt Plug, the replacement of the Old Channel / Union Canal diversion structures and the replacement of Anker Pond. All of these structures leak and do not allow for accurate release of water.

On-farm Conservation

Most of the farms in PCWCD irrigate by flooding. Other methods of irrigation such as sprinklers may be more efficient but may be economically unfeasible for all farmers. For those who irrigate by flooding, conservation can be achieved by increasing irrigation efficiency. The following is a list of on-farm conservation measures that may be implemented within the District.

Agricultural Water Audits. The basic steps in an Agricultural Water Audit include:

- Determine water use.
- Identify on-farm conservation measures that have already been implemented.
- Review irrigation system type, layout, and current irrigation schedule.
- Evaluate irrigation system efficiency. Perform irrigation system field tests to determine irrigation efficiency.
- Review crop types, water and energy costs, and other irrigation-related matters.
- Conduct a water quality test to determine total dissolved solids and the leaching fraction.
- Identify all appropriate conservation measures for the farm's irrigation systems, including technology-based and practice-based measures.
- Create an evaluation that includes observations and recommendations on benefits and costs of recommended measures, irrigation system design, operation, and maintenance.
- Review conservation measure annually to evaluate the success of measures that have been implemented and to identify additional measures that may be appropriate.

Soil Moisture Measurement/Monitoring. There are several different methods for soil moisture measurement. They include the following:

- Estimating Soil Moisture by Appearance and Feel
- Measuring Soil Moisture by Soil Sampling
- Measuring Soil Moisture with Permanent, Fixed-Location Instruments

The four commonly used fixed location moisture monitoring methods include; porous blocks, tensiometers, neutron probes and reflectometers. Manufactures of these devices provide instructions for their installation and operation.

Evapotranspiration (Crop Water Use). Evapotranspiration (ET) is the water removed from the soil by soil evaporation and plant transpiration or crop water use.

Maximum yield is directly related to ET. Yield increases linearly with ET and maximum yield cannot be reached unless the maximum ET level is reached. Nevertheless the application of extra water beyond ET demand will not increase yield. Since all irrigation water cannot be converted into ET and yield, the goal should be to improve irrigation efficiency to match as closely as possible the yield-ET linear relationship.

Irrigation system capacity should be determined using peak ET rates. Irrigation scheduling should be done according to daily and weekly rates. Long term average ET rates can be used to determine net crop irrigation requirements. Aggregate ET rates can help PCWCD manage supply allocations for all water users. The following factors affect ET:

- Weather
- Crop Type
- Crop Growth Stage

- Crop Variety
- Crop Population
- Surface Cover
- Tillage
- Availability of Soil Water

Precision Leveling. Laser leveling can improve flood irrigation efficiencies but it should be accompanied by soil surveys to make certain water is properly applied. Leveling should be done no less than every 3 to 5 years. Many of the farms in PCWCD currently use laser leveling

Conservation Recommendations

Seepage

The last extensive flow studies were performed on the canal system in 1969 and 1970. Some of the canals in those studies have since been abandoned. There have also been improvements made to the system since that time, for example the replacement of Sommers Dam. Other efficiencies have been added due to improved management. Because of these changes it is recommended that a new flow survey be performed on the entire system to determine current losses and to use as a benchmark for future conservation efforts. The new survey should also include a study of the Pitt-Taylor diversion canal. The purpose of the survey should be to determine if canals or portions of canals should be lined.

No study has been done to determine the integrity of the Upper and Lower Pitt-Taylor Dams. However a dam safety inspection report written in 1998 by the Nevada Department of Water Resources stated the following concerning the Upper Pitt-Taylor Dam:

"Seepage all along the embankment/foundation contact and foundation continues unabated...The seepage through and under the embankments should be care fully monitored and in increases in flow, turbidity or channelization immediately reported to the State Engineer."

The Lower Pitt-Taylor Dam was evaluated in the same report which included the following:
"Lower Pitt-Taylor Dam is in poor condition with deteriorated outlet works and severe seepage...During the last inspection the rate of seepage along the entire downstream toe of the dam was the worst I had ever witnessed with concentrated flow in numerous locations... The seepage through and under the embankments should be care fully monitored and in increases in flow, turbidity or channelization immediately reported to the State Engineer."

It is recommended that a more extensive survey be done to determine the composition of the dams embankments and what can be done to correct seepage problems. Test wells should be drilled and monitored as part of the study. The outlet structures on both the Upper and Lower Pitt-Taylor Dams should be replaced.

Weeds

There is an ongoing effort to reduce the amount of tamarisk in PCWCD. However there are other invasive weeds within the Humboldt River system that can also cause damage to riparian areas as well as spread to neighboring farms. It is recommended that a weed survey be performed along the water system that will evaluate weed conditions and identify any problems or potential problems caused by the presence of aggressive species.

Water Measurement

A survey of water measurement devices in PCWCD should be conducted. The survey should include an evaluation of existing devices that determines if device is calibrated, properly installed and well suited for the location and conditions. Possible sites for additional measurement devices should also be identified. In certain areas automated monitoring should be considered an option.

Automation

Automation is included as part of the proposed improvements on the Pitt-Taylor diversion dam and structure, the Old Channel and Union canal structures and Anker Pond. In addition to these projects other sites should be evaluated for installation of automated monitoring equipment.

Replacement of Structures

It is recommended that the following structures be replaced or installed within the next three to five years:

- Replacement of the Pitt-Taylor diversion dam and diversion structure
- The replacement of the control structures on the Upper and Lower Pitt-Taylor Dams
- The installation of a back up structure at the Humboldt Plug
- The replacement of the Old Channel / Union Canal diversion structures
- The replacement of Anker Pond
- The installation of slide gates on the Pitt and Rodgers Dams

On-Farm Conservation

PCWCD should encourage on-farm conservation efforts as much as possible. Information on government incentives for on-farm water efficiency measures should be sought after and passed on to district farmers. These include in-kind services, educational programs, demonstration projects and financial incentives including tax incentives, low-interest loans, equipment purchase subsidies, and water charge discounts or rebates.

1.5 CONDITION ASSESSMENTS

Introduction

The PCWCD system consists of approximately 108 miles of canals and ditches, nine dams, two reservoirs and a number of diversion structures that vary in size, construction, and age. Some of the dams and diversion structures date back to the early 1900's including the Pitt Taylor Diversion, Upper and Lower Pitt Taylor reservoirs and outlets, and the Pitt Dam.

Facility assessment descriptions vary from good to poor. Assessment considerations include the physical condition of the structure, the condition of the channel immediately adjacent to the structure both upstream and downstream, and the operation of the control devices (flashboards and/or gates).

The assessment of canals also includes general rankings of good, fair or poor. It was observed that all of the canals have some combination of these conditions along their length. For example, sections of canals that would be considered good have characteristics of unobstructed flow, low evaporation, low seepage and low erosion.

Assessments

Pitt-Taylor Diversion Dam, Diversion Structure and Canal

The Pitt-Taylor Diversion Dam is in poor condition. The dam consists of ten buttresses with eleven flashboard bays. There is visual evidence of deterioration on all of the buttresses, some with as much as fifty to seventy five percent surface spalling. All of the buttresses have cracking with some cracks extending completely through the buttress. The river channel both upstream and downstream of the dam is in poor condition. Erosion has caused the formation of a shoal on the upstream side blocking at least three of the dam's eleven bays. The exclusive use of flashboards to control flow through the dam is also a concern. Flooding in May and June of 2005 made it nearly impossible to reach the flashboards to regulate flow creating a safety hazard for PCWCD personnel. The flashboards are also difficult to remove and replace due to advanced deterioration of the keyways in the buttresses.

The diversion structure is also in very poor condition. In addition to spalling, parts of the structure have completely disintegrated, exposing the steel reinforcing bars.

The Pitt-Taylor Canal supplies water to the Pitt-Taylor Reservoirs and to a single user (Flying M Ranch). There are only two structures in the canal between its origin at the Pitt-Taylor Diversion and its destination at the Upper Pitt-Taylor Reservoir. The first, the Flying M diversion, is approximately 2.6 miles downstream of the Pitt-Taylor Diversion, is in poor condition and unable to handle the original designed flow capacity of 300 cfs. The second structure is a bridge crossing the canal near the diversion structure that provides access to the Flying M Ranch.

The condition of the canal itself varies from fair to poor along its 14 mile length. Five miles downstream of the Pitt-Taylor Diversion the canal bank has been breeched. Much of the canal is overgrown with tamarisk and other invasive plants. In many areas the canal cross-section is inconsistent with the original design dimensions in width and depth.

Upper Pitt-Taylor Dam and Control Structure

A dam safety inspection was performed in 1998 by the State of Nevada Division of Water Resources. In 1997 the reservoir had been full to capacity so there was water in the reservoir when it was inspected. Seepage was detected in several areas along the length of the dam. The following was taken from the inspection report:

"Upper Pitt Taylor Dam was in poor condition with a deteriorated outlet, heavily eroded and over-steep embankments and uncontrolled foundation seepage."

A safety inspection performed by GA Engineering and Planning in December 2001 stated;

"Some evidence of animal burrowing was found on the mortared rock at the entrance to the dam's outlet structure. Vertical cracking of the mortar was also evident. Evidence of soil cracks, possible future sloughing was detected near the outlet structure. The downstream side of the outlet structure has experienced significant damage and should be repaired and armored, or replaced. Erosion of the dam's downstream face in the form of gullies was found at several sites along the dams crest. The vegetation growing on the dam's face and crest should be removed. The two slide gates without mechanisms for operation should be fitted with such mechanisms... Construction of a spillway should be seriously considered to protect the dam from breaching."

Additionally it is unlikely the outlet structure or the dam could withstand a moderate seismic event with the reservoir at full capacity.

Lower Pitt-Taylor Dam and Control Structure

The condition of Lower Pitt-Taylor Dam was described in a 1998 dam safety report prepared by the State of Nevada Division of Water Resources. At the time there was water in the reservoir. The following excerpt was taken from the report.

"Lower Pitt-Taylor Dam is in poor condition with deteriorated outlet works and severe seepage."

The dam was inspected again in December 2001 by GA Engineering and Planning. The following description was taken from that report.

"No evidence of animal burrowing was found on the dam. No evidence of sloughing was detected. The vegetation (willows) growing on the dams face and crest should be removed. Improved access to the top of the control structure should be installed. The right slide gate stem should be repaired or replaced...At some future time, the outlet structure will need to be repaired and armored or replaced. Construction of a spillway should be seriously considered to protect the dam from breaching."

Young Dam, Diversion Structure and Canal

The dam appeared to be in good condition. The bottom of the canal on the downstream side of the dam is armored with rip-rap. There was some scour in the channel bottom just downstream of the dam and undercutting could be a problem. The jack operated slide gate and flash boards all appeared to be in good operational condition. Also the diversion structure and canal appear to be completely functional and in good condition.

Pitt Dam

The condition of the dam is fair. Spalling was observed on approximately fifty percent of the buttress and abutment surfaces. A Schmidt impact hammer was used to do preliminary field testing of the strength of the concrete. Four random spots on the dam were tested with the average result being approximately 1800 psi. There is a substantial crack that has resulted in the separation and dislocation of a portion of the east end abutment. There are 7 flashboard bays that back up water behind the dam and one slide gate bay that controls flow through the dam. During minor flooding in May and June of 2005 it was discovered that more slide gates may be needed in place of flashboards in some of the bays for safe and reliable flow control. The vehicular bridge across the crest is in fair condition.

Old Channel / Union Diversion Structure and Canals

Both of the diversion structures are in fair to poor condition. The Union Canal bottom is armored on the immediate downstream side of the bridge and the Old Channel Canal bottom is armored on the downstream side of the diversion structure. There is evidence of scour in the channel bottom on the downstream side of the Old Channel structure. There is spalling on fifty percent of the surfaces of both structures and the passages beneath the bridge.

There are several structures along both of the canals that are in good to poor condition. These include diversion structures for the 12 laterals along the Old Channel and the structure at the junction of the Big Meadow and Arobio canals on the Union. The condition of the Big Meadow, Irish and Arobio canals and their associated laterals also varies along their length from good to poor. Chapter 5 includes a discussion on seepage in these canals

The concrete diversion structure at the junction of the Big Meadow, Union and Arobio canals is in poor condition with areas of severe spalling and cracking in the concrete. This junction also has pipes that run underneath the adjacent road and railroad tracks that are undersized. The Irish-American canal is in fair condition but it includes a pipe that crosses over the Arobio canal that is undersized and should be replaced. The Arobio canal is in fair condition.

There are two backup structures on the Old Channel Canal that are in poor condition and operate inefficiently. These include the backups at the #5 diversion and the #7 diversion. Water is diverted into the #2 diversion ditch by pump (also known as the “Cowboy Pump). Currently the pump operates inefficiently for lack of proper head at the pump intake.

Irish-American Dam

The Irish-American Dam facility consists of only a drop structure. The dam was observed from a distance and appeared to be just a simple In-stream concrete structure with no means of flow control. A good portion of the structure was cracked and spalled. Although the structure is not used to control flow it may be useful for erosion control. In its absence channel cutting could become problem. The condition of the dam is poor.

Rodgers Dam, Diversion Structure and Canal

The dam appeared to be in good operational condition. The diversion structure also appeared to be well maintained and in good condition. The condition of the canal varied from good to fair. Immediately

upstream from where the canal joins the Union Canal there is a steel pipe flume measuring seven feet in diameter by 300 feet long that crosses over the Humboldt River. During high flow conditions in spring of 2005 it was observed that the flume diameter may be inadequate for higher flows. When flows reached approximately 285 cfs it became necessary to open a normally unused bypass canal in order to convey excess water that wasn't passing through the flume.

Union-Rodgers Canal

The canal is in good to fair condition. According to the 1970 flow study the canal actually had positive gains in flow probably due to return flows from irrigated lands and measurement error.

Rodgers Ditch

The 1970 system flow study indicated the Rodgers Lateral had some seepage loss. Farr West Engineering personnel observed that the lateral appeared to be clean and in fair condition.

Seven Lateral

The Seven Lateral serves only one user. It is long and deep in spots with evidence of erosion. The 1970 flow study indicated some seepage loss.

Tule Lateral

The back-up structure toward the end of the Tule Lateral appeared to have seepage problems. The lateral was dry when it was inspected but PCWCD personnel have observed that the structure leaks when it is closed. It is not certain whether the water is coming from underneath the structure or passing over one side. It did appear that the structure is lower then the wall at the diversion. There is also a large amount of sedimentation on the upstream side of the structure and some scour on the downstream side with some evidence of undercutting.

Lakeshore Lateral

The Lakeshore Lateral is deep on the upper end and has high seepage loss according to the 1970 flow study. This lateral has no users and serves as the supply source for Anker Pond.

Reed Lateral

This lateral is in good condition but according to the 1970 flow study it had very high seepage losses.

Copenhagen Lateral

The Copenhagen is in fair condition. However the outlet structures at the corner of Westergard and Carpenter road, are in poor condition and are undersized.

Anker Pond

The control structures at the pond are in fair condition. The pond is basically a polygonal shaped earthen tub with 5 sides. Three sides have concrete control structures, one side is bordered by the road and inlet conduit that runs underneath, and the fifth side, which is also the longest, is an earthen embankment. The embankment is approximately 60 feet long by 20 feet wide and borders the southwestern side of the pond. This appears to be the weak point in the pond and it has the potential to fail.

The canals fed by Anker Pond and their associated control structures appear to be in fair to poor condition. There is evidence of erosion in the West Lakeshore Lateral. The flume in the East Lakeshore lateral that runs under Carpenter Road is in poor condition and may not have sufficient flow capacity. The flume in the Anker ditch that runs under Westergard Road is also in need of replacement.

Sommers Dam and Canal

The Sommers Dam facilities consist of the Dam itself and the Sommers Canal. The Dam was built in 2001 and is in excellent condition. The canal also appears to be good condition.

Big Five Facilities

The facilities include the Big Five Dam and Canal and the Seventeen Canal. The Dam and both canals appear to be in good condition although the dam may be too small for its location and it may be the cause for high water at the Sommers Dam during flood years. There are 2 or three diversions along the Big Five Canal that are in poor condition. The canal also runs parallel to a drainage ditch and there is some seepage into that ditch.

Humboldt River Plug

The Plug's weakness becomes apparent when water levels exceed the crest height. The action of the water flowing over the crest erodes the down stream side quickly causing the dam to fail. Once the Plug fails the District is unable to back up irrigation water for the lower end of the system. This weakness in the system also limits the amount of water that can be released from Rye Patch Reservoir which becomes a serious problem in flood years. At flows above 2000 cfs the Plug is at risk of washing out and has failed three times in the past 19 years.

1.6 PROPOSED SYSTEM IMPROVEMENTS

Introduction

Recommendations for proposed improvements take into consideration the following factors:

- Conservation
- Maintaining capacity
- Improve Operation and Maintenance
- Safety

Because conditions vary at each facility some of the proposed improvements will satisfy all of these factors; and others only part.

Pitt-Taylor Diversion Dam and Diversion Structure

The dam and diversion structure are old and in advanced stages of deterioration. It is recommended that both the dam and diversion structure be redesigned and replaced. Replacement would include improvements to the river channel in areas adjacent to the structures both upstream and downstream, demolition of the old structures and construction of the new ones, including the installation of a remote monitoring system. The objectives of the improvements would be the efficient delivery of water to the Flying M diversion, better management of water stored in the Pitt-Taylor Reservoirs, better control of water flowing into Rye Patch Reservoir and safe operation of the gates.

Pitt-Taylor Diversion Canal

The canal should be cleaned, reshaped and lined in sections where high seepage is present. The Flying M diversion structure should be replaced. The objectives of the improvements would be to increase the amount of water stored, improve delivery to the Flying M Ranch, decrease erosion and potential failure of canal banks, and decrease seepage and losses to invasive plants.

Upper Pitt-Taylor Dam

The Upper Pitt-Taylor Dam is in poor condition. The outlet structure should be replaced. An extensive study should be performed on the dam to determine improvement options. The study should include the installation of test wells to monitor seepage, an evaluation of the stability of the embankments and an analysis of the possible effects of catastrophic failure. An emergency plan and maintenance procedures should be created that cover all possible contingencies. The objectives of the improvements would be to improve control of water emptied into the Lower Pitt-Taylor Dam, eliminate leaks, determine if failure of the Upper Pitt-Taylor Dam will cause the subsequent failure of the Lower Pitt-Taylor Dam and provide emergency/maintenance options.

Lower Pitt-Taylor Dam

The control structure has outlived its useful life. The control structure in the dam should be replaced. An extensive study should be performed on the dam to determine improvement or maintenance requirements. The study should include the installation of test wells to monitor seepage, an evaluation of the stability of the embankments and an analysis of the possible effects of catastrophic failure. An emergency plan and maintenance procedures should be created that cover all possible contingencies. The objectives of the improvements would be to improve the control of flow into Rye Patch, eliminate loss of water due to leaks, determine how to improve the embankments, and provide emergency/maintenance options.

Young Dam

Although the dam itself is in good condition there the existing rip-rap should be removed and a new concrete apron constructed. Depending upon the evaluation of undercutting, a new cutoff wall should be considered. The objectives of the improvements would be to eliminate seepage and undercutting so the structure could be preserved.

Pitt Dam

The dam should be retrofitted with additional slide gates. The minimum number of slide gates that should be added will need to be determined by a flow analysis of the bridge. The objectives of the improvements would be to improve flow control, reduce leakage and improve safety.

Irish-American Dam

Although the dam is not used as a control structure, it may be useful in preventing erosion in the channel upstream of its location. The condition of the dam should be evaluated to determine if it could fail in sustained high flows. A study should be performed to determine how the channel would be affected in the event of failure. The objectives of the improvements would be to determine the function of the dam and if it needs to be replaced.

Rodgers Dam

The dam should be retrofitted with additional slide gates. The objectives of the improvements would be to improve flow control, reduce leakage, and improve safety.

Rodgers Canal

An engineering study should be done to determine the flumes capacity to handle flows similar to those experienced during the spring of 2005 (estimated at 285 cfs). If it is discovered that the flume is undersized, it should be replaced. If the flume is adequate, some modifications may need to be performed. The objectives of the improvements would be to determine if the flume needs to be replaced or if modification will solve the problem.

Big Five Dam

The Dam should be enlarged to accommodate higher releases in flood years. The objectives of the improvements would be to prevent high water at Sommers Dam and allow for higher releases from Rye Patch.

Big Five Canal

There are 2 to 3 diversion structures along the canal that should be replaced. Also the canal should be included in a system-wide flow study to determine how much water is being lost to seepage and/or management. Depending upon the extent of the seepage the canal should be concrete lined or sealed with a polymer sealant. The objectives of the improvements would be to improve delivery and reduce losses due to seepage.

Old Channel / Union Canals Diversion Structures

The condition of the structures and the channel bottom immediately downstream of the structures is fair to poor. At a minimum the control structures for both the Union and Old Channel Canals should be replaced. Holmstrom Road Bridge may need to be replaced as well in order to install larger pipe under the bridge. The Channel immediately downstream of the control structures should be reshaped and re-armored. Remote monitoring devices should also be installed at this site. The objectives of the improvements would be to improve the measurement of water passing through an important point in the system, increase capacity, and prevent failure and flooding.

Old Channel Canal

The Old Channel should be included in a system-wide flow study to determine the amount of water being lost to seepage and/or management. Depending upon the results of the study the canal should be sealed or lined.

The structures at the #5 and #7 ditches should be replaced. A backup structure should be installed at the #2 ditch to create more head for the Cowboy Pump. The objectives of the improvements would be to improve delivery and reduce seepage losses.

Union Canal

The Union should be included in a system-wide flow study to determine the amount of water being lost to seepage and/or management. Depending upon the results of the study the canal should be sealed or lined with concrete in areas of greatest loss. The control structure at the Union, Big Meadow and Arobio should be replaced. The objectives of the improvements would be to improve delivery and reduce seepage losses.

Big Meadow Ditch

The Big Meadow should be included in a system-wide flow study to determine the amount of water being lost to seepage and/or management. Depending upon the results of the study the canal should be sealed or lined with concrete in areas of greatest loss. The pipe running under the highway should be replaced. The objectives of the improvements would be to increase delivery capacity and reduce seepage loss.

Irish American Ditch

The Irish-American should be included in a system-wide flow study to verify the high seepage loss reported in the 1970 study. Depending upon the results of the study the canal should be sealed or concrete lined in areas of greatest loss. The pipe running over the Arobio Ditch should be replaced. The objectives of the improvements would be to increase capacity and reduce seepage loss.

Arobio Ditch

The Arobio should be included in a system-wide flow study to determine the amount of water being lost to seepage and/or management. Depending upon the results of the study the canal should be sealed or lined in areas of greatest loss. The objective of the improvements would be to reduce seepage.

Union-Rodgers Canal

Because this canal is a key component of the Lower Valley system, a study should be conducted to determine its current true flow characteristics. Depending upon the results of the study the canal should be sealed or lined in areas of greatest loss. The objectives of the improvements would be to determine canal efficiency and whether it should be sealed or lined.

Tule Lateral

The backup and diversion structures near the end of the lateral should be redesigned and replaced. The objectives of the improvements would be to improve delivery of the irrigation water to users and reduce seepage.

Rodgers Ditch, Seven, Lakeshore and Reed Laterals

The laterals should be included in a system-wide flow study to determine the amount of water being lost to seepage and/or management. Depending upon the results of the study the canals should be sealed or lined with concrete in areas of greatest loss. The objectives of the improvements would be to reduce seepage loss.

Copenhagen Lateral

The structures at the end of the ditch should be replaced. The Ditch should be included in the system flow study and sealed or lined accordingly. The objectives of the improvements would be to improve delivery efficiency and reduce seepage loss.

Anker Pond

The pond should be replaced and the gates should be automated. Remote monitoring should also be installed. The objectives of the improvements would be to eliminate seepage and potential for failure as well as improve delivery.

Anker Pond supplies three laterals, the East, West (Including the Harper), and Anker ditches. These ditches appear to be in fair to poor condition and should be included in the aforementioned flow study. There is evidence of erosion in the West Lakeshore Lateral. The flume in the East Lakeshore lateral that runs under Carpenter Road is in poor condition and may not have sufficient flow capacity. The flume in the Anker ditch that runs under Westergard Road is also in need of replacement.

Humboldt River Plug

A new back up structure should be constructed to replace the Plug. The objectives of the improvements would be to eliminate seepage and potential for failure as well as improve delivery.

1.7 ESTIMATES

All costs have been estimated using May 2005 dollar values and current local economic conditions. Costs have not been adjusted in anticipation of inflation or price increases. Final project costs will depend on actual labor and material costs, market competition, final project scope, schedule and other variable factors.

Proposed projects for which cost estimates were not prepared may require additional studies and preliminary designs that are beyond the scope of this plan.

Preliminary Cost Estimates

Pitt-Taylor Diversion Dam and Diversion Structure

The following preliminary cost estimate was taken from the preliminary engineering report prepared by Dyer Engineering Consultants, Inc. (see appendix A) and is based on the preliminary specifications included in that report.
Preliminary Cost Estimate for Replacement of Pitt-Taylor Diversion Dam and Diversion Structure:

Grand Total: $1,020,416

Replacement of the Outlet Structures for the Upper and Lower Pitt-Taylor Dams

The preliminary cost estimate for the replacement of both the outlet structures in the Upper and Lower Pitt-Taylor Dams is the same because the designs will likely be similar. Note the combined total.

Preliminary Cost Estimate for the Replacement of the Upper and Lower Pitt-Taylor Outlet Structures:

Grand Total (per structure): $743,018
Combined Total: $1,486,037

Installation of a Back up Structure at the Humboldt Plug

The preliminary cost estimate for the back up structure is derived from the Option 1 estimate included in the Dam Rehabilitation Feasibility Study performed by URS/Dames & Moore (see appendix A. Note that the dam was erroneously referred to as Big Five Dam). Since the original estimate was completed in January 2001, costs in table 8.3 reflect a 5% per year increase to account for inflation.

Preliminary Cost Estimate for the Installation of a Back Up Structure at the Humboldt Plug:

Grand Total: $503,006

Old Channel / Union Canals Diversion Structures

Preliminary Cost Estimate for Replacement of Old Channel / Union Canals Diversion Structures:

Grand Total: $603,168

Anker Pond

The preliminary estimate for Anker pond includes costs for the replacement of the pond as well as armoring of the canal sections immediately adjacent to the pond.

Preliminary Cost Estimate for Replacement of Anker Pond:

Grand Total: $450,455

Pitt Dam

The preliminary estimate for Pitt Dam includes the installation of five new slide gates. The estimate does not include any concrete work and assumes that the gates can be retrofitted with minimal or no modification to the existing buttresses other then the removal of stop logs.

Preliminary Cost Estimate for Installation of Gates in Pitt Dam:

Grand Total: $198,500

Rodgers Dam

The preliminary estimate for Rodgers Dam includes the installation of five new slide gates. The estimate does not include any concrete work and assumes that the gates can be retrofitted with minimal or no modification to the existing buttresses other then the removal of stop logs.

Preliminary Cost Estimate for Installation of Gates in Rodgers Dam:

Grand Total: $181,469

1.8 PRIORITIZATION OF IMPROVEMENTS

With the input of the PCWCD Board of Directors and General Manager, four different factors were established to determine the order of implementation for each of the 28 proposed projects. The following are the factors considered to be the most important to the Board and General Manager:

1. Conservation
2. Maximize Capacity
3. Improve Operation and Maintenance
4. Safety

Proposed Projects

Each project was evaluated and ranked according to each of the factors above. The sum of the individual factor rankings was then used to establish an overall ranking. Table 1.5 shows all of the projects and their order of precedence.

TABLE 1.5

Project Priorities

System Element	Proposed Improvements	RANK
Pitt-Taylor Diversion	Replace dam and diversion structure	1
Upper Pitt Taylor Dam	Replace control structure	2
Lower Pitt Taylor Dam	Replace control structure	3
Plug at end of Humboldt	Install back up structure	4
Old Channel/Union Diversions	Replacement	5
Anker Pond	Replacement	6
Pitt Dam	Install slide gates	7
Rodgers Dam	Install slide gates	8
Union, Big Meadow, Arobio	Replace Diversion at junction of canals	9
Cowboy Pump (Old Channel)	Install back-up structure	10
#5 (Old Channel) Structure	Replacement	11
#7 (Old Channel) Structure	Replacement	12
Rodgers Canal	Evaluate capacity of flume	13
Pitt-Taylor Canal	Reshape and line	14
Upper and Lower Valley Systems	Canal Lining	15
Irish American Canal	Replace pipe over Arobio Canal	16
Copenhagen Lateral	Replace outlet structures at lower end	17
Upper and Lower Valley Systems	Measuring Device Survey	18
Tule Back-up Structure	Replacement	19
Upper and Lower Valley Systems	Flow study	20
Upper and Lower Pitt Taylor Dams	Condition survey	21
Big Five Dam	Survey to evaluate capacity	22
Pitt-Taylor Canal	Replace Flying M diversion structure	23
Young Dam	Install concrete apron and cutoff wall	24
Upper and Lower Pitt Taylor Dams	Maintenance Procedures	25
Upper and Lower Pitt Taylor Dams	Emergency Plan	26
Upper and Lower Valley Systems	Weed Survey	27
Irish American Dam	Dam inspection and evaluation	28

1.9 FUNDING ALTERNATIVES

Activities in the plan that will require funding include studies, design services, and facilities construction. Because of the number and magnitude of the proposed projects it will be necessary to implement them in phases according to priority. Table 1.6 is a list of the highest priority proposed projects and the order in which they should be implemented.

TABLE 1.6

Priority	Project	Estimated Cost
1	Replacement of the Pitt-Taylor Diversion Dam and Structure	$1,020,416
2	Replacement of Upper Pitt-Taylor Dam Control Structure	$742,018
3	Replacement of Lower Pitt-Taylor Dam Control Structure	$742,018
4	Installation of a Back up Structure at the Humboldt Plug	$503,006
5	Replacement of Old Channel / Union Canals Diversion Structure	$603,168
6	Replacement of Anker Pond	$450,455
7	Installation of slide gates on Pitt Dam	$198,500
8	Installation of slide gates on Rodgers Dam	$181,469
	Total:	**$4,441,050**

Funding Options

Funding options for the above mentioned proposed projects are as follows:

- **Water Conservation Grant - C**an be used to finance 85% of the project costs.
- **Matching Funds From the U.S. Bureau of Reclamation (USBR)** - The maximum amount provided by the USBR will be $40,000 for the Union Canal structure and $45,000 for the Old Channel Canal structure. PCWCD will need to match these amounts for each structure.
- **PCWCD Capital Improvement Fund -** PCWCD has approximately $300,000 in an emergency needs/capital improvement fund.
- **PCWCD In-kind Project Funding –** PCWCD has personnel and equipment that can be utilized to implement portion of the above mentioned projects. The District has established a $34.00/hr. labor rate as well as per hour rates for the operation of its heavy equipment.

Project Total and Funding

Table 1.7 is a summary of the potential funding for high priority proposed projects.

TABLE 1.7

Potential Funding Source	
State Board of Finance	$3,774,893
U.S. Bureau of Reclamation Matching Funds*	$85,000
PCWCD Capital Improvement Fund	$300,000
PCWCD In-kind and/or Loans	$281,158
Total Funding:	**$4,441,050**

***These funds may only be applied to the replacement of the Old Channel/Union Canal diversion structures.

It should be noted that the PCWCD may use only a portion of its capital improvement fund or none at all since the fund is also used for emergencies. Also since the matching funds from the USBR can only be applied to the replacement of the Old Channel / Union Canals Structures, the PCWCD has an automatic commitment to provide at least $85,000 to that project. If the PCWCD decides not to use its available capital it will make up the difference in loans and in-kind funding.

1.10 IMPLEMENTATION SCHEDULE

The proposed Phase I project is the replacement of the Pitt-Taylor diversion dam and diversion structure. The projected schedule for this project is the following:

Entity	Action	Date
State Finance Board	Submit Letter of Intent	January 2006
State Finance Board	Submit Project Application	April 2006
Engineer	Begin Design	May 2006
Contractor	Begin Construction	October 2006

Implementation of subsequent projects will be scheduled before the completion of projects under construction.

Proposed projects that involve the replacement of facilities must be started at the end of the irrigation season and completed prior to the next irrigation season. Other limiting factors that could delay the start or completion of projects include:

- Freezing temperatures
- Water stored in the Upper and/or Lower Pitt-Taylor Reservoirs

It may be possible to do multiple projects simultaneously but care should be taken not overextend available project funding and resources.

Chapter 2
INTRODUCTION

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INTRODUCTION **1**

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2.1 PURPOSE OF THE PLAN

The objective of the PCWCD Master Plan is to provide a long range strategy to implement necessary improvements to the system. The intent of the improvements is to maximize use of water supplies, increase conservation, reduce operating costs, and ensure efficient and safe delivery to water users in PCWCD. The plan assesses the condition of system facilities, makes recommendations for proposed improvements, prioritizes proposed improvements and provides estimated costs for high priority projects.

2.2 HISTORY OF PCWCD

Circa 1862 the first irrigation ditches were constructed by early settlers in the Lovelock Valley. Thirty years later approximately 75 percent of the water rights in the valley had been established.

By the early 1900's the demands on the Humboldt grew as the population increased. In 1900, 14,000 acres were under irrigation with most of the land producing alfalfa. Increasing demand became the motivation for improving the management of Humboldt River water.

In 1913 the Humboldt-Lovelock Power and Irrigation Company (HLPIC) built two shallow off-stream reservoirs, the Upper and Lower Pitt-Taylor. The reservoirs were originally designed to store a total of 49,000 acre feet but that amount was reduced to 35,000 (20,000 in the Upper Pitt-Taylor and 15,000 in the Lower) for safety reasons. The reservoirs were filled by a canal originating at a diversion on the Humboldt River about 14 miles upstream. The diversion was built at the same time as the reservoirs and was originally known as Thacker Dam (Pitt-Taylor Diversion).

Because of increasing water use in the Upper Humboldt Basin, Lower Basin users began to experience shortages. For this reason the Nevada State Engineer ordered a general adjudication of the Humboldt River system in 1923, designating the Sixth Judicial Court in Winnemucca as the decree court. In 1931, Hon. George A. Bartlett issued a final decree establishing water rights for the Humboldt Basin. In 1934 the Edwards decree (after Judge H.W. Edwards) was issued. The purpose of the Edwards decree was to correct errors and omissions in the Bartlett Decree. The Bartlett and Edwards Decrees together became known as the Humboldt River Decree. In 1938 the Nevada Supreme Court finalized and affirmed the Humboldt River Decree, halting all future challenges.

In 1926 the Lovelock Irrigation District was formed for the purpose of exploring potential storage sites on the Humboldt River and these efforts intensified after the Bartlett adjudication in 1931. To facilitate the implementation of such a project the District was reorganized under the Nevada Irrigation District Act and changed its name to the Pershing County Water Conservation District (PCWCD).

In the early 1930's the PCWCD began negotiations with the United States Bureau of Reclamation for the construction of the Humboldt Project, a project that eventually would include an in-stream dam, reservoir, water rights, and lands in Lander County. Funding for the project was approved in August 1933 and received Presidential approval in November 1935.

The Water District and Bureau of Reclamation decided upon a location for the reservoir construction at the present site of Rye Patch Reservoir. However, before construction could begin the District needed to acquire additional water rights. Willing sellers were located upstream in Lander County and the District entered into purchase agreements with several ranch owners in the Valmy and Battle Mountain areas. The agreements included the acquisition of over 30,000 acres of land and appurtenant water rights from two ranches in the Battle Mountain area and an additional 30,580 of water rights from properties near by.

After the necessary water rights were obtained the Water District Directors decided to proceed with the project. By 1935 all prerequisite contracts and transactions for construction were complete. Construction of the Rye Patch Dam began in January 1935 and was completed in January 1936 with a design capacity of 170,000 acre-feet.

In the early 1940's the PCWCD assumed the operation and maintenance of the Humboldt Project, including the Dam, Reservoir and the purchased lands in Lander County. In the early 1990's it was determined that the dam needed to be modified with modifications being completed in 1996. The modifications increased the capacity of the reservoir to 213,000 acre feet.

From 1913 to the present several smaller diversion structures and delivery canals were built down stream of the Rye Patch Reservoir, most before 1935. An example would be the Pitt Dam in the Upper Lovelock Valley which was built in 1915. The two newest structures in the PCWCD system are the Big Five Dam (rebuilt in the early 1960's), and the Sommers Dam (built in 2001).

Today the PCWCD operates and maintains the Upper and Lower Pitt-Taylor and Ryepatch storage facilities as well as all of the associated canals and diversion structures pertaining to the District. Irrigation is critical to agriculture in the District and currently there are 37,506 acres of irrigable land within the district with approximately 32,000 acres being irrigated annually.

2.3 PCWCD OPERATION AND MAINTENANCE CONCERNS

The PCWCD stores water from seasonal runoff in the Rye Patch and the Pitt-Taylor Reservoirs. Dry winters however make it impossible to store enough water to meet the irrigation needs within the District. For this reason it is important that the PCWCD system functions as efficiently as possible, thereby maximizing use of available water. This maximization of water resources will require improvements to the District's delivery and storage facilities to insure efficient system operation.

Most of the diversion structures in the PCWCD system were built before 1935 and many of these structures have exceeded their useful life. The Pitt-Taylor Diversion Dam and Structure were constructed in 1913 and are in very poor condition and will need to be replaced soon. Replacement of these structures would allow for more efficient delivery of irrigation water and increased storage. Also the cross-sectional shape of the Pitt-Taylor diversion canal is inconsistent with the original design dimensions and is overgrown with Tamarisk. The canal has been breeched in at least one location and has the potential for failure in several others.

The control structures on both the Upper and Lower Pitt-Taylor Dams need to be replaced. The structures were built in 1913 and are in an advanced state of deterioration. Two of the three outlet gates on the Upper Pitt-Taylor structure are non-operational and beyond repair. The concrete on both the Upper and Lower structures is in poor condition and the structures leak. Additionally, seepage has been detected in both dams.

The Pitt Dam is the main control structure in the Upper Valley and the Rodgers Dam is its Lower Valley counterpart. Both of these dams control a substantial amount of District water and are old but serviceable. Currently the dams control water mainly with stop logs but could be made more efficient by installing slide gates.

The diversion structure at the junction of the Old Channel and Union Canals is old and deteriorating. Much of the water used in the Upper and Lower Valleys is delivered directly or indirectly by these canals. Accurate measurement and control at this point in the system would contribute to improved water management. Automated monitoring and control should be included in the replacement of this structure.

Most of the canals in the system are in need of improvement. The last system wide flow studies were performed in 1969 (Upper Valley) and 1970 (Lower Valley) and those studies revealed losses due to seepage and management. Since that time there have been physical and managerial changes in the system as well as improvements in flow measurement techniques that would justify a new assessment of system losses. Once current losses are quantified, measures to reduce those losses can be identified and implemented. Possible measures may include canal lining or sealing and reshaping.

Anker Pond is also a control junction that is in need of improvement. It is a simple structure with an average flow rate of 90 cfs passing through it during the irrigation season. Automated monitoring and control would also be useful at this location.

The Humboldt Plug at the end of the system is a nothing more than a soil and rubble dam in the river. Although the Plug is crude, its function is crucial for irrigation delivery to 23% of the 37,500 irrigable acres within the district. The plug has failed several times in the history of the district and should be replaced with an engineered structure.

2.4 SCOPE OF PLAN

2.4.1 Description of PCWCD

Farr West Engineering personnel along with Bennie Hodges of the PCWCD and Dan Dyer of Dyer Engineering Consultants, Inc. toured both the Upper and Lower Valley portions of the PCWCD delivery systems prior to the creation of the plan. The purpose of the tour was to inspect and become familiar with the location and condition of PCWCD facilities including dams, canals, diversion structures and district headquarters. Additional visits were later made to selected facilities to gather more detailed information. Descriptions of facilities are based on onsite inspections as well as information gathered from PCWCD personnel and the Nevada Department of Water Resources. Facility descriptions in the plan include the location of the facility, a physical description, and a brief history (if available).

2.4.2 Water Rights and System Capacity and Demand

The plan describes water rights allotted and distributed to owners by the PCWCD. It includes rights owned by individual farmers, PCWCD, the State of Nevada and the United States. The plan also describes storage facilities and their capacities as well as system demands according to irrigable acreage.

2.4.3 Conservation

Potential conservation measures are identified and recommendations regarding their implementation are made. Both District and on-farm measures are described, evaluated and encouraged by the plan.

2.4.4 Condition Assessment

The condition of each of the facilities described in the plan (structures and canals) has been assessed based on visual inspection by Farr West Engineering personnel and the last flow studies that were performed. Condition assessments are also based on information provided by Nevada State Dam Inspection Reports. Facility assessments include a determination as to whether the facility has outlived its useful life and is in need of replacement.

2.4.5 Proposed Improvements

Recommendations for the improvement of facilities relate directly to the condition assessment. All recommendations are made with respect to the condition of the facility. Recommendations to improve or replace a facility are made independent of cost. The criteria for proposed improvements are conservation, maintaining capacity, efficiency of operation and maintenance and safety. Each recommendation describes the problem, provides a solution, and specifies the objectives of the improvements. Higher priority proposed projects include estimates.

2.4.6 Estimates

Cost estimates have been created for 8 of the 28 proposed projects. Projects that have been estimated are those that play a substantial role in the efficient operation of the system and are in urgent need of replacement or renovation. Projects with cost estimates include;

- Replacement of Pitt-Taylor Diversion Dam and Structure
- Replacement of the Upper and Lower Pitt-Taylor reservoir outlet structures
- Installation of a back up structure at the end of the Humboldt (Plug)
- Replacement of Old Channel / Union Canals Diversion Structure
- Replacement of Anker Pond
- Addition of Slide Gates to Pitt Dam
- Addition of Slide Gates to Rodgers Dam

As higher priority projects are completed, cost estimates should be made for the remaining projects on the plan list.

2.4.7 Prioritization of Projects

Proposed projects have been ranked according to the same factors that were used to make recommendations for their replacement or renovation; conservation, capacity, operation and maintenance and safety. All projects have been prioritized regardless of whether or not they were estimated.

2.4.8 Funding Alternatives

High priority projects will be funded through a combination of grants from the State of Nevada Board of Finance, the United States Bureau of Reclamation, the PCWCD Capital Improvement Fund as well as in-kind services from PCWCD personnel and equipment.

2.4.9 Implementation Plan

The implementation of the proposed projects will need to occur in phases because projects have to be completed between irrigation seasons. For this reason only the first project's (Pitt-Taylor Diversion Dam replacement) schedule is included in the plan. As projects near completion, those projects next in priority can then be scheduled.

Chapter 3
DESCRIPTION OF PERSHING COUNTY WATER CONSERVATION DISTRICT

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DESCRIPTION OF PERSHING COUNTY **1**

WATER CONSERVATION DISTRICT **1**

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3.1 DESCRIPTION OF PCWCD MANAGEMENT STRUCTURE

3.1.1 Board of Directors

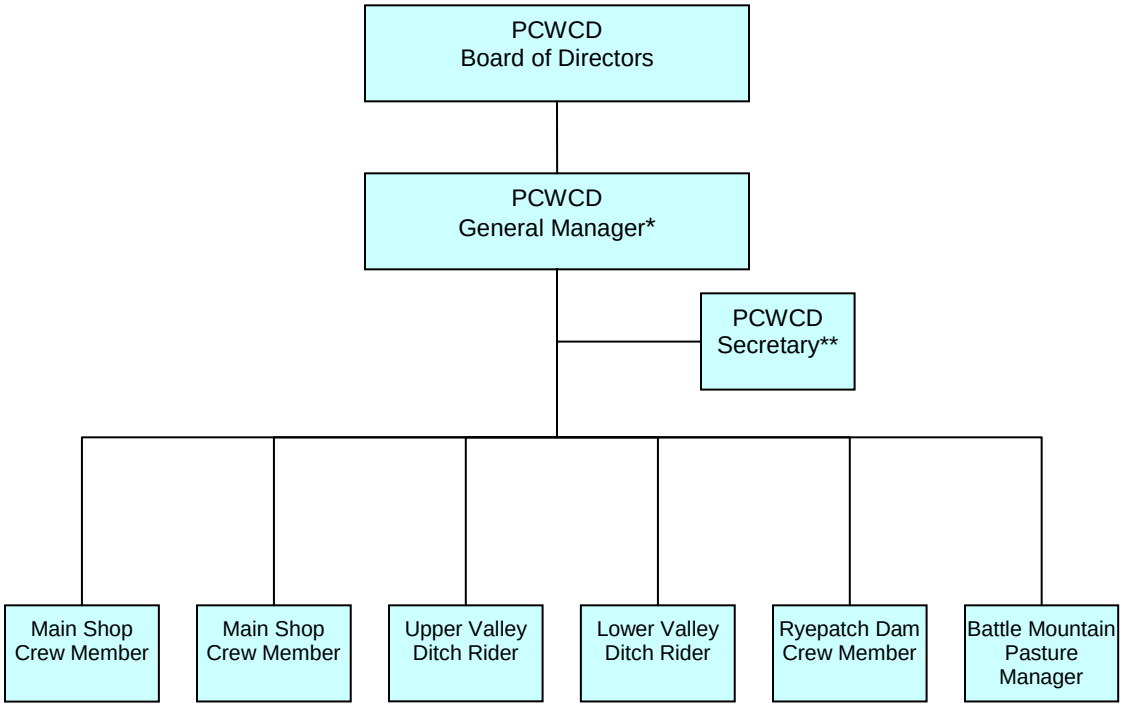
The PCWCD is governed by a seven member Board of Directors representing the District constituency. Elections are held every 4 years to elect board members and any constituent of the PCWCD is eligible to run for a Board position. The PCWCD General Manager serves as Secretary to the Board (a Board appointment). The Board of Directors is organized and functions in accordance with the Nevada Revised Statutes (NRS) 539 (Nevada Irrigation Districts Act).

3.1.2 PCWCD Staff

The seven member staff of the PCWCD is managed by the District General Manager, Mr. Benjamin Hodges. The Board and staff organization is shown in figure 3.1.

FIGURE 3.1

PCWCD Organization Chart



*The General Manager also serves as Secretary to the PCWCD Board. The position of Secretary is a Board appointment.
**The Secretary also serves as the Treasurer of the PCWCD Board. The position of Treasurer is a Board appointment.

3.2 DESRIPTION OF PCWCD BUILDINGS AND EQUIPMENT

3.2.1 PCWCD Buildings

The PCWCD shop and administrative office are housed in a 4000 sq. foot building situated on a three acre parcel. The administrative portion of the facility includes an office for the District General Manager, a reception area and a conference room. The remainder of the building is used as a fabrication and maintenance equipment shop. The property is fenced and has space for storing PCWCD heavy equipment and construction materials.

3.2.2 PCWCD Equipment

The following equipment is owned and operated by the PCWCD for the purpose of maintaining canals and structures within the District.

1. 3, International 10 wheel dump trucks.
2. 1, 1982 Peterbilt Tractor with low-boy trailer.
3. 1, 1992 Peterbilt Tractor with belly dump trailer.
4. 1, John Deere 690 Excavator with standard reach boom (also has a 50’ auxiliary boom).
5. 1, John Deere 790 Excavator with 60’ boom.
6. 1, John Deere 710 Backhoe.
7. 1, Caterpiller 950 Wheel Loader
8. 1, Motor Grader

In addition to the above equipment the PCWCD rents the following:

1. Dozer

3.3 DESCRIPTION OF WATER SYSTEM FACILITIES

The facilities owned, operated, and maintained by PCWCD are:

- Pitt-Taylor Diversion Dam
- Upper Pitt-Taylor Reservoir/Dam
- Lower Pitt-Taylor Reservoir/Dam
- Young Dam
- Pitt Dam
- Irish-American Dam
- Rodgers Dam
- Sommers Dam
- Big Five Dam
- Humboldt River Plug
- Pitt-Taylor Canal
- Young Canal
- Old Channel Canal (including 12 laterals)
- Union Canal (supplies the Big Meadow, Irish-American, and Arobio Ditches)
- Rodgers Canal
- Union-Rodgers Canal (supplies the Rodgers, Seven, Tule, Lakeshore and Reed laterals).
- Union Lateral (supplies the Upper Lakeshore, West, East, and Reed laterals)
- Anker Pond (supplies the West Lakeshore, East Lakeshore, and Anker laterals)

See figures 3.2 and 3.3 which diagram the Upper-Valley and Lower-Valley distribution systems.

FIGURE 3.2

Upper-Valley Distribution System

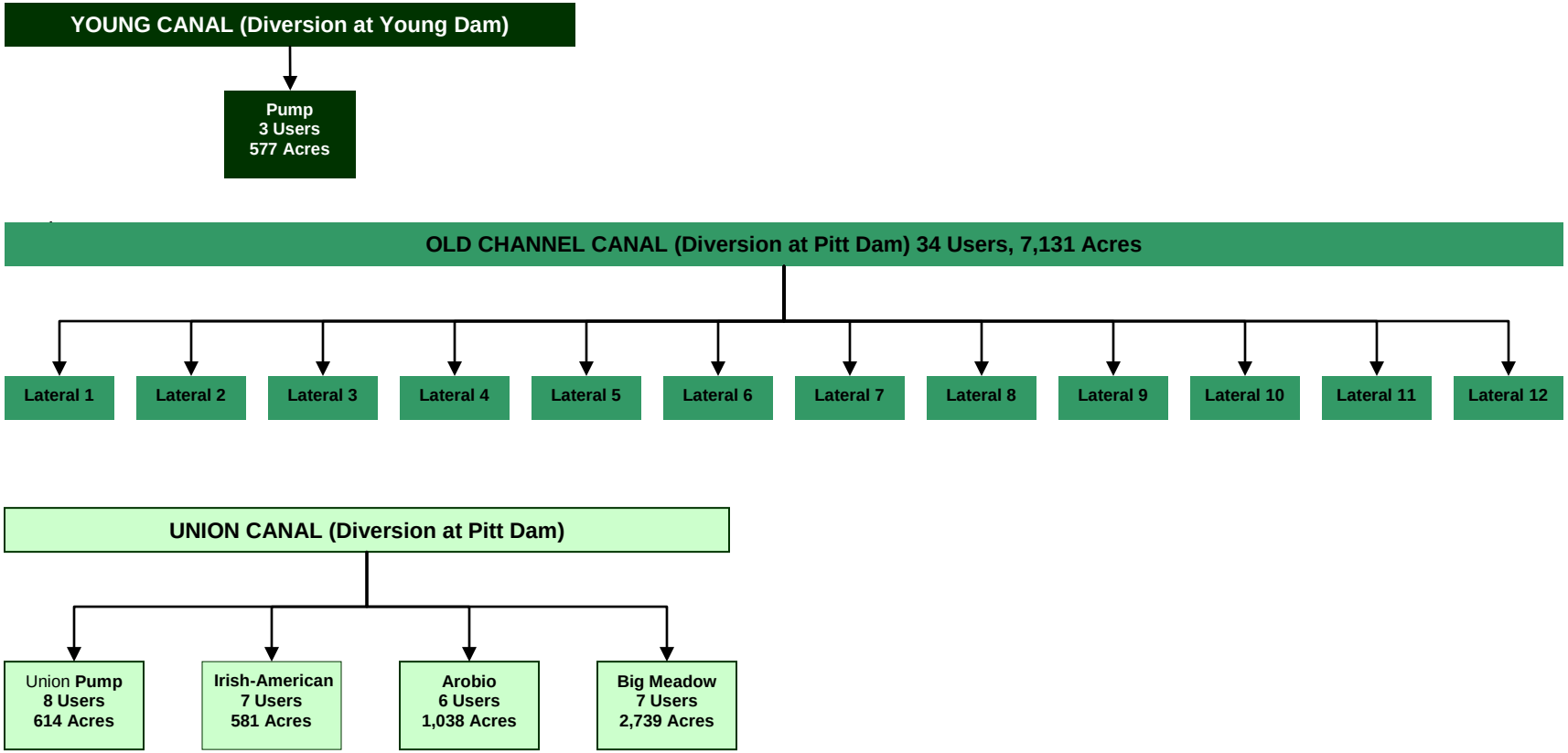
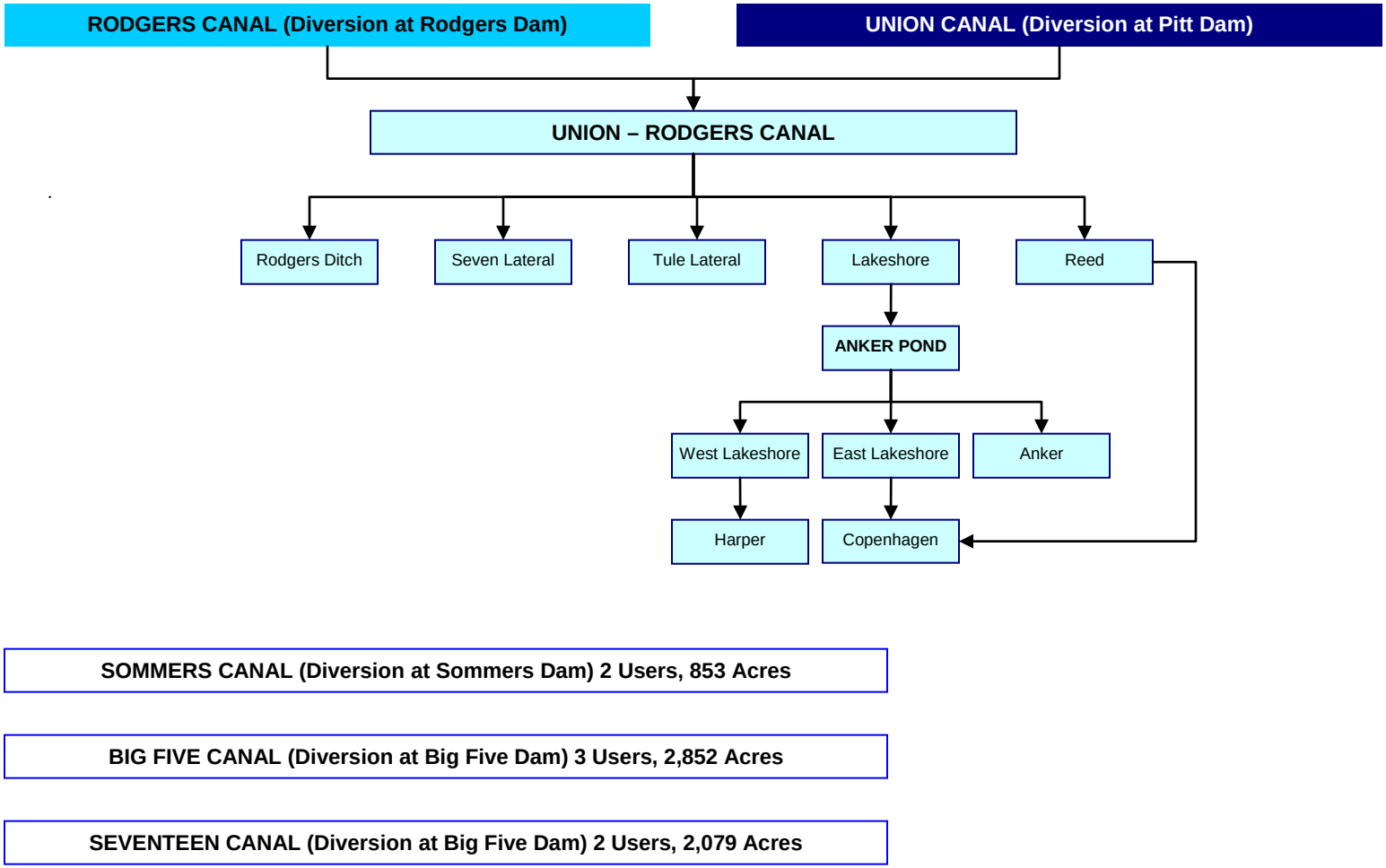


FIGURE 3.3

Lower-Valley Distribution System



Per State Dam inspection reports there are two different drainage areas in the PCWCD system. The Upper and Lower Pitt Taylor Dams share one watershed and the Young, Pitt, Irish-American, Rodgers, Sommers and Big Five Dams share the other. The following descriptions of these watersheds are taken from inspection reports prepared for the State of Nevada by GA Engineering and Planning:

Pitt-Taylor Reservoirs
"The Upper and Lower Pitt-Taylor Dams are located at the lower end of the Humboldt River watershed. The principal source of water for the Humboldt River is snowmelt in the mountains of north-central and northeastern Nevada. The reservoir is located in the alluvial floor with the Majuba Mountains to the west and Thunder Mountain to the east."

