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Strategic Water Supply

Feasibility Study

Revised Draft

*Developed by:*

New Mexico Environment Department

Eastern Research Group, Inc.



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EXECUTIVE SUMMARY

Governor Michelle Lujan Grisham announced her intention to establish a Strategic Water Supply (SWS) at the 2023 United Nations Climate Change Conference. The SWS would incentivize private sector investment in the development of treatment facilities for deep non-potable brackish water and produced water resources through commitments to purchase treated water for specific industrial end uses, supporting the transition to renewable energy and advanced manufacturing. For example, the SWS serves to decrease our reliance on limited freshwater resources as New Mexico increases its use of carbon-free energy pursuant to the 2019 Energy Transition Act.

This feasibility study presents an analysis of the technical and economic viability of the proposed New Mexico SWS, including considerations for the use of incentives to attract private sector participation in the initiative. The study is limited to consideration of industrial end uses under two scenarios that reflect expectations for development of relevant regulations: closed-loop projects with no environmental discharge of treated water (near term) and projects with environmental discharge (longer term). The focus of the study is to define project characteristics, such as locations and end uses, that appear to have a good fit with the objectives and scope of the SWS initiative. The study is also intended to inform the level of funding needed for the initiative as well as a future request for proposals (RFP) from potential participants in the initiative.

The study explores technical issues related to produced water and brackish water resources, potential end uses, treatment, transportation and storage, brine and residuals management and economic feasibility.

# INTRODUCTION

## Purpose

This feasibility study presents an analysis of the technical and economic viability of the proposed New Mexico SWS, including considerations for the use of incentives to attract private sector participation in the initiative. The study is limited to consideration of industrial end uses under two scenarios that reflect expectations for development of relevant regulations: closed-loop projects with no environmental discharge[[1]](#footnote-2) of treated water (near term) and projects with environmental discharge (longer term). The focus of the study is to define project characteristics, such as locations and end uses, that appear to have a good fit with the objectives and scope of the SWS initiative. The study is also intended to inform the level of funding needed for the initiative as well as a future request for proposals (RFP) from potential participants in the initiative.

## Context

Developing alternative water sources is a necessity to preserve fresh water and crucial for New Mexico's economic and environmental sustainability, as the state faces declining surface water and groundwater supplies related to climate change and usage patterns.[[2]](#footnote-3) Water shortages have devastating consequences for the state's communities and economy. The development of alternative water sources would also enable the state to attract new industries that are currently constrained by water availability, such as renewable energy, advanced manufacturing, and other opportunities. These industries could create new jobs, increase tax revenues, and diversify the state's economy while preserving freshwater resources.

New Mexico will have approximately 25 percent less water available in rivers and aquifers by the year 2072, which equates to a 750,000 acre feet shortfall when applying water usage rates from the past decade.[[3]](#footnote-4) Annual demand for water has been projected to increase by nearly 440,000 acre-feet between 2010 and 2060 under a high-growth scenario, with the highest increases in the San Juan Basin planning region, followed by the Middle Rio Grande planning region (Figure 1). The SWS is part of the State’s broader 50-Year Water Action Plan that addresses increased demand and reduced supplies in the future, which includes water conservation, new water supplies, and water and watershed protection.

Underground reserves of brackish water and wastewater from the oil and gas industry represent two major untapped water resources that offer the potential to offset reliance on freshwater resources with appropriate regulatory controls to protect the environment and human health. It has been estimated that between two and four billion acre-feet of brackish water exists in New Mexico’s brackish aquifers,[[4]](#footnote-5) though information about the quality and volume of water in these aquifers is vastly inconsistent throughout the State due to a lack of aquifer characterization studies for the majority of deep and shallow aquifers in NM. The deep brackish water aquifers[[5]](#footnote-6) in New Mexico are almost entirely undeveloped. The New Mexico oil and gas industry disposes of approximately 85 million gallons per day of produced water,[[6]](#footnote-7) a byproduct of oil and gas production.[[7]](#footnote-8) These alternative water sources require appropriate treatment prior to use, which is becoming more feasible through technological advances in water treatment technology.

Figure 1. Projected increase in demand from 2010 to 2060, High Projection[[8]](#footnote-9)

A map of different regions

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With the SWS, New Mexico would join other states and countries in efforts to develop brackish water resources and reuse treated produced water. Several countries in the Middle East and North Africa have prioritized desalination projects that enable the use of brackish water for agriculture and potable use. Small scale projects using treated produced water for beneficial uses have been completed in Colorado, Wyoming and Oklahoma. Treated produced water is regularly released to surface water in Pennsylvania, while permits have allowed treated produced water discharge in Arkansas and West Virginia. These examples of treatment and use of brackish and produced water are explored in additional detail below.

## Description of Strategic Water Supply

The proposed SWS would address the challenge of decreasing water supplies through the development of alternative water resources, with the intention of supporting New Mexico’s transition to renewable energy and advanced manufacturing, making water available for these expanding and emerging industrial uses. The SWS would offer an incentive to private sector participants, in the form of a commitment to selected businesses to purchase treated water, at specified qualities and quantities, that would reduce the risk of investments needed to build and operate water treatment facilities.

This effort promises to address the needs of New Mexico communities to have access to freshwater resources. By alleviating industrial demand for freshwater with treated produced and brackish water, competition for this vital resource between industry, agriculture, and residential consumers can be reduced. At the same time, the SWS can support economic development to sustain the New Mexico economy into the future, bringing jobs in advanced manufacturing and other sectors to the state. The SWS would also address concerns about current practices with respect to disposal of produced water from the oil and gas industry, especially seismicity related to deep well injection that may lead to restrictions on the practice and have potentially severe impacts on the industry and the state economy.

## Approach

This feasibility study is based on several sources of information. Earlier this year, the New Mexico Environment Department (NMED) issued a Request for Information (RFI) to gather technical and economic information from individuals, businesses, academia, government agencies and other stakeholders related to the sourcing, treatment, delivery, storage and industrial uses of brackish water and produced water. Fifty responses were received, and the information from those responses is incorporated into the analysis. In addition, meetings with potential SWS participants, New Mexico state government officials and other stakeholders were used to enhance understanding of the technical, regulatory and practical issues relevant to the initiative. On June 27, 2024, NMSU hosted “Strategic Water Supply: State of the Science Symposium,” bringing together academic researchers, industry, legislators, tribal leaders, non-governmental organizations and other stakeholders to discuss the available research results relevant to the development of the SWS. Finally, other available information in published research or other sources were leveraged to inform the study.

The focus of the study is to define project characteristics, such as locations and end uses, that appear to have a good fit with the objectives and scope of the SWS initiative. Location will be a critical factor for SWS projects given the high cost of transportation for water. Therefore, ideally, project locations would have the following characteristics:

* **Water Source:** By locating treatment facilities in proximity to water sources, transportation costs can be minimized. In addition, the water quality of different sources may facilitate different project types.
* **Labor Force:** Depending on the project type, the availability of a labor force with necessary qualifications will be needed for both the treatment facility and end users.
* **End Users:** Project locations should also be in proximity to the treatment location, also to minimize transportation costs.
* **Infrastructure:** Infrastructure needs will also depend on the project type and might include transportation infrastructure for end products as well as access to the electricity grid to support treatment facilities and end users.

Figure 2 provides a simplified illustration of the intersection of these key project characteristics that would be desirable for SWS projects.

Figure 2. Intersection of desirable SWS project location characteristics

A diagram of a diagram of water supply

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Below, we discuss produced and brackish water sources in turn, followed by discussions of other aspects of potential SWS projects. As mentioned above, the study considers two scenarios that reflect expectations for development of relevant regulations: closed-loop projects with no environmental discharge (near term) and projects with environmental discharge (longer term). The study concludes with identification of opportunities for project types in specific locations and associated challenges, applying the lens of desirable key project characteristics described above.

# Produced Water

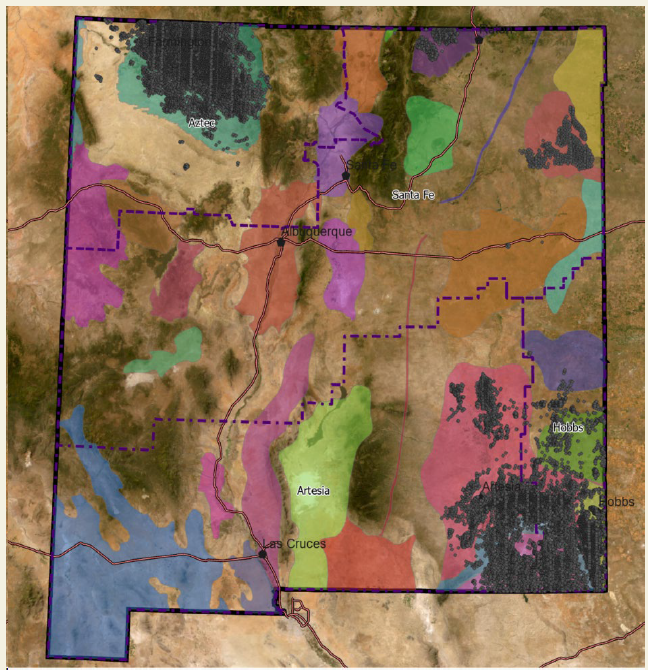
## Description

Produced water is a byproduct of oil and gas drilling and production that primarily consists of naturally occurring highly saline water but may also include the fluids (i.e., “flowback”) that are initially returned in the first few weeks after a well is hydraulically fractured. After the initial flowback period, the produced water transitions to naturally occurring formation waters. In general, four to seven barrels of produced water are generated for every barrel of oil produced.[[9]](#footnote-10) Produced water quantity and quality varies significantly depending on the formation from which it is extracted. In the San Juan Basin of New Mexico, produced water is lower in salinity than in the Permian Basin of New Mexico. Produced water requires treatment prior to reuse.

## New Mexico produced water resources

As produced water is a byproduct of oil and gas production, this section begins with some background on New Mexico’s oil and gas industry. New Mexico is the nation’s second largest crude-oil producing state, after Texas, accounting for 14 percent of total U.S. crude oil production in 2023.[[10]](#footnote-11) Oil and gas extraction accounted for 9 percent of NM GDP in 2022[[11]](#footnote-12), not including any indirect or induced impacts associated with the industry. According to the New Mexico Bureau of Geology and Mineral Resources, oil and gas production is primarily in the Permian Basin in the southeast (Lea, Eddy, Chaves, and Roosevelt Counties) and the San Juan Basin in northwestern New Mexico (San Juan, Rio Arriba, Sandoval, and McKinley Counties) (Figure 3). The Permian/Delaware is focused on oil production, with the San Juan basin generally producing more dry natural gas[[12]](#footnote-13). However, due to the associated gas that is produced with the increased emphasis on crude oil in the Permian Basin, the Permian Basin produces significantly more gas currently than the San Juan Basin[[13]](#footnote-14). As of 2023, 16 percent of gas was produced from the San Juan Basin, and 84 percent was from the Permian Basin.[[14]](#footnote-15) For 2023 oil production, 98 percent was from the Permian Basin, and 2 percent was from the San Juan Basin.[[15]](#footnote-16)

Figure 3. Active wells and hydrocarbon basins in New Mexico.[[16]](#footnote-17)



A December 2023 analysis performed by New Mexico’s State Investment Council forecasts that, barring a significant decline in the average price of oil, production will likely reach a peak of around 800 million barrels per year around 2030. The optimistic scenario projects peak production to reach 1 billion barrels per year (Figure 4).[[17]](#footnote-18)

Figure 4. New Mexico oil production projections[[18]](#footnote-19)

A graph showing the price of oil

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Notes: Y-axis is millions of barrels of oil; WTI-West Texas Intermediate, a commonly used benchmark used in the oil commodity market.

### Produced water volumes

With oil and gas production trends, the volume of produced water generated by the oil and gas industry has increased by a factor of about 2.4 from 2017 to 2023; data from the New Mexico Oil Conservation Division (OCD) indicates a total estimated volume for 2023 exceeding 2 billion barrels[[19]](#footnote-20). The increased volume of produced water is driven by activity in the Permian (Table 1). Approximately 87 times more produced water is generated in the Southeast (Permian) oil and gas production areas than in the Northwest (San Juan); activity in the Permian generates 99% of the state’s produced water[[20]](#footnote-21). Data in Figure 5 and Figure 6 show trends in the total volumes of produced water as well the volumes injected for disposal or other purposes (e.g., secondary oil recovery)[[21]](#footnote-22) from 2017-2023. If oil production continues to increase in the Permian, produced water volumes will also increase.

A caveat regarding produced water volumes is that reported values in the state database can be updated by tens of millions of barrels even months or years after the 45-day lag period specified in the reporting requirements[[22]](#footnote-23). With the much larger produced water volumes in the Permian, such changes are less likely to obscure large-scale increases or decreases than in the San Juan.

Table 1. Produced water volumes and injected\* volumes 2017-2023[[23]](#footnote-24)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **PW NW Oil Wells (bbls)** | **PW NW Gas Wells (bbls)** | **% PW from Oil Wells** | **% PW from Gas Wells** | **Total PW (NW) (bbls)** | **Injected NW  (bbls)** | **Injected NW  (bbls)** |
| 2017 | 2,768,333 | 30,172,152 | 8 | 92 | 32,940,485 | 22,788,439 | 69% |
| 2018 | 3,027,168 | 20,708,727 | 13 | 87 | 23,735,895 | 23,250,850 | 98% |
| 2019 | 5,227,376 | 33,556,791 | 13 | 87 | 38,784,167 | 26,145,527 | 67% |
| 2020 | 4,361,311 | 31,639,771 | 12 | 88 | 36,001,082 | 22,608,646 | 63% |
| 2021 | 6,220,095 | 16,374,183 | 28 | 72 | 22,594,278 | 24,037,871 | 106% |
| 2022 | 6,220,095 | 19,222,501 | 24 | 76 | 25,442,596 | 27,949,590 | 110% |
| 2023 | 7,933,236 | 16,135,828 | 33 | 67 | 24,069,064 | 25,314,274 | 105% |
| **Year** | **PW SE Oil Wells (bbls)** | **PW SE Gas Wells (bbls)** | **% PW from Oil Wells** | **% PW from Gas Wells** | **Total PW (SE) (bbls)** | **Injected SE  (bbls)** | **Injected SE  (bbls)** |
| 2017 | 768,047,215 | 74,945,196 | 91 | 9 | 842,992,411 | 773,100,908 | 92% |
| 2018 | 888,097,670 | 121,446,563 | 88 | 12 | 1,009,544,233 | 834,592,835 | 83% |
| 2019 | 1,052,941,499 | 210,265,513 | 83 | 17 | 1,263,207,012 | 935,088,753 | 74% |
| 2020 | 1,015,442,900 | 297,627,274 | 77 | 23 | 1,313,070,174 | 932,684,928 | 71% |
| 2021 | 1,204,830,263 | 382,507,921 | 76 | 24 | 1,587,338,184 | 955,901,679 | 60% |
| 2022 | 1,496,753,760 | 539,151,516 | 74 | 26 | 2,035,905,276 | 993,978,295 | 49% |
| 2023 | 1,562,082,322 | 540,265,233 | 74 | 26 | 2,102,347,555 | 1,000,028,416 | 48% |

Note: PW=produced water, NW=Northwest (San Juan), SE=Southeast (Permian), bbls=barrels.

\* Injected volumes do not differentiate between injection for disposal and injection for enhanced recovery.

Figure 5. Produced water volumes in the Permian and San Juan Basins

Figure 6. Produced water injection volumes in the Permian and San Juan Basins

### Produced water quality

Total dissolved solids (TDS) is the most commonly cited water quality parameter for produced water because of its importance in oil and gas operations and in the management of the produced water. However, produced water is a complex mixture with a number of constituents of concern that can be naturally occurring or introduced in as additives in fracturing fluids:[[24]](#footnote-25), [[25]](#footnote-26), [[26]](#footnote-27)

* Suspended solids, oils, and grease
* Salts (dissolved solids)
* Dissolved organics (e.g., petroleum hydrocarbons, volatile and semi-volatile compounds)
* Metals
* Dissolved gasses (e.g., H2S, NH3)
* Naturally occurring radioactive material
* Chemical additives for hydraulic fracturing
* Microorganisms

The chemical additives for hydraulic fracturing fluid themselves comprise an extensive list of ingredients added to fracturing fluids in low concentrations: acids, biocides, breakers, clay stabilizers, corrosion inhibitors, scaling inhibitors, non-emulsifiers, iron control agents, gelling agents, friction reducers, and cross-linkers[[27]](#footnote-28). Some additives are claimed to be confidential business information, limiting the amount of information about them that is publicly available. This also makes it more difficult for investigators to perform a full characterization of the flowback portion of the produced water because some specific constituents are unknown.

Publicly available produced water chemistry data in New Mexico are relatively limited, including in terms of the water quality parameters and analytes. Basic produced water data in New Mexico can be obtained from the New Mexico Produced Water Data Portal, created by the New Mexico Produced Water Research Consortium (NMPWRC). It is a free and publicly accessible database of all currently available produced water quality and quantity data in New Mexico. The portal currently accesses data for quarter townships, with monthly data on produced water quantities as well as available data on water quality.[[28]](#footnote-29) The portal allows for displaying trends for a number of parameters and constituents (TDS, turbidity, pH, total organic carbon, sodium, chloride, total petroleum hydrocarbons, gross alpha and beta, uranium, thorium); all of these are not available for all entries.

The U.S. Geological Survey (USGS) maintains the National Produced Waters Geochemical Database.[[29]](#footnote-30) Information is from a variety of sources, but most of the New Mexico data were obtained from the former NM WAIDS website[[30]](#footnote-31). The database can accommodate entries for large number of organic and inorganic constituents, but most New Mexico entries do not have comprehensive data, however, and many samples do not have all major ions. The most recent sampling dates for the Permian and San Juan entries are 2001 and 2004, respectively, and they are from conventional oil and gas wells (current Permian production is primarily unconventional, and significant hydraulic fracturing occurs in the San Juan as well). Data from the USGS PWDB does, however, illustrate the higher TDS in the Permian compared to the San Juan (Table 2). It also illustrates the variability as the samples come from various formations within each basin.

Other analyses show similar trends. An analysis of 46 produced water samples from unconventional operations in the Permian Basin yielded TDS concentrations ranging from 100,830 – 201,474 mg/L, with a mean of 128,651 mg/L[[31]](#footnote-32). In the San Juan, researchers used the New Mexico Produced Water Quality Database (vs), noting that, “Median TDS in the San Juan is less than 15,000 mg/L in contrast to the Permian, where it exceeds 100,000 mg/L.” [[32]](#footnote-33) For comparison, fresh water is generally considered to have a TDS less than 1,000 mg/L, with EPA’s secondary drinking water standard (not mandatory or enforceable) for TDS set at < 500 mg/L.[[33]](#footnote-34)

Table 2. Total Dissolved Solids (TDS) Data for Produced Water from Conventional Wells in the Permian and San Juan Basins in New Mexico. Record from the USGS National Produced Waters Geochemical Database[[34]](#footnote-35).

|  | **Permian Basin** | **San Juan Basin** |
| --- | --- | --- |
| No. records | 7,847 | 2,744 |
| Date range | 1928-2001 | 1917-2004 |
| Mean (mg/L) | 90,344 | 20,512 |
| Median (mg/L) | 62,098 | 14,156 |
| 90th percentile (mg/L) | 216,394 | 40,822 |
| 10th percentile (mg/L) | 9,200 | 2,386 |

The TDS and other basic water quality data do not address concerns over the many possible other constituents in produced water and the implications for treatment and possible health implications should discharge be eventually permitted. Recent work by NMPWRC researchers has begun to address the need for thorough chemical analyses of produced water. A 2022 study characterized Permian Basin produced water, analyzing for >300 analytes including organics, inorganics, and radionuclides[[35]](#footnote-36). In fourteen produced water samples from unconventional wells in the Delaware (Permian) Basin in NM, ninety-one of the >300 analytes were detected. . The mean ammonia concentration was 432 mg/L. Several radionuclides were detected (Ra, U, Th, Po, and Pu), a mean level of 469.3 pCi/ for total Ra (Ra-226+Ra-228). Targeted analysis of organic compounds yielded concentrations for 28 compounds. The highest VOCs were BTEX, although some volatile compounds may have been lost during transit and storage. Other compounds quantified were SVOCs (phenol and pyridine with highest concentrations), and alcohols (methanol, ethanol). Diesel-range organic, gasoline-range organics, and motor oil-range organics were also identified. In one sample, five PFAS compounds were detected. Because these samples had been treated for injection for disposal, some compounds may not have been associated with hydraulic fracturing fluid. This study illustrates the range of compounds that can be present and the need for additional sampling, including raw produced water before any treatment.

A composite geochemical database for coalbed methane produced water quality in the Rockies included more than 600 data points in the San Juan Basin, with data for metals, radionuclides, and limited hydrocarbons[[36]](#footnote-37). Total recoverable hydrocarbon was detected, as well as BTEX.

### Produced water variability

Both produced water volumes and chemistry can vary both geographically (e.g., by geologic formation, between basins, depending on hydraulic fracturing fluid ingredients) and temporally (i.e., how long after fracturing the samples are taken). When a well is hydraulically fractured, the initial flowback water is more dilute immediately after fracturing than a few weeks later, and the composition of the eventual, routinely produced water can be significantly different, including much more saline. The initial flowback rate can also be higher than the rate of produced water generation during the well’s production phase.

As examples of efforts to determine variability, a principal components analysis of a coalbed methane produced water database tied variability in produced water quality to the geology and geochemistry of the coalbed formations as well as recharge[[37]](#footnote-38). For volume, OCD data show that within the same district, total produced volumes can vary significantly among operators[[38]](#footnote-39).

Assessment of variability is needed to assess treatment needs and reuse options. However, some of the variability in quantity and quality will be dampened during aggregation of produced water from multiple producers by mid-stream oil and gas produced water companies. With networks of piping for transport of produced water, storage capabilities, and the ability to treat the water and handle management (e.g., including recycling and disposal), mid-stream companies can service several operators. While many producers manage their own produced water, mid-stream providers play a significant role in produced water management in NM, and continued growth is expected[[39]](#footnote-40). Where produced water is managed by such a provider detailed analyses at individual production sites may have received less attention than monitoring the quality of the aggregated produced water. However, this also means that contaminants will be introduced and pooled during aggregation, including any that were not anticipated and not included in a targeted list of analytes for the waters.

## Current practices for produced water management in New Mexico

Produced water in New Mexico may be managed by injection for disposal via salt water disposal (SWD) wells (Figure 7); injection for enhanced oil recovery; reuse for drilling, well work, well stimulation (including hydraulic fracturing), or other facility uses; and pitting and evaporation. As noted above, mid-stream companies handle significant amounts of produced water in New Mexico, managing any necessary treatment and conveyance for disposal or reuse. The exact percentages of produced water managed by mid-stream providers vs. producers is not readily available.

Produced water management differs between the Permian and San Juan basins. OCD data show that the estimated percentage of produced water injected in 2023 is higher in the San Juan than in the Permian, where the injected proportion has decreased from 92 percent in 2017 to 48 percent in 2023, despite increases in volumes (Table 1)[[40]](#footnote-41). The OCD data are, however, limited in not differentiating between injection for disposal and injection for secondary oil recovery. Produced water volumes and injection volumes are both increasing in the Permian, while the San Juan data for 2017-2023 show increases and decreases but not a consistent trend.

Recycling of produced water for use in oil and gas production has increased in the Permian due to advances in industry practice, technological advances, and freshwater scarcity. The New Mexico OCD data for injection volumes in Table 1 do not include volumes reused for new well stimulation, and injection is understood to include only injection within NM. The decreased percentage of produced water that is injected in the Permian (Table 1) indicates increased use of other means of management, such as reuse for new well stimulation or transport to Texas for disposal via injection. OCD data on water use for stimulation of new wells specifies volumes of produced water used[[41]](#footnote-42) and can be compared to total produced water to estimate the percentage of produced water reused for new well stimulation. In 2023, about 223 million barrels of produced water were used in well stimulations out of approximately 2.126 billion barrels of produced water generated. This indicates that approximately 11% of produced water was reused for new well stimulation. In 2021 and 2022, 12% and 13% of produced water was reused, respectively.

The combination of injected and reused produced water does not account for all produced water generated. The remaining percentages (27% for 2021, 37% for 2022, and 41% for 2023) may correspond to produced water transported for injection into SWD wells in Texas. According to a 2023 news article, an estimated 34% of the produced water from the Delaware Basin in NM was being sent to TX for disposal via SWDs. The associated volume is 1.8 million barrels of produced water per day. The magnitude of this practice is causing induced seismicity in the basin and necessitating restrictions[[42]](#footnote-43).

Reuse estimates vary with the method of estimation and definitions of categories. The results of a questionnaire to state agencies by the Ground Water Protection Council (GWPC) indicated that in 2021, 20.2 percent of produced water in New Mexico was reported to be reused within the oil and gas industry for drilling, well work, well stimulation or other facility uses (see Table 2).[[43]](#footnote-44) The GWPC statistics also indicate that a small portion of produced water in the state is evaporated in lined pools (Table 3), although this is believed to be higher. The GWPC data indicate that 717 million bbl were injected during 2021, which is less than reported in the OCD data in Table 1.

