

**PRODUCED WATER BENEFICIAL REUSE
FRAMEWORK FOR PILOT STUDY AUTHORIZATION**

Railroad Commission of Texas
Oil and Gas Division
Technical Permitting Section
Environmental Permits and Support Unit

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INTRODUCTION

Produced water means the water (brine) brought up from the subsurface during the extraction of oil and gas, and can include formation water, hydraulic fracturing fluid flowback, and any chemicals added downhole or during the drilling, completion, and or/water separation processes.

Produced water has the potential to have a significant positive impact on the State's limited water resources. Produced water may contain amounts of minerals, organic compounds, and other substances that make it unsuitable as a water supply source for most human, agricultural, environmental, or industrial uses. However, water treatment technology exists to treat produced water so that the treated fluid may become available for many uses. A number of U.S. states currently allow for treated produced water to be land applied or surface discharged under applicable permits, but significant potential health and safety, practical, logistical, and economic challenges warrant additional investigation in the State of Texas. The oil and gas industry currently recycles some treated and untreated produced water through normal oil and gas operations, such as to provide makeup water for hydraulic fracture stimulation and completion fluids. However, the use of treated produced water outside of downhole and oil and gas industrial scenarios has, for the most part, not been explored.

In response to the potential for treated produced water to have a significant and positive impact on water resources in Texas, the Legislature created the Texas Produced Water Consortium to organize stakeholders and to facilitate the safe development of treated produced water as a potential water resource. The Railroad Commission of Texas (RRC) is the agency charged with regulating the oil and gas industry, and the Legislature has directed RRC to encourage recycling of produced water for beneficial purposes.

Operators are now proposing pilot studies to explore the health and safety, practical, logistical, and economic challenges to implementation of various produced water treatment technologies. This document describes RRC staff's approach for evaluating applications and granting authority for operators to conduct pilot studies in which produced water is treated and made available for beneficial reuses outside of regular oil and gas operations, and it provides a template for an application for such a pilot study. This approach is based on existing statutes and rules, as well as RRC's mission, which is to serve Texas by our stewardship of natural

resources and the environment, our concern for personal and community safety, and our support of enhanced development and economic vitality for the benefit of Texans.

AUTHORITY

The RRC's general recycling authority can be found in Natural Resources Code §122 (relating to Treatment and Recycling for Beneficial Use of Fluid Oil and Gas Waste), which states the RRC shall adopt rules that encourage fluid oil and gas waste recycling for beneficial purposes. The RRC has promulgated rules in 16 Texas Administrative Code (TAC) §3.8 (relating to Water Protection) that provide for three categories of recycling: prohibited, authorized, and permitted (16 TAC §3.8(d)(7)(A), (B), and (C), respectively). In addition, 16 TAC Chapter 4 contains rules for commercial recycling of oil and gas waste. The permitted recycling provisions in 16 TAC §3.8(d)(7)(C) provide the framework that RRC staff will employ to authorize pilot studies for the recycling of produced water:

(C) Permitted recycling.

(i) Treated fluid may be reused in any manner, other than the manner authorized by subparagraph (B) of this paragraph¹, pursuant to a permit issued by the director on a case-by-case basis, taking into account the source of the fluids, the anticipated constituents of concern, the volume of fluids, the location, and the proposed reuse of the treated fluids. Fluid that meets the requirements of a permit issued under this clause is a recyclable product.

Any activity that may be authorized by the RRC is also constrained by specific statutory and regulatory obligations. Notably, pursuant to 16 TAC §3.8(b), no person conducting activities subject to regulation by the RRC may cause or allow pollution of surface or subsurface water in the state. Pollution of surface or subsurface water in the state is defined in 16 TAC §3.8(a)(28) as the alteration of the physical, thermal, chemical, or biological quality of, or the contamination of, any surface or subsurface water in the state that renders the water harmful, detrimental, or injurious to humans, animal life, vegetation, or property, or to public health, safety, or welfare, or impairs the usefulness or the public enjoyment of the water for any lawful or reasonable purpose.

¹ The “*authorized*” recycling referenced in subparagraph (B) states that: (1) no permit is required if treated fluid is recycled for use as makeup water for a hydraulic fracturing fluid treatment(s), or as another type of oilfield fluid to be used in the wellbore of an oil, gas, geothermal, or service well; (2) treated fluid may be reused in any other manner, other than discharge to waters of the state, without a permit from the Commission, provided the reuse occurs pursuant to a permit issued by another state or federal agency; and (3) if treatment of the fluid results in distilled water, no permit is required to use the resulting distilled water in any manner other than discharge to waters of the state. Note that the term “distilled water” is defined in 16 TAC §3.8(a)(47) as “*water that has been purified by being heated to a vapor form and then condensed into another container as liquid water that is essentially free of all solutes.*” The rule authorizes the use of distilled water from a treatment process for any purpose; however, RRC reserves the right to require an operator to conduct sampling and analysis to determine and demonstrate that the definition of distilled water is satisfied.

Produced water recycling thus far has mostly been confined to uses related to downhole oil and gas exploration and production activities. Pursuant to 16 TAC §3.8(d)(7)(B)(ii), a permit is not required if the treated fluid is to be used in a wellbore. There is interest from policymakers and operators in expanding acceptable re-use scenarios beyond oil and gas (downhole) uses, notably for irrigation of non-food crops, non-specific pasture irrigation, or other similar uses. Because these are novel uses for treated produced water, special care and concern is warranted in determining whether to authorize a particular recycling activity.

