Feasibility Design Report — Santa Margarita River Conjunctive Use Project

San Diego County, California

Prepared by:
U.S. Department of the Interior, Bureau of Reclamation
Technical Service Center, Denver, Colorado

Prepared for:

U.S. Department of the Interior
Bureau of Reclamation
Southern California Area Office
Temecula, California

Fallbrook Public Utility District
Fallbrook, California

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Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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The report writers wish to acknowledge that many people have been involved in the planning concepts for this study. Early planning efforts date back to March of 2004. Various personnel from Fallbrook Public Utility District, Marine Corps Base Camp Pendleton, Reclamation's Southern California Area Office, Stetson Engineers, and Reclamation's Technical Service Center have provided assistance and guidance. Over the study duration, team members changed but the process continued forward. All these unnamed and numerous past and present participants deserve thanks for their efforts.

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U.S. Department of the Interior — Bureau of Reclamation

Fallbrook Public Utility District

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Contents

Acronyms and Abbreviations

af	acre-feet
af/y	acre-feet per year
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
BF	backfill
BP	booster plant
cfm	cubic feet per minute
cfs	cubic feet per second
CIP	clean-in-place
DBP	disinfection byproducts
DON	Department of the Navy
EC	erosion control
EMWD	Eastern Municipal Water District
ETB	excavate, trench, and backfill
Exc	excavation
Fab	fabricate
Fe	iron
F&I	furnish and install
Fnd	foundation
FPUD	Fallbrook Public Utility District
FRP	form, reinforce, and place
gpm	gallons per minute
hp	horsepower

Hz	hertz
ID	internal diameter
IDC	interest during construction
IM	iron-manganese
LC	Lower Colorado
LS	lump sum
MCBCP	Marine Corps Base Camp Pendleton
MCC	motor control center
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mg/L	milligrams per liter (equivalent to parts per million)
MGD	millions of gallons per day
Mn	manganese
MOU	memorandum of understanding
mrem/yr	millirems per year
m/s	meters per second
MWD	Municipal Water District of Southern California
NTU	nephelometric turbidity units
OM&R	operations, maintenance, and replacement
pCi/L	picocuries per liter
PLC	programmable logic controller
psi	pounds per square inch
PVC	polyvinyl chloride
RCWD	Rancho California Water District
RO	reverse osmosis
RTU	remote terminal unit
SCADA	supervisory control and data acquisition
SDCWA	San Diego County Water Authority
SDG&E	San Diego Gas and Electric Company
SMCL	Secondary Maximum Contaminant Level
SMR	Santa Margarita River
SMRCUP	Santa Margarita River Conjunctive Use Project
SRA	submit, review, and approve
SWRCB	California State Water Resources Control Board
TDS	total dissolved solids
TEFC	totally enclosed, fan-cooled
TOC	total organic carbon
TON	threshold odor number
UG	underground
USACE	U.S. Army Corps of Engineers
WTP	water treatment plant
µg/L	micrograms per liter (equivalent to parts per billion)
µmho/cm	micromhos per centimeter

Executive Summary

Background

The Santa Margarita River rises in southwestern Riverside County, California, and flows through Marine Corps Base Camp Pendleton (MCBCP), in northwestern San Diego County, on its way to the Pacific Ocean (Figure 1-1). Ownership of the river's waters has long been disputed between MCBCP and the adjacent Fallbrook Public Utility District (FPUD). The Santa Margarita River Conjunctive Use Project (SMRCUP) was proposed to improve water supply reliability for both MCBCP and FPUD by better managing the yields of the lower Santa Margarita River, and to help resolve several decades of litigation between these parties.

This feasibility design report has been prepared by the Bureau of Reclamation (Reclamation) on behalf of MCBCP and FPUD.

Proposed New Facilities

The following is a description of the new facilities associated with the Proposed Action. The new facilities have been designed to minimize or avoid impacts to sensitive environmental resources to the extent possible. The majority of the project components will be located on FPUD property or within existing roadways, rights-of-way, and other disturbed or developed areas to minimize impacts to existing environmental resources.

Groundwater Production Wells and Collection System

The water supply for the Proposed Action will be delivered from existing and new groundwater production wells that are operated and maintained by MCBCP. The existing and planned production wells are predominantly located within the Ysidora and Chappo sub-basins, and each includes a high-pressure pump. These wells are to have individual pumping rates from 750 to 1,500 gallons per minute. The Proposed Action would provide the capacity to extract water from the wells at flow rates as high as 13.5 cubic feet per second (cfs) (during the wet months of a wet year). Raw groundwater will be lifted from MCBCP to FPUD in a bidirectional pipeline that crosses MCBCP and the Fallbrook Naval Weapons Station property. Two lift stations on MCBCP will lift the water. The FPUD property is adjacent to the Naval Weapons Station and currently holds FPUD's wastewater treatment plant and a small solar facility.

Water Treatment Plant (WTP) and Treatment Train

The new Fallbrook Water Treatment Plant will be located next to FPUD's existing wastewater treatment plant and will reuse some of the existing drying beds for solids drying prior to off-site removal. A new tank at the Gheen Zone will also be constructed for extra storage. A civil site plan is shown as Figure 1-3. The treatment train is designed to provide potable water. The feasibility-level design for the proposed treatment train is summarized below. The new treatment plant design includes the following components:

- Feed groundwater equalization tank
- Pretreatment with potassium permanganate oxidation to precipitate out iron and manganese
- Reverse osmosis (RO) desalination and RO bypass line for blending
- Adjustment of RO product pH using sodium hydroxide
- Primary disinfection through addition of sodium hypochlorite
- Secondary disinfection using chloramines derived from ammonia hydroxide

Process Flows and Mass Balance Diagrams

The process flow diagram for the SMRCUP unit is provided as Figure 4-1. Feed water for the plant is provided by existing MCBCP groundwater wells. Treatment plant product is pumped to the Gheen Tank for storage and transport to Red Mountain Reservoir. Three waste streams exit the facility including:

- Iron and manganese treatment system solids discharge to existing sludge drying beds
- RO concentrate discharges to ocean outfall
- RO clean-in-place system neutralized waste stream discharges to FPUD's sewer

Design flow and water quality inputs are summarized in Table ES-1.

Table ES-1. Water Quality Inputs

Feed Water Quality Parameters[1]	Value
Groundwater Maximum Flow (cfs)	13.5
Design TDS (mg/L)	900
Design pH	7.4
Design Fe (mg/L)	0.4
Design Mn (mg/L)	0.5
Design TOC (mg/L)	3.0

[1] TDS, total dissolved solids; TOC, total organic carbon; mg/L, milligrams per liter.

Equipment removal efficiencies are summarized in Table ES-2.

Table ES-2. Mass Balance Diagram Equipment Removal and Recovery Efficiency

Process Flow Diagram Equipment	Removal/Recovery Percentage
Iron and Manganese Plant	Mn Removal – 97% Fe Removal – 97% Process Recovery – 100%
RO Plant	Salt Rejection – 96.4% Process Recovery – 85%

Removal percentages are based on manufacturer discussions and product information. Design constituent concentrations were applied to maximum peak flows to create the mass balance diagram. The target product-water TDS concentration is 500 mg/L as provided by the client and recommended by the Environmental Protection Agency's secondary maximum contaminant levels. Unit process sizing was based on the maximum groundwater feed flow expected to occur in July of a wet year. The pretreatment oxidation, RO antiscalant addition, clean-in-place chemical requirements, post-treatment chemical neutralization, disinfection, and waste neutralization chemical estimates are based on a maximum feed water peak flow of 8.73 million gallons per day (MGD) (13.5 cfs). Additionally, feed, product and solids pumps were sized based on the maximum peak flow rate.

1. Pretreatment / Iron and Manganese Removal

Feed water is stored in an equalization tank at low flows to provide sufficient volume for downstream processes. After oxidation with potassium permanganate, filters are able to remove 97 percent of the iron and manganese in the system, reducing the effluent iron and manganese concentrations to 10 micrograms per liter (µg/L). Iron and manganese system reject streams flow to reclaim tanks for solids separation. The liquid is decanted and returned to the start of the iron and manganese process for treatment. The solids are pumped to existing sludge drying beds at the facility for disposal.

2. Desalination

The feed water for the plant has relatively low salinity. Therefore, to maximize the RO treatment process efficiency, the effluent from the iron and manganese plant is split into two lines prior to desalination. The first split line is the RO bypass line. This line receives no further treatment until the post-treatment disinfection; it bypasses the RO desalination units and feeds directly into the clearwell. The volumetric flow of this line is 4.27 MGD (6.6 cfs), or 49 percent based on the RO unit salt rejection and recovery to ensure that the blended flow in the clearwell achieves a TDS concentration of 500 mg/L.

The second line feeds the RO desalination process at a maximum flow of 4.46 MGD (6.9 cfs). Antiscalant is added to the RO feed. The RO plant rejects 96.4 percent of the influent salts, resulting in a process recovery of 85 percent. Treated flows from the RO plant are neutralized with sodium hydroxide. They achieve a maximum flow rate of 3.81 MGD (5.9 cfs). Concentrate flows from the RO unit are discharged to an ocean outfall with a maximum flow of about 0.65 MGD (1.0 cfs) and a TDS concentration of 5,816 mg/L, based on the 900-mg/L design TDS feed concentration.

3. Post-treatment:

The RO feed, product, and the bypass lines are blended in the clearwell to achieve the target TDS of 500 mg/L. Sodium hypochlorite is added for primary disinfection and ammonia hydroxide is added last to form a chloramine residual in the pipeline. Chloramines are a weaker disinfectant than hypochlorite but are longer lasting, which is beneficial within a long pipeline. Chloramines also prevent the formation of disinfection byproducts. Treated water from the clearwell is transported to the Gheen Tank. The maximum treated flow for the SMRCUP treatment plant is estimated to be about 8.01 MGD (12.4 cfs), or 92 percent of the feed groundwater flow based on cumulative process recoveries in the system.

SMRCUP Product Flows

Table ES-3 presents a summary of the average and maximum feed and product flows for the SMRCUP plants. The average and maximum product flows from the SMRCUP treatment plant are 1.16 MGD (1.8 cfs) and 8.01 MGD (12.4 cfs), respectively. Overall recovery of the SMRCUP WTP is 92 percent.

Table ES-3. SMRCUP Feed and Product Water Flow Summary

Month	Average Flows (cfs)		Maximum Flows (cfs)	
	Feed Flow	WTP Product	Feed Flow	WTP Product
Jan	0.0	0.0	8.8	8.1
Feb	0.0	0.0	8.3	7.6
March	1.8	1.7	9.8	9.0
April	2.6	2.4	10.9	10.0
May	1.7	1.6	10.0	9.2
June	4.3	4.0	12.1	11.1
July	4.8	4.4	13.5	12.4
Aug	4.6	4.2	12.5	11.5
Sept	3.9	3.6	11.6	10.7
Oct	0.7	0.6	9.2	8.5
Nov	0.0	0.0	6.4	5.9
Dec	0.0	0.0	5.7	5.2
Average	2.0	1.8	9.9	9.1
Min	0.0	0.0	5.7	5.2
Max	4.8	4.4	13.5	12.4

1 Introduction

The Santa Margarita River (SMR) rises in southwestern Riverside County, California, and flows through Marine Corps Base Camp Pendleton (MCBCP), in northwestern San Diego County, on its way to the Pacific Ocean (Figures 1-1 and 1-2). Ownership of the river's waters has long been disputed between MCBCP and the Fallbrook Public Utility District (FPUD), which serves the community of Fallbrook just east of the Camp. (See section 2.1.1 for a court history regarding waters in the Santa Margarita River basin.) The Santa Margarita River Conjunctive Use Project (SMRCUP) was proposed to improve water supply reliability for both MCBCP and FPUD by better managing the yields of the lower Santa Margarita River, and to help resolve several decades of litigation between these parties.

This feasibility design report has been prepared by the Bureau of Reclamation (Reclamation) on behalf of MCBCP and FPUD. The study was funded by Reclamation's Southern California Area Office and performed by personnel of Reclamation's Technical Service Center in Denver, Colorado. This report has the engineered construction components organized into two primary work groupings: water treatment and the product water transmission from the treatment plant to an FPUD service connection below Red Mountain Reservoir. Two (2) pumping plants will be built to lift the treated water about 550 feet. One will be at the water treatment plant; the other will be at an FPUD site approximately two-thirds of the way along the pipeline to Red Mountain Reservoir. About 6.7 miles of 24-inch pipe will be installed for the water transmission pipeline.

Raw waters will be furnished by MCBCP to a site owned by FPUD near the Fallbrook Gate. The new water treatment plant will be constructed at this FPUD site. See Figures 1-1, 1-2, 1-3, and B1 for the layout of the proposed facilities. MCBCP will be supplying water from existing and new groundwater wells located on the base.

MCBCP will separately build the pipeline to deliver the raw water to the FPUD site. The pipeline will run from MCBCP wells, across the Naval Weapons Station, to the FPUD site (Figure 1-2). That raw water supply pipeline work will be outside this study. The hydrologic availability of water that MCBCP will furnish has been studied and reported by Stetson Engineers (2007a, b). The amount of supplied water will differ by years and by seasons within each year. By agreement between MCBCP and FPUD, up to 800 acre-feet of water could be supplied in a peak maximum month. Although varying amounts of water will be delivered each year and through the months within each year, hydrologic studies predict that in an average year about 3,100 acre-feet would be furnished by MCBCP. The 800-acre-feet-per-month maximum established the furnished raw water design flow rate to be as high as 13.5 cubic feet per second (cfs).

Figure 1-1. Location of the Santa Margarita Conjunctive Use Project

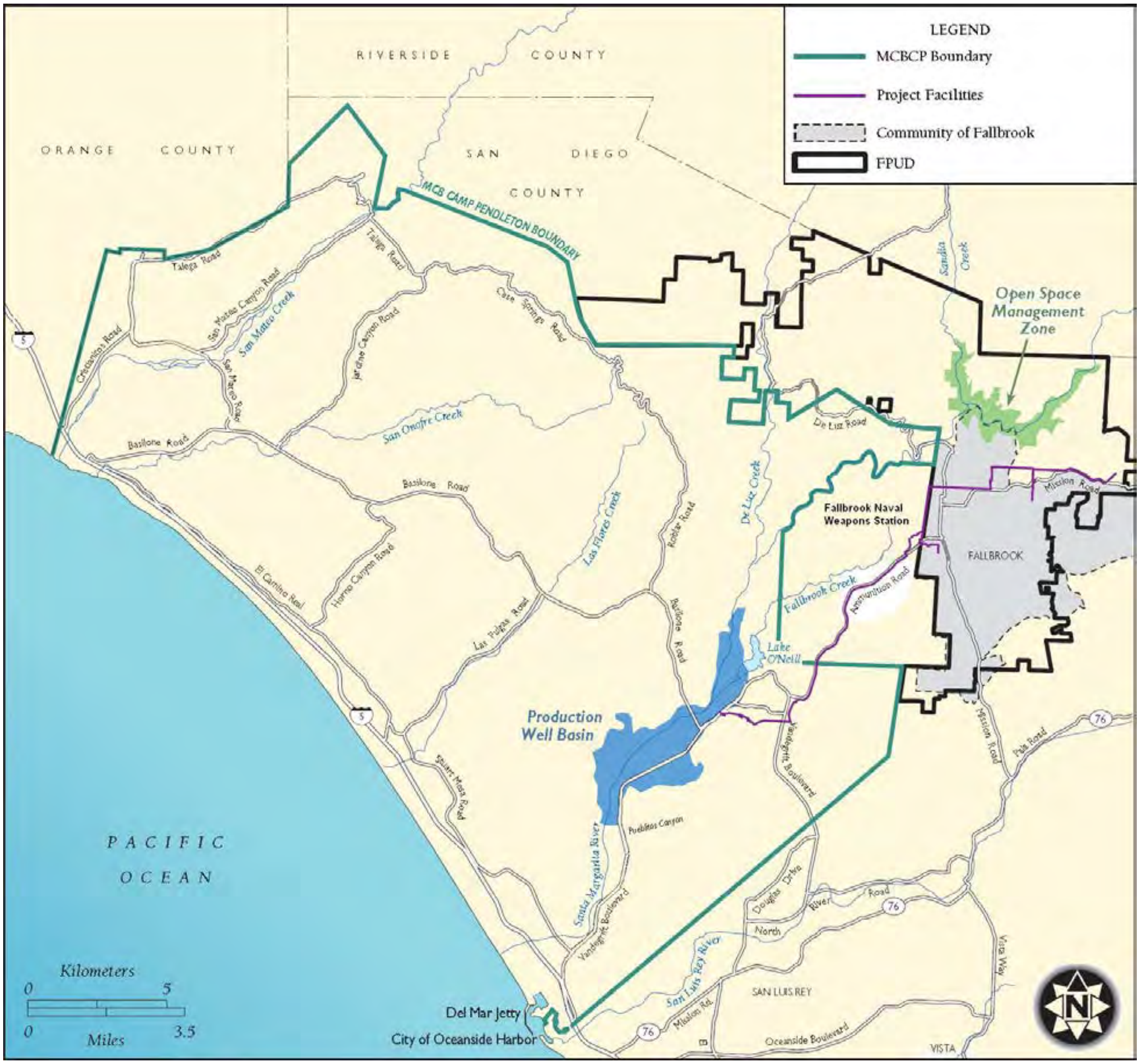


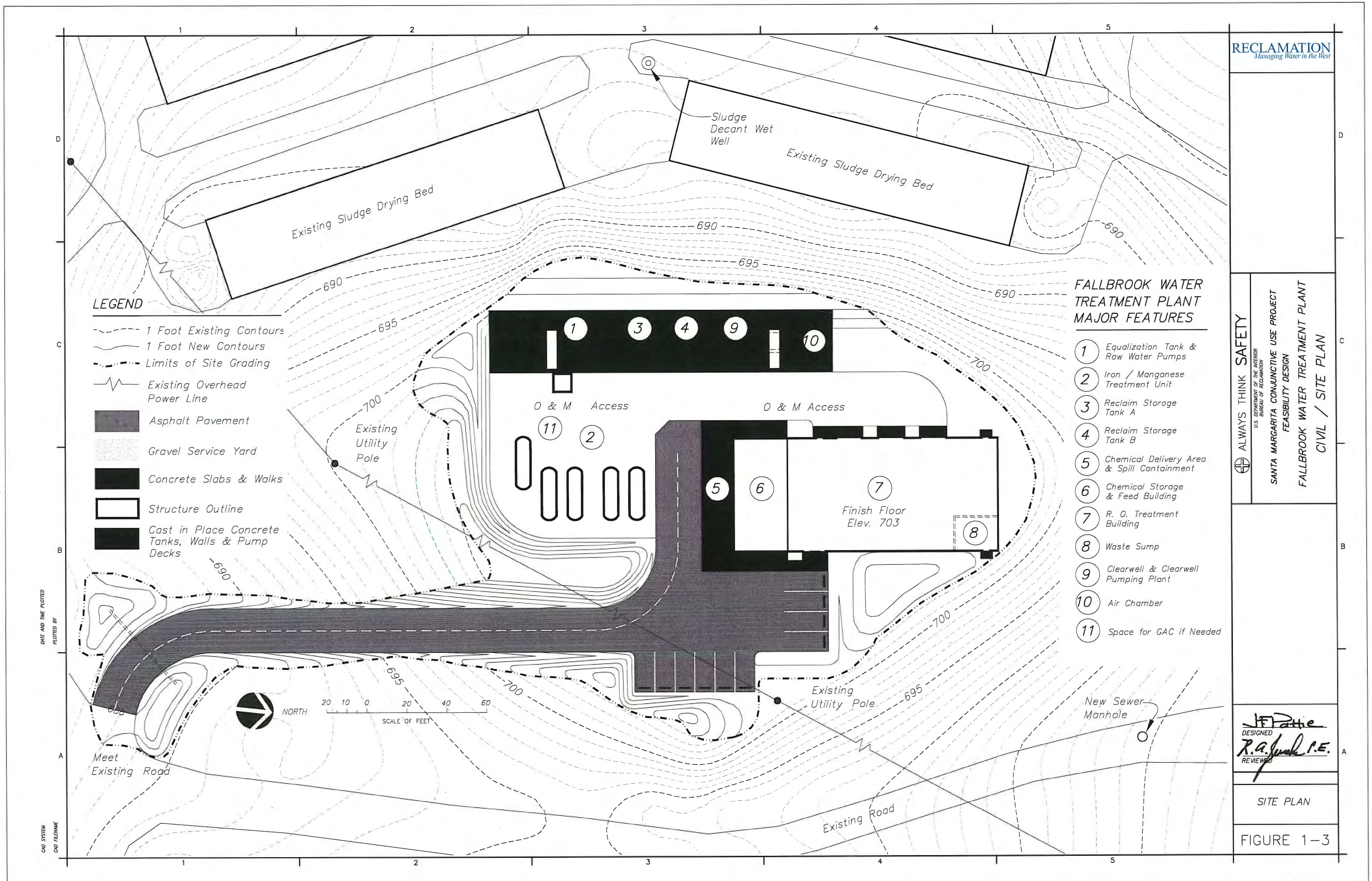
Figure 1-2. Location of project facilities relative to MCBCP and the community of Fallbrook.

The new raw water treatment plant will be owned and operated by FPUD. Treatment processes are developed based on the MCBCP groundwater quality. More details on the treatment processes are found in the water treatment section. Included with the water treatment plant is a brine disposal connection to dispose of saline reject water and backwash water. This connection will make use of an existing nearby outfall, and FPUD has agreements in place to use the outfall for this added capacity. The treated water will be pumped from the product clearwell for transmission. About 12.4 cfs is the maximum treated water flow rate.

The treated water will be delivered to FPUD system users via two (2) pipeline reaches between the new water treatment plant and Red Mountain Reservoir.

Reach 1 will lift the water about 400 feet to a new storage tank at FPUD's Gheen site about 4 miles away. FPUD has an existing tank at the site that is used to control pressure to an elevation about 1037 feet above mean seal level in the service zone. An accompanying operating tank for this project will be built nearby. The treated water will then be given a booster lift of about 110 feet from the Gheen site to the higher 1140-foot elevation service connection below the FPUD Red Mountain Reservoir. This second reach is about 2.1 miles long. Both reaches will use 24-inch diameter pipeline.

An added project benefit is that these pipelines can be used in emergency conditions during drought years to return water to MCBCP. If a drought or an emergency were to occur on MCBCP, by use of sectional valves on these pipelines up to 21 cfs of treated water can be returned from the FPUD piping to the MCBCP raw water pipeline system. Bypass valves installed by the water treatment plant and by the Gheen tee will allow a direct flow from the FPUD Red Mountain service connection to the MCBCP raw water line.



RECLAMATION
Managing Water in the West
Existing Sludge Drying Bed
Sludge Decant Wet Well
Existing Sludge Drying Bed
LEGEND
1 Foot Existing Contours
1 Foot New Contours
Limits of Site Grading
Existing Overhead Power Line
Asphalt Pavement
Gravel Service Yard
Concrete Slabs & Walks
Structure Outline
Cast in Place Concrete Tanks, Walls & Pump Decks
O & M Access
O & M Access
Existing Utility Pole
Finish Floor Elev. 703
Existing Utility Pole
New Sewer Manhole
Meet Existing Road
Existing Road
NORTH
SCALE OF FEET
FALLBROOK WATER TREATMENT PLANT MAJOR FEATURES
1 Equalization Tank & Raw Water Pumps
2 Iron / Manganese Treatment Unit
3 Reclaim Storage Tank A
4 Reclaim Storage Tank B
5 Chemical Delivery Area & Spill Containment
6 Chemical Storage & Feed Building
7 R. O. Treatment Building
8 Waste Sump
9 Clearwell & Clearwell Pumping Plant
10 Air Chamber
11 Space for GAC if Needed
ALWAYS THINK SAFETY
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
SANTA MARGARITA CONJUNCTIVE USE PROJECT
FEASIBILITY DESIGN
FALLBROOK WATER TREATMENT PLANT
CIVIL / SITE PLAN
DESIGNED
REVIEWED
SITE PLAN
FIGURE 1-3

2 Background and Scope

The purpose of the Proposed Action is to efficiently meet the long-term water demands of MCBCP and FPUD, reduce dependence on imported water, maintain watershed resources, and improve water supply reliability by managing the yield of the lower SMR basin. The Proposed Action would also provide a physical solution to long-standing litigation. The Proposed Action would achieve the following specific needs of both MCBCP and FPUD:

- Satisfy MCBCP and FPUD's future water demands while reducing the dependence on costly imported water.
- Connect MCBCP to an off-base water supply (i.e., imported water via the San Diego Aqueduct) to provide a supplemental water source during drought or emergency situations.
- Upgrade MCBCP's existing groundwater diversion and recovery facilities, and maximize subsurface water storage and water rights to meet future water supply demands.
- Provide FPUD with a local water source, reduce its dependency on imported water supplies, and thereby reduce costs. As a publicly held water district, FPUD has an obligation to provide adequate water quantities of acceptable quality to customers within its service area at the lowest possible cost. In addition to providing additional water supply, development of an adaptive groundwater management program would allow FPUD significant flexibility in meeting water demands and controlling water costs.
- Permanently protect the FPUD's open-space management zone upstream of the conjunctive use project.
- Manage the lower SMR groundwater basins to improve groundwater quality, and maximize the amount of surface and groundwater available to meet the ecological needs of sensitive habitats within the SMR basin.

The Proposed Action would also resolve the water rights issues between MCBCP and FPUD and satisfy the Court's order to find a "physical solution" to the ongoing dispute in *United States v. Fallbrook Public Utility District et al.* MCBCP and Fallbrook entered into a memorandum of understanding (MOU) in 2001 agreeing to jointly participate in the project in good faith and with full cooperation. Reclamation, MCBCP, and FPUD signed a conceptual points of agreement document in January 2011.

Imported water alone is not likely to support MCBCP's and FPUD's water demand in the future, as drought and statewide water supply issues may limit the availability of imported water. The advantages of developing a viable conjunctive use project for FPUD include reduced dependency on imported water supplies and development of a local water supply, thereby reducing costs. As a publicly held water district, FPUD has an obligation to provide adequate water quantities of acceptable quality to customers within its service area at the lowest possible cost. In addition to providing additional water supply, development of an adaptive groundwater management program would allow FPUD significant flexibility in meeting water demands and controlling water costs.

MCBCP would benefit from the establishment of a southern connection to imported water supplies and upgrades to the existing groundwater diversion and recovery facilities, providing increased water supplies to accommodate future growth. MCBCP has an interest in maximizing subsurface water storage and water rights to meet current and future water supply demands.

Reclamation's development of a conjunctive use project in this area would create an opportunity to satisfy not only future water demands and economic factors associated with the purchase of imported water, but also the ecological demands of sensitive habitats that depend on both the surface and groundwater within the SMR basin.

2.1 Project Background

2.1.1 Legal History of Santa Margarita River Conjunctive Use Project

In the late 1880s, developers of land in the Fallbrook area of northern San Diego County formed Fallbrook Water and Power Company, seeking to construct a dam on the lower SMR as the source of both water and power. Rancho Santa Margarita, the original owner of the MCBCP and Naval Weapons Station lands, filed suit to stop the dam construction, giving rise to more than 100 years of water rights litigation on the river.

Due to litigation and lack of finances, the Fallbrook Water and Power Company dissolved and the original dam project was abandoned. In 1891, attempts were made to form an entity known as Fallbrook Irrigation District. However, the Supreme Court ruled that the statute under which the irrigation district had been formed, the Wright Act, was unconstitutional, halting those water development plans. In 1922, FPUD was formed to provide water to the 500-acre Fallbrook township. Then, in 1925, Fallbrook Irrigation District was reinstituted. After years of studies, FPUD pursued investigations to construct a dam in the lower basin near the confluence of the SMR and Sandia Creek. In the meantime, Rancho Santa Margarita had started a long-running battle with Vail Ranch, the main upstream water user, over rights to the river's waters.

In 1928, Fallbrook Irrigation District filed suit to condemn (take possession of) unused riparian rights on the River, notwithstanding the ongoing dispute between

Rancho Santa Margarita and Vail Ranch. In 1930, the year of the initial judgment in the Vail litigation, Fallbrook Irrigation District was issued a permit to construct a dam and appropriate 35,000 acre-feet (af) for SMR storage and 15,000 af per year (af/y) for annual use. However, because of financial problems, Fallbrook Irrigation District could not build the dam and, in 1937, the irrigation district was taken over by FPUD.

In 1940, Rancho Santa Margarita and Vail Ranch settled their lawsuit by way of a stipulated judgment. Under the 1940 settlement, one-third of the natural flow of the river was allocated to Vail Ranch and two-thirds to Rancho Santa Margarita. FPUD was not a party to the suit. Later in 1942, the Department of the Navy (DON) condemned part of Rancho Santa Margarita as the site for MCBCP.

Following further investigations by the U.S. Army Corps of Engineers, MCBCP and FPUD applied for water rights permits to divert and store water from the SMR. In 1946 and 1947, FPUD was granted three 10,000-af permits for the diversion and storage of water from the SMR at the Fallbrook Reservoir site. In 1948, DON filed for a permit to build De Luz Dam at MCBCP. Then in 1949, the two parties agreed on a plan to build a multi-purpose dam at the De Luz site to serve them both.

In 1951, the United States (on behalf of MCBCP) abandoned its State water rights application and brought suit against FPUD and about 3,600 other upstream users to claim MCBCP's right to the flow of the SMR (*United States v. Fallbrook Public Utility District, et al.*; Case No 1247-SD-C). In September 1963, following the final judgment and decree in the case, the United States filed application 21471 for diversion and storage of SMR surface flow. In 1973, the California State Water Resources Control Board (SWRCB) separated this application into two parts, 21471A and 21471B. The SWRCB ordered a license be issued for application 21471A to allow diversion of up to 4,000 af/y into percolation ponds for storage in MCBCP's lower Santa Margarita underground basins and later use for military, domestic, municipal, and agricultural purposes. Application 21471B was for above-ground storage of up to 165,000 af/y in De Luz Dam for such uses as well as for incidental flood control and recreational purposes. The SWRCB ultimately issued a license for application 21471A (percolation pond license) and a permit for application 21471B for the facility that, 5 years later, was to become part of the MCBCP -FPUD "Two-Dam Project." The 1950's also saw the FPUD acquire approximately 1,392 acres of land surrounding the old Fallbrook-Lippincott dam site. The property was acquired through eminent domain for the Two-Dam Project.

Following years of decisions and appeals, the U.S. District Court issued a modified final judgment and decree in 1966. In 1968, MCBCP and FPUD entered into an MOU for the purpose of settling the SMR water rights claims that had been the subject of litigation between them since 1951. This 1968 MOU called for the construction of two above-ground storage facilities that became known as the "Two-Dam Project." In his 1968 "Order Approving Memorandum of Understanding and Agreement and Amending Modified Final Judgment and Decree," Federal District Court Judge Carter emphasized "that the water rights of the stream system cannot be developed fully in the absence of a 'physical solution' which makes equitable provisions as between [MCBCP and FPUD] for the manner in which each of them shall make use of the waters of the stream system to which it is entitled under its water rights . . . ." In 1974, Fallbrook and MCBCP assigned their water rights permits to Reclamation (permits 15000, 8511, and 11357) in anticipation of construction of the Two-Dam Project.

Because of environmental and funding concerns as well as other factors associated with the Two Dam Project, in the late 1980s the parties decided to pursue an alternative, environmentally preferable "physical solution." In 1990, FPUD and MCBCP entered into an agreement entitled the "Conjunctive Use Agreement," to cooperatively manage the aquifer and river on MCBCP, giving birth to the currently used name for the long-sought "physical solution" to the water supply needs of MCBCP and FPUD. This agreement was contingent upon the use of reclaimed water under a proposed 1990 "Four-Party Agreement" between MCBCP, FPUD, Rancho California Water District (RCWD) and Eastern Municipal Water District (EMWD). Under the Four-Party Agreement, MCBCP and FPUD would have agreed to support a basin plan amendment that relaxed the water quality standards in the SMR watershed to facilitate the use and discharge of excess treated wastewater by EMWD and RCWD. In return, EMWD and RCWD would have agreed to augment the flows of the SMR with the discharge of the highly treated wastewater and make a significant capital investment in a reverse osmosis (RO) plant at MCBCP in order to mitigate the degradation of MCBCP's groundwater supply resulting from upstream stormwater pollution and agricultural return flows. For a variety of reasons, the Four-Party Agreement never materialized, and this failed agreement was the subject of the 2008 litigation in the Central District of California *United States v. Eastern, et al.* FPUD joined the United States as a co-plaintiff in this litigation.

Also in the early 1990s, RCWD petitioned the SWRCB to change its permit 7032 in a manner that would allow RCWD to increase its pumping in the upper basin and change the place where it could use that water. MCBCP then submitted a protest to the SWRCB regarding RCWD's petition, and this protest led to a negotiated settlement in 2002: the "Cooperative Water Resources Management Agreement" (CWRMA) between RCWD and MCBCP. Under CWRMA, RCWD guarantees certain minimum flows in the SMR by directly discharging water in the river upstream from MCBCP. Additionally, CWRMA requires that RCWD manage its groundwater pumping in an area upstream of "the Gorge" (Temecula Canyon) on a safe-yield basis and mandates a cooperative monitoring program to assess the impacts of CWRMA on the water supply, water quality, and riparian habitat within MCBCP. In 2009, the SWRCB approved RCWD's petition to change permit 7032 and included the CWRMA flow requirements as a condition to RCWD's permit 7032.

MCBCP and FPUD have continued and focused their efforts to find an alternative "physical solution":

- In 2001, they entered into an MOU agreeing to jointly pursue a project with full cooperation.
- In fiscal year 2004, Reclamation received an appropriation to study the feasibility of the SMRCUP.
- On September 13, 2004, Reclamation, MCBCP, and FPUD signed an MOU agreeing to jointly participate in the design and possible construction and operation of a "physical solution" to the *United States v. Fallbrook Public Utility District, et al.* lawsuit. Reclamation is responsible for completing the feasibility study; Reclamation and DON are joint lead agencies for completing the Federal Environmental Impact Statement (EIS); and FPUD is the lead agency for completion of the State-mandated Environmental Impact Report (EIR).
- On November 1, 2004, Reclamation and DON published a Notice of Intent to prepare an EIS in the Federal Register (U.S. Navy and Bureau of Reclamation 2004).
- On December 14, 2004, Reclamation and DON sent a Notice of Preparation to the California State Clearinghouse.
- On March 30, 2009, President Obama signed Public Law 111-11 (HR 146), the Omnibus Public Land Management Act of 2009. Title IX, Section 9108 of this act contains the construction authority for the SMRCUP. This authority expires in April 2019.
- On January 19, 2011, Reclamation, MCBCP, and FPUD signed a conceptual project framework agreement that outlines the framework of the conjunctive use project.

2.1.2 Context and Legal and Institutional Framework

2.1.2.1 Context

This subsection discusses the context within which the Proposed Action has been planned and its alternatives developed. In particular, given MCBCP's size, land-use requirements, and location — 125,000 acres of undeveloped and relatively pristine land circumscribed by the unceasing urbanization of Orange, Riverside, and San Diego Counties — MCBCP commanders and staff leaders long ago incorporated into the base's business and operational paradigm the need not only to consider the environmental impacts of the base's actions, but to ensure that action alternatives are planned, constructed, and operated in such a way as to go beyond regulatory compliance (i.e., to proactively support habitat and species and to pursue the *sustainable use* of natural resources such as water).

MCBCP is being progressively pressured by the urbanization occurring all around it and by the increasing habitat and species stewardship requirements resulting from such urban growth. There is a direct correlation between urban growth and the increase in endangered species populating the base. This pinch between the related phenomena of urbanization and endangered species is most strongly exemplified in the resultant management pressures attending the base's substantial native water supply. The pressure from surrounding urbanization is particularly relevant to the SMR, whose tributaries extend far off the base's property into the highly developing communities of Temecula and Murrieta and which, as noted in Section 1.3, above, satisfies more than 70 percent of the base's military, municipal, agricultural, domestic, and industrial water demand.

Upstream of MCBCP, increased development in the SMR watershed causes more urban runoff, adversely affecting the quality of the base's water supply. Downstream from these urban centers, on the base itself, the DON's commitments under the Endangered Species Act (ESA) may necessitate an allocation of surface water (streamflow) to the conservation of riparian habitats and associated species. Thus, the base's own military, municipal, and domestic water demand is under dual pressures from upstream urban development and downstream ecosystem needs.

MCBCP has developed a well-deserved reputation within the environmental community for its environmental stewardship excellence. MCBCP has become a refugium for many of the region's species, several of which are officially designated as "threatened" or "endangered." The fact that it has continued to be an environmental steward throughout decades of urban development and growth, relates not only to the Marine Corps training mission, which requires large amounts of property to remain undeveloped, but, perhaps more importantly, to the extraordinary compliance and "beyond-compliance" efforts of the expert biologists, botanists, environmental engineers, and ecosystem specialists employed at the base's environmental office, the Assistant Chief of Staff, Environmental Security Office. This office has been recognized over the years for the quality and consistency of the advice it provides and the actions it champions to ensure MCBCP's training and national defense missions are accomplished in a manner that not only minimizes and/or avoids adverse environmental impacts or threats, but that also enables natural habitat and species to thrive. Thus, as with all water resource management projects, the Proposed Action, from its inception, has been analyzed, studied, and planned with the needs of the ecosystem, including in-stream beneficial flow requirements for habitat and species, as one of the major factors driving the project's alternatives analysis.

2.1.2.2 Legal and Institutional Framework

The purpose of the Proposed Action is to provide a physical solution to long-standing litigation, meet the water demands of MCBCP and FPUD, reduce dependence on imported water, maintain watershed resources, and improve water supply reliability by managing the yield of the lower SMR basin. This action is needed to satisfy the unresolved water rights dispute in the lower SMR basin and to help meet the water demands of MCBCP and FPUD. A Decision Memorandum was created by Reclamation, MCBCP, and FPUD describing an interagency agreement to jointly participate in the design and possible construction of a "physical solution" to the unresolved litigation (Reclamation

2006). In January 2011, Reclamation, MCBCP, and FPUD signed a project conceptual framework agreement. The Proposed Action would operate within a legal and institutional framework that has been shaped by legislative, judicial, and Federal and State regulatory action.

2.1.2.2.1 Congressional Authorization

The Omnibus Public Land Management Act of 2009 was signed March 30, 2009 (Public Law 111-11). It includes a section sponsored by Congressman Issa that authorizes the Secretary of the Interior, after certain conditions are met, to construct the facilities needed to extract additional water from the SMR through a joint project. The conjunctive use project legislation is an outgrowth of the "physical solution" recommended by a Federal judge in 1968 in order to facilitate the settlement of the longstanding water rights dispute outlined above. The legislation contains certain conditions that must be satisfied before Reclamation is authorized to construct the project.

2.1.2.2.2 Federal Court

The Proposed Action constitutes the "physical solution" that promises to conclude more than 60 years of negotiation and litigation between MCBCP and FPUD over the right to use water from the SMR. The litigation commenced in 1951 with a federal lawsuit, *United States v. Fallbrook Public Utility District, et al.* (1247-SD-C), filed by the United States on behalf of MCBCP against FPUD and all water users within the SMR to quiet title to MCBCP's SMR water rights (*note:* "quiet title" is a legal action brought to obtain final determination as to the title of a specific piece of property, or in this case water rights). The 1951 litigation is still open today with regular Court status calls, quarterly Watershed Steering Committee meetings, and an Annual Report filed by the court-appointed SMR Watermaster. The Proposed Action is the settlement of the longstanding water rights dispute between MCBCP and FPUD and a settlement agreement will be forwarded to Federal Court for approval. A court-approved settlement agreement is a condition that must be satisfied before Reclamation is authorized to construct the project.

2.1.2.2.3 Secretariat Decisions

Public Law 111-11 identifies Secretariat-level decisions impacting the Proposed Action. Namely, the Secretary of the Interior must determine that the Proposed Action has completed the economic, environmental, and engineering feasibility studies as a condition that must be satisfied before Reclamation is authorized to construct the project. Additionally, pursuant to the Public Law 111-11, the Secretary of the Navy is authorized to make decisions concerning the DON's share of project costs, control of project facilities located within MCBCP, and sale of DON's excess water produced by the project.

2.1.2.2.4 Federal and State Regulatory Agencies

Many Federal and State laws establish requirements for adequate planning, implementation, and management of water resources. Regulations have been developed to augment and clarify the laws and to provide details not included in the laws. The Proposed Action must comply with applicable rules and regulations promulgated by all of the following:

- USEPA,
- U.S. Fish and Wildlife Service,
- U.S. Army Corps of Engineers,
- California State Coastal Commission,
- California Department of Fish and Game,
- SWRCB, and
- California Department of Public Health (CDPH).

Additionally, several agencies may have some level of discretionary project approval authority over the Proposed Action, including the San Diego Regional Water Quality Control Board, SWRCB, Army Corps of Engineers, and California Coastal Commission. Lastly, consultations may be required with the Fish and Wildlife Service, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, California Department of Fish and Game, and the State Historic Preservation Office. The Federal and State regulatory requirements are briefly outlined in Section 1.7. While the Proposed Action must comply with all applicable State and Federal regulatory requirements and approvals, the SWRCB must grant the necessary water right permits to implement to the Proposed Action before Reclamation is authorized to construct the project.

2.1.2.2.5 Water Rights Permitting

Water right approvals are needed from the State of California to implement to the Proposed Action. The relevant agency is the SWRCB, which has the authority to administer previously issued water rights and to grant new water rights.

Reclamation, DON, and FPUD hold various water rights to waters of the Santa Margarita River basin (Tables 2-1 and 2-2). The project proponents intend to exercise the majority of the water rights listed below for the benefit of their constituents by means of the Proposed Action. The resulting conjunctive use project water yield will be shared between MCBCP and FPUD. MCBCP will operate the project on base. Water for on-base use will be treated on base. MCBCP will deliver raw water from the wells tapping the underground aquifers to FPUD via the new pipeline. FPUD will treat its share of project yield at a new water treatment plant to be located at the upper end of the pipeline, at the boundary between FPUD and the Naval Weapons Station, as further discussed in Section 6.1.

In addition to the Federal Court Case 1247, there is a 1940 State Court stipulated judgment settling a dispute between MCBCP's predecessor and certain upstream water right holders (*Rancho Santa Margarita v. Vail*, SD Superior Court No. 42850), which addresses MCBCP's riparian water rights.

Table 2-1. FPUD and MCBCP Santa Margarita River Basin Water Rights Permits and Licenses

Permit / License Number	Status	Holder	Priority Date	Storage Site	Annual Amount (af)	Storage Period
8511	Permit	Reclamation	10/11/46	Fallbrook Reservoir	10,000	01/01–12/31
11356	Permit	FPUD	11/28/47	Lake Skinner	10,000	11/01–06/01
11357	Permit	Reclamation	11/28/47	Fallbrook Reservoir	10,000	11/01–06/01
15000	Permit	Reclamation	09/23/63	De Luz Reservoir	165,000	01/01–12/31
10494	License	DON	09/23/63	Underground	4,000	10/01–06/30

Table 2-2. Other MCBCP Santa Margarita River Basin Water Rights

Water Right	Status	Owner	Annual Amount	Diversion Period
Riparian	Active	MCBCP	(Not applicable.)	Year- round
Pre-1914 Appropriative Right	Active	MCBCP	1,200 af	Year-round

The CWRMA is one of the tools used to manage the division of water addressed under the 1940 stipulated judgment. It has been incorporated into Case 1247, and is subject to the continuing jurisdiction of the Federal Court in that case. As discussed above in Section 1.5.1, the DON was issued a permit through application 21471 for the Two-Dam Project and the existing groundwater recharge operations with a priority date in 1963. In 1973 the SWRCB separated the two portions of the permit, issued a license to the DON for the groundwater portion (license 10494), and required the DON to assign the surface water portion (application 21471B) to Reclamation (permit 15000). Similarly, FPUD's three 10,000-af permits (permits 8511, 11356, and 11357) were to be assigned to Reclamation for the storage of water in Fallbrook Reservoir (the second dam of the Two-Dam proposal in the Santa Margarita Project). The permit assignments to Reclamation were in anticipation that the water facilities would be constructed by Reclamation for the benefit of the DON and FPUD. These permits (15000, 8511, 11356, and 11357) were assigned to Reclamation by DON and FPUD under SWRCB Order WR 73-50.

Since that time, Reclamation assigned permit 11356 back to FPUD for its Lake Skinner project. FPUD has worked to perfect permit 11356 by re-locating the point of diversion to Lake Skinner in Riverside County. Lake Skinner and permit 11356 are not part of the Proposed Action. The three remaining water rights permits held by Reclamation provide the legal basis for appropriating additional water for a joint conjunctive use project. This project is the environmentally preferable approach to the Two-Dam Project.

The Proposed Action would require SWRCB approval to change three of the existing permits (15000, 8511, and 11357) to conform the water rights to the project, and to extend the time within which water can be put to beneficial use. The required petitions for change and extension are pending at the SWRCB. Among other things, these petitions propose to move the points of diversion downstream to the project point of diversion within MCBCP, where the existing sheet pile weir will be replaced by an improved inflatable diversion facility. Direct diversion and diversion to storage will be accommodated through the conjunctive use project facilities. This project also requires a petition to redistribute storage from the unconstructed above-ground reservoirs previously contemplated, to the underground storage basin. The required underground storage supplement has also been filed with the SWRCB. A water availability analysis has been conducted and published (Stetson Engineers 2007a) to support changes to and extension of the existing permits and any new water right permits that may be required. The project's EIS/EIR will include an evaluation of the impacts of the Proposed Action and alternatives on hydrologic, biological, and other resources, and identifies mitigation measures for environmental impacts.

3 Water Quantity and Quality

3.1 Water Quantity

The proposed treatment plant will treat water from the groundwater basins in MCBCP. The basins contain enough water to pump out only during wet periods, which may not occur every year. Table 3-1 presents projected pumping rates for the wells in average, wet and dry years.

Table 3-1. Monthly Projections of Groundwater Flows
(Flows in millions of gallons per day)

Month	Water Year Type		
	Dry Year	Average Year	Wet Year
January	0	0	5.7
February	0	0	5.4
March	0	1.2	6.3
April	0	1.7	7.0
May	0	1.1	6.5
June	0	2.8	7.8
July	0	3.1	8.7
August	0	3.0	8.1
September	0	2.5	7.5
October	0	0.5	5.9
November	0	0	4.1
December	0	0	3.7

MCBCP operates a series of wells within its boundaries, in groundwater basins adjacent to the SMR. Base personnel alone will decide which wells are or are not pumped. The wells connect to a central pipe that runs through the well field, out from MCBCP, and to the Fallbrook WTP. The water is blended from as many as 14 contributing wells. Groundwater would be pumped from four (4) existing wells located in the Chappo Basin, four (4) existing wells in the Upper Ysidora Basin, five (5) new groundwater wells in the Upper Ysidora Basin and one (1) new well in the Chappo Basin. The well locations are shown in Figure 3-1. Gallery wells, which are wells located adjacent to the river, are not planned for use.

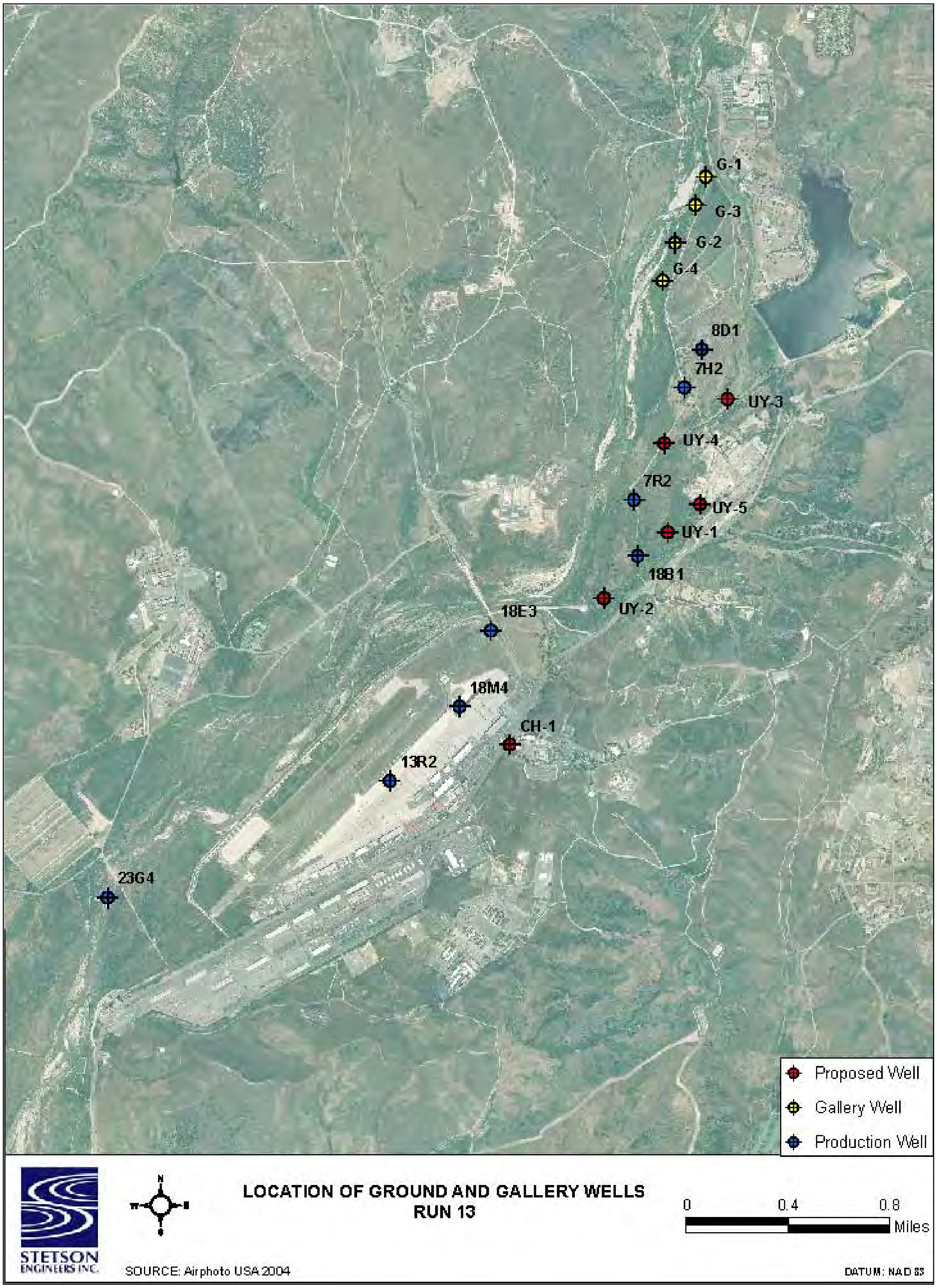


Figure 3-1. Wells used in the Santa Margarita River Conjunctive Use Project.

Of the wells noted above, flow data and iron and manganese water quality data are currently available for only six of them. Wells used to determine influent iron and manganese concentrations were:

- Existing Chappo wells 2301, 23063, 23073, and 330923
- Existing Ysidora wells 2603 and 26071

3.2 Water Quality

The basins are highly conductive, so there is not a large variation in water quality from well to well. The exact water quality at any point in time is impossible to predict due to the many wells that are planned for use. Water quality analyses are available for each of the wells from 2001 to 2007. These analyses examined the majority of inorganic parameters, pH, total dissolved solids (TDS), major cations and major anions.

Fallbrook has asked Reclamation to provide a feasibility-level design and cost estimate for a plant that meets the Safe Drinking Water Act. Design of a water treatment plant considers the State Health Department's limits, and those are used when they are more stringent than the Federal limits. Table 3-2 lists the average and range of water quality results from the contributing wells for the years 2001 to 2007. It also lists the design influent value Reclamation used for the Fallbrook WTP, and the Federal and State allowable limits. Additional information for all Safe Drinking Water Act parameters can be found at http://water.epa.gov/drink/contaminants/index.cfm. California's Public Drinking Water Program regulations can be found at this website: http://www.cdph.ca.gov/programs/Pages/DWP.aspx.

There are many Safe Drinking Water Act parameters for which Reclamation did not receive any data. These include volatile organic compounds and synthetic organic compounds. For this report, Reclamation has assumed that this missing data will not affect the feasibility-level design. There are several considerations that support this assumption:

- Many of the parameters for which no data exist are not typically found in groundwater. The EPA's Ground Water Rule, promulgated under the Safe Drinking Water Act, addresses only groundwater contaminants and sets forth a much smaller set of requirements than would apply if surface water was to be treated.
- MCBCP has analyzed many of these wells for a longer period of time than the period of record used here. If an analyzed parameter exceeds its maximum contaminant level (MCL) in any well, it is highly likely that the staff at the base would take the well off-line if the contaminant could not be reduced to acceptable levels.
- MCBCP has been using water from the aquifer with only iron and manganese treatment and has continuously met all State and Federal MCLs.

Table 3-2. Influent Design and Regulatory Water Quality Values

Parameter	Units	Proposed Design Influent Value [1]	Max in Data	Regulatory MCLs		Camp Pendleton Combined Wells, 2301 - 330923		
				EPA	CDPH[2]	Avg	Min	Max
Microbiological Agents								
Virus	Count	NA	NA	4 log [3]	4 log [3]	NA	NA	NA
Turbidity	NTU	0.5	25.3	0.3		0.5	0	25.3
General Chemistry								
pH	pH units	7.3	8.2	6.5-8.5		7.3	5.4	8.2
Conductivity	µmho/cm	1600	1660	NA	NA	1240	0.9	1660
Total Dissolved Solids	mg/L	[4] 900	943	500	NA	746	500	943
Color - Apparent	color units	4.0	102	15	NA	3.4	0	102
Odor	TON	0.2	3	3	NA	0.2	0	3.0
Total Hardness	mg/L	380	472	NA	NA	378	246	472
Aggressive Index[5]	None	12	13	NA	NA	12.1	7.7	13.0
Total Organic Carbon	mg/L	[4] 3.0	5.3	NA	NA	1.8	1.0	5.3
Cations								
Aluminum [6]	µg/L	ND	ND	50-200	200	0	0	0
Boron	µg/L	130	264	NA	**NA**	127	0	264
Calcium	mg/L	100	854	NA	NA	98.3	65.0	854
Iron	µg/L	[4] 400	2230	300	NA	208	0	2230
Magnesium	mg/L	40	325	NA	NA	38.2	20.0	325
Manganese	µg/L	[4] 500	2830	50	NA	298	0	2830
Nickel	µg/L	1.0	109	NA	100	0.6	0	109
Potassium	mg/L	4.0	7	NA	NA	3.8	1.9	7.0
Silver	µg/L	ND	ND	0.1	NA	0	0	0
Sodium	mg/L	114	144	NA	NA	113	81.8	144
Zinc	µg/L	2.0	228	5000	NA	2.2	0	228
Anions								
Alkalinity as $CaCO_3$	mg/L	200	370	NA	NA	197	129	370
Carbonate Alkalinity	mg/L	0.025	2.8	NA	NA	0.025	0	2.8
Bicarbonate Alkalinity	mg/L	200	370	NA	NA	205	129	370
Chloride	mg/L	165	430	250	NA	164	125	430
Sulfate	mg/L	200	500	250	NA	193	0	500
Inorganic components								
Antimony	µg/L	0.03	3	6	6	0.03	0	3.0
Arsenic	µg/L	1.0	14	10	10	0.73	0	14.0

Parameter	Units	Proposed Design Influent Value [1]	Max in Data	Regulatory MCLs		Camp Pendleton Combined Wells, 2301 - 330923		
				EPA	CDPH[2]	Avg	Min	Max
Barium	µg/L	60	292	2000	1000	116	100	292
Beryllium	µg/L	0.02	1.0	4	4	0.014	0	1.0
Cadmium	µg/L	ND	ND	5	5	0	0	0
Chromium	µg/L	0.008	1.5	100	50	0.008	0	1.5
Copper	µg/L	4.0	612	1300	1300	3.7[3]	0	612
Cyanide	µg/L	ND	ND	200	150	0	0	0
Fluoride	mg/L	0.4	2.5	2	2	0.4	0	2.5
Lead	µg/L	0.05	9.1	15	15	0.048	0	9.1
Mercury	µg/L	ND	ND	2	2	0	0	0
Nitrate as $N0_3$	mg/L	2.0	10	45	45	1.9	0	9.9
Nitrite as N	µg/L	5.0	630	1000	1000	5.1	0	630
Nitrate + Nitrite as N	µg/L	430	2200	10000	10000	428	0	2200
Selenium	µg/L	0.5	41	50	50	0.5	0	41.0
Thallium	µg/L	ND	ND	2	2	0	0	0
Radiological components								
Gross Alpha	pCi/L	3.0	7.7	15	15	2.8	0	7.7
Gross Beta	mrem/yr	2.5	14	4	4 (or 50 pCi/L)	2.4	([7])	14.0
Radium 226	pCi/L	0.2	0.8	NA	NA	0.2	0	0.8
Radium 228	pCi/L	0.4	3.1	NA	NA	0.4	0	3.1
Strontium 90	pCi/L	0.1	5.0	8	8	0.1	([7])	5.0
Uranium	µg/L	2.0	5.5	30	20	1.8	0.2	5.5

NOTES: mg/L, milligrams per liter; mrem/yr, millirems per year; NA, not available; ND, not detected; NTU, nephelometric turbidity units; pCi/L, picocuries per liter; TON, threshold odor number; µg/L, micrograms per liter µmho/cm, micromhos per centimeter.

1. In most cases, the proposed design concentration is the average value of all the wells to account for blending. Maximum well values were used in RO performance analysis and results complied with SDWA.
2. California limits came from the EPA/State of California comparison chart of MCLs (CDPH 2008).
3. Treatment must remove or inactivate 99.99 percent of viruses.
4. Proposed design concentration value based on flow weighted mass balance. See Table 3-1 of the August 2009 Draft Feasibility Engineering Report.
5. Index per Appendix A, August 2009 Draft Feasibility Engineering Report.
6. Data set contains mostly 0 µg/L. It is assumed that the zeros represent non-detect readings per email between Stetson Engineers and MCBCP.
7. Negative value reported; questionable.

- The fact that there will be water from as many as fourteen (14) wells implies that a single well's contribution of a high contaminant value will be mitigated when it comingles with water from the other wells.
- The treatment process proposed here utilizes a reverse osmosis (RO) membrane. RO membranes reject dissolved salts and other molecules. They are able to purify salty and lower quality waters. The water from the RO unit contains significantly less mineral content than the RO bypass so that when it combines with water from the RO bypass, the result is water in compliance with all applicable regulations. The treatment technique proposed eliminates or greatly reduces many of the regulated contaminants for which no data was available.

Plant influent design values were based on a review of the 2001–2007 well water quality analyses. When compared to the California or Federal MCLs, major water quality issues for treatment are as follows:

Total Dissolved Solids - TDS is a measure of the dissolved inorganic content of water. It is a measure representative of the salt content. EPA has a Secondary Maximum Contaminant Level (SMCL) of 500 mg/L for TDS. The SMCL indicates the level at which the water is deemed undesirable for consumption, although it is not toxic.

The average TDS concentration of the combined wells is approximately 750 mg/L. That figure represents various wells during many differing wet and dry periods. The maximum reported value is 943 mg/L. A conservative design value of 900 mg/L was used in the 2011 Feasibility Design Report.

Sulfate - The design groundwater concentration of sulfate is 200 mg/L, which is near the SMCL of 250 mg/L. Through desalination, sulfate will be reduced to well below the SMCL.

Iron and Manganese - Iron and manganese (Fe/Mn) both have SMCLs. The iron SMCL is 0.3 mg/L (300 µg/L) and the manganese SMCL is 0.05 mg/L (50 µg/L). Above these levels, water will be undesirable due to metallic taste and staining of plumbing fixtures and clothing.

Iron and manganese are frequently spoken of together because they are similar in occurrence and effects. Both metals are only soluble in water in their reduced oxidation state. When water is oxygenated, both iron and manganese will oxidize and change to less soluble forms. The metals then precipitate and may be removed from the water as settled or filtered solids.

In the case of the SMRCUP treatment facility, the presence of iron and manganese in significant concentration would foul the reverse osmosis process if they are not removed in a pretreatment process. The groundwater average concentrations for iron and manganese are 210 and 300 µg/L, respectively. The flow-weighted 90th-percentile values for iron and manganese are 280 and 380 µg/L, respectively. The design concentrations are 400 µg/L iron and 500 µg/L manganese.

Silica - Silica is of concern, as it is a common constituent of groundwater that is sparingly soluble. It is a common foulant to reverse osmosis membranes. There is not much data on the SMRCUP groundwater silica concentration. The only data point available is a single determination of 26.8 mg/L, which is a concentration significant enough to warrant consideration in the reverse osmosis treatment process.

Initial process modeling of reverse osmosis treatment showed that with 78 percent recovery of permeate, the silica concentration in the concentrate would be near saturation. This consideration will factor into the choice of antiscalant to be added to the process.

Solids - Solids suspended in the water present a sanitary and aesthetic issue. The aesthetic issue is that cloudy water is undesirable for consumption. The sanitary issue is that solids serve as a substrate on which microbes may be transported through the water. In the case of membrane treatment via reverse osmosis, solids also present a fouling issue and must be removed before the treatment stream reaches the membranes.

The groundwater from the Santa Margarita basin has a low level of solids. The average turbidity is 0.5 nephelometric turbidity units (NTU) with many readings of zero from several of the wells. The maximum recorded value is 25 NTU, but this is an outlier far above the typical values. This level of suspended solids means the SMRCUP water, unlike most groundwaters, would not require a coagulation/filtration process. The analyses show that the majority of the solids are iron and manganese, so those would be the most significant constituents to address during pretreatment.

Volatile and Synthetic Organics - The Santa Margarita groundwater basin has been contaminated with 1,2,3-trichloropropane. Some wells in the area have had detectable levels of 1,2,3-trichloropropane, and the amount does not appear to be decreasing with time. Those wells are not currently being pumped. The wells that will be used for the SMRCUP should not have any detectable volatile organic compounds (VOCs) or synthetic organic compounds (SOCs) in their groundwater.

Total Organic Carbon – Total organic carbon (TOC) is a gross measurement of all organic material in the water, including VOCs and SOCs. TOC provides an indication of the level of regulated disinfection byproducts likely to form. High TOC values (generally over 4 mg/L) indicate that if disinfected with chlorine-based chemicals, chlorinated disinfection byproducts (DBP) will form. The groundwater from the blend of the wells has an arithmetic mean TOC concentration of 1.8 mg/L and a maximum value of 5 mg/L. The flow-weighted average groundwater TOC is 3.0 mg/L. This is a moderate amount of TOC that should not pose a problem to reverse osmosis treatment. Several Southern California utilities are operating reverse osmosis treatment without prior TOC removal (e.g., by use of carbon or media filters). Those utilities are not currently experiencing problems with fouling.

