PARSONS

Alternative Brine Disposal Evaluation Report La Quinta Desalination Facility

REVISED DRAFT

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PORT OF CORPUS CHRISTI AUTHORITY

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Executive Summary

The Corpus Christi area has concerns related to the future limited water supply, as the area has reached supply trigger points and expects demand to exceed the 70% level by 2022. To help supplement water supply, the Port of Corpus Christi Authority (PCCA) has initiated permitting projects to bring on-line new desalination facilities which will supply industrial water for the region. A proposed project is located on port-owned property on the north side of Corpus Christi Bay, called the La Quinta site.

The proposed desalination facility is projected to produce up to 30 MGD of fresh, industrial-use water. The facility will utilize the seawater reverse osmosis (SWRO) process, which will withdraw seawater from Corpus Christi Bay and extract fresh water, but produces a by-product water stream with concentrations of salts elevated to approximately twice salinity of typical seawater (brine). The flowrate of brine by-product is predicted to measure approximately 57 MGD. This by-product discharge will meet all regulatory requirements before it is returned to the bay. Therefore, PCCA has submitted an application for a wastewater discharge permit associated with the proposed desalination facility, with discharge to the deep La Quinta ship channel adjacent to the site.

PCCA has implemented this feasibility study to investigate alternatives for disposal of the by-product liquid stream to minimize impacts to the marine ecosystem. This study investigated two different categories of managing the brine produced in the desalination process: beneficial reuse by other parties and disposal as a wastewater.

Options for beneficial reuse include:

- Bauxite Residual Treatment
- Use in Foundries and Metalworks
- Heat Transfer
- Vapor Absorption Refrigeration
- Food Products Preservation

The identified alternatives relating to disposal as a wastewater include:

- Channel discharge as originally indicated in TCEQ permit application, via diffuser to ship channel
- Channel discharge with two concurrent outfalls, one in the ship channel and another in the bay
- Channel discharge from a smaller 20 MGD desalination plant
- Channel discharge, combining the effluent with nearby industrial discharges
- Combined effluent with industrial discharges, and a smaller 20 MGD plant
- Deep well injection field
- Channel discharge with 25% of effluent to deep well injection
- Evaporation – natural, via large evaporation ponds
- Evaporation – thermal/mechanical, via large high-energy equipment
- Bauxite residuals ponds, sending all effluent to nearby bauxite disposal ponds
- Channel discharge, with 5 MGD sent to bauxite residuals ponds, and a 20 MGD plant
- Channel discharge, combined with industrial discharges, and 5 MGD sent to residuals ponds
- Channel discharge, combined with industrial discharges, 5 MGD sent to residuals ponds, and a 20 MGD Plant

Note that some alternatives included a smaller desalination plant, producing 20 MGD instead of the projected 30 MGD. Such a plant would produce a brine flow of 38 MGD at the same salinity as the larger plant.

With the exception of the bauxite residual treatment, none of the beneficial reuse options presented feasible opportunities, as they involved high costs to deliver small flows of brine to remote locations. Bauxite residual treatment was only feasible in combination with disposal alternatives, where only a small fraction of the generated brine could be accommodated in the bauxite residual treatment scheme. Alternatives that incorporate this feature are feasible and PCCA could continue its commitment to this concept.

The alternatives were preliminarily sized, the amount of infrastructure, capital and operating costs were estimated and combined into a net present value. In addition, the alternatives were scored according to criteria of potential net environmental impact, probable public acceptance, and schedule. The net environmental impact and probable public acceptance scores are subjective, but were made based on the consultant's experience with desalination permitting issues considering the Corpus Christi area.

The results of the investigation is presented in Table ES-1. Some alternatives, as read in Section 4, were so costly or unfeasible that they were excluded from the scoring process.

Table ES-1 Summary of Disposal Alternatives

Alternative	Discharge to Bay (flow, MGD @ salinity, g/L)	Capital Cost ($millions)	Annual Cost ($millions)	Evaluation Score*
A. Existing La Quinta Channel Discharge Concept	57 @ 48	17	0.6	15
B. Bay Discharge with 2 Outfalls	57 @ 48	24	0.8	13
C. La Quinta Discharge, 20 MGD Plant	38 @ 48	14	0.5	16
D. Combined Effluent with Nearby Industry	63 @ 43	21	0.6	16
E. Combined Effluent with Nearby Industry, 20 MGD Plant	44 @ 41	15	0.5	17
F. Deep Well Injection Field	none	181	6.8	11
G. La Quinta Discharge with 25% Deep Well Injection	43 @ 48	55	3.2	13
H. Evaporation – Natural	none	440	1.7	NE
I. Evaporation – Thermal/Mechanical	none	550	68	NE
J. Bauxite Residuals Beds – Full Flow	57 @ 48	NE		
K. Channel Discharge, 5 MGD Reuse, 20 MGD Plant	33 @ 48	17	1.5	15
L. Channel Discharge, Combined Effluent, 5 MGD Reuse	58 @ 43	20	1.9	14
M. Channel Discharge, Combined Effluent, 5 MGD Reuse, 20 MGD Plant	39 @ 41	19	1.6	16

*Higher score is more attractive
Costs are for disposal only
NE = not evaluated
MGD = million gallons per day
g/L =grams per liter

The scores of the evaluated alternatives all rank very closely. The highest score was for a 20 MGD desalination plant which discharges to the channel after combining with an adjacent, low-salinity industrial effluent. It scores higher because the cost is less for the infrastructure to accommodate the smaller effluent flow rate, and the effluent salinity concentration is lower because of mixing with the industrial flow.

The highest scoring alternative with 30 MGD desalination production also combines the brine effluent with a low-salinity effluent from a nearby industry. This results in a 10% lower salinity concentration due to mixing with the other effluent, leading to a higher score under the criterion of net environmental impact. Alternative A, the baseline original concept, trails this alternative by only 1 point but costs 20% less.

There are advantages to the bauxite reuse options as well. Item M ranks the best among beneficial reuse with 5 MGD transferred to the bauxite ponds. Furthermore, when this alternative includes the 20 MGD facility, it has the advantage of less brine discharged to the channel and with lower concentrations due to mixing with other nearby industry thus lowering the effluent salinity.

The PCCA is presented with the following choices as the result of this study. Many alternatives are all close enough to not be objectively superior to other alternatives and are considered probable to obtain a permit based on the technical merits. PCCA may have other certain subjective criteria or preferences that could drive a decision to proceed. The selection of a combined effluent requires discussions with the TCEQ and the adjacent industry.

20 MGD Alternatives Recommended

C. La Quinta Channel Discharge, 20 MGD Plant
E. Combined Effluent with Nearby Industry, 20 MGD Plant
M. La Quinta Discharge, Combined Effluent, 5 MGD Reuse, 20 MGD Plant

30 MGD Alternatives Recommended

A. Existing La Quinta Channel Discharge Concept
D. Combined Effluent with Nearby Industry
L. La Quinta Discharge, Combined Effluent, 5 MGD Reuse

These alternatives are recommended to be tested with preliminary discharge modeling, and if that proves successful, to continue with the other aspects of this project, identifying a formal alternative to advance for the resubmitted permit application, anti-degradation evaluation, and review of the draft permit to be supplied by the TCEQ.

During the investigation and evaluation of the original discharge concept as presented in the permit application documents, difficulties with the location and configuration of the outfall diffuser were revealed and must be corrected before advancing. Preliminary modeling of the discharge shows that the discharge of an undiluted effluent from a 30 MGD desalination plant can meet effluent standards if the location and diffuser design is modified.

1 Introduction

1.1 Project Background

Growth in the Corpus Christi area has strained the existing surface water supply. A lack of reliable water supply may discourage future industrial development in the area. The Port of Corpus Christ Authority (PCCA), to further its mission to “leverage commerce to drive prosperity” is striving to augment the water supply in the area to support continued economic development. Given the location of Corpus Christi along the Gulf of Mexico, and in particular, the Port of Corpus Christi Authority’s (PCCA’s) role and strategic location on the sea, focusing on seawater desalination to produce fresh water is the logical alternative to pursue. Seawater desalination provides an unlimited, 100% reliable and sustainable resource to create freshwater.

To that end, the PCCA is permitting projects to bring on-line new desalination facilities in the area. One potential project is located on port-owned property on the north side of Corpus Christi Bay, called the La Quinta site. Such a facility, if implemented soon, may become the first large-scale seawater desalination facility in Texas. Such a project will be a groundbreaking example to provide freshwater resources for industry along the remainder of the coast.

The proposed desalination process is seawater reverse osmosis (SWRO). The facility will withdraw seawater from Corpus Christi Bay and extract fresh water, effectively by capturing H_2O molecules and leaving other components of seawater behind. By removing some of the pure water molecules, the concentrations of salts in the reject fluid are elevated to approximately twice the original salt concentration. As such, it is considered a waste product and, in the current regulatory framework, cannot be returned to the bay or other waterbodies without meeting regulatory limits. Therefore, PCCA has submitted an application for wastewater discharge associated with the proposed desalination facility.

The desalination by-product does not include chemicals or waste products typical with some other types of production of other chemicals, materials, or manufactured products. It does not include bacteriological pathogens or pose a sanitary risk of disease.

The proposed facility is configured to produce 30 MGD of fresh, although non-potable, water for use by industry. The production will result in approximately 57 MGD of desalination by-product (brine). Without identification of a suitable alternative, this brine will be returned to the bay at the La Quinta Ship Channel.

PCCA strives to construct and operate the desalination facility in the most environmentally acceptable manner and is seeking the best strategy to manage the resulting by-product to minimize impacts to the marine ecosystem.

1.2 Project Scope

Parsons was contracted to evaluate brine management alternatives and to assist in developing a regulatory permitting strategy that will allow the plant to obtain a discharge permit for the desalination by-product. The strategies and alternatives are focused on either disposing of the by-product via different methods or identifying other beneficial re-uses.

The tasks for the overall project at large are listed below.

Task 1 - Document Review and Antidegradation Memo

Task 2 - Alternative Brine Disposal Evaluation

Task 3 - Copano Mud Beds Feasibility and Treatability Study for RO Reject Disposal

Task 4 - Update Discharge Permit and Technical Information

Task 5 - Update Water Quality Model

Task 6 - Review Draft and Final Permits

This report is for Task 2, identifying, developing, and evaluating methods to manage, permit, and dispose of the concentrated saline by-product of the desalination process. Task 3 has been completed and is linked to this task. Tasks 1, 4, 5, and 6 are dependent on final selection of alternatives that are presented in this report.

2 Project Description

2.1 Site Description

The proposed desalination facility is located along the northern shore of Corpus Christi Bay, as seen in Figure 1.

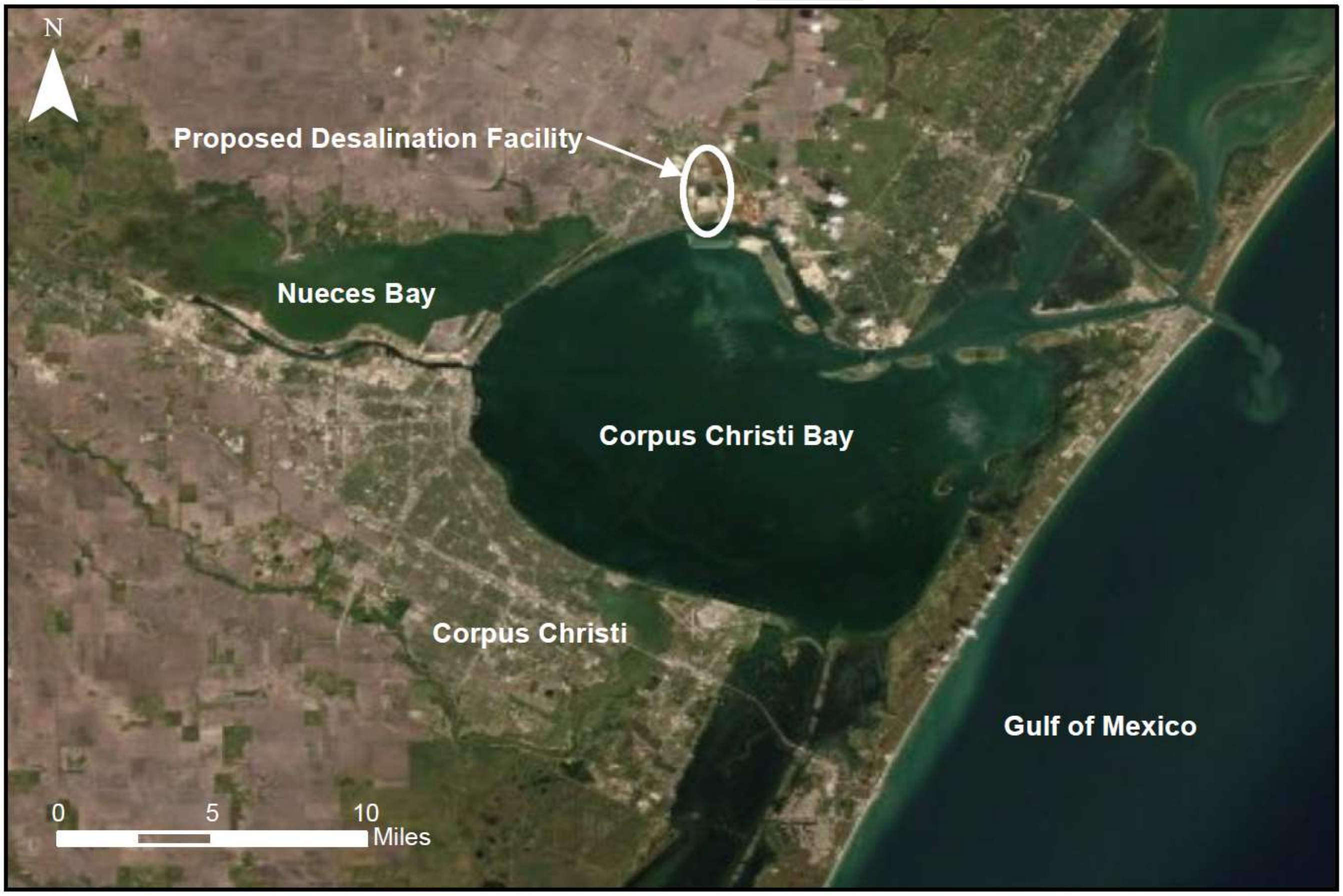


Figure 1 Project Regional Map

Figure 2 provides an aerial photo of the location of the proposed desalination facility on the north shore of Corpus Christi Bay. The region is generally flat and slightly above sea level.

Very important in this project is the La Quinta ship channel, a 45-foot deep, 6-mile long channel along the north shore of Corpus Christi Bay, ending with a turning basin in front of the proposed desalination site.

It is important to note the nature of the surroundings of the project site, which are a few industries and other smaller residential communities, and the site's relative isolation. The project area is bordered on the north and west by miles of agricultural land. Many other industries and residents are found in Corpus Christi, but that is approximately 10 miles across the bay. The site's remoteness is a disadvantage when considering potential customers with regard to the beneficial re-use of the desalination by-product, due to the length of piping required.

While the ship channel is relatively deep, the remainder of Corpus Christi Bay in the region seen below measures between 8 and 15 feet deep.

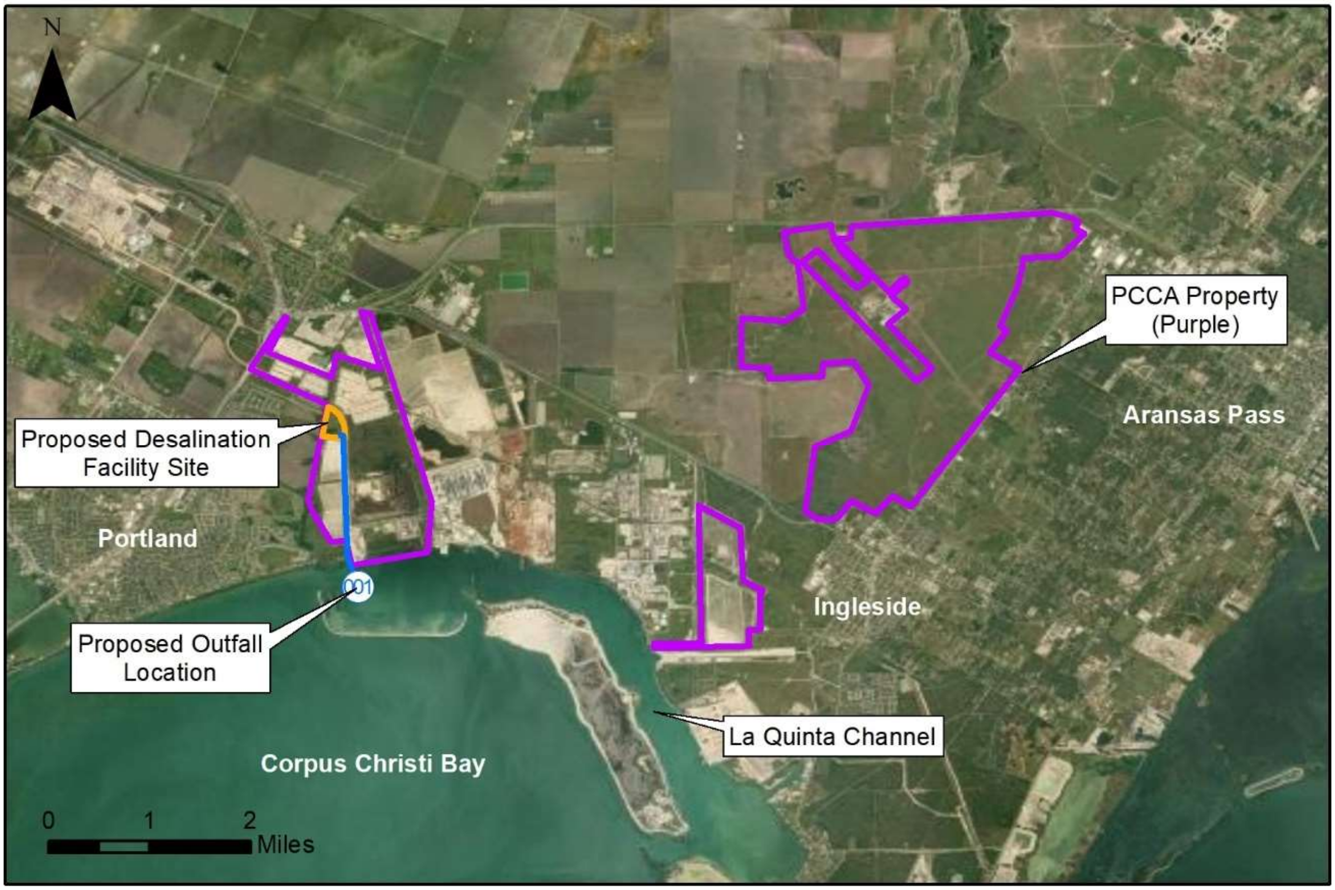


Figure 2 Project Area

2.2 Proposed Desalination Facility

The proposed desalination facility has a preliminary design rating of 30 MGD of produced fresh industrial (non-potable) water. The desalination process employs the reverse osmosis (RO) process to separate fresh water (very low in total dissolved solids) from the other components of seawater (salts, minerals, microbes, silts). The reverse osmosis process utilizes ultra-thin membranes that, under high pressure, permit passage of water molecules while leaving other molecules and matter behind. Because the thin reverse osmosis membranes are subject to clogging, the candidate water must undergo several pretreatment steps before delivery to the RO units.

After separation of the fresh water, a stream of unwanted, more concentrated seawater remains. The fluid stream from the membrane separation process is called reverse osmosis reject water (RORW). RORW will have high total dissolved solids (salts and minerals) and as such must be disposed of appropriately. While this liquid has concentrations of salts worthy of concern, it nonetheless does not contain any materials that were not in the seawater at the beginning of the process. The proposed facility will not introduce raw materials, perform or promote any chemical reactions, or produce any chemicals. In fact, given that the pretreatment steps before the RO process actually remove most particles and solid matter and dispose of it outside of the RORW stream, the combined by-product stream from the desalination facility is likely to be less contaminated than the native seawater that was withdrawn.

Figure 3 illustrates a simplified block flow diagram for the desalination process.

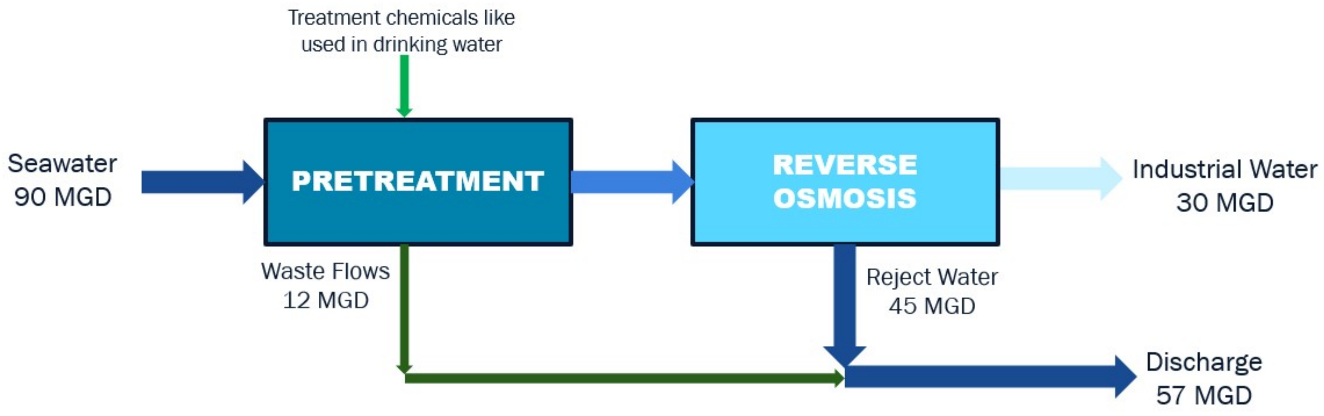


Figure 3 Simplified Process Flow Diagram for Desalination Process

Of importance is the intake and discharge locations within the water body. The plant intake is approximately one-half mile west of the discharge location. The discharge is located in the western end of the La Quinta ship channel turning basin, a feature approximately 3 times deeper than the adjacent bay and where a larger volume of seawater is present for mixing.