PILOT STUDIES

A pilot study is the focused and attentive execution of an activity that is performed on a limited scale to evaluate the efficacy of the activity and whether the activity can be successfully implemented on a larger scale, and to use the learnings of the study to inform various aspects of the activity, including health and safety, practical, logistical, and economic considerations.

Pilot studies also provide significant value as a means of informing regulatory policy and requirements. That is, the results of pilot studies will be used to shape the future regulatory program in a manner that is protective of the RRC's regulatory obligations as stated in statute, rule, and its mission.

An application for a pilot study for produced water recycling will be considered by RRC staff on a case-by-case basis. RRC staff will consider information from the five categories identified in 16 TAC §3.8(d)(7)(C)(i), which include the source of the fluids, the anticipated constituents of concern, the volume of fluids, the location, and the proposed reuse of the treated fluids.

RRC Pilot Study Program Goals

RRC staff has constructed this pilot study framework for the purpose of developing a program for the safe and economical recycling of produced water. This will be examined through multiple pilot studies that generate information to further industry and society's knowledge and understanding of produced water recycling benefits and risks. RRC staff established the following pilot study program goals:

1. To establish the public's trust that treated produced water can be reused in certain activities that are safe and protective of human health and the environment.
2. To provide an efficient regulatory program for operators to assess the effectiveness of water treatment technologies.

3. To provide an efficient and effective regulatory program to assess the suitability of applying treated produced water to specific beneficial purposes.

RRC Pilot Study Objectives

Individual pilot studies will assess the efficacy of specific treatment technologies and reuse scenarios. From the RRC perspective, the objectives of each produced water recycling pilot study should include:

1. Obtain administrative documentation of the pilot study.
2. Characterize the source fluids.
3. Describe the treatment technology.
4. Characterize the treated fluids and their consistency in quality (i.e., levels of constituents other than H₂O).
5. Identify the constituents of concern.
6. Describe the reuse scenario.
7. Describe the water treatment methodologies (i.e., modalities) and how they will directly affect the reuse scenario (i.e., water constituents' accumulation into soil, crop absorption, other).
8. Identify constraints associated with the proposed reuse activity.

Pilot Study Considerations

Administrative Considerations

Authorization for a treated produced water pilot study will only be issued to an organization with an active Organization Report (Form P-5) and the necessary financial assurance required by 16 TAC §3.78.

RRC staff will limit the duration of pilot study permits to one year. In addition, the RRC authorization may include limits on the volume of produced water that is treated and the methods and means by which the treated fluid is reused.

The duration of a pilot study may be extended, provided the activity is in good standing with its authorization requirements. An operator should request an extension 60 days prior to the expiration of the current authorization.

Pilot studies cannot be performed as commercial endeavors without considering the financial security requirements of 16 TAC §3.78 and the Oil & Gas Division's notice requirements for commercial facility applications.

The treated water generated through a produced water pilot study must be applied to the specific beneficial purpose(s) described in the authorization or be disposed of in accordance with RRC rules.

Authorization for a treated produced water pilot study will include reporting requirements that will include quarterly and final reports.

Fluid Source Considerations

Produced water is not defined in statute or rule. However, the definition of fluid oil and gas waste in Natural Resources Code §122.001(2) includes "produced water" and other fluids:

"Fluid oil and gas waste" means waste containing salt or other mineralized substances, brine, hydraulic fracturing fluid, flowback water, produced water, or other fluid that arises out of or is incidental to the drilling for or production of oil or gas.

The definition of oil and gas waste in Natural Resources Code §91.1101 includes "salt water" and other fluids.

In federal regulations, produced water is defined in 40 §CFR 435.11(bb):

Produced water means the water (brine) brought up from the hydrocarbon-bearing strata during the extraction of oil and gas, and can include formation water, injection water, and any chemicals added downhole or during the oil/water separation process.

A general discriminator for the definition of produced water for the purpose of this document and program would be the aspect of the fluid having been "produced" through an oil and gas well, even if the fluid was first introduced into the subsurface by the well.

At this point, however, there are some oil and gas wastes that are liquid in form that should not be considered in pilot studies of produced water. These include contact stormwater, liquids

from washout pits, and possibly other liquid oil and gas wastes that were not produced through the normal drilling, completion, or operation of an oil or gas well.

Constituents of Concern and Proposed Reuse Scenario Considerations

Recent compilation studies by the Groundwater Protection Council, the Texas Produced Water Consortium, the U.S. Environmental Protection Agency, and the U.S. Bureau of Reclamation have identified many chemical constituents that may be present in produced water. Generally, produced water may contain²:

- Mineral salts including cations and anions dissolved in water (often expressed as salinity, conductivity, or total dissolved solids [TDS])
- Organic compounds including volatile and semi-volatile organics, hydrocarbons, organic acids, waxes, and oils,
- Inorganic metals and other inorganic constituents including compounds such as sulfate and ammonia,
- Naturally occurring radioactive material (NORM) that leached into the produced water from some formations or precipitated due to water mixing,
- Chemical additives to improve drilling and production operations, and
- Transformational byproducts that can form from the interaction between added chemicals and formation water.

The Texas Produced Water Consortium cited a large database of more than 17,000 produced water samples that showed the following range of some inorganic constituents:³

² Produced Water Report: Regulations, Current Practices, and Research Needs. Groundwater Protection Council, 2019. Accessed on April 12, 2023.

https://www.gwpc.org/sites/gwpc/uploads/documents/Research/Produced_Water_Full_Report_Digital_Use.pdf

³ Beneficial Use of Produced Water in Texas: Challenges, Opportunities and the Path Forward. Texas Produced Water Consortium Report to the Texas Legislature 2022. <https://www.depts.ttu.edu/research/tx-water-consortium/downloads/22-TXPWC-Report-Texas-Legislature.pdf>. Accessed on April 12, 2023.