The DBP issue will be mitigated by the blending of RO treated water with the less-treated groundwater. There will not be enough TOC remaining in the blended water to present a DBP problem.

It is expected that organic matter will be removed in the iron/manganese and RO treatment units, just as has been done at the MCBCP plant for years. In the unforeseen event that organic matter in the groundwater exceeds expected maximum levels such that additional treatment is needed, granular activated carbon (GAC) may be used to remove enough TOC in a side stream so that when blended back to the mainstream, the fully treated water is safe to drink. To size the GAC unit, the most current well water quality should be shared with Fallbrook and its design engineers, to minimize this added treatment unit cost.

A groundwater quality monitoring scheme is also recommended so FPUD knows if influent water quality is poorer than expected. For organics, this includes using a total organic carbon (TOC) analyzer in the equalization tank. One manufacturer of TOC analyzers, GE Water and Process Technologies, offers model Sievers 5310, which appears to fit this need.

Microbiology - The microbiological quality of the SMRCUP water is good; results are typically negative for coliform and fecal coliform presence, and heterotrophic plate counts are near zero. Groundwater is generally thought to be free of enteric viruses, although recent studies have shown some contamination may occur in proximity to concentrated sources. Virus levels have not been checked.

No other priority pollutants are present in levels approaching primary MCLs. The goal of the FPUD WTP is to reduce the above-named contaminants to concentrations below those established under the Safe Drinking Water Act. This feasibility-level design considers 90th percentile raw water quality well values when sizing and selecting water treatment units.

Some wells in the area have had detectable levels of 1,2,3-trichloropropane; however, those wells are not currently being pumped. Since FPUD will utilize the same water that MCBCP receives, it is recommended that the operators of the MCBCP WTP, P113:

- Share their raw water-quality data with FPUD WTP operators so that, as final design nears, FPUD has the latest information on well-water quality, should adjustments to this design be necessary; and
- Share their treatment plant operating data with FPUD so that FPUD staff understand how plant operations may be affected by recent changes in well-water quality.

4 Water Treatment Process Flows and Mass Balance

4.1 Water Treatment Process Flows

This section of the report describes the flows and mass balances, and concludes with a description of equipment utilization. Section 5 further describes treatment plant unit operations and equipment. Feed water to the plant will be provided by existing MCBCP groundwater wells. The water treatment plant equipment was sized based on the data presented in Table 4-1, for the peak wet year flow. The maximum groundwater that the SMRCUP plant can treat is 8.73 million gallons per day (MGD) (13.5 cfs). The SMRCUP treatment design includes the following major components:

- Iron and manganese removal with potassium permanganate oxidation
- Desalination via:
  - RO using thin-film-composite Koch 8040-ULP-400 membranes or similar,
  - Antiscalant addition, and
  - pH adjustment of RO product with sodium hydroxide
- Disinfection in the clearwell using:
  - Sodium hypochlorite for primary disinfection, followed by
  - Addition of ammonium hydroxide to form chloramines for secondary disinfection

A process flow diagram for the SMRCUP unit processes is provided as Figure 4-1. Treatment plant product is pumped to the Gheen Tank for storage and transport to the reservoir. Three waste streams exit the facility including:

- Iron and manganese treatment system solids discharge to existing sludge drying beds
- RO concentrate discharges to ocean outfall
- RO clean-in-place (CIP) system neutralized waste stream discharges to city sewer

Design flow and water quality inputs are summarized in Table 4-1. In an October 2010 Technical Memorandum, FPUD stated that MCBCP will provide an average of 3,100 af/y (4.28 cfs or 1,922 gpm). This flow rate is used to calculate the yearly operations and maintenance costs later in this report. Equipment removal efficiencies are summarized in Table 4-2. Removal percentages are based on manufacturer discussions and product information. Design constituent concentrations were applied to average and maximum flows to create the mass balance diagrams in Figures 4-2 and 4-3. The target product water TDS concentration is 500 mg/L as provided by the client and recommended by the EPA's SMCLs.

Table 4-1. Mass Balance Diagram Flow and Water Quality Inputs

Process Flow Diagram Inputs	Value
Groundwater: Maximum Flow (cfs) Average Flow (cfs)	 13.5 4.28
Design TDS (mg/L)	900
Design pH (S.U.)	7.4
Design Fe (mg/L)	0.40
Design Mn (mg/L)	0.50
Design TOC (mg/L)	3.0

Table 4-2. Mass Balance Diagram Equipment Removal and Recovery Efficiency

Process Flow Diagram Equipment	Removal/Recovery Percentage
Iron and Manganese Unit	Mn Removal – 97% Fe Removal – 97% Process Recovery – 100%
RO Unit	Salt Rejection – 96.4% Process Recovery – 85%

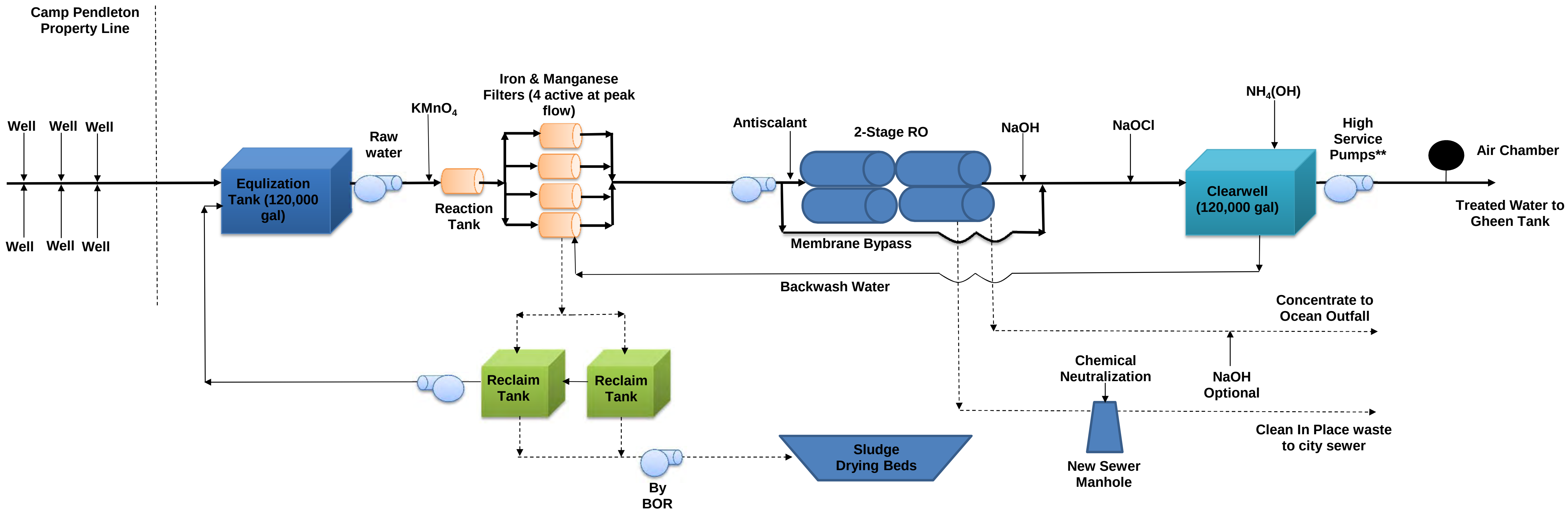
Unit process sizing was based on the maximum groundwater feed flow expected to occur in May of a wet year. The pretreatment oxidation, RO antiscalant addition, CIP chemical requirements, post-treatment chemical neutralization, disinfection and waste neutralization chemical estimates are based on a maximum feed water peak flow of 8.73 MGD (13.5 cfs or 6,059 gallons per minute (gpm)). Additionally, feed, product and solids pumps were sized based on the maximum peak flow rate.

4.1.1 Iron and Manganese Removal

As stated previously, a peak groundwater flow of 8.73 MGD (13.5 cfs; 6,059 gpm) is considered the maximum influent into the system. Feed water is stored in an equalization tank at low flows to provide sufficient volume for downstream processes. After oxidation with potassium permanganate, the iron-manganese (IM) filters are able to remove 97 percent of the iron and manganese in the system reducing the effluent iron and manganese concentrations to approximately 12 and 15 µg/L, respectively. The iron and manganese system reject streams flow to reclaim tanks for solids separation. In the reclaim tanks, the liquid is decanted and returned to the influent pipe of the iron and manganese process for treatment while the solids slurry is separately pumped to existing sludge drying beds.

4.1.2 Desalination

The feed water for the plant has relatively low salinity. Therefore, to maximize the RO treatment process efficiency, the effluent from the iron and manganese plant is split into two (2) lines prior to desalination. Some of the flow bypasses the RO unit and receives no further treatment until post-treatment disinfection in the clearwell. The maximum flow of this portion is 4.27 MGD (6.6 cfs; 2,969 gpm) or 49 percent and was derived by mass balance using the RO unit's salt rejection capability and water recovery. The blended flow ensures a final TDS concentration of 500 mg/L or less, and the concentration of all other parameters are within regulatory requirements in the clearwell.



* Raw water pumps will be controlled by level in clearwell.
** High service pumps controlled by level in Gheen tank.

Legend

→ (heavy)	Main Line
→	Minor Line
- - - →	Waste Line
NaOCl	Sodium Hypochlorite
NaOH	Sodium Hydroxide
$NH_4(OH)$	Ammonium Hydroxide
$KMnO_4$	Potassium Permanganate

Figure 4-1
Process Flow Diagram

Santa Margarita Conjunctive Use Project

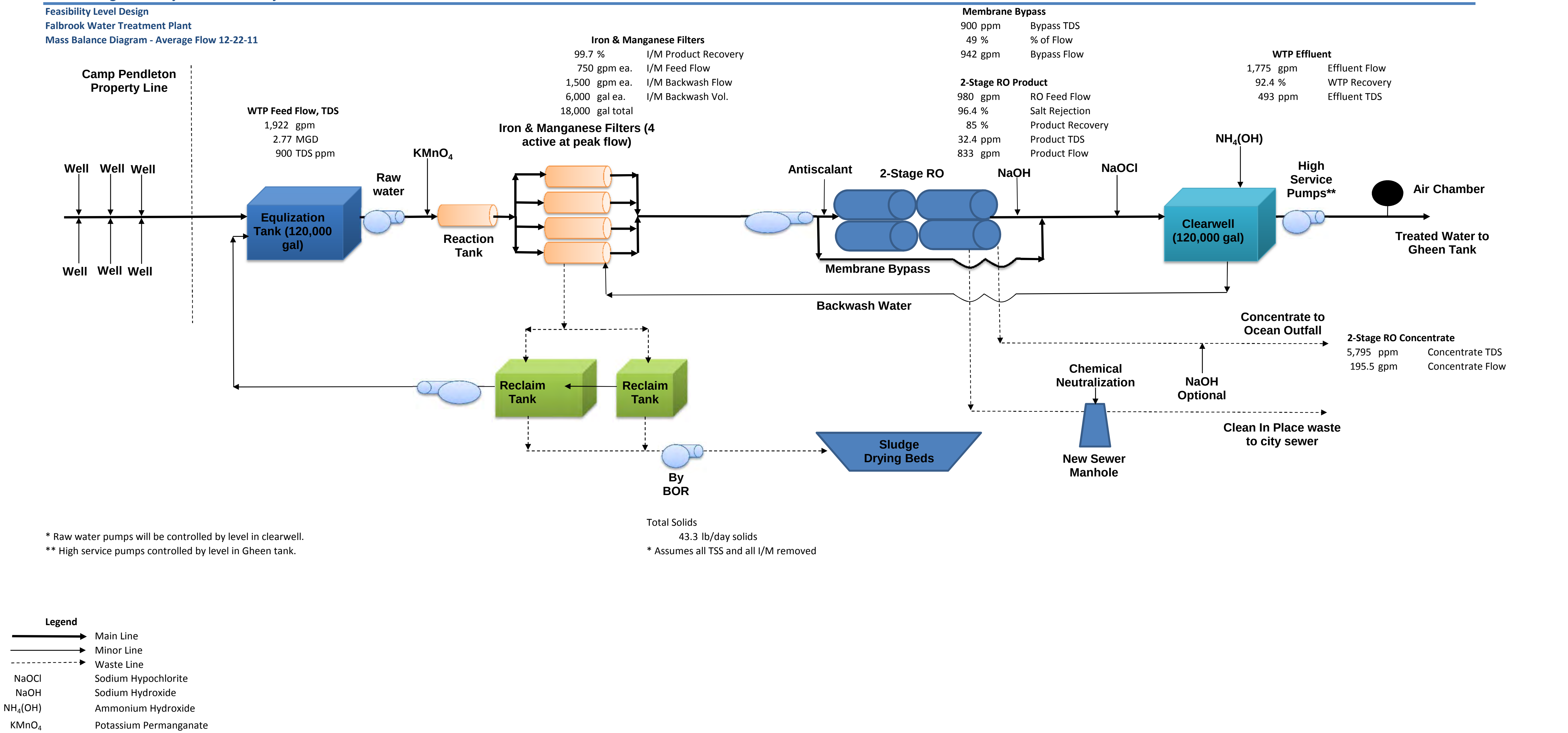
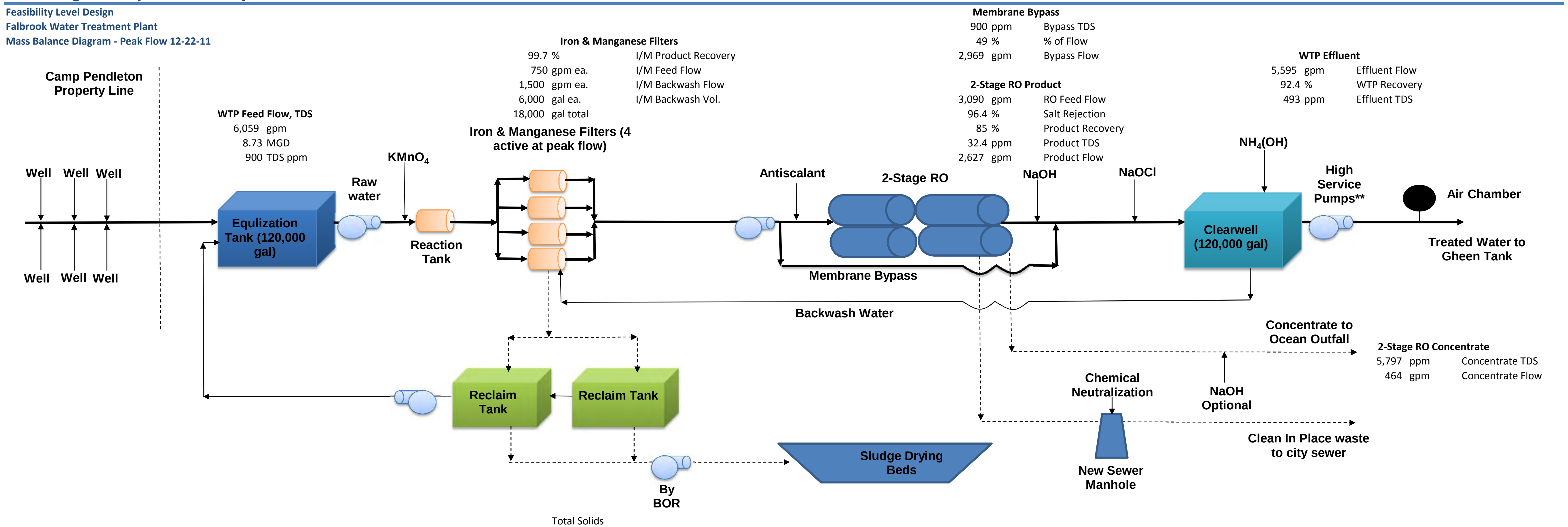


Figure 4-2
Mass Balance Diagram
Average Flow Condition

Santa Margarita Conjunctive Use Project

Feasibility Level Design
Falbrook Water Treatment Plant
Mass Balance Diagram - Peak Flow 12-22-11



* Raw water pumps will be controlled by level in clearwell.
** High service pumps controlled by level in Gheen tank.

Legend

(thick arrow)	Main Line
(thin arrow)	Minor Line
(dashed arrow)	Waste Line
NaOCl	Sodium Hypochlorite
NaOH	Sodium Hydroxide
$NH_4(OH)$	Ammonium Hydroxide
$KMnO_4$	Potassium Permanganate

Figure 4-3
Mass Balance Diagram
Peak Flow Condition

To ensure that blended water quality meets regulatory limits in the clearwell a variety of water quality compositions were evaluated based on well-field water-quality data. Design water quality is based on 90th percentile data points. Maximum concentrations for each parameter were evaluated to ensure blended water quality is not projected to exceed either the EPA or CDPH MCLs. Under maximum water quality concentrations, the RO design is able to provide sufficient treatment to achieve a blended water quality within regulated MCLs. Sulfate, a secondary contaminant, exceeds the recommended (but non-enforceable) maximum contaminant level goal (MCLG) of 250 mg/L when feed concentrations exceed 490 mg/L. During final design it is recommended that system operation be evaluated at a slightly lower bypass percentage if sulfate concentrations exceed 490 mg/L.

Water stability was evaluated to identify issues related to mixing the effluent from the proposed RO system with FPUD water. Water stability calculations were completed based on Fallbrook's Public Utility Department 2012 Water Quality Report and the projected blended water quality. A number of indices were calculated to compare water stability, including the Langelier Saturation Index (LSI), Ryznar Stability Index (RSI), Stiff and Davis Index, and Larson-Skold Index (see table 4-3). Blended RO product water is in equilibrium with respect to calcium carbonate, so precipitation and dissolution are both unlikely to occur in the system. Current FPUD water is undersaturated and tends to dissolve calcium carbonate. Based on water stability indices, the blended RO product water composition will be compatible with the existing system.

Table 4-3. Distribution System Water Stability Calculations

Water Stability Analysis	Fallbrook Public Utility Department Water Quality Report: 2012	Blended Water Quality[1]
Langelier Saturation Index	–1.10	0.08
Ryznar Stability Index	9.05	8.04
Stiff and Davis Index	–1.0	0.19
Larson-Skold Index	2.64	2.96

[1] Blending ratio of 49% RO permeate and 51% bypass.

The remaining 51 percent of IM flow is directed to the RO desalination units at a maximum flow of 4.46 MGD (6.9 cfs; 3,090 gpm). Antiscalant is added to the RO feed, which allows the RO unit to achieve high recoveries without scaling. The RO plant rejects 96.4 percent of the influent salts, resulting in an RO process recovery of 85 percent. A maximum treated water flow of 3.81 MGD (5.9 cfs; 2,627 gpm) from the RO plant is neutralized with sodium hydroxide. A maximum concentrate flow of about 0.67 MGD (1.03 cfs; 464 gpm) from the RO unit will be discharged to an ocean outfall. The highest TDS concentration expected is 5,795 mg/L based on a 900 mg/L design TDS feed concentration.

The RO product water and the RO bypass line are blended in the clearwell to achieve the target TDS of 500 mg/L. This feasibility design assumes separate product and bypass lines into the clearwell. Having one combined line may use less piping, but it would require the addition of a pressure regulating valve to the RO product line to match RO bypass line pressure from the upstream equalization pumps.

During final design, RO concentrate parameters will have to be scrutinized for compliance with the outfall's discharge permit limits. This information was not available at the time this report was written, so the need for local concentrate treatment, if any, could not be assessed.

4.1.3 Disinfection

Sodium hypochlorite is added for disinfection and ammonia hydroxide is added to protect against DBP formation. The hypochlorite provides strong disinfection for a short period of time, then the ammonia is added to produce combined chlorine, or chloramine, for continued disinfection. Chloramine is a weaker disinfectant, but it does not form as many DBPs as free chlorine.

Treated water from the clearwell is transported to the Gheen Tank. The maximum treated flow from the SMRCUP treatment plant is estimated to be about 8.06 MGD (12.4 cfs) or 92 percent of the feed groundwater flow based on cumulative process recoveries in the system.

4.1.4 Summary of SMRCUP Process Flows

The average and maximum feed and product flows for the Fallbrook WTP are summarized in Table 4-4. Minimum flows are not shown but would be zero in dry years. The average and maximum product flows from the Fallbrook WTP are 1.16 MGD (1.8 cfs) and 8.06 MGD (12.4 cfs), respectively. Overall recovery of the Fallbrook WTP is 92 percent.

4.1.5 WTP Equipment Usage

Tables 4-5 and 4-6 show how many iron and manganese filtration units and how many RO skids are needed in the Fallbrook WTP based on the process flows described above and on the following assumptions:

- The capacity of one (1) iron and manganese filtration unit is 1,500 gpm (3.34 cfs), and there are four (4) units to meet a peak flow condition of 6,014 gpm (13.5 cfs).
- The capacity of one (1) RO skid is 2.3 cfs or 1,030 gpm, and there are four (4) RO skids total at the WTP, with three (3) active and one (1) redundant, to meet peak capacity of 6.9 cfs.
- Minimum flow through one (1) RO skid is roughly 1.2 cfs. If the minimum flow can't be provided to a skid, then it needs to be shut down. During low-flow periods the skids can be rotated in operation to treat cumulative flows of 1.2 cfs from the equalization tank.

Table 4-4. SMRCUP Feed and Product Water Flow Summary

Month	Average		Maximum	
	Feed Flow (cfs)	WTP Product (cfs)	Feed Flow (cfs)	WTP Product (cfs)
Jan	0.0	0.0	8.8	8.1
Feb	0.0	0.0	8.3	7.6
March	1.8	1.7	9.8	9.0
April	2.6	2.4	10.9	10.0
May	1.7	1.6	10.0	9.2
June	4.3	4.0	12.1	11.1
July	4.8	4.4	13.5	12.4
Aug	4.6	4.2	12.5	11.5
Sept	3.9	3.6	11.6	10.7
Oct	0.7	0.6	9.2	8.5
Nov	0.0	0.0	6.4	5.9
Dec	0.0	0.0	5.7	5.2
Average	2.0	1.8	9.9	9.1
Min	0.0	0.0	5.7	5.2
Max	4.8	4.4	13.5	12.4

During a maximum flow year, the SMRCUP plant has four (4) out of four (4) iron and manganese filtration skids running and three (3) out of four (4) RO skids running.

During an average flow year, the SMRCUP plant has two (2) out of four (4) iron and manganese filtration skids running and one (1) out of four (4) RO skids running.

Although not depicted in these tables, during a low-flow year, the SMRCUP plant would have no iron and manganese filtration skids running and no RO skids running.

4.2 Mass Balance Diagrams

Using the flows described above, mass balances for estimating TDS, iron and manganese were developed for average and peak flow conditions. These balances are shown as Figures 4-2 and 4-3 for average and peak flows. Average flow is the average monthly flow occurring in an average year and peak flow is the peak monthly flow that occurs in a wet year. These values are highlighted in Tables 4-5 and 4-6, respectively.

Mass balances show the disposition of flows and mass loadings of contaminants of concern as they travel through the water treatment process. Also shown are this design’s recommended sizes of the raw water equalization tank and finished water clearwell. Contaminants of concern are the iron, manganese, and turbidity, which end up in the sludge drying bed, and the total dissolved solids, which are removed in the RO unit and sent to the ocean by the outfall.

Table 4-5. Unit Process Product Flow and Units in Operation During an Average Year

Month	Feed Flow: Average Year		Iron and Manganese Plant			RO Plant		
	Feed Flow (cfs)	Total WTP Product (cfs)	Feed Flow (cfs)	Product Flow (cfs)	Number of Units in Operation*	Feed Flow (cfs)	Product Flow (cfs)	Number of Units in Operation*
Jan	0.0	0.0	0.0	0.00	0	0.00	0.00	0
Feb	0.0	0.0	0.0	0.00	0	0.00	0.00	0
March	1.8	1.7	1.8	1.79	1	0.92	0.78	1
April	2.6	2.4	2.6	2.59	1	1.32	1.12	1
May	1.7	1.6	1.7	1.69	1	0.86	0.73	1
June	4.3	4.0	4.3	4.28	2	2.19	1.86	1
July	4.8	4.4	4.8	4.78	2	2.44	2.07	2
Aug	4.6	4.2	4.6	4.58	2	2.34	1.99	2
Sept	3.9	3.6	3.9	3.88	2	1.98	1.69	1
Oct	0.7	0.6	0.7	0.70	1	0.36	0.30	1
Nov	0.0	0.0	0.0	0.00	0	0.00	0.00	0
Dec	0.0	0.0	0.0	0.00	0	0.00	0.00	0
Average	2.0	1.8	2.0	2.00	1	1.02	0.86	1
Min	0.0	0.0	0.0	0.00	0	0.00	0.00	0
Max	4.8	4.4	4.8	4.79	2	2.44	2.07	2

*Out of a maximum of four available.

Table 4-6. Unit Process Product Flow and Units in Operation During a Maximum Year

Month	Feed Flow: Wet Year		Iron and Manganese Plant			RO Plant		
	Feed Flow (cfs)	WTP Product (cfs)	Feed Flow (cfs)	Product Flow (cfs)	Number of Units in Operation	Feed Flow (cfs)	Product Flow (cfs)	Number of Units in Operation
Jan	8.8	8.1	8.8	8.77	3	4.47	3.80	2
Feb	8.3	7.6	8.3	8.28	3	4.22	3.59	2
March	9.8	9.0	9.8	9.77	3	4.98	4.24	3
April	10.9	10.0	10.9	10.87	3	5.54	4.71	3
May	10.0	9.2	10.0	9.97	3	5.08	4.32	3
June	12.1	11.1	12.1	12.06	4	6.15	5.23	3
July	13.5	12.4	13.5	13.46	4	6.86	5.83	3
Aug	12.5	11.5	12.5	12.46	4	6.36	5.40	3
Sept	11.6	10.7	11.6	11.57	4	5.90	5.01	3
Oct	9.2	8.5	9.2	9.17	3	4.68	3.98	3
Nov	6.4	5.9	6.4	6.38	2	3.25	2.77	2
Dec	5.7	5.2	5.7	5.68	2	2.90	2.46	2
Average	9.9	9.1	9.9	9.87	3	5.03	4.28	3
Min	5.7	5.2	5.7	5.68	2	2.90	2.46	2
Max	13.5	12.4	13.5	13.46	4	6.86	5.83	3

5 Water Treatment Plant Components

As shown in Figure 1-3, the Fallbrook WTP will include (1) a large cast-in-place concrete structure consisting of four tanks, two sets of pumps, and an air chamber; (2) a separate iron-manganese treatment area, and (3) the main WTP building, housing chemical storage tanks, the RO treatment facilities, and the intake sump for the clean-in-place system. Treated water from the WTP will be piped about 4 miles to the Gheen storage tank and pumping plant and, from there, about 2½ miles farther to Red Mountain Reservoir. These facilities are described in greater detail below.

Recent (2008 to 2012) water-quality data for treated water from MCBCP's P113 WTP indicate that disinfection byproducts comply with the SDWA. Since that plant uses the same water treatment processes as proposed in this design (with the exception of potassium permanganate in lieu of sodium hypochlorite to oxidize IM) and FPUD's new WTP will treat the same water, piloting to verify treatment plant process performance is not recommended for FPUD.

5.1 Concrete Structures

The large cast-in-place concrete structure is 171.5 feet long by 31 feet wide and 16 feet deep, and it is divided into the following four (4) separate tank sections:

(1) Raw water equalization tank with raw water pumping plant,

(2) Reclaim storage tank A,

(3) Reclaim storage tank B, and

(4) Clearwell with blended flow chamber, pumping wetwell and treated water pumping plant.

The walls, base slab and deck are all 18-inch-thick reinforced concrete. A mid-span support beam was included for the deck. To support the beam in the longer raw water equalization tank and clearwell, columns are included in the design. The walls and floors of this structure are designed in accord with the American Concrete Institute's Code ACI 350 to prevent water from migrating through the concrete. Two (2) hatches with ladders are included to provide access into each of the individual tanks.

The concrete deck over the equalization tank and the clearwell tank support the vertical turbine pumps and the motor control cabinets. The clearwell deck also supports an air chamber attached to the discharge manifold for the treated water pumps.

The clearwell's blended flow chamber has a series of internal walls that provide a serpentine travel path for the treated water. This travel path allows the required contact time for the treated water to mix with chlorine. At the end of the blended flow chamber, the water passes through a measuring weir en route to the pumping wetwell.

An 8-foot-high concrete wall above the deck elevation was incorporated into the design on the north, west, and south sides. The purpose of the wall is to act as a sound barrier between the pumps and any residential property located to the west of the plant.

The deck slab is sloped one-eighth-inch per foot toward the east to provide drainage of water from the deck surface. The bottoms on the tanks are sloped to facilitate draining or cleaning of the tank floors. For the two (2) reclaim tanks, recessed sump areas are included for small solids-handling pumps. The structure is assumed to be on rock and will require no special foundation treatment. Backfill will come from material excavated at the site.

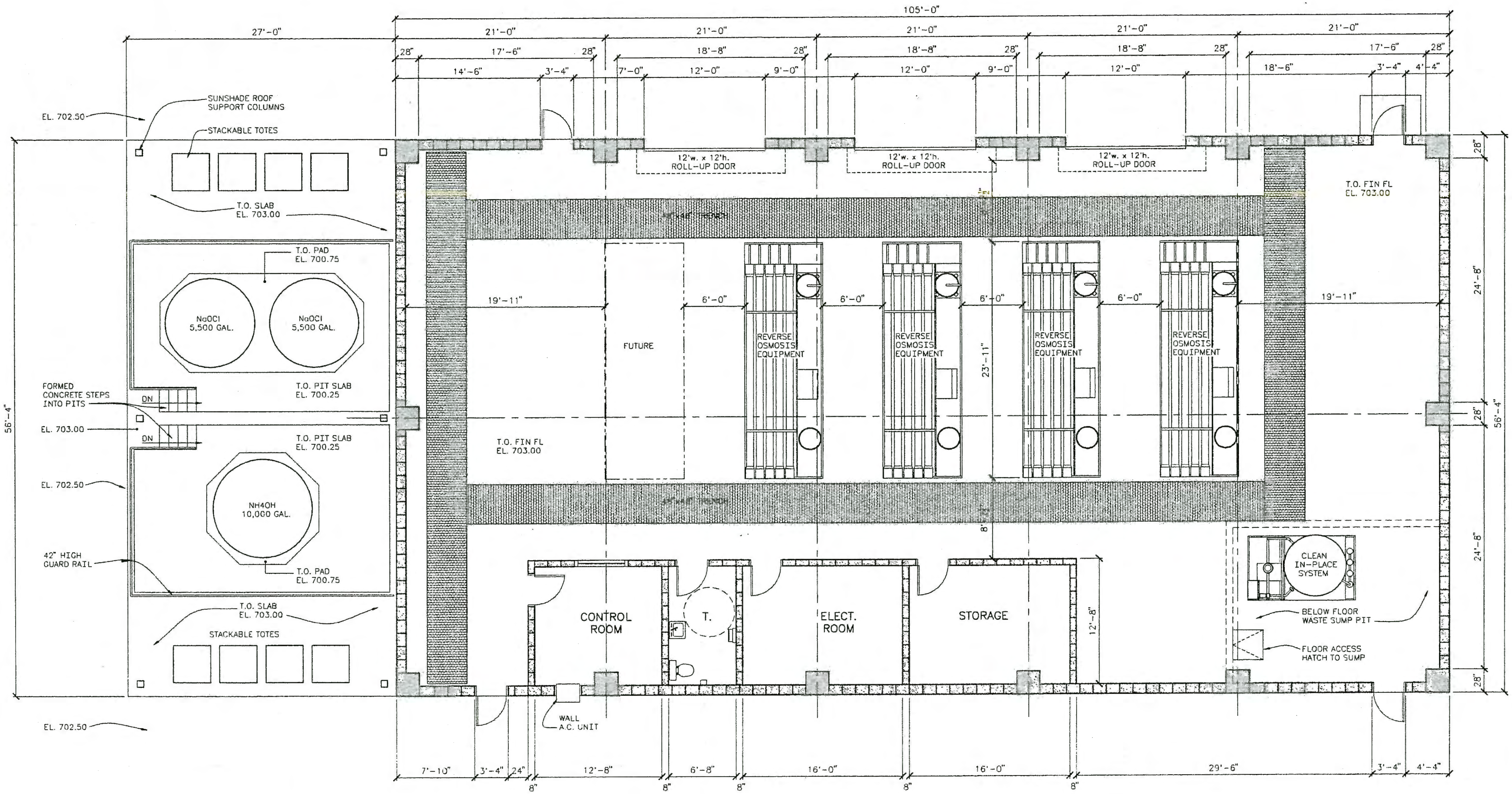
Figures 5-1 through 5-5 illustrate the structural aspects of this common wall construction structure.

5.2 Building Foundation

Based on the limited geological data available, we made the assumption, for this design level, that both the raw water tank/pumping plant and the clearwell tank/pumping plant would be founded on rock. Note this is one combined structure. Additional geological investigations will be needed before the final foundation design for this structure can be completed. This would involve drilling additional holes to determine the exact depths to solid rock under the proposed location of this combined structure. A rock surface contour drawing would then be drawn based on these drill hole logs.

If the additional geological studies and the rock surface contour map show that the structures are not completely on rock, then the designers could propose two possible corrective actions to prevent differential settlement of the structure. One would be to over-excavate the rock and backfill up to the foundation level with selected materials. The second would be to remove the soil down to rock, from under that portion of the structure that would be on soil, and use backfill concrete to bring that area of the excavation up to the foundation level.

Since rock excavation is more expensive than removing consolidated fill, and our cost estimates include a significant amount of rock excavation (6,800 cubic yards) for the treatment site, the costs, plus contingencies, are felt to be adequate for any needed over-excavation and select fill to obtain a stabilized surface for the foundations.



FLOOR PLAN

SCALE OF FEET

ALWAYS THINK SAFETY

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

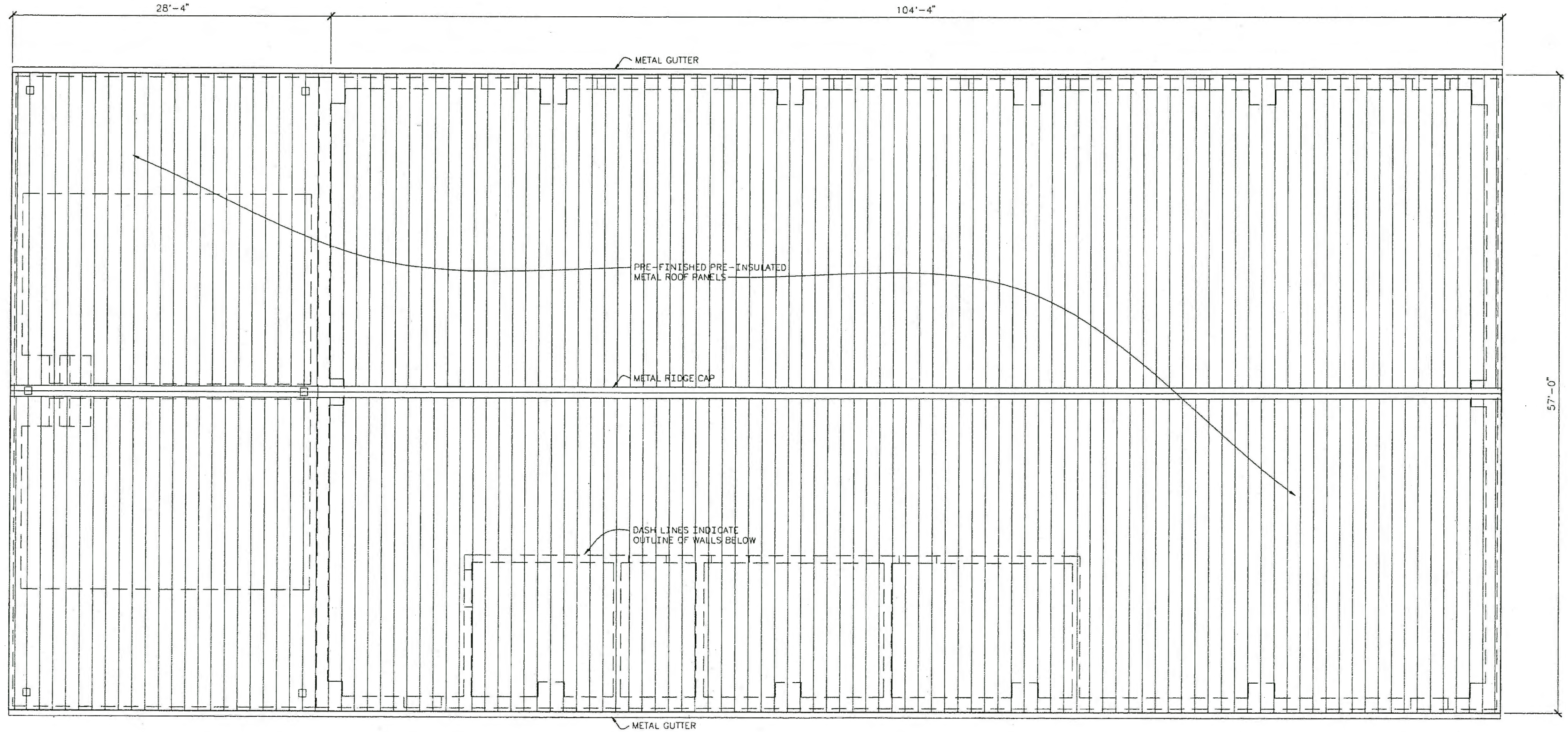
SANTA MARGARITA RIVER CONJUNCTIVE USE PROJECT
FEASIBILITY DESIGN

FALLBROOK WATER TREATMENT PLANT
R.O. BUILDING
FLOOR PLAN

DESIGNED V. NEUMAYER
REVIEWED Gary Snyder PE

DENVER, COLORADO 2011 05 2?

Figure 5–1
SHEET 1 OF 1



ROOF PLAN

0 5 10 15
SCALE OF FEET

ALWAYS THINK SAFETY

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BUREAU OF RECLAMATION

SANTA MARGARITA RIVER CONJUNCTIVE USE PROJECT
FEASIBILITY DESIGN

CAMP PENDELTON TO FALLBROOK INTERTIE

ARCHITECTURAL
ROOF PLAN

DESIGNED J. NEUMAIER
REVIEWED [signature] P.E.

DENVER, COLORADO 2009 09 15

Figure 5-2

SHEET 1 OF 1

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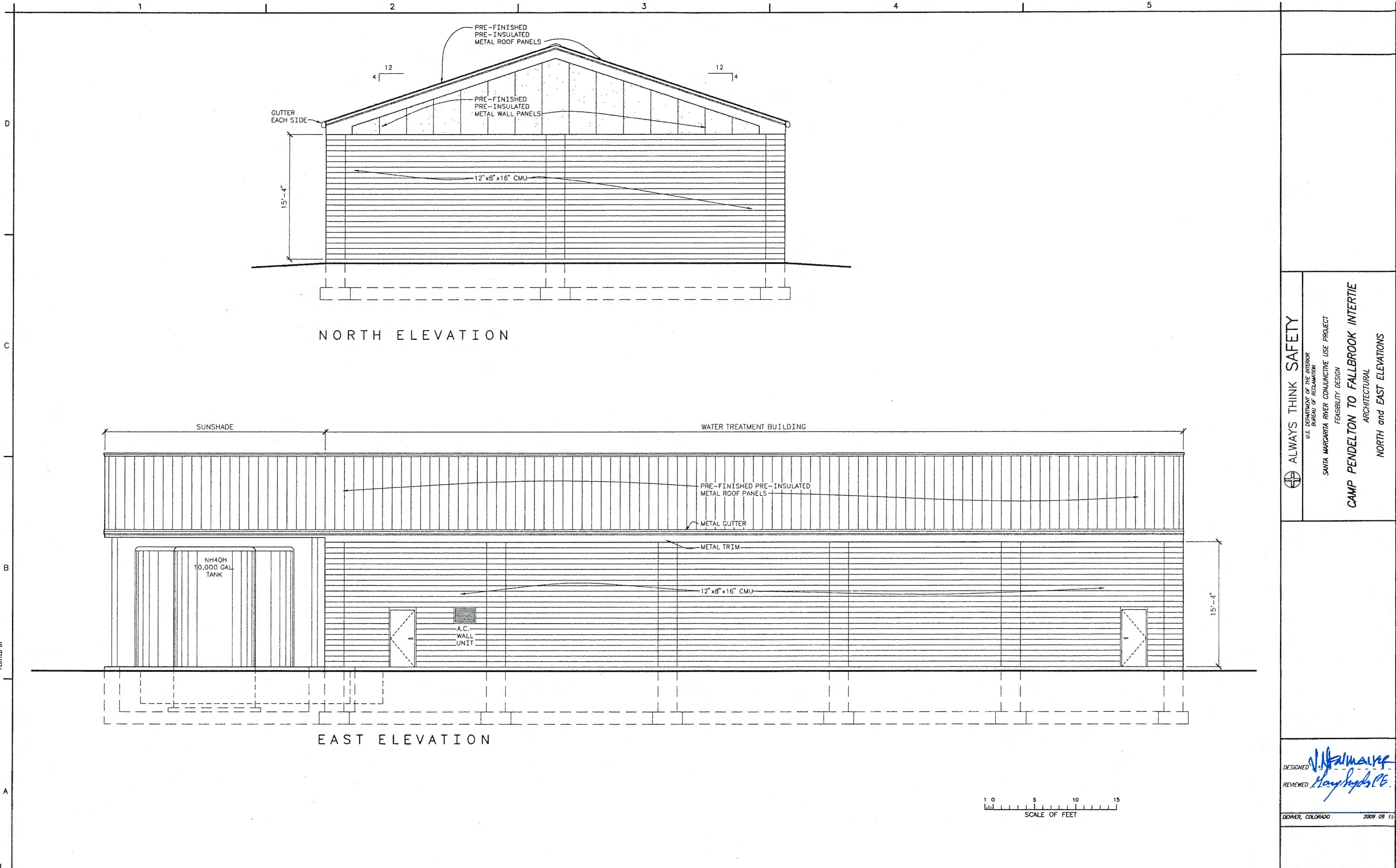
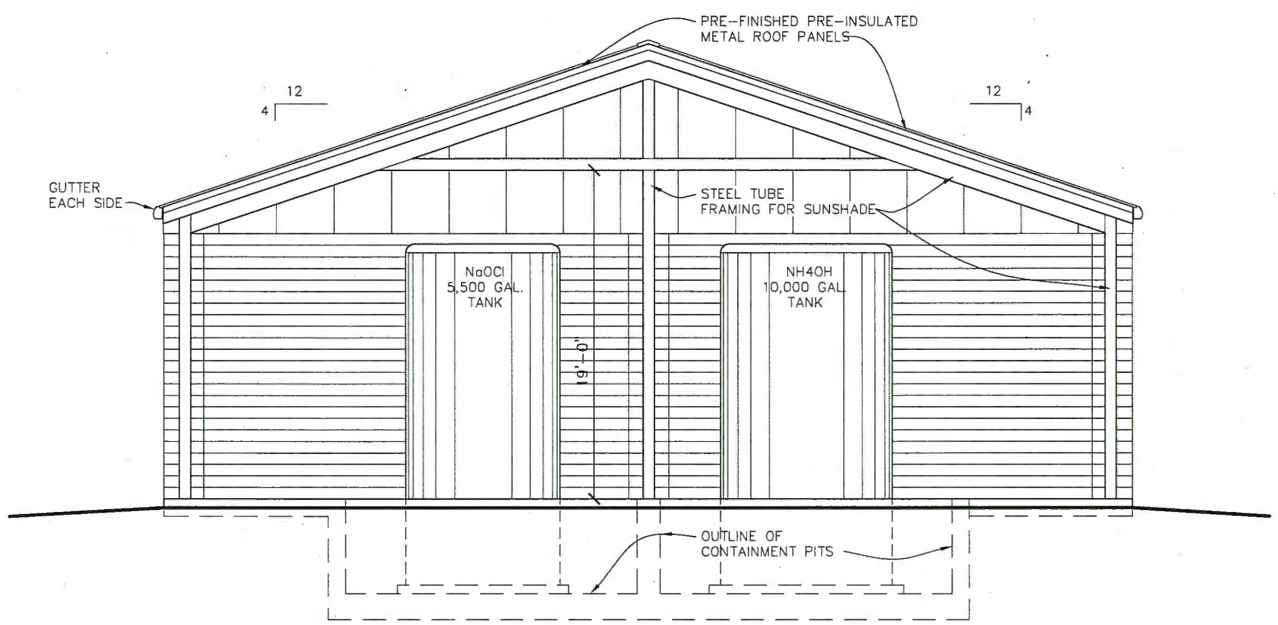
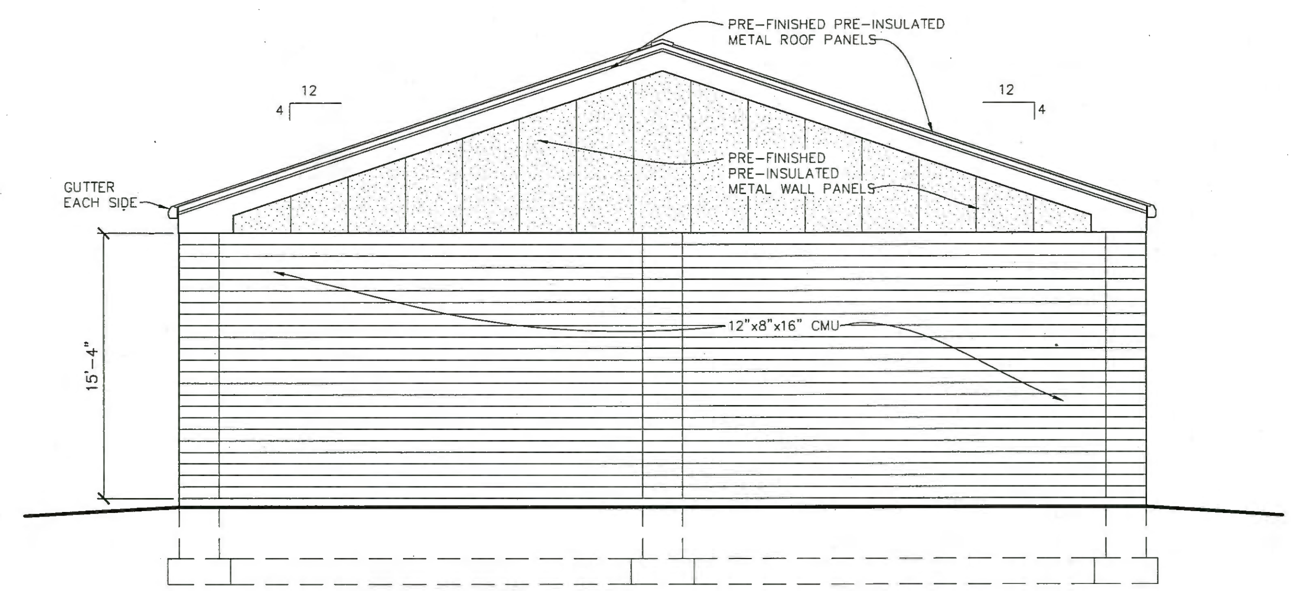


Figure 5-3

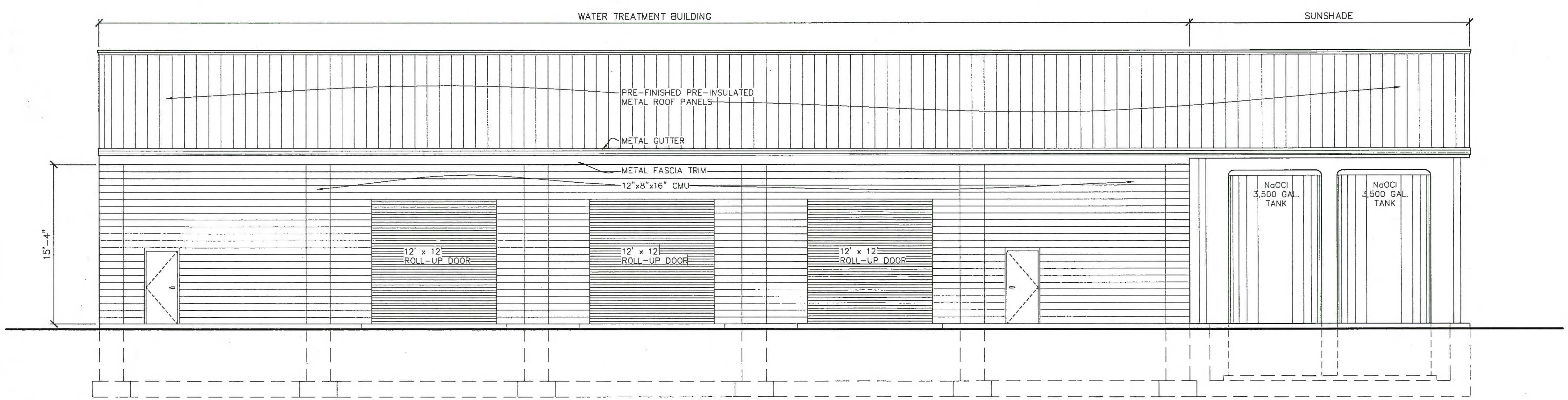
SHEET 1 OF 1



SOUTH ELEVATION @ SUNSHADE



SOUTH ELEVATION @ BUILDING



WEST ELEVATION

0 5 10 15
SCALE OF FEET

ALWAYS THINK SAFETY

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SANTA MARGARITA RIVER CONJUNCTIVE USE PROJECT
FEASIBILITY DESIGN

CAMP PENDELTON TO FALLBROOK INTERTIE

ARCHITECTURAL
SOUTH and WEST ELEVATIONS

DESIGNED N. Niedermeyer
REVIEWED [signature] PE

DENVER, COLORADO 2009 09 15

Figure 5-4
SHEET 1 OF 1

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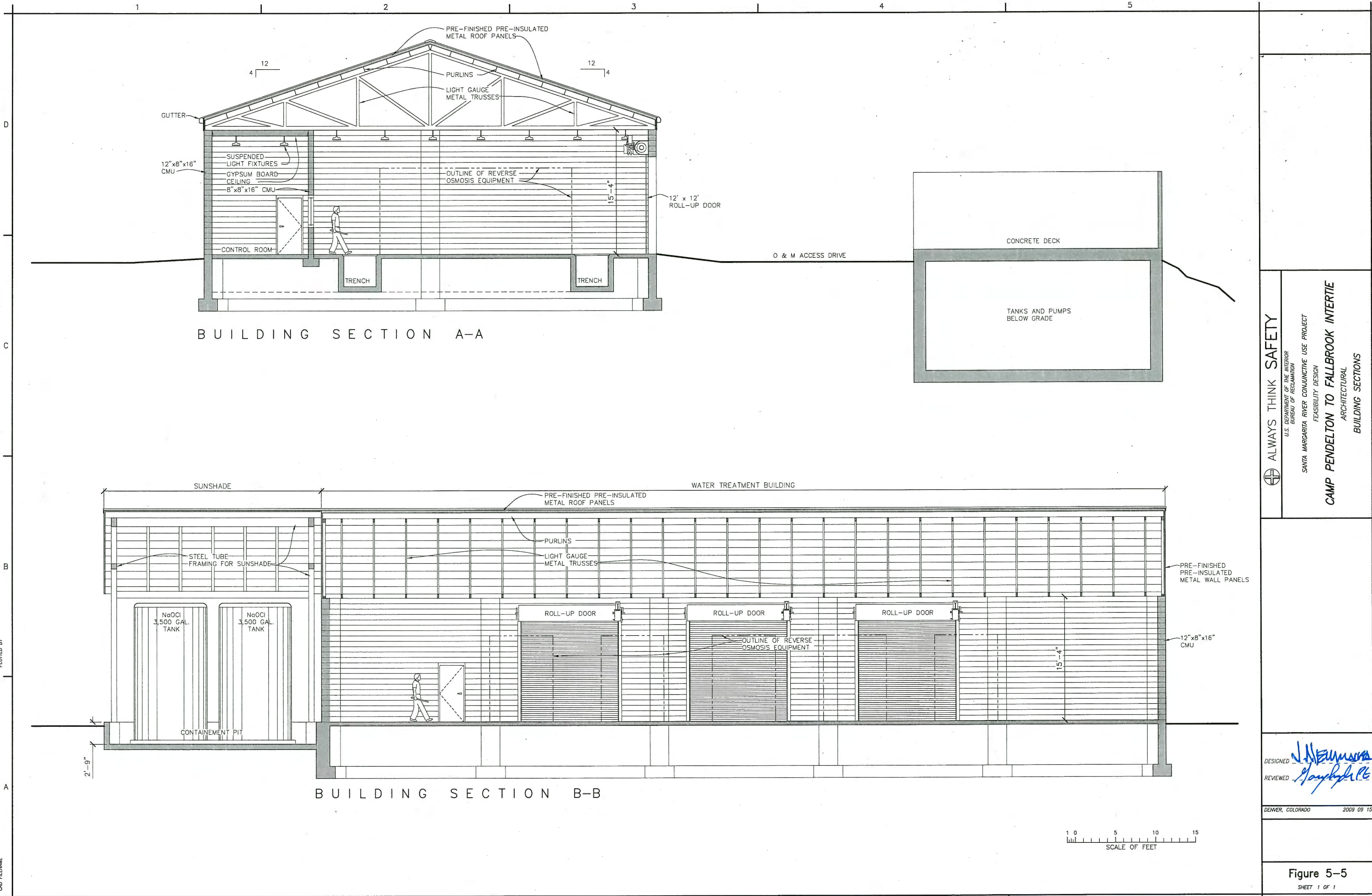
PRE-FINISHED PRE-INSULATED METAL ROOF PANELS
PURLINS
LIGHT GAUGE METAL TRUSSES
GUTTER
12"x8"x16" CMU
SUSPENDED LIGHT FIXTURES
GYPSUM BOARD CEILING
8"x8"x16" CMU
OUTLINE OF REVERSE OSMOSIS EQUIPMENT
15'-4"
12' x 12' ROLL-UP DOOR
CONTROL ROOM
TRENCH
TRENCH
O & M ACCESS DRIVE
CONCRETE DECK
TANKS AND PUMPS BELOW GRADE
BUILDING SECTION A-A
SUNSHADE
WATER TREATMENT BUILDING
PRE-FINISHED PRE-INSULATED METAL ROOF PANELS
PURLINS
LIGHT GAUGE METAL TRUSSES
STEEL TUBE FRAMING FOR SUNSHADE
PRE-FINISHED PRE-INSULATED METAL WALL PANELS
NaOCl 3,500 GAL. TANK
NaOCl 3,500 GAL. TANK
ROLL-UP DOOR
ROLL-UP DOOR
ROLL-UP DOOR
OUTLINE OF REVERSE OSMOSIS EQUIPMENT
12"x8"x16" CMU
15'-4"
CONTAINEMENT PIT
2'-9"
BUILDING SECTION B-B
SCALE OF FEET
ALWAYS THINK SAFETY
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
SANTA MARGARITA RIVER CONJUNCTIVE USE PROJECT
FEASIBILITY DESIGN
CAMP PENDELTON TO FALLBROOK INTERTIE
ARCHITECTURAL
BUILDING SECTIONS
DESIGNED
REVIEWED
DENVER, COLORADO
2009 09 15
SHEET 1 OF 1
DATE AND TIME PLOTTED
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Figure 5-5

5.3 Iron and Manganese Removal

Removing iron and manganese from the groundwater is necessary to meet CDPH Secondary Drinking Water Standards, and it also helps to prolong the life of the RO membranes. The Secondary Drinking Water Standards state that iron and manganese concentrations should be less than 0.3 mg/L and 0.05 mg/L, respectively. When exposed to air, soluble iron and manganese form reddish brown and black deposits and stains on pipes, fixtures, hard surfaces, and clothing.

Iron and manganese concentrations in water are typically oxidized by air, chlorine, or potassium permanganate ($KMnO_4$). A following filter, typically greensand is used to remove any iron or manganese in the water through adsorption or co-precipitation. There are variations to this form of treatment, by different manufacturers, stating different competitive advantages (mostly related to plant footprint, backwash rate, and plant efficiency). One such company, Filtronics, uses a naturally occurring mined substance that complies with ANSI 60/61 standards. CDPH has approved the Filtronics media for a hydraulic loading rate of as much as 10 gpm per square foot.

The iron and manganese removal filters planned for the Fallbrook WTP are anticipated to reduce the content of both metals to less than 0.01 mg/L. These filters will also remove other contaminants such as TOC or hydrogen sulfide. Table 5-1 shows the feed water quality.

Table 5-1. Water Quality Inputs

Feed Water Quality Parameters	Value
Design pH	7.4
Design Fe (mg/L)	0.4
Design Mn (mg/L)	0.5
Design TOC (mg/L)	3.0

Final design of the iron and manganese removal filters should be coordinated with the California Department of Public Health for the latest acceptable filtration rates.

The Fallbrook WTP design involves one (1) Model V-6000 oxidation tank (96 inches in diameter × 162 inches long), which discharges to four (4) Model FH-16 filters. First, the feed water will be treated with liquid potassium permanganate ($KMnO_4$) to oxidize the metals, then the entire flow will pass through the reaction vessel at a pressure of 125 pounds per square inch (psi). The flow emerging from the oxidation vessel is monitored and directed to the filters using regulating valves. Each 84-inch-diameter by 254-inch-long filter has a minimum and maximum flow range at a maximum operating pressure of 60 psi. The units are placed into or out of service depending on the flow from the equalization tank pumps. Piping will be installed to bypass the oxidation tank and filters.

The filters will be backwashed at least every 24 hours with pressurized water from the treated water pipe by the clearwell (the 24-inch “Reach 1” pipeline that runs to the Gheen tank). When the differential pressure across a filter reaches 10 psi, or when 24 hours of treatment has passed, a backwash will be triggered to flush the accumulated solids from the filter to the reclaim tank. Backwashes will also be programmed more frequently if needed based on the incoming water quality. Backwashes must be scheduled at least daily to properly remove the oxidized metals from the filter media. The initial oxides are easily removed by backwashing, but over time those oxides will transform to other types of oxides that are bound more tightly to the filter media.

The waste from the backwash process will be stored in two (2) reclaim tanks, where the solids from the backwash will slowly settle to the bottom of the tanks and the cleaner water from the top will be decanted and recycled back into the process, to improve plant efficiency. The solids will settle to a concentration of 1 to 3 percent in the bottom of the tank. The reclaim tanks will be located next to the feed and clearwell tanks, and constructed of reinforced concrete. The concentrated waste from the reclaim tanks, estimated at 1 percent solids, will be pumped to an existing sludge drying bed adjacent to the WTP site.

Any oxidized metals that remain in the treatment stream following the removal process can cause harm to the RO membranes. Iron and manganese removal efficiencies are summarized in Table 5-2.

Table 5-2. Iron and Manganese Removal and Recovery Efficiency

Process Flow Diagram Equipment	Removal/Recovery Percentage
Iron and Manganese Plant	Mn Removal – 97% Fe Removal – 97% Process Recovery – 100%

Removal percentages were estimated based on discussions with the manufacturer and product information, assuming that iron and manganese concentrations in the feed water will be at the 90th percentile. Design constituent concentrations were assumed during maximum peak flows to create the mass balance diagram (Figure 4-3). Filtration unit process sizing was based on the maximum groundwater feed flow expected to occur in July of a wet year. The chemical requirements for pretreatment oxidation, RO antiscalant addition, the CIP process, post-treatment chemical neutralization, disinfection, and waste neutralization were estimated based on a maximum feed water peak flow of 8.7 MGD (13.5 cfs). Additionally, the feed product and solids pumps were sized based on the maximum peak flow rate.

5.4 Desalination

Desalination is needed at the Fallbrook WTP because the TDS of the water exceeds Safe Drinking Water Act limits. As previously described in section 3, the EPA standard is 500 mg/L and the design maximum raw water value used in this design is 900 mg/L. RO uses a semi-permeable membrane and pumping to overcome osmotic pressure resistance sufficiently that purified water will pass through the membrane but suspended solids and most dissolved solids will not.

There are many available membranes that can meet the target TDS level. Reclamation ran membrane software projection programs provided by two membrane manufacturers and found that three types of membranes were appropriate for the treatment needs. These three types are:

(1) Nanofiltration membranes,

(2) Low- pressure/low-energy brackish water membranes, and

(3) High-rejection brackish water membranes.

Characteristics of each type of membrane are briefly described below.

Nanofiltration membranes have lower salt rejection characteristics than brackish-water RO membranes, but operate at lower pressures. They commonly reject divalent solutes more effectively than monovalent solutes and range in salt rejection properties from 50 to 90 percent. These membranes effectively produce a larger permeate stream than an RO membrane, but the permeate is of lower quality. Although nanofiltration membranes are capable of handling higher flows, a greater percentage of the feed water must be treated to achieve an acceptable blended discharge quality for release.

Low-pressure/low-energy membranes offer an intermediate rejection and operating pressure option to the RO and nanofiltration options. Membrane manufacturers have focused on designing higher flux and high rejection energy saving modules that are referred to as low energy or low pressure RO. The low pressure RO membranes can achieve salt rejection above 99 percent depending on the salt content of the feed water, while operating at higher flux rates than high-pressure RO membranes.

High-rejection membranes operate at higher pressure but have higher salt rejection than both nanofiltration and low-energy/low-pressure reverse-osmosis membranes. High-rejection membranes are employed where the source water includes problematic constituents that are likely to exceed regulatory standards without high levels of rejection. These membranes effectively produce a higher quality permeate stream than a nanofiltration membrane, but the pressure requirements for operation are higher.

Using the design water quality provided in Table 5-3 and desalting modeling programs, it was determined that thin-film-composite, ultra-low-pressure membranes were the best fit for this water composition. Comparison of feed pressure and permeate TDS to determine the optimal membrane type for this water composition is provided in Appendix A – Membrane Selection Evaluation.

Table 5-3. RO Desalination Design Feed, Product, Reject, and Blended Water Quality Concentrations

Analyte	Units	Design Feed Concentration	RO Product Concentration	Reject Concentration	Blended Water Quality[1]
Bicarbonate	mg/L	205.0	15.12	1,278.7	112.0
Calcium	mg/L	100.0	1.28	659.4	51.6
Chloride	mg/L	169.8	6.47	1,095.3	89.8
Magnesium	mg/L	40.6	0.52	267.7	21.0
Nitrate (as NO_3)	mg/L	3.6	0.60	20.6	2.13
Potassium	mg/L	5.3	0.48	32.6	2.94
Silica	mg/L	26.8	1.37	170.9	14.3
Sodium	mg/L	113	8.07	707.6	61.6
Sulfate	mg/L	216	1.44	1,431.8	110.9
pH	---	7.4	6.27	8.2	7.18
Fluoride	mg/L	0.464	0.01	3.0	0.24
Iron	mg/L	0.012	0.007	0.08	0.02
Manganese	mg/L	0.015	0.008	0.1	0.02
TDS	mg/L	900	32.40	5,795	476.3
Sum of Ions	mg/L	880	35.35	5,672	466.4

1 Note: Blended concentrations of analytes not listed, such as arsenic, chromium, and zinc meet MCLs prior to treatment due to non-detects at the well field or after passage through the RO system.

