



Angeles Link – Phase 1
Quarterly Report (Q3 2024)

For the period of July 1, 2024 through September 30, 2024

Appendix 1A - Draft Reports:
Safety Study
Water Evaluation
Workforce Study

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ANGELES LINK PHASE 1

PLAN FOR APPLICABLE SAFETY REQUIREMENTS

DRAFT – June 2024

SoCalGas commissioned this analysis from Burns & McDonnell. The analysis was conducted, and this report was prepared, collaboratively.

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1.0 LIST OF ABBREVIATIONS AND ACRONYMS

ABET	Accreditation Board for Engineering and Technology
AICHE	American Institute of Chemical Engineers
ANSI	American National Standards Institute
API	American Petroleum Institute
API RP	American Petroleum Institute Recommended Practice
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BVPC	Boiler and Pressure Vessel Code
BTU	British Thermal Units
CBO	Community Based Organizations
CBOSG	Community Based Organizations Stakeholder Group
CCM	Control Center Modernization
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CHS	Center for Hydrogen Safety
CISA	Cybersecurity and Infrastructure Security Agency
CPUC	California Public Utilities Commission
DOT	Department of Transportation
EERE	U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy
ERM	Enterprise Risk Management
ESD	Emergency Shutdown Devices
FEMA	Federal Emergency Management Agency

GIS	Geographic Information System
GO	General Order
GTI	Gas Technology Institute
HCA	High Consequence Areas
HySafe	International Association for Hydrogen Safety
ILI	Inline Inspection
ISO	International Organization for Standardization
LNG	Liquefied Natural Gas
MAOP	Maximum Allowable Operating Pressure
MJ	Megajoule
mol	Mole
MSP	Material Specification
NFPA	National Fire Protection Association
NPS	Nominal Pipe Size
O&M	Operations and Maintenance
OPM	Optical Pipeline Monitoring
OQ	Operator Qualifications
OSHA	Occupational Safety and Health Administration
PAG	Planning Advisory Group
PDCA	Plan-Do-Check-Act
PHMSA	Pipeline and Hazardous Materials Safety Administration
PIR	Potential Impact Radius
ppb	Parts per billion

PPE	Personal Protective Equipment
ppm	Parts per million
RAMP	Risk Assessment Mitigation Phase
SCC	Standards Council of Canada
scf	Standard Cubic Foot
SIF	Serious Injuries and Fatalities
SMS	Safety Management System
SMYS	Specified Minimum Yield Strength
SoCalGas	Southern California Gas Company
THT	Tetrahydrothiophene
TSA	Transportation Security Administration

2.0 EXECUTIVE SUMMARY

Southern California Gas Company (SoCalGas) is proposing the Angeles Link Project (Angeles Link) to develop a clean renewable hydrogen¹ pipeline system to facilitate transportation of clean renewable hydrogen from multiple potential regional third-party production sources to various delivery points and end users in Central and Southern California, including in the Los Angeles Basin. The CPUC Phase 1 Decision² requires SoCalGas to, among other things, evaluate safety concerns involved in the pipeline transmission, storage, and transportation of clean renewable hydrogen.

As detailed herein, this study demonstrates that Angeles Link can be safely designed, constructed, operated, and maintained in accordance with existing regulations and industry standards and best practices pertaining to hydrogen; adapting corollary safety regulations and industry standards and best practices to suit the specific properties and characteristics of hydrogen; and developing new standards and practices specific to the transport of hydrogen.

Key Findings

- **Existing Hydrogen-Specific Requirements, Codes, and Industry Standards Will Help Promote Safety.**

Regulatory requirements and industry-standard codes exist for the transportation of hydrogen gas by pipeline, primarily anchored by Title 49 Code of Federal Regulations (CFR) Part 192 Subparts A through P and the CPUC's General Order (GO) 112-F governing natural gas transmission and distribution and addressing flammable gases such as hydrogen. Current federal minimum safety standards for pipelines transporting natural and other gases include hydrogen and do not specify differences and considerations for hydrogen specifically versus natural gas (and other gases). Other hydrogen-specific standards and specifications also exist and are applied in the industry (e.g., American Society of Mechanical Engineers (ASME) B31.12 or National Fire Protection Association (NFPA 2)), although they are not specifically incorporated into 49 CFR Part 192 or CPUC GO 112-F by direct reference. There are approximately 1,600 miles of hydrogen pipelines operating in the United States today that are regulated via industry standards.

- **Existing Requirements Applicable to the Natural Gas System Can Be Leveraged and Tailored to Promote the Safe Transportation of Hydrogen for the Benefit of the Public, Our Employees, Contractors, and Our Infrastructure.**

A clean renewable hydrogen system (gaseous hydrogen) can leverage many of the existing requirements of an analogous natural gas system. Where hydrogen's physical and chemical

¹ In the California Public Utilities Commission (CPUC) Angeles Link Phase 1 Decision (D).22-12-055 (Phase 1 Decision), clean renewable hydrogen refers to hydrogen that does not exceed 4 kilograms of carbon dioxide equivalent (CO₂e) produced on a lifecycle basis per kilogram of hydrogen produced and does not use fossil fuels in the hydrogen production process, where fossil fuels are defined as a mixture of hydrocarbons including coal, petroleum, or natural gas, occurring in and extracted from underground deposits.

² CPUC Decision 22-12-055.

properties differ from natural gas, influence from SoCalGas's existing natural gas system plans including safety systems, specifications, procedures, and training will provide a basis for designing, constructing, and operating Angeles Link. SoCalGas's catalog of specifications and standards for its existing natural gas pipeline system (as of August 2023) implements federal and state pipeline safety requirements, industry standards, and best practices across the required aspects of design, material sourcing, construction, operation, maintenance, inspection, and reporting for a natural gas transmission and distribution system. In consideration of Angeles Link, SoCalGas will leverage existing specifications and develop new specifications (as appropriate), including but not limited to material specifications, fabrication and welding requirements, safety plans, quality management plans, approved manufacturer's lists, operator qualification procedures, fire protection and prevention strategies, corrosion control requirements, inspection requirements, and reporting requirements.

- **Safety Will Be Foundational and Factored into All Aspects of System Design, from Material Selection to Sizing and Compression Requirements and Control Room Operations, and Risk Mitigation, from Personal Protective Equipment to Odorization, Cybersecurity, Etc.**

Transmission pipeline construction, operations, and maintenance safety considerations for a clean renewable hydrogen system can take into account the various existing SoCalGas safety systems that promote safety for the public, infrastructure, SoCalGas employees, and contractors. Major topics reviewed in this assessment include safety considerations with respect to material, design, construction requirements, operations, inspections and maintenance activities, Personal Protection Equipment (PPE), security (both physical and cyber), and odorization of 100% clean renewable hydrogen.

A preliminary design basis will include the identification of key factors such as the operating and design characteristics of clean renewable hydrogen for Angeles Link, which will be used in the determination of preliminary pipeline sizing, compression requirements, and pipeline material selection. Subsequently, construction, operation, and maintenance requirements, such as 49 CFR Part 192, will contribute to that basis. In addition to the federal regulations, there are applicable and/or hydrogen-specific industry codes and standards that are already in existence and will be considered, such as API 5L, API 1104 and ASME B31.12³. New rules or changes to existing rules would go through the rulemaking process as described by the Federal Register (Office of the Federal Register).⁴ This process includes stages for development, rule proposal, soliciting comments from the public and those directly affected by the proposed rule, finalizing the rule, integration of the rule, and providing interpretation (if necessary).

³ API 5L pipe specifications. American Piping Products. (2024, January 4). [https://amerpipe.com/products/api-5l-pipe-specifications/API standard 1104](https://amerpipe.com/products/api-5l-pipe-specifications/API%20standard%201104), 22nd edition. Energy API. (n.d.). <https://www.api.org/products-and-services/standards/important-standards-announcements/1104>, B31.12 - Hydrogen Piping & Pipelines: Digital Book. ASME. (n.d.). <https://www.asme.org/codes-standards/find-codes-standards/b31-12-hydrogen-piping-pipelines>.

⁴ The Federal Register. Federal Register: Request Access. (n.d.). <https://www.federalregister.gov/>.

In general, PPE used by SoCalGas employees, contractors, or any other personnel accessing a SoCalGas facility (or as otherwise required by SoCalGas at a project or work site), is covered by California Occupational Safety and Health Administration (OSHA) and addressed within NFPA 2112. Special considerations must be made for hydrogen service, due to its low ignition energy, flame temperature, and flame speed. Anti-static and flame-resistant clothing or coveralls and non-metallic (or non-sparking materials) should be considered. SoCalGas should review its procedures to determine if changes should be made regarding PPE for employees working on hydrogen pipelines.

Hydrogen, like natural gas, is odorless. Assessing odorizing the 100% clean renewable hydrogen transported through the proposed Angeles Link infrastructure to indicate the presence of hydrogen is an important consideration in the development of applicable safety protocols. The selection of the appropriate odorizing agent is important to avoid impacts on downstream customers that require relatively pure hydrogen for their uses and may require downstream customers to “scrub” the odorant from the received hydrogen. Industry research on the implications of odorant in a pure hydrogen system is ongoing and should be monitored during the development of Angeles Link to identify industry best practices.

Control room operations are critical elements to safely and efficiently operate hydrogen pipeline infrastructure and can provide early opportunities to mitigate risk. The control room operators monitor the pressure and flow of gas in the system utilizing a supervisory control and data acquisition (SCADA) system 24 hours a day, 365 days a year. SCADA provides live data which is used to quickly detect potential abnormalities in pipeline operation, including potential leaks and changes in pressure and flow. In addition, SoCalGas’s monitoring, and installations of rupture-mitigation valves and automated valves are consistent with PHMSA’s valve rules in case of rupture. SoCalGas uses a SCADA system today to monitor the gas-transmission system including associated pipelines, line compressor stations, and underground storage facilities. A hydrogen system may require a separate SCADA system to monitor the pipeline and compressor station operations.

Physical and cyber security requirements are primarily addressed by the Transportation Security Administration (TSA) as part of Homeland Security.⁵ It is envisioned that a clean renewable hydrogen pipeline system could follow the same philosophy SoCalGas currently uses for the physical and cyber security of its existing natural gas system. Physical and cyber security requirements should be addressed with third-party clean hydrogen producers and third-party hydrogen storage providers if applicable.

- **Existing Emergency Response and Public Awareness Plans Can Be Leveraged and Tailored for Hydrogen’s Specific Properties and Characteristics.**

⁵ 49 of the United States Code, Transportation Security Administration, section 114(s); <https://www.dhs.gov/publication/2023-biennial-national-strategy-transportation-security>

Emergency response plans and procedures promote effective emergency incident management and are designed to address unanticipated or emergency situations. This includes employees who are trained and equipped to respond promptly to protect the public, maintain system reliability, and restore the affected system and Company operations to normal status. The emergency response plan should contain hydrogen-specific details and provide the framework for the emergency response protocol, including dispatch of personnel to a potential hydrogen leak site. SoCalGas can leverage its existing Operating and Maintenance Procedures (O&M Plan) which include comprehensive safety and emergency response procedures and protocols that address safety of the public and employees, during emergencies, and comply with all applicable state and federal safety requirements.

SoCalGas should continue compliance with Public Awareness Plans requirements pursuant to 49 CFR § 192.616 that would specify the hydrogen infrastructure to have markers indicating the transported fuel, hydrogen, and an emergency phone number which should be monitored 24/7 by the control room or a separate emergency response desk. Hydrogen control room and emergency response personnel will require hydrogen-specific training in the physical and chemical properties and the execution of the emergency plans. First responder awareness level training can be provided by multiple organizations and provides an overview on hydrogen for fire, law enforcement, emergency medical personnel and others.⁶ SoCalGas may also consider separate gas controllers and emergency response teams for the natural and hydrogen gas systems since natural gas and hydrogen are different fuels with different physical and chemical properties. Gas controllers' training will require operator qualifications unique to the hydrogen system, including knowledge of the abnormal operating conditions associated with hydrogen compressor and pipeline operations.

- **Hydrogen-Specific Training for Employees and Contractors that Incorporate Industry Lessons Learned Can Be Collaboratively Developed.**

Training on the operational considerations and key risks of hydrogen for SoCalGas employees and contractors can be developed. Additionally, the public should be provided access to information about the risks and safety measures associated with hydrogen, supporting public outreach and long-term project input considerations, similar to the training materials and programs for the public that SoCalGas offers on natural gas. Several organizations and consultants currently offer training specific to the risks associated with designing, constructing, operating, and maintaining a hydrogen system. As the hydrogen energy market continues to grow, additional training and certifications may become available.

As the Angeles Link Project progresses, safety will remain foundational. Collaboration amongst industry stakeholders, regulatory bodies, research institutions, first responders and the communities,

⁶ This introduction to Hydrogen Safety for First Responders is a Web-based course that provides an "awareness level" overview of hydrogen for fire, law enforcement, and emergency medical personnel. American Institute of Chemical Engineers: Center for Hydrogen Safety, <https://www.aiche.org/ili/academy/courses/ela253/introduction-hydrogen-safety-first-responders>.

will play a key role in the continued development of regulations, specifications, standards, and other requirements to safely design, construct, operate and maintain a clean renewable hydrogen pipeline transportation system. SoCalGas is well positioned to build, operate, and maintain a clean renewable hydrogen pipeline system due to its long-standing experience operating and maintaining a highly developed gas transmission and distribution system, existing highly trained and qualified workforce, and comprehensive established integrity management and emergency response procedures.

Stakeholder Input Summary

The input and feedback from stakeholders including the Planning Advisory Group (PAG) and Community Based Organization Stakeholder Group (CBOG) has been helpful to the development of this draft Safety Study. SoCalGas has also routinely met with the California Public Utilities Commission's (CPUC)'s Safety Enforcement Division to provide updates and to collaborate on the project. As further detailed in Section 13 below, in response to stakeholder comments received thus far, the Center for Hydrogen Safety, Hydrogen Safety Panel is conducting a third-party review of this safety study, with results of their review expected to be incorporated into the final report. Additionally, the following topics for: Safety Management Systems (SMS) framework, odorant feasibility, Emergency Response protocols, and Public Awareness plans, are described in Sections 4, 6, 7, 8, respectively.

3.0 INTRODUCTION

The transmission of clean renewable hydrogen across the value chain must prioritize safety and leverage applicable industry experience and best practices, regulations, codes, and standards. Hydrogen has been used for decades across the globe, including for heavy industries (e.g., oil refineries and chemical plants) and transportation (e.g., vehicle fueling stations). In addition, there are over 1,600 miles of hydrogen pipelines currently operating in the U.S. today, owned by merchant hydrogen producers.⁷ This industry experience makes the properties and risks associated with hydrogen well known. Additionally, many rules and regulations for natural gas transportation in transmission and distribution pipelines are applicable or can be used to draw sufficiently accurate parallels to transmission and distribution pipelines for clean renewable hydrogen.

SoCalGas is regulated by the California Public Utilities Commission (CPUC) and has over 150 years of experience transporting natural gas via pipeline. Safety is foundational to all aspects of SoCalGas's business⁸ and is reflected in the safety plans, programs, policies, standards, and procedures that are designed to support a strong safety culture, as well as the company's comprehensive Safety Management System (SMS) framework, which is implemented consistent with American Petroleum Institute Recommended Practice (API RP) 1173.⁹

⁷ Hydrogen pipelines | Department of Energy. (n.d.-b). <https://www.energy.gov/eere/fuelcells/hydrogen-pipelines>.

⁸ Additional information regarding SoCalGas's commitments to safety can be found in Section II of SoCalGas's 2023 Gas Safety Plan, available at <https://www.socalgas.com/sites/default/files/2023-Gas-Safety-Plan.pdf>.

⁹ API 1173 is a "pipeline" safety management system, designed to support the safe delivery of energy with safe pipeline operations by helping pipeline operators understand, manage, and continuously improve safety.

SoCalGas defines safety as the presence of controls for known hazards, actions to anticipate and guard against unknown hazards, and the commitment to continuously improve the ability to recognize and mitigate hazards. SoCalGas’s safety focus is comprehensive and systemic and includes all activities – from the office to the field – to advance public safety, infrastructure safety, employee safety, and contractor safety.

Safety is embedded throughout Angeles Link’s planning, engineering, and design process as well as through the execution of construction and long-term operation and maintenance. The objective of this Plan for Applicable Safety Requirements (Safety Study) is to evaluate federal, state, and industry codes, standards, and best practices for their application to pipeline transmission, storage, and transportation of clean renewable hydrogen as applicable to Angeles Link. This evaluation includes providing an assessment of applicable safety requirements for employee, contractor, system, and public safety. This Safety Study identifies potential updates or modifications to SoCalGas’s standards, specifications, and procedures (covering construction, operations, and maintenance) to address hydrogen-specific considerations, as applicable. This Safety Study also outlines the unique considerations associated with hydrogen while outlining actively documented mitigations, standards, and procedures.

4.0 SOCALGAS SAFETY MANAGEMENT SYSTEM

SoCalGas has implemented a comprehensive safety management system,⁵ consistent with API 1173, to promote the safe and reliable delivery of service to its customers and integrate public safety, infrastructure safety, employee safety, and contractor safety systems. SoCalGas’s SMS documents and connects SoCalGas’s comprehensive set of safety plans, programs, and procedures in place that address specific infrastructure or activity areas. The SMS encompasses all aspects of safety relevant to SoCalGas’ business, including employee safety, contractor safety, public safety, and infrastructure safety. It applies to all SoCalGas assets and operations as well as to all employees, from senior management to those on the frontline.

SoCalGas designed its SMS to be consistent with American Petroleum Institute (API) Recommended Practice 1173. API 1173 provides a framework for managing safety holistically through the integration of various activities including risk and asset management, formal processes and procedures, systematic decision making, monitoring of program effectiveness, safety culture, audits, and increased communications. While API 1173 is designed to address recommended practices around Pipeline Safety Management Systems, SoCalGas has developed its SMS to apply comprehensively to safety at SoCalGas.

SoCalGas acknowledges that assessment, learning, and continuous improvement are essential to a strong safety management system. Accordingly, in 2021, SoCalGas engaged the American Petroleum Institute to perform a maturity assessment of SoCalGas’s SMS. At that time, SoCalGas’s SMS scored a 3.06, which indicates SoCalGas’s SMS is “Implemented: Organizational structures are in place, processes are fully developed, and procedures and programs documented and functional.” Since that assessment, SoCalGas has and is implementing improvements to continue maturing its SMS.

The ten essential elements of API 1173 are detailed below as well as how relevant activities at SoCalGas and the information within this study can be leveraged together for application in the development of Angeles Link.

1. Leadership and Management Commitment is demonstrated through organizational goals, objectives, and a company culture that encourages openness and prioritizes learning from incidents and events. SoCalGas plans to begin integrating hydrogen safety goals into its programs and plans such as including hydrogen safety awareness in employee and contractor safety dialogues and forums. To lead these efforts, SoCalGas created a Senior Vice President of Engineering & Major Projects and Chief Clean Fuels Officer position that leads Angeles Link and other hydrogen projects. This position reports directly to SoCalGas's President and integrates core engineering and construction functions that are vital to current safe work practices and clean fuels projects of the future.
2. Risk Management is advanced by developing a systemic and systematic way to evaluate risks to safety and then develop strategies on how to manage them through preventive controls, monitoring, and mitigation measures. SoCalGas advances its structured enterprise risk management efforts through a Chief Risk Officer and Enterprise Risk Management (ERM) organization. Two key components of SoCalGas's approach to enterprise risk management are (1) the development and filing of a Risk Assessment Mitigation Phase (RAMP) Report to the CPUC every three years and (2) the ongoing maintenance of an enterprise risk registry. SoCalGas plans to integrate hydrogen and hydrogen assets into this existing risk management process. Initial Risk Management considerations are detailed in Section 4: Risk Management.
3. Stakeholder Engagement is promoted through structured processes and plans for communication and engagement with internal and external stakeholders regarding risk and safety. SoCalGas maintains robust processes for stakeholder engagement as noted in Section 8: Awareness, Education, and Training and is implementing additional stakeholder engagement for Angeles Link.¹⁰
4. Operational Controls are addressed through procedures for safe work practices to promote operations, maintenance, control of materials, and emergency response activities. As detailed in this study, SoCalGas recognizes that existing practices, policies, and procedures will need to be evaluated and evolve to transport hydrogen. SoCalGas is in the process of reviewing and updating existing operational controls to provide for the safe transportation of hydrogen (See Appendix

¹⁰ SoCalGas established a Planning Advisory Group (PAG) to receive technical advice and to collaborate on Project design and development. The stakeholders include government entities, environmental justice nonprofits, environmental nonprofits, labor groups, industry, academia, and ratepayer advocates. Through the PAG, SoCalGas coordinates with stakeholders on hydrogen market issues, technical issues, environmental impacts, and environmental justice issues. SoCalGas also established a separate and parallel Community Based Organization Stakeholder Group (CBOSG) engagement process. The CBO stakeholder group is composed of 25 organizations that represent disadvantaged communities (DACs), social justice and environmental justice groups, faith-based organizations, school groups, and tribal organizations. It was established to preliminarily provide these members a better understanding of Angeles Link and engage in a collaborative process where the needs and concerns of represented communities are heard.

A).¹¹ These updates will further enhance its capacity to systematically review a change, including the assessment and mitigation of risks associated with the change. Management of Change is a continuously expanding component of the Operational Controls, a structured process for identifying potential risks associated with changes. Management of Change is an important, enterprise-wide process to safely integrate changes related to hydrogen transportation.

5. Incident Investigation, Evaluation, and Lessons Learned details practices for investigating, evaluating, and learning from incidents and near-misses. SoCalGas has established incident investigation procedures for analyzing natural gas related accidents and failures for the purpose of determining the causes of the failure and identifying learnings to minimize the possibility of recurrence, consistent with federal Pipeline and Hazardous Materials Safety Administration (PHMSA) and Department of Transportation (DOT) regulations (see 49 CFR §192.617, Investigation of Failures), which provide a foundation for application to hydrogen pipelines. SoCalGas has also integrated new and emerging practices related to Human and Organizational Performance by developing a Learning Team framework to assess and improve practices and activities while partnering with employees closest to the work. SoCalGas routinely references lessons learned published by the Pacific Northwest National Laboratories H2Tool website as noted in Section 10: Lessons Learned.
6. Safety Assurance is advanced by regularly assessing whether expected progress toward effective risk management and improved safety performance are being achieved. SoCalGas gathers and maintains data related to its activities and safety performance. Key safety performance metrics (e.g., third party dig ins, Serious Injuries and Fatalities [SIFs], Gas In-line Inspection [ILI] mileage) are reported publicly to the Commission as part of the Commission's Safety Performance Metric Reporting process. Furthermore, SoCalGas's Quality Management Department performs quality assurance on major pipeline and infrastructure projects and maintenance activities such as leak survey, leak detection, and locate and mark of infrastructure on both its distribution and transmission system. Many of SoCalGas's existing metrics and measures would be similarly applicable to hydrogen safety (for example, Job Safety Observations, Near Miss / Stop the Job Reporting) and SoCalGas plans to develop additional safety performance metrics specifically related to hydrogen.
7. Management Review and Continuous Improvement is demonstrated through the review of performance to determine the extent to which goals and objectives have been met. SoCalGas engages in external benchmarking efforts through trade organizations; relationships with peer companies; and through its Advisory Safety Council, which provides feedback on SoCalGas's

¹¹ For example, SoCalGas has developed and collaborated with manufacturers to support operation of hydrogen assets; uses company operations standards to guide system-wide consistency in daily operations or event-driven operation; uses material specification (MSP) sheets to specify SoCalGas's requirements for material(s) used in pipeline construction and company operations; uses line classes to specify the allowable piping components for a given service and define the governing code(s). Standards, MSPs, and line classes are also shared with contractors when appropriate to provide transparency and information in regard to safely operating SoCalGas assets.

approach to safety through independent members with deep experience and proven leadership in the areas of safety management systems, public safety, community relations, regulatory oversight and industry safety. In addition to existing internal processes for performance and goal review and continuous improvement, with respect to Angeles Link specifically, SoCalGas's review process for the Angeles Link Phase 1 studies includes subject matter expert reviews internally and externally. This also includes the review and feedback coordinated through the PAG and CBOSG engagement process, and third-party review of this Plan for Applicable Safety Requirements by the Hydrogen Safety Panel (HSP), which was founded by the U.S. Department of Energy to develop and implement guidance, procedures, and best practices that would ensure safety in the operation, handling, and use of hydrogen and hydrogen systems.

8. Emergency Preparedness and Response is promoted through procedures that detail plans to address potential types of emergencies, notification requirements, identification of response resources, use of Incident Command Structure, communication plans, training and drill requirements, and improvement processes. SoCalGas's Emergency Management department is a centralized and dedicated department that supports business operations with first responder outreach and emergency response, preparedness, and recovery. Furthermore, Emergency Management maintains SoCalGas's business continuity (BC) program that addresses continuity of operations and essential functions in the event of a business disruption. The BC program contains multiple BC plans that contain the assessment of potential impacts, mitigations of risks, and processes and procedures to continue operations and essential functions in the event of a business disruption. SoCalGas utilizes the Federal Emergency Management Agency (FEMA) Incident Command System (ICS), which allows for a multi-level emergency response, and is a nationally recognized standardized approach to incident management. SoCalGas regularly conducts outreach to first responders in accordance with 49 CFR § 192.615(c), California Public Utilities Code § 956.5 and API 1162 as noted in Section 7: Control Room and Emergency Response. SoCalGas has already met with first responders such as local fire departments to coordinate and share knowledge on hydrogen safety-related preparedness and response.
9. Competence, Awareness, and Training is demonstrated through processes to evaluate, determine, and enable the appropriate level of competence, including education, training, and experience. SoCalGas has administered hydrogen safety education facilitated by third parties for employees supporting hydrogen projects. SoCalGas has proactively joined with supporting organizations to present hydrogen awareness information to CBOSGs as well as strengthen the connections within academia. SoCalGas has also collaborated with other industry partners to develop pathways to acquire hydrogen training for various levels of personnel. For additional information see Section 8: Awareness, Education, and Training.
10. Documentation and Recordkeeping is advanced through procedures for the identification, distribution, and control of required documents. SoCalGas maintains a comprehensive Information Management Policy, detailed Record Retention Schedule(s), and every employee is responsible to review, evaluate, and manage Company-related information (records and non-records) within their possession or control in accordance with these policies. These same processes will be used in maintaining documentation and recordkeeping related to Angeles Link.

5.0 PHYSICAL AND CHEMICAL PROPERTIES OF HYDROGEN

The safe transmission, compression, storage, and transportation of hydrogen must account for physical and chemical properties associated with pure hydrogen. To illustrate the properties of hydrogen, Table 1 *Properties of Hydrogen Compared to Natural Gas*, compares hydrogen's properties and characteristics to natural gas.

Table 1 - Properties of Hydrogen Compared to Natural Gas

<u>Property / Characteristic</u>	<u>Hydrogen Gas</u>	<u>Natural Gas</u>	<u>Comparison / Comment</u>	<u>Management</u>
Visibility	Colorless	Colorless	Both natural gas and hydrogen are colorless	N/A
Odor	Odorless	Odorless	Both natural gas and hydrogen are odorless	Addition of an odorant, such as mercaptans, which are currently used to odorize natural gas
Toxicity	No toxicity risk when inhaled in small quantities.	No toxicity risk when inhaled in small quantities.	Neither hydrogen nor natural gas are toxic in their pure forms. Both gases can potentially displace oxygen in an enclosed space, resulting in an asphyxiant hazard.	Leak detection, hydrogen gas detectors, addition of odorant
Flammability Range	4% to 75% in air	5% to 15% in air	With hydrogen's wider flammability range, it can combust in a broader set of circumstances than natural gas.	Leak detection, hydrogen gas detectors, and addressing hazards in an electrical area
Combustion Byproduct	Water Nitrous Oxides (NO _x)*	Carbon Dioxide, Carbon Monoxide, NO _x , Sulfur Oxides (SO _x)*	Combustion temperatures and fuel quality and composition influence combustion byproducts	See the discussion below regarding adiabatic flame temperatures

<u>Property / Characteristic</u>	<u>Hydrogen Gas</u>	<u>Natural Gas</u>	<u>Comparison / Comment</u>	<u>Management</u>
Molecular Weight/Size	H ₂ Very light/small (2.02 g/mol)	CH ₄ (Methane) Heavier/larger chains (16.04 g/mol)	The hydrogen (H ₂) molecules are relatively much smaller than methane (CH ₄) and can permeate into the base materials containing the hydrogen. Permeation into base materials may result in increased embrittlement in steel pipes, resulting in cracking/fracturing. While methane and hydrogen are lighter than air, hydrogen will rise and disperse more quickly than methane when released into the atmosphere.	Material selection and internal coating (pipelines/tanks) considerations to reduce the potential for cracking/fracturing and embrittlement
Corrosivity	Inherently non-corrosive	Inherently non-corrosive	While both hydrogen and natural gas are non-corrosive, they can impact materials in certain conditions. As indicated previously, hydrogen can act to embrittle steel in certain conditions. Additionally, hydrogen can interact with metals to form metal hydrides. For hydrogen and natural gas, impurities (like water) can result in metal degradation and corrosion.	Commodity purity requirements Regular inspections

<u>Property / Characteristic</u>	<u>Hydrogen Gas</u>	<u>Natural Gas</u>	<u>Comparison / Comment</u>	<u>Management</u>
Ignition Energy	0.02 mJ (or lower)	0.25 mJ – 0.5 mJ (or higher)	Hydrogen and natural gas ignition energy can vary depending on the mixture, temperature, and pressure. Hydrogen’s lower ignition energy indicates it is more easily ignited than natural gas, given an identical ignition energy source.	Precise hydrogen ignition control equipment; Non-spark personal protective equipment
Heating Value (lower/higher)	51,600 / 61,000 Btu/lb 290 / 340 Btu/scf	20,300 / 22,500 Btu/lb 980 / 1,100 Btu/scf	To match the energy content of natural gas, hydrogen must be provided at a greater volumetric flow rate.	Design the pipeline on a volumetric basis to meet desired energy needs.
Flame Speed	~200-300 cm/s	~30-40 cm/s	Hydrogen’s flame speed is approximately ten times faster than that of natural gas. A hydrogen flame propagates more rapidly than natural gas, impacting combustion systems (e.g., an engine designed for a natural gas fuel source cannot run reliably on a hydrogen fuel source without modification).	Modifications to combustor design to manage flame speed

<u>Property / Characteristic</u>	<u>Hydrogen Gas</u>	<u>Natural Gas</u>	<u>Comparison / Comment</u>	<u>Management</u>
Adiabatic Flame Temperature	~4,000 °F	~3,565 °F	Hydrogen's adiabatic flame is approximately 500 °F hotter than that of natural gas, which requires considerations for proper materials and mitigating potential increases in oxides of nitrogen (NO _x) emissions.	Select materials that can withstand the increase in temperature, modify the combustion air/fuel ratios, control flame hot spots, and increase emission treatment. See <i>section on materials within the Pipeline Sizing and Design Study</i>

<u>Property / Characteristic</u>	<u>Hydrogen Gas</u>	<u>Natural Gas</u>	<u>Comparison / Comment</u>	<u>Management</u>
Compressibility	Additional compressor horsepower is required per unit of energy vs natural gas due to lower molecular weight.		<p>Due to its low molecular weight relative to natural gas, hydrogen requires additional power to compress, given a consistent compression ratio. Due to hydrogen's low volumetric energy density compared to natural gas, additional hydrogen must be compressed to transmit an equivalent amount of energy.</p> <p>Natural gas typically increases in temperature when compressed and decreases when depressurized. Hydrogen has a negative Joule-Thomson coefficient, which has a slight cooling effect as hydrogen is compressed adiabatically, but the added energy from compression results in an overall temperature increase. The negative Joule-Thomson coefficient also causes an increase in temperature during depressurization.</p>	Appropriate compression and hydrogen cooling/heating system design

In summary, there are many similarities between hydrogen and natural gas operations and gas handling. While there are some differences in their properties and characteristics, a variety of existing practices can be modified to manage these differences. Risk management of any gas system should be similar in prioritizing safety measures for materials, design, operation, and maintenance. Eliminating hazards and detecting leaks are a critical component of monitoring and mitigating risk.

6.0 RISK MANAGEMENT

SoCalGas’s SMS establishes a unified systemic approach to managing safety across the enterprise, and includes the necessary organizational structures, accountability, policies, and procedures. The system is comprehensive and iterative in nature, and designed to identify, manage, and reduce risks and help prevent or mitigate the likelihood and consequences of safety incidents, including serious injuries to employees, contractors, or the public, as well as unintended releases or Abnormal Operating Conditions.

Risk management is an element of SoCalGas’s SMS, and the existing risk management approach will be beneficial in incorporating and addressing hydrogen infrastructure. SoCalGas’s enterprise risk management (ERM) is modeled after International Organization for Standardization (ISO) Standard 31000 and is a comprehensive framework to identify, assess, respond to and report on key risks. The SMS utilizes Plan-Do-Check-Act (PDCA), which serves as a core component of SoCalGas’s SMS. The PDCA cycle is iterative and intended to continuously improve safety at SoCalGas. Furthermore, execution of the PDCA supports the ERM framework.

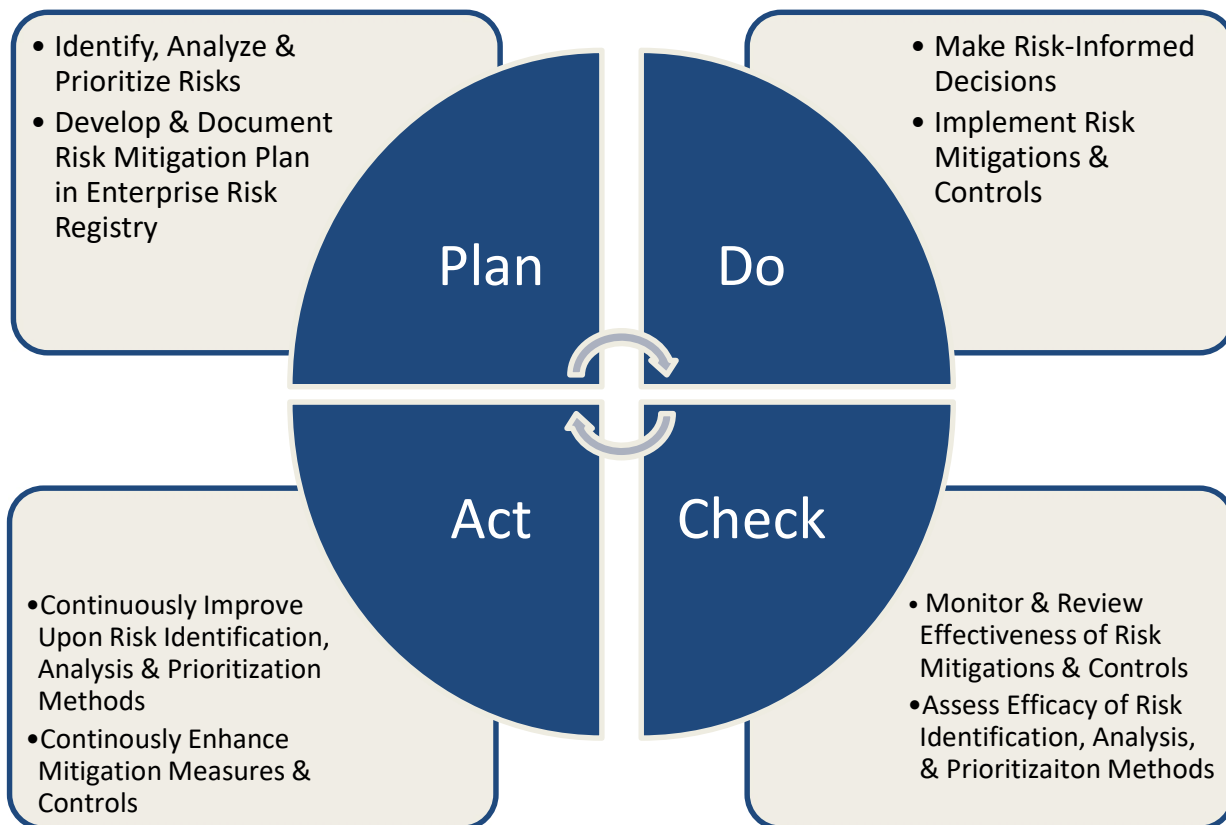


Figure 1 – Risk Management

Table 2, *Risk Management* below identifies potential considerations regarding the transportation of fuel by pipeline, as well as potential risk management. The management of risk would include considerations for internal integrity management processes, training, design, engineering, and implementation of regulatory requirements mandated by PHMSA and the CPUC. The following table outlines these considerations for transmission, compression, storage, and transportation and includes potential management. As with any installation, site and situation-specific mitigations must be considered.

Table 2 – Risk Management

<u>Description of Risk</u>	<u>Potential Consequences</u>	<u>Potential Management</u>
Stakeholder engagement and safety training	Public awareness plans and local first responder liaisons are not specific to hydrogen, leading to potentially inappropriate reactions to incidents.	Update Public Awareness Plan material for hydrogen infrastructure to inform the public and emergency responders on the fundamentals of hydrogen and differences versus natural gas (what may be familiar). For internal resources, widespread safety training from industry associations and organizations like GTI, AGA, and others.
Design, construction, operations & maintenance	Equipment failures, leaks/accidents could create a potential risk of fire or explosion. If a significant failure occurs, the shutdown could lead to fuel shortages and service disruptions, impacting areas adjacent to the failure location(s) and the end users.	Monitoring API and other organizations’ research and development of hydrogen pipe specifications to incorporate current industry best practices.
	Properties of hydrogen that differ from natural gas are not appropriately accounted for in design and construction, leading to failures and impacting areas adjacent to the failure location(s) and the end users.	For purposes of this report, it is assumed that the Angeles Link infrastructure would be an entirely new system constructed with 100% hydrogen-compatible material, compatible welding specifications, and the latest industry best practice construction techniques, helping to minimize damage and leak events.
	Potential for ignition, which could create risk of fire or explosion.	Regular maintenance and compliance with all safety regulations, including leak detection, monitoring, and conducting regularly scheduled leakage surveys.

<u>Description of Risk</u>	<u>Potential Consequences</u>	<u>Potential Management</u>
Natural disasters and third-party damages	Higher populated areas increase the risk of threats like third-party damage and impacts on people and property affected.	<p>The Angeles Link infrastructure would be an entirely new system constructed with hydrogen-compatible material, compatible welding specifications, and the latest industry best practice construction techniques, helping to minimize damage and leak events. Additionally, the pipeline will be buried with adequate cover and signage along the route in accordance with federal and state pipeline safety standards.</p> <p>The SoCalGas Public Awareness Plan will help inform the public about hydrogen, the specific pipeline route, emergency contacts, and additional relevant information.</p>
	Damage to aboveground assets/equipment could create a potential risk of fire or explosion.	Upgrade physical security with technology designed to minimize occurrences of vehicles driving through gates or penetrating fences, such as bollards or concrete barriers.
	A seismic event could damage the pipeline if not appropriately designed. This damage could create a potential risk of fire, explosion, and potential fuel shortages and service disruptions.	<p>Available seismic notifications systems and resulting system shutoffs, including actuated mainline valves with pressure monitoring for line break scenarios installed on either side of a major fault crossing.</p> <p>Installation of low-density backfill material (i.e., Geofoam) to account for pipeline displacement and reduce stresses.</p> <p>Other design considerations include minimizing pipeline changes across fault lines to reduce stress concentrations of an earth load applied to the pipeline due to a seismic event.</p>
	Individuals could gain access to the pipeline infrastructure aboveground assets or equipment, intending to vandalize or do harm. This could result in infrastructure damage and lead to significant repairs and disruptions to service.	<p>100% security camera coverage of all aboveground sites with real-time monitoring in a central security center or control room.</p> <p>All doors into buildings are locked and equipped with intrusion detection capabilities.</p>

7.0 KEY SAFETY CODES

There are numerous existing codes, specifications, standards, and regulatory requirements applicable to transporting gas in a pipeline. SoCalGas is familiar with, and actively implements applicable codes and standards in connection with its existing natural gas transportation system. Certain codes and standards, including PHMSA’s regulations contained in 49 CFR Part 192, also apply to the transportation of hydrogen.

In addition, there are a number of hydrogen-specific industry standards that provide best practices that should be considered for hydrogen pipelines.

Federal Regulations

1. 49 CFR Part 192, *Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards and Integrity Management*, is a comprehensive federal code covering design, materials, welding, testing, and topics in operations, maintenance, and operator qualifications (OQ). Under 49 CFR Part 192, code section 192.7 contains the documents incorporated by reference partly or wholly which include industry codes and standards, some of which may apply to hydrogen assets. Current federal minimum safety standards for pipelines transporting natural and other gases include hydrogen and do not specify differences and considerations for hydrogen specifically versus natural gas (and other gases).
2. 49 CFR Part 191, *Transportation of Natural and Other Gas by Pipeline; Annual, Incident, and Other Reporting* covers the requirements for reporting incidents, safety-related conditions, annual pipeline summary data, and other reporting. 49 CFR Part 191 would apply to hydrogen pipelines with potential changes to the format of the forms associated with reporting. 49 CFR Part 191 does not distinguish between natural gas, hydrogen, liquefied natural gas (LNG) or liquid pipelines. Part 191 is primarily a reporting section and requires establishing an Operator ID (OPID) before constructing new transportation assets.
3. 49 CFR Part 173, *Shippers – General Requirements for Shipments and Packaging* provides the requirements for transporting hazardous materials, including hydrogen, in mobile storage containers and pressure vessels. Part 173 covers the classification (hydrogen is classified as a Class 2.1 flammable gas), packaging, hazard communication, and the required transport driver training(s). Additionally, referencing 49 CFR 178, Part 173 covers the requirements for pressure vessels should hydrogen be transported as a compressed gas.¹²
4. Occupational Safety and Health Administration (OSHA), Code of Federal Regulations, Title 29, Part 1910, Subpart H. Hazardous Materials – This code addresses hydrogen as a hazardous material. 29 CFR Section 1910.103 is specific to hydrogen.

State Requirements

1. The CPUC is the agency authorized by PHMSA to oversee intrastate gas pipeline facilities in California. CPUC General Order (GO) No. 112-F, *State of California Rules Governing Design, Construction, Testing, Operation, and Maintenance of Gas Gathering, Transmission, and Distribution Piping Systems within the State of California*, is focused on many of the same regulatory requirements as 49 CFR Part 192. General Order No. 112-F incorporates by reference the current version of 49 CFR Part 192 and specifies additional rules and requirements to the Federal Pipeline Safety Regulations (49 CFR Parts 191, 192, 193, and 199).

¹² This Safety Study references 49 CFR Part 173 for shipments and packaging for containers that may contain hydrogen gas as a potential consideration but does not imply it will be incorporated within Angeles Link, as Angeles Link is proposed as a pipeline infrastructure project.

2. The California Health and Safety Code contains requirements that govern the handling, storage, and transmission of hazardous materials:
 - a. Division 20, Chapter 6.95, *Hazardous Materials Release Response Plans and Inventory* – This plan aims to prevent or minimize harm to public health and safety and the environment from a release or threatened release of a hazardous material.
 - b. Sections 25531 - 25543.3, California Accidental Release Prevention (CalARP) program – The purpose of this program is to prevent accidental releases of those substances determined to potentially pose the greatest risk of immediate harm to the public and the environment.
3. Cal/OSHA Code of Regulations. Title 8, General Industry Safety Orders – This code establishes minimum workplace safety standards. Part 5473 includes language specific to hydrogen systems and storage (refer to Subchapter 7, Group 20, Article 138).

Industry Codes and Standards

1. NFPA 2, *Hydrogen Technologies Code* – This code provides fundamental safeguards for hydrogen generation, installation, storage, piping, use, and handling. It is backed by a knowledgeable technical committee and is a valuable resource as an industry best practice, although it is not incorporated by reference into 49 CFR Part 192.
2. API RP 1162, *Public Awareness Programs for Pipeline Operators* – This recommended practice, incorporated by reference into 49 CFR Part 192, addresses the development, implementation, evaluation, and documentation of pipeline public awareness programs. The content of an operator's public awareness program should be modified when referring to a hydrogen pipeline versus a natural gas pipeline even though API 1162 does not distinguish between natural gas and hydrogen from a procedural perspective. This recommended practice is focused on creating awareness with the affected public, excavators, and local governments on the location of gas infrastructure and steps that can prevent incidents/accidents and providing information on how to report emergencies.
3. California Government Code 4216, *Protection of Underground Infrastructure* – This code is related to damage prevention for underground infrastructure. 49 CFR § 192.614 also has specific requirements related to damage prevention, including the requirement to participate in a public service program, such as a one-call system. These requirements would also apply to hydrogen pipelines.
4. API RP 1173, *Pipeline Safety Management Systems* – This recommended practice relates to all pipeline systems and includes roles and responsibilities within the operator's company from the top down. This recommended practice will continue to guide the development and maintaining of a pipeline safety management system for hydrogen pipelines. This process standard is commodity/fuel agnostic and outlines the process for creating a safety management plan.
5. *ASME Boiler and Pressure Vessel Code (BPVC)* – BPVC is a set of codes and standards developed by ASME to regulate the design, construction, inspection, and maintenance of boilers and pressure vessels. Pressure vessels used for hydrogen storage would incorporate the requirements of BPVC, including, but not limited to:

- a. BPVC Section VIII -Division 3 Article KD-10 provides special requirements for stationary pressure vessels in high-pressure hydrogen service.
 - b. BPVC Section XII provides the requirements for tanks and pressure vessels used for transportation up to 3,000 psig and volumes greater than 120 gallons.
6. ASME B31.8, *Gas Transmission & Distribution Piping Systems* – This code is applicable to the design, fabrication, installation, inspection, and testing of pipeline facilities used in the transportation of gas. Safety aspects of the operation and maintenance of those facilities, such as emergency plans, training programs, and prevention of accidental ignition are also covered. This code is considered an existing industry best practice, standard, and reference document although it is not wholly incorporated by reference into 49 CFR Part 192 (per §192.7).
 7. ASME B31.12, *Hydrogen Piping and Pipelines* – This code is applicable to piping and pipelines in gaseous hydrogen service. Guidelines are provided for the design, construction, and operation of hydrogen piping and pipeline systems for the safety, integrity, and reliability of these systems. The code covers a wide range of system components, including pipes, fittings, valves, pressure vessels, and associated equipment and is one of the most reputable hydrogen codes adopted by regulatory authorities. ASME B31.12 is not currently incorporated by reference into 49 CFR Part 192.
 8. *Compressed Gas Association (CGA) G-5, Hydrogen* – This specification is intended to provide background information and recommended practices covering the manufacture, distribution, and use of hydrogen. It summarizes the chemical and physical properties of hydrogen and provides guidance on critical aspects of hydrogen system design, including pressure relief and venting. This specification is referenced in NFPA 2 while it is not incorporated by reference into 49 CFR Part 192.

As the hydrogen economy further develops, additional industry best practices and technical specifications will likely emerge.¹³ 49 CFR § 192.7 contains the list of documents incorporated by reference partly or wholly. The list will likely expand as more standards, best practices and technical specifications are developed for hydrogen pipelines. Existing codes and standards are not considered regulations or requirements unless incorporated by reference in the Code of Federal Regulations. Industry best practices may be beneficial as reference points in the development of hydrogen infrastructure, as well as to review, and potentially incorporate, as appropriate.

Finally, international codes can be used as a reference point or basis for development of standards in the United States. Access to these international codes may provide value in understanding certain best practices for similar systems as well as potential application(s) to enhance safety.

¹³ Core objectives of the hydrogen industry are supported by SoCalGas’s collaboration with and support of organizations such as: Pipeline Research Council International (PRCI), NYSEARCH (Natural Gas RD&D), and Low-Carbon Resources Initiative (LCRI).

8.0 SPECIFICATIONS, STANDARDS & PROCEDURES EVALUATION

In accordance with PHMSA and CPUC regulations, SoCalGas has an extensive set of specifications, standards, and procedures for its existing natural gas system, which can be modified for hydrogen as appropriate. The evaluation conducted as part of this work scope focused on the existing specifications, standards, and procedures provided by SoCalGas. The methodology applied is discussed in Appendix A, *SoCalGas Standards Review Summary*. The critical identifier is “Transportation,” which places hydrogen pipeline infrastructure involved in transporting hydrogen from third-party production and third-party storage to end users under the jurisdiction of PHMSA. If new codes and standards are developed and released for incorporation into the federal safety standards, SoCalGas should update and revise the necessary specifications, standards, and procedures to comply with the requirements for safe hydrogen transportation. Currently, industry best-practice standards are available for hydrogen-specific pipelines. For example, until hydrogen-specific codes for pipe specifications and design, welding, weld flaw criteria and evaluation, and inspection and testing are developed, regulations and standards like ASME B31.12 could be used for guidance.

Recommendations for updates to procedures that will cover operations and maintenance of the hydrogen pipeline during normal operating conditions, abnormal operating conditions, leak investigation, repairs, and emergency response are contained in Appendix A, *SoCalGas Standards Review Summary*. Procedures to be developed will follow industry best practices to meet the requirements set out by PHMSA and the CPUC to include information and details such as the following:

1. Code specific language
2. Discussion of the requirements of the procedure
3. Methodology of “How To” execute the procedure
4. Records required and retention time

The following sub-sections discuss the existing specifications, standards, and procedures applicable to SoCalGas’s natural gas system, and explain how these specifications, standards, and procedures should be reviewed by SoCalGas to determine whether they could apply to Angeles Link, whether modifications would be required for Angeles Link, or whether new specifications, standards, and procedures may be necessary for Angeles Link.

Pipeline Materials, Design, Construction, and Testing Evaluation

Transmission pipeline construction is identified in 49 CFR Part 192 Subpart B through Subpart G and Subpart J. Construction qualifications for hydrogen facilities will require pipe material specifications, welding specifications, and other typical construction activities specific to hydrogen and may overlap with existing qualifications. The following regulations listed below include many of the requirements that SoCalGas should consider for review.

- 49 CFR Part 192 Subpart B, requirements for pipeline material selections, as prescribed in 49 CFR § 192.51, the minimum requirements for the selection and qualification of pipe and components for use in pipelines. Further information regarding material selection can be found in the *Pipeline Sizing and Design Criteria Study (Design Study)*.
- 49 CFR Part 192 Subpart C, requirements for new pipelines incorporates API Specification 5L “Specification for Line Pipe” by reference. Pipe manufacturers will seek API 5L certification that

the pipe manufactured and tested in accordance with API 5L will be acceptable for hydrogen service.

- 49 CFR Part 192 Subpart D lists the minimum requirements for design and qualification of pipeline components including prescribing minimum requirements for the design and installation of pipeline components and facilities, along with protection against accidental over pressuring.
- 49 CFR Part 192 Subpart E, *Welding of Steel in Pipelines*, addresses welding procedures, welding qualifications, and other issues. 49 CFR Part 192 also incorporates by reference other API Recommended Practices for transporting pipe, and API Standard 1104 “Welding of Pipelines and Related Facilities” is also incorporated by reference. These Standards and Recommended Practices must be updated to include specific hydrogen specifications.

Operations & Maintenance Procedures Evaluation

Existing SoCalGas natural gas operations and maintenance (O&M) procedures provide a basis for evaluations for hydrogen-specific requirements. O&M procedures were reviewed to provide guidance, including with respect to hydrogen safety, abnormal operating conditions, PPE required, and other topics. Specifically, procedures for leak survey/detection, fire prevention/detection, and purging hydrogen systems will be needed during pipeline, compressor, and other maintenance activities.

Typical O&M safety considerations for 100% hydrogen systems were reviewed to guide pipeline and facilities handling hydrogen; many of the O&M tasks will be structured similarly for hydrogen as they are for natural gas. 49 CFR Part 192 is the primary federal code for O&M of gas pipeline systems. GO 112-F contains additional requirements by the CPUC.

Potential for Future Odorization

Based on known factors and existing general management best practices, an odorant may be required under 49 CFR §192.625, *Odorization of gas*. For Angeles Link transmission pipeline infrastructure, the criteria in §192.625(b) will determine the requirements for odorization.

There have been several studies on the feasibility of odorizing hydrogen and the options for doing so. One such study, performed by DNV GL and SGS Nederland in 2020 for Gasunie Transport Services B.V. and Netbeheer Nederland (DNV GL and SGS Nederland, 2020), tested various types of odorants with various samples/mixtures of natural gas and hydrogen, including a 100% hydrogen sample. A panel was exposed to each sample, and several questions were asked regarding the odor and familiarity of the smell. The results of the study conclude that the mixtures of natural gas and hydrogen and pure hydrogen can be sufficiently odorized with existing odorants.

Another study conducted by MARCOGAZ in 2021 (MARCOGAZ, 2021) investigated odorization of hydrogen and hydrogen and natural gas blends. The report cites several studies from various countries, including the one performed by DNV GL/SGS Nederland. These studies concluded that all the odorants were judged suitable for use in a 100% hydrogen gas for combustion applications. Further research would be required if the intention is to supply hydrogen to stationery fuel cells or fuel cell vehicles. Experience in this matter is limited as most pure hydrogen pipelines to date are strictly for industrial purposes and are not odorized.

The MARCOGAZ report identifies potential areas for further study:

- Possible effects on odorization due to differences in physical properties of the mixture of gas and odorant (density, vapor pressure, etc.)
- Possible chemical reaction between hydrogen and odorant at high-pressure condition
- Possible effects of high concentrations of hydrogen on gas odorant
- Influences from possible impurities from hydrogen production

A discussion on odorants with Arkema Inc. was also conducted. Arkema is a global producer/manufacturer of chemicals, including odorants, for natural gas pipelines. They have also conducted tests similar to the DNV GL/SGS Nederland study and found that odorizing hydrogen will likely be feasible, and that the odorant will not interfere with leak detection technology or explosimeters. If the hydrogen is intended for fuel cells, injected odorant may need to be scrubbed out as it may impact fuel cell system performance. From the discussion with Arkema, hydrogen for use in fuel cells must be >99.97% pure; for more general use, such as combustion or blending, it can be >98% pure.

Per the studies and discussions conducted, the odorant known as tetrahydrothiophene (THT) has been identified to be compatible with a pure hydrogen system. Complementary to the studies discussed, another research study conducted by DNV GL in 2022 for Stedin and Gaz Réseau Distribution France (GRDF) (DNV GL 2022), identified three sulfur free odorants and their suitability for hydrogen in the gas grid. Due to the disadvantages of using THT in hydrogen such as for fuel cell systems, alternative sulfur-free odorants were investigated for hydrogen distribution. The odorant 2-hexyne was found not to have an adverse effect on the performance of fuel cells and was able to maintain stability in hydrogen, therefore appeared suitable for use as a sulfur-free odorant in hydrogen. As research on odorizing hydrogen gas continues, studies are revealing odorization of 100% hydrogen gas is likely to be feasible.

Leak Survey, Detection, Mitigation, and Repair

Leak management is a critical component of system operations and maintenance for several reasons including safety, environmental protection, resource conservation, and infrastructure integrity. SoCalGas has a record of successful application and continuous improvement of leak management, including the adoption of best practices such as aerial monitoring, electronic recordkeeping, use of artificial intelligence, and increased survey frequency. SoCalGas projects such as the Control Center Modernization (CCM) will utilize new field assets such as Optical Pipeline Monitoring (OPM) stations and above ground methane sensors in High Consequence Areas (HCAs).

As hydrogen pipelines are designed and installed, SoCalGas should evaluate inclusion of multiple methods of leak detection. This comprehensive leak detection system should leverage design and construction standards which may include the installation of fiber optic cables for the Angeles Link pipeline. Fiber optic technology may be used to detect and alert SoCalGas to potential events such as unauthorized digging, ground movement, heavy equipment mobilization, subsidence, and pipeline leakage/rupture. Identifying potential gas leaks and other indicators of potential leaks through continuous monitoring utilizing technologies suggested in Table 3, below, would enhance safety and operation of the pipeline. In addition, pipeline patrols performed by trained and qualified individuals within structured scheduled times that meet or exceed Federal and State requirements will provide further active monitoring and safety enhancement. Monitoring systems would alert SoCalGas to potential leaks or ruptures along the pipeline route and enable automatic response and deployment of the appropriate resources to respond and mitigate safely and efficiently.

SoCalGas's existing processes, technology, reporting, compliance, and safety notifications related to leak survey and leak detection would require certain modification for hydrogen leak consequences, but the framework from the natural gas system can be used as a starting point. The areas that will be focused on will be:

1. Leak survey and identifying "Abnormal Operating Conditions" for hydrogen.
2. Leak detection – using the appropriate equipment for detection, including confirmation of equipment calibration.
3. Leak mitigation and repair – requiring engineering and technical support.

Leak Survey

The existing SoCalGas leak survey processes, technology, reporting, compliance, and safety notifications provide a basis for applicability to the hydrogen pipeline and facilities. Current federal regulations (e.g., 49 CFR Part 192) in conjunction with stricter California GO112F regulations require Transmission pipeline leak surveys to be conducted:

- At least twice each calendar year, not exceeding 7.5 months
- Twice each calendar year, not exceeding 7.5 months, for non-odorized pipelines in a Class 3 location¹⁴, and
- Four times each calendar year, not exceeding 4.5 months, for non-odorized pipelines in a Class 4 location¹⁵.

Leak Detection

Leak detection equipment is available and can be utilized for hydrogen detection. Leak detection equipment can be categorized into the following uses:

- Permanently Mounted
- Mobile (Personal and Deployable)
- Aerial Leak Survey

Permanently Mounted Hydrogen Detectors



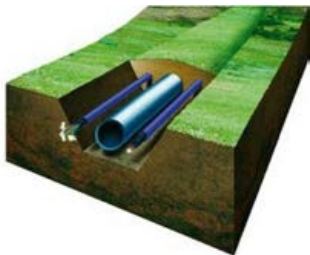
Per federal regulation 49 CFR §192.736, *Compressor stations: Gas detection*, each compressor building in a compressor station must have a fixed gas detection and alarm system, unless the building is constructed so that at least 50% of its upright side area is permanently open or is located in an unattended field compressor station of 1,000 horsepower or less.

¹⁴ A Class 3 location is: (i) Any class location unit that has 46 or more buildings intended for human occupancy; or (ii) An area where the pipeline lies within 100 yards (91 meters) of either a building or a small, well-defined outside area (such as a playground, recreation area, outdoor theater, or other place of public assembly) that is occupied by 20 or more persons on at least 5 days a week for 10 weeks in any 12-month period. (The days and weeks need not be consecutive.)

¹⁵ A Class 4 location is any class location unit where buildings with four or more stories above ground are prevalent.

Permanently mounted detection equipment should be installed near all above ground assets, in compressor stations, and at underground storage locations. Table 3, *Permanently Mounted Hydrogen Detectors*, lists various equipment identified as options for SoCalGas to consider.

Table 3: Permanently Mounted Hydrogen Detectors

<u>Equipment Name/Model</u>	<u>Specifications/Details</u>
<p>SBS-H2 Hydrogen Gas Detector (Exponential Power, n.d.)</p> 	<ul style="list-style-type: none"> • Electronic spec sheet available (SBS) • Alarm at 1% and 2% hydrogen • Fail safe mode in event of loss of power
<p>Nitto: Hydrogen Detection Tape (Nitto, Inc., n.d.)</p> 	<ul style="list-style-type: none"> • Color changing tape that detects hydrogen • Can be used on welds, fittings, equipment • Mainly used at stations
<p>OptaSense: Fiber optic pipeline detections: Real-time Pipeline Leak Detection System (Luna Innovations, 2023)</p>	<ul style="list-style-type: none"> • Uses multimode leak detection (temp, pressure, ground strain, acoustic changes) • Detects 0.1% leak size
<p>Omnisens Lynx: Pipeline - Securing asset integrity (Omnisens, n.d.)</p> 	<ul style="list-style-type: none"> • External fiber optic cable used to detect leaks, ground movement, and 3rd party intrusion • Continuous, real-time monitoring • Leak detection based on temperature change along the line • Geohazard and 3rd party intrusions detected by strain and/or vibrations


Mobile Hydrogen Detection Equipment

Detection equipment to monitor and alarm for the presence of hydrogen should be worn or carried by operations personnel as appropriate during operations and maintenance activities. Table 4, *Mobile*

Hydrogen Detection Equipment, lists the available equipment for consideration by SoCalGas for personal wear.

Table 4: Mobile Hydrogen Detection Equipment


Equipment Name/Model	Specifications/Details
<p>Industrial Scientific – Multi-sensor: MX6 iBrid® Multi-Gas Detector (Industrial Scientific Corporation, n.d.)</p>  <ul style="list-style-type: none"> • 24 "Plug-and-Play" field-replaceable sensors including PID and Infrared options • Up to 6 gases monitored simultaneously • Simple, user-friendly, customizable, menu-driven navigation • Five-way navigation button • Durable, concussion-proof overmold • Optional integral sampling pump with strong 30.5 meter (100 feet) sample draw • Full-color graphic LCD is highly visible in a variety of lighting conditions • Powerful, 95 dB audible alarm 	<ul style="list-style-type: none"> • Electronic spec sheet available (Industrial Scientific Corporation, 2019) • Up to 6 gases monitored simultaneously • Optional integral sampling pump with strong 30.5 m (100 ft) sample draw; 20 hour run time with pump, 36 hours without pump • Operating temperatures range from -4°F to 131°F • Full-color graphic LCD is highly visible in a variety of lighting conditions • Powerful, 95 dB audible alarm • Hydrogen: <ul style="list-style-type: none"> ○ Range 0-2,000 ppm range, 0.10 ppm resolution ○ Response time: T50: 25 seconds, T95: 60 seconds ○ Calibration gas: 100 ppm hydrogen ○ Accuracy: +/-6%
<p>Industrial Scientific – Single Gas: GasBadge® Pro Single-Gas Detectors (Industrial Scientific Corporation, n.d.)</p> 	<ul style="list-style-type: none"> • Electronic spec sheet available (Industrial Scientific Corporation, 2017) • Range: 0-2,000 ppm • Event logger for 15 alarm events • Replaceable battery with a 2,600-hour run time
<p>Dräger: X-am 8000, 5000, 2500, 5600 all can be combined with Hydrogen sensors, Hydrogen H2 – Detectors & Protection Equipment (Dräger, n.d.)</p> 	<ul style="list-style-type: none"> • Electronic spec sheet available (Dräger, 2022) • 1-5 gas sensors • 40-hour charge time • Normally 1 second measuring interval • Sensors range: 0-2,000 ppm <ul style="list-style-type: none"> ○ DrägerSensor XXS CO/H2 Compensated ○ DrägerSensor XXS H2
<p>Grainger Industrial Supply (Various other hydrogen gas detectors)</p>	<ul style="list-style-type: none"> • Combustible Gas Detectors

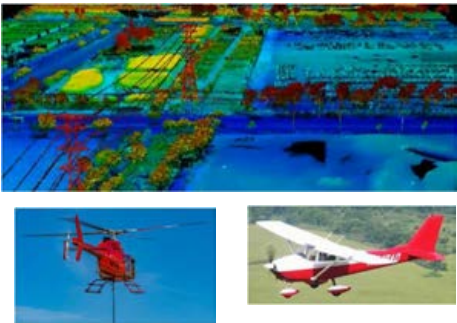
<u>Equipment Name/Model</u>	<u>Specifications/Details</u>
<p>Industrial Scientific – Radius® BZ1 Area Gas Monitor (Industrial Scientific Corporation, n.d.)</p>  <ul style="list-style-type: none"> • Detect up to seven gases simultaneously with 22 sensor options, including PID • Know what's happening at a distance thanks to the largest display of any area monitor and customizable alarm action messages like "EVACUATE" or "VENTILATE" • Gain real-time visibility and respond faster in an emergency by pairing with the RGX® Gateway and iNet Now for live monitoring • DualSense® Technology increases worker safety by using two sensors to detect the same gas • SafeCore® Module houses all critical technology out of the elements for fewer false alarms 	<ul style="list-style-type: none"> • Electronic spec sheet available (Industrial Scientific Corporation, n.d.) <ul style="list-style-type: none"> ○ Rechargeable battery ○ Temp range: -4F to 131F ○ 108 Decibel alarm @ 3.3ft away ○ H2 range: 0-2,000 ppm ○ Logs 60 events ○ H2 sensor: 17156650-C Part #

Aerial Leak Survey Hydrogen Detection Equipment

Equipment that could be mounted on drones or manned aircraft is presented in Table 5, *Aerial Leak Survey Equipment for Hydrogen Detection*, for SoCalGas’s consideration. Drone options present advantages as they can fly at lower altitudes and slower speeds for more accurate hydrogen detection compared to manned aerial aircrafts.

Table 5: Aerial Leak Survey Equipment for Hydrogen Detection

<u>Equipment Name/Model</u>	<u>Specifications/Details</u>
<p>Sniffer 4D – Mobile Air Pollutant Mapping System – Drone-based Air Pollutant Mapping System (TPI, n.d.)</p> 	<ul style="list-style-type: none"> • Attachable to drones, planes, trucks/cars, and is wearable. • Wide-range H2 Sensing Module <ul style="list-style-type: none"> ○ Detection method: electrochemistry ○ Range: 0-5,000ppm ○ Detection limit: 17ppm ○ Repeatability: <5%FS ○ Overall response time (t90): <55s (0-400ppm) ○ Theoretical resolution: <0.7ppm ○ On-chip proprietary individual difference compensation algorithms ○ Support “Dormant Mode,” warm-up time from a cold start: <10s ○ Zero drift: <±20ppb/year (in laboratory environment) ○ Est. service life: >24months ○ Operating temperature: -30-50°C ○ Operating humidity: 15-90%RH • Sniffer4D – Mobile Air Pollutant Mapping System (TPI, n.d.) comprises of various components that can be mounted on a moving platform. • Electronic spec sheet available (TPI, 2023)

<p>Hawkeye Helicopter – Fixed wing airplane or rotor-wing aircraft (Hawkeye Helicopter, n.d.)</p> 	<ul style="list-style-type: none"> • Variety of top technology partners nationwide • Detect leaks, encroachment, and/or erosion • Laser aerial leak detection capable of detecting minute PPM levels at ground level • Aerial video including GIS centerline data as well as a host of other references • Aerial photography to assist in right-of-way certification, project planning and maintenance, structure counts, and more • High-density LiDAR data • Infrared and Corona inspections
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Furthermore, the *Supraparticles for Bare-Eye H2 Indication and Monitoring: Design, Working Principle, and Molecular Mobility* (Adv. Funct. Mater. 2022) research article recognizes sensors and indicators for hydrogen are essential in safely managing hydrogen by applying sensing agents to make hydrogen visible. This research introduces sensors with the capability to enable bare-eye detection of hydrogen leaks and can be applied as powders, inks, paints, or coatings. The research concluded the ability to synthesize and investigate a particulate additive for real-time monitoring and the presence of hydrogen gas, detectable by the bare eye for a wide variety of applications during hydrogen production, transport, and storage.

As summarized in this study, there are known leak detection options and equipment for hydrogen pipelines. Multiple vendors have been identified that can provide leak detection equipment specifications for hydrogen detection for permanently mounted, mobile detection equipment, fiber optics, and options for aerial leak detection. Information regarding other hydrogen detection equipment based on literature review is provided in the parallel “Leakage Report.”

Leak Mitigation and Repair

Field workforce responsible for operating and maintaining Angeles Link must be trained appropriately to enable rapid leak response. The following actions may be required in response to an identified leak depending on the specific circumstances:

- Steps and measures to protect public and operator personnel per 49 CFR §192.711 – Requirements and techniques for temporary and permanent repairs on a hydrogen pipeline may differ from natural gas pipelines and would require operator qualifications specific to those tasks.
- Report the safety-related pipeline condition per 49 CFR §191.23 and SoCalGas procedures – These requirements and procedures would likely not require changes to operator’s skill or tasks related to Angeles Link.
- Communicate emergency incidents per 49 CFR §192.615 and SoCalGas procedures.
- Pipeline section isolation – The Angeles Link pipeline infrastructure would be required to follow the PHMSA Valve Installation and Minimum Rupture Detection Standards, rupture mitigation valves and isolation criteria, which would align with SoCalGas’s natural gas system requirements for new construction and certain replacement projects.
- Traffic diversion at road crossings.

- Compressor station sites placed in Fail-Safe Mode.

49 CFR §§ 191.15 and 191.17 contain the requirements for incident reporting and annual reports. 49 CFR §§ 191.23 and 191.25 contain the requirements for safety-related condition reporting. For repairing leaks, PHMSA has proposed a new addition to the 49 CFR Part 192 code to establish minimum criteria for leak grades and associated repair schedules to be prioritized by safety and environmental hazard (Pipeline and Hazardous Materials Safety Administration, 2023). This proposed rule aims to define the criteria and repair schedules to prioritize environmental risks along with the risks to persons and property.

Integrity Management

Transmission integrity management is governed by 49 CFR Part 192 Subpart O, which prescribes the requirements for an Integrity Management Program for covered segments along a gas transmission pipeline. This regulation requires pipeline operators to assess, identify, and address the safety of assets that are located in HCAs. The future framework for an integrity management program could likely continue to follow current requirements specified in 49 CFR Part 192 Subpart O. Certain processes/calculations and assessment technologies and/or intervals may change as outlined in the following integrity management activities. Damage prevention, Public Awareness Plans, and coordination with local responders increase the effectiveness of educating landowners and the general public about the presence of a new hydrogen pipeline, decreasing the likelihood of damage that can significantly impact the integrity of the pipeline infrastructure.

Class Location - The process for determining class location along a pipeline is to utilize a buffer of 660 feet on either side of the pipeline centerline and identify structures or well-defined outside areas along the pipeline that fall within a one-mile sliding segment (see 49 CFR § 192.5, Class locations).

The gas factor for hydrogen in the equation for calculating the potential impact radius (PIR), utilized for determining HCAs and moderate consequence areas (MCAs) along a pipeline route differs from the factor for natural gas. Per the final report issued by Michael Baker Jr., Inc., June 2005, "TTO Number 13, Potential Impact Radius Formulae for Flammable Gases Other Than Natural Gas Subject to 49 CFR 192", which can be found on PHMSA's website (PHMSA, n.d.), the factor for hydrogen is 0.47, which leads to the following formula for calculating the PIR:

$$r=0.47\sqrt{p \cdot d^2}$$

where:

r = the PIR in feet,

p = the pipeline maximum operating pressure in pounds per square inch, and

d = the nominal pipeline diameter in inches.

Once the PIR is calculated, the HCAs and MCAs can be determined for the hydrogen pipeline using the same methodology as for a natural gas pipeline.

To note, the factor for hydrogen (0.47) is lower than the factor for natural gas (0.69), which results in lower PIR than a similar pipeline carrying natural gas. This could result in fewer HCAs and MCAs identified

for a hydrogen pipeline versus a natural gas pipeline, and potentially differing class locations along the pipeline route.

The process for determining class location, HCAs, and MCAs utilizes public data to evaluate structure counts and identified sites via class studies and/or field verification. A pipeline system can be modeled in a Geographic Information System (GIS) which allows for electronic data integration. Operations, integrity management, and technical services teams continually review and update (where needed) this information. Future Angeles Link infrastructure could be comprehensively evaluated using similar methods and processes in order to comprehensively determine the class location along the pipeline.

Threat Identification/Evaluation - Threats to a hydrogen pipeline are similar to threats for a natural gas pipeline while the degree of risk may vary. Data gathering and integration would likely be substantially similar as data sources and methodology would remain the same.

Risk Assessment - The risk algorithm should be adjusted to account for differences in the physical and chemical properties of hydrogen versus natural gas. Risk assessment is an annual process that is completed to support assessment types and scheduling, along with identifying appropriate preventive and mitigative measures.

Pigging – In-line inspection (ILI) of pipelines, such as through the use of smart pigs, may help to identify pipeline integrity issues that could result in pipeline failures. ILI of hydrogen pipelines is possible and can be utilized as one of the assessment methods identified by 49 CFR Part 192 Subpart O, *Gas Transmission Pipeline Integrity Management*, which requires regular assessment of pipeline segments that could affect a high consequence area. One such vendor, TD Williamson (TDW), has successfully inspected hydrogen pipelines via ILI using modifications to their existing tools. They concluded, "In terms of general pigging of new, converting, and operational pipelines carrying pure or blended hydrogen, existing tools can be modified or implemented with minimal engineering or cost. For ILI, combination tools and multiple mission runs can be used to establish needs to be addressed before hydrogen service with no changes required. When hydrogen pipelines are in service, especially those transporting highly pure hydrogen, a significant redesign of the ILI tools is required. However, it has been proven that successful inspection can be achieved under operational conditions." (Romney, Barker, Geren, & Kirkwood, 2021).

Rosen Group (Rosen) has also been researching and developing solutions for assessing hydrogen pipelines via ILI. (ROSEN Group, n.d.)

Pipeline operators also have an option of "batching" ILI tools, meaning the tool is loaded into the middle of two isolation pigs (one in front of the ILI tool and one behind) and the ILI tool is in a compatible pressurized gas, such as nitrogen (or a slug of diesel if the tool requires a liquid coupling). ILI inspections are one potential component of the overall Integrity Management Program governed by Subpart O of 49 CFR Part 192. Overall, the hydrogen industry is actively pursuing enhancing pigging solutions to proactively design, construct, or retrofit pipelines to incorporate the appropriate ILI tools to identify hydrogen pipeline integrity concerns. ILI vendors are currently developing and modifying ILI tools to perform assessments in pure hydrogen service.

Hydrostatic Testing – Hydrostatic testing (hydrotesting) of transmission pipelines is governed by 49 CFR Part 192 Subpart J, *Test Requirements*, which generally requires hydrotesting of new gas pipelines prior to placing into service. Testing will be dependent on pipe grade, pipe diameter, wall thickness, planned Maximum Allowable Operating Pressure (MAOP), hoop stress as a function of Specified Minimum Yield Strength (SMYS), and Class Location. The testing requirements remain applicable to hydrogen pipelines.

Cathodic Protection – Cathodic Protection is governed by 49 CFR Part 192 Subpart I, *Requirements for Corrosion Control*. This subpart contains all the requirements for cathodic protection and other external and internal corrosion control. Requirements for external corrosion control are expected to be the same between natural gas and hydrogen pipelines as they will be exposed to the same environments regardless of commodity transported; external coatings and other external protection mechanisms are effective for both pipeline systems. Internal corrosion control, such as internal tank coatings, will be specifically based on the physical and chemical properties of hydrogen.

Emergency Shutdowns

Emergency shutdown systems are a collection of devices that are primarily located at compressor stations and may also be located at other facilities. They are governed by 49 CFR §192.167, *Compressor Stations: Emergency Shutdown*, which contains all the requirements for emergency shutdown devices (ESD). ESD Systems must meet the following requirements listed in 49 CFR §192.167(a):

- ESD Systems must be able to block gas out of the compressor station and blow down the station piping.
- ESD Systems must discharge gas from the blowdown piping at a location where the gas will not create a hazard.
- ESD Systems must provide means for the shutdown of gas compressing equipment, gas fires, and electrical facilities in the vicinity of gas headers and in the compressor building, except that:
 - Electrical circuits that supply emergency lighting required to assist Station Personnel in evacuating the compressor building and the area in the vicinity of the gas headers must remain energized; and
 - Electrical circuits needed to protect equipment from damage may remain energized.
- ESD Systems must be operable from at least two locations, each of which is:
 - Outside the gas area of the compressor station;
 - Near the exit gates if the compressor station is fenced or near emergency exits if not fenced; and
 - Not more than 500 feet (153 meters) from the limits of the compressor station.

An ESD system is ultimately an engineered assembly of control devices. When activated during an emergency they will stop equipment that is part of a specific operating system, close certain valves to isolate that system, and may open other valves to cause the system to depressurize to atmosphere. The objective of an ESD is to get the system to a safe condition.

Other Safety Factors

Hydrogen PPE

Wearing PPE is a common practice in the pipeline industry to increase the personal safety of personnel in the work environment. By providing proper PPE to SoCalGas personnel, SoCalGas provides protective equipment in case an unanticipated event occurs during the performance of work on pipeline infrastructure or while responding to abnormal operating conditions or emergencies. SoCalGas will advise contractor personnel of the minimum PPE requirements. Contractors should be informed of the need to provide PPE to contractor personnel and the minimum standards for hydrogen PPE. Testing and performance of PPE should also account for any applicable changes in specifications for use for hydrogen systems. PPE may be grouped into the following two categories:

- PPE for routine O&M
- PPE worn for emergency events

Mobile leak detectors like those worn by operating personnel are also a form of PPE; there are available options for hydrogen detection, which are covered in the *Workforce Planning & Training Evaluation* study, under the *Leak Survey, Detection, Mitigation, and Repair* section. Research from Bulwark Protection, a leading industry PPE and flame-resistant clothing expert and supplier, is summarized in this section to present data on fire and heat rating capabilities of PPE clothing and gear in the event of a hydrogen fire.

The flame resistance of the PPE was reviewed, which is the property of a material/clothing whereby combustion is prevented, terminated, or inhibited following the application of a flaming or non-flaming source of ignition (i.e., a flame or electric arc), with or without subsequent removal of the ignition source.

Standards reviewed include NFPA 2112, NFPA 2113, and ASTM 1930 (Manikin Test). Table 6, *PPE Standards and Uses*, summarizes the standards related to PPE and how they are utilized.

Table 6 – PPE Standards and Uses

<u>Standard</u>	<u>Description</u>	<u>Use</u>
<p>NFPA 2112, Standard on Flame-Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire</p>	<p>Specifies performance requirements and test methods for flame-resistant fabric and garments. (National Fire Protection Association, 2023)</p>	<p>Protects workers from flash fire exposure and injury through the specified requirements and test methods for constructing flame-resistant garments.</p> <p>Per Bulwark Protection;</p> <ul style="list-style-type: none"> • Materials should be tested for a Heat Transfer Performance (HTP) of at least: <ul style="list-style-type: none"> - Spaced (layered) 6 cal/cm² - Base layer “skin contact” 3 cal/cm² • Test for thermal shrinkage • Emblems are placed on the exterior of the garment. <ul style="list-style-type: none"> - Standard for all flame-resistant garments. • Standard against flammable dust, gas, and liquids. • Utilizes the Manikin test (ASTM F1930) for material testing. • Utilizes standard propane as the source gas for the flame test. • Exposure for 3 seconds to flame. (3 seconds is defined as the upper limit of flash fire). • Must have >50% 2nd and 3rd degree body burn combination to pass.

<u>Standard</u>	<u>Description</u>	<u>Use</u>
NFPA 2113, Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire	Specifies selection, care, use, and maintenance requirements for garments compliant with NFPA 2112. (National Fire Protection Association, 2020)	Reduce health and safety risks associated with incorrect selection, use, and maintenance, and contamination and damage of flame-resistant garments.
ASTM 1930, Standard Test Method for Evaluation of Flame-Resistant Clothing for Protection Against Fire Simulations Using an Instrumented Manikin	This test method predicts human skin burn injury for single-layer garments or protective clothing ensembles mounted on a stationary upright instrumented manikin, which is then exposed in a laboratory to a simulated fire environment with controlled heat flux, flame distribution, and duration. The average exposure heat flux is 84 kW/m ² (2 cal/s-cm ²), with durations up to 20 s. (American Society for Testing and Materials, 2023)	Measures the thermal protection provided by different materials, garments, clothing ensembles, and systems when exposed to a specified fire. Provides predicted skin burn injury for a specific garment or protective clothing ensemble when exposed to a laboratory simulation of a fire.

In summary, NFPA 2112, combined with ASTM F1930, is the material standard that dictates how materials should be tested and how results are accepted/recorded. NFPA 2112 is currently the only industry standard covering various fuels and is widely accepted by the oil & gas industry. Continued dialogue with PPE vendors is recommended to address anti-static issues and other specific concerns with materials used in coveralls, earmuffs, and other items.

Security (Physical and Cyber Security Procedures)

The TSA/Homeland Security define Critical Infrastructure in the Energy Sector to include assets, systems, or networks both physical and virtual, that are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof.¹⁶ This definition includes natural gas pipeline infrastructure currently owned and operated by SoCalGas. As such, existing SoCalGas security policies regarding both physical and cyber security should be reviewed and updated accordingly to include references to hydrogen infrastructure, as appropriate. SoCalGas may also consider a review with third-party owners/operators of hydrogen production sites and hydrogen storage that Angeles Link interfaces with to evaluate the compatibility of their physical and cybersecurity plans with that of SoCalGas. For

¹⁶ Critical Infrastructure Sectors: CISA. Cybersecurity and Infrastructure Security Agency CISA. (n.d.). <https://www.cisa.gov/topics/critical-infrastructure-security-and-resilience/critical-infrastructure-sectors>.

example, hydrogen production sites may be considered Critical Infrastructure if the loss of production negatively impacts downstream users as defined by TSA/Homeland Security Guidelines.

Physical Security

Physical security at Critical Infrastructure sites is a requirement of and is subject to audit by TSA/Homeland Security. These requirements include access controls such as: perimeter security fences, locked gates, and site security cameras for these sites. Site specific security measures are also required for facilities including valve sites, receipt meter stations, delivery meter stations, and compressor/regulator stations. Other physical concerns may be facility related such as gates, fence height, razor wire, electronic access to sites, door alarms, security cameras, and other physical access concerns.

SoCalGas's physical requirements for perimeter security at compressor stations, block valve sites, and meter/regulator stations are based on the TSA/Homeland Security Guidelines to prevent intrusion by non-SoCalGas personnel. SoCalGas should consider the same physical security procedures for all Angeles Link sites as specified by TSA/Homeland Security Guidelines for Critical Infrastructure. SoCalGas may also consider a review with third-party owners/operators of hydrogen production sites and hydrogen storage for their physical and cybersecurity plans and compatibility with SoCalGas's physical and cybersecurity plans.

Cyber Security

The threat environment in the cyber security realm is continuously changing, so security practices must also advance. The TSA/Homeland Security provides guidelines for security measures to protect Critical Infrastructure for natural gas and hazardous liquid transmission pipeline systems, natural gas distribution pipeline systems, and liquefied natural gas facility operators within the TSA "Pipeline Security Guidelines" document.¹⁷

The Cybersecurity and Infrastructure Security Agency (CISA) conducts specialized security and resilience assessments on the nation's critical infrastructure.¹⁸ Applicability of CISA's assessment requirements for Angeles Link has yet to be determined as it will depend on the completion of the final route selection and design of the pipeline system. If an assessment is required, the pipeline's SCADA system would be evaluated for compliance with TSA/Homeland Security Guidelines and may be based on the same activity for the natural gas system. Critical Infrastructure and the necessary Physical Security requirements are based on the location of pipeline assets; therefore, an assessment must be conducted on the hydrogen system once the detailed design is developed.

SoCalGas has hardened security measures implemented for its critical gas facilities and the alarm response protocols that have been established will support a Critical Infrastructure analysis. After the Critical Infrastructure analysis is completed and submitted to the TSA, SoCalGas's next steps would be to perform a security vulnerability assessment and inventory for cyber-sensitive assets, including SCADA

¹⁷ Pipeline security guidelines. (n.d.-c). https://www.tsa.gov/sites/default/files/pipeline_security_guidelines.pdf.

¹⁸ Critical infrastructure assessments: CISA. Cybersecurity and Infrastructure Security Agency CISA. (n.d.-a). <https://www.cisa.gov/critical-infrastructure-assessments>.

system and control center/backup centers. After completing these steps, SoCalGas would determine the need to install cybersecurity protection systems.

Other DOT Requirements (Drug & Alcohol Testing)

DOT drug and alcohol testing requirements are specified by 49 CFR Part 199. Part 199 applies to the transportation of natural gas, hydrogen, LNG, and liquids pipelines rather than a specific fuel. Therefore, drug and alcohol testing pursuant to 49 CFR Part 199 is not dependent on the fuel being transported and would apply to the potential workforce personnel for the proposed Angeles Link as defined in the SoCalGas Drug & Alcohol Plan. The Drug & Alcohol Plans specifies testing pools and the number of drug/alcohol tests required yearly. In addition, all new employees joining SoCalGas for the hydrogen system that are in positions subject to drug and alcohol testing would require pre-employment drug/alcohol testing. SoCalGas's construction contractors would need to provide verification that construction personnel have followed testing procedures stated in the construction contractor's Drug & Alcohol Plan.

9.0 CONTROL ROOM AND EMERGENCY RESPONSE

SoCalGas operations are driven by safety and, accordingly, SoCalGas has an Emergency Management Preparedness and Response Policy, which illustrates SoCalGas's commitment to safety and strategies for preparedness. As hydrogen gets further integrated into SoCalGas's procedures and policies, certain aspects of the emergency response procedures may require modification and updates to apply more specifically to hydrogen assets.

Gas Control & Control Room Management

SoCalGas is an existing pipeline operator and, as such, has Control Rooms where Gas Control operations personnel monitor and/or control pipeline facilities in real-time, 24 hours a day, seven days a week. This monitoring covers both SoCalGas and San Diego Gas & Electric's combined gas-transmission systems, including associated pipelines, line compressor stations, and underground storage facilities. Therefore, SoCalGas has a comprehensive Control Room Management Plan which can be leveraged and subsequently tailored specifically to hydrogen operations.

Supervisory Control and Data Acquisition System

SCADA systems consist of both software and hardware components and enable remote and on-site monitoring of data gathered from various equipment and systems at different geographical locations. Pieces of data are continuously collected in real-time from multiple sources along the pipeline and at other related appurtenances or facilities and then displayed in the Control Room through a Human Machine Interface (HMI). Attributes can be assigned within the electronic system to automatically trigger alarms or notifications if conditions deviate from preassigned thresholds or parameters. These SCADA systems allow for the integration of a variety of different technologies in the field with an electronic management information system.

The hydrogen pipeline system is anticipated to require a SCADA system to allow for remote monitoring and operation of the pipeline and compressor station components. SoCalGas may elect to integrate this system as appropriate to their existing SCADA operations and/or train existing System Operators.

Control Center Modernization (CCM)

Independent of Angeles Link, SoCalGas is in the process of implementing the CCM project, which will further digitalize the existing natural gas transmission and distribution pipeline system with new field assets such as OPM stations and HCA methane sensors. The CCM project will drive the change or creation of new and existing business processes that will enhance the following:

- OPM stations and HCA methane sensors on the transmission system;
- Alarm response, planned/unplanned incidents, and maintenance activities related to the newly deployed distribution and transmission field assets;
- Coordination with Distribution Field Operations, Dispatch, Transmission, and Emergency Management and Preparedness organizations; and
- Data analysis through new situational awareness platforms being introduced via CCM technologies.

The system design, and new and enhanced processes developed for the CCM project may be beneficial and potentially leveraged in the planning and implementation of Angeles Link.

Emergency Response Procedures

The Emergency Management Preparedness and Response Policy documents how SoCalGas prepares and responds to emergencies by using the Plan-Do-Check-Act (PDCA) cycle for continuous improvement of its processes. This document provides an overall guide to SoCalGas's employees and contractors when responding to health and safety related incidents to protect employees, contractors, customers, the public, and property. SoCalGas Emergency Management Department is staffed with a Watch Office that provides 24/7 monitoring of its service territory and oversees an Emergency Operations Center (EOC) which may be activated when there are large impacts or a natural disaster event that may require coordination and communication with multiple internal and/or external organizations. The Watch Office provides real-time data monitoring, using tools such as Data Capable, to increase situational awareness and identify potential hazards, create executive notifications, convene situational awareness meetings, and timely regulatory reporting to external agencies. Based on the evaluation of the incident, the Watch Office will then recommend if an EOC activation is required. Once activated, one of the objectives of the EOC is to offer timely, accurate information to government officials, regulatory authorities, employees, customers, the public, and the media. Furthermore, SoCalGas Regional Public Affairs department provides courtesy notifications to local public officials when there is a leak on a transmission line or a reportable incident. Existing SoCalGas emergency response procedures, programs, technology, reporting, and safety plans should be updated for applicability to hydrogen pipeline and facilities. The existing emergency response procedures focus on the SoCalGas natural gas system, comprising transmission pipelines, storage fields, compressor stations, and extensive distribution systems – including residential, commercial, and industrial meters. Emergency Response personnel, including Control Room personnel and field personnel responding to indications of leaks or rupture incidents, require detailed training on hydrogen's physical and chemical properties.

Emergency response requirements are specified in 49 CFR § 192.615 and, in compliance with these requirements, SoCalGas has established written procedures to minimize hazards that result from a gas pipeline emergency. SoCalGas's existing emergency response procedures for the natural gas system provide a foundation and framework for emergency plans that are specific to hydrogen.

Notification of Leaks

SoCalGas receives notifications of potential leaks for its existing infrastructure through a variety of ways such as monitoring systems, leak surveys and patrols, as well as customer calls. Depending on odorization or equipment selections, leak notification procedures may need updates to address a 100% hydrogen system. The process by which leak notifications are received, and personnel are dispatched may need modification, and personnel receiving the notifications may need specific language to communicate to the person(s) making the notification and to first responders at the location of the reported leak.

Leak notifications may be received from compressor station sites and valves, meter, and regulator sites along the pipeline routes, as well as the third-party hydrogen production sites and third-party hydrogen storage sites. They can be received in several ways, including notifications from SoCalGas employees through regular monitoring, public notifications, gas-detecting equipment and instrumentation, and emergency response (fire, police, and other law enforcement). Leak notifications should be corroborated with leak detection equipment located at each site, with SoCalGas operations personnel dispatched for emergency response to confirm and mitigate leaks immediately.

Liaison with Local Emergency Response

Coordination with local emergency responders may include hydrogen-specific information and training, including proper equipment and awareness of the differences between hydrogen and natural gas. As hydrogen's physical and chemical properties differ from those of natural gas (refer to Section 2.0, *Physical and Chemical Properties of Hydrogen*, of this study), emergency response personnel should be trained to handle mitigating and preventing situations involving hydrogen. This may include hydrogen-specific training and changes to equipment utilized for emergencies.

To be prepared in the event of an emergency, it is important to liaise with the local emergency responders and appropriately communicate potential differences in their response, equipment, and resources for incidents involving hydrogen, as opposed to natural gas. SoCalGas's existing Emergency Management Preparedness and Response Policy has a robust external stakeholder engagement outreach program that can be leveraged for Angeles Link. The outreach program includes a First Responder Program developed to educate first responders (fire and police) on safely working with SoCalGas personnel when responding to natural gas-related incidents. The program also establishes local contact between SoCalGas field operations and first responders and provides information about SoCalGas's response capabilities and the level of participation during a unified command.

Damage Prevention

A damage prevention program to prevent damage to a pipeline from excavation activities is required pursuant to 49 CFR § 192.614. The One Call system, also known as 811,¹⁹ is a critical tool for preventing accidental damage to underground utility assets during construction or excavation. Contractors and

¹⁹ Pipeline Safety Stakeholder Communications. PHMSA. (n.d.). <https://primis.phmsa.dot.gov/comm/cbyd.htm>.

excavators use this system before digging to identify the location of utility assets such as natural gas, water, electricity, and telecommunications. Contractors or anyone digging can call the toll-free 811 number or submit an online request, providing details about the proposed excavation location. The One Call system then notifies all relevant utility owners in the vicinity. Utility personnel mark the exact location of their facilities on the ground, enabling safe excavation practices. While the system primarily covers existing utility assets, it is essential to include emerging hydrogen infrastructure. Overall, the One Call system enhances safety, protects critical infrastructure, and promotes responsible construction practices while mitigating damages before they occur.

10.0 AWARENESS, EDUCATION, AND TRAINING

Hydrogen has been used in various forms for decades across a variety of industries, but it is acknowledged that public awareness of the transmission and distribution of pure hydrogen as part of an energy utility delivery system is relatively new. SoCalGas employees and contractors will require appropriate documented and accredited training to construct, operate, and safely maintain hydrogen transmission and distribution systems. Furthermore, the public should be provided access to educational materials on hydrogen safety. Given the global interest in the implementation of hydrogen as a clean energy source, there are several organizations currently providing training to owners, operators, contractors, and other interested parties. As the adoption of hydrogen continues to accelerate, additional resources and new accreditations and certifications may become available and must be evaluated.

Public Awareness Plans

PHMSA requires pipeline operators to develop and implement public awareness plans and damage prevention programs (see 49 CFR § 192.616 and § 192.614). Public awareness plans must comply with the requirements of API RP 1162, first edition. API RP 1162 includes guidance for pipeline operators to develop and implement Public Awareness Programs to communicate safety and other relevant information to all stakeholders, emergency response agencies, and local government officials, and excavators. The existing SoCalGas Public Awareness Plan for natural gas infrastructure can serve as a template. SoCalGas's damage prevention program contains additional requirements that can also be incorporated and can follow closely with SoCalGas natural gas infrastructure language.

In addition to PHMSA's requirements, SoCalGas must comply with California Public Utilities Code Section 956.5, which requires that at least once per calendar year, owners and operators of intrastate transmission and distribution lines shall meet with each local fire department having fire suppression responsibilities in the area where those lines are located to discuss and review contingency plans for emergencies involving the intrastate transmission and distribution lines within the jurisdiction of the local fire department.

In compliance with 49 CFR § 192.616, SoCalGas implements an existing Public Awareness Program for its natural gas system, which includes the following:

- Enhance safety through increased public awareness and knowledge;
- Reduce third party damage to pipeline facilities; and
- Provide better understanding of pipeline emergency response.

These objectives are achieved by educating the public on:

- The existence and purpose of pipelines;
- Use of a one-call notification system prior to excavation and other damage prevention activities;
- Possible hazards associated with unintended releases from a pipeline facility;
- Physical indications that such a release may have occurred; and
- Steps that should be taken for safety in the event of a pipeline release and procedures to report such an event.

The current SoCalGas Public Awareness Plan follows the guidance provided in API RP 1162, *Public Awareness Programs for Pipeline Operators*. Specifically, the plan identifies the audiences to be considered for targeted communications, the frequency of messages, the messages to be delivered to each audience, and the methods and vehicles for delivering the messages. Furthermore, SoCalGas has specific measures to evaluate the effectiveness of its public awareness program and materials. The public awareness plan identifies communications for sharing pipeline safety risk information with those residing near the pipelines and defines a mechanism whereby the public can report safety risk issues to SoCalGas.

SoCalGas's public awareness program implements the public awareness plan to inform and educate customers, affected public, pertinent public officials and municipal staff, first responders/emergency officials, and persons engaged in excavation-related activities about the prevention and recognition of gas pipeline emergencies. This program also includes the process for reporting an incident to SoCalGas and the appropriate public officials including first responders. SoCalGas's First Responder Outreach program networks with over 200 agencies to acquaint first responders with gas pipeline emergencies response, types of gas pipeline emergencies and to engage in mutual assistance to minimize hazards to life or property. Accordingly, the specific details on what information is conveyed and the product descriptions will differ depending on the type of gas being transported. An example of a key difference is the use of pipeline markers/signage along a pipeline route. API RP 1162 has prescriptive language for the size, lettering, and marker information. The existing SoCalGas line markers indicate natural gas is being transported through the pipeline; therefore, for a dedicated clean renewable hydrogen pipeline, SoCalGas will need to create line markers to indicate hydrogen gas is being transported through the pipeline. Leveraging the SoCalGas existing public awareness program will lay the groundwork to make the necessary adjustments required to reflect the operations of a dedicated clean renewable hydrogen pipeline.

Education and Safety Training

SoCalGas is continually increasing its knowledge, education, and understanding of hydrogen through training materials and courses offered by outside accredited organizations. As SoCalGas's knowledge base and expertise continue to grow, and hydrogen-specific codes and regulations take shape, safety training requirements will be developed for inclusion into the Angeles Link O&M manual and OQ training program. Skillsets related specifically to hydrogen pipeline systems will be evaluated and operating and maintenance procedures will be identified to meet the requirements of 49 CFR Part 192 Subpart N, *Qualification of Pipeline Personnel*. Pipeline personnel will be trained, tested, and evaluated according to a written qualification program. Furthermore, as preliminarily identified in Appendix A, *SoCalGas Standards Review Summary*, the training associated with the standards and procedures potentially

applicable to Angeles Link should be updated or created for the applicable job classifications. Training conducted prior to completion of the O&M plan and OQ training program could incorporate the physical and chemical properties of hydrogen, PPE, and leak detection, providing a basis for hydrogen safety training. Additional considerations for hydrogen education and training for the workforce for Angeles Link are included in the *Workforce Planning & Training Evaluation* study.

SoCalGas's [H2] Innovation Experience²⁰ is a fully integrated demonstration project that shows how renewable hydrogen could be used to safely transition to clean and resilient energy systems of the future. Providing public awareness and visibility into these advancements, along with collaboration with industry experts to help prepare additional standards for dedicated pipelines for hydrogen transport, support the development of transmission pipeline procedures inclusive of safety requirements.

Accredited Organizations

Several organizations are accredited to provide hydrogen safety training and operator training. The following organizations are summarized below for SoCalGas to consider for further information and potential outreach:

AICHE – Center for Hydrogen Safety²¹

The American Institute of Chemical Engineers' (AIChE's) Center for Hydrogen Safety (CHS) is a global non-profit organization promoting hydrogen safety and best practices worldwide. The CHS provides education and resources for several aspects of hydrogen, including publications, conference information and proceedings, first responder training, safety training, webinars, and other general information.

AIChE is a member society of the Accreditation Board for Engineering and Technology (ABET). It plays a role in the accreditation process for chemical engineering programs to verify specific quality standards are met.

Baker Engineering and Risk Consultants, Inc. (BakerRisk)²²

BakerRisk is an international consulting firm with over 175 qualified/certified scientists and engineers in the U.S., Canada, and the U.K. offices. Through specialized testing services and research and development (R&D) for studying various hazards, BakerRisk aims to support its clients in preventing, quantifying, and mitigating accidents. BakerRisk provides training on hydrogen safety and offers in-person and virtual training options.

²⁰ [H2] innovation experience: SoCalGas, A Sempra Energy utility. (n.d.-b). <https://www.socalgas.com/sustainability/h2home>.

²¹ CHS: Center for Hydrogen Safety. AIChE. (2024, May 1). <https://www.aiche.org/chs>.

²² Risk management, training, engineering services. BakerRisk. (2024, January 25). <https://www.bakerrisk.com/>.

Canadian Standards Association (CSA Group)

The CSA Group, accredited by the Standards Council of Canada (SCC), is internationally recognized, and its standards and certifications are often accepted and adopted globally. The CSA Group collaborates with regulatory authorities and government agencies to align the developed standards and certification programs with regulatory requirements.

As part of the growing interest in hydrogen as a fuel source, the CSA Group established the CSA Hydrogen Advisory Group (H2AG), which includes participants from various representative categories across the hydrogen ecosystem, to actively monitor hydrogen activities and engage with stakeholders to evaluate and address potential standardization needs. Participants in the H2AG represent various categories from production to end use in industries like transportation, fuel and appliances, petroleum and natural gas, and natural resources.

Dräger²³

Dräger is an international company with a presence in over 190 countries. Dräger manufactures medical and safety technology products in hospitals, fire departments, emergency services, authorities, and mining industries. Dräger offers several types of safety solutions/technologies for detection and PPE, also including providing guidance on planning, installing, and maintaining safety and gas detection systems.

Gas Technology Institute (GTI)²⁴

GTI Energy is a research and training organization aiming to advance economy-wide decarbonization of energy systems. For the past 80 years, GTI Energy has been mainly focused on natural gas and energy training, but also conducts workshops and hosts conferences.

GTI Energy also collaborates with industry experts to conduct research, product development, and demonstration projects focused on clean hydrogen production, storage, delivery, and use through its GTI Energy's Hydrogen Technology Center.

International Association for Hydrogen Safety (HySafe)²⁵

HySafe is an international association that focuses on hydrogen safety through collaboration, research, and the exchange of information among professionals and organizations. The association contributes to developing guidelines and publications addressing various aspects of hydrogen safety, including production, storage, transportation, and utilization. HySafe also organizes conferences, workshops, and events to provide a forum for presenting research findings and discussions and disseminating information related to hydrogen safety.

²³ Welcome to dräger us. Leading Medical & Safety Technology. (n.d.). https://www.draeger.com/en-us_us/Home.

²⁴ Home. GTI Energy. (2024, May 14). <https://www.gti.energy/>.

²⁵ Safety, I. A. for H. (n.d.). HySafe. <https://hysafe.info/>.

U.S. Department of Energy’s Office of Energy Efficiency and Renewable Energy (EERE)²⁶

The EERE accelerates development and facilitates the deployment of energy efficiency, renewable energy technologies and market-based solutions that strengthen U.S. energy security, environmental quality, and economic vitality. The Hydrogen Safety Panel (HSP) and the Hydrogen Tools Portal (H2Tools) are two initiatives of the EERE.

The HSP was established in 2003 and consists of members assembled to provide guidance and expertise on hydrogen safety, including considerations for hydrogen technologies, safety engineering, and related fields. The HSP offers recommendations, best practices, collaboration, and insights to support the safe handling, transportation, storage, and use of hydrogen.

H2Tools was developed by the Pacific Northwest National Laboratory through support from EERE, whose goal is to support the implementation of the practices and procedures that will ensure safety in the handling and use of hydrogen in various fuel cell applications. The portal combines and enhances the utility of various tools and web-based content on the safety aspects of hydrogen and fuel cell technologies to help inform those tasked with designing, approving, or using systems and facilities and those responding to incidents.

11.0 LESSONS LEARNED

The Hydrogen Safety Panel has collected incidents involving various hydrogen infrastructure and documented them in the March 2020 “Hydrogen Incident Examples” (Pacific Northwest National Laboratory, 2020).²⁷ While these incidents do not involve SoCalGas, the lessons learned from these incidents are valuable for SoCalGas’s continued hydrogen safety planning and are compiled in the H2Tools.org Lessons Learned database.²⁸ A sample of the incidents identified and the lessons learned, which involve pressure relief devices, hydrogen cylinders, small diameter piping, fueling stations and compression equipment, are summarized in Table 7 below, *Hydrogen Safety Lessons Learned*.

Table 7 - Hydrogen Safety Lessons Learned

<u>Incident Category</u>	<u>Description/Root Cause</u>	<u>Lessons Learned</u>
Pressure Relief Device Incidents	- On January 15, 2002, an uncontrolled hydrogen release occurred due to the rupture of a hydrogen storage tube’s burst disc. This disc failed due to being	- Eliminate burst discs from hydrogen storage assembly. Redesign venting system for the pressure relief valves to prevent or inhibit moisture build up and allow moisture drainage.

²⁶ Office of Energy Efficiency & Renewable Energy | Department of Energy. (n.d.-c). <https://www.energy.gov/eere/office-energy-efficiency-renewable-energy>.

²⁷ Hydrogen incident examples. (n.d.-b). https://h2tools.org/sites/default/files/Hydrogen_Incident_Examples.pdf.

²⁸ Lessons learned | hydrogen tools. (n.d.-d). https://h2tools.org/lessons?search_api_fulltext=.

<u>Incident Category</u>	<u>Description/Root Cause</u>	<u>Lessons Learned</u>
	<p>overloaded by mechanical stresses developed as water expanded and formed ice while in direct contact with the burst disc. The degraded condition of the vent cap (defective equipment) enabled water to access the burst disc.</p> <ul style="list-style-type: none"> - On Jan 8, 2007, an explosion occurred during a delivery of compressed hydrogen gas at a coal-fired power plant. Evidence pointed to the premature failure of a pressure relief device rupture disk, which had been repaired by the vendor six months before the explosion. 	<ul style="list-style-type: none"> - Contract documents for the hydrogen and nitrogen supplies will stipulate that suppliers of potentially hazardous equipment will provide plant management with written documentation describing the supplier's preventive maintenance program. - Verify that all pressure relief devices contain fuse-backed adapters. - Explore eliminating rupture disk pressure relief devices and substituting spring-style relief valves. - Confirm that temporary offices/facilities are not co-located with hazardous chemical storage sites. - Job Hazard Analysis (JHA) to be done on unloading hydrogen - A competent plant employee must be present during all hydrogen unloading activities.
<p>Hydrogen Cylinder Incidents – Hydrogen Gas Regulator Failure</p>	<p>On February 6, 2013, a single-stage regulator "failed" while flowing hydrogen gas from a standard 200 ft³ gas bottle. During the event, a solenoid valve was opened to allow hydrogen to flow when a loud noise was noted, and gas began flowing out of the pressure relief valve on the side of the regulator. It was noted that the low-pressure gauge on the regulator was "pegged" at the high side (200 psi). The valve on the bottle was shut off, and the hydrogen flow was immediately stopped. Hydrogen flowing out of the relief valve did not ignite. With the bottle shutting off, the regulator was replaced with another regulator of the same type, and activities continued.</p> <p>The failed regulator was taken apart to determine the failure's cause. A small elastomeric ring that seals the internal nozzle to the seat assembly was deformed</p>	<ul style="list-style-type: none"> - Without additional protection, downstream components can be exposed to pressures exceeding the set pressure to the full bottle pressure. If items downstream of the regulator are not rated for full bottle pressure, it is recommended that protection be added to the system. - Pressure relief device discharges need to be routed to a safe location. In a pressure-relieving event, the flow must be directed away from personnel, preferably so that the shut-off valve can be accessed safely. - Adequate ventilation is an important consideration in the layout of a compressed gas system. Inert gases (as potential asphyxiants) and toxic and

<u>Incident Category</u>	<u>Description/Root Cause</u>	<u>Lessons Learned</u>
	<p>and lodged in the nozzle orifice, preventing the seat assembly from properly seating and allowing high-pressure hydrogen to flow into the low-pressure side of the regulator continuously. The regulator has a pressure relief valve as protection, and it operated properly, relieving the pressure in the system. Fortunately, nothing downstream of the regulator was damaged. What led to the failure of the elastomer ring has yet to be discovered (at the time of reference writing).</p>	<p>flammable gases can pose a significant hazard if not properly ventilated.</p>
<p>Piping Incidents – Failure of Stainless-Steel Valves due to Hydrogen Embrittlement</p>	<p>On August 19, 1986, difficulties were experienced with two solenoid-operated globe valves in a charging system. When shut, the valves could not be reopened without securing all charging pumps. During a refueling outage, the two valves were disassembled and examined to determine the cause of the malfunction. It was found that the springs of the disc guide assembly in both valves had undergone complete catastrophic failure. The springs initially had 25 coils and were found in sections of only 1-2 coils. Metallurgical analysis of the failed springs attributed the probable cause of failure to hydrogen embrittlement. The springs are made of 17-7 PH stainless steel.</p> <p>Discussion with the valve manufacturer revealed that similar failures occurred on three previous occasions. These spring failures were also attributed to hydrogen embrittlement.</p>	<ul style="list-style-type: none"> - Onsite personnel must ensure that their vendors receive comprehensive specifications on the application, use and service conditions associated with all stainless-steel valves implemented in applications susceptible to hydrogen embrittlement. - A web-based resource developed by Sandia National Laboratories to provide data on hydrogen embrittlement of various materials is available at Technical Reference for Hydrogen Compatibility of Materials.
<p>Piping Incidents – Hydrogen Leak from Underground Pipe and Explosion</p>	<p>On October 31, 1980, an explosion occurred at a NASA hydrogen storage and use facility that had been in a non-operational mode for several months while undergoing modifications for future tests. No one was in the facility at the time of the explosion. The facility's other supply systems and utilities had been severed or ruptured. Shrapnel and debris were ejected up to 540 feet away. Firefighters and emergency</p>	<ul style="list-style-type: none"> - Active H₂ sensors should be installed and continuously monitored in all enclosed buildings near H₂ sources. All buildings near areas where hydrogen is used should be designed to preclude H₂ entrapment (e.g., sloping roof with ventilation at the highest point). - Underground carbon steel lines beneath concrete pad areas should

<u>Incident Category</u>	<u>Description/Root Cause</u>	<u>Lessons Learned</u>
	<p>medical personnel were sent to the area to verify that no one was injured and to extinguish small residual fires.</p> <p>Damage was significant, including the destruction of two support buildings. Costs incurred from the explosion were estimated to be approximately \$5.9 million. Detectable levels of gaseous hydrogen were recorded at several locations adjacent to the concrete pad for five days following the event.</p> <p>The findings of the investigation board were as follows:</p> <ul style="list-style-type: none"> - The explosion was the result of a hydrogen leak. - A gaseous hydrogen leak occurred in an underground NPS 3 ASTM A106 Grade B, XXS WT carbon steel pipe. The pipe was coated with coal tar primer and coal tar enamel, wrapped with asbestos felt impregnated with coal tar, covered with a second coat of coal tar enamel, and wrapped in Kraft paper in accordance with American Water Works Association Standard G203. The source of the leak was an oval hole about 0.15 x 0.20 inches at the pipe's inner surface and about 2 inches in diameter at the outer surface of the pipe. Upon excavation of the pipe, it was noted that the coating was not present at the leak point. This resulted in galvanic corrosion over 15 years and the eventual rupture when high-pressure gas was applied to the thin pipe membrane. The pipe was 8 feet 9 inches below the concrete pad. - Before the pipe rupture, a pneumatically operated gaseous hydrogen isolation gate valve, 	<p>not be used for H₂ transmission. All H₂ lines are now stainless steel and above ground at this NASA location.</p> <ul style="list-style-type: none"> - H₂ transmission lines buried underground should be proof-tested and leak-checked periodically. - Any below-grade piping installation should be in open trenches covered by grating. - Facilities should be protected from H₂ at a safe distance by manual isolation valves. If remote-operated valves (ROVs) are required for operational isolation, the ROVs should be in series with and downstream of the manual isolation valve. - The pressure between isolation valves and stand shut-off valves should be routinely monitored daily. - Field repair of mechanically severable valves in high-pressure systems should be eliminated. - Valves repaired in the field should be subjected to functional and leak checks, including actuator and valve seals at simulated operating conditions. A written procedure should be prepared and used. - Valves utilizing pneumatic actuators should have the actuator piston and piston nut staked (or locked by other positive means) in the installed condition. - All high-pressure gas lines scheduled to be inactive for over six months should be physically isolated from active systems by blind flanges. - Supply system status of pressure vessels and lines (pressure and quantity) should be recorded at the start and completion of operations

<u>Incident Category</u>	<u>Description/Root Cause</u>	<u>Lessons Learned</u>
	<p>designed for 6000 psi service, and located about 280 feet from the facility, failed in the open position. Pneumatic pressure had been removed earlier in the day, and failure analysis indicated that the valve had been damaged during recent field servicing. This allowed hydrogen gas from two hydrogen storage tanks to enter the pipe.</p> <ul style="list-style-type: none"> - Gaseous hydrogen was trapped in large quantities in sand and gravel under the apron surface (a 1-foot-thick concrete pad about 160 x 140 feet). The hydrogen then entered the basement of the electrical control and instrumentation terminal building, located immediately adjacent to the facility, through penetrations in the basement wall, including cable ducts, cable pulls, and two 24-inch-diameter air conditioning ducts. Gaseous hydrogen was transported through the air conditioning ducts to a support building about 90 feet from the terminal building. - An explosion originated in the basement of the terminal building through electrical contact with a sump pump motor. A shock wave traveled through the air conditioning ducts and caused a second explosion of lesser magnitude in the support building. The actual ignition source in the terminal building is unknown; an electrical arc from a sump pump was the most likely source. - The TNT equivalent of the blast was between 100 and 475 pounds, depending on the location. - After that event, no mild steel was again used for high pressure hydrogen piping at that site. 	<p>each day. All reservoirs should be isolated each day before weekends and holidays at the close of business.</p> <ul style="list-style-type: none"> - Corrosion protection systems for underground lines should be reviewed and tested to confirm the adequacy of the systems. - Operational and support buildings at hazardous sites should be isolated (i.e., interconnecting air conditioning systems should be avoided). Seals should physically isolate buildings connected to hazardous sites by tunnels and conduits. If physical isolation is impractical, positive airflow should be maintained in tunnels and conduits. - Explosive gas detection meters should be included in the equipment carried by firefighters and emergency medical personnel. - Fire alarm transmitters should be located at all hazardous locations. - Emergency instructions for isolating H₂ and utilities for hazardous locations should be permanently posted with names and telephone numbers of key individuals to be contacted.

<u>Incident Category</u>	<u>Description/Root Cause</u>	<u>Lessons Learned</u>
<p>Hydrogen Compressor Incidents – Compressor Piping Incident</p>	<p>On April 5, 2006, the malfunctioning of the non-return valve of the hydrogen compressor caused the pressure between the hydrogen bottle and the compressor to rise to the maximum allowed pressure of 275 bar. The rupture disk of the safety valve broke, and the hydrogen content of the gas bottle and the pipe section involved was released on top of the building. The flame was seen for a very short period by a guard.</p> <p>The non-return valve was dismantled, cleaned, and tested. After positive testing, the system was restarted and pressurized without further malfunctioning.</p>	<p>The following corrective actions were taken:</p> <ul style="list-style-type: none"> - The non-return valve was dismantled, cleaned, and tested. After positive testing, the system was restarted and pressurized without further malfunctioning. - The hydrogen discharge pipe was extended from the low roof of the compressor building (2.5 m) to the higher roof of a neighboring building (6 m). With this modification, potential hydrogen ignition would occur approximately 6 meters from the ground, farther from personnel than the 2.5 meters of the previous situation. - The compressor was sent to the manufacturer for preventive maintenance to lower the frequency of component malfunctioning. - Plans for regular maintenance of the non-return valve will be recorded in the next revision of the Design and Safety Report. - A flame arrestor was purchased and mounted at the end of the exhaust pipe on top of the building.
<p>System Design, Operator, and Maintenance Incidents – Hydrogen Storage Siting [Near Miss]</p>	<p>On April 27, 1989, during an inspection, three potential safety problems were identified concerning the location of a hydrogen storage facility. The hydrogen storage facility was on a building's roof, made of 30-inch-thick reinforced concrete. The following potential safety problems were identified during the inspection:</p> <ol style="list-style-type: none"> 1. Hydrogen gas leakage from the storage facility near the air intakes of the building's ventilation system had the potential introduce a flammable or explosive gas mixture into the enclosure. Because the hydrogen storage facility, containing four 8000-scf hydrogen tanks at up to 2450 psig, 	<p>The hydrogen facility in this example did not meet industrial guidelines for facilities of this type from the standpoint of (1) the separation distance needed between a hydrogen pipe break and the building ventilation intake to prevent the buildup of a flammable or explosive gas mixture inside the enclosure, and (2) the separation distance needed to prevent damage to safety-related structures resulting from the explosion of an 8,000-scf hydrogen tank.</p> <p>Safety concerns such as hydrogen leaks and storage tank detonations must be considered and used to create effective new construction designs that mitigate the</p>

<u>Incident Category</u>	<u>Description/Root Cause</u>	<u>Lessons Learned</u>
	<p>was Seismic Category II, a seismic event may result in a hydrogen leak. Furthermore, the pressure relief valves in the hydrogen facility exhausted downward to within 6 inches of the roof near the ventilation system air intakes.</p> <p>2. A detonation of a hydrogen storage tank could structurally damage and affect the performance of safety-related equipment on the building's roof, such as the ventilation system intake and exhaust structure, the emergency pressurization system, and the building itself.</p> <p>3. An explosion of the hydrogen delivery truck that provides hydrogen to the facility through a fill line located at ground level on the wall of the auxiliary building could structurally damage safety-related component cooling water pumps located inside the auxiliary building and near the hydrogen fill line.</p>	<p>consequences of such events. Existing buildings that house hydrogen storage tanks must properly analyze the risks associated with using and storing such systems.</p>
<p>System Design, Operator, and Maintenance Incidents – Improper Purging Procedure Results in Hydrogen Fire</p>	<p>On December 31, 1969, steam turbines at a power station drove a large, hydrogen-cooled generator. During maintenance shutdowns, the hydrogen cooling loop in the generator was purged with carbon dioxide. After carbon dioxide concentrations were measured with a densitometer to verify the complete removal of hydrogen, the generator was purged with air and the maintenance was performed.</p> <p>This purging procedure was used before the explosion. The carbon dioxide reading was reported to be 100% at the top of the generator. The cooling system was then purged with air, and a 1/2-inch pipe in the cooling loop was cut to install some new instrumentation. When the pipe was cut, pressurized gas was emitted at the opening. Workers assumed the gas was either carbon dioxide or air and proceeded with the new instrument installation. Unfortunately,</p>	<p>This incident illustrates the importance of thoroughly purging hydrogen from a large, complex piece of equipment. Uniform mixing and dilution are unlikely in all the partially enclosed spaces, crevices, etc. If a hazardous operation such as welding must be performed with an atmosphere of air (instead of inert gas) in the equipment, then reliable gas concentration measurements should be obtained at several different locations. In the case of the generator, a direct measure of hydrogen concentration was more reliable than the 100 percent CO2 reading on the densitometer. Furthermore, the gas composition should have been determined at the welding site and the generator's top.</p>

<u>Incident Category</u>	<u>Description/Root Cause</u>	<u>Lessons Learned</u>
	<p>some hydrogen was still in the pipe and the rest of the cooling loop. When the welder struck an arc, a flame developed at the pipe opening and flashed back into the generator. This caused a low-level explosion within the generator shroud. The explosion damaged the generator's ventilation baffle plates and auxiliary equipment, which caused the plant to be out of service for 26 days.</p>	
<p>System Design, Operator, and Maintenance Incidents – Flanged Joint Hydrogen Gas Leak and Fire</p>	<p>On June 8, 1998, during the operation of a succinic acid plant, hydrogen leaked from a flanged joint on a safety valve at the upper part of a reactor, which generated a hydrogen flame. Before the incident, the safety valve was removed and reattached during an inspection at a turnaround shutdown. An incorrectly sized, smaller gasket was installed in the joint, and the tightening force on the bolts was inadequate. Therefore, a gap was generated as time passed, and unreacted hydrogen leaked.</p>	<ul style="list-style-type: none"> - Construction errors are more difficult to detect once construction is complete. It is important to develop and use a systematic oversight process to minimize construction errors during the construction process. - Thorough control of parts during the construction process is required. - Bolts should be tightened equally and fully. - A new support for distributing the weight of piping is installed. - Thoroughness of checks after construction is going to be initiated.
<p>Fueling Station Incidents – Pressure Relief Device Fails</p>	<p>On May 4, 2012, a pressure relief valve failed on a high-pressure storage tube at a hydrogen fueling station, causing the release of approximately 300 kilograms of hydrogen gas. The gas ignited at the exit of the vent pipe and burned for 2 1/2 hours until the local fire department permitted technicians to enter the station and stop the flow of gas. During this incident, the fire department evacuated nearby businesses and an elementary school, closed adjacent streets, and ordered a high school to shelter in place.</p> <p>The station's operating systems worked as designed for an emergency. All equipment and fuel supplies were completely isolated, and all storage vessels were within</p>	<ul style="list-style-type: none"> - These problems could have been avoided by adequate quality assurance/quality control procedures during the design and safety reviews. - The canopy was added to the station after the HazOps review. The prestart-up safety review by all parties and the local authority having jurisdiction did not recognize the setback distance of the canopy. Had an engineering management of change, follow-up HazOp or other form of risk assessment been conducted, the vent likely stacks adjacent to the canopy would have been raised to avoid damage in the event of a fire.