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Table 7: Assumed chemical composition of produced water for treatment based on 17,000+ samples from the Midland and Delaware basins (* Na was adjusted slightly where necessary to achieve electroneutrality).

Species	Concentration (mg/L)			
	Seawater	25 th Percentile	50 th Percentile	75 th Percentile
Calcium (Ca)	408	1,723	2,728	3,794
Magnesium (Mg)	1,298	299	464	640
Sodium (Na)*	10,768	34,417	43,336	49,458
Potassium (K)	396	359	501	643
Barium (Ba)	-	1	2	3
Strontium (Sr)	-	293	506	691
Iron (Fe)	-	17	36	68
Manganese (Mn)	-	0.6	1.1	1.9
<i>Total cations</i>	12,870	37,122	47,592	55,325
Sulfate (SO ₄)	2702	282	421	690
Chloride (Cl)	19364	57,012	73,586	84,843
Bromide (Br)	67	401	549	674
Phosphate (PO ₄)	-	32	48	66
Boron (B)	-	40	49	61
Silica (SiO ₂)	5	10	13	17
Bicarbonate (HCO ₃)	146	256	366	525
Carbon Dioxide (CO ₂)	9.19	110	220	374
<i>Total anions</i>	22,284	58,033	75,035	86,880
<i>Total TDS</i>	35,154	95,155	122,627	142,204
<i>Alkalinity (as mg/L CaCO₃)</i>	120	210	300	431

³³ Xu, P.; Hightower, M., Characterization of Produced Water and Surrounding Surface Water in the Permian Basin. In *Produced Water Society Seminar 2022*, Houston TX, 2022.

The U.S. EPA's study of hydraulic fracturing⁴ compiled extensive documentation of chemical constituents found in produced water from throughout the United States. All three of these studies noted a significant degree of variation in the chemical constituents of produced water. Produced water contains chemical constituents that are native to the producing formation and may contain chemical constituents that were introduced during oil and gas exploration and production activities.

The release of treated or untreated produced water is a regulatory concern to the RRC; high salt content could be immediately harmful to plant life and soil health, and lower concentrations of various constituents could present adverse effects over time. The thresholds for concern are not certain at this time because of the complexity and diversity of produced water, but also because regulators and the industry have not quantified the potential harm that

⁴ Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States. U.S. EPA. EPA-600-R-16-236Fa. December 2016. www.epa.gov/hfstudy. Accessed on April 12, 2023.

may come through human or environmental exposure to the constituents of concern in treated or untreated produced water. Generally, however, a regulatory concern will arise if the chemical constituents of produced water may:

- Cause pollution of surface or subsurface water,
- Harm natural resources or the environment,
- Harm personal and community safety, or
- Harm the economic vitality of Texas.

For the purposes of a pilot study, the analysis of produced water will be considered to assess the potential long-term risks posed by the activity and to monitor the soil conditions in the application area.

As described below, RRC staff have established three appendices (A, B, and C) that identify the primary analytical considerations for pilot studies. An applicant may propose a variance from the requirements in the appendices with justification, subject to RRC staff approval. The actionable analytical requirements will be specified in the letter of authorization or permit issued by RRC staff.

Sampling and Analysis Protocol No. 1

Appendix A contains the details of Sampling and Analysis Protocol No. 1. The RRC will require detailed analysis of untreated and treated produced water for the purpose of supporting academic or consortium-supported assessment of the risks associated with the recycling of produced water for beneficial purposes. This analysis will be comprehensive and will include the sampling and analysis schedule contained in Appendix A, which will be included as a requirement of the pilot study authorization.

The outcome of academic or consortium-supported risk assessment will inform RRC's future produced water recycling program. Namely, to meet the RRC's goal of establishing the public's trust that treated produced water can be reused in activities that are safe and protective of human health and the environment. But the results of the Protocol No. 1 analyses will not be actionable by the RRC for the purposes of pilot study operations. That is, RRC does not anticipate the need to revoke or alter an authorization based on these analytical results, although the RRC may decline to renew or extend an existing pilot study authorization.

Sampling and Analysis Protocol No. 2

Appendix B contains the details of Sampling and Analysis Protocol No. 2. The RRC anticipates that most pilot studies requiring RRC authorization will include some aspect of the treated produced water being applied to the ground surface for irrigation of pastureland or a specific agricultural crop.⁵ Therefore, a two-element (treated water and soil) sampling program will be required to assess the treated produced water and its impact on the soil environment. This analysis will generally be consistent with RRC's current land application program—soil and treated produced water samples for selected analytes to assess soil health and constituent accumulation. However, consistent with the practice of the New Mexico Produced Water Research Consortium, RRC will adopt the recommendations of the U.S. Bureau of Reclamation⁶ with some modification (Appendix C).

Importantly, the specific requirements of Protocol No. 2 may be further modified case-by-case based on the specific beneficial reuse scenario(s) planned by the applicant.

For soil sampling, the evaluation area should be subdivided into six equal-area plots, three of which will be application plots and three of which will be control or blank plots. An application plot is a plot of land on which treated produced water will be applied and soil samples will be collected. A control or blank plot is a plot of land on which treated produced water will not be applied, but soil samples will be collected. For example, purposes, the following guidelines will discuss using a 1-acre plot for a pilot study. It is anticipated that each operated produced water treatment pilot will be assessed as unique knowing that some aspects of each pilot conducted may vary from one study to another.