Previous Reclamation RO designs considered large-diameter membrane elements such as the 18-inch mega-magnum by Koch. The industry standard large-diameter RO element size is 16 inches in diameter. Due to the wide flow variability as shown in Table 3-1, a four (4)-unit (skid) design using standard 8-inch-diameter membrane elements is recommended, as shown in Figure 5-6. The 8-inch membrane modules are manufactured by almost every commercial membrane manufacturer, which will give Fallbrook a competitive advantage at final bid. Each skid-mounted system includes a feed pump, RO vessels, RO membrane elements, associated piping, valve controls, instruments, and sample and instrument panels. Feed pressure at the maximum influent flow of 6.9 cfs was modeled at 120 psi with concentrate pressure of 92.6 psi.

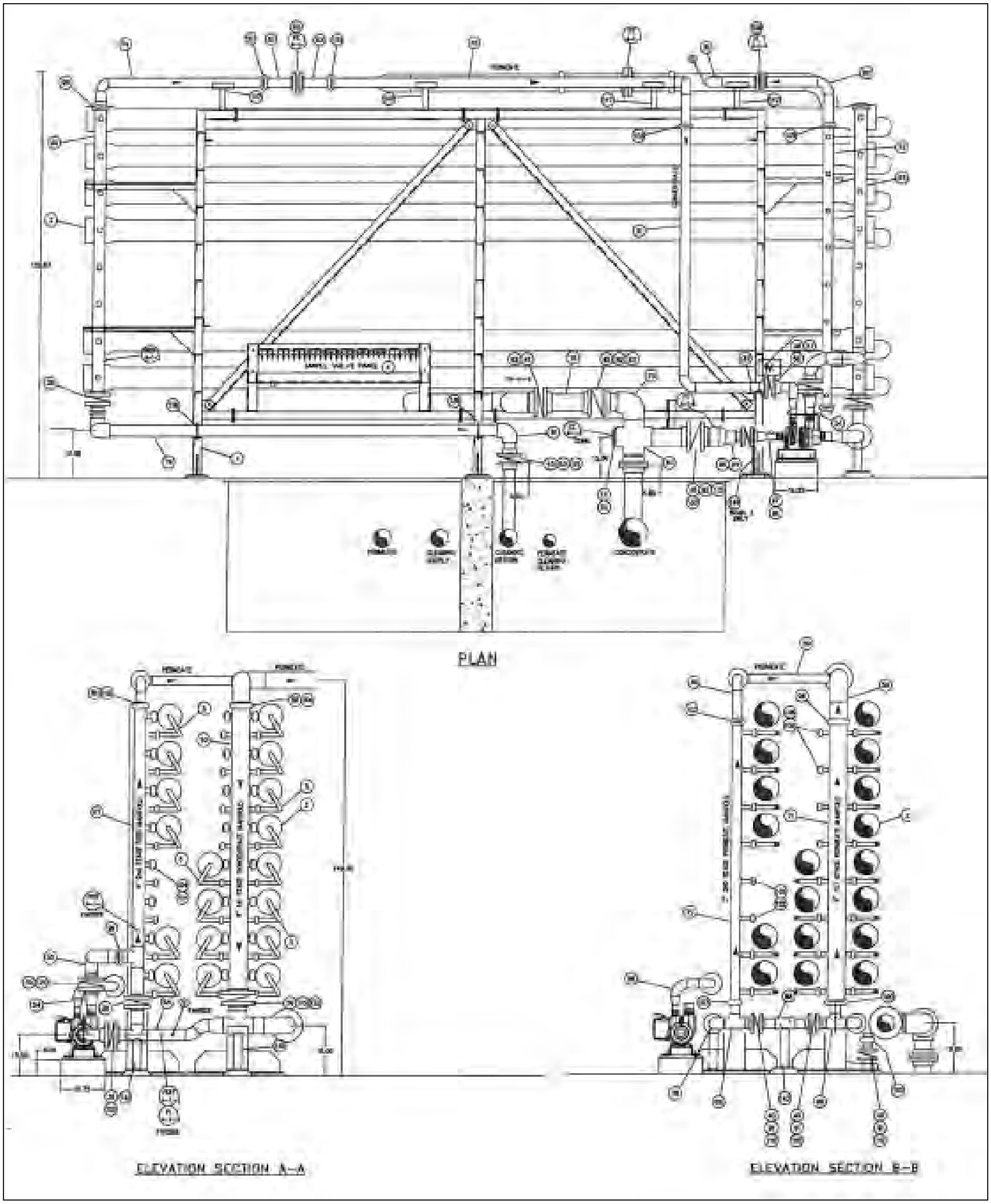


Figure 5-6. Reverse osmosis skid (from H_2O Innovations Inc.)

Product water from the iron and manganese plant will enter the RO units at approximately 70-75 psi and split between the RO feed and an RO bypass. The residual pressure from the iron and manganese plant will provide the initial feed pressure for the RO system, and booster pumps on the RO skids will provide the remaining feed pressure. The RO bypass water will discharge into the clearwell for blending. Alternatives to explore in final design include:

- Placing a pressure-regulating valve on the RO product line to match the RO bypass line pressure, so one pipe can be used instead of having two separate lines to the clearwell.
- Using one (1) common manifold and fewer pumps to feed the four (4) skids.

The thin-film-composite 8040-ULP-400 membranes selected from Koch Membrane Systems are projected by manufacturer software to achieve a total recovery of 85 percent in a two-stage system. Percent removal of salts was projected to be 96.4 percent. It is recommended that a three-stage configuration be considered in the final design if manufacturer claimed projections of rejection and recovery are not achievable through the use of a two-stage configuration. Considerations when further evaluating the two stage system in final design include:

- RO systems conventionally operate at 50-percent recovery per membrane stage, with a maximum recovery of 75 percent in a two-stage system. A third stage should be considered if the two-stage design is not expected to meet the projected recovery of 85 percent.
- Velocity should be limited in the RO design to avoid telescoping in the first stage of the two-stage configuration.
- At high recoveries, scaling in the second stage of the two-stage configuration should be re-evaluated to compare to a three-stage configuration.

The RO building was sized to accommodate a fifth RO unit for redundancy, or a three-stage configuration, offering flexibility to allow Fallbrook to modify or upgrade the RO system at any time. As mentioned in chapter 3, for final design, the MCBCP raw water quality data should be shared with FPUD operators and designers, so that they can adjust this design as needed should there be a change in raw-water quality from the data presented here. The RO unit is expected to remove organic matter sufficiently, just as MCBCP's P113 WTP has been doing since 2008. Specifically, the use of GAC upstream of RO should be avoided when possible, as GAC has been shown to add fine carbon particles or biological species to membranes.

In addition to iron and manganese pretreatment, antiscalant and cartridge filtration will be used prior to the RO unit intake. Cartridge filters are contained on a separate skid-mounted system and rely on the residual influent pressure for filtration. An antiscalant skid-mounted system is also included with these units. A summary of all the RO system components is included in Table 5-4.

Table 5-4. RO System Summary

Antiscalant System	
Antiscalant tank volume	200 gallons
Number of dosing pumps	2
Pump capacity	0.2–1.0 gallons per hour
Pump control	Proportional to feed flow to RO units
Cartridge Filters	
Number of units	3 — each rated for 1,400 gpm
Feed flow	4,120 gpm
Design pressure	100 psi
Cartridge rating	10 microns
Cartridge type	Polypropylene (wound or melt blown)
RO Units	
Number of units:	4
Max feed flow:	1,030 gpm
Max permeate flow:	825 gpm
Max reject flow:	205 gpm
Recovery:	85 %
Array	16 – 8 (7 element)
Number of membranes	168
Feed pressure	150 psi
Feed pump	1,030 gpm @ 200 psi, ~150 horsepower
CIP System	
Number of units:	1
Tank volume	1,500 gallons
Pump flow	320 gpm (sized to clean 8 vessels)
Pump power	~25 horsepower
Cartridge filter rating	320 gpm

An RO CIP is required every 6 to 12 months. The RO CIP involves re-circulating some of the treated water and soaking the membranes first with a low–pH detergent and then with a high-pH detergent to remove foulants that have accumulated on the membrane surface. If a membrane volume is estimated to be 5.8 gallons per element, then with 168 elements per skid a total of 975 gallons would be required per cleaning per skid. The CIP pump is sized to clean eight (8) vessels or 56 elements or a third of each skid. CIP chemicals are neutralized in the CIP tank before discharge into the city sewer system. The RO concentrate reject (1.0 cfs reject at 5,795 mg/L during 6.9 cfs RO feed, 13.5 cfs plant feed, and 85 percent recovery) is discharged directly into an ocean outfall for disposal.

5.5 Clearwell Disinfection

The clearwell, described structurally in section 5.1, provides the contact time needed to meet disinfection credit for giardia and virus removal. Sodium hypochlorite is added for this purpose as the primary disinfectant. This report assumes that 4-log removal for virus control is needed.

A secondary disinfectant is needed to protect the water quality and the pipeline in Reach 1 from forming biological growth and slimes. For secondary disinfection, ammonia hydroxide is injected in the pumping wetwell portion of the clearwell where excellent mixing occurs after the weir. The combination of the ammonia hydroxide with the previously added sodium hypochlorite will form chloramines, a weaker, but longer lasting disinfectant than hypochlorite. Chloramines are commonly used where water is distributed through long pipelines. Chloramines also are less likely to form DBPs. This design will also utilize the height of water over the weir to accurately calculate flow pacing and dosing. A dosing ratio of 4:1 chlorine to ammonia, and a resulting chloramine concentration of 11.75 mg/L are planned.

5.6 Chemicals, Storage, and Feed

5.6.1 Chemicals

Chemicals necessary for process treatment were selected based on water chemistry and desired treatment objectives. The following chemicals were selected for the listed purposes:

***Potassium permanganate ($KMnO_4$)* –** A 5-percent solution of potassium permanganate is injected into the iron/manganese removal reaction tank at a concentration of 1.24 mg/L to oxidize iron and manganese in the raw water feed.

***Sodium Hypochlorite (NaOCl)* –** A 12.5-percent solution of sodium hypochlorite is used for disinfection. As much as 3 mg/L is injected into the blend flow chamber of the clearwell to disinfect the combined RO product and bypass flow prior to discharge to the FPUD system.

***Antiscalant* –** Antiscalant is injected into the RO feed stream to increase the solubility of sulfates and carbonates to prevent them from combining with calcium and scaling the RO membranes.

***Sodium hydroxide (NaOH)* –** The reverse osmosis process reduces the pH of the product stream. A 30-percent solution of sodium hydroxide (caustic) is injected into the RO product stream to raise the pH to a neutral level. A standard commercial concentration of 50 percent must be maintained above

70 ° F to prevent crystallization. The 30-percent solution strength was selected to eliminate heat tracing of the storage tank and piping.

Ammonium hydroxide (NH_4OH) – A 19.5-percent solution of ammonium hydroxide is injected into the treated water discharge pump sump to react with the previously injected chlorine (sodium hypochlorite) to form chloramines.

5.6.2 Chemical Storage

Chemical storage was designed to provide a minimum 30-day supply of process chemicals at maximum treatment capacity. Table 5-5 lists the estimated amounts needed for a 30-day supply.

Although 30 days usage at a maximum treatment flow would require only 1,290 gallons of ammonium hydroxide, a 10,000-gallon steel tank was provided to accommodate a typical commercial delivery quantity of 6,700 gallons. If ammonium hydroxide can be economically purchased in smaller quantities, the tank and containment sizing can be revised during final design.

Table 5-5. Estimated Quantities of Chemicals Needed to Supply the Fallbrook Water Treatment Plant for 30 Days

Chemical	30-Day Storage Quantity	
	@Avg. feed (4.8 cfs)	@Max. feed (13.5 cfs)
Sodium hydroxide (NaOH)	385 gallons	1,084 gallons
Potassium permanganate ($KMnO_4$)	860 pounds	2,713 pounds
Sodium hypochlorite (NaOCl)	1,866 gallons	5,885 gallons
Ammonium hydroxide (NH_4OH)	459 gallons	1,290 gallons
Antiscalant	96 gallons	268 gallons

Two (2) 3,500-gallon fiberglass-reinforced plastic tanks store the sodium hypochlorite. The tanks are located outside of the treatment building under a sunshade on elevated pads within a concrete containment basin. The containment basins for sodium hypochlorite and ammonium hydroxide are sized per code to hold one tank volume. For sodium hypochlorite that is 3,500 gallons and for ammonium hydroxide it is 7,500 gallons, slightly more than a delivery volume.

The remaining chemicals are delivered and stored in 330-gallon totes. Totes will be stacked two-high on a containment pallet capable of holding the volume of one tote. Totes for sodium hydroxide will be handled using a forklift and stored under the sunshade on the north and south aprons of the chemical storage area. Chemical injection pumps and accessories will be located adjacent to the totes with their own containment. The totes for the antiscalant will be stored and dispensed inside the treatment building.

Potassium permanganate will be delivered and stored as a dry powder in 25-pound containers on pallets. A 100-square-foot storage building will house the pallets and a solution mix-and-feed system including chemical injection pumps and accessories.

5.6.3 Chemical Feed

Chemical injection equipment is sized using one (1) active pump and one (1) spare pump for each chemical. Each pump has a turndown ratio of 10:1 allowing it to cover minimum to maximum flow ranges. For the chemicals inside the containment basins, the chemical injection pumps and accessories will be located adjacent to the tanks.

The following describes the injection controls philosophy for the Fallbrook WTP.

- Injection of potassium permanganate for iron and manganese removal will be paced by a flowmeter located downstream of the raw water feed pumps.
- Injection of antiscalant will be paced by the RO feed flowmeter.
- Injection of sodium hydroxide will be paced by pH and flow readings on the RO product line.
- Injection of sodium hypochlorite for disinfection will be paced by the total blend flow from the flowmeters on the RO product and RO bypass lines.
- Injection of ammonium hydroxide will be paced by the flowmeter and chloramine analyzer on the treated water pump discharge pipeline.

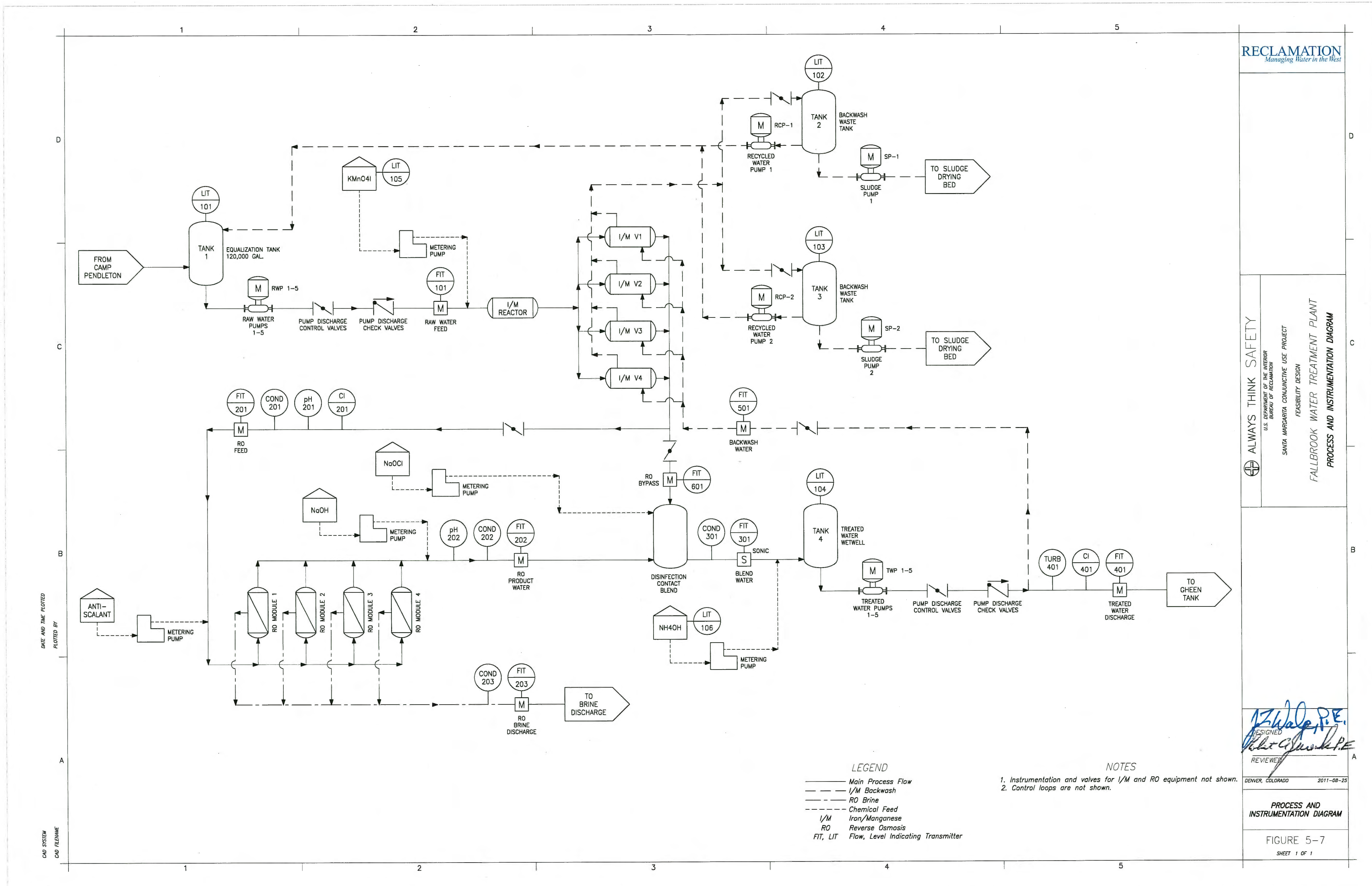
5.7 Instrumentation and Controls

5.7.1 Measurement and Control of Membrane Water Treatment Operating Parameters

Water treatment plant operators rely on instrumentation located throughout the plant which monitors key process variables. Process control parameters and the affected flowstream for membrane systems are summarized in Table 5-6. A process and instrumentation diagram is provided as Figure 5-7.

Table 5-6. Process Control Parameters

Parameter	Affected Flowstream:
Flow rates	Feed, product, and concentrate flows
Pressures	Feed and concentrate flows
Conductivity	Feed, product, and concentrate flows
Temperature	Feed flows
pH	Feed and product flows
Turbidity	Feed flows
Silt Density Index (SDI)	Feed flows


RECLAMATION
Managing Water in the West
FROM CAMP PENDLETON
LIT 101
TANK 1
EQUALIZATION TANK 120,000 GAL.
RWP 1-5
RAW WATER PUMPS 1-5
PUMP DISCHARGE CONTROL VALVES
PUMP DISCHARGE CHECK VALVES
FIT 101
RAW WATER FEED
KMnO4I
LIT 105
METERING PUMP
I/M REACTOR
I/M V1
I/M V2
I/M V3
I/M V4
LIT 102
TANK 2
BACKWASH WASTE TANK
RCP-1
RECYCLED WATER PUMP 1
SP-1
SLUDGE PUMP 1
TO SLUDGE DRYING BED
LIT 103
TANK 3
BACKWASH WASTE TANK
RCP-2
RECYCLED WATER PUMP 2
SP-2
SLUDGE PUMP 2
TO SLUDGE DRYING BED
FIT 201
COND 201
pH 201
Cl 201
RO FEED
FIT 501
BACKWASH WATER
NaOCl
METERING PUMP
NaOH
METERING PUMP
RO BYPASS
FIT 601
pH 202
COND 202
FIT 202
RO PRODUCT WATER
DISINFECTION CONTACT BLEND
COND 301
FIT 301
SONIC
BLEND WATER
LIT 104
TANK 4
TREATED WATER WETWELL
TWP 1-5
TREATED WATER PUMPS 1-5
PUMP DISCHARGE CONTROL VALVES
PUMP DISCHARGE CHECK VALVES
TURB 401
Cl 401
FIT 401
TREATED WATER DISCHARGE
TO GHEEN TANK
ANTI-SCALANT
METERING PUMP
RO MODULE 1
RO MODULE 2
RO MODULE 3
RO MODULE 4
NH4OH
LIT 106
METERING PUMP
COND 203
FIT 203
RO BRINE DISCHARGE
TO BRINE DISCHARGE
LEGEND
Main Process Flow
I/M Backwash
RO Brine
Chemical Feed
I/M Iron/Manganese
RO Reverse Osmosis
FIT, LIT Flow, Level Indicating Transmitter
NOTES
1. Instrumentation and valves for I/M and RO equipment not shown.
2. Control loops are not shown.
ALWAYS THINK SAFETY
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
SANTA MARGARITA CONJUNCTIVE USE PROJECT
FEASIBILITY DESIGN
FALLBROOK WATER TREATMENT PLANT
PROCESS AND INSTRUMENTATION DIAGRAM
DESIGNED
REVIEWED
DENVER, COLORADO 2011-08-25
PROCESS AND INSTRUMENTATION DIAGRAM
FIGURE 5-7
SHEET 1 OF 1
DATE AND TIME PLOTTED
PLOTTED BY
CAD SYSTEM
CAD FILENAME

Each of these parameters should be measured on a continuous basis, except SDI, which should be measured no less than daily. From these basic parameters, system operators can track performance and adjust process variables as needed for successful, reliable operation. Omitted from this discussion are detailed technical process terms which are derived from the basic parameters listed above.

Control of a WTP requires information on the operation to be measured, recorded, and analyzed daily to track changes and make system adjustments. Instrumentation is typically used to measure operating parameters. Data acquisition is gathering and recording system information. Gathering information consists of taking samples or using in-line instruments to measure operating parameters. Recording the information is used to maintain a log of system operation in order to monitor long-term trends. Adjusting or controlling the system is done by observing system parameters and then operating valves, pumps, or other system equipment to maintain parameters within desired ranges. An automated system uses a computer or other programmable device to monitor system parameters and make changes to maintain desired conditions instead of requiring a system operator to do it manually. These features are discussed more fully below.

Instrumentation **-** Instruments used to measure the parameters listed above vary from simple analog indicators — e.g., pressure gauges or thermometers — to continuous measuring devices which can be remotely monitored and recorded. On a typical RO system with automatic controls, instrumentation will normally be continuous and connected to a remote monitoring and control system such as a programmable logic controller (PLC). Specific types of instrumentation are as follows:

1. *Flow* – Magnetic-type flowmeters, of the sizes indicated below, using a flange spool with Teflon lining, are designed for the following waterlines:
    a. Raw water feed, 18-inch
    b. RO feed, 10-inch
    c. RO product, 8-inch
    d. RO reject, 6-inch;
    e. RO bypass, 12-inch;
    f. Treated water discharge, 16-inch
    g. Backwash water supply, 8-inch.

    Flowmeter instrumentation provides a local flow rate and total flow and transmits the signal electronically to the PLC.

2. *Pressure* – Pressure is measured with transducers connected to the PLC. Gauges can be provided for local spot-checking of operating pressures.

3. *Conductivity* – This parameter is measured as current divided by the resistance to current flow between two (2) electrodes placed in the water flowing through the pipes. The lower the conductivity value the

purer the water. It is related to a standard sodium-chloride solution but is usually calibrated for the specific salts in the feed water.

4. *Temperature* – The temperature is measured using a thermocouple device. This is usually reported in degrees Celsius and is used to reference water production to a standard of 25°C.
5. *pH* – The pH (or “potential of hydrogen”) value is the logarithm of the reciprocal of the hydrogen-ion concentration in gram atoms per liter. pH provides a measure on a scale from 0 to 14 of the acidity or alkalinity of a solution (where 7 is neutral, greater than 7 is acidic and less than 7 is basic).
6. *Turbidity* – This is a measure of suspended particles in the water and EPA regulations require a value of less than 1 NTU in the final water.
7. *SDI* – This is used to estimate the fouling potential of the feed water on the membranes. A 0.45-micrometer filter is exposed to the feed water under pressure, and the filtration rates are calculated. Usually the desired index after pretreatment is a value of less than 5, and a value of less than 3 is preferred.

Data Acquisition – Data acquisition consists of recording operating parameters from instrumentation or sampling to maintain a log of system operation. WTP operators usually monitor process operations and collect data for system managers, regulators, and others. Data may be recorded either manually on paper forms or automatically through use of data loggers or computer database systems.

Purpose – The purpose of data acquisition is to be able to look for trends in system operation which indicate undesired changes and allow adjustments to operation to maintain desired water quality and treatment efficiency.

Analysis – Once operating data are recorded, the data can be analyzed for different trends and efficient operating characteristics. Data trends are then compared to desired conditions and normalized to standard reference conditions.

Automation – A control program is written for the RO PLC. The program monitors the operating parameters and compares them to desired set points. If a parameter departs from the desired range, the PLC adjusts valve openings, pump speeds, chemical injection rates, etc., to bring the system back to the desired conditions. If the PLC cannot bring the system back within set points, then alarms alert an operator so the problem can be investigated.

5.7.2 Instrumentation and Controls

The following describes the specific instrumentation planned for the Fallbrook WTP and the Gheen Tank:

Equalization Tank Level Sensor/Transmitter (LIT 101) - Signal is used to control raw water pumps. As level increases or decreases within a specified range, pumps are turned on or off to maintain level in the tank.

Raw Water Feed Flowmeter/Transmitter (FIT 101) – Signal is used to pace the injection of potassium permanganate into the feed stream for the iron/manganese reaction tank. Signal is also used with the signal from the RO feed flowmeter/transmitter (FIT 201) to set RO feed and bypass flow rates.

RO Feed Flowmeter/Transmitter (FIT 201) – Signal is used with FIT 101 signal to control RO feed and bypass flow rates. Signal is also used to pace antiscalant metering pump.

RO Feed pH Sensor/Transmitter (pH 201) – Signal is used to monitor RO feed pH.

RO Feed Conductivity Sensor/Transmitter (COND 201) – Signal is used to monitor RO feed conductivity.

RO Product Flowmeter/Transmitter (FIT 202) – Signal is used with FIT 201 and FIT 203 to monitor system recovery. Signal also used with FIT 101 and FIT 201 to calculate flow signal to pace sodium hypochlorite metering pump for disinfection injection.

RO Product Conductivity Sensor/Transmitter (COND 202) – Signal is used to monitor RO product conductivity for blend calculations.

RO Product pH Sensor/Transmitter (pH 202) – Signal is used with FIT 202 to pace sodium hydroxide metering pump to increase RO product pH to required level.

RO Brine Conductivity Sensor/Transmitter (COND 201) – Signal is used to monitor RO brine conductivity.

RO Brine flowmeter/transmitter (FIT 203) – Signal is used with FIT 201 and FIT 202 to monitor system recovery.

Blend Water Flowmeter/Transmitter (FIT 301) – Signal is used to pace ammonium hydroxide metering pump for transition to chloramines disinfection protection.

Blend Water Conductivity Sensor/Transmitter (COND 301) – Signal is used to monitor blend flow conductivity for desired treatment level. May be used to adjust RO feed and bypass control valves to maintain treated conductivity.

Treated Water Wetwell Level Sensor/Transmitter (LIT 104) - Signal is used to control treated water pumps. As level increases or decreases within a specified range, pumps are turned on or off to maintain level in the tank.

Treated Water Turbidity Analyzer/Transmitter (TURB 401**) –** Signal is used to monitor compliance with drinking water standards.

Treated Water Chloramine Sensor/Transmitter (Cl 401) – Signal is used to monitor chloramine level in treated water delivered to the system. Signal provides control signal for ammonium hydroxide metering pump.

Treated Water Discharge Flowmeter/Transmitter (FIT 401) – Signal is used with a totalizer to monitor the quantity of water delivered to the system.

Backwash Water Flowmeter/Transmitter (FIT 501) – Signal is used to control flow rate and pressure for iron/manganese filter backwash. May control backwash valve on manifold or individual backwash valves at filter vessels.

Backwash Waste Tank (Tank 2) Level Sensor/Transmitter (LIT 102) – Signal is used to control recycled water pump 1 (RCP-1) and sludge pump 1 (SP-1) for discharge of water to equalization tank and sludge drying beds. Signal is also used to select which backwash waste tank is in service.

Backwash Waste Tank (Tank 3) Level Sensor/Transmitter (LIT 103) – Signal is used to control recycled water pump 2 (RCP-2) and sludge pump 2 (SP-2) for discharge of water to equalization tank and sludge drying beds. Signal is also used to select which backwash waste tank is in service.

Gheen Tank Level Sensors/Transmitters (LIT 601) – Signal is used to control booster pumps. As level increases or decreases within a specified range, pumps are turned on or off to maintain level in the tank.

5.8 Residuals

The source water for the Fallbrook WTP does not contain appreciable amounts of solids. The turbidity, which is a surrogate measure of suspended solids, is typically between 0 and 1 NTU with occasional readings of up to 25 NTU. This turbidity level corresponds to an estimated 1 mg/L of suspended solids. In addition to suspended solids, there is iron and manganese in the groundwater. The use of desalination membranes requires that these constituents be removed or be kept in a dissolved or reduced chemical state until the stream has passed the membranes; otherwise membrane fouling will occur. Since keeping the iron and manganese in a dissolved state leaves the constituents in the water, where they could subsequently prove to be a problem for water users, our recommendation is to remove them upstream of the desalination unit. This treatment will result in dissolved forms of iron and manganese being removed as insoluble particulate forms. The removal of the particulate forms will generate a sludge residual. This residual will make up the majority of all residual solids at the treatment facility.

The removal of the dissolved iron and manganese will be accomplished by oxidation prior to filtration. The oxidized forms of iron and manganese are less soluble than the reduced forms and will precipitate and be captured by a proprietary granular media filter. The solids will accumulate on the filter material and be released during backwashes. As the backwashes may also remove some of the filter media, the filters should be inspected periodically to determine whether more granular media needs to be added. The backwash stream will be directed to two (2) reclaim tanks where the solids will separate from the clarified water. The solids settled in the reclaim tanks will be pumped through a 3-inch pipe to drying beds that are adjacent to the treatment facility.

At the design concentrations of 400 µg/L for iron, 500 µg/L for manganese, and 1 mg/L for suspended solids, approximately 43 pounds of dry sludge will be generated per day at the average flow of 1922 gpm (4.28 cfs). At peak flow of 6,059 gpm (13.5 cfs), the sludge generation is approximately 138 pounds per day.

FPUD owns six (6) abandoned sludge-drying beds, which are located to the west of the Fallbrook WTP. The drying beds are at a lower elevation than the reclaim tanks, but the solids flow will be pumped to ensure proper velocity for keeping the pipe clear of obstruction. Two (2) drying beds are more than adequate to dry the expected solids load from the WTP over a one-year period. Plans call for the two closest drying beds to the WTP to be refurbished with new perforated collection pipes. The beds have concrete floors and walls. Sloped floors direct the water draining from the sludge to a central channel. The water collected will be piped to a wet well between the two drying beds. The wet well will contain a submersible pump that will boost the water to an existing FPUD sanitary sewer manhole.

Each drying bed is 5,940 square feet in area (two side-by-side units, each 18 ft wide and 165 ft. long). Deposition of sludge to a depth of 6 inches when dried allows for application of 2,970 cubic feet of sludge. At average flow, each drying bed would take 15 years to fill. At peak flow, each bed would take 4.7 years to fill. The dried solids collected in the bed will be scraped up and removed manually either when the bed is filled to capacity or when the water is no longer able to percolate through the accumulated deposits. At these low loadings one sludge drying bed is more than adequate. However, for redundancy, the two closest two drying beds are planned for use as shown in Figure 1-3.

5.9 Yard Piping

Yard piping is the buried and exposed piping in and around the WTP. Yard pipe includes the following waterlines:

- Iron and manganese treatment unit influent, bypass, backwash supply and backwash waste;
- Reverse osmosis feed, product, concentrate, and bypass lines;
- Domestic potable water pipeline;

- Domestic sewer line;
- Residuals tank decant pipeline; and
- The treated water pipeline.

Figure 5-8 (following page 68) shows the yard piping for the Fallbrook WTP. FPUD's standard for process piping 6" and greater is to use cement mortar-lined steel pipe fabricated in compliance with American Water Works Association (AWWA) Standard C200. Piping above grade is painted; that below grade is cement mortar coated.

The waterline from MCBCP, which delivers the well water to the Fallbrook WTP, was not included in this estimate, as it is assumed that this 24-inch waterline will be installed and paid for by MCBCP. A small portion of this line on Fallbrook property has been accounted for in the Reach 1 quantities. It is recommended that FPUD install an altitude valve just upstream of the raw water equalization tank. Although the supervisory control and data acquisition (SCADA) system between MCBCP and the Fallbrook WTP will control flow to the WTP, the purpose of the altitude valve is to provide an automatic shutoff of water feeding into the raw water equalization tank, in the event the SCADA system fails.

Pipelines were sized to achieve a conservative 5-feet-per-second (ft/s) velocity. Table 5-7 shows how each nonchemical pipe's diameter was determined using a 5-ft/s velocity.

All iron and manganese and reverse osmosis process pipes are schedule 40 steel.

The source of service and domestic water will be a tap on the FPUD water line. For this feasibility-level design, the tap is assumed to be from the existing waterline northwest of the plant. Although this location is farther from the plant than the clearwell pump manifold (and, hence, requires a longer pipeline), it is less prone to surges from the clearwell pumps.

Domestic wastewater from the plant will be routed by gravity to the existing FPUD sanitary sewer line located just to the east of the plant. A new manhole plus 620 feet of 3-inch pipe is planned for this purpose.

The residuals tank decant pipeline is a 3-inch-diameter, schedule 80 polyvinyl chloride (PVC) force main that directs the solids from a pump serving each residuals tank.

The treated water pipeline is planned to be a 24-inch steel pipe. This line leaves the plant clearwell on Fallbrook property and, like the raw water line to the plant, has been accounted for in the Reach 1 quantities.

Table 5-7. Pipe Design Flow and Diameter

Pipe	Q (ft^3/s)	V (ft/s)	D Calc (in)	D Design (in)	Length (ft)
I/M Influent	13.5	5	22.26	24	125
I/M Bypass	13.5	5	22.26	24	100
Individual I/M (1/3 flow)	4.5	5	12.85	12	60
I/M B/W Waste	0.18	5	2.57	3	130
+-I/M B/W Supply	3.34	5	11.07	12	170
I/M Solids	0.18	5	2.57	3	520
RO Feed - Common (Outside)	13.5	5	22.26	24	140
RO Feed - Common (Inside)	13.5	5	22.26	24	95
Individual RO Feed - Inside (1/4 flow)	3.38	5	11.13	12	10
Individual RO Product - Inside (1/4 flow of 80%)	1.72	5	7.94	8	8
RO Product - Common (Inside)	6.86	5	15.86	16	61
RO Product - Common (Outside)	6.86	5	15.86	16	95
RO Bypass - Inside	6.6	5	15.56	16	120
RO Bypass - Outside	6.6	5	15.56	16	90
Individual Brine - Inside	0.34	5	3.54	4	8
Brine - Inside Common	1.37	5	7.09	8	85
Brine - Outside	1.37	5	7.09	8	410
Domestic Waste - Outside	1	5	6.06	8	120
Potable Water	3.2	5	10.84	12	400
Sludge Decant	0.18	5	2.57	3	620
Reclaim Decant	0.18	5	2.57	3	45

For above-ground lines, the costs for pipe include all supports and painting. For buried lines, an average depth of cover of 3 feet is assumed. Trench sections are based on a 1.5 horizontal to 1 vertical side slope and 6 inches of pipe bedding under the pipe. Costs also include compacted backfill. Also, since the site of the WTP is on compacted fill material, no rock excavation is assumed.
For the liquid and solids pipes from the reclaim tanks, schedule 80 PVC is assumed. For all of the nonchemical pipes, schedule 40 steel pipe is assumed

For the chemical feed piping, materials were selected considering the characteristics of the chemical. A summary of each type of material is shown below. All of the chemical pipelines and the indoor process pipes are shown in Figure 5-9 (following page 68).

(1) Sodium hypochlorite (NaOCl) – Fiberglass reinforced plastic

(2) Potassium permanganate – PVC

(3) Antiscalant - PVC

(4) Sodium hydroxide (NaOH) – PVC

(5) Ammonium hydroxide (NH_4OH) – Steel

(6) Chemical spill drain line – PVC

5.10 Pumping

5.10.1 Raw Water Feed Pumps

There are five (5) raw water feed pumps that can pump slightly more than the 13.5-cfs wet year maximum flow: three (3) one-quarter-size units and two (2) one-eighth-size units for pumping the well water collected in the equalization tank through the iron and manganese removal process to the RO unit. The pumps are vertical turbine type with above-deck discharge. With five (5) units operating, a combined total flow of 13.72 cfs is pumped through the Fe/Mn removal process modules. The three (3) one-quarter-size units each have a rated pumping capacity of 3.43 cfs (1,540 gpm) and the two (2) one-eighth-size units each have a rated pumping capacity of 1.72 cfs (770 gpm). The total dynamic head for each of the pumps is 108 feet (47 psi). The 1,540-gpm units are driven by 60-horsepower (hp) motors and the 770 gpm units by 30-hp motors. Motors are vertical induction, TEFC (totally enclosed, fan-cooled) type operating at 1,800 rpm, 460 volts/3 phase/60 Hz. Each motor is inverter rated for possible future use with a variable frequency drive if necessary to vary pump speed and maintain a constant flow through the Fe/Mn removal process to the RO high-pressure pumps. The raw-water pumping plant plan and sections are provided in Figure 5-10.

5.10.2 WTP Clearwell Pumps

There are five (5) clearwell pumps: three (3) one-quarter-size units and two (2) one-eighth-size units for pumping treated water to the storage tank at the Gheen Booster Pumping Plant. Figures 5-11 and 5-12 show the clearwell pumping plant plans. The pumps are vertical turbine type with above-deck discharge. With five (5) units operating, a combined total flow of 12.5 cfs is pumped to the Gheen tank. The three (3) one-quarter-size units each have a rated pumping capacity of 3.12 cfs (1,400 gpm), and the two (2) one-eighth size units each have a rated pumping capacity of 1.56 cfs (700 gpm). The total dynamic head for each of the pumps is 403 feet. The 1,400-gpm units are driven by 200-hp motors, and the 700-gpm units by 100-hp motors. Motors are vertical induction, WPI enclosure type operating at 1,800 rpm, 460 volts/3 phase/60 Hz. A 15-foot-diameter by 14-foot-high cylindrical air chamber tank is provided on the 24-inch diameter clearwell discharge piping for surge protection. An air compressor system provides the needed air-over-water pressure for air chamber operations.

5.10.3 Gheen Booster Pumping Plant

There are five (5) booster pumps: three (3) one-quarter-size units and two (2) one-eighth-size units for pumping treated water from the Fallbrook Gheen Tank to Red Mountain Reservoir. They are installed outside on a concrete slab located below the Gheen storage tank. The site plan for the Gheen booster pumping plant is provided as Figure 5-13, and sections are provided in Figure 5-14. The pumps are double-suction, horizontal centrifugal, split-case-type pumps with motor-operated isolation butterfly valves on the suction and discharge unit piping. A check valve is installed on the pump discharge to prevent reverse flow through the pump when the unit is stopped or power to the motor is interrupted. With five (5) units operating, a combined total flow of 12.5 cfs is pumped to Red Mountain Reservoir. The three (3) one-quarter-size units each have a rated pumping capacity of 3.12 cfs (1,400 gpm), and the two (2) one-eighth-size units each have a rated pumping capacity of 1.56 cfs (700 gpm). The total dynamic head for each of the pumps is 159 feet. The 1,400-gpm units are driven by 75-hp motors, and the 700-gpm units by 50-hp motors. Motors are vertical induction, TEFC enclosure type operating at 1,800 rpm, 460 volts/3 phase/60 Hz. A 15-foot-diameter by 14-foot-high cylindrical air chamber tank is provided on the 24-inch-diameter discharge piping for surge protection. The air chamber plan and sections are provided as Figure 5-15. An air compressor system provides the needed air-over-water pressure for air chamber operations.

5.10.4 Pumping Philosophy

The envisioned plant is a supply-driven design which will treat all raw water delivered from MCBCP up to 13.7 cfs, slightly above the maximum expected wet year flow of 13.5 cfs.. Water will be delivered to the equalization tank. A level sensor in the equalization tank will monitor tank level. The signal will be used by the plant SCADA system to start or stop the raw water feed pumps as required to maintain the level in the tank between the high and low set-point levels. As the level increases, flows to the treatment process will increase in a stepwise manner as the two (2) one-eighth-capacity and the three (3) one-quarter-capacity pumps are cycled as shown in Table 5-8.

Table 5-8. Raw Water Pump Cycles

Number of Pumps Operating		Flow Rate	
1/8th cap.	1/4th cap.	cfs	gpm
1	0	1.72	770
0	1	3.43	1,540
1	1	5.15	2,310
0	2	6.86	3,080
1	2	8.58	3,850
0	3	10.29	4,620
1	3	12.01	5,390
2	3	13.73	6,160

Flows from the raw-water pumps are fed to the iron and manganese removal process. As flows increase, more filter modules will be placed in service.

Discharges from the iron and manganese removal process will be split between the RO treatment process and the bypass flow. The SCADA system will be programmed to maintain RO recovery and system blend ratios to meet 500 mg/L TDS using flow rates, conductivities, and pH readings from the process instrumentation. Blend and recovery ratios will be controlled with butterfly valves on the bypass and RO feed pipelines.

A level sensor in the clearwell's pumping chamber will monitor its level. The signal will be used by the plant SCADA system to start or stop the clearwell pumps as required to maintain the level in the pumping chamber between the high and low set points. As the level increases, flows to the Gheen tank pipeline will increase in a stepwise manner as the two (2) one-eighth-capacity and three (3) one-quarter-capacity pumps are cycled as shown in Table 5-9.

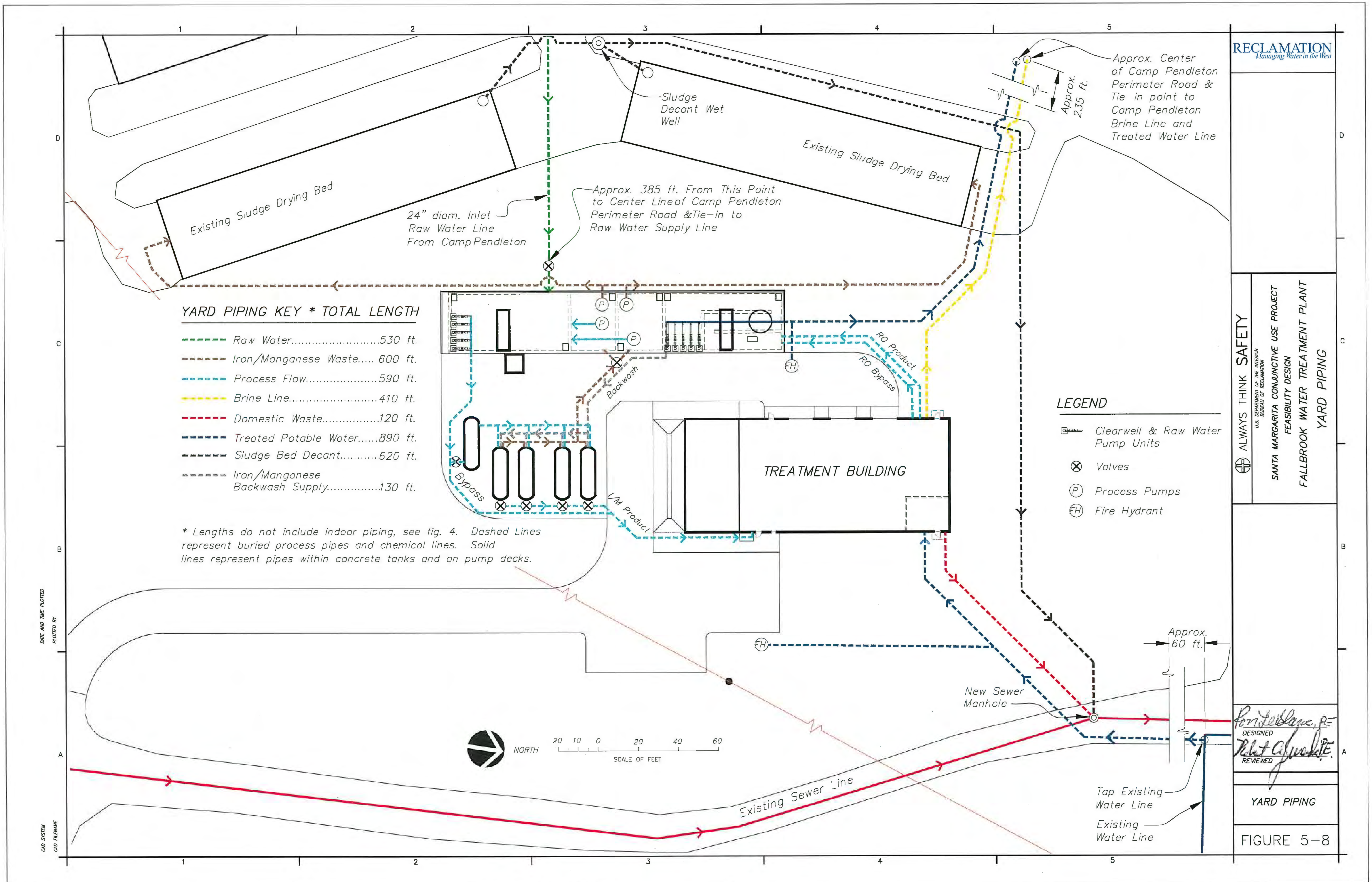
Table 5-9. Clearwell Pump Cycles

Number of Pumps Operating		Flow Rate	
1/8th cap.	1/4th cap.	cfs	gpm
1	0	1.56	700
0	1	3.12	1,400
1	1	4.68	2,100
0	2	6.24	2,800
1	2	7.80	3,500
0	3	9.36	4,200
1	3	10.92	4,900
2	3	12.48	5,600

A level sensor in the Gheen tank will monitor the tank level. This signal will be used by the local remote terminal unit (RTU) control system to start or stop the Gheen booster pumps as required to maintain the level in the Gheen tank between the high and low set-point levels. As the level increases, flows to the Red Mountain Reservoir will increase in a stepwise manner as the two (2) one-eighth-capacity and three (3) one-quarter-capacity pumps are cycled as shown in Table 5-10.

Similarly, as supply flows from MCBCP decrease, control systems will be programmed to reduce plant flows in a stepwise manner by cycling pumps off.

This control scheme assumes all water supplied to the plant is delivered to Red Mountain Reservoir, the most upstream delivery point. If Fallbrook desires to store water in any of the three (3) downstream pumping wetwells (equalization tank, clearwell pumping chamber, or the Gheen tank), this will limit the ability to move water up to Red Mountain Reservoir. If a high level is reached in any of the tanks, a stop signal must override the downstream pumps' controls.


RECLAMATION
Managing Water in the West
Approx. Center of Camp Pendleton Perimeter Road & Tie-in point to Camp Pendleton Brine Line and Treated Water Line
Approx. 235 ft.
Sludge Decant Wet Well
Existing Sludge Drying Bed
Existing Sludge Drying Bed
24" diam. Inlet Raw Water Line From Camp Pendleton
Approx. 385 ft. From This Point to Center Line of Camp Pendleton Perimeter Road & Tie-in to Raw Water Supply Line
YARD PIPING KEY * TOTAL LENGTH
Raw Water..........................530 ft.
Iron/Manganese Waste..... 600 ft.
Process Flow.....................590 ft.
Brine Line..........................410 ft.
Domestic Waste.................120 ft.
Treated Potable Water......890 ft.
Sludge Bed Decant...........620 ft.
Iron/Manganese Backwash Supply...............130 ft.
* Lengths do not include indoor piping, see fig. 4. Dashed Lines represent buried process pipes and chemical lines. Solid lines represent pipes within concrete tanks and on pump decks.
RO Product
RO Bypass
Backwash
Bypass
I/M Product
TREATMENT BUILDING
LEGEND
Clearwell & Raw Water Pump Units
Valves
Process Pumps
Fire Hydrant
Approx. 60 ft.
New Sewer Manhole
Tap Existing Water Line
Existing Water Line
Existing Sewer Line
NORTH
20 10 0 20 40 60
SCALE OF FEET
ALWAYS THINK SAFETY
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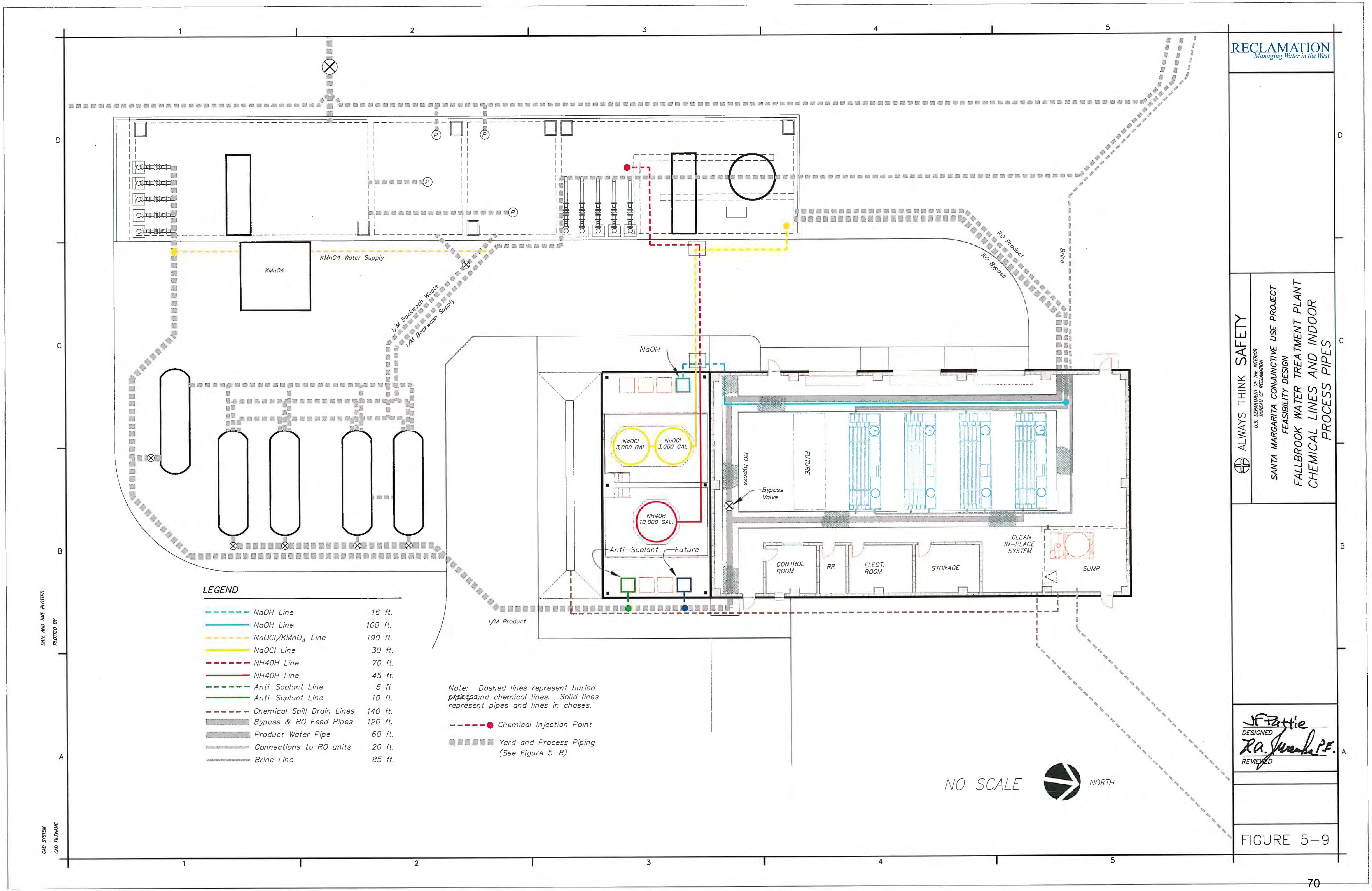
BUREAU OF RECLAMATION
SANTA MARGARITA CONJUNCTIVE USE PROJECT
FEASIBILITY DESIGN
FALLBROOK WATER TREATMENT PLANT
YARD PIPING
DESIGNED
REVIEWED
YARD PIPING
FIGURE 5-8



RECLAMATION
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SANTA MARGARITA CONJUNCTIVE USE PROJECT
FEASIBILITY DESIGN
FALLBROOK WATER TREATMENT PLANT
CHEMICAL LINES AND INDOOR
PROCESS PIPES
KMnO4 Water Supply
KMnO4
I/M Backwash Waste
I/M Backwash Supply
RO Product
RO Bypass
Brine
NaOH
NaOCl 3,000 GAL.
NaOCl 3,000 GAL.
NH4OH 10,000 GAL.
Anti-Scalant
Future
RO Bypass
FUTURE
Bypass Valve
CLEAN IN-PLACE SYSTEM
CONTROL ROOM
RR
ELECT. ROOM
STORAGE
SUMP
I/M Product
LEGEND
NaOH Line 16 ft.
NaOH Line 100 ft.
NaOCl/KMnO4 Line 190 ft.
NaOCl Line 30 ft.
NH4OH Line 70 ft.
NH4OH Line 45 ft.
Anti-Scalant Line 5 ft.
Anti-Scalant Line 10 ft.
Chemical Spill Drain Lines 140 ft.
Bypass & RO Feed Pipes 120 ft.
Product Water Pipe 60 ft.
Connections to RO units 20 ft.
Brine Line 85 ft.
Note: Dashed lines represent buried piping and chemical lines. Solid lines represent pipes and lines in chases.
Chemical Injection Point
Yard and Process Piping (See Figure 5-8)
NO SCALE
NORTH
DESIGNED
REVIEWED
FIGURE 5-9

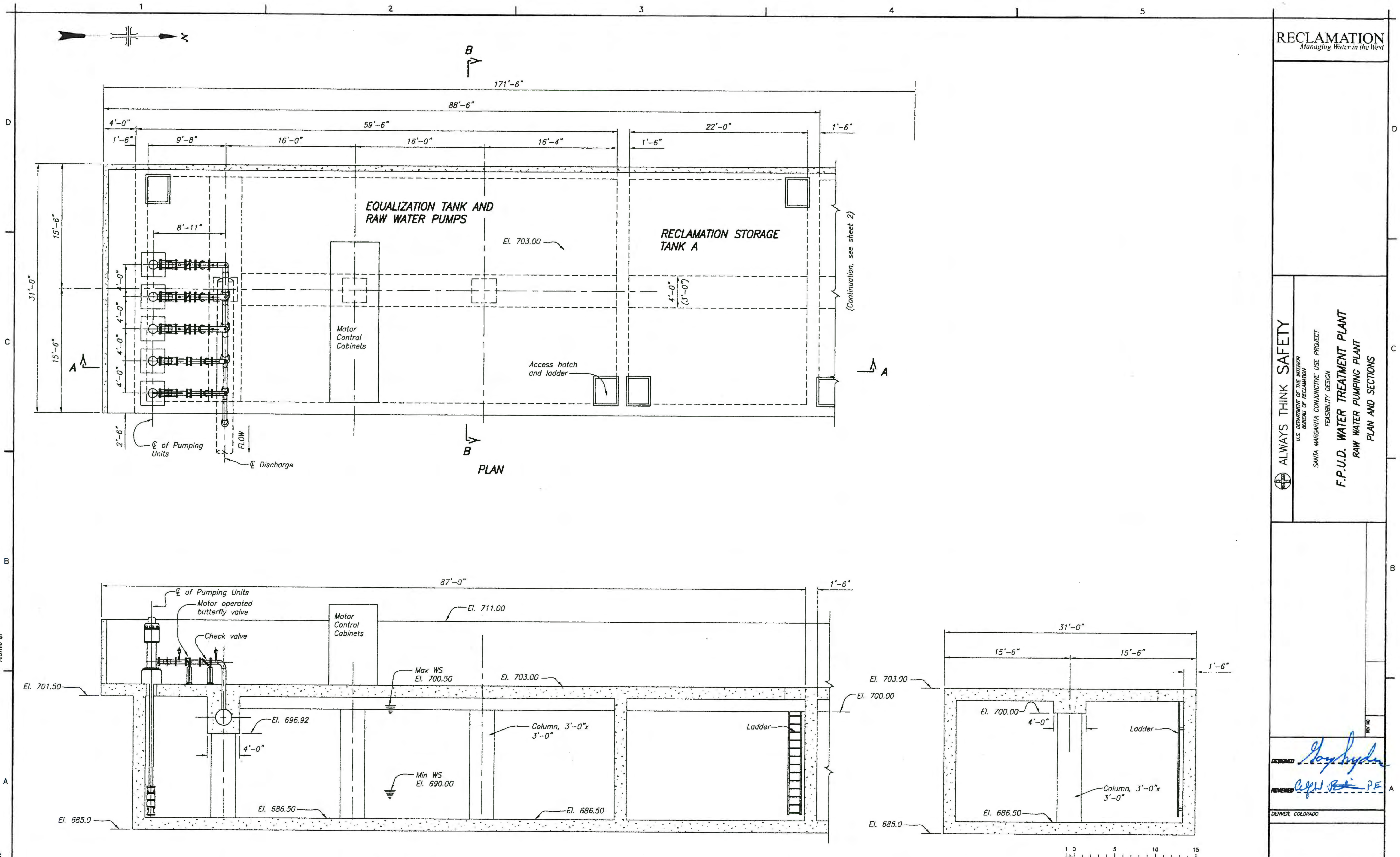
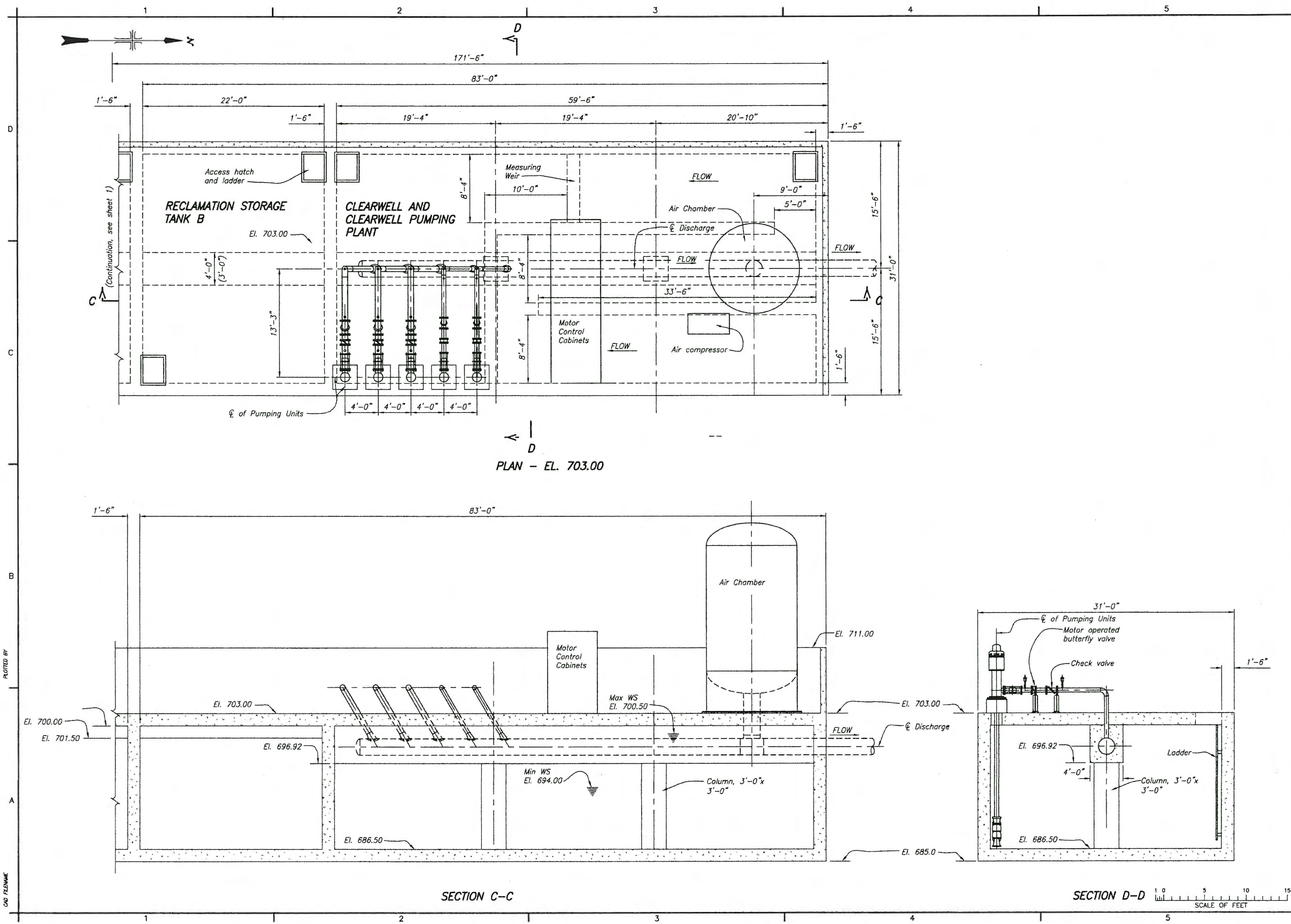