<u>Incident Category</u>	<u>Description/Root Cause</u>	<u>Lessons Learned</u>
	<p>acceptable and safe pressure and temperature limits before and throughout the incident.</p> <p>After a thorough analysis of the incident, corrective actions were taken to replace pressure relief valves, heighten vent stacks, modify response procedures, and improve communication procedures with first responders. A considerable amount of time was taken to review the station design, evaluate emergency action plans and procedures, meet with the public, train first responders, and conduct follow-up drills with employees and first responders. The station reopened nine months after the incident and has since been fully operational.</p> <p>Three root causes were noted during the investigation: (1) the use of incompatible materials in the manufacturing of the PRD valve, (2) improper assembly resulting in over-torquing of the inner assembly, and (3) over-hardening of the inner assembly materials by the valve manufacturer.</p>	<ul style="list-style-type: none"> - Before reopening the station, physical changes were made using the correct PRD valves and higher vent stacks. New and modified procedures were instituted to improve the timely communication of station status during emergencies. Additional training of personnel focused on improving the response time and effective communication between employees, first responders, and the hydrogen equipment supplier.
<p>Fueling Station Incidents – Fueling Station High-Pressure Storage Leak</p>	<p>On June 10, 2019, a hydrogen leak originating from a tank within a high-pressure storage unit serving a hydrogen vehicle fueling station resulted in a fire and explosion. No damage was reported to the separate forecourt hydrogen dispenser or other major station components within the backcourt compound.</p> <p>The incident's root cause was subsequently identified as an assembly error of a specific plug in a hydrogen tank in the high-pressure storage unit. The inner bolts of the plug had not been adequately torqued. This led to a hydrogen leak, creating an ignited mixture of hydrogen and air. The source of the ignition has not been positively identified. An inspection and integrity verification program for the high-pressure storage units with similar plugs was implemented,</p>	<ul style="list-style-type: none"> - Implement rigorous assembly, verification, and documentation procedures for equipment. - Increase automated leak detection frequency.

<u>Incident Category</u>	<u>Description/Root Cause</u>	<u>Lessons Learned</u>
	including check and re-torque of tank plugs. Additional measures implemented include revised assembly, verification, and documentation of procedures and increased automated leak detection frequency. Depending on the site, additional ignition control measures are considered, including loose gravel removal/smooth surface around the high-pressure storage unit, additional backcourt compound ventilation, and higher extent use of explosion-proof components.	

The main causes of the identified failures were due to component failure or equipment design/selection issues. A general conclusion from these incidents is that there is great importance in safe and proper equipment design and construction as well as development of procedures for O&M. Lessons learned focus on having the right materials and operating procedures for hydrogen service.

12.0 CONCLUSION

The safe transportation of hydrogen gas in pipelines is paramount to harnessing its potential as a clean and sustainable energy source. As illustrated above, the safe transportation of 100% clean renewable hydrogen by pipeline is feasible. The identified safety requirements, ranging from material selection, pipeline design, leak detection and monitoring programs, emergency response procedures, and public awareness plans, form a comprehensive framework to mitigate risks associated with hydrogen transport.

Safe pipeline management is achieved through a combination of codes, regulations, standards, and best practices that are paired with considerations on system architecture, operational controls, procedures, continuous improvement and evaluation, and management of change. This structure and content can be tailored to align with the physical and chemical properties that are unique to hydrogen. Lessons learned can be leveraged to further refine and establish new standards, design, procedures, and best practices as part of continuous improvement.

Evaluation of SoCalGas gas standards and specification sheets resulted in identification of potential impacts, required updates, and/or new processes to be created to accommodate a 100% clean renewable hydrogen pipeline system. The following specification and standard topics that cover SoCalGas’s current natural gas operations can be considered for potential modifications or new specifications/standard development for implementation of a clean renewable hydrogen energy transport system:

1. Material requirements
2. Material traceability requirements
3. Facility maps (for new production, transmission, and storage facilities)
4. Control room management plan

5. Equipment specifications (e.g., gas compressor specifications and pressure vessel specifications updated to include specifics for hydrogen service)
6. Fire prevention and protection plan
7. Operator qualification program
8. Corrosion control and monitoring requirements
9. Leak testing and monitoring requirements
10. Integrity management programs

The evaluation provides transparency into how established safety requirements are embedded in the existing framework and confirms that the current natural gas infrastructure Specifications, Standards & Procedures provide a solid foundation for building the hydrogen infrastructure Specification, Standards & Procedures.

The existing SoCalGas Control Room Management and Emergency Response Plan could be leveraged as a basis for Angeles Link. Once the preferred system route of Angeles Link is identified, future discussions with Gas Control and Emergency Response teams are needed to further revise and develop these procedures. For Emergency Response, SoCalGas may consider hydrogen-specific items such as notification practices, reportability, and coordination between First Responding Agencies (i.e., Local Fire Department, Police Departments, County EOCs, etc.). Hydrogen training for these Emergency and First Responding groups is available and would be a new activity due to the difference in nature of hydrogen and natural gas fuel sources. SoCalGas may consider establishing separate Gas Control and Emergency Response teams for hydrogen.

Education and training requirements for the workforce operating and maintaining hydrogen infrastructure can be applied to the development of training programs and operator qualifications. Organizations already accredited to undertake various hydrogen safety education and training include: AIChE, BakerRisk, CSA Group, Dräger, GTI, HySafe, and EERE. Various resources for education and training are available for both pipeline operators, emergency and first responders, and the public. Additionally, public awareness plans are both required and support safe operations of pipeline facilities and should be developed to support new hydrogen infrastructure as appropriate.

In conclusion, pipeline transportation of clean renewable hydrogen is feasible and can be safely achieved through compliance with Federal and State codes, standards, regulations, and procedures identified within this document. The application of and compliance with these elements must be intrinsically integrated throughout design and development choices, asset management structure, procedures, training, operations, and handling of hydrogen within a hydrogen pipeline system. Industry recommended best practices and lessons learned can be applied. SoCalGas is well positioned to safely build, operate, and maintain a clean renewable hydrogen pipeline system by leveraging its experience operating and maintaining a developed gas transmission and distribution system, existing highly trained and qualified workforce, and comprehensive integrity management and emergency response procedures.

13.0 STAKEHOLDER COMMENTS

The input and feedback from stakeholders including the Planning Advisory Group (PAG) and Community Based Organization Stakeholder Group (CBOSSG) has been instructive to the development of this Safety Study. Some of the feedback that has been received related to this Safety Study is summarized below. All

feedback received is included, in its original form, in the quarterly reports submitted to the CPUC and published on SoCalGas's website.²⁹ Feedback topics that were not addressed are also identified.

Quarter 1 to Quarter 4 2023 Reports

- **California Hydrogen Business Council**
 - Engage Center for Hydrogen Safety for Angeles Link Project.
- **Protect Playa Now**
 - At the workshop on July 19, 2023, news broke that there was a hydrogen explosion in Kern County at a bus fueling station. A person raised their hand and shared this information. The CBO Stakeholder group has not received any response from SoCalGas.
- **Food and Water Watch**
 - A comprehensive plan must be presented to the CBOSG regarding SoCalGas's emergency response protocols in the event of a hydrogen leak, and the protocol for how SoCalGas would report and work with local and state government entities in the event of a leak.
- **Air Products**
 - CPUC has yet to determine that hydrogen transportation would be subject to CPUC jurisdiction and therefore it is unclear whether General Order 112 would be applicable.
- **Communities for Better Environment**
 - Questions regarding specific protocols for alerting residents along transmission corridor for safety risks.

Preliminary Data & Findings Document

- Two comment letters received from Communities for a Better Environment and Air Products
 - One letter requested a preliminary risk analysis and further safety considerations for the major risks of leakage, exposure, flammability, storage, explosion, and end-use related health risks.
 - One letter raised questions about the use of odorants, diffusion of hydrogen relative to the odorant, and compatibility with pipe materials and end uses.

Summary of How Comments were Addressed

- The Center for Hydrogen Safety, Hydrogen Safety Panel is conducting a third-party review of the safety study, *Plan for Applicable Safety Requirements* with results of their review expected end of second quarter 2024.
- Emergency response protocols are described in section 7.0 and Public Awareness Plans in section 8.0.
- Incorporated Safety Management System (SMS) framework, with American Petroleum Institute Recommended Practice (API RP) 1173 – Risk Management section 4.0.
- Regarding the Kern County incident in July 2023, SoCalGas is not involved in this incident. The incident is still under investigation and the lessons learned have not been published at this time.

²⁹ Angeles Link: SoCalGas, A Sempra Energy utility. (n.d.-a).
<https://www.socalgas.com/sustainability/hydrogen/angeles-link>.

The Center for Hydrogen Safety's H2 Tools website³⁰ was utilized and incorporated the lessons learned in section 9.0.

- The CPUC's Decision 22-12-055 (OP 6 (f)) requires SoCalGas to evaluate safety concerns involved in pipeline transmission, storage, and transportation of hydrogen applicable to the Angeles Link Project. Regulatory requirements and industry-standard codes exist for hydrogen, primarily anchored by 49 Code of Federal Regulations (CFR) Part 192 Subparts A through P and the California Public Utilities Commission (CPUC) General Order (GO) 112-F governing natural gas transmission and distribution and addressing flammable gases such as hydrogen. As such, potential safety best practices may be derived from GO 112-F and should be appropriately evaluated as it may apply to a clean renewable hydrogen transport system.
- Several odorant studies are incorporated in section 6.0 to support the considerations and feasibility of odorizing hydrogen.

Stakeholder engagement plays a pivotal role for the Angeles Link project to foster inclusive feedback in the design and decision-making process, build trust and transparency, and provide lasting benefits to the communities SoCalGas serves. Throughout Phase 1 of Angeles Link, workshops, and quarterly meetings with Community Based Organizations (CBO) and Planning Advisory Group (PAG) were conducted to provide feasibility study updates and solicit stakeholder feedback and involvement. Additionally, SoCalGas has routinely met with the California Public Utilities Commission's Safety Enforcement Division to provide updates and to collaborate on the project.

³⁰ Home | hydrogen tools. (n.d.-a). <https://h2tools.org/>.

14.0 GLOSSARY

Accreditation Board for Engineering and Technology (ABET) - Accredited college and university programs in the disciplines of applied and natural science, computing, engineering and engineering technology at the associate, bachelor's and master's degree levels. ³¹

American Institute of Chemical Engineers (AIChE) - World's leading organization for chemical engineering professionals, with more than 60,000 members from more than 110 countries. ³²

American National Standards Institute (ANSI) - A private, nonprofit organization that administers and coordinates the U.S. voluntary standards and conformity assessment system. ³³

American Petroleum Institute (API) - Formed in 1919 as a standards-setting organization and has developed more than 800 standards to enhance operational and environmental safety, efficiency and sustainability. ³⁴

American Society for Testing and Materials (ASTM) - A nonprofit organization that develops and publishes approximately 12,000 technical standards, covering the procedures for testing and classification of materials of every sort ³⁵

American Society of Mechanical Engineers (ASME) - A nonprofit professional organization that enables collaboration, knowledge sharing, and skill development across all engineering disciplines, while promoting the vital role of the engineer in society. ³⁶

Batching of In-Line-Inspection tools - The tool is loaded into the middle of two isolation pigs (one in front of the ILI tool and one behind) and the ILI tool is in a compatible pressurized gas, such as nitrogen (or a slug of diesel if the tool requires a liquid coupling)

³¹ About abet. ABET. (2023, October 2). <https://www.abet.org/about-abet/>.

³² About Aiche. AIChE. (2023, July 7). <https://www.aiche.org/about> <https://www.aiche.org/about>.

³³ American National Standards Institute. (n.d.). ANSI introduction. ANSI. <https://www.ansi.org/about/introduction> <https://www.ansi.org/about/introduction>.

³⁴ About API. Energy API. (n.d.-a). <https://www.api.org/about> <https://www.api.org/about>.

³⁵ ASTM International. ANSI Webstore. (n.d.). https://webstore.ansi.org/sdo/astm?msclkid=b5145c8e3c9110b215d53ac1f2f86bb8&utm_source=bing&utm_medium=cpc&utm_campaign=Standards-US&utm_term=ASTM+standards+store&utm_content=ASTM ASTM International. ANSI Webstore. (n.d.). https://webstore.ansi.org/sdo/astm?msclkid=b5145c8e3c9110b215d53ac1f2f86bb8&utm_source=bing&utm_medium=cpc&utm_campaign=Standards-US&utm_term=ASTM+standards+store&utm_content=ASTM.

³⁶ About ASME. ASME. (n.d.-a). <https://www.asme.org/about-asmef#:~:text=Founded%20in%201880%20as%20the%20American%20Society%20of,the%20vital%20role%20of%20the%20engineer%20in%20society>.

Boiler and Pressure Vessel Code (BPVC) - Issued once every two years, is comprised of 32 separate volumes which establish rules of safety governing the design, fabrication and inspection of boilers and pressure vessels, including nuclear power systems. ³⁷

California Public Utilities Commission (CPUC) - Regulates privately owned electric, natural gas, telecommunications, water, railroad, rail transit, and passenger transportation companies, in addition to authorizing video franchises. ³⁸

Cathodic Protection - A technique to prevent corrosion of a metal surface by making that surface the cathode of an electrochemical cell. ³⁹

Center for Hydrogen Safety (CHS) - Nonprofit, non-bias, corporate membership organization within AIChE that promotes the safe operation, handling, and use of hydrogen and hydrogen systems across all installations and applications. ⁴⁰

Code of Federal Regulations (CFR) - A codification (arrangement of) the general and permanent rules published in the Federal Register by the executive departments and agencies of the Federal Government.

⁴¹**Community Based Organizations (CBO):** A public or private nonprofit organization representing a community or a significant segment of a community and working to meet community needs. ⁴²

Compressed Gas Association (CGA) - An American National Standards Institute (ANSI) accredited Standards Developing Organization, CGA works directly with federal, state, and provincial agencies and fire code officials to promote safe and responsible practices and regulations. ⁴³

³⁷ 2023 ASME BPVC is now shipping! 2023 ASME BPVC - Boiler Pressure Vessel Code | American Society of Mechanical Engineers. (n.d.).

https://store.accuristech.com/pages/bpvc_boiler_pressure_vessel_code?sid=msn&utm_source=bing&utm_medium=cpc&msclkid=f8a6a620c76c16f248c7c0793a9b1a9d&utm_campaign=ASME+BPVC&utm_term=2023+boiler+pressure+vessel+code&utm_content=2023+ASME+BPVC.

³⁸ Auth, T. (n.d.). About the CPUC <https://www.cpuc.ca.gov/about-cpuc/cpuc-overview/about-us#:~:text=About%20the%20California%20Public%20Utilities%20Commission%20%28CPUC%29%20The,transportation%20companies%2C%20in%20addition%20to%20authorizing%20video%20franchises>.

³⁹ The Federal Register. Federal Register: Request Access. (n.d.-a). <https://www.ecfr.gov/current/title-40/chapter-1/subchapter-1/part-280>.

⁴⁰ Center for Hydrogen Safety Fact Sheet. AIChE. (2019, May 24). <https://www.aiche.org/CHS/center-hydrogen-safety-fact-sheet>

⁴¹ National Archives and Records Administration. (n.d.). Code of federal regulations. National Archives and Records Administration. <https://www.archives.gov/federal-register/cfr>.

⁴² Community-Based Organization (CBO): NIH. Community-Based Organization (CBO) | NIH. (n.d.). <https://clinicalinfo.hiv.gov/en/glossary/community-based-organization-cbo>.

⁴³ What we do. Compressed Gas Association. (n.d.). <https://www.cganet.com/what-we-do/>.

Control Center Modernization (CCM) - Will further digitalize the existing natural gas transmission and distribution system with new field assets such as optical pipeline monitoring (OPM) stations and high consequence area (HCA) methane sensors.

Control Room Operators - Monitor the pressure and flow of gas in the system utilizing a supervisory control and data acquisition (SCADA) system 24 hours a day, 365 days a year.

Cybersecurity and Infrastructure Security Agency (CISA) - Works with partners to defend against today's threats and collaborate to build a more secure and resilient infrastructure for the future. ⁴⁴

Department of Transportation (DOT) - A federal agency of the United States government that oversees the transportation system of the country. The DOT aims to ensure the safety, efficiency, accessibility, and sustainability of various modes of transportation, such as air, road, rail, water, and transit. The DOT also supports the development and innovation of transportation infrastructure, technology, and policy.

Emergency Shutdown Devices (ESD) - Systems designed to rapidly shut down the pipeline operation in the event of a detected leak or other hazardous situations that will isolate sections of the pipeline to minimize risks.

Enterprise Risk Management (ERM) - ERM extends beyond compliance and financial risk by using a comprehensive approach to view risks across five categories: compliance, financial, operational, reputational, and strategic. ⁴⁵

Federal Emergency Management Agency (FEMA) - FEMA's mission is to help people before, during and after disasters, and our core values and goals help us achieve it. ⁴⁶

Gas Technology Institute (GTI) - An organization dedicated to advancing the economy-wide transformation needed to deeply decarbonize energy systems while supplying the energy needed to support rising standards of living and economic growth worldwide. ⁴⁷

Geographic Information System (GIS) - Geographic Information Systems (GIS) are systems that capture, store, analyze, and display spatial or geographic data. GIS can be used to create maps, models, and simulations that show the patterns, relationships, and trends of various phenomena that occur on the Earth's surface or in the atmosphere.

⁴⁴ About Cisa: CISA. Cybersecurity and Infrastructure Security Agency CISA. (n.d.). <https://www.cisa.gov/about>.

⁴⁵ Centers for Disease Control and Prevention. (2020, June 29). Enterprise risk management. Centers for Disease Control and Prevention. <https://www.cdc.gov/other/riskmanagement.html#:~:text=ERM%20extends%20beyond%20compliance%20and%20financial%20risk%20by,as%20well%20as%20a%20more%20transparent%2C%20risk-aware%20culture>.

⁴⁶ About Us. FEMA.gov. (n.d.). <https://www.fema.gov/about>.

⁴⁷ Vision. GTI Energy. (2024, May 17). <https://www.gti.energy/about/vision/>.

High Consequence Areas (HCA) - Unusually sensitive environmental areas (defined in 195.6), urbanized areas and other populated places (delineated by the Census Bureau, and commercially navigable waterways).⁴⁸

Hydrotesting - The method used to pressure test an extinguisher's critical components (cylinder, shell, hose assembly, etc.) for leaks and structural flaws by pressurizing them with a liquid.⁴⁹

Inline Inspection (ILI) - A technique used to assess the integrity of natural gas transmission pipelines from the inside of the pipe and is used by SoCalGas as part of its ongoing pipeline integrity program.⁵⁰

International Association for Hydrogen Safety (HySafe) - The focal point for all hydrogen safety related issues.⁵¹

International Organization for Standardization (ISO) - Brings global experts together to agree on the best way of doing things – for anything from making a product to managing a process.⁵²

Material Specification (MSP) - Detail the physical and chemical properties, manufacturing processes, and performance characteristics of the selected materials. This includes information on strength, durability, finish, and any specific testing or certification required.⁵³

Maximum Allowable Operating Pressure (MAOP) - Maximum Allowable Operating Pressure (MAOP) is the maximum pressure at which the equipment may be operated under; in other words, it is the maximum pressure in the new and cold condition of the equipment.

National Fire Protection Association (NFPA) - Started as a Boston-based organization for fire sprinkler codes has grown to become the leading global advocate for the elimination of death, injury, property, and economic loss due to fire, electrical, and related hazards.⁵⁴

⁴⁸ HL Im fact sheet. PHMSA. (n.d.-a). <https://www.phmsa.dot.gov/pipeline/hazardous-liquid-integrity-management/hl-im-fact-sheet>.

⁴⁹ ETool: Evacuation plans and procedures - emergency standards - portable fire extinguishers - hydrostatic testing. Occupational Safety and Health Administration. (n.d.-a). <https://www.osha.gov/etools/evacuation-plans-procedures/emergency-standards/portable-extinguishers/hydro>.

⁵⁰ In-line inspection of pipelines - SoCalGas. (n.d.-b). <https://www.socalgas.com/documents/news-room/factsheets/In-LinePipelineInspection.pdf>.

⁵¹ Why to become member? (n.d.). <http://www.hysafe.org/WhyMember#:~:text=What%20is%20IA%20HySafe%3F%20The%20International%20Association%20for,by%20the%20European%20Commission%20co-funded%20network%20of%20excellence>.

⁵² About ISO. ISO. (2024a, March 14). <https://www.iso.org/about-us.html>.

⁵³ Forehand, L. (n.d.). Chapter 6: Building Materials and Specifications. Building Systems and Codes for Designers. <https://lbcc.pressbooks.pub/buildingsystemsandcodes/chapter/building-materials-and-specifications/>.

⁵⁴ Learn more about NFPA: The National Fire Protection Association. nfpa.org. (n.d.). <https://www.nfpa.org/About-NFPA>.

Nominal Pipe Size (NPS) - Related to the inside diameter in inches, and NPS 12 and smaller pipe has outside diameter greater than the designated size. ⁵⁵

Occupational Safety and Health Administration (OSHA) - Assures safe and healthful working conditions by setting and enforcing standards, and by providing training, outreach, education and assistance. ⁵⁶

Operations and Maintenance (O&M) - Activities performed by an individual, or group of individuals, (1) to perform a function on a pipeline facility, or (2) to provide upkeep of a pipeline facility. This includes in-kind replacement of an existing section of pipe necessitated by severe corrosion, where the capacity of the pipe segments is maintained, and service is not expanded. It also includes maintenance and repair tasks performed on the right-of-way or within the confines of a “pipeline facility”, as defined. This would include ordinary repairs to a pipeline, including replacement of one or more pipe joints or segments that have been severely damaged by threats such as corrosion or third-party damage. ⁵⁷

Operator Qualification (OQ) - Each pipeline operator is responsible for developing an OQ program, following their written OQ plan, establishing a covered task list applicable to their system, and defining the training and qualification requirements for personnel performing covered tasks on their pipeline facility. ⁵⁸

Optical Pipeline Monitoring (OPM) - The Optical Pipeline Safety Monitoring System (OPM) sends pulses of light the thickness of a human hair through glass that can be measured inside the optical cable. When installed along a pipeline, the technology can detect vibrations, stress, or abnormal changes in temperature to within 20 feet of where a problem may be developing. ⁵⁹

Personal Protective Equipment (PPE) - Equipment worn to minimize exposure to a variety of hazards. ⁶⁰

Piggability - In-Line Inspection (ILI) tools are referred to as "intelligent" or smart Pipeline Integrity Gauges (PIG's) which are devices that travel inside the pipeline and collect data using various sensors. There are different types of ILI tools, such as: Cleaning PIGs, smart PIGs, etc.

⁵⁵ PI-21-0008. PHMSA. (2021, September 1). <https://www.phmsa.dot.gov/regulations/title49/interp/pi-21-0008>.

⁵⁶ Occupational Safety and Health Administration (OSHA): Usagov. Occupational Safety and Health Administration (OSHA) | USAGov. (n.d.). <https://www.usa.gov/agencies/occupational-safety-and-health-administration>.

⁵⁷ Pipeline Safety Stakeholder Communications. PHMSA. (n.d.-d). <https://primis.phmsa.dot.gov/comm/glossary/index.htm?nocache=5217#OperationsandMaintenanceTasks>.

⁵⁸ Operator qualification overview. PHMSA. (n.d.-a). <https://www.phmsa.dot.gov/pipeline/operator-qualifications/operator-qualification-overview>.

⁵⁹ SoCalGas' Innovative Optical Pipeline Safety Monitoring System set to expand after successful pilot program: SoCalGas Newsroom. (2023, September 6). <https://newsroom.socalgas.com/stories/socalgas-innovative-optical-pipeline-safety-monitoring-system-set-to-expandafter#:~:text=The%20Optical%20Pipeline%20Safety%20Monitoring%20System%20%28OPM%29%20sends,feet%20of%20where%20a%20problem%20may%20be%20developing>.

⁶⁰ Personal Protective Equipment. (n.d.-b). <https://www.osha.gov/sites/default/files/publications/osha3151.pdf>.

Pipeline and Hazardous Materials Safety Administration (PHSMA) - Mission is to protect people and the environment by advancing the safe transportation of energy and other hazardous materials that are essential to our daily lives. ⁶¹

Potential Impact Radius (PIR) - The radius of the potential impact circle (PIC), measured in feet surrounding the point of failure, within which the potential failure of a pipeline could have significant impact on people or property. ⁶²

Risk Assessment Mitigation Phase (RAMP) - Identification of major risks to be addressed, examination of alternative mitigation options and their expected risk reduction, and a description of a proposed risk mitigation plan. ⁶³

Safety - The presence of controls for known hazards, actions to anticipate and guard against unknown hazards, and the commitment to continuously improve the ability to recognize and mitigate hazards.

Safety Management System (SMS) - Formal, top-down, organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls. It includes systematic procedures, practices, and policies for the management of safety risk. ⁶⁴

Specified Minimum Yield Strength (SMYS) - SMYS is the minimum yield strength, expressed in pounds per square inch (psi) gage, prescribed by the specification under which pipe material is purchased from the manufacturer. ⁶⁵

Standards Council of Canada (SCC) - A Crown corporation established by an Act of Parliament in 1970 to foster and promote voluntary standardization in Canada. ⁶⁶

Tetrahydrothiophene (THT) - Appears as a water-white liquid. About the same density as water and insoluble in water. Vapors heavier than air. Used as a solvent and to make other chemicals. ⁶⁷

⁶¹ PHMSA's mission. PHMSA. (n.d.-a). <https://www.phmsa.dot.gov/about-phmsa/phmsas-mission>.

⁶² PHMSA's mission. PHMSA. (n.d.-a). <https://www.phmsa.dot.gov/about-phmsa/phmsas-mission>.

⁶³ Auth, T. (n.d.). Sempra 2021 ramp. California Public Utilities Commission. <https://www.cpuc.ca.gov/about-cpuc/divisions/safety-policy-division/risk-assessment-and-safety-analytics/risk-assessment-mitigation-phase/sempra-ramp/sempra-2021-ramp>.

⁶⁴ Safety Management System (SMS). | Federal Aviation Administration. (n.d.). <https://www.faa.gov/about/initiatives/sms>.

⁶⁵ Pipeline Safety Stakeholder Communications. PHMSA. (n.d.). <https://primis.phmsa.dot.gov/comm/glossary/index.htm?nocache=5217#SpecifiedMinimumYieldStrength>.

⁶⁶ SCC. ISO. <https://www.iso.org/member/1619.html>.

⁶⁷ U.S. National Library of Medicine. (n.d.). Tetrahydrothiophene. National Center for Biotechnology Information. PubChem Compound Database. <https://pubchem.ncbi.nlm.nih.gov/compound/tetrahydrothiophene>.

Transportation Security Administration (TSA) - Protects the nation's transportation systems to ensure freedom of movement for people and commerce. ⁶⁸

U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) - EERE's mission is to accelerate the research, development, demonstration, and deployment of technologies and solutions to equitably transition America to net-zero greenhouse gas emissions economy-wide by no later than 2050, and ensure the clean energy economy benefits all Americans, creating good paying jobs for the American people—especially workers and communities impacted by the energy transition and those historically underserved by the energy system and overburdened by pollution. ⁶⁹

Unified Command (UC) - A collaborative process that allows agencies with different responsibilities for an incident to work together to manage it. It's an application of the Incident Command System (ICS) that's used when more than one agency is involved, or when the incident crosses political jurisdictions.

⁶⁸ Transportation Security Administration (TSA): Usagov. Transportation Security Administration (TSA) | USAGov. (n.d.). <https://www.usa.gov/agencies/transportation-security-administration>.

⁶⁹ About the office of Energy Efficiency and Renewable Energy | Department of Energy. (n.d.). <https://www.energy.gov/eere/about-office-energy-efficiency-and-renewable-energy>.

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16.0 APPENDICES

- Appendix A - SoCalGas Standards Review Summary

Appendix A

SOCALGAS STANDARDS REVIEW SUMMARY

49 CFR Part 192 and GO-112F are the regulatory codes having jurisdiction for pipelines transporting hydrogen and other gases. This applies to both SoCalGas natural gas infrastructure and the proposed Angeles Link hydrogen infrastructure. These regulatory codes cover a wide variety of requirements which can generally be grouped into: Design, Construction, Operations and Maintenance. 49 CFR Part 192.605 contains specific language for a procedural manual for operations, maintenance, and emergencies. Regulatory code(s) for hydrogen transportation in pipelines will impact SoCalGas's existing specifications, standards, and procedures (SSPs) accordingly. Code-specific language is an important component of the SSPs that can drive the workforce training program and operator qualification program for operator personnel.

Methodology for Specifications, Standards & Protocols Evaluation

The evaluation conducted as part of this work scope focused on the existing specifications, standards, and procedures for applicability to hydrogen gas and potential for new procedure development. SoCalGas specifications, standards, and procedures were reviewed and categorized per the following methodology:

1. Specifications, standards, and procedures were reviewed by regulatory codes outlined in the document profile summary (at the end of each SSP), emphasizing 49 CFR Part 192 and CPUC GO-112F requirements. Each SSP was reviewed for applicability and efficacy for hydrogen infrastructure.
 - Not applicable to hydrogen service (no changes)
 - Changes/editing are not required but are applicable for hydrogen service
 - Changes/editing will be required for hydrogen service
 - New standards, specifications, or procedures that may be needed due to evolving hydrogen regulations
2. The SSP review was documented and formatted to include the SSP number, Title, and applicable 49 CFR Part 192 regulatory codes, along with the above designated categories.

Summary

The following specification and standard topics covering SoCalGas's current natural gas operations should be considered for modifications or new specifications / standard development for implementation of a clean renewable hydrogen energy transport system:

1. Material requirements
2. Material traceability requirements
3. Facility maps (for new production, transmission, and storage facilities)
4. Control room management plan
5. Equipment specifications (e.g., gas compressor specifications and pressure vessel specifications updated to include specifics for hydrogen service)
6. Fire prevention and protection plan

7. Operator qualification program
8. Corrosion control and monitoring requirements
9. Leak testing and monitoring requirements
10. Integrity management programs

Of the approximate 1,600 SSPs reviewed;

- Approximately 21% of SoCalGas's current SSPs are not applicable to hydrogen service
- Approximately 34% of SoCalGas's current SSPs are applicable to hydrogen service and may require changes or revisions
- Approximately 30% of SoCalGas's current SSPs are applicable but may not require changes or revisions
- The remaining 15% of SoCalGas's current SSPs may require a new SSP specific to hydrogen service



Jacobs



Angeles Link | Water Resources Evaluation – Draft Report

SoCalGas commissioned this study from Rincon Consultants and Jacobs Engineering Group. The study was conducted, and this report was prepared, collaboratively.

July 2024

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July 2024

Angeles Link | Summary of Water Resources Evaluation – Draft Report

Southern California Gas Company (SoCalGas) is proposing to develop a clean renewable hydrogen¹ pipeline system to facilitate transportation of clean renewable hydrogen from multiple regional third-party production sources and storage sites to various delivery points and end users in Central and Southern California, including in the Los Angeles Basin. SoCalGas commissioned Rincon Consultants, Inc. (Rincon) with subconsultant Jacobs Engineering Group to assist in the preparation of this Water Resources Evaluation (WRE or Study). This Study is being prepared pursuant to the California Public Utilities Commission’s (CPUC) Angeles Link Memorandum Account Decision D.22-12-055, Ordering Paragraph (OP) 6 (b), which states SoCalGas shall provide the findings from Phase 1 feasibility studies for “identification of the potential sources of hydrogen generation and water and estimating the costs of the hydrogen.”

The objective of this WRE is to evaluate potential water availability for third-party hydrogen production; the water quality requirements for water treatment to meet the technical requirements of electrolyzers; a high-level cost estimate for key aspects of water management; and potential challenges and opportunities for the development of water supply sources that may support third-party clean renewable hydrogen production within SoCalGas’s service territory. The WRE is a compilation of five separate chapters: (1) Chapter 1: Water Availability Study; (2) Chapter 2: Water Quality Requirements; (3) Chapter 3: Acquisition and Purification Costs; (4) Chapter 4: Challenges and Opportunities; (5) Chapter 5: Supplemental Desktop Analysis – Greenhouse Gas Emissions Associated with Water Treatment and Conveyance.

Key Findings

The key findings are presented below and are discussed further within this WRE.

- Water required for the portion of clean renewable hydrogen production that Angeles Link could transport is a small percentage (approximately 0.02 to 0.10 percent) of California's total water usage each year.
- Multiple water supply sources can be identified to meet water demand for the clean renewable hydrogen production that Angeles Link could transport, including existing water supplies and new water supplies that could be developed.

¹ In the California Public Utilities Commission (CPUC) Angeles Link Decision (D).22-12-055 (Decision), clean renewable hydrogen refers to hydrogen that does not exceed 4 kilograms of carbon dioxide equivalent (CO₂e) produced on a lifecycle basis per kilogram of hydrogen produced and does not use fossil fuels in the hydrogen production process, where fossil fuels are defined as a mixture of hydrocarbons including coal, petroleum, or natural gas, occurring in and extracted from underground deposits.

Water Resources Evaluation

- Examples of potential water sources include surface water, treated wastewater, groundwater, agricultural industry water, brine line flows, advanced water treatment concentrate, oil & gas industry water, inland brackish water, dry weather flows, and urban storm water capture and reuse.
- Third-party producers may use different mechanisms to acquire water supplies to meet production needs, including exchange agreements, local water agencies, and water markets, or through acquisition of land purchase with water rights.
- Shifting water demands and obligations may present opportunities for development of new water supplies.
- The menu of water sources that feed specific production projects can be further evaluated on a case-by-case basis as more details on specific production projects develop.

Stakeholder Input

The input and feedback from stakeholders including the Planning Advisory Group (PAG) and Community Based Organization Stakeholder Group (CBOSG) have been helpful to the development of the Angeles Link Phase 1 studies. Some of the feedback received related to the WRE is summarized below. The technical approach as well as preliminary findings for this Study were shared with the PAG/CBOSG. All feedback received is included, in its original form, in the quarterly reports submitted to the CPUC and published on SoCalGas' website.²

PAG/CBOSG Meetings

SoCalGas has conducted a series of meetings and presentations to CBOSG and PAG members, including on February 15, 2024, during which the Water Resources Evaluation was presented to PAG members. SoCalGas provided an overview of the scope of work conducted and the key initial findings. Feedback was received from PAG members, and several themes emerged, including:

- Geographic scope of analysis
- Water needs quantification
- Environmental impacts and climate change
- Energy use and potential greenhouse gas emissions
- Local community effects

Preliminary Data & Findings

- Preliminary data and findings were published on April 11, 2024, to the PAG/CBOSG Living Library, which is a dedicated Project virtual database available to PAG/CBOSG members.
- SoCalGas received six comment letters on the preliminary data and findings from Environmental Defense Fund, Communities for a Better Environment, Food and Water Watch, Protect Playa Now, and Physicians for Social Responsibility – Los Angeles, and Air Products.
- The comments within the comment letters generally align with the key themes that emerged at PAG/CBOSG meetings, as noted above.

² <https://www.socalgas.com/sustainability/hydrogen/angeles-link>

Summary of How Comments are Addressed

Geographic Scope of Analysis. The geographic scope of analysis applied to the WRE was defined as SoCalGas’ service territory and certain select adjacent areas. This broad area was used rather than focusing on specific areas of potential hydrogen production or “production hubs,” because the ability to access, transfer or trade water supply across regions reduces the need to limit supply sources to production hubs. Future clean renewable hydrogen producers will be responsible for securing the necessary quantities and sufficient quality of water to support their respective projects. As a feasibility-level study, the broad geographic scope of analysis in the WRE serves to facilitate the identification of a variety of options for future producers to select or build from.

Water Needs Quantification. The WRE included quantification of the volume of water anticipated to be needed to produce the amount of hydrogen associated with projected demand throughout SoCalGas’s service territory, including for the portion that would be conveyed by Angeles Link. This quantification was based in part upon electrolyzer specifications and estimates associated with the electrolysis processes, discussed in Chapter 2. In addition to the estimates provided, an amount of water would be lost during the treatment processes, where the amount lost would depend upon the selected supply source type(s) and the source water quality. Water needs calculations may be refined as project-specific information on clean renewable hydrogen production projects becomes available.

Environmental Impacts and Climate Change. The purpose of the Water Resources Evaluation was to provide an initial understanding of the landscape for water supply availability for clean renewable hydrogen development in California. Potential environmental impacts of water use for clean renewable hydrogen development will depend upon numerous factors and site-specific features and considerations, and therefore are not detailed for the purposes of this feasibility Study. However, environmental considerations informed the identification of potential supply source types, including the avoidance of groundwater that is not sustainably managed, and the use of waste streams that could provide a number of benefits, including to the environment. For instance, treating concentrated wastewater or brine flows to create a water supply source for clean renewable hydrogen removes the disposal needs and associated environmental hazards from managing the waste stream. It is anticipated that the appropriate public agencies (e.g., state, county, city) would evaluate the potential environmental impacts and measures to avoid or minimize the impacts associated with water supply development pursuant to the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA), as applicable, before issuing approvals for clean renewable hydrogen production projects.

Energy Use and Air Emissions. Water supply management requires energy use, including for treatment and conveyance, which can be substantial depending upon the level of treatment conducted and distance conveyed. To address questions regarding energy use and potential greenhouse gas (GHG) emissions associated with providing the quantity and quality of water needed for clean renewable hydrogen production, a supplemental technical memorandum was prepared in direct response to this stakeholder feedback and is included as Chapter 5, *Supplemental Desktop Analysis – Greenhouse Gas Emissions Associated with Water Treatment and Conveyance*. In response to this stakeholder feedback, Chapter 5 was developed and includes a literature review of existing publications and high-level overview of key data points and variables reflecting the type and intensity of GHG emissions associated with the energy needed for water supply management, primarily treatment and conveyance. Without more information on specific third-party clean renewable hydrogen production projects at this feasibility stage or details on the specific water supply sources that may be used, a quantitative analysis of potential GHG emissions associated with those production projects is not feasible. In addition, as summarized above in response to comments on environmental impacts and climate change, third-party

Water Resources Evaluation

clean renewable hydrogen production projects would undergo review under CEQA and NEPA, as applicable, and such review would include analysis of potential GHG emissions associated with water supply treatment and conveyance for those projects.

Local Community Effects. The identification of potential water supply source types was informed by parameters including a lack of resource competition with existing and anticipated water uses, specifically those associated with population growth. Water supply management throughout California is conducted on state, regional, and local levels, with the availability of water sources varying by location, climatic conditions, and existing and anticipated demands. It is anticipated that third-party clean renewable hydrogen producers would pursue water supply sources managed according to all applicable regulatory requirements in place to balance California’s water supplies and demands.

In addition, it is anticipated that third party clean renewable production projects would undergo thorough environmental review, including a review of potential impacts associated with water supply development, pursuant to CEQA and/or NEPA, as applicable, at the time such projects are proposed. As a component of the CEQA/NEPA analysis, potential issues that could affect local communities would be evaluated through several resource areas, including but not limited to, hydrology and water quality, land use and planning, and biological resources (including creeks, waterways and wetlands).

SoCalGas understands concerns around affordability related to water needed by third-party producers of clean renewable hydrogen. Water rates in California are set by public processes and are based on a variety of factors. Ultimately, third-party clean hydrogen producers will select the water source(s) that may supply specific production projects, and that selection may inform future rate setting of a local water agency.

Study Introduction, Background and Overview of Chapters

SoCalGas commissioned this Water Availability Study from Rincon Consultants. The study was conducted, and this report was prepared, collaboratively.

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Introduction

This report provides the Water Resources Evaluation (WRE) prepared for Southern California Gas Company's (SoCalGas) proposed Angeles Link project (Angeles Link). The WRE is part of a larger feasibility investigation (Phase 1) being conducted for the development of a system that will transport clean renewable hydrogen for use in Central and Southern California, including the Los Angeles Basin. On December 15, 2022, the California Public Utilities Commission (CPUC) adopted Decision 22-12-055 (Decision) authorizing the establishment of SoCalGas's Angeles Link Memorandum Account (Memorandum Account) to track costs for advancing Phase 1 of Angeles Link. The Decision states SoCalGas shall provide findings from its Phase 1 feasibility studies, including studies that identify the potential sources of clean renewable hydrogen generation and water and estimate the costs of the clean renewable hydrogen production that could support Angeles Link (Decision, Ordering Paragraph (6)(b)).

Angeles Link would transport clean renewable hydrogen anticipated to be produced by future third-party producers to end users in Central and Southern California. The responsibility to secure sufficient water quantity and quality for future clean renewable hydrogen production projects will be held by third-party producers.³

An analysis of potential demand for clean renewable hydrogen through 2045 was prepared as a separate Phase 1 feasibility analysis, referred to herein as the "Demand Study," which assessed potential hydrogen demand throughout SoCalGas's service territory by 2045. The portion of that demand that would Angeles Link proposes to transport, also referred to as the "Angeles Link potential throughput," includes approximately 0.5 million metric tonnes per year (MMT/Y) in a low case scenario and up to 1.5 MMT/Y in a high case scenario. The Demand Study's estimated range of potential scenarios of overall demand for clean renewable hydrogen for SoCalGas's service territory and Angeles Link's proposed throughput scenarios are summarized in Table INTRO-1, below.⁴

Table INTRO-1 Demand Study Projections, Angeles Link Potential Throughput, and Associated Water Needs

Scenario	Clean Renewable Hydrogen Demand (MMT/Year) ¹	Water Needs (AFY) ¹	Water Needs (MGD) ¹
SoCalGas Service Territory			
Low Demand	1.9	20,900	19
High Demand	5.9	64,700	59
Angeles Link Potential Throughput			
Low Case	0.5	5,500	5
High Case	1.5	16,500	15

¹ MMT/year = million metric of tons per year; AFY = acre-feet per year; MGD = million gallons per day.

³ Please also refer to SoCalGas's Production Planning and Assessment Study (Production Study).

⁴ The Demand Study also identified a moderate demand scenario of 3.2 MMT/Year in SoCalGas's service territory by 2045. Angeles Link also has a medium case scenario of throughput of 1.00 MMT/Y. For purposes of the feasibility analysis in this Study, this Study analyzes potential water demands for the low and high ranges of the Demand Study (1,9-5.9 MMT/Y) and low and high ranges of the proposed Angeles Link throughput (0.5-1.5 MMT/Y).

Water Resources Evaluation

The magnitude of total water needs associated with anticipated demands for clean renewable hydrogen was used to inform the technical analyses summarized herein, and to facilitate identification of Study findings.

Background

The Water Resources Evaluation is a compilation of five separate chapters which can be reviewed independently or as a part of this larger WRE. The five chapters are presented below and summarized in the next section, *Overview of Chapters*.

- **Chapter 1: Water Availability Study.** A feasibility-level analysis of water supply for clean renewable hydrogen development was conducted to identify a variety of water supply source types based upon anticipated availability and potential for sustainable management,⁵ among other factors.
- **Chapter 2: Water Quality Requirements.** An analysis of water quality required for clean renewable hydrogen production was conducted based on technical requirements of the electrolyzer(s) that may be used to produce clean renewable hydrogen.
- **Chapter 3: Acquisition and Purification Costs.** High-level cost estimates were developed for key aspects of water supplies that could support third-party clean renewable hydrogen production (including water conveyance, treatment, and waste management).
- **Chapter 4: Challenges and Opportunities.** Challenges and opportunities were identified at a high level for the development of water supply sources that may support clean renewable hydrogen production in the study area.
- **Chapter 5: Supplemental Desktop Analysis – Greenhouse Gas Emissions Associated with Water Treatment and Conveyance.** In direct response to stakeholder feedback, a supplemental desktop analysis of potential greenhouse gas emissions associated with water treatment and conveyance was prepared.

For consistency across chapters, the parameters presented in Table INTRO-1 for the anticipated demand for clean renewable hydrogen and associated water needs, were used to inform the analyses presented in each chapter of the Water Resources Evaluation.

⁵ See, e.g., https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-6-Sustainable-Management-Criteria-DRAFT_ay_19.pdf

Overview of Chapters

Chapter 1: Water Availability Study

Scope of Work/Technical Approach

Pursuant to the Decision, the Water Resources Evaluation included preparation of a Water Availability Study, the purpose of which was to identify and characterize potential water supply sources that could support future third-party production of clean renewable hydrogen. While SoCalGas would not produce clean renewable hydrogen as part of the Angeles Link project, the purpose of the Water Availability Study was to provide potential water supply sources for third-party clean renewable hydrogen producers to pursue, to the extent that those resources have not already been acquired by hydrogen producers or other projects.

A key factor applied to the identification of potential water supply sources for clean renewable hydrogen production was a lack of interference with existing and planned uses of the respective water supply source. Therefore, treated wastewater streams were considered to be unavailable to clean renewable hydrogen production if they were part of an existing or planned water recycling or water reuse project. Similarly, groundwater was assumed to be unavailable unless the respective basin was not affected by overdraft and was sustainably managed, including under an adjudication judgment facilitating water market activity.

To avoid potential competition for water supply, the approach applied for the Water Availability Study involved the collection and review of applicable state-required land use and water supply planning documents, including: Urban Water Management Plans (UWMPs) which are required of supply providers with 3,000 or more service connections or delivering 3,000 AFY or more of water; Groundwater Sustainability Plans (GSPs) addressing individual groundwater basins for compliance with the Sustainable Groundwater Management Act (SGMA); and the California Water Plan maintained by the California Department of Water Resources (DWR) to plan for and provide for the sustainable management of water resources throughout the state. In addition, initial input from water agencies and managers was collected through agency outreach efforts.

Initial outreach with relevant water agencies was conducted to facilitate meaningful collaboration between future hydrogen producers and agencies involved in the development and distribution of water supply within SoCalGas's service territory. The agency outreach effort involved identifying agencies based upon ownership and operation of existing water supply projects and infrastructure, size, and location. Virtual meetings were conducted with water agencies, for discussion of the respective agencies' water supply sources, programs, and facilities, as well as potential opportunities for the development of water supply for clean renewable hydrogen production through partnership with future hydrogen producers. Input from water agencies and managers helped to inform consideration of creative or alternative means of developing potential water supply sources for clean renewable hydrogen production, such as treatment of flows currently managed as waste.

The Water Availability Study provides a thorough characterization of existing water supply management in Southern California, with descriptions of existing water supply sources, water supply development projects, and water demands in key sectors including urban (municipal and

industrial), agricultural, and environmental uses. As discussed above, potential water supply sources were eliminated from consideration if they were (1) fully allocated or planned for use in meeting existing or anticipated water needs for a given area, (2) part of existing or planned water recycling or reuse projects, (3) part of the sustainable management of local groundwater resources for SGMA compliance, or (4) if use would conflict with existing or anticipated water needs. Potential supply source types were not eliminated based upon cost, quality, complexity, or acquisition or development.

Overview and Findings

The Water Availability Study produced a menu of 10 potential water supply sources determined to be feasible for future acquisition or development by third-party clean renewable hydrogen producers to support their respective projects, as presented in Table INTRO-2, below.

Table INTRO-2 Potential Water Supply Sources

Source Type	Overview*
Imported Surface Water	Imported surface water from the SWP, Colorado River, and CVP may be purchased from a contractor to the respective project from within the contractor’s existing allocations.
Treated Wastewater	Treated wastewater is highly treated and disinfected at wastewater treatment facilities where it is available for purchase if not already planned for beneficial reuse; this water would be purchased from the treatment provider.
Groundwater	Local groundwater being sustainably managed by local agencies under SGMA or by Court-ordered adjudication may be available in DWR-designated Low Priority basins, adjudicated areas, or groundwater storage banks.
Agricultural Industry Water	Agricultural industry water includes agricultural field drainage, surface water runoff, subsurface drainage, and used wash water that may be captured or diverted for treatment and reuse.
Brine Line Flows	Brine line flows are highly concentrated with salts and other contaminants that could be diverted at the point of origin, or from the brine line directly, for further treatment and reuse.
Advanced Water Treatment Concentrate	Advanced water treatment concentrate is wastewater from treatment processes that may be diverted at the point of origin for further treatment and reuse.
Oil & Gas (O&G) Industry Water	O&G industry water includes refinery offset water from reduced or halted refinery operations and produced water that may be treated for reuse.
Inland Brackish Groundwater	Inland brackish groundwater arises from natural and manmade sources, and may be extracted for treatment and reuse.
Dry Weather Flows	Dry weather flows are on-precipitation flows accumulating in municipal storm sewer systems during dry weather conditions that may be collected and treated for reuse.
Urban Stormwater Capture and Reuse	Urban stormwater capture and reuse refers to stormwater runoff that is captured for storage, treatment, and reuse before reaching discharge outlets during precipitation events.

* CVP = Central Valley Project; DWR = Department of Water Resources; O&G = oil and gas; SGMA = Sustainable Groundwater Management Act; SWP = State Water Project

Table INTRO-3, below, provides an overview of existing mechanisms that can be used to acquire or develop water supply, to assist future clean renewable hydrogen producers in securing sufficient water quantity and quality for their respective projects.

Table INTRO-3 Potential Water Supply Acquisition Mechanisms

Acquisition Mechanism	Overview*
Exchange Agreements	Exchange agreements may be developed between future clean renewable hydrogen producers and water agencies with sufficient surplus supply or supply development potential.
Local Water Agencies	Agencies may have supply available for purchase or may partner with future producers to develop a supply source for mutual benefit. Agencies may also consider the inclusion of future production projects in UWMP projections of water needs and availability.
Water Markets	Water markets may be used, including for adjudicated groundwater resources and surplus surface flows, as available.
Land Purchase with Water Rights	Land purchase with water rights may be available, depending upon the physical availability of water, population growth projections, land use planning and zoning, and project proposals submitted to the local land use agency.

* SWP = State Water Project; UWMP = Urban Water Management Plan

The Water Availability Study did not develop estimates of water needs for individual clean renewable hydrogen production projects. However, as described above, water needs associated with clean renewable hydrogen development potential were estimated based upon the projected demands for clean renewable hydrogen throughout SoCalGas’s service territory (as described in the Angeles Link Phase 1 Demand Study) as well as upon the estimated volume of clean renewable hydrogen Angeles Link is expected to transport in the long term.

To provide context to the scale of anticipated water needs for clean renewable hydrogen production, the Water Availability Study presented overall rates of applied water use in California, where “applied water” refers to the amount of water provided for use in the urban and agricultural sectors and dedicated for environmental uses and obligations on an annual basis. Table INTRO-4, below, shows average annual applied water rates in California.

Table INTRO-4 Average Annual Statewide Applied Water¹

Sector	Dry Year (AFY) ³	Wet Year (AFY) ³
Urban ²	7,000,000 (12%)	8,000,000 (8%)
Agriculture	33,000,000 (53%)	30,000,000 (29%)
Environment	22,000,000 (35%)	65,000,000 (62%)
Total	62,000,000	103,000,000

¹ “Applied water” refers to the volume of water provided for use in the urban and agricultural sectors, and dedicated for use in the environmental sector, and varies annually depending upon demand and climatic conditions.

² The urban sector, also referred to as “Municipal and Industrial” (M&I) includes commercial, industrial, and residential uses.

³ The values shown in parentheses indicate the percentage of total applied water use represented by the respective sector.

Source: PPIC 2023

Applied water for the urban sector tends to increase during wet years, when water conservation requirements are less stringent, while applied water for the agricultural sector decreases during wet years, when increased precipitation reduces needs for irrigation. Applied water for environmental uses and obligations increases during wet years due to increased precipitation replenishing natural systems and environmental needs. Table INTRO-5, below, compares applied water rates to the water needs of service territory-wide demands and Angeles Link expected throughput, as previously presented in Table INTRO-1, in the this introduction.

Table INTRO-5 Water for Clean Renewable Hydrogen vs Statewide Applied Water

Demand Scenarios	Water Needs for Production (AFY) ¹	Dry Year Applied Water (62 MAFY) ¹	Wet Year Applied Water (103 MAFY) ¹
SoCalGas Service Territory			
Low Demand	20,900	0.03%	0.02%
High Demand	64,700	0.10%	0.06%
Angeles Link Throughput			
Low Case	5,500	0.01%	< 0.01%
High Case	16,500	0.03%	0.02%

¹ AFY = acre-feet per year; MAFY = million acre-feet per year
 Source: PPIC 2023

The comparisons provided above between applied water rates and water needs for clean renewable hydrogen production demonstrate that the water needed by third-party producers to meet demands for clean renewable hydrogen represents a small percentage of total applied water in California. The amount of water needed to meet the portion of demand that would be served by Angeles Link would be even smaller, with the Low Case scenario needs under wet year conditions representing less than 0.01 percent of total applied water.

Overall findings of the Water Availability Study are summarized below.

- A substantial portion of water demands for clean renewable hydrogen production may be met using existing water supply sources and mechanisms of acquisition.
- The quantity of water needed by third-party producers of clean renewable hydrogen to meet the projected demands across SoCalGas’s service territory by 2045, including the portion that would be transported by Angeles Link, comprises a small percentage of the total amount of water used in California each year.
- Third-party producers of clean renewable hydrogen may draw from a number of water supply sources to meet the water needs of their respective projects producing clean renewable hydrogen throughout SoCalGas’s service territory, including for Angeles Link’s throughput.
- Water needs of clean renewable hydrogen projects could be refined in the future, as projects are developed, and proposed projects are submitted to the appropriate agencies for approvals.
- As water supply planning documents including UWMPs continue to be updated in the future, and clean renewable hydrogen projects are proposed via applications submitted to the respective land use agencies, associated water needs of such projects may be incorporated into agency projections and planning documents.

Chapter 2: Water Quality Requirements

Scope of Work/Technical Approach

An analysis of water quality requirements for clean renewable hydrogen production was conducted. The scope of work for assessment of water quality included collecting water quality specifications for the electrolyzers that could be used to generate clean renewable hydrogen and conducting a desktop review to evaluate the efficiency of these systems. Pretreatment requirements for potential water supply sources were assessed, including consideration of electrolyzer efficiencies. Water

quality requirements were established based on electrolyzer type (e.g., alkaline, polymer electrolyte membrane or solid oxide).

Overview and Findings

The two main technologies available for use in large-scale hydrogen generation include alkaline electrolysis and polymer electrolyte membrane (PEM) electrolysis. Solid oxide electrolysis cell (SOEC) is another electrolyzer technology that is not as widely commercialized but may be an efficient option, and membraneless technologies were also considered as an emerging technology in large-scale hydrogen production. Electrolyzer water quality requirements depend upon the type of electrolysis technology used. Table INTRO-6, below, provides an overview of typical requirements.

Table INTRO-6 Water Quality Requirements by Electrolyzer Type

Electrolyzer Technology	Typical Water Quality Requirements
Alkaline Electrolyzer	Ultrapure water is typically required. Recommended higher water conductivity of <5 $\mu\text{S}/\text{cm}$. ¹
Polymer Electrolyte Membrane (PEM) Electrolyzer	Ultrapure water is required. Suggested water conductivity of <0.2 for PEM electrolyzers.
Solid oxide electrolysis cell (SOEC)	Some manufacturers suggest using deionized or boiler feed water but most typically do not require high quality water.
Membraneless electrolyzers	Some systems use untreated seawater or potable water, while others require demineralized or deionized water with a specific pH.

¹ $\mu\text{S}/\text{cm}$ = microsiemens per centimeter (unit of measurement of electric conductivity)

As shown above, alkaline and PEM electrolysis technologies involve the use of ultrapure water.⁶ Ultrapure waste has been highly treated and purified, including with respect to electric resistivity and other characteristics. Treating and purification to ultrapure standards requires pretreatment of raw water as well as polishing of treated water. The final pretreatment step typically uses reverse osmosis (RO). Table INTRO-7, below, provides an overview of the water quality treatment stages to produce ultrapure water, based upon initial treatment equivalent to tertiary-treated recycled water.

Table INTRO-7 Target Contaminants for Water Quality Treatment by Inflow Type

Inflow Water Quality	Treatment Stage	Target Contaminants
Tertiary-treated, ¹ potable water	Pretreatment for RO ²	Suspended solids, oil and grease, organics, microorganisms, nuisance compounds (e.g. iron, manganese, hardness)
Demineralized water, boiler feeder water	RO	TDS, ² conductivity, total and dissolved organic compounds, and other dissolved contaminants, e.g. boron
Deionized, ultrapure water	Post-RO Polishing	Gas, silica, conductivity, and TOC ²

¹ Tertiary treatment of water eliminates non-biodegradable pollutants, phosphorus, and nitrogen in the water, and follows primary treatment (removal of solids) and secondary treatment (removal of dissolved and suspended organic compounds).
² RO = reverse osmosis; TDS = total dissolved solids; TOC = total organic compounds

It was determined that for alkaline and PEM electrolysis technologies, between approximately 950 and 1,100 gallons of ultrapure water would be required per day per megawatt (MW) of electrolyzer capacity. The amount of source water required to produce sufficient ultrapure water would vary

⁶ Please also refer to SoCalGas's Production Study.

depending upon the quality of the supply source type and the extent of required water quality treatment. The extent of water quality treatment required was used to inform calculation of the amount of water that would be lost to treatment and cooling, and the total amount of source water required to produce clean renewable hydrogen using the available electrolysis technologies.

Chapter 3: Acquisition and Purification Costs

Scope of Work/Technical Approach

High-level cost estimates of the main cost components of water supply were developed, including for water acquisition, treatment, concentrate management, and conveyance. Costs were expressed in unit costs (i.e., costs per unit hydrogen produced or costs per unit volume of water). This approach supported the calculation of rough estimates of potential costs associated with respective water supply sources identified in the Water Availability Study. The cost outputs were presented in life cycle and unit cost formats to facilitate the comparison of costs across potential water supply sources and to support the development of costs for specific water supply projects or water supply portfolios that may be defined in the future.

Overview and Findings

An analysis of potential costs associated with water supply acquisition and development was conducted for supply source types identified in the menu of options from the Water Availability Study (see Section ES-1). This analysis was informed by the water quality requirements of the electrolysis technology types available and the extent of water quality treatment required for each potential source type (see Section ES-2), as well as management of waste materials generated during treatment processes. Total dissolved solids (TDS) concentration was identified as a key determining factor of cost, as water quality polishing systems typically require TDS concentration of less than 350 milligrams per Liter (mg/L), and most of the supply source types identified in the Water Availability Study have TDS concentrations above this level. Location of the potential source types and extent of conveyance required were also found to be key determining factors of cost.

The acquisition and purification costs analysis considered the location of water supply sources and treatment facilities relative to clean renewable hydrogen production projects, and assessed how transportation needs would affect cost. Factors considered included the length of pipelines, and future production sites, as well as the energy needs of conveyance, which would increase in relation to topographic relief.

Conceptual supply projects were developed to assess costs and create cost estimates. Assuming the average total project cost of the conceptual projects, the water supply costs for 0.5 MMT/Y to 1.5 MMT/Y of clean renewable hydrogen would range from \$445 million to 1,335 million, including construction and net present value operation and maintenance for 30 years of operation.

Chapter 4: Challenges and Opportunities

Scope of Work/Technical Approach

Challenges and opportunities related to water supply and treatment were assessed for three key topics, including: (1) potential water supply sources, (2) geographic location, setting, and distance to clean renewable hydrogen production, and (3) requirements for conveyance, including methods and

distance. Challenges considered included those factors that could have significant impacts on water availability, or that could jeopardize access to water for clean renewable hydrogen production. Challenges associated with advancing pipelines through developed areas, potentially introducing infrastructure relocation and disturbances to traffic and businesses, as well as through undeveloped areas, could result in environmental impacts that require mitigation.

Opportunities included identification of potential source types and transportation methods that could streamline the provision of water supply at the locations of clean renewable hydrogen production, and could improve cost as well as reliability of hydrogen supply. Technology improvements may also be available to support the electrolysis process, as discussed in SoCalGas’s Production Study. The analysis also considered cost-streamlining options, such as prioritizing water supply sources close to hydrogen production areas. Acquiring surface water through an exchange would provide another opportunity to address conveyance challenges. One of the primary benefits of an exchange project is that it provides a potential approach to avoid the need to construct pipelines from coastal and urban areas to the potential areas for hydrogen production.

Overview and Findings

Table INTRO-8 provides an overview of potential challenges, mitigation strategies, and opportunities associated with the supply source types identified in the Water Availability Study.

Table INTRO-8 Challenges and Opportunities of Potential Supply Source Types

Supply Source Type	Challenges	Mitigation Strategies	Opportunities
Imported Surface Water	Long-term reliability and drought-year availability, and regulatory permitting issues of exchange projects.	Explore water banking options to store excess water when available for use as needed.	Partnerships in distribution and conveyance of surface water, and development of exchange supply in areas where there is a need for diversification.
Treated Wastewater	Reliability of supply (conservation efforts reducing water use can also reduce wastewater flows) and management of concentrate.	Contribute funds for the expansion of wastewater treatment facilities in growing areas; identify other sources for a diverse supply portfolio.	Partnerships to facilitate gathering effluent from multiple facilities and conveying it to hydrogen production areas for treatment and use.
Groundwater	Concentrate management, including potential cost and operation of large evaporation basins or pipelines for disposal. Source reliability may pose an additional challenge.	Coordinate with Groundwater Sustainability Agencies (GSAs) for possible partnership on supply improvement and mutual benefit projects such as banking.	Partnerships to support sustainable groundwater management such as through mutually beneficial groundwater banking projects.
Agricultural Industry Water	Treatment of agricultural drainage water is expected to be challenging due to very high TDS concentrations.	Target source water where the removal of agricultural discharge would be particularly beneficial to receiving waterways.	Partnerships to enhance access to agricultural industry water, and partnerships for the implementation of salinity management projects.

Supply Source Type	Challenges	Mitigation Strategies	Opportunities
Brine Line Flows	Cost and implementation of concentrate disposal pipelines or evaporation basins.	Locate the project treatment facility close to the source concentrate pipeline and use that existing pipeline to dispose the concentrate generated from water treatment processes.	Partnerships between brine line flow contributors and hydrogen producers.
Advanced Water Treatment Concentrate	Water quality characteristics would pose additional operational challenges and costs, such as higher energy costs, more frequent backwash of processes, scaling of treatment equipment and concentrate pipelines.	Use or expand the existing concentrate disposal system; locate the project treatment plant at or near the advanced water treatment facility for direct delivery of treated water to the production site.	Partnerships to enhance access to concentrate supply and partnerships related to the distribution and conveyance of concentrate for hydrogen production.
O&G Industry Water	Long-term reliability; concentrate management, treatment, and operational issues.	Further treatment of the residuals/concentrate to reduce the potential need for handling as hazardous wastes.	Partnerships to use or repurpose existing oilfield waste disposal systems; partnerships related to the distribution and conveyance of O&G production water from multiple oil fields or refineries for hydrogen production.
Inland Brackish Groundwater	Concentrate management; source reliability due to a finite volume of brackish groundwater available; potential connection between brackish groundwater and drinking water aquifers.	Develop projects to comply with regulatory requirements of salt and nutrient management or to address brackish groundwater caused by previous land uses.	Partnerships to fund or assume operation of desalination systems, which may enhance access to brackish groundwater sources while allowing water agencies to shift funding and resources to projects that provide a more cost-effective supply for their ratepayers.
Dry Weather Flows	Reliability; concentrate management; treatment complexity; operational issues.	Gather dry weather flows from multiple watersheds and convey that water to hydrogen production areas for treatment and use.	Partnerships related to the distribution and conveyance of dry weather flows; collaboration with agencies with interests related to the benefits of capturing and treating dry weather flows.
Urban Stormwater Capture	Reliability; flow fluctuations.	Divert stormwater from multiple stormwater basins within a watershed to allow for diversion of stormwater flows for a longer duration between storm events.	Partnerships with agencies that need to improve or repair existing flood control or stormwater systems.

Chapter 5: Supplemental Desktop Analysis

Scope of Work/Technical Approach

This supplemental desktop analysis provides information related to potential GHG emissions associated with the treatment and conveyance of water supply in California, to address comments received from the PAG and CBOSG members. This report does not include quantification of GHG emissions associated with the potential supply source types identified in the Water Resources Evaluation; rather, it provides information, including data and methodology, to provide additional context at this stage of potential future GHG emissions associated with future water supply development. This supplemental analysis is informed by review of available literature and resources.

Overview and Findings

This supplemental analysis finds the extent of GHG emissions associated with water supply management depends on many factors, including, but not limited to, the type and amount of electricity used for a given activity (i.e., for pumping needs depending on local topography or whether gravity is available for conveyance or for treatment needs depending on the quality of the water). Water quality treatment and water conveyance are the most energy-intensive aspects of water supply management.

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Chapter 1: Water Availability Study

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Acronyms

AF	acre-feet
AFY	acre-feet per year
ASR	Aquifer Store and Recovery
AVEK	Antelope Valley-East Kern
AWMP	Agricultural Water Management Plan
AWPF	Advanced Water Purification Facility
AWTF	Advanced Water Treatment Facility
BAP	Base Annual Production
BLM	Bureau of Land Management
CalEPA	California Environmental Protection Agency
CalGEM	California's Geologic Energy Management Division
CARB	California Air Resources Board
CBP	Chino Basin Program
CCC	California Coastal Commission
CCR	California Code of Regulations
CCST	California Council on Science and Technology
CDA	Chino Desalter Authority
CDFA	California Department of Food and Agriculture
CEC	California Energy Commission
CNRA	California Natural Resources Agency
CPUC	California Public Utilities Commission
CNRA	California Natural Resources Agency
CR	Colorado River
CRB	Colorado River Board
CRS	Congressional Research Service
CTP	Coastal Treatment Plant
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
CVP	Central Valley Project
CVSC	Central Valley Salinity Coalition
CVWD	Coachella Valley Water District
CWC	California Water Code

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CWC	California Water Commission
Delta	Sacramento-San Joaquin River Delta
DOGGR	Division of Oil, Gas, and Geothermal Resources
DPR	direct potable reuse
DWR	Department of Water Resources
EMWD	Eastern Municipal Water District
EO	Executive Order
EWA	Encina Wastewater Authority
EWMP	Efficient Water Management Practices
FPA	Free Production Allowance
FWA	Friant Water Authority
GHC	Green Hydrogen Coalition
GRF	Groundwater Recovery Facility
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
IEUA	Inland Empire Utilities Agency
IID	Imperial Irrigation District
JCSD	Jurupa Community Services District
JPA	Joint Powers Authority
LACSD	Los Angeles County Sanitation Districts
LADWP	Los Angeles Department of Water and Power
LASAN	Los Angeles Sanitation and Environment
LCWSP	Lower Colorado Water Supply Project
MAFY	millions of acre-feet per year
Metropolitan	Metropolitan Water District of Southern California
MGD	millions of gallons per day
M&I	municipal and industrial
MOU	Memorandum of Understanding
MPN	most probable number
MS4	municipal separate storm sewer system
MMT	million metric tons
MWD	Municipal Water District
NCWA	Northern California Water Association

NPDES	National Pollutant Discharge Elimination System
NTC	Notice to Contractors; Notice to SWP Long-Term Water Supply Contractors
OC-San	Orange County Sanitation District
O&G	oil and gas
PFAS	per- and polyfluoroalkyl substances
PHWA	Port Hueneme Water Agency
PNNL	Pacific Northwest National Laboratory
PPIC	Public Policy Institute of California
PPR	Present Perfected Rate
PVID	Palo Verde Irrigation District
QSA	Quantification Settlement Agreement
RRF	Resource Recovery Facility
RTP	Regional Treatment Plant
RWQCB	Regional Water Quality Control Board
SAWPA	Santa Ana Watershed Protection Authority
SCE	Southern California Edison
SCWD	South Coast Water District
SD	Sanitation District
SD	Secondary Disinfected
SGMA	Sustainable Groundwater Management Act
SJRNA	San Joaquin River Exchange Contractors Water Authority
SJV	San Joaquin Valley
SJVGB	San Joaquin Valley Groundwater Basin
SJRRP	San Joaquin River Restoration Program
SLC	San Luis Canal
SNMP	Salt and Nutrient Management Plan
SoCalGas	Southern California Gas Company
SOCWA	South Orange County Wastewater Authority
SU	Secondary Undisinfected
SWMP	Stormwater Management Program
SWP	State Water Project
SWRCB	State Water Resources Control Board
T	Tertiary

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TDS	total dissolved solids
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USCB	U.S. Census Bureau
USDOJ	U.S. Department of the Interior
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Society
UV	ultraviolet
UWCD	United Water Conservation District
UWMP	Urban Water Management Plan
WBMWD	West Basin Municipal Water District
WDR	Waste Discharge Requirements
WEF	Water Education Foundation
WMWD	Western Municipal Water District
WPCF	Water Pollution Control Facility
WQCP	Water Quality Control Plant
WRE	Water Resources Evaluation
WRC	Water Resource Center
WRD	Water Replenishment District of Southern California
WRP	Water Reclamation Plant
WRP	Water Resilience Portfolio
WRRF	Water Resource Recovery Facility
WSCP	Water Shortage Contingency Plan
WSS	California Water Supply Strategy
WWD	Westlands Water District
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant

Glossary of Key Terms

- **Adjudication** occurs when water users within a basin are in dispute over legal rights to the water, and a court issues a ruling known as an adjudication; an adjudication judgment defines the area of adjudication (which may include an entire basin, a portion of a basin, or a group of basins), and defines the following: 1) who the water rights owners are (“parties” to the adjudication), 2) how much groundwater each water rights owner can extract, and 3) who the Watermaster will be for the administration and enforcement of the adjudication judgement (see “Watermaster” definition below).
- **Advanced water treatment** is a tertiary-level process that reduces impurities in wastewater to levels below those attainable through conventional secondary or biological treatment. The process typically involves membrane filtration, reverse osmosis, and oxidation (see below).
- **Agricultural wash water** refers to water that is applied to produce to remove soil and debris prior to the produce being received by produce buyers and distributors. Spent wash water is referred to as “process wastewater.”
- **Applied water** refers to the volume of water provided for use in the urban (M&I) and agricultural sectors, and dedicated to environmental uses and obligations; applied water rates vary annually depending upon demands and climatic conditions.
- **Basin Priority** is a ranking assigned by the Department of Water Resources (DWR) to individual groundwater basins to reflect the current condition of each basin, with High Priority basins being affected by long-term overdraft.
- **Beneficial use** refers to the uses of water necessary for the survival or wellbeing of humans, plants, and wildlife. Beneficial use designations are assigned to surface water and groundwater resources by the RWQCB for waters in their respective regions. Water quality objectives and management actions and programs are included in each Basin Plan and are designed to support the designated beneficial uses.
- **Brackish groundwater.** Brackish groundwater is water that occurs below the ground surface and is characterized by salinity levels between freshwater and seawater. In coastal areas, brackish groundwater is commonly caused by seawater intrusion. In inland areas, brackish groundwater typically occurs from soil conditions and discharges from water quality treatment facilities. It can be treated to reduce total dissolved solids (TDS) concentrations for reuse for non-potable purposes like irrigation or industrial processes, providing an alternative water source in regions with limited freshwater availability.
- **Brackish water** has high salinity content that is higher than freshwater and lower than seawater.
- **Brine** is a solution of highly concentrated salts, with TDS concentrations higher than seawater. Brine is a byproduct of water treatment processes and can be repurposed for specific industrial applications or resource recovery purposes.
- **Brine lines** are conveyance systems dedicated to brine, which collect brine flow from multiple dischargers and convey it to a treatment facility where it is treated for disposal in compliance with regulatory discharge requirements.
- **California Aqueduct.** The California Aqueduct is the key feature of the State Water Project (SWP), owned and operated by the DWR. The California Aqueduct specifically serves as conveyance for the SWP; flows contained within the aqueduct belong to contractors and customers of the SWP who hold contracted allocations to the water.

- **Central Valley Project (CVP).** The CVP is a federal power and water project that consists of reservoirs, canals, aqueducts, and pumping plants to convey surface water from the Sacramento River, where it collects behind Shasta Dam and Trinity Dam, and delivers it to irrigation and municipal water customers in the San Joaquin Valley.
- **Colorado River.** Water from the Colorado River is managed through a joint federal/state project that imports water from the Lower Basin of the Colorado River watershed and conveys that water through the Colorado River Aqueduct to municipal and agricultural demands in Southern California.
- **Concentrate** refers to the brine stream that is produced as a byproduct of advanced water treatment processes, specifically membrane filtration and reverse osmosis.
- **Conjunctive Use Management.** Conjunctive use of water resources refers to the coordinated use of surface water and groundwater resources to maximize each resource. Conjunctive use management involves actively recharging groundwater with surface water supplies and monitoring to assess and control for water quality implications, among other types of management techniques. An important consideration in conjunctive use management is the presence of water rights held by tribal communities.
- **Decision 22-12-055 (Decision)** was adopted by the California Public Utilities Commission (CPUC) on December 15, 2022, authorizing the establishment of SoCalGas’s Angeles Link Memorandum Account to track costs for advancing the first phase of the Angeles Link project.
- **Demand Study** is part of a separate Phase 1 feasibility study for Angeles Link, prepared to define a range of potential scenarios of demand for clean renewable hydrogen that could occur by 2045 across SoCalGas’s service territory, spanning from a low demand or conservative scenario to a high demand or ambitious scenario.
- **Desalter.** A desalter is a facility designed to remove salts and other water quality constituents from water, lowering TDS concentrations and converting previously unusable brackish groundwater into high-quality drinking water.
- **Developed water** refers to water supply that is controlled and managed such as through treatment, conveyance, storage, or trade, to be available for specific purposes.
- **Dry weather flow** occurs in the absence of precipitation due to surface discharges from activities such as watering lawns, operating car washes, and discharge of treated wastewater from wastewater treatment plants.
- **Effluent** is treated flow discharged from a wastewater treatment facility.
- **Exchange Water.** Under an agreement for exchange water, a water seller provides its excess supplies to a water buyer and in exchange, the buyer provides a replacement water supply to the seller. The replacement water supply is provided in amounts equal to the amount of water purchased and must be made available to the seller within its service area.
- **Fracking/fracturing** is an oil and gas (O&G) production process that involves injecting liquid at high pressure into the ground to force open existing fissures and extract O&G. Fracking permits are no longer issued in the State of California; existing fracking operations are allowed to continue but will be phased out as they reach their useful operational lifetime.
- **Groundwater** is defined by the state as “all water beneath the surface of the earth within the zone below the water table in which the soil is completely saturated with water but does not include water that flows in known and definite channels.” Cal. Water Code Section 10752.
- **Injection wells** are used to place fluids in the subsurface for disposal, dilution, storage, or reuse. Injection wells are regulated and permitted by California’s Geologic Energy Management Division (CalGEM), formerly the Division of Oil, Gas, and Geothermal Resources (DOGGR).

- **Membrane filtration** removes solids, bacteria, protozoa, and some viruses by pumping recycled water (treated wastewater) through tubes filled with tiny membranes made up of hollow fibers.
- **Municipal Separate Storm Sewer Systems (MS4s)** are stormwater conveyance and discharge systems that are separate from the local sanitary sewer systems, and do not route flows through a treatment facility prior to discharge.
- **O&G Industry** refers generally to activities associated with the production of oil and gas resources from below the ground surface.
- **Offset water** refers to water that was used in O&G production or refinery operations that becomes available for other uses once the respective activities cease.
- **Outfall** is the point where treated or reclaimed water is intentionally released from a water treatment facility or distribution system, either into a water body or for specific environmental/agricultural purposes, marking the endpoint of the water reuse process.
- **Overdraft** occurs when the amount of water entering a groundwater basin is consistently less than the amount of water leaving the basin. The effects of overdraft over time can include seawater intrusion (an ongoing issue along the coast), land subsidence (a long-standing issue in the San Joaquin Valley), and overall groundwater depletion (an issue throughout the state).
- **Oxidation** destroys any organisms remaining after reverse osmosis by using ultraviolet (UV) light and hydrogen peroxide (H₂O₂) to disinfect the flow of trace organic compounds.
- **PFAS (per- and polyfluoroalkyl substances)**. PFAS are a large group of manufactured substances that do not occur naturally and are resistant to heat, water, and oil. PFAS originate from four sources including: fire foams used in fire training/fire response sites, industrial and manufacturing sites, landfills, and wastewater treatment plants.
- **Plumes**. A plume is a concentrated area of groundwater contamination occurring near the source of the contamination, such as the discharge point for effluent from a wastewater treatment facility.
- **Potable Reuse**. Water Code Section 13561 defines potable recycled water use as including:
 - *Indirect Potable Reuse for groundwater recharge* = recycled water that replenishes groundwater designated as a source of water supply for a public water system
 - *Reservoir water augmentation* = recycled water that replenishes surface water reservoir designated as a source of water supply for a public water system
 - *Direct Potable Reuse (DPR)* = recycled water that contributes directly to a public water system or raw water supply immediately upstream of a water treatment plant
- **Potable water** is water that is suitable for human consumption based upon state and federal regulations for drinking water.
- **Produced water** is water that underlies oil and gas fields and is brought to the surface along with oil and gas as a result of pumping activities. Produced water is typically high in salt content and contains salts and minerals from the subsurface.
- **Reclaimed water** refers to recycled water that is applied to beneficial use. Reclamation requirements include “fit-for-purpose” specifications, which define the treatment requirements to bring water from a particular source to the quality needed for a given use while ensuring public health, environmental protection, or specific user needs (USEPA 2023).
- **Recycled water** is highly treated wastewater (municipal sewage) that has been filtered and disinfected at a wastewater treatment facility.
- **Refinery** is an industrial process plant where crude oil is transformed into products such as gasoline, diesel fuel, asphalt base, fuel oils, heating oil, kerosene, and liquefied petroleum gas.

Refining breaks crude oil down into its various components, which are then selectively reconfigured into new products. All refineries involve three basic steps, including separation, conversion, and treatment. Most of the water used in a petroleum refinery is used for cooling purposes; water can be used for boiler feed water, fire protection, sanitary services, and processing (Sensorex 2022).

- **Reverse Osmosis** removes salts, viruses, pharmaceuticals, and pesticides from the filtered recycled water by using high pressure to force it through membranes with microscopic holes.
- **Secondary Undisinfected (SU) water** is oxidized wastewater. This water is typically suitable for surface irrigation of limited crop types and flushing of sanitary sewers.
- **Secondary Disinfected-23 (SD-23) water** is wastewater that has been oxidized and disinfected with total coliform bacteria not exceeding a most probable number (MPN) of 23 per 100 milliliters. This water is typically used for surface irrigation of limited crop types, landscape impoundments, and other industrial or commercial processes.
- **Secondary Disinfected-2.2 (SD-2.2) water** is wastewater that has been oxidized and disinfected with total coliform bacteria not exceeding MPN of 2.2 per 100 milliliters. This water is typically used for similar applications as SD-23 water with some additions.
- **State Water Project (SWP).** The SWP conveys surface water from the Sierra Nevada Mountains, where it originates as snowmelt, to SWP contractors in Southern California via a system of canals, tunnels, and pipelines, for distribution to individual customers.
- **Surface Water** is defined by the State of California as water in a “stream, lake, or other body of water” and “subterranean streams flowing through known and definite channels.” (California Water Code Section 1200)
- **Table A** water refers to the maximum amount of water each SWP contractor can receive each year. DWR uses Table A to allocate SWP supplies and costs among the contractors.
- **Tertiary (T) water** is wastewater that has been filtered and disinfected with median coliform bacteria not exceeding MPN of 2.2 per 100 milliliters. This water has the widest applications, including landscape irrigation, food crops, recreational impoundments, dual plumbed facilities, and industrial and commercial processes.
- **Transfer Water.** A water transfer is a means of providing water to areas of critical need from other areas that have surplus for the given year. Transfers are designed for use as short-term solutions to water supply challenges. A transfer differs from an “exchange” in that it does not involve the provision of a replacement water supply.
- **Wastewater** refers to untreated municipal sewage unless specified otherwise.
- **Water Source** refers to both the origin of water (surface water or groundwater) and the place where water is obtained for use (ex., water recycling facility, desalter facility, reservoir, low-elevation collection area, discharge pipe, etc.)
- **Water supply** refers to water that is procured or developed to meet the water needs of a particular use, in this case the development of clean renewable hydrogen.
- **Watermaster** refers to the court-appointed parties responsible for overseeing the day-to-day administration of water rights within an adjudicated groundwater basin and, when necessary, for taking enforcement action related to compliance of water users with the adjudication judgment.

Executive Summary

This Water Availability Study summarizes one chapter of the larger Water Resources Evaluation (WRE) being prepared as part of the Phase 1 feasibility studies conducted in support of the proposed Angeles Link project (Angeles Link). Pursuant to the California Public Utilities Commission (CPUC)'s Decision 22-12-055 (Decision), the purpose of this Water Availability Study is to identify and characterize potential water supply sources that could support future third-party production of the clean renewable hydrogen that Angeles Link could transport to end users in Central and Southern California, including the Los Angeles Basin (inclusive of the Ports of Los Angeles and Long Beach).¹

The study area considered for this Water Availability Study is generally defined by the boundaries of SoCalGas's service territory; certain potential water sources located outside SoCalGas's service territory were also included based on resource-specific features and potential to contribute to water supply availability. The approach to this Water Availability Study included conducting initial inquiries to select water agencies and regional water suppliers to inform identification of potential supply sources. To provide context for the potential water supply sources, identified herein, this Water Availability Study includes background information on water supply management in California, with descriptions of key regulatory agencies, laws and regulations, and major water supply sources including the State Water Project, the Central Valley Project, and the Colorado River.

Under separate Phase 1 feasibility analyses for Angeles Link, a clean renewable hydrogen Demand Study was prepared, which identified a range of potential demand scenarios for clean renewable hydrogen across SoCalGas's service territory by 2045. The overall projected demand spans from a low demand (conservative scenario) of 1.9 million metric tons per year (MMT/Year) to a high demand (ambitious scenario) of 5.9 MMT/Year.² The Angeles Link system would transport a portion of the overall projected demand for clean renewable hydrogen, with a proposed throughput of approximately 0.5 MMT/Year under a low case scenario and up to 1.5 MMT/year under a high case scenario.³ The following tables quantify water needs for each projected demand scenario:

- Table 1.ES-1 presents water needs for the production of clean renewable hydrogen in amounts meeting projected demands throughout SoCalGas's service territory, and
- Table 1.ES-2 presents water needs for the expected Angeles Link throughput, or the portion of the overall demand for clean renewable hydrogen that would be transported by Angeles Link.

SoCalGas would not produce clean renewable hydrogen as part of the Angeles Link project; rather, SoCalGas would implement the Angeles Link system to transport clean renewable hydrogen

¹ Other chapters of the WRE include an evaluation of water quality requirements for clean renewable hydrogen production (Chapter 2), an evaluation of estimated acquisition, conveyance, and purification costs (Chapter 3), a summary analysis of potential risks and opportunities related to water resources (Chapter 4), and a high level analysis of potential greenhouse gas emissions associated with water conveyance and treatment (Chapter 5).

² The Demand Study also identifies a potential mid-range or moderate demand scenario for clean renewable hydrogen by 2045. To evaluate the potential water resources third-party clean renewable hydrogen producers may draw upon, this Water Availability Study focuses on the low and high demand levels at each end of the potential demand range.

³ The Demand Study also identified a moderate demand scenario of 3.2 MMT/Year in SoCalGas's service territory by 2045. Angeles Link also has a medium case scenario of throughput of 1.00 MMT/Y. For purposes of the feasibility analysis in this Study, this Study analyzes potential water demands for the low and high ranges of the Demand Study (1.9-5.9 MMT/Y) and low and high ranges of the proposed Angeles Link throughput (0.5-1.5 MMT/Y).

produced by third parties. Additional details on the water needs for clean renewable hydrogen production are provided in Chapter 3, *Acquisition and Purification Costs*, of the WRE.⁴

Table 1.ES-1 Water Needs: SoCalGas Service Territory Projected Demands

Demand Scenario	Clean Renewable Hydrogen Demand (MMT/Year) ¹	Water Needs (AFY) ¹	Water Needs (MGD) ¹
Low Demand	1.9	20,900	18.7
High Demand	5.9	64,700	57.8

¹ MMT/year = million metric of tons per year; AFY = acre-feet per year; MGD = million gallons per day.

As mentioned above, while Table 1.ES-1 above presents overall projected demand for clean renewable hydrogen across SoCalGas’s service territory, Table 1.ES-2, below, presents the portion of that overall expected demand that would be served by the Angeles Link system.

Table 1.ES-2 Water Needs: Angeles Link Throughput

Throughput Scenario	Clean Renewable Hydrogen Throughput (MMT/Year) ¹	Water Needs (AFY) ¹	Water Needs (MGD) ¹
Low Case	0.5	5,500	4.9
High Case	1.5	16,500	14.7

¹ MMT/year = million metric of tons per year; AFY = acre-feet per year; MGD = million gallons per day.

This Water Availability Study provides a high-level overview of potential water supply sources that third-party clean renewable hydrogen producers may draw upon for their respective projects. The potential water supply sources identified herein may be used to produce clean renewable hydrogen for the overall service territory demand, as well as the portion of that demand that would be transported by Angeles Link.

Water supply management throughout California is conducted on state, regional, and local levels, with the availability of water sources varying by location and climatic conditions. Agencies must manage their respective supply sources throughout seasonal and annual fluctuations to accommodate existing demands and obligations in key sectors including municipal and industrial (“M&I” or “urban”), agricultural, and environmental sectors. The volume of water provided for use in the urban and agricultural sectors, and dedicated for use in the environmental sector, is referred to as “applied water” and varies depending upon demand and climatic conditions. For example, during wet years characterized by higher-than-average precipitation, less applied water is typically used by the agricultural sector because precipitation reduces the need for irrigation, while more water is used by the urban sector due to reduced conservation requirements, and more water is dedicated to environmental uses, as the increased precipitation would increase flows in waterways and habitat areas.

Table 1.ES-3, below, provides an overview of the total amount of applied water throughout California for each of the three key sectors: urban, agricultural, and environmental. These totals were determined through consideration of applied water usage reported to the State by numerous

⁴ Additional details on the water demand estimates required for clean renewable hydrogen production are provided in the acquisition and purification cost estimate portion of the WRE (Chapter 3). Water needs calculations assume all clean renewable hydrogen assessed herein would be electrolytic hydrogen, i.e. produced using electrolyzers. Water needs would decrease if other sources of clean renewable hydrogen are produced and conveyed to meet demand.

agencies throughout California between 1998 and 2018 (PPIC 2023a). This 20-year timeframe included periods of varying drought intensity, and is considered representative of typical climatic conditions throughout the state; totals are provided for dry year (drought) conditions and wet year (surplus) conditions, representing climatic variations over the 20-year timeframe.

Table 1.ES-3 Average Annual Applied Water¹ in California

Sector	Dry Year (AFY) ³	Wet Year (AFY) ³
Urban ²	7,000,000 (12%)	8,000,000 (8%)
Agriculture	33,000,000 (53%)	30,000,000 (29%)
Environment	22,000,000 (35%)	65,000,000 (62%)
Total	62,000,000	103,000,000

¹“Applied water” refers to the volume of water provided for use in the urban and agricultural sectors, and dedicated for use in the environmental sector, and varies annually depending upon demand and climatic conditions.

²The Urban sector, also referred to as “Municipal and Industrial” (M&I) includes commercial, industrial, and residential uses.

³The values shown in parentheses indicate the percentage of total applied water use represented by the respective sector.

Source: PPIC 2023a

The table above shows that under both dry year and wet year conditions, the urban sector receives the least amount of applied water, while the agricultural sector receives the most applied water under dry year conditions, when more irrigation is needed due to reduced precipitation. The highest volume of applied water is dedicated to environment uses during wet year conditions, when higher-than-average precipitation results in surplus water supply availability. Table 1.ES-4, below, provides comparison between the total amount of applied water use in California (Table 1.ES-3) and the amount of water needed to meet the total demand for clean renewable hydrogen throughout SoCalGas’s service territory (Table 1.ES-1).

Table 1.ES-4 Water for SoCalGas Service Territory Demand vs Statewide Applied Water

Demand Scenarios	Water Needs for Production (AFY) ¹	Dry Year Applied Water (62 MAFY) ²	Wet Year Applied Water (103 MAFY) ²
Low Demand	20,900	0.03%	0.02%
High Demand	64,700	0.10%	0.06%

¹ AFY = acre-feet per year

² MAFY = million acre-feet per year; Source: PPIC 2023a

The table above shows that water needs for the High Demand scenario for clean renewable hydrogen would represent a maximum of 0.10 percent of total applied water in California, while the Low Demand scenario would represent a maximum of 0.03 percent of total applied water. Table 1.ES-5, below, provides comparison between the total amount of applied water use in California (Table 1.ES-3) and the amount of water needed for the expected Angeles Link throughput portion of clean renewable hydrogen demand (Table 1.ES-2).

Table 1.ES-5 Water for Angeles Link Throughput vs Statewide Applied Water

Angeles Link Throughput Scenarios	Water Needs for Throughput (AFY) ¹	Dry Year Applied Water (62 MAFY) ²	Wet Year Applied Water (103 MAFY) ²
Low Case	5,500	0.01%	< 0.01%
High Case	16,500	0.03%	0.02%

¹ AFY = acre-feet per year

² MAFY = million acre-feet per year; Source: PPIC 2023a

The table above shows that for the Angeles Link portion of total clean renewable hydrogen demand, water needs for the High Case scenario would represent a maximum of 0.03 percent of total applied water in California, while the Low Case scenario would represent a maximum of 0.01 percent of total applied water. The comparisons provided in Table 1.ES-4 and Table 1.ES-5 demonstrate that the volumes of water needed by third-party producers to meet demands for clean renewable hydrogen across the SoCalGas service territory by 2045 represents a small percentage of total applied water in California. The volumes of water needed to meet the portion demand that would be served by Angeles Link would be even smaller, with the Low Case scenario needs under wet year conditions representing less than 0.01 percent of total applied water.

Considering the size of existing water needs and obligations throughout the state (Table 1.ES-3), the representative portions of those quantities needed to meet clean renewable hydrogen demands (Table 1.ES-4) and Angeles Link throughput (Table 1.ES-5), and the extensive systems in place to make water supply available throughout the state (Part 2, *Supply Management in California*), third-party clean renewable hydrogen producers may draw upon a number of water supply sources for their respective development projects. This Water Availability Study identifies some of the different water source types that could potentially provide water supply for future production projects, as well as the mechanisms through which third-party producers may acquire various water sources.⁵

Table 1.ES-6, below, gives an overview of the water source types identified in this Water Availability Study as having potential to provide water supply for future clean renewable hydrogen projects developed by third-party producers. These source types are generally presented in descending order of anticipated size and potential for development. The various water supply sources for clean renewable hydrogen production include but are not necessarily limited to the source types presented below and detailed in Part 3, *Potential Water Supply Sources*.

Table 1.ES-6 Potential Water Supply Sources

Source Type	Overview
Imported Surface Water	Surface water in California is available through three major water projects, including the Central Valley Project (CVP), the State Water Project (SWP), and the Colorado River. Accessing surface water from existing water rights holders could provide a large source of supply for future clean renewable hydrogen production.

⁵ The water resources described in this study have been identified as potential resources for third-party clean renewable hydrogen producers to pursue to the extent that those resources have not already been acquired by hydrogen producers or other potential users that have projects further developed in the planning process.

Source Type	Overview
Treated Wastewater	Recycled water is highly treated wastewater (municipal sewage) that has been filtered and disinfected at a wastewater treatment facility. There are numerous recycled water facilities in Southern California. Facility capacity, inflows, and outflows are documented in water quality permits and Urban Water Management Plans (UWMPs), which were used to identify and quantify flows of treated wastewater that are currently discharged without being reused. Treated wastewater that is being discharged from treatment facilities without further reuse or plans for future reuse could supply clean renewable hydrogen production projects.
Groundwater	Groundwater in California is managed by local agencies under the Sustainable Groundwater Management Act (SGMA), to reverse overdraft and create long-term sustainable conditions. As groundwater basins recover from overdraft conditions, local resources may become more available. Depending on site-specific conditions at the time of future project development, individual clean renewable hydrogen producers can further evaluate groundwater as a potential supply source. There may be opportunities to develop groundwater as a supply source in Low Priority basins and in adjudicated areas, depending upon site-specific conditions and other demands. In addition, groundwater “banks,” or aquifer storage and recovery (ASR) projects, may be used to facilitate a water supply exchange (see description provided in Table ES-7, <i>Potential Water Supply Acquisition Mechanisms</i> , for “Exchange Agreements”).
Agricultural Industry Water	Agricultural industry water includes two potential water supply sources associated with ongoing agricultural operations: (i) agricultural field drainage; and (ii) wastewater from produce washing operations. Agricultural field drainage refers to surface water runoff and shallow subsurface drainage of irrigation and water precipitation. Agricultural wash water or process water refers to water that is applied to produce to remove soil and debris prior to distribution to buyers and customers. As a potential supply source, systems could be used to capture and reuse field drainage water and process wastewater could be diverted prior to disposal for treatment and reuse by hydrogen producers.
Brine Line Flows	Brine lines are used to remove salts and other contaminants from a given watershed area to protect the quality of local surface water and groundwater resources. Brine flows that are currently planned for discharge to a brine line for disposal could be diverted for use in clean renewable hydrogen production. Water quality treatment of brine line flows would be needed to remove high concentrations of total dissolved solids (TDS) and other constituents.
Advanced Water Treatment Concentrate	An advanced water treatment facility (AWTF) uses secondary-treated recycled water to conduct further water quality treatment and produce tertiary-level treated water. This process creates waste flow consisting of highly saline brine, or “concentrate.” This waste flow can be either recycled for reuse or treated for disposal. Concentrate from advanced water treatment that is not currently reused or planned for beneficial reuse could supply clean renewable hydrogen production.
Oil & Gas (O&G) Industry Water	O&G industry water from refinery offset water and/or produced water could be developed as a water supply source. Refinery offset water includes the water gained from the reduction or cessation of refinery operations, and could be developed as O&G operations are phased out in accordance with state goals and objectives. The amount of water per barrel of oil produced is expected to vary by refinery location, depending upon multiple factors including the source water, other refinery operations and processes, and requirements of the facility-specific discharge permit. Separately, produced water includes water brought to the surface along with oil and gas as a result of pumping. Treated produced water could be acquired by a hydrogen producer from the oil field operator prior to its discharge to land.
Inland Brackish Groundwater	Brackish groundwater can occur from both natural sources (geology and soils) and from manmade sources (discharges from wastewater treatment plants and agricultural runoff). Brackish groundwater located in inland areas without natural drainage outlets and that is not currently managed or does not have plans for management for beneficial use could provide a supply source for clean renewable hydrogen production. Use of inland brackish water as a supply source would not compete with the needs of other water users because it would provide beneficial use to brackish water that otherwise poses water quality concerns and management issues.

Source Type	Overview
Dry Weather Flows	Dry weather flows are discharges of flows that enter a Municipal Separate Storm Sewer System (MS4) during dry weather conditions and, as a result of low volume and velocity, these flows accumulate within the MS4 causing water quality concerns and potential violation of the MS4 operating permit (NPDES). Dry weather flows are known to be problematic for local flood control agencies with insufficient resources to remove and dispose of them. Dry weather flows that are not reused or planned for beneficial use could provide a potential source for clean renewable hydrogen production projects.
Urban Stormwater Capture and Reuse	Stormwater runoff occurs in direct response to precipitation events. Stormwater runoff that can be captured before reaching a discharge outlet can be stored and treated for future use. Multiple southern California water agencies have existing stormwater capture and reuse programs; however, these are generally not considered currently available because the respective agencies have developed such programs to improve their own water supply portfolios. Clean renewable hydrogen producers could work with agencies overseeing stormwater capture projects to evaluate sources that may become available in the future or may develop new stormwater capture projects as a potential new source for clean renewable hydrogen production.

Table 1.ES-7, below, provides a summary of some potential water supply acquisition mechanisms for clean renewable hydrogen producers.

Table 1.ES-7 Potential Water Supply Acquisition Mechanisms

Acquisition Mechanism	Overview
Exchange Agreements	A water “exchange” is an agreement under which a water seller provides an amount of surplus water to a buyer and the buyer provides a replacement water supply in the same amount to the seller within the seller’s service area or territory. An exchange agreement for clean renewable hydrogen production in Southern California would likely involve the SWP because imported surface water supplies comprise a substantial portion of Southern California’s water supply portfolio and most water agency supplies are comprised at least in part of imported surface water. Groundwater banking using ASR (aquifer storage and recovery) techniques may be used to support an exchange agreement by providing necessary storage, particularly in desert areas.
Local Water Agencies (e.g., purchase available supply, develop partnerships for mutual benefit)	Water supply may be purchased from local water agencies drawing upon their locally available supplies such as imported surface water, sustainably managed groundwater, developed water such as treated wastewater, and surplus water from previous wet weather years that has been stored in water banks for future use. In addition, there may be opportunities for future clean renewable hydrogen producers to partner with local water agencies for mutual benefit, to develop new water supply source(s) for producers while relieving existing management challenges for agencies. For example, future supply source development could involve the collection and treatment of existing waste streams, removing the agency’s burden of managing them. Local water agencies plan for and provide the amount of water they anticipate being needed within their respective service areas based upon population growth projections, land use planning and zoning, and project proposals submitted to the local land use agency. Urban Water Management Plans (UWMPs) are updated every five years with supply and demand projections. As future applications for clean renewable hydrogen projects are submitted to applicable planning departments, water agencies may consider them for inclusion in UWMP projections.

Acquisition Mechanism	Overview
Water Markets (e.g., adjudicated groundwater rights, wet weather surplus flows)	Water supplies could be accessed by contracts in water markets. For example, certain adjudicated groundwater basins have water markets that cover yearly or permanent water rights that can be purchased. Adjudicated groundwater basins are subject to the management direction of a court-ordered basin adjudication, administered by a court-designated Watermaster. In some adjudicated areas, unused allocations or surplus water supply is available for purchase through existing water markets, subject to review and approval of the Watermaster. In addition, wet weather surplus flows may be available for purchase from SWP contractors through existing water markets. Wet weather flows consist of surface water runoff that occurs during years of above-average precipitation, including snowpack. Wet weather flows can result in surplus flows, which consist of any supply available in excess of local demands.
Land Purchase with Water Rights	The purchase of land with certain attached water rights could allow the new landowner to use water associated with the attached rights for “reasonable and beneficial purposes.” The availability of water rights associated with specific properties can be determined through review of property ownership records to confirm the type of right(s) associated with the subject property and that such rights were not previously severed from the subject property. Use of such water for clean renewable hydrogen production would be subject to other potential constraints, such as compliance with the Sustainable Groundwater Management Act (SGMA), which may require water rights holders to reduce their rates of groundwater production towards the common purpose of achieving and maintaining sustainable groundwater conditions while supporting existing uses (see Section 3.3, <i>Groundwater</i>).

Based on the review of the identified water sources and the potential supply acquisition mechanisms, this Water Availability Study makes the following key findings.

Key Findings

- The volume of water needed for third-party clean renewable hydrogen producers to produce the quantity of clean renewable hydrogen to meet 2045 demand across SoCalGas’s service territory comprises a small percentage (0.02 to 0.10 percent) of total annual applied water in California for urban (M&I), agricultural, and environmental purposes.
- Third-party clean renewable hydrogen producers may draw from a number of water supply sources to meet the water needs to produce the clean renewable hydrogen to meet the overall expected SoCalGas service territory demand and the portion of that demand that would be transported by Angeles Link.
- The water supply sources identified in Part 3 of this chapter may be considered by third-party clean renewable hydrogen producers to pursue quantities sufficient to meet the water needs for their respective projects to produce the clean renewable hydrogen to meet the overall service territory demand, including expected Angeles Link throughput.
- A substantial portion of water needs for clean renewable hydrogen production may be met using existing water supply sources and mechanisms of acquisition. New supply sources may also be developed to support clean renewable hydrogen production projects.
- Shifting water needs and obligations may change over time as uses for water in the state evolve and may present opportunities for new water supply development, such as but not limited to water offset from reduced oil and gas operations, additional storage and banking, expanded wastewater treatment, and increased desalination. These shifts will be documented in water supply providers’ UWMP updates, which occur every five years and include projections of the

water needs and supply availability within the respective UWMP area over a 20-year planning horizon.

- The potential water supply sources available to feed specific clean renewable production projects can be further evaluated and developed on a case-by-case basis as more details on specific clean renewable hydrogen production projects are developed.

Part 1: Introduction and Background

1.1 Angeles Link Project

This Water Availability Study has been prepared as part of the WRE being prepared in support of the Angeles Link project (Angeles Link) proposed by Southern California Gas Company (SoCalGas).

1.1.1 Overview

Angeles Link is envisioned as a non-discriminatory pipeline system that is dedicated to public use and aims to facilitate transportation of clean renewable hydrogen from multiple regional third-party production sources and storage sites to various end users in Central and Southern California, including the Los Angeles Basin. Angeles Link is intended to serve difficult-to-electrify sectors, including power generation, mobility, and industrial uses.

1.2 Water Needs for Clean Renewable Hydrogen

This section identifies water needs to produce clean renewable hydrogen in amounts sufficient to meet demand throughout SoCalGas's service territory, as well as to meet the portion of expected demand that would be served by Angeles Link, also referred to as "throughput." While SoCalGas would not produce clean renewable hydrogen as part of Angeles Link, SoCalGas would implement Angeles Link to transport clean renewable hydrogen produced by third parties. Under separate Phase 1 feasibility analyses for Angeles Link, a clean renewable hydrogen Demand Study was prepared to define potential demand scenarios for clean renewable hydrogen by 2045, quantifying demand for SoCalGas's service.

The Demand Study identified a range of scenarios from a low demand (conservative scenario) of 1.9 million metric tons per year (MMT/Year) to a high demand (ambitious scenario) of 5.9 MMT/Year. Within this overall demand, throughput for the Angeles Link system would be approximately 0.5 MMT/Year under a low case scenario and up to 1.5 MMT/Year under a high case scenario.⁶ The following tables quantify water needs for each scenario defined in the Demand Study, as follows:

- Table 1-1 provides an overview of water needs for clean renewable hydrogen demand throughout SoCalGas's service territory, and
- Table 1-2 provides an overview of water needs for the Angeles Link throughput portion of clean renewable hydrogen demand.

Additional details on the water needs for clean renewable hydrogen production are provided in the acquisition and purification cost estimate portion (Chapter 3) of the WRE.⁷

⁶ The Demand Study also identified a moderate demand scenario of 3.2 MMT/Year in SoCalGas's service territory by 2045. Angeles Link also has a medium case scenario of throughput of 1.00 MMT/Y. For purposes of the feasibility analysis in this Study, this Study analyzes potential water demands for the low and high ranges of the Demand Study (1.9 to 5.9 MMT/Y) and low and high ranges of the proposed Angeles Link throughput (0.5 to 1.5 MMT/Y).

⁷ Additional details on the water demand estimates required for clean renewable hydrogen production are provided in the acquisition and purification cost estimate portion (Chapter 3) of the WRE. Water needs calculations assume all clean renewable hydrogen assessed herein would be electrolytic hydrogen, i.e. produced using electrolyzers. Water needs would decrease if other sources of clean renewable hydrogen are produced and conveyed to meet demand.

Table 1-1 Water Needs: SoCalGas Service Territory Demands

Demand Scenario	Clean Renewable Hydrogen Demand (MMT/Year) ¹	Water Needs (AFY) ¹	Water Needs (MGD) ¹
Low Demand	1.9	20,900	18.7
High Demand	5.9	64,700	57.8

¹ MMT/year = million metric of tons per year; AFY = acre-feet per year; MGD = million gallons per day.

While the table above shows water needs for clean renewable hydrogen demand throughout SoCalGas’s service territory, Table 1-2, below, shows water needs for the Angeles Link throughput portion of that overall demand.

Table 1-2 Water Needs: Angeles Link Throughput

Throughput Scenario	Clean Renewable Hydrogen Throughput (MMT/Year) ¹	Water Needs (AFY) ¹	Water Needs (MGD) ¹
Low Case	0.5	5,500	4.9
High Case	1.5	16,500	14.7

¹ MMT/year = million metric of tons per year; AFY = acre-feet per year; MGD = million gallons per day.

As added context for the volumes of water needed to produce clean renewable hydrogen for the identified expected demand, Table 1-3 quantifies applied water use rates throughout California, which are compared to clean renewable hydrogen water needs in the SoCalGas service area. Table 1-4 presents this information in comparison to the Angeles Link expected throughput. “Applied water” refers to the volume of water provided for use in the urban (municipal and industrial, or “M&I”) and agricultural sectors, and dedicated for use in the environmental sector, and varies annually depending upon demand and climatic conditions. Applied water totals were determined through research and consideration of usage reported to the State by numerous agencies throughout California between 1998 and 2018 (PPIC 2023c). This 20-year timeframe included periods of varying drought intensity, and is therefore considered representative of typical climatic conditions; totals are provided for dry year (drought) conditions and wet year (surplus) conditions, representing climatic variations over the 20-year timeframe.

Table 1-3 Average Annual Applied Water in California

Sector	Dry Year (AFY) ²	Wet Year (AFY) ²
Urban ¹	7,000,000 (12%)	8,000,000 (8%)
Agriculture	33,000,000 (53%)	30,000,000 (29%)
Environment	22,000,000 (35%)	65,000,000 (62%)
Total	62,000,000	103,000,000

¹ The Urban sector, also referred to as “Municipal and Industrial” (M&I) includes commercial, industrial, and residential uses.

² The values shown in parentheses indicate the percentage of total applied water use represented by the respective sector.

Source: PPIC 2023a

The table above shows that under both dry year and wet year conditions, the Urban sector receives the least amount of applied water, while the Agriculture sector receives the most applied water under dry year conditions, and the Environment sector receives the most under wet year conditions.

Table 1-4 Water for SoCalGas Service Territory Demand vs Statewide Applied Water

Demand Scenarios	Water Needs for Production (AFY) ¹	Dry Year Applied Water (62 MAFY) ²	Wet Year Applied Water (103 MAFY) ²
Low Demand	20,900	0.03%	0.02%
High Demand	64,700	0.10%	0.06%

¹ AFY = acre-feet per year

² MAFY = million acre-feet per year; Source: PPIC 2023a

As shown in the table above, total applied water in California averaged 62 MAFY under dry year conditions, inclusive of all three sectors (urban, agricultural, and environmental), and 103 MAFY under wet year conditions. In comparison, water needs for the High Demand scenario for clean renewable hydrogen throughout SoCalGas’s service territory represent a maximum of 0.10 percent of total applied water in California, while the Low Demand scenario represents a maximum of 0.03 percent of total applied water. The table below provides comparison between applied water use rates and water needs for the expected Angeles Link throughput portion of overall demand.

Table 1-5 Water for Angeles Link Throughput vs Statewide Applied Water

Angeles Link Throughput Scenarios	Water Needs for Throughput (AFY) ¹	Dry Year Applied Water (62 MAFY) ²	Wet Year Applied Water (103 MAFY) ²
Low case scenario	5,500	0.01%	< 0.01%
High case scenario	16,500	0.03%	0.02%

¹ AFY = acre-feet per year

² MAFY = million acre-feet per year; Source: PPIC 2023a

Table 1-5, above, shows that for the Angeles Link throughput portion of total clean renewable hydrogen demand, water needs for the High Case scenario would represent a maximum of 0.03 percent of total applied water in California, while the Low Case scenario would represent a maximum of 0.01 percent of total applied water. The comparisons provided in Table 1-4 and Table 1-5 demonstrate that the volumes of water needed by third-party producers to meet demands for clean renewable hydrogen across the SoCalGas service territory by 2045 represent small percentages of total applied water in California. The volumes of water needed for the Angeles Link throughput scenarios would be even smaller, with the Low Case scenario needs under wet year conditions representing less than 0.01 percent of total applied water.

1.3 Approach to Analysis for this Water Availability Study

1.3.1 Study Areas

This study area was selected to provide a reasonable basis to evaluate potential water resource availability for the clean renewable hydrogen production that could utilize Angeles Link. The study area for this Water Availability Study includes SoCalGas’s service territory as well as other geographic areas to include opportunities third-party producers may pursue to develop and wheel water to areas where it is needed. Figure 1-1, below, provides an overview of SoCalGas’ service territory, which represents the primary extent of the study area for this Water Availability Study, as

well as select resources located outside SoCalGas’s service territory based upon resource-specific features. The resources located outside of SoCalGas’s service territory that are included in this Water Availability Study consist of the following:

- Existing wastewater treatment facilities in the San Joaquin Valley just north of SoCalGas’s service territory are considered for the potential for treated effluent to be acquired as a water supply source (see Section 3.2, *Treated Wastewater*).
- The Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) program, also located in the San Joaquin Valley, is considered in this study as relevant to brackish groundwater as a potential supply source (see Section 3.8.1, *Brackish Plumes*).
- Treated effluent from Encina Wastewater Authority’s (EWA) facilities in San Diego County, along the southern boundary of SoCalGas’s service territory, is considered for potential acquisition through an exchange agreement (see Part 4, *Mechanisms of Supply Acquisition*).

Considerations associated with water supply conveyance and treatment are addressed in separate chapters of the WRE, including Chapter 2, *Water Quality Requirements*, Chapter 3, *Acquisition and Purification Costs*, and Chapter 4, *Challenges and Opportunities*. In addition, Chapter 5, *Supplemental Desktop Analysis*, is provided to address GHG emissions associated with water treatment and conveyance.

1.3.2 Review of Previous Feasibility Analysis

In 2021, SoCalGas commissioned SPEC Services (SPEC) to prepare a series of pre-feasibility studies to assess the potential for large-scale development of hydrogen infrastructure in California. As part of the 2021 SPEC studies, Rincon Consultants, Inc. prepared a preliminary evaluation of potential water supply sources, referred to as the “2021 SPEC water study.” The Water Availability Study presented herein was informed by the 2021 SPEC water study, and expands upon that study’s approach, content, and findings as applicable for the purposes of Angeles Link Phase 1.

This Water Availability Study builds upon the 2021 SPEC water study through use of an expanded study area, and through outreach with public water agencies. First, the study area used in the 2021 SPEC water study focused on certain identified production hub regions within SoCalGas’s service territory where it was anticipated that clean renewable hydrogen production projects would be concentrated. In comparison, this Water Availability Study did not limit potential water sources to anticipated hub regions; rather, as noted in Section 1.4.1, *Study Area*, this Water Availability Study considers SoCalGas’s entire service territory as well as select potential sources that are located outside the service territory but may have potential to provide water supply for clean renewable hydrogen production. As a result, this Water Availability Study identifies a different range of potential water supply sources than were previously considered in the pre-feasibility analyses including the 2021 SPEC water study.

Second, preparation of the 2021 SPEC water study did not involve direct inquiries to public agencies or water providers. In comparison, this Water Availability Study involved direct inquiries to certain water managers and agencies throughout the study area to inform characterization of the types and extent of water source(s) that could be available for clean renewable hydrogen development (see Section 1.4.5, *Agency Outreach*).

Figure 1-1 SoCalGas Service Territory



1.3.3 Review of Planning Documents and Other Studies

To support the Water Availability Study, applicable state-required land use and water supply planning documents were collected and reviewed, including: Urban Water Management Plans (UWMPs) which are required of supply providers with 3,000 or more service connections or delivering 3,000 AFY or more of water; Groundwater Sustainability Plans (GSPs) addressing individual groundwater basins for compliance with the Sustainable Groundwater Management Act (SGMA) (see Section 3.3, *Groundwater*); and the California Water Plan maintained by the California Department of Water Resources (DWR) to plan for and provide for the sustainable management of water resources throughout the state.

Future clean renewable hydrogen projects that would utilize Angeles Link have not yet been developed, and associated water needs are therefore not considered in the aforementioned water supply planning documents. However, as future clean renewable hydrogen projects are proposed via applications submitted to the respective land use agencies, associated water needs will be incorporated into the applicable water supply planning and management documents, including through coordination between future producers and water managers.

Other existing studies and literature related to water resources and hydrogen production in California were reviewed for the purposes of this Water Availability Study. One study included the HyBuild Los Angeles Phase 2 Report (“HyBuild LA Report”) prepared by the Green Hydrogen Coalition (GHC) for its proposed HyBuild Los Angeles (HyBuild LA) initiative. The GHC is an educational non-profit organization established in 2019 that operates under a mission to “facilitate policies to advance the production and use of green hydrogen at scale in all sectors where it will accelerate the transition to a carbon free energy system” (GHC 2023a). The HyBuild LA initiative is part of GHC’s HyBuild North America platform, which it created to launch green hydrogen ecosystems across North America (GHC 2023b).