Soil sampling will generally follow the guidelines found below.

For each 1-acre plot,

- The 1-acre plot is to be subdivided geometrically into four quadrants (see Figure 1).
 - Within each quadrant there will be 1 soil sample collected from each depth zone as defined below.
 - One soil sample must be collected from Zone 1 (0-12 inches depth) from the center of the quadrant.
 - One soil sample must be collected from Zone 2 (12-24 inches depth) from the center of the quadrant.

⁵ RRC does not have the jurisdiction to authorize the discharge of treated produced water to surface water or for aquifer recharge. Such authorization may be obtained from the Texas Commission on Environmental Quality.

⁶ Oil and Gas Produced Water Management and Beneficial Use in the Western United States. U.S. Department of the Interior, Bureau of Reclamation. September 2011. Table 9, Constituent limits for irrigation water (adapted from Rowe and Abdel-Magid, 1995)

- One soil sample must be collected from Zone 3 (24-36 inches depth) from the center of the quadrant.
- The four soil samples collected for each depth zone will be composited into one single combined soil sample representing the entire 1-acre plot at each prescribed depth.
- Three combined soil samples will be submitted for lab testing for each 1-acre plot.

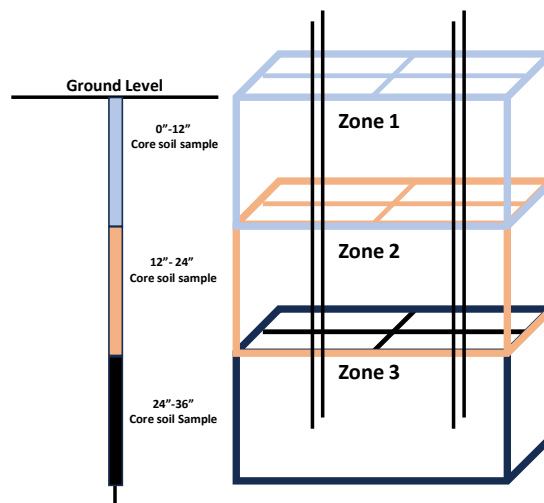


Figure 1

Location and Fluid Volume Considerations

Generally, the application must demonstrate the operator's ability to manage the volume of produced water being treated, and the ground surface must be sufficiently capable of receiving the treated produced water without deleterious effects. The following will be general requirements of the authorization:

- The location must be suitable for the activity (no surface water features, not in a flood plain, and not in a wetlands or sensitive environment.)
- The topography should be flat or gently sloped.
- The soil type must be suitable for the proposed reuse scenario, including liquid volume and rate loading.
- The amount of water to be applied must be specified in terms of both total aggregate volume and application rate (volume / day).

- Plans for measuring and reporting rain fall amounts, and how those additional water volumes will be incorporated into the maximum application volumes will be required. Any diluent or addition of water from any source will add an obligation to the operator to ensure that new water source is tested and assessed for composition much the same as if it were a raw water source to be treated.
- Application by irrigation must be controlled and by sprinkler or drip system.
- The applied liquid must infiltrate into the soil horizon.
- The applied liquid must not accumulate on the surface (pool).
- The applied liquid must not runoff or cause erosion.
- The applied fluid must not contact groundwater or surface water.
- Applied fluids must be contained within the designated application area. Berms or other containment features may be required.
- An assessment of the occurrence and quality of groundwater is recommended and may be required.
- The facility must have adequate storage for the volume of produced water to be managed.
- The facility must have a contingency plan for the storage or disposal of treated fluid in the event application of the treated fluid is not authorized (i.e., during rainfall events, when the ground is frozen) or if a process or quality control requirement prevents fluid from being applied to the ground surface.

PILOT STUDY APPLICATION

Pre-application meetings with RRC staff are encouraged.

Applicant/Operator Information

Provide the following information for the applicant/operator:

- Organization (Operator/P-5) information
 - Operator name

- Operator number
- Project Contact Information (must be an employee of the operator organization)
 - Project Contact Name
 - Title
 - Address
 - Phone number(s)
 - email address
- The application must include the following signed and dated certification statement: "I certify that I am authorized to make this application, that this application was prepared by me or under my supervision and direction, and that the data and facts stated herein are true, correct, and complete to the best of my knowledge."

Project Description

Provide a brief project description for the purpose of providing an introduction/orientation to the project details contained in subsequent parts of the application.

Project Location

- Surface owner information
 - Identity of surface owner
 - Provide proof of surface owner consent (this information must establish that the surface owner is aware of the activities to be performed on the property and the potential risks associated with those activities.)
 - Provide the surface lease/use agreement.
- Notice.
 - The applicant shall comply with the notice provisions of 16 TAC §3.8(d)(6)(C), as if the produced water recycling project utilizes a pit.
 - The applicant shall demonstrate that notice has been provided.
- Property Description
 - Provide a map to the project location with directions sufficient for RRC staff to find the pilot project location.
 - Describe the size and features of the pilot project property, including:
 - Tract size
 - Size of treatment area
 - Size of evaluation/application/reuse area
 - Topography
 - Property boundaries
 - Surface water and drainage features
 - The project may not be located in a wetlands (use the U.S. Fish and Wildlife Service's National Wetlands Inventory Wetlands Mapper

available at <https://fwsprimary.wim.usgs.gov/wetlands/apps/wetlands-mapper/>, or provide a site-specific assessment and determination).