FIGURE 5-10

SHEET 1 OF 1



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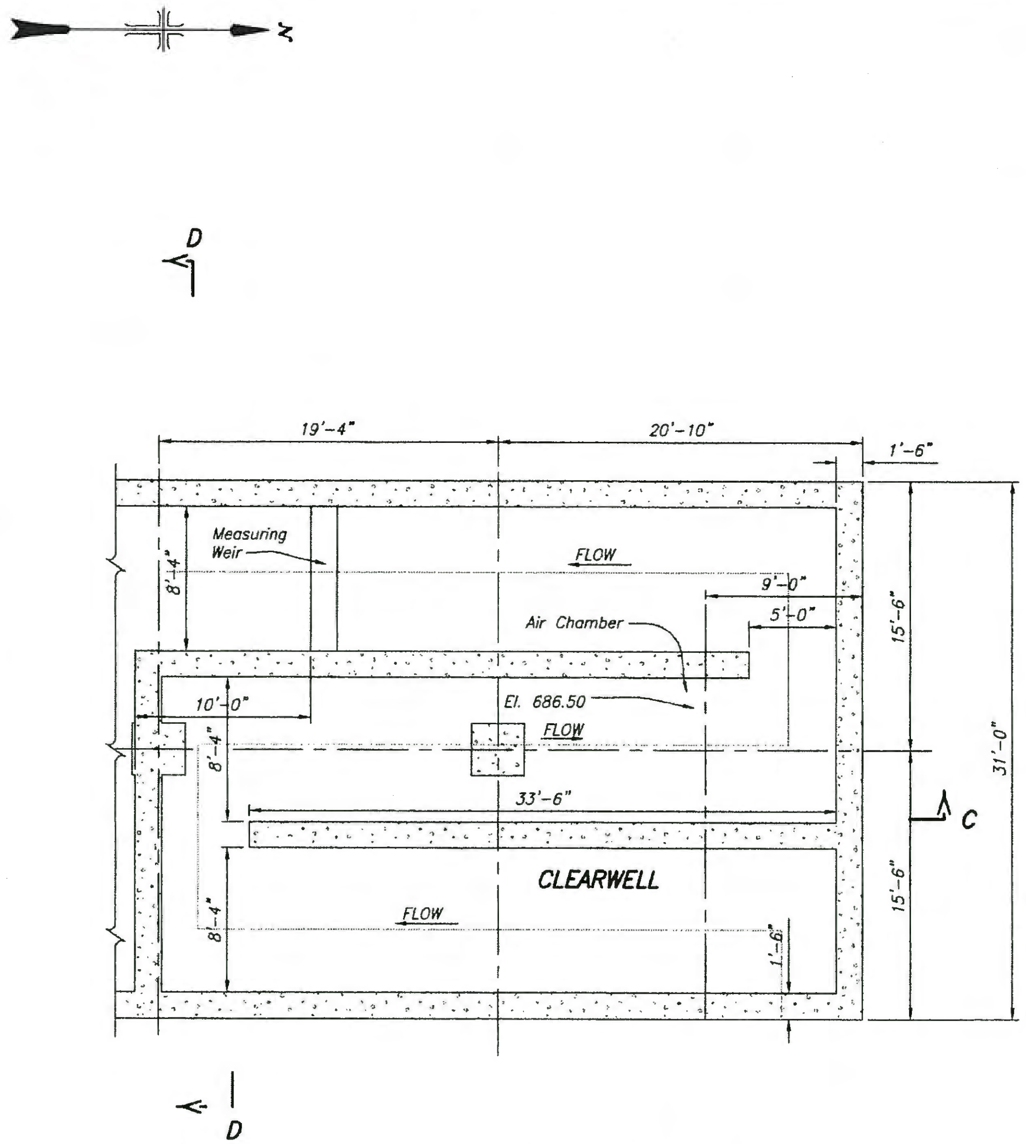
SANTA MARGARITA CONJUNCTIVE USE PROJECT
FEASIBILITY DESIGN

F.P.U.D. WATER TREATMENT PLANT
CLEARWELL PUMPING PLANT
PLAN

DESIGNED
REVIEWED
DENVER, COLORADO

FIGURE 5-11
SHEET 1 OF 1



PART PLAN – EL. 686.50

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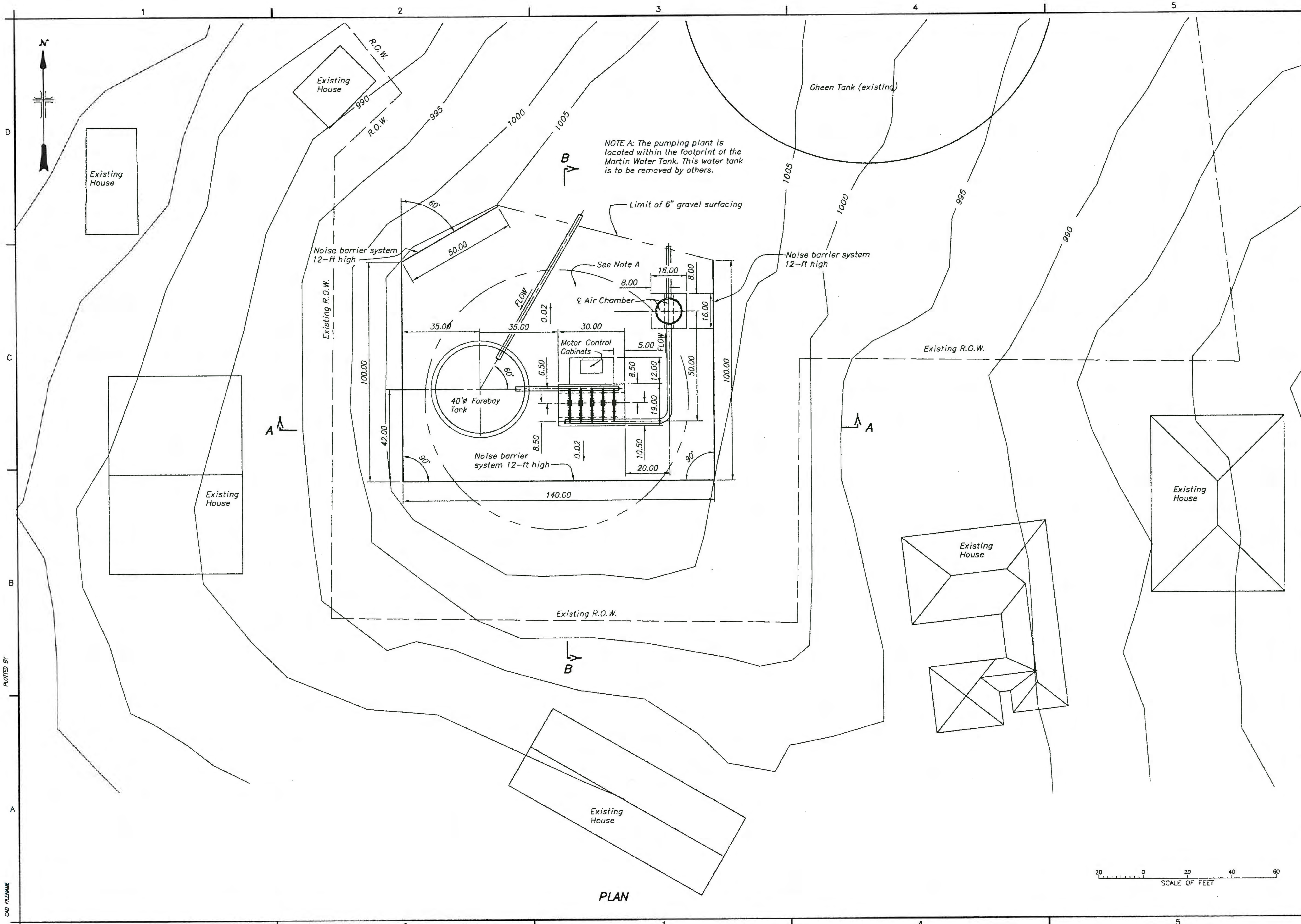
SANTA MARGARITA CONJUNCTIVE USE PROJECT
FEASIBILITY DESIGN

F.P.U.D. WATER TREATMENT PLANT
CLEARWELL PUMPING PLANT
PART PLAN EL. 686.50

DESIGNED
REVIEWED
DENVER, COLORADO

SCALE OF FEET

FIGURE 5–12
SHEET 1 OF 1



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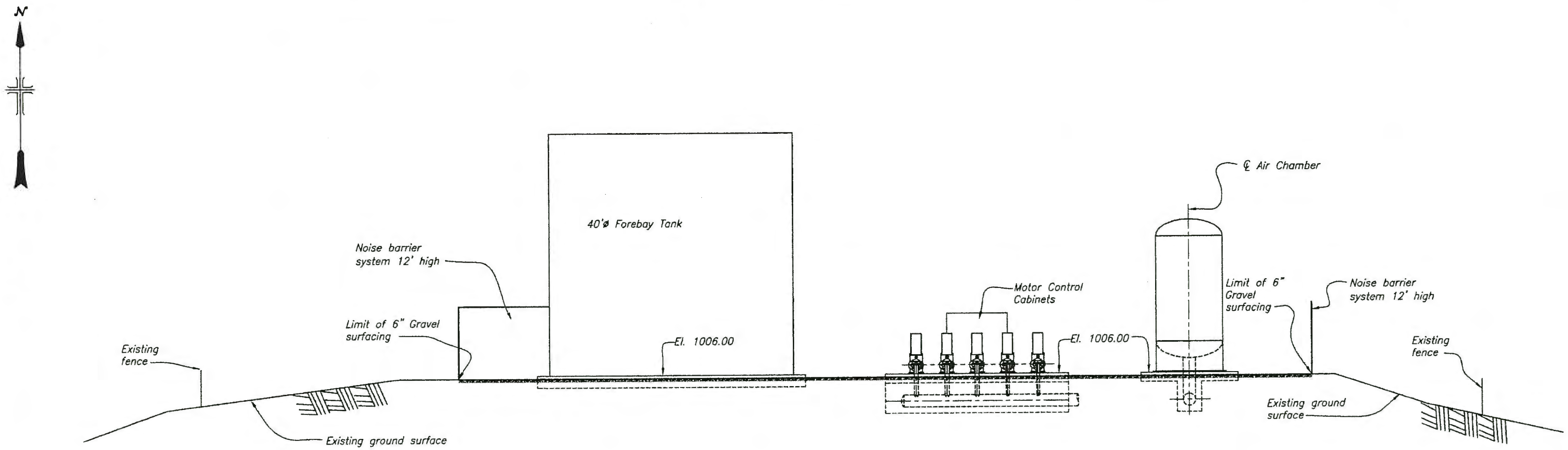
SANTA MARGARITA CONJUNCTIVE USE PROJECT
FEASIBILITY DESIGN

GHEEN BOOSTER PUMPING PLANT
SITE PLAN

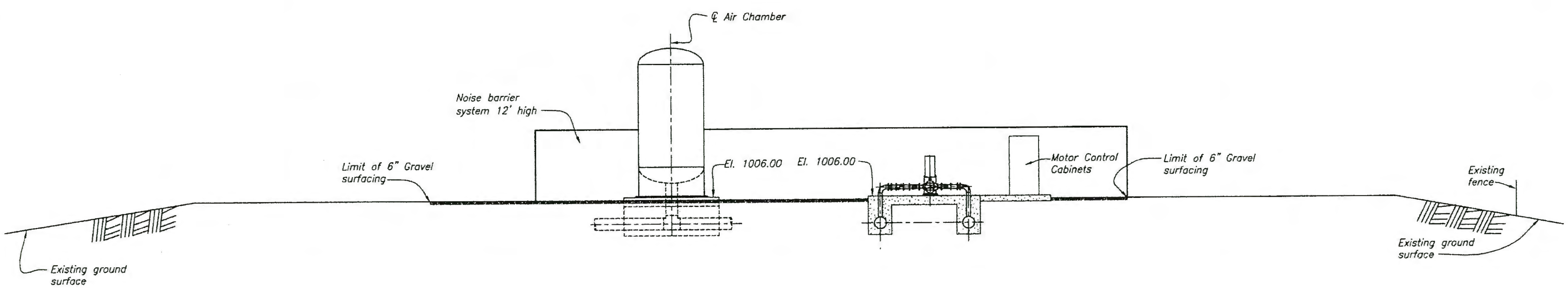
DESIGNED
REVIEWED ... P.E.

DENVER, COLORADO

FIGURE 5-13
SHEET 1 OF 1



SECTION A – A



SECTION B – B

10 0 10 20 30
SCALE OF FEET

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SANTA MARGARITA CONJUNCTIVE USE PROJECT
FEASIBILITY DESIGN

GHEEN BOOSTER PUMPING PLANT
SECTIONS A–A AND B–B

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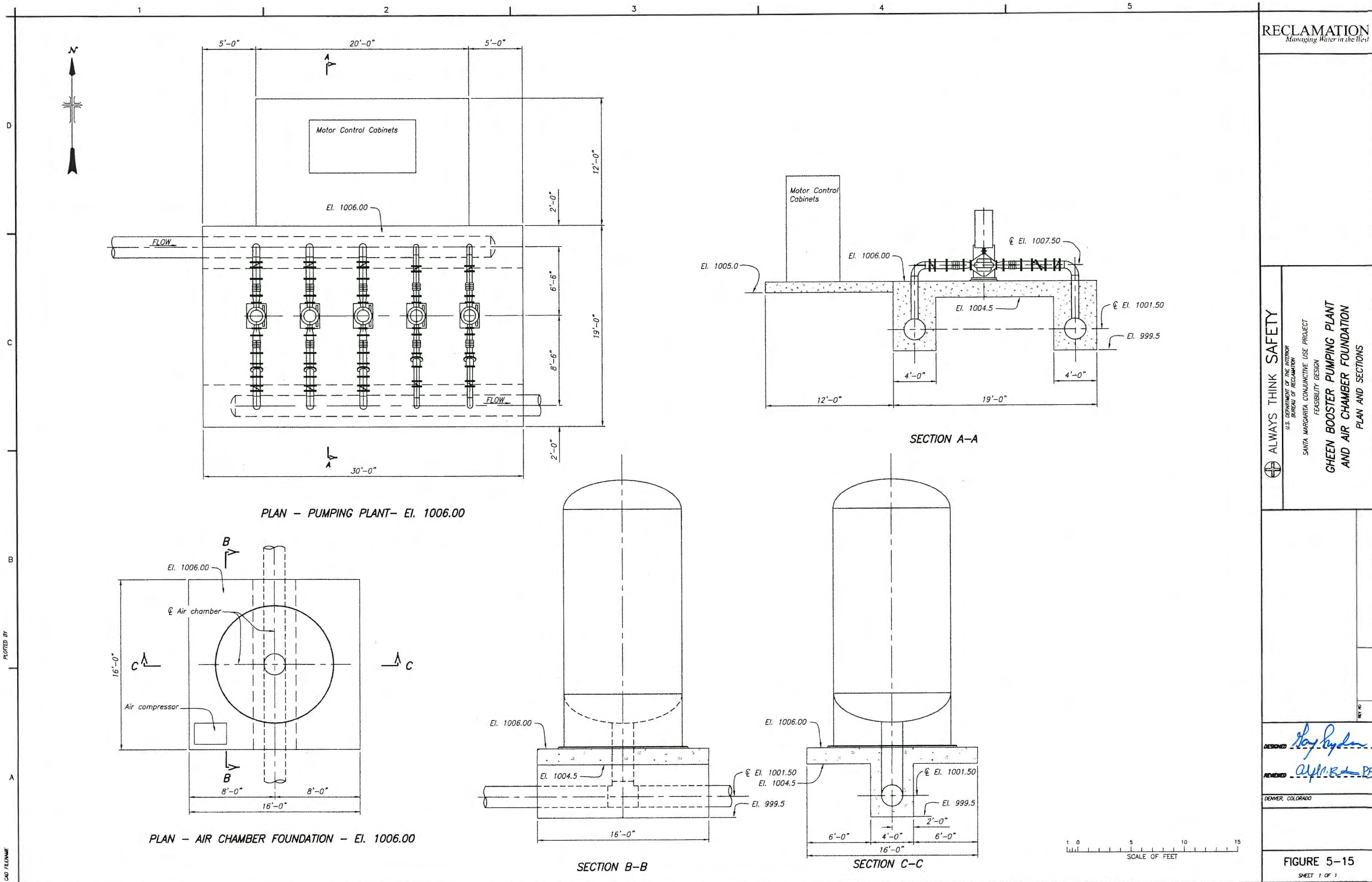
DENVER, COLORADO

FIGURE 5–14
SHEET 1 OF 1

DATE AND TIME PLOTTED
PLOTTED BY
CAD SYSTEM
CAD FILENAME


RECLAMATION
Managing Water in the West
PLAN – PUMPING PLANT– El. 1006.00
Motor Control Cabinets
El. 1006.00
FLOW
5'-0"
20'-0"
5'-0"
12'-0"
2'-0"
6'-6"
19'-0"
8'-6"
2'-0"
30'-0"
SECTION A–A
Motor Control Cabinets
El. 1006.00
El. 1005.0
℄ El. 1007.50
El. 1004.5
℄ El. 1001.50
El. 999.5
4'-0"
4'-0"
12'-0"
19'-0"
PLAN – AIR CHAMBER FOUNDATION – El. 1006.00
El. 1006.00
℄ Air chamber
Air compressor
16'-0"
8'-0"
8'-0"
16'-0"
SECTION B–B
El. 1006.00
El. 1004.5
℄ El. 1001.50
El. 1004.5
El. 999.5
16'-0"
SECTION C–C
El. 1006.00
℄ El. 1001.50
El. 999.5
2'-0"
6'-0"
4'-0"
6'-0"
16'-0"
SCALE OF FEET
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SANTA MARGARITA CONJUNCTIVE USE PROJECT
FEASIBILITY DESIGN
GHEEN BOOSTER PUMPING PLANT
AND AIR CHAMBER FOUNDATION
PLAN AND SECTIONS
DESIGNED
REVIEWED
DENVER, COLORADO
FIGURE 5–15
SHEET 1 OF 1

Table 5-10. Gheen Pump Cycles

Number of Pumps Operating		Flow Rate	
1/8th cap.	1/4th cap.	cfs	gpm
1	0	1.56	700
0	1	3.12	1,400
1	1	4.68	2,100
0	2	6.24	2,800
1	2	7.80	3,500
0	3	9.36	4,200
1	3	10.92	4,900
2	3	12.48	5,600

This sequential stoppage from a high-level condition will cause a reduction in treatment plant flow. Eventually, this condition will require a signal to MCBCP to reduce water deliveries to the treatment plant. Communication between MCBCP and FPUD would be required to develop the SCADA logic that would be used to coordinate raw-water deliveries to the treatment plant.

5.11 Steel Pipe, Manifolds, and Valves

Design Requirements **–** The WTP clearwell pumping plant will have five (5) vertical turbine pumps. The Gheen booster pumping plant will have five (5) horizontal centrifugal pumps. Steel piping will be needed for the pump discharges at both of these plants and for the pump suction lines at the Gheen plant.

Design Decisions **–** For both of the pumping plants, steel piping will connect the individual pump discharge lines into a single manifold. The manifold will extend from the pumping plant to the line pipe connection. The individual steel pipe branches and the main manifold are sized to limit the flow velocity and minimize friction loss.

At the Gheen booster pumping plant, the steel suction manifold starts at the connection to the upstream line pipe. The suction manifold continues into the pumping plant structure, where it divides into the individual pump intake lines that feed the pumping units.

Pipes, valves, flange supports, and pipe anchors are provided where required. A sleeve-type coupling is provided for each individual suction pipe and discharge pipe between the pump and the steel piping to allow for installation and removal of the valves and pump as needed. At the WTP clearwell pumping plant, a harness stud assembly will be installed around each of these sleeve-type couplings to resist thrust loads from the pumps on each individual suction pipe and discharge pipe. At the Gheen booster pumping plant, all above-grade couplings and pressure piping will be restrained.

A hydraulic dampened check valve is installed on each pump discharge line to prevent reverse flow through the pumps during normal operation and also in case of power failure.

A motor-operated butterfly valve will be installed on each pump discharge line at the raw water, clearwell, and Gheen pumping plants and also on the suction line at the Gheen pumping plant. These valves serve as isolation valves for maintenance on the pumps and the check valves.

For both pumping plants, combination type air valves will automatically release air and admit air during normal operations.

For the WTP clearwell pumping plant only, throttling air valve assemblies and combination air valve assemblies will be provided on each pump discharge line. The throttling air valve assemblies are located on the pump discharge lines immediately downstream from the pumps. The throttling air valves will discharge high volumes of air in the pump column pipe and the empty pipe between the pump and the check valve during pump start-up.

Design Stresses and Codes - The pipe is to comply with AWWA Standard C200 and AWWA Design Manual M-11. The maximum allowable design stress of the steel is 18,000 psi. Pipe wall thicknesses are determined using internal pressure or handling as the design criteria. Minimum plate thicknesses for handling are in accordance with AWWA recommendations. This minimum thickness needed for handling is the lesser of $d/288$ or $(d+20)/400$, where d is the diameter in inches. The minimum pipe wall thickness is one-quarter inch. After fabrication, all manifolds and piping would be hydrostatically tested to 1.5 times the design pressure or 100 psi, whichever is greater.

Steel plate used for the manifolds and discharge pipes will conform to ASTM A36 or ASTM A283. Steel meeting either of these standards will have good welding properties and resistance to brittle fracture.

5.12 Electrical and SCADA

5.12.1 Water Treatment Plant Electrical Equipment

Incoming Power – There is a 480-volt powerline at the site, owned by San Diego Gas and Electric Company (SDG&E). A new SDG&E service connection could be installed or the service at the adjacent barn structure could be upsized. Either approach would require a new transformer (likely pad mounted) from SDG&E, a new meter, and a utility disconnect.

Main Plant 480 Volt Power Distribution Switchgear Equipment – The incoming power will enter an electrical switchgear lineup. This switchgear will supply 480-volt power to four motor control centers; raw water feed equipment, Fe/Mn equipment, RO equipment, and clearwell pump equipment. This main distribution switchgear serves as the primary disconnect for the entire plant and as a means for disconnecting major subsystems at the plant.

Motor Control Centers – There are four (4) motor control centers (MCCs):

(1) Raw water feed – This MCC supplies power to three (3) 60-hp pumps, two (2) 40-hp pumps, and a lighting panel.

(2) Clearwell – This MCC supplies power to three (3) 200-hp pumps, two (2) 100-hp pumps, and an air chamber.

(3) RO (reverse osmosis) – This MCC supplies power to four (4) 100-hp pumps, a reverse osmosis CIP system, a heating and ventilating system, an uninterruptible power supply for small electronic loads, and two (2) 15-kilovolt-ampere load centers for supplying lower-voltage power to plant valves and monitoring equipment.

(4) Fe/Mn – This MCC supplies power to three (3) 15-hp pumps, one (1) 15-hp air compressor, six (6) small pumps, and two (2) 15-kilovolt-ampere load centers for supplying lower-voltage power to plant valves and monitoring equipment.

Nonsegregated Bus – 480-volt nonsegregated phase bus will transmit power from the main low-voltage switchgear to the MCCs. This type of bus is required for the high-amperage of the MCCs.

Lighting Systems – The lighting systems provide general and task illumination in the plant process area and the plant office areas. Convenience 120-V receptacles have been provided throughout the plant to facilitate routine inspection, maintenance, and operation. Ground fault circuit interrupter type receptacles are provided in damp areas and for exterior receptacles.

Control and Monitoring – Interfaces will be provided for the programmable logic controller for remote control and monitoring. See description of the SCADA system for additional information.

5.12.2 Gheen Booster Pumping Plant Electrical Equipment

SDG&E will provide 480-volt power to this facility. Power will be supplied to a motor control center for three (3) 75-hp pumps, two (2) 50-hp pumps, and one (1) air chamber. A load center will be used to convert the 480-volt power to 120 volts for a programmable logic controller and outdoor lighting.

Interfaces will be provided for the programmable logic controller for remote control and monitoring.

5.12.3 SCADA

Plant Automation – The control and monitoring system architecture was designed to match existing FPUD facilities. This includes an operator workstation located at the WTP, redundant main processing, and redundant communication within the

WTP. The main processing RTUs will be Allen-Bradley ControlLogix platforms, and the local RTU panels will be Allen-Bradley CompactLogix platforms. Each local RTU panel includes an operator interface terminal showing the operations of its specific process.

Communication System – Within the WTP, RTUs will communicate with each other through a redundant ControlNet communication network. WTP information will be communicated via radio to the FPUD SCADA Master station through the RTUs at the main WTP.

Gheen Site Automation – Radio communication will also be used as a link between the WTP and the Gheen tank site. The RTU at the Gheen site will control the water pumped to Red Mountain Reservoir based on the water surface elevation.

5.13 Potential Organic Matter Removal Using GAC

Based on the performance of MCBCP's P113 water treatment plant, organic matter removal in the Fallbrook WTP should be sufficient using the IM, reverse osmosis process proposed in this feasibility design. In the unlikely event that concentrations of organic matter increase in the groundwater, it can be removed using granular activated carbon (GAC). A GAC filter should be located after the IM filters so the carbon is not adversely affected by iron and manganese in the water. GAC filters resemble the iron and manganese steel tanks and can be designed and oriented vertically rather than horizontally. Space on the WTP site for a GAC filter is shown in Figure 1-3.

Organic contaminants can be removed by GAC with an empty bed contact time of 10 minutes. Since influent and desired effluent concentrations of any organic pollutant are unknown at this time, capital and O&M costs are shown graphically as a function of flow rate treated, in chapters 8 and 9, respectively. GAC filter costs are provided for information only and are not included in the total cost of the project or the cost-to-benefit ratios in chapter 10.

For organic matter removal, many water treatment plants across the country are shifting away from GAC as an adsorber, and instead, use GAC as a biofilter. A biofilter allows microorganisms on the carbon to reduce the organic matter through a biodegradation process, rather than an adsorption process. Based on these recent trends, the O&M costs presented are felt to be conservatively high since biofilters are not backwashed nearly as often.

It is recommended that prior to final design for the FPUD WTP, well water quality from MCBCP's wells be obtained and reviewed for the presence of natural and synthetic organic matter. Understanding the amount and type of TOC influent concentrations will improve the design of any organic matter removal filter.

6 Site and Water Treatment Plant Building Features

6.1 Sitework

The site selected for the proposed Fallbrook WTP is a low hill on FPUD property, adjacent to and west of the town's new solar park installation. A site survey was performed in April to confirm and adjust topography found on existing drawings to the actual site survey. The top portion of the hill will be graded flat to provide a pad for the plant and yard. Excess material from grading will be used on site for road and site grading. Access to the site is gained through an existing fenced gate from Alturas Road and through the solar park.

The WTP site offers a place for contractor use (staging) or for temporary excess cut disposal. To reduce dust, asphalt pavement will be provided for the plant access drive and for the chemical delivery and parking areas. The cast-in-place concrete tanks and pumping deck structures (features 1, 3, 4, 9, and 10 on Figure 1-3) will be partially excavated into the hill with about one-third of the west walls exposed above grade. For personnel safety, visual screening, equipment protection, and reduction of pump noise transmission, the concrete walls will extend 8 feet above the deck on the south, west, and north sides of the structure.

Removal of a few small trees will be required. The existing utility poles and overhead lines have been avoided in the design. All storm surface run-off will be routed to on-site detention basins.

6.2 Architectural

This building design was based on Fallbrook's Red Mountain disinfection facility. The building is 105 feet long by 56.3 feet wide and has an attached 27-foot-long sunshade roof extension on the south side. The exterior bearing walls are constructed of 12-inch by 8-inch by 16-inch concrete masonry units supporting light-weight-gauge steel trusses with a clear span of 56.3 feet wide. The roof pitch will have a 4/12 slope. Steel purlins will be attached to the trusses supporting the pre-finished, pre-insulated metal roof panels. The panels are 4 inches thick and have an R-33 insulation value per ASTM C 236. The gable end, pre-finished, pre-insulated, metal wall panels will be 2.5 inches thick and have an R-20 insulation value. A sunshade will be created by extending the building roof 27 feet to the south. The sunshade will be supported by a steel tube framework and will protect two (2) 3,500-gallon sodium hypochlorite tanks and one (1) 10,000-gallon ammonium hydroxide tank from the weather. Each of these tanks will be located in a 33-inch-deep containment pit. The containment pits will have formed concrete access stairs and 42-inch-high guard rails around them.

The interior of the building will have a control room, an electrical room, a storage room, and a toilet room with walls constructed of 8-inch by 8-inch by 16-inch concrete masonry unit walls. The control room and the toilet room will have ceilings, and the other rooms will be open to the roof structure. The control room will be air conditioned using a through-the-wall type unit. A 48-inch by 48-inch-deep pipe trench will enter the building in the southeast corner, will extend along each side of the reverse osmosis equipment, and will exit through the northwest corner of the building. A waste sump with a floor hatch will be located in the northeast corner of the building, below the floor.

6.3 Building Mechanical

6.3.1 Service Water System

The service water system in the treatment plant will provide water for general usage from service water hose outlets and will supply water to equipment such as evaporative coolers in the heating and ventilating system.

Service water hose outlets will be located around the interior and exterior perimeter of the plant. Spacing of the outlets will allow a hose to reach all locations around the plant. Four (4) three-quarter-inch diameter, 75-foot-long hoses will be supplied and hung on wall-mounted hose racks.

6.3.2 Sanitary Waste Systems

The sanitary waste system at the plant will remove waste from the toilet, lavatory, and an integral trap-floor drain in the restroom. Hub and spigot cast iron soil pipe will be used for all embedded piping. Hubless cast iron soil pipe will be used for all exposed piping. Treatment plant sanitary waste will be routed to the existing Fallbrook sanitary sewer system located east of the plant.

6.3.3 Domestic Water System

Domestic water will be supplied to the restroom and to each of the three (3) safety showers. A single electric point-of-use water heater will be installed under the restroom lavatory.

Both the water closet and lavatory located in the restroom are designed using low-flow fixtures and are compliant with the Americans with Disabilities Act.

Three (3) safety shower and eye/face wash units will be provided at the plant. One unit will be inside the plant near the reverse osmosis clean-in-place system. An electric point-of-use water heater specifically designed for safety showers will be installed near the safety shower and eye/face wash unit to provide tepid water as required by code. A heat-traced, freeze-proof unit will be installed in each of the two (2) chemical containment areas outside of the plant. Two units are required since the containment areas are separated by a 3-foot wall. An electric point-of-use water heater specifically designed for safety showers will be installed upstream of the two (2) showers to provide tepid water. A single heater was selected instead a heater for each unit, since it is assumed that the two units outside of the plant would not be used simultaneously.

6.3.4 Compressed Air

A single portable air compressor will be provided for operation of pneumatic tools during maintenance operations. The compressor will supply 10 cubic feet per minute (cfm) at 125 psi, and have an integral 20-gallon receiver tank.

6.3.5 Fire Suppression

Six (6) 20-pound portable dry chemical wall mounted fire extinguishers will be provided within the plant. They will be located so that personnel will not need to travel more than 50 feet to reach an extinguisher. Two (2) additional extinguishers will be mounted to the outside wall in the chemical storage area. A total-flooding, clean-agent fire-suppression system will be used in the control room to protect electronic equipment.

A sprinkler system will not be included in the interior of the plant. A dry-pipe sprinkler system will be used to sprinkle the outdoor chemical storage area. A dry-pipe system was selected to prevent freezing of water in the outdoor piping.

6.3.6 HVAC

The RO equipment in the process area of the plant will generate enough byproduct heat to require an evaporative cooler to maintain an acceptable operating temperature range in the facility. The evaporative cooler will be a 100,000-cfm single-inlet, double-fan type. Air will be relieved from the process area via two (2) 50,0000-cfm wall exhaust fans. For times when cooling is not required in the plant, a supplemental exhaust fan will serve the process area to ensure adequate ventilation in the space. Electric unit heaters will be provided to ensure that the space remains above 45 °F.

The control room will be provided with a through-the-wall heat pump unit for heating and cooling. The electrical room, where motor control centers and no heat producing equipment are located, will be provided with a transfer air fan to move air from the process area through the electrical room to ensure that this room remains within an acceptable operating range. The electrical room transfer air is then exhausted into the storage room through a series of openings and dampers which ensures adequate storage room ventilation.

6.3.7 Crane/Service Bay

The WTP building has been evaluated for an overhead crane. Discussions with membrane manufacturers suggest that repairs or replacement to the RO skid or any other large piece of equipment will be very infrequent. Therefore, building overhead cranes can facilitate large skid or pump removals, but having one is considered optional and not necessary. FPUD prefers not to use an overhead crane but instead favors the use of forklifts, which they already own. The large RO skids will require a crane to offload from the delivery truck. Once the RO skids are on the ground, forklifts can be used to transport them through the large overhead doors into the building. Individual RO element vessels can also be removed from an RO skid with a forklift. In addition, the District may consider purchasing forklift attachments which can push the required number of RO elements through the pressure vessels. Ample room is provided in the WTP building to allow maintenance crews to work on equipment. Typical RO plants of this size with skid-mounted water treatment plant equipment do not have a separate service bay.

Based on the above rationale, the cost of adding an overhead crane and service area to the WTP and the outdoor raw water pump station does not appear to be justified.

7 Water Conveyance Pipelines

7.1 Transmission Pipeline Reaches

Water from the treatment plant will need to meet the FPUD water system zone elevations in order to be delivered to the FPUD system. Pumping will be required for two lifts. The key map plan and hydraulic table, Figure B1 (Appendix B), shows the hydraulic concept and pipe routing. Thirty-two plan and profile drawings (Figures B2 to B33) then depict the pipeline installation for the Feasibility Design Report.

The transmission pipe will be placed in an excavated earth trench and then buried. Reach 1 will begin at the Fallbrook WTP and initially run north inside the NWS base fence (Figures B2 to B8). It will cross Fallbrook Creek and Ammunition Road within a few hundred feet. Farther north, on the line of Dougherty Street in Fallbrook, the pipeline will turn east, crossing the NWS fence boundary (Figure B8), and will run generally eastward, with a couple jogs to the north. for about 3 miles (Figures B8 to B21). The next major intersection turn is a tee south toward the Gheen site (Figure B21). At this location, a sectionalizing valve vault would be constructed. Pipe would run south from this box, crossing Mission Road, extending to the FPUD Gheen site. At the Gheen site, the pipe will terminate in a new combination storage and regulating tank (Figure B23). The normal water surface in the new Gheen tank will match the zone 1037 elevation pressure basis.

Pipe Reach 2 will begin with a booster pumping plant placed at the Gheen site (Figure B23). This plant will be connected just beyond the new tank. The tank will be used as a forebay for the next lift. Pipe from this pumping plant will run north, in a common trench with the last section of the Reach 1 pipe noted above, to the tee valve vault box (Figure B21). At the vault, the pipeline will turn east and continue to an FPUD service connection below Red Mountain Reservoir (Figures B25 to B33). Pressure at this service zone is about 1140 elevation, based on the water surface in Red Mountain Reservoir.

The developed plan and profile drawings were used for estimating construction costs. Alignments were developed in cooperation with FPUD and MCBCP. Cost considerations include construction methods, roads or utility crossings, natural or human constructed obstacles, cultural and historic sites, and environmental factors.

Design Data Utilized – The plan and profile drawings provided in Appendix B were developed from Google Earth surface data. FPUD provided GIS data for locations of existing buried water mains, water service lines, sanitary sewer mains and sanitary sewer service laterals. This data was used to determine the number of locations that the 24-inch pipe would cross existing utilities. Actual depths of the existing utilities were not provided; therefore, the following constant depths were assumed:

- Water mains – 3.5 feet of cover
- Water service lines – 2.5 feet of cover
- Sanitary sewer mains – 8 feet of cover
- Sanitary sewer laterals – 6 feet of cover.

Information on existing buried gas lines and communication cables were not provided by FPUD and therefore would need to be included in the project contingencies.

***Special Considerations for Pipeline Construction* –** Normal and routine open cut and burial pipeline construction is typically expected along the transmission pipeline. Dust control is assumed to be required during construction. Two areas will require special construction techniques. The first area is on Reach 1 near Fallbrook Creek and the Fallbrook Gate. Just outside the treatment plant yard, the product pipeline runs north toward Fallbrook Creek and the Ammunition Road Gate. This is a heavily used gate and road. The gate needs to be open for possible emergencies. Following in Table 7-1 are considerations for this gate crossing area.

Table 7-1. Pipeline Considerations at Fallbrook Gate

Method	Considerations
Typical open cut at the gate	Least cost, but would restrict traffic, not likely to be allowed. This gate is also a congested area with other buildings.
Span above ground on supports at the gate	More costly; height must be about 20 ft (or higher?). Would require supports at about 55-foot intervals. Not a preferred method due to seismic considerations.
Bore and jack under the gate	Probably most costly, as requires a special set-up. However, completely avoids gate impacts. Boring would be about 10 feet below ground level.
Re-route away about 500 feet west of the gate	Adds cost to route west and then back east again. Will impact hydraulics (extra friction length = extra pumping). Still requires a road crossing.

For this Feasibility Design Report, the bore and jack method has been selected for the Fallbrook gate area. The bore length would be about 400 feet from the jacking pit to the receiving pit. An outer 48-inch casing pipe would first be bored. After this is finished, the 24-inch carrier pipe would be jacked through. After the jacking is finished, the annular space would be filled with grout. It should be noted that boring has been used on other projects in the nearby Fallbrook area with successful results. Though the other crossing methods may be re-evaluated, when the project goes to final design, including this more costly method in cost estimates will help ensure that adequate funding will be available.

Just upstream from this pit area, the pipeline would cross Fallbrook Creek. Based on the size of the creek and the location of the crossing, an open-cut crossing was selected. Some diversion and care of Fallbrook Creek may be necessary during construction of the crossing.

The second area requiring specialized techniques is the double pipe trench crossing of Mission Road, affecting both Reach 1 and Reach 2. Two options were considered: a bore-and-jack method and a vertical trench. Traffic impacts to this area were not deemed as critical by FPUD. Traffic could be limited to one lane at a time, with the lane restriction being accommodated by flaggers. Temporary steel covers would allow traffic flow over parts of the trench not being actively worked. However, due to difficulties coordinating traffic control and the heavy use of Mission Road, the bore-and-jack method has been selected for the Mission Road crossing.

Pipe Design – Pipe designs were based on the treated product flow rate amount, internal pressures based on topographic placement below the hydraulic grade line, and the possible external loadings. Secondary internal pressure considerations include identifying pumping needs, outlining plant manifold valve controls, calculating potential hydraulic transients, and then checking the added transient pressures. Flow rates were initially used to select a diameter for a velocity between 4 and 5 ft/s. For a product flow of 12.4 cfs, this resulted in selecting a 24-inch internal diameter (ID) pipe size.

Pumping requirements were provided to mechanical engineers for selecting appropriate water transmission equipment and valves. Pumps were in turn coordinated with electrical engineers for motors and plant controls. Pumping friction losses were calculated to be about 1.9 feet for every 1,000 feet of the 24-inch ID pipe. Hydraulic transient studies were made to check on increased internal pressures created by typical operating emergencies. The final design internal pressure is based on an additional analysis with transient pressure. Internal pressures were used for estimating the pipe wall thickness requirements.

Pipe Types – Various pipe types exist that may meet the requisite diameter and internal pressure needs. Maximum pressures in the lower elevation portions of Reach 1 are equivalent to approximately 550 feet of water. Reach 2 pressures are approximately 275 feet. Potential pipe types include ductile iron, PVC, fiberglass, and steel. Designs recognize that Reach 1 pressures are approximately 250 psi, a high limit for PVC type. At this study level, the potential pipe types are competitive in price. As such, cost estimates are based on the weight needed for steel pipe. The weight of steel needed is a function of the thickness needed for the internal pressure. Steel pipe is a type commonly used by FPUD. Should this project go forward, the potential pipe types will be further investigated and design selections will be made in consultation with the FPUD staff.

Pipe Trench and Installation – The pipe will be placed in a buried pipe trench, except where otherwise shown. See Figures B2 to B33 (Appendix B) for the Reach 1 and 2 plan and profiles. The regional bury standard is 30 inches minimum cover depth according to FPUD. The typical pipe trench will be excavated into earth excavated by common means. Three trench profiles were used for the cost estimates: a standard pipe section in areas where space is not limited, a vertical pipe section typically used along traffic corridors, and a double pipe trench section on Reach 1 and Reach 2. Figure B36 in Appendix B shows the outline and dimensions used to develop excavation and backfill quantities.

Geologic data furnished by FPUD, along with MCBCP experience constructing other pipelines in the immediate area, show that common excavation is the usual case. The excavated material can be screened and re-used in the trench for the flexible pipe bedding and sidewall support. The near-surface trenches will not encounter a water table.

Some rock excavation is anticipated, as there are rock outcrops visible along the plan alignment. The majority of the geology in the Fallbrook area consists of deeply weathered granodiorite (Woodson Mountain, specific gravity = 2.65, light tan in color). The rock was determined to be rippable based on discussions with FPUD and MCBCP, and the use of seismic velocity charts. Charts of ripper performance estimated by seismic wave velocities have been developed from field tests conducted in a variety of materials. Seismic velocity data is available from the USGS on their Global Vs30 Map Server. Vs30 is the average shear-wave velocity down to 30 meters for a given area based on known geology and topographic features. By overlaying available VS30 data onto the plan alignment for the pipeline, the geologic map overlay shows the majority of the alignment occurs in areas with shear-wave velocities less than 620 meters per second (m/s). In general, the charts show shear-wave velocities less than 1,000 m/s in rock types found in the Fallbrook area, indicating that the rocks are rippable and will not require blasting. The overlay was also used to determine the quantity of rock excavation used for the cost estimate. Approximately 4,028 linear feet of open trench construction located on Reach 2 encroaches on rock types having seismic wave velocities greater than 760 m/s. As a result, approximately 4,000 cubic yards of excavation was estimated in rock. This amount of rock excavation represents approximately 11 percent of the overall alignment length. See Figure B34 for the geologic map overlay.

Quantity calculations were made based on the associated plan and profiles. Table 7-2 shows a summary of pipe design, type, and trench and installation methods. A typical trench drawing is provided in Figure B36. An average excavation cover depth of 3.5 feet was assumed. This assumption makes the average excavation depth about 6 feet. While most of the pipe will be installed in open areas, a few road crossings will be needed. Most of these will be in Reach 1. About 20 percent of the Reach 1 trench and 20 percent of the Reach 2 trench will have compacted backfill under roadways. Quantity estimates include materials for road crossing surface replacements also.

Table 7-2. Pipe Design, Type, and Trench and Installation Methods

Pipeline — assumed pipe type and joining methods	Trench geometry			Trench materials expected
	Bottom width 24" ID pipe	Average cover	Side slopes H:V	
Reach 1 and 2 — Rubber gasketed joints, steel assumed	Bottom width = Pipe OD + 2 feet	3.5 feet, 2.5 feet min.	0.75:1	Decomposed granite, sandy clays, refilled

Pipeline Appurtenant Structures – Air valves at high points and drains at low points are typically required on pipelines. These are generally a small-cost item. A number for each item has been included based on the topographic high and low points. A flowmeter near the treatment plant will measure the shared raw water furnished by MCBCP. Butterfly valves in vaults will be used for MCBCP return flow and sectional control. A typical isolation valve drawing is provided in Figure B35.

Hydraulic Transients and Pressure Designs - Transient cases were studied for pumping plant operations. The working assumption is for a plant operating with all pumps on (full capacity) and an emergency loss of electrical power. Air chambers will dampen the hydraulic shock. Air chambers were sized to keep transients not more than about twice the pumping friction loss head or more than half the static design pressure. Table 7-3 shows the estimated air chamber design conditions.

Table 7-3. Air Chamber Design Conditions

Chamber location, tank site only	Ground Elevation (approx. at site)	Static Water Surface Elevation in Pipe	Tank Volume, cubic feet	TDH, feet (approx.)	Pump (P) and Surge (S) Hydraulic Grade Line Elevations
Reach 1 - Water treatment plant	700	1037	1,800	387	P = 1083, S = 1132
Reach 2 - Gheen booster	1000	1140	2,200	140	P = 1164, S = 1185

Generalized hydraulic profiles are shown as Figures 7-1 and 7-2. The design pressure line for Reach 1 is based on the return flow scenario. For this case, with the Gheen tee valves bypassed, the line will experience pressure directly from the Red Mountain zone. Reach 2 design pressures are set for the pumping case, with the transient surge in the table above, to move water from the Gheen to the Red Mountain zone.

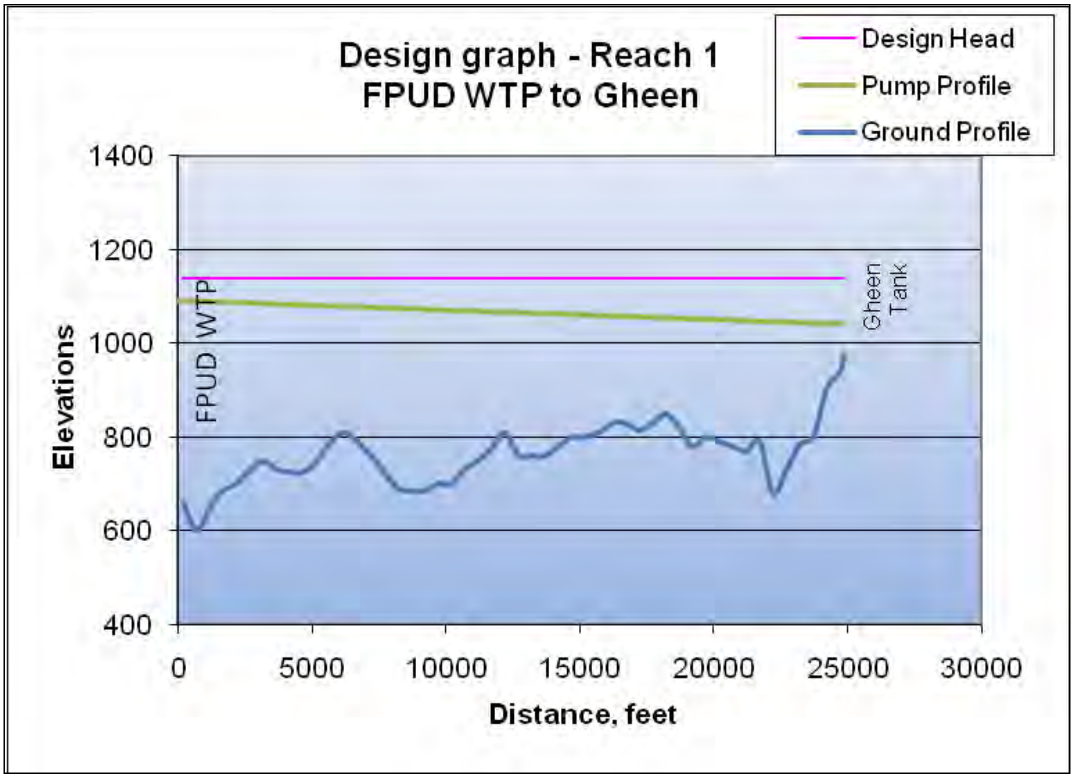


Figure 7-1. Reach 1 hydraulic profile.

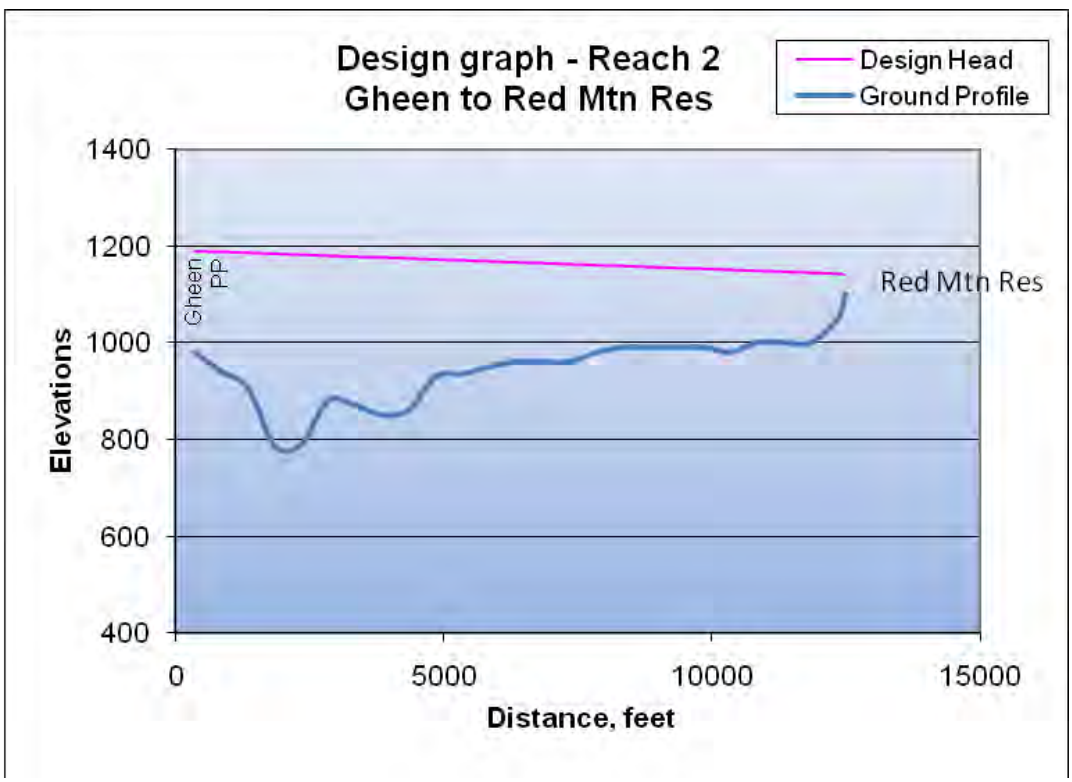


Figure 7-2. Reach 2 hydraulic profile.

8 Costs

8.1 Field Construction Costs Summary

The total field cost, in FY 2011 dollars, for the entire project is $44,200,000. This total is shown below, separated into the Fallbrook WTP and Reach 1 at $38,000,000 (Table 8-1) and the Gheen Booster Pump Plant plus Reach 2 at $6,200,000 (Table 8-2).

Table 8-1. Fallbrook WTP and Reach 1 Construction, Contract, and Field Costs

Feature	Details	Sub-Cost
Fallbrook WTP	Water treatment plant building and concrete Fire protection HVAC Treatment process equipment, yard pipe Raw water pumps, steel manifolds, valves Chemical storage, feeders, and instrumentation Electrical switchgear, MCC's wiring, SCADA Clearwell, pumps, valves, and air chamber Subtotal	$2,048,804 $251,588 $10,336,465 $1,032,680 $302,238 $1,772,430 $2,338,465 $18,082,670
Reach 1	24-inch pipe to Gheen site	$6,117,628
Subtotal		**$24,200,298**
Mobilization @ ±5%		$1,200,000
Escalation @ ±2%/yr. for 4.5 yrs		$2,367,382
Design contingencies		$2,776,768
Allowance for Procurement @ ±3%		$916,333
Contract cost (rounded)		**$31,000,000**
Construction contingencies		$7,000,000
Field cost		**$38,000,000**
Non-contract costs	Non-contract cost percentage (27.5%) provided by LC Region per memorandum dated March 14, 2013.	$10,000,000
Construction cost		**$48,000,000**

Table 8-2. Gheen Pump Plant and Reach 2 Construction, Contract, and Field Costs

Feature	Details	Sub-Cost
Gheen Booster Pumping Plant	Concrete including Sound barrier Mechanical pumps and motors Steel pipe, Valves, and Air chamber Electrical including Power, MCCs, and SCADA Subtotal	$518,850 $341,000 $536,914 $251,155 $1,647,919
Reach 2	24-inch pipe from Gheen site , FPUD service connection	$2,338,773
Subtotal		**$3,986,692**
Mobilization @ ±5%		$200,000
Escalation @ ±2%/yr. for 4.5 yrs		$390,212
Design contingencies		$457,691
Allowance for procurement @ ±3%		$151,037
Contract cost (rounded)		**$5,200,000**
Construction contingencies		$1,000,000
Field cost		**$6,200,000**
Non-contract costs	Non-contract cost percentage (27.5%) provided by LC Region per Memorandum, dated March 14, 2013.	$1,700,000
Construction cost		**$7,900,000**

8.2 Explanation of Costs

Origin and Source of the Cost Estimates – These estimates were prepared by the Estimating, Specifications, and Construction Management Group at Reclamation's Technical Service Center (Denver, Colorado). The estimates are in accordance with Reclamation Manual Directives and Standards FAC 09-01 and FAC 09-03.

Purpose and Intended Use of the Cost Estimates – Feasibility-level construction costs for the Santa Margarita Conjunctive Use Project were developed by preparing estimate worksheets and assembling the worksheets in two groups, representing related features. The first group of estimate worksheets included the water treatment plant, Reach 1 pumps, Reach 1 piping, and related features. This group of estimate worksheets had an estimated total field cost of $38,000,000. The second group of estimate worksheets included the Gheen Booster Pumping Plant, Reach 2 piping, and related features; and had an estimated total field cost of $6,200,000.

The estimates were prepared at a unit price level of July 2011. Typical production rates, typical construction practices, procurement using a request for proposals contracting method, current construction economic conditions, and site conditions (as provided) were assumed and applied to these cost estimates.

The cost estimates were prepared utilizing feasibility-level design information. These designs are at a planning stage; therefore the resulting estimates have inherent levels of risk and uncertainty. The cost estimates are intended to be used as a basis for budget authorization, appropriation, and funding.

Feasibility-Level Cost Estimates – Basic Scope – Feasibility cost estimates are based on information and data obtained during planning level investigations. These investigations provide sufficient information to permit the preparation of preliminary layouts and designs, from which approximate quantities for each kind, type, or class of material, equipment, or labor were obtained. These estimates may be used to assist in the selection of a preferred plan, to determine the economic feasibility of construction features, and to support seeking construction authorization.

Basis of Cost Estimate – The feasibility estimate unit price were developed using a semi-detailed method. Specific construction activities were identified for major cost drivers. Costs for labor, equipment, materials, and other resources were developed. Production rates, overheads, and taxes were applied to develop the applicable unit prices. Vendor quotations were obtained for major equipment, materials, supplies, and other items. Minor cost items were priced using historical bid and industry standard reference cost data.

Price Level – All unit prices are in July 2011 dollars.

Mobilization – A value of approximately 5 percent was used for mobilization. Mobilization costs include contractor costs for mobilizing personnel, equipment, and materials to the project site for initial project setup; establishment of offices, buildings, and other necessary general facilities for the contractor's operations at the site; premiums paid for performance and payment bonds; and other miscellaneous items. The assumed approximate 5-percent value in the cost estimates is based upon past experience of similar jobs.

Escalations – An allowance for escalation from the July 2011 unit price level to the “Notice to Proceed” milestone was included in the estimate. Based on the preliminary draft schedule, it was assumed that the Notice to Proceed milestone for construction would occur approximately in January 2016.

For projects that are to be developed over an extended period of time, or at some distant time in the future, it is prudent to incorporate some consideration of the time value of money.

The costs estimates also include escalation during construction in the unit prices. The construction duration was estimated to be approximately 24 months.

***Design Contingency* –** In accordance with *Reclamation Manual* Directive and Standard FAC 09-01 (4) (E) (1) (Reclamation 2007c), design contingencies allow for uncertainties within the design and the respective level of detail and knowledge used to develop the estimated cost. Design contingencies are intended to account for three types of uncertainties inherent as a project advances from the planning stage through final design, which directly affects the estimated cost of the project. These include (1) minor unlisted items, (2) minor design and scope changes, and (3) minor cost estimating refinements. The *Cost Estimating Handbook*, "Appraisal Estimate" section (pages 2–7), recommends that unlisted items be at least 10 percent (15 percent is typically used).

Minor unlisted items that were not quantified or priced in the cost estimate include, but are not limited to, grouting; crossing Fallbrook Creek; ancillary components to isolation valves, air valves, and drains; sleeve couplings; filling bypass lines; pipe cathodic protection; erosion control; curb and gutter or sidewalk encountered in the urban areas; fence crossings; and replacing topsoil. Minor design and scope changes that may also occur include, but are not limited to, the use of CLSM for pipe backfill (instead of selected native fill bedding) and the presence of weak soil conditions instead of moderate-strength soil conditions.

***Allowance for Procurement Strategies* –** The allowance for procurement strategies was set at approximately 3 percent. A line item allowance for procurement strategies was included in the feasibility cost estimates to account for additional costs when solicitations will be advertised and awarded under other than full and open competition. These include solicitations that will be set aside under socio-economic programs, along with solicitations that may limit competition or allow award to other than the lowest bid or proposal.

These estimates assume a request for proposals will be issued and that contractors' proposals will be evaluated based on the technical and cost considerations. Contractors' technical proposals would be evaluated along with their experience with similar projects, and their proposed costs would be compared to other proposals and to the Independent Government Cost Estimate.

***Construction Contingency* –** Feasibility estimates include a percentage allowance for construction contingencies as a separate item to cover additional costs due to unforeseeable difficulties at the site, changed site conditions, and other difficulties encountered by the contractor and negotiated during the construction period. The allowance is based on engineering judgment of the risks of site conditions, reliability of the site data, adequacy of the projected quantities, and general knowledge of site conditions.

The estimates include a value of approximately 20 percent for design contingencies based on past experience with similar projects

Non-Contract Costs – Non-contract costs will be added into the project's cost estimate and economic cost-benefit analysis. An estimate of 27.5 percent of the total cost, or $11.7 million, will address the following non-contract cost items:

- Feasibility study and environmental document completion
- Water rights permits and other permits (Clean Water Act, etc.)
- Environmental monitoring (e.g., archeological-cultural resources, biological resources)
- Pre-construction biological resource surveys
- Revegetation/restoration of impacted habitats and other mitigation costs
- New easements
- Construction survey data
- Engineering and other costs
- Contract award administration
- Project management and other administrative actions
- Quality assurance
- Preparation of construction reports and closeout.

LC Region's past construction projects that have post-feasibility non-contract costs have ranged from 25 to 30 percent of the contract's value.

8.3 Potential Costs of Using GAC for Organic Matter Removal

Capital costs for a potential GAC system to treat a partial flow stream are based on information obtained from Malcolm Pirnie/ARCADIS on their recent installations. The installed costs to treat 4 and 6 MGD are $1.3 million and $1.8 million, respectively. Plotting these costs as shown in Figure 8-1 provides capital cost information for various flow rates. These costs are provided for information and future use only and are not included in the total plant cost estimate since there is a good likelihood that such organic matter contamination will be avoided due to high level monitoring of the influent water quality by both MCBCP and FPUD.

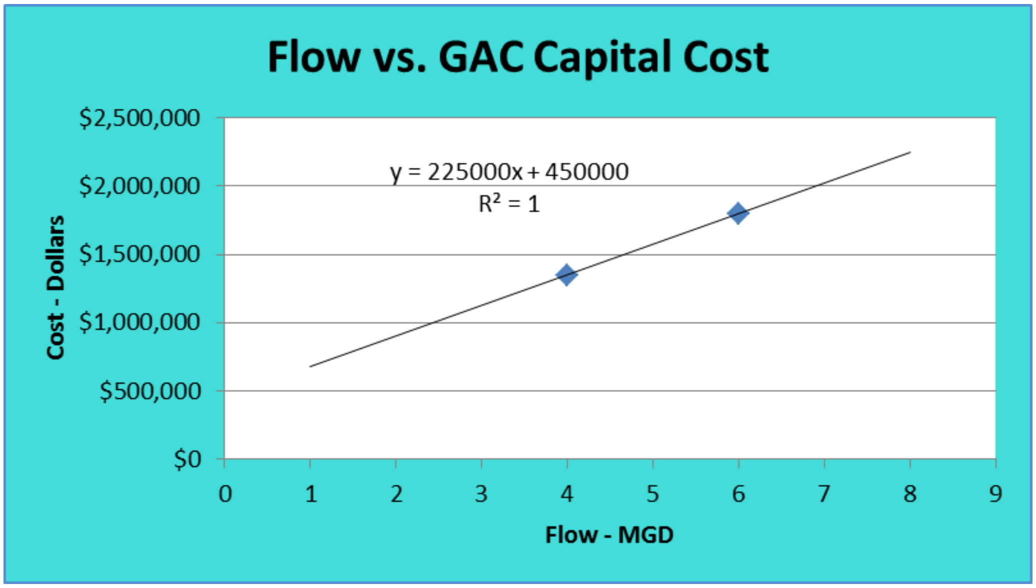


Figure 8-1. Potential capital costs of a GAC facility versus flow rates.

9 Operations, Maintenance, and Replacement Program and Annual Costs

9.1 General

The importance of an organized and planned operations, maintenance, and replacement (OM&R) program cannot be overstated in terms of adding and maintaining value to any utility system. An OM&R program provides vital information to the administrative and operating personnel. OM&R information allows staff to optimize the performance of the infrastructure (i.e., to keep the pumping or treatment units at their most efficient operating points while minimizing maintenance) at the lowest possible cost. Without a robust OM&R program, utilities often find themselves in reactive as opposed to proactive modes, handling more emergency situations and operating at higher costs than needed.

It is assumed that Fallbrook already has an OM&R program in place from which both operators and their managers are obtaining the necessary information to maintain a reliable, efficient, and safe operation. The annual OM&R costs presented below assume that the new Fallbrook WTP, Reach 1, the Gheen Pump Plant, and Reach 2 will be added to an existing OM&R program. They do not therefore include start-up costs for a new OM&R program. They include *labor, power, chemicals, maintenance materials,* and *replacement* for the infrastructure proposed.

9.2 OM&R Program

Clearly there are distinct differences between the types of information needed by utility managers and by operators. Operating personnel need information that allows them to optimize the operation of the equipment in the plant. This includes the defined functions or objectives and how to properly care for (calibrate and maintain) each piece of equipment. They also play a key role in collecting and documenting the necessary responses for both routine and nonroutine operations and maintenance.

Administratively, utility managers must support and provide the staffing and financial resources to the operating personnel.

To achieve both types of requirements, a typical OM&R Program includes the following subsystems.

Plant Records – Records documenting all aspects of operations, maintenance, personnel, costs, and emergencies are needed. Records provide the data from which decisions are made. A records system is a critical component of an OM&R program.

***Standard Operating and Maintenance Procedures* –** Standard operating and maintenance procedures for manufacturer's equipment is critical information to operating staff. This information includes a maintenance management system that will ensure the planning and scheduling of both routine and nonroutine maintenance. Standard operating and maintenance procedures also include having required spare parts, tools, and supplies available; identifying in-house and contract maintenance activities in advance; and routinely performing general housekeeping tasks.

***Emergency Preparedness* –** Emergency preparedness includes identification of procedures and plans to handle unexpected situations. These procedures include a list of emergency contact information, definitions of the feasible types of emergencies, and an emergency response plan for each type of emergency.

***Safety* –** Safety practices, both general and site specific, need to be understood by staff working on or in close contact with the facilities. This includes having proper safety facilities (e.g., eye wash/safety shower, respirators, placards and other warning signs) and personnel protective equipment (e.g., protective eyewear, steel-toed boots, gloves, and clothes coverings) and being trained in their use.

***System/Equipment Description* –** Descriptions of each piece of equipment (plus the integration of all equipment into the overall project) provide the staff with knowledge of system components, their function and how they relate to each other.

***Equipment specifications* –** Specifications for each piece of equipment in the system are often needed for maintenance, repair, or replacement.

9.3 OM&R Costs

Presented below are the annual OM&R costs for a 50-year life for the Fallbrook WTP, the Gheen Pump Station, and Reaches 1 and 2 pipeline segments based on an average annual flow of 3,100 acre-feet per year (1,922 gpm), as noted in a Technical Memorandum from the City of Fallbrook to Greg Kryz, Reclamation Project Manager, dated October 4, 2010. These costs do not include costs for operating the groundwater wells nor for delivery of water from MCBCP. As stated above, it is assumed that Fallbrook already has an OM&R program in place for its other facilities and therefore costs to initiate such a program are not needed. The five OM&R cost categories are labor, power, chemicals, maintenance materials, and replacement. The replacement costs are based on the periodic replacement of equipment and material over the life of the project. These replacement costs are present-valued to today's dollars, and the annual equivalent cost is estimated to be consistent with the annual operations and maintenance costs. It is also assumed that the plant will only operate approximately 80 percent of the year, based upon historical flow data from the wells at MCBCP. The assumptions used for each of these five categories along with summary tables for each component can be found in Appendix C – Operation, Maintenance, and Replacement Program and Annual Costs. Table C5 in that appendix contains the useful life and total cost of components of the WTP, pipeline Reach 1, pipeline Reach 2, and the Gheen Pumping Booster Plant.