Table 3. Produced water management practices for New Mexico - 2021[[44]](#footnote-45)

|  |  |  |
| --- | --- | --- |
| **Management Practice** | **Total Volume of Produced Water Managed by that Practice (bbl/year)** | **Percentage of Produced Water Managed by that Practice** |
| Injection for Disposal by Operator | 717,435,541 | 79.6% |
| Evaporation | 1,762,644 | 0.2% |
| Reuse Within the Oil & Gas Industry | 181,970,412 | 20.1% |
| Other | 29,225 | <0.01% |
| TOTAL | 901,197,822 | 100% |

Notes: Other represents the volume of produced water that was spilled and not recovered.

Figure 7. Locations of gas, oil, and salt water Disposal wells in the San Juan and Permian Basins[[45]](#footnote-46).

A map of a desert with red and blue spots

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## Produced water management in other states and countries

Other major oil and gas producing states use a variety of strategies for produced water management. Texas produced the largest quantity of crude oil and natural gas in the nation in 2022.[[46]](#footnote-47) In 2021, total produced water volume in Texas was estimated at 8,107,645,550 bbls (approximated from volumes handled via various management practices)[[47]](#footnote-48). According to Texas Railroad Commission data compiled by GWPC (2022), most produced water is injected. In 2021, about 43.7% of produced water was injected for disposal by the operators, 32.1% was used for secondary oil recovery, and 32.1% was injected for disposal at commercial facilities[[48]](#footnote-49). No produced water was reported as having been used for beneficial reuse in 2021.

Arizona’s produced water production has decreased in recent years. The amount of actively producing wells has also declined. In 2021, produced water volume in Arizona totaled 10,715 bbls, with 100 percent of produced water being injected for disposal.[[49]](#footnote-50) Oklahoma was the nation’s sixth-largest producer of natural gas and crude oil in 2023.[[50]](#footnote-51) In 2021, total produced water volume in Oklahoma was 1,744,894,591 bbls. About 56 percent of produced water was injected for secondary recovery, 30 percent was injected for disposal by the operator, and 14 percent was injected for disposal commercially or offsite.[[51]](#footnote-52) Colorado was the nation’s fourth-largest producer of crude oil and eighth-largest producer of natural gas in 2022.[[52]](#footnote-53) In 2021, total produced water volume in Colorado was 280,460,737 bbls. Colorado’s produced water management approaches vary more than other states’, with 56 percent of produced water injected for disposal by the operator, 31 percent injected for secondary recovery, 7 percent reused within the oil and gas industry, 5 percent discharged to surface waters, 1.6 percent injected for disposal by a third party, and less than 0.01 percent evaporated or infiltrated by unlined sump.[[53]](#footnote-54)

In Kern County, California, treated produced water has been used to irrigate crops, including food crops.[[54]](#footnote-55) The produced water is treated by oil producers and then is sent to local water districts. The local water districts then blend the treated produced water with other sources before sending it to agricultural users for irrigation.[[55]](#footnote-56) The four local water districts that use treated produced water monitor the quality of the water and are overseen by the regional water board[[56]](#footnote-57) [[57]](#footnote-58). However, there are some caveats with this reuse worth noting. Produced water from hydraulically fractured wells is not allowed to be used for agricultural purposes. Additionally, produced water in California generally has a higher starting quality than New Mexico’s produced water[[58]](#footnote-59). TDS in California’s produced water ranges from less than 2,000 mg/L to over 30,000 mg/L[[59]](#footnote-60), with Kern County produced water often under 10,000 ppm[[60]](#footnote-61); this is significantly less saline than produced water from the Permian Basin and generally less saline than San Juan Basin produced water.

Produced water from coal-bed methane in Wyoming can be discharged to surface waters[[61]](#footnote-62) and is also used for irrigation and livestock.[[62]](#footnote-63) Wyoming’s coal-bed methane produced water typically has a very high starting quality; entries for the Powder River Basin in the USGSPWDB[[63]](#footnote-64) indicate a median TDS of about 7,000 mg/L. Produced water with relatively low TDS values may require minimal or in some cases no treatment in order to be safely used in discharge applications.

A few companies have received National Pollution Discharge Elimination System (NPDES) permits for treated produced water in other states. Fairmont Brine Processing had an NPDES permit for its produced water treatment plant in West Virginia that began operating in 2014, but the plant was closed in 2018.[[64]](#footnote-65) Southwestern Energy received a permit to discharge treated produced water into the White River in Arkansas, but the operation was closed due to high operating costs. Eureka Resources has a produced water treatment plant in Wysox, Pennsylvania that has a permit to discharge into the Susquehanna River after extracting salts and disposing of other contaminants separately.[[65]](#footnote-66)

## Additional information needs and ongoing efforts to support development of produced water resources

It is acknowledged that additional data are needed to better understand produced water quality and how it varies over space and time to inform the development of treatment technologies and management approaches.[[66]](#footnote-67) Existing publicly accessible do not contain the needed level of information for the San Juan and Permian/Delaware basins in New Mexico. Where present, data often include primarily inorganic constituents, sometimes only TDS concentrations. As noted in Section 2.2.2, a large number of inorganic and organic constituents can occur in produced water.

In addition to a broader suite of metals and organics, researchers specifically note the need for determining PFAS and radionuclide concentrations, including temporal and spatial distributions.[[67]](#footnote-68) Concern has also arisen that constituents of concern may be missed even in more thorough analyses because they are not expected or claimed as proprietary (for hydraulic fracturing additives) and therefore not included in a targeted analyte list.

Assessment of toxicity is also needed for produced water assessment. While less crucial for a closed-loop reuse scenario, toxicity information is a valuable complement to chemical analyses, especially if discharge of treated produced water is an eventual possibility. A 2020 study developed a framework for identifying constituents of concern in produced water. The study used toxicological hazard data to build the framework, and one of the observations was that 56% of the compounds evaluated had not been studied for safety or toxicity mechanisms. Additionally, there was insufficient information to conduct a risk assessment for 86% of the compounds.[[68]](#footnote-69)

### Sample analysis developments – non-target analyses

Non-targeted analysis (NTA) is an area of active research with the potential to allow better characterization of the complex chemistry of produced water. It is an evolving discipline that expands analyses beyond a targeted list of specific compounds in order to gain as much information as possible about the sample. Whereas targeted analysis requires determining ahead of time which constituents to analyze for and allows for quantification, NTA captures a broad set of data from which the compounds and chemical classes present are then identified through a variety of data analysis techniques. A frequently used analytical method for NTA is liquid chromatography-mass spectrometry (LC-MS). Compounds can be detected at very low concentrations (sub-ppt). NTA is useful for screening, guiding choices for further targeted analysis, and making qualitative toxicity assessments. For detailed produced water characterization, a three -step combination of targeted analysis (i.e., NPDES+ analyte list), whole effluent toxicity testing (WET), and NTA, can produce information useful for environmental and human health considerations.

There are currently several areas of ongoing development for NTA. Data analysis methods are evolving, and the libraries of spectra against which to compare the LC-MS results require ongoing development to support identification of compounds and chemical classes. Analytical challenges such as matrix effects need to be taken into consideration. Also, because a variety of specific techniques are used, results may not be comparable among laboratories. NTA is not widely performed at this time, although some commercial laboratories do perform it.

### Ongoing and planned research

In line with these needs, researchers with the NMPWRC have been working to characterize the water quality of raw and treated produced water. These efforts include sampling and analysis to assess the effectiveness of produced water treatment in both the San Juan and Permian Basins. Work on the analytical aspects of characterization includes development of an “NPDES+” targeted analyte list containing about 400 constituents, toxicity testing, and non-targeted analysis (NTA) for organic constituents[[69]](#footnote-70).

The NMPWRC’s future research plans include pilot demonstration projects for testing produced water treatment trains, targeted and NTA of water, plants, and soils, and WET. Research also aims to develop a human health and environmental risk assessment framework for managing risks associated with fit-for-purpose reuse[[70]](#footnote-71). Such continued research on characterization and treatment effectiveness is also needed to support the development of formal water quality standards for environmental discharge of treated produced water. Such standards are necessary to ensure human health and environmental safety in addition to meeting the needs of end users.

## Potential environmental impacts

The potential environmental impacts related to the reuse of treated produced water outside the oilfield include:

* **Potential human health and environmental impacts:** As noted above, research is ongoing to identify potentially harmful constituents (via targeted and non-target analysis) in produced water to ensure that these are addressed with appropriate treatment prior to environmental discharge and that this information is also available in the event of spills.
* **Disposal of residual constituents:** All treatment methods eventually require disposal of residual constituents. For produced water, the primary residual constituent is brine (salt), however other constituents found in the source water will also need to be disposed of. Disposing of these residual constituents is a nontrivial factor that can be very costly. Disposal issues are discussed in additional detail below in the discussion on brine and residuals management.
* **Energy use associated with water treatment:** Desalination is an energy-intensive process.[[71]](#footnote-72) The energy source to support desalination projects should be considered within the context of the State’s decarbonization goals.

## Regulatory/permitting issues

The Produced Water Act (PWA) provides jurisdictional and legal clarity over produced water in New Mexico. It states that ownership and liability for produced water are limited to the entity in possession of the water, and it gives regulatory authority over the reuse of produced water within oilfields to the Oil Conservation Division of the Energy, Minerals and Natural Resources Department. Another part of the PWA clarifies that the Environment Department has regulatory authority over uses of produced water outside of oilfields and tasks the Water Quality Control Commission (WQCC) with adopting regulations regarding the reuse of produced water outside of the oil and gas industry.[[72]](#footnote-73)

Those regulations (Ground and Surface Water Protection – Supplemental Requirements for Water Reuse) have not been adopted as of August 2024, but they are currently being developed and considered as part of an ongoing rulemaking process. As of August 2024, the draft regulations would only allow the use of treated produced water outside of oilfields for closed-loop demonstration and industrial projects with no discharge that might directly or indirectly affect ground or surface water. For demonstration and industrial projects, the proposed rule establishes a process that requires that a produced water notice of intent be submitted to NMED’s ground water quality bureau, upon which NMED will make a determination as to whether the project meets requirements set forth in the rule.[[73]](#footnote-74) The proposed rule states that no discharge permits for treated produced water will be issued until standards specific to treated produced water are developed and adopted. In addition, the proposed rule prohibits treated produced water discharge to surface waters of the state.

Under the Clean Water Act, 40 CFR 435 subpart E, the discharge of treated produced water is allowed west of the 98th meridian into surface waters for agricultural and wildlife propagation applications if it meets NPDES standards.[[74]](#footnote-75) While New Mexico does not have primacy over implementing and administering NPDES permitting within its borders, NMED would have to certify any NPDES permit for discharge of treated produced water. The Oil Conservation Division prohibits surface discharges of produced water within the oilfield. For uses of produced water outside of the oilfield, the PWA requires permitting from the Environment Department. NMED’s proposed rule states that the department shall deny certification of any federal permit proposing to discharge untreated or treated produced water to a surface water of the state.

## Produced Water Conclusions

***Produced water volumes and characteristics***

* More than 2 billion barrels of produced water were generated in New Mexico in 2023 according to OCD data. 99% was generated in the Permian Basin in New Mexico.
* In terms of general quality, San Juan produced water is significantly less saline (median < 15,000 mg/L TDS) than Permian produced water (median >100,000 mg/L TDS). This makes treatment of San Juan produced water easier than treatment of Permian produced water.
* Produced water can have a wide range of organic and inorganic constituents, both naturally occurring and introduced. However, publicly available data on produced water in New Mexico are patchy in coverage and generally do not have data for a significant range of analytes.

***Characterization needs and approaches***

* Work is ongoing to better characterize produced water characteristics. Several considerations have been raised with respect to thorough characterization of produced water chemistry and toxicity:
  + Some constituents may not be anticipated ahead of time and therefore not analyzed for in targeted lists of constituents.
  + Some additives in hydraulic fracturing fluids are claimed as proprietary, making characterization challenging.
  + Radionuclides and PFAS have been raised as specific data needs in addition to a broad range of organic constituents.
  + One study noted a lack of adequate toxicity data for many produced water constituents.
* Better understanding of the constituents in produced water and their toxicities is needed in order to implement appropriate safeguards for transport and to be prepared for emergency response and cleanup in the event of a spill or leak.
* Non-targeted analysis (NTA) is evolving and shows promise for screening and as a complement to targeted analysis. Combining it with a targeted list and whole effluent toxicity testing can provide useful environmental and human health information about produced water.
  + Such an approach can be used to test treatment effectiveness by obtaining a baseline on raw produced water and doing the same testing on treatment effluents.
  + NTA is not yet routinely used. NTA methods will ultimately need to be efficient and available if they are to be more commonly employed.

***Variability and scaling***

* Produced water is known to vary both spatially and temporally in both quantity and quality. Variability needs to be understood in order to plan treatment to consistently produce an adequate amount of treated water with the desired water quality for an end user.
* SWS projects will need to be scaled appropriately to match volumes that can be treated by either individual producers or mid-stream water management companies to consistently produce the needed volume.
* Produced water in New Mexico is managed primarily through a combination of injection for disposal or secondary oil recovery (about 48% in 2023), reuse for new well completions (about 11% in 2023), and transport across state lines for disposal via injection well in TX. The estimated amount sent to TX has increased from 27% in 2021. A 2023 article estimated the daily amount transported to TX from NM to be 1.8 million barrels. Given this enormous amount of produced water, thought will need to be given regarding how many (and what capacity) projects would ultimately be needed (both part of the SWS and done independently) to meaningfully reduce the amount of produced water being disposed of via SWD wells.

# Brackish water

## Description

Brackish water generally refers to water found in the natural environment that has a higher salinity than freshwater and has a total dissolved solids (TDS) concentration of 1,000-10,000 mg/L.[[75]](#footnote-76) Water that has a TDS >10,000 mg/L is considered to be saline or brine. As part of the SWS, New Mexico is currently considering and evaluating the feasibility of using deep (> 2,500 ft) and non-potable (> 1,000 mg/L TDS) water to diversify the water supply and reduce the demand on New Mexico’s freshwater supplies. These resources are largely undeveloped due to the costs of characterizing the deep aquifers, constructing wells, and water treatment.

## New Mexico brackish water resources

New Mexico has deep brackish water aquifers that have the potential to be used as valuable resources to supplement the current water supply in the State. The discussion presented here is primarily based on available data from existing water wells, however more data is needed to better understand how this resource could contribute to New Mexico’s SWS.

The New Mexico Bureau of Geology and Mineral Resources (NMBGMR) reviewed data available for 17 regions to explore brackish water potential.[[76]](#footnote-77) Figure 8 shows where these 17 regions are.[[77]](#footnote-78) The colors indicate the average total dissolved solids (TDS) based on regional approximations, with blue indicating lowest TDS levels, followed by purple, orange, and finally red. Each of the 17 brackish water regions have unique characteristics (such as geologic setting, aquifer characteristics, recharge and discharge areas). Site specific studies are needed to validate TDS values represented in this Figure 8.

Figure 8. Map of potential brackish water regions in New Mexico

A map of different colors

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Source: New Mexico Bureau of Geology and Mineral Resources[[78]](#footnote-79)

Notes: Assessment of brackish water resources using data from existing water wells. Regions are colored based on average total dissolved solids (TDS). Blue: TDS below 1,000 mg/L, water is considered potable. Purple: TDS between 1,000-3,000 mg/L, water is considered slightly brackish. Orange: TDS between 3,000-10,000 mg/L, water is considered brackish. Red: TDS greater than 10,000 mg/L, water is considered saline or brine. These results are based on regional approximations. Site specific studies are needed to confirm these results.

A 2016 report[[79]](#footnote-80) from NMBGMR provides an overview of data available for each of these 17 regions. Appendix A provides tables showing a summary of water chemistry associated with each region. The data set includes water samples collected from existing wells, which in most cases are domestic, irrigation or water supply wells. At the time of the study, deep wells (greater than 2,500 ft deep) in brackish water areas were very limited which biased their findings. Based on the data available at the time of the study, deep brackish water resources were best characterized in the southeast and northwest regions of New Mexico. A main finding of the report is that more research is needed to better understand the amount and quality (water chemistry) of brackish aquifer reserves that could supplement New Mexico’s water supply. Though there is more research and data needed to understand how, at the state level, New Mexico’s brackish water resources could support state efforts to diversify the water supply, the data that currently exist can be used to identify regions where developing brackish water resources may have the greatest opportunity for public or private beneficial use. In these regions, more localized characterization of the brackish water resource is needed to bring a brackish water treatment project to fruition.

## Deep brackish water basins in New Mexico with potential technical feasibility

Of the data available to the state, we have highlighted three deep brackish water basins that may be suitable as an alternative water supply. There may be more data from the private sector that would further bolster these findings or indicate other regions that may be suitable, however this report focuses on findings that can be drawn from data that are currently available to the State. These basins are described below, with cities that may be particularly posed to benefit from desalinated brackish water from these basins noted in brackets. It is important to note that these basins have higher potential connection with shallower fresh water resources, though more research is needed to verify this occurrence.[[80]](#footnote-81)

**Española Basin [Santa Fe]:** The Española Basin, located in the Santa Fe region of north central New Mexico, has a substantial data set available which was evaluated as part of the 2016 NMBGMR report. From the available data, NMBGMR finds that warm, mineralized groundwater from the deep regions of the aquifer may contain high TDS (as reflected from the maximum DS value of 30,000 mg/L) as well as elevated levels of arsenic and other undesirable constituents. NMBGMR notes that the data suggest the presence of deep brackish water reserves of an unknown volume in this basin.

Table 4. Española Basin, summary of water chemistry

A table with numbers and symbols

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Source: NMBGMR, 2016.

**Mesilla Basin [Santa Teresa]:** The Mesilla Basin, located in the Lower Rio Grande region, south of Las Cruces in the southern region of New Mexico near New Mexico’s border with Texas and Mexico, has a relatively large, though irregularly distributed, data set available which was evaluated as part of the 2016 NMBGMR report. The data set does, however, lack records associated with deeper parts of the basin (mean well depth of only 339 ft, max well depth of 1,880 ft). From the available data, NMBGMR finds that there is generally high mineral content and elevated levels of arsenic in the Mesilla Basin.

Table 5. Mesilla Basin, summary of water chemistry

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Source: NMBGMR, 2016.

A forthcoming 2024 Bureau of Reclamation Report[[81]](#footnote-82) used data from 239 wells to assess the brackish water resource in the Mesilla Basin. These wells ranged in water depth from 0 to 1,750 ft. They found that the TDS concentrations are less than 1,000 mg/L in the northern part of the basin, though concentrations exceed 1,000 mg/L in the southern part, at points finding 3,000-35,000 mg/L, particularly at increasing depth. The report cites an estimate from Hawley, 2016 that there may be 60 to 65 million acre feet of brackish water in the Mesilla Basin.

**Albuquerque Basin [Albuquerque]:** Of the 17 brackish water basins in New Mexico, the 2016 NMBGMR report includes an exceptionally large data set for the Albuquerque Basin. From the 2016 report, the data indicate that water quality in the basin is generally good (less than 1,000 mg/L TDS), though the deeper portions of the basin remain unexplored and therefore the water quality at greater depths remains unknown. The 2016 report does indicate that there are high levels of arsenic as well as potentially high mineral content.

Table 6. Albuquerque Basin, summary of water chemistry

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Source: NMBGMR, 2016.

A 2008 aquifer test report prepared by INTERA for Sandoval County Water Administrator, a county just north of Albuquerque, and provided by OSE for the purposes of this feasibility study, estimated that there could be between 576,000 acre feet to 2,657,280 acre feet in the groundwater below Sandoval County in the Rio Puerco aquifer. The Rio Puerco aquifer is a confined aquifer at a depth of 3,500 ft and which overlaps geographically in some places with the Albuquerque Basin. The findings of this aquifer test report served as the basis for a 2011 Preliminary Engineering Report prepared for Sandoval County.[[82]](#footnote-83) Rio Rancho is the most populous city in Sandoval County. There are two deep wells in this region (northwest of Albuquerque) that NMBGMR provided information on. POD 1 was drilled to a depth of 6,460 feet below ground level and POD 2 was drilled to a depth of 3,840 feet below ground level. POD 1 had a TDS of 12,400 mg/l (for a sample collected in 2011 under uncertain purge conditions), and POD 2 had a TDS of 12,000 mg/l (for a sample collected in 2008 midway through a 30-day flow test, after the pre-sample purge was completed).

## Brackish water resource development in other states or countries

### Other States

Within the U.S., brackish water has been used in a variety of industries, as shown in Figure 9. Brackish groundwater use in the U.S. has increased by about 400 percent between 1985 and 2010, with the largest use of this water being for mining (including oil and gas).

Figure 9. Saline groundwater use by water use category, 1985-2010[[83]](#footnote-84)

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Municipal desalination water treatment facilities can be found throughout the United States. A 2018 report from the U.S. Bureau of Reclamation (USBR) documents characteristics of municipal desalination plants in the U.S. [[84]](#footnote-85) The majority of these facilities are inland (97 percent), while only 3 percent treat seawater. From 1969 to 2017, 406 municipal desalination facilities with 25,000 gpd capacity and above were constructed, with 86 facilities built between 2010 to 2017.

The USBR 2018 report on the 406 municipal brackish water treatment facilities in the U.S. outlines the different treatment processes used at these facilities. Two facilities use reverse osmosis followed by a thermal (evaporation/distillation) process. All other facilities used membrane only processes for desalination. These membrane-only processes are brackish water reverse osmosis (BWRO), nanofiltration (NF), electrodialysis reversal (EDR), and seawater reverse osmosis (SWRO). Some of the facilities used advanced pretreatment processes such as microfiltration (MF) and ultrafiltration (UF). Figure 10 shows the number of plants by membrane type and time period of the facilities evaluated in the USBR, 2018 report.

Figure 10. Number of U.S. municipal desalination plants by membrane type and time period

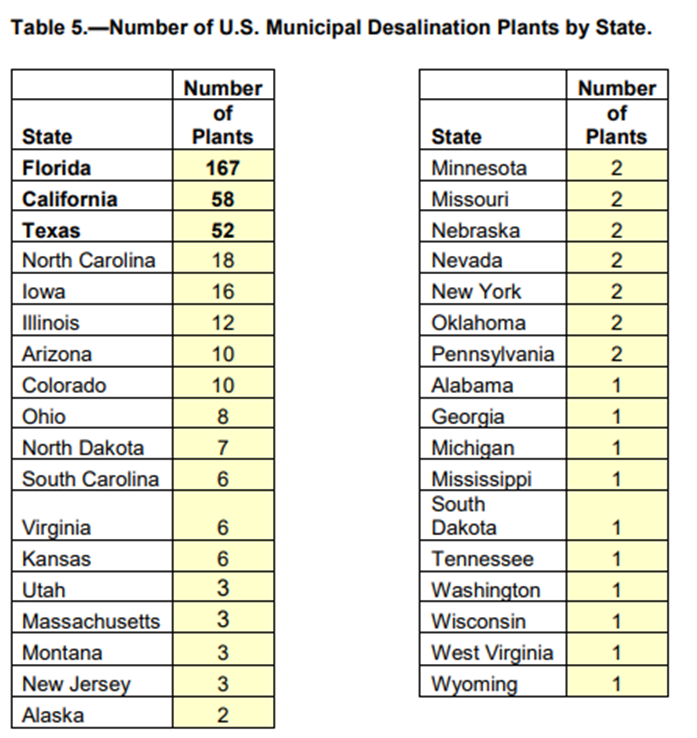
A graph of different colored and blue lines

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Source: USBR, 2018.[[85]](#footnote-86)

Florida, California, and Texas have the greatest number of municipal desalination plants in the U.S, as shown in Table 7. from the 2016 NMBGMR report. Based on data from 2010-2017, the average municipal desalination plant size was 7.1 MGD in California, 5.57 MGD in Florida, and 1.4 MGD in Texas.

Table 7. Number of U.S. municipal desalination plants by state



Source: USBR, 2018.[[86]](#footnote-87)

The USBR, 2018 report also collected data on the concentrate management strategy used by each of the 406 municipal desalination facilities in their dataset. Figure 11 shows the percentage of these facilities that use different concentrate management strategies.

