RECLAMATION

*Managing Water in the West*

# Draft Feasibility Report Appendix C - Engineering Designs and Costs

**Los Vaqueros Reservoir Expansion Investigation**

**January 2018**

# Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

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.

# Contents

**Chapter 1 Introduction ..... 1-1**
Background ..... 1-1
Study Location ..... 1-2
Project Objectives ..... 1-3
Primary Planning Objectives ..... 1-3
Secondary Planning Objective ..... 1-3
Final Comprehensive Alternatives Considered in the Feasibility Report ..... 1-3
Alternative 1A ..... 1-7
Alternative 1B ..... 1-7
Alternative 2A ..... 1-8
Alternative 4A ..... 1-8
Organization of This Appendix ..... 1-8
**Chapter 2 Engineering Setting ..... 2-1**
Existing Facilities ..... 2-1
Old River Intake and Pump Station ..... 2-1
Old River Pipeline ..... 2-1
Middle River Intake and Pump Station ..... 2-1
Middle River Pipeline ..... 2-2
Transfer Reservoir ..... 2-2
Transfer Pumping Plant ..... 2-2
Flow Control Station 1 ..... 2-2
Flow Control Station 2 ..... 2-2
Transfer Pipeline ..... 2-2
Los Vaqueros Pipeline ..... 2-3
Los Vaqueros Dam and Reservoir ..... 2-3
Mokelumne Aqueduct Intertie ..... 2-3
Surveying and Mapping Information ..... 2-3
Survey Datum and Benchmarks ..... 2-3
Aerial Imagery ..... 2-4
Topographic Information ..... 2-4
Geotechnical Analysis ..... 2-4
**Chapter 3 Design Criteria ..... 3-1**
General ..... 3-1
Civil ..... 3-1
Conveyance Pipeline Design Criteria ..... 3-2
Appurtenances ..... 3-13
Siting and Land Requirements ..... 3-15
Geotechnical Considerations ..... 3-16
Trenches and Shoring ..... 3-16
Pipeline Crossings ..... 3-17
Cathodic Protection ..... 3-19

Other General Civil Design Criteria ..... 3-19
Operational, Hydraulic, and Mechanical ..... 3-22
Operational Design Criteria ..... 3-22
Hydraulic Design Criteria ..... 3-23
Mechanical ..... 3-24
Electrical ..... 3-29
Conclusions and Recommendations ..... 3-29
Codes, Standards, and Recommended Practices ..... 3-30
Equipment Load Estimates ..... 3-33
Power Distribution ..... 3-34
Equipment ..... 3-35
Power Distribution System Analyses ..... 3-43
Grounding ..... 3-48
Lighting ..... 3-49
Electric Equipment Seismic/Wind Anchorage and Miscellaneous Requirements ..... 3-50
Equipment Finish ..... 3-50
Altitude ..... 3-50
Outdoor Equipment ..... 3-50
Hazardous and Corrosive Areas ..... 3-50
Electrical Enclosures ..... 3-50
Instrumentation ..... 3-51
Codes, Standards and References ..... 3-52
Design Criteria ..... 3-53
Control System Architecture ..... 3-54
Process Requirements and Design Criteria ..... 3-55
Major Controller Hardware and Software Components ..... 3-59
Design Philosophy ..... 3-64
Control Mode Design Considerations ..... 3-65
Security and Telecommunication ..... 3-66
Structural ..... 3-66
Governing Codes and Standards ..... 3-66
Reference Specifications, Codes, and Standards ..... 3-67
Structural Systems, Design Methods, and Assumptions ..... 3-68
Structural Design Criteria ..... 3-70
Geotechnical Assumptions and Foundation Systems ..... 3-72
Architectural ..... 3-74
Architectural Design Philosophy ..... 3-74
Architectural Program ..... 3-74
Architectural Design Criteria ..... 3-75
**Chapter 4 Dam and Reservoir Elements ..... 4-1**
275 TAF Dam Raise Design ..... 4-1
Appurtenant Facilities ..... 4-4
Spillway ..... 4-4
Inlet / Outlet Works ..... 4-4
Reservoir Oxygenation System ..... 4-4
Dam Construction ..... 4-5

Dam Raise Materials ..... 4-5
Material Borrow Areas ..... 4-5
Materials and Equipment Stockpile and Staging Areas ..... 4-6
Materials Disposal ..... 4-6
Draining the Reservoir for Construction ..... 4-6
Kellogg Creek Flow Bypass ..... 4-8
Construction Activities ..... 4-8
Expanded Recreation Facilities ..... 4-8
Marina Complex Relocation ..... 4-9
New Los Vaqueros Watershed Trail ..... 4-10
Los Vaqueros Interpretive Center ..... 4-13
Los Vaqueros Watershed Office Barn ..... 4-13
**Chapter 5 Conveyance and Pumping Facilities ..... 5-1**
Hydraulic Modeling ..... 5-1
Delta Transfer Pipeline sizing ..... 5-2
Working and Shut off Pressure ..... 5-3
Transfer-Bethany Pipeline and Expanded Transfer Pump Selection ..... 5-5
Surge Analysis ..... 5-7
Assumptions and Methodology ..... 5-8
Transient Analysis ..... 5-9
Transfer Pump Station Modifications ..... 5-15
Hydraulic Modeling Summary ..... 5-15
Power Requirements ..... 5-17
Control and Monitoring ..... 5-18
Expanded Transfer Pump Station and Reservoir ..... 5-18
Facility Siting ..... 5-18
Pump Station ..... 5-18
Pump Station Suction and Discharge Piping ..... 5-18
Reservoir ..... 5-19
Reservoir Piping ..... 5-19
Power Requirements ..... 5-20
See Chapter 3, the Electrical Design Criteria for details. ..... 5-21
Control and Monitoring ..... 5-21
MCC Building ..... 5-21
Delta-Transfer Pipeline ..... 5-22
Pipe Materials ..... 5-22
Pipeline Alignment ..... 5-22
Pipeline Construction Methods and Special Crossings ..... 5-22
Pipeline Connections ..... 5-23
Pipeline Profile and Appurtenances ..... 5-23
Cathodic Protection ..... 5-23
Additional Easements ..... 5-24
Utilities ..... 5-24
Transfer-Bethany Pipeline ..... 5-24
Neroly High Lift Pump Station ..... 5-25
Hydraulic Modeling Summary ..... 5-25

Canal Turnout ..... 5-29
Pump Station ..... 5-29
Pipelines ..... 5-30
Power Requirements ..... 5-33
Control and Monitoring ..... 5-34
Existing Old River Intake and Pump Station ..... 5-35
Power Requirements ..... 5-35
Control and Monitoring ..... 5-36
Existing Middle River Intake and Pump Station ..... 5-36
Control and Monitoring ..... 5-36
Pumping Plant #1 Replacement ..... 5-36
**Chapter 6 Associated Local Projects ..... 6-1**
Brentwood Pipeline ..... 6-1
EBMUD-CCWD Intertie Pump Station ..... 6-2
EBMUD Walnut Creek Pumping Plant Variable Frequency Drives ..... 6-4
ECCID Intertie Pipeline ..... 6-4
EBMUD Mokelumne Aqueduct Relining ..... 6-7
**Chapter 7 Project Schedule and Cost Estimates ..... 7-1**
Project Schedule ..... 7-1
Work Packages and Schedule Summary ..... 7-2
Work Package 1: Transfer-Bethany Pipeline ..... 7-2
Work Package 2: Expanded Transfer Pump Station and Transfer Pump Station Modifications ..... 7-3
Work Package 3: Neroly Pump Station ..... 7-3
Work Package 4: Pumping Plant #1 Replacement ..... 7-3
Work Package 5: Los Vaqueros Reservoir Modifications ..... 7-3
Work Package 6: Expanded Recreation Facilities ..... 7-4
Work Package 7: Delta-Transfer Pipeline ..... 7-4
Reclamation Cost Estimate Methods ..... 7-5
Cost Estimate Levels ..... 7-5
Price Level ..... 7-5
Cost Estimate Components and Allowances ..... 7-6
Major Cost Estimate Assumptions ..... 7-9
Risk and Uncertainty ..... 7-10
Project Costs ..... 7-10
**Chapter 8 References ..... 8-1**

## Figures

Figure 1-1. Major Components of Alternatives 1A, 1B, and 2A ..... 1-5

Figure 1-2. Major Components of Alternative 4A ..... 1-6

Figure 4-1. 275 TAF Reservoir – Plan View of Dam Raise ..... 4-2

Figure 4-2. 275 TAF Reservoir – Profile View of Dam Raise & Construction Phasing ..... 4-3

Figure 4-3. Proposed Borrow Locations for the 275 TAF Dam Raise ..... 4-7

Figure 4-4. Proposed Relocation of the Marina Complex ..... 4-11
Figure 4-5. Los Vaqueros Watershed Trails ..... 4-12
Figure 5-1. Hydraulic Grade Line – Delta Transfer Pipeline ..... 5-4
Figure 5-2. Pressure – Delta Transfer Pipeline ..... 5-4
Figure 5-3. Pump Selection – Expanded Transfer Pump Station ..... 5-6
Figure 5-4. Hydraulic Grade Line – Transfer-Bethany Pipeline ..... 5-6
Figure 5-5. Elevations Following Loss of Power – Old River Pipeline – Scenarios 1 and 2 .... 5-10
Figure 5-6. Elevations Following Loss of Power – Middle River / Delta Transfer Pipeline – Scenarios 1 and 2 ..... 5-10
Figure 5-7. Elevations Following Loss of Power – Middle River / Delta Transfer Pipeline – Scenarios 3 and 4 ..... 5-11
Figure 5-8. Old River Surge Tanks – Dedicated Flow through Old River Pipeline ..... 5-12
Figure 5-9. Middle River Surge Tanks – Dedicated Flow through Middle River / Delta-Transfer Pipeline ..... 5-12
Figure 5-10. HGL Elevations Following Loss of Power – Transfer-Bethany Pipeline ..... 5-14
Figure 5-11. Expanded Transfer Surge Tanks ..... 5-14
Figure 5-12. Transfer Pump Station Modifications ..... 5-15
Figure 5-13. Transfer Pump Station System Curve ..... 5-16
Figure 5-14. Neroly Pump Station System Curve ..... 5-26
Figure 5-15. Hydraulic Gradeline – Los Vaqueros Pipeline – Neroly Pump Station to Transfer Storage Tank – 300 cfs ..... 5-27
Figure 5-16. Comparison of Calculated Pressure and Pipeline Pressure Rating – Neroly and Los Vaqueros Pipelines – Neroly Pump Station to Transfer Storage Tank – 300 cfs ..... 5-27
Figure 5-17. Surge Head Profile following Power Failure – Neroly Pump Station ..... 5-28
Figure 6-1. Location of the proposed Replacement for the Pumping Plant # 1 ..... 5-38
Figure 6-2. Proposed Brentwood Pipeline ..... 6-3
Figure 6-3. Location of Proposed EBMUD Walnut Creek Pumping Plant Variable Frequency Drives ..... 6-5
Figure 6-4. Proposed Alignment of the ECCID Intertie Pipeline ..... 6-6

# Tables

Table 1-1. Summary of Facilities and Operations for the Revised No-Action and Final Comprehensive Alternatives ..... 1-4
Table 2-1. Geotechnical Characteristics and Potential Design and Construction Issues ..... 2-6
Table 3-1. Summary of Proposed Pipeline Size and Flow Rate ..... 3-2
Table 3-2. Pipeline Design Pressures and Factors of Safety ..... 3-5
Table 3-3. Pipeline Design – Live Load Effect ..... 3-7
Table 3-4. Pipeline Deflection Limits ..... 3-8
Table 3-5. Pipeline Deflection Lag Factor ..... 3-9
Table 3-6. Minimum Utility Clearances for the Old River Pipeline ..... 3-18
Table 3-7. General Pipeline Design Criteria Summary ..... 3-21
Table 3-8. Yard Valving and Appurtenances Design Criteria ..... 3-25
Table 3-9. Expanded Transfer Pump Station Design Criteria ..... 3-26
Table 3-10. Power Wiring Color Code Summary ..... 3-41
Table 3.11. Glossary of Instrumentation and Control Terms ..... 3-52
Table 3-12. Instrumentation Design Criteria ..... 3-58
Table 3-13. Minimum Structural Live Loads ..... 3-70
Table 3-14. Structural Materials of Construction ..... 3-74
Table 4-1. Characteristics of the Los Vaqueros Dam Modification ..... 4-1
Table 4-2. Summary of Expanded Recreation Facilities ..... 4-9
Table 5-1. Comparison of Flow and Velocity for Various Pump Station and Pipeline Operational Scenarios ..... 5-3
Table 5-2. Pump Characteristics ..... 5-7
Table 5-3. Existing Surge Tank Summary ..... 5-8
Table 5-4. Summary of Pipeline Construction Methods ..... 5-32
Table 6-1. Summary of Associated Local Projects ..... 6-1
Table 7-1. Summary of Work Package Durations ..... 7-4
Table 7-2. Non Contract Cost Work Breakdown Structure ..... 7-7
Table 7-3. Summary of Estimated Costs for All Alternatives ($ millions) ..... 7-11

# Attachment

**Attachment 1 – Geotechnical and Seismic Evaluations (Conveyance Facilities)**

- Attachment 1A – Geotechnical and Seismic Evaluations TM (March 2007)
- Attachment 1B – Geotechnical Considerations Addendum (October 2015)

**Attachment 2 – 275 TAF Dam Raise Design**

- Attachment 2A – Dam Stability
- Attachment 2B – Site Seismicity
- Attachment 2C – Construction Materials
- Attachment 2D – Design Drawings
- Attachment 2E – Cost Estimates

**Attachment 3 – Conveyance and Pumping Drawings**

- Attachment 3A – Delta-Transfer Pipeline Drawings
- Attachment 3A-1 – Typical Delta-Transfer Pipeline Trench Construction Layouts
- Attachment 3B – Pumping and Controls Drawings
- Attachment 3C – Transfer-Bethany Pipeline Drawings
- Attachment 3D – Neroly Pump Station Conceptual Plan and Profile

**Attachment 4 – Construction Schedule and Cost**

- Attachment 4A – Construction Schedule
- Attachment 4B – Construction Cost Estimates

# Abbreviations and Acronyms

| | |
|---|---|
| ºC | degrees Celsius |
| °F | degrees Fahrenheit |
| 2012 IBC | 2012 International Building Code |
| 2013 CBC | 2013 California Building Code |
| AC | alternating current |
| ADA | American's with Disabilities Act |
| ANSI | American National Standards Institute |
| ASCE | American Society of Civil Engineers |
| ASTM | American Society for Testing and Materials |
| AWG | American Wire Gage |
| AWWA | American Water Works Association |
| BAWSCA | Bay Area Water Supply and Conservation Agency |
| Bay Area | San Francisco Bay Area |
| BBID | Byron-Bethany Irrigation District |
| CALFED | CALFED Bay-Delta Program |
| CARV | combination air release and air/vacuum valve |
| CBC | California Building Code |
| CCWD | Contra Costa Water District |
| cfs | cubic feet per second |
| CLSM | controlled low-strength material |
| CPU | central processing unit |
| CVP | Central Valley Project |
| CVPIA | Central Valley Project Improvement Act |
| DC | direct current |
| Delta | Sacramento-San Joaquin Delta |
| DTP | Delta Transfer Pipeline |
| DWR | California Department of Water Resources |
| EBMUD | East Bay Municipal Utility District |
| ECCID | East Contra Costa Irrigation District |
| ECCID Intertie | East Contra Costa Irrigation District's existing Bixler Intake |
| EIR | Environmental Impact Report |
| EIS | Environmental Impact Statement |
| EL | elevation |
| ETPS | Expanded Transfer Pump Station |
| FS | factor of safety |
| ft/sec | feet per second |
| GFCI | ground-fault circuit interrupter |
| HGL | hydraulic grade line |
| HI | Hydraulic Institute |

| | |
|---|---|
| HMI | human machine interface |
| hp | horsepower |
| I&C | Instrumentation and Control |
| I/O | input/output |
| IEEE | Institute of Electrical and Electronics Engineers |
| Investigation | Los Vaqueros Reservoir Expansion Investigation |
| ISA | The Instrumentation, Systems, and Automation Society |
| kPa | kiloPascal |
| ksi | kips per square inch |
| kV | kilovolt |
| kVA | thousand volt amps |
| LED | light-emitting diode |
| LiDAR | Light Detection and Ranging |
| Local Agency Partners | Prospective Bay Area partner water agencies including CCWD, ACWD, Santa Clara Valley Water District, Water Conservation District Zone 7, EBMUD, BAWSCA, BBID, City of Brentwood, East Contra Costa Irrigation District, San Francisco Public Utilities Commission, and San Luis & Delta-Mendota Water Authority |
| LOR | Local/Off/Remote |
| mA | milliamp |
| MCC | Motor Control Center |
| MG | million gallons |
| MG1 | Motors and Generators - 1 |
| mm | millimeter |
| msl | mean sea level |
| MV | medium voltage |
| MVA | thousand volt amps |
| NAD 27 | North American Datum 1927 |
| NEC | National Electrical Code |
| NECA | National Electrical Contractor Association |
| NEMA | National Electrical Manufacturers Association |
| NFPA | National Fire Protection Association |
| OCPD | Overcurrent Protection Device |
| OIU | Operator Interface Unit |
| OM&R | operations, maintenance, and replacement |
| OPCC | opinion of probable construction cost |
| ORP | Old River Pipeline |
| P&ID | Piping and Instrumentation Diagrams |
| PG&E | Pacific Gas and Electric Company |
| PID | Proportional-Integral-Derivative |
| PLC | programmable logic controller |

| | |
|---|---|
| PS | pump station |
| psf | pounds per square foot |
| psi | pounds per square inch |
| PVC | polyvinyl chloride |
| Reclamation | U.S. Department of the Interior, Bureau of Reclamation |
| Refuges | wildlife refuges located south of the Delta that are designated in the CVPIA |
| RT | radiographic test |
| RVSS | reduced-voltage-solid-state |
| SCADA | Supervisory Control and Data Acquisition |
| TAF | thousand-acre-feet |
| TBD | to be determined |
| TCC | Time Current Coordination |
| TCE | temporary construction easement |
| TCP/IP | Transmission Control Protocol/Internet Protocol |
| TDH | Total Dynamic Head |
| TM | Technical Memorandum |
| UL | Underwriters Laboratories |
| UPS | uninterruptable power supplies |
| USACE | U.S. Army Corps of Engineers |
| V | volt |
| VFD | variable frequency drive |
| WSEL | water surface elevation |

# Chapter 1
# Introduction

This technical appendix to the Feasibility Report for the Los Vaqueros Reservoir Expansion Investigation (Investigation) documents the engineering and cost estimate analyses to support federal plan formulation and evaluation. The Investigation is a feasibility study evaluating alternatives to develop environmental water supplies, and improve the reliability and quality of San Francisco Bay Area (Bay Area) water supplies, primarily through the expansion of Los Vaqueros Reservoir in Contra Costa County, California.

## Background

Los Vaqueros Reservoir is located in the coastal foothills west of the Sacramento-San Joaquin Delta (Delta) in the eastern Bay Are ea. Contra Costa Water District (CCWD), owner and operator of the reservoir, provides water for 500,000 customers throughout central and eastern Contra Costa County as one of the largest urban water districts in California (CCWD 2017). CCWD completed construction of the original 100-thousand-acre-foot (TAF) Los Vaqueros Project in 1997. CCWD stores water in Los Vaqueros Reservoir that is diverted from the Delta when water quality is favorable, for later release and blending when Delta water quality is degraded. An initial expansion, Phase 1, to 160 TAF was completed in 2012. The primary purpose of both phases of the project is to address seasonal water quality degradation associated with CCWD's Delta water supplies, and CCWD's dry year reliability. The 160 TAF reservoir also provides important emergency water supply storage and, as secondary benefits, recreation and flood management.

Expansion of the Los Vaqueros Reservoir was one of five potential surface water storage projects identified by the CALFED Bay-Delta Program (CALFED) as warranting further study. In 2001, the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), California Department of Water Resources (DWR), and CCWD began appraisal-level studies of the potential to expand Los Vaqueros Reservoir to address regional water quality and supply reliability needs. The appraisal-level studies indicated that expanding the reservoir to as much as 500 TAF capacity was technically feasible and could provide water quality and supply reliability to agencies in the region, as well as providing potential benefits to fisheries sensitive to water management operations in the Delta.

Subsequently, Reclamation was directed in Public Law 108-7 (Omnibus Appropriations Act of 2003) to conduct a feasibility-level investigation of the potential expansion of Los Vaqueros Reservoir. In 2004, voters in CCWD's service area were asked to vote on whether CCWD should consider expanding the reservoir. The advisory ballot measure won approval, and as a result, the proposed expansion project was further developed and refined through preparation of environmental documentation in accordance with the National Environmental Policy Act and California Environmental Quality Act, and extensive public outreach.

After the Draft Environmental Impact Statement (EIS)/Environmental Impact Report (EIR) was published in 2009 by Reclamation and CCWD, a two-step approach was implemented for expanding Los Vaqueros Reservoir. This was done in order for CCWD to move forward with addressing urgent water supply and quality needs, particularly during dry years, while the feasibility-level investigation was still in process. The initial expansion was completed as a local action by CCWD, without financial assistance from the Federal government. Because it was done without State or Federal assistance, this feasibility-level investigation was put on hold until after completion of the initial expansion. To implement this initial expansion, the CCWD Board of Directors certified the EIS/EIR (Reclamation 2010) and approved an expansion from 100 TAF to 160 TAF on March 31, 2010. Reclamation issued a Record of Decision in February 2011 to enter into an Integrated Operations Agreement with CCWD based on the 2010 EIS/EIR. Construction on the initial expansion began in early 2011 and was completed in 2012.

Reclamation, DWR, and CCWD continue to investigate the feasibility of larger expansion alternatives, as documented in this appendix, because the earlier appraisal-level studies indicated that an additional expansion of Los Vaqueros Reservoir beyond the initial 60 TAF would provide additional regional water supply reliability and statewide environmental benefits. This feasibility-level investigation includes updates to the project plans and studies previously performed to account for significant changes to existing conditions that have occurred since the 2010 EIS/EIR was released, as well as to account for changes that are anticipated to take place within the coming years. These changes include CCWD's initial expansion of Los Vaqueros Reservoir to 160 TAF and the operation of this expanded storage space, other local infrastructure changes (e.g., Contra Costa Canal Replacement Project), likely water management constraints resulting from regulatory actions in the Delta and large programs such as Bay Delta Conservation Plan, and new project beneficiaries to participate in the Investigation.

## Study Location

Los Vaqueros Reservoir is located in the Kellogg Creek watershed of Contra Costa County, California in the central and south Delta. The reservoir lies in the foothills west of the Delta and east of the Bay Area. The study area for the Investigation includes the Los Vaqueros Reservoir watershed and associated facilities, central and south Delta, and service areas of potential local partner water agencies. The central and south Delta is roughly bound by the San Joaquin River on the north and the boundaries of the legal Delta to the south (as established in Section 12220 of the California Water Code). Potential local partner water agencies include CCWD, Alameda County Water District, Santa Clara Valley Water District, the Alameda County Flood Control and Water Conservation District, Zone 7, East Bay Municipal Utility District (EBMUD), Bay Area Water Supply and Conservation Agency (BAWSCA), Byron-Bethany Irrigation District (BBID), City of Brentwood, East Contra Costa Irrigation District (ECCID), San Francisco Public Utilities Commission, and San Luis & Delta-Mendota Water Authority. These are collectively referred to as Local Agency Partners herein. Other potential partners include the CDFW and USFWS, managing agencies of the south-of-Delta

Central Valley Project Improvement Act (CVPIA)-designated wildlife refuges (Refuges), and the Grassland Water District which represents the landowners of those privately owned/managed wetlands also included in these fourteen total Refuges.

Due to the potential influence on other programs and projects, an extended study area was identified for the Investigation. The extended study area includes south-of-Delta Central Valley wildlife Refuges, operational areas of the Central Valley Project (CVP) and SWP, and the service areas of other Bay Area water agencies that may be indirectly affected by project operations.

## Project Objectives

The Investigation focuses on using an expanded Los Vaqueros Project to accomplish the following planning objectives:

### Primary Planning Objectives

- Develop water supplies for environmental water management that supports fish protection, habitat management, and other environmental water needs.

- Increase water supply reliability for water providers within the Bay Area to help meet municipal and industrial water demands during drought periods and emergencies or to address shortages due to regulatory and environmental restrictions.

### Secondary Planning Objective

- Improve the quality of water deliveries to municipal and industrial customers in the Bay Area, without impairing the project's ability to meet the environmental and water supply reliability objectives stated above.

## Final Comprehensive Alternatives Considered in the Feasibility Report

The final Comprehensive Alternatives being evaluated in the Feasibility Report are summarized in Table 1-1. These alternatives are refined options of the original four alternatives evaluated in the 2010 EIS/EIR and account for changes to existing conditions that have occurred since the 2010 EIS/EIR was released (e.g., expansion of Los Vaqueros Reservoir to 160 TAF, completion of other local projects). They also account for changes that are anticipated to take place within the coming years. These alternatives are operated to provide varying levels of emphasis to the above project objectives.

Alternatives 1A, 1B, and 2A would expand Los Vaqueros Reservoir storage from 160 TAF to 275 TAF, build a new Delta-Transfer Pipeline, and relocate the existing Marina Complex and Los Vaqueros Watershed trails and access roads that would be inundated by the reservoir expansion. None of these would occur under Alternative 4A. All of the action alternatives would upgrade the existing Transfer Facility, build a new Transfer-Bethany Pipeline, and add facilities to deliver water to the Transfer Facility from the Rock Slough Intake, which entails building a

new Neroly High-Lift Pump Station. CCWD is also considering the replacement of Pumping Plant #1.

A list of the major components for all the alternatives is provided in Table 1-1 below. Alternatives 1A, 1B, and 2A differ from one another only in the proposed operations of the facilities. Figure 1-1 shows the facilities associated with alternatives 1A, 1B, and 2A. Figure 1-2 shows the facilities associated with alternative 4A.

Table 1-1. Summary of Facilities and Operations for the Revised No-Action and Final Comprehensive Alternatives

| | No Action | Alternatives 1A, 1B, 2A[1] | Alternative 4A |
|---|---|---|---|
| **Existing Facilities (no change)** | | | |
| Old River Intake | 250 cfs | 250 cfs | 250 cfs |
| Middle River Intake | 250 cfs | 250 cfs | 250 cfs |
| Old River Pipeline | 320 cfs | 320 cfs | 320 cfs |
| Los Vaqueros Pipeline | 400 cfs | 400 cfs | 400 cfs |
| Transfer-Los Vaqueros Pipeline (Fill/Release) | 200/400 cfs | 200/400 cfs | 200/400 cfs |
| EBMUD-CCWD Intertie | 155 cfs | 155 cfs | 155 cfs |
| Transfer Reservoir | 4 million gallons | 4 million gallons | 4 million gallons |
| **Proposed Modifications to Existing Facilities** | | | |
| Los Vaqueros Reservoir Capacity | 160 TAF | 275 TAF | 160 TAF |
| Los Vaqueros Reservoir Maximum Water Surface Elevation | 507 feet | 560 feet | 507 feet |
| Transfer Pump Station Capacity | 150 cfs | 200 cfs | 200 cfs |
| **Proposed New Facilities** | | | |
| Transfer-Bethany Pipeline Capacity | None | 300 cfs | 300 cfs |
| Delta-Transfer Pipeline Capacity | None | 180 cfs | None |
| Expanded Transfer Facility Pump Station Capacity | None | 300 cfs | 300 cfs |
| Expanded Transfer Facility Storage Reservoir Capacity | None | 5 million gallons | 5 million gallons |
| Neroly High-Lift Pump Station Capacity | None | 350 cfs[2] | 350 cfs[2] |
| Pumping Plant #1 Capacity | 200 cfs | 350 cfs | 350 cfs |
| **Los Vaqueros Watershed Facilities** | | | |
| Los Vaqueros Marina Complex | No change | Relocated upslope | No change |
| Los Vaqueros Watershed Trails | None | Expanded | None |
| Los Vaqueros Interpretive Center | No change | Improved | Improved |
| Los Vaqueros Watershed Office Barn | No change | Seismically upgraded and improved | Seismically upgraded and improved |
| **Associated Local Projects[3]** | | | |
| EBMUD Mokelumne Aqueduct relining | None | Included | Included |
| EBMUD Walnut Creek Pumping Plant Variable Frequency Drives | None | Included | Included |
| EBMUD-CCWD Intertie Pump Station | None | 155 cfs | 155 cfs |
| Brentwood Pipeline | None | Included | Included |
| ECCID Intertie | None | 80 cfs | 80 cfs |

Notes:

[1] Alternatives 1A, 1B, and 2A differ from one another only in the proposed operations of the facilities.

[2] Permitted capacity is 350 cfs as defined in the Supplement to the Final EIS/EIR. 300 cfs is the capacity modeled and designed under the Feasibility Study to reflect the current operation requirements.

[3] Local Projects developed separately from the Feasibility Study, but linked to the operations of the project.

Key:
CCWD = Contra Costa Water District
cfs = cubic-feet per second
EBMUD = East Bay Municipal Utility District
ECCID = East Contra Costa Irrigation District
TAF = 1,000 acre-feet

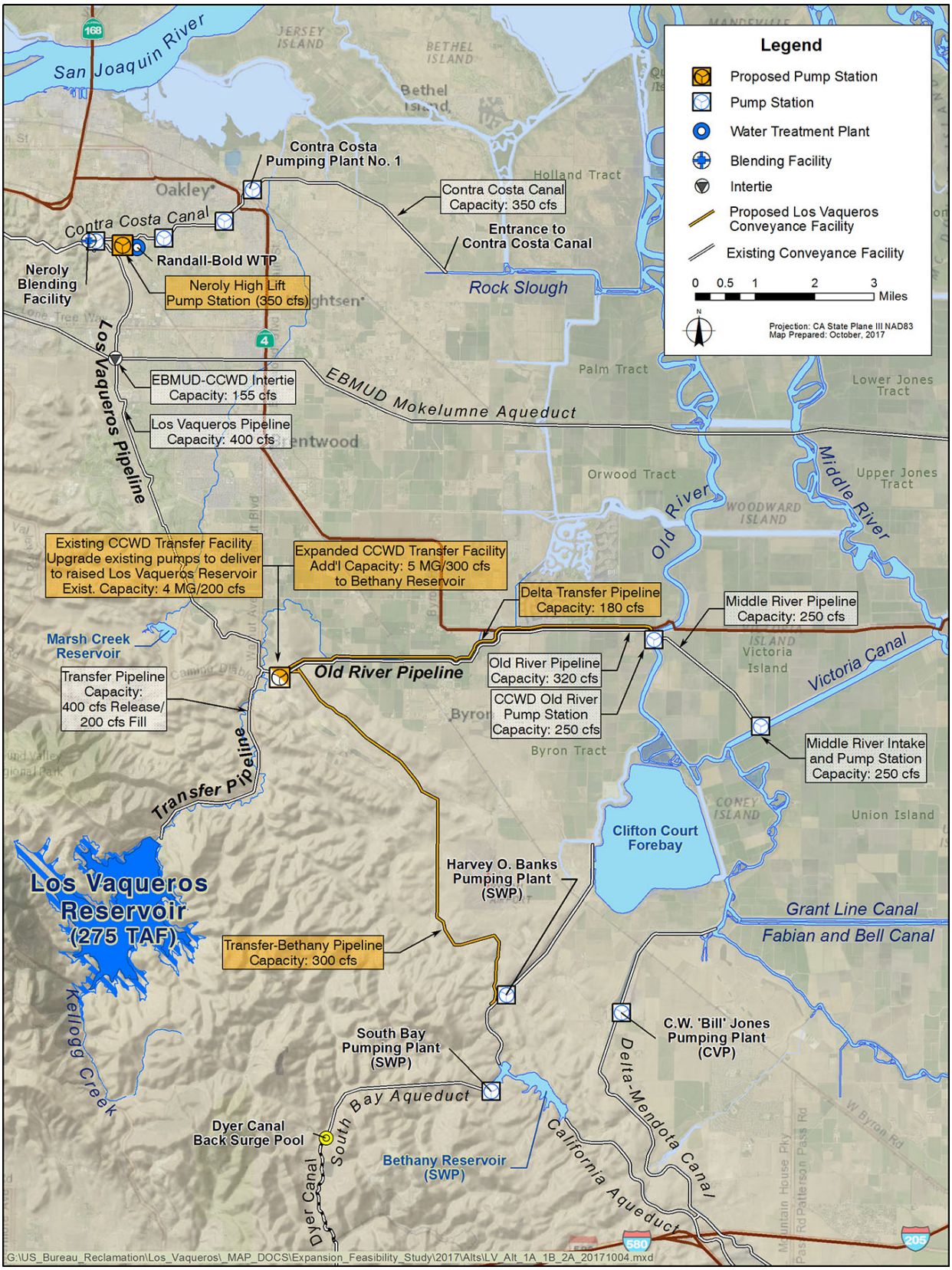


Figure 1-1. Major Components of Alternatives 1A, 1B, and 2A

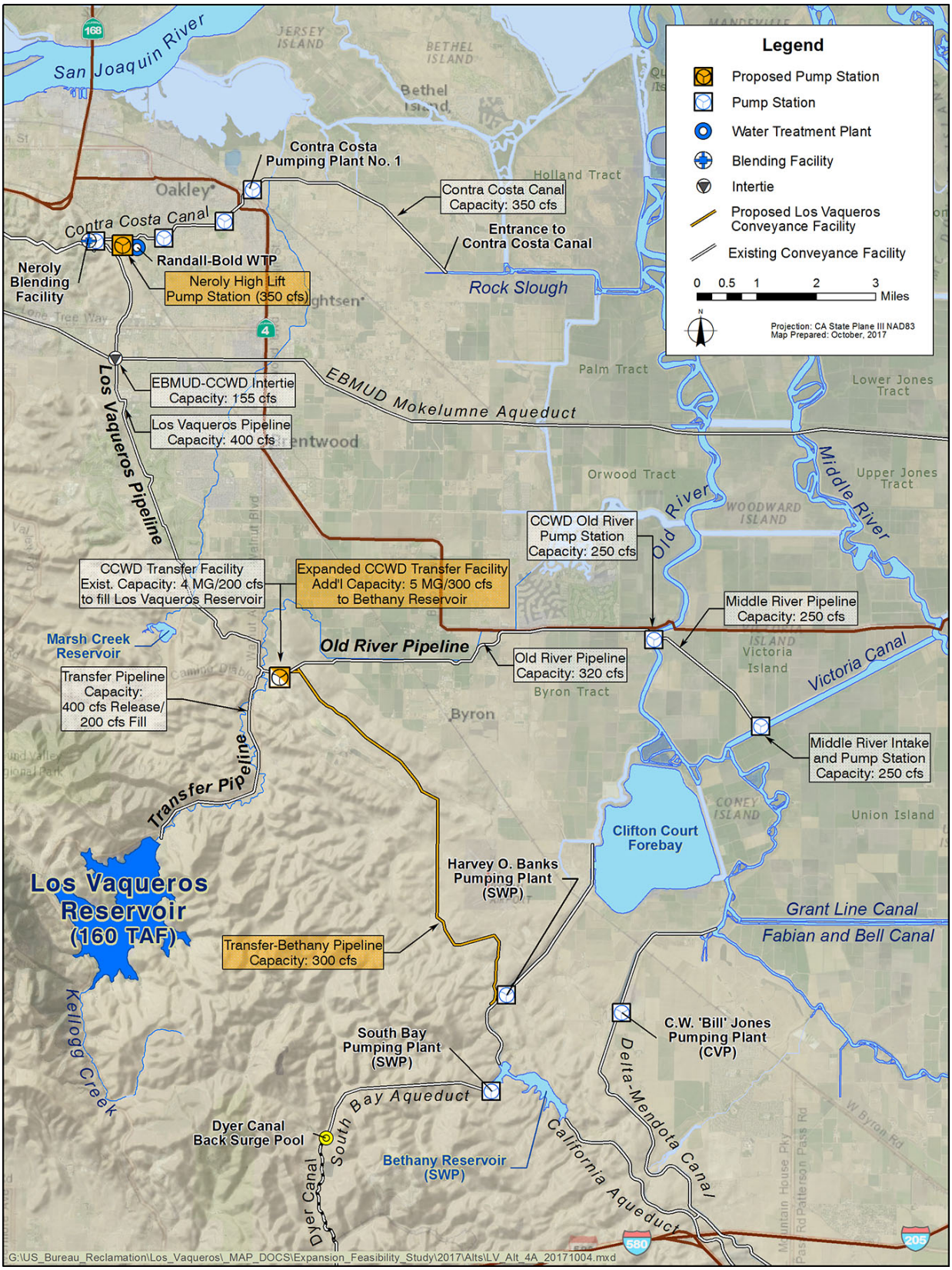


Figure 1-2. Major Components of Alternative 4A

### Alternative 1A

Alternative 1A is formulated to maximize deliveries for water supply reliability to the Local Agency Partners, including drought and emergency supply reliability. The operations follow these four priorities:

1) Available water (Delta surplus and Local Agency Partners' water rights and contracts) would first be delivered to meet Local Agency Partner demand, if any.

2) If water and CCWD system capacity were still available, water would then be stored in Los Vaqueros Reservoir for later use by the Local Agency Partners.

3) If additional CCWD system capacity were still available and if CVP north-of-Delta storage conditions allowed withdrawals (high storage conditions only), the next priority would be to wheel CVPIA Level 2 Refuge water through CCWD facilities for delivery to the Refuges. Conducted in coordination with Refuge managers, this operation would release capacity at Jones Pumping Plant that could them be used to move additional water to CVP south-of-Delta contractors. This wheeling operation would not provide additional water supply to the Refuges; rather the released capacity at Jones Pumping Plant could be used to make additional CVP allocations or water transfers.

4) If water and CCWD system capacity were still available after the above three operations, additional deliveries would then be made to help meet Incremental Level 4 Refuge demand.

### Alternative 1B

Alternative 1B includes the same facilities as Alternative 1A. Alternative 1B is formulated to maximize potential project deliveries to both Local Agency Partners and Refuges. Alternative 1B balances the priorities of water supply reliability to the Local Agency Partners with environmental water management for the Refuges. The operations follow these four priorities:

1) Available water (Delta surplus and Local Agency Partners' water rights and contracts) would first be delivered to meet Local Agency Partner demand, if any.

2) If water and CCWD system capacity were still available, additional deliveries would then be made to help meet Incremental Level 4 Refuge allocations.

3) If water and CCWD system capacity were still available, water would then be stored in Los Vaqueros Reservoir for later use by the Local Agency Partners or Refuges.

4) If additional CCWD system capacity were still available after the above three operations, the next priority would be to wheel Delta surplus water through CVP facilities to meet Level 2 Refuge demands. Conducted in coordination with the Refuge managers, this operation would release capacity at Jones Pumping Plant to move additional water to CVP south-of-Delta contractors. Wheeling would not provide a new water supply to the Refuges; rather the released capacity at Jones Pumping Plant could be used to make additional CVP allocations or water transfers.

### Alternative 2A

Alternative 2A includes the same facilities as Alternatives 1A and 1B. Alternative 2A is formulated to maximize potential project deliveries to the Refuges, prioritizing environmental water management operations. The operations follow these three priorities:

1) Available water (Delta surplus and Local Agency Partners' water rights and contracts) would first be delivered to help meet Incremental Level 4 Refuge allocations.

2) If water and CCWD system capacity were still available, water would then be stored in Los Vaqueros Reservoir for later use by the Refuges.

3) If water and CCWD system capacity were still available after the above two operations, additional deliveries would be made to meet any Local Agency Partner water supply needs.

### Alternative 4A

Alternative 4A would not expand the existing 160 TAF Los Vaqueros Reservoir storage capacity or build a new Delta-Transfer Pipeline but would make all of the other major physical improvements identified for Alternatives 1A, 1B, and 2A. Alternative 4A would include an upgrade of the Transfer Facility, a new Transfer-Bethany Pipeline, and facilities to enable filling of Los Vaqueros Reservoir from the Rock Slough Intake. Similar to Final EIS/EIR Alternative 4, Alternative 4A has a Los Vaqueros Reservoir storage capacity of 160 TAF. Alternative 4A uses similar operational priorities as Alternative 1B, with the exception of the wheeling operation, which is not included. Alternative 4A is formulated to maximize potential project deliveries to both the Local Agency Partners and Refuges, but without the benefit of expanded storage in Los Vaqueros Reservoir.

## Organization of This Appendix

This appendix is organized as follows:

**Chapter 1**, **Introduction**, provides an overview of the Investigation.

**Chapter 2, Engineering Setting**, summarizes the existing Los Vaqueros Project and related facilities, and the geotechnical analyses.

**Chapter 3, Design Criteria,** describes the design criteria for the new facilities.

**Chapter 4, Dam and Reservoir Elements**, documents dam and related designs for expansion of Los Vaqueros Reservoir from 160 TAF to 275 TAF. Design drawings for the dam raise are included in Attachment E.

**Chapter 5, Conveyance, Pumping Facilities, and Related Facilities,** documents design activities related to the conveyance, and pumping facilities considered in the alternatives, and includes facility layouts, hydraulic review, and other conceptual designs. Detailed drawings (10 percent level of design) for the conveyance elements are included in Attachment 3.

**Chapter 6**, **Asset Relocations**, summarizes required major relocations associated with the expanded reservoir and conveyance facilities.

**Chapter 7, Construction Schedule and Cost Estimates,** documents the "Class 4" estimates of probable cost prepared for each of the alternatives.

**Chapter 8, References**, lists the sources used in preparing this technical appendix.

This appendix also includes design drawings and supporting technical reports, included as attachments. These attachments, referenced throughout this document, include the following:

- **Attachment 1– Geotechnical and Seismic Evaluations (Conveyance Facilities)** documents existing and available geotechnical information used to support design of conveyance and pumping facilities.

- **Attachment 2 – 275 TAF Dam Design and Cost Estimates** documents the design of the 275 TAF dam raise and appurtenant facilities, including the stability and seismic analysis, embankment materials, design drawings, and cost estimates.

- **Attachment 3 – Conveyance & Pumping Design Drawings** includes drawings for the conveyance and pumping elements of each of the alternatives under consideration by the Investigation.

- **Attachment 4 – Construction Schedule and Cost Estimate** documents the construction schedule and cost estimates each of the alternatives.

- **Attachment 5 – Relocations** includes drawing related to existing facilities that would need to be relocated as part of an expansion project.

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# Chapter 2
# Engineering Setting

This chapter describes major existing facilities, available geotechnical data, and established engineering design criteria for the expansion project. The engineering design criteria provide the engineering parameters necessary for the feasibility-level engineering design work presented in this appendix.

## Existing Facilities

The existing Los Vaqueros Project provides 160 TAF of offstream water storage to improve water quality and provide emergency water supplies for CCWD customers. Water is diverted from the Delta at the Old River Intake and Pump Station, and Middle River Intake and Pump Station, and pumped to Los Vaqueros for storage. Water can be delivered by gravity to the Contra Costa Canal, or can be pumped directly from the Old or Middle rivers to the Contra Costa Canal, for blending with other CCWD water supplies to meet CCWD water quality targets.

The existing Los Vaqueros Project comprises the primary facilities described in this section. These facilities, in conjunction with proposed new facilities, are included in the various action alternatives described in Chapter 1.

### Old River Intake and Pump Station

The Old River Intake and Pump Station are located on a 16.8-acre site adjacent to the Old River, immediately south of the Highway 4 crossing. The facility diverts water from the Old River through a positive barrier fish screen with an area of 1,250 square feet. The pumping plant includes five fixed speed 50 cubic feet per second (cfs) pumps with a total capacity of 250 cfs. The intake was configured to accommodate an additional 70 cfs of intake capacity with additional fish screens.

### Old River Pipeline

The Old River Pipeline is a 78-inch-diameter (American Water Works Association (AWWA) C300) reinforced concrete cylinder pipe that conveys water from the Old River Pumping Plant to the Transfer Reservoir and Pump Station and to the Los Vaqueros Pipeline. The Old River Pipeline has a capacity of 320 cfs, is 34,700 feet long, and lies within an 85-foot-wide right-of-way.

### Middle River Intake and Pump Station

The Middle River Intake and Pump Station, was constructed in 2010 to provide more pumping capacity to the Transfer Facility and onward to other associated CCWD infrastructure. This facility lifts water from Victoria Canal (roughly southeast of the existing Old River Intake and Pump Station) to the Transfer Facility for delivery to Los Vaqueros Reservoir or the Contra Costa Canal. The current configuration includes five pumps, three fixed speed 50 cfs pumps and two with variable frequency drives, with a total capacity of 250 cfs.

### Middle River Pipeline

The Middle River Pipeline conveys the Middle River Pump Station discharge approximately 30,000 feet across Victoria Island before tunneling beneath the Old River and connecting to the Old River Pipeline. The pipeline is constructed of 72-inch diameter steel pipe with cement mortar lining and coating and has a capacity of 250 cfs. Three butterfly isolation valves are installed in the pipeline, one valve is located on the Middle River Pump Station site and two valves are located on either side of the Old River tunnel crossing. The pipeline includes an impressed current cathodic protection system; the cathodic protection system has two deep bed anodes installed at the Middle and Old River Pump Stations.

### Transfer Reservoir

The Transfer Reservoir serves as the hydraulic grade line control for the conveyance system. The 4-million-gallon (MG) reservoir provides a stable pumping head for the Old River Pump Station and Transfer Pump Station (and would serve similar functions for proposed facilities). It also provides hydraulic control for operation of Flow Control Stations 1 and 2, and necessary storage for operation of the system. The Transfer Reservoir includes an emergency overflow, which prevents pressure buildup in the Los Vaqueros and Old River pipelines if Flow Control Station 1 is not functioning properly. This existing overflow is sized to convey gravity flows of up to 500 cfs, based on uncontrolled flow, in the Transfer Pipeline from Los Vaqueros Reservoir.

### Transfer Pumping Plant

The Transfer Pumping Plant is currently used to lift water from the Old River Pipeline to Los Vaqueros Reservoir. The design capacity of the existing pumping plant is 200 cfs, provided by four fixed speed pumps rated at 50 cfs each. The Old River Pumping Plant operates at a flow rate equal to or greater than the flow rate at the Transfer Pumping Plant to deliver water to Los Vaqueros Reservoir. When Old River Pumping Plant flow exceeds flow from the Transfer Pumping Plant, the excess flow is delivered to the Contra Costa Canal through the Los Vaqueros Pipeline.

### Flow Control Station 1

The existing Flow Control Station 1 controls the rate of flow from Los Vaqueros Reservoir to the Contra Costa Canal. This station dissipates excess energy (head) in the Transfer Pipeline when water is released from Los Vaqueros Reservoir.

### Flow Control Station 2

The existing Flow Control Station 2 controls the water surface level in the Transfer Reservoir as well as the maximum downstream water surface elevation in the Contra Costa Canal. This station dissipates excess energy (head) in the Los Vaqueros Pipeline to help maintain a stable water level in the Transfer Reservoir.

### Transfer Pipeline

The existing Transfer Pipeline is a 72-inch-diameter steel pipe, mortar-lined and mortar-coated (AWWA C200), which conveys water to and from Los Vaqueros Reservoir. The Transfer Pumping Plant pumps water through this pipeline into Los Vaqueros Reservoir, and deliveries from the reservoir flow by gravity to the junction with the inlet to Flow Control Station 1. The pressure rating of the pipe varies along the pipeline from 100 pounds of pressure per square inch

(psi) to 200 psi. The Transfer Pipeline is 19,600 feet long and can convey up to 200 cfs from the Transfer Facility to the reservoir, and 400 cfs from the reservoir to the Transfer Facility.

### Los Vaqueros Pipeline

The existing Los Vaqueros Pipeline conveys water by gravity from the discharge of Flow Control Station 1 (junction of the Transfer Pipeline and Old River Pipeline) to the delivery point at within an 85-foot right-of-way, the pipeline consists of two continuous segments: the first is 18,000 feet long with 96-inch-diameter pipe, and the second is 29,000 feet long with 90-inch-diameter pipe. The pipeline has a capacity of 400 cfs.

### Los Vaqueros Dam and Reservoir

Los Vaqueros Dam is a zoned earthfill embankment dam located on Kellog Creek. The crest of the dam, at an elevation of 523 feet, is about 230 feet above the downstream toe. The dam comprises an embankment volume of approximately 3.8 million cubic yards, and has a crest width of 30 feet and length of 1,300 feet. Releases are made via a variable-elevation outlet gallery. The reservoir formed by the dam has a capacity of 160 TAF at gross pool.

### Mokelumne Aqueduct Intertie

A 52 cfs intertie between EBMUD's Mokelumne Aqueduct and CCWD's Los Vaqueros Pipeline was completed in 2007. The intertie is being used to fill Los Vaqueros Reservoir or for direct delivery to CCWD. Water delivered from the Mokelumne Aqueduct is of very high quality (averaging 7 to 8 milligrams per liter chloride) compared with CCWD's Delta supplies, and has a recognizable positive impact on Los Vaqueros operations. Operation standards/requirements related to the intertie include the following:

- Deliveries will be made preferentially to Los Vaqueros Reservoir, with deliveries made directly to the Contra Costa Canal only when the reservoir was full or if water was needed to meet an immediate CCWD water quality target.

- Deliveries will be made from the intertie to the Transfer Facility via gravity (pressure in the Mokelumne Aqueduct is sufficient to deliver water through reverse flow to the Transfer Facility, from which it would be pumped to Los Vaqueros Reservoir).

- Reservoir releases and/or Old River Pipeline deliveries to CCWD cannot be made while Mokelumne Intertie deliveries are being made to Los Vaqueros Reservoir (a single pipeline is available for both actions).

## Surveying and Mapping Information

Surveying and mapping information to support the feasibility level design were obtained from the original Los Vaqueros Project information, as well as from information obtained spec filly for this Investigation.

### Survey Datum and Benchmarks

Survey horizontal datum was based on the California State Plane System, Zone 3 for North American Datum 1927 (NAD 27) Survey vertical datum was based on the National Geodetic

Vertical Datum (NGVD 1929) in U.S. survey feet. The horizontals and vertical datums are selected to maintain consistency with the original Los Vaqueros Project technical documents.