2.2.1 INTAKE

PCCA submitted a water rights permit application in August of 2019. The permit is currently in process; a hearing occurred on July 13, 2021. The draft permit, identified as #13630, permits a withdrawal of 101,334 acre-ft/year from the La Quinta channel of Corpus Christi Bay, within the San Antonio-Nueces Coastal Basin.

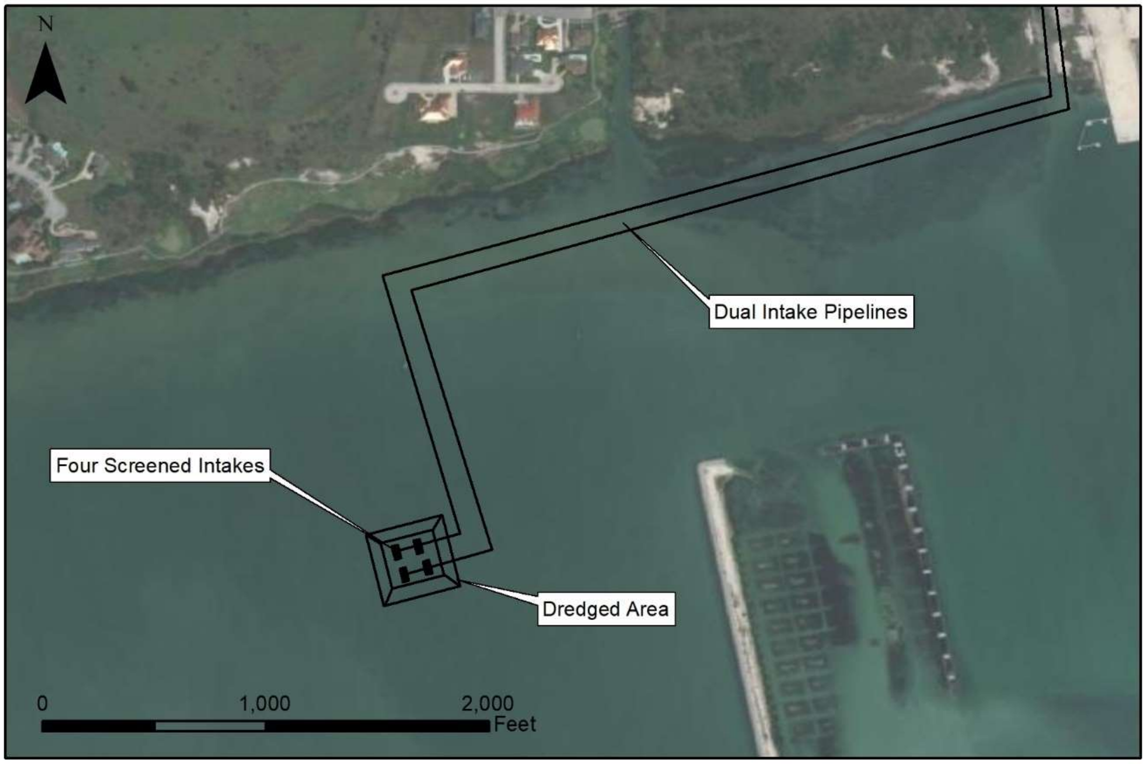
The proposed intake is a series of inlet pipes located at the bottom of the seabed, as indicated in Figure 4. The intake would be screened and properly designed to avoid intake of marine life.

The resulting salinity in the effluent is the primary concern during permitting. The effluent salinity, whether for discharge or alternative uses, is highly dependent on the influent salinity.

A Texas Commission on Environmental Quality (TCEQ) surface water quality monitoring station, number 13709 (see Figure 5), is located near the project location and was utilized to evaluate historical salinity in the

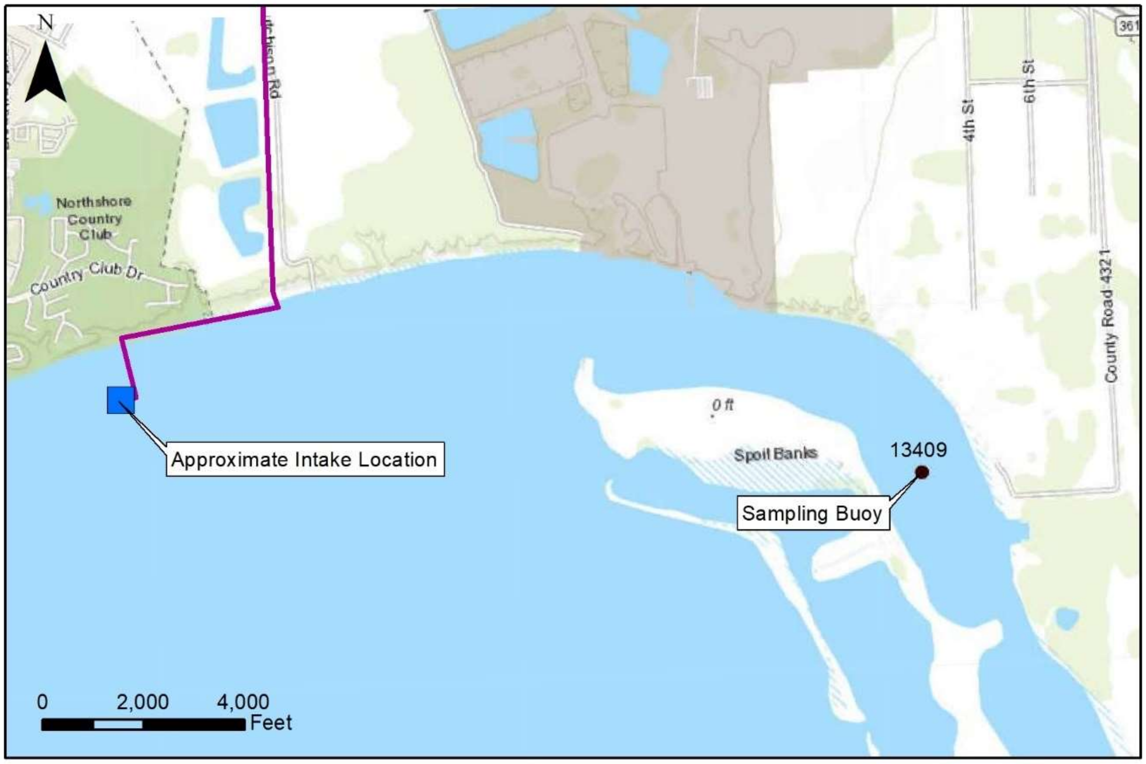
La Quinta Channel. Data were downloaded from the TCEQ website and the last 20 years were evaluated. The data set comprises 184 values of salinity and includes samples from multiple depths at the same sampling event.

The data were evaluated based on season and percentile. The resulting data are presented in Table 1 and plotted over time in Figure 6. The salinity in the bay varies over seasons and years. The overall average of all samples over the entire 20 years of data is 31.69 grams per liter (g/L). These values are very important in understanding that salinity changes significantly over time, which means that the desalination plant will have to adjust its operations to produce freshwater, and with those changes in operations, the salinity of the resulting RORW will also vary.



from permit application

Figure 4 Location of Proposed Intake



captured from TCEQ website

Figure 5 Location of Water Quality Data Used for Salinity

Table 1 - Salinity Values in La Quinta Channel at Buoy Near Project Site

Season	Average, g/L	5th percentile, g/L	95th percentile, g/L
Winter	30.90	26.61	34.80
Spring	31.30	27.74	34.39
Summer	32.67	24.12	38.74
Fall	32.21	20.88	40.50

2.2.2 POTENTIAL DISCHARGE

In March of 2018, PCCA submitted an industrial wastewater permit application to the Texas Commission on Environmental Quality (TCEQ) for the proposed desalination facility. PCCA filed an updated TPDES permit application with the TCEQ on August 28, 2019 for the wastewater discharge from a 30 MGD Industrial Water Desalination Facility. Numerous discussions and meetings have occurred with the TCEQ since that time, and PCCA has since requested Parsons to assist in evaluating additional options for disposal or reuse of the RORW.

The discharge would also include an outfall diffuser to provide rapid mixing of the effluent and to reduce potential localized effects from a concentrated RORW stream in the channel. After PCCA provides feedback on the various disposal alternatives, the TCEQ permit application will be modified as necessary.

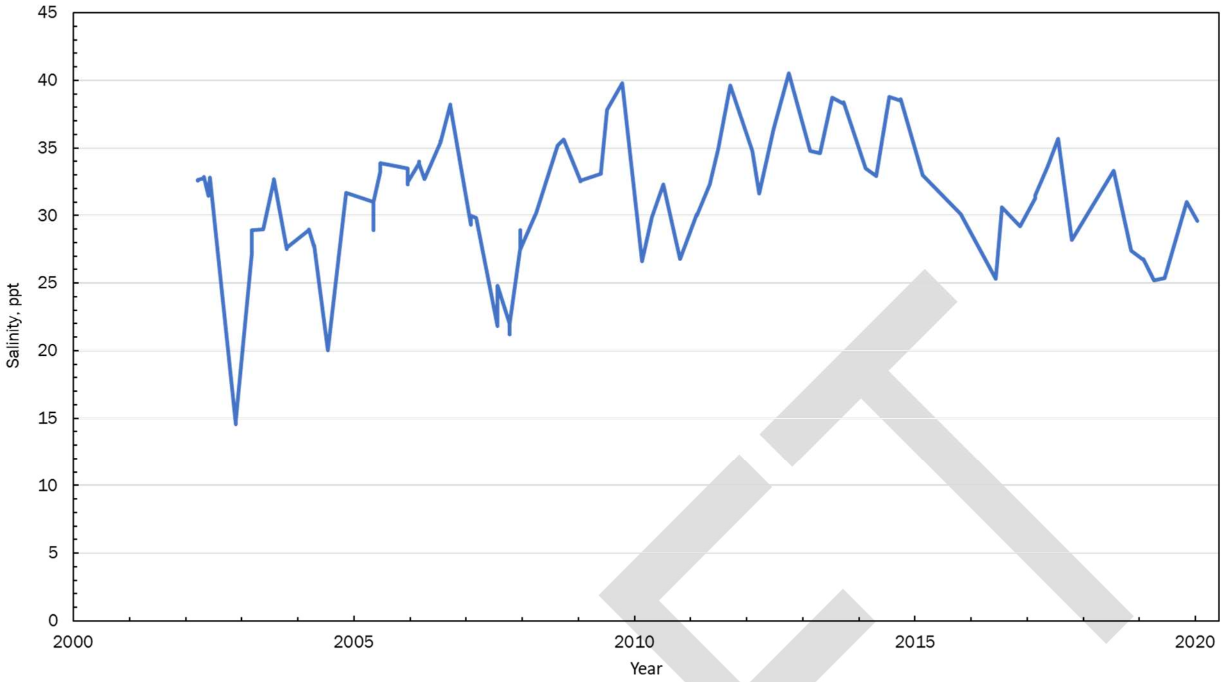


Figure 6 Historical Salinity Values in La Quinta Channel near Project Site

Figures 7 and 8 illustrate key components of the proposed plant.

The flow and salinity of the proposed RORW vary according to the salinity of the seawater extracted from the bay, the desired production of freshwater, and other operational parameters for the SWRO process. The typical condition assumed for the design is that the SWRO units are operated where 40% of the influent passes the membranes to produce 30 MGD of low-TDS freshwater, while the remaining 60% of the pumped influent is discharged as RORW, with nearly all the salinity.

The average condition of discharge for the proposed facility is 57 MGD at a salinity of 48 g/L. This is based on the average salinity found in the bay (31.7 g/L) and a 40% RO permeate value. For other considerations described in Section 5, a worst case scenario uses a 95th percentile of salinity in the bay of 40.5 g/L (see Table 1), and a 50% RO permeate value, resulting in effluent parameters of 40 MGD and 71 g/L.

The discharge location shown in the permit application (as depicted in Figure 8) was discovered to be inappropriate as prelminary modeling was being conducted for a project phase after this Feasibility Study. The proposed outfall diffuser is nestled into the corner of the deep turning basin. There, it is believed salt concentrations will accumulate as the walls of the deep dredged basin limit currents and mixing Because it was not discovered until late in the Feasibility Study process, the figures herein are left depicting the outfall as originally planned. Suggestions for a more appropriate outfall location will be provided after the submittal of this report. The outfall location as shown in Figure 8 does not have an material impact on the selection of disposal alternatives or alter the recommendations of this report.

from TCEQ permit application.

Figure 7 Proposed Desalination Plant Layout and Discharge

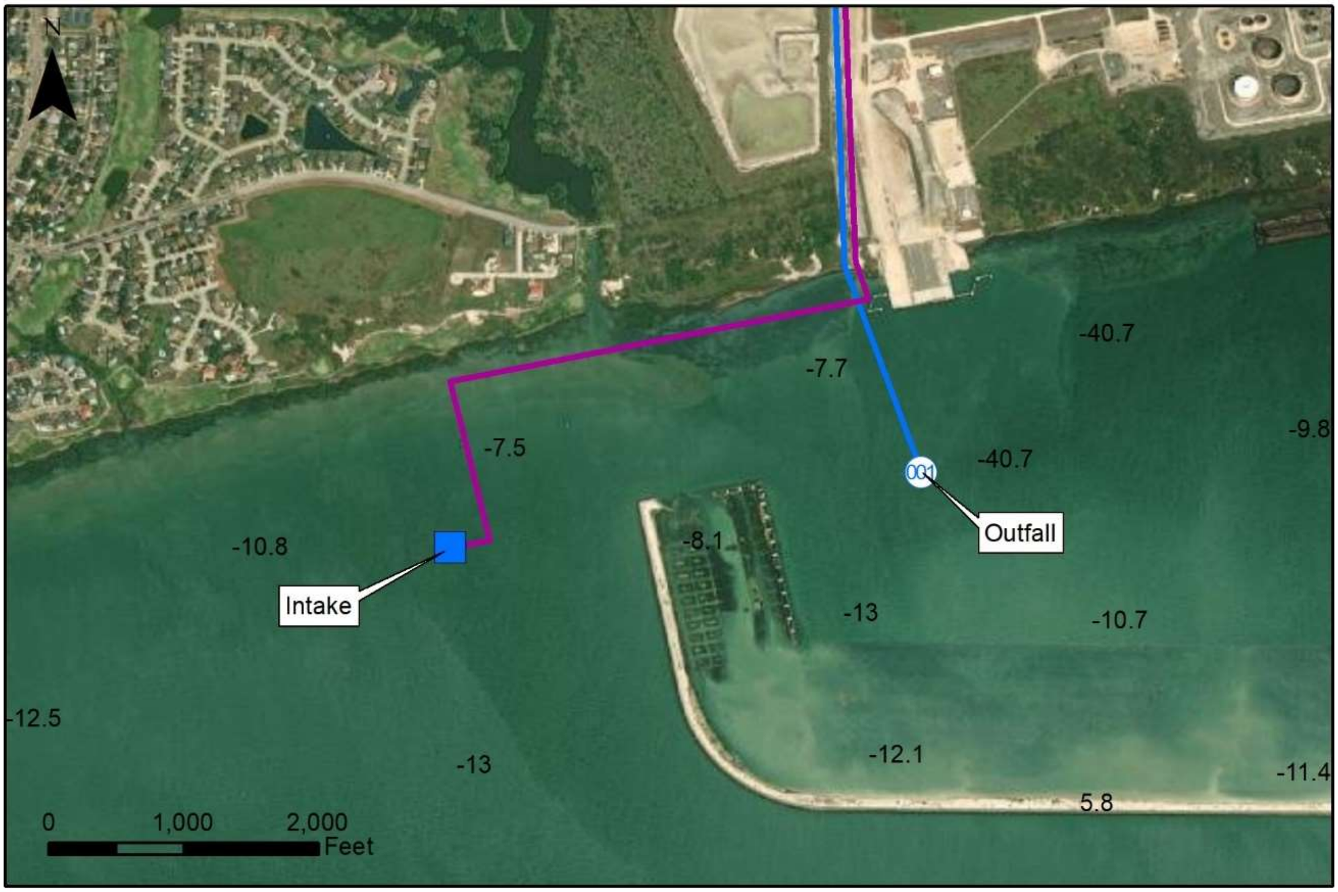


Figure 8 Initial Proposed Intake and Discharge Locations in Corpus Christi Bay

3 Alternatives Generation

The disposal of a large quantity of RORW water presents unique challenges due to the large volume (> 50 MGD) as well as the elevated salt concentrations (>40 g/L). The identification and generation of alternatives for this situation was based on two main concepts:

- disposal of the RORW in the most reliable and agreeable method likely to have consensus among stakeholders which could result in an issued permit
- identification of potential reuse of the RORW by other entities

Disposal of the RORW focused on typical technologies utilized in the desalination industry. These include discharge to a receiving saltwater body, deep well injection, natural or thermal-mechanical evaporation, and co-mingling with other nearby discharges of lesser salinity.

The opportunities for beneficial reuse of the RORW are based on site specific opportunities in the Corpus Christi vicinity. The plant is estimated to produce up to 57 MGD of RORW. This is equivalent to the water use of a city of half a million people. No single industrial facility is likely to consume such a volume of salt water, so a number of candidate recipient facilities would have to be identified. In addition, an industrial facility willing to accept any significant flow of the saline RORW would face similar discharge issues as found for the original facility. An industrial facility that could accept RORW and consume it completely, creating a zero-liquid-discharge (ZLD) situation, is unlikely to utilize any significant fraction of the projected flow from the La Quinta facility. Finding the number of industries utilizing a small fraction of the RORW is difficult, even in an industry-dense region like the La Quinta area. Beneficial reuse of brine is not a common or important consideration in the desalination industry; if it were, desalination design guidelines would direct engineers to locate desalination facilities near industries that would utilize the brine.

Because of the difference in the magnitude of flows between various alternatives such as disposal versus re-use, the alternatives are grouped into two main categories: a) general disposal methods, and b) opportunities for beneficial re-use, which would result in peripheral subtractions of small flowrates from the primary RORW volume. Potential re-use opportunities are listed first, followed by other disposal alternatives for larger flows.

3.1 Potential Re-use Opportunities

Several theoretical candidates have been identified for beneficial reuse, that is, industries or entities that may be willing to receive some flow of a concentrated brine solution. The brine solution is highly saline, but also relatively pure, having been highly treated to remove particulate matter and other contaminants in the pretreatment steps. The below opportunities are described further in Section 4.

a. Bauxite Residual Treatment Nearby former alumina production facilities in the area produced bauxite residuals that are stored in several large earthen impoundments in the area. Brine solutions applied to the bauxite residuals can improve the character of the stored residuals.

b. Use in Foundries and Metalworks This contemplates utilizing the brine as cooling water to rapidly cool the steel in addition to other uses in the industry.

c. Heat Transfer Brine could be used in lieu of pumped seawater for general cooling at a variety of industries, especially power generation.

d. Vapor Absorption Refrigeration This involves the use of brine as a coolant in a refrigeration process. The brine has a lower freezing point than fresh water.

e. Food Products Preservation Use of brine to preserve foods in large-scale production facilities.

Existing industries within the Corpus Christi area were investigated for potential re-use opportunities. All existing industries already have their source water for their current capacities. It is unlikely to be beneficial to either party to change water sources and modify the current process. In addition, the industry would likely have to amend their existing TPDES discharge permit for this water source and potentially face similar challenges for permitting a more saline waste stream. If the plant moves forward, the availability of the clean, saline water should be publicized for any industries for potential future use in addition to the new desalinated industrial water product from the plant.

3.2 Background of Alternative Generation

The disposal of a large volume of a high-concentration brine waste-stream is a difficult issue to resolve. This is a problem for all desalination plants world-wide, and especially in the United States. There is simply no easy or inexpensive way to dispose of 40 – 60 MGD of a saline waste-stream. Treating this amount of flow takes large pieces of equipment, pumps, and pipe and large amounts of energy to pump and manage it. The disposal alternatives presented here are available in the desalination industry and are as presented in publications such as Seawater Desalination Costs-White Paper by WaterReuse Association 2011.

In considering the alternatives, a few key concepts must be described and considered.

3.2.1 TCEQ DISCHARGE MIXING ZONE FOR MARINE DISCHARGES

TCEQ water quality standards establish a 200-ft regulatory mixing zone, a 50-ft zone of initial dilution (ZID) and a 400 ft human health mixing zone for toxic pollutants which are applied for all discharges to marine waters, regardless of the flow. Water quality standards must be met from any discharge at these boundaries. However, a mixing zone size is not established for a natural pollutant such as salinity in this situation. For a discharge of a large volume or elevated concentrations, it would be very beneficial to utilize a diffuser to rapidly mix the effluent and meet water quality standards, and thus demonstrate that the discharge will not affect marine life or human health. This concept of rapid mixing applies to salinity as well. Rapid mixing with a diffuser will enable the effluent salinity concentration to decrease quickly within a short distance from the outfall to within a few percentage points of the ambient concentration.

3.2.2 THE CLEAN WATER ACT AND TCEQ RULES

Federal and state authorities also require that an antidegradation evaluation must take place for all new permits and major amendments. An antidegradation review confirms that a water quality segment will not be significantly degraded due to the new discharge or amended permit conditions. This means that all water quality concentrations must be maintained and that pollutants will not be present above water quality standards or substantially increased from ambient levels. Antidegradation reviews have recently become a larger topic of discussion in permitting. TCEQ is now requiring applicants to perform an antidegradation review and submit the results to TCEQ.

3.2.3 LACK OF CONTAMINANTS IN DISCHARGE

In the case of the reverse osmosis desalination facility proposed, seawater is withdrawn from the saline water body, and the reverse osmosis project removes fresh water, and leaves approximately half of the seawater, but with virtually all the salts. This results in a more concentrated effluent to be released back to the bay. While it may appear that the liquid released back to the bay contains a large mass of salt, in reality, it is the exact same salt mass that was extracted from the bay originally. Therefore, on a mass balance basis the desalination facility is a net-zero-mass of salt contributing to the water body. Actually, the mass of salt is slightly less upon return to the water body as some salt is removed in sludges and other minor wastes that might be disposed of in a landfill. In practice, the key to eliminating environmental impacts from the release is to rapidly disperse the salt back into the receiving water and thus not have any localized affect from increased concentrations. In addition, if any of the reject water can be used for other beneficial uses, this will also reduce the total salt discharged back to the bay.