"The drainage area for the Humboldt River at Imlay, Nevada is 15,500 square miles (per the USGS). The average annual precipitation in the vicinity of the reservoir ranges from 4 inches on the valley floor to 20 inches on the adjoining mountain tops. The average annual runoff is less then one inch and annual evaporation is 51 inches. The soil in and around the reservoir consists of unconsolidated alluvial silt and sand. Vegetation in the vicinity of the reservoir includes sagebrush and saltcedar (a member of the Tamarisk family)."

"The USGS monitors the Humboldt River flows at Imlay, Nevada and have determined flood frequencies for the Humboldt River above the Upper Pitt-Taylor Reservoir to be the following:

10-Year Flood	*2,000 cubic feet*
25-Year Flood	*3,000 cubic feet*
50-Year Flood	*3,800 cubic feet*
100-Year Flood	*4,800 cubic feet*

Nevertheless these numbers are limited by the conveyance capacity of the diversion ditch that supplies the reservoir."

Young, Pitt, Irish-American, Rodgers, Sommers, and Big Five Dams
"The drainage area for the Young, Pitt, Irish-American, Rodgers, Sommers and Big Five Dams and Humboldt River is north of Lovelock and includes approximately 16,300 square miles. The Young, Pitt, Irish-American, Rodgers, Sommers and Big Five Dams are downstream of the Ryepatch Reservoir and the Humboldt River flows into the Dams are regulated by Ryepatch Reservoir."

"According to watershed characteristics published by the State of Nevada Division of Water Resources, The average annual precipitation ranges from 4 to 6 inches, average annual runoff is less than ½ inch, and annual evaporation is 50 to 52 inches."

"As per the best available monitoring data from the USGS, the following flood frequencies were projected for the dams mentioned above:

10-Year Flood	*3,000 cubic feet*
25-Year Flood	*4,500 cubic feet*
50-Year Flood	*6,000 cubic feet*
100-Year Flood	*8,000 cubic feet*

3.3.1 Pitt-Taylor Diversion Dam and Diversion Structure

3.3.1.1 Location. The Pitt-Taylor Diversion Structures are located on the Humboldt River and can be found on the Mill City, Nevada 7.5 minute map (see figure 3.21). The structure is located in the northwest corner of Section 29, Township 33 North, and Range 35 East. The latitude for the structure is 40 degrees, 42 minutes, and 29.97 seconds. The longitude is 118 degrees, 4 minutes, and 44.89 seconds.

A preliminary engineering report summarizing the condition and replacement options for the Pitt-Taylor diversion structure has been prepared by Dyer Engineering Consultants Inc. and is included in Appendix A of this plan.

3.3.2 Upper Pitt-Taylor Dam

3.3.2.1 Location. The Upper Pitt-Taylor Dam is located approximately 115 miles northeast of Reno, Nevada, and about 40 miles north of Lovelock, Nevada. The reservoir is on the east shore of the Ryepatch Reservoir and the Humboldt River. The dam and the reservoir can be found on the Rye Patch Reservoir North, Nevada Pershing County 7.5 minute topographic map (see figure 3.22) and the Eugene Mountains: 1:1,000,000 scale topographic map. The Upper Pitt-Taylor Dam is located in Section 17, Township 32 North, and Range 33 East. The outlet structure for the Dam is located in Section 16, Township 32 North, and Range 33 East. The latitude for the Dam is 40 degrees, 38 minutes, 20 seconds. The longitude is 118 degrees, 16 minutes, 30 seconds.

3.3.2.2 Physical Description and History. The following description comes from the Dam Safety Inspection Report prepared by GA Engineering and Planning for the State of Nevada;

"Upper Pitt Taylor Dam is an earthen dike, approximately 6,500 feet in length. The dams height (measured from the toe to the crest on the downstream side of the dam at the outlet structure) is 16 feet. The dam runs generally southeast to northwest for 4,000 feet then turns to the west for 2,500 feet. Top width of the dam is 22 feet. The dam's crest is used as a road. The downstream side slope of the dam is 2 feet horizontal to 1.5 feet vertical on the upper 8 feet and 8 feet horizontal to 1 foot vertical for the lower 8 feet."

The control structure on the dam was built with steel reinforced concrete and has three openings. The reservoir side openings measure 4 feet high by 4 feet 6 inches wide. The outlet side openings are arched and are 5 feet 3 inches high from the bottom of the opening to the top of the arch and 4 feet 10 inches wide. Water flow through the openings was originally controlled by three wooden slide gates however only the center gate is currently operational with the other two being in the closed position. The gates are 4 feet 10 inches wide by 6 feet high and the center gate is operated with a manual rack and pinion mechanism. The distance from the opening on the reservoir side to the outlet on the canal side is approximately 46 feet. See Appendix B for a copy of an original contract drawing of the structure.

Construction on the Upper Pitt-Taylor Reservoir began in 1909 and water was turned into the reservoir for the first time in November of 1912. In 1915 the dam and the levees were raised to 19 feet in order to increase storage. The Upper and Lower Pitt-Taylor Reservoirs were the main storage facilities prior to the construction of the Rye Patch Reservoir in 1935 however their capacities were insufficient to meet water storage needs.

The State of Nevada Defines the Upper Pitt-Taylor Reservoir as an intermediate sized dam with a reservoir capacity of approximately 22,000 acre feet with a top of dam capacity of 29,000 acre feet. The dam is classified by the State as a long term storage dam, which means that it is used for recreation or storage of irrigation water. The Upper Pitt-Taylor Dam is considered a low hazard dam because if breached the water in the Upper Pitt-Taylor would flow into the Lower Pitt Taylor. The criteria for a low hazard dam is a 500 year event on a large or very large structure (>1000 acre feet). Figure 3.4 shows the road at the crest of the dam, Figure 3.5 shows the rip rap on the dam bank, Figure 3.6 is a photograph of the outlet structure on the canal side and figure 3.7 is a photograph of the outlet canal connecting the two Pitt-Taylor Reservoirs. The Upper Pitt-Taylor Reservoir discharges directly into the Lower Pitt-Taylor. The National Identification Number for the Upper Pitt-Taylor Dam is NV00062.

FIGURE 3.4

Road on the crest of Upper Pitt-Taylor Dam

FIGURE 3.5

Rip Rap on the embankment of Upper Pitt-Taylor Dam

FIGURE 3.6

Canal side of Upper Pitt-Taylor outlet structure

FIGURE 3.7

Outlet canal of Upper Pitt-Taylor Reservoir

3.3.3 Lower Pitt-Taylor Dam

3.3.3.1 Location. The Lower Pitt-Taylor Dam is located approximately 110 miles northeast of Reno,Nevada, and about 35 miles north of Lovelock, Nevada. The reservoir is on the east shore of the Ryepatch Reservoir and the Humboldt River. The dam and the reservoir can be found on the Rye Patch Reservoir South, Nevada Pershing County 7.5 minute topographic map (see figure 3.22) and the Eugene Mountains: 1:1,000,000 scale topographic map. The Lower Pitt-Taylor Dam is located in Section 17, Township 32 North, and Range 33 East. The outlet structure for the Dam is located in the South one-half of Section 30, Township 32 North, and Range 33 East. The latitude for the Dam is 40 degrees, 36 minutes, 17 seconds. The longitude is 118 degrees, 18 minutes, 5 seconds. The elevation of the reservoir is 4147 feet.

3.3.3.2 Physical Description and History. The dam is an earthen structure, approximately 3000 feet long and was constructed of native soils borrowed from both sides of the embankment. The height of the dam measured at the outlet from the toe to the crest on the upstream side is 36 feet. The dam runs southeast to northwest. The dam is 22 feet wide at the crest and is used as a road. The slope on the downstream side of the dam is 4:1.5 and the slope on the reservoir side is 2:1.5 on the upper 12 feet and 8:1 on the lower 24 feet (see figure 3.8). The upper 12 feet of the dam has rip-rap and there is a spillway southeast of the dam.

The reservoir outlet works is constructed of steel reinforced concrete and has two arched openings on the reservoir side that transition into a single 6 foot by 7 foot arched opening on the outlet side (see figure 3.9). On the reservoir side two 3 foot 6 inch by 4 foot gates are controlled by a hand operated rack and pinion style system (see figures 3.9 and 3.10). The Lower Pitt-Taylor discharges directly into Rye Patch Reservoir. The State of Nevada defines the Lower Pitt-Taylor Reservoir as an intermediate sized dam with a reservoir capacity of approximately 13,000 acre feet with a top of dam capacity of 21,000 acre feet. The dam is classified by the State as a long term storage dam, which means that it is used for recreation or storage of irrigation water.

The Pitt-Taylor Reservoirs were intended for irrigation storage. Construction on the Lower Pitt-Taylor Reservoir began in 1909. Water was turned into the reservoir for the first time in November of 1912. In 1915 the dam and the levees were raised to 38 feet to increase storage. The Upper and Lower Pitt-Taylor Reservoirs were the primary storage facilities prior to the construction of the Ryepatch Reservoir in 1935 however their capacities were insufficient to meet water storage needs.

FIGURE 3.8

Slope on reservoir side of Lower Pitt-Taylor

FIGURE 3.9

Outlet structure on Lower Pitt-Taylor dam

FIGURE 3.10

Lower Pitt-Taylor outlet works

FIGURE 3.11

Lower Pitt-Taylor outlet gate control

The Lower Pitt-Taylor Dam is considered a low hazard dam because if breached the water in the Lower Pitt-Taylor would flow into Ryepatch Reservoir. The criteria for a low hazard dam is a 500 year event on a large or very large structure (>1000 acre feet). The National Identification Number for the Lower Pitt-Taylor Dam is NV00063.

3.3.4 Young Dam

3.3.4.1 Location. The Young Dam is located on the Humboldt River in Township 28 North, Range 32 East. The Dam can be found on the Arabia, Nevada 7.5 minute topographic map (see figure 3.23). The Dam is at elevation 4025 feet (approximate), latitude 40 degrees, 16 minutes, and 59.54 seconds and longitude 118 degrees, 22 minutes, and 46.36 seconds.

3.3.4.2 Physical Description. The Young Dam consists of three large steel reinforced buttresses and concrete abutments that form four bays. Three of the four bays have integrated keyways for flash boards that back up and control the height of the water behind the dam. The fourth bay has a jack operated slide gate used to control the flow though the dam. The height of the dam from toe to crest is 4 feet (approximate) and the length of the crest is approximately 30 feet (see figure 3.12).

The Young Dam is used to divert water to the Young Canal. The Young Dam has not been identified by the state and does not have either a State or National I.D Number.

FIGURE 3.12

The Young Dam

3.3.5 Pitt Dam

3.3.5.1 Location. The Pitt Dam is located on the Humboldt River in the east half of Section 6, Township 27 North, Range 32 East. The Dam can be found on the Lovelock, Nevada 7.5 minute topographic map (see figure 3.24). The Dam is at elevation 4005 (approximate), latitude 40 degrees, 14 minutes, 5 seconds, and longitude 118 degrees, 25 minutes, and 14 seconds.

3.3.5.2 Physical Description and History. The Pitt Dam is an eight-buttress dam constructed of steel reinforced concrete (see figure 3.13). The banks on both sides downstream of the dam are armored with rip-rap and the dam has a steel reinforced concrete toe and erosion control slab. The height of the dam from toe to crest is 15 feet and the length of the crest is approximately 85 feet. The dam has two railcar chassis placed end to end that provide the structure for a vehicular bridge that runs the length of the crest (see figure 3.13). Steel reinforced wooden flash boards in seven of the eight bays control the height of the water behind the dam and a manually operated rack and pinion operated slide gate in the eighth bay controls the release of water from the dam. The dam is used to back up water for diversion to the Old Channel and Union Canals. The Pitt Dam was constructed in 1915.

The Pitt Dam is considered a small dam by State of Nevada since the potential reservoir capacity (approximately 150 acre feet) is less than 1,000 acre feet. The Pitt Dam is used for irrigation purposes and is considered a low hazard dam because if breached the increased flows would be insignificant. The National Identification Number for the Pitt Dam is NV00203.

FIGURE 3.13

View of Pitt Dam from the down stream side. The dam has a total of 9 buttresses.

FIGURE 3.14

Looking from west to east across the Pitt Dam Bridge. Note gate control on the left.

3.3.6 Irish American Dam

3.3.6.1 Location. The Irish-American Dam is located on the Humboldt River in the south-eastern corner of Section 7, Township 27 North, Range 32 East. The Dam can be found on the Lovelock, Nevada 7.5 minute topographic map (see figure 3.24). The Dam is at elevation 3991 feet (approximate), latitude 40 degrees, 13 minutes, 3.43 seconds, and longitude 118 degrees, 25 minutes, and 23.71 seconds.

3.3.6.2 Physical Description. The Irish-American Dam is nothing more than a drop structure. There are no control features on or near the dam and no water is diverted at that location.

3.3.7 Rodgers Dam

3.3.7.1 Location. The Rodgers Dam is situated just northeast of Lovelock on the Humboldt River. It is located in the northeast quarter of Section 24, Township 27 North, Range 31 East. The latitude of the dam is 40 degrees, 11 minutes, 57 seconds and the longitude is 118 degrees, 26 minutes, 27 seconds. The dam is at elevation 3995 and can be found on the Lovelock, Nevada 7.5 minute series topographic map (see figure 3.25).

3.3.7.2 Physical Description. The Rodgers Dam is constructed of eight steel reinforced concrete buttresses and abutments. The height of the dam from toe to crest is 10 feet and the length of the crest is 80 feet. There is a steel grate foot bridge on the crest of the dam and an erosion control slab on the downstream side. The height of the water on the upstream side is controlled by flash boards in nine bays that average ten feet in width (see figure 3.15 below).

FIGURE 3.15

Rodgers Dam

The Rodgers Dam is considered a small dam by State of Nevada since the potential reservoir capacity (approximately 50 acre feet) is less than 1,000 acre feet. The Rodgers Dam is used for irrigation purposes, is a diversion for the Rodgers Canal and is considered a low hazard dam because if breached the increased flows would be insignificant. The National Identification Number for the Rodgers Dam is NV00202.

3.3.8 Sommers Dam

3.3.8.1 Location. The Sommers Dam is situated on a diversion from the Humboldt River down stream of an earthen plug in the River south of Lovelock. It is located on the north-central edge of Section 1, Township 25 North, Range 31 East. The latitude of the Dam is 40 degrees, 4 minutes, and 14.72 seconds and the longitude is 118 degrees, 26 minutes, and 46.76 seconds. The Dam is at elevation 3920 (approximate) and can be found on the Wildhorse Pass, Nevada 7.5 minute series topographic map (see figure 3.26).

3.3.8.2 Physical Description and History. The Sommers Dam consists of five steel reinforced concrete buttresses. The downstream banks on either side of the dam are armored with rip-rap. The dam has integrated keyways for wooden flash boards that back up and control the height of the water behind the dam in five of the six bays and a jack operated slide gate in the sixth that controls the release of water from the dam. The dam has a steel reinforced toe and erosion control slab. The height of the dam from toe to crest is 7'1" and the length of the crest is approximately 50 feet (see figure 3.16). The Sommers Dam was built in 2001 by PCWCD crews.

FIGURE 3.16

Sommers Dam

The Sommers Dam is used to divert water to the Sommers Canal. It is not identified by the state and does not have a State or National I.D Number.

3.3.9 Big Five Dam

3.3.9.1 Location. The Big Five Dam is situated on a diversion from the Humboldt River south of Lovelock. It is located in the north-central edge of Section 11, Township 25 North, Range 31 East. The latitude of the dam is 40 degrees, 3 minutes, 21 seconds North and the longitude is 118 degrees, 28 minutes West. The dam is at elevation 3920 (approximate) and can be found on the Wildhorse Pass, Nevada 7.5 minute series topographic map (see figure 3.26).

3.3.9.3 Physical Description and History. The Big Five Dam structure consists of five steel reinforced concrete buttresses. The banks on either side of the Dam are armored with rip-rap. The Dam has integrated keyways for wooden flash boards that back up and control the height of the water behind the dam. There is a 10 foot long erosion control slab at the toe of the dam. The height of the dam from toe to crest is 5 feet and the length of the crest is approximately 50 feet. There is a plank foot bridge across the top of the dam (see figure 3.17). The State of Nevada approved the construction of the dam in 1956 but the dam still had not been constructed by 1962. The exact year of construction is unknown.

FIGURE 3.17

The Big Five Dam

The Big Five Dam is considered a small dam by the State of Nevada since the potential reservoir capacity (approximately 45 acre-feet) is less then 1,000 acre-feet. The Dam is used for irrigation purposes and is considered a low hazard dam because there is no one living near the dam and if breached the increased flows would be insignificant. The dam is a diversion for both the Big Five and Seventeen Canals. The State of Nevada identification number for the Big Five Dam is J-19 and the National identification number is NV00060.

3.3.10 Pitt-Taylor Diversion Canal

The Pitt-Taylor Diversion Canal originates at the Pitt-Taylor diversion dam on the Humboldt River and ends at the inlet of the Upper Pitt-Taylor Reservoir. The reservoir inlet is located in Section 10, Township 32 North, Range 33 East. The latitude of the inlet is 40 degrees, 39 minutes, 15 seconds North and the longitude is 118 degrees, 14 minutes, 58 Seconds West. The inlet is at elevation 4156 and can be found on the Imlay, Nevada 7.5 minute series topographic map (see figure 3.21).

The original design of the canal included a base width of 25 feet, a top width of 39 feet, and a depth of 7 feet (the canal dimensions for side hill slopes was 18, 42, and 8 feet respectively).The original design flow capacity of the canal was 300 cfs. The Pitt-Taylor diversion canal is approximately 13.7 miles long and has only one diversion which supplies water to the Flying M Ranch.

3.3.11 Young Canal

The Young Canal originates at the Young Dam. It is located on the Humboldt River in Township 28 North, Range 32 East and can be found on the Arabia, Nevada 7.5 minute topographic map (see figure 3.23). The Dam is at elevation 4,025 (approximate), latitude 40 degrees, 16 minutes, and 59.54 seconds North and longitude 118 degrees, 22 minutes, and 46.36 seconds West. The diversion provides water to only one user.

3.3.12 Old Channel Canal and Diversion Structure

The Old Channel Canal originates at Holmstrom Road approximately 0.6 miles downstream of a diversion at the Pitt Dam. The head of the canal can be found on the Lovelock, Nevada Pershing County 7.5 minute topographic map (see figure 3.24) and is located in Section 6, Township 27 North, and Range 32 East. The latitude for the origin is 40 degrees, 13 minutes, 52 seconds North. The longitude is 118 degrees, 25 minutes, 40 seconds West. The elevation at this point is 4,006 feet. The canal flows westward for 4 miles, averages 24 feet in width at the bottom and has a total of 12 laterals that serve 34 users irrigating 7,131 acres. A flow study done by PCWCD, The Big Meadow Soil Conservation District (BMSCD), and the USDA Soil Conservation Service in 1969 recorded an average flow in the canal of 40 cfs (see figure 3.18).

FIGURE 3.18

Old Channel Diversion Structure

3.3.13 Union Canal and Diversion Structure

The Union Canal shares the same diversion and origin (see figure 3.19) as the Old Channel Canal. The canal is 4 miles long, averages 20 feet in width at the bottom and ends where it joins the Rodgers Canal to become the Union–Rodgers. The canal has 4 diversions; The Union Pump serving 8 users and 614 acres, the Irish–American Canal serving 7 users and 581 acres, the Arobio Canal serving 6 users and 1,038 acres, and the Big Meadow Canal serving 7 users and 2,739 acres. Average flow in the canal in 1969 was approximately 162 cfs. This estimate is may be close to current flow rates.

FIGURE 3.19

Union Canal Control Structure (Union structure is at left. The structure at right center is the Old Channel).

3.3.14 Rodgers Canal

The Rogers Canal originates at a diversion at the Rogers Dam. The location of the diversion can be found on the Lovelock, Nevada Pershing County 7.5 minute topographic map (see figure 3.25) and is located in Section 24, Township 27 North, and Range 31 East. The latitude is 40 degrees, 11 minutes, 54 seconds North. The longitude is 118 degrees, 26 minutes, 26 seconds West. The elevation at the diversion is 3,983 feet. The canal flows to the Southwest for 1.5 miles at which point it joins the Union Canal to form the Union Rodgers. The canal averages 23 feet in width at the bottom and has no diversions.

3.3.15 Union-Rodgers Canal

The origin of the Union-Rodgers Canal can be found on the Lovelock, Nevada Pershing County 7.5 minute topographic map (see figure 3.29) and is located in Section 25, Township 27 North, and Range 31 East. The latitude is 40 degrees, 10 minutes, 59 seconds North. The longitude is 118 degrees, 27 minutes, 21 seconds West. The elevation at the origin is 3,980 feet. The Union-Rodgers supplies most of the irrigation water used in the lower valley. It is 10 miles long, averages 32 feet in width at the bottom and has five main diversions; Rodgers Ditch and Tule, Seven, Lakeshore and Reed Laterals. In 1970 the average flow in the Union-Rodgers was 100 cfs. Since there has been little change since then that flow is probably still accurate. The canal supplies 34 users with 19,042 irrigated acres. The Union-Rodgers terminates in Section 2, Township 26 North, Range 31 East. The latitude is 40 degrees, 3 minutes, 24 seconds North, longitude is 118 degrees, 28 minutes, 32.4 seconds West and the elevation is 3,914 feet.

3.3.16 Rodgers Ditch

The Rodgers Ditch can be found on the Lovelock, Nevada 7.5 minute topographic map (see figure 3.29) and is located in Section 3, Township 26 North, and Range 31 East. It originates at latitude 40 degrees, 9 minutes, 4 seconds North, longitude 118 degrees, 28 minutes, 31.5 seconds West and elevation 3,960 feet. It ends at latitude 40 degrees, 8 minutes, 38 seconds North, longitude 118 degrees, 29 minutes, 5 seconds West and elevation 3,954 feet. The Rodgers Ditch serves two of the 34 users in the Union-Rodgers system, is one mile long, averages 10 feet in width at the bottom and has an average flow of 22 cfs.

3.3.17 Seven Lateral

The Seven Lateral serves only one of the 34 users included in the Union-Rodgers system. The canal originates (see figure 3.29) at latitude 40 degrees, 9 minutes, 30.13 seconds North and longitude 118 degrees, 27 minutes, 32.63 seconds West, and flows for seven miles ending at latitude 40 degrees, 4 minutes, 50.36 seconds North and longitude 118 degrees, 26 minutes, 33.76 seconds West. Originating and terminating elevations are 3,962 and 3,920 respectively. The canal has a bottom width averaging eight feet and has an average flow of 26 cfs.

3.3.18 Tule Lateral

Tule Lateral originates (see figure 3.29) at 40 degrees, 9 minutes, 30.11seconds North and longitude 118 degrees, 27 minutes, 22.59 seconds West, and flows for two miles ending at latitude 40 degrees, 7 minutes, 46.23 seconds North and longitude 118 degrees, 27 minutes, 22.59 seconds West. Starting elevation is 3,962 feet and ending is 3,940 feet. The lateral serves two of the Union-Rodgers thirty four users, has an average bottom width of fifteen feet and an average flow of 26 cfs.

3.3.19 Lakeshore Lateral

The Lakeshore Lateral originates (see figure 3.29) at latitude 40 degrees, 8 minutes, 37.89 seconds North; longitude 118 degrees, 28 minutes, 31.50 seconds West; and ends at latitude 40 degrees, 6 minutes, 54.26 seconds North; longitude 118 degrees, 29 minutes, 56.55 seconds West. The beginning and ending elevations are 3,953 and 3,940 respectively. The lateral is 2.5 miles long with an average bottom width of twenty feet and average flow of 48 cfs.

There are no users on the Lakeshore Lateral which supplies Anker Pond. Anker Pond in turn diverts water to the West and East Lakeshore and Anker ditches.

3.3.20 Reed Lateral

This lateral originates (see figure 3.29) at latitude 40 degrees, 7 minutes, 46.22 seconds North; longitude 118 degrees, 28 minutes, 30 seconds West; and ends at latitude 40 degrees, 6 minutes, 54.26 seconds North; longitude 118 degrees, 29 minutes, 56.55 seconds West. and ends at latitude 40 degrees, 6 minutes, 55.17 seconds North; longitude 118 degrees, 29 minutes, 19.40 seconds West. The lateral begins at elevation 3,948 and ends at 3,940 feet. It is 1.5 miles long with an average bottom width of nine feet and serves four users. It can also supply water to the Copenhagen Lateral.

3.3.21 Copenhagen Lateral

The Copenhagen Lateral originates (see figure 3.30) at the junction of Reservation and Carpenter Roads just east of Anker Pond and can be supplied by both the Reed and East Lakeshore Laterals. The lateral runs south for three miles along Carpenter Road and serves seven users. It starts at an elevation of 3,940 and ends at 3,917 feet with an average bottom width of eight feet and average flow of 21 cfs.

3.3.22 Anker Pond

Anker Pond can be found next to Reservation Road on the Wildhorse Pass, Nevada Pershing County 7.5 minute topographic map (see figure 3.30) and is located in Section 16, Township 26 North, and Range 31 East. The latitude is 40 degrees, 6 minutes, 54 seconds North. The longitude is 118 degrees, 29 minutes, 57 seconds West. The elevation at the pond is 3,940 feet.

The volume of Anker pond is approximately .25 acre feet and it is fed by the Lakeshore Lateral. Its function is to act as a distribution junction for the West Lakeshore, East Lakeshore, and Anker ditches. The pond has steel reinforced concrete sides only at the diversion structures. The remainder of the pond is bordered by earthen dikes (see figure 3.20). There are two 48 inch wide control gates for the West Lakeshore, one 42 inch wide gate for the Anker and two 42 inch openings with stop logs for the East Lakeshore. The current estimated combined flow out of the pond is 75 to 90 cfs.

FIGURE 3.20

Anker Pond control gates for Anker and West (far right) Lakeshore ditches

The three ditches supplied by Anker Pond (see figure 3.30) have the following characteristics;

West Lakeshore – 3.5 miles long, 4 users, 28 cfs average flow (also supplies the Harper Ditch)
East Lakeshore – 1.5 miles long, 3 users, 18 cfs average flow (also supplies the Copenhagen)
Anker – 4.5 miles long, 11 users, 29 cfs average flow

3.3.23 Sommers Canal

The Sommers Canal originates (see figure 3.26) at the Sommers Dam and flows west for 1.5 miles. In 1970 the average flow in the canal was 20 cfs and current flows are comparable. The Sommers Canal supplies two users with 853 acres.

3.3.24 Big Five Canal

The Big Five Canal originates (see figure 3.26) at the Big Five Dam and flows west for approximately 3.5 miles. In 1970 the Big Five had the highest flows in the lower valley at 38 cfs and that is likely still the case since the irrigated acreage is the same. The Big Five Canal serves 3 users with 2,852 acres.

3.3.25 Seventeen Canal

The Seventeen Canal also originates (see figure 3.26) at the Big Five Dam and flows 4.3 miles to the southwest. The average flow in 1970 was 32 cfs and is comparable with current flows since the irrigated acreage is the same. The Seventeen Canal serves 2 users with 2,079 acres.

3.3.26 Humboldt River Plug

The Humboldt Plug (see figure 3.21) is located just beyond the diversion for the Big Five Canal at approximately Township 26 North, and Range 31 East. The latitude is 40 degrees, 4 minutes, 18 seconds North. The longitude is 118 degrees, 26 minutes, 2 seconds West. The elevation at the plug is 3,930 feet.

The plug is nothing more then a soil and rip rap dike that dams the river. Nevertheless the plug is important because it backs water up into the diversions for the Sommers and Big Five dams which irrigate 23% of the overall irrigable acreage in the District.

FIGURE 3.21

Humboldt River Plug

3.4 MAPS

The maps in this section are intended for quick reference. Full-sized maps are included in Appendix D of the plan. Those maps show property owners, the Pitt-Taylor facilities, and the Upper and Lower Lovelock Valley system.

FIGURE 3.22

Location of Pitt-Taylor Diversion

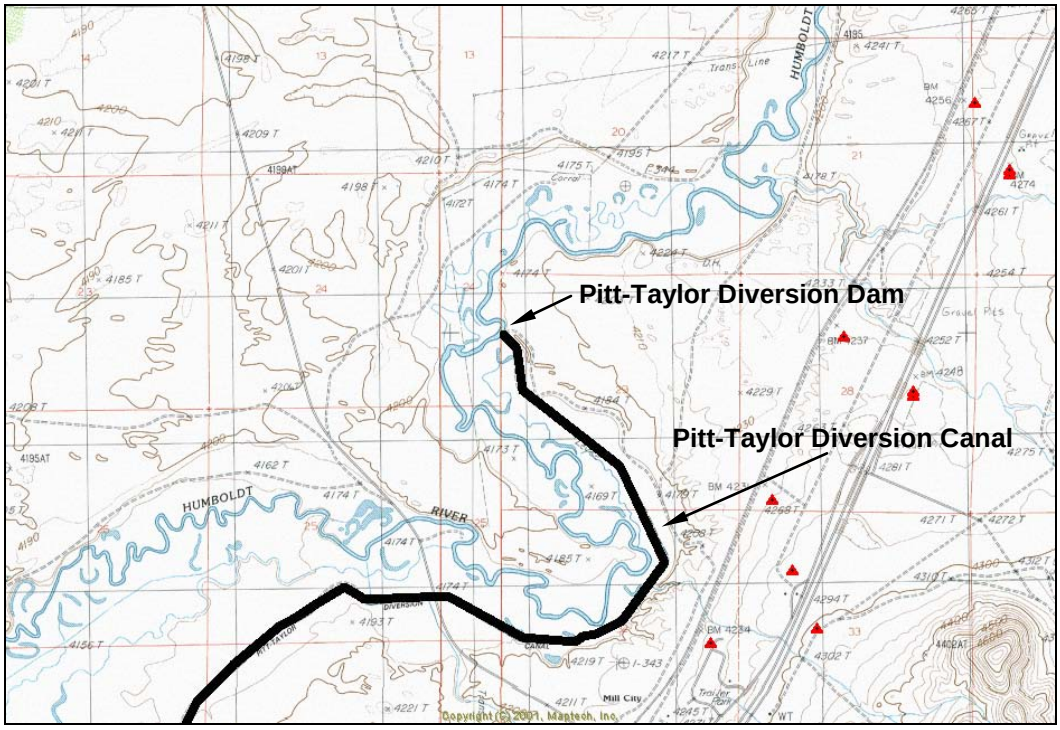


FIGURE 3.23

Location of Upper and Lower Pitt-Taylor Dams and Outlet Structures

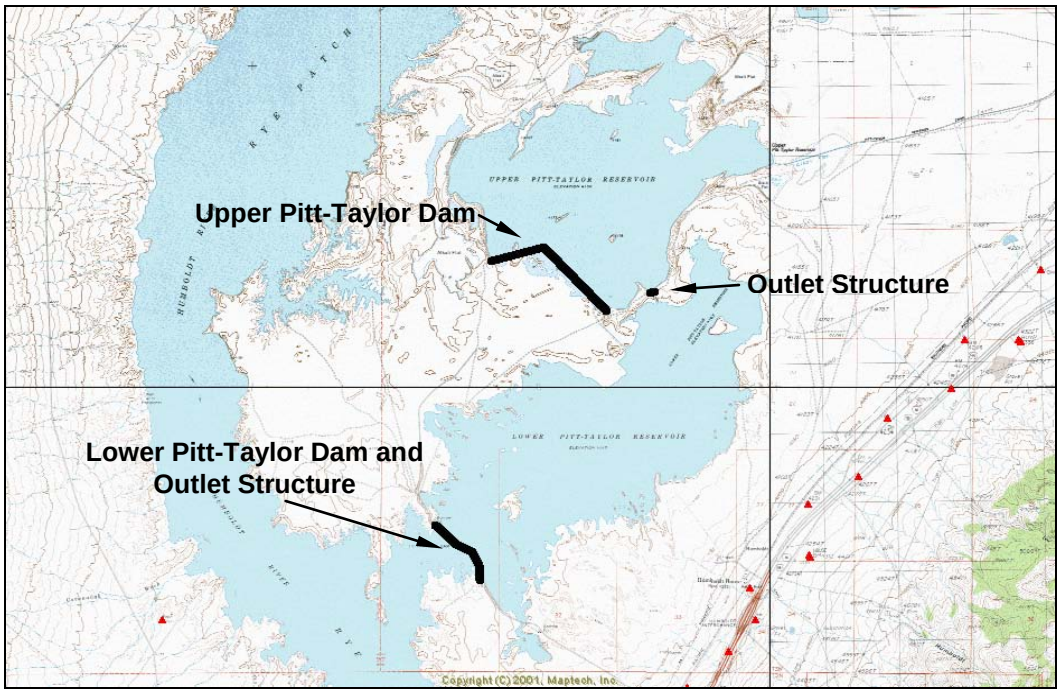


FIGURE 3.24

Location of Young Dam

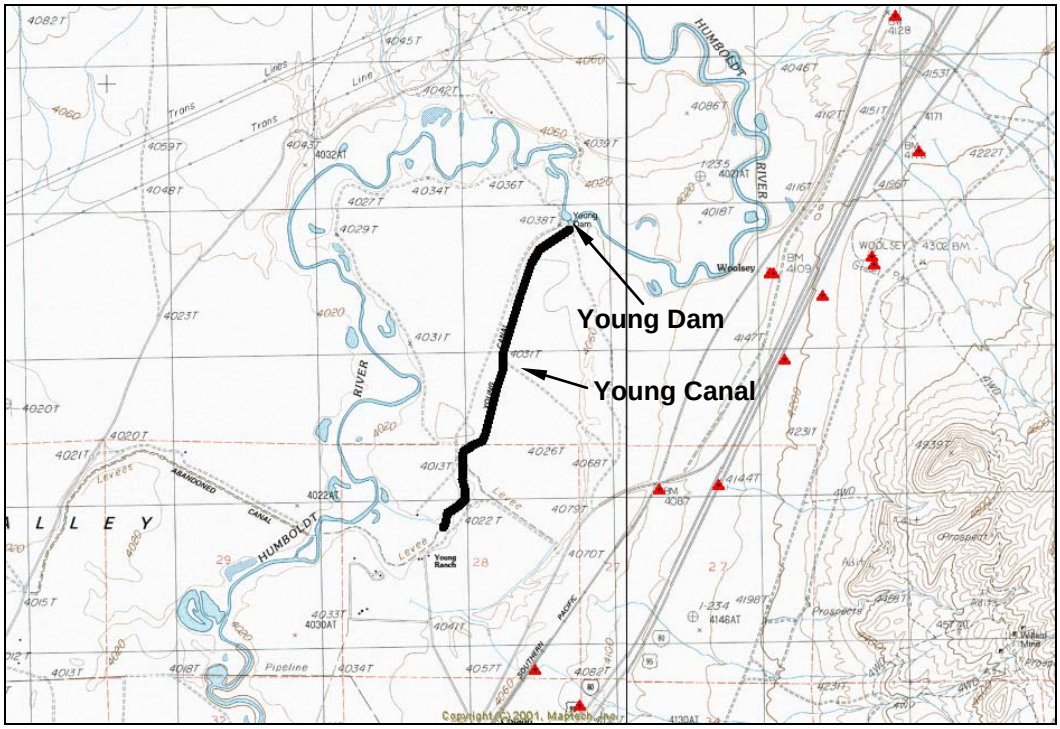


FIGURE 3.25

Location of Pitt Dam, Old Channel / Union Canals Junction, and Irish American Dam

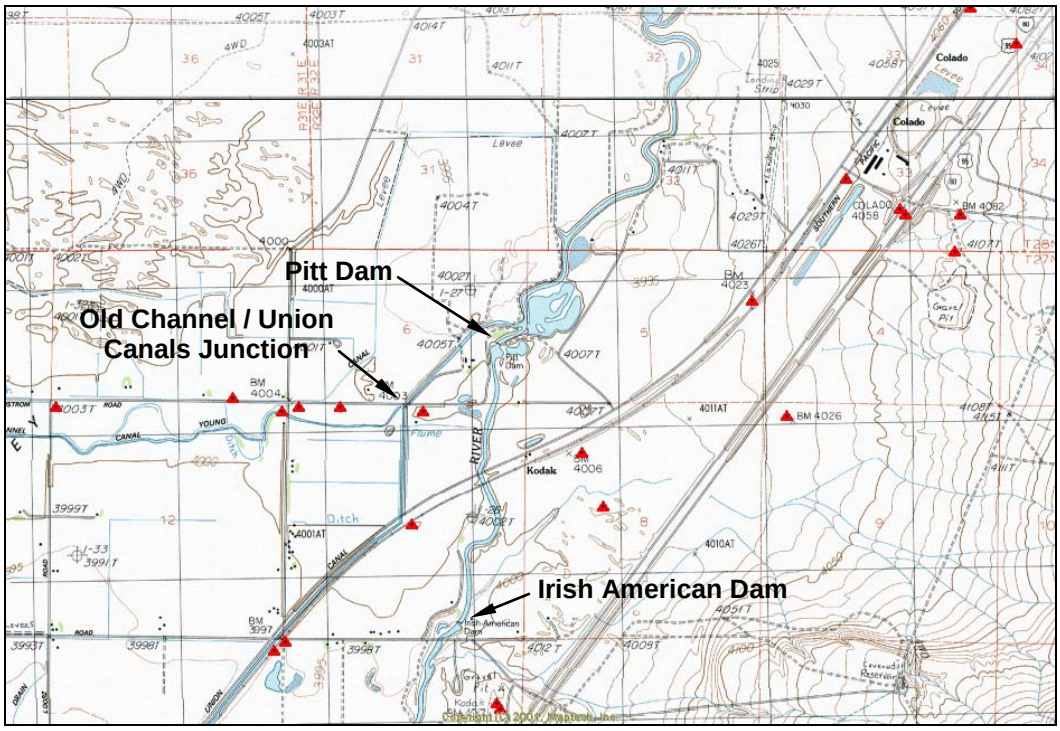


FIGURE 3.26

Location of Rodgers Dam and Canal

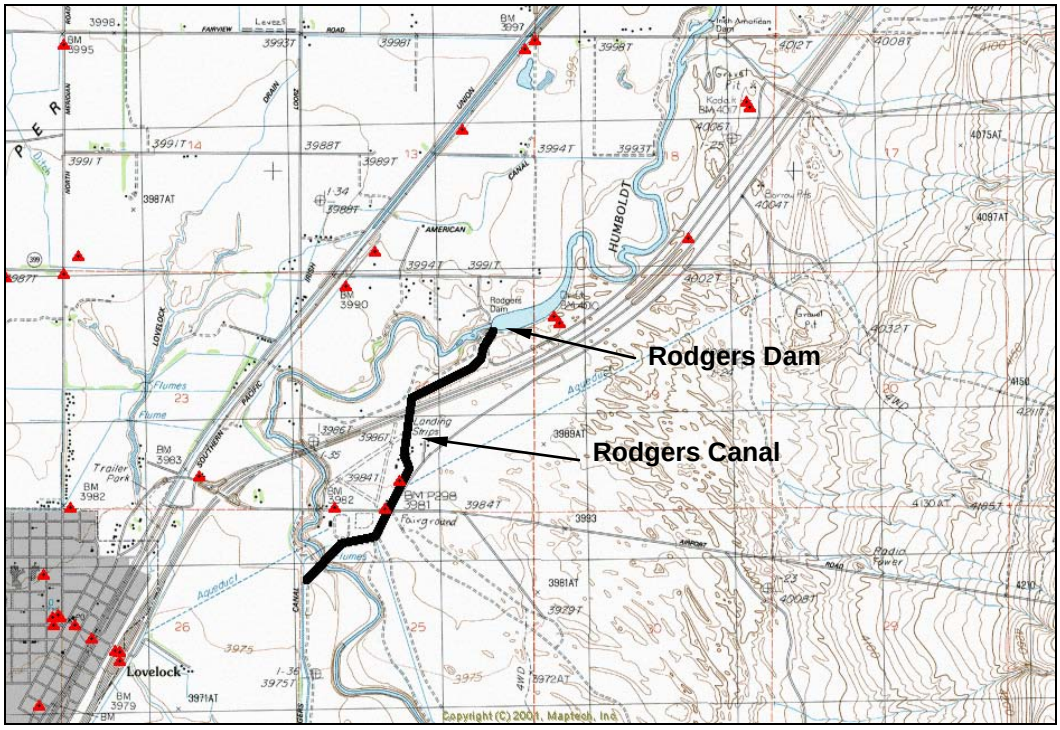


FIGURE 3.27

Location of Sommers and Big Five Dams, and Sommers, Big Five, and Seventeen Canals

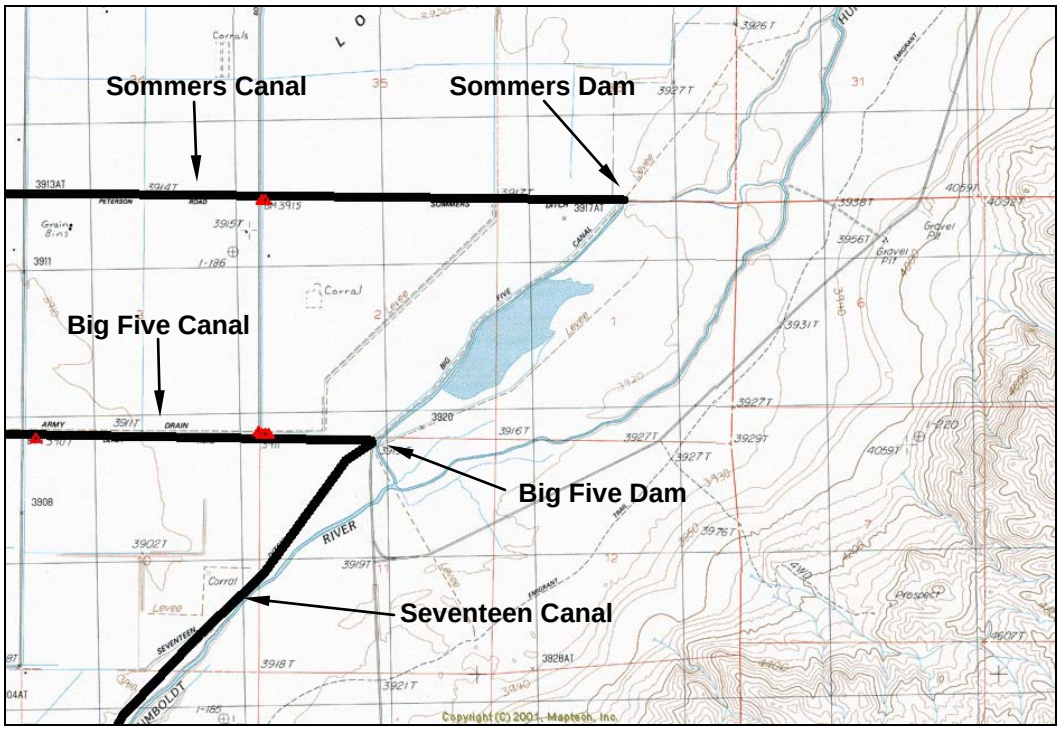


FIGURE 3.28

Location of Old Channel Canal

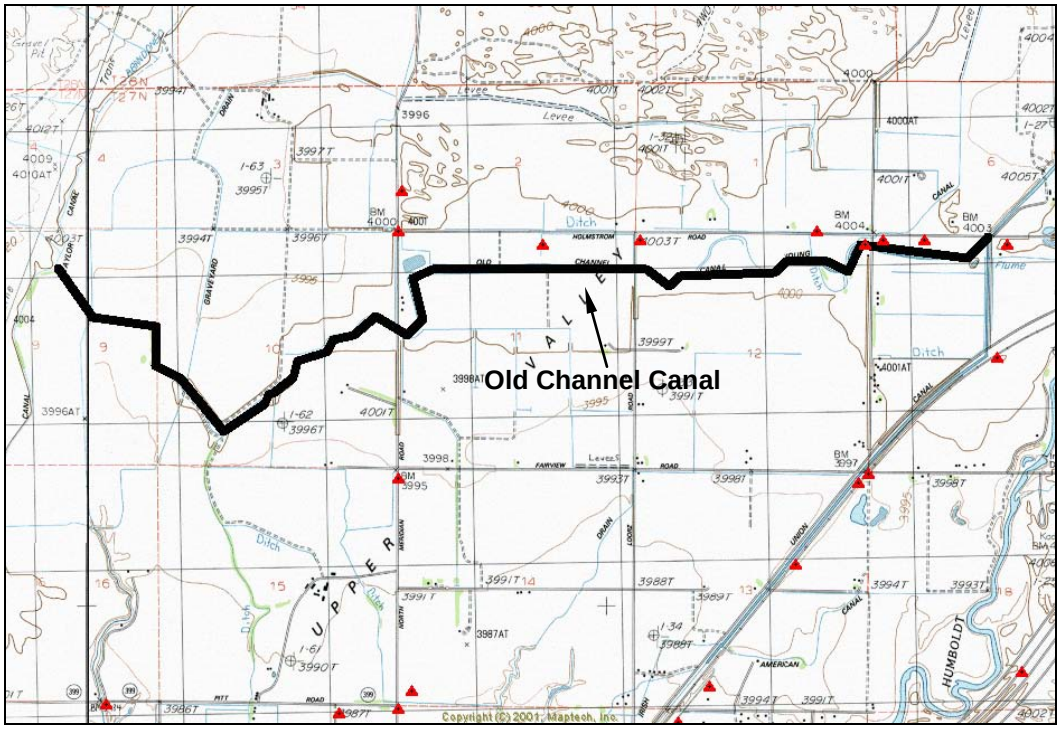


FIGURE 3.29

Location of Union, Big Meadow, Irish American and Arobio Canals

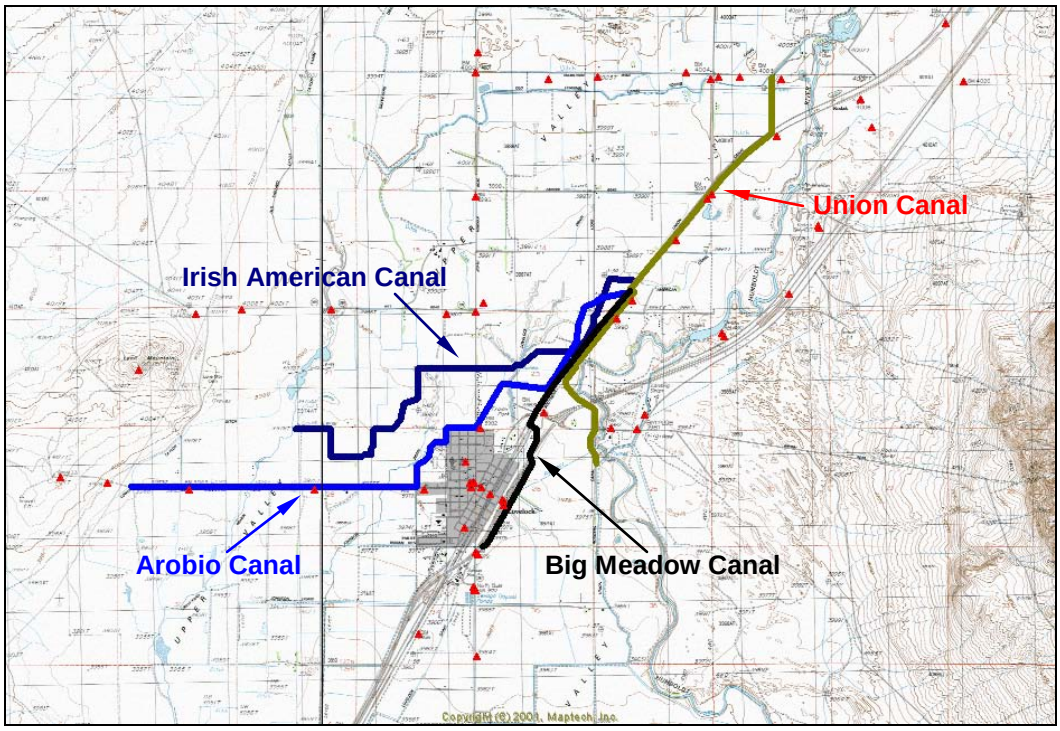


FIGURE 3.30

Location of Union-Rodgers Canal and Rodgers, Seven, Lakeshore, Tule and Reed Laterals

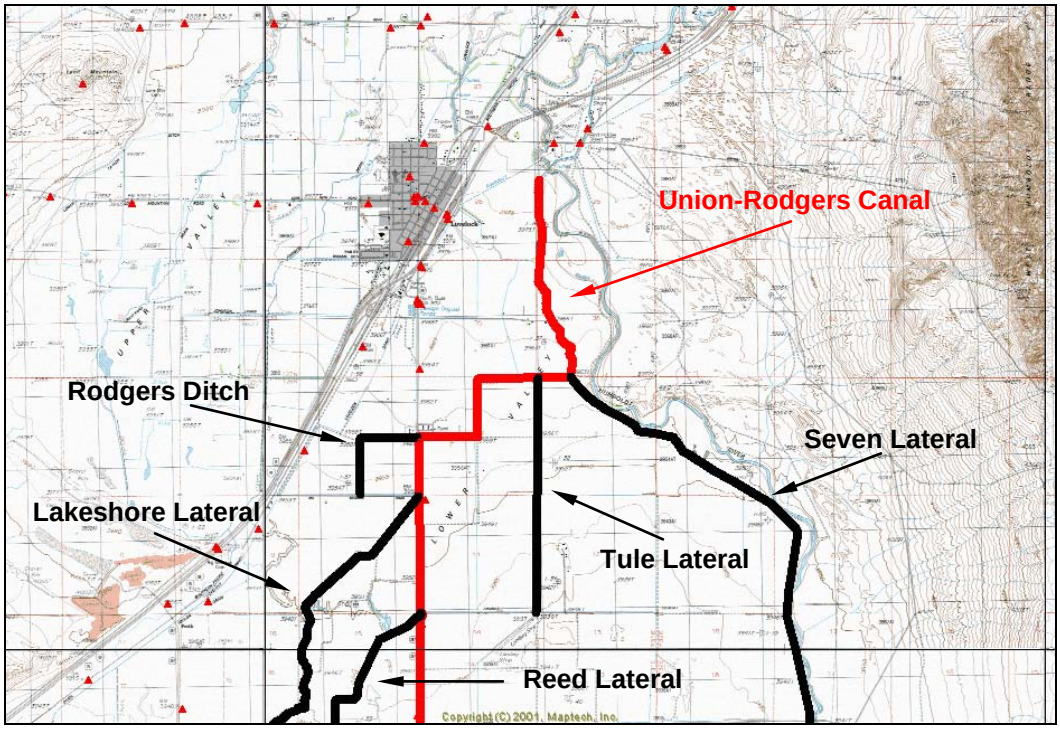
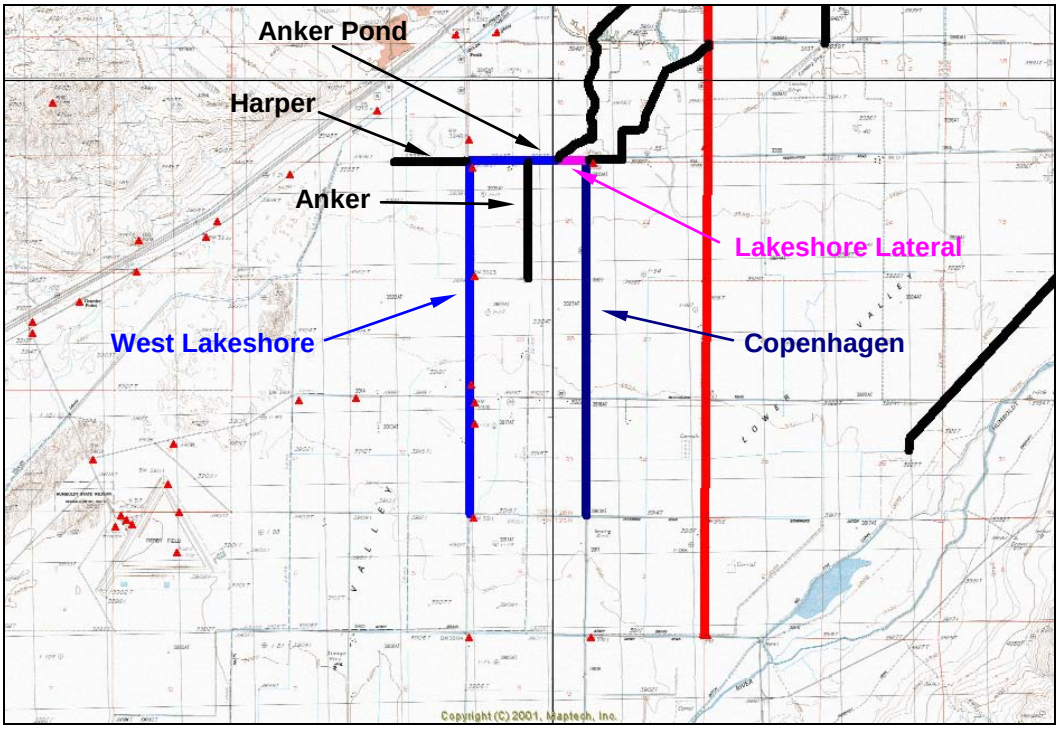


FIGURE 3.31

Location of Anker Pond, West Lakeshore, Harper, Anker, East Lakeshore and Copenhagen Canals



Chapter 4
WATER RIGHTS, SYSTEM CAPACITIES, STORAGE AND DEMAND

CHAPTER 4 ..... **1**

WATER RIGHTS, SYSTEM CAPACITIES, STORAGE **1**

AND DEMAND **1**

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4.1.2 PCWCD and Water Rights *1*

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4.3 EXISTING AND FUTURE DEMANDS 6

4.1 WATER RIGHTS

4.1.1 Historical Origins of Humboldt River Water Rights

Settlers constructed the first irrigation ditches in the Lovelock area around 1862. By 1892 (approximate) 75 percent of the water rights had been established.