The Record drawings for the original Los Vaqueros Project provided a listing of the horizontal coordinate locations (in the NAD 27–based California Coordinate Systems) for pumping plant facilities property lines. The pipelines rights-of-way and temporary construction easements are also identified, primarily by dimensioned offsets from the pipeline centerline, with identified horizontal coordination locations.

### Aerial Imagery

2014 aerial images were purchased from Contra Costa County. The 2014 images were based on the survey horizontal datum of California State Plane System, Zone 3 for North American Datum 1983. The 2014 images were converted to the NAD 27 to fit the horizontal control used for the original Los Vaqueros System Project. The 2014 images reflect a near-current depiction of surface visible facilities, and are sufficient to support and conduct the feasibility-level designs.

### Topographic Information

Available survey and mapping for the original Los Vaqueros Project were conducted in December 1991 covered a mapping area of approximately 101,000 lineal feet by 1,250 feet, and included the Los Vaqueros, Transfer and Old River Pipeline alignments and Old River Intake and Transfer Facility sites. Digital topographic mapping was produced for mapping accuracy standards for 2-foot and 1-foot contour interval mapping, respectively for the pipelines and pumping plant facilities. Spot elevations were shown in appropriate locations and at a minimum of 50-foot intervals through flat areas.

Light Detection and Ranging (LiDAR) mapping produced in 2007 for mapping accuracy standards for 2-foot contour interval mapping was obtained. The 2007 LiDAR mapping is considered a useful tool to readily assess changes in the topography that have occurred in the years since 1991, particularly along long stretches of the pipeline alignments.

The original Los Vaqueros Project topography will be used for the majority of the feasibility-level pipeline designs, given the availability of detailed information on the existing pipelines. At some locations, such as the expanded transfer facility and reservoir, the 2007 LiDAR mapping will supplement the 1991 mapping information due to limited 1991mapping coverage.

## Geotechnical Analysis

Geotechnical characteristics and potential design and construction issues for the conveyance and pumping facilities is included in Attachment 1, and summarized in Table 2-1. Attachment 1A contains a March 2007 feasibility-level geotechnical and seismic evaluation based on existing data and considering project facilities proposed at that time. Attachment 1 B contains an October 2015 addendum to the Attachment 1A evaluation with consideration of the currently proposed project facilities. The Mokelumne-Transfer Pipeline and Expanded Old River Intake and Pump Station, discussed in Attachment 1B, have since been removed from the proposed project. The Neroly Pump Station and Transfer-Bethany Pipeline are currently at the appraisal level of design and will include geotechnical evaluations in the next design phase.

The new and modified conveyance and pumping facilities are grouped in three areas as functions of general site subsurface conditions and anticipated performances, as follows:

- **Area 1** – Delta-Transfer Pipeline (Sta. 0+00 to Sta. 100+00) and Expanded Old River Intake and Pump Station;

- **Area 2** – Delta-Transfer Pipeline (Sta. 100+00 to Sta. 250+00); and

- **Area 3** – Delta-Transfer Pipeline (Sta. 250+00 to Sta. 375+00), Transfer-LV Pipeline, Mokelumne-Transfer Pipeline, Expanded Transfer Pump Station and Transfer Pump Station.

Surface faulting is not a hazard at the new and modified facilities because no active faults that would rupture the surface are identified in the project area (DWR 2009).

It is assumed that the new and modified facilities could not be struck by a tsunami because the project area is located within the San Joaquin Delta at least 50 miles from the Pacific Ocean. Although no maps of tsunami hazards in the Delta were found in the publications reviewed, potential risks of catastrophic inundation are assumed to be small. This is because the tsunami hazards map west of the Delta area indicates a maximum inundation of 3 feet above mean sea level and tsunami effects would be attenuated in Suisun and Grizzly bays before reaching the Delta area (DWR 2016).

Table 2-1. Geotechnical Characteristics and Potential Design and Construction Issues

| Subject | Area 1 | Area 2 | Area 3 |
|---|---|---|---|
| Predominant Geotechnical Characteristics | Saturated medium stiff silty clay / clayey silt, loose silty sand / sandy silt, and muck | Partially saturated medium stiff to stiff silty clay / clayey silt, and loose silty sand / sandy silt | Dry stiff to hard silty clay / clayey silt, and dense silty sand / sandy silt |
| Design and Construction Issues: | | | |
| *Pipe Buoyancy* | Yes | No | No |
| *Delta Subsidence* | Yes | No | No |
| *Bearing Capacity* | Yes | Possible [1] | No [4] |
| *Settlement* | Yes | Possible [1, 2] | Yes [5, 6] |
| *Trenching and Temporary Excavation* | Yes | Yes [2] | Yes, localized [5, 6] |
| *Seismic Shaking* | Yes | Yes [2] | Yes [5, 6] |
| *Irrigation and Drainage Crossings* | Yes | Yes [2] | No |
| *Road Crossings* | No | Yes | Yes |
| *Creek Crossings* | No | Yes [2] | Yes [2] |
| *Canal Crossings* | No | Yes [2] | No |
| *Borrow Sources* | Yes | Possible [3] | No |
| *Corrosion Potential* | Yes | Yes [2] | Yes |
| *Expansive Soils* | Yes | Yes [2] | Yes [2] |
| *Levee Failure* | Yes | No | No |
| *Scour* | No | No | Possible [3] |
| *Rock Excavation* | No | No | Possible [3] |

Notes:

Yes = issues are expected; No = issues are not expected; Possible = potential issues to be confirmed in next design phase.

[1] Possible issues for structures that might be built in Area 2; no issues are expected for the pipeline.

[2] Issues similar to those described in Area 1 (see Area 1 for descriptions of issues)

[3] Possible issues that cannot be currently confirmed due to insufficient information.

[4] No bearing capacity issues are expected at Expanded Transfer Pump Station and Transfer Pump Station, but allowable bearing pressure is provided in Area 3.

[5] Issues are expected to be localized adjacent to Kellogg Creek where the soils could be soft / loose and saturated.

[6] Localized issues adjacent to Kellogg Creek similar to those described in Area 1 (see Area 1 for descriptions of issues).

A geotechnical evaluation was performed for the Los Vaqueros Dam raise element and is included in **Attachment 2**.

# Chapter 3
# Design Criteria

Engineering criteria were developed for the feasibility study based on previously accepted criteria identified for the Los Vaqueros Project, industry practice, codes and standards, and professional judgment. These criteria are appropriate for defining project elements, and developing feasibility-level construction estimates for use in comparing and screening alternatives. The design criteria should be reviewed and updated prior to beginning a detailed design effort.

Design criteria for conveyance and pumping facilities are presented below. Neroly Pump Station and Transfer Bethany Pipeline are not specifically addressed but the fundamental criteria would also apply to these facilities, which are further described in Chapter 5 of this document. Dam and Reservoir elements are described in Chapter 4 of this document.

## General

Project facilities covered by the design criteria presented in this section include new pipelines, pump stations, and associated appurtenant facilities.

The 66-inch diameter Delta-Transfer Pipeline, will be routed parallel to the existing 78-inch diameter Old River Pipeline to convey water from Old River and Middle River Intake Pump Stations to the raw water storage and distribution system. The pipeline will tie into existing piping at the Old River Intake facility and at the Transfer facility. The pipeline will include isolation valves and a flow meter.

The Expanded Transfer Pump Station, will be located adjacent to the existing Transfer Pump Station, and will have the capability to pump water from both the Old River and Delta Transfer pipelines to Bethany Reservoir. The pump station will include six – 50 cfs capacity vertical turbine pumps, a new electrical substation, and a Motor Control Center (MCC). A new 5 MG reservoir will be located adjacent to the pump station and will provide hydraulic grade line (HGL) control for the Old River and Middle River pump stations, among other hydraulic functions.

All elevations used on the Project are referenced to the National Geodetic Vertical Datum of 1929.

## Civil

This section provides civil discipline design criteria.

## Conveyance Pipeline Design Criteria

Key conveyance pipeline design considerations and design criteria for the Delta Transfer Pipeline addressed herein include hydraulic capacity, pipe material selection, pipe design pressures, flow velocity, pipe structural design, fittings and specials, and pipe joints. The proposed Delta-Transfer Pipeline would begin at a connection to the 78-inch Old River Pipeline vertical riser section on the Old River Pump Station site and extend to the 96-inch Los Vaqueros Pipeline connection on the Transfer Facility site.

### *Hydraulic Criteria*

The hydraulic design criteria are presented in the Operational, Hydraulic, and Mechanical section of this chapter. A principal goal of the hydraulic analysis is to establish a recommended diameter for the Delta-Transfer Pipeline. The design flow capacity and recommended diameter for the Delta Transfer Pipeline is shown in Table 3-1.

Table 3-1. Summary of Proposed Pipeline Size and Flow Rate

| Pipeline | Design Flow Rate (cfs) | Pipeline Diameter (inches) | Approximate Length (feet) |
|---|---|---|---|
| Delta-Transfer | 180[1] | 66 | 37,320[2] |

Notes:
[1]Assumes that the existing 78-inch diameter Old River Pipe delivers approximately 320cfs to the Transfer Facility
[2]The pipe length extends from the connection to the 78-inch Old River Pipeline vertical riser section on the Old River Pump Station site and extends to the 96-inch Los Vaqueros Pipeline connection on the transfer Facility site.
Key:
cfs= cubic feet per second

The hydraulic evaluations also provide input to development of design criteria related to working pressures, transient pressures and flow velocity as described in paragraphs below.

### *Pipe Material*

A pipeline material evaluation was performed during the original Los Vaqueros Project. The evaluation identified two suitable pipe material options: welded steel pipe per AWWA C200 and reinforced concrete cylinder pipe per AWWA C300. These materials were judged to be suitable for installation based on the rugged nature of construction, ability to meet the project's pressure requirements, flexibility with fittings and connections, ability to resist thrust, and performance during seismic events. Both pipe types are considered potentially viable for the currently planned facilities, and in the past a minimum of two pipe materials were included in the design to encourage increased competition among pipe suppliers of different pipe materials. However, steel pipe with welded joints provides a more seismically resilient pipe system which is considered to provide superior performance under design seismic conditions. Therefore the design criteria, plans, and cost estimates are based on the use of welded steel pipe. Further analysis should be conducted during design development to evaluate the market conditions and the number of manufacturers capable of delivering each pipe type before a final decision is made on inclusion of reinforced concrete cylinder pipe in the final design.

**Lining** Steel Pipe with a diameter of 66 inches and under shall have a factory spun cement mortar lining per AWWA C205. This is consistent with the lining for the adjacent Old River Pipeline.

**Coatings** The buried AWWA C200 steel pipe for the Old River Pipeline has a 1-inch minimum thick cement mortar coating per AWWA C205 with a 25-mil overcoat of 100 percent solids coal tar epoxy. Coal tar epoxy is not usually specified due to manufacturing application limitations associated with its use, and concerns about potential carcinogenic effects. For this reason, a flexible coating is recommended for the steel pipe in lieu of the cement mortar coating. Flexible coatings may be either be a polyethylene tape wrapped coating per AWWA C214 or a polyurethane coating per AWWA C222. Heat shrink sleeves are recommended for coating all pipe joints in the field per AWWA C216.

Pipe specials, fittings, and flanges shall be field coated with cold-applied petrolatum and petroleum wax tape, in accordance with AWWA C217. The exterior protection of all irregular-shaped fittings will require filler approved by the wax tape manufacturer. Wax tapes are subject to mechanical and soil stress, and must be protected with an outer wrap of fiberglass mat or suitable tape. Total applied thickness to be specified will depend on both soil and service conditions; however, at no time shall the thickness of the tape be less than 40 mils.

### *Design Pressures*

Key pipeline design pressures are discussed in the following paragraphs.

**Working Pressure** The working pressure is defined as the maximum operating pressure at various points along the pipeline based on the maximum pumped HGL while flow is delivered through the Delta Transfer Pipeline to the terminal reservoirs located at the Transfer Pump Station site. Since the pipeline may be fed from either the Middle River or Old River Pump Station or both, several operating conditions must be considered. The working pressure at any point along the alignment is equal to the difference between the maximum HGL and the pipe centerline elevation. This maximum working pressure is presented under the Operational, Hydraulic, and Mechanical section.

Pipe pressure classes will be developed starting at 50 psi and increasing in 25 psi increments up to the maximum pressure class required. For the Delta Transfer Pipeline, the pressure class starts at 200 psi at the lower elevations near the Old River pump station and decreases to a 50-psi pressure class at the high elevations near the Transfer Facility. The pipe extending past the terminal reservoirs to the connection point with the 96-inch Los Vaqueros Pipeline will be 50-psi pressure class. Stationing corresponding to the beginning and ending limits of each pressure class will be developed during the design development stage.

**Transient Pressures** Hydraulic transient pressures result from sudden velocity changes in the water flowing through a pipeline. These transient (or surge) pressures can propagate from closing a valve too rapidly or may result from an electrical power failure at a pump station that causes a sudden pump shut down. Other causes may include modulating a regulating valve too quickly or a sudden release of entrapped air from the pipeline. The most common cause of a pipeline surge condition for a pumped water transmission main is electric power failure at the pump station.

Pipelines will be provided with appurtenant features, as required, to assure that maximum transient pressures do not exceed 133 percent of the steady state design pressure. Appurtenant features may include hydrodynamic surge tanks.

**Pump Shutoff Pressure** There are mainline isolation valves on the Delta Transfer Pipeline just downstream of the meter vault on the Old River Pump Station site and just prior to the terminal reservoir turnout connection at the Transfer Facility site. If the isolation valve near the reservoir turnout should be closed, and either pump station is on line, the pumps would be pumping against a closed valve and the pressure in the pipeline would rise to the full pump shutoff pressure. Based on preliminary pump selections, the pump shutoff HGL is approximately 655 feet. The resulting pump shutoff pressures must also be considered in the design of the pipe. Based on an assumed 655-foot HGL, the maximum shutoff pressure in the pipe near the Old River Pump Station (where the pipe centerline is at approximately -20 feet elevation) is approximately 293 psi.

**Test Pressures** Test pressure is the pressure in the pipeline during pressure testing. The test pressure should be limited to 1.33 times the working pressure.

### *Flow Velocity*

The velocity of the flow will control the amount of headloss in the pipeline for any given pipe diameter. As the pipe diameter decreases and the velocity increases, the headloss in the pipeline increases. If the headloss is too high, the pipeline is not efficiently sized for the required flow. There is a trade-off between increased pipe cost for a larger pipe diameter and increased pumping energy costs. Also, higher velocities increase the potential for more severe hydraulic transient conditions.

Typically the most efficient pipeline sizing for a pumped water transmission line coincides with a maximum velocity in the range of 7 to 8 feet per second (ft/sec). The design velocity for the 66-inch-diameter Delta Transfer Pipeline is approximately 7.5 ft/sec. Typically, the maximum desired velocity for cement mortar lined pipe in continuous service is approximately 10 ft/sec. However, pipelines and valving systems can occasionally accommodate much higher velocities without damage, including velocities as high as 15 ft/sec through flow valves. Velocities through valves are usually limited to prevent damage to valve seats.

### *Pipe Structural Design*

The water transmission pipe design must be integrated with the design of all the system elements including the upstream pump stations to ensure that the pipelines will be capable of withstanding all design pressure and operating conditions. The system hydraulics evaluation is the overarching information that must be used to correctly design the pipe. Pipes shall be capable of withstanding the maximum internal pressures (working/test/shutoff/surge) and the maximum external loading configuration acting independently on the pipe. No reduction of external loads due to internal pressure will be allowed.

Steel pipe is considered a flexible pipe system and will be designed using the flexible pipeline design methods noted in AWWA M11, “Steel Pipe – A Guide for Design and Installation.” All steel pipe will be consistent with the requirements of AWWA C200 and other AWWA standards as referenced elsewhere in this design criteria document, except where project specific criteria are more stringent.

There are three main parts to steel pipe design:

1. Hoop stress and handling requirements.

2. Deflection limitation.

3. Buckling avoidance.

Design criteria for each of these topics is discussed in the following sub-sections.

**Hoop Stress and Handling Requirements**

*Hoop Stress Requirements* Waterlines are subject to hydraulic pressures within the pipeline and must have adequate pipe wall strength to resist the induced stresses with a suitable factor of safety. The greater wall thickness for the pipe, defined by internal hydrostatic pressures from the working, test, surge, or shutoff head conditions, will control the hoop stress design. Dynamic forces (thrust stresses) are included in the pipeline design only if their additive stress to internal pressure, Poisson's ratio, temperature stresses, and other applied stresses (total stress condition) would exceed the allowable stress for the selected steel.

Hoop stress is calculated based on applied hydraulic pressures within the pipeline and the allowable stress in the steel must be factored to provide a suitable factor of safety (FS) for design. Typically, the design must consider both maximum working pressure and pump shutoff pressure for pumped systems. Design hoop stress calculations must also consider test pressures and transient (surge) pressures. The following Table 3-2 summarizes the various design pressures, and factors of safety established for use in hoop stress calculations. Note, in some cases these factors of safety are more conservative than AWWA M-11 Guidelines.

Table 3-2. Pipeline Design Pressures and Factors of Safety

| Design Pressure Condition | Factor of Safety | Allowable Stress (psi) [2] | Percent of Yield | Comment |
|---|---|---|---|---|
| Working Pressure[1] | 2.0 | 21,000 | 50.0% | |
| Test Pressure | 1.5 | 28,000 | 66.7% | Test Pressure is established at 1.33 times working pressure |
| Transient Pressure | 1.5 | 28,000 | 66.7% | Transient Pressure limited to 1.33 times working pressure |
| Pump Shutoff Pressure | 1.5 | 28,000 | 66.7% | Based on actual pump shutoff |

Notes:
[1] Maximum operating pressure for pumped pipelines and maximum static pressure for gravity pipelines
[2] Assumes 42,000 psi Minimum Yield Steel
Key:
psi = pounds per square inch

The hoop stress calculation is based on the Barlow (AWWA M11 § 4.1) formula:

$$P = \frac{2tS}{D}$$

Where: $S$ = the allowable hoop stress (psi).

$t$ = pipe wall thickness (inches).

$D$ = Pipe OD (inches) –outside diameter of the steel can.

P = Design Pressure (psi)

and $S$ = Ys/FS.

$Y_s$ = Yield stress (psi).

$FS$ = Factor of Safety.

Allowable stress and factors of safety for different design pressure conditions are taken from the above table. Allowable hoop stress from working pressure is the lesser of the following: 50 percent of yield stress (FS=2), but with a limiting value (maximum allowable hoop stress) of 21 kips per square inch (ksi) for mortar lined pipe and 16.5 ksi for mortar coated pipe.

*Handling Requirements* The minimum wall thickness for handling should be based on the following formula, for mortar lined pipe:

$$t \geq \frac{D}{240}$$

Where: $t$ = minimum wall thickness, inches.

$D$ = outside pipe diameter (pipe can OD), inches.

*Minimum Wall Thickness* The minimum wall thickness for the pressure and handling condition is the greater wall thickness of the requirements listed above.

**Deflection Limits of Flexible Pipe** Deflection limits of flexible pipe are based on load calculations similar to that used for rigid conduits. However, due to pipe flexibility and its effect on differential settlement of the soil column over the pipe, computation of the dead load is simplified.

*Loads on Flexible Pipe* Two conditions for external loads shall be considered:

Live load plus dead load with full depth of cover. Note that the effect of live loads diminishes with depth of cover.

Live load plus dead load with minimal cover. The minimal cover used in the calculation should be coordinated with the specifications. The specifications should state the amount of cover required prior to operating heavy equipment above the pipe. The live load should represent the heaviest equipment anticipated for use in compaction or hauling material above the pipe.

*Live Loads* Live loads are generally categorized into distributed and impact loads, the distributed traffic loads are as defined in Table 3-3, below. At a depth greater than 8 feet, the effect of the wheel load becomes insignificant.

Table 3-3. Pipeline Design – Live Load Effect

| **Highway HS-20 Loading** | | **Railroad E-80 Loading** | |
|---|---|---|---|
| **Load (psf)** | | **Soil Cover (feet)** | **Load (psf)** |
| 1 | 1,800 | 2 | 3,800 |
| 2 | 800 | 5 | 2,400 |
| 3 | 600 | 8 | 1,600 |
| 4 | 400 | 10 | 1,100 |
| 5 | 250 | 12 | 800 |
| 6 | 200 | 15 | 600 |
| 7 | 176 | 20 | 300 |
| 8 | 100 | 30 | 100 |

Note: Neglect live load when less than 100 psf, use dead load only. Table from AWWA M11 Design Manual.

Key:
psf = pounds per square foot

*Concentrated Loads* If large concentrated loads are anticipated over the pipeline they should also be considered in the design on an item by item basis.

*Earth Loads* Common conservative design practice, for buried steel pipelines, is to calculate dead loads on flexible pipes for the positive projecting embankment condition (i.e., at transition width). This is called the prism load. The unit weight of soil should be developed by the project geotechnical engineer based on the geotechnical exploration and testing program documented in the geotechnical reports. Backfill height and trench conditions will be provided in the project drawings.

The earth load varies with soil characteristics. More importantly, it varies with installation conditions. Following AWWA M11, when a flexible pipe is buried in an embankment or wide trench, the settlement ratio for the soil is assumed to be zero. As such, the prism of soil over the pipe is used in the AWWA calculation as a resultant earth load (Prism Load) and is used for the pipeline installation condition.

The Prism Load will be calculated using the following equation:

$$W_c = HwB_c$$

Where: $W_c$ = Dead load on conduit, pound per linear foot.

$H$ = Height of fill above pipe, feet.

$w$ = Unit weight of backfill material, pound per cubic foot.

$B_c$ = Outside diameter of the pipe, feet.

*Pipe Deflection* Minimum wall thickness for external loads shall be determined using the Modified Iowa formula, as presented in AWWA M11:

$$\Delta D_v = D_L[\frac{KWr^3}{(EI + 0.061E'^{r^3})}]$$

Where: $\Delta D_v$ = Pipe vertical deflection in inches.

$D_L$ = Deflection lag factor.

$K$ = Bedding constant (0.1).

$W$ = Load per unit of pipe length, pound per linear inch.

$r$ = Pipe radius, inch.

$EI$ = Pipe wall stiffness.

$E'$ = Modulus of soil reaction, psi.

Where: $E$ = Modulus of elasticity (30,000,000 psi for steel and 4,000,000 psi for cement mortar).

$I$ = Transverse moment of inertia per unit of length of individual pipe wall components, inch.

The limiting value of allowable deflection will normally be the maximum deflection that does not impact the integrity of the lining or coating system on the pipe. Limit deflection for pipelines to the limits noted below in Table 3-4.

Table 3-4. Pipeline Deflection Limits

| Pipe Type | Deflection Limit |
|---|---|
| Steel Pipe, dielectrically (i.e., Polyurethane) lined and coated | 3.75%[1] |
| Steel pipe, mortar lined and dielectrically coated (i.e., tape wrap or polyurethane) | 2.25%[1] |
| Steel pipe, mortar lined and coated | 1.5%[1] |

Note:
[1] Limits are 75% of AWWA allowable limits.

The following Table 3-5, Deflection Lag Factor, should be considered and applied as appropriate for selection of the deflection lag factor.

Table 3-5. Pipeline Deflection Lag Factor

| | Granular Soils/CLSM | | Cohesive Soils | |
|---|---|---|---|---|
| **Pressure** | **Cover <2D** | **Cover >2D** | **Cover <2D** | **Cover >2D** |
| >30 psi | 1.0 to 1.15 | 1.1 to 1.2 | 1.15 to 1.25 | 1.2 to 1.352 |
| <30 psi | 1.1 to 1.2 | 1.15 to 1.25 | 1.2 to 1.35 | 1.25 to 1.5 |

Key:
CLSM= controlled low strength material
D= diameter of pipe
PSI = pounds per square inch

The bedding constant should be 0.1 (approximately 60-degree bedding angle). Modulus of soil reaction (composite E') should be as recommended by the Geotechnical Report. Composite E' is the combination of $E'_n$, (modulus of soil reaction for the native surrounding soils) and $E'_b$ (modulus of soil reaction for the pipe zone material).

The pipe wall thickness required to meeting deflection requirements is the second design wall thickness calculated. If either calculated thickness is greater than the normal maximum plate thickness that can be used in pipe manufacture by spiral weld machines, then improvement of the bedding and backfill around the pipe may be required to strengthen the pipe/soil interaction, reduce deflection, and reduce the minimum wall thickness.

*Pipe Buckling* The third calculation set for pipe wall thickness is the buckling equation. The first step in this process includes defining the allowable buckling pressure using the allowable buckling pressure equation in AWWA M11 (Equation 6-7).

$$q_a = \left(\frac{1}{FS}\right)\left(32R_\omega B' E' \frac{EI}{D^3}\right)^{1/2}$$

Where: $q_a$ = Allowable buckling pressure in psi (kiloPascal (kPa)).

FS = 2.0 (factor of safety).

D = Diameter of pipe, in. (millimeter (mm)).

$R_w$ = Water buoyancy factor.

= $1 - 0.33\ (h_w/h),\ 0 \leq h_w \leq h$

$h_w$ = Height of water surface above top of pipe, in. (mm).

h = Height of ground surface above top of pipe, in. (mm).

B' = Empirical coefficient of elastic support (dimensionless).

= $1/[1 + 4e^{-0.065H}]$

= $1/[1 + 4e^{-0.213H}]$ (equivalent metric equation)

Where: H = Height of fill above pipe, feet (meter).

E' = modulus of soil reaction.

EI = Pipe wall stiffness.

This equation defines the limit of collapse (radial hoop) pressure that the pipe can sustain with an appropriate factor of safety.

For normal pipe installations, there are two additional calculations required to determine if applied loads (pressures) exceed the allowable pressure, from the calculation above. The first of these equations calculates the applied pressure from groundwater, soil and vacuum pressures, as given by AWWA M11 (Equation 6-8). This pressure must be lower than the allowable pressure. If not, the pipe wall thickness must be increased to resist buckling.

$$\gamma_\omega h_\omega + R_\omega \frac{W_c}{D} + P_v \leq q_a$$

Where: $h_\omega$ = Height of water above pipe, in. (mm).

$\gamma_\omega$ = Specific weight of water = 0.0361 pounds per cubic inch (0.0098 kPa/cubic mm).

$P_v$ = Internal pressure in psi (kPa); atmospheric pressure less absolute pressure inside the pipe, in psi (kPa).

$W_c$ = Vertical soil load on pipe per unit length, in pounds per inch. (kPa/mm).

At certain points along the pipeline (e.g., at right-of-way crossings), it is appropriate to consider live loads as a component of the external buckling load. However, the simultaneous application of live-load and internal vacuum transient is not normally required. Where live loads are considered, the buckling requirement is satisfied by AWWA M11 (Equation 6-9). Thus, the second buckling pressure equation deals with groundwater, soil and live load pressures on the pipe and is calculated using the equation that follows. This pressure must also be lower than the allowable pressure. If not, the pipe wall thickness must be increased to resist buckling.

$$\gamma_\omega h_\omega + R_\omega \frac{W_c}{D} + \frac{W_L}{D} \leq q_a$$

Where: $W_L$ = Live load on the pipe per unit length, in pounds per inch. (kPa/mm).

Additional Pipe Load (Stress) Conditions

Additional pipe load (stress) conditions include the following:

Poisson’s ratio.

Temperature change (thermal stresses).

Thrust forces.

Each of these design conditions create additional stresses in the pipe wall that must be accounted for in the design to provide adequate pipe life and avoid overstressing the pipe material.

*Poisson's Ratio* Poisson's ratio is the force applied to the pipe as a result of internal pressure and acts uniformly around the pipe in a longitudinal direction. As the pipe expands due to the hoop stress (internal pressure), it also shrinks in length due to Poisson's effect.

Poisson's ratio for steel is usually given as 0.30 and mortar is given as 0.25. Therefore, the longitudinal stress created by internal pressure would be 30 percent of the applied hoop stress.

*Thermal Stresses* Temperature-induced thermal stresses are created in the pipe as a result of temperature fluctuations over the daily operation of the facility. The stress induced into the pipe wall due to temperature changes is:

$$\sigma_P = P \times t \times \alpha$$

Where: $\sigma_P$ = Induced pipe stress.

$t$ = Temperature change (degrees Fahrenheit (°F)).

$\alpha$ = Thermal expansion coefficient for steel, $6.5 \times 10^{-6}$ inch/°F

The specifications must state the maximum allowable temperature of the steel when the closure joints are welded. If controlled low-strength material (CLSM) is used to backfill the pipe zone, the maximum temperature of the CLSM must also be stated in the specifications. The force due to a drop in temperature, between the time the joints are welded and the pipe is placed in service, will always create tension in the pipe wall. Temperature stresses must be considered in the combined stress analysis described in this sub-section.

*Thrust Forces* Waterlines are subject to hydraulic thrust forces at the locations of change in direction or diameter, wyes, tees, or termination at a plug or valve. Thrust is generated by internal hydrostatic pressure and dynamic (momentum) forces. Dynamic forces are usually not significant in pipelines unless velocity head is large in comparison with hydrostatic pressure.

In high velocity pipelines, however, dynamic thrust may be sizeable. Hydrostatic pressure will usually be the greatest long-term pressure the pipeline is subjected to and governs the design of thrust anchorage. Thrust design pressure is the larger of working pressure, test pressure, or pump shutoff pressure.

Transient pressures (surge), however, may also be considered as thrust-generating forces if potential exists for greatly exceeding the test pressure or shutoff pressure. The Design Engineer should estimate the magnitude of hydrostatic thrust force at the bends, dead ends, branches, and closed valves, and shall ensure that anchorage of pipelines to withstand the applied thrust forces is accomplished through the use of restrained joints. Restrained joints rely on the transfer of thrust to the soil by friction between the pipe surface and the soil. Thrust blocks will not be allowed.

Design of restrained joint systems is not covered by this Design Criteria summary; however, most pipe manufacturers provide literature on the subject for use with their pipe materials. It is important to understand each thrust restraint design method as they differ widely between manufacturers. These methods vary in the way the thrust loading is applied to the pipe, and in some cases, the side soil adjacent to the pipe. Therefore, the adjacent soil properties could also be required depending on the method chosen for design.

In addition, several soil factors used in the design vary by manufacturer method. It is important to identify this information in the Geotechnical Report, including safe bearing load of undisturbed in situ soil, soil cohesion, angle of internal friction, and soil unit weight.

The most conservative method is the one presented in AWWA M11 (shown in Figure 13-16 and Equation 13-6), and will be the recommended method for thrust restraint length calculations for the projects (Note, be sure to apply the correct formula per the July 2004 Errata issued for equation 13-16 for the Fourth Edition of AWWA M11).

The thrust loads must be capable of being carried by the pipeline and joint system used. The design of fillet welds at the pipe joints will be required to verify that the load transfer can take place across the welded joint. Circumferential fillet weld design is covered in AWWA M11 on pages 220 through 222 of the Fourth Edition. The following longitudinal joint efficiencies are to be used in joint design:

e = 0.45 (single-welded lap).

e = 0.55 (double-welded lap).

e = 0.70 (butt weld, no radiographic test (RT).

e = 0.85 (butt weld, partial RT).

e = 1.00 (butt weld, full RT).

See AWWA C206 for guidance on welding procedures.

Check to verify that the combined applied stresses do not exceed the allowable weld stress. The axial stresses can never exceed half of the hoop stresses caused by internal pressure. Also, the tension and the thermal tension stress is not additive since tension can only exist if it is not restrained and the thermal stress can only exist if the pipe is restrained.

### *Fittings and Specials*

Fittings should have standard dimensions in accordance with AWWA C208. In general, large radius bends (R = 2.5D) should be used to minimize head losses and reduce stress levels in the fittings.

### *Joints*

All pipe shall use lap welded slip joints. An inside lap weld will be used for pipes 48 inches and larger. Internal and external lap welds may be used when thrust design requirements exceed capability of internal single weld. Pipes 42 inches and smaller shall be welded from the outside.

During design the pipeline Engineer shall verify the pipe, fittings, and field welds are suitable to handle resist thrust forces. Joints welded inside and outside may be required for high thrust areas. Thrust restraint requirements will be shown on the Design Drawings.

Butt straps will be allowed for applications requiring field adjustment or closures. Butt straps shall be welded from the inside and outside and incorporate threaded holes to allow testing by an air and soap test.

## Appurtenances

Pipeline appurtenances (including air release valves, combination air release and air/vacuum valves (CARV), blowoff valves, isolation valves, manways, and pipeline markers) will be provided along the pipeline where needed to support pipeline function and operation. Exact appurtenance locations will consider conflicts with other structures, vehicular traffic, existing utilities, and will avoid those locations most vulnerable to damage or vandalism. The appurtenances will be co-located in vaults where possible to reduce costs and space requirements. Where the Delta Transfer Pipeline runs parallel to the existing Old River Pipeline, it is anticipated that appurtenances will be located in approximately the same location (stationing) as the existing appurtenances for ease of access and operation. The purpose of each appurtenance and key design criteria are described below:

### *Air Valves*

Descriptions and design criteria associated with air release valves, air and vacuum valves, and CARVs are summarized below.

**Air Release Valves** The purpose of air release valves is to vent relatively small quantities of air that accumulate at the high points in the pipeline during normal system operations. Valves are typically located at all high points, although they may also be located along long flat or descending slopes, or descending grade breaks at significant vertical bends where velocities may be insufficient to keep air pockets moving forward to the next high point. Air vales are typically sized based on the maximum differential pressure at each valve location based on an air flow rate equal to 2 percent of the maximum water flow rate, using manufacturer design recommendations for orifice diameter and valve size. For the purposes of this conceptual design air release valves have been sized and located to match air valves on the existing parallel Old River Pipeline. Final air valve sizing and locations will be determined during final design.

**Air and Vacuum Valves** The purpose of air and vacuum valves is to exhaust or admit large volumes of air during filling or draining of the pipeline. They are located at high points or significant changes in grade. Valves are sized for the worst case of filling or draining the pipeline. The worst case for draining typically occurs during a pipeline failure. Large steel pipe may collapse under significant negative pressures, so the collapse pressure must be checked based on the appropriate AWWA M-11 formula. Valves are then sized using the maximum filling rate, maximum draining rate, pipe collapse pressure, and manufacturer performance graphs. Straight air and vacuum valves are not proposed for this project but this function will instead be provided through the use of combination air release and air/vacuum valves described below.

**Combination Air and Vacuum Valves** CARVs incorporate operating features of both air release valves and air and vacuum valves. These valves will be provided at all pipeline high points along the alignment, and at significant downward grade breaks, and potentially along long continuous slopes at a spacing of 2,500 feet. Sizing is based on the criteria described in the two paragraphs above. For the purposes of this conceptual design, CARVs have been assumed to be sized and located to match CARVs on the existing parallel Old River Pipeline. Final air valve sizing and locations will be determined during final design.

CARVs and air release valves must be inspected and serviced regularly. To facilitate inspection and preserve valve function, the valves are placed in individual access vaults that can be accessed at grade in an accessible location. A typical air valve detail is used for air release and CARV valves as shown on the conceptual design drawings, based on the detail used for the existing Old River Pipeline. The installation is shown to be combined with a manway, which is typical for these installations.

### *Blowoff Valves and Pipeline Draining*

Blowoffs are valved pipeline outlets located at low points located between adjacent high points in the pipeline profile to allow the pipeline to be drained. Blowoffs are used to drain and flush the pipeline prior to internal pipeline inspection or repairs. A typical blowoff detail is proposed as shown on the conceptual design drawings, based on the detail used for the existing Old River Pipeline. They consist of a 24-inch manway outlet with a reducing flange, an 18-inch gate valve, an 18-inch riser pipe extending to the top of the vault and above grade, with a 12-inch flanged outlet. Use of a portable pump is required to drain the pipeline completely.

The operational approach for draining the Delta Transfer Pipeline should be similar to the current plan for draining the Old River Pipeline. That is, the pipeline should first be drained back to the Old River to reduce the head at other blowoff locations, thereby reducing the volume and velocity of discharges from blowoffs to canals, creeks, and other water courses along the pipeline alignment. The procedure to dewater the Delta River Pipeline would be as follows:

1. The Old River Pump Station would be shut down.

2. At the Transfer Facility site, the Delta Transfer Pipeline Isolation valve leading to the Expanded Transfer Facility Reservoir and other facilities at the site would be closed, and two valves at the Old River Pump Station site connecting to the Old River pipeline would be closed to isolate the Delta Transfer Pipeline.

3. The Middle River pump station and the Old River Pipeline would remain on line and continue to deliver water to the Transfer Facility.

4. The 24-inch drain valve at the Old River Pumping Plant would be opened to drain the majority of the Delta Transfer Pipeline water back to the pump station wetwell.

5. Remaining water in the Delta Transfer Pipeline would be then be drained through blowoffs at the Reclamation District 800 irrigation canal, Kellogg Creek, and other individual pipeline low points via other blowoffs.

Generally, blowoffs are sized so that a given pipeline reach can drain within 12 to 24 hours. However, in this case, all blowoff are proposed at 12-inch diameter to match blowoff facilities provided on the existing Old River Pipeline. Actual drain rates may need to be throttled to a lower flow rate to avoid overloading local ditches and waterways with runoff.

#### *Isolation Valves*

A mainline isolation and flow trimming valve will be provided for the Delta Transfer Pipeline at the Old River Pump Station site for isolation and flow control purposes. This valve will be located downstream of the new meter vault. The planned configuration uses a reduced diameter ball valve for flow trimming and a bypass with another ball valve. The bypass piping is used for pipeline filling and flow control at low flows and includes a fixed orifice sleeve to produce back pressure on the bypass valve to avoid cavitation on the bypass valve. This isolation and flow trimming valve configuration matches the approach used for the existing 78-inch Old River Pipeline but is scaled down to accommodate the smaller flow through the 66-inch-diameter pipeline.

Other mainline isolation valves are planned to allow isolation of the Delta-Transfer Pipeline from the Old River Pipeline, as shown on the drawings at the Old River Pump Station Site and the Expanded Transfer Facility. There will be no main line isolation valves along the length of the Delta-Transfer Pipeline, which is consistent with the approach for the Old River Pipeline. The mainline isolation valves will be full diameter butterfly valves either located in vaults or above grade when associated with above grade piping as shown.

Additional smaller isolation valves will be required at blowoffs, air valves, and any other connections to the pipeline. Butterfly valves are used on the air valve connections and gate valves are used on the blowoff connections to match existing details. These valves are located with vaults as shown in the details.

#### *Access Manways*

The pipeline interior is entered through access manways consisting of 24-inch-diameter flanged outlets, located inside vaults. The manways allow worker entry during construction for welding, cleaning, coating and inspection activities. The manways may also be used periodically during the pipeline's active life for inspection and minor repairs. Based on the Old River Pipeline design, manways will be provided at all air valve and blowoff locations and no other intermediate locations; this provides access typically at about 3,000 feet or less spacing, except for two reaches where the distance between manways extends from about 3,000 to 4,500 feet.

#### *Pipeline Markers*

Right-of-way signs exist at ingress/egress points and pipeline station markers along the existing Old River Pipeline at 1,000-foot intervals centered on the pipe. There are also existing markers placed close to valves and other appurtenances. New pipeline markers will be provided using the existing marker detail to locate the Delta Transfer Pipeline centerline location, stationing, and appurtenances.

### Siting and Land Requirements

The Delta Transfer Pipeline alignment has been designed with the intention of staying on one side of the existing Old River Pipeline and within the existing permanent easement of the Old

River Pipeline. The existing permanent easement is 85 feet wide and the existing Old River Pipeline is situated off center of the easement (i.e., 50 feet available on one side of the Old River Pipeline centerline and 35 feet is available on the opposite side). Typically, the side in which there is a 50-foot-wide corridor allows for the most optimal space for construction and later maintenance. The proposed Delta Transfer Pipeline alignment will be placed between 15 and 25 feet offset from the centerline of the Old River Pipeline and installed within the existing easement along the north side of the Old River Pipeline. The north side is typically the wider side of available easement. However, there are some relatively short sections where the north side of the alignment falls within the narrow side of the existing permanent easement.

To provide sufficient space for construction, in a cost effective manner, it is recommended that additional temporary construction easements be acquired along the length of the proposed alignment. Locations and lengths of additional temporary construction easements (TCE) vary along the pipeline due to available space within and outside the easement. The additional TCE is shown on the plan and profile of the conceptual drawings where available, recognizing that there are some areas where it is not feasible to acquire additional easements due to existing development.

Along with the TCE needed for construction it is suggested that additional permanent easements be acquired for future maintenance along particular lengths of the pipeline. In these areas the pipeline is being constructed in the narrow side of the available easement which leads to limited space on the north side for future maintenance. By acquiring this additional easement, similar trench slopes can be used to excavate and access the pipe in the future if needed.

## Geotechnical Considerations

Based on previous geotechnical investigations, the soils around the existing Old River Pipeline can be generally divided into three distinct strata, the levee fill, the peaty or topsoil materials, and the alluvial soils.

Levee fill is found around the Old River Pump Station. The peaty soils were found in many areas of the alignment but were contained within approximately15 feet below the surface. Below the top soil and peaty layers, alluvial soils composed of silty clay or clayey silt with intermittent thin layers of silty or clayey sand were encountered.

The majority of the Delta Transfer Pipeline is located in alluvial soils that are relatively weak and with a shallow ground water table. This is especially true for areas closest to the Old River Pump Station, where the ground elevation is below 0 feet, therefore dewatering may be needed during construction. These soils also have high liquefaction potential which needs to be taken into design consideration for the pipeline. Soils throughout the area may have moderate to high expansion potential and are not suitable for structure backfill or structure support. The project area is also located in a seismically active area with several faults nearby.

## Trenches and Shoring

Open cut trenches are allowed for areas where there is adequate space for stable trench slopes. This method will be used for a majority of the alignment, but for areas where there is little room for safe trenches, shoring can be used to support the trench walls where appropriate for the soil conditions. It will be the contractor's responsibility to provide temporary shoring that is

compliant with California Occupational Safety and Health Administration. Trench sections have been developed for the conceptual design and can be found on drawing GC-1 of the Los Vaqueros Conceptual Drawing package.

## Pipeline Crossings

The Delta Transfer Pipeline will cross the following types of facilities and waterways:

- Roads
- Railroads
- Pipelines
- Underground telephone and Fiber Optic Cables
- Agricultural Drainage channels
- Creeks

This section describes general conceptual design approaches and design criteria for these crossings, as shown on the design drawings. These criteria will need to be further developed and reviewed with owners or agencies responsible for approving or permitting the crossing designs during later design development stages.

This section does not address the following types of crossings which may require agreements with owners or agencies but do not specifically effect the pipeline design:

- Overhead powerline crossings
- Overhead telephone line crossings
- Privately owned drainage and irrigation channels

This section does not address specific cathodic protection and test station connections that may be required at utility crossings. Specific criteria for these features should be developed during the later design development phase.

### *Road Crossings*

**Open Cut** Bixler Road and Hoffman Lane are existing paved roads under Contra Costa County Public Works Department jurisdiction. The current conceptual design is based on an assumed open cut road crossing approach at these locations using similar design details as those developed for the previous Old River Pipeline. The County will require traffic control, detour plans, compaction requirements, and surface restoration conforming to Caltrans requirements.

**Bore and Jack** Trenchless crossings are proposed at the Byron Highway and Vasco Road. The crossings would be constructed by slipping the pipeline inside a steel casing (minimum 78 inches in diameter) installed via the bore and jack construction method. Casing spacers and installation

details will be similar to the casing installations provided for the Old River Pipeline at these locations.

### *Railroad Crossing*

The Southern Pacific Railroad crossing will be constructed by slipping the pipeline inside a steel casing (minimum 78 inches in diameter) installed under the railroad tracks via the bore and jack construction method. The design will be done in accordance with Southern Pacific Transportation Company design and construction requirements as outlined in the Southern Pacific Lines Common Standards. This includes a minimum 5.5 feet of cover from the top of the casing to the base of the rail. However, because of the vertical location of other utilities at the crossing it is likely the depth of cover will be closer to approximately 10 feet or more. The design should consider potential settlement and provide appropriate settlement monitoring during construction.

### *Pipeline Crossings*

**Petroleum and Natural Gas Pipeline Crossings** The Delta Transfer Pipeline will cross several petroleum and natural gas pipelines. Preliminary information regarding the approximate location diameter, owner, and minimum clearance requirements for these crossings based on data from the previous Old River Pipeline design is shown in Table 3-6. Facility Owners should be contacted to identify specific additional crossing criteria and requirements. In addition, further investigation is required to determine if there are additional petroleum or natural gas pipelines along the current alignment.

Table 3-6. Minimum Utility Clearances for the Old River Pipeline

| Station | Diameter | Owner | Product | Minimum Vertical Clearance (inches) |
|---|---|---|---|---|
| 127+85 | 42 | PG&E | Natural Gas | 12 |
| 210+60 | 4 | PG&E | Natural Gas | 12 |
| 239+25 | 12 | Santa Fe Pacific | Refined Products | 24 |
| 240+30 | 8 | Chevron | Refined Products | 12 |
| 240+65 | 12 | Unocol | Natural Gas | 24 |
| 348+10 | 26 | PG&E | Natural Gas | 12 |
| 348+20 | 18 | Chevron | Crude Oil | 12 |

Key:
PG&E = Pacific Gas and Electric Company

**Water Transmission and Irrigation Pipelines** The Delta Transfer Pipeline will cross numerous water transmission and irrigation pipelines. Typically there is a 12-inch minimum vertical clearance required for these pipeline crossings. The utilities and agencies that own and operate these pipelines have specific criteria governing the crossing of their pipelines. These additional requirements should be identified during design development.

**Telephone and Fiber Optic Cable Crossings** The pipeline alignment crosses both Verizon and US Sprint communication cables. The conceptual design is based on a 12-inch minimum vertical clearance required for these crossings. The companies that own and operate these communication cable crossings have specific criteria governing the crossing of their facilities. These additional requirements should be identified during design development.

### *Drainage Channel Crossings*

The Delta Transfer Pipeline crosses the Reclamation District 800 drainage channel near stations 34+50, and 100+40 and another relatively large earthen drainage canal at station 80+70. Reclamation District 800 requires a minimum vertical clearance of 8 feet between invert of the ditch and the top of the pipeline. Lean concrete or CLSM placed in the pipe zone is also required at these three crossings to protect the pipeline during channel cleaning operations. The total flow of the channel must be diverted during construction. The crossing details will use details similar to the corresponding Old River Pipeline crossings.

Other minor earthen drainage canals or ditches will be crossed without concrete or CLSM trench backfill, similar to the corresponding Old River Pipeline crossings.

### *Creek Crossings*

The Delta Transfer Pipeline crosses Frisk Creek near station 113+70. The conceptual design is based on the approach used for the Old River Pipeline Crossing of Frisk Creek and requires concrete encasement to protect the pipe from potential damage during high flow scour events. The top of the pipe must be placed below a maximum scour depth or 5 feet below the invert of the stream whichever is greater. The crossing shown in the conceptual design drawings corresponds to the open cut construction design approach used for the Old River Pipeline crossing. However, ultimately the final design crossing criteria must be based on the current requirements of the appropriate regulatory agencies. The open cut construction method may not be possible any more if the permitting requirements have changed significantly and trenchless methods may ultimately be required.

## Cathodic Protection

Assuming steel pipe is to be used for the construction of this pipeline, cathodic protection will be necessary. Although no new soil corrositivity testing has been done at this time it is assumed that the corrosion control and cathodic protection criteria for the existing Old River Pipeline are appropriate for this new pipeline as well.

Based on the previous criteria for the Old River Pipeline there will need to be an impressed current cathodic protection system using deep well anodes and test stations located at approximately every 1,000 feet, at foreign pipeline crossings, and at pipe casings. These are the assumed requirements at this stage of conceptual development. Further investigations will be needed during the actual design phase of this pipeline.

## Other General Civil Design Criteria

This section describes other general civil design requirements and design criteria associated with work along the pipeline alignment, at the Expanded Transfer Facility, and at the Old River Pump Station facility.

### *Access and Grading Requirements*

Access to pipeline facilities and appurtenances is necessary for future maintenance. Since the Delta Transfer Pipeline will run parallel to the existing Old River Pipeline and appurtenances for the new pipeline have been clustered near the existing appurtenances, the existing access roads can be used for access to most new appurtenances. However, there will likely be some locations

where slight modifications are needed. This may require the construction of extensions to existing gravel roads.

New paved access roads will be provided at the Expanded Transfer Facility including the area around the reservoir tank, the surge tanks, the pumping plant, and the MCC building. These areas will be paved with 2½-inch asphalt concrete pavement over 12 inches of aggregate base. A 16-foot-wide paved access road will be provided around the circumference of the reservoir tank. Paved areas should be graded to a minimum 2-percent slope with curbs and gutters for drainage.

Permanent cut slopes around the Expanded Transfer Facility reservoir shall be a maximum 2H:1V for stability and ease of maintenance. Permanent fill slopes will vary depending on location around the site but shall be a maximum of 2H:1V. Maximum temporary cut and fill slopes will be determined by the contractor based on geotechnical recommendations.

### *Stormwater Control*

For stormwater drainage, storm drain pipes will be provided around the Expanded Transfer Facility where new impervious surfaces have been installed. Currently there are several drains around the existing Transfer Facility site which drain to a catch basin and then are released to a ditch offsite. The new facility's drainage system may tie into the existing system and discharge to the same location if pipe capacity is adequate. New catch basins and storm drain piping will be needed as well as curb and gutters around the Expanded Transfer Site to properly drain storm water. At the top of the cut slope for the new facility a concrete lined v-ditch will be provided to intercept runoff and guide the flow to drains which will then outfall offsite, similar to the existing facility. Stormwater concerns will be evaluated during design to determine if a new outfall is needed to accommodate the increased runoff flow from the site.

### *Valve Vaults*

Main line isolation valve vaults will be designed with removable concrete panels for the installation of the valves and possible future maintenance requirements. The design of the vault lids and removable panels will be traffic rated to accommodate vehicle loads. Two 30-inch-by-26-inch access hatches will be provided so that maintenance staff can access either side of the pipe within the vault. Ladders will be provided as well as an elevated walkway to access the valve for maintenance and manual operation if necessary. A sump and sump pump is to be provided in the bottom of the vault for drainage. Inlet and outlet ventilation pipes and ventilation fan are also provided.