3.2.4 PERMITTING MULTIPLE OUTFALLS

TCEQ routinely permits multiple outfalls for large industrial facilities. Typically, these convey wastewater from different processes as well as stormwater from multiple areas of a plant. Therefore, the potential permitting of multiple outfalls from a desalination facility could also be a benefit as it spreads the larger flows and salt concentrations associated with the discharge over a larger area which prevents any localized salinity affect from elevated concentrations. This is a benefit to the ecosystem and bay as a diffuser can be placed on more than one outfall to rapidly mix and disperse the salinity back into the system from where it was removed originally.

3.2.5 SITE ISOLATION

The proposed desalination facility is located adjacent to a deep ship channel in a relatively remote area, surrounded by a few large industrial properties. The large distances and more limited uses are beneficial when considering compatibility with adjacent non-industrial uses, but the distances are disadvantageous when identifying potential alternatives for re-use opportunities. Given the elevation and level topography of the region, pumping is required to deliver any re-use water to a location, and the cost of construction, operation of pipelines, and pumping systems to deliver significant flows over long distances required to reach other entities is significant.

3.2.6 DEEP WELL INJECTION FOR DESALINATION REJECT

Deep injection wells are of depths (e.g., 5,000 feet) extending well below any potable-water aquifer and are thus hydraulically isolated from any aquifer. The fluid is pumped at pressure into a suitable strata, where it moves through the strata, never to be accessed by humans for a period of geological time.

Texas developed rules to allow this particular application (30 TAC 331 Subchapter L: General Permit Authorizing Use of a Class I Injection Well to Inject Nonhazardous Desalination Concentrate or Nonhazardous Drinking Water Treatment Residuals). The regulation allows the TCEQ to issue an individual permit or a general permit to inject nonhazardous desalination concentrate and would typically be issued just to a non-commercial type associated desalination facility. The Port would be such a facility where only salt waste would be disposed without any other waste streams. An individual permit is required if the conditions for a general permit are not met.

A Class I UIC General Permit WDWG010000 Permit Application is very simple, requirements are like other non-hazardous waste/wastewater land disposal permit applications. There is a $100 application fee and $50 Notice fee for a new permit (page 4 of application). A Notice of a complete application and draft permit are mailed to the landowner where the well is located and adjacent landowners (page 19), including landowners with mineral rights if different that surface landowners. A map identifying these landowners must be included in the application.

The TCEQ provides a Construction Guidance for Class I Injection wells on their website.

3.3 Preliminary Generation of Alternatives

A. **Existing La Quinta Bay Discharge Concept** As a baseline, the original concept as proposed in the wastewater discharge application is followed. This involves a proposed 30 MGD plant with 57 MGD of RORW to be discharged into the La Quinta channel utilizing a single diffuser.

B. **Bay Discharge with 2 Outfalls** This is the same concept as Alternative A, but with a second, more distant diffuser to assist with greater mixing over a larger area.

C. **La Quinta Discharge, 20 MGD Plant** The same concept as alternatives A and B, but with a 20 MGD freshwater production and 40 MGD discharge.

D. **Combined Effluent with Nearby Industry** Combine the 57 MGD discharge from the 30 MGD plant with adjacent industries.

E. **Combined Effluent with Nearby Industry, 20 MGD Plant** Combine 40 MGD discharge from a 20 MGD plant with adjacent industries.

F. **Deep Well Injection Field** Create a series of deep injection wells to dispose of the 57 MGD effluent into a deep non-potable groundwater source

G. **La Quinta Discharge with 25% Deep Well Injection** Use injection wells to dispose of 25% of the RORW, with the remainder disposed of in the La Quinta Channel with one diffuser

H. **Evaporation - Natural** Construct extensive lagoons nearby to allow RORW to evaporate.

I. **Evaporation – Thermal/Mechanical** Use industrial evaporative processes (thermal, mechanical vapor compression and crystallization) to evaporate the brine to its solids components for disposal.

J. **Red Mud Complete** Deliver all RORW to the nearby Red Mud beds for treatment

K. **La Quinta Discharge, 5 MGD Reuse, 20 MGD Plant** Discharge 35 MGD of RORW from a 20 MGD plant to La Quinta Channel, divert 5 MGD to Red Mud Beds for treatment / evaporation.

L. **La Quinta Discharge, Combined Effluent, 5 MGD Reuse** Deliver 5 MGD to Red Mud Beds, comingle remaining 52 MGD RORW with nearby industrial discharges.

M. **La Quinta Discharge, Combined Effluent, 5 MGD Reuse, 20 MGD Plant** Deliver 5 MGD to Red Mud Beds, comingle remaining 35 MGD RORW from a 20 MGD production plant with nearby industrial discharges.

An ocean outfall was briefly considered due to TCEQ rules allowing for expedited discharge permitting for such facilities as noted in the "Marine Seawater Desalination Diversion and Discharge Zone Study 2018" authored by Texas Parks and Wildlife Department and Texas General Land Office related to HB 2031 of the 84th Legislature. Relative to the shallow, enclosed bay, the larger deeper ocean provides additional volume, depth and stronger currents for mixing to accommodate large brine discharges. However, the alternative was quickly discarded as infeasible given the required pipeline diameter and the 15+ miles to reach the Gulf of Mexico across Corpus Christi Bay.

Another concept not considered is co-mingling with powerplant once-through cooling water. This is a common practice with many advantages, but no large-scale power station with once-through seawater cooling is found near the proposed plant site.

4 Description of Alternatives

4.1 Alternative A: Existing La Quinta Channel Discharge Concept

Alternative A is the baseline case, continuing the project concept as originally conceived in the permit application. It is the simplest case. This alternative involves the discharge of the entirety of the RORW stream through a single outfall pipe and diffuser. The diffuser is located at the bottom of the 45-foot deep La Quinta ship channel. The diffuser would rapidly mix the exiting high-salt fluid and quickly come to ambient conditions. The main components related to Alternative A are illustrated in Figure 9.

The outfall pipeline would be constructed at the bottom of the La Quinta Channel and is located approximately 1,700 feet from the shore. The location was chosen to make available the entire 45-foot deep water column for mixing, and to avoid damage from maritime vessels. Both the pipeline and diffuser would be designed and constructed to withstand marine forces and avoid any possible interferences from ship traffic and channel maintenance procedures.

The key to permittability is to demonstrate via Coremix modeling that the salinity is quickly diffused and returns to near-normal concentrations within the established distance.

The main costs associated with this option is the outfall pipeline and diffuser. The pipeline required is 54 inches in diameter, and is approximately 1,700 feet long. The pipeline and the diffuser at its terminus would be constructed at sea.

Summary of Disposal Components for Alternative A

6,200 feet of 54” pipe on land to outfall
1,700 feet of 54” pipe on seabed to diffuser
Diffuser for 57 MGD
57 MGD pump station at 400 HP for outfall

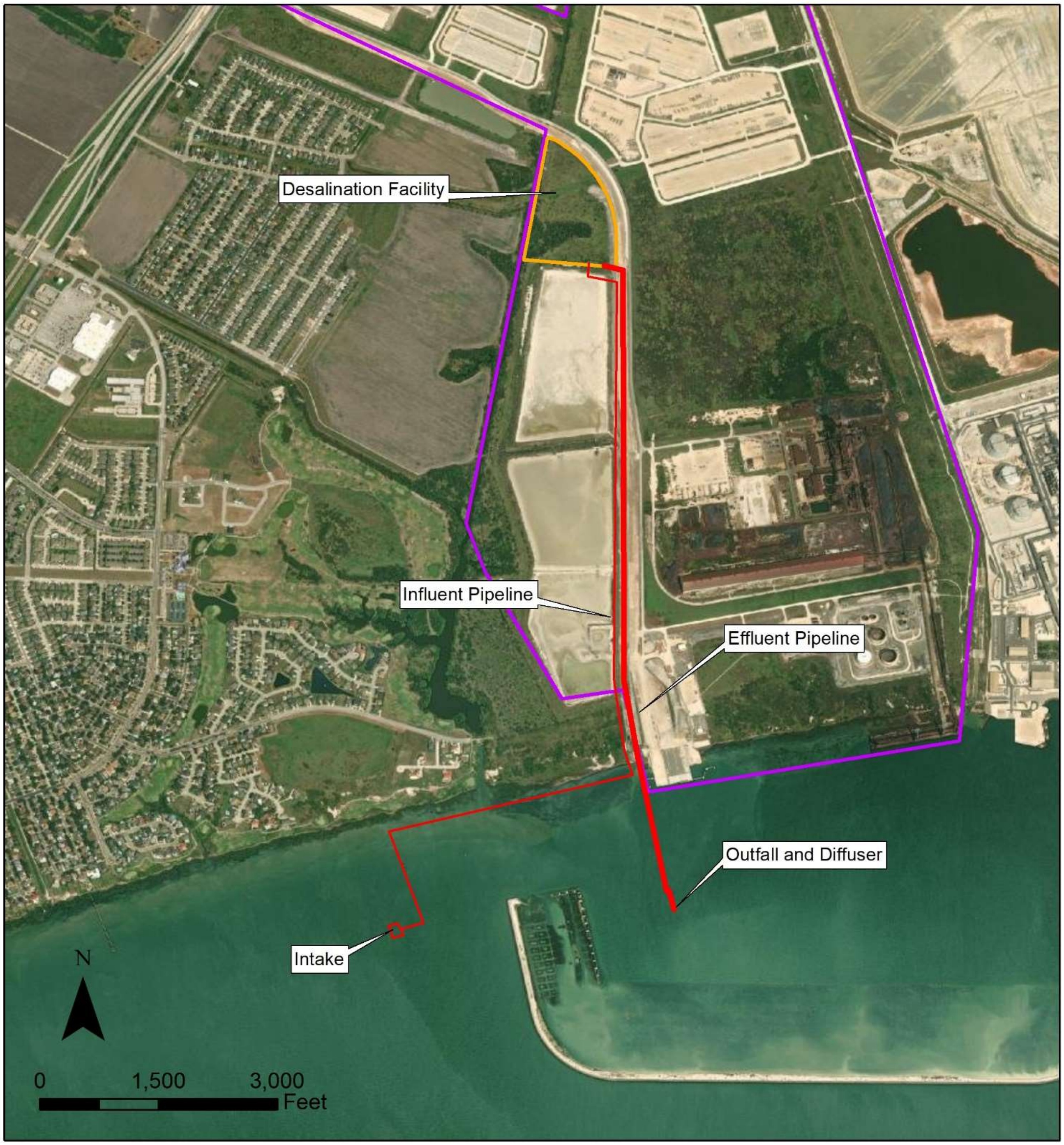


Figure 9 Alternative A, Overall Schematic

4.2 Alternative B: Bay Discharge with 2 Outfalls

Alternative B is nearly the same as Alternative A, except that an additional 1-mile of discharge piping and a diffuser are added. The extended outfall measures approximately 5,300 ft. The bay is approximately 14 feet deep at this location, so the second diffuser is present in a more shallow location than the first diffuser. In both cases, the effluent salinity is 48 g/L, exiting either diffuser.

The extension is configured to convey approximately half of the RORW flow, or 28 MGD, requiring a diameter of 36 inches. The pipeline would similarly be embedded in a trench. Each diffuser is designed to convey half the flow – or another ratio that is most appropriate given the hydraulic conditions and modeling results at the point of design.

The location of the second diffuser, while in a shallower depth, nonetheless presents advantages. We believe that the open bay has equal or better mixing conditions. The velocity of currents and wind mixing effects will be greater and it is away from other industrial outfalls which could lead to overlapping mixing zones or cumulative effects.

The extended outfall pipeline adds significant cost to the alternative but may be more advantageous when permitting.

Summary of Disposal Components for Alternative B

6,200 feet of 54" pipe on land to outfall
1,700 feet of 54" pipe on seabed to diffuser #1
5,200 feet of 36" pipe on seabed from diffuser #1 to diffuser #2
2 diffusers each for 28 MGD
57 MGD pump station at 760 HP for outfalls 1 and 2

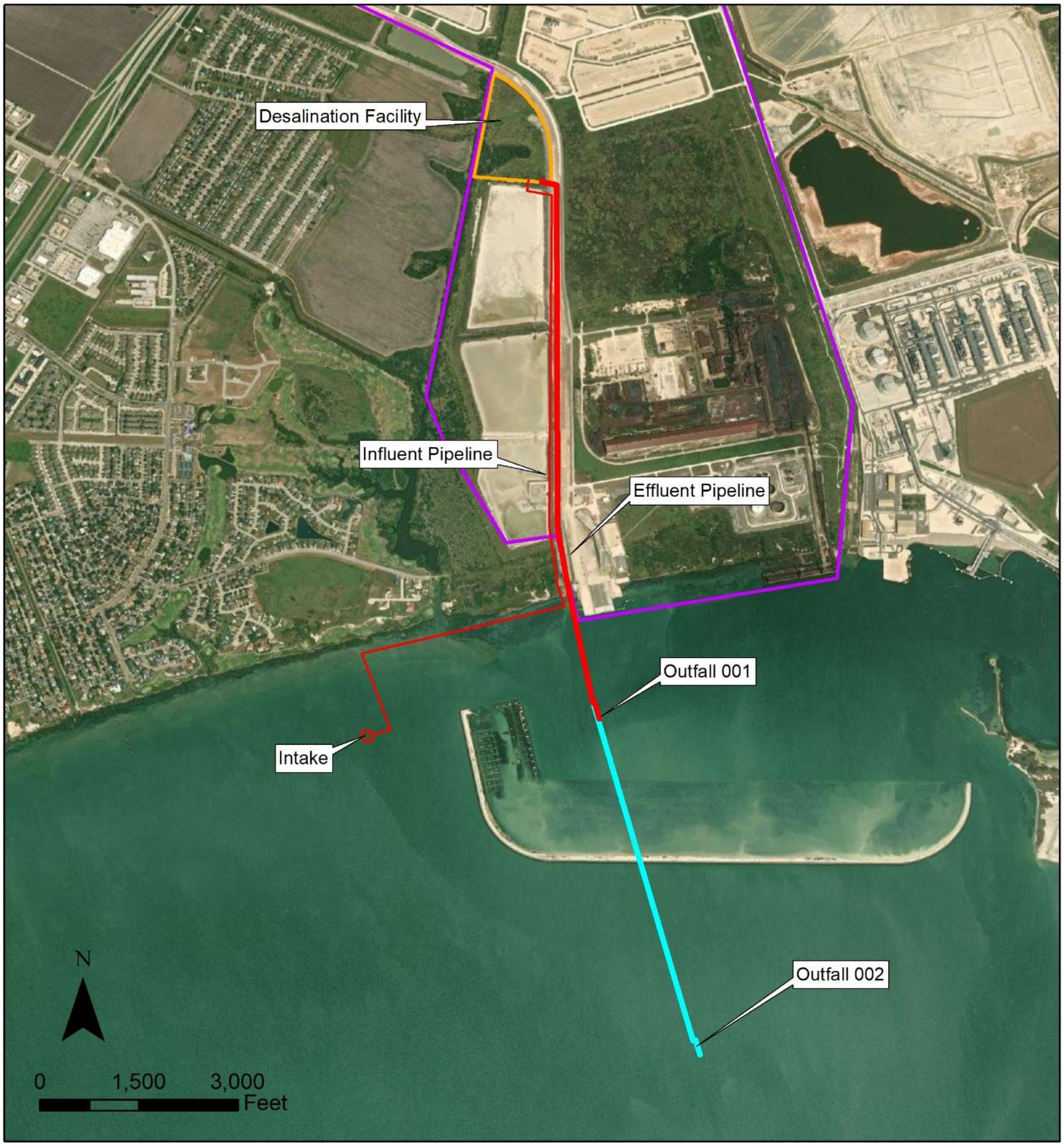


Figure 10 Alternative B, Overall Schematic

4.3 Alternative C: La Quinta Discharge, 20 MGD Plant

Alternative C is nearly identical to Alternative A, except that a 20 MGD desalination facility is proposed. Here, it is contemplated that a discharge application for a smaller RORW outfall of 38 MGD would be less likely to have permitting obstacles. Because of the smaller outfall flow, mixing with ambient water could be faster and the associated infrastructure is smaller and less costly. The schematic of Figure 11 applies to this alternative as well. The effluent salinity would be equal to the other two alternatives, 48 g/L

Summary of Disposal Components for Alternative C

6,200 feet of 48” pipe on land to outfall
1,700 feet of 48” pipe on seabed to diffuser
Diffuser for 40 MGD
38 MGD pump station at 250 HP for outfall

4.4 Alternative D: Combined Effluent with Nearby Industry

One standard practice in desalination discharges is to combine the saline RORW with permitted discharges from conventional wastewater treatment facilities, especially those of low-salinity discharges. The effluents would be combined prior to discharge, thereby lowering the salinity of the effluent leaving the outfall pipe. The lowering of the salinity occurs by dilution and no chemical reactions, conversions, or precipitation would occur to reduce salinity.

TCEQ and EPA databases were queried for existing dischargers along the north shore of the bay. The average daily flow values reported in recent months were also collected. The results are found in Table 2.

Table 2 - List of Wastewater Discharge Permits in Project Area

PERMITTEE	NPDES_NUM	Permitted Flow (MGD)	Average Flow (MGD)
Gregory Power Partners LLC	TX0137502	0.918	0.255
GCGV Asset Holding LLC	TX0137715	9.03	0.275
Voestalpine Texas LLC	TX0134911	6.02	0.329
Occidental Chemical Corp/ Ingleside	TX0104876	2.79	2.045
The Chemours Co fc LLC	TX0008907	4.61	2.62
Corpus Christi Liquefaction (Cheniere)	TX0133991	Not available	0.166

Figure 12 illustrates the locations. The ideal candidate would be a large municipal wastewater treatment plant, whose flow can range up to the 57 MGD of this project at a minimum. No such discharges are found nearby. As seen in Table 2, the flows are relatively modest and would not greatly reduce the salinity in the RORW release, however some benefit may be seen in initial dilutions.

Of the discharges in the table, it is known that Voestalpine and Chemours are saline discharges and would have little effect on diluting the salinity from the proposed La Quinta outfall. The Occidental Chemical facility is known to be affiliated with another proposed desalination facility, so it is excluded as well. The discharge from the Gregory Power Partners is quite small and would have a negligible effect on the salinity from the La Quinta desalination outfall, so it too is excluded.

Figure 11 Alternative D, Location of Nearby Industrial Discharges

Only one candidate remains, the GCGV facility. In this alternative, the existing GCGV discharge pipeline is intercepted in front of the La Quinta desalination facility (see Figure 11). A vault is constructed around that pipeline, and valves are installed to permit that discharge to be redirected to the La Quinta effluent sump, where it mixes with the RORW prior to being pumped out to the PCCA outfall. The connection to the GCGV pipeline must include valves and controls to permit the GCGV facility to discharge directly as they currently are permitted. GCGV would likely maintain their permit to allow them to keep operating their commercial facility and discharge if needed, without any impacts from the PCCA operations.

This option would have to have be permitted in cooperation with the GCGV facility.

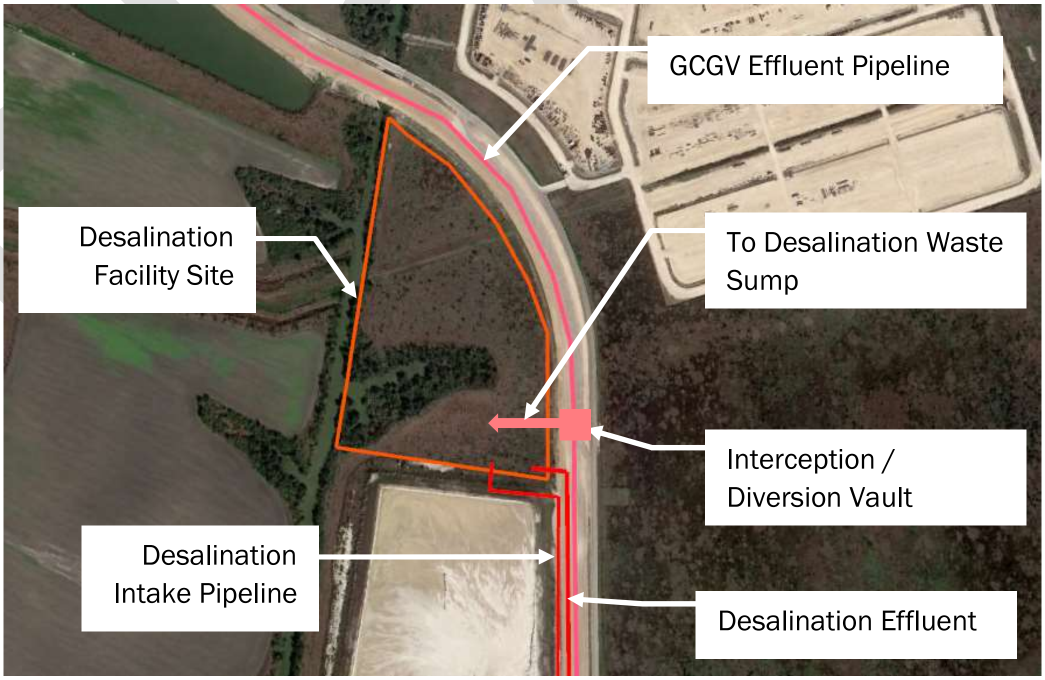


Figure 12 Alternative D, Point of Connection for CGCV Outfall

The GCGV facility is permitted to discharge up to 9 MGD. However, permittees often operate at average daily flows less than the permitted value and can be obligated to expand the plant if flows grow towards the permitted flow. Hence, a value of 6 MGD is utilized in this scenario as the flow from the GCGV facility.

Current data shows GCGV only discharging approximately 1 MGD. However, that facility is still undergoing construction, and it is assumed that the flow will rise to 6 MGD shortly after completion of construction.

Hence, by combining the effluents, the average salinity would decrease from 48 g/L to 43 g/L.