Because of the unreliable flows in the Humboldt River, water use in the Humboldt Basin became a heated issue. By the early 1900's who should receive how much was debated at both state and local levels. In 1903 these debates led water users on the upper and lower Humboldt to take their claims to the Nevada State Engineer's office.

In 1904 a group of irrigators united to form the Humboldt-Lovelock Irrigation Light and Power Company. The company filed applications in 1908 and 1911 with the State for 300 cfs of water and 57,000 acre-feet of water (respectively) from the Humboldt River. In 1913 the company constructed two shallow off-stream reservoirs called the Upper and Lower Pitt-Taylor Reservoirs but the capacity of these reservoirs was insufficient to meet irrigation requirements in the area.

Ten years later in 1923 the State Engineer's office ordered a general adjudication of the Humboldt River system. A final decree establishing water rights was not issued until 1931 by Hon. George A. Bartlett of the Sixth Judicial District Court in Winnemucca. The Bartlett Decree adjudicated water rights along the Humboldt River and its tributaries. In addition to the adjudication of the river systems water rights, the decree recognized that the that the surface waters within the Humboldt River system were already fully appropriated, leaving no surplus water for irrigation during an average, or normal water year.[1] The Bartlett Decree also recognized differences in growing seasons between the upper and lower Humboldt River basins and divided the river system into two districts, District No. 1 below Palisade, Nevada and District No. 2 above Palisade. Additionally the decree established three classes of lands with different irrigation requirements and periods.

The water rights adjudicated by the Bartlett Decree were modified by the Edwards Decree in 1935. The primary purpose of the Edwards Decree was to correct errors and omissions in the Bartlett Decree. Judge H.W. Edwards made rulings for modifications which came about due to protests resulting from the Bartlett Decree. The most important change made by the Edwards Decree was the removal of the formal division of the Humboldt system into the two Districts below and above Palisade (Districts No. 1 and No. 2 respectively). The Edwards Decree instead established specific irrigation seasons and reaffirmed the three land classes, water duty for each class, and the period over which water was to be distributed to these lands instituted in the Bartlett Decree. Since most of the corrected water rights in the Edwards Decree applied to the upper Humboldt basin (above Palisade), the Edwards Decree was used for distribution of water in the upper basin while the Bartlett Decree was applied to and used for the distribution of water in the lower basin. The Edwards Decree also allowed for a flow of 1.23 cfs per 100 acres of decreed land or at proportional rates.

4.1.2 PCWCD and Water Rights

In 1926 the Lovelock Irrigation District was organized for the purpose of considering possible storage sites on the Humboldt River. In order to facilitate the construction of the Humboldt Project, the District reorganized under the Nevada Irrigation District Act becoming the Pershing County Water Conservation District (PCWCD). It also initiated the acquisition of the additional water rights needed to make the Humboldt Project feasible. Figure 4.1 is a chronology of agreements related to the acquisition of lands and water rights in the Valmy and Battle Mountain areas.

FIGURE 4.1

PCWCD Water Rights Chronology

Date	Description
August 24, 1933	Public Works Administration approves allotment of $2 million for creation of Humboldt Project
January 15, 1934	Contract between PCWCD and Aldous Family to purchase Aldous Ranch (voided by expiration of time).
January 27, 1934	Contract between PCWCD and Filippini Ranching Company to purchase Argenta Ranch and Muleshoe Ranch (voided by expiration of time).
June 30, 1934	Stipulation and Agreement between PCWCD and all protestants (T.S. Cattle Company, Russell Land & Cattle Co., W.E. and William Licking, Hibernia Savings & Loan Society (successor to X. Rodwell Meyer), John E. Marble, Grayson w. Hinckley & Co., and Humboldt Land & Cattle Co. providing for execution of individual land swaps and settlements to address injury and to avoid further uncertainty under decree in Crum v. Dunphy
July 15, 1934	Land and Water Rights Purchase Contract between PCWCD and the Aldous Family providing for PCWCD's purchase of Aldous Ranch.
July 25, 1934	Amended and Supplemented Land and Water Rights Purchase Contract between PCWCD and Filippini Ranching Company providing for PCWCD's purchase of Argenta and Muleshoe Ranches.
August 31, 1934	Stipulation and Agreement between PCWCD and W.E. and William Licking settling protests to Rye Patch Reservoir water transfers by, inter alia, granting 300 acres and water rights in Sec. 15, T32N, R45E, and providing Licking with a 5 year lease of the Aldous property (no water use) from 1/17/35 to 1/17/40.
September 10, 1934	Stipulation and Agreement between PCWCD and Russell Land & Cattle Co. settling protests to Rye Patch Reservoir water transfers by granting to RL&CCo. 761 acres and water rights (except for 67.7 dry ac) in Sec. 2 and 3, T3SN, R42E and Sec. 34, T36N, R42E and in exchange, getting 562.18 a.f. of water rights from Sec. 1 land 14, T3SN R42E and Sec. 29, T36N R42E
September 20, 1934	Stipulation and Agreement between PCWCD, T.S. Cattle Company and Hibernia Savings & Loan Society settling protests to Rye Patch Reservoir water transfers by granting an undivided S/8 and 3/8 interest respectively to each to 640 acres and water rights located in the N'/$_2$ of Sec. 1 and 2 in T32N, R46E
October 1, 1934	Contract Ilr-774 between USA and PCWCD for acquisition of water rights and construction of Rye Patch Dam and maximum loan of $1,500,000.00 to be repaid over 40 year period
November 17, 1934	Agreement and Assignment between PCWCD, Bureau of Reclamation and Filippini Ranching Company assigning to the Bureau of Reclamation the PCWCD's rights under the July 25, 1934 purchase contract between PCWCD and Filippini Ranching Company.
December 12, 1934	Agreement and Assignment between PCWCD, Bureau of Reclamation and Aldous Family assigning to the Bureau of Reclamation the PCWCD's rights under the July 15, 1934 purchase contract between PCWCD and the Aldous Family.

December 22, 1934	USA notice to Charles S. and Hortense B. Aldous requesting them to obtain title insurance on their property to facilitate conveyance to USA.
January 14, 1935	Extension Agreement between PCWCD, Bureau of Reclamation and Aldous Family extending time for performance of purchase agreement terms and conditions.
January 17, 1935	Warranty Deed executed by Aldous Family conveying the Aldous Ranch to USA for $33,500 • 15,000 acres • 4154.06 a.f.
January 25, 1935	Deed from Filippini Ranching Company to Hibernia Savings & Loan Society conveying a 3/8 interest in 640 acres in T23N, R46E Instrument unknown from Filippini to T.S. Cattle Co. Instrument unknown from Filippini to W.E. Licking
January 26, 1935	Warranty Deed executed by Filippini Ranching Company conveying Argenta and Muleshoe Ranches to United States of America for $181,000 • 16,000 acres less 640 ac to T.S. Cattle Co. and Hibernia S&L Soc. and less 300 ac to W.E. Licking • Together with all water, water rights, ditches and ditch rights appurtenant...
February 5, 1935	Warranty Deed from Ellison Ranching Co. to USA • 18,000 acres • 15,379.22 a.f. Instrument unknown from ER Co. to Russell L&C Co. • 761 acres
February 7, 1935	Deed from Russell Land and Cattle Co. to USA • Conveyance of water only • 562.18 a.f. • 3.645 cfs
March 2, 1935	Deed from Louis G. and Katherine V. Hammond to USA • 1350 acres • 2,988.29 a.f.
March 4, 1935	Warranty Deed from Zebulon and Celina Silve to USA • 800 acres • 1,282.87 a.f.
	Instrument unknown from John G. Taylor Inc. to USA (#9731) • 7,000 ac. • 6084.06 a.f.
	Instrument Unknown from Bains to USA • 1,800 acres • 2,626.27
	Deed and Assignment from John G. Taylor to USA on _____ (#10065) • 1154.84 acres • 1657.57 a.f. • 9.385 cfs

4.1.2.1 Statutory and Regulatory Considerations Regarding Nevada Water Rights

The Nevada State Water Plan, Part 1, Section 3 states the following;

"All waters within the boundaries of Nevada, whether above or beneath the ground surface, belong to the public and are managed on their behalf by the State. The State Engineer is responsible for the administration of Nevada Water Law, which ensures that these waters are managed so that sufficient quantities are available to preserve our quality of life and to protect existing water rights. Entities within the State can apply for the right to use that water. Like many of the western states, Nevada water law is founded on the doctrine of prior appropriation - "first in time, first in right." Under this doctrine, the first user of water from a watercourse acquires a priority right to the water and to the extent of its use under that right."

This means that the water within the state belongs to the public but the right to use the water may be obtained by individuals through diversion for beneficial use. This policy infers that during those times when water from a particular source does not meet the demand of all those holding rights to that source, those who have the earliest established rights will have first claim to the available water.

Nevada water law is set forth in Nevada Revised Statutes (NRS), Chapters 533 and 534. Additionally, court decisions have also defined Nevada water law issues and the surface waters in the upper and lower Humboldt River basins are managed in accordance with the Bartlett and Edwards Decrees described in section 4.1.1.

4.1.2.2 Summary of Water Rights

Water rights within the PCWCD consist of both direct diversion rights and storage rights. The diversion rights were originally appurtenant to land purchased by the PCWCD in Battle Mountain, Nevada in the 1930's (see figure 4.1 for chronology). As part of the purchase agreement the water rights were transferred to farmland in and around Lovelock, the transfer being approved by the Nevada State Engineer in 1934. Currently water rights held in the Lovelock area are owned by individual farmers, PCWCD, the State of Nevada and the United States but PCWCD controls the allotment and distribution of water to all owners.

Table 4.1 shows direct diversion water rights, table 4.2 storage rights for Rye Patch Reservoir ~~,~~and ~~-~~Table 4.3 PCWCD storage rights.~~ and table 4.4 Nevada Division of Wildlife (NDOW) water rights.~~

TABLE 4.1

Direct Diversion Rights

Application Numbers	Certificate Number	Date Approved	Acre-feet	CFS	Priority Date	PCWCD Predecessor in Title
9729, 12955	5041	11/9/60	15,434.95	78.063	1873 1893	Filippini
9730, 12953	4436	4/23/56	4,154.08	20.068	1871 1914	Aldous
9731, 12954	4437	4/23/56	4,579.42	30.572	1873 1877	Taylor
9732, 12952	4572	7/3/57	14,432.32	91.494	1873 1887	Ellison
9733, 12951	4435	4/23/56	1,282.01	6.342	1873 1894	Silve
9734, 12950	4571	7/3/57	3,023.49	9.911	1874	Hammond
9735, 12949	4570	7/3/57	2,626.30	13.509	1874 1887	Bain
9821, 12948	4434	4/23/56	1,925.52	13.615	1863 1866	Callahan
9928, 12947	5040	11/9/60	562.17	3.610	1873 1880	Russell Land & Cattle Co.
10065, 12957	5180	8/14/61	1,647.18	9.385	1877	John G. Taylor, Inc.
		Total	**49,667.44**	**276.57**		

TABLE 4.2

Storage Rights for Rye patch Reservoir

Reservoir	Application Numbers	Certificate Number	Date Approved	Acre-feet	CFS	Priority Date
Rye Patch	9716, 12956	4506	4/3/57	100,000.00	5,000.0	12/12/33
Rye Patch	10283	9258	8/30/78	15,152.32	5,000.0	8/13/38
			Total	**115,152.32**	**10,000.0**	

TABLE 4.3

PCWCD Storage Rights

Reservoir	Application Numbers	Certificate Number	Date Approved	Acre-feet	CFS	Priority Date
Big Five*	Bartlett	Decree	10/20/31	400.00	*	1900
Big Five*	Bartlett	Decree	10/20/31	4,400.00	*	1922
Pitt-Taylor	1098	2130	9/18/35	20,200.00	300.00	8/21/08
Pitt-Taylor	1948	2131	9/18/35	29,570.00	450.00	2/10/11
			Total	**54,570.00**	**750.00**	

*The Big Five storage rights have been transferred to Rye Patch Reservoir.

~~TABLE 4.4~~

~~NDOW Water Rights~~

~~Application Numbers~~	~~Certificate Number~~	~~Date Approved~~	~~Acre-feet~~	~~CFS~~	~~Priority Date~~
	~~9740~~	~~1/27/82~~	~~10,200~~	~~100~~	~~1972~~
	~~9741~~	~~1/27/82~~	~~21,573~~	~~2,000~~	~~1972~~
	~~9742~~	~~1/27/82~~	~~21,573~~	~~200~~	~~1972~~
		~~**Total**~~	~~**31,773***~~	~~**2,300**~~	

~~*Although individual certificates provide greater diversion per State Engineer's Ruling combined total for three permits is 31,773 acre-feet annually~~

4.2 STORAGE AND CAPACITIES

There are three principle storage facilities used by PCWCD; Rye Patch Reservoir and the Upper and Lower Pitt-Taylor Reservoirs. Table 4.5 shows the active capacities for each of these reservoirs.

TABLE 4.5

Reservoir Capacities

Reservoir	Active Storage Capacity (acre-feet)	Outlet Works Release Capacity (cfs)
Rye Patch	213,000	1,000
Upper Pitt-Taylor	~~19~~20,000	50 to 150*
Lower Pitt-Taylor	~~13~~15,000	50 to 150*

*Rough estimate based on outlet area times flow velocity.

Storage capacity at the other dams in the system is negligible.

4.3 EXISTING AND FUTURE DEMANDS

Currently there are 37,506 irrigable acres within PCWCD, approximately 32,000 of which are irrigated annually. It is not anticipated that the amount of irrigable acres will increase in the near future. The number of acres that are irrigated each year is limited to the amount of water available. For example the amount of water allotted to PCWCD users in the 2004 irrigation season was .75 feet per irrigable acre whereas in 2005, an unusually wet year, it was 3 feet.

[1] Nevada Division of Water Planning, "*Nevada State Water Plan, Background and Resource Assessment Section 8*"

CHAPTER 5
CONSERVATION

CHAPTER 5 ..... **1**

CONSERVATION **1**

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5.1 INTRODUCTION AND OVERVIEW

Conservation of water is a high priority for the PCWCD. During the 2004 irrigation season water users within the district were allotted 25 percent of their contracted water amount because of several dry years in the Humboldt system.

Agriculture accounts for nearly 80 percent of water consumed in the United States (i.e., withdrawn from surface or groundwater sources and lost to the immediate water environment through evaporation, plant transpiration, incorporation in products or crops, or consumption by humans or livestock)[1]. Nevertheless demand for urban, industrial, environmental and other uses is increasing. Because the largest portion of overall consumption is used for agriculture, agricultural water conservation can have a greater effect on overall water supplies then any of the alternative uses.

PCWCD plays a critical role in the success of agriculture in the Lovelock area. Currently there are 37,506 acres of irrigable land within the District with approximately 32,000 acres being irrigated annually[2]. Pershing County as a whole is one of the foremost agricultural production regions in Nevada and presently ranks 5th in the State in cash receipts for agricultural products[3]. Alfalfa hay, alfalfa seed, wheat, oats, and barley are the principle crops.

Since water resources in the District are limited, implementing conservation measures at both the District and farm levels could improve the PCWCD's ability to deliver water in wet as well as dry years. However, the District and irrigators can only afford to apply newer irrigation technologies when benefits exceed costs[4]. Eight barriers to farm-level irrigation improvements were identified in the 1998 Farm and Ranch Irrigation Survey (FRIS). Table 5.1 includes the FRIS results for Nevada.

TABLE 5.1

Barriers to Making Improvements to Reduce Energy or Conserve Water: 1998 and 1994 (Nevada)*

TOTAL FARMS SURVEYED

Farms	Acres in Farms	Acres Irrigated	Acre-feet Applied
1038	2,846,472	297,158	744,080

SURVEY RESULTS

Barrier	Farms	Acres Irrigated	Acre-feet Applied
Have not investigated improvements	174	96,979	300,721
Risk of reduced yield of poor crop quality	179	78,258	194,239
Physical field/crop conditions	144	163,789	394,378
Improvements will not reduce costs enough to cover installation costs	425	166,212	471,352
Cannot finance improvements	363	176,495	515,280
Landlord will not share in cost	81	29236	70,078
Uncertain about future water rights	344	75,566	216,715
Will not be farming this place long enough to justify improvements	218	52,280	176,502
Other	141	21,463	90,096

*More then one reason could have been given.

In Nevada the "perceived economic benefits" (4) and "availability of financing" (5) are the primary farm-level barriers to irrigation system improvements across farm-size classes[5]. This is consistent with the fact that larger irrigated farms generally incur greater per acre irrigation costs[6]. According to the survey smaller farms have the additional barrier of not having investigated the merits of system improvements (1). This barrier could be overcome through increased education provided through the extension service or even the district where possible. Additionally, creative public/private financing approaches should be investigated to alleviate the economic concerns associated with farm conservation improvements.

Although there has been some hesitation to implement irrigation conservation improvements for the above mentioned reasons, the 1998 FRIS also provides information regarding Nevada farms that have implemented improvements and the accompanying results. Table 5.2 includes these results.

TABLE 5.2

Energy and /or Water Conservation Improvements: 1994 and 1998 (Nevada)*

TOTAL FARMS THAT IMPLEMENTED IMPROVEMENTS IN LAST 5 YEARS

Farms	Acres in Farms	Acres Irrigated	Acre-feet Applied
726	2,534,684	397,772	1,195,332

RESULTS OF IMPROVEMENTS

Barrier	Farms	Acres Irrigated	Acre-feet Applied
Improved crop yield	323	288,642	863,652
Reduced energy costs	220	168,671	502,750
Reduced water applied	483	253,388	744,210
Reduced labor costs	337	214,580	654,421
Other	30	16,354	52,780

*More than one result could have been given.

Table 5.2 shows that farms that have applied water conserving improvements have benefited economically in addition to saving water and energy. Employment of conservation measures can[7]:

- Improve reliability of existing water supplies.
- Reduce overall operating costs for water users.
- Postpone the need for new or expanded water supplies, storage capacity, or drainage remediation.
- Result in higher crop yields.
- Reduce the impacts of drought.
- Under some circumstances, yield conserved water for additional agricultural or urban need.

The purpose of this Chapter is to discuss potential areas of conservation as it applies to PCWCD and its customers. Because of costs it is impractical to expect on-farm conservation to contribute substantially to the conservation efforts. For this reason it is important that the District make as many improvements as possible utilizing its own resources as well as funds made available from other sources. Conservation measures have the potential to reduce costs for both the District and individual farmers, make water management easier and more efficient, and increase yields. Because of this farmers should be made aware of any available financing for conservation purposes as well as any other incentives that encourage conservation.

5.2 PCWCD BASE CONSERVATION MEASURES

PCWCD is continually working on delivery system improvements. They include ongoing maintenance consisting of regularly scheduled ditch cleaning, construction of new gate and diversion structures, installation of rip-rap in high erosion areas, installation of water measurement devices, and sealing of canals with polymer based additives. In addition to these, the University of Nevada, in conjunction with the USDA and the Nevada Department of Agriculture, has instituted a salt cedar (Tamarisk) eradication program within the District.

PCWCD is also seeking to renovate or replace some of the important structures in the delivery system. These upgrades include the replacement of the Pitt-Taylor diversion dam and diversion structure, replacement of the Upper and Lower Pitt-Taylor outlet structures, installation of a back up structure at the Humboldt Plug, replacement of the Old Channel/Union canal diversion structure, installation of slide gates in the Pitt and Rodgers Dams, reconstruction of Anker Pond and its control structures, and the systematic improvement of various other smaller structures.

5.3 POTENTIAL CONSERVATION MEASURES WITHIN THE PCWCD

5.3.1 Seepage Loss

A water measurement survey was performed on the Upper Lovelock Valley PCWCD delivery system in 1969 and another was done on the Lower Valley system in 1970. Since that time none of the canals has been lined and no additional flow studies have been conducted so it will be necessary to assume that the old data is reasonably accurate. Table 5.3 summarizes the results of these surveys.

TABLE 5.3

Seepage Losses in Canals

Canal	Length (mi)	Average Flow (cfs)	Average Loss/Mile (cfs)	Average Loss (%)
Young	2.0	25.7	1.4	11.0
Old Channel	4.0	40.0	0.8	6.5
Old Channel Laterals	Variable	Variable	Variable	16.0
Union	4.0	162.0	7.0	10.0
Irish American	3.8	16.1	3.2	Up to 62.0
Arobio	5.5	17.0	Unknown	Unknown
Big Meadow	2.5	29.0	0.3	2.4
Union-Rodgers	10.0	100.0	+1.4	+7.9
Rodgers Ditch	1.0	22.0	1.0	3.8
Seven Lateral	5.0	26.0	0.3	7.0
Tule Lateral	2.0	26.0	Unknown	Unknown
Upper Lakeshore Lateral	2.5	48.0	2.5	12.9
Reed Lateral	1.5	19.0	2.0	16.4
West Lakeshore Lateral/Harper	4.5	28.0	0.4	5.6
East Lakeshore Lateral	1.5	18.0	0.0	0.0
Anker	Unknown	Unknown	Unknown	Unknown
Copenhagen	3.0	21.0	1.0	13.1
Sommers	1.5	20.0	1.0	6.4
Big Five	4.0	38.0	9.0	23.4
Seventeen	3.5	32.0	1.0	10.6

By applying the above average loss percentages from table 5.3 to the irrigable acreage in PCWCD, table 5.4 shows the potential losses in acre-ft for each of the principle canal systems. For the Old Channel system the loss percentage for the canal and its twelve laterals is an average. The Union-Rodgers system includes all of the canals in the lower valley with the exception of the Sommers, Big Five, and Seventeen Canals. The percentage loss for the Union-Rodgers system is also an average of all the losses of the canals in that system. It should be noted that the averages used on the larger canal systems are probably well below the actual seepage losses. For example the seepage loss recorded for the Union-Rodgers and the East Lakeshore in 1970 was positive but the study also indicated that the accuracy of the measurements was questionable and that there may have been tail water reentering the canals from irrigated lands.

TABLE 5.4

Potential Losses Due to Seepage in Acre-feet

System	Irrigable Acres	Amount Lost (%)	Amount Lost (AF)
Young	577	11.0	63
Old Channel	7,131	11.3	806
Irish American	581	62.0	360
Arobio	1,038	Unknown	Unknown
Big Meadow	2,739	2.4	66
Union-Rodgers	19,656	7.1	1,395
Sommers	853	6.4	55
Big Five	2,852	23.4	667
Seventeen	2,079	10.6	220
Total	**37,506**	**7.0**	**2,511**

In addition to the above mentioned canals, the Upper and Lower Pitt-Taylor Reservoirs and the Pitt-Taylor diversion canal show evidence of seepage losses, however flow studies have never been performed on the reservoirs or the canal.

5.3.2 Weeds

Weeds growing in waterways can reduce flow by clogging the stream beds and trapping sediment along the banks. Uncontrolled weeds can take as much as 5 millimeters of water per day from soil, reducing the moisture available for crops and even lowering crop yields. Weeds also compete with crops for sunlight, space and vital nutrients, further jeopardizing crop vitality and yield[8]. Because of this weed control is vital to water conservation efforts in PCWCD. For farmers, crop rotations, effective tillage practices, and herbicides are options for controlling weeds. The “Nevada Weed Identification and Control Guide” provides a list of weeds considered to be Riparian Noxious/Invasive Weeds. Because of their direct impact on water conservation within the PCWCD, a list of the most invasive weeds that grow in the riparian areas of Pershing County including in and around PCWCD facilities is included below.

5.3.2.1 Saltcedar (Tamarisk). In Pershing County the invasive plant that consumes the largest amount of water is Saltcedar. Saltcedar (*Tamarix chinensis, T. ramosissima, and T. parvifolia)* are invasive, shrubby trees that are rapidly colonizing riparian areas in Nevada. They were introduced into the United States in the early 1800’s as ornamentals and to prevent soil erosion along streams.[9] The plant grows 5 to 20 feet tall and can be identified by its pale blue green leaves and pink to white flowers. In Pershing County saltcedar occupies former croplands in the Humboldt sink and grows along many of the canals that are part of the PCWCD water delivery system.

Saltcedar is classified as a phreatophyte, meaning it uses very large amounts of water. A study being conducted by the USDA indicates that one saltcedar branch can consume 300 grams of water per hour. Problems associated with saltcedar include lowering of the water table which in turn kills native plants. Saltcedar also poisons surrounding soils by excreting salts through special glands and by dropping large amounts of salt filled leaves. Over time, buildup of salt in the soil prevents the establishment of desirable forage species. Saltcedar also reduces stream flow by using soil moisture that would contribute to the stream as well as trapping sediment along stream banks. As this occurs, the flood plain becomes larger which increases evaporation and water use by plants.

Saltcedar is difficult to eradicate. Mechanical control is ineffective. Chemical control can work but there are only two herbicides that effectively control saltcedar (triclopyr (Garlon 4) and imazapyr (Arsenal)). A biological control research program that has had some success is currently being conducted in Pershing County in an area near Lovelock, Nevada. The program involves the release of a leaf beetle imported from China called the *Diorhabda elongada.* Prior to release the

beetles were approved by the USDA as a biological control agent for saltcedar in the United States. The beetles defoliate the trees which eventually kills them. They were originally released in the Lovelock area in 2001 on private and federally owned land covering approximately 25-30 acres but have since spread to 2000+ acres. The initial results of the program have been encouraging and many of the trees have already been defoliated and are dying. The program is led by the USDA Agricultural Research Service and the University of Nevada Reno with the cooperation of the Nevada Department of Agriculture. More information can be found in University of Nevada Reno Cooperative Extension Fact Sheet FS-02-93.

5.3.2.2 Tall Whitetop. Tall whitetop (*Lepidium latifolium*) also known as perennial pepperweed, thrives in riparian environments. The plants consume large amounts of water and like tamarisk act as salt pumps, bringing salt to the soil surface making it difficult for native plants to grow. Tall whitetop competes with native plants for soil moisture tends to dominate areas it has invaded. Tall whitetop also accelerates stream bank erosion.

Tall whitetop grows from 1 to over 3 feet tall and has bright green to gray-green leaves. The plant blooms in early summer through fall and has dense clusters of white flowers near the ends of branches. The plants have extensive root systems and numerous seeds that can be spread in many ways including by water.

Mechanical control of the plants has proven ineffective. Research is currently being done to find a biological control but to date there is no disease or insect that will kill the plant. Chemical control in the form of herbicides is the only way to effectively control tall whitetop. More information can be found in University of Nevada Reno Cooperative Extension Fact Sheet FS-99-95.

5.3.2.3 Whitetop. Whitetop (*Cardaria draba*) also known as hoary cress has many of the same environmental impacts of tall whitetop. A large stand of the plants can use large amounts of water and will exclude beneficial native plants.

Whitetop grows up to 2 feet tall and has 1 to 1 ½" long blue-green leaves. The plants have white flower clusters that bloom in the spring.

Whitetop can be controled mechanically in small seedling stands in the spring and fall. Currently there are no biological controls and few chemical controls. More information can be found in University of Nevada Reno Cooperative Extension Fact Sheet FS-02-56.

5.3.2.4 Purple Loosestrife. Purple Loosestrife (*Lythrum salicaria L.*) tends to form dense stands in streams, canals, and ditches. It will eventually overwhelm and exclude native plants. It will grow in the water and clog waterways.

The plant grows 6 to 8 feet tall and has simple leaves covering the length of the shaft. The flowers are rose-purple and have 5 to 7 petals.

Purple Loosestrife can be killed mechanically by flooding be must be replaced with another competitive species or it will return. Currently there are 4 insects and 4 pathogens that provide effective biological control. Use of chemical control is limited due to the fact that the plant grows in or near the water. More information can be found in University of Nevada Reno Cooperative Extension Fact Sheet FS-02-58.

5.3.2.5 Poison Hemlock and Western Water Hemlock. Poison hemlock (*Conium maculatum*) is generally found at lower elevations in riparian areas or at least areas with sufficient soil moisture. It grows 6 to 8 feet tall and has shiny green fern-like shaped leaves and white flowers which bloom from June to August.

Western water hemlock (*Cicuta douglasii*) is more poisonous then Poison hemlock and is considered the most violently toxic plant in North America. It grows 3 to 7 feet tall with green

leaves that have a toothed margin. The white flowers grow in clusters. Western water hemlock is a wetland plant.

Both types of hemlock use large amounts of water and crowd out native species, eventually dominating their environment. Both types of hemlock can be mechanically and chemically controlled. Only poison hemlock can be biologically controlled by the European Palearctic moth which has already colonized Nevada. More information can be found in University of Nevada Reno Cooperative Extension Fact Sheet FS-04-09.

5.3.2.6 Eurasian or spiked watermilfoil. This plant is currently only found in Lake Tahoe and part of the upper end of the Truckee River. It is considered a threat to the Stillwater Wildlife Refuge and potentially can be spread on boating and fishing equipment to other lakes and waterways which includes Rye Patch Reservoir. It grows rapidly in water and forms a dense canopy that can clog waterways inhibiting flow. More information can be found in University of Nevada Reno Cooperative Extension Fact Sheet FS-02-09

5.3.3 Water Measurement

During field reconnaissance by Farr West Engineering personnel it was discovered that the PCWCD system could benefit from additional water measurement devices.

Water measurements can provide the data necessary for[10]:

- Determining irrigation efficiency.
- Improving water management.
- Completing annual water reports.

Water measurement devices can also help in the evaluation of seepage losses in unlined canals, prevent excess runoff, and help facilitate equitable distribution of water within the District[11]. One of the primary benefits of accurate water measurement is that the use of the water can be more precisely monitored, which would help PCWCD manage available water during dry years.

Measurement devices should match the specific conditions of the waterway. The following is a list of selection criteria taken from the United States Bureau of Reclamation (USBR) Water Measurement Handbook.

5.3.3.1 Accuracy Requirements. Most water measurement devices can produce accuracies of $\pm$ 5 percent. This level of accuracy however is only achieved if the device is appropriate for the site conditions. The USBR Water Measurement Handbook can provide more information on measurement error reduction.

5.3.3.2 Cost. Measurement device costs include the cost of the primary measurement device, installation, secondary device (some primary devices rely on a secondary device for calibration or an additional measurement), and operation and maintenance.

5.3.3.3 Legal Constraints. Some governmental or administrative water boards require that only certain types of water measurement devices be used. In such cases the standard for water measurement is established by the governing body and selection of the device has already been done.

5.3.3.4 Flow Range. Many measurement devices are only accurate within a limited flow range. Large errors in measurement can occur when flow is outside this range. Generally the device should be selected to cover the desired range. Choosing a device that can handle a larger than necessary flow rate could result in elimination or measurement capability at lower flow rates, and vice versa.

5.3.3.5 Head Loss. Most water measurement devices require a drop in head. On existing irrigation systems such additional head may not be available. On new projects it may be possible to design

the system with additional head loss at a reasonable cost. Often a tradeoff will exist between the cost of a measuring device and the amount of head loss required. For example some devices are expensive but require little head loss while others are inexpensive but require high head loss.

5.3.3.6 Adaptability to Site Conditions. Selection of a measurement device must consider the site of the proposed measurement. The device chosen should be compatible with the physical characteristics of the site and not alter the hydraulic conditions so as to interfere with normal operation and maintenance.

5.3.3.7 Adaptability to Variable Operating Conditions. Measurement devices should be able to measure over the range of operating conditions encountered (e.g., variations in upstream and downstream head). Devices like flumes or weirs should be avoided if downstream water levels can, under some conditions, submerge the device. Also, the information provided by the device needs to be useful for the operators. Devices that are difficult or time consuming to operate are more likely to be used incorrectly.

5.3.3.8 Type of Measurement and Records Needed. Since flow rates change over time, a single instantaneous reading may not accurately reflect the total volume of water delivered. Where accounting for water volume is desired, a method of accumulated individual measurements is needed. Many water measurement methods are suitable for making temporary measurements (flow surveys) or performing occasional verification checks of other devices. The method chosen for such a measurement might be quite different from that chosen for continuous monitoring.

5.3.3.9 Operating Requirements. All measurement devices require different levels of training and ability to operate. The requirements of the operating personnel in using the devices and techniques for their desired purposed can be easily overlooked and must be considered in meter selection.

5.3.3.10 Ability to Pass Sediment and Debris. Some measuring devices are sensitive to the accumulation of debris. Devices that work well in closed conduits are not usable in culverts or inverted siphons because of debris in the water. Generally speaking, most devices will require some regular maintenance and cleaning. Selecting a device that functions well with a reasonable amount of debris at the measurement site may reduce maintenance requirements.

5.3.3.11 Device Environment. Devices with moving parts and/or sensors can be adversely affected by environmental conditions. Temperatures can cause parts to expand and contract as well as freeze openings closed. Acidity and alkalinity in water can corrode metal parts. Minerals and biological growths can encrust and impair moving parts and plug pressure transmitting ports. Sediment can abrade parts or consolidate and impair mechanical movement. Devices that depend upon electronic devices and transducers should be appropriately housed to protect them from harsh environments.

5.3.3.12 Maintenance Requirements. The type and amount of maintenance varies with different measurement methods. Regardless of the method a regular maintenance schedules and procedures are recommended for all types of devices.

5.3.3.13 Construction and Installation Requirements. Devices which can be easily retrofitted into existing systems are preferable to those that require excessive modification to the conveyance system. An easier retrofit will require less down time and can help avoid unforeseen problems.

5.3.3.14 Device Standardization and Calibration. A standard water measurement device infers a documented history of performance based on theory, controlled calibration, and use. A truly standard device has been fully described, accurately calibrated, correctly constructed, properly installed, and sufficiently maintained to fulfill the original installation requirements and flow condition limitations. Commercially available devices do not always satisfy the requirements of a standard device.

When measuring devices are fabricated onsite or are poorly installed, small deviations from the specified dimensions can occur. These deviations can affect the calibration. In such instances an onsite calibration should be performed.

5.3.3.15 Field Verification, Troubleshooting and Repair. After construction or installation of a device, some verification of the calibration is generally recommended. For some devices errors occur as components wear and the calibration drifts away from the original. Because of this occasional checking of the device is required to insure that it is still performing correctly. Selection of devices may depend on how they fail and how easy it is to verify that they are performing properly.

5.3.3.16 User Acceptance of New Methods. Selection of a measurement device must consider the past history of the practice at the site. When improved water measurement methods are needed, proposing changes that build on established practice are generally easier to institute than radical changes. It can be beneficial to select a new method that allows conversion to take place in stages to provide educational examples and demonstrations of the new devices and procedures.

5.3.3.17 Vandalism Potential. Instrumentation located near public access is a prime target for vandalism. In these instances measurement devices with less instrumentation or instrumentation that can be protected with housing, or buried in a vault should be considered.

5.3.3.18 Impact on Environment. There are potential environmental impacts associated with the installation and operation of measuring devices. These include the possible constriction of the channel, slowing of upstream flow, and accelerated flow through the device. Changes in flow conditions can alter channel erosion, local flooding, public safety, and aquatic habitat. These factors should be considered when selecting a device.

Table 5.5 matches measurement methods with applications. This table should be used in conjunction with a system survey to determine the ideal location for measurement devices. Once the devices are installed, a maintenance program that includes regular testing, calibration and repair should be instituted.

TABLE 5.5

Measurement Methods for Open Channel Conveyance Systems

Application	Method																		
	Periodic Current Metering*	Current Metering	Broad Crested Weirs	Short Crested Weirs	Sharp Crested Weirs	Movable Weirs	Long Throated Flumes	Short Throated Flumes	Sluice Gates	Rated Sluice Gates	Radial Gates	Check Gates	Overshot Gates	Meter Gates	Acoustic Velocity **Meters	Acoustic Doppler Velocity Profiles	Float Velocity/Area Method	Slope-Area Method	Constant Head Orifice
NATURAL CHANNELS																			
Rivers	X		X	X			X								X	X	X	X	
Intermediate-sized and Small Streams		X	X	X			X	X							X		X		
REGULATED CHANNELS																			
Gated Spillways									X		X								
Ungated Spillways			X	X															
Large Canal Control Structures									X		X	X	X						
Large Canal Other			X				X	X							X				
Small Canals															X				
Small Canals, Short-throated Flumes					X														
Small Canals, Long-throated Flumes			X																
Small Canals, Rated Flow Control Structures									X		X	X	X						
Small Canals, Other																	X		
Farm Pipe Turnouts***		X	X	X	X		X	X						X					
Farm Other						X				X									X

*Periodic current metering of a control section to establish stage-discharge relation.
**AVM-Transit Time
***Short inverted siphons, submerged culverts, etc.

5.3.4 Automation

There are a number of sites in the District that would benefit from automated monitoring and gate control. The Pitt-Taylor diversion, the Old Channel/Union Canal control structures, and Anker Pond are the most likely candidates for automation based on the criterion of delivery volume. By applying the flow rates from table 5.3, table 5.7 shows the amount of water that flows through these control structures at 15, 30 and 60 minute intervals.

TABLE 5.7

Flow through selected control structures

		FLOW THROUGH STRUCTURE (AF)		
Structure	**Flow (cfs)**	**15 min**	**30 min**	**60 min**
Pitt-Taylor Diversion Structure	300	6	12	25
Old Channel Structure	40	1	2	3
Union Structure	162	3	7	13
Anker Pond	90	2	4	7

The table above can be used to estimate the amount of water that can be conserved at structures with high flows. Manual control limits the precision of the release and retention of water at these sites. Automated monitoring and control could insure accurate deliveries in regard to timing and volume.

The USBR has had success with a number of canal automation projects in the United States, China, and Malaysia. According to the USBR the basic components of a simple canal automation set-up include the following:

- Datalogger/Controller
- Water level sensor
- Cellular phone, telephone or radio
- Modem
- Solar energy system
- Enclosures
- Gate actuators

Automated systems include one-time initial and incremental costs. One-time costs include dataloggers/controllers and modems while incremental costs will depend on the number of gates and/or measurement devices at each site. The estimated cost for automated monitoring at the Pitt Taylor diversion is $8,500 (included in the report by Dyer Engineering Consultants Inc. in Appendix A). Costs to install similar equipment at other sites will range from $8,000 to $10,000 depending upon specific configurations. Automation equipment can be installed in existing structures or included in new construction.

5.3.5 Replacement of Aging Control Structures

Currently a number of important control structures within the District are operating at a low level of efficiency. The Pitt-Taylor diversion dam and diversion structure leak and the channel upstream is in poor condition. Considering the importance of these structures, the existing method of releasing of water from the dam and the diversion is crude and inefficient. The replacement of these facilities would improve the delivery of water to the Pitt-Taylor Reservoirs as well as flow that continues downstream to the Rye Patch Reservoir.

The control structures on the Upper and Lower Pitt-Taylor Dams are also in poor condition. Both structures leak and could be seriously damaged in a moderate seismic event. If either of these structures became inoperable, it would be useless to store water in either one. The Upper Pitt-Taylor currently is permitted to hold 19,000 acre-feet and the Lower Pitt-Taylor holds 13,000 acre-feet.

Conservation measures down stream of Rye Patch Dam would include the installation of slide gates on the Pitt and Rodgers Dams, the installation of a back up structure at the Humboldt Plug, the replacement of the Old Channel / Union Canal diversion structures and the replacement of Anker Pond. All of these structures leak and do not allow for accurate release of water.

5.3.6 On-farm Conservation

Most of the farms in PCWCD irrigate by flooding. Other methods of irrigation such as sprinklers may be more efficient but may not be economically feasible for all farmers. For those who irrigate by flooding, conservation can be achieved by increasing irrigation efficiency. The following is a list of on-farm conservation measures that may be implemented within the District.

5.3.6.1 Agricultural Water Audits. To identify system strengths and/or weaknesses, a farm irrigation audit should be conducted prior to the implementation of system upgrades. The purpose for an audit is to identify ways to save water and energy, improve crop yields, lower farm chemical needs, save money, and comply with conservation guidelines or policies[12]. The basic steps in an Agricultural Water Audit include:

- Determine water use.
- Identify on-farm conservation measures that have already been implemented.
- Review irrigation system type, layout, and current irrigation schedule.
- Evaluate irrigation system efficiency. Perform irrigation system field tests to determine irrigation efficiency.
- Review crop types, water and energy costs, and other irrigation-related matters.
- Conduct a water quality test to determine total dissolved solids and the leaching fraction.
- Identify all appropriate conservation measures for the farm's irrigation systems, including technology-based and practice-based measures.
- Create an evaluation that includes observations and recommendations on benefits and costs of recommended measures, irrigation system design, operation, and maintenance.
- Review conservation measure annually to evaluate the success of measures that have been implemented and to identify additional measures that may be appropriate.

5.3.6.2 Soil Moisture Measurement/Monitoring. Soil moisture is the fundamental piece of empirical data from which farmers determine crop irrigation requirements. Farmers can use soil moisture data in conjunction with weather data and crop evapotranspiration (ET, see section 5.5.3) requirements to schedule irrigations precisely (how much and when to irrigate). By doing so they can optimize crop yields while saving water and energy. There are several different methods for soil moisture measurement. They include the following:

- Estimating Soil Moisture by Appearance and Feel
- Measuring Soil Moisture by Soil Sampling
- Measuring Soil Moisture with Permanent, Fixed-Location Instruments

There are four main commonly used fixed location moisture monitoring methods; porous blocks, tensiometers, neutron probes and reflectometers. Manufactures of these devices provide instructions for their installation and operation. An evaluation of the various methods is shown in table 5.8. Methods are evaluated on a scale of 1 to 10 with 10 being superior.

TABLE 5.8
Qualitative Evaluation of Various Soil Water Measurement Methods

	Method*							
Evaluation Criteria	**NP**	**TDR**	**GS**	**AP**	**AQ**	**TM**	**GB**	**WB**
Initial Cost	3	1	8	2	7	8	8	8
Field Site Setup Requirements	7	3	10	3	10	7	6	6
Obtaining a Routine Reading	8	8	1	8	4	10	8	8
Interpretation of Readings	10	10	10	10	3	5	3	5
Accuracy	10	10	10	8	2	7	2	3
Maintenance	9	9	8	9	7	3	9	9
Special Considerations	2	8	5	8	9	7	5	8
Composite Rating	49	49	52	48	42	47	41	47

*NP=NEUTRON PROBE, TDR=TIME DOMAIN REFLECTOMETRY, GS=GRAVIMETRIC SAMPLING, TROXLER SENTRY 200-AP, AQ=AQUATERR PROBE, TM=TENSIOMETER, GB=GYPSUM BLOCK, WB=WATERMARK BLOCK

5.3.6.3 Evapotranspiration (Crop Water Use). Evapotranspiration (ET) is the water removed from the soil by soil evaporation and plant transpiration or crop water use[13].

Maximum yield is directly related to ET. Yield increases linearly with ET and maximum yield cannot be reached unless the maximum ET level is reached. Nevertheless the application of extra water beyond ET demand will not increase yield. Since all irrigation water cannot be converted into ET and yield, the goal should be to improve irrigation efficiency to match as closely as possible the yield-ET linear relationship.

Irrigation system capacity should be determined using peak ET rates. Irrigation scheduling should be done according to daily and weekly rates. Long term average ET rates can be used to determine net crop irrigation requirements. Aggregate ET rates can help PCWCD manage supply allocations for all water users. The following factors affect ET:

- Weather
- Crop Type
- Crop Growth Stage
- Crop Variety
- Crop Population
- Surface Cover
- Tillage
- Availability of Soil Water

5.3.6.4 Precision Leveling. Laser leveling can improve flood irrigation efficiencies but it should be accompanied by soil surveys to make certain water is properly applied. Leveling should be done no less than every 3 to 5 years. Many of the farms in the PCWCD currently use laser leveling

5.4 CONSERVATION RECOMMENDATIONS

5.4.1 Seepage

Recently the PCWCD began using a polymer based sealant (see Appendix C) to seal canal bottoms. The sealant covers an average of six miles of canal assuming an average canal bottom width of 32 feet which includes five feet of canal bank on either side. The current cost for this treatment is approximately $400.00 per mile of canal. PCWCD started applying the sealant prior to the last irrigation season but no study has been performed to verify its effectiveness. However water retention has been observed in the canals at the end of the irrigation season.

The last extensive flow studies were performed on the canal system in 1969 for the Upper Valley and 1970 for the Lower. Some of the canals in those studies have since been abandoned. There have also been improvements made to the system since that time, for example the replacement of Sommers Dam. Other efficiencies have been added due to improved management. Because of these changes it is recommended that a new flow survey be performed on the entire system to determine current losses and to use as a benchmark for future conservation efforts, including the lining of canals. The new survey should also include a study of the Pitt-Taylor diversion canal. The purpose of the survey should be to determine if canals or portions of canals should be lined.

No study has been done to determine the integrity of the Upper and Lower Pitt-Taylor Dams. However a dam safety inspection report written in 1998 by the Nevada Department of Water Resources stated the following concerning the Upper Pitt-Taylor Dam:

"Seepage all along the embankment/foundation contact and foundation continues unabated...The seepage through and under the embankments should be care fully monitored and increases in flow, turbidity or channelization immediately reported to the State Engineer."

The Lower Pitt-Taylor Dam was evaluated in the same report which included the following:

"Lower Pitt-Taylor Dam is in poor condition with deteriorated outlet works and severe seepage...During the last inspection the rate of seepage along the entire downstream toe of the dam was the worst I had ever witnessed with concentrated flow in numerous locations... The seepage through and under the embankments should be care fully monitored and in increases in flow, turbidity or channelization immediately reported to the State Engineer."

It is recommended that a more extensive survey be done to determine the composition of the dams embankments and what can be done to correct seepage problems. Test wells should be drilled and monitored as part of the study. The outlet structures on both the Upper and Lower Pitt-Taylor Dams should be replaced.

5.4.2 Weeds

There is an ongoing effort to reduce the amount of tamarisk in PCWCD. However there are other invasive weeds within the Humboldt River system that can also cause damage to riparian areas as well as spread to neighboring farms. It is recommended that a weed survey be performed along the water system that will evaluate weed conditions and identify any problems or potential problems caused by the presence of aggressive species.

5.4.3 Water Measurement

A survey of water measurement devices in PCWCD should be conducted. The survey should include an evaluation of existing devices that determines if the device is calibrated, properly installed and well suited for the location and conditions. Possible sites for additional measurement devices should also be identified. In certain areas automated monitoring should be considered an option. The evaluations should be done using the criteria in section 5.3.3.

5.4.4 Automation

Automation is included as part of the proposed improvements on the Pitt-Taylor diversion dam and structure, the Old Channel and Union canal structures and Anker Pond. In addition to these projects other sites should be evaluated for installation of automated monitoring equipment.

5.4.5 Replacement of Structures

It is recommended that the following structures be replaced or installed within the next three years:

- Replacement of the Pitt-Taylor diversion dam and diversion structure
- The replacement of the control structures on the Upper and Lower Pitt-Taylor Dams
- The installation of a back up structure at the Humboldt Plug
- The replacement of the Old Channel / Union Canal diversion structures
- The replacement of Anker Pond
- The installation of slide gates on the Pitt and Rodgers Dams

5.4.6 On-Farm Conservation

PCWCD should encourage on-farm conservation efforts as much as possible. Information on government incentives for on-farm water efficiency measures should be sought after and passed on to district farmers. These include in-kind services, educational programs, demonstration projects and financial incentives including tax incentives, low-interest loans, equipment purchase subsidies, and water charge discounts or rebates.

5.4.7 Other Conservation Measures

An important part of this plan is the proposed replacements of certain structures. These structures include:

- The Pitt-Taylor Diversion Dam and Structure
- Upper and Lower Pitt-Taylor Dam outlet structures
- Old Channel/Union Canal control structures
- Anker Pond

Replacement of these structures will improve the control of flow in locations where volume is high. It will also reduce leaking and even the possibility of failure. In the case of the Pitt-Taylor structures it will increase the amount of water that can be stored.

Additional less extensive modifications are recommended for the Pitt and Rodgers Dams (installation of additional slide gates). The addition of slide gates to these structures will reduce leaks and improve the precision of release or retention from the dams. It will also improve the safety of operation.

[1] United States Department of Agriculture, Economic Research Service, "Irrigation and Water Use: Questions and Answers": Is There Potential for Water Conservation Improvement in the West?

[2] Pershing County Water Conservation District, *Title Transfer Handbook,* pp. 17

[3] Don Breazeale and Marty Owens, *2002 – 2003 Pershing County Agricultural Statistics,* UNR Cooperative Extension Service Fact Sheet-04-40

[4] United States Department of Agriculture, Economic Research Service, "Irrigation and Water Use: Questions and Answers": What are the barriers to producers adopting more water-conserving irrigation systems?

[5] United States Department of Agriculture, Economic Research Service, "Irrigation and Water Use: Questions and Answers": What are the barriers to producers adopting more water-conserving irrigation systems?

[6] United States Department of Agriculture, Economic Research Service, "Irrigation and Water Use: Questions and Answers": How Much Do Irrigation Costs Vary by Farm Size?

[7] United State Bureau of Reclamation, Water Conservation field Services Program: "About the Program"

[8] M. B. Kirkham, "Water Conservation Practices", *Irrigation Business & Technology ,* vol. VIII, no. 4, August/Septermber 2000, pp. 17-21, 30.

