Oil and Gas Produced Water in Texas

What We Know and Still Need to Understand Before Moving Beyond the Oil Field

March 2025

This paper was authored by Dan Mueller in collaboration with Texas Living Waters partner organizations and Environmental Defense Fund.

***Texas Living Waters** is a collaboration of conservation and community-focused groups working to ensure Texas has the water it needs for thriving communities and abundant fish and wildlife. One of our shared priorities is to ensure responsible deployment of new supply strategies such as produced water.*

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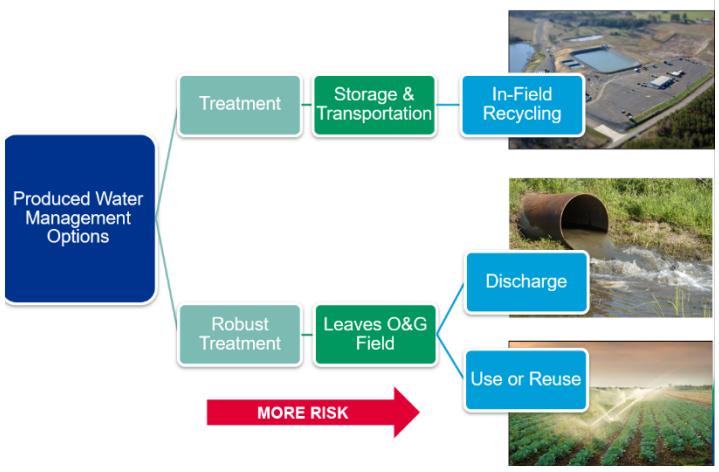
Texas Living Waters Position Paper
March 2025

Texas' population growth and recurring significant droughts coupled with already stressed water supplies (surface water and groundwater) have created scarcity and competition among water users and have driven state lawmakers to invest in new water supplies. This is exemplified by the voter-approved establishment of a $1 billion water fund to be administered by the Water Development Board and used on water-related infrastructure and water sources across the state. Of this fund, 25% is directed to promoting the development of new water including desalination of marine, brackish, and oil and gas produced water.

Produced water is the wastewater byproduct that occurs during the extraction of oil and gas from underground reservoirs. Water trapped with the oil and gas resource exits the production well along with oil and gas for the life of the producing well. The vast majority of produced water is currently reinjected into disposal wells (saltwater disposal wells, SWDs); however various factors including cost for disposal, induced seismicity potential caused by reinjection, impact on area water resources, and others (more discussion on these later) are driving attention to alternate produced water management options. Notably the recycle of produced water, or potential beneficial reuse or discharge of treated produced water.

Recycling produced water entails using this fluid instead of other water sources (brackish, saline, and fresh) in the hydraulic fracturing process, reducing the demand on these other water resources. Recycling requires little to no treatment of the produced water and the fluid stays within the oil and gas production operation, minimizing the volume requiring disposal.



From EDF presentation

Beneficial reuse, including discharge, of produced requires robust treatment of this fluid followed by release to the environment. Pathways of release include discharge to surface waters, aquifer storage and recovery, irrigation or other forms of land application, and industrial processes. The risk of adverse impacts to human health and the environment are elevated when the treated produced water is intentionally released necessitating the critical need to identify and address potential risks.

Beneficial reuse of the oil and gas produced water presents several challenges and concerns related to possible adverse impacts to human health and the environment. There are significant knowledge and regulatory gaps specific to this complex and highly variable fluid including the following.

- Constituents of concern potentially present, specifically the ability to identify their presence, and risk and toxicity if released to the environment.
- Treatment process capabilities to remove constituents of concern to levels appropriate for beneficial reuse.
- Economics (i.e., all-in costs) to adequately treat produced water to a quality required for beneficial reuse.
- Regulatory framework required for a permitting process to ensure beneficial reuse activities are properly designed, implemented, and monitored.

Much focus on produced water recycle and reuse is on the Permian Basin located in the western portion of Texas and extending into the southeastern portion of New Mexico. It is the largest oil producing field in the United States and one the largest producing fields in the world. Situated in a water resource stressed, arid area, the Permian Basin has the greatest volume of generated produced water in the state.