Summary of Disposal Components for Alternative D

6,200 feet of 60” pipe on land to outfall
1,700 feet of 60” pipe on seabed to diffuser
Diffuser for 63 MGD
63 MGD pump station at 360 HP for outfall
Diversion vault, valving, and controls on GCGV discharge

4.5 Alternative E: Combined Effluent with Nearby Industry, 20 MGD Plant

Alternative E is configured exactly like the preceding alternative, except that a smaller desalination facility is proposed. The 20 MGD proposed facility would produce 38 MGD of RORW. As such, a smaller flowrate of RORW is combined with the GCGV effluent, meaning that the GCGV component is a higher fraction of the total, and the salinity is reduced. The salinity of the effluent would drop from 48 g/L to 41 g/L.

As well, the components of the outfall (pipe, pumping, diffuser) are reduced accordingly.

Summary of Disposal Components for Alternative E

6,200 feet of 48” pipe on land to outfall
1,700 feet of 48” pipe on seabed to diffuser
Diffuser for 44 MGD
44 MGD pump station at 300 HP for outfall
Diversion vault, valving, and controls on GCGV discharge

4.6 Alternative F: Deep Well Injection Field

Alternative F introduces a completely different concept for managing the RORW. Instead of discharging the RORW back to the bay from which it was originally extracted, in this alternative the RORW is pumped into an array of deep wells. Because the flowrate for a deep well is limited in comparison to the volume to be disposed of in this project, approximately 38 injection wells are required. To ensure that the receiving aquifer can accept and disseminate the injected fluids, the wells are spaced widely apart, approximately 1,600 feet in this case.

Figure 13 reveals the resulting configuration.. The wells alignment is maximized to be located on port property. The remainder of the wells are located along public rights-of-way. The well field is approximately 11 miles long. Each well site would feature its own injection pump and well head, assumed to be installed on private property adjacent to the public lands, so significant land acquisition is required.

The field is intended to discharge to the Frio geologic formation. The prospects for better hydraulic conductivity are close to the coastline. The alignment is only an estimate based on subjective comments from Parsons staff geologists. The final design could vary widely regarding the spacing of the wells (either greater or shorter spacing). The final design is only determined after test wells into the exact formation are drilled and completed. Only then can the feasibility be confirmed, along with the final design and operational parameters.

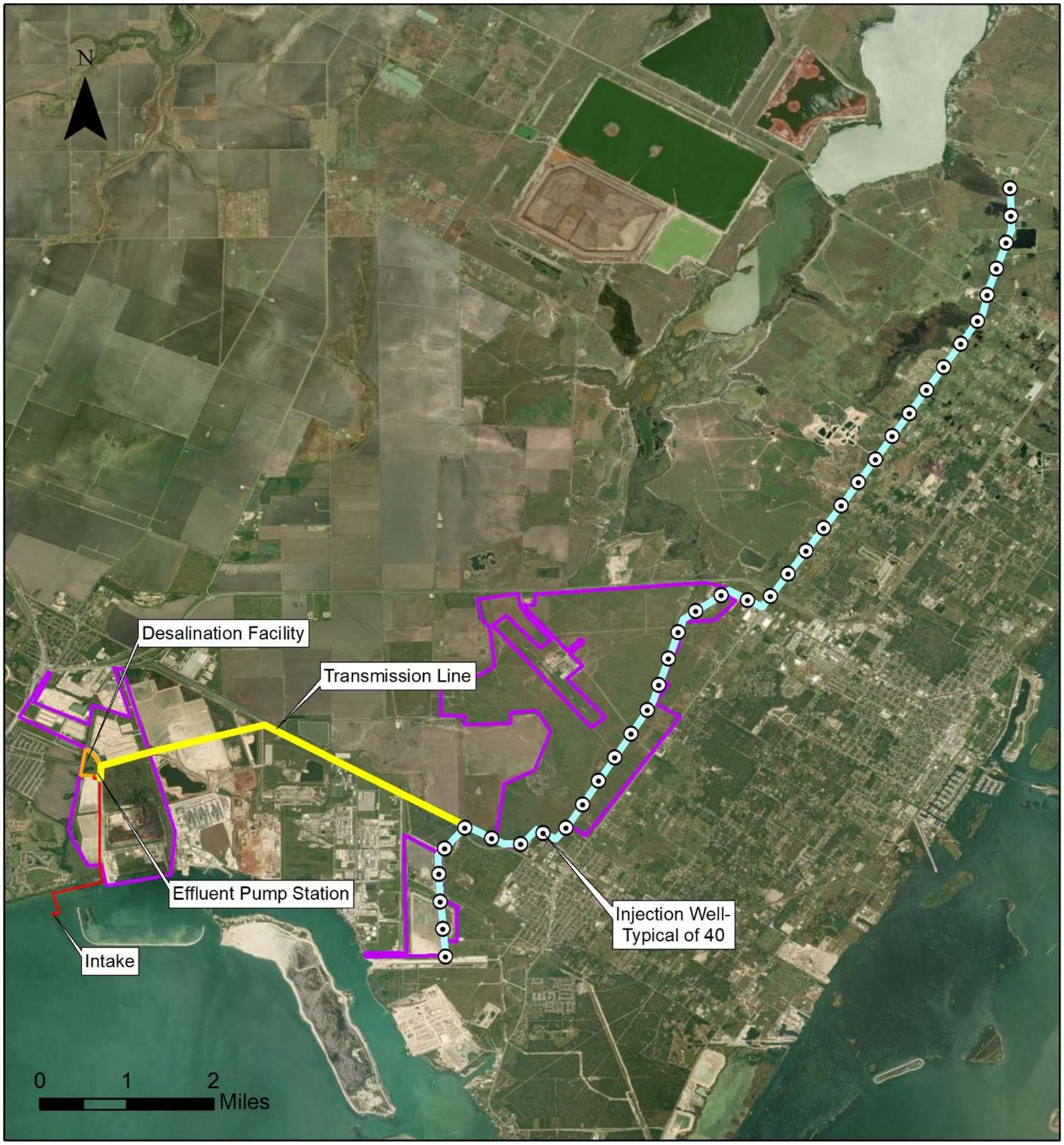


Figure 13 Alternative F, Alignment of Injection Wells and Pipelines

The wells are operated at very high pressure to force the liquid from the well into the strata. The high pumping cost for each well contributes to a very high annual cost due to electricity cost. Also, given the distances to the nearest and furthest injection wells, significant pumping cost is incurred to deliver the RORW to each well via the transmission pipeline from the desalination plant and along the axis of the wells.

Disposal Components for Alternative F

22,400 feet of 60-inch transmission line
65,000 feet of distribution pipelines between 18 and 48 inches
57 MGD transmission pump station at 2,200 HP
40 injection pumping stations, 1,000 gpm at 190 HP
40 deep wells to be drilled and finished
Purchase 20 well sites
11 miles of easements

4.7 Alternative G: La Quinta Discharge with 25% Deep Well Injection

For this alternative, approximately one-quarter of the 57 MGD RORW from a full-scale plant is disposed of via injection wells like Alternative F. The remaining RORW is then delivered to the outfall in the La Quinta channel. The configuration of this alternative is illustrated in Figure 14.

For this configuration, only 75% of the salinity proposed in Alternative A is discharged to the receiving body. The rest is disposed of in the injection well field. The injection well field and accompanying infrastructure for the injection wells (pumps, pipes) is significantly less, along with the operating costs. The infrastructure for the outfall and diffuser is slightly reduced compared to Alternative A.

Disposal Components for Alternative G

6,200 feet of 48” pipe on land to outfall
1,700 feet of 48” pipe on seabed to diffuser
Diffuser for 43 MGD
43 MGD pump station at 300 HP for outfall
22,400 feet of 30-inch transmission line
16,000 feet of distribution pipelines between 18 and 30 inches
14 MGD transmission pump station at 460 HP to injection wells
10 injection pumping stations, 1,000 gpm at 190 HP
10 deep wells to be drilled and finished

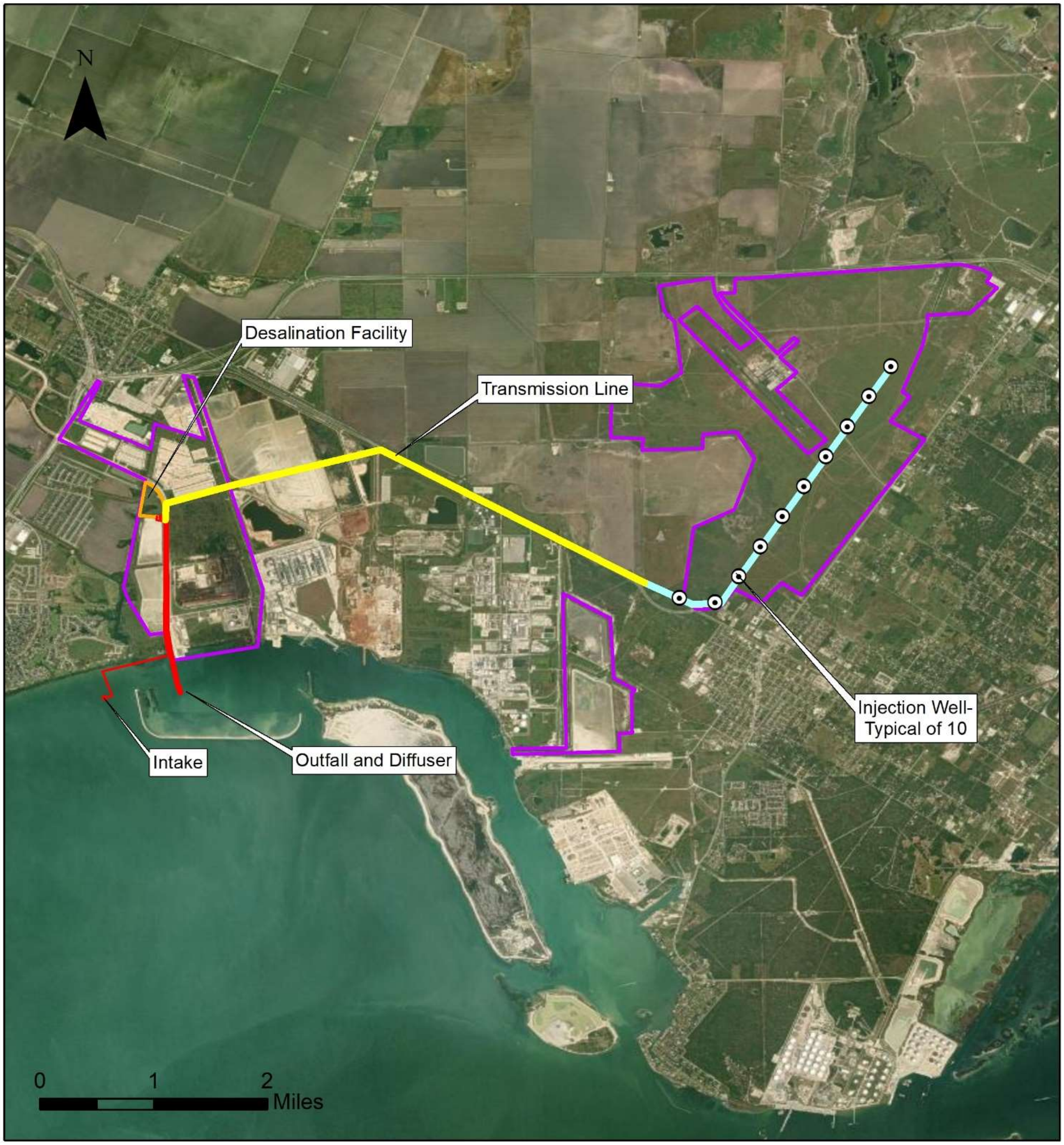


Figure 14 Alternative G, Overall Schematic of Injection Wells and La Quinta Channel Discharge

4.8 Alternative H: Evaporation – Natural

Evaporation fields can be an alternative for disposing of RORW. The concept is to spray or discharge the solution into an impounding structure with an extensive surface area exposed to the sun and wind. The meteorological conditions permit or foster the evaporation of the brine, leaving behind only formerly dissolved solids from the fluid. This can be a very economical solution for the arid regions of the middle east with high temperatures, desert climates, and expanses of available land.

The key to this alternative is the historical evaporation rates available in the project region. Texas Water Development Board (TWDB) measures and publishes historical evaporation data. The evaluation of the available data is presented in Appendix A. The evaporation rate for the region is approximately 23 inches per year. If one multiplies the evaporation rate value by a horizontal area (units of length squared), a total volume evaporated (under the average condition) can be determined.

In this case, the target RORW to be managed is 57 MGD, which equates to 69,540 acre-feet per year. Dividing that figure by the 23 inches per year of evaporation (1.92 ft) comes to a value of 36,000 acres of required area. This area is represented by a square 7.5 miles per side. As an exercise, a series of evaporation beds were projected in the area (Figure 15), selecting obvious tracts of existing parcels and respecting roads and residences. The area shown only comprises about half of the required acreage. Red lines represent large-diameter pipeline to transmit the flows to each of the beds. Note that the furthest pond lies over 10 miles away.

The ponds proposed for this alternative would be formed with earthen dikes constructed from native materials. The ponds would be 10 to 15 feet deep to accommodate successive years with below normal evaporation and to present necessary freeboard. Over 5 million cubic yards of earth would be moved to create the ponds required.

Representative land values were researched for San Patricio and Refugio counties. Prices ranged from $5,000 to $50,000 per acre, meaning the minimum cost to acquire the required land would start at $180 million.

Because of the infeasibility of acquiring the 36,000 acres of land and the overall cost of this alternative, it is discarded from further evaluation.

Disposal Components for Alternative H

Acquire 36,000 acres of land
Construct 20 impoundments at 1,800 acres each
Construct earthen dikes totaling 5.6 cubic yards of earth moved and compacted
14 miles of 42” pipe to impoundments
14 miles of 60” pipe to impoundments
28 MGD transmission pump station at 600 HP
57 MGD transmission pump station at 750 HP

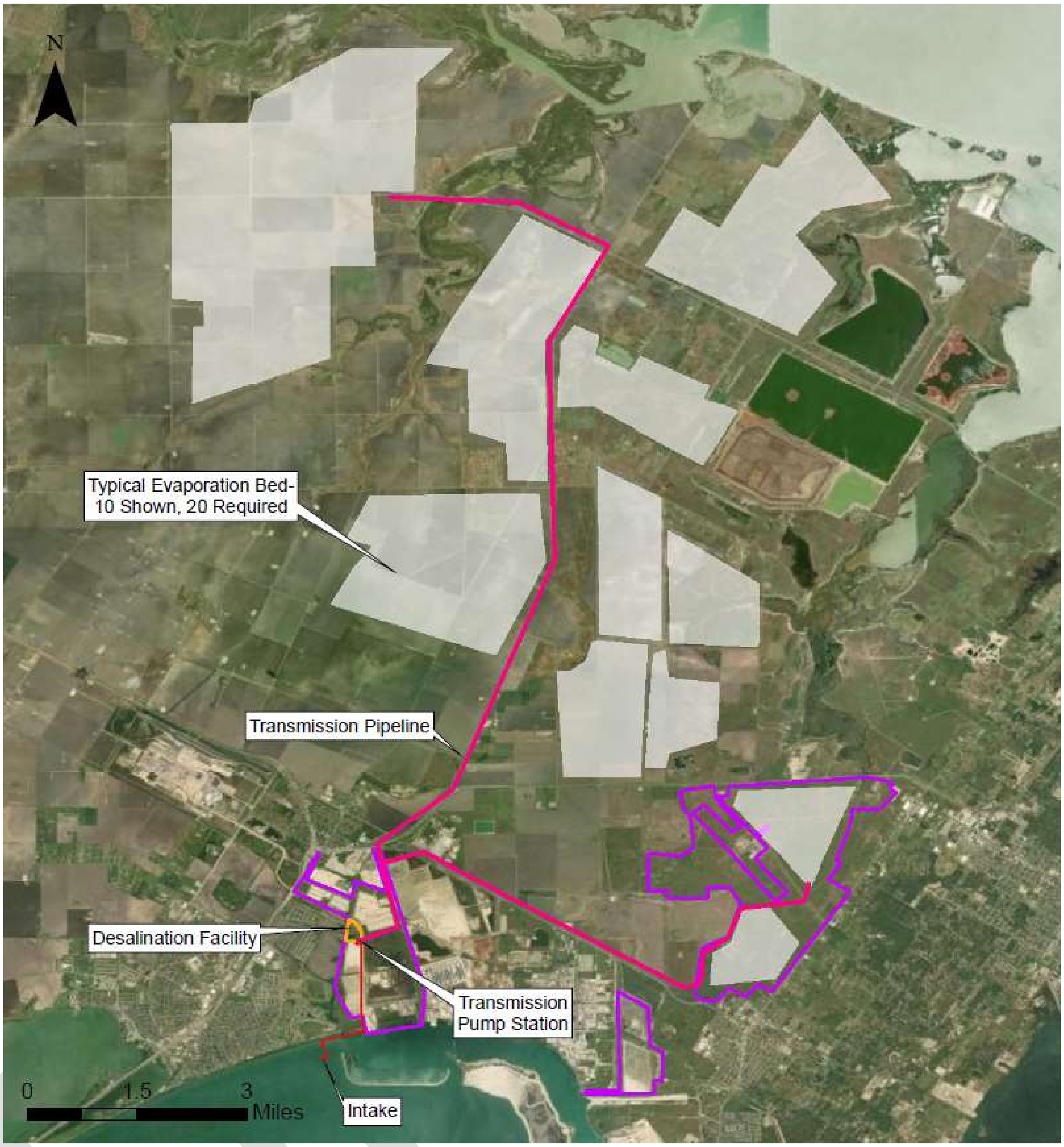


Figure 15 Alternative H, Schematic of Example Evaporation Beds

4.9 Alternative I: Evaporation – Thermal / Mechanical

It is possible to completely evaporate the RORW using thermal or mechanical methods where the final product is either a dry salt or a very concentrated salt slurry, where there is no discharge at all except or possibly a truck taking remaining solids to a landfill. These are "zero-liquid discharge" (ZLD) solutions that remove water and crystalize the remaining residuals into a low-volume, near-solid material. Such systems are extremely expensive and are generally intended for dealing with flowrates several orders of magnitude below this project. These are complicated mechanical processes, and often are at industrial facilities that offer waste heat or for niche industries with small wastes.

Parsons obtained quotations from at least one provider for an evaporative unit, it was priced at approximately $15 per gallon treated, meaning a capital cost of approximately $800 million. These processes also have high energy costs, as there is no way of avoiding the thermal demand to evaporate water.

Due to the extreme costs, this alternative is discarded from future consideration.

4.10 Alternative J: Bauxite Residual Beds – Full Flow

Nearby former alumina production facilities in the area produced bauxite residuals that are stored in impoundments in the area. Brine solutions applied to the bauxite residuals are known to improve the character of the stored residuals and can aid in the ultimate disposal of the residuals.

Several candidate bauxite residuals disposal areas (BRDAs) are found approximately 8 miles north of the La Quinta site, along Copano Bay. The owner of these facilities has allowed PCCA to study the concept of applying the RORW to beds 2 and 3, as identified in the image below. Additional details on the history and conditions of the beds are found in Section 4.14.

This alternative proposes the application of the entire 57 MGD of RORW to the BRDAs. In this scheme, the salts in the RORW react with the high pH bauxite residuals to lower the pH, and possibly modify the solids to form a sludge with more desirable characteristics. While the condition of the stored solids improves, it was hoped that the RORW applied to the BRDAs would evaporate, leading to a zero-discharge system where no wastewater discharge permit would be required.

To verify this concept, Parsons performed a treatability study analyzing the application rates of a surrogate RORW to actual samples collected at the site. The results, as described in Appendix B, were favorable; the application of a saline solution lowered the pH of the stored solids. However, as expected, the reaction between the bauxite residuals and the brine solution did not appreciably lower the salinity of the brine.

Unfortunately, the flowrate of RORW generated of 57 MGD does not compare to the surface area of the BRDAs available for evaporation. The sum of the BRDA surface area is approximately 1,600 acres. As described in Section 4.8, the average evaporation for the area is 23 inches per year. The evaporation of 23 inches per year, applied over the available 1,600 acres, leads to a maximum evaporation rate of 3 million gallons per day. Perhaps this value could be increased by applying mechanical evaporative enhancements, but it would not increase beyond 10% of the total RORW produced.

As such, on average, 57 MGD would be applied, and only 3 to 5 MGD would evaporate. Hence, 54 MGD of brine water, now having been mixed with the bauxite residual waste product, would have to be disposed of. The only feasible manner would be to pump this material back towards the La Quinta channel.

In addition, it was proposed that the RORW be delivered to the BRDAs utilizing existing, twin 18-inch pipelines that the former alumina production facility used to convey the slurry to the beds. Unfortunately, these pipelines do not have the hydraulic capacity to convey the full 57 MGD and another 48-inch pipeline would be required.

This condition is subjectively worse than disposing of the RORW directly from the desalination facility without pumping to the BRDAs and back. As such, the concept of applying all 57 MGD of RORW to the BRDAs is discarded as infeasible.

4.11 Alternative K: La Quinta Discharge, 5 MGD Reuse

For Alternative K, a smaller 20 MGD production facility is utilized and an amount of RORW equal to the evaporation rate is delivered to the mud beds as a beneficial reuse concept to treat the bauxite residuals. A value of 5 MGD for beneficial reuse and evaporation is assumed. The remaining 33 MGD RORW produced from a 20 MGD production facility is discharged through the outfall as described in Alternative C.

The RORW is delivered to the mud beds utilizing one of the existing 18-inch twin pipelines. However, the system requires a pump station and a new pipeline from the desalination plant to the end of the existing pipeline terminus. The RORW is mixed with the accumulated red mud using a dredging apparatus. After mixing, the RORW remains in the large impoundments until it evaporates as a zero liquid discharge concept. More details on the RORW application to the bauxite residuals is discussed in Section 4.14.

This alternative has characteristics very similar to Alternative C but has the added benefit of returning less salinity (on a mass basis) to the bay than what was extracted at the intake while demonstrating PCCA's commitment to best environmental practices. It also demonstrates that reuse is feasible, and the owners are progressively using the desalination by-product to treat the red mud and reduce environmental impacts.