- The project may not be located in a floodplain (use the Federal Emergency Management Agency National Flood Hazard Layer available at <https://www.fema.gov/flood-maps/national-flood-hazard-layer>, or provide a site-specific assessment and determination.)

Fluid Sources

- Describe the fluid sources that will be used, whether from specific operators, fields, etc..
- Describe the known and anticipated chemical constituents and concentrations of the produced water to be treated. Include available analytical results.
 - Identify constituents of concern
 - Quantify constituents of concern

Treatment Area

- Provide a diagram of the treatment process equipment layout, including receiving, treating, and storing equipment or pits.
 - The use of a pit will require filing Form H-11, Application for Permit to Use or Maintain a Pit, which is available at <https://www.rrc.texas.gov/oil-and-gas/oil-and-gas-forms/>
- Describe the treatment process.
 - The description should be of sufficient detail to categorize the treatment processes and identify the role of individual process units. RRC does not intend to infringe on proprietary information but does need a general understanding of the processes for categorization.
 - Describe the intended treatment rates.
 - Describe the treatment goals and quality control.
 - Describe how concentrated brines and other waste will be managed.

Evaluation/Application/Reuse Area

For this framework, RRC staff anticipates that pilot studies will include the land application of treated fluid, including irrigation. If another method of reuse is proposed, the elements of this part of the application shall be adjusted accordingly.

- Describe the proposed evaluation/application/reuse scenario.
- Describe the soil horizon and soil characteristics of the evaluation/application/reuse area.
 - Site-specific soil characterization is preferred and should include the following:

- Soil classification
 - Geotechnical soils analysis, if available
 - Geochemical soils analysis, including baseline soils analysis (see Appendix B)
- USDA soil surveys may be accessed at the U.S. Department of Agriculture Natural Resources Conservation Service
<https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>
- Describe the subsurface
 - Geology to 40 feet
 - Hydrogeology, including depth to groundwater and the direction of flow.
 - Identify water wells within one-half mile of the evaluation/application/reuse area using resources from the Texas Water Development Board (Water Well Report Viewer available at <https://www.tceq.texas.gov/gis/waterwellview.html>, and Groundwater Data Viewer available at <https://www3.twdb.texas.gov/apps/WaterDataInteractive/GroundwaterDataViewer/?map=sdr>.)
- Describe the methods of treated produced water application.
 - Volume and rate
 - Equipment used to apply treated fluid (the equipment capacity must be sufficient to accommodate the treatment and application rates.
- Describe how treated fluid will be confined to the evaluation/application/reuse area.
 - Berms may be necessary to prevent runoff and run-on.
 - If the applicant asserts berms are not necessary, the applicant shall provide a plan for monitoring the evaluation/application/reuse area and for sampling soils beyond the application areas that may be subject to runoff.

Operations Plan

The application shall address how the applicant/operator will manage the following:

- Site security.
- Spills.
- Quality control issues, such as treated fluid not meeting the treatment goals or requirements for land application of treated fluid.
- Other operational issues that may occur; and
- Closure of the pilot study facilities.

PILOT STUDY AUTHORIZATION CONDITIONS

Authorization for a pilot study to treat produced water and make treated water available for beneficial reuse outside of regular oil and gas operations shall include conditions consistent

with RRC's other waste management permitting programs. The specific conditions listed below may change based on case-by-case information or as the pilot project program develops.

General Conditions

- The authority granted by this permit is effective <start date> and will expire on <end date>.
- This permit may be considered for administrative renewal upon review by the RRC. Any request for renewal should be received at least 60 days prior to the permit expiration date.
- This permit is nontransferable without the written consent of the RRC. A written request for permit transfer must be filed with Technical Permitting in Austin at least 60 days before the transfer takes place.
- Unless otherwise required by the conditions of this permit, the construction, use, and maintenance of the facility must be in accordance with the information represented in the permit application and attachments thereto.
- Any deviation from this permit must be approved by amendment from Technical Permitting in Austin before implementation.
- This permit does not authorize the discharge of any oil and gas waste.
- A sign must be posted at the entrance to the recycling pilot study facility. The sign must be readily visible and show the operator's name, facility name, and permit number in letters and numerals at least three (3) inches in height.

Authorized Waste

- This permit authorizes the treatment and recycling of produced water only. No other oil and gas wastes may be treated and applied to the designated application/reuse areas.

Recycling and Reuse Scenario

- A condition that describes the application area.
- Treated fluid may not be applied to the ground surface if the concentration of any of the constituents exceeds the analytical limitations in Appendix C.
- The treated fluid must be applied to the land area in such a manner that it will not pool or migrate off the application area or enter any water courses or drainage ways, including any drainage ditch, dry creek, flowing creek, or any other body of surface water.
- To prevent any standing or pooled rainwater, or other liquid, in the application area, treated fluid will not be applied during periods of rainfall or when the ground surface is frozen.

- Any standing or pooled rainwater, or other liquid, in the application area or within the perimeter must be removed within 72 hours and disposed of in an authorized manner.
- The maximum daily wastewater application rate for the application area must not exceed a total of <volume> barrels per day (BPD).
- The wastewater must be applied using <methodology in application>.
- If any part of the land application area becomes saturated, all treated fluid application must cease until it has had time to dry.