The GHC partnered with the Pacific Northwest National Laboratory (PNNL) Sustainability Team to evaluate water needs and supply availability for the HyBuild LA initiative and to develop the HyBuild LA Report. The PNNL evaluated water for the proposed scale of the HyBuild LA green hydrogen system plan, as well as potential for green ammonia due to stakeholder feedback seeking to understand the process requirements of a potential green ammonia industry. The HyBuild LA Report determined that water needs for green hydrogen and green ammonia production could be met using recycled or repurposed water sources, including wastewater recycled from other sectors and repurposed water currently used in the local oil and gas sectors. (GHC 2023a)

Another study reviewed was a 2019 market briefing from IHS Markit Ltd, which merged with S&P Global in 2022, entitled, “Hydrogen in the Golden State – Implications for Water.” The market briefing stated that “local water deliveries” are the largest source of water supply in California; “local water deliveries” is water provided by local water agencies, typically sourced from precipitation stored in reservoirs for use throughout the year (IHS Markit 2019). The IHS Markit briefing further stated that groundwater is “the swing source” of water supply during dry years, but acknowledges that groundwater is also “difficult to replenish relative to the historical rate of withdrawals” and, with implementation of SGMA, “less groundwater may be available during dry years than what has historically been used” (IHS Markit 2019).

In addition, IHS Markit discussed water consumption declines anticipated to occur in other industries as California moves to decarbonized conditions and suggests that those declines in other industries could create water availability for clean renewable hydrogen production. The specific activities that are anticipated to decline by 2050, thereby freeing up water supply, include: refining

gasoline and diesel, oil production, and thermal power generation, all of which are anticipated to cease in a “deeply decarbonized California” (IHS Markit 2019).

1.3.4 Agency Outreach

The approach to this Water Availability Study involved conducting initial outreach with water agencies and regional water suppliers within the study area. Agencies for initial outreach were identified based upon location, size, and existing facility ownership and operations. Facilities were identified through review of regulatory permit records for facilities that treat municipal and industrial wastewater within the study area. Agency contact was first made electronically via introductory emails containing an overview of Angeles Link and the Phase 1 feasibility studies.

Virtual meetings were conducted with responding parties including the Metropolitan Water District of Southern California (“Metropolitan”), which serves 26 member agencies including cities, municipal water districts, and one county water authority. Metropolitan member agencies deliver water supply to 19 million people throughout the study area including within Los Angeles, Orange, Riverside, San Bernardino, San Diego and Ventura counties. Virtual meetings were also held with Encina Wastewater Authority (EWA), Los Angeles Department of Water and Power (LADWP), Orange County Sanitation District (OC-San), and Santa Ana Watershed Protection Authority (SAWPA). The virtual meetings included discussion of the respective parties’ water supply sources, programs, and facilities, as well as potential opportunities for the development of water supply sources for clean renewable hydrogen production.

In response to outreach efforts, on October 17, 2023, Metropolitan provided a letter to SoCalGas expressing concerns about climate change and willingness to partner on the production of green energy. The letter included the following statements (Metropolitan 2023e):

- Metropolitan has historically been open to collaboration and negotiations with other water agencies and stakeholders within California to manage water resources effectively. Metropolitan has participated in water transfers, exchanges, and agreements with other agencies and regions to address water supply challenges, especially during periods of drought or when water demand is high.
- Out-of-region water exchanges can involve Metropolitan obtaining water from sources outside of its immediate service area in California. The specifics of these exchanges can vary depending on the agreements and arrangements in place at any given time.
- Metropolitan is willing to work with SoCalGas on exchanges either on the Colorado River or the State Water Project.⁸ In these arrangements, SoCalGas would pay into or directly produce new supplies of water that directly benefit Metropolitan’s service area, and then exchange the new supplies for out-of-region imported water supplies. Quantification of a proposed exchange would depend upon case-by-case evaluation of the potential benefit of the proposed exchange to the Southern California region’s well-being and water supply security.

Input received from water agencies and managers informed the identification of potential supply sources presented in Part 3, *Potential Water Supply Sources*.

⁸ The letter from Metropolitan refers to SoCalGas as the party potentially pursuing water supply development. As noted earlier in this Water Availability Study, SoCalGas would not be developing water supplies for Angeles Link, as third-party producers would produce the clean renewable hydrogen that Angeles Link would convey. SoCalGas conducted agency outreach for informational purposes to support the analysis in this study.

Part 2: Supply Management in California

Water supply management in California involves oversight by multiple regulatory agencies, as well as numerous applicable laws and regulations, with federal, state, and local agencies responsible for various permits and authorizations. This background section is provided to inform discussion of potential water supply sources for clean renewable hydrogen production.

2.1 Regulatory Agencies

Key agencies and entities involved in the management and regulation of water supply in California are identified in Table 1-6, below, and include entities on the federal, state, and local levels.

Table 1-6 Key Agencies & Entities – California Water Supply

Name	Overview
Federal	
U.S. Army Corps of Engineers (USACE)	The USACE regulates discharge of dredge or fill material into waters of the United States under Section 404 of the Clean Water Act (CWA). “Waters of the United States” is used as a threshold term in the CWA to define the geographic scope of federal jurisdiction of waterways. The U.S. Environmental Protection Agency (USEPA) and the USACE have authority to define the limits of navigable waters in regulations.
U.S. Bureau of Reclamation (USBR)	The USBR is part of the U.S. Department of Interior and operates federal water projects including dams and canals. In California, the USBR manages the Central Valley Project (CVP), which was constructed in the 1930s to transport water from Northern California to Central California. The California Department of Water Resources (DWR) administers long-term water supply contracts to CVP contractors. The USBR also manages most of the Colorado River’s water supply allocations to California and issues water contracts to Colorado River Entitlement Holders. The CVP and Colorado River are discussed in Section 2.3, <i>Key Water Supply Projects</i> .
State	
California Coastal Commission (CCC)	The CCC regulates the use of land and water in the coastal zone through implementation of the Coastal Act. A coastal permit is generally required from the CCC for development activities including construction of buildings, divisions of land, and activities that change the intensity of use of land or public access to coastal waters.
California Department of Water Resources (DWR)	The DWR oversees water resources planning, regulates groundwater, reviews water agency groundwater and water supply planning documents, and operates the state’s water storage and supply systems. The DWR operates the State Water Project (SWP), which supplies water from the Sacramento-San Joaquin River Delta in Northern California to SWP contractors in Central and Southern California. The State Water Resources Control Board (SWRCB) reports that two-thirds of Californians receive water supply from the SWP; as discussed below, whereas DWR is responsible for water supply, the SWRCB is responsible for water rights and quality.
California Environmental Protection Agency (CalEPA)	CalEPA is the state’s regulatory agency that enforces pollution control laws, including water pollution, and oversees six other state agencies, including the State Water Resources Control Board (SWRCB). CalEPA is one of the three agencies tasked with developing California’s Water Resilience Portfolio.
California Natural Resources Agency (CNRA)	The CNRA oversees several state entities including DWR and the California Water Commission and is one of the three agencies tasked with developing California’s Water Resilience Portfolio. The purpose of the CNRA is to support regional water resilience, including through drought and flood conditions.

Name	Overview
California Water Commission	The California Water Commission advises DWR on water planning and management priority, approves all DWR rules and regulations, and advises DWR on SWP operations based upon annual reviews. It also administers the <i>Water Storage Investment Program</i> to fund water storage projects. In 2022, the California Water Commission developed a white paper on how the state can support the development of well-managed groundwater trading programs with appropriate safeguards for vulnerable water users (CWC 2022). The California Water Commission is currently assessing the state’s role in financing conveyance projects in support of the Water Resilience Portfolio.
Colorado River Board (CRB) of California	The CRB of California was established in 1937 to protect California’s rights and interests in the resources provided by the Colorado River and to represent California in discussions and negotiations regarding the Colorado River and its management. Seven counties in Southern California receive water and hydroelectric energy from the Colorado River. Colorado River water is used for drinking water by over 19 million people in Southern California and irrigates over 600,000 acres of agricultural lands that produce fruits, vegetables, and other crops that help feed our nation’s families (CRBC 2023a).
Geologic Energy Management Division (CalGEM)	CalGEM, formerly the Division of Oil, Gas, and Geothermal Resources (DOGGR), oversees the drilling, operation, maintenance, and plugging and abandonment of oil, natural gas, and geothermal energy wells in California.
SWRCB and Regional Water Quality Control Boards (RWQCBs)	Under the federal CWA and the state’s <i>Porter-Cologne Water Quality Control Act</i> , the SWRCB and its nine RWQCBs have regulatory authority over surface water rights and water quality in California. Each RWQCB maintains a Water Quality Control Plan (Basin Plan) and is responsible for issuing discharge permits and enforcing water quality regulations. The SWRCB Division of Water Rights oversees water transfers in California under the Water Transfers Program, which covers both temporary (less than one year, Water Code Section 1725) and long-term exchanges (more than one year, Water Code Section 1735).
Local	
Groundwater Sustainability Agencies (GSAs)	A GSA may be a single agency, a group of agencies operating under a Memorandum of Understanding (MOU), or a Joint Powers Authority (JPA) comprised of multiple agencies which form a separate legal entity. The Sustainable Groundwater Management Act (SGMA) requires that GSAs are formed by local public agencies; private water companies are only represented in a GSA when partnered with a public agency. SGMA further mandates that each delineated groundwater basin that is subject to SGMA has a DWR-approved GSA for management.
Metropolitan Water District of Southern California (Metropolitan)	Metropolitan serves 26 public water agencies including cities, municipal water districts and one county water authority that deliver supplies directly or indirectly to 19 million people in Los Angeles, Orange, Riverside, San Bernardino, San Diego and Ventura counties. Metropolitan has imported water from the Colorado River since 1941 and from Northern California via the State Water Project (SWP) since the early 1970s. Metropolitan is the largest single contractor of the SWP and a major supporter of Southern California water conservation and water recycling programs, along with other local water management activities (Metropolitan 2023d).
Watermasters	A Watermaster is responsible for overseeing the administration of water rights within an adjudicated groundwater basin and, when necessary, for taking enforcement action related to compliance of water users with the adjudication judgment for the respective groundwater basin.
Other local entities	Other local entities include water agencies, irrigation districts, sanitation districts, wastewater treatment providers, water rights holders, and others.
Sources: USBR 2023a; DWR 2022a; WEF 2023a, 2023b	

The federal, state, and local entities identified above reflect those which are specifically involved in California water supply planning and management, as relevant to this Water Availability Study.

2.2 Laws and Regulations

Laws and regulations addressing the management and regulation of water supply in California, including related plans, programs and policies where relevant, are presented in Table 1-7, below.

Table 1-7 Water Supply Laws, Regulations, Policies, and Associated Plans and Programs

Name	Overview
California Code of Regulations (CCR)	<p>CCR Title 22 includes the state guidelines for how treated/recycled water is used and discharged. Title 22 defines approved uses for recycled water by treatment level including:</p> <ul style="list-style-type: none"> ▪ 40 uses for disinfected tertiary recycled water (ex., irrigating parks), ▪ 24 uses for disinfected secondary recycled water (ex., irrigating animal feed), and ▪ Seven uses for undisinfectated secondary recycled water (ex., industrial uses). <p>The SWRCB is responsible for permitting recycled water projects and approving Title 22 engineering reports for proposed uses, ensuring consistency with the Title 22 approved uses.</p>
California Water Code (CWC)	<p>The CWC determines the limits of waters of the state and regulates discharges to state waters. CWC Division 2 (Water) requires a water right for any water taken from a lake, river, stream, or creek, or from groundwater; the SWRCB is the only agency with authority to administer water rights. New uses of existing surface water resources require approval of a water right license from the SWRCB. Groundwater rights do not specially require a license; groundwater is regulated by local entities such as local water agencies, districts, and GSAs.</p>
California Water Plan (“Water Plan”)	<p>The Water Plan is a strategic plan designed to manage and develop water resources in a manner that is both sustainable and equitable. The Water Plan is maintained by the DWR in accordance with CWC Section 10005(a). It is updated every 5 years and has most recently been updated for 2023 (DWR 2023e). Key information included in the Water Plan includes:</p> <ul style="list-style-type: none"> ▪ Status and trends for water-dependent natural resources, water supplies, and agricultural, urban, and environmental demands (see Section 2.6, <i>Existing Demands & Regulations</i>). ▪ Recommended actions, funding sources, and an investment strategy for responding to water supply challenges including declining groundwater levels and unreliable water supplies. ▪ Assessment of challenges and opportunities related to climate change including droughts and floods, rising temperatures, declining fish populations, and groundwater overdraft.
California Water Resilience Portfolio (WRP)	<p>The California WRP is prepared and updated by the CNRA, CalEPA, and California Department of Food and Agriculture (CDFA) in response to Executive Order (EO) N-10-19. This EO requires state agencies to plan response actions for effects of climate change while ensuring the availability of clean and reliable water supplies to meet demands. The WRP directly informs the California Water Plan, described above. It identifies goals and management actions associated with water supply diversification, supply reliability, and infrastructure needs for storage, conveyance, flood protection, and recharge, among other related factors.</p>
California Water Supply Strategy (WSS)	<p>The WSS was prepared in 2022 By the State of California, including the state’s Natural Resources Agency, DWR, Water Boards, Environmental Protection Agency (EPA), and Department of Food & Agriculture. The purpose of the WSS was to update the WRP (see above) based on new data and accelerating climate change, which is projected to reduce California’s water supplies by 10 percent over the next 20 years, or approximately 450,000 acre-feet per year (AFY), for a total of up to nine million acre-feet (MAF). The WSS (and WRP, as updated) identify the following strategies to respond to this anticipated water loss (CNRA et al 2022):</p> <ol style="list-style-type: none"> 1) Create 4.0 MAF of new storage space, 500,000 AFY of additional groundwater recharge, 250,000 AFY of new stormwater capture by 2030 and 500,000 AFY by 2040. 2) Recycle and reuse at least 800,000 AFY by 2030 and 1.8 MAF by 2040. 3) Reduce water use by at least 500,000 AFY through efficiency and conservation. 4) Increase brackish groundwater desalination by 28,000 AFY by 2030 and 84,000 AFY by 2040.

Name	Overview
California Recycled Water Policy / Water Recycling Policy	The SWRCB’s Water Recycling Policy was established in 2019 and requires local water and wastewater stakeholders to develop Salt and Nutrient Management Plans (SNMPs) to promote basin-wide management of salts and nutrients in groundwater. Many groundwater basins contain salts and nutrients that exceed or threaten to exceed water quality objectives established in the Basin Plans. The purpose of the SNMPs is to identify all sources of salts and nutrients in groundwater basins and manage them in a manner that preserves, enhances, and restores the quality of groundwater for drinking and other beneficial uses (SWRCB 2023a, SWRCB 2023b). Many SNMPs identify use of recycled water for groundwater recharge to manage salt and nutrient levels.
CARB 2022 Scoping Plan	In 2006, the Legislature passed the California Global Warming Solutions Act of 2006 (Assembly Bill 32), which created a multi-year program to reduce greenhouse gas emissions in California. The CARB 2022 Scoping Plan lays out a path to achieve targets for carbon neutrality and reduce anthropogenic greenhouse gas emissions by 85 percent below 1990 levels no later than 2045, as directed by Assembly Bill 1279 (CARB 2022). The CARB 2022 Scoping Plan targets phaseout of fossil fuel production to meet the state’s carbon neutrality goals.
California Senate Bill (SB) 100	SB 100, officially titled the “100 Percent Clean Energy Act of 2018,” mandates the state of California to achieve 100 percent clean, carbon-free electricity by 2045. SB 100 sets interim targets of 50 percent renewable energy by 2026 and 60 percent by 2030. SB 100 builds on previous legislation, including the Renewables Portfolio Standard (RPS), presented above, to accelerate the transition to renewable energy sources like wind, solar, and geothermal. SB 100 aims to reduce GHG emissions, combat climate change, and promote public health and environmental sustainability. It also encourages innovation and investment in clean energy technologies and infrastructure.
Sustainable Groundwater Management Act (SGMA)	Established in September 2014 as part of California Water Code, SGMA provides a framework for local groundwater management. The purpose of SGMA is for local agencies and stakeholders to coordinate groundwater management. Many of California’s groundwater basins are in overdraft, which occurs when groundwater extraction exceeds recharge which leads to a decline in groundwater levels. SGMA requires local agencies to reverse groundwater overdraft and sustainably manage groundwater resources by ensuring groundwater extraction no longer exceeds recharge (DWR 2023d). SGMA requires local agencies to form Groundwater Sustainability Agencies (GSAs), who are responsible for management of local groundwater. GSAs are required to adopt and implement Groundwater Sustainability Plans (GSPs), and bring overdrafted basins into balanced levels of pumping and recharge within the timelines established by SGMA. GSPs include an assessment of existing groundwater conditions, identify existing uses of groundwater, and identify management actions and water projects needed to achieve sustainable groundwater conditions (DWR 2023d). Successful management requires DWR approval of a GSP for each basin, and proven accomplishment of specific sustainability goals to reverse overdraft and create sustainable groundwater conditions by 2040. The purpose of this is to facilitate local groundwater management and sustainable groundwater conditions throughout the state.
Urban Water Management Planning Act	This Act requires preparation of an Urban Water Management Plan (UWMP) by every water supplier that serves more than 3,000 urban connections or delivers 3,000 AFY or more of water. Each UWMP characterizes existing and anticipated water needs and available supplies and identifies projects to improve supply reliability.

Name	Overview
Waste Discharge Requirements (WDR) Program	<p>The WDR program regulates wastewater that is discharged to land, with core program areas including but not limited to: agricultural uses, Aquifer Storage and Recovery (ASR), treated groundwater from cleanup operations, and recycled water. WDRs protect surface water by prescribing requirements for discharge to waters that are not federally jurisdictional waters of the U.S., which are addressed under the National Pollutant Discharge Elimination System (NPDES) Program. WDRs also protect groundwater by prescribing waste containment, treatment, and control requirements.</p> <p>The NPDES program regulates wastewater that is discharged from point sources to navigable water, which refers to federally jurisdictional waters of the U.S. “Waters of the United States” is used as a threshold term in the federal CWA to define the geographic scope of federal jurisdiction of waterways and give authority to the U.S. Environmental Protection Agency (USEPA) and the USACE to define the limits of these waters in regulations.</p>

2.3 Key Water Supply Projects

There are three projects in California that provide imported surface water supplies throughout the state, including the SWP, the Colorado River, and the Central Valley Project (CVP). Each of these projects is described in respective sections below. This information is presented to inform discussion of potential exchange agreements which are a mechanism to supply water within SoCalGas’s service territory. Exchange agreements are discussed further in Part 4, *Mechanisms for Supply Acquisition*, in Section 4.1, *Exchange Agreements*. In addition, Part 3, *Potential Water Supply Sources*, describes how each of the imported surface water projects described herein provide water within SoCalGas’s service territory; see Section 3.1, *Imported Surface Water in the Study Area*.

2.3.1 State Water Project

The SWP is a conveyance system that provides surface water from the Feather River watershed and Central Valley runoff to SWP contractors in Southern California. Specifically, the SWP diverts water from the Feather River in Sacramento County. There are four main tributaries to the Feather River, including the South Fork, Middle Fork, North Fork, and West Branch, which converge approximately one mile upstream of Lake Oroville to form the main stem of Feather River (DWR 2023b). Lake Oroville is located in the foothills of the western Sierra Nevada, and receives snowmelt from the Sierra Nevada via the four tributaries of Feather River north of Oroville Dam. Figure 1-2, below, provides an overview of the SWP system.

The SWP conveys water from the Feather River watershed through the Sacramento-San Joaquin River Delta (Delta) to SWP contractors in Central and Southern California. The Delta is formed by the Sacramento River flowing south to meet the north-flowing San Joaquin River just south of Sacramento, where the rivers mingle with smaller tributaries and tidal flows (WEF 2023c). Freshwater from the rivers flows through the Carquinez Strait, a narrow break in the Coast Range, into San Francisco Bay’s northern arm to form the Bay Delta (WEF 2023c). Brackish water forms a marshy transition area between the freshwater of the rivers and the salt water of the ocean. The extent of the brackish transition area depends upon climatic conditions and is annually variable.

The figure below shows that south of the Delta, SWP water is conveyed via pipelines, aqueducts, and reservoirs; specifically, this figure shows a SWP aqueduct/pipeline (the California Aqueduct) extending south from the Delta to San Luis Reservoir, where a “joint-use” aqueduct referred to as the San Luis Canal (SLC) continues south. The SLC conveys water for both the California SWP and the federal CVP, transitioning back to the state-only California Aqueduct in the southern portion of the

San Joaquin Valley. The 444-mile-long California Aqueduct (including the joint-use SLC portion) conveys SWP water into Southern California, with several branches of the California Aqueduct conveying SWP water throughout SoCalGas’s service territory.

Section 3.1, *Imported Surface Water in the Study Area*, provided in Part 3, *Potential Water Supply Sources*, discusses SWP water as a potential water supply source throughout SoCalGas’s service territory; see Section 3.1.1, *SWP Water*, for detailed discussion of SWP conditions within SoCalGas’s service territory.

Figure 1-2 State Water Project Overview



Source: DWR 2023d

SWP Contractors and Allocations

Water in the SWP system is fully allocated to 29 contractors, which are public agencies that distribute SWP water to other agencies and individual connections in their service territories. The maximum amount of SWP water that each SWP contractor may receive in a given year is referred to as “Table A” water; Table 1-8, below, provides an overview of Table A allocations per contractor.

Table 1-8 SWP Contractors and Table A Allocations¹

SWP Water Contractor	Table A Allocation (AFY)
Feather River Region	
County of Butte	27,500
Plumas County FC&WCD	2,700
City of Yuba City	9,650
Subtotal	39,850
North Bay Region	
Napa County FC&WCD	29,025
Solano County WA	47,756
Subtotal	76,781
South Bay Region	
Alameda County FC&WCD	80,619
Alameda County WD	42,000
Santa Clara Valley WD	100,000
Subtotal	222,619
San Joaquin Valley Region	
Oak Flat WD	5,700
County of Kings	9,305
Dudley Ridge WD	41,350
Empire West Side ID	3,000
Kern County WA	982,730
Tulare Lake Basin WSD	87,471
Subtotal	1,129,556
Central Coastal Region	
San Luis Obispo County FC&WCD	25,000
Santa Barbara County FC&WCD	45,486
Subtotal	70,486
Southern California Region	
Antelope Valley-East Kern WA	144,844
Santa Clarita Valley WA	95,200
Coachella Valley WD	138,350
Crestline-Lake Arrowhead WA	5,800
Desert WA	55,750
Littlerock Creek ID	2,300
Metropolitan	1,911,500

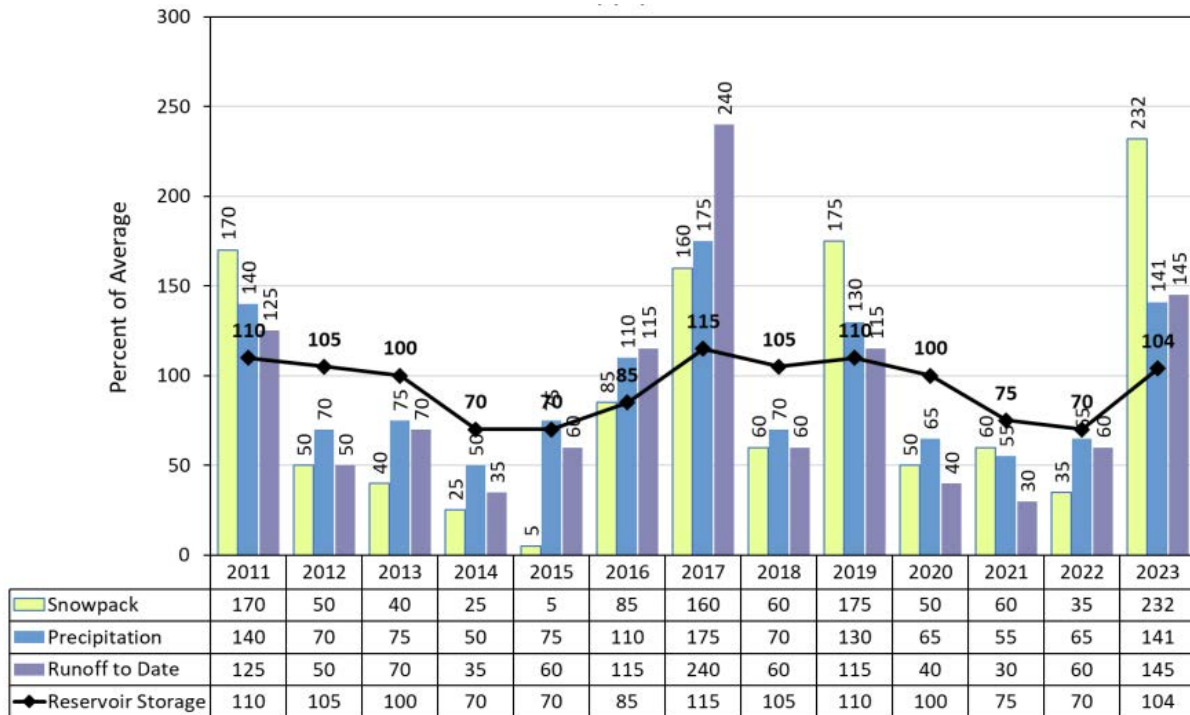
SWP Water Contractor	Table A Allocation (AFY)
Mojave WA	89,800
Palmdale WD	21,300
San Bernardino Valley MWD	102,600
San Gabriel Valley MWD	28,800
San Geronio Pass WA	17,300
Ventura County WPD	20,000
Subtotal	2,633,544
Total	4,172,836

¹ AFY = Acre-Feet per Year; FC&WCD = Flood Control and Water Conservation District; ID = Irrigation District; MWD = Mutual Water District; WA = Water Agency; WD = Water District; WDSC = Water District of Southern California; WPD = Watershed Protection District
Source: DWR 2023c

The table above shows that Table A allocations total 4,172,836 AFY for all 29 SWP contractors; this is the maximum amount of water each contractor may receive through the SWP system each year. The amount of water that is physically available in the SWP system depends upon climatic and drought conditions, which affect rates of precipitation, size of the Sierra Nevada snowpack, and the rate and timing of snowmelt runoff to Lake Oroville. The DWR, which is responsible for operation of the SWP, notifies SWP contractors of the availability of SWP water throughout the year by issuing “Notices to SWP Long-Term Water Supply Contractors,” or “Notices to Contractors” (NTCs).

Each NTC provides timely updates on SWP operations, hydrologic conditions, water supply programs, fees and funding information, among other key information. Select NTCs also announce the portion of Table A allocations DWR is able to fulfill based on current hydrologic conditions, as a percentage of total Table A contracts. Drought conditions that affect the amount of water in storage or the amount of runoff anticipated as snowmelt result in contractors receiving a smaller portion of their Table A allocations, while normal water year conditions and wet-weather conditions result in full distribution of Table A allocations. Figure 1-3, *Statewide Hydrologic Conditions, 2011-2023*, below, portrays statewide hydrologic conditions for a 13-year period, 2011 through 2023, using the key indicators of precipitation, snowpack, runoff, and reservoir storage; this data is displayed as a percentage of average conditions, such that values below 100 are below average and those above 100 are above average (DWR 2023a, pg. 19).

Figure 1-3 Statewide Hydrologic Conditions, 2011-2023



Source: DWR 2023a, pg. 19

The figure above shows that between 2011 and 2023, the lowest and highest hydrologic conditions occurred in 2014 and 2017, respectively. During both water year 2014 and water year 2017, four NTCs were issued by DWR to SWP contractors with updated Table A fulfillment amounts, presented as percentages of total Table A contracted allocations.

The figure above also shows that water year 2022/2023 was characterized by unusually wet conditions compared to average; this resulted in a surplus of water supply available through the SWP system, which is discussed further in Part 4, *Mechanisms of Supply Acquisition*, Section 4.3.2, *Wet Weather Surplus Flows*. However, the amount of water in storage and being conveyed through the SWP system changes throughout the year, depending upon existing and projected hydrologic conditions in combination with infrastructure capacity. Despite the unusually wet 2022/2023 conditions, DWR projected that initial Table A contract fulfillments in 2024 would be just 10 percent of Table A allocations (DWR 2023i). This was due to precipitation in October/November of 2023 being only about half of average, which indicated a dry pattern through the end of 2023 and the beginning of 2024.

Table 1-9, below, provides an overview of NTCs issued during 2014, 2017, and 2023, representing the lowest hydrologic year, the highest hydrologic year, and the most recent complete water year from the historical period represented in Figure 1-3, above. This table is informed by 12 separate NTCs, consisting of four from each of the years 2014 (DWR 2014), 2017 (DWR 2017), 2023 (DWR 2023f, 2023g, 2023h), and 2024 (DWR 2023i). These NTCs announced Table A fulfillment amounts as percentages of total Table A contracted amounts under dry year conditions (2014), wet year conditions (2017), and current Conditions (2023).

Table 1-9 Table A Fulfillment (AFY)¹ – Dry Year (2014), Wet Year (2017), and Current (2023)

Note SWP Contractor	Table A	2014: ²				2017:					2023:			
		5%	0%	5%	10%	20%	45%	60%	85%	30%	35%	75%	100%	
County of Butte	27,500	1,375	0	1,375	2,750	5,500	12,375	16,500	23,375	8,250	9,625	20,625	27,500	
Plumas County FCWCD	2,700	135	0	135	270	540	1,215	1,620	2,295	810	945	2,025	2,700	
City of Yuba City	9,650	483	0	483	965	1,930	4,343	5,790	8,203	2,895	3,378	7,238	9,650	
Napa County FC&WCD	29,025	1,451	0	1,451	2,903	5,805	13,061	17,415	24,671	8,708	10,159	21,769	29,025	
Solano County WA	47,756	2,388	0	2,388	4,776	9,551	21,490	28,654	40,593	14,327	16,715	35,817	47,756	
Alameda County FCWCD	80,619	4,031	0	4,031	8,062	16,124	36,279	48,371	68,526	24,186	28,217	60,464	80,619	
Alameda County WD	42,000	2,100	0	2,100	4,200	8,400	18,900	25,200	35,700	12,600	14,700	31,500	42,000	
Santa Clara Valley WD	100,000	5,000	0	5,000	10,000	20,000	45,000	60,000	85,000	30,000	35,000	75,000	100,000	
Oak Flat WD	5,700	285	0	285	570	1,140	2,565	3,420	4,845	1,710	1,995	4,275	5,700	
County of Kings	9,305	465	0	465	931	1,861	4,187	5,583	7,909	2,792	3,257	6,979	9,305	
Dudley Ridge WD	41,350	2,068	0	2,068	4,135	8,270	18,608	24,810	35,148	12,405	14,473	31,013	41,350	
Empire West Side ID	3,000	150	0	150	300	600	1,350	1,800	2,550	900	1,050	2,250	3,000	
Kern County WA	982,730	49,137	0	49,137	98,273	196,546	442,229	589,638	835,321	294,819	343,956	737,048	982,730	
Tulare Lake Basin WSD	87,471	4,374	0	4,374	8,747	17,494	39,362	52,483	74,350	26,241	30,615	65,603	87,471	
San Luis Obispo County FCWCD	25,000	1,250	0	1,250	2,500	5,000	11,250	15,000	21,250	7,500	8,750	18,750	25,000	
Santa Barbara County FCWCD	45,486	2,274	0	2,274	4,549	9,097	20,469	27,292	38,663	13,646	15,920	34,115	45,486	
Antelope Valley-East Kern WA	144,844	7,242	0	7,242	14,484	28,969	65,180	86,906	123,117	43,453	50,695	108,633	144,844	
Santa Clarita Valley WA	95,200	4,760	0	4,760	9,520	19,040	42,840	57,120	80,920	28,560	33,320	71,400	95,200	

Angeles Link
Water Resources Evaluation

Note SWP Contractor	Table A	2014: ²				2017:					2023:			
		5%	0%	5%	10%	20%	45%	60%	85%	30%	35%	75%	100%	
Coachella Valley WD	138,350	6,918	0	6,918	13,835	27,670	62,258	83,010	117,598	41,505	48,423	103,763	138,350	
Crestline-Lake Arrowhead WA	5,800	290	0	290	580	1,160	2,610	3,480	4,930	1,740	2,030	4,350	5,800	
Desert WA	55,750	2,788	0	2,788	5,575	11,150	25,088	33,450	47,388	16,725	19,513	41,813	55,750	
Littlerock Creek ID	2,300	115	0	115	230	460	1,035	1,380	1,955	690	805	1,725	2,300	
Metropolitan	1,911,500	95,575	0	95,575	191,150	382,300	860,175	1,146,900	1,624,775	573,450	669,025	1,433,625	1,911,500	
Mojave WA	89,800	4,490	0	4,490	8,980	17,960	40,410	53,880	76,330	26,940	31,430	67,350	89,800	
Palmdale WD	21,300	1,065	0	1,065	2,130	4,260	9,585	12,780	18,105	6,390	7,455	15,975	21,300	
San Bernardino Valley MWD	102,600	5,130	0	5,130	10,260	20,520	46,170	61,560	87,210	30,780	35,910	76,950	102,600	
San Gabriel Valley MWD	28,800	1,440	0	1,440	2,880	5,760	12,960	17,280	24,480	8,640	10,080	21,600	28,800	
San Geronio Pass WA	17,300	865	0	865	1,730	3,460	7,785	10,380	14,705	5,190	6,055	12,975	17,300	
Ventura County WPD	20,000	1,000	0	1,000	2,000	4,000	9,000	12,000	17,000	6,000	7,000	15,000	20,000	
Total:	4,172,836	208,642	0	208,642	417,284	834,567	1,877,776	2,503,702	3,546,911	1,251,851	1,460,493	3,129,627	4,172,836	

¹ AFY = acre-feet per year. Table A allocations are the amounts of State Water Project (SWP) water promised to each SWP contractor in contracts with the state through the Department of Water Resources (DWR); Table A allocations are contracted amounts that do not change in response to hydrologic conditions or the actual amount of water that is physically available. Table A fulfillment refers to the amount of SWP water that is physically available at a given time, represented as a percentage of Table A allocations. The ability of the State (DWR) to fulfill its Table A contracts with SWP contractors fluctuates throughout the year, depending upon hydrologic conditions and the amount of water currently stored in and being conveyed through the SWP. The DWR notifies SWP contractors of fulfillment amounts through Notices to Contractors (NTCs) which are issued as fulfillment ability changes, and are therefore issued multiple times throughout a year.

² During water year 2014, two NTCs were issued announcing 5 percent fulfillment of Table A allocations; as described for footnote (1), fulfillment of Table A allocations changes throughout the year depending upon hydrologic conditions and the physical availability of water within the SWP system. A 5 percent fulfillment indicates the state is able to deliver 5% of each contractor's Table A allocation of the SWP.

Source: DWR 2014; DWR 2017; DWR 2023f, 2023g, 2023h, 2023i

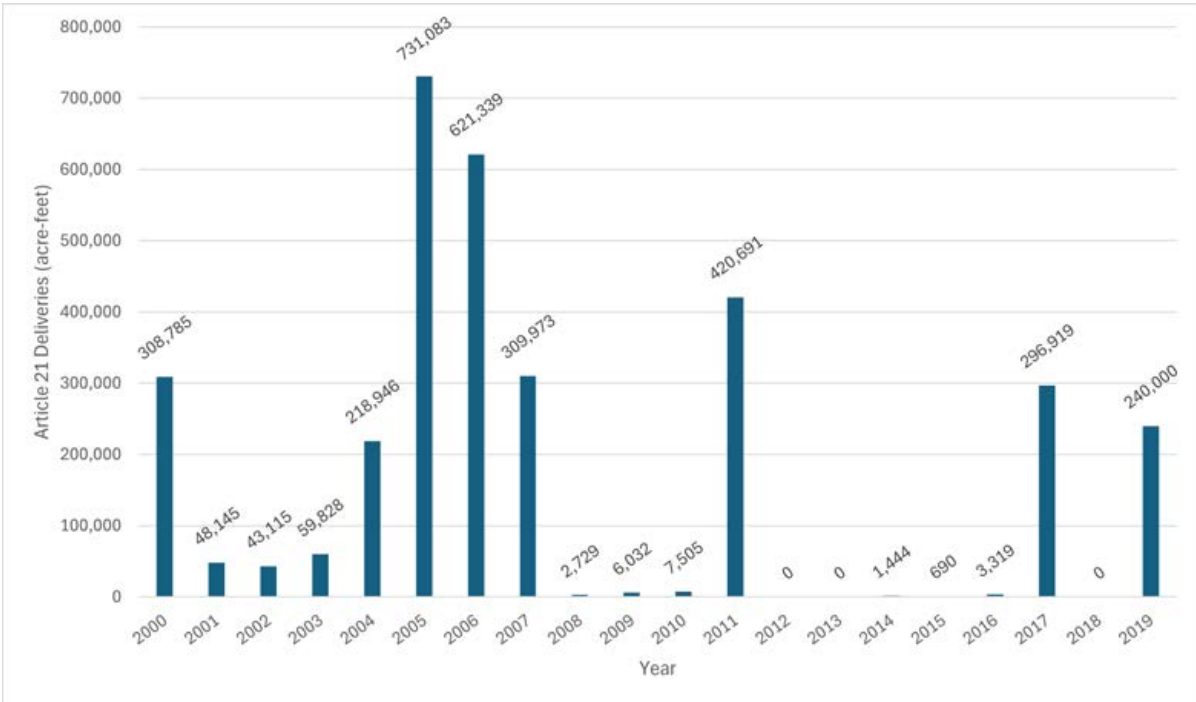
The table above shows that at the end of 2023, the SWP was operating at full capacity, with 100 percent of all SWP contractors’ Table A allocations being fulfilled.

Section 3.1.1, *SWP Water*, includes discussion of DWR’s Delta Conveyance Project which, as proposed, would provide a dual conveyance system for SWP water through the Delta, thereby increasing capabilities to capture wet weather flows for use during dry year conditions. This expansion of SWP facilities would increase the reliability of SWP water deliveries to south-of-Delta SWP contractors and improve the fulfillment allocations shown in the table below. The Delta Conveyance Project would not alter existing water rights or Table A contract amounts. As discussed in Section 3.1.1, the DWR is currently conducting Tribal engagement and regulatory compliance for the Delta Conveyance Project. A new cost estimate and a benefit-cost analysis for the project are expected to be provided by the Delta Construction Authority in mid-2024 (DWR 2023n).

Article 21 Water

During some “wet weather” years, SWP contractors may have access to additional flows provided through the SWP conveyance system, but which are separate and in addition to Table A allocations. These surplus flows are authorized under Article 21 of the SWP Long-Term Water Supply Contracts, and are referred to as “Article 21 water.” The mechanisms for how Article 21 can be used to procure additional supply are discussed in Part 4, Mechanisms of Supply Acquisition, in Section 4.3.2, Wet Weather Surplus Flows. The following graphics are provided to demonstrate the volume of Article 21 flows that have been obtained by SWP contractors both cumulatively Figure 1-4 and per contractor Figure 1-5. Between 2000 and 2017, a total of 3,080,543 acre-feet of Article 21 water was provided by DWR to individual SWP contractors. Article 21 water was also distributed in 2019, in the amount of 242,000 acre-feet (DWR 2023m).

Figure 1-4 Annual Article 21 Deliveries to SWP Contractors, 2000-2019

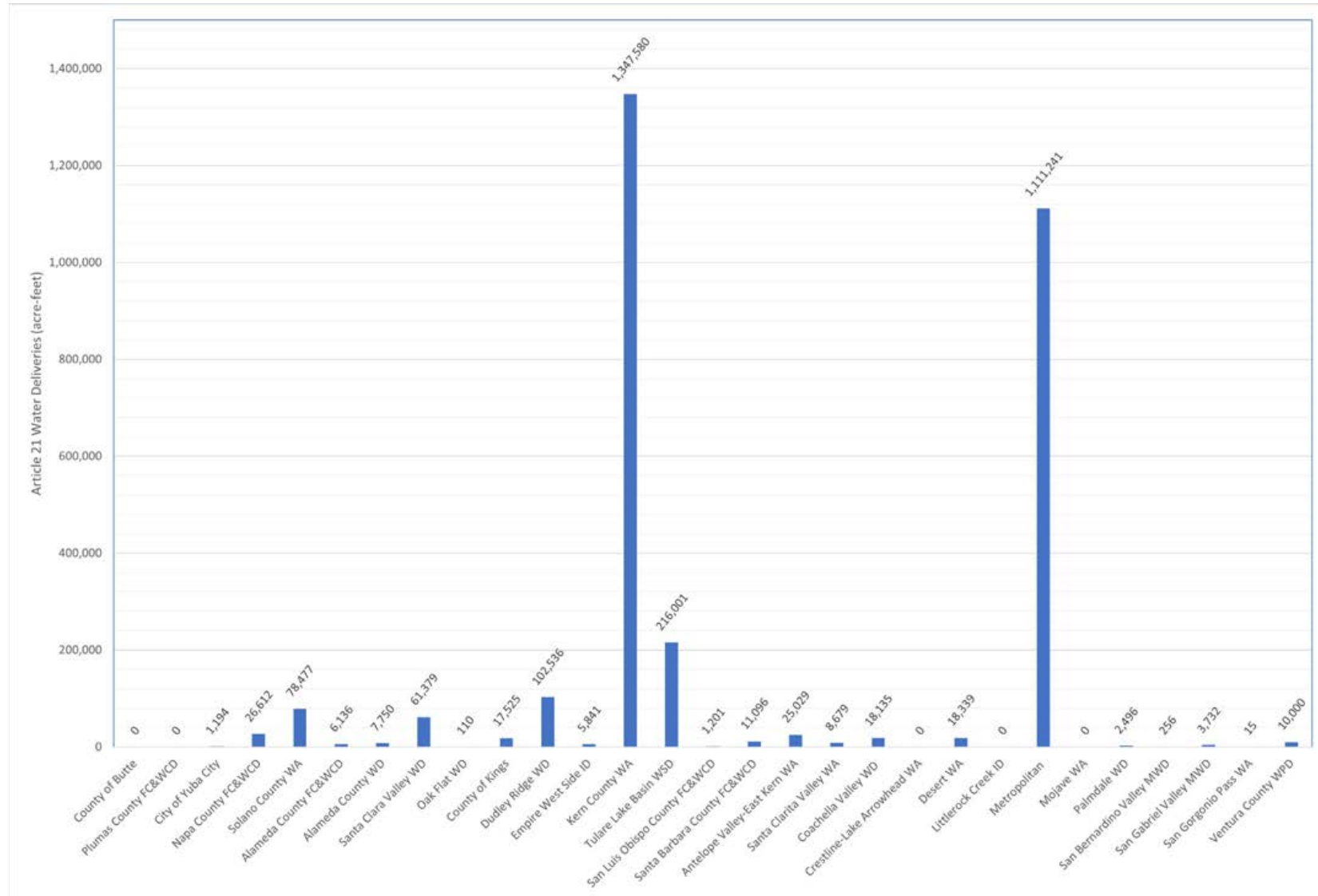


Source: Austin 2018; DWR 2023m

Angeles Link
Water Resources Evaluation

In addition to the Article 21 deliveries shown above, the State also released Article 21 water in 2023; as of April 2023, approximately 265,000 acre-feet of Article 21 water had been made available to SWP contractors (DWR 2023). Figure 1-5, below, shows how the Article 21 water was distributed among the 29 SWP contractors during the historical period of 2000 through 2017.

Figure 1-5 Total Article 21 Water Deliveries (acre-feet) per SWP Contractor, 2000-2017



Source: Austin 2018

California Aqueduct

A series of figures is presented on the following pages to show the alignment for each branch of the California Aqueduct, and to identify the facilities, communities, and other features existing along the branch alignments. These figures include the following:

- Figure 1-6, shows that the Coastal Branch conveys SWP water into San Luis Obispo County and Santa Barbara County;
- Figure 1-7, shows the West Branch conveys SWP water into Los Angeles County, ending at Castaic Lake, and the East Branch conveys water into San Bernardino County and Riverside County, ending at Lake Perris (which is also the southern-most SWP facility);
- Figure 1-8, shows the East Branch serves the Inland Empire and conveys SWP water from Silverwood Lake to Lake Perris, with an East Branch Extension conveying SWP water farther southeast into San Bernardino County;
- Figure 1-9, shows the East Branch Extension of the California Aqueduct conveys SWP water to Low Desert Contractors that otherwise would have no connection to SWP facilities, including the Coachella Valley Water District, Desert Water Agency, San Bernardino Valley Municipal Water District, and San Geronimo Pass Water Agency.

These figures are provided to inform consideration of where SWP water could potentially be available as a supply source for clean renewable hydrogen production, based on where existing facilities are located. Future clean renewable hydrogen production facilities may be located near or along existing SWP facilities. See Part 4, *Mechanisms of Supply Acquisition*, for a general discussion of water supply acquisition mechanisms and Section 4.1, *Exchange Agreements*, for discussion of exchange as a mechanism to acquire water supply for clean renewable hydrogen development.

Section 3.1, *Imported Surface Water in the Study Area*, further discusses SWP supplies and facilities.

Figure 1-6 SWP Facilities – CA Aqueduct Coastal Branch



Figure 1-7 SWP Facilities – CA Aqueduct West Branch and East Branch



Source: SWC 2023b

Figure 1-8 SWP Facilities – CA Aqueduct East Branch, Inland Empire



Source: SWC 2023c

Figure 1-9 SWP Facilities – High and Low Desert Regions

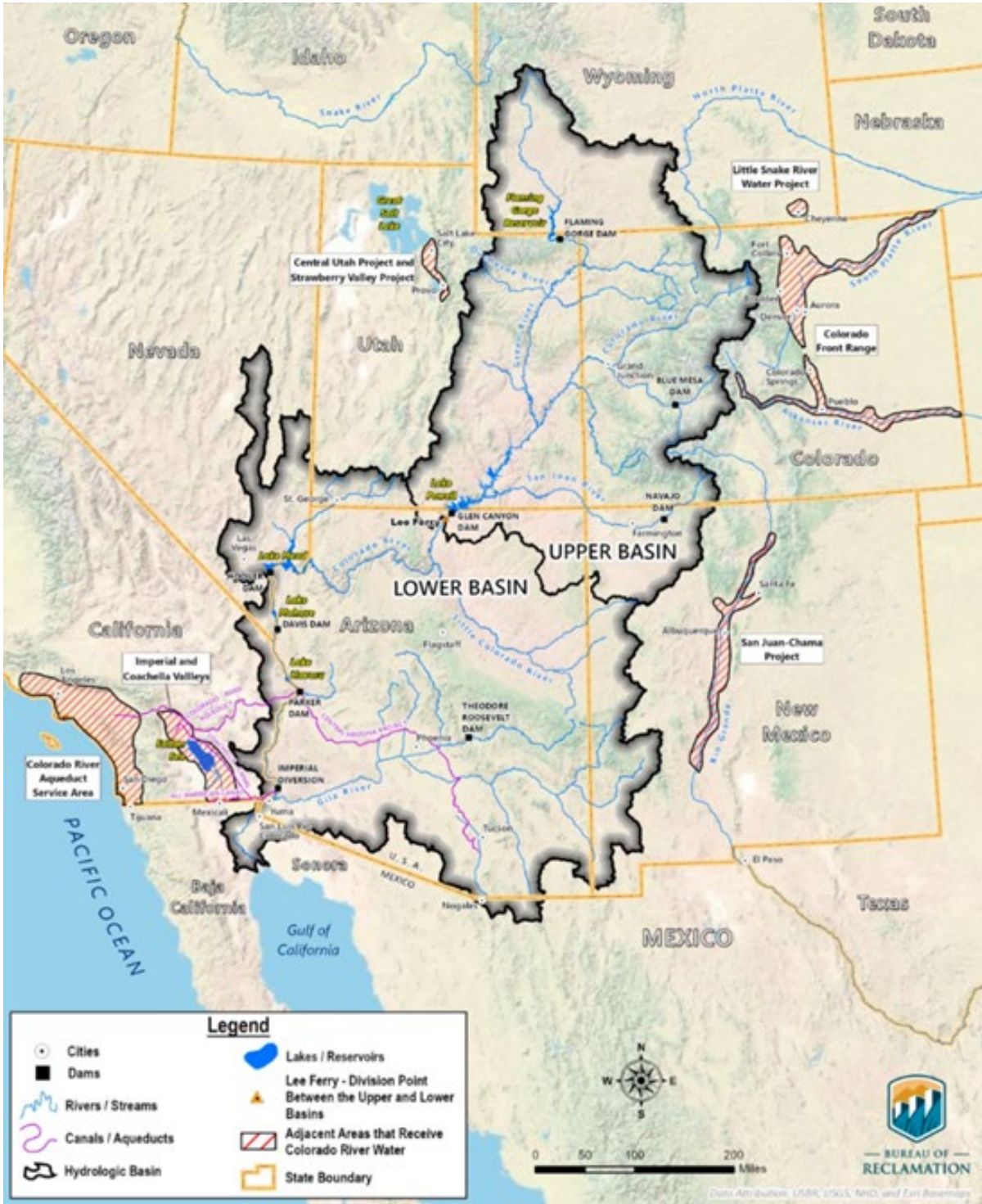


Source: SWC 2023d

2.3.2 Colorado River

Colorado River water is conveyed into Southern California via the Colorado River Aqueduct, which is owned and operated by Metropolitan. Figure 1-10, below, provides an overview of the Colorado River and its Upper and Lower Basins.

Figure 1-10 Colorado River Basin and Facilities



Source: USBR 2021a

Section 3.1, *Imported Surface Water in the Study Area*, details Colorado River entitlements for Southern California contractors in Table 1-16, *Colorado River Water Entitlements in California*. Similar to the SWP, Colorado River water is fully allocated to existing contractors, which may sell or authorize use of portions of their existing allocations and as supplies are available.

The Upper Basin and Lower Basin of the Colorado River were defined in the 1922 Colorado River Compact, which also allocated 7.5 MAFY to each basin. In the Lower Basin, California is authorized 4.4 MAFY, nearly 59 percent, of the Lower Basin's total allocations. Conflicts between signatories to the Colorado River Compact are long-standing, particularly regarding California's agricultural and municipal interests, and priority uses over Colorado River water. A contract called the Seven-Party Agreement was established in 1931 to help settle these conflicts. Claimants of the Seven-Party Agreement who were able to reach consensus in the Seven-Party Agreement on the amounts of water to be allocated to each entity include the following: Palo Verde Irrigation District (PVID), Yuma Project, Imperial Irrigation District (IID), Coachella Valley Irrigation District, Metropolitan, City of San Diego, and County of San Diego.

In 2007, in response to six years of severe drought in the Colorado River Basin, federal officials and representatives of the seven basin states adopted a framework to better respond to drought and coordinate the operations of Lake Powell and Lake Mead, two key reservoirs on the Colorado River. The Interim Guidelines were adopted because in addition to water supply, there was concern that if Lake Mead's elevation dropped to 1,050 feet above sea level, hydroelectric-generation capacity at Hoover Dam would be compromised (WEF 2023c).

The following sections, *Near-Term Colorado River Operations*, and *Lower Colorado Conservation and Efficiency Program*, describe decisions and management direction for the Colorado River that developed in 2023. The efforts described below build off the 2007 Interim Guidelines (valid through December 2025) and update management guidance and requirements to account for the effects of climate change and drought, as well as population increases.

Near-Term Colorado River Operations

In 2023, USBR developed revisions to the 2007 Interim Guidelines in response to the potential for continued low-runoff conditions in the Colorado River. These revisions represent *Near-Term Colorado River Operations*, which address the operation of Glen Canyon and Hoover Dams beginning on October 1, 2023, for the 2024 operating year. The *Near-Term Colorado River Operations* were developed in response to USBR's determination that potential impacts of low-runoff conditions (during winter of 2022/2023 and the remainder of the interim period through 2026) pose risks to routine operations of Glen Canyon and Hoover Dams, which necessitate modified operating guidelines (USBR 2023a). Also in October 2023, the USBR determined ongoing cutbacks were sufficient to avoid critically low reservoir levels through October 2025 (USBR 2023c).

The modification of operating guidelines put forward in the *Near-Term Colorado River Operations* adjusts management practices in response to drought conditions and disputes over water rights and allocations. The proposed *Near-Term Colorado River Operations* were analyzed in a 2023 Draft Supplemental Environmental Impact Statement (EIS) to the 2007 EIS for the Lower Basin Interim Guidelines (USBR 2023a). However, the 2023 Supplemental EIS was temporarily withdrawn from public review in May 2023, when the U.S. Department of the Interior (USDOI) announced the *Lower Colorado Conservation and Efficiency Program*, discussed below. USBR developed new analyses, adding in the Conservation Program as an additional alternative, as part of an updated Draft Supplemental EIS published in October 2023 (USBR 2023a).

Lower Colorado River Basin System Conservation and Efficiency Program

The *Lower Colorado River Basin System Conservation and Efficiency Program* (“Conservation Program”) is a consensus-based funding program which commits to conserving Colorado River water through 2026, when the current operating guidelines are set to expire (USDOI 2023). The Conservation Program is funded through the Inflation Reduction Act, and through an existing Intentionally Created Surplus extraordinary conservation water storage program, to provide resources for water management and conservation efforts in the Colorado River Basin and other basins experiencing comparable levels of long-term drought (CRBC 2023b). Through this program, the USBR is accepting proposals describing lower Colorado River Basin conservation projects that would reduce consumptive use of Colorado River water having a recent history of use (USBR 2023b).

California’s Colorado River contractors and entitlement holders have collaborated with the USBR to develop proposals that will conserve up to 1.6 million acre-feet of water through 2026 for the benefit of the Colorado River System as part the Conservation Program (CRBC 2023b). To date, the USDOI has announced investments in the following Conservation Program projects (USDOI 2023):

- 127,000 AFY conserved through 21 water recycling projects (\$281 million);
- 125,000 AFY in 2024 and 2025, and multiple other savings, through water conservation funding for the Gila River Indian Community (\$233 million);
- 140,000 AF in Lake Mead in 2023 and up to 393,000 AF through 2025, through eight new agreements that commit water entities in Tucson and Phoenix areas to conserve use;
- \$73 million for infrastructure repairs on water delivery systems, including \$19.3 million in fiscal year 2022 and another \$54 million announced in April 2023;
- \$71 million for 32 drought resiliency projects to expand access to water through groundwater storage, rainwater harvesting, aquifer recharge and water treatment;
- \$50 million over the next five years to improve key water infrastructure and enhance drought-related data collection across the Upper Colorado River Basin; and
- \$20 million in new, small surface and groundwater storage investments.

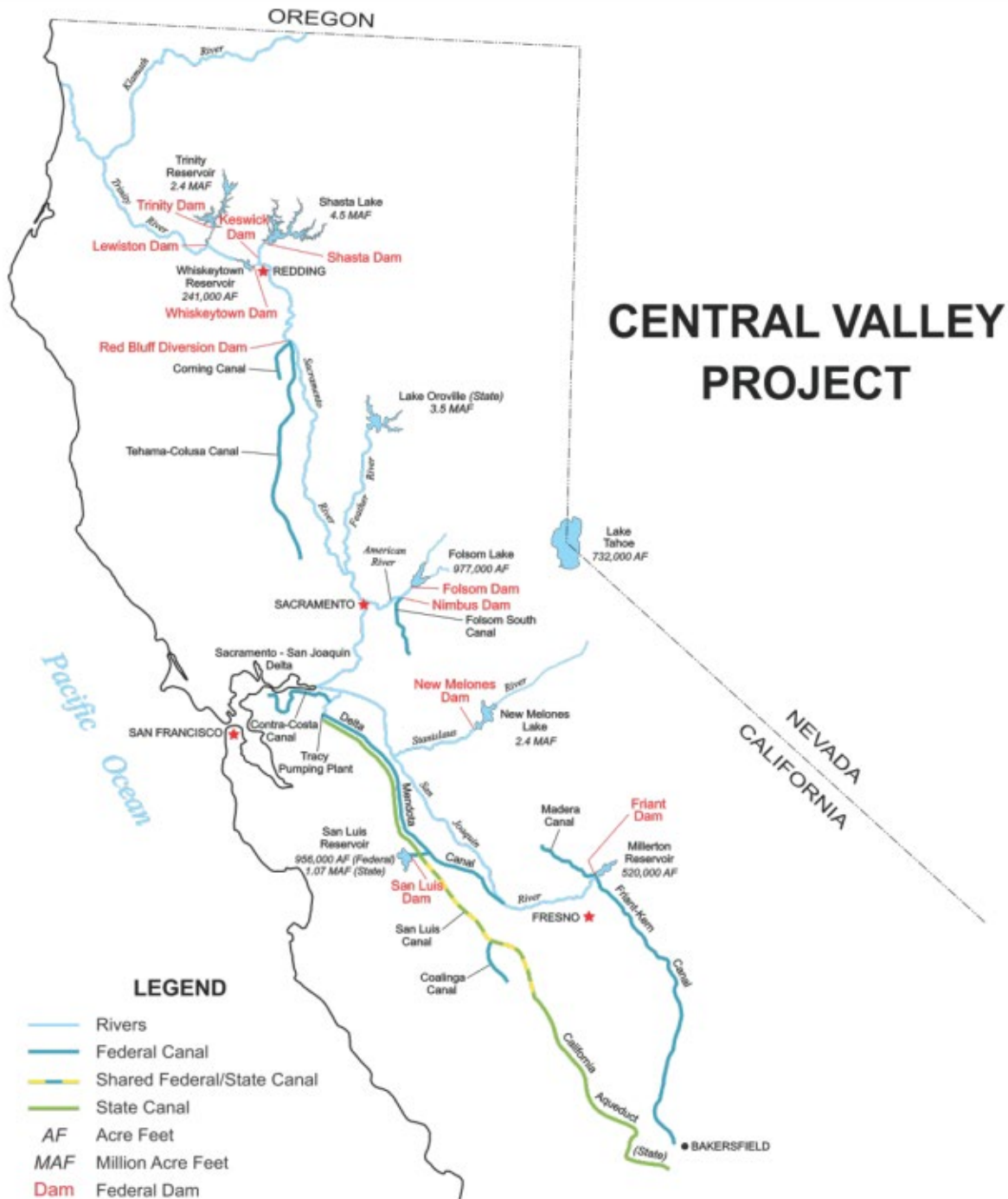
Each of California’s Colorado River contractors and entitlement holders, including Metropolitan, IID, PVID, CVWD, Bard Water District, and the Fort Yuma Quechan Indian Tribe, will conserve water by leaving it in the Colorado River as part of the Conservation Program (CRBC 2023b).

2.3.3 Central Valley Project

The CVP is a federal public works project, constructed and operated by U.S. Bureau of Reclamation (USBR). The CVP is a complex, multi-purpose network of dams, reservoirs, canals, hydroelectric powerplants and other facilities that extend over 400 miles between Northern and Central California. It also reduces flood risk for the Central Valley, and supplies water to major urban centers in the Greater Sacramento and San Francisco Bay areas, as well as producing electrical power (USBR 2023d). CVP facilities extend from Shasta Dam on the Sacramento River near Redding to as far south as Bakersfield, in the southern San Joaquin Valley portion of Central California (USBR 2023d).

Figure 1-11, below, provides an overview of the CVP service area and primary features.

Figure 1-11 Central Valley Project Infrastructure and Storage



Source: USBR 2023f

The Sacramento River carries water to the Sacramento-San Joaquin River Delta; once water reaches the southern end of the Delta, CVP facilities include pump stations and other infrastructure to lift CVP water out of the Delta and into conveyance and storage facilities for delivery to south-of-Delta contractors. At the southern end of the CVP system, water is stored in the New Melones Reservoir for distribution to water rights holders in the Stanislaus River watershed and CVP contractors in the

northern San Joaquin Valley. This portion of the CVP consists of the Friant Division, one of eight management divisions on the CVP, and is located within the northern-most portion of SoCalGas’s service territory; see detailed discussion in Section 3.1, *Imported Surface Water in the Study Area*.

CVP facilities have a total cumulative capacity of approximately 12 million acre-feet. The CVP has long-term agreements to supply water to more than 250 contractors in 29 counties. During an average water year, CVP water deliveries include the following (CRS 2017):

- 5 million acre-feet of system-wide water deliveries to farms for agricultural (irrigation) uses;
- 600,000 acre-feet to municipal and industrial (M&I) users;
- 410,000 acre-feet to wildlife refuges (statutory requirements with agencies); and
- 800,000 acre-feet for other fish and wildlife needs (statutory requirements with agencies).

The quantities above reflect deliveries for the CVP system as a whole, including for contractors located both north and south of the Delta. The discussion provided below, under “CVP Contractors and Allocations,” identifies the south-of-Delta contractors and their respective allocations, as well as historical data on fulfillment rates. North-of-Delta contractors are not detailed herein, due to their substantial geographic distance outside the study area used for this Water Availability Study (see Section 1.4.1, *Study Area*).

CVP Contractors and Allocations

Water in the CVP system is fully allocated to more than 250 contractors throughout Northern and Central California, both north and south of the Delta. As noted above, for the purposes of this Water Availability Study, information is provided for south-of Delta contractors. Table 1-10, below, identifies all south-of-Delta CVP contractors by water supply unit, and provides the maximum CVP water delivery amount per water supply unit, as well as the amount designated for agricultural uses and non-agricultural uses, including the amount historically used for M&I uses (USBR 2016).

Table 1-10 CVP Water Allocations (AFY)¹ – South of Delta

Water Supply Unit	CVP Contractors	Max Contract Amount	Contract Amount for Ag	Contract Amount non-Ag	M&I Historical Use ²
Delta-Mendota Canal	<ul style="list-style-type: none"> ▪ Banta-Carbona Irrigation District ▪ Byron-Bethany Irrigation District 1 ▪ Del Puerto Water District ▪ Eagle Field Water District ▪ Mercy Springs Water District ▪ Oro Loma Water District ▪ Pajaro Valley WMA ▪ Patterson Irrigation District ▪ The West Side Irrigation District ▪ Tracy, City of ▪ U.S. Department of Veteran Affairs ▪ West Stanislaus Irrigation District ▪ Westlands Water District 	330,100	318,396	11,704	10,986

Water Supply Unit	CVP Contractors	Max Contract Amount	Contract Amount for Ag	Contract Amount non-Ag	M&I Historical Use ²
Mendota Pool	<ul style="list-style-type: none"> ▪ Coelho Family Trust ▪ Fresno Slough Water District ▪ James Irrigation District ▪ Laguna Water District ▪ USBR District No. 1606 ▪ Tranquility Irrigation District ▪ Westlands Water District (assigned from Oro Loma) 	60,278	60,278	0	0
Cross Valley Canal	<ul style="list-style-type: none"> ▪ Fresno, County of ▪ Hills Valley Irrigation District ▪ Kern-Tulare Water District ▪ Lower Tule River Irrigation District ▪ Pixley Irrigation District ▪ Tri-Valley Water District ▪ Tulare, County of 	128,300	127,406	894	0
San Felipe	<ul style="list-style-type: none"> ▪ San Benito County Water District ▪ Santa Clara Valley Water District 	196,300	60,744	135,556	135,556
San Luis Unit	<ul style="list-style-type: none"> ▪ Avenal, City of ▪ California, State of ▪ Coalinga, City of ▪ Huron, City of ▪ Pacheco Water District ▪ Panoche Water District ▪ San Luis Water District ▪ Westlands Water District 	1,397,920	1,375,253	22,667	14,254
Total		2,112,898	1,942,077	170,821	160,796

¹ CVP water allocations are shown in acre-feet per year (AFY).

² M&I Historical Use was calculated based upon the past three years of unconstrained CVP delivery for all contractors except Contra Costa Water District, Santa Clara, and Byron Bethany, where historical use figure represents an amount agreed upon in contract renewal or other agreements with USBR.

Source: USBR 2016

The table above shows that a total of 2,112,898 AFY of CVP water is allocated to south-of-Delta contractors. Of this total, approximately 92 percent (1,942,077 AFY) is dedicated for agricultural uses and approximately 170,821 AFY for non-agricultural uses, of which approximately 160,796 AFY has historically been used for M&I uses.

Similar to the SWP, the reliability of delivery of water supply allocated under the CVP is variable and depends upon factors including weather and drought conditions, contractual obligations, and other demands on water in the CVP system. Table 1-11, below, provides an overview of historical fulfillments of CVP allocations to south-of-Delta contractors, shown as a percentage of total contracted allocations. The use types presented below include those defined by the 2006 *San Joaquin River Restoration Settlement*, including Wildlife Refuges, Settlement Contractors, Eastside Division Contractors, and Friant Class 1 and Class 2 contractors. The 2006 Settlement was between the U.S. Departments of the Interior and Commerce, the Natural Resources Defense Council, and the Friant Water Users Authority, and resolved an 18-year lawsuit. The 2006 Settlement resulted in the federal San Joaquin River Restoration Settlement Act, which was passed in March 2009 with 32 contractors (districts and cities) party to the Settlement (SJRRP 2024).

Table 1-11 CVP South of Delta Allocations – Historical Fulfillment (%) by Use Type¹

Year	Agriculture	Urban (M&I)	Wildlife Refuges	Settlement Contractors	Eastside Division Contractors	Friant Class 1	Friant Class 2
2023	100	100	100	100	100	100	70
2022	0	PHS ²	SC ²	SC ²	0	30	0
2021	5	55	75	75	100	20	0
2020	15	65	100	100	100	20	0
2019	35	75	100	100	100	100	100
2018	20	70	100	100	100	30	9
2017	65	90	100	100	100	100	100
2016	5	55	100	100	0	30	6
2015	0	25	75	75	0	0	0
2014	0	50	40	40	55	0	0
2013	25	75	100	100	100	65	0
2012	30	75	75	75	100	35	0
2011	50	75	100	100	100	100	20
2010	5	55	100	100	100	100	0
2009	10	60	100	100	12	77	18
2008	40	75	100	100	23	100	5
2007	50	75	100	100	29	65	0
2006	100	100	100	100	100	100	100
2005	85	100	100	100	28	100	100
2004	70	95	100	100	0	100	8
2003	75	100	100	100	0	100	5
2002	70	95	100	100	0	100	8
2001	49	77	100	100	22	100	5

¹The use types presented above include those defined by the 2006 *San Joaquin River Restoration Settlement*, including Wildlife Refuges, Settlement Contractors, Eastside Division Contractors, and Friant Class 1 and Class 2 contractors. At the Friant Division, a two-class system is used to determine water rights under the Settlement, where Class 1 consists of the first 800,000 acre-feet developed and accessible for delivery (usually for M&I use or for districts without access to groundwater supply); and Class 2 consists of the next 1.4 million acre-feet developed, primarily for groundwater recharge projects (WEF 2014).

² PHS = public health and safety needs; SC = Shasta Critical (as defined in their contract)

Source: USBR 2023e

The table above demonstrates that the amount of fulfillment of contracted CVP allocations vary substantially, similar to the other key water supply projects. CVP facilities within SoCalGas's service territory are detailed in Section 3.1, *Imported Surface Water in the Study Area*.

2.4 Urban Water Management Planning

California law (CWC Sections 10610-10656 and Section 10608) requires urban water supply providers within the state of California to prepare a UWMP if they have at least 3,000 service connections or deliver more than 3,000 AFY of water within their service territory. Each UWMP quantifies the anticipated water needs and available supply sources within service territory being addressed. UWMPs include supply and availability projections over a minimum 20-year planning

horizon and with consideration to drought conditions. The purpose of a UWMP is to support the water suppliers' long-term resources planning so that there are sufficient reliable water supply sources available to support existing and anticipated water needs. UWMPs are required to be updated every five years, with calculations adjusted to account for any changes in population projections, land use plans, climatic conditions, water supply development projects, and other factors affecting water supply availability to the respective planning area. As such, UWMPs provide a "snapshot" of existing conditions within the planning area, and projected conditions which are updated based upon the best available data as reviewed every five years.

Demand and supply projections in a UWMP typically do not reflect substantial amounts of surplus supply availability. This is because UWMPs are designed to provide the water supplies needed to satisfy anticipated water needs within a specific area, based upon known and anticipated land uses. UWMP projections are required to address a minimum 20-year planning horizon. Some agencies project farther into the future, depending upon funding, data availability, and other factors. UWMPs estimate and account for water needs of future development projects based upon project applications that have been submitted to applicable land use planning agencies and are available for public review. UWMPs identify water supply development projects as needed to supplement existing supplies and meet projected demands; such projects may include but are not limited to conservation, water recycling and water reuse, treatment of waste streams, stormwater capture and reuse, and purchase of surplus supplies when available.

Based on the review of UWMPs throughout SoCalGas's service territory conducted to support this Water Availability Study, clean renewable hydrogen projects were not accounted for in the 2020 UWMP supply availability projections. As future applications for clean renewable hydrogen projects are submitted to local county planning departments for consideration of approval, water agencies may consider those projects for incorporation into their UWMP projections of demand and supply. For example, when clean renewable hydrogen projects are formally proposed for consideration by local planning agencies, UWMPs would account for the water needs of those projects. UWMPs are required to be updated every five years; therefore, the 2020 UWMPs that were used to inform this analysis contain the most current data available until UWMPs are updated in 2025.

Below is an overview of some of the required contents of a UWMP, demonstrating how UWMPs are used to plan for and provide sufficient water supply to meet demands within their service areas.

- **System Water Use:** Presents water use data for the past five years and projects water needs for the next 20 years, accounting for population growth, land use changes, and conservation measures. These projections are updated with every UWMP five-year update, accounting for changes including population growth and land use changes.
- **System Supplies:** Describes the current and planned sources of water supply for the UWMP area including surface water, groundwater, imported water, recycled water, desalinated water, and transfers and exchanges, and quantifies the amount of water available from each source for the next 20 years under normal, single dry year, and multiple dry year scenarios.
- **Water Supply Reliability Assessment:** Evaluates the reliability of the water supply sources and compares the total water supply with the total water needs over the next 20 years under normal, single dry year, and multiple dry year scenarios. It also discusses how climate change may affect the water supply reliability.
- **Water Shortage Contingency Plan (WSCP):** Describes response actions the water supplier will take during water shortages of varying levels of severity, including a drought risk assessment, a six-stage shortage response plan, a communication strategy, a compliance and enforcement

strategy, a legal authority statement, a financial plan, a monitoring and reporting plan, and a plan update schedule.

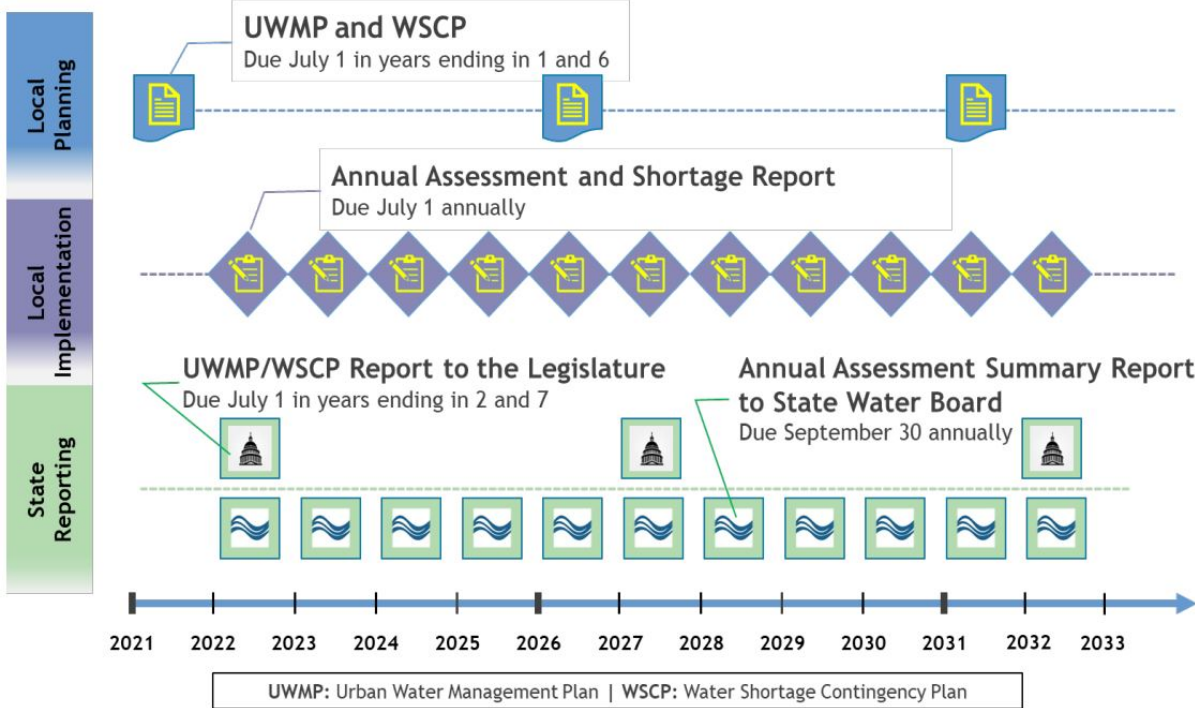
- **Demand Management Measures:** Describes the demand management measures the urban water supplier has implemented or plans to implement to achieve water use efficiency. Includes a description of each measure, its implementation status, its estimated water savings, its costs and benefits, and its funding sources.

In addition to five-year updates of UWMPs, agencies responsible for preparing UWMPs are also required to prepare and maintain the following reports:

- **Annual Water Supply and Demand Assessment (Annual Assessment)** – evaluates the anticipated water supply and demand for the current year and the next three years under normal, single dry year, and multiple dry year scenarios. This is similar to a UWMP except the Annual Assessment is prepared every year and projects for three years, whereas the UWMP is prepared every five years and projects for five years.
- **Annual Water Shortage Assessment Report (Annual Shortage Report)** – summarizes the results of the Annual Assessment and any response actions from the UWMP triggered by water shortage conditions.

The Annual Assessment and Annual Shortage Report are important tools for drought response as they help to proactively prepare for water shortages and implement strategies to increase water availability and efficiency. Figure 1-12, below, provides an overview of the timeline and reporting frequency of UWMPs and WSCPs, as well as Annual Assessments and Annual Shortage Reports.

Figure 1-12 Water Shortage Contingency Planning and Implementation Timeline



Source: DWR 2022b

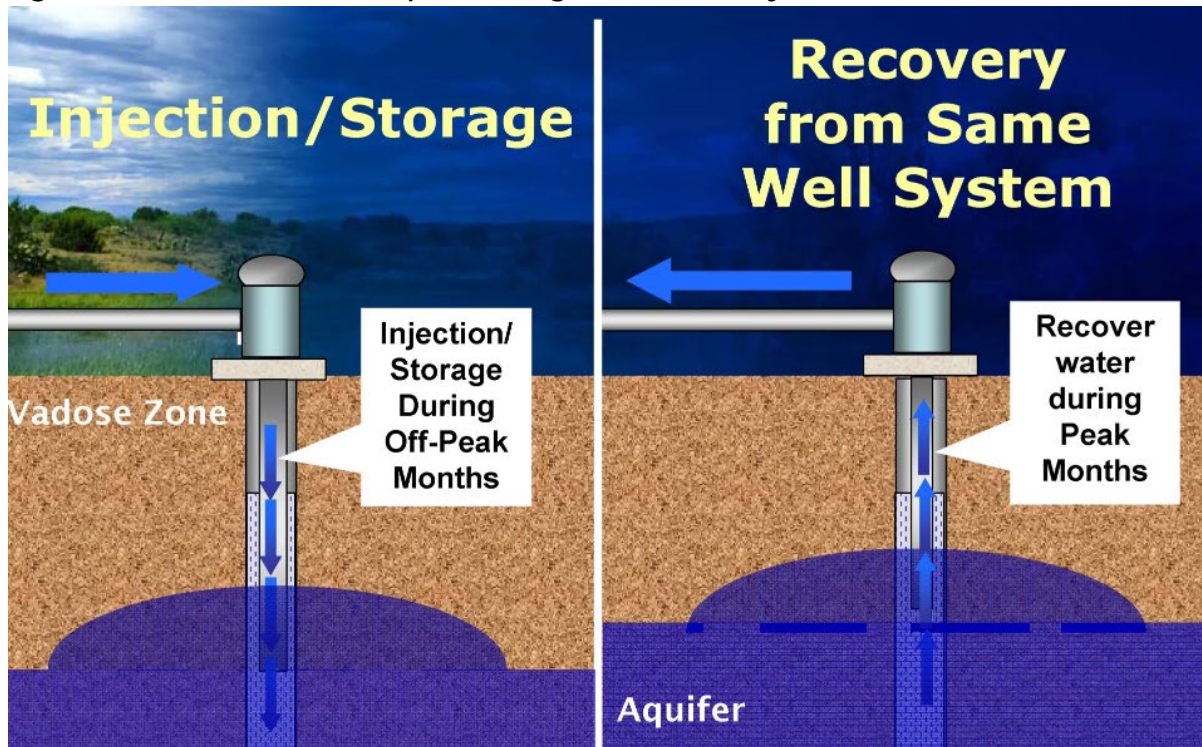
As shown above, the first year of reporting under the Water Conservation and Drought Planning Act was 2022; therefore, long-term data is not currently available. However, data will continue to be collected and reported annually, building valuable information that will help water managers address water availability and predict and respond to drought and shortage conditions.

2.5 Conjunctive Use Management

Conjunctive use refers to the coordinated management of surface water and groundwater supplies, to maximize opportunities for beneficial use of the overall water supply. It is anticipated that water supply for clean renewable hydrogen development will come from multiple sources, depending upon the point of use and available supply sources and supply acquisition mechanisms available. Conjunctive use management could contribute to supply development for clean renewable hydrogen by providing storage of acquired supplies as they become available, for use as needed to produce clean renewable hydrogen. Hydrogen producers may partner with local water agencies to participate in or develop conjunctive use projects, towards the purpose of securing sufficient water supply for clean renewable hydrogen development. See Section 4.2, *Local Water Agencies*, for discussion of how water supply may be acquired from local agencies through purchase or through partnership on the development of new water supply.

A common method of conducting conjunctive use management is through aquifer storage and recovery (ASR), which involves storing surplus water in the ground during wet periods of high availability, and withdrawing these stored supplies for use during dry periods of low or restricted surface water availability. Figure 1-13, below, provides an overview of typical ASR processes.

Figure 1-13 Schematic of Aquifer Storage and Recovery



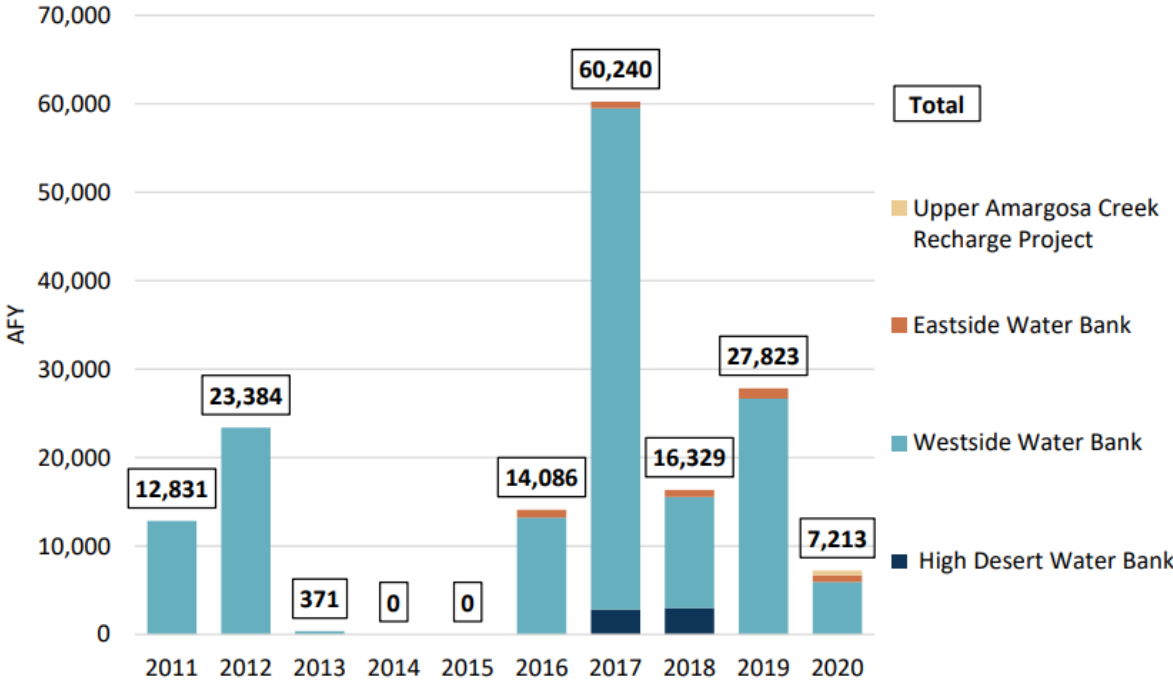
Source: Coyote Gulch 2018

ASR is conducted both actively, where surface water is intentionally injected or percolated into the ground for later use, and passively, where surface water is relied on during wet years and groundwater is relied on during dry years. ASR may also be used to facilitate exchange agreement(s) as a mechanism to acquire water supply for clean renewable hydrogen; see Section 4.1, *Exchange Agreements*, for further discussion. ASR is conducted throughout SoCalGas’s service territory to support conjunctive use management efforts and provide supply reliability, particularly through drought conditions. As an example of the scale of water storage that can be conducted through ASR programs, the Antelope Valley-East Kern (AVEK) water agency uses extensive groundwater banks in the Antelope Valley region of Southern California to store SWP water during times of surplus, and recover the supplies during dry periods. Active AVEK groundwater banks include:

- Westside Water Bank, operational since 2010;
- Eastside Water Bank, operational since 2016;
- Upper Amargosa Creek Recharge Project, operational since 2019 (AVEK, City of Palmdale, Palmdale Water District, and Los Angeles County Waterworks District 40); and
- High Desert Water Bank, planned operational in 2024 (AVEK 2021).

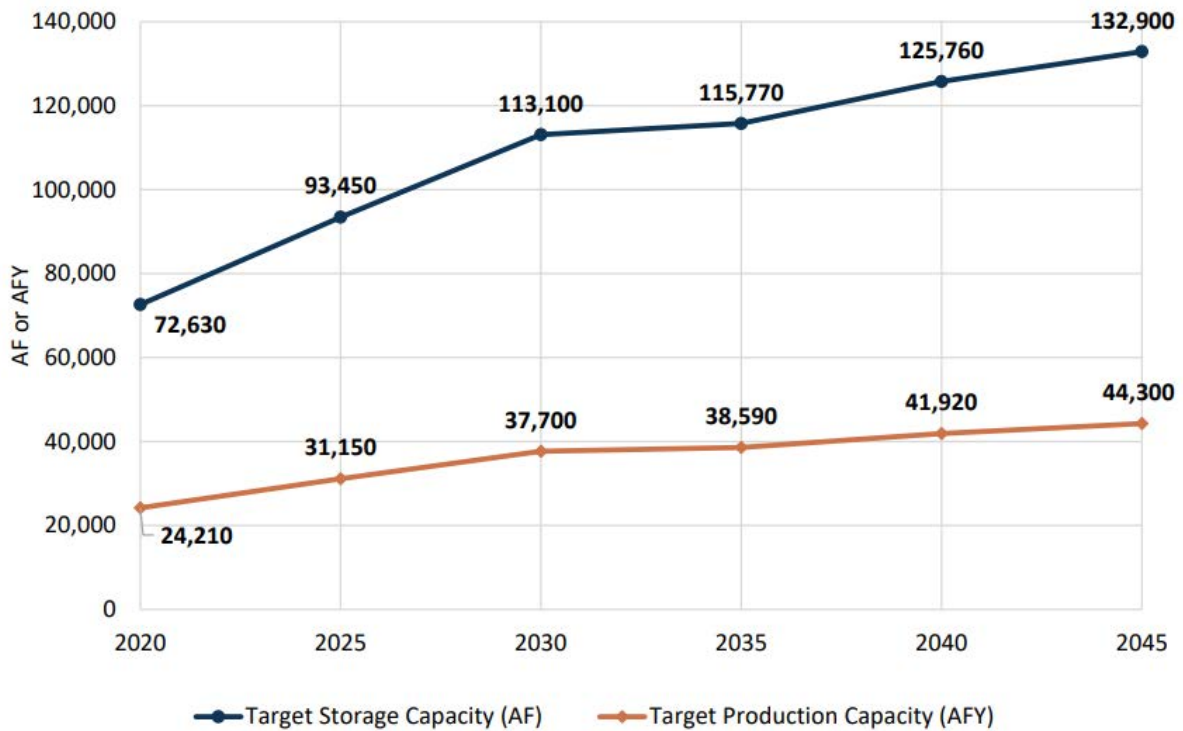
Figure 1-14 and Figure 1-15, below, portray the amounts of water contributed to AVEK banks each year, and AVEK’s target amounts for storage and recovery capacities from its banking program. There are additional active ASR projects in SoCalGas’s service territory. This information is provided as an illustrative example to demonstrate the scale of water quantities that are actively being managed through ASR within SoCalGas’s service territory. As mentioned above, AVEK’s projects are presented as an example of ASR occurring in the region; ASR is actively used throughout SoCalGas’s service territory, beyond AVEK’s management area.

Figure 1-14 AVEK Imported Water Deliveries to Groundwater Banking Sites, 2011-2020



Source: AVEK 2021

Figure 1-15 AVEK Groundwater Banking Target Storage and Production Capacities



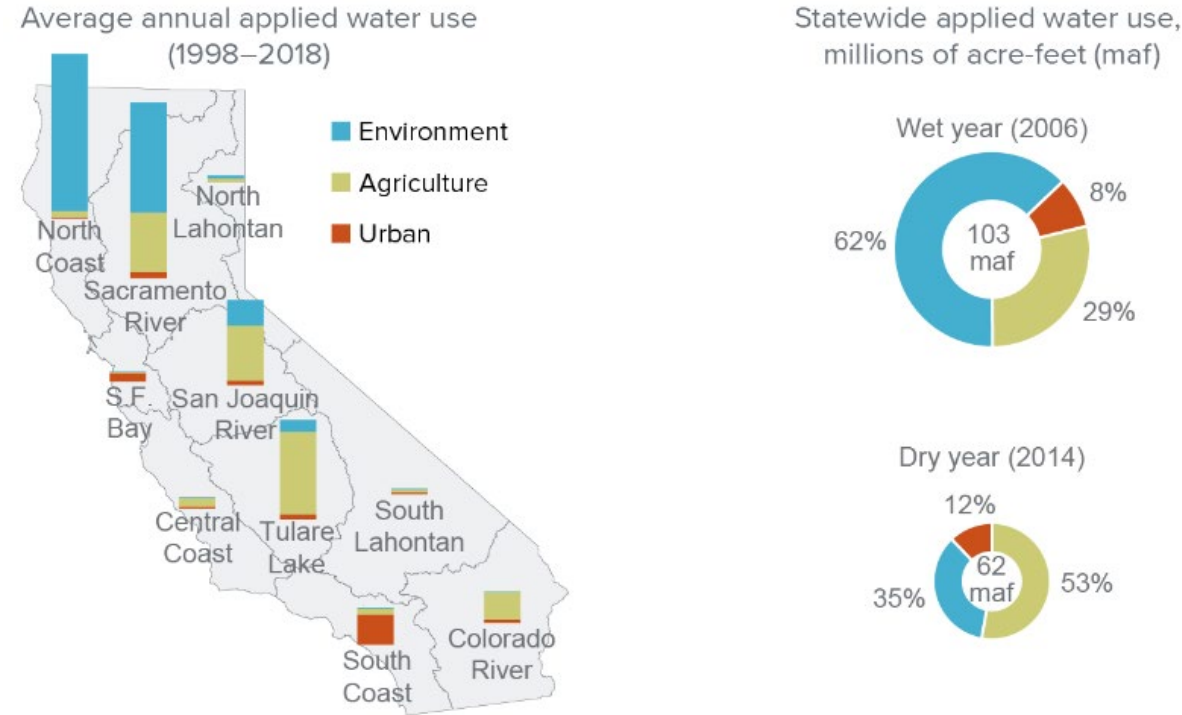
Source: AVEK 2021

Figure 1-14 demonstrates that the amount of imported surface water contributed to AVEK banks can vary substantially from year to year, reflecting variabilities in deliveries of imported surface water supplies. Figure 1-15 demonstrates how AVEK is developing its banks to provide sufficient storage and recovery capacity to compensate for SWP deliveries that are reduced to 10 percent of contracted allocations for three consecutive years. Figure 1-15 further demonstrates how reliability could be built even when contributions to the program are variable.

2.6 Existing Demands and Obligations

This section provides an overview of existing water needs and water supply obligations within SoCalGas’s service territory. As discussed in Section 2.4, *Urban Water Management Planning*, existing water needs and obligations are accounted for in local agencies’ UWMPs, as part of water supply reliability planning to meet all demands within the respective service area. Water use varies substantially across regions and between wet and dry years. Shifting water needs and obligations may change over time as uses for water in the state evolve. Figure 1-16, below, portrays the average applied water use rates for 1998 through 2018 for uses including urban and municipal, agricultural, and environmental.

Figure 1-16 Average Annual Applied Water Use, 1998-2018



Source: PPIC 2023a

The figure above shows that between 1998 and 2018, the total amount of applied water use for urban, agricultural, and environmental uses averaged 103 MAFY during wet year conditions (representative year 2006) and 62 MAFY during dry year conditions (representative year 2014). Commercial, industrial, and residential uses are included in the urban category. Table 1-12, below, provides a breakdown of applied water use rates by use type.

Table 1-12 Average Annual Applied Water Use, 1998-2018

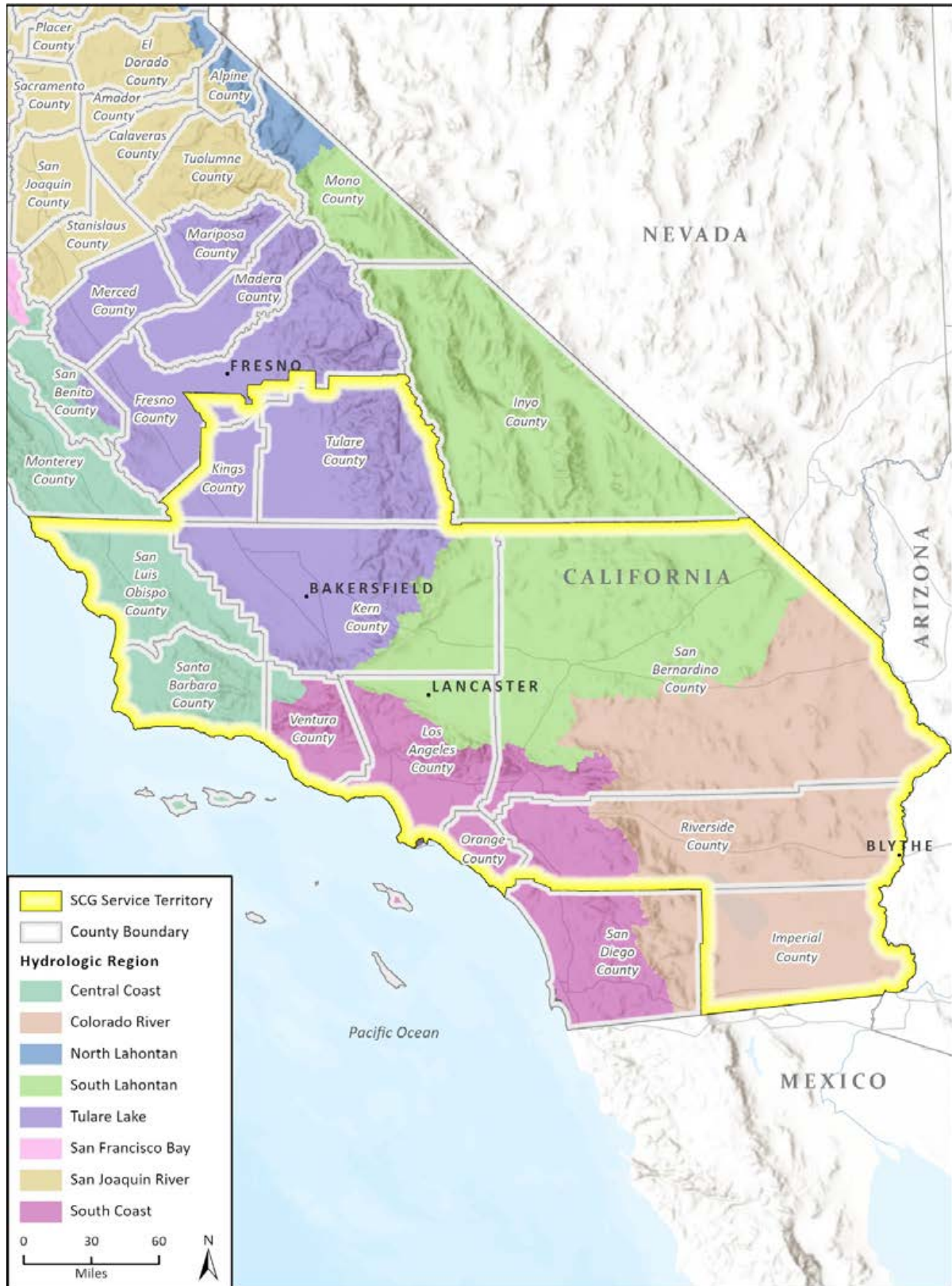
Use Type	Dry Year (AFY)	Wet Year (AFY)
Urban	7,000,000	8,000,000
Agriculture	33,000,000	30,000,000
Environment	22,000,000	65,000,000
Total	62,000,000	103,000,000

Source: PPIC 2023a

The use types characterized in the figure and table above are discussed in the following sections to anticipate how applied use rates may occur in the future, including: Section 2.6.1, *Urban and Municipal Demands*, Section 2.6.2, *Agricultural Demands*, and Section 2.6.3, *Environmental Obligations*.

Figure 1-17, below, portrays the county and hydrologic regions within SoCalGas’s service territory, which are discussed in the following sections addressing existing demands and obligations.

Figure 1-17 Counties and Hydrologic Regions in SoCalGas's Service Area



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2.6.1 Urban and Municipal Demands

Urban and municipal water needs are estimated based upon population growth rates. Table 1-13, below, provides population projections for counties within SoCalGas's service territory.

Table 1-13 Population Projections for Counties within SoCalGas's Service Area

County	2020	2030	2040	2050	2060	Percent Change 2020-2060
Fresno ¹	1,008,966	1,096,638	1,170,525	1,226,158	1,272,559	20.7
Imperial	179,489	206,486	222,307	235,339	246,235	27.1
Kern	909,997	1,019,221	1,127,781	1,217,086	1,295,502	29.8
Kings	152,627	165,752	176,940	185,868	192,955	20.9
Los Angeles	9,989,165	10,322,678	10,286,350	10,061,774	9,697,634	-3.0
Orange	3,184,101	3,291,863	3,315,726	3,268,048	3,166,309	-0.6
Riverside	2,422,764	2,728,068	2,933,038	3,059,095	3,129,833	22.6
San Bernardino	2,182,740	2,368,002	2,536,592	2,681,796	2,818,707	22.6
San Luis Obispo	282,231	284,729	284,346	274,677	263,650	-7.0
Santa Barbara	448,096	469,717	479,622	479,532	473,067	5.3
Tulare	473,736	516,810	551,563	575,525	591,539	19.9
Ventura	842,921	872,856	885,628	873,594	849,091	0.7
Total	22,076,833	23,342,820	23,970,418	24,138,492	23,997,081	8.0

¹ This table reflects county-wide data; however, only a small portion of Fresno County is within SoCalGas's service territory.

Sources: DOF 2023; USCB 2023

The table above shows that in July 2020, the total population of counties in SoCalGas's service territory was approximately 22 million people (USCB 2023). This table also indicates:

- Fresno, Imperial, Kern, Kings, Riverside, San Bernardino, and Tulare County populations increase by approximately 20 to 30 percent by 2060;
- Santa Barbara and Ventura county populations increase by less than six percent by 2060; and
- Los Angeles, Orange, and San Luis Obispo county populations reduce by three to seven percent through 2060.

The total population of counties within SoCalGas's service territory is anticipated to increase by approximately eight percent by 2060. With an existing population of approximately 22 million, an eight percent increase would add approximately 1.76 million individuals to the service territory, such that total population in 2060 would be approximately 23.76 million individuals.⁹

Per capita water use in California has been steadily decreasing since before the drought of 2012-2016 (PPIC 2023a). Total urban water use has plateaued, even as California's population grew by 5.5 million between 2000 and 2020 (PPIC 2023a). This trend indicates that although urban populations have been growing, per-capita demands have been reducing, such that the same amount of water can serve the needs of more individuals. The DWR and SWRCB have recommended that urban water

⁹ These totals include Fresno County; however, only a small portion of southern Fresno County is within SoCalGas's service territory. Therefore, these estimates are highly conservative.

suppliers achieve an indoor water use efficiency standard of 47 gallons per day by 2025 and 42 gallons by 2030 and beyond, noting that the current statewide median indoor residential water use is 48 gallons per capita per day, and that a quarter of California households already use less than 42 gallons per capita per day (SWRCB 2021).

The SWRCB has also been adopting increased efficiency standards for indoor and outdoor use, and has proposed regulations to mandate conservation measures at over 400 cities and water agencies and could save about 413,000 AFY by 2030 (SWRCB 2023c).

2.6.2 Agricultural Demands

Agricultural water use in California accounts for approximately 40 percent of all water use in the state, while urban uses account for 10 percent and environmental obligations account for approximately 50 percent; on average, farms use approximately 80 percent of all water used by homes and businesses (PPIC 2023a, 2023d). The San Joaquin Valley produces more than half of the state's total agricultural output; in 2018, about 4.5 million acres of cropland were irrigated in the San Joaquin Valley, using a total of approximately 16.1 million acre-feet per year (MAFY) of water (PPIC 2023b). Throughout the state in an average year, approximately 9.6 million acres are irrigated with roughly 34 MAFY of water (DWR 2023j).

There is ongoing pressure on the agricultural industry to reduce water use rates, such as through conservation, use of improved technologies, shifting patterns in the location and type of irrigated crops, and fallowing actively irrigated lands to relieve water needs, particularly in areas dependent on overdrafted groundwater basins. The Public Policy Institute of California (PPIC) estimates that by 2040, approximately 3.2 MAFY or 20 percent of existing water supplies in the San Joaquin Valley will be unavailable due to the combined impacts of SGMA and bringing groundwater basins into balanced conditions, as well as the effects of climate change and environmental regulations (PPIC 2023b). However, PPIC research also suggests that changes in land use and agricultural operations could create increased opportunities for water markets and trading (PPIC 2023c); see Section 3.4, *Agricultural Industry Water*, and Section 4.3, *Water Markets*. The PPIC concluded that with the right incentives, and with cooperative planning and implementation, land use transitions could occur in ways that would allow agriculture to thrive while minimizing the downsides of fallowing, and potentially creating water availability through markets and trading (PPIC 2023c).

Reporting conducted under the Water Conservation Act of 2009 (SB X7-7) helps to identify and monitor trends in agricultural water uses and efficiency practices. SB X7-7 requires agricultural water suppliers serving more than 25,000 irrigated acres to adopt and submit to DWR an Agricultural Water Management Plan (AWMP), which must include reports on the implementation status of specific Efficient Water Management Practices (EWMPs) (DWR 2023j). Agricultural water suppliers that provide water for the irrigation of 10,000 to 25,000 acres are not required to prepare or submit AWMPs, unless state funds are made available to do so (DWR 2023j). The use of recycled water for irrigation is exempted from SB X7-7 requirements for AWMPs, as the use of recycled water supports the same purpose of AWMPs, to reduce water needs and improve efficient uses.

Table 1-14 on the following page presents the total acreage of harvested crops within the counties in SoCalGas's service territory. The purpose of this table is to convey trends in agricultural production which correlate with water needs for agriculture and to use these trends to inform consideration of water availability in agricultural areas. This table shows that with the exception of the COVID-19 pandemic years of 2020-2021, annual crop production in SoCalGas's service territory has been relatively stable over the past decade. If annual production of harvested crops continues to remain steady, agricultural demands are also likely to remain similar to existing conditions.

Table 1-14 Harvested Acreage of Crops Within SoCalGas's Service Territory, 2011-2021

County	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020 ²	2021 ²
Fresno ¹	1,981,209	1,960,450	1,750,000	1,73,0959	1,740,689	1,805,920	1,827,828	1,853,795	1,950,505	1,104,301	1,721,307
Imperial	579,717	604,117	550,011	482281	514,718	515,343	512,164	513,468	572,349	540,751	1,008,081
Kern	2,288,600	2,273,999	2,250,996	2261285	2,166,523	2,252,354	2,252,715	2,234,001	2,236,204	675,229	4,151,893
Kings	825,131	832,883	820,142	721896	750,274	746,677	791,216	815,343	832,247	789,794	1,458,571
Los Angeles	17,384	15,524	13,907	16,088	27,111	27,111	0	172	0	0	0
Orange	1,007	1,035	908	787	676	543	386	1,252	879	554	862
Riverside	197,841	212,737	210,452	202,516	198,536	194,027	188,597	189,819	198,258	206,977	417,152
San Bernardino	1,407,348	1,404,316	1,385,202	1,384,955	1,385,313	1,385,763	1,428,069	1,384,055	1,368,626	1,368,577	1,370,845
San Luis Obispo	1,141,588	1,135,433	1,118,327	1,115,318	1,122,220	1,131,373	1,121,563	1,126,355	1,125,001	1,133,915	210,848
Santa Barbara	708,982	707,036	710,006	711,585	708,207	705,397	692,730	663,676	661,801	658,770	1,313,091
Tulare	1,667,812	1,677,908	1,693,245	1,456,951	1,780,288	1,802,587	1,742,002	1,664,712	1,624,808	1,657,491	3,396,675
Ventura	186,173	190,792	197,108	195,930	297,085	293,146	293559	313,461	294,127	293,500	548,536
Total	11,002,792	11,016,230	10,700,304	10,280,551	10,691,640	10,860,241	10,850,829	10,760,109	10,864,805	8,429,859	15,597,861

¹ This table reflects county-wide data; however, only a small portion of Fresno County is within SoCalGas's service territory.

² Variations in the 2020 and 2021 crop productions were a result of the COVID-19 pandemic.

Source: USDA 2012, 2013, 2015a, 2015b, 2016, 2018a, 2018b, 2020, 2021, 2022, 2023

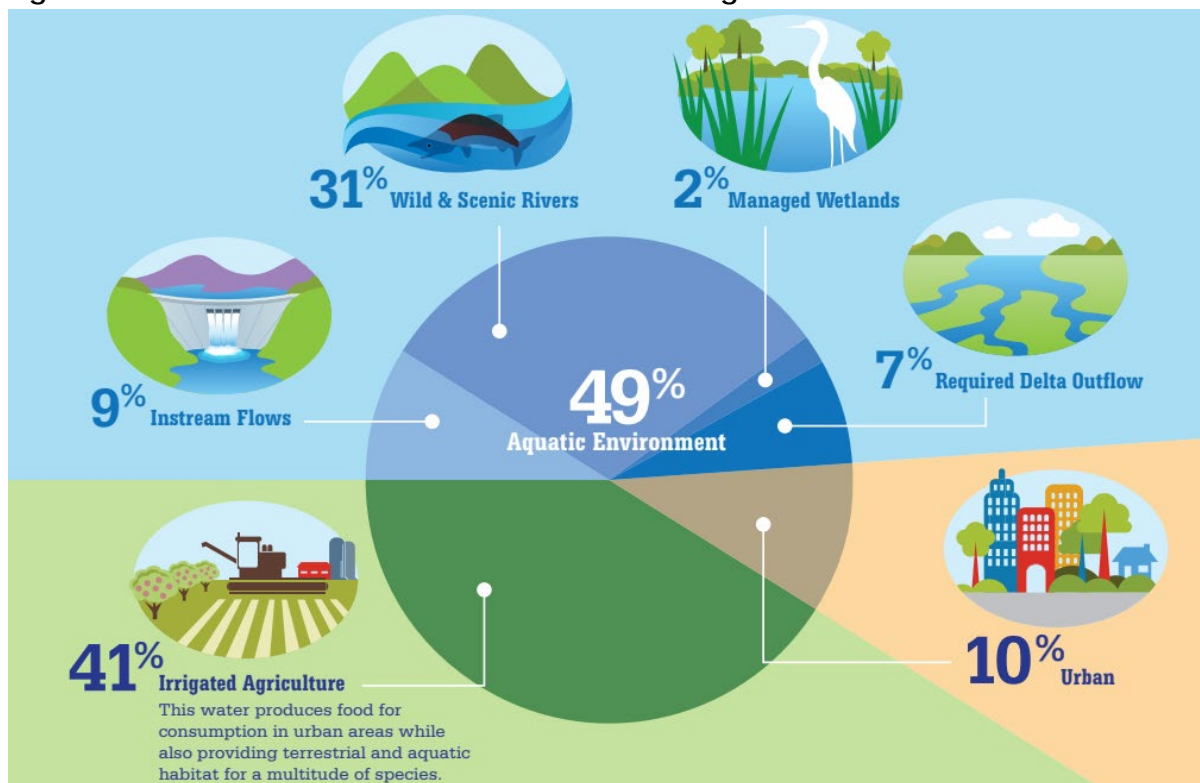
2.6.3 Environmental Obligations

Environmental obligations are water needs associated with the health and balance of rivers and wetlands, and the habitats and species supported by these resources. As shown in Table 1-12, *Average Annual Applied Water Use, 1998-2018*, in the introduction to this section, average annual applied water use for environmental obligations between 1998 and 2018 ranged between 22 MAFY for dry year conditions and 65 MAFY for wet year conditions. Environmental water obligations fall under four categories:

- **Wild and Scenic Rivers**— waters protected under federal and state laws;
- **Instream flows**— required for maintaining habitat within streams;
- **Required Delta Outflow**— water quality improvements for agricultural and urban uses; and
- **Managed wetlands**— wetlands within wildlife preserves (PPIC 2019).

Figure 1-18, below, provides an overview of applied water use for each of the environmental obligation categories listed above, as well as the portion of state-wide water supply applied to irrigated agriculture and urban uses.

Figure 1-18 Distribution of Environmental Water Obligations



Source: NCWA 2015

Within the CVP and SWP systems, introduced in Section 2.3, *Key Water Supply Projects*, environmental obligations are given the first priority for water deliveries from each system; only after these priorities are met is water supplied to the SWP and CVP (DWR 2022a). Although environmental obligations are treated as priority demands under the CVP and SWP, at the height of the 2012-2016 drought, the state reduced water allocations for environmental uses in order to

reserve critical supplies for farms and cities. This indicates that during extended drought periods, all water use sectors are affected, and urban and agricultural demands can be prioritized above environmental obligations when critical.

For purposes of this study, water used for environmental obligations is presumed to be not available as a potential water supply source for clean renewable hydrogen production.

2.7 Climatic Variability

Climatic variation refers to changes in climate that affect temperature and precipitation as well as water supply and demand. The following sections discuss climate variability with consideration to water supply and demands.

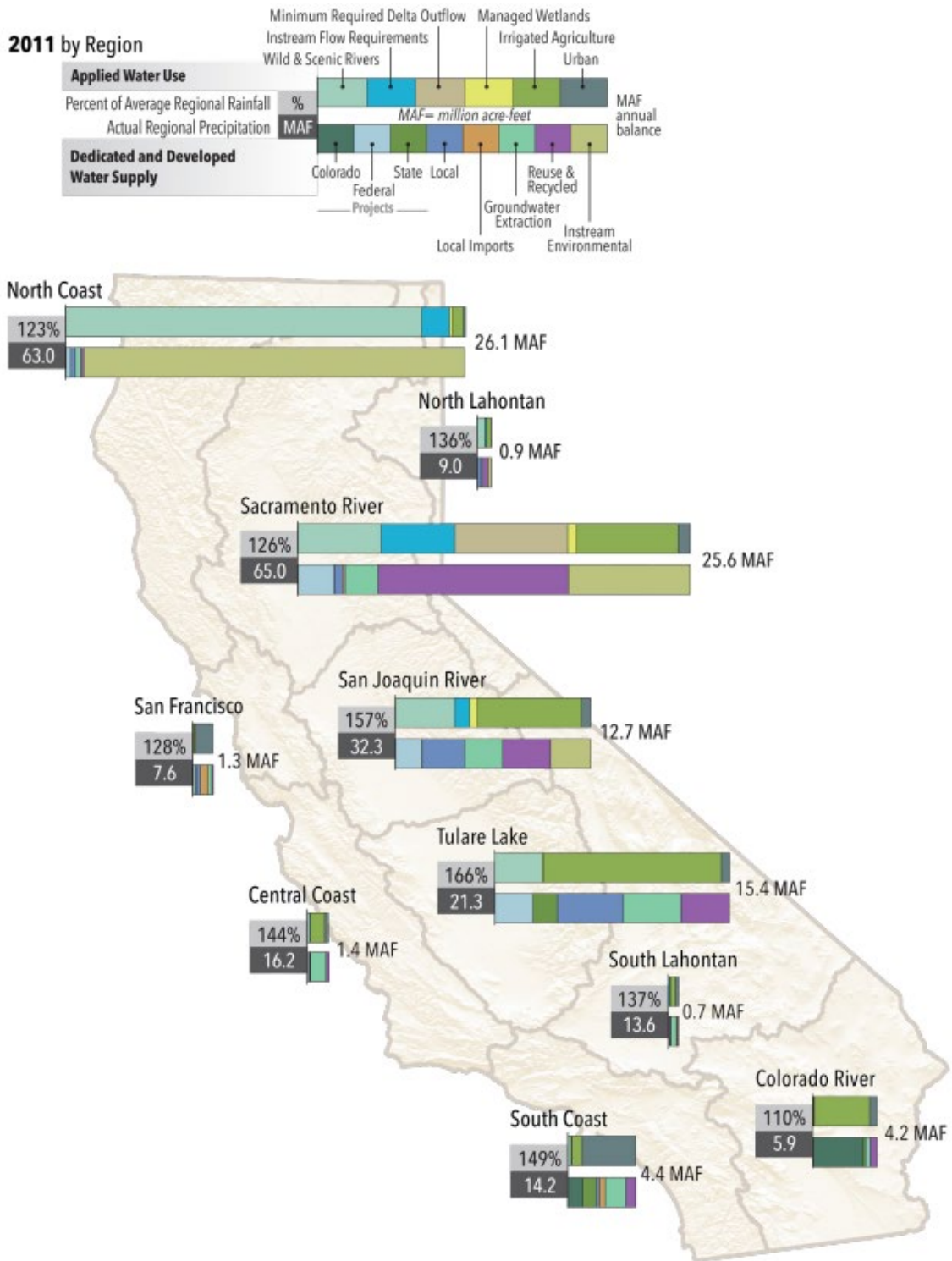
2.7.1 Supply and Demand in Wet and Critically Dry Years

This section discusses trends in water supply availability and demands under “wet year” conditions and “dry year” conditions, where the former represents a water year with above-average rainfall and the latter represents a water year with below-average rainfall. The purpose of this section is to convey how climatic variations can affect water supplies and uses, and to inform consideration of water supply availability for clean renewable hydrogen production.

Figure 1-19, below, reflects wet year conditions, using 2011 as the representative year, and Figure 1-20 reflects critically dry year conditions, using 2014 as the representative year. While these figures portray state-wide trends, SoCalGas’s service territory includes five DWR-defined hydrologic regions in the central and southern portions of the state, including the Tulare Lake, Central Coast, South Lahontan, South Coast, and Colorado River Hydrologic Regions.

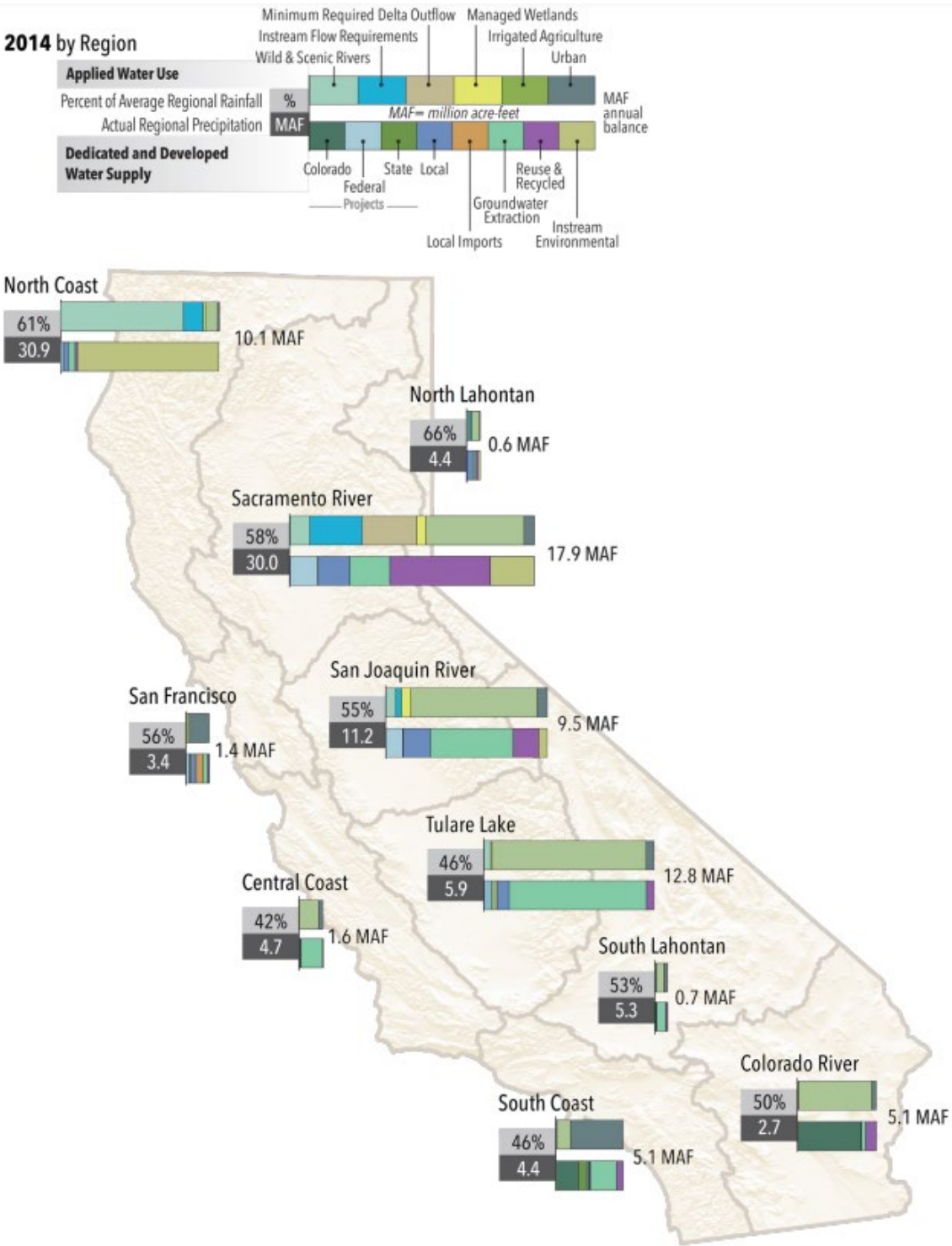
These figures indicate that during dry years, the distribution of water use is adjusted in each hydrologic region to meet priority needs first. During wet years, agricultural and environmental uses are supported through multiple water supply sources, whereas dry year uses are limited to agriculture and rely entirely on groundwater resources.