Disposal Components for Alternative K

6,200 feet of 48" pipe on land to outfall
1,700 feet of 48" pipe on seabed to diffuser
Diffuser for 33 MGD
33 MGD pump station at 190 HP for outfall
10,500 feet of transmission pipeline at 18 inches to existing pipelines
Use existing 18" pipeline to mud beds
5 MGD transmission pump station at 264 HP for mud beds
Dredge and distribution system at Bed 2

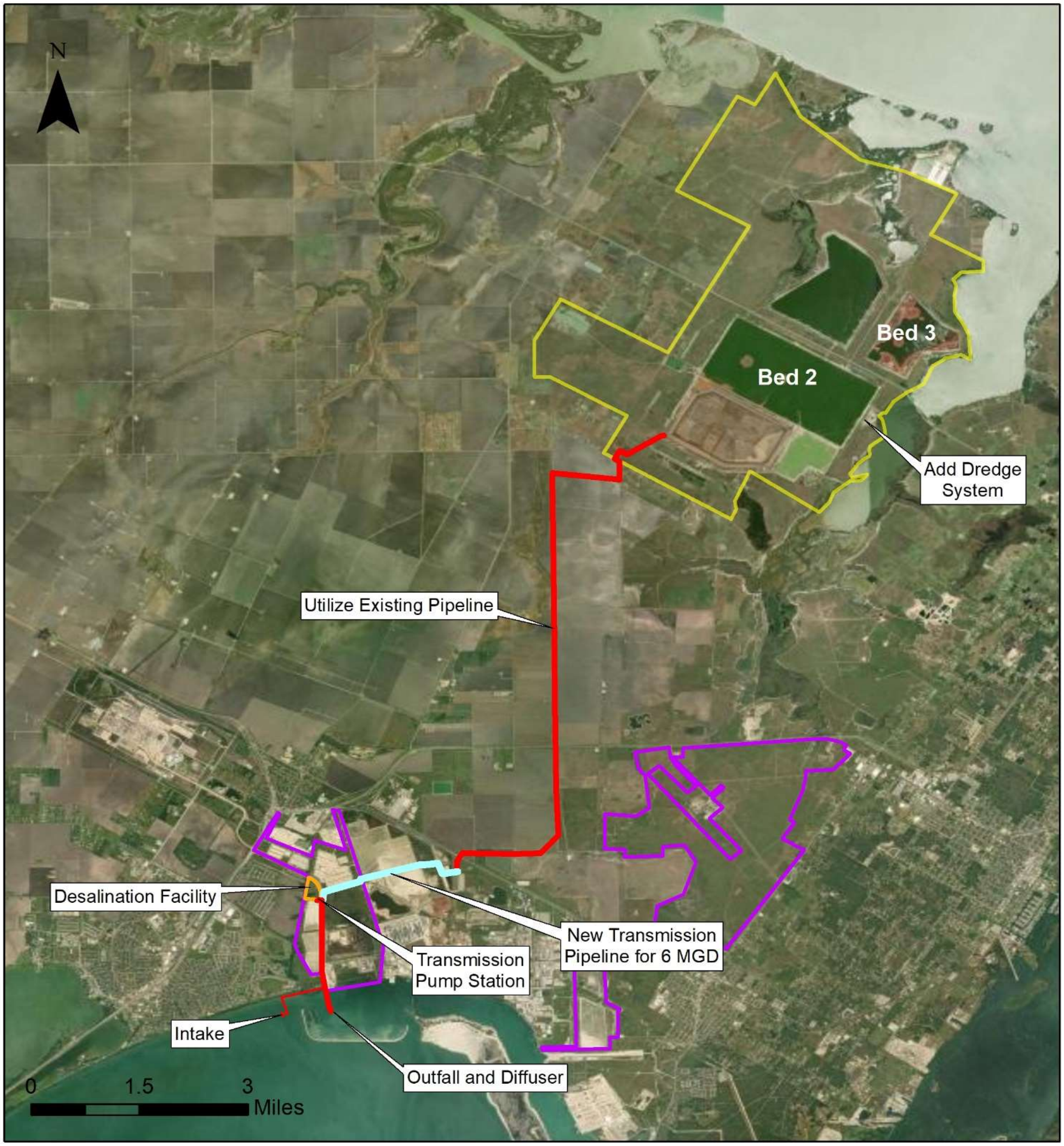


Figure 16 Alternative K, Overall Schematic

4.12 Alternative L: La Quinta Discharge, Combined Effluent, 5 MGD Reuse

This alternative is a combination of alternatives A, D, and K. The main discharge is through an outfall to the La Quinta channel, with a combined effluent having received the GCGV effluent. The same 5 MGD of RORW is delivered to the BRDAs for treatment. This configuration presents two benefits: the mass of salinity returned to the channel is reduced (as some is diverted to the BRDAs), and, the concentration of salinity in the flow discharged to the bay is reduced via the combination with the low-salts GCGV flow. This scenario is presented with the two outfall configuration noted below.

Disposal Components for Alternative L

6,200 feet of 54” pipe on land to outfall
1,700 feet of 54” pipe on seabed to diffuser
Diffuser for 58 MGD
58 MGD pump station at 420 HP for outfall
10,500 feet of transmission pipeline at 18 inches to existing pipelines
[Use existing 18” pipeline to mud beds]
5 MGD transmission pump station at 264 HP for mud beds
Dredge and distribution system at mud beds
Diversion vault, valving, and controls on GCGV discharge

4.13 Alternative M: La Quinta Discharge, Combined Effluent, 5 MGD Reuse, 20 MGD Plant

This alternative is very similar to the preceding alternative, except that the desalination facility is designed, permitted, and constructed to produce 20 MGD of industrial water, as compared to 30 MGD for most of the other alternatives.

The RORW flowrate from the desalination facility is 38 MGD for that plant. A flow of 5 MGD is delivered to the BRDAs, reducing the overall mass load of salinity being returned to the bay. The GCGV flow would be incorporated in the PCCA outfall, reducing the concentration of the salinity in the discharge, and having a greater affect in reducing the salinity concentration compared to Alternative L.

Disposal Components for Alternative M

6,200 feet of 48” pipe on land to outfall
1,700 feet of 48” pipe on sea bed
Diffuser for 39 MGD
39 MGD pump station at 231 HP for outfall
10,500 feet of transmission pipeline at 18 inches to existing pipelines
[Use existing 18” pipeline to mud beds]
5 MGD transmission pump station at 264 HP for mud beds
Dredge and distribution system at mud beds
Diversion vault, valving, and controls on GCGV discharge

4.14 Opportunity a: Treatment of Bauxite Residuals

As described for Alternatives J and K, existing impoundments storing residual solids resulting from bauxite processing are found in the area. It is known that saline solutions can react with the high-pH bauxite residuals to lower their pH. This presents an opportunity for PCCA to dispose of a portion of the RORW and for one of the Port’s customers to improve the condition of the accumulated waste products for ultimate disposal. To confirm the potential of this opportunity, the PCCA commissioned Parsons to perform a treatability study to investigate the effects of applying RORW to the actual bauxite residuals found at the site. This study is detailed in Appendix B, "Treatability and Feasibility Study for Copano Mud Beds with RO Reject Disposal."

The proposed site of the BRDAs is shown in Figure 17. The owners of the BRDAs have offered beds 2 and 3 as candidates to receive the RORW. Table 3 presents the characteristics of the 2 candidate BRDAs.

Figure 17 BRDA Site Boundary and Identification of Beds

Table 3 - Characteristics of Beds for This Study and Bauxite Residual Volume

Characteristic	Source	Bed 2	Bed 3
Year constructed	Design drawings	1968	1976
Area, acres	Google Earth	1,203	412
Top levee elevation, feet	Design drawings	29.5	31
Approximate water surface elevation, feet	Visual estimation	24.0	--
Approximate elevation of bauxite residual, feet	Documents provided	21	21
Approximate depth of bauxite residual, feet	Site operator's description	12	16
Estimated quantity of bauxite residual, million cubic yards	Calculation, area x depth	23	10
Typical pH	Site operator's description	10.5	12.5

As discussed for alternatives J and K, the flowrate of RORW far exceeds the evaporative capacity of the ponds by a factor of 10. As such, this opportunity is reduced to consider the application of RORW at a rate matching the evaporation rate, or 3 to 5 MGD.

This configuration is illustrated in Figure 16. The alternative consists of a pump station and new transmission pipeline to convey 5 MGD from the desalination effluent sump to existing pipelines operated by the BRDA owners. From there, the RORW is conveyed in an existing pipeline north to the beds.

The existing pipeline system in Figure 16 consists of 2, 18-inch diameter steel pipelines which conveyed the bauxite residual slurry from the former alumina production facility to the impoundments. Both ceased service of slurry transport with the plant closure in 2016. Now, one is in service to convey irrigation water, while the other remains dormant. The site personnel indicated that the pipelines are rated for 600 psi and mentioned that the pipeline conveys approximately 800,000 gallons per day (gpd) of effluent.

Infrastructure to implement this opportunity consists of a new 10,500-foot, 18-inch pipeline from the desalination facility to the existing pipeline. A 125 HP pumping facility is required to deliver the flow to the beds.

The bauxite residuals currently are encountered in a settled and stable mass on the floor of the impoundments. To enhance and foster the reaction of the bauxite residuals with the RORW, the solids could be properly mixed. A dredging system (Figure 18) is proposed to excavate the accumulated solids, mix them vigorously with the RORW, then pump the combined solution to another part of the pond to react and settle. The dredging and pumping should create a slurry with fine particles, providing a greater exposure to and contact with the saline solution, and hence a better opportunity for the ions in the reverse osmosis reject water to react with the bauxite residual.

The slurry is pumped in a pipeline over a distance of up to 2,500 feet, then discharged back into the same impoundment, where the solids will settle out of the solution, likely over a large radius of distribution.

Figure 18 Example Floating Dredge System Suitable for Mixing RORW and Bauxite Residuals

A representative implementation of this system would occur as follows.

Begin pumping RORW to the beds in proportion to each bed's surface area. The salinity in the beds will gradually increase as the saline reject water mixes with any existing water while evaporation occurs simultaneously.

When a depth of water above the solids is sufficient to float the dredge equipment, begin dredging operations, working slowly across the bed in a straightforward pattern.

This dredging machine can excavate 300 cubic yards per hour. Given the processing rate, the 40-foot boom width of the proposed equipment, and the 12-foot depth of residuals in Bed 2, the dredging machine will advance at a rate of 17 feet per hour. Assuming that the dredge is operated for a standard 8-hour day, and knowing that Bed 2 has a short dimension of 4,800 feet, the dredge will require approximately 35 workdays to make one pass along the short dimension.

Bed 2 is 10,400 feet long, which results in 260 40-foot passes. This indicates that the entire Bed 2 will require approximately 9,000 days to complete one entire pass across the entire bed. This is approximately 30 years. Of course, a larger dredge, operating more often, can reduce this time frame, but the magnitude of the task is to be noted. Multiple dredges could be procured, including for Bed 3.

The TDS of the reverse osmosis reject water does not improve, and could not be discharged to a freshwater water body. The deposited bauxite residuals should experience a lower pH, a potential benefit to the owners of that facility.

Perhaps a passive solution, of simply pumping reverse osmosis reject water to the two beds, to be allowed to react with the solids and evaporate, is a more appropriate solution. The bauxite residuals treatment scheme does come with additional costs and risks. It is assumed that the owners will charge a price to accept the RORW and they may attach limitations to the flow.

4.15 Opportunity b: Foundries

This opportunity contemplates utilizing the brine at a metals production facility. An industry resource states that steel foundries can utilize 1.6 m^3 to 3.3 m^3 per ton of steel produced.[1]. That resource also mentions that “Even though the steel industry uses large quantities of water, very little of that water is actually consumed as most is reused or returned to source.” The same reference states that water use is either cooling water used for power generation, or process uses such as descaling and dust scrubbing. The source warns that “salt concentrations in water circulation systems can affect vital equipment.” It appears that highly saline RORW would not be viable as a general rule.

A new foundry by Steel Dynamics, Inc. (SDI) is nearing completion on the northeast side of Sinton, Texas. This plant publicizes a production rate of up to 3 million tons per year of flat roll steel. That equates to approximately 9 million m^3 of water demand, or approximately 6.5 MGD using the utilization rate described above.

The project was recently issued a wastewater discharge permit to Chiltipin Creek (WQ0005283000). The permit states that “Direct cooling, indirect cooling, and rinsing are the primary uses of water throughout the steel plant. Service water is obtained primarily from the Mary Rhodes pipeline with some water supplemented by an on-site deep well. Fire protection, make-up water, and other miscellaneous processes use approximately 5 million gallons of service water from the storage pond daily.”

The permitted discharge flowrate is 1.5 MGD and the TDS limitation is 0.257 g/L. The proposed desalination effluent concentration would make its use at this facility very unlikely due to the discharge into a freshwater stream. However, for the purpose of this evaluation, it is assumed there is some zero-discharge process in

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[1] https://www.worldsteel.org/publications/position-papers/water-management.html

the facility that can utilize the RORW without mixing with other plant wastes that are treated and discharged to Chiltipin Creek.

A proposed system to supply 5 MGD to the foundry would be 24-inch pipeline 17 miles long, driven by a 125 HP pumping system. This system has a capital cost of $15 million and an annual operating cost of $75,000 per year. On a price-per-gallon basis, this is more expensive than pumping it through the discharge outfall. This cost does not consider other items such as easements for the 17-mile pipeline.

Located much closer to the La Quinta site is the Tianjin Pipe Corporation – America, also known as TPCO America. They are located on the northeast corner of the intersection of state highways 36 and 361. This facility purports to produce 500,000 tons per year of steel pipe. Using the same water usage factor as the SDI facility, it is estimated that they utilize up to 1.1 MGD. That facility does not have a discharge permit. Pumping RORW to that facility could also be feasible.

Figure 19 Metals Fabrication Facilities

In summary, there is a low likelihood that this is a viable opportunity given the low volume of water they use.

4.16 Opportunity c: Heat Transfer

Brine could be used in lieu of pumped seawater for general cooling in an industrial application. The most common and feasible application would be at a thermal power generation facility with a once-through seawater cooling process. There are two once-through systems in the region, but both are 10 miles away or more, and both across the bay from the La Quinta facility. Sending any large amount of the RORW to those facilities would be cost prohibitive and require them to re-permit their discharge to account for the added salinity.

The RORW would not be used as make-up water for any other cooling system, as those systems use fresh water and are especially averse to build up of salts and total dissolved solids.

4.17 Opportunity d: Vapor Absorption Refrigeration

Vapor absorption refrigeration involves the use of brine as a coolant in a refrigerative process. The brine has a lower freezing point than fresh water, and lithium bromide is added to enhance the thermodynamic properties. This type of system of refrigeration or cooling is typically done where an excess heat source is available. It is often applicable for industrial manufacturing facilities, but also at university campuses, larger hospital complexes, or large hotels.

However, these are closed loop systems with low water demands. Only a relatively small volume of brine is required, as very little refrigerant is wasted. Hence, any realization of this opportunity would be inconsequential to the overall flow.

4.18 Opportunity e: Food Products Preservation

Brine can be used as a preservation method in large-scale food production facilities. One example is meat processing and packing. A candidate food processing facility is a large meat production facility that is located on the western side of Corpus Christi, 15 miles away from the La Quinta facility, across Nueces Bay. A media release suggests this facility processes 740 head of cattle per day on average, with a capacity of up to 1,400 head per day[2]. Some guidance documents indicate that total water demand for slaughterhouses ranges from 150 to 600 gallons per head of cattle processed.[3]. This leads to a potential water demand at this facility of 0.1 to 0.8 MGD, with uses said to be facility cleaning and some treatment of meat products.

The facility discharges to the City of Corpus Christi municipal sewer system, which would likely prohibit a saline discharge arising from brine as a wash-down source. It is assumed that the volume used for treating or packaging of canned products, for which the brine may be applicable, is a very small percentage of the estimated 0.1 to 0.8 MGD.

Considering the magnitude of the potential brine use at this facility and its 15-mile distance from the La Quinta site, this opportunity is discarded.

5 Evaluation and Comparison of Alternatives

The alternatives were evaluated based on several subjective and objective criteria. Three of the alternatives described above (H, I, J) are deemed not feasible in Section 3, were not evaluated or scored, and are omitted from further discussion. A matrix displaying the evaluation is presented in Table 4 after the following discussion of the criteria.

5.1 Evaluation Criteria and Scoring

The alternatives were evaluated for the criteria of net environmental impact, probable public acceptance, life-cycle cost, and schedule. Each alternative was assigned a score for each of the evaluation criteria. The point scale for all criteria range from 1 to 5 points, with 1 being the undesirable and 5 favorable. The first two criteria are relatively subjective, the cost scoring is quantitative based on the calculated life cycle cost. Because of its importance, the evaluation of costs is described separately below.

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[2] https://tscra.org/stx-beef-opens-in-south-texas/

[3] Fact Sheet, Meat and Poultry Processing, North Carolina Division of Pollution Prevention and Environmental Assistance

Total Flow to Bay @ Concentration: This lists the total flow of RORW discharged to the bay, and the reference concentration. This column is descriptive and not scored – its impact is represented by the following criterion. The concentration used is based on a plant achieving 40% permeate recovery with 32 g/L influent salinity, resulting in a RORW salinity of 48 g/L. This represents an average overall salinity condition. Salinities of the discharge drop by simple ratios as other non-saline flows are combined with the RORW. Calculations for effluent salinities, including salinities in a worst case scenario, are presented in Appendix C.

Net Environmental Degradation to Marine Ecosystem – this is a subjective criterion gauging whether discharges may appear to harm or degrade the receiving water body. Lower volume discharges and lower concentrations in the discharge are more favorable and receive a higher score.

Probable Public Acceptance – this is a subjective criterion based on the degree of acceptance that the public may have to the alternative.

Schedule – This criterion is somewhat quantitative, considering the estimated length to obtain permits and to construct the facility. A shorter period is considered most favorable and would receive a higher score. A more protracted schedule to begin operations receives a smaller score.

Infrastructure Needs - this is a reference to illustrate the magnitude of new infrastructure required. It is not scored in the evaluation, as it is reflected in the cost.

5.2 Cost Development and Scoring

Costs generally were developed using parametric cost data. The objective for the cost estimates was to understand the order of magnitude costs of the alternatives, and to differentiate the scoring of the alternatives. The costs described herein are only related to the management of the RORW and do not reflect the total cost of the entire desalination facility. Costs for pipelines were taken from recent projects in Texas. Cost databases such as RS Means were utilized for certain earthwork categories. Real estate prices were observed through on-line sources for agricultural or rural properties. Prices for pumping stations were obtained from published parametric costs curves. Operation and maintenance costs include 9 cents per kilowatt-hour for electricity, and varying labor rates for personnel and staffing. Costs for deep well injection construction were compared with costs for injection wells prepared in San Antonio and other background sources. Some costs for major equipment were obtained from product vendors, for both capital and operating costs.

To reflect varying operation and maintenance costs – especially the electricity costs from pumping systems – a net present value of each of the alternatives was calculated. The annual operation and maintenance costs also included personnel costs – some systems are grander in expanse and require more personnel to operate and maintain the systems. Often, these personnel costs were greater than costs for electricity. Annual costs were returned to present day pricing assuming a 30 year period and an interest rate of 3%.

Appendix D provides the capital and annual costs for each of the alternatives. The costs are summarized in Table 5. All alternatives considered are listed and most have a cost assigned, even though the most unfeasible alternatives are omitted from Table 4.

The scoring for cost was quantitative, based on the net present value. For this evaluation of disposal alternatives, $35M or less net present value receives 5 pts, $36 to $50 million receives 4 pts, $51 to $100 million receives 3 pts, $100 to $200 million receives 2 pts and greater than $200 million receives 1 pt. These costs do not include the cost of constructing or operating the desalination facility.

Table 4 - Matrix of Alternatives and Scoring

ID	Name	Description	Total Flow to Bay @ Salinity (MGD @ g/L)	Net Environmental Degradation to Marine Ecosystem	Probable Public Acceptance	Life Cycle Cost	Schedule	Infrastructure Needs	TOTAL SCORE	Comments
A.	Existing La Quinta Bay Discharge Concept	Short discharge to La Quinta channel outfall	57 @ 48	3 – discharging brine 50% more saline than receiving body	3	5	4	1,700-ft outfall and diffuser	15	Discharge of higher salinity brine product. Intake in proximity to discharge.
B.	Bay Discharge with 2 Outfalls	Discharge to channel plus an additional diffuser 1 mile into bay	57 @ 48	3 – discharging brine 50% more saline than receiving body	2	4	4	1 mile pipeline and diffuser	13	Additional outfall added to reduce potential localized concern by dividing discharge into two locations. Intake in proximity to discharge to address antidegradation.
C.	La Quinta Discharge, 20 MGD plant	20 MGD plant results in 38 MGD discharge to channel	38 @ 48	4 – discharging more saline brine, but less flow	3	5	4	Reduced cost due to lower production volume	16	Smaller 20 MGD production facility and thus smaller discharge, if needed in order to obtain permit. Depends on modeling and TCEQ considerations.
D.	Combined Effluent with Nearby Industry	Utilize existing effluents of 6 MGD to dilute TDS concentration	63 @ 43	4 –reduced brine concentration albeit 10% higher flow	3	5	4	Additional connection and or pipeline for industries. Larger diffuser	16	Utilize GCGV initially and other industry if available to obtain 10% lower TDS. Requires larger discharge permit for combined outfall. TCEQ discussion required. Many nearby candidate discharges also high in TDS and excluded.
E.	Combined Effluent with Nearby Industry, 20 MGD Plant	Discharge to channel from a smaller plant combined with 6 MGD from nearby facilities	44 @ 41	5– reduced concentration and lower flow	3	5	4	Additional connection and pipeline for industries.	17	Utilize GCGV initially and other industry if available to obtain 15% lower TDS. Requires discharge of 46 mgd. TCEQ discussion required.
F.	Deep Well Injection Field	40 disposal wells; long transmission pipes @ 48"; high-pressure pumping	0	5 – no discharge to bay	4	0	2	Pipeline and deep wells. No discharge or diffuser	11	Some wells can be on PCCA property; other landowners required for wells and easements. Zero liquid discharge to surface water bodies.
G.	LaQuinta Discharge with 25% Deep Well Injection	14 MGD disposed via 10 wells plus 43 MGD discharge to channel	43 @ 48	4 – same high salinity but lower flow	4	2	3	Smaller outfall pipeline and some deep wells.	13	43 mgd discharge to La Quinta Channel and 14 MGD disposed of through 10 injection deep wells, which reduce salt mass returned to bay, thus be environmentally beneficial.
K.	La Quinta Discharge with 5 MGD Reuse, 20 MGD Plant	20 MGD plant, send 5 MGD to mud lakes with rest discharged to channel	33 @ 48	4 – same high salinity but lower flow	3	4	4	Additional pumps and equipment for mixing in mud lakes	15	Smaller plant of 20 mgd produced water. Demonstrates commitment to beneficial reuse at mud lakes. Mud lakes scheduled to be closed in 2047.
L.	La Quinta Discharge, Combined Effluent, 5 MGD Reuse	Discharge to channel, combine with nearby industrial effluent, while sending 5 MGD to mud lakes	58 @ 43	4 – TDS concentration diluted by 10%	3	3	4	Additional pumps and equipment for mixing in mud lakes; connection to industrial discharge	14	Lowest discharge TDS of all 30 MGD alternatives. Utilize GCGV initially and other industry if available to obtain 15% lower TDS. Requires larger discharge permit for combined outfall. TCEQ discussion required. Demonstrates commitment to beneficial reuse at mud lakes. Mud lakes scheduled to be closed in 2047.
M.	La Quinta Discharge, Combined Effluent, 5 MGD Reuse, 20 MGD plant	20 MGD plant, discharge to channel, combine with nearby industrial effluent, while sending 5 MGD to mud lakes	39 @ 41	5– reduced TDS concentration from dilution and less flow than Alternative L	3	4	4	Additional pumps and equipment for mixing in mud lakes; connection to industrial discharge	16	Smaller plant of 20 mgd produced water and smaller discharge. Utilize GCGV initially and other industry if available to obtain 15% lower TDS. Requires larger discharge permit for combined outfall. TCEQ discussion required. Demonstrates commitment to beneficial reuse at mud lakes. Mud lakes scheduled to be closed in 2047.