Figure 11. U.S. municipal desalination concentrate disposal option use by location

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Source: USBR, 2018.[[87]](#footnote-88)

The Kay Bailey Hutchison Water Treatment Plant in Texas is the world’s largest inland desalination plant with a capacity to treat up to 27.5 million gallons per day of brackish groundwater.[[88]](#footnote-89) About 83 percent of the water is recovered for use while the remainder is produced as a concentrate. The concentrate is disposed through deep-well injection.[[89]](#footnote-90)

### International

Internationally, brackish water management varies. In the Middle East and North Africa, brackish water management is the highest priority, with many countries researching ways to use and/or clean brackish water. In Egypt, farmers in the northern Nile Delta have transitioned agricultural lands to fish farms because of the availability of brackish water. In southern Tunisia, reverse osmosis is being used to desalinate brackish water for use as drinking water. The Tunisian government subsidizes investments into desalination and plans to increase desalination capacity to 50 million cubic meters per day by 2030. In the UAE, membrane desalination is used to convert brackish water into water suitable for irrigation. In Yemen, brackish water is used to irrigate tolerant crops near the coastline, while brackish water is used for rock cutting in the highlands.[[90]](#footnote-91)

Desalinated brackish water accounts for more than 20 percent of all water used in Gulf Cooperation Council (GCC) countries, which includes Bahrain, Kuwait, Oman, the UAE, Qatar, and Saudi Arabia. In Kuwait, Bahrain, Qatar, and the UAE, over 50 percent of total water used is desalinated brackish water.[[91]](#footnote-92) Based on current desalination capacity and expectations for technological advancement, desalination capacity in GCC countries is expected to increase to 40 million cubic meters per day by 2050.[[92]](#footnote-93)

## Additional information needs to support brackish water projects

Though there are data that suggest areas that may be most promising for developing brackish water resources (e.g., Santa Fe, Santa Teresa, Albuquerque), full characterization of these resources at the localized level is needed to site the well and understand the treatment processes required to treat the brackish water to the desired water quality of the end user. This type of localized characterization may be pursued by the public sector or by private industry depending on the purpose of the project.

Full characterization will require collecting additional data. This data could be collected through various methods. The costliest method of data collection to support characterizing brackish water resources is drilling new deep exploratory wells. The cost of drilling new wells could be avoided through partnering with oil and gas companies to collect information from oil and gas exploratory wells. For example, oil and gas companies could allow for additional data to be collected from their wells before they are plugged and abandoned. Similarly, the cost of drilling new wells could be avoided by using “orphan” wells. Orphan wells are wells that were used by the oil and gas industry but were not plugged after they stopped producing and do not have a solvent owner of record. There are over 1,700 orphan wells in New Mexico.[[93]](#footnote-94) Oil and gas companies could also share data from the shallow (approximately shallower than 2,500 ft) portions of their wells. Sharing this data with the State would help further characterize groundwater resources without requiring drilling new wells. Repurposing seismic lines from the oil and gas industry could also serve as a data collection mechanism to support further subsurface resource characterization. Geology mapping and other techniques such as transient electromagnetic (TEM) and magnetotelluric surveys[[94]](#footnote-95) could also be used to characterize these deep brackish water resources.

Aquifer testing such as pumping tests can be performed to understand what capacity desalination plant the aquifer can support. Characterization will also provide data to answer the question of how long the resource will be available based on the expected withdrawal rates. For example, short and long term pumping tests can be used to collect information on how the aquifer will perform under the expected pumping rates, to explore how much water it can produce and for how long, and to determine if there are any impacts to surrounding water resources such as nearby shallow aquifers and rivers. Performing pumping tests can also serve as an opportunity to test water quality to identify if there is any variation in water quality within the aquifer. Additionally, characterization efforts to understand the volume of water stored in the deep brackish basins of New Mexico may be an important priority for the State as they plan to diversify their water supply. Regardless of whether characterization is pursued by the public sector or by private industry, the State of New Mexico has a vested interest in the data from these characterization efforts.

## Potential environmental impacts

More data may be needed to understand the potential environmental impacts of withdrawing from New Mexico’s deep brackish water aquifers and treating this water. OSE determines whether there will be any residual impacts on water resources (impacts to upper aquifers, rivers, etc.) from proposed exploratory wells based on the currently available data. More data would allow for a more thorough evaluation of potential residual impacts. Though more data will lead to more informed decisions, there are many environmental impacts that could occur, including:

* **Land surface subsidence:** This could occur when sediments compact due to the removal of groundwater. When groundwater is removed, the open pore spaces that remain are filled in by the sediment above, causing the land elevation to decrease. This is referred to as subsidence. Land surface subsidence can damage infrastructure (for example: bridges, buildings, foundations, and underground structures) and could cause salt water intrusion into freshwater aquifers.
* **Salt water intrusion into freshwater aquifers:** This could occur if the brackish water aquifer is connected to a freshwater aquifer. A thorough understanding of the region’s geologic and hydrologic properties (including the geologic structure of the aquifer, the distribution of hydraulic properties of the aquifer, and the presence of fine-grained confining units that could impede salt water from moving into the freshwater aquifer) is needed to determine whether this may occur. Salt water intrusion into freshwater aquifers could be a major concern if the freshwater is used for drinking water or other purposes that would be impacted by the introduction of salt water to the resource. Additionally, salt water intrusion into freshwater aquifers could negatively impact the surrounding environment due.
* **Decreased flow in rivers:** Groundwater pumping can decrease flows in rivers if the water source is hydrologically connected to rivers. It is possible for deep brackish water basins to be hydrologically connected to surface water such as rivers, and therefore studies must be done to ensure pumping from these basins will not impact rivers and other surface water sources. Decreasing flows in rivers could impact species such as fish which may be impacted from a change in water level. Additionally, decreasing flows could impact those that rely on the water for drinking water, agricultural purposes, or other uses. Based on current New Mexico law (NMSA Chapter 72[[95]](#footnote-96)) the OSE , can condition groundwater permits by requiring that any groundwater pumping that impacts flows in the Rio Grande to be “offset” by retiring other water rights. OSE is responsible for conducting hydrologic modeling to determine whether a new well will impact the Rio Grande. More data would allow OSE to perform a more detailed analysis on potential impacts to the Rio Grande and other rivers.
* **Disposal of residual constituents:** There are many different treatment processes that can be used to treat brackish water, but they all eventually require disposal of residual constituents. For brackish water, the primary residual constituent is a salt brine, however other constituents found in the source water will also need to be disposed of. Constituents can include arsenic, uranium, and fluoride, all of which have EPA standards defined for maximum contaminant levels in drinking water. The amount of brine and other constituents generated as a byproduct from brackish water treatment depends on the concentration of each in the source water. Disposing of these residual constituents is a nontrivial factor that can be economically costly and have environmental impacts on the disposal area if not disposed of properly. Technological advances, including mineral recovery, can make desalination more cost effective.
* **Energy use associated with desalinization:** Desalination is an energy-intensive process, of which the energy required to run the treatment processes can account for 40% of the overall cost of the water for reverse osmosis plants.[[96]](#footnote-97) Based on a 2012 report assessing the cost of brackish groundwater desalination in Texas[[97]](#footnote-98), the power cost ranges from 5.9-8.35 cents per kWh for the 6 desalination plants they evaluated. The energy source to support desalination projects could be considered within the context of the State’s decarbonization goals to limit any impact to achieving these goals and more broadly to limit contribution to greenhouse gas emissions. When choosing an energy source, it is important to consider the desalination treatment technology that will be used (for example, thermal desalination or membrane desalination) and the geographic region. Given the solar power potential in New Mexico, solar power may be an appropriate efficient and renewable energy source to power brackish water desalination plants. For thermal desalination plants, heat from concentrated solar power could be used to efficiently power the desalination process. For membrane desalination plants, electricity from solar power could be used.[[98]](#footnote-99)

## Regulatory/permitting issues

### Governmental Oversight

Characterization of brackish water aquifers may be undertaken by both the public and private sectors. Private sector projects that are funded with public monies could be required to share information to increase public confidence that adequate information has been collected especially regarding the longevity of the resource. Currently, the Office of the State Engineer (OSE) requires testing to be performed by a certified laboratory for all permitted deep non-potable groundwater. This testing includes open-hole logging, mud logging, cement bond logging, and aquifer testing.

### Water Rights

New Mexico has a complicated system of water rights. Ownership of deep water resources are not included in the conventional water rights system, though the potential impacts of deep brackish aquifer development on water resources with associated water rights are assessed by the Office of the State Engineer (OSE).

### Appropriating Deep Non-Potable Water

New Mexico’s regulatory framework (NMSA 1978, § 72-12-25) allows OSE to permit development of water resources that are deeper than 2,500 ft and has a salinity greater than 1,000 ppm TDS, as this is considered to be deep non-potable water. The 2016 NMBGMR report on brackish water quality in New Mexico, which utilized water samples collected from existing wells, had very limited data from deep wells (greater than 2,500 ft deep) in brackish water areas. Additional research is needed to verify that regions currently identified as potentially suitable deep brackish water basins (Española Basin, Mesilla Basin, and the Albuquerque Basin) do in fact have significant water resources at the depth that allows for OSE permitting.

## Brackish Water Conclusions

**More data and data sharing is necessary.** To understand how deep brackish water resources can supplement New Mexico’s fresh water supplies, a robust understanding of the groundwater basins is needed. This understanding could be based on verified data collected by the State or made available to the State by the private sector. To support this effort, characterization testing guidelines could be established that clearly outline what type of testing needs to be done and what data needs to be collected for projects that receive public investment. These guidelines could be established by NMED, OSE, NMBGMR, and EMNRD, and other agencies that have an interest in data that could be gathered through efforts to characterize brackish aquifers. Characterization testing guidelines could include testing for chemical characteristics (such as major-ion concentrations and constituents of concern) and hydrologic characterizations (such as depth, thickness, flow patterns, recharge rates, aquifer material, residence time, and hydraulic properties). Similarly, public investment to develop brackish water resources could require that any aquifer characterization testing data be shared with the State in a format that can be readily added to a database that enables further analysis and research. By requiring data sharing for any projects that receive public investment, the State will deepen its understanding about the full extent of brackish water resources in New Mexico. This information could be used to determine the best use of resources to advance the use of deep brackish water to diversity the State’s water supply. The State agency that will receive the data could create an electronic data system to ensure that data is shared in a readily usable format for regulators. This could mean providing a standard Excel template that all data submissions must conform to. Without requiring data sharing, the State will continue to have a limited understanding of its deep brackish water resources. These data can support long-term water resources planning efforts by the State.

**Bringing a project to fruition is a lengthy, and sometimes winding, process.** Brackish water desalination projects can take many years, even decades, to bring from concept phase to completion. Steps involved include siting the appropriate location for the source well, drilling the well, performing water quality tests and pumping rate tests, developing and running a pilot project, and constructing the full-scale desalination treatment plant. Due to the significant cost of constructing full-scale desalination treatment plant, generally all projects include the pilot testing phase to identify and resolve any issues with the treatment process. As a project progresses through each step, more information is gathered that can be used to determine whether the project should progress. For example, results from water quality and pumping rate tests, and findings from the pilot treatment phase, will provide information that can be used to reassess the economic feasibility of the project. Projects that were initially thought to be economically feasible may prove otherwise as more data is collected. Though each project will be different and therefore will have a different time frame, the ongoing work in Santa Teresa can be a reference point for potential project timelines. The Santa Teresa project began as a concept in 2017 and has not yet begun the pilot project phase. Identifying an end user for the brackish water early in the project may help to advance the project in a timelier manner because it can help to constrain the potential uses, and therefore treatment and production requirements, of the project.

**There are regions that show promising potential, and a water resource development roadmap could support sustainable management.** Deep brackish water basins near Santa Fe, Santa Teresa, and Albuquerque may be suitable for desalination and could serve as an important water source to these regions that have a growing need for alternative water sources. These deep brackish water, and others in New Mexico, are largely a nonrenewable resource because they do not recharge at an appreciable rate. Therefore, carefully considering what the long-term plan is for end users of this water, and the potential impact on other water resources once the water is no longer available, may be an important planning step. For example, if economic development and population growth in a region is fueled by the availability of brackish water resources, what will it mean for the region when that water resource is no longer available? Are there other water resources that can support the increased demand brought on by economic development and population growth? This question could be carefully considered now as the State considers alternative water supplies.

**Factors such as brine disposal and pumping costs could be key cost considerations.** Brackish water treatment requires disposing of the residual constituents in the water, salt brine being the primary constituent. The costs associated with brine disposal can be very costly and may be an important factor when determining if a project is economically feasible. Similarly, the cost of pumping brackish water from deep aquifers is costly and increases as more water is withdrawn and the water level decreases. This increase in cost is due to the additional energy needed to access the water. The power cost could range from 5.9-8.35 cents per kWh, based on a 2012 report assessing the cost of brackish groundwater desalination in Texas.[[99]](#footnote-100) As characterization of deep brackish aquifers is completed throughout the State, it will be important to consider whether all of the water in the aquifer can be cost effectively utilized, or if it becomes economically infeasible at a certain depth.

**There may be environmental impacts to consider.** Utilizing deep brackish water resources as an alternative water source may lead to negative environmental impacts such as land surface subsidence, salt water intrusion into freshwater aquifers, and decreased flow in rivers. Also, given the State’s decarbonization goals, it may be important to consider the energy sources for water desalination treatment plants to understand the impact on achieving these goals.

# potential end uses

## Introduction

The intention of the SWS is to support industrial projects within New Mexico that align with the state’s development goals. One of these goals is supporting the clean energy transition by supporting clean energy and advanced manufacturing industries that facilitate the clean energy transition. The SWS could provide the water necessary for these industries, many of which require large volumes of water, to operate in New Mexico. Equally important are the state’s goals of creating local economic development, diversifying the state’s economy, and alleviating pressure on the state’s freshwater resources. The potential end uses for SWS water discussed below fit under some or all of these development goals.

The potential end uses are categorized under two scenarios: a “no discharge” scenario where any discharge of SWS water into the environment would be prohibited, and a “discharge” scenario where SWS water could be discharged provided that it met water quality standards set by the state. End uses that are feasible in the no discharge scenario would also be feasible in discharge scenario. However, the end uses in the discharge scenario section would likely only be feasible in the discharge scenario, either because discharge is necessary for the end use or because of economic constraints that a no discharge scenario would impose on an end use. Table 8 summarizes the end uses discussed in this section.

Table 8. Summary of Strategic Water Supply Potential End Uses

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **End Use** | **Scenario** | **Type of Use** | **Approximate Gallons of Water per Day** | **Water Quality Needed** |
| Green Hydrogen Production | No Discharge or Discharge | Consumptive | 250,000 to 700,000 | Higher than potable |
| Data Centers | Discharge | Recirculated | 150,000 to 450,000 | Lower than potable |
| Semiconductor Manufacturing | Discharge | Recirculated | 2,000,000 to 4,000,000 | Ultra-pure water |
| Solar Panel Manufacturing | Discharge | Recirculated | 1,000,000 to 3,000,000 | Ultra-pure water |
| Electric Vehicle Manufacturing | Discharge | Recirculated | 1,000,000 for assembly, 1,000,000 for battery production | Lower than potable for cooling, potable for production |
| Pumped Storage Hydropower | Discharge | Recirculated | 300,000 to 8,000,000 | Lower than potable |
| Cement/Concrete Production | Discharge | Consumptive and Recirculated | 100,000 to 200,000 | Lower than potable for cooling, potable for production |

## No Discharge Scenario

### Green Hydrogen

A potential end use for SWS projects is green hydrogen, which is hydrogen produced using renewable energy. Producing a kilogram of green hydrogen requires about 2.4 gallons of water directly plus an additional 2.6 to 5.3 gallons for other processes involved in the production process, such as water purification and cooling, which makes the total about 5 to 7.7 gallons of water per kilogram of hydrogen.[[100]](#footnote-101) At the facility scale, one example is Plug Power’s STAMP site in New York, which will produce 75,000 kg of hydrogen per day and is expected to use an average of 240,000 gallons of water per day in normal conditions and 254,000 gallons per day when additional cooling is needed.[[101]](#footnote-102) In their response to the SWS RFI, Plug Power stated that a typical 45 ton per day hydrogen plant (about 41,000 kg per day) uses 540 cubic meters of water per day (roughly 140,000 gallons per day). A second example is the ACES hydrogen hub in Delta, Utah, which is expected to produce 100,000 kg of hydrogen per day and use 755 acre-feet of water per year (roughly 675,000 gallons per day). The ACES hub is also expected to need 220 MW of power and about 112 acres of land (237 acres if the access roads and utility corridors are included).[[102]](#footnote-103)

The quality of water needed for green hydrogen electrolyzers is quite high. The water needs to have a low electrical conductivity, as water with higher levels of electrical conductivity is less pure and has concentrations of dissolved particles that hinder hydrogen production. In terms of microsiemens per cm, a measurement of conductivity over one centimeter, the water used should have a conductivity of less than 1 microsiemens per cm for alkaline electrolyzers and less than 0.1 microsiemens per cm for Proton Exchange Electrolyzers (PEM).[[103]](#footnote-104) For context, the conductivity of tap water is typically between 50 and 800 microsiemens per cm.[[104]](#footnote-105) Plug Power’s RFI response recommended slightly less stringent requirements; for Proton Exchange Electrolyzers they recommended a conductivity less than 350 microsiemens per cm, TDS < 200 ppm, hardness < 150 ppm, and turbidity < 1.5 NTU. Additionally, there is ongoing research into using untreated seawater and produced water for green hydrogen production using methods such as photocatalytic hydrogen production.[[105]](#footnote-106) Plug Power also stated that they would initially be willing to pay $0.04 per gallon of water that met their quality needs but would want the price of water to come down to $0.01 per gallon in the long run. This is higher than Trevi Systems’ estimate for hydrogen companies’ willingness to pay in their RFI response, which was $2,000 per acre-foot (about $0.006 per gallon).

## Discharge Scenario

### Data Centers

One potential end use of water for the SWS is data centers. Data centers use a considerable amount of water, largely for cooling purposes. Prior to its recent expansion, Facebook’s data center in Los Lunas used an average of 153,000 gallons of water per day in 2020 and had a maximum one-day demand of 1.5 million gallons.[[106]](#footnote-107) In 2021, Google reported that its data centers used an average of 450,000 gallons of water per day.[[107]](#footnote-108) For comparison, the average U.S. household uses roughly 300 gallons of water per day[[108]](#footnote-109), so the Los Lunas Facebook data center, prior to its expansion, had the same daily water use as about 510 households, and the typical Google data center has the same daily water use as 1,500 households.

Large data centers also require significant amounts of land and energy in addition to large quantities of water. One estimate is that a typical 100,000 square foot data center uses about 20 megawatts of power.[[109]](#footnote-110) The expanded Facebook data center in Los Lunas takes up about 3.8 million square feet and uses at least 635 megawatts of power.[[110]](#footnote-111) While the Facebook data center uses renewable energy, other large data centers using fossil fuels could require significant amounts of water for power generation. In 2021, natural gas plants in the U.S. used an average of 2,803 gallons of water per megawatt hour, and coal plants used an average of 19,185 gallons per megawatt hour.[[111]](#footnote-112) Trevi Systems, a water treatment company, estimated in their response to the SWS RFI that data centers would have a willingness to pay between $2,200 and $2,500 per acre-foot of water. However, having examples of what data centers currently pay for water would provide a clearer picture of their willingness to pay.

In terms of the water quality needed for cooling data centers, the main concerns are avoiding corrosion, microbial growth, scaling, and fouling. IBM recommends using water with a relatively high quality water for the cooling loop that comes into contact with computing components, with a conductivity less than or equal to 10 microsiemens per cm.[[112]](#footnote-113) More generally, the American Society for Civil Engineers notes that data centers can use treated effluent and reclaimed water for cooling, but that doing so can reduce the useful lifetime of the data center’s equipment.[[113]](#footnote-114)

### Semiconductors

Semiconductor manufacturing is an essential industry for the clean energy transition, and production of semiconductors in the U.S. is projected to triple by 2032.[[114]](#footnote-115) Semiconductor manufacturing is also a very water intensive industry that could benefit from access to SWS water. Intel’s Rio Rancho plant for example withdrew 756 million gallons of groundwater (an average of about 2 million gallons per day) in 2020. After the recent expansion of that plant, Intel estimated that it would use 1 to 3 million gallons per day.[[115]](#footnote-116) Intel has a special contract with the Albuquerque Bernalillo County Water Utility Authority for a water rate of $118,097.63 per month for non-potable water[[116]](#footnote-117), but that is only for a portion of the water that the plant uses.

In 2016, Samsung’s 2.3 million square foot semiconductor plant in Austin, Texas, which produces about 92,000 wafers per month[[117]](#footnote-118), was using about 4 million gallons per day, at a cost of $700,000 per month.[[118]](#footnote-119) That amounts to roughly $0.006 per gallon, but that doesn’t account for the plant’s 40 percent water recycling rate at the time or any additional costs of polishing the water to an ultra-pure standard, so the actual cost per gallon was likely higher. Trevi Systems’ estimate for semiconductor plant willingness to pay was $2,500 per acre-foot (roughly $0.008 per gallon). Across the industry, it’s estimated that a typical facility uses between 2 and 4 million gallons of ultra-pure water per day[[119]](#footnote-120), while another estimate put the potential demand of modern plants as being upwards of 5 million gallons per day.[[120]](#footnote-121)

Most of the water used by semiconductor plants is ultra-pure water, which has very stringent quality requirements. ASTM International has a set of standards for ultra-pure water used by semiconductor and other electronics manufacturers, with the type 1 ultra-pure water used by semiconductor manufacturers needing a resistivity greater than 18 million megaohms (in terms of conductivity, that’s equivalent to less than 0.056 microsiemens per cm).[[121]](#footnote-122) Semiconductor plants also use water for other purposes, such as cooling, that can be done with water similar in quality to tap water.[[122]](#footnote-123) Besides having access to lots of water, semiconductor plants need significant amounts of energy. TSMC’s plant in Arizona for example is anticipated to use about 200 MW of power[[123]](#footnote-124) for a plant capable of producing 20,000 wafers per month.[[124]](#footnote-125) Semiconductor plants also need to co-locate with suppliers of certain inputs (e.g., specialty chemicals and gases).[[125]](#footnote-126)

### Solar Panel Manufacturing

An industry adjacent to semiconductors that could benefit from SWS projects is solar panel manufacturing. Assembling solar panels is water intensive because solar panels use semiconductors, which also means that most of the water required is ultra-pure water. For example, Canadian Solar reported that in 2022, it used an average of 750 tons of water (about 180,000 gallons) and 171 megawatt hours of electricity to make 1 megawatt worth of solar panels[[126]](#footnote-127), which is enough power for approximately 173 homes.[[127]](#footnote-128) Maxeon’s future 160-acre plant in Albuquerque, which will be able to produce 3 gigawatts worth of solar panels a year[[128]](#footnote-129), is expected to use 2.8 million gallons per day.[[129]](#footnote-130)

Cleaning solar panels after they’ve been installed on the other hand requires a relatively small amount of water, with estimates ranging from 1 to 5 million gallons of water per year to clean 100 megawatts worth of solar panels[[130]](#footnote-131), an average of roughly 3,000 to 14,000 gallons per day. About 10 acres are needed to produce a megawatt of solar power[[131]](#footnote-132), so 100 megawatts worth of solar panels is around 1,000 acres. For regular cleaning of installed solar panels, it's recommended to use water with a low mineral content and a hardness less than 75 ppm in order to avoid issues with scaling.[[132]](#footnote-133)

### Electric Vehicle Manufacturing

Electric vehicle manufacturing also requires substantial amounts of water. Tesla’s 2,500 acre assembly plant in Austin, Texas uses an average of 2.78 m3 (734 gallons) of water per car assembled plus an additional 0.84 m3 (222 gallons) for each car’s battery pack, with painting and cooling being the most water intensive processes. The average amount of water used by the automotive industry as a whole for assembling cars is 3.68 m3 (972 gallons) per car.[[133]](#footnote-134) The plant is capable of producing about 375,000 electric vehicles per year[[134]](#footnote-135), so at peak production the plant uses an average of a little under 1 million gallons of water per day. Large battery manufacturing plants for electric vehicles requires large quantities of water as well; one estimate is that a representative facility uses 440 million gallons per year (about 1.2 million gallons per day), with a majority of the water being used for cooling.[[135]](#footnote-136) Industrial cooling water can have a somewhat lower quality than other applications. Tesla uses industrial wastewater to offset freshwater use in its cooling systems.[[136]](#footnote-137) The main concern with cooling water quality is preventing scaling; it’s recommended that cooling water should have a hardness no greater than 350-450 ppm and a pH between 6.8 and 7.5.[[137]](#footnote-138)

### Pumped Storage Hydropower

Pumped storage projects use a system of two reservoirs of water to store excess energy generated by other sources and then create hydropower when needed, which is particularly beneficial for intermittent renewables such as wind and solar. Pumped storage requires large volumes of water, both to establish the reservoirs (if the project doesn’t take advantage of existing bodies of water) and to replenish water lost from evaporation. A Southwest Research Institute analysis considered the water needs of three potential pumped storage sites in western Texas.[[138]](#footnote-139) A 50 MW project site would need to be able to store about 200 million gallons in the upper reservoir, had a lower reservoir volume of 365 million gallons, and would need about 117 million gallons of make-up water per year (around 320,000 gallons per day). A 100 MW project site would need to be able to store around 1.1 billion gallons in the upper reservoir, had a lower reservoir volume of about 1.5 billion gallons, and would need about 587 million gallons of make-up water per year (around 1.6 million gallons per day). A 1,000 MW project site would need to be able to store roughly 8 billion gallons in the upper reservoir, had a lower reservoir volume of around 10.5 billion gallons, and would need about 3 billion gallons of make-up water per year (about 8.2 million gallons per day).