Monitoring and Analysis

- All chemical laboratory analyses required to be performed in accordance with this permit must be performed using appropriate Environmental Protection Agency (EPA) methods or Standard Methods by an independent, National Environmental Laboratory Accreditation Program (NELAP) certified laboratory neither owned nor operated by the permittee. Any sample collected for laboratory analysis must be collected and preserved in a manner appropriate for that analytical method as specified by 40 CFR, Part 136.
- The sampling and analysis program shall include any necessary field and laboratory quality control and quality assurance activities, samples, documentation, analysis, and review.
- Untreated produced water shall be sampled and analyzed for the parameters and constituents listed in Appendix A at the start of any land application activities and every 90 days thereafter.
- Treated produced water shall be sampled and analyzed for the parameters and constituents listed in Appendix A at the start of any land application activities and every 90 days thereafter.
- Treated produced water shall be sampled and analyzed for the parameters and constituents listed in Appendix B Table 1 at the start of any land application activities, every 30 days thereafter, and at the end of land treatment activities.
- Treated produced water shall be sampled and analyzed for the parameters and constituents listed in Appendix B Table 1 at the start of any land application activities, every 30 days thereafter, and at the end of land treatment activities.
- Soil samples shall be collected for analysis before land application activities commence, every 30 days thereafter, at the end of land application activities, and 90 days after the end of land application activities.
 - Based on the results of the initial baseline soil sampling and analysis results, RRC staff will establish analyte-specific concentration limits for the soil.
 - It is recommended that the soil sampling and analysis necessary to establish these soil concentration limits be completed during the pilot study application phase.
 - The permit will prohibit the application of produced water once the soil concentration limits have been reached.

- Soil samples will be analyzed according to Appendix B Table 2.
- Soil samples shall be collected as follows:
 - One soil sample must be collected from Zone 1 (0 to 12 inches depth) for each equidimensional, 1-acre area of the plot.
 - One soil sample must be collected from Zone 2 (12 to 24 inches depth) for each equidimensional, 1-acre area of the plot.
 - One soil sample must be collected from Zone 3 (24 to 36 inches depth) for each equidimensional, 1-acre area of the plot.
 - A minimum of four composite soil samples must be collected from 1-acre area of each plot each zone.
 - One composite soil sample should consist of at least four (4) discrete samples collected from the same plot and zone and homogenized.

Reporting

- The permittee shall report the date treatment activities begin to the Technical Permitting Section in Austin.
- The permittee shall report the date application activities ceased to the Technical Permitting Section in Austin.
- A final report shall be submitted 120 days after land treatment activities ceased containing any additional treatment, application, sampling, and analysis activities that have occurred since the most recent 90-day report, and the final soil samples collected for analysis 90 days after the end of application.
- The permittee shall submit a report to the Technical Permitting Section in Austin for each 90-day period the pilot program is in operation. Operation begins when treatment begins. Reports are due 30 days after the end of the 90-day period.
- The report shall include a description and tabulations of pilot study activities during the reporting period, including volume of produced water treated, volume of treated produced water applied to the reuse scenario, and volume of waste generated.
- The report shall include a summary of fluid and soil sampling activities that occurred during the reporting period.
- The report shall include a tabular summary of fluid and soil sampling results received during the reporting period.
- Laboratory analytical reports and the corresponding chain of custody shall be included for all chemical analyses performed.

APPENDIX A: SAMPLING AND ANALYSIS PROTOCOL NO. 1, ANALYSIS OF UNTREATED AND TREATED PRODUCED WATER TO SUPPORT A RISK ASSESSMENT

The following sampling and analysis of untreated and treated produced water will be required at the start of any land application activities and every 90 days thereafter. The sampling and analysis program shall include any necessary laboratory field and laboratory quality control and quality assurance activities, documentation, analysis, and review.

Protocol 1			
Category	Subcategory	Analyte	Method
Anions		Bromide	EPA 300.0/300.1; SW-846 9056A
Anions		Chloride	EPA 300.0/300.1; SW-846 9056A
Anions		Fluoride	EPA 300.0/300.1; SW-846 9056A
Anions		Nitrogen, nitrate	EPA 300.0/300.1; SW-846 9056A
Anions		Nitrogen, nitrite	EPA 300.0/300.1; SW-846 9056A
Anions		Phosphate	EPA 300.0/300.1; SW-846 9056A
Anions		Sulfate	EPA 300.0/300.1; SW-846 9056A
General		Alkalinity, total and bicarbonate	SM 2320B
General		Asbestos	EPA 100.1, 100.2
General		Chemical Oxygen Demand	SM 5220C, D, ASTM D1252B, EPA 410.X
General		Cyanide, total	EPA-NERL 335.4
General		Dissolved Oxygen	EPA-NERL 360.1
General		Electrical Conductivity	SM 2510B
General		Hardness (total or dissolved)	EPA-NERL 130.1
General		Surfactants - methylene blue active substances	SM 5540C
General		Nitrogen, ammonia	EPA 350.2
General		Oxidation Reduction Potential	USGS-OWQ NFM 6.5
General		pH	ASTM D6569
General		Specific Gravity	USGS-NWQL I-1312