Although there is heightened awareness and discussion around the potential beneficial reuse of produced water outside oil and gas operations, it is important to recognize the most cost effective and achievable use of produced water is to recycle it for oil and gas well completions (hydraulic fracturing). Recycling produced water reduces the volume requiring disposal and lessens the demand for other, higher quality water resources. Although data is sparse, it is currently estimated that recycle rates in the Permian Basin are around 50% to 60% even though a number of oil and gas producers have set much higher goals. Maximizing recycle rates is an obvious path forward to minimize impacts to other, more usable water resources as well as minimizing produced water disposal volumes.

Throughout the entire discussion of produced water management and potential beneficial reuse of treated produced water it is important to note that this fluid is the most challenging and costly to treat as opposed to other lower-quality waters such as brackish and saline water resources. Additionally, produced water generation is dependent on oil and gas production; therefore, this potential water source is diminishing and finite. Although it is impossible to predict when oil and gas generation will peak and decline; the reality is that at some point in the future, oil and gas will cease to be the dominant energy source it is today. When oil and gas production declines, so will the generation of produced water.

However, even with the above situations and conditions, the current reality is that due to drivers previously mentioned and discussed in further detail later in this paper, it makes sense to explore other ways to deal with this waste stream. The possibility to robustly treat this water to a quality that could be beneficially used is an alternative that may be viable, although as previously mentioned, there are significant challenges and knowledge gaps to be addressed.

The following presents background on produced water, challenges related to beneficial reuse, current efforts and progress being made to narrow critical knowledge gaps, areas of concern that still need to be addressed, and specific policy recommendations to help answer the questions on how produced water can potentially be used to help meet the growing water demands of our State.

What is produced water?

In the early 2000s innovations in oil and gas production that coupled horizontal drilling with hydraulic fracturing of tight shale formations, releasing the oil and gas (and trapped water in these formations), opened new oil and gas reserves not only in the US but around the world. Oil and gas exploration and production in the Permian Basin surged as a result, placing it again as one of the largest producing areas in the world.

Hydraulic fracturing injects a large amount of water mixed with fracturing fluid that is a mixture of chemicals and proppants (solid particles, primarily sand, which keep fractures open). The volume of water used for hydraulic fracturing depends on several factors including the formation characteristics and the horizontal length of the well. The recently published Texas Produced Water Consortium (TXPWC) report to the Texas Legislature (2024)[1] estimated that approximately 21 million gallons of water is required to fracture a typical well in the Permian Basin.[2] Much of the water/chemical mixture injected as part of the fracturing process returns to the surface with the oil and gas and trapped formation waters thus adding to the total volume of generated produced water.

How much produced water is generated and how is it currently managed?

The TXPWC 2024 report estimates current Permian Basin in Texas generated produced water at 12 million barrels per day (504 Mgal/d, 1,547 Ac-ft/d) with a projection of up to 15 million barrels per day (630 Mgal/d, 1,935 Ac-ft/d) by 2042.[3] It is important to note that these volumes are estimates since oil and gas producers are not required to report volumes of produced water.

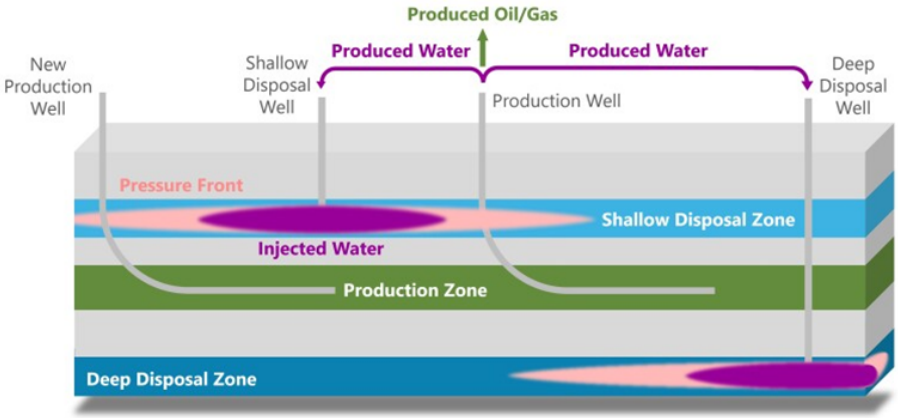
The same is true for water used for well completion (hydraulic fracturing) in part because state law exempts oil and gas producers from permitting requirements and from reporting requirements for groundwater use. However, the TXPWC 2024 report estimates 8.1 million barrels per day (340 Mgal/d, 1,044 Ac-ft/d) current water use for oil and gas exploration and production in the Permian Basin in Texas.