The quality of water needed for pumped storage is potentially much lower than other applications. The Southwest Research Institute analysis discusses a 30 MW project in Japan that successfully used seawater for pumped storage. However, this required the use of specific materials to mitigate corrosion of the water pipe and equipment, and a liner was needed to prevent seawater from seeping into the local groundwater from the upper reservoir.[[139]](#footnote-140) The Southwest Research Institute analysis also considers the use of produced water from the Permian Basin. The analysis notes that produced water with similar TDS and chloride levels as seawater could be feasible to use in pumped storage from a technical point of view; however, high evaporation rates could result in a build-up in salinity that would need to be managed using lower salinity make-up water or disposal of some of the reservoir water into SWD wells. Given the potential to use lower quality water for pumped storage, the water quality needed for pumped storage projects would likely be determined by environmental discharge standards for SWS water rather than the technical quality needs of pumped storage.

There are a number of considerations for the siting of a pumped storage project. The reservoirs take up significant amounts of land. For example, the 50 MW project from the Southwest Research Institute analysis, the smallest of the three, would require 60 acres for the upper reservoir and 32 acres for the lower reservoir. There also needs to be a substantial elevation difference between the two reservoirs; each of the proposed sites in Texas from the Southwest Research Institute analysis had an elevation difference of around 400 feet between the upper and lower reservoirs. Additionally, a pumped storage project needs a large source of wind or solar power to store energy from.

### Cement and concrete

Cement and concrete production could also be potential end users for SWS projects. Cement is a key ingredient in concrete, acting as a binding agent for other ingredients and making up approximately 10 to 15 percent of a concrete mixture. For cement production, raw materials are ground with water before being put into the kiln during the wet process, and there is also a need for equipment cooling during cement and concrete production. Major cement companies such as Heidelberg Cement, Holcim, and Cemex use an average of about 250 liters of water per metric ton of cement they produce, which is about 66 gallons.[[140]](#footnote-141) A typical cement plant produces one million metric tons of cement per year[[141]](#footnote-142), so the annual water use of a typical plant is about 250 million liters, or roughly 200,000 gallons per day. The Tijeras cement plant near Albuquerque produces roughly 450,000 metric tons of cement per year[[142]](#footnote-143); based on the 250 liters of water per metric ton estimate, the plant can be estimated to use roughly 80,000 gallons per day. Most of the water used by cement plants is for cooling purposes[[143]](#footnote-144), which does not require a particularly high quality of water. Cemex for example has a plant in Colombia that uses sewer water from an ice cream company for cooling water.[[144]](#footnote-145)

Water is also an important component for mixing concrete, with about 25 percent of the concrete mixture consisting of water.[[145]](#footnote-146) Potable water is generally preferred for mixing water, as salt and other impurities can interfere with the setting process, although some non-potable waters could be suitable.[[146]](#footnote-147),[[147]](#footnote-148) ASTM International has specific guidelines for the water quality for ready-mixed concrete.[[148]](#footnote-149) Cement production requires a significant amount of power; cement producers typically require 20-40 megawatts of power.[[149]](#footnote-150) Besides a stable energy supply and water, cement factories prefer locations with access to raw materials (e.g., limestone, shale, clay), proximity to transportation infrastructure such as highways and railroads, and an available workforce.[[150]](#footnote-151) Lastly, it is important to note that additional environmental regulations set by New Mexico could apply to cement and concrete produced using water from the SWS if the water was incorporated directly into the final product.

## Potential End Use Examples

The following case studies illustrate the benefit of offsetting freshwater resources through water reuse while summarizing state agency jurisdiction.

Under the Oil and Gas Act, the OCD regulates the following: the disposition, handling, transport, storage, recycling, treatment and disposal of produced water during, or for reuse in, the exploration, drilling, production, treatment or refinement of oil or gas, including disposal by injection pursuant to authority delegated under the federal Safe Drinking Water Act, in a manner that protects public health, the environment and fresh water resources.

The PWA provides that: “[f]or uses regulated by the water quality control commission pursuant to the Water Quality Act, a person shall obtain a permit from the department of environment before using the produced water, the recycled or treated water or treated product or any byproduct of the produced water.”

HB 546 then amended the Water Quality Act (WQA) to state that: the WQCC “shall adopt regulations to be administered by the department of environment for the discharge, handling, transport, storage, recycling or treatment for the disposition of treated produced water, including disposition in road construction maintenance, roadway ice or dust control or other construction, or in the application of treated produced water to land, for activities unrelated to the exploration, drilling, production, treatment or refinement of oil or gas; and may adopt regulations to be administered by the department of environment for surface water discharges.”

The PWA does not regulate or distinguish “on-lease” vs. “off-lease” uses of produced water as a demarkation of jurisdiction. Instead, the statues (the PWA, Oil and Gas Act, and WQA) direct readers to look at whether produced water is being used for activities related to exploration, drilling, production, treatement or refinement of oil or gas. Or, instead, if the disposition of the treated produced water is for some other purpose, incluidng disposition in road construction maintainent, dust control, other construction, or in the application of treated produced water to land.

**Example 1: Use in oil and gas well completion operations.***Estimated freshwater savings: 812 thousand to 31 million gallons per year*

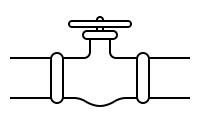
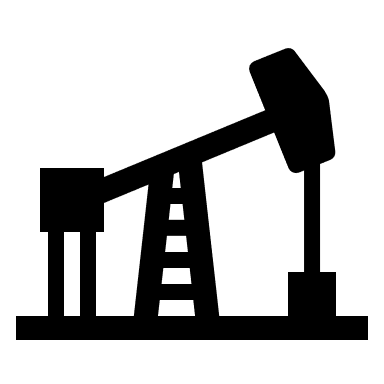
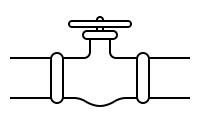
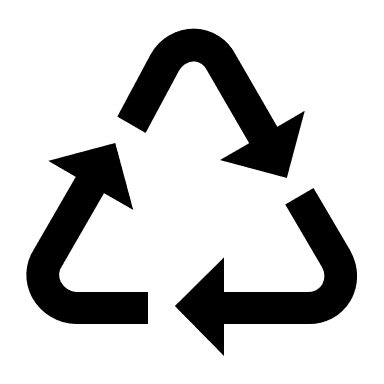
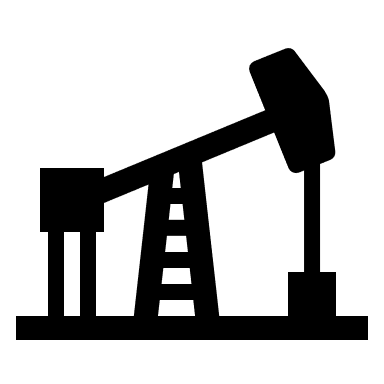
Raw, untreated Produced Water is produced from a communitized area containing several leases, regulated by the Bureau of Land Management.

The produced water is gathered and transported by pipeline to a recycling facility permitted by OCD.

The produced water is recycled by the operator of the recycling facility

The produced water is then transported by pipeline to another operator’s lease to use in hydraulic fracturing.

The recycled produced water is then used by the other operator’s oil and gas well completions.



In example 1, none of these activities are regulated by NMED pursuant to the PWA or the WQA. The OCD has jurisdiction over each of these activities because the recycled produced water is being used for activities related to the drilling and production of oil and gas.

In 2023, OCD approved a total of 2,999 application for permit to drill (APDs).[[151]](#footnote-152) The drilling and well completion process involves the use of cement to secure pipelines and casing, presenting an opportunity for the industry to mitigate freshwater consumption by substituting it with treated produced water.

Cement used in drilling, specifically Class C cement, which is intended for surface-to-6,000-foot applications when early strength is essential and available in all three sulphate resistance levels, consumes approximately 4.77 gallons of water per cubic foot (ft³). The amount of cement required per project varies significantly depending on well depth and dimensions, ranging from 57 ft³ to 2,208 ft³ for typical wells with depths averaging 5,426 feet.[[152]](#footnote-153) Consequently, the volume of water needed per project ranges from 271 gallons to 10,534 gallons.

Given the issuance of 2,999 APDs in New Mexico in 2023, the total water usage for cementing operations across the state is estimated to fall between 812,429 and 31,590,266 gallons per year. This range underscores the potential impact of substituting freshwater with treated produced water in reducing overall water consumption in the drilling process.

According to industry professionals, typical deep wells can exceed 1000 barrels (42,000 gallons) per project for cementing, which means freshwater savings would surpass 125,000,000 gallons if these projects used treated produced/brackish water.

**Example 2: Use in refinery operations.**

*Estimated freshwater savings: 60.2 million gallons per year*

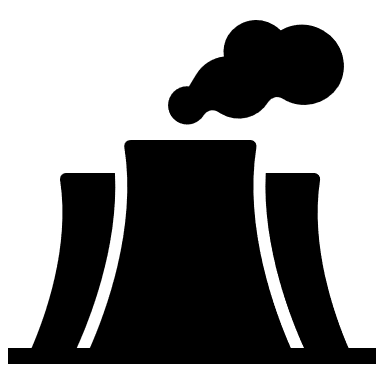
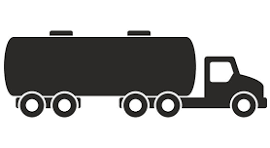
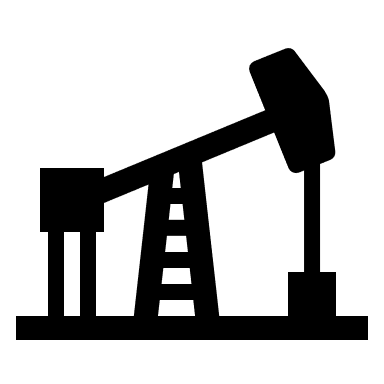
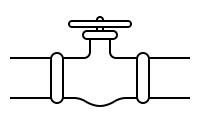
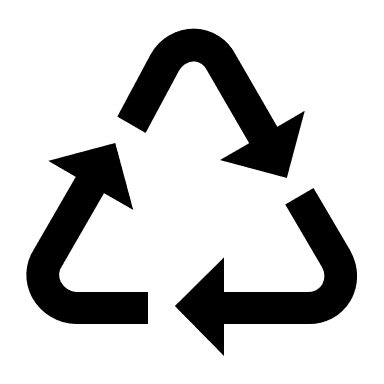
Raw, untreated produced water is produced from a State oil and gas unit that multiple oil and gas leases are committed to.

The produced water is gathered and transported by pipe to a commercial water recycling facility regulated by OCD.

The water is treated at the recycling facility in a manner that is sufficient for it to be used for industrial cooling at a refinery.

The treated produced water is transported by truck to the refinery.

The treated produced water is used by the refinery for industrial cooling in a closed loop system with no planned discharge.



None of these activities are regulated by NMED pursuant to the PWA or the WQA. The OCD has jurisdiction to regulate these activities under the Oil and Gas Act.

The U.S. Department of Energy’s Refinery Water Study states that “a typical refinery will use about 1.5 barrels of water to process 1 barrel of crude oil. However, water use can vary significantly, depending on the design of the facility.”[[153]](#footnote-154) Given that New Mexico produces ~110,000 barrels of crude oil per day, freshwater savings would reach 60.2 million gallons per year if processes used treated produced water.

**Example 3: Use for industrial cooling for data centers***Estimated freshwater savings: 218,718,000 gallons per year*

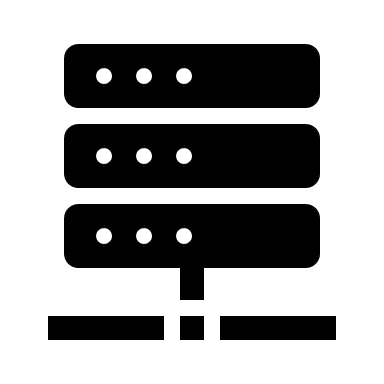
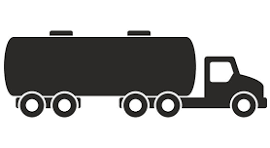
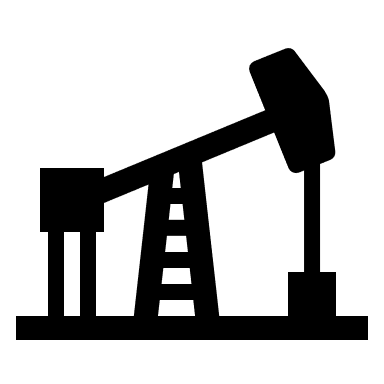
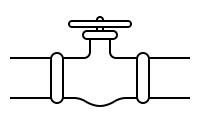
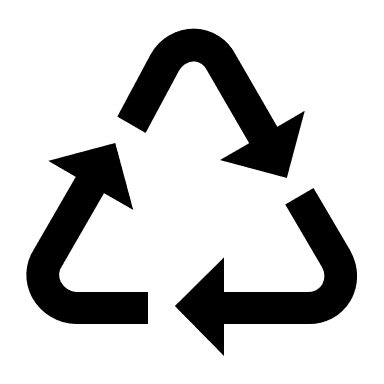
Raw, untreated Produced Water is produced from a well on a large federal oil and gas unit.

The produced water is then treated at a facility located on the oil and gas unit that treats water from several wells subject to the unit agreement.

The treated produced water is transported off the unit (i.e., “off-lease”) to a data center to use for industrial cooling.

The data center uses the treated produced water for industrial cooling in a closed loop system with no-intended discharge.

The produced water is gathered and transported by pipe to a non-commercial water recycling facility regulated by OCD.



In example 3, the production and treatment of the produced water is subject to OCD’s jurisdiction and authority. However, the transportation of the treated produced water to the data center to use in industrial uses and the use of the treated produced water falls under items that the WQA requires the WQCC to issue regulations to regulate.

The PWA provides that “[f]or uses regulated by the water quality control commission pursuant to the Water Quality Act, a person shall obtain a permit from the department of environment before using the produced water, the recycled or treated water or treated product or any byproduct of the produced water.”

As a result, NMED could issue a permit before the treated produced water is used in the industrial cooling application. To create certainty for this type of project, NMED could create a streamlined permit (outside of the current groundwater permit that exists today) which requires financial assurance and provides that the use of the water is authorized because there is no allowance for discharge – planned or unplanned.

Per Section 4.3.1, the Meta data center in Los Lunas used 153,000 gallons of water per day in 2020 and Google reported that its data centers used an average of 450,000 gallons of water per day in 2021. Annually, this equtes to 54,468,000 gallons of water and 164,250,000 gallons of water. If Meta continues to operate in New Mexico and Google opens a data center here as well, the combined operation could use 218,718,000 gallons of fresh water annually.

**Example 4: Use to create cement for wind turbine installations.***Estimated freshwater savings: 105,000 gallons of water per wind turbine installed*

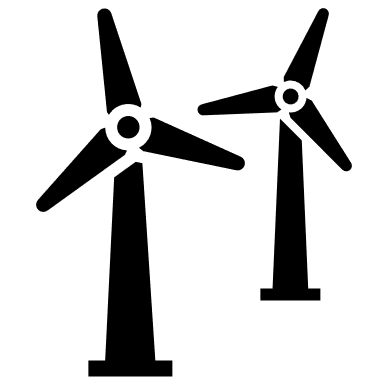
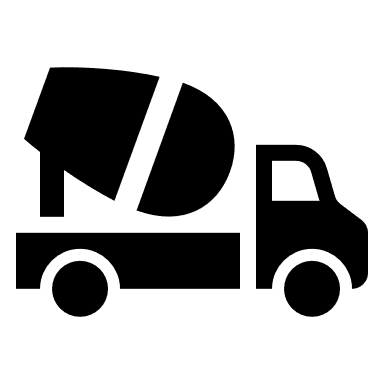
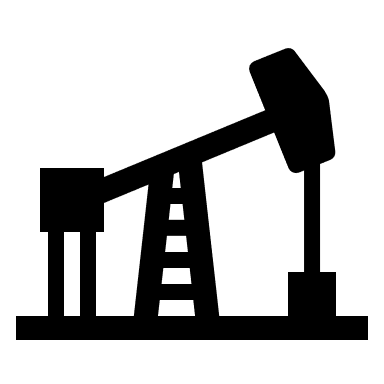
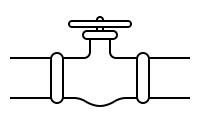
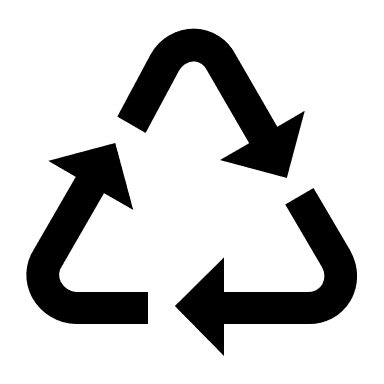
Raw, untreated Produced Water is produced from a well on a large federal/state oil and gas unit.

The produced water is then treated at a facility located on the oil and gas unit that is regulated by the OCD.

Some of the treated produced water is transported “off-lease” to a cement mixing business to make cement.

The treated produced water is used to make the cement. There is no intended or planned discharge of the treated produced water.

The cement is then used in to install wind turbines.



In Example 5, the production and treatment of the produced water is subject to OCD’s jurisdiction and authority. The NMED has jurisdiction over the treated produced water after it leaves the unit because it will then be used for activities unrelated to the exploration, drilling, production, treatment or refinement of oil or gas. To create certainty for this type of project, NMED could create a streamlined permit (outside of the current groundwater permit that exists today) which requires financial assurance and provides that the use of the water is authorized because there is no allowance for discharge – planned or unplanned. However, NMED does not currently issue groundwater permits to cement plants.

Foundations for a two-megawatt (MW) wind turbine range from 15 – 20 feet deep and can use up to 30,000 tons of cement. New Mexico in 2023 generated nearly 40% of electricity using wind energy, which has a current capacity of 4,400 MW.[[154]](#footnote-155) Continued buildout of wind turbines would require large amounts of water to be used in the cement foundations.

Assuming the average base for a wind turbine is ~10,000 ft3 it would require 105,000 gallons of water per wind turbine. Substituting freshwater in the cement for treated produced water would save 231,000,000 gallons of water if New Mexico doubled its current wind energy capacity and installed 2,200 more turbines.

**Example 5: Use in geothermal operations.***Estimated freshwater savings: 28,000,000 gallons to 147,000,000 gallons per year*

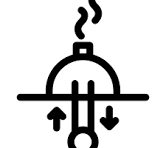
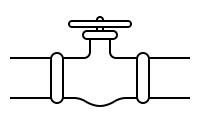
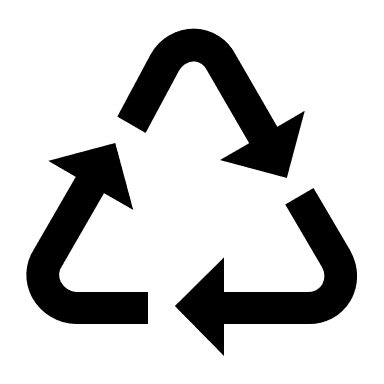
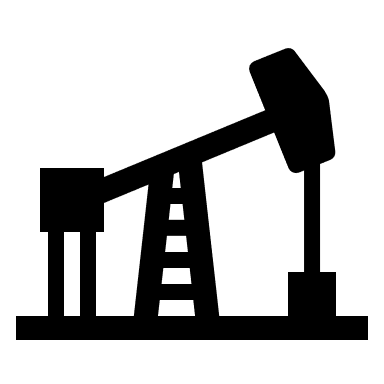
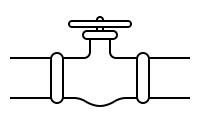
Raw, untreated Produced Water is produced from an oil and gas lease.

The produced water is then treated at a facility located on the oil and gas lease that is regulated by the OCD.

The treated produced water is transported off-lease to a company to use in geothermal operations.

The treated produced water is put downhole in geothermal wells with adequate casing to protect freshwater zones.

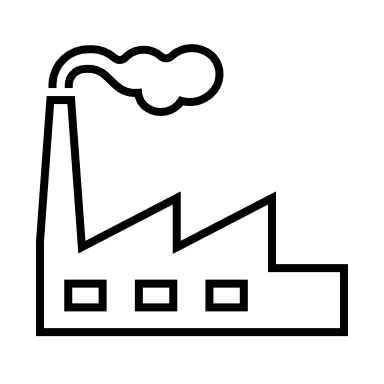
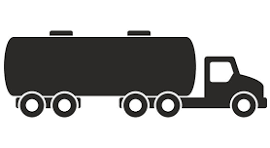
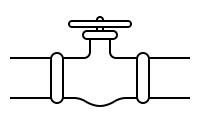
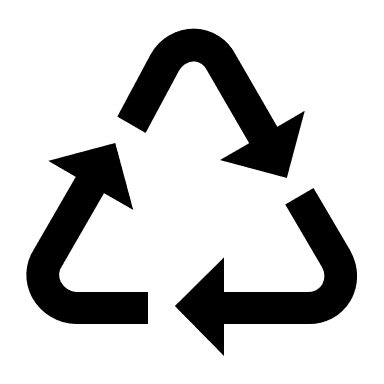
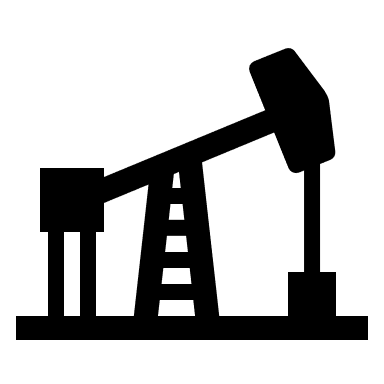
The produced water is gathered and transported by pipeline to a recycling facility permitted by OCD.



In Example 6, the production and treatment of the produced water is subject to OCD’s jurisdiction and authority. The NMED will have jurisdiction over the treated produced water after it leaves the unit because it will then be used for activities unrelated to the exploration, drilling, production, treatment or refinement of oil or gas. EMNRD will have jurisdiction over the geothermal operation. To create certainty for this type of project, NMED could create a streamlined permit (outside of the current groundwater permit that exists today) which requires financial assurance and provides that the use of the water is authorized because there is no allowance for discharge – planned or unplanned.

The consumption of water for geothermal processes is highly variable depending on the configuration of the technology, the cooling systems, and the geothermal reservoir temperature. Currently, New Mexico does not have a geothermal power plant in operation. There is one facility that was acquired in May of 2024, but is not operating at this time. The National Renewable Energy Laboratory (NREL) has a table from a 2019 publication listing different configurations and water consumption, which varies from 800 to 4,200 gallons of water consumed per MWh of power generated.[[155]](#footnote-156) NREL states the average geothermal systems generate 4 MWh, which in terms of a year is 35,040 MWh.[[156]](#footnote-157) So, depending on the location and configuration, a geothermal operation could use between 28 million gallons and 147 million gallons of water per year.

**Example 7: Use in industrial cooling for advanced manufacturing facilities.***Estimated freshwater savings: 3,650,000,000 gallons per year*



Raw, untreated Produced Water is produced from a well developing several leases committed to a Joint Operating Agreement.

Raw, untreated Produced Water is then gathered and transported by a midstream company to a commercial water recycling & treatment facility licensed by OCD.

The produced water is treated by the midstream at the recycling and treatment facility to a condition appropriate for use in industrial cooling.

The treated produced water is transported by truck to an industrial site.

The industrial site uses the treated produced water for industrial cooling. The water is not discharged or intended to be discharged in this use.

In Example 7, the production and treatment of the produced water is subject to OCD’s jurisdiction and authority. However, the transportation of the treated produced water to the data center to use in industrial uses and the use of the treated produced water falls under items that the WQA requires the WQCC to issue regulations to regulate.

The PWA provides that “[f]or uses regulated by the water quality control commission pursuant to the Water Quality Act, a person shall obtain a permit from the department of environment before using the produced water, the recycled or treated water or treated product or any byproduct of the produced water.”

To create certainty for this type of project, NMED could create a streamlined permit (outside of the current groundwater permit that exists today) which requires financial assurance and provides that the use of the water is authorized because there is no allowance for discharge – planned or unplanned.

Per Section 4.3.2, 4.3.3, and 4.3.4, the Semiconductor Industry, Solar Panel Manufacturing, and Electric Vehicle Manufacturing use between one and five million gallons per day per facility. Assuming one facility from each industry expands into New Mexico, this could consume ten million gallons per day of fresh water or 3.7 billion gallons per year.

## Potential End Uses Conclusions

When considering potential end uses for SWS projects, there are several key considerations to consider:

* The amount of water needed for different potential end uses varies significantly; some projects might need 100,000 gallons per day, while others might need millions of gallons per day.
* The quality of water needed for different potential end uses also varies significantly. Cooling water for example can have a lower quality than potable water, but other applications require ultra-pure water.
* End users have additional needs besides water, such as land and power, that need to be considered when planning a project.
* Under a “no discharge” scenario the types of end users may be more limited, as some end uses require the discharge of water into the environment, while other end uses might not be economically feasible under a no discharge scenario.
* End uses where water is incorporated into the final product, such as cement and concrete production, could potentially be subject to additional regulation by New Mexico.
* Until standards for discharge of treated produced water are developed and adopted in New Mexico, potential end uses are limited. Such limitations primarily due to a lack of state rules – not technological limitations.