9.4 O&M Costs of Using GAC for Potential Organic Matter Removal

O&M costs for GAC are shown in Figure 9-1 and are estimated to be $120,000 per year at a flow of 3.0 MGD and $227,710 per year at a flow of 7.8 MGD. These costs are from the EPA's LT2ESWT Rule Technologies and Cost Document, December 2005, pages 4-79 through 4-89.

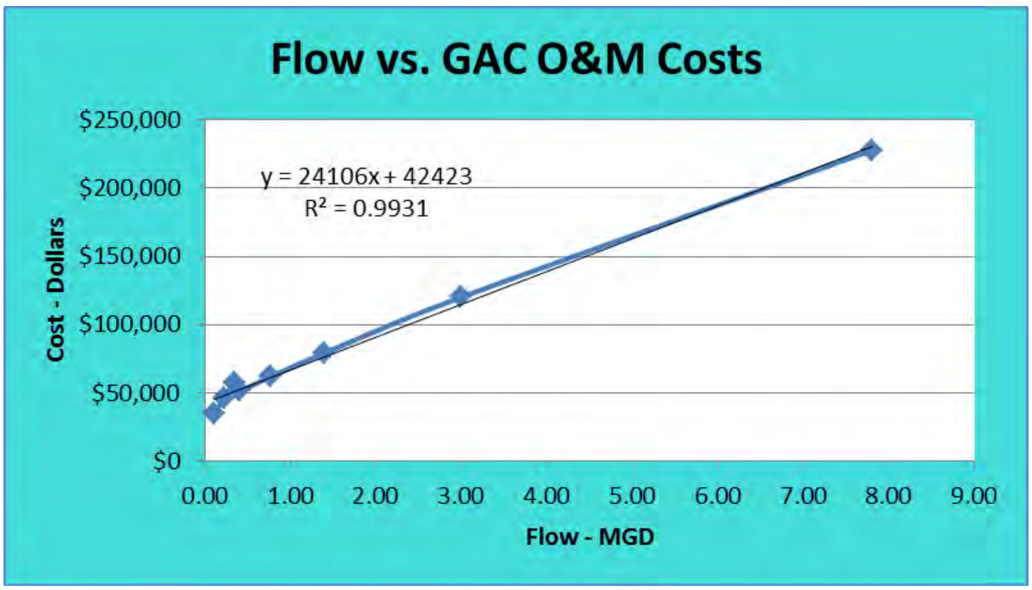


Figure 9-1. Estimated annual O&M costs of GAC versus flow rates.

9.5 Summary

The estimated costs for each of the five OM&R categories for the Fallbrook WTP, the Gheen Pump Station, and Reaches 1 and 2 pipeline segments are presented below in Table 9-1. The total estimated annual OM&R costs for the Fallbrook WTP, the Gheen Pump Station, and Reaches 1 and 2 pipeline segments are shown in Table 9-2.

Table 9-1. Summary of Annual OM&R Costs (in $) by Category

Feature	Labor	Power	Chemicals	Maintenance Materials	Replace-ment	Total
Fallbrook WTP	289,070.08	354,537.79	198,226.71	66,344.00	391,000	1,299,178.58
Pipeline Reach 1	([1])	0	0	16,874.17	1,000	17,874.17
Subtotal	289,070.08	354,537.79	198,226.71	83,218.17	392,000	**1,317,052.75**
Gheen Pump Station	5,506.18	45,348.80	0	1,600.00	19,500	71,954.98
Pipeline Reach 2	([1])	0	0	5,544.40	500	6,044.40
Subtotal	5,506.18	45,348.80	0	7,144.40	20,000	**77,999.38**
Total	**294,576.26**	**399,886.59**	**198,226.71**	**90,362.57**	**412,000**	**1,395,052.13**

[1] These costs are included in the WTP costs.

Table 9-2. Summary of Annual OM&R Costs by Feature

Feature	OM&R Costs
Fallbrook Water Treatment Plant	$1,299,178.58
Pipeline Reach 1	$17,874.17
Subtotal	**1,317,052.75**
Gheen Pump Station	$71,954.98
Pipeline Reach 2	$6,044.40
Subtotal	**$77,999.38**
Total OM&R Costs	**1,395,052.13**

10 Economic Analyses

The economic analysis for this project consists of estimating the benefits that would be generated from the project and the associated project costs. The annual benefits are present-valued over the life of the project (50 years) and then the annual equivalent value is estimated from the total present value based on the FY 2013 plan formulation and evaluation interest rate of 3.75 percent and a 50 year period. Project costs are converted to an annual equivalent value using the same interest rate and time period so that the project costs can be compared to project benefits on the same basis.

10.1 Project Benefits

The primary quantitative benefit that would be produced by this project is an additional municipal and industrial (M&I) water supply to Fallbrook particularly under drought conditions. This project will provide FPUD with a local water source, reduce its dependency on imported water supplies, and thereby reduce costs. If the project was not constructed then the water district would have to rely on water supplies from the MWD (Municipal Water District of Southern California) water system. Being able to avoid purchasing water supplies from MWD could produce a cost savings if the project costs are less than the cost of that water.

To estimate the water cost savings, the price for water from MWD is used to identify the M&I water supply benefits from the project. Data was collected from water rate Web sites of MWD and of the San Diego County Water Authority (SDCWA) to provide current and projected water rates. These rates were converted to a per-acre-foot basis that would be used to estimate the lowest cost alternative to providing the same water supply that the project would be producing. The water rates used in the benefit analysis consist of: MWD Tier 1 water supply rate, Delta water supply surcharge, water supply surcharge, System access rate, water stewardship rate, system power rate, and water treatment charges and other transportation charges. Additional charges that are based on SDCWA's allocation of costs to FPUD for MWD water supplies are also included in the overall per acre foot rate. This overall rate is projected out from 2015 to 2017 based on SDCWA five-year forecasts (February 2011). From 2018 to 2026 rates were increased at 5.1 percent per year based on an historical annual average rate increase for MWD water. The water rate is capped at the 2026 value for the remaining project life. The annual projected per acre-foot cost from this alternative water source is then multiplied by the annual water amount estimated from the hydrologic model developed by Stetson Engineers. This calculation provides the annual water supply benefit, which is then present-valued over the 50-year life of the project. This method is applied to each year that water would be produced from the project and the present value of the benefits is summed. The total present value of the water supply benefits is approximately $108 million dollars. The total present value of M&I water supply benefits is converted to an annual equivalent value so that a correct comparison can be made with the annual equivalent value of the project costs. The annual equivalent value is approximately $5.1 million. Additional information can be found in Appendix D – Estimated Water Cost Savings Attributable to the Project.

10.1.1 Non-Quantitative Benefits

Some project benefits cannot be estimated in a quantitative format but are still relevant based on the implementation of the project. These non-quantitative benefits are discussed below.

10.1.1.1 Water Quality Improvements from the Preservation of 1,392 Acres of FPUD Land

There are approximately 18 river miles from the confluence of Murrieta and Temecula creeks to the SMRCUP diversion structure on MCBCP. Nearly a third of the river miles are within the 1,392-acre parcel of land that FPUD had acquired in the 1950s in connection with the planned Two-Dam Project. A two-year SMR water quality study demonstrated that this nearly intact 18-mile stretch of river is a significant factor in maintaining and improving water quality (e.g., through its assimilative capacity) before the water is diverted by MCBCP for later potable use and delivery to FPUD for treatment. A main project component is protection of the FPUD-owned land in perpetuity. If the project is not done, the land could be made available for development (e.g., residential and agricultural development), which would reduce the assimilative capacity of this river stretch. Research has shown that waters draining off of developed lands in the watershed above this portion of the river are high in nutrients, salinity, and other constituents that require water treatment to make the supply potable. Further degradation of water quality would result in additional costs for water treatment and for waste disposal, and would therefore impact the potential project benefits.

10.1.1.2 Potential Fish and Wildlife Benefits Based on the Potential of Improved Habitat Conditions

There is potential for improving fish and wildlife habitat. During the 2010 public review of the water rights filings, some statewide environmental groups submitted written comments opposing the project concepts. Local groups, however, have been in favor of the project proposal because it would preserve the FPUD-owned land along the river. The local environmental groups note that the FPUD land is the last intact wildlife linkage between the coastal plain and the inland mountain ranges remaining in all of southern California. Without the FPUD land, the project would face opposition from both local and State-level environmental groups, which would represent a significant change in their current support and increase the possibility of legal challenges.

Protecting the FPUD land would help preserve a riparian habitat that benefits threatened and endangered species. There are currently no data to develop monetary values associated with these types of benefits for SMRCUP. Still, the qualitative value from the potential to improve preservation of habitat should be considered in the project decision process.

The FPUD land also represents a major recreation area for local residents and the surrounding communities. Multi-use trails and several picnic areas are maintained by the local Fallbrook Land Conservancy. The property also abuts a county park that permits access by horseback riders throughout the FPUD land. Current recreation activities in the project area consist mostly of hiking, some fishing along the Santa Margarita River, and wildlife viewing. Similar activities also occur in a State park that borders the project area. The park manager estimated approximately 5,000 recreation relation visitations annually. Unfortunately, there are no recreation visitation data for the project portion that covers Fallbrook. If the project were not implemented, the land area would not be open to recreation visitation, and the benefits from such recreation activities would be lost. Without reliable recreation visitation data, no benefit estimate can be derived for project implementation. Still, the recreation opportunities that would be provided by SMRCUP should be considered in the overall decision process. If the land is not maintained as part of the project, a local and regional recreational area could be lost to the public.

10.2 Project Costs

10.2.1 Construction Costs

The construction costs to the project are based on current design and schedule to construct a water treatment plant, a water transmission system, and a pumping plant to deliver and treat water for FPUD. Table 10-1 displays the construction costs, including non-contract costs, that were estimated in Section 8, Tables 8-1 and 8-2. The mobilization, design, and construction contingency costs are allocated among the project features.

Table 10-1. Project Construction Costs by Feature

Feature	Construction Costs
Fallbrook Water Treatment Plant	$36,000,000
Pipeline Reach 1	$12,000,000
Subtotal	**$48,000,000**
Gheen Pump Station	$4,634,500
Pipeline Reach 2	$3,265,500
Subtotal	**$7,900,000**
Total Construction Costs	**$55,900,000**

Based on information provided by the design engineers and cost estimators, the construction period will be greater than 1 year from the start of construction. Therefore, interest during construction (IDC) is estimated for this project. The construction period is estimated to be approximately 1 year and 9 months. Based on this construction schedule, IDC is calculated using the compound interest method and the planning interest rate of 3.75 percent. The estimated IDC is $2,115,900 and is added to the total construction cost of $55,900,000 to derive a total project construction cost of $58,015,900. The total project construction cost is converted to an annual equivalent cost basis to be comparable to the annual OM&R costs for the project. The FY 2013 plan formulation and evaluation interest rate of 3.75 percent and a 50-year period are used to convert the total construction cost to an annual equivalent cost of $2,586,000.

10.2.2 Operation, Maintenance, and Replacement Costs

The annual costs for OM&R for this project were shown in Section 9, above, in Table 9-2. The periodic replacement costs are present-valued over the 50-year life of the project and then converted to an annual equivalent value again using the plan formulation and evaluation interest rate of 3.75 percent. The annualized replacement cost, $412,000, is added to the operation and maintenance costs for a total annual OM&R cost of $1,395,000. Table 10-2 shows project costs converted to an annual equivalent basis.

Table 10-2. Project Costs

Type of Expense	Amount
Project Construction Costs	$55,900,000
Project IDC	$2,115,900
Annual Equivalent Cost (@3.75%, 50 Years)	$2,586,000
Annual OM&R Costs	$1,395,000
Total Annual Equivalent Project Costs	**$3,981,000**

10.3 Benefit-Costs Analysis

Table 10-3 lists the benefits and costs associated with the implementation of the Santa Margarita River Conjunctive Use Project. All quantifiable benefits and costs associated with the project are estimated on a present-value equivalent basis using 3.75 percent and a 50-year project life.

Table 10-3. Benefit-Costs Analysis

Project Benefits:	
Annual Equivalent Benefits	$5,105,000
Project Costs	
Annual Equivalent Costs	–$3,981,000
Net Present Value	**$1,124,000**

The net present value $1,124,000, which is the difference between the annual equivalent benefit value and costs, is positive. The benefit-cost ratio is approximately 1.28, which indicates the annual benefits are greater than the annual costs. These two indicators show that the project is economically feasible based on the data provided.

11 Construction Considerations

A summary level construction schedule was developed for the proposed work and is provided as Figure 11-1. The overall construction duration for the project features spans approximately 22 months. The construction schedule was set using an assumed award date of January 4, 2016. The award date was determined by allowing two (2) years for the funding, pilot studies, and the final design process to be completed. Utilizing this award date, the completion of project is anticipated to occur approximately in September 2017.

As the construction schedule was being developed, no constraints were imposed based on yearly spending or budget caps. The construction schedule was based on a logical sequencing of work activities and interdependencies between features. The durations used for activities in the schedule were based on past performance of similar work for Reclamation projects and based on information from the construction industry. The durations incorporate time for weather delays and normal equipment breakdowns. As the preliminary designs and concepts are developed, the activity durations will be somewhat better defined. Typical construction protocols will be employed. Access, staging, and storage areas will be identified for the particular construction work areas or pieces. Air pollution and dust control techniques will be required.

The construction schedule was organized into three groups of activities: Fallbrook WTP, product pipeline, and Gheen Booster Pumping Plant. The construction schedule was developed with the assumption that construction activities could be concurrent in all three areas. It has been assumed that the project will have one prime contractor and several specialty subcontractors to complete the various construction activities concurrently.

The Fallbrook WTP site construction activities include sitework and the installation of the iron and manganese units, the underground equalization tanks and pumps, the storage tanks, the clearwell and pumping plant, and the main reverse osmosis treatment plant building and equipment. The construction duration of the WTP is on the project schedule critical path. It is anticipated to require 21 months to complete the construction, installation, testing and commissioning of the treatment plant facilities. On this site, there is an existing overhead power line and potential underground utilities that will need to be relocated and protected. These utility relocations will require additional coordination.

The pipeline construction activities include installation of the transmission product pipeline and associated sitework. The transmission pipeline is a 24-inch steel pipe that is divided into Segments 1, 2, and 3 on the plans. Segment 1 is the

24-inch pipe section of Reach 1, Segment 2 is the double-pipe trench section of Reaches 1 and 2, and Segment 3 is the 24-inch pipe section of Reach 2. For the construction schedule, it was assumed each reach will be installed sequentially. An installation production rate of 150 linear feet per day, utilizing one crew, was assumed for the 24-inch steel pipe. Segment 2 is a double pipeline with an assumed production rate of 100 linear feet per day. The total length of 24-inch pipe to be installed from the WTP to the Red Mountain Reservoir is approximately seven miles (35,500 ft). The production rates were determined with the understanding that a majority of the pipeline installation is within the existing road right-of-way and will require trench boxes to minimize the trench width. Several existing utilities such as water lines and sewer lines are in close proximity to the product pipeline, both horizontally and vertically. This will restrict the pipelaying activities and significantly slow down the operations due to limited access for equipment and locations for stockpiling of material. Traffic control and signage will be critical to ensure safety and allow the contractor as much room as possible to install the pipeline. Installation of the 24-inch pipe — including boring for the road crossings, the valve vault, the flowmeter and vault, and the valves, and including testing — is anticipated to require approximately 15 months.

The Gheen Booster Pumping Plant requires sitework and installation of the pipe manifold and pumping plant equipment. The construction of the pumping plant will require approximately nine (9) months. The pumps are anticipated to be special-order items, which will require long lead times for fabrication and delivery.

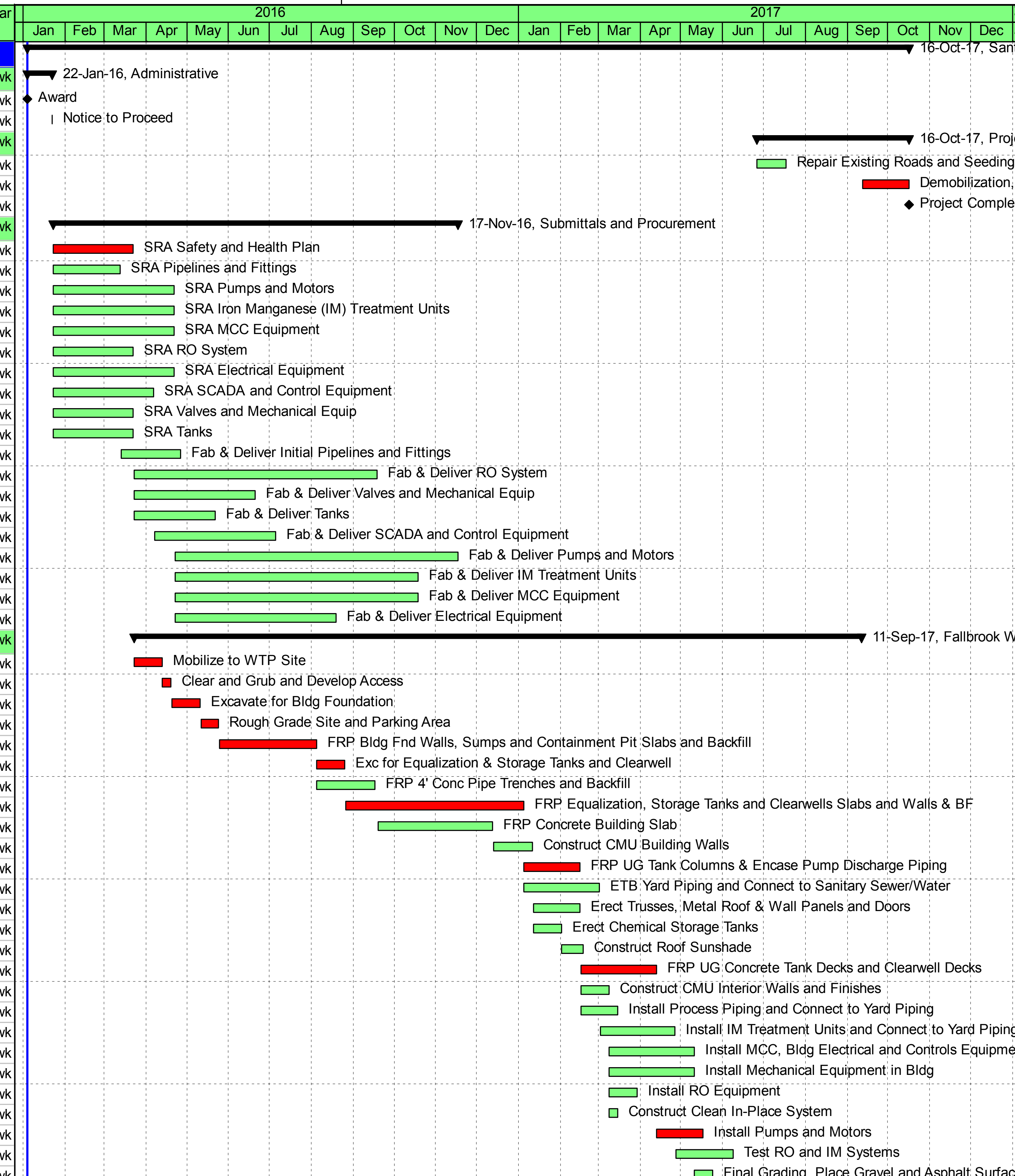
Activities in the construction schedule were assigned to a calendar. Most construction activities occur based on a normal five-day work week with no work on holidays. Submittals and fabrication activities are assumed to span a seven-day week, so the durations projected for these activities are calendar days, instead of the “work days” that are used for most other activities.

Abbreviations used in the schedule include:

SRA	Submit, review, and approve	ETB	Excavate, trench, and backfill
Fab	Fabricate	EC	Erosion control
FRP	Form, reinforce, and place	BP	Booster plant
IM	Iron manganese	Exc	Excavation
RO	Reverse osmosis	BF	Backfill
Fnd	Foundation	UG	Underground
MCC	Motor control center		

Overall the construction schedule provides one scenario of many possible scenarios to complete the project. The schedule will be further developed and the construction contract award date will be adjusted during the final design phase of the project.

Activity ID	Activity Name	Original Duration	Start	Finish	Total Float	Calendar
Santa Margarita Conjunctive Use Project - Feasibility		457	04-Jan-16	16-Oct-17	0	
Administrative		15	04-Jan-16	22-Jan-16	0	5 day/wk
A1000	Award	0	04-Jan-16		0	5 day/wk
A1010	Notice to Proceed	1	22-Jan-16	22-Jan-16	0	5 day/wk
Project Completion		79	26-Jun-17	16-Oct-17	0	5 day/wk
B2370	Repair Existing Roads and Seeding	15	26-Jun-17	17-Jul-17	39	5 day/wk
B2360	Demobilization, Punchlist and Cleanup	25	12-Sep-17	16-Oct-17	0	5 day/wk
B2350	Project Complete	0		16-Oct-17	0	5 day/wk
Submittals and Procurement		300	23-Jan-16	17-Nov-16	167	7-day/wk
A1020	SRA Safety and Health Plan	60	23-Jan-16	22-Mar-16	0	7-day/wk
A1030	SRA Pipelines and Fittings	50	23-Jan-16	12-Mar-16	9	7-day/wk
A1060	SRA Pumps and Motors	90	23-Jan-16	21-Apr-16	139	7-day/wk
A1110	SRA Iron Manganese (IM) Treatment Units	90	23-Jan-16	21-Apr-16	162	7-day/wk
A1070	SRA MCC Equipment	90	23-Jan-16	21-Apr-16	176	7-day/wk
A1050	SRA RO System	60	23-Jan-16	22-Mar-16	227	7-day/wk
A1090	SRA Electrical Equipment	90	23-Jan-16	21-Apr-16	236	7-day/wk
A1100	SRA SCADA and Control Equipment	75	23-Jan-16	06-Apr-16	281	7-day/wk
A1080	SRA Valves and Mechanical Equip	60	23-Jan-16	22-Mar-16	296	7-day/wk
A1040	SRA Tanks	60	23-Jan-16	22-Mar-16	347	7-day/wk
A1120	Fab & Deliver Initial Pipelines and Fittings	45	13-Mar-16	26-Apr-16	9	7-day/wk
A1140	Fab & Deliver RO System	180	23-Mar-16	18-Sep-16	227	7-day/wk
A1170	Fab & Deliver Valves and Mechanical Equip	90	23-Mar-16	20-Jun-16	296	7-day/wk
A1130	Fab & Deliver Tanks	60	23-Mar-16	21-May-16	347	7-day/wk
A1190	Fab & Deliver SCADA and Control Equipment	90	07-Apr-16	05-Jul-16	281	7-day/wk
A1150	Fab & Deliver Pumps and Motors	210	22-Apr-16	17-Nov-16	139	7-day/wk
A1200	Fab & Deliver IM Treatment Units	180	22-Apr-16	18-Oct-16	162	7-day/wk
A1160	Fab & Deliver MCC Equipment	180	22-Apr-16	18-Oct-16	176	7-day/wk
A1180	Fab & Deliver Electrical Equipment	120	22-Apr-16	19-Aug-16	236	7-day/wk
Fallbrook Water Treatment Plant		375	23-Mar-16	11-Sep-17	25	5 day/wk
B2000	Mobilize to WTP Site	15	23-Mar-16	12-Apr-16	0	5 day/wk
B2010	Clear and Grub and Develop Access	5	13-Apr-16	19-Apr-16	0	5 day/wk
B2020	Excavate for Bldg Foundation	15	20-Apr-16	10-May-16	0	5 day/wk
B2300	Rough Grade Site and Parking Area	10	11-May-16	24-May-16	0	5 day/wk
B2030	FRP Bldg Fnd Walls, Sumps and Containment Pit Slabs and E	50	25-May-16	04-Aug-16	0	5 day/wk
B2040	Exc for Equalization & Storage Tanks and Clearwell	15	05-Aug-16	25-Aug-16	0	5 day/wk
B2070	FRP 4' Conc Pipe Trenches and Backfill	30	05-Aug-16	16-Sep-16	25	5 day/wk
B2050	FRP Equalization, Storage Tanks and Clearwells Slabs and Wa	90	26-Aug-16	04-Jan-17	0	5 day/wk
B2110	FRP Concrete Building Slab	60	19-Sep-16	12-Dec-16	25	5 day/wk
B2080	Construct CMU Building Walls	20	13-Dec-16	11-Jan-17	25	5 day/wk
B2180	FRP UG Tank Columns & Encase Pump Discharge Piping	30	05-Jan-17	15-Feb-17	0	5 day/wk
B2060	ETB Yard Piping and Connect to Sanitary Sewer/Water	40	05-Jan-17	01-Mar-17	20	5 day/wk
B2090	Erect Trusses, Metal Roof & Wall Panels and Doors	25	12-Jan-17	15-Feb-17	25	5 day/wk
B2140	Erect Chemical Storage Tanks	15	12-Jan-17	01-Feb-17	158	5 day/wk
B2280	Construct Roof Sunshade	12	02-Feb-17	17-Feb-17	158	5 day/wk
B2190	FRP UG Concrete Tank Decks and Clearwell Decks	40	16-Feb-17	12-Apr-17	0	5 day/wk
B2120	Construct CMU Interior Walls and Finishes	15	16-Feb-17	08-Mar-17	25	5 day/wk
B2220	Install Process Piping and Connect to Yard Piping	20	16-Feb-17	15-Mar-17	50	5 day/wk
B2210	Install IM Treatment Units and Connect to Yard Piping	40	02-Mar-17	26-Apr-17	20	5 day/wk
B2250	Install MCC, Bldg Electrical and Controls Equipment	45	09-Mar-17	10-May-17	25	5 day/wk
B2260	Install Mechanical Equipment in Bldg	45	09-Mar-17	10-May-17	25	5 day/wk
B2130	Install RO Equipment	15	09-Mar-17	29-Mar-17	40	5 day/wk
B2150	Construct Clean In-Place System	5	09-Mar-17	15-Mar-17	65	5 day/wk
B2160	Install Pumps and Motors	25	13-Apr-17	17-May-17	0	5 day/wk
B2330	Test RO and IM Systems	30	27-Apr-17	08-Jun-17	20	5 day/wk
B2290	Final Grading, Place Gravel and Asphalt Surfacing	10	11-May-17	24-May-17	100	5 day/wk

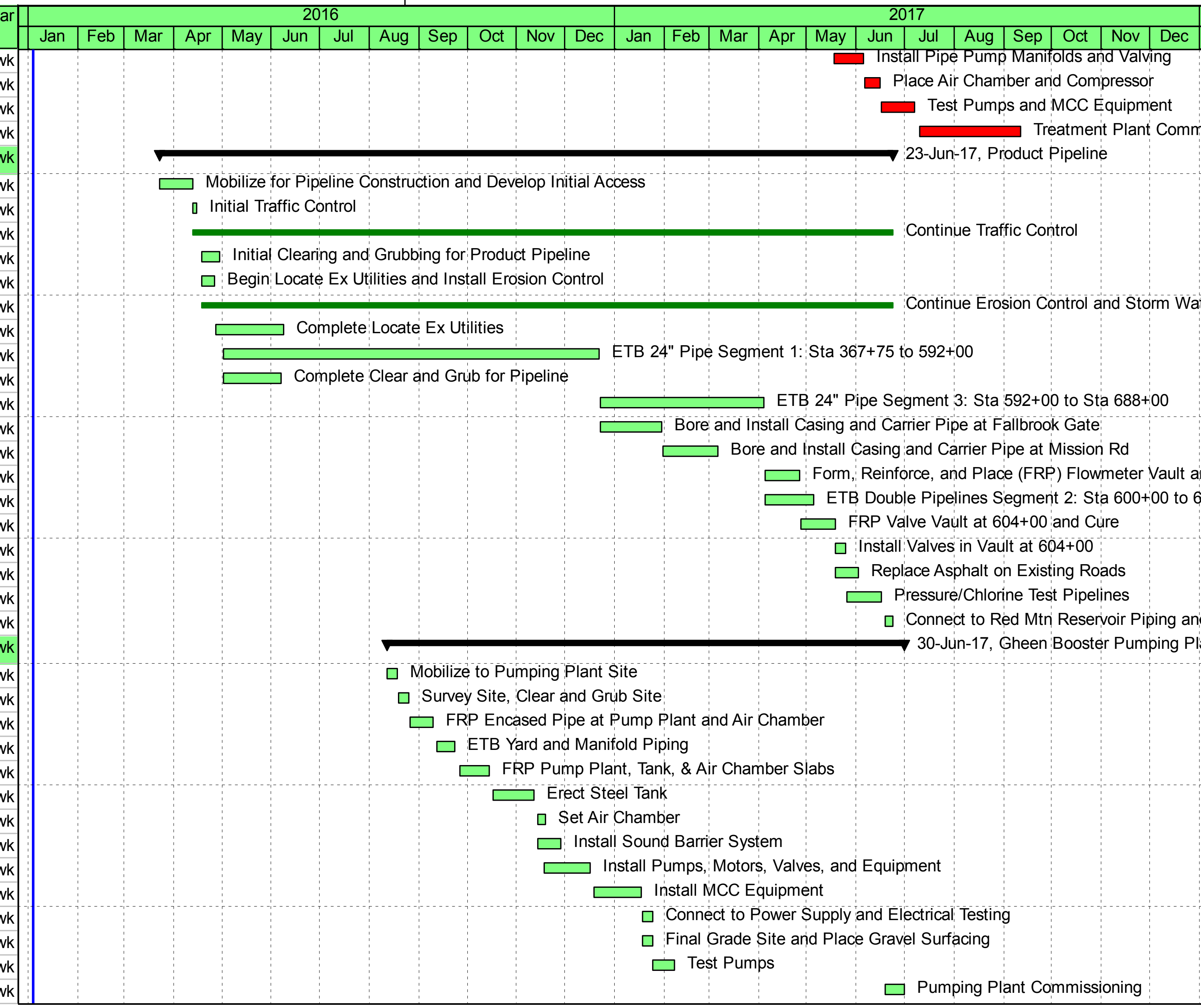


Remaining Level of Effort | Remaining Work | ◆ Milestone
Actual Work | Critical Remaining Work | Summary

Santa Margarita Conjunctive Use Project - Feasibility

Government Construction Schedule

Activity ID	Activity Name	Original Duration	Start	Finish	Total Float	Calendar
B2170	Install Pipe Pump Manifolds and Valving	12	18-May-17	05-Jun-17	0	5 day/wk
B2310	Place Air Chamber and Compressor	8	06-Jun-17	15-Jun-17	0	5 day/wk
B2320	Test Pumps and MCC Equipment	15	16-Jun-17	07-Jul-17	0	5 day/wk
B2340	Treatment Plant Commissioning	45	10-Jul-17	11-Sep-17	0	5 day/wk
Product Pipeline		321	23-Mar-16	23-Jun-17	54	5 day/wk
C1010	Mobilize for Pipeline Construction and Develop Initial Access	15	23-Mar-16	12-Apr-16	4	5 day/wk
C1130	Initial Traffic Control	3	13-Apr-16	15-Apr-16	4	5 day/wk
C1140	Continue Traffic Control	306	13-Apr-16	23-Jun-17	9	5 day/wk
C1030	Initial Clearing and Grubbing for Product Pipeline	10	18-Apr-16	29-Apr-16	4	5 day/wk
C1040	Begin Locate Ex Utilities and Install Erosion Control	7	18-Apr-16	26-Apr-16	7	5 day/wk
C1180	Continue Erosion Control and Storm Water Control	303	18-Apr-16	23-Jun-17	9	5 day/wk
C1160	Complete Locate Ex Utilities	30	27-Apr-16	08-Jun-16	142	5 day/wk
C1000	ETB 24" Pipe Segment 1: Sta 367+75 to 592+00	165	02-May-16	22-Dec-16	4	5 day/wk
C1150	Complete Clear and Grub for Pipeline	25	02-May-16	06-Jun-16	144	5 day/wk
C1020	ETB 24" Pipe Segment 3: Sta 592+00 to Sta 688+00	71	23-Dec-16	04-Apr-17	4	5 day/wk
C1050	Bore and Install Casing and Carrier Pipe at Fallbrook Gate	25	23-Dec-16	30-Jan-17	62	5 day/wk
C1170	Bore and Install Casing and Carrier Pipe at Mission Rd	25	31-Jan-17	06-Mar-17	62	5 day/wk
C1060	Form, Reinforce, and Place (FRP) Flowmeter Vault and Cure	16	05-Apr-17	26-Apr-17	4	5 day/wk
C1090	ETB Double Pipelines Segment 2: Sta 600+00 to 619+69 to G	23	05-Apr-17	05-May-17	18	5 day/wk
C1070	FRP Valve Vault at 604+00 and Cure	16	27-Apr-17	18-May-17	4	5 day/wk
C1080	Install Valves in Vault at 604+00	5	19-May-17	25-May-17	4	5 day/wk
C1100	Replace Asphalt on Existing Roads	10	19-May-17	02-Jun-17	69	5 day/wk
C1110	Pressure/Chlorine Test Pipelines	15	26-May-17	16-Jun-17	4	5 day/wk
C1120	Connect to Red Mtn Reservoir Piping and WTP	5	19-Jun-17	23-Jun-17	9	5 day/wk
Gheen Booster Pumping Plant		226	12-Aug-16	30-Jun-17	34	5 day/wk
D3080	Mobilize to Pumping Plant Site	5	12-Aug-16	18-Aug-16	120	5 day/wk
D3000	Survey Site, Clear and Grub Site	5	19-Aug-16	25-Aug-16	120	5 day/wk
D3010	FRP Encased Pipe at Pump Plant and Air Chamber	10	26-Aug-16	09-Sep-16	120	5 day/wk
D3030	ETB Yard and Manifold Piping	10	12-Sep-16	23-Sep-16	120	5 day/wk
D3020	FRP Pump Plant, Tank, & Air Chamber Slabs	15	26-Sep-16	14-Oct-16	120	5 day/wk
D3060	Erect Steel Tank	20	17-Oct-16	11-Nov-16	140	5 day/wk
D3040	Set Air Chamber	5	14-Nov-16	18-Nov-16	140	5 day/wk
D3090	Install Sound Barrier System	10	14-Nov-16	28-Nov-16	180	5 day/wk
D3050	Install Pumps, Motors, Valves, and Equipment	20	18-Nov-16	16-Dec-16	96	5 day/wk
D3070	Install MCC Equipment	20	19-Dec-16	17-Jan-17	96	5 day/wk
D3110	Connect to Power Supply and Electrical Testing	5	18-Jan-17	24-Jan-17	96	5 day/wk
D3100	Final Grade Site and Place Gravel Surfacing	5	18-Jan-17	24-Jan-17	146	5 day/wk
D3120	Test Pumps	10	25-Jan-17	07-Feb-17	96	5 day/wk
D3140	Pumping Plant Commissioning	10	19-Jun-17	30-Jun-17	4	5 day/wk



Remaining Level of Effort | Remaining Work | Milestone | Actual Work | Critical Remaining Work | Summary

12 Environmental Considerations

As part of the overall project planning study, the SMRCUP includes development of a joint environmental impact statement and environmental impact report (EIS/R) to comply with the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) respectively. The EIS/R addresses the project's purpose and need, three project alternatives, existing resources within the project area, potential impacts and mitigation/conservation measures.

The proposed action is the first alternative. This alternative includes the project components designed and assessed in the feasibility study and components to be designed and completed by the MCBCP. This latter work includes installation of a new diversion weir, a fish bypass structure, upgrades to the headgate, a diversion canal, recharge ponds (7), new groundwater wells, two pump stations, and a bidirectional pipeline to the FPUD property bordering the Naval Weapons Station. Alternative two is a larger version of the proposed action with the following exceptions: the WTP is an expansion of an existing MCBCP WTP, and the bidirectional pipeline extends all the way to FPUD's Red Mountain reservoir. Alternative 3 is a no-action alternative.

The EIS/R field work associated with the three alternatives is complete. A draft version of the EIS/R was submitted to Reclamation, MCBCP, and FPUD for review the first week of June 2013. Other supporting environmental documents have assumed concurrence from the regulatory agency or are also in draft review prior to initiating consultation. The cultural resources report required for compliance with the National Historic Preservation Act was submitted to the State Historic Preservation Office (SHPO) in December 2012. The SHPO comment period passed with no comments. Draft biological assessments (BAs) for the U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service were submitted to the project partners for review. MCBCP is the lead entity on Endangered Species Act (ESA) consultations with both services.

ESA consultations could impact MCBCP's design and operation of any new diversion weir, but there are no known issues associated with the EIS/R, SHPO concurrence, or ESA consultations that could impact Reclamation's design. The ESA consultations with both services are anticipated to start in the fall of 2013, pending MCBCP's approval of the draft BAs. A public review of the EIS/R is scheduled for September 2013.

13 References

CDPH. 2008. Maximum contaminant levels and regulatory dates for drinking water, U.S. EPA vs. California. California Department of Public Health, Division of Drinking Water and Environmental Management. November 2008. http://www.cdph.ca.gov/certlic/drinkingwater/Documents/DWdocuments/EPAandCDPH-11-28-2008.pdf

Reclamation. 2006. Decision regarding alternative for further study, Santa Margarita Conjunctive Use Project. SCAO-7000, ADM-13.00. Bureau of Reclamation, Southern California Area Office, Temecula, CA, December 11, 2006. http://www.usbr.gov/lc/socal/reports/memo_061211.pdf

Stetson Engineers. 2007a. Santa Margarita River Conjunctive Use Project Final Technical Memorandum No. 1.0: Statistical analysis of Santa Margarita River surface water availability at the conjunctive use project's point of diversion. Prepared by: Stetson Engineers. Prepared for: Bureau of Reclamation, Southern California Area Office, Fresno, CA.

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U.S. Navy and Bureau of Reclamation. 2004. Notice of intent to prepare an environmental impact statement/environmental impact report for the Santa Margarita River Conjunctive Use Project, San Diego County, CA. Federal Register, November 1, 2004, v. 69, no. 210, FR Doc 04-24335. http://www.thefederalregister.com/d.p/2004-11-01-04-24335

Appendix A – Membrane Selection Evaluation

Reclamation's feasibility-level design for the SMRCUP involves groundwater quality with salinity at ~900 mg/L, dictating the need for a desalination process to treat feed flows to potable water standards. Reverse osmosis was selected as the desalination process for salinity removal after the iron and manganese removal process. This appendix describes how a suitable membrane was selected for the RO process.

Membrane projection software (IMSDesign and ROSA) was utilized to run projections of effluent TDS and feed pressure for a variety of membrane types. Due to low osmotic pressure in the feed stream, low pressure/low energy RO membranes reduce TDS as effectively as brackish water membranes at significantly lower feed pressures. Figure A1 depicts feed pressures for the membranes considered from the two membrane companies that can meet a 400-mg/L design effluent concentration.

Three types of membranes were selected for analysis: (1) nanofiltration, (2) low pressure RO, and (3) brackish water membranes. The ESPA2+ (low pressure RO), ESPA4 (lowest pressure RO), and ESNA1-LFS (nanofiltration) were selected to span the operating range of potential membranes for the SMRCUP design. Table presents a summary of the Hydranautics IMSDesign membrane specifications.

Table A1. Hydranautics IMSDesign Specifications for Three RO Membranes

Module	Nominal productivity (gpd)	Ion Rejection	Element Size, in.	Element Type	Feed Bypass
ESNA1-LFS	8,200	91.0%	8.0 x 40.0	Softening composite	36%
ESPA4	12,000	99.2%	8.0 x 40.0	Lowest pressure composite	41%
ESPA2+	12,000	99.6%	8.0 x 40.0	Low pressure composite	44%

Evaluation

To determine which membrane type should be used for the SMRCUP, the following four evaluation criteria were evaluated:

- Number of membrane elements and plant footprint
- Ratio of treated product volume to reservoir volume
- Nanofiltration/reverse osmosis (NF/RO) process chemical requirements
- Power cost of treated water

Descriptions of the criteria and a summary of how these membranes compare to each one follow:

Number of Membrane Elements and Plant Footprint: A maximum flow of 13.5 cfs was used as the design feed flow. The NF/RO process is designed with a bypass loop, which provides a smaller plant size with a blended effluent stream. The membrane rejection directly dictates the amount of water that requires NF/RO treatment to meet a design 400 mg/L blended TDS goal. The higher rejection membranes operate with a lower feed volume, therefore requiring fewer membrane modules and a smaller plant footprint.

Treated Product Volume to Reservoir: Treated water volume is proportional to a membrane's specific ion rejection capacity (similar to the number of membrane elements required for treatment). The more water that can be bypassed, the lower the concentrate stream and the higher total volume of treated water sent to the reservoir. To meet concentrate requirements for silica (<180 mg/L) and membrane operational parameters, the recovery of the NF/RO plant was determined to be 85 percent.

NF/RO Process Chemical Requirements: Process chemicals required for the NF/RO process include feed water acid adjustment for pH reduction, antiscalant for sparingly soluble salt species, and caustic neutralization of both the permeate and concentrate streams. Post-treatment chemicals for stabilization were omitted for this evaluation. Chemical requirements for antiscalant are based on the volume of water treated in the NF/RO plant. Membrane software projections confirm:

1) Acid requirements to lower the pH are necessary for very high ion rejection membranes;
2) Acid may be eliminated for feed water pH adjustment purposes for the lower rejection membranes; and
3) Caustic is not required for the concentrate stream in any of the projected scenarios; however, permeate streams require an upward pH adjustment.

The higher rejection membranes, requiring acid adjustment, require increased amounts of caustic to neutralize the permeate flows. Additionally, the low rejection NF membranes require greater amounts of caustic than the intermediary composite due to higher volumes of water treated in the NF/RO process.

Power Cost of Treated Water: The projection software creates an estimated power requirement per volume of water treated based on each membrane option. Using an estimated power cost of 12.5¢ per kilowatt-hour and assuming maximum production year-round, the annual cost of treatment for the NF/RO process was calculated. The power cost is relative to the required feed pressure for the membrane module and the volume of water treated. The highest power costs are associated with the high rejection membranes, which require higher feed pressure for operation. Although the lowest rejection membranes require less feed pressure, they provide higher plant flows and total treated volumes. Therefore, the most cost-effective option in this comparison is the intermediate lowest pressure RO composite module, with lower required pressure and intermediate flow requirements.

Criteria results for the three membrane module types are summarized in Table A2, and full projection summary information is tabulated in Table A3.

Table A2. Membrane Module Rankings

Evaluation Criteria	Membrane Type		
	ESNA1-LFS, Nanofiltration	ESPA4, Lowest Pressure Reverse Osmosis	EPSA2+, (Low Pressure/Low Energy Reverse Osmosis
Ability to Bypass flow, Productivity	Worst	Moderate	Best
Productivity	Moderate	Best	Best
Acidic Chemicals	Best	Best	Worst
Caustic Chemicals	Moderate	Best	Worst
RO/NF Chemicals (antiscalant and CIP)	Highest Cost	Moderate Cost	Lowest Cost
Power Cost	Moderate	Best	Worst

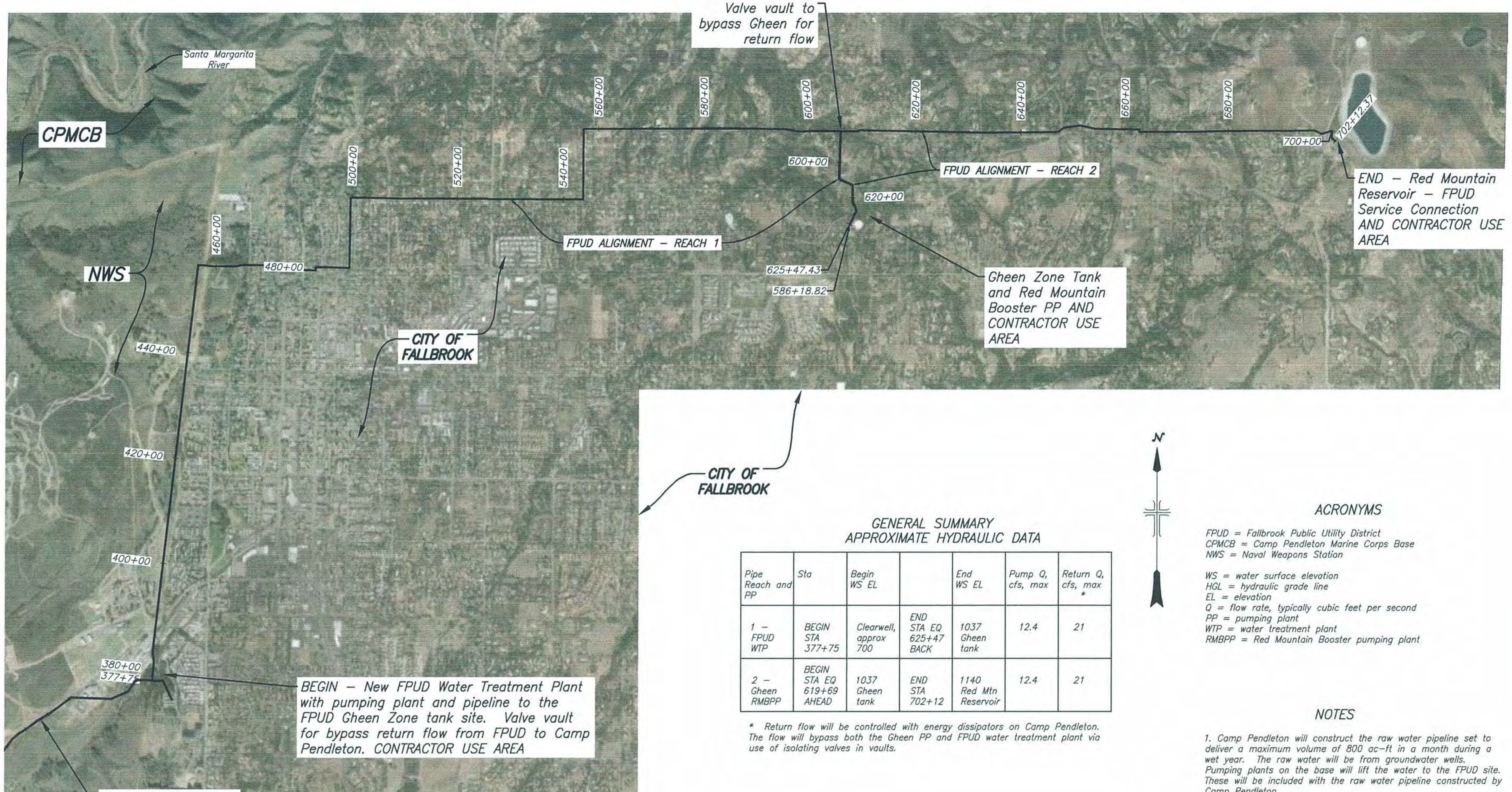
Recommendation

Based on comparing the results of each membrane to the four evaluation criteria, the ESPA4 membrane is recommended for use at the SMRCUP facility. A design TDS concentration of 400 mg/L was used for effluent concentrations. This intermediate pressure membrane allows for sufficient reduction of salinity and reduction of chloride to less than 50 mg/L in the blended stream, and it maintains a manageable concentrate water composition with respect to silica. The ESPA4 operates at a lower driving pressure than either of the other tested membranes, and yet maintains sufficient rejection to allow a sizable bypass stream to decrease the overall plant size. The combination of lower influent flows and low driving pressure makes this option the most cost effective. Additionally, lower treated flow requirements also reduce the requirement for caustic chemicals.

Table A3. Overall Comparison of Membrane Module Types

Product Specifications	Module		
	ESNA1-LFS	ESPA4	ESPA2+
Nominal production (gpd)	8,200	12,000	12,000
Rejection	91.0%	99.2%	99.6%
Element Type	Softening composite	Lowest pressure composite	Low pressure composite
Number of Membrane Elements and Plant Footprint			
Stage arrays 1:2	73:38	67:35	59:30
Total elements required	666	612	534
Element square footage	1,522	1,399	1,221
Treated Product Volume to Reservoir			
Bypass flow	36%	41%	44%
Product flow (cfs)	11.3	11.5	11.6
Perm. TDS (mg/L)	119.5	46.1	10.2
Blended chloride (mg/L)	79.6	64.9	66.6
Concentrate SiO_2 (mg/L)	92.7	100.2	106.3
NF/RO Process Chemical Requirements			
NaOH (gal.)	494	455	864
H_2SO_4 (gal.)	0	0	296
NaOCl (gal.)	11,728	11,837	11,903
NH_4OH (gal.)	1,208	1,226	1,237
Anti-scalant (kg/yr)	18,780	17,186	16,494
CIP chemicals (kg/yr)	5,040	4,632	4,041
Power Cost of Treated Water			
Feed pressure (psi)	88.5	84.8	113.3
Power (kwhr/kgal)	1.11	1.07	1.42
Power cost ($/yr)	$207,574	$182,894	$232,927

Appendix B – Water Conveyance Pipeline Drawings



CITY OF FALLBROOK

GENERAL SUMMARY APPROXIMATE HYDRAULIC DATA

Pipe Reach and PP	Sta	Begin WS EL		End WS EL	Pump Q, cfs, max	Return Q, cfs, max *
1 – FPUD WTP	BEGIN STA 377+75	Clearwell, approx 700	END STA EQ 625+47 BACK	1037 Gheen tank	12.4	21
2 – Gheen RMBPP	BEGIN STA EQ 619+69 AHEAD	1037 Gheen tank	END STA 702+12	1140 Red Mtn Reservoir	12.4	21

* Return flow will be controlled with energy dissipators on Camp Pendleton. The flow will bypass both the Gheen PP and FPUD water treatment plant via use of isolating valves in vaults.

N

ACRONYMS

FPUD = Fallbrook Public Utility District
CPMCB = Camp Pendleton Marine Corps Base
NWS = Naval Weapons Station

WS = water surface elevation
HGL = hydraulic grade line
EL = elevation
Q = flow rate, typically cubic feet per second
PP = pumping plant
WTP = water treatment plant
RMBPP = Red Mountain Booster pumping plant

NOTES

1. Camp Pendleton will construct the raw water pipeline set to deliver a maximum volume of 800 ac–ft in a month during a wet year. The raw water will be from groundwater wells. Pumping plants on the base will lift the water to the FPUD site. These will be included with the raw water pipeline constructed by Camp Pendleton.

2. The FPUD product pipeline will have the bi–directional flow capability to return flow to the base as well. Bypass valves in vaults will be installed at the Gheen tee and the FPUD WTP site. Return flow will use the incoming raw water pipeline on the base. Return flow energy dissipation will be provided by Camp Pendleton at their pumping plant.

PLAN

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2010 FEASIBILITY STUDY CONCEPT

SANTA MARGARITA RIVER CONJUCTIVE USE PROJECT STUDY
FALLBROOK PIPELINE AND SYSTEM LAYOUT
KEY MAP PLAN AND HYDRAULIC TABLE

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REVIEWED BY:

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FIGURE B1

SHEET 1 OF 1

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PLAN

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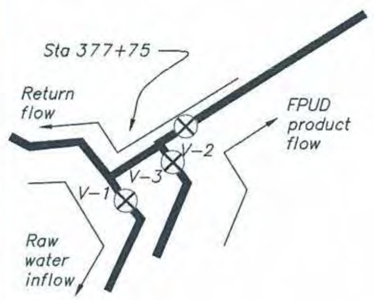
DETAIL – CONNECTION AND VALVE OPERATIONS

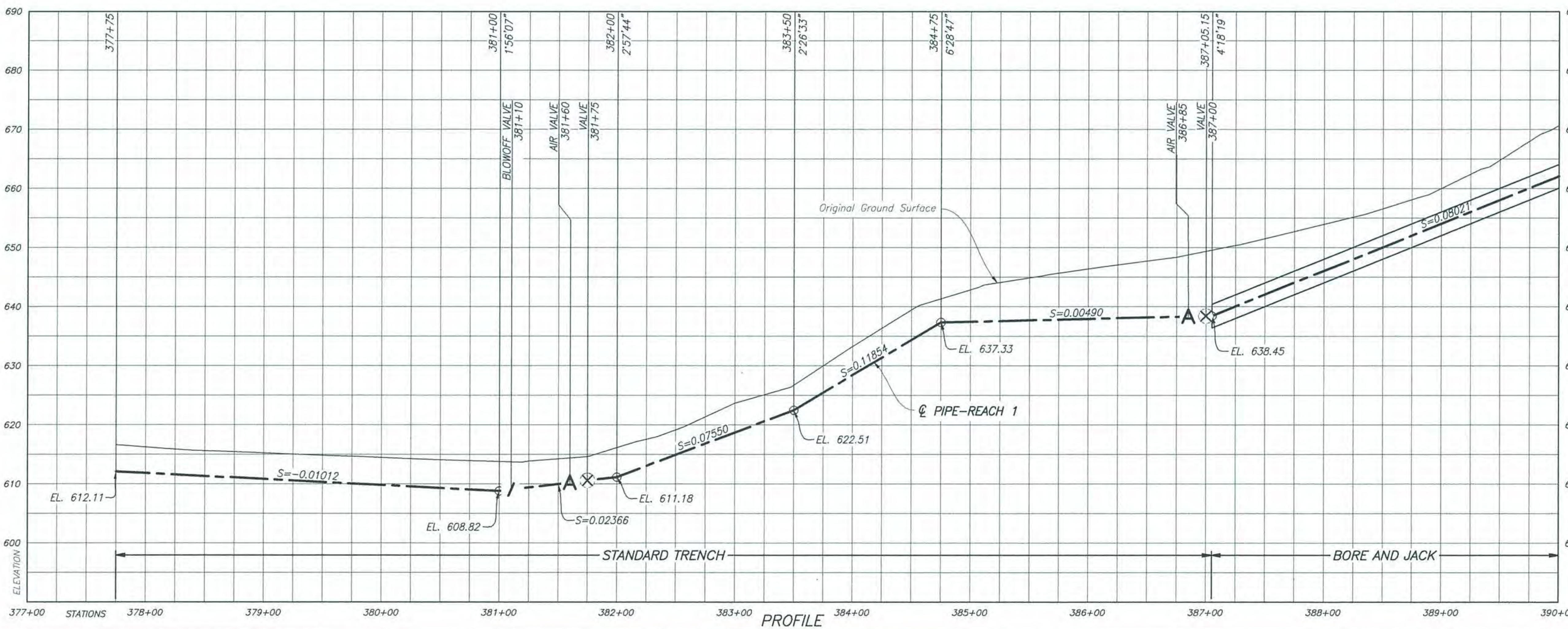


Valve	Normal flow	Return flow*
V-1	Open	Closed
V-2	Open	Closed
V-3	Closed	Open

* Return flow valve operations to be coordinated with Camp Pendleton

LEGEND

- A AIR VALVE
- ⊗ VALVE
- / BLOWOFF VALVE
- UNPAVED ROAD RESTORATION
- PAVED ROAD RESTORATION



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FPUD PRODUCT TRANSMISSION PIPELINE
REACH 1
337+75 TO 390+00
PLAN & PROFILE

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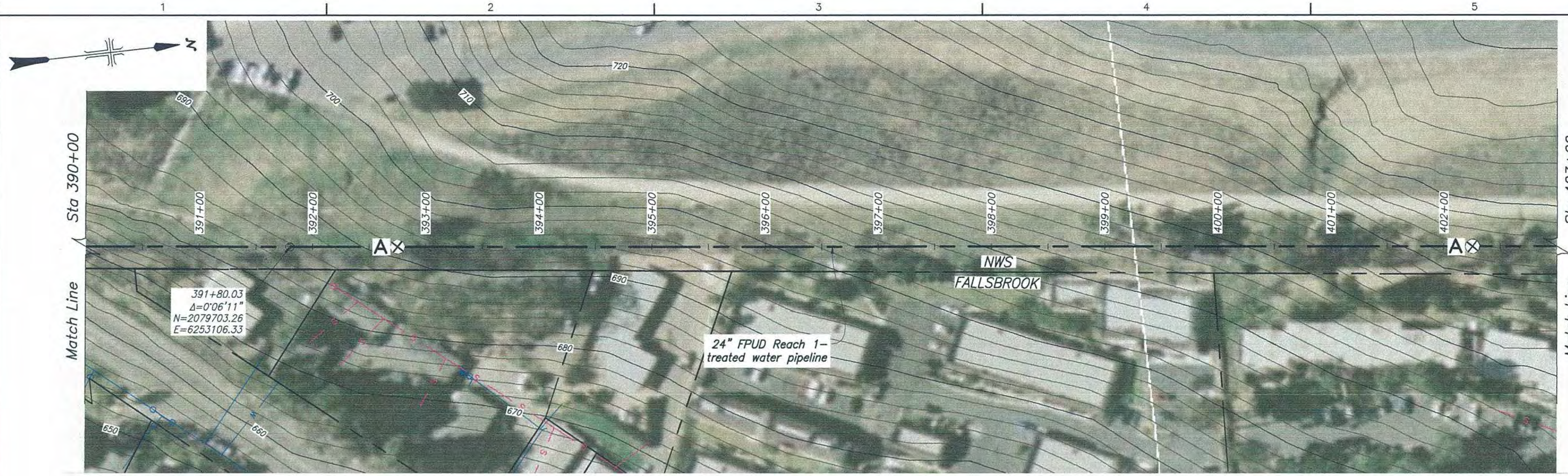
FIGURE B2

SHEET 1 OF 32



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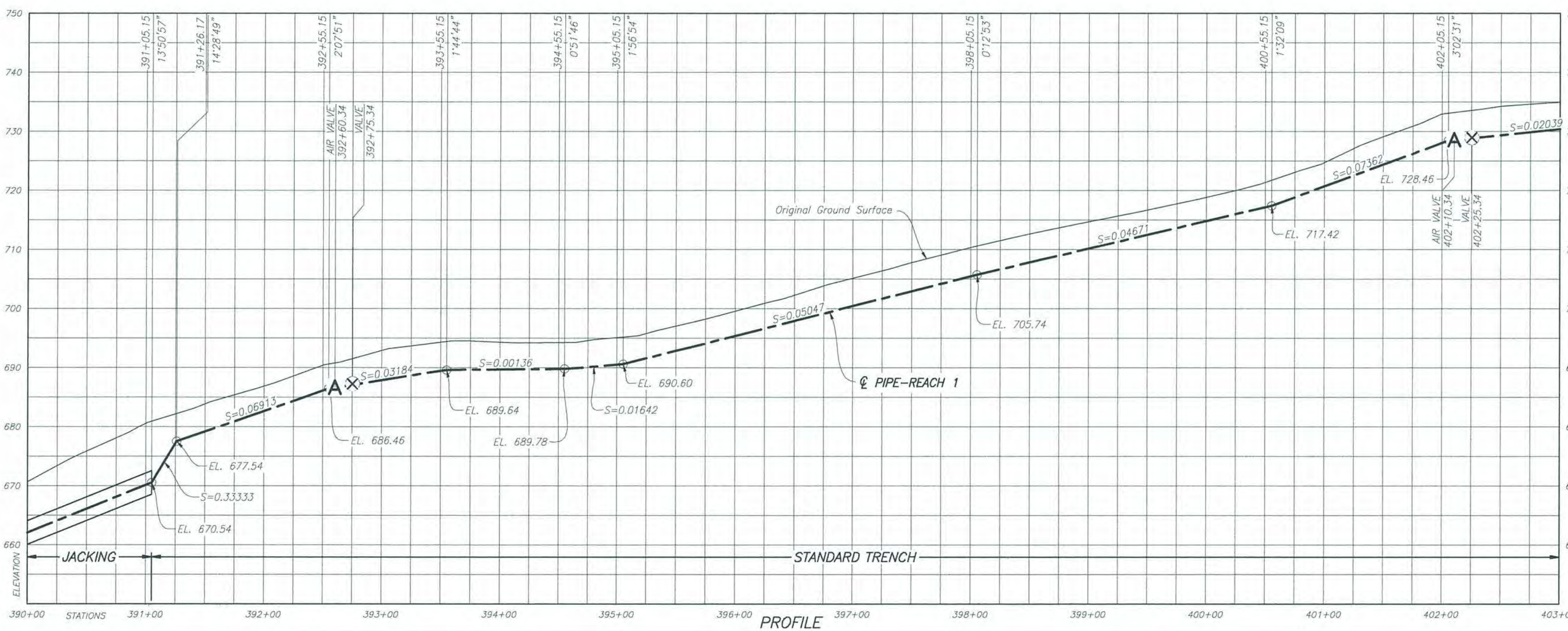

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REACH 1
390+00 TO 403+00
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FIGURE B3
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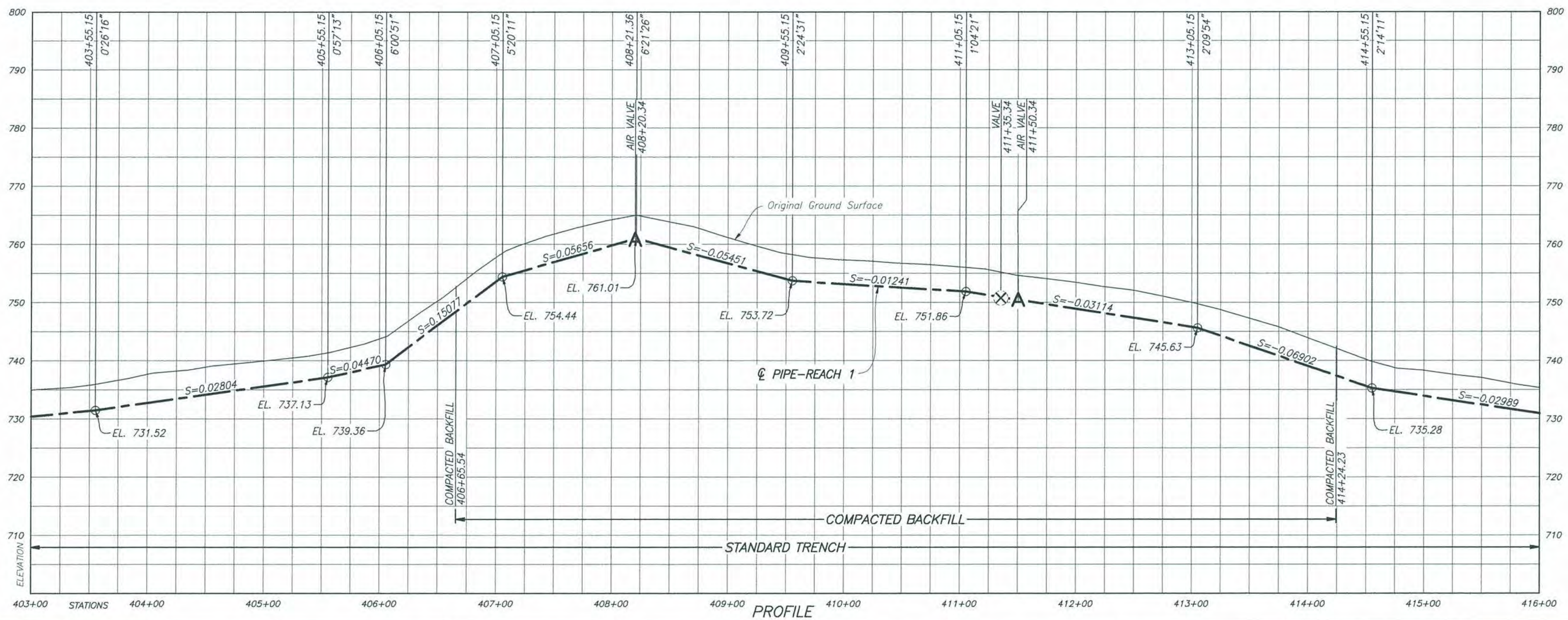