Generally, the produced water is collected and stored in storage pits and tanks before being transported by trucks or pipelines to SWDs to be reinjected into zones above or below the oil and gas producing zones. While the majority of all produced water is disposed of through re-injection, increasing operational cost, limited disposal capacity, and increased regulation in response to seismic activity associated with these injection wells are pushing oil and gas producers toward alternative approaches.

[1] "Beneficial Use of Produced Water in Texas", Texas Produced Water Consortium Report to the Texas Legislature 2024. TXPWCFINALDRAFT.pdf

[2] Texas Produced Water Consortium Report to the Texas Legislature 2024, Addendum 9

[3] Texas Produced Water Consortium Report to the Texas Legislature 2024, Addendum 9



From B3 Insight presentation - 2024

Recycling vs reuse

Produced water recycling (using it to fracture subsequent wells) is the "low hanging fruit" - an effective and economically feasible approach to reducing disposal costs and depletion of limited groundwater resources. For the most part, producers are striving to increase the volumes of produced water recycled; however, data is sparse on the actual numbers. The TXPWC 2024 report estimates that recycling rates are in the vicinity of 50% with some estimates as high as 60%.[4] Regardless, there remains an opportunity to reduce disposal – and to reduce overall water demand for oil and gas production – just by increasing recycling efforts.

The treatment of produced water for surface water discharge or beneficial uses that require a higher level of water quality (e.g., agriculture, livestock, industry, fish and wildlife habitat, human consumption) is currently under consideration by both industry and policy makers in Texas. Driving consideration of this produced water management option includes the following:

- Economics related to both the cost for disposal and the potential that there may be a market for the sale of treated produced water to other water users. Disposal by injection at SWDs has been limited in certain areas due to seismic events attributed to disposal operations. Cost for disposal rises with the limiting of SWD disposal options, and in some cases oil and gas production may be reduced because of the lack of SWD options in reasonable vicinity of producing wells.

  Assuming produced water can be effectively and reliably treated to a high quality, there could be a market for this treated effluent. Although at this time it appears that the cost to robustly treat produced water is more expensive (potentially many times more expenses – again, data is sparse) that other water sources, the ability to realize some revenue from the sale of treated produced water and the avoided cost for disposal could defray the high cost of treatment.

- Lessening the impact on other water sources and potentially supplementing available usable water is important in the arid area in which the Permian Basin is situated. Providing an additional water source would be of benefit.

[4] Texas Produced Water Consortium Report to the Texas Legislature 2024, Addendum 9

According to the TXPWC 2024 report (referencing TWDB data), West Texas will have an average annual water shortfall of 1.05 million Ac-ft/year by 2070. In this water stressed area, all water sources and water conservation options will be explored to meet this shortfall. With the assumptions listed above regarding if produced water can be economically treated to a quality appropriate for use by other users, treated produced water may present a water source to meet some of this shortfall. However, it is important to recognize that the generation of produced water is dependent on oil and gas production. It is a finite, diminishing (at some point) water source; important for long-term water planning to account for this reality.

- An additional item to note is the possible overlap of orphan/improperly plugged oil and gas well issues with produced water treatment technology. As the technical, economic, and regulatory challenges to discharge or beneficial reuse of produced water are narrowed, this information could be used to manage and address environmental impacts from the oil and gas tainted waters flowing from orphaned/improperly plugged wells.