# Produced water and brackish water treatment

While produced water treatment is typically more intense and requires more treatment processes compared to brackish water treatment, both produced and brackish water treatment share similar treatment requirements and processes, such as desalination for the removal of dissolved solids. The following sections explore the specific treatment technologies and techniques for produced and brackish water treatment, as well as their applicability, advantages, disadvantages, and other technical considerations.

## Produced water treatment

Although typical produced water management consists of injection via salt water disposal wells, produced water treatment and reuse has become an increasingly researched topic due to water scarcity and challenges with current produced water management strategies, such as induced seismicity from injection. While produced water treatment and reuse is still being researched and characterized, several industrial facilities have been treating produced water for various uses and have demonstrated successful full-scale produced water treatment trains/projects[[157]](#footnote-158). These treatment trains/projects consist of varying treatment technologies, which are selected based off of several different parameters such as untreated produced water quality, desired effluent (treated) water quality, available land area/footprint, regulatory considerations, and brine/residuals management criteria.

Produced water treatment technologies can generally be divided into five main categories: preliminary, primary, secondary, tertiary and desalination, and post treatment or polishing (Figure 12)[[158]](#footnote-159), [[159]](#footnote-160), [[160]](#footnote-161), [[161]](#footnote-162):

* **Preliminary treatment** technologies generally consist of basic separations process such as screening and grit removal, in addition to any chemical addition for primary treatment unit processes such as ferric chloride for coagulation and flocculation.
* **Primary treatment** technologies are designed to remove larger suspended particles and oil droplets in the produced and consist primarily of coagulation/flocculation, sedimentation, and oil-water separation. Specific technologies for oil-water separation include hydrocyclones, skimmers, and API and CPI separators.
* **Secondary treatment** technologies are designed to remove much smaller oil droplets and suspended particles in addition to soluble organic matter and other contaminants. Secondary treatment generally consists of dissolved gas/air flotation, biological treatment (activated sludge, biologically aerated filters), and certain types of media filtration (walnut shell, cartridge, gravel, anthracite, etc.).
* **Tertiary treatment and desalination** for produced water is generally the most intensive step and is used to remove dissolved solids and other contaminants not removed during the primary and secondary treatment stages[[162]](#footnote-163). Common technologies used during tertiary treatment include membrane filtration (microfiltration [UF], ultrafiltration [UF], nanofiltration [NF], reverse osmosis [RO], electrodialysis [ED], forward osmosis [FO]), adsorption (granular activated carbon [GAC], ion exchange), absorption (macro-porous polymer extraction [MPPE]), distillation (multiple effect distillation [MED], mechanical vapor recompression [MVR] and compression [MVC], multi stage flash [MSF] distillation, membrane distillation [MD]), and evaporation (freeze thaw evaporation [FTE], evaporation ponds)[[163]](#footnote-164).
* **Post treatment or polishing** is not always required depending on the end use of the treated water, however, it can be beneficial in certain scenarios. This treatment step usually consists of pH adjustment, corrosion inhibition, and disinfection.



Figure 12. Produced water treatment process.

It is important to note that each of the aforementioned technologies have their own advantages and disadvantages with regards to chemical consumption, energy efficiency and consumption, robustness and sensitivity, biosolids and residual waste stream generation, and reliability and characterization. For example, RO is a very reliable and proven technology with high removal of TDS, however, this technology has relatively high energy consumption, produces a residual waste brine stream, has high pretreatment requirements, and can suffer from membrane fouling, especially at high TDS concentrations[[164]](#footnote-165). On the contrary, distillation does not have strict pretreatment requirements, and is capable of treating water with very high TDS concentrations, however, distillation has much higher energy requirements compared to RO and still produces a significant amount of brine waste. As a hybrid alternative to both membrane filtration and distillation, MD is capable of treating high-salinity waters at low temperatures and high water recoveries, however, the commercialization of MD is still in early stages, and the long-term reliability of MD is still uncharacterized[[165]](#footnote-166). As a final example, AOPs do not have any residual wastes, do not have strict pretreatment requirements, are effective against many trace organic compounds, require minimal equipment, and have low energy consumption, however, they are largely ineffective at removing dissolved solids and have high chemical dosing requirements[[166]](#footnote-167). It is important to note that the produced water treatment technologies listed above are in different stages of research and do not all have the same reliability and characterization, however, advancements for these technologies are still being made, leading to greater robustness, treatment efficacy, and energy efficiency.

As stated above, a large disadvantage to distillation and membrane technologies is the production of a residual brine stream. Specifically for membrane technologies, RO and ED can operate at water recoveries of around 80% (therefore producing a brine stream equal to 20% of the influent flow). Higher water recoveries can be obtained, however, this comes at the cost of increased membrane fouling and higher energy consumption. Therefore, until improvements are made to RO and ED to increase water recoveries substantially, brine disposal will be a major challenge, especially for inland treatment operations. The methods for inland brine disposal include injection, surface water discharge, sewer discharge, evaporation, and crystallization, with all of these methods posing their own advantages and disadvantages. Brine disposal by injection is very common and low cost, however, induced seismicity from injection has presented a major challenge for this disposal method. Surface water discharge and sewer discharge are similarly common and low cost, however, these methods can have severely negative environmental impacts. Evaporation is a method to reduce the overall volume of the brine by evaporating as much water from the solution as possible, thus generating a more concentrated brine stream[[167]](#footnote-168). As a form of zero-liquid discharge (ZLD), crystallization is often employed after evaporation to further remove the remaining water from the brine, thus producing a solid waste. While evaporation and crystallization have low direct environmental impacts compared to the other brine disposal options, these methods come with their own disadvantages such as high footprint (in the case of evaporation ponds) and high energy consumption (in the case of crystallizers and evaporators). Overall, brine disposal is a major challenge for RO and ED desalination systems and specific disposal methods should be carefully selected, in addition to informing the technologies necessary for produced water treatment.

The treatment technologies used for produced water treatment are also highly dependent upon the raw produced water quality and desired treated water quality. For example, for raw produced waters with TDS concentrations higher than that of seawater (> 35,000 mg/L), thermal technologies (i.e., distillation) are usually required, thus resulting in much higher energy demands. The raw produced water quality can also affect treatment performance. In the case of RO, higher TDS concentrations of the raw produced water can result in membrane fouling, higher energy consumption, and decreased water recovery. In the case where high-quality effluent is required, multiple treatment barriers might be necessary as well as any post treatment and polishing requirements for specific end users. Regulations for produced water treatment and reuse will also inform the level of treatment required, with stricter requirements on effluent water quality necessitating higher levels of treatment.

As a part of the overall treatment process, monitoring for the treated produced water and the various treatment technologies will be necessary, however, the level of monitoring required will be dependent upon regulations and any agreements between the treatment facility and the end user. Due to the many organic and inorganic contaminants present in raw produced water, robust water quality monitoring will be needed to determine the overall treatment efficacy and potential impacts of the treated produced water for the end user or other applications.

For end users that require ultra-pure water such as semiconductor, pharmaceutical, solar photovoltaic cell, and green hydrogen manufacturers, additional treatment will be necessary prior to the manufacturing process. Typically, these manufacturers produce ultra-pure water by treating municipal water on-site. This treatment is generally conducted through various filtration, ultraviolet disinfection, and ion exchange treatment processes. Depending on the agreement between the produced water treatment facility and the end user, ultra-pure water treatment could be installed and combined with other treatment processes at the produced water treatment facility, thus saving on manufacturing costs for the end user.

Depending on regulatory requirements, a potentially large cost for the end user will be the disposal of the treated produced water after it has been used in the manufacturing process. For nonconsumptive water uses such as semiconductor, pharmaceutical, and solar photovoltaic cell manufacturing, a “no discharge” scenario would pose significant challenges as any process water would have to be evaporated, resulting in extremely high energy consumption to dispose of the process water (treated produced water). Under a “no discharge” scenario, the high costs associated with the disposal of the process water would essentially limit any potential end users to only those with consumptive water use (i.e., green hydrogen).

## Brackish water treatment

In 2010, there were 649 active desalination plants in the United States, with a total treatment capacity of 402 million gallons per day. Approximately 67 percent of the total treated water was used for municipal purposes, with 18 percent used for industry, 9 percent used for power, and the remaining 6 percent allocated for other uses.[[168]](#footnote-169) The treatment techniques for brackish water generally consist of either RO, ED, or distillation (MED, MVC, MVR, MSF). Compared to seawater that can have TDS concentrations greater than 35,000 ppm, brackish water generally has 10,000 ppm TDS or less, however, the TDS concentration and other contaminant concentrations of brackish water can vary greatly between brackish water aquifers. Additionally, brackish water might contain elevated levels of arsenic, minerals, and other undesirable constituents as compared to seawater.

Similar to produced water treatment, the level of treatment and the specific technologies required for brackish water treatment are highly dependent upon the initial water quality and desired effluent water quality. Generally, brackish water treatment is conducted by ED or RO, however, for lower concentrations of TDS, other membrane filtration technologies such as NF or UF can be considered. It is important to note that a liquid brine waste stream is also produced during brackish water treatment if utilizing RO or ED. The most common method of brine disposal for inland brackish water facilities is surface water discharge (47 percent), sewer discharge (42 percent), and deep well injection (9 percent), however, surface water brine discharge is proving to have very negative environmental impacts, and sewer discharge can put a heavy burden on wastewater treatment plants.[[169]](#footnote-170)

## Produced water and brackish water treatment conclusions

* Produced water and brackish water can be treated effectively to generate high quality effluent.
* There are many treatment technologies available for both produced and brackish water treatment, however, each specific technology has its own advantages and disadvantages. Treatment trains should be designed with these advantages and disadvantages in mind to produce the highest quality effluent possible while minimizing risk and cost. Major considerations for the viability of specific treatment technologies are the following:
  + Energy efficiency and consumption
  + Waste and other residuals (i.e., brine)
  + Chemical consumption
  + Treatment efficacy (i.e., contaminant removal)
  + Water recovery
* The level of treatment and specific technologies required for produced water and brackish water treatment are highly dependent upon the initial source water quality as well as the desired effluent quality. Specifically, high TDS concentrations of the initial source water might require more energy intensive treatment processes and can affect treatment performance (e.g., membrane fouling, water recovery, etc.).
* Regulations and agreements between end users and produced water treatment facilities will ultimately inform the levels of treatment and monitoring required for produced water treatment and reuse.
* Brine disposal is a major challenge to inland produced water and brackish water treatment.
* For end users that require ultra-pure water, additional treatment will be needed prior to the manufacturing process.
* Discharge requirements for the end user will have a significant impact on which types of manufacturers will be able to use treated produced water (i.e., consumptive vs. nonconsumptive use).

# TRANSPORTATION AND STORAGE

Capital and operating costs of developing storage and transportation infrastructure are also important factors that affect the feasibility and affordability of water processing projects. Depending on the distance and terrain, transporting water from one location to another can be very expensive and energy intensive. For example, a commenter from the request for information (RFI) estimated that it would cost $1 million per mile for a large aqueduct, but we do not have other reliable estimates for different modes and scales of water transportation. Similarly, we lack data on the costs and benefits of storing treated or untreated water in reservoirs, aquifers, tanks, or other facilities. These costs may vary depending on the quality, quantity, and duration of storage, as well as the environmental and social impacts of the storage infrastructure. Therefore, more research is needed to understand the trade-offs between transporting and storing water versus using it locally. This would help decision-makers to optimize the allocation and distribution of water resources in a cost-effective and sustainable way.

# Brine and residuals management

As discussed above, the oil & gas (O&G) industry currently disposes of significant volumes of produced water through salt water injection/disposal wells. This has led to increased seismicity in these regions,[[170]](#footnote-171) which in turn has led to concern about this practice. Increased seismic activity has also led to interstate tensions between New Mexico and Texas. There may be other, economically beneficial ways to dispose of residuals from treated produced water, though challenges still remain (technological and regulatory) that warrant further research for viability and cost effectiveness. The Oil Conservation Division has had to take steps to curtail injection in parts of the Permian to address seismicity concerns. Similarly, as brackish water resources in New Mexico are explored as an alternative water supply, the metals and minerals that remain after treatment can pose both a challenge and an opportunity.

**Cost.** Brine and residuals management associated with desalination and treated produced water is nontrivial and can be very costly. If using evaporation ponds for large amounts of treated water, the size required for the evaporation problems becomes a concern with significant capital costs associated with it. Costs of the evaporation ponds needed for to support treatment/disposal processes of large amounts of water may be prohibitive.

**Enhanced resource recovery.** Valuable constituents could be recovered from produced water during the treatment process, which ultimately could be sold to the market and help to offset the costs associated with treatment. Valuable constituents that could be recovered include insoluble hydrocarbons, lithium, iodine, and many more.[[171]](#footnote-172) Though not yet proven in practice, brine could also be used to create cement and asphalt in a manner that releases significantly less CO2 than current production practices.[[172]](#footnote-173) There is also interest in using brine from desalination plants in chlor-alkali electrolysis to produce chlorine and sodium hydroxide.[[173]](#footnote-174)

There are a number of existing technologies for extracting resources from brine. Resources can be precipitated from brine using evaporation ponds or mechanical thermal evaporation methods, and then separated and chemically treated. Precipitation of resources from brine can also be facilitated using chemical methods that target specific compounds. Membrane methods that are used in desalination, such reverse osmosis, forward osmosis, osmotically assisted reverse osmosis, nanofiltration, and electrodialysis, can tailored to extract specific compounds from brine for enhanced resource recovery.[[174]](#footnote-175)

However, these methods face barriers that can limit their economic viability.[[175]](#footnote-176) Many of these methods, particularly mechanical thermal evaporation and electrodialysis, are energy intensive processes. Evaporation ponds are less energy intensive, but require significant amounts of land and the use of liners to prevent brine from leaking out into the environment. Chemical precipitation meanwhile sometimes requires a one to one (or higher) ratio of chemical reagents to the target compound, and the value of the compounds targeted by chemical methods might only be slightly higher than the cost of the chemicals needed to extract them. Given these potential constraints, it will likely be important to characterize the concentrations of resources within SWS waters prior to treatment to assess the viability of enhanced resource recovery for a given project.

Although there does not currently seem to be any large-scale operations extracting resources from desalination brines, there are a number of companies and initiatives working on enhanced resource recovery. A company called Upwell Water is investing in a plant to extract gypsum and hydrochloric acid from the brine of the Kay Bailey Hutchison desalination plant in El Paso.[[176]](#footnote-177) The company Element3 Resources recently completed a pilot project where they successfully extracted lithium from Permian Basin produced water.[[177]](#footnote-178) One of the RFI respondents, Enviro Water Minerals, has worked on designs for a number of enhanced resource recovery technologies and is currently assessing their feasibility for desalination projects in the Middle East. A California company called Magrathea Metals has extracted small quantities of magnesium from desalination brines and other saline solutions in pilot projects and is currently in the process of scaling their technology.[[178]](#footnote-179) Oregon State University is piloting brine mining technologies in a partnership between academia, industry, and government.[[179]](#footnote-180) Brine mining is also planned to be incorporated into the NEOM initiative in Saudi Arabia.[[180]](#footnote-181)

**Improve rate of water recovery.** Current technology allows for a water recovery rate from brackish water of approximately 83-85 percent. If this rate of recovery is increased, it would be possible to produce a smaller volume of brine for a given amount of treated water. Reducing the volume of brine can reduce disposal costs significantly. In order to improve the rate of water recovery, constituents such as calcium carbonate, silicas, and others must be removed. There are different methods and different stages of the treatment process that constituents can be removed, but regardless of the method chosen there will always be solids that require disposal.

**Energy security.** Recovering the metals and minerals that exist in brackish water resources could provide energy security to the U.S. and decrease energy dependence on nations such as China.

# economic feasibility

New Mexico has considered the use of advance commitments to purchase treated produced and treated brackish water to incentivize private sector investment in construction and operation of water treatment facilities. Advance contracts for treated water purchases could de-risk these investments by providing certainty that a buyer will purchase treated water at specified qualities and quantities, for a specified price, over a given period of time. New Mexico is also considering other incentives and funding models as well.

This section explores the price that water treatment businesses would need to participate in the initiative, with calculations of the net present value of a purchase commitment. This is compared to the price that potential end users might be willing to pay for treated water. It is this gap between the price that water treatment facilities would need and the price that end users would accept that the SWS might support to incentivize private sector investment. End user willingness to pay for treated water is presented in relation to project costs. Discussions of the incentive mechanism and duration are also provided.

## Supply Side: Water Processing Costs Structure

Water processing costs vary depending on the source, method, and goal of treatment. Figure 13 illustrates the components of a project from source to end user, each step having implications for project costs and potential revenue streams.

Figure 13. Flow chart of brackish water and produced water sourcing, treatment, and use for no-discharge and discharge scenarios

A diagram of a process

Description automatically generated

### Cost Components

Costs associated with water treatment can be broadly grouped into CAPEX (capital expenditures, such as construction costs) and OPEX (operation and maintenance expenses, such as labor, energy, and membrane replacement). Figure 14 presents the major water processing costs associated with the respective CAPEX and OPEX categories, showing the large number of factors affecting water treatment cost estimates.

Figure 14. Desalination CAPEX and OPEX costs

A diagram of a company's company

Description automatically generated

Source: QWI DesalData Report, 2024.[[181]](#footnote-182)

Further dissecting water treatment costs, Figure 15 shows that OPEX accounts for approximately 62 percent of the cost of water for an average desalination plant.[[182]](#footnote-183) The major categories are energy, labor, and chemicals, which account for around 82 percent of the operational costs. The most relevant capital expenses correspond to land, equipment, buildings, and design costs. Other indirect costs, such as insurance and project overhead, also contribute to CAPEX. In terms of OPEX, the major costs are chemicals, labor, energy, and maintenance.

Unfortunately, the lack of consistent data about different facilities makes it difficult to directly compare the specific components included in each estimation. However, most sources agree that most of the costs of a reverse osmosis desalination system, for example, correspond to electrical energy, capital, and maintenance costs, as shown in Figure 15. These comprise about 90 percent of the total costs.

Figure 15. CAPEX/OPEX spending by category and plant type

A diagram of a graph

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Source: QWI DesalData Report, 2024.[[183]](#footnote-184)

Energy costs are a key component due to the extensive power required. For a given TDS level, energy is the most important factor in evaluating the cost of a desalination. The cost also depends on the technology employed. Due to its comparatively small energy demand and the lower overall water-producing cost, RO desalination is one of the most widely accepted techniques. In contrast, one of the main disadvantages of thermal systems is the large amount of energy required, which also limits their capacity to work within non-centralized systems. In contrast, RO can operate through the regular electric grid, facilitating its adoption.

The levelized cost of water (LCOW) is a commonly used indicator for comparing different water treatment systems. After accounting for the water production capacity, the LCOW is calculated by adding all the annual costs (operation and maintenance) with the amortized construction costs. The LCOW is governed by feedwater quality, treatment processes and goals, plant capacity, concentrate disposal and waste management, climate, land availability, and energy price. LCOW initially decreases sharply with a larger plant capacity, reaching a stable level for larger plants’ capacities. However, despite the economies of scale of treatment infrastructure, decentralized systems can reduce costs by minimizing storage and distribution costs.

Based on Edirisooriya et al. 2024[[184]](#footnote-185), Figure 16 reports estimated water processing costs for different technologies. Two key elements stand out for the purpose of our analysis. First, brackish water reverse osmosis (BWRO) has a low processing cost, making it less costly than some non-potable water sources currently used for irrigation. Second, produced water costs are highly variable depending on their specific project characteristics.

Figure 16. LCOW (in 2023 USD) for developing alternative water supplies

A chart with text and numbers

Description automatically generated with medium confidence

Source: Edirisooriya et al. (2024), Figure 3. LCOW (in 2023 USD) for developing alternative water supplies. Based on data they collected from Borch et al., Keller et al., Plumlee et al., Xu et al., Quon et al., Cooper et al., American Water Works Association (AWWA), and Cooley and Phurisamban.

Note: Axis displaying values in $/bbl added by this report’s authors.

SWRO: Seawater Reverse Osmosis; MF-RO-UV-H202: Micro-Filtration-Reverse Osmosis-Ultraviolet-H202; MF-RO: Micro-Filtration Reverse Osmosis; BWRO: Brackish Water Reverse Osmosis.

Following Edirisooriya et al. (2024), the following are approximated costs for different technologies and plant sizes, as reported in Figure 17:

* BWRO generally has the lowest treatment costs, ranging from $0.09/bbl for a 630 bbl/day plant (100 m3 /d) to $0.06/bbl for a plant with a capacity of 6290 bbl/day (1000 m3 /d).
* Microfiltration (MF)–RO treatment of municipal secondary or tertiary effluent has costs from $0.43/bbl for a 630 bbl/day plant (100 m³/day) to $0.25/bbl for a 6290 bbl/day plant (1000 m³/day), then decreases to $0.094/bbl for a 243,660 bbl/day plant (38,754 m³/day).
* Advanced oxidation step using ultraviolet light and hydrogen peroxide can be added to MF–RO to further polish product water quality. The LCOW is estimated at $0.50/bbl, $0.28/bbl, and $0.20/bbl for a 630 bbl/day (100 m³/day), 6290 bbl/day (1000 m³/day), and 244,000 bbl/day (38,800 m³/day) plant capacity, respectively.

These costs directly reflect how LCOW changes depending on desired water quality and plant size. However, water treatment costs can vary throughout a plant's lifecycle. For example, Edirisooriya et al. (2024) mention that BW desalination costs at the Kay Bailey Hutchinson Desalination Plant in El Paso, Texas, increased by over 30 percent from $0.06/bbl to $0.084/bbl when its feedwater TDS increased from 2000-2500 mg/L to 2500−3600 mg/L.

Figure 17. LCOW by technology and plant capacity

A graph of different colored lines

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Source: Edirisooriya et al. (2024)[[185]](#footnote-186)

Notes: lines representing Brackish Water Reverse Osmosis (BWRO), Microfiltration Reverse Osmosis (MF-RO), Microfiltration Reverse Osmosis (MF-RO-UV-H2O2), Seawater Reverse Osmosis (SWRO).

The cost structure of water processing plants also implies a trade-off for firms between operational and capital costs. The LCOW, which includes both types of costs, is lower for bigger plants. However, firms that choose smaller plants with lower capital costs can potentially implement them faster, but they tend to have higher operational costs. On the other hand, bigger plants may need financial support for longer to become profitable, increasing total SWS costs. Ultimately, the choice between these technologies will depend on factors such as long-term water demand forecasts, energy costs, and funding availability for larger projects.

The trade-off between operational and capital costs that affects water processing plants also impacts potential energy sources, which are crucial due to the high energy needs of processing water. Renewable energy technologies, such as wind or solar power, usually have high capital costs, but low operational costs, as they do not rely on fuel prices or water availability. However, they also face challenges with intermittency, storage, and grid integration, which may raise their overall costs. Desalination technologies, on the other hand, have more stable and predictable operational costs, but they change depending on the quality of the input water, the energy source, and the size of the plant. Therefore, firms must weigh the trade-offs between capital and operational costs, as well as the risks and uncertainties associated with different technologies, when selecting the best water supply option. Notably, the chosen duration for the incentive structure of the AMC can affect firms’ financial planning and, thus, their technology choices, which is discussed further below.

### Treatment of produced water

The treatment costs of produced water are highly variable depending on the presence of different types of contaminants and salinity The treatment costs of produced water are highly variable depending on the presence of different types of contaminants and salinity. Processing costs have been estimated at 1.50 $/bbl to 1.91 $/bbl treating hypersaline produced water (e.g., unconventional produced water in the Permian Basin) using waste heat and low-temperature thermal distillation technologies.[[186]](#footnote-187)

A 2022 report by Kanalis Group[[187]](#footnote-188) for the New Mexico Produced Water Research Consortium states that San Juan produced waters have a TDS range of 10,000 ppm to 30,000 ppm. This water quality is usually treated with brackish or seawater reverse osmosis (RO) membranes. On the other hand, Permian Basin produced water has higher levels of organics and TDS and can range from 30,000 to 150,000 ppm TDS. Produced waters that exceed 40,000 to 50,000 ppm need thermal treatment technologies, which makes produced water treatment generally six to ten times more costly.