Figure 1-19 Wet Year (2011) Water Uses and Supplies



Source: DWR 2019

Figure 1-20 Critical Dry Year (2014) Water Uses and Supplies



Source: DWR 2019

2.7.2 Drought Response & Climate Change

Climate change affects California’s water supply availability through multiple means, particularly reduced snowpack in the Sierra Nevada Mountains, which results in reduced flows in the SWP and CVP and deliveries of water that are smaller than contracted amount for most years. Rising temperatures are predicted to reduce snowpack by more than one third in 2050 and by more than half in 2100, even if precipitation levels remain stable (State of California 2023). Rising temperatures also affect California’s precipitation cycles, with multi-year wet and dry periods making it difficult to predict future average precipitation rates. However, climate change predictions agree that even if precipitation remains stable or increases, drought severity and number of dry years will continue to increase, and more extreme precipitation events will occur.

Figure 1-21, below, includes two photos of Lake Oroville that were taken three months apart, one in December 2022 which shows dramatically low water levels in the lake, and one in March 2023 which shows the reservoir at near-full capacity. As discussed in Section 2.3.1, *State Water Project*, the SWP (California Aqueduct) initiates at Lake Oroville, conveying the captured Sierra Nevada snowmelt through the Delta to SWP Contractors and connections in Southern California.

Figure 1-21 Lake Oroville Storage, December 2022 and March 2023



Source: Metropolitan 2023c

The dramatic difference between these conditions, just three months apart, demonstrates that local water supply reliability is a critical aspect of water supply management in the face of climate change, as there are water needs in Southern California regardless of whether there is SWP water in Lake Oroville. In addition to variable and hard-to-predict precipitation, climate change is also projected to result in sea level rise, potentially causing more frequent periods of water quality degradation in the Delta, which could require increased Delta outflow to maintain water quality objectives (DWR 2022a). As discussed in Section 2.3.1, *State Water Project*, the Delta is formed by the Sacramento River flowing south to meet the north-flowing San Joaquin River; the Delta supports important environmental habitat and endangered species, as well as key water supply projects. The effects of climate change on the Delta will increase the importance of Delta management to protect supply quantity and quality for both human and environmental needs.

While effects on the Delta influence availability of both CVP water and SWP water, the effects of climate change also exacerbate long-standing issues with water supply entitlements to Colorado River water; see Section 2.3.2, *Colorado River*. Southern California relies on the Colorado River for about 25 percent of its water supply; however, the system is in the midst of a 23-year drought, the most serious in 1,200 years, and the system’s reservoirs were threatening to drop to catastrophic levels (Metropolitan 2023b). Please see Section 2.3.2, *Colorado River*, for discussion of the decisions

and management direction for the Colorado River that have developed through 2023, which build off the 2007 Interim Guidelines (valid through December 2025) and update management guidance and requirements to account for the effects of climate change and drought, as well as population increases.

The pressures introduced by climate change on all three of the major water supply projects in California, including the SWP (see Section 2.3.1, *State Water Project*), the Colorado River (see Section 2.3.2, *Colorado River*), and the CVP (see Section 2.3.3, *Central Valley Project*), indicate that local water supply resiliency and reduced dependence on imported water supplies are critical aspects to climate change response and water supply reliability throughout the state. As discussed throughout this report, any supply sources that are currently or planned for use to recharge local groundwater basins and improve local water supply reliability are considered unavailable as a supply source for clean renewable hydrogen development for purposes of this study. The development of any local supply source that would help to reduce an area's dependence on imported water supply is also considered a priority, and such sources are not considered available to clean renewable hydrogen production for purposes of this study.

Part 3: Potential Water Supply Sources

For the purposes of this analysis, “water source” refers to both the origin of water (surface water or groundwater) and the place where water is obtained for use (ex., water recycling facility, desalter facility, reservoir, low-elevation collection area, discharge pipe, etc.), and “water supply” refers to water that is procured or developed to meet the water needs of a particular use, in this case the development of clean renewable hydrogen.

Water supply for clean renewable hydrogen development is anticipated to come from multiple sources. Naturally occurring sources consist of groundwater and surface water, including rainfall and snowpack, which are used in accordance with state regulations and designated water rights. Other sources are anthropogenically developed and consist of water and wastewater that has been treated for reuse. Developed supply sources are made available for use or made available in a certain area through treatment, conveyance, storage, and/or agreements with water supply providers or public agencies responsible for delivering water supply for beneficial uses within their respective service areas.

Given the complexity of water supply sources and management in California, and considering the existing systems available to move water supply throughout the state, there is a variety of potential water supply sources that could be acquired or developed for clean renewable hydrogen production. Third-party producers of clean renewable hydrogen may draw upon these options of water supply sources to produce quantities of clean renewable hydrogen to meet the projected demands across the SoCalGas service territory and the portion of the demand that Angeles Link would transport. The water supply sources summarized in this Part have been identified as having potential for third-party producers to pursue for acquisition or development to support respective future projects.

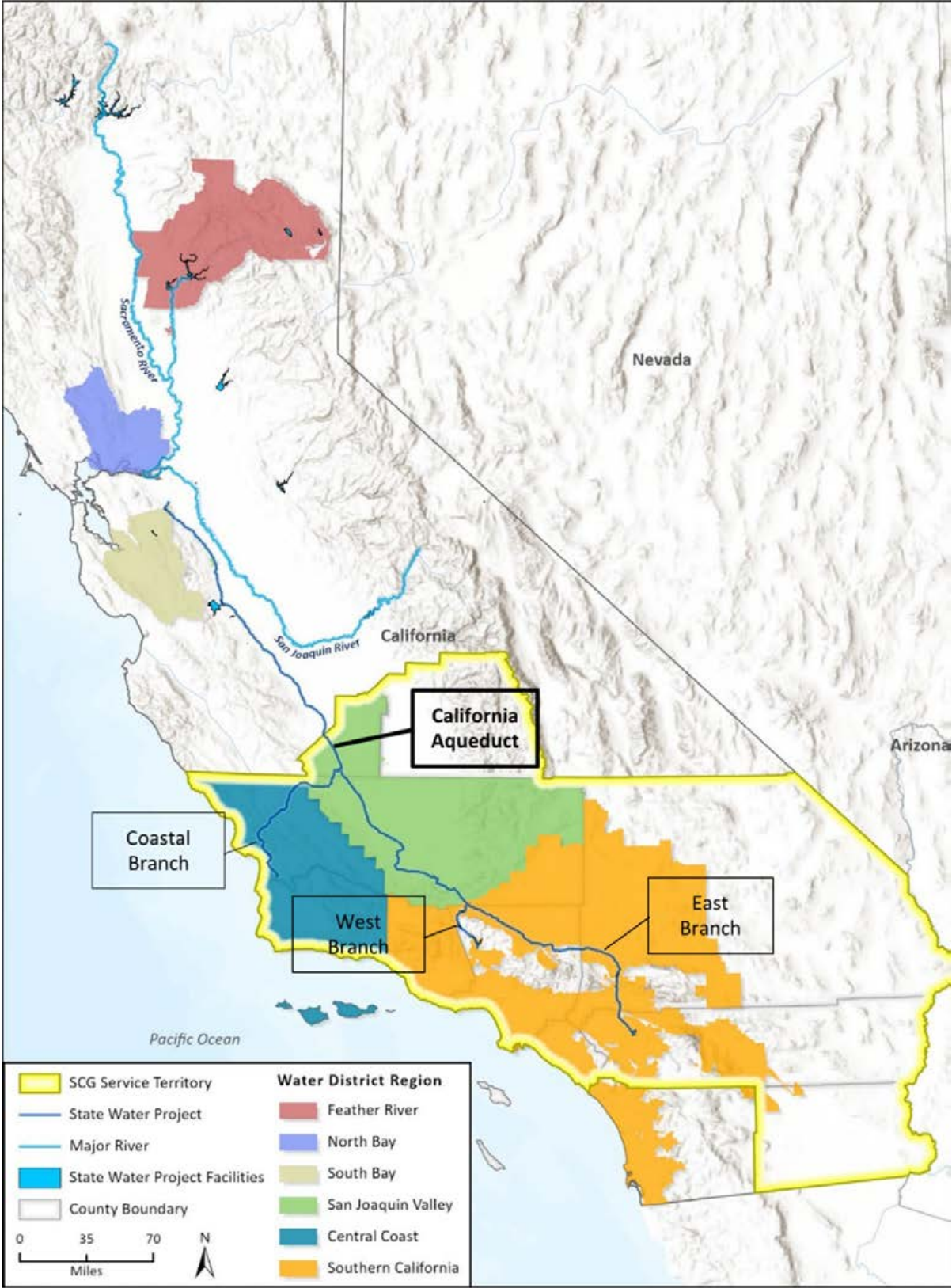
3.1 Imported Surface Water in the Study Area

Imported surface water supply sources include the State Water Project (SWP), the Colorado River (CR), and the Central Valley Project (CVP), as introduced in Section 2.3, *Key Water Supply Projects*, of Part 2, *Supply Management In California*. As described therein, each of these projects allocates water supply to contract holders of the respective project. To acquire water supply from the SWP, CR, or CVP, the water must be purchased from a contractor to the respective project from within the contractor’s existing allocations. This section provides an overview of imported surface water supplies and facilities within SoCalGas’s service territory.

3.1.1 SWP Water

The SWP is introduced in Section 2.3.1, *State Water Project*, which provides an overview of the state-wide storage and conveyance system, contractors and allocations, hydrologic conditions, fulfillment quantities and trends, and key infrastructure and facilities. Figure 1-22, below, provides an overview of the SWP system and management regions, as well as the California Aqueduct branches in Southern California. SoCalGas’s service territory in Southern California encompasses three branches of the California Aqueduct, including the Coastal Branch, West Branch, and East Branch, as discussed further below.

Figure 1-22 SWP Management Regions and SoCalGas's Service Area



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As shown in the figure above, the California Aqueduct branches off its main stem at several locations within SoCalGas’s service territory. These begin in the northern portion of the service territory, just south of Kettleman City in Kings County, where the Coastal Branch diverges to deliver SWP water to Kern, Santa Barbara, and San Luis Obispo counties. The main stem of the Aqueduct splits again on the south side of the Tehachapi Mountains in southern Kern County, where the West Branch diverges to store SWP water in Pyramid Lake and Castaic Lake in Los Angeles County, and the East Branch diverges to store SWP water in Silverwood Lake in San Bernardino County and Lake Perris in Riverside County (WEF 2023a).

Table 1-15, below, details the Table A SWP allocations held by contractors within SoCalGas’s service territory. As discussed in Section 2.3.1, *State Water Project*, under “SWP Contractors and Allocations,” “Table A” refers to the contracted amount of SWP water each contractor is promised to receive under its respective SWP contract with the DWR. Table A allocations are the maximum amount of SWP water contractors are promised. The actual amount of SWP water delivered is commonly less than Table A, due to hydrologic and climatic conditions that reduce the physical presence and availability of SWP water in the system; less often, the amount delivered may also be more than a contractor’s Table A allocations, such as in response to wet weather conditions that create surplus supply availability (see discussion in Section 2.3.1 under “Article 21 Water”).

Table 1-15 SWP Water Contracted Allocations (Table A) within SoCalGas Service Territory

SWP Contractor	Contracted Allocation (AFY)¹
San Joaquin Valley Region	
Oak Flat Water District	5,700
County of Kings	9,305
Dudley Ridge Water District	41,350
Empire West Side Irrigation District	3,000
Kern County Water Agency	982,730
Tulare Lake Basin Water Storage District	87,471
Subtotal	1,129,556
Central Coastal Region	
San Luis Obispo County Flood Control & Water Conservation District	25,000
Santa Barbara County Flood Control & Water Conservation District	45,486
Subtotal	70,486
Southern California Region	
Antelope Valley-East Kern Water Agency (AVEK)	144,844
Santa Clarita Valley Water Agency	95,200
Coachella Valley Water District	138,350
Crestline-Lake Arrowhead Water Agency	5,800
Desert Water Agency	55,750
Littlerock Creek Irrigation District	2,300
Metropolitan Water District of Southern California (Metropolitan) ²	1,911,500
Mojave Water Agency	89,800
Palmdale Water District	21,300
San Bernardino Valley Municipal Water District	102,600

SWP Contractor	Contracted Allocation (AFY)¹
San Gabriel Valley Municipal Water District	28,800
San Geronio Pass Water Agency	17,300
Ventura County Watershed Protection District	20,000
Subtotal	2,633,544
TOTAL SWP Allocations within SoCalGas's Service Area	3,833,586

¹ AFY = acre-feet per year; SWP contracted allocations refer to Table A contract amounts; see Section 2.3.1, *State Water Project*, under "SWP Contractors and Allocations" for further discussion.

² A portion of Metropolitan's service area is within a portion of San Diego County located outside of SoCalGas's service territory.

Source: DWR 2023c

The table above indicates that within SoCalGas's service territory, SWP allocations total 3,833,586 AFY. The SWP was designed to deliver 4,172,786 AFY of water, indicating, 91 percent of all SWP water is delivered within SoCalGas's service territory. The three largest SWP contractors are: AVEK (144,844 AFY), Kern County Water Agency (982,730 AFY), and Metropolitan (1,911,500 AFY).

The actual amount of SWP water available for delivery varies each year, depending on drought and rainfall conditions and impacts on endangered species. DWR changes the amount of water allocated to the water contractors multiple times per year based on the actual water availability. Between 1996 and 2023, the amount of SWP water that was physically delivered to SWP contractors represented between zero and 75 percent of the contracted allocations (DWR 2023c). Water deliveries have averaged approximately 2.8 million acre-feet per year (MAFY) over the last decade (WEF 2023a), representing approximately 35 percent of total SWP allocations.

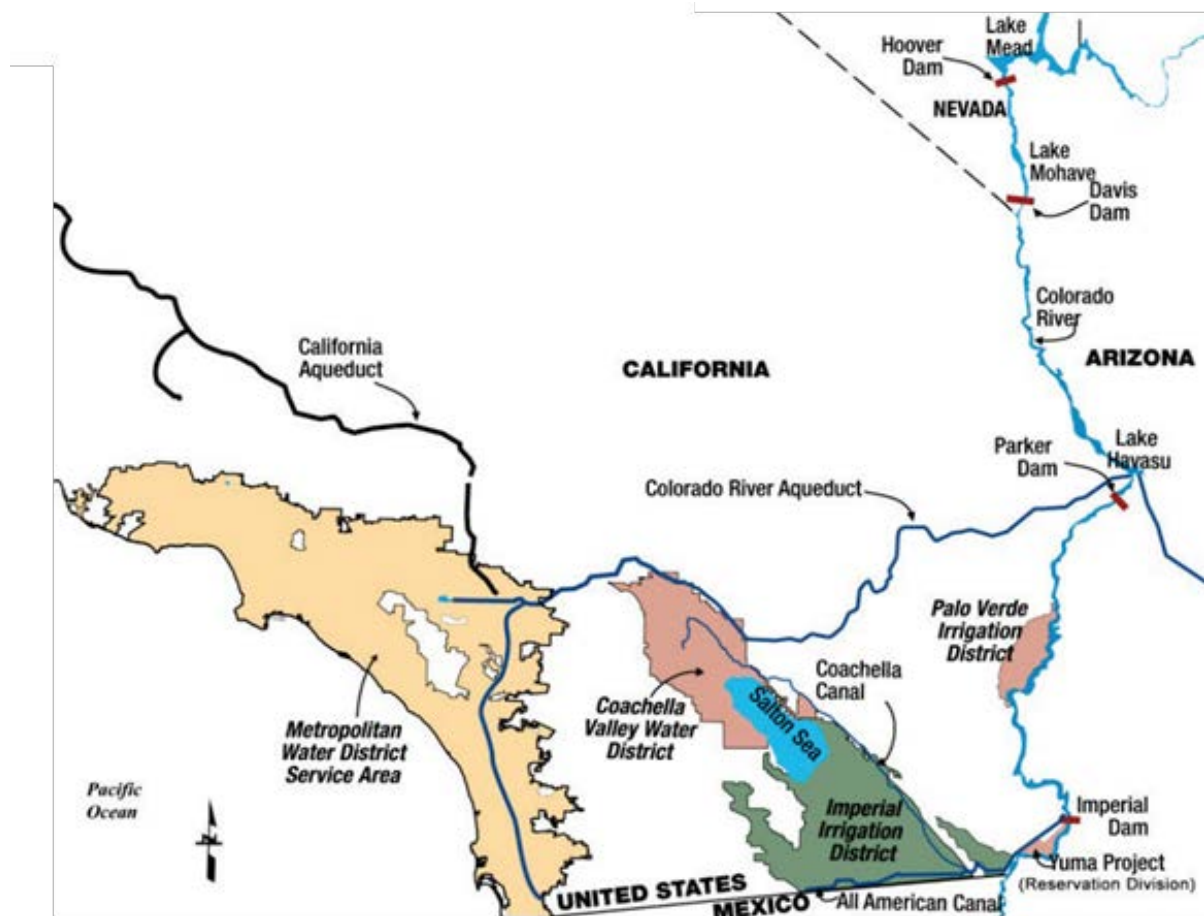
Efforts to improve the reliability of SWP deliveries to south-of-Delta contractors include DWR's development of the proposed Delta Conveyance Project, which would expand existing SWP facilities through the Sacramento-San Joaquin Delta. The Delta Conveyance Project would implement new water intake facilities on the Sacramento River in the north Delta, and a tunnel to divert and move water entering the north Delta from the Sacramento Valley watershed to existing SWP facilities in the south Delta. These improvements would result in a dual conveyance system for SWP water through the Delta, facilitating the capture and storage of more water during wet seasons to improve water availability during dry seasons, while also protecting against earthquake disruptions to the existing system. The Delta Conveyance Project would not alter Table A contract amounts; rather, it would increase the reliability of contract fulfillment for Table A contractors south of the Delta.

The DWR initiated planning for the Delta Conveyance Project in response to an April 2019 Executive Order directing the assessment of a single-tunnel project, compared to the dual-tunnel design of the previously approved All California WaterFix project, which was not implemented due to environmental and regulatory issues. The DWR has completed its California Environmental Quality Act (CEQA) review processes for the Delta Conveyance Project, and certified its Environmental Impact Report (EIR) for the project in December 2022. As of the time of this study, tribal engagement and regulatory compliance efforts are ongoing for the Delta Conveyance Project, as the DWR pursues numerous state and federal permits or authorizations required by the State Water Resources Control Board (SWRCB), the Delta Stewardship Council, and the state and federal Endangered Species Acts (ESAs). A new cost estimate and a benefit-cost analysis for the Delta Conveyance Project are expected to be provided by the Delta Construction Authority in mid-2024 (DWR 2023n).

3.1.2 Colorado River Water

Colorado River water enters California in the southeastern portion of the state, where the Colorado River Aqueduct initiates at Lake Havasu, formed by Parker Dam at the California border with Arizona. Figure 1-23, below, provides an overview of the Colorado River Aqueduct alignment through Southern California and the agencies which hold entitlements to Colorado River water.

Figure 1-23 California Entities Using Colorado River Water



Source: Metropolitan 2021

Table 1-16, below, lists the Southern California entitlements to Colorado River water, presented in order of priority ranking.

Table 1-16 Colorado River Water Entitlements in California

Contractor or Decree Name	Diversion (AFY)
Federal	
Chemehuevi Indian Reservation	11,340
Fort Yuma Indian Reservation	71,616
Colorado River Indian Reservation (Nov 22, 1873)	10,745
Colorado River Indian Reservation (Nov 16, 1874)	40,241
Colorado River Indian Reservation (May 15, 1876)	5,860
Fort Mojave Indian Reservation	16,720
Present Perfected Rates (PPRs)^a	
PPRs consist of 59 agencies and private entities listed in Article II(B)(3) of the 1964 Supreme Court Decree (<i>Arizona v. California</i>) that settled disputes raised in 1952 over claims to Colorado River water in the Lower Basin (USBR 2023). Under this decree, during any year when less than 7.5 MAF are available to fulfill the Lower Basin states' (California, Nevada, Arizona) total allocations, the Secretary of the Interior must provide supply to the PPRs in order of priority, regardless of state lines. The remaining amount of Lower Basin states' allocation is distributed to the Lower Basin states only after PPR water supplies are met. Finally, surplus water contracts are fulfilled only after the Lower Basin states' allocations are delivered.	3,824
Seven-Party Agreement^b	
1. Palo Verde Irrigation District (104,500 acres) ^c	
2. Yuma Project (25,000 acres) ^c	
3(a). IID and lands in Imperial and Coachella Valleys to be served by the All American Canal (AAC)	3,850,000
3(b). Palo Verde Irrigation District (16,000 acres of mesa lands) ^c	
4. Metropolitan and/or City of Los Angeles and/or others on coastal plain	550,000
5(a). Metropolitan and/or City of Los Angeles and/or others on coastal plain	550,000
5(b). City and/or County of San Diego	112,000
6(a). IID and lands in Imperial and Coachella Valleys to be served by the AAC	300,000
6(b). Palo Verde Irrigation District (16,000 acres of mesa lands) ^c	
7. All remaining water available for use in California for agricultural uses	-
TOTAL acre-feet of the 1931 Seven Party Agreement (USBR 2021b)^d	5,362,000
Surplus Water Contracts	
Bureau of Land Management (BLM)	1,000
BLM (in lieu of water pumped from Lower Colorado Water Supply Project [LCWSP] facilities or in the event the LCWSP is non-functional)	1,150
Coachella Valley Water District	100,000
Department of the Navy	25
Needles, City of	10,000

Contractor or Decree Name	Diversion (AFY)
Metropolitan Water District of Southern California	180,000
<p>Notes:</p> <ol style="list-style-type: none"> PPRs include the following 59 agencies and entities, listed in order of priority ranking: Yuma Associates Ltd. And Winterhaven Water District; Wavers; Stephenson (PPR No. 30); Campbell, Terry E. and Carol J.; Maureen E. and Robert M. Buncati; Bruncati Family Trust 12/19/02; Sunrise Management LLC; Gary J. George; Robert L. & Christine M.; Lake enterprises of California, LLC; Gowan, Sonny (Grannis); Morgan; Milpitas (PPR No. 34); Simons; Colorado River Sportsmen’s League; Milpitas (PPR No. 37); Andrade (PPR No. 38); Reynolds; Cooper; Chagnon; Lawrence; Needles, City of (PPR No. 43); Needles, City of (PPR No. 44); Conger; G. Draper; McDonough; Faubion; Dudley; Douglas; Beauchamp; Clark; Lawrence; J. Graham; Geiger; Schneider; Martinez; Earle; Diehl; Reid; Graham; Cate; McGee; Stallard (PPR No. 64); Randolph; Stallard (PPR No. 66); Keefe; C. Ferguson; W. Ferguson; Vaulin; Salisbury; Hadlock; Streeter; J. Draper; Fitz; Williams; Estrada; Whittle; Corrington; Tolliver. The Seven-Party Agreement of 1931 (Metropolitan et al. 1931) details these original allocations of Colorado River water. California later reduced its use of Colorado River water to 4.4 MAFY under the 2003 Quantification Settlement Agreement (USDOI 2003), which set aside decades-old disputes and facilitated water transfers from farms to cities, funded linking the All-American and Coachella Canals, and led to new agricultural conservation in California and partnership with Metropolitan (Metropolitan 2023d). Uniquely, the PVID’s Colorado River rights are not quantified by volume; rather, their water rights allow for irrigation and potable water to serve 104,500 acres in the Palo Verde Valley (overlying the Palo Verde Valley Groundwater Basin; see Section 3.3, <i>Groundwater</i>) and 16,000 acres on the Palo Verde Mesa (overlying the Palo Verde Mesa Groundwater Basin; see Section 3.3, <i>Groundwater</i>) each year. In addition, the U.S. Bureau of Land Management (BLM)’s Yuma Project receives Colorado River water from the All American Canal to irrigate the California portion of the project, which consists of 25,000 acres in Imperial County; the remainder of the Yuma Project’s total 68,000 acres is located in Yuma County, Arizona. During the term that the Colorado River Water Delivery Agreement (Federal Quantification Settlement Agreement) dated October 10, 2003, remains in effect, the delivery of Colorado River water will be in accordance with the terms as set forth in that agreement, including Exhibit B which identifies specific entitlements during the time the agreement is in effect (USDOI 2003). <p>Source: USBR 2021b; USDOI 2003</p>	

As shown in the table above, Colorado River water users in California include Metropolitan, Coachella Valley Water District (CVWD), Imperial Irrigation District (IID), and Palo Verde Irrigation District (PVID); these agencies receive and distribute Colorado River water to customers within their respective service territories, including within SoCalGas’s service territory. Metropolitan holds a fourth-priority right to 550,000 AFY of California’s apportionment of 4.4 MAFY, which is 59 percent of the Lower Basin states’ total apportionment of 7.5 MAFY. Metropolitan also holds Surplus Water Contracts amounting to 180,000 AFY.

3.1.3 CVP Water

The majority of the CVP occurs outside of SoCalGas’s service territory; however, the southern-most portion of the CVP consists of the Friant Division, which extends CVP water conveyance into SoCalGas’s service territory via the Friant-Kern Canal. The Friant-Kern Canal supplies San Joaquin River water stored at Millerton Lake to more than 30 irrigation districts and cities, as well as 15,000 family farms (FWA 2023). The Friant Water Authority (FWA) represents the majority of Friant Division water users and maintains and operates the Friant-Kern Canal. There are 32 CVP contractors within the Friant Division, of which 19 are located within SoCalGas’s service territory.

Table 1-17, below, identifies the Friant Division contractors within SoCalGas’s service territory, and the contracted allocation of CVP water held by each, followed by Figure 1-24, which provides an overview of the CVP system and facilities, including within SoCalGas’s service territory.

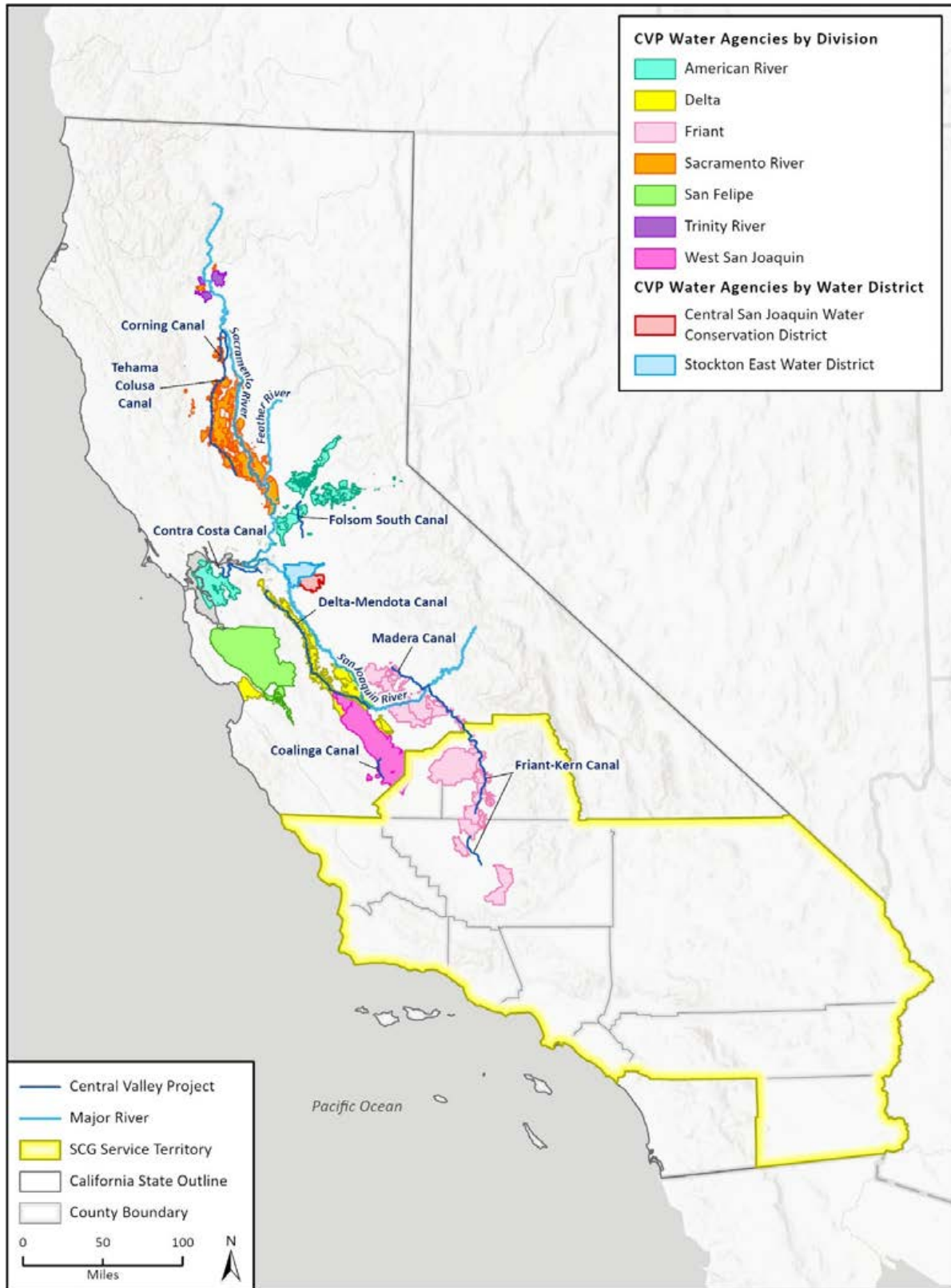
Table 1-17 CVP Contracted Allocations to Friant Division Contractors

Region	Contracted Allocation (AFY)
Arvin-Edison Water Storage District	351,675
Delano-Earlimart Irrigation District	183,300
Exeter Irrigation District	30,100
Ivanhoe Irrigation District	7,000
Kaweah Delta Water Conservation District	8,600
Kern-Tulare Water District	5,000
Lewis Creek Water District	1,200
Lindmore Irrigation District	55,000
Lindsay, City of	2,500
Lindsay-Strathmore Irrigation District	27,500
Lower Tule River Irrigation District	299,200
Porterville Irrigation District	45,000
Saucelito Irrigation District	54,300
Shafter-Wasco Irrigation District	89,600
Southern San Joaquin Municipal Utility District	142,000
Stone Corral Irrigation District	10,000
Tea Pot Dome Water District	7,200
Terra Bella Irrigation District	29,000
Tulare Irrigation District	171,000
Total Allocations with SoCalGas's Service Area	1,519,175
Source: USBR 2016	

The table above indicates that of the 19 Friant Division contractors within SoCalGas's service territory, five have CVP allocations of more than 100,000 acre-feet per year (AFY), all of which are irrigation districts which primarily provide water for agricultural irrigation. These allocations are contracted amounts but do not represent the physical amount of water received each year, which is dependent upon climatic conditions and supply availability in the source waters. The USBR changes the amount of water annually delivered to contractors based on the actual water availability, including for environmental needs.

Section 2.3.3, *Central Valley Project*, discusses the physical deliveries of CVP water and provides quantification of annual fulfillment amounts in Table 1-11. Similar to SWP deliveries discussed above, deliveries of CVP water vary depending upon climatic conditions and drought, and can range between 0 and 100 percent fulfillment of contracted allocations to CVP water. Figure 1-24, below, provides an overview of the CVP system and facilities, including within SoCalGas's service territory.

Figure 1-24 CVP Divisions and SoCalGas's Service Territory



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Source: USBR 2021a

3.2 Treated Wastewater

Recycled water is highly treated wastewater (municipal sewage) that has been filtered and disinfected at a wastewater treatment facility. For the purposes of this analysis, treated wastewater that is currently being discharged from treatment facilities without further reuse or plans for future reuse¹⁰ is considered available as a potential water supply source for clean renewable hydrogen production.,.

Wastewater Treatment Facilities

Table 1-18, below, provides an overview of estimated discharges of treated wastewater from each facility shown in the following Figure 1-25. These estimates are informed by data provided to DWR for the 2020 UWMP cycle, and therefore reflect 2020 conditions. To isolate those discharges of treated wastewater from discharges that would be reused through other projects and activities, individual UWMPs were reviewed and quantities of treated wastewater planned for reuse were subtracted from total discharges of treated wastewater from respective facilities. The purpose of this approach was to differentiate to the extent feasible between discharges for disposal versus discharges for reuse; discharges conducted for disposal are considered potentially available as a supply source for clean renewable hydrogen production, while discharges planned for reuse are not available as a potential supply source. Further investigation and evaluation of site-specific conditions will help to determine how much treated wastewater could be made available for clean renewable hydrogen from the identified facilities, and whether additional facilities should be included as potential supply sources. As discussed in Section 2.4, *Urban Water Management Planning*, UWMPs are updated by water providers every five years; the next round of UWMP updates will occur in 2025.

Table 1-18 Recycled Water Facilities Discharging Treated Effluent (2016-2020)¹

Facility ²	Agency (owner/operator, if different) ³	Discharge (MGD)	Treatment Level ⁴
Reedley WWTP	Reedley, City of	0.57	SU
Dinuba WWRP	Dinuba, City of	0.59	SU
Coalinga Domestic WWTP	Coalinga, City of	0.28	SU
City of San Luis Obispo WRRF	San Luis Obispo, City of	1.07	T
Bakersfield WWTP No. 3	Bakersfield, City of	10.86	SU
Lancaster WRP	LACWD 40, Antelope Valley (LACSD)	11.74	T
Palmdale WRP	LACWD 40, Antelope Valley (LACSD 20)	7.69	T
Adelanto WWTF	Adelanto, City of	2.68	SU
Goleta WWTP	Goleta Water District (Goleta SD)	3.62	SD-2.2
El Estero WWTP	Montecito Water District (Montecito SD)	5.19	SU
El Estero WRC	Santa Barbara, City of	4.91	SD-23
Montecito WWTP	Montecito Water District (Montecito SD)	0.64	SU
Oxnard WWTP	Oxnard, City of	8.40	SD-2.2

¹⁰ Recycled water that is currently reused or is planned for reuse is based on information in 2020 UWMPs and considered unavailable to future hydrogen development for purposes of this study.

Facility ²	Agency (owner/operator, if different) ³	Discharge (MGD)	Treatment Level ⁴
Simi Valley WQCP	Ventura County Waterworks District No 08	7.07	T
San Jose Creek WRP	San Gabriel Valley Water Company (LASAN)	5.82	T
Rialto WWTP	Rialto, City of	7.24	T
Banning WWTP	Banning, City of	1.95	SU
Long Beach WRP	Long Beach, City of	3.13	T
OC-San Plant No. 2	Huntington Beach, City of (OC-San)	66.96	SD-2.2
Laguna Niguel RTP	Moulton Niguel Water District (SOCWA)	3.57	T
MNWD Plant 3A	Moulton Niguel Water District (SOCWA)	0.85	T
San Clemente WRP	San Clemente, City of (SOCWA)	2.86	SU
J.B. Latham Plant	Moulton Niguel Water District (MNWD)	11.15	SU
JB Latham Plant and CTP	South Coast Water District (SOCWA)	1.96	SD-2.2
CVWD WRP-10	CVWD	1.53	T
CVWD WRP-7	CVWD	1.16	T
CVWD Avenue 54 WWTP	Coachella, City of (Coachella SD)	2.77	SU
CVWD WRP-4	CVWD	5.85	SD-23
Blythe WWTP	Blythe, City of	1.39	SD-23
Encina WPCF (to San Elijo)	Carlsbad MWD	23.18	SU
Encina WPCF	San Dieguito Water District	10.12	SU
Hale Avenue RRF (to San Elijo)	Escondido, City of	11.36	T
San Elijo WRF	San Dieguito Water District	1.47	T
South Bay WRP	San Diego, City of	4.41	SU
Brawley WWTP	Brawley, City of	0.92	SD-2.2
City of Imperial WWTP	Imperial, City of	1.20	SD-2.2
Calexico WWTP	Calexico, City of	2.57	SD-2.2
El Centro WWTP	El Centro, City of	3.16	SD-23
Total		241.90	

¹ Facility information was sourced from 2020 Urban Water Management Plans (UWMPs), which updated 2015 UWMPs and reflect observed conditions for years 2016-2020 as well as projected conditions through 2040; the next UWMP update cycle will occur in 2025, and will account for changed supplies and demands occurring since the 2020 update cycle.

² CTP = Coastal Treatment Plant; RRF = Resource Recovery Facility; RTP = Regional Treatment Plant; WPCF = Water Pollution Control Facility; WQCP = Water Quality Control Plant; WRC = Water Resource Center; WRP = Water Reclamation Plant; WRRF = Water Resource Recovery Facility; WWTF = Wastewater Treatment Facility; WWTP = Wastewater Treatment Plant

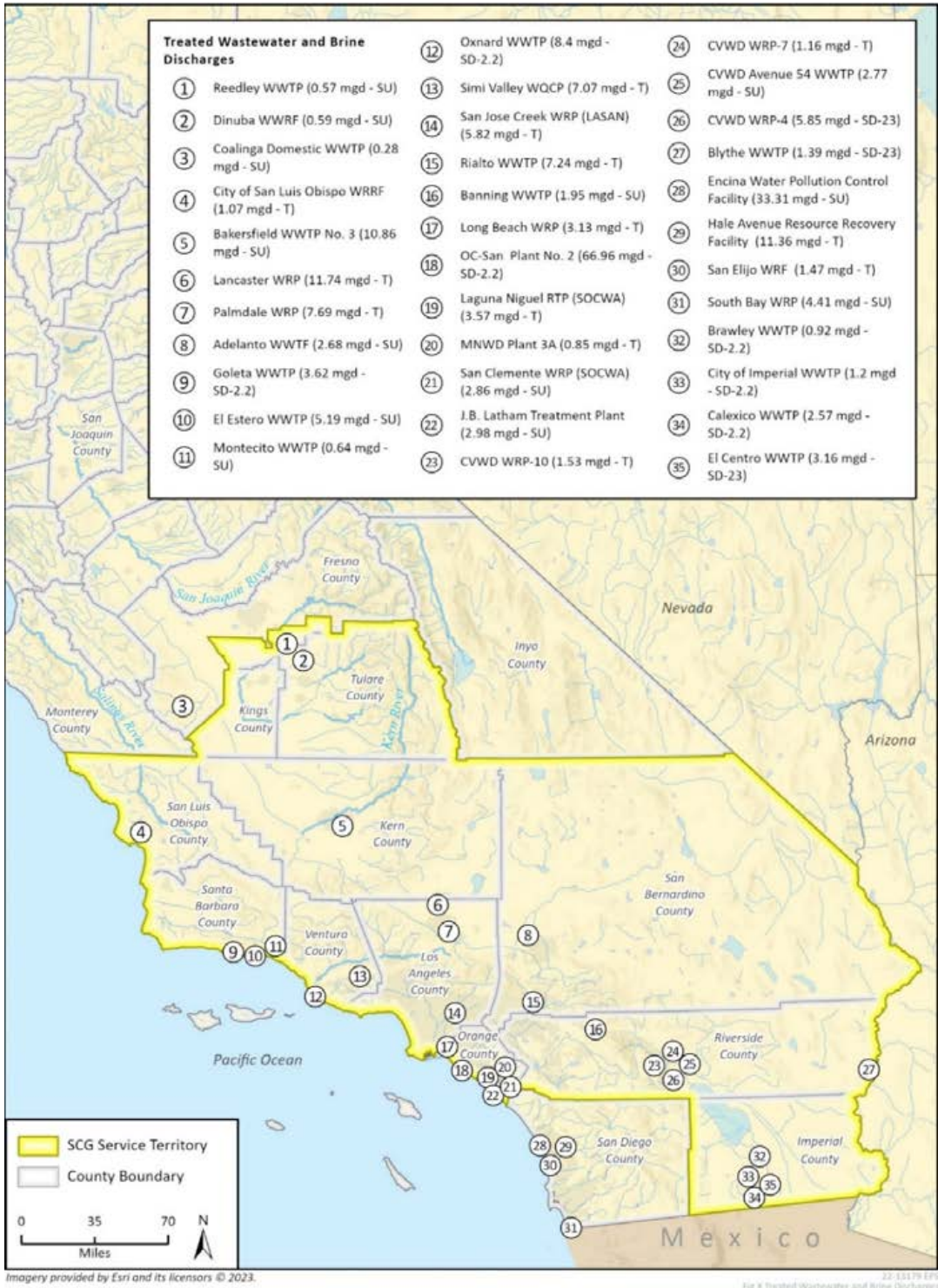
³ CVWD = Coachella Valley Water District; LACSD = Los Angeles County Sanitation Districts; LASAN = City of Los Angeles Sanitation & Environment; SD = Sanitary District; SOCWA = South Orange County Wastewater Authority

⁴ SU = Secondary, Undisinfected; SD-23 = Secondary, Disinfected-23; SD-2.2 = Secondary, Disinfected-2.2; T = Tertiary

Figure 1-25, below, provides an overview of the locations of recycled water facilities within SoCalGas’s service territory, as well as several adjacent facilities that are currently discharging treated wastewater without further reuse. The select adjacent facilities are included due to site-

specific considerations, such as, but not limited to, the regional importance of the facility and the amount of recycled water produced.

Figure 1-25 Wastewater Treatment Facilities Discharging Treated Flows (2016-2020)¹



1. Facility information was sourced from 2020 Urban Water Management Plans (UWMPs), which updated 2015 UWMPs and reflect observed conditions for years 2016-2020 as well as projected conditions through 2040; the next UWMP update cycle will occur in 2025, and will account for changed supplies and demands occurring since the 2020 update cycle.

3.3 Groundwater

Groundwater is an important supply source in California, with about 83 Percent of Californians depending on groundwater for some portion of their supplies and many communities entirely dependent upon their local groundwater resources (DWR 2023k). There are 515 defined groundwater basins throughout the state. In 2014, the Sustainable Groundwater Management Act (SGMA) was passed, requiring all groundwater basins to be ranked by DWR in order of priority, as either Very Low, Low, Medium, or High Priority. All High and Medium Priority basins are required to be managed in accordance with a Groundwater Sustainability Plan (GSP) administered by a Groundwater Sustainability Agency (GSA) for compliance with SGMA. An overview of SGMA is provided in Table 1-7, presented in Section 2.2, *Laws and Regulations*; SGMA is also discussed as relevant in the basin prioritization sections below.

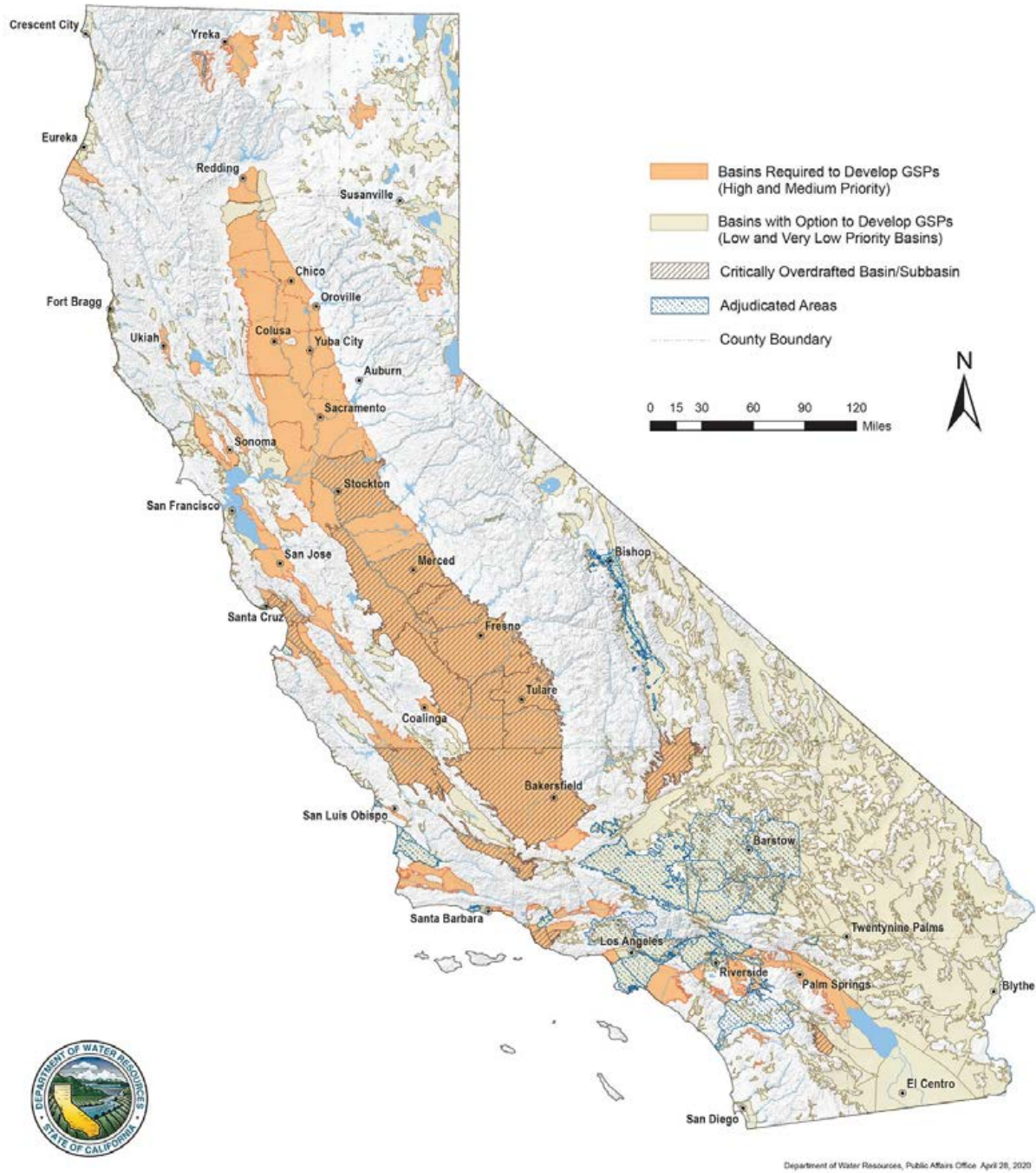
3.3.1 Basin Prioritization and Availability

In accordance with SGMA, the DWR has ranked each of California's 515 defined groundwater basins into one of four categories: Very Low Priority; Low Priority; Medium Priority; and High Priority. Prioritization rankings are based upon consideration of eight components identified in California Water Code Section 10933(b) as follows:

- 1) The population overlying the basin or subbasin;
- 2) The rate of current and projected growth of the population overlying the basin or subbasin;
- 3) The number of public supply wells that draw from the basin or subbasin;
- 4) The total number of wells that draw from the basin or subbasin;
- 5) The irrigated acreage overlying the basin or subbasin;
- 6) The degree to which persons overlying the basin or subbasin rely on groundwater as their primary source of water;
- 7) Any documented impacts on the groundwater within the basin or subbasin, including overdraft, subsidence, saline intrusion, and other water quality degradation; and
- 8) Any other information determined to be relevant by the department, including adverse impacts on local habitat and local streamflow (DWR 2023i).

Based on consideration of the above components, DWR has identified California's 515 defined groundwater basins as consisting of 46 High Priority basins, 48 Medium Priority basins, 11 Low Priority basins, and 410 Very Low Priority basins (DWR and CNRA 2020). The 94 Medium and High Priority basins, in combination with adjudicated areas which have existing governance and oversight in place, account for 98 percent (20 MAFY) of all groundwater pumping in California (DWR 2023i). The 421 Low and Very Low Priority basins account for two percent (0.408 MAFY) of all groundwater pumping in the state (DWR 2023i). Figure 1-26, below, provides an overview of groundwater basin prioritization, followed by discussion of rankings under respective headings.

Figure 1-26 California Groundwater Basin Prioritization



Source: DWR 2023i

Figure 1-26 above shows that High and Medium Priority basins are concentrated in California’s Central Valley, while Low and Very Low Priority basins are concentrated in the High Desert region of Southern California, extending through Blythe in eastern Riverside County. Discussion of groundwater as a potential supply source for clean renewable hydrogen is provided below, by priority ranking. Adjudicated basins, which are primarily located within Low and Very Low Priority basins, are discussed in Section 3.3.2, *Adjudicated Groundwater Basins*.

High Priority Basins

As shown in Figure 1-26 above, High and Medium Priority basins are concentrated in California's Central Valley, where critically overdrafted basins are also concentrated. As defined by SGMA, "A basin is subject to critical overdraft when continuation of present water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts." Therefore, critically overdrafted groundwater basins are not considered a potential supply source for clean renewable hydrogen for purposes of this study. However, not all High Priority basins are critically overdrafted.

High Priority basins are persistently overdrafted, meaning that more water leaves the basin than recharges to it. The purpose of a GSP is to reverse overdraft conditions, create sustainable conditions, and maintain sustainable conditions. As such, a High Priority basin may be currently overdrafted but may be managed with progress towards sustainable conditions. Use of groundwater from an overdrafted basin could exacerbate the overdraft conditions, assuming existing reliance on the basin continues unabated. To avoid contributing to existing adverse conditions, groundwater basins that are currently overdrafted and not managed towards sustainability are not a potential supply source for clean renewable hydrogen production for purposes of this study. However, depending upon the management approach and physical conditions in a High Priority groundwater basin, it is possible that a supply source could be developed within the guidelines of the basin's GSP.

For example, in the High Priority-designated Westside Subbasin of the San Joaquin Valley Groundwater Basin (SJVGB), the Darden Clean Energy Project ("Darden") was proposed in application documents submitted to the California Energy Commission (CEC) in November 2023 to use groundwater from the High Priority basin to meet a portion of its water needs, in compliance with SGMA. The Darden project would construct and operate a 1,150-megawatt (MW) solar photovoltaic (PV) facility and an up to 1,150-MW green hydrogen generator, as well as a battery energy storage system (BESS), transmission and conveyance facilities, and appurtenances (IP Darden I LLC 2023b, pg. 2-1). The Darden project facilities would be capable of producing up to 220 tonnes¹¹ per day of pure, gaseous hydrogen (CEC 2024). The Darden project's total water needs would be up to approximately 21,990 AF for the combined construction and operational water needs over a future projection of 20 years, with the operational demands each year estimated to be 1,039 AFY (IP Darden I LLC 2023a, pg. 5.13-43).

The Darden project proposes to obtain the water supply for the solar facility component through the acquisition of property and use of landowner groundwater rights in the Westside Subbasin (IP Darden I LLC 2023a, pgs. 5.13-41, 5.13-42). Based upon the terms of an Option Agreement between Westlands Water District (WWD) and the Applicant, the Darden project would receive 2 AFY for every 320 acres of land acquired within the project site for solar energy development. As the primary GSA for the Westside Subbasin, WWD's groundwater allocations (as specified in the Option Agreement with the Applicant) are assumed to be consistent with the objectives of SGMA and the Westside Subbasin GSP. In total, approximately 9,000 acres of land would be acquired under the Darden project proposal and landowner rights would provide 56 AFY of water (or a total of up to 1,120 AF over 20 years) produced from onsite wells for the solar facility component of the project

¹¹ A tonne is a metric measurement of weight equivalent to 1,000 kilograms; 220 tonnes per day is equivalent to 220,000 kilograms per day, for a total annual production rate, assuming consistent daily production, of up to 80,300 tonnes (80.3 million kilograms).

(IP Darden I LLC 2023a, pg. 5.13-42). See Section 4.4, *Land Purchase with Water Rights*, for further discussion of this supply acquisition method.¹²

Medium Priority Basins

As noted above, Medium Priority basins are required by SGMA to be managed under a GSP implemented by a DWR-approved GSA, as are High Priority basins. The difference between a High Priority basin and Medium Priority basin is the score assigned by DWR based upon consideration of the eight components listed in the introduction to this section, from California Water Code Section 10933(b). High and Medium Priority Basins are generally grouped together in DWR maps and analyzed as basins that require GSPs. Depending upon the physical conditions and management approach of a given basin, Medium Priority basins could potentially provide water supply for future clean renewable hydrogen projects. As with High Priority basins, availability should be assessed by potential third-party clean renewable hydrogen producers on a case-by-case basis, in coordination with the respective GSA(s).

Low and Very Low Priority Basins

Groundwater basins that are designated as Low or Very Low Priority, which are not considered by the state to be at risk of overdraft, and which are not restricted by water rights requirements, may present an opportunity to supply water to future clean renewable hydrogen projects. A Low or Very Low Priority basin is not impacted by overdraft conditions, and in some cases may be characterized by surplus conditions. Low and Very Low Priority basins are commonly managed through compliance with water rights requirements.

For example, in eastern Riverside County, the city of Blythe overlies two Very Low Priority groundwater basins, the Palo Verde Valley Groundwater Basin (PVVGB) and the Palo Verde Mesa Groundwater Basin (PVMGB), as shown in Figure 1-27, below. The PVVGB is hydrologically connected to the Colorado River and receives most of its recharge as infiltration from the overlying Colorado River. Most discharge (outflow) of water from this basin occurs via municipal and agricultural wells, evapotranspiration, and as underflow returning to the Colorado River (USGS 2013). Contracted allocations of Colorado River water do not change when the water infiltrates into underlying groundwater basins from the river channel. As such, some Colorado River water rights holders obtain their allocations by pumping Colorado River water from hydrologically connected groundwater, such as the PVVGB.

The PVVGB and PVMGB are located within the service territory of the Palo Verde Irrigation District (PVID) and as noted above, the PVVGB is hydrologically connected to the Colorado River. The PVID holds some of the highest priority rights to Colorado River water, including the State of California's Priority 1 rights, as well as a shared portion of the state's Priority 3 rights; see Table 1-16, *Colorado River Water Entitlements in California* (see Section 3.1.2, *Colorado River Water*). Uniquely, the PVID's Colorado River rights are not quantified by volume; rather, their water rights allow for

¹² The Darden project proposes to obtain water supply for the green hydrogen production component of the project through surplus surface water flows that occurred during the 2022/2023 water year and would be purchased as Article 21 water from WWD; see Section 4.3.2, *Wet Weather Surplus Flows*, for discussion of this mechanism for supply acquisition (IP Darden I LLC 2023a, pg. 5.13-53). Under the Darden project, the purchased Article 21 water would be stored via aquifer storage and recovery (ASR), also referred to as "groundwater banking," for use as needed over the life of the project (IP Darden I LLC 2023a, pg. 5.13-53). As of October 2023, approximately 43,000 AF of this supply source was available through WWD. Operation of the electrolyzer for the green hydrogen component of the project would require approximately 1,000 AFY, or approximately 20,000 AF in total (IP Darden I LLC 2023a, pg. 5.13-53).

irrigation and potable water to serve 104,500 acres in the Palo Verde Valley (overlying the PVVGB), and 16,000 acres on the Palo Verde Mesa (overlying the PVMGB) each year.

In addition to the PVID's rights to water in the PVVGB and PVMGB, water supply is also managed through agricultural fallowing. Under a 35-year agreement (initiated in 2005) between Metropolitan and PVID, farmers in the Palo Verde Valley are paid to refrain from irrigating up to 28 percent of their farmland at Metropolitan's call, making water available for the communities served by Metropolitan (Metropolitan 2022b). The water saved from fallowing remains in the Colorado River Aqueduct and connected groundwater as it passes through the Palo Verde Valley, continuing into Metropolitan's service territory to the west. Metropolitan also owns about 22,000 acres of irrigable farmland in the Palo Verde Valley, and participates in the fallowing program (Metropolitan 2022b).

It is possible, as in the PVVGB and PVMGB, that water may be procured from Low and Very Low Priority basins through multiple mechanisms, depending upon physical conditions and management of the basin. Please see Part 4, *Mechanisms of Supply Acquisition*, for further discussion.

Figure 1-27 Palo Verde Groundwater Basins



3.3.2 Adjudicated Groundwater Basins

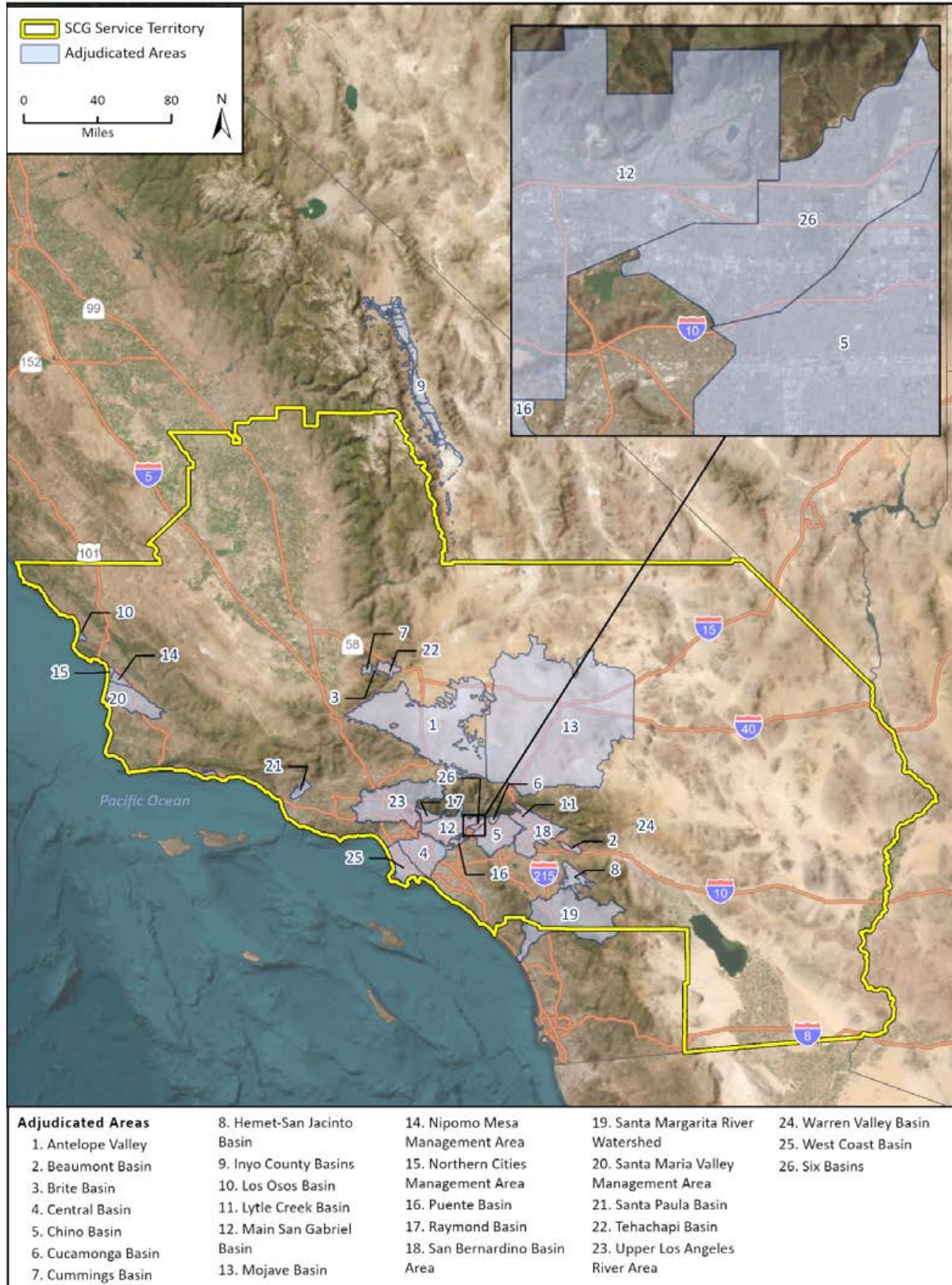
Groundwater adjudication occurs when a legal dispute over the uses of groundwater in a given area results in a court-ordered Adjudication Judgement, which identifies all parties to the judgement

(water rights holders within the adjudication area) and quantifies the rights of each party to the judgment. The court also designates a Watermaster responsible for administration of the judgment, with the Watermaster typically consisting of a Board of Directors comprised of agencies and other stakeholders within the adjudication area. An adjudication judgment generally assigns base annual production (BAP) rights to each party, which is the total amount of water each party is allowed to produce annually. Some Watermasters also assign a variable free production allowance (FPA) each year, with the FPA being the portion of the BAP that each party is allowed to pump for the respective year; the FPA may be adjusted throughout the year as needed to support sustainable management of the basin.

An adjudication judgment may address an entire groundwater basin, a portion of a groundwater basin, or portions of multiple basins. Figure 1-26, presented above in Section 3.8.1, indicates that most adjudicated areas are located in Southern California; Figure 1-28, below, identifies adjudicated areas within and adjacent to SoCalGas's service territory. The largest adjudicated area shown below is identified as number 13, the Mojave Basin adjudication area; this area consists of multiple groundwater basins including: Coyote Lake Valley (Basin No. 6-037), Caves Canyon Valley (Basin No. 6-038), Lower Mojave River Valley (Basin No. 6-040), and Antelope Valley (Basin No. 6-044). All four of these basins are managed under the adjudication judgment for the Mojave Basin Area (MBA), administered by the Mojave Water Agency (MWA) as the designated Watermaster.

Please see Section 4.3.1, *Adjudicated Groundwater Rights*, for discussion of adjudicated areas, as allowed by the respective adjudication judgment and Watermaster.

Figure 1-28 Adjudicated Groundwater Basins in SoCalGas's Service Territory



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 Additional data provided California Department of Water Resources, 2023.

22-13179 EP9
 Fig X Adjudicated GW Basins

3.4 Agricultural Industry Water

This category for “agricultural industry water” includes two potential water supply sources associated with ongoing agricultural operations throughout the study area: agricultural field drainage, and wastewater from produce washing operations, each of which is described below.

3.4.1 Agricultural Drainage

Agricultural drainage refers to surface water runoff and shallow subsurface drainage of irrigation water and precipitation. Some agricultural operations conduct drainage water recycling, which is the practice of capturing excess water from fields, storing the collected water, and using it to irrigate crops when there is a supply deficit. The use of systems to capture and reuse agricultural drainage could also potentially facilitate supply development for clean renewable hydrogen. Agricultural drainage collection is typically accomplished by two means: surface drainage features such as ditches and channels that use gravity to move flows to a storage area, and subsurface drainage consisting of pipes that facilitate the movement of excess water away from the target area to a storage area. The latter, involving subsurface drainage, is typically referred to as “tile drainage.”

The quantification of potential agricultural drainage capture from a specific area depends upon site-specific conditions, including but not limited to the following: size and topography of the subject site; geologic and soil conditions; intensity of agricultural water application; rates and patterns of precipitation and evapotranspiration; existing and planned land cover; underlying groundwater conditions; and presence of shallow groundwater. Water quality constituents of concern that are commonly present in agricultural drainage include total dissolved solids (TDS), selenium (Se), boron (B), and chlorine (Cl), as well as pesticides, metals, or contaminants of emerging concern (CECs) including per- and polyfluoroalkyl substances (PFAS). In the San Joaquin Valley, agricultural drainage can have TDS concentrations of up to 20,000 mg/L (ACS ESTE 2022).

In 2018, approximately 24.5 MAFY of irrigation water was applied to approximately 8.4 million acres of land across California (ACS ESTE 2022). It has been estimated based upon irrigation volumes, irrigation consumptive use volumes, and area of farmland currently managed with tile drainage that approximately 419 MGD of drainage could be potentially captured and reused from existing agricultural operations throughout the state (ACS ESTE 2022). Approximately eight percent of the tile drainage considered in these estimates are associated with San Joaquin Valley farming operations (33.52 MGD), while nearly 90 percent of the estimated tile drainage occurred in the Imperial Valley (377.1 MGD) within Riverside and Imperial counties (ACS ESTE 2022). As noted above, there are multiple site-specific considerations that contribute to the amount of tile drainage that can be captured for potential reuse; coordination by potential third-party clean renewable hydrogen producers with individual landowners and agricultural producers is needed to quantify drainage capture potential on a site-specific basis.

3.4.2 Agricultural Wash Water (Process Wastewater)

Agricultural wash water refers to water that is applied to produce to remove soil and debris prior to the produce being received by produce buyers and distributors. After produce is washed and the process wastewater (spent wash water) is reused to the extent feasible, the process wastewater is disposed of via discharge to an existing municipal sewer system, which conveys the process wastewater to a wastewater treatment facility for treatment to acceptable constituent levels prior to discharge, or it is disposed of via discharge to land in accordance with waste discharge requirements (WDRs) or conditional waivers of WDRs (Orders) issued by the SWRCB. The SWRCB

regulates water quality from point-source and nonpoint-source agricultural drainage under the Irrigated Lands Regulatory Program, through which the SWRCB issues WDRs and Orders to growers (SWRCB 2023d). These WDRs and Orders contain conditions requiring water quality monitoring of receiving waters and corrective actions when impairments are found.

As a potential supply source for clean renewable hydrogen, process wastewater would be diverted prior to disposal, for treatment and reuse by hydrogen producers. The amount of process wastewater available from a given facility depends upon the size of facility operations and the permitted discharge limits, which vary by facility as determined by the SWRCB. For the purposes of this analysis, a case study is used to characterize process wastewater as a potential supply source for clean renewable hydrogen development. This case study is the Shafter Carrot Packing Plant, which is owned and operated by Grimmway Enterprises, Inc. in Shafter, California, and operates under WDR Order R5-2021-0029 (Central Valley Region RWQCB 2021). Below is an overview of agricultural wash water processes and process wastewater reuse and disposal for this facility:

- Trailers loaded with carrots are parked in soaker sheds where the carrots are rinsed with groundwater produced from an on-site well;
- Carrots are flushed from the trailers using recycled process wastewater;
- Carrots pass through a cleaning station and hydro-cooling process for rinsing with chlorinated water;
- Process wastewater is either recirculated through the wash system or discharged to settling ponds (Central Valley Region RWQCB 2021).

Process wastewater that is not reused is discharged to a Land Application Area at the Shafter Airport Wastewater Treatment Facility (WWTF) under WDR Order R5-2015-0057, which authorizes an average monthly discharge (of process wastewater) of 0.700 MGD and maximum annual discharge of 182 million gallons (MG). Table 1-19, below, provides an overview of process wastewater discharges from the Shafter facility for years 2017 through 2019, indicating discharges for this facility were consistent with the WDR limitations of 0.700 MGD or 182 MG/year.

Table 1-19 Wash Water Case Study – Discharge Rates, 2017-2019

Year	Gallons per Year	MGD	Acre-feet per year
2017	121,827,000	0.33	373.87
2018	149,105,400	0.41	457.59
2019	171,900,600	0.47	527.54

Source: Central Valley Region RWQCB 2021

As noted above, as a potential supply source for clean renewable hydrogen development, process wastewater would be diverted from agricultural wash facilities prior to discharge for disposal, and conveyed for treatment and use in clean renewable hydrogen production. The amount of process wastewater associated with a given operation depends upon factors such as the commodity processed, the process unit operations used, the daily-production performance level, and the seasonal variation, e.g., growing condition and crop age at harvest. Coordination by potential third-party clean renewable hydrogen producers with individual facility owners and operators would be needed to quantify supply source potential from process wastewater on a site-specific basis.

3.5 Brine Line Flows

Brine lines are used to remove salts and other contaminants from a given watershed area to protect the quality of local surface water and groundwater resources. Use of this supply source could involve diverting the brine flows at the point of origin, or diverting collective flows from the brine line directly; either way, brine flows could be removed from the local watershed which would be beneficial to local water quality, and could relieve local water managers from water quality treatment processes, including as related to brine. It is anticipated that the use of this supply source would not compete with the needs of other water users because the brine is a waste stream, and is not planned for any use other than disposal at this time.

3.5.1 Brine Line Dischargers

Table 1-20, below, provides an overview of two brine lines within SoCalGas’s service territory, including the Inland Empire Brine Line in Riverside County (SAWPA), which is fully developed and operational, and the Salinity Management Pipeline in Ventura County (Calleguas MWD), which is partially implemented with final phases undergoing planning and design.

Table 1-20 Brine Line Dischargers

Brine Line	Dischargers / Connections
Inland Empire Brine Line <ul style="list-style-type: none"> ▪ SAWPA, Riverside County ▪ 30 MGD maximum flow ▪ ~12 MGD average flow 	Trucked Disposal Collection Stations: <ul style="list-style-type: none"> ▪ IEUA Collection Station ▪ San Bernardino Collection Station ▪ Western Municipal Water District (WMWD) Collection Station ▪ Eastern Municipal Water District (EMWD) Collection Station <hr/> Desalters: <ul style="list-style-type: none"> ▪ Arlington (WMWD) ▪ Chino I (Chino Desalter Authority (CDA) / IEUA) ▪ Chino II (CDA / Jurupa Community Services District (JCSDD)) ▪ Menifee (EMWD) ▪ Perris (EMWD) ▪ Perris II (EMWD) ▪ Temescal (Corona) <hr/> Direct Dischargers (Industrial): <ul style="list-style-type: none"> ▪ Mission Linen Supply ▪ OLS Energy ▪ Repet, Inc. ▪ Del Real, LLC ▪ Magnolia Foods, LLC ▪ Metal Container Corporation ▪ Southern California Edison (SCE) Mira Loma Peaker Plant ▪ City of Colton – Aqua Mansa Power Plant ▪ Mountainview Generating Station ▪ Rialto Bioenergy Facility LLC ▪ Aramark Uniform & Career Apparel LLC ▪ Dart Container Corporation ▪ Frutarom USA Inc. ▪ Wellington Foods Inc. <hr/> Wastewater RO Concentrate Dischargers: <ul style="list-style-type: none"> ▪ Yucaipa Valley WD Wohholz Regional Water Recycling Facility ▪ City of Beaumont WWTP

Brine Line	Dischargers / Connections
Salinity Management Pipeline <ul style="list-style-type: none"> ▪ Calleguas MWD, Ventura County ▪ 19.1 MGD maximum flow ▪ ~10 MGD average flow 	<ul style="list-style-type: none"> ▪ Ventura WaterPure ▪ Port Hueneme Water Agency (PHWA) Brackish Water Demonstration Facility ▪ Oxnard Advanced Water Purification Facility ▪ United Water Conservation District (UWCD) Brackish Groundwater Desalter ▪ Camrosa Water District Water Reclamation Facility ▪ Round Mountain Water Treatment Plant ▪ Pleasant Valley Mutual Desalter ▪ North Pleasant Valley Desalter ▪ Las Posas Ag Desalter ▪ Moorpark Desalter ▪ Santa Rosa Ag Desalter ▪ Camrosa Desalter ▪ Conejo Valley Desalter ▪ Triunfo-Las Virgenes Pure Water ▪ West Simi Desalter

Sources: SAWPA 2023, 2019; Calleguas MWD 2023

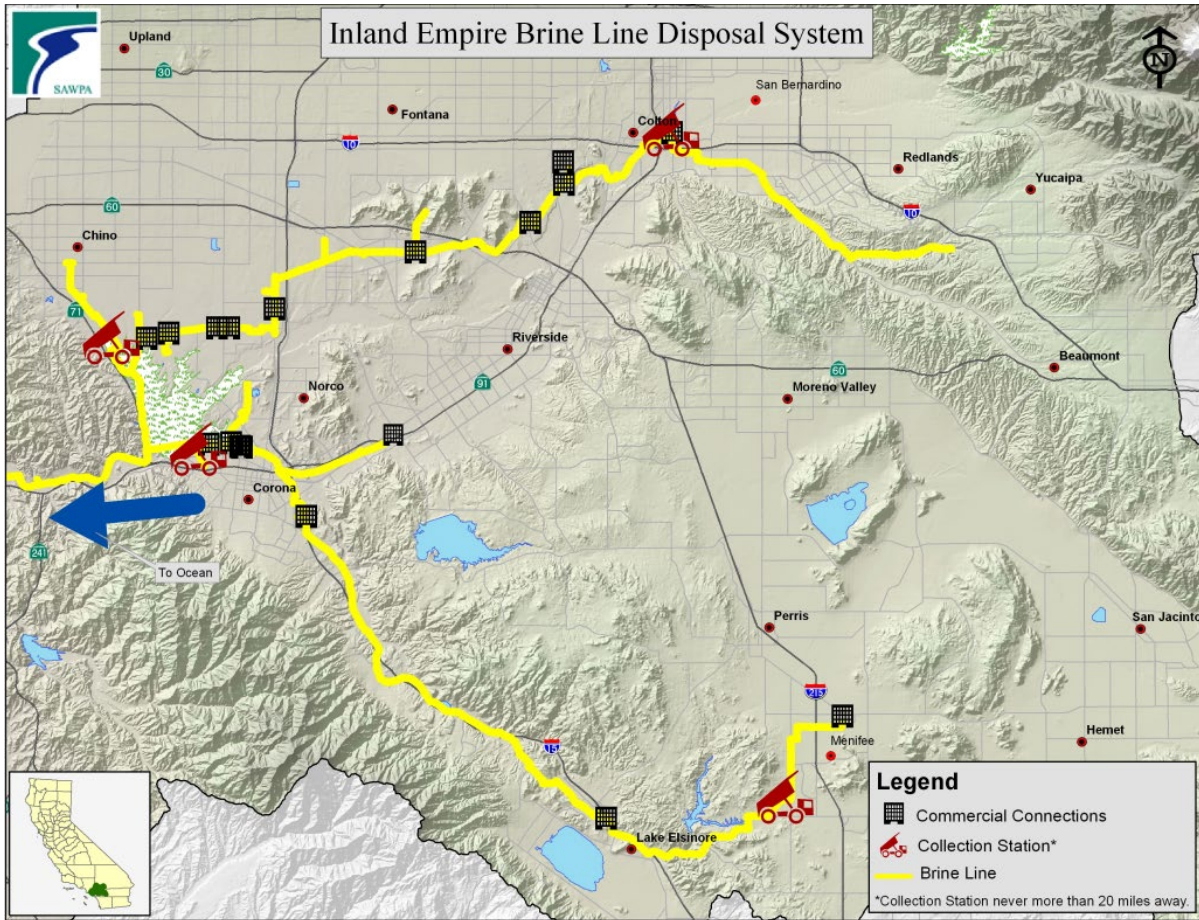
The table above shows that SAWPA’s Inland Empire Brine Line has a maximum capacity of 30 MGD and Calleguas MWD’s Salinity Management Pipeline has a maximum capacity of 19.1 MGD. These maximum capacities are determined by outfall requirements for each project. In 2020, approximately 12 MGD of brine were removed from the Santa Ana River Watershed through disposal to the Inland Brine Line (SAWPA 2021). As a potential supply source for clean renewable hydrogen production, the target of this source is any brine flows that are currently or planned for discharge to a brine line for disposal, without further treatment and reuse. The 12-MGD average flows in the Inland Empire Brine Line are not planned for further treatment and reuse, and are therefore potentially available to support clean renewable hydrogen production.

As a potential supply source for clean renewable hydrogen production, brine line flows could be diverted from the point of origin or from a connection or discharge point along the brine line. For example, SAWPA’s Inland Empire Brine Line has existing connection points where it receives flows collected from respective origin points. Trucked disposal is conducted at four separate collection stations, identified on Figure 1-29, below. The collection stations include:

- Inland Empire Utilities Agency (IEUA) Collection Station (16400 El Prado Road, Chino CA 91718);
- San Bernardino Valley Municipal Water District (MWD) Collection Station (Water Reclamation Plant, 399 Chandler Place, San Bernardino CA 92408);
- Western MWD Collection Station (City of Corona Wastewater Treatment Plant No. 1, 2205 Railroad Street, Corona CA 92880); and
- Eastern MWD Collection Station (Menifee Valley Truck Waste Disposal Facility, 29541 Murrieta Rd, Murrieta, CA 92586) (SAWPA 2023).

Figure 1-29, below, provides an overview of the Collection Station locations and Commercial Connections, which reflect the Inland Empire Brine Line’s direct connections.

Figure 1-29 Inland Empire Brine Line



Source: San Bernardino Valley MWD 2023

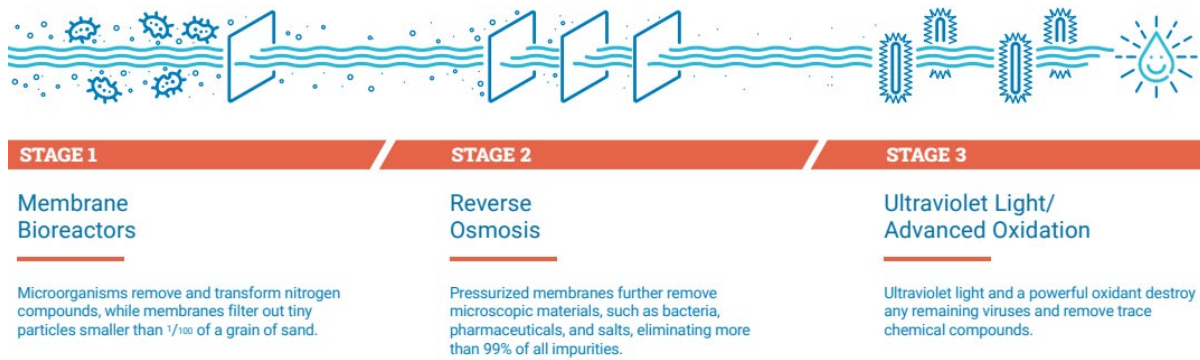
The figure above shows there are currently 14 direct connections to the Inland Empire Brine Line for industrial dischargers. The brine line provides disposal of brine for seven desalter facilities, which remove salts and other water quality constituents from water.

The diversion of brine for clean renewable hydrogen production could transfer the costs of waste stream treatment and connection to the discharge line (Brine Line) from existing brine dischargers to future hydrogen producers. The treatment of brine as a supply source would result in its own waste stream, which would likely have more concentrated brine and contaminants of concern.

3.6 Advanced Water Treatment Concentrate

Advanced Water Purification Facilities (AWPF) processes use secondary-treated wastewater to conduct further water quality treatment and produce tertiary-level treated water. This involves several processes including membrane filtration, reverse osmosis, and oxidation, as shown in Figure 1-30, below. Concentrated wastewater is created during Stages 1 and 2, as both stages involve removing impurities from the secondary-treated wastewater, which creates a concentrate consisting of highly saline brine that can be either recycled for reuse or treated for disposal.

Figure 1-30 Overview of AWP Treatment



Source: Metropolitan 2022a

Use of this supply source would not compete with the needs of other water users because it is a waste stream, and is not planned for any use other than disposal. Use of this supply source could potentially relieve operators of advanced water purification facilities from the cost of disposing of concentrate, while also removing salts and contaminants from the basin.

3.6.1 Advanced Water Treatment Projects

Table 1-21, below, identifies existing and planned recycled water projects within SoCalGas’s service territory that use advanced water treatment processes at this time. The concentrate amounts shown below reflect the total amount of concentrate produced under respective projects, using an assumed recovery rate of 80 percent in the treatment processes. The actual efficiency rate of each project will depend upon concentration of TDS in the associated flow. As noted above, the target of this supply source is the concentrate produced as a by-product of treatment processes.

Table 1-21 Potable Reuse Projects in SoCalGas’s Service Territory

Project ¹	Agency ²	Operational	Project Size (AFY)	Concentrate (MGD)
Alamitos Barrier	LADPW	existing	6,000	1.07
ARC Project	WRD	existing	10,000	1.79
Burbank Recycled Water	BWP	existing	1,814	0.32
Central Coast Blue	SLO CSD	2025	3,566	0.64
Chino Basin Program	IEUA	existing	15,000	2.68
City of Oxnard	Oxnard, City of	2030	7,000	1.25
City of Santa Monica	Santa Monica, City of	2023	1,650	0.29
D.C. Tillman WRP AWP	LASAN	2026	21,283	3.80
		2025	17,000	3.04
Dominguez Gap Barrier	LADPW	existing	4,700	0.84
		2024	8,500	1.52
East County AWP Project	East County AWP JPA	construction	12,882	2.30
GWR Plus	Eastern MWD	existing	30,000	5.36
GWRS	OCWD & OCSD	existing	134,000	23.93

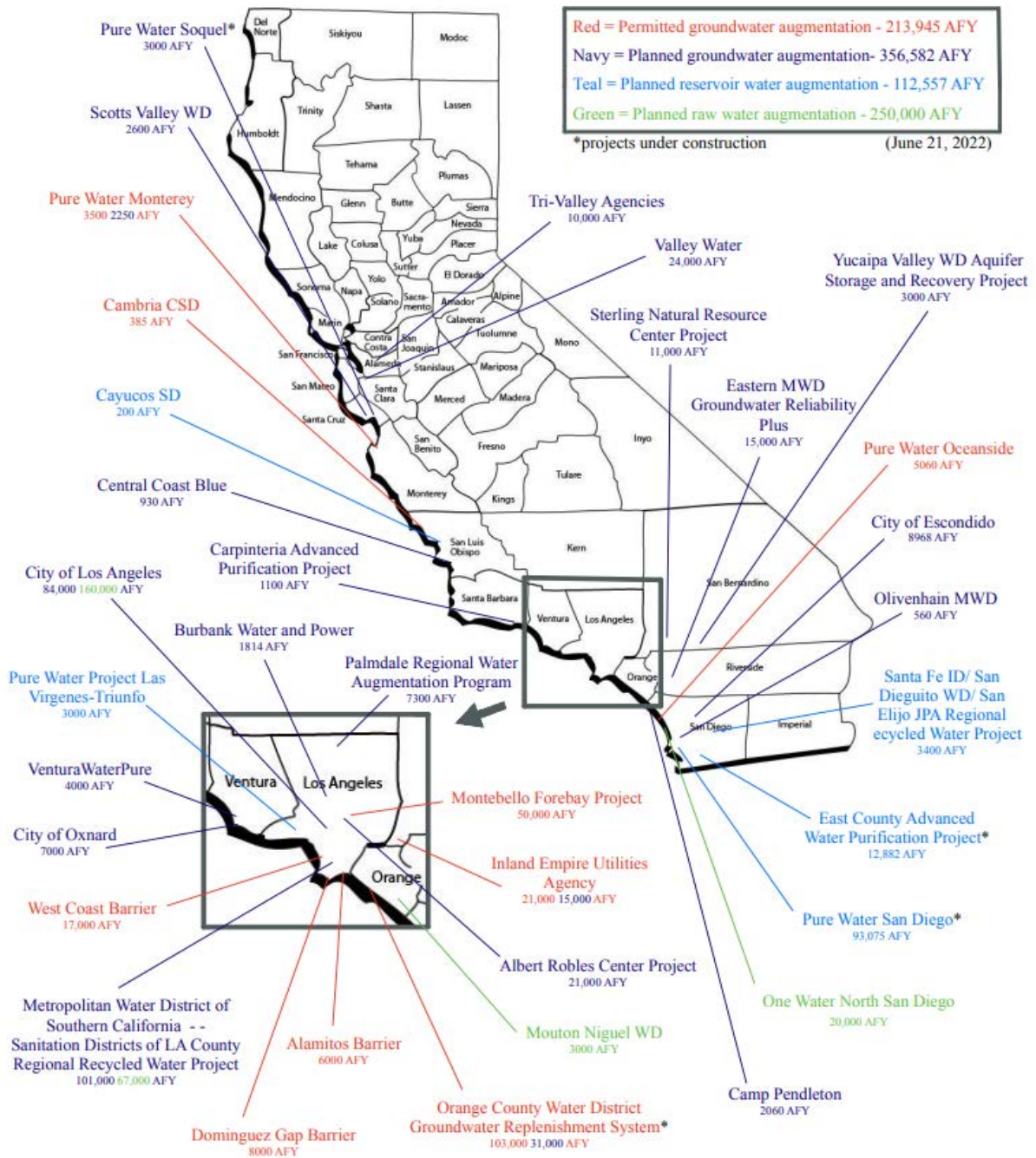
Project ¹	Agency ²	Operational	Project Size (AFY)	Concentrate (MGD)
Montebello Forebay GWRP	LADPW	existing	51,000	9.11
Operation NEXT	LASAN & LADWP	2046	158,000	28.21
		2035	190,000	33.92
		2035	85,000	15.18
Pure Water Oceanside	Oceanside, City of	construction	5,601	1.00
Pure Water Las Virgenes-Triunfo	Las Virgenes-Triunfo JPA	2029	3,000	0.54
Pure Water San Diego - Phase One	San Diego, City of	planning	33,604	6.00
Pure Water San Diego - Phase 2	San Diego, City of	planning	59,368	10.60
Pure Water Southern California	Metropolitan & LACSD	2028	33,600	6.00
		2032	112,000	20.00
		2036	155,000	27.68
		planning	168,022	30.00
RWAP - AWP	Palmdale Water District	planning	5,325	0.95
Ventura Pure Water	Ventura, City of	2030	4,000	0.71
West Coast Basin Barrier	LADPW	existing	17,000	3.04
Total			1,353,915	241.77

¹ ARC Project = Albert Robles Center Project; AWP = Advanced Water Purification Facility; DCT WRP = Donald C. Tillman Water Reclamation Plant; GWR Plus = Groundwater Reliability Plus; GWRP = Groundwater Recharge Project; GWRS = Groundwater Replenishment System

² BWP = Burbank Water and Power; East County AWP JPA = East County Advanced Water Purification Joint Powers Authority; Eastern MWD = Eastern Municipal Water District; IEUA = Inland Empire Utilities Agency; LADPW = Los Angeles County Department of Public Works; LASAN = City of Los Angeles Sanitation Districts; Metropolitan = Metropolitan Water District of Southern California; OCSD = Orange County Sanitation District; OCWD = Orange County Water District; RWAP = Regional Water Augmentation Program; SLO CSD = San Luis Obispo County Sanitation District; WRD = Water Replenishment District of Southern California
Source: WaterReuse California 2023a, 2023b

The table above indicates that there are 22 projects at this time within SoCalGas’s service territory that employ the use of advanced water treatment techniques and create a concentrated brine stream. Figure 1-31, below, provides a map of potable reuse projects throughout the state, including those listed above.

Figure 1-31 Potable Reuse Projects in California



Source: WateReuse 2023b

Figure 1-31 above indicates at this time the majority of potable reuse projects throughout the state are located in Southern California, including both planned and permitted projects consisting of groundwater augmentation projects, reservoir augmentation projects, and raw water augmentation projects. Each of these projects is a type of potable reuse; these projects use advanced water treatment processes to create potable water.

3.7 Oil & Gas Industry Water

As a potential supply source for clean renewable hydrogen, the target of O&G industry water includes “offset” water that becomes available due to the reduction and cessation of water use at refineries, and “produced” water that is currently discharged without reuse.

- **Refinery Offset water** from the cessation of O&G refinery operations could become available if the refinery owner does not transition the site to other industrial use(s) that would rely on the same water supply and if future developers of clean hydrogen projects are able to secure access to this potential source. Water sources for O&G refineries in Southern California include treated wastewater and groundwater; offset water may not be available if it is needed to reverse overdraft conditions in the groundwater basin for compliance with SGMA.
- **Produced water** is brought to the surface along with oil and gas as a result of pumping conducted to produce oil and gas materials. If produced water is not reused in the O&G production process, it may be disposed of by discharge to land, which requires water quality treatment for compliance with a National Pollutant Discharge Elimination System (NPDES) discharge permit. As a potential supply source, the treated produced water could be acquired by a hydrogen producer from the oil field operator prior to its discharge to land.

In addition to the above, the O&G industry also uses “process water” for some methods of extraction and production including hydraulic fracturing, or “fracking,” which involves injecting liquid at high pressure into the ground to force open existing fissures and extract O&G. Fracking permits are no longer issued in the State of California; existing fracking operations are allowed to continue, but will be phased out as they reach their useful operational lifetime. Process water is not included as a potential water supply source for clean renewable hydrogen production because its use is being phased out in California; through compliance with state law, process water from fracking will no longer be part of the O&G industry and therefore is not available as a potential supply source for clean renewable hydrogen.

Since 2021, California’s Geologic Energy Management Division (CalGEM, previously DOGGR) has been directed via California Governor Executive Order (EO) to cease the issuance of new fracking permits by January 2024. The EO does not ban existing fracking, but it does direct the California Air Resources Board (CARB) to analyze pathways to phase out oil extraction across the state by no later than 2045. CARB is evaluating this phase-out under the 2022 Climate Change Scoping Plan, which was developed to achieve state-wide reductions in greenhouse gas emissions and economy-wide carbon neutrality by 2045 (CARB 2022).

3.7.1 Refinery Offset Water

CARB has evaluated pathways to phase out oil extraction across the state under the CARB 2022 Scoping Plan (see Table 1-7). It was determined by CARB that complete cessation of fossil fuel production by 2045 would not be feasible; however, crude oil production has been steadily decreasing even without the CARB 2022 Scoping Plan (CARB 2022). Specifically, CARB noted that crude oil production peaked in 1986 at 402 million barrels, and has been decreasing by an average of six million barrels per year to about 200 million barrels in 2020 (CARB 2022). Under business-as-usual conditions, CARB has projected that crude oil production in California will decrease by an additional 52 percent to 97 million barrels in 2045 (CARB 2022).

Table 1-22, below, provides an overview of existing oil refineries in California. Under current state law, O&G refineries are not required to report water usage. The amount of water per barrel of oil produced is expected to vary by refinery location, depending upon multiple factors including the source water, other refinery operations and processes, and requirements of the facility-specific discharge permit. Further investigation by third-party clean renewable hydrogen producers could include coordination with O&G companies to characterize water use at respective facilities and explore whether offset water could be developed for clean renewable hydrogen production. Direct coordination between hydrogen producers and O&G companies may also help to develop offset water as a supply source.

Table 1-22 Current California Oil Refinery Locations and Capacities¹

Refinery Name	Barrels/Day	% of State Production	Location (County)
Phillips 66, Wilmington Refinery	139,000	8.00%	Los Angeles
Phillips 66, Rodeo San Francisco Refinery ²	120,200	6.90%	Los Angeles
Valero Energy, Wilmington Refinery	85,000	4.90%	Los Angeles
Kern Energy, Bakersfield Refinery	26,000	1.50%	Los Angeles
San Joaquin Refining Company Inc., Bakersfield Refinery	15,000	0.90%	Los Angeles
Lunday Thagard, South Gate Refinery	8,500	0.50%	Los Angeles
Valero Wilmington Asphalt Refinery	6,300	0.40%	Los Angeles
PBF Energy, Torrance Refinery	160,000	9.20%	Kern
PBF Energy, Martinez Refinery	156,400	9.00%	Kern
Valero Energy, Benicia Refinery	145,000	8.30%	Kern
Marathon Petroleum Corp., Carson Refinery ³	363,000	20.90%	Contra Costa
Chevron U.S.A. Inc., El Segundo Refinery	269,000	15.50%	Contra Costa
Chevron U.S.A. Inc., Richmond Refinery	245,271	14.10%	Contra Costa
Talley Asphalt Inc., Kern Refinery	1,700	0.10%	San Francisco
Marathon Martinez, Golden Eagle Refinery ⁴	0	0%	Solano
Total	1,740,371	100%	

¹ Data in this table represents total crude oil capacity, not gasoline, distillate production, diesel fuel production or production of other products. Capacity numbers do not change or often vary year to year. Production potential varies depending on time of year and status of the refinery. A rule of thumb is that roughly 50 percent of total capacity is gasoline production (about 1.0 million barrels of gasoline - 42 million gallons - is produced per day).

² Phillips 66 Rodeo and Santa Maria began reporting as one entity as of 2017.

³ Marathon Carson and Wilmington began reporting as one entity as of 2019.

⁴ Marathon Martinez, Golden Eagle Refinery's status is idle as of August 2020 with approved plans to convert to a Renewable Fuels Facility, which would repurpose the existing Refinery to discontinue refining of crude oil and switch to production of fuels from renewable feedstock sources including rendered fats, soybean and corn oil, and potentially other cooking and vegetable oils, but excluding palm oil.

Source: CEC 2023

As noted in the table above, the amount of offset water that may become available from oil refineries phasing out production activities in accordance with the CARB 2022 Scoping Plan depends in part on the source(s) of water that is used at the subject O&G facility. This is due to other existing and anticipated uses that are anticipated to rely on the given source, and whether such needs take

priority over other needs, including clean renewable hydrogen production. Table 1-23, below, provides an overview of water supply sources that are typically used in refineries and identifies considerations associated with each source’s availability as offset water.

Table 1-23 Water Sources for California Refineries

Source	Availability as Offset Water
Municipal Wastewater	Municipal wastewater will continue to be generated once O&G operations cease. In addition, as discussed in Section 3.2, <i>Treated Wastewater</i> , there are regional water recycling programs being developed and implemented throughout SoCalGas’s service territory. This is a potentially reliable source of offset water that could be used for clean renewable hydrogen production.
Surface Water	In SoCalGas’s service territory, surface water is primarily imported SWP water. As discussed in Section 2.3, <i>Key Water Supply Projects</i> , deliveries of SWP water are regularly less than contracted allocations; surface water would therefore be an inconsistent source of offset water, unless storage during surplus is used to provide consistency.
Groundwater	As O&G operations cease, groundwater previously used as a supply source could become available as offset water, if the affected basin is being managed in accordance with SGMA and rights to the groundwater are not owned by the refinery. Oil refineries may sell or lease water rights to other users, as available. Section 3.3, <i>Groundwater</i> , provides discussion of groundwater management and potential availability based upon priority rankings and SGMA compliance, also discussed in Section 4.4.2, <i>SGMA and Water Rights</i> .

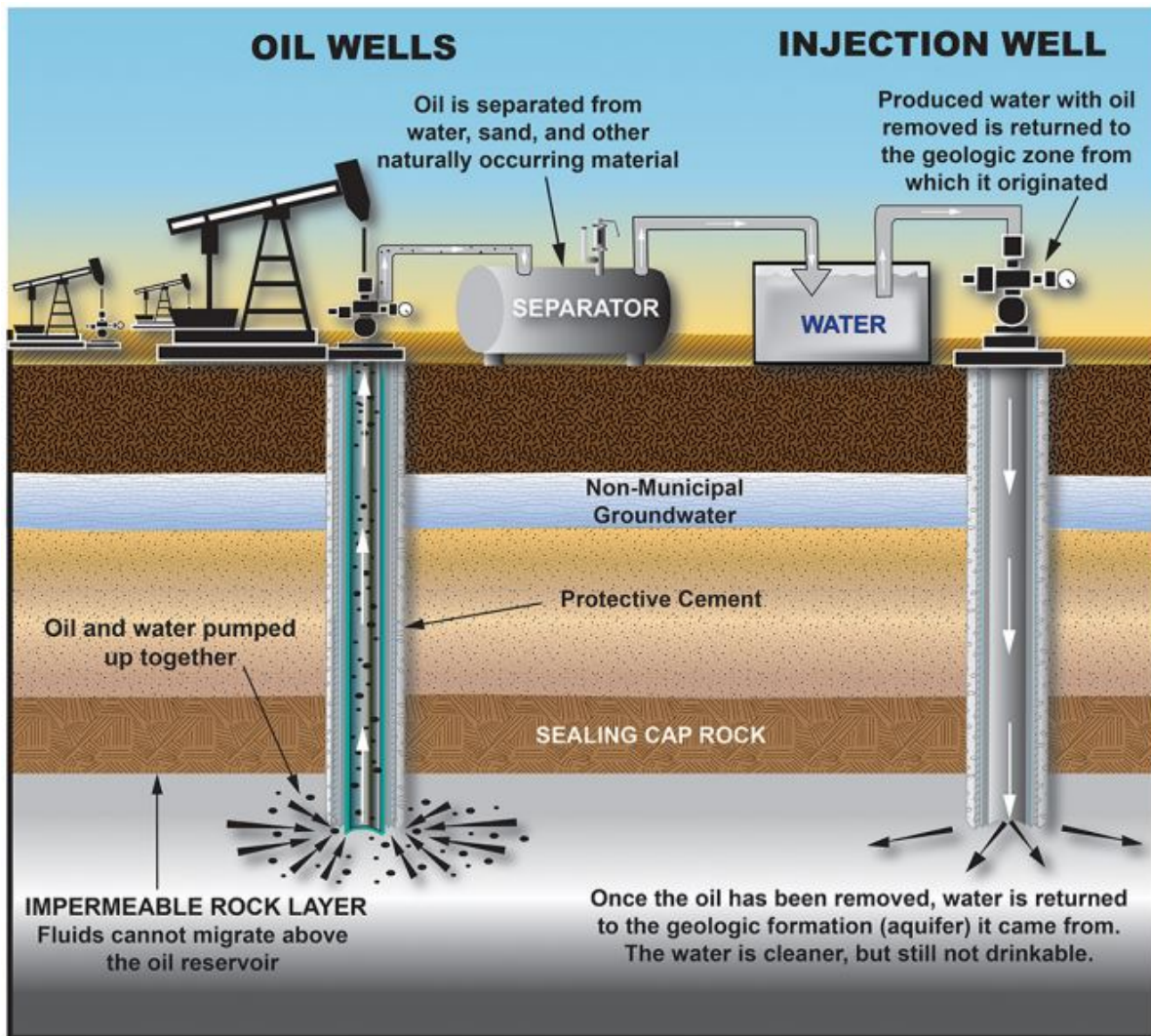
In summary, the availability of offset water from refinery operations will depend upon the timing of phasing out of refinery operations, whether the facility would be repurposed to other uses relying on the same water, and the source of water.

3.7.2 O&G Produced Water

As described in the introduction to this section, produced water is water that is incidentally brought to the surface along with oil and gas as a result of pumping conducted to produce oil and gas materials. Produced water typically has elevated TDS concentrations because while in the subsurface, the minerals in soils can leach into the water. If contaminants are present, they can also leach into the groundwater that becomes produced water during O&G production.

Figure 1-32, below, provides an overview of how produced water is separated from minerals and other constituents at the surface. The target of this potential supply source is any produced water that is not reused in the O&G production processes or for a beneficial use such as groundwater recharge or irrigation.

Figure 1-32 Produced Water from Oil and Gas Operations



Source: CalGEM 2023

To determine the amount of produced water that may be available from a given O&G operation, this study considered the amount of produced water that is reused in the O&G production processes; for any produced water that is reused in ongoing O&G operations, this study presumed that such water is not available as a potential supply source for clean renewable hydrogen production. Table 1-24, below, details the sources of water used in O&G operations, including produced water, for four major oil-producing areas in California, including the Los Angeles Basin, San Joaquin Valley, Santa Barbara-Ventura, and Santa Maria Basin.

Table 1-24 Breakdown of Water Sources for O&G Operations (AFY)

Source Water	Los Angeles Basin		San Joaquin Valley		Santa Barbara / Ventura		Santa Maria Basin	
	Saline	Fresh/Brackish	Saline	Fresh/Brackish	Saline	Fresh/Brackish	Saline	Fresh/Brackish
Drilling and Other Oilfield Waste	71.72		25.72	44.28	21.24			
Municipal Wastewater		2,108.72						
Other	573.12	0.44		27.08	74.04	0.28		
Produced Water	120,772.64	86.08	197,490.16	843.80	11,080.20		9,899.16	
Surface Water	1,202.52							
Water Supplier (not operator-owned)	12.24	57.92	758.84	1,677.44		12.96		
Groundwater Well (operator-owned)	875.96			3,352.44	212.12	0.12		65.56
Well Stimulation Recovered Fluids				2,928.28				
Total (all sources)	123,508.20	2,253.16	198,274.72	8,873.32	11,387.60	13.36	9,899.16	65.56
Produced Water (portion of total)	98.21%	1.79%	95.72%	4.28%	99.88%	0.12%	99.34%	0.66%

Source: CCST 2019

The table above shows that for each of the oil-producing areas reflected, produced water comprises a substantial portion of saline water sources. The amount of produced water available from a given operation depends upon site-specific conditions and other existing or planned uses for the produced water. Produced water that is disposed of without being reused is considered available as a potential supply source for clean renewable hydrogen production. Table 1-25, below, details how produced water is reused or disposed of for each of the oil-producing areas presented above.

Table 1-25 Breakdown of Destinations for Produced Water (AFY)

Source Water	Los Angeles Basin		San Joaquin Valley		Santa Barbara / Ventura		Santa Maria Basin	
	Saline	Fresh/ Brackish	Saline	Fresh/ Brackish	Saline	Fresh/ Brackish	Saline	Fresh/ Brackish
DISPOSAL:								
Discharge to Land	1.96	n/a	469.60	27.48	n/a	n/a	n/a	n/a
Discharge to Lined Pond	0.16	0.04	0.08	n/a	n/a	n/a	36.28	n/a
Discharge to Unlined Pond	380.80	34.16	4,088.56	95.80	8.12	n/a	n/a	n/a
Public Wastewater System	1,568.52	4.76	n/a	n/a	0.72	n/a	n/a	n/a
Discharge to Surface Water ¹	n/a	n/a	70.40	n/a	n/a	n/a	400.16	n/a
Subtotal (Disposed):	1,949.48	38.96	4,628.64	123.28	8.84	0.00	436.44	0.00
REUSE:								
Subsurface Injection (UIC)	112,950.92	76.36	190,466.16	3,412.52	4,770.84	5,776.36	6,592.68	n/a
Reuse- Operator Facilities	75.20	n/a	2,090.52	n/a	103.16	n/a	75.12	n/a
Reuse - Other Operator or Oil Field	7,967.96	n/a	5,147.08	827.76	41.28	n/a	n/a	n/a
Reuse - Agriculture or Recharge	n/a	n/a	34,329.44	1,437.68	n/a	n/a	n/a	n/a
Reuse - Well Stimulation	n/a	n/a	5,172.84	3.28	n/a	n/a	n/a	n/a
Reuse - Well Work	16.80	n/a	685.28	n/a	9.56	n/a	n/a	n/a
Reuse - Other	565.76	0.04	7,265.80	n/a	22.32	n/a	n/a	n/a
Subtotal (Reused):	123,528.08	115.36	249,785.76	5,804.52	4,956.00	5,776.36	7,104.24	0.00
Total Produced Water²	125,477.56	154.32	254,414.40	5,927.80	4,964.84	5,776.36	7,540.68	0.00

¹ Discharge to surface water is listed under disposal methods, but depending upon the receiving water affected, there may be environmental requirements to maintain certain flow levels, which would make the water unavailable as a supply source for clean renewable hydrogen production.

² "Total Produced Water" shown in Table 1-25 is higher than the "Total (all sources)" amount shown in Table 1-24 because more produced water is generated than is reused as a supply source for the respective O&G operations.

Source: CCST 2019

Table 1-26, below, summarizes produced water (saline and fresh/brackish) that is currently disposed of without beneficial reuse.

Table 1-26 Produced Water Currently Disposed without Reuse

O&G Production Area	Disposal of Produced Water (AFY)	Disposal of Produced Water (MGD)
Los Angeles Basin	1,988.44	1.78
San Joaquin Valley	4,751.92	4.24
Santa Barbara/Ventura	8.84	0.01
Santa Maria Basin	436.44	0.39
Total	7,185.64	6.41

Source: CCST 2019

The table above shows that a cumulative total of 7,185.64 AFY (6.41 MGD) of produced water is disposed of in the Los Angeles Basin, San Joaquin Valley, Santa Barbara/Ventura, and Santa Maria Basins. Coordination by third-party clean renewable hydrogen producers with O&G field operators is recommended to assess the amount of produced water potentially available from respective fields, based upon the constraints noted above.

3.8 Inland Brackish Groundwater

Brackish groundwater has TDS concentrations of approximately

1,000 to 10,000 mg/L (versus brine which has TDS concentrations of up to 35,000 mg/L). As a potential supply source for clean renewable hydrogen production, the target of this supply source is brackish groundwater located in inland areas where it does not have a natural drainage outlet, and is not currently managed or planned to be managed for beneficial reuse. For the purposes of this study, it is presumed that use of inland brackish water as a supply source would not compete with the needs of other water users because it would provide beneficial use to brackish water that otherwise poses water quality concerns and potentially threatens the viability of local land uses. In some cases, use of this water could relieve local water and land use managers from the cost of conducting water quality remediation for brackish groundwater plumes. In overdrafted groundwater basins, the local GSP should be consulted regarding SGMA compliance. In the San Joaquin Valley, a potential supply includes priority management areas identified by the Central Valley Salinity Coalition (CVSC) through the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) program.

Brackish groundwater also occurs in coastal areas as a result of seawater intrusion, which is commonly managed with a “seawater intrusion barrier” involving the injection of water into the subsurface to create a buffer between groundwater wells and seawater. The use of inland brackish water as a supply source could have the greatest potential for mutual benefit to the local area.

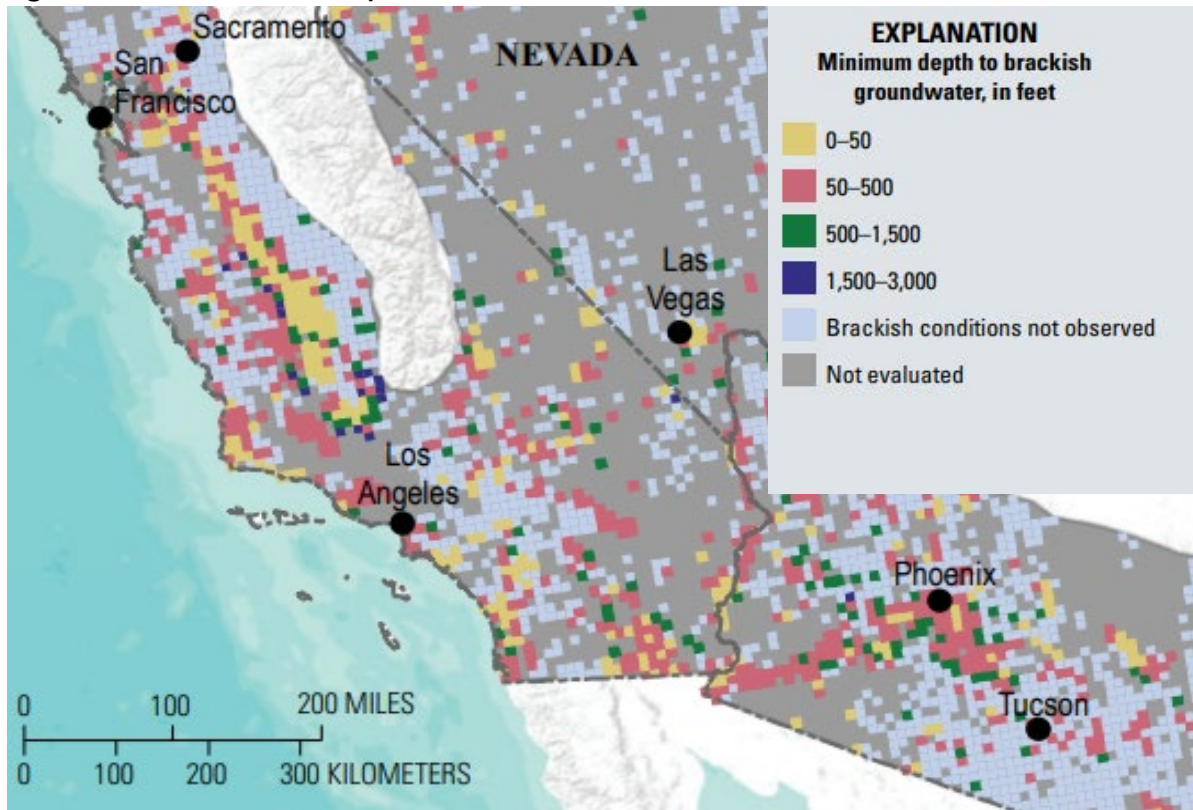
3.8.1 Brackish Plumes

Brackish groundwater can occur from both natural sources (geology and soils) and from manmade sources (such as discharges from wastewater treatment plants and agricultural runoff). Brackish groundwater can be managed as both a supply source, by pumping and treating it to water quality standards that facilitate reuse, as well as for remediation purposes, reducing salt concentrations that have adverse effects on land uses that rely on groundwater.

In inland areas, affected land uses commonly include agricultural irrigation, and municipal uses for communities that are not connected to a major surface water project (i.e., the SWP, CVP, or Colorado River; see Section 4.1, *Exchange Agreements*). In inland areas, including throughout the Inland Empire, brackish groundwater does not have an outlet to the ocean and is not caused by seawater intrusion. This brackish groundwater tends to accumulate into “plumes” which are volumes of contaminated groundwater (such as high salts creating brackish conditions) that extend away from the original source of contamination. The size and shape of a contaminated plume can be determined by collecting measurements from multiple wells in the vicinity of the plume.

Figure 1-33, below, portrays the depth to brackish groundwater for areas with available data, to demonstrate the extent of known shallow brackish plumes (within 50 feet and between 50 and 500 feet), and to portray the extent of brackish conditions that have either not been evaluated or where brackish conditions have not been observed. Areas of brackish groundwater shown in Figure 1-33 could be targeted for treatment, in collaboration with local water managers, towards the purpose of creating a new water supply source for clean renewable hydrogen production while also relieving local water managers of the cost and effort associated with remediating brackish groundwater.

Figure 1-33 Minimum Depth to Brackish Groundwater



Source: USGS 2018

Figure 1-33 above shows that there are known shallow brackish plumes in portions of Southern California, particularly in inland areas, as well as in the San Joaquin Valley where brackish groundwater more commonly occurs within the first 50 feet. The list below, while not exhaustive of all groundwater desalination projects, highlights large-scale brackish groundwater desalination projects that have been implemented throughout SoCalGas’s service territory (CalDesal 2022):

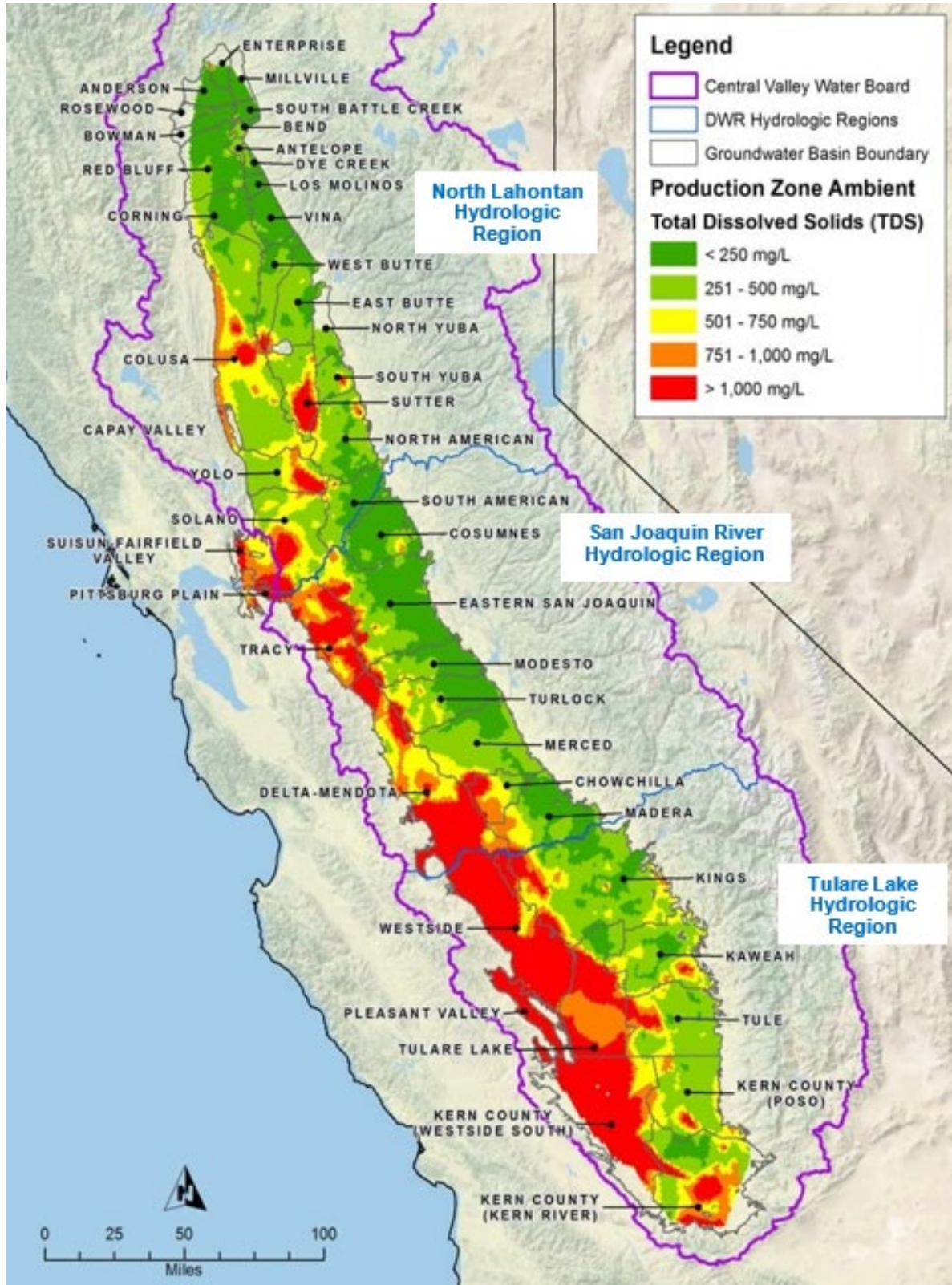
- In Ontario, the Chino Basin Desalter Authority produces 14 MGD of fresh water by desalinating brackish water pumped from wells throughout the Chino area.
- In Orange County, the South Coast Water District (SCWD) operates the Groundwater Recovery Facility (GRF), which provides approximately 15 percent of SCWD's water supply portfolio by conducting reverse osmosis to remove salts from local brackish groundwater; other supply sources include imported water from northern California (SWP) and the Colorado River.
- Eastern Municipal Water District (EMUD) in Perris is currently constructing its third Desalter as part of its Groundwater Reliability Plus Program, which cumulatively will produce 14 MGD of fresh water from brackish groundwater.
- In Torrance, the Water Replenishment District of Southern California (WRD) operates the Goldsworthy Groundwater Desalter, which creates five MGD of fresh water through desalting local brackish groundwater.
- In Carson, West Basin Municipal Water District (WBMWD) operates the C. Marvin Brewer Desalter Treatment Facility, which purifies one MGD of brackish groundwater for potable use.

The list above demonstrates there are different types of groundwater desalination projects occurring in SoCalGas's service territory. In addition to point source discharges such as those noted above, contaminated plumes also occur from non-point sources. In the Central Valley and the San Joaquin Valley (which comprises the southern portion of the Central Valley), regional drainage issues have resulted in substantial salt accumulation in the soils, and subsequently the groundwater. Regional planning for salts management in this area is being conducted by the Central Valley Salinity Coalition (CVSC) through the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) program. CV-SALTS is designed to address regional salinity issues from brackish groundwater in the Central Valley, which includes the San Joaquin Valley portion of SoCalGas's service territory.

One of the management strategies being pursued through the CV-SALTS program is desalination and reuse of brackish groundwater. Figure 1-34, below, provides an overview of TDS concentrations in the Central Valley; as shown, the highest TDS concentrations occur in the Tulare Lake Hydrologic Region, which encompasses the San Joaquin Valley and the northern portion of SoCalGas's service area. The figure below indicates that the western portion of the San Joaquin Valley is most affected by brackish groundwater; this is likely due to the natural characteristics of soils from the Coast Range which create water quality issues from irrigation and leaching to the groundwater. These high-TDS areas would most benefit from brackish groundwater management through proposals under the CVSC's CV-SALTS program.

Coordination with CVSC and local GSAs by potential third-party clean renewable hydrogen producers would be needed to identify local opportunities for the creation of a new water supply from brackish groundwater. There may be opportunities for mutual benefit through the CV-SALTS program, by advancing the CVSC's purpose to reduce regional brackish groundwater contamination, while also creating a new water supply for clean renewable hydrogen production.

Figure 1-34 Salt Accumulation in the Central Valley



Source: CVSC 2023

3.9 Dry Weather Flows

Dry weather flows are discharges of flows that enter a Municipal Separate Storm Sewer System (MS4) during dry weather conditions and, as a result of low volume and velocity of flows during dry-weather conditions, these flows accumulate within the MS4 causing water quality concerns and potential violation of the MS4 operating permit (NPDES). Dry weather flows also commingle with other native water that, without human intervention, may provide replenishment to any given source, and includes rainfall, stream channel infiltration, and tributary runoff.