Table 5 - Alternatives Cost Summary

Alternative	Capital Cost	Annual Cost	Net Present Value
A - Existing La Quinta Bay Discharge Concept	17	0.6	29
B - Bay Discharge with 2 Outfalls	24	0.8	40
C - La Quinta Discharge, 20 MGD Plant	14	0.5	25
D - Combined Effluent with Nearby Industry	21	0.6	33
E - Combined Effluent with Nearby Industry, 20 MGD Plant	15	0.5	26
F - Deep Well Injection Field	181	6.8	315
G - La Quinta Discharge with 25% Deep Well Injection	55	3.2	119
H - Evaporation – Natural	440	1.5	469
I - Evaporation – Thermal/Mechanical	550	68	1,874
J – Bauxite Residuals Beds – Full Flow	discarded		
K - La Quinta Discharge, 5 MGD Reuse	17	1.4	45
L - La Quinta Discharge, Combined Effluent, 5 MGD Reuse	20	1.6	51
M - La Quinta Discharge, Combined Effluent, 5 MGD Reuse, 20 MGD Plant	19	1.3	46

All costs in million dollars.

5.3 Discussion

The original scope of this feasibility analysis was to identify potential alternative methods of disposal to avoid some or all of the discharge to Corpus Christi Bay. It is widely held that disposal of brine reject water from large scale production facilities is a difficult and expensive task. Available alternative methods of disposal besides outfalls back to the original source exist, but all are extremely expensive in comparison, and where found in practice are typically for small systems, orders of magnitude below the projected 30 MGD production capacity of the La Quinta facility, or in places where water is very scarce such as the middle east. Of the thirteen alternatives investigated in this study, only one alternative that does not have a discharge to the bay remains in the matrix – Alternative F, Deep Well Injection Field. This alternative has costs 5 to 10 times that of other alternatives due to the high capital and operation costs of a large number of injection wells.

The scoring parameters in Table 5 are summed to provide an overall assessment of each alternative and a comparative ranking. The ten judged alternatives result in a range between 11 and 17, out of a total possible score of 20. Six alternatives out of the ten scored 15 or better, meaning they scored 75% or better of the total points. In general, the scoring produced a group of alternatives with very close scores—this was somewhat expected as 3 alternatives were already discarded after the initial evaluation.

Alternative A is the baseline case, proposing to discharge the entire flow of RORW (57 MGD) at the average concentration of salinity (48 g/L) directly to the channel via a high-rate mixing diffuser. This solution is the most economical of the alternatives producing 30 MGD of desalinated water. It could be implemented very quickly, but a point is deducted from the scoring from the schedule to account for a protracted permitting process. The environmental and public acceptance criteria also have reduced scores because of the observed opposition to discharging a high-saline brine to the bay.

Alternative B adds a second outfall to the concept of Alternative A. The first diffuser would be in the deep La Quinta channel and the other approximately 1 mile further out in the more shallow bay. The multiple diffusers would distribute the brine over a wider geographical expanse. The TCEQ has said informally that it is acceptable to have two outfalls for a facility and is a common occurrence with permitting industrial facilities. This alternative scores worse than Alternative A for cost because of the added cost of extending an outfall pipeline 5,000 feet into the bay. The score for public acceptance is also reduced because it is anticipated that two outfalls would alarm opponents more than one outfall.

Alternative C is identical to Alternative A, except that it features a 20 MGD production rate, which leads to a RORW generation rate of 38 MGD. Because of the simplicity of this alternative and the smaller infrastructure required to discharge the lower RORW flow, the capital cost of this alternative is the lowest of all alternatives, and 20% less than Alternative A. This alternative is awarded one point higher in the environmental criterion than Alternative A because it is discharging 33% less brine flow, despite the brine being the same concentration.

Alternative D combines the effluent from the desalination facility with the industrial wastewater discharge from an adjacent entity. There is minimal cost associated with the infrastructure required to intercept the GCGV flow, and a minimal incremental cost for the slightly larger infrastructure necessary to convey the combined discharge and the outfall diffuser. PCCA would assume some risk by tying its discharge to another party. If the adjacent industry stopped its discharge, or discharged non-compliant wastewater, the desalination production could be reduced or ceased to cope with problems with the industry's discharge. However, PCCA would not be responsible for others discharge as each would still have an independent monitoring location and reporting to TCEQ. This alternative results in a lower concentration of salinity in the discharge, but yet this is offset by the increase in total flow. As such, in the environmental degradation score, it is assigned a 4, and results in a total score of 16, tying with Alternative C.

Alternative E is identical to the prior alternative, except that a 20 MGD plant is proposed, with a lower effluent flow. In combining with the discharge from the adjacent industrial facility, the non-saline industrial discharge becomes a greater fraction of the total, so the salinity drops even lower, tied for the lowest of all the alternatives. Because of the lowest salinity, and less discharge flow, a maximum 5 points is assigned in the environmental criterion. Because the RORW flow is lower, this has smaller infrastructure costs. This results in the best score among all alternatives. However, it does not produce 30 MGD of fresh water, and may not be desirable.

Alternative F discharges nothing to the bay, instead disposing of the RORW through a complex series of deep injection wells into isolated geological formations. This measure scores a maximum 5 in the environmental category. However, its net present value cost is more than 5 times the previously described alternatives, and it scores a zero in that criterion. It scores poorly for schedule as well, given the length of time necessary to drill and develop 40 wells 5,000 feet deep. These factors lead to the worst score in the matrix.

Alterative G seeks to reduce the discharge to the bay by diverting one-quarter of the RORW flow to a reduced-scale deep well injection system. The discharge remains at 48 g/L in salinity. This alternative still scores poorly in cost and schedule, resulting in a total of 13, behind most other alternatives.

Alternative K contemplates sending 5 MGD of RORW to the bauxite residuals disposal areas for treatment and evaporation. The remainder of the RORW is discharged to the bay. The cost for this alternative is elevated compared to others, due to the construction and operation of the pipeline to convey the RORW from the plant site to the mud beds. The removal of the 5 MGD from the discharge to the bay is of little effect, as the salinity remains the same. The total points for this alternative matches that of the base case, Alternative A, yet does not produce 30 MGD and is slightly more complex and employs other risks by pumping a fraction of the RORW to the mud beds..

Alternative L is an amalgamation of most of the alternatives proposed. It has the discharge from a 30 MGD production facility, diverts 5 MGD of RORW to the mud beds, combines the remaining RORW with the industrial effluent of the adjacent industry, and then discharges the combined effluent via two diffusers, one in the channel and another 1 mile out in the bay. This project scores similarly to Alternative A, but with elevated costs and presenting no other synergism from compiling all the concepts.

Alternative M is the same as Alternative L, except that a 20 MGD production facility is proposed. It scores similarly in the criteria, except that the salinity concentration is reduced and it garners a maximum 5 points in the environmental category. Its total score is equal to Alternative A, but has less production of fresh water and is a more complex, costlier system, but it does comply with PCCA's commitment to delivery brine to the bauxite residuals beds.

The alternatives with outfalls combining with adjacent industrial discharges of low TDS result in an effluent with a salinity reduced by 10% or more, which could have a notable effect on salinity modeling for the diffuser, and eventually the potential ease of securing a permit. It depends on the adjacent industry accepting the proposal, and that the facility will produce the flows described in this report. This scenario would require further discussion with the adjacent industry and with the TCEQ concerning how final permit conditions and outfalls would be described and permitted. This would also require additional modeling to ensure the larger flows could be acceptable with an appropriately sized diffuser. These alternatives are also competitive economically, because the lone acceptable industrial discharge is the one closest to the proposed facility and the industrial discharge can be combined with a minimum of infrastructure.

Among the alternatives for plants that produce 30 MGD industrial water, the average effluent concentration is going to be either 48 g/L, or 43 g/L for alternatives combining with industry. Preliminary modeling indicates that the discharge in Alternative A can be successfully diffused and comply with regulations. Parsons cannot quantify the environmental worth of the 5 g/L reduction on the discharge to the bay. . It is understood that salinity is a key issue focused on by the public, but it cannot be determined that the public would accept a 43 g/L discharge and reject a 48 g/L discharge. Based on the scoring and overall evaluations, Alternative A and D provide the best opportunity to permitting and constructing the full size 30 MGD facility.

Parsons also considered alternatives for a 20 MGD plant, in case a smaller footprint and volume of water would satisfy immediate industrial needs. One could consider a phased facility of a 20 MGD followed by a 10 MGD plant expansion. This may also be easier to permit as it would allow time to establish baseline effluent data and conduct additional environmental studies prior to full buildout of the 30 MGD plant. Considering the 20 MGD options, Alternatives E, and M provide the lowest brine concentrations. Alternatives K and M incorporate reuse for bauxite residuals into an overall water strategy. Alternative M will be more expensive but maybe be more acceptable to the public due to reduced brine discharges.

Of the opportunities for beneficial re-use of the RORW, only bauxite residuals treatment presents a feasible potential. Considering PCCA's commitment to implementing the bauxite residual treatment concept, Alternatives L and M are feasible. The remaining reuse opportunities do not appear feasible given the remote distances to potential customers, the cost to implement them, the small volumes involved, and its inherent competition with the fresh water being produced there.

5.4 Recommendations

The following alternatives are recommended. They are all considered close in overall rankings to not be objectively superior to each other. PCCA may have other certain subjective criteria or preferences that could drive the decision between which alternative to pursue and advance. The following alternatives are all, in Parsons' opinion, possible and likely to obtain a permit based on the technical merits.

These alternatives are recommended to be tested with preliminary diffuser modeling, and if that proves successful, to continue on with the other aspects of this project, identifying a formal alternative to advance for the resubmitted permit application, anti-degradation evaluation, and review of the draft permit supplied by the TCEQ.

The recommendations are presented in two matrices. The first matrix presents the effluent characteristics and cost of the recommended alternatives based on average effluent conditions. These conditions result from an average 31.7 g/L intake salinity and a 40% RO permeate value. Following that is another matrix showing the alternatives under a worst-case scenario, which assumes a 95th percentile influent salinity and a 50% RO permeate value. This latter condition results in a higher effluent salinity, although a lower flowrate of RORW. The matrices below are rearranged and simplified versions of Table 4 to directly compare the recommendations based on strategic decisions by PCCA: what size plant to construct, whether to combine with other industrial effluents, and the benefits of sending effluent to the bauxite residual ponds.

Table 6 - Average Effluent Characteristics and Costs of Recommended Alternatives

	Straight Discharge		Combined w/ Industrial Effluent		Combined with Industrial Effluent & Residuals Treatment	
Production Flow, MGD	Discharge MGD @ g/L	Capital Cost $millions	Discharge MGD @ g/L	Capital Cost $millions	Discharge MGD @ g/L	Capital Cost $millions
20	38 @ 48	14	44 @ 41	15	39 @ 41	19
30	57 @ 48	17	63 @ 43	21	58 @ 43	20

calculated from average intake salinity at 40% RO permeate

Table 7 - Worst Case Effluent Characteristics and Costs of Recommended Alternatives

	Straight Discharge		Combined w/ Industry (GCGV)		Combined w/ Industry and 5 MGD Beneficial Reuse	
Production Flow, MGD	Discharge MGD @ g/L	Capital Cost $millions	Discharge MGD @ g/L	Capital Cost $millions	Discharge MGD @ g/L	Capital Cost $millions
20	27 @ 71	14	33 @ 58	15	28 @ 55	19
30	40 @ 71	17	46 @ 61	21	41 @ 60	20

calculated from 95th percentile intake salinity at 50% RO permeate

6 Conclusions

This feasibility study demonstrates that any reasonably economical disposal alternative must involve a discharge to Corpus Christi Bay, either solely or in combination with other components. Alternatives which resulted in no discharge to the bay were found in screening to be prohibitively expensive.

The most economical alternatives are those that discharge the entirety of the RORW to the La Quinta channel for a 30 MGD and 20 MGD plant (Alternatives A and C). Parsons believes that these discharges can also be permittable with an appropriate diffuser outfall design and location and with an antidegradation and modeling memo that shows mixing conditions that create salinity concentrations approaching ambient conditions within a short distance of the discharge.

The final evaluation reveals that several alternatives are very closely grouped in scoring, for a 20 or 30 MGD production facility, the alternative that discharges to the La Quinta Channel after comingling with the effluent of an adjacent industry ranks the highest, closely followed by the original concept of discharging all the RORW to the channel. Diverting an appropriate flow for reuse to the bauxite residuals beds is also feasible but more costly.

APPENDIX A

EVALUATION OF HISTORICAL NET EVAPORATION

PARSONS

SUBJECT PCCA LA QUINTA DESALINATION ALTERNATIVES
EVAPORATION RATE AVAILABLE AT SITE
JOB NO. 452541.20000
SHEET NO. 1 OF 2
BY T. WILSHUSEN DATE 4/21/21 CHECKED MN DATE 6/9/21

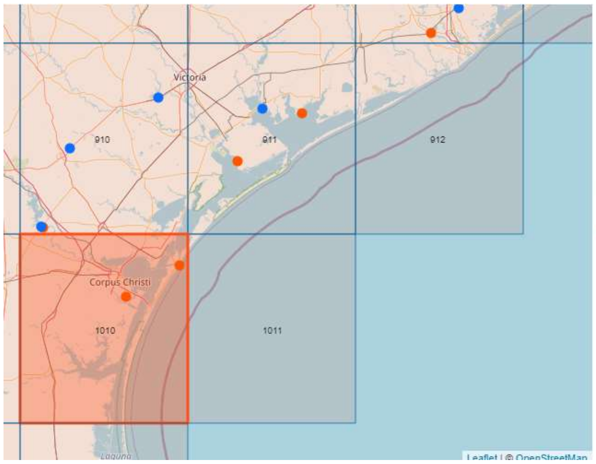
INVESTIGATE EVAPORATION RATE AVAILABLE AT THE PROPOSED DESALINATION PLANT IN SAN PATRICIO COUNTY, TX

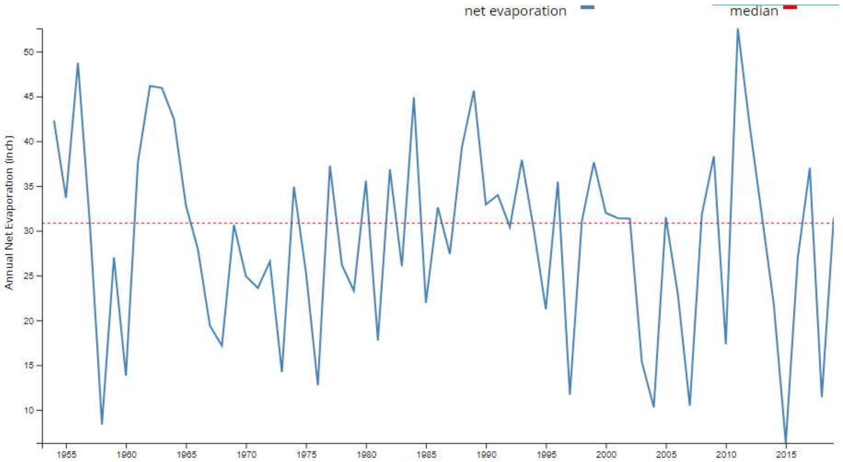
Texas Water Development Board publishes evaporation data on its website:

https://waterdatafortexas.org/lake-evaporation-rainfall

Potential site is on north side of Corpus Christi Bay. Site is in TWDB quadrant 1010.

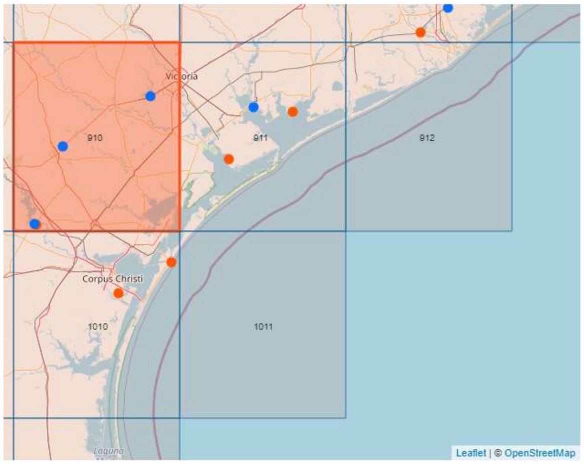
NET evaporation:

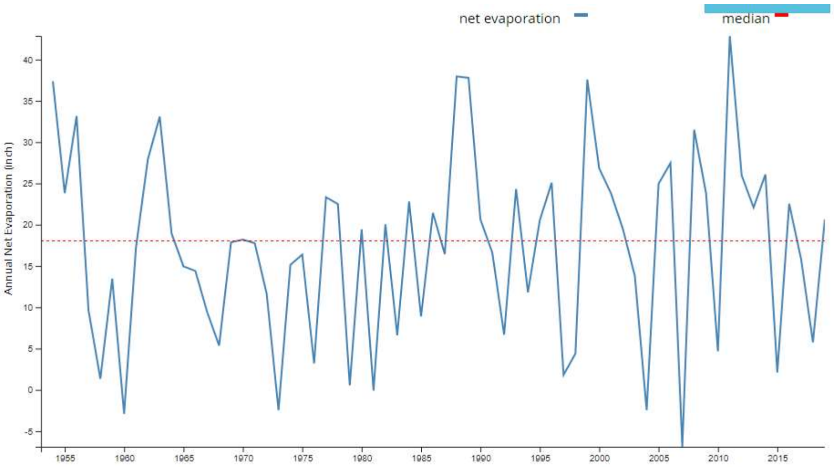




The data shown in the graph were downloaded and analyzed. The average evaporation rate is about 31”

However, the two quads above it show significantly less net evaporation—about 18”.



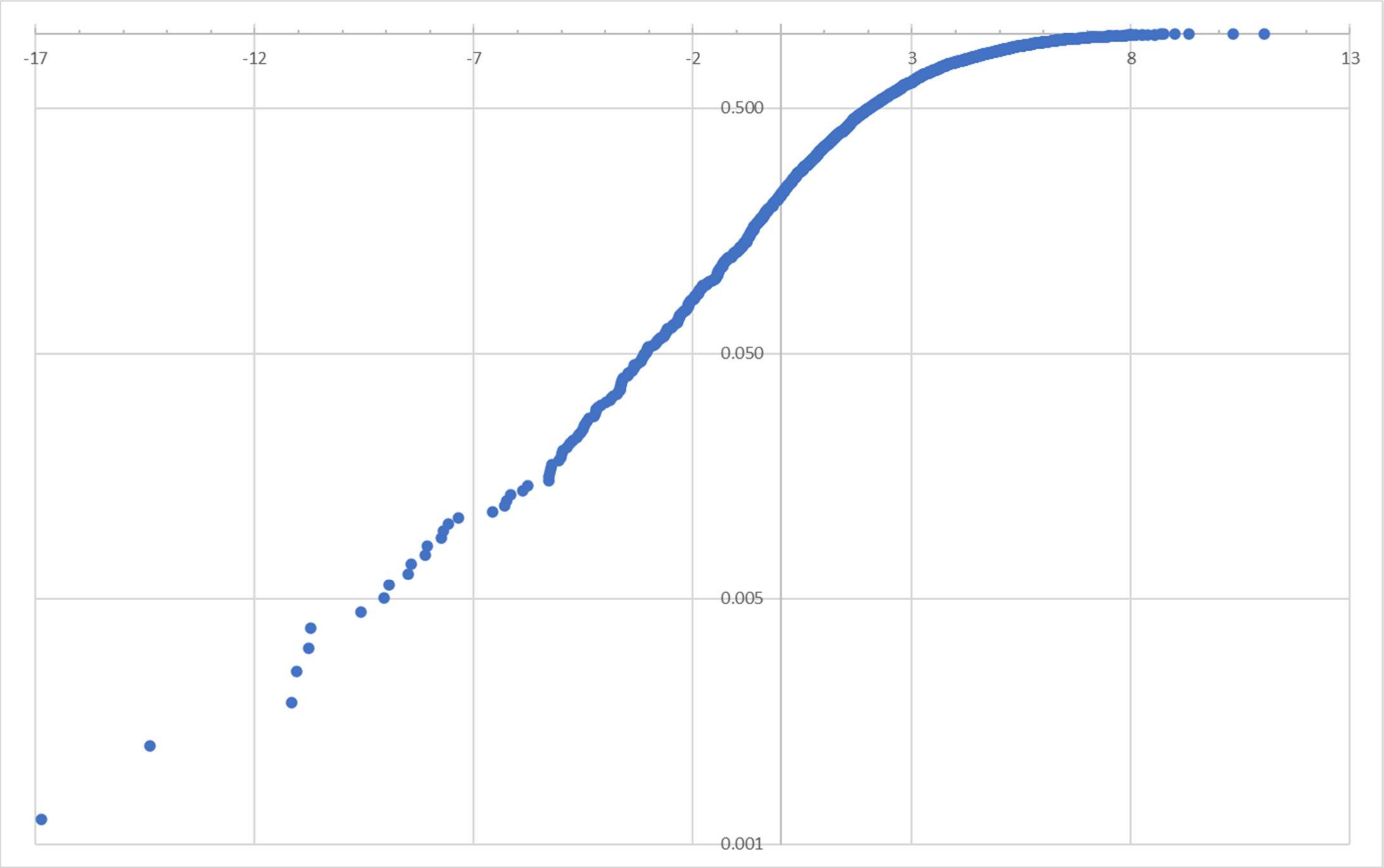


Downloaded the individual monthly data for the two quads 1010 and 910 in a spreadsheet.