Estimated project costs for potential SWS projects are presented below for the two major oil and gas producing regions in New Mexico: the Permian and San Juan Basins. Raw produced water quality differs between these two regions, with higher salinities in the Permian requiring more expensive treatment processes. NMSU has estimated per barrel costs for 1 and 5 million gallons per day (MGD) facilities in these two regions, assuming a thermal process is used in conjunction with post-treatment polishing in the Permian, and less expensive membrane technology is used in the San Juan.[[188]](#footnote-189) In addition, three RFI respondents (Aquality Solutions, Occidental Petroleum, and HF Sinclair) provided estimated prices they need to be paid per barrel to cover their costs to treat produced water for industrial use in these two regions.[[189]](#footnote-190) ERG calculated the present value of project costs based on facility capacity, per barrel costs or prices, and project timeframe.[[190]](#footnote-191) The present value of SWS support is the value of upfront costs (capital costs) plus the present value of annual costs over the period of support. Table 10 and Table 11 summarize the estimated project cost estimates for produced water projects in the Permian and San Juan Basins, respectively.

Table 9. Estimated Produced Water SWS Project Cost Estimates: Permian Basin

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Component** | **NMSU** | **NMSU** | **Aquality Solutions** | **Occidental Petroleum** |
| **End Use** | Industrial and commercial applications | Industrial and commercial applications | Industrial applications | Hydrogen, semiconductors, or cooling water |
| **Capacity** | 1 MGD | 5 MGD | 4.2 MGD | 0.9 MGD |
| **Cost/Price of Treated Water ($/bbl)\*** | $1.89-$2.14 | $1.12-$1.52 | $1.50 | $1.00 |
| **Timeframe** | 20 years\*\* | 20 years\*\* | 5 years | 5 years |
| **SWS Project Cost** | $269-$304 million | $796-$1,080 million | $258 million | $37 million |

\*bbl=barrel

\*\*Timeframe of 20 years assumed based on timeframe used in NMSU study for Santa Teresa, discussed in more detail below.

Additional notes:  
[1] Occidental Petroleum’s RFI response assumed the use of existing recycling facilities' infrastructure.

[2] After debt service, Aquality Solutions expects the price for the treated produced water to be between $1.20 and $1.30 per barrel. The pricing for treated water has been developed using a "cost plus" model that incorporates a 20 percent return.

[3] Discount rates used by RFI respondents in price calculations were not disclosed in these submissions.

[4] Aquality Solutions estimated the timeframe to be a minimum of 5 years.

Table 10. Estimated Produced Water SWS Project Cost Estimates: San Juan Basin

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Component** | **NMSU** | **NMSU** | **HF Sinclair** | **Aquality Solutions** |
| **End Use** | Industrial and commercial applications | Industrial and commercial applications | Hydrogen production | Industrial applications |
| **Capacity** | 1 MGD | 5 MGD | 0.5 MGD | 4.2 MGD |
| **Cost/Price of Treated Water ($/bbl)** | $1.47-$1.59 | $0.70-$0.95 | $0.55-$1.00 | $1.50 |
| **Duration of Agreement** | 20 years\* | 20 years\* | 5 years | 5 years |
| **SWS Project Cost** | $209-$226 million | $497-$675 million | $11-$20 million | $258 million |

\*Timeframe of 20 years assumed based on timeframe used in NMSU study for Santa Teresa.

Additional notes:  
[1] HF Sinclair’s RFI response assumed the use of existing recycling facilities' infrastructure.

[2] After debt service, Aquality Solutions expects the price for the treated produced water to be between $1.20 and $1.30 per barrel. The pricing for treated water has been developed using a "cost plus" model that incorporates a 20 percent return.

[4] Discount rates used by RFI respondents in price calculations were not disclosed in these submissions.

[6] Aquality Solutions estimated the timeframe to be a minimum of 5 years.

In addition to the costs of a treatment facility, the costs of a produced water treatment project will also be determined by water transportation and storage needs, as well as potential disposal cost savings, and the value of potentially recoverable minerals. It is assumed that the NMSU and RFI respondent estimates do not include transportation and storage, disposal cost savings or potential revenue from recovery of valuable minerals.

Transportation between the source, treatment facility and end user add to project costs. A rough estimate of the cost for large diameter pipeline is approximately $1 million per mile that would be considered an additional upfront project cost. Our expectation is that projects will be designed to minimize the need for transportation as much as possible to reduce costs, by locating treatment facilities and end users in proximity to water sources. The establishment of pipelines involves logistical challenges and costs related to securing rights of way, though these are not considered here.

Diversion of produced water to treatment and reuse will reduce disposal costs. Oil and gas companies currently pay disposal costs for salt water disposal (SWD), which is estimated to be approximately $0.70-$1.00/barrel. It may be reasonable to assume that oil and gas companies will be willing to pay up to their current disposal costs to participate in a project that would divert produced water away from disposal. However, the midstream operations that currently aggregate produced water from many production wells for disposal or reuse will likely continue to be involved in projects due to their existing transportation infrastructure, expertise and relationships. The continued involvement of midstream companies implies an associated cost. Therefore, we assume a potential cost savings of less than what oil and gas companies currently pay for disposal.

We have calculated project costs including the cost of 25 miles of pipeline and a cost savings of $0.50/barrel for disposal costs that would be avoided. Approaches for recovering valuable minerals from produced water are still under development, and we have not included the impacts of any potential revenue in our estimates. While it is reasonable to assume that projects will require storage to accommodate fluctuations in the amount of water at different stages of a process, we have not included any estimates of the costs of storage. These rough estimates of cost savings for disposal and additional costs for water transportation are taken into account to calculate net project costs. Table 11 and Table 12 present these estimates of net project costs.

Table 11. Net Costs for Produced Water Projects: Permian Basin

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Component** | **NMSU 1 MGD** | **NMSU 5 MGD** | **Aquality** | **Occidental** |
| **Initial Project Cost** | $269-304 million | $796-1,080 million | $258 million | $37 million |
| **Disposal Cost** | $71 million | $355 million | $86 million | $18 million |
| **Transportation Cost 25 miles** | $20 million | $20 million | $24 million | $24 million |
| **Net SWS Project Cost** | $218-253 million | $461-745 million | $196 million | $42 million |

Note: Disposal costs calculated as the present value over project lifespan.

Table 12. Net Costs for Produced Water Projects: San Juan Basin

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Component** | **NMSU 1 MGD** | **NMSU 5 MGD** | **HF Sinclair** | **Aquality** |
| **Initial Project Cost** | $209-226 million | $497-675 million | $11-20 million | $258 million |
| **Disposal Cost** | $71 million | $355 million | $10 million | $86 million |
| **Transportation Cost 25 miles** | $20 million | $20 million | $24 million | $24 million |
| **Net SWS Project Cost** | $158-175 million | $163-340 million | $25-34 million | $196 million |

Note: Disposal costs calculated as the present value over project lifespan.

### Treatment of brackish water

As discussed previously, brackish water treatment is more prevalent in practice than produced water treatment for use outside the oilfield. Table 13 provides examples of specific plants, including their levelized cost of water, capital cost, and capacity. The ranges displayed evidence that actual economic feasibility of the projects will rely on specific cost components of specific projects (e.g., feedwater TDS, plant scale, etc).

Table 13. Cost references from desalination plants

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Type** | **Water cost ($/bbl)** | **Capital cost** | **Costs components included** | **Capacity** | **Source** |
| BWRO | 0.07-0.09 | $91 million | Levelized cost of water | 27.5-33 million gallons per day | Pei Xu, 2023, New Mexico Legislature Handout[[191]](#footnote-192) |
| BW | 0.08 | N/A | Cost to process 10,000 ppm TDS water | 100 million gallons per day system | Ashok Ghosh (RFI) |
| BW | 0.1 | N/A | Average cost of treated brackish water from 7 treatment plants in Texas in 2011 (adjusted for inflation) | N/A | NONA Technologies (RFI) |
| BWRO | 0.12 | $54 million (~$10 million according to alternative source) | RO recovery of about 80% to achieve potable water of about 800 mg/l TDS | 2.8 million gallons per day (potable water) | New Mexico Legislature Handouts[[192]](#footnote-193),[[193]](#footnote-194) |
| BW/SW | 0.13 | N/A | Cost to process 100,000 ppm TDS water | 100 million gallons per day system | Ashok Ghosh (RFI) |
| BWRO | 0.13-0.16 | $143 million | Levelized cost of water | 12.2 million gallons per day (3.1; 5.6; 3.5) | Pei Xu, 2023, New Mexico Legislature Handout |
| BWRO | 0.13-0.26 | N/A | Unspecified | N/A | Water Technology[[194]](#footnote-195) |
| BW EDR | 0.24 | $100 million | Levelized cost of water | 6 million gallons per day | Pei Xu, 2023, New Mexico Legislature Handout |
| BW | 0.37 | $3 million | Levelized cost of water | 0.5 million gallons per day | Jacob's Well (RFI) |
| N/A | 0.42-0.84 | N/A | Levelized cost of water | N/A | Baryon (RFI) |

For the SWS, estimated project costs are presented below for brackish water projects, based on an NMSU feasibility study for a project in Santa Teresa[[195]](#footnote-196) and two responses to the RFI. The NMSU study provides an estimate of the upfront costs ($269.4 million) and the present value of annual costs ($43.9 million) for a 5 MGD facility. These estimates were used to calculate a per-barrel cost. In addition, two RFI respondents (Jacob’s Well and NONA Technologies) provided estimated price per barrel that they would need to cover their costs to treat brackish water for industrial use. These prices were used with facility capacity and timeframe to calculate total project cost. The NMSU estimates include several costs that may not be included in the estimates from the RFI respondents: supply wells and supply line to the treatment facility, disposal wells and disposal line, and other supporting infrastructure including connection to the distribution system. Table 14 summarizes the estimated project cost estimates for brackish water projects.

Table 14. Brackish Water Project Cost Estimates

|  |  |  |  |
| --- | --- | --- | --- |
| **Component** | **NMSU** | **Jacob's Well** | **NONA Technologies** |
| **End Use** | Potable | Industrial applications | Semiconductors, chemical processing or manufacturing |
| **Annual Capacity** | 5 MGD | 0.5 MGD | 1 MGD |
| **Cost/Price of Treated Water ($/bbl)** | $0.36\* | $0.37 | $0.23 |
| **Duration of Agreement** | 20 years | 10 years | 20 years |
| **Project Cost** | $256 million | $14 million | $33 million |

\*ERG calculated per barrel costs based on NMSU estimates of upfront and annual costs.

Additional notes:

[1] Jacob’s Well cost is $0.37 for the first 10 years with capital costs, then $0.28 after capital costs are paid off.

[2] NONA Technologies' capacity is based on a suggested minimum of 1 million gallons per day.

## Demand Side: Willingness to pay for water

To incentivize end users to participate in SWS projects, treated water must be priced at a level that they are willing to pay. Understanding the current freshwater rates for industrial users in the regions of interest provides insight into what end users might be willing to pay. One of the main challenges in assessing the willingness to pay for water by use is the lack of consistent and comparable data on the prices and costs of diverse sources and qualities of water. The RFI responses provide examples of the current or expected prices of treated brackish and produced water for various uses. Still, they vary widely depending on the location, volume, treatment method, and end use of the water.

Based on the RFI responses and further exploration of alternative data sources, Table 15 presents a range of water prices for different uses. Treated water prices vary highly depending on initial and objective water quality, ranging from $0.16/bbl for municipal irrigation and uses not involving direct human contact to $1.9/bbl for green hydrogen and $2.5/bbl or more for other more specific uses. In Santa Teresa, the Camino Real Regional Utility Authority charges a freshwater rate for industrial users of $5.00 per 1,000 gallons ($0.21 per barrel) for use over 100,000 gallons per month. For the Albuquerque area, the Albuquerque-Bernalillo County Water Utility Authority charges about $2.14 per 100 cubic feet ($0.12 per barrel) for freshwater for industrial uses. In the San Juan Basin, the city of Farmington has freshwater rates for industrial users ranging from $4.59 to $5.26 per 1,000 gallons ($0.19 to $0.22 per barrel). In the Permian Basin, the city of Carlsbad charges $98.47 per 1,000 gallons of freshwater for industrial users ($4.14 per barrel). However, whether this would be the rate applied to manufacturing companies is unclear; Carlsbad’s water statutes define industrial property as, “all of the property used in connection with a business in which a product is manufactured or used by a common carrier, utility or governmental agency”, but defines industrial water user as only including water hauling, brine production, oilfield servicing, oil and gas production, and resale of water for non-domestic purposes. If manufacturing companies fall under the commercial water rate instead, the corresponding rate is $2.62 per 1,000 gallons ($0.11 per barrel) for use over 500,000 gallons per month.

Table 15. Water price by use

|  |  |  |  |
| --- | --- | --- | --- |
| **Use/Category** | **Price ($/bbl)** | **Detail** | **Source** |
| Industrial | 0.08 | Price of freshwater for industrial users in Las Cruces | City of Las Cruces |
| Industrial | 0.12 | Price of freshwater for industrial users in Albuquerque and Bernalillo County | Albuquerque Bernalillo County Water Utility Authority |
| Industrial | 0.18 | Price of freshwater for industrial users in Los Lunas | Los Lunas Water Division |
| Industrial | 0.19-0.22 | Range of prices for non-residential users of freshwater in Farmington | City of Farmington |
| Industrial | 0.21 | Price of freshwater for industrial users in Santa Teresa for monthly usage over 100,000 gallons | Camino Real Regional Utility Authority |
| Industrial | 0.26-0.32 | Expected price for data centers, hydrogen companies, semiconductors | Trevi Systems (RFI) |
| Industrial | 0.32-0.58 | The expected range of what some industries are willing to pay for treated water | OneWater P3 Gurus (RFI) |
| Industrial | 0.52 | Price of desalinated water from the Carlsbad desalination plant | Global Water Farms (RFI) |
| Industrial | 1.68 | What Plug Power would be initially willing to pay for fit for purpose water for hydrogen (short run) | Plug Power (RFI) |
| Industrial | 0.42 | What Plug Power would be initially willing to pay for fit-for-purpose water for hydrogen (long run) | Plug Power (RFI) |
| Industrial | 1.93 | Expected price for hydrogen | Infrastruk (RFI) |
| Landscape irrigation | 0.15 | Expected price | OPUS 2G (RFI) |
| Oil & Gas | 0.50-1.50 | Price range currently paid by the oil and gas industry for freshwater | NGL Water Solutions (RFI) |
| Oil & Gas | 0.50-1.50 | Oil and gas companies' cost for freshwater | NGL Water Solutions (RFI) |
| Oil & Gas | 2.55-10.00 | Price paid by Texas' oil and gas companies in 2022 to have produced water treated | Global Water Farms (RFI) |

Prices for industrial water by utilities in the geographics considered most likely candidates for SWS projects (Carlsbad, Farmington and Santa Teresa) were used as an estimate of how much an industrial end user would be willing to pay for treated produced or treated brackish water. With these prices, facility capacity and project timeframe, total payments from end users were calculated and compared to project costs. Table 16 and Table 17 show net project costs and payments from end users to calculate an overall total for each project. In areas where alternative water sources are limited or unavailable, end users may be willing to pay a premium because they otherwise would not have a reliable water source at the quantities that they need for their facility.

Table 16. Project Costs and End User Payments: Produced Water

|  |  |  |  |
| --- | --- | --- | --- |
| **Region/Project** | **Net Project Cost** | **Payment from End Users** | **Net Project Cost Less Payments from End Users** |
| Permian |  |  |  |
| NMSU 1 MGD | $218-$253 million | $16 million | $202-$238 million |
| NMSU 5 MGD | $461-$745 million | $78 million | $383-$667 million |
| Aquality | $196 million | $19 million | $177 million |
| Occidental | $42 million | $4 million | $38 million |
| San Juan |  |  |  |
| NMSU 1 MGD | $158-$175 million | $30 million | $128-$145 million |
| NMSU 5 MGD | $163-$340 million | $149 million | $13-191 million |
| HF Sinclair | $25-$34 million | $4 million | $20-$30 million |
| Aquality Solutions | $196 million | $36 million | $159 million |

Table 17. Project Costs and End User Payments: Brackish Water

|  |  |  |  |
| --- | --- | --- | --- |
| **Project** | **Net Project Cost** | **Payment from End Users** | **Net Project Cost Less Payments from End Users** |
| NMSU | $256 million | $149 million | $107 million |
| Jacob's Well | $14 million | $8 million | $6 million |
| NONA Technologies | $33 million | $30 million | $3 million |

## Incentives for private sector participation in Strategic Water Supply

NMED is considering the use of advance commitments to purchase treated produced and treated brackish water to incentivize private sector investment in construction and operation of water treatment facilities. Two forms of advance commitments are advance market commitments (AMCs) and advance purchase commitments (APCs). AMCs are commitments to potential suppliers as a group, while APCs are commitments to individual suppliers.[[196]](#footnote-197)

Both AMCs and APCs are considered “pull” mechanisms. Unlike “push” funding, which directly finances upfront costs such as construction or R&D, AMCs and APCs incentivize the end product, encouraging firms to invest in capacity and production to meet future demand that is guaranteed by the contract. In the context of water processing, a “pull” funding mechanism can be especially advantageous for several reasons:

* **Risk Mitigation:** Pull mechanisms mitigate risks associated with high upfront investments by guaranteeing a market for their product, thus encouraging investment in innovative solutions that might otherwise be deemed too risky.
* **Information Asymmetry:** Governments often lack the specific technical knowledge required to make informed decisions about water processing technologies. Pull mechanisms allow firms to determine the most efficient and cost-effective technologies.
* **Dynamic Efficiency:** Pull mechanisms promote dynamic efficiency by rewarding successful outcomes rather than funding the R&D process. Firms are motivated to continuously improve and adapt their technologies to meet the contract’s requirements, leading to better water processing solutions over time.
* **Capacity Building:** Water processing requires substantial infrastructure and capacity development, with a cost structure characterized by high initial investment and low marginal costs. By incentivizing private sector investment, AMCs and APCs promote more rapid expansion of water treatment capacity, which is crucial for addressing water scarcity.

Pull mechanisms like AMCs and APCs offer a strategic way to encourage investment in water processing technologies. They leverage market forces to overcome information asymmetries and incentivize firms to develop and scale up efficient and effective water processing solutions, ensuring that societal needs are met without the need for the government to involve itself in the technological development process directly. This pull structure is particularly beneficial for complex and essential services like water processing, where the end goal is clear, but the path to achieving it is not.

## Incentive duration

Analyzing the trade-offs of different incentive durations is crucial in determining the most effective subsidy strategy for companies with high capital costs. This analysis explores how varying the length of the subsidy period impacts financial outlays, investor confidence, and long-term sustainability, considering factors such as alternative source prices, variable costs, technological advancements, and market demand. Understanding these dynamics helps craft a balanced approach that supports initial project development while ensuring viability beyond the subsidy period.

**Short-Term Subsidies (e.g., 5 Years):**

* Increased Investor Confidence: A substantial upfront subsidy may attract investors by reducing initial capital costs and avoiding long-term policy uncertainty, encouraging them to commit to the project.
* Risk of Unsustainability: Companies need to achieve profitability or break-even status quickly after the subsidy period ends. This requires a rapid ramp-up in efficiency and client acquisition.
* Operational Readiness: Projects that can amortize costs quickly (as seen in some produced water projects) are more likely to thrive under a short-term subsidy. However, projects with longer payback periods may struggle.

**Long-Term Subsidies (e.g., 15-20 Years):**

* Lower Annual Subsidy Costs: Spreading the subsidy over a longer period reduces the annual financial outlay, imposing a lower cost on New Mexico’s yearly budget.
* Extended Support: Long-term subsidies provide a safety net, allowing companies more time to stabilize operations, refine processes, and build a customer base.
* Dependency Risk: Prolonged financial support might lead to dependency, where companies rely on subsidies rather than striving for self-sufficiency.
* Higher Overall Costs: Over time, the cumulative cost of a long-term subsidy may be higher, especially when accounting for inflation and potential increases in operational costs.

**Factors Influencing Project Sustainability Beyond Subsidies:**

* Alternative Source Prices: The prices of alternative water sources are likely to rise, potentially making subsidized projects more competitive after the funding stops.
* Variable Costs Evolution: Operational costs, such as energy, labor, and maintenance, will evolve. Projects with decreasing or stable variable costs are better positioned for long-term success.
* Technological Advancements: Innovations in water treatment technology can reduce costs and improve efficiency, enhancing the sustainability of projects beyond the subsidy period. However, committing to large plants relying on current technologies can place a burden by complicating the adoption of future technologies.
* Market Demand: Steady or growing demand for treated water, influenced by industrial growth and regulatory changes, supports project viability.
* Regulatory Environment: Changes in regulations, particularly those affecting water quality standards and disposal requirements, can impact the cost structure and market dynamics for treated water.
* Partnership Opportunities: Encouraging partnerships with private investors, local governments, and industries can spread financial risks and enhance the resource pool for these projects.

Balancing short-term and long-term subsidies involves weighing the trade-offs between immediate financial outlays and long-term sustainability risks. By considering factors such as alternative source prices, variable costs, technological advancements, and market demand, a more informed decision can be made. Additional viewpoints, including economic impact, regulatory environment, and partnership opportunities, further enrich the analysis, ensuring that subsidies are structured to foster sustainable and profitable water processing projects.

## Economic Feasibility Conclusions

The SWS would address the gap between the price that water treatment suppliers need to cover their capital investment and operating costs and the price that end users are willing to pay. The estimates above provide a rough idea of the level of funding that would be needed to support produced water and brackish water treatment projects through the SWS. Taking into account disposal cost savings and payments from end users, produced water projects are estimated to cost between $13 and $191 million in the San Juan and between $38 and $667 million in the Permian, for projects with varying capacities and durations of support. Brackish water projects are estimated to cost between $3 and $107 million, after taking into account payments from end users for projects with varying capacities, although much of the difference is likely due to omission of well construction and other costs in the RFI responses. Duration of funding and consideration of end user payments can substantially affect required funding levels. Additional findings of the economic analysis follow below.

**Investment Risk:** The SWS addresses investment risk by committing to purchasing treated water at a given price, with risks related to the volatility of a potential market for treated water being transferred to the State. This assumption of risk has important implications for the state, especially if a potential end user identified as the off-taker for a project either is no longer operational (for existing facilities) or fails to materialize. Undertaking water treatment projects in areas where multiple end users may be available to utilize treated water would reduce this risk.

**Sustainability**: As discussed above, the sustainability of a project beyond the life of an incentive depends on a treatment facility’s ability to cover operating costs in an unsubsidized market, which assumes there will be an end user willing to pay a price sufficient to cover operating costs. The state’s commitment is unlikely to last over the envisioned lifespan of a facility. However, projections about operating costs and what end users will be willing to pay in 10 or 15 years is difficult.

**Complementary Funding Sources:** To the extent that other sources of funding for capital investments are available, the amount of support necessary to incentivize a project through the SWS will be reduced. Appendix B describes other potential sources of capital funding.

**Value of alternative to SWD:** Concerns about seismicity related to SWD may lead to constraints on current produced water disposal practices, which could severely limit oil and gas production activity and increase the amount that the oil and gas industry is willing to pay for alternatives to SWD, such as diversion to a treatment facility for reuse outside the oil and gas industry. In that case, the need to subsidize produced water treatment may be reduced or eliminated.

**Costs of closed loop requirement:** The SWS requirement that projects be closed loop with no environmental discharge of waste streams associated with treated brackish or produced water, may impose significant additional costs on end users, and may need to be reflected in pricing of water to compensate for costs related to this requirement. These costs may be prohibitive, limiting potential projects in a no-discharge scenario to consumptive uses, such as hydrogen production.

**Treated water quality related to alternative sources:** The end quality of treated water for any of the above-referenced projects may be higher than the quality of water available from local utilities, which would lead to overestimating the real difference in prices, for example, as the price for higher-quality water, such as ultra-pure water for chip manufacturing, would presumably be higher than the price of drinking water.

**Increasing water prices:** Calculations presented here assume that water prices from local utilities are constant over time. With increasing scarcity and new federal requirements to remove emerging contaminants, such as PFAS, it may be true that the price of water from local water utilities for industrial uses will increase over time, especially over longer time frames (e.g., 20 or 30 years). One estimate from a 2008 report from NMSU projected that the price of water in New Mexico would be 15 percent to 60 percent higher in 2030 compared to 2000, depending on different climate change scenarios.[[197]](#footnote-198)

# conclusion

This feasibility study provides a review of technological and economic considerations for the development of the envisioned SWS. Below, the lens of desirable characteristics is applied to discuss potential locations and project types for produced water (Section 9.1) and brackish water (Section 9.2) that appear to fit well within the objectives and scope of the SWS, under two scenarios that reflect expectations for development of relevant regulations: closed-loop projects with no environmental discharge (near term) and projects with environmental discharge (longer term). The study concludes with some overall findings that are intended to inform the development of the SWS.

## Produced Water

The two major oil and gas producing regions in the state offer ready supplies of raw produced water that might be considered for potential development of treatment facilities. In general, produced water will entail higher treatment costs than brackish water, though treatment facilities may obtain raw produced water for free or even be paid to take the water. Both regions have limited local labor force, are relatively remote, requiring transportation of any end products, and lack existing end users in the target sectors, e.g., advanced manufacturing and renewable energy generation and storage. In a closed-loop scenario, hydrogen production projects may have a good fit, as it represents a consumptive use of water. An additional alternative water supply may be needed to supply cooling needs, due to discharge associated with cooling systems that would be costly to manage or eliminate. In a scenario with environmental discharge, additional project types become feasible. In either scenario, a project with a single end user that might be attracted to develop in this region includes the risk that the end user may not materialize or may not remain operational through the lifespan of the treatment facility.