[9] Wayne Johnson, Jason Davison, James Young, and Tina Kadrmas, *Managing Saltcedar",* University of Nevada Cooperative Extension

[10] Danny H. Rogers and Richard D. Black, *"irrigation Water Measurement"* , Kansas State University Cooperative Extension Service Irrigation Management Series

[11] United States Bureau of Reclamation, *"Water Measurement Manual"* Revised Reprint 2001

[12] Amy Vickers, *Handbook of Water Use and Conservation,* WaterPlow Press, June 2002

[13] Norman L. Klocke, Kenneth G. Hubbard, William L. Kranz, and Darrell G. Watts, *"Evapotranspiration or Crop Water Use",* University of Nebraska-Lincoln Cooperative Extension, Institute of Agriculture and Natural Resources

Chapter 6
CONDITION ASSESSMENT

CHAPTER 6 – CONDITION ASSESSMENT **1**

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6.1 INTRODUCTION

The PCWCD system consists of approximately 108 miles of canals and ditches, nine dams, two reservoirs and a number of diversion structures that vary in size, construction, and age. Some of the dams and diversion structures date back to the early 1900's including the Pitt Taylor Diversion, Upper and Lower Pitt Taylor reservoirs and outlets, and the Pitt Dam.

The purpose of this chapter is to provide a detailed assessment of the condition of the control structures and a general assessment of the canals and ditches in the PCWCD system. More detailed information regarding canals is included in Chapter 5 – "Conservation".

The assessed condition of the control structures including dams, diversion/division structures and canals is divided according to canal system and includes the following:

- Pitt-Taylor Diversion Dam, Diversion Structure and Canal
- Upper Pitt-Taylor Dam
- Lower Pitt-Taylor Dam
- Young Dam, Diversion Structure and Canal
- Pitt Dam
- Irish-American Dam
- Rodgers Dam
- Sommers Dam
- Big Five Dam
- Old Channel / Union Diversion Structure and Canals
- Rodgers Canal
- Union-Rodgers Canal
- Anker Pond
- Humboldt Plug

Facility assessment descriptions vary from good to poor. Assessment considerations include the physical condition of the structures, the condition of the channel immediately adjacent to the structures both upstream and downstream, and the operation of the control devices (flashboards and/or gates).

The assessment of canals also includes general rankings of good, fair or poor. It was observed that all of the canals have some combination of these conditions along their length. For example, sections of canals that would be considered good have characteristics of unobstructed flow, low evaporation, low seepage and low erosion.

6.2 CONDITION ASSESSMENTS

6.2.1 Pitt-Taylor Diversion Dam, Diversion Structure and Canal

The Pitt-Taylor diversion facilities include the Pitt-Taylor Diversion Dam, Diversion Structure and Canal. The Dam is an on-stream dam that backs up water on the Humboldt River for diversion to the Pitt-Taylor Canal. Both the structures and the canal were constructed circa 1910.

The Pitt-Taylor Diversion Dam is in poor condition. The dam consists of ten buttresses with eleven flashboard bays. There is visual evidence of deterioration on all of the buttresses, some with as much as fifty to seventy five percent surface spalling (see figure 6.1). All of the buttresses have cracking with some cracks extending completely through the buttress. The river channel both upstream and downstream of the dam is in poor condition. Erosion has caused the formation of a shoal on the upstream side blocking at least three of the dams eleven bays (see figure 6.2). The exclusive use of flashboards to control flow through the dam is also a concern. Flooding in May and June of 2005 made it nearly impossible to reach the flashboards to regulate flow creating a safety hazard for PCWCD personnel. The flashboards are also difficult to remove and replace due to advanced deterioration of the keyways in the buttresses.

FIGURE 6.1

Spalling and Cracking on Pitt-Taylor Diversion Dam

FIGURE6.2

Pitt-Taylor Diversion Dam looking from upstream down. Note sandbar on the right.

The diversion structure is also in very poor condition. In addition to spalling, parts of the structure have completely disintegrated, exposing the steel reinforcement (see figure 6.3).

A more detailed preliminary engineering report on the condition of the dam and diversion structure has been prepared by Dyer Engineering Consultants Inc. and is included in Appendix A of this plan.

FIGURE 6.3

Pitt-Taylor Diversion Structure

The Pitt-Taylor Canal supplies water to the Pitt-Taylor Reservoirs and to a single user (Flying M Ranch). There are only two structures in the canal between its origin at the Pitt-Taylor Diversion and its destination at the Upper Pitt-Taylor Reservoir. The first, the Flying M diversion, is approximately 2.6 miles downstream of the Pitt-Taylor Diversion, is in poor condition and unable to handle the original designed flow capacity of 300 cfs (see Figure 6.4). The second structure is a bridge crossing the canal near the diversion structure that provides access to the Flying M Ranch.

FIGURE 6.4

Flying M Diversion Structure

The condition of the canal itself varies from fair to poor along its 14 mile length. Five miles downstream of the Pitt-Taylor Diversion the canal bank has been breeched. Much of the canal is overgrown with tamarisk and other invasive plants (see figure 6.5). In many areas the canal cross-section is inconsistent in width and depth (see Chapter 3 section 3.3.10 for original design dimensions).

FIGURE6.5

Pitt-Taylor Canal. Note Heavy Tamarisk Growth.

6.2.2 Upper Pitt-Taylor Dam and Control Structure

The Upper Pitt-Taylor Reservoir facilities include the reservoir itself, a dam and an outlet structure. The reservoir is supplied by the Pitt-Taylor Canal and empties into the Lower Pitt-Taylor Reservoir. The outlet structure that controls flow into the Lower Pitt-Taylor Reservoir is located about 2300 feet northeast of the southeast end of the dam.

A dam safety inspection was performed in 1998 by the State of Nevada Division of Water Resources. In 1997 the reservoir had been full to capacity so there was water in the reservoir when it was inspected. Seepage was detected in several areas along the length of the dam (see Chapter 5, Section 5.4.1). The following was taken from the inspection report:

"Upper Pitt Taylor Dam was in poor condition with a deteriorated outlet, heavily eroded and over-steep embankments and uncontrolled foundation seepage."

A safety inspection performed by GA Engineering and Planning in December 2001 stated;

"Some evidence of animal burrowing was found on the mortared rock at the entrance to the dam's outlet structure. Vertical cracking of the mortar was also evident. Evidence of soil cracks, possible future sloughing was detected near the outlet structure. The downstream side of the outlet structure has experienced significant damage and should be repaired and armored, or replaced. Erosion of the dam's downstream face in the form of gullies was found at several sites along the dams crest. The vegetation growing on the dam's face and crest should be removed. The two slide gates without mechanisms for operation should be fitted with such mechanisms... Construction of a spillway should be seriously considered to protect the dam from breaching."

Field examination of the dam by Farr West Engineering personnel in October of 2004 confirmed that the above described conditions had not changed. Additionally it is unlikely the outlet structure or the dam could withstand a moderate seismic event with the reservoir at full capacity (see figure 6.6).

FIGURE 6.6

Upper Pitt-Taylor Control Structure

6.2.3 Lower Pitt-Taylor Dam and Control Structure

The Lower Pitt-Taylor facilities include the reservoir, dam and control structure. The reservoir is fed through a canal between the Upper and Lower Pitt-Taylor Reservoirs and the outlet empties into Rye Patch Reservoir. Unlike the Upper Reservoir the control structure is located in the middle of the dam.

The condition of Lower Pitt-Taylor Dam was described in a 1998 dam safety report prepared by the State of Nevada Division of Water Resources. At the time there was water in the reservoir. The following excerpt was taken from the report.

"Lower Pitt-Taylor Dam is in poor condition with deteriorated outlet works and severe seepage."

The dam was inspected again in December 2001 by GA Engineering and Planning. The following description was taken from that report.

"No evidence of animal burrowing was found on the dam. No evidence of sloughing was detected. The vegetation (willows) growing on the dams face and crest should be removed. Improved access to the top of the control structure should be installed. The right slide gate stem should be repaired or replaced...At some future time, the outlet structure will need to be repaired and armored or replaced. Construction of a spillway should be seriously considered to protect the dam from breaching."

During a visit to the dam by Farr West Engineering personnel it was observed that the above mentioned conditions had not changed except that improved access to the control structure had been installed.

6.2.4 Young Dam, Diversion Structure and Canal

The Young Dam facilities include the Young Dam, Diversion Structure and Canal. The Dam is an in stream dam in the Humboldt River that diverts water into the Young Canal. The canal flows south for approximately 1.8 miles before it rejoins the Humboldt.

The dam appeared to be in good condition. The bottom of the canal on the downstream side of the dam is armored with rip-rap. There was some scour in the channel bottom just downstream of the dam and undercutting could be a problem. The jack operated slide gate and flash boards all appeared to be in good operational condition (see figure 6.7).

The diversion structure and canal appear to be completely functional and in good condition.

FIGURE 6.7

Young Dam

6.2.5 Pitt Dam

The Pitt Dam facilities include the dam itself and the vehicular bridge that spans the crest. The condition of the dam is fair. Spalling was observed on approximately fifty percent of the buttress and abutment surfaces. A Schmidt impact hammer was used to do preliminary field testing of the strength of the concrete. Four random spots on the dam were tested with the average result being approximately 1800 psi. There is a substantial crack that has resulted in the separation and dislocation of a portion of the east end abutment (see figure 6.8). There are 7 flashboard bays that back up water behind the dam and one slide gate bay that controls flow through the dam. During minor flooding in May and June of 2005 it was discovered that more slide gates may be needed in place of flashboards in some of the bays for safe and reliable flow control. The vehicular bridge across the crest is in fair condition.

FIGURE 6.8

Downstream side of Pitt Dam. Note crack on abutment.

6.2.6 Old Channel / Union Diversion Structure and Canals

The facilities at this diversion include the diversion structures for the Old Channel and Union Canals, a bridge on Holmstrom Road under which both canals pass, and the origin of the canals themselves. These facilities supply water to most of the Upper Valley with the exception of the minor contribution made by the Young Canal.

Both of the diversion structures are in fair to poor condition. The Union Canal bottom is armored on the immediate downstream side of the bridge and the Old Channel Canal bottom is armored on the downstream side of the diversion structure. There is evidence of scour in the channel bottom on the downstream side of the Old Channel structure. There is spalling on fifty percent of the surfaces of both structures and the passages beneath the bridge (see figures 6.9 and 6.10).

FIGURE 6.9

Old Channel Control Structure

FIGURE 6.10

Downstream Side of Union Control Structure

There are several structures along both of the canals that are in good to poor condition. These include diversion structures for the 12 laterals along the Old Channel and the structure at the junction of the Big Meadow and Arobio canals on the Union. The condition of the Big Meadow, Irish and Arobio canals and their associated laterals also varies along their length from good to poor. Chapter 5 includes a discussion on seepage in these canals

The concrete diversion structure at the junction of the Big Meadow, Union and Arobio canals is in poor condition with areas of severe spalling and cracking in the concrete (see figure 6.11). This junction also has pipes that run underneath the adjacent road and railroad tracks that are undersized. The Irish-American canal is in fair condition but it includes a pipe that crosses over the Arobio canal that is undersized and should be replaced. The Arobio canal is in fair condition.

There are two backup structures on the Old Channel Canal that are in poor condition and operate inefficiently. These include the backups at the #5 diversion and the #7 diversion. Water is diverted into the #2 diversion ditch by pump (also known as the “Cowboy Pump). Currently the pump operates inefficiently for lack of proper head at the pump intake.

FIGURE 7.11

Junction of Union, Big Meadow and Arobio Canals

6.2.7 Irish-American Dam

The Irish-American Dam facility consists of only a drop structure. The dam was observed from a distance and appeared to be just a simple In-stream concrete structure with no means of flow control. A good portion of the structure was cracked and spalled. Although the structure is not used to control flow it may be useful for erosion control. In its absence channel cutting could become problem. The condition of the dam is poor (see figure 6.12).

FIGURE 6.12

Irish American Dam

6.2.8 Rodgers Dam, Diversion Structure and Canal

The Rodgers dam facilities include the Rodgers Dam, Diversion Structure, and Canal. The dam appeared to be in good operational condition. The diversion structure also appeared to be well maintained and in good condition. The condition of the canal varied from good to fair. Immediately upstream from where the canal joins the Union Canal there is a steel pipe flume measuring seven feet in diameter by 300 feet long that crosses over the Humboldt River. During high flow conditions in spring of 2005 it was observed that the flume diameter may be inadequate for the higher flows. When flows reached approximately 285 cfs it became necessary to open a normally unused bypass canal in order to convey excess water not passing through the flume.

6.2.9 Union-Rodgers Canal

The Union-Rodgers Canal facilities include the canal itself and five diversions; Rodgers Ditch, Tule Lateral, Seven Lateral, Reed Lateral and Lakeshore Lateral. The canal is in good to fair condition. According to the 1970 flow study the canal actually had positive gains in flow probably due to return flows from irrigated lands and measurement error.

6.2.10 Rodgers Ditch

The 1970 system flow study indicated the Rodgers Lateral had some seepage loss (see Chapter 5, table 5.3). Farr West Engineering personnel observed that the lateral appeared to be clean and in fair condition.

6.2.11 Seven Lateral

The Seven Lateral serves only one user. It is long and deep in spots with evidence of erosion. The 1970 flow study indicated some seepage loss (see Chapter 5, table 5.3).

6.2.12 Tule Lateral

The back-up structure toward the end of the Tule Lateral appeared to have seepage problems. The lateral was dry when it was inspected (see Chapter 6, figure 6.13) but the PCWCD personnel have observed that the structure leaks when it is closed. It is not certain whether the water is coming from

underneath the structure or passing over one side. It did appear that the structure is lower then the wall at the diversion. There is also a large amount of sedimentation on the upstream side of the structure and some scour on the downstream side with some evidence of undercutting.

FIGURE 6.13

Tule Lateral Diversion Structure

6.2.13 Lakeshore Lateral

The Lakeshore Lateral is deep on the upper end and has high seepage loss according to the 1970 flow study (see table 5.3). This lateral has no users and serves as the supply source for Anker Pond.

6.2.14 Reed Lateral

This lateral is in good condition but according to the 1970 flow study it had very high seepage losses.

6.2.15 Copenhagen Lateral

The Copenhagen is in fair condition. However the outlet structures at the corner of Westergard and Carpenter roads, are in poor condition and are undersized (see figure 6.14).

FIGURE 6.14

Copenhagen Control Structures

6.2.16 Anker Pond

The Anker Pond system includes the pond which is supplied by the Lakeshore lateral, the East, West (Including the Harper), and Anker ditches. The outlet to the Lower Lakeshore is controlled with one slide gate, the outlet to the West is controlled with two slide gates and the outlet to the East Lakeshore is controlled with stop logs in two openings.

The control structures at the pond are in fair condition. The pond is basically a polygonal shaped earthen tub with 5 sides. Three sides have concrete control structures, one side is bordered by the road and inlet conduit that runs underneath, and the fifth side, which is also the longest, is an earthen embankment. The embankment is approximately 60 feet long by 20 feet wide and borders the southwestern side of the pond. This appears to be the weak point in the pond and it has the potential to fail.

The canals fed by Anker Pond and their associated control structures appear to be in fair to poor condition. There is evidence of erosion in the West Lakeshore Lateral. The flume in the East Lakeshore lateral that runs under Carpenter Road is in poor condition and may not have sufficient flow capacity. The flume in the Anker ditch that runs under Westergard Road is also in need of replacement.

6.2.17 Sommers Dam and Canal

The Sommers Dam facilities consist of the Dam itself and the Sommers Canal. The Dam was built in 2001 and is in excellent condition. The canal also appears to be good condition.

6.2.18 Big Five Facilities

The facilities include the Big Five Dam and Canal and the Seventeen Canal. The Dam and both canals appear to be in good condition although the dam may be too small for its location and it may be the cause for high water at the Sommers Dam and the Humboldt Plug during flood years. There are 2 or three diversions along the Big Five Canal that are in poor condition. The canal also runs parallel to a drainage ditch and there is some seepage into that ditch.

6.2.19 Humboldt River Plug

The Humboldt Plug is simply an earthen and rip rap dam in the river at the end of the PCWCD system that backs up water into the diversions for the Big Five and Sommers Dams. The Plug's weakness becomes apparent when water levels exceed the crest height. The action of the water flowing over the crest erodes the top of the dam as well as the down stream side causing the dam to fail. When the Plug fails the District is unable to back up irrigation water for the lower end of the system. In fact, the loss of this dam affects 23% of the total irrigable acreage in the District. This weakness in the system also limits the amount of water that can be released from Rye Patch Reservoir which becomes a serious problem in flood years. At flows above 2000 cfs the Plug is at risk of washing out and has failed three times in the past 19 years. Regarding the materials in the dam, a Dam Feasibility Study conducted by URS/Dames & Moore of Sacramento California states the following:

"The permeable materials used to construct the dam to date are incapable of preventing piping action...The cohesive strength of materials at the top of the dam is lower than that associated with materials at the bottom of the dam which are less likely to move because of the weight of the material overlain on top of them. As a result, when the water flow occurs over the dam, the surface soil particles will begin to move with the flow of water, eventually causing the top of the dam to washout."

A copy of the URS/Dames & Moore report is included in Appendix X. Note that the report erroneously refers to the Plug as Big Five Dam.

Chapter 7
PROPOSED SYSTEM IMPROVEMENTS

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7.1 INTRODUCTION

This chapter provides recommendations for improvements to PCWCD facilities. The recommendations are based on conservation information in Chapter 5 and condition assessments in Chapter 6. Recommendations take into consideration the following factors:

- Conservation
- Maintaining capacity
- Improve Operation and Maintenance
- Safety

Because conditions vary at each facility some of the proposed improvements will satisfy all of these factors; and others only part.

The purpose of the Master Plan is to evaluate system strengths and weaknesses and focus on facilities in greatest need of improvement. Only the highest priority projects have been estimated here. Once these projects are complete, the cost of smaller improvements can be estimated with assistance from the as-built experience gained.

7.2 RECOMMENDED IMPROVEMENTS

7.2.1 Pitt-Taylor Diversion Dam and Diversion Structure

Problem
The dam and diversion structure are old and in advanced stages of deterioration. The river channel immediately upstream and downstream of the dam is in poor condition. Flow through the dam is obstructed in spots and difficult to control in flood conditions. In wet years when water is diverted to the Pitt-Taylor Reservoirs for storage, the dam leaks and water continues downstream to Rye Patch Reservoir, allowing for the possibility of exceeding its maximum capacity. Both the Dam and the Diversion are unsafe during high flows and there is the possibility of catastrophic failure during a seismic event.

Recommendations
It is recommended that both the dam and diversion structure be redesigned and replaced. Replacement would include improvements to the river channel in areas adjacent to the structures both upstream and downstream, demolition of the old structures and construction of the new ones, including the installation of a remote monitoring system.

Objectives

- Efficient delivery of irrigation water to the Flying M diversion
- Better management of water stored in the Pitt-Taylor Reservoirs
- Better control of water flowing into Rye Patch Reservoir
- Safe operation of gates
- Overall improved conservation of available water

Estimated Cost: $1,020,416

A detailed description of the replacement of the Pitt-Taylor diversion dam and structure prepared by Dyer Engineering Consultants, Inc. is included in Appendix A of this plan.

7.2.2 Pitt-Taylor Diversion Canal

Problem
There are many sections of the canal that are choked with tamarisk. The cross sectional shape of the canal is inconsistent with the original design dimensions and there are areas where the bank has been

breeched. There is evidence of seepage in several spots. The capacity of the canal limits the amount of water that can be stored in the Pitt-Taylor Reservoirs. The diversion structure that provides water to the Flying M Ranch leaks and needs to be replaced.

Recommendations
The canal should be cleaned, reshaped and lined in sections where high seepage is present. The Flying M diversion structure should be replaced.

Objectives

- Increase the amount of water stored
- Improve delivery to the Flying M Ranch
- Decrease erosion and potential failure of canal banks
- Decrease seepage and losses to invasive plants

7.2.3 Upper Pitt-Taylor Dam

Problem
The Upper Pitt-Taylor Dam is in poor condition. The embankments are eroded and over-steep with seepage being observed at the foundation level. There is excessive vegetation growth on the embankments. The outlet structure has cracks and animal burrows. Two of the three slide gates are non-functional. It is anticipated that with the reservoir at capacity, the outlet structure could not withstand a significant seismic event.

Recommendations
The outlet structure should be replaced. An extensive study should be performed on the dam to determine improvement options. The study should include the installation of test wells to monitor seepage, an evaluation of the stability of the embankments and an analysis of the possible effects of catastrophic failure. An emergency plan and maintenance procedures should be created that cover all possible contingencies.

Objectives
The replacement of the control structure, survey, and emergency plan and maintenance procedures should accomplish the following:

- Improve control of water emptied into the Lower Pitt-Taylor Dam
- Eliminate leaks through the control structure
- Determine if failure of the Upper Pitt-Taylor Dam will cause the subsequent failure of the Lower Pitt-Taylor Dam (Emergency Plan)
- Determine what needs to be done to improve the condition of embankments.
- Provide options in the event of a failure (Emergency Plan)
- Provide a way to preserve the dam until rehabilitation or replacement can be implemented (Maintenance Procedures).

Estimated Cost to Replace Control Structure: $743,018

7.2.4 Lower Pitt-Taylor Dam

Problem
The condition of the Lower Pitt-Taylor Dam is identical to the Upper Pitt-Taylor Dam. Seepage, erosion and areas of excessive vegetation are all present. The control structure has outlived its useful life.

Recommendations
The control structure in the dam should be replaced. An extensive study should be performed on the dam to determine improvement or maintenance requirements. The study should include the installation of test

wells to monitor seepage, an evaluation of the stability of the embankments and an analysis of the possible effects of catastrophic failure. An emergency plan and maintenance procedures should be created that cover all possible contingencies.

Objectives
The objectives are identical to those for the Upper Pitt-Taylor Dam:

- Better control of flow into Rye Patch Reservoir
- Eliminate leaks through the control structure
- Determine what needs to be done to improve the condition of embankments.
- Provide options in the event of a failure (Emergency Plan)
- Provide a way to preserve the dam until rehabilitation or replacement can be implemented (maintenance procedures).

Estimated Cost to Replace Control Structure: $743,018

7.2.5 Young Dam

Problem
Although the dam itself is in good condition there was some scour in the channel bottom just upstream of the dam and undercutting could be a problem.

Recommendations
The existing rip-rap should be removed and a new concrete apron constructed. Depending upon the evaluation of undercutting, a new cutoff wall should be considered.

Objectives

- Elimination of seepage
- Elimination of undercutting
- Preservation of the existing structure

7.2.6 Pitt Dam

Problem
The Pitt Dam diverts water to the two main supply canals in the Upper Valley. The dam has eight bays, seven back up water behind the dam with flashboards and one controls flow with a rack and pinion operated slide gate. The flashboards leak and with only one slide gate, larger releases of water are less than accurate. Also during flooding in May and June of 2005 it was discovered that removal of flashboards during a high flow is difficult and hazardous.

Recommendations
The dam should be retrofitted with additional slide gates. The minimum number of slide gates that should be added will need to be determined by a flow analysis of the bridge.

Objectives

- Improve control of flow through the dam
- Reduce leakage
- Improve dam operation safety

Estimated Cost to Install Slide Gates: $198,500 (Budget for five gates)

7.2.7 Irish-American Dam

Problem
The dam is old and has cracks and spalling. Although the dam is not used a control structure, it may be useful in preventing erosion in the channel upstream of its location.

Recommendations
The condition of the dam should be evaluated to determine if it could fail in sustained high flows. A study should be performed to determine how the channel would be affected in the event of failure.

Objectives

- Determine the function and need for the dam
- Determine the remaining useful life of the dam
- Determine if dam needs to be replaced

7.2.8 Rodgers Dam

Problem
The Rodgers Dam diversion supplies most of the lower valley water and has problems similar to the Pitt Dam. Flow through the dam is controlled by flashboards that are difficult to manipulate in high water.

Recommendations
The dam should be retrofitted with additional slide gates. The minimum number of slide gates that should be added will need to be determined by a flow analysis of the bridge.

Objectives

- Improve control of flow through the dam
- Reduce leakage
- Improve safety of dam operation

Estimated Cost to Install Slide Gates: $181,469 (Budget for five gates)

7.2.9 Rodgers Canal

Problem
During high water conditions in the spring of 2005 it was discovered that the flume that crosses the Humboldt River may not have sufficient capacity for higher flows. PCWCD was forced to open a normally unused canal in order to release excess flow.

Recommendations
An engineering study should be done to determine the flumes capacity to handle flows similar to those experienced during the spring of 2005 (estimated at 285 cfs). If it is discovered that the flume is undersized, it should be replaced. If the flume is adequate, some modifications may need to be performed.

Objectives

- Determine if flume needs to be replaced
- Determine if modifications are necessary

7.2.10 Big Five Dam

Problem
The Big Five Dam is the last dam in the PCWCD system. It is in good condition but it may be too small to function properly in flood years causing high water at the Sommers Dam.

Recommendations
The Big Five Dam should be enlarged to accommodate higher releases in flood years.

Objectives

- Prevent high water at the Sommers Dam
- Allow for higher releases from Rye Patch during flood years

7.2.11 Big Five Canal

Problem
The canal runs parallel to a drainage ditch and appears to be seeping into that ditch. There are also 2 to 3 diversion structures along the canal that should be replaced.

Recommendations
The diversion structures that are questionable should be replaced. Also the canal should be included in a system-wide flow study to determine how much water is being lost to seepage and/or management. Depending upon the extent of the seepage the canal should be lined with concrete or sealed with a polymer sealant (see Appendix C).

Objectives

- Improve irrigation delivery
- Reduce losses due to seepage

7.2.12 Old Channel / Union Canals Diversion Structures

Problem
These structures control the water for most of the Upper Valley. The condition of the structures and the channel bottom immediately downstream of the structures is fair to poor. The capacity of the flow into the canals is limited by the size of the conduits running under Holmstrom Road. Considering the amount of water that passes through these structures, flow measurement is poor.

Recommendations
At a minimum the control structures for both the Union and Old Channel Canals should be replaced. Holmstrom Road Bridge may need to be replaced as well in order to install larger pipe under the bridge. The Channel immediately downstream of the control structures should be reshaped and re-armored. Remote monitoring devices should also be installed at this site. Figure 7.1 is a drawing of the existing structures and figure 7.2 is a drawing of the proposed preliminary design.

Objectives

- Improve measurement of water passing through key location in system
- Improve irrigation delivery
- Increase capacity
- Prevent failure or flooding

Estimated Cost: $603,168

7.2.13 Old Channel Canal

Problem
According to the 1969 flow study, the Old Channel has seepage problems. Also the #5 and #7 diversion ditch structures are in poor condition. There is not enough head at the #2 ditch pump (Cowboy Pump) for the pump to operate efficiently.

Recommendations
The Old Channel should be included in a system-wide flow study to determine the amount of water being lost to seepage and/or management. Depending upon the results of the study the canal should be sealed or lined with concrete.

The structures at the #5 and #7 ditches should be replaced. A backup structure should be installed at the #2 ditch to create more head for the Cowboy Pump.

Objectives

- Improve delivery to 12 laterals
- Reduce losses due to seepage

7.2.14 Union Canal

Problem
According to the 1969 flow study the Union canal loses water to seepage. Also the control structure at the junction of the Union, Big Meadow, and Arobio is in poor condition.

Recommendations
The Union should be included in a system-wide flow study to determine the amount of water being lost to seepage and/or management. Depending upon the results of the study the canal should be sealed or concrete lined in areas of greatest loss. The control structure at the Union, Big Meadow and Arobio should be replaced.

Objectives

- Improve delivery to the Big Meadow, Irish American, Arobio and Union-Rodgers
- Reduce losses due to seepage

7.2.15 Big Meadow Ditch

Problem
According to the 1970 flow study the Big Meadow canal loses water to seepage and the pipe running under the road is undersized for current flows.

Recommendations
The Big Meadow should be included in a system-wide flow study to determine the amount of water being lost to seepage and/or management. Depending upon the results of the study the canal should be sealed or concrete lined in areas of greatest loss. The pipe running under the road should be replaced.

Objectives

- Increase the volume capacity of the pipe that passes under the road
- Reduce losses due to seepage
- Improve irrigation delivery

7.2.16 Irish American Ditch

Problem
According to the 1970 flow study the Irish-American has extremely high seepage loss. There is also an undersized pipe on the Irish that crosses over the Arobio.

Recommendations
The Irish-American should be included in a system-wide flow study to verify the high seepage loss reported in the 1970 study. Depending upon the results of the study the canal should be sealed or concrete lined in areas of greatest loss. The pipe running over the Arobio Ditch should be replaced.

Objectives

- Increase flow capacity
- Reduce losses due to seepage
- Improve irrigation delivery

7.2.17 Arobio Ditch

Problem
It is likely that the Arobio has seepage loss but the study done in 1970 did not include loss data.

Recommendations
The Arobio should be included in a system-wide flow study to determine the amount of water being lost to seepage and/or management. Depending upon the results of the study the canal should be sealed or lined with concrete in areas of greatest loss.

Objectives

- Reduce losses due to seepage
- Improve irrigation delivery

7.2.18 Union-Rodgers Canal

The Union-Rodgers Canal facilities include the canal itself and four main diversions; Rodgers Ditch and the Tule, Seven, and Reed Laterals. The canal is good to fair condition. According to the 1970 flow study the canal had positive flow gains but the study did not substantiate the reasons for the gains.

Recommendations
Because this canal is a key component of the Lower Valley system, a study should be conducted to determine its current true flow characteristics. Depending upon the results of the study the canal should be sealed or lined with concrete in areas of greatest loss.

Objectives

- Determine the efficiency of the canal (i.e. losses)
- Determine the type of improvements required, including lining or sealing

7.2.19 Tule Lateral

Problem
The back-up structure near the end of the Tule Lateral leaks. The structure appears to be lower then the wall at the diversion structure. There is also a large amount of sedimentation on the upstream side of the structure and some scour and evidence of undercutting on the downstream side.

Recommendations
Redesign and replace the backup and diversion structures.

Objectives

- Conservation of water
- Improved delivery to users

7.2.20 Rodgers Ditch

Problem
The 1970 system flow study indicated the Rodgers Ditch had some seepage loss (see Chapter 5, table 5.3).

Recommendations
The Rodgers Ditch should be included in a system-wide flow study to determine the amount of water being lost to seepage and/or management. Depending upon the results of the study the canal should be sealed or concrete lined in areas of greatest loss.

Objectives

- Reduce losses due to seepage
- Improve irrigation delivery

7.2.21 Seven Lateral

The Seven Lateral serves only one user. It is long and deep in spots with evidence of erosion. The 1970 flow study indicated some seepage loss (see Chapter 5, table 5.3). Recommendations for this lateral are the same as for the Rodgers Ditch.

7.2.22 Lakeshore Lateral

The Lakeshore Lateral is deep on the upper end and has high seepage loss according to the 1970 flow study (see Chapter 5, table 5.3). This lateral has no users and serves as the supply source for Anker Pond. Recommendations for the Lakeshore Lateral are the same as the Rodgers Ditch and Seven Lateral.

7.2.23 Reed Lateral

This lateral is in good condition but according to the 1970 flow study it had very high seepage losses. Recommendations for the Lakeshore Lateral are the same as the Rodgers Ditch and Seven Lateral.

7.2.24 Copenhagen Lateral

Problem
The outlet structures at the corner of Carpenter and Westergard Roads are in poor condition and are undersized (see Chapter 6, figure 6.14). Also the 1970 study indicated seepage losses in the ditch.

Recommendations
The structures at the end of the ditch should be replaced. The Ditch should be included in the system flow study and sealed or lined accordingly.

Objectives

- Improve irrigation delivery efficiency
- Reduce losses due to seepage

7.2.25 Anker Pond

Problem
The design of Anker Pond is poor considering the volume of water that it controls. With the exception of the control structures it consists of simple earthen dikes constructed from native soils. There is evidence of seepage and potential for failure of at least one of its sides.

Recommendations
The pond should be replaced and the gates should be automated. Remote monitoring should also be installed. Figure 7.3 is a drawing of the existing structure and figure 7.4 is a drawing of the proposed preliminary design.

Objectives

- Eliminate seepage losses
- Eliminate potential for failure
- Improve delivery efficiency

Estimated Cost of Pond Replacement: $450,455

Anker Pond supplies three laterals, the East, West (Including the Harper), and Anker ditches. These ditches appear to be in fair to poor condition and should be included in the aforementioned flow study. There is evidence of erosion in the West Lakeshore Lateral. The flume in the East Lakeshore lateral that runs under Carpenter Road is in poor condition and may not have sufficient flow capacity. The flume in the Anker ditch that runs under Westergard Road is also in need of replacement.

7.2.26 Humboldt River Plug

Problem
The Plug does not have sufficient structural capacity to withstand flows above 2000 cfs. If the Plug fails water cannot be diverted to the Big Five and Sommers Dam systems (23% of the total irrigable acreage in the District). The plugs lack of stability also limits the amount of water that can be released from Rye Patch Reservoir.

Recommendations
A new dam structure should be constructed to replace the Plug (see appendix A for the URS/Dames & Moore design recommendations. Note that the report erroneously refers to the plug as Big Five Dam).

Objectives

- Eliminate seepage losses
- Eliminate potential for failure
- Allow for greater releases from Rye Patch during flood years

Estimated Cost for Back up Structure: $503,006

Chapter 8
COST ESTIMATES

CHAPTER 8 ..... **1**

COST ESTIMATES **1**

8.1 INTRODUCTION 1
8.2 PRELIMINARY COST ESTIMATES 2
8.2.1 Pitt-Taylor Diversion Dam and Diversion Structure *2*
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8.2.7 Rodgers Dam *7*

8.1 INTRODUCTION

Preliminary cost estimates have only been prepared for those proposed projects that are major components of the PCWCD system and whose need for replacement is most urgent. These projects have been designated high priority due to the deteriorated condition of the existing facilities and the importance of their role in the PCWCD delivery system. Projects considered to be critical include the replacement of the Pitt-Taylor diversion dam and diversion structure, replacement of the outlet structures on the Upper and Lower Pitt-Taylor Dams, the installation of a back up structure at the Humboldt Plug, the addition of slide gates to the Pitt and Rodgers Dams, replacement of the Old Channel/Union Canal diversion structures and replacement of Anker Pond.

The preliminary cost estimate for the replacement of the Pitt-Taylor diversion dam and structure is included in the preliminary report prepared by Dyer Engineering Consultants, Inc. (see Appendix A of this plan) and is based on the preliminary specifications included in that report. Estimates for the Old Channel/Union structures and Anker Pond replacements are also based on those specifications. Costs for the installation of slide gates on the Pitt and Rodgers Dams are based on bid information and construction costs considered reasonable and customary. All costs have been prepared using May 2005 dollar values and current local economic conditions. Costs have not been adjusted in anticipation of inflation or price increases. Final project costs will depend on actual labor and material costs, market competition, final project scope, schedule and other variable factors.

Proposed projects for which cost estimates were not prepared may require additional studies and preliminary designs that are beyond the scope of this plan.

8.2 PRELIMINARY COST ESTIMATES

8.2.1 Pitt-Taylor Diversion Dam and Diversion Structure

The following preliminary cost estimate (Table 8.1) was taken from the preliminary engineering report prepared by Dyer Engineering Consultants, Inc. (see appendix A) and is based on the preliminary specifications included in that report.

TABLE 8.1

Preliminary Cost Estimate for Replacement of Pitt-Taylor Diversion Dam and Diversion Structure

Item No.	Description	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Total Cost
1	Mobilization		lump		$40,000
2	Demolition		lump		$40,000
3	Site Preparation - Stripping		lump		$10,000
4	Dewatering		lump		$150,000
5	Foundation Preparation	40	sq.yd.	$28.00	$1,120
6	Floor Slab Preparation	2400	sq.ft.	$18.00	$43,200
7	Excavation - Riprap Riverbed	506	cu.yd.	$16.00	$8,096
8	Excavation - River Deposition	2300	cu.yd.	$8.00	$18,400
9	Zone I - Earthfill General	500	cu.yd.	$22.00	$11,000
10	Zone II - Drain Rock	10	cu.yd.	$30.00	$300
11	Zone III - Earthfill Gravel	30	cu.yd.	$75.00	$2,250
12	Rip-rap	86	cu.yd.	$70.00	$6,020
13	Wire Mattress		lump		$48,500
14	Rip-rap Geotextile Fabric	1003	sq.yd.	$2.20	$2,207
15	Radial Gates	4	lump		$153,000
16	Sluice Gates	2	lump		$26,000
17	Concrete	332	cu.yd.	$510.00	$169,320
18	Stop logs/Flashboards	53	boards	$140.00	$7,420
19	Remote Monitoring		lump		$8,500
20	Geotechnical Investigation		lump		$36,000
21	Permits (404, Rolling Stock, etc.)		lump		$35,000
				Sub-Total	$816,333
22	Engineering - Final		5%		$40,817
23	Contingencies/Unlisted Items		20%		$163,267
				Grand Total	**$1,020,416**

8.2.2 Replacement of the Outlet Structures for the Upper and Lower Pitt-Taylor Dams

Table 8.2 is a preliminary cost estimate for the replacement of the outlet structures in the Upper and Lower Pitt-Taylor Dams. Note that the cost per structure is the same because the designs will likely be similar. Also note the combined total.

TABLE 8.2

Preliminary Cost Estimate for the Replacement of the Upper and Lower Pitt-Taylor Outlet Structures

Item No.	Description	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Total Cost
1	Mobilization		lump		$40,000
2	Demolition		lump		$50,000
3	Site Preparation - Stripping		lump		$20,000
4	Dewatering		lump		$50,000
5	Foundation Preparation	1290	sq.yd.	$28.00	$36,120
6	Floor Slab Preparation	2400	sq.ft.	$18.00	$43,200
7	Excavation - Existing structure	2800	cu.yd.	$16.00	$44,800
8	Earthfill General	2000	cu.yd.	$22.00	$44,000
9	Base Gravel	1290	cu.yd.	$30.00	$38,700
10	Rip-rap	100	cu.yd.	$70.00	$7,000
11	Gabion Mattress	44	cu.yd.	$132.00	$5,808
12	Rip-rap Geotextile Fabric	1003	sq.yd.	$2.20	$2,207
13	Gates	3	lump	$15,000.00	$45,000
14	Concrete	258	cu.yd.	$510.00	$131,580
15	Geotechnical Investigation		lump		$36,000
				Sub-Total	$594,415
22	Engineering - Final		5%		$29,721
23	Contingencies/Unlisted Items		20%		$118,883
				Grand Total (per structure)	**$743,018**
				Combined Total:	$1,486,037

8.2.3 Installation of a Back up Structure at the Humboldt Plug

Table 8.3 is a preliminary cost estimate derived from the Option 1 estimate included in the Dam Rehabilitation Feasibility Study performed by URS/Dames & Moore. Since the original estimate was completed in January 2001, costs in table 8.3 reflect a 5% per year increase to account for inflation.

TABLE 8.3

Preliminary Cost Estimate for the Installation of a Back Up Structure at the Humboldt Plug

Item No.	Description	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Total Cost
1	Mobilization		lump		$25,526
2	Surveying		lump		$10,721
3	Temporary Flow Diversion		lump		$12,763
4	Dewatering		lump		$14,677
5	Excavation	3,000	cu.yd.	4	$15,315
6	Sheet Pile		lump		$92,530
7	New Embankment	1,250	cu.yd.	4.25	$6,780
8	Revetment		lump		$155,706
9	Energy Disipation		lump		$2,276
10	Geotextile		lump		$4,493
			Sub-Total		$340,787
11	Design				$61,389
12	Construction Management				$32,673
13	Contingencies/Unlisted Items		20%		$68,157
				Grand Total	**$503,006**

8.2.4 Old Channel / Union Canals Diversion Structures

Table 8.2 is based on the preliminary specifications included in the report prepared by Dyer Engineering Consultants, Inc. (see appendix A).

TABLE 8.4

Preliminary Cost Estimate for Replacement of Old Channel / Union Canals Diversion Structures

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization		lump		$40,000
2	Demolition		lump		$20,000
3	Site Preparation - Stripping		lump		$10,000
4	Dewatering		lump		$30,000
5	Foundation Preparation	18	sq.yd.	$28.00	$504
6	Floor Slab Preparation	540	sq.ft.	$18.00	$9,720
7	Excavation - Riprap Riverbed	50	cu.yd.	$16.00	$800
8	Excavation - River Deposition	200	cu.yd.	$8.00	$1,600
9	Earthfill General	150	cu.yd.	$22.00	$3,300
10	Earthfill Gravel	10	cu.yd.	$75.00	$750
11	Rip-rap	10	cu.yd.	$70.00	$700
12	Gabion Mattress (Optional)	10	cu.yd.	$132.00	$1,320
13	16' Radial Gates	2	ea.	$38,250.00	$76,500
14	Concrete	84	cu.yd.	$510.00	$42,840
15	Remote Monitoring		lump		$8,500
16	Geotechnical Investigation		lump		$36,000
17	Replacement of Holmstrom bridge		lump		$200,000
				Sub-Total	$482,534
18	Engineering - Final		5%		$24,127
19	Contingencies/Unlisted Items		20%		$96,507
				Grand Total	**$603,168**

8.2.5 Anker Pond

The preliminary estimate for Anker pond includes costs for the replacement of the pond as well as armoring of the canal sections immediately adjacent to the pond.

TABLE 8.5

Preliminary Cost Estimate for Replacement of Anker Pond

Item No.	Description	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Total Cost
1	Mobilization		lump		$40,000
2	Demolition		lump		$20,000
3	Site Preparation - Stripping		lump		$10,000
4	Dewatering		lump		$30,000
5	Foundation Preparation	29	sq.yd.	$28.00	$812
6	Floor Slab Preparation	2105	sq.ft.	$18.00	$37,890
7	Excavation - Canals	28	cu.yd.	$16.00	$448
8	Excavation - Pond Deposition	267	cu.yd.	$8.00	$2,136
9	Earthfill General	272	cu.yd.	$22.00	$5,984
10	Earthfill Gravel	28	cu.yd.	$75.00	$2,100
11	Rip-rap	37	cu.yd.	$70.00	$2,590
12	Slide Gates	5	ea.	$13,000.00	$65,000
13	Concrete	181	cu.yd.	$510.00	$92,310
14	Perimeter Security Fencing		lump		$6,594
15	Remote Monitoring and Gate Control		lump		$8,500
16	Geotechnical Investigation		lump		$36,000
				Sub-Total	$360,364
17	Engineering - Final		5%		$18,018
18	Contingencies/Unlisted Items		20%		$72,073
				Grand Total	**$450,455**

8.2.6 Pitt Dam

The preliminary estimate for Pitt Dam includes the installation of five new slide gates. The estimate does not include any concrete work and assumes that the gates can be retrofitted with minimal or no modification to the existing buttresses other then the removal of stop logs.

TABLE 8.6

Preliminary Cost Estimate for Installation of Gates in Pitt Dam

Item No.	Description	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Total Cost
1	Mobilization		lump		$20,000
2	Demolition		lump		$2,000
3	Dewatering		lump		$10,000
4	Slide Gates w/ Actuators	5	ea	$19,600.00	$98,000
5	Gate Installation		lump		$28,800
				Sub-Total	$158,800
10	Engineering - Final		5%		$7,940
11	Contingencies/Unlisted Items		20%		$31,760
				Grand Total	**$198,500**

8.2.7 Rodgers Dam

The preliminary estimate for Rodgers Dam includes the installation of five new slide gates. The estimate does not include any concrete work and assumes that the gates can be retrofitted with minimal or no modification to the existing buttresses other then the removal of stop logs.

TABLE 8.7

Preliminary Cost Estimate for Installation of Gates in Rodgers Dam

Item No.	Description	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Total Cost
1	Mobilization		lump		$20,000
2	Demolition		lump		$2,000
3	Dewatering		lump		$10,000
4	Slide Gates w/ Actuators	5	ea	$16,875.00	$84,375
5	Gate Installation		lump		$28,800
				Sub-Total	$145,175
10	Engineering - Final		5%		$7,259
11	Contingencies/Unlisted Items		20%		$29,035
				Grand Total	**$181,469**

Chapter 9
PRIORITIZATION OF IMPROVEMENTS

CHAPTER 9 ..... **1**

PRIORITIZATION OF IMPROVEMENTS **1**

9.1 INTRODUCTION 1
9.2 PROPOSED PROJECTS 1

9.1 INTRODUCTION

Since it would be unfeasible to simultaneously execute all of the projects recommended in Chapter 8, a prioritization of projects is necessary. With the input of the PCWCD Board of Directors and General Manager, four different factors were established to determine the order of implementation for each of the 28 proposed projects. The following are the factors considered to be the most important to the Board and General Manager:

1. Conservation
2. Maximize Capacity
3. Improve Operation and Maintenance
4. Safety

9.2 PROPOSED PROJECTS

Each project was evaluated by assigning a ranking from 1 to 5 (1 means that the project meets the factor best, 5 the worst) for each of the factors above. The sum of the individual factor rankings was then used to establish an overall ranking. Projects with the lowest overall ranking sums are considered to be highest priority. Table 9.1 shows all of the projects and their order of precedence. Note that the first three projects (Pitt-Taylor Diversion, Upper and Lower Pitt-Taylor dam outlet structures) on the list are considered to be one project.

TABLE 9.1

PCWCD Summary of Capital Improvements in Order of Priority (Factors ranked 1 to 5 with 1 indicating highest level of compliance, 5 the lowest)

			PRIORITIZATION FACTORS					
System Element	**Proposed Improvements**	**Estimated Cost**	**CONSERVATION**	**MAINTAIN CAPACITY**	**IMPROVE O&M**	**SAFETY**	**TOTAL**	**RANK**
Pitt-Taylor Diversion	Replace dam and diversion structure	$1,020,416	1	1	1	1	4	1
Upper Pitt Taylor Dam	Replace control structure	$743,018	1	1	1	1	4	2
Lower Pitt Taylor Dam	Replace control structure	$743,018	1	1	1	1	4	3
Plug at end of Humboldt	Install back up structure	$503,006	1	1	1	1	4	4
Old Channel/Union Diversions	Replacement	$603,168	1	1	1	1	4	5
Anker Pond	Replacement	$450,455	1	1	1	2	5	6
Pitt Dam	Install slide gates	$198,500	1	2	1	1	5	7
Rodgers Dam	Install slide gates	$181,469	1	2	1	1	5	8
Union, Big Meadow, Arobio	Replace Diversion at junction of canals	Not Estimated	1	1	1	3	6	9
Cowboy Pump (Old Channel)	Install back-up structure	Not Estimated	2	1	1	3	7	10
#5 (Old Channel) Structure	Replacement	Not Estimated	2	1	1	3	7	11
#7 (Old Channel) Structure	Replacement	Not Estimated	2	1	1	3	7	12
Rodgers Canal	Evaluate capacity of flume	Not Estimated	2	1	2	3	8	13
Pitt-Taylor Canal	Reshape and line	Not Estimated	1	2	2	4	9	14
Upper and Lower Valley Systems	Canal Lining	Not Estimated	1	1	2	5	9	15
Irish American Canal	Replace pipe over Arobio Canal	Not Estimated	2	2	2	4	10	16
Copenhagen Lateral	Replace outlet structures at lower end	Not Estimated	2	2	2	4	10	17
Upper and Lower Valley Systems	Measuring Device Survey	Not Estimated	2	2	1	5	10	18
Tule Back-up Structure	Replacement	Not Estimated	2	3	2	4	11	19
Upper and Lower Valley Systems	Flow study	Not Estimated	2	2	2	5	11	20
Upper and Lower Pitt Taylor Dams	Condition survey	Not Estimated	3	4	3	2	12	21
Big Five Dam	Survey to evaluate capacity	Not Estimated	3	2	2	5	12	22
Pitt-Taylor Canal	Replace Flying M diversion structure	Not Estimated	3	4	2	4	13	23
Young Dam	Install concrete apron and cutoff wall	Not Estimated	3	3	2	5	13	24
Upper and Lower Pitt Taylor Dams	Maintenance Procedures	Not Estimated	4	4	2	3	13	25
Upper and Lower Pitt Taylor Dams	Emergency Plan	Not Estimated	5	5	3	1	14	26
Upper and Lower Valley Systems	Weed Survey	Not Estimated	3	4	4	5	16	27
Irish American Dam	Dam inspection and evaluation	Not Estimated	4	5	5	5	19	28

Chapter 10
FUNDING ALTERNATIVES

CHAPTER 10 ..... **1**

FUNDING ALTERNATIVES **1**

10.1 INTRODUCTION 1
10.2 FUNDING OPTIONS 1
10.3 PROJECT TOTAL AND FUNDING 2

10.1 INTRODUCTION

The purpose of this chapter is to discuss funding alternatives for the implementation of proposed Master Plan projects. Activities in the plan that will require funding include studies, design services, and facilities construction. Because of the number and magnitude of the proposed projects it will be necessary to implement them in phases according to priority. Table 10.1 is a list of the highest priority proposed projects and the order in which they should be implemented.

TABLE 10.1

Priority	Project	Estimated Cost
1	Replacement of the Pitt-Taylor Diversion Dam and Structure	$1,020,416
2	Replacement of Upper Pitt-Taylor Dam Control Structure	$742,018
3	Replacement of Lower Pitt-Taylor Dam Control Structure	$742,018
4	Installation of a Back up Structure at the Humboldt Plug	$503,006
5	Replacement of Old Channel / Union Canals Diversion Structure	$603,168
6	Replacement of Anker Pond	$450,455
7	Installation of slide gates on Pitt Dam	$198,500
8	Installation of slide gates on Rodgers Dam	$181,469
	Total:	**$4,441,050**

10.2 FUNDING OPTIONS

Funding options for the above mentioned proposed projects are as follows:

- **Water Conservation Grant -** This grant from the State Board for Financing Water Projects can be used for 85% of the project costs.
- **Matching Funds From the U.S. Bureau of Reclamation (USBR)** - The USBR has offered to match funds for the replacement of the Old Channel / Union Canals diversion structure. The maximum amount provided by the USBR will be $40,000 for the Union Canal structure and $45,000 for the Old Channel Canal structure. To receive the maximum possible funding, PCWCD will need to match these amounts for each structure.
- **PCWCD Capital Improvement Fund –** The PCWCD has approximately $300,000 set aside for the purpose of funding emergency needs/capital improvements.
- **PCWCD In-kind Project Funding –** The PCWCD has personnel and equipment that can be utilized to implement portion of the above mentioned projects. The District has established a $34.00/hr. labor rate as well as per hour rates for the operation of its heavy equipment included in table 10.2.
- **Loans –** The PCWCD can compensate for any gaps in funding by borrowing the difference.

TABLE 10.2

Equipment*	Rate/hr
John Deere 790 excavator w/ 60’ boom	$100.00
John Deere 690 excavator w/ 50’ boom	$70.00
John Deer 710 backhoe	$70.00
Cat 950 Wheel Loader	$70.00
International 10 wheel dump truck	$60.00
Tractor w/ low-boy transport trailer	$60.00
Tractor w/ belly-dump trailer	$60.00

*All equipment rates include operators

10.3 PROJECT TOTAL AND FUNDING

Table 10.3 is a summary of the project total and potential funding for high priority proposed projects.

TABLE 10.3

	Amount
Total Proposed Projects Estimated Cost:	**$4,441,050**
Potential Funding Source	
State Board of Finance	$3,774,893
U.S. Bureau of Reclamation Matching Funds*	$85,000
PCWCD Capital Improvement Fund	$300,000
PCWCD In-kind and/or Loans	$281,158
Total Funding:	**$4,441,050**

***These funds may only be applied to the replacement of the Old Channel/Union Canal diversion structures.

It should be noted that the PCWCD may use only a portion of its capital improvement fund or none at all since the fund is also used for emergencies. Also since the matching funds from the USBR can only be applied to the replacement of the Old Channel / Union Canals Structures, the PCWCD has an automatic commitment to provide at least $85,000 to that project. If the PCWCD decides not to use its available capital it will make up the difference in loans and/or in-kind funding.

Chapter 11
IMPLEMENTATION SCHEDULE

CHAPTER 11 ..... **1**
IMPLEMENTATION SCHEDULE **1**
11.1 SCHEDULE 1

11.1 SCHEDULE

Although the replacement of the Old Channel / Union Canal Structures is ranked 5th on the priority list it will probably need to be completed first. The reason for this is that the USBR has placed a time limit on the matching funds it is offering. These funds originally needed to be used by the end of 2005 but an extension has been filed to allow for use in 2006. Depending upon the availability of resources the proposed first priority project, the replacement of the Pitt-Taylor diversion dam and diversion structure, could be implemented simultaneously. In that case the projected schedule for these projects is the following:

Entity	Action	Date
State Finance Board	Submit Letter of Intent	January 2006
State Finance Board	Submit Project Application	April 2006
Engineer	Begin Design	May 2006
Contractor	Begin Construction	October 2006

Subsequent projects will be scheduled before the completion of the current project. Once the first projects are completed the remaining projects will be implemented in the following order:

1. Upper Pitt-Taylor Outlet Structure
2. Lower Pitt-Taylor Outlet Structure
3. Installation of a Back-up Structure at the Humboldt Plug
4. Replacement of Anker Pond
5. Installation of slide gates on Pitt Dam
6. Installation of slide gates on Rodgers Dam

Proposed projects that involve the replacement of facilities must be started at the end of the irrigation season and completed prior to the next irrigation season. Other limiting factors that could delay the start or completion of projects include:

- Freezing temperatures
- Water stored in the Upper and/or Lower Pitt-Taylor Reservoirs

It may be possible to do multiple projects simultaneously but care should be taken not overextend available project resources. Because of the above mentioned limitations it may be impossible to complete all of the proposed projects within a two year period.