### *Restoration*

During pipeline construction, the top 2 feet of soil will be stockpiled and used as final trench backfill. In grazing lands and in grassy open fields, grass will be planted to reduce the potential for erosion and weed growth. Where row crops exist the surface will be returned to original grade, but rows will not be reproduced.

Restoration of the rights-of-way/easements after construction will be part of the construction contract. Final backfill under paved areas will meet design standards of the appropriate agency. Road surfaces, curbs, gutters and other surface improvements, disturbed during construction, will be replaced.

### *Design Criteria Summary*

Table 3-7 presents a brief general summary of the key pipeline and civil design criteria described in this section.

Table 3-7. General Pipeline Design Criteria Summary

| Description | Criteria |
|---|---|
| Pipeline Material | Welded steel pipe (AWWA C200) has been assumed at this stage of the design. Reinforced concrete cylinder pipe (AWWA C300) may also be suitable and could be considered later during design as well. |
| Maximum Pipeline Velocity | 10 fps |
| Standard Joint | Steel spigot and bell rings with welded joints for welded steel pipe (AWWA C200), or a rubber gasket joint for reinforced concrete cylinder pipe (AWWA C300). |
| Pressure Class of Pipe | Varies – 200 psi maximum working pressure |
| Lining | Cement mortar lining per AWWA C205. |
| Coating | Polyethylene tape wrapped coating per AWW C214 or a polyurethane coating per AWWA C222. |
| Working Pressure | 2.0 factor of safety |
| Transient Pressure | Less than 133% of the working pressure with a 1.5 factor of safety |
| Pump Shutoff Pressure | Based on actual pump shutoff with a 1.5 factor of safety |
| Test Pressures | Limited to 1.33 times the working pressure with a 1.5 factor of safety |
| Deflection Limits | Limit of 2.25% for mortar lined and dielectrically coated (i.e., tape wrap or polyurethane) steel pipe.<br>Bedding constant factor should be 0.1 (approximately 60 degree bedding angle) |
| Fittings and Specials | Fittings will be designed in accordance with AWWA C208 and large radius bends (R=2.5) should be used where possible. |
| Air Release Valves | Size based on the maximum water flow rate using manufacturer design recommendations.<br>Located to match air valves on the existing parallel Old River Pipeline. |
| Combination Air and Vacuum Valves (CARVs) | Provided at all pipeline high points and at significant downward grade breaks.<br>Located to match CARVs on the existing parallel Old River Pipeline. |
| Blowoff Valves | Provided at all low points.<br>A typical blowoff consists of a 24-inch manway outlet, an 18-inch gate valve, an 18-inch riser, and a 12-inch flanged outlet.<br>All blowoffs are proposed at 12-inch diameter to match blowoff facilities on the existing Old River Pipeline. |
| Isolation Valves | Mainline isolation valves allow isolation of the Delta Transfer Pipeline from the Old River Pipeline and the Expanded Transfer Facility.<br>No mainline isolation valves are located along the length of the Delta Transfer Pipeline. |
| Access Manways | 24-inch diameter flanged outlets will be provided at all air valve and blowoff locations with no other intermediate locations. |
| Pipeline Markers | At every 1,000 feet centered on the new pipeline |
| Bore and Jack | A steel casing (minimum 18-inch diameter larger than carrier pipe OD) will be provided at trenchless crossings |
| Railroad Crossing | A steel casing (minimum 18-inch diameter larger than carrier pipe OD) will be provided at trenchless crossings.<br>Installations will comply with railroad agency requirements. |

Table 3-7. General Pipeline Design Criteria Summary (contd.)

| Description | Criteria |
|---|---|
| Utility Crossings | For water transmission and irrigation pipelines a 12-inch minimum vertical clearance will be required along with additional clearances and criteria per agency requirements.<br>For telephone and fiber optic cable crossings a 12-inch minimum vertical clearance will be required along with additional clearances and criteria per agency requirements. |
| Drainage Channel Crossings | Lean concrete or CLSM placed in the pipe zone for all three major channel crossings.<br>For crossing the Reclamation District 800 channel a minimum vertical clearance of 8 feet between the invert of the ditch and top of pipe.<br>Other minor earthen drainage canals or ditches will not require concrete or CLSM backfill. |
| Creek Crossing | Concrete encasement required for the Frisk Creek crossing.<br>Top of pipe must be placed below a maximum scour depth or 5 feet below the invert of the stream, whichever is greater. |
| Cathodic Protection | Impressed current cathodic protection using deep well anodes and test stations located at approximately every 1,000 feet, at foreign pipeline crossings, and at pipe casings. |
| Access and Grading | Paved access will be 2 ½-inch AC pavement over 12 inches of aggregate base and graded to a 2% slope.<br>Permanent cut slopes will be maximum 2H:1V<br>Permanent fill slopes will be maximum 2H:1V |
| Isolation Valve Vaults | Removable concrete panels for installation and maintenance of valves<br>Lid and panels will be traffic rated<br>Two 30-inch by 26-inch access, with ladders, on either side of the pipe<br>A sump and sump pump<br>Inlet and outlet ventilation pipes with a fan |
| Restoration | Hydroseed grassy fields and slopes for stability.<br>Replace landscaping and surface improvements in kind.<br>Row crops will not be replaced. |

Key:
AC = Asphalt Concrete
AWWA = American Water Works Association
CARV = combination air release and air/vacuum valve
CLSM = controlled low strength material
fps = feet per second
psi = pounds per square inch

# Operational, Hydraulic, and Mechanical

This section covers design criteria used for operational, hydraulic, and mechanical design of project facilities.

## Operational Design Criteria

The following is a list of operational flow design criteria:

- The maximum combined pipeline flow capacity from the Old River and Middle River Pump Stations (both nominal 250 cfs capacity) to the Transfer Pump Station and new Expanded Transfer Pump Station (ETPS) shall be 500 cfs.

- The total flow from the Middle River Pump Station may be directed to both the existing Old River Pipeline and the new Delta-Transfer Pipeline. Alternatively, flow may be directed exclusively to either one or the other pipeline, up to the pipeline's design capacity.

- The total flow from the Old River Pump Station may be directed to both the existing Old River Pipeline and the new Delta-Transfer Pipeline. Alternatively, flow may be directed exclusively to either one or the other pipeline, up to the pipeline's design capacity.

- At the ETPS/Transfer site flow from the Delta-Transfer Pipeline may be:

  - Comingled with the flow from the Old River Pipeline and routed to the Contra Costa Canal via the Los Vaqueros Pipeline.

  - Comingled with the flow from the Old River Pipeline and pumped to either Bethany Reservoir via the Expanded Transfer Pump Station or to Los Vaqueros Reservoir via the Transfer Pump Station.

  - Isolated from the flow from the Old River Pipeline and routed to the Contra Costa Canal via the Los Vaqueros Pipeline.

  - Isolated from the flow from the Old River Pipeline and pumped to Bethany Reservoir via the Expanded Transfer Pump Station.

- At the ETPS/Transfer site flow from the Old River Pipeline may be:

  - Comingled with the flow from the Delta-Transfer Pipeline and routed to the Contra Costa Canal via the Los Vaqueros Pipeline.

  - Comingled with the flow from the Delta-Transfer Pipeline and pumped to either Bethany Reservoir via the Expanded Transfer Pump Station or to Los Vaqueros Reservoir via the Transfer Pump Station.

  - Isolated from the flow from the Delta-Transfer Pipeline and routed to the Contra Costa Canal via the Los Vaqueros Pipeline.

  - Isolated from the flow from the Delta-Transfer Pipeline and pumped to Los Vaqueros Reservoir via the Tranfer Pump Station.

  - Isolated from the Delta-Transfer Pipeline, with the Delta-Transfer Pipeline isolation valve closed, and used to feed the ETPS Station to pump to Bethany Reservoir.

## Hydraulic Design Criteria

Pipelines will be sized to provide a maximum velocity of less than 10 ft/sec. As identified in the Civil Design Criteria, a 66-inch diameter was selected for the Delta Transfer Pipeline and provides a velocity of approximately 7.5 ft/sec at the design flow (180 cfs). The Bethany Pipeline was assumed to be an 84-inch diameter providing a velocity of approximately 7.8 ft/sec at 300 cfs.

A system head curve for the Expanded Transfer Pump Station will be developed using the Hazen Williams Equation. A Hazen Williams C-Factor of 113 was determined for the Middle River Pipeline as part of the existing system hydraulic model development (refer to Existing System

Hydraulic Model Technical Memorandum (TM), MWH, December 2015) and was applied to both the Delta Transfer and Bethany Pipelines.

A surge analysis will be performed to evaluate and recommend surge mitigation measures. It is anticipated that surge mitigation devices will include hydro pneumatic surge tanks manifolded and connected to the pump station discharge header.

## Mechanical

This section includes a listing of codes, standards and recommended practices that will be used on the project, mechanical design criteria for yard valving and appurtenances for the Delta-Transfer Pipeline at both the Old River Pump Station and the Expanded Transfer Pump Station sites, the equipment at the Expanded Transfer Pump Station, and the Expanded Transfer Reservoir. Note that no modifications to the Old River and Middle River Pump Stations are anticipated in the proposed project.

### *Codes, Standards & Recommended Practices*

The following standards and references will be used for the sizing and design of the pump station, mechanical equipment, and appurtenances:

- American National Standards Institute (ANSI)/Hydraulic Institute (HI) Pump Intake Design Standard 9.8
- ANSI/HI Rotodynamic Pump for Pump Piping Standard 9.6.6
- EM 110-2-3105 Mechanical and Electrical Design of Pumping Stations by U.S. Army Corps of Engineers (USACE)
- Pumping Station Design by Garr M. Jones
- AWWA M-11 Steel Pipe – A Guide for Design and Installation

### *Yard Valving and Appurtenances Design Criteria*

Design criteria for yard valving and appurtenances are provided in Table 3-8 below. Yard piping design criteria will be as stated in the Civil discipline design criteria section of this chapter.

Table 3-8. Yard Valving and Appurtenances Design Criteria

| Item | Design Criteria |
|---|---|
| Delta-Transfer Pipeline Isolation Valve Station at Old River Facility Site | Motorized ball valve, AWWA C-507, with modulating ball valve bypass for pipeline filling and low flow trimming. Locate in buried concrete vault. |
| Delta-Transfer and Old River Pipeline Flow Routing Valves at Old River Facility Site | Motorized Butterfly valves, resilient seated AWWA C-504, 3 – new located in buried concrete vaults, 1 – existing |
| Delta-Transfer Pipeline Isolation Valve at Expanded Transfer Site | Motorized Butterfly valve, resilient seated AWWA C-504, located in buried concrete vault |
| Delta-Transfer and Old River Pipeline Downstream Isolation Valves at tie-in near Flow Control Station 1 | Motorized Butterfly valves , resilient seated AWWA C-504, located in buried concrete vaults |
| Air Release Valves, Air and Vacuum Valves, and CARVs | To be provided along the piping at local high points where required for air release and/or vacuum relief. Standard detail will be provided. Refer to Civil discipline design criteria. |
| Blowoff Assemblies | To be provided at local low points where pipeline draining for inspection or repair is required. Standard detail will be provided. Refer to Civil discipline design criteria. |

Key:
AWWA = American Water Works Association
CARV = combination air release and air/vacuum valve

### *Expanded Transfer Pump Station Design Criteria*

Pump systems will be designed in accordance with guidelines established by the Hydraulic Institute Standards. Pumps will be selected to operate within their Preferred Operating Region during continuous operation, or within its Allowable Operating Region for intermittent operation. Pumps' best efficiency point will be optimized as close as possible to the operating point where the pumps are anticipated to operate most of the time to save energy consumption.

The pump station suction configuration will be designed to the latest Hydraulic Institute Standards ANSI/HI 9.8 - Pump Intake Standards. Computational fluid dynamic model of the pump intake configuration may be required to verify flow approach of the pump meets the recommended criteria by HI.

Pumps will be vertical, multi-stage turbine pumps similar in design and construction as the existing pump station. The ETPS will take suction from the Delta-Transfer Pipeline through a suction piping manifold. Each pump will be installed inside a fabricated steel, mortar lined and coated "can" or "barrel." The motor and discharge head will be founded on finished grade and the pump discharge valves will be located above ground. The header pipe will be located below ground and will routed to connect to the Bethany Pipeline.

It is anticipated that surge tanks will be used for hydraulic surge projection similar to the existing pump stations with air and vacuum valves strategically located where identified in the hydraulic transient analysis. Pump station piping and valve design criteria will essentially follow the same criteria as the existing Transfer pump station. Design criteria for the Expanded Transfer Pump Station is summarized in Table 3.9.

Table 3-9. Expanded Transfer Pump Station Design Criteria

| Item | Design Criteria |
|---|---|
| Type of Pumps | Vertical turbine pumps in barrels |
| Number of Pumps | 6 (all duty) |
| Design Flow | 50 cfs each |
| Total Pump Station Design Flow | 300 cfs |
| Design TDH at Design Flow | 126 feet |
| Pump Check and Flow Control | Ball Valve, AWWA C-507, with check and flow control actuation on each pump discharge |
| Pump Isolation | Motorized Butterfly Valve, resilient seated AWWA C-504 |
| Minimum Pump Efficiency at Best Efficiency Point | 80 percent |
| Pump Materials of Construction: | |
| All materials in contact with water | NSF 61 and Lead Reduction Act Compliant |
| Impeller | 316 stainless steel |
| Bowl | Ductile iron, epoxy lined and coated |
| Wear Rings | Hard stainless steel |
| Bowl Bearing | Lead free bismuth bronze |
| Intermediate Bearings | Neoprene with non-metallic backing |
| Pump Shaft | Open line shaft, product lubricated |
| Pump Column | Fabricated steel, epoxy lined and coated |
| Coupling | Adjustable spacer type coupling |
| Motor (also refer to Electrical discipline design criteria presented in this document) | Constant Speed, Induction type |
| Motor Horsepower | 1,250 HP each |
| Expanded Transfer Pump Station Flow Meter Isolation Valve | Motorized Butterfly valve, resilient seated AWWA C-504, located in buried concrete vault |
| Process Piping Velocity | Pump Suction Piping: < 8 ft/sec<br>Pump Discharge Piping: <10 ft/sec |
| Hydropneumatic surge tanks | Sized to mitigate surge pressures due to loss of power at the pump station |

Key:
AWWA = American Water Works Association
cfs = cubic feet per second
HP = Horse Power
ft = feet
ft/sec = feet per second
NSF = National Sanitation Foundation
TDH = Total Dynamic Head

### *Expanded Transfer Reservoir*

The following design criteria apply to the new reservoir associated with the Expanded Transfer Pump Station.

- The primary Expanded Transfer Reservoir functions are similar to those described for the existing Transfer Reservoir in the original Los Vaqueros Reservoir design and summarized as follows:
  - Provide a stable water surface elevation for operation of the pumps at the Old River and Middle River Pump Stations.
  - Provide hydraulic level control for the flow control valves at Flow Control Stations 1 and 2.
  - Provide a stable suction pressure for operation of the Expanded Transfer pumps.

  - Provide storage volume required for the controlled shutdown of the Old River/Middle River pumps or the Transfer/Expanded Transfer pumps.

  - Provide a controlled emergency overflow to prevent pressure buildup in the Los Vaqueros, Old River, or Delta-Transfer Pipelines.

- It is assumed that the reservoir will be a coated steel above ground reservoir similar to the existing reservoir. As noted in the original design, the steel tank has a lower capital cost than alternative materials and allows better access for maintenance and sediment removal.

- Reservoir capacity requirements determined as follows:

  - Normal tank operating water surface elevation (WSEL) = 213 feet, same as existing 4 MG Transfer reservoir tank. The tanks are interconnected.

  - Normal operating WSEL band is calculated based on 20 minutes of flow from 2 pumps (all new and existing project pumps are nominal 50 cfs capacity). The calculated volume is split between the existing and the new reservoir tanks and added above and below the normal operating WSEL.

  - Required storage above the normal operating WSEL band is calculated from the volume pumped during the orderly shutdown of the Old River and Middle River Pump Stations, which each include five pumps. The shutdown sequence includes 5 minutes to verify Transfer or Expanded Transfer pump failure and begin the shutdown sequence at the Old River and Middle River Intakes, 2 minutes for controlled closure of each pump control butterfly valve, and a 1-minute stagger between complete shutdown of one pump and initiation of the shutdown sequence for the next pump. The total time for the controlled shutdown is assumed to be 19 minutes (with the first pump shutting down after 7 minutes on each successive pump shut down in 3-minute increments). The calculated volume is split between the existing and the new reservoir tanks and added above the upper WSEL band.

  - Required storage below the normal operating WSEL band is calculated from the volume pumped during the orderly shutdown of the Transfer (four pumps) and Expanded Transfer Pump Stations (six pumps). The shutdown sequence includes 5 minutes to verify Old River or Middle River pump failure and begin the shutdown sequence at the Transfer and Expanded Transfer Pump Stations, 1 minute for controlled closure of each pump control butterfly valve, and a 2-minute stagger between complete shutdown of one pump and initiation of the shutdown sequence for the next pump. The total time for the controlled shutdown is assumed to be 22 minutes (with the first pump shutting down after 7 minutes on each successive pump shut down in 3-minute increments). The calculated volume is split between the existing and the new reservoir tanks and added below the upper WSEL band.

  - The grand total storage required was calculated at approximately 9 million gallons. With the existing 4-million-gallon Transfer Reservoir the required volume of the new Expanded Transfer Reservoir is 5 million gallons.

- New reservoir height will match the existing reservoir height at 26 feet tall to the overflow. Required radius will be 90 feet, as compared to the existing reservoir radius of 81 feet.

- Inlet/Outlet pipe designed for maximum 8 ft/sec velocity at 300 cfs flow rate.

- Internal tank overflow piping will be provided and will be set at the same elevation as the existing Transfer reservoir tank. Tank overflow will be routed to tie into the existing transfer reservoir overflow pipe and directed to Kellog Creek. Confirmation of the appropriate sizing of the combined overflow pipe will need to be evaluated in the next phase of design. The pipe may require enlargement to carry the combined flow.

### *HVAC*

Ventilation will be provided for the new electrical MCC building serving the new Expanded Transfer Pump Station. The ventilation system will be similar to the existing Transfer Pump Station MCC building and will include louvered access doors and two exhaust fans with output ducted to louvered roof dormers. The ventilation system will be sized for sufficient air flow to maintain interior air temperature at no greater than ten degrees above exterior air temperature.

### *Plumbing*

Plumbing facilities will include small diameter potable and non-potable piping. As the existing nearby Transfer MCC building has a bathroom, no bathroom will be provided in the new Expanded Transfer MCC building.

**Plumbing Codes, Standards and Regulations** Plumbing system design will conform to the following codes and standards and any supplementary requirements of regulatory authorities having jurisdiction.

- Latest applicable version of California Building Code and Ordinances and Amendments

- Latest applicable version of International Plumbing Code

- Latest applicable version of International Fire Code

- Latest applicable version of National Fire Protection Association (NFPA)

**Design Criteria**

- Where available, water pressure from potable water system to buildings should be a minimum of 50 pounds per square inch gauge.

- Light duty hose valves for building exterior wash-down will be 3/4-inch globe valves with hose thread adapters.

- Medium-duty hose valves for exterior wash-down will be 1-inch globe valves with hose thread adapters.

- Pipe 3-inch and smaller shall be Type K copper tube with silver soldered fittings

## Electrical

This section discusses the criteria to be used for electrical design. The governing standards, codes and practices are included.

### Conclusions and Recommendations

The programmable logic controller (PLC) programming should be standardized. This includes the following areas of programming:

- Logic Address – Identification of address symbols.

- Descriptions – Address descriptions to indicate function.

- Use of Rung Comments

- Use of Page Titles

- Use of sub-routines and program files

- Use and provision of data files for plant Supervisory Control and Data Acquisition (SCADA) interface use.

- Use of calculations and conversion standards for use in reporting data acquisition

- Structure of data files for Plant Use.

- Provision of fully configured input/output (I/O) database and mapping.

The following PLC architecture approach is recommended:

- Use of individual PLC's at each new facility.

- Each motor controller will communicate with the network via Modbus Transmission Control Protocol/Internet Protocol (TCP/IP).

- Each of the motor controllers would also communicate with a small, dedicated operator interface unit (OIU), located on the front of each motor controller.

- The OIU would be used to indicate individual motor controller parameters including alarms and set points.

- Hardwired switches will be provided for local control operations, including a local/off/remote (LOR) selector switch with Start and Stop pushbuttons for pump start/stop control and a speed controller or potentiometer for local pump speed control in the local mode only.

This approach would allow the individual motor controller, local switches and associated motor controller OIU to operate independently from the CCWD PLC/SCADA system. This approach would be beneficial if a failure of either the area PLC or the communication network should occur. The hardware cost for each would be very similar, as the Remote I/O units would instead become part of the motor controller. The software configuration cost would be less with this approach as the programming responsibility for the motor controller operation would be transferred to the motor controller manufacturer from the PLC programmer reducing the probable coordination costs.

## Codes, Standards, and Recommended Practices

The work will be specified in accordance with the current applicable provisions of codes, standards, and recommended practices published by the following organizations:

- ANSI
- American Society for Testing and Materials (ASTM)
- Electrical Testing Laboratories
- Illuminating Engineering Society of North America
- Insulated Cable Engineers Association
- Institute of Electrical and Electronics Engineers (IEEE)
- The Instrumentation, Systems, and Automation Society (ISA)
- International Electrical Testing Association
- National Electrical Manufacturers Association (NEMA)
- National Electrical Installation Standards
- National Electrical Contractor Association (NECA)
- NFPA
- Underwriters Laboratories (UL)
- Occupational Safety and Health Administration

***Specific Codes, Standards & Recommended Practices***

The work will be specified in accordance with specific codes, standards and recommended practices. The latest edition in effect at final design will be used. Performance will be specified to follow applicable requirements of:

- 2011 (NFPA 70 – National Electrical Code (NEC))
- 2013 California Electrical Code (based on the 2011 NEC) – California Code of Regulations Title 24 Part 3
- 2012 International Building Code (2012 IBC)
- 2013 California Building Code Part 1 and 2 (based on the 2012 IBC) – California Code of Regulations Title 24 Part 2 Volume 1 of 2 and Volume 2 of 2
- 2013 California Energy Code – California Code of Regulations Title 24 Part 6
- 2012 International Fire Code
- 2013 California Fire Code (based on the 2012 International Fire Code) – California Code of Regulations Title 24 Part 9
- 2013 California Administrative Code – California Code of Regulations Title 24 Part 1 including Chapter 10 Administrative Regulations for the California Energy Commission
- 2013 California Mechanical Code (based on the 2012 Uniform Mechanical Code) – California Code of Regulations Title 24 Part 4
- 2003 (R2010) ANSI/NEMA C37.57 Std for Switchgear Testing
- 2011 ANSI/NEMA C84.1 American National Standard for Electric Power Systems and Equipment – Voltage Ratings (60 Hertz)
- 2014 NEMA Motors and Generators – 1 (MG1) Motors and Generators
- 2010 American Society of Civil Engineers (ASCE)/SEI 7-10 Minimum Design Loads for Buildings and Other Structures: including Chapter 13, "Seismic Design Requirements for Nonstructural Components," and Appendix 11A.1.3.10, "Quality Assurance Provisions" – "Special Inspection and Testing" – "Mechanical and Electrical Components"
- 1993 IEEE 141 (R 1999) IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (Red Color Book)
- 2001 IEEE 242 IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Color Book)
- 1997 IEEE 399 IEEE Recommended Practice for Industrial and Commercial Power System Analysis (Brown Color Book)

- 2014 IEEE 519 IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
- 2006 IEEE 551 IEEE Recommended Practice for Calculating Short-Circuit Currents in Industrial and Commercial Power Systems (Violet Color Book)
- 2006 IEEE 1015 IEEE Recommended Practice for Applying Low Voltage Circuit Breakers Used in Industrial and Commercial Power Systems (Blue Color Book)
- 2002 IEEE 1584 IEEE Guide for Performing Arc-Flash Hazard Calculations
- 2011 IEEE 1584b Amendment to IEEE Guide for Performing Arc-Flash Hazard Calculations IEEE Std 1584-2002
- 2013 IEEE 1584.1 IEEE Guide for the Specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculation Study in Accordance with IEEE Std 1584™
- 2015 IEEE Std C37.20.2™ Standard for Metal-Clad Switchgear
- 2013 IEEE Std C37.20.3™ Standard for Metal-Enclosed Interrupter Switchgear (1 kilovolt (kV)- 38 kV)
- 2013 IEEE Std C37.20.4™ Standard for Indoor AC Switches (1 kV to 38 kV) for Use in Metal-Enclosed Switchgear
- NECA 1 Standard for Good Workmanship in Electrical Construction (ANSI)
- NECA 101 Standard for Installing Steel Conduits (Rigid, intermediate metal conduit, and steel electrical metal tubing) (ANSI)
- NECA/NEMA 605 Installing Underground Nonmetallic Utility Duct (ANSI)
- 2013 International Electrical Testing Association ATS (ANSI) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
- 2015 NFPA 101 Life Safety Code
- 2012 NFPA 497 Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
- 2016 NFPA 820 Standard for Fire Protection in Wastewater Treatment and Collection Facilities
- 2012 NESC C2 National Electrical Safety Code
- UL 508A-2013 Standard for Industrial Control Panels

- 2015 NFPA 70E Standard for Electrical Safety in the Workplace
- 2015 NFPA 79 Electrical Standard for Industrial Machinery

#### *NFPA 70E Standard for the Electrical Safety in the Workplace*

Based on interpretations of the NFPA 70E, segregation of electrical rooms, locked and accessible to qualified and trained electrical staff to house indoor electrical equipment (480 volts (V) and above) is suggested. Low Voltage cabinets (120V panel boards, PLC cabinets) will be installed in adjacent rooms. This minimizes the risks of arc flash exposure to maintenance staff that may not be trained in arc flash safety and allow them to access the cabinets wearing non arc flash rated work clothes.

#### *Energy Efficiency Guidelines*

Work will be specified to comply with the National Energy Efficiency requirements as applicable, including the Energy Independence and Security Act of 2007. In particular, Title 10 Code of Federal Regulations, Part 431, Energy Efficiency Program for Certain Commercial and Industrial Equipment, including Subpart B, Paragraph 431.25 for Electric Motors; Subpart K, Paragraph 431.196 for Distribution Transformers; and Subpart L, Paragraph 431.206 for Exit Signs.

Work and materials will be specified to comply with the 2013 California Energy Code (Title 24 Part 6).

NEMA premium efficiency motors will be specified, per NEMA MG1, where general purpose and inverter-duty motors are applied, with the size and speed range listed for premium efficiency motors in 2014 NEMA MG1.

The lighting and lighting control will comply with requirements of 2013 California Energy Code (Title 24 Part 6).

The power monitoring will comply with requirements of 2013 California Energy Code (Title 24 Part 6).

The voltage drop will comply with requirements of 2013 California Energy Code (Title 24 Part 6).

#### *Inspection Authority*

The Authority Having Jurisdiction for electrical work will be Contra Costa County.

### Equipment Load Estimates

#### *4000 V Vertical Pump Load Estimate for Expanded Transfer Pump Station*

The approximate load of 6 1,250 HP is 6 x 1,250 thousand volt amps (kVA) = 7,500 kVA. This will constitute most of the Expanded Transfer Pump Station load. This will be refined during the next stage of design when the specific pump sizes and speeds are selected from the pump universe of potential vendors.

### *Auxiliary Equipment Load Estimate for Expanded Transfer Pump Station*

The approximate load of the auxiliary and facility equipment is estimated at 225 kVA. This will be refined during the next stage of design when the specific equipment is identified and sized for the project. The 120 volt 3-phase load is estimated at 45 kVA. The 120 volt 1-phase load is estimated at 25 kVA.

### *Old River Pump Station Vault Load Estimate*

The increase in the 480 volt auxiliary transformer load is estimated to be 75 kVA so the auxiliary transformer size will increase from 150 kVA to 225 kVA.

## Power Distribution

The expected power for the new Expanded Transfer Pump Station facilities is to be supplied by the utility Pacific Gas and Electric Company (PG&E). The same PG&E substation, distribution poles and rights of way that feed the existing Transfer Pump Station facilities are expected to be used to feed the new Expanded Transfer Pump Station facilities. PG&E will need to engineer and design their distribution to support the total load at this location.

### *Main Power Feed*

The utility PG&E delivers 21 kV power via distribution poles from their substation to the end overhead pole on the hill adjacent to the existing Transfer Pump Station facilities overlooking the 21 kV to 4.16 kV existing outdoor substation and adjacent MCC building housing the existing medium voltage motor controls. The existing PG&E feed then goes into underground ductbank to the facility existing substation at the end overhead pole on top of the hill. The new 21 kV power feed to the new Expanded Transfer Pump Station facilities is expected to go underground in conduit ductbank from this same pole and feed the new facility 21 kV to 4.16 kV substation.

### *20.78 kV Site Distribution*

The new underground ductbank carrying 21 kV power to the new substation for the new Expanded Transfer Pumping Station facilities will follow the hill top ridge to a transition point to go down the hill to the new facility location. This will be laid out in more detail when the location of the new facilities are completed including the new 20.78 kV/4.16 kV substation.

### *20.78 kV / 480 Volt Substation*

Due to voltage drop and motor starting issues the new substation shall match the existing substation in rating and footprint at a nominal base 15 thousand volt amps (MVA) size. This may be reduced after the PG&E requirements and Utility impedances are determined for this project and motor starting and voltage drop calculations are performed to show that a smaller substation will meet the various requirements.

### *Switchboard*

Switchboard(s) shall distribute 480V 3-phase 3-wire power in the MCC building to the various loads.

### *Motor Control Centers*

Motor control centers shall house collections of motor controllers including smaller 6-pulse variable frequency drives, reduced voltage solid state starters for large constant speed motors, and contactor starters for smaller constant speed motors.

### *Miscellaneous Electrical Distribution*

Stand-alone 480//208/120V 3-phase 4-wire lighting transformer with matching lighting panelboards shall be provided for indoor and outdoor lighting. Stand-alone 480//240/120V 1-phase 3-wire power transformers with matching power panelboards may be provided for auxiliary equipment

### *Utilization Voltages*

Power equipment shall use 480 volt distribution power in general. Specialized power equipment such as battery chargers and other auxiliaries may use 240V single phase distribution. Indoor lighting and receptacles shall use 120V distribution power in general. Nearby outdoor lighting and receptacles shall use 120V distribution power. Distant outdoor lighting may use 208 or 240 or 480V distribution power depending on distance and power requirements. The large vertical turbine pump motors shall use the nominal 4,160V power similar to the existing pumps.

### *Existing Utility 21 kV Feed*

The existing 21 kV feed to the existing facilities are expected to remain as they currently exist.

## Equipment

The electrical distribution equipment will be designed to support the selected equipment for this facility. This includes compliance with current PG&E requirements and applicable codes and standards of the day.

### *Distribution System Equipment – General*

The distribution system equipment will be similar to what was installed in the existing Transfer Pump Station facility, existing Old River Intake facility and existing Middle River Intake facility. Power factor correction equipment will be used to comply with the utility PG&E voltage drop requirements and support the delivered voltage during motor starting by lowering the required Utility system current draw during a starting event. A switched power factor correction capacitor will be provided to each motor starter to correct the power factor to 0.95 when running at speed. A large solid state switched power factor correction capacitor bank shall provide the large reactive motor starting current during a motor start to support the system voltage and continuously adjust the reactive kVA provided as the motor come up to speed to keep a slightly lagging power factor.

### *20.78 kV/4.16 kV Substation and 4.16 kV Switchgear*

The proposed 20.78 kV/4.16 kV substation and 4.16 kV switchgear is proposed to match the existing Transfer Pump Station facility substation and switchgear. This was done to accommodate voltage drop restrictions that are expected from the utility PG&E and accommodate motor starting issues related to large premium efficiency induction motors. After motor starting and load flow studies are conducted with proposed vendors and their equipment, Utility impedance data is made available, and Utility voltage drop limitation are identified specifically for this facility lower rated equipment may be considered.

### *Transformers*

Transformers will be new equipment for the new facilities. All applicable new transformers shall comply with the Department of Energy increased efficiency requirements effective January 1, 2016 for low and medium voltage transformers per 10 CFR 431.

### *Switchboards*

Indoor, front-accessible, fixed mounted circuit breaker switchboards, in NEMA 1-gasketed enclosures will be provided. Specification section 26 22 00, Low-Voltage Switchboards will contain additional requirements.

### *Motor Control Centers*

Reduced-voltage-solid-state (RVSS), full-voltage-non-reversing, full-voltage-reversing, two-speed-two winding and two-speed-single-winding, other non-variable-frequency starters, and smaller variable frequency drives (VFD) powering motors less than 60 horsepower (hp) will be located within the MCCs.

### *Panelboards*

Panelboard schedules showing panelboard description and equipment numbers, bus ratings (short-circuit interrupting and withstand, voltage, current and phase), mounting type, main and branch circuit breaker ampere ratings and number of poles, circuit numbers, load descriptions and equipment tag numbers, connected volt-amperes per phase, connected volt-ampere subtotals per phase, total connected load in volt-amperes, and a demand load estimate will be prepared.

Panelboards will be sized to accommodate expected loads in accordance with the NEC. In addition, the following requirements will be adhered to:

1. Each panelboard will be sized to accommodate 25 percent spare capacity, with at least 25 percent spare circuit breakers and will be fully bussed.

2. Panelboards will be in NEMA 1 enclosures as a minimum when in ventilated Electrical rooms. For outdoor installation and damp indoor locations NEMA 4X stainless steel enclosures will be used.

3. Machine-printed directories, with circuit descriptions complying with the 2011 NEC will be provided within each panelboard.

Specification section 26 12 16, panelboards and general purpose dry type transformers, will contain additional requirements.

### *Variable Frequency Drives*

VFDs will be the most current model (no end-of-production) made by Eaton, ABB, Siemens, Rockwell/Allen Bradley, Schneider or Toshiba and using the latest technology and fabrication. VFDs powering motors smaller than 60 hp will be group mounted in motor control centers.

For mitigating the effects of carrier frequency problems between VFDs and their respective motors, all VFDs will, at a minimum, be provided with load-side rate of change of voltage with respect to time or similar output filters. All VFDs will have input line reactors. Additional filtering equipment as required to comply with specified harmonic limitations shall be provided.

Bypass contactors are not anticipated for any VFDs. Specification section 26 29 23, Variable Frequency Drive Units, will contain additional requirements.

### *Motors*

Where applicable, electric motors will comply with NEMA MG1. Also, premium efficient motors will be provided, as defined in NEMA MG1, for all new motor-driven equipment complying with California Title 24 Part 6 – California Energy Code. Motors used with VFDs will comply with NEMA MG1, Part 31. Motors will be suitable for the indicated or required starting method and the environments in which they are installed. Motors will be equipped with space heaters, thermostats/thermistors, or both, will be provided with shaft bearing grounding rings, insulated bearings and properly and adequately circuited to their respective controllers with VFD lead cables. Specification section 26 05 10 – Electric Motors, will contain additional requirements.

Motors larger than 25 HP will be suitable for RVSS starters.

Medium voltage motors will be suitable for RVSS starter starting, have weatherproof II enclosures, have one resistance temperature detector bearing temperature detectors per bearing, have two resistance temperature detectors per phase for a total of six, have a space heater to prevent condensation, and have vibration sensing equipment.

### *Uninterruptable Power Supply Units*

Battery-type uninterruptable power supplies (UPS) will be provided to supply power to critical instrumentation and control loads (e.g., PLC) and analytical instruments such as flow meters and analyzers. Each of these UPS(s) for these critical systems will provide battery backup for at least 30 minutes and will have both automatic internal static-switch bypass and manual external maintenance bypass (furnished as an integral part of the UPS package and fabricated by the same manufacturer, as the UPS). A UPS in the new Electrical Building sized for PLC, instrumentation, and controls to match the instrumentation work will be provided. Specification section 26 33 53, Uninterruptible Power, Single Phase, will contain additional requirements.

### *Disconnect Switches*

Local disconnect switches at all motors that are remote (greater than 50 feet), out-of-sight, or both, from their respective controllers will be provided. This requirement applies to motors at all utilization voltages less than 600V. Additional requirements:

1. All motor disconnect switches will be equipped with an auxiliary contact (or an additional pole if auxiliary contacts are not available, e.g., 120V toggle switches), which will be wired to the applicable PLC controlling the motor circuit, to provide “Switch Closed” position indication to the SCADA system.

2. All disconnect switches sized larger than 15 ampere and rated for 600V or less will be fusible and be equipped with time-delay current-limiting fuses appropriate for the branch circuit providing a minimum interrupting rating of 100 kiloampere symmetrical.

3. Where used at motors fed from VFDs or for motors with integral space heaters, or both, switches with auxiliary contacts (early-break/late-make), wired into VFD and motor controls, to disable controllers if the switches are open, will be provided.

4. An informational sign on each 480V motor disconnect switch, rated 30A and larger, that states "AVOID OPENING/CLOSING SWITCH IF MOTOR CIRCUIT IS ENERGIZED" will be provided.

5. Enclosed safety switches, rated 600V and 30A and larger, will be provided in NEMA 4X, Type 316 stainless steel, enclosures. Outlet boxes with matching conduit types and with weatherproof covers, for all motor-rated toggle-type switches will be provided;

6. The above requirements will not apply to motor installations where installing a local disconnect switch at the motor is impractical (e.g., submersible pump) or would create a more hazardous condition.

### *Overload Protection*

Each motor will have thermal overload protection in all ungrounded phases per the NEC. Controller-mounted relays will have an external manual reset.

### *Ground Fault Protection for Vault Equipment*

All electrical equipment installed in an underground vault will have the line side of the feeder protected by a ground-fault circuit interrupter (GFCI) rated overcurrent protective device in the panelboard or MCC, control panel, or other power supply mounted above ground. The following will have GFCI protection in or as a part of the overcurrent protective device:

1. Lighting.

2. Convenience outlets.

3. Ventilation fans.

4. Sump pump(s).

### *Convenience Receptacles*

The following receptacle requirements will be adhered to:

1. Duplex receptacles for general service will be installed on walls or columns and no more than 25 feet apart in all process areas and in Electrical rooms. There will be at least four duplex receptacles in each room, on each exterior equipment pad, and where required by the NEC for heating, air-conditioning, and refrigeration equipment. In NEMA 1 dry areas, receptacles will be industrial-spec grade NEMA 5-20R. Receptacles will be spaced such that from any location in a room or space two receptacles can be reached with a 25-foot extension cord in all accessible areas of the facilities.

2. Heavy duty, corrosion-resistant GFCI receptacles, in weatherproof/in-use enclosures, will be installed in outdoor damp and wet areas and in indoor areas subject to wash down or corrosive environments, and as required by code. Feed-through GFCI receptacles will not be used to serve downstream receptacles requiring GFCI protection.

3. GFCI circuit breakers in panelboards, in lieu of GFCI receptacles, will not be used.

4. Weatherproof GFCI outlets will be installed on the exterior of new buildings and at outdoor equipment pads. Outlets will be mounted no more than 50 feet apart. Roofs having any mechanical equipment using electric power will have a minimum of two weatherproof GFCI outlets that are within 10 feet of the mechanical equipment.

Specification section 26 05 36, Wiring Devices, will contain additional requirements.

***Conduit and Raceway Systems***

The following conduit and raceway requirements will be adhered to:

1. Separate raceway systems will be provided for each of the following:

    a. 24V direct current (DC) digital control and analog signal circuits

    b. 120V alternating current (AC) digital control circuits

    c. 120/208V and 120/240V AC power circuits

    d. 480V AC power circuits (conduits/ducts for 480V AC circuits will be combined within the same ductbanks as conduits/ducts for 120/208V and 120/240V AC power circuits)

    e. 20.78 kV AC power circuits, with separate conduits/raceways for each unit substation current and future.

    f. Fiber optic cables (2-inch minimum conduit size for all installations)

2. Minimum sizes of conduits will be 3/4-inch for exposed work and 1-inch when encased in floor slabs or when otherwise concealed. Conduit sizes that will be used for all above ground circuits are 1-inch, 2-inch and 4-inch, for all above-ground (i.e., not in ductbanks) circuits. Conduit-fill calculations will be based on conductors with XHHW insulation.

3. At least three pipe-outside-diameters, center-to-center spacing, between adjacent conduits placed in concrete slabs or walls will be provided. If conduits of different sizes are run adjacent to each other, the average outside diameter for the calculation will be used.

4. For circuits below 600V, the number of conduit bends to a total of 270 degrees will be limited, at which point pull or junction boxes will be provided. For circuits above 600V, conduit bends to 180 degrees between manholes or pull boxes will be limited.

5. The maximum cable length between manholes will be less than 400 feet for an essentially straight run and reduced by 50 feet for each bend of 45 degrees; and by 100 feet for each bend of 90 degrees. Bends will be made with the largest radius possible.

6. For exterior areas (even if covered) and interior areas classified as damp/wet or "corrosive," rigid, (polyvinyl chloride (PVC))-coated galvanized rigid steel conduit that is resistant to direct sunlight will be used.

7. For exterior, underground, concrete-encased ductbanks, PVC Schedule 40 conduit will be used; however, for all elbows and bends, factory-fabricated, PVC-coated, rigid galvanized steel, with the largest available radii will be used. Field bends will not be used. The only conduit sizes that will be used in ductbanks are 2-inch, 4-inch, 5-inch and 6-inch; 1-inch conduits will only be used when included for a dedicated circuit, such as street lighting circuits.

8. For direct-buried conduits not encased in concrete, PVC Schedule 80 conduit will be used.

9. PVC-coated steel elbows and riser conduits for all below-grade/below-slab conduits that extend through slabs will be used. All through-slab conduits will be terminated flush with finished slabs with embedded PVC-coated steel conduit couplings, with factory plugs.

10. For analog process instrumentation wiring, for interior (exposed and concealed) and exterior areas, rigid galvanized steel in noncorrosive, non-damp/wet environments and PVC-coated galvanized-steel conduit in any situation that may be corrosive or damp/wet will be used.

11. For low-level process instrumentation wiring for underground installations, PVC-coated galvanized-steel conduit will be used.

12. All power, control, and instrumentation circuits will be routed in separate conduits.

13. Underground conduit runs of two or more conduits will be installed with interlocking spacers every five feet.

Specification sections 26 05 33, Electrical Raceway Systems, and Section 26 05 43, Underground Raceway Systems, will contain additional requirements.

### *Conductor and Raceway Schedules*

Each circuit will be identified with a unique tag, usually consisting of alphanumeric characters based on Piping and Instrumentation Diagrams (P&ID) designations for control wiring and equipment designations for power wiring. Other power wiring will also require panelboard circuit designations for identification. Raceway schedules will be provided for all distribution circuits and control/instrumentation circuits. All circuits and associated raceways on site and within a building will be shown on the site and building plans. Exceptions to this are conduits used for interior and exterior lighting and receptacle branch circuit runs.

### *Wire and Cable (17.8.16)*

The following wire and cable requirements will be adhered to:

1. All power wire sizes will be increased to accommodate harmonic currents when feeding, or being fed from, equipment that generates harmonic currents.

2. Conductors will be De-rated, per NEC correction factors, for all power circuits installed in non-air-conditioned interior spaces and all exterior locations, for use in an environment with a maximum ambient temperature of 45 degrees Celsius (ºC).

3. All power wiring shall be copper stranded conductors. All power conductors shall have type XHHW-2 insulation. All control wiring shall be stranded and have type XHHW-2 insulation.

4. Cross-linked polyethylene (XHHW-2) insulation will be used for all power and control wiring rated for 600V and applied to all 480V and lower voltage AC and DC systems.

5. Specialty VFD-rated, 1,000V, multi-conductor, shielded cables, with individual conductors insulated with XHHW-2, such as manufactured by Belden Cable, will be used for the output leads between VFDs and their respective motors, especially for lead lengths exceeding 100 feet. Shielded cables will be used, with PVC jacket, for installations in conduit and shielded, jacketed cables, with armor casing, for installations in cable trays.

6. Low-voltage wiring systems will be sized, rated 1,000V or less, based on 75ºC temperature rating of wire insulation.

7. All power wiring will be color-coded and solid colors will be used through the entire length of the conductor using the color coding specified in Table 3-10 below.

Table 3-10. Power Wiring Color Code Summary

| **Wire Tape Color or Wire Insulation Color Table For Wire Identification** | | **Color For Voltage** | |
|---|---|---|---|
| | **208/120** | **480/277** | **12470** |
| Phase A | BLACK | BROWN | BLACK |
| Phase B | RED | ORANGE | RED |
| Phase C | BLUE | YELLOW | BLUE |
| Neutral | WHITE | GRAY | N/A |
| Switch Traveler Leg | PURPLE | | |
| Ground | GREEN | GREEN | GREEN |

Key:
N/A = Not Applicable

8. To reduce electrical noise in instrument circuits, twisted-shielded-pair or triad instrumentation/signal cable for all 24V DC analog circuits will be used. The shield will be grounded at only one end, i.e., where the input signal arrives. Instrumentation/signal cable will comply with Insulated Cable Engineers Association S-73-532/NEMA WC 57 Standard for Control, Thermocouple Extension, and Instrumentation Cables.

9. Each control wire and twisted-shielded-pair/triad instrument/signal cable with a unique wire and cable number will be tagged. Each control wire, pair/triad, with the separate and unique numbers at the field end and at the final point of termination, as well as all

accessible terminal junction box in-between will be tagged. The same wire numbers will be used for identifying terminals on terminal blocks whenever wires are landed on them.

10. Grounding cable will be insulated copper with XHHW-2 600V insulation, or uninsulated copper conductor, sized as required to comply with the NEC, at a minimum. All power cable and conduit/raceway and all control cable and conduit/raceway will contain a code complying grounding cable.

11. Special cable will include cable supplied with equipment, prefabricated cable, coaxial cable, communication cable, etc. This cable will normally be supplied by a particular manufacturer. Special cable will be installed in accordance with the manufacturer's recommendations.

12. Individual wires of control or instrument/signal cables will not be spliced. Where distances preclude use of uninterrupted lengths of wires or cables, circuits using interim terminal junction boxes will be extended, with each incoming and outgoing wire terminated on a separate, tagged terminal of terminal blocks mounted inside the terminal junction box.

13. NEMA 1 enclosures will be provided for terminal junction boxes located in indoor dry and conditioned spaces; all other terminal junction boxes will be provided with NEMA 4X, Type 316 stainless steel, enclosures. Terminal junction boxes will be provided with hinged covers, and with a terminal for each active wire and each spare wire, and with additional 20-percent spare terminals (with a minimum of five).

14. If other types and constructions of cable are required as design and construction of the project progresses, those will be designated and routed as required.

15. No. 12 American Wire Gage (AWG) copper will be used for lighting and convenience outlets as a starting minimum size. Full size neutral will be used as a minimum. Lighting and receptacle loads will not be combined on the same circuit.

16. A neutral conductor will be provided for each individual power circuit. Combined neutrals will not be used.

17. All equipment will have its wire and cables in separate conduits for power, control, and monitoring (communications and signal/instrumentation). There will not be more than three power conductors per conduit run.

18. All medium-voltage cable will be stranded copper, shielded, insulated for a minimum of 133 percent of the standard nominal system voltage being used. The insulation will be Ethylene-Propylene-Rubber. The wire stranding will have a semiconducting conductor shield. The insulation will have a semiconducting insulation shield. The shield conductor will be copper. The cable will have a PVC jacket. The cable will be rated medium voltage (MV)-105. All medium-voltage cable will comply with ICE S-93-639/NEMA WC742006 5-46kV, Shielded Power Cable for Use in the Transmission and Distribution of Electrical Energy. The minimum size of medium-voltage cables, for distribution circuits from the service entrance 20.78 kV switchgear to the new unit substation will be

No. 4/0 AWG copper, with a No. 1/0, 600V, XHHW-2 equipment grounding conductor, regardless of load and overcurrent protection device ratings.

Based on control and signal circuits designated in P&IDs, the following number of spare control/signal wires or cables will be provided:

1. 20-percent spare control wires (minimum of two No. 14 wires) from each defined field device to its respective local control panel or interim telephone junction box that interfaces with an exterior ductbank.

2. 20-percent spare signal cables (minimum of one shielded pair or triad) from each defined field device to its respective local control panel or interim telephone junction box that interfaces with an exterior ductbank.

3. 20-percent spare control wires (minimum of four #14 wires) within each multi-conductor (Tray Cable type) control cable routed through an exterior ductbank between telephone junction boxes within separate buildings, and extended through building interiors to PLC or control cabinets or other final circuit-termination points.

4. 20-percent spare signal cables (minimum of two shielded pair or triad) within each multiconductor (Tray Cable type) signal cable routed through an exterior ductbank between terminal junction boxes within separate buildings, and extended through building interiors to PLC cabinets.

5. All spare wires will be landed onto individual spare terminal points within telephone junction boxes, control/PLC cabinets, or other final circuit-termination.

During detailed design technical specifications will contain additional requirements.

#### *Electrical Equipment Identification*

1. All electrical equipment will be identified and tagged with a unique numbering system.

2. Laminated-plastic engraved nameplates will only be used for electrical equipment installed indoors in electrical rooms/buildings in dry non-corrosive areas. All other nameplates will be embossed/engraved Type 316 stainless steel suitable for use outdoors, in corrosive areas with exposure to sun and high-ambient temperature.

### Power Distribution System Analyses

1. A short circuit and coordination study will be performed during construction by the contractor or by a selected manufacturer of the major electrical equipment, for the actual equipment being installed, to ensure proper short-circuit equipment rating of the equipment based on the short-circuit fault current availability from the point of service. This study will build on the requirements of previous short-circuit study evaluations available from the owner and will include the existing Transfer Pump Station electrical facilities. The study will be specified to be prepared by a professional engineer, registered in the State of California. The report will be required to show the single-line diagrams for the new electrical system, including the 20.78 kV metal enclosed service entrance facility main circuit breaker and related feeder fused switches and the 20.78 kV – 4.16 kV

substations' 15 MVA transformer power source and secondary 4.16 kV overcurrent protection device (OCPD); 4.16 kV – 480 V transformer power source; 480V power panelboards, switchboards, MCCs, and 480 motors, with corresponding short-circuit data. The fault current available (both maximum and minimum values and X/R ratios) from the utility company (PG&E) will be obtained by the study provider and will be confirmed by the local utility with a signed letter confirming the data. The report will be specified to show a tabulation of protective devices, time-current characteristic curves of each device and their settings. The same studies shall be provided for standby engine generator set.