**San Juan Basin**

Given lower salinity levels of produced water in the San Juan Basin, treatment costs will be lower for projects undertaken in this region. However, overall produced water volumes are lower than in the Permian but are likely to be sufficient to support a treatment facility in this area.

**Permian Basin**

The lower water quality of raw produced water in the Permian Basin translates to higher treatment costs, though research indicates that treatment trains can be assembled to remove identified contaminants. The abundance of produced water being generated in this region means that source water will be readily available, and projects that divert water from disposal are potentially more viable as suppliers may be willing to pay a treatment facility to take the water, and larger scale projects may contribute to addressing issues around current disposal practices. Otherwise, many of the same considerations that apply to the San Juan also apply to the Permian.

## Brackish Water

There has been some exploration of brackish water basins in New Mexico that informs the feasibility of developing brackish water treatment projects in these regions. These regions of further investigation meet multiple criteria that make them potentially promising places to develop brackish water supplies. Namely, these regions are developed or will be developed, are in need of water, and have relatively good data available (in comparison with other regions in New Mexico). While additional water quality characterization is needed, treatment costs for brackish water projects are expected to be lower than for produced water projects. End uses with more stringent water quality requirements, such as semiconductor manufacturing, may be more suitable for brackish water projects. Limitations on discharge for brackish water projects need to be clarified, but if there are no closed-loop requirements, an expanded set of potential end uses may be feasible for brackish water projects. The possibility of having several potential end users in proximity reduces the risk that there might be no off-taker for projects in these areas. This section discusses the opportunities and challenges associated with developing brackish water resources in two places that meet these criteria: Santa Teresa and Albuquerque.

**Santa Teresa**

Located in the southern region of New Mexico near New Mexico’s border with Texas and Mexico (part of the Lower Rio Grande region), Santa Teresa has been identified as a region with great economic development potential as it is a land port of entry to Mexico, it has a growing industrial base and increasing population. An ongoing suit from Texas against New Mexico and Colorado arguing that New Mexico’s groundwater withdrawals along the lower Rio Grande are violating the Rio Grande Compact has made it clear that New Mexico must diversify its water supply in this region if economic growth is to continue.

In recognition of the high need for water in this region and the potentially suitable brackish water source, a pilot project is ongoing to provide additional information on the characteristics of the aquifer that is necessary to inform the decision as to whether the project is viable, and specific treatment technologies that would be appropriate. The development and planning for this project have been ongoing for over 5 years.[[198]](#footnote-199) As discussed above, a feasibility study has been completed with estimated project costs for different sized facilities. The experience so far with the potential Santa Teresa project may be illustrative of the time and resources required to bring a brackish water treatment project concept to the point where potential funding sources, such as the SWS, might be explored. It is unclear whether the current timeline for additional characterization work necessary to inform project design is in line with SWS timelines.

**Albuquerque Basin**

The Albuquerque metropolitan area is located in the Albuquerque Basin. As the Albuquerque metropolitan area continues to grow, there will be more demand for water in this already water stressed region. The Albuquerque Basin may provide an alternative water supply for these regions. Though the Albuquerque region generally has brackish water supply potential through the Albuquerque Basin, careful consideration must be given to the location of treatment and the location of end users.

# Appendix A: BRACKISH AQUIFER WATER CHEMISTRY[[199]](#footnote-200)

Table 18. San Luis Basin, summary of water chemistry

A table with numbers and symbols

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Table 19. Española Basin, summary of water chemistry

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Table 20. Albuquerque Basin, summary of water chemistry

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Table 21. Socorro-La Jencia Basins, summary of water chemistry

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Table 22. San Marcial and Engle Basins, summary of water chemistry

A table with numbers and symbols

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Table 23. Palomas Basin, summary of water chemistry

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Table 24. Mesilla Basin, summary of water chemistry

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Table 25. Jornada del Muerto Basin, summary of water chemistry

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Table 26. Estancia Basin, summary of water chemistry

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Table 27. Mimbres Basin, summary of water chemistry

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Table 28. San Agustin Basin, summary of water chemistry

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Table 29. Tularosa Basin, summary of water chemistry

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Table 30. Roswell Artesian Basin, summary of water chemistry

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Table 31. Capitan Reef aquifer, summary of water chemistry

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Table 32. Raton and Las Vegas Basins, summary of water chemistry

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Table 33. High Plains aquifer, summary of water chemistry

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Table 34. San Juan Basin, summary of water chemistry

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# APPENDIX B: Other sources of funding for upfront costs

## EPA Water Infrastructure Finance and Innovation Act

The EPA’s Water Infrastructure Finance and Innovation Act fund is a loan program for public and private entities that can be used to support brackish water desalination as well as alternative water supply projects, which would likely include produced water recycling. The program supports late-stage development, construction, property acquisition, and meeting project capital requirements. Projects must have a minimum cost of $20 million ($5 million for small communities) in order to qualify. The loan can cover up to 49 percent of a project’s cost and can have a repayment period of up to 35 years at an interest rate based on a comparable term U.S. treasury bond.

## U.S. Bureau of Reclamation

Another source of federal funding is the U.S. Bureau of Reclamation’s Title XVI Water Reclamation and Reuse Program, which has the express purpose of funding water recycling and desalination projects in the western U.S. The Reclamation and Reuse Program can provide up to 25 percent cost-shared funding, with a per project maximum of $30 million. Other subsets of Title XVI include the Desalination Construction Program and the Large-Scale Water Recycling Program, both of which received hundreds of millions from the Bipartisan Infrastructure Law. These programs also provide up to 25 percent cost-shared funding for projects, with the Large-Scale Water Recycling Program supporting projects with a minimum total cost of $500 million. Title XVI funding can be used to support the planning, design, and construction costs of desalination and water reuse projects.

## Clean Water Act State Revolving Fund

The Clean Water Act State Revolving Fund could potentially be used to support desalination projects. Each state administers their own fund, which is funded by the federal government and state contributions, and can issue loans, loan guarantees, and debt purchases for a wide variety of water projects. Since 2015, New Mexico has typically disbursed $15 million to $25 million from its revolving fund each year for loans durations of up to 30 years, with an interest rate of 2.375 percent for private entities and between 0 percent and 1 percent for public entities. Using the state revolving fund to support SWS projects could face some difficulties; the fund prioritizes projects that focus on protecting water quality rather than supplying water, and the eligibility of private projects is more limited than public projects.

## DOE Inflation Reduction Act

Green industry end users for the SWS could take advantage of Department of Energy loan programs that received billions in funding from the Inflation Reduction Act. One such program is the Title 17 Clean Energy Financing – Innovative Energy and Innovative Supply Chain program, which can be used by green hydrogen, solar and wind manufacturers, and other green industries. The Innovative Energy and Innovative Supply Chain program can also support projects related to critical minerals. As water treatment projects for the SWS could potentially supply critical minerals in addition to treated water, those treatment projects might be able to qualify for this loan program. Loans from the program typically cover 50 percent to 70 percent of a project’s total costs and are typically over $100 million in value. Another Department of Energy program is the Advanced Technology Vehicles Manufacturing Loan Program, which can be used for industries such as electric and hybrid vehicle manufacturing, EV battery manufacturing, and charging infrastructure components. The program provides loans at U.S. treasury rates.

## New Mexico Programs

In addition to federal sources of funding, New Mexico has several incentives that it offers to large industrial projects. Discretionary funding from the Local Economic Development Act (LEDA) can be used to reimburse some of the land, construction, and infrastructure costs of manufacturing projects that support the state’s economic development goals. The size of the incentive varies from project to project based on factors such as a project’s total investment, job creation, and quality of jobs created. In 2021, LEDA was expanded to allow 50 percent of state and local gross receipts taxes on the construction costs of projects to be reimbursed for projects with total construction costs of $350 million or more. Other state incentives include industrial revenue bonds, where a company leases land from a local government in order to abate property taxes for up to 30 years, and the high wage jobs tax credit, which offers tax incentives for the first four years of a project’s operation for urban jobs created with wages over $60,000 and rural jobs created with wages over $40,000.