Dry weather flows that pose management challenges due to water quality considerations and retention within the drainage system could be ideal as a supply source for clean renewable hydrogen production. The collection and reuse of dry weather flows could present a solution to local flood control districts with insufficient funding to effectively manage dry weather flows. Assuming the use of dry weather flows would not injure existing water users, use of this supply source could relieve local agencies from the cost of disposing of dry weather flow issues, while also removing contaminants contained therein from the basin.

3.9.1 Accumulation Areas

An MS4 is a stormwater conveyance and discharge system that is separate from the local sanitary sewer systems, and does not route flows through a treatment facility prior to discharge. MS4s use a series of structures such as roadside culverts, pipes, ditches, and retention basins designed to guide stormwater through developed areas for discharge without treatment to outfalls permitted under the NPDES program. These NPDES permits are commonly called “MS4 permits” or “Stormwater Permits,” and are issued by the SWRCB through its nine RWQCBs; these permits require implementation of a Stormwater Management Program (SWMP) for permit compliance. The SWMP must include pollution prevention measures, treatment or removal techniques, monitoring, use of legal authority, and other appropriate measures to control the quality of stormwater discharged to storm drains and eventually to waters of the United States.

During wet weather conditions, there is sufficient flow volume and velocity within an MS4 system that the flow travels through the system and discharges without accumulating within the system.

During dry weather conditions, runoff that occurs from non-weather events such as car washing and other wastewater discharges also enters the MS4, but due to the lower volume and velocity of dry weather conditions, these flows accumulate within the system, causing water quality concerns and risking violation of the MS4 permit conditions. Dry weather flows contain high bacteria that may be as high as wastewater, including heavy metals, pet waste, trash, and petroleum products. This can be particularly challenging for flood control districts that do not have funding to collect and treat dry weather flow, but also are obligated to water quality discharge requirements for their MS4 permits. Efforts to manage dry weather runoff include collection and disposal to an existing brine line, collection and diversion to a wastewater treatment facility, diversion to a detention pond for infiltration and evaporation, and other potential methods.

In inland areas, the quantity of dry weather flow depends largely on weather conditions and water conservation practices among other factors. Coordination by third-party clean renewable hydrogen producers with individual flood control districts and MS4 operators should be conducted to characterize dry weather flow as a potential supply source.

3.10 Urban Stormwater Capture and Reuse

Water supply derived from urban stormwater capture can create a water supply from runoff that would otherwise be discharged across the ground surface or through the local stormwater conveyance system. Some water agencies such as the Los Angeles Department of Water and Power (LADWP) are undertaking large-scale stormwater capture and reuse programs, which allow the agency to collect flows during wet periods and store that water for later use during dry periods.

Stormwater capture and reuse may be conducted on various scales, and could be scaled to project-specific sizes. Supply generation can be seasonally limited and may not provide a constant supply source. Urban capture and reuse programs are also typically developed to provide local water supply resiliency, and decrease the area's reliance on imported supply. Future clean renewable hydrogen producers could work with agencies overseeing stormwater capture projects or could help develop stormwater capture projects as a potential water source for hydrogen development.

Part 4: Mechanisms of Supply Acquisition

Water supply for clean renewable hydrogen development may be acquired through several different mechanisms, including through exchange agreements, working with local water agencies (purchase available supplies or develop partnerships for mutual benefit), participation in water markets, or through purchase of land with water rights. Each of these mechanisms is described in the sections below.

4.1 Exchange Agreements

A water “exchange” is an agreement under which a water seller provides an amount of surplus water to a buyer and the buyer provides a replacement water supply in the same amount to the seller, within the seller’s service area or territory. A replacement water supply could consist of a new facility or participation in existing supply development projects or programs.

Exchange agreements are anticipated to have the greatest potential to provide water supply for clean renewable hydrogen development, compared to the other supply acquisition mechanisms discussed herein and the water supply sources discussed in Part 3, *Potential Water Supply Sources*. This is due to the potential for exchange agreements to provide large quantities of water, and to provide such water in areas where naturally occurring sources may be limited.

4.1.1 Water Sources for Exchange Agreements

The specific water sources used in an exchange agreement are determined by the parties involved in the exchange, based upon their location and available supply source(s). However, any exchange agreement to support clean renewable hydrogen production is anticipated to involve one or more of the imported surface water supply projects in California, because imported surface water supplies comprise a substantial portion of Southern California’s water supply portfolio and most water agency supplies are comprised at least in part of imported surface water.

Imported surface water in Southern California is provided through the SWP, the Colorado River, and the CVP; see Section 2.3, *Key Water Supply Projects*. For each of these projects, water is distributed to contractors that hold water allocations to the respective projects; contractors distribute their portion of the project to individual connections and water agency customers to meet water needs projected in their respective UWMPs (see Section 2.4.1, *Urban Water Management Plans*). Water from the SWP, Colorado River, or CVP, can be obtained through purchase or transfer of rights from an existing contractor, or through exchange for a replacement supply.

Section 3.1, *Imported Surface Water in the Study Area*, provides an overview of the facilities and allocations associated with the SWP, CR, and CVP that are present within SoCalGas’s service territory.

4.1.2 Examples of Scale and Source

Exchange agreements have historically been used in California to facilitate land uses and maximum beneficial use of available water supply sources. This section provides brief summaries of several different types of existing exchange agreements used to provide water supply in areas that would not otherwise have access to the subject supply source(s).

Coachella Valley Water District and Metropolitan

CVWD receives its allocation of SWP through Metropolitan, allowing CVWD to access SWP water despite not having an infrastructure connection to the SWP system or California Aqueduct. CVWD does have a direct connection to the Colorado River Aqueduct, which continues west past CVWD's service area into Metropolitan's service area and Metropolitan, in turn, has direct connections to the SWP system.

CVWD has entitlements for both SWP water and Colorado River water; therefore, to collect its portion of SWP water, CVWD has an exchange agreement with Metropolitan. Under this agreement, CVWD withholds a portion of Metropolitan's Colorado River water from the Colorado River Aqueduct in an amount equal to CVWD's allocation of SWP water for the given year; in exchange, Metropolitan keeps the same amount of water from the SWP's California Aqueduct, effectively completing the exchange of SWP water for Colorado River water, allowing CVWD to utilize its full allocations (as available) from both projects.

San Joaquin River Exchange Contractors

Exchange agreements have been used throughout the history of California's development. In the early 1870's in the Central Valley, irrigation canals began to be constructed to divert water from the San Joaquin River and the Kings River to allow for irrigation in the western portion of Fresno, Madera, Merced, and Stanislaus counties. As the need for more irrigation and farmable land in the Central Valley increased, the USBR began construction of the CVP in 1933 (see Section 2.3.3, *Central Valley Project*). One of the dams constructed was the Friant Dam, located north of Fresno, which was needed to provide water the San Joaquin River to agricultural uses on the east side of the Central Valley (SJRWA 2023). This would impact water supply from the San Joaquin River that farmers on the west side of the valley depend on. Therefore, the San Joaquin River Exchange Contractors ("Exchange Contractors") and the "Friant Division Contractors" were formed.

- Exchange Contractors are the original water rights holders for use of San Joaquin River water on the west side of the Central Valley. USBR acquired water rights for the Friant Division in 1939 through purchase and exchange agreements with these original water rights holders. USBR delivers CVP water to the Exchange Contractors in amounts equal to each Exchange Contractor's original rights to San Joaquin River water (FWA 2018).
- Friant Division Contractors include 32 water districts and agencies that receive water supply from Lake Millerton, which is formed by Friant Dam and entrains water from the San Joaquin River. Friant Division Contractors pay for the operation and maintenance of facilities used to provide CVP water to the Exchange Contractors (FWA 2018), without which the Friant Division Contractors would not have access to San Joaquin River water.

As summarized above, the Exchange Contractors retained their rights to the San Joaquin River water through the exchange agreement. In normal water years, the Exchange Contractors are guaranteed 100 percent of their contractual water allotment (840,000 AFY) and in critical years the amount is 75 percent (650,000 AFY) (SJRWA 2018).

Chino Basin Program

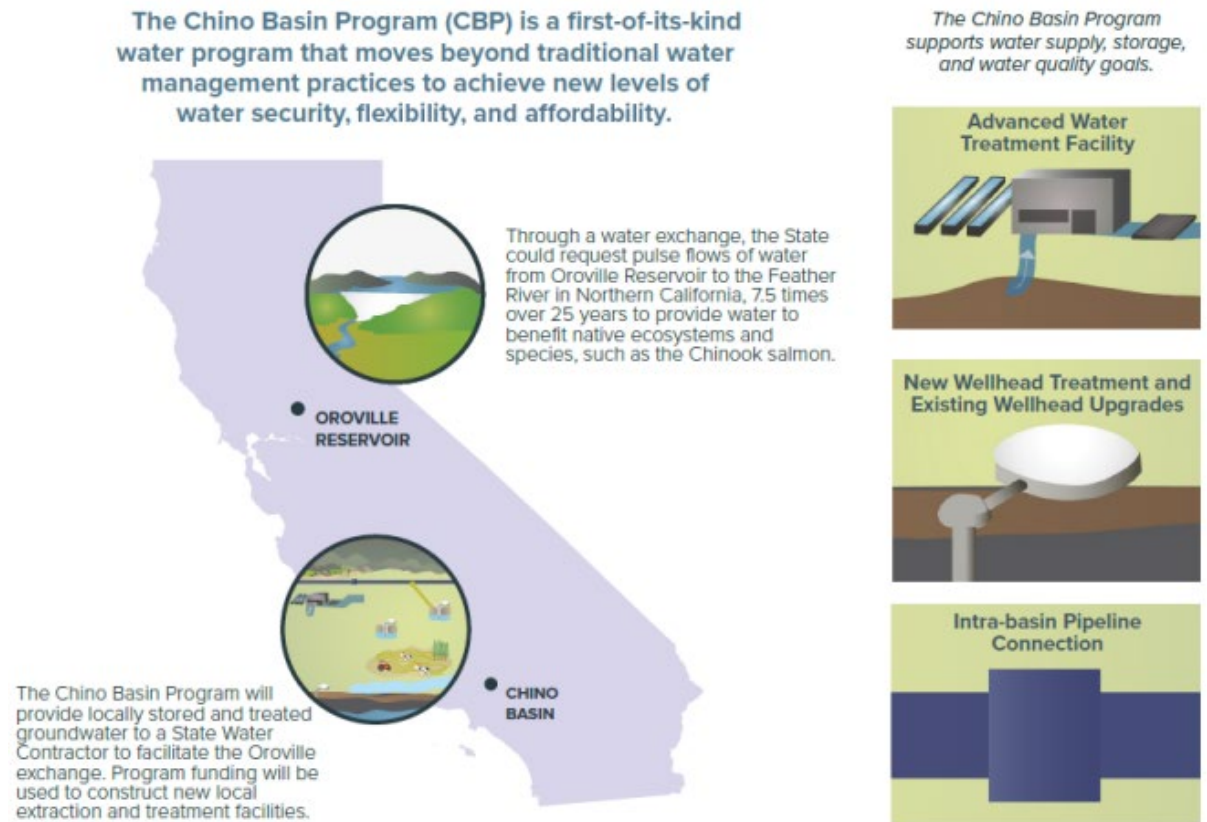
The CBP is a 25-year conjunctive use project, under which Inland Empire Utilities Agency (IEUA) uses a new advanced water purification facility (AWPF) to create a new recycled water supply amounting to 15,000 AFY. Over the program's 25-year lifetime, creating 15,000 AFY of recycled water will

generate 375,000 acre-feet of total new supply. Under the exchange agreement between IEUA and DWR, new supply from the AWPf will be stored in the Chino Groundwater Basin (“Chino Basin”), and will be provided to DWR incrementally over the project’s 25-year lifetime. DWR may request portions of this new supply in “call years” which occur once every 7.5 years, for a maximum request of 50,000 acre-feet in one call year.

DWR receives its share of the new supply in Northern California, at the headwaters of the SWP, not at the location of the AWPf and Chino Basin. This is accomplished through exchange, using IEUA’s SWP Contractor partner for this project to facilitate the physical exchange of water; IEUA’s SWP Contractor partner for the CBP is Metropolitan. DWR accesses the exchange water by withholding it in Lake Oroville rather than releasing the flows into the Feather River for conveyance to SWP contractors in Southern California (as discussed in Section 2.3.1, *State Water Project*, the Feather River provides the headwaters for the SWP as snowmelt from the Sierra Nevada Mountains). Metropolitan, as IEUA’s SWP Contractor partner in Southern California, will then receive up to 50,000 acre-feet less from the SWP system for the given call year, and Metropolitan will in turn withhold this amount from deliveries of SWP water to IEUA during the respective call year, effectively completing the exchange between DWR and IEUA (Metropolitan 2021).

Figure 1-35, below, provides an overview of the CBP.

Figure 1-35 Location and Features of the Chino Basin Program



Source: CWC 2022

4.2 Local Water Agencies

Water agencies provide water for various potable (drinkable) and non-potable (not drinkable) purposes, referred to collectively as “Municipal and Industrial” or “M&I” water. M&I water use includes all residential, commercial, institutional, and industrial uses. Developers of clean renewable hydrogen projects may reach out to water agencies for exploring several alternatives of securing water supply, described below.

4.2.1 Purchase Available Supply

Water supply may be purchased from local water agencies drawing upon their locally available supplies, which may include imported surface water, sustainably managed groundwater, developed water such as treated wastewater, and surplus water from previous wet weather years that has been stored in water banks for future use. As discussed in Section 2.4, *Urban Water Management Planning*, water needs associated with anticipated M&I uses and associated water supply availability are documented in agency-specific UWMPs. Clean renewable hydrogen production projects are not documented in the current UWMPs reviewed from water agencies within SoCalGas’s territory. However, future clean renewable hydrogen producers can work closely with water agencies with specific project proposals. Water agencies that are interested in supporting hydrogen development may start to include water needs for those projects in their supply planning and UWMPs or commit to serve specific projects.

4.2.2 Partnership for Mutual Benefit

Water supply may be developed through partnerships between future hydrogen producers and water agencies. Such partnerships could be designed for mutual benefit, by providing a water supply source for clean renewable hydrogen development, while also supporting local development of supplemental supply sources, or removing a nuisance for the local agency. For example, as discussed in Part 3, *Potential Water Supply Sources*, supply sources that could potentially be developed for clean renewable hydrogen include existing waste streams (brine line flows) and dry weather flows, which commonly pose a management challenge to local agencies that do not have the resources to proactively manage such issues.

4.3 Water Markets

A “water market” refers to the transfer or sale of water or water rights from one user to another, typically from an agricultural to an urban water agency (WEF 2023b).

4.3.1 Adjudicated Groundwater Rights

Please see Section 3.3.2, *Adjudicated Groundwater Basins*, for discussion of adjudicated basins with respect to basin prioritization rankings.

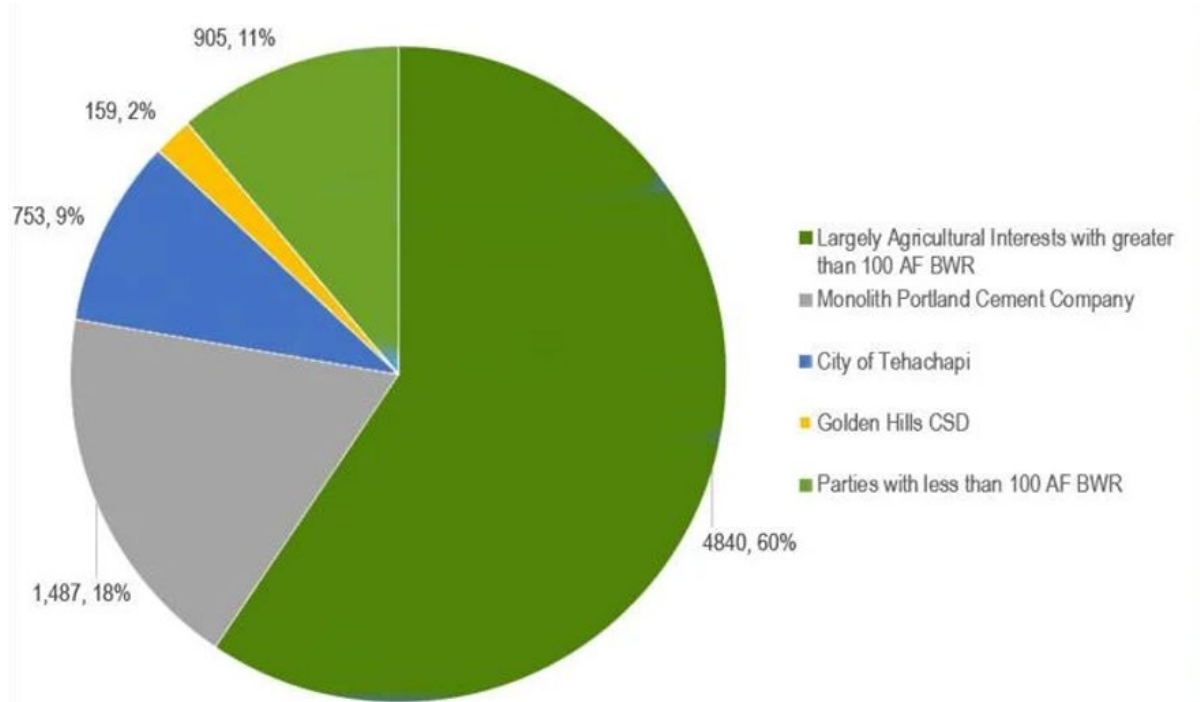
In some adjudicated areas, unused allocations or surplus water supply is available for purchase through existing water markets, subject to approval of the Watermaster. The conditions placed on water rights transfers or sales within adjudicated areas vary depending upon the specific Adjudication Judgement and Watermaster. In many adjudicated areas, groundwater is required to be used within the same basin, while in other areas it is possible to convey or exchange adjudicated

groundwater to locations outside the basin. Amendments to an adjudication judgment may also be issued as needed to revise water rights information, including but not limited to ownership.

The Tehachapi Basin, identified as adjudicated basin number 22 in Figure 1-28, *Adjudicated Groundwater Basins in SoCalGas’s Service Territory* (see Section 3.3.2, *Adjudicated Groundwater Basins*), provides an example of how water rights in an adjudicated basin can shift between water rights holders, including changes of ownership. The Tehachapi Basin is managed by the Tehachapi-Cummings County Water District (TCCWD) as the court-designated Watermaster responsible for compliance with the adjudication judgment. As stipulated by the court in the adjudication judgment, the average annual safe yield for the Tehachapi Basin is 5,500 AFY (TCCWD 2022).

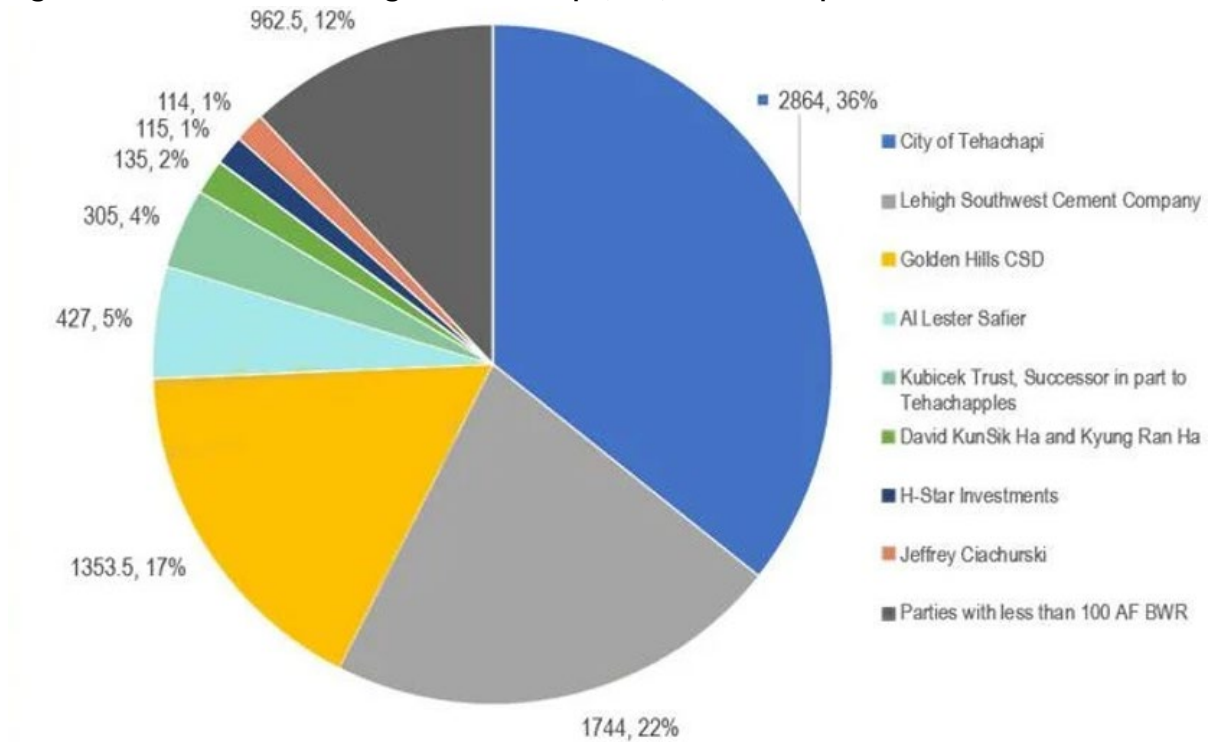
Since adjudication of the Tehachapi Basin in 1971, the City of Tehachapi has systematically increased its share of base annual production (BAP) water rights in the basin from approximately nine percent in 1971 to approximately 36 percent in 2018 (TCCWD 2022). This effort has been in response to land use and economic changes, as agriculture has diminished in importance to the local economy and population continues to increase (TCCWD 2022). Figure 1-36 and Figure 1-37, below, provide an overview of these base water rights in 1971 and in 2018, for comparison.

Figure 1-36 Base Water Rights Ownership (AFY) – Tehachapi Basin, 1971



Source: Elliot 2023; TCCWD 2022

Figure 1-37 Base Water Rights Ownership (AFY) – Tehachapi Basin, 2022



Source: Elliot 2023; TCCWD 2022

Figure 1-36 and Figure 1-37 above demonstrate that a water market can be used to change the distribution and ownership of water rights in an adjudicated area. These figures also show that a substantial portion of base water rights in the Tehachapi Basin are owned by a cement company; in 1971 the Monolith Portland Cement Company held rights to 1,487 AFY of water from the Tehachapi Basin, then changed ownership over the years, becoming the Lehigh Southwest Cement Company by 2018 with rights to 1,744 AFY (Elliot 2023). Cement manufacturing comprises a substantial portion of base water rights in the Tehachapi Basin because the 1971 adjudication judgement determined Base Water Rights by the “doctrine of mutual prescription,” which does not consider priority of uses, but rather defines Base Water Rights as the “highest continuous extractions of water by a party from the basin for beneficial use in any period of five consecutive years after the commencement of overdraft in Tehachapi Basin” (Elliot 2023).

The acquisition of base water rights is conducted through purchase, annexation, and consolidation. If base water rights may be purchased or leased from existing rights holders within an adjudicated Tehachapi Basin, and if that water may be used outside the Tehachapi Basin, it could potentially be developed as a water supply source for clean renewable hydrogen development. Other adjudicated basins present similar opportunities. Third-party clean renewable hydrogen producers should consider the potential to acquire water supply through an adjudication judgment on a case-by-case basis including through coordination with respective Watermasters.

4.3.2 Wet Weather Surplus Flows

Wet weather flows consist of surface water runoff that occurs during years of above-average precipitation, including snowpack. Wet weather flows can result in surplus flows, which consist of any supply available in excess of local demands. This is water that is available after all existing

demands and contractual obligations are met for the respective water year. Wet weather surplus flows may be available for purchase from SWP contractors through existing water markets.

As discussed in Section 2.3.1, *State Water Project*, under “Article 21 Water,” during some wet weather years (as determined by DWR), SWP contractors may have access to additional flows provided through the SWP conveyance system, separate and in addition to Table A allocations. The availability of Article 21 water, also referred to as “interruptible water,” may not be carried over for delivery in a subsequent year, and may not affect approved deliveries of Table A water to SWP contractors. There is no storage for Article 21 water in the SWP system; it must be taken from the system as available (Austin 2018). If an eligible SWP contractor does not have the ability to receive or store Article 21 water when it is available to them, the contractor may enter an agreement with DWR to provide storage through a “change in point of deliveries” agreement. (Austin 2018)

As an example of how surplus water may be procured through existing markets, the Darden Clean Energy Project (see Section 3.3.1, *Basin Prioritization and Availability*), located in Fresno County, proposed in November 2023 application documents to the CEC to procure the majority of its operational water from surplus supplies purchased through WWD. The targeted surplus occurred in response to unusually high precipitation during water year 2022-2023; as proposed, this water would be purchased from WWD as Article 21 water, then stored for the Darden project through groundwater banking conducted in collaboration with WWD. The water would be accessed as needed throughout the lifetime of the project, with its entire operational demands of 1,039 AFY met using surplus flows acquired from WWD during and since the wet water year of 2022/2023. (IP Darden I LLC 2023)

4.4 Land Purchase with Water Rights

In California, water rights permits typically specify the allowed uses for the subject water. There are certain water rights associated with land ownership that may provide a potential mechanism to acquire water supply for the production of clean renewable hydrogen. The availability of water rights associated with specific properties can be determined through review of property ownership records to confirm the type of right(s) associated with the subject property, and to confirm that such rights were not previously severed from the subject property.

The purchase of land with attached water rights would allow the new landowner to use water associated with the attached rights for “reasonable and beneficial” purposes. As such, the purchase of land with water rights could provide a potential water supply source for the production of clean renewable hydrogen.

4.4.1 Water Rights Attached to Real Estate

California has a complex legal framework for water rights attached to real estate. This section provides an overview of the types of water rights applicable to the potential possibility of acquiring water supply through the purchase of land with attached water rights.

Overlying Groundwater Rights

Landowners in California are entitled to pump and use a “reasonable amount” of groundwater from beneath their land, as long as it is put to a “beneficial, non-wasteful” use. The concepts of “safe yield,” “surplus,” and “overdraft” are key to assessing how much water can reasonably be

withdrawn from a basin, and are determined on a basin-specific basis by the local management agencies (WEF 2023d).

An overlying groundwater right is the right of a landowner to extract groundwater from beneath their property, for use on land overlying the subject groundwater basin. Overlying rights:

- Are contingent upon the produced water being put to “reasonable and beneficial use;”
- Are correlative (related to each other), meaning the rights are held in common with all real property-based users of the same water source;
- In the event of a water shortage, responsibility for the shortage is shared by all users regardless of their location within the basin, and landowners are expected to collectively reduce their pumping rates as needed for alignment with the safe yield of the basin;
- Are not lost due to nonuse; and
- Cannot be used outside the subject groundwater basin (BBK 2021).

Riparian Water Rights

Riparian rights are held by landowners with property bordering streams, and entitle the landowner to use a correlative share (see above) of the water flowing past his or her property. Riparian rights:

- Do not require permits, licenses, or government approval;
- Apply only to the water which would naturally flow in the stream;
- Do not entitle a water use that diverts water to storage for use in the dry season;
- Do not entitle use of the water on land outside of the watershed; and
- Remain with the property when it changes hands unless the subject parcel(s) have been severed from the adjacent water source (SWRCB 2020).

Under California law, a riparian water right arises by virtue of ownership of riparian land, which is defined as the smallest parcel of land contiguous to a watercourse, in a single chain of title from the original private owner, that is within the watershed of the subject watercourse (BBK 2021). Riparian rights have a higher priority than appropriative rights (see below); the priorities of riparian right holders of a common resource generally carry equal weight, such that during drought conditions, all common riparian rights holders share the shortage among themselves.

Appropriative Rights

In contrast with riparian and overlying water rights, water transported away from its source for use on land that is not adjacent to the surface water source or at a location outside the watershed or groundwater basin generally falls under a different category of water rights, and thus is subject to a distinct set of rules and regulations. In California, this use is categorized as an “appropriative” water right. Appropriative water rights:

- Are generally junior to riparian and overlying rights, which means that appropriative rights can only be exercised when there is surplus water after overlying and riparian uses are met;
- Are subject to the doctrine of prior appropriation, which means that priority is determined based upon the date the use began or the date a permit was obtained;
- Can be used at locations separate from where they originate;
- Can be lost through nonuse; and
- May be subject to the state permitting authority (BBK 2021).

4.4.2 SGMA and Water Rights

The Sustainable Groundwater Management Act (SGMA) requires land use plans to consider groundwater sustainability plans and to assess the impact of land use on groundwater. SGMA prioritizes local management of groundwater resources; if local entities are unable to manage the local resources, the SWRCB may intervene to develop and implement a GSP for the respective basin. State intervention would generally be an undesirable outcome for most local agencies. Table 1-7, presented in Section 2.2, *Laws and Regulations*, describes that the purpose of SGMA is for local agencies and stakeholders to conduct groundwater management towards the purpose of reversing overdraft conditions and achieving sustainable conditions according to a SGMA-established timeline.

SGMA does not alter water rights, including overlying groundwater rights, riparian water rights, and appropriative rights, as discussed above in Section 4.4.1, *Water Rights Attached to Real Estate*. However, due to the correlative nature of the types of water rights associated with land ownership, water rights holders may be expected to reduce their use of water rights as needed to achieve the goals of SGMA. Compliance with SGMA requires DWR approval of a GSP for the basin, and proven accomplishment of specific sustainability goals to reverse overdraft and create sustainable groundwater conditions. The GSP typically quantifies the groundwater budget and safe yield of a subject basin, and may set limits to the amounts of groundwater that can be produced while supporting sustainable conditions in the basin.

Therefore, although SGMA does not alter water rights, compliance with SGMA may require water rights holders to reduce their rates of groundwater production towards the common purpose of achieving and maintaining sustainable groundwater conditions while supporting existing uses. There is incentive for landowners with attached water rights to comply with the respective GSP because non-compliance with SGMA could result in state intervention. Although GSPs may result in reduced pumping rates, GSPs may also allow for specific water uses that were either not previously documented, were unclear, or were previously not available.

As discussed in Section 3.3.1, *Basin Prioritization and Availability*, the Darden Clean Energy Project, as proposed in November 2023 application documents to the CEC, would acquire part of its water supply through the acquisition of land with attached water rights. Based upon the terms of a confidential Option Agreement between WWD and the Applicant, the Darden project companies would receive 2 AFY for every 320 acres of land acquired within the project site and developed for solar energy. WWD is also the primary GSA for the Westside Subbasin, and is responsible for SGMA compliance and the development of sustainable groundwater conditions. Therefore, WWD's approval of these water rights is consistent with the Westside Subbasin GSP and SGMA objectives.

Part 5: Conclusions

Water supply for future clean renewable hydrogen projects may be sourced from existing supply sources (see Part 3) including: (i) imported surface water; (ii) treated wastewater; (iii) groundwater; (iv) agricultural industry water; (v) brine line flows; (vi) advanced water treatment concentrate; (vii) oil and gas industry water; (viii) inland brackish groundwater; (ix) dry weather flows; and (x) urban stormwater capture and resource. Water supply may be acquired by future clean renewable hydrogen producers through various mechanisms (see Part 4) including: (i) exchange agreements; (ii) purchase from or partnership with local water agencies; (iii) participation in water markets; and (iv) land purchase with water rights. In addition to these existing supply sources and mechanisms of acquisition, new supply opportunities may also be developed between future hydrogen producers and local water agencies.

Below is an overview of key conclusions of this Water Availability Study, prepared under the Water Supply Evaluation of the Angeles Link Phase 1 feasibility investigations.

- The volume of water needed for third-party clean renewable hydrogen producers to produce the quantity of clean renewable hydrogen to meet 2045 demand across SoCalGas’s service territory comprises a small percentage (0.02 to 0.10 percent) of total annual applied water in California for urban (M&I), agricultural, and environmental purposes.
- Third-party clean renewable hydrogen producers may draw from a number of water supply sources to meet the water needs to produce the clean renewable hydrogen to meet the overall expected SoCalGas service territory demand and the portion of that demand that would be transported by Angeles Link.
- The water supply sources identified in Part 3 of this chapter may be considered by third-party clean renewable hydrogen producers to pursue quantities sufficient to meet the water needs for their respective projects to produce the clean renewable hydrogen to meet the overall service territory demand, including expected Angeles Link throughput.
- A substantial portion of water needs for clean renewable hydrogen production may be met using existing water supply sources and mechanisms of acquisition. New supply sources may also be developed to support clean renewable hydrogen production projects.
- Shifting water needs and obligations may change over time as uses for water in the state evolve and may present opportunities for new water supply development, such as but not limited to water offset from reduced oil and gas operations, additional storage and banking, expanded wastewater treatment, and increased desalination. These shifts will be documented in water supply providers’ UWMP updates, which occur every five years and include projections of the water needs and supply availability within the respective UWMP area over a 20-year planning horizon.
- The potential water supply sources available to feed specific clean renewable production projects can be further evaluated and developed on a case-by-case basis as more details on specific clean renewable hydrogen production projects are developed.

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Chapter 2: Water Quality Requirements for Hydrogen Generation

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Water Quality Requirements for Hydrogen Generation

Executive Summary

This technical memorandum (TM) provides findings based on a desktop level review of water quality requirements for the production of clean renewable hydrogen as part of the Water Resources Evaluation to support the Phase 1 feasibility studies for the Angeles Link project (“Angeles Link”) proposed by Southern California Gas Company (SoCalGas). This technical memorandum provides an overview of the water requirements for hydrogen generation via electrolysis. While SoCalGas would not produce clean renewable hydrogen as part of Angeles Link, the purpose of this memorandum is to summarize the water quality and quantity requirements for the electrolyzers that third-parties may use to produce clean renewable hydrogen.

First, this technical memorandum considers electrolysis technologies involved in hydrogen production and details three primary commercialized electrolysis technologies: alkaline, polymer electrolyte membrane (PEM), and solid oxide electrolysis cell (SOEC) electrolyzers.

Second, the memorandum summarizes water quality specifications for electrolyzers. Water quality is critical to the lifespan and efficiency of electrolyzers, with impurities potentially causing damage or repairs. The memorandum specifies that treatment of feed water is necessary for current technologies like PEM and alkaline electrolyzers, with Reverse Osmosis (RO) being a common pretreatment method. The memorandum also summarizes the expected water quality, treatment stages, and target contaminants for various source waters, emphasizing the need for ultrapure water to prevent electrolyzer damage.

Finally, the memorandum discusses the overall water quantity requirements for hydrogen generation, which includes water consumed in the pretreatment process, the electrolysis process itself, and cooling of electrolyzer equipment. It explains that water quantity consumed in electrolysis is directly proportional to the amount of hydrogen produced, with specific figures provided for the water required per kilogram of hydrogen and per day per MW of electrolyzer capacity. Additionally, this memorandum outlines the cooling water quantity requirements, comparing closed-loop air cooling and open-loop cooling towers in terms of water usage and efficiency.¹

1. Electrolysis Technologies for Hydrogen Production

Electrolysis of water to produce hydrogen involves using electricity to decompose water (H₂O) into oxygen (O₂) and hydrogen (H₂) gas (Rodriguez, 2020) by providing electricity as summarized in the following chemical equation:



The above chemical reaction shows that energy is a required input for generating hydrogen in addition to water. Electrolyzers used for clean renewable hydrogen generation typically contain anodes and cathodes submerged in electrolyte. The types of electrolyzers differ by the type of electrolytes and electrodes used.

There are two water electrolysis technologies that have been commercialized and used in large-scale hydrogen generation projects (Schmidt et al., 2017), namely alkaline electrolyzers and polymer

¹ For additional analysis of estimated water quantities, see further analysis in Chapter 3, Technical Memorandum for Water Acquisition and Purification Costs.

electrolyte membrane (PEM) Electrolyzers. Solid oxide electrolysis cell (SOEC) electrolyzer technology is not as widely commercialized but has drawn great attention in the past few decades as an efficient electrolyzer technology (Schmidt et al., 2017).

2. Electrolyzer Water Quality Specifications

Water quality used for water electrolysis can impact the life span of an electrolyzer because certain ions, molecules, and compounds present in the water can cause irreversible damage to electrolyzers. Hence, treatment of feed water for electrolyzers are required using the current electrolyzer technologies, such as PEM and alkaline electrolyzers (Schmidt et al., 2017). The water quality requirements for an electrolyzer vary depending on the type of electrolyzer technology and the manufacturer. Reverse osmosis is commonly used as the main pretreatment technology for electrolyzers (Simoes et al., 2021). **Table 2-1** summarizes the expected water quality, treatment stage, and target contaminants removed.

Table 2-1. Treated Water Quality, Treatment Stage, and Target Contaminants

Potential Source Water	Treatment Stage	Expected Treated Water Quality	Treatment Stage	Target Contaminants
Water sources of lower quality than recycled water or potable water ¹	Pretreatment for RO	Recycled water and potable water	Pretreatment for RO, processes vary depending on water quality	Suspended solids, oil and grease, organics, microorganisms, nuisance compounds (e.g., iron, manganese, hardness) (MWH, 2012)
Recycled water and potable water	Reverse Osmosis	Deminerlized water, boiler feed water	Reverse Osmosis	Total dissolved solids, conductivity, total and dissolved organic compounds, and other dissolved contaminants, e.g., boron (MWH, 2012)
Deminerlized water	Post-RO Polishing	Deionized, ultrapure water	Post-RO Polishing	Gas, silica, conductivity, and TOC (MWH, 2012)

Note: ¹ Chapter 1 (Water Availability Study) considered imported surface water, treated wastewater, groundwater, agricultural industry water, brine line flows, advanced treatment concentrate, inland brackish groundwater, dry weather flows, and urban stormwater capture and reuse.

Treatment of source water to ultrapure water has two main steps: pretreatment of raw water and polishing to ultrapure water. The pretreatment process is designed to remove the bulk of the constituents, such as suspended solids, salts, organics, and microorganisms, from a selected source water supply, such as municipal potable water, seawater, and groundwater. The number of pretreatment steps required can vary depending on the source water quality; and the use of RO is commonly used as the final pretreatment step. For example, groundwater contains dissolved redox-active species such as iron and manganese, which can precipitate and damage RO and require removal of these constituents. Pretreatment steps required could involve oxidation and sand filtration prior to RO. Seawater requires the removal of suspended solids, organics, and microorganisms before RO. The polishing step is typically used to remove constituents that are present in low concentrations and are difficult to be removed to levels meeting the electrolyzer feed water requirements using RO along. These constituents include conductivity (ions contents), hardness, total organic carbon (TOC), and silica.

The water quality after RO is usually of high purity already. Water resistivity, water conductivity, total organic carbons (TOC), are commonly used to indicate the level of water purity instead of measuring individual ions or organic species that still be present in the water. Certain difficult-to-remove contaminants that have high potential to cause damages to electrolyzers, such as silica, are the exceptions and they usually have separate water quality requirements specified by manufacturers. **Table 2-2** shows the water quality specifications for ultrapure water defined by American Society for Testing and Materials (ASTM).

Table 2-2. Water Quality Specifications for Ultrapure Water (ASTM, 2023)

Water Quality Parameter	Value	
	Type I Ultrapure Water Defined by ASTM	Type II Ultrapure Water Defined by ASTM
Water resistivity (MΩ/cm)	>18	>1
Water conductivity (µS/cm)	<0.056	<1.0
TOC (ppb)	<50	<50
Silica (µg/L)	<3	<3

The two main electrolyzer technologies, PEM and alkaline electrolyzers, require ultrapure water. Ultrapure water for alkaline electrolyzer can be obtained by advanced water treatment processes, such as double-pass reverse osmosis (RO) followed by electrodeionization (EDI) as the polishing step. In contrast, PEM requires advanced water treatment and continuous internal water polishing in the electrolyzer cells. Most PEM electrolyzer manufacturers suggest ASTM D1193-06 Type I or II water; however, there are exceptions. For example, Eurowater, an electrolyzer supplier, only requires water conductivity of <0.2 µS/cm and <5 µS/cm for PEM and alkaline electrolyzers, respectively (Eurowater, 2023).

Unlike PEM and alkaline electrolyzers that require ultrapure feed water, SOECs usually has lower water quality requirements because it operates at very high temperature (650 to 1,000 °C) where steam is fed into the electrolyzer (Schmidt et al., 2017). As noted above, different membraneless electrolyzers require different water quality depending on their materials and/or operation conditions. Some of membraneless electrolyzer technologies can use seawater as feed water directly without any pretreatment necessary, such as sHYp. Other membraneless technologies such as CPH2 electrolyzer only require potable water quality, while others such as Hydrox electrolyzer require demineralized or deionized water with a specific pH. Table 2-3 summarizes the water quality requirements for these electrolyzer technologies.

Table 2-3. Typical Water Quality Summary Table

Electrolyzer Technologies	Typical Water Quality Requirements
Alkaline Electrolyzer	Alkaline electrolyzers typically require ultrapure water. Higher water conductivity of <5 µS/cm for Alkaline electrolyzers has also been recommended.
PEM Electrolyzer	PEM electrolyzers require ultrapure water. Various sources such as Eurowater suggests water conductivity of <0.2 for PEM electrolyzers.
SOEC	Some SOEC manufacturers such as Sunfire suggest using deionized or boiler feed water but most of the SOECs such as Nexceris' SOEC usually do not require high quality water (Sunfire and Nexceris).
Membraneless electrolyzers	Some membraneless electrolyzers such as sHYp electrolyzer use untreated seawater. Some such as CPH2 electrolyzer work with potable water, while others such as Hydrox electrolyzer require demineralized or deionized water with a specific pH.

3. Water Quantity Requirements

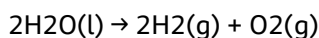
Water quantity requirements consists of three main components:

- Water consumed in pretreatment process
- Water quantity consumed in electrolysis process
- Water utilized in cooling of electrolyzer equipment

This section discusses water demands for the electrolysis process and cooling for PEM technology. Water demands for pretreatment processes and estimates of the combined water demands for pretreatment, electrolysis, and cooling for the production of clean renewable hydrogen are discussed in Chapter 3, Technical Memorandum for Water Purification and Acquisition Costs.

3.1 Water Quantity Requirements for Hydrogen Generation

Water quantity consumed in water electrolysis process is directly proportional to the amount of hydrogen produced because of the conservation of mass. The chemical reaction for water electrolysis summarized in the equation below.



The molecular mass of water (H₂O) is 18.015 g/mol, while the molecular mass of hydrogen (H₂) is 2.016 g/mol and the molecular mass of oxygen (O₂) is 31.998 g/mol.

Therefore, for every 36.030 g of water that is electrolyzed, 4.032 g of hydrogen and 31.998 g of oxygen are produced. More simply, for every 1 kg of H₂ produced, 9 kg of H₂O is required from a stoichiometric point of view (Shi et al, 2020). One kilogram of water is equivalent to one liter of water, so therefore 9 liters (2.378 gallons) of ultrapure water is needed to produce 1 kg of hydrogen (Shi et al, 2020).

3.2 Water Quantity per Size of Electrolyzer

The amount of water required is proportional to the electrical load of the electrolyzers and electrical efficiency of electrolyzers. The electrical efficiency of an electrolyzer is a measure of how effectively it converts electrical energy into the chemical energy stored in hydrogen gas. It is typically expressed in terms of the amount of electrical energy required to produce one kilogram of hydrogen (kWh/kg). The energy stored in one kilogram of hydrogen is 39.4 kWh (higher heating value). Therefore, a 100% efficient liquid water electrolyzer would consume 39.4 kWh/kg.

The electrical efficiency of an electrolyzer depends on various factors, such as the design of the electrolyzer, the type of electrode materials used, the temperature and pressure of the electrolyte, and the purity of the water. Generally, modern electrolyzers have electrical efficiencies ranging from 70% to 80%, meaning that it takes between 50 and 60 kWh of electrical energy to produce one kilogram of hydrogen gas (O. Schmidt et al, 2027).

Based on the rate of 50 to 60 kWh/kg, the amount of hydrogen produced per MW electrolyzer size is between 480 and 400 kg/day, respectively. Therefore, the water quantity required in the electrolysis process using technologies such as alkaline electrolyzers and PEM, is between 1,100 and 950 gallons of ultrapure water per day per MW of electrolyzer capacity. The source water quantity required to produce ultrapure water is larger because of treatment losses and will vary depending on the quality of the source water.

3.3 Electrolyzer Cooling Water Quantity Requirements

The cooling requirements of an electrolyzer depend on the amount of heat generated during the electrolysis process, which can be influenced by factors such as the current density, the operating voltage, and the flow rate of the electrolyte. In general, the higher the current density and the operating voltage, the greater the heat generated by the electrolyzer. SOEC usually does not have large cooling demands since the thermal energy from the high temperature outlet gases of SOEC is utilized to preheat the inlet gases via a heat exchanger network.

There are two main methods of cooling for an electrolyzer: closed-loop air cooling and open-loop cooling towers as shown in **Figure 2-1**. Cooling methods should be selected based on environmental, location, water availability, and electrolyzer manufacturer recommendations.

- Closed-loop air cooling involves using a cooling system that circulates air through a heat exchanger to remove the heat generated by the electrolyzer. The heated air is then discharged outside the facility. This method is typically used for smaller electrolyzers and in situations where water is not readily available or is expensive. Closed-loop air cooling typically requires between 0 and 100 gallons of water per day per MW of electrolyzer capacity (R. Niekerk and R. Manita, 2022).
- Open-loop cooling towers use water as the cooling medium. The hot water from the electrolyzer is circulated through a cooling tower, which is cooled by evaporation and then returned to the electrolyzer. Open-loop cooling towers typically require between 2,000 and 4,000 gallons of water per day per MW of electrolyzer capacity (R. Niekerk and R. Manita, 2022; Eurowater, 2023).

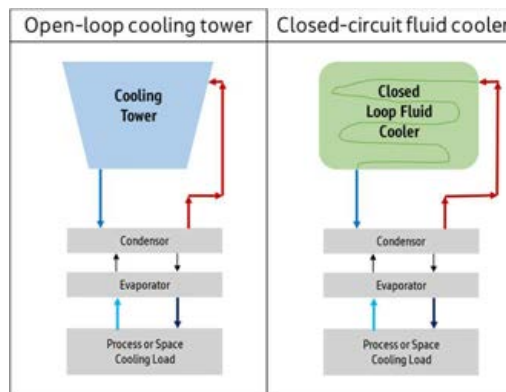


Figure 2-1. Main Cooling Technologies used for PEM and Alkaline Electrolyzers (modified from Michaels Energy, 2023.)

4. Summary

Electrolysis of water uses electricity to break down water into oxygen (O₂) and hydrogen (H₂) gas. When coupled with renewable energy, electrolysis is a pathway to producing clean renewable hydrogen. Currently, the most readily available electrolyzer technology includes alkaline and PEM electrolyzers. However, SOEC and other advanced technologies are rapidly gaining interest and availability.

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Chapter 3: Water Acquisition and Purification Costs

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Appendices

Appendix A Treatment Cost Summary Outputs

Appendix B Concentrate Management Cost Summary Outputs

Appendix C Conveyance Cost Summary Outputs

Acronyms and Abbreviations

\$M	million dollars
AF	acre-foot
AFC	air fin cooling
AFY	acre-foot per year
ASTM	ASTM International
AWT	advanced water treatment
AWTF	Advanced water treatment facilities
BAC	biological activated carbon
CVP	Central Valley Project
DWR	California Department of Water Resources
EDI	electrodialysis
EMWD	Eastern Municipal Water District
EPA	United States Environmental Protection Agency
GPD/MW	gallons per day per megawatt of electrolyzer capacity
GSA	Groundwater Sustainability Agencies
HDD	horizontal directional drilling
HDPE	high-density polyethylene
kg	kilogram(s)
kWh	kilowatt(s) per hour
mg/L	milligram(s) per liter
MG	million gallon(s)
MGD	million gallons per day
MMTY	million metric tons per year
MS4	Municipal Separate Storm Sewer System
NPV	net present value
NSQD	National Stormwater Quality Database
O&G	oil and gas
O&M	operations and maintenance
PVC	polyvinyl chloride
RO	reverse osmosis
RPD	Replica™ Parametric Design

Water Resources Evaluation

SAWPA	Santa Ana Watershed Project Authority
SoCalGas	Southern California Gas Company
SWP	State Water Project
TDS	total dissolved solids
TM	technical memorandum
TOC	total organic carbon
UF	ultrafiltration

1. Introduction

This chapter documenting Water Acquisition and Purification Costs has been prepared as part of the Water Resources Evaluation being prepared for the Angeles Link project (Angeles Link) proposed by Southern California Gas Company (SoCalGas). The Water Resources Evaluation is part of a larger feasibility study being conducted by SoCalGas in support of SoCalGas's proposed development of a pipeline system that will transport clean renewable hydrogen for use in Central and Southern California, including the Los Angeles Basin. The purpose of the Water Resources Evaluation is to identify and characterize water supply sources and identify costs associated with those sources that third-party producers may pursue to produce clean renewable hydrogen.

This chapter relies on and incorporates analysis from the following two studies that were prepared separately as part of the Water Resources Evaluation for the Angeles Link Phase 1 feasibility analyses:

1. Chapter 1: Water Availability Study: identifies and characterizes potential water supply sources that could support future third-party clean renewable hydrogen production.
2. Chapter 2: Water Quality Requirements for Hydrogen Generation: identifies water quality requirements for the production of clean renewable hydrogen.

1.1 Scope of Work

The scope of work for this chapter includes:

- Conducting a high-level engineering evaluation to identify water treatment and conveyance needs for the water supply types that have been identified in the Water Availability Study.
- Developing rough order-of-magnitude cost estimates for treatment, concentrate management, water acquisition, and conveyance for the water supply types that have been identified in the Water Availability Study.

The Water Availability Study (refer to Chapter 1) identified the following potential supply types:

- Source 1: Imported Surface Water
- Source 2: Treated Wastewater
- Source 3: Groundwater
- Source 4: Agricultural Industry Water
- Source 5: Brine Line Flows
- Source 6: Advanced Water Treatment Concentrate
- Source 7: Oil & Gas (O&G) Industry Water
- Source 8: Inland Brackish Groundwater
- Source 9: Dry Weather Flows
- Source 10: Urban Stormwater Capture and Reuse

Section 3 of this chapter describes each of these source types and summarizes their water quality characteristics.

1.2 Technical Approach

The technical approach used for this chapter is to develop high-level cost estimates of the main cost components of water supply (water acquisition, treatment, concentrate management, and conveyance) to support clean renewable hydrogen production for the potential identified source types in the Water Availability Study. Since specific water supply projects have not yet been identified, these costs are expressed in unit costs (i.e., costs per unit volume of water). This will support calculating rough estimates of the potential costs for third-party producers developing specific water sources for clean renewable hydrogen production.

1.3 Chapter Organization

The following is the organization of this chapter:

- Section 1: Introduction, presents the objective and approach for this task of the Water Resources Evaluation.
- Section 2: Cost Estimate Approach, describes the approach used to develop cost estimates for water supply and treatment for each of the potential sources that have been identified.
- Section 3: Water Source Types and Water Quality Characteristics, describes the potential supply types that were identified and their water quality characteristics.
- Section 4: Water Quality Requirements for Electrolyzers and Cooling, presents an overview of the water quality requirements for hydrogen production electrolyzers and cooling systems.
- Section 5: Treatment Processes and Costs, presents an evaluation of the processes and costs for pretreatment of the identified water supply sources.
- Section 6: Concentrate Management Costs, presents cost estimates for two potential concentrate management options.
- Section 7: Conveyance Costs, presents cost estimates for two potential conveyance construction methods.
- Section 8: Water Acquisition Costs, presents cost estimates for acquisition of the water supplies for the potential sources that have been identified.
- Section 9: Cost Summary, overall cost estimates for the conceptual water supply scenarios developed for this chapter.
- Section 10: Estimates of Overall Water Demands and Water Supply Costs, presents estimates of the overall water demands for Angeles Link inclusive of treatment and production demands and associated water supply costs.
- Section 11: References, lists the references cited in this chapter.

1.4 Key Terms

- **Advanced Water Treatment (AWT).** Advanced water treatment is pursued after water/wastewater treatment to further remove trace constituents still present in the water.
- **Antiscalant.** A polymer used to inhibit crystalized mineral salts from forming on surfaces (i.e., scale).
- **Air Fin Cooling (AFC).** A cooling process that uses ambient air to cool the system and extended surfaces (fins) to increase heat transfer from the closed-loop air system.
- **Backwash.** A process used to clean filtration tanks where water is pumped backward through the media filters to clean.
- **Biological Activated Carbon (BAC).** A process used in water purification that utilizes both adsorption onto activated carbon and degradation of pollutants through biofilms.
- **Biological Treatment.** Biological treatment refers to microorganisms used to consume organic waste present in the water being treated.
- **Blow Down.** Water used in a cooling tower is drained to prevent/minimize build-up on the system from mineral scale and total dissolved solids.
- **Brackish Groundwater.** Groundwater with elevated dissolved solids (salt content). For this assessment, groundwater with Total Dissolved Solids (TDS) concentration (a measure of salt content) exceeding 1,000 milligrams per liter (mg/L) is considered brackish.
- **Brine.** A solution with a higher amount dissolved solids (salt content) than brackish water.

- **California Code of Regulations Title 22.** Set forth by the State Water Resources Control Board, Title 22 details water quality requirements and treatment standards dependent on the end use of the water being treated.
- **California Code of Regulations Title 27.** Title 27 of the California Code of Regulations is a set of regulations pertaining to waste disposal on land. It is a joint effort of the California Department of Resources Recycling and Recovery and the State Water Resources Control Board. The regulations cover the criteria for all waste management units, facilities, and disposal sites, including landfills.
- **Clarification.** A treatment process that removes gravity-settled suspended solids and scum floating on the water's surface.
- **Concentrate.** A liquid waste stream generated during reverse osmosis treatment that contains elevated concentrations of dissolved solids (salts).
- **Conveyance.** Pipelines, pump stations, and other associated equipment needed to move water from the source location to the hydrogen production facility.
- **Desalination/Desalinated (Water).** A treatment process that removes salt from seawater.
- **Dewatering.** (Used in conjunction with thickening) A process done to minimize the volume of waste being disposed of.
- **Dissolved Air Flotation.** A treatment process that dissolves air into the water under pressure and then releases the water into a separate tank at atmospheric pressure. This causes contaminants to float to the surface of the water.
- **Divalent Ions.** Of an atom that has a valency of two.
- **Dry Weather Flow.** Dry weather flow occurs in the absence of precipitation, typically from surface discharges.
- **Effluent.** Water discharged from a system/process.
- **Electrodialysis (EDI).** A process where ions are moved across a semipermeable membrane with the help of an electric field.
- **Electrolyzer.** A technology that employs electrolysis. The process that separates the hydrogen atoms from the oxygen atom in water to produce hydrogen and oxygen gas.
- **Equalization.** Buffering or equalizing characteristics, such as flowrate, of wastewater before it enters a treatment facility.
- **Exchange mechanism (including imported surface water).** Water acquired through an exchange agreement with existing water rights holders by developing a replacement water source.
- **Flocculation.** Flocculation is a treatment process in which solids cluster, or floc, together to create heavier particles that can be extracted more easily from the water.
- **Freeboard.** In the context of evaporation ponds, freeboard refers to an additional amount of depth added onto the calculated depth to prevent the concentrate from overflowing.
- **Greenfield Project.** A project without any previous infrastructure.
- **Influent.** Water entering a system/process.
- **Lime.** Lime is used in water/wastewater treatment to soften water by removing magnesium and calcium ions from the water. Additionally, lime can be used as a coagulant to aid in the removal of solids from water.
- **Microfiltration.** Microfiltration is a filtration process with a pore-sized membrane filter that contaminated water is pushed through.
- **Oil and gas (O&G) production wastewater (produced water).** Water that is pumped to the surface during the extraction of O&G.
- **Ozone.** An oxidizer that neutralizes biological matter instantly.

- **Pretreatment.** Pretreatment is integral to the success of the following treatment processes as each process of wastewater treatment targets the removal of specific contaminants. Without the required pretreatment, the processes to follow would not be as effective.
- **Residuals.** For this study, solid or liquid wastes produced during treatment of water source for hydrogen supply.
- **Reverse Osmosis (RO).** A tertiary treatment process where water is pushed through a semipermeable membrane in order to separate water molecules from other contaminants in the water. This assessment discusses both a single-pass system and a double-pass system. A single-pass RO system only passes water through the system once, and a double-pass system has the permeate from the first pass go through a second stage of RO.
- **Scalant.** Crystallized mineral salts that form on surfaces.
- **State Water Project (SWP).** The California State Water Project allocates water from Northern California rivers to water scarce areas across the state.
- **Surface Water.** Surface water refers to any body of water on the earth's surface such as streams, rivers, lakes, and reservoirs.
- **Surfactants.** A substance that reduces the surface tension of the liquid it is dissolved in.
- **Suspended Solids.** Small solid particles in water that remain in suspension.
- **Tertiary-Treated Recycled Water.** Reclaimed wastewater that has undergone preliminary, primary, secondary, and tertiary treatment.
- **Total Dissolved Solids (TDS).** A measure of the dissolved salt content in a liquid.
- **Total Organic Carbon (TOC).** A measure of organic compounds that contain carbon.
- **Thickening.** (Used in conjunction with dewatering) A process that increases the concentration of solids and decreases the volume of sludge present.
- **Ultrafiltration (UF).** A filtration process where water is pushed through multiple semi permeable membranes to remove suspended solids.
- **Ultrapure Water.** Ultrapure water is required for the success of an electrolyzer. It is as close to H₂O as possible, meaning it is purified according to stringent requirements.

2. Cost Estimate Approach

This section describes the approach used to develop cost estimates for water supply and treatment for each of the water sources identified in the Water Availability Study (Chapter), including an overview of the conceptual framework for cost development, tools used to develop the cost estimates, key assumptions, and a discussion of cost outputs.

2.1 Conceptual Framework

The conceptual framework for the cost estimates is as follows:

- The source (raw) water flow for treatment is 10 million gallons per day (MGD).
- The water quality varies among the source types (refer to Section 3).
- The water treatment plant is co-located with the hydrogen production facility.
- Concentrate produced during treatment is discharged to new evaporation ponds that are co-located with the treatment facility or conveyed to an existing brine disposal facility.

The 10 MGD for source water flows corresponds to approximately 1.0 million metric tons per year (MMTY) of clean renewable hydrogen production (refer to Section 10). For purposes of the Angeles Link Phase 1 feasibility analysis, this is assumed to be reasonable source water flow for developing water supply and treatment costs for third-party producers given the scale of the production projects expected to produce clean renewable hydrogen for use in Central and Southern California by 2045, including the volume Angeles Link proposes to transport (approximately 0.5-1.5MMTY).

2.2 Cost Estimating Tools

The following tools were used to develop the cost estimates:

- Replica™ Parametric Design (RPD), Internal Jacobs cost database for conveyance system components
- A hydraulic model (Applied Flow Technology's Fathom™ software), used to estimate pumping horsepower power consumption for source water conveyance

RPD is a proprietary Jacobs' model used to design and estimate costs for water and wastewater facilities. This tool generates conceptual designs based on standard facility arrangements resulting in quantity take-offs for cost estimates. RPD is a parametric estimating system based on standardized infrastructure models and uses actual cost data from existing facilities designed or constructed by Jacobs. The internal costs database is augmented with cost data from RSMeans® and is updated frequently. The capital cost includes the labor, materials and equipment for all unit process construction. Operations and maintenance (O&M) costs include equipment maintenance, electricity, chemical consumption, labor, and residuals management.

2.3 Common Assumptions for Construction Cost Development

Common assumptions used to develop the construction cost estimates are as follows.

- All costs presented are in 2023 dollars.¹
- Facilities would be developed on greenfield sites.
- An installation cost of 20% is added to equipment cost.
- Approximately 55% of the material cost before markup is taxable material.
- A sales tax of 8.25% was added to the taxable component of the material cost.

¹ 2023 dollars were used as this analysis was initiated in late 2023.

- Cost allowances were assumed for select cost components.
 - Finishes – 2% of material costs
 - Instrumentation and controls – 2% of material costs
 - Mechanical – 2% of material costs
 - Electrical – 2% of material costs
- The applied contractor markups include overhead profit, mobilization/bonds/insurance, and contingency.
 - Overhead – 12% of the project cost
 - Profit – 10% of the project cost and overhead
 - Mobilization/bonds/insurance – 3% of project costs, overhead, and profit
 - Contingency – 30% of project costs, overhead, profit, and mobilization/bonds/insurance

The estimates are for construction only and exclude costs for land acquisition and non-construction elements sometimes included in capital cost estimates (e.g., permitting, engineering, services during construction, and commissioning).

2.4 Common Assumptions for Operations and Maintenance Costs

The following are common assumptions used to develop the O&M cost estimates.

- Energy consumption for treatment is estimated based on the amount of water treated and treatment processes used. The detailed assumptions are presented in Section 5.
- Energy consumption for conveyance is estimated based on the amount of water conveyed, the assumed distance, and the elevation increase. The detailed assumptions are presented in Section 7.
- The cost of power is \$0.185 per kilowatt hour (kWh) based on long term average cost data for California available from U.S. Energy Information Administration (1990 to 2017).
- Chemical costs are based on cost data incorporated into the RPD database.
- The average hourly rate for O&M labor is \$35 per hour.
- Labor requirements are similar to those required for municipal water or wastewater treatment plants.
- Maintenance and replacement cost for treatment process equipment.
- Residuals management and disposal.
- 10% additional O&M cost was included to count for the use of vehicles, laboratories, office equipment and other required miscellaneous expenses.
- 10% additional O&M cost was included for O&M cost contingency.

2.5 Cost Outputs

The cost outputs are presented in life cycle and unit cost formats to allow for comparison of costs among the water sources and to support the development of costs for specific water supply projects or water supply portfolios that might be defined by third-party producers for future production projects. For life cycle costs, the inflation and discount rates used to establish net present value (NPV) were assumed to be 2% and 8%, respectively, and the project duration was assumed to be 30 years. **Table 3-1** summarizes the unit cost formats that were developed.

The cost estimates that were developed are for the concept screening, or Class 5 estimates (AACE 2000). Given the conceptual nature of these estimates and the limited project definition, the accuracy of these estimates is considered to be -50% to +100%.

Table 3-1. Unit Cost Formats

Cost Component	Unit Cost Format	Cost Bookend Range
Conveyance Cost	\$/mile	Trenching vs HDD
Water Treatment Cost	\$/MG	Source Specific
Concentrate Management Cost	\$/MG	Brine Line vs Evaporation Ponds
Source Water Acquisition	\$/MG	Source Specific

HDD = horizontal directional drilling (a type of trenchless construction method)
MG = million gallon(s)

3. Water Source Types and Water Quality Characteristics

This section describes the potential supply types that were identified in the Water Availability Study and their water quality characteristics.

3.1 Description of Potential Water Sources

The Water Availability Study (Chapter 1) focused on identifying potential water sources that third-party producers could pursue to produce clean renewable hydrogen (Rincon 2024). **Table 3-2** presents an overview of the supply sources that were identified.

Table 3-2. Identified Potential Water Sources for Clean Renewable Hydrogen Production

Supply Source	Description
Imported Surface Water	Generally, surface water in California is available through three major water projects, including the Central Valley Project (CVP), the State Water Project (SWP), and the Colorado River. Accessing surface water from existing water rights holders could provide a large source of supply for future clean renewable hydrogen production.
Treated Wastewater	Recycled water is highly treated wastewater (municipal sewage) that has been filtered and disinfected at a wastewater treatment facility. There are numerous recycled water facilities in Southern California. Facility capacity, inflows, and outflows are documented in water quality permits and Urban Water Management Plans, which were used to identify and quantify flows of treated wastewater that are currently discharged without being reused. Treated wastewater that is being discharged from treatment facilities without further reuse or plans for future reuse could supply clean renewable hydrogen production projects.
Groundwater	Groundwater in California is managed by local agencies under the Sustainable Groundwater Management Act, to reverse overdraft and create long-term sustainable conditions. As groundwater basins recover from overdraft conditions, local resources may become more available. Depending on site-specific conditions at the time of future project development, individual clean renewable hydrogen producers can further evaluate local groundwater as a potential supply source. There may be opportunities to develop groundwater as a supply source in Low Priority basins and in adjudicated areas, depending upon site-specific conditions and other demands. In addition, groundwater banks, or aquifer storage and recovery projects, may be used to facilitate a water supply exchange.
Agricultural Industry Water	Agricultural industry water includes two potential water supply sources associated with ongoing agricultural operations: agricultural field drainage and wastewater from produce washing operations. Agricultural field drainage refers to surface water runoff and shallow subsurface drainage of irrigation and water precipitation. Agricultural wash water or process water refers to water that is applied to remove soil and debris prior to distribution to buyers and customers. As a potential supply source, systems could be used to capture and reuse field drainage water and process wastewater could be diverted prior to disposal for treatment and reuse by hydrogen producers.
Brine Line Flows	Brine lines are used to remove salts and other contaminants from a given watershed area to protect the quality of local surface water and groundwater resources. Brine flows that are currently planned for discharge to a brine line for disposal could be diverted for use in clean renewable hydrogen production.
Advanced Water Treatment (AWT) Concentrate	An advanced water treatment facility (AWTF) uses secondary-treated recycled water to conduct further water quality treatment and produce tertiary-level treated water. This process creates waste flow consisting of highly saline brine or concentrate. This waste flow can be either recycled for reuse or treated for disposal. Concentrate from AWT that is not currently reused or planned for beneficial reuse could supply clean renewable hydrogen production.

Supply Source	Description
O&G Industry Water	O&G industry water from refinery offset water and/or produced water could be developed as a water supply source. Refinery offset water includes the water gained from the reduction or cessation of refinery operations and could be developed as O&G operations are phased out in accordance with state goals and objectives. The amount of water per barrel of oil produced is expected to vary by refinery location, depending on multiple factors, including the source water, other refinery operations and processes, and requirements of the facility-specific discharge permit. Separately, produced water includes water brought to the surface along with O&G because of pumping. Treated produced water could be acquired by a hydrogen producer from the oil field operator prior to its discharge to land.
Inland Brackish Groundwater	Brackish groundwater can occur from both natural sources (geology and soils) and from manmade sources (discharges from wastewater treatment plants and agricultural runoff). Brackish groundwater located in inland areas without natural drainage outlets and that is not currently managed or does not have plans to be managed for beneficial use could provide a supply source for clean renewable hydrogen production. Use of inland brackish water as a supply source would not compete with the needs of other water users because it would provide beneficial use to brackish water that otherwise poses water quality concerns and management issues.
Dry Weather Flows	Dry weather flows are discharges of flows that enter a Municipal Separate Storm Sewer System (MS4) during dry weather conditions and, because of low volume and velocity, these flows accumulate within the MS4, causing water quality concerns and potential violation of the MS4 operating permit (National Pollutant Discharge Elimination System). Dry weather flows are known to be problematic for local flood control agencies with insufficient resources to remove and dispose of them. Dry weather flows that are not reused or planned for beneficial use could provide a potential source for clean renewable hydrogen production projects.
Urban Stormwater Capture and Reuse	Stormwater runoff occurs in direct response to precipitation events. Stormwater runoff that can be captured before reaching a discharge outlet can be stored and treated for future use. Multiple Southern California water agencies have existing stormwater capture and reuse programs; however, these are generally not considered currently available because the respective agencies have developed such programs to improve their own water supply portfolios. Clean renewable hydrogen producers could work with agencies overseeing stormwater capture projects to evaluate sources that may become available in the future or may develop new stormwater capture projects as a potential new source for clean renewable hydrogen production.

Source: modified from Table ES-6 Potential Supply Sources in the Chapter 1: Water Availability Study (Rincon 2024)

3.2 Water Quality Characteristics

The water quality characteristics of the source water will influence the treatment required to produce water for hydrogen production. The total dissolved solids (TDS) concentration of the source water has the most impact on treatment costs and treated water recovery. Reverse osmosis (RO) treatment will be needed for most source types to produce water with the TDS concentrations required for electrolyzer feed and cooling (refer to Section 4). **Table 3-3** presents examples of TDS concentrations for the supply sources that have been identified.

Table 3-3. Total Dissolved Solids Concentrations for Identified Water Sources

Source	Unit	Value
Source 1: Imported surface water	mg/L	320 ^[a]
Source 2: Treated wastewater	mg/L	890 ^[b]
Source 3: Groundwater	mg/L	485 ^[c]
Source 4: Agricultural industry water	mg/L	15,000 ^[d]
Source 5: Brine line flows	mg/L	5,210 ^[e]
Source 6. Advanced water treatment concentrate	mg/L	2,950 ^[b]
Source 7: Oil and gas industry water	mg/L	22,500 ^[f]
Source 8: Inland brackish groundwater	mg/L	1,810 ^[g]
Source 9: Dry weather flows	mg/L	2,470 ^[h]

Source	Unit	Value
Source 10: Urban stormwater capture and reuse	mg/L	168 ^[i]

mg/L = milligram(s) per liter

- [a] SWP Water – Lake Perris Outlet (average of 2022 samples): wdl.water.ca.gov/WaterDataLibrary. Given that third-party producers would be responsible for acquiring and treating the water for clean renewable hydrogen production and the precise source of water is unknown at this time, this cost analysis assumes a TDS concentration from SWP to evaluate one TDS value for this water source for purposes of this analysis. Other imported surface water sources, such as water from the Colorado River, may have a higher TDS value.
- [b] Municipal recycled water and concentrate data from West Basin Municipal Water District Recycled Water Master Plan (HDR 2022). This cost analysis assumes a TDS concentration from one recycled water treatment facility to evaluate one TDS value for this water source for purposes of this analysis. Other sources of treated wastewater may have higher or lower TDS values.
- [c] Average of TDS concentrations of produced groundwater for the groundwater basins relevant for the *Water Supply Study: Southern San Joaquin, Antelope Valley, Coachella, and Palo Verde Groundwater Basin* (DWR 2010).
- [d] Arias-Paic et al (2022). Agricultural industry water includes agricultural drainage and agricultural wash water (discharge). To provide a conservative estimate of treatment costs, this study assumes TDS concentrations are representative of agricultural drainage for this source.
- [e] Santa Ana Watershed Project Authority (January-March 2023 data) (SAWPA 2023).
- [f] Lester et al (2015). O&G industry water includes water produced during O&G extraction and water used for refining or production. To provide a conservative estimate of treatment costs, this study assumes TDS concentrations are representative of produced water for this source.
- [g] Well bend for Eastern Municipal Water District (EMWD) Perris II Desalter (CH2M 2008). This cost analysis assumes a TDS concentration from one water district to evaluate one TDS value for this water source for purposes of this analysis. Other sources of inland brackish groundwater may have higher or lower TDS values.
- [h] Jacobs internal data (2023, unpublished).
- [i] Average of TDS concentrations for stormwater from Los Angeles, Orange, Riverside, San Bernardino and San Diego Counties (<https://bmpdatabase.org/national-stormwater-quality-database>).

Other water source-specific water quality characteristics that influence the pretreatment steps for RO (e.g., removal of suspended solids or organics) or other membrane processes are summarized in Section 5. These pretreatment processes will affect overall treatment costs.

4. Water Quality Requirements for Electrolyzers and Cooling

This section presents an overview of the water quality requirements for hydrogen production electrolyzers and cooling systems. The Water Quality Requirements for Hydrogen Generation (see Chapter 2 of this Water Resources Evaluation) provides additional information regarding the requirements for hydrogen production electrolyzers and cooling systems.

4.1 Requirements for Hydrogen Production Electrolyzers

The water quality required for hydrogen production depends on the type of electrolyzer technology employed, see also the separate SoCalGas Angeles Link Phase 1 feasibility study, the *Draft Production and Planning Assessment* (Production Study). The technologies currently available at large scales typically require the deionized water (or ultrapure quality, meeting the ASTM International (ASTM)² D1193-06 Type II or Type I water quality standards) as feed water. The larger electrolyzer systems typically incorporate RO and electrodialysis (EDI) treatment to polish the feed water to meet the ASTM Type II or Type I standards. RO is a treatment process where water is pushed through a semipermeable membrane in order to separate water molecules from dissolved solids and other constituents in the water. EDI is a treatment process where ions are moved across a semipermeable membrane with the help of an electric field.

Based on the input provided by Nel Hydrogen (2023), these polishing systems require TDS concentrations less than 350 mg/L and total organic carbon (TOC) concentrations less than 5 mg/L (Table 3-4). The anticipated TDS and TOC concentrations for all potential supply types identified in Chapter 1: Water Availability Study (Rincon 2024) exceed these limits, with the exception of surface water sources and urban stormwater capture and reuse (refer to Table 3-3). Consequently, pretreatment by RO will be required for those remaining eight supply sources.

Table 3-4. Water Quality Requirements for Electrolyzer Supplier’s Polishing Treatment System

Parameter	Value (mg/L)
TDS	<350
TOC	<5
Total suspended solids	<1
Total Silica (as SiO ₂)	<30

4.2 Cooling Water Requirements for Electrolyzers

Water quality requirements for electrolyzer cooling vary depending on the cooling technology employed. More water efficient cooling technology tends to require cooling water with higher water quality. There are two main types of cooling technologies commonly used in the market: water-cooled system (cooling towers) and air-cooled system.

Cooling towers use water evaporation to cool the fluid. They can be configured into an open-loop system, which will expose the water to be cooled directly to the air, or a closed-loop system, which will use an intermediate fluid to transfer heat from the warm fluid via heat exchangers and cool the intermediate fluid via a cooling tower or air cooling.

For cooling towers, water is lost through evaporation, and the loss is replenished by providing makeup water. The overall process increases the TDS in the recirculated water. TDS levels in cooling water are controlled by water discharges through blow down when TDS reaches specified thresholds, and any water lost is replenished. A typical TDS concentration threshold for blowdown water is approximately 5,000 mg/L. To maintain a reasonable cycle of concentration (5 or higher), the cooling makeup water TDS

² ASTM stands for the American Society for Testing and Materials. It is an internationally recognized organization that develops and delivers voluntary consensus standards for improving product quality across various industries and applications. www.astm.org

concentration needs to be less than 1,000 mg/L to maintain a TDS threshold of 5,000 mg/L for blowdown water.

An air-cooled cooling system, such as air fin cooling (AFC) systems, can be operated without water—where ambient temperature is lower than the temperature of the fluid—but it will lose the efficiency as the air temperature approaches the fluid temperature. The AFC may use water to lower the temperature of air entering the system with spray or adiabatic pads utilizing the latent heat of vaporization, and it is used commonly for the installations in warm climatic conditions. The AFC with spray does not generate a blowdown stream because water is sprayed into the air in fine mist right at the air intake, and all water will be evaporated as intake air is cooled down. To avoid scaling of the cooling fins, water with a low TDS concentration should be used. Based on information from AFC system suppliers, a TDS level of 10 mg/L is recommended to minimize scaling on the fins, which can reduce the cooling efficiency. Water with higher TDS concentrations, however, can be used with descaling agents to remove the mineral scale that has accumulated on the cooling system (Menze, pers. comm. 2023). For many of the supply sources that have been identified, RO pretreatment will be needed to achieve the water quality necessary for AFC with a spray system.

5. Treatment Processes and Costs

This section presents an evaluation of the processes and costs for pretreatment of the identified water supply sources to levels required for hydrogen production electrolyzers and cooling (refer to Section 4 of this chapter). The treatment process for each source type was developed using the TDS concentrations presented in Table 2-2 and other assumed source water quality characteristics. **Figures 3-1 through 3-10** are conceptual process flow diagrams that illustrate the expected pretreatment process required for each supply source. **Appendix A** includes summary RPD costs outputs.

5.1 Source 1 - Imported Surface Water

Imported surface water includes water from the SWP, the CVP, and the Colorado River. Without additional details on the particular water sources third-party producers may pursue for clean renewable hydrogen production at this feasibility stage, the surface water source for this scenario is assumed to be the SWP to evaluate one potential imported surface water source for purposes of the cost estimates at this stage. As shown in Table 3-3, SWP water is expected to have one of the lowest TDS of the water supply sources that have been identified. RO treatment prior to the electrolyzer's polishing treatment system is not included for this source because its TDS (315 mg/L) is less than required for electrolyzer (350 mg/L). The SWP water, however, is expected to have total suspended solids and organics that will need to be removed to meet the water quality requirements shown in Table 3-4.

The treatment requirements for imported water sourced from CVP are expected to be similar to those for the SWP water, but imported Colorado River would require additional treatment. The TDS concentrations of imported Colorado River water have ranged from approximately 500 to 800 mg/L (MWD and BOR, 1999). Consequently, RO treatment would be required for imported Colorado River water to produce acceptable water quality for electrolyzer feed and cooling.

5.1.1 Treatment Processes

The treatment process for Source 1 is shown on **Figure 3-1**. The major unit processes and equipment that are included in the cost estimate are as follows.

- Plant feed water storage/equalization tank
- Plant feed pump station
- Membrane separation of solids (ultrafiltration [UF])
- Solids thickening with flocculation tanks and solids settling
- Solids dewatering including thickened solids storage
- Treated water equalization/storage tank

For this source, a UF system will be required to provide feed water of acceptable quality for the polishing treatment systems that are included with electrolyzers, but RO will not be required because the TDS concentration of SWP water is less than 350 mg/L (Table 3-3). Solids in the UF backwash will be thickened and dewatered and disposed of separately. Based on the consultant's experience, a water recovery of 98% is estimated to be achievable for SWP using these processes.

5.1.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year) and following the cost estimate approach described in Section 2. A summary of the cost estimate is provided in **Table 3-5**.

Table 3-5. Planning-Level Cost Estimate, Imported Surface Water

Item	Estimate	+100%	-50%
Treatment Construction Cost, \$M	\$98.5M	\$197M	\$49.2M
Treatment Annual O&M, \$M/year	\$8.1M	\$16.2M	\$4.0M
NPV of Total Project Cost over 30 years, \$M	\$210M	\$420M	\$105M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, \$/MG	\$1,916	\$3,833	\$958
Energy Consumption, kWh/year	14.0M	NA	NA

\$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.2 Source 2 - Treated Wastewater

Treated wastewater is the effluent from a water reclamation facility effluent that has been treated to meet the water quality criteria specified in the *California Code of Regulations* Title 22 for disinfected tertiary recycled water.

5.2.1 Treatment Processes

Treated wastewater will need to be treated further to meet the requirements for the electrolyzer feed and cooling. Treated wastewater typically contains TDS concentrations that exceed the water quality requirements specified by electrolyzer vendors (e.g., greater than 350 mg/L [Table 3-3]), so RO treatment will be needed to meet the water quality requirements as described in Section 4.1. In addition, particulate and colloidal organic particles as well as total suspended solids will need to be removed prior to RO to avoid RO membrane fouling that degrades RO performance. Microfiltration or UF is commonly used as the pretreatment for RO for this source water type. In this chapter, UF is assumed for RO feed water pretreatment. Additionally, membrane systems require inflow to be relatively stable. To buffer the flow variation, equalization is also provided upstream of the membrane processes. In addition, pH adjustment is also added to meet the pH range specified by electrolyzer vendors.

The treatment process for Source 2 is shown on **Figure 3-2**. The major unit processes and equipment that are included in the cost estimate are as follows:

- Feed water storage/equalization tank
- Plant feed pump station
- Membrane separation of solids (UF)
- UF backwash water clarification and return flow pumps
- UF backwash solids holding
- UF backwash dewatering and return flow pumps
- RO, single-pass system to lower the TDS level
- Post-RO treatment to adjust pH (decarbonator)
- Treated water equalization/storage tank

The treated water recovery rate for the UF was assumed to be 95%; however, assuming that the clarified backwash water return will be transferred back to the UF feed, which increases the water recovery, the net recovery for the UF system was estimated to be 98% (used for cooling). Overall recovery for UF-RO treatment of 85% (used for electrolyzer feed) is achievable based on the consultant's experience. The estimated water recovery rates for cooling and electrolyzer feed are 98% and 85%, respectively.

5.2.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in **Table 3-6**.

Table 3-6. Planning-Level Cost Estimate, Treated Wastewater

Item	Estimate	+100%	-50%
Treatment Construction Cost, \$M	\$207M	\$414M	\$103M
Treatment Annual O&M, \$M/year	\$16.0M	\$32.0M	\$8.0M
NPV of Total Project Cost over 30 years, \$M	\$426M	\$853M	\$213M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, \$/MG	\$3,895	\$7,790	\$1,947
Energy Consumption, kWh/year	13.9M	NA	NA

\$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.3 Source 3 - Groundwater

The use of groundwater as a supply requires extraction wells and a pipeline system to convey the groundwater to the treatment facility.

5.3.1 Treatment Processes

Groundwater is expected have a TDS concentration that slightly exceeds the acceptable limits for electrolyzer feed and cooling (e.g., 485 mg/L vs. 350 mg/L, respectively). In this case, a portion of the process flow (50%) can be treated with RO, and the permeate can be blended with groundwater to produce treated water that has a TDS concentration less than 350 mg/L. The treatment process for Source 3 is shown on **Figure 3-3**. The major unit processes and equipment that are included in the cost estimate are as follows.

- Groundwater extraction wells
- Feed water storage/equalization
- Membrane separation of solids (UF)
- UF backwash water clarification and return flow pumps
- UF backwash solids holding
- UF backwash dewatering and return flow pumps
- RO, single-pass system to lower the TDS level for 50% of the process flow (5 MGD)
- Post-RO treatment to adjust pH (5 MGD) (decarbonator)
- Bypass line from the UF discharge to the treated water tank for blending
- Treated water equalization/storage tank

Based on the consultant's experience, an overall treated water recovery of approximately 95% is achievable for groundwater using these processes.

5.3.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in **Table 3-7**.

Table 3-7. Planning-Level Cost Estimate, Groundwater

Item	Estimate	+100%	-50%
Treatment Construction Cost, \$M	\$156M	\$312M	\$78M
Treatment Annual O&M, \$M/year	\$11.7M	\$23.4M	\$5.9M
NPV of Total Project Cost over 30 years, \$M	\$314M	\$628M	\$157M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, \$/MG	\$2,868	\$5,735	\$1,434
Energy Consumption, kWh/year	17.1M	NA	NA

\$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.4 Source 4 - Agricultural Industry Water

Agricultural industry water includes two potential water supply sources associated with ongoing agricultural operations: agricultural field drainage and wastewater from produce washing operations. The water quality characteristics of these sources are very different. The consultant assumed that potable quality water with relatively low TDS concentration would be needed for washing operations. Agricultural field drainage, however, can have elevated TDS concentrations (e.g., 15,000 mg/L [Table 3-3]). Other constituents of concern for the treatment of agricultural drainage include high levels of calcium sulphate originated from the soil conditioning gypsum application and selenium, which is prevalent in the soil naturally in the Central Valley and other regions in California. To provide a conservative estimate of the treatment costs for agricultural industry water, this chapter assumes the water quality characteristics of agriculture drainage for this source.

5.4.1 Treatment Processes

The treatment process for Source 4 is shown on **Figure 3-4**. The major unit processes and equipment that are included in the cost estimate are as follows.

- Drainage water intake structure with screens
- Feed water storage/equalization
- Feed water softening
- Softening process residuals dewatering
- Decarbonization process of the softened feed water
- Membrane separation of solids (UF)
- RO, double-pass system to lower the TDS level
- Treated water equalization/storage tank

Based on the consultant's experience, a treated water recovery of 75% is achievable for agriculture industry water (drainage) using these processes.

5.4.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in **Table 3-8**.

Table 3-8. Planning-Level Cost Estimate, Agricultural Industry Water

Item	Estimate	+100%	-50%
Treatment Construction Cost, \$M	\$308M	\$617M	\$154M
Treatment Annual O&M, \$M/year	\$32M	\$64M	\$16M
NPV of Total Project Cost over 30 years, \$M	\$741M	\$1,482M	\$370M
Annual Source Water Usage, MG/year	3650	3650	3650
Treatment Cost, \$/MG	\$6,767	\$13,533	\$3,383
Energy Consumption, kWh/year	60.2M	NA	NA

\$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.5 Source 5 - Brine Line Flows

In Southern California, RO concentrate from inland brackish groundwater desalination facilities is typically discharged into inland brine lines, such as Inland Empire Brine Line, for ocean discharge (SAWPA 2010).

To use this source for clean renewable hydrogen generation, the brine line flows would be intercepted and diverted for treatment.

5.5.1 Treatment Processes

Brine line flows typically contain concentrated level of ions, organics, nutrients, and other chemicals added to the RO treatment process (Greenlee et al 2010; WRF 2006). Treatment will be required to remove these constitutes to levels acceptable for electrolyzer feed and cooling. The treatment process for Source 5 is shown on **Figure 3-5**. The major unit processes and equipment that are included in the cost estimate are as follows.

- Feed concentrate storage/equalization
- Treatment facility feed pump station
- Antiscalant removal process (ozone treatment)
- Magnesium-enriched lime softening process for softening and silica removal
- Carbon dioxide removal process
- Microfiltration/UF for remaining precipitate removal
- Weak acid ion exchange for removal of scaling divalent ions
- RO, single-pass system to lower the TDS level below the required quality
- Treated water equalization/storage tank

Based on the consultant's experience, a treated water recovery of 85% is achievable for brine line flows using these processes.

5.5.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in **Table 3-9**.

Table 3-9. Planning-Level Cost Estimate, Brine Line Flows

Item	Estimate	+100%	-50%
Treatment Construction Cost, \$M	\$319M	\$638M	\$159M
Treatment Annual O&M, \$M/year	\$37.0M	\$74.1M	\$18.5M
NPV of Total Project Cost over 30 years, \$M	\$829M	\$1,657M	\$414M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, \$/MG	\$7,567	\$15,134	\$3,784
Energy Consumption, kWh/year	22.9M	NA	NA

\$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.6 Source 6 - Advanced Water Treatment Concentrate

In Southern California, an increasing number of agencies are implementing potable water reuse that requires the use of RO to meet regulatory water quality requirements. RO concentrate generated from these treatment facilities is typically disposed of (SWRCB 2023). For this source, the chapter assumes that concentrate would be diverted prior to disposal and conveyed to a treatment plant.

5.6.1 Treatment Processes

RO concentrate generated from AWTF typically contains concentrated level of ions, organics, nutrients, and other chemicals added to the RO treatment process (WRF 2006). Treatment will be required to remove these constitutes to levels acceptable for electrolyzer feed and cooling. The treatment process for

Source 6 is shown on **Figure 3-6**. The major unit processes and equipment included in the cost estimate are as follows:

- Feed concentrate storage/equalization
- Treatment facility feed pump station
- Antiscalant removal process (ozone treatment)
- Biological activated carbon (BAC)
- Magnesium-enriched lime softening process for softening and silica removal
- Carbon dioxide removal process
- Microfiltration/UF for remaining precipitate removal
- Weak acid ion exchange for removal of scaling divalent ions
- RO, single-pass system to lower the TDS level below the required quality
- Treated water equalization/storage tank

Based on the constituents commonly present in concentrate, constituents that require treatment include antiscalant used at the AWTF, organic constituents of wastewater origin, and reactive silica (WRF 2006). Ozone treatment can reduce the antiscalant and break down some of the recalcitrant organic constituents. BAC is included to further reduce organic constituents. Ozone-BAC treatment is followed by a magnesium-enriched lime softening process to reduce hardness and reactive silica. UF is used to remove silica precipitation products, and weak acid ion exchange is used to reduce the residual magnesium to minimize the scaling potential for the RO process. As the typical TDS level in the AWT concentrate is expected to be approximately 5,000 mg/L (Table 3-3), a single-pass RO should reduce the TDS level below the required 350 mg/L for the polishing treatment included with the electrolyzer systems. Concentrate from the treatment process would be treated with evaporation or disposed of via existing brine disposal infrastructure. It was assumed that the residuals generated from the softening and filtration process would be dewatered within the facility and disposed of offsite. Based on the consultant’s experience, a treated water recovery of 85% is achievable for AWT concentrate using these processes.

5.6.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in **Table 3-10**.

Table 3-10. Planning-Level Cost Estimate, Advanced Water Treatment Concentrate

Item	Estimate	+100%	-50%
Treatment Construction Cost, \$M	\$351M	\$702M	\$175M
Treatment Annual O&M, \$M/year	\$37.5M	\$75.0M	\$18.8M
NPV of Total Project Cost over 30 years, \$M	\$867M	\$1,734M	\$433M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, \$/MG	\$7,917	\$15,833	\$3,958
Energy Consumption, kWh/year	23.1M	NA	NA

\$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.7 Source 7 - Oil and Gas Industry Water

O&G industry water includes water from produced water and/or refinery offset water that could be developed as a water supply source. During O&G production, water is also extracted. This water typically contains high salinity and soluble and insoluble oil/organics, suspended solids, and chemicals used for O&G production (e.g., surfactants and biocides) (Lester et al. 2015). Offset water includes groundwater or surface water currently used for refining and may become available for supply in the future. Offset water is expected to have substantially lower TDS concentrations than water generated during O&G production. To provide a conservative estimate of the treatment costs, this chapter assumes the water quality characteristics of produced water for this source.

5.7.1 Treatment Processes

The treatment process for Source 7 is shown on **Figure 3-7**. The major unit processes and equipment that are included in the cost estimate are as follows.

- Inlet screens
- Oil/grease separator
- Dissolved air flotation for solids removal
- Pretreated water transfer pump station
- Feed water storage/equalization tank
- Biological treatment feed pump station
- Biological treatment for biodegradable organics and nutrient removal with membrane separation of solids (membrane bioreactor)
- Biosolids thickening and dewatering
- RO, consisting of a double-pass system to reduce the TDS level below the required quality
- Post-RO treatment to adjust pH (decarbonator)
- Treated water equalization/storage tank

The pretreatment processes include screens, oil separator, and solids removal. Given the high TDS concentration for this source, a double-pass RO system will be required to provide feed water that meets the requirements for electrolyzer systems. Based on the consultant's experience, a treated water recovery of 75% is achievable for this source.

5.7.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in **Table 3-11**. The O&M cost includes disposal of the solids produced by the.

Table 3-11. Planning-Level Cost Estimate, Oil and Gas Industry Water

Item	Estimate	+100%	-50%
Treatment Construction Cost, \$M	\$387M	\$773M	\$193M
Treatment Annual O&M, \$M/year	\$48.8M	\$97.6M	\$24.4M
NPV of Total Project Cost over 30 years, \$M	\$1,058M	\$2,116M	\$529M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, \$/MG	\$9,661	\$19,323	\$4,831
Energy Consumption, kWh/year	69.9M	NA	NA

\$M = million dollars

M = million kilowatt hours per year

NA = not applicable

5.8 Source 8 - Inland Brackish Groundwater

Brackish groundwater has been identified as a potential supply for clean renewable hydrogen production (Rincon 2024). The use of brackish groundwater for supply will require extraction wells and a pipeline system to convey the brackish groundwater to the treatment facility.

5.8.1 Treatment Processes

Brackish groundwater has elevated TDS concentrations (1,800 mg/L, [Table 3-3]), and RO treatment will be required to reduce TDS to levels acceptable for electrolyzer feed and cooling. The treatment process

for Source 8 is shown on **Figure 3-8**. The major unit processes and equipment that are included in the cost estimate are as follows.

- Brackish groundwater extraction wells
- Plant feed pump station
- Feed water storage/equalization
- Media filtration for solids removal
- Backwash solids clarification and clarified return flow pumps
- Backwash solids holding
- Backwash solids dewatering and filtrate return pumps
- RO, single-pass system to lower the TDS level below the required quality
- Post-RO treatment to adjust pH (decarbonator)
- Treated water equalization/storage tank

The media filtration process was included to remove suspended solids. If iron and manganese removal were required, specialty media filters, such as green sand filters, with the addition of oxidants upstream, such as chlorine might be used in place of regular media filters. Based on the TDS concentrations presented in Section 3, a single-pass RO system will be sufficient to meet the water quality requirements for the polishing treatment systems included with electrolyzers (Table 3-4). Based on the consultant's experience, a treated water recovery of 85% is achievable for brackish groundwater using these processes.

5.8.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in **Table 3-12**.

Table 3-12. Planning-Level Cost Estimate, Inland Brackish Groundwater

Item	Estimate	+100%	-50%
Treatment Construction Cost, \$M	\$207M	\$414M	\$104M
Treatment Annual O&M, \$M/year	\$13.7M	\$27.3M	\$6.8M
NPV of Total Project Cost over 30 years, \$M	\$395M	\$790M	\$198M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, \$/MG	\$3,607	\$7,215	\$1,804
Energy Consumption, kWh/year	19.8M	NA	NA

\$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.9 Source 9 - Dry Weather Flows

Dry weather flows are flows that are collected into stormwater collection systems during dry weather. The flows could be generated from runoff that originates from landscape irrigation, car washing, and other activities producing runoff from pavements, groundwater infiltration, and illegal discharge of water/liquid into stormwater drains. In urban areas, dry weather flows contain constituents both from road surfaces and of unknown origins, and their characteristics are not well documented and are highly variable. Dry weather flow is assumed to be diverted from a storm drain system at an appropriate location and conveyed to the hydrogen production facility for treatment.

5.9.1 Treatment Processes

Dry weather flows commonly contain oil and grease, large debris, suspended solids, organics, elevated TDS concentrations, and other regulated constituents (Stein and Ackerman 2007). RO treatment will be needed because the TDS concentrations are elevated for this source (2,460 mg/L, Table 3-3). The treatment process for Source 9 is shown on **Figure 3-9**. The major unit processes and equipment that are included in the cost estimate are as follows:

- Influent screen
- Oil/grease separator
- Dissolved air flotation
- Pretreated water transfer pump station
- Feed water storage/equalization tank
- UF feed pump station
- Membrane separation of solids (UF)
- RO, single-pass system to lower the TDS level below the required quality
- Post-RO treatment for pH adjustment (decarbonator)
- Treated water storage/equalization tank

Given the water quality expected for dry weather flows, pretreatment to remove oil/grease and particulate matter will be required before UF and RO treatment. Solids in the pretreatment and UF backwash will be thickened and dewatered and disposed of separately. Based on the consultant’s experience, a treated water recovery of 85% is achievable for dry weather flows using these processes.

5.9.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in **Table 3-13**.

Table 3-13. Planning-Level Cost Estimate, Dry Weather Flows

Item	Estimate	+100%	-50%
Treatment Construction Cost, \$M	\$304M	\$608M	\$152M
Treatment Annual O&M, \$M/year	\$21.2M	\$42.4M	\$10.6M
NPV of Total Project Cost over 30 years, \$M	\$596M	\$1,191M	\$298M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, \$/MG	\$5,439	\$10,878	\$2,720
Energy Consumption, kWh/year	21.6M	NA	NA

\$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.10 Source 10 - Urban Stormwater Capture and Reuse

Urban stormwater flows are flows that are collected into stormwater collection systems during wet weather. The flows are primarily the runoff from paved surface in urban areas. The US EPA has compiled stormwater quality data across the US in the National Stormwater Quality Database (NSQD). Stormwater quality data for Southern California was obtained from the NSQD, and this information was used to develop the treatment processes for urban stormwater capture and reuse. Based on this data, the TDS concentration of this source is expected to be relatively low (approximately 168 mg/L [Table 3-3]). Although RO treatment is not required, suspended solids concentrations are expected to be elevated (e.g., 155 mg/L [NSQD]) and will require treatment. For this source, stormwater flow is assumed to be diverted from a retention basin at an appropriate location and conveyed to the hydrogen production facility for treatment.

5.10.1 Treatment Processes

The treatment process for Source 10 is shown on **Figure 3-10**. The major unit processes and equipment that are included in the cost estimate are as follows.

- Influent screens
- High-rate solids removal
- Solids holding tank, solids dewatering process, and the dewatering return flow pumps
- Feed water storage/equalization tank
- Ultrafiltration for solids removal

- Treated water storage/equalization tank

Based on the consultant's experience, an overall treated water recovery of 98% is achievable for urban stormwater capture and reuse using these processes, assuming the solids processing return flows and UF backwash flow to be returned to the feed to the treatment system.

5.10.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in **Table 3-14**.

Table 3-14. Planning-Level Cost Estimate, Urban Stormwater Capture and Reuse

Item	Estimate	+100%	-50%
Treatment Construction Cost, \$M	\$134	\$268	\$67
Treatment Annual O&M, \$M/year	\$9.8M	\$19.7M	\$4.9M
NPV of Total Project Cost over 30 years, \$M	\$267M	\$533M	\$133M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, \$/MG	\$2,436	\$4,872	\$1,218
Energy Consumption, kWh/year	8.7M	NA	NA

\$M = million dollars

M = million kilowatt hours per year

NA = not applicable

5.11 Treatment Cost Summary

An overall summary of treatment costs based on 10-MGD source flows is as follows.

- Total treatment costs in the NPV over the 30-year project period for the source types range from \$210M for the imported surface water to \$1,058M for the O&G production wastewater, with corresponding unit costs of \$1,916/MG and \$9,661/MG, respectively.
- The energy consumption associated with treatment ranges from 8.7M to 69.9M kWh/year.

Table 3-15 provides a more detailed summary of the treatment costs and associated energy consumption.

Table 3-15. Treatment Cost Summary ^[a,b]

Source	Treated Water Yield (MGD ^[c])	O&M (\$/year)	Total Project Cost ^[d] (\$)	Unit Cost (\$/MG)	Energy Consumption (kWh/year)
Source 1: Imported surface water	9.8	\$8.1M	\$210M	\$1,916	14.0M
Source 2: Treated wastewater	8.6	\$16.0M	\$426M	\$3,895	13.9M
Source 3: Groundwater	9.5	\$11.7M	\$314M	\$2,868	17.1M
Source 4: Agricultural industry water	7.5	\$32.1M	\$741M	\$6,767	60.2M
Source 5: Brine line flows	8.5	\$37.0M	\$829M	\$7,567	22.9M
Source 6: Advanced water treatment concentrate	8.5	\$37.5M	\$867M	\$7,917	23.1M
Source 7: O&G industry water	7.5	\$48.8M	\$1,058M	\$9,661	69.9M
Source 8: Inland brackish groundwater	8.5	\$13.7M	\$395M	\$3,607	19.8M
Source 9: Dry weather flows	8.5	\$21.2M	\$596M	\$5,439	21.6M
Source 10: Urban stormwater capture and reuse	9.8	\$9.8M	\$267M	\$2,436	8.7M

^[a] All costs are based on 10 MGD of source water flow.

^[b] Costs are presented in 2023 dollars; cost accuracy is +100%, -50%.

^[c] The treated water yield is the flow rate of treated water (in MGD) produced from 10 MGD of source water flow.

^[d] Construction costs plus NPV O&M costs for 30 years of operation.

6. Concentrate Management Costs

With the exception of SWP water and urban stormwater capture and reuse, the remaining source types that have been identified will require RO pretreatment to achieve the water quality required for hydrogen production electrolyzers and cooling, which will produce a concentrate, or high-salinity waste liquid, that will need to be managed. The cost and implementation challenges associated with concentrate management can be significant. The management approaches depend on the composition and volume of the concentrate, land availability, proximity to existing concentrate disposal facilities, and other factors.

This section presents planning-level cost estimates for two options for concentrate management to provide a range of potential costs for potential third-party production projects

1. Discharge to existing brine disposal facilities
2. Evaporation ponds

Appendix B includes cost summary outputs for the concentrate management options.

6.1 Existing Brine Disposal Facilities

Concentrate disposal via an existing brine disposal facility will be the least cost concentrate management approach if the existing disposal facility (e.g., a brine line) is located near the source water treatment plant. The Inland Empire Brine Line managed by the Santa Ana Watershed Project Authority (SAWPA) is an example of an existing brine disposal facility. The Inland Empire Brine Line conveys high salt content wastewater generated from the inland facilities to the wastewater treatment plant operated by the Orange County Sanitation District for discharge to the Pacific Ocean.

6.1.1 Assumptions

As described above, the use of an existing brine line for concentrate management will be the least costly approach if the treatment plant is located close to a brine line. Assumptions regarding the distance to the brine line connection point and other key inputs needed for costing this alternative are as follows.

- The distance between the treatment facility and the closest brine line connection point is 5 miles. This is consistent with the assumption that the use of a brine line for disposal would be an appropriate option for facilities located near an existing brine line.
- There is no elevation difference between the treatment facility and the brine line connection, consistent with the nearby connection point assumed for this option.
- Given that the assumed distance to the connection point is nearby and the elevation gain is negligible, residual pressure from the RO process is sufficient to convey brine to the brine line. Therefore, an additional pump station is not required.
- The concentrate pipeline is constructed of polyvinyl chloride (PVC), which is more compatible with the brine than steel pipe, and is installed using cut-and-fill construction methods.
- Based on treated water recovery rates for the water source, the concentrate flow rate is 2.5 MGD for O&G industry water and agricultural industry water, 0.5 MGD for non-brackish groundwater, and 1.5 MGD for the other supply sources that produce concentrate.
- Corresponding pipe diameters are 10 inches, 14 inches, and 6 inches, respectively, to maintain approximately 5.5 feet per second of velocity.
- O&M costs include discharge fees; discharge fees for SAWPA's Inland Empire Brine Line were assumed for costing (\$0.00184 per gallon) (Mosher 2021).
- The maintenance and replacement cost of valves along the pipeline is not considered for this analysis.

6.1.2 Estimated Costs

For the supply sources evaluated that require RO treatment, the brine yields for 10-MGD source flows range from approximately 0.5 MGD to 2.5 MGD. **Table 3-16** summarizes the capital, annual O&M, and lifecycle costs for the water sources that have been identified.

Table 3-16. Planning-level Costs Estimates for Concentrate Management, Existing Brine Disposal Facilities^[a,b]

Source	Construction Costs (\$)	Annual O&M Costs (\$/YR)	Total NPV Cost ^[c] (\$)	Unit Cost Cost(\$/MG)
Source 1: Imported Surface Water	\$0	\$0	\$0	\$0
Source 2: Treated Wastewater	\$6.4M	\$1.0M	\$20.5M	\$187
Source 3: Groundwater	\$2.3M	\$0.3M	\$7.0M	\$85
Source 4: Agricultural Industry Water	\$9.9M	\$1.7M	\$33.3M	\$304
Source 5: Brine Line Flows	\$6.4M	\$1.0M	\$20.5M	\$187
Source 6: Advanced Water Treatment Concentrate	\$6.4M	\$1.0M	\$20.5M	\$187
Source 7: O&G Industry Water	\$9.9M	\$1.7M	\$33.3M	\$304
Source 8: Inland Brackish Groundwater	\$6.4M	\$1.0M	\$20.5M	\$187
Source 9: Dry Weather Flows	\$6.4M	\$1.0M	\$20.5M	\$187
Source 10: Urban Stormwater Capture and Reuse	\$0	\$0	\$0	\$0

^[a] All costs are based on 10 MGD of source water flow.

^[b] Costs are presented in 2023 dollars; cost accuracy is +100%, -50%.

^[c] Construction costs plus NPV O&M costs for 30 years of operation.

6.2 Evaporation Ponds

For projects that do not have access to an existing brine disposal pipeline or when constructing a new pipeline is infeasible, evaporation ponds can be used for disposal of RO concentrate. The evaporation ponds rely on the solar energy to evaporate water. Evaporation ponds are land intensive, and their effectiveness depends on the climatic conditions of the site.

6.2.1 Assumptions

Key assumptions for developing costs for concentrate management with evaporation basins are as follows.

- Approximate concentrate flow rates for the respective water sources were determined based on the assumed overall recovery and the source water intake of 10 MGD.
- Approximate concentrate salinity was estimated based on the source water TDS used to develop the treatment facility concept and the assumed UF-RO recovery.
- The approximate size of the evaporation basins is based on the concentrate flow rates, salinity, and climate conditions, which are based on the average conditions for San Joaquin Valley, Blythe, and Lancaster, California. Those areas are identified for potential production facilities by third-party clean renewable hydrogen producers in the SoCalGas Phase 1 feasibility Production Study prepared separately as part of the Angeles Link Phase 1 feasibility analyses.
- Consistent with standard design practices for evaporation basins, two evaporation ponds are assumed, each with 4 to 5 feet of pond depth depending on the evaporation rate at the assumed salinity; an additional 3 feet of freeboard.
- Ponds are lined with high-density polyethylene (HDPE) liners to align with regulatory requirements (*California Code of Regulations* Title 27).
- O&M costs include the transport and disposal of accumulated salt.
- Evaporation ponds were assumed to be located next to the water treatment facility.

- Land acquisition costs for the evaporation pond site is not included in the estimate because these costs can vary widely based on project location and therefore are difficult to generalize.

6.2.2 Estimated Costs

The evaporation pond cost estimate was developed using the RPD tool. For the sources evaluated that require RO treatment, the brine yields for 10-MGD source flows range from approximately 0.7 MGD to 2.5 MGD. **Table 3-17** summarizes the capital, annual O&M, and lifecycle costs for the water sources that have been identified.

Table 3-17. Planning-level Costs Estimates for Concentrate Management, Evaporation Ponds^[a,b]

Source	Construction Costs (\$)	Annual O&M Costs (\$/year)	Total NPV Cost ^[c] (\$)	Unit Cost (\$/MG)
Source 1: Imported Surface Water	\$0	\$0	\$0	\$0
Source 2: Treated Wastewater	\$132M	\$1.3M	\$151M	\$1,376
Source 3: Groundwater	\$71M	\$1.9M	\$97.4M	\$889
Source 4: Agricultural Industry Water	\$291M	\$25.8M	\$318M	\$2,900
Source 5: Brine Line Flows	\$152M	\$7.8M	\$259M	\$2,365
Source 6: Advanced Water Treatment Concentrate	\$152M	\$4.4M	\$213M	\$1,944
Source 7: O&G Industry Water	\$229M	\$33.6M	\$691M	\$6,313
Source 8: Inland Brackish Groundwater	\$152M	\$11.5M	\$310M	\$2,830
Source 9: Dry Weather Flows	\$152M	\$3.7M	\$203M	\$1,849
Source 10: Urban Stormwater Capture and Reuse	\$0	\$0	\$0	\$0

^[a] All costs are based on 10 MGD of source water flow.

^[b] Costs are presented in 2023 dollars; cost accuracy is +100%, -50%.

^[c] Construction costs plus NPV O&M costs for 30 years of operation.

6.3 Summary of Concentrate Management Costs

For the eight source types that are expected to require RO treatment and will produce concentrate, the planning-level costs for concentrate management range from \$889/MG to \$6,313/MG for evaporation basins and from \$100/MG to \$311/MG for discharge to existing brine disposal facilities. Imported surface water (SWP water) and urban stormwater capture and reuse do not have associated concentrate management costs because these sources do not require RO treatment.

Although land acquisition and other cost factors would need to be considered, locating the treatment near existing brine disposal facilities may be an opportunity to reduce overall project costs. In this case, treated rather than untreated source water would be conveyed to the hydrogen production facility. This may be more feasible for the concentrate source types because these sources are essentially diversions of flows that would be discharged to existing brine lines.

7. Conveyance Costs

This section presents planning-level cost estimates for pipelines and related infrastructure to convey water from the potential source location to the water treatment facility. Costs were developed for two construction techniques to provide a range of potential costs for conveyance.

- Cut and fill
- Horizontal direction drilling (a type of trenchless construction methods)

Appendix C includes summary cost outputs for conveyance.

7.1 Key Assumptions

Key assumptions used for developing costs for conveyance are as follows.

- Source water flows are 10 MGD. 10 MGD for source water flows corresponds to approximately 1.0 MMTY of clean renewable hydrogen production (refer to Section 10). For purposes of the Angeles Link Phase 1 feasibility analysis, this is assumed to be reasonable source water flow for developing conveyance costs for third-party producers given the scale of the production projects expected to produce clean renewable hydrogen for use in Central and Southern California by 2045, including the volume Angeles Link proposes to transport (approximately 0.5-1.5MMTY).
- The distance between the source and treatment facility is 25 miles. Potential conveyance distances could range from less than 5 miles to greater than 100 miles. A distance of 25 miles is a reasonable conveyance distance to develop unit costs for the scale of projects expected.
- The elevation difference between the source and treatment facility is 100 feet. Although the actual elevation differences between the source and treatment plant will vary based site-specific conditions, this provides a reasonable estimate of pumping lift to support the development of unit costs.
- The conceptual pipeline design incorporates a single pump station (housed within a building), isolation valves, and combination air-relief valves. Costs for a surge system were incorporated with an allowance (10% of costs of the pump station building).
- Piping is 30-inch DR17 PVC, which provides acceptable flow velocities of up to 6 feet per second, is compatible with the water sources that have been identified, and can accommodate the anticipated pipeline pressures.
- The O&M cost estimates include power costs for pumping water from the source to the treatment plant and maintenance and replacement for pump station equipment.

7.2 Estimated Costs

The estimated conveyance costs of 10-MGD source flows are the same for all identified water source types. The estimated energy consumption for conveyance (pumping source water) is 5.7M kWh/year. Table 3-18 summarizes the capital, annual O&M, and lifecycle costs for cut-and-fill and HDD construction methods.

Table 3-18. Planning-level Costs Estimates for Conveyance^[a,b]

Source	Distance (Miles)	Construction Costs (\$)	Annual O&M Costs (\$/year)	Total NPV Cost ^[c] (\$)	Unit Cost (\$/Mile)
Cut-and-Fill Construction	25	\$115M	\$1.1M	\$131M	\$5.2M
HDD Construction	25	\$125M	\$1.1M	\$141M	\$5.6M

^[a] All costs are based on 10 MGD of source water flow.

^[b] Costs are presented in 2023 dollars, cost accuracy is +100%, -50%.

^[c] Construction costs plus NPV O&M costs for 30 years of operation.

8. Water Acquisition Costs

This section presents costs estimates for acquisition of the water supplies for the supply sources that have been identified.

8.1 Key Assumptions

Water acquisition costs were estimated based on published estimates if available.

- For surface water (Source 1), the acquisition mechanism is assumed to be an exchange. The cost for surface water exchange is based on the difference in cost of water associated with the exchange project and the costs of untreated surface water that is provided in exchange.
 - The cost of water for the exchange project was assumed to be equivalent to the total costs of water for inland brackish groundwater developed for this chapter (Source 8) including treatment, conveyance, acquisition, and concentrate management (brine line disposal) (\$1,663 per acre-foot [AF]).
 - The cost for untreated surface water was assumed to be equivalent to published costs for untreated surface water provided by the Metropolitan Water District (\$855/AF for 2023) (MWD 2022).
 - The resulting acquisition cost is \$1,259/AF.
- Acquisition cost for treated wastewater (Source 2) was assumed to be the average of the published retail rates for treated wastewater for the Inland Empire Utility District (IEUA 2022), EMWD (2024), and the Coachella Valley Water District (CVWD 2024a).
 - The resulting acquisition cost is \$440/AF.
- For groundwater (Source 3), acquisition is assumed to occur via a combination of groundwater pumped by the project developer and water purchased (assumed to be groundwater) from a water purveyor. Two acquisition mechanisms were assumed because project developers may not be able to meet the full water demand with site-produced groundwater, so they may need to purchase groundwater from a purveyor to meet the overall water demand for their project. For this chapter, 75% of the water demand (7.5 MGD) was assumed to be groundwater pumped by the project developer, and 25% (2.5 MGD) was assumed to be groundwater purchased from a water purveyor.
 - The acquisition cost for pumping is assumed to be similar to the fees levied by Groundwater Sustainability Agencies (GSAs) and the California Department of Water Resources (DWR) for groundwater basin management. The published management fees for DWR are \$10, \$25, \$40, and \$55 per AF of groundwater pumped, depending on the status of the groundwater basin (DWR 2024); the GSA for the Indian Wells Valley Groundwater Basin levies a pumping fee \$105/AF (IWVGA 2020); and the Mid Kings River GSA has proposed a pumping fee \$95/AF (MKRGSA 2024). The average of these fees (\$55/AF) was assumed as the acquisition cost for pumped groundwater.
 - The acquisition cost for retail water is assumed to be the average of industrial water rates for the Coachella Valley Water District, City of Blythe, City of Bakersfield, and Los Angeles County Water Works in Palmdale (CVWD 2024b; City of Blyth 2024; City of Bakersfield 2024; LACWD 2024). These are water purveyors with service areas near the areas that have been identified for potential hydrogen production as part of the Angeles Link Phase 1 feasibility analyses. The average water cost for these purveyors is \$571/AF.
 - The overall acquisition cost is \$184/AF.
- For inland brackish groundwater (Source 8), the acquisition costs are assumed to be the same as that for pumped groundwater, \$55/AF.
- Published estimates of the acquisition costs for the remaining sources were not available. These sources are waste streams or are sources without existing demands. They are not expected to have significant acquisition costs, but the agencies involved may require administrative or infrastructure fees to use these sources. A nominal cost of \$100/AF was assumed to provide a conservative estimate of the acquisition cost for these sources.

8.2 Estimated Costs

Table 3-19 summarizes the estimated for source water acquisition.

Table 3-19. Planning-level Costs Estimates for Source Water Acquisition^[a]

Source	Unit Cost (\$/AF)	Annual Costs ^[b] (\$/YR)	Total NPV Cost ^[c] (\$)	Cost/Volume (\$/MG)
Source 1: Imported Surface Water	\$1,259	\$14.1M	\$423M	\$3,863
Source 2: Treated Wastewater	\$440	\$4.9M	\$68.7M	\$628
Source 3: Groundwater	\$184	\$2.1M	\$29.3M	\$267
Source 4: Agricultural Industry Water	\$100	\$1.1M	\$15.6M	\$143
Source 5: Brine Line Flows	\$100	\$1.1M	\$15.6M	\$143
Source 6: Advanced Water Treatment Concentrate	\$100	\$1.1M	\$15.6M	\$143
Source 7: O&G Industry Water	\$100	\$1.1M	\$15.6M	\$143
Source 8: Inland Brackish Groundwater	\$55	\$0.6M	\$8.6M	\$78
Source 9: Dry Weather Flows	\$100	\$1.1M	\$15.6M	\$143
Source 10: Urban Stormwater Capture and Reuse	\$100	\$1.1M	\$15.6M	\$143

^[a] Costs are presented in 2023 dollars, cost accuracy is +100%, -50%.

^[b] Assuming 10 MGD (11,200 AF per year) source water flows.

^[c] Total NPV acquisition costs for 30 years of operation.

9. Cost Summary

This section presents a summary of the overall cost estimates for the conceptual water supply scenarios developed for this chapter and the associated unit cost outputs for the following project elements:

- Water treatment
- Concentrate management
- Conveyance
- Water acquisition

9.1 Combined Project Cost Estimates

Combined project costs that incorporate the costs for water treatment, concentrate management, conveyance, and water acquisition were developed for each supply source assuming 10-MGD source water flows and 25 miles of conveyance (**Table 3-20**). The combined project costs range from \$414M to \$1,906M. The costs per unit volume of water supplied range from \$3,655/MG to \$17,403/MG, with an overall average of \$8,124/MG. For these scenarios, the overall cost for Source 10 (urban stormwater), is the lowest, and the overall cost for Source 7 (O&G industry water) is the highest of the sources that were evaluated.