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FPUD PRODUCT TRANSMISSION PIPELINE
REACH 1
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FIGURE B4
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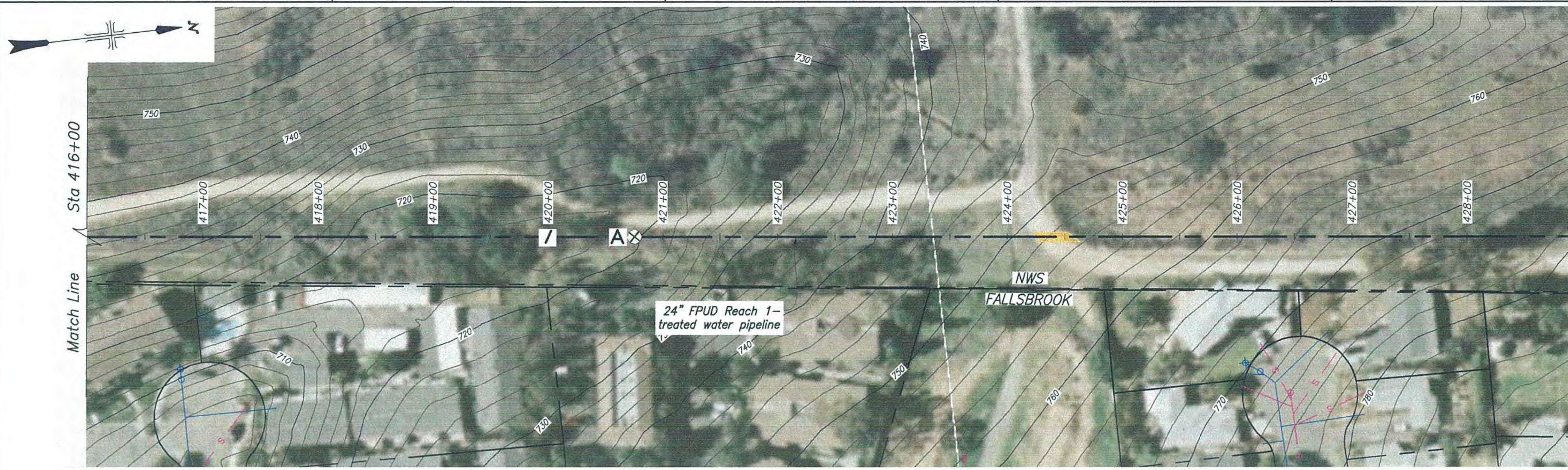

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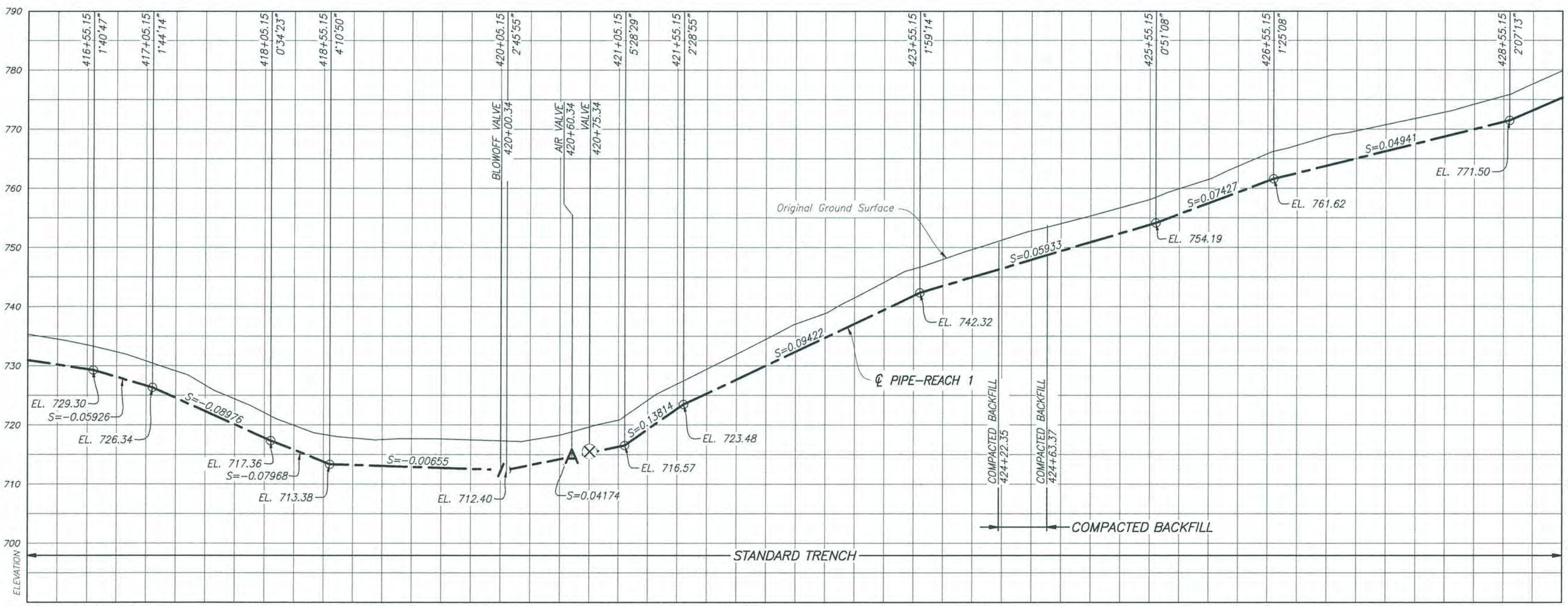

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FPUD PRODUCT TRANSMISSION PIPELINE
REACH 1
416+00 TO 429+00
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FIGURE B5

SHEET 4 OF 32

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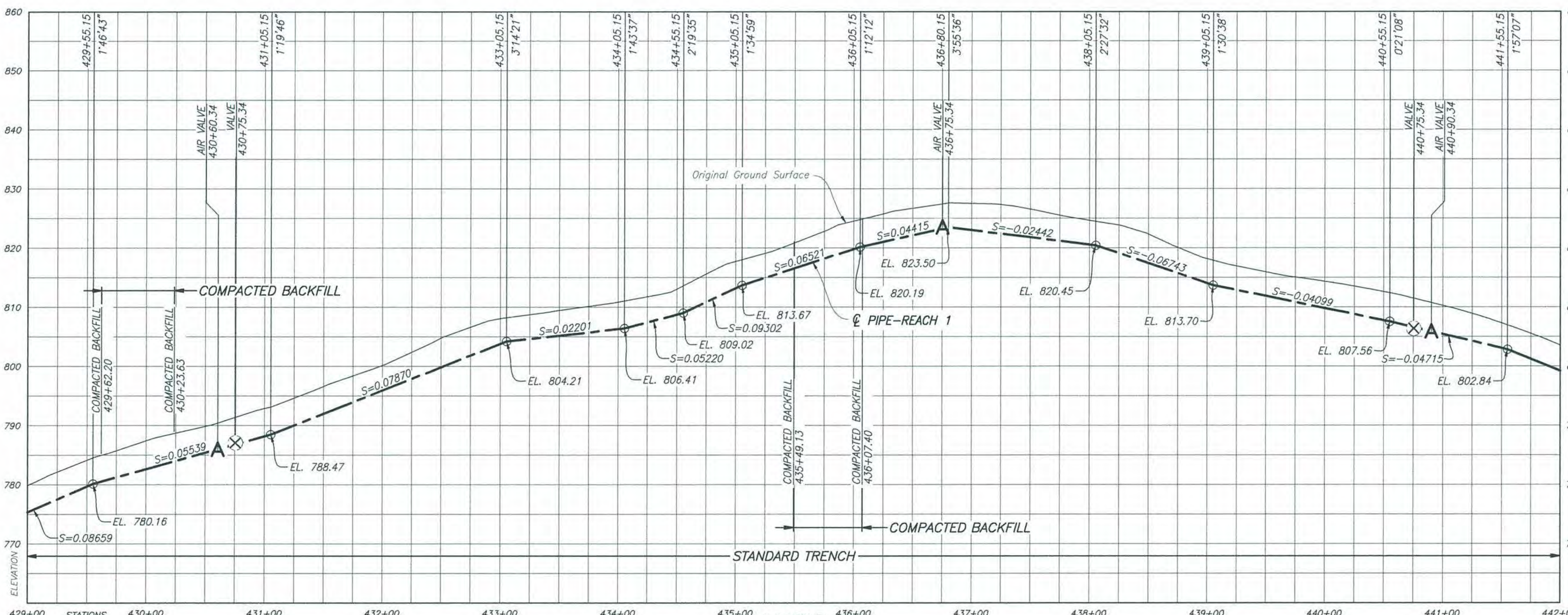

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FPUD PRODUCT TRANSMISSION PIPELINE
REACH 1
429+00 TO 442+00
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FIGURE B6
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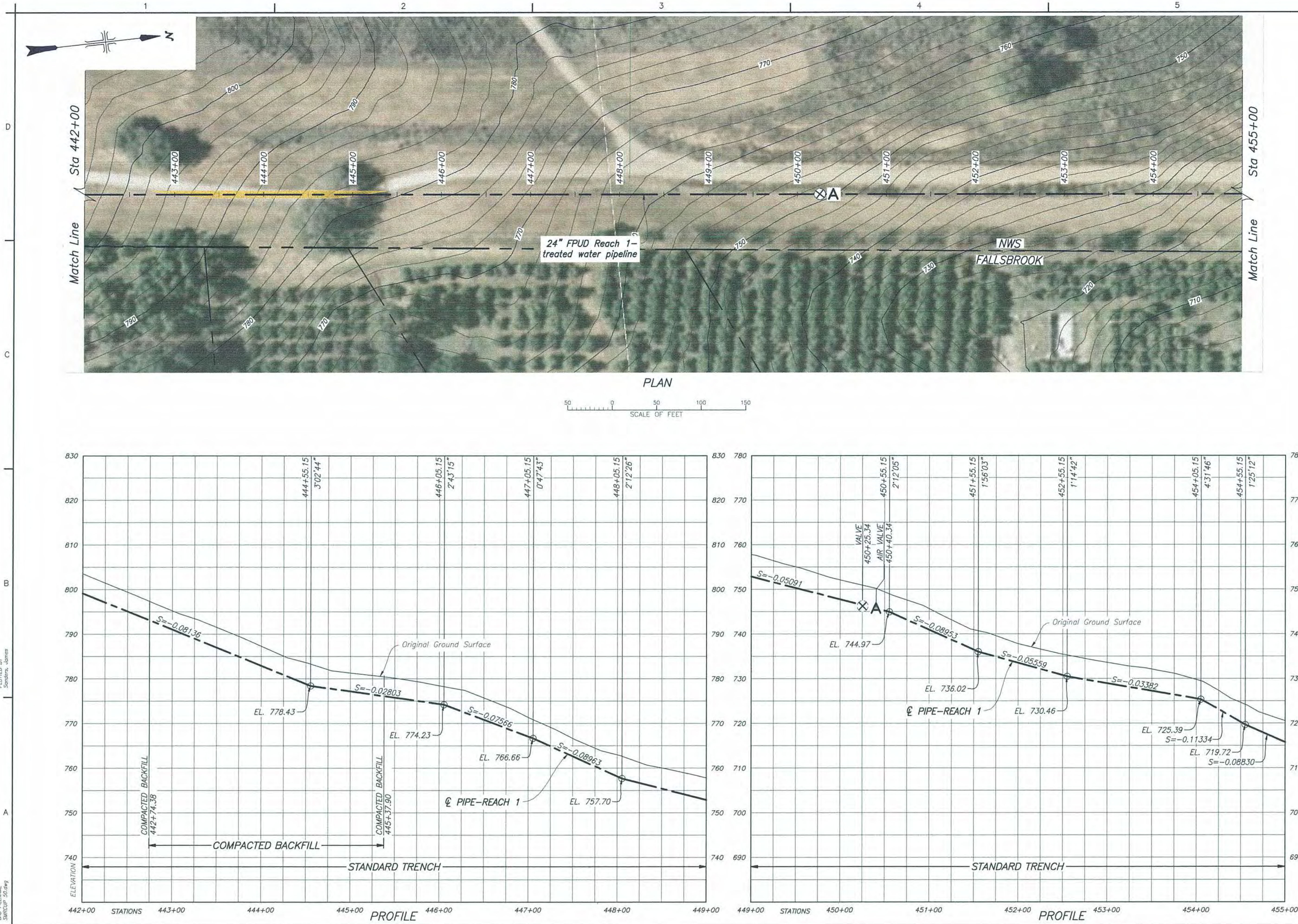

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FPUD PRODUCT TRANSMISSION PIPELINE
REACH 1
442+00 TO 455+00
PLAN & PROFILE

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FIGURE B7

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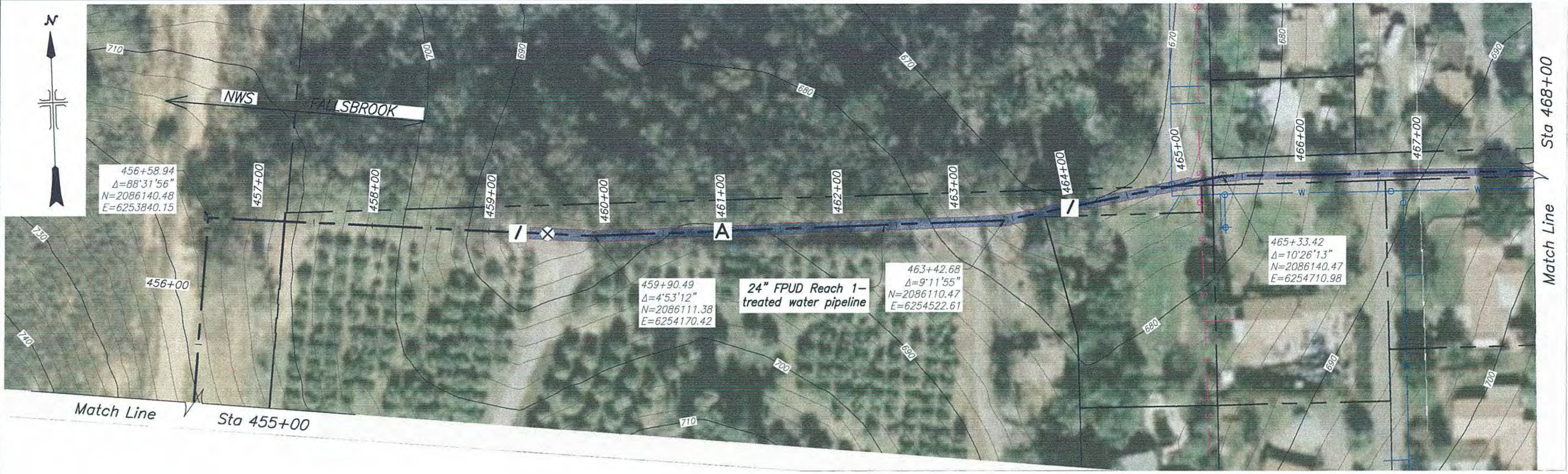

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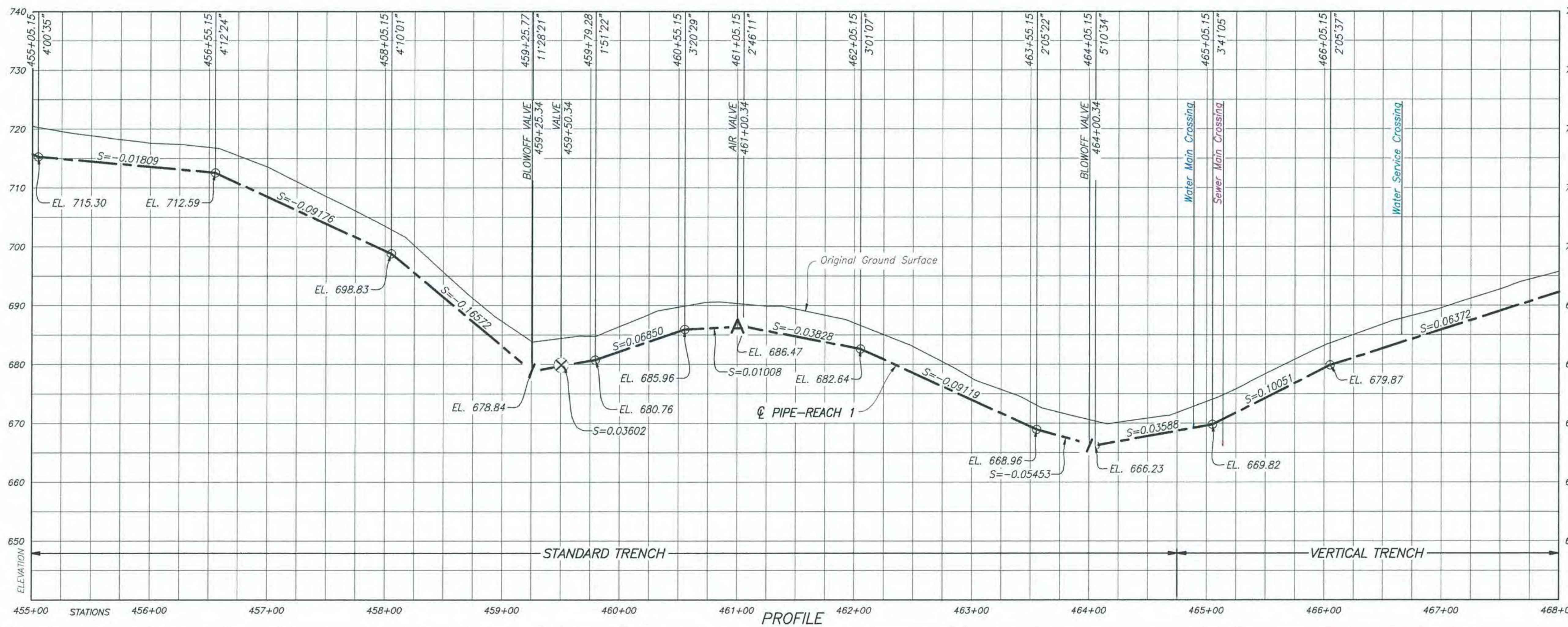

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REACH 1
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FIGURE B8

SHEET 7 OF 32

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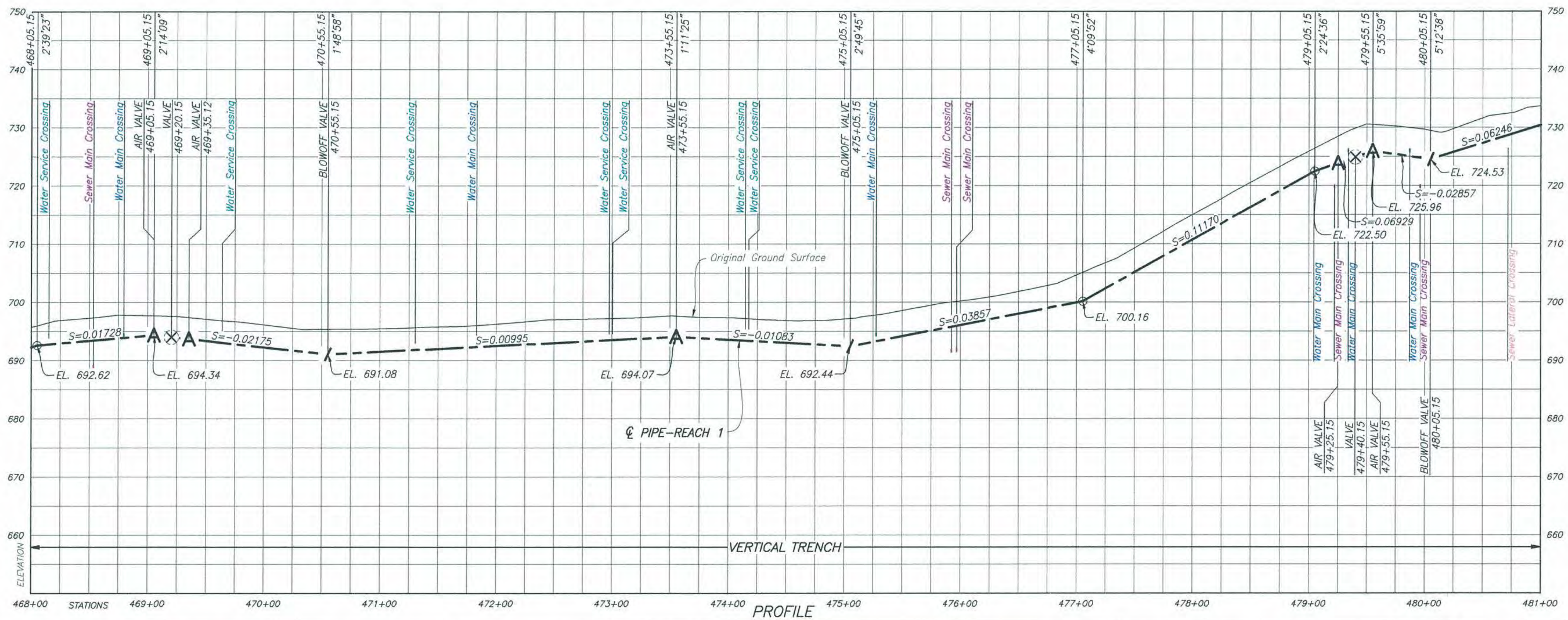

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FIGURE B9

SHEET 8 OF 32

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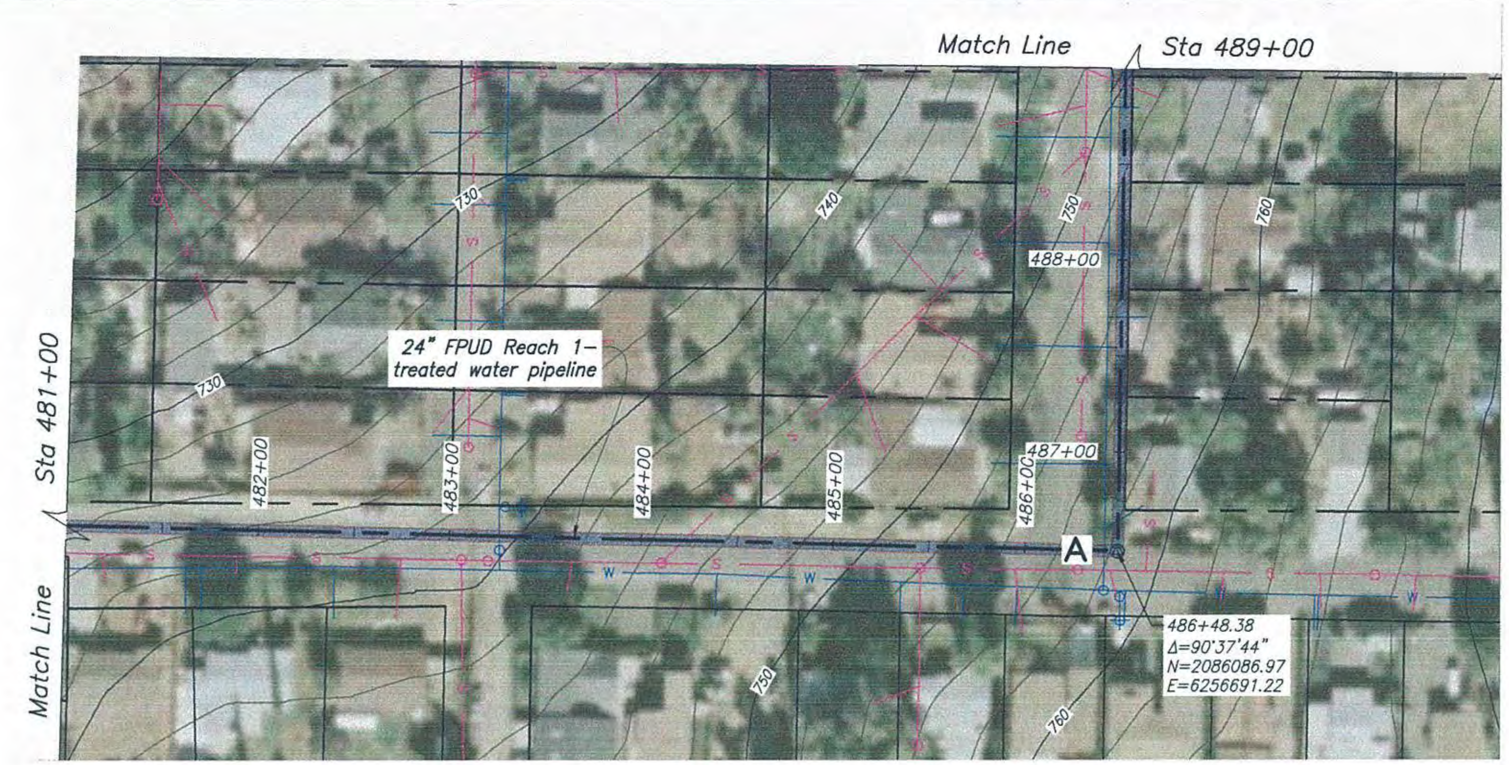

PLAN

SCALE OF FEET

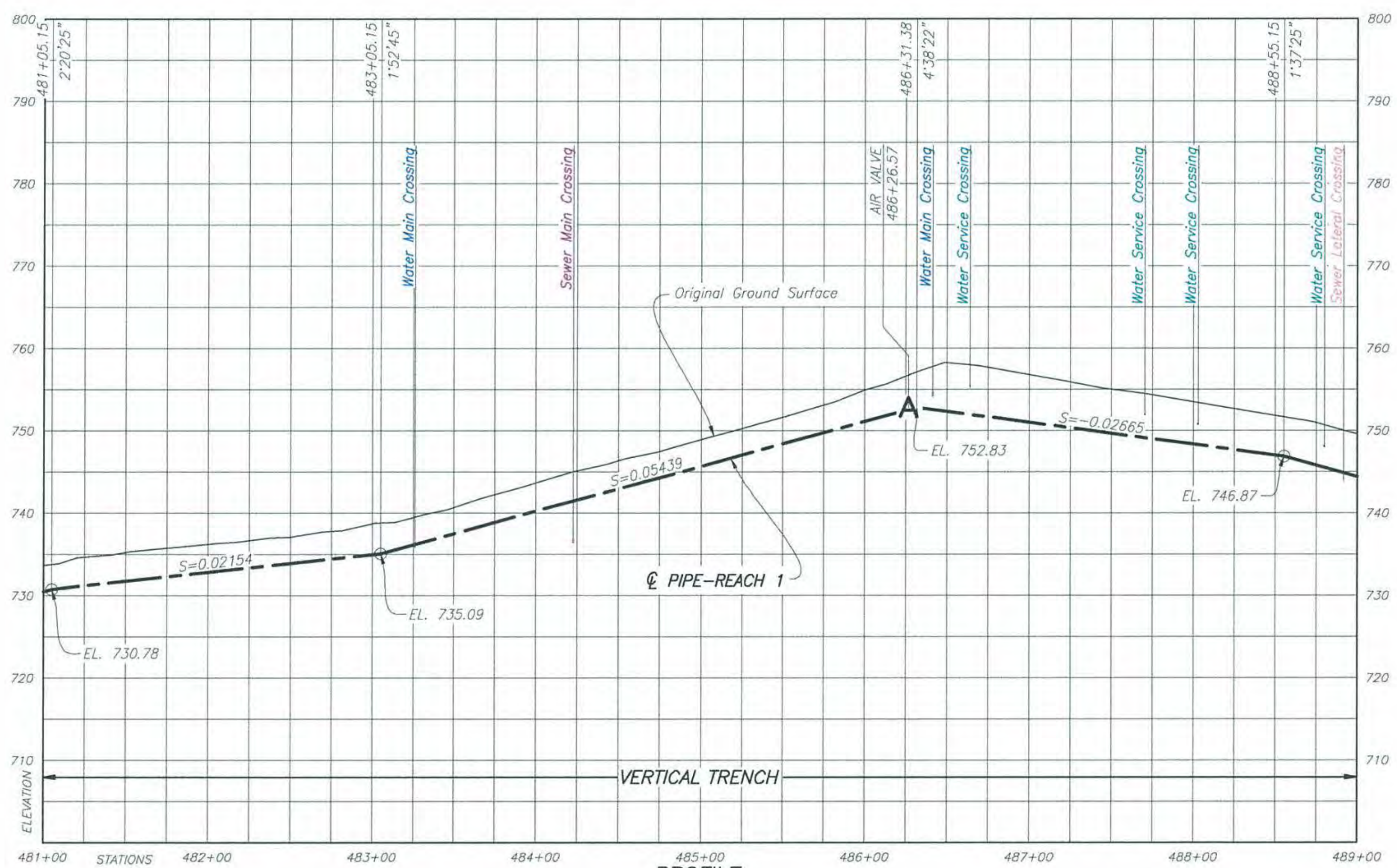

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FIGURE B10

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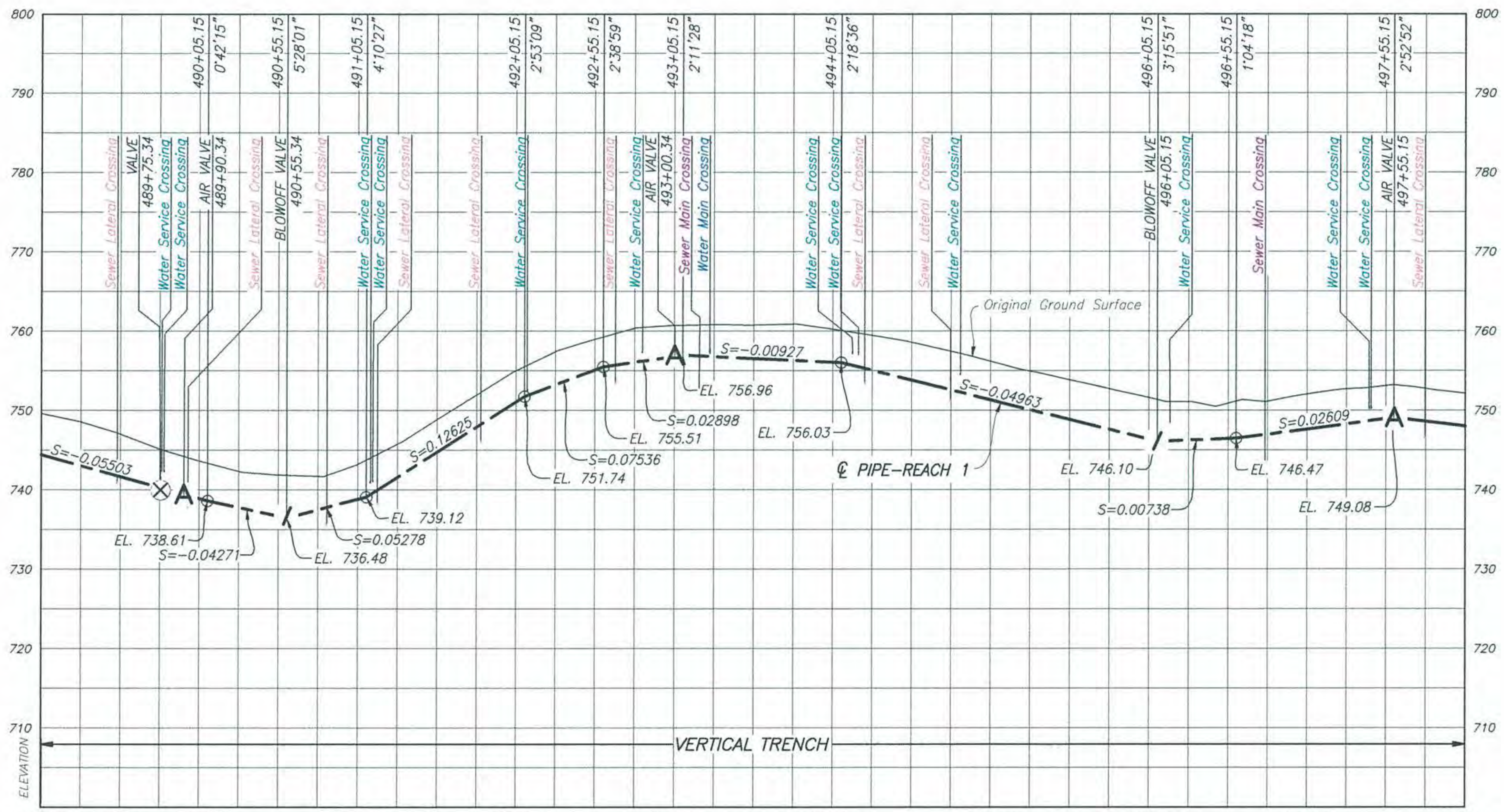
PLAN



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REACH 1
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FIGURE B11

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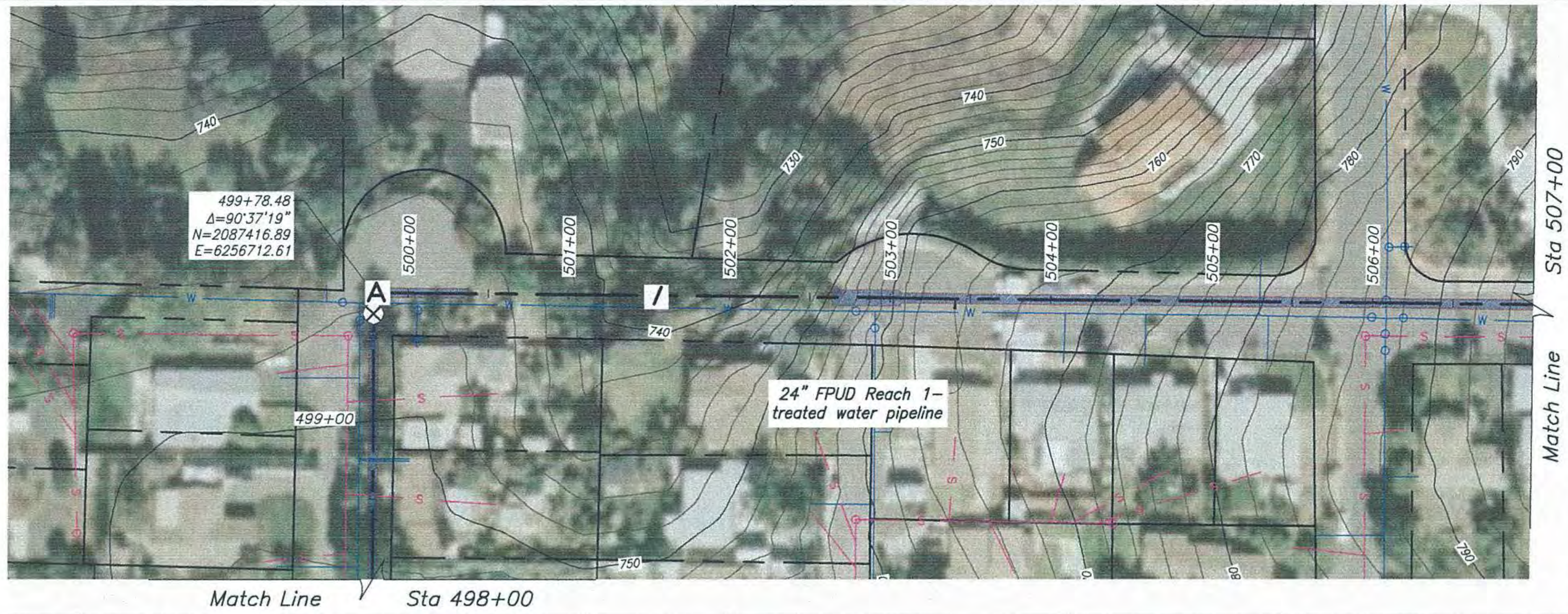

PLAN

SCALE OF FEET

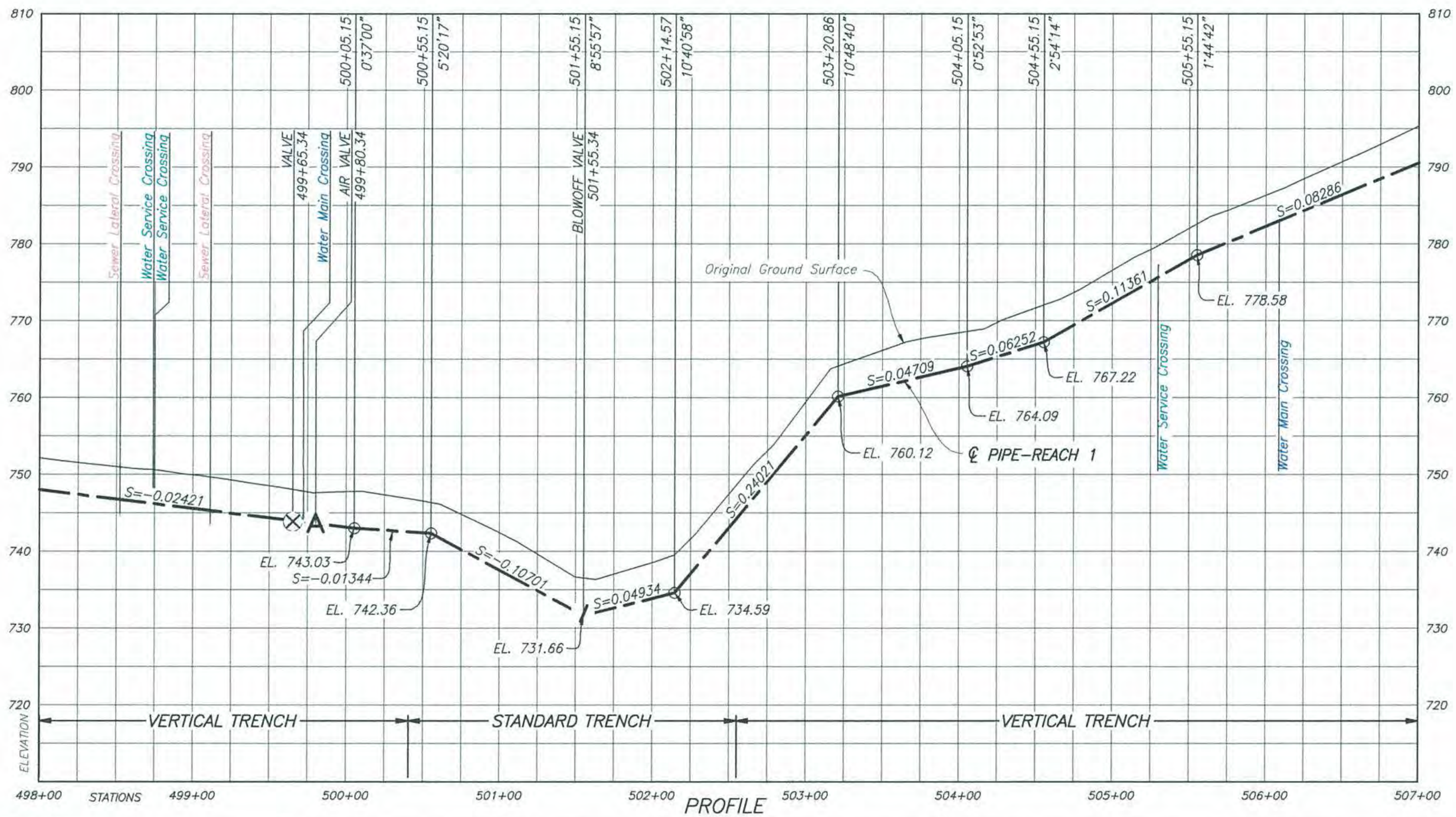

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FIGURE B12
SHEET 11 OF 32

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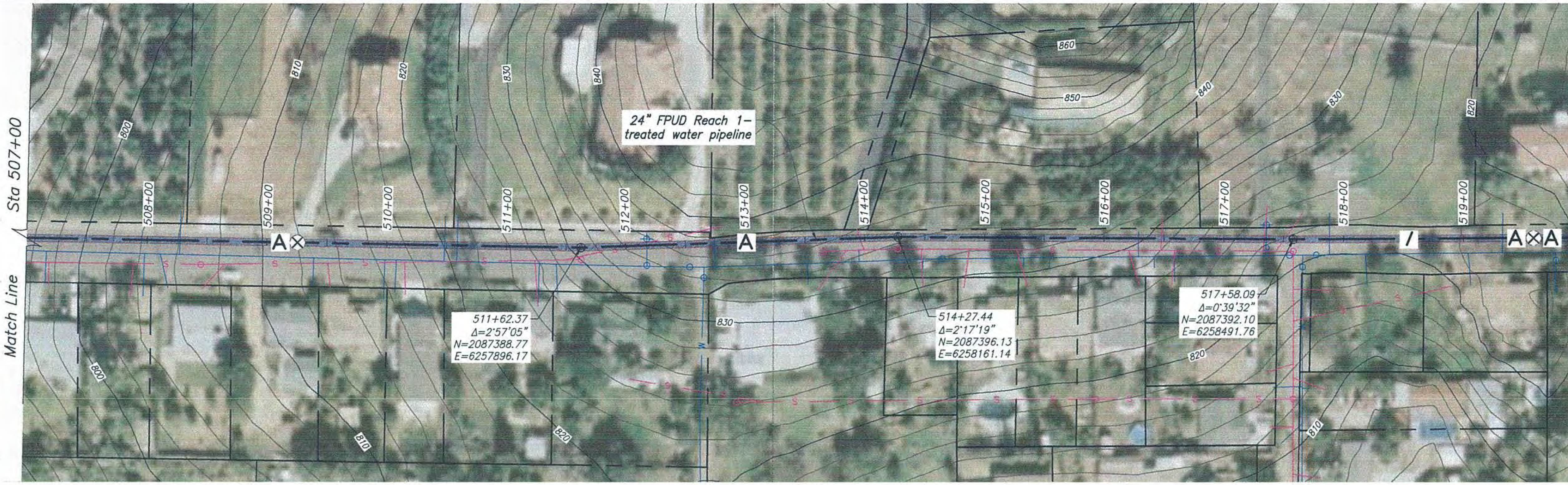

PLAN

SCALE OF FEET

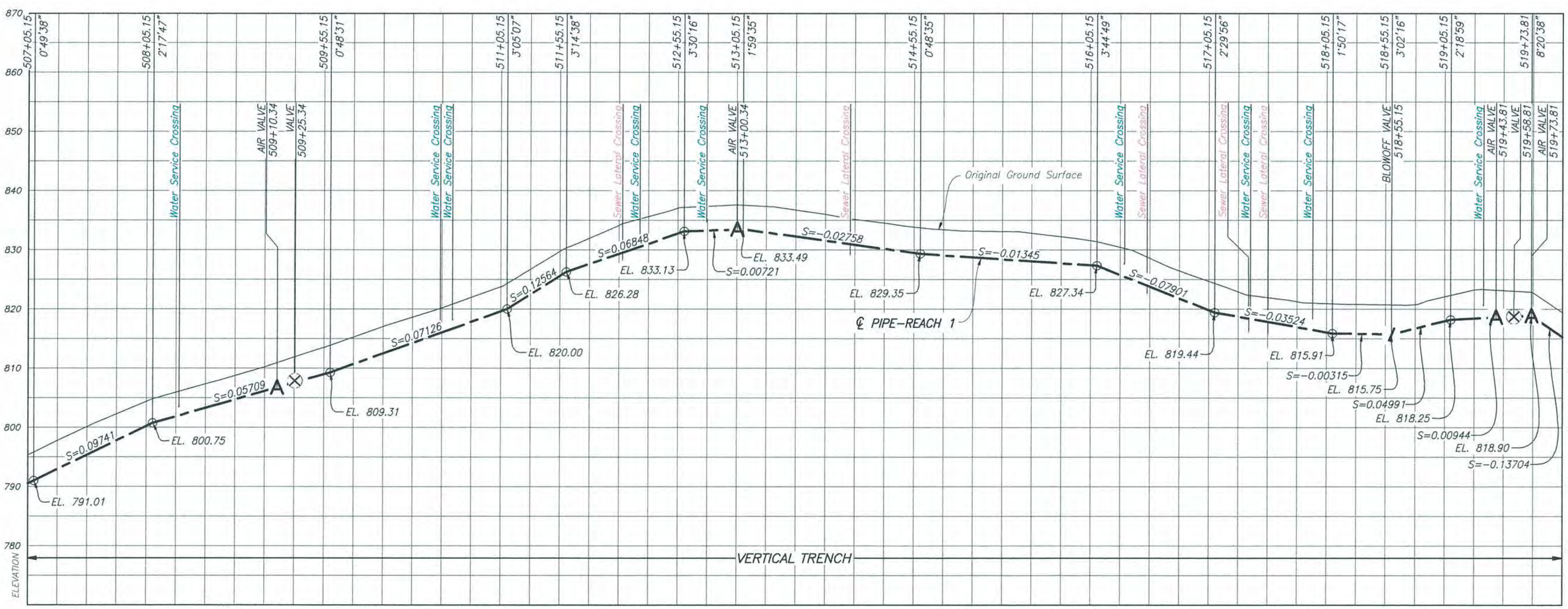

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FIGURE -13

SHEET 12 OF 32

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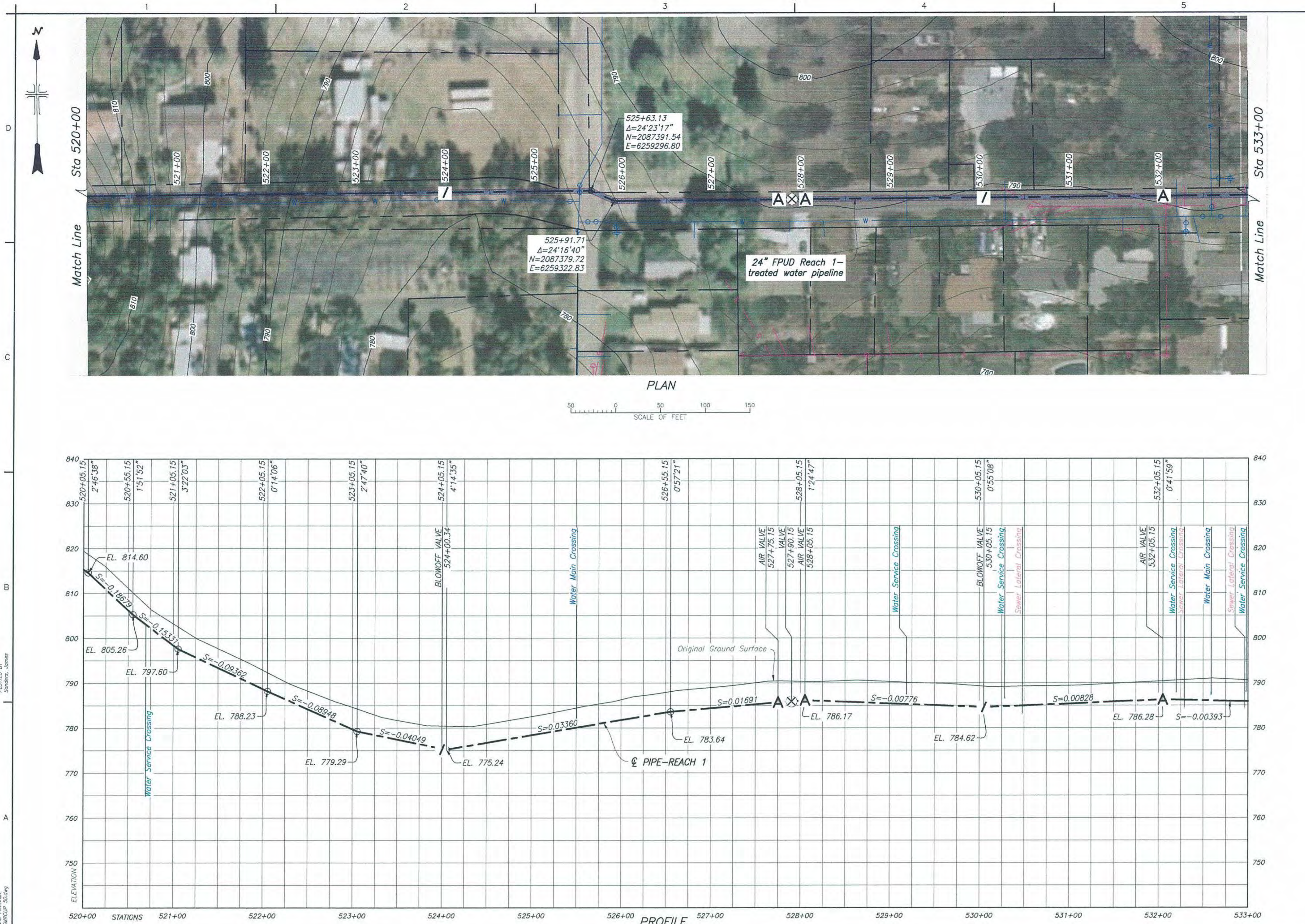

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REACH 1
520+00 TO 533+00
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FIGURE B14

SHEET 13 OF 32

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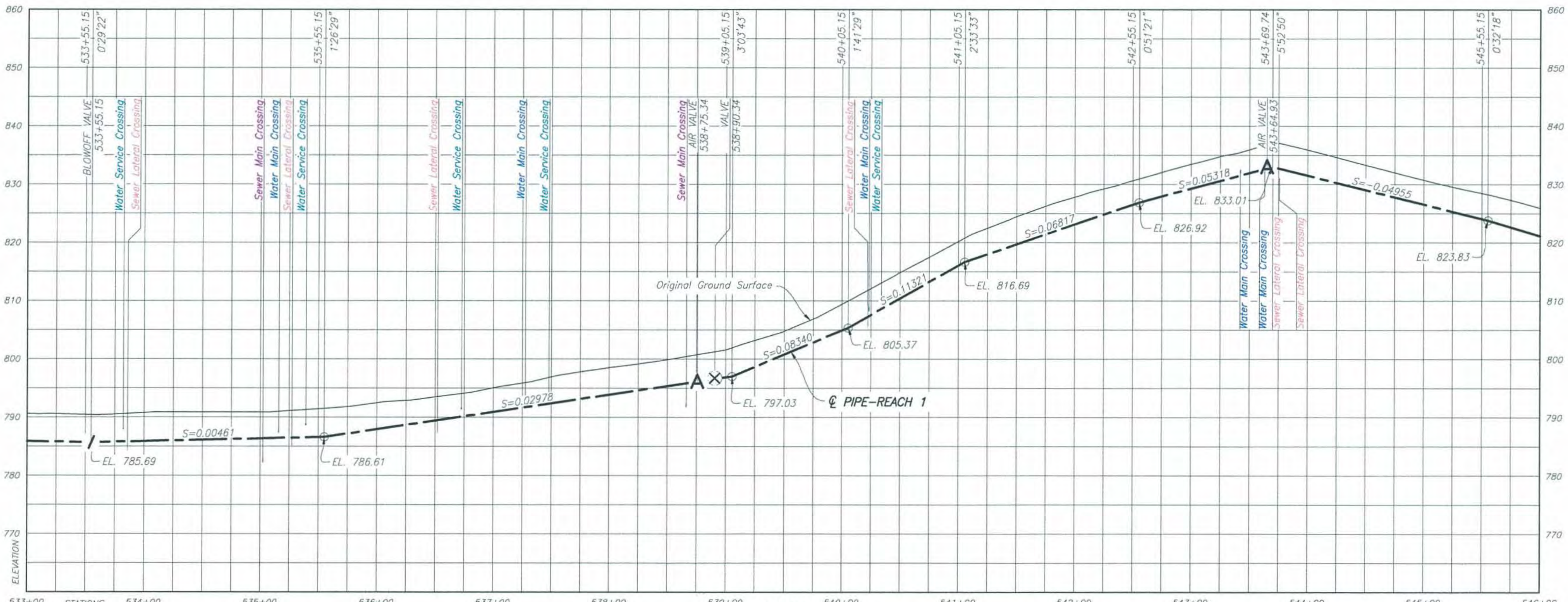
PLAN

SCALE OF FEET



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REACH 1
533+00 TO 546+00
PLAN & PROFILE

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FIGURE B15
SHEET 14 OF 32

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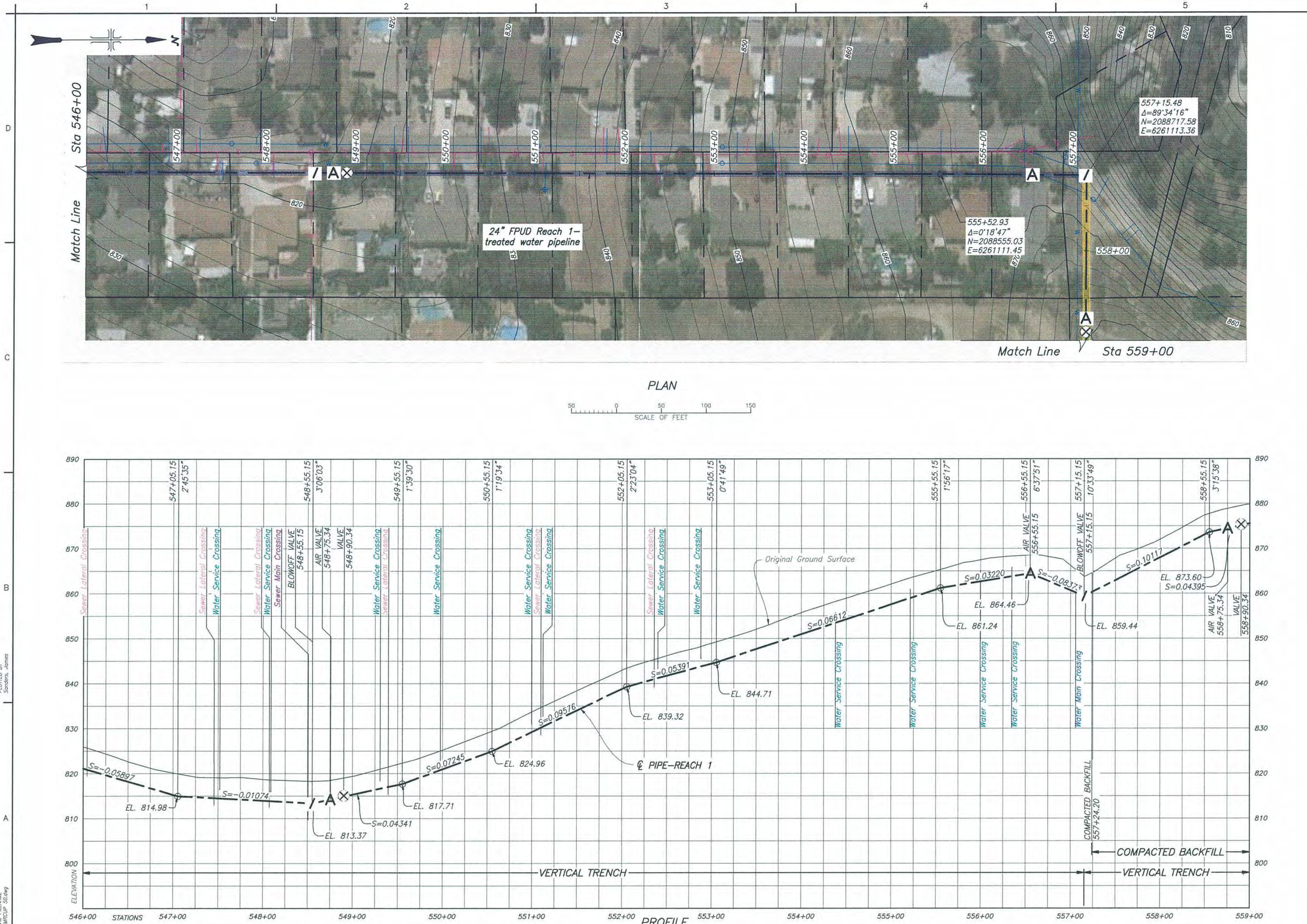
CAD FILENAME SMRCUP 30.dwg



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REACH 1
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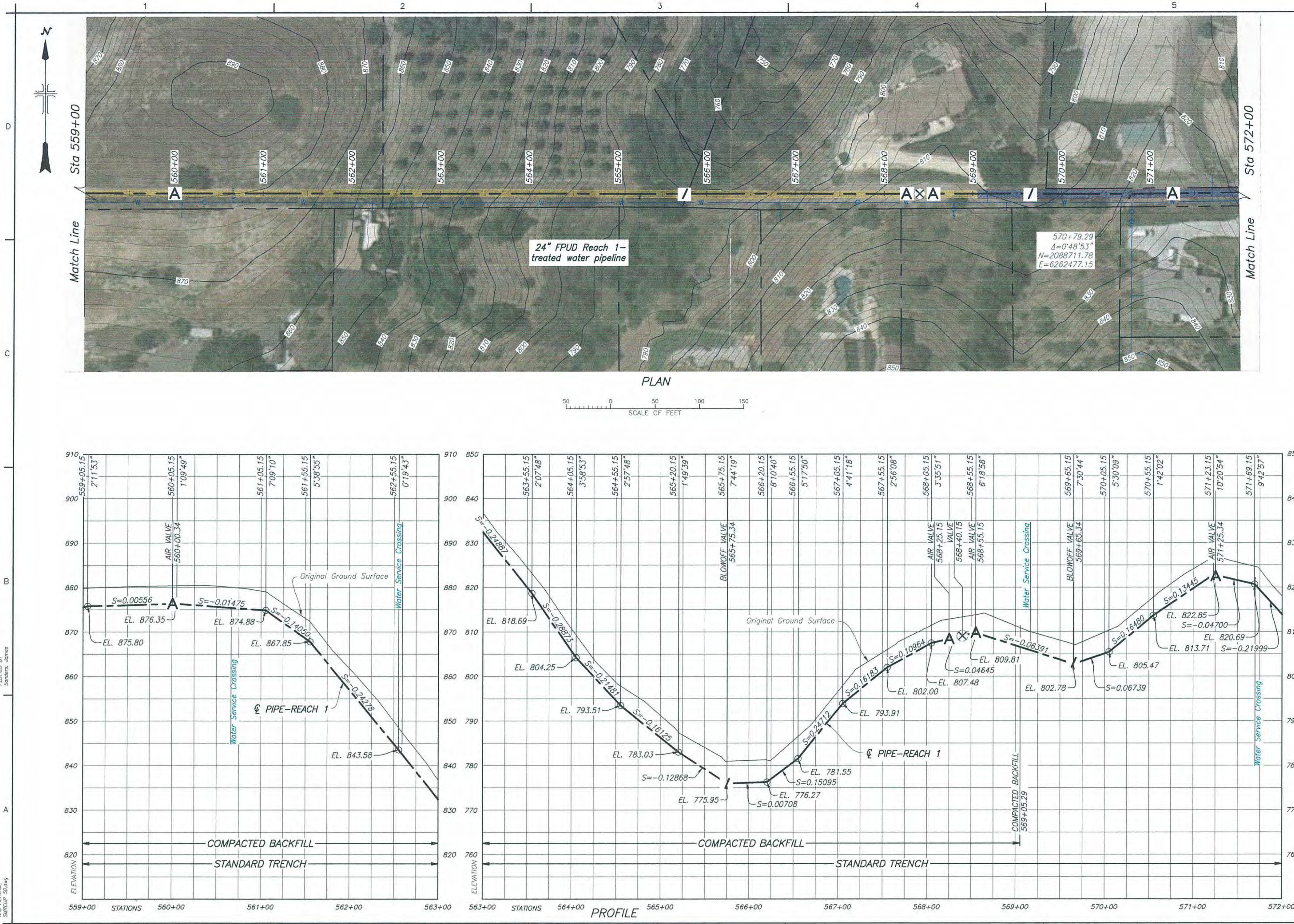
FIGURE B16
SHEET 15 OF 32



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REACH 1
559+00 TO 572+00
PLAN & PROFILE