Appendices

APPENDICES.....**1**

APPENDIX A - ENGINEERING REPORTS.....1
APPENDIX B - CONTRACT DRAWING OF UPPER PITT-TAYLOR OUTLET STRUCTURE 2
APPENDIX C – POLYMER SEALANT SPECIFICATION 3
APPENDIX D – SYSTEM MAPS.....4

APPENDIX A - ENGINEERING REPORTS

Appendix A includes the following:

- Preliminary Engineering Report for the replacement of the Pitt-Taylor Diversion Dam and Structure prepared by Dyer Engineering Consultants Inc.
- Feasibility Study for the replacement of the Humboldt River Plug prepared by URS/Dames & Moore, Sacramento, California

PITT-TAYLOR DIVERSION STRUCTURE (THACKER DAM)

EXECUTIVE SUMMARY

The existing diversion structure is deteriorating, and will need to be replaced (See Sheet 1 of 3). However, the unexposed concrete of the structure (below ground level) may be sound. This could not be confirmed as part of this investigation. Core sampling of the floors of the structures would be necessary to determine the extent of removal that would be needed.

The structure is considered to be in poor condition. Rehabilitation of the structure may be needed within 2 to 5 years. Two alternatives are presented for consideration. Both alternatives assume removal of existing wingwalls and sidewalls to sound concrete near ground level. The existing concrete floor in both the Diversion Dam and the Canal Inlet will be maintained. The existing piers would be removed to floor level, and the floors removed at least three inches to assure bonding of the new floors to sound concrete.

The proposed replacement structures would raise the floor level one foot above the existing floors. Raising the floor level could cause additional downstream river channel scouring. Some rubble produced by structure removal may be placed in the scour hole to armor it against additional scour, however the surface revetment is a revetment mattress constructed of local minus 6 inch rock in a wire cage. Raising the floor of the canal inlet structure would improve water delivery to the canal.

A subsurface investigation has not been conducted at the site. The condition of the subsoils is unknown, however it is assumed that the foundation will not be altered. A subsurface exploration plan is recommended here.

PROBLEM IDENTIFICATION

The concrete throughout is in poor condition. Minor spalling is evident on most surfaces and there is ice damage near the water level. Flashboards are difficult to remove or place, particularly during high flows. Sedimentation in the upstream impoundment has made the north quarter of the diversion structure ineffective. In addition, the stream channel upstream of the structure is eroding the bank and progressing south. Eventually the flow will undercut the canal inlet. See Sheet 2 of 3 for existing structure configuration.

REHABILITATION OPTIONS

Alternative #1

This alternative would replace the existing diversion structure with a series of flashboard bays, similar to the existing structure, except for a water control gate adjacent to the east

headwall to bypass low flows and to provide for sluicing in front of the canal inlet structure. Flashboard bays and a water control gate would also be used in the canal inlet structure.
This alternative is not presented in more detail on the drawings because its operation would be similar to that of the existing structure. The difficulties of placing and removing flashboards would be similar to those encountered in the existing structure and are well known.

Alternative #2 (Preferred Alternative)

This alternative proposes installing three 7' x 16' radial gates, five 6' flashboard bays, and one 6' x 6' water control gate in the diversion structure; one 7' x 16' radial gate and one 5' x 5' water control gate in the canal inlet structure. A maximum radial gate height of 7' is standard and would not require special fabrication. When the radial gates are closed, river flows can pass safely over them. Seven (7) feet of gate height should be sufficient to divert water to the canal (See Sheet 3 of 3).

This combination of gates and flashboards should provide easy control for almost any flow condition in the river. Seven feet of flashboards could remain in-place except for extreme high flows in the river. The discharge capacity of the diversion structure and canal inlet structure under various operating conditions are shown in Table 1. Note that discharge to the canal may be controlled by canal capacity and not by the capacity of the gates.

The radial gates lend themselves to remote control. They can be operated by small electric motors powered by photovoltaic systems. Costs have been prepared accordingly.

STRUCTURE OUTLET PROTECTION

Discharge velocities through the Diversion Structure and Canal Inlet gates will be slightly accelerated above existing conditions. This is partly due to the position of the gates and flashboards and partly due to the configuration of the radial gates and flashboards. Most of the hydraulic energy will be dissipated in the ever-present tail water. Additional erosion protection is required downstream of the structures. An 8 foot wide strip of 8" wire basket mattress is proposed as represented on Sheet 3. The mattress is underlain by 6" of bedding gravel.

Table 1: Discharge Capacity of Structures Under Various Operating Conditions

	Diversion Structure			Flow (cfs)	Canal Inlet		Flow (cfs)
	Radial	Sluice	Flashboards*		Radial	Sluice	
Case 1: Max. capacity upstream depth = 11' operating head = 1.0'	Open	Open	Open	4000	Open	Open	1000
Case 2: upstream depth = 11' operating head = 1.0'	Open	Open	Closed	3560	Open	Open	1000
Case 3: upstream depth = 11' downstream depth = 7' max.	Closed	Open	Closed	2430	Closed	Closed	275
Case 4: upstream depth = 7' canal inlet op. head = 1.0'	Closed	Closed	Closed	0	Open	Open	610

*Note: flashboards in-place to 7' considered closed

UPSTREAM CHANNEL CONDITIONS AND PROPOSED TREATMENT

The diversion structure is located at the downstream end of a sweeping channel curve. This has caused excessive erosion on the outside of the curve and sediment deposition on the inside of the curve. The outside of the curve should be sloped to 1.7 horizontal to 1.0 vertical and protected to a vertical height of 12' for approximately 300' upstream from the canal inlet structure (See Sheet 1 of 3). Since flow velocities are low, 1.5' of riprap or an equivalent 8" wire basket mattress should provide adequate protection. A 10 oz/yd^2 of GSE nonwoven filter fabric (NW10) or equivalent should be placed under the revetment and anchored per the manufacturer's recommendation.

Loose rock riprap should be added at the toe of the revetment slope as shown on Sheet 1. This riprap will provide stability to the revetment slope, stabilize the streambed near the line of highest velocities, and fill in any undercutting which may occur.

SEDIMENT REMOVAL AND CONTROL

The sediment deposit should be removed to the structure floor level, or at least to the height of the radial gates in in-place flashboards. A water current deflection dike could be placed in the main channel to direct higher flow velocities more evenly across the Diversion Structure.

The fluvial characteristics of streams are difficult to predict. However a dike constructed from the south bank, at a distance of 200 feet upstream, toward the north abutment at a

bearing of approximately 240 degrees WSW should be considered to improve stream flow characteristics and reduce sediment aggradation on the north riverbank.

COSTS

Below is a summary of the preliminary estimated project costs. Costs have been estimated in part using a preliminary set of specifications which are located in the Attachments section of this document.

Item No.	Description	Estimated Quantity		Estimated Unit Cost	Estimated Total Cost
1	Mobilization		lump		$40,000
2	Demolition		lump		$40,000
3	Site Preparation - Stripping		lump		$10,000
4	Dewatering		lump		$150,000
5	Foundation Preparation	40	sq. yd.	$28.00	$1,120
6	Floor Slab Preparation	2400	sq. ft.	$18.00	$43,200
7	Excavation - Riprap Riverbed	506	cu.yd.	$16.00	$8,096
8	Excavation - River Deposition	2300	cu.yd.	$8.00	$18,400
9	Zone I - Earthfill General	500	cu.yd.	$22.00	$11,000
10	Zone II - Drain Rock	10	cu.yd.	$30.00	$300
11	Zone III - Earthfill Gravel	30	cu.yd.	$75.00	$2,250
12	Rip-rap	86	cu.yd.	$70.00	$6,020
13	Wire Mattress		lump		$48,500
14	Rip-rap Geotextile Fabric	1003	sq. yd.	$2.20	$2,207
15	Radial Gates	4	lump		$153,000
16	Sluice Gates	2	lump		$26,000
17	Concrete	332	cu.yd.	$510.00	$169,320
18	Stop logs/Flashboards	53	boards	$140.00	$7,420
19	Remote Monitoring		lump		$8,500
20	Geotechnical Investigation		lump		$36,000
21	Permits (404, Rolling Stock, etc.)		lump		$35,000
	Subtotal				$816,333
22	Engineering - Final		5%		$40,817
23	Contingencies/Unlisted Items		20%		$163,267

Grand Total:	$1,020,416

RECOMMENDATIONS

It is recommended that several actions be completed during the final engineering process:

1. Obtain accurate topo of the Diversion Structure, Canal Inlet Structure, and upstream channel areas
2. Complete a thorough foundation investigation
3. Complete a hydrologic basin flood model in order to further develop operating criteria during various flood events
4. Conduct a fluvial analysis in order to select the most appropriate configuration for a fluvial control structure

ATTACHMENTS

DISCHARGE CAPACITY OF DIVERSION AND CANAL INLET STRUCTURES UNDER VARIOUS CONDITIONS

Case 1

Maximum capacity of structures.
Upstream water depth 11'.
Operating head 1.0'.

Diversion Structure

Radial gates and flashboard bays fully open	Q=3800 cfs
Sluice gate (water control gate) fully open	Q= 200 cfs
Total	Q=4000 cfs

Canal Inlet Structure

Radial gate and water control gate fully open	Q=1000 cfs

Note: Discharge to the canal is probably limited by canal capacity and not by the capacity of the gates.

Case II

Upstream water depth 11'.
Operating head 1.0'.

Diversion Structure

Radial gates fully open Flashboard bays with flashboards in-place to 7'	Q=3355 cfs
Sluice gate fully open	Q= 200 cfs
Total	Q=3560 cfs

Canal Inlet Structure

Same as Case I	Q=1000 cfs

Case III

Upstream water depth 11'.
Downstream water depth 7' maximum.

Diversion Structure (overflow capacity)

Radial gates closed
Flashboards in-place to 7'
Sluice gate open

Radial gates (overflow)		Q=1265 cfs
Flashboard bays		Q= 790 cfs
Sluice gate		Q= 375 cfs
	Total	Q=2430 cfs

Canal Inlet Structure

Radial gate closed
Water control gate closed

Radial gate (overflow)	Q= 275 cfs

Case IV

Upstream water depth 7' (top of radial gates and flashboards)
Sluice gate closed

Diversion Structure	Q= 0 cfs

Canal Inlet Structure

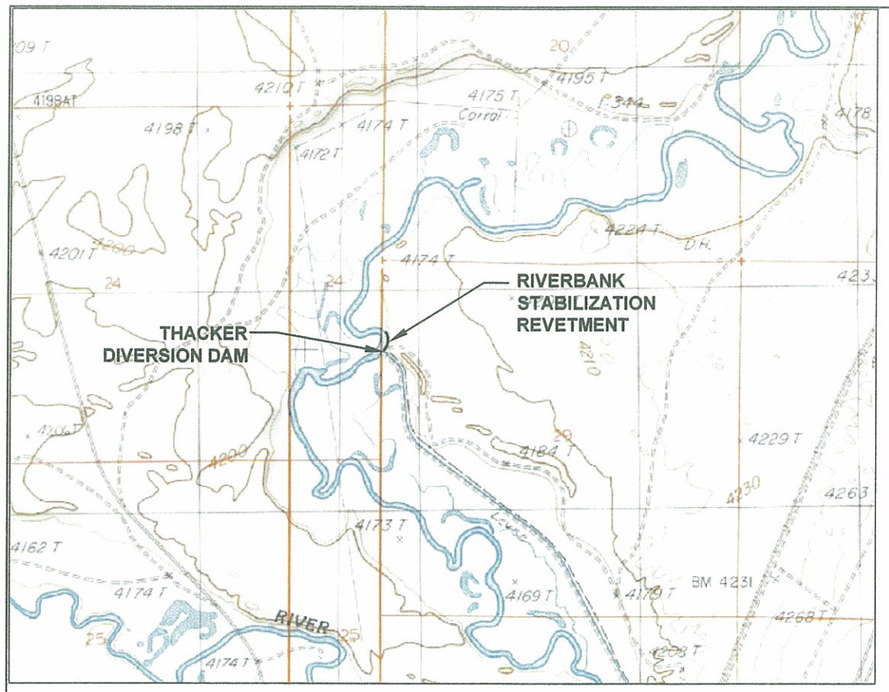
Operating head 1.0'
Radial gate open
Water control gate open

Radial gate		Q= 480 cfs
Water control gate		Q= 130 cfs
	Total	Q= 610cfs

Note: Flow may be controlled by canal capacity and not by the capacity of the gates

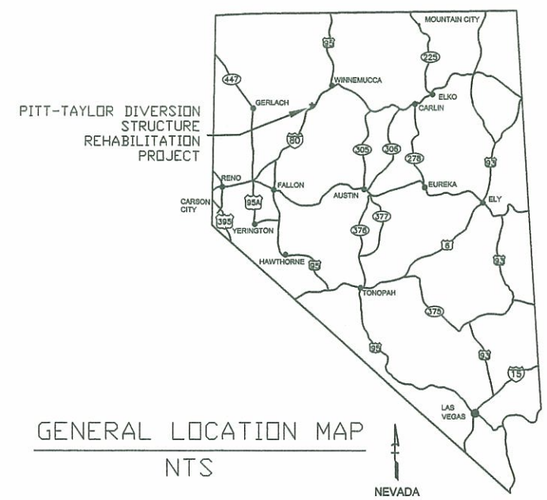
PITT–TAYLOR DIVERSION STRUCTURE REHABILITATION PROJECT

PERSHING COUNTY WATER CONSERVATION DISTRICT



LOCATION MAP

0 .5 1 MILE

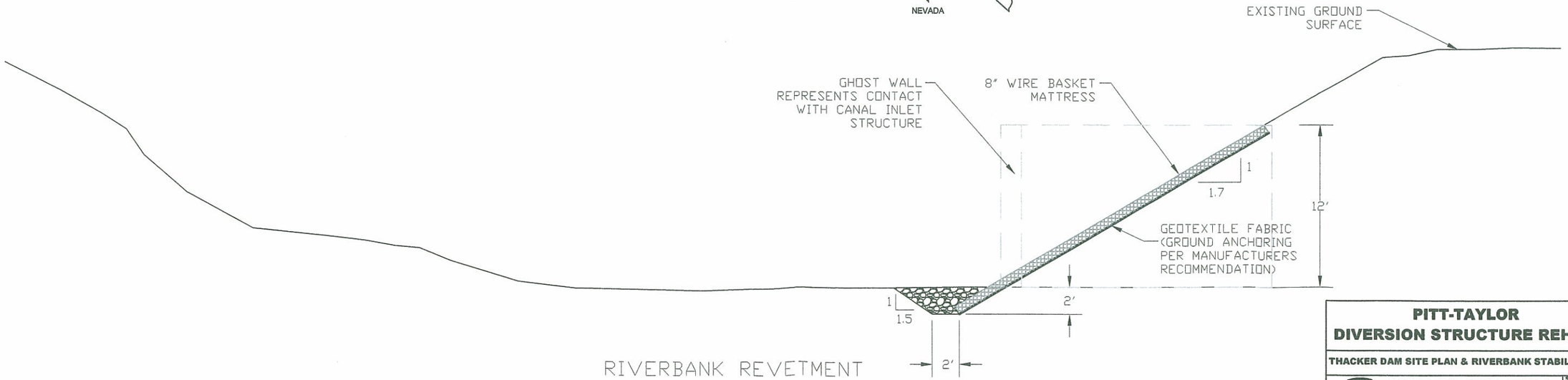


GENERAL LOCATION MAP

NTS

LIST OF DRAWINGS:

1. SITE PLAN
2. EXISTING DIVERSION STRUCTURE & INLET
3. PROPOSED DIVERSION STRUCTURE & INLET



RIVERBANK REVETMENT CROSS SECTION

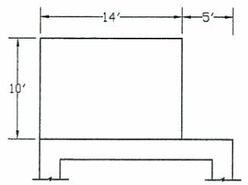
NTS

PITT-TAYLOR DIVERSION STRUCTURE REHAB

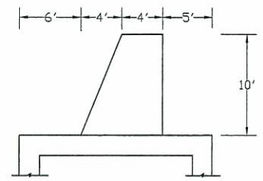
THACKER DAM SITE PLAN & RIVERBANK STABILIZATION

DYER ENGINEERING CONSULTANTS, INC.
1575 DELUCCHI LN. STE. 204, RENO, NV. 89502

PROJECT NO.	DESIGN BY:	DRAWN BY:	CHECKED BY:	DATE:	SHEET NO.
FARR-4	DLD	SEB	DLD	04/27/2005	1 OF 3



BRIDGE PIER SECTION A-A'



FLASHBOARD PIER SECTION B-B'

PLAN VIEW

ELEVATION VIEW

0 10
SCALE (FEET)

PITT-TAYLOR

DIVERSION STRUCTURE REHAB

EXISTING DIVERSION AND INLET

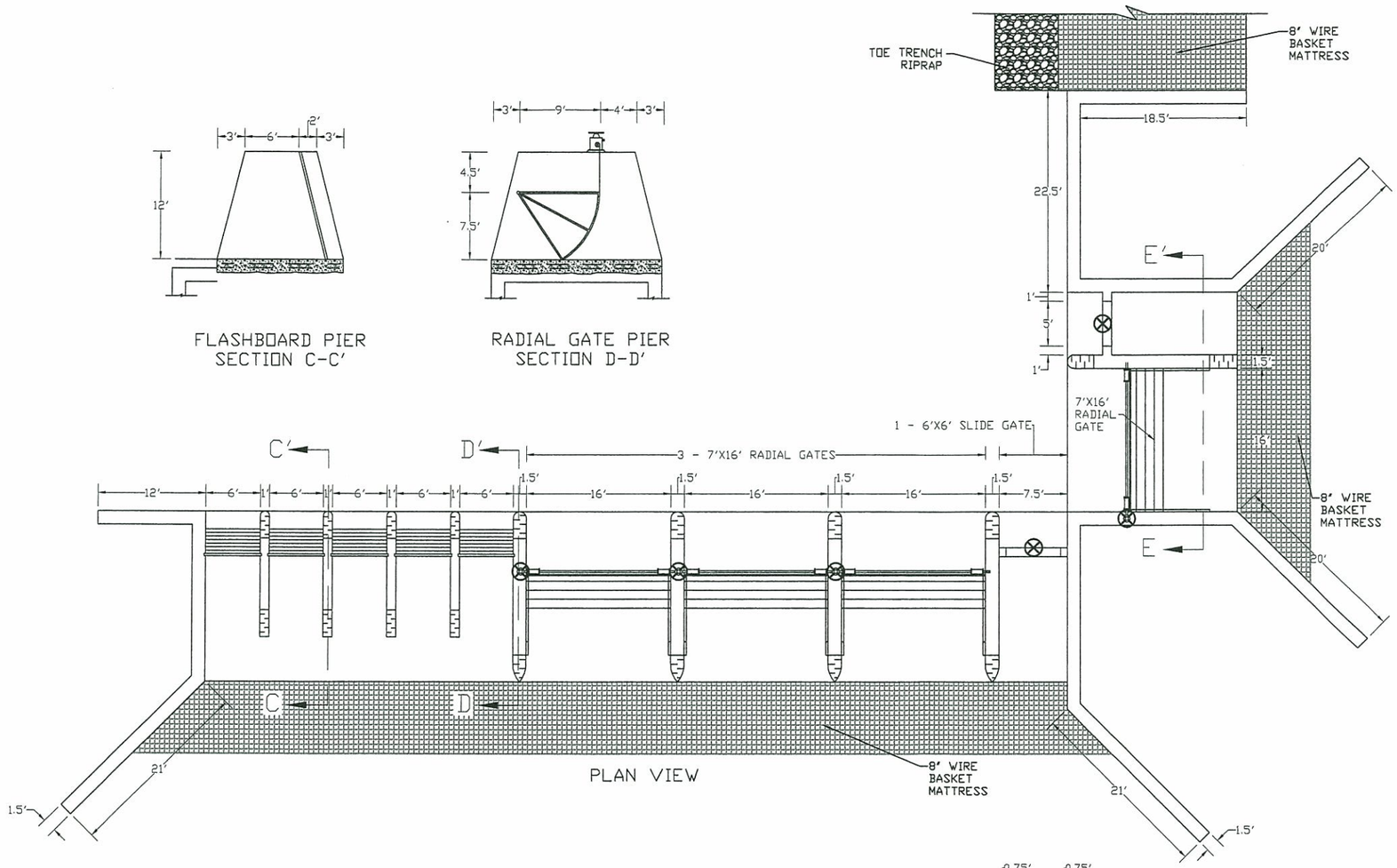
DYER ENGINEERING CONSULTANTS, INC.
1575 DELUCCHI LN. STE. 204, RENO, NV. 89502

SHEET NO. 2 OF 3

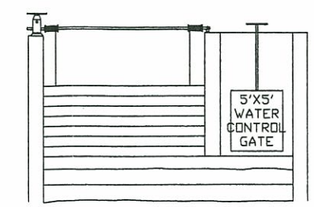
PROJECT NO.	DESIGN BY:	DRAWN BY:	CHECKED BY:	DATE:
FARR-4	LJS	SEB	DLD	04/27/2005

FLASHBOARD PIER
SECTION C-C'

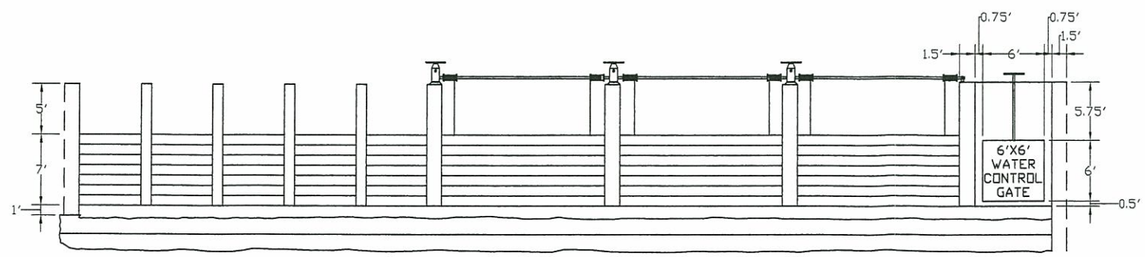
RADIAL GATE PIER
SECTION D-D'



PLAN VIEW



SECTION E-E'



ELEVATION VIEW

0 10
SCALE (FEET)

PITT-TAYLOR
DIVERSION STRUCTURE REHAB

PROPOSED DIVERSION AND INLET

DYER ENGINEERING CONSULTANTS, INC.
1575 DELUCCHI LN. STE. 204, RENO, NV. 89502

SHEET NO. 3 OF 3

PROJECT NO.	DESIGN BY:	DRAWN BY:	CHECKED BY:	DATE:
FARR-4	LJS	SEB	DLD	04/27/2005

PITT-TAYLOR DIVERSION STRUCTURE (THACKER DAM)
Proposed Structure Removal

VOLUME OF CONCRETE IN EXISTING STRUCTURE

Diversion Structure:

Sidewalls and Piers (remove to floor level)

Sidewalls	
(2) x 23 x 13 x 2 =	1196 Cu. Ft.
Wingwalls	
Downstream	
(2) x 21 x 15 x 1.5 =	945
Upstream, West Bank	
(1) x 12 x 1.5 x 13 =	234
Bridge Piers	
(3) x 10 x 14 x 2 =	840
Flashboard Piers	
(7) x 10 x ((8+4)/ 2) x 2 =	840
Floor (Surface Removal ≈ 4 “)	
(1) 19 x 101 x 0.33 =	640
Subtotal =	4695 Cu. Ft.
	27

TOTAL VOLUME IN EXISTING DIVERSION STRUCTURE = 174 Cubic yards

Canal Inlet Structure:

Sidewalls and Piers (remove to floor level)

Sidewalls	
(2) x 8 x 12 x 2 =	384
(2) x 11 x 12 x 1.5 =	396
Center Wall	
(1) 19 x 12 x 1.5 =	342
Piers	
(2) x 12 x ((8+4)/2) x 1.5 =	216
Upstream Wingwall	
(1) 22.5 x 12 x 2 =	540
Downstream Wingwalls	
(1) 20 x 12 x 1.5 =	360
(1) 23 x 12 x 1.5 =	414
Floor (Surface Removal ≈ 4”)	
(1) 19 x 25 x 0.33 =	158

Subtotal = $\frac{2810}{27}$ Cu. Ft.

TOTAL VOLUME IN CANAL INLET STRUCTURE = 104 Cubic yards

TOTAL CONCRETE STRUCTURE REMOVAL = 174 + 104 = 278 Cubic Yards

VOLUME OF CONCRETE IN PROPOSED REPLACEMENT STRUCTURE

Diversion Structure:

Sidewalls	
(1) x 20 x 12 x 1.5 =	360 Cu. Ft.
(1) x 19 x 12 x 1.5 =	342
Diversion Structure Wingwalls	
(2) 21 x 15 x 1.5 =	945
West Upstream Wingwall	
(1) x 13 x 12 x 1.5 =	234
Radial Gate Piers	
(4) x ((19+13)/2) x 12 x 1.5 =	1152
Flashboard Piers	
(4) x ((14+8)/2) x 12 x 1.0 =	528
Sluice Gate Headwall	
(1) [(7.5 x 12) – (6 x 6)] x 1.0 =	54
Floor of Structure	
(1) x 100 x 19 x 1.34 =	2546

Subtotal = $\frac{6161}{27}$ Cu. Ft.

TOTAL DIVERSION STRUCTURE = 228 Cubic Yards

Canal Inlet Structure:

Sidewalls	
(2) x 19 x 12 x 1.5 =	684
Diversion Structure Wing Walls	
(2) x 12 x 20 x 1.5 =	720
Upstream Headwall	
(1) x 22.5 x 12 x 1.5 =	405
(1) x 18.5 x 12 x 1.5 =	333
Radial Gate Pier	
(1) x 11 x ((19+13)/2) x 1.5 =	264
Water Control Gate Headwall	
(1) [(7 x 11) - (5 x 5)] x 1.0 =	52
Floor of Structure	
(1) x 27 x 19 x 1.34 =	687

Subtotal = 3145 Cu. Ft.
27

TOTAL CANAL INLET STRUCTURE = 117 Cubic Yards

TOTAL PROPOSED CONCRETE VOLUME = 228 + 117 = 345 Cubic Yards

UPSTREAM BANK STABILIZATION

Extend riprap 2 ft. below river bed and 12 ft. vertical height above river bed.

Rock Riprap

Length ~ 300 ft. S = 1.7 : 1.0

Slope Length ~ 27.6 ft.

Thickness ~ 1.5 ft.

V = (300 x 27.6 x 1.5)/27 = 460 Cubic Yards

Alternative Wire Basket Mattress

Length ~ 300 ft.

Slope Length ~ 27.6 ft.

Thickness ~ 8 in.

A = (300 x 27.6)/9 = 920 Square Yards and 204 Cubic Yards of Rock

Use geotextile fabric under either alternative

Length ~ 300 ft.

Slope Length plus 2.5 ft extra for anchoring ~ 30.1 ft.

A = 300 x 30.1 = 9030 Square Feet = 1003 Square Yards

Trench Rock at toe of Riprap or Mattress

Length ~ 300 ft.

$A_{total} = A_{trench} – A_{mattress}$

A_{total} = 10.4 – 2.6 = 7.8 Square Feet

V = 300 x 7.8 = 2331 Cubic Feet = 86 Cubic Yards

Wire Basket Mattress at Diversion & Canal Outlets

A = (100x8) + (32x8) = 1056 Square Feet = 117 Square Yards

PRELIMINARY CONSTRUCTION SPECIFICATIONS PREPARED TO ASSIST IN COST ESTIMATING

EARTHFILL

1. SCOPE

The work shall consist of the construction of earth embankments, other earthfills, and earth backfills required by the Construction Drawings and Specifications.

Earthfill is composed of natural earth materials that can be placed and compacted by construction equipment operated in a conventional manner. The work and payment for earthfill is described in this section.

Earth backfill is composed of natural earth materials placed and compacted in confined spaces or adjacent to structures (including pipes) by means of hand tamping, manually directed power tampers or vibrating plates, or equivalent. While earth backfill is described herein, it should be noted that earth backfill adjacent to concrete structures is considered incidental to concrete placement and paid accordingly.

2. MATERIALS

All fill materials shall be obtained from required excavations and designated borrow areas. The selection, blending, routing and disposition of materials in the various fills shall be subject to approval by the Engineer.

Fill materials shall contain no frozen soil, sod, brush, roots or other perishable materials. Rock particles larger than the maximum size specified for each type of fill shall be removed prior to compaction of the fill.

The types of materials used in the various fills shall be as listed and described in the Specifications and drawings.

1. FOUNDATION PREPARATION

Foundations for earthfill shall be stripped to remove vegetation and other unsuitable materials or shall be excavated as specified.

Except as otherwise specified, earth foundation surfaces shall be graded to remove surface irregularities and shall be scarified parallel to the axis of the fill or otherwise acceptably scored and loosened to a minimum depth of two (2) inches. The moisture content of the loosened material shall be controlled as specified for the earthfill, and the surface materials of the foundation shall be compacted and bonded with the first layer of earthfill as specified for subsequent layers of earthfill.

Earth abutment surfaces shall be free of loose, uncompacted earth in excess of two inches in depth normal to the slope and shall be at such moisture content that the earthfill can be compacted against them to produce a good bond between the fill and the abutments.

Rock foundation and abutment surfaces shall be cleared of all loose materials by hand or other effective means and shall be free of standing water when fill is placed upon them. Occasional rock outcrops in earth foundations for earthfill, except in dams and other structures designed to restrain the movement of water, shall not require special treatment if they do not interfere with compaction of the foundation and initial layers of the fill or the bond between the foundation and the fill.

Foundation and abutment surfaces shall be not steeper than one (1.5) horizontal to one (1) vertical unless otherwise specified. Test pits or other cavities shall be filled with compacted earthfill conforming to the Specifications for the earthfill to be placed upon the foundation.

2. PLACEMENT

Earthfill shall not be placed until the required excavation and foundation preparation have been completed and the foundation has been inspected and approved by the Engineer. Earthfill shall not be placed upon a frozen surface, nor shall snow, ice, or frozen material be incorporated in the earthfill matrix.

Earthfill shall be placed in approximately horizontal layers. The thickness of each layer before compaction shall not exceed the maximum thickness specified in Subsection 10 or shown on the drawings. Materials placed by dumping in piles or windrows shall be spread uniformly to not more than the specified thickness before being compacted.

Hand compacted earth backfill shall be placed in layers whose thickness before compaction does not exceed the maximum thickness specified for layers of earth backfill compacted by manually directed power tampers.

Earth backfill shall be placed in a manner which will prevent damage to the structures and will allow the structures to assume the loads from the earth backfill fill gradually and uniformly. The height of the earth backfill adjacent to a structure shall be increased at approximately the same rate on all sides of the structure.

Earthfill and earth backfill in dams, levees and other structures designed to restrain the movement of water shall be placed so as to meet the following additional requirements:

a. The distribution of materials throughout each zone shall be essentially uniform, and the earthfill shall be free from lenses, pockets, streaks or layers of material differing substantially in texture, moisture content, or gradation from the surrounding material. Zone earthfills shall be constructed concurrently unless otherwise specified.

b. If the surface of any layer becomes too hard and smooth for proper bond with the succeeding layer, it shall be scarified parallel to the axis of the fill to a depth of not less than two (2) inches before the next layer is placed.

c. The top surfaces of abutments and embankments shall be maintained approximately level during construction, except that a crown or cross-slope of approximately two (2) percent shall be maintained to ensure effective drainage, and except as otherwise specified for drainfill or sectional zones.

d. Canal embankments shall be constructed in continuous layers to facilitate construction or to allow the passage of stream flow during construction are specifically authorized in the contract.

e. Embankments built at different levels as described under (c) or (d) above shall be constructed so that the slope of the bonding surfaces between embankment in place and embankment to be placed is not steeper than three (3) feet horizontal to one (1) foot vertical. The bonding surface of the embankment in place shall be stripped of all material not meeting the requirements of this Specification, and shall be scarified, moistened and re-compacted when the new earthfill is placed against it. This is to insure a good bond with the new earthfill and to obtain the specified moisture content and density at the contact of the in place and new earthfills.

5. CONTROL OF MOISTURE CONTENT

During placement and compaction of earthfill and earth backfill, the moisture content of the materials being placed shall be maintained within the specified range.

The application of water to the earthfill materials shall be accomplished at the borrow areas insofar as practicable. Water may be applied by sprinkling the materials after placement on the earthfill, if necessary. Uniform moisture distribution shall be obtained by disking.
Material that is too wet when deposited on the earthfill shall either be removed or be dried to the specified moisture content prior to compaction.

If the top surface of the preceding layer of compacted earthfill or a foundation or abutment surface in the zone of contact with the earthfill becomes too dry to permit suitable bond it shall either be removed or scarified and moistened by sprinkling to an acceptable moisture content prior to placement of the next layer of earthfill.

6. COMPACTION

a. Equipment

The Contractor shall use a minimum 10-ton (static drum weight) vibratory roller, or equivalent, for compaction of the Type I fill materials. A smooth-drum roller is required for all granular soil fill. A rubber tire roller may be required for the foundation

preparation of the clayey or silty soils in the foundation area and for compaction of the clay liner in the Pitt-Taylor canal.

Vibratory roller equipment shall have a vibration meter mounted to the frame showing actual vibrations achieved during compaction. Vibratory shall vibrate in the 1200 to 1800 rpm range. If alternative equipment is available, it shall be approved by the PCWCD Field Representative and the Engineer.

The Contractor will be permitted to use alternative equipment provided that he can demonstrate to the Engineer that such alternate equipment shall compact the fill material to a density not less than that which would be produced by the equipment specified. If the Contractor wishes to use alternative equipment, it shall be approved by the PCWCD Field Representative and the Engineer. The Engineer's approval of the use of alternative equipment may be conditional upon the Contractor's construction of test fills at his own expense. Any approval of alternate equipment will not relieve the Contractor from responsibility of obtaining the specified degree of compaction.

Special compactors shall include: loaded dump trucks, pneumatic rubber-tired rollers, hand-guided heavy duty mechanical tampers, hand-guided vibratory rollers and such other compaction equipment as may be approved by the Engineer for use in restricted areas and near certain installations. Special compactors shall be capable of producing, with a reasonable number of passes, the specified densities in the fill material on which they are used.

Only hand-guided mechanical tampers or hand-guided vibratory rollers shall be used for compaction around, over, near, or adjacent to concrete structures.

a. Methods

Earthfill. Earthfill shall be compacted according to the following requirements for the class of compaction specified:

Class A compaction. Each layer of earthfill shall be compacted as necessary to provide the density of the earthfill matrix not less than the minimum density specified. The earthfill matrix is defined as the portion of the earthfill material finer than the maximum particle size used in the compaction test method specified.

Class B compaction. Each layer of earthfill shall be compacted to a mass density not less than the minimum density specified.

Class C compaction. Each layer of earthfill shall be compacted by the specified number of passes of the type and weight of roller or other equipment specified, or by an approved equivalent method. Each pass shall consist of at least one passage of the roller wheel or drum over the entire surface of the layer.

Class D Earth backfill. Earth backfill adjacent to structures shall be compacted to a density equivalent to that of the surrounding in-place earth materials or adjacent required earthfill or earth backfill. Compaction shall be accomplished by means of hand tamping or manually directed power tampers, plate vibrators, walk-behind, miniature, or self-propelled rollers. Unless otherwise specified, heavy equipment including backhoe mounted powertampers, or vibrating compactors and manually directed vibrating rollers, shall not be operated within two (2) feet of any structure. Towed or self-propelled vibrating rollers shall not be operated within five (5) feet of any structure. Compaction by means of drop weights operating from a crane or hoist will not be permitted.

Compacting of earth backfill adjacent to structures shall not be started until the concrete has attained the strength specified herein. The strength will be determined by compression testing of test cylinders cast by the Contractor's quality control personnel for this purpose and cured at the work site in the manner specified in ASTM C 31 for determining when a structure may be put into service.

When the required strength of the concrete is not specified as described above, compaction of earth backfill adjacent to structures shall not be started until the following time intervals have elapsed after placement of the concrete.

Structure	Time Interval
Vertical or near-vertical walls with earth loading on one side only	14 days
Walls backfilled on both sides simultaneously	7 days
Concrete piers and spillway risers, cast-in-place (inside forms removed)	l4 days

7. REWORKING OR REMOVAL AND REPLACEMENT OF DEFECTIVE EARTHFILL

Earthfill placed at densities lower than the specified minimum density or at moisture contents outside the specified acceptable range of moisture content or otherwise not conforming to the requirements of the Specifications shall be reworked to meet the requirements or removed and replaced by acceptable earthfill. The replacement earthfill and the foundation, abutment and earthfill surfaces upon which it is placed shall conform to all requirements of this Specification for foundation preparation, approval, placement, moisture control and compaction.

8. TESTING

During the course of the work, the Engineer will perform such quality assurance tests as are

required to identify materials; determine compaction characteristics; determine moisture content; and determine density of earthfill in-place. Tests performed by the Engineer will be used to verify that the earthfills conform to contract requirements of the Specifications and not as a replacement for the Contractor's quality control program. The Contractor shall perform all quality control testing, in conformance with an approved quality control system or ASTM standards.

Densities of earthfill requiring Class A compaction will be determined in accordance with ASTM D l556, D 2167, D 2922 or D 2937 except that the volume and moist weight of included rock particles larger than those used in the compaction test method specified for the type of fill will be determined and deducted from the volume and moist weight of the total sample prior to computation of density or if using the nuclear gauge, added to the specified density to bring it to the measure of equivalent composition for comparison. The density so computed will be used to determine the percent compaction of the earthfill matrix. Unless otherwise specified, moisture content will be determined by one of the following methods: ASTM D 22l6, D 3017, D 4643, D 4944, or D 4959.

9. EXECUTION

a. Summary

All fill shall be compacted according to ASTM D698 for the Pitt-Taylor Diversion Dam Rehabilitation Project. A summary of the soil material specifications is presented in the following table and specified in detail, below:

Fill Soil Classification	**Source**	**Class/Lift Thickness (before compact.)**	**% Density (Unless otherwise stated)**
Type I - General Fill	Contractors choice, pending approval by PCWCD	Class A / 12"	95
Type II - Structural Fill	Unspecified (same as surrounding soil)	Class D / 6"	95 (Using hand tamping equipment)
Type III - Drain Fill /Filter Blanket	Unspecified	Class C (one pass) / 8"	No requirement
Type IV - Rock Riprap (See separate section for specs.	Nominal size 12" from local pit	No requirement	No requirement

a. Materials and Compaction Requirements

Type I - General Fill. Compacted general fill shall be used to construct the abutment fill that is not under the proposed structures. This shall include all site grading to the contours represented on the Construction Drawings or to the base of the rock riprap revetment. Compacted general fill shall consist of inorganic gravel soils from the White Gate Pit or from excavation of the north abutment, having a maximum rock size of 3".

Compacted general fill shall be moisture conditioned to within plus or minus two percent of optimum moisture content, placed in 12-inch maximum loose lifts, and compacted to a minimum of 95 percent of maximum density (ASTM D-698).

The backfill used for the fill should meet the following gradation:

Type I General Fill

SIEVE SIZE	PERCENT PASSING
3-inch	100
No. 4	30-100
No. 200	3-35

Type II - Structural Fill. Compacted structural fill shall be used within a lateral distance of 2 feet of all concrete structures. This does not include Drain Fill.

Compacted structural fill shall consist of inorganic soils from the surrounding soil. Grain-size distribution is specified under Types I of this Construction Specification.

Compacted fill shall be moisture conditioned to within two percent of optimum moisture content, placed in 6-inch maximum loose lifts and compacted to a minimum of 95 percent of maximum density by hand tamper, unless otherwise specified.

While earth backfill is described herein, it should be noted that backfill adjacent to concrete structures is considered incidental to concrete placement and paid accordingly. No separate payment for Structural Fill will be allowed.

Type III - Drain Fill. Select fine-grained drain rock fill is to provide rapid drainage around the drainage pipe behind the truss abutments. The drain rock fill shall consist of free draining clean fine gravel with the following gradation:

Type III Drain Fill

US Standard Sieve Size	Percent Passing by Dry Weight
1- inch	100
No. 4	40 – 75
No. 100	0 – 10
No. 200	0 – 3

The drain rock fill may be hand placed and spread with an 6-inch thickness. No moisture content requirements are specified. Compaction of the drain fill shall be by a minimum of one pass. Alternatively, the Drain Rock material may be replaced by an underlayment of geotextile Filter Fabric, provided it is designed and approved by the Engineer.

STRUCTURE CONCRETE

l. SCOPE

The work shall consist of furnishing, forming, placing, finishing, and curing Portland cement concrete as required to build the structures described in Subsection 24 of this Specifications.

2. MATERIALS

Aggregates shall conform to the requirements of Material Specification 522 unless otherwise specified. The grading of coarse aggregates shall be as specified in Subsection 24.

Portland cement shall conform to the requirements of Material Specification 53l for the specified type.

Fly ash shall conform to the requirements of Material Specification 532.

Air-entraining admixtures shall conform to the requirements of Material Specification 533. If air- entraining cement is used, any additional air-entraining admixture shall be of the same type as that in the cement.

Water reducing and/or retarding admixtures shall conform to the requirements of Material Specification 533.

Curing compound shall conform to the requirements of Material Specification 534.

Preformed expansion joint filler shall conform to the requirements of Material Specification 535.

Waterstops shall conform to the requirements of Material Specifications 537 and 538 for the specified kinds.

Water used in mixing and curing concrete shall be clean and free from injurious amounts of oil, salt, acid, alkali, organic matter or other deleterious substances.

3. CLASS OF CONCRETE

Concrete for structures shall be classified as follows:

Class of Concrete	Maximum Net Water Content (gallons/bag)	Minimum Cement Content (bags/cu. yd.)
4000M	6	6

4. AIR CONTENT AND CONSISTENCY

Unless otherwise specified, the slump shall be 2 to 4 inches. If air entrainment is specified, the air content by volume shall be 4 to 7 percent of the volume of the concrete. When specified, directed or approved by the Engineer, a water-reducing, set-retarding or other admixture shall be used. High Range Water Reducing

Agents (Superplasticizers), may be used to increase workability, reduce water content and control concrete temperature in hot weather. The maximum slump after adding high range water reducing agents shall be 7-1/2 inches.

5. DESIGN OF THE CONCRETE MIX

The proportions of the aggregates shall be such as to produce a concrete mixture that will work readily into the corners and angles of the forms and around reinforcement when consolidated, but will not segregate or exude free water during consolidation.

Fly ash may be used as a partial substitution for Portland cement in an amount not greater than 25 percent (by weight) of the cement in the concrete mix, unless otherwise specified.

Prior to placement of concrete, the Contractor shall furnish the Engineer, for approval, a statement of the materials and mix proportions (including admixtures, if any) he intends to use. The statement shall include evidence satisfactory to the Engineer that the materials and proportions will produce concrete conforming to this Specifications. The materials and proportions so stated shall constitute the "job mix." After a job mix has been approved, neither the source, character or grading of the aggregates nor the type or brand of cement or admixture shall be changed without prior notice to the Engineer. If such changes are necessary, no concrete containing such new or altered materials shall be placed until the Engineer has approved a revised job mix.

6. INSPECTION AND TESTING

The Engineer shall have free entry to the plant and equipment furnishing concrete under the contract. Proper facilities shall be provided for the Engineer to inspect materials, equipment and processes and to obtain samples of the concrete. All tests and inspections will be conducted so as not to interfere unnecessarily with manufacture and delivery of the concrete.

7. HANDLING AND MEASUREMENT OF MATERIALS

Materials shall be stockpiled and batched by methods that will prevent segregation or contamination of aggregates and insure accurate proportioning of the ingredients of the mix.

Except as otherwise provided in Subsection 8, cement and aggregates shall be measured as

follows:

Cement shall be measured by weight or in bags of 94 pounds each. When cement is measured in bags, no fraction of a bag shall be used unless weighed.

Aggregates shall be measured by weight. Mix proportions shall be based on saturated, surface-dry weights. The batch weight of each aggregate shall be the required saturated, surface-dry weight plus the weight of surface moisture it contains.

Water shall be measured, by volume or by weight, to an accuracy within one percent of the total quantity of water required for the batch.

Admixtures shall be measured within a limit of accuracy of three percent.

8. MIXERS AND MIXING

Concrete shall be uniform and thoroughly mixed when delivered to the work site. Variations in slump of more than one (l) inch within a batch will be considered evidence of inadequate mixing and shall be corrected by increasing mixing time or other acceptable alternative.

For stationary mixers, the mixing time after all cement and aggregates are in the mixer drum shall be not less than 1-1/2 minutes. When concrete is mixed in a truck mixer, the number of revolutions of the drum or blades at mixing speed shall be not less than 70 nor more than l00.

Unless otherwise specified, volumetric batching and continuous mixing at the construction site will be permitted. The batching and mixing equipment shall conform to the requirements of ASTM Specification C 685 and shall be demonstrated prior to placement of concrete, by tests with the job mix, to produce concrete meeting the specified proportioning and uniformity requirements. Concrete made by this method shall be produced, inspected, and certified in conformance with Subsections 6, 7, 8, l3, and l4 of ASTM Specification C 685.

No mixing water in excess of the amount called for by the job mix shall be added to the concrete during mixing or hauling or after arrival at the delivery point.

9. FORMS

Forms shall be of wood, plywood, steel or other approved material and shall be mortar tight. The forms and associated falsework shall be substantial and unyielding and shall be constructed so that the finished concrete will conform to the specified dimensions and contours. Form surfaces shall be smooth and free from holes, dents, sags or other irregularities. Forms shall be coated with a non-staining form release agent before being set into place.

Metal ties or anchorages within the forms shall be equipped with cones, she-bolts or other devices that permit their removal to a depth of at least one inch without injury to the concrete. Ties designed to break off below the surface of the concrete shall not be used without cones.

All edges that will be exposed to view when the structure is completed shall be chamfered, unless finished with molding tools as specified in Subsection l8.

l0. PREPARATION OF FORMS AND SUBGRADE

Prior to placement of concrete, the forms and subgrade shall be free of chips, sawdust, debris, water, ice, snow, extraneous oil, mortar, or other harmful substances or coatings and the temperature of all surfaces to be in contact with the new concrete shall be not be less than 40° F. Any oil on the reinforcing steel or other surfaces required to be bonded to the concrete shall be removed. Rock surfaces shall be cleaned by air-water cutting, wet sandblasting or wire brush scrubbing, as necessary, and shall be wetted immediately prior to placement of concrete. Earth surfaces shall be firm and damp. Placement of concrete on mud, dried earth or un-compacted fill or frozen subgrade will not be permitted.

Items to be embedded in the concrete shall be positioned accurately and anchored firmly.

Weepholes in walls or slabs shall be formed with nonferrous materials.

ll. CONVEYING

Concrete shall be delivered to the site and discharged into the forms within l-1/2 hours after the introduction of the cement to the aggregates. In hot weather or under conditions contributing to quick stiffening of the concrete, the time between the introduction of the cement to the aggregates and discharge shall not exceed 45 minutes.

The Engineer may allow a longer time, provided the setting time of the concrete is increased a corresponding amount by the addition of an approved set-retarding admixture. In any case, concrete shall be conveyed from the mixer to the forms as rapidly as practicable by methods that will prevent segregation of the aggregates and no loss of mortar occurs.

l2. PLACING

Concrete shall not be placed until the subgrade, forms, steel reinforcement, and embedded items have been inspected and approved. No concrete shall be placed except in the presence of the Engineer. The Contractor shall give reasonable notice to the Engineer each time he intends to place concrete. Such notice shall provide sufficient time for the Engineer to inspect the subgrade, forms, steel reinforcement and other preparations for compliance with the Specifications. "Other preparations" include but are not limited to the concrete mixing plant, delivery equipment system, placing, finishing, and curing equipment and system, schedule of work, workforce, heating or cooling facilities if applicable. Deficiencies are to be corrected before concrete is delivered for placing.

The concrete shall be deposited as closely as possible to its final position in the forms and shall be worked into the corners and angles of the forms and around all reinforcement and embedded

items in a manner to prevent segregation of aggregates or excessive laitance. Formed concrete shall be placed in horizontal layers not more than 20 inches thick. Concrete shall not be dropped more than five feet vertically unless suitable equipment is used to prevent segregation. When high range water reducing agents are used, the concrete shall not be allowed to drop more than 10 feet. Hoppers and chutes, pipes or "elephant trunks" shall be used as necessary to prevent segregation and the splashing of mortar on the forms and reinforcing steel above the layer being placed.

Immediately after the concrete is placed in the forms, it shall be consolidated by spading, hand tamping or vibration as necessary to insure smooth surfaces and dense concrete. Each layer shall be consolidated to insure monolithic bond with the preceding layer. If the surface of a layer of concrete in-place sets to the degree that it will not flow and merge with the succeeding layer when spaded or vibrated, the Contractor shall discontinue placing concrete and shall make a construction joint according to the procedure specified in Subsection l3.

If placing is discontinued when an incomplete horizontal layer is in place, the unfinished end of the layer shall be formed by a vertical bulkhead.

13. CONSTRUCTION JOINTS

Construction joints shall be made at the locations shown on the drawings. If construction joints are needed which are not shown on the drawings, they shall be placed in locations approved by the Engineer.

Where a feather edge would be produced at a construction joint, as in the top surface of a sloping wall, an insert form shall be used so that the resulting edge thickness on either side of the joint is not less than 6-inches.

In walls and columns, as each lift is completed, the top surfaces shall be immediately and carefully protected from any condition that might adversely affect the hardening of the concrete.

Steel tying and form construction adjacent to concrete in-place shall not be started until the concrete has cured at least l2-hours. Before new concrete is deposited on or against concrete that has hardened, the forms shall be re-tightened. New concrete shall not be placed until the hardened concrete has cured at least l2-hours.

Surfaces of construction joints shall be cleaned of all unsatisfactory concrete, laitance, coatings or debris by washing and scrubbing with a wire brush or wire broom or by other means approved by the Engineer. The surfaces shall be kept moist for at least one hour prior to placement of the new concrete.

l4. EXPANSION AND CONTRACTION JOINTS

Expansion and contraction joints shall be made only at locations shown on the drawings.

Exposed concrete edges at expansion and contraction joints shall be carefully tooled or chamfered, and the joints shall be free of mortar and concrete. Joint filler shall be left exposed for its full length with clean and true edges.

Preformed expansion joint filler shall be held firmly in the correct position as the concrete is placed.

When open joints are specified, they shall be constructed by the insertion and subsequent removal of a wooden strip, metal plate or other suitable template in such a manner that the corners of the concrete will not be chipped or broken. The edges of open joints shall be finished with an edging tool prior to removal of the joint strips.

l5. WATERSTOPS

Waterstops shall be held firmly in the correct position as the concrete is placed. Joints in metal waterstops shall be soldered, brazed or welded. Joints in rubber or plastic waterstops shall be cemented, welded or vulcanized as recommended by the manufacturer.

l6. REMOVAL OF FORMS

Forms shall not be removed without the approval of the Engineer. Forms shall be removed in such a way as to prevent damage to the concrete. Supports shall be removed in a manner that will permit the concrete to take the stresses due to its own weight uniformly and gradually.

l7. FINISHING FORMED SURFACES

Immediately after the removal of the forms:

- All fins and irregular projections shall be removed from exposed surfaces.

- The holes produced on all surfaces by the removal of form ties, cone-bolts, and she-bolts shall be cleaned, wetted and filled with a dry-pack mortar consisting of one part Portland cement, three parts sand that will pass a No. 16 sieve, and just sufficient water to produce a consistency such that the filling is at the point of becoming rubbery when the material is solidly packed.

l8. FINISHING UNFORMED SURFACES

All exposed surfaces of the concrete shall be accurately screeded to grade and then float finished, unless specified otherwise.

Excessive floating or troweling of surfaces while the concrete is soft will not be permitted.

The addition of dry cement or water to the surface of the screeded concrete to expedite finishing will <u>not</u> be allowed.

Joints and edges on unformed surfaces that will be exposed to view shall be chamfered or finished with molding tools.

l9. CURING

Concrete shall be prevented from drying for a curing period of at least 7 days after it is placed. Exposed surfaces shall be kept continuously moist for the entire period, or until curing compound is applied as specified below. Moisture shall be maintained by sprinkling, flooding or fog spraying or by covering with continuously moistened canvas, cloth mats, straw, sand or other approved material. Wood forms left in-place during the curing period shall be kept continuously wet. Formed surfaces shall be thoroughly wetted immediately after forms are removed and shall be kept wet until patching and repairs are completed. Water or covering shall be applied in such a way that the concrete surface is not eroded or otherwise damaged.

Concrete, except at construction joints, may be coated with the approved curing compound in lieu of continued application of moisture, except as otherwise specified in Subsection 24. The compound shall be sprayed on the moist concrete surfaces as soon as free water has disappeared, but shall not be applied to any surface until patching, repairs and finishing of that surface are completed. The compound shall be applied at a uniform rate of not less than one gallon per 175 square feet of surface and shall form a continuous adherent membrane over the entire surface. Curing compound shall be thoroughly mixed before applying and continuously agitated during application. Curing compound shall not be applied to surfaces requiring bond to subsequently placed concrete, such as construction joints, shear plates, reinforcing steel and other embedded items. If the membrane is damaged during the curing period, the damaged area shall be re-sprayed at the rate of application specified above. Surfaces covered by the membrane shall not be trafficked unless protected from wear.