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Protocol 1			
Category	Subcategory	Analyte	Method
General		Sulfide	EPA-NERL 376.1
General		Total Dissolved Solids	SM 2540C
General		Total Organic Carbon	EPA 415.1
General		Total Suspended Solids	SM 2540B
General		Turbidity	EPA-NERL 180.1
Metals		30 Metals	SW-846 6010 or 6020
Metals		Mercury	SW-846 7470
Organics	Semi-Volatile Organic Compounds (SVOC)		SW-846 8270
Organics	SVOC - Agent Breakdown Products		EPA Method 538
Organics	SVOC - Carbonyl Compounds		SW-846 8315
Organics	SVOC - Dioxins		EPA 1613B
Organics	SVOC - Explosives		SW-846 8095
Organics	SVOC - Organic Acids		SW-846 8015
Organics	SVOC - PAH		SW-846 8015
Organics	SVOC - Pesticides/Herbicides		SW-846 8081
Organics	SVOC - PFAS	PFOS, PFOA, PFHxS	EPA 537.1
Organics	SVOC - Polychlorinated biphenyls (PCBs)	Aroclors	SW-846 8082
Organics	SVOC - Polychlorinated biphenyls (PCBs)	World Health Organization list of congeners	EPA 1668a
Organics	TPH	Diesel Range Organics (DRO) [C10-C28]	SW-846 8015D
Organics	TPH	Gasoline Range Organics (GRO) [C6-C10]	SW-846 8015D
Organics	TPH	Oil Range Organics (ORO) (C28-40)	SW-846 8015D

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Protocol 1			
Category	Subcategory	Analyte	Method
Organics	Volatile Organic Compounds (VOC)		SW-846 8260
Organics		Oil and Grease	EPA-EAD 1664
Organics		Total Organic Halides (TOX)	SW-846 9020
Radionuclides		Gross Alpha/Beta	EPA 900.0/9310; EPA 600/00-02
Radionuclides		Radium 226, pCi/L	EPA 903.1
Radionuclides		Radium-228	EPA 904.0 - radium; SW-846 9320; Gamma Spec EPA 901.1

APPENDIX B: SAMPLING AND ANALYSIS PROTOCOL NO. 2, ANALYSIS OF TREATED PRODUCED WATER AND SOIL TO SUPPORT APPLICATION MONITORING

The following sampling and analysis of treated produced water will be required at the start of any land application activities, every 30 days thereafter, and at the end of the application period. Sampling and analysis shall include any necessary field and laboratory quality control and quality assurance activities, documentation, analysis, and review.

TABLE 1 Protocol 2 – Treated Produced Water		
Category	Analyte	Method
Anions	Chloride	EPA 300.0/300.1; SW-846 9056A
Anions	Fluoride	EPA 300.0/300.1; SW-846 9056A
Anions	Nitrogen, nitrate	EPA 300.0/300.1; SW-846 9056A
Anions	Nitrogen, nitrite	EPA 300.0/300.1; SW-846 9056A
Anions	Phosphate	EPA 300.0/300.1; SW-846 9056A
Anions	Sulfate	EPA 300.0/300.1; SW-846 9056A
General	Alkalinity	SM 2320B
General	Conductivity, electrical	SM 2510B
General	Hardness	EPA-NERL 130.1
General	Nitrogen, ammonia	EPA 350.2
General	pH	ASTM D6569
General	Sodium Adsorption Ratio (SAR)	Calculated
General	Temperature	EPA-NERL 170.1
General	Total Dissolved Solids	SM 2540C
General	Turbidity	EPA-NERL 180.1
Metals	Aluminum	SW-846 6010 or 6020
Metals	Arsenic	SW-846 6010 or 6020
Metals	Beryllium	SW-846 6010 or 6020
Metals	Boron	SW-846 6010 or 6020

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TABLE 1		
Protocol 2 – Treated Produced Water		
Category	Analyte	Method
Metals	Cadmium	SW-846 6010 or 6020
Metals	Calcium (for SAR)	SW-846 6010 or 6020
Metals	Chromium	SW-846 6010 or 6020
Metals	Cobalt	SW-846 6010 or 6020
Metals	Copper	SW-846 6010 or 6020
Metals	Iron	SW-846 6010 or 6020
Metals	Lead	SW-846 6010 or 6020
Metals	Lithium	SW-846 6010 or 6020
Metals	Magnesium (for SAR)	SW-846 6010 or 6020
Metals	Manganese	SW-846 6010 or 6020
Metals	Molybdenum	SW-846 6010 or 6020
Metals	Nickel	SW-846 6010 or 6020
Metals	Phosphorus	SW-846 6010 or 6020
Metals	Potassium	SW-846 6010 or 6020
Metals	Selenium	SW-846 6010 or 6020
Metals	Sodium (for SAR)	SW-846 6010 or 6020
Metals	Total Metals	SW-846 6010 or 6020
Metals	Vanadium	SW-846 6010 or 6020
Metals	Zinc	SW-846 6010 or 6020
Organic	Total Oil and Grease	EPA-EAD 1664
Organic	Total Organic Carbon	EPA-NERL 415.1
Organic	Total Petroleum Hydrocarbons	SW-846 8015D
Radionuclides	Gross Alpha/Beta	EPA 900.0/9310; EPA 600/00-02
Radionuclides	Radium 226, pCi/L	EPA 903.1
Radionuclides	Radium-228	EPA 904.0 - radium; SW-846 9320; Gamma Spec EPA 901.1

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The following sampling and analysis of soil will be required at the start of any land application activities, every 30 days thereafter, and at the end of the application period. Sampling and analysis shall include any necessary field and laboratory quality control and quality assurance activities, documentation, analysis, and review.