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FIGURE B17

SHEET 16 OF 32

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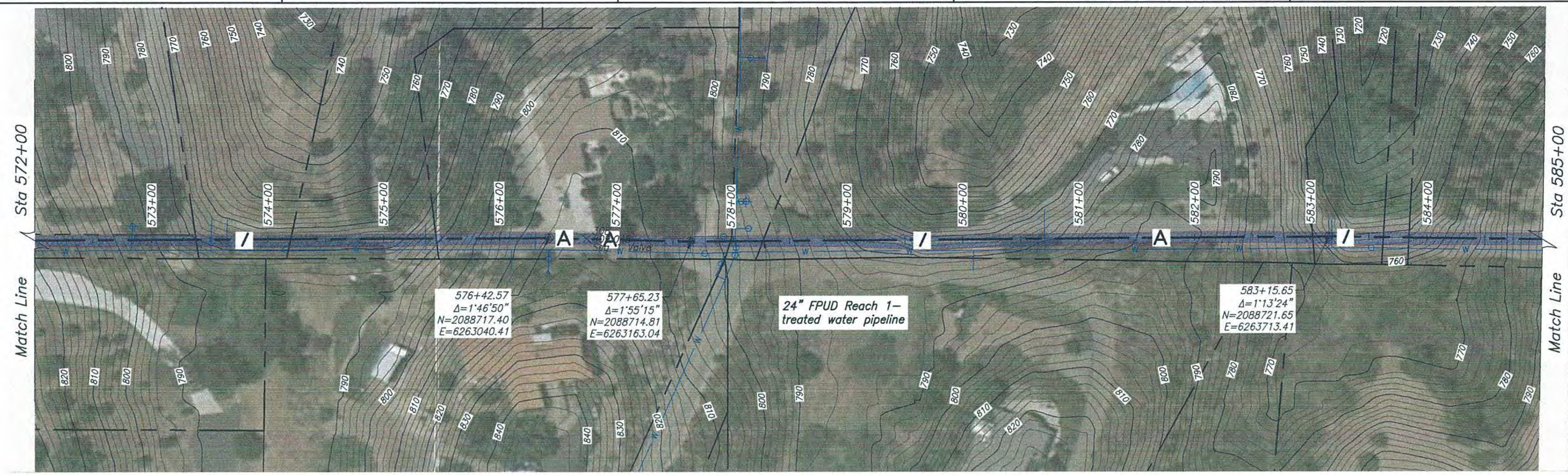
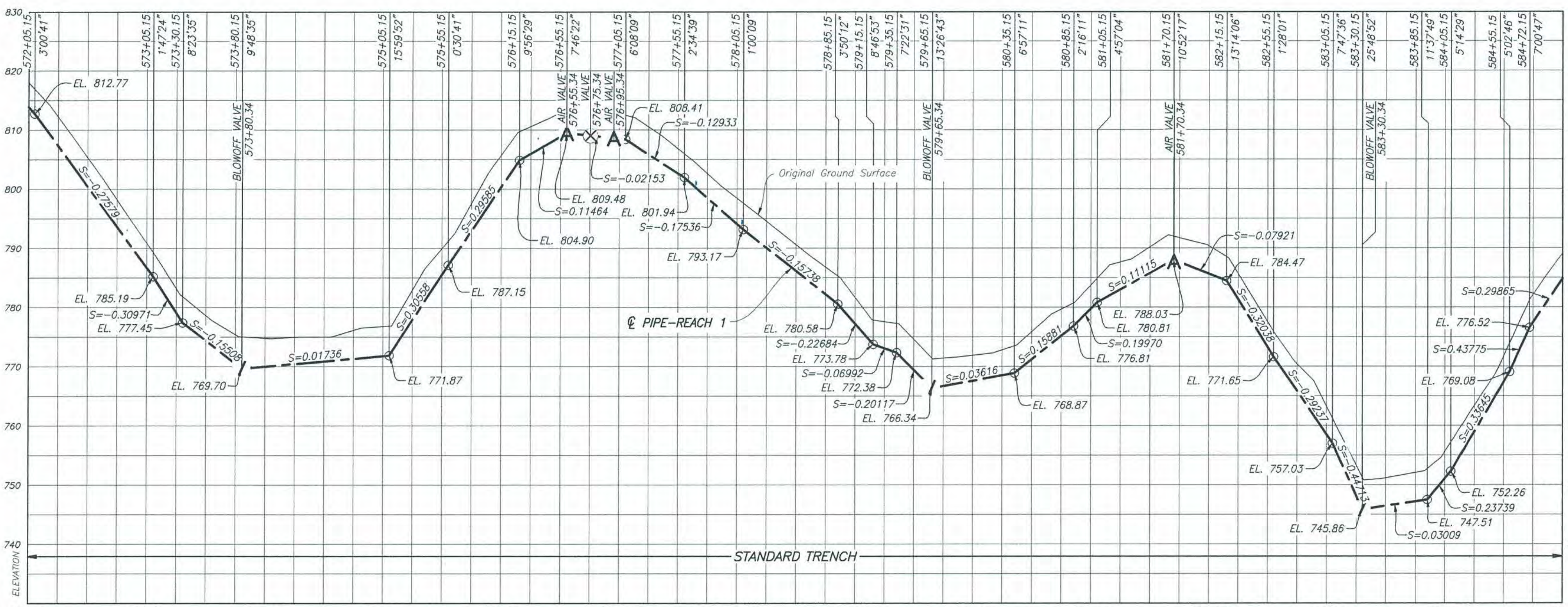


PLAN

SCALE OF FEET



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REACH 1
572+00 TO 585+00
PLAN & PROFILE

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FIGURE B18
SHEET 17 OF 32

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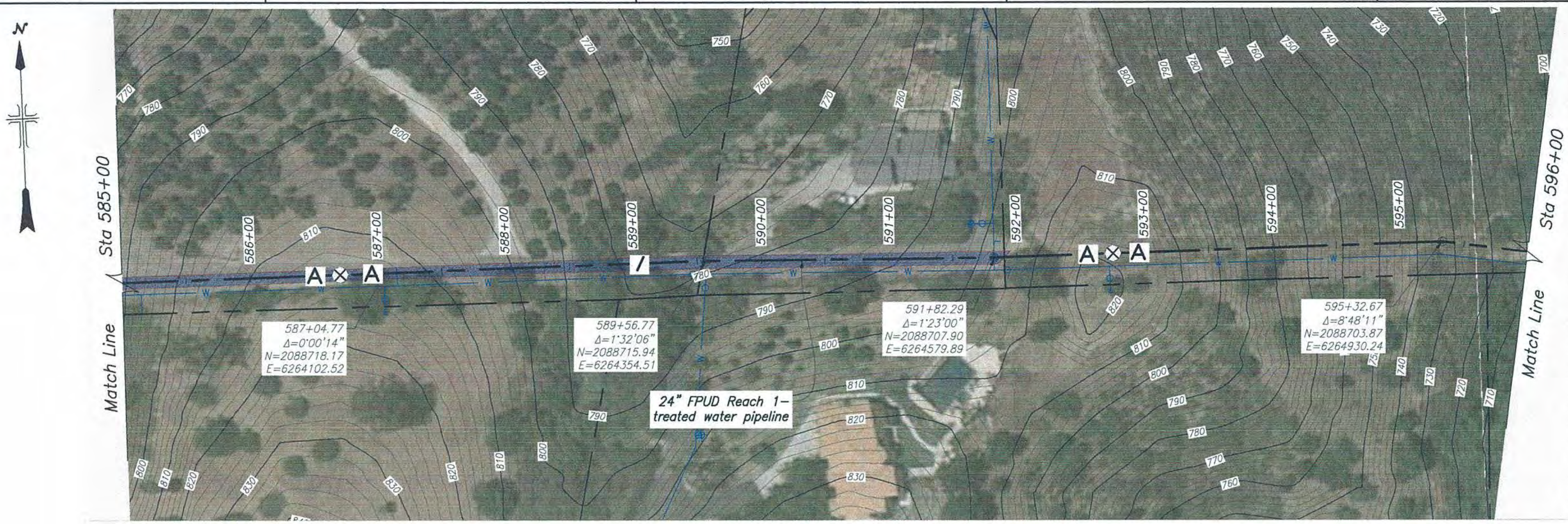
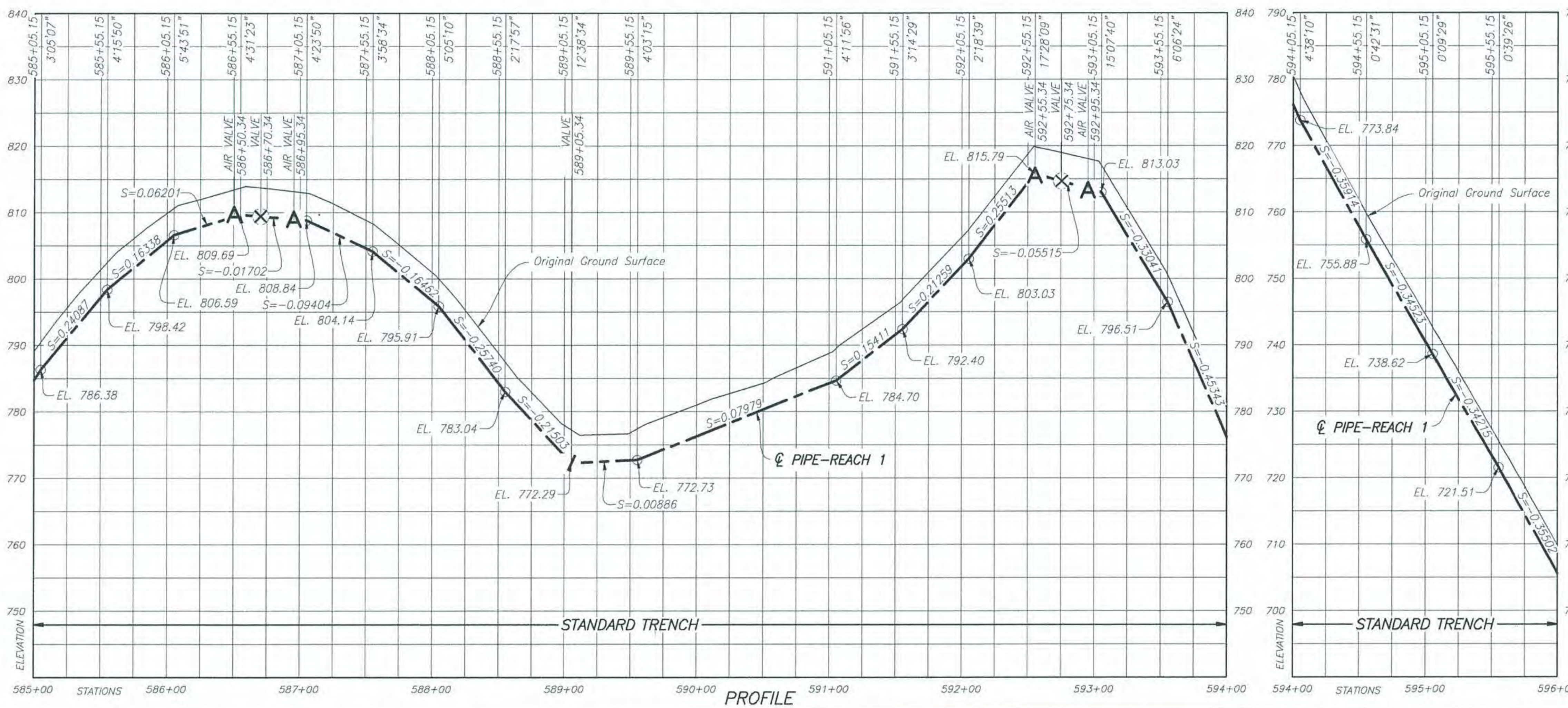


PLAN

SCALE OF FEET



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REACH 1
585+00 TO 596+00
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FIGURE B19

SHEET 18 OF 32

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CAD FILENAME SMRCUP 50.dwg

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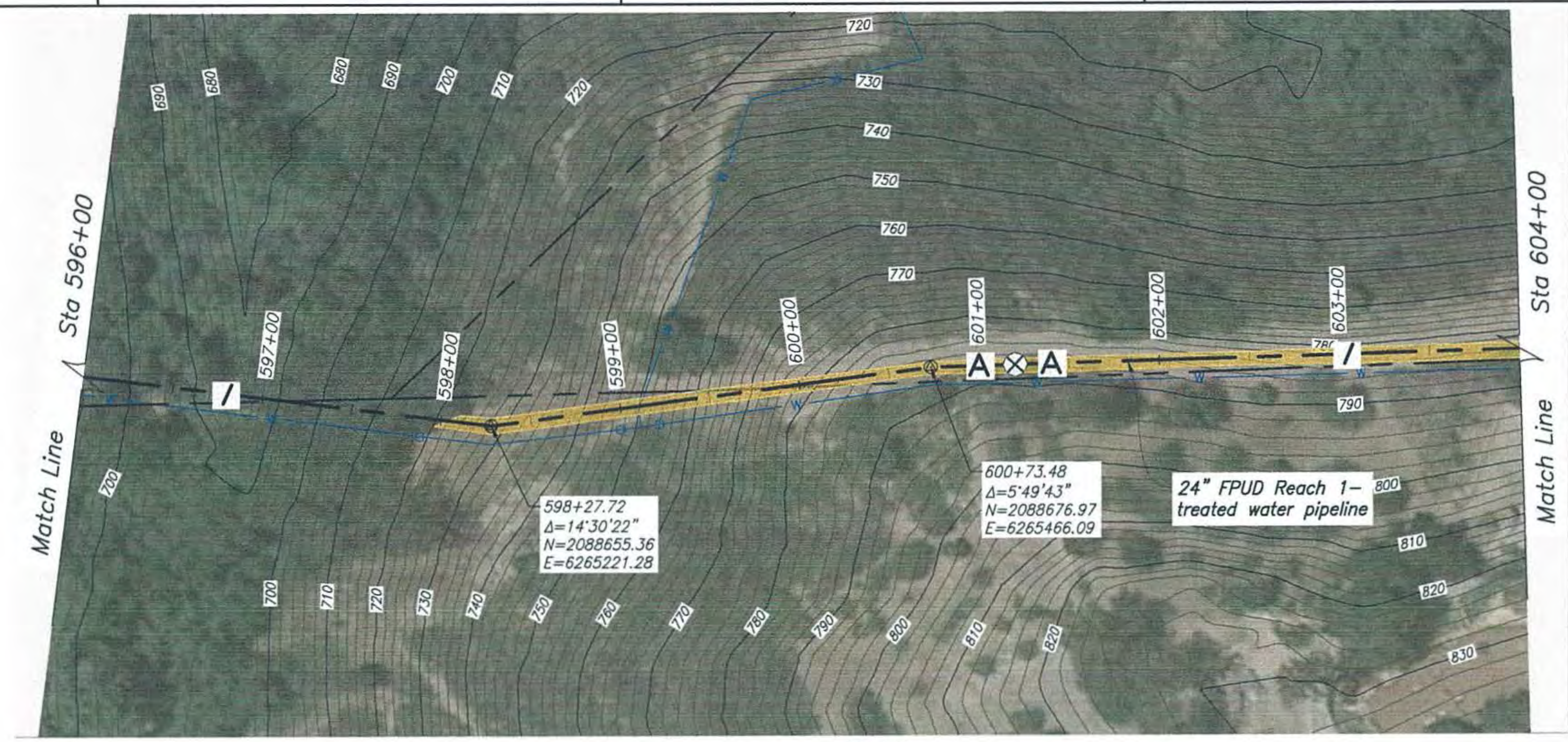
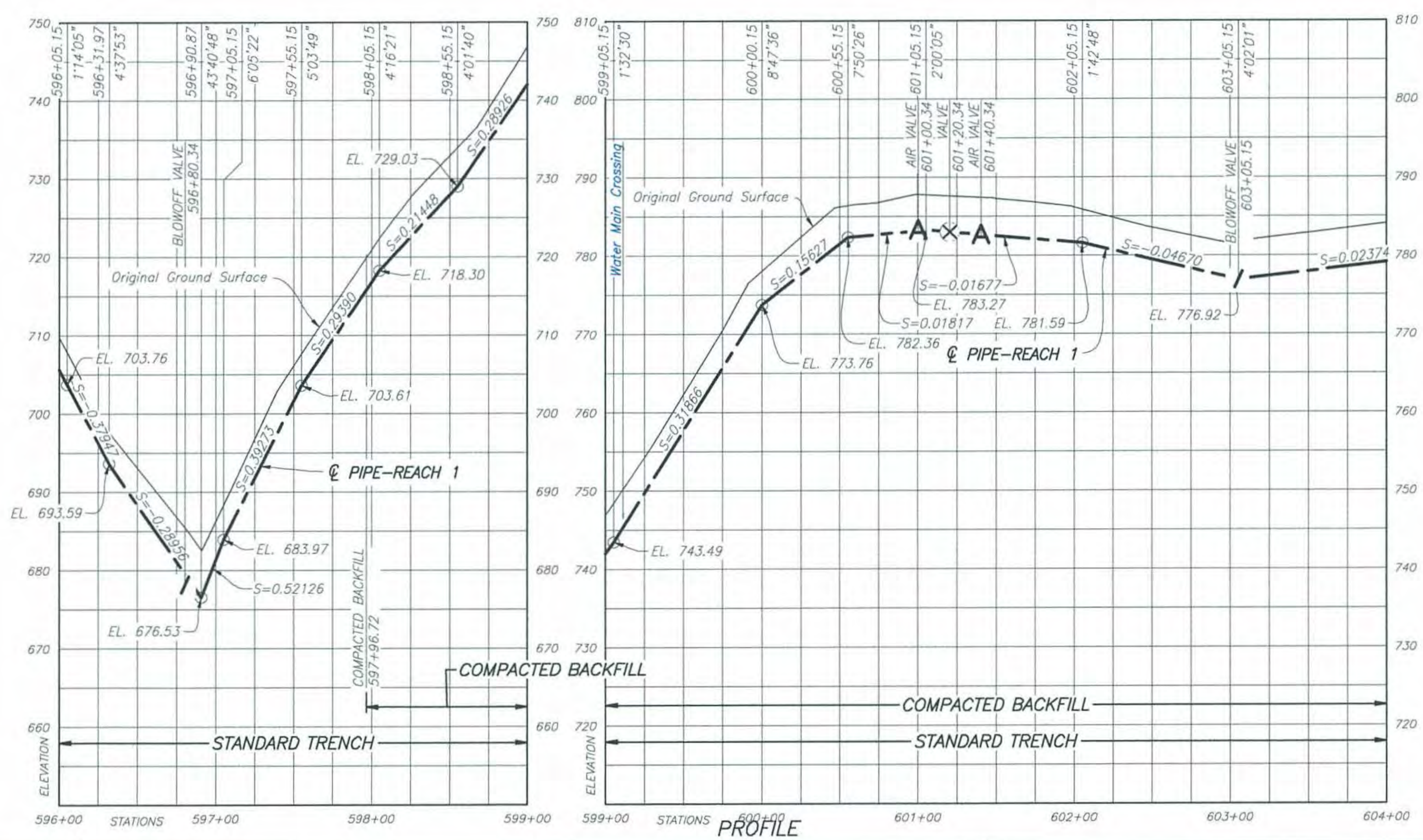


PLAN

50 0 50 100 150
SCALE OF FEET



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REACH 1
596+00 TO 604+00
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FIGURE B20

SHEET 19 OF 32

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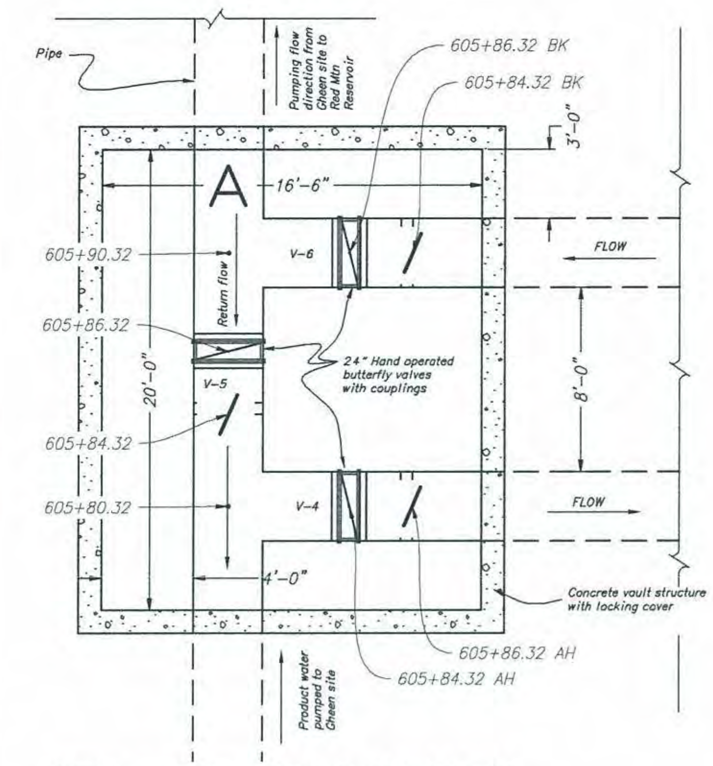
PLAN



DETAIL – VALVE VAULT PI STA 605+85

VALVE OPERATIONS TABLE

Valve	Normal flow	Return flow*
V-4	Open	Closed
V-5	Closed	Open
V-6	Open	Closed

* Return flow valve operations to be coordinated with Camp Pendleton

NOTES

1. For the normal pumping case, valves V-4 and V-6 would be open and the main line valve V-5 would be closed. For the emergency bypass return case, these will change as shown on the table. Pressure reduction and return flow control to Camp Pendleton's system will be coordinated with the base.

2. Sectionalizing isolation valves outside vault are not shown. Air valves and drains are not shown either.

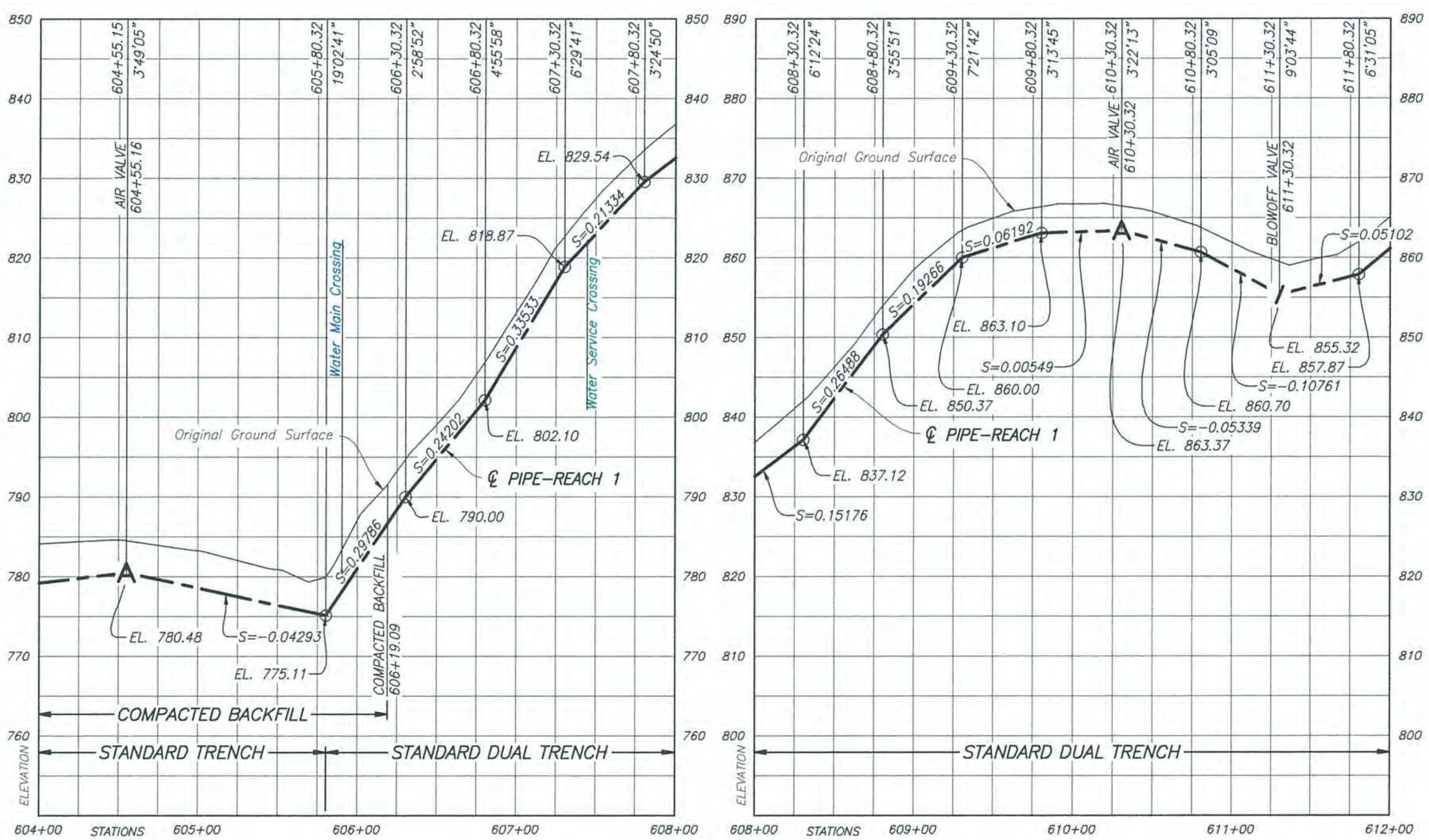


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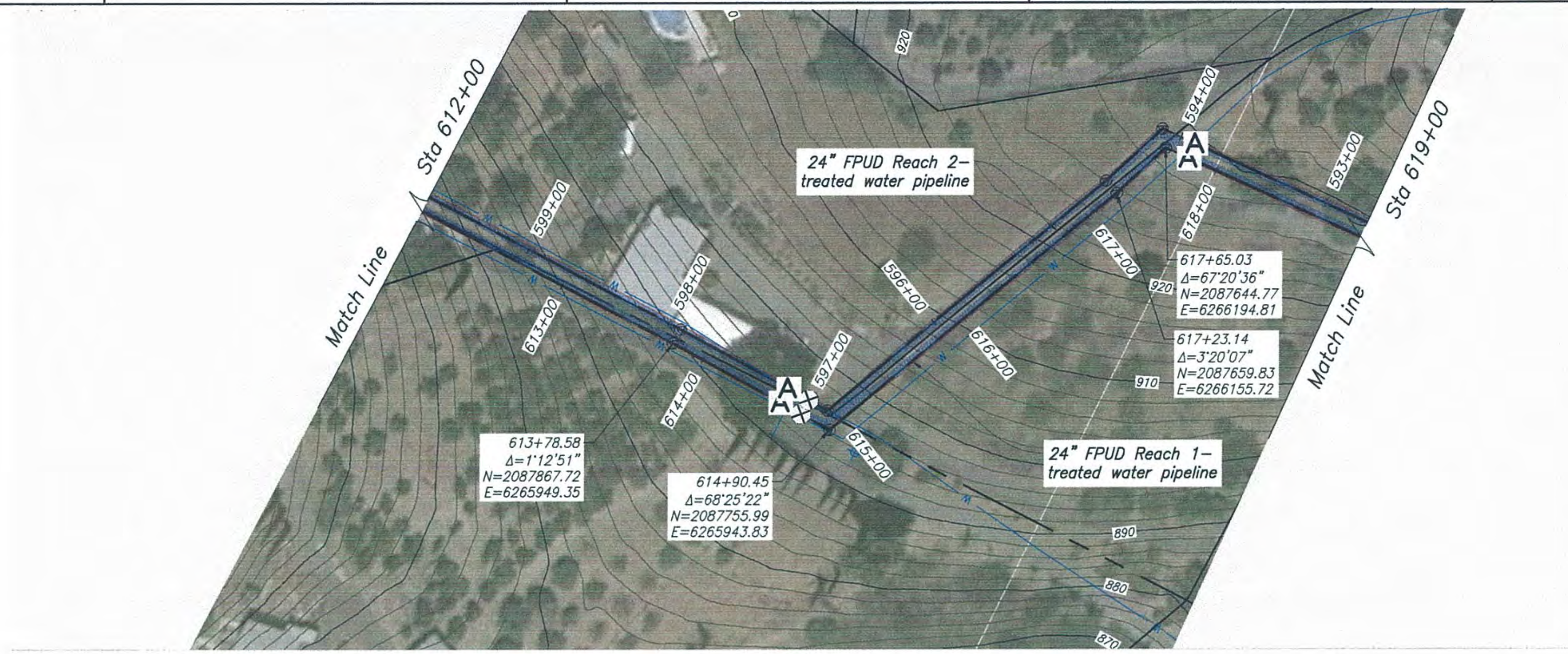
FIGURE B21
SHEET 20 OF 32



PLAN

SCALE OF FEET

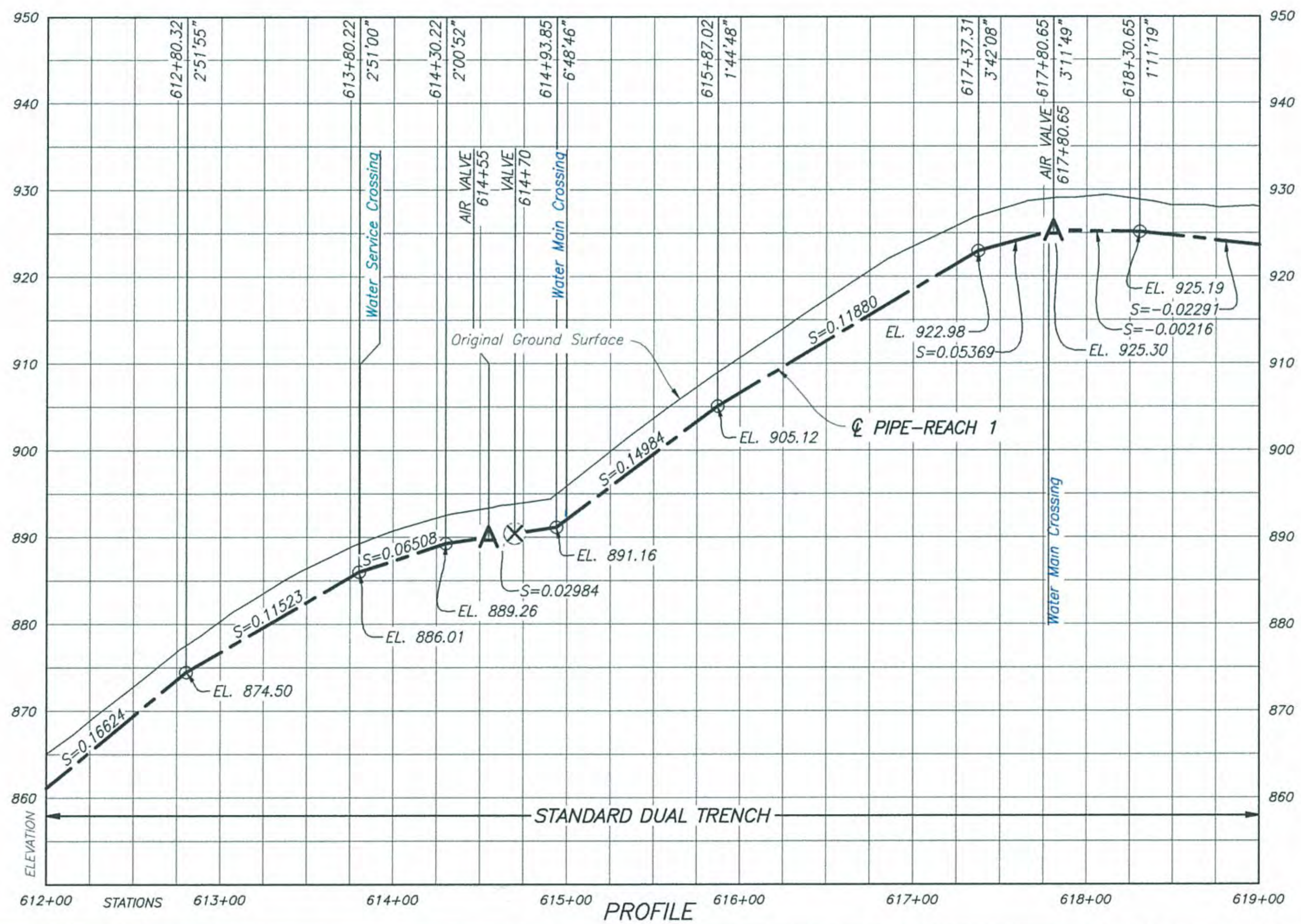


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FIGURE B22

SHEET 21 OF 32

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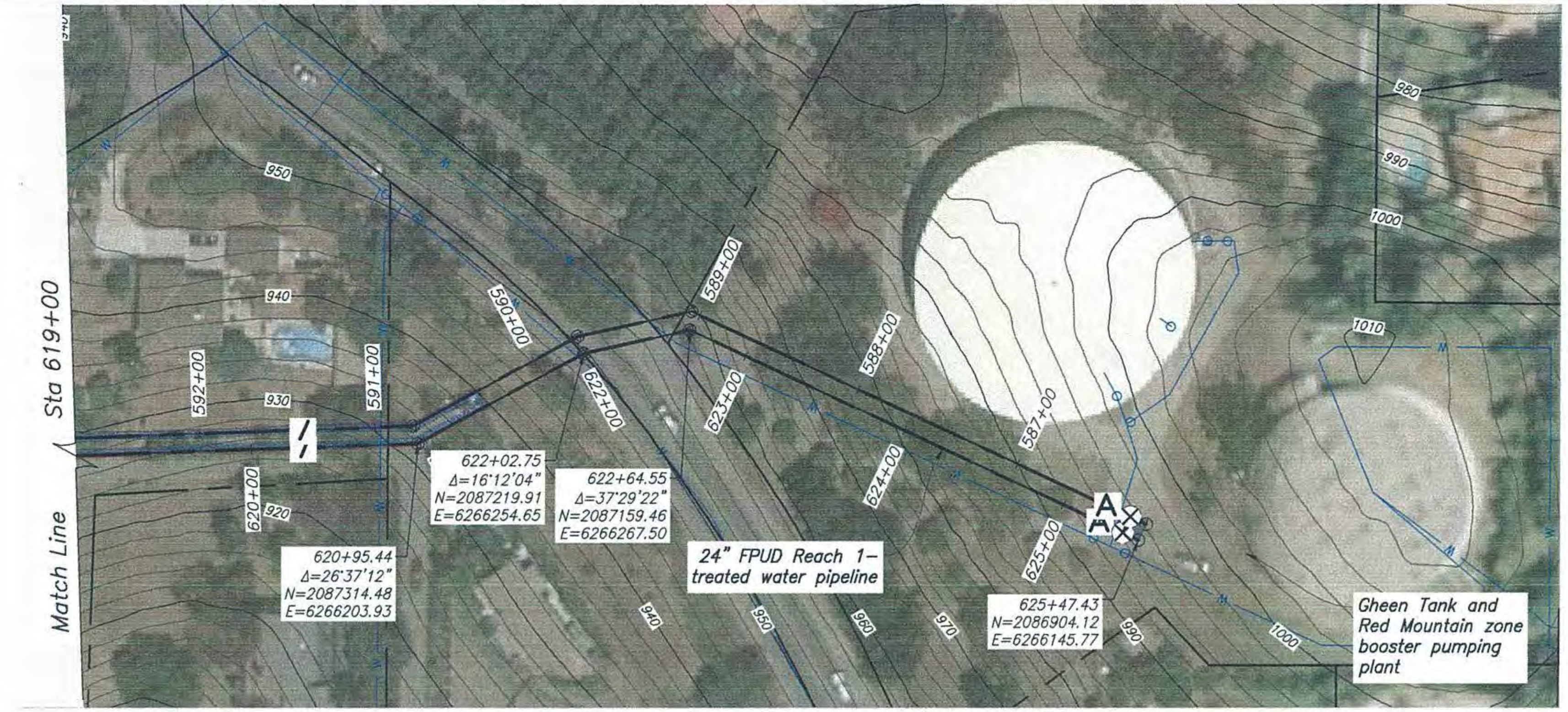


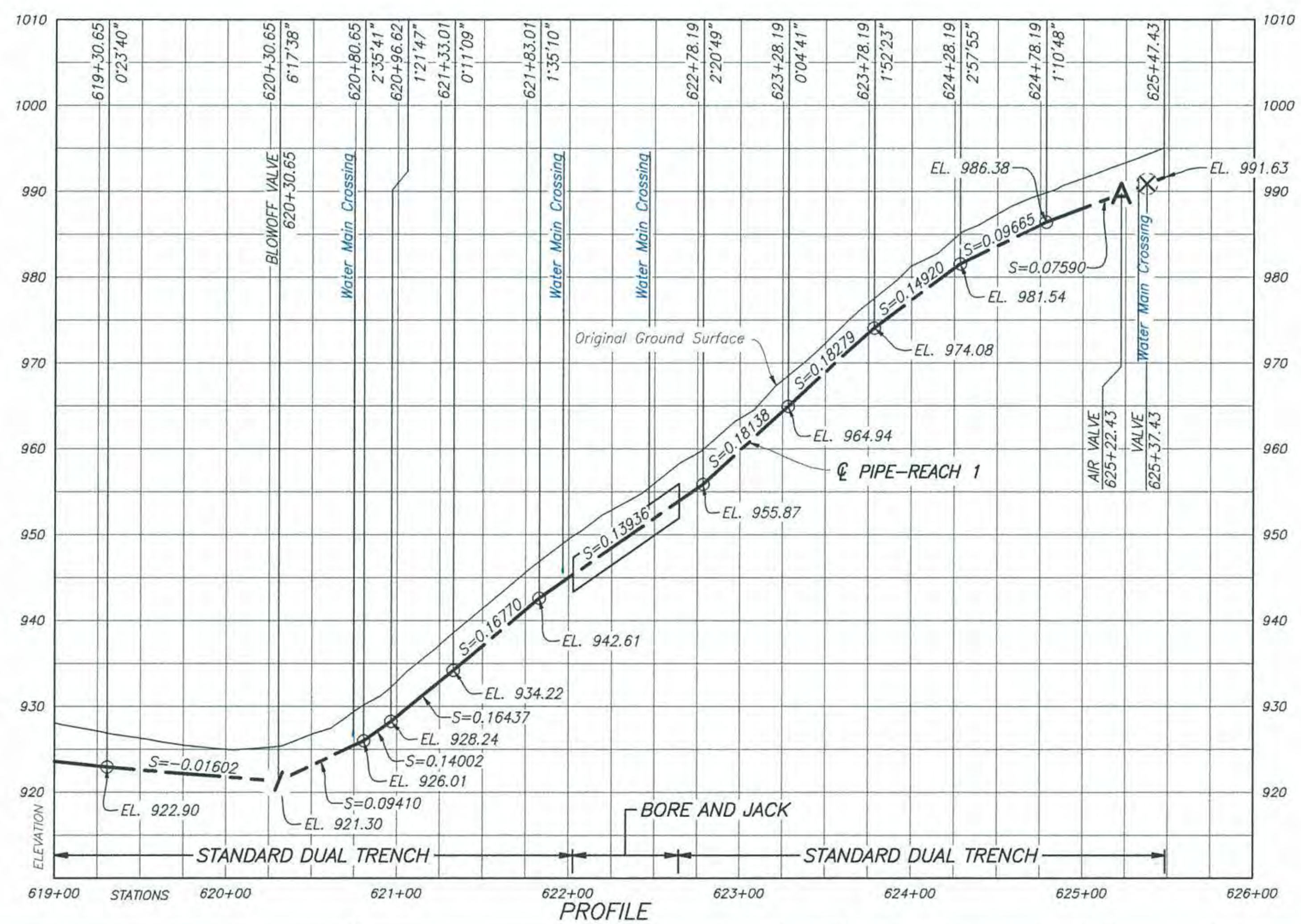
PLAN

SCALE OF FEET

BOOSTER PP DATA

Q,(cfs)	12.4
HEAD LIFT, (ft)	103*

* Approximate static lift



PROFILE

NOTES

1. Reach 1 end from tee. Tank static HGL 1037'
2. Reach 2 begin to tee, Reservoir static HGL 1140.

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REACH 1
619+00 TO 625+47.43
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FIGURE B23
SHEET 22 OF 32

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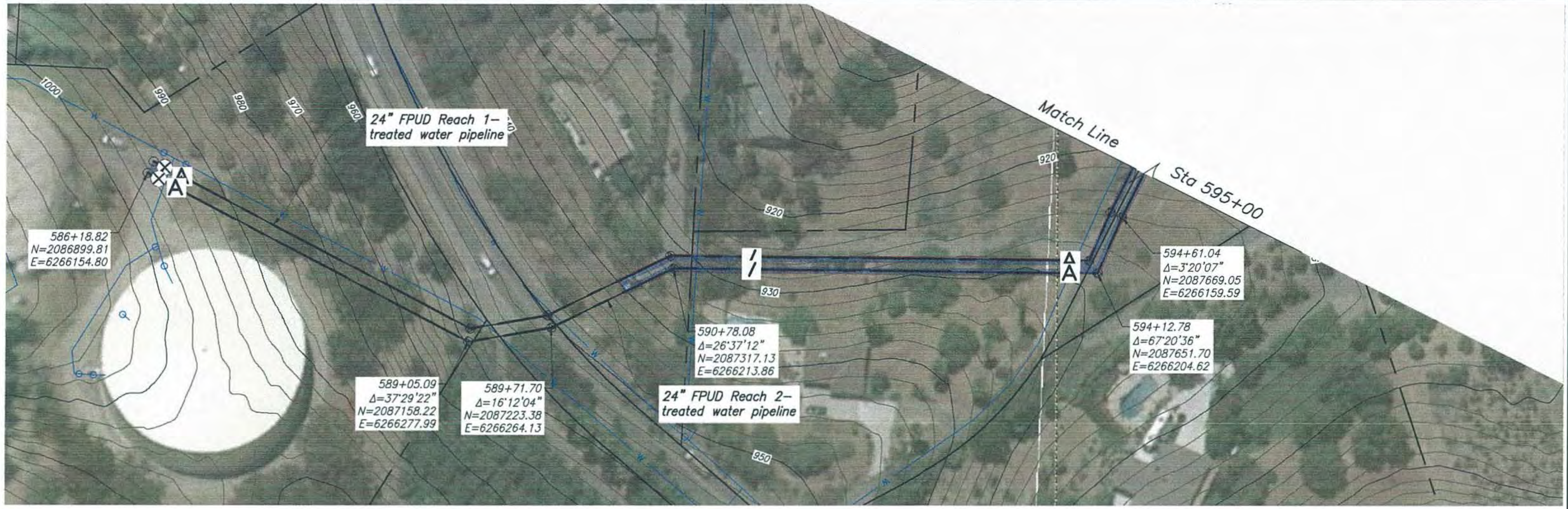
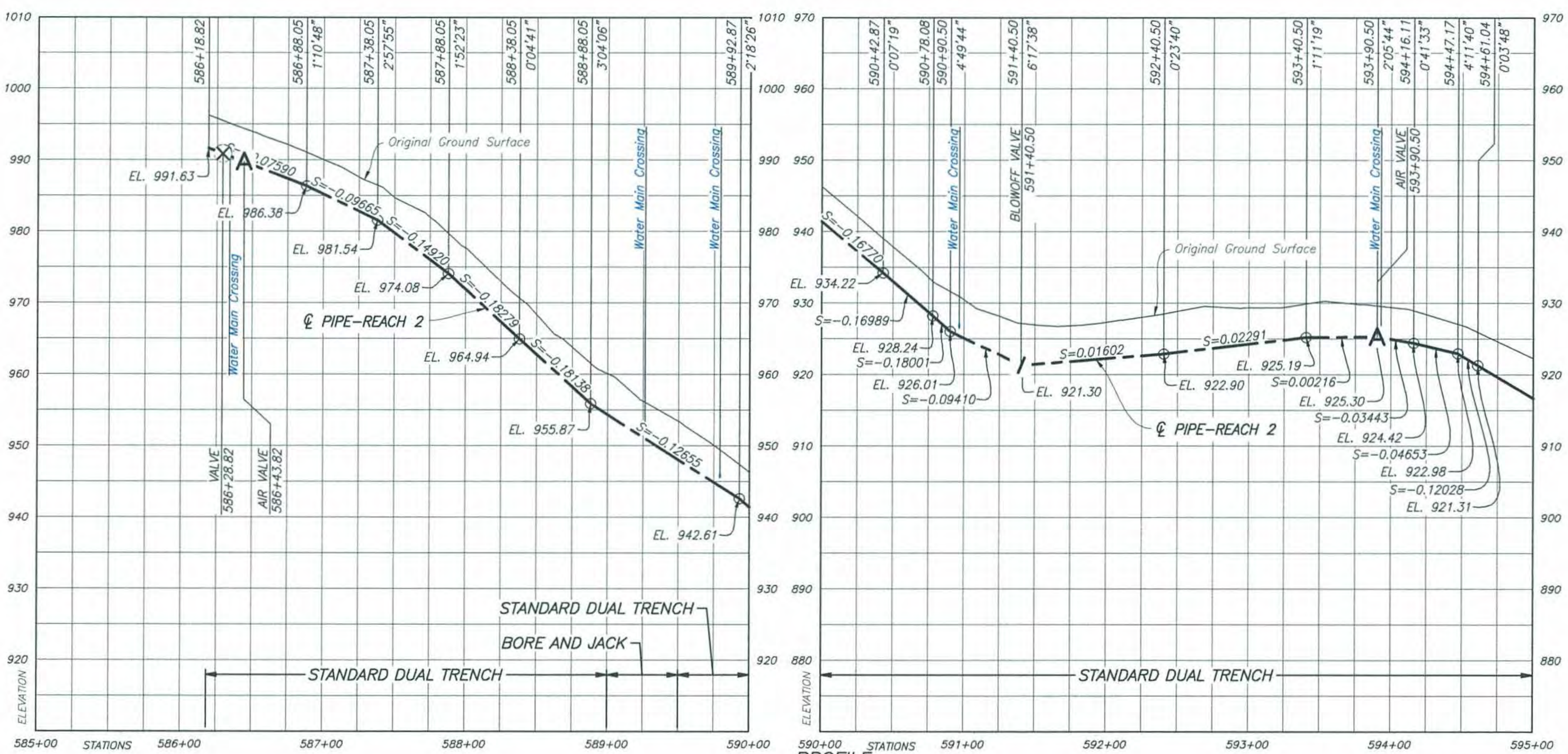


PLAN

SCALE OF FEET



PROFILE

NOTES

1. Reach 1 end from tee. Tank static HGL 1037'
2. Reach 2 begin to tee, Reseervoir static HGL 1140.

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FPUD PRODUCT TRANSMISSION PIPELINE
REACH 2
586+18.82 TO 595+00
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FIGURE B24

SHEET 23 OF 32

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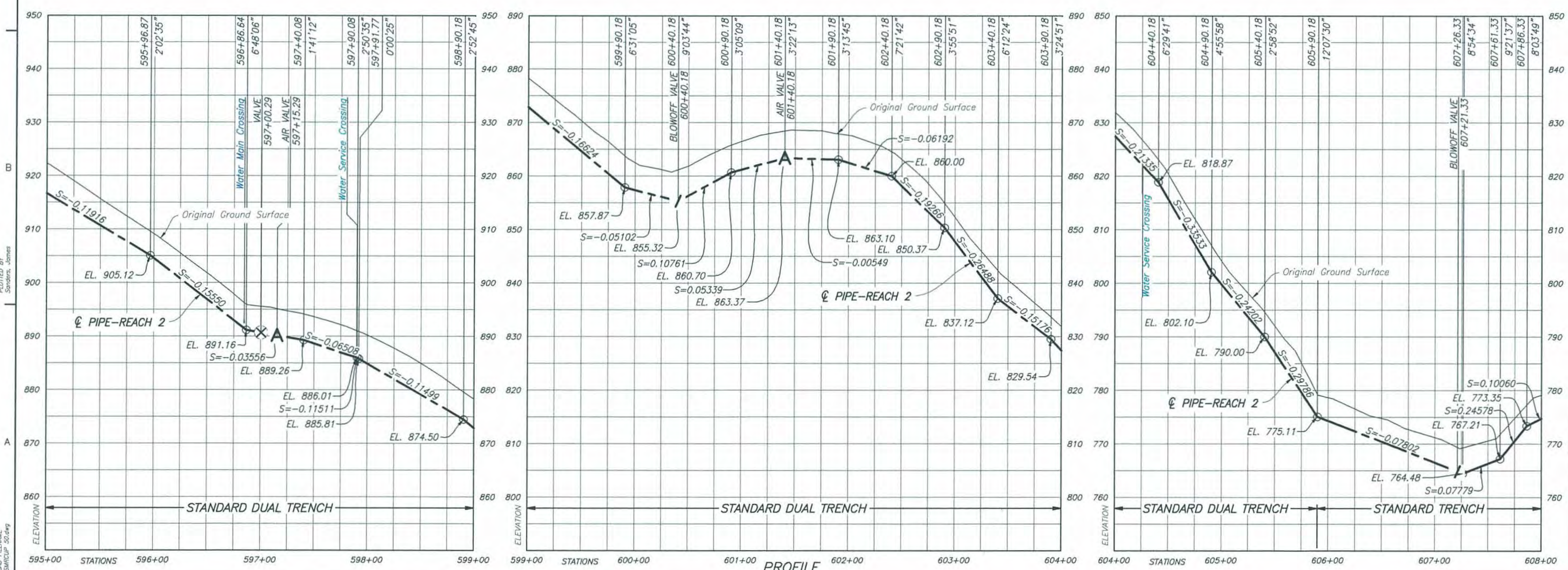

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REACH 2
595+00 TO 608+00
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FIGURE B25
SHEET 24 OF 32

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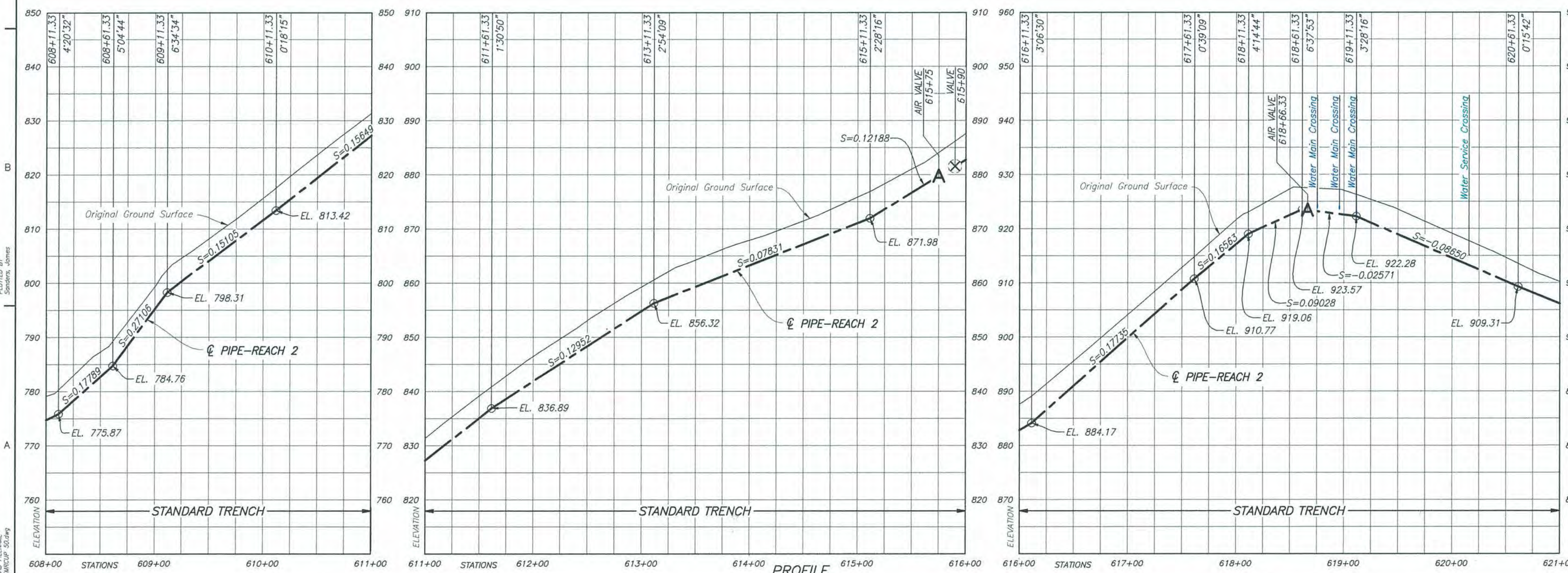
CAD FILENAME SMRCUP 50.dwg



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REACH 2
608+00 TO 621+00
PLAN & PROFILE

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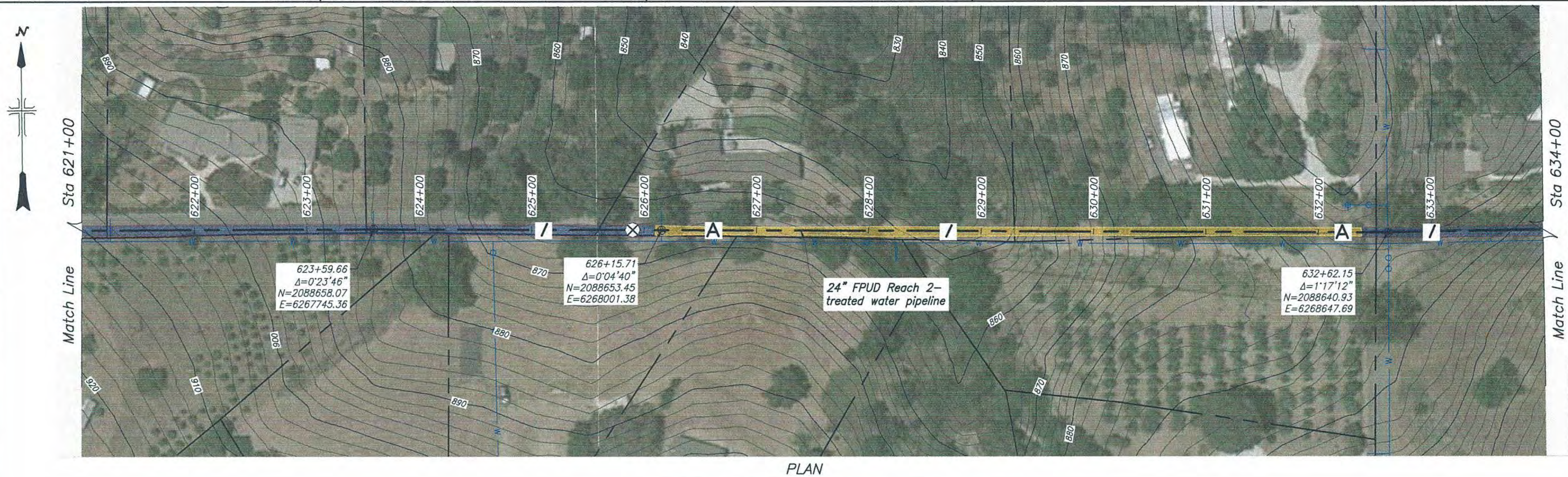
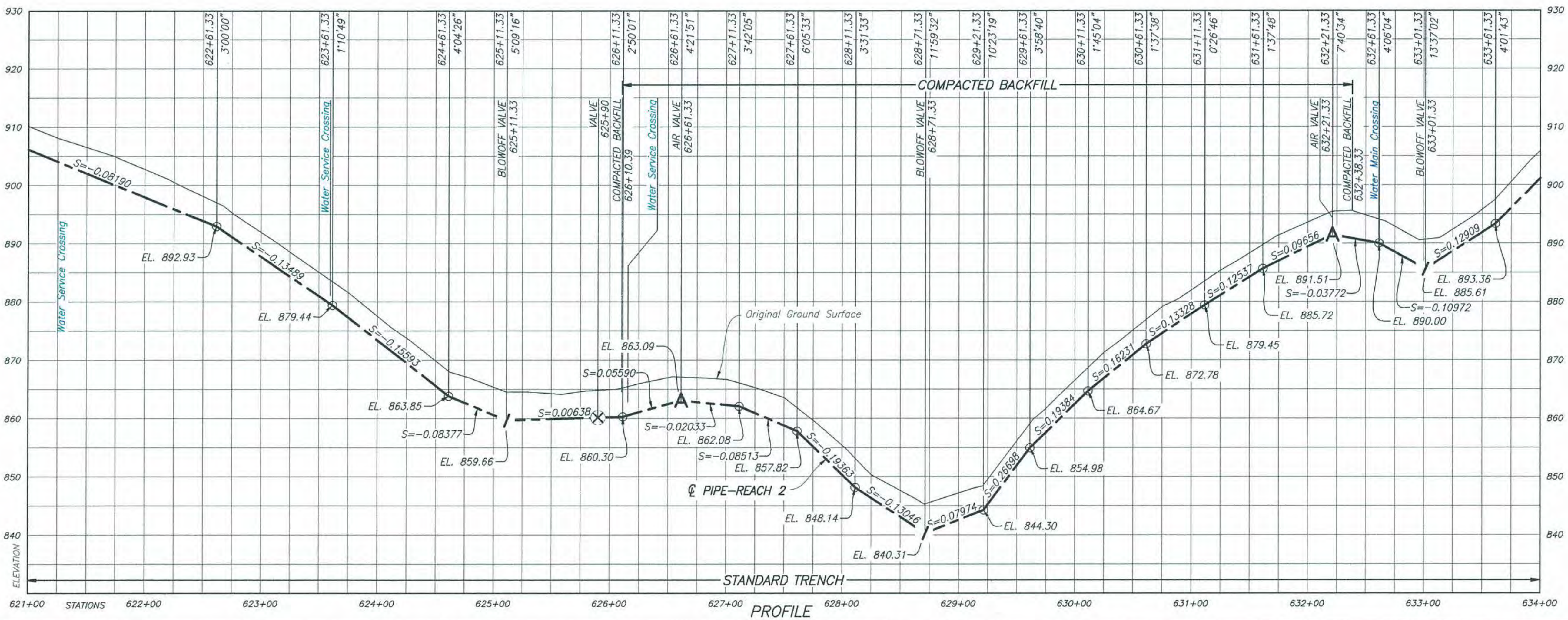
FIGURE B26

SHEET 25 OF 32





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CAD FILENAME SMRCUP 50.dwg

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REACH 2
621+00 TO 634+00
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FIGURE B27

SHEET 26 OF 32

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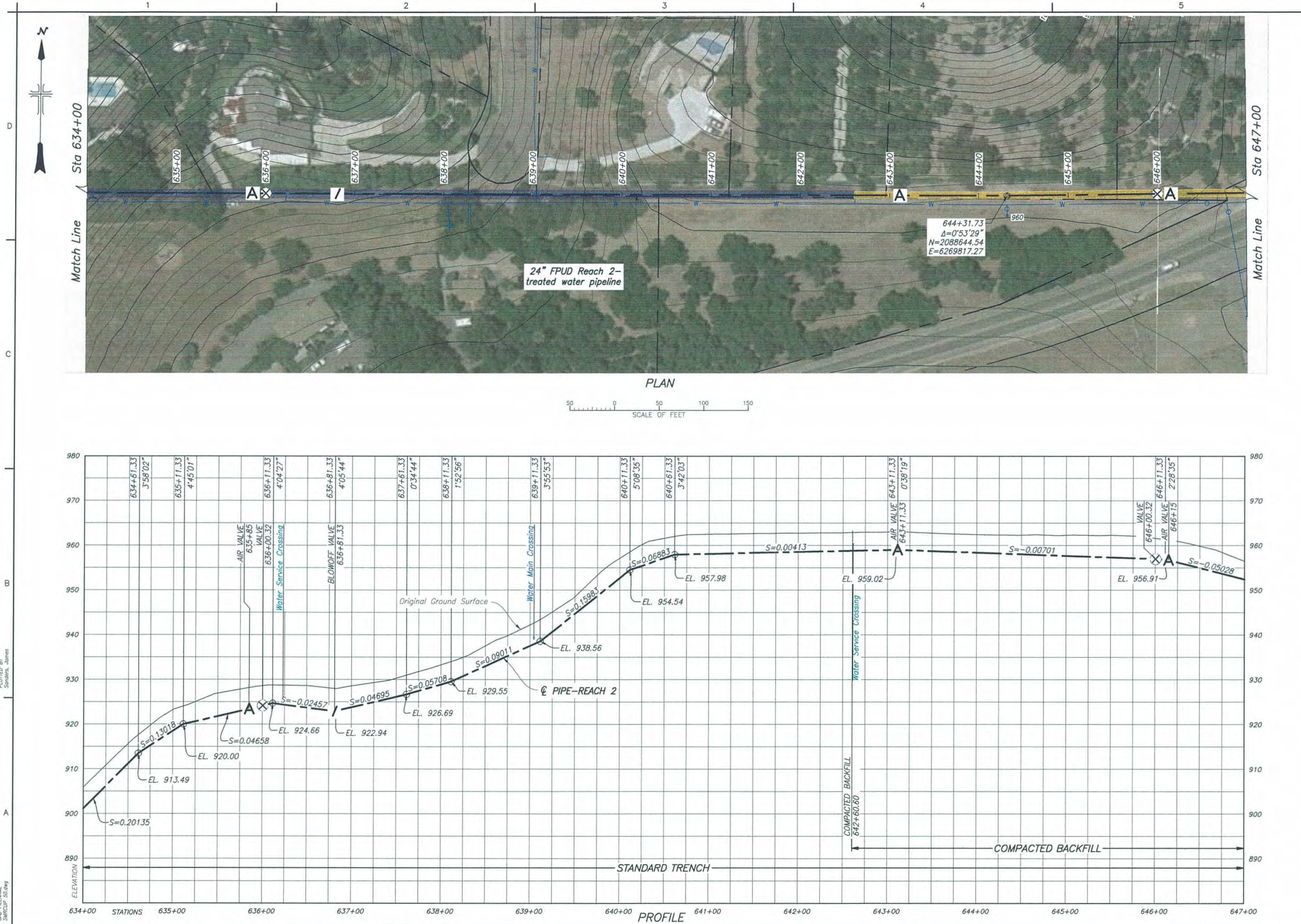

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REACH 2
634+00 TO 647+00
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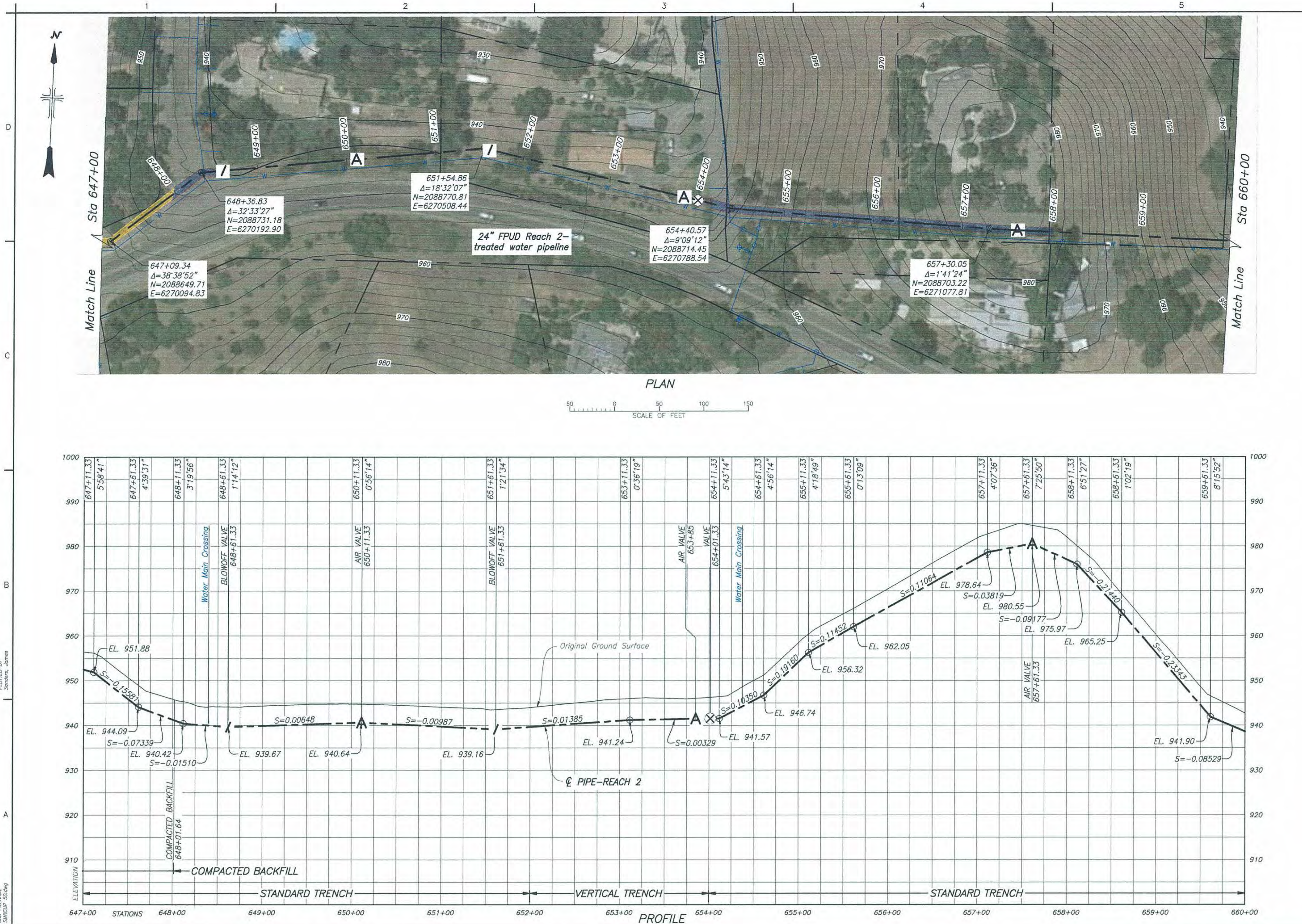
FIGURE B28
SHEET 27 OF 32