There are significant knowledge gaps and challenges to discharge or beneficial reuse of treated produced water including: constituents of concern in produced water, treatment technology's capabilities to treat constituents of concern to a safe level for intentional release to the environment, and the all-in cost for the required treatment. While recycling produced water requires minimal to no treatment, the cost for robust treatment of produced water is significant. Although again, data is sparse in part due to limited full-scale robust treatment facilities operating anywhere in the US, the 2022 TXPWC report stated that current assessment of potential treatment options average $2.25/bbl ($17,458/Ac-ft) to $10/bbl ($75,584/Ac-ft).[5]

There are areas in the US where treated produced water is being discharged and being used for agriculture irrigation

There are examples of treated produced water being either discharged or used for irrigation in the US, most notably in Pennsylvania, California, the Montana/Dakota area, and to a degree Colorado. However, it is important to consider that the makeup of produced water (including salinity but also other potential constituents of concern) vary significantly both geographically and over time. Therefore, conditions and situations pertaining to treated produced water reuse in other areas do not automatically translate to potential beneficial reuse options in the Permian Basin.

In Pennsylvania, Eureka Resources operated three produced water treatment facilities, one being the Standing Stone facility that had an NPDES permit to discharge into the Susquehanna River. However, the Standing Stone facility is now closed with closure attributed to downturn in produced water sent to the facility for treatment. According to PA Environmental Digest article in 2023[6], the Pennsylvania Department of Environmental Protection inspected the Standing Stone facility and found the plant shut down and all workers laid off. Numerous environmental issues were found including unresolved wastewater leaks, tanks holding water with some lacking functional containment, and "state Solid Waste Management Act violations that remain open for waste on the ground and other violations of the

[5] "Beneficial Use of Produced Water in Texas: Challenges, Opportunities and the Path Forward", Texas Produced Water Consortium Report to the Texas Legislature 2022, page 18. 22-TXPWC-Report-Texas-Legislature.pdf

[6] PA Environment Digest

permit". The article also noted that in addition to closing the Standing Stone Facility, Eureka plans to close or sell its two remaining oil and gas wastewater treatment plants, both located in Williamsport.

In California, treated oil and gas produced water has been used to irrigate crops for over 30 years. However, in recent years individuals and groups have questioned this practice and if there are sufficient science and regulatory protections in place to address possible impacts to human health and the environment. Studies have been conducted and a 2023 report by The Water Research Foundation titled "Potential of Oilfield Produced Water for Irrigation in California"[7] noted the following.

- To date, reuse of oilfield produced water (OPW) for irrigation is a fairly limited practice in California that has not been subject to the same level of rigorous scientific and regulatory scrutiny as municipal recycled water.
- Notable gaps on the chemical makeup, toxicity, and transformation products; fate and transport; and plant uptake and accumulation have been identified as prohibitive for conducting a rigorous risk assessment and drawing conclusive findings. Exposure routes are diverse and chronic exposure to low concentrations of some of these chemicals may have effects that are not yet observed or measurable. More information is needed to fill these gaps including chemical mass or concentrations, frequency of use, and the impacts on crops and soil ecosystems before the human health and agronomic risks associated with the long-term use of OPW for agricultural irrigation can be fully assessed.
- The knowledge gaps discussed in this report and other recent studies point to several key areas where additional research, data and monitoring, risk assessments, and other information are needed to develop a regulatory framework for OPW that mirrors the approach and fit-for-purpose best practices adopted in regulations on the use of recycled water in California.

There are additional occurrences in the Dakota and Montana area and in Colorado where discharge of treated produced water is permitted. Colorado recently formed a produced water consortium to more closely look at the science and regulatory framework related to reuse of produced water outside oil and gas operations.[8]

EPA has just initiated a study (discussed later in this paper) to collect data on ongoing research and permitted discharge of treated produced water west of the 98th meridian (covered under 40 CFR 435 Subpart E). One of this study's goals is to fill data gaps regarding treatment technologies being researched and used, and the economics of this treatment.