Average of all months is 1.93179 in/mo over = 23.2 in/yr.

	Inches/month	Inches/year
average	1.932	23.182
90TH PERCENTILE:	5.57	66.84
10TH PERCENTILE:	-1.504	-18.048

SUBJECT	PCCA LA QUINTA DESALINATION ALTERNATIVES	**JOB NO.**	452541.20000
	EVAPORATION RATE AVAILABLE AT SITE	**SHEET NO.**	2 **OF** 2
BY	T. WILSHUSEN **DATE** 4/21/21	**CHECKED**	MN **DATE** 6/9/21



Typically evaporation rate by area:

23.18 inches / year (1 acre) (43,560 ft^2/acre)(7.48 gal/ft^3) (1 ft/12 in) = 629,000 gal/acre/year

= 1,724 gal/acre/day

= 0.001724 MGD/acre

Use MGD/acre value above to estimate required acreage for any identified waste flow, or to find acceptable waste flow for any dedicated area.

APPENDIX B

TREATABILITY STUDY

Treatability and Feasibility Study for Copano Mud Beds with RO Reject Disposal

DRAFT

Prepared for:

PORT OF CORPUS CHRISTI AUTHORITY

Prepared by:

PARSONS

June 28, 2021

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1 Introduction

1.1 Project Background

Growth in the Corpus Christi area has strained its water supply. A lack of reliable water supply is beginning to discourage industrial development in the area. The Port of Corpus Christ Authority (PCCA), to further its mission statement to “leverage commerce to drive prosperity” is striving to augment the water supply in the area and encourage development. Given the location of Corpus Christi near the Gulf of Mexico, and in particular PCCA’s role and strategic location on the coast, desalination to produce fresh water is the logical alternative to pursue.

To that end, the Port is evaluating projects to install desalination facilities in the area. One potential project is located on port-owned property on the north side of Corpus Christi Bay, called the La Quinta site. The objective for the proposed facility is to produce fresh water suitable for industrial use among the many industries present adjacent to the proposed facility. Such a facility, if implemented soon, may become the first large-scale seawater desalination facility in Texas and on the Gulf Coast. Such a project will be a groundbreaking example to provide fresh water resources for industry along the remainder of the coast.

The desalination process in this instance is proposed to withdraw seawater from Corpus Christi Bay and extract fresh water, essentially by capturing H_2O molecules and leaving other components of seawater behind. The water that remains after the freshwater is extracted is the same material that was present in the seawater as it was pumped from the sea, although with less of a freshwater component; the concentrations of salts in the fluid are elevated to approximately twice of the salt concentration originally. As such, it is considered a waste product and can be returned to the bay or other water bodies only by meeting regulatory limits.

The PCCA has submitted an application for wastewater discharge associated with the proposed desalination facility. The wastewater discharge would enter the La Quinta ship channel, running along the north side of Corpus Christ Bay. The permit application proposes to discharge the desalination by-product liquids via a diffuser at a depth of 45 feet in the channel.

1.2 Project Scope

The overall project aims to investigate alternative methods to dispose of the by-products of the desalination process, and to assist with certain procedures and documents related to the wastewater discharge permit application and any changes that may result from the feasibility study. The tasks for the project at large are listed below.

Task 1 -	Document Review and Antidegradation Memo
Task 2 -	Alternative Brine Disposal Evaluation
Task 3 -	Copano Mud Beds Feasibility and Treatability Study for RO Reject Disposal
Task 4 -	Update Discharge Permit and Technical Information
Task 5 -	Update Water Quality Model
Task 6 -	Review Draft and Final Permits

This report is for Task 3, which evaluates the application of the concentrated saline by-product of the desalination process by applying it to nearby bauxite residual disposal areas. The investigation activities are focused on determining beneficial outcomes of mixing desalination reject stream with the stored residuals. The scope also includes collecting samples of actual materials stored there, delivering samples to Parsons' treatability laboratory, and coordinating advanced analyses as required with 3rd-party laboratories.

1.3 Objective of Treatability Study

The treatability study focuses on confirming the potential of beneficial reuse and quantifying the behavior of the bauxite residual after application of the saline desalination by-product, as well as any changes to the character of the by-product after reaction with the bauxite residual. The bauxite residual is known to have an elevated pH, and published research and histories of the process indicate that the saline by-product may react with the bauxite residual to lower its pH and otherwise create a more manageable sludge. A key objective of the study is to identify the ratio of the bauxite residual solids to the desalination by-product liquid that results in optimal improvement.

2 Project Description

2.1 Site Description

The project site is located along a 13-mile long north-south axis running from the northern shore of Corpus Christi Bay to Copano Bay, as seen in relation to the City of Corpus Christi in Figure 1.

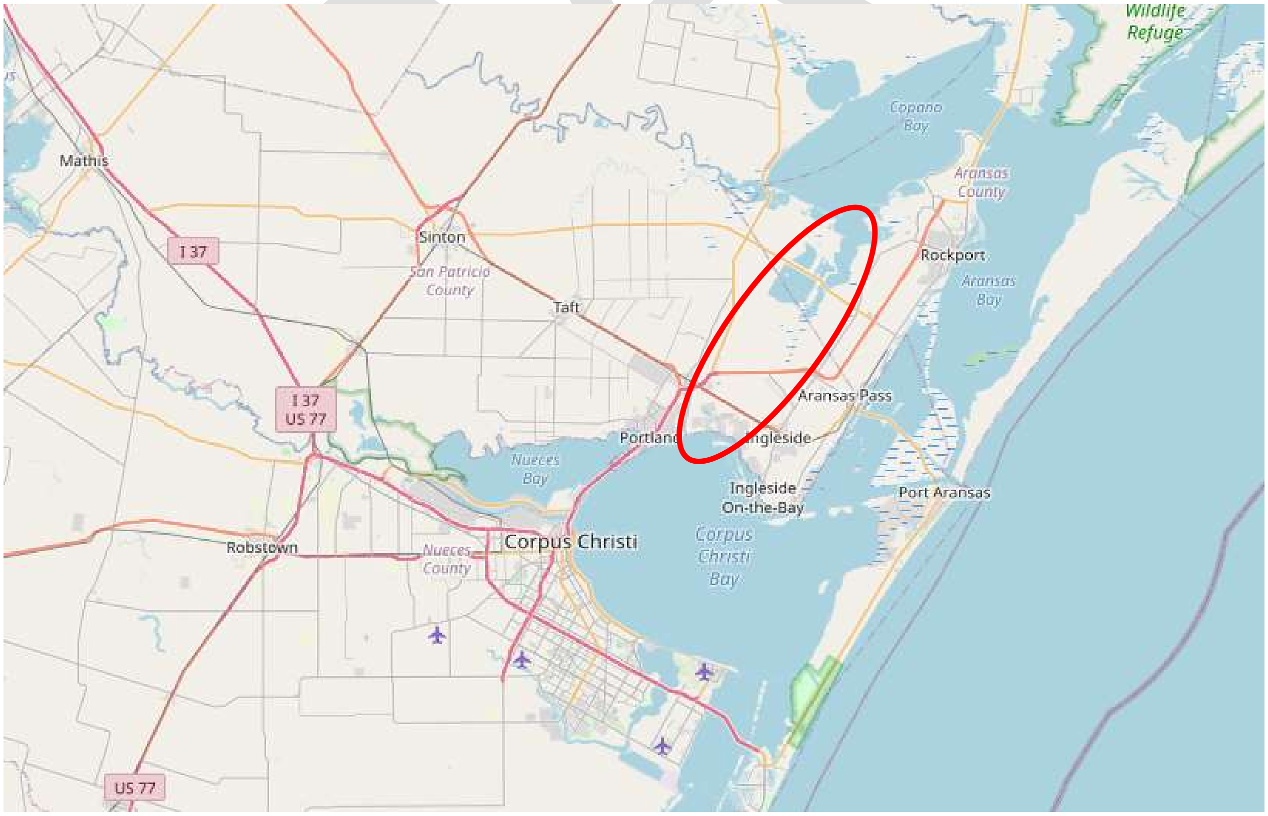


Figure 1. Project Location Map

Figure 2 illustrates the main components of this project, which include PCCA property, the bauxite residuals disposal areas (BRDAs), the proposed desalination facility location, and an existing pipeline connecting the BRDAs to the former aluminum production site on the northern shore of Corpus Christi Bay. These items are described in more detail in the following sections.

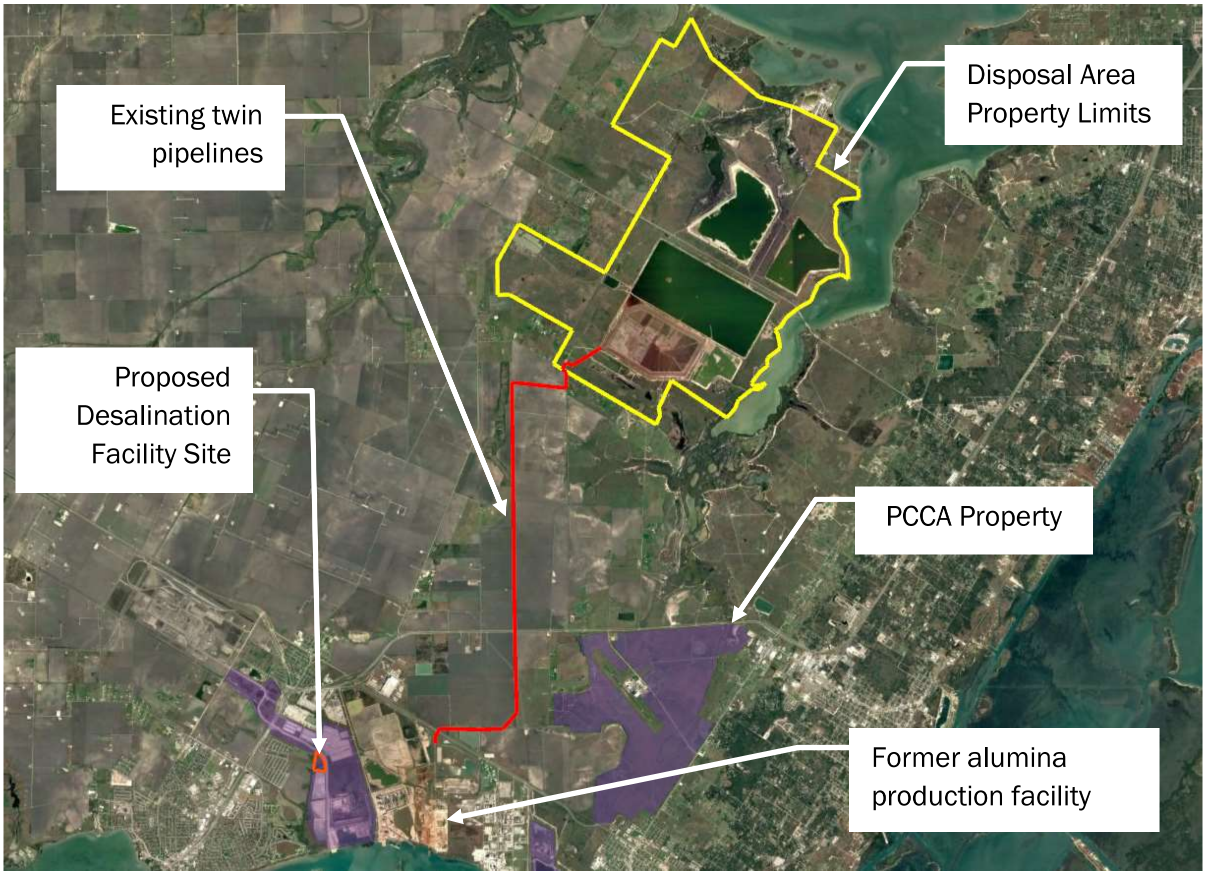


Figure 2. Components of Project

2.2 Proposed Desalination Facility

In March of 2018 the PCCA submitted an industrial wastewater permit application to the Texas Commission on Environmental Quality affiliated with the proposed desalination facility. The application was revised in 2019. The proposed desalination facility is illustrated in Figure 3.

The desalination process employs reverse osmosis to separate fresh water (low in total dissolved solids) from the other components of seawater (mostly salts and minerals). After separation of the fresh water, a stream of more concentrated seawater remains. This fluid stream is called reverse osmosis reject water (RORW). RORW must be disposed of appropriately. Figure 4 illustrates a simplified block flow diagram for the desalination process, as well as indicating the proposed flow rates for the facility.

This treatability study focuses on only the by-product from the reverse osmosis project; it does not include any simulation or evaluation of the pretreatment waste stream indicated in the block diagram. The RORW stream is to be applied to the bauxite residue, with the expectation that the residue will improve in certain characteristics, resulting in beneficial conditions.

From Attachment 9 of Wastewater Discharge Permit Application WQ0005253000, by Wood, Inc.

Figure 3. Proposed Desalination Plant Layout, Intake, and Discharge

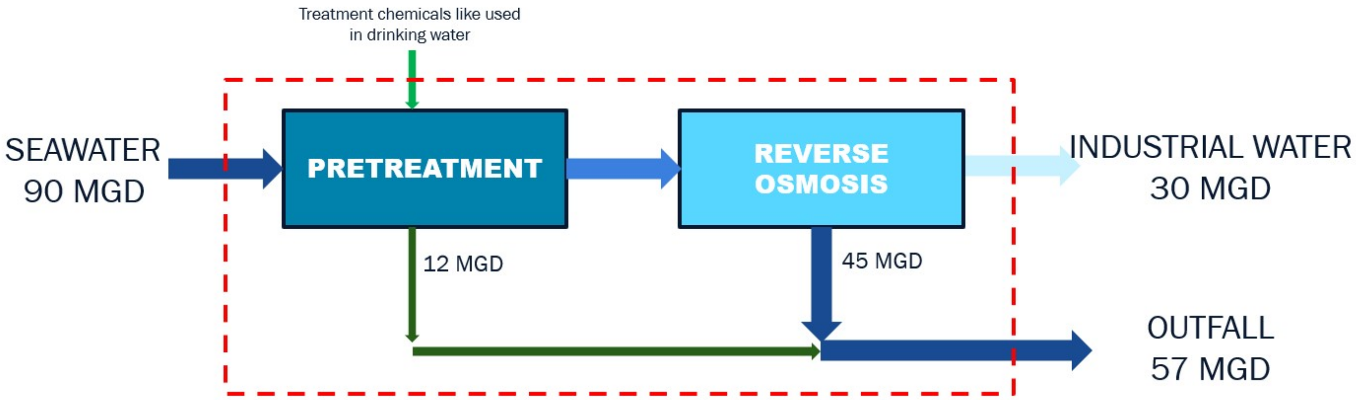


Figure 4. Simplified Process Flow Diagram for Desalination Process

The estimated concentrations found in the reverse osmosis reject water are found in the wastewater permit application (see Table 1). These concentrations are, roughly, double the concentrations found in typical seawater.

2.3 Bauxite Residuals History

An alumina production facility was constructed on the north shore of the bay in 1953. The facility operated until 2016, when it closed and its owners entered bankruptcy. The production facility has been demolished and the site is undergoing environmental remediation.

Table 1. Estimated Concentrations in Wastewater Discharge of Proposed Desalination Facility

Constituent	Units	Value
Sodium (Na)	mg/L	18,500
Calcium (Ca)	mg/L	2,720
Magnesium (Mg)	mg/L	2,240
Potassium (K)	mg/L	590
Barium (Ba)	mg/L	0.06
Strontium (Sr)	mg/L	11.0
Iron (Fe)	mg/L	2.4
Bicarbonate (HCO_3)	mg/L	230
Chloride (Cl)	mg/L	36,700
Sulfate (SO_4)	mg/L	4,800
Nitrate (NO_3)	mg/L	3.1
Fluoride (F)	mg/L	3.2
Silicon Dioxide (SiO_2)	mg/L	8.0
Boron (B)	mg/L	8.0
Total Dissolved Solids	mg/L	66,000
pH	s.u.	7.5
Temperature	°C	14-32
Total Organic Carbon	mg/L	1.0
Total Suspended Solids	mg/L	15

Until 1972, waste materials from the alumina production, called bauxite residuals, were stored in above-ground impoundments at the plant site in extensive areas along the north shore of the bay. These areas are not part of this project.

Starting in 1968, the alumina production entity obtained the site near Copano Bay and began constructing the impoundments (see Figure 5). These are constructed from earthen dikes and are called bauxite residual disposal areas, or BRDAs, and are colloquially called beds. The owners constructed Beds 1 and 2 around 1968 and discharge of the waste materials began there in approximately 1972. Beds 3 and 4 were added in the 70's. The waste deliveries ceased with the plant closure in 2016.

Some documents reviewed for this project suggest that the bauxite residual was mainly placed into Bed 1, with the remainder of the beds functioning as supplemental ponds, which only received materials for short periods related to maintenance or other reasons. However, historical aerial photos in Google Earth® indicate that residuals were placed in the other beds quite routinely, and they accumulated significant quantities of waste materials.

This BRDAs site, after the bankruptcy of its previous owners, is now owned by Copano Enterprises, LLC, doing business as CE Ranch, LLC. The site is managed by a 3rd party.

Figure 5. BRDA Site Boundary and Identification of Beds

2.4 Pipeline

The pipeline system in Figure 2 consists of 2, 18-inch diameter steel pipelines. They conveyed the bauxite residual slurry from the alumina production facility to the impoundments. Both ceased service of slurry transport with the plant closure in 2016. Now, one is still in service to convey treated municipal wastewater from the municipality of Aransas Pass from their treatment facility to the BRDA site, while the other remains dormant.

The treated wastewater is used to irrigate Bed 1, or is discharged to Bed 2 for evaporation. The site personnel indicated that the pipelines are rated for 600 psi. The site personnel mentioned that the pipeline can convey approximately 800,000 gallons per day (gpd) of effluent. However, the document submitted to the TCEQ titled “Notice of Applied Materials – Semi-Annual Report No. 5” dated December 11, 2020, the owners describe that approximately 83 million gallons of Aransas Pass wastewater effluent have arrived to the site. This calculates to approximately 450,000 gpd.

2.5 Existing Conditions and Operations of BRDAs

2.5.1 EXISTING

The current BRDA area (Figure 5) contains four separate areas or impoundments that received the bauxite residuals. As indicated in the image of Figure 5, beds 2 through 4 are mostly impounding water. Bed 1 is undergoing active closure, attempting to form a stable cover that will support vegetation. The 5th area identified as decant is used to manage waters at the site.

The beds were constructed between 1968 and 1976, with some improvements, heightening of dikes, and repairs since. The berms containing the impoundments were constructed from local Beaumont clays, and seem to be relatively watertight, given the results from sampling of adjacent monitoring wells.

The owners of the site have granted permission to PCCA to investigate the potential use of beds 2 and 3. Both beds are quite similar, with the characteristics as noted below.

Table 2. Characteristics of Beds for This Study and Bauxite Residual Volume

Characteristic	Source	Bed 2	Bed 3
Year constructed	Design drawings	1968	1976
Area, acres	Google Earth	1,203	412
Top levee elevation, feet	Design drawings	29.5	31
Approximate water surface elevation, feet	Visual estimation	24.0	--
Approximate elevation of bauxite residual, feet	Documents provided	21	21
Approximate depth of bauxite residual, feet	Site operators description	12	16
Estimated quantity of bauxite residual, million cubic yards	Calculation, area x depth	23	10
Typical pH	Site operators description	10.5	12.5

The BRDAs do not have a discharge for any water captured and managed within the dikes, and the state permits to manage the BRDAs do not permit discharge. The only escape for water accumulated in or pumped to the beds is via evaporation.

2.5.2 SITE VISIT

Parsons personnel visited the La Quinta Mud Lakes Facility on March 31st, 2021 to perform visual inspections of existing Beds 1, 2, and 3 and finalize the sampling plan. Parsons personnel were hosted by Keith Hill of Rexco, Inc. contracted operators of the site, and Keith Schmidt of CE Ranch. Also in attendance was Sarah Garza of PCCA.

The parties were able to drive up to the middle of Bed 1, which is dry, hard, and stable on top. It is graded to drain from the center to the outer edge. Bed 1 has been treated for several years to create a viable surface for vegetative growth, with the addition of shredded waste lumber, cotton refuse and other mulch. The treatment operations of the bed are ongoing.

An example of the character of the bauxite residual in Bed 1 was excavated from 5 feet below ground, revealing the unexposed and unaltered bauxite residual (see Figure 6). The residuals in Bed 1 had a sticky and highly plastic texture, something different from any typical natural soil. The material was somewhat similar to thick peanut butter.

Figure 6. Bauxite Residual Excavated from Bed 1

Bed 2 is mostly submerged, and the participants could only observe from its perimeter dike. No samples were demonstrated here. CE Ranch personnel mentioned that Bed 2 has around 12 feet of bauxite residual – colloquially called "red mud" due to its appearance and texture - and the pH is around 10.5 standard units (s.u.)