Table 3-20. Combined Project Costs for 10 MGD Source Flows^[a,b]

Total Project Cost ^[c]	Source 1: Imported Surface Water	Source 2: Treated Wastewater	Source 3: Groundwater	Source 4: Agricultural Industry Water	Source 5: Brine Line Flows	Source 6: Advanced Water Treatment Concentrate	Source 7: O&G Industry Water	Source 8: Brackish Groundwater	Source 9: Dry Weather Flows	Source 10: Urban Stormwater Capture and Reuse
Treatment (\$)	\$210M	\$426M	\$314M	\$741M	\$829M	\$867M	\$1,058M	\$395M	\$596M	\$267M
Concentrate (\$)										
Evaporation Basins	\$0	\$151M	\$97.4M	\$318M	\$259M	\$213M	\$691M	\$310M	\$203M	\$0
Existing Brine Line	\$0	\$20.5M	\$7.0M	\$33.3M	\$20.5M	\$20.5M	\$33.3M	\$20.5M	\$20.5M	\$0
Conveyance (\$)										
Cut-and-Fill	\$131M	\$131M	\$131M	\$131M	\$131M	\$131M	\$131M	\$131M	\$131M	\$131M
HDD	\$141M	\$141M	\$141M	\$141M	\$141M	\$141M	\$141M	\$141M	\$141M	\$141M
Acquisition (\$)	\$423M	\$68.7M	\$29.3M	\$15.6M	\$15.6M	\$15.6M	\$15.6M	\$8.6M	\$15.6M	\$15.6M
Combined Costs (\$)										
High-Cost Options	\$774M	\$787M	\$582M	\$1,216M	\$1,245M	\$1,237M	\$1,906M	\$855M	\$956M	\$424M
Low-Cost Options	\$764M	\$646M	\$481M	\$921M	\$996M	\$1,034M	\$1,238M	\$555M	\$763M	\$414M
Unit Cost, Flow (\$/MG)										
High-Cost Options	\$7,068	\$7,184	\$5,312	\$11,101	\$11,366	\$11,293	\$17,403	\$7,805	\$8,727	\$3,868
Low-Cost Options	\$6,977	\$5,901	\$4,395	\$8,410	\$9,097	\$9,444	\$11,305	\$5,069	\$6,969	\$3,777

^[a] Costs are presented in 2023 dollars, cost accuracy is +100%, -50%.

^[b] Assuming 10-MGD source water flows.

^[c] Total project costs are sum of construction and MPV O&M costs for 30 years of operation.

9.2 Unit Cost Summary

As described in Section 2 of this chapter, the major cost elements associated with water supply and treatment have been presented as unit costs to support the development of cost estimates for third-party clean renewable production projects as those details projects develop in the future. **Table 3-21** summarizes the costs for the major project elements in unit costs format.

Table 3-21. Summary of Unit Cost Outputs^[a]

Cost Component	Units	Estimate ^[b,c]	+100%	-50%
Conveyance Cost				
Cut-and-Fill Construction	\$/mile	\$5.2M	\$10.4M	\$2.6M
HDD Construction		\$5.6M	\$11.3M	\$2.8M
Water Treatment Cost				
Source 1: Imported Surface Water	\$/MG	\$1,916	\$3,883	\$958
Source 2: Treated Wastewater		\$3,894	\$7,789	\$1,947
Source 3: Groundwater		\$2,868	\$5,735	\$1,434
Source 4: Agricultural Industry Water		\$6,767	\$13,533	\$3,383
Source 5: Brine Line Flows		\$7,567	\$15,134	\$3,784
Source 6: Advanced Water Treatment Concentrate		\$7,917	\$15,833	\$3,958
Source 7: O&G Industry Water		\$9,661	\$19,323	\$4,831
Source 8: Inland Brackish Groundwater		\$3,067	\$7,215	\$1,804
Source 9: Dry Weather Flows		\$5,439	\$10,878	\$2,720
Source 10: Urban Stormwater Capture and Reuse		\$2,436	\$4,872	\$1,218
Concentrate Management Cost- Evaporation Ponds				
Source 1: Imported Surface Water	\$/MG	\$0	\$0	\$0
Source 2: Treated Wastewater		\$1,376	\$2,751	\$688
Source 3: Groundwater		\$889	\$1,779	\$445
Source 4: Agricultural Industry Water		\$2,900	\$5,800	\$1,450
Source 5: Brine Line Flows		\$2,365	\$4,729	\$1,182
Source 6: Advanced Water Treatment Concentrate		\$1,944	\$3,888	\$972
Source 7: O&G Industry Water		\$6,313	\$12,627	\$3,157
Source 8: Inland Brackish Groundwater		\$2,830	\$5,611	\$1,415
Source 9: Dry Weather Flows		\$1,849	\$3,699	\$925
Source 10: Urban Stormwater Capture and Reuse		\$0	\$0	\$0
Concentrate Management Cost- Brine Line				
Source 1: Imported Surface Water	\$/MG	\$0	\$0	\$0
Source 2: Treated Wastewater		\$187	\$374	\$94
Source 3: Groundwater		\$85	\$171	\$43
Source 4: Agricultural Industry Water		\$304	\$608	\$152
Source 5: Brine Line Flows		\$187	\$374	\$94
Source 6: Advanced Water Treatment Concentrate		\$187	\$374	\$94
Source 7: O&G Industry Water		\$304	\$608	\$152
Source 8: Inland Brackish Groundwater		\$187	\$374	\$94
Source 9: Dry Weather Flows		\$187	\$374	\$94
Source 10: Urban Stormwater Capture and Reuse		\$0	\$0	\$0
Source Water Acquisition				
Source 1: Imported Surface Water	\$/MG	\$3,863	\$7,726	\$1,932
Source 2: Treated Wastewater		\$628	\$1,256	\$314
Source 3: Groundwater		\$267	\$534	\$134
Source 4: Agricultural Industry Water		\$143	\$286	\$72
Source 5: Brine Line Flows		\$143	\$286	\$72
Source 6: Advanced Water Treatment Concentrate		\$143	\$286	\$72
Source 7: O&G Industry Water		\$143	\$286	\$72
Source 8: Inland Brackish Groundwater		\$78	\$156	\$39
Source 9: Dry Weather Flows		\$143	\$286	\$72
Source 10: Urban Stormwater Capture and Reuse		\$143	\$286	\$72

^[a] All costs are based on 10 MGD of source water flow.

^[b] Costs are presented in 2023 dollars; cost accuracy is +100%, -50%.

^[c] Unit costs include construction costs plus NPV O&M costs for 30 years of operation.

10. Estimates of Overall Water Demands and Water Supply Costs

Under separate Phase 1 feasibility analyses for Angeles Link, a clean renewable hydrogen Angeles Link Demand Report (Demand Study) was prepared, which identified a range of potential demand scenarios for clean renewable hydrogen across SoCalGas's service territory by 2045 (SoCalGas 2024). The overall projected demand spans from a low demand (conservative scenario) of 1.9 million metric tons per year (MMT/Year) to a high demand (ambitious scenario) of 5.9 MMT/Year. The Angeles Link system would transport a portion of the overall projected demand for clean renewable hydrogen, with a proposed throughput of approximately 0.5 MMT/Year under a low case scenario and up to 1.5 MMT/year under a high case scenario. This section presents estimates of the corresponding water demands and the associated water supply costs for the overall projected demand for clean renewable hydrogen within SoCalGas's service territory by 2045, as well as the water demands for the portion of that clean renewable hydrogen that Angeles Link proposes to transport.

10.1 Water Demands

The overall source water demand associated with the production of clean renewable hydrogen consists of three main components:

- Electrolyzer demands, water consumed by electrolyzer systems to produce clean renewable hydrogen
- Electrolyzer cooling demands, water consumed during cooling of the electrolyzer systems
- Pretreatment demands, water consumed during pretreatment of source water to levels needed for electrolyzer feed and cooling

10.1.1 Electrolyzer Demands

Water demand required for the electrolysis process is discussed in Chapter 2, Water Quality Requirements for Hydrogen Generation. The estimated demand ranges from approximately 950 to 1,100 gallons per day of ultrapure water per megawatt of electrolyzer capacity (GPD/MW). Refining this estimate to account for losses within the electrolyzer process due to evaporation and leaks, the estimated ultrapure water demand of 1,200 GPD/MW was used as a planning-level estimate for this chapter.

As mentioned in Section 4.1.1, typical large electrolyzer systems include RO and EDI polishing of the feed water for the electrolyzer. Treatment losses associated with these processes increase the overall water demand for electrolyzer systems. The water recovery rate of the RO-EDI processes depends on the treated water quality and site-specific conditions. Based on the consultant's experience, however, a treated water recovery of 85% is achievable for the RO-EDI treatment included with electrolyzer systems. The corresponding electrolyzer water demand including treatment losses for the RO-EDI system is 1,413 GPD/MW capacity.

10.1.2 Electrolyzer Cooling Demands

The water cooling demands for electrolyzers will vary depending on the technology employed.

- For open-loop system cooling, the cooling demands depend on the amount of water evaporated for cooling and the cycle of concentration for the recirculating water to maintain the operational TDS. A typical water demand of 3,790 GPD/MW for open cooling systems has been reported by Niekerk and Manita (2022).
- Typical treated water demands for closed-loop cooling (AFC) with spray systems range from 46 to 79 GPD/MW (Niekerk and Manita 2022).

For the purposes of this chapter, AFC with a spray system is assumed to be the option third-party producers may pursue for cooling because it has lower water demands than open-loop system cooling systems. For this chapter, 79 GPD/MW was used as a planning-level estimate for cooling water demands.

10.1.3 Pretreatment Demands

Based on the treated water yield that was estimated for each of the supply sources, the water lost during pretreatment for electrolyzer feed (feed to the RO-EDI polishing) and cooling ranges from approximately 2% to 25% of the source water flow, depending on source type (refer to Section 5.11). The average water losses for pretreatment for this portfolio of water sources is approximately 13%. The combined demands for electrolyzer feed and electrolyzer cooling is approximately 1,492 GPD/MW. Assuming this combined demand estimate and the average water loss for pretreatment for the supply portfolio, the average source water demand would be approximately 1,722 GPD/MW.

10.1.4 Total Source Water Demands

A typical 1 MW electrolyzer facility will produce approximately 175 metric tons of hydrogen per year, based on the stoichiometric water demand and the electrolyzer energy efficiency. Based on 0.000175 MMTY production per 1 MW, and the average water demand of 1,722 GPD/MW for the supply sources that were evaluated, the total source water demand for the production of 1 MMTY of clean renewable hydrogen is approximately 9.8 MGD for this water portfolio. **Table 3-22** summarizes the estimated average water demands for the range of clean renewable hydrogen supply that Angeles Link anticipates conveying over time.

Table 3-22. Estimated Water Demands for Angeles Link Estimated Throughput^[a]

Hydrogen Supply (MMTY)	Electrolyzer Demand (MGD AFY)	Electrolyzer Cooling Demand (MGD AFY)	Source Water Pretreatment Demand ^[b] (MGD AFY)	Total Source Water Demand (MGD AFY)
0.5	4.0 4,500	0.2 200	0.7 800	4.9 5,500
1	8.1 9,100	0.5 600	1.3 1,500	9.8 11,000
1.5	12.1 13,600	0.7 800	2.0 2,200	14.7 16,500

^[a] Note the sum of the individual components and totals may differ because of rounding

^[b] Based on the average water recovery efficiency for pretreatment for the supply sources that have been identified
MGD | AFY = million gallons per day | acre-feet per year; the AFY value that is shown is rounded to the nearest 100 AFY

Table 3-23 summarizes the estimated water demands for the overall range of demand for clean renewable hydrogen in SoCalGas' service territory.

Table 3-23. Estimated Water Demands for Clean Renewable Hydrogen in SoCalGas' Service Territory^[a]

Hydrogen Supply (MMTY)	Electrolyzer Demand (MGD AFY)	Electrolyzer Cooling Demand (MGD AFY)	Source Water Pretreatment Demand ^[b] (MGD AFY)	Total Source Water Demand (MGD AFY)
1.9	15.4 17,00	1.0 1,100	2.3 2,600	18.7 20,900
5.9	47.8 53,500	3.0 3,400	7.1 8,000	57.8 64,700

^[a] Note the sum of the individual components and totals may differ because of rounding

^[b] Based on the average water recovery efficiency for pretreatment for the supply sources that have been identified
MGD | AFY = million gallons per day | acre-feet per year; the AFY value that is shown is rounded to the nearest 100 AFY

10.2 Overall Water Supply Costs

Assuming the average total project cost for the conceptual supply projects developed for this chapter (\$8,124 per MG) and the estimated total source water demands summarized in Table 3-22, the water supply costs corresponding to 0.5 MMTY to 1.5 MMTY of clean renewable hydrogen supply would range from \$436M to \$1,308M, inclusive of construction costs and NPV O&M costs for 30 years of operation.

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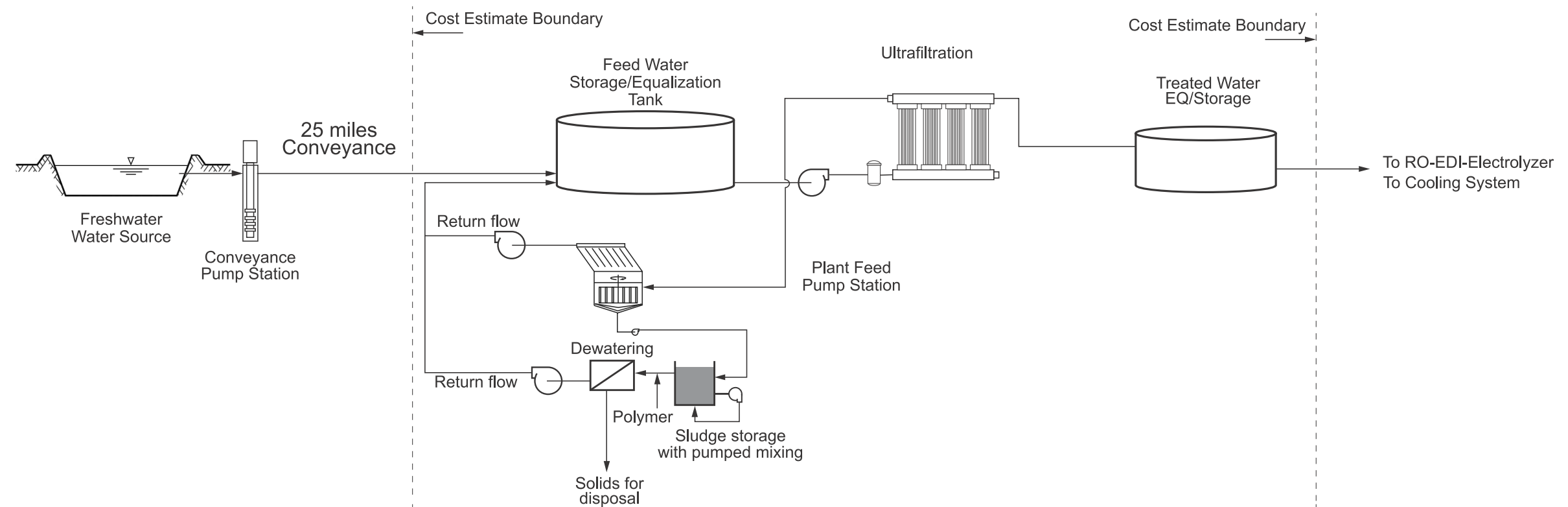
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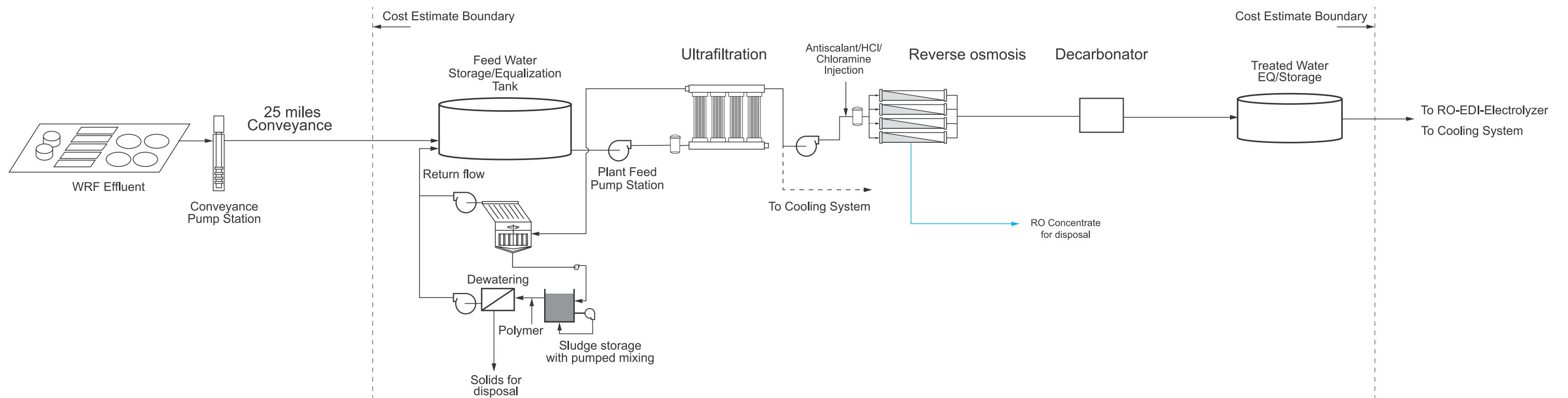
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Figures



Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

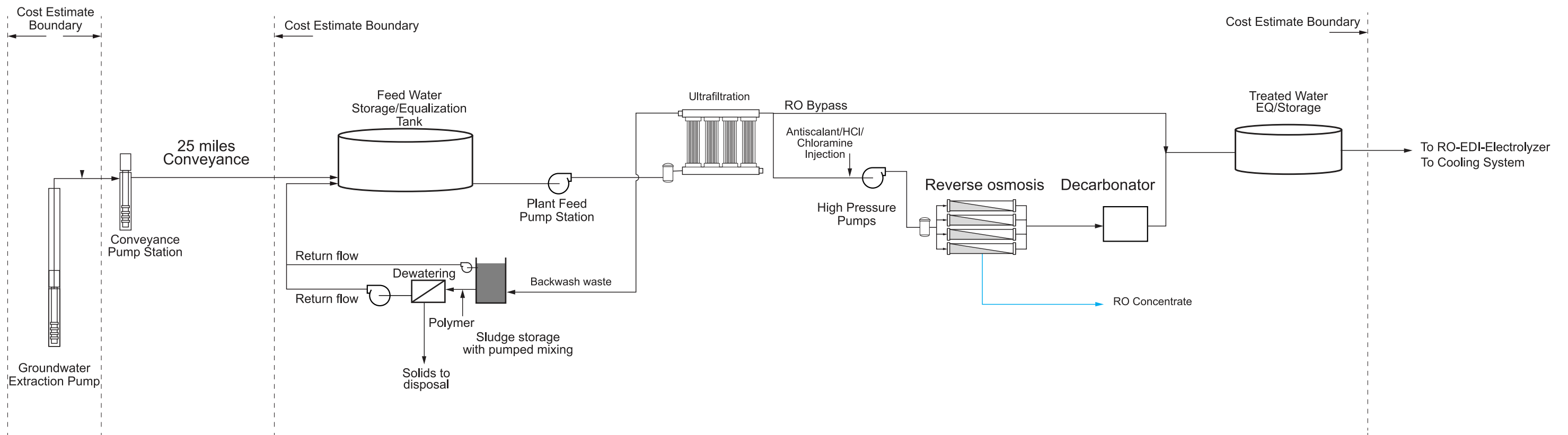
Figure 3-1
Process Flow Diagram for Treatment of
Source 1: Imported Surface Water



Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-2
Process Flow Diagram for Treatment of
Source 2: Treated Wastewater

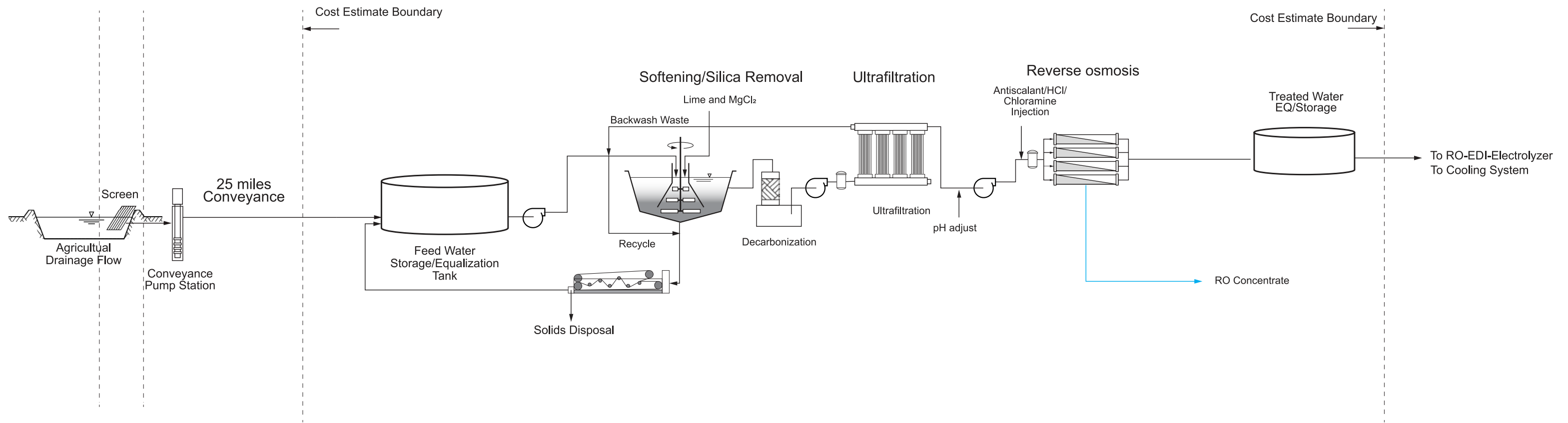




Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-3
Process Flow Diagram for Treatment
of Source 3: Groundwater

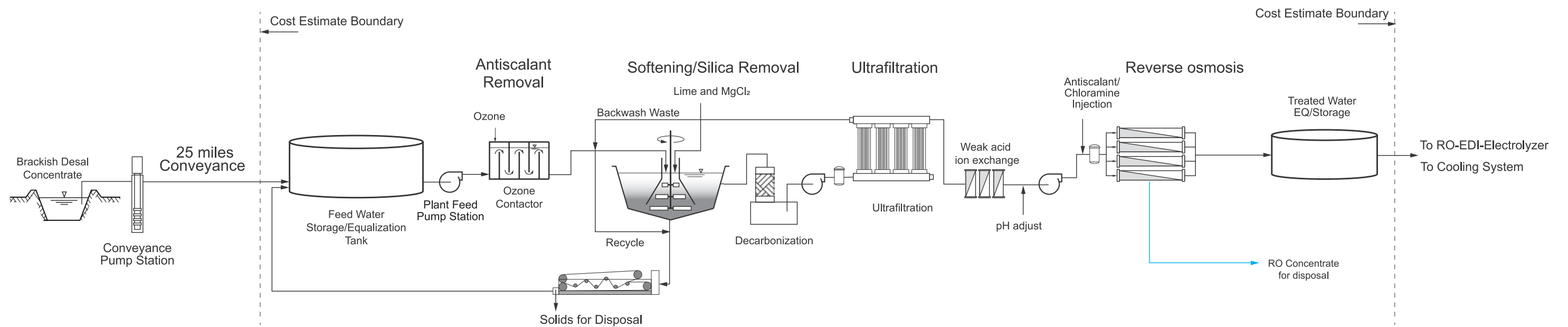




Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-4
Process Flow Diagram for Treatment of
Source 4: Agricultural Industry Water





Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-5
Process Flow Diagram for Treatment of
Source 5: Brine Line Flows

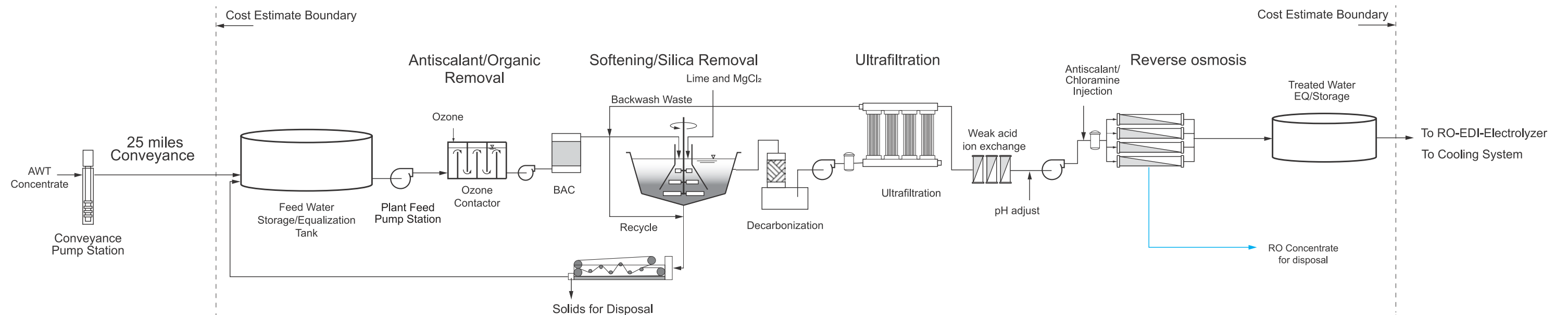
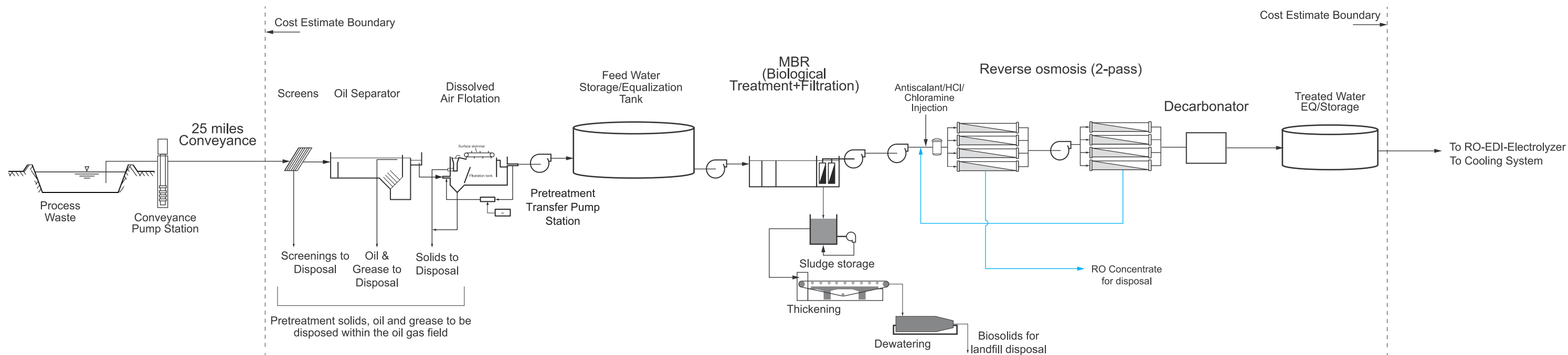


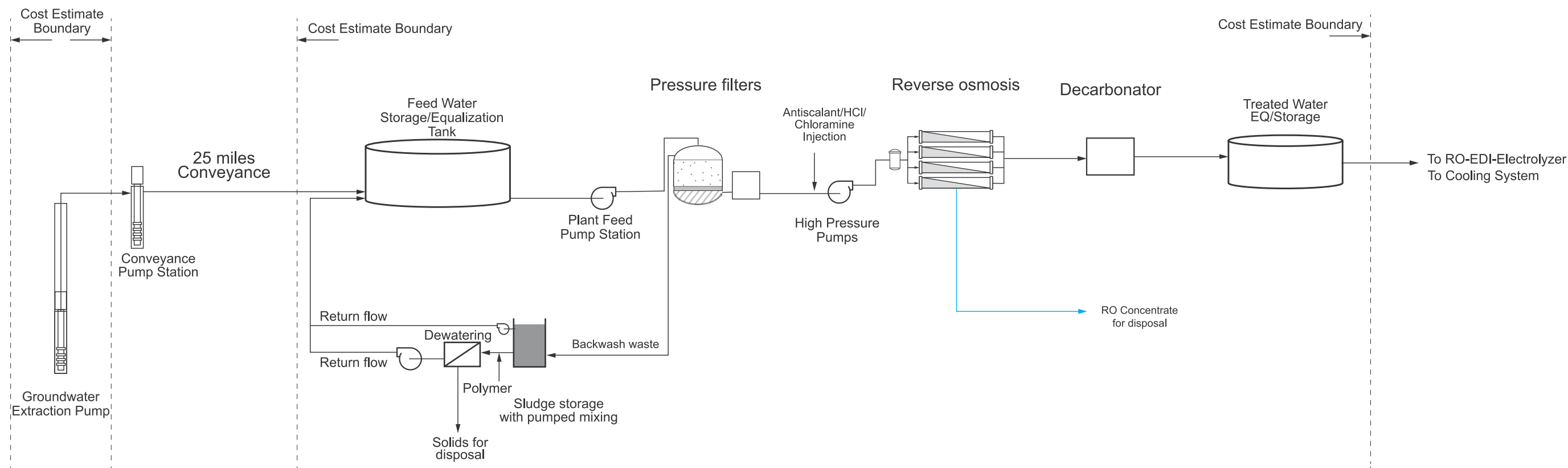
Figure 3-6
Process Flow Diagram for Treatment of Source 6: Advanced Water Treatment Concentrate

Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.



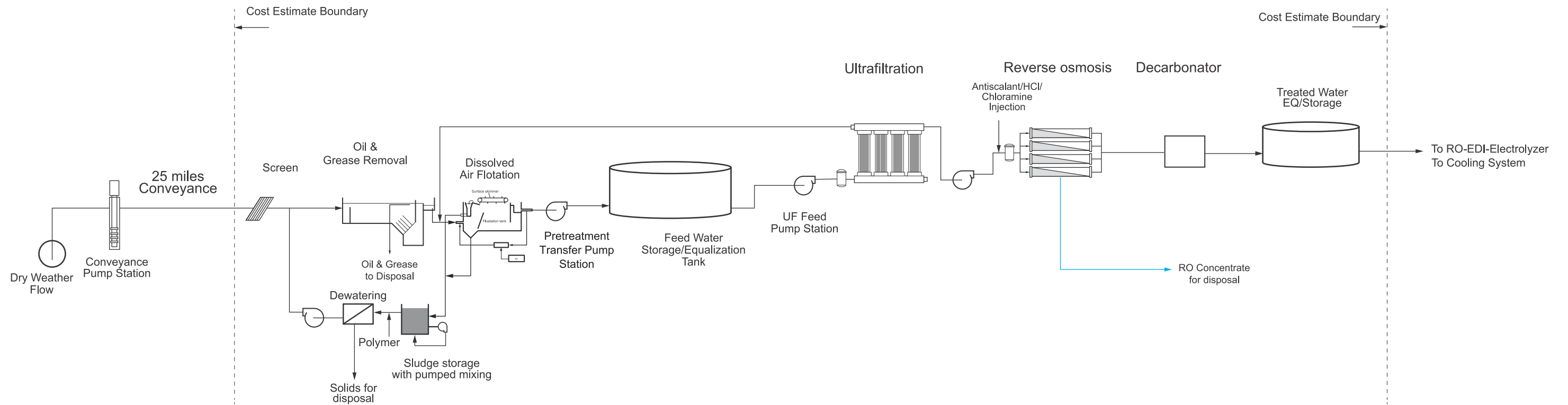
Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-7
Process Flow Diagram for Treatment of
Source 7: O&G Industry Water



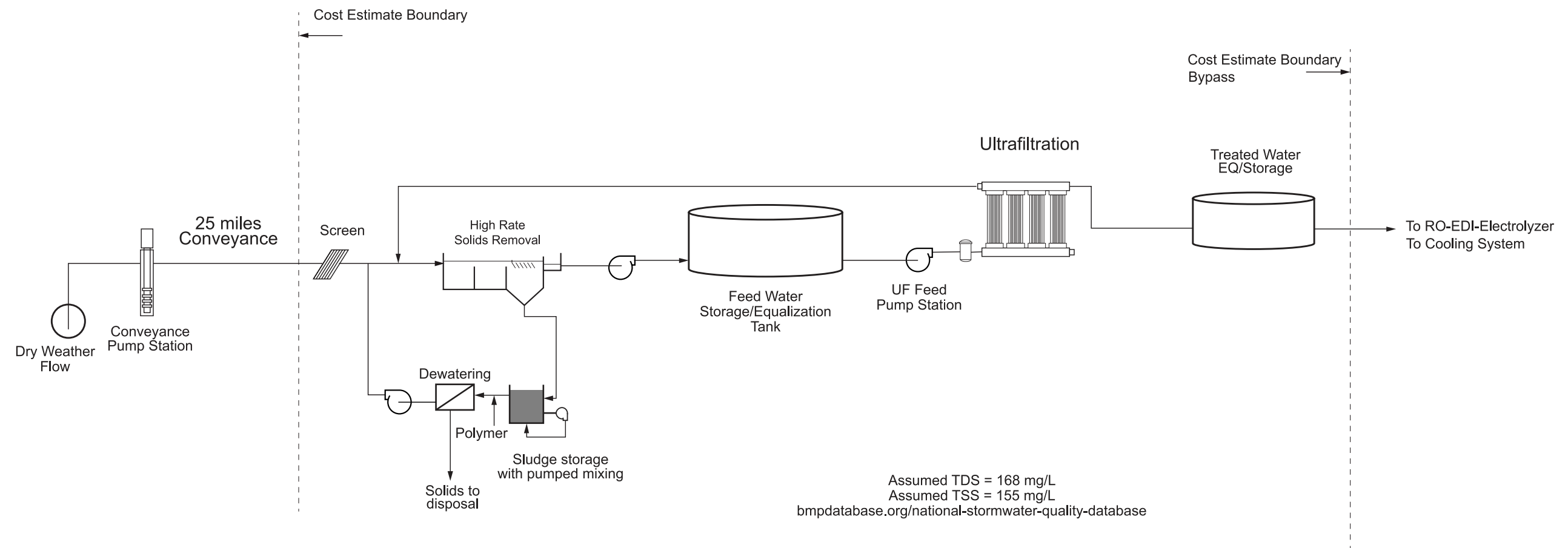
Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-8
Process Flow Diagram for Treatment of
Source 8: Inland Brackish Groundwater



Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-9
Process Flow Diagram for Treatment of
Source 9: Dry Weather Flows



Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-10
Process Flow Diagram for Treatment of
Source 10: Urban Stormwater Capture and Reuse

Appendix A

Treatment Cost Summary Outputs



Replica - Parametric Design

Jacobs

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source 1: Imported Surface Water Roundup to the nearest:

Project Location (City): Los Angeles \$1,000

Project Location (State): CALIFORNIA

Project Location (Country): USA

Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Steel Clearwell: Feed	\$733,000
	Yes	Horizontal PS: PlantFeed	\$5,937,000
	Yes	Lamella Clarifier: New	\$3,420,000
	Yes	In-Plant PS: Return	\$407,000
	Yes	Small Surge Basin: New	\$516,000
	Yes	WTP Belt FP: New	\$3,787,000
	Yes	In-Plant PS: Filtrate	\$413,000
	Yes	Pall - Large: New	\$17,414,000
	Yes	Steel Clearwell: Treated	\$1,465,000
	Yes	Vertical Turbine PS: Dist	\$5,105,000
SUBTOTAL - PROJECT COST			\$39,197,000
ADDITIONAL PROJECT COSTS:			
<i>Demolition:</i>		0.00%	\$0
<i>Overall Sitework:</i>		6.00%	\$2,352,000
<i>Plant Computer System:</i>		6.00%	\$2,352,000
<i>Yard Electrical:</i>		9.00%	\$3,528,000
<i>Yard Piping:</i>		8.00%	\$3,136,000
<i>UD #1 Default Description</i>		0.00%	\$19,694,000
<i>UD #2 Default Description</i>		0.00%	\$0
<i>UD #3 Default Description</i>		0.00%	\$0
SUBTOTAL with Additional Project Costs			\$50,565,000
RED FLAGS:			
1	<i>Rock Excavation</i>		
2	<i>Pile Foundations</i>		
3	<i>Seismic Foundations</i>		

4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			
23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				\$50,565,000
TAX:		8.25%	\$27,810,750	\$2,294,387
SUBTOTAL with Tax				\$52,859,387
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	\$52,859,387	\$6,344,000
Subtotal				\$59,203,387
Profit		10.00%	\$59,203,387	\$5,921,000
Subtotal				\$65,124,387
Mob/Bonds/Insurance		3.00%	\$65,124,387	\$1,954,000
Subtotal				\$67,078,387
Contingency		30.00%	\$67,078,387	\$20,124,000
SUBTOTAL with Markups				\$87,202,387
LOCATION ADJUSTMENT FACTOR		112.9	\$87,202,387	\$98,452,000
SUBTOTAL - with Local Adjustment Factor				\$98,452,000
MARKET ADJUSTMENT FACTOR			\$98,452,000	\$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				\$98,452,000
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:				
Name of Process Reviewer			Garcia-Aleman, Jesus	

Name of Estimator Reviewer		Meyer, Ed	
MAXIMUM CONSTRUCTION COST			\$98,452,000



Replica - Parametric Design

DESIGN FACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

Linked to Replica - Parametric Design Facilities File:

https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Document

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source 1: Imported Surface Water

Project Location (City): Los Angeles

Project Location (State): CALIFORNIA

Project Location (Country): USA

Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
19	Yes	Steel Clearwell: Feed	\$0
20	Yes	Horizontal PS: PlantFeed	\$145,000
21	Yes	Lamella Clarifier: New	\$290,000
22	Yes	In-Plant PS: Return	\$13,000
23	Yes	Small Surge Basin: New	\$62,000
24	Yes	WTP Belt FP: New	\$281,000
25	Yes	In-Plant PS: Filtrate	\$13,000
26	Yes	Pall - Large: New	\$4,129,000
27	Yes	Steel Clearwell: Treated	\$0
28	Yes	Vertical Turbine PS: Dist	\$1,440,000

Additional Project Costs:

Biosolids Disposal	\$36,000
Standard Items	\$638,000
User Defined Items	\$0

Plant O&M Labor	\$1,049,000
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TOTAL - ANNUAL O&M COST **\$8,096,000**



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source 2: Treated Wastewater Roundup to the nearest:

Project Location (City): Los Angeles \$1,000

Project Location (State): CALIFORNIA

Project Location (Country): USA

Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Steel Clearwell: Feed EQ	\$1,544,000
	Yes	Steel Clearwell: RO EQ	\$1,544,000
	Yes	BWRO: New	\$27,613,000
	Yes	Pall - Large: New	\$28,001,000
	Yes	Air Stripper: New	\$5,378,000
	Yes	Horizontal PS: PlantFeed	\$9,413,000
	Yes	Lamella Clarifier: New	\$3,473,000
	Yes	In-Plant PS: Return	\$526,000
	Yes	Small Surge Basin: New	\$516,000
	Yes	WTP Belt FP: New	\$3,787,000
	Yes	In-Plant PS: Filtrate	\$545,000

SUBTOTAL - PROJECT COST \$82,340,000

ADDITIONAL PROJECT COSTS:

Demolition:	0.00%		\$0
Overall Sitework:	6.00%		\$4,941,000
Plant Computer System:	6.00%		\$4,941,000
Yard Electrical:	9.00%		\$7,411,000
Yard Piping:	8.00%		\$6,588,000
UD #1 Default Description	0.00%	\$41,364,000	\$0
UD #2 Default Description	0.00%		\$0
UD #3 Default Description	0.00%		\$0

SUBTOTAL with Additional Project Costs \$106,221,000

RED FLAGS:

1	Rock Excavation		
2	Pile Foundations		

3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			
23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				\$106,221,000
TAX:		8.25%	\$58,421,550	\$4,819,778
SUBTOTAL with Tax				\$111,040,778
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	\$111,040,778	\$13,325,000
Subtotal				\$124,365,778
Profit		10.00%	\$124,365,778	\$12,437,000
Subtotal				\$136,802,778
Mob/Bonds/Insurance		3.00%	\$136,802,778	\$4,105,000
Subtotal				\$140,907,778
Contingency		30.00%	\$140,907,778	\$42,273,000
SUBTOTAL with Markups				\$183,180,778
LOCATION ADJUSTMENT FACTOR		112.9	\$183,180,778	\$206,812,000
SUBTOTAL - with Local Adjustment Factor				\$206,812,000
MARKET ADJUSTMENT FACTOR			\$206,812,000	\$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				\$206,812,000

Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		Garcia-Aleman, Jesus	
Name of Estimator Reviewer		Meyer, Ed	
MAXIMUM CONSTRUCTION COST			\$206,812,000

	A	B	C	E
1	<u>Replica - Parametric Design</u>			
2	DESIGN FACILITIES LIFE CYCLE COST ANALYSIS MODULE			
3	File Version: <u>3/17/2023</u>			
4	Linked to Replica - Parametric Design Facilities File:			
5	https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum			
6				

7	Project Name:	Clean Renewable Hydrogen Water Treatment Cost Estimate
8	Project Number:	_____
9	Project Manager:	_____
10	Estimator:	_____
11	Project Description:	Source 2: Treated Wastewater
12	Project Location (City):	Los Angeles
13	Project Location (State):	CALIFORNIA
14	Project Location (Country):	USA
15	Cost Basis (Month/Year):	December/2023
16		

	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
17				
18		Yes	Steel Clearwell: Feed EQ	\$0
19		Yes	Steel Clearwell: RO EQ	\$0
20		Yes	Pall - Large: New	\$4,569,000
21		Yes	BWRO: New	\$7,782,000
22		Yes	Air Stripper: New	\$449,000
23		No	Mech Evaporation: New	\$0
24		No	Evap Ponds: New	\$0
25		No	Vertical Turbine PS: DistPS	\$0
26		Yes	Horizontal PS: PlantFeed	\$47,000
27		No	Horizontal PS: SourceFeed	\$0
28		Yes	Lamella Clarifier: New	\$304,000
29		Yes	In-Plant PS: Return	\$20,000
30		Yes	Small Surge Basin: New	\$62,000
31		Yes	WTP Belt FP: New	\$281,000
32		Yes	In-Plant PS: Filtrate	\$21,000
33				

		Additional Project Costs:	
34		Biosolids Disposal	
35			\$36,000
36		Standard Items	
37		User Defined Items	
			\$0

	A	B	C	E
38				
39			Plant O&M Labor	\$1,049,000
40				
41	TOTAL - ANNUAL O&M COST			\$15,959,000



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		Project Unit: >>>		<i>(For example: MGD, HP, GPM...)</i>
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Project Name:	Clean Renewable Hydrogen Water Treatment Cost Estimate
Project Number:	_____
Project Manager:	_____
Estimator:	_____
Project Description:	Source 3: Groundwater Roundup to the nearest:
Project Location (City):	Los Angeles \$1,000
Project Location (State):	CALIFORNIA
Project Location (Country):	USA
Cost Basis (Month/Year):	December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Vertical Turbine PS: New	\$3,337,000
	Yes	Horizontal PS: PlantFeed	\$11,658,000
	Yes	Pall - Large: New	\$16,431,000
	Yes	BWRO: New	\$16,296,000
	Yes	Air Stripper: New	\$5,535,000
	Yes	Steel Clearwell: New	\$1,405,000
	Yes	Steel Clearwell: Treated	\$1,405,000
	Yes	WTP Belt FP: New	\$5,063,000
	Yes	Small Surge Basin: New	\$510,000
	Yes	In-Plant PS: Filtrate	\$408,000

SUBTOTAL - PROJECT COST			\$62,048,000
ADDITIONAL PROJECT COSTS:			
Demolition:	0.00%		\$0
Overall Sitework:	6.00%		\$3,723,000
Plant Computer System:	6.00%		\$3,723,000
Yard Electrical:	9.00%		\$5,585,000
Yard Piping:	8.00%		\$4,964,000
UD #1 Default Description	0.00%	\$31,170,000	\$0

UD #2 Default Description		0.00%		\$0
UD #3 Default Description		0.00%		\$0
SUBTOTAL with Additional Project Costs				\$80,043,000
RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			
23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				\$80,043,000
TAX:		8.25%	\$44,023,650	\$3,631,951
SUBTOTAL with Tax				\$83,674,951
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	\$83,674,951	\$10,041,000
Subtotal				\$93,715,951
Profit		10.00%	\$93,715,951	\$9,372,000
Subtotal				\$103,087,951
Mob/Bonds/Insurance		3.00%	\$103,087,951	\$3,093,000
Subtotal				\$106,180,951
Contingency		30.00%	\$106,180,951	\$31,855,000

SUBTOTAL with Markups			\$138,035,951
LOCATION ADJUSTMENT FACTOR	112.9	\$138,035,951	\$155,843,000
SUBTOTAL - with Local Adjustment Factor			\$155,843,000
MARKET ADJUSTMENT FACTOR		\$155,843,000	\$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			\$155,843,000
MAXIMUM CONSTRUCTION COST			\$155,843,000

	A	B	C	E
1	<h1 style="margin: 0;"><u>Replica - Parametric Design</u></h1>			
2	FACILITIES LIFE CYCLE COST ANALYSIS MODULE			
3	File Version: <u>3/17/2023</u>			
4	Linked to Replica - Parametric Design Facilities File:			
5	https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum			
6				

7	Project Name:	Clean Renewable Hydrogen Water Treatment Cost Estimate	
8	Project Number:	_____	Life Cycle Anal
9	Project Manager:	_____	i =
10	Estimator:	_____	n =
11	Project Description:	Source 3: Groundwater	Annual Inflation:
12	Project Location (City):	Los Angeles	
13	Project Location (State):	CALIFORNIA	
14	Project Location (Country):	USA	
15	Cost Basis (Month/Year):	December/2023	
16			

	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost (Year 1)
17				
18		Yes	Vertical Turbine PS: New	\$890,000
20		Yes	Horizontal PS: PlantFeed	\$61,000
21		Yes	Pall - Large: New	\$3,973,000
22		Yes	BWRO: New	\$3,762,000
23		Yes	Air Stripper: New	\$566,000
24		Yes	Steel Clearwell: New	\$0
25		Yes	Steel Clearwell: Treated	\$0
27		Yes	WTP Belt FP: New	\$298,000
29		Yes	Small Surge Basin: New	\$62,000
30		Yes	In-Plant PS: Filtrate	\$13,000
31				

		Additional Project Costs:	
32		Biosolids Disposal	\$0
33		Standard Items	\$1,029,000
34		User Defined Items	\$0
35			
36			
37		Plant O&M Labor	\$1,070,000
38			

	A	B	C	E
39	TOTAL - ANNUAL O&M COST			\$11,724,000



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		Project Unit: >>>		<i>(For example: MGD, HP, GPM...)</i>
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Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source: 4 Agricultural Industry Water Roundup to the nearest:

Project Location (City): Los Angeles **\$1,000**

Project Location (State): CALIFORNIA

Project Location (Country): USA

Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Submersible IPS: New	\$2,901,000
	No	Screening and Grit: New	\$0
	Yes	Concrete Clearwell: FeedEQ	\$1,733,000
	Yes	Lamella Clarifier: New	\$16,505,000
	Yes	Air Stripper: New	\$8,699,000
	Yes	Pall - Large: New	\$27,845,000
	Yes	1st Pass SWRO: New	\$36,493,000
	Yes	2nd Pass SWRO: New	\$15,433,000
	No	Concrete Clearwell: PureWater	\$0
	Yes	WTP Belt FP: New	\$10,075,000
	Yes	RW Screening PS: New	\$1,655,000
	Yes	Steel Clearwell: TreatedEQ	\$1,405,000

SUBTOTAL - PROJECT COST			\$122,744,000
ADDITIONAL PROJECT COSTS:			
Demolition:	0.00%		\$0
Overall Sitework:	6.00%		\$7,365,000
Plant Computer System:	6.00%		\$7,365,000
Yard Electrical:	9.00%		\$11,047,000
Yard Piping:	8.00%		\$9,820,000
UD #1 Default Description	0.00%	\$61,658,000	\$0
UD #2 Default Description	0.00%		\$0
UD #3 Default Description	0.00%		\$0
SUBTOTAL with Additional Project Costs			\$158,341,000

RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			
23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				\$158,341,000
TAX:		8.25%	\$87,087,550	\$7,184,723
SUBTOTAL with Tax				\$165,525,723
CONTRACTOR MARKUPS:				
	Overhead (includes General Conditions and General Administrative Costs)	12.00%	\$165,525,723	\$19,864,000
	Subtotal			\$185,389,723
	Profit	10.00%	\$185,389,723	\$18,539,000
	Subtotal			\$203,928,723
	Mob/Bonds/Insurance	3.00%	\$203,928,723	\$6,118,000
	Subtotal			\$210,046,723
	Contingency	30.00%	\$210,046,723	\$63,015,000
SUBTOTAL with Markups				\$273,061,723
LOCATION ADJUSTMENT FACTOR				
		112.9	\$273,061,723	\$308,287,000
SUBTOTAL - with Local Adjustment Factor				\$308,287,000
MARKET ADJUSTMENT FACTOR				
			\$308,287,000	\$0

SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			\$308,287,000
MAXIMUM CONSTRUCTION COST			\$308,287,000

	A	B	C	E
1	<h1 style="margin: 0;"><u>Replica - Parametric Design</u></h1>			
2	FACILITIES LIFE CYCLE COST ANALYSIS MODULE			
3	File Version: <u>3/17/2023</u>			
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5	https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum			
6				

7	Project Name:	Clean Renewable Hydrogen Water Treatment Cost Estimate	Life Cycle Anal
8	Project Number:	_____	i =
9	Project Manager:	_____	n =
10	Estimator:	_____	Annual Inflation:
11	Project Description:	Source: 4 Agricultural Industry Water	
12	Project Location (City):	Los Angeles	
13	Project Location (State):	CALIFORNIA	
14	Project Location (Country):	USA	
15	Cost Basis (Month/Year):	December/2023	
16			

	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost (Year 1)
17				
18		Yes	Submersible IPS: New	\$869,000
20		Yes	Concrete Clearwell: FeedEQ	\$3,000
21		Yes	Lamella Clarifier: New	\$1,609,000
22		Yes	Air Stripper: New	\$455,000
23		Yes	Pall - Large: New	\$7,063,000
24		Yes	1st Pass SWRO: New	\$12,400,000
25		Yes	2nd Pass SWRO: New	\$3,175,000
27		Yes	WTP Belt FP: New	\$2,511,000
28		Yes	RW Screening PS: New	\$882,000
29		Yes	Steel Clearwell: TreatedEQ	\$0
30				

31	Additional Project Costs:		
32		Biosolids Disposal	\$0
33		Standard Items	\$2,036,000
34		User Defined Items	\$0
35			
36		Plant O&M Labor	\$1,070,000
37			

	A	B	C	E
38	TOTAL - ANNUAL O&M COST			\$32,073,000



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate
Project Number: _____
Project Manager: _____
Estimator: _____
Project Description: Source 5: Brine Line Flows Roundup to the nearest:
Project Location (City): Los Angeles \$1,000
Project Location (State): CALIFORNIA
Project Location (Country): USA
Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Steel Clearwell: Feed	\$1,544,000
	Yes	Horizontal PS: Feed	\$12,171,000
	Yes	Ozone O-U: New	\$11,342,000
	Yes	Circular Clarifier: Soften	\$4,498,000
	Yes	Dry Chemical: Lime	\$7,278,000
	Yes	Air Stripper: New	\$11,421,000
	Yes	Pall - Large: New	\$29,202,000
	Yes	Ion Exchange: WAC	\$10,211,000
	Yes	Liquid Chemical: WACRO	\$367,000
	Yes	1st Pass SWRO: New	\$27,167,000
	Yes	Steel Clearwell: Store	\$1,544,000
	Yes	WTP Belt FP: Res	\$9,230,000
	Yes	Dry Chemical: MgO	\$992,000

SUBTOTAL - PROJECT COST				\$126,967,000
ADDITIONAL PROJECT COSTS:				
Demolition:		0.00%		\$0
Overall Sitework:		6.00%		\$7,619,000
Plant Computer System:		6.00%		\$7,619,000
Yard Electrical:		9.00%		\$11,428,000
Yard Piping:		8.00%		\$10,158,000
UD #1 Default Description		0.00%	\$63,780,000	\$0
UD #2 Default Description		0.00%		\$0
UD #3 Default Description		0.00%		\$0
SUBTOTAL with Additional Project Costs				\$163,791,000
RED FLAGS:				

1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			
23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				\$163,791,000
TAX:		8.25%	\$90,085,050	\$7,432,017
SUBTOTAL with Tax				\$171,223,017
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	\$171,223,017	\$20,547,000
Subtotal				\$191,770,017
Profit		10.00%	\$191,770,017	\$19,178,000
Subtotal				\$210,948,017
Mob/Bonds/Insurance		3.00%	\$210,948,017	\$6,329,000
Subtotal				\$217,277,017
Contingency		30.00%	\$217,277,017	\$65,184,000
SUBTOTAL with Markups				\$282,461,017
LOCATION ADJUSTMENT FACTOR		112.9	\$282,461,017	\$318,899,000
SUBTOTAL - with Local Adjustment Factor				\$318,899,000
MARKET ADJUSTMENT FACTOR			\$318,899,000	\$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				\$318,899,000

Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		Garcia-Aleman, Jesus	
Name of Estimator Reviewer		Meyer, Ed	
MAXIMUM CONSTRUCTION COST			\$318,899,000



Replica - Parametric Design

DESIGN FACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

Linked to Replica - Parametric Design Facilities File:

https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Document

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source 5: Brine Line Flow

Project Location (City): Los Angeles

Project Location (State): CALIFORNIA

Project Location (Country): USA

Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
18	Yes	Steel Clearwell: Feed	\$0
19	Yes	Horizontal PS: Feed	\$53,000
20	Yes	Ozone O-U: New	\$1,426,000
22	Yes	Circular Clarifier: Soften	\$208,000
23	Yes	Dry Chemical: Lime	\$2,706,000
24	Yes	Air Stripper: New	\$294,000
25	Yes	Pall - Large: New	\$5,980,000
26	Yes	Ion Exchange: WAC	\$7,637,000
27	Yes	Liquid Chemical: WACRO	\$101,000
28	Yes	1st Pass SWRO: New	\$6,915,000
30	Yes	Steel Clearwell: Store	\$0
32	Yes	WTP Belt FP: Res	\$2,468,000
33	Yes	Dry Chemical: MgO	\$118,000

Additional Project Costs:

Biosolids Disposal	\$6,023,000
Standard Items	\$2,065,000
User Defined Items	\$0

	A	B	C	E
41		Plant O&M Labor		\$1,049,000
42				
43	TOTAL - ANNUAL O&M COST			\$37,043,000



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source 6: Advanced Water Treatment Concentrate **Roundup to the nearest:**

Project Location (City): Los Angeles **\$1,000**

Project Location (State): CALIFORNIA

Project Location (Country): USA

Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Steel Clearwell: Feed	\$1,544,000
	Yes	Horizontal PS: Feed	\$12,171,000
	Yes	Ozone O-U: New	\$11,342,000
	Yes	Filters: BAC	\$12,700,000
	Yes	Circular Clarifier: Soften	\$4,498,000
	Yes	Dry Chemical: Lime	\$7,278,000
	Yes	Air Stripper: New	\$11,421,000
	Yes	Pall - Large: New	\$29,202,000
	Yes	Ion Exchange: WAC	\$10,211,000
	Yes	Liquid Chemical: WACRO	\$367,000
	Yes	1st Pass SWRO: New	\$27,167,000
	Yes	Steel Clearwell: Store	\$1,544,000
	Yes	WTP Belt FP: Res	\$9,230,000
	Yes	Dry Chemical: MgO	\$992,000
SUBTOTAL - PROJECT COST			\$139,667,000
ADDITIONAL PROJECT COSTS:			
Demolition:		0.00%	\$0

Overall Sitework:		6.00%		\$8,381,000
Plant Computer System:		6.00%		\$8,381,000
Yard Electrical:		9.00%		\$12,571,000
Yard Piping:		8.00%		\$11,174,000
UD #1 Default Description		0.00%	\$70,160,000	\$0
UD #2 Default Description		0.00%		\$0
UD #3 Default Description		0.00%		\$0
SUBTOTAL with Additional Project Costs				\$180,174,000
RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			
23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				\$180,174,000
TAX:		8.25%	\$99,095,700	\$8,175,395
SUBTOTAL with Tax				\$188,349,395

CONTRACTOR MARKUPS:			
Overhead (includes General Conditions and General Administrative Costs)			
	12.00%	\$188,349,395	\$22,602,000
Subtotal			\$210,951,395
Profit	10.00%	\$210,951,395	\$21,096,000
Subtotal			\$232,047,395
Mob/Bonds/Insurance	3.00%	\$232,047,395	\$6,962,000
Subtotal			\$239,009,395
Contingency	30.00%	\$239,009,395	\$71,703,000
SUBTOTAL with Markups			\$310,712,395
LOCATION ADJUSTMENT FACTOR	112.9	\$310,712,395	\$350,795,000
SUBTOTAL - with Local Adjustment Factor			\$350,795,000
MARKET ADJUSTMENT FACTOR		\$350,795,000	\$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			\$350,795,000
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		Garcia-Aleman, Jesus	
Name of Estimator Reviewer		Meyer, Ed	
MAXIMUM CONSTRUCTION COST			\$350,795,000

	A	B	C	E
1	<u>Replica - Parametric Design</u>			
2	DESIGN FACILITIES LIFE CYCLE COST ANALYSIS MODULE File Version: <u>3/17/2023</u> Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum			
3				
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7	Project Name:	<u>Clean Renewable Hydrogen Water Treatment Cost Estimate</u>
8	Project Number:	_____
9	Project Manager:	_____
10	Estimator:	_____
11	Project Description:	<u>Source 6: Advanced Water Treatment Concentrate</u>
12	Project Location (City):	<u>Los Angeles</u>
13	Project Location (State):	<u>CALIFORNIA</u>
14	Project Location (Country):	<u>USA</u>
15	Cost Basis (Month/Year):	<u>December/2023</u>
16		

	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
17				
18		Yes	Steel Clearwell: Feed	\$0
19		Yes	Horizontal PS: Feed	\$53,000
20		Yes	Ozone O-U: New	\$1,426,000
21		Yes	Filters: BAC	\$813,000
22		Yes	Circular Clarifier: Soften	\$208,000
23		Yes	Dry Chemical: Lime	\$2,706,000
24		Yes	Air Stripper: New	\$294,000
25		Yes	Pall - Large: New	\$5,666,000
26		Yes	Ion Exchange: WAC	\$7,637,000
27		Yes	Liquid Chemical: WACRO	\$101,000
28		Yes	1st Pass SWRO: New	\$6,672,000
30		Yes	Steel Clearwell: Store	\$0
32		Yes	WTP Belt FP: Res	\$2,468,000
33		Yes	Dry Chemical: MgO	\$118,000

		Additional Project Costs:	
36		Biosolids Disposal	\$6,023,000
37		Standard Items	\$2,271,000
38		User Defined Items	\$0
39			

	A	B	C	E
40				
41	Plant O&M Labor			\$1,049,000
42				
43	TOTAL - ANNUAL O&M COST			\$37,505,000



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source 7: Oil and Gas Industry Water Roundup to the nearest: \$1,000

Project Location (City): Los Angeles

Project Location (State): CALIFORNIA

Project Location (Country): USA

Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Submersible IPS: New	\$3,073,000
	Yes	Screening and Grit: New	\$12,031,000
	Yes	Aeration Basin: Main	\$13,679,000
	Yes	Blowers: Main	\$6,630,000
	Yes	MBR: Main	\$17,540,000
	Yes	GBT: GBT	\$4,931,000
	Yes	WWTP BFP: BFP	\$3,530,000
	Yes	IWP Oil Water Sep: New	\$7,131,000
	Yes	DAF: New	\$4,489,000
	Yes	Steel Clearwell: Feed EQ	\$1,465,000
	Yes	Steel Clearwell: RO EQ	\$1,465,000
	Yes	1st Pass SWRO: New	\$36,084,000
	Yes	2nd Pass SWRO: New	\$14,803,000
	Yes	Air Stripper: New	\$3,324,000
	Yes	WAS Storage: MBR	\$5,784,000
	Yes	Horizontal PS: ToFeedEQ	\$17,951,000
SUBTOTAL - PROJECT COST			\$153,910,000
ADDITIONAL PROJECT COSTS:			
Demolition:		0.00%	\$0
Overall Sitework:		6.00%	\$9,235,000
Plant Computer System:		6.00%	\$9,235,000
Yard Electrical:		9.00%	\$13,852,000
Yard Piping:		8.00%	\$12,313,000
UD #1 Default Description		0.00%	\$77,316,000
UD #2 Default Description		0.00%	\$0

UD #3 Default Description		0.00%		\$0
SUBTOTAL with Additional Project Costs				\$198,545,000
RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			
23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				\$198,545,000
TAX:		8.25%	\$109,199,750	\$9,008,979
SUBTOTAL with Tax				\$207,553,979
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	\$207,553,979	\$24,907,000
Subtotal				\$232,460,979
Profit		10.00%	\$232,460,979	\$23,247,000
Subtotal				\$255,707,979
Mob/Bonds/Insurance		3.00%	\$255,707,979	\$7,672,000
Subtotal				\$263,379,979
Contingency		30.00%	\$263,379,979	\$79,014,000
SUBTOTAL with Markups				\$342,393,979
LOCATION ADJUSTMENT FACTOR		112.9	\$342,393,979	\$386,563,000

SUBTOTAL - with Local Adjustment Factor			\$386,563,000
MARKET ADJUSTMENT FACTOR		\$386,563,000	\$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			\$386,563,000
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		Garcia-Aleman, Jesus	
Name of Estimator Reviewer		Meyer, Ed	
MAXIMUM CONSTRUCTION COST			\$386,563,000



Replica - Parametric Design

DESIGN FACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

Linked to Replica - Parametric Design Facilities File:

https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Document

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source 7: Oil and Gas Industry Water

Project Location (City): Los Angeles

Project Location (State): CALIFORNIA

Project Location (Country): USA

Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
18	Yes	Submersible IPS: New	\$1,051,000
19	Yes	Screening and Grit: New	\$1,759,000
20	Yes	Aeration Basin: Main	\$308,000
21	Yes	Blowers: Main	\$1,668,000
22	Yes	MBR: Main	\$5,257,000
23	Yes	GBT: GBT	\$363,000
24	Yes	WWTP BFP: BFP	\$195,000
25	Yes	IWP Oil Water Sep: New	\$627,000
26	Yes	DAF: New	\$347,000
27	Yes	Steel Clearwell: Feed EQ	\$0
28	Yes	Steel Clearwell: RO EQ	\$0
29	Yes	1st Pass SWRO: New	\$12,379,000
30	Yes	2nd Pass SWRO: New	\$3,112,000
31	Yes	Air Stripper: New	\$288,000
32	Yes	WAS Storage: MBR	\$597,000
36	Yes	Horizontal PS: ToFeedEQ	\$771,000

Additional Project Costs:

[Biosolids Disposal](#) \$1,536,000

[Standard Items](#) \$2,502,000

	A	B	C	E
42			<u>User Defined Items</u>	\$0
43				
44			<u>Plant O&M Labor</u>	\$16,016,000
45				
46	TOTAL - ANNUAL O&M COST			\$48,776,000



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source 8: Inland Brackish Groundwater Roundup to the nearest:

Project Location (City): Los Angeles **\$1,000**

Project Location (State): CALIFORNIA

Project Location (Country): USA


Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Vertical Turbine PS: Intake	\$12,034,000
	Yes	Steel Clearwell: Feed	\$1,557,000
	Yes	BWRO: New	\$22,962,000
	Yes	Air Stripper: New	\$7,901,000
	Yes	Horizontal PS: Feed	\$11,751,000
	Yes	Steel Clearwell: Treated	\$1,557,000
	Yes	WTP Belt FP: New	\$3,787,000
	Yes	Small Surge Basin: New	\$1,534,000
	Yes	In-Plant PS: Return	\$526,000
	Yes	In-Plant PS: Filtrate	\$545,000
	Yes	VP Filter: New	\$17,979,000
	Yes	Steel Clearwell: Backwash	\$91,000
	Yes	Filter BW PS: New	\$216,000

SUBTOTAL - PROJECT COST			\$82,440,000
ADDITIONAL PROJECT COSTS:			
Demolition:	0.00%		\$0
Overall Sitework:	6.00%		\$4,947,000
Plant Computer System:	6.00%		\$4,947,000
Yard Electrical:	9.00%		\$7,420,000
Yard Piping:	8.00%		\$6,596,000
UD #1 Default Description	0.00%	\$41,416,000	\$0
UD #2 Default Description	0.00%		\$0
UD #3 Default Description	0.00%		\$0
SUBTOTAL with Additional Project Costs			\$106,350,000

RED FLAGS:			
1	Rock Excavation		
2	Pile Foundations		
3	Seismic Foundations		
4	Dewatering Conditions		
5	Wetlands Mitigation		
6	Weather Impacts		
7	Depth of Structures		
8	Local Building Code Restrictions		
9	Coatings or Finishes		
10	Building or Architectural Considerations		
11	Client Material Preferences		
12	Client Equipment Preferences		
13	Piping Galleries, Piping Trenches, Piping Racks		
14	Yard Piping Complexity		
15	Existing Site Utilities (New, Retrofit, and Complexity)		
16	I & C Automation (New or Retrofit)		
17	Electrical Feed (New or Retrofit)		
18	Electrical Distribution		
19	Shoring		
20	Contamination		
21	User Defined Red Flag 1		
22	User Defined Red Flag 2		
23	User Defined Red Flag 3		
24	User Defined Red Flag 4		
25	User Defined Red Flag 5		
26	User Defined Red Flag 6		
27	User Defined Red Flag 7		
TOTAL - RED FLAGS			\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs			\$106,350,000
TAX:		8.25%	\$58,492,500
SUBTOTAL with Tax			\$111,175,631
CONTRACTOR MARKUPS:			
Overhead (includes General Conditions and General Administrative Costs)		12.00%	\$111,175,631
Subtotal			\$124,517,631
Profit		10.00%	\$124,517,631
Subtotal			\$136,969,631
Mob/Bonds/Insurance		3.00%	\$136,969,631
Subtotal			\$141,079,631
Contingency		30.00%	\$141,079,631
SUBTOTAL with Markups			\$183,403,631
LOCATION ADJUSTMENT FACTOR		112.9	\$183,403,631
SUBTOTAL - with Local Adjustment Factor			\$207,063,000
MARKET ADJUSTMENT FACTOR			\$0

SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			\$207,063,000
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		Garcia-Aleman, Jesus	
Name of Estimator Reviewer		Meyer, Ed	
MAXIMUM CONSTRUCTION COST			\$207,063,000

	A	B	C	E
1	 <h1 style="text-align:center; margin:0;"><u>Replica - Parametric Design</u></h1> <h2 style="text-align:center; margin:0;">FACILITIES LIFE CYCLE COST ANALYSIS MODULE</h2> <p>File Version: <u>3/17/2023</u></p> <p>Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Document</p>			
2				
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6				

7	Project Name: <u>Clean Renewable Hydrogen Water Treatment Cost Estimate</u>
8	Project Number: _____
9	Project Manager: _____
10	Estimator: _____
11	Project Description: <u>Source 8: Inland Brackish Groundwater</u>
12	Project Location (City): <u>Los Angeles</u>
13	Project Location (State): <u>CALIFORNIA</u>
14	Project Location (Country): <u>USA</u>
15	Cost Basis (Month/Year): <u>December/2023</u>
16	

	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
17				
18		Yes	Vertical Turbine PS: Intake	\$1,699,000
19		Yes	Steel Clearwell: Feed	\$0
20		Yes	BWRO: New	\$6,699,000
21		Yes	Air Stripper: New	\$798,000
22		Yes	Horizontal PS: Feed	\$60,000
23		Yes	Steel Clearwell: Treated	\$0
27		Yes	WTP Belt FP: New	\$281,000
28		Yes	Small Surge Basin: New	\$106,000
29		Yes	In-Plant PS: Return	\$20,000
30		Yes	In-Plant PS: Filtrate	\$21,000
31		Yes	VP Filter: New	\$1,573,000
32		Yes	Steel Clearwell: Backwash	\$0
33		Yes	Filter BW PS: New	\$2,000
35				

		Additional Project Costs:	
36		Biosolids Disposal	\$10,000
37		Standard Items	\$1,341,000
38		User Defined Items	\$0
39			
40			

	A	B	C	E
41		Plant O&M Labor		\$1,049,000
42				
43	TOTAL - ANNUAL O&M COST			\$13,659,000



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/16/2023

Project Name:	Clean Renewable Hydrogen Water Treatment Cost Estimate
Project Number:	_____
Project Manager:	_____
Estimator:	_____
Project Description:	Source 9: Dry Weather Flows Roundup to the nearest:
Project Location (City):	Los Angeles \$1,000
Project Location (State):	CALIFORNIA
Project Location (Country):	USA
Cost Basis (Month/Year):	December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Screening and Grit: New	\$2,782,000
	Yes	IWP Oil Water Sep: New	\$7,414,000
	Yes	WAS Storage: New	\$11,163,000
	Yes	Centrifuge Dew: New	\$29,642,000
	Yes	In-Plant PS: Cent	\$286,000
	Yes	Horizontal PS: PrimEff	\$4,229,000
	Yes	Steel Clearwell: New	\$1,465,000
	Yes	Horizontal PS: Feed	\$3,641,000
	Yes	Pall - Large: New	\$27,901,000
	Yes	BWRO: New	\$22,331,000
	Yes	Air Stripper: New	\$4,500,000
	Yes	Steel Clearwell: ROEff	\$1,465,000
	Yes	DAF: DAFalt	\$4,301,000
SUBTOTAL - PROJECT COST			\$121,120,000
ADDITIONAL PROJECT COSTS:			
Demolition:	0.00%		\$0
Overall Sitework:	6.00%		\$7,268,000
Plant Computer System:	6.00%		\$7,268,000
Yard Electrical:	9.00%		\$10,901,000
Yard Piping:	8.00%		\$9,690,000
UD #1 Default Description	0.00%	\$60,844,000	\$0
UD #2 Default Description	0.00%		\$0
UD #3 Default Description	0.00%		\$0
SUBTOTAL with Additional Project Costs			\$156,247,000

RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			
23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				\$156,247,000
TAX:		8.25%	\$85,935,850	\$7,089,708
SUBTOTAL with Tax				\$163,336,708
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	\$163,336,708	\$19,601,000
Subtotal				\$182,937,708
Profit		10.00%	\$182,937,708	\$18,294,000
Subtotal				\$201,231,708
Mob/Bonds/Insurance		3.00%	\$201,231,708	\$6,037,000
Subtotal				\$207,268,708
Contingency		30.00%	\$207,268,708	\$62,181,000
SUBTOTAL with Markups				\$269,449,708
LOCATION ADJUSTMENT FACTOR		112.9	\$269,449,708	\$304,209,000
SUBTOTAL - with Local Adjustment Factor				\$304,209,000
MARKET ADJUSTMENT FACTOR			\$304,209,000	\$0

SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			\$304,209,000
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		Garcia-Aleman, Jesus	
Name of Estimator Reviewer		Meyer, Ed	
MAXIMUM CONSTRUCTION COST			\$304,209,000



Replica - Parametric Design

FACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

Linked to Replica - Parametric Design Facilities File:

https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source 9: Dry Weather Flow

Project Location (City): Los Angeles

Project Location (State): CALIFORNIA

Project Location (Country): USA

Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
18	No	Trench Style IPS: New	\$0
19	Yes	Screening and Grit: New	\$361,000
20	Yes	IWP Oil Water Sep: New	\$715,000
21	No	IWP DAF: New	\$0
22	Yes	WAS Storage: New	\$1,221,000
23	Yes	Centrifuge Dew: New	\$4,561,000
24	Yes	In-Plant PS: Cent	\$10,000
25	Yes	Horizontal PS: PrimEff	\$129,000
26	Yes	Steel Clearwell: New	\$0
27	Yes	Horizontal PS: Feed	\$60,000
28	Yes	Pall - Large: New	\$4,559,000
29	Yes	BWRO: New	\$5,648,000
30	Yes	Air Stripper: New	\$390,000
31	Yes	Steel Clearwell: ROEff	\$0
32	No	Vertical Turbine PS: Dist	\$0
33	Yes	DAF: DAFalt	\$347,000
34	No	Evap Ponds: New	\$0

Additional Project Costs:

[Biosolids Disposal](#)

\$159,000

	A	B	C	E
38			Standard Items	\$1,969,000
39			User Defined Items	\$0
40				
41			Plant O&M Labor	\$1,049,000
42				
43	TOTAL - ANNUAL O&M COST			\$21,178,000



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		Project Unit: >>>		(For example: MGD, HP, GPM...)
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Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source 10: Urban Stormwater Capture and Reuse Roundup to the nearest:

Project Location (City): Los Angeles **\$1,000**

Project Location (State): CALIFORNIA

Project Location (Country): USA

Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Screening and Grit: Screen	\$2,755,000
	Yes	Lamella Clarifier: New	\$5,665,000
	Yes	Small Surge Basin: New	\$860,000
	Yes	WTP Belt FP: New	\$5,305,000
	Yes	In-Plant PS: Filtrate	\$531,000
	Yes	In-Plant PS: FeedTank	\$6,734,000
	Yes	Steel Clearwell: Feed	\$1,405,000
	Yes	Pall - Large: New	\$28,677,000
	Yes	Steel Clearwell: Treated	\$1,405,000

SUBTOTAL - PROJECT COST			\$53,337,000
ADDITIONAL PROJECT COSTS:			
Demolition:	0.00%		\$0
Overall Sitework:	6.00%		\$3,201,000
Plant Computer System:	6.00%		\$3,201,000
Yard Electrical:	9.00%		\$4,801,000
Yard Piping:	8.00%		\$4,267,000
UD #1 Default Description	0.00%	\$26,796,000	\$0
UD #2 Default Description	0.00%		\$0
UD #3 Default Description	0.00%		\$0
SUBTOTAL with Additional Project Costs			\$68,807,000

RED FLAGS:			
1	Rock Excavation		
2	Pile Foundations		
3	Seismic Foundations		
4	Dewatering Conditions		
5	Wetlands Mitigation		
6	Weather Impacts		
7	Depth of Structures		
8	Local Building Code Restrictions		
9	Coatings or Finishes		
10	Building or Architectural Considerations		
11	Client Material Preferences		
12	Client Equipment Preferences		
13	Piping Galleries, Piping Trenches, Piping Racks		
14	Yard Piping Complexity		
15	Existing Site Utilities (New, Retrofit, and Complexity)		
16	I & C Automation (New or Retrofit)		
17	Electrical Feed (New or Retrofit)		
18	Electrical Distribution		
19	Shoring		
20	Contamination		
21	User Defined Red Flag 1		
22	User Defined Red Flag 2		
23	User Defined Red Flag 3		
24	User Defined Red Flag 4		
25	User Defined Red Flag 5		
26	User Defined Red Flag 6		
27	User Defined Red Flag 7		
TOTAL - RED FLAGS			\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs			\$68,807,000
TAX:		8.25%	\$37,843,850
SUBTOTAL with Tax			\$71,929,118
CONTRACTOR MARKUPS:			
Overhead (includes General Conditions and General Administrative Costs)		12.00%	\$71,929,118
Subtotal			\$8,632,000
Profit		10.00%	\$80,561,118
Subtotal			\$88,618,118
Mob/Bonds/Insurance		3.00%	\$88,618,118
Subtotal			\$2,659,000
Contingency		30.00%	\$91,277,118
SUBTOTAL with Markups			\$118,661,118
LOCATION ADJUSTMENT FACTOR		112.9	\$118,661,118
SUBTOTAL - with Local Adjustment Factor			\$133,969,000
MARKET ADJUSTMENT FACTOR			\$0

SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			\$133,969,000
MAXIMUM CONSTRUCTION COST			\$133,969,000

	A	B	C	E
1	<u>Replica - Parametric Design</u>			
2	REPLICA			
3	FACILITIES LIFE CYCLE COST ANALYSIS MODULE			
4	File Version: <u>3/17/2023</u>			
5	Linked to Replica - Parametric Design Facilities File:		https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum	
6				

7	Project Name:	Clean Renewable Hydrogen Water Treatment Cost Estimate	
8	Project Number:	_____	Life Cycle Anal
9	Project Manager:	_____	i =
10	Estimator:	_____	n =
11	Project Description:	Source 10: Urban Stormwater Capture and Reuse	Annual Inflation:
12	Project Location (City):	Los Angeles	
13	Project Location (State):	CALIFORNIA	
14	Project Location (Country):	USA	
15	Cost Basis (Month/Year):	December/2023	
16			

	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost (Year 1)
17				
18		Yes	Screening and Grit: Screen	\$365,000
19		Yes	Lamella Clarifier: New	\$741,000
20		Yes	Small Surge Basin: New	\$64,000
21		Yes	WTP Belt FP: New	\$329,000
22		Yes	In-Plant PS: Filtrate	\$21,000
23		Yes	In-Plant PS: FeedTank	\$407,000
24		Yes	Steel Clearwell: Feed	\$0
25		Yes	Pall - Large: New	\$5,960,000
26		Yes	Steel Clearwell: Treated	\$0
27				

28	Additional Project Costs:			
29		Biosolids Disposal		\$0
30		Standard Items		\$885,000
31		User Defined Items		\$0
32				
33		Plant O&M Labor		\$1,070,000
34				
35	TOTAL - ANNUAL O&M COST			\$9,842,000

Appendix **B**

Concentrate Management Cost Summary Outputs

Capital and O&M Estimates for Existing Brine Disposal Facilities

The cost estimates are based on the the estimated concentrate flow rates for each source type, which are summarized below

0.5 mgd	Source 3: Groundwater
1.5 mgd	Source 2: Treated Wastewater
1.5 mgd	Source 5: Brine Line Flows
1.5 mgd	Source 6: Advanced Water Treatment Concentrate
1.5 mgd	Source 8: Inland Brackish Groundwater
1.5 mgd	Source 9: Dry Weather Flows
2.5 mgd	Source 4: Agricultural Industry Water
2.5 mgd	Source 7: Oil and Gas Industry Water

Source 3. Groundwater Concentrate conveyance pipeline cost estimate - 0.5 mgd	Cost
Project Construction cost estimates	
Point A SS reservoir to Point B SS reservoir	
Direct costs subtotal	\$ 1,217,425
Sales tax on material @ 8.25%	\$ 52,870
General conditions @ 7%	
Sub total w/General conditions	\$ 1,270,295
Contractor overhead @ 12%	\$ 152,435
Contractor profit @ 10%	\$ 127,030
Mobilization/Bonds and Insurance @ 3%	\$ 38,109
Subtotal W/O Contingency	\$ 1,587,869
Owner Contingency @ 30%	\$ 476,361
Total Conveyance construction cost w/o escalation	\$ 2,065,000
Total Conveyance Construction Cost with location factor adjustment (12.9%)	\$ 2,331,000

Source 2: Treated Wastewater; Source 5: Brine Line Flows; Source 6: Advanced Water Treatment Concentrate; Source 8: Inland Brackish Groundwater; Source 9: Dry Weather Flows Concentrate conveyance pipeline cost estimate - 1.5 mgd	Cost
Project Construction cost estimates	
Point A SS reservoir to Point B SS reservoir	
Direct costs subtotal	\$ 3,361,954
Sales tax on material @ 8.25%	\$ 146,003
Sub total w/General conditions	\$ 3,507,957
Contractor overhead @ 12%	\$ 420,955
Contractor profit @ 10%	\$ 350,796
Mobilization/Bonds and Insurance @ 3%	\$ 105,239
Subtotal W/O Contingency	\$ 4,384,946
Owner Contingency @ 30%	\$ 1,315,484
Total Conveyance construction cost w/o escalation	\$ 5,701,000
Total Conveyance Construction Cost with location factor adjustment (12.9%)	\$ 6,436,000

Source 4. Agricultural Industry Water Source 7. O&G Industry Water Concentrate conveyance pipeline cost estimate - 2.5 mgd	Cost
Project Construction cost estimates	
Point A SS reservoir to Point B SS reservoir	
Direct costs subtotal	\$ 5,158,031
Sales tax on material @ 8.25%	\$ 224,003
Sub total w/General conditions	\$ 5,382,034
Contractor overhead @ 12%	\$ 645,844
Contractor profit @ 10%	\$ 538,203
Mobilization/Bonds and Insurance @ 3%	\$ 161,461
Subtotal W/O Contingency	\$ 6,727,542
Owner Contingency @ 30%	\$ 2,018,263
Total Conveyance construction cost w/o escalation	\$ 8,746,000
Total Conveyance Construction Cost with location factor adjustment (12.9%)	\$ 9,874,000

Brine Conveyance O&M

Brine Line O&M - \$0.00184/gal for disposal fee		0.00184
	MGD	\$/yr
	0.5 \$	335,800
	1.5 \$	1,007,400
	2.5 \$	1,679,000

Estimated Concentrate Flow Rates

0.5 mgd	Source 3: Groundwater
1.5 mgd	Source 2: Treated Wastewater
1.5 mgd	Source 5: Brine Line Flows
1.5 mgd	Source 6: Advanced Water Treatment Concentrate
1.5 mgd	Source 8: Inland Brackish Groundwater
1.5 mgd	Source 9: Dry Weather Flows
2.5 mgd	Source 4: Agricultural Industry Water
2.5 mgd	Source 7: Oil and Gas Industry Water

Capital and O&M Estimates Evaporation Basins



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source 2: Treated Wastewater Roundup to the nearest:

Project Location (City): Los Angeles **\$1,000**


Project Location (State): CALIFORNIA

Project Location (Country): USA

Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Evap Ponds: New	\$67,924,000
SUBTOTAL - PROJECT COST			\$67,924,000
RED FLAGS:			
1		Rock Excavation	
2		Pile Foundations	
3		Seismic Foundations	
4		Dewatering Conditions	
5		Wetlands Mitigation	
6		Weather Impacts	
7		Depth of Structures	
8		Local Building Code Restrictions	
9		Coatings or Finishes	
10		Building or Architectural Considerations	
11		Client Material Preferences	
12		Client Equipment Preferences	
13		Piping Galleries, Piping Trenches, Piping Racks	
14		Yard Piping Complexity	
15		Existing Site Utilities (New, Retrofit, and Complexity)	
16		I & C Automation (New or Retrofit)	
17		Electrical Feed (New or Retrofit)	
18		Electrical Distribution	
19		Shoring	
20		Contamination	
21		User Defined Red Flag 1	
TOTAL - RED FLAGS			\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs			\$67,924,000

TAX:		8.25%	\$37,358,200	\$3,082,052
SUBTOTAL with Tax				\$71,006,052
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	\$71,006,052	\$8,521,000
Subtotal				\$79,527,052
Profit		10.00%	\$79,527,052	\$7,953,000
Subtotal				\$87,480,052
Mob/Bonds/Insurance		3.00%	\$87,480,052	\$2,625,000
Subtotal				\$90,105,052
Contingency		30.00%	\$90,105,052	\$27,032,000
SUBTOTAL with Markups				\$117,137,052
LOCATION ADJUSTMENT FACTOR		112.9	\$117,137,052	\$132,248,000
SUBTOTAL - with Local Adjustment Factor				\$132,248,000
MARKET ADJUSTMENT FACTOR			\$132,248,000	\$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				\$132,248,000
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:				
Name of Process Reviewer			Garcia-Aleman, Jesus	
Name of Estimator Reviewer			Meyer, Ed	
MAXIMUM CONSTRUCTION COST				\$132,248,000

	A	B	C	E
1	 <h1 style="text-align: center;"><u>Replica - Parametric Design</u></h1> <h2 style="text-align: center;">FACILITIES LIFE CYCLE COST ANALYSIS MODULE</h2> <p>File Version: <u>3/17/2023</u></p> <p>Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Document</p>			
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6				
7	Project Name:		<u>Clean Renewable Hydrogen Water Treatment Cost Estimate</u>	
8	Project Number:		_____	
9	Project Manager:		_____	
10	Estimator:		_____	
11	Project Description:		<u>Source 2: Treated Wastewater</u>	
12	Project Location (City):		<u>Los Angeles</u>	
13	Project Location (State):		<u>CALIFORNIA</u>	
14	Project Location (Country):		<u>USA</u>	
15	Cost Basis (Month/Year):		<u>December/2023</u>	
16				
17	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
24		Yes	Evap Ponds: New	\$1,336,000
33				
40				
41	TOTAL - ANNUAL O&M COST			\$1,336,000



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		Project Unit: >>>		<i>(For example: MGD, HP, GPM...)</i>
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Project Name:	Clean Renewable Hydrogen Water Treatment Cost Estimate
Project Number:	_____
Project Manager:	_____
Estimator:	_____
Project Description:	Source 3. Groundwater Evap Pond Roundup to the nearest:
Project Location (City):	Los Angeles \$1,000
Project Location (State):	CALIFORNIA
Project Location (Country):	USA
Cost Basis (Month/Year):	December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Evap Ponds: New	\$28,401,000


SUBTOTAL - PROJECT COST			\$28,401,000
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ADDITIONAL PROJECT COSTS:			
Demolition:	0.00%		\$0
Overall Sitework:	6.00%		\$1,705,000
Plant Computer System:	6.00%		\$1,705,000
Yard Electrical:	9.00%		\$2,557,000
Yard Piping:	8.00%		\$2,273,000
UD #1 Default Description	0.00%	\$14,270,000	\$0
UD #2 Default Description	0.00%		\$0
UD #3 Default Description	0.00%		\$0

SUBTOTAL with Additional Project Costs			\$36,641,000
---	--	--	---------------------

RED FLAGS:			
1	Rock Excavation		
2	Pile Foundations		
3	Seismic Foundations		
4	Dewatering Conditions		
5	Wetlands Mitigation		
6	Weather Impacts		
7	Depth of Structures		
8	Local Building Code Restrictions		
9	Coatings or Finishes		
10	Building or Architectural Considerations		

11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			
23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				\$36,641,000
TAX:		8.25%	\$20,152,550	\$1,662,585
SUBTOTAL with Tax				\$38,303,585
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	\$38,303,585	\$4,597,000
Subtotal				\$42,900,585
Profit		10.00%	\$42,900,585	\$4,291,000
Subtotal				\$47,191,585
Mob/Bonds/Insurance		3.00%	\$47,191,585	\$1,416,000
Subtotal				\$48,607,585
Contingency		30.00%	\$48,607,585	\$14,583,000
SUBTOTAL with Markups				\$63,190,585
LOCATION ADJUSTMENT FACTOR		112.9	\$63,190,585	\$71,343,000
SUBTOTAL - with Local Adjustment Factor				\$71,343,000
MARKET ADJUSTMENT FACTOR			\$71,343,000	\$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				\$71,343,000
MAXIMUM CONSTRUCTION COST				\$71,343,000

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1	 <h1 style="text-align: center;"><u>Replica - Parametric Design</u></h1> <h2 style="text-align: center;">FACILITIES LIFE CYCLE COST ANALYSIS MODULE</h2> <p>File Version: 3/17/2023</p> <p>Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Document</p>			
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7	Project Name: <u>Clean Renewable Hydrogen Water Treatment Cost Estimate</u>			Life Cycle Analysis:
8	Project Number: _____			i =
9	Project Manager: _____			n =
10	Estimator: _____			Annual Inflation:
11	Project Description: <u>Source 3. Groundwater Evap Pond</u>			
12	Project Location (City): <u>Los Angeles</u>			
13	Project Location (State): <u>CALIFORNIA</u>			
14	Project Location (Country): <u>USA</u>			
15	Cost Basis (Month/Year): <u>December/2023</u>			
16				
17	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost (Year 1)
34		Yes	Evap Ponds: New	\$370,000
35				
36	Additional Project Costs:			
37			Biosolids Disposal	\$0
38			Standard Items	\$472,000
39			User Defined Items	\$0
40				
41			Plant O&M Labor	\$1,070,000
42				
43	TOTAL - ANNUAL O&M COST			\$1,912,000



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		Project Unit: >>>		<i>(For example: MGD, HP, GPM...)</i>
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Project Name:	Clean Renewable Hydrogen Water Treatment Cost Estimate
Project Number:	_____
Project Manager:	_____
Estimator:	_____
Project Description:	Source 4.Agricultural Industry Water Evap Pond Roundup to the nearest:
Project Location (City):	Los Angeles \$1,000
Project Location (State):	CALIFORNIA
Project Location (Country):	USA
Cost Basis (Month/Year):	December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Evap Ponds: New	\$115,958,000


SUBTOTAL - PROJECT COST			\$115,958,000
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ADDITIONAL PROJECT COSTS:			
Demolition:		0.00%	\$0
Overall Sitework:		6.00%	\$6,958,000
Plant Computer System:		6.00%	\$6,958,000
Yard Electrical:		9.00%	\$10,437,000
Yard Piping:		8.00%	\$9,277,000
UD #1 Default Description		0.00%	\$58,250,000
UD #2 Default Description		0.00%	\$0
UD #3 Default Description		0.00%	\$0

SUBTOTAL with Additional Project Costs			\$149,588,000
---	--	--	---------------

RED FLAGS:			
1	Rock Excavation		
2	Pile Foundations		
3	Seismic Foundations		
4	Dewatering Conditions		
5	Wetlands Mitigation		
6	Weather Impacts		
7	Depth of Structures		
8	Local Building Code Restrictions		
9	Coatings or Finishes		
10	Building or Architectural Considerations		

11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			
23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				\$149,588,000
TAX:		8.25%	\$82,273,400	\$6,787,556
SUBTOTAL with Tax				\$156,375,556
CONTRACTOR MARKUPS:				
	<i>Overhead (includes General Conditions and General Administrative Costs)</i>	12.00%	\$156,375,556	\$18,766,000
	<i>Subtotal</i>			\$175,141,556
	Profit	10.00%	\$175,141,556	\$17,515,000
	<i>Subtotal</i>			\$192,656,556
	Mob/Bonds/Insurance	3.00%	\$192,656,556	\$5,780,000
	<i>Subtotal</i>			\$198,436,556
	Contingency	30.00%	\$198,436,556	\$59,531,000
SUBTOTAL with Markups				\$257,967,556
LOCATION ADJUSTMENT FACTOR		112.9	\$257,967,556	\$291,246,000
SUBTOTAL - with Local Adjustment Factor				\$291,246,000
MARKET ADJUSTMENT FACTOR			\$291,246,000	\$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				\$291,246,000
MAXIMUM CONSTRUCTION COST				\$291,246,000

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1	 <h1 style="text-align: center;"><u>Replica - Parametric Design</u></h1> <h2 style="text-align: center;">FACILITIES LIFE CYCLE COST ANALYSIS MODULE</h2> <p>File Version: <u>3/17/2023</u></p> <p>Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Document</p>			
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6				
7	Project Name: <u>Clean Renewable Hydrogen Water Treatment Cost Estimate</u>			Life Cycle Analysis:
8	Project Number: _____ i =			
9	Project Manager: _____ n =			
10	Estimator: _____ Annual Inflation:			
11	Project Description: <u>Source 4. Agricultural Industry Water Evap Pond</u>			
12	Project Location (City): <u>Los Angeles</u>			
13	Project Location (State): <u>CALIFORNIA</u>			
14	Project Location (Country): <u>USA</u>			
15	Cost Basis (Month/Year): <u>December/2023</u>			
16				
17	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost (Year 1)
18		Yes	Evap Ponds: New	\$22,851,000
19				
20	Additional Project Costs:			
21	Biosolids Disposal			\$0
22	Standard Items			\$1,923,000
23	User Defined Items			\$0
24				
25	Plant O&M Labor			\$1,070,000
26				
27	TOTAL - ANNUAL O&M COST			\$25,844,000



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		Project Unit: >>>		(For example: MGD, HP, GPM...)
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Project Name:	Clean Renewable Hydrogen Water Treatment Cost Estimate
Project Number:	
Project Manager:	
Estimator:	
Project Description:	Source 5: Brine Line Flows Roundup to the nearest:
Project Location (City):	Los Angeles \$1,000
Project Location (State):	CALIFORNIA
Project Location (Country):	USA
Cost Basis (Month/Year):	December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Evap Ponds: New	\$77,969,000

SUBTOTAL - PROJECT COST			\$77,969,000
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RED FLAGS:			
1	Rock Excavation		
2	Pile Foundations		
3	Seismic Foundations		
4	Dewatering Conditions		
5	Wetlands Mitigation		
6	Weather Impacts		
7	Depth of Structures		
8	Local Building Code Restrictions		
9	Coatings or Finishes		
10	Building or Architectural Considerations		
11	Client Material Preferences		
12	Client Equipment Preferences		
13	Piping Galleries, Piping Trenches, Piping Racks		
14	Yard Piping Complexity		
15	Existing Site Utilities (New, Retrofit, and Complexity)		
16	I & C Automation (New or Retrofit)		
17	Electrical Feed (New or Retrofit)		
18	Electrical Distribution		
19	Shoring		
20	Contamination		
21	User Defined Red Flag 1		
22	User Defined Red Flag 2		

23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				\$77,969,000
TAX:		8.25%	\$42,882,950	\$3,537,843
SUBTOTAL with Tax				\$81,506,843
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	\$81,506,843	\$9,781,000
Subtotal				\$91,287,843
Profit		10.00%	\$91,287,843	\$9,129,000
Subtotal				\$100,416,843
Mob/Bonds/Insurance		3.00%	\$100,416,843	\$3,013,000
Subtotal				\$103,429,843
Contingency		30.00%	\$103,429,843	\$31,029,000
SUBTOTAL with Markups				\$134,458,843
LOCATION ADJUSTMENT FACTOR		112.9	\$134,458,843	\$151,805,000
SUBTOTAL - with Local Adjustment Factor				\$151,805,000
MARKET ADJUSTMENT FACTOR			\$151,805,000	\$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				\$151,805,000
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:				
Name of Process Reviewer			Garcia-Aleman, Jesus	
Name of Estimator Reviewer			Meyer, Ed	
MAXIMUM CONSTRUCTION COST				\$151,805,000

	A	B	C	E
1	 <h1 style="text-align: center;"><u>Replica - Parametric Design</u></h1> <h2 style="text-align: center;">FACILITIES LIFE CYCLE COST ANALYSIS MODULE</h2> <p>File Version: <u>3/17/2023</u></p> <p>Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum</p>			
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7	Project Name:		<u>Clean Renewable Hydrogen Water Treatment Cost Estimate</u>	
8	Project Number:		_____	
9	Project Manager:		_____	
10	Estimator:		_____	
11	Project Description:		<u>Source 5: Brine Line Flows</u>	
12	Project Location (City):		<u>Los Angeles</u>	
13	Project Location (State):		<u>CALIFORNIA</u>	
14	Project Location (Country):		<u>USA</u>	
15	Cost Basis (Month/Year):		<u>December/2023</u>	
16				
17	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
34		Yes	Evap Ponds: New	\$7,786,000
35				
42				
43	TOTAL - ANNUAL O&M COST			\$7,786,000



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FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		Project Unit: >>>		(For example: MGD, HP, GPM...)
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Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source 6: Advanced Water Treatment Concentrate **Roundup to the nearest:**

Project Location (City): Los Angeles **\$1,000**

Project Location (State): CALIFORNIA

Project Location (Country): USA

Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Evap Ponds: New	\$78,207,000


SUBTOTAL - PROJECT COST			\$78,207,000
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RED FLAGS:

1	Rock Excavation		
2	Pile Foundations		
3	Seismic Foundations		
4	Dewatering Conditions		
5	Wetlands Mitigation		
6	Weather Impacts		
7	Depth of Structures		
8	Local Building Code Restrictions		
9	Coatings or Finishes		
10	Building or Architectural Considerations		
11	Client Material Preferences		
12	Client Equipment Preferences		
13	Piping Galleries, Piping Trenches, Piping Racks		
14	Yard Piping Complexity		
15	Existing Site Utilities (New, Retrofit, and Complexity)		
16	I & C Automation (New or Retrofit)		
17	Electrical Feed (New or Retrofit)		
18	Electrical Distribution		
19	Shoring		
20	Contamination		
21	User Defined Red Flag 1		
22	User Defined Red Flag 2		

23	User Defined Red Flag 3		
24	User Defined Red Flag 4		
25	User Defined Red Flag 5		
26	User Defined Red Flag 6		
27	User Defined Red Flag 7		
TOTAL - RED FLAGS			\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs			\$78,207,000
TAX:		8.25%	\$3,548,643
SUBTOTAL with Tax			\$81,755,643

CONTRACTOR MARKUPS:			
Overhead (includes General Conditions and General Administrative Costs)			
	12.00%	\$81,755,643	\$9,811,000
Subtotal			\$91,566,643
Profit	10.00%	\$91,566,643	\$9,157,000
Subtotal			\$100,723,643
Mob/Bonds/Insurance	3.00%	\$100,723,643	\$3,022,000
Subtotal			\$103,745,643
Contingency	30.00%	\$103,745,643	\$31,124,000
SUBTOTAL with Markups			\$134,869,643
LOCATION ADJUSTMENT FACTOR	112.9	\$134,869,643	\$152,268,000
SUBTOTAL - with Local Adjustment Factor			\$152,268,000
MARKET ADJUSTMENT FACTOR		\$152,268,000	\$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			\$152,268,000
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		Garcia-Aleman, Jesus	
Name of Estimator Reviewer		Meyer, Ed	
MAXIMUM CONSTRUCTION COST			\$152,268,000

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1	 <h1 style="text-align: center;"><u>Replica - Parametric Design</u></h1> <h2 style="text-align: center;">FACILITIES LIFE CYCLE COST ANALYSIS MODULE</h2> <p>File Version: 3/17/2023</p> <p>Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Document</p>			
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7	Project Name: <u>Clean Renewable Water Treatment Cost Estimate</u>			
8	Project Number: _____			
9	Project Manager: _____			
10	Estimator: _____			
11	Project Description: <u>Source 6: Advanced Water Treatment Concentrate</u>			
12	Project Location (City): <u>Los Angeles</u>			
13	Project Location (State): <u>CALIFORNIA</u>			
14	Project Location (Country): <u>USA</u>			
15	Cost Basis (Month/Year): <u>December/2023</u>			
16	_____			
17	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
34		Yes	Evap Ponds: New	\$4,406,000
35				
42				
43	TOTAL - ANNUAL O&M COST			\$4,406,000



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FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		Project Unit: >>>		<i>(For example: MGD, HP, GPM...)</i>
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Project Name:	Clean Renewable Hydrogen Water Treatment Cost Estimate	
Project Number:		
Project Manager:		
Estimator:		
Project Description:	Source 7: Oil and Gas Industry Water	Roundup to the nearest:
Project Location (City):	Los Angeles	\$1,000
Project Location (State):	CALIFORNIA	
Project Location (Country):	USA	
Cost Basis (Month/Year):	December/2023	

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Evap Ponds: New	\$117,578,000

SUBTOTAL - PROJECT COST			\$117,578,000
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RED FLAGS:			
1	Rock Excavation		
2	Pile Foundations		
3	Seismic Foundations		
4	Dewatering Conditions		
5	Wetlands Mitigation		
6	Weather Impacts		
7	Depth of Structures		
8	Local Building Code Restrictions		
9	Coatings or Finishes		
10	Building or Architectural Considerations		
11	Client Material Preferences		
12	Client Equipment Preferences		
13	Piping Galleries, Piping Trenches, Piping Racks		
14	Yard Piping Complexity		
15	Existing Site Utilities (New, Retrofit, and Complexity)		
16	I & C Automation (New or Retrofit)		
17	Electrical Feed (New or Retrofit)		
18	Electrical Distribution		
19	Shoring		
20	Contamination		
21	User Defined Red Flag 1		
22	User Defined Red Flag 2		

23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				\$117,578,000
TAX:		8.25%	\$64,667,900	\$5,335,102
SUBTOTAL with Tax				\$122,913,102
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	\$122,913,102	\$14,750,000
Subtotal				\$137,663,102
Profit		10.00%	\$137,663,102	\$13,767,000
Subtotal				\$151,430,102
Mob/Bonds/Insurance		3.00%	\$151,430,102	\$4,543,000
Subtotal				\$155,973,102
Contingency		30.00%	\$155,973,102	\$46,792,000
SUBTOTAL with Markups				\$202,765,102
LOCATION ADJUSTMENT FACTOR		112.9	\$202,765,102	\$228,922,000
SUBTOTAL - with Local Adjustment Factor				\$228,922,000
MARKET ADJUSTMENT FACTOR			\$228,922,000	\$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				\$228,922,000
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:				
Name of Process Reviewer			Garcia-Aleman, Jesus	
Name of Estimator Reviewer			Meyer, Ed	
MAXIMUM CONSTRUCTION COST				\$228,922,000



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DESIGN FACILITIES LIFE CYCLE COST ANALYSIS MODULE

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Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source 7: Oil and Gas Industry Water

Project Location (City): Los Angeles

Project Location (State): CALIFORNIA

Project Location (Country): USA

Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
	Yes	<u>Evap Ponds: New</u>	\$33,604,000
TOTAL - ANNUAL O&M COST			\$33,604,000



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		Project Unit: >>>		(For example: MGD, HP, GPM...)
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Project Name:	Clean Renewable Hydrogen Water Treatment Cost Estimate	
Project Number:		
Project Manager:		
Estimator:		
Project Description:	Source 8: Inland Brackish Groundwater	Roundup to the nearest:
Project Location (City):	Los Angeles	\$1,000
Project Location (State):	CALIFORNIA	
Project Location (Country):	USA	
Cost Basis (Month/Year):	December/2023	


Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Evap Ponds: New	\$77,969,000

SUBTOTAL - PROJECT COST			\$77,969,000
--------------------------------	--	--	--------------

RED FLAGS:

1	Rock Excavation		
2	Pile Foundations		
3	Seismic Foundations		
4	Dewatering Conditions		
5	Wetlands Mitigation		
6	Weather Impacts		
7	Depth of Structures		
8	Local Building Code Restrictions		
9	Coatings or Finishes		
10	Building or Architectural Considerations		
11	Client Material Preferences		
12	Client Equipment Preferences		
13	Piping Galleries, Piping Trenches, Piping Racks		
14	Yard Piping Complexity		
15	Existing Site Utilities (New, Retrofit, and Complexity)		
16	I & C Automation (New or Retrofit)		
17	Electrical Feed (New or Retrofit)		
18	Electrical Distribution		
19	Shoring		
20	Contamination		
21	User Defined Red Flag 1		
22	User Defined Red Flag 2		

23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				\$77,969,000
TAX:		8.25%	\$42,882,950	\$3,537,843
SUBTOTAL with Tax				\$81,506,843
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	\$81,506,843	\$9,781,000
Subtotal				\$91,287,843
Profit		10.00%	\$91,287,843	\$9,129,000
Subtotal				\$100,416,843
Mob/Bonds/Insurance		3.00%	\$100,416,843	\$3,013,000
Subtotal				\$103,429,843
Contingency		30.00%	\$103,429,843	\$31,029,000
SUBTOTAL with Markups				\$134,458,843
LOCATION ADJUSTMENT FACTOR		112.9	\$134,458,843	\$151,805,000
SUBTOTAL - with Local Adjustment Factor				\$151,805,000
MARKET ADJUSTMENT FACTOR			\$151,805,000	\$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				\$151,805,000
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:				
Name of Process Reviewer			Garcia-Aleman, Jesus	
Name of Estimator Reviewer			Meyer, Ed	
MAXIMUM CONSTRUCTION COST				\$151,805,000

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1	<u>Replica - Parametric Design</u>			
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3	FACILITIES LIFE CYCLE COST ANALYSIS MODULE			
4	File Version: <u>3/17/2023</u>			
5	Linked to Replica - Parametric Design Facilities File:			
6	https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum			
7	Project Name:	Clean Renewable Hydrogen Water Treatment Cost Estimate		
8	Project Number:	_____		
9	Project Manager:	_____		
10	Estimator:	_____		
11	Project Description:	Source 8: Inland Brackish Groundwater		
12	Project Location (City):	Los Angeles		
13	Project Location (State):	CALIFORNIA		
14	Project Location (Country):	USA		
15	Cost Basis (Month/Year):	December/2023		
16				
17	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
34		Yes	Evap Ponds: New	\$11,491,000
35				
42				
43	TOTAL - ANNUAL O&M COST			\$11,491,000



Replica - Parametric Design



FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/16/2023

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate

Project Number: _____

Project Manager: _____

Estimator: _____

Project Description: Source 9: Dry Weather Flows **Roundup to the nearest:**

Project Location (City): Los Angeles **\$1,000**

Project Location (State): CALIFORNIA

Project Location (Country): USA

Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Evap Ponds: New	\$77,969,000
SUBTOTAL - PROJECT COST			\$77,969,000
RED FLAGS:			
1		Rock Excavation	
2		Pile Foundations	
3		Seismic Foundations	
4		Dewatering Conditions	
5		Wetlands Mitigation	
6		Weather Impacts	
7		Depth of Structures	
8		Local Building Code Restrictions	
9		Coatings or Finishes	
10		Building or Architectural Considerations	
11		Client Material Preferences	
12		Client Equipment Preferences	
13		Piping Galleries, Piping Trenches, Piping Racks	
14		Yard Piping Complexity	
15		Existing Site Utilities (New, Retrofit, and Complexity)	
16		I & C Automation (New or Retrofit)	
17		Electrical Feed (New or Retrofit)	
18		Electrical Distribution	
19		Shoring	
20		Contamination	
21		User Defined Red Flag 1	
22		User Defined Red Flag 2	
23		User Defined Red Flag 3	
24		User Defined Red Flag 4	

25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				\$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				\$77,969,000
TAX:		8.25%	\$42,882,950	\$3,537,843
SUBTOTAL with Tax				\$81,506,843
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	\$81,506,843	\$9,781,000
Subtotal				\$91,287,843
Profit		10.00%	\$91,287,843	\$9,129,000
Subtotal				\$100,416,843
Mob/Bonds/Insurance		3.00%	\$100,416,843	\$3,013,000
Subtotal				\$103,429,843
Contingency		30.00%	\$103,429,843	\$31,029,000
SUBTOTAL with Markups				\$134,458,843
LOCATION ADJUSTMENT FACTOR		112.9	\$134,458,843	\$151,805,000
SUBTOTAL - with Local Adjustment Factor				\$151,805,000
MARKET ADJUSTMENT FACTOR			\$151,805,000	\$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				\$151,805,000
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:				
Name of Process Reviewer			Garcia-Aleman, Jesus	
Name of Estimator Reviewer			Meyer, Ed	
MAXIMUM CONSTRUCTION COST				\$151,805,000



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7	Project Name:	<i>Clean Renewable Hydrogen Water Treatment Cost Estimate</i>		
8	Project Number:	_____		
9	Project Manager:	_____		
10	Estimator:	_____		
11	Project Description:	<i>Source 9: Dry Weather Flows</i>		
12	Project Location (City):	<i>Los Angeles</i>		
13	Project Location (State):	<i>CALIFORNIA</i>		
14	Project Location (Country):	<i>USA</i>		
15	Cost Basis (Month/Year):	<i>December/2023</i>		
16				
17	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
34		Yes	Evap Ponds: New	\$3,685,000
35				
42				
43	TOTAL - ANNUAL O&M COST			\$3,685,000

Appendix **C**

Conveyance Cost Summary Outputs

Conveyance Alternative 1 - Point A - Surface storage reservoir at source to Point B - Surface storage reservoir at H2 plant, 25 miles Open Cut Construction	Cost
Project Construction cost estimates	
Direct costs subtotal	\$ 59,549,470
Sales tax on material @ 8.25%	\$ 2,860,738
Sub total w/General conditions	\$ 62,410,208
Contractor overhead @ 12%	\$ 7,489,225
Contractor profit @ 10%	\$ 6,241,021
Mobilization/Bonds and Insurance @ 3%	\$ 2,284,214
Subtotal W/O Contingency	\$ 78,424,667
Owner Contingency @ 30%	\$ 23,527,400
Total Conveyance construction cost w/o escalation	\$ 101,953,000
Total Conveyance Construction Cost with Location Factor (12.9%)	\$ 115,105,000

Conveyance Alternative 2 - Point A - Surface storage reservoir at source to Point B - Surface storage reservoir at H2 plant, 25 miles HDD Construction	Cost
Project Construction cost estimates	
Direct costs subtotal	\$ 65,095,634
Sales tax on material @ 8.25%	\$ 2,860,738
Sub total w/General conditions	\$ 67,956,372
Contractor overhead @ 12%	\$ 8,154,765
Contractor profit @ 10%	\$ 6,795,637
Mobilization/Bonds and Insurance @ 3%	\$ 2,487,203
Subtotal W/O Contingency	\$ 85,393,978
Owner Contingency @ 30%	\$ 25,618,193
Total Conveyance construction cost w/o escalation	\$ 111,013,000
Total Conveyance Construction Cost with Location Factor (12.9%)	\$ 125,333,677

Conveyance System O&M Cost Estimate	Cost
Material Cost	\$ 598,723
Sales tax on material @ 8.25%	\$ 49,395
Sub total w/General conditions	\$ 678,008
Contractor overhead @ 12%	\$ 81,361
Contractor profit @ 10%	\$ 67,801
Mobilization/Bonds and Insurance @ 3%	\$ 24,815
Subtotal W/O Contingency	\$ 851,985
Owner Contingency @ 30%	\$ 255,596
Total equipment construction cost w/o escalation	\$ 1,107,581
Maintenance cost at 3.05% of equipment cost	\$ 33,781
Replacement cost at 3.3% of equipment cost	\$ 36,550
Pump Power Cost	\$ 1,056,077
O&M Cost Subtotal	\$1,126,409

Chapter 4: Challenges and Opportunities Related to Water Supply and Treatment

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Appendices

Appendix A Challenge and Opportunity Tables

Acronyms and Abbreviations

AWT	Advanced Water Treatment
CVP	Central Valley Project
mg/L	milligram(s) per liter
MGD	million gallons per day
O&G	oil and gas
O&M	operations and maintenance
RO	reverse osmosis
ROW	right-of-way
SoCalGas	Southern California Gas Company
SWP	State Water Project
TDS	total dissolved solids
TM	technical memorandum

1. Introduction

This technical memorandum (TM) addressing the challenges and opportunities related to water supply and treatment has been prepared as part of the Water Resources Evaluation prepared for the Angeles Link project (Angeles Link) proposed by Southern California Gas Company (SoCalGas). The Water Resources Evaluation is part of a larger feasibility study being conducted by SoCalGas to support the development of a pipeline system that will transport clean renewable hydrogen for use in Central and Southern California, including the Los Angeles Basin. The purpose of the Water Resources Evaluation is to identify and characterize water supply sources and identify costs associated with those sources that third-party producers may pursue to produce clean renewable hydrogen.

This chapter relies on and incorporates analysis from the following three technical studies that were prepared separately and incorporated as chapters of the Water Resources Evaluation for the Angeles Link Phase One feasibility analyses:

- Chapter 1: Water Availability Study
- Chapter 2: Technical Memorandum for Water Quality Requirements for Hydrogen Generation
- Chapter 3: Technical Memorandum for Water Acquisition and Purification Costs

1.1 Objectives

The objective of this chapter is to identify and characterize potential challenges and opportunities third-party developers may face when developing water supplies for clean renewable hydrogen production, including the portion of clean renewable hydrogen production that Angeles Link may transport.

Specifically, this evaluation considers challenges and opportunities for the following potential supply sources that were identified as part of the Water Availability Study (Chapter 1):

- Imported Surface Water
- Treated Wastewater
- Groundwater
- Agricultural Industry Water
- Brine Line Flows
- Advanced Water Treatment Concentrate
- Oil & Gas (O&G) Industry Water
- Inland Brackish Groundwater
- Dry Weather Flows
- Urban Stormwater Capture and Reuse

Section 2 of this chapter summarizes each of these source types.

1.2 Technical Approach

This chapter provides a qualitative analysis of the potential challenges and opportunities for third-party clean renewable hydrogen producers associated with the water supply and treatment that may support future production by considering the following three separate assessment areas:

1. The qualities of the potential water supply sources identified for production
2. Conveyance
3. Geographic setting of the identified potential water supply sources

The qualitative analysis in this chapter is based on the professional opinion of the consultant team based on the evaluation of potential water supply sources as identified in Chapter 1 (Water Availability Study) and the team's professional experience in developing potential water supply sources for different projects. This analysis is intended to be preliminary for purposes of the Angeles Link Phase 1 feasibility analyses. Third-party producers would likely conduct additional analysis of the challenges and opportunities associated with water supply and treatment as more details on specific production projects are developed.

1.2.1 Identified Water Supply Sources

For the assessment area related to the identified water supply sources, the following approach was used:

- Identify evaluation categories for specific supply sources (e.g., supply reliability, stakeholder considerations, etc.).
- Identify challenges and opportunities specific to each supply source.
- Identify and develop potential strategies to mitigate potential challenges and to capture opportunities that have been identified, where applicable.

1.2.2 Conveyance

Some of the sources that have been identified are located in coastal or urban areas of Central and Southern California. Pipelines may be needed to convey water from the coastal and urban areas to the production areas. However, as discussed further in Chapter 1 (Water Availability Study), significant conveyance may not be necessary for all potential water supply sources, as sources could be developed through a water exchange mechanism. In some instances, conveyance of water from source locations to a site for hydrogen production may be necessary and may pose challenges for certain supply types. For this assessment area, the common challenges related to conveyance were identified and discussed.

1.2.3 Geographic Setting

For the assessment area related to geographic setting, the following assessment approach was used:

- Identify general categories of challenges and opportunities related to the geographic setting of the water sources.
- Group the source locations into broad geographic categories with different challenges and opportunities.

1.3 Chapter Organization

The following is the organization of this chapter:

- Section 1: Introduction - presents the objective and approach for this chapter.
- Section 2: Description - summarizes potential water sources for hydrogen production.
- Section 3: Water Supply Challenges and Opportunities - presents an evaluation of challenges and opportunities related to identified water source types.
- Section 4: Conveyance Challenges - summarizes challenges related to conveyance that are common to all supply types.
- Section 5: Geographic Challenges and Opportunities - presents a summary of the challenges and opportunities related to geographic settings.
- Section 6: Summary – summarizes the findings of this assessment.
- Section 7: References - lists the references cited in this chapter.

1.4 Key Terms

- **Conveyance.** Pipelines, pump stations, and other associated equipment needed to move water from the source location to the hydrogen production facility.
- **Brackish Groundwater.** Groundwater with elevated dissolved solids (salt content). For this assessment, groundwater with total dissolved solids concentration (a measure of salt content) exceeding 1,000 milligrams per liter is considered brackish.
- **Brine minimization.** Process modifications that increase the efficiency of reverse osmosis treatment resulting in lower volumes of concentrate (brine) and higher volumes of treated water.

- **Challenge.** For this study, a challenge is defined as a barrier (e.g., cost, permitting, reliability) to implementing a water supply project for hydrogen production.
- **Concentrate.** A liquid waste stream generated during reverse osmosis treatment that contains elevated concentrations of dissolved solids (salts).
- **Coastal (geography).** For this study, areas within the jurisdiction of the California Coastal Commission.
- **Dry Weather Flow.** Dry weather flow occurs in the absence of precipitation, typically from surface discharges.
- **Ecological Flows.** Regulatorily required discharges from wastewater treatment plants to support ecological water demands.
- **Opportunity.** For this study, an opportunity is an action that can be taken to mitigate barriers (e.g., cost, permitting, reliability) to implementing a water supply project for hydrogen production.
- **Other (geography).** For this study, areas located outside of city limits and the jurisdiction of the California Coastal Commission.
- **Process Upset.** An operating condition for a treatment plant that results in non-compliance or taking the system offline unexpectedly, reducing the volume treated water produced for hydrogen production.
- **Recycled Water/Wastewater Effluent.** Recycled water is highly treated wastewater effluent that has been filtered to remove solids and other impurities and disinfected (depending on treatment level).
- **Residuals.** For this study, solid or liquid wastes produced during treatment of water source for hydrogen production.
- **Total Dissolved Solids (TDS).** A measure of the dissolved salt content in a liquid.
- **Urban (geography).** For this study, areas within the jurisdictional boundaries of a city (city limits).
- **Water Exchange.** Water exchange involves delivery of water by one water user to another water user. The receiving water user will be required to return the water at a specified time or when the conditions of the parties' agreement are met.
- **Water Banking.** A project that stores excess surface water, when available, in the subsurface, and recovers the stored water when surface water is unavailable for a project's demands.