Although surface discharge and beneficial reuse of treated produced water is occurring; it is not without challenges and potential long-term environmental issues; without concerns around critical knowledge gaps addressing risks to human health and the environment or providing basis for regulatory program (as in California); or lacking specifics to treatment technology capabilities, limitations, and all-in treatment costs. This demonstrates the need for continued science and data gathering to inform industry practice and regulatory frameworks for this practice.

[7] Potential of Oilfield Produced Water for Irrigation in California

[8] Colorado Produced Water Consortium | Department of Natural Resources

Produced water quality and challenges to robust treatment and setting effluent quality targets

Produced water is a complex fluid that varies in quality geographically between oil and gas basins and subbasins, and over time from individual production wells. This fluid has a high total dissolved solids (TDS, or salt) content, typically higher than seawater and in many cases (including most of the Permian Basin) many times greater (2x to 4x, even as high as 10x) than seawater.

There is more than just elevated TDS that is a concern when considering treating produced water to a quality appropriate for discharge or potential beneficial reuse. The fluid contains many other constituents of concern including inorganics, organics, and potentially radionuclides. Some of the chemicals present are a result of the fracturing chemicals (of which not all are known due to the proprietary nature of fracturing chemical makeup) but many are present in the formation water that is trapped with the oil and gas reserve, and also present as a result of maintenance chemicals that are added over the life of a production well. Additionally, research has shown that some produced water constituents present could be a result of chemical reactions that occur in the high heat/high pressures that exist in a well.

A recent study of produced water from across the U.S. identified more than 1,100 chemical compounds potentially present in produced water. Of those identified, only 25% had approved analytical methods (methods available to regulators for establishing treatment standards, and methods routinely run by commercial labs) and only 14% had toxicity values available for developing risk assessments.[9]

The lack of analytical methods and toxicological information on constituents potentially present in produced water is a significant challenge to designing and monitoring treatment processes, as well as implementing regulatory programs to ensure effluent discharges are appropriate for the designated use while remaining protective of human health and the environment. In essence, you are not going to find what you are not, or cannot, look for. A significant knowledge gap that must be narrowed before beneficial reuse of produced water can move safely forward.

Progress in narrowing critical knowledge gaps

Progress is being made in narrowing critical knowledge gaps as a result of collaborative efforts in the New Mexico Produced Water Research Consortium (NMPWC) and the TPWC; academic and industry-led research; Texas Railroad Commission (RRC) pilot project guidance, proposed rules on pits for recycled produced water, and requests for funding for a system to track on produced water including injection volumes; and most recently by an EPA-led project study of the agricultural and wildlife use subcategory for discharge of treated produced water west of the 98th meridian.

The NMPWC is in its 5th year with recent progress on research into the chemical “unknowns” in produced water – using research analytical methods to more thoroughly characterize constituents in produced water, development of a risk and toxicity process to determine levels of potential risk of identified constituents of concern, and initiation of scaled-up (outside of the lab) pilot projects to determine the capabilities and limitations of treatment technologies. All efforts are work in progress.

[9] Danforth et al. An integrative method for identification and prioritization of constituents of concern in produced water from onshore oil and gas extraction, Environmental International.

Data, particularly from the pilot projects, is slow in coming, but technical evaluation teams are in place to review and comment on the data once received.

The TXPWC is entering its third year. With funding from the recent legislative session ($5 million), plans are being formulated to initiate pilot treatment programs this coming year. There is overlap of membership in the NMPWRC and TXPWC (industry, academia and others) and between consortium committees and research teams and leadership; so, there are processes for sharing of data and data evaluations as each group's efforts move forward.

There are a few industry-led pilot projects that are being conducted outside the New Mexico and Texas consortiums' efforts but there are indications that data from these pilots will be shared with the consortiums.