2. A summary report of all the studies performed, including load flow and voltage drop study, short-circuit study, protective device coordination and evaluation study, arc-flash study, and harmonic analysis will be specified to be provided. SKM software or equal will require to be used to help generate the report, organize the information, and perform the calculations. All electronic data input to the software and output from the software will be submitted to the owner along with the software identification and version to allow future engineers to perform future studies. The report will be specified to use the design names and identification so the design and the report are tied together and can be related.

3. The objective of the load flow, motor starting and voltage drop studies is to document wire and transformer sizes and taps are adequate and set to deliver power at maximum future load with a delivery voltage that does not fall below the minimum equipment utilization voltage per the voltage standards with minimum allowable utility voltage being provided. At the same time, for minimum load and maximum utility voltage, and the transformer taps set for maximum load, the voltage drop study will document that equipment utilization voltages do not exceed the maximum allowable standard value for one running piece of equipment and all others turned off. The report will also be used to verify compliance with maximum voltage-drop limits per local energy code requirements.

4. The objective of the short-circuit study is to document adequate short-circuit interrupting ratings of OCPDs (including circuit breakers and fuses), and withstand ratings for equipment, for the complete project. Additional short-circuit studies will be performed to support the arc-flash calculations where minimum fault values may be required to obtain worst-case arc-flash energies.

5. The objective of the protective device coordination and evaluation study is to provide the settings for the adjustable OCPDs and document coordination and selectivity for all the protective devices. Also the protective device coordination and evaluations study will document protection of equipment in accordance with current codes and standards.

6. The objective of the arc-flash study is to provide arc-flash energy calculations for documenting the required personal protective equipment requirements for owner's staff, contractors, maintenance, and operation personnel working in or around the related electrical equipment. The contractor will furnish and install the arc-flash warning labels on all equipment to comply with NFPA 70E and NEC requirements.

7. The objective of the harmonic analysis is to ensure compliance with IEEE 519-2014 and to verify that excessive harmonic voltages and currents do not occur with respect to resonant systems in particular when reduced voltage solid state starting large motors where the applied voltage waveform is chopped up to the load to reduce the applied voltage.

During detailed design technical specifications will contain additional requirements.

***Load Flow, Voltage Drop and Motor Starting Study***

1. A complete load flow and voltage drop study of the new electrical system from the 20.78 kV utility supply at the substations supplying power down to each and every significant load will be specified to be provided.

2. Three steady state studies will be specified for three cases using Utility current impedance data as follows:

   – The existing Transfer Pump Station and the new Expanded Transfer Pump Station all at maximum rated load.

   – The new Expanded Transfer Pump Station at maximum rated load and Transfer Pump Station pumps are not running.

   – The existing Transfer Pump Station at maximum rated load and the new Expanded Transfer Pump Station pumps are not running.

3. The study will be specified to document design compliance with ANSI/NEMA C84.1 2011 American National Standard for Electric Power Systems and Equipment – Voltage Ratings (60 Hertz) minimum and maximum voltages.

4. Each power source will be specified to have calculations showing the maximum voltage is not exceeded at each load with no equipment running and the minimum voltage is not reached at each load with maximum running load. The calculation will be done with a computer program, such as SKM or equal.

5. For the low-voltage part of the system (600V or less) the voltage drop shall comply with California Title 24 Part 6 – California Energy Code requirements for voltage drop.

6. The Load Flow and Voltage Drop Study will be specified to be performed in accordance with IEEE 399-1997 IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis.

7. Two motor starting studies will be provided to document the voltages on the various busses stay within the ANSI/NEMA C84.1 limits during the last motor start as follows:

   – The existing Transfer Pump Station will have all pumps running at rated load and the new Expanded Transfer Pump Station will have all pumps running except the last pump being started. The study shall document the buss voltages while starting the last pump motor with all other pumps running at full load.

- The new Expanded Transfer Pump Station will have all pumps running at rated load and the existing Transfer Pump Station will have all pumps running except the last pump being started. The study shall document the buss voltages while starting the last pump motor with all other pumps running at full load.

***Short-Circuit Study***

1. A complete worst-case short-circuit study of the new electrical system from the 20.78 kV Utility supply at the substation supplying power down to each and every load will be specified to be provided. Some trial and error studies will need to be performed to get the worst case with the highest fault current.

2. The study will be specified to cover the Utility source maximum available fault level and the current Utility source available fault level as two separate studies.

3. The study will document design compliance with protective device and equipment short circuit interrupting and withstand ratings having a minimum margin of at least 20 percent over the future build-out installation. The short-circuit studies will be in accordance with IEEE Standards 141, 242, 399, 551, and 1051.

4. The calculations will be done with a computer program, such as SKM or equal.

5. Complete studies will be performed for line to ground faults for the two cases named above – Utility maximum available fault level and current Utility fault level.

***Protective Device Coordination and Evaluation Study***

1. A complete Protective Device Coordination and Evaluation study of the project's new electrical system from the 20.78 kV utility supply at the substations supplying power down to each and every load will be specified to be provided.

2. The study will be specified to provide the settings for each and every adjustable protective device. Time Current Coordination (TCC) plots will be specified to be drawn to show proper selectivity and coordination for all protective devices.

3. The TCC plots will be specified to be drawn and generated from a computer program, such as SKM or equal.

4. A summary table of settings and devices will be specified to be generated and published for use by the OWNER and CONTRACTOR.

5. Each TCC plot will be specified to have a partial single line showing the arrangement and identification of the protective devices in the TCC plot.

6. A full set of ground fault TCC plots, coordination documentation and settings will be specified to be provided similar to the phase TCC plots with related partial single lines having the arrangement and identification information shown.

7. The results of the protective device evaluation study will be specified to be presented in tabular form with device names listed in the first column, the equipment ratings in the

next columns, and the fault exposure in the next columns that can be compared to the equipment ratings and the final columns will be pass or fail and associated remarks.

8. The plotting and presentation will be specified to be performed with a computer program, such as SKM or equal.

9. The Protective Device Coordination and Evaluation Study will be specified to comply with IEEE 399-1997 IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis.

### *ARC-Flash Study*

1. A complete arc-flash study will be specified to be provided for the project's new electrical system from the 20.78 kV utility supply at the substation supplying power down to each and every load as recommended in NFPA 70E for the two short-circuit studies noted above.

2. Arc-flash calculation will be specified to be performed per IEEE 1584-2002, IEEE Guide for Performing Arc-Flash Hazard Calculations, and NFPA 70E-2012, Standard for Electrical Safety in the Workplace.

3. The calculation will be specified to be performed using a computer program, such as SKM or equal.

4. These calculations will be repeated after an 85 percent reduction in fault available from the utility for the two cases above. The worst case results for the four cases shall be tabulated and submitted.

### *Harmonic Analysis for Application of Capacitor Power Factor Correction*

1. A complete Harmonic Analysis will be specified to be provided for the project's new electrical system from the 20.78 kV utility supply at the substation supplying power down to each and every load for the facility operating at full rated capacity. The analysis and calculations will present system impedance graphs versus frequency to show the electrical system natural resonances. The analysis and calculations will present expected Total Harmonic Distortion for voltage and current at each voltage level at each power transformer primary and secondary with a breakdown for each frequency component listed in the IEEE 519-2014 tables, including Table 1 for Voltage Distortion Limits and Table 2 for Current Distortion Limits. The studies will be conducted for the maximum peak load at the facilities during a motor start using a reduced voltage solid state motor starter that provides typical RVSS harmonic voltages and currents while reducing the applied voltage to the motor load using solid state switching during the initial start.

2. Harmonic calculations and analysis will be specified to be performed per IEEE 519-2014, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems, and IEEE 399-1997, IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis.

3. The calculations will be specified to be performed using a computer program, such as SKM or equal.

4. Harmonic measurements of current and voltage will be specified to be recorded during actual system operation during a motor RVSS start and then compared to the calculated results to verify that the calculations are reasonable, to demonstrate no severe harmonic distortion or resonance is present in the system and to show that compliance with IEEE 519-2014 recommendations has been achieved. These measurements will be specified to be made a part of the complete Harmonic Analysis study report.

### *Electrical Equipment Control*

The Instrumentation and Control section in this document contains the "Control System Philosophy" for electrical equipment. The following requirements will be adhered to as well as coordinated with "Instrumentation and Controls Design Criteria on Performance Requirements" section:

1. Ladder-type control diagrams will be prepared for each motor (excluding motors that are provided as part of a packaged system where the control diagrams will be provided by the manufacturer), showing all control wiring, pilot devices, auxiliary contacts, inputs and outputs between the starter and Instrumentation and Control (I&C) I/O boards, and external connections.

2. Each motor starter will be wired to receive LOCAL, OFF, REMOTE, and PLC RUN or remote equipment control panel command contacts, to accomplish the control discussed above.

3. Controls and safety shutdown interlocks (e.g., pressure switches, no flow switches, and low-low-level switches) will be directly wired to the motor control circuit. A reset pushbutton and control relay will be provided to reset the pump or motor or equipment after a shutdown.

All motor control circuits will be designed for 120V. All motor starters will have individual control power transformers with 120V secondary and with primary and secondary overload and short circuit protection.

## Grounding

A complete grounding and bonding system will be provided for the new facilities according to the NEC, California Title 24 Part 3 – California Electrical Code, and as will be specified in Specifications Section 26 05 26, Grounding. Where any of these conflict, the most stringent requirements will be used.

### *Grounding System Electrodes*

The grounding electrode system will consist of recognized building steel, reinforcing steel, approved water and process pipes, driven electrodes, buried/encased ground mats, concrete encased Ufer electrodes, and buried cables (ground rings). The grounding electrode system installed for this project will have a maximum resistance to ground of 5 ohms. If more than one rod is required, rods will be installed at least one rod length apart. At a minimum, two rods, at opposing corners of facilities, will be accessible for inspection via test wells. At a minimum, 4/0 AWG bare copper conductors will be used to interconnect the ground rods and other electrodes. In addition to other NEC-required grounding electrodes, a concrete-encased Ufer grounding electrode will be provided for each building and structure.

All underground duct banks will be encased in reinforced concrete and will have a continuous 4/0 bare copper grounding conductor placed throughout the length of each duct bank. This grounding conductor will then be thermos-welded to the rebar, encased in the concrete and thermos-welded to the 4/0 grounding grid conductor at each end of all electrical equipment, enclosures, and electrical equipment stands, for a continuous grounding system.

### *Equipment Grounding*

At a minimum, the following requirements will be adhered to:

1. The non-current-carrying metal parts of all electrical equipment, devices, panelboards, metallic raceways and metallic supports/structures of electric items will be connected to the equipment grounding/bonding conductors.

2. Main bonding jumpers will be connected between the service equipment ground bus, the neutral bus, and the grounding electrode system.

3. A separate equipment grounding conductor, sized in accordance with the NEC, will be provided in raceways for all feeder and branch circuit raceways and integral with all power and 120V control cables.

4. The equipment grounding conductor for feeder and branch circuits will be bonded to its respective panelboard, MCC, Substation, or switchgear at each termination.

5. Junction boxes will be connected to the equipment grounding system with grounding clips mounted directly on the box or with 3/8-inch machine screws or equal.

6. The metal sheeting and any exposed vertical metal structural elements of each building will be grounded.

7. Metal fences enclosing electrical equipment will be grounded.

8. Metal equipment platforms, poles or other metal structures, which support electrical equipment, will be grounded.

9. All conduits entering and leaving metal enclosures or cabinets will be bonded to such via conduit ground bushings. Any conduit penetrations in the top or sides of metal enclosures or cabinets will be done via threaded type hubs such as Meyer's and ground bushing style lock rings made for such hubs. Sealing lock rings are not allowed.

Good electrical connections between the grounding system and metal frames and railing that support pushbutton stations, receptacles, instrument cabinets, etc., and metallic raceway containing the circuits to these devices will be provided.

## Lighting

Light-emitting diode (LED) lighting will be used for both indoor and outdoor lighting. The lighting will be designed to comply with California Title 24 Part 6 – the California Energy Code that regulates to minimize energy use.

## Electric Equipment Seismic/Wind Anchorage and Miscellaneous Requirements

1. Seismic anchorage calculations will be provided for all electrical equipment over 400 pounds in weight. In addition, seismic functionality will be required for all electrical equipment that can be provided with a manufacturer's certification that the equipment will not undergo a loss of its intended function after application of specified earthquake motions. Compliance with California Title 24 Part 2, the 2012 IBC and ASCE/SEI 7-10, Chapter 13, Seismic Design Requirements for Non-Structural Components, is required for seismic loads and associated anchoring and foundations.

2. Wind anchorage calculations will be required for all exterior electrical equipment over 100 pounds in weight and all luminaire poles over 10 feet high. Compliance with the 2012 IBC and Southern Nevada Building Officials Amendments for the 2012 IBC will be required for wind loads and associated anchoring and foundations.

## Equipment Finish

Electrical materials and equipment will be provided with the manufacturer's standard finish system. Enclosures for equipment located outdoors, and subject to direct sun exposure, will be suitable for a high semi-arid solar energy/high ultraviolet light energy environment. The following paragraphs contain additional equipment enclosure requirements, especially for corrosive locations unsuitable for stainless steel materials.

## Altitude

Materials and equipment will be provided suitable for installation and operation under rated conditions at an elevation of 200 feet above sea level in a semi-arid environment rich in solar ultraviolet energy.

## Outdoor Equipment

Equipment and devices to be installed outdoors, or in unheated or non-air-conditioned indoor spaces, will be capable of continuous operation within an ambient temperature range of -8°C to 48°C (18 to 117°F); outdoor equipment that is only rated for 40°C will be de-rated for the environment. Additional equipment such as sunshades, heating equipment, or cooling equipment will be provided so that this performance requirement can be met.

## Hazardous and Corrosive Areas

The limits of corrosive areas will be specifically defined on the electrical drawings. To the greatest extent possible, electrical equipment will be located outside of these areas.

## Electrical Enclosures

The following requirements will be adhered to:

1. MCCs, panelboards, and switch boards in Electrical Rooms will be NEMA 1 gasketed enclosures for indoor, dry, air-conditioned locations; NEMA 4X (Type 316 stainless steel) enclosures will be provided for indoor non-air-conditioned spaces, and all outdoor locations; NEMA 4X (Type 316 stainless steel) will be provided for corrosive environments where type 316 stainless steel holds up. Fiber-reinforced plastic will be used for enclosures only for corrosive locations unsuitable for stainless steel enclosures;

and, Regardless of the location, the enclosure material will be compatible with the chemicals being used in the area where the equipment is being installed.

2. All enclosures will be UL listed; all assembled control panels will be UL listed as a complete assembly.

3. Custom-made control panels, comprised of a UL-listed enclosure and UL 508 listed system components, will be UL 508A listed as a complete assembly, with a labeled integrated short-circuit current withstand rating, and will comply with Article 409 of the NEC.

## Instrumentation

This section describes and identifies the Instrumentation and Control equipment, networks and processes required to implement control and monitoring of the project's facility with minimal attention to its daily routine operation. The design philosophy, design criteria, materials of construction, instrumentation equipment manufacturers and related control and monitoring philosophy to meet the intent of the project are discussed.

To document the following I&C items that will be used to provide a final Facilities design:

- Preferred I&C equipment including PLCs, operator interfaces, communication devices and field instruments.

- Design criteria standards that include tag numbering conventions, Local/remote control parameters and color usage conventions.

- Intelligent P&IDs for the Facilities and associated facilities.

- Control strategies, using MWH's Control Loop Description format that describes both the main pumping system and the auxiliary systems incorporating both local and operator interface controls and how these are used to control each piece of equipment or process.

- SCADA interface description that includes how the new information generated by the new Facilities will be integrated into the existing SCADA system.

Table 3.11. Glossary of Instrumentation and Control Terms

| Term | Definition |
|---|---|
| A/M | Auto-Manual |
| ATS | Automatic Transfer Switch |
| DCS | Distributed Control System |
| GUI | Graphic User Interface |
| H/O/A | Hand-Off-Auto |
| H/O/R | Hand-Off Remote |
| HMI | Human Machine Interface |
| L/O/R | Local-Off-Remote |
| L/R | Local-Remote |
| LAN | Local Area Network |
| LCP | Local Control Panel |
| LCS | Local Control Station |
| LOS | Lockable Off Switch |
| MCC | Motor Control Center |
| O/A/C | Open-Auto-Close |
| O/S/C | Open-Stop-Close |
| OIU | Operator Interface Unit |
| PCIS | Process Control and Instrumentation System |
| PID | Proportional-Integral-Derivative |
| PLC | Programmable Logic Controller |
| S/S | Start-Stop |
| SCADA | Supervisory Control and Data Acquisition |
| SCADA | Supervisory Control and Data Acquisition |
| VCP | Vendor Control Panel (Supplied by Equipment Vendor) |
| VSD | Variable Speed Drive |
| WAN | Wide Area Network |

## Codes, Standards and References

- UL – 508, Standard for Safety, Industrial Control Panels.
- ANSI.
- ASTM International
- Deutsche Industrie-Norm – VDE 0611, Specification for modular terminal blocks for connection of copper conductors up to 1000V AC or DC.
- ISA standards including:
  - S5.1, Instrumentation Symbols and Identification
  - S5.4, Instrument Loop Diagrams
  - S50.1, Compatibility of analog signals for electronic industrial process instruments
  - TR20.00.01, Specification forms for process measurement and control instruments, Part 1: General
- NEC

- NFPA
- IEEE – C62.41, recommended practice on surge voltages in low-voltage AC power circuits.
- NEMA, including
- 250, Enclosures for Electrical Equipment (1,000V maximum)
- ICS 1, Industrial Control and Systems General Requirements

## Design Criteria

The overall control system design should be one which highlights ease of use, resiliency to component failure, modular construction/maintenance, and regional parts and support availability. The process control system will be designed in accordance with typical commercial production facilities standards. Design criteria intended to support this philosophical approach are bulleted below.

- The system installation approach will be geared toward location of electronic components within secured facilities to the greatest extent possible. Where electronic components must be installed outdoors, enclosures will be secured.
- Use of air conditioning units in remote panels will be avoided, if possible: panels components will be designed for extreme conditions and outdoor panels will be designed to reflect/radiate heat away from the panel.
- The selected control system equipment will be required to have regional repair, and configuration support and readily available spare parts.
- Centralized control of the new expansion facilities will be added to the existing CCWD Bollman Control Center, thereby concentrating key components within secure areas.
- The use of redundant components will allow the process to continue uninterrupted and maintenance tasks to be planned/scheduled:
  - Redundant Wide Area Network (WAN) fiber optic cabling
  - Use of redundant controllers when appropriate
  - Use of redundant online power supplies for panels, communication hubs and key network components.
- Mechanical, hydraulic and reserve battery power solutions for protection against power failure or cycling.

### *Wiring of Field Sensors*

Field sensors, process control equipment, and final control elements will be directly wired to PLCs. Control logic will reside in the PLCs. Control logic will not be distributed outside the

individual facility control system, except in the case of vendor furnished packages. PLC and remote I/O cabinets will be strategically located throughout the facilities. Considerations in selecting locations will be the process area, reducing conduit and wiring lengths, non-hazardous locations, and non-corrosive locations.

#### *Communications*

Communications to valve actuators, instruments, power monitoring and motor controllers will be by network communications when cost effective. For other interfaces and instruments, hard wiring or owner preferred equipment will be used.

#### *Local Control*

Local control will typically be performed via control panels and pushbutton control stations. Lock-out stop pushbuttons will be provided at each piece of equipment. Where system control panels or area control panels are required, local monitoring and control of equipment will be provided via an electronic Operator Interface Terminals will be used. These touch screen panels may be used to display complex local controls at the field panel. The Operator Interface Terminals will communicate with the local PLC and will be configured to display specific data for the process area and will allow control of local equipment.

#### *Programmable Logic Controllers*

The PLCs will have the appropriate processing and memory capacity. PLCs will have redundant power supplies. The inputs and outputs for the PLC will be 24 volts of direct current for the discrete points, and 4-20 miliampere DC points for the analog signal inputs and outputs. Network compatible cards may be used for power management and protection devices, variable speed drive units and the like using standardized interface protocols.

#### *Design for Future Considerations*

In general all site control systems and local networks will be designed in anticipation of connection and integration into a centrally managed and administered control network while minimizing installed cost. To this end, the site design will seek to employ common hardware, software, data transfer methodologies, communication medium type and communication protocols.

### Control System Architecture

#### *Control System Philosophy*

The general control philosophy for the new expansion facilities is to provide a high level of automation with the minimal use of selector switches and pushbutton controls. Manual control will typically be performed from the computer based control system and not via control panels and pushbutton control stations. Lock-out stop pushbuttons will be provided at each piece of equipment. Control logic will not be distributed outside of the individual facilities remote terminal unit system, except in the case of vendor furnished packages.

A remote terminal unit cabinet will be located in the Expanded Transfer Pump Station MCC room. The main process equipment packages will each be supplied with a main hot standby redundant PLC processors, along with I/O cabinets or additional PLC cabinets which will accommodate all I/O points for the new facility. Each PLC and I/O cabinet will be supplied power from an uninterruptible power supply.

A licensed multiple address radio system and a spread spectrum radio system will communicate from the Expanded Transfer Pump Station PLC to the Bollman Control Center. The PLC cabinet includes a local Human Machine Interface (HMI) which allows operators to control on-site equipment and monitor off-site facility conditions. The Ethernet switch in the PLC cabinet will provide connection capability for additional PLCs and workstations that are anticipated in future phases of the expansion of the project. Existing workstations at the Bollman Control Center Control Room will serve as the operation staff's primary "window" into the new facilities, and will be configured to display all process information. HMI terminals at the PLC cabinets will serve as the secondary "window" into the process for the operations staff, but are intended primarily for use by operators during testing and startup. The touch screen HMI terminals will allow the operations staff to locally monitor the individual equipment processes for the facility systems.

#### *PLC Requirements*

The PLCs will match with the Owner's current PLC manufacturer and will be Schneider Electric Modicon Quantum. PLCs will have redundant hot standby processors and redundant 24V DC power supplies. The inputs and outputs for the PLC will be 24V DC for the discrete points, and 4-20 milliamps (mA) DC points for the analog signal inputs and outputs. Network compatible cards will be used for power management and protection devices, variable speed drive units and the like using standardized interface protocols.

## Process Requirements and Design Criteria

#### *Instrumentation Design Criteria*

- "Smart" instruments will be used where cost effective, with hardwired instruments in all other cases.
- Outdoor instruments will be designed with appropriate environmental considerations.
- Analyzers will be reagent-less type and equipped with smart sensors.
- Ultrasonic measurement will be the preferred level measurement technology for balance tanks, wet wells, reservoirs and chemical storage tanks.
- Hydrostatic level sensors will be employed where applicable.
- Ultrasonic flow meters will be the preferred flow measurement instrument in primary process.
- 24V DC or loop-power will be the preferred scheme with quick-connections for signal (and power where applicable).

Communications to valve actuators, instruments, and motor controllers will be by network communications when cost effective. For other interfaces and instruments, hard wiring or owner preferred equipment will be used. The inter-site communication medium multiple address radio system licensed radio. All controllers and control panels will be furnished with monitored, redundant power supplies and all area equipment groupings will be supported by smart UPS

units (with relay-card interface), monitored by the control system via hardwire connection. Links to the portable emergency generator systems will also be established for system and fuel status monitoring.

I/O depicted on the P&ID drawings for each process area will be displayed on the HMI control screens and all analog data (as well as alarms and status points) will be historically collected, recorded and trended. Generated control screens will be consistent in presentation, quality, color usage, symbol usage, and navigation options will be developed through meetings with Contra Costa Water District.

### *Piping and Instrumentation Diagrams*

P&IDs will be developed to approximately 50 percent complete as part of Administrative Draft Feasibility Report for the facility and associated facilities. Overview P&ID drawing GI-01 is attached to this memorandum. The P&IDs will be drawn in compliance with ISA Standard S5.1. Diagram format including symbols and abbreviations will be shown.

### *Level Measurement*

Reservoir or tank level measurements will be made using a differential pressure actuated transducer or an ultrasonic level transducer and transmitter. The analog signal will be taken back to the Expanded Transfer Pump Station PLC.

### *Level Switch*

A reservoir or tank high and/or low level switch will be provided to increase reliability of detecting a level alarm before the reservoir or tank overflows or the pumps associated with the low level in the reservoir or tank shut down.

Depending upon the final configuration of a process area, an area flood monitoring switch will be provided to detect accumulation of water resulting from a high level in a sump or flooded floor.

Level switch digital signals will be taken back to the Expanded Transfer Pump Station PLC.

### *Pressure Measurement*

Selected pressure measurements of process lines will be monitored by the process area PLC.

### *Pressure Switch*

A Low suction pressure switch will be hardwired into the pump control circuit to provide pump protection. An auxiliary contact on the pressure switch will be taken to the pump PLC for monitoring and alarming purposes.

### *Temperature Measurement*

Process temperature measurements will be made using a resistance temperature detector and temperature transmitter. The analog signal will be taken back to the Expanded Transfer Pump Station PLC.

### *Flow Measurement*

Most process flow rate measurements will be measured using an ultrasonic flowmeter. Some measurements will be measured by propeller type flow meters where the flow ranges will be

limited to about a 6:1 turndown. Air flow measurements will be measured by a mass thermal flow type flowmeter. The flow rate signals will be transmitted to the Expanded Transfer Pump Station PLC and totalized.

### *Analytical Measurement*

The process will be measured for water quality with the respective analyzers. The analyzers will generally measure turbidity, pH, conductivity, oxidation reduction potential (ORP), chlorine residual, ammonia, and other parameters. All analytical measured signals will be transmitted to the Expanded Transfer Pump Station PLC.

### *Instrument List Table of Manufacturers*

As a minimum, all work and equipment will conform to the instrumentation design criteria defined in Table 3-12.

Table 3-12. Instrumentation Design Criteria

| Measurement | Sensor Type | Preferred Manufacturer | Applications |
|---|---|---|---|
| **Measurement Devices** | | | |
| Flow Measurements | Ultrasonic | Accusonics | Raw water |
| Level Measurements | Ultrasonic | Endress Hauser or Pulsar | Reservoir, Tank, Basin or Wet well level, Chemical Tanks |
| | Pressure | Endress Hauser | Chemical Tanks, Pressurized Tanks |
| Pressure Measurements | Gage Pressure | Endress Hauser | Process pipelines, pressure vessels |
| DP Measurements | Differential Press. | Endress Hauser or Rosemount | Loss of Head, Filter Differential Pressure, Pressurized Tanks |
| Temperature Measurements | Resistance Temperature Detector | Interface Devices | Process Temperature, Ambient Temperature, motor and pump bearings |
| **Analyzers** | | | |
| Turbidity | Low Turbidity | Hach-GLI | Filtered water, finished water |
| | High Turbidity | Hach | Raw water |
| Chlorine Residual | | Rosemount | All process water |
| Ozone Concentration | Gas | IN USA | Ozone generation |
| | Dissolved | IN USA | Contact basin |
| **Suspended Solids** | | | |
| Dissolved Oxygen | Optical | Hach/Insite | |
| Ambient Oxygen | | | |
| **Analyzers** | | | |
| Vibration Measurements | Vibration | Bentley Nevada | Large pump and motor monitoring |
| Weight Measurements | Strain Gage | | Bulk chemical tanks |
| | Hydraulic | | Bulk chemical tanks |
| **Switches** | | | |
| Flow Switches | Thermal | Fluid Components, Inc. | Process lines, seal water, chemical flows |
| | Vane | W. E. Anderson | Air duct ventilation |
| | Paddle | McDonnell & Miller | Emergency shower lines |
| Level Switches | Electrode Probe | Warrick, BW Vibrating Fork, Endress Hauser | Chemical day tanks |
| | Float | Flygt, Kari, Consolidated Electric | Dirty water levels, sludge, adhesive processes |
| | Magnetic | Magtech | Side mounted level gauges |
| Pressure Switches | Pressure | Ashcroft, SOR, United Electric | Process lines |
| Flood Switches | Float | Flygt, Kari, Consolidated Electric | Vaults, sumps, potential flood areas |
| Temperature Switches | Capillary | Ashcroft | Motor and pump bearings |
| **Alarm Indicators** | | | |
| Beacon Alarms | Strobe/Rotating | Federal Signal | Confined spaces |
| Panel Alarms | Incandescent | Panalarm, Rochester | Local control panels, usually vendor package systems |
| **Indicators** | | | |
| Side Mounted Level Gage | Magnetic Follower | Magtech | Chemical Tanks, Pressure Tanks |
| Flow Indicator | Rotating Wheel | Gems | Chemical flow lines, low flow rate applications |
| | Rotameter (water) | Brooks, Pennwalt | Seal water lines, analyzer sample lines, transport water |
| | Rotameter (air) | Headland, Universal | Bubbler panels, air supply lines |
| Pressure Gages | Bourdon | Ashcroft, Ametek | Pump suction/discharge lines, pressurized process lines |

## Major Controller Hardware and Software Components

### *Communication Media/Networks*

The communication media for the PLC wide area network is via radio network that will communicate via Kregor Peak to the Bollman Control Center. New Ethernet switches located in PLC and remote I/O cabinets will be 1,000 megabits per second, managed industrial grade switches from Cisco. These switches will provide 100-Base-T ports for CAT-6e Ethernet cable.

### *Signal Levels*

- Analog Inputs – Conventional Two Wire and Intelligent Transmitters:
  - Signal level to the PLC will be an isolated 4-20mA DC.
  - All instrument shields will be terminated at the PLC control panels.
  - For instruments wired directly to the PLC, the 24V DC loop power will be from the PLC control panel.
- Analog Inputs – Four Wire Transmitters:
  - Signal level to the PLC will be an isolated 4-20mA DC.
  - Signal power supply will be from the transmitter.
- Analog Outputs:
  - Signal from the PLC will be isolated 4-20mA DC at 24V.
  - Signal power supply will be from the PLC.

### *Control Methods*

Each piece of equipment, such as a pump or valve, etc., will be controlled from the Bollman Control Center. Local manual control will be through the use of hardwired selector switches and pushbuttons at the equipment. Remote manual control, via the computer control system, will be from the SCADA System HMIs. All automatic functions will be provided through the local PLC, with a supervisory interface through the central computer control system. Local monitoring of individual equipment packages will be available at the PLC panel mounted HMI terminals.

Control panels supplied with vendor-supplied package type equipment, such as sump pumps, will locally control the equipment in an automatic mode with monitoring performed through the Expanded Transfer Pump Station SCADA control system.

### *PLC Hardware Requirements*

Each redundant PLC central processing unit (CPU) will be of solid-state design. All CPU operating logic will be contained on plug-in modules for quick replacement. The controller will be capable of operating in a hostile industrial environment (i.e., subject to heat, electrical transients, radio frequency interference, and vibration) without fans, air conditioning, or electrical filtering.

Each PLC will have all of the capabilities required to implement the control schemes and database. PLCs will have floating point math and Proportional-Integral-Derivative (PID) controller modulating capability. Each CPU will provide internal fault analysis with a fail-safe mode and an output for remote alarming.

Each central processor will contain all the relays, timers, counters, number storage registers, shift registers, sequences, arithmetic capability, and comparators necessary to perform the control functions. It will be capable of interfacing sufficient discrete inputs, analog inputs, discrete outputs, and analog outputs to meet the requirements and have at least 100 percent excess capacity. All PLCs will be provided to support and implement closed loop floating and PID control which will be directly integrated into the PLC control program. The power supply will contain capacitors to provide for orderly shutdown in the event that incoming power fails. If this occurs, the processor will cease operation, forcing all outputs off. The processor will have a key type memory protect switch to prevent unauthorized program changes.

Each programmable controller will be equipped with nonvolatile flash memory of sufficient capacity to store the control program, tag data, and unit operating system with room for 50 percent growth. An indicator will show the status of the batteries and a reference will be available through the discrete outputs, to alert the Operator that the batteries need to be changed. Each controller will be supplied with an internal lithium battery which will retain the program during power outages for up to one year.

Each programmable controller will be capable of being programmed with an IEC61131-3 compliant software using simple "ladder diagram" language, and Sequential Functional Blocks. It will be capable to be reprogrammed locally with a portable laptop computer or from a remote location via a control system network. Where indicated, the controller will support hot-standby CPU redundancy. Controls will be able to switched from the primary to the secondary processor (and vice versa), automatically or manually, without interruption of plant control processes.

Each programmable logic controller will be equipped, or will have access via a linked backplane, to the following communication options as required on the Control Network Block Diagrams:

- One industrial standard, IEEE 802.3, 10 Base-T Ethernet communication port (RJ45)
- One RS-232-C serial programming port
- One Modbus TCP/IP communication port
- Remote I/O Adapter module (where applicable).

The 32-bit CPU will support floating-point math and PID functions. Processors will be web-enabled and will support all onboard memory.

Discrete Input Modules: All contact closure inputs from devices external to the programmable controller module will be optically isolated from foreign power sources and wiring or other I/O Modules. The modules will have LEDs to indicate status of each discrete input. The input modules will have a maximum of 16 points each. The PLC system will support discrete input hardware consisting of the following types:

- Powered DC inputs for devices which operate at 24V DC.

Discrete Output Modules: All contact closure outputs for ON/OFF operation of devices external to the programmable controller module will be optically isolated from inductively generated, normal mode and low energy, common mode transients. All output modules will have LEDs to indicate status of each output point. Each output point will be individually isolated, fused and connected to interposing relays as required. The PLC system will also offer discrete output hardware consisting of the following types:

- Outputs for equipment which operate on 24V DC.

Analog Input Modules: Analog inputs of 4 to 20mA DC signals with an analog to digital conversion performed with a minimum of 16-bit precision. The analog to digital conversion will be updated with each scan of the processor. Analog input modules will have a minimum of eight inputs each. Input modules will be source or sink to handle 2-wire or 4-wire transmitters respectively.

Analog Output Modules: Analog outputs of 4 to 20mA DC output signals where each output circuit will perform a digital to analog conversion (minimum 12-bit precision) with each scan of the processor. Each analog output module will have a minimum of four isolated output points which will be rated for loads of up to 1200 ohms.

### *Enclosure Requirements/Area Classifications*

The following NEMA ratings for enclosure panels will be specified for the classified areas within the project:

- General Purpose: Enclosures will be NEMA 12.

- Outdoor Locations: Instruments and control panels will have NEMA 4X 316 stainless steel enclosures and be mounted ¼" from walls unless otherwise noted.

- Damp locations: Locations indoor and 2 feet below grade or classified as damp locations will conform to outdoor location requirements. An exception is that the space from walls may be less than ¼."

- Splash Locations: Areas that are designated as splash proof will have the same requirements as outdoor locations except that the enclosures will be NEMA 4.

- Corrosive Locations: Enclosures will be stainless steel NEMA 4X and all electrical hardware will be PVC coated.

- Hazardous Locations: Areas designated as hazardous will have all electrical installations suitable for Class 1, Division 1 or 2, Group C or D locations as required by NFPA 820.

### *Backup Power Supplies (Uninterruptable Power Supply)*

UPS will be provided for each of the new facilities. The UPS will maintain conditioned power to all associated loads under normal conditions (line power available) and also under battery-powered conditions (for a specified time period). UPS units mounted within panels will be

secured to a shelf attached to the panel backplane. Floor mounted UPS units will follow NEC code clearance requirements.

### *Human Machine Interface*

Local monitoring and control of equipment will be provided via an HMI. The HMI will communicate with the local PLC and will be configured to display specific data for the Expanded Transfer Pump Station.

The HMI configuration will include requirements that all command outputs to equipment and set point adjustments require verification of action.

The operator display panel will meet the following requirements:

- An HMI which allows the operator to select objects on the screen, with a minimum of 120 touch cells.
- Display will be pixel-based and will support a minimum of 256 colors.
- A library of graphic symbols to use for display generation.
- Security features will require a password to control any equipment.
- An ability to communicate over Modbus or TCP/IP to the facility PLC.

### *Hardwired Safety Interlocks*

All interlocks deemed critical to the protection of personnel and major equipment will be hardwired to the MCC with isolated inputs to the PLC. Interlocks and control devices not deemed critical for the protection of personnel and major equipment will be wired to the PLC.

All interlocks will be in affect when equipment is operated via the PLC. The critical interlocks only will be in affect when equipment is operated from the HOA station.

### *Software Programming*

The following terms are used in the software programming of PLC/SCADA functions:

- Operator Settings: Operator set or entered values will be constants that are adjustable or set from operator displays. Examples of operator set or entered values are controller set points, batch set points, etc. Specific values that are required to be operator set will be noted in the process control strategy descriptions.
- Tunable Values: Tunable values will be constants that are adjustable at engineer level displays without requiring any software reconfiguration. These values will not generally be adjustable from operator level displays.

The following general PLC functions will be specified to be provided:

- All analog and discrete inputs to the PLC will be displayed. Both RUNNING and OFF input states will be displayed.

- All analog inputs will have instrument failure alarms when the input is below 0 percent or above 100 percent for a tunable time initially set at 10 seconds.

- All discrete FAIL inputs will be alarmed. Other discrete inputs will be alarmed as noted in the control strategy descriptions.

- When alarms are specified in the control strategy descriptions, alarms will be initiated from the applicable inputs. If discrete inputs are not available, the specified alarms will be initiated from the applicable analog input.

- All analog inputs will be trended.

- All flow inputs and equipment run times will be totalized and recorded. All totalized values will be displayed.

- Displays will be grouped functionally for ease of operation. Both analog and discrete functions associated with an item of equipment or a group of equipment will be provided on the same display.

- All discrete outputs will generally be maintained outputs. For START/STOP PLC functions, the PLC will issue a maintained START command until a RUNNING state is no longer detected or when a STOP command is issued. When a momentary command is required, the PLC will issue the command for 2 seconds, and then remove the signal.

- For equipment that is controllable from the PLC, a control mode status signal will be sent to the PLC to indicate when the PLC is allowed to control the equipment. The PLC will monitor the control mode status (LOCAL/REMOTE) and attempt to control only equipment that is in the REMOTE mode.

- For equipment that the PLC is allowed to control, the PLC will provide a FAIL alarm if the equipment fails to comply with a PLC command signal (START, STOP, OPEN, CLOSE) that has been present for more than a tunable time period. In this event, the command will be removed subsequent to the expiration of the tunable time period.

- All PID control functions (Proportional, Proportional + Integral, and Proportional + Integral +Derivative) will be provided with standard analog controller functions and operator interfaces including the following:

  - AUTO/MANUAL mode selection: In AUTO, the output of the controller will be based on the PID control calculation. In MANUAL, the output of the controller will be operator adjustable. Transfer between operational modes will be bumpless.

  - LOCAL/REMOTE set point selection: In LOCAL, the set point will be operator adjustable. In REMOTE, the set point will be adjustable from a REMOTE set point input.

  - Set point, process variable, and controller output will be displayed.

- Provisions will be included to prevent reset windup on the controllers.

When equipment is tagged "OUT OF SERVICE" by the operator, all associated equipment will have their alarms inhibited until the tagged equipment is re-tagged IN SERVICE.

## Design Philosophy

The Expanded Transfer Pump Station facility will be designed for unattended operation using a PLC based control system with remote monitoring and control. The control system will be automated to achieve maximum efficiency without providing undue complexity to the operations or maintenance personnel. Four levels of control will be provided (where appropriate):

- Local Manual Control
- Local Automatic Control
- Remote Manual Control
- Remote Automatic Control

A single LOR selector switch will be provided to implement this functionality. Remote manual or auto control is selectable from either the local HMI or from the HMI at the Bollman control center.

Each of the above control methods is described as follows:

### *Local Manual Control*

Local manual control will be provided from either a Field Control Station conveniently located on or near to the equipment, or, as in the case of a pump, from the MCC. Local manual control is engaged when the LOR switch is selected to Local. With the switches in these positions all control from the PLC is inhibited.

Selection of local manual control implies that the operator has accepted full responsibility for the operation of that equipment and is providing due diligence. In the case of taking local manual control of one of the Distribution Pumps, protecting the pump from running dry will be provided by a Low Suction Pressure Switch, "hard wired" into the pump control circuit. Thus irrespective of the LOR switch position, low suction protection will always be provided.

### *Local Automatic Control*

Local automatic control is implemented when the LOR switch is selected to Local. Local automatic control will only activate when all devices required are also selected to local automatic control (e.g., local automatic control) of a distribution pump can only be achieved when the associated discharge valve is also selected to local automatic control.

### *Remote Manual Control*

Remote control is engaged when the LOR switch is selected to Remote. Remote manual is then selected from either the local OIU or from the HMI at the SCADA control center.

Remote manual control allows the operator to assume full responsibility for starting and stopping the piece of equipment. Except for the instance of manual remote control a distribution pump, where the low suction pressure switch will automatically stop the pump, all other equipment will remain in the same state until issued some alternative remote manual command.

When the LOR switch on a device operating in remote manual control is moved from the Remote position the device immediately changes state as the switch goes to the off position.

#### *Remote Automatic Control*

Remote control is engaged when the LOR switch is selected to Remote. Remote auto control is then selected from either the local OIU or from the HMI at the SCADA control center.

Remote automatic control will be managed by the main facility PLC, which will continue operating in remote automatic control even if "off-site" communication is lost. Control parameters in the main PLC may be changed from either the local HMI or the Bollman Control Center HMI providing the operator has the appropriate authorization.

#### *Emergency Shutdown*

One emergency shutdown button will be located on a field control panel. The emergency stop pushbutton will shut down all pumps. The field control panel will also contain an emergency stop reset button that can only be operated locally. The pumps will only become available once the reset has been operated.

### Control Mode Design Considerations

The Instrumentation and Control system will be designed to implement the control modes as efficiently and as effectively as possible while complying with all appropriate standards and guidelines. Design choices will be made that provide potential minimum long term cost of ownership both in terms of energy use and equipment maintenance.

#### *Control Monitoring Requirements*

The control and monitoring objective is to provide efficient and effective control of the pumping station. This will be accomplished by ensuring adequate and sufficient information is available to both the automatic control system and the supervisory system.

#### *Tagging and Naming Conventions*

All instrument tag letters will follow ISA S5.1 standard

All tagging, wire numbering and equipment numbering and naming will comply with CCWD standards.

All instrument tag numbers will comply with the following standards:

Example: 152-LAH-01A

152 – Facility Number

LAH – ISA abbreviation

01 – Loop Number

A- Suffix used if a redundant instrument is used for the same measurement or digital reference (example: redundant pressure transmitters)

### Security and Telecommunication

The primary security facilities include a perimeter laser security system, a keycard entry system, and live Ethernet based "IP Address" security cameras.

A new telephone and data communication system will be installed at the Expanded Transfer Pump Station. The telephone and data system will include the following;

- A digital telephone line
- An analog burglar alarm line
- An analog fire alarm line
- A backup analog burglar/fire alarm line
- Ethernet based "IP Address" security cameras

Analog telephone service will be provided by extending the analog lines of an existing AT&T trunk line that feeds the existing Transfer Pump Station facility. Digital telephone service and Ethernet based security cameras service will be provided through a connection to the District's Wide Area Network via a series of microwave towers connecting to the District's main campus.

Telephone and data service at the Expanded Transfer Pump Station will be connected to Old River Pump Station and Middle River Pump Station through a fiber optic line running along the new 66-inch pipeline connecting the new Transfer Pump Station and Old River Pump Station. Old River Pump Station are connected to Middle River Pump Station via an overhead fiber optic line that uses the same route as the existing Western Area Power Authority 69 kV line. Backup telephone and data service at Expanded Transfer Pump Station will be established by extending the existing service at the existing Transfer Pump Station.

The Expanded Transfer Pump Station Electrical Building includes an intrusion limit at each exterior door, the intrusion switches will be monitored by the SCADA system.

## Structural

All structures, including nonstructural components and nonbuilding structures, identified within the project scope shall be designed in accordance with the structural design criteria provided in this section.

### Governing Codes and Standards

- 2013 California Building Code (2013 CBC), based on 2012 IBC.

- Minimum Design Loads for Buildings and Other Structures 7-10 – American Society of Civil Engineers.

- Where the design references listed below are used, the 2013 CBC modifications to those standards shall apply. Additionally, the ASCE 7-10 modifications to the standards shall apply, unless specifically stated otherwise in the 2013 CBC.

## Reference Specifications, Codes, and Standards

2013 CBC California Building Code

2012 IBC International Building Code

AASHTO AASTHO LRFD Bridge Design Specifications (2014 edition)

California Amendments to the AASHTO LRFD Bridge Design Specification – Six Edition

ACI 318 Building Code Requirements for Structural Concrete and Commentary (2011 edition)

ACI 350 Code Requirements for Environmental Engineering Concrete Structures and Commentary (2006 edition)

ACI 350.1 Tightness Testing of Environmental Engineering Concrete Structures (2010 edition)

ACI 350.3 Seismic Design of Liquid Containing Concrete Structures and Commentary (2006 edition)

ACI 350.4R Design Considerations for Environmental Engineering Concrete Structures (2004 edition)

ADM Aluminum Design Manual (2010 edition)

AISC American Institute of Steel Construction:

AISC 325 – Steel Construction Manual, 14$^{th}$ Edition (2010 edition)

AISC 360 – Specifications for Structural Steel Buildings (2010 edition)

AISC 303 – Code of Standard Practice for Steel Buildings and Bridges (2010 edition)

AISC 327 – Seismic Design Manual (2012 edition)

AISC 341 – Seismic Provisions for Structural Steel Buildings (2010 edition)

ASCE 7 American Society of Civil Engineers Standard 7-10 Minimum Design Loads for Buildings and Other Structures (2010 edition)

AWS D1.1 Structural Welding Code – Steel (2015 edition)

AWD D1.2 Structural Welding Code – Aluminum (2014 edition)

EM 1110-2-2100 Stability Analysis of Concrete Structures, USACE

EM 1110-2-2504 Design of Sheet Pile Retaining Walls (USACE)

EM 1110-2-2906 Design of Pile Foundations (USACE)

Moody EM No. 27 A Water Resources Technical Publication, Engineering Monograph No. 27: Moments and Reactions for Rectangular Plates by W.T. Moody / United States Department of Interior Bureau of Reclamation – reprinted 1986

MWH MWH Americas, Inc. Design Quality Procedures

TMS 402 Building Code Requirements for Masonry Structures (2011 edition)

TMS 602 Specifications for Masonry Structures (2011 edition)

## Structural Systems, Design Methods, and Assumptions

***Hydraulic Structures:***

1. Hydraulic structures shall be designed and constructed of cast-in-pace reinforced concrete in accordance with ACI 350-06.

2. Hydrodynamic forces shall be determined in accordance with ACI 350.3-06.

3. The following hydraulic structures have been identified within the project scope:

    a. Pump Station (Expanded Transfer Facility).

    b. Vertical Turbine Pump – Wet Well (Expanded Transfer Facility)

    c. Transfer Pipeline Isolation Valve Vault (Expanded Transfer Facility).

    d. Delta-Transfer Pipeline Isolation Valve Vault (Expanded Transfer Facility).

    e. Delta-Transfer Pipeline Meter Station Vault (Old River Facility).

    f. Delta-Transfer Pipeline Isolation Valve Station Vault (Old River Facility).

***Non-Hydraulic Structures – Buildings:***

1. Buildings shall be designed and constructed of reinforced concrete block masonry and a reinforced concrete foundation.

2. Each above ground roof system will consist of a light-gauge pre-engineered truss steel joist or structural steel beams with metal roof decking.

3. For non-hydraulic structures with a top slabs, each floor level shall be designed and constructed of cast-in-place concrete slabs system with reinforced concrete beams (where applicable).

4. The following buildings (non-hydraulic structures) have been identified within the project scope:

    a. MCC Electrical Building (Expanded Transfer Facility).

***Nonstructural Components:***

1. Unless otherwise indicated, all nonstructural components shall be designed in accordance with Chapter 13 of ASCE 7.

2. Nonstructural component structures that are contained inside liquid-containing structures shall be designed to resist hydrodynamic forces in accordance with Chapter 15 of ASCE 7.

3. Nonstructural components and their anchorage subjected to vibrations shall be designed in accordance with ACI 350.4R.

4. The following nonstructural components have been identified within the project scope:

    a. Pipe supports (Expanded Transfer Facility and Old River Facility) – as applicable.

    b. Elevated structural steel platforms with galvanized steel grating inside the reinforced concrete vaults (Expanded Transfer Facility and Old River Facility).

    c. Vertical turbine pump anchorage (Expanded Transfer Facility).

***Nonbuilding Structures:***

1. Unless otherwise indicated, all nonbuilding structures shall be designed in accordance with Chapter 15 of ASCE 7.

2. Nonbuilding structures and nonstructural component structures that are contained inside liquid-containing structures shall be designed to resist hydrodynamic forces in accordance with Chapter 15 of ASCE 7.

3. Nonbuilding structures and their anchorage subjected to vibrations shall be designed in accordance with ACI 350.4R.

4. The following nonbuilding structures have been identified within the project scope:

    a. 5 million gallon steel tank foundation of reinforced concrete (Expanded Transfer Facility).

    b. 21 kV substation foundation of reinforced concrete, including aluminum platform grating (Expanded Transfer Facility).

    c. Surge control tank reinforced concrete foundation (Expanded Transfer Facility).

d. Vertical Turbine Pump Foundation / Wet Well Top Slab (Expanded Transfer Facility).

e. Pipe Bridge of reinforced concrete (Old River Facility).

## Structural Design Criteria

### *General Criteria*

Unless otherwise indicated by the Lead Structural Engineer, all the structures covered by this section shall be designed to meet the requirements for the risk category and environmental exposure herein:

a. Risk Category: III

b. Environmental Exposure: Normal

### *Live Loads*

All structures within the project scope shall be designed for the minimum live loads as shown in Table 3-13.