Bed 3 was found mostly dry as compared to the aerial imagery of Figure 5. The operator stated that Bed 3 had been pumped out (see Figure 7). The visitors were able to easily walk across the surface of the accumulated residuals with no issues. An example of the material in Bed 3 was exposed by digging by hand with a shovel a few feet deep. This material seemed even more plastic and pliable, and appeared to have more moisture content than the Bed 1 example.

3 Methods

Parsons performed treatability testing combining red mud from the La Quinta Mud Lakes Facility with surrogate reverse osmosis reject water (RORW). The goal of this testing was to explore the potential for synergistic beneficial reuse of the RORW to ameliorate elevated pH levels in the red mud while reducing the total dissolved solids (TDS) of the RORW. This section presents procedures and results from this bench-scale treatability study including effects on pH, conductivity/total dissolved solids, alkalinity, and metals concentrations.

3.1 Sample Collection

During the conversations at the beginning of this project, the site owners offered to perform the sample collection. This is because the location of the samples, especially from the submerged Bed 2, required heavy equipment to access a suitable depth for sample collection.

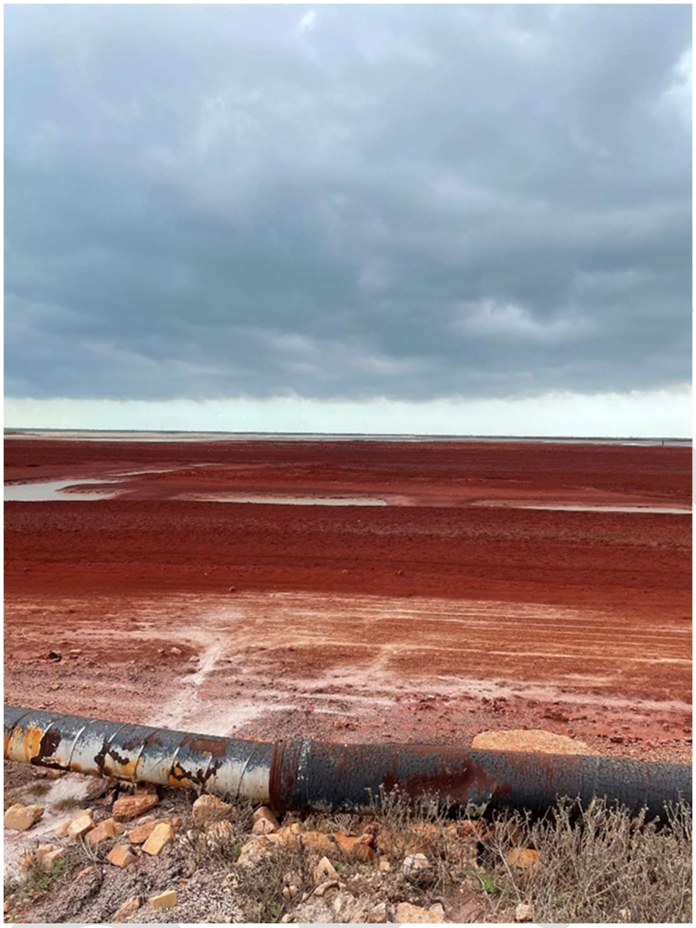


Figure 7. View of Bed 3 During Site Visit

During the site visit of March 31, 2021, Parsons left containers suitable to contain and ship the samples. These consisted of a standard-sized cooler and 2 separate 2-gallon cylindrical containers with sealable lids. Instructions were provided to site personnel to collect composite samples from each bed.

The samples were received by the Parsons Treatability Laboratory in Syracuse, New York on April 13.

3.2 Laboratory Methods and Procedures

3.2.1 SURROGATE RO REJECT TEST WATER PREPARATION

Because the proposed desalination plant is not operating and there is no source of the actual RORW, and artificial solution must be prepared to simulate the future liquid. The target surrogate liquid was effectively a seawater mixture with twice the amount of salts.

Parsons prepared a 10 L sample of surrogate RO reject test water (surrogate RORW). The target conditions for the surrogate RORW are specified in Table 3.

Table 3. Specified Surrogate RORW Characteristics

Parameter	Units	Target
Calcium	mg/L	1,031
Sodium	mg/L	23,104
Bicarbonate	mg/L	654
Chloride	mg/L	41,383
Total Dissolved Solids	mg/L	60,000
pH	Std Units	7.5

The surrogate RORW was prepared according to the recipe in Table 4. The sodium chloride portion of the mixture was retail consumable sea salt (Lior brand Fine Sea Salt Natural Red Sea Salt). The remaining constituents were from laboratory chemicals.

Table 4. Surrogate RORW Reject Recipe

Compound	Molecular Formula	Mass (g/L)
Calcium Chloride	$CaCl_2$ Anhydrous	2.856
Sodium Bicarbonate	$NaHCO_3$	0.901
Sodium Chloride	NaCl	58.107
Potassium Chloride	KCl	9.061

The recipe in Table 4 resulted in the target concentrations in Table 3 plus 4,752 mg/L potassium.

Parsons measured the conductivity in the surrogate RORW at 100,100 microsiemens (µS) using an Oakton® CON2700 bench-top conductivity meter. Parsons calculated an estimated total dissolved solids (TDS) concentration of 60,500 mg/L using guidance from Advanced Sensor Technologies, Inc. (www.astisensor.com; Appendix A) using a conversion factor of 0.6048 for NaCl, which is the predominant compound in the surrogate RO reject test water, at the magnitude of conductivity measured.

3.2.2 RED MUD CHARACTERIZATION

Parsons received two 2-gallon buckets containing red mud samples. One bucket arrived with a separate liquid layer. This sample was thoroughly homogenized prior to testing. The characteristics of the red mud samples are summarized in Table 5.

Table 5. Red Mud Characteristics

Red Mud Bed	Total Solids (%)	Moisture Content (%)	pH (std units)
Bed 2	59.5	40.5	12.05
Bed 3	75.6	24.4	11.75

3.2.3 APPLICATION RATIO SCREENING

Existing literature about the application of the treatability of bauxite residue with saline waters suggested solid-to-liquid application ratios on the order of 1:1 to 1:4. In the initial screening, Parsons applied solid-to-liquid (red mud-to-RORW) ratios ranging from 1:3 to 1:100 wet weight basis using standard jar test procedures. The red mud from Bed 2 and from Bed 3 were tested separately. A total of 600 grams of red mud plus surrogate RORW was combined for each application ratio. The surrogate RORW and red mud were transferred into one-quart wide-mouth clear glass jars placed on a 6-place gang stirrer After an initial period of mixing at 200 RPM, the mixing was halted and material which stuck on the mixing blades was manually scraped off. Mixing was then resumed at 100 RPM for 60 minutes. Figure 8 illustrates the jar testing configuration.

At the end of the mixing period, the solids were allowed to settle for 60 minutes. At the end of the settling period, the relative volumes of the settled solids and liquid layers were measured visually, and the pH of the supernatant analyzed. Figure 9 illustrates the character of the settled jar test samples.

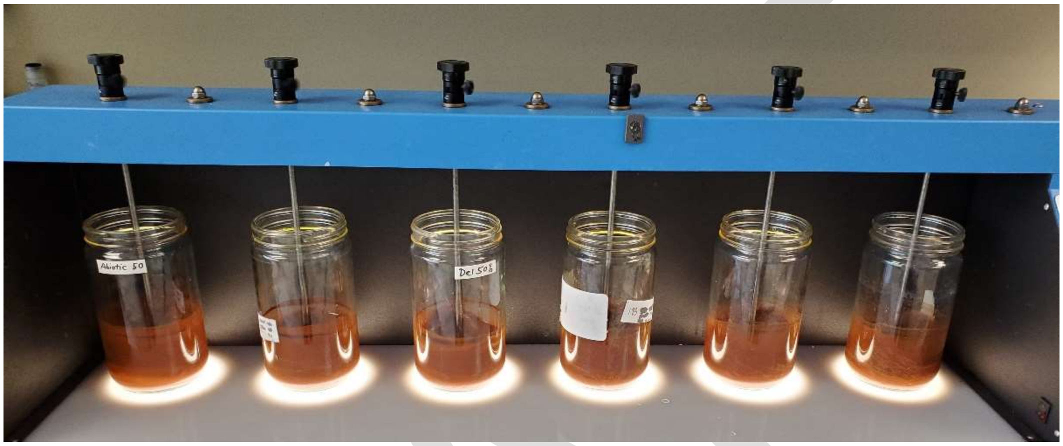


Figure 8. Jar Testing of Red Mud

Figure 9. Jar Test Samples After Settling

3.2.4 APPLICATION RATIO TESTING: OPTIMIZATION TESTING

Upon review of the range-finding results, Parsons performed additional testing with two – three application ratios for each red mud bed based on the pH values obtained during range-finding; the selection of the optimization ratios is discussed in the Results section (Section 4). Additionally, Parsons prepared applications of red mud with deionized water. The same methods used for the range-finding tests were applied during optimization testing. Parsons measured pH as well as conductivity in the supernatant from each application ratio, and collected samples for analysis of TAL metals and alkalinity by a commercial analytical laboratory.

4 Results

4.1 Application Ratio Screening Tests

Table 6 summarizes the results obtained during the screening tests.

Table 6. Screening Results

Mix Ratio (Solid-to Liquid)[1]	**None**	**1:3**	**1:5**	**1:10**	**1:30**	**1:50**	**1:100**
Bed 2							
pH	12.05	11.58	11.29	10.63	8.08	7.91	7.63
Liquid Volume (%)	--	50%	60%	80%	85%	90%	98%
Settled Solids Volume (%)[2]	--	50%	40%	20%	15%	10%	2%
Bed 3							
pH	11.75	10.93	9.87	8.57	7.79	7.60	7.50
Liquid Volume (%)	--	50%	60%	80%	83%	90%	95%
Settled Solids Volume (%)[2]	--	50%	40%	20%	17%	10%	5%

[1] Mass of red mud (wet) to mass of surrogate RO reject.
[2] Estimated based on visual observation.

4.2 Optimization Application Ratio Testing

Parsons tested application ratios of 1:10 and 1:20 in an attempt to optimize on the quantity of red mud mixed with the surrogate RORW while targeting pH values below 10. Control tests with deionized water were performed at the same application ratios. An additional application ratio for Bed 2 of 1:25 with surrogate RORW was selected upon measurement of pH values in the supernatant of 1:10 and 1:20 mix application ratios. The optimization test results are summarized in Table 7. Metals analyses are presented in Table 8.

4.3 Discussions of Results

The results show clear pH attenuation when the surrogate RORW is mixed with the Red Mud. A mix ratio of at least 1:25 was required to reduce pH in Bed 2 to < 10 s.u.; range-finding studies showed that a mix ratio of 1:30 reduced pH in Bed 2 to around 8.1 s.u. A 1:10 mix ratio in Bed 3 successfully dropped pH below 10 s.u. with 1:20 dropping pH below 9 s.u.

Although the results indicate a clear reduction in pH, the overall TDS in the surrogate RORW was largely unchanged. It is assumed the pH reduction effect involved calcium in the RORW reacting with carbonate species in the red mud; however, calcium comprised only a small percent of total TDS. Most of the surrogate RORW TDS is comprised of components including sodium and chloride which would not have taken place in reaction resulting in pH reduction.

Table 7. Optimization Test Results

Test Matrix	Surrogate RORW			Deionized Water	
Mix Ratio (Solid-to Liquid)(1)	1:10	1:20	1:25	1:10	1:20
Bed 2					
pH	11.48	10.57	10.00	11.94	11.72
TDS (mg/L)	62,000	60,800	60,900	8,070	3,760
Alkalinity	226	49	22	Not measured	
Settled Solids Volume (%)(2)	30%	20%	20%	30%	20%
Bed 3					
pH	9.84	8.75	--	11.58	11.27
TDS	59,700	60,100	--	2,040	1,090
Alkalinity	110	76	--	Not measured	
Settled Solids Volume (%)(2)	30%	20%	--	30%	20%

(1) Mass of red mud (wet) to mass of surrogate RO reject.

(2) Estimated based on visual observation.

Table 8. Optimization Test Results for Metals

Metal	Units	Surrogate RORW			Deionized Water		MDL
		1:10	1:20	1:25	1:10	1:20	
Bed 2							
Barium	mg/L	0.0014	0.0047	0.0059	0.0011	0.0013	0.0010
Calcium	mg/L	1.6	7.0	18	0.80	0.97	0.096
Chromium	mg/L	0.064	0.024	0.038	0.059	0.030	0.0016
Copper	mg/L	0.015	ND	ND	0.021	0.012	0.012
Cobalt	mg/L	ND	0.0036	0.0034	ND	ND	0.0015
Iron	mg/L	0.78	1.3	2.8	0.54	0.68	0.040
Magnesium	mg/L	ND	0.051	0.19	ND	ND	0.040
Manganese	mg/L	0.017	0.024	0.050	0.023	0.031	0.0030
Nickel	mg/L	ND	0.0046	0.0067	0.0032	0.0034	0.0021
Potassium	mg/L	4600	5900	4700	68	33	Note (1)
Silver	mg/L	ND	0.0091	ND	ND	ND	0.0050
Sodium	mg/L	25000	29000	24000	3500	1700	Note (2)
Vanadium	mg/L	1.9	0.44	0.29	3.2	1.9	0.0019
Zinc	mg/L	ND	ND	0.0043	ND	ND	0.0037
Mercury	µg/L	ND	ND	ND	ND	ND	0.079
Bed 3							
Barium	mg/L	0.0050	0.0058	--	0.0059	0.013	0.0010
Calcium	mg/L	200	340	--	1.8	4.1	0.096
Chromium	mg/L	1.1	0.50	--	1.1	0.59	0.0016
Copper	mg/L	0.024	0.018	--	0.030	0.022	0.012
Cobalt	mg/L	0.0046	0.0036	--	0.0031	0.0063	0.0015
Iron	mg/L	2.2	2.1	--	4.0	9.1	0.040
Magnesium	mg/L	0.14	0.68	--	0.049	0.16	0.040

Metal	**Units**	**Surrogate RORW**			**Deionized Water**		**MDL**
		1:10	**1:20**	**1:25**	**1:10**	**1:20**	
Manganese	mg/L	0.039	0.036	--	0.12	0.30	0.0030
Nickel	mg/L	0.0057	0.0045	--	0.016	0.043	0.0021
Potassium	mg/L	4800	5500	--	16	8.6	Note (1)
Silver	mg/L	0.0051	0.014	--	ND	ND	0.0050
Sodium	mg/L	24000	26000	--	850	430	Note (2)
Vanadium	mg/L	0.13	0.041	--	3.4	1.8	0.0019
Zinc	mg/L	0.0042	0.0045	--	0.0065	0.031	0.0037
Mercury	µg/L	ND	ND	--	0.11	0.22	0.079

(1) MDL for potassium ranged from 0.20 mg/L (tests with DI water) up to 4.1 – 41 mg/L range (tests with surrogate RORW).

(2) MDL for sodium ranged from 4.8 - 12 mg/L (tests with DI water) up to 24 - 48 mg/L range (tests with surrogate RORW).

Additionally, as demonstrated by co-mingling of red mud with deionized water, the red mud contributed TDS into the water. The additional TDS from the red mud would have largely negated or even surpassed the decrease in TDS owing to pH reduction reactions which would have used up calcium in the surrogate RORW. Alkalinity measurements trended similarly to the pH values for given mix ratios.

Calcium concentrations are presented in Figure 10.

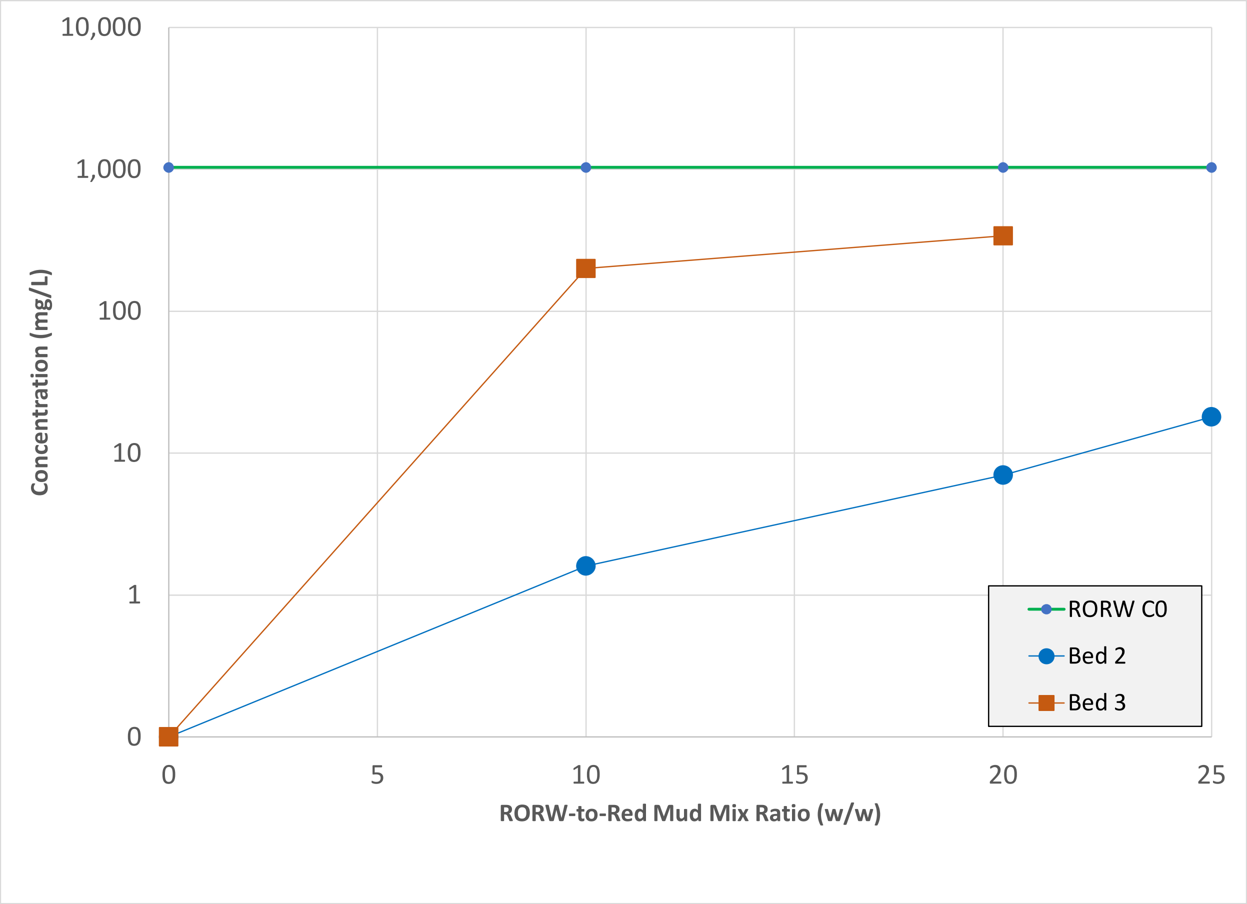


Figure 10. Calcium Concentrations as a Function of Mix Ratio

The results are summarized as follows:

Calcium. Calcium concentrations were significantly lower in the surrogate RORW after mixing with the red mud.

- The calcium was essentially used up in the tests with red mud from Bed 2 with only a slight increase as the RORW-to-red mud ratio increased.
- The higher residual calcium concentrations from testing with Bed 3 compared to Bed 2 and the correspondingly lower pH at given mix ratios may reflect the lower starting pH in Bed 3 and a lower buffering effect such that less calcium was required to effect a change in pH.

Sodium and Potassium. Concentrations of monovalent cations including sodium and potassium did not decrease; in contrast, their concentrations may have slightly increased commensurate with the amount contributed by the red mud (based on results of testing with deionized water).

Heavy / Other Metals. Concentrations of most metals which were not present in the original surrogate RORW (before mixing with red mud) were similar following mixing with red mud between RORW and distilled water, with certain exceptions; for example:

- Vanadium was higher in distilled versus RORW for both Bed 2 and Bed 3. A portion of vanadium contributed by the red mud may have precipitated upon mixing with surrogate RORW.
- Iron concentrations in surrogate RORW mixed with red mud were higher than deionized water in Bed 2 but lower in Bed 3.

4.4 Analytical Conclusions

The following conclusions were developed based on the results of testing:

- The anecdotal red mud samples showed elevated pHs above 11.5.
- The application of surrogate RORW to red mud was effective in reducing the pH of the red mud. It is assumed the reduction in pH was due primarily to reaction of calcium in the RORW with carbonate in the red mud. The reduction in pH was independent of dilution effects as evidenced by comparing testing between surrogate RORW and deionized water at the same application ratios.
- The selection of optimum application ratio (solids-to-liquid; wet basis) to adjust pH to 10 or lower, independent of specific criteria, was approximately 1:25 for Bed 2 and 1:10 for Bed 3. Increasing to a slightly higher ratio (1:30) for Bed 2 would result in a pH closer to 7 – 8 range.
- Bed 3 appears to be more readily neutralized by surrogate RORW based on lower solids-to-liquid ratios to effect a given adjustment in pH, and this is before taking into consideration that the Bed 3 material has a higher solids content (i.e., more solids being commingled with surrogate RORW at a given ratio compared to Bed 2).
- A minimal reduction in TDS in the RORW after reaction was observed. This is not unexpected since a majority of the TDS was accounted for by sodium and chloride, which would not be expected to take part in reactions between the RORW and red mud (e.g., neutralization reactions with calcium and carbonate).
- The red mud itself added around 5 – 10% to the TDS of the surrogate RORW based on tests performed with deionized water.

- Alkalinity measurements based on titration method in Standard Methods 2320B trended similarly to pH at the different mix ratios.
- The reaction of calcium with carbonate in the red mud would be expected to generate a precipitate which would add to the overall mass of solids. The evaporation of RORW in the beds will add additionally to the overall solids.
- Conclusions regarding sequestration or mobilization of metals were presented primarily to understand observations regarding changes in pH and corresponding TDS concentrations and were not performed to address toxicity.

5 Application to In-situ Residue

As calculated and described in other documents in this project, the estimated reliable, long-term evaporation rate from the two beds available for this project, totaling 1,615 acres in surface area, relates to approximately 3