20. REMOVAL AND REPLACEMENT OR REPAIR

When concrete is honeycombed, damaged or otherwise defective, the Contractor shall remove and replace the structure or structural member containing the defective concrete or, where feasible, correct or repair the defective parts. The Engineer will determine the required extent of removal, replacement or repair. Prior to starting repair work the Contractor shall obtain the Engineer's approval of his plan for effecting the repair. The Contractor shall perform all repair work in the presence of the Engineer.

2l. CONCRETING IN COLD WEATHER

Concrete shall not be mixed nor placed when the daily <u>minimum</u> atmospheric temperature is less than 40°F unless facilities are provided to prevent the concrete from freezing. The use of accelerators or antifreeze compounds will <u>not</u> be allowed.

22. CONCRETING IN HOT WEATHER

The Contractor shall apply effective means to maintain the temperature of the concrete below 90°F during mixing, conveying and placing.

23. MEASUREMENT AND PAYMENT

For items of work for which specific unit prices are established in the contract, concrete will be measured to the neat lines shown on the drawings and the volume of concrete will be computed to the nearest 0.l cubic yard. Measurement of concrete placed against the sides of an excavation without the use of intervening forms will be made only to the neat lines or pay limits shown on the drawings. No deduction in volume will be made for chamfers, rounded or beveled edges or for any void or embedded item that is less than five (5) cubic feet in volume.

Payment for each item of structure concrete will be made at the contract unit price or the contract lump sum, whichever is applicable, for that item. Such payment will constitute full compensation for all labor, materials, equipment, transportation, tools, forms, falsework, bracing and all other items necessary and incidental to the completion of the work, except items listed for payment elsewhere in the contract.

Compensation for any item of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in Subsection 24 of this Specifications.

24. EXECUTION

a. Specific Materials

Portland Cement shall conform to ASTM C150, Type II

Cement shall be American-made Portland cement, free from water soluble salts or alkalies which will cause efflorescence on exposed surfaces.

Portland cement shall be an approved brand conforming to ASTM C150 Type II.

High early strength cement may only be used with the permission of the Engineer given in writing and shall conform to ASTM C150 Type III.

Only one brand of cement shall be used through-out the work for exposed concrete.

The Contractor shall be responsible for whatever steps are necessary to insure that no visual variations in color will result in exposed concrete, and shall place on order a sufficient quantity of this cement to complete the concrete work.

Place bituminous preformed expansion joint filler only at location specified on the Construction Drawings. Bituminous type preformed expansion joint filler shall conform to the requirements of ASTM D994 or D1751. The filler shall be placed in accordance with manufactures specifications.

a. Aggregates

Aggregates shall conform to ASTM C33, "Specifications for Concrete Aggregates." Fine aggregate shall consist of washed inert natural and conforming to the requirements of ASTM C33 and the following additional requirements.

Sieve	Retained (5)
# 4	0-5
# 16	25-40
# 50	70-87
#100	93-97
F.M. (Plus or Minus 0.20)	2.87
Organic	Plate 2 maximum
Silt	100% min. compressive ratio
Soundness	sulfate, 5 cycles
Mortar Strength	5% max. loss, magnesium

Coarse aggregate shall consist of well graded crushed stone or washed gravel conforming to the requirements of ASTM C33 and the following additional requirements.

Designated Size	1 to 1-1/2", 1", 3/4", ½"
F.M. (plus or minus 0.20)	7.20 6.95 6.70 6.10
Organic	Plate 1 maximum
Silt	1.0% Maximum
Soundness	cycles

Maximum designated aggregate sizes shall be 3/4" for all reinforced sections larger than three and one half (3-1/2) inches in thickness, and all plain sections between three and one half (3-1/2) inches and nine (9) inches in thickness, inclusive.

Water used in mixing concrete shall be clean, free of deleterious amounts of acids, oils, salts, alkalies, organic materials and other substances that may be deleterious to concrete or steel.

Admixtures shall be indicated. Additional mixtures, not referenced, shall not be used without prior written approval of the Engineer.

Water Reducing Agent: ASTM C494, Type A, and approved by the Engineer.

Air Entraining Agent: ASTM C260, 4% to 7% and approved by the Engineer. Use in all

concrete exposed to weather as required by ACI 301.

Admixtures (e.g., calcium chloride) causing accelerated setting of cement in concrete shall not be used without written approval of the Engineer.

Admixtures shall be premixed in solution form and dispensed as recommended by the manufacturer. The water in the solution shall be included in the computation of water-cement ratio.

Concrete curing compounds that are commercial sprayed-on curing compound conforming to ASTM C309 will generally be allowed, provided the Engineer's approval is obtained in writing beforehand for the specific product being used.

b. Concrete Mixing

Type and strength shall be:

- Type: Working stress Type Concrete
- Minimum compressive strength in place, at 28 days, shall be as follows:
- All Concrete 4,000 psi

Use air entrained concrete for all structures. Proportion entrained air as determined by ASTM C233, C260, and ACI-302.

Slump and workability shall be:

- Slump as determined by ASTM C143 as follows:
- Slum for all concrete for the Pitt-Taylor Diversion Structure Rehabilitation Project 2"-4"
- Compression, slump and air testing to be performed per 50 cy or per day whichever is more frequent, see Section 11

Workability shall be such that the concrete will completely embed and bond to reinforcing without separation of materials.

Mix and deliver concrete in accordance with ACI 301, Chapter 7, and ASTM C94.

Cooled or heated water shall be used in accordance with ACI 306 and 605.

- Ready mixed concrete shall be transported to the site in watertight agitator or mixer trucks loaded not in excess of rated capacities.

- Concrete shall be delivered and discharged within 1-1/2 hours before the drum was revolved 300 times after introduction of water to the cement and aggregates or the cement to the aggregates.

- Central mixed concrete shall be plant mixed a minimum of five (5) minutes.

- Agitation shall begin immediately after the premixed concrete is placed in the truck and shall continue without interruption until discharged.

Attention is called to the importance of scheduling and dispatching trucks from the batching point so that they shall arrive at the site of work just before the concrete is required, thus avoiding excessive mixing of concrete while waiting or delays in placing successive layers of concrete in the forms.

- Concrete shall be mixed only in quantities for immediate use.

- Concrete which has set shall not be retempered and shall be discarded.

- On-site disposal shall not be allowed.

If during the course of the work, it is impossible to secure concrete of the required workability and strength with the materials being furnished by the Vender, the Engineer may order such changes in the proportions or materials, or both, as may be necessary to secure the desired properties, subject to the stated requirements.

ROCK RIPRAP

1. SCOPE

The work shall consist of the construction of rock riprap revetments and blankets, including filter or bedding where specified.

2. MATERIALS

Rock riprap shall be obtained from designated sources. It shall be free from dirt, clay, sand, rock fines and other materials not meeting the required gradation limits.

At least thirty (30) days prior to delivery of rock from other than designated sources, the Contractor shall designate in writing the source from which rock materials will be obtained and provide information satisfactory to the Contracting Officer that the material meets contract requirements. The Contractor shall provide the Contracting Officer's Technical Representative (COTR) free access to the source for the purpose of obtaining samples for testing. The size and grading of the rock shall be as specified in Section 7

Rock from approved sources shall be excavated, selected, and processed to meet the specified quality and grading requirements at the time the rock is installed.

When requested by the Contracting Officer, a gradation quality control check shall be made by the Contractor and subject to inspection by the COTR. The test shall be performed at the work site, according to ASTM D 5519 Test Method B Size, *Size-Range Grading*, on a test pile of representative rock. The weight or size of the test pile shall be large enough to ensure a representative gradation of rock from the source and to provide test results within a five (5) percent accuracy.

Based on a specific gravity of 2.65 (typical of limestone and dolomite), and assuming the individual rock is shaped midway between a sphere and a cube, typical size/weight relationships are:

Sieve Size of Rock	Approximate Weight of Rock	Weight of Test Pile
16 inches	300 pounds	6,000 pounds
11 inches	100 pounds	2,000 pounds
6 inches	15 pounds	300 pounds

The results of the test shall be compared to the gradation required for the project. Test pile results that do not meet the Construction Specifications shall because for the rock to the rejected. The test pile that meets contract requirements shall be left on the job site as a sample for visual comparison. The test pile shall be used as part of the last rock riprap to be placed.

3. SUBGRADE PREPARATION

The subgrade surfaces on which the rock riprap, filter, bedding or geotextile is to be placed shall be cut or filled and graded to the lines and grades shown on the drawings. When fill to subgrade lines is required, it shall consist of approved materials and shall conform to the requirements of the specified class of earthfill.

Rock riprap, filter, bedding or geotextile shall not be placed until the foundation preparation is completed and the subgrade surfaces have been inspected and approved.

4. EQUIPMENT-PLACED ROCK RIPRAP

The rock riprap shall be placed by equipment on the surfaces and to the depths specified. The rock riprap shall be installed to the full course thickness in one operation and in such a manner as to avoid serious displacement of the underlying materials. The rock for riprap shall be delivered and placed in a manner that will ensure that the riprap in-place shall be reasonably homogeneous with the larger rocks uniformly distributed and firmly in contact one to another with the smaller rocks and spalls filling the voids between the larger rocks. Some hand placing may be required to provide a neat and uniform surface.

Rock riprap shall be placed in a manner to prevent damage to structures. Hand placing will be required as necessary to prevent damage to any new and existing structures.

5. FILTER OR BEDDING

When the contract specifies filter, bedding or geotextile beneath the rock riprap, the designated material shall be placed on the prepared subgrade surface as specified. Compaction of filter or bedding aggregate will not be required, but the surface of such material shall be finished reasonably smooth and free of mounds, dips, or windrows.

1. EXECUTION

Rock Riprap. Place loose rock riprap at the toe of the slope revetment on the riverbank to the lines and grades represented on the Construction Drawings. Prior to any Contractor operations in the riprap source, the Contractor shall submit, to the PCWCD, plans for developing the source and transporting the materials to the site. No rock source is identified

Loose Rock Riprap may be used in place of the wire cage and rock revetment. If an inexpensive source of rock can be found, the proposed wire cage with rock revetment should be reconsidered for cost feasibility. The Engineer shall be advised of such rock and suitability and cost analyses should be completed.

PCWCD reserves the right to make inspection of the quarry site and operations. The Contractor shall clear, strip, develop, and operate the quarry. The Contractor shall excavate and transport the rock materials to the site. Blasting shall be in accordance applicable standard and

regulations.

The rock fragments for riprap shall be dense, sound, and resistant to abrasion and shall be free from cracks, seams, and other defects that would tend to increase unduly their destruction by water and frost actions. The rock riprap shall be reasonably well graded within the gradations limits of the following table. The rock riprap shall have a nominal size of approximately 12-inches in diameter.

Type IV Rock Riprap

MATERIAL SIZE	PERCENT PASSING*
18-inch	100
14-inch	60 - 80
8 inch	20 - 40
3-inch	0 - 20**

* Sand and rock dust shall be less than 5 percent, by weight, of total riprap material.

** The percentage of this size material shall not exceed an amount which will fill the voids in larger rock.

The rock riprap need not be compacted but shall be placed to grade in a manner to ensure that the larger rock fragments are uniformly distributed and the small rock fragments serve to fill the spaces between the larger rock fragments.

Bedding for Riprap. The bedding for the rock riprap at the downstream side of the Diversion Dam and the Canal Inlet structures shall consist of 6-inches of well graded Filter Blanket media (crushed well-graded drain rock) or alternatively, a pit run Filter Blanket media (poorly graded) underlain by a geotextile filter fabric. Bedding for rock riprap shall be placed to the lines, grades and thicknesses at the locations shown on the Construction Drawings and elsewhere as directed.

Filter Blanket Materials (without an underlying geotextile filter fabric) shall be obtained from an approved commercial source. This material shall serve as a bedding for the riprap as well as a filter. It shall be a crushed stone processed to meet the gradation requirements shown in the table below.

Alternative Filter Blanket Fill

SIEVE SIZE	PERCENT PASSING
3-inch	100
1-½-inch	65 - 80
d-inch	25 - 40
No. 4	15 - 30
No. 100	0 - 5

The Filter Blanket need not be compacted in place, but shall be placed in such a manner as will result in a uniform 8-inch thick layer of bedding for riprap. The Filter Blanket shall be placed in all areas to receive rock riprap. It shall be placed so as to ensure the best practical distribution of the material and minimize segregation.

Alternative Filter Blanket. The alternative filter blanket shall consist of 8-inches of the available drain rock underlain by a geotextile filter fabric. The alternative Filter Blanket material shall meet the following gradation and be underlain with the geotextile specified below.

Alternative Type VII Filter Blanket Underlain by Geotextile

SIEVE SIZE	PERCENT PASSING
3-inch	100
No. 4	5-50
No. 100	0 - 5

The Alternative Filter Blanket need not be compacted in place, but shall be placed in such a manner as will result in a uniform thick layer of bedding for riprap. The Filter Blanket shall be placed in all areas to receive rock riprap and shall be underlain in all areas by a geotextile filter fabric. It shall be placed so as to ensure the best practical distribution of the material and minimize segregation.

Geotextile Filter Fabric. A geotextile shall be placed on the finished graded ground surface between the fill slope and the Alternative Filter Blanket (riprap bedding) and the embankment soils. The filter fabric shall be a non-woven 10 oz. per square yard geotextile such as GSE non-woven NW10, or equivalent approved by the Engineer.

The geotextile shall be place so as to extend perpendicular to the grade (rather than parallel). The fabric shall be anchored into the underlying soil at the top of the riprap to provide stability. The fabric shall be overlapped a minimum of 18-inch to ensure contact between strips.

Big 5 Dam Rehabilitation
Feasibility Study
Pershing County, Nevada
For
Pershing County Water
Conservation District,
Lovelock, Nevada

Prepared by
URS/Dames & Moore
Sacramento, California

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Big 5 Dam Rehabilitation Feasibility Study
Pershing County, Nevada

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Big 5 Dam Rehabilitation Feasibility Study
Pershing County, Nevada

1.0 INTRODUCTION

The Big 5 Dam is an existing earth and rubble plug-type diversion dam located on the Humboldt River outside of Lovelock, Nevada. This feasibility study has been prepared for the Pershing County Water Conservation District (PCWCD) to evaluate options for rehabilitation of this structure.

Sections 1.0 and 2.0 provide background information on the project and the dam. Section 3.0 presents four options for dam rehabilitation and evaluates each option against cost and longevity criteria to select a preferred alternative.

1.1 Background

The PCWCD of Nevada is responsible for the operation and maintenance of the Humboldt Project, a plan designed to provide seasonal and long-term regulation of the Humboldt River and to increase the amount of water available to its various water users. The PCWCD responsibilities pertinent to this document, involve management of the water distributed from the Humboldt Project, specifically, the management of the storage capacity of Rye Patch Reservoir and flow diversion at the Big Five Dam.

The Big 5 Dam is a plug earthen dam located along the Humboldt River, approximately 8 miles south of Lovelock, Nevada. It is constructed of concrete and asphalt rubble and borrowed native soil. Its purpose is to divert irrigation water from the Humboldt into the Big Five Diversion Canal. The Rye Patch Dam and Reservoir, located approximately 26 miles north of Lovelock (Figure 1) control the flow of water to the Big 5 diversion.

The Big 5 Dam regularly sustains damage due to erosive actions resulting from excessive flows down the Humboldt River. Although no measuring device is available to directly measure flow at the plug, low levels of degradation are first observed when flows at the Rye Patch structure exceed 1,500 to 2,000 cfs. More extensive damage occurs when flows overtop the dam (flows in excess of 3,000 cfs). Major repair or replacement has occurred six times in the last 30 years, all associated with overtopping events. The Rye Patch Dam and Reservoir have outlet works and spillway capacities of 1,000 cfs and 20,000 cfs, respectively, into the Humboldt River.

1.2 Purpose

The purpose of this document is to evaluate the feasibility of four design options for a permanent structure in the Humboldt River to maintain the required flow to the Big Five Diversion Canal.

1.3 Scope

The scope of this feasibility study document is to provide historic and current background site information and to identify and develop four design options for a structure that would be able to safely pass flows during a reasonable maximum flood event. Overflow protection, consisting of a spillway flow control structure will be considered as part of the design. The four designs will then be evaluated with respect to expected longevity of the completed structure and economics and a preferred design selected for design and construction at the end of the irrigation season in the year 2001.

2.0 PROBLEM ASSESSMENT

2.1 Site Topography

A topographic survey of the Big 5 Dam and its immediate surroundings was conducted by Desert Mountain Surveying on July 29, 1999. The topographic map presented in Figure 2 shows that the site topography in the vicinity of the Big 5 Dam is relatively flat except where the banks of the river and canal slope down to meet the water's edge. The elevation of the ground surface and the top of the dam is 3,930 to 3,931 feet above mean sea level (msl). The minimum elevation of the channel of 3,915 feet msl, is found in an area downstream of the current dam where scouring is apparent. Specific elevations are provided below:

Site Feature	Elevation (feet msl)
Ground surface	3,930 to 3,931
Top of Dam	3,929 to 3,930
Big 5 Diversion Channel (flowline)	3,921 to 3,924
Upstream Channel of the Big 5 Dam (flowline)	3,922 to 3,924
Downstream Channel of the Big 5 Dam (flowline)	3,915 to 3,922

The following are topographic data that affect construction of the dam:

- The section of the channel just upstream of the dam is slightly higher in elevation than that of the Big 5 Diversion Canal, presumably due to sedimentation. This rise in elevation may favorably affect the cost of dewatering;
- There is an elevation drop of approximately 9 feet between the upstream and downstream sides of the dam. This drop in elevation will affect the flow velocity which will affect the selection of the sheet pile and revetment; and
- 1 The bi-level surface of the channel downstream of the dam where the elevation drops to 3,915 feet msl appears to be due to soil erosion. This area will be backfilled and compacted prior to placement of revetment to help reduce erosion of the bottom of the channel. The reduction in height of the new dam should reduce the extent of erosion but energy dissipation units are recommended where the hydraulic jump is anticipated to protect the revetment from a similar type of erosion.

The alternatives presented in this document will not attempt to remedy the elevation difference at the fork in the river between the diversion channel and the river channel. This elevation difference is believed to be associated with a build-up of sediments in the river channel (upstream of the dam). Alternatives presented will, however, attempt to minimize erosion downstream of the plug.

2.2 Climate

Climate data is available for 1928 through 1995 at the Lovelock Station. During that time, the following conditions were observed:

Parameter	Minimum	Maximum	Average
Minimum air temperatures	30.3 °F	40.3 °F	35.7 °F
Maximum air temperatures	63.8 °F	71.7 °F	67.8 °F
Cumulative Precipitation in a day	1.8 inches	12.3 inches	5.5 inches
Snow depth	0 inches	41 inches	9.0 inches

Construction of the embankment is targeted for the months of November and December, when irrigation needs and flows from ryepatch are at their lowest. Although rain and snow are not anticipated during field activities, cold weather (temperatures in the 30s and 40s) is expected during construction.

2.3 Site Geologic Conditions

Geologic conditions are based on data from a total of seven test pits (TP-1 through TP-7) excavated in the vicinity of the Big 5 plug dam in April 1999 (Figure 2), field observations, and personal conversations with PCWCD personnel.

The test pits were excavated to depths ranging from 6 to 15 feet below ground surface (bgs) at the locations indicated on Figure 2 using a backhoe. The lithologic stratigraphy and saturated soil conditions were noted and summarized in Table 2. Soil and ground water conditions are described below.

Soil

The soil type was noted at each test pit. In general, the soil is a loose, silty evaporitic sand, with a high salt content. This type of soil is often referred to as "popcorn" or "sugar" soil.

Groundwater

Ground water in the Big 5 Dam area is related to the water level in the channel. Depth to ground water, measured at each of the test pits was evaluated based on moist soil conditions. Depth to ground water ranged from 4 to 10 feet bgs (Table 1). Corresponding ground water elevations ranged from 3,917.50 (questionable) to 3,924.50 feet msl. These levels correspond to a distance of 1.5 feet below to 5.5 feet above the average water level of 3,919 feet msl in the channel upstream of the dam.

2.4 Dam Structure

The Big 5 Dam is an earth and rubble plug-type diversion dam. The dam was originally constructed of borrowed native soil with a core constructed of concrete and asphalt rubble piled along the centerline of the dam gap. Additional concrete and asphalt rubble was then placed along the banks of the dam. The PCWCD has reported erosion damage to the dam on a relatively frequent basis. Subsequent repairs to

erosion have been made over the years by the PCWCD staff using concrete, asphalt rubble and borrowed native soil.

2.5 Historical Flow Data and Dam Failures

Flow information for the Big 5 Dam is based on historical flow data from Rye Patch Resevoir. Normal flows from Rye Pach Reservoir range from 200 to 600 cfs, with flows ranging from zero to 750 cfs during irrigation season (March 15 to November 15). The PCWCD has not noted any observable damage to the dam associated with normal flow conditions.

The dam has failed 6 times in the last 30 years. The most recent dam failures are listed below with the associated flow conditions noted at the Rye Patch Reservoir.

Date	Flowrate at Rye Patch Reservoir
1983	744,000 acre-ft released
1984	1,400,000 acre-ft released
1998	617,000 acre-ft released

The following estimated flows from Rye Patch Reservoir have been correlated with various levels of damage to the Big 5 Dam:

- 1,500 – 2,000 cfs – dam begins to degrade after a few days. Evidence of erosion can be seen at the bank of the dam structure.
- 3,000 cfs – Damage to the top of the dam. The base of the dam appears to withstand these flows and the river does not overflow the bank.
- 5,000 to 5,500 cfs: the banks of the river overflow and flooding occurs.
- 7,500 cfs: the banks of the river flooded.

2.6 Failure Mechanisms

Structural damage to the existing dam as a result of the erosive action of flowing water has resulted in failure of the dam 6 times in the last 30 years. The mechanism of these failures is believed to be a combination of scour, piping, and overtopping.

Scour: Scour is the erosive action of flowing water in the stream that removes and carries away material from the bed and banks. This action occurs on the upstream side of the dam where the water overtops the dam, and on the downstream side of the dam near the hydraulic jump.

Piping: Piping is the formation of channels (preferential pathways) through the dam and the banks of the channel through water erosion. The permeable materials used to construct the dam to date are incapable of preventing piping action. As the channels grow in size, soil particles are carried away by the force of

water flowing through the channels. Flow of water through the channels then increase until the force of the water results in the collapse of portions of the dam.

Overtopping/Washout: Overtopping occurs when flow in the river channel rises over the top of the dam. The cohesive strength of materials at the top of the dam is lower than that associated with materials at the bottom of the dam which are less likely to move because of the weight of the material overlain on top of them. As a result, when the water flow occurs over the dam, the surface soil particles will begin to move with the flow of water, eventually causing the top of the dam to washout.

3.0 DEVELOPMENT AND ANALYSIS OF REHABILITATION OPTIONS

This section presents a description of four options for rehabilitation of the Big 5 Dam, selection of the height of the embankment and products of construction, comparison of the four options, and selection of the preferred option. The four options for rehabilitation of the Big 5 Dam being evaluated are:

- Option 1 – Sheet Pile Wall with Scour/Erosion Protection
- Option 2 - Sheet Pile Wall with Scour/Erosion Protection (With Flow Control)
- Option 3 – Embankment Dam with Scour/Erosion Protection
- Option 4 - Embankment Dam with Scour/Erosion Protection (With Flow Control)

All four options provide concrete revetment underlain by a geotextile fabric for scour and erosion protection:

- Geotextile fabric. A geotextile fabric placed over the soil will be selected to help hold the soil of the embankment and the channels in place.

- Revetment. Concrete revetment will be placed over the geotextile to hold the soil embankment in place and prevent erosion.

Option #3 is the most basic option. The remaining options build on this basic design and add seepage protection and/or flow control capabilities:

- Seepage protection. All options will start with a compacted embankment. Options #1 and #2 will then add a sheet pile wall to minimize seepage beneath and around the embankment. The use of an impermeable wall as a component of the plug will reduce the erosive action of water through the dam that causes loss of soil particles. The result is a longer anticipated life of the dam. Because the existing plug is constructed around a debris and rubble core, one side effect of the use of the sheet pile is the need to construct a new plug from the ground up so that the sheet pile is not damaged when it is driven through the plug. Options #3 and #4 include the construction of a shallow clay plug which will help control seepage, although not to the same extent as the sheet pile wall of options #1 and #2.

- Flow control. A flow control device is provided as a component of Options #3 and #4. The flow control device selected is a K-rail wall rather than a more traditional means of flow control due to cost considerations. This wall will be used to ensure that a sufficient flow of water is provided to the Diversion Canal. Although the K-rail wall will provide sufficient flow control, an increase in the dam height can provide equivalent water retention down the diversion, avoiding the installation and maintenance difficulties inherent in the flow control structure.

3.1 Comparison Criteria

The criteria that will be used for comparison of the options are as follows:

- Ability of the option to meet all design objectives;

- Cost effectiveness of design, construction, and construction management phases of work;
- Expected longevity of each option;
- Operation and maintenance costs; and
- Opportunities for PCWCD to directly participate in construction, thereby conserving capital.

3.2 Design Basis

General assumptions and design objectives associated with rehabilitation of the Big 5 Dam are listed below. Assumptions specific to each alternative will be presented in following sections.

Assumptions:

1. The topographic map provided in Figure 2 is a relatively accurate depiction of the site conditions.
2. Construction is scheduled to occur during a 4 to 6 week window of time between the end of the irrigation season and the start of the freeze. The irrigation season ends November 15. Construction is assumed to start 2 weeks later (November 29), after the site has an opportunity to dry out. Construction must be complete within 2 to 3 weeks (December 13 to 20) in order to beat the freeze.
3. Soil conditions are poor with a tendency to erode, indicating the need to provide erosion and scour protection.
4. Local materials available for construction include soil and rubble from the existing dam as well as native soil removed from a borrow site within one mile of the job site.

   BRIDGE LOAD LIMIT WILL NOT BE A FACTOR
5. The haul route from the dam to Lovelock is approximately 13 miles. Approximately 8 miles are paved. The remaining 5 miles are unpaved, but in good condition for truck traffic. A maximum weight limits of 10 tons has been established to protect a bridge along the haul route. An alternate route that avoids the weight limitations of the bridge is available but is longer in travel distance and not in as good of condition.
6. The PCWCD has the following earth moving equipment as well as their own equipment operators. A listing of their earth moving equipment and labor is provided:
   - One (1) Track Excavator with 60' reach (60" bucket)
   - One (1) Standard Excavator (60" bucket)
   - One (1) Rubber-tired back hoe
   - One (1) 850 Blade Dozer (D6 or D7 equivalent)
   - Three (3) 10-Wheel dump trucks (10 to 12 cy capacity)
   - 4-man crew
7. Permitting and notification considerations need to be addressed. Potential regulatory agencies that may require permits, or at minimum, notification prior to initiation of rehabilitation of the dam include: U.S. Fish & Game, Nevada Department of Wildlife, and Nevada State Lands.

Design Objectives:

1. The minimum diversion flow requirement for the new dam is 750 cfs, measured at Rye Patch Reservoir.

2. The dam must be able to withstand normal flow conditions of 1,000 cfs, measured at Rye Patch Reservoir. For selection of revetment, it is assumed that a 2 to 3-ft high dam can withstand being overtopped by a 3-ft high wall of water. *

3. The dam serves as a road. The new dam will have a 15-ft wide section that will serve the same purpose. According to the PCWCD, if dual use of the plug as a road becomes a design constraint, this design objective can be dropped.

4. The PCWCD would like to improve the longevity of the dam and to reduce the amount of operational and maintenance required after the rainy season each year.

5. The PCWCD would like to utilize their equipment and labor as appropriate to reduce construction costs.

3.3 Embankment Height and Product Selection

This section will discuss selection of the height of the new embankment and selection of materials of construction for the revetment, geotextile, sheet pile and flow control structure. The existing topographic map is provided on Figure 2 and the cross-sections for each option are provided on Figures 3 and 4.

Embankment Height

The existing dam is 6 feet tall. A height of 2 feet has been selected for options provided with flow control (Options #2 and #4); and a height of 3 feet has been selected for options without flow control (Options #1 and #3). Channel calculations were conducted to evaluate the height of the dam. As noted below, however, the flows calculated do not correlate well with the PCWCD observations and historic flow measurements at Rye Patch Dam and Reservoir:

- Design Criteria: The plug must be designed to diverted 750 cfs of flow to the diversion channel and it must also be able, structurally, to withstand normal flows of 1,000 cfs from the reservoir.

- Channel calculations indicate that embankment heights of 2 feet (elevation 3,926 ft msl) and 3 feet (elevation 3,927 ft msl) will divert 3,500 cfs and 5,400 cfs of water, respectively to the Big 5 Diversion Canal. This is much greater than has been observed by the PCWCD who estimate the diverted flows at 1,000 cfs for similar heights of the current plug.

- A flow of 3,000 cfs measured at Rye Patch Reservoir results in damage to the top of the dam. A flow of 5,000 to 5,500 cfs measured at Rye Patch Reservoir results in overflow of the banks of the river and flooding.

Channel calculation uncertainties are associated with errors in the calculation associated with irregularities in the channel sides and bottom. For this reason, observations by the PCWCD personnel have been given more weight than the channel calculations.

Based on the level of the river during a normal irrigation season of 2 to 3 feet, it is believed that the height of the dam will ensure that flows diverted will meet PCWCD diversion flow requirements and that overtopping will not occur during periods of normal flow.

Revetment Selection

Three types of revetment were considered as part of this study:

- Hand-placed, pre-fabricated, interlocking concrete blocks. These pre-fabricated concrete blocks are delivered to the site on a flat bed truck and installed by hand. Each concrete block is interlocked with surrounding pieces to prevent individual pieces from moving. This type of revetment is typically used in situations where a relatively small amount of revetment is required and in areas where flows are fairly low. Heavy equipment or loads should not be driven across revetment constructed with interlocking blocks as they may break the concrete interlocks.
- Concrete Pillows. This type of revetment is constructed onsite. A custom-sewn fabric with pillows is delivered to the site, set in place, and filled with a high (9-sack) sack concrete mix. The completed product is an articulating block. This type of revetment can handle higher flow conditions than the hand-placed concrete blocks. It can handle flows similar to the medium-sized cabled concrete systems. If the concrete pillows are used, consideration will need to be given to the quality of water for mixing the grout and the time for the concrete to set at temperatures anticipated in November and December. This type of revetment offers no flexibility should settlement occur.
- CHOSEN Pre-fabricated, cabled concrete systems. Concrete blocks are cabled together in sheets. Each sheet is custom-built based on the design drawings, delivered to the site on a flat-bed truck, set in place with a crane, and anchored to adjacent sheets. This type of revetment is more stable than the hand-placed interlocking blocks or the pillows. The cabled systems are available in a variety of sizes, depending on flow conditions. This type of revetment provides some flexibility after installation.

Proposals from two vendors were reviewed. Vendors used modeling programs to select the most appropriate revetment for this application. Assumptions included a plug height of 2 to 3 feet (elevation of top surface of plug of 3930 ft msl), a worst-case flood condition of a 3-ft tall wall of water flowing over the structure, channel slopes of 2:1 to 4:1, a safety factor of 1.5 and the following calculated parameters under these conditions:

Parameter	3-ft dam	2-ft dam
Flowrate	2,120 cfs	1,350 cfs
Velocity	6.31 ft/s	6.25 ft/s

Armoflex pre-fabricated, cabled concrete revetment system by Amortec Concrete Erosion Control Systems was selected for the Big 5 Plug Dam due to its ability to handle the shear and uplift forces anticipated when flows overtop the plug. A variety of block configurations and grades of concrete are offered by Amortec. The three grades of concrete used in the Armoflex system are described below:

- Armoflex L-45: 4-3/4" thick concrete blocks.
- Armoflex L-55: 6" thick concrete blocks.
- Armoflex L-85: 9" thick concrete blocks.

The block size selected was based on revetment selected to handle these flows is Armorflex L-85 from Erosion Technology. The concrete blocks are the thickest and heaviest concrete blocks offered by the vendor.

Up to 15,500 square feet of revetment is required to cover the embankment, approximately 20 feet of the upstream channel and approximately 40 feet of the downstream channel. Once a configuration of the completed dam and channel is selected, engineering drawings of the configuration will be generated and submitted to the revetment manufacturer and the contractor. The manufacturer will custom-manufacture cabled sheets of revetment and ship them to the site. At the site, the contractor will dewater the river upstream and downstream of the plug then construct a compacted dirt embankment in accordance with the design. The sheets of revetment will be placed over the embankment per the manufacturer's instructions, anchored together, and anchored into the ground. Installation will require a crane for placement. A brochure for this product is provided in Appendix A.

Energy Dissipation System Selection

The cross-sections in Figures 3 and 4 show an area of erosion on the downstream side of the dam. This drop indicates the potential need for a means of energy dissipation at the bottom of the dam. A-Jacks energy dissipation blocks by Amortec Concrete Erosion Control Systems was selected for the Big 5 Plug Dam due to its compatibility with the Armoflex cabled system selected for the revetment. The A-Jacks units are hand-installed assemblies that can be designed into the revetment system by the manufacturer to ensure stability of the completed revetment system. A brochure for this product is provided in Appendix A.

Seepage Protection Selection

Sheet pile was selected to provide seepage protection for Options #1 and #2. The basis for sheet pile selection is based on a maximum 9-ft water head difference between the up- and downstream sides of the dam. This is based on a top of dam elevation of 3927 ft msl (3-ft high dam) and a downstream flowline elevation of 3918 ft msl. PVC sheet pile was selected over coated steel sheet pile due to its relatively low cost, higher resistance to saline conditions, and because the soil in the vicinity of the plug will not provide much upward resistance during installation. The PVC sheet pile selected is Model 500 by Materials International. Installation of the sheet pile requires a piece of equipment such as a crane, backhoe or excavator that can pick the sheet pile up. A team of laborers will guide the sheet pile into place. With the soil types found at the site, the excavator bucket may be able to push the sheets into the ground, though a vibrohammer attachment is recommended. A brochure for this product is found in Appendix A.

CHECK INTO PLASTIC SHEETPILE GOOD IDEA FOR OTHER PROJECTS.

In options #3 and #4, a clay plug select fill is included for seepage control. This plug consists of placing imported clay in a trench within the core of the dam structure. This plug will provide some level of control of the seepage through the dam, although not the level provided by the PVC sheet pile wall.

Flow Control Selection

Flow control is considered as part of Options #2 and #4. It will be used to limit the flow to the Big 5 Diversion Canal to less than 1,000 cfs so that erosion of the Diversion Channel is minimized. Traditional methods of flow control such as a gate or hinged weir structure are relatively expensive. For the Big 5 Plug, purchase and installation of a traditional structure is expected to cost at least $40,000. The method of flow control selected for Options #2 and #4 is placement of K-rail on the revetment of a 2-foot-high dam. As shown on Figures 3 and 4, the dam will be 15-feet wide. The K-rail will be set on the upstream side of the high point of the dam. The number of K-rail and spacing of the K-rail on the dam will control the amount of water diverted to the Big 5 Diversion Canal.

Operations and maintenance (O&M) associated with the use of flow controls is expected to be included in the PCWCD operating costs. Flow control O&M costs include the onsite labor and equipment costs to add or remove K-rail from the dam and is dependent on the number of times the K-rail are added and removed from the dam. K-rail would be added when additional flow is needed for irrigation; K-rail would be removed when flow to the diversion is adequate or in the event of potential flood conditions that could wash the K-rail down the River. Though it may be necessary to use a means of flow control, there are disadvantages to the use of K-rail as a means of flow control. These include:

- A shorter life span of the plug and increased failure potential is anticipated. Water flow around the K-rail will generate eddies that would be expected to loosen soil particles in the vicinity of the K-rail, resulting in slow erosion of the dam over time. Removal of the K-rail when not needed is therefore highly recommended.

- The PCWCD will need to be able to anticipate flows high enough to result in movement of the K-rail. Small movements will likely result in minor damage to the revetment in a localized area. Large movements can result in downstream damage that can be more substantial.

- The PCWCD personnel will need to adequately protect the revetment from damage by placing a 3- to 6- inch layer of soil between the revetment and the K-rail.

The cost for purchase and installation of 120 linear feet of used K-rail from a local supplier has been included in the cost. Because the PCWCD has a free supply of K-rail and will use their personnel to transport the K-rail to the site and place the K-rail on the dam, this cost can be considered a saving. The K-rail will sit on top a 3- to 6-inch layer of soil placed over the revetment. No anchors will be used to secure the K-rail to the dam

3.4 Rehabilitation Option Descriptions

A brief description of each option is provided below, followed by a brief description of O&M activities. Components included with all 4 options are listed below:

- Up to 15,500 square feet of cabled revetment. This is the amount required to cover the embankment, approximately 20 feet of the upstream channel and approximately 40 feet of the downstream channel.
- Up to 15,500 square feet of geotextile filter placed under the revetment to hold the underlying soil in place.
- A line of energy dissipation blocks will be installed at the hydraulic jump, downstream of the dam to help prevent degradation of the revetment.

A summary of each option's ability to meet the design criteria, cost, longevity of the final structure, and opportunities for participation by PCWCD in construction is provided in Table 3 and discussed briefly below. A profile of each alternative is provided in Figures 3 and 4.

Option 1 – Sheet Pile Wall with Scour/Erosion Protection (Without Flow Control)
Option 1 is a 3-ft high embankment provided with a 20-ft tall sheet pile wall for seepage protection and geotextile and revetment for scour/erosion protection.

Option 2 - Sheet Pile Wall with Scour/Erosion Protection (With Flow Control)
Option 2 is a 2-ft high embankment that has been provided with a 19-ft tall sheet pile wall for seepage protection and geotextile and revetment for scour/erosion protection, and a K-rail wall for flow control.

Option 3 – Embankment Dam with Scour/Erosion Protection (Without Flow Control)
Option 3 is a 3-ft high embankment with geotextile and revetment for scour/erosion control. No provisions are made for seepage protection or flow control.

Option 4 - Embankment Dam with Scour/Erosion Protection (With Flow Control)
Option 4 is a 2-ft high embankment dam with geotextile and revetment for scour/erosion protection and a K-rail wall for flow control.

Operations and Maintenance
There is only one operation and maintenance requirement associated with the four options: the revetment for all four options will need to be covered with a minimum of 3 inches of soil to prevent ultraviolet degradation of the geotextile. Use of the plug as a road for heavy equipment with tracks should be minimized. If the PCWCD plans to drive track equipment over the plug, however, a minimum of 6 inches of soil placed over the revetment will help protect the concrete from damage from the tracks.

For the two flow control options (Options #2 and #4), additional O&M is required to place the K-rail on the dam and remove it a minimum of one time per year.

Cost Estimate

The cost estimate for the four options is provided in Appendix B. Costs are summarized below.

Options	Capital Costs	Annual O&M Costs
Option #1	$394,100	$1,500
Option #2	$389,400	$4,700
Option #3	$285,900	$1,500
Option #4	$289,200	$4,700

The capital costs are higher than was estimated as part of the rough cost estimate submitted to the PCWCD in July 1999. The primary reason for the discrepancy is the selection of a more robust grade of revetment. The use of the more robust grade of revetment increases the price for purchase, installation and transportation. These costs can be reduced by using a less robust product by relaxing the criteria of 3 feet of water overtopping the dam and/or by relaxing the manufacturer's recommended safety factor of 1.5.

Comparison of Options

As shown in Table 3, in general, the more design criteria that are met, the higher the cost for construction. Options #3 and #4 are the least expensive options, but also the least reliable. Although budget constraints make Options #3 and #4 the only viable option for the PCWCD at this time, it is believed that use of a solid core (Options #1 and #2) will greatly increase the reliability and longevity of the final product. In the interest of economics, however, Options #1 and #2 are removed from further consideration at this time.

Option #3, the most basic option, provides the geotextile filter and the revetment to protect the channel and the dam from erosion/scour. Option #4 has the advantage of providing flow control capabilities to address downstream aesthetics. Longevity of Option #3 is approximately 10 years, assuming the absence of a storm that floods the banks of the river. Option #4 has a slightly shorter anticipated longevity because the use of the K-rail as a means of flow control is expected to cause some disruption of the embankment, but it too will increase longevity of the plug over that of the current structure.

A comparison of Options #3 and #4 are provided in Table 4. The most important criteria to the PCWCD when evaluating these two options side by side are the longevity of the structure, flow control and the cost:

- Longevity: In general, Option #3 is expected to have the greater longevity and reliability due to the presence of the flow control devices that would cause some degradation of the dam structure over time.

- Flow Control: Option #4 has the advantage over Option #3 by providing flow control as part of the option.

- Cost: Option #3 is the less expensive alternative because of the cost associated with the placement and removal of the K-rail.

Using the criteria listed in Table 4, Option #3, the basic structure without flow control is the preferred option.

Selected Alternative

As discussed above and shown in the matrix in Table 3, the preferred alternative is Option 3, the Scour/Erosion Protection (Without Flow Control) option. This is the most basic structure alternative provided. This alternative will provide scour and erosion protection to improve the longevity of the dam.

It is noted that cost savings can be realized by the PCWCD if the contractor selected for the project is willing to coordinate their services with those of the PCWCD personnel. PCWCD activities may include soil moving activities such as those associated with demolition and rebuilding of the plug, dewatering activities, transport of borrowed soil to the site for reuse, and transport of unneeded materials away from the site. Some of the contractors contacted were willing to work with PCWCD labor and equipment to realize cost savings. The cost savings will depend on the amount of work that each particular contractor would be willing to have PCWCD conduct. In order for this to occur, additional information regarding personnel capabilities will need to be provided to the contractor when they provide a competitive bid.

4.0 CONCLUSION

Based on the alternative analysis conducted in Section 3.0, the selected option for rehabilitation of the dam structure is placement of erosion/scour protection (option 3). No seepage controls or flow control units will be installed.

TABLE 1
Test Pit Soil and Ground Water Data
Big 5 Dam Rehabilitation Feasibility Study
Pershing County Water Conservation District
Pershing County, Nevada

Test Pit Number	Ground Elevation (ft msl)[a]	Depth to GW (ft bgs)	GW Elevation (ft msl)	Total Depth of Test Pit (ft bgs)	Soil Description	Sample Description	Notes
TP-1	3,930.0	10	3,920.0	15	0-2 ft bgs: Light Brown silty fine sand, alkaline, loose. 2 - 10 ft bgs: Greenish gray silty fine samd, damp, v. loose with lenses of silt and fine sand. 10-15 ft bgs: Gray clayey silt, soft, wet, some root gragments and some black organic pockets.	2 samples collected: 1) composite bucket sample of the 2-10 ft material and 2) baggie sample of the material found at 10 to 12 ft bgs.	Caving starting ~9 ft bgs. Weeds and sage at surface. Base of root zone @ 2 ft bgs
TP-2	3,931.0	8	3,923.0	14	0 to 1 ft bgs: asphalt fill. 1 to 14 ft bgs: Greenish gray silty fine sand, v. loose, damp.	2 samples collected: 1) Tube sample collected at 32 in.bgs and 2) Tube sample collected at 36 in. bgs.	Caving ~9 ft bgs.
TP-3	3,931.0	9	3,922.0	13	Greenish gray, silty fine sand, damp to moist, v. loose, some sandy and silty lenses.	Composite bucket sample collected of the 3 to 7-ft bgs area.	Caving ~8 ft bgs. Root zone to ~6 ft bgs
TP-4	3,925.5	8	3,917.5	10	Greenish gray silty fine sand, v. loose, damp to moist, with some sandier and siltier lenses. Possibly siltier at the base (10 ft bgs).	No sample collected.	Caving. Weeds and sage at ground surface.
TP-5	3,931.0	8	3,923.0	11	0 to 2.5 ft bgs: fill, concrete, asphalt, silty sand. 2.5 to 11 ft bgs: greenish gray silty fine sand (much less silt than in other pits), damp to moist, v. loose. More lenses of sand, less lenses of silt.	No sample collected.	Caving ~7 ft bgs.
TP-6	3,926.5	4	3,922.5	6	Greenish gray silty finesand with gray silt lenses, v. loose. Operator says this is fill material from washouts over the last 2 years.	No sample collected.	Caving @ 2 ft bgs. Fill material from washouts.
TP-7	3,928.5	4	3,924.5	6	0 to 4: Greenish gray, silt with some fine sand, salt, moist. 4 to 6: fine sand with little silt, greenish gray, v. loose, wet.	2 sleeve samples and 1 baggies sample @ 3 ft bgs.	Caving ~ 6 ft bgs.

a: Estimated, based on the topographic map, Figure 2.
Note: average water level is 3919 ft msl.
Note: all data collected during site visit on April 16, 1999.
ft msl: feet above mean sea level
ft bgs: feet below ground surface.
GW: ground water

TABLE 2
Annual Peak Discharge Rates Above 1,000 cfs at Rye Patch Dam
Big 5 Dam Rehabilitation Feasibility Study
Pershing County Water Conservation District
Pershing County, Nevada

Date	Annual Peak Discharge Rate (cfs)	Qualification Code
July 10, 1896	1,510	5
May 12, 1987	3,050	5
March 17, 1901	2,620	5
June 6, 1906	1,010	5
May 4, 1907	2,220	5
July 8, 1912	1,240	5
July 23, 1913	1,270	5
May 2, 1914	2,000	1,5
June 7, 1917	1,910	5
May 29, 1919	1,280	5
July 2, 1921	1,980	5
May 27, 1922	2,280	5
June 19, 1945	2,000	6
April 29, 1946	1,730	6
May 11, 1952	4,720	6
May 25, 1967	1,120	6
May 20, 1969	1,110	6
June 6, 1971	2,020	6
April 12, 1972	1,060	6
June 8, 1975	1,700	6
June 25, 1980	1,380	6
June 16, 1983	3,940	6
May 28, 1984	7,960	6,7
March 29, 1985	1,190	6
May 28, 1986	7,960	6
July 21, 1995	1,200	6
June 11, 1996	1,180	6
July 4, 1997	1,410	6
June 9, 1998	2,400	6

Peak Discharge Qualification Codes:

1 = Discharge is a maximum daily average.
5 = Discharge affected to an unknown degree by regulation or diversion.
6 = Discharge affected by regulation or diversion
7 = Discharge is an historic peak.

Reference: U.S. Gological Survey website (http://waterdata.usgs.gov/nwis-w/NV

All data collected at the Humboldt River Station Near Rye Patch, Nevada (Station No. 103355000)

TABLE 3
Alternative Comparison
Big 5 Dam Rehabilitation
Pershing County, Nevada

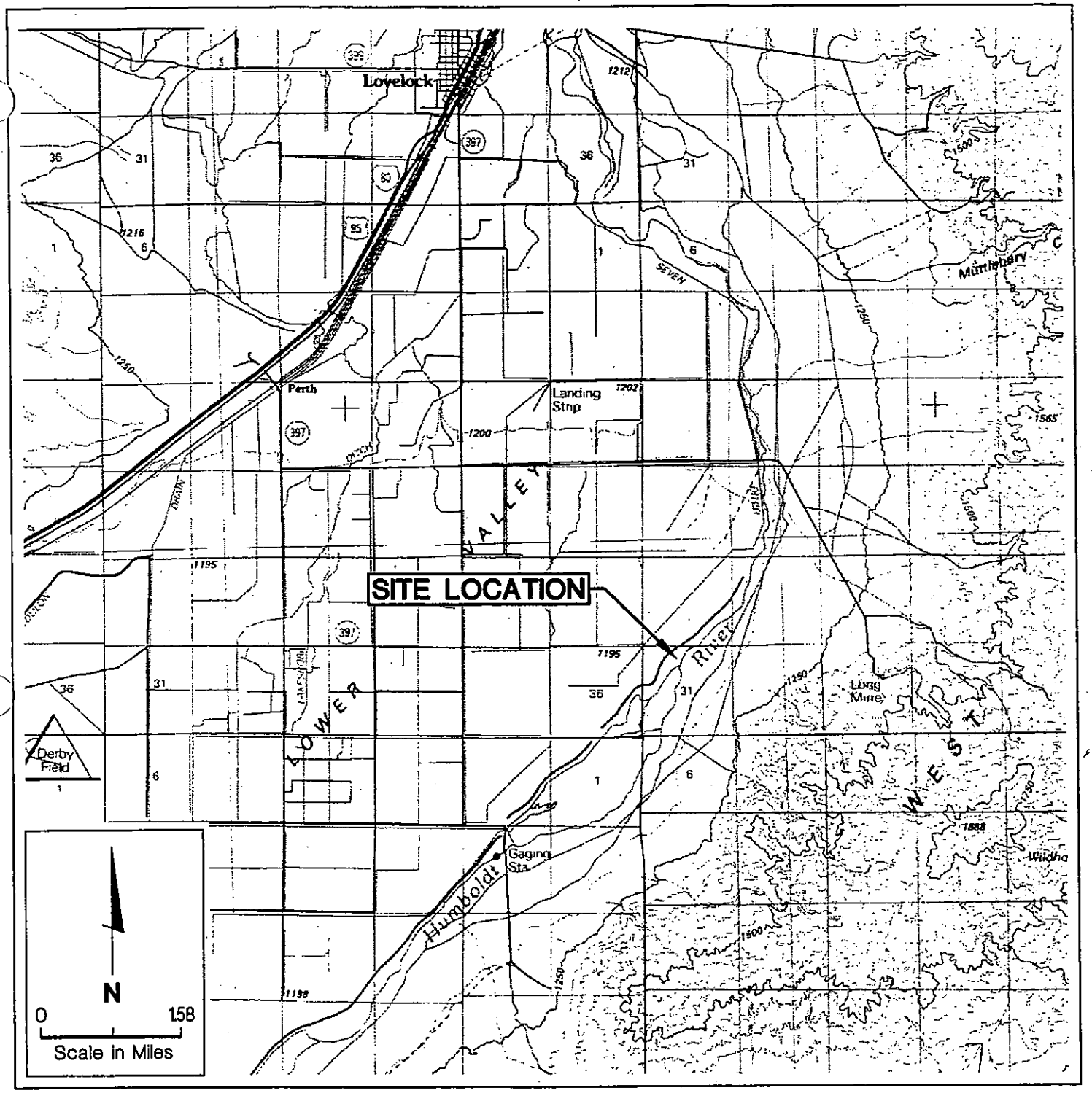
CRITERIA	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Flow Criteria	X	X	X	X
Continued Use of Dam as a Road	X	X	X	X
Improved Longevity of the Dam	X	X	X	X
Erosion/scour Protection	X	X	X	X
Seepage Protection	X	X		
Flow Control		X		X
PCWCD Assistance Opportunities	X	X	X	X
Capital Cost	$378,000	$370,100	$268,300	$268,300
Operations & Maintenance Cost	$1,500	$4,700	$1,500	$4,700

TABLE 4
Alternative Selection Matrix
Big 5 Dam Rehabilitation
Pershing County, Nevada

CRITERIA	OPTION 3	OPTION 4
Flow Criteria	4	4
Continued Use of Dam as a Road	4	2
Improved Longevity of the Dam	2	1
Erosion/scour Protection	4	4
Seepage Protection	1	1
Flow Control	0	4
PCWCD Assistance Opportunities	2	2
Capital Cost	4	4
Operations & Maintenance Cost	4	2
Total Score	51	43

Rating of 0 to 4 is given for each option in each category. A rating of 4 indicates the most preferred option. A rating of 1 indicates the least preferred option. A rating of zero indicates that the option does not meet the criteria.

The cost ranking is given a weight factor of 4.
The longevity is given a weight factor of 2.
All other criteria are given a weight factor of 1.