Table 3-13. Minimum Structural Live Loads

| Area | Uniform Load | Concentrated Load |
|---|---|---|
| 1. Elevated Slabs | 100 psf | 1,000 lb |
| 2. Roof Live Load | 20 psf | 300 lb |
| 3. Floor Live Load | | |
| Process Area | 250 psf | 3,000 lb |
| Electrical Rooms | 300 psf | 3,000 lb |
| Stairs and Landings | 100 psf | 300 lb |
| Platforms | 100 psf | 300 lb |
| Traffic Areas | | HS20 (vehicle load) |

Key:
HS20 = Highway Semi-Trailer Truck 20 tons
lb = pound
psf = pounds per square foot

### *Snow Design Criteria*

Snow load criteria shall be developed in accordance with Chapter 7 of ASCE 7 and the local authority having jurisdiction. All structures within the project scope shall be designed for the following:

1. Ground Snow Load, $P_g$: 0 pounds per square foot (psf) ($\leq$ 1,500 feet)

2. Snow Exposure Factor, $C_e$: 1.0

3. Snow Load Importance Factor, $I_s$: 1.1

4. Thermal Factor, $C_t$: 1.0

### *Flood Design Criteria*

All structures within the project scope shall be designed to resist loads and buoyant forces associated with the following flood criteria:

1. 100 Year Flood Elevation to be determined (TBD)

### *Hydraulic Design Criteria*

All hydraulic structure designs shall consider fluid levels at static and seismic conditions. Hydrodynamic forces shall be determined in accordance with ACI 350.3-06 and shall consider unbalanced fluid loads wherever they occur.

Hydrostatic (non-seismic load cases): Maximum overflow condition TBD

Hydrodynamic forces: Normal high-water operating level TBD

### *Wind Design Criteria*

For developing the required wind loading associated with the main wind force resisting systems and components and cladding, the following wind design parameters shall be developed in accordance with Chapters 26 through 31 of ASCE 7 and the local authority having jurisdiction:

1. Basic 3-second Wind Gust Speed: 110 miles per hour.

2. Exposure Category: C

3. Internal Pressure Coefficient: +/- 0.18 , +/- 0.55

4. Components and Cladding: Per ASCE 7-10

5. Topographic Factor, Kzt: 1.0

### *Seismic Design Criteria*

For developing the required seismic loading associated with the seismic force resisting systems, nonstructural components, and nonbuilding structures, the following seismic design parameters shall be developed in accordance with ASCE 7, and the local authority having jurisdiction:

Expanded Transfer Facility:

Seismic Importance Factor, I: 1.25

Mapped spectral response acceleration parameters at short periods: SS = 1.50 g

Mapped spectral response acceleration parameters at 1-second periods: S1 = 0.568 g

Site Class (pending Geotechnical investigation): D

Long-Period Transition Period, TL: 8 seconds

Design Spectral Response Acceleration at Short Period: SDS = 1.00 g

Design Spectral Response Acceleration at 1-Second Period: SD1 = 0.568 g

Seismic Design Category: D

Old River Facility:

The Old River Facility has been categorized as Site Class F which will require a site specific analysis. However, since the structures that will be constructed on site (Meter Vault, Isolation Valve Vault, and the Pipe Bridge) appear to have structure periods less than 0.5 seconds, then map-based ground motions for Site Class D may be used per ASCE 7-10, Chapter 20, however liquefaction mitigation must still be addressed. This will need to be confirmed by the Geotechnical Engineer prior to final design.

Seismic Importance Factor, I: 1.25

Mapped spectral response acceleration parameters at short periods: SS = 1.239g

Mapped spectral response acceleration parameters at 1-second periods: S1 = 0.424g

Site Class (pending Geotechnical): D

Long-Period Transition Period, TL: 8 seconds

Design Spectral Response Acceleration at Short Period: SDS = 0.830g

Design Spectral Response Acceleration at 1-Second Period: SD1 = 0.446g

Seismic Design Category: D

1. Soil Design Criteria

All structures shall be designed to resist static and dynamic earth pressures in accordance with the project geotechnical report, ASCE 7, the 2013 CBC:

a. Buried structures and other structures resisting vertical and lateral earth pressures shall be designed to resist soil earth pressures outlined in the project geotechnical report.

b. The effects of groundwater shall be taken into account during the design of buried structures and recommendations outlined in the project geotechnical report.

c. Dynamic lateral earth pressures associated with seismic events shall be based on the recommendations outlined in the project geotechnical report.

## Geotechnical Assumptions and Foundation Systems

A complete, final geotechnical investigation and report will be required prior to the design of the structures outlined in the project scope. For the basis of this report, the following document was referenced: "*Draft Addendum to Technical Memorandum: Geotechnical Considerations"* by MWH dated October 2015. The following preliminary geotechnical parameters have been assumed for preliminary design for the anticipated range of soil bearing capacities:

Expanded Transfer Facility – High Soil Bearing Capacity Areas:

1. Minimum Foundation Design Criteria:
    a. Foundation Type: Spread footings, continuous footings, and mat foundations.
    b. Minimum footing depth: 18 inches
    c. Minimum footing width: Varies / as required.
    d. Allowable bearing pressure (to be confirmed during the final report):
        i. Static: 3,000 psf (DL+LL)
        ii. Short Term Loading (including wind and seismic): 4,000 psf

Expanded Transfer Facility – Lower Soil Bearing Capacity Areas:

1. Minimum Foundation Design Criteria:
    a. Foundation Type: mat foundations and piles.
    b. Minimum footing depth: 18 inches
    c. Minimum footing width: Varies/as required.
    d. Allowable bearing pressures (to be confirmed during the final report):
        i. Static Loading: 1,000 psf (DL+LL)
        ii. Short Term Loading (including wind and seismic): 1,330 psf
2. Unless specifically outlined or indicated in the project geotechnical report, the following safety factors shall be used in accordance with ACI 350.4.R:
    a. Buoyancy: 1.25
    b. Overturning:
        i. Static Loading: 1.50 (DL + LL)
        ii. Short Term Loading (wind and seismic): 1.10
    c. Sliding:
        i. Static Loading: 1.50 (DL + LL)
        ii. Short Term Loading (wind and seismic): 1.10

Table 3-14. Structural Materials of Construction

| Material | | Strength / ASTM |
|---|---|---|
| Concrete: | Structural [1] | f'c = 4,000 psi |
| | Civil and Sitework [1] | f'c = 3,000 psi |
| | Lean (unreinforced) [1] | f'c = 2,000 psi |
| Masonry: | Normal weight bock per ASTM C90 | |
| | Concrete Masonry Units [1] | f'm =1,500 psi (assemblage) |
| | Mortar [1] | f'c = 1,800 psi, ASTM C270 M or S |
| | Grout [1] | f'c = 2,000 psi, ASTM C476 |
| Reinforcement: | Typical (U.O.N.) | fy= 60 ksi, ASTM A615 |
| | Welded and Special Seismic Force Resisting Systems | fy= 60 ksi, ASTM A706 |
| Structural Steel: | Wide Flange Shapes | ASTM A992 |
| | Hollow Structural Sections (HSS) | ASTM A500, Grade B |
| | Pipes | ASTM A53, Type E, Grade B |
| | Plates, Bars, Sheets (U.O.N.) | ASTM A36 |
| | All other standard shapes | ASTM A36 |
| Metal Deck: | Roof | fy= 38 ksi or 50 ksi, ASTM A653 |
| Stainless Steel: | Typical and anaerobic conditions | Type 304 |
| | Submerged or corrosive areas | Type 316 |
| | Weldable | Type 304 L or Type 316 L |
| Aluminum: | All applications (U.O.N.) | 6061-T6 |
| | Handrails and grating | 6061 or 6063 |
| Anchors: | Headed and dry conditions | ASTM F1554, Grade 36, 55 |
| | Exterior conditions | ASTM A193, Grade B7 |
| | Submerged and wet conditions | ASTM F593, Type 304 or 316 |
| Waterstops: | New construction | PVC flat-strip |
| | Retrofit | Hydrophillic |
| Gaskets: | Neoprene | |

Note:
[1] Required minimum compressive strength in 28-days.
Key:
ASTM = American Society for Testing and Materials
f'c = compressive stress
fy = yield stress
ksi = kips per square inch
psi = pounds per square inch
PVC = polyvinyl chloride

# Architectural

## Architectural Design Philosophy

The architectural style for the new electrical building will be consistent with the functional character and external appearance of the existing electrical building in order to create a unified appearance at the facility. The building will be designed to accommodate the electrical equipment operation and maintenance.

## Architectural Program

The new electrical building (also identified as the MCC building) will be designed as a one-story, 1,867 square foot facility of approximately 26'-8" x 70'-0" x 15'-4" clear height. To maximize efficiency and to minimize maintenance costs, special consideration will be given to the overall life cycle cost and constructability. Creative design will be balanced by the realities of traditional operating and maintenance practices. The architectural objective is to provide a project that is aesthetically pleasing, functional, and economical.

## Architectural Design Criteria

The architectural parameters of the building and all of its components will include compliance to state, local, and federal standards.

### *Codes, Standards, and References*

- 2016 California Building Code (CBC)
- 2016 California Energy Conservation Code
- Occupational Safety and Health Administration
- Americans with Disabilities Act (ADA)
- Accessible and Usable Buildings and Facilities ICC A117.1 – 2009

**Code Evaluation** Based on the CBC, it has been determined that the occupancy classification for the new electrical building will be Group F-1 Moderate Hazard Factory Industrial Occupancy.

The construction classification has been identified as Type IIB.

The building/structure is exempt from ADA based on 2010 ADA Standards for Accessible Design, Section 203: "General Exceptions; Machinery Spaces: Spaces frequented only by service personnel for maintenance, repair or occasional monitoring of equipment shall not be required to comply with these requirements or to be on an accessible route. Machinery spaces include, but are not limited to, water or sewage treatment pump rooms and stations; electrical substations and transformer vaults; and highway and tunnel utility facilities." Except for regular monitoring and maintenance of equipment, the electrical building is not intended for human occupancy for extended periods of time. The primary purpose of the electrical building is to house electrical equipment in support of water conveyance.

### *General Standards*

**Exterior Walls** The exterior walls will consist of integrally colored, 12-inch-by-8-inch-by-16-inch concrete masonry units. Surface textures will be split face, and smooth face. Concrete masonry units exposed to the exterior shall receive a spray-applied, clear penetrating sealer. All exterior walls will be fully grouted and reinforced as required by the code and/or contract documents.

The exterior material color and texture will match the existing adjacent building in order to create a uniform appearance on the project site.

**Carpentry** Pressure treated wood blocking, and roof nailers, as shown on the contract documents will be provided for rough carpentry work.

**Moisture Protection** Roof system will be provided with R-20 rigid insulation board.

Caulking, sealing, and moisture protection will be provided for weather tight construction.

A plastic vapor retarder will be placed over the backfill and under the new concrete floor slab.

**Roof Construction** The roof system for the building will consist of a Polyvinylidene Fluoride factory finish standing seam metal roofing system, on R-19 rigid insulation, attached to the roof structure. The roof system will meet UL Class A rating and satisfy wind uplift requirements for this area.

Polyvinylidene Fluoride factory finished flashing, gutters and down spouts will be provided.

**Doors and Frames** Exterior doors and frames will be flush galvanized steel with an epoxy/polyurethane protective coating.

**Finish Hardware** All doors will have heavy-duty panic hardware with stainless steel locksets, stainless steel hinges with non-removable security pins, closers, hold-open device, rain drips and weather stripping.

**Louvers** Aluminum louvers with factory finish consisting of 0.8-mil (0.02 mm) nominal primer with 0.8-mil (0.02 mm), Polyvinylidene Fluoride Color Coat will be provided as required.

**Interior Finishes** Interior finishes in the building will be as follows

- Flooring will be concrete slab with a steel trowel finish.
- Walls will be unpainted concrete masonry units.
- Exposed structural ceilings will unfinished.

**Signage** Signage will be provided per the appropriate authorities, agencies, and the building code for applicable areas.

**Specialties** Fire protection will be provided with portable fire extinguishers per the appropriate authorities, agencies, and the building code.

**Exterior Lighting** Lightning shall satisfy functional and security needs while not creating light pollution in the form of point sources of direct glare which are visible from a distance. Fixtures shall be low level, directional light fixtures, which illuminate immediate areas, carefully selected for efficiency and cut-off.

# Chapter 4
# Dam and Reservoir Elements

This Chapter summarizes the 275 TAF dam raise design and associated modification of appurtenant facilities, and dam construction activities. Detailed on stability and seismic analyses are included in Attachment 2. In addition, information on the Marina Complex Relocation, the new Los Vaqueros Watershed Trail, and the expanded recreation facilities is included.

## 275 TAF Dam Raise Design

Table 4-1 summarizes the characteristics of the existing 160-TAF reservoir (Alternative 4A), and the dam raise for the 275-TAF reservoir expansion (Alternatives 1A, 1B, and 2A). The existing dam would be raised by building on top of the existing dam structure. Reservoir expansion to 275 TAF would raise the water surface level 50 feet for a maximum reservoir water surface elevation of 560 feet above mean sea level (msl) (from 510 feet msl). The reservoir water surface area (inundation area) would expand approximately 600 acres from 1,900 acres to 2,500 acres.

Table 4-1. Characteristics of the Los Vaqueros Dam Modification

| Reservoir Capacity (TAF) | Maximum Reservoir Water Surface Elevation (msl) | Dam Crest Elevation (msl) | Maximum Dam Height Above Downstream Toe (feet) | Total Embankment Volume (Existing plus New) (million cubic yards) | Dam Crest Length (feet) |
|---|---|---|---|---|---|
| No Action, Alternative 4A | | | | | |
| 160 | 510 | 523 | 230 | 3.8 | 1,300 |
| Alternatives 1A, 1B, and 2A | | | | | |
| 275 | 560 | 572 | 282 | 7.6 | 1,630 |

Key:
msl = mean sea level
TAF = thousand acre-feet

Like the existing dam, the raised dam would be a central core earthfill embankment. Figure 4-1 shows a plan view of the proposed 275-TAF reservoir dam, and Figure 4-2 shows a profile view of the raised dam atop the existing dam. The dam would be raised by building on top of both the upstream and downstream shells of the dam. The existing vertical central core and the filter/drainage system would be raised as shown in Figure 4-2. The dam axis would move about 45 feet upstream. Detailed dam design drawings are included in Attachment 2.

The dam would be 282 feet high and have a crest (or top) elevation of 572 feet msl. The water surface elevation would be 560 feet msl when expanded to the 275-TAF capacity. The dam crest would be 30 feet wide and about 1,630 feet long. The downstream and upstream slopes would be

about 2.25:1 and 3.5:1, respectively. The new embankment fill would add about 4.8 million cubic yards to the current dam volume of 2.8 million cubic yards for a total of 7.6 million cubic yards of embankment fill.

The existing reservoir would need to be drained prior to construction. It would remain drained and out of service throughout the estimated 3-year construction period and be refilled following construction completion. The process of draining the reservoir is described below. The raised dam would include monitoring and recording instrumentation, similar to the existing equipment, to measure internal water pressures within and seepage from the dam and foundation, settlement of the dam, and earthquake-induced accelerations and deformations. The instruments would include foundation and embankment piezometers, internal and surface settlement and movement sensors, a seepage measurement weir and a series of strong motion acceleragraphs.

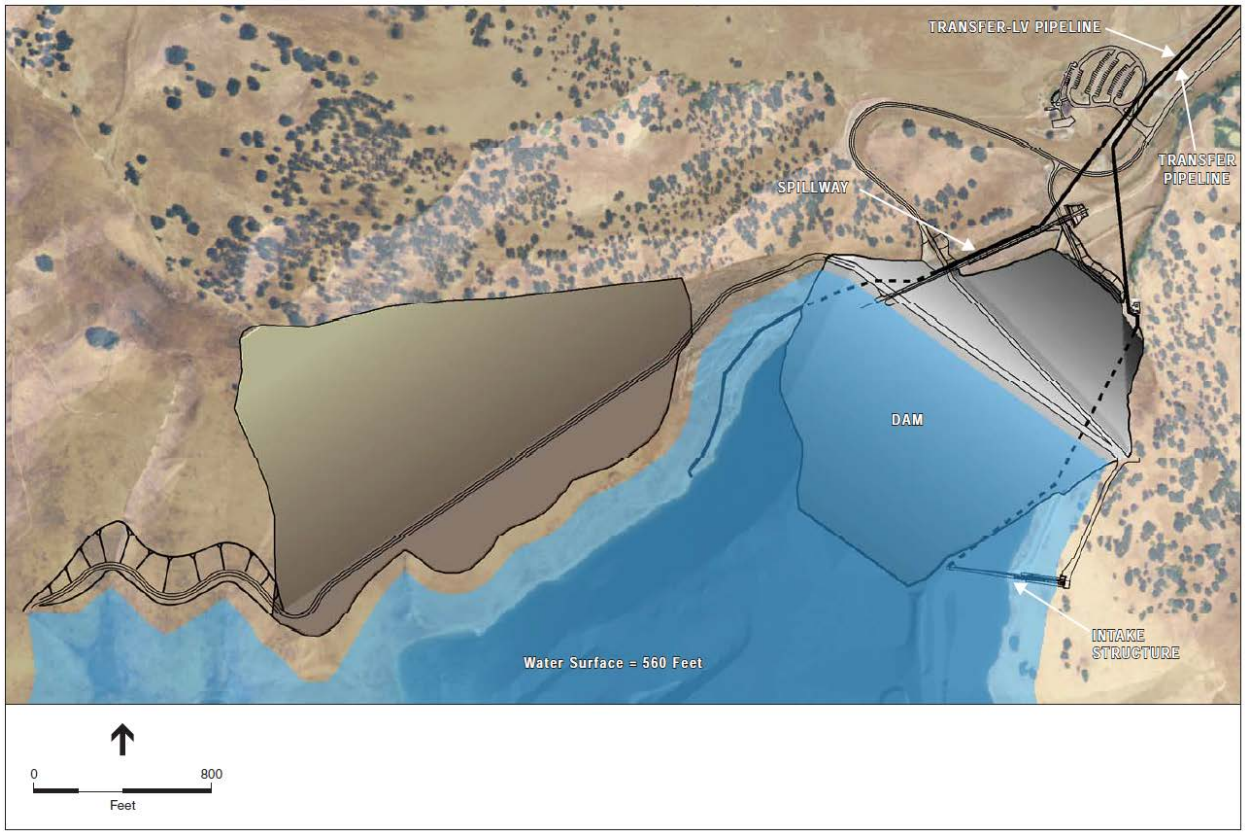


Figure 4-1. 275 TAF Reservoir – Plan View of Dam Raise

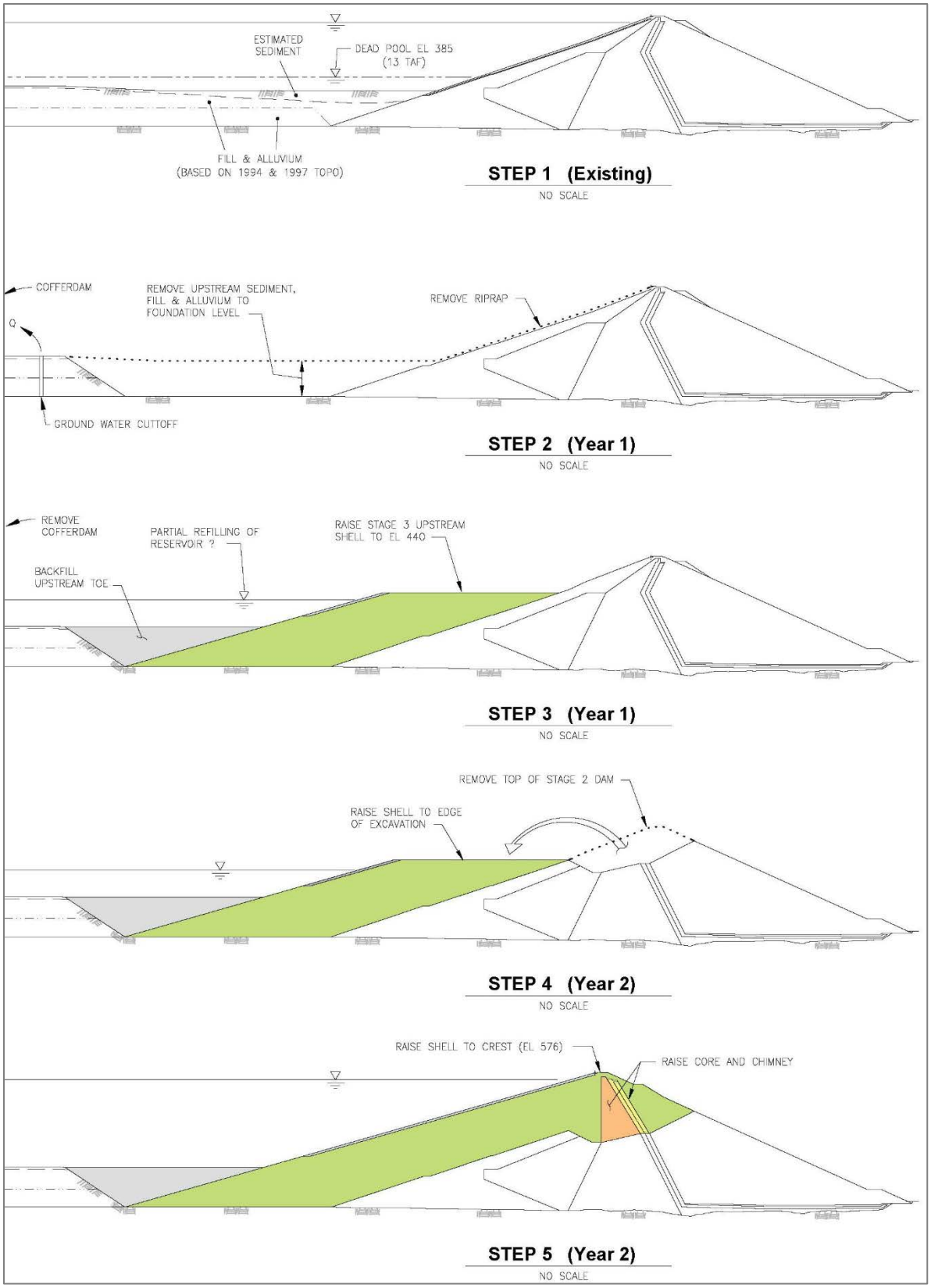


Figure 4-2. 275 TAF Reservoir – Profile View of Dam Raise & Construction Phasing

# Appurtenant Facilities

## Spillway

The spillway (a channel over the dam that allows for overflow from the reservoir) for the 275-TAF reservoir would be an extension of the existing spillway on Los Vaqueros Dam. The new portion of the spillway would be about 375 feet long and would have a rectangular cross-section of 15 feet. The existing stilling basin (an impoundment to slow the water conveyed through the spillway) at the base of the chute and a riprap-lined discharge channel to Kellogg Creek would be retained. The spillway would have the capacity to convey the Probable Maximum Flood to ensure that even in the most extreme storm conditions, water levels in the reservoir would not overtop the dam.

## Inlet / Outlet Works

The fill/release capacity through Transfer-LV pipeline is limited to the existing capacity of 200 cfs/400 cfs. There would be no modifications to the existing inlet/outlet works with the 275 TAF dam (i.e., no additional ports, resizing of facilities or changes to any control systems at the dam). There will be changes/replacement of at least three of the slide gates in the intake ports, and possibly the two blow-off valves, in the outlet to accommodate the additional head in the reservoir. The sloping structure will also be extended up the slope to retain the same general configuration it has now.

All pump-in and release flows will be routed via the existing inlet/outlet works. The existing facility is a 7-foot-diameter, steel-lined sloping structure with five ports that can be used to release water from different reservoir water levels to satisfy water quality needs. Water flowing out of the reservoir through the port structure (also known as an intake structure because water is being brought into a water system from a reservoir) would be routed through the existing steel- and concrete-lined outlet tunnel to an outlet structure at the toe of the dam that includes various valves and connects to the Transfer-LV Pipeline that runs to the Transfer Facility. The existing outlet tunnel, outlet structure, and associated valves would be reused without major modification.

The new second tunnel/pipe through the left abutment will be used only to comply with regulatory requirements for emergency reservoir evacuation. It will not connect to the Transfer pipeline. DWR's Division of Safety of Dams guidelines for emergency drawdown (or "evacuation") of large reservoirs require that the dam facilities have the capability to lower the reservoir level by an amount equal to 10 percent of the hydraulic head behind the dam in ten days, and to evacuate the entire reservoir in 120 days. These guidelines are met at Los Vaqueros Reservoir via the outlet tunnel and a valve in the outlet structure that discharges the emergency release flows directly into Kellogg Creek.

## Reservoir Oxygenation System

The existing reservoir has an oxygenation system that is designed to enhance the quality of water in the hypolimnion, which is the bottom or lower zone of water within the reservoir. This system would need to be relocated and/or upgraded to accommodate the reservoir expansion. Oxygenating the hypolimnion helps maintain sufficient residual oxygen in the deeper reservoir waters, which improves water quality, reduces tastes and odors so water from this level in the reservoir can be used for consumption, and makes the water habitable for fish. During the

oxygenation process, liquid oxygen is vaporized, piped to a diffuser grid on the bottom of the reservoir, and then released into the reservoir as oxygenated bubbles.

The existing oxygenation facilities are on the downstream face of the dam and include two horizontal liquid oxygen tanks, ambient vaporizers, control valving, instrumentation and telemetry panel, and site access for liquid oxygen delivery and operation personnel. Liquid oxygen is generated off site and trucked to facility storage tanks. These facilities would be relocated in the same general area as part of the dam modification process under any alternative and may be upgraded to effectively oxygenate the larger reservoir.

## Dam Construction

Construction of the expanded reservoir would involve the dam raise as well as construction of the appurtenant facilities. The following subsections describe the construction of these aspects of the project.

### Dam Raise Materials

Raising the existing dam requires additional claystone and sandstone materials to enlarge the dam shell as well as clay material to extend the dam core. To minimize truck trip length and associated emissions and to reduce cost, most of the materials for the dam raise would be obtained from sites within the watershed from designated borrow areas. The dam would have a system of filters and drains to control seepage through the dam and foundation. Materials for sand filters and gravel drains would be imported from commercial sources within the region. Haul distances would be between 25 and 30 miles. Other materials required for construction of the dam raise and associated facilities include both raw and pre-fabricated materials that would be transported to the project site such as gravel, aggregate, bulk cement, steel, pipeline segments, pre-fabricated building materials, and mechanical and electrical equipment.

Sand, gravel, and rock materials imported to the project area would be tested prior to acquisition and transport to determine the presence of hazardous, corrosive, or other substances that could affect use of the materials, environmental exposure, or disposal options. CCWD's construction specifications require contractors to ensure these materials meet industry standards set forth by the American Society of Testing and Materials, among other groups.

### Material Borrow Areas

The embankment fill for the 275 TAF dam is approximately 4.72 million cubic yards, which includes the fill volume replacing the volume excavated from the crest of the Stage 2 dam (0.46 million cubic yards). With the Stage 2 dam volume of approximately 3.60 million cubic yards, the total volume of the Stage 3 dam will be approximately 7.86 million cubic yards.

With the exception of relatively small volumes of sand and gravel and rock for the filters, drains, and riprap/bedding, all of the additional fill will be obtained from on site. The majority of the onsite materials (4.30 million cubic yards) will be for construction of the shells (Zone 4). A relatively small volume (0.3 million cubic yards) is required for the core (Zone 1). Attachment 2C provides detailed information on the borrow site areas.

Most of the 4.3 million cubic yards of earthfill for the 275-TAF dam raise would be used for the upstream and downstream shells. The proposed source for the shell materials would be within the 143-acre shell borrow area located on the southeast end of the prominent ridge separating the north and south arms of the existing reservoir, as shown in Figure 4-3. Most of the shell borrow area would be within the 275-TAF Los Vaqueros Reservoir boundary and would be inundated after construction. Part of the shell borrow area would result in a cut slope approximately 100 feet above the water line after inundation of the 275-TAF reservoir. The proposed grade would be approximately two percent, and the area would be revegetated. The Panoche formation claystones and sandstones from both areas are anticipated to have excavation, compaction and strength characteristics similar to the materials used for both the original dam and the 160-TAF dam raise.

Clay for the core would be obtained from the same borrow source used for the 160-TAF construction, the naturally occurring alluvial deposits in the valley floor approximately 2.5 miles downstream of the dam. The borrow area would occur within the 58-acre area defined in Figure 4-3. The area defined by the limits includes the access haul road from Walnut Boulevard. The previously proposed core borrow described the 2010 Final EIR/EIS was upstream of the dam in the area currently inundated by the 160-TAF Los Vaqueros Reservoir. The proposed downstream borrow source would produce the quality of materials required for the core without the need to dry saturated clays from the previously proposed, currently inundated core borrow area back to a suitable compaction moisture content.

### Materials and Equipment Stockpile and Staging Areas

Although the dam raise would be constructed in large part from local materials quarried from nearby borrow areas, certain materials would need to be imported and stockpiled near the dam in sufficient quantity to maintain an adequate flow of materials. Some material would be stockpiled adjacent to the existing dam on the downstream side. An estimated 15-acre stockpile/staging area was identified along Walnut Boulevard near the entrance to the watershed. Alternative 4 would not require a 15-acre stockpile/staging area.

### Materials Disposal

For the 275-TAF reservoir, excess earthen materials would be disposed of within the reservoir inundation zone at a suitable distance from the dam to avoid interference with reservoir operations.

### Draining the Reservoir for Construction

Raising the existing dam for expansion to 275 TAF would require construction on the upstream and downstream sides of the existing dam and would therefore require that the reservoir be empty during construction. Draining the reservoir would be accomplished primarily by the planned release of the water into the CCWD distribution system, which could take six months to one year to accomplish. The existing reservoir water elevation would be drawn down to the level of the lowest port on the existing reservoir outlet (350 feet in elevation). The remaining 3 to 4 TAF of water that could not be released through the dam outlet would be pumped out through the lower port. It is expected that this water would be adequately mixed and aerated and would be either sent down the transfer pipeline for use in the CCWD service area or discharged to a creek or drainage channel consistent with regulations. Any water not suitable for release may require evaporation ponds or special treatment.

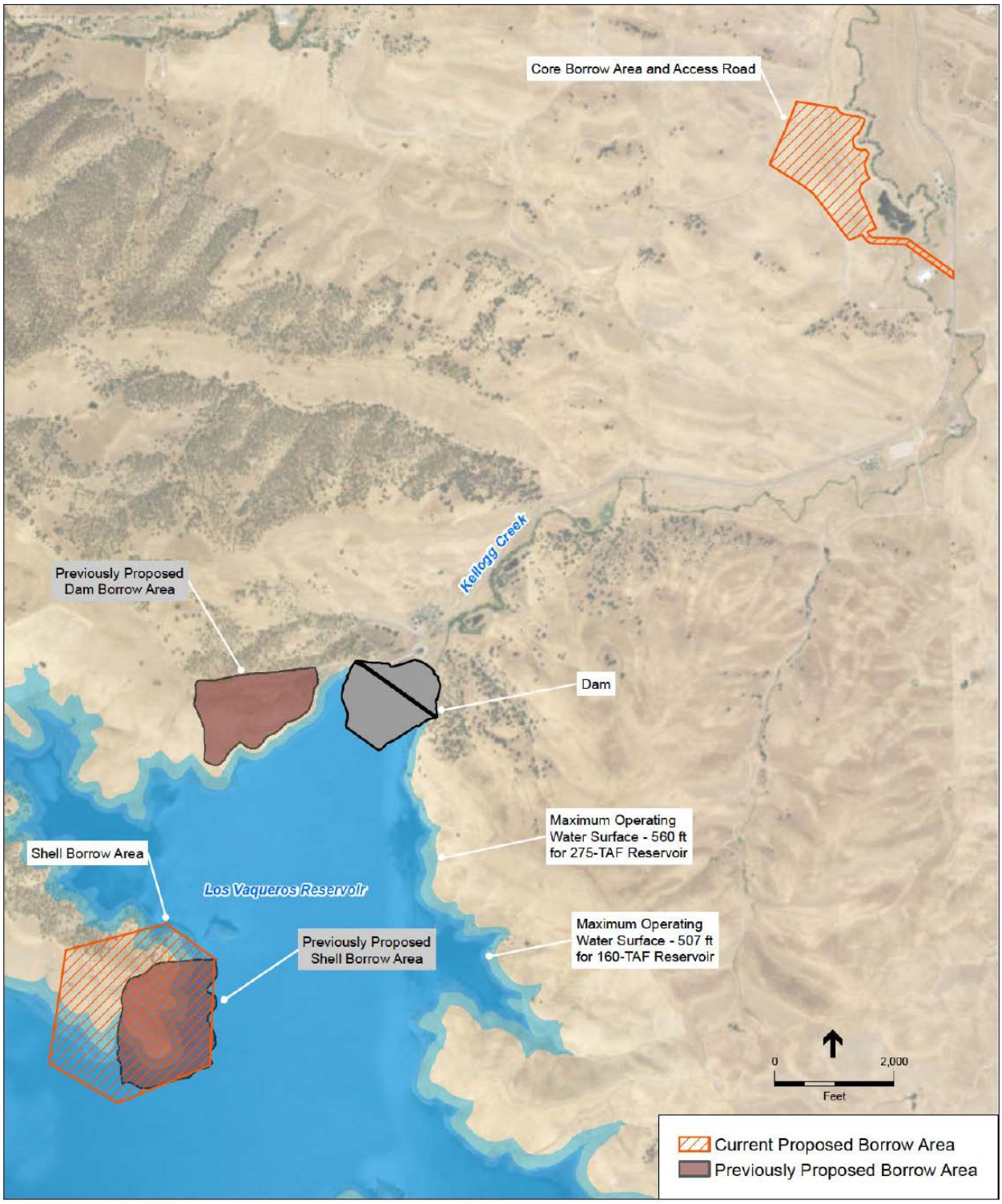


Figure 4-3. Proposed Borrow Locations for the 275 TAF Dam Raise

The Los Vaqueros Reservoir would be out of service for about four years from the time the reservoir was completely drained to allow for construction of the dam expansion through refilling the expanded reservoir. The amount of time needed to refill the reservoir would depend on hydrologic conditions and Delta water quality during the refilling. During this period, CCWD would be able to meet its water quality goals in all but short portions of the driest years using its current intakes at Old and Middle Rivers, Rock Slough intake, and its intertie with EBMUD.

### Kellogg Creek Flow Bypass

Once the remaining water is removed, a groundwater cutoff trench would be installed upstream of the dam footprint to enable excavation of the foundation upstream of the toe of the existing dam. A temporary cofferdam would be constructed upstream of the cutoff trench. A temporary diversion pipe would be installed to divert any inflows from Kellogg Creek around the dam and into Kellogg Creek to maintain the flows required in CCWD's water rights and Biological Opinions and to sustain the habitats dependent on these flows.

### Construction Activities

Construction of the 275-TAF reservoir dam, including appurtenant facilities, is estimated to require 24 to 30 months. Construction phasing is depicted on Figure 4-2. As described above, prior to construction, water would be drained from the existing reservoir. Once the remaining water is removed, a groundwater cutoff trench would be installed upstream of the dam footprint to enable excavation of the foundation upstream of the toe of the existing dam. A temporary cofferdam would be constructed upstream of the cutoff trench.

About 1,000,000 cubic yards of wet alluvium and spoil from the existing dam would be excavated between the groundwater cutoff and the upstream shell of the dam. The wet soil would be moved to a location on the reservoir floor to dry.

Construction of the dam embankment would begin in the second half of Year 1 and be completed in Year 2. Grouting the upper abutments would occur concurrently with foundation excavation and embankment fill placement. About four months would be required to place about 100,000 cubic yards of concrete on the left abutment.

Construction of the extension of the existing sloping intake tower and structural modification of the existing outlet control structure could be completed in the first construction season. Construction of the mechanical/electrical and structural components of the outlet sloping intake structure and the downstream inlet/outlet control structures would be completed in Year 1 once the extension of the sloping intake structure is finished. Equipment would include dump trucks, a small bulldozer, vibratory rollers, front-end loaders, and the concrete mixing plant.

## Expanded Recreation Facilities

This section covers the expanded recreation facilities, as summarized in Table 4-2.

Table 4-2. Summary of Expanded Recreation Facilities

| Facility | No Action | Alternatives 1A, 1B, 2A | Alternative 4A |
|---|---|---|---|
| **Marina Complex Relocation** | No change | Relocated upslope | No change |
| **Los Vaqueros Watershed Trail** | No change | Expanded | None |
| **Los Vaqueros Interpretive Center** | No change | Improved | Improved |
| **Los Vaqueros Watershed Office Barn** | No change | Seismically upgraded and improved | Seismically upgraded and improved |

## Marina Complex Relocation

For Alternatives 1A, 1B, and 2A, the existing Marina Complex, including the facilities at the south cove and the end of Los Vaqueros Road, would be inundated to make way for an expanded 275 TAF reservoir. Since Los Vaqueros Reservoir would not be expanded in Alternative 4A, the existing Marina Complex would not need to be relocated in that alternative.

In Alternatives 1A, 1B, and 2A, a new Marina Complex would replace the existing Marina Complex upslope of the existing facilities at the southern end of Los Vaqueros Reservoir (see Figure 4-4). The new Marina Complex would have a footprint of about 22 acres. This new Marina Complex replaces the previously proposed marina facilities on the northern end of the Reservoir described in the Final EIS/EIR, as well as the approximately 8 acres of fishing facilities at the southern end of the Reservoir including fishing piers, fish cleaning stations, parking, etc., as previously proposed in the Final EIS/EIR. The new Marina Complex would be compliant with the ADA and would include:

1. Parking, including ADA-accessible stalls and turnouts as close and as level as possible to the reservoir;

2. A boat launch ramp for servicing the rental fleet and for contractor's boats;

3. Covered picnic areas with concrete tables/benchesa play area, shade structures, remote restrooms, and other visitor amenities;

4. An outdoor amphitheater;

5. A Marina building, with room for a building lobby, interpretive displays, offices to accommodate up to 15 employees, requisite bathrooms and septic system, retail area, and food service area with sinks;

6. Outbuildings for storage, workshop space, water treatment and electrical equipment, and a large enclosed yard for larger items and other storage;

7. Fishing piers, fish cleaning stations, and a fish plant tube; and

8. Docks, which would include a dock surface smoother, two covered berths for patrol boats, berths for 50 electric-powered rental boats and three pontoon boats, davits (small cranes) to lift rental boats out of the water for cleaning, and a large boat house with room to hang life jacket/personal floatation devices and gear.

The connections to the trails near the new Marina Complex would be slightly modified from what was shown in the Final EIS/EIR, but the footprint area would remain the same as was previously analyzed.

### New Los Vaqueros Watershed Trail

A new 0.5-mile ADA accessible interpretive trail would be built surrounding the Mortero Wetland Complex, which is located adjacent to the Walnut Staging Area at the northern end of the Los Vaqueros Watershed (see Figure 6-5). The new trail would include interpretive displays, viewing facilities, and shade structures and would generally follow the existing gravel road/trail with loops, turnouts, and rest areas. Approximately 0.5 acres of open space areas would be disturbed.

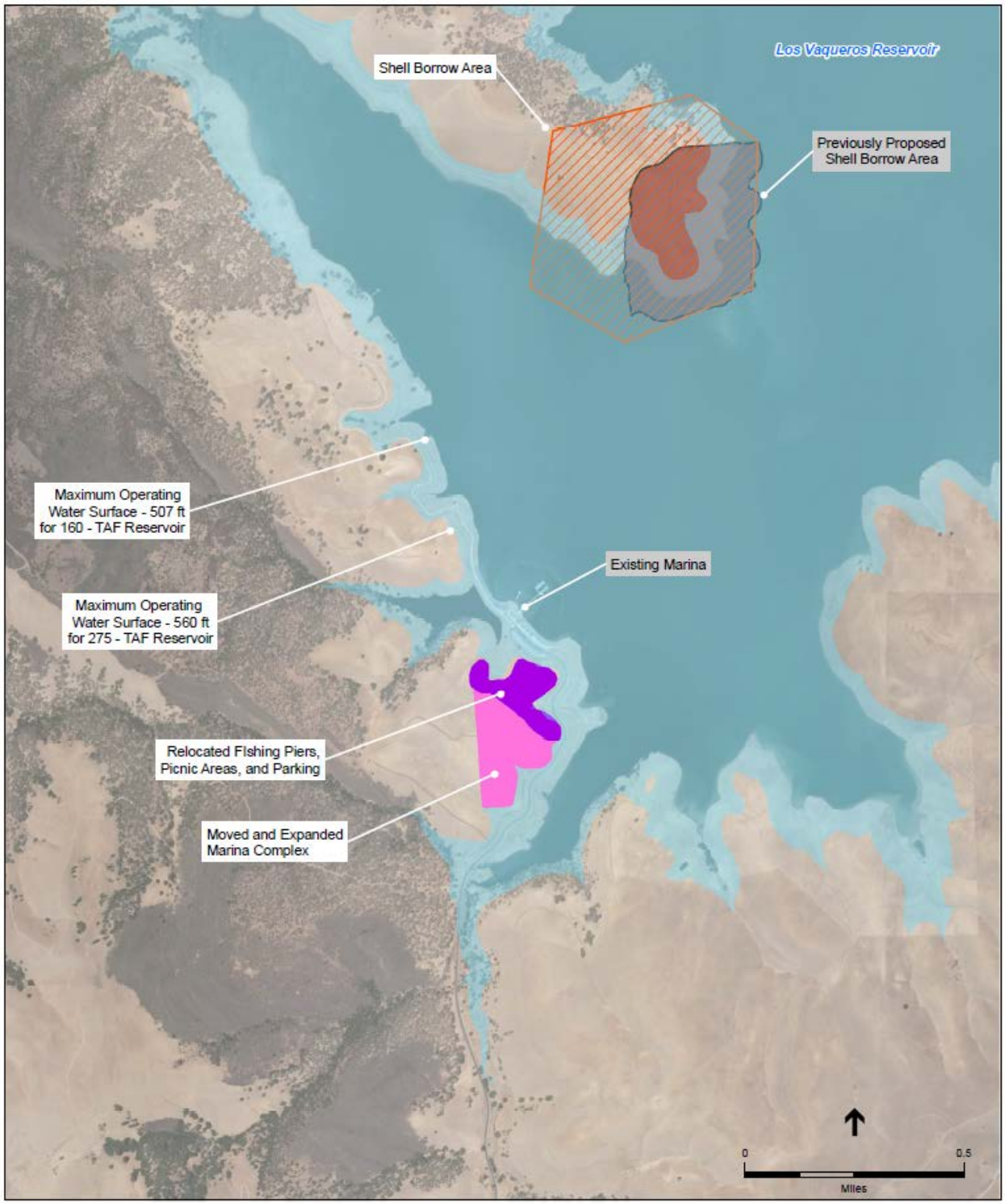


Figure 4-4. Proposed Relocation of the Marina Complex

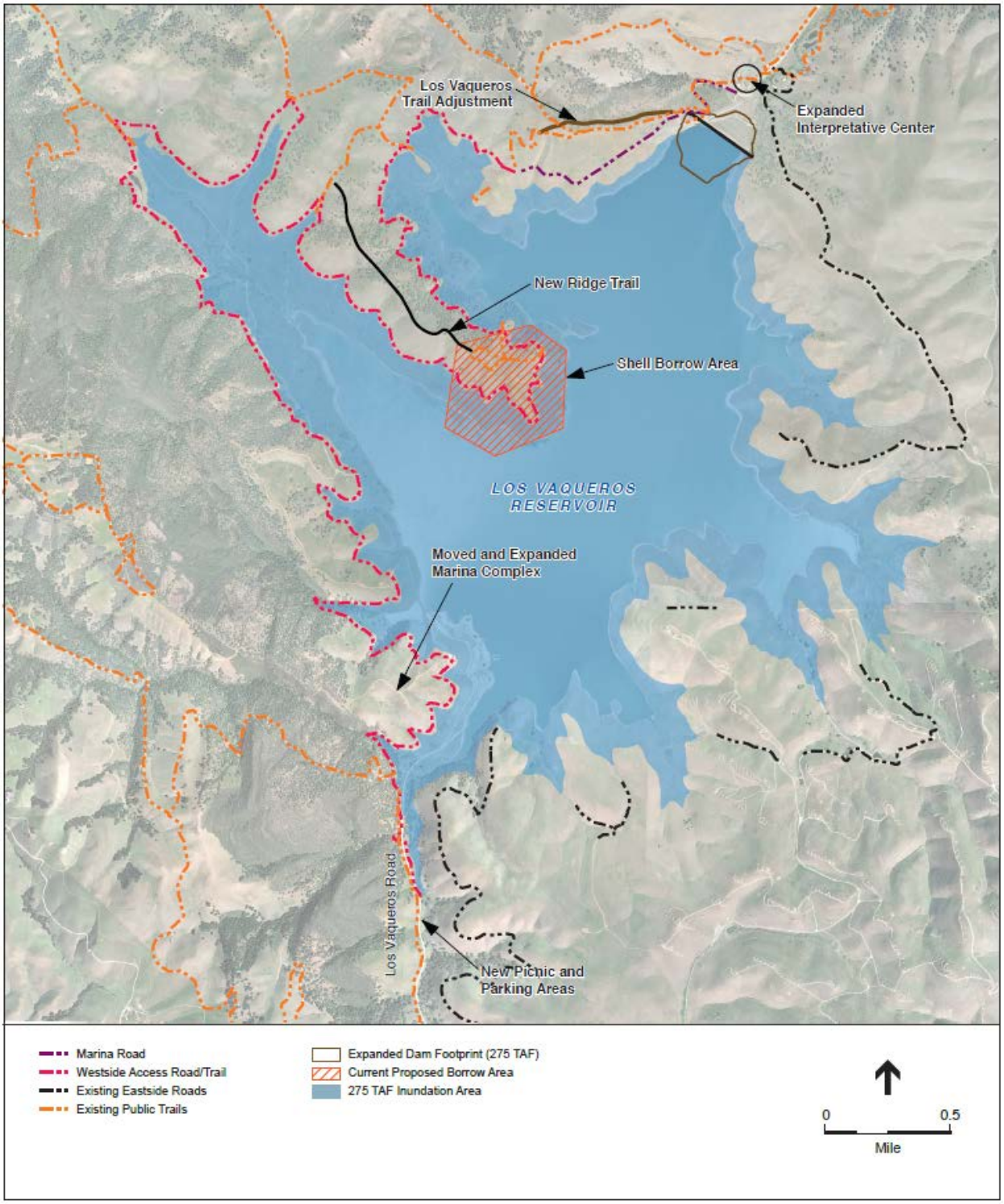


Figure 4-5. Los Vaqueros Watershed Trails

### Los Vaqueros Interpretive Center

The previously proposed second interpretive center that was to be part of the Northern Marina Complex has been eliminated. Instead, the existing Los Vaqueros Interpretive Center would be upgraded and enlarged within the existing developed location just north of the dam along Kellogg Creek, as shown in Figure 6-5. This site has an educational pond, which would remain unchanged.

### Los Vaqueros Watershed Office Barn

The existing old barn near the Los Vaqueros Watershed Office would be seismically and structurally upgraded (without expanding the existing footprint) and would contain an interpretive exhibit about ranching history in the area and a classroom area for demonstrations and to complement the existing outdoor education program. A new conservation and native plant demonstration garden of up to approximately 80’ by 90’ in area and an expanded parking area of up to approximately 60’ by 80’ to accommodate school buses would be located in the vicinity of the old barn. The new garden and parking facilities would be located within the existing footprint of disturbed area adjacent to the existing Watershed Office (see Figure 6-5).

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# Chapter 5
# Conveyance and Pumping Facilities

This Chapter documents the design development for:

- Upgrades to Existing Transfer Station
- Expanded Transfer Station
- Delta-Transfer Pipeline
- Transfer-Bethany Pipeline
- Neroly High Lift Pumping Station

The Chapter also discusses potential modifications to allow the integration of the new facilities with the exiting Old River Intake and Pump Station and Middle River Intake and Pump Station.

In addition, the design for the replacement of Pumping Plant #1 to accommodate higher flows is summarized.

A discussion of system hydraulic modeling is presented first, followed by a review of proposed pumping and ancillary facilities and existing facilities listed above. Engineering drawings supporting the design are provided in Attachment 3.

## Hydraulic Modeling

A hydraulic analysis was conducted of the Los Vaqueros System to determine:

- Sizing of the Delta Transfer Pipeline
- Sizing of the Transfer-Bethany Pipeline and the Transfer Expansion Pumps
- Maximum steady state and shut off pressures of the Middle River, Old River, Delta Transfer, and Transfer-Bethany pipelines
- Transient pressures along the Middle River, Old River, Delta Transfer, and Transfer-Bethany pipelines during a surge event to evaluate existing surge tanks and size proposed surge tanks at the ETPS

The proposed Delta-Transfer Pipeline begins at the connection of the Middle River Pipeline to the Old River Pipeline and parallel's the Old River Pipeline to the proposed ETPS.

The new Delta-Transfer Pipeline will be hydraulically connected to both the Middle River and Old River Pipelines. Through a series of valves and connection pipe arrangements, the system can be operated as either parallel pipelines providing flow split between both pump stations, or as a dedicated pipeline conveying water from either Old River or the Middle River pump stations to the Transfer Facility as well as the Neroly Blending Facility. Under normal conditions both pipelines will be operated in parallel providing comingled flow from the Middle River and Old River Pump Stations to the Transfer Facility.

## Delta Transfer Pipeline sizing

The Delta-Transfer Pipeline is sized to convey 180 cfs at a maximum velocity of 10 ft/sec to minimize potential erosion of the cement mortar lining which can occur at sustained velocities over 12 ft/sec.

The headloss in the pipeline is directly related to the velocity in the pipeline for any given pipe diameter. As the pipe diameter decreases and the velocity increases, the headloss in the pipeline increases. There is a trade-off between increased pipe cost for a larger pipe diameter and increased pumping energy costs. Also, higher velocities increase the potential for more severe hydraulic transient conditions.

As identified in the Existing System Hydraulic Model TM (MWH 2015b), Hazen Williams C-Factors of 115 and 113 were determined from operational data for the Old River and Middle River Pipelines, respectively. A C-factor of 113 has been applied to the proposed Delta-Transfer Pipeline.