TABLE 2 Protocol 2 - Soil		
Category	Analyte	Method
Anions	Chloride	EPA 300.0/300.1; SW-846 9056A
Anions	Fluoride	EPA 300.0/300.1; SW-846 9056A
Anions	Nitrogen, nitrate	EPA 300.0/300.1; SW-846 9056A
Anions	Phosphate	EPA 300.0/300.1; SW-846 9056A
Anions	Sulfate	EPA 300.0/300.1; SW-846 9056A
General	Alkalinity	SM 2320B
General	Conductivity, electrical	SM 2510B
General	Nitrogen, ammonia	EPA 350.2
General	pH	ASTM D6569
General	Sodium Adsorption Ratio	Calculated
Metals	Aluminum	SW-846 6010 or 6020
Metals	Arsenic	SW-846 6010 or 6020
Metals	Beryllium	SW-846 6010 or 6020
Metals	Boron	SW-846 6010 or 6020
Metals	Cadmium	SW-846 6010 or 6020
Metals	Calcium (for SAR)	SW-846 6010 or 6020
Metals	Chromium	SW-846 6010 or 6020
Metals	Cobalt	SW-846 6010 or 6020
Metals	Copper	SW-846 6010 or 6020
Metals	Iron	SW-846 6010 or 6020
Metals	Lead	SW-846 6010 or 6020
Metals	Lithium	SW-846 6010 or 6020
Metals	Magnesium (for SAR)	SW-846 6010 or 6020
Metals	Manganese	SW-846 6010 or 6020
Metals	Molybdenum	SW-846 6010 or 6020
Metals	Nickel	SW-846 6010 or 6020
Metals	Phosphorus	SW-846 6010 or 6020
Metals	Potassium	SW-846 6010 or 6020
Metals	Selenium	SW-846 6010 or 6020
Metals	Sodium (for SAR)	SW-846 6010 or 6020
Metals	Total Metals	SW-846 6010 or 6020

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TABLE 2		
Protocol 2 - Soil		
Category	Analyte	Method
Metals	Vanadium	SW-846 6010 or 6020
Metals	Zinc	SW-846 6010 or 6020
Organic	Total Oil and Grease	EPA-EAD 1664
Organic	Total Organic Carbon	EPA-NERL 415.1
Organic	Total Petroleum Hydrocarbons	SW-846 8015D
Radionuclides	Gross Alpha/Beta	EPA 900.0/9310; EPA 600/00-02
Radionuclides	Radium 226, pCi/L	EPA 903.1
Radionuclides	Radium-228	EPA 904.0 - radium; SW-846 9320; Gamma Spec EPA 901.1

APPENDIX C: APPLICATION LIMITS FOR TREATED PRODUCED WATER APPLIED TO SOIL

Category	Parameter	Method	Upper Limit or Range	Units
Anions	Chloride	EPA 300.0/300.1; SW-846 9056A	100	mg/L
Anions	Fluoride	EPA 300.0/300.1; SW-846 9056A	1	mg/L
Anions	Nitrogen, nitrate	EPA 300.0/300.1; SW-846 9056A	45	mg/L
Anions	Nitrogen, nitrite	EPA 300.0/300.1; SW-846 9056A	10	mg/L
General	Alkalinity	SM 2320B	100	mg/L
General	Conductivity, electrical	SM 2510B	1500	µmho/cm
General	Hardness	EPA-NERL 130.1	150	mg/L
General	Nitrogen, ammonia	EPA 350.2	30	mg/L
General	pH	ASTM D6569	6.5-8.4	std. units
General	Sodium Adsorption Ratio	Calculated	4	meq/L
General	Temperature	EPA-NERL 170.1	20-30	°C
General	Total Dissolved Solids	SM 2540C	1000	mg/L
General	Turbidity	EPA-NERL 180.1	30	NTU
Metals	Aluminum	SW-846 6010 or 6020	5	mg/L
Metals	Arsenic	SW-846 6010 or 6020	0.1	mg/L
Metals	Beryllium	SW-846 6010 or 6020	0.1	mg/L
Metals	Boron	SW-846 6010 or 6020	0.75	mg/L
Metals	Cadmium	SW-846 6010 or 6020	0.01	mg/L
Metals	Chromium	SW-846 6010 or 6020	0.1	mg/L
Metals	Cobalt	SW-846 6010 or 6020	0.05	mg/L
Metals	Copper	SW-846 6010 or 6020	0.2	mg/L
Metals	Iron	SW-846 6010 or 6020	5	mg/L
Metals	Lead	SW-846 6010 or 6020	5	mg/L
Metals	Lithium	SW-846 6010 or 6020	2.5	mg/L
Metals	Manganese	SW-846 6010 or 6020	0.2	mg/L
Metals	Molybdenum	SW-846 6010 or 6020	0.01	mg/L
Metals	Nickel	SW-846 6010 or 6020	0.2	mg/L
Metals	Phosphorus	SW-846 6010 or 6020	5	mg/L
Metals	Selenium	SW-846 6010 or 6020	0.02	mg/L
Metals	Sodium (for SAR)	SW-846 6010 or 6020	100	mg/L
Metals	Total Metals	SW-846 6010 or 6020	10	mg/L
Metals	Vanadium	SW-846 6010 or 6020	0.1	mg/L

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Category	Parameter	Method	Upper Limit or Range	Units
Metals	Zinc	SW-846 6010 or 6020	2	mg/L
Organic	Total Oil and Grease	EPA-EAD 1664	35	mg/L
Organic	Total Organic Carbon	EPA-NERL 415.1	10	mg/L
Organic	Total Petroleum Hydrocarbons	SW-846 8015D	10	mg/L
Radionuclides	Gross Alpha/Beta	EPA 900.0/9310; EPA 600/00-02	15	pCi/L
Radionuclides	Radium 226, pCi/L	EPA 903.1	30	pCi/L
Radionuclides	Radium-228	EPA 904.0 - radium; SW-846 9320; Gamma Spec EPA 901.1	30	pCi/L