1. For the purposes of this feasibility study, environmental discharge refers to discharge of treated water to surface water or ground water, and unrelated to the exploration, drilling, production, treatment, or refinement of oil or gas. [↑](#footnote-ref-2)
2. Office of the Governor, 2024, 50-Year Water Action Plan, https://www.nm.gov/wp-content/uploads/2024/01/New-Mexico-50-Year-WaterAction-Plan.pdf. [↑](#footnote-ref-3)
3. Office of the Governor, 2024. [↑](#footnote-ref-4)
4. Office of the Governor, 2023, Gov. Lujan Grisham to establish first-fo-its-kind Strategic Water Supply --$500 million investment will leverage advanced market commitments, December 5, https://www.governor.state.nm.us/2023/12/05/gov-lujan-grisham-to-establish-first-of-its-kind-strategic-water-supply-500-million-investment-will-leverage-advanced-market-commitments/. [↑](#footnote-ref-5)
5. Deep brackish aquifers refer to aquifers at a depth greater than 2500 feet and salinity greater than 1000 ppm total dissolved solids (TDS). [↑](#footnote-ref-6)
6. Stoll, Zachary, 2024, Research Assistant Professor, New Mexico State University, personal communication. [↑](#footnote-ref-7)
7. Produced water disposal is generally by injection into deep wells. [↑](#footnote-ref-8)
8. New Mexico Office of the State Engineer, 2018, New Mexico State Water Plan Part II: Technical Report, https://www.ose.nm.gov/Planning/SWP/2018/3-2018\_SWP\_Part\_II\_Technical\_Report\_plusAppendixes.pdf. [↑](#footnote-ref-9)
9. NMED, 2019, Produced Water Factsheet, https://www.env.nm.gov/wp-content/uploads/sites/16/2019/10/Produced-Water-Factsheet\_ENGLISH\_-FINAL-191010.pdf. [↑](#footnote-ref-10)
10. U.S. Energy Information Administration (EIA), 2024, New Mexico State Energy Profile, <https://www.eia.gov/state/print.php?sid=NM#:~:text=New%20Mexico%20is%20the%20nation's,total%20U.S.%20crude%20oil%20production> . [↑](#footnote-ref-11)
11. U.S. Bureau of Economic Analysis, 2024, Gross Domestic Product, [www.bea.gov/data/gdp](https://apps.bea.gov/itable/?ReqID=70&step=1&_gl=1*hrn939*_ga*ODE0NTQwNDkzLjE3MjAyMTAyOTI.*_ga_J4698JNNFT*MTcyNDcwOTcyOC41LjEuMTcyNDcxMDA2NS41MC4wLjA.#eyJhcHBpZCI6NzAsInN0ZXBzIjpbMSwyOSwyNSwzMSwyNiwyNywzMF0sImRhdGEiOltbIlRhYmxlSWQiLCI1MDUiXSxbIk1ham9yX0FyZWEiLCIwIl0sWyJTdGF0ZSIsWyIwIl1dLFsiQXJlYSIsWyIzNTAwMCJdXSxbIlN0YXRpc3RpYyIsWyItMSJdXSxbIlVuaXRfb2ZfbWVhc3VyZSIsIkxldmVscyJdLFsiWWVhciIsWyIyMDIyIl1dLFsiWWVhckJlZ2luIiwiLTEiXSxbIlllYXJfRW5kIiwiLTEiXV19). [↑](#footnote-ref-12)
12. New Mexico Bureau of Geology and Mineral Resources, 2024, Frequently Asked Questions About Oil and Gas, https://geoinfo.nmt.edu/faq/energy/petroleum/home.html. [↑](#footnote-ref-13)
13. OCD Statistics, 2024a. Statewide Natural Gas and Oil Production Summary including Produced Water and Injection by month. Originally downloaded 2/13/2024 from: <https://www.emnrd.nm.gov/ocd/ocd-data/statistics/>. [↑](#footnote-ref-14)
14. Ibid. [↑](#footnote-ref-15)
15. Ibid. [↑](#footnote-ref-16)
16. Murphy, K. 2024. Testimony Background Information: GIS Maps and Charts. New Mexico Environment Department. Data from State Land Office GIS: <https://www.nmstatelands.org/maps-gis/gis-data-download/>. [↑](#footnote-ref-17)
17. New Mexico Legislative Finance Committee, 2023, Money Matters: Analysis by the LFC Economists, https://nmlegis.gov/handouts/ALFC%20121123%20Item%201%20General%20Fund%20Consensus%20Revenue%20Estimate%2012.9.23.pdf. [↑](#footnote-ref-18)
18. Ibid. [↑](#footnote-ref-19)
19. OCD Statistics, 2024. [↑](#footnote-ref-20)
20. OCD Statistics, 2024. [↑](#footnote-ref-21)
21. Secondary oil recovery means injecting water into an oil reservoir to displace oil and move it towards a production well. [↑](#footnote-ref-22)
22. OCD Statistics, 2024. [↑](#footnote-ref-23)
23. Murphy, Kathleen, 2024. [↑](#footnote-ref-24)
24. Hightower, M., et al., 2021, NM Produced Water Data Portal, NM Produced Water Research Consortium – Year-end Meeting, December 1-2, <https://nmpwrc.nmsu.edu/files/NMPWRC-Data-Portal-Session-all-combined.pdf>. [↑](#footnote-ref-25)
25. Society of Petroleum Engineers (SPE). Undated. Challenges in Reusing Produced Water <https://www.spe.org/en/industry/challenges-in-reusing-produced-water/> [↑](#footnote-ref-26)
26. Jiang, W., Xu, X., Hall, R., Zhang, Y., Carroll, K.C., Ramos, F., Engle, M.A., Lin, L., Wang, H., Sayer, M. and Xu, P., 2022, Characterization of produced water and surrounding surface water in the Permian Basin, the United States, *Journal of Hazardous Materials* 430:128409, <https://doi.org/10.1016/j.jhazmat.2022.128409>. [↑](#footnote-ref-27)
27. Jiang, W., Lin, L., Xu, X., Cheng, X., Zhang, Y., Hall, R., and Xu, P. 2021. A critical review of analytical methods for comprehensive characterization of produced water. Water, 13, 183. [↑](#footnote-ref-28)
28. New Mexico Produced Water Research Consortium and the Ground Water Protection Council, 2024, New Mexico Produced Water Data Portal, https://nm.waterstar.org/. [↑](#footnote-ref-29)
29. U.S. Geological Survey, 2023, U.S. Geological Survey National Produced Waters Geochemical Database (ver. 3.0, December 2023). <https://www.usgs.gov/tools/us-geological-survey-national-produced-waters-geochemical-database-ver-30-december-2023>. [↑](#footnote-ref-30)
30. Cather, M., Lee, R., Gundiler, I., Sung, A. 2005. NM WAIDS: A Produced Water Quality and Infrastructure GIS Database for New Mexico Oil Producers (Final Technical Progress Report). New Mexico Petroleum Recovery Research Center, DE-FC26-02NT15134. [↑](#footnote-ref-31)
31. Jiang et al., 2022. [↑](#footnote-ref-32)
32. Zemlick, K., et al., 2018, Mapping the energy footprint of produced water management in New Mexico, *Environmental Research Letters*13:024008, <https://doi.org/10.1088/1748-9326/aa9e54>. [↑](#footnote-ref-33)
33. New Mexico Bureau of Geology and Mineral Resources, 2015, “Brackish and Saline Groundwater in New Mexico,” *New Mexico Earth Matters*. [↑](#footnote-ref-34)
34. Ibid. [↑](#footnote-ref-35)
35. Jiang et al., 2022. [↑](#footnote-ref-36)
36. Dahm, KG., Guerra, K.L., Xu, P., and Drewes, J. 2011. Composite geochemical database for coalbed methane produced water quality in the Rocky Mountain Region. Environmental Science and Technology, 45, 7655-7663. [↑](#footnote-ref-37)
37. Dahm, K.G., Guerra, K.L., Munakata-Marr, J., and Drewes, J.E. 2014. Trends in water quality variability for coalbed methane produced water. Journal of Cleaner Production, 84, 840-848. [↑](#footnote-ref-38)
38. OCD Statistics, 2024b. C-115 Produced Water by Operator, by Year. <https://www.emnrd.nm.gov/ocd/ocd-data/statistics/>. [↑](#footnote-ref-39)
39. Boyd, D. 2023. Third-Party Companies Expanding Water Treatment, Reuse and Disposal Capabilities. The American Oil and Gas Reporter. <https://www.aogr.com/magazine/editors-choice/third-party-companies-expanding-water-treatment-reuse-and-disposal-capabilities>. [↑](#footnote-ref-40)
40. OCD Statistics, 2024a. Statewide Natural Gas and Oil Production Summary including Produced Water and Injection by Month. <https://www.emnrd.nm.gov/ocd/ocd-data/statistics/>. Download 2/13/2024. [↑](#footnote-ref-41)
41. OCD, 2024. Industry Oversight, O/G Permitting, OCD Permitting, Operator Data, Water Use Report <https://wwwapps.emnrd.nm.gov/OCD/OCDPermitting/Reporting/Wells/WaterUseSummaryReport.aspx>. Download 2/14/2024. [↑](#footnote-ref-42)
42. Patton, P. 2023. Texas is giving away revenue and taking New Mexico’s waste. Dallas Morning News, Jan. 21, 2023. [↑](#footnote-ref-43)
43. Groundwater Protection Council (GWPC), 2022, U.S. Produced Water Volumes and Management Practices in 2021, https://www.gwpc.org/wp-content/uploads/2021/09/2021\_Produced\_Water\_Volumes.pdf. [↑](#footnote-ref-44)
44. GWPC, 2022. [↑](#footnote-ref-45)
45. Murphy, K. 2024. Testimony Background Information: GIS Maps and Charts. New Mexico Environment Department. Data from OCD GIS Hub. <https://ocd-hub-nm-emnrd.hub.arcgis.com/>. [↑](#footnote-ref-46)
46. U.S. Energy Information Administration, 2023, Texas State Profile and Energy Estimates, https://www.eia.gov/state/?sid=TX. [↑](#footnote-ref-47)
47. GWPC, 2022. [↑](#footnote-ref-48)
48. GWPC, 2022. [↑](#footnote-ref-49)
49. GWPC, 2022. [↑](#footnote-ref-50)
50. U.S. Energy Information Administration (EIA), 2023, Oklahoma State Profile and Energy Estimates, https://www.eia.gov/state/?sid=OK. [↑](#footnote-ref-51)
51. GWPC, 2022. [↑](#footnote-ref-52)
52. U.S. Energy Information Administration, 2023, Colorado State Profile and Energy Estimates, https://www.eia.gov/state/?sid=CO. [↑](#footnote-ref-53)
53. GWPC, 2022. [↑](#footnote-ref-54)
54. California Water Boards, 2016, Frequently Asked Questions About Recycled Oilfield Water for Crop Irrigation, https://www.waterboards.ca.gov/publications\_forms/publications/factsheets/docs/prod\_water\_for\_crop\_irrigation.pdf. [↑](#footnote-ref-55)
55. Cawelo Water District, 2024, Recycled Produced Water, https://www.cawelowd.org/recycled-produced-water/. [↑](#footnote-ref-56)
56. California Water Boards, 2016. . [↑](#footnote-ref-57)
57. Cawelo Water District, 2024. . [↑](#footnote-ref-58)
58. Edalat, A., and Hoek, E., 2020, Techno-Economic Analysis of RO Desalination of Produced Water for Beneficial Reuse in California, https://www.mdpi.com/2073-4441/12/7/1850. [↑](#footnote-ref-59)
59. Edalat and Hoek, 2020. [↑](#footnote-ref-60)
60. GWPC, 2023, Produced Water Report: Regulations & Practice Updates, https://www.gwpc.org/wp-content/uploads/2023/06/2023-Produced-Water-Report-Update-FINAL-REPORT.pdf. [↑](#footnote-ref-61)
61. The Ruckelshaus Institute of Environment and Natural Resources, 2005, Water Production from Coalbed Methane Development in Wyoming: A Summary of Quantity, Quality, and Management Options, https://www.uwyo.edu/haub/\_files/\_docs/ruckelshaus/pubs/2005-cbm-water-final-report.pdf. [↑](#footnote-ref-62)
62. GWPC, 2023. [↑](#footnote-ref-63)
63. U.S. Geological Survey, 2023, [↑](#footnote-ref-64)
64. U.S. Environmental Protection Agency, 2024, Fairmont Brine Site, https://response.epa.gov/site/site\_profile.aspx?site\_id=16192. [↑](#footnote-ref-65)
65. GWPC, 2023. [↑](#footnote-ref-66)
66. Hightower et al., 2021. [↑](#footnote-ref-67)
67. Jiang et al., 2022. [↑](#footnote-ref-68)
68. Danforth, C., Chiu W., Rusyn, I., Schultz, K., Bolden, A., Kwiatkowski, C., and Craft, E. 2020. An integrative method for identification and prioritization of constituents of concern in produced water from onshore oil and gas extraction. Environment International, 134, 105280. [↑](#footnote-ref-69)
69. Xu, P., Young, R., Zhang, Y., and Stoll, Z. 2024. Recommended Technologies for Produced Water. Strategic Water Supply: State of the Science Symposium, June 27, 2024, Las Cruces, NM. [↑](#footnote-ref-70)
70. Ibid. [↑](#footnote-ref-71)
71. U.S. Department of Energy, 2019, Desalination: Powering the Blue Economy: Exploring Opportunities for Marine Renewable Energy in Maritime Markets, https://www.energy.gov/sites/default/files/2019/09/f66/73355-7.pdf. [↑](#footnote-ref-72)
72. New Mexico Legislature, 2019, Produced Water Act, https://www.nmlegis.gov/Sessions/19%20Regular/final/HB0546.pdf. [↑](#footnote-ref-73)
73. New Mexico Environment Department, 2024, Water Reuse, https://www.env.nm.gov/wp-content/uploads/2024/05/Second-Amended-Proposed-Reuse-Regulations-20.6.8-NMAC-2-Ext.pdf. [↑](#footnote-ref-74)
74. U.S. Code of Federal Regulations, 2024, 40 CFR 435 Subpart E, https://www.ecfr.gov/current/title-40/chapter-I/subchapter-N/part-435. [↑](#footnote-ref-75)
75. Units for TDS are provided in either ppm or mg/L, which are equivalent measures. These units are used interchangeably in this report. [↑](#footnote-ref-76)
76. The 17 brackish water regions identified are: San Luis Basin, Espanola Basin, Albuquerque Basin, La Jencia Basins, Palomas Basin, Mesilla Basin, Jornada del Muerto Basin, Estancia Basin, Miembres Basin, San Agustin Basin, Tularosa Basin, Roswell Basin, Capital Reef, Raton Basin, Las Vegas Basin, High Plains Aquifer, and San Juan Basin. [↑](#footnote-ref-77)
77. New Mexico Bureau of Geology and Mineral Resources, 2023, New Mexico: Regional Brackish Water Assessments, https://geoinfo.nmt.edu/resources/water/projects/bwa/home.html. [↑](#footnote-ref-78)
78. New Mexico Bureau of Geology and Mineral Resources, 2024, New Mexico: Regional Brackish Water Assessments, https://geoinfo.nmt.edu/resources/water/projects/bwa/home.html#:~:text=For%20this%20assessment%20of%20brackish,saline%20or%20brine%20(red). [↑](#footnote-ref-79)
79. Land, L., 2016, Overview of Fresh and Brackish Water Quality in New Mexico, https://geoinfo.nmt.edu/publications/openfile/downloads/500-599/583/OFR-583\_NM\_BrackishHR.pdf. [↑](#footnote-ref-80)
80. Direct communications with Stacy Timmons, New Mexico Bureau of Geology & Mineral Resources. [↑](#footnote-ref-81)
81. USBR, 2024, Assessment and Implementation Framework for Transboundary Brackish Groundwater Desalination in South-central New Mexico, https://www.usbr.gov/research/dwpr/DWPR\_Reports.html [↑](#footnote-ref-82)
82. CDM, 2011, Preliminary Engineering Report, https://www.sandovalcountynm.gov/wp-content/uploads/2017/06/PER\_Revised\_Submittal20110415.pdf [↑](#footnote-ref-83)
83. U.S. Geological Survey, 2017, https://pubs.usgs.gov/pp/1833/pp1833.pdf. [↑](#footnote-ref-84)
84. U.S. Bureau of Reclamation, 2018, Desalination and Water Purification Research and Development Program Report No. 207, https://www.usbr.gov/research/dwpr/reportpdfs/report207.pdf. [↑](#footnote-ref-85)
85. U.S. Bureau of Reclamation, 2018, Desalination and Water Purification Research and Development Program Report No. 207, https://www.usbr.gov/research/dwpr/reportpdfs/report207.pdf. [↑](#footnote-ref-86)
86. U.S. Bureau of Reclamation, 2018, Desalination and Water Purification Research and Development Program Report No. 207, https://www.usbr.gov/research/dwpr/reportpdfs/report207.pdf [↑](#footnote-ref-87)
87. U.S. Bureau of Reclamation, 2018, Desalination and Water Purification Research and Development Program Report No. 207, https://www.usbr.gov/research/dwpr/reportpdfs/report207.pdf. [↑](#footnote-ref-88)
88. U.S. Bureau of Reclamation, 2014, Estimating the Cost of Brackish Groundwater Desalination in Texas, https://usbr.gov/gp/otao/estimating\_cost\_brackish\_groundwater\_desalination\_texas.pdf. [↑](#footnote-ref-89)
89. Texas Water Development Board, 2012, Cost of Brackish Groundwater Desalination in Texas, https://www.twdb.texas.gov/innovativewater/desal/doc/Cost\_of\_Desalination\_in\_Texas.pdf. [↑](#footnote-ref-90)
90. The Joint Water-Agriculture Ministerial Council, 2022, The Status, Treatment Methods, and Use of Brackish Water in the Arab Region, https://www.aoad.org/Mini%20Fifth%20Meeting/3-5%20the%20use%20of%20brackish%20water/The%20status,%20treatment%20methods,%20and%20use%20of%20brackish%20water%20in%20the%20Arab%20region%20EN.pdf. [↑](#footnote-ref-91)
91. Dawoud, M., et al., 2020, Towards sustainable desalination industry in Arab region: challenges and opportunities, https://www.deswater.com/DWT\_articles/vol\_193\_papers/193\_2020\_1.pdf. [↑](#footnote-ref-92)
92. Dawoud et al. 2020. [↑](#footnote-ref-93)
93. New Mexico Energy, Minerals, and Natural Resources Department, 2022, Orphan Well Clean-Up Work Begins, https://www.emnrd.nm.gov/officeofsecretary/wp-content/uploads/sites/2/orphan\_wells\_cleanup\_11\_2022.pdf [↑](#footnote-ref-94)
94. Gonzalez-Duque, D., et al., 2024, Groundwater Circulation Within the Mountain Block: Combining Flow and Transport Models with Magnetotelluric Observations to Untangle Its Nested Nature, https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2023WR035906?af=R. [↑](#footnote-ref-95)
95. 2023 New Mexico Statutes Chapter 72 - Water Law. https://law.justia.com/codes/new-mexico/chapter-72/ [↑](#footnote-ref-96)
96. U.S. Department of Energy 2019. <https://www.energy.gov/sites/default/files/2019/09/f66/73355-7.pdf> [↑](#footnote-ref-97)
97. Texas Water Development Board, 2012. <https://www.twdb.texas.gov/innovativewater/desal/doc/Cost_of_Desalination_in_Texas.pdf> [↑](#footnote-ref-98)
98. IRENA, 2012, Water Desalination Using Renewable Energy. <https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2012/IRENA-ETSAP-Tech-Brief-I12-Water-Desalination.pdf> [↑](#footnote-ref-99)
99. Texas Water Development Board, 2012. <https://www.twdb.texas.gov/innovativewater/desal/doc/Cost_of_Desalination_in_Texas.pdf> [↑](#footnote-ref-100)
100. Ramirez, K., et al., 2023, Hydrogen Reality Check: Distilling Green Hydrogen’s Water Consumption, https://rmi.org/hydrogen-reality-check-distilling-green-hydrogens-water-consumption/. [↑](#footnote-ref-101)
101. Valdez, T., 2022, Electrolyzers and Water: Saving Water, Powering the World with Green Hydrogen, https://www.plugpower.com/water-electrolysis-powering-the-world-with-green-hydrogen/. [↑](#footnote-ref-102)
102. National Renewable Energy Laboratory, 2023, Green Hydrogen: A Briefing for Land Managers, https://www.nrel.gov/docs/fy23osti/83885.pdf. [↑](#footnote-ref-103)
103. Madsen, H., 2022, Water treatment for green hydrogen: what you need to know, https://hydrogentechworld.com/water-treatment-for-green-hydrogen-what-you-need-to-know. [↑](#footnote-ref-104)
104. Fondriest Environmental Learning Center, 2014, Conductivity, Salinity & Total Dissolved Solids, https://www.fondriest.com/environmental-measurements/parameters/water-quality/conductivity-salinity-tds/. [↑](#footnote-ref-105)
105. Ahsan, T., et al., 2024, Photocatalytic Hydrogen Production with Ag-G-TiO2: A Green Energy Solution Using Diverse Feedstocks, SWS State of the Science Symposium poster presentation. [↑](#footnote-ref-106)
106. Davis, T., 2021, Facebook data center water use scrutinized, https://www.abqjournal.com/news/local/facebook-data-center-water-use-scrutinized/article\_521c48ac-c971-577c-bed2-3b0c7df4b0cc.html. [↑](#footnote-ref-107)
107. Holzle, U., 2022, Our commitment to climate-conscious data center cooling, https://blog.google/outreach-initiatives/sustainability/our-commitment-to-climate-conscious-data-center-cooling/. [↑](#footnote-ref-108)
108. U.S. Environmental Protection Agency, 2024, How We Use Water, https://www.epa.gov/watersense/how-we-use-water. [↑](#footnote-ref-109)
109. Zhang, M., 2024, Data Center Power: A Comprehensive Overview of Energy, https://dgtlinfra.com/data-center-power/. [↑](#footnote-ref-110)
110. Schatz, J., 2021, Facebook Offers Rare Glimpse of Los Lunes Data Center, https://abq.news/2021/10/facebook-offers-rare-glimpse-of-los-lunas-data-center/. [↑](#footnote-ref-111)
111. McArdle, P., 2023, U.S. electric power sector continues water efficiency gains, https://www.eia.gov/todayinenergy/detail.php?id=56820. [↑](#footnote-ref-112)
112. IBM, 2021, Water cooling system specification and requirements, https://www.ibm.com/docs/en/power8?topic=cooling-water-system-specification-requirements. [↑](#footnote-ref-113)
113. Ahmad, R., 2024, Engineers often need a lot of water to keep data centers cool, https://www.asce.org/publications-and-news/civil-engineering-source/civil-engineering-magazine/issues/magazine-issue/article/2024/03/engineers-often-need-a-lot-of-water-to-keep-data-centers-cool. [↑](#footnote-ref-114)
114. Semiconductor Industry Association, 2024, America Projected to Triple Semiconductor Manufacturing Capacity by 2032, the Largest Rate of Growth in the World, https://www.semiconductors.org/america-projected-to-triple-semiconductor-manufacturing-capacity-by-2032-the-largest-rate-of-growth-in-the-world/. [↑](#footnote-ref-115)
115. Associated Press, 2022, Computer chip maker to pay $32M for water pipeline, https://apnews.com/article/technology-business-albuquerque-utilities-water-utilities-1f969c6143dca658d988e5ff2d9fcf14. [↑](#footnote-ref-116)
116. Albuquerque Bernalillo County Water Utility Authority, 2024, Water and Sewer Rate Ordinance, https://www.abcwua.org/wp-content/uploads/2022/07/Section-1-Water-and-Sewer-Rate-Ordinance-1.pdf. [↑](#footnote-ref-117)
117. Alam, S., et al, 2022, Harnessing the power of the semiconductor value chain, https://www.accenture.com/content/dam/accenture/final/industry/communications-and-media/document/Accenture-Semiconductor-Value-Chain-Report.pdf. [↑](#footnote-ref-118)
118. Price, A., 2018, Samsung’s monthly Austin water bill roughly $700,000 a month, https://www.statesman.com/story/news/2016/09/26/samsungs-monthly-austin-water-bill-roughly-700000-a-month/9913815007/. [↑](#footnote-ref-119)
119. Baskaran, A., 2017, Waste Not, Want Not – Water Use in the Semiconductor Industry, https://www.sustainalytics.com/esg-research/resource/investors-esg-blog/waste-not-want-not-water-use-in-the-semiconductor-industry. [↑](#footnote-ref-120)
120. VerWey, J., 2021, No Permits, No Fabs: The Importance of Regulatory Reform for Semiconductor Manufacturing, https://cset.georgetown.edu/publication/no-permits-no-fabs/. [↑](#footnote-ref-121)
121. ASTM International, 2018, Standard Guide for Ultra-Pure Water Used in the Electronics and Semiconductor Industries, https://www.astm.org/d5127-13.html. [↑](#footnote-ref-122)
122. Heilweil, R., 2023, Want to Win a Chip War? You’re Gonna Need a Lot of Water, https://www.wired.com/story/want-to-win-a-chip-war-youre-gonna-need-a-lot-of-water/. [↑](#footnote-ref-123)
123. Arizona Technology Council, 2021, Utility company makes progress on infrastructure for Taiwan Semiconductor Project in north Phoenix, https://www.aztechcouncil.org/utility-company-makes-progress-on-infrastructure-for-taiwan-semiconductor-project-in-north-phoenix/. [↑](#footnote-ref-124)
124. Ford, B., 2023, U.S. Semiconductor Building Boom Underway, https://www.phcppros.com/articles/17786-us-semiconductor-building-boom-underway. [↑](#footnote-ref-125)
125. VerWey, J. 2021. [↑](#footnote-ref-126)
126. Canadian Solar, 2022, ESG Sustainability Report, https://www.canadiansolar.com/canadian-solar\_esg-report//wp-content/uploads/2023/08/Canadian-Solar-2022-ESG-Report-vFinal.pdf. [↑](#footnote-ref-127)
127. Solar Energy Industries Association, 2024, What’s in a Megawatt? Calculating the Number of Homes Powered by Solar Energy, https://www.seia.org/initiatives/whats-megawatt. [↑](#footnote-ref-128)
128. Maxeon, 2023, Maxeon Solar Technologies Selects Albuquerque, New Mexico as Site for New 3-Gigawatt Solar Cell and Panel Manufacturing Facility, https://mediaroom.maxeon.com/2023-08-10-Maxeon-Solar-Technologies-Selects-Albuquerque,-New-Mexico-as-Site-for-New-3-Gigawatt-Solar-Cell-and-Panel-Manufacturing-Facility. [↑](#footnote-ref-129)
129. U.S. Department of Energy, 2024, Environmental Assessment – Golden Eagle, https://www.energy.gov/sites/default/files/2024-01/Project%20Golden%20Eagle%20MDS\_EA\_01\_08\_2024.pdf. [↑](#footnote-ref-130)
130. Panat, S., and Varanasi, K., 2022, Electrostatic dust removal using adsorbed moisture-assisted charge induction for sustainable operation of solar panels, https://www.science.org/doi/10.1126/sciadv.abm0078. [↑](#footnote-ref-131)
131. Wyatt, J., et al, 2021, The True Land Footprint of Solar Energy, https://betterenergy.org/blog/the-true-land-footprint-of-solar-energy/. [↑](#footnote-ref-132)
132. RenewSys, 2022, Water rules for cleaning solar panels, https://www.renewsysworld.com/post/water-rules-for-cleaning-solar-panels. [↑](#footnote-ref-133)
133. Agatie, C., 2023, Tesla Explains How it Achieves Record Breaking Water Saving at Giga Berlin, https://www.autoevolution.com/news/tesla-explains-how-it-achieves-record-breaking-water-economy-at-giga-berlin-213982.html. [↑](#footnote-ref-134)
134. Kane, M., 2023, Tesla’s Annual Vehicle Capacity Increased to Over 2.3 Million, https://insideevs.com/news/692819/tesla-production-sites-model-assignment-october2023/. [↑](#footnote-ref-135)
135. Chumak, D., 2024, The Opportunity for Water Reuse at Battery Gigafactories, https://www.batterytechonline.com/battery-manufacturing/the-opportunity-for-water-reuse-at-battery-gigafactories. [↑](#footnote-ref-136)
136. Agatie, C. 2023. [↑](#footnote-ref-137)
137. Efficient Plant, 2008, Enhanced Cooling Tower Maintenance Saves Water, https://www.efficientplantmag.com/2008/10/enhanced-cooling-tower-maintenance-saves-water/. [↑](#footnote-ref-138)
138. Southwest Research Institute, 2019, Optimizing West Texas Wind and Solar Energy Generation Using Closed-Loop Pumped Storage Hydropower, https://www.swri.org/sites/default/files/brochures/closedloop-pumped-storage-hydropower\_1.pdf. [↑](#footnote-ref-139)
139. Rather than having a traditional lower reservoir, the Philippine Sea was used as the lower body of water for this pumped storage project. As such, a liner was only needed for the upper reservoir. [↑](#footnote-ref-140)
140. Cemnet, 2021, The cement industry must tackle water management head on, https://www.cemnet.com/News/story/171382/the-cement-industry-must-tackle-water-management-head-on.html. [↑](#footnote-ref-141)
141. MTR Industrial Separations, 2024, Cement Plants, https://www.mtrinc.com/cement-plants/. [↑](#footnote-ref-142)
142. New Mexico Bureau of Geology and Mineral Resources, 2020, Industrial Mineral Resources in New Mexico, https://geoinfo.nmt.edu/resources/minerals/industrial/home.html. [↑](#footnote-ref-143)
143. U.S. Environmental Protection Agency, 2023, Cement Manufacturing Effluent Guidelines, https://www.epa.gov/eg/cement-manufacturing-effluent-guidelines. [↑](#footnote-ref-144)
144. CEMEX, 2022, Water Security 2022, https://www.cemex.com/documents/d/cemex/2022-cdp-water-security. [↑](#footnote-ref-145)
145. Cemnet, 2021. [↑](#footnote-ref-146)
146. American Concrete Institute, 2024, Technical Questions, https://www.concrete.org/tools/frequentlyaskedquestions.aspx?faqid=703. [↑](#footnote-ref-147)
147. Sestakova, J., 2022, Water quality for concrete mixes: does it matter, https://www.water-direct.co.uk/water-quality-for-concrete-mixes/. [↑](#footnote-ref-148)
148. ASTM International, 2024, Standard Specifications for Ready-Mix Concrete, https://www.astm.org/c0094\_c0094m-23.html [↑](#footnote-ref-149)
149. Convergent Energy and Power, 2023, A Solid Idea: Battery Energy Storage Systems for Cement Production Facilities, https://resources.convergentep.com/a-solid-idea-battery-energy-storage-systems-for-cement-production-facilities [↑](#footnote-ref-150)
150. Agico Cement, 2023, Guide to Cement Plants Site Selection, https://www.cement-plants.com/guide-to-cement-plants-site-selection/ [↑](#footnote-ref-151)
151. OCD Statistics, https://www.emnrd.nm.gov/ocd/ocd-data/statistics/ [↑](#footnote-ref-152)
152. U.S. Energy Information Administration (EIA), Average Depth of Crude Oil and Natural Gas Wells, https://www.eia.gov/dnav/pet/pet\_crd\_welldep\_s1\_a.htm#:~:text=Notes:%20Average%20depth%20may%20not%20equal%20averaging%20of%20components%20due [↑](#footnote-ref-153)
153. Potential Vulnerability of US Petroleum Refineries to Increasing Water Temperature and/or Reduced Water Availability, January 2016, https://www.energy.gov/sites/prod/files/2016/03/f30/US%20DOE%20Refinery%20Water%20Study.pdf [↑](#footnote-ref-154)
154. U.S. Energy Information Administration, Independent Statistics and Analysis, June 2024, https://www.eia.gov/state/analysis.php?sid=NM [↑](#footnote-ref-155)
155. [NREL 2021 U.S. Geothermal Market Report Released | Department of Energy](https://www.energy.gov/eere/articles/nrel-2021-us-geothermal-market-report-released) [↑](#footnote-ref-156)
156. [2021 U.S. Geothermal Power Production and District Heating Market Report (nrel.gov)](https://www.nrel.gov/docs/fy21osti/78291.pdf) [↑](#footnote-ref-157)
157. Cooper et al., 2021, Oil and Gas Produced Water Reuse: Opportunities, Treatment Needs, and Challenges, https://www.osti.gov/biblio/1840921 [↑](#footnote-ref-158)
158. Amakiri et al., 2022, Review of oilfield produced water treatment technologies, https://doi.org/10.1016/j.chemosphere.2022.134064 [↑](#footnote-ref-159)
159. Abass A. Olajire, 2020, Recent advances on the treatment technology of oil and gas produced water for sustainable energy industry-mechanistic aspects and process chemistry perspectives, https://doi.org/10.1016/j.ceja.2020.100049 [↑](#footnote-ref-160)
160. Gamwo et al., 2022, Produced Water Treatment Technologies: An Overview, https://www.osti.gov/servlets/purl/1873997 [↑](#footnote-ref-161)
161. Scanlon et al., 2020, Can we beneficially reuse produced water from oil and gas extraction in the U.S.?, https://www.sciencedirect.com/science/article/pii/S0048969720305957#s0070 [↑](#footnote-ref-162)
162. Igunnu and Chen, 2012, Produced water treatment technologies, https://doi.org/10.1093/ijlct/cts049 [↑](#footnote-ref-163)
163. Ibrahim et al., 2023, Advances in Produced Water Treatment Technologies: An In-Depth Exploration with an Emphasis on Membrane-Based Systems and Future Perspectives, https://doi.org/10.3390/w15162980 [↑](#footnote-ref-164)
164. Patel et al., 2021, Energy Consumption of Brackish Water Desalination: Identifying the Sweet Spots for Electrodialysis and Reverse Osmosis, https://doi.org/10.1021/acsestengg.0c00192 [↑](#footnote-ref-165)
165. Parani and Oluwafemi, 2021, Membrane Distillation: Recent Configurations, Membrane Surface Engineering, and Applications, 10.3390/membranes11120934 [↑](#footnote-ref-166)
166. Sanchez-Rosario and Hildenbrand, 2022, Produced Water Treatment and Valorization: A Techno-Economical Review, https://doi.org/10.3390/en15134619 [↑](#footnote-ref-167)
167. Saltworks, 2017, How to Manage Brine Disposal & Treatment, https://www.saltworkstech.com/articles/how-to-manage-brine-disposal-and-treatment/ [↑](#footnote-ref-168)
168. Water Resources Mission Area, 2021, National Brackish Groundwater Assessment: How is Brackish Groundwater Being Used, https://www.usgs.gov/mission-areas/water-resources/science/national-brackish-groundwater-assessment-how-brackish. [↑](#footnote-ref-169)
169. Ahdab, Y., and Lienhard, J., 2021, Desalination of brackish groundwater to improve water quality and water supply, https://dspace.mit.edu/bitstream/handle/1721.1/126566/Ahdab-Lienhard-Groundwater\_Desalination\_Chapter-R1.pdf?sequence=1&isAllowed=y. [↑](#footnote-ref-170)
170. Garthwaite, J., 2022, “Earthquakes from oil field wastewater,” Stanford Doerr School of Sustainability, https://sustainability.stanford.edu/news/earthquakes-oil-field-wastewater. [↑](#footnote-ref-171)
171. Cooper, C., et al. 2021. [↑](#footnote-ref-172)
172. New York University Abu Dhabi, 2023, Climate Challenge – Kemal Celik, https://nyuad.nyu.edu/en/news/latest-news/science-and-technology/2023/may/climate-challenge-kemal-celik.html. [↑](#footnote-ref-173)
173. Sharma, P., et al, 2023, Valorization of Seawater Reverse Osmosis Brine by Monovalent Ion-Selective Membranes through Electrodialysis, https://doi.org/10.3390/membranes13060562. [↑](#footnote-ref-174)
174. Sharkh, B.A., et al, 2022, Seawater desalination concentrate – a new frontier for sustainable mining of valuable minerals, https://doi.org/10.1038/s41545-022-00153-6. [↑](#footnote-ref-175)
175. Sharkh, B.A., et al, 2022. [↑](#footnote-ref-176)
176. Mendoza-Moyers, D., 2023, Incoming $100 million facility looks to turn brine waste into water, expand El Paso’s water supply, https://elpasomatters.org/2023/11/21/facility-to-boost-el-pasos-water-supply/. [↑](#footnote-ref-177)
177. McEwen, M., 2024, Oil Report: Advances made in extracting critical minerals from produced water, https://www.mrt.com/business/oil/article/mineral-extraction-produced-water-18761317.php. [↑](#footnote-ref-178)
178. Robbins, J., 2024, In Seawater, Researchers See an Untapped Bounty of Critical Metals, https://e360.yale.edu/features/desalination-saltwater-brine-mining. [↑](#footnote-ref-179)
179. Oregon State University, 2023, Brine Miners: Extracting Value, Reducing Waste, https://research.engr.oregonstate.edu/brineminers/home. [↑](#footnote-ref-180)
180. Voutchkov, N., et al, 2023, Innovative system for separation of monovalent salts from seawater brine for beneficial use, https://smartwatermagazine.com/news/neom/innovative-system-separation-monovalent-salts-seawater-brine-beneficial-use. [↑](#footnote-ref-181)
181. GWI DesalData, 2024, GWI DesalData Report, https://www.desaldata.com/ [↑](#footnote-ref-182)
182. These estimates include saltwater and brackish water desalination and different processing technologies, which may have different cost structures. [↑](#footnote-ref-183)
183. GWI DesalData, 2024, GWI DesalData Report, https://www.desaldata.com/ [↑](#footnote-ref-184)
184. Edirisooriya, M., et al., 2024, Economic feasibility of developing alternative water supplies for agricultural irrigation, https://doi.org/10.1016/j.coche.2023.100987. [↑](#footnote-ref-185)
185. Edirisooriya, M., et al., 2024, Economic feasibility of developing alternative water supplies for agricultural irrigation, https://doi.org/10.1016/j.coche.2023.100987 [↑](#footnote-ref-186)
186. Edirisooriya, M., et al., 2024, Economic feasibility of developing alternative water supplies for agricultural irrigation, https://doi.org/10.1016/j.coche.2023.100987. [↑](#footnote-ref-187)
187. Kanalis Group, 2022, Bench-scale Treatment Study of Produced Water from the Southern San Juan Basin New Mexico: Volume 1, https://nmpwrc.nmsu.edu/files/Kanalis-Final-Report-NMPWC-Approved-Vol-1.pdf. [↑](#footnote-ref-188)
188. Xu, Pei, 2024, Research on Treatment of Produced Water for Reuse, Legislative Finance Committee, Water Subcommittee, June 11, <https://www.nmlegis.gov/handouts/ALFC%20061124%20Item%208%202024%20update%20of%20NMPWRC%20for%20LFC.pdf>. [↑](#footnote-ref-189)
189. Estimated project costs for Aquality Solutions are included in both regions, as no region was specified in their RFI response. [↑](#footnote-ref-190)
190. A 2% real discount rate is used in all calculations of present value presented here, to be consistent with NMSU methodology. [↑](#footnote-ref-191)
191. Xu, P. 2023, Desalination Research Facing New Mexico’s 21st Century Water Challenges, https://www.nmlegis.gov/handouts/ALFC%20062723%20Item%2010%20Brackish%20water%20desalination%20Pei%20Xu%202023\_6\_28\_edits.pdf. [↑](#footnote-ref-192)
192. New Mexico Legislature Handout, Alamogordo Regional Water Supply: New Mexico’s First Large-Scale Municipal Desalination Project, https://www.nmlegis.gov/handouts/STTC%20101713%20Item%205%20Alamogordo%20Desalination.pdf. [↑](#footnote-ref-193)
193. Xu, P. 2023, Desalination Research Facing New Mexico’s 21st Century Water Challenges. [↑](#footnote-ref-194)
194. Water Technology, SAWS Brackish Groundwater Desalination Plant, San Antonio, https://www.water-technology.net/projects/saws-brackish-groundwater-desalination-plant-san-antonio/#:~:text=The%20total%20cost%20of%20the%20project%2C%20including%20that,the%20Texas%20Water%20Development%20Board%20for%20the%20project. [↑](#footnote-ref-195)
195. Xu, Pei, 2023, Water Desalination Feasibility Study for Santa Teresa, Science, Technology and Telecommunications Committee, October 31, <https://www.nmlegis.gov/(X(1)S(3laa5nopicwuk2i5u3m0c4m0))/handouts/STTC%20103023%20Item%208%20Santa%20Teresa%20Brackish%20water%20desalination.pdf>. [↑](#footnote-ref-196)
196. Thornton, I., et al., 2022, “ ‘No Regrets’ purchasing in a pandemic: making the most of advance purchase agreements,” *Globalization and Health*, vol. 18, no. 6, https://globalizationandhealth.biomedcentral.com/articles/10.1186/s12992-022-00851-3. [↑](#footnote-ref-197)
197. Hurd, B., and Coonrod, J., 2008, Climate Change and Its Implications for New Mexico’s Water Resources and Economic Opportunities, https://pubs.nmsu.edu/research/economics/TR45.pdf. [↑](#footnote-ref-198)
198. Falk, M., 2019, Desalination Plant Could Supply Santa Teresa With Water, https://www.krwg.org/regional/2019-01-29/desalination-plant-could-supply-santa-teresa-with-water. [↑](#footnote-ref-199)
199. Land, L., 2016 Overview of Fresh and Brackish Water Quality in New Mexico, https://geoinfo.nmt.edu/publications/openfile/downloads/500-599/583/OFR-583\_NM\_BrackishHR.pdf. [↑](#footnote-ref-200)