Using the flow and velocity estimates described above, a pipeline diameter of 66 inches has been selected for the new Delta-Transfer Pipeline. The hydraulic model was used to verify the sizing and hydraulic performance of the Delta-Transfer Pipeline assuming all pumps at both pump stations are operating, and operation of the system can occur either as an independent dedicated supply pipeline or operating in parallel with the Old River Pipeline. The model predicted flow and velocity within both the new Delta-Transfer Pipeline and Old River Pipeline for each operational scenario is summarized in Table 5-1.

When the pipelines are operated in parallel with water comingled at the Old River Pump Station, the estimated flow in the Delta-Transfer Pipeline is 184 cfs, flow in the Old River Pipeline is 314 cfs, and the total flow conveyed by both pump stations is approximately 500 cfs. Although not identified in Table 5-1, the effective pumping rates from the Middle River and Old River Pump Stations are 276 cfs and 219 cfs, respectively. The results of the hydraulic analysis show that the proposed 66-inch-diameter Delta-Transfer Pipeline is adequately sized and provides the 184 cfs flow at a velocity of 7.8 ft/sec.

As shown in Table 5-1, the estimated flow within the new Delta-Transfer Pipeline ranges from 200 cfs to 240 cfs when the pipeline is operating as a dedicated pipeline with either pump station providing supply.

Table 5-1. Comparison of Flow and Velocity for Various Pump Station and Pipeline Operational Scenarios

| Operating Pump Station | Parallel Operation[1] | | | | Independent Pipeline Operation | | | |
|---|---|---|---|---|---|---|---|---|
| | Delta Transfer Pipeline | | Old River Pipeline | | Delta Transfer Pipeline | | Old River Pipeline | |
| | Flow (cfs) | Velocity (ft/sec) | Flow (cfs) | Velocity (ft/sec) | Flow (cfs) | Velocity (ft/sec) | Flow (cfs) | Velocity (ft/sec) |
| **Middle River** | --- | --- | --- | --- | 240 | 10.1 | 283 | 8.5 |
| **Old River** | --- | --- | --- | --- | 200 | 8.4 | 255 | 7.7 |
| **Both Pump Stations** | 184 | 7.8 | 314 | 9.5 | 281 | 11.8 | 394 | 11.9 |

Note:
[1] Parallel operation assumes flow is comingled
Key:
cfs = cubic feet per second
ft/sec = feet per second

## Working and Shut off Pressure

The working pressure is defined as the maximum operating pressure along the pipeline; it is based on the maximum steady state hydraulic grade line while flow is delivered through the Delta-Transfer Pipeline to the terminal reservoirs located at the Transfer Facility. Since the pipeline may be supplied from either the Middle River or Old River Pump Stations individually, or from both pump stations under a parallel operating condition, all three operating conditions must be considered. Furthermore, since the yard piping is set up so that either pipeline (Old River Pipeline or Delta-Transfer Pipeline) can be taken out of service for maintenance it is possible to direct the combined total flow from both pump stations through the Delta-Transfer Pipeline. Although not a normal operating condition, this operating scenario would yield the highest operating HGL, and should be considered the maximum operating HGL. The internal working pressure in the pipe at any point along the alignment is then equal to the difference between this maximum HGL and the pipe centerline elevation.

Mainline isolation valves are proposed along the new Delta-Transfer Pipeline just downstream from the meter vault on the Old River Pump Station site and just before the terminal reservoir turnout connection at the Transfer Facility. If the isolation valve near the reservoir turnout should be closed and either pump station is on line, the pumps would be pumping against a closed valve and the pressure in the pipeline would rise to the full pump shutoff pressure. The resulting pump shutoff pressures must also be considered in the design pressure of the pipe.

HGLs were developed from the model results for both maximum and minimum flow conditions. The maximum flow condition represents all pumps operating at each station and the minimum flow represents one pump operating at the Middle River Pump Station. The HGLs along with the pipeline elevation for the Delta-Transfer Pipeline are provided in Figure 5-1. The corresponding estimated pressures for each operational scenario are presented in Figure 5-2.

From Figure 5-2, the maximum shut off pressure occurs from the Middle River Pump Station. The maximum working pressure occurs when both pump stations are pumping through the

Delta-Transfer Pipeline. The maximum shut off pressure ranges from 220 psi to 300 psi along the pipeline and the maximum working pressure ranges from 35 psi to 200 psi.

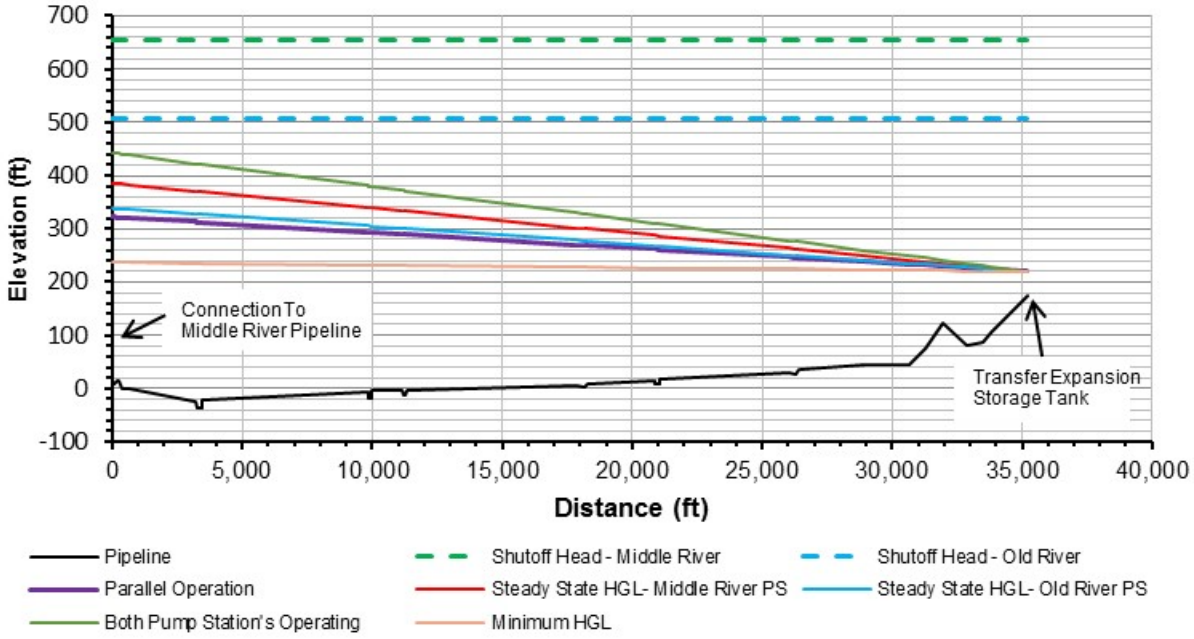



Figure 5-1. Hydraulic Grade Line – Delta Transfer Pipeline

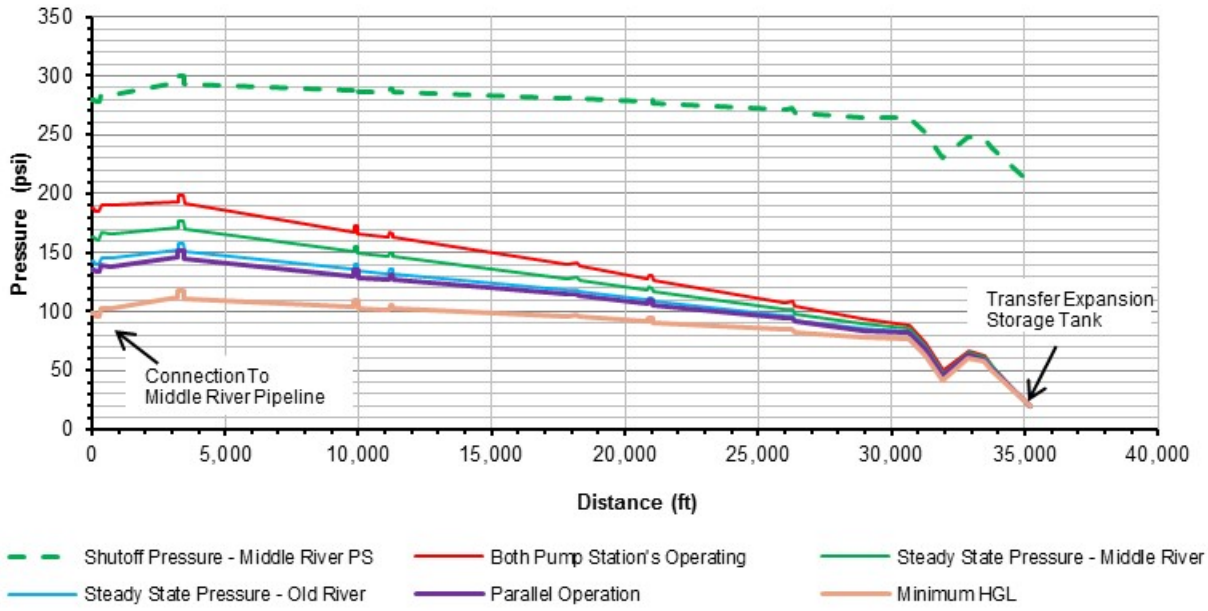



Figure 5-2. Pressure – Delta Transfer Pipeline

## Transfer-Bethany Pipeline and Expanded Transfer Pump Selection

The proposed Transfer-Bethany Pipeline was incorporated in to the existing system hydraulic model. The model has been used to size the pipeline assuming a maximum 300 cfs pumped from the expanded transfer pump station, a maximum of 400 cfs conveyed by gravity from the Los Vaqueros Reservoir, and a maximum velocity of approximately 10 ft/sec. Using the flow and velocity estimates described above, a pipeline diameter of 84 inches has been selected for the Transfer-Bethany Pipeline. An 84-inch-diameter pipeline provides an estimated velocity of 7.8 ft/sec at 300 cfs and 10.4 ft/sec at 400 cfs. Although the velocity at 400 cfs slightly exceeds the maximum proposed velocity of 10 ft/sec, the pipe sizing was determined to be acceptable since this operational scenario would occur infrequently and the estimated velocity is less than 12 ft/sec which is the critical velocity to prevent scour damage to cement mortar lining.

The model has been used to develop a system curve of the Transfer-Bethany pipeline assuming: an 84-inch-diameter; water depth of 20 feet in the ETPS Reservoir located on the Transfer Facility site; a water surface elevation of 245 feet in the Bethany Reservoir; and a C-Factor of 113. The selected C-Factor is consistent with the Delta Transfer Pipeline and Middle River Pipeline as identified in the Existing System Model TM (MWH 2015b).

Pump configurations ranging from eight to four duty pumps were evaluated using pump performance curves from numerous pump manufacturers. Due to the shape and slope of the system curve, a single pump model could not be identified to meet the full range of flows crossing the system curve, which creates a critical operating point where the first pump does not cross the system curve.

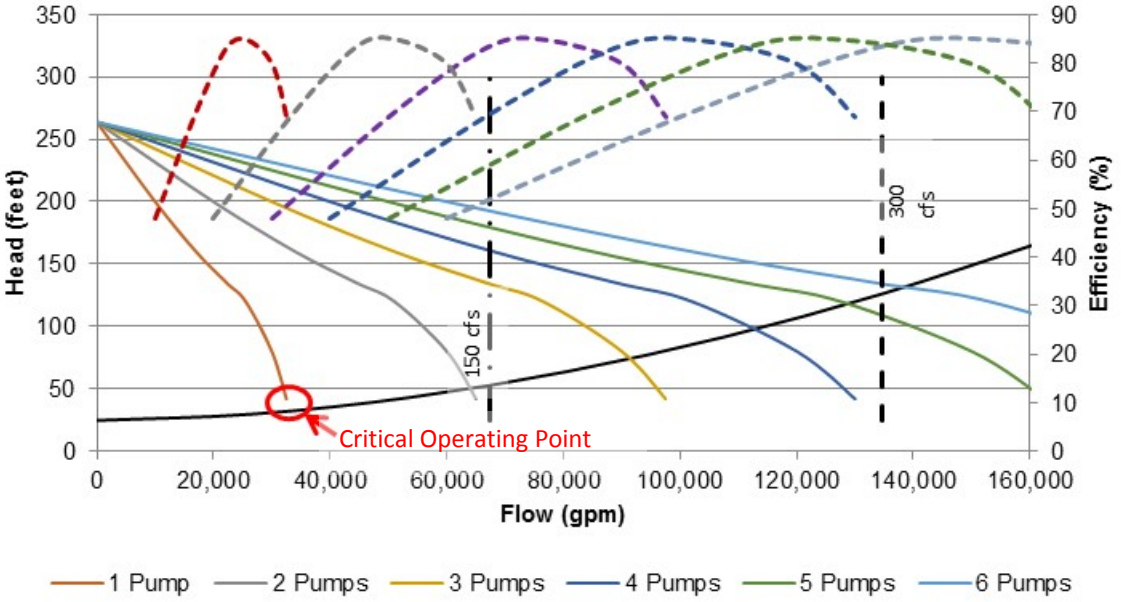
Based upon a review of available pumps, the six-pump configuration using Sulzer Model SJT-42KMC – 3-Stage pump operating at 590 revolutions per minute fitted with a 1,250 hp motor was selected as the preferred pump configuration for the ETPS. The system curve along with the preferred pump performance curve is presented in Figure 5-3. The selected pump provides high efficiencies (85 percent at best efficiency point) over the pump operating range including pump run out.

As shown in Figure 5-3, the pump performance curve does not cross the system curve when a single pump is operating, creating a critical operating point. There are three general approaches to address this concern. The first option is to set the minimum station flow at 140 cfs with two pumps operating together. This option is the simplest, economical and reliable method of operating the pump as compared to the other options, provided the District would agree to operate the system at a minimum flow of 140 cfs.

The second option would be using a VFD for each pump motor to adjust the pump speed so that the pump performance will intersect the system curve at approximately 90-percent speed. This will add slight complexity to the pump station control, additional cost for VFD and additional maintenance.

The third option would be to provide a throttling valve to create an artificial pressure increase so the operating point of the pump will be inside the Allowable Operating Region. This option would add cost for the pump control valve and complexity of controls.

Figure 5-4 shows the pipeline profile, the maximum and minimum hydraulic grade lines, and shut off head condition along the Transfer-Bethany Pipeline using the preferred pump.




Key:
gpm = gallons per minute
rpm = revolutions per minute

Figure 5-3. Pump Selection – Expanded Transfer Pump Station

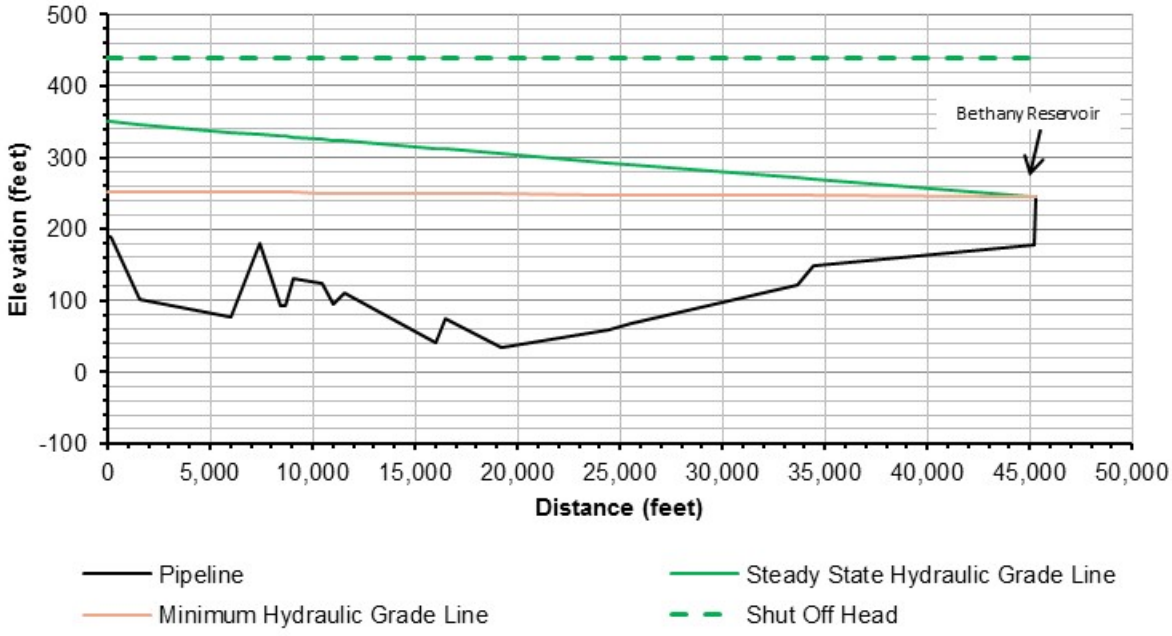



Figure 5-4. Hydraulic Grade Line – Transfer-Bethany Pipeline

## Surge Analysis

Hydraulic transient pressures result from sudden velocity changes in the water flowing through a pipeline. These transient (or surge) pressures can propagate from closing a valve too rapidly or may result from an electrical power failure at a pump station that causes a sudden pump shut down. Other causes may include modulating a regulating valve too quickly or a sudden release of entrapped air from the pipeline. The most common cause of a pipeline surge condition for a pumped water transmission main is electric power failure at the pump station.

A preliminary hydraulic transient analysis has been completed for the Delta-Transfer Pipeline and associated pump stations as well as the Expanded Transfer Pump Station and Transfer-Bethany Pipeline using InfoSurge by Innovyze and the existing system hydraulic model.

The preliminary transient analysis evaluated surge conditions developed along the Old River, Middle River, new Delta-Transfer, and Transfer-Bethany pipelines due to sudden power loss occurring at the Middle River Pump Station, Old River Pump Station, and proposed ETPS. The results will be used to determine if the existing surge tanks at the Middle River and Old River Pump Stations are adequately sized to control surge conditions developed along the Old River, Middle River, and Delta Transfer pipelines and size surge tanks at the ETPS to control surges along the Transfer-Bethany Pipeline.

### *Physical Facilities*

The rated characteristics of the pumps for each pump station modeled are summarized in Table 5-2.

Table 5-2. Pump Characteristics

| Pump Station | Old River | Middle River | Expanded Transfer |
|---|---|---|---|
| **Pump Make/Model** | **Goulds 34GHX-34GHC** | **Fairbanks Morse 40GM-7100AW** | **Sulzer SJT-42KMC 3-Stage** |
| **Number of Pumps** | 5 | 5 | 6 |
| **Rated Flow (gpm)** | 26,000 | 24,580 | 25,500 |
| **Rated Head (ft)** | 250 | 364 | 120 |
| **Rated Efficiency (%)** | 88 | 87 | 85 |
| **Speed (rpm)** | 900 | 890 | 590 |
| **Motor Horsepower** | 2,100 | 3,000 | 1,250 |
| **Specific Speed** | 2,308 | 1,674 | 2,598 |
| **Total WR2 (lb-ft$^2$) [1]** | 5,536 | 4,800 | 4,200 |

Note:
[1] Estimated combined pump and motor rotational moment of inertia
Key:
% = percent
ft = feet
gpm = gallons per minute
lb-ft$^2$ = pounds per square foot
rpm = revolutions per minute

Both the Old River and Middle River Pump Stations use surge tanks to control transients. The physical features of these existing surge tanks are summarized in Table 5-3.

Table 5-3. Existing Surge Tank Summary

| Pump Station | Old River | Middle River |
|---|---|---|
| Number of Surge Tanks | 2 | 2 |
| Volume / Tank ($ft^3$) | 7,060 | 5,300 |
| Steady State Air Content (%) | 30 - 40 | 10 - 30 |
| Number – Size of Connecting Pipe(s) | Outflow: 2 – 24" diameter<br>Inflow: 1 – 24" diameter | Outflow: 2 – 24" diameter<br>Inflow: 2 – 24" diameter |

Key:
% = percent
$ft^3$ = cubic feet

Each surge tank at the Old River Pump Station has two 24-inch connection pipes, one of which is fitted with a check valve. Flow is allowed to freely exit the tank (downsurge) through both connection pipes but is restricted to only one connection (due to the check valve) upon flow return to the tank (upsurge). Based upon the Middle River As-built drawings, the two 24-inch connection pipes allow free discharge and return flow to the two Middle River surge tanks.

## Assumptions and Methodology

The following general assumptions and boundary conditions have been used in the transient model development and throughout this analysis.

The wave speed, or celerity, was calculated to be 3,300 ft/sec assuming rigid pipe materials (concrete and steel). The pipe roughness (C-Factors) factors used correspond to the values identified in the hydraulic modelling section. A 1.2 polytrophic gas exponent was used to represent actual expansion and contraction of the surge tank's air volume.

Upon loss of power the model software uses the combined rotational moment of inertia of the pump and motor and a representative four quadrant pump curve to determine the decaying flow from the pump during the run down. The rotational moment of inertia ($WR^2$) of the combined pump and motor was estimated. Check valves were added just downstream from the pump nodes to simulate near instantaneous closure upon flow reversal.

When a downsurge of –14.7 pounds per square inch gauge (full vacuum) occurs in the transient model, the subsequent positive surge pressure results become erroneous. This is due to the limited capabilities of the transient model to represent two phase flow (gas and liquid) and predict "water hammer" spikes resulting from a vapor cavity collapse. Therefore, the formation of a full vacuum condition in the system is used as a qualitative measure of an unacceptable hydraulic condition since the upsurge pressure cannot be accurately determined. Without knowing the upsurge pressure, it is not possible to predict if a certain pipe material could withstand the resultant upsurge pressure. Therefore, for this work, a minimum allowable pressure of -5 pounds per square inch gauge was selected because pipelines are susceptible to cavitation and buckling from severe vacuum pressures and because vacuum valves have been found to choke at differential pressures greater than -7 pounds per square inch gauge. Also the use of cement mortar lining is susceptible to cracking and flattening when subjected to tensional stresses that may result on the interior pipeline wall from full vacuum pressures.

## Transient Analysis

Surge tanks were evaluated as the primary surge mitigation devices since they are used at all existing Los Vaqueros Project pump stations. Flywheels were not considered since the proposed pumps are "canned" type vertical turbine pumps. Air/vacuum valves may be considered as supplemental surge control at high points if surge tanks can be sized to mitigate the hydraulic transients.

**Old River and Delta Transfer Pipelines** Since the proposed operation of the Old River and Delta-Transfer pipelines include a hydraulic connection at the existing Middle River Pipeline tie-in at the Old River Pipeline, the transient analysis of this system will include the following scenarios:

- **Scenario 1** – Simultaneous power loss at both pump stations while the pipelines are operated as parallel pipelines discharging to the Transfer Facility.
- **Scenario 2** – Power loss at Middle River Pump Station conveying flow through the Middle River and Delta-Transfer pipelines to the Transfer Facility.
- **Scenario 3** – Power loss at Old River Pump Station conveying flow through the Delta Transfer Pipeline to the Transfer Facility.
- **Scenario 4** – Power loss at both the Middle River and Old River Pump Stations conveying flow through the Delta Transfer Pipeline to the Transfer Facility.

The scenarios identified above will be used to determine if the existing surge tanks are adequate to protect the system and if required, recommend additional surge mitigation measures.

Initially, the model included air volume set points of 30 percent of the total volume in the Middle River surge tanks and 40 percent in the Old River surge tanks. The preliminary transient analysis results determined that the proposed air volume set point within the Middle River surge tanks required adjustment. The analysis determined that an air volume set point of 25 percent was required for the Middle River surge tanks and 40 percent within the Old River surge tanks. Using the proposed air volume set points resulted in adequate surge protection using the existing surge tanks.

The pipeline profile along with the minimum, maximum, and steady state hydraulic grade lines were estimated from the surge model for each scenario. Figures 5-5 and 5-6 show the surge modelling results along both the Old River and Middle River/Delta-Transfer pipelines for Scenarios 1 and 2. The surge modelling results for Scenarios 3 and 4 are shown in Figure 5-7. It should be noted that the hydraulic grade line begins at the Old River Pump Station under Scenario 3 (Figure 5-7) since Old River is pumping through the Delta-Transfer Pipeline to the Transfer Facility.

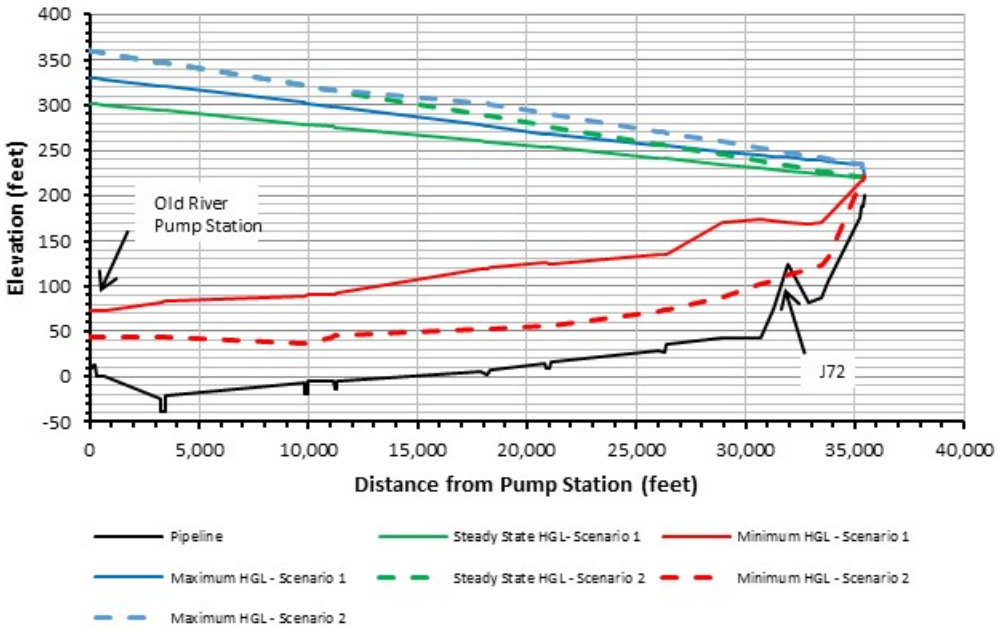



Figure 5-5. Elevations Following Loss of Power – Old River Pipeline – Scenarios 1 and 2

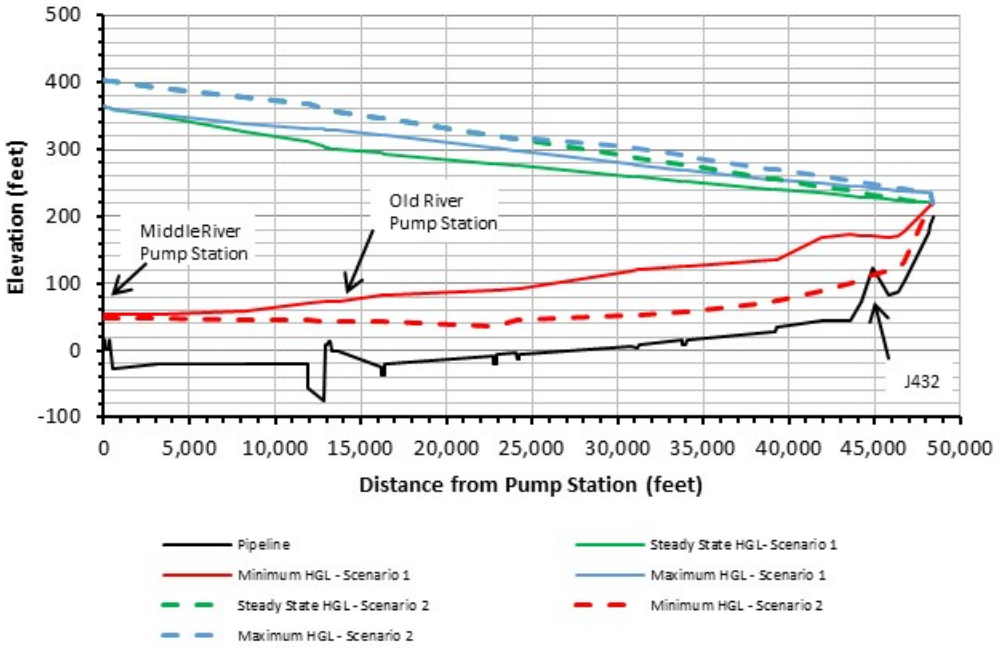



Figure 5-6. Elevations Following Loss of Power – Middle River / Delta Transfer Pipeline – Scenarios 1 and 2

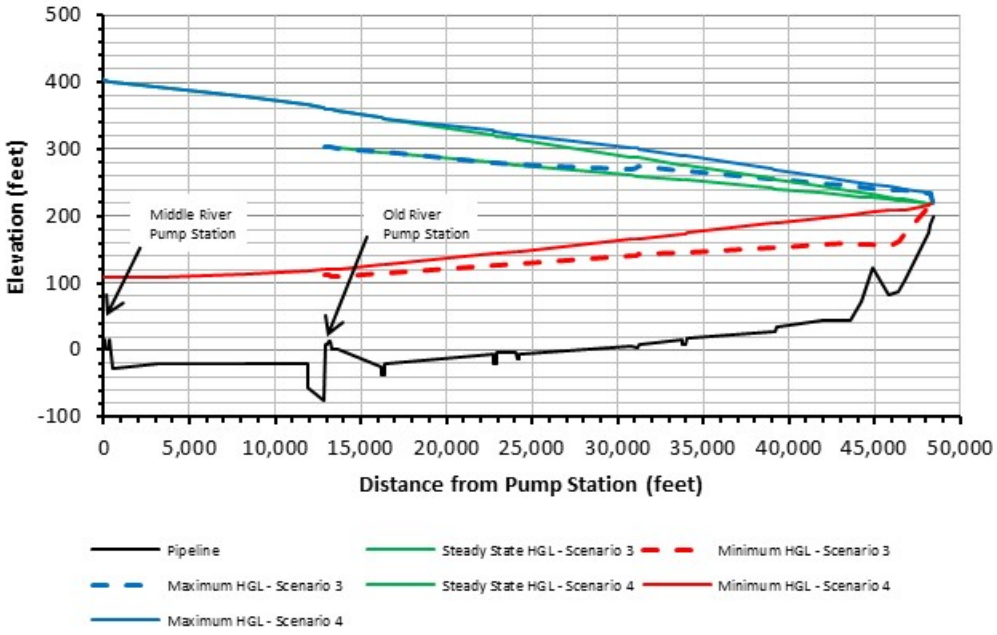
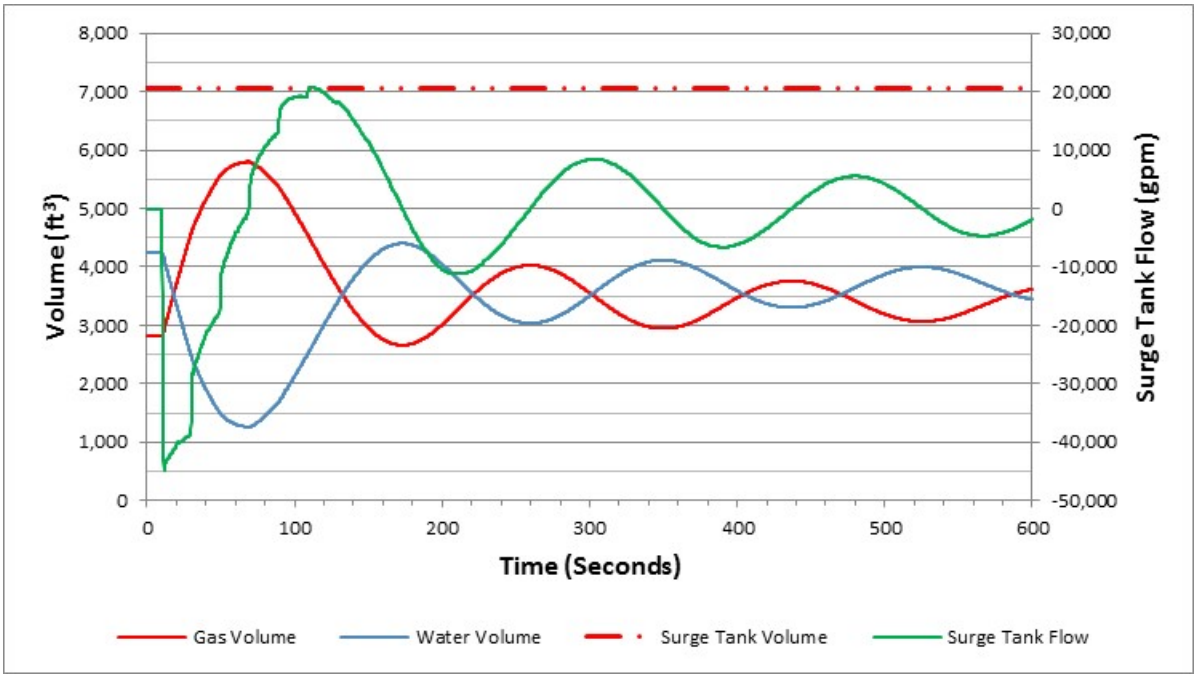



Figure 5-7. Elevations Following Loss of Power – Middle River / Delta Transfer Pipeline – Scenarios 3 and 4

As shown in Figures 5-5, 5-6, and 5-7, the critical surge condition occurs under Scenario 2 when the two pipelines are used individually pumping directly from each pump station to the transfer facility with no hydraulic connection between the two systems. Under this scenario, the minimum head falls below the pipeline at model junctions J72 (Figure 5-5) and J432 (Figure 5-6) with the estimated minimum pressure of approximately -4 psi occurring over ½ second then subsequently increasing and remaining positive for the duration of the analysis. These minimum pressures are acceptable and do not warrant additional surge mitigation devices to protect the pipeline during the downsurge.

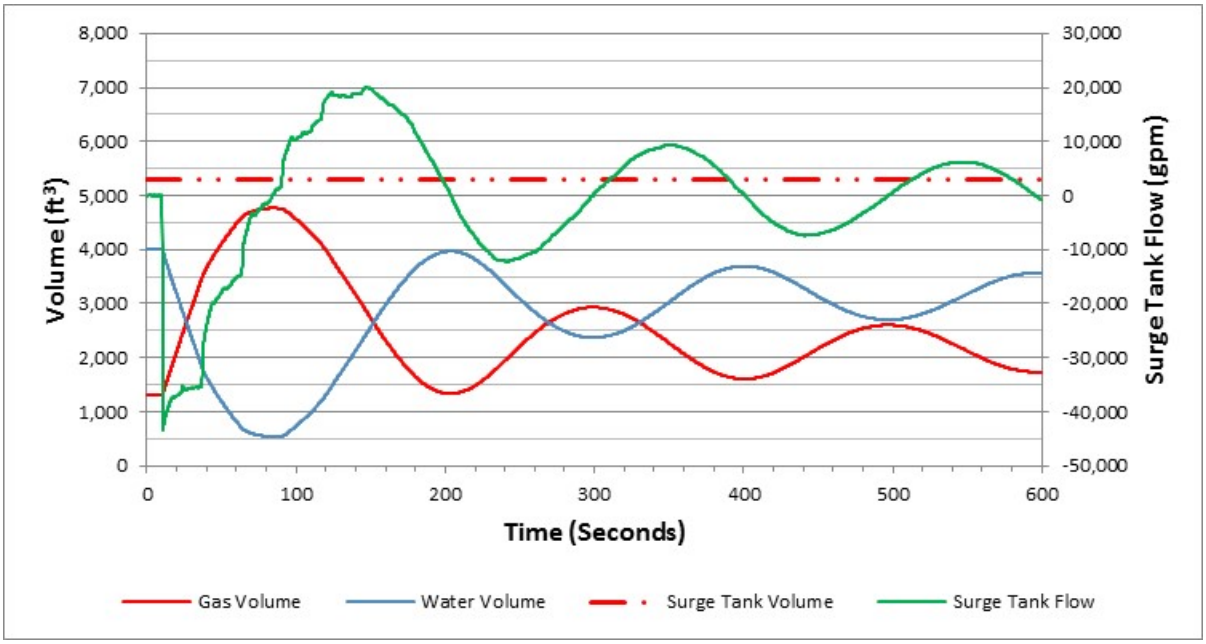
The model predicted performance of the existing surge tanks for the critical surge condition is shown in Figures 5-8 and 5-9. The red line shows the change in gas volume, with the red dashed line representing the total volume of the surge tank; the blue line shows the change in water volume; and the green line shows the flowrate in and out of the tank, with a negative flow representing flow out of the tank. As shown in Figures 5-8 and 5-9, the minimum water volume in the surge tank ranges from approximately 10 percent to 18 percent for both pump stations.

A refined transient analysis is recommended to be completed during the Investigation final design phase to confirm mitigation measures that should be employed to protect the pipe from excessive hydraulic transient conditions and confirm the maximum transient pressures for use in the final design of the pipeline and pump station.




Key:
$ft^3$ = cubic feet
gpm = gallons per minute

Figure 5-8. Old River Surge Tanks – Dedicated Flow through Old River Pipeline




Key:
$ft^3$ = cubic feet
gpm = gallons per minute

Figure 5-9. Middle River Surge Tanks – Dedicated Flow through Middle River / Delta-Transfer Pipeline

**Expanded Transfer Pump Station and Transfer-Bethany Pipeline** The transient analysis of the ETPS and Transfer-Bethany pipeline was evaluated with all six pumps operating (300 cfs), a 20-foot water depth on the Transfer Facility storage tanks, and a water surface elevation of 245 feet in the Bethany Reservoir. This evaluation was performed to determine the number and size of surge tanks required to mitigate transients developed due to power loss at the ETPS.

The transient analysis determined that three, 12-foot-diameter by 44-foot-long surge tanks providing a volume of 5,300 cubic feet (each), with an air volume set point of 40 percent, are required to mitigate the downsurge during power loss. Each surge tank is assumed to be connected to a 72-inch-diameter header pipe by two 18-inch-diameter pipelines. One of the 18-inch-diameter connection pipes is fitted with a check valve. This allows unrestricted flow from the surge tanks through the two 18-inch-diameter pipelines (downsurge), but restricts the flow entering the surge tank during the upsurge.

Figure 5-10 shows the pipeline profile as well as the minimum, maximum, and steady state hydraulic grade lines along the new Transfer-Bethany Pipeline. As shown in Figure 5-10, downsurge conditions are the most critical during the surge event since the maximum head during the surge event corresponds approximately to the steady state hydraulic grade line. The minimum head along the pipeline approximately 34,000 feet downstream from the ETPS approaches the pipeline elevation but remains positive.

The model predicted performance of the surge tanks is shown in Figure 5-11. The solid red line shows the change in gas volume, with the red dashed line representing the total volume of the surge tank. The blue line shows the change in water volume, and the green line shows the flowrate in and out of the tank, with a negative flow representing flow out of the tank. The minimum water volume within the surge tank is approximately 5 percent of the total volume.

The proposed surge tank sizing should be adequate for the expanded transfer pump station and Transfer-Bethany pipeline at a design flow of 300 cfs. Although the transient model was not evaluated when transferring water from the Los Vaqueros Reservoir to the Bethany Reservoir at the maximum design flow of 400 cfs, the closure time of the flow control valves should be set to minimize transients developed during the operation of these valves. A refined transient analysis is recommended to be completed during the final design of the pump station and pipeline to verify the assumptions and optimize the sizing and configuration of the surge tanks and determine the closure time of the flow control valves during the 400-cfs operating condition.

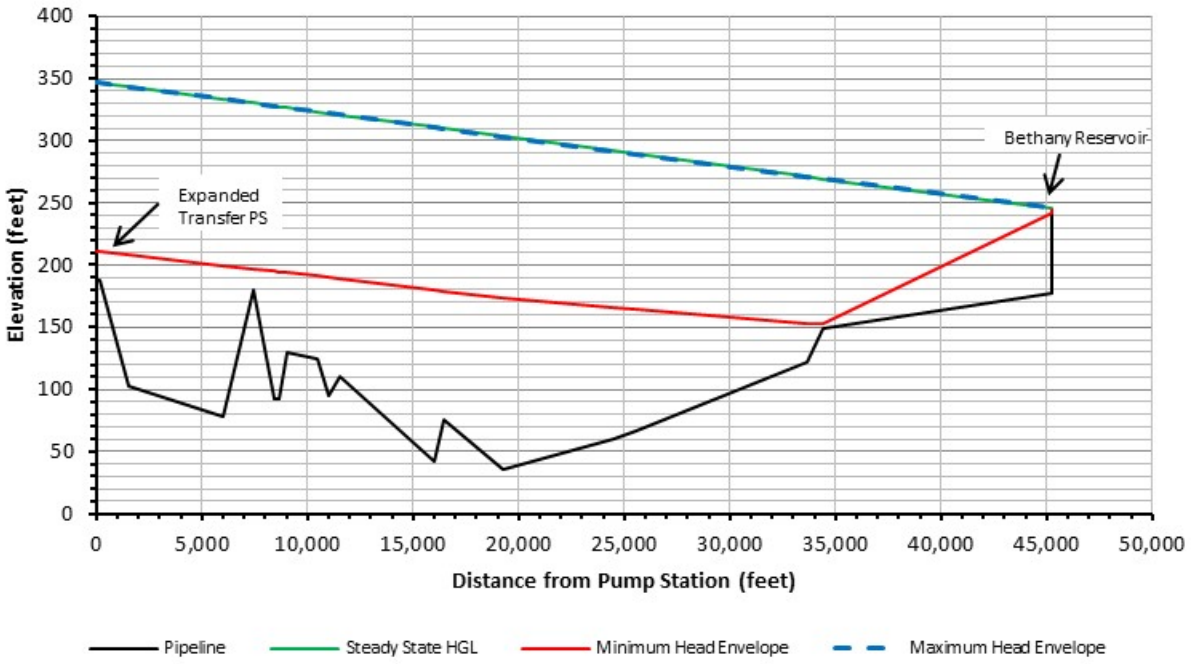
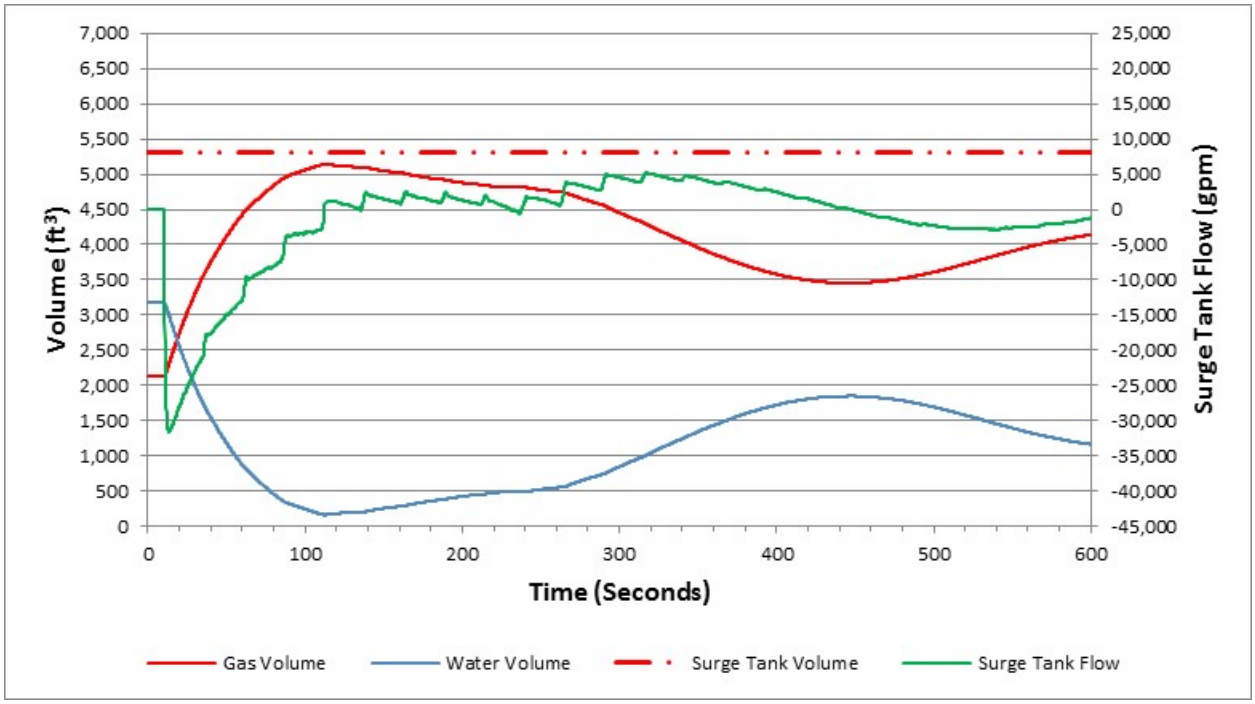



Figure 5-10. HGL Elevations Following Loss of Power – Transfer-Bethany Pipeline




Key:
$ft^3$ = cubic feet
gpm = gallons per minute

Figure 5-11. Expanded Transfer Surge Tanks

# Transfer Pump Station Modifications

This section describes the modifications required at the existing Transfer Pump Station to maintain a 200 cfs pumping capacity at the new maximum Los Vaqueros Reservoir water surface elevation resulting from the proposed reservoir expansion. Hydraulic modeling was performed to estimate system requirements for the Transfer Pump Station (PS) with the expanded Los Vaqueros Reservoir water surface elevation. New pump and motor requirements were then estimated. New Transfer PS Power and Control requirements were also evaluated. See Figure 5-12 for an overall site plan of the Transfer PS Modifications. The general design criteria for all engineering disciplines presented in Chapter 3 are assumed for new facilities required to complete the transfer pump station modifications described below.

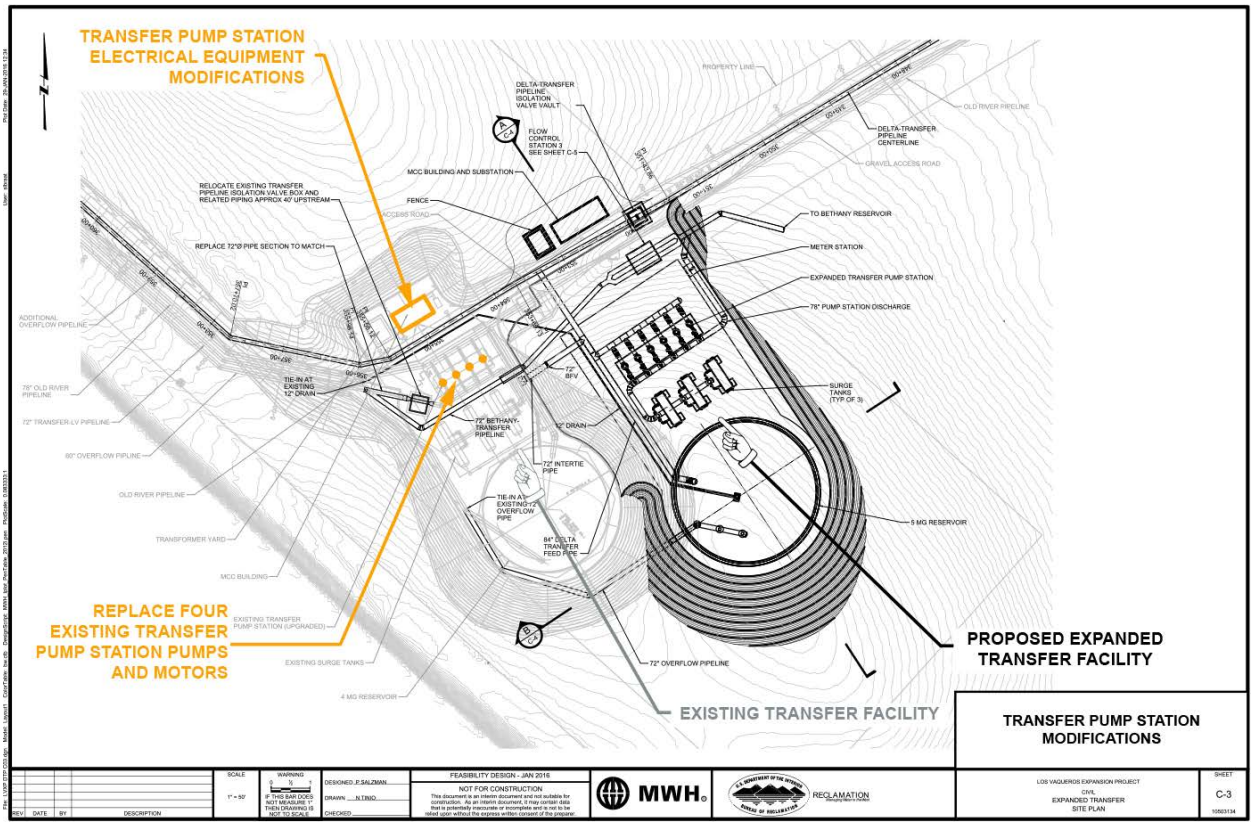



Figure 5-12. Transfer Pump Station Modifications

## Hydraulic Modeling Summary

The proposed capacity expansion of the Los Vaqueros Reservoir will increase the storage volume to 275 TAF with operating levels ranging from elevation 448 feet to 560 feet. Based upon this maximum water surface elevation, the existing Transfer pumps do not meet the new hydraulic criteria to fill the reservoir. Hydraulic analyses were conducted using the Infowater model of the existing system to estimate improvements to the Transfer PS to convey 200 cfs to Los Vaqueros Reservoir at the new maximum water surface elevation.

The hydraulic model was used to develop system curves of the Transfer system, which includes the 4 million gallon Transfer Storage Tank, the four-pump Transfer Pump Station, and the 72-

inch diameter Transfer Pipeline. A normal operating water depth of 20 feet in the Transfer Storage tank was assumed and Los Vaqueros Reservoir levels of 448 feet and 560 feet. A C-Factor of 135 was used to represent the hydraulic resistance of the transfer pipeline as identified in the Existing System Model TM.

The model estimated that the transfer pumps would require a duty point of 50 cfs at 385 feet Total Dynamic Head (TDH). Several pump manufacturers were contacted to obtain representative pump performance curves. Figure 5-13 shows the system curves for high and low reservoir levels along with the pump performance curve for WEHR Model 37TKM for single and multiple pump operation. An estimated 3,250 hp motor would be needed for this pump selection. The preferred operating range of the pump is represented by the shaded region along the pump curve and ranges from approximately 50 cfs to 83 cfs.