REFERENCE: USGS Lovelock NEVADA; 40118-A1-TM-100
Photorevised 1984

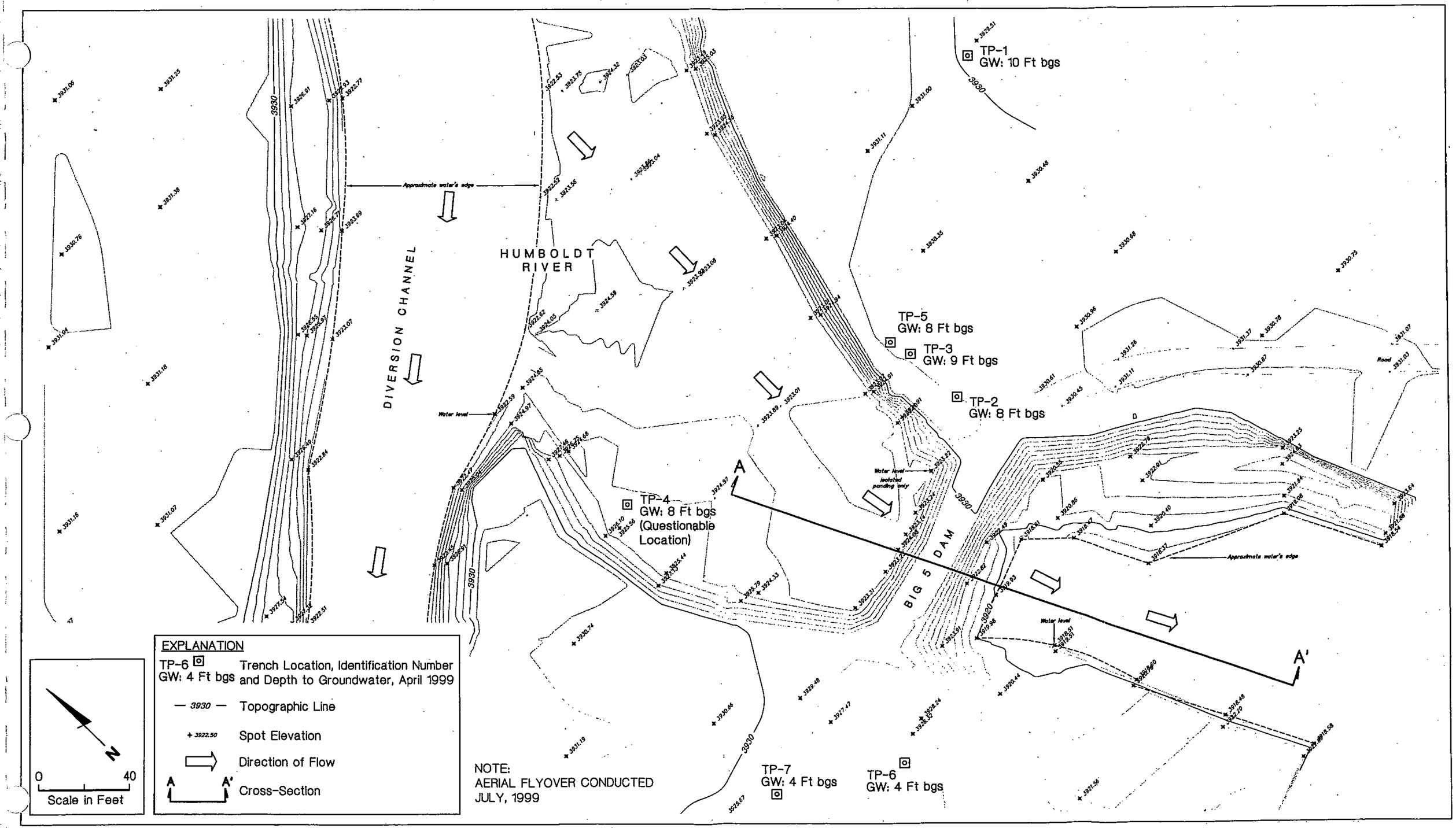
URS

SITE VICINITY MAP

Rehabilitation Feasibility Study
Big Five Dam
Pershing County, Nevada

Big5Dam lea Jan 23, 2001 010121SVM.DWG

FIGURE 1



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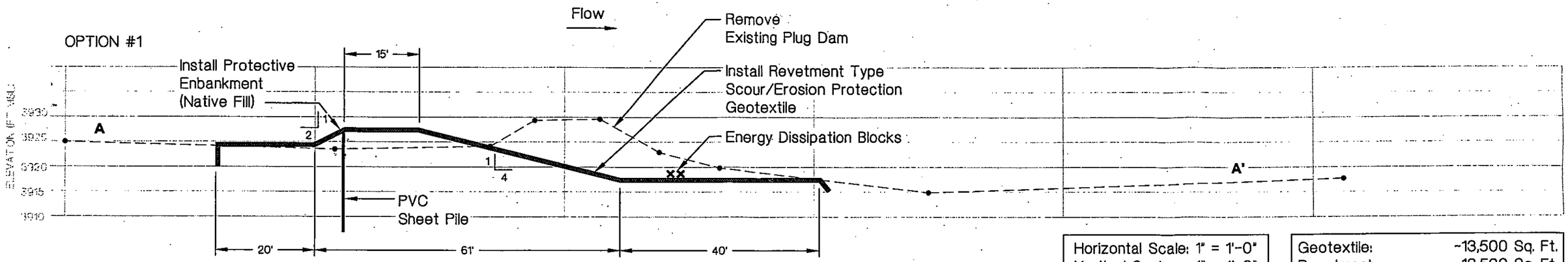
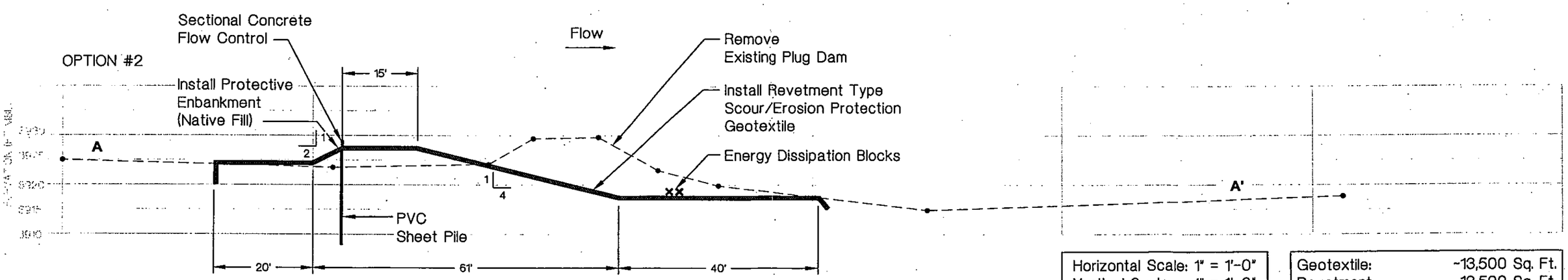
TOPOGRAPHIC MAP
Rehabilitation Feasibility Study
Big Five Dam
Pershing County, Nevada



Horizontal Scale:	1" = 1'-0"
Vertical Scale:	1" = 1'-0"

Geotextile:	~13,500 Sq. Ft.
Revetment:	~13,500 Sq. Ft.
Sheet Pile:	200 LF x 20' Tall



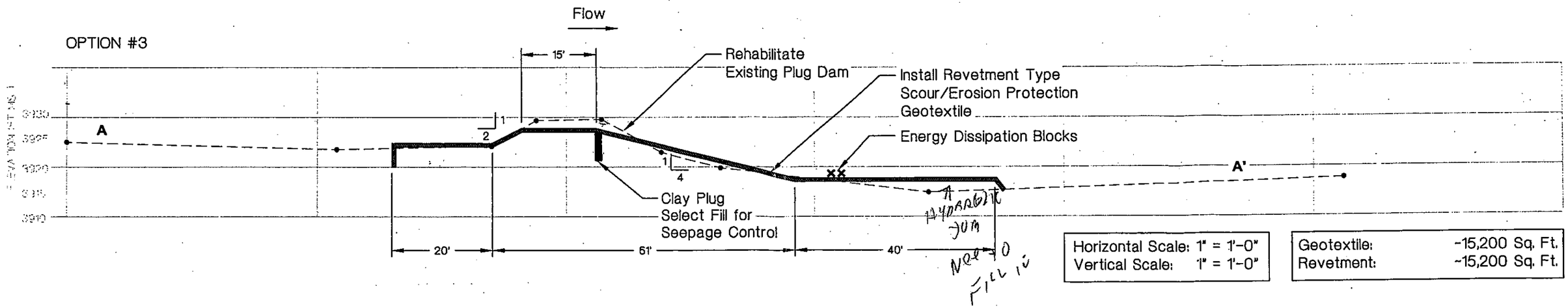
Horizontal Scale:	1" = 1'-0"
Vertical Scale:	1" = 1'-0"

Geotextile:	~13,500 Sq. Ft.
Revetment:	~13,500 Sq. Ft.
Sheet Pile:	200 LF x 19' Tall
Sectional Concrete:	K-RAIL ~135 LF

URS

CROSS SECTION SCHEMATIC
OPTION 1 AND 2
Rehabilitation Feasibility Stu
Big Five Da
Pershing County, Nevad

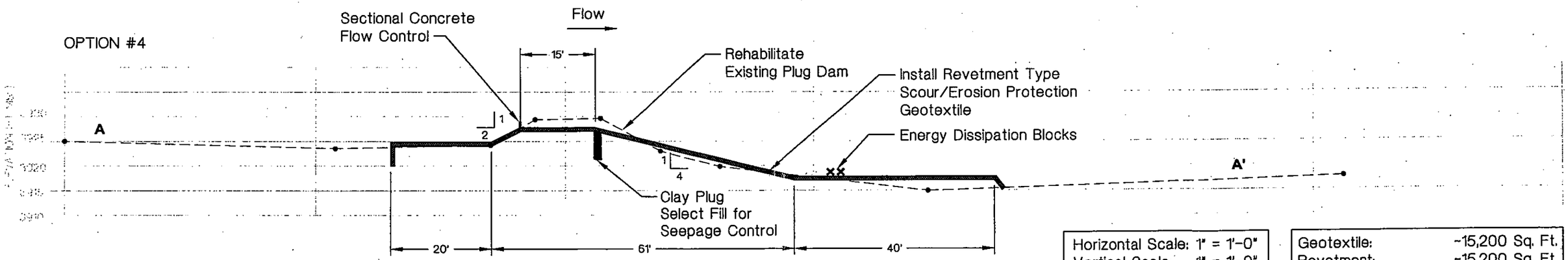
OPTION #3



Horizontal Scale:	1" = 1'-0"
Vertical Scale:	1" = 1'-0"

Geotextile:	~15,200 Sq. Ft.
Revetment:	~15,200 Sq. Ft.

OPTION #4



Horizontal Scale:	1" = 1'-0"
Vertical Scale:	1" = 1'-0"

Geotextile:	~15,200 Sq. Ft.
Revetment:	~15,200 Sq. Ft.
Sectional Concrete:	K-RAIL ~135 LF

CROSS SECTION SCHEMATIC
OPTION 3 AND 4

Rehabilitation Feasibility Study
Big Five Dam
Pershing County, Nevada

URS

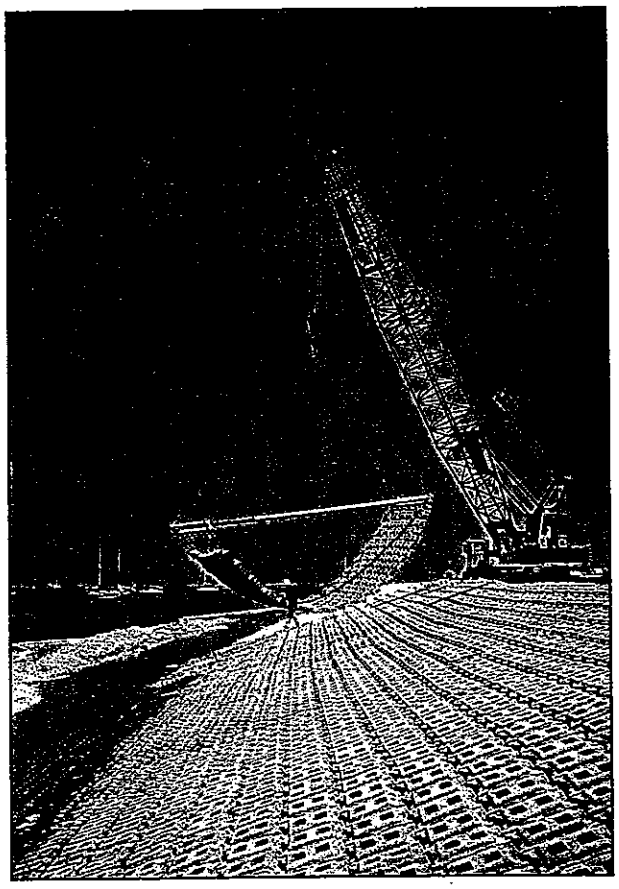
APPENDIX A

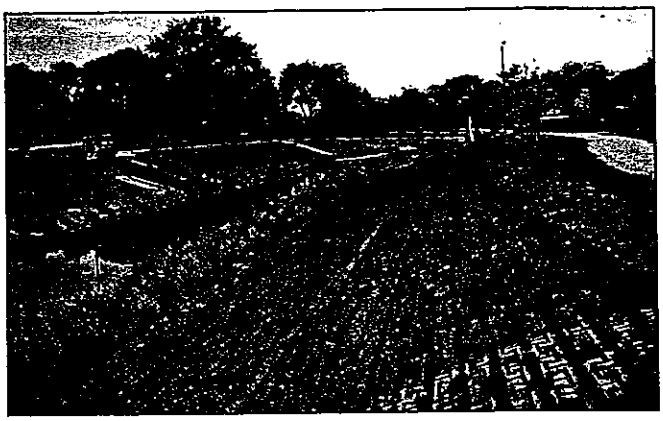
PRODUCT BROCHURES
FOR SELECTED MATERIALS OF CONSTRUCTION

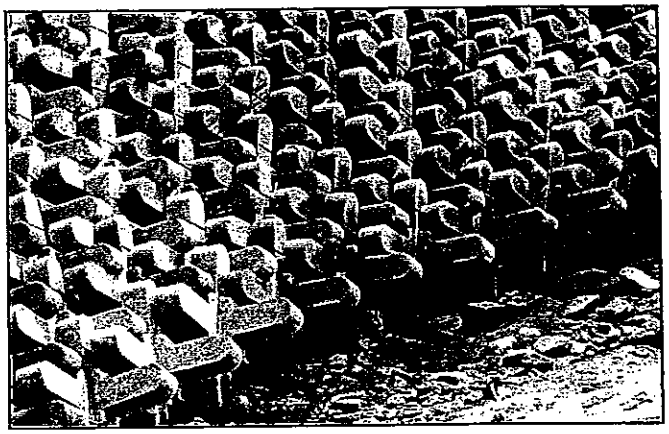
ARMORTEC

Concrete Erosion Control Systems

SECURING THE ENVIRONMENT







SOLUTIONS FOR:

- Flood Channel and Culvert Lining
- Riverbank and Lake Shoreline Protection
- Boat Ramps and Access Roads
- Levee Installations
- Water Treatment Facilities
- Coastal and Wave Applications
- Dam Overtopping Protection
- Spillways and Retention Basins
- Pipeline and Cable Protection
- Energy Dissipation

Providing Erosion Control Solutions and Professional Support for more than 15 years

ARMORFLEX®

ARTICULATED CONCRETE MATS

Armorflex blocks are cabled together longitudinally with polyester, galvanized steel or stainless steel cables. This provides ease of handling and installation, as well as an increased factor of safety.

Mats are installed over a geotextile filter on a prepared subgrade using conventional construction equipment.

Armorflex is offered in several block classes varying in thickness from 4.75" to 9" and is available in open or closed-cell blocks.

Armorflex open-cell mats can be revegetated to provide an environmentally attractive alternative to traditional concrete or rip-rap. Open-cell mats may also be backfilled with stones or other material.

Applications

Channel Lining

Shoreline Protection

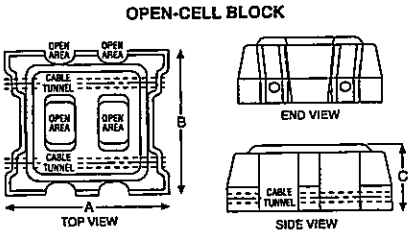
Boat Ramps and Access Roads

Dam Overtopping Protection

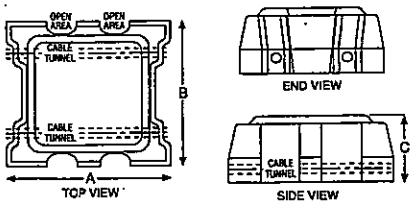
Pipeline and Cable Protection

Bridge Abutment Protection

OPEN-CELL BLOCK



CLOSED-CELL BLOCK



Armorflex Block Specifications (Typical Values)

Concrete Block Class		Specific Weight lbs./cu. ft.	Compressive Strength lbs./sq. in.	Maximum Absorption	Nominal Dimensions In.			Gross Area/ Block sq. ft.	Block Weight**		Open Area %
					A	B	C		lbs.	lbs./sq. ft.	
S-Class Open Cell	30S	130-150	4000	12 lbs./cu. ft.	13.0	11.6	4.75	0.98	31-36	32-37	20
	50S	130-150	4000	12 lbs./cu. ft.	13.0	11.6	6.0	0.98	45-52	45-53	20
S-Class Closed Cell	45S	130-150	4000	12 lbs./cu. ft.	13.0	11.6	4.75	0.98	39-45	40-45	10
	55S	130-150	4000	12 lbs./cu. ft.	13.0	11.6	6.0	0.98	53-61	54-62	10
Open Cell	40	130-150	4000	12 lbs./cu. ft.	17.4	15.5	4.75	1.77	62-71	35-40	20
	50	130-150	4000	12 lbs./cu. ft.	17.4	15.5	6.0	1.77	81-94	46-53	20
	60	130-150	4000	12 lbs./cu. ft.	17.4	15.5	7.5	1.77	99-113	56-64	20
	70	130-150	4000	12 lbs./cu. ft.	17.4	15.5	9.0*	1.77	120-138	68-78	20
Closed Cell	45	130-150	4000	12 lbs./cu. ft.	17.4	15.5	4.75	1.77	78-89	43-50	10
	55	130-150	4000	12 lbs./cu. ft.	17.4	15.5	6.0	1.77	94-108	53-61	10
	75	130-150	4000	12 lbs./cu. ft.	17.4	15.5	7.5	1.77	120-138	68-78	10
	85	130-150	4000	12 lbs./cu. ft.	17.4	15.5	9.0*	1.77	145-167	82-95	10

** Block height may vary by approximately 0.5" based on local manufacturer's capabilities.*
*** Block weight may vary by 2% based on the specific gravity of locally available aggregate material.*

A-JACKS®

CONCRETE ARMOR UNITS

A-Jacks armor units may be assembled into a continuous, flexible matrix which provides protection against high-velocity flow.

The matrix of A-Jacks units can be backfilled with topsoil and vegetated to increase the stability of the system and provide a habitat for fish and wildlife. The patented, two-component design allows for economical transport and on-site assembly.

Applications

Shoreline Stabilization

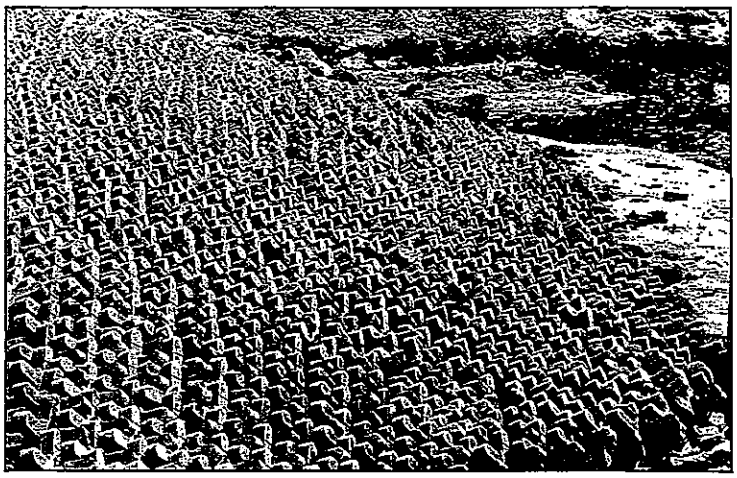
Stream and Riverbank Restoration

Protection of Coastal Structures

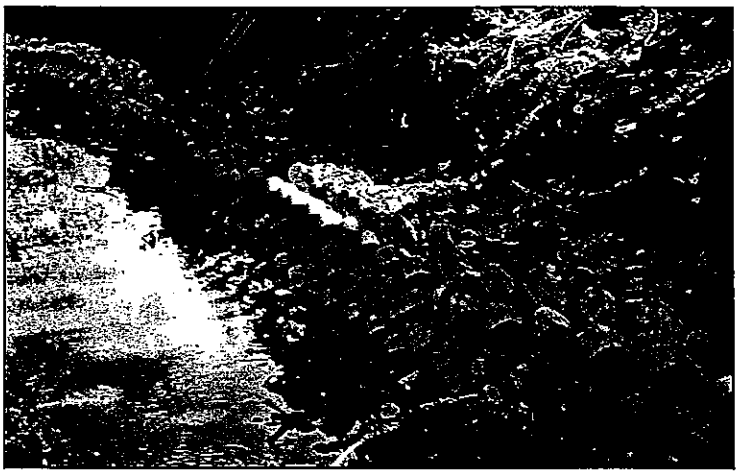
Energy Dissipation

Bridge Scour Protection

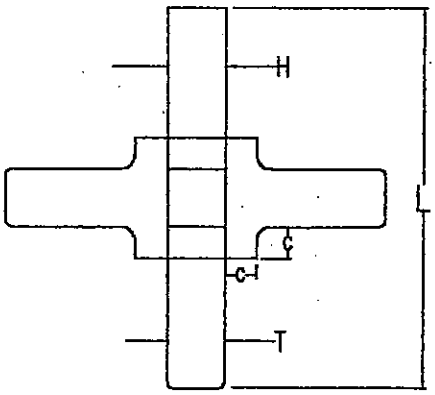
Habitat Creation



A matrix of A-Jacks units stabilizes shorelines and other areas subject to waves or high-velocity flow.



A-Jacks used for streambank restoration provide permanent protection and stabilization at the base of eroding banks.



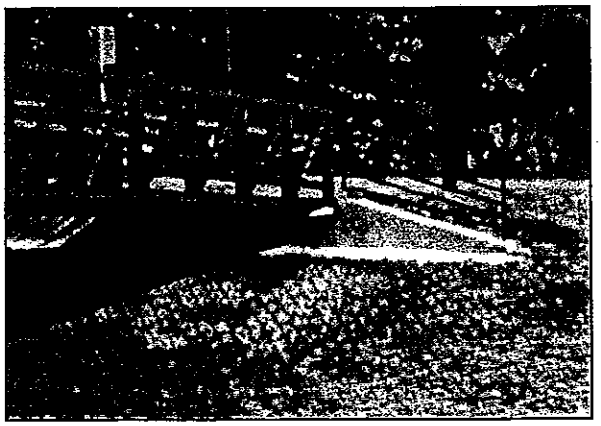
A-Jacks	L(in)	T(in)/H(in)	C(in)	Vol(ft³)	Wt(lbs)
AJ-24	24	3.68	1.84	0.56	78
AJ-36	36	5.52	2.76	1.89	265
AJ-48	48	7.36	3.68	4.49	629
AJ-72	72	11.04	5.52	15.14	2,120
AJ-96	96	14.72	7.36	35.87	5,022

ARMORLOC®

INTERLOCKING CONCRETE BLOCKS

Armorloc blocks are hand placed over a site-specific geotextile.

Armorloc can be revegetated to provide attractive hard armor erosion control.



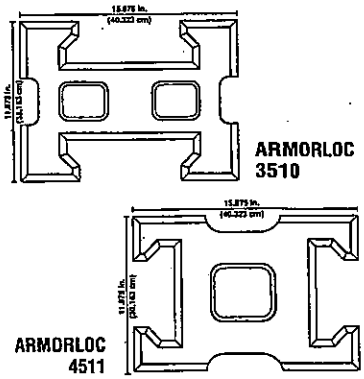
The interlocking design of Armorloc keys each block into four adjacent blocks to hold it firmly in place and resist lateral movement. This system is able to withstand the erosive forces of waves and stream flow in light to moderate conditions.

Benefits

- Easily installed in hard-to-reach areas
- No heavy equipment or skilled labor is required for installation
- Cost-effective
- Ideal for revegetation
- Interlocking blocks conform to ground contours

ARMORLOC Block Specifications

	TECHNICAL DATA			DIMENSIONS AND WEIGHTS				
Block	Specific Weight lbs/ft³	Compressive Strength psi	Max. Absorption, Avg. of 3 Units 10 lbs/ft³	Thickness Inches	Gross Area/ Grid ft²	Weight/ Grid lbs	Weight/ Area lbs/ft²	Open Area %
3510	130-150	4000 min.	10	4	1.0	30-35	30-35	25
4511	130-150	4000 min.	10	5.25	1.1	44-50	40-45	20



ARMORTEC
Concrete Erosion Control Systems

P.O. Box 20308 Bowling Green KY 42102
800-305-0523 FAX 270-783-8952
www.armortec.com

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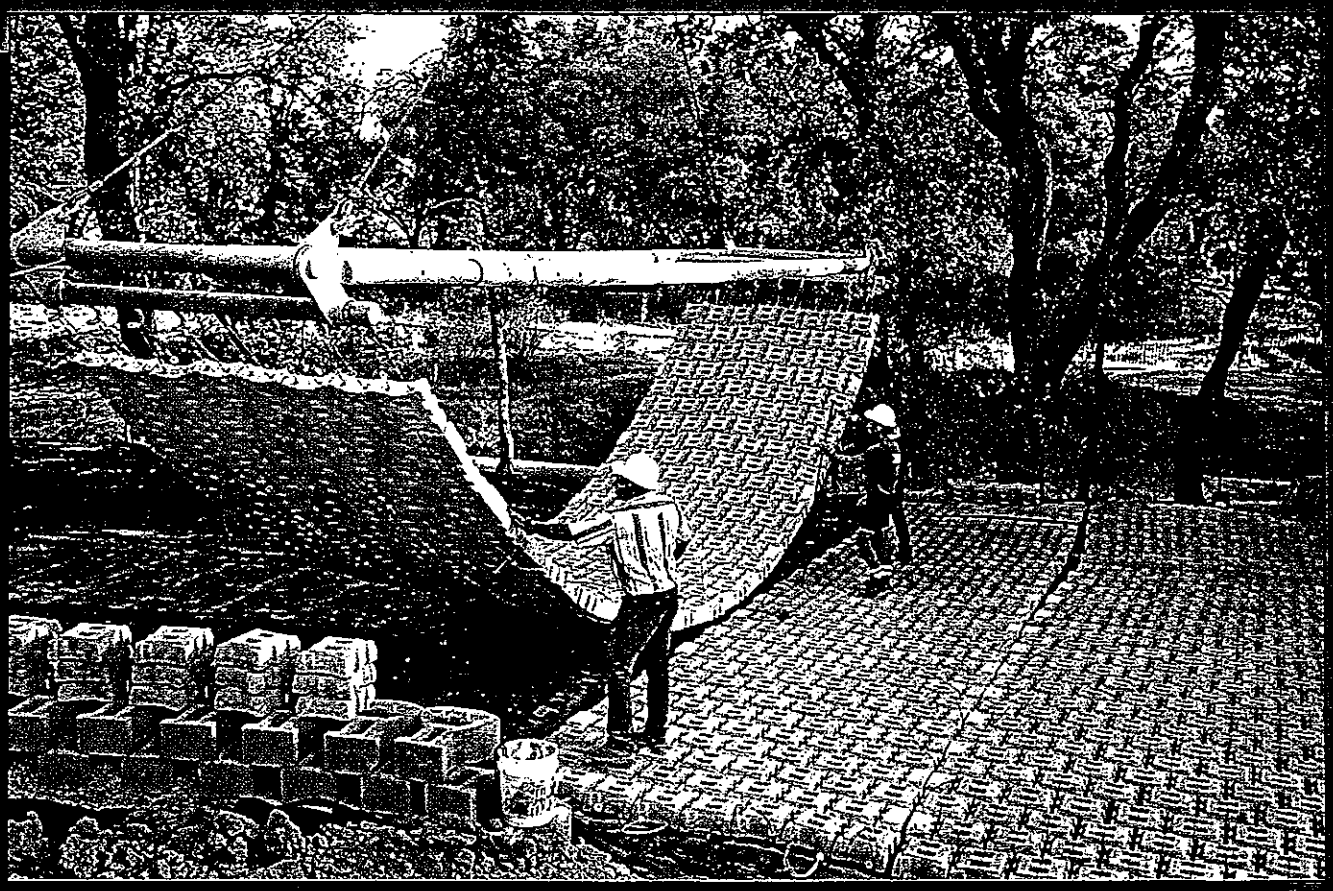
CB&E California Builder & Engineer
ACP Associated Construction Publications
Construction news coverage of California, western Arizona, western Nevada and Hawaii
January 16, 1995 $3.00

FLOOD PROTECTION



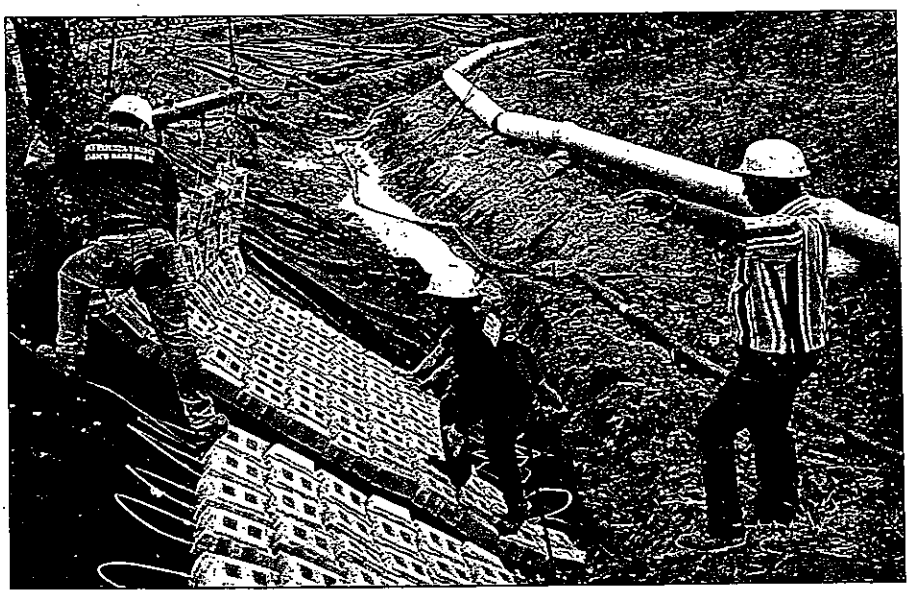
Key to Road Realignment

CMG CONSTRUCTION MAGAZINE GROUP, INC.

FLOOD PROTECTION

Key to Road Realignment

Concrete Block Mats Prevent Flood Waters From Undermining Base of Retaining Wall



The Armorflex mats were custom-made to conform to the different lengths of the slope and to fit around the bases of trees. This mat is being placed using a special spreader bar that allows the mat to hang vertically.

When the City of Roseville, Calif. decided to realign Old Auburn Road to remove a hairpin turn, the project involved the banking of the roadway at a spot where it brushed against the edge of Linda Creek. The roadway has had this dangerous hairpin turn since 1986, when it was realigned after a flood washed out the bridge.

American Engineering and Asphalt Co., Sacramento, Calif., won the $1 million contract to realign the roadway in June of last year. The job called for importing 15,000 cu. yds. of fill from a nearby city-owned lot to add a super, or banked asphalt roadway, and backfilling a new retaining wall, which was to be constructed to contain the fill. The 12- to 14-ft.-high, 140-ft.-long keystone wall was also designed to protect the fill against a potential 100-year flood. The wall was to be built on a one-foot by four-foot compacted aggregate base leveling course.

In order to prevent the creek from undermining the retaining wall, Sacramento-based consulting engineer Dames and Moore called for the installation of Armorflex mats constructed of open-cell concrete blocks laced together with galvanized multi-strand steel aircraft cables. This method has been used successfully at other locations in Roseville.

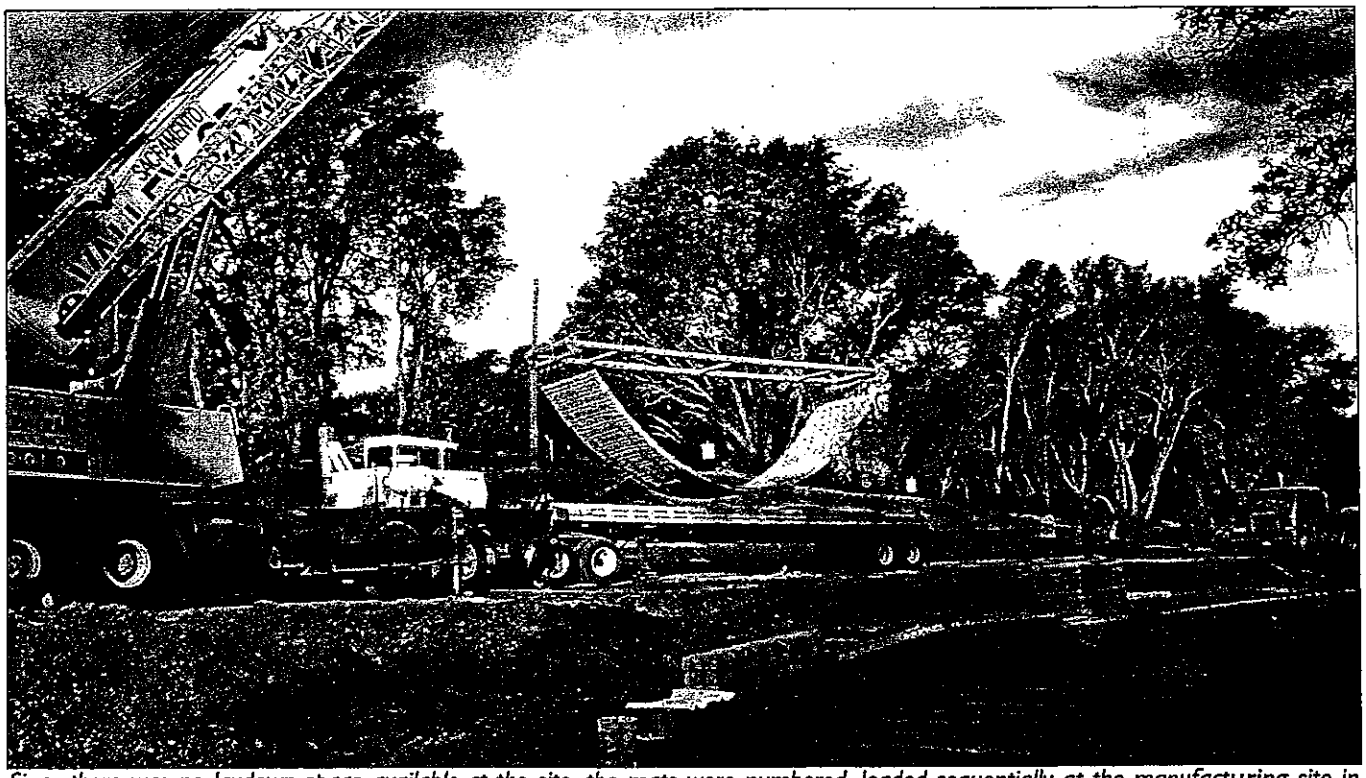
Since the contract allowed only 35 days to complete the work once the road was closed, American Engineering devised a way to complete as much as possible prior to closing the road. This work entailed stripping vegetation from slope and some grading of the creek bank. A woven filter fabric was placed on the bank where the Armorflex was to be installed. The fabric, Mirafi 70/20, is specially designed for use under the mats and allows the roots from plants to penetrate the mesh to reach deeper into the soil.

A sandbag dam was created to control the flow of the creek during the project. The water behind the dam was diverted into a 300-ft.-long, 16-in.-diameter pipeline that carried it by gravity flow through the site.

Much of the extensive storm drain system for the new roadway, consisting of over 1,500 feet of pipe with diameters ranging from 12 inches to 30 inches, was installed before the old road was closed. The contractor chose to put in the drain system as the fill was being placed to avoid trenching through the fill after it was brought up to sub-grade.

Once the roadway was closed, American Engineering removed the old pavement using a pulverizing machine. Paddlewheel scrapers were used to pick up the grindings, which were mixed in with the imported fill to build up the new banked roadway. At the same time, a trench was exca-

Sixty-one panels of Armorflex, covering roughly 10,000 sq. ft. of surface area, will prevent flood waters from undermining the retaining wall. The standard-sized mat was eight feet wide by 27 feet long and weighed 8,000 lbs.



Since there was no laydown space available at the site, the mats were numbered, loaded sequentially at the manufacturing site in Southern California, and delivered in order of their use. A Link-Belt crane lifted them off the trailer and placed them into position.

vated for the footing of the retaining wall. The precast Basalite interlocking decorative keystones were placed by hand to create the retaining wall.

The fill material was hauled from the borrow site by bottom dumps and delivered to the fill area, where it was spread out, sprayed with water and compacted by a sheepsfoot compactor to 95 percent. Geogrid mesh panels were attached to the back of the retaining wall each time the fill rose approximately three feet vertically. These panels extended back into the fill and anchored the soil to the wall. Crushed rock was used to fill the voids in and behind the keystone blocks.

When the retaining wall was four feet tall, the installation of the Armorflex began. Earth anchors similar to expansion bolts were installed in front of the retaining wall to provide an anchor point for the top of the mats. Since there was no laydown space available at the site, the mats were numbered, loaded sequentially at the manufacturing site in Southern California, and delivered in order of their use. An 80-ton FMC hydraulic crane supplied by Sacramento Valley Crane was used to lift the mats off the trailers and place them on the slope. The seemingly over-capacity crane was needed because the only place the crane could be positioned was on the road, thus requiring a significant reach to position the mats.

The trucks brought the Armorflex to a spot on the roadway, a spreader bar was attached to the mats, and they were quickly placed in position. Sixty-one panels of Armorflex, covering roughly 10,000 sq. ft. of surface area, were used to protect the slope, which varied from 25-to-1 to 2-to-1. While the standard-sized mat used in this project was eight feet wide and 27 feet long and weighed 8,000 lbs., many of the mats were smaller and custom-designed to surround the trunks of oak trees.

Because of the presence of the oak trees, the steep slopes in some areas and the narrow creek bed, American Engineering made their own spreader bar to place the mats. Normally the spreader bar holds the top and bottom of the mat like a big swing as it is hoisted. The custom spreader bar held only the top end, allowing the mat to hang vertically. Workers helped position the mat as it was lowered into place. The custom spreader bar also allowed the mats to be lowered through the canopy of the oak trees for placement around the bases of their trunks.

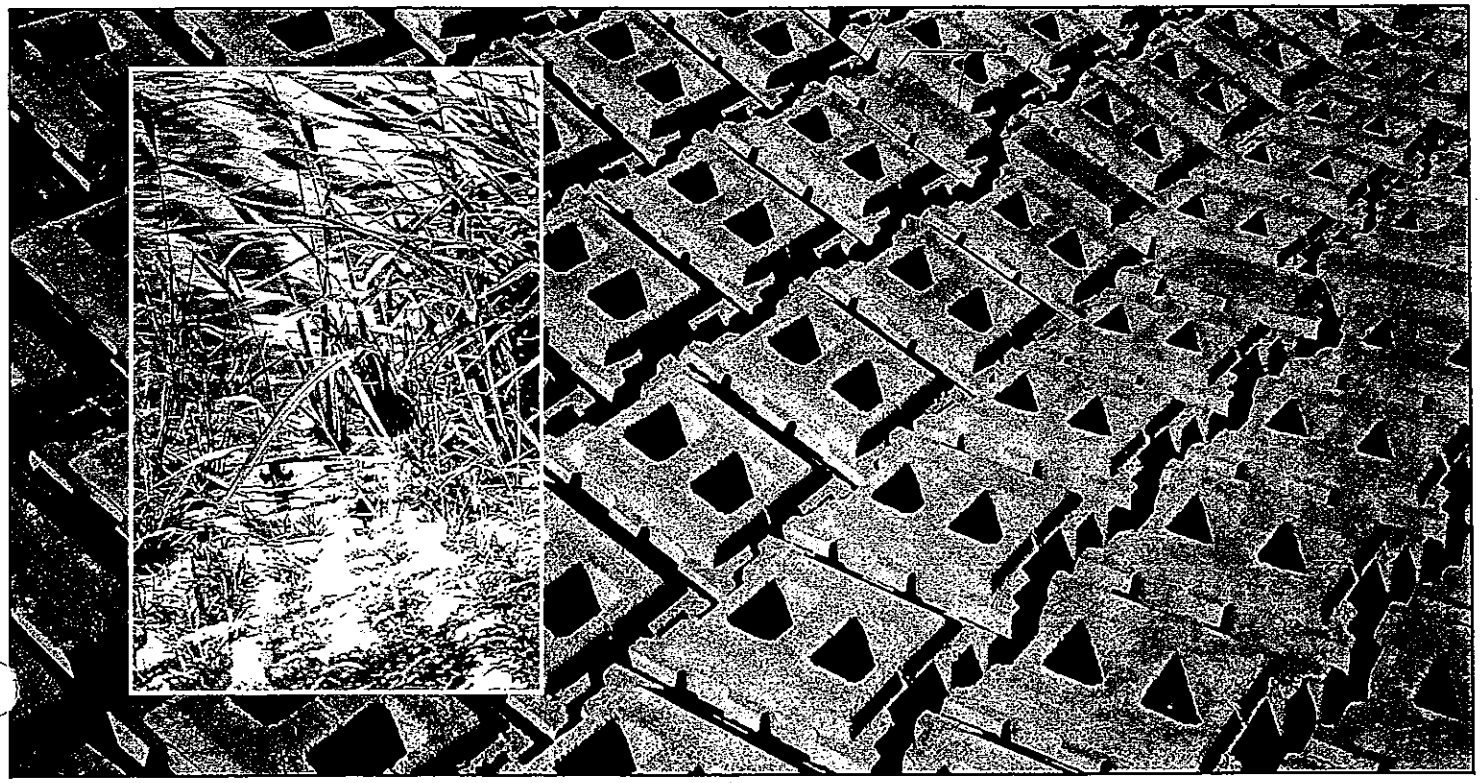
After the mats were placed on the slope, adjacent mats were laced together with steel cable. A concrete band was poured to fill the gap between the top of the Armorflex mats and the face of the retaining wall. A skid steer loader was used to dump soil on the mat, and laborers worked the soil into the open cells of the concrete block mat. The surface was then hydroseeded to re-vegetate the slope.

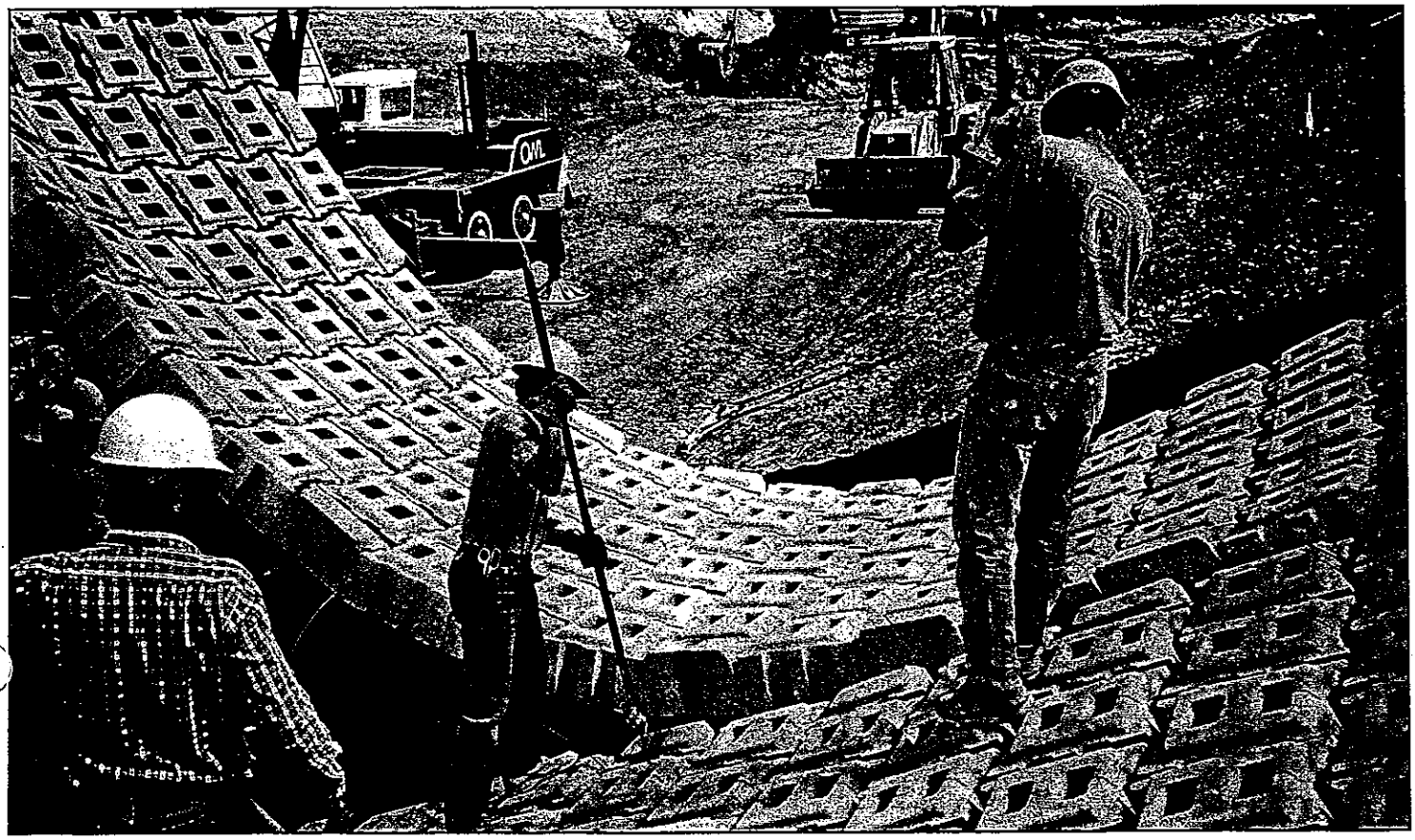
The cross section of the roadway consisted of 18 inches of aggregate base topped by five inches of asphaltic concrete. Roughly 11,200 tons of base material was used, along with 2,500 tons of asphaltic concrete, which American Engineering and Asphalt placed using a Blaw-Knox PF180H paver.

L-659"

ARMORFLEX®

Armortec, Erosion Control Products
3260 Pointe Parkway, Suite 200, Norcross, GA 30092, (770) 409-9002





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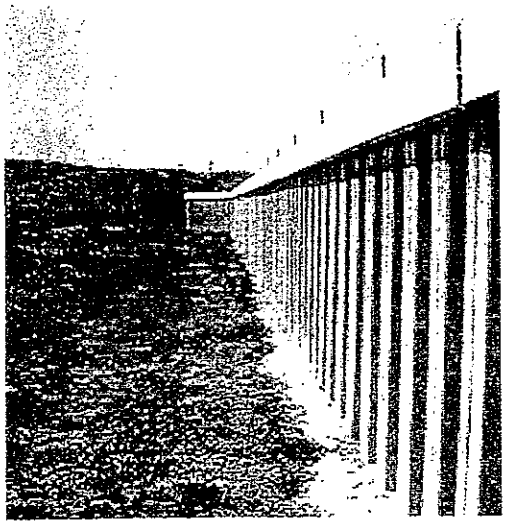
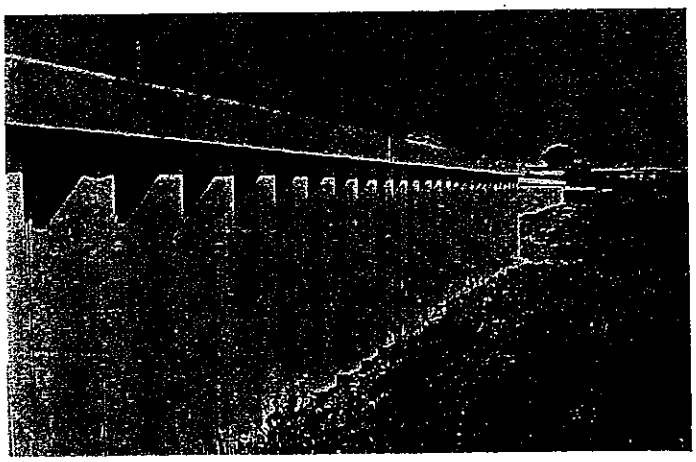
The City of Benicia

Benicia, California



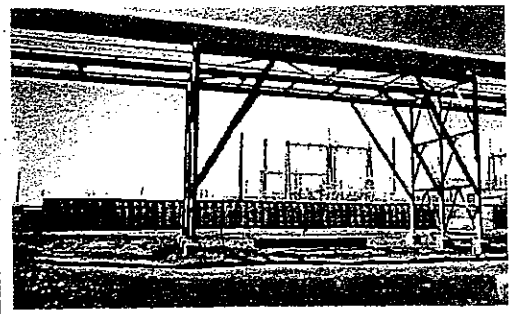
This 7-foot tall cantilevered GeoGuard 500 wall, with a poured concrete cap, was utilized for this project to take advantage of GeoGuard's longevity, cost-benefits, and aesthetics.

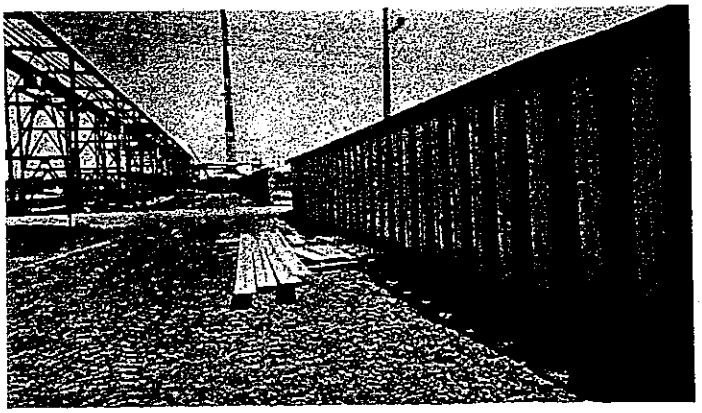


Phillips Petroleum Generating Plant

Sweeney, Texas

This major oil company generating plant was endangered each year with flooding caused by tropical storms. This 8-foot, GeoGuard 500 cantilevered wall with a wood cap provides flood protection





for even the most extreme conditions. Including installation costs, GeoGuard provided substantial cost savings over steel sheet piling.

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February 2000

COVER

Bright idea

Vinyl sheets cut project costs

www.mvn.usace.army.mil

Dollars and sense

Using vinyl instead of steel saves money

By Maurice Ruffin

Since the Corps first drove sheet piling decades ago, steel has been the material of choice.

Now, The New Orleans District has pioneered the use of vinyl sheet piling to replace steel in some cases. New projects using vinyl sheets in seepage cut-off walls are expected to lead to a myriad of other uses for the Corps in the near future.

"It is a never ending accumulation of savings for the Corps and our cost-sharing partners, and its here to stay," said Chief of Cost Engineering Branch John Bivona. He said that the money-saving uses of the vinyl sheet pilings might still be unknown, if not for the insight of Wade Wright, a technician in civil engineering.

"The credit belongs to Wade for having the initiative to organize the VE (value engineering) study on vinyl sheet piling," Bivona said.

Wright came up with the idea in late 1997 as he searched for an alternative to cold-rolled steel, which tended to allow some seepage.

"I wanted something with more water-tight integrity," said Wright, who then began to investigate the possibility of using vinyl. One reason it would prove to be a good alternative is because it features an I-beam locking system, which resists separation once driven into the ground and provides a tighter seal against water seepage.

In January 1998, Wright initiated the study and wrote specifications on the properties of vinyl sheet pilings. Word spread and he began receiving calls from engineers at other Corps districts who were interested in using vinyl in their projects.

Private industry has been using the material in limited areas for a few years, Bivona said, but that to his knowledge NOD is the first Corps district to design projects that specify vinyl as sheet piling material.

The vinyl sheet pilings save the Corps 30 to 50 percent compared with steel. The reasons are at least three-fold.

First, the steel sheet piling that NOD uses costs $10 to $12 per square foot, vinyl only $4.50 to $7.50. Second, vinyl sheet pile is lighter than steel.

Whereas, the steel weighs between 20 and 22 pounds per square foot, the vinyl weighs from three and a half to five pounds. This means lower transportation costs for NOD since more vinyl sheets can be loaded on each delivery truck.

Also, while the steel sheets necessitate that heavy lifting equipment be used, workers can carry vinyl sheets. Third, lighter pile-driving equipment can be used, which results in even more savings.

Engineering division has specified vinyl sheet use on five projects that are under construction. It has already been placed in the ground in a SELA project at the Woodmere-Sunnymeade canals. The accumulated savings for these projects will total up to $100,000.

"This may seem like a small savings, but it represents a significant beginning as the majority of flood control projects require seepage cut-offs," Bivona said.

"The vinyl sheet pilings are made of modified PVC (polyvinyl chloride), a plastic that can be placed in the same environments as steel," said Peter Manning of Materials International in Atlanta, the company that won the bid on the first NOD project using the vinyl sheets.

"And, vinyl, unlike steel, does not corrode when exposed to the elements," said Manning.

"Salt, water, sunlight...all these things take a toll on steel. Vinyl will outlast steel every day of the week and taxpayers get to save a tremendous amount of money as a result," said Manning.

Yet, despite the advantages of using vinyl, the material is not expected to replace steel completely.

"Vinyl is a cost effective alternative to steel, but it is not a one to one substitute because it depends on the application. It is only a definite replacement in appropriate seepage cut-offs," Bivona said.

"Vinyl's only real disadvantage is that it is not as strong as steel, which means that it can not be used in applications that require steel's ability to withstand extreme weight," said Wright.

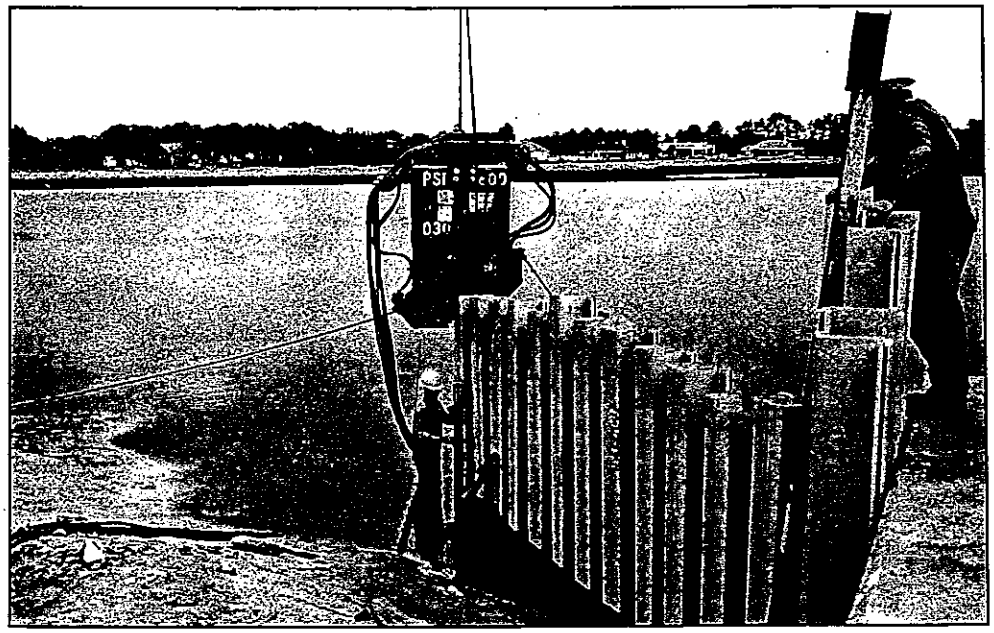
Manning agrees. "Vinyl is never going to replace steel. It's an alternative. Steel has structure and strength that vinyl doesn't. You're not going to build the Superdome on top of vinyl," he said.