The RRC has issued a "Produced Water Beneficial Reuse Framework for Pilot Study Authorization".[10] This authorization offers a framework for the design and implementation of a pilot study to evaluate produced water treatment processes. Additionally, the RRC also proposed rules regarding pits that hold oil and gas wastes as well as pits for recycled produced water[11], and requested funding for a system to track data on produced water and injection volumes. Specifically, as part of its 2025-2026 Legislative Appropriations request, the RRC has asked for an exceptional item which they refer to as a Produced Water and Injection Data Reporting System. The Railroad Commission proposes development of a new system that would collect produced water and injection data and make it available to industry, state regulators, and other interested parties. RRC is requesting 2 FTEs and $7,685,824 for development of this system.[12]

EPA recently initiated a study of treated produced water discharged under 40 CFR 435 Subpart E, which applies to facilities located west of the 98th meridian. Per EPA's website, "EPA promulgated the Subpart E regulations in 1979." Many changes have occurred in the industry since that time. The agency is beginning a study that will evaluate whether there are affordable and available treatment technologies that can reduce the discharge of pollutants from this industry. The study will inform whether updates to the Subpart E regulations are warranted.[13]

[10] Pilot Projects

[11] The proposed rules are partially in response to passage of HB 3516 in the 87th Legislative session, which encouraged the RRC to prioritize recycling of oil and gas liquid wastes, including produced water. In addition to House Bill 3516, House Bill 2201 (87th Legislature, 2021) directed the Commission to adopt rules governing permissible locations for pits used by commercial oil and gas disposal facilities and Senate Bill 1541 (85th Legislature, 2017) required the Commission to incorporate criteria for beneficial uses of recycled drill cuttings. The recent rulemaking is intended to address several of the bills passed in recent years by the Legislature to encourage recycling in the oil field as a priority. https://www.rrc.texas.gov/media/hhup0zyl/prop-new-and-amend-ch4-and-3-8-08152024-sig.pdf

[12] The RRC LAR can be found here - https://www.rrc.state.tx.us/media/yxyowmwu/lar-26-27.pdf. The exceptional item request is Item 1.

[13] Oil and Gas Extraction Effluent Guidelines | US EPA

EPA conducted a previous study of the management of produced water from onshore oil and gas wells.[14] This study solicited feedback from stakeholders to better understand produced water generation, management, and disposal options at the regional, state and local levels. Main concerns raised by stakeholder meetings include the following.

- Available data on the chemistry of produced waters.
- Performance of treatment technologies.
- Availability of analytical methods for measuring the constituents in produced water.
- Potential toxicity of constituents in produced water.
- Potential impacts to downstream users.

Concerns and continued efforts to address concerns

Although progress is being made to narrow the critical knowledge gaps around potential beneficial reuse of produced water, there are still issues to need be more fully identified and addressed – there is still work to be done. This includes the following.

- Specific constituents of concern in produced water.
- Capabilities and limitations of treatment technologies to adequately treat constituents of concern.
- Economics (i.e., all-in costs) to adequately treat produced water to a quality required for beneficial reuse.
- Information and scientifically defensible data to inform the development of regulatory programs specific to beneficial reuse of produced water.

Constituents of concern in produced water – Questions still exist on constituents of concern in produced water, including the potential lack of analytical methods to identify and quantify constituents and lack of toxicity information to allow the evaluation of concentration levels that could pose risk to human health and environment if released. All this will be required to determine target effluent levels required for specific potential beneficial reuse options.

Progress is being made by researchers into non-targeted chemical analysis to identify constituents potentially present that currently do not have approved analytical methods (analytical methods that can be run by commercial labs and that can be used in regulatory programs), but questions still exist.

Additionally, toxicity data and subsequent risk assessment of constituents of concern are areas that must be a continuing focus of research efforts. The NMPWRC has developed a process to incorporate data from chemical analyses of produced water from pilot projects into a program to develop risk and toxicity profiles. This process/program was a result of collaborative effort by experts in risk and toxicity. What is lacking at this point is produced water analytical data, particularly from scaled-up treatment technology pilot programs.

Capabilities and limitations of treatment technologies – A few scaled-up treatment process pilot projects were conducted in 2024 and more are planned in 2025; some under the leadership of the consortiums (Texas and New Mexico) and potentially following the RRC framework, and some industry-

[14] Final Report: Oil and Gas Extraction Wastewater Management | US EPA

led. As pilot testing data is made available and additional pilot testing is performed, transparency of data and data evaluation is critically important.