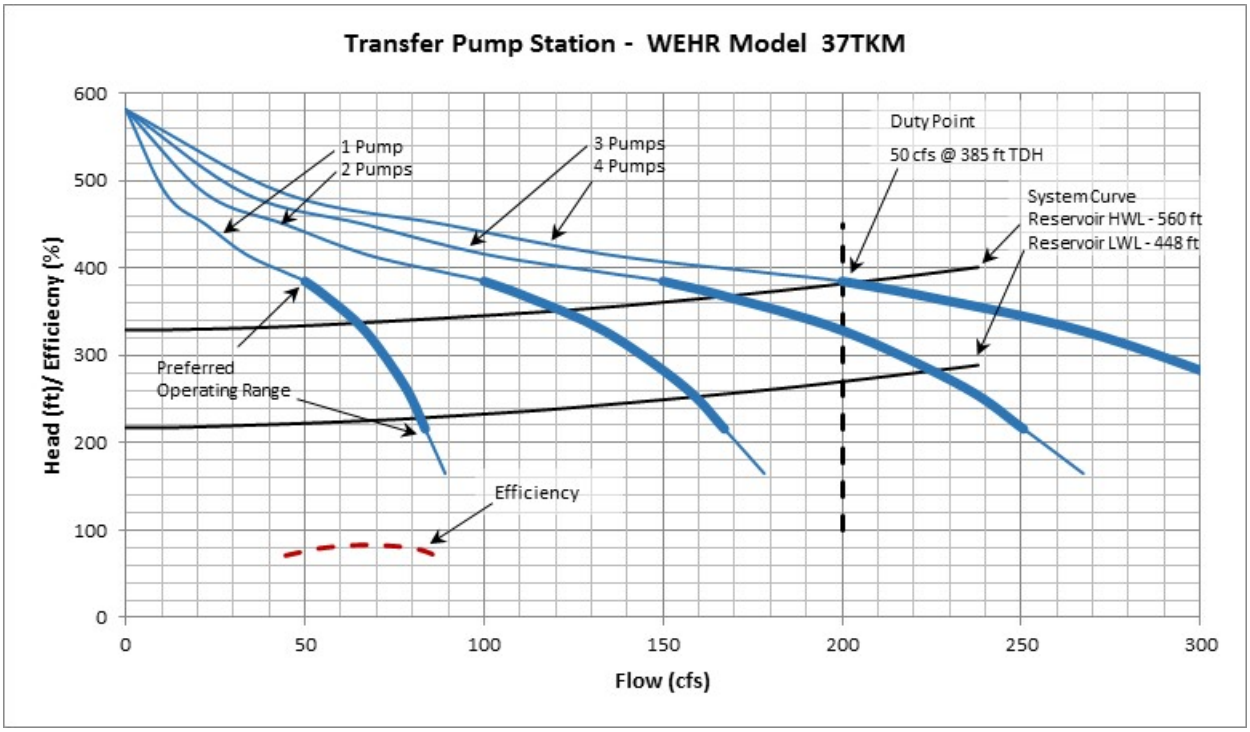



Figure 5-13. Transfer Pump Station System Curve

Figure 5-13 shows that the preferred operating range of the pump is large enough that it crosses the system curves corresponding to minimum and maximum reservoir levels indicating that VFDs or control valves are not required to control the discharge from the station at lower reservoir levels. This arrangement is consistent with the current pump station operation. Results also indicate that three pumps could be used under normal operating conditions to convey the 200 cfs design flow, which saves potential operational costs, and essentially provides a redundant pump. Three pumps operating at the minimum reservoir level (448 feet) would convey approximately 225 cfs to the los Vaqueros Reservoir, this discharge provides a velocity of 8 feet per second, which is acceptable.

Since the pump duty point was selected to convey the design flow (200 cfs) at a full reservoir level; pump motor sizing could be minimized by reducing the required duty point. However, reducing the duty point also reduces the available discharge as the reservoir nears full operating conditions. Based upon the shape of the WEHR pump performance curve, selection of a pump duty point approximately 50 cfs at 325 feet TDH would reduce the available capacity to approximately 160 cfs under full reservoir conditions (Elevation (EL) 560 feet), with four pumps operating, and reduce motor sizing to approximately 2500 hp. This operational scenario should be evaluated further during design development if this alternative is selected.

The existing Transfer PS surge system was evaluated with the addition of the WEHR pump. Model results determined that the existing surge tanks located at the Transfer PS are adequate to protect the system. However, the surge system should be re-evaluated during design development.

As previously stated, the preferred operating range of the pump crosses the system curves corresponding to minimum and maximum reservoir levels indicating that VFDs or control valves are not required to control the discharge from the station at lower reservoir levels. The existing transfer pipeline was evaluated by another consultant which determined that it was adequately sized for the additional operating pressure. Therefore, replacement the existing transfer pumps are the only process mechanical improvement required at the Transfer PS to convey the design discharge (200 cfs) to the proposed expanded Los Vaqueros Reservoir.

### Power Requirements

The existing Transfer PS was designed to accommodate up to 3,500 hp synchronous motors so no major additions or changes need to be performed or added regarding the existing facility electrical capacity. Minor MV MCC changes are required that include changing the current transformers and power fuses that are sized for 2,100 hp to 3,250 hp size units. The protective relays need all their settings adjusted for the new motor size. The motor excitation might need to be changed depending on the new motor particular needs as compared to the existing motors. Constant speed synchronous motors are assumed to be used to make use of their power factor correction capability and reuse the existing MCC set up for constant speed synchronous motor control and operation. The line reactors for the solid state starters will likely need to be replaced. The existing transformer at 15 MVA is expected to be suitable for the four new 3,250 hp pump motors. The existing switchgear is sized for 15 MVA transformer and does not need to be changed. The wall mounted series line reactor may need to be replaced, or provided if not installed, to accommodate the new larger motor starting and running currents.

The PG&E feed to the Transfer PS and related PG&E substation is expected to grow substantially as the existing feed probably only accommodates the four existing 2,100 hp pumps and is not expected to accommodate the replacement four 3,250 hp pumps and the new six 1,250 hp pumps of the new Expanded Transfer Pump Station. This was discussed in our previous Pumping and Controls Technical Memorandum (Pumping and Controls TM) and mentioned again here for completeness. Our design planning stops at the existing 21 kV service and that is where PG&E planning, engineering and design picks up. The PG&E infrastructure ahead of the pump station may require capacity upgrades to meet the needs of the higher horsepower pumping station. This work will need to be coordinated with PG&E during design. No cost for PG&E upgrades has been included in the opinion of probable construction cost (OPCC).

### Control and Monitoring

The existing CCWD SCADA HMI and Transfer PS and Reservoir PLC software packages will need to be modified to incorporate new analog and discrete I/O communicated from the new Neroly PS flow meter, pressure transmitter and positions and statuses from the new Los Vaqueros and Neroly PS pipeline isolation valve actuators. The planned Expanded Transfer PS PLC will also need to be configured to similarly process the preceding information.

## Expanded Transfer Pump Station and Reservoir

The ETPS and Reservoir will be used to direct water from the Old River, Middle River, or Neroly Pump Stations to Bethany Reservoir via the new Transfer-Bethany Pipeline. The Pump Station will have a 300 cfs design flow capacity and the reservoir will have a 5 million gallon storage capacity. Refer to project design criteria presented in Chapter 3 and to the Hydraulic Modeling section of this chapter for additional design detail.

### Facility Siting

A location adjacent to the existing Transfer Pump Station and Reservoir has been selected for the ETPS and Reservoir. The proposed site minimizes the length of piping to the Transfer-Bethany Pipeline tie-in and intertie piping between the Old River Pipeline and Delta-Transfer Pipeline supplies. The adjacent location will also help minimize additional operation and maintenance staff travel time.

### Pump Station

The pump arrangement is similar to the existing Transfer Pump Station (refer to Design Drawings in Attachment 3B). Six 50 cfs capacity vertical turbine pumps powered by 1,250 hp constant speed motors will provide the pump station's 300-cfs design flow capacity. The pumps will each be located in a pressurized "can" or "barrel" configuration. Based on preliminary pump selection and HI design criteria the cans are tentatively sized at 72 inches in diameter.

Due to the wide range of system head requirements, design elements are required to maintain conditions within the maximum Allowable Operating Region at combined pump station flow rates less than 140 cfs (refer to System Hydraulic Modeling section of this chapter). It is currently assumed that a hydropneumatically actuated pump control valve (ball valve) will be provided on each pump discharge to control pump performance at low system flows. It is recommended that a detailed evaluation of alternative approaches, such as use of VFDs or setting a design minimum pump station flow rate greater than 140 cfs, be considered in the next phase of design.

Power will be provided to the pumps from a new substation and new MCC building as described later in this chapter.

### Pump Station Suction and Discharge Piping

An 84-inch-diameter pipe will be routed from the Delta-Transfer Pipeline to the ETPS's buried 84-inch-diameter suction header. 54-inch-diameter buried suction pipes will be routed to the pump cans from the header. Manual butterfly isolation valves will be provided on each suction pipe.

The 30-inch pump discharge piping will be routed above ground before expanding to 36 inches in diameter and then being routed to the buried 78-inch-diameter discharge header. The discharge piping will include a manual butterfly isolation valve as well as a flow control ball valve, as previously described.

A buried 72-inch-diameter pipeline will be routed from the pump discharge header to surge tanks. It is anticipated that up to three surge tanks will be required as described in the System Hydraulic Modeling section of this chapter.

The discharge piping will be routed to the new Transfer-Bethany Pipeline, directly downstream from Flow Control Station 3. The Transfer-Bethany Pipeline will begin downstream from the discharge header of the existing Transfer Pump Station and in addition to facilitating pumped flow from the ETPS, will facilitate a gravity flow rate of up to 400 cfs from Los Vaqueros Reservoir to Bethany Reservoir. Flow Control Station 3 is required to control the high head flow from Los Vaqueros Reservoir. The features of the Transfer-Bethany Pipeline are described later in this chapter. A feasibility-level Flow Control Station 3 layout is provided in Attachment 3B, for reference.

### Reservoir

The reservoir will be a 5-million-gallon capacity above ground steel tank. Sizing of the tank was previously described in the Los Vaqueros Expansion Project Design Criteria Technical Memorandum (MWH 2016). The primary functions of the tank are summarized below, for reference:

- Provide a stable water surface elevation for operation of the pumps at the Old River and Middle River Pump Stations.
- Provide hydraulic level control for the flow control valves at Flow Control Stations 1 and 2.
- Provide a stable suction pressure for operation of the Expanded Transfer pumps.
- Provide storage volume required for the controlled shutdown of the Old River/Middle River pumps or the Transfer/Expanded Transfer pumps.
- Provide a controlled emergency overflow to prevent pressure buildup in the Los Vaqueros, Old River, or Delta-Transfer Pipelines.

The tank will have a 91 foot radius and will be approximately 30 feet tall. The tank will typically operate at the same 213-feet WSEL as the existing Transfer Facility reservoir tank. It is anticipated that the tank will be built on a reinforced concrete ring footing foundation with a layer of asphaltic cement pavement laid beneath the tank.

### Reservoir Piping

The 84-inch-diameter pipe routed to the pump station suction header will continue underground past the header and provide flow to and from the reservoir through an upturned 90-degree elbow. All piping under the reservoir will be concrete encased.

A buried 72-inch intertie pipeline will be provided between the 84-inch supply/withdrawal pipe and the existing 72-inch pipe supplying the existing Transfer Pump Station and Reservoir. The pipeline will include a motorized isolation valve. It is assumed that the isolation valve would normally be open to allow both pump stations to operate using a combined water source, however the valve could be closed to allow the pump stations to operate using different water sources.

It is currently assumed that the reservoir overflow piping configuration will be similar to the existing Transfer Pump Station reservoir. The piping will consist of three standpipes inside the reservoir, each with a weir near the top of the reservoir. Three overflow pipes would connect to a manifold, which would then combine to a single pipeline which would be routed to tie-in at the existing Transfer reservoir overflow pipeline which terminates at an energy dissipation structure at Kellogg Creek. Design criteria for the ETPS Reservoir overflow piping and the combined overflow piping will need to be confirmed and coordinated with currently proposed Los Vaqueros Reservoir overflow facilities' modifications.

A 12-inch sediment flushing and washdown drain pipe will be routed from the reservoir to a tie-in at the existing 12-inch drain pipe from the Transfer reservoir. The existing pipe continues to drying beds at the base of the hill. It is assumed that use of the drying beds may be staggered to accommodate the sediment generated by the ETPS Reservoir.

## Power Requirements

Delivery of PG&E power is expected to follow the same overhead route and come from the same PG&E substation to deliver power to the new ETPS and Reservoir at 21 kV.

The ETPS and Reservoir will require a 21 kV substation to transform PG&E power down from the delivery voltage of 21 kV to the pump utilization voltage of 4.16 kV. The new substation will match the existing Transfer Pump Station substation to power the six new pumps. The auxiliary equipment and support equipment will be powered from a new 225 kVA dry-type indoor 480-volt 3-phase transformer and matching power distribution panel board to deliver 480 volts for utilization equipment. The 120-volt loads will be powered from a 45-kVA 3-phase transformer and matching lighting panel board. The 125 volts of direct current loads will be powered from the MCC building station 125 volts of direct current battery and its related charger via a DC distribution panel board. The power distribution and utilization equipment will be similar to the existing facilities.

Site lighting will be required. Maintenance receptacles both indoor and outdoor will be required. Instrumentation will require wiring in and around the MCC building, the pumps, the reservoir and the vaults. The MCC building will require ventilation. The surge tanks will require air compressors. A cathodic protection system will need to be supported. 480 volt welding receptacles for maintenance will be required.

Pump control valves will have standard 480-volt 3-phase AC motor actuators.

For the new underground valves and one new flow meter they will be located at or near the MCC building for the ETPS and Reservoir. The new meter and new underground valves are to be installed in vaults built to house them.

The loads in a typical vault are expected to match existing that would include lights, ventilation fans, cathodic protection, instrumentation, maintenance receptacles, irrigation controllers, sump pumps and the valve actuators. The large valve actuators are expected to match existing and use 125-volt DC motors. The much smaller bypass valve actuators are expected to match existing and use 480-volt 3-phase AC motor actuators.

See Chapter 3, the Electrical Design Criteria for details.

### Control and Monitoring

The existing CCWD SCADA HMI and the new ETPS and Reservoir PLC software packages will incorporate new analog and discrete I/O that will control and monitor six new ETPS pumps, the new Expanded Transfer Reservoir, the new Expanded Transfer Surge Control System and the new Flow Control Station 3 that controls flow from the existing Los Vaqueros Dam to the existing Bethany Reservoir. The new signals will also include I/O from the new ETPS discharge flow meter, pressure transmitter and new Flow Control Station 3 flow control valves and positions and statuses from the new Transfer-Bethany pipeline isolation valve actuators as described above.

### MCC Building

The architectural style for the new MCC building will be consistent with the functional character and external appearance of the existing electrical building to create a unified appearance at the facility. The building will be a slab-on-grade one-story, 1,867 square foot facility of approximately 26’-8” x 70’-0” x 15’-4” clear height.

Roof and wall insulation will be designed to meet California Energy Efficiency Standards.

The exterior walls will consist of integrally colored, 12-inch-by-8-inch-by-16-inch concrete masonry units. Surface textures will be split face, and smooth face. Concrete masonry units exposed to the exterior shall receive a spray-applied, clear penetrating sealer. All exterior walls will be fully grouted and reinforced as required by the code.

The roof system for the building will consist of a Polyvinylidene Fluoride (Kynar) factory finish standing seam metal roofing system, on rigid insulation, attached to the roof structure. The roof system will meet UL Class A rating and satisfy wind uplift requirements for this area.

Doors will be galvanized, hollow steel, painted with an epoxy/ polyurethane coating. Doors will be sized for removal of equipment and meet the requirements for personnel egress. Doors will be designed so that the maximum operational force is 15-pound force to unlatch, 30-pound force to set the door in motion and 15-pound force to swing the leaf to a full open position.

The ventilation system will be similar to the existing Transfer Pump Station MCC building and will include louvered, doors and two exhaust fans with output ducted to louvered roof dormers. The ventilation system will be sized for sufficient air flow to maintain interior air temperature at no greater than ten degrees above exterior air temperature.

# Delta-Transfer Pipeline

This section provides a summary of the design development of the Delta Transfer Pipeline (DTP). Refer to the design criteria presented in Chapter 3 of this report for additional detail.

The Los Vaqueros Conveyance Facilities Pipelines (Bid Package 2) Old River, Transfer & Los Vaqueros Pipelines Record Drawings (Record Drawings) prepared by Montgomery Watson, May 1998 were used extensively in the DTP design. The DTP will parallel the existing ORP and have similar criteria and appurtenances to that of the existing ORP. Limited field reconnaissance and a review of current aerial photography was conducted to assess current surface facilities and support the design.

## Pipe Materials

The estimated flow for the pipeline is 180 cubic feet per second. It is assumed that maximum pipe velocities will be limited to approximately 6 to 8 feet per second. Using these flow and velocity estimates a pipeline diameter of 66-inches was selected.

Several pipe materials are considered suitable for the anticipated operating pressures, soil conditions and size of the DTP; AWWA C200 steel pipe, and AWWA C300 reinforced concrete pressure pipe, steel cylinder type. Both of these pipeline materials were specified as alternatives for the ORP. AWWA C200 mortar lined and coated steel pipe has been selected for the purposes of this feasibility level investigations. Reinforced concrete cylinder pipe and other lining and coating materials could be considered during detailed design work.

## Pipeline Alignment

Conceptual level drawings (Attachment 3A – Delta Transfer Pipeline Drawings) have been prepared to support the OPCC development. The DTP will be located parallel to the existing ORP from the tie-in at the Old River Pump Station to the vicinity of the Transfer Facility, a distance of approximately 6 ½ miles. The Record Drawings for the ORP were used as a basis for defining the proposed alignment and profile for the OPCC development. The existing ORP is 78 inches in diameter.

The DTP alignment has been located with the intention of keeping the DTP pipeline on one side of the ORP and within the existing permanent easement for the existing ORP. The existing permanent easement is 85 feet wide and the existing ORP is situated off center of the easement (i.e., 50 feet available on one side of the ORP centerline and 35 feet is available on the opposite side). Typically, the side in which there is a 50-foot-wide corridor allows for the most optimal space for construction and later maintenance. The proposed DTP alignment will be placed between 15 to 25 feet offset from the centerline of the ORP and installed within the existing easement along the north side of the ORP which is typically the wider side of available easement. However, there are some relatively short sections where the north side of the alignment falls within the narrow side of the existing permanent easement.

## Pipeline Construction Methods and Special Crossings

Most of the alignment will be installed by open cut construction, however, there are two locations where trenchless construction is necessary. There have been relatively few improvements in the area around the pipe easement since the ORP was constructed so there are

no locations where additional trenchless crossings are needed. Therefore special crossing techniques are assumed to be similar to those techniques used for the ORP. The trenchless crossings under the Byron Highway and Vasco road will both require 78-inch-diameter casings to support the bore and jack method assumed and to allow for subsequent installation of the 66-inch diameter DTP carrier pipe. The Union Pacific Railroad crossing will also need a casing to be installed by trenchless methods per Union Pacific Railroad standards. Although bore and jack method has been assumed for the purpose of developing a cost estimate other trenchless methods, such as microtunneling, may be considered during later design work.

### Pipeline Connections

The DTP runs from east to west beginning at the Old River Facility where there is an intake and a pump station. Currently the Old River Facility pumps raw water from the Old River to the Transfer Facility through the ORP and, as of 2010, flow from the Middle River Facility is brought through the ORP as well. To allow for maximum operational flexibility it is desirable to have the option to pump water from Middle River through either pipeline (existing ORP or proposed DTP) as well as be able to pump water from Old River through either pipeline.

To accomplish this a connection to the Middle River Pipeline is planned which would then connect directly to the new DTP as well as a connection to the ORP. Several valves will be needed to operate this configuration including the introduction of a 78" isolation valve to the existing ORP. By using this configuration there will be flexibility in directing flow from both sources through either pipeline. These pipe connections are shown as yard piping and will be included with the Pumping and Transfer Facilities TM.

At the west end, the DTP connects to the Transfer Facility. This facility is currently used to convey flow to the Los Vaqueros Reservoir and to the Neroly Blending Facility. A proposed expanded Transfer Facility would have the ability to convey water through the proposed Bethany Pipeline (by others) to the Bethany Reservoir. The DTP will require connections to the Expanded Transfer Facility, the Transfer Facility, and to the ORP. These pipe connections are shown in drawings included in Attachment 3B, as are required connections at the Old River Intake and Pumping facility.

### Pipeline Profile and Appurtenances

The existing profile for the ORP as shown on the Record Drawings was used as a basis for the creation of the new profile for the DTP. Similar design criteria were also used for the DTP. It has been assumed that the depth of cover from the surface to the elevation at the top of the DTP will be similar to the existing ORP. Since the profile is assumed to be similar to the existing ORP, appurtenances such as combination air release valve, air release valves, and blowoffs have been placed at locations similar to those that are existing. Manways for access into the pipeline will also be provided. Manways are planned at all blowoff, air release valve, and combination air release valve locations. No additional intermediate manways are planned.

### Cathodic Protection

Assuming steel pipe is to be used for the construction of this pipeline then cathodic protection will be necessary. Although no soil corrositivity reports have been done at this time, we have assumed that the corrosion control and cathodic protection criteria for the original ORP can be used for this new pipeline as well.

Based on the criteria for the ORP, there will need to be test stations approximately every 1,000 feet, at foreign pipeline crossings, and at pipe casings. An impressed current system using deep well anodes will be provided for corrosion protection. These are the assumed requirements at this stage of design development. Further investigations will be needed during the final design phase of this pipeline.

### Additional Easements

To provide sufficient space for construction in a cost effective manner it is recommended that additional temporary construction easements be acquired along the length of the proposed alignment. Locations and lengths of additional TCEs vary along the pipeline due to available space within and outside the easement. Typical trench construction layouts and easement requirements for construction of the pipeline have been prepared and are presented in Attachment 3A-1. The additional TCE requirements are shown on the plan and profile drawings where available, recognizing that there are some areas where it is not feasible to acquire additional easements due to existing development.

Along with the TCE needed for construction, it is suggested that additional permanent easements be acquired for future maintenance along particular lengths of the pipeline. In these areas the pipeline is being constructed in the narrow side of the available easement which leads to limited space on the north side for future maintenance. By acquiring this additional easement, similar trench slopes can be used to excavate and access the pipe in the future if needed. The recommended additional permanent easements are also shown on the typical construction layouts in Attachment 3A-1 and on the plan and profile drawings in Attachment 3A.

### Utilities

Utilities and utility crossings for the DTP have been identified using the Record Drawings for the existing ORP. The DTP will parallel the existing ORP within its right of way, and there have been limited development in the area. Limited field reconnaissance and a review of current aerial photography was also conducted to assess current surface facilities and support the design. Utilities are shown on the design drawings for DTP in Attachment 3A. During the detailed design phase for the preparation of the bid-package, utilities information need to be verified.

Using the previously described assumptions and criteria, a set of plan and profile drawings for the DTP have been created and these are located in Attachment 3A. The drawings have been developed using the Record Drawings from the Los Vaqueros Project, updated aerial images from 2014, and updated topography in the form of LiDAR mapping, from 2008. The aerial image is intended to assist in showing surface improvements above and near the proposed pipeline alignment. The drawings show the proposed pipeline relative to the existing ORP as well as showing where the pipeline would be installed relative to existing structures.

## Transfer-Bethany Pipeline

The Transfer-Bethany Pipeline would connect the Transfer Facility with the California Aqueduct. The Transfer-Bethany Pipeline would have a capacity of 300 cfs, and 84 inches in diameter. It will be approximately 8 miles long (about 41,000 feet). Water would be conveyed through the Transfer-Bethany Pipeline to Bethany Reservoir for delivery to South Bay water

agencies, wildlife refuges, and other south of Delta CVP contractors. The general design criteria for all engineering disciplines presented in Chapter 3 are assumed for the Transfer-Bethany Pipeline further described below.

The Transfer-Bethany Pipeline would start on the eastern side of Vasco Road near the Expanded Transfer Facility with a connection to the Delta-Transfer Pipeline and extend approximately 8 miles southeast to the California Aqueduct. The Transfer-Bethany Pipeline would likely follow valley alignments, crossing low-lying saddles to avoid steep terrain. The alignment would extend southeast generally parallel to Vasco Road for about 3.9 miles to the corner of where Armstrong Road turns south. The pipeline would continue south along Armstrong Road for about 1.3 miles and then traverse southeast overland approximately 1.5 miles to a point close to the California Aqueduct. The pipeline would continue an additional 0.4 mile south and then would terminate with an outfall structure into the California Aqueduct. The Transfer-Bethany Pipeline would tie into the California Aqueduct just north of Bethany Reservoir in the Bethany Recreation Area. Plan and profiles of the Transfer-Bethany Pipeline are shown in in Attachment 3C.

A geotechnical investigation is planned to confirm existing ground conditions along the length of the pipeline sections, and to finalize the design.

## Neroly High Lift Pump Station

The development of planning level concepts for the proposed Neroly PS is described in this section. The work is based upon a review of existing plan drawings, aerial photographs, and the existing system hydraulic model. Hydraulic modeling was performed to estimate system requirements for the Neroly PS. Facility location, sizing, and planning-level design was then performed for the Canal Turnout, Pump Station, and Pipelines. Preliminary power and control requirements were also investigated. An overall site plan of proposed facilities and a profile of proposed suction and discharge pipelines is provided in Attachment 3D. The general design criteria elements for all engineering disciplines presented in Chapter 3 may be assumed for new facilities described below.

### Hydraulic Modeling Summary

The proposed Neroly PS will convey a maximum of 300 cfs from the Contra Costa Canal to the Transfer and Expanded Transfer Pump Station Storage Tanks through the existing Los Vaqueros Pipeline. Hydraulic analyses were completed using the Infowater model of the existing system. The hydraulic model was used to develop a system curve of the Neroly PS assuming a water depth of 6 feet in the canal and a minimum hydraulic grade water surface elevation of 60 feet at the Neroly PS; water depth of 20 feet (design operating water depth, El 220 feet) in the Transfer and Expanded Transfer Storage Tanks, which operate at the same WSEL; and a C-Factor of 125 was used to represent the hydraulic resistance of all piping, which is consistent with the findings of the Existing System Model TM.

Since the system must all be integrated, it was deemed prudent to match the current capacity of the Transfer and Expanded Transfer pumps. The Neroly PS will contain six 50 cfs pumps to match the nominal capacity of pumps at Transfer and Expanded Transfer and to provide the maximum design capacity of 300 cfs determined from water system modeling conducted as part

of this planning level analysis. The current model determined that the pumps would require a duty point of 50 cfs at 235 feet TDH. Several pump manufacturers were contacted to obtain representative pump performance curves. The system curve along with the pump performance curve for WEHR Model 37TKM (4 Stage), which requires a minimum 1,750 hp motor, is presented in Figure 5-14. The preferred operating range of the pump is represented by the shaded region along the pump curve and ranges from approximately 39 cfs to 68 cfs.

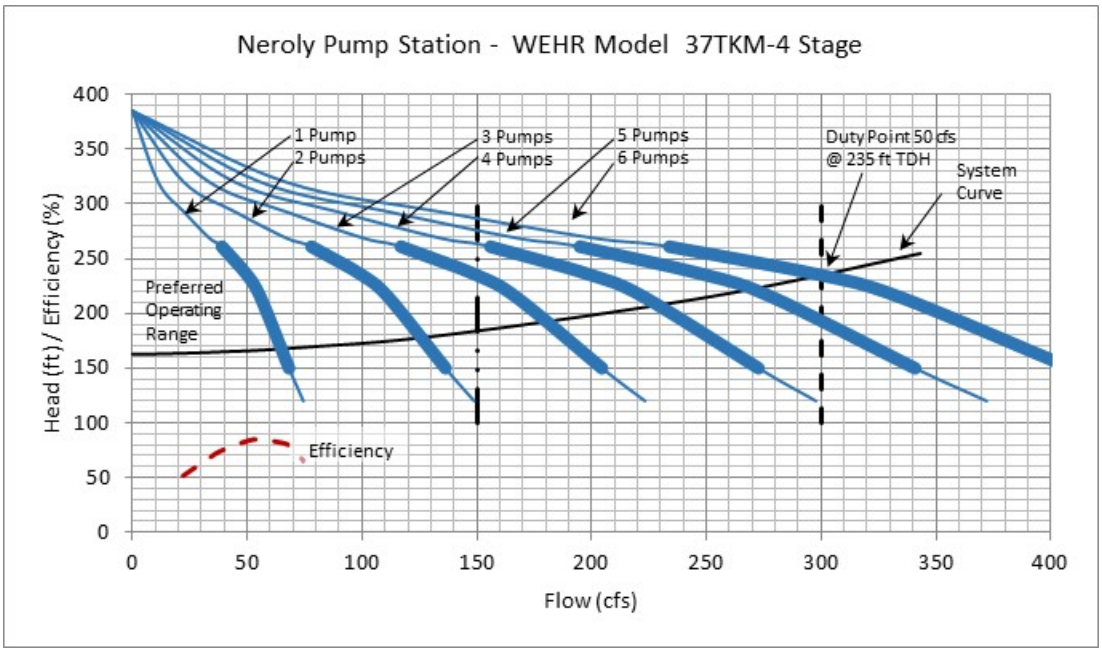



Figure 5-14. Neroly Pump Station System Curve

It is anticipated that two of the pump motors will be provided with VFDs to assist operations in maintaining target water surface elevations at the Transfer and/or Expanded Transfer storage tanks. The hydraulic gradeline and elevation along the Los Vaqueros Pipeline from the Neroly PS to the Transfer Storage Tank are shown in Figure 5-15.

Figure 5-16 compares the calculated steady state operating pressure from the proposed Neroly PS to the pipeline pressure rating identified on the Los Vaqueros Pipeline As-built Drawings. Results show that the calculated operating pressure is less than the pipeline pressure rating, with the maximum operating pressure of 100 psi occurring approximately 3,600 feet downstream of the proposed Neroly PS.

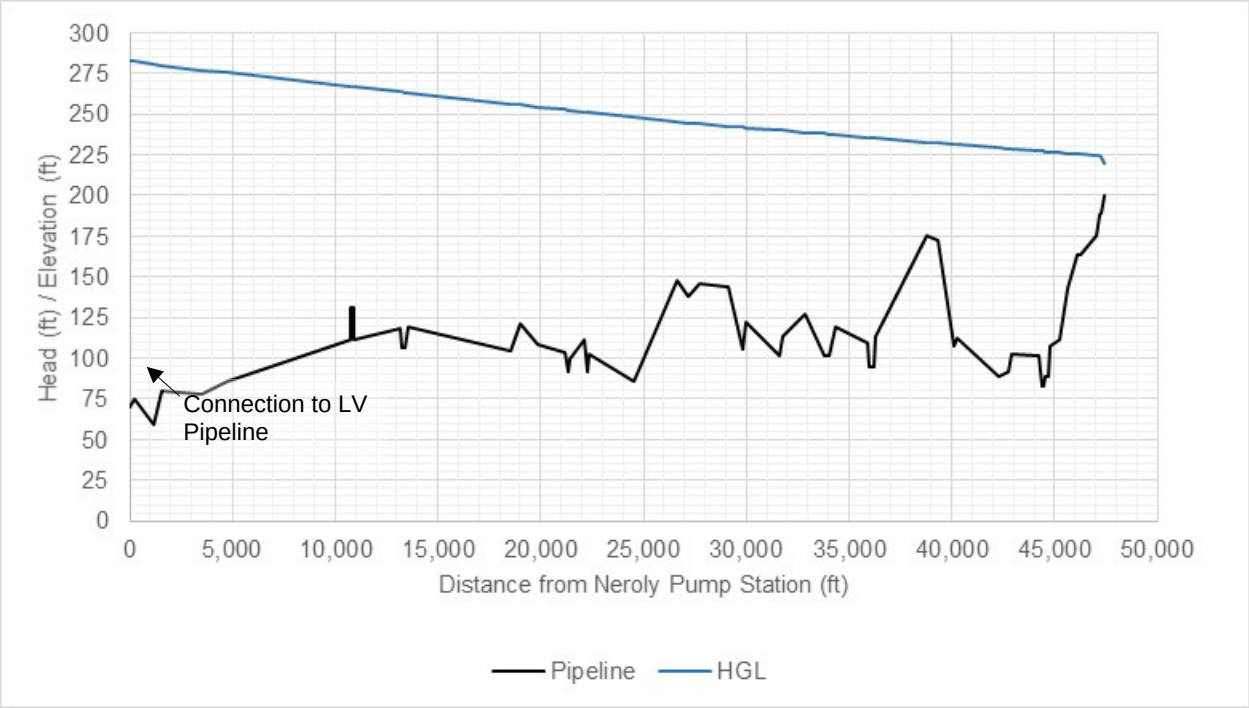



Figure 5-15. Hydraulic Gradeline – Los Vaqueros Pipeline – Neroly Pump Station to Transfer Storage Tank – 300 cfs

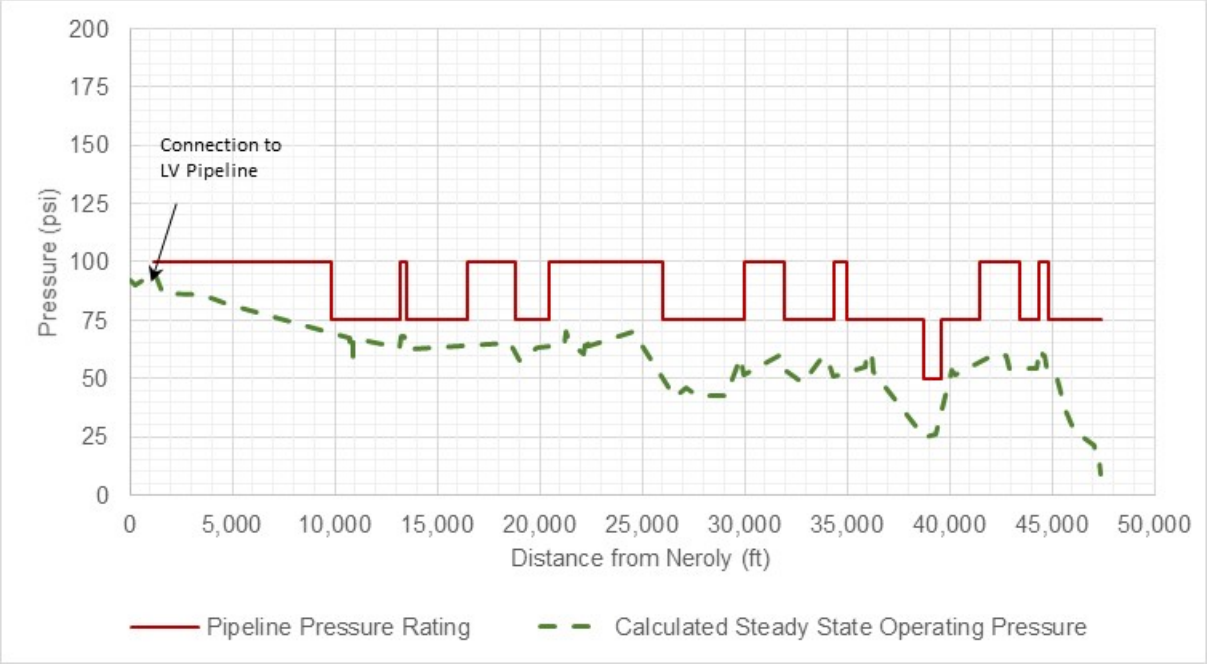



Figure 5-16. Comparison of Calculated Pressure and Pipeline Pressure Rating – Neroly and Los Vaqueros Pipelines – Neroly Pump Station to Transfer Storage Tank – 300 cfs

### *Surge Analysis*

A preliminary surge analysis was performed for the proposed Neroly PS. The model also included use of the existing combination air/vacuum valves along the Los Vaqueros Pipeline to assist in surge control. Surge model results predict that two 3,000-cubic-foot surge tanks are required at the proposed Neroly PS. The tanks would each be 12-feet in diameter and approximately 30-feet long.

The surge head profile along the Los Vaqueros Pipeline following power failure at the Neroly PS is presented in Figure 5-17. The pipeline is represented by the black line; the steady state gradeline (300 cfs) is shown by the gray line; the red line represents the minimum surge head; and the blue line is the maximum surge head. Surge modelling results determined that a surge tank volume of approximately 6,000-cubic-feet located at the Neroly PS along with the existing combination air/vacuum valves mitigate transients along the Los Vaqueros Pipeline resulting from power loss at the Neroly PS. However, due to the relatively large tank size, it was assumed that two 3,000-cubic-foot surge tanks with a 50 percent air/water ratio would be used for planning purposes, These results are considered preliminary and surge modelling for several operational scenarios should be conducted during next steps in design development along with further information on the proposed pump station and pumping equipment. In addition, the existing combination air/vacuum valves would be considered surge critical. Therefore, a redundant combination air/vacuum valve should be provided at each location to ensure successful operation during a surge event if one valve fails or is taken out of service for maintenance.

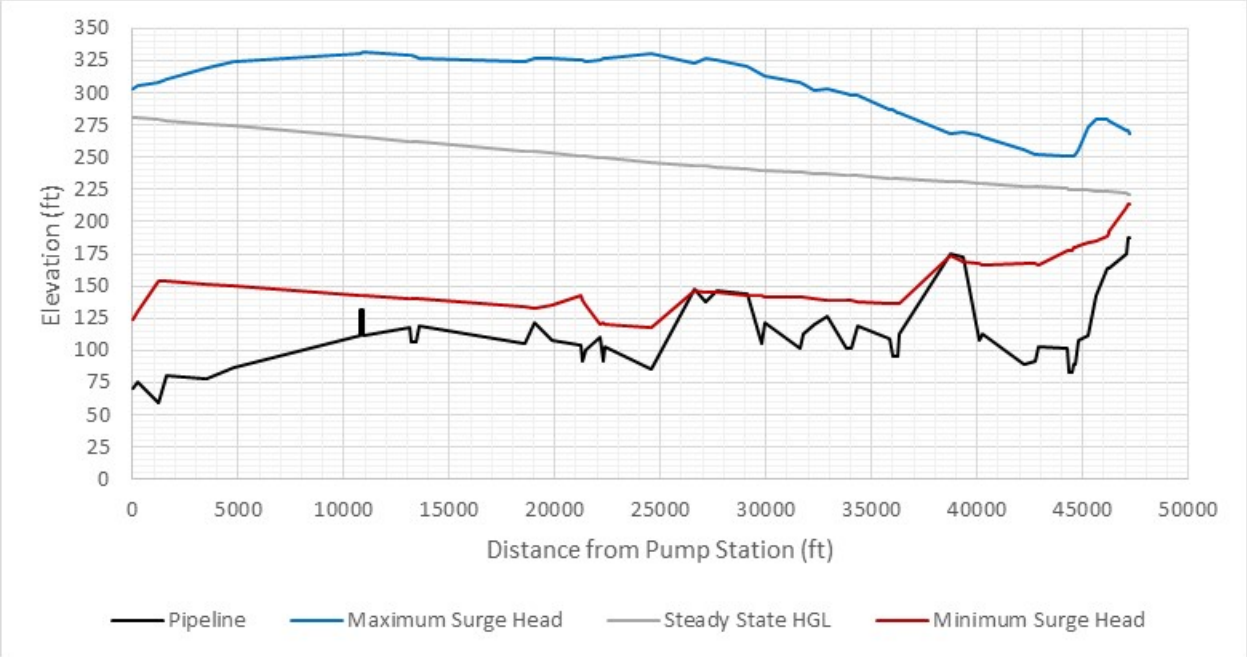



Figure 5-17. Surge Head Profile following Power Failure – Neroly Pump Station

## Canal Turnout

The turnout from the Contra Costa Canal will be located approximately 2,700 feet downstream of Canal Pumping Plant 3. The location was selected by inspecting aerial photography and estimating a convenient point for a pipeline crossing of Laurel Road to optimize pipeline routing to the Neroly PS, which had a fixed location on the Randall Bold Water Treatment Plant site confirmed by CCWD staff. The turnout location could be moved up to approximately 200 feet upstream or downstream without significantly impacting the facility design if future field reconnaissance or detailed property boundary analysis indicated an alternative optimum site.

The turnout will consist of a reinforced concrete structure with bar screens and motor operated slide gates, similar to the existing turnout for the Randall Bold Water Treatment Plant. CCWD reported that canal operating water depth in this reach varied between a minimum of 6.02 feet and a maximum of 9.31 feet. The bar screens will start at the top of the canal lining at approximate EL 81.7 and slope down to the canal base at approximate EL 70.8, matching the existing canal side slope of 1¼: 1. A concrete slab behind screens will slope down to the invert of the twin 78-inch suction pipelines at approximately EL 67.1, where a concrete headwall will be constructed. This elevation will set the crown of the 78-inch pipes at EL 73.6 which will provide approximately 3.2 feet (one-half pipe diameter) of submergence at minimum canal operating depth. The exact elevation of the pipelines will be coordinated with the elevation of the nearby Multipurpose Pipeline Project pipeline in the next phase of design.

Mounted to the approximately 15-foot-tall, 24-foot-long headwall will be twin 78-inch-square slide gates for suction pipeline isolation. A central dividing wall between the gates will include stoplog slots to be used for pipeline isolation during construction and for gate maintenance. The gates will include electric motor operators. Both gates may be closed to fully isolate the Neroly PS or a single gate may be closed during lower flow demands to maintain minimum sediment transport velocities in the suction pipeline.

Construction of a canal turnout would typically require that the canal be taken out of service for a period of time, or constructed during a planned outage. For the current work it is anticipated that the out of service period could be up to 2 months. If this length of down time is not feasible, it will be necessary to fabricate and deploy a temporary coffer dam, or equivalent approach, to allow isolation of the work area while permitting continued canal flow.

## Pump Station

The proposed Neroly PS was located adjacent to Laurel Rd. within the westerly side of the Randall-Bold Treatment Plant site based on direction from CCWD staff. The pumps and discharge piping will be located outdoors within a paved area. An associated MCC building will be located adjacent to the pump station and is described in the Power Requirement section of this TM. Water is diverted from the Contra Costa Canal to the pump station through parallel 78-inch diameter pipelines. Several station configurations were considered. However, due to the depth of the influent pipes (approximately 28 feet) at the pump station site, either a buried wet well or canned vertical turbine pump arrangement are appropriate for the station. The canned vertical turbine pump arrangement was selected for the purposes of this planning level TM and is described in more detail below.

The parallel 78-inch influent pipes manifold into a single 108-inch diameter suction header (centerline EL 68.0) at the pump station site, and 48-inch diameter suction piping from the header is routed to each pump. Finished grade at the station site was estimated at EL 88.0 based upon site topography. The pump suction inlet was estimated at EL 52.0 based upon the Hydraulic Institute recommended distance of 4 times the pump bell diameter below the inlet pipe to provide sufficient submergence. This results in pump can that is approximately 36 feet below grade. The steel pump cans would be 72-inches in diameter.

Each pump would be equipped with a 36-inch-diameter discharge pipe and appurtenances located above grade which would manifold into an 84-inch-diameter below grade header, similar to the layout of the existing Transfer PS. As can be seen in Figure 5-3, one pump at runout produces a maximum of 68 cfs, resulting in a maximum suction and discharge pipe velocities of 5.0 feet per second and 8.9 feet per second, respectively.

The above discussion and inspection of the profile figure in Attachment 3D reveal that locating the Neroly PS at the Randall Bold Water Treatment Plant requires a relatively deep excavation. The deep excavation is due both to the relative high ground level at Randall Bold WTP relative to the canal and Hydraulic Institute submergence requirements for the can-style pump station. While the current proposed location has several advantages including property ownership and ease of access for operation and maintenance, the possibility of locating the pump station adjacent to the Canal could be investigated during the next phase of design. The Canal location could offer advantages relative to depth of excavation, simplify the current suction piping requirements, and allow additional flexibility in routing of the discharge piping across Laurel Road and through the Treatment Plant site.

## Pipelines

Preliminary design concepts were developed for the Neroly PS suction and discharge piping. Potential modifications required for the existing Los Vaqueros Pipeline were also considered. The development of planning level concepts for the pipelines are based on review of existing plan drawings and aerial photographs; no field reconnaissance was conducted to assess current surface facilities, nor has any utility research been conducted.

### *Suction Pipeline*

The estimated flow is 300 cfs. It is assumed that maximum pipe velocities will be limited to less than 5 feet per second. Using these flow and velocity estimates, two 78-inch diameter pipelines have been selected as the pipe size for the purposes of this planning-level analysis.

For purposes of preparing the OPCC, cement mortar lined and coated steel pipe (AWWA C200) has been used for the pipeline material based on the pipe diameter and the material properties. Reinforced concrete cylinder pipe (AWWA C300) could also be considered during design development.

Conceptual level plan and profile drawings (Attachment 3D) have been prepared to support the planning-level design and OPCC development. The suction pipeline is proposed to connect approximately perpendicular to the existing Contra Costa Canal. From there the pipeline extends south and then slightly southeast to cross in an alignment perpendicular to the existing Laurel Road, a six lane roadway with a center dividing strip. The suction pipelines end at the planned

Neroly PS on the north side of the Randall Bold Water Treatment Plant site. The total length of the dual Suction pipeline alignment is approximately 1,000 feet as shown.

### *Discharge Pipeline*

The discharge pipeline extends from the planned Neroly PS to a connection point on the existing 90-inch-diameter Los Vaqueros Pipeline. The estimated flow is 300 cfs. The discharge pipe is planned as a single 84-inch-diameter pipe. At this flow rate the maximum pipe velocity is approximately 7.8 feet per second, which is reasonable and acceptable. The pipeline size could be further optimized during design development.

Cement mortar lined and coated steel pipe (AWWA C200) has been assumed as the material of choice for this pipeline based on the pipe diameter and the material properties. Reinforced concrete cylinder pipe (AWWA C300) could also be considered during design development, since this is the material that was used for much of the existing Los Vaqueros Pipeline.

As shown in the Figures in Attachment 3D, the discharge pipeline is proposed to extend southwesterly from the Neroly PS discharge header, passing through a flow meter (located inside a vault) and crossing perpendicular to the two lane Neroly Rd and the adjacent railroad tracks to a location approximately 200 ft. southwest of the railroad crossing. The alignment then turns west a short distance to a point near the top of the slope at the Lindsey Stormwater Detention Basin. From there the pipeline turns slightly to run southwesterly again and cross down the slope of the basin and run parallel to the slope, crossing under the existing box culvert at Antioch Creek to a connection point with the existing Los Vaqueros Pipeline. The total length of the discharge pipeline is approximately 1,155 feet as shown.

The proposed connection to the Los Vaqueros Pipeline is approximately 2,800 feet upstream of the existing Neroly Blending Facility (shown as Station 27+70 on Figure 5-1). The connection point is located just off the gravel road at the north end of the Lindsey stormwater detention basin on the south side of Laurel Road. The proposed pipe connection is located here so the new discharge pipeline can cross the drainage channel (Antioch Creek) under the existing box culvert to avoid potential environmental impacts to riparian and/or wetland areas further to the south. It should be noted that the Los Vaqueros Pipeline is nearly 30 feet deep at this location. Therefore, substantial shoring will be required to stabilize and protect the toe of the embankment slope during construction of the deep valve vaults and the deep sections of the discharge pipeline.

Two isolation valves placed in separate valve vaults are planned at the connection point as shown in Attachment 3D, as this approach is considered most cost efficient due to the size of the vault that would be required to accommodate the two valves and tee in a single vault. The gravel access road should provide good access to the two valves for operation and maintenance. The top of the vaults would be brought up to a level above the maximum water level in the adjacent distension basin and appropriate grading must be provided so that there is good access to the top of the vaults during all water levels in the basin. During design development the possible use of a single valve vault should be considered further.

### *Suction and Discharge Pipeline Construction Methods*

Most of the pipeline alignments will be installed by open cut construction. However, trenchless construction methods should be used where the alignment crosses railroads or significant

roadways (defined as more than two lanes with a median for this planning level study). Two trenchless construction areas are shown on the drawings. The trenchless crossings will need a casing with a diameter equal to the outside diameter of the carrier pipe plus 18 inches to support the tunneled construction method used. Once the casing is placed, the 78-inch or 84-inch-diameter carrier pipe is installed inside the casing on casing isolation skids. The discharge pipe trenchless crossing will also need to accommodate electrical conduits routed from the pump station to the isolation valve vaults. The specific method or methods of tunneling to be used by the Contractor will depend upon site specific geotechnical soil and groundwater conditions yet to be determined. This should be considered further during design development.

Planned methods of construction by approximate pipeline station are summarized in Table 5-4 below. All stations are in reference to the Figures in Attachment 3D.

Table 5-4. Summary of Pipeline Construction Methods

| Begin Station | End Station | Construction Method | Trenchless Identification | Length (feet) |
|---|---|---|---|---|
| 0+00 | 1+10 | Open Cut | | 110 |
| 1+10 | 2+80 | Trenchless | Laurel Rd. | 170 |
| 2+80 | 10+00 | Open Cut | | 720 |
| 11+00 | 13+60 | Open Cut | | 350 |
| 13+60 | 17+40 | Trenchless | Neroly Road and Railroad Crossing | 400 |
| 17+40 | 22+55 | Open Cut | | 515 |

***Suction and Discharge Pipeline Profile and Appurtenances***

Minimum cover depth criteria for the pipelines have been established as follows:

1) Minimum cover in undeveloped areas is 5 feet
2) Minimum cover depth under roadways is 7 feet
3) Minimum cover for trenchless casing installations is two times the diameter of the casing

Attachment 3D includes a preliminary conceptual profile drawings for the pipelines. We anticipate the following basic profile conditions.

1) Suction Pipelines – The dual suction pipelines will start at the canal at elevation and generally slope down to a low point at the trenchless crossing at Laurel Road. The profile then slopes upward to the connection at the upstream side of the Neroly PS.

2) Discharge Pipeline – The discharge pipeline profile starts at the Neroly PS and slopes down toward the Neroly Road and Railroad crossing, where the pipe would drop vertically down to the trenchless casing elevation. At the far end of the trenchless casing the pipe rises vertically to a shallow depth. From there the pipe slopes up at minimum cover depth to a high point near the edge of the Lindsey basin where it then slopes down the steep slope at minimum cover depth and then slopes more gently downward to the connection at the existing Los Vaqueros Pipeline.