2. Description of Potential Water Sources

Chapter 1, Water Supply Availability, focused on identifying water sources that could be used for the production of clean renewable hydrogen that do not have existing demands or otherwise would not compete with existing and planned land uses (Rincon 2024). In addition, several of the proposed sources involve the treatment and reuse of waste streams and thus could be considered a new supply source. Table 4-1 presents an overview of the ten supply sources that were identified.

Table 4-1. Identified Water Sources for Clean Renewable Hydrogen Production

Supply Source	Description
Imported Surface Water	Surface water in California is available through three major water projects, including the Central Valley Project (CVP), the State Water Project (SWP), and the Colorado River. Accessing surface water from existing water rights holders could provide a large source of supply for future clean renewable hydrogen production.
Treated Wastewater	Recycled water is highly treated wastewater (municipal sewage) that has been filtered and disinfected at a wastewater treatment facility. There are numerous recycled water facilities in Southern California. Facility capacity, inflows, and outflows are documented in water quality permits and Urban Water Management Plans, which were used to identify and quantify flows of treated wastewater that are currently discharged without being reused. Treated wastewater that is being discharged from treatment facilities without further reuse or plans for future reuse could supply clean renewable hydrogen production projects.
Groundwater	Groundwater in California is managed by local agencies under the Sustainable Groundwater Management Act, to reverse overdraft and create long-term sustainable conditions. As groundwater basins recover from overdraft conditions, local resources may become more available. Depending on site-specific conditions at the time of future project development, individual clean renewable hydrogen producers can further evaluate local groundwater as a potential supply source. There may be opportunities to develop groundwater as a supply source in Low Priority basins and in adjudicated areas, depending upon site-specific conditions and other demands. In addition, groundwater banks, or aquifer storage and recovery projects, may be used to facilitate a water supply exchange.
Agricultural Industry Water	Agricultural industry water includes two potential water supply sources associated with ongoing agricultural operations: agricultural field drainage and wastewater from produce washing operations. Agricultural field drainage refers to surface water runoff and shallow subsurface drainage of irrigation and water precipitation. Agricultural wash water or process water refers to water that is applied to remove soil and debris prior to distribution to buyers and customers. As a potential supply source, systems could be used to capture and reuse field drainage water and process wastewater could be diverted prior to disposal for treatment and reuse by hydrogen producers.
Brine Line Flows	Brine lines are used to remove salts and other contaminants from a given watershed area to protect the quality of local surface water and groundwater resources. Brine flows that are currently planned for discharge to a brine line for disposal could be diverted for use in clean renewable hydrogen production.
Advanced Water Treatment (AWT) Concentrate	An advanced water treatment facility (AWTF) uses secondary-treated recycled water to conduct further water quality treatment and produce tertiary-level treated water. This process creates waste flow consisting of highly saline brine or concentrate. This waste flow can be either recycled for reuse or treated for disposal. Concentrate from AWT that is not currently reused or planned for beneficial reuse could supply clean renewable hydrogen production.
O&G Industry Water	O&G industry water from produced water and/or refinery offset water could be developed as a water supply source, as O&G operations are phased out in accordance with state goals and objectives. Refinery offset water includes the water gained from the reduction or cessation of refinery operations. The amount of water per barrel of oil produced is expected to vary by refinery location, depending on multiple factors, including the source water, other refinery operations and processes, and requirements of the facility-specific discharge permit. Separately,

Supply Source	Description
	produced water includes water brought to the surface along with O&G because of pumping. Treated produced water could be acquired by a hydrogen producer from the oil field operator prior to its discharge to land.
Inland Brackish Groundwater	Brackish groundwater can occur from both natural sources (geology and soils) and from manmade sources (discharges from wastewater treatment plants and agricultural runoff). Brackish groundwater located in inland areas without natural drainage outlets and that is not currently managed or does not have plans to be managed for beneficial use could provide a supply source for clean renewable hydrogen production. Use of inland brackish water as a supply source would not compete with the needs of other water users because it would provide beneficial use to brackish water that otherwise poses water quality concerns and management issues.
Dry Weather Flows	Dry weather flows are discharges of flows that enter a Municipal Separate Storm Sewer System (MS4) during dry weather conditions and, because of low volume and velocity, these flows accumulate within the MS4, causing water quality concerns and potential violation of the MS4 operating permit (National Pollutant Discharge Elimination System). Dry weather flows are known to be problematic for local flood control agencies with insufficient resources to remove and dispose of them. Dry weather flows that are not reused or planned for beneficial use could provide a potential source for clean renewable hydrogen production projects.
Urban Stormwater Capture and Reuse	Stormwater runoff occurs in direct response to precipitation events. Stormwater runoff that can be captured before reaching a discharge outlet can be stored and treated for future use. Multiple Southern California water agencies have existing stormwater capture and reuse programs; however, these are generally not considered currently available because the respective agencies have developed such programs to improve their own water supply portfolios. Clean renewable hydrogen producers could work with agencies overseeing stormwater capture projects to evaluate sources that may become available in the future or may develop new stormwater capture projects as a potential new source for clean renewable hydrogen production.

Source: modified from Table ES-6 Potential Supply Sources in the Chapter 1: Water Availability Study (Rincon 2024)

Chapter 1 also identified potential mechanisms that may be available to acquire these supply sources (Rincon 2024):

- Exchange agreements
- Direct purchase or partnership with local agencies
- Water markets
- Purchase of land with water rights

Although more than one acquisition mechanism may be possible for each supply source, specific mechanisms were assumed to develop cost estimates for water supplies to support hydrogen production, as summarized in Chapter 3:

- Surface water: SWP water acquired using an exchange agreement
- Groundwater: acquired by a combination of water rights associated with purchased land (pumping of groundwater) and direct purchase from a local agency
- Inland brackish groundwater: acquired by water rights associated with purchased land (pumping of brackish groundwater)
- All other supply sources: acquired by direct purchase

The same acquisition mechanisms were assumed for this chapter when evaluating challenges and opportunities for the identified supply sources.

3. Water Supply Challenges and Opportunities

This section presents an evaluation of challenges and opportunities for the water sources that were identified as part the Chapter 1: Water Availability Study.

3.1 Evaluation Categories

As described in Section 1 of this chapter, the Chapter 1 of the Water Availability Study identified a portfolio of potential water supply types that could support clean renewable hydrogen production. Third-party clean renewable hydrogen producers may draw from those potential water supply sources to produce hydrogen, and the menu of specific water sources would be developed on a case-by-case basis as details of specific production projects develop. Note that project-level analysis for specific proposed clean renewable hydrogen production projects would be speculative if conducted at this time, given the unknown variables associated with a project-level analysis (e.g., specific menu of water supply sources, specific size of production facilities). For purposes of this analysis in this feasibility phase, this chapter focused on evaluation categories that may be common to most of the supply sources third-party producers may draw upon. The following evaluation categories were considered:

- **Concentrate management:** refers to issues related to the management of reverse osmosis (RO) concentrate generated during treatment of source water to produce high-purity water for hydrogen production
- **O&M:** refers to issues related to operating the treatment facilities
- **Partnerships:** refers to issues related to partnerships, and mutual benefits that may ease access to water supply sources, enhance reliability, or simplify operations
- **Regulatory compliance:** refers to issues related to regulatory compliance for supply or residual management
- **Supply reliability:** refers to long-term supply reliability for the water source
- **Stakeholder considerations:** refers to stakeholder benefits and concerns for accessing the water supply
- **Treatment:** refers to issues related to treating water that meets quality requirements for hydrogen production

Category-specific challenges and opportunities were identified for each of the water sources that have been identified. A summary of these findings is presented in the following sections. **Table A-1 in Appendix A** summarizes the challenges and opportunities for the supply sources that have been identified.

3.2 Imported Surface Water

Imported surface water exchange using a new water supply developed elsewhere could potentially be used as an important mechanism to facilitate water access in remote inland areas where large-scale renewable energy production projects and may be more favorable without the need to construct long conveyance pipelines. Another advantage of treating surface water sources for hydrogen production is that it is expected to be less energy intensive than other sources because the concentration of total dissolved solids (TDS) is relatively low (e.g., 320 milligrams per liter [mg/L] for SWP water); refer to Chapter 3). The following are important considerations regarding the use of imported surface water, acquired through exchange, as a source for hydrogen production.

- The principal challenge for the imported surface water exchange source is providing a long-term reliable supply of imported surface water for a production project. A surface water exchange project would involve the development of a new water source (e.g., recycled water reuse or desalination) to offset the amount of imported surface water diverted for hydrogen production. Even when coupled with development of a new supply source to offset the exchange of surface water, the amount of surface water available year-over-year may vary based on hydrologic conditions and existing demands, especially during droughts. For example, the SWP, which conveys water from the Bay Delta Area in

Northern California to Southern California, received the lowest initial allocation of zero percent on December 1, 2021, with limited water designated only for any unmet human health and safety needs (CDWR 2022).

- A potential mitigation strategy for this supply variability challenge is for project developers to explore water banking options (surface or subsurface storage) to store excess surface water during wet years and to recover the stored water when surface water supply is less or not available to meet a particular production project's need.
- Other challenges are related to potential regulatory issues associated with the permitting of the related exchange projects (e.g., a desalinization or reuse project) and the management of concentrate generated during water treatment for the related exchange projects.
- Important opportunities include partnerships related to the distribution and conveyance of surface water and partnerships related to the development of an exchange supply in areas where there is a need to diversify supplies. Partnerships of this nature may support a reliable exchange supply for hydrogen production.

3.3 Treated Wastewater

The use of treated wastewater as a water source would involve diversion, and treatment of wastewater effluent to produce high-purity water for hydrogen production. The following are important considerations for the use of treated wastewater as a source for hydrogen production.

- The primary challenges for the use of treated wastewater as a source are related to the reliability of supply and concentrate management.
- Conservation efforts that reduce water use can result in lower wastewater flows over time, or there may be future plans for indirect or direct potable reuse of the wastewater effluent, which may result in less effluent available as a source of water for hydrogen production. For example, the State Water Resource Control Board is implementing conservation standards for water use that may reduce wastewater flows (SWRCB 2024). A potential mitigation approach for reliability challenges would be to identify other sources of water and to maintain a diverse portfolio of sources.
- The primary challenges associated with concentrate management are related to potential cost and implementation issues associated with the need to construct large concentrate evaporation basins or long pipelines for concentrate disposal.
- Opportunities related to recycled water/wastewater effluent include partnerships that ease access to this supply source. In areas experiencing population growth, wastewater agencies may need to expand their wastewater treatment plant to accommodate the additional wastewater flows. Contributing funding for plant expansion may provide access to a reliable supply of wastewater effluent for hydrogen production.
- Coordinating partnerships that facilitate gathering of wastewater effluent from multiple facilities and conveying that water to hydrogen production areas may facilitate the supply of treated wastewater for production projects. Partnership strategies like these may enhance access to treated wastewater sources.
- Further treatment of treated wastewater will be needed to produce high-purity water for hydrogen production, but treatment is expected to be less challenging than for other of the potential supply sources (e.g., concentrate sources, O&G industry water, and agriculture industry water, and dry weather flows) because TDS concentrations are lower for this source (approximately 890 mg/L) (refer to Chapter 3).

3.4 Groundwater

The use of groundwater as a source for hydrogen production would involve the extraction and treatment of groundwater to produce high-purity water for hydrogen production. The following are important considerations for the use of groundwater as a source for hydrogen production.

- The primary challenge for the use of groundwater water as source is related to concentrate management. This includes the potential cost and implementation issues associated with the need to construct large concentrate evaporation basins or long pipelines for concentrate disposal.
- The source reliability may pose an additional challenge because groundwater pumping may need to be reduced if it adversely impacts the sustainability of the groundwater basin.
- Treatment is expected to be less challenging than for many of the other identified sources because groundwater is expected to have relatively low TDS concentrations (e.g., 485 mg/L) and would only require partial RO treatment (refer to Chapter 3).

3.5 Agricultural Industry Water

Agricultural industry water includes agricultural field drainage and wastewater from produce washing operations. The use agricultural industry water would involve the diversion and treatment of these source flows to produce high-purity water for hydrogen production. The following are important considerations for the use of agricultural industry water as a source for hydrogen production.

- The primary challenges for the use of agricultural industry water as source are related to concentrate management and treatment.
- The challenges associated with concentrate management are related to potential cost and implementation issues associated with the need to construct large concentrate evaporation basins or long pipelines for concentrate disposal.
- Treatment of agricultural industry water is expected to be challenging, at least for the agricultural drainage component of this source. Agricultural drainage can have very high TDS concentrations (e.g., 15,000 mg/L) and other scale-forming minerals (refer to Chapter Part 3). These water quality characteristics would pose additional operational challenges and costs, such as higher energy costs, more frequent backwash of processes, and scaling of treatment equipment and concentrate pipelines. In addition, the potential exists for treatment residuals and concentrate to require management as hazardous wastes because of elevated concentrations of metals.
- Potential opportunities include partnerships to enhance access to agricultural industry water and partnerships related to the distribution and conveyance of agricultural industry water for hydrogen production. In addition, the salt content of agricultural drainage and wastewater used in food processing can be challenging to manage, sometimes requiring specific treatment, infrastructure, or management approaches to comply with discharge limits. Diverting these flows for hydrogen production may be beneficial to agricultural producers, irrigation districts, and regulatory agencies involved with agricultural industry water. Partnerships with these entities to develop infrastructure to divert agricultural industry water may increase access to this supply source.

3.6 Brine Line Flows

The use of brine line flows as a water source would involve harvesting RO concentrate from turnouts on inland concentrate pipelines that convey concentrate to coastal outfalls for disposal and treating the harvested concentrate to produce high-purity water for hydrogen production. The following are important considerations for the use of brine line flows as a water source for hydrogen production.

- The primary challenges associated with the use of brine line flows for hydrogen production are related to the cost and implementation challenges associated with construction of concentrate disposal pipelines or evaporation basins.
- Treatment of brine line flows is expected to be more challenging than surface water, groundwater or treated wastewater because the concentrate will have relatively high TDS concentrations (e.g., 5,120 mg/L, refer to Chapter 3). In addition, this concentrate source will also contain dissolved

constituents that can foul RO membranes, similar to concentrate from advanced water treatment facilities.

- Potential opportunities exist to avoid costs for construction of evaporation basins or long conveyance pipelines for concentrate disposal by locating the project treatment facility close to the source concentrate pipeline and to use that existing pipeline to dispose the concentrate generated from water treatment processes to generate water for hydrogen production. For this source water, it would be more advantageous to convey product water to the hydrogen production facility so that concentrate generated could be discharged back into the existing brine line for disposal.

3.7 Advanced Water Treatment Concentrate

RO is commonly used during the advanced treatment of wastewater effluent, which produces concentrate (brine) as a waste stream. The use of this concentrate as a water source would involve diverting the advanced water treatment plant concentrate for further treatment to produce high-purity water for hydrogen production. The following are important considerations for the use of advanced water treatment concentrate as a water source for hydrogen production.

- The primary challenges associated with the advanced recycled water treatment concentrate for hydrogen production are cost and implementation challenges associated with construction of disposal pipelines or evaporation basins. Like brine line flows, the additional treatment of advanced water treatment concentrate will produce a concentrate waste stream that will contain even higher concentrations of dissolved salts, which can lead to scaling and plugging of concentrate pipelines. In addition, the required areas for evaporation ponds can be large, resulting in increased land acquisition costs for the project or otherwise competing with land needed for renewable energy generation.
- All advanced water treatment plants have an existing concentrate disposal system. A potential mitigation approach related to concentrate management for this water source would be to use or expand the existing concentrate disposal systems for these facilities. This would likely require the project treatment plant for hydrogen production to be located at or near the advanced water treatment facility, and in this case, treated water would be conveyed to the hydrogen production site.
- Potential opportunities also include partnerships to enhance access to concentrate supply and partnerships related to the distribution and conveyance of concentrate for hydrogen production. In addition, for water agencies planning to construct advanced recycled water treatment facilities, identifying cost-effective approaches for the management and disposal of RO concentrate is a critical factor for planning and design of the advanced water treatment facility. These agencies may view partnerships with entities that would acquire and take responsibility for their RO concentrate as beneficial because this would reduce capital and operating costs for the advanced water treatment facility, especially for facilities that do not have close access to concentrate disposal pipelines or outfalls.
- Treatment of concentrate from advanced water treatment facilities is expected to be more challenging than surface water, groundwater, or municipal wastewater because the concentrate will have relatively high TDS concentrations (approximately 2,950 mg/L), foulants of RO membranes, such as organics and other scale-forming minerals, such as calcium and phosphate (refer to Chapter 3). All of these water quality characteristics would pose additional operational challenges and costs, such as higher energy costs, more frequent backwash of processes, scaling of treatment equipment and concentrate pipelines.

3.8 Oil and Gas Industry Water

The use of O&G industry water as a source would involve diverting production water after separating O&G components and treating production water to produce high-purity water for hydrogen production. In addition, this source also includes water currently used for O&G production and refining that would become available for use as a source for hydrogen production as these industries contract over time. The following are important considerations regarding the use of O&G industry water as a source for hydrogen production.

- The long-term reliability of O&G production water is a potential challenge. Conceptually, less produced water may be available for hydrogen production if oil fields become less productive or oil production becomes less favorable over time. If this occurs, however, other water sources (e.g., groundwater or surface water) used for oil production and refining could be available to offset the loss of produced water supply.
- Concentrate management, treatment, and O&M issues related to the characteristics of oilfield production water would also pose challenges. Oilfield production water is considered to be the most challenging of the potential sources to treat for hydrogen production (refer to Chapter 3). For example, the TDS concentrations of this source are expected to be elevated (e.g., 22,500 mg/L, refer to Chapter 3). In addition, O&G production water can contain organic substances, toxic metals, and naturally occurring radioactive constituents that may become concentrated during treatment (Lester et al. 2015).
- If the concentrations of hazardous constituents in the treatment residuals or concentrate exceed regulatory thresholds, they would need to be handled as hazardous wastes, which would increase the costs and complexity of residuals management for this source. A potential mitigation strategy for this challenge would be further treatment of the residuals/concentrate to reduce the volumes of these waste streams that would require special handling and disposal requirements.
- Potential opportunities include using or repurposing existing oilfield waste disposal systems and partnerships related to the distribution and conveyance of O&G production water from multiple oil fields or refineries for hydrogen production. If the source water treatment facility for hydrogen production is located near existing O&G production centers, purchasing or repurposing existing waste injection wells and conveyance used for disposal of O&G production wastes may be an opportunity to reduce the overall costs for concentrate management.

3.9 Inland Brackish Groundwater Desalination

The use of inland brackish groundwater as a source for hydrogen production would involve the extraction and treatment (desalination) of brackish groundwater to produce high-purity water for hydrogen production. The following are important considerations for the use of inland brackish groundwater as a source for hydrogen production.

- Like concentrate from advanced water treatment facilities and bine lines, the primary challenges associated with the desalination of inland brackish groundwater as a source of water for hydrogen production are related to concentrate management.
- The source reliability may pose an additional challenge. In general, a finite volume of brackish groundwater may be available for hydrogen production, and in some cases, the brackish aquifer zones are not entirely separated from drinking water aquifers. In these cases, brackish groundwater pumping may need to be reduced if it adversely impacts the sustainability of the groundwater basin.
- In some cases, brackish groundwater projects have been implemented to comply with regulatory requirements related to salt and nutrient management of the groundwater basin (e.g., Chino Basin Desalter) or to address brackish groundwater caused by previous land use practices (e.g., the CV-Salts program). Partnership opportunities may exist to fund or assume operation of these obligatory desalination systems, which may enhance access to brackish groundwater sources, while allowing water agencies to shift funding and resources to projects that provide a more cost-effective supply for their ratepayers.
- Treatment is expected to be more challenging than surface water, urban stormwater, groundwater, and municipal wastewater because brackish groundwater can have relatively high TDS concentrations (e.g., 1,800 mg/L; refer to Chapter 3). In addition, this concentrate source will also contain dissolved constituents that can foul RO membranes, similar to concentrate from advanced water treatment facilities.

3.10 Dry Weather Flows

The use of dry weather flows as a water source would involve diverting and treating dry weather flows to produce high-purity water for hydrogen production. The following are important considerations regarding the use of dry weather flows as a source for hydrogen production.

- The primary challenges associated with the use of dry weather flow are related to reliability, concentrate management, treatment complexity, and O&M issues.
- In general, treatment of dry weather flow is expected to be more complex than most of the other potential sources because of the additional pretreatment needed to remove oil/grease and particulates from dry weather flows before treatment via ultrafiltration and RO (refer to Chapter 3). Also, given the contaminants sometimes found in dry weather flows (e.g., metals [Stein et al, 2008]), the potential exists for treatment residuals and concentrate to require management as hazardous wastes.
- Potential opportunities include partnership related to the distribution and conveyance of dry weather flows for hydrogen production and collaboration with agencies with interests related to the benefits of capturing and treating dry weather flows. Given the distributed nature of dry weather flows, coordinating partnerships that facilitate the gathering of dry weather flows from multiple watersheds and conveying that water to hydrogen production areas may facilitate the large-scale use of dry weather flows for hydrogen production. In addition, given the broad environmental benefits (e.g., reduced contaminant loading to receiving waters) of diverting dry weather flows, partnering with municipalities, regulatory agencies, flood control districts, and non-governmental agencies to divert these flows may enhance access to this supply source.

3.11 Urban Stormwater Capture and Reuse

The use of urban stormwater capture and reuse as a water source would involve diverting stormwater from a flood control or stormwater retention basin and treating these flows to produce high-purity water for hydrogen production. The following are important considerations regarding the use urban stormwater capture and reuse as a source for hydrogen production.

- The primary challenges associated with the use of use urban stormwater capture are related to the reliability and flow fluctuations.
- Urban stormwater flows are dependent on the occurrence of storm events and therefore, are not available continuously. In addition, available flows are expected to fluctuate over a broad range. One mitigation approach for these challenges is to divert stormwater from multiple stormwater basins within a watershed. This combined storage may allow for diversion of stormwater flows for a longer duration between storm events.
- In general, treatment of urban stormwater is expected to be less complex than most of the other potential sources because the TDS concentrations of this source are expected to be relatively low (e.g., 168 mg/L, refer to Chapter 3).
- Potential opportunities include partnerships with agencies to that need to improve or repair existing flood control or stormwater systems. Partnering with these agencies to make needed improvements or repairs may increase access to this source.
- In addition, combining the collection and treatment systems for dry weather flows and urban stormwater capture and reuse is a potential opportunity to reduce costs and improve the reliability of supply.

4. Conveyance Challenges

Conveyance of source water, treated water, and concentrate may pose potential challenges for each of the potential supply sources third parties may pursue for clean renewable hydrogen production as identified in the Chapter 1: Water Availability Study. As described in Section 5 of this chapter, some potential sources identified may be located in coastal or urban areas throughout Southern California. Clean renewable hydrogen production areas, however, are expected to be located farther inland in areas that are favorable for renewable energy, as described in the Production and Planning Assessment (Production Study) prepared as a separate Angeles Link Phase 1 feasibility study. Long pipelines may be needed to convey water from the coastal and urban areas to the production areas.

Required conveyance may add to the associated cost and implementation challenges for the water sources that have been identified. In addition, the topographic relief between the coastal and urban areas of Southern California and the intervening mountainous terrain between the coast and the expected areas for hydrogen production can exceed thousands of feet, which could lead to energy needs and energy costs associated with pumping water supplies or concentrate. Other implementation challenges associated with conveyance may also apply. For example, advancing pipelines through developed areas may require the relocation of existing infrastructure and traffic and business disturbances, even with the use of tunneling methods. In addition, the construction of pipelines through undeveloped areas may have environmental impacts that require mitigation (e.g., for pipeline alignments that traverse surface water features or otherwise impact critical habitats). In addition, securing easements for this conveyance is also expensive and can lead to delays. These challenges and associated permitting requirements may pose additional barriers for conveyance projects.

Potential opportunities exist to minimize challenges associated with conveyance. Prioritizing sources close to the hydrogen production areas would mitigate construction and cost challenges associated with long conveyance requirements. Acquiring surface water through an exchange provides another opportunity to mitigate challenges associated with conveyance. One of the primary benefits of an exchange project is that it provides a potential approach to avoid the need to construct pipelines from coastal and urban areas to the areas for hydrogen production. As described in Chapter 1 (Water Availability Study [Rincon 2024]), several regional surface water conveyance systems, the State Water Project for example, may provide an opportunity for surface water exchange that could reduce the need to construct and operate long pipeline systems to convey water for hydrogen production.

5. Geographic Challenges and Opportunities

This section presents an evaluation of potential implementation challenges related to the geographic setting of the potential water sources.

5.1 Geographic Categories

Considering the locations of the potential water supply sources, and the different characteristics of those locations, the source locations were grouped into the following broad geographic categories with different project implementation challenges.

- Coastal – water sources located within the jurisdiction of the California Coastal Commission
- Urban – water sources located within the incorporated limits of a city
- Other – water sources located outside coastal and urban zones

For the purpose of this evaluation, the following implementation challenges were evaluated to assess challenges and opportunities associated with the geography of potential supply sources.

- Land availability – land availability for project development and right-of-way (ROW) for conveyance
- Construction challenges – level of existing development that can interfere with constructing treatment facilities and conveyance
- O&M challenges – degree of constraints on implementing repairs and coordination to implement intrusive O&M activities, potentially resulting in more downtime
- Conveyance challenges – potential long conveyance distance from geographic areas and renewables areas for hydrogen production
- Permitting complexity – geographic permitting complexities that pose challenges for project development across multiple public agencies

5.2 Geographic Challenges

In general, the potential project impacts for the area are similar for many of the geographic implementation challenges for each of the three geographic categories. **Table A-2 in Appendix A** presents the category-specific challenges and opportunities for the geographic settings. The following summarizes important considerations regarding potential project geographies.

- Project implementation in coastal geographies may be more challenging than urban and other settings. Permitting, in particular, is expected to be complex because of the need to comply with coastal development permitting requirements. In addition, sources in coastal settings are expected to require longer pipelines to convey source water to hydrogen production areas.
- Many of the implementation challenges for urban settings are similar to those for coastal settings. Land availability and conveyance, however, are expected to be significant challenges for projects in urban settings.
- Some of the potential sources are located outside of coastal and urban settings. Many of potential implementation challenges for projects in other settings may apply. However, land availability and conveyance may pose less of a challenge for water supply sources in other settings.

6. Summary

Supply reliability, concentrate management, and conveyance are the primary challenges for each of the identified supply source types. Challenges related to treatment vary among the source types based on differences in the water quality and may result in increased treatment and operational costs for some sources (e.g., produced water and dry weather flows). In general, water supply projects located in non-coastal, non-urban settings would have fewer implementation challenges. Accommodating for supply reliability long term is another concern for each of the supply types.

Concentrate management may also pose a challenge for all supply types. If access to an existing concentration disposal pipeline is unavailable for the project, or it is located too far away to economically convey concentrate to that location, alternative concentrate management methods, such as evaporation ponds or mechanical evaporative methods, might need to be used. Potential opportunities exist to mitigate these challenges for several source types. For produced water, project developers may be able to utilize existing oilfield wastewater disposal wells for concentrate disposal. For advanced recycled water treatment, brackish groundwater, and desalter sources, project developers may be able to utilize or expand existing brine disposal systems. In this case, the project treatment plant would likely need to be located near the source water diversion location, and product water would be conveyed to the hydrogen production site.

Conveyance may also pose challenges for all supply types. As discussed in Section 5 of this chapter, the principal challenge for conveyance is related to the cost to construct and operate conveyance systems. These concerns could be mitigated in part by prioritizing water sources located near the hydrogen production site. Acquiring imported surface water through an exchange could provide another potential strategy to avoid the challenge associated with long conveyance distances.

Third-party producers may need to acquire supply from multiple sources and supply for certain clean renewable hydrogen production projects. The locations of potential sources are distributed throughout Central and Southern California. Opportunities may exist for coordinating entities/partnerships to facilitate the gathering and conveyance of water supplies from distributed sources throughout Central and Southern California to potential hydrogen production sites. This may help accommodate supply reliability for future production projects. These coordinating entities could include a consortium of hydrogen producers, an independent joint powers agency tasked with gathering and conveying water supplies to hydrogen producers, or other partnerships among the parties involved in clean renewable hydrogen production.

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Appendix A

Challenge and Opportunity Tables

Table A-1. Challenges and Opportunities – Supply Sources

Category	Title	Challenge/ Opportunity Description	Challenge/ Opportunity	Notes/Mitigation/Opportunity Capture Actions
Concentrate Management	Concentrate Disposal Conveyance	A long conveyance run for concentrate disposal and/or construction of a new outfall may be required .	Challenge	Locating treatment near an existing disposal conveyance/outfall would reduce the need for long conveyance runs or construction of a dedicated outfall.
Concentrate Management	Land Requirements for Concentrate Evaporation Ponds	Large areas of land may be required for construction of concentrate evaporation ponds, which may increase overall costs and compete with land needed for renewable systems (electricity generation).	Challenge	Implement brine minimization to reduce volume of brine to be disposed of (additional energy demands).
Concentrate Management	Existing Concentrate Disposal Conveyance/ Outfalls	Instead of constructing a new concentrate management system, connect to an existing concentrate disposal pipeline or outfall.	Opportunity	<ul style="list-style-type: none"> Use of existing concentrate disposal conveyance/outfall would avoid the need to construct a new disposal pipeline/outfall, concentrate evaporation basin, or other concentrate management systems. Specifically for O&G industry water, purchasing or repurposing existing waste injection wells and conveyance used for disposal of O&G production wastes may be an opportunity to reduce the overall costs for concentrate management for O&G production water.
O&M	Concentrate plugging - Pipelines	Concentrate chemistry leads to scaling and plugging of the concentrate pipeline, impacting recovery.	Challenge	<ul style="list-style-type: none"> Expected to be more challenging for O&G industry water, agricultural industry water, and the concentrate sources Plan for additional O&M of the concentrate pipeline. Incorporate redundancy in the design of the concentrate pipeline.
O&M	Process Upset	For example, treatment system outage caused by mechanical or performance issues, impacting recovery and system uptime.	Challenge	<ul style="list-style-type: none"> Process upset is expected to be more likely for O&G industry water, agricultural industry water, dry weather flows, and the concentrate sources. Conduct additional pretreatment to mitigate scaling. Incorporate treatment redundancy to ensure supply.
O&M	Waste Classification - Concentrate	Due to concentration of hazardous chemicals, the RO concentrate may be classified as hazardous waste.	Challenge	<ul style="list-style-type: none"> More likely for O&G industry water, agricultural industry water, and the concentrate sources. Implement brine minimization to reduce volume of brine to be disposed of (additional energy demands). Conduct treatment to remove hazardous constituents from the concentrate (additional treatment costs).
O&M	Waste Classification - Residuals	Due to concentration of hazardous chemicals, solid residuals from the treatment may be classified as hazardous waste.	Challenge	Dispose of wastes in hazardous waste landfill (additional costs).
Partnerships	Coordinating Partnerships	Acquiring and conveying water supplies from many distributed sources may be needed for third-party hydrogen production projects. Given the dispersed nature of these sources, coordinating entities/partnerships may be needed for such a system to be implementable. These coordinating entities could include a consortium of hydrogen producers, an independent joint powers agency tasked with gathering and conveying water supplies to hydrogen producers, or other partnerships among other parties involved in hydrogen production.	Opportunity	As the details for specific clean renewable hydrogen production projects evolve, facilitate the development of partnerships among the parties involved to coordinate the acquisition and conveyance of source water supplies for hydrogen production.
Partnerships	Surface Water Exchange	Potential synergies exist for supply projects that would provide water supply diversification for areas that only have access to one source of imported water (e.g., areas that are 100% dependent on State Water Project water). Partnerships could involve constructing, partnering, or funding local water supply projects (e.g., brackish desalinization and recycled water projects) for potable supply within the imported water service areas. The treated water would be distributed within the local service area in lieu of imported surface water deliveries.	Opportunity	Coordinate with agencies involved with the conveyance and supply of imported surface water, as well as local agencies reliant on imported surface water to identify mutually beneficial partnership opportunities for surface water exchange.
Partnerships	Private-Public Partnerships, Treated Wastewater - Wastewater Treatment Plant Expansions	Availability of recycled municipal wastewater may be greater for new plants or plants undergoing expansion because those discharges may not have yet been allocated to other uses (e.g., further treatment for potable uses or use for environmental flows). Thus, partnership opportunities with agencies undertaking or planning to expand their wastewater treatment plants may increase access to this source. Potential partnerships mechanisms may include the purchase of municipal wastewater and/or contributing funding for wastewater treatment plant construction or expansion.	Opportunity	Identify regions experiencing or projecting population growth, coordinate with agencies in these areas to identify those constructing or expanding wastewater treatment plants, and explore partnerships to gain access to the wastewater from those plants.
Partnerships	Concentrate Harvesting	Identifying cost-effective approaches for the management and disposal of RO concentrate from advanced water treatment plants may be critical for agencies operating or planning to construct advanced water treatment plants. Thus, these agencies may view partnerships with entities that would acquire and take responsibility for their RO concentrate as beneficial, especially for advanced water treatment plants where traditional disposal approaches for RO concentrate is challenging.	Opportunity	Coordinate with agencies operating discharging concentrate sources to identify mutually beneficial partnership opportunities for diverting their concentrate streams for hydrogen production.

Category	Title	Challenge/ Opportunity Description	Challenge/ Opportunity	Notes/Mitigation/Opportunity Capture Actions
Partnerships	Private-Public Partnerships, Brackish Water Desalters	In some cases, the agencies have implemented inland brackish water desalter systems to comply with regulatory requirements to improve or maintain the salt balance in a groundwater basin. In this context, the brackish groundwater systems are analogous to groundwater remediation projects. These agencies may view private partnerships that operate or fund these types of projects as beneficial because this would allow the agencies to divert funding allocated for desalter construction and operation to less costly supply sources. Such partnerships may ease access to brackish groundwater supplies for hydrogen production.	Opportunity	Identify those agencies conducting brackish groundwater desalination as a regulatory obligation, and coordinate with these agencies to identify partnership opportunities for groundwater desalters.
Partnerships	Multiple -Benefit Projects, Dry Weather Flow	Dry weather flows in storm water systems can pose compliance challenges for municipal agencies and can be a source of contaminant loading to receiving waters and associated aquatic habitats. Thus, diverting dry weather flows for hydrogen production may provide multiple benefits (e.g., source water for hydrogen production, improved municipal compliance, and benefits to the environment). Given the broad benefits of diverting dry weather flows, partnering with municipalities, regulatory agencies, flood control districts, and non-governmental agencies to divert these flows may increase access to this supply source for hydrogen production.	Opportunity	Identify those agencies/receiving waters that would benefit most from dry weather flow diversion and coordinate with the appropriate agencies, regulators, and non-government entities in these watersheds to identify partnership opportunities for dry weather flow diversion
Partnerships	Agricultural Salt Management, Agricultural Industry Water	The salt content of agricultural drainage and wastewater used in food processing can be challenging to manage, sometimes requiring specific treatment, infrastructure, or management approaches to comply with discharge limits. Diverting these flows for hydrogen production may be beneficial to agricultural producers, irrigation districts, and regulatory agencies involved. Partnerships with these entities to develop infrastructure to divert agricultural industry water may increase access to this supply source.	Opportunity	Identify those entities that would benefit most from diversion of agricultural industry water and coordinate with these entities to identify partnership opportunities for diversion of this source.
Partnerships	Stormwater Infrastructure Improvements, Urban Stormwater Capture and Reuse	In some cases, agencies may need to improve or repair their flood control or stormwater systems (e.g., channel repairs, levee repairs, or the construction of retention basin). Partnerships with agencies that need to improve their flood control or stormwater systems may increase access to this source. Potential partnership mechanisms may include contributing funding for flood control/stormwater system repairs or expansions.	Opportunity	Identify those agencies/receiving waters that need to implement flood control/stormwater system improvements or repairs and identify partnership opportunities for stormwater capture and reuse.
Regulatory	Regulatory Compliance	Regulatory compliance issues that impact supply or concentrate disposal.	Challenge	<ul style="list-style-type: none"> For surface water exchange, permitting of new exchange projects (e.g., ocean desalinization, brackish groundwater, or reuse) may be difficult because impacts or mitigation may be too costly or difficult to make the projects feasible; target investments in existing desalinization, reuse or brackish groundwater projects (expansion of those existing projects) or new projects that have already been identified with mitigable permitting challenges; look for multi-benefit opportunities; add value to local communities For treated wastewater, diverting wastewater discharge for hydrogen generation may decrease ecological flows; develop mitigations for reduced flows; engage with parties to understand potential concerns related to the change in discharge For dry weather flows and stormwater capture and reuse, regulatory changes may reduce diversions to support other demands (e.g., to ensure ecological purposes); diversify supply.
Stakeholder	External Stakeholders	External stakeholder involvement in development of water supply source.	Opportunity	<ul style="list-style-type: none"> Address potential impacts related to water supply (e.g., supply available, water prices) from development of water supplies that will support hydrogen production. Develop robust stakeholder engagement plan during the planning phase that includes early identification, assessment, mapping, and engagement planning for external stakeholders; conduct early and active engagement.
Supply Reliability	Long-Term Reliability, Surface Water	For surface water, required volume of produced water may not be available long term because of competing demands for surface water, climatic conditions, or other constraints.	Challenge	<ul style="list-style-type: none"> Contribute (invest) in water banking operations and recover banked storage when needed to maintain reliable supply Identify alternative local water sources to diversify supply
Supply Reliability	Long-Term Reliability, Treated Wastewater	For treated wastewater, required volume of recycled water may not be available long term because of conservation efforts or other actions that can reduced wastewater flows.	Challenge	Identify alternative water sources to diversify supply
Supply Reliability	Long-Term Reliability, Groundwater Sources	For groundwater and inland brackish groundwater, required volume of produced water may not be available long term because pumping may impact groundwater sustainability.	Challenge	Identify alternative water sources to diversify supply
Supply Reliability	Long-Term Reliability, Urban Stormwater Capture and Reuse	For stormwater capture and reuse, stormwater will not be available continuously as a supply for hydrogen production (only available during storm events).	Challenge	Identify alternative water sources to diversify supply

Category	Title	Challenge/ Opportunity Description	Challenge/ Opportunity	Notes/Mitigation/Opportunity Capture Actions
Supply Reliability	Long-Term Reliability, O&G Production Water	O&G production water, required volume of produced water may not be available long term because of a decline in oil production over time.	Challenge	<ul style="list-style-type: none"> Shift to using water sources previously used for O&G production and refining (e.g., surface water or groundwater) that become available as O&G production declines. Identify alternative water sources (other water sources) to diversify supply
Treatment	Treatment Complexity	The more complex the treatment system, the more operational downtime is expected to be needed for maintenance.	Challenge	<ul style="list-style-type: none"> Treatment for surface water, groundwater, and dry weather flows may be less complicated. Treatment for concentrate sources and brackish groundwater may be moderately complicated. Treatment for O&G industry water, agricultural industry water, and dry weather flows is expected be the most complicated of the sources that have been identified. For mitigation, plan for additional O&M, and incorporate redundancy in the treatment system.
Treatment	Supply Volume Fluctuation	Quantity of water supply fluctuates substantially, impacting recovery.	Challenge	<ul style="list-style-type: none"> General mitigations include Incorporating flow equilibration and adding treatment capacity to accommodate higher flows. For stormwater capture and reuse, flows may fluctuate significantly based on the availability of stormwater. This source will require significant equilibration storage to accommodate these fluctuations. This may be mitigated in part by diverting water from multiple existing stormwater retention basins.
Treatment	Water Quality Fluctuations	Quality of the produced water fluctuates substantially, impacting recovery.	Challenge	<ul style="list-style-type: none"> Plan for additional O&M. Add treatment capacity to accommodate higher flow.

O&M = operations and maintenance
RO = reverse osmosis

Table A-2. Implementation Challenges and Opportunities – Geographic Settings

Title	Challenge/Opportunity Description	Notes/Mitigation/Opportunity Capture Actions
Land Availability	Land availability for project development and ROW for conveyance	<ul style="list-style-type: none"> In general, land may be unavailable in coastal areas for development, and ROW access can be difficult to obtain. In general, less land is available in urban areas for development, and ROW access can be difficult to obtain. In general, more land is available in non-urban/non-coastal areas for development, and ROW may be more attainable.
Construction Challenges	Level of existing development that can interfere with the construction of treatment facilities and conveyance	<ul style="list-style-type: none"> In generally dense, urban and costal settings, significant existing infrastructure can interfere with the construction of treatment facilities and conveyance. A lower-density setting and fewer construction interferences are expected for non-urban/non-costal settings.
O&M Challenges	Degree of constraints on implementing repairs and coordination to implement intrusive O&M activities, potentially resulting in more downtime	<ul style="list-style-type: none"> Constraints on implementing repairs are likely for coastal settings; public coordination and approval may be needed from multiple agencies to implement intrusive O&M activities. Some constraints on implementing repairs are expected for urban settings; public coordination and agency approval may be needed. Few constraints on implementing repairs are expected in lower-density, non-urban/non-costal settings.
Conveyance Challenges	Long conveyance distance from geographic area to hydrogen production locations	<ul style="list-style-type: none"> For all geographies, one opportunity to reduce costs and to avoid potential challenges associated with conveyance is prioritizing source types that are located near the hydrogen production facility because the associated conveyance distances would be shorter. Shorter pipeline runs may be needed to convey water supply from sources located in non-coastal/non-urban regions.
Permitting Complexity	Geographic permitting complexities that pose challenges for project development	<ul style="list-style-type: none"> For all geographies, one opportunity to mitigate potential challenges related to permitting is early and proactive engagement with applicable agencies and stakeholders in order to understand their permitting requirements, concerns, and preferred approaches for mitigation. In general, project permitting is expected to be complex for costal settings, potentially requiring permits from multiple agencies, as well as compliance with Costal Commission permitting, and associated analyses and impact mitigation requirements (e.g., sea level rise). Project permitting is also expected to be complex for urban settings and for non-urban/non-coastal, potentially requiring permits from multiple agencies.

ROW = right-of-way

Chapter 5: Supplemental Desktop Analysis - Greenhouse Gas Emissions Associated with Water Treatment and Conveyance

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Appendices

Appendix A Delta Conveyance Project Mitigation Measure to Develop and Implement a GHG Reduction Plan to Reduce GHG Emissions from Construction and Net CVP Operational Pumping to Net Zero

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Acronyms

AF	acre-feet
AFY	acre-feet per year
AQ	air quality
CAP	Climate Action Plan
CBOSG	Community Based Organization Stakeholder Group
CEQA	California Environmental Quality Act
CH ₄	methane
CO ₂	carbon dioxide
CO ₂ e	carbon dioxide equivalent
CVP	Central Valley Project
EIR	Environmental Impact Report
GHG	greenhouse gas
GWP	global warming potential
HFC	hydrofluorocarbons
IEUA	Inland Empire Utilities Agency
kWh	kilowatt hour
LADWP	Los Angeles Department of Water and Power
m ³	cubic meter
Metropolitan	Metropolitan Water District of Southern California
MG	million gallons
MGD	million gallons per day
MT	million tons
MWh	megawatt hours
N ₂ O	nitrous oxide
NEPA	National Environmental Policy Act
NO _x	nitrogen oxide
PAG	Planning Advisory Group
PCS	pressure control structure
PFC	perfluorocarbons
RRWP	Regional Recycled Water Program
SCE	Southern California Edison

Water Resources Evaluation

SF6	sulfur hexafluoride
SWP	State Water Project
T&D	transmission and distribution
UWMP	Urban Water Management Plan
WESim	Water-Energy Simulator
WRE	Water Resources Evaluation

Executive Summary

At SoCalGas's request, this supplemental desktop analysis was prepared in direct response to stakeholder feedback during Phase 1 of Angeles Link, including in response to comments received verbally during meetings with the Angeles Link Planning Advisory Group (PAG) and Community Based Organization Stakeholder Group (CBOSG) members and in response to written comments received on the preliminary findings provided for the Water Resources Evaluation (WRE).

Specifically, PAG and CBOSG members expressed concerns about the potential greenhouse gas (GHG) emissions associated with the development of water supplies for clean renewable hydrogen production, including emissions associated with conveyance and treatment of different water supply sources.

SoCalGas does not propose to directly develop water supplies or produce clean renewable hydrogen as part of the Angeles Link project, as described in the Production and Planning Assessment (Production Study) prepared as a separate Angeles Link Phase 1 feasibility study. A detailed, quantified analysis of potential GHG emissions associated with water conveyance and treatment is outside the scope of the WRE. In addition, a quantified analysis would not be feasible during this feasibility stage without more information on the specific options for water supply sources third-party producers may develop to produce clean renewable hydrogen. However, to understand more about the potential GHG emissions associated with water supply development more generally, Rincon prepared this supplemental analysis to provide a high-level overview of existing published data and studies regarding potential GHG emissions associated with the energy required to conduct water supply treatment and conveyance.

This supplemental analysis is informed by review of available literature and resources, finding the extent of GHG emissions associated with water supply management depends on many factors, including, but not limited to, the potential distance required for conveyance, the initial water quality of the source water, and type and amount of electricity used for a given activity (i.e., for pumping needs depending on local topography or whether gravity is available for conveyance or for treatment needs depending on the quality of the water). As more details on specific clean renewable hydrogen production projects emerge, potential GHG emissions associated with water supply development could be further evaluated on a case-by-case basis. SoCalGas anticipates clean renewable production projects would undergo a thorough environmental review under the California Environmental Quality Act (CEQA) and/or the National Environmental Policy Act (NEPA), as applicable, when such projects apply for discretionary permits from federal, state, and/or local agencies as applicable. That environmental review would likely include an analysis of potential GHG emissions associated with development of those projects.

1 Scope

This report has been prepared as part of the WRE for the Phase 1 feasibility studies conducted for SoCalGas's Angeles Link project. As noted in Chapter 1, *Water Availability Study*, of the WRE, water supply sources that may be considered by third-party clean renewable hydrogen producers to pursue quantities sufficient to meet the water needs for their respective projects were identified. The ultimate location, capacity and design of those production projects will be determined by the clean hydrogen producers.

The purpose of this report is to provide a high-level overview of information related to potential GHGs associated with the treatment and conveyance of water supply in California and to address comments received from the PAG/CBOSG stakeholders. This report does not include quantification of GHG emissions associated with the potential supply source types identified in the WRE; rather, it provides information, including data and methodology, to offer additional context at this stage regarding potential future GHG emissions associated with water supply development. Potential GHG emissions from combustion associated with Angeles Link infrastructure, including from third-party production and storage activities, as well as potential GHG combustion emissions reductions from displacing fossil fuels with hydrogen in various sectors are evaluated in the Greenhouse Gas Emissions Evaluation Draft Report (GHG Study) being prepared as a separate Phase 1 analysis. Given the scope of the feasibility analyses, the GHG Study's evaluation of potential GHG emissions associated with third-party production does not include an assessment of emissions associated with conveyance and treatment of water sources that may feed specific third-party production projects.

The type and extent of GHG emissions associated with water supply management are related to treatment and conveyance, and depend upon numerous factors such as, but not limited to, the potential distance required for conveyance, the initial water quality of the source water, and the type and amount of electricity used for a given activity. Water quality treatment and water conveyance are the most energy-intensive aspects of water supply management. The GHG emissions associated with a given activity are calculated based upon the activity's energy usage.

The principle anthropogenic (human-made) GHGs are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and fluorinated compounds, including sulfur hexafluoride (SF₆), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). Those that are associated with combustion include CO₂, CH₄, and N₂O. To quantify GHG emissions, a carbon dioxide equivalent (CO₂e) is calculated, where CO₂e is a metric measure used to compare the emissions from various GHGs based on their global warming potential (GWP). This is done by converting quantities of other gases to the equivalent amount of CO₂ that would result in the same GWP, where CO₂ has a GWP value of one. CO₂e is typically expressed in weight of CO₂e per unit of energy used.

2 Literature Review

Published resources included in this literature review were identified because they contain data and methodology that may be helpful to informing analysis of potential GHG emissions associated with use of water supplies, including emissions associated with water treatment and conveyance. Table 5-1, below, provides an overview of the published resources discussed herein.

Table 5-1 Overview of Published Resources

Resources	Information / Findings
Implications of Future Water Supply Sources for Energy Demands (WRF 2012)	The Water-Energy Simulator (WESim) analytical tool is used to evaluate the energy and greenhouse gas implications of water management. The tool is suitable for individual water utilities and groups of water utilities, as well as policy and decision makers.
Energy Demands on Water Resources: Report to Congress of the Interdependency of Energy and Water (USDOE 2006)	This report is a response to a Congressional directive within a letter to the Secretary of Energy from the chairmen and ranking members of the House and Senate Subcommittees on Energy and Water Development Appropriations, dated December 9, 2004, wherein they asked for “a report on energy and water interdependencies, focusing on threats to national energy production that might result from limited water supplies.”
Metropolitan Water District of Southern California (Metropolitan), Climate Action Plan (Metropolitan 2022)	This Climate Action Plan (CAP) sets targets for reducing GHG emissions from Metropolitan’s operations, including conveyance, storage, treatment, and delivery of water to its 26 member water agencies. The CAP also complements Metropolitan’s existing long-range planning efforts, including the Integrated Water Resources Plan, Energy Sustainability Plan, and Capital Investment Plan.
Delta Conveyance Project, Environmental Impact Report (EIR), Chapter 23: Air Quality (DWR 2023)	The Delta Conveyance Project is a proposed project to modernize State Water Project (SWP) infrastructure in the network of waterways comprising the Sacramento-San Joaquin Delta that collects and moves water to homes, farms, and businesses to major regions in California from the Bay Area to Southern California. The Air Quality and Greenhouse Gases (GHG) chapter of the Final EIR (DWR 2023, Chapter 23) describes the environmental setting and study area for air quality and GHG emissions; analyzes impacts that could result from construction, operation, and maintenance of the project; and provides mitigation measures to reduce the effects of potentially significant impacts. Analysis includes detailed mitigation to provide net zero emissions.
Annual Summary of Greenhouse Gas Emissions Data Reported to the California Air Resources Board (CARB 2023)	Under California’s <i>Regulation for the Mandatory Reporting of Greenhouse Gas Emissions</i> , industrial sources (i.e. emitters of GHG emissions), fuel suppliers, and electricity importers must report their annual GHG emissions to the California Air Resources Board (CARB). Certain water supply providers are subject to CARB reporting, with emissions resulting from water treatment, conveyance, and other activities conducted to support water supply-related operations.

The discussions below present key information and findings from the resources identified above, as relevant to the analysis of potential GHG emissions associated with water treatment and conveyance.

Implications of Future Water Supply Sources for Energy Demands (WRF 2012)

Capturing and treating surface water requires an average of around 1,400 kWh/MG, or 0.37 kWh per cubic meter (kWh/m³). Groundwater supplies require slightly more energy, around 1,800 kWh/MG (0.48 kWh/m³). Energy requirements for wastewater treatment vary depending on the type of treatment conducted, ranging from less than 1,000 kWh/MG (0.26 kWh/m³) for basic treatment to more than 1,900 kWh/MG (0.50 kWh/m³) for advanced treatment. (WRF 2012)

The median energy intensity for imported water is around 3,000 kWh/MG (0.79 kWh/m³), with low and high values ranging from 1,900 kWh/MG (0.50 kWh/m³) to 5,300 kWh/MG (1.4 kWh/m³). Imported water energy demands are particularly high due to the use of extensive pumping, where gravity flow is not available to provide conveyance. (WRF 2012)

For example, water from the Hetch Hetchy system, which is owned and operated by the City of San Francisco, extends more than 100 miles largely by the force of gravity, with energy requirements of two kWh/MG (5.3×10^{-4} kWh/m³) (WRF 2012); as such, water from the Hetch Hetchy system would have lower associated GHG emissions, with reduced energy needs due to the use of gravity flow. In contrast, SWP water and Colorado River water is imported to Southern California over hundreds of miles and steep terrain, with energy needs of up to approximately 7,500 kWh/MG (2.0 kWh/m³) (WRF 2012); as such, these imported water sources have higher rates of GHG emissions than gravity-driven systems.

Energy Demands on Water Resources: Report to Congress of the Interdependency of Energy and Water (USDOE 2006)

Table 5-2, below, provides an overview of statewide energy requirements for water supply and treatment (USDOE 2006, pg. 25).

Table 5-2 California Statewide Energy Requirements for Water Supply and Treatment

Water Cycle Phase	kWh/MG ¹ – Low	kWh/MG ¹ - High
Supply and Conveyance	0	16,000
Treatment	100	1,500
Distribution	700	1,200
Wastewater Collection and Treatment	1,100	4,600
Wastewater Discharge	0	400
Total	1,900	23,700
Recycled Water Treatment and Distribution for Non-Potable Uses ²	400	1,200

¹ kWh = kilowatt hours; MG = million gallons.

² Recycled water is presented separately as a non-potable supply, versus the potable water cycle phases presented above.

Source: USDOE 2006, pg. 25

The study found that the biggest difference among regions in rates of energy use is the amount of energy used to supply water for agriculture. In general, per capita non-agricultural use of energy for water is similar from region to region. However, within regions, there can be substantial variation in energy requirements for water supply and treatment, depending on the source, the distance water is conveyed, and the local topography. (USDOE 2006, pg. 25)

The report also concluded that local, alternative water sources have relatively high treatment energy requirements compared to traditional water sources; however, in regions like the South Coast, they are still typically lower than the energy requirements for the conveyance of imported water (except for the most energy-intensive source, seawater desalination). (USDOE 2006, pg. 25)

Metropolitan Water District of Southern California, Climate Action Plan (2022)

Most GHG emissions from Metropolitan’s operations are associated with electricity for importing water; therefore, Metropolitan emissions are highly dependent on where water is sourced. Metropolitan’s 2020 Urban Water Management Plan (UWMP) provided historical data on water delivery from 1990 to 2020, which was used as a proxy to develop an emission factor for future deliveries. Metropolitan projected that in 2020, it would deliver a total of 1,794,625 acre-feet of water with associated GHG emissions totaling 234,329 MT CO₂e, for an emission factor of 0.17054 MT CO₂e per AF of water delivered. (Metropolitan 2022)

Table 5-3, below, provides an overview of Metropolitan’s estimates of GHG emissions associated with their respective facilities and operational activities. These estimates include direct emissions from fuel uses (gasoline, diesel, propane, and natural gas), and indirect emissions from the purchase and consumption of electricity used for the transmission, treatment, and distribution of water.

Table 5-3 Water Infrastructure – Energy Use and GHG Emissions (2017)

Consumption Source¹	Electricity Consumption (MWh)¹	GHG Emissions (MT CO₂e)¹
Treatment Plants	48,789	11,727
Pumping Plants – Wholesale Power	1,313,240	176,080
Pumping Plants – Retail Power	4,875	1,172
Reservoirs	2,539	610
Power Plants & PCS	2,125	511
Older Facilities	8,074	1,941
Misc. Energy Usage	1,960	471
T&D Losses	14,687	1,969

¹ GHG = greenhouse gas; MT CO₂e = million tons of carbon dioxide equivalent; MWh = megawatt hours (1 MWh = 1,000 kilowatt hours); PCS = pressure control structure; T&D = transmission and distribution.

Source: Metropolitan 2022, pgs. 78, 79

Metropolitan’s CAP also included projections of GHG emissions from its planned Regional Recycled Water Program (RRWP), anticipated operational in 2031. The RRWP would produce up to 150 million gallons per day (MGD) of purified water and the conveyance of purified water via approximately 60 miles of pipelines (Metropolitan 2021). Table 5-4 provides an overview of the calculated energy needs and associated GHG emissions for the RRWP.

Table 5-4 Regional Recycled Water Program – Projected Operational Emissions

Year	Electricity Consumption (MWh) ¹	GHG Emissions (MT CO ₂ e) ¹
2035	594,675	87,675
2040	594,675	57,643
2045	594,675	27,611

¹ 264,988 MWh per year for operations at the AWTP and an additional 329,687 MWh per year to operate the pump stations; 1 Megawatt hour = 1,000 kilowatt hours

² GHG = greenhouse gas; MT CO₂e = million tons of carbon dioxide equivalent; MWh = megawatt hours (1 MWh = 1,000 kilowatt hours)

Source: Metropolitan 2022, pg. 256

Operational electricity demand was estimated to be 264,988 MWh per year for operations at the AWTP and an additional 329,687 MWh per year to operate the pump stations which will move water from the AWTP to the spreading grounds and injection wells (Metropolitan 2022, pg. 256). The total estimated emissions associated with this electricity demand are anticipated to decrease annually. With the implementation of California Senate Bill (SB) 100, which established a policy requiring renewable energy and zero-carbon resources supply 100 percent of electric retail sales to end-use customers by 2045, GHG emissions from electricity consumed at the AWTP would be reduced to zero MT of CO₂e by 2045. (Metropolitan 2022, pg. 256)

Delta Conveyance Project EIR (2023)

The Delta Conveyance Project is a proposed project to modernize State Water Project (SWP) infrastructure in the network of waterways comprising the Sacramento-San Joaquin Delta that collects and moves water to homes, farms, and businesses to major regions in California from the Bay Area to Southern California. The California Department of Water Resources (DWR) certified a Final Environmental Impact Report (EIR) for the Delta Conveyance Project (DWR 2023) that includes calculations of GHG emissions associated with the facility, including CO₂, CH₄, N₂O, SF₆, and HFCs. Emissions were estimated for the EIR based on consideration project-specific activity data, relevant agency guidance and published literature, and emissions factors and methodologies from models including CalEEMod (<https://www.caleemod.com/>), EMFAC (<https://arb.ca.gov/emfac/>), and AP-42, the U.S. Environmental Protection Agency’s Compilation of Air Emissions Factors from Stationary Sources (<https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors-stationary-sources>).

Total net additional emissions generated by construction of the Delta Conveyance Project and displaced purchases of CVP electricity are estimated to be approximately 629,356 metric tons CO₂e. These emissions exceed the net zero threshold adopted by DWR; however, Mitigation Measure AQ-9, *Develop and Implement a GHG Reduction Plan to Reduce GHG Emissions from Construction and Net CVP Operational Pumping to Net Zero*, outlines a menu of feasible GHG reduction strategies that could be individually or collectively implemented to achieve the magnitude of GHG reductions required to meet the project’s maximum total mitigation commitment (DWR 2023, pg. 178). Mitigation Measure AQ-9 is presented in full in Appendix A to this report, as an example of potential mitigation to address GHG emissions from water infrastructure projects.

Annual Summary of Greenhouse Gas Emissions Data Reported to the California Air Resources Board (CARB 2023)

Reporting of GHG emissions by major sources is required by the California Global Warming Solutions Act of 2006 (AB 32). The *Regulation for the Mandatory Reporting of Greenhouse Gas Emissions* applies to emitters including electricity generators, industrial facilities, fuel suppliers, and electricity importers. Some of these emitters include major water purveyors that own and operate water supply facilities including for conveyance, storage, treatment, and distribution, as well as other types of facilities such as for power generation. Table 5-5, below, provides an overview of data reported by such parties to CARB for 2022; this is the most recent data available at the time of preparation of this supplemental analysis.

Table 5-5 GHG Emissions Data Reported to CARB by Water Purveyors

Water Purveyor	Facility	City (County)	Total CO ₂ e ¹
Central Contra Costa Sanitary District	All facilities	Martinez (Contra Costa)	70,753
City of San Diego Public Utilities Dept.	North City Water Reclamation Plant	San Diego (San Diego)	3,815
	Point Loma Treatment Plant	San Diego (San Diego)	15,072
East Bay Municipal Utility District	All facilities	Oakland (Alameda)	37,292
Encina Wastewater Authority	Encina Water Pollution Control Facility	Carlsbad (San Diego)	97,058
Los Angeles County Sanitation Districts	Hyperion Water Reclamation Plant	Playa del Rey (Los Angeles)	101,872
	Joint Water Pollution Control Plant	Carson (Los Angeles)	25,496
Orange County Sanitation District	Plant 1	Fountain Valley (Orange)	29,186
	Plant 2	Huntington Beach (Orange)	6,325
San Francisco Water, Power, Sewer	San Francisco Southeast Treatment Plant	San Francisco (San Francisco)	35,918
City of San Jose, City of Santa Clara	San Jose-Santa Clara Regional Wastewater Facility	San Jose (Santa Clara)	10,238
City of Tulare	Tulare Water Pollution Control Facility	Tulare (Tulare)	3,815

¹ Carbon dioxide equivalent (CO₂e) is a metric measure used to compare the emissions from various GHGs based on their global warming potential; see Section 1, *Scope*.

Source: CARB 2023

Data reported under the *Regulation for the Mandatory Reporting of Greenhouse Gas Emissions*, including as presented in the table above, is used by the State's Cap-and-Trade Program and included in California Greenhouse Gas Inventory.

3 Summary Findings

This section provides the Summary Findings identified as part of this report, the purpose of which is to provide a high-level overview of information related to potential GHGs associated with the treatment and conveyance of water supply in California and to address comments received from the PAG/CBOSSG stakeholders. The Summary Findings include the following:

- Land use changes and technological advancements will influence emissions from water treatment and conveyance. Irrigation pump energy use produced 12.6 million metric tonnes of CO₂e in the US in 2018, predominantly attributable to groundwater pumping. Groundwater reliance, irrigated area extent, water demand, fuel choice, and electrical grid emissions intensity drove spatial heterogeneity in emissions. (Driscoll et al. 2024)
- Local, alternative water sources have relatively high treatment energy requirements compared to traditional water sources; however, in regions like the South Coast, they are still typically lower than the energy requirements for conveyance of imported water (except for the most energy-intensive source, seawater desalination). (WRF 2012)
- Third parties constructing and operating water infrastructure projects may implement mitigation measures for emissions; for example, the Final EIR for the Delta Conveyance Project identifies Mitigation Measures AQ-9, which requires implementation of a GHG Reduction Plan to minimize emissions from project construction and operation (DWR 2023, pg. 178).

4 References

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Appendix A

Delta Conveyance Project EIR, Air Quality and Greenhouse Gases

Mitigation Measure AQ-9: Develop and Implement a GHG Reduction Plan to Reduce GHG Emissions from Construction and Net CVP Operational Pumping to Net Zero

Mitigation Measure AQ-9: Develop and Implement a GHG Reduction Plan to Reduce GHG Emissions from Construction and Net CVP Operational Pumping to Net Zero

Prior to issuance of the first construction or grading permit for the project, DWR will retain a qualified consultant to develop a GHG Reduction Plan (Plan) to mitigate GHG emissions resulting from construction and displaced purchases of CVP electricity to net zero. Net additional GHG emissions from construction and displaced purchases of CVP electricity have been quantified as part of this Final EIR and total between 398,106 and 629,346 metric tons CO_{2e}, depending on the alternative. Construction of the compensatory mitigation restoration sites is predicted to generate an additional 3,883 metric tons CO_{2e}. This yields a reduction commitment of up to 633,229 metric tons CO_{2e} needed to meet the net zero performance standard. The net zero performance standard may be achieved based on actual emissions calculations, as described below. The reduction commitment may therefore change based on project activities and adoption of new state regulations. Notably, if CARB's amendments to the Regulation for Reducing Sulfur Hexafluoride Emissions from Gas Insulated Switchgear (SF₆ Switchgear Regulation) are not adopted, DWR must reduce annual ongoing SF₆ from electrical transmission beyond 2045. This is further discussed below.

Required content for the Plan is identified in Section A below, including potential GHG reduction strategies to achieve the net zero performance standard. Monitoring, reporting, and enforcement requirements for future implementation of the Plan are outlined in Section B.

A. Required Plan Contents

- 1) *Emissions Quantities and Reduction Commitments:* GHG emissions from construction and displaced purchases of CVP electricity must be mitigated to net zero on a continual basis throughout construction and operations. This will require DWR to constantly “stay ahead” of the estimated emissions through early investment in GHG reduction efforts prior to construction (to ensure mitigation of unavoidable initial construction GHG emissions) and advanced planning for GHG reductions so that throughout the construction and operational period, the net effect of project emissions and this mitigation is that the project will not result in any increase in GHG emissions over baseline conditions. Since some of the planning will rely on the estimated GHG reduction value of future actions during construction and operation, there may be some need for “catch up” GHG reductions if emissions are higher than expected or reduction results are lower than expected. Conversely, if emissions are lower than expected or reduction results are higher than expected, there may be some building up of “forward credits” for the next phase of construction and/or operations.
- 2) *Plan Development:* Developing a fixed and rigid implementation strategy up-front to cover 12 to 14 years of construction, depending on the alternative, followed by project operation will be restrictive and will potentially preclude DWR from pursuing future reduction technologies that could be economically or environmentally superior to options that are currently available.

Given the constraints associated with developing a fixed and rigid reduction plan to cover all project emissions, the Plan may be developed and implemented over multiple phases. A phased approach provides increased implementation and management flexibility. It also enhances Plan quality as lessons learned during initial phases are applied to future reduction efforts. The first phase of the Plan must address no fewer

1 than the first 5 years of construction. The Plan will be amended to provide
2 implementation details for subsequent phases according to the requirements in Section
3 B below.

4 The Plan will identify the amount of GHG emissions anticipated in the covered phase, as
5 well as emissions from prior phases (if applicable) and the projected total net emissions
6 of the project. This Final EIR presents an estimate of annual GHG emissions generated
7 by project construction and displaced purchases of CVP electricity. Although this
8 inventory could be used exclusively to inform the required mitigation commitment, the
9 methods used to quantify emissions in the Final EIR were conservative. They also do not
10 account for any GHG reduction strategies that may be implemented by DWR pursuant to
11 this measure. Accordingly, this Final EIR likely overestimates actual GHG emissions that
12 would be generated by the project. DWR may therefore reanalyze GHG emissions for
13 any phase of the project to update the required reduction commitment to achieve net
14 zero.

15 An updated emissions analysis conducted for the Plan will be performed using approved
16 emissions models and methods available at the time of the reanalysis. The analysis must
17 use the latest available engineering data for the project, inclusive of any required
18 environmental commitments or GHG emissions reduction strategies. Consistent with the
19 methodology used in this Final EIR, emissions factors may account for enacted
20 regulations that will influence future year emissions intensities (e.g., fuel efficiency
21 standards for on-road vehicles). Emissions from displaced purchases of CVP electricity
22 will be derived by subtracting the project total energy consumption from what would
23 have been generated by the system without implementation of the project, and then
24 multiplying the net change in energy consumption by the statewide grid average
25 emissions intensity.

- 26 3) *GHG Reduction Strategies*: Each phase of the Plan will identify the GHG reduction
27 strategies that will be implemented during that phase to achieve the net zero
28 performance standard. Strategies that could be used in formulating the Plan are
29 summarized below. GHG reduction strategies must be verifiable and feasible to
30 implement. The Plan will identify the entity responsible for implementing each strategy
31 (if not DWR) and the estimated GHG reduction that will be achieved by implementation
32 of the strategy. If the selected strategies are shown to exceed total net emissions of that
33 phase, the estimated surplus can be applied as a credit in future phase(s), as explained
34 in Section B.1.

35 Environmental commitments (Section A.3a) are required project design features that
36 must be incorporated into the Plan. Following environmental commitments, DWR will
37 prioritize selected strategies as: (1) on-site construction strategies (Section A.3b); (2)
38 off-site strategies (Section A.3c); and (3) GHG credits (Section A.3d). The order of
39 priority for the location of selected strategies will be: (1) within the project right-of-
40 way; (2) within communities surrounding the water conveyance alignment (e.g., Hood);
41 (3) throughout California's Central Valley and Northern California; (4) in the State of
42 California; (5) in the United States; and (6) outside of the United States. If using off-site
43 strategies or GHG credits, the Plan must present substantial evidence to explain why
44 higher priority strategies were deemed infeasible as defined under CEQA.

1 It is possible that some of the strategies could independently achieve the net zero
2 performance standard for the project. Various combinations of strategies could also be
3 pursued to optimize total costs or community co-benefits. DWR will be responsible for
4 determining the overall mix of strategies necessary to ensure the performance standard
5 to mitigate the significant GHG impact is met.

6 The list of strategies presented in this section is not exclusive. DWR may include
7 additional or new strategies to reduce GHG emissions to the extent that they become
8 commercially available and cost effective and earn a track-record for reliability in real-
9 world conditions. This may include new equipment and vehicle systems (e.g.,
10 autonomous construction equipment, fuel-cells), new energy systems (e.g., battery
11 storage), or other technologies (e.g., carbon capture and storage).

- 12 a. Environmental Commitments: All phases of the Plan must incorporate the following
13 environmental commitments. Refer to Appendix 3B, *Environmental Commitments*
14 *and Best Management Practice*, for measure descriptions and Chapter 3, *Description*
15 *of the Proposed Project and Alternatives*.
- 16 i. EC-7: *Off-Road Heavy-Duty Engines*
 - 17 ii. EC-8: *On-Road Haul Trucks*
 - 18 iii. EC-9: *On-Site Locomotives*
 - 19 iv. EC-10: *Marine Vessels*
 - 20 v. EC-13: *DWR Best Management Practices to Reduce GHG Emissions*
 - 21 vi. Install electric vehicle (EV) charging stations at employee park-and-ride lots
22 (see Chapter 3, Section 3.4.13, *Park-and-Ride Lots*).
 - 23 vii. Require electric shuttles and buses to transport employees from the park-and-
24 ride lots to construction sites (see Chapter 3, Section 3.4.13).
- 25 b. On-Site Construction Strategies: Strategies to reduce on-site construction emissions
26 may include but are not limited to the following.
- 27 i. *Purchase Zero-Carbon Electricity*: Enter into a power purchase agreement,
28 where feasible, with utilities that provide electricity service to the study area
29 to purchase construction electricity from renewable sources. Renewable
30 sources must be zero-carbon energy sources (e.g., wind, solar, hydro) and may
31 not be accounted to utility RPS goals.
 - 32 ii. *Optimize Delivery Logistics*: Utilize freight instead of on-road haul trucks to
33 deliver construction materials and equipment, if feasible.
- 34 c. Off-Site Strategies: Off-site strategies to reduce emissions may include but are not
35 limited to the following.
- 36 i. *Support Community Building Energy Efficiency Improvements*: In coordination
37 with local utilities, fund or contribute to an energy efficiency improvement
38 program to achieve reductions in residential and commercial natural gas and
39 electricity usage. Potential building improvements may include energy
40 efficient appliances, energy efficient boilers, installation of alternative water

- 1 heaters in place of natural gas storage tank heaters, installation of induction
2 cooktops in place of gas ranges, or installation of cool roofs or green roofs.
- 3 ii. *Support Community Renewable Energy Projects:* In coordination with local
4 utilities, fund or contribute to community solar, wind, or other renewable
5 energy projects or programs. This could include providing funding to support
6 utility programs that will allow homeowners to install solar photovoltaic
7 systems at zero or minimal up-front cost. All projects installed under this
8 measure must be designed for high performance (e.g., optimal full-sun
9 location, solar orientation) and additive to utility RPS goals.
- 10 iii. *Support Energy Decarbonization Projects:* In coordination with local utilities,
11 fund or contribute to community infrastructure projects (e.g., retirement of
12 natural gas facilities) to support decarbonization of the electric power sector.
- 13 iv. *Support Community Transit Programs:* In coordination with local transit
14 providers, fund or contribute to programs to increase the use of public transit
15 (e.g., increased transit frequency, reduced transit fares).
- 16 v. *Support Community Pedestrian Network Improvements:* In coordination with
17 local authorities, fund or contribute to programs to increase sidewalk
18 coverage to improve pedestrian access and interconnectivity of the pedestrian
19 network.
- 20 vi. *Support Community Bicycle Network Improvements:* In coordination with local
21 authorities, fund or contribute to programs to construct or improve bicycle
22 lane facilities (Class I, II, or IV) or bicycle boulevards.
- 23 vii. *Support Community Carshare or Bikeshare Programs:* In coordination with
24 local authorities, fund or contribute to the deployment of neighborhood/city
25 conventional or electric carshare or bikeshare programs.
- 26 viii. *Support Transportation Decarbonization Projects:* In coordination with local
27 authorities, utilities, or transit providers, fund or contribute to community
28 infrastructure projects (e.g., electric-transit buses, EV infrastructure) to
29 support decarbonization of the transportation sector.
- 30 ix. *Support Biomass Waste Digestion and Conversion Facilities:* Fund or contribute
31 financing to facility development either through power purchase agreements
32 or up-front project financing. Projects should be awarded through a
33 competitive bidding process and chosen for GHG reduction and other
34 environmental benefits to the project area. Projects could provide a range of
35 final products: electricity generation, compressed natural gas for
36 transportation fuels, and pipeline quality biomethane. Renewable electricity
37 generation may not be accounted to RPS goals.
- 38 x. *Support Agriculture Waste Conversion Development:* Fund or contribute
39 financing to the re-commissioning of thermal chemical conversion facilities to
40 process collected agricultural biomass residues. Project funding should
41 provide incentives to farmers in the project area to deliver agricultural wastes
42 to existing facilities.

- 1 *xi. Increase Renewable Energy Purchases for Operations:* Increase renewable
2 energy purchases under DWR’s REPP) to reduce project emissions. The REPP
3 identifies the quantity of renewable electricity resources that DWR will
4 purchase each year to achieve the GHG emissions reduction goals laid out in
5 its Update 2020.
- 6 *xii. Support Tidal Wetland Inundation Projects:* Expand the number of subsidence
7 reversal and/or carbon sequestration projects currently being undertaken by
8 DWR on Sherman and Twitchell Islands. Existing research at the Twitchell
9 Wetlands Research Facility demonstrates that wetland restoration can
10 sequester 25 tons of carbon per acre per year. Measure funding could be used
11 to finance permanent wetlands for waterfowl or rice cultivation, creating co-
12 benefits for wildlife and local farmers.
- 13 *xiii. Support Urban Tree Planting:* In coordination with local authorities, fund,
14 contribute to, or implement a program to expand urban tree planting. The
15 program should prioritize native tree species that require minimal water and
16 maintenance, low-biogenic VOC emitting tree species, and low-allergen tree
17 species. All trees should be appropriately distanced from buildings, especially
18 in high fire areas.
- 19 *xiv. Conserve Agricultural Lands:* In coordination with local authorities, fund a
20 program to protect agricultural lands from conversion to urban or rural
21 residential development.

- 22 d. GHG Credits: A GHG credit enables development projects to compensate for their
23 GHG emissions and associated environmental impacts by financing reductions in
24 GHG emissions elsewhere. GHG credits derived from completed prior actions are
25 referred to as “GHG offsets” or “carbon offsets.” GHG credits derived from future
26 contracted actions are referred to as “GHG future credits” or “GHG future mitigation
27 units” (FMUs). GHG credits (including offsets) are classified as either compliance
28 credits or voluntary credits. Compliance offsets can be purchased by covered
29 entities subject to the cap-and-trade regulation to meet predetermined regulatory
30 targets (to date, the cap-and-trade regulation only allows the use of GHG offsets, not
31 GHG future credits). Voluntary offsets or voluntary GHG future credits are not
32 associated with the cap-and-trade regulation and are purchased with the intent to
33 voluntarily meet carbon neutral or other environmental obligations.

34 As of June 2021, DWR has 59,552 credits registered with the American Carbon
35 Registry (ACR).¹⁹ One credit is equal to a GHG reduction or GHG removal
36 enhancement of 1 metric ton of CO₂e. All GHG credits must be created through a
37 CARB-approved registry. These registries are currently the ACR, Climate Action
38 Reserve, and Verra, although additional registries may be accredited by CARB in the
39 future. These registries use robust accounting protocols for all GHG credits created
40 for their exchange, including the six currently approved CARB protocols. This
41 mitigation measure specifically requires GHG credits created for the project to
42 originate from a CARB-approved protocol or a protocol that is equal to or more

¹⁹ Of the 59,552 issued credits, 7,147 credits were issued to the ACR-controlled buffer pool. Credits issued to the buffer pool cannot be used as project mitigation.

1 rigorous than CARB requirements under 17 Cal. Code Regs. Section 95972. The
2 selected protocol must demonstrate that the reduction of GHG emissions are real,
3 permanent, quantifiable, verifiable, enforceable, and additional. Definitions of these
4 terms from 17 Cal. Code Regs. Section 95802(a) are provided below (the original
5 text used the term *offset*, which has been replaced in the text below with the generic
6 term *GHG credit*, as this measure allows for use of both offsets and FMUs).

- 7 • **Real:** GHG reductions or GHG enhancements result from a demonstrable action
8 or set of actions, and are quantified using appropriate, accurate, and
9 conservative methodologies that account for all GHG emissions sources, GHG
10 sinks, and GHG reservoirs within the [GHG credit] project boundary and account
11 for uncertainty and the potential for activity-shifting leakage and market-
12 shifting leakage.
- 13 • **Additional:** GHG reductions or removals that exceed any GHG reduction or
14 removals otherwise required by law, regulation, or legally binding mandate, and
15 that exceed any GHG reductions or removals that would otherwise occur in a
16 conservative business-as-usual scenario.
- 17 • **Permanent:** GHG reductions and GHG removal enhancements are not
18 reversible, or when GHG reductions and GHG removal enhancements may be
19 reversible, mechanisms are in place to replace any reversed GHG emissions
20 reductions and GHG removal enhancements to ensure that all credited
21 reductions endure for at least 100 years.
- 22 • **Quantifiable:** The ability to accurately measure and calculate GHG reductions
23 or GHG removal enhancements relative to a project baseline in a reliable and
24 replicable manner for all GHG emissions sources, GHG sinks, or GHG reservoirs
25 included within the [GHG credit] project boundary, while accounting for
26 uncertainty and activity-shifting leakage and market-shifting leakage.
- 27 • **Verified:** A [GHG credit] project report assertion is well documented and
28 transparent such that it lends itself to an objective review by an accredited
29 verification body.
- 30 • **Enforceable:** The authority for CARB to hold a particular party liable and to
31 take appropriate action if any of the provisions of this article are violated.

32 Note that this definition of enforceability is specific to the cap-and-trade
33 regulation, where CARB holds enforcement authority, but this measure will
34 employ GHG credits from the voluntary market, where CARB has no
35 enforcement authority. Applying the definition to this mitigation measure
36 means that GHG reductions must be owned by a single entity and be backed by a
37 legal instrument or contract that defines exclusive ownership.

38 GHG credits may be in the form of GHG offsets for prior reductions of GHG emissions
39 verified through protocols or FMUs for future committed GHG emissions meeting
40 protocols. Because emissions reductions from GHG offsets have already occurred,
41 their benefits are immediate and can be used to compensate for an equivalent
42 quantity of project-generated emissions at any time. GHG credits from FMUs must
43 be funded and implemented within 5 years of project GHG emissions to qualify as a
44 GHG credit under this measure (i.e., there can only be a maximum of 5 years lag

1 between project emissions and their real-world reductions through funding an FMU
2 in advance and implementing the FMU on the ground). Any use of FMUs that result
3 in a time lag between project emissions and their reduction by GHG credits from
4 FMUs must be compensated through a pro-rated surcharge of additional FMUs
5 proportional to the effect of the delay. Since emissions of CO₂ in the atmosphere
6 reach their peak radiative forcing within 10 years, a surcharge of 10% for every year
7 of lag between project emissions and their reduction through an FMU will be added
8 to the GHG credit requirement (i.e., 1.10 FMUs will be required to mitigate 1 metric
9 ton of project GHG emissions generated in the year prior to funding and
10 implementation of the FMU).

11 Consistent with the priorities outlined above in Section A.2, GHG credits from
12 reduction projects in geographies closest to the water conveyance alignment (i.e.,
13 Sacramento and Central Valley) will be prioritized before projects in larger
14 geographies (i.e., Southern California, California, United States, internationally).
15 DWR will inform brokers of the required geographic prioritization for the
16 procurement of GHG credits. GHG credits from reduction projects identified in the
17 Sacramento and Central Valley that are of equal or lesser cost compared to the
18 settlement price of the latest cap-and-trade auction must be included in the
19 transaction. GHG credits from reduction projects in larger geographies may be
20 purchased if adequate credits cannot be found in the Sacramento and Central Valley
21 or they exceed the price maximum identified above. The economic and geographic
22 analysis undertaken to inform the selection of GHG credits must be provided as part
23 of the required documentation discussed below in Section B.3.

24 All GHG credits will be verified by an independent verifier accredited by the ANSI
25 National Accreditation Board (ANAB) or CARB, or an expert with equivalent
26 qualifications to the extent necessary to assist with the verification. Following the
27 standards and requirements established by the accreditation board (ANAB or
28 CARB), the verifier will certify the following.

- 29 • GHG credits conform to a CARB-approved protocol or a protocol that is equal to
30 or more rigorous than CARB requirements under 17 Cal. Code Regs. Section
31 95972. Verification of the latter requires certification that the credits meet or
32 exceed the standards in 17 Cal. Code Regs. Section 95972.
- 33 • GHG credits are real, permanent, quantifiable, verifiable, enforceable, and
34 additional, as defined in this measure.
- 35 • GHG credits were purchased according to the geographic prioritization standard
36 defined in this measure.

37 Verification of GHG offsets must occur as part of the certification process for
38 compliance with the accounting protocol. Because FMUs are GHG credits that will
39 result from future projects, additional verification must occur beyond initial
40 certification. Verification for FMUs must include initial certification and
41 independent verification every 5 years over the duration of the FMU generating the
42 GHG credits. The verification will examine both the GHG credit realization on the
43 ground and its progress toward delivering future GHG credits. DWR will retain an
44 independent verifier meeting the qualifications described above to certify

1 reductions achieved by FMUs are achieved following completion of the future
2 reduction project.

3 **B. Implementation and Enforcement**

4 1) *Phased Analysis and Plan Amendments:* As described above in Section A.1, the Plan may
5 be developed and implemented over multiple phases. Prior to the start of each phase,
6 DWR will update the Plan to calculate the amount of GHG emissions anticipated in the
7 covered phase, as well as emissions from prior phases (if applicable) and the projected
8 total net emissions of the project. The Plan will identify the specific GHG reduction
9 strategies that will be implemented to meet the net zero performance standard for the
10 covered phase and quantify the expected reductions that will be achieved by each
11 strategy. All emissions and reductions will be quantified in accordance with the
12 requirements outlined in Section A.1.

13 DWR will retain a qualified professional firm where the supervising staff has at least 10
14 years of experience performing air quality and GHG analysis to assist with its review and
15 approval of the Plan. Subsequent amendments to the Plan will identify reductions that
16 have been achieved during prior phases and determine if those reductions exceed
17 emissions generated by the project. If the GHG reduction strategies implemented by
18 DWR result in a surplus of reductions above the net zero performance standard, the
19 balance of those reductions may be credited to subsequent phases.

20 The final phase of the Plan must address operational emissions following construction,
21 accounting for regulations adopted at that time that will reduce project emissions.
22 Specifically, DWR will confirm statewide emissions from electricity transmission will
23 achieve carbon neutrality no later than December 31, 2045, pursuant to SB 100 and the
24 SF₆ Switchgear Regulation (or subsequent regulations). If GHG emissions from displaced
25 purchases of CVP electricity are expected to persist beyond 2045, DWR will calculate the
26 amount of GHG emissions anticipated until the industry achieves carbon neutrality. The
27 final Plan will identify GHG reduction strategies that will be implemented by DWR to
28 meet the net zero performance standard for these emissions.

29 2) *Timing and Execution:* DWR will prepare the Plan (or first phase of the Plan) prior to
30 issuance of the first construction or grading permit for the project. If DWR elects to use a
31 phased approach, the first phase of the Plan must identify the expected future phases
32 and schedule for amending the Plan to cover future phases.

33 Environmental Commitments and selected on-site construction strategies will be
34 included in construction permits (as applicable) and contractor bid
35 packages/agreements. Selected off-site strategies will be completed or operational
36 before completion of the applicable phase. If GHG credits are pursued, DWR will enter
37 the necessary contract(s) to purchase credits prior to the start of each phase. All credits
38 must be retired before completion of the applicable phase.

39 3) *Reporting:* DWR will conduct annual reporting to verify and document that selected
40 strategies achieve sufficient emissions reductions to mitigate project emissions to net
41 zero. Each report should describe the GHG reduction strategies that were implemented
42 over the prior year, summarize past, current, and anticipated project phasing, document
43 compliance with Plan requirements, and identify corrective actions (if any) needed to
44 ensure the Plan achieves the net zero performance standard. If GHG credits have been

1 purchased to reduce emissions for the reporting year, the annual report must include
2 copies of the offset retirement verification.

3 DWR will retain a qualified professional firm where the supervising staff has at least 10
4 years of experience performing air quality and GHG analysis to assist with its review and
5 approval of the annual reports. Annual reports will be finalized and posted on DWR's
6 website by December 31 of the following year.

7 ***Mitigation Impacts***

8 *Compensatory Mitigation*

9 Construction of compensatory mitigation sites described in Appendix 3F would result in short-term
10 GHG emissions.

11 As described in Appendix 3F, actions undertaken for initial compensatory mitigation would restore
12 freshwater marsh along I-5 and wetland, open-water, and upland natural communities on Bouldin
13 Island. Compensatory mitigation would also convert existing agriculture land on Bouldin Island to
14 wetlands, riparian habitat, ponds, and grassland. For the I-5 ponds, it is proposed that the existing
15 grasslands, riparian habitat, wetlands, and ponds would be replaced by improved grassland,
16 wetland, riparian, and open-water habitat. The types of construction activities and equipment
17 needed for habitat restoration are similar to what would be required for construction of the project,
18 although they would be of substantially lesser magnitude. Table 23-75 summarizes emissions that
19 would be generated by construction equipment utilized for initial compensatory mitigation
20 restoration activities, which are expected to occur during the first 3 years of construction. The
21 emissions estimates include implementation of quantifiable air quality environmental
22 commitments, as discussed under Impact AQ-1.

23 **Table 23-75. GHG Emissions from Construction of Initial Compensatory Mitigation Sites (metric**
24 **tons CO₂e)**

Year	I-5 Ponds	Bouldin Island	Total
CY 1	1,533	288	1,821
CY 2	1,725	322	2,048
CY 3	14	0	14
Total ^a	3,273	610	3,883

25 CO₂e = carbon dioxide equivalent; CY = construction year; I- = Interstate.

26 ^a Values may not add due to rounding.

27
28 As shown in Table 23-75, annual emissions from construction of the initial compensatory mitigation
29 sites would exceed the analysis threshold of net zero emissions. Additional channel margin and tidal
30 habitat may be created within the North Delta Arc as part of the CMP that could increase
31 construction emissions, although the specific design criteria required to support emissions
32 quantification are not yet developed. This would be a significant impact. Mitigation Measure AQ-9
33 would mitigate emissions from construction to net zero through the development and
34 implementation of a GHG mitigation program. This measure ensures emissions from construction of
35 the compensation mitigation restoration sites would not result in a significant GHG impact. Therefore,
36 the project alternatives combined with compensatory mitigation would not change the overall
37 impact conclusion of less than significant with mitigation.



ANGELES LINK PHASE 1

WORKFORCE PLANNING & TRAINING EVALUATION

DRAFT – JULY 2024

SoCalGas commissioned this analysis from Burns & McDonnell. The analysis was conducted, and this report was prepared, collaboratively.

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LIST OF ABBREVIATIONS AND ACRONYMS

<u>Abbreviation</u>	<u>Term/Phrase/Name</u>
AI	Artificial Intelligence
CBOSG	Community Based Organization Stakeholder Group
CCM	Control Center Modernization
CFR	Code of Federal Regulations
CPUC	California Public Utilities Commission
CIS	Close Interval Survey
CP	Cathodic Protection
DBE	Disadvantaged Business Enterprise
DOT	Department of Transportation
ESCMP	Environmental and Safety Compliance Management Program
GIS	Geographic Information Systems
H2Edge	Hydrogen Education for a Decarbonized Global Economy
HCA	High Consequence Area
I&C	Instrument and Control
ILI	In-line Inspection
ISN	ISNetwork
MAOP	Maximum Allowable Operating Pressure
MCAs	Moderate Consequence Areas
MEA	MEA Energy Association
MFL	Magnetic Flux Leakage
NCCER	National Center for Construction Education and Research

<u>Abbreviation</u>	<u>Term/Phrase/Name</u>
NFPA	National Fire Protection Association
O&M	Operations and Maintenance
OQ	Operator Qualification
PAG	Planning Advisory Group
PIR	Potential Impact Radius
PHMSA	Pipeline and Hazardous Materials Safety Administration
SAP	Systems Analysis Programming
SCADA	Supervisory Control and Data Acquisition Systems
SoCalGas	Southern California Gas Company
SSP	Standards, Specifications, and Procedures
TSA	Transportation Security Administration
TVC	Traceable, Verifiable, and Complete

EXECUTIVE SUMMARY

Southern California Gas Company (SoCalGas) is proposing to develop a clean renewable hydrogen pipeline system to facilitate transportation of clean renewable hydrogen from multiple regional third-party production sources and storage sites to various delivery points and end users in Central and Southern California, including in the Los Angeles Basin. The California Public Utilities Commission's (CPUC) Phase 1 Decision, approving the Memorandum Account for SoCalGas's proposed Angeles Link requires SoCalGas to evaluate workforce planning and training. SoCalGas has the ability to leverage its experience building and managing gas infrastructure for the planning and training of its workforce, with an emphasis on safety as a core value. As such, this study will evaluate applicable construction practices as it pertains to planning, designing, and constructing hydrogen infrastructure. Additionally, routine operations and maintenance protocols that will be executed by SoCalGas employees will drive the skills and training that may apply to operating and maintaining clean renewable hydrogen infrastructure. Furthermore, the development of hydrogen infrastructure could potentially impact the economies of Central and Southern California and would create incremental jobs within the regions. This evaluation was completed through literature review, employment impact analysis, and data from other Phase 1 Studies, including the *Pipeline Sizing and Design Criteria Study (Design Study)*.

The intention of this *Workforce Planning & Training Evaluation Study (Workforce Study)* is to provide recommendations for the creation of a workforce that is trained and qualified with appropriate skills to design, construct, operate, and safely maintain hydrogen infrastructure. This study looks at the following steps to transition the workforce for a hydrogen economy, with safety principles for the public, employees, contractors, and infrastructure as the foundation:

- 1) Identify and review federal and state design, construction, maintenance, inspection, and operational requirements for a clean renewable hydrogen system. This study looks at the skillsets, education, and training that will be necessary to comply with those regulations (as well as any emerging regulations) and provide a basis for establishing training programs and workforce planning. As part of this review, the number of workers required both for the construction of Angeles Link and to support routine operation and maintenance activities will be estimated and will inform the appropriate time needed to structure applicable training and accommodate the growing demand for hydrogen jobs.
- 2) Compare skillsets of the existing SoCalGas workforce to properly plan to address any potential changes and/or enhancements needed to support the safe construction, operation, inspection, and ongoing maintenance of Angeles Link. Identifying workforce tools for hydrogen assets, as well as compliance with regulatory requirements, such as Title 49 Code of Federal Regulations (49 CFR) Part 192: Transportation of Natural and Other Gas by Pipeline, and best practices that drive the pipeline operator qualifications are also significant considerations which will result in designing the necessary training for operations personnel.

In response to stakeholder feedback A *Southern California Gas Company Employment Impact Analysis* report (Employment Impact Analysis) was conducted to determine estimates for potential job creation during construction and operations. This content is briefly discussed in

Section 2.0 and the complete analysis is provided in Appendix A. The analysis does not specifically identify union jobs however, approximately 88% of the current SoCalGas Gas Transmission organization is union represented.

Key Findings

- **Existing Framework Can Inform Workforce Planning and Training.** Workforce planning and training for Angeles Link infrastructure can utilize SoCalGas’s existing workforce planning programs, models, and philosophies in place for the natural gas infrastructure as a baseline for development. SoCalGas’s existing workforce planning programs align with the vision of a successful workforce transition in support of the hydrogen economy as stated in the *Workforce Required to Advance Canada’s Hydrogen Economy*, which noted that “the technical skills and knowledge required by the hydrogen economy can be found within the existing labor market. There are enough similarities to enable workers to acquire hydrogen skills and knowledge through accelerated training programs such as micro-credential programming, bootcamps, and work-integrated learning.”¹
- **Safety Experience Can Be Leveraged in Planning for Angeles Link.** SoCalGas’s longstanding experience in operating and maintaining a safe and reliable natural gas pipeline system can be leveraged to optimize both planning considerations and implementation of appropriate mitigations. This study evaluates potential concerns and identifies mitigations, in Table 1 of Section 3.0, Planning Considerations below, associated with workforce planning for the construction and O&M of new infrastructure like Angeles Link.
- **Positive Employment Impacts.** An Employment Impact Analysis – included in Appendix A – was conducted to estimate the number of jobs that could be potentially created for Angeles Link.

Construction Job Findings

- In total, there could be almost 53,000 direct construction-related jobs generated by Angeles Link.
- The total employment impact could increase to almost 75,000 jobs when indirect and induced impacts are included.

Operations & Maintenance Job Findings

- In total, there could be approximately 100 direct annual operations-related jobs.
- The total employment impact could increase to almost 400 annual jobs when indirect and induced impacts are included.

¹ Hufnagel-Smith, Pat. (2022). Assessing the Workforce Required to Advance Canada’s Hydrogen Economy. Transition Accelerator Reports Vol. 4, Issue 4, Pg. 1-45. ISSN 2562-6264.

- **Construction Resources Are Likely Available and Accessible.** Based on past experience, many of the field personnel with these transferrable skill sets could be from labor unions. Multiple trade unions, including pipe trades representatives, carpenters, operating engineers, laborers, and electrical workers that could support construction of the pipeline and/or compressor stations, will be essential to the contracted workforce needed for Angeles Link.
- **Operations & Maintenance Resources Are Likely Available and Accessible.** The workforce for Angeles Link includes field personnel that are union represented SoCalGas employees responsible for operating and maintaining hydrogen infrastructure along with engineering, technical, and operations and maintenance management personnel. Job classifications for these personnel are expected to be similar to SoCalGas’s current workforce as supported in the published *European Hydrogen Skills Strategy* that states, “workers from declining or transitioning sectors, especially from the oil and gas industry, have been identified as a key target group due to their highly convertible skills to working hydrogen.”² Furthermore, the workforce for operations and maintenance (O&M) includes field personnel who will comply with federal and state standards, specifications, and procedures, such as 49 CFR Part §192.605 and contained in an O&M Manual.
- **Existing Workforce Can Be Leveraged for Operation & Maintenance Activities.** The existing SoCalGas natural gas workforce is experienced and trained to conduct the required tasks to operate and maintain pipeline infrastructure. These existing SoCalGas personnel can successfully transition to these O&M tasks with additional training to hydrogen specific equipment and procedures. Examples include:
 - SoCalGas’s current personnel utilized for leak survey on the natural gas infrastructure are trained per the existing SoCalGas O&M manual and Operator Qualifications requirements and have the required skillsets necessary to conduct leak surveys and operate leak detection equipment. This allows for a streamlined transition to hydrogen pipeline leak survey tasks and associated training for use of hydrogen leak detection equipment. Leak surveys follow the requirements in 49 CFR Part §192.706.
 - SoCalGas has a robust Integrity Management Program (IMP) in place for its natural gas infrastructure, which can be adapted for Angeles Link and incorporate existing and future regulations applicable to Angeles Link. In-line inspection (ILI) tools such as the magnetic flux leakage (MFL) designed for natural gas pipelines are being tested for use with hydrogen pipelines, with modifications made to address the unique characteristics of hydrogen. The Angeles Link infrastructure will include inline inspection (ILI) capabilities, which will allow for periodic

²ERASMUS+ Project, European Hydrogen Skills Strategy, <https://greenskillsforhydrogen.eu/public-deliverables/eu-hydrogen-skills-strategy/>

assessments of moderate and high consequence areas using smart tools capable of inspecting pipelines transporting hydrogen.

- **Technology Impacts.** Angeles Link may require certain SoCalGas’s existing systems to be modified. The necessary technological advances appear to be feasible. However, the changes can also have an impact on the workforce. This study examined potential impacts to Close Interval Survey (CIS), Asset Management and Work Management Information Systems, and SCADA, and found that these systems and tools may need to be upgraded or modified further. The technological advances for these systems and practices can be a dynamic process as the potential need for monitoring and tracking real-time data for hydrogen pipelines grows. Furthermore, the workforce that manages or conducts the tasks to monitor, collect, and analyze the data may need to be organized and coordinated specifically for hydrogen infrastructure.
- **Existing Procedures & Training Can Be Leveraged for Angeles Link.** SoCalGas’s existing procedures and training for natural gas infrastructure can be applied to hydrogen infrastructure, with modifications where necessary to account for differences in properties between the two gases.

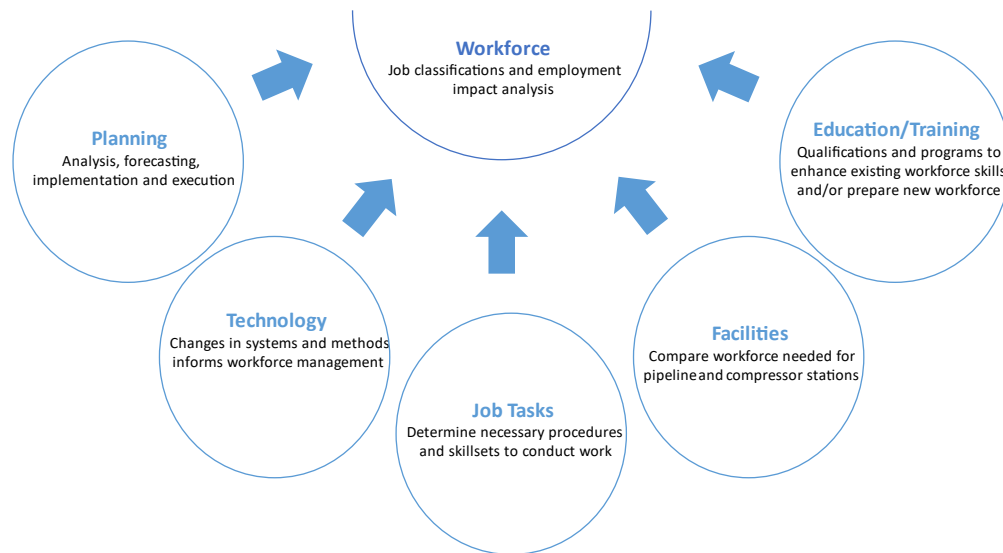
Stakeholder Input Summary

The input and feedback from stakeholders including the Planning Advisory Group (PAG) and Community Based Organization Stakeholder Group (CBOSG) has been informative to the development of this draft Workforce Study. As further detailed in Section 8.0 below, in response to stakeholder comments received thus far, an employment impact analysis was conducted to estimate the number of potential jobs that could be created by Angeles Link. The analysis is explained further in Section 2.0 and Appendix A, respectively.

1. INTRODUCTION

The Phase 1 Decision (OP 6 (e)) requires SoCalGas to evaluate workforce planning and training. This study evaluates construction practices and operations and maintenance protocols as it can be applied to a clean renewable hydrogen system that consists primarily of transmission pipeline and compressor stations. As illustrated in Figure 1 below, the Workforce Study evaluates and provides recommendations for the creation of a workforce trained and qualified with appropriate skills to construct, operate, and maintain hydrogen infrastructure. The workforce considerations in planning for an infrastructure project will guide the steps in preparing, implementing, and executing the resources needed to support Angeles Link. These steps include assessing technologies, work activities, and facilities that will inform the capabilities and skillsets necessary to identify appropriate education and training to develop the workforce. Fundamentally, the final steps would consist of workforce resourcing by fulfilling the number of jobs needed to execute the project with a trained and well qualified workforce.

Figure 1: Workforce Approach



The workforce includes, but is not limited to, primarily contracted field workforce that would be responsible for constructing Angeles Link, including contracted personnel responsible for supervising, managing, and administering the construction workforce and the supporting engineering and technical staff. This study also provides insight into the roles and skills that will be applied by SoCalGas union represented employees to execute critical transmission and compression activities, and operational and maintenance tasks, including leak survey and integrity management practices. Furthermore, including an analysis of the employment and economic impacts of Angeles Link connects the number of potential jobs that will be needed for a workforce specific to Angeles Link. Workforce related to third-party hydrogen producers and end users, third-party storage providers, and SoCalGas distribution and customer service organizations were excluded from this study.

Workforce Planning (WP) is a standard process an organization uses to analyze its workforce and determine the steps it must take to support key business objectives. Defining and optimizing the workforce that can execute a safe clean renewable hydrogen transport system is a continuous process designed to align workforce needs with SoCalGas’s long term strategic goals. WP helps SoCalGas plan for the appropriate level and timing of workforce with the necessary skills to design, build, operate and maintain hydrogen infrastructure. There are eight key components to the WP process: Business Strategy Alignment, Workforce Analysis, Demand Forecasting, Supply Analysis, Gap Analysis, Action Planning, Implementation & Execution, and Monitoring and Evaluation.

- 1) **Business Strategy Alignment:** Aligning workforce planning with the company's strategic goals³ establishes that the workforce is prepared to meet the future demands of the business. SoCalGas will align its workforce to have the necessary skills to support the company's goal of developing and maintaining hydrogen infrastructure.
- 2) **Workforce Analysis:** Assessing the current workforce to understand existing skills, capabilities, and performance. SoCalGas needs to identify existing skills that can be leveraged to support the hydrogen infrastructure and determine if there are any skills gaps that need to be addressed. Preliminary assessments addressed in Sections 3.0 through 6.0 identify potential skillsets, safety protocols, and capabilities that can be leveraged from the existing workforce and may apply to construction, operating, and maintaining hydrogen infrastructure.
- 3) **Demand Forecasting:** SoCalGas will need to forecast the roles and number of workforce needed for Angeles Link, based on the design and requirements of the hydrogen infrastructure. Experiences with natural gas infrastructure can be leveraged to develop a forecast. Preliminary forecasts and modeling were conducted in Section 2.0 Employment Impact Analysis and 5.0 Comparison to Existing SoCalGas Facilities to address the potential need.
- 4) **Supply Analysis:** Assessing internal talent pipelines and understanding external labor market conditions. SoCalGas must determine if existing workforce can transition into new hydrogen roles, or whether collaboration with external partners is needed to develop a talent pipeline. Analysis will be conducted upon further refinement of project plans in subsequent phases.
- 5) **Gap Analysis:** Identifying the gaps between the current workforce levels and skills against future needs. Section 3.0 Planning Considerations and Section 5.0 Comparison to Existing SoCalGas Facilities identifies potential gaps between current workforce and future needs.
- 6) **Action Planning:** Developing strategies to address identified gaps, such as talent acquisition, and training required. New training, safety protocols, and operating procedures may need to be developed specifically for the hydrogen infrastructure as suggested in Section 3.2 Education, Operator Qualifications, and Training.
- 7) **Implementation and Execution:** Implementation involves detailed planning, assigning responsibilities, and ensuring workforce is allocated appropriately. This can also include integration of any new training, technology, safety protocols and operating procedures. Implementation would be conducted upon further refinement of project plans in subsequent phases.

³ SoCalGas's mission is to build the cleanest, safest, most innovative energy infrastructure company in America. In alignment with this mission and California's decarbonization goals, SoCalGas aims to achieve net-zero greenhouse gas (GHG) emissions for scopes 1, 2, 3 by 2045.

- 8) Monitoring and Evaluation:** The workforce plan should be continuously monitored to assess effectiveness and make necessary adjustments.

As the hydrogen economy continues to expand, the specific skills and necessary education and training for the workforce needs to be assessed. A broad range of job positions will be needed to plan and execute Angeles Link. The Queensland Government states, “Key skills for the hydrogen industry will also include project management, design, and workplace safety.... A strong foundational knowledge of safety requirements will be essential. Workers with existing skills will need to be upskilled to become familiar with the properties of hydrogen.”⁴ The regulations and codes/standards establishes the pipeline operator qualifications and the necessary training. See the *Plan for Applicable Safety Requirements (Safety Study)* for a list of the applicable regulations, codes, standards, and best practices to consider to safely design, construct, operate and maintain Angeles Link. In turn, those job positions that will be required to carry out these tasks, whether in the field or in the office, will need to be quantified to determine workers needed to construct Angeles Link, as well as operate and maintain it.

The transmission of clean renewable hydrogen across the value chain must prioritize safety and leverage applicable industry experience, best practices, regulations, codes, and standards. There are a number of rules and regulations for natural gas transportation in pipelines that are applicable or can be used to draw parallels to pipelines for clean renewable hydrogen. Specifically, 49 CFR Part 192, *Code of Federal Regulations: Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards*, Subparts A through P, and the CPUC General Order No. 112-F, *State of California Rules Governing Design, Construction, Testing, Operation, and Maintenance of Gas Gathering, Transmission, and Distribution Piping Systems*, provide a foundation for establishing the tasks needed to meet the requirements for pipeline safety and the associated training programs, which can be utilized for workforce planning and the specific skillsets and training required by the workforce. These subparts contain requirements for procedures including materials, design, construction, welding, corrosion, testing, operations and maintenance, qualification of pipeline personnel, and integrity management. Industry best practices for developing procedures to meet the requirements set out by the Pipeline and Hazardous Materials Safety Administration (PHMSA) and the CPUC can include the following items:

1. Code specific language.
2. Discussion of the requirements of the procedures associated with design, construction, testing, operation, and maintenance.
3. Methodology of “How To” execute the procedure.
4. Records required and retention time for those records.

Title 49 CFR Part §192.605 contains the following pipeline operation requirements:

§192.605 Procedural manual for operations, maintenance, and emergencies.

⁴ Queensland Government “Hydrogen Industry Workforce Development Roadmap 2022-2032”, <https://www.publications.qld.gov.au/dataset/hydrogen-industry-workforce-development-roadmap-2022-2032>

(a) General. Each operator shall prepare and follow for each pipeline a manual of written procedures for conducting operations and maintenance activities and for emergency response. For transmission lines, the manual must also include procedures for handling abnormal operations. This manual must be reviewed and updated by the operator at intervals not exceeding 15 months, but at least once each calendar year. This manual must be prepared before operations of a pipeline system commence.

(b) Maintenance and normal operations. The manual required by paragraph (a) of this section must include procedures for the following, if applicable, to provide safety during maintenance and operations.

(c) Abnormal operation. For transmission lines, the manual required by paragraph (a) of this section must include procedures for the following to provide safety when operating design limits have been exceeded.

Workforce training is an integral part of workforce planning. Through review of the current Standards, Specifications, and Procedures (SSPs) per the *Safety Study*, and the current training programs for SoCalGas's natural gas pipeline system, there is already a basis for training that would be applicable to Angeles Link construction and operations. Modifications/revisions and new developments to the SoCalGas SSPs to account for differences between hydrogen and natural gas would enable SoCalGas to further develop additional training for a new workforce as well as enhance existing training for current employees for Angeles Link with safety at the forefront. Furthermore, Deloitte's analysis of hydrogen jobs suggests that the emerging hydrogen economy will likely offer the core natural gas workforce many opportunities to transfer into new roles across decarbonization strategies.⁵

This study focuses on the considerations for what action needs to take place to supply the existing workforce and emerging workforce with the hydrogen skills and training necessary to adapt to the energy transition so that all levels of occupation have an opportunity for a fulfilling career in the hydrogen industry.

2. EMPLOYMENT IMPACT ANALYSIS

An analysis was conducted to estimate the potential economic and employment impact of Angeles Link. For the purposes of this analysis, Angeles Link is assumed to be located in Central and Southern California, specifically in Los Angeles⁶, Kern, Kings, and Fresno counties and the cost estimate applied in this analysis is based on Scenario 7 as described in the cost estimate section in the Design Study. Increases to route mileage and changes in location may result in an increase to workforce estimates. For purposes of a conservative analysis, the Scenario 7 (the shortest of the Preferred Routes identified in the Routing Study – Preferred Route A) was utilized for the Employment Impact

⁵ Deloitte, "The natural gas utility workforce in a decarbonizing world", <https://www2.deloitte.com/content/dam/Deloitte/us/Documents/energy-resources/us-the-natural-gas-utility-workforce-in-a-decarbonizing-world.pdf>

⁶ Los Angeles County estimation includes pipeline mileage within Orange and Ventura counties.

Analysis. Scenario 7 assumes 390 miles of pipeline installed and two compressor stations constructed.

This analysis identifies the potential direct, indirect, and induced⁷ economic and employment impacts for the four-county area in total and disaggregated by county. A *Southern California Gas Company Employment Impact Analysis* report (Employment Impact Analysis) is provided in Appendix A. Results were derived from an economic impact model developed using IMPLAN economic multiplier data and methodology. IMPLAN⁸ is a widely-accepted and utilized software input-output modeling program that performs economic impact analysis for planning purposes. IMPLAN models the way a dollar injected into one sector is spent and re-spent in other sectors of the economy, generating waves of economic activity. The model uses national industry data and county-level economic data to generate a series of multipliers, which in turn estimates the total economic implications of economic activity.

The following economic and employment factors were estimated in this analysis:

- Direct output and employment impacts associated with the direct construction, operation, and maintenance of the Project
- Direct, indirect and induced impacts to the regional economic output, regional employment and regional employee compensation
- Disadvantaged Business Enterprise (DBE) participation, based upon SoCalGas's stated policy and experience⁹
- Tax revenues during construction and operation, including:
 - Property taxes
 - Payroll taxes (California only)
 - Sales/Use tax

2.1. Construction Job Findings

- In total there could be almost 53,000 direct construction related jobs generated by Angeles Link.
- The total employment impact could increase to almost 75,000 jobs when indirect and induced impacts are included.

2.2. Operations & Maintenance Job Findings

- In total, there could be approximately 100 direct annual operations-related jobs.
- The total employment impact could increase to almost 400 annual jobs when indirect and induced impacts are included.

⁷ Induced impacts include the value of goods and services purchased throughout the regional economy -- goods and services not directly associated with Angeles Link, but which would otherwise not be purchased without the activity generated by Angeles Link.

⁸ Economic input output modeling application; <https://implan.com/>

⁹ Supplier diversity: SoCalGas, A Sempra utility. (n.d.). <https://www.socalgas.com/for-your-business/supplier-diversity>

3. PLANNING CONSIDERATIONS

Important considerations must be made associated with workforce planning and training applicable to large-scale infrastructure projects such as Angeles Link. The application of technology in order to support safe operations, regulatory requirements, and optimized efficiency drives components of training, staffing, and organizational structure. Similarly, effective training, education, and the integration of technology to support processes is necessary to achieve safe and efficient operations.

As the project proceeds from design to construction to commissioning and operations, effective training would be continuously updated and reviewed. The existing considerations and potential mitigations associated with workforce planning and training applicable to Angeles Link are included in Table 1 below.

Table 1 – Considerations Associated with Workforce Planning and Training and Potential Mitigation

Considerations	Potential Mitigation
Skills Gap	<ul style="list-style-type: none"> • Identify skill requirements - Identify the specific skills and qualifications required for various roles involved in pipeline construction (such as welders, engineers, project managers, safety personnel, environmental specialists, etc.) and for SoCalGas employees in pipeline operations (pipeline and compressor station). • Safety and regulatory compliance - Provide workforce with adequate training on safety protocols, environmental compliance, and regulatory requirements specific to hydrogen infrastructure. • Skill gap analysis - Conduct a skill gap analysis to identify any shortages in the required skill sets within the existing workforce. Determine whether additional training or recruitment is needed. • Consider operator qualifications for both natural gas and hydrogen systems.
Shortage of workers	<ul style="list-style-type: none"> • Determine workforce size - Estimate the number of workers required at different stages of the project, considering factors like construction phases, locations and routes, pipeline segments, compressor stations, and the complexity of the work. • Continuous monitoring and adaptation - Regularly monitor workforce performance, project progress, and any changes in project requirements. Adapt the workforce plan as needed as the project evolves.
Mechanical issues due to utilizing components familiar to natural gas systems, but not compatible with hydrogen	<ul style="list-style-type: none"> • Proper training given to the operations workforce to confirm appropriate material and component selection. Operator qualifications would help drive appropriate training and awareness to operations personnel. • Training programs - Develop training programs to enhance the skills of the existing workforce or prepare new hires for specific roles. Training should cover technical skills, safety protocols, and any unique aspects related to hydrogen infrastructure.

Considerations	Potential Mitigation
Coordination with workforces from 3 rd party hydrogen producers and storage facilities	<ul style="list-style-type: none"> • Establish communication channels with 3rd party hydrogen producers and storage facilities to understand their workforce capabilities and constraints. • Establish receipt points at hydrogen producers and storage facilities to be remotely monitored through SCADA.

Technical competency gained through training and previous work experience would continue to be reviewed as part of the risk and mitigation assessment. The optimal approach is to integrate existing SoCalGas natural gas personnel familiar and experienced with natural gas pipeline construction and operations/maintenance, particularly for high-pressure pipelines, to perform similar activities for new hydrogen infrastructure. As new construction and operations personnel are hired, they can be trained and integrated into either natural gas or hydrogen or rotate between both infrastructure systems.

3.1. Technology & Implementation

Levering technology and communications tools currently in use by SoCalGas within the existing natural gas pipeline infrastructure may be considered for use within the proposed Angeles Link infrastructure. Potential changes to these tools and methods must be thoroughly studied to develop a strategic approach to skill development and resource allocation. Methods of data collection, application of procedures, technology integration, the effects of technology on process, and electronic information management inform how a workforce could be organized and managed to maximize operational efficiencies. As technology continues to evolve, including recent developments in artificial intelligence (AI), to support hydrogen and other pipeline systems, systems supporting safety and system reliability will also continue to evolve.

The following examples of existing systems and methods may need to be evaluated for potential impacts to workforce tasks and organization are as follows:

1. Close Internal Survey (CIS)
2. Asset Management and Work Management Information Systems
3. Supervisory Control and Data Acquisition (SCADA) systems

3.1.1. Close Interval Survey (CIS)

Close interval survey (CIS) is an existing method used to assess the adequacy of cathodic protection (CP) or to identify locations where a current may be leaving the pipeline. Examples are Interruptions in the pipeline external coating which may cause corrosion, and for the purpose of quantifying voltage (IR) drops other than those across the structure electrolyte boundary, such as when performed as a current interrupted, depolarized, or native survey.

This method of direct assessment is expected to be utilized for Angeles Link, as external corrosion monitoring and mitigation would be similar for hydrogen pipelines as compared to natural gas pipelines. API 5L, *Specification for Line Pipe*, is expected to incorporate hydrogen pipe specifications, and therefore specific guidance on corrosion monitoring and mitigation will be determined and adjusted as needed.

CIS is used to supplement data obtained from traditional CP surveys where readings are taken at test stations on an annual schedule (not to exceed 15 months) per 49 CFR Part 192.465. CP survey technology is expanding to allow real-time data collection utilizing satellite and other forms of data transmission. The technology has already been proven for rectifier readings to reduce the required bi-monthly field reads (not to exceed 2.5 months between inspections), which can now be collected remotely in real-time for each of the rectifiers. The skills required to perform CIS and CP surveys include knowledge of calibrating and using the appropriate equipment, technical and engineering support to analyze data, and specifying mitigation procedures, including coating repair and possible pipe replacements. These skills are similar to those required for natural gas infrastructure, with the addition of hydrogen-specific safety training to account for any differences in physical and chemical properties.