The key to the future of vinyl sheet piling in Corps projects will come by using it selectively.

Bivona said about a dozen new SELA seepage projects will use vinyl sheet pilings and that further applications are being explored.

These applications might include flood-walls and, possibly, in slope stabilization and channel-lining projects.

Many of the benefits that may come from the use of vinyl are yet to be discovered, but one thing is for certain — the Corps will continue to save money as the use of vinyl as a steel alternative grows.



Interlocking sheets of vinyl sheet piling are driven at one time with a 3,000-lb. vibratory hammer. The I-Beam lock design and a driving guide help allow the crew to drive a pair of 16-foot sheets in approximately 90 seconds at this non-Corps project.

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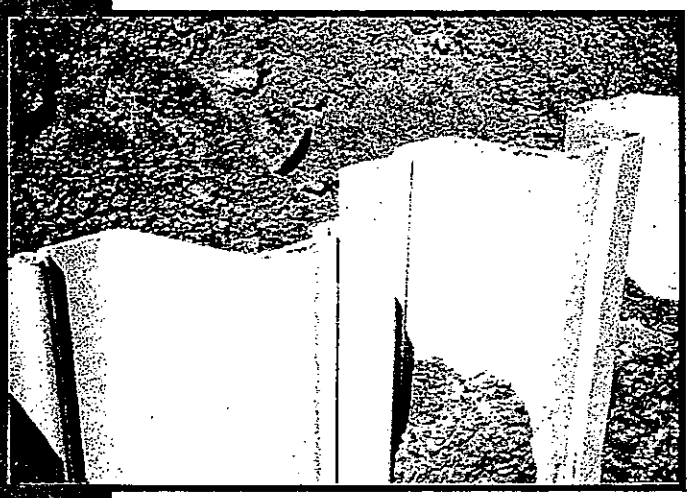
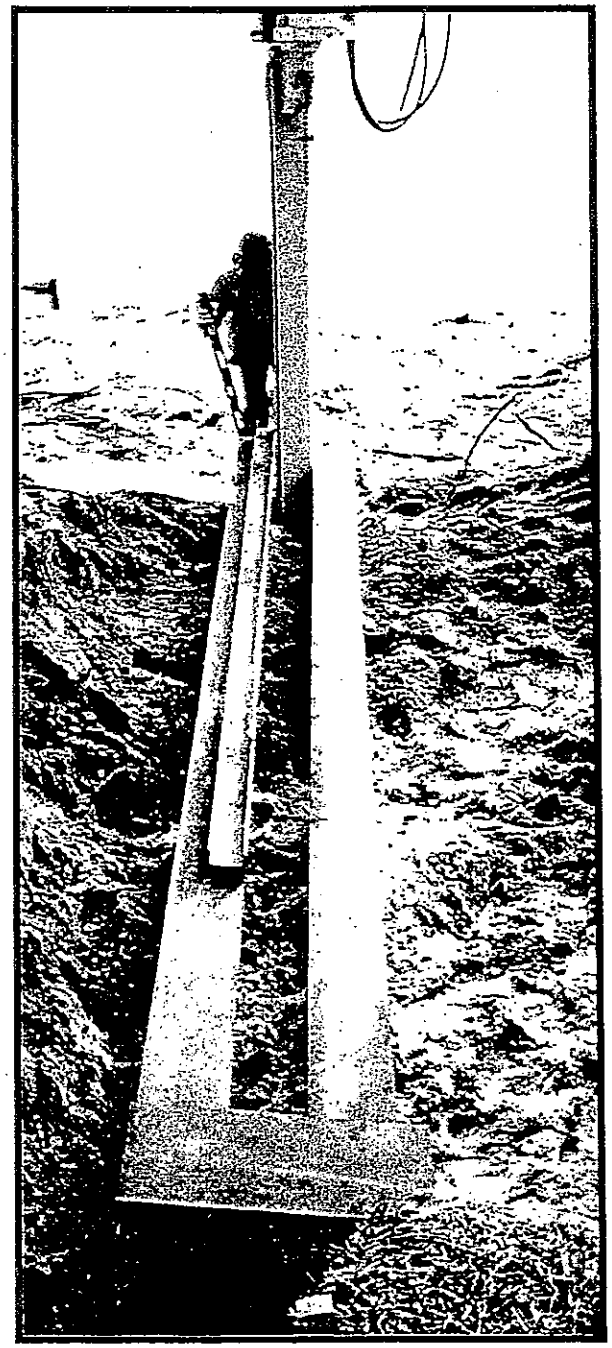
Driving Guides

Emergency Watershed Project
Dickinson City, Florida





ShoreGuard® 400 was installed with a vibratory hammer. The driving guide allows for proper alignment and facilitates installation in a timely manner, while not compromising the integrity of the vinyl sheet piling.

This project was performed in conjunction with Dickenson City and the USDA.

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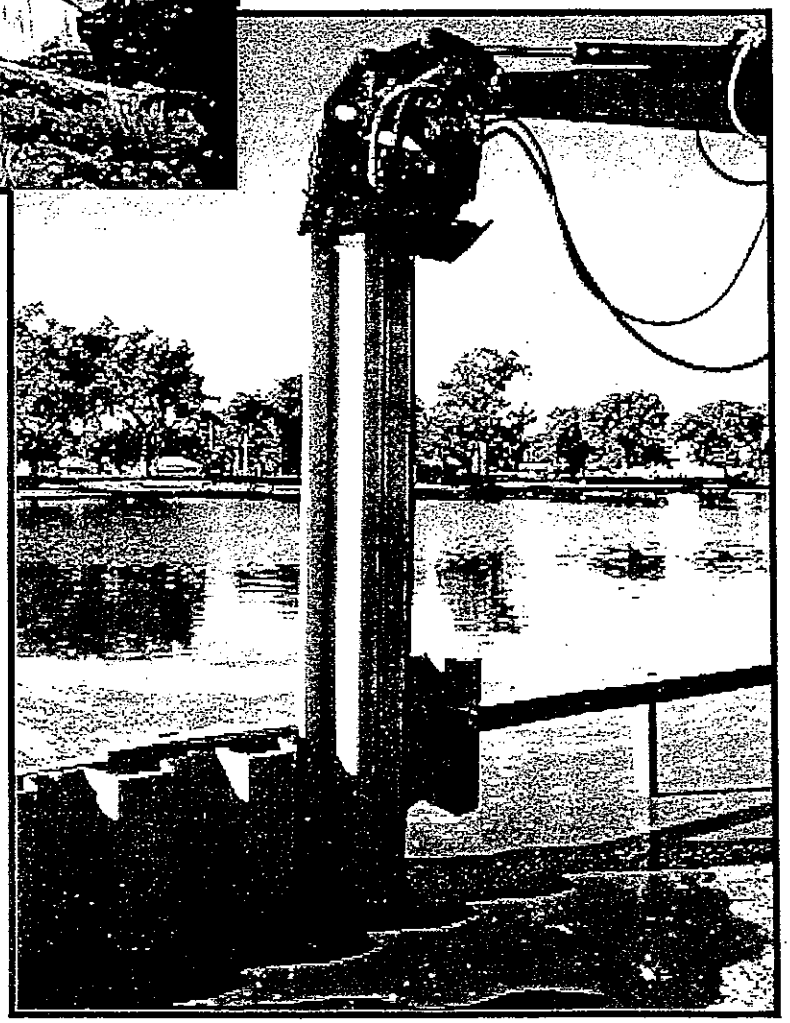
ShoreGuard. Sheet Piling

Vibratory Plate Compactor Installation

Sheet piling used as a leading edge drive guide



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Specifying ShoreGuard® Sheet Piling

1. Acceptable Manufacturer

1.1 ShoreGuard sheet piling manufactured by:

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1.2 Manufacturer must have a minimum of 10,000,000 square feet of sheet piling in service.

1.3 Manufacturer must have sheet piling in service that has performed for a minimum of 10 years.

1.4 Any deviation from these specifications must be approved in writing or the deviation will be considered as non-compliance.

2. ACCEPTABLE PRODUCT

2.1 Sheet piling shall be ShoreGuard _____, as manufactured by Materials International or *approved equal*.

2.1.1 The term equal shall be defined as meeting or exceeding *all* physical property requirements. *Approved equal* shall be equal or better in Long-Term Allowable Moment, weatherability, weight per foot, depth of section, section modulus, tensile strength, impact resistance, modulus of elasticity, and have a factor of safety for no creep (max. 5% strain) when stressed long-term at the allowable moment.

Characteristic	Units	ShoreGuard 700	ShoreGuard 550	ShoreGuard 500	ShoreGuard 400	ShoreGuard 300	ShoreGuard 150
Standard Color		Grey					
Custom Colors		Beige, Brown, Green, Sandstone					
Standard Lengths	Feet	18, 20, 22	14, 16, 18	14, 16, 18	12, 14, 16	10, 12, 14, 16	6, 8, 10
Standard Packaging	Sheet Piling per Bundle	12	20	20	20	20	40
Long-term allowable moment rating	Foot-pounds/Linear foot	8,890	5,000	4,223	3,889	2,889	1,334
Factor of safety for creep		1.5	1.5	1.5	1.5	1.5	1.5
Factor of safety for durability &		1.5	1.5	1.5	1.5	1.5	1.5
Transmissivity	Centimeters per second for SW soils	4.15×10^{-6}	4.15×10^{-6}	2.7×10^{-6}	2.7×10^{-6}	2.7×10^{-6}	2.5×10^{-6}
Weight	Pounds per square foot (lbs/ft^2)	8.0	5.4	5.0	4.1	3.2	2.6
Nominal Thickness	Inches	0.450	0.400	0.400	0.325	0.250	0.200
Linear Coverage	Inches	12	12	12	12	12	10.5
Depth of section	Inches	10	8	8	8	7	5
Section modulus	Cubic inches/Linear foot (in^3/ft)	40	22.5	19	17.5	13	6
Tensile strength by ASTM D-638	Pounds per square inch (lbs/in^2)	6,300	6,300	6,300	6,300	6,300	6,300
Impact strength by ASTM D-4226	Inch-pounds/Square	15,000	15,000	15,000	13,750	13,750	11,000
Modulus of elasticity by ASTM D-790	Pounds/Square inch	380,000	380,000	380,000	380,000	380,000	380,000
I-Beam Lock™		Yes	Yes	Yes	Yes	Yes	Yes
Co-Extrusion		Yes	Yes	Yes	Yes	Yes	Yes
UV Protection		Yes	Yes	Yes	Yes	Yes	Yes
Strong Back Ribs™		Yes	Yes	No	No	No	No

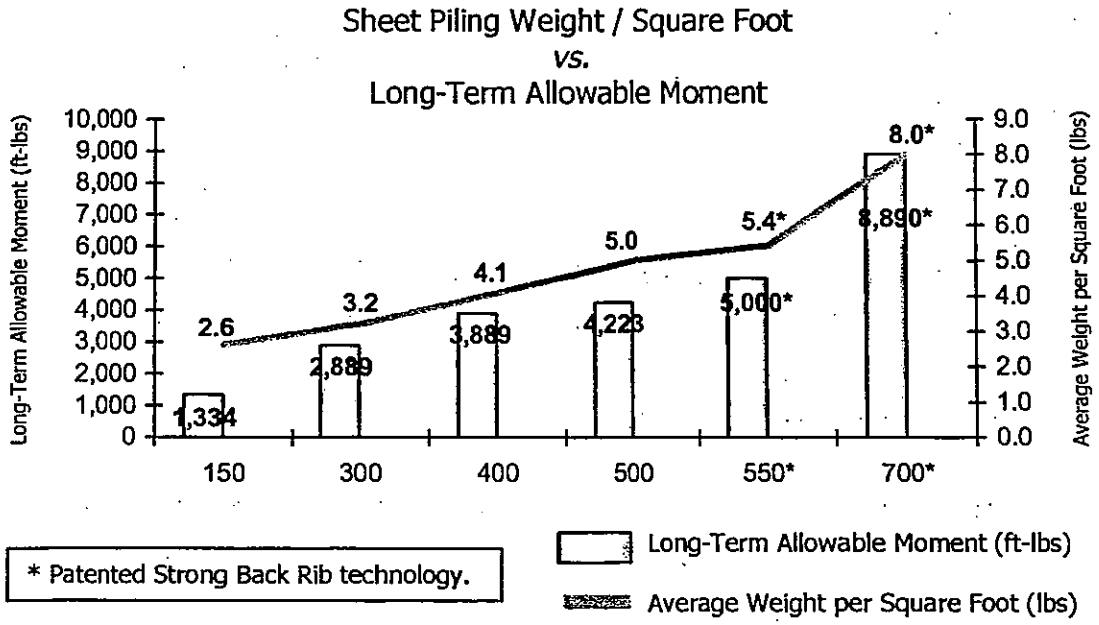
2. Acceptable Product (continued)

2.2 ShoreGuard sheet piling must be rigid, impact modified, UV resistant and have a weatherable virgin capstock to insure long-term color consistency.

2.2.1 ShoreGuard color shall be light grey, beige, dark brown, light green, or sandstone.

2.2.2 A sample of ShoreGuard sheet piling of the appropriate color must be submitted and approved prior to submittal of bid.

2.3 The long-term allowable moment rating of the ShoreGuard sheet piling must meet or exceed _____ foot pounds per linear foot.



* Patented Strong Back Rib technology.

2.3.1 The long-term allowable moment rating of the ShoreGuard sheet piling must be defined by accepted industry standards in order to be used in conventional beam equations in structural designs.

2.3.2 The long-term allowable moment rating is defined as the rating at which ShoreGuard sheet piling will perform when subjected to constant loading. The units are reported in foot-pounds per linear foot.

2.3.3 The long-term allowable moment rating of the ShoreGuard sheet piling must be equal to or greater than the design loading of the structure as determined by the engineer.

2.

Acceptable Product (continued)

2.3.4 Documentation of the method of calculating the long-term allowable moment rating must be submitted in writing.

2.3.5 The long-term allowable moment is to be used as the principle design value only when each and every critical design element set forth below is met or exceeded.

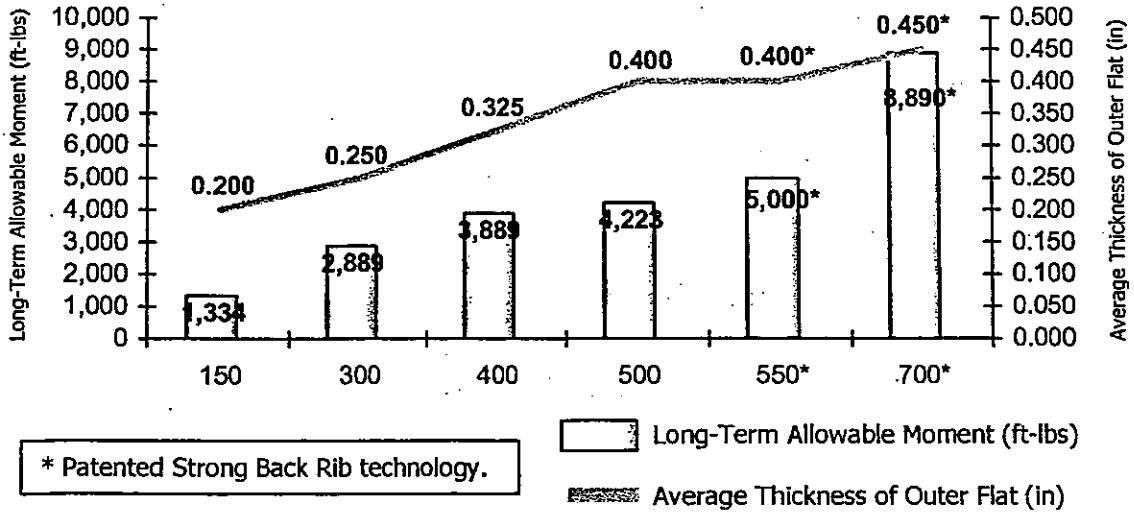
2.3.5.1 The ShoreGuard sheet piling weight must meet or exceed _____ pounds per square foot.

2.3.5.2 The ShoreGuard sheet piling must have a section modulus that meets or exceeds _____ cubic inches per linear foot.

2.3.5.3 The ShoreGuard sheet piling must have the appropriate thickness in the outer flat section to accommodate the expected loads. Long-term performance under load is a function of the maximum tensile force acting on the outside flat section of the sheet piling. The chart below defines the appropriate thickness of the outer flat section to accommodate each loading requirement.

Thickness of Outer Flat		Long-Term Allowable Moment Rating	
0.200	inches	**1,334**	foot-pounds
0.250	inches	**2,889**	foot-pounds
0.325	inches	**3,889**	foot-pounds
0.400	inches	**4,223**	foot-pounds
0.400*	inches*	**5,000***	foot-pounds
0.450*	inches*	**8,890***	foot-pounds

Thickness of Outer Flat
vs.
Long-Term Allowable Moment



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2.

ACCEPTABLE PRODUCT (CONTINUED)

2.3.5.4 The shape and section modulus of the ShoreGuard sheet piling must be optimized for maximum long-term performance through the use of AutoCAD Solid Modeling.

2.3.5.4.1 Documentation of rating compliance of the ShoreGuard sheet piling must be submitted in writing.

2.3.5.4.2 The ShoreGuard must have an I-Beam Lock™ interlock design to reinforce the rigidity of the sheet piling during installation.

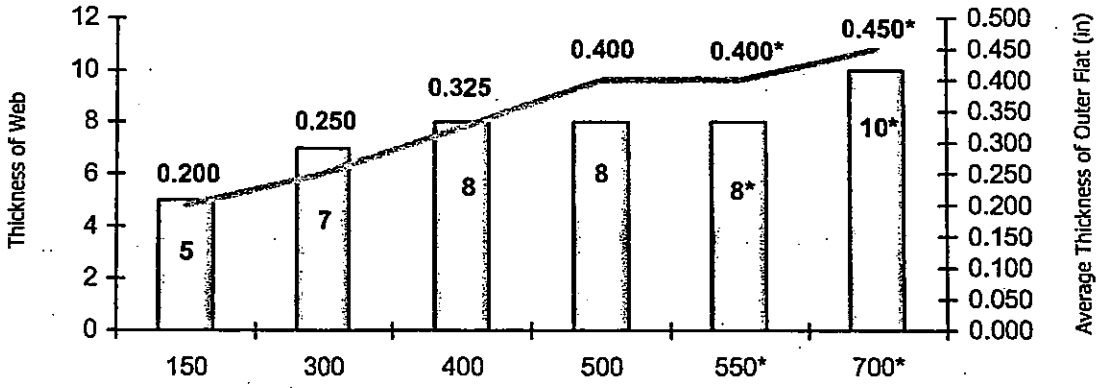
2.3.5.4.3 The ShoreGuard must have an I-Beam Lock™ interlock design to maintain long-term loading performance.

2.3.5.5 The ShoreGuard sheet piling must have a depth of section of _____ inches.

2.3.5.5.1 The web geometry must have the appropriate ratio of wall thickness to cross section depth and the angle of the web to prevent the web section from yielding under load or "web crippling".

Thickness of Web	Depth of Cross Section
0.200 inches	**5** inches
0.250 inches	**7** inches
0.325 inches	**8** inches
0.400 inches	**8** inches
0.400 inches*	**8** inches*
0.450 inches*	**10** inches*

Relationship Between Thickness of Web and the Depth of Cross Section



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Depth of Cross Section (in)

Thickness of Web (in)

2. ACCEPTABLE PRODUCT (CONTINUED)

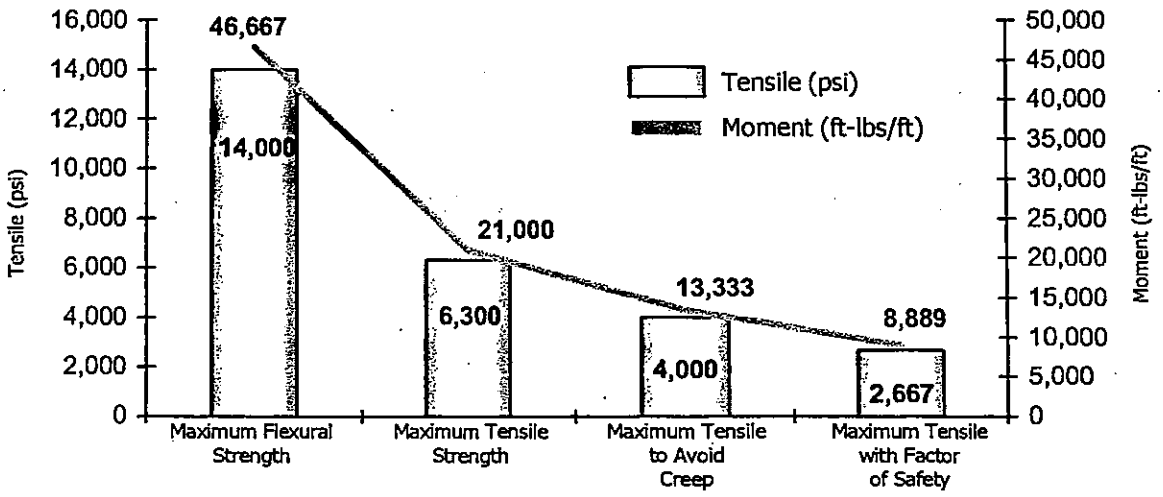
2.3.5.6 The ShoreGuard sheet piling must be manufactured from weatherable, UV resistant vinyl.

2.3.5.7 The following factors of safety must be included in the long-term allowable moment rating:

2.3.5.7.1 A factor of safety of no less than 1.5 must be applied to preclude creep failure. The tensile stress must therefore be reduced from 6,300 psi to 4,000 psi to maintain stresses in the material below a 5% strain.

2.3.5.7.2 A factor of safety of 1.5 must be applied as a durability and construction factor of safety. The tensile stress is therefore reduced from 4,000 psi to 2,667 psi.

Design Values Utilized *vs.* Long-Term Allowable Moment
(Section Modulus of 40)



3. IMPACT RESISTANCE

3.1 The ShoreGuard sheet piling must have impact resistance that meets or exceeds _____ inch-pounds per square inch.

3.1.1 ShoreGuard must be rigid, impact modified, UV resistant and have a weatherable virgin capstock to insure long-term impact resistance.

3.1.2 Impact resistance to be measured by ASTM D-4226 Procedure B.

3.1.3 ASTM D-4226 Procedure B to be performed on the interlocks, as well as the flat sections of the sheet piling.

4. INSTALLATION AND DRIVEABILITY

4.1 The ShoreGuard sheet piling must have an I-Beam Lock™ interlock design.

4.1.1 The ShoreGuard must be installed in an appropriate vertical and horizontal alignment.

4.1.2 The ShoreGuard must have an I-Beam Lock™ interlock design to reinforce the rigidity of the sheet piling during installation.

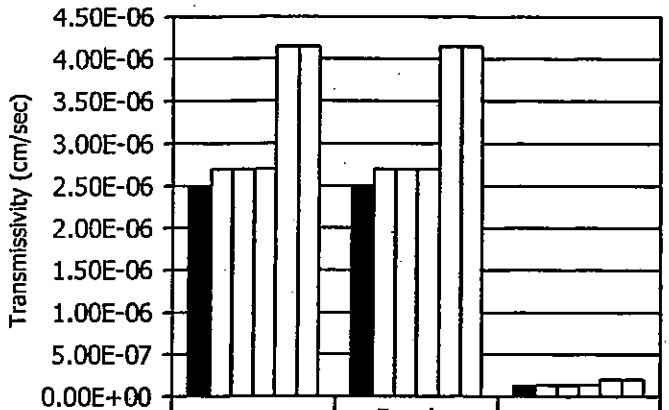
4.1.3 Use manufacturer's (Materials International, Inc.) corner pieces for 45 and 90° bends.

5. TRANSMISSIVITY RATING

5.1 The Transmissivity Rating of the ShoreGuard sheet piling must be a maximum of _____ centimeters/second.

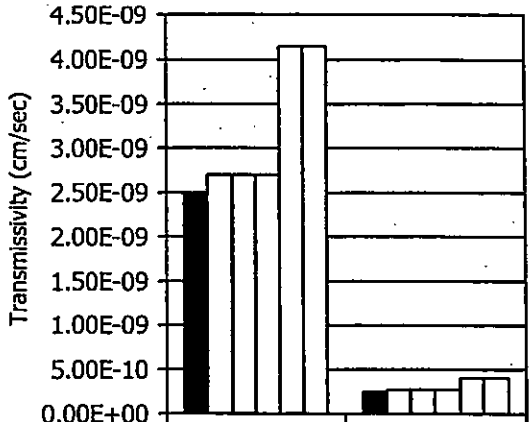
ShoreGuard Sheet Piling Transmissivity in Typical Soils

Sands



Transmissivity	Well-Graded Sands	Poorly-Graded Sands	Sand-Silt Mix
■ 150	2.50E-06	2.50E-06	1.25E-07
□ 300	2.70E-06	2.70E-06	1.35E-07
□ 400	2.70E-06	2.70E-06	1.35E-07
□ 500	2.70E-06	2.70E-06	1.35E-07
□ 550*	4.15E-06	4.15E-06	2.08E-07
□ 700*	4.15E-06	4.15E-06	2.08E-07

Gravels



Transmissivity	Poorly-Graded Silty Gravels	Poorly-Graded Clayey Gravels
■ 150	2.50E-09	2.50E-10
□ 300	2.70E-09	2.70E-10
□ 400	2.70E-09	2.70E-10
□ 500	2.70E-09	2.70E-10
□ 550*	4.15E-09	4.15E-10
□ 700*	4.15E-09	4.15E-10

* Patented Strong Back Rib technology.

Physical properties are defined by ASTM Test Standards for Plastic Building Products. The values shown are nominal and may vary. The information found in this document is believed to be true and accurate. No warranties of any kind are made as to the suitability of ShoreGuard for particular applications or the results obtained therefrom. ShoreGuard® is a registered trademark of Materials International, Inc. United States Patent Numbers 5,145,287; 5,881,508; 6,000,883; 09/033,782; DES420,154; 6,033,155. Other patents pending. ©2000 Materials International, Inc. All Rights Reserved.

APPENDIX B

COST ESTIMATE

TABLE B-1
Feasibility Study Cost Estimate
Big 5 Dam Rehabilitation
Pershing County, Nevada

DESCRIPTION	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Mobilization/Demobilization	**$20,000**	**$20,000**	**$20,000**	**$20,000**
Surveying Services	**$8,400**	**$8,400**	**$8,400**	**$8,400**
Temporary Flow Diversion				
Length	150 lf	150 lf	150 lf	150 lf
Unit Price	$10,000	$10,000	$10,000	$10,000
Extended Price	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Dewatering				
duration	6 wk	6 wk	4 wk	4 wk
Generator	$7,000	$7,000	$4,500	$4,500
Submersible Pumps	$4,500	$4,500	$3,000	$3,000
Extended Price	**$11,500**	**$11,500**	**$7,500**	**$7,500**
Excavation				
Volume	3,000 cy	2,200 cy	920 cy	880 cy
Unit Price	$4	$4	$4	$4
Extended Price	**$12,000**	**$8,800**	**$3,680**	**$3,520**
Sheet Pile (PVC)				
Length	220 lf	220 lf		
Depth	20 lf	19 lf		
Area	4,400 sf	4,180 sf		
Unit Price (Sheet Pile + Transport)	$5.00 per sf	$5.00 per sf		
Sheet Pile + Transport	$22,000.00	$20,900.00		
Hardware	1000 ea	1000 ea		
Unit Price (Installation)	2.25 X $3.20 per sf	2.25 X $3.20 per sf		
Installation	$49,500	$47,025		
Extended Price	**$72,500**	**$68,925**		
New Embankment				
Volume	1,250 cy	1,050 cy	1,080 cy	720 cy
Unit Price	$4.25	$4.25	$4.25	$4.25
Extended Price	**$5,313**	**$4,463**	**$4,590**	**$3,060**
Revetment				
Area	14,000 sf	14,000 sf	15,500 sf	15,500 sf
Unit Price (product + installation)	$5.50 per sf	$5.50 per sf	$5.50 per sf	$5.50 per sf
Product + installation	$77,000.00	$77,000.00	$85,250.00	$85,250.00
Unit Price (Transportation)	$1,500 per load	$1,500 per load	$1,500 per load	$1,500 per load
Transportation	$45,000	$45,000	$45,000	$45,000
Extended Price	**$122,000**	**$122,000**	**$130,250**	**$130,250**
Energy Dissipation				
Length	200 lf	200 lf	160 lf	160 lf
Unit size	1.75 lf/unit	1.75 lf/unit	1.75 lf/unit	1.75 lf/unit
Unit Price	$10.00 per unit	$10.00 per unit	$10.00 per unit	$10.00 per unit
Purchase Price	$1,142.86	$1,142.86	$914.29	$914.29
Transportation	$500	$500	$500	$500
Installation	$140	$140	$140	$140
Extended Price	**$1,783**	**$1,783**	**$1,554**	**$1,554**
Clay Plug				
Excavate Trench			$1,280	$1,280
Select Import Clay			$2,700	$2,700
Place and Compact			$250	$250
Extended Price			**$4,230**	**$4,230**

TABLE B-1
Feasibility Study Cost Estimate
Big 5 Dam Rehabilitation
Pershing County, Nevada

DESCRIPTION	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Geotextile				
Area	16,000 sf	16,000 sf	16,000 sf	16,000 sf
Unit Price (product + installation)	$0.22 per sf	$0.22 per sf	$0.22 per sf	$0.22 per sf
Product + installation	$3,520	$3,520	$3,520	$3,520
Extended Price	**$3,520**	**$3,520**	**$3,520**	**$3,520**
Flow Control Structure				
Length		120 lf		100 lf
Unit Price		$500 /unit		$500 /unit
Purchase Price		$3,000		$2,500
Transportation		$800		$800
Installation		$600		$600
Extended Price		**$4,400**		**$3,900**
Capital Cost - subtotal	$267,000	$263,800	$193,700	$195,900
Contingency @ 20%	$53,400	$52,800	$38,700	$39,200
Design	$48,100	$47,500	$34,900	$35,300
Construction Management	$25,600	$25,300	$18,600	$18,800
Capital Cost - Total	**$394,100**	**$389,400**	**$285,900**	**$289,200**
Operations and Maintenance	**$1,500**	**$4,700**	**$1,500**	**$4,700**

APPENDIX B - CONTRACT DRAWING OF UPPER PITT-TAYLOR OUTLET STRUCTURE

Appendix B includes a copy of the original contract drawing of the Upper Pitt-Taylor Dam outlet structure. The structure was constructed circa 1913.

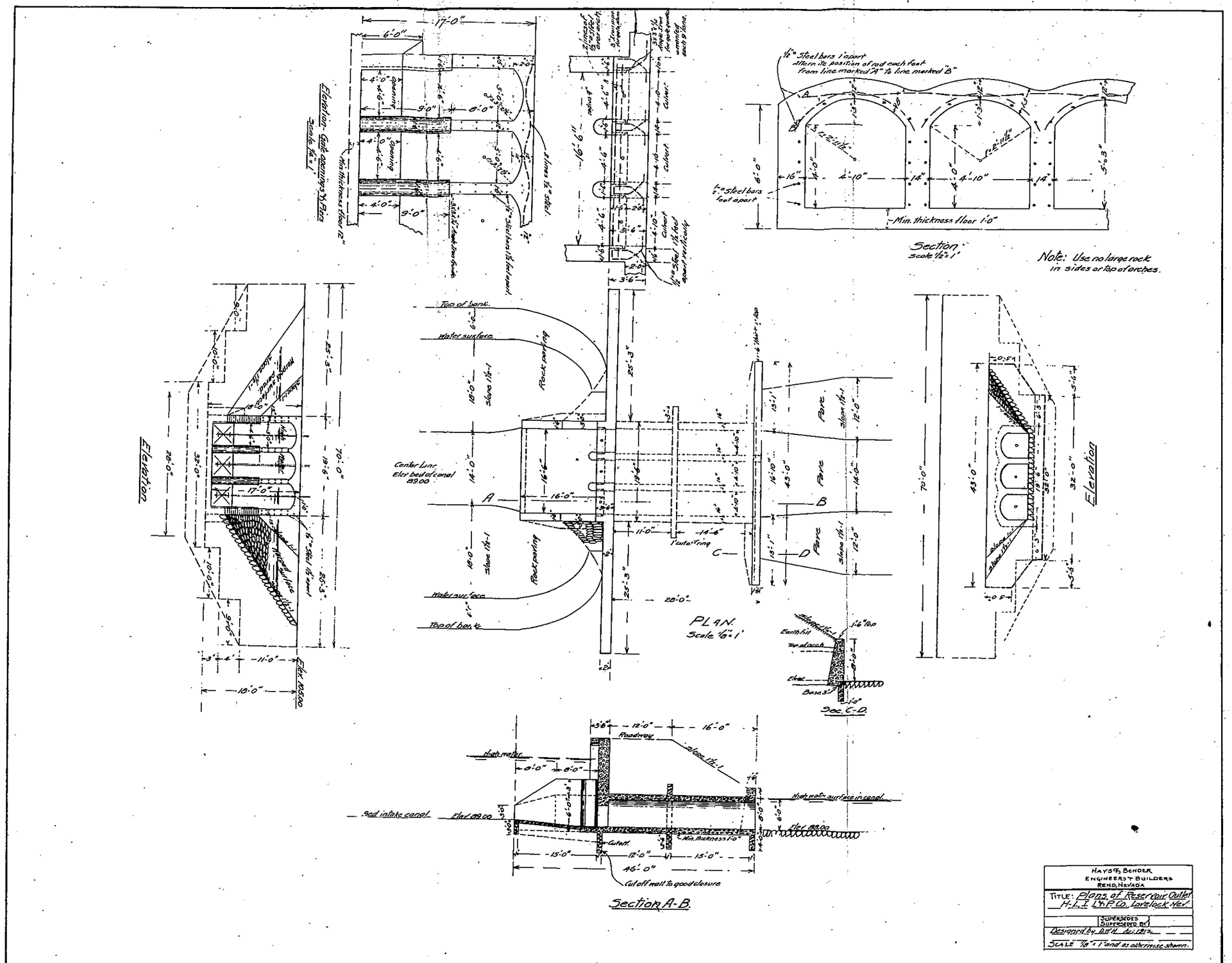

Elevation - Gate openings 3'x7' Pairs
Scale 1/4" = 1'
Section
Scale 1/2" = 1'
Note: Use no large rock in sides or top of arches.
Elevation
PLAN
Scale 1/8" = 1'
Sec. C-D
Section A-B
Elevation
Cut off wall to good closure
Min. thickness 1'-0"
Min. thickness floor 12"
Center Line Elev bed of canal 89.00
Water surface
Top of bank
Rock packing
Pave
Roadway
Cutoff
Elev 89.00
Elev 105.00
HAYS & BENDER
ENGINEERS & BUILDERS
RENO, NEVADA
TITLE: Plans of Reservoir Outlet
H.L.L. & P.P. Co. Lovelock Nev.
SUPERSEDES
SUPERSEDED BY
Designed by D.H.H. Dr. D.H.H.
SCALE 1/8" = 1' and as otherwise shown.

PLATE II

APPENDIX C – POLYMER SEALANT SPECIFICATION

Appendix C includes the specification sheet for the polymer sealant that PCWCD has been using to reduce seepage in some of the system canals.

Emulsified PAM SEALANT

IMPROVES MANAGEMENT OF IRRIGATION WATER. WHEN USED ACCORDING TO DIRECTIONS, PRODUCT HAS SHOWN TO REDUCE WATER LOSS IN CANALS DUE TO LEAKAGE AND SEEPAGE.

COMPOSITION

30% Liquid anionic polyacrylamide

All ingredients are exempt from the requirements or a tolerance as specified in 40 CFR 180.1001,c.

CAUTION:

KEEP OUT OF REACH OF CHILDREN Read entire label for additional precautions.

NON-PLANT FOOD PRODUCT MAY BE HARMFUL IF SWALLOWED.

Avoid contact with eyes. Flush eyes with large quantities of water. **DO NOT RUB.** Contact Physician.

General Information

Emulsified PAM is a proprietary linear polymer mixture of polyacrylamide when used according to directions may significantly reduce water loss in canals due to leakage and seepage. EMULSIFIED PAM flocculates suspended soil particles in irrigation water thus increasing their molecular weight, which promotes the heavy soil particles to drop to the bottom of the canal and seal existing cracks. Optimal application can be influenced by a variety of factors and therefore, it is recommended the user carefully observe the application to assure the desired results are achieved. EMULSIFIED PAM is recommended for use at 4 - 10 gallons per treated acre and can be applied in a broadcast application either diluted with water or by itself. **To avoid product degradation and equipment corrosion, do not use iron, copper or aluminum containers or equipment. Shake well before using this product. Store at temperatures above 40 degrees F. Exercise caution, spilled product creates very slippery conditions when wet.** Contain the spill and collect without the use of water. Thoroughly collect spilled material by means of a suitable absorbent material and dispose of properly.

APPLICATION: EMULSIFIED PAM can be applied in a broadcast application directly to the dry canal 2-5 days prior to the first water flow. EMULSIFIED PAM should be applied at a rate of 4 – 10 gallons per treated acre. To calculate treated acres multiply the canal width by lineal feet and divide by 43,560 (square feet per acre). EMULSIFIED PAM can be applied broadcast as is or diluted with water depending upon application equipment. **To prevent plugging, remove all screens prior to application.** For applications not diluted with water, clear sprayer, pump, and lines thoroughly with crop oil to remove any water and/or product residues. For applications diluted into water, fill sprayer with appropriate volume of water and slowly add EMULSIFIED PAM while maintaining agitation. For best results, it is recommended to use 1 gallon of EMULSIFIED PAM per 100 gallons of water, (additional water volumes may be necessary to accommodate various types of application equipment). Do not attempt to mix more than 1 gallon of EMULSIFIED PAM with less than 100 gallons of water as the material may become too thick to spray.

PRECAUTIONARY STATEMENTS

BEFORE USING THIS PRODUCT, READ ALL PRECAUTIONS, DIRECTIONS FOR USE, CONDITIONS OF SALE-LIMITED WARRANTY AND LIMITATIONS OF LIABILITY AND REMEDIES. KEEP OUT OF REACH OF CHILDREN. **CAUTION: SPILLED MATERIAL CREATES EXTREMELY SLIPPERY CONDITIONS. IF SPILLED CONTAIN, ABSORB WITH A SUITABLE ABSORBENT, AND DISPOSE OF ACCORDING TO LOCAL REGULATIONS.**

WHAT TO DO IN CASE OF CONTACT

If on skin: remove contaminated clothing and wash skin with soap and water. Call a physician. If swallowed: do not induce vomiting. Immediately call a physician. If in eyes: flush eyes with clean water for 15 minutes. Immediately call a physician. If inhaled: Move to fresh air and call a physician if irritation develops or persists.

STORAGE AND DISPOSAL

Store in original container only. Keep container tightly closed, do not allow water to be introduced into the contents of this container. Do not store near heat or open flame. Avoid contact with strong oxidizing agents. **Do not allow product to freeze in cold weather conditions.**

CONTAINER DISPOSAL: Triple rinse (or equivalent) and add rinse aid to spray tank, then offer for recycling or reconditioning, or puncture and dispose of according to state and local authorities. If burned, stay out of smoke.

50 Gallons

Always read and follow label directions before buying or using this product. PROVEN QUALITY. EMULSIFIED PAM must not be repackaged without written permission. Notice to Buyer: The statements contained herein, including all descriptions of products and methods, test results, and suggestions are provided for your consideration only as general information and are not to be construed to constitute any representation or warranty, express or implied. Users assume full responsibility for determining the appropriate application of any products, method, or suggestions and for adopting such precautions against damage to property or injury to person's area as necessary or advisable under the circumstances. No statement contained herein is to be construed to constitute the permission, recommendation or encouragement of any use or application that many infringe any patents now or hereafter in existence. NO WARRANTY OF MERCHANTABILTY OR WARRANTY OR SUITABILITY OF FITNESS FOR A PARTICULAR PURPOSE IS MADE. No warranty, express or implied, is made except as may be provided in the Sales Contract or Invoice applicable to the goods in question.180402

Emulsified PAM SEALANT

IMPROVES MANAGEMENT OF IRRIGATION WATER. WHEN USED ACCORDING TO DIRECTIONS, PRODUCT HAS SHOWN TO REDUCE WATER LOSS IN CANALS DUE TO LEAKAGE AND SEEPAGE.

COMPOSITION

30% Liquid anionic polyacrylamide

All ingredients are exempt from the requirements or a tolerance as specified in 40 CFR 180.1001,c.

CAUTION:

KEEP OUT OF REACH OF CHILDREN Read entire label for additional precautions.

NON-PLANT FOOD PRODUCT MAY BE HARMFUL IF SWALLOWED.

Avoid contact with eyes. Flush eyes with large quantities of water. **DO NOT RUB.** Contact Physician.

How Do I Use the Product?

Emulsified PAM Sealant should be applied directly to the canal 2-5 days prior to the first water flow at a rate of approximately 4-10 gallons per treated acre. Rates can vary with different soil conditions, so prior soil testing is recommended. The keys to success rely heavily on the applied rate and having the initial water flow contain adequate amounts of sediment. If the water does not contain sufficient amounts of sediment (suspend solids) you will not achieve the desired results.

Should the Product be Diluted?

It is best to apply the product as is without adding additional water. A large amount of water is necessary to dilute the product (100 - 200 to 1) so a normal spray pattern can be achieved. Make sure the spray equipment does not have any residual water for it is likely your system will plug up as you start to spray. Run corn oil (vegetable oil) through the entire system before you pump the **Emulsified PAM Sealant**. The corn oil helps remove any excess water from the lines and coats the system. Also, remove any line screens from your spray system.

If you need to add water, fill the sprayer with the appropriate water volume first, then add the Emulsified PAM Sealant slowly while you agitate the solution (spray back into the tank if necessary). Do not attempt to mix less than 1 gallon of **Emulsified PAM Sealant** water with 100 gallons of water as the material will become too thick to spray.

What Results Can Be Expected?

Results vary with every application, but 80% - 90% seal rates are not uncommon. Your individual results vary due to local conditions and soil types. Here are the most common reasons for product failure:

1). Low sediment levels in initial water flow.
2). Application made more than 1 week prior to initial water flow.
3). Application rates of less than the necessary concentrate per treated acre.
4). Excess amount of brush/grass in canal bed.
5). Failure to apply the product to the entire canal bed and sides.
6). Application made too far upstream from the primary leak.

CAUTION:

Spilled product will create extremely slippery conditions when wet. Do not apply water. Contain the spill with dirt or a suitable absorbent material and dispose of properly.

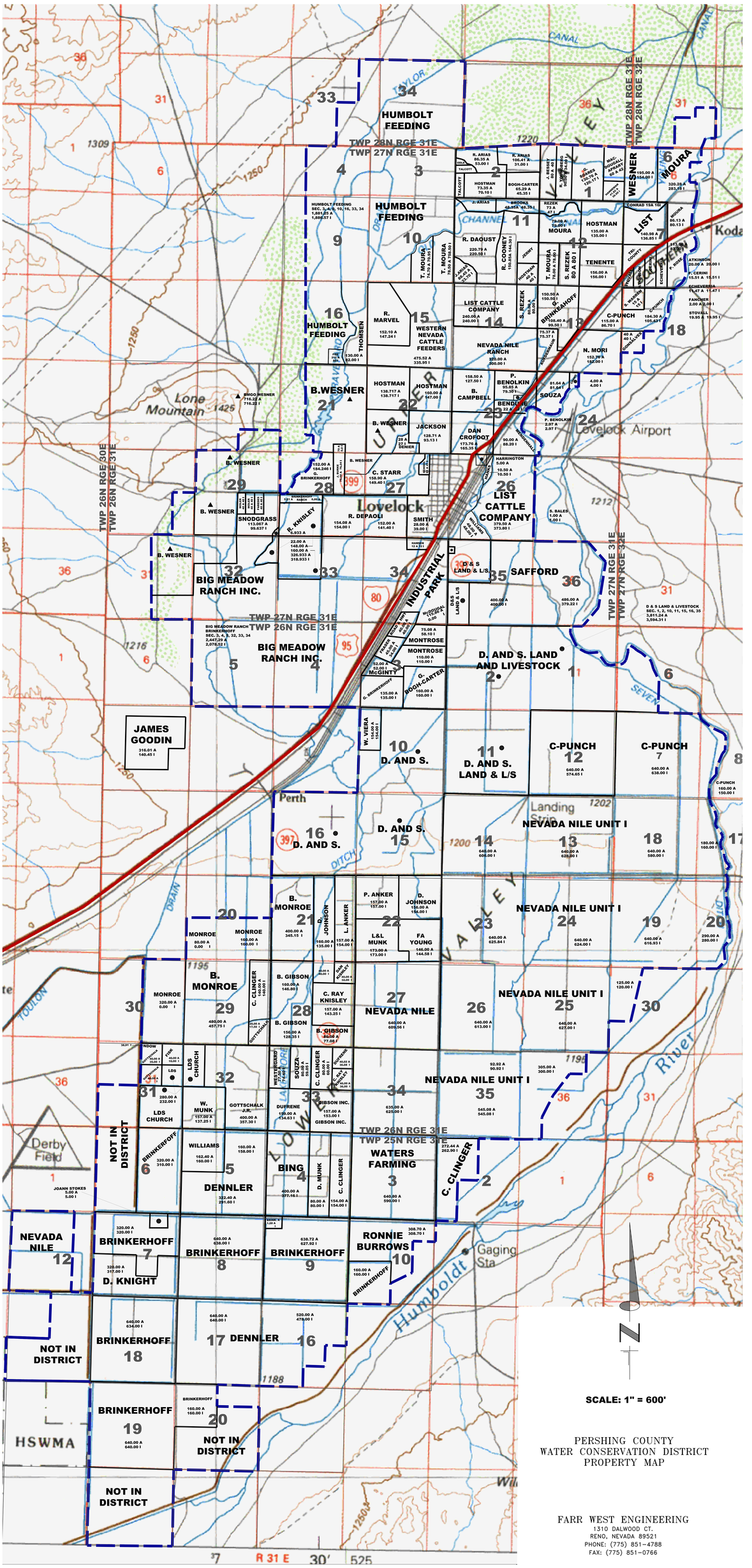
APPENDIX D – SYSTEM MAPS

Appendix D includes the following large maps of the PCWCD system:

Exhibit 1 – Map of the property owners in the PCWCD

Exhibit 2 – Location Map of the Pitt-Taylor Facilities

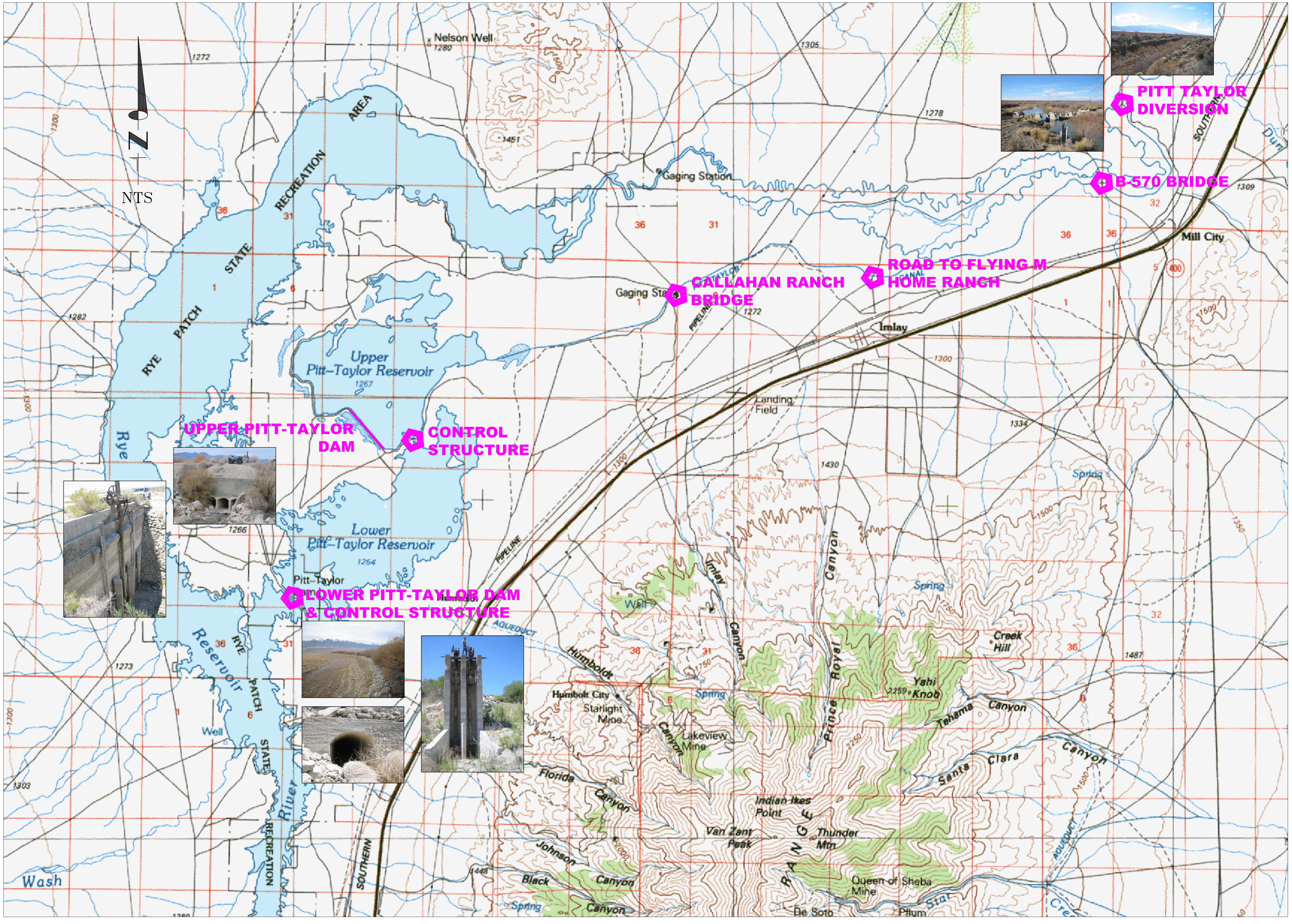
Exhibit 3 – Location Map of the Upper and Lower Lovelock Valley systems



PERSHING COUNTY
WATER CONSERVATION DISTRICT
PROPERTY MAP

FARR WEST ENGINEERING
1310 DALWOOD CT.
RENO, NEVADA 89521
PHONE: (775) 851-4788
FAX: (775) 851-0766

EXHIBIT 1



REVISIONS

PREP. BY	DATE	APPROVED

DESIGNED: BRF
DRAWN: KSN
CHECKED:

PERSHING COUNTY
WATER CONSERVATION DISTRICT
RYE PATCH AREA
DISTRIBUTION SYSTEM

FARR WEST ENGINEERING
1310 DALWOOD CT.
RENO, NEVADA 89521
PHONE: (775) 851-4788
FAX: (775) 851-0766

EXHIBIT 2

C:\Documents and Settings\Kate Nelson\My Documents\FARR WEST ENGINEERING\PCWCD\Maps\Water Distribution System.dwg, 5/7/2009 1:09:52 PM, Adobe PDF

C:\Documents and Settings\Kate Nelson\My Documents\FARR WEST ENGINEERING\PCWCD\Maps\Lovelock Distribution System.dwg, 5/7/2009 1:05:19 PM, Adobe PDF (temporary).pc3

(A) YOUNG DAM

(B) OLD CHANNEL & UNION CANAL

(J) SOMMERS DAM

(C) PITT DAM

(K) HUMBOLT RIVER PLUG

(D) OLD CHANNEL DIVERSION

(L) OUTLET STRUCTURES AT END OF COPENHAGEN 3

(E) IRISH AMERICAN DROP STRUCTURE

(M) BIG 5 DAM

(F) ROGERS DAM

(G) UNION CANAL & BIG MEADOWS

(H) TULE CANAL BACKUP STRUCTURE

(I) ANKER POND

SCALE: 1" = 2000'

EXHIBIT 3		FARR WEST ENGINEERING 1310 DALWOOD CT. RENO, NEVADA 89521 PHONE: (775) 851-4788 FAX: (775) 851-0766	PERSHING COUNTY WATER CONSERVATION DISTRICT	DESIGNED: BRF DRAWN: KSN CHECKED:

REVISIONS		
PREP. BY	DATE	APPROVED