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Managing Water in the West

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SANTA MARGARITA RIVER – CALIFORNIA
2010 FEASIBILITY STUDY CONCEPT

SANTA MARGARITA RIVER CONJUNCTIVE USE PROJECT STUDY
FPUD PRODUCT TRANSMISSION PIPELINE
REACH 2
647+00 TO 660+00
PLAN & PROFILE

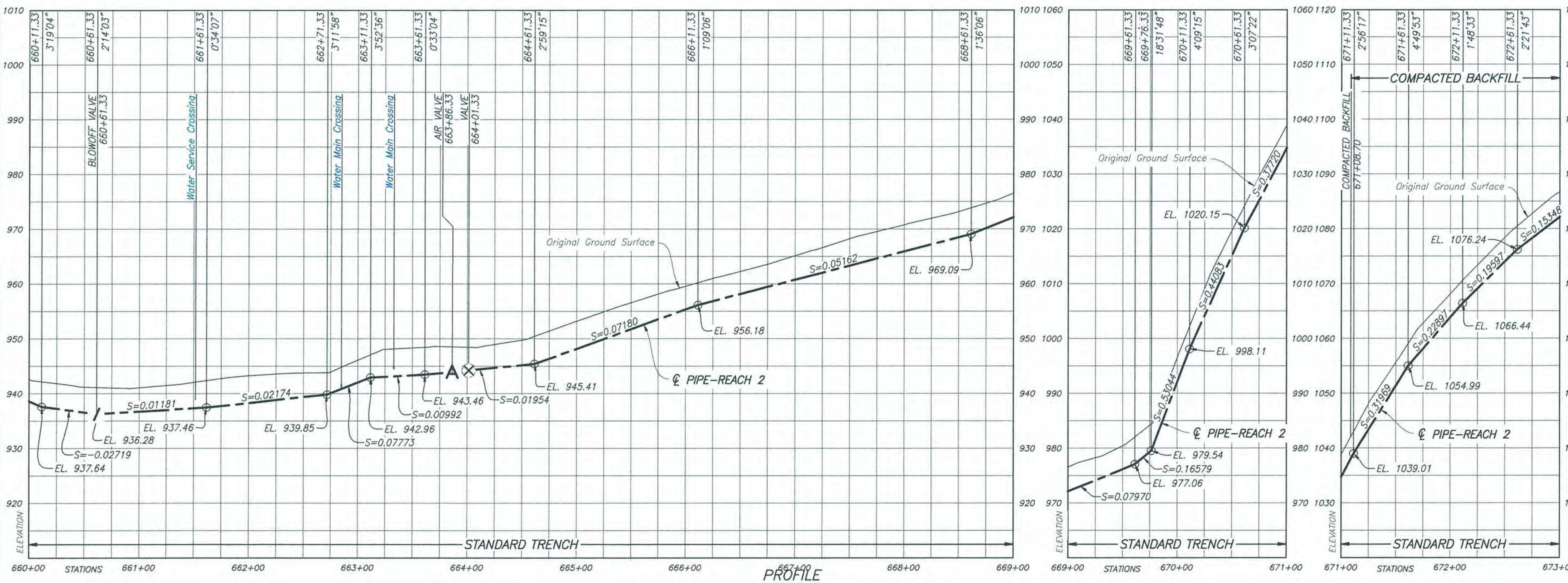
DESIGNED BY
REVIEWED BY

DENVER, CO 08-30-13

FIGURE B29
SHEET 28 OF 32

PLAN

SCALE OF FEET



PROFILE

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FPUD PRODUCT TRANSMISSION PIPELINE
REACH 2
660+00 TO 673+00
PLAN & PROFILE

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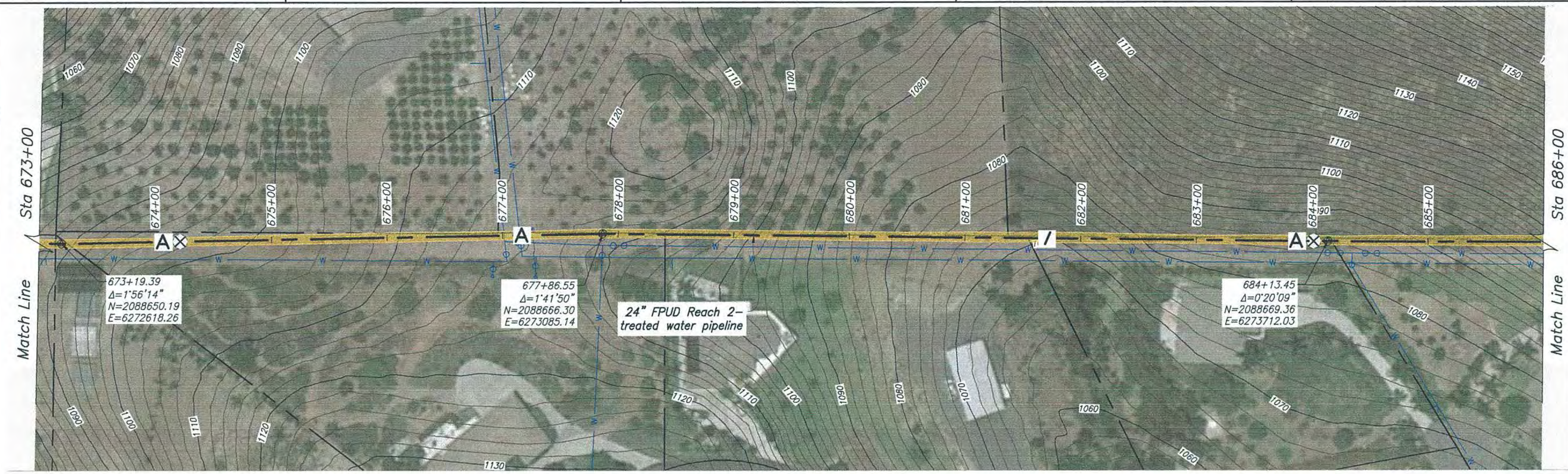
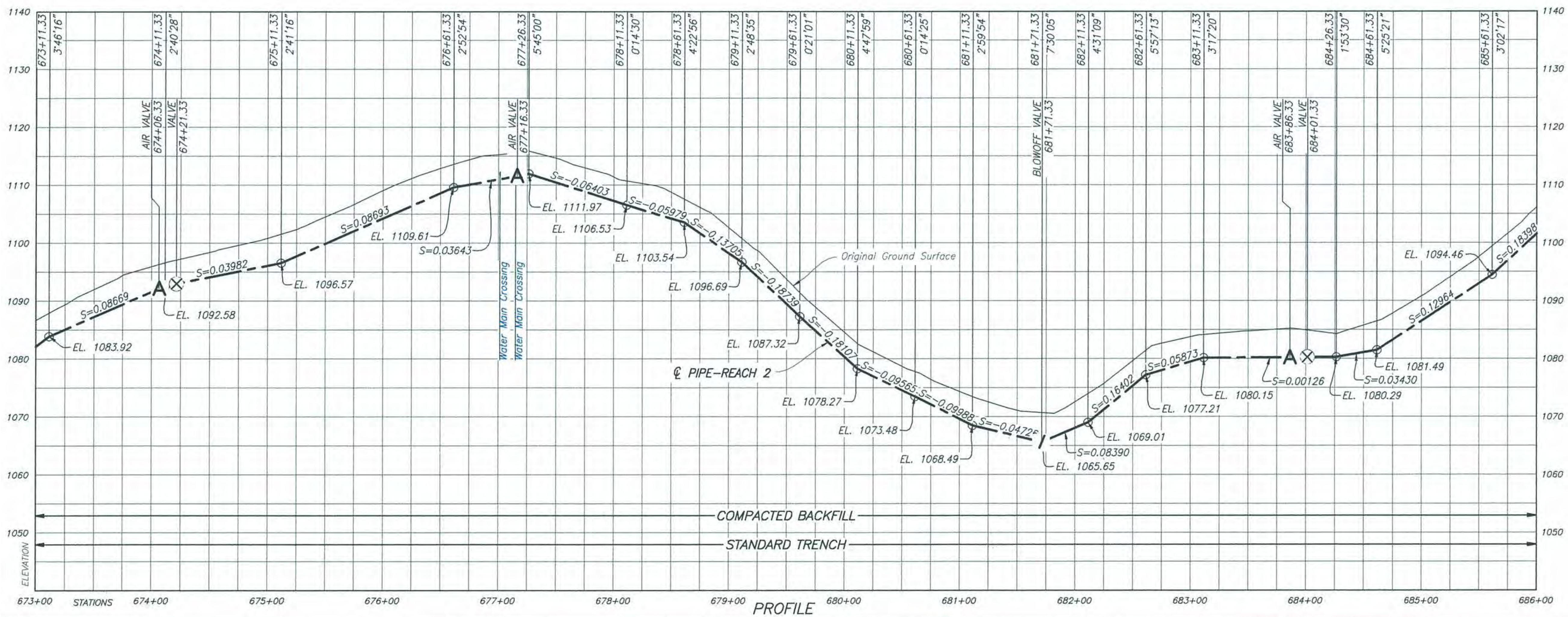
FIGURE B30
SHEET 29 OF 32

DATE AND TIME PLOTTED 9/26/2013 3:32 PM
PLOTTED BY Sanders, James
CAD SYSTEM AutoCAD Civil 3D 2012
CAD FILENAME SMRCUP 30.dwg



PLAN

SCALE OF FEET



PROFILE

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CAD SYSTEM AutoCAD Civil 3D 2012
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FPUD PRODUCT TRANSMISSION PIPELINE
REACH 2
673+00 TO 686+00
PLAN & PROFILE

DESIGNED BY
REVIEWED BY

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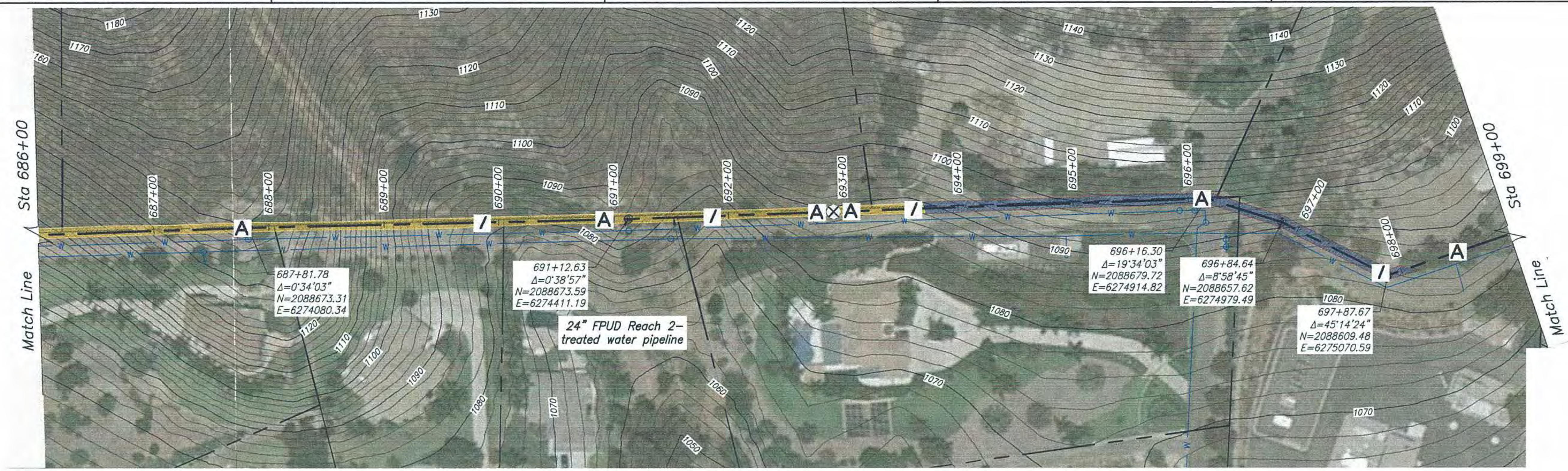
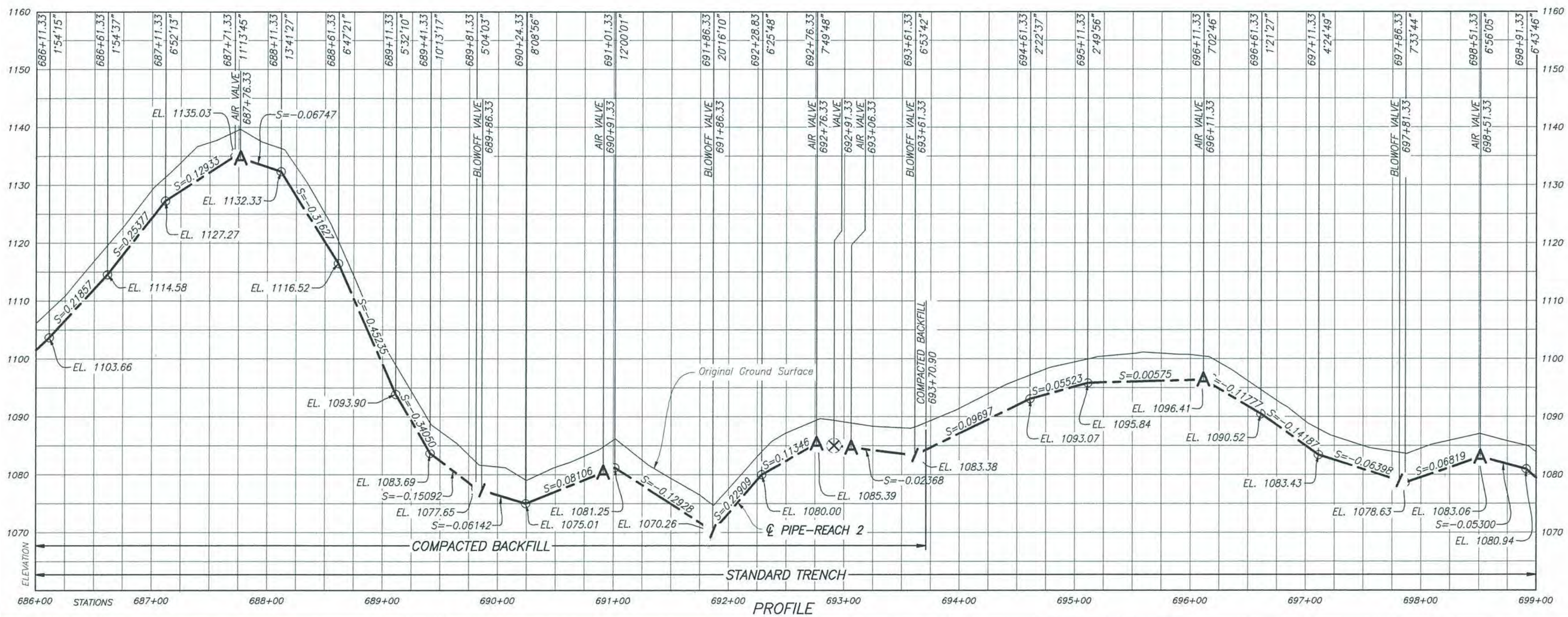
FIGURE B31
SHEET 30 OF 32



PLAN

SCALE OF FEET



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FPUD PRODUCT TRANSMISSION PIPELINE
REACH 2
686+00 TO 699+00
PLAN & PROFILE

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FIGURE B32

SHEET 31 OF 32

DATE AND TIME PLOTTED 9/26/2013 3:32 PM
PLOTTED BY Sanders, James

CAD SYSTEM AutoCAD Civil 3D 2012
CAD FILENAME SMRCUP 32.dwg

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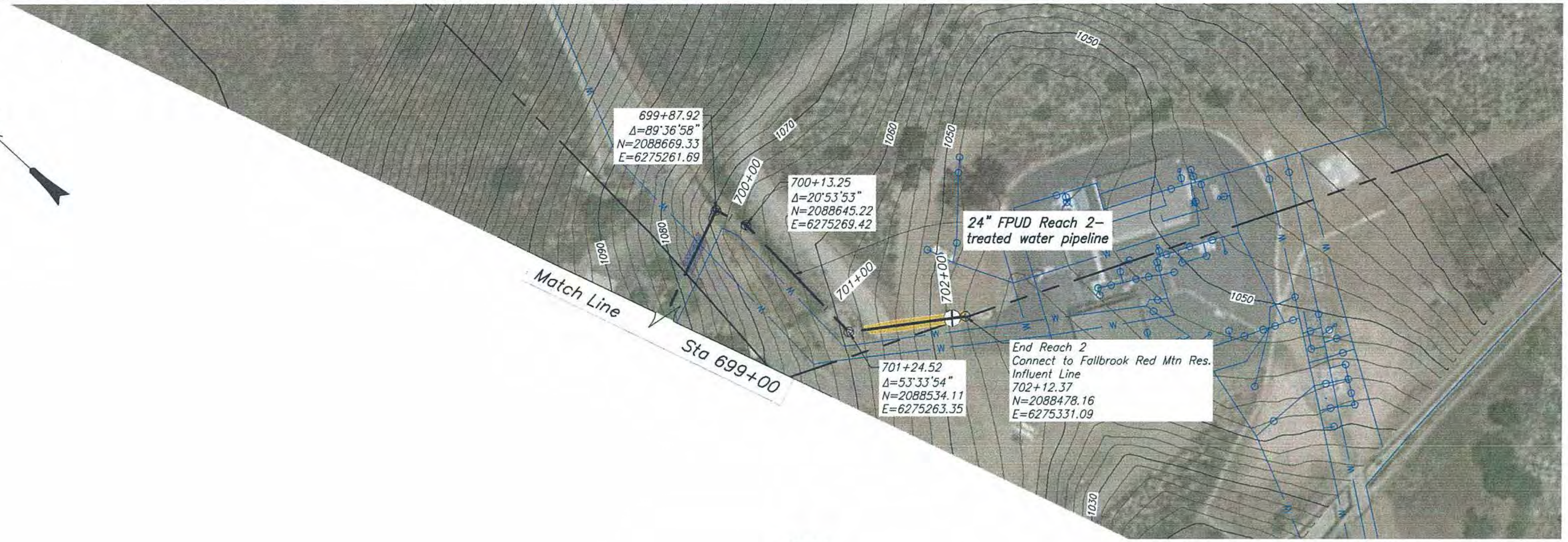

PLAN

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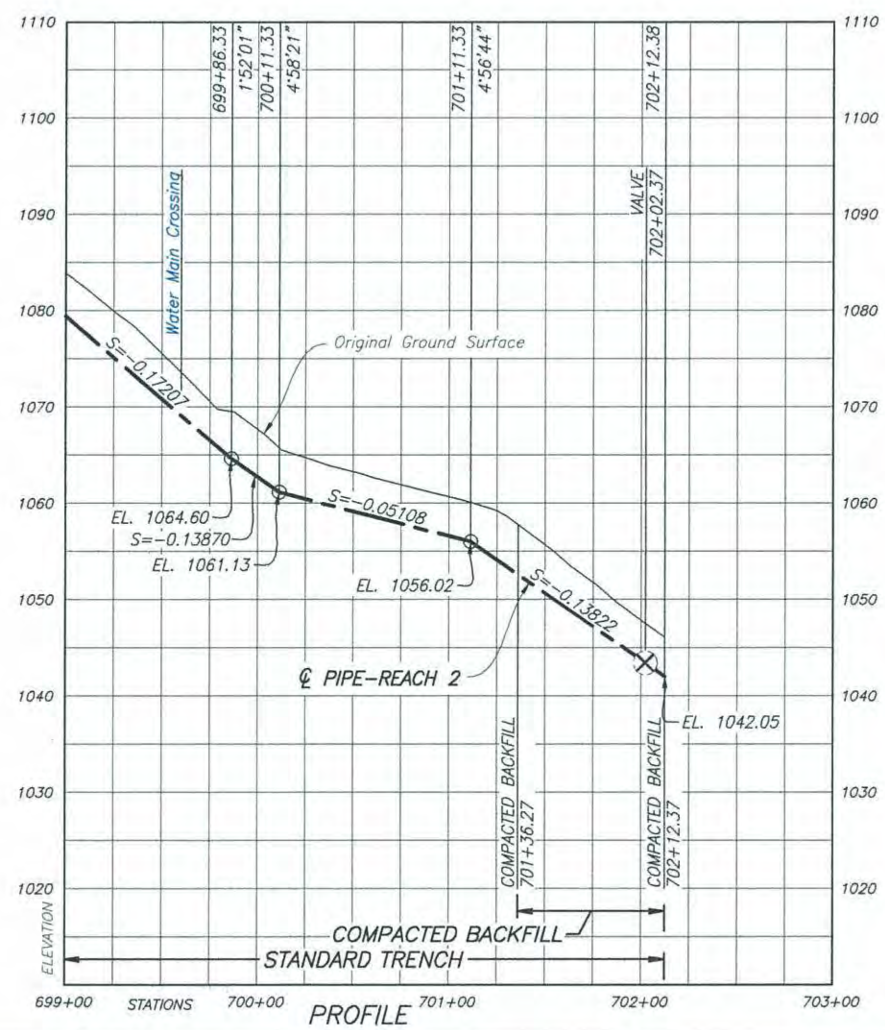
SCALE OF FEET



PROFILE

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FPUD PRODUCT TRANSMISSION PIPELINE
REACH 2
699+00 TO 702+12.37
PLAN & PROFILE

DESIGNED BY
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FIGURE B33

SHEET 32 OF 32

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9/26/2013 3:33 PM
PLOTTED BY
Sanders, James

CAD SYSTEM
AutoCAD Civil 3D 2012
CAD FILENAME
SMRCUP 50.dwg

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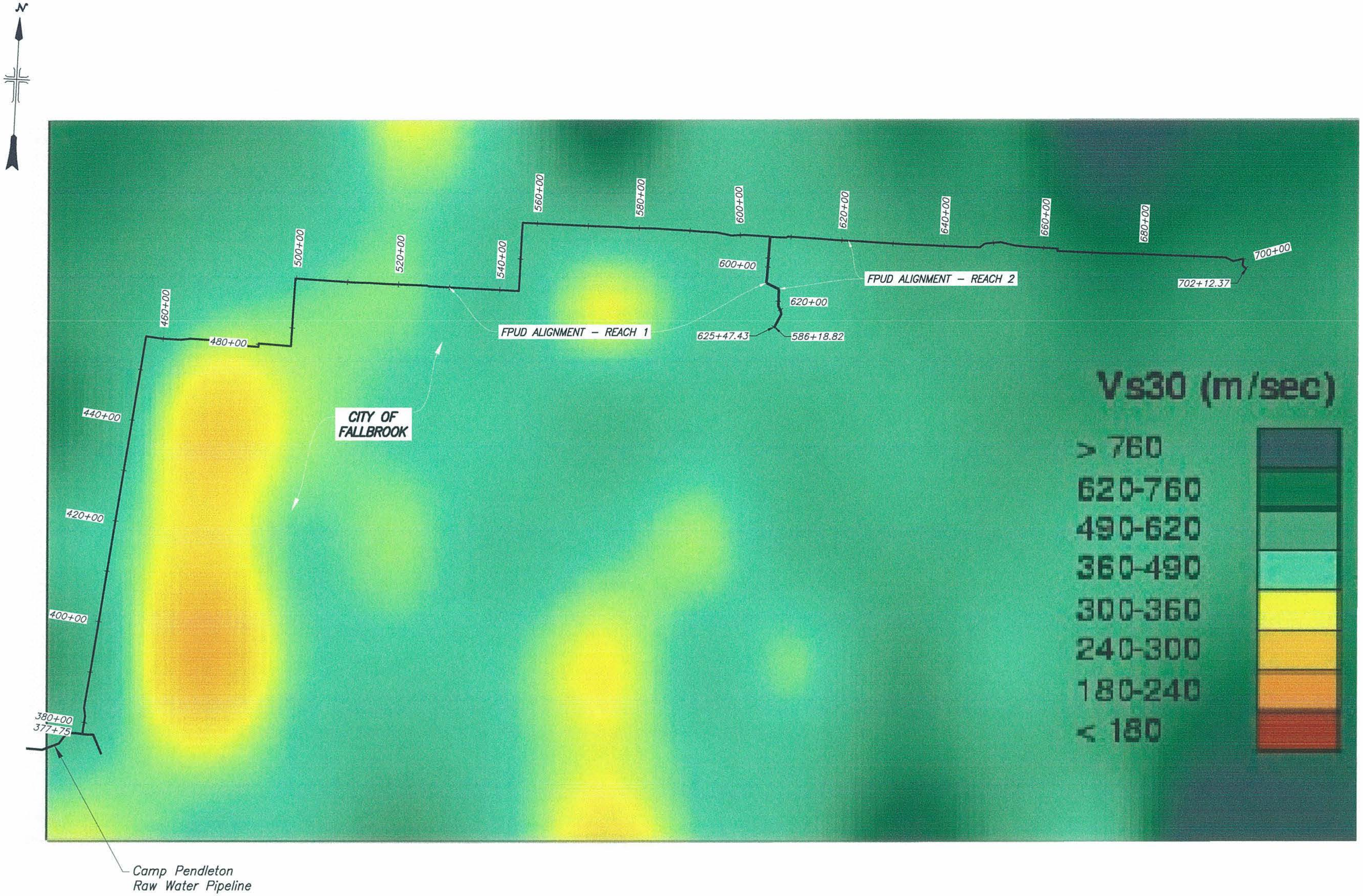

PLAN

1000 0 1000 2000 3000
SCALE OF FEET

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SANTA MARGARITA RIVER – CALIFORNIA
2010 FEASIBILITY STUDY CONCEPT

SANTA MARGARITA RIVER CONJUCTIVE USE PROJECT STUDY

FALLBROOK PIPELINE AND SYSTEM LAYOUT

GELOGICAL MAP OVERLAY

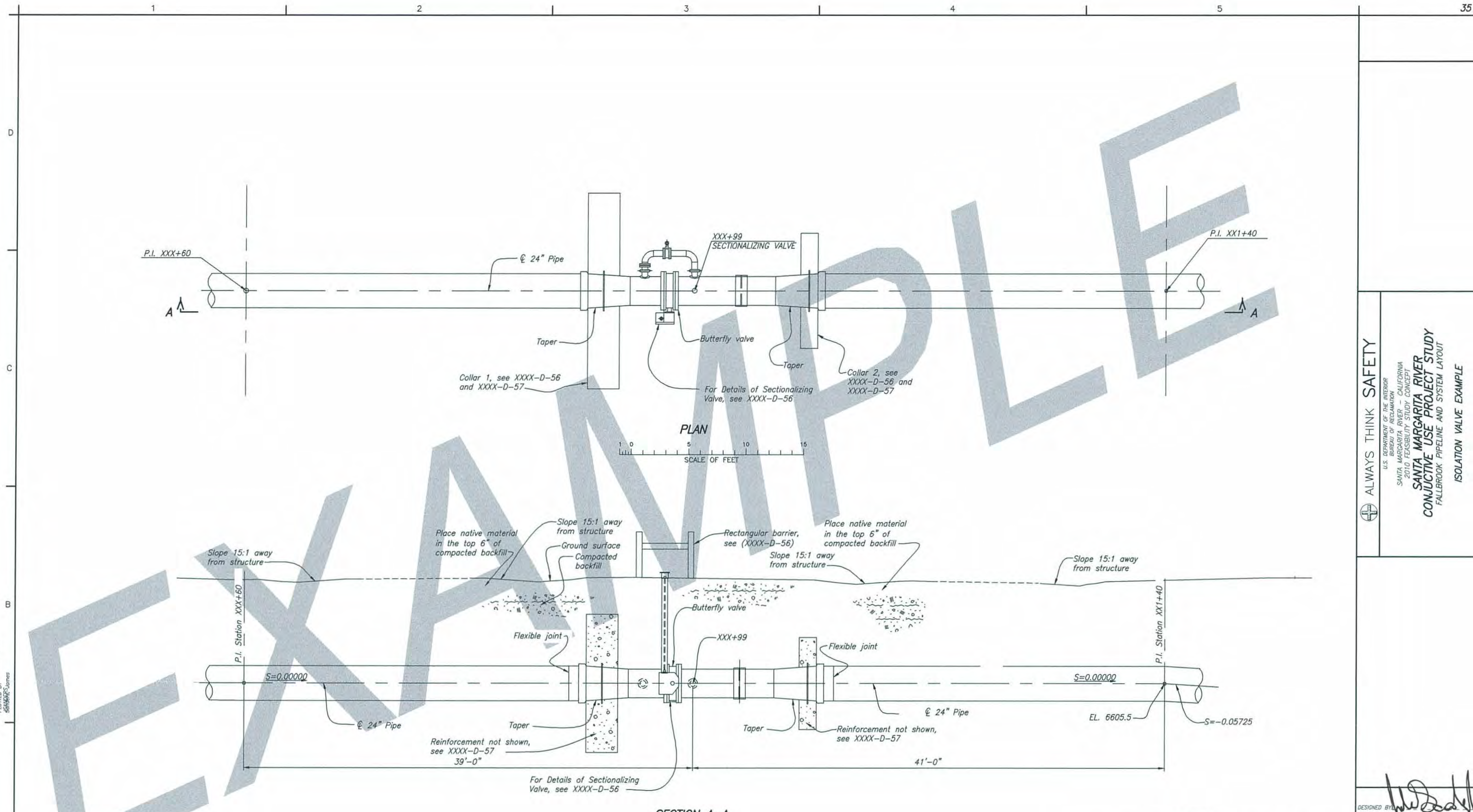
DESIGNED BY:
REVIEWED BY:

DENVER, CO 08-30-13

FIGURE B34
SHEET 1 OF 1

DATE AND TIME PLOTTED 9/26/2013 3:33 PM
PLOTTED BY Sanders, James

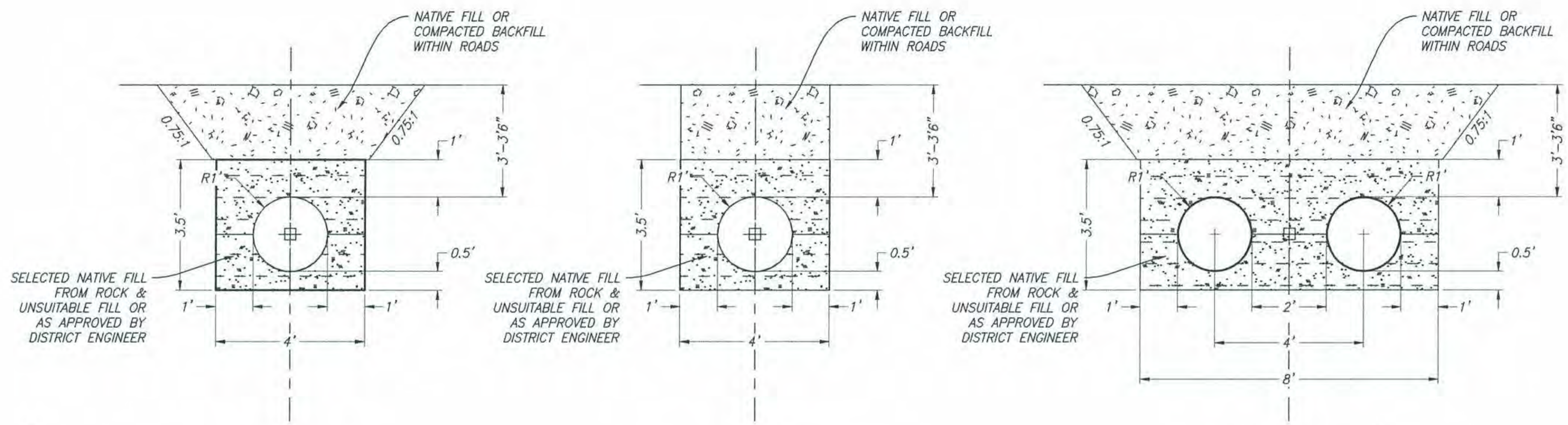
CAD SYSTEM AutoCAD Civil 3D 2012
CAD FILENAME Geology Map.dwg



NOTES

1. For details of blowoff with manhole, see XXXX–D–44.
2. For details of sectionalizing valve, see XXXX–D–56.
3. Use native material in top 6" of compacted backfill.
4. For pipe trench earthwork, see XXXX–D–40.
5. Locate barrier posts as directed by District Engineer. For barrier posts detail, see XXXX–D–54.
6. P.I. is point of intersection.

RECLAMATION
Managing Water in the West



STANDARD PIPE TRENCH
1"=2'

VERTICAL PIPE TRENCH
1"=2'

DOUBLE PIPE TRENCH
1"=2'

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SANTA MARGARITA RIVER
CONJUCTIVE USE PROJECT STUDY
FALLBROOK PIPELINE AND SYSTEM LAYOUT

TYPICAL TRENCH SECTION

DESIGNED BY:
REVIEWED BY:

DENVER, CO 08-30-13

FIGURE B36
SHEET 1 OF 1

DATE AND TIME PLOTTED 9/26/2013 3:33 PM
PLOTTED BY Sanders, James

CAD SYSTEM AutoCAD Civil 3D 2012
CAD FILENAME Typical Trench Sections.dwg

Appendix C – Operations, Maintenance, and Replacement Program and Annual Costs

The five categories of Operations, Maintenance, and Replacement are presented below with costs and assumptions listed.

1. Labor

a. Labor rates for the various levels of workers were obtained from the U.S. Bureau of Labor Statistics, Water and Wastewater Treatment Plant Operators, Occupational Employment and Wages, May 2010, for the Los Angeles – Long Beach, California area. They include operators at $33.09/hour. It was assumed that supervisor rates would be 25 percent higher than operator rates. Therefore a supervisor rate of $41.36/hour was used.

b. Labor for the Fallbrook WTP assumes: four full-time plant operators who double as laboratory, mechanical, and electrical technicians, plus one full-time supervisor. It is also assumed that the operators will perform building and grounds maintenance. Each operator and the supervisor are assumed to work 40 hours per week. These staffing needs are based upon information in Table 25.1, Water Treatment Plant Design, Fourth Edition, McGraw-Hill Books, 2005.

c. Labor for the Gheen Pumping Station assumes that one of the WTP plant operators will spend approximately 4 hours per week at the pumping station.

d. Labor for Reaches 1 and 2 pipeline segments is assumed to be included in the above categories.

e. Other water treatment (WT) equipment in Table C1 includes neutralizing wastes, record keeping, maintenance management, and other standard operating procedures.

f. The labor cost for the plant operating 100 percent of the year is $361,337.60 for the Fallbrook WTP plus $6,882.72 for the Gheen Pumping Station. The costs shown in Table C1 are adjusted for a yearly operating run time of 80 percent.

Table C1. Annual Labor Costs

Feature		Labor Costs
WTP Labor Costs:	Percent of Total	
Raw Water Pumping	10	$36,134.76
Fe/Mn	15	$54,201.64
Reverse Osmosis	15	$54,201.64
Chemical Feed Systems	15	$54,201.64
Tanks – chemical storage	5	$18,067.88
Tanks – underground concrete	5	$18,067.88
Other WT Equipment (e above)	10	$36,134.76
Finished Water Pumping	10	$36,134.76
Residuals	15	$54,201.64
WTP Total at 100% yearly operating time	100	$361,337.60
Gheen Pump Station – at 100% yearly operating time		$6,882.72
Costs Based on 80% Yearly Operating Time:		
Fallbrook WTP		$289,070.08
Gheen Pump Station		$5,506.18
Pipeline Reach 1		Included above
Pipeline Reach 2		Included above
Total Labor Cost		**$294,576.26**

2. **Power**
   a. It is assumed that power is only needed for the Fallbrook Water Treatment Plant and the Gheen Pumping Station and not for the pipelines.
   b. A local power rate of $0.125 per kilowatt-hour was used (provided by email from Jack Beebe, FPUD, dated March 25, 2011).
   c. An plant usage factor of 90 percent was assumed. This factor considers downtime for scheduled maintenance of major equipment or power failures. This is above and beyond the assumed 80 percent yearly plant operation.
   d. Pump efficiencies of 75 percent and motor efficiencies of 85 percent were used.
   e. HVAC power costs assume the plant requires heating and cooling 24 hours a day, 7 days a week for the 80 percent of the year it is in operation.
   f. Plant space thermostat set points were assumed to be 50 °F for heating and 100 °F for cooling.
   g. Control room thermostat set points were assumed to be 68 °F for heating and 75 °F for cooling.
   h. For plant lighting an assumed usage rate of 2 watts per square foot was used. For outdoor lighting, a 50-percent value of the indoor lighting was used.
   i. Other WT equipment in Table C2 includes flow meters and instruments not covered in other sections.

j. The power cost for the plant operating 100 percent of the year is $482,155.26 for the Fallbrook WTP and $56,686.00 for the Gheen Pumping Station. The costs shown in Table C2 are adjusted for a yearly operating run time of 80 percent.

Table C2. Annual Power Costs

Feature	Power Cost
Fallbrook WTP:	
Raw Water Pumping	$81,654.14
Fe/Mn	$3,137.52
Reverse Osmosis	$57,347.56
Chemical Feed Systems	$452.24
Tanks	$0.00
Other WT Equipment (i above)	$405.15
HVAC	$82,470.00
Lighting	$9,855.00
Finished Water Pumping	$244,962.41
Residuals	$1,871.24
Fallbrook WTP based upon 100% yearly operating time	$482,155.26
Gheen Pump Station at 100% yearly operating time	$56,686.00
Costs Based on 80% Yearly Operating Time:	
Fallbrook WTP	$354,537.79
Gheen Pump Station	$45,348.80
Total Power Cost	**$399,886.59**

3. **Chemicals**
   a. It is assumed that chemicals will be used at Fallbrook WTP only; no chemicals will be used at the Gheen Pumping Station or along the pipeline reaches.
   b. An average WTP flow rate of 1,922 gpm and a 100-percent plant usage factor were assumed for chemical calculations.
   c. Costs for chemicals delivered to the Fallbrook WTP were obtained from local chemical providers and are as follows:
      i. Sodium hypochlorite – $0.30/lb (Univar)
      ii. Potassium permanganate – $3.59/lb (Western Chemical)
      iii. Anti-scalant – $3.50/lb (Avista Technologies)
      iv. Sodium hydroxide - $0.26/lb (Univar)
      v. Ammonium hydroxide – $0.67/lb (Univar)
      vi. Acid/alkaline solutions for cleaning in place (CIP) – acid assumed at $0.48/lb and alkaline assumed at $0.26/lb
      vii. Acid/alkaline solutions for waste neutralization – acid assumed at $0.48/lb and alkaline assumed at $0.26/lb

d. Cleaning chemicals for CIP are assumed to be 2-percent citric acid and 2-percent sodium tripolyphosphate.
e. CIP is assumed to be performed twice a year per train.
f. Waste neutralization is assumed to require 200 gallons per year acid and 200 gallons per year alkaline.
g. Annual chemical costs are shown below in Table C3.

Table C3. Annual Chemical Costs for the Fallbrook WTP

Unit Process or Plant Component	Annual Chemical Cost
Potassium permanganate for iron and manganese oxidation	$37,717.71
Sodium hypochlorite for disinfection	$66,750.00
Anti-scalant	$35,000.00
Sodium hydroxide	$12,090.00
Ammonium hydroxide	$25,795.00
Acid/alkaline for CIP	$12,000.00
Acid/alkaline for waste neutralization	$1,508.00
Future chemical	$7,366.00
Total chemical costs	**$198,226.71**

4. Maintenance Materials

a. Each item is assumed to encompass a $1,000/year maintenance cost unless otherwise stated.
b. Water treatment instruments are assumed to encompass a $2,000/year maintenance cost.
c. The Gheen Pumping Station is assumed to encompass a $2,000/year maintenance cost.
d. For reverse osmosis, maintenance materials are assumed to equal 1.5 percent of capital costs, which is $61,500, estimated by the manufacturer's representative.
e. The pipeline cost of 0.5 percent of construction cost per year is based upon the San Luis Feasibility Study, dated June, 2006.
f. HVAC equipment is assumed to run 24 hours per day, 7 days per week while plant is operational. HVAC maintenance costs are assumed to be $40/hour.
g. Fe/Mn filter and reaction vessels are required to be painted every 5 years to prolong the life of the vessels.
h. Fe/Mn residuals are assumed to have a sludge weight of 80 pounds per cubic foot at an assumed production rate of 80 pounds per day. One drying bed will be used per year and the sludge removed once per year, rotating the use of the drying beds every other year.
i. The building structure is concrete masonry units with a metal roof and steel doors. The doors may need to be repainted; the roof and walls are almost maintenance free.

j. The maintenance and materials cost for the plant operating 100 percent of the year is $82,930.00 for the Fallbrook WTP and $2,000.00 for the Gheen Pumping Station. The costs shown in Table C4 are adjusted for a yearly operating run time of 80 percent.

Table C4. Annual Maintenance Materials Costs

Feature	Maintenance Materials Cost
Fallbrook WTP:	
Raw Water Pumping	$1,000.00
Fe/Mn	$1,000.00
Filter and Reaction Vessels	$4,400.00
Reverse Osmosis (includes cartridge filters)	$61,500.00
Chemical Feed Systems	$1,000.00
Tanks – chemical storage	$1,000.00
Tanks – underground concrete	$1,000.00
Other WT Equipment – flow meters	$1,000.00
Other WT Equipment – instruments	$2,000.00
Other WT Equipment – yard piping	$1,000.00
Other WT Equipment – HVAC	$1,780.00
Other WT Equipment – lighting	$1,000.00
Finished Water Pumping	$1,000.00
Residuals – minor pump items	$1,000.00
Residuals – non-hazardous waste disposal	$2,250.00
Residuals – pipe cleaning	$1,000.00
Fallbrook WTP total at 100% yearly operating time	$82,930.00
Gheen Pump Station at 100% yearly operating time	$2,000.00
Pipeline Reach 1 at 100% yearly operating time	$21,092.71
Pipeline Reach 2 at 100% yearly operating time	$6,930.50
Costs Based on 80% Yearly Operating Time:	
Fallbrook WTP	$66,344.00
Gheen Pump Station	$1,600.00
Pipeline Reach 1	$16,874.17
Pipeline Reach 2	$5,544.40
Total Maintenance Materials Cost	**$90,362.57**

5. Replacement

a. The “useful life” for each major piece of equipment has been estimated and is shown in Table C5, along with the source or reference for that estimate. Replacement costs, in present worth dollars for future replacement are shown in Table C6 with the current replacement value.

Table C5. OM&R Equipment Replacement and Useful Life Table

Feature/Equipment	Quantity	Est. Cost Per Unit	Est. Total Cost	Est. Useful Life (yrs)	Source of Useful Life Estimate
Fallbrook WTP:					
F & I operator work station	1 each	$13,000.00	$13,000.00	5	Engineer
Fe/Mn pH probe	1 each	$1,152.00	$1,152.00	5	Manufacturer
RO membranes	1 LS	$580,300.00	$580,300.00	5	Manufacturer
F & I operator interface terminal	5 each	$4,200.00	$21,000.00	10	Engineer
F & I programmable controller	1 LS	$42,000.00	$42,000.00	10	Engineer
F & I remote terminal unit	1 LS	$88,000.00	$88,000.00	10	Engineer
F & I radio communication	1 LS	$5,900.00	$5,900.00	10	Engineer
F & I software	1 LS	$12,500.00	$12,500.00	10	Engineer
NaOCl metering pump	2 each	$3,400.00	$6,800.00	10	Manufacturer
Blend feed pumps for chlorination	2 each	$3,400.00	$6,800.00	10	Manufacturer
NH_4OH metering pumps for chloramination	2 each	$3,400.00	$6,800.00	10	Manufacturer
NaOH metering pumps for RO product pH adjustment	2 each	$3,400.00	$6,800.00	10	Manufacturer
Antiscalant metering pump	2 each	$3,400.00	$6,800.00	10	Manufacturer
Fe/Mn valve actuators	2 each	$8,640.00	$17,280.00	10	Manufacturer
Fe/Mn flow meters	9 each	$4,320.00	$38,880.00	10	Manufacturer
Fe/Mn chem. feed pumps and skids	1 LS	$14,805.00	$14,805.00	10	Manufacturer
Fe/Mn turbidity analyzer	1 each	$3,600.00	$3,600.00	10	Manufacturer
Fe/Mn oxidation-reduction potential probe	1 each	$1,152.00	$1,152.00	10	Manufacturer
Fe/Mn chlorine analyzer	1 each	$5,040.00	$5,040.00	10	Manufacturer
Fe/Mn reclaim pumps	3 each	$6,048.00	$18,144.00	10	Manufacturer
Level sensors & transmitters - ultrasonic type	4 each	$3,300.00	$13,200.00	10	Engineer
pH sensors & transmitters	2 each	$4,000.00	$8,000.00	10	Engineer
Chlorine analyzer & transmitters	2 each	$6,200.00	$12,400.00	10	Engineer
Turbidity analyzer & transmitters	1 each	$3,300.00	$3,300.00	10	Manufacturer
Conductivity sensors & transmitters	4 each	$2,500.00	$10,000.00	10	Engineer
Fe/Mn solids pump (Zoeller N140)	1 each	$2,300.00	$2,300.00	10	Engineer
Decant pump (Zoeller G 185)	1 each	$2,300.00	$2,300.00	10	Engineer

Feature/Equipment	Quantity	Est. Cost Per Unit	Est. Total Cost	Est. Useful Life (yrs)	Source of Useful Life Estimate
SCADA programming	1 LS	$72,000.00	$72,000.00	10	Engineer
Fe/Mn butterfly valves	3 each	$2,880.00	$8,640.00	12.5	Manufacturer
3" asphalt pavement	165 yd^3	$340.00	$56,100.00	15	Engineer
Flow meters - magnetic type	1 LS	$76,700.00	$76,700.00	15	Engineer
Fe/Mn PLC & HMI	1 LS	$14,400.00	$14,400.00	15	Manufacturer
Fe/Mn media replenishment	1 each	$82,080.00	$82,080.00	15	Manufacturer
Drench shower with eyewash	1 each	$2,500.00	$2,500.00	15	Engineer
Heat trace shower with eye/face wash unit	2 each	$2,900.00	$5,800.00	15	Engineer
Tankless electric water heater	2 each	$1,000.00	$2,000.00	15	Engineer
Gravel service yard	105 yd^3	$38.00	$3,990.00	15	Engineer
Compressed air system	1 LS	$5,700.00	$5,700.00	15	Engineer
F & I outdoor enclosure	2 each	$1,050.00	$2,100.00	20	Engineer
Backflow prevention valve	1 each	$2,000.00	$2,000.00	20	Engineer
RO non-membranes	1 LS	$5,319,700.00	$5,319,700.00	20	Manufacturer
NaOCl storage tank – 5,500 gallon	2 each	$10,000.00	$20,000.00	25	Engineer
NH_4OH Storage Tank - 10,000 gallon	1 each	$25,500.00	$25,500.00	25	Engineer
Clearwell MCC	1 LS	$110,000.00	$110,000.00	25	Engineer
Fe/Mn pH monitor	1 each	$3,240.00	$3,240.00	25	Manufacturer
Fe/Mn oxidation-reduction potential monitor	1 each	$3,240.00	$3,240.00	25	Manufacturer
Fe/Mn MCC	1 LS	$80,000.00	$80,000.00	25	Engineer
HVAC system	1 LS	$160,000.00	$160,000.00	25	Engineer
Raw water feed MCC	1 LS	$84,000.00	$84,000.00	25	Engineer
RO System MCC	1 LS	$105,000.00	$105,000.00	25	Engineer
Clean agent fire extinguishing system	1 LS	$25,000.00	$25,000.00	25	Engineer
Dry pipe sprinkler system	1 LS	$11,500.00	$11,500.00	25	Engineer
Interior CIP pipe and valves	1 LS	$15,500.00	$15,500.00	25	Engineer
F & I 480-volt bus	1 LS	$230,000.00	$230,000.00	25	Engineer
F & I indoor enclosure	1 each	$5,000.00	$5,000.00	30	Engineer
Fe/Mn filter vessels	4 each	$187,200.00	$748,800.00	30	Manufacturer
Fe/Mn reaction vessel	1 each	$187,200.00	$187,200.00	30	Manufacturer

Feature/Equipment	Quantity	Est. Cost Per Unit	Est. Total Cost	Est. Useful Life (yrs)	Source of Useful Life Estimate
Raw Water - 1/4 feed motors, 60 hp	3 each	$27,000.00	$81,000.00	30	Engineer
Raw Water - 1/8 feed motors, 40 hp	2 each	$26,000.00	$52,000.00	30	Engineer
Above-ground yard/interior piping	1 LS	$130,030.00	$130,030.00	30	Engineer
Clearwell motor 1/4, 200 hp	3 each	$45,000.00	$135,000.00	35	Engineer
Clearwell Motor 1/8, 100 hp	2 each	$32,000.00	$64,000.00	35	Engineer
Raw Water - 1/4 feed pumps, Weir-Floway Pump Model 16JKM	3 each	$105,000.00	$315,000.00	35	Engineer
Raw Water - 1/8 feed pumps, Weir-Floway Pump Model 14JKL	2 each	$94,000.00	$188,000.00	35	Engineer
Clearwell pump 1/4, Weir-Floway Pump Model 14JKL	3 each	$115,000.00	$345,000.00	40	Engineer
Clearwell pump 1/8, Weir-Floway Pump Model 13XKL	2 each	$105,000.00	$210,000.00	40	Engineer
Metal building	1 LS	$486,380.00	$486,380.00	50	Architect
Concrete clearwells	1 LS	$1,302,970.00	$1,302,970.00	50	Engineer
Concrete structures	1 LS	$494,900.00	$494,900.00	50	Engineer
Clearwell steel piping	1 LS	$8,678.00	$8,678.00	50	Engineer
Clearwell flanges	1 LS	$11,520.00	$11,520.00	50	Engineer
Clearwell valves	1 LS	$63,697.00	$63,697.00	50	Engineer
Clearwell air chamber	1 LS	$197,600.00	$197,600.00	50	Engineer
Raw water pumping, steel piping	1 LS	$301,600.00	$301,600.00	50	Engineer
Raw water pumping, flanges	1 LS	$10,650.00	$10,650.00	50	Engineer
Raw water pumping, valves	1 LS	$84,429.50	$84,429.50	50	Engineer
Metal Fabrication for building	1 LS	$329,000.00	$329,000.00	50	Architect
Fallbrook WTP Subtotal			**$13,234,197.50**		
Gheen Booster Pumping Plant:					
F & I remote terminal unit	1 LS	$10,500.00	$10,500.00	10	Engineer
F & I radio communication	1 LS	$3,300.00	$3,300.00	10	Engineer
Gravel surfacing	1,500 yd^3	$38.00	$57,000.00	15	Engineer
F & I outdoor enclosure	1 each	$1,050.00	$1,050.00	20	Engineer
Sound barrier system	1 LS	$206,800.00	$206,800.00	25	Engineer
MCC	1 LS	$86,000.00	$86,000.00	25	Engineer
75-hp motor for Aurora 413 pump	3 each	$29,000.00	$87,000.00	35	Engineer
50-hp motor for Aurora 412 pump	2 each	$18,500.00	$37,000.00	35	Engineer

Feature/Equipment	Quantity	Est. Cost Per Unit	Est. Total Cost	Est. Useful Life (yrs)	Source of Useful Life Estimate
Aurora Pump Model 413	3 each	$45,000.00	$135,000.00	40	Engineer
Aurora Pump Model 412	2 each	$41,000.00	$82,000.00	40	Engineer
Steel piping	1 LS	$11,742.00	$11,742.00	50	Engineer
Flanges	1 LS	$10,695.00	$10,695.00	50	Engineer
Valves	1 LS	$115,157.00	$115,157.00	50	Engineer
Air chamber	1 LS	$119,320.00	$119,320.00	50	Engineer
200,000-gallon steel tank	1 LS	$280,000.00	$280,000.00	50	Engineer
Concrete underground tank	1 LS	$242,200.00	$242,200.00	50	Engineer
Gheen Subtotal			**$1,484,764.00**		
Pipeline Reach 1					
Flowmeters	1 each	$6,000.00	$6,000.00	50	Engineer
Flowmeter structure	1 LS	$18,450.00	$18,450.00	50	Engineer
Valves	1 LS	$120,650.00	$120,650.00	50	Engineer
Reach 1 Subtotal			**$145,100.00**		
Pipeline Reach 2					
Valves	1 LS	$66,550.00	$66,550.00	50	Engineer
Reach 2 Subtotal			**$66,550.00**		
Total			**$14,930,611.50**		

Notes:
1) F&I, furnish and install; MCC, motor control center; LS, lump sum.
2) No buried pipe or conduit is included in the table.
3) Items included in table are highlighted on the cost estimate spreadsheets.
4) Costs shown are installed costs.
5) Where only equipment cost was given, a 44% installation cost was added (based upon equipment cost from vendors versus installed costs on the cost estimate sheets).

To calculate the present worth of a future replacement cost, the current replacement value was discounted over the 50-year life of the project using the plan formulation and evaluation interest rate of 3.75 percent.

b. The Fe/Mn filter and reaction vessels are assumed to have a 30-year life if painted every 5 years; otherwise the useful life is 5 years. This information is from the manufacturer.

Table C6. Summary of Present Value of Future Replacement Costs

Equipment	Current Cost	Present Value of Future Replacement Costs
Fallbrook Water Treatment Plant	$26,529,000	$8,772,000
Gheen Pump Station	$1,905,000	$437,500
Pipeline Reach 1	$145,000	$21,300
Pipeline Reach 2	$67,000	$9,800
Total Present Value of Future Replacement Costs	**$28,646,000**	**$9,240,600**

Appendix D – Estimated Water Cost Savings Attributable to the Project

To estimate the water cost savings, the price for water from MWD is used to identify the M&I water supply benefits from the project. The data presented in Table D1 was collected from MWD and SDCWA water rate websites to provide current and projected water rates.

Table D1. M&I Water Rate Estimate

MWD Charges	Cost in dollars per acre-foot		Comments
	1/1/2011	1/1/2012	
Tier 1 water supply	104	106	
Delta supply surcharge	51	58	
Water supply surcharge	0		
System access rate	204	217	
Water stewardship rate	41	43	
System power rates	127	136	
Full service untreated volumetric rate (MWD charges)	**527**	**560**	
Treatment surcharge	217	234	
Water standby charge	10	10	
Transportation charge	75	85	
Full service treated charge	**829**	**889**	
Readiness-to-serve charge	36	37	Based on 2011 MWD invoice to FPUD: $343,501.*
Capacity charge	25	26	Based on 2011 MWD invoice to FPUD: $247,480.*
Emergency storage charge	109	110	Based on 2011 MWD invoice to FPUD: $1,034,433.*
Total M&I estimate	**999**	**1,062**	
Replenishment rate MWD	436		
Readiness-to-serve charge	15	37	Based on 2011 MWD invoice to FPUD: $343,501.*
Capacity charge	36	26	Based on 2011 MWD invoice to FPUD: $247,480.*
Emergency storage charge	45	110	Based on 2011 MWD invoice to FPUD: $1,034,433.*

*Invoice amount divided by 10-year average delivery of 9,343 af to derive cost per acre-foot.

The overall rate derived in Table D1 is projected through 2064 in Table D2. Rate increases through 2017 are based on SDCWA five-year forecasts (February 2011). From 2018 to 2026, rates were increased at 5.1 percent per year based on an historical annual average rate increase for MWD water. The water rate is capped at the 2026 value for the remaining project life. The annual projected per-acre-foot cost from this alternative water source is then multiplied by the annual water amount estimated from the hydrologic model developed by Stetson Engineers. This calculation provides the annual water supply benefit, which is then present-valued over the 50-year life of the project.

Table D2. M&I Water Rate Projections

Year	MWD Full Service Tier 1 Untreated ($/af)	Annual Change	SDCWA Treated Water Rates for FPUD ($/af)	
1990	197			
1991	222	12.7%		
1992	269	21.2%		
1993	318	18.2%		
1994	335	5.3%		
1995	344	2.7%		
1996	344	0.0%		
1997	349	1.5%		
1998	349	0.0%		
1999	349	0.0%		
2000	349	0.0%		
2001	349	0.0%		
2002	349	0.0%		
2003	326	–6.6%		
2004	326	0.0%		
2005	331	1.5%		
2006	331	0.0%		
2007	331	0.0%		
2008	351	6.0%		
2009	412	17.4%		
2010	484	17.5%		
2011	527	8.9%	**999**	
2012	560	6.3%	**1,062**	
2013		5.1%	**1,117**	
2014		5.1%	**1,174**	
2015		5.1%	**1,234**	
2016		5.1%	**1,297**	
2017		5.1%	**1,363**	
2018		5.1%	**1,433**	
2019		5.1%	**1,507**	
2020		5.1%	**1,584**	
2021		5.1%	**1,665**	
2022		5.1%	**1,750**	
2023		5.1%	**1,839**	
2024		5.1%	**1,933**	
2025		5.1%	**2,032**	
2026			**2,136**	
2027			**2,136**	
2028			**2,136**	

Data source: SDCWA Five-year rate forecast, Feb. 24, 2011

All in treated Water rate +Readiness to serve, capacity, emergency storage per AF charges

1990–2012 Avg. annual tier 1 rate = 5.1159%

Rates assumed to be capped at this level for rest of project life.

Year	MWD Full Service Tier 1 Untreated ($/af)	Annual Change	SDCWA Treated Water Rates for FPUD ($/af)	
2029			**2,136**	
2030			**2,136**	
2031			**2,136**	2,246
2032			**2,136**	2,360
2033			**2,136**	2,481
2034			**2,136**	2,608
2035			**2,136**	2,742
2036			**2,136**	2,882
2037			**2,136**	3,029
2038			**2,136**	3,184
2039			**2,136**	3,347
2040			**2,136**	3,518
2041			**2,136**	3,698
2042			**2,136**	3,888
2043			**2,136**	4,086
2044			**2,136**	4,295
2045			**2,136**	4,515
2046			**2,136**	4,746
2047			**2,136**	4,989
2048			**2,136**	5,244
2049			**2,136**	5,513
2050			**2,136**	5,795
2051			**2,136**	6,091
2052			**2,136**	6,403
2053			**2,136**	6,730
2054			**2,136**	7,074
2055			**2,136**	7,436
2056			**2,136**	7,817
2057			**2,136**	8,217
2058			**2,136**	8,637
2059			**2,136**	9,079
2060			**2,136**	9,543
2061			**2,136**	10,032
2062			**2,136**	10,545
2063			**2,136**	11,084
2064			**2,136**	11,651

Table D3. Total M&I Benefit — Estimated Avoided Purchases of MWD Water Over the Life of the Project

Year	Annual Avg M&I Water (af)	Additional Water (af)	Treated M&I Water Rate[1] ($)	Total Value ($)	Present Value Coefficient @3.75%	Present Value ($)
2012	0		1,062	0		0
2013	0		1,117	0		0
2014	0		1,174	0		0
2015	5780		1,234	7,132,275	1	7,132,275
2016	3820		1,297	4,954,867	0.963855	4,775,775
2017	960		1,363	1,245,202	0.929017	1,156,814
2018	500		1,433	681,722	0.895438	610,440
2019	261		1,507	374,064	0.863073	322,845
2020	0		1,584	0	0.831878	0
2021	2720		1,665	4,307,359	0.801810	3,453,683
2022	2223		1,750	3,700,412	0.772829	2,859,785
2023	0		1,839	0	0.744895	0
2024	0		1,933	0	0.717971	0
2025	150		2,032	290,006	0.692020	200,690
2026	650		2,136	1,320,984	0.667008	881,106
2027	263		2,136	561,834	0.642899	361,203
2028	0		2,136	0	0.619662	0
2029	2400		2,136	5,127,006	0.597264	3,062,177
2030	5600		2,136	11,963,013	0.575676	6,886,824
2031	2310		2,136	4,934,743	0.554869	2,738,135
2032	5848		2,136	12,492,804	0.534813	6,681,318
2033	3880		2,136	8,288,659	0.515483	4,272,660
2034	1255		2,136	2,680,997	0.496851	1,332,056
2035	750		2,136	1,602,189	0.478892	767,276
2036	880		2,136	1,879,902	0.461583	867,731
2037	1300		2,136	2,777,128	0.444899	1,235,542
2038	1300		2,136	2,777,128	0.428819	1,190,884
2039	925		2,136	1,976,033	0.413319	816,732
2040	580		2,136	1,239,026	0.398380	493,603
2041	3706	3334	2,136	7,916,951	0.383981	3,039,955
2042	5980	1320	2,136	12,774,789	0.370102	4,727,972
2043	5460	2370	2,136	11,663,938	0.356725	4,160,814
2044	5980	1000	2,136	12,774,789	0.343831	4,392,368
2045	5120	640	2,136	10,937,612	0.331403	3,624,761
2046	5460	2075	2,136	11,663,938	0.319425	3,725,752
2047	5980	1480	2,136	12,774,789	0.307879	3,933,094
2048	5120	160	2,136	10,937,612	0.296751	3,245,750
2049	5120	480	2,136	10,937,612	0.286025	3,128,434
2050	3020	0	2,136	6,451,482	0.275687	1,778,590
2051	3400	480	2,136	7,263,258	0.265722	1,930,011
2052	3020	0	2,136	6,451,482	0.256118	1,652,341
2053	1300	0	2,136	2,777,128	0.246861	685,564
2054	3740	2120	2,136	7,989,584	0.237938	1,901,026
2055	5980	1750	2,136	12,774,789	0.229338	2,929,743
2056	5460	2560	2,136	11,663,938	0.221049	2,578,297
2057	5980	1110	2,136	12,774,789	0.213059	2,721,782
2058	5460	2260	2,136	11,663,938	0.205358	2,395,282

Year	Annual Avg M&I Water (af)	Additional Water (af)	Treated M&I Water Rate[1] ($)	Total Value ($)	Present Value Coefficient @3.75%	Present Value ($)
2059	5980	680	2,136	12,774,789	0.197935	2,528,582
2060	5120	800	2,136	10,937,612	0.190781	2,086,689
2061	5460	2210	2,136	11,663,938	0.183885	2,144,827
2062	3880	0	2,136	8,288,659	0.177239	1,469,073
2063	1300	0	2,136	2,777,128	0.170833	474,424
2064	3400	320	2,136	7,263,258	0.164658	1,195,954

Total M&I Benefit Value =

Average Annual Value	**5,106,005**
Total Present Value	**114,550,637**

[1] Water rate values from Table D2.