Most desalination technologies were designed to desal brackish and saline waters. Produced water with typically many times higher TDS concentrations and numerous additional constituents than brackish and saline waters present significant challenges to generating a high-quality effluent. Therefore, scaled-up pilot treatment projects are required to evaluate treatment technologies'/processes' capabilities and limitations. Scaled-up pilot projects are costly and the failure of treatment systems to perform as designed is expected as part of any testing effort. This is not a failure of a testing program, but the normal process when engineering new/modified systems to treat a new and complex waste stream.

It is critical that pilot projects be properly designed and implemented for sufficient duration to allow for the collection and evaluation of data to generate scientifically defensible data. Data collected must not only include information on the treatment process, but also include data on generated waste streams and total all-in cost (i.e. operations and maintenance, power, waste stream management) for treatment.

Final disposition of treated effluent must also be considered and evaluated. If some form of land application or irrigation is considered for disposition of the treated effluent, pilot project evaluations must also include not only plant vitality (does it live or die) but also the potential long-term impacts to plants (is the plant/crop stressed thus making it more susceptible to disease) and the soil.

A comprehensive evaluation and vetting of a treatment technology should be conducted in phases. Once a treatment process is initially vetted as capable of generating an effluent of sufficient quality for the planned beneficial reuse, a longer more stringent testing process should be conducted to verify the treatment is both effective and reliable. EPA has a protocol for this verification process – "Protocol for the Verification of Wastewater Treatment Technologies". [15]

Economics of robust treatment of produced water – Although there are claims being made on how cost-effective robust treatment of produced water may be, the data is sparse. Critical in the evaluation of the feasibility of beneficial reuse of produced water is the all-in cost that includes the following.

- Cost for collecting and transporting produced water from the point of generation to the point of treatment.
- Cost of constructing the treatment facility (amortized over the life of the facility).
- Cost of operating the treatment facility including labor, operations and maintenance (including routine maintenance), and power. The latter is likely significant and one cost item that has not been readily shared as part of current discussions and presentations of pilot projects.
- Properly managing all generated waste streams.
- Transporting treated effluent to final point of use or disposition.

As previously mentioned, the estimated cost to treat produced water ranges from $2.25/bbl ($7,759/Ac-ft) to $10/bbl ($75,584/Ac-ft). It is likely these cost estimates do not include all the items listed above.

[15] PROTOCOL FOR THE VERIFICATION OF WASTEWATER TREATMENT TECHNOLOGIES | US EPA ARCHIVE DOCUMENT

Informing regulatory programs – A number of critical knowledge gaps still exist related to potential beneficial reuse of produced water – gaps critical to the development of a regulatory program. Current regulatory programs (i.e., effluent limitations, water quality guidance, etc.) were not developed specific to treated produced water. It is important that any regulatory effort does not move faster than the science and technology advances required to fill the needed information.

This includes the following.

- What are reasonable potential beneficial reuse option(s)?
- Has treatment technology been properly tested/vetted.
- Has sufficient toxicity/risk assessments been completed to inform setting effluent guidelines. This includes bioaccumulation/persistent constituents of concern.
- Are new analytical methods needed? The unknown/unknown question.
- Are there emerging contaminants to be considered? PFAS has been identified as present in some produced water, but its source(s) are not known. Was it present in the fracturing chemical mix or present in the fracturing water source?

The New Mexico Environmental Department has publicly stated that discharge permits will not be considered until peer-reviewed science is available to support setting standards. This is not the case in Texas where there are currently two new NPDES permit applications under TCEQ review for treated produced water discharge into Pecos watershed. There are a few permits for discharge of produced water from stripper wells (marginal oil and gas well that is nearing the end of its economically useful life) in the Eagle Ford shale basin in south Texas but the focus on large volumes of potential permitted discharge of treated produced water will be in the Permian Basin.

Talking points/policy recommendations

The following resultant talking points/policy recommendations have been developed based on the current state of play of produced water and produced water management, continuing research and investigations narrowing the critical knowledge gaps around its potential beneficial reuse, as well as expected near-future regulatory and legislative actions.