Based on this anticipated profile, the approximate locations of combination air valves, air release valves and blowoff appurtenances are shown in Attachment 3D.

#### *Pipeline Construction Easements*

The suction pipeline alignment on the north side of Laurel Road requires a permanent easement of approximately 85 feet plus additional temporary easement width (approximately 40 feet) for a total construction width of approximately 125 feet for the open trenched sections of the alignment. Easement width requirements should be confirmed during design development.

Once the discharge pipeline alignment leaves the Contra Costa Water District property at the Neroly Road crossing, the pipeline requires a permanent easement of approximately 85 feet plus additional temporary easement width (approximately 40 feet in width) for a total construction width of approximately 125 feet for the open trenched sections of the alignment. These easement widths are consistent with the easements used for the 90-inch-diameter Los Vaqueros Pipeline.

The proposed locations of permanent and temporary easements are shown in Attachment 3D. Costs for easements have not been included in the OPCC at this time.

#### *Los Vaqueros Pipeline Modifications*

A preliminary analysis has been performed to determine whether the existing Los Vaqueros Pipeline is capable of handling the pressure required by the new pumped operating condition from the Neroly PS, and if not, to determine what modifications may be required to which portions of the pipeline. During scoping, a very preliminary analysis showed that there may be up to approximately a half-mile length of the Los Vaqueros pipeline that could be over pressurized. However, a refined hydraulic analysis, as shown on Figure 5-16, indicates that the entire Los Vaqueros Pipeline should be capable of handling the discharge pressure from the proposed Neroly PS. The figure shows the design pressure in the Los Vaqueros pipeline when pumping from the Neroly PS at the 300 cfs design flow rate (the dashed green line) and the design pressure rating of the existing pipe based on the as-built pressure class of the pipe (solid red line). It shows that the rated pressure of the entire Los Vaqueros Pipeline is above the design pumping pressure condition. Therefore, this planning level analysis indicates there is no need to parallel or replace any of the Los Vaqueros Pipeline. This should be further confirmed during design development through a review of actual Los Vaqueros pipe shop drawings and comparison to final design pressure requirements.

Two new valve vaults are required at the connection to the Los Vaqueros Pipeline. These vaults should provide space for isolation valves on both the 84-inch discharge pipeline and the 90-inch Los Vaqueros Pipeline. The new valve cut in to the Los Vaqueros Pipeline will require a short term shutdown of the pipeline operation to complete the work. When the Neroly PS is operating, the isolation valve on the Los Vaqueros pipeline should be closed to send pressurized flow to the south and shut off flow toward the Neroly Blending Facility.

### Power Requirements

The power requirements for the Neroly PS will be proportional to the running pump load of a maximum of six 2,000-hp pumps. We would propose a similar outdoor substation to that used in the existing Old River Pump Station layout with the same nominal 15 MVA transformer size

with a 69 kV feed. The fenced area required for the substation would be approximately 80 feet by 110 feet.

The power source for the Neroly PS substation is assumed to be an extension from the existing Western Area Power Authority overhead 69 kV transmission feed that runs along the Contra Costa Canal and feeds the Randal Bold Water Treatment Plant for the normal power source for the MCC "MVMC" Multipurpose Pipeline Project pump station via its 69 kV/4.16 kV substation. The feed is assumed to be routed underground to the existing Multipurpose Pipeline Project substation and then routed overhead to the Neroly PS substation as indicated in Attachment 3D. No cost for Western Area Power Authority upgrades that could be required ahead of the plant has been included in the OPCC.

The smaller auxiliary support items near the new the pump station would be powered from the pump station auxiliary 480V transformer in the electrical building. These would include the turnout gates and a flow meter. It is currently assumed that 480V power would also be routed to the two remote pipeline isolation valves using oversized conductor wire for the long, 1,200-foot run.

The same 2-VFD synchronous transfer control MCC would be applied to this Neroly PS that was applied to the Expanded Transfer PS providing a highly desired low starting current associated with VFD operation. It is assumed that the same model (Powerflex 7000 air cooled B frame for general control with direct to drive active front end rectifier and common mode choke) Rockwell Automation VFD proposed for the Expanded Transfer PS would be used. This higher horsepower VFD has the same footprint size as the lower horsepower unit proposed for the Expanded Transfer MCC building.

The MCC building footprint size for the electrical equipment will be similar to that previously indicated (Pumping and Controls TM) for the Expanded Transfer Pump Station at about 30 feet by 73 feet. The other interior electrical equipment footprint is expected to be the same as well. The building will be slab on grade construction with concrete masonry unit walls and standing seam metal roofing. Because the Expanded Transfer PS was using the existing Transfer PS's control room, testing room and storage an additional 10 feet in building length may be required to accommodate these requirements at the Neroly PS location. Note that the dimensions may grow with a different equipment manufacturer or supplier. Also, motor speed has not been taken into consideration to date, and a lower speed motor may require a larger size VFD from a given manufacturer/supplier.

## Control and Monitoring

The existing CCWD SCADA HMI and the new Neroly PS PLC software packages will incorporate new analog and discrete I/O that will control and monitor six new Neroly PS pumps, the new Neroly PS Surge Control System and the new Contra Costa Canal turnout gates. The new signals will also include I/O from the new Neroly PS discharge ultrasonic flow meter, pressure transmitter and positions and statuses from the new Los Vaqueros and Neroly PS pipeline isolation valve actuators. Incorporation of status of the Transfer and proposed Expanded Transfer PS flow rates along with their respective Reservoir Tank water surface elevations will also be required.

# Existing Old River Intake and Pump Station

The existing Old River Pump Station can produce a nominal maximum 250 cfs flow rate via the Old River Pipeline using five 50 cfs capacity vertical turbine pumps with constant speed motors. No modifications to this facility are proposed under the considered Investigation alternatives.

New facilities will be required at the Old River Pump Station site to integrate the new Delta-Transfer Pipeline (refer to Drawings C-1 and C-2 in Attachment 3B). A 78-inch-diameter butterfly valve and two 66-inch-diameter butterfly valves, along with a short segment of 66-inch-diameter pipe will be required to allow both the Old River and Middle River Pump Stations to discharge either to the Old River Pipeline or to the Delta-Transfer Pipeline. The 78-inch valve and a 78 x 66 x 78-inch tee will be cut into the existing Old River Pipeline. The 66-inch pipe routed from the tee will include a 66-inch butterfly valve and will connect to the Delta-Transfer Pipeline. In addition a 72 x 66 x72-inch tee will be cut into the existing Middle River Pipeline and will include a 66-inch butterfly valve. The 66-inch pipeline routed from this tee will include a butterfly valve and will be the start of the Delta-Transfer Pipeline.

A flow meter and a downstream isolation valve station for the Delta-Transfer Pipeline will also be located at the Old River Pump Station site (refer to Drawings C-1 and C-2 in Attachment 3B). The meter and the valve station will be located in separate buried concrete vaults near similar existing vaults for the Old River Pipeline.

The isolation valve station will include a mainline motorized ball valve as well as a bypass line with modulating ball valve to be used during pipeline filling. The two valves are currently assumed to be 54 and 18 inches in diameter, respectively. Valve sizing will be confirmed in the next phase of design.

### Power Requirements

The power source for the new equipment and new vaults that house them will be from the existing Old River Pump Station. All electric power to the existing vaults is provided by an existing 150 kVA 480 volt 3-phase transformer. The 150 kVA transformer powers power panel board PP-A. PP-A distributes power to the equipment in and around the vaults. To accommodate four new vaults and their associated equipment a larger transformer will replace the 150 kVA transformer with a new matching larger panel board that will back feed the existing 225 amp power panel board PP-A as well as feed all the new valve vault equipment and associated loads.

The loads in a typical vault are expected to match existing similar vaults that would include lights, ventilation fans, cathodic protection, battery chargers, instrumentation, maintenance receptacles, irrigation controllers, sump pumps and the valve actuators. The large valve actuators are expected to match existing and use 125-volt DC motors with a large battery and a trickle charger. The much smaller bypass valve actuators are expected to match existing and use 480-volt 3-phase AC motor actuators. The 120-volt loads will be supplied by a local outdoor mini-power center (combined encapsulated transformer and distribution load center) to match existing vault facilities.

Refer to Los Vaqueros Expansion Project Design Criteria Technical Memorandum (MWH 2016) for details.

### Control and Monitoring

The existing CCWD SCADA HMI and Old River PLC software packages will need to be modified to incorporate new analog and discrete I/Os from the new Delta-Transfer Pipeline flow meter, pressure transmitter and positions and statuses from the new Delta-Transfer and Old River pipeline isolation valve actuators described above. Incorporation of status of the new ETPS and Reservoir (described later in this TM) flow rate and WSEL will also be required.

## Existing Middle River Intake and Pump Station

The existing Middle River Pump Station can produce a nominal maximum 250 cfs flow rate via five 50 cfs capacity vertical turbine pumps. Three of the pumps have constant speed motors while the other two have variable frequency drives. No modifications to this facility are proposed under the considered Investigation alternatives.

### Control and Monitoring

The existing CCWD SCADA HMI and Middle River PLC software packages will need to be modified to incorporate new analog and discrete I/O from the new Delta-Transfer Pipeline flow meter, pressure transmitter and positions and statuses from the new Delta-Transfer and Old River pipeline isolation valve actuators described above. Incorporation of status of the new ETPS and Reservoir (described later in this TM) flow rate and WSEL will also be required.

## Pumping Plant #1 Replacement

Replacement of Pumping Plant #1 on the Contra Costa Canal would be needed to match the designed and permitted Rock Slough Intake diversion capacity of 350 cfs. The separately-approved Contra Costa Canal Replacement Project, which is replacing the open channel portion of the Contra Costa Canal with a buried pipe, will lower the operating water surface levels at Pumping Plant #1 due to the friction losses added by the pipeline. Pumping would be limited to approximately 200 cfs using the existing Pumping Plant #1 pumps after the completion of the Canal Replacement Project, which is assumed for the 160 TAF No Project/No Action Alternative. Larger horsepower pumps set at a lower elevation (than existing) at Pumping Plant #1 would be needed to move the same amount of water (350 cfs) as previously has been moved through this system.

A larger new building and upgraded electrical facilities are also included in the proposed upgrade of Pumping Plant #1 and would be built in the vicinity of the existing Pumping Plant #1 structure in the existing Contra Costa Canal right-of-way owned by Reclamation. (See Figure 6-1.) The proposed Pumping Plant #1 upgrade would involve demolition of the existing Pumping Plant #1 building and construction of a new building to house the upgraded pumps and appurtenances. The building would be constructed of concrete and would be similar in height to the existing Pumping Plant #1, approximately 35 feet tall. The square footage of the building would increase to approximately 4,000 square feet. The new pump station would have a total of six new pumps, three pumps in each of two parallel wet wells. A dedicated force main would carry flow from each pump. The below-grade valves would be housed within a valve box. The pump motors

would be centered above the pumps and mounted on a floor slab with bottom elevation at approximately +16 feet.

New power lines and substations would be required for the new Pumping Plant #1. Currently, incoming power is stepped down to 2300 volt, three phase, 60 hertz at a single existing Western Area Power Administration transformer with a capacity at 1500 kVA. The new pump station would require a maximum of 2,100 horse power and would require two new 2000-kVA transformers.

To construct the new Pumping Plant #1, the encased portion of the Contra Costa Canal would be isolated and dewatered. Sheet piling is already installed around much of the forebay of Pumping Plant #1, and additional sheet piling would be installed to isolate the construction site from the Contra Costa Canal. The site would be excavated to construct the foundation for the building and the wet wells, and to tie into the encased portion of the Contra Costa Canal. The existing pipeline is buried approximately 15 feet below the grade line and excavation may need to occur down to 25 feet below the grade line. During the construction of the foundation, wet wells, and pipeline tie-in, groundwater dewatering would be required to keep the site dry.

Figure 6-1. Location of the proposed Replacement for the Pumping Plant # 1

# Chapter 6
# Associated Local Projects

This chapter describes local projects associated with the expansion of Los Vaqueros Reservoir. These local facilities provide additional benefits and services to CCWD and other Investigation local partners. These local facilities were developed separately from the Feasibility Study, but are linked to the operations of the project.

Table 6-1. Summary of Associated Local Projects

| Associated Local Projects | Associated Local Projects | Associated Local Projects | Associated Local Projects |
|---|---|---|---|
| Brentwood Pipeline | None | Included | Included |
| EBMUD-CCWD Intertie Pump Station | None | 155 cfs | 155 cfs |
| EBMUD Walnut Creek Pumping Plant Variable Frequency Drives | None | Included | Included |
| ECCID Intertie | None | 80 cfs | 80 cfs |
| EBMUD Mokelumne Aqueduct Relining | None | Included | Included |

Key:
CCWD = Contra Costa Water District
cfs = cubic-feet per second
EBMUD = East Bay Municipal Utility District
ECCID = Eastern Contra Costa Irrigation District

## Brentwood Pipeline

A new pipeline to move blended water from CCWD's Neroly Blending Facility to the City of Brentwood Water Treatment Plant would be constructed in all the action alternatives. Water from the Los Vaqueros Pipeline is blended with water in the Contra Costa Canal from the Rock Slough Intake at the Neroly Blending Facility. The up-to 48-inch diameter pipeline would be sized for flows up to 46.5 cfs (30 million gallons per day). The new pipeline would divert water from the Contra Costa Canal downstream of Flow Control Station #2 of the Los Vaqueros Pipeline to provide blended water from the Los Vaqueros Pipeline and the Contra Costa Canal. The pipeline would extend approximately 4,500 feet to the east, parallel to the south side of the Contra Costa Canal, and connect to the existing City of Brentwood Water Treatment Plant Inlet Pipeline, as shown in Figure 6-2. The new pipeline would cross beneath the Highway 4 overpass, be constructed using standard open-trench construction techniques, and would cross the Union Pacific railroad tracks likely using trenchless techniques, such as jack and bore or microtunnel. Construction could result in limited temporary impacts to the East Bay Regional Park District trail, which is located on the north side of the Contra Costa Canal. Segments of the pipeline may be constructed within existing roadways, which would require traffic control and short-duration

closures. An easement or license from Union Pacific Railroad would be required, along with encroachment permits from the City of Brentwood and City of Oakley and licenses from Reclamation for segments of the pipeline within the Reclamation right-of-way along the Contra Costa Canal.

## EBMUD-CCWD Intertie Pump Station

A new high-lift pump station would be constructed at the EBMUD-CCWD to provide the 300 feet of head needed to lift water from Los Vaqueros Pipeline to EBMUD's Mokelumne Aqueduct #2, allowing water to be delivered at sufficient pressure and rates for EBMUD's use. The pump station would be approximately 9,675 square feet in size; note that this does not include any land that would be needed for an electrical substation or other similar facility, if needed. It would consist of four 2,000 hp pumps (three running to provide 85 million gallons per day plus one standby pump). This pumping plant could cause very high surge pressures on the Los Vaqueros Pipeline, so significant surge controls would be needed. EBMUD would need to purchase land for the pump station.

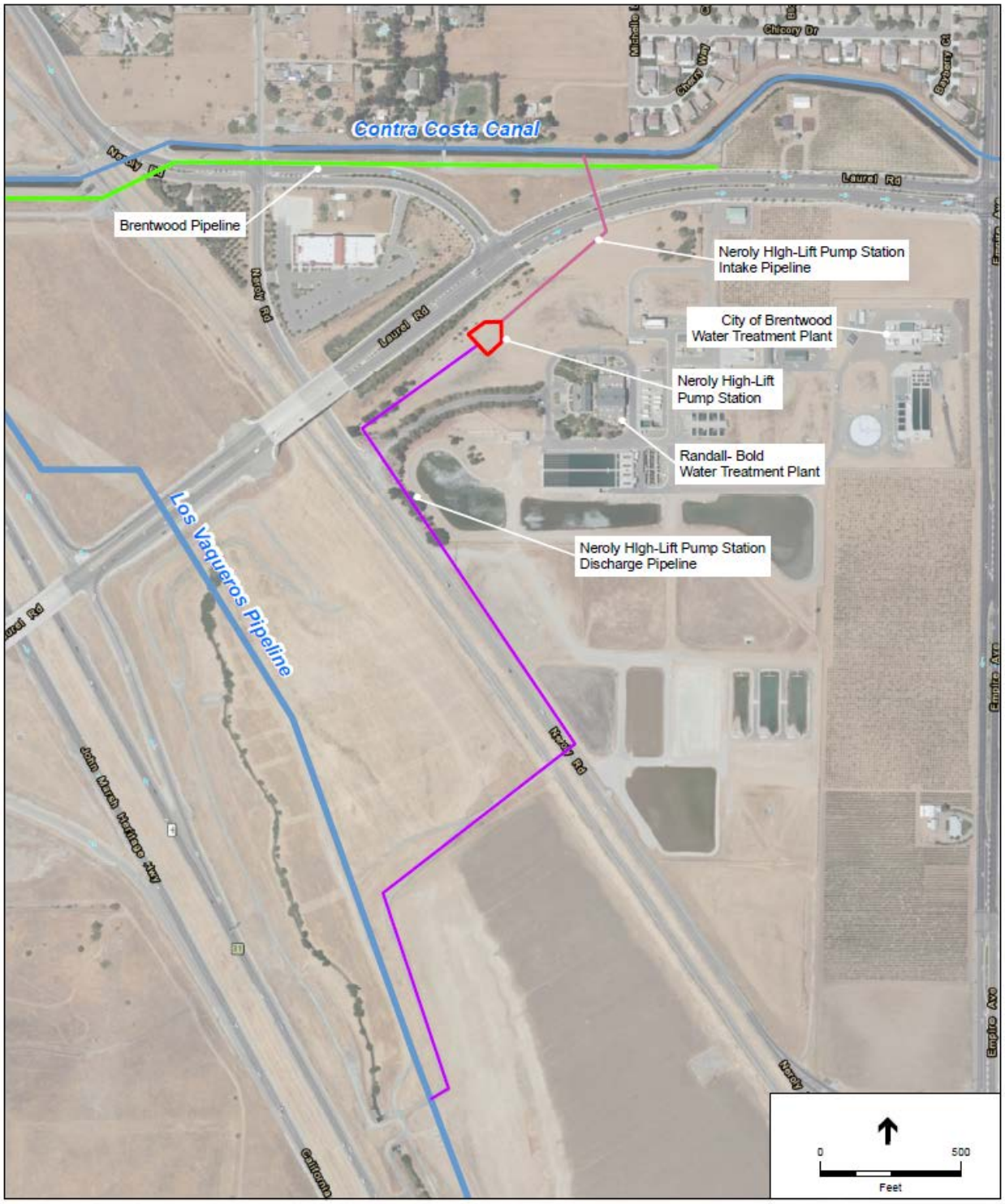



Figure 6-2. Proposed Brentwood Pipeline

## EBMUD Walnut Creek Pumping Plant Variable Frequency Drives

The installation of variable frequency drives at EBMUD's Walnut Creek Pumping Plant has been added to all of the proposed action alternatives to facilitate deliveries through the EBMUD-CCWD Intertie from EBMUD's Mokelumne Aqueduct #2 to the Los Vaqueros Pipeline. Currently, EBMUD meets its customer demand by managing flow rates on the three separate Mokelumne Aqueducts using a combination of pumping and gravity flows. The ability to throttle pumping on these aqueducts is limited. When flow is being conveyed through the EBMUD-CCWD Intertie from Mokelumne Aqueduct #2 to or from Los Vaqueros Pipeline, it is very challenging operationally to balance the flows entering EBMUD's Walnut Creek Pumping Plant with the demands on the other side. Variable frequency drives on all three aqueducts to would allow adjustments of supply to meet EBMUD service area demand while managing deliveries to the Los Vaqueros system.

The installation of variable frequency drives at EBMUD's Walnut Creek Pumping Plant would require the construction of two new buildings to house the variable frequency drives. A new structure approximately 200' by 25' and 20' tall would be located adjacent to the building housing Walnut Creek Raw Water Pumping Plants 1 and 2 (see Figure 6-3). A second structure, 180' by 25' and 15' tall, would be located next to Pumping Plant #3. Both of these structures would be located on EBMUD property.

## ECCID Intertie Pipeline

A new intertie pipeline of up to 80-cfs capacity between the existing Transfer Facility and East Contra Costa Irrigation District's existing Bixler Intake (ECCID Intertie) would be constructed to deliver water from CCWD facilities to ECCID. The proposed alignment of the approximately 7-mile-long ECCID intertie pipeline would run north along Walnut Boulevard in Brentwood and east parallel to ECCID's main distribution canal, as shown in Figure 6-4. Encroachment permits from the City of Brentwood would be required for the portion of the intertie pipeline constructed along Walnut Boulevard. ECCID maintains a cleared dirt right-of-way approximately 100 feet wide on the north side of the canal and an asphalt road of the canal road on their 100-foot wide right-of-way on the south side of the canal. Construction of the east-west portion of the proposed ECCID intertie pipeline would occur entirely within the existing right-of-way along the canal. The new pipeline would be constructed using standard open-trench construction techniques. Construction within existing roadways would require traffic control and short-duration closures.

Figure 6-3. Location of Proposed EBMUD Walnut Creek Pumping Plant Variable Frequency Drives

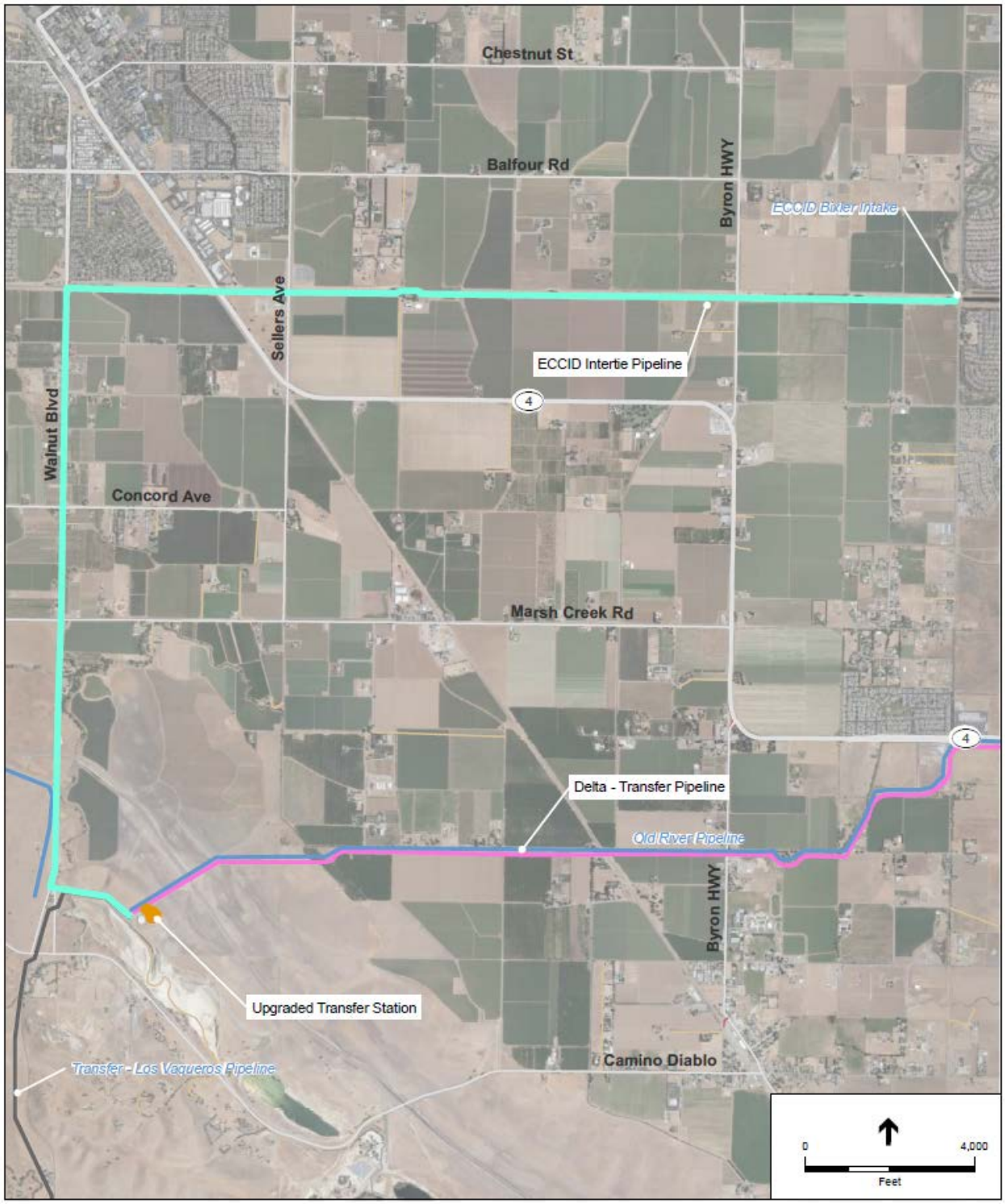



Figure 6-4. Proposed Alignment of the ECCID Intertie Pipeline

## EBMUD Mokelumne Aqueduct Relining

Project operations to ensure water supply reliability would require the use of EBMUD's Mokelumne Aqueduct No. 2 to convey water to Los Vaqueros. However, this aqueduct is in need of extensive maintenance. The planned Mokelumne Aqueduct Relining Project would contribute to the overall reliability of the Investigation by ensuring there is hydraulic capacity to convey water to the Los Vaqueros Reservoir and by reducing the risk of aqueduct failure. The maintenance project will preserve the integrity of the pipe and restore its hydraulic capacity.

Aqueduct No. 2 is a 67-inch steel pipeline that was installed in 1949. Cement mortar lining on the interior of the pipe helps to protect it from corrosion. Inspections have shown extensive damage to this lining in all of Aqueduct No. 2. This damaged lining needs to be replaced to protect the steel pipeline from internal corrosion. Over the course of the project, the existing cement mortar lining will have to be removed before a new lining can be applied. The project will also require the installation of manholes and concrete vaults to facilitate the access of personnel and construction equipment.

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# Chapter 7
# Project Schedule and Cost Estimates

This chapter provides a summary description of the preliminary project schedule and potential work packages for the Investigation. It also describes the methods and general approach used in developing cost estimates for Investigation project facilities. Attachment 4A contains preliminary schedules for each of the potential work packages as well as an overall project schedule. Attachment 4B contains construction cost estimate worksheets for the seven potential work packages as well as operation and maintenance and pumping cost worksheets. Designs and cost estimates of project features have been developed primarily to a feasibility-level and will be suitable for congressional authorization and appropriation when the appraisal-level Neroly Pump Station, Pumping Plant #1 Modifications, and Marina Relocation and Trails Improvements projects are further developed.

## Project Schedule

The preliminary schedules for the work to be performed and the sequencing necessary to build the identified new facilities and modify existing facilities for the major components of the project alternatives have been included in this document (refer to Attachment 4B). The included major components are:

- Transfer-Bethany Pipeline
- Expanded Transfer Facility
- Transfer Pump Station Modifications
- Neroly Pump Station
- Pumping Plant #1 Replacement
- Los Vaqueros Reservoir Modifications – 275 TAF Dam Raise
- Los Vaqueros Marina Complex Relocation
- Los Vaqueros Watershed Trails
- Delta-Transfer Pipeline

Activities in the preliminary construction schedules were assigned durations that allow the work to be performed in accordance with activity requirements. Construction activities occur based on a normal five-day work week with major holidays and winter weather days as non-work days.

Construction activities will be phased, when feasible, to avoid environmental impacts and/or effects on existing water operations.

The schedules include only facility design, construction, and project-specific permits. It is anticipated that the environmental review for the Investigation will be completed by January 2019 and that final design and construction would begin in February 2019. It is also assumed that project-specific environmental work, including permitting, would be further refined during the respective design periods.

The preliminary construction schedules are based on a logical sequencing of work activities and interdependencies between features, as applicable. The preliminary construction schedule for each feature has been determined based on timing of work, location, and type of construction.

The preliminary construction schedules provide only one scenario of many possible scenarios to complete the work. Duration and project sequencing may and probably will vary as assumption and constraints evolve and become better defined during the final design and permitting process. The schedules represent the technical work constraints and do not try to anticipate budget, resource availability, all environmental constraints/windows, and other stakeholder preferences, which could impact the schedule. The schedules provide only a starting point and not the final baseline for discussions regarding regional resources, budget restrictions, stakeholder preferences, and contract coordination. As project design and permitting progress, a higher level of confidence regarding relevant assumptions and constraints will ensue and the schedule will become better defined.

## Work Packages and Schedule Summary

The major components of the Investigation may be divided into individual "work packages" representing discrete projects that could be constructed and/or contracted independently. Summaries are included below for a possible work breakdown that includes seven work packages for distributing construction of the major facilities included in Alternatives 1A, 1B, 2A, and 4A. The approximate construction cost dollar values of the packages are provided. Please refer to the cost estimating section of this TM for additional cost detail.

This work package distribution reflects only one approach and it is understood that alternative approaches will be developed and evaluated during the final design phase. A full analysis identifying strengths and weaknesses regarding packaging the work into particular construction contracts will be undertaken at that time.

### Work Package 1: Transfer-Bethany Pipeline

Work Package 1 would include the construction of the Transfer-Bethany Pipeline. The work would include an approximately 42,000 foot long pipeline and an outlet structure at the California Aqueduct. The pipeline will be needed to facilitate draining of the Los Vaqueros Reservoir for the proposed Dam raise. The dollar value of this work package is approximately $144 million (October 2015 basis).

### Work Package 2: Expanded Transfer Pump Station and Transfer Pump Station Modifications

This work package would include construction of both the Expanded Transfer Pump Station, which will direct water to Bethany Reservoir, and the Transfer Pump Station Modifications, which will direct water to the enlarged Los Vaqueros Reservoir. The Expanded Transfer Pump Station's ability to direct water to Bethany Reservoir will be needed to provide water system reliability during Los Vaqueros Reservoir modifications.

The Expanded Transfer Pump Station work will include a 6-pump, 300 cfs capacity pump station as well as a 5 million gallon capacity steel reservoir. The project will also include significant site earthwork, surge tanks, reservoir overflow pipeline, and tie-ins to the Delta Transfer Pipeline, Transfer-Bethany Pipeline, and existing Transfer Facility. The work would also include construction of a new power substation and approximately 5 miles of high voltage power lines routed to the site. The dollar value of this portion of the work package would be approximately $36 million (October 2015 basis).

The modifications to the existing Transfer Pump Station would include four replacement higher-head pumps and electrical system upgrades. The dollar value of this portion of the work package would be approximately $11 million (October 2015 basis).

### Work Package 3: Neroly Pump Station

This work package would include construction of the six-pump, 300 cfs capacity Neroly Pump Station and associated CCWD main canal intake and suction and discharge pipelines, which will direct water to both the modified Transfer Pump Station and Expanded Transfer Pump Station. From these two pump stations, water may be directed to Los Vaqueros Reservoir or Bethany Reservoir, respectively. The Neroly Pump Station's ability to both use an alternate intake water source and direct water to Bethany Reservoir will be needed to provide water system reliability during Los Vaqueros Reservoir modifications. The dollar value of this work package is approximately $37 million (October 2015 basis).

### Work Package 4: Pumping Plant #1 Replacement

Replacement of Pumping Plant #1 on the Contra Costa Canal would be needed to maintain the designed and permitted Rock Slough Intake diversion capacity of 350 cfs. The separately-approved Contra Costa Canal Replacement Project, which is replacing the open channel portion of the Contra Costa Canal with a buried pipe, will lower the operating water surface levels at Pumping Plant #1 due to the friction losses added by the pipeline. Pumping would be limited to approximately 200 cfs using the existing Pumping Plant #1 pumps after the completion of the Canal Replacement Project. Larger horsepower pumps set at a lower elevation (than existing) at Pumping Plant #1 would be needed to move the same amount of water (350 cfs) as previously has been moved through this system. Completion of the Replacement project will be required to maintain water system reliability during Los Vaqueros Reservoir modifications. The dollar value of this work package is approximately $20 million (October 2015 basis).

### Work Package 5: Los Vaqueros Reservoir Modifications

The Los Vaqueros Reservoir modifications required to increase the capacity enlargement to 275 TAF are best suited to a single work package procurement to maximize execution efficiencies. The work package would include the construction of the enlarged dam, roller compacted

concrete embankment, spillway, inlet and outlet works. Site preparation, ancillary roadway construction, and final grading and landscaping would also be included in the package. Coordination of the timing of the Los Vaqueros Reservoir drawdown and other associated operational impacts on the water storage and conveyance system have been considered and will be evaluated in more detail and a refined schedule relative to the other work packages will be developed in the next phase of project development. The dollar value of this work package is approximately $267 million (October 2015 basis).

### Work Package 6: Expanded Recreation Facilities

The existing Marina Complex, including the facilities at the south cove and the end of Los Vaqueros Road, would be inundated to make way for an expanded 275 TAF reservoir. A new Marina Complex would replace the existing Marina Complex upslope of the existing facilities at the southern end of Los Vaqueros Reservoir. The new Marina Complex would have a footprint of about 22 acres. A new 0.5-mile ADA accessible interpretive trail would be built surrounding the Mortero Wetland Complex, which is located adjacent to the Walnut Staging Area at the northern end of the Los Vaqueros Watershed. The dollar value of this work package is approximately $237 million (+/- 30 percent, October 2015 basis).

### Work Package 7: Delta-Transfer Pipeline

Work Package 7 would include construction of the approximately 37,400 foot long Delta-Transfer Pipeline. The pipeline work is primarily open cut but would include at least three bore and jack crossings. The work would also include tie-in facilities at both the Old River and Transfer Facilities. The tie-in construction would include isolation valve vaults and a metering valve vault. The dollar value of this work package is approximately $17.5 million (October 2015 basis).

It is anticipated that all work packages will be executed in approximately the numerical order indicated and all completed within a seven year period. The attached schedule bar charts (see Attachment 4A) provide one version of the schedules. Schedule analyses to determine best-, likely-, and worst-case scenarios will be performed during the final design phase of the project. The approximate feasibility level design and construction schedule durations for the individual work packages in our judgment based on current analysis are presented in Table 7-1.

Table 7-1. Summary of Work Package Durations

| Work Package | Approximate Duration[1] |
|---|---|
| WP1 – Transfer-Bethany Pipeline | 4 years and 8 months |
| WP2 – Expanded Transfer Pump Station and Transfer Pump Station Modifications | 4 years and 4 months |
| WP3 – Neroly Pump Station | 4 years and 11 months |
| WP4 – Pumping Plant #1 Replacement | 4 years and 1 month |
| WP5 – Los Vaqueros Reservoir Modifications | 4 years and 7 months |
| WP6 – Expanded Recreation Facilities | 3 years and 6 months |
| WP7 – Delta-Transfer Pipeline | 4 years and 1 month |

Note:
[1] Includes permitting, final design, procurement, construction, startup and testing, and project closeout

At this stage in design, the durations can be expected to vary by +/- 30-percent to the final durations. The schedules assume initial and sustained integration of technical, environmental,

and cultural efforts during the pre-construction phase, and assume no schedule constraints related to these issues would be encountered. The schedules do not consider commercial concerns not yet identified in the planning process. Schedule and risk reduction will be continually addressed as the designs are fully developed.

For the dam raise, construction schedule assumes that the reservoir is at Elevation 350 feet at the start of the construction season. A great deal depends on the time required to excavate to the upstream foundation. Twenty weeks is assumed on the schedule, but this would require two large drag-lines (with associated support trucks and equipment) to achieve. Unforeseen site conditions could increase the excavation schedule and the overall schedule for the embankment construction in subsequent years.

## Reclamation Cost Estimate Methods

The following sections define Reclamation cost estimate levels and allowances for Investigation alternatives.

### Cost Estimate Levels

Different levels of cost estimates are required to plan and fund projects. As a project moves through its development, each subsequent estimate level reflects increasing detail and refinement of project features. Reclamation recognizes six different levels of construction cost estimates, as follows (Reclamation 2007a):

- Preliminary
- Appraisal
- Feasibility
- Percent (%) Design (post-authorization)
- Prevalidation of Funds (Prevalidation)
- Independent Government Cost Estimate

Cost estimates are typically developed in the chronological order shown, and each supersedes the previous estimate. They differ in degree of detail, refinement, use, and confidence, depending on the amount of certainty regarding engineering and geological data, and other factors (e.g., environmental considerations, land acquisition costs, and procurement methods) known at the time the cost estimates are prepared (Reclamation 2007a). For the Investigation alternatives, feasibility and appraisal-level cost estimates have been developed for project facilities.

### Price Level

All feature costs have been escalated or de-escalated using Reclamation construction cost trends indices to bring all costs to an October 2015 price level (Reclamation 2016).

## Cost Estimate Components and Allowances

Depending on the level of study, it is often impractical to identify all items or unknown risks associated with a project. Accordingly, appraisal, feasibility, and percent design estimates typically contain allowances shown as separate line items for mobilization, design contingencies, allowance for procurement strategies, and construction contingencies as part of the project field cost. Field cost is an estimate of capital costs of a feature or project from award to construction closeout.

### *Mobilization*

Mobilization costs include contractor bonds, and the cost of mobilizing contractor personnel and equipment to the project site during initial project setup and the contractor's field oversight expenses. For most Investigation features, a value of 5-10 percent has been used for the mobilization allowance, unless it was estimated as a specific line item.

### *Design Contingency*

Design contingency is 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. For Investigation, typical design contingency allowances ranges from 10 to 20 percent of the subtotal of all listed pay items and mobilization. In general, the less refined the estimate, the higher the percentages used. As more details are developed to refine a specific cost estimate, the number of direct-cost line items increases, the accuracy of the quantity take-offs increases, and the allowance for design contingency decreases.

### *Allowance for Procurement Strategies*

An allowance for procurement strategies may be included in appraisal- and feasibility-level cost estimates to account for additional costs when solicitations will be advertised and awarded under other than full and open competition or for alternative delivery schemes. These include solicitations that will be set aside under socioeconomic programs, along with solicitations that may limit competition or allow award to other than the lowest bid or proposal. For the Investigation, this allowance ranged from 0 to 5 percent depending on the feature and potential for set aside solicitations.

### *Construction Contingency*

Appraisal- and feasibility-level cost estimates shall include a percentage allowance for construction contingencies as a separate line item to cover minor differences in actual and estimated quantities market unknowns, project risks, unforeseeable difficulties at the site, changed site conditions, possible minor changes in plans, and other uncertainties. The allowance is based on engineering judgment of the major pay items in the estimate, reliability of the data, adequacy of the projected quantities, and general knowledge of site conditions. For the Investigation, the allowance ranges from 20 to 25 percent of the subtotal of all listed pay items, mobilization, design contingency, and allowance for procurement strategies.

### *Construction Cost*

Construction cost is the sum of the feature field costs plus non-contract costs.

### *Non-Contract Costs – General*

Non-contract costs refer to costs of work or services provided in support of the feature construction, and distributed costs (or other work that can be attributed to the feature as a whole). Distributed costs include facilitating services, investigations, design and specifications, construction management, environmental compliance, and archeological considerations. Non-contract costs are divided into a detailed work breakdown structure. The draft work breakdown structure is shown in Table 7-2. Each category in the work breakdown structure will be estimated based on the defined scope and the level of effort that will be required to complete the category. Currently, the non-contract costs are estimated to be 40 percent of the total field cost. This percent allowance is estimated by CCWD reflecting their prior experience with the original Los Vaqueros Dam construction (completed in 1998) and Phase 1 reservoir expansion to 160 TAF (completed in 2012).

Table 7-2. Non Contract Cost Work Breakdown Structure

| COMPONENT | PERCENT | NOTE |
|---|---|---|
| Design, and Design Services During Construction | 15.4% | of construction |
| Construction Management | 8.0% | of construction |
| Environmental Compliance & Permitting | 1.6% | of construction |
| Environmental and Cultural Resources Monitoring, and Mitigation During Construction[1] | 4.0% | of construction |
| Monitoring and Mitigation Post Construction[1] | 3.0% | of construction |
| Administrative, Project Management, Legal, and Contract/Agreement Resolution[2] | 8.0% | of construction |
| **TOTAL** | **40.0%** | |

Note:
[1] Does not include acquisitions of mitigation lands
[2] Reflect CCWD leading and managing phase 2 expansion activities.

### *Non-Contract Costs – Lands*

Project lands includes lands to be acquired in fee for affected lands, and in fee and by temporary or permanent easement for pipeline alignments, pump station footprints, and staging and construction activities. Using an abbreviated valuation process, values for private lands within or near the pipeline alignments have been estimated as $1.13 million (October 2015 basis) for Alternative 4A and $3.57 million (October 2015 basis) for Alternatives 1A, 1B, and 2A. These costs are included in addition to the 40.0 percent of non-itemized Non-Contract Costs in Table 7-2, above. The Real Estate Appendix details acquisition criteria and valuation approach for project area lands. In addition, additional land acquisition would likely be required for environmental mitigation. The amount of required mitigation lands and their location have not been determined yet. Input from the resources agencies during permitting phase will determine these costs.

### *Interest During Construction*

Interest during construction is interest that accrues on a loan that finances the construction of an alternative. It was applied over the assumed construction period of 7 years at rate of 3.5 percent. For this planning level interest during construction estimate, the construction cost spending forecast for each work package was estimated to be equal across all years over the assumed

construction period for that work package. The detailed construction schedule for all work packages is included in Attachment 4A.

### *Total Capital/Investment Cost*

Total capital, or investment, cost is the sum of the construction costs and interest during construction.

### *Total Annual Cost*

Costs are annualized to facilitate comparison to annual benefits. Total annual costs for each alternative have been estimated by interest and amortization of the investment cost over 100 years and at a discount rate of 3.5 percent. This discount rate was used in the analysis of the project for the application for State of California Water Storage Investment Program funding and remains to provide consistency. The current Federal discount rate is 3.125 percent (Fiscal Year 2016) (which would be consistent with other CALFED storage projects and Federal Principles and Guidelines). Estimates for annual operations, maintenance, and replacement (OM&R) costs are shown in Attachment 4B and include feature specific OM&R and additional CCWD system pumping energy use.

**Feature Specific OM&R Costs** Feature specific OM&R estimates consider additional annual operations and maintenance labor, and major replacements over 100 years based on line items identified from field cost estimates. The major replacement estimates include contingencies for mobilization (5 percent), design (10 percent), construction (20 percent), and non-contract costs (25 percent). The operation and maintenance labor cost include a 10 percent design contingency as well as a 10 percent non-contract cost contingency.

Feature specific estimates include OM&R costs for proposed Transfer-Bethany Pipeline, Expanded Transfer Pump Station, Neroly Pump Station, Pumping Plant #1 Replacement, Los Vaqueros Dam and Reservoir Modifications, and Delta-Transfer Pipeline. It is assumed that the OM&R costs for the existing Transfer Pump Station modifications included in Work Package 2 and the Marina and Trails modifications included in Work Package 6 will not change significantly from pre-project levels and so no additional costs were included. In addition, only incremental costs associated with added features were included in the Los Vaqueros Dam and Reservoir Modifications costs. No OM&R costs were developed for Associated Local Facilities at this time.

Proposed alternatives would result in existing facilities (e.g., Delta intakes and pumps, Los Vaqueros and Transfer-LV pipelines, etc.) being utilized more heavily to convey increased water deliveries than under without-project conditions. Depending on the specifications for each facility, this could result in increases in replacement costs. Incremental increases in replacement costs for the existing facilities due to increased use under project alternatives would need to be included as project costs. Those incremental replacement costs are under development and will be included as they become available.

**CCWD Additional Energy Use Costs** Delivering new water supply from the expanded Los Vaqueros Reservoir to beneficiaries would increase energy use throughout the CCWD's system. Annual costs associated with increases in CCWD's system energy are shown in **Attachment 4B.** These costs have been developed based on changes in pumping and energy requirements for each

alternative from the modeling appendix. The price per kilowatt hour is estimated to be about $0.067, which is also consistent with energy costs assumed for the Upper San Joaquin River Basin Storage Investigation.

## Major Cost Estimate Assumptions

The assumptions listed for direct cost line items, and specifically factors used to determine indirect costs, are critically important to the overall accuracy of the estimate and should be reviewed and understood by all parties. The employed pricing methodology will be consistent with a detailed unit price. All capital construction cost estimates have been escalated or de-escalated to October 2015 price level using Reclamation indices as previously noted. No escalation from notice to proceed to mid-point of construction or escalation from published price level to notice to proceed is included in the cost estimates.

The estimates of construction costs shown, and any resulting conclusions on the project's financial requirements, economic feasibility, or funding requirements, have been prepared from the best information available at the time the estimate was prepared. Final project costs and resulting feasibility would depend on actual labor and material costs, competitive market conditions, and other variable factors, and should include escalation from published price level to the notice to proceed in future feasibility-level estimates. Accordingly, the final project cost will vary from the estimate. Therefore, project feasibility, benefit/cost analysis, risk, and funding would need to be carefully reviewed before making specific funding decisions and/or establishing the project budget.

### *Competitive Market Conditions at the Time of Bid Tender*

Estimates assume that Builder's Risk Insurance would be available to the contractor. If Builder's Risk Insurance is not available to the contractor because of the scope, security implications, or magnitude of the project, increased bid margins can be expected since the contractor would need to assume and include costs against those additional risks.

### *Major Cost Estimate Exclusions*

Major exclusions from the cost estimates include the following:

- Costs associated with loss of water due to construction requirements affecting dam or conveyance operation
- Escalation from published price level to notice to proceed
- Escalation from notice to proceed to midpoint of construction
- Impacts due to multiple construction contracts, market conditions, and number of bidders.

### *Program Cost Drivers*

Although not included in the estimates of first costs, cost escalation can be a significant cost factor for the program and should be included for economic studies and future project budgeting. Total contingency is another significant cost driver. As explained previously, contingency consists of three separate components: estimating accuracy allowance, risk provision for unknowns supported by probability theory, and an unlisted items allowance.

### Risk and Uncertainty

With each aspect of this report, certain assumptions have been made based on engineering and scientific judgment. Careful consideration has been given to the methodologies and evaluations for hydrology and system operations, cost estimates, and biological analyses. Analyses have been developed with advanced modeling and estimating tools using historical data and trends. While this is an effective way to help predict outcomes for future operations, biological conditions, and costs, many uncertainties could affect the findings in the Engineering Summary Appendix. Various uncertainties and risks associated with the Investigation are discussed in the Plan Formulation Appendix to the Feasibility Report.

All cost estimates, even at a feasibility-level, have inherent risks and uncertainties. The Investigation team has no control over the costs of labor, materials, competitive bidding environments, unidentified field conditions, financial and/or commodity market conditions, or any other factors likely to affect the cost estimates of the Study alternatives, all of which are and will unavoidably remain in a state of change, especially in light of high market volatility attributable to Acts of God and other market forces or events beyond the control of the parties. As such, these estimates are based on normal market conditions, defined by stable resource supply/demand relationships, and do not account for extreme inflationary or deflationary market cycles. These estimates are a "snapshot in time" and their reliability will degrade over time. No warranty, promise, guarantee or representation, either expressed or implied, is given that proposals, bids, project construction costs, or cost of operations and maintenance functions will not vary significantly from these cost estimates.

## Project Costs

Table 7-3 summarizes project cost estimates for the Los Vaqueros Expansion alternatives in millions of dollars. No costs for associated local facilities are included in the summary.

Table 7-3. Summary of Estimated Costs for All Alternatives ($ millions)

| Item | Alternative | | | |
|---|---|---|---|---|
| | 1A | 1B | 2A | 4A |
| **Work Package 1: Transfer-Bethany Pipeline** | | | | |
| Transfer-Bethany Conveyance Facilities OPCC | $144.36 | $144.36 | $144.36 | $144.36 |
| **Work Package 2: Expanded Transfer Pump Station and Transfer Pump Station Modifications** | | | | |
| Expanded Transfer Pump Station OPCC | $36.00 | $36.00 | $36.00 | $36.00 |
| Existing Transfer Pump Station Modifications OPCC | $10.90 | $10.90 | $10.90 | $10.90 |
| **Work Package 3: Neroly Pump Station** | | | | |
| Neroly Pump Station OPCC | $37.00 | $37.00 | $37.00 | $37.00 |
| **Work Package 4: Pumping Plant #1 Replacement** | | | | |
| Pumping Plant #1 Improvement OPCC | $17.80 | $17.80 | $17.80 | $17.80 |
| **Work Package 5: Los Vaqueros Reservoir Modifications** | | | | |
| 275 TAF Dam Raise OPCC | $267.00 | $267.00 | $267.00 | $0.00 |
| **Work Package 6: Expanded Recreation Facilities** | | | | |
| Marina Complex Relocation OPCC | $21.00 | $21.00 | $21.00 | $0.00 |
| Watershed Trails OPCC | $0.60 | $0.60 | $0.60 | $0.00 |
| Los Vaqueros Interpretive Center Improvement OPCC | $0.71 | $0.71 | $0.71 | $0.00 |
| Watershed Office Barn and Interpretive Features OPCC | $0.74 | $0.74 | $0.74 | $0.00 |
| **Work Package 7: Delta-Transfer Pipeline** | | | | |
| Delta-Transfer Pipeline OPCC | $44.52 | $44.52 | $44.52 | $0.00 |
| **Total Field Cost for Work Packages** | **$580.63** | **$580.63** | **$580.63** | **$246.06** |
| Land Acquisition Cost [1] | $3.57 | $3.57 | $3.57 | $1.13 |
| Total Annual Operations, Maintenance, and Replacement [2] | $9.85 | $9.85 | $9.85 | $7.75 |
| Increase in Replacement Costs for Existing Facilities [3] | TBD | TBD | TBD | TBD |
| Increased Annual Energy Costs | $3.41 | $3.78 | $3.71 | $3.08 |

Notes:

General: October 2015 dollar values. Non-contract costs, interest during construction, and annualized project costs are not included in this summary.

[1] Additional information found in Appendix E – Real Estate Appendix.

[2] Operation, maintenance, and replacement costs cover only new or modified facilities.

[3] Increased replacement costs of existing facilities due to reoperation under proposed alternatives are under development.

Key:

OPCC = opinion of probable construction cost

TAF = thousand acre feet

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# Chapter 8
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