3.1.2. Asset Management and Work Management Information Systems

Asset Management and Work Management Information Systems include information systems to plan, design, build, maintain, monitor, and decommission energy infrastructure assets. Applications including and not limited to GIS, Engineering design systems (e.g. AutoCAD), System Analysis Programming (SAP) for a variety of enterprise areas, and mobile work execution systems are important components and tools for existing natural gas infrastructure and potential future hydrogen system operations and integrity management. SAP incorporates information functionally through different internal applications such as SAP Plant Maintenance, used for maintenance and inspection, and SAP Construction Planning Design systems which are associated with planning and construction. Key aspects of asset management would include retention of traceable, verifiable, and complete (TVC) records of the new hydrogen system and use of a geospatial database. Digital Construction Management (DCM) tools are now available for use to collect TVC records as required by 49 CFR Part 192. The data collected by DCM tools can be efficiently downloaded to a GIS system along with pipeline routing locations. Personnel capable of managing the required data and the supporting tools will be an important resource in compliance and data management. As data for integrity management is collected in accordance with 49 CFR Part 192 Subpart O, GIS systems would become the primary repository for all hydrogen infrastructure data and material tracking. Technical advancements, such as AI, could be used with GIS to analyze the data for various processes, including maximum allowable operating pressure (MAOP) verification, assessment scheduling, and identifying rupture mitigation valves.

As much of the focus of the PHMSA's Mega Rule relates to TVC data and data integration, having an accurate and robust GIS can be essential to maintaining compliance and pipeline integrity. The existing SoCalGas GIS database is expected to incorporate the Angeles Link infrastructure data, with asset information incorporated in existing database(s) with minimal upgrades or modifications. Any ongoing support to maintain the Angeles Link system and data is expected to be covered through existing databases and processes, and any future modifications will be determined as Angeles Link progresses.

3.1.3. SCADA

SCADA is the primary system to monitor and control a high-pressure pipeline. Inclusion of Angeles Link infrastructure to SoCalGas's existing natural gas infrastructure will add a significant amount of

field data points, necessitating a review of the capacity of SoCalGas's existing SCADA system. Angeles Link could result in expanding the system into more remote locations. As a result, communications paths for SCADA would need to be evaluated to support reliable network connections.

Independent of Angeles Link, SoCalGas is in the process of implementing the Control Center Modernization (CCM) program, which will further digitalize the existing natural gas transmission and distribution pipeline system. CCM will implement industry leading technologies in field sensors, advanced analytics, visualization, reporting, and operations technology network communication that will enhance real-time monitoring and control of SoCalGas's pipeline infrastructure, providing a platform for future clean energy projects. These upgrades to SoCalGas's control center operations will be considered in evaluating SCADA system needs for hydrogen-related projects. Natural gas control room personnel possess skills and experience that can be valuable for collaborating with hydrogen gas control personnel, and existing training and processes on the current SCADA system can be leveraged for hydrogen infrastructure (e.g., OQ and control room management procedures). As contemplated, the Angeles Link infrastructure will contain new transmission pipeline, and thus the use of Rupture Mitigation Valves will likely be required. The SCADA system would be appropriately designed to allow for optimized rupture detection, and SCADA specialists will be leveraged to confirm SCADA system requirements can fully support future clean fuels (e.g., Angeles Link) infrastructure.

3.1.4. Future Technology Considerations

Additional considerations that are recommended to be included during the next phase of Angeles Link are:

1. Leveraging existing data management tools such as AVEVA PI. AVEVA PI focuses on data infrastructure for collection, storage, and analysis of data, and turning data into insights with enterprise-wide accessibility and integration.
2. The requirements of the Transportation Security Administration (TSA)/Homeland Security Guidelines for Critical Energy Infrastructure¹⁰, which may impact the design of any needed SCADA system upgrades/replacements as well as physical security requirements. SoCalGas's Corporate Security group has governance responsibility for oversight, conducting and coordinating any organization-wide security and/or investigative risk assessments.
3. The PHMSA Valve Rule¹¹ requirements that impact all new transmission pipeline infrastructure including hydrogen, necessitating the need for installing rupture mitigation valves.

¹⁰ 49 of the United States Code, Transportation Security Administration, section 114(s);

<https://www.dhs.gov/publication/2023-biennial-national-strategy-transportation-security>

¹¹ Pipeline Safety: Amendments to Parts 192 and 195 to Require Valve Installation and Minimum Rupture Detection Standards, <https://www.reginfo.gov/public/do/eAgendaViewRule?pubId=202204&RIN=2137-AF06>

3.2. Education, Operator Qualifications, and Training

The regulations and codes that will provide a basis for establishing hydrogen training programs and workforce planning should be incorporated into SoCalGas's existing employee development programs and will be key in addressing potential knowledge gaps associated with hydrogen operations. SoCalGas employee development programs employ a variety of learning and development approaches, including classroom, online, and other specific training for necessary job skills. Furthermore, employees receive learning tools and programs for both technical and soft skills, encompassing compliance, job-specific, leadership, and soft-skills training curricula. Integrating technical expertise with essential soft skills is vital for fostering well-rounded talent. By combining these two facets, employees can thrive in a dynamic work environment, adapt to challenges, and contribute effectively to their teams and organizations. Training topics include the understanding of and compliance with labor and employment laws, business policies, and safety practices and procedures as well as leadership development. Technical training includes coursework designed for all union represented job classifications including for Gas Transmission as well. The learning and development programs support SoCalGas's goals of maintaining high levels of performance in safety, job-specific technical skills, leadership excellence, customer satisfaction, operational excellence, and cost management.

Training and OQ are intricately linked. Training operations personnel is generally unique to a pipeline operator and is focused on how personnel are expected to perform specific operations or maintenance tasks on the pipeline equipment according to a set of written procedures. OQs, however, are specified in 49 CFR Part 192 Subpart N and are required for all covered tasks, which are identified by the operator. SoCalGas will determine if field personnel can carry OQs for both natural gas pipeline O&M and Angeles Link hydrogen pipeline O&M, or if they must be carried by separate personnel.

Angeles Link personnel training can be accomplished by closely following the required O&M Manual, per 49 CFR Part §192.605(a). Some of standard industry procedures contain the following four basic parts:

- Code specific reference.
- Generic description of the work to be performed in compliance with code.
- "How to" section which describes how the work is to be performed, e.g., how to perform valve maintenance.
- Records required and retention time for the records.

49 CFR Part §192.605(a) specifies that the O&M Manual must be reviewed and updated (if required) with effective dates tracked at intervals not exceeding 15 months, but at least once each calendar year. This timeframe will allow for refresher training on specific training and procedures associated with maintaining hydrogen (e.g. Angeles Link) infrastructure.

OQ is specific to covered tasks on a pipeline system. 49 CFR Part 192 Subpart N contains scope, definitions, qualification program, record keeping, and general sections. As SoCalGas reviews the OQ program to determine covered tasks required for Angeles Link, a third-party contractor specializing in OQ programs may be consulted.

3.2.1. Personnel Training

The continued safe construction, maintenance, integrity management, and replacement of SoCalGas's pipeline system is executed by operations employees who receive training from the Gas Operations Training and Development department. Gas Operations Training and Development provides Field Technical Skills Training. The Operations Field Technical Skills Training team provides Gas Transmission, Gas Distribution, and Storage with the training and services described below. These trainings and services are necessary to enable SoCalGas to follow applicable laws, regulations, and standards, as well as to help maintain the safety of the workforce and the public.

- Centralized and /or decentralized technical skills training is provided to employees who are new to their jobs, require refresher training, have been promoted to positions requiring additional technical skills, receive new equipment or technology, or are being introduced to changes in regulations.
- Compliance-driven qualifications and certifications are conducted for employees who perform such activities as operating cranes, welding on steel pipes, or conducting plastic fusion joints.
- Instructional design services include updating existing training modules and developing new modules, as needed, in response to changes in gas standards, regulations, technology, or equipment. The Field Technical Skills Training team also explores new innovations for training, such as online training and multi-media training aids.
- Field Training Instructors conduct on-the-job training as an integral part of an employee's training experience.

Operations personnel for Angeles Link would benefit from the Gas Operations Training and Development department by receiving the required training to perform the tasks they are assigned and the advanced skills necessary to operate and maintain hydrogen infrastructure. Personnel, such as compressor station operators, would need to complete training on the hydrogen compressor equipment start-up, shutdown, and maintenance. Similarly pipeline operators would need to complete training on valve maintenance, pipeline patrolling, and other tasks. The need to maintain a trained and well qualified workforce is essential to support the safety and reliability of pipeline infrastructure.

3.2.2. Operator Qualifications

An integral component of overall workforce proficiency is the OQ program, which is essentially the management and process for the qualification of pipeline personnel as mandated by Title 49 of the CFR Section 192, Subpart N and G.O. 112-F. For new hydrogen infrastructure, SoCalGas would be required to follow 49 CFR Part 192 Subpart N, *Qualification of Pipeline Personnel*, which includes defining an abnormal operating condition. Qualification of pipeline personnel would apply to all operating infrastructure including Control Room Management and Emergency Response.

Evaluation of operator personnel includes written examination, oral examination, work performance history review, and observation during performance on the job, on the job training, and/or simulations. Once personnel have been evaluated, the trained (qualified) personnel have

the skills necessary to perform the assigned covered tasks and recognize and react to potential abnormal operating conditions.

There are potential benefits regarding OQs for hydrogen infrastructure that may include a single qualification for some OQ tasks. Operator qualifications for both natural gas infrastructure and hydrogen infrastructure may provide efficiency between the two types in areas like corrosion control and pipeline patrolling where natural gas and hydrogen infrastructure are located in close proximity.

3.2.3. Accredited Training and OQ Companies

The following accredited training and OQ third party companies could potentially assist SoCalGas with enhancing the effectiveness of workforce training. These vendors provide support to pipeline operators in developing and maintaining an OQ plan and provide OQ training per the requirements of 49 CFR Part 192 Subpart N:

- **National Center for Construction Education and Research (NCCER) (NCCER, n.d.)**
NCCER is a non-profit education foundation established in 1996 that provides various credential and certification training. After the Operator Qualification rule was adopted into Subpart N of 49 CFR Part 192, NCCER developed a pipeline training program as part of operators' OQ programs to help meet Pipeline and Hazardous Materials Safety Administration (PHMSA)'s standards. The OQ program incorporates self-paced, online covered task training and real-time, digital submission of performance evaluations conducted in the field. As an example, NCCER offers 154 covered task trainings and estimates more than 190 covered task training offerings as of the end of 2023.
- **MEA Energy Association (MEA Energy Association, n.d.)**
The MEA Energy Association (MEA) is a trade association founded over 115 years ago that provides online technical courses, safety assessments, evaluator training, and operator qualification compliance tools for field personnel in the energy distribution industry. Specifically, MEA's "EnergyU" system provides OQ training, testing, badges, and evaluations and they also offer information management services through ISNetworld (ISN).
- **Veriforce (Veriforce, n.d.)**
Veriforce was founded in 1993, and provides supply chain risk management solutions, including operator qualification platforms (e.g. software, documentation and reporting, audit support, evaluator authorization, and training content). Veriforce supports operators in identifying specific covered tasks, customizing OQ programs, and managing drug & alcohol compliance.
- **Energy Worldnet (Energy Worldnet, n.d.)**
Energy Worldnet was founded in 1994 with a focus on providing operational and safety training, including solutions and tools to manage and train various workforces. These include online training associated with OQ (e.g. DOT, ASME), safety (OSHA), pipeline inspection, etc., as well as solutions associated with pipeline safety management systems and contractor management.

3.2.4. Environmental and Safety Compliance Management Program

The SoCalGas operations standard for the Environmental and Safety Compliance Management Program (ESCMP) applies to all employees and provides the training and compliance framework that is fundamental to the employee's roles and responsibilities at SoCalGas. ESCMP would require revisions to include the requirements for transporting pure hydrogen gas as it would pertain to compliance, training, environmental & safety goals, and assessments of compliance.

Environmental and safety compliance will require SoCalGas to identify all applicable laws, rules, and regulations, as well any other potential requirements. The specific requirements for hydrogen infrastructure would be incorporated into ESCMP in order for employees to receive the necessary training and implement the appropriate compliance measures.

Compliance with all applicable laws, rules, and regulations, as well as the requirements of the internal policies, practices, and procedures (as published in the SoCalGas Environmental and Safety Standards) is the responsibility of all SoCalGas employees. SoCalGas leadership will regularly identify environmental and safety laws and regulations applicable to SoCalGas and, as needed, establish internal policies, practices, procedures, and guidance to foster ongoing training and compliance. Consistency with the appropriate environmental and safety standards is the responsibility of the owners of business unit operating standards.

Developing, identifying, scheduling, and reviewing the employee's respective environmental and safety training responsibilities are reviewed and confirmed by the directors, managers, and supervisors of each business unit. These individuals must confirm that the appropriate environmental and safety training complies with applicable regulations and internal procedures and are identified and completed as required, including documentation confirming completion of applicable training. The processes and programs are reviewed annually for appropriateness and compliance.

Self-assessments are performed to assess compliance at a facility or locale with the applicable regulatory environmental and safety requirements and internal company policies, identifying any inconsistencies and the appropriate corrective action(s). The ESCMP management review process includes distributing ESCMP communications, conducting annual ESCMP management reviews, compiling the findings, and developing recommendations and goals with executives, as well as verifying and certifying that compliance processes and activities reasonably promote compliance with safety and environmental laws and regulations and company policies and procedures.

SoCalGas's current Gas Safety Plan provides references to the existing safety programs, plans, and procedures in place for specified infrastructure or areas of company activity. Revisions to the Safety Plan Matrix for the natural gas infrastructure to include the Angeles Link hydrogen infrastructure would align with the results of the evaluation of SoCalGas's specifications, standards, and procedures (SSPs) from the Phase 1 Plan for Applicable Safety Requirements. This evaluation identified the current SoCalGas natural gas operations SSPs that should be considered for modification or new development for implementing hydrogen transmission and distribution infrastructure. As those SSPs are modified/developed, the Safety Plan Matrix would need to incorporate those as appropriate. Ultimately, identifying, assessing, and implementing changes

will be a continuous improvement process for ESCMP in order to fulfill the training and compliance needs of Angeles Link.

4. KEY IMPACTED OPERATOR TASKS

4.1. Leak Survey, Detection, Mitigation and Repair

Leak management is a critical component of system operations and maintenance for several reasons, including safety, environmental protection, resource conservation, and infrastructure integrity. Title 49 CFR Part 192 and GO 112-F contain requirements for the transportation via pipeline of natural gas and other gases, such as hydrogen. However, it is not currently known if or how these requirements may change in the future as hydrogen pipeline infrastructure may expand. Leak survey and leak detection methods may be modified by PHMSA and/or the CPUC as the pipeline industry gains more experience and collects operating data from hydrogen pipeline systems.

SoCalGas's existing processes, technology, reporting, compliance, and safety notifications related to leak survey and leak detection would require certain modification for hydrogen leak consequences, but the framework from the natural gas system can be used as a starting point. The areas that will be focused on are as follows:

1. Leak survey and identifying "Abnormal Operating Conditions" for hydrogen.
2. Leak detection – using the appropriate equipment for detection, including confirmation of equipment calibration.
3. Leak mitigation and repair – requiring engineering and technical support.

Hydrogen leak detection equipment is readily available from a variety of vendors, including detection equipment that can be calibrated to 100% hydrogen. Detection of hydrogen leaks from the hydrogen infrastructure can be accomplished utilizing leak detection equipment that is worn or carried by hydrogen pipeline operating personnel while performing routine operations and maintenance activities, including conducting leak surveys of pipelines with equipment, as well as when responding to identified abnormal operating conditions. In addition, fixed-mounted leak detection equipment located inside compressor station buildings and in areas containing above-ground hydrogen gas facilities can provide effective and continuous leak monitoring for hydrogen. Operators must identify Abnormal Operating Conditions on the hydrogen pipeline that may indicate a component malfunction or deviation from normal operations. Leak detection/gas detection in compressor stations is governed by §192.736, *Compressor stations: Gas detection*. Leak detection equipment vendors can also supply this hydrogen detection equipment for compressor stations. Angeles Link operations and maintenance teams would need specific training on the leak detection equipment selected for detecting hydrogen. Contractors would also need to be trained and supply their own leak detection equipment appropriate for hydrogen detection when working on hydrogen infrastructure. Further information regarding leak surveys, detection and mitigation can be found in the *Safety Study*.

4.2. Integrity Management

It is unlikely that major changes to overall integrity management requirements would be implemented for hydrogen gas infrastructure. The framework already in place for natural gas infrastructure provides a basis for evaluating the integrity of pipeline infrastructure and the associated risks. SoCalGas's existing integrity management programs have been implemented for over 20 years with oversight from its experienced and trained workforce to maintain safety and regulatory compliance. SoCalGas's current workforce is equipped to adjust integrity management programs to incorporate the differences in properties of hydrogen and other associated hydrogen infrastructure changes.

Additional considerations that may affect workforce planning and training for the Angeles Link infrastructure are related to integrity assessments (in-line inspection, direct assessment, etc.) for natural gas systems compared to hydrogen systems. There may be differences in conducting integrity assessments such as tool modifications for a hydrogen environment, which in turn lead to safety procedure updates and follow-on training and/or qualifications. Other considerations may include the parameters associated with risk assessments and data integration aspects of the integrity management program to account for the differences between the types of gases being transported.

4.3. Control Room Management

SoCalGas's control room management procedures may be applicable to hydrogen infrastructure with some modifications. The potential for additional SoCalGas control personnel, specific to the hydrogen system, separate from the existing natural gas system control personnel, is yet to be determined but will include the following control room management tasks.

Hydrogen system control room management:

- 24/7 system operations monitoring
- SCADA monitoring
- Potential rupture mitigation response
- Responding to emergency notifications

SoCalGas is constructing a new control center which may have designated responsibilities for the control of both natural gas and hydrogen systems. OQ for hydrogen gas control personnel may be different due to the physical and chemical properties of hydrogen. Separate control room management plans may be implemented for natural gas and hydrogen. An alternate approach to consider for staffing gas control and emergency response functions would be to rotate gas control personnel and emergency response personnel between natural gas and hydrogen infrastructure, thereby providing cross-training of personnel.

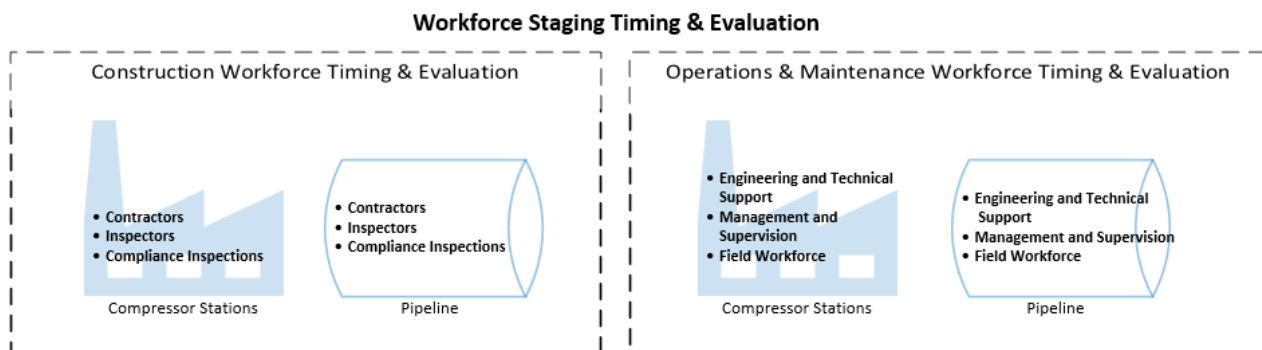
5. COMPARISON TO EXISTING SOCALGAS FACILITIES

The construction of the Angeles Link infrastructure will be similar to construction for natural gas infrastructure. The operations and maintenance of Angeles Link will also be similar to operations and maintenance of natural gas infrastructure. Therefore, when reviewing workforce staging for

Angeles Link, there is value in reviewing and comparing the workforce needs and requirements of natural gas assets that are similar in size and scale.

Workforce Staging consists of two major sections: 1) Workforce Staging for Construction and 2) Workforce Staging for Operations & Maintenance (O&M) of Angeles Link. Construction Workforce Staging is further divided into Compressor Station Construction and Pipeline Construction. Compressor station construction is uniquely different from pipeline construction, and each requires different skillsets to be utilized. Figure 2 below, illustrates the workforce staging for pipeline and compressor stations as it may apply to the construction phase and operations and maintenance. Workforce Staging for O&M of hydrogen infrastructure is similarly divided into Compressor Station O&M and Pipeline O&M. These are the workforce groups to be considered for SoCalGas operations personnel as the Angeles Link construction sites are completed and operating the infrastructure begins. The skillsets for operations and maintenance of the compressor station(s) and pipeline segments are expected to mirror title 49 CFR Part 192 regulatory compliance requirements. The SoCalGas Workforce Planning Subject Matter Experts (SMEs) can provide reviews of Workforce Staging as the Angeles Link project moves from design through construction, commissioning, and operation.

Figure 2 - Workforce Staging Timing & Evaluation



5.1. Construction Workforce

Construction workforce staging would be based on the number of pipeline construction spreads, compressor station construction sites, third-party hydrogen production, and third-party storage facilities and follow contractor-proposed workforce. As explained in Section 2.0 Employment Impact Analysis, one of the possible scenarios selected to conduct the employment impact analysis consisted of 390 miles of pipeline to be installed and two compressor stations to be constructed. The range of jobs required for the construction workforce staging at any point in the construction phase will vary. An example of the job titles/roles that may be required for construction of the Angeles Link infrastructure could include, but is not limited to the following:

Table 2 - Example Job Title/Roles

Job Title/Role
Manager/Superintendent
Safety/Quality Assurance/Inspector
Pipefitter
Carpenter
Welder
Operator/Driver
Mechanic
Electrician
Laborer

Note: The “Job Title/Role” includes senior, supervisor, and manager levels as well as helpers, foreman, etc.

5.2. Operations & Maintenance Workforce

SoCalGas’s processes and procedures for its existing natural gas facilities (per 49 CFR Part 192 Subparts A through P) were reviewed, and an analogous comparison was performed, which identified a workable framework or basis for the hydrogen facilities. This review was completed as part of the *Plan for Applicable Safety Requirements* study.

For purposes of this study, workforce requirements of an existing SoCalGas natural gas compressor station and pipeline segments will be used for comparison to the potential workforce requirements for Angeles Link. The following provides a comparison of existing natural gas infrastructure and how those may translate to the needs or requirements of hydrogen infrastructure.

5.2.1. SoCalGas Compressor Station Example

Typical compressor station operations positions include compressor operators, compressor maintenance personnel, instrument, and control (I&C) personnel, valve and regulator maintenance personnel, and engineering/technical support personnel. Depending on equipment, location, and setup, these facilities may be staffed continuously or remotely operated. On-site personnel perform different tasks inside the compressor stations and could draw upon skillsets already being utilized for the natural gas system.

Hydrogen compressor station operations are unique to the selected compressor OEM. Staging would be dependent on SoCalGas electing to operate locally/on-site or operate remotely, and thus it has not yet been determined whether hydrogen compression will be centrifugal or reciprocating.

Workforce requirements and sizing of the compressor facilities are assumed to be similar to existing facilities. The following table is a summary of the potential workforce that may be required for operation and maintenance of a compressor station for Angeles Link:

Table 3 - Example Compressor Station Job Title/Roles

Job Title/Role	Estimated Count
Station Technician	4 – 6
Station Maintenance	4 – 6
Station Operations	8 – 10
Instrumentation and Measurement	4 – 6
Technical Services*	1 – 2
Total	21 – 32

*Note: The “Job Title/Role” includes senior, supervisor, and manager levels as well as technicians and specialists. *Technical Services are not directly staffed at a station but provide consistent direct support to compressor operations.*

5.2.2. SoCalGas Pipeline Segment Example

Skillsets for hydrogen pipeline operations and maintenance are not expected to differ significantly from natural gas pipeline operations and maintenance as discussed below.

Considerations for the hydrogen pipeline segment impacting workforce staging include:

- Requirement for Rupture Mitigation Valves – To be installed on new transmission pipelines 6-inches and greater OD that are located in a High Consequence Areas (HCAs) or Class 3 or Class 4 location, or if located in a Class 1 or Class 2 location and have a potential impact radius (PIR) greater than 150 ft.
 - Operated during normal, abnormal, and emergency operating conditions.
 - Monitored for valves status, upstream pressure, and downstream pressure. Point-to-point verification between SCADA system displays and the installed valves, sensors, and communications equipment must be conducted.
 - Requires valve maintenance at least once each calendar year, not exceeding 15 months.
 - Testing and verifying internal communication plans and testing any backup SCADA will also follow annual intervals, not to exceed 15 months.
- Class Location, HCAs, and Moderate Consequence Areas (MCAs) can impact leak survey, patrolling, and integrity management for pipelines.
 - As class location increases, the number of leakage surveys per year increases.
 - As class location increases, the number of patrols per year increases.
 - If HCAs are identified, integrity management will be required, which is outlined in 49 CFR Part 192 Subpart O and includes assessments, risk and threat analysis, preventative and mitigation measures, etc. Section 4.2, *Integrity Management*, of this study contains potential changes related to hydrogen infrastructure.

The following table is a summary of the workforce that may be required for operation and maintenance of the pipeline infrastructure for Angeles Link using similar applicable natural gas

pipeline systems within an area of SoCalGas service territory averaging approximately 250 miles of pipeline:

Table 4 - Example O&M Job Title/Roles

Job Title/Role	Estimated Count
Field Operations/Technicians	8 - 12
Instrument, Measurement and Control	6 - 8
Cathodic Protection/Corrosion	1 - 2
Pipeline Integrity*	1 - 2
Technical Services*	1 - 3
Total	17 - 27

*Note: The "Job Title/Role" includes senior, supervisor, and manager levels as well as technicians and specialists. *These groups directly provide consistent support to pipeline operations.*

As discussed in the above examples, employment numbers for work at compressors stations and work for pipeline operations can be considered based on current workforce resourcing for existing SoCalGas assets. Variables such as the number of compressor stations, the mileage of pipeline, and location will ultimately influence estimates of operations-related jobs needed to operate and maintain Angeles Link. The *Employment Impact Report* in Appendix A considers Scenario 7 from the Design Study to arrive at a detailed estimate. This scenario evaluates 390 miles of pipelines and two compressor stations and results in an estimate of approximately 100 direct annual operations-related jobs that could be created to operate and maintain Angeles Link. Future comparisons may provide more information once refined pipeline routes and compressor station details are determined.

Angeles Link and the natural gas infrastructure would both be governed by 49 CFR Part 192 with the same regulatory requirements. Examples of these activities include valve maintenance, leak survey, and corrosion protection. Compressor station operations would include original equipment manufacturer (OEM) recommended O&M tasks and training provided by OEM manufacturers on the principles and operation of hydrogen gas compression. The applicable subparts of the regulatory code were reviewed for corrosion control, and operations and maintenance requirements per the following list in Table 5 (this is not an exhaustive list) and may be applicable to compressor stations and pipeline segments.

Table 5 - Pipeline and Compressor Station Requirements

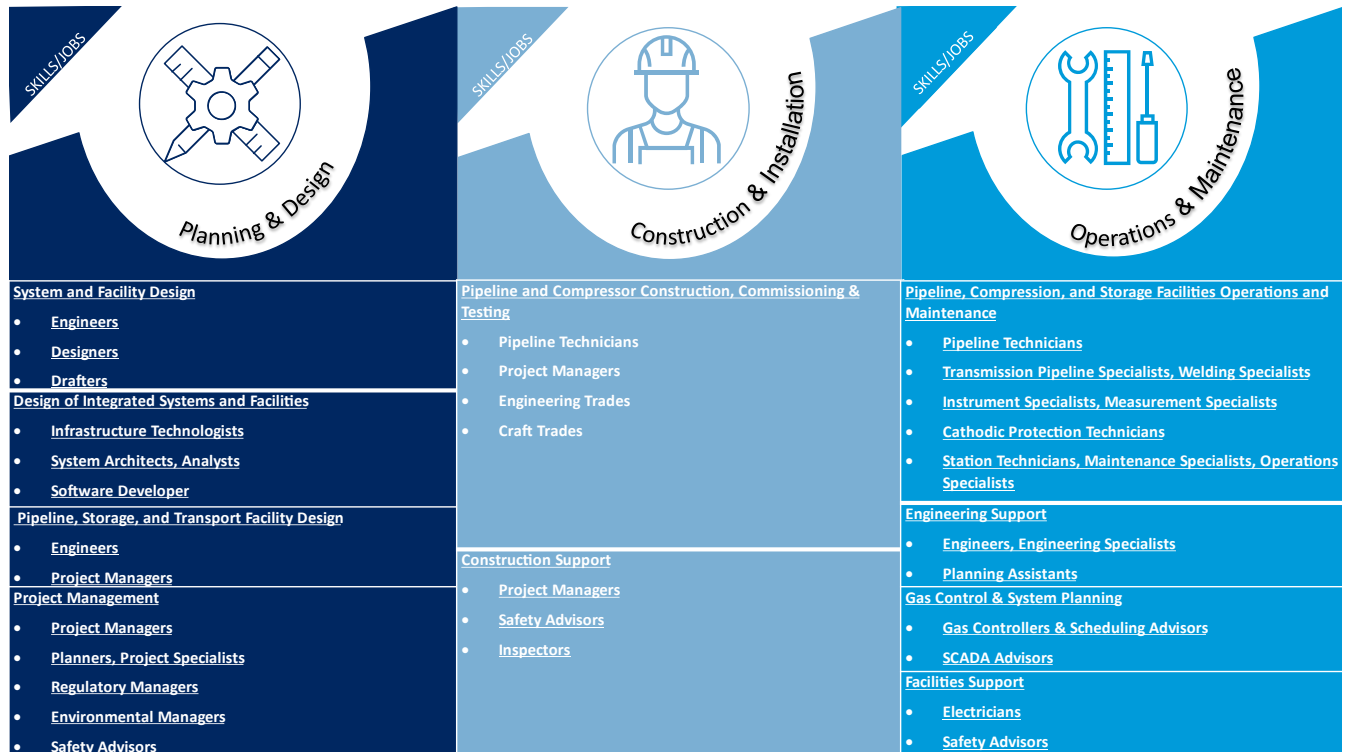
49 CFR Part 192 Code Section	Applicable to Natural Gas Infrastructure	Applicable to Angeles Link Hydrogen Infrastructure
Subpart I – Requirements for Corrosion Control		
§192.455 External corrosion control: Buried or submerged pipelines installed after July 31.1971	Yes	Yes
§192.461 External corrosion control: Protective coating	Yes	Yes
§192.463 External corrosion control: Cathodic protection	Yes	Yes
§192.465 External corrosion control: Monitoring and remediation	Yes	Yes
<i>Corrosion control requirements for natural gas infrastructure and Angeles Link may be similar</i>		
Subpart L – Operations		
§192.605 Procedure manual for operations, maintenance, and emergencies	Yes	Yes
§192.609 Change in class location: Required study	Yes	Yes
§192.613 Continuing surveillance	Yes	Yes
§192.614 Damage prevention program	Yes	Yes
§192.615 Emergency plans	Yes	Yes
§192.616 Public awareness	Yes	Yes
§192.631 Control room management	Yes	Yes
<i>Operating requirements for natural gas infrastructure and Angeles Link may be similar</i>		
Subpart M – Maintenance		
§192.705 Transmission lines: Patrolling	Yes	Yes
§192.706 Transmission lines: Leakage surveys	Yes	Yes
§192.707 Line markers for mains and transmission lines	Yes	Yes
§192.710 Transmission lines: Assessments outside of HCAs	Yes	Yes
§192.711 Transmission lines: General requirements for repair procedures	Yes	Yes
§192.731 Compressor stations: Inspection and testing of relief devices	Yes	Yes
§192.735 Compressor stations: Storage of combustible materials	Yes	Yes
§192.736 Compressor stations: Gas detection	Yes	Yes
<i>Maintenance requirements for natural gas infrastructure and Angeles Link may be similar</i>		

6. HUMAN RESOURCES

The workforce for Angeles Link infrastructure would include field personnel responsible for operating and maintaining hydrogen infrastructure, engineering and technical support for hydrogen infrastructure, and operations and maintenance management and supervision. SoCalGas’s natural gas pipeline systems were reviewed for potential workforce roles and requirements that could apply to Angeles Link. Figure 2 below is a listing that includes but is not

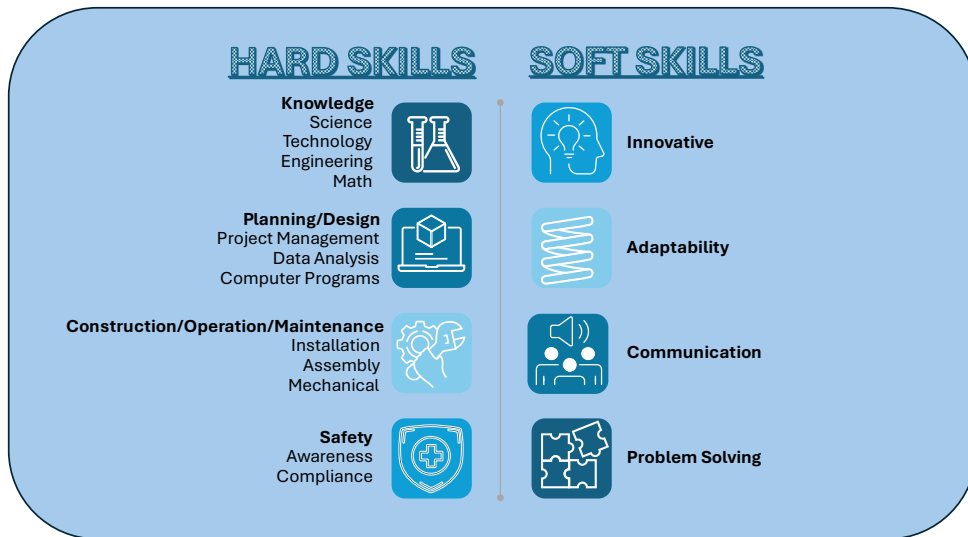
limited to the workforce roles that may be required for design, construction, and operation and maintenance of the pipeline infrastructure for Angeles Link.

Figure 2 - Applicable Workforce Roles



Understanding the tasks, responsibilities, and requirements associated with the roles, help in identifying the skills needed to perform the job effectively. There are many hard skills (technical skills) and soft skills (interpersonal and behavioral skills) that will be needed to support roles to construct, operate and maintain pipeline infrastructure. The figure below includes an example of skills that are transitional and beneficial for the workforce to support Angeles Link. Different roles emphasize different skills, and they may vary in the range of competency and ability needed.

Figure 3 - Applicable Workforce Skills



6.1. Job Classifications

SoCalGas develops training plans by job classification that include courses required to perform skilled work, meet company objectives, and satisfy required compliance training. SoCalGas prioritizes a framework to support employees to have skills and abilities to operate and maintain a safe and reliable system. As addressed by the ERASMUS+ Project, including Figure 4:

An analysis of the prevalent themes mentioned by industry experts when describing job roles and skill requirements in the hydrogen sector reveals 11 areas of knowledge. This underscores the diverse skills and knowledge necessary in the hydrogen sector, spanning from production and operation to safety, storage, and legal considerations. The occurrence of these themes in the occupational profiles identified is analyzed. Among the identified themes, “operation,” “maintenance,” and “hazards” can be classified as skills, while the other listed elements would rather belong to the “knowledge” category. This categorization highlights that the “knowledge” items encompass critical areas of understanding, whereas the “skills” items involve the ability to perform specific tasks effectively. The classification of “hazards” under skills is due to its practical implementation of safety protocols and practices to address risks.¹²

¹² ERASMUS+ Project, European Hydrogen Skills Strategy, <https://greenskillsforhydrogen.eu/public-deliverables/eu-hydrogen-skills-strategy/>

Figure 4 - ERASMUS+ Project Skills & Knowledge Required

SKILLS & KNOWLEDGE REQUIRED	OCCURRENCE	%
Production	103	11%
Hazards	87	10%
Systems	61	7%
Operation	57	6%
Maintenance	57	6%
Electrolysis	57	6%
Storage	55	6%
Fuel cell	55	6%
Transport	44	5%
Refueling	29	3%
Legal & permitting	23	3%

The themes Hazards, Systems, Operations, and Maintenance are representative of job roles and skill requirements of SoCalGas’s existing natural gas system for transmission and compressor stations as well as potential job roles and skill requirements for Angeles Link. Job classifications are expected to be similar for both the natural gas infrastructure and the hydrogen infrastructure, so the effort for SoCalGas to establish job classifications specific to Angeles Link could be based upon the existing job classifications. SoCalGas has the opportunity to separate the job classifications or provide opportunities for cross-training and OQ qualifications for the existing workforce where desired.

1. Potential for separate job classifications for the hydrogen system, such as:
 - i. Facility operations
 - ii. Facility maintenance
 - iii. Leak survey
 - iv. Valve maintenance
 - v. Emergency response
 - vi. Public liaison with emergency response agencies

SoCalGas will be able to leverage its existing operations and maintenance, technical/engineering and management/supervisory workforce to support and develop Angeles Link. Additionally, SoCalGas’s well-developed and proven control room management and OQ programs will provide an excellent foundation for corresponding Angeles Link workforce programs.

7. COMMUNITY ENGAGEMENT AND EMPLOYMENT

According to the National Association of State Energy Officials (NASEO), “The anticipated growth of the clean hydrogen industry in the United States provides states with an opportunity to bring good-paying jobs and economic development benefits to their communities, while reducing emissions in hard-to-abate sectors. The expansion of the clean hydrogen economy can also help states support a just transition by offering meaningful career pathways to workers in industries currently tied to fossil fuel production, transport, and use. Clean hydrogen jobs require many of the same skills needed for jobs in the fossil fuel and industrial sectors.”¹³ To develop clean renewable hydrogen knowledge and skills, the workforce needs access to quality and relevant education and training programs. Building a pipeline of skilled, adaptable workers for the hydrogen industry allows for those opportunities to pursue various job pathways depending on their skills, knowledge, interests, and goals. Knowledge sharing and providing those educational and training solutions in partnership with the communities, government, labor, and organizations is essential. As mentioned above in Section 3.2, Education, Qualifications, and Training, SoCalGas’s programmatic workforce training is targeted to create economic prosperity for the individuals and local communities within its service territory. These programs provide training and soft skills to enable adults, young adults, and veterans the opportunity to obtain meaningful and gainful employment.

SoCalGas’s ASPIRE 2045¹⁴ sustainability strategy sets forth SoCalGas’s aim to achieve net zero greenhouse gas emissions in the company’s operations and delivery of energy by 2045, and includes goals related to safety, diversity equity and inclusion (DE&I), and investment in underserved communities. This sustainability strategy supports SoCalGas’s priority for developing the energy workforce of the future to construct, install, and maintain hydrogen infrastructure. As evaluated through SoCalGas’s workforce development programs and procedures, SoCalGas’s workforce planning includes managing the recruitment and selection of a qualified and diverse workforce, while complying with legal requirements throughout the staffing process. Internal and external recruitment activities are conducted for all positions; SoCalGas partners with colleges, veteran and disability support groups, and local communities to source qualified and diverse candidates to fill job vacancies. Furthermore, these recruitment efforts will be focused on communities along the Angeles Link route. Approximately one-half of the SoCalGas workforce is union represented, with several unions governed by a Joint Steering Committee. SoCalGas continuously supports that union represented positions are appropriately leveled, paid fairly, and includes safeguards for compliance with federal and state labor laws.

This Workforce Study is a proactive evaluation, which allows for a preliminary assessment of existing relative skills through the planning of Angeles Link while allowing the evolution of the hydrogen industry to further refine new skillsets that may be needed. The education and training

¹³ NASEO, State Strategies to Develop and Support the Emerging Clean Hydrogen Workforce, https://mojo.naseo.org/data/sites/1/documents/publications/NASEO_Emerging%20Clean%20Hydrogen%20Workforce_FINAL.pdf

¹⁴ SoCalGas, ASPIRE 2045 https://www.socalgas.com/sites/default/files/2022-02/SoCalGas_Sustainability_Strategy_final.pdf

developed from these outcomes will in turn support preparation for the workforce for SoCalGas and the local communities it serves. SoCalGas has been actively supporting and promoting education and training programs to equip existing and new workers with the necessary skills to fulfill a wide range of jobs in the renewable hydrogen economy. SoCalGas has been collaborating and in some instances initiating the development and progression for education and training programs that will address industry specific needs and be tailored to building job pathways. Additionally, SoCalGas is locally supporting development of hydrogen certificate programs for the local community colleges as well as coordinating learning engagement activities for students, such as STEM events and supporting construction academies.

Furthermore, SoCalGas’s ASPIRE 2045 sustainability strategy includes a goal of achieving 45% spending with diverse businesses by 2025. The recently published SoCalGas Supplier Diversity Annual Report¹⁵ states that in 2023 SoCalGas spent approximately 44% of its total supply management purchases with diverse business enterprise (DBE) vendors, surpassing the CPUC’s goal for the 30th consecutive year and nearing SoCalGas’s 45% goal. SoCalGas’s 2023 Supplier Diversity Highlights are shown in Figure 5 below.

Figure 5 - SoCalGas 2023 Supplier Diversity Highlights



SoCalGas’s supplier diversity initiatives, such as hosting webinars, networking sessions, business boot camps, matchmaking and mentoring events further contribute to supporting diverse business enterprises. Investments in technical assistance and development programs continue with capacity building, mentoring, outreach, and alliances and allows opportunities for the local communities to be engaged and benefit from these programs.

¹⁵ SoCalGas Supplier Diversity Report 2023 Annual Report, https://www.socalgas.com/sites/default/files/2024-03/2023-24_SD_annual_report.pdf

8. STAKEHOLDER COMMENTS

The input and feedback from stakeholders including the Planning Advisory Group (PAG) and Community Based Organization Stakeholder Group (CBOSG) has been essential to the development of this draft Study. Some of the feedback that has been received related to this Study is summarized below. All feedback received is included, in its original form, in the quarterly reports submitted to the CPUC and published on SoCalGas's website.⁹

- **Comments made by: Communities for Better Environment and South Coast Air Quality Management District**
 - Stakeholders suggested inclusion of job estimates potentially created by Angeles Link.
 - Request to include references to worker safety concerns related to transporting 100% hydrogen by pipeline.

Summary of How Comments Were Addressed

- Employment Impact Analysis that estimates job creation associated with Angeles Link is provided in Appendix A.
- Employee safety is addressed throughout the study and is specifically evaluated in the *Plan for Applicable Safety Requirements Study (Safety Study)*

Throughout Phase 1 of Angeles Link, workshops, and quarterly meetings with the Community Based Organizations Stakeholder Group (CBOSG) and Planning Advisory Group (PAG) were conducted to provide feasibility study updates and solicit stakeholder feedback and involvement.

9. CONCLUSION

Angeles Link requires careful workforce planning and resourceful training to confirm the safety, efficiency, and success of the project. Workforce planning involves strategic management of human resources, and training is essential to equip personnel with the necessary skills and knowledge for the construction and operation of hydrogen system. A pure clean renewable hydrogen system can leverage many of the existing requirements of SoCalGas's natural gas system. In consideration of Angeles Link, SoCalGas's existing procedures and training for natural gas infrastructure can be applied to hydrogen infrastructure, with modifications where necessary to account for differences in properties between the two gases. Workforce planning and training for the Angeles Link infrastructure can therefore utilize the existing models and philosophies in place for the natural gas infrastructure as a baseline for development.

As proposed, Angeles Link has potential for significant impact to job creation during both construction and operation. The Employment Impact Analysis included in Appendix A concludes that Angeles Link could generate approximately 75,000 jobs when considering direct, indirect, and induced impacts. It is estimated that 53,000 direct construction-related jobs could be created (approximately 10,500 jobs per year during peak construction) while approximately 100 direct annual operations and maintenance-related jobs could be added as part of Angeles Link. These

employment estimates represent full-time, part-time, and seasonal employment based on specific routing scenario for a 390-mile route with two compressor stations¹⁶.

SoCalGas is uniquely well-positioned to operate and maintain a clean renewable hydrogen pipeline system due to its vast experience operating and maintaining a highly developed gas transmission and distribution system, existing highly trained and qualified workforce, and comprehensive programs and procedures. SoCalGas will be able to leverage its existing operations and maintenance, technical/ engineering, and management/supervisory workforce to support and develop Angeles Link. Additionally, SoCalGas's well-developed and proven control room management and OQ programs will provide an excellent foundation for corresponding Angeles Link workforce programs. The existing SoCalGas personnel can successfully transition to these O&M tasks with additional training to hydrogen specific equipment and procedures. Leak management is a critical component of system operations and maintenance for several reasons including safety, environmental protection, resource conservation, and infrastructure integrity. The SoCalGas natural gas workforce is experienced and trained in the required skills needed to conduct leak survey and use of leak detection equipment per existing Operator Qualifications and O&M procedures. These personnel can transition to the leak survey tasks with training on the hydrogen leak detection equipment and hydrogen leak consequences.

Control room operations are critical elements for safely and efficiently operating hydrogen pipeline infrastructure. Independent of Angeles Link, SoCalGas is in the process of implementing a Control Center Modernization (CCM) program, which will enable Gas Control to further digitalize the existing natural gas transmission system with new field assets. The CCM will enhance the real-time monitoring on SoCalGas's pipeline system, and it presents opportunities that can be leveraged to result in robust oversight on future clean renewable hydrogen pipelines. SoCalGas may consider separate system gas controllers and emergency response teams for the natural and hydrogen gas systems. Gas controllers' training will require operator qualifications unique to the hydrogen system, including knowledge of the abnormal operating conditions associated with hydrogen compressor and pipeline operations.

SoCalGas actively monitors emerging issues through participation in industry associations, review of PHMSA advisory bulletins, and open communication and collaboration with legislative and regulatory groups as well participation in public forums. For the Angeles Link Project, through utilization and modification where necessary of existing procedures, programs, and practices, SoCalGas can effectively implement comprehensive workforce training and qualification for Angeles Link personnel. This will include O&M and OQ training programs, implementation of the ESCMP program, and adaptation of the comprehensive Gas Safety Plan. Implementation of federal and state pipeline safety requirements across the required aspects of design, material sourcing, construction, operation, maintenance, inspection, and reporting for a natural gas transmission and distribution system can support mitigation of critical considerations associated with workforce planning for Angeles Link. These same efforts can be applied externally while supporting and collaborating with industry partners, academia, unions, government, and communities.

¹⁶ The number of jobs will be refined in a future phase once the preferred route is identified and refined.

Specifically, within the industry, SoCalGas is in partnership with a joint industry project to develop a conceptual hydrogen certification pathway to educate a range of personnel. Nationally, SoCalGas has joined the Hydrogen Education for a Decarbonized Global Economy (H2EDGE) initiative to advance emerging hydrogen workforce by developing newly trained personnel and enabling the existing workforce to migrate into the hydrogen field by way of enhanced industry coordination and workforce readiness initiatives, made possible by training, education, and recruitment of qualified people.

The workforce needed to construct, operate, and maintain the proposed Angeles Link project will include, but is not limited to, the field workforce responsible for constructing, operating, and maintaining the Angeles Link infrastructure, including management personnel responsible for the field workforce. It also includes engineering and technical staff supporting the hydrogen infrastructure and field workforce. As proposed, Angeles Link could be an economic boon that extends California's position as a leader on clean energy well into the future, potentially attracting thousands of upskilled and reskilled jobs. The estimates from the Employment Impact Analysis also represent the potential availability of well-paid jobs. More significantly the possibility of potentially creating up to almost 75,000 jobs (when direct, indirect, and induced impacts are included), represents real and meaningful opportunities for participation in the clean energy economy.

10. GLOSSARY

California Public Utilities Commission (CPUC) - Regulates privately owned electric, natural gas, telecommunications, water, railroad, rail transit, and passenger transportation companies, in addition to authorizing video franchises.¹⁷

Cathodic Protection - A technique to prevent corrosion of a metal surface by making that surface the cathode of an electrochemical cell.¹⁸

Centrifugal compression - Compresses fluid (a gas or gas/liquid mixture) into a smaller volume while simultaneously increasing the pressure and temperature of the fluid.¹⁹

Close Interval Survey (CIS) - An existing method used to assess the adequacy of cathodic protection (CP) or to identify locations where a current may be leaving the pipeline, such as interruptions in the pipeline external coating which may cause corrosion, and for the purpose of

¹⁷ Auth, T. (n.d.-a). About the California Public Utilities Commission (CPUC). California Public Utilities Commission. [https://www.cpuc.ca.gov/about-cpuc/cpuc-overview/about-us#:~:text=About%20the%20California%20Public%20Utilities%20Commission%20%28CPUC%29%20The,transportation%20companies%2C%20in%20addition%20to%20authorizing%20video%20franchises>About%20the%20California%20Public%20Utilities%20Commission%20\(CPUC\)](https://www.cpuc.ca.gov/about-cpuc/cpuc-overview/about-us#:~:text=About%20the%20California%20Public%20Utilities%20Commission%20%28CPUC%29%20The,transportation%20companies%2C%20in%20addition%20to%20authorizing%20video%20franchises>About%20the%20California%20Public%20Utilities%20Commission%20(CPUC))

¹⁸ About the California Public Utilities Commission (CPUC). (n.d.). <https://www.cpuc.ca.gov/about-cpuc/cpuc-overview/about-us>

¹⁹ Selecting a centrifugal compressor - aiche. (n.d.-d). <https://www.aiche.org/sites/default/files/cep/20130644.pdf>

quantifying voltage (IR) drops other than those across the structure electrolyte boundary, such as when performed as a current interrupted, depolarized, or native survey.

Control Center Modernization (CCM) - Will enable Gas Control to further digitalize the existing natural gas transmission system with new field assets such as optical pipeline monitoring (OPM) stations and high consequence area (HCA) methane sensors.

Department of Transportation (DOT) - A federal agency of the United States government that oversees the transportation system of the country. The DOT aims to ensure the safety, efficiency, accessibility, and sustainability of various modes of transportation, such as air, road, rail, water, and transit. The DOT also supports the development and innovation of transportation infrastructure, technology, and policy.

Digital Construction Management (DCM) - These systems take advantage of modern technologies such as cloud computing, artificial intelligence, and real-time data processing to streamline and coordinate work processes across an organization and throughout the project.

Direct Economic and Employment Impacts - The set of expenditures applied to the I-O multipliers for an impact analysis. It is one or more production changes or expenditures made by producers/consumers as a result of an activity or policy. Direct effects can be positive or negative.²⁰

Environmental and Safety Compliance Management Program (ESCMP) - Based on compliance, training, environmental & safety goals, and assessments of compliance.

Geographic Information Systems (GIS) - Geographic Information Systems (GIS) are systems that capture, store, analyze, and display spatial or geographic data. GIS can be used to create maps, models, and simulations that show the patterns, relationships, and trends of various phenomena that occur on the Earth's surface or in the atmosphere.

High Consequence Areas (HCA) - Unusually sensitive environmental areas (defined in 195.6), urbanized areas and other populated places (delineated by the Census Bureau, and commercially navigable waterways.²¹

Indirect Economic and Employment Impacts - Business to business purchases in the supply chain taking place in the region that stem from the initial industry input purchases.²²

Induced Economic and Employment Impacts - Impacts include the value of goods and services purchased throughout the regional economy -- goods and services not directly associated with the

²⁰ Demski, J. (n.d.). Understanding IMPLA

N: Multipliers. Understanding IMPLAN: Multipliers. <https://blog.implan.com/understanding-implan-multipliers>

²¹ HL IM fact sheet. PHMSA. (n.d.-a). <https://www.phmsa.dot.gov/pipeline/hazardous-liquid-integrity-management/hl-im-fact-sheet>

²² Demski, J. (n.d.-a). Understanding IMPLAN: Multipliers. Understanding IMPLAN: Multipliers. <https://blog.implan.com/understanding-implan-multipliers>

project, but which would otherwise not be purchased without the activity generated by that project.

Inline Inspection (ILI) - A technique used to assess the integrity of natural gas transmission pipelines from the inside of the pipe and is used by Southern California Gas Company (SoCalGas) as part of its ongoing pipeline integrity program.²³

Integrity Management Program (IMP) - The Gas Transmission Integrity Management Rule resulted in regulations (49 CFR Part 192, Subpart O) which specify how pipeline operators must identify, prioritize, assess, evaluate, repair and validate the integrity of gas transmission pipelines that could, in the event of a leak or failure, affect High Consequence Areas (HCAs) within the United States. These HCAs include certain populated and occupied areas.²⁴

Location Class 1 - Any 1.6km (1 mile) section that has ten or fewer buildings intended for human occupancy. A Location Class 1 is intended to reflect areas such as wasteland, deserts, wetlands, mountains, grazing land, farmland and sparsely populated areas.²⁵

Location Class 1, Division 1 - Not applicable to hydrogen service and not recognized in this Code.²⁶

Location Class 1, Division 2 - Class 1 where the design factor of the pipe is equal to or less than .72 and has been tested to 1.1 times the maximum-operating pressure (ASME B31.12, PL-3.7.1-6 provides exceptions to design factor).²⁷

Location Class 2 - Any 1.6 km (1 mile) section that has more than 10 but fewer than 46 buildings intended for human occupancy. A Location Class 2 is intended to reflect areas where the degree of the population is intermediate between Location Class 1 and Location Class 3, such as fringe areas around cities and towns, industrial areas, ranch or country estates, etc.²⁸

Location Class 3 - Any 1.6 km (1 mile) section that has 46 or more buildings intended for human occupancy, except when a Location Class 4 prevails. A Location Class 3 is intended to reflect areas such as suburban housing developments, shopping centers, residential areas, industrial areas, and other populated areas not meeting Class 4 requirements.²⁹

Location Class 4 - Includes areas where multistory buildings are prevalent, where traffic is heavy or dense, and where there may be numerous other utilities underground. Multistory means four

²³ In-line inspection of pipelines - SoCalGas. (n.d.-b). <https://www.socalgas.com/documents/news-room/fact-sheets/In-LinePipelineInspection.pdf>

²⁴ Transmission Integrity Management Program (TIMP). PHMSA. (n.d.-a). <https://www.phmsa.dot.gov/pipeline/gas-transmission-integrity-management/gas-transmission-integrity-management-gt-im-overview>

²⁵ ASME B31.12, PL-3.2.2

²⁶ ASME B31.8

²⁷ ASME B31.12, PL-3.2.2

²⁸ ASME B31.12, PL-3.2.2

²⁹ ASME B31.12, PL-3.2.2

or more floors above ground, including the first or ground floor. The depth of basements or number of basement floors is immaterial.³⁰

Longshoremen - A Longshoreman, also known as a dock worker or a stevedore, plays a crucial role in the maritime industry, primarily responsible for the loading, unloading, securing, and transferring of cargo in ports.³¹

Moderate Consequence Areas (MCA) - An onshore area that is within a potential impact circle, as defined in §192.903, containing either: (i) Five or more buildings intended for human occupancy; or (ii) Any portion of the paved surface, including shoulders, of a designated interstate, other freeway, or expressway, as well as any other principal arterial roadway with 4 or more lanes.³²

National Center for Construction Education and Research (NCCER) - A non-profit education foundation established in 1996 that provides various credential and certification training.

National Fire Protection Association (NFPA) - Started as a Boston-based organization for fire sprinkler codes has grown to become the leading global advocate for the elimination of death, injury, property, and economic loss due to fire, electrical, and related hazards.³³

Operator Qualification (OQ) - Each pipeline operator is responsible for developing an OQ program, following their written OQ plan, establishing a covered task list applicable to their system, and defining the training and qualification requirements for personnel performing covered tasks on their pipeline facility.³⁴

Optical Pipeline Monitoring (OPM) - The Optical Pipeline Safety Monitoring System (OPM) sends pulses of light the thickness of a human hair through glass that can be measured inside the optical cable. When installed along a pipeline, the technology can detect vibrations, stress, or abnormal changes in temperature to within 20 feet of where a problem may be developing.³⁵

Pipeline and Hazardous Materials Safety Administration (PHMSA) - Mission is to protect people and the environment by advancing the safe transportation of energy and other hazardous materials that are essential to our daily lives.

³⁰ ASME B31.12, PL-3.2.2

³¹ Longshoreman. BuildStream. (n.d.). <https://www.buildstream.co/job-descriptions/longshoreman>

³² Govinfo. (n.d.-b). <https://www.govinfo.gov/content/pkg/CFR-2022-title49-vol3/pdf/CFR-2022-title49-vol3-sec192-919.pdf>

³³ Learn more about NFPA: The National Fire Protection Association. nfpa.org. (n.d.-a). <https://www.nfpa.org/About-NFPA>

³⁴ Operator qualification overview. PHMSA. (n.d.-d). <https://www.phmsa.dot.gov/pipeline/operator-qualifications/operator-qualification-overview>

³⁵ SoCalGas' Innovative Optical Pipeline Safety Monitoring System set to expand after successful pilot program: SoCalGas Newsroom. SoCalGas. (2023a, September 6). <https://newsroom.socalgas.com/stories/socalgas-innovative-optical-pipeline-safety-monitoring-system-set-to-expand-after#:~:text=The%20Optical%20Pipeline%20Safety%20Monitoring%20System%20%28OPM%29%20sends,feed%20of%20where%20a%20problem%20may%20be%20developing.>

Pipeline Safety Management System (PSMS) - A holistic approach to enhancing pipeline safety by promoting safety awareness, vigilance, and cooperation company-wide. A successfully implemented PSMS will highlight safety risks and provide a framework for addressing them with the goal of reducing pipeline incident rate and liability costs. ³⁶

Reciprocating Compression - Positive displacement in which the compressing and displacing element is a piston having a reciprocating motion within a cylinder. ³⁷

Supervisory Control and Data Acquisition Systems (SCADA) - The primary network to monitor pipeline system performance, gather critical operating data (flow, pressures, and temperatures), including leak detection information, and compressor performance among other data.

Systems Analysis Programming (SAP) - SAP has the capabilities to plan, schedule, execute and refine operations and asset maintenance. SAP Plant Maintenance (PM) is a module within the SAP ERP (Enterprise Resource Planning) software suite. Its primary focus is on managing and maintaining an organization's assets and equipment. Here are some key points about SAP PM:

1. Maintenance Activities: SAP PM handles various maintenance activities performed in a plant, including:

- Inspections: Identifying damages and issues.
- Notifications: Reporting maintenance needs.
- Corrective Maintenance: Repairing technical objects.
- Preventive Maintenance: Scheduled maintenance to prevent breakdowns.
- Repairs: Addressing equipment failures.

2. Benefits:

- Streamlines maintenance processes.
- Optimizes resource utilization.
- Improves overall equipment effectiveness.

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³⁶ Aga-Guideline-for-Implementation-of-PSMS.pdf. (n.d.-b). <http://pipelinesms.org/wp-content/uploads/2019/05/AGA-guideline-for-implementation-of-PSMS.pdf>

³⁷ PetroWiki. (2015, June 2). Reciprocating compressor. https://petrowiki.spe.org/Reciprocating_compressor

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12. APPENDICES

- Appendix A – Employment Impact Analysis



**SOUTHERN CALIFORNIA GAS COMPANY: ANGELES LINK
EMPLOYMENT IMPACT ANALYSIS**

Rea & Parker Research
Draft 2024

SoCalGas commissioned this analysis from Rea & Parker Research. The analysis was conducted, and this report was prepared, collaboratively.

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SOUTHERN CALIFORNIA GAS COMPANY: ANGELES LINK EMPLOYMENT IMPACT ANALYSIS

EXECUTIVE SUMMARY

The purpose of this report is to estimate the economic and employment impact of the Southern California Gas Company Angeles Link project. For the purposes of this report, the Angeles Link project is assumed to be located in Los Angeles¹, Kern, Kings, and Fresno counties. The following economic and employment factors will be estimated in this report:

- Direct output and employment² impacts associated with the direct construction, operation, and maintenance of the Project
- Direct, indirect and induced impacts to the regional economic output, regional employment and regional employee compensation,
- Disadvantaged Business Enterprise (DBE) participation, based upon SoCalGas's stated policy and experience.
- Tax revenues during construction and operation, including:
 - Property taxes
 - Payroll taxes (California only)
 - Sales/Use tax

This report identifies the potential direct, indirect and induced economic and employment impacts for the four-county area in total and disaggregated by county. This executive summary provides an overview, while the body of the report provides more details.

Key Findings

Construction

- The total direct expenditure benefits for the five-year construction period are estimated to be \$9.2 billion³, which amount expands to \$13.9 billion when the multiplier effects of spending and re-spending (indirect and induced benefits) are factored into the analysis.
 - Direct impacts include employment, payroll, and revenue uniquely and specifically generated by the project's revenues and expenditures.

¹ Los Angeles County estimation includes pipeline mileage within Orange and Ventura counties.

² Employment represents full-time, part-time, and seasonal employment.

³ Construction cost estimates were provided by SoCalGas's cost estimate chapter in the Pipeline Sizing & Design Criteria study and subject to change.

- Indirect impacts are the purchases made between and among industries and government as they respond to new demands of directly impacted industries.
 - Induced impacts include the value of goods and services purchased throughout the regional economy -- goods and services not directly associated with the project, but which would otherwise not be purchased without the activity generated by that project.
- In total, there could be almost 53,000 direct construction-related jobs generated by the project.
 - The total employment impact could increase to almost 75,000 jobs when indirect and induced impacts are included.
 - Labor income during construction, including benefits, payroll taxes, and proprietor income, is estimated to equal \$3.8 billion direct (\$72,000 per job) and \$5.3 billion direct, indirect, and induced (\$71,000 per job).
 - Diverse Business Enterprises (DBEs) could directly receive \$4.0 billion in the form of construction labor and materials contracts and could create 23,000 jobs during these years.
 - State and local governments are estimated to benefit by \$213.5 million in total payroll, sales, and property taxes during construction.

Annual Operations

- The total direct annual expenditure benefits from operations are estimated to be \$109.6 million, which expands to \$166.8 million when the multiplier effects of spending and re-spending (indirect and induced benefits) are factored into the analysis.
- In total, there could be approximately 100 direct annual operations-related jobs (actual estimate=104) in the four counties. The total employment impact increases to almost 400 annual jobs (actual estimate = 399 jobs) when indirect and induced impacts are included.
- Annual labor income, including benefits, payroll taxes, and proprietor income, is estimated to equal \$21.2 million direct (an average of \$204,000 per job) and \$41.0 million direct, indirect, and induced (an average of \$103,000 per job).
- State and local governments are estimated to benefit by \$137.4 million annually in total payroll, sales, and property taxes from Angeles Link operations.

SOUTHERN CALIFORNIA GAS COMPANY: ANGELES LINK EMPLOYMENT IMPACT ANALYSIS

The purpose of this report is to estimate the economic and employment impact of the Angeles Link project. Southern California Gas Company (SoCalGas) is proposing to construct the Angeles Link project that will be a “high-pressure, non-discriminatory pipeline system that is dedicated to public use and will transport clean, renewable hydrogen from regional third-party production and storage sites to end users in Central and Southern California, including the LA Basin, inclusive of the Ports of Los Angeles and Long Beach⁴.” Construction is planned for five years (2028-2033).



This report will develop estimates for the following economic and employment factors in the four counties traversed by one potential route for Angeles Link (Los Angeles⁵, Kern, Kings, and Fresno) and for the four counties aggregated:

- Direct output and employment impacts associated with the direct construction and operation and maintenance of the Project
- Direct, indirect and induced impacts to the regional economic output, regional employment and regional employee compensation,
- Disadvantaged Business Enterprise (DBE) participation, based upon the Owner’s stated policy and experience.
- Assessment of Bureau of Labor Statistics/Census data regarding anticipated jobs and education requirements regarding Low-Income and DBE job availability.
- Tax revenues during construction and operation, including, but not limited to:
 - Property taxes
 - Payroll taxes (California only)
 - Sales/Use tax

Economic and Employment Impact Methodology

The economic and employment impacts that Angeles Link could be expected to provide to the various counties discussed herein is modeled in this report using the IMPLAN Input-Output Model. The 1976 National Forest Management Act required the USDA Forest Service to create

⁴ Description courtesy of SoCalGas.

⁵ Los Angeles County estimates are inclusive of pipeline mileage within Orange and Ventura counties.

5-year management plans. These plans required alternative land management options to be presented, each of which would have resource and socio-economic effects on local communities. The Forest Service, in cooperation with the Federal Emergency Management Agency (FEMA), contributed considerable resources to the creation of FORPLAN (a linear programming model used to estimate land management resource outputs) and IMPLAN to estimate the economic effects of these outputs on local communities.

In 1988, the Agricultural Economics Department of the University of Minnesota made the decision to offer IMPLAN software, data, and technical support to non-Forest Service users. In 1993 Minnesota IMPLAN Group (MIG) was formed to update and improve the IMPLAN software to make it more functional and accessible to a wider range of users. This new version used a modeling system based on the creation of a Social Accounting Matrix (SAM) – an extension of the input-output accounts, and resulting SAM Multipliers. IMPLAN Pro 2.0 became available in May 1999, IMPLAN Version 3.0 was released on November 3, 2009, with an updated version 3.1 issued since. IMPLAN now operates from a Cloud platform.

IMPLAN's Social Accounting System is an input-output model that describes and estimates the industry average transactions that occur between enterprises that produce goods and services and intermediate and final consumers of those products and services. The IMPLAN Social Accounting Matrix, therefore, is designed to provide a complete and accurate “snapshot” of the economy and its spending patterns.

At the heart of economic impact models are multipliers. Multipliers are a numeric way of describing the secondary impacts stemming from an economic event. For example, an employment multiplier of 1.8 indicates that for every 10 employees hired in the given industry, 8 additional jobs would be created in other industries, such that 18 total jobs would be added to the given economic region. Industries that produce goods and services for consumer consumption must purchase products, raw materials, and services from other companies to create their product. These vendors must also procure goods and services. This is a continuous cycle that ultimately depletes the funds from the region’s economy. There are three types of

effects measured with a multiplier: the direct, the indirect, and the induced effects. The direct effect is the known or predicted change in the local economy that is to be studied. The indirect effect is the business-to-business transactions required to satisfy the direct effect. Finally, the induced effect is derived from local spending on goods and services by people working to satisfy the direct and indirect effects.

- Direct impacts include employment, payroll, and revenue uniquely and specifically generated by the project's revenues and expenditures.
- Indirect impacts are the changes in inter-industry purchases and government expenditures as they respond to new demands of directly affected industries.
- Induced impacts include the value of goods and services purchased by money generated by direct and indirect impacts throughout the regional economy -- goods and services not directly associated with the project, but which would otherwise not be purchased without the activity generated by that project.

Two distinct economic impacts could occur due to the project: 1) construction of the project could generate economic and employment activity, and 2) post-construction on-going operations of Angeles Link could generate additional economic and employment activity for years to come. These impacts are the focus of the balance of this report.

Economic and Employment Impact of Construction

The economic impact of the construction of Angeles Link is estimated using the IMPLAN category of Construction of New Power and Communications Structures. The IMPLAN Industry Schemes represent rollups of North American Industry Classification System (NAICS) descriptions, and each IMPLAN Industry has its own spending pattern derived from Bureau of Economic Analysis (BEA) expenditures patterns. **Table 1** shows the multipliers and economic impact factors for the four counties. Application of these multipliers to the total construction cost of approximately

\$9.2 billion is discussed below and reflected in summary form in **Table 2** and in individual impact detail in **Charts 1, 2, 3, and 4**⁶.

Table 1 IMPLAN Multipliers SoCalGas Angeles Link: Construction				
	Fresno County	Kern County	Kings County	Los Angeles County
Direct, Indirect and Induced Output Multiplier	1.513158	1.430898	1.228683	1.646880
Direct Jobs⁷ per \$1 million output	5.33	5.23	6.31	5.84
Direct, Indirect, and Induced jobs per \$1 million output	8.07	7.44	7.55	8.72
Direct Labor Income⁸ per \$1 million output	\$443,373	\$435,486	\$381,944	\$420,037
Direct, Indirect, and Induced Labor Income per \$1 million output	\$605,943	\$564,282	\$441,121	\$633,060

⁶ Construction cost estimates shown in Table 2 and reflected in Charts 1, 2, 3, and 4 were provided by SoCalGas’s cost estimate chapter in the *Pipeline Sizing & Design Criteria study* in total and for each county.

⁷ An Industry-specific mix of full-time, part-time, and seasonal employment. An annual average that accounts for seasonality and follows the same definition used by the Bureau of Labor Statistics (BLS) and BEA. In IMPLAN, Employment is not equal to full time equivalents (FTE). For these pipeline transportation jobs, FTE is 97.15% of the IMPLAN total. Therefore, IMPLAN methodology has estimated 49,932 direct annual construction and construction-related jobs, whereas an FTE estimate would be 48,509 FTE jobs. This difference is considered by this report to be insignificant and likely within IMPLAN’s margin of error.

⁸ Labor Income consists of two parts. The first, Employee Compensation, is the total payroll cost of wage and salary employees to the employer. This includes wages and salaries, all benefits (e.g., health, retirement) and payroll taxes (both sides of social security, unemployment insurance taxes, etc.). It is also referred to as fully-loaded payroll. The second piece of Labor Income is Proprietor Income (PI). PI consists of payments received by self-employed individuals and unincorporated business owners.

**Table 2
Economic and Employment Impact of SoCalGas Angeles Link: Construction**

	Fresno County	Kern County	Kings County	Los Angeles County	Four-County Total
Direct Economic Impact (=Construction Cost)	\$481,917,244	\$2,120,435,874	\$1,819,041,255	\$4,742,672,536	\$9,164,066,910
Direct, Indirect and Induced Economic Impact⁹	\$729,216,913	\$3,034,127,451	\$2,300,519,647	\$7,810,612,546	\$13,874,476,577
Direct Construction Jobs¹⁰	2,569	11,090	11,478	27,697	52,834
Direct, Indirect and Induced Jobs during Construction¹¹	3,889	15,776	13,734	41,536	74,755
Direct Labor Income during Construction¹²	\$213,669,094	\$923,420,625	\$694,772,130	\$1,992,099,462	\$3,823,961,310
Direct, Indirect and Induced Labor Income during Construction¹³	\$292,014,812	\$1,196,524,877	\$802,417,607	\$3,002,395,375	\$5,293,352,721
Direct Labor Income per Job Created¹⁴	\$83,184	\$83,267	\$60,530	\$71,924	\$72,377
Labor Income per Total Direct, Indirect, and Induced Jobs	\$75,086	\$75,844	\$58,427	\$72,599	\$70,809

⁹ Construction Cost * Output Multiplier for each county

¹⁰ Construction Cost * Direct Jobs per \$ million Multiplier for each county

¹¹ Construction cost * Direct, Indirect and Induced Jobs Multiplier for each county.

¹² Construction cost * Direct Labor Income Multiplier for each county

¹³ Construction cost *Direct, Indirect and Induced Labor Income Multiplier for each county

¹⁴ Labor Income/Jobs Created—includes benefits and proprietor income

Economic Impact of Construction

Table 2 shows that the four counties assumed to be traversed by Angeles Link in this analysis are estimated to directly benefit by an amount equal to the construction costs of \$9,164,066,910, with Los Angeles County receiving more than one-half of these expenditures (approximately \$4.7 billion), followed by Kern County (more than 2.1 billion), Kings County (more than \$1.8 billion), and Fresno County (just shy of \$0.5 billion). When indirect and induced factors are introduced, this amount of economic impact is estimated to increase by \$4.7 billion to 13.9 billion. Los Angeles County is estimated to account for more than one-half of the activity (more than \$7.8 billion). Kern County (more than \$3.0 billion), Kings County (\$2.3 billion), and Fresno County (approximately three-fourths of one billion dollars) follow. **Chart 1** presents a graphical depiction of this economic impact.

Construction Period Jobs

Utilizing the IMPLAN job generation model “power structure construction” category from **Table 1**, Angeles Link can be expected to generate between 5.23 direct jobs per million dollars of construction cost (Kern County) and 6.31 Jobs per \$ million (Kings County)—equaling a total of 52,834 direct jobs during the planned construction period.

Again, Los Angeles County’s 27,697 jobs are estimated to account for more than one-half of direct job creation, followed by Kings County (11,478 jobs), Kern County (11,090 jobs) and Fresno County (2,569 jobs). This number of jobs increases to almost 75,000 when Indirect and induced impacts are added. Kern County demonstrates a greater multiplier than does Kings County and moves ahead of Kings County when indirect and induced jobs are included. These data are found in **Table 2** and **Chart 2**.

Chart 1 SoCalGas: Angeles Link Economic Impact--Construction

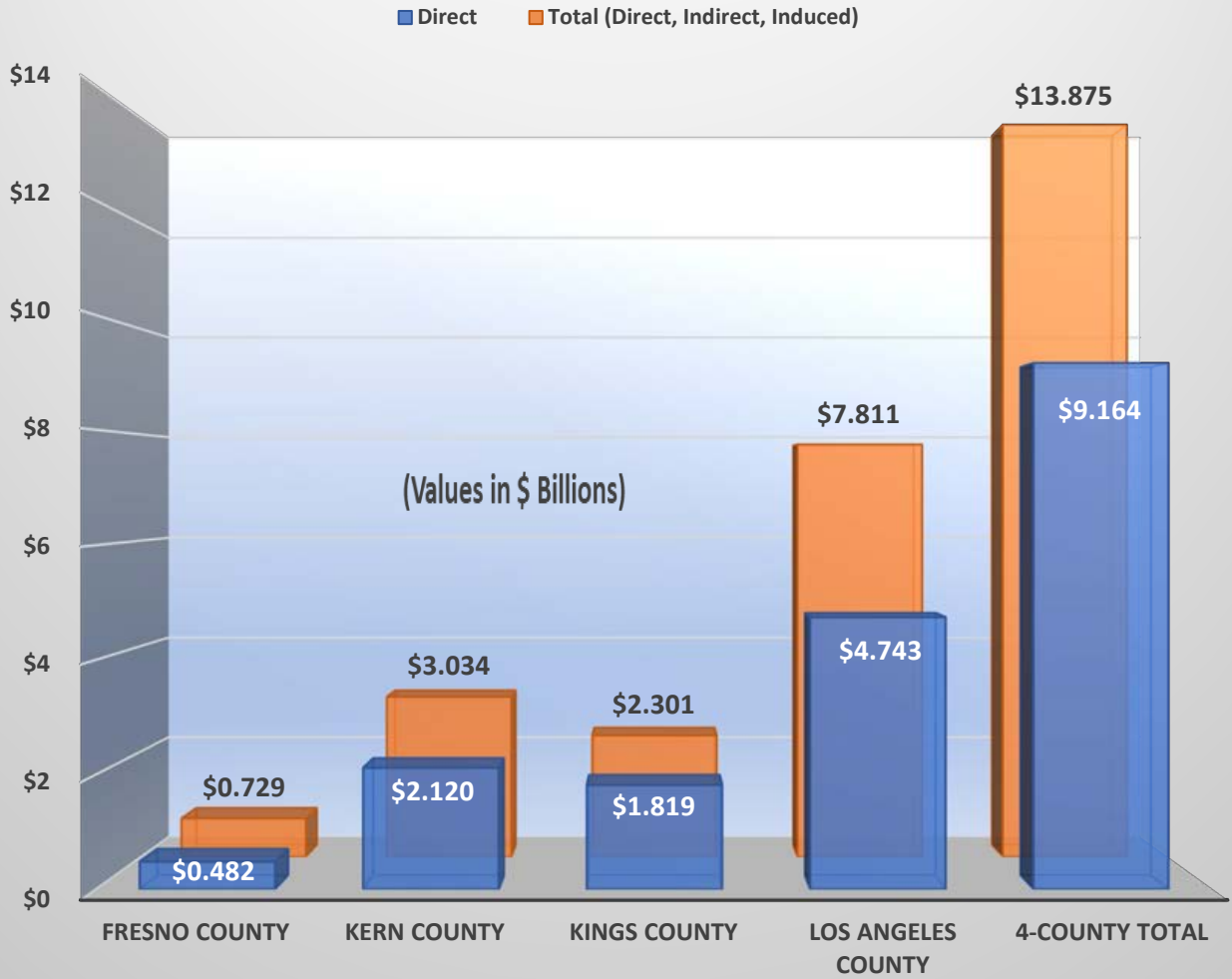
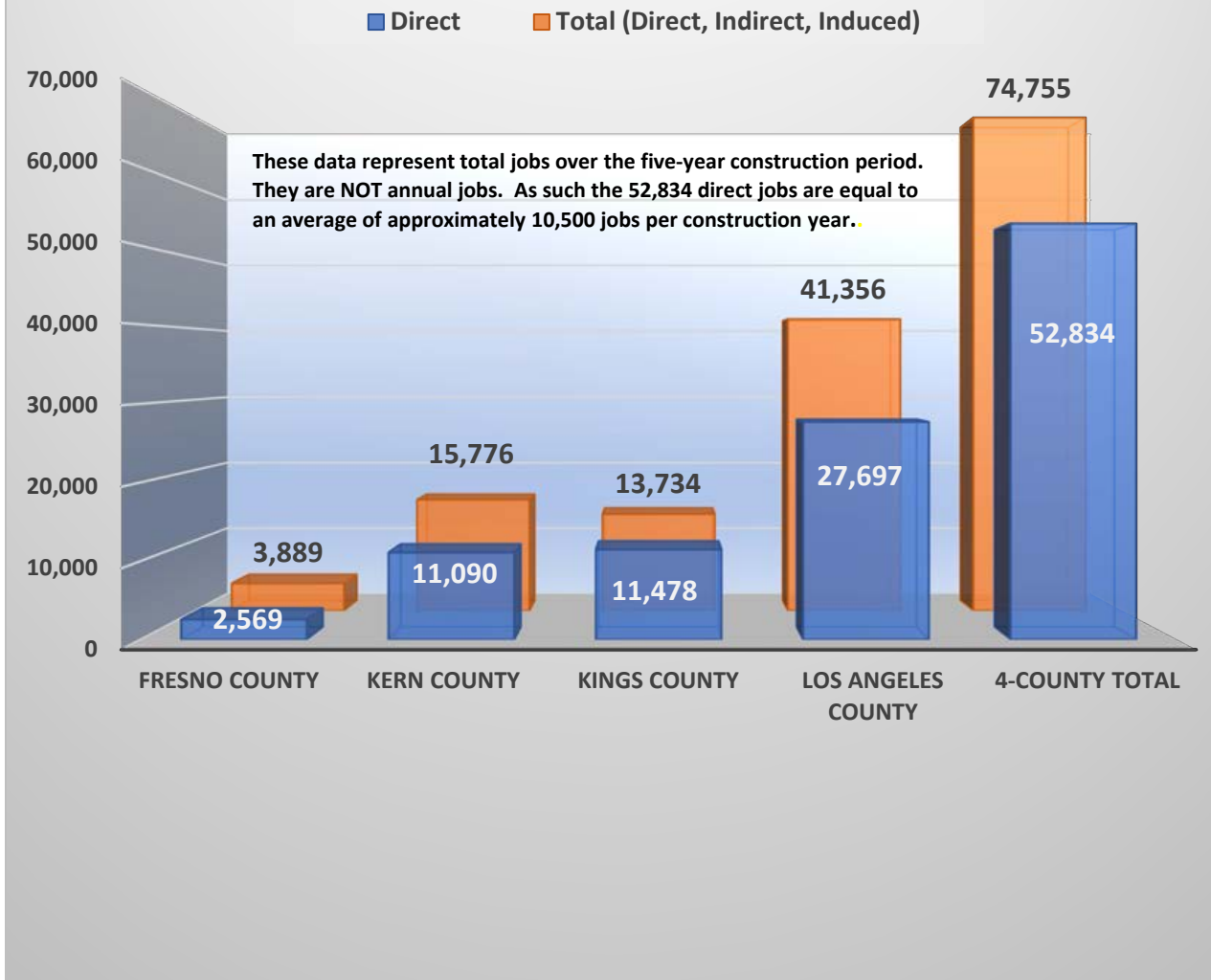


Chart 2 SoCalGas: Angeles Link Job Generation Construction Period



Labor Income during Construction

Direct labor income is estimated to total \$3.8 billion according to IMPLAN (\$72,400 per direct construction job¹⁵). The four counties are estimated to reap indirect and induced labor income

¹⁵ Including benefits, payroll taxes, and proprietor income

of almost \$1.5 billion (\$67,000 per indirect and induced job). Total construction-period labor income, therefore, is estimated to equal \$5.3 billion (\$70,800 per direct, indirect, and induced job). Kern County and Fresno County demonstrate the highest labor income per job (**Table 2 and Charts 3 and 4**). Los Angeles County follows closely, with Kings County quite a bit lower.

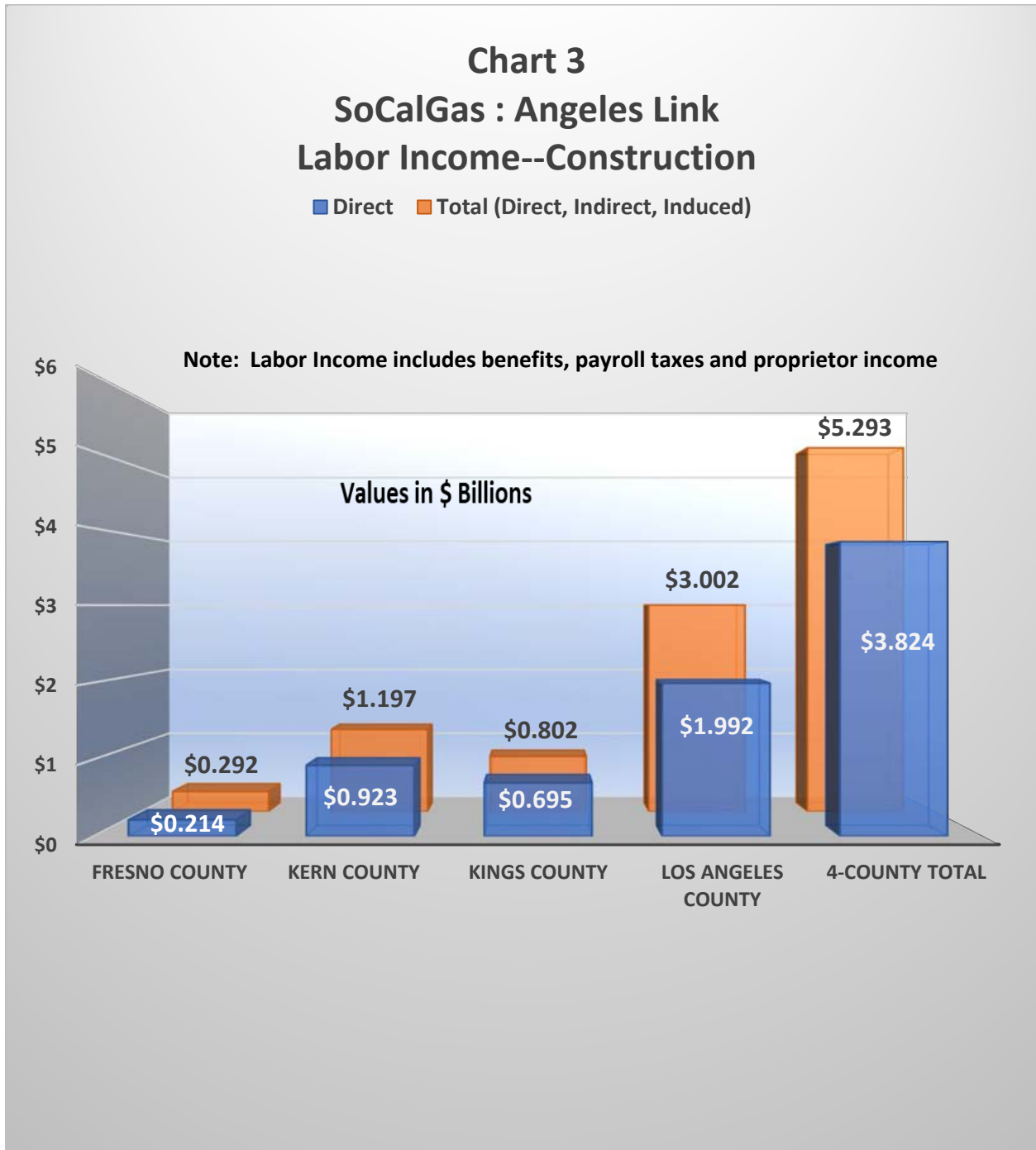
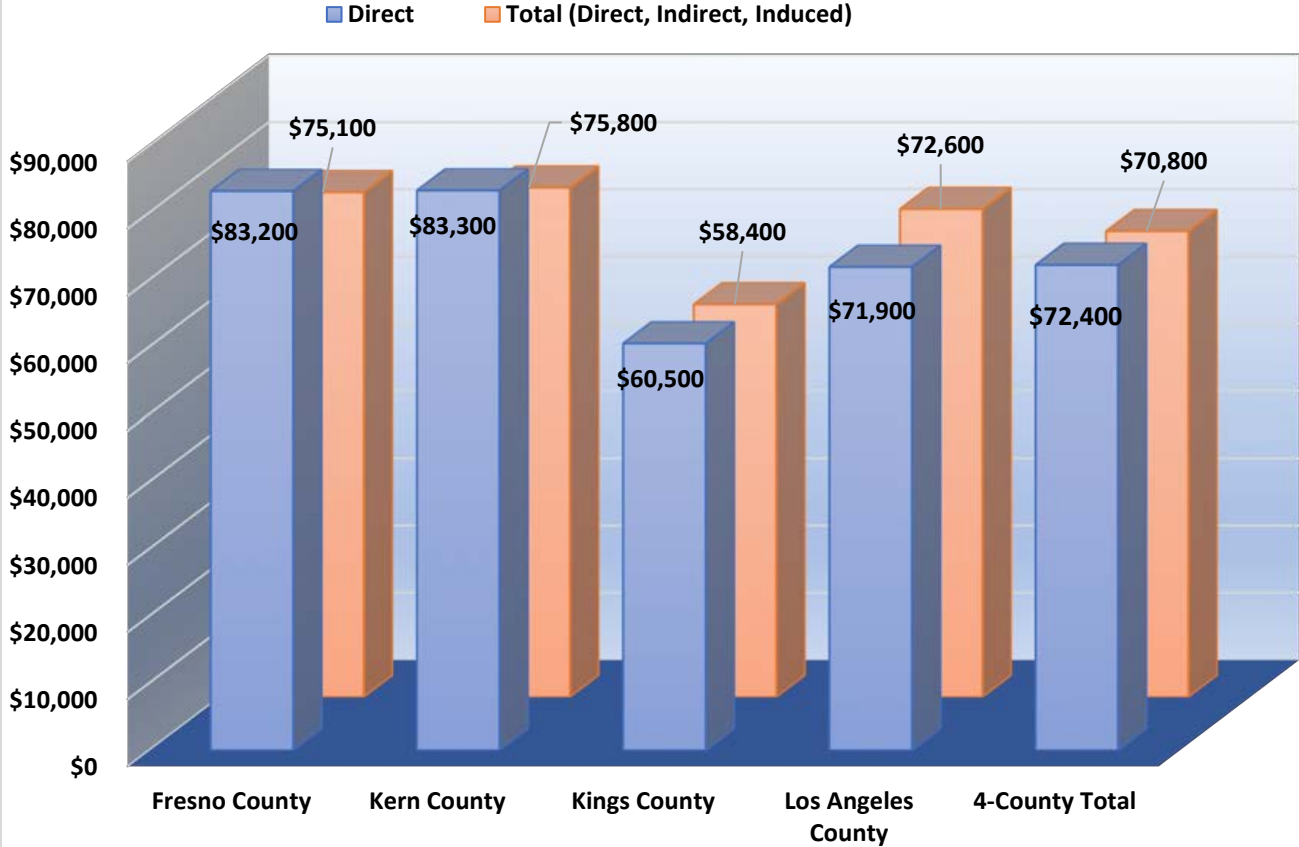


Chart 4 SoCalGas: Angeles Link Labor Income per Job Generated during Construction

Note: Labor Income includes benefits, payroll taxes and proprietor income



Diverse Business Enterprises Workers During Construction

Diverse Business Enterprises (DBEs) could comprise a significant portion of the construction materials and labor components of the Angeles Link. In 2023, SoCalGas purchased 44% of its goods and services from diverse suppliers – enterprises owned by minorities, women, LGBT individuals, and disabled veterans¹⁶. Continuing purchases spent with diverse suppliers at a minimum of 44% is the objective for SoCalGas’s Angeles Link. As such, it can be estimated that over \$4.0 billion¹⁷ will be spent with or contracted to Diverse Business Enterprises in Los Angeles County, Kern County, Kings County, and Fresno County for the first phase of the Angeles Link construction¹⁸. Direct DBE jobs are estimated to be more than 23,000, using the same 44 percent factor.

Since the proportion of these expenditures that DBE enterprises will spend with other DBE enterprises is unknown, it is not possible to precisely apply multipliers to these DBE contracted expenditures that can indicate induced and indirect DBE benefits; however, were these funds to be spent and re-spent among other DBE firms in a manner similar to that projected for direct expenditures, these expenditures could multiply to \$6.1 billion of DBE economic impact and almost 33,000 direct, indirect, and induced DBE jobs during the project construction period.

¹⁶ <https://www.socalgas.com/for-your-business/supplier-diversity> https://www.socalgas.com/sites/default/files/2024-03/2023-24_SD_annual_report.pdf

¹⁷ Direct expenditures of \$9,164,066,910 * 44%

¹⁸ This standard can be met anywhere in the project area and cannot be delineated by County. Therefore, this determination is made for the aggregated 4-county region.

Economic and Employment Impact During Annual Operations

Angeles Link’s annual operations fall into the IMPLAN category of Pipeline Transportation. **Table 3** shows the multipliers and economic impact factors for the four counties assumed to be traversed by Angeles Link separately and aggregated, as was provided for construction estimates.

Application of these multipliers to Angeles Link’s annual operations is discussed below and reflected in **Table 4** and **Charts 5, 6, 7, and 8**.

Table 3 IMPLAN Multipliers SoCalGas Angeles Link: Annual Operations				
	Fresno County	Kern County	Kings County	Los Angeles County
Direct, Indirect and Induced Output Multiplier	1.571672	1.442175	1.209915	1.672197
Direct Jobs¹⁹ per \$1 million output	0.89	0.95	0.98	0.94
Direct, Indirect and Induced Jobs per \$1 million output	3.88	3.58	2.26	4.31
Direct Labor Income²⁰ per \$1 million output	\$211,059	\$189,733	\$186,146	\$197,599
Direct, Indirect and Induced Labor Income per \$1 million output	\$387,569	\$440,999	\$254,239	\$443,384

¹⁹ An Industry-specific mix of full-time, part-time, and seasonal employment. An annual average that accounts for seasonality and follows the same definition used by the Bureau of Labor Statistics (BLS) and BEA. In IMPLAN, Employment is not equal to full time equivalents (FTE). For these pipeline transportation jobs, FTE is 92.16% of the IMPLAN total. Therefore, IMPLAN methodology has estimated 104 direct annual jobs operating and maintaining the pipeline and compressors; whereas an FTE estimate would be 96. This difference is considered by this report to be inconsequential.

²⁰ Labor Income consists of two parts. The first, Employee Compensation, is the total payroll cost of wage and salary employees to the employer. This includes wages and salaries, all benefits (e.g., health, retirement) and payroll taxes (both sides of social security, unemployment insurance taxes, etc.). It is also referred to as fully-loaded payroll. The second piece of Labor Income is Proprietor Income (PI). PI consists of payments received by self-employed individuals and unincorporated business owners.

Annual Operations Economic Impact

Table 4					
Annual Economic and Employment Impact of SoCalGas Angeles Link:					
	Fresno County	Kern County	Kings County	Los Angeles County	Four-County Total
Direct Economic Impact (=Annual Operating Expenditures)	\$4,819,172	\$21,204,359	\$27,684,050	\$55,937,098	\$109,644,673
Direct, Indirect and Induced Economic Impact²¹	\$7,285,008	\$30,580,396	\$33,495,347	\$95,469,234	\$166,829,985
Direct Annual Jobs²²	4	20	27	53	104
Direct, Indirect and Induced Annual Jobs²³	19	76	63	241	399
Direct Labor Annual Income²⁴	\$1,012,643	\$4,023,171	\$5,153,362	\$11,053,100	\$21,242,176
Direct, Indirect and Induced Annual Labor Income²⁵	\$1,863,275	\$7,311,391	\$7,038,365	\$24,801,611	\$41,014,642
Direct Annual Labor Income per Job Created²⁶	\$236,099	\$199,719	\$189,944	\$210,211	\$203,698
Annual Labor Income per Total Direct, Indirect, and Induced Jobs	\$99,906	\$96,584	\$112,495	\$102,873	\$103,051

Table 4 shows that the estimated annual direct operating cost in these four counties totals approximately \$110 million per year (\$109,644,673). This consists of annual pipeline operating costs estimated at 1 percent of capital (construction) costs (\$91,640,669) plus variable costs for the system’s compressors (\$18,004,004). The 1 percent operating costs are allocated in **Table 4** to each county in proportion to their capital costs, and compressor costs are split between Kings

²¹ Operating Expenditures* Output Multiplier for each county

²² Operating Expenditures * Direct Jobs per \$ million Multiplier for each county

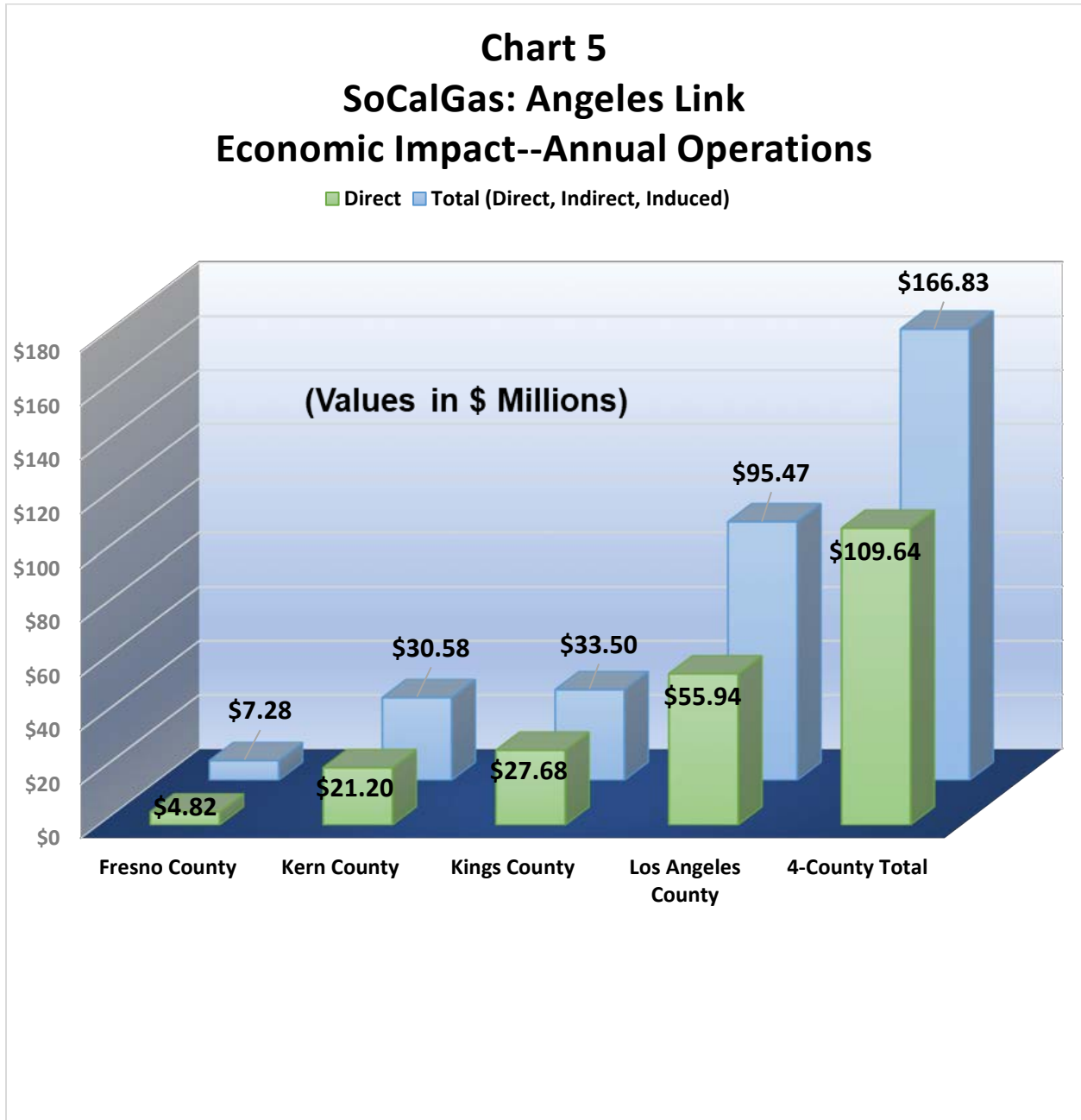
²³ Operating Expenditures * Direct, Indirect and Induced Jobs Multiplier for each county.

²⁴ Operating Expenditures * Direct Labor Income Multiplier for each county

²⁵ Operating Expenditures *Direct, Indirect and Induced Labor Income Multiplier for each county

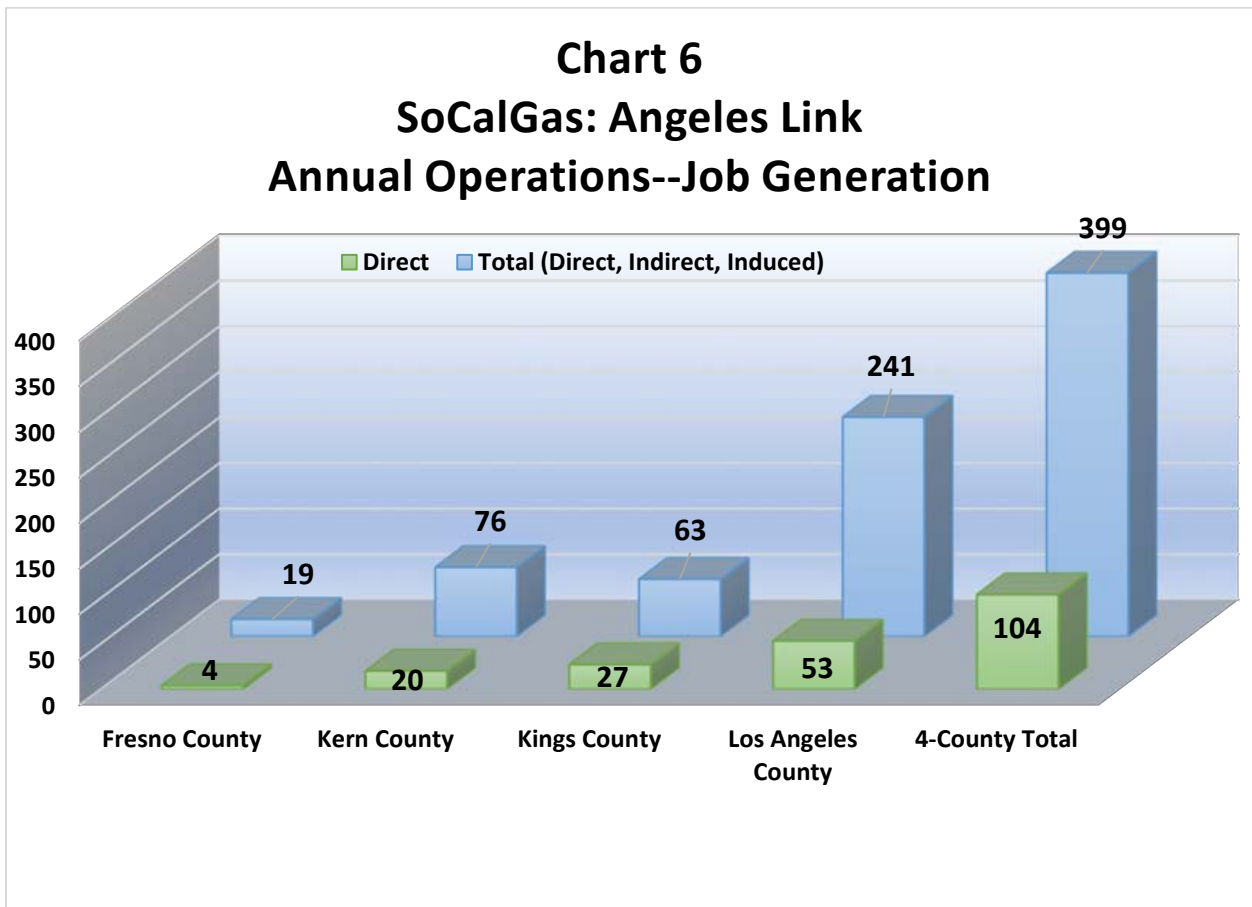
²⁶ Labor Income/Jobs Created—includes benefits and proprietor income

County (\$9,493,637) and Los Angeles County (\$8,510,367). **Chart 5** presents a visual depiction of the impacts to these counties from the annual operations of Angeles Link.



Annual Operations Jobs

Utilizing IMPLAN job generation model pipeline transportation category (**Table 3**), Angeles Link can be expected to generate a total of 104 direct jobs annually during operations. Again, Los Angeles County's 53 jobs represents approximately one-half of direct job creation, followed by Kings County (27 direct jobs), Kern County (20 direct jobs) and Fresno County (4 direct jobs). This number of jobs increases almost four-fold to 399 when Indirect and induced jobs are added. Los Angeles County is dominant with over 60 percent of all direct, indirect, and induced jobs and Kern County again demonstrates a greater multiplier than Kings County and moves ahead of Kings County when indirect and induced jobs are included. These data are found in **Table 4** and **Chart 6**.



Labor Income from Annual Operations

Direct labor income is estimated to total just over \$21 million (\$21,242,176) according to IMPLAN (\$203,700 per direct annual operations job). Considering that the calculation includes benefits, payroll taxes, and income to business owners, this figure represents a broader measure of income than what is directly received by employees alone.

The four counties are estimated to gain indirect and induced labor income of \$19,772,466—\$67,000 per indirect and induced job. Total annual labor income from operations is estimated to equal approximately \$41.0 million (\$103,100 per direct, indirect, and induced job). Unlike construction, where Kern County and Fresno County demonstrated the highest labor income per job and Kings County was lowest by far, Kings County demonstrates the highest annual labor income at \$112,500 per worker (**Table 2** and **Charts 7 and 8**).

Chart 7 SoCalGas: Angeles Link Annual Operations Labor Income

■ Direct ■ Total (Direct, Indirect, Induced)

Note: Labor Income includes benefits, payroll taxes and proprietor income

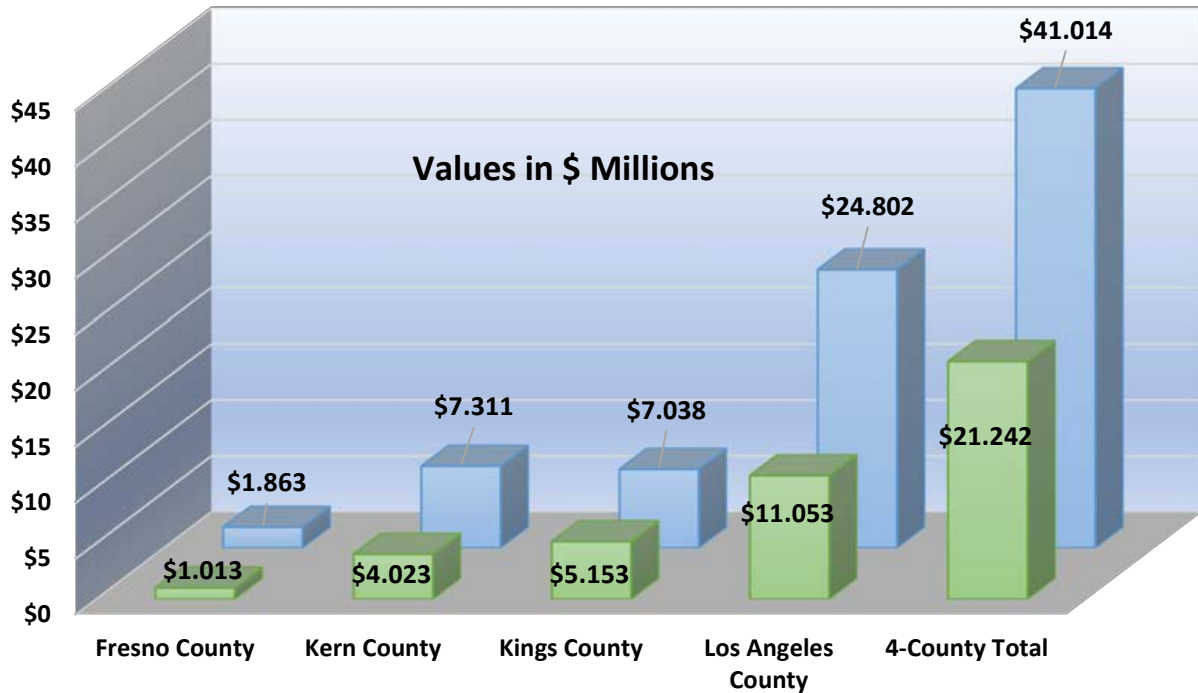


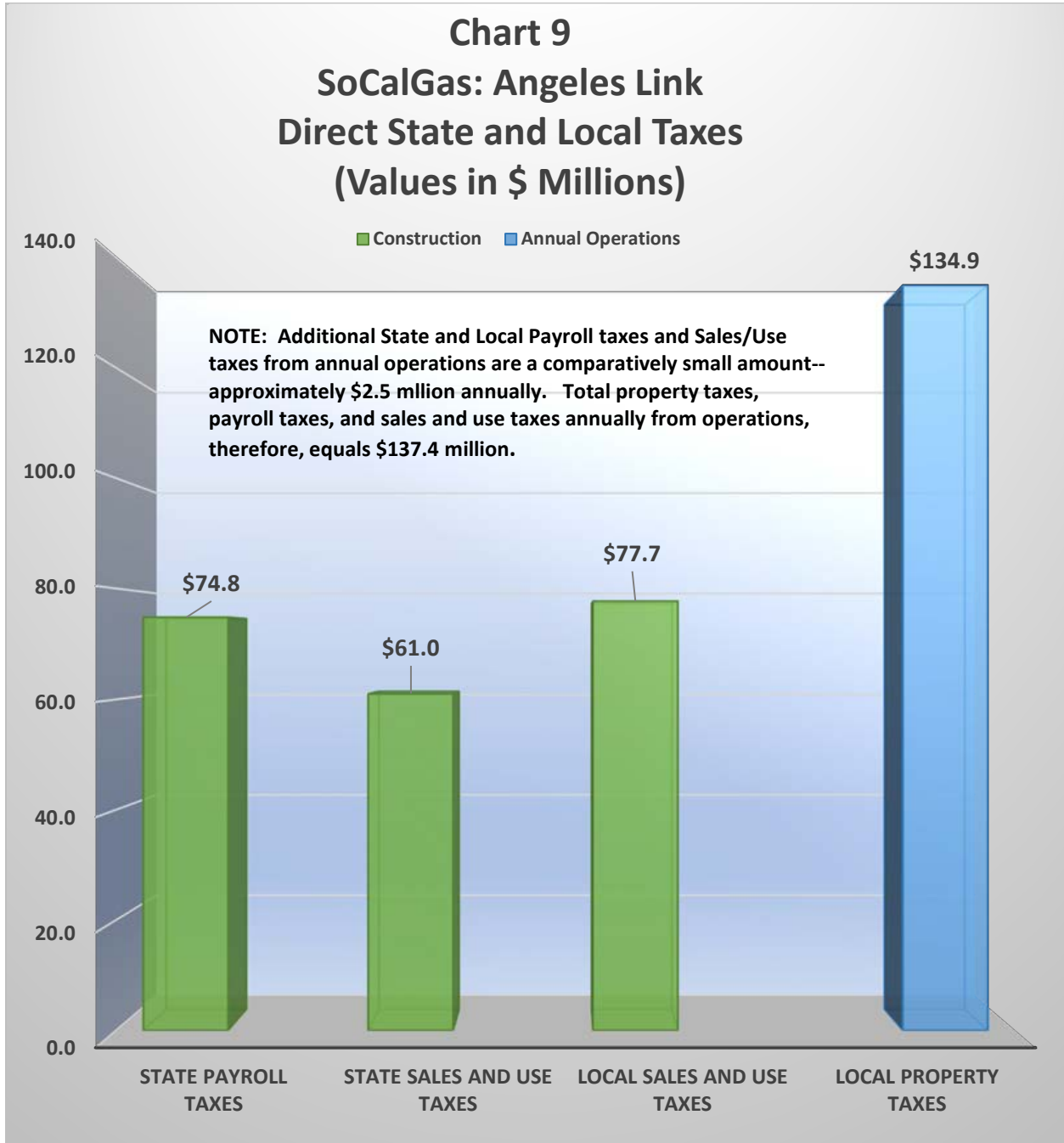
Chart 8 SoCalGas: Angeles Link Annual Operating Labor Income per Job Created

Note: Labor Income includes benefits, payroll taxes and proprietor income



Payroll, Sales, and Property Tax Revenue: State of California and Four Counties

Chart 9 indicates the payroll, sales and property tax revenue that is estimated to be received by the State and the four counties during construction and then from annual operations of Angeles Link.



During construction, it is anticipated that the State of California could receive at least \$74.8 million in payroll taxes and \$61.0 million in sales and use taxes. It is also anticipated that local governments could receive \$77.7 million in sales and use taxes during the construction period. Annual operations could generate \$134.9 million in local property taxes. A smaller amount of annual payroll and sales/use taxes (approximately \$2.5 million annually) could accrue to the State and local governments from operations. These estimates are based on the following facts and assumptions.

State payroll taxes consist of three components:

- Unemployment Insurance (UI) paid by the employer at a rate of 1.5%-to-6.2% of the first \$7,000 received by the employee in any given calendar year. Using the initial rate that new employers pay of 3.4%, this computes to \$238 per employee per year. Some construction workers will work in more than one year and others will be part-time. Accordingly, the estimated number of construction period direct, indirect, and induced workers (74,775) will likely be lower than the number of workers for whom the tax is ultimately payable. Assuming that there are 1.5 times more annual workers for whom unemployment insurance is paid than the IMPLAN estimate for total jobs created, it can be very conservatively estimated that approximately \$357 will be paid to the State for each of the IMPLAN estimated 74,775 workers during the five-year construction period. That computes to approximately \$26.7 million in State of California Unemployment Insurance taxes during construction and an additional \$0.14 million annually during operations.²⁷
- Employment Training Tax (ETT) for the State is 0.1% of the first \$7,000. Again, using the 1.5 worker factor for the construction period, this computes to \$7.8 million during construction.²⁸ Annual operations are a modest \$0.04 million.

²⁷ 399 direct, indirect, and induced annual workers * \$357

²⁸ 74,755*(.01*7,000)*1.5

- State Disability Insurance Tax (SDI). Beginning January 1, 2024, this tax is set at 1.1% of earnings, with no limit on earnings for tax purposes. As discussed above, this report estimates construction period labor income at \$5.3 billion. Recognizing that this amount includes payroll taxes, benefits, and proprietor income, 75% of this total will be estimated to be taxable earnings, resulting in \$43.7 million in SDI during construction and \$0.68 million for annual operations²⁹.
- Total State payroll taxes from these three taxes during construction are, therefore, estimated to equal \$78.2 million, with an additional \$0.86 million annually from operations (**Chart 9**).

Sales and Use taxes are received by both the State and Local governments. The total amount depends upon where the goods are purchased (California county, other states, international) and if the goods are taxable at all. That said, past studies that the author has conducted for various California utilities, among others, indicates that sales and use taxes during construction have averaged approximately 1% of the total economic impact. The basic sales tax rate in California is 7.25%; however, localities can add up to 3% to this tax for local purposes. As such, the average sales tax rate in the State is presently 8.56%. Of this amount, 3.9375% goes to the State General Fund, 1% goes to the jurisdiction in which the sale took place, 1.5625% goes to counties for health and social welfare programs, 0.5% goes to cities and counties for public safety and 0.25% goes to counties for transportation. The difference between the 7.25% basic rate and 8.56% average actual sales tax rate represents an additional 1.31% for localities. As such, the 1% construction period sales and use tax estimate (\$138.7 million)³⁰ is allocated in this analysis 44% to the State (\$61.0 million) and 56% to localities (\$77.7 million)—**Chart 9**. Sales and Use taxes from annual operations is estimated to total \$1.67 million (.73 million to the State and .94 locally).

²⁹ A commonly used formula to calculate employee cost was first coined by Massachusetts Institute of Technology senior lecturer and Main Street Partners LLC Managing Director Joseph Hadzima. Hadzima proposes in the Boston Business Journal that the true employer cost for an employee is between 1.25 and 1.4 times the worker's base salary. This includes per-employee payroll taxes and employee benefits costs and yields an estimate of 70%-80% of the total cost being base salary.

³⁰ 1% * \$13.87 billion direct, indirect, and induced impact

Property taxes represent the largest source of revenue for localities. The State receives almost no property tax revenue; property tax is dedicated to school districts, counties, and city governments, and selected special districts. Property tax rates in California are 1% of the assessed value; however, local governments may add local property tax increases subject to approval by voters. The average tax rate in Los Angeles County is 1.64%, Kern County is 1.48%, Fresno County is 1.37%, and Kings County is 1.05%³¹. Applying these percentages to the construction value and assuming no additional real property construction or acquisitions as part of the indirect and induced impacts, property taxes from annual operations are estimated to be \$134.9 million per year to local governments³².

STATEMENT OF INDEPENDENT RESEARCH

Richard A. Parker, Ph.D. is President of Rea and Parker, Incorporated dba Rea & Parker Research. Rea & Parker Research is committed to independent, nonpartisan research and publication, and to maintaining the highest level of integrity in pursuit of this mission. Results were derived from an economic impact model developed using IMPLAN economic multiplier data and methodology.

Rea & Parker Research is an economic and survey/market research consulting firm based in San Diego, California. Rea & Parker Research was founded by Richard A. Parker, Ph.D. and Louis M. Rea, Ph.D. in 1984 and has grown into a well-respected, financially stable, and substantial research organization with clients throughout the State of California and the Southwest. Dr. Parker is President of Rea & Parker Research and Dr. Rea presently serves Rea & Parker Research in an occasional “of counsel” role for survey research only.

Rea & Parker Research has extensive experience in public and urban affairs regarding the collection and analysis of economic, demographic, attitudinal, and market-related data through

³¹ <https://trends.ownwell.com/>

³² \$77.8 million Los Angeles County, \$31.4 million Kern County, \$19.1 million Kings County, and \$6.6 million Fresno County.

survey research, focus group analysis, and the application of statistical impact models. Dr. Parker, in particular, is a highly regarded economic consultant, especially in the areas of economic and employment impact analysis, fiscal impact analysis, urban economic development, and site specific commercial, retail, and residential financial and economic evaluation.

THE AUTHOR

- *Richard A. Parker, Ph.D.* is President of Rea & Parker Research and is Professor Emeritus in the School of Public Affairs at San Diego State University where he continues to teach graduate and undergraduate courses in statistics, survey research, urban economic development, public policy, and finance. He possesses extensive analytical experience in statistical survey research, market analysis, land use, real estate development and valuation, and transportation and water issues.
- Dr. Parker is a graduate of Brown University and the University of California--Berkeley. He earned degrees in Business Administration from those institutions (Bachelor of Science and Master of Business Administration (MBA)). He also possesses a graduate degree in City Planning (Master of City Planning) from San Diego State University and a Ph.D. in Business from UCLA and Pacific Western University.
- Dr. Parker specializes in fiscal impact studies, urban development, economic impact modeling, job generation and socioeconomic and demographic analyses. He has consulted in these fields for many public utilities, transportation agencies, general governmental agencies and legislative bodies, private development--residential, retail, hospitality, American Indian economic development, and public/affordable housing development and finance, among many others.
- Dr. Parker has published a variety of articles, monographs, and books on these subjects, received the Bernays Mark of Merit for Special Purpose Publications, and was named as one of the top 50 alumni from the School of Public Affairs at San Diego State. He has participated in various panel discussions, delivered expert testimony to legislatures and to courts of law, and has appeared on several radio and television programs.