- **Managing produced water is a waste management issue.**
    - The low hanging fruit is the recycling of produced water (requiring minimal or no treatment) for completion of subsequent oil and gas wells. This will lessen the demand for other water resources.
    - At the same time, recognize that drivers exist that may limit produced water disposal options and using this fluid for other purposes warrants consideration.

- **Recognize that produced water is a diminishing water supply, fully dependent on oil and gas production**.
    - It may be years or decades before dependence on oil and gas declines but when it does decline, produced water generation will also decline.
    - It is important and prudent in planning for the potential beneficial reuse of produced water to incorporate that at some point in time the availability of this water supply will decline.
- **Of elevated TDS waters specifically mentioned in the recently approved Texas Water Fund (brackish, saline, produced water), produced water is the most complex and difficult to treat.**
    - Data is sparse on the capabilities and limitations of robustly treating produced water including the all-in costs. More research and scaled-up pilot projects are needed to more fully vet treatment technologies.
    - It makes more sense from both the economic and technical perspective to invest in less complex and easier to treat water sources (brackish and saline), getting more gallons of usable water for the dollar.
        - Data is sparse on all-in cost to robustly treat produced water and many factors impact that cost, but for relative comparison purposes:
            - Cost to robustly treat produced water is estimated between $17,458/Ac-ft to $75,580/Ac-ft.
            - Cost to desal brackish water is estimated between $360/Ac-ft to $790/Ac-ft.
- **There are critical knowledge gaps regarding beneficial reuse of produced water that must be filled to ensure reuse options are protective of human health and the environment.**
    - Support TXPWC's continued efforts with following conditions.
        - The TXPWC must operate as a true consortium/collaboration efforts and transparency of data and data evaluations.
        - The consortium's role is to provide scientifically defensible data/information to the TCEQ/RRC in developing regulatory standards/rules/guidance.
        - Consortium's role is not to set or develop regulatory standards/rules/guidance.
    - Prioritize potentially attainable produced water beneficial use options based on current science.
        - Maximize recycle of produced water over other beneficial reuse options.
        - Industrial closed-loop systems
        - Non-edible food crops
        - Others
        - Last on the list (and maybe never a realistic option) – human consumption
    - Support a request by the RRC for $7.685 million in additional monies and 2 FTEs to create a Produced Water and Injection Data Reporting System.

- **TCEQ/RRC regulatory programs addressing beneficial reuse/intentional release must utilize the developing science around appropriate analytical methods, risk assessments of constituents of concern, and appropriately vetted treatment technologies**.
    - Acknowledge the need for data on produced water constituents and volume, management practices, treatment capabilities and limitations, and economics for treating produced water to a quality appropriate for beneficial reuse.
    - Before authorizing discharges, develop improved water quality standards, both narrative and numerical, specific to constituents of concern in produced water (including salinity standards).
        - TCEQ should adopt protective numerical or narrative water quality standards for salinity adequate to minimize potential adverse impacts from produced water discharges into specific coastal waters and into or adjacent to other waters in the state.
        - Similarly, TCEQ should adopt protective numerical water quality standards for the toxic substances present in produced water discharges.
        - TCEQ should ensure that whole effluent toxicity (WET) testing protocols are adequate to assess both acute and chronic risks from produced water discharges.
    - Recognize treated produced water is a relatively new and complex waste stream.
    - Support and follow the New Mexico Environmental Department's public stance on waiting for the needed science before considering discharge permits.
    - Balance the need for TCEQ/RRC to wait for science to inform rules/regulations with the need for scaled up pilot projects to advance vetting of treatment technologies and the science around potential beneficial uses.
    - Critically important to all the above is the need for regulatory staff expertise in the science, technology, and regulatory basis to successfully develop and implement the required activities.
- **Engage in current (and if others are submitted) NPDES permit applications.**
    - Bring attention to the probable need for new analytical methods to be incorporated into permit monitoring requirements.
    - Include WET testing in permit monitoring requirements.
    - Ensure the proposed treatment technology/technologies have been appropriately vetted to effectively and reliably treat produced water to required effluent quality.

This paper was authored by Dan Mueller in collaboration with Texas Living Waters partner organizations and Environmental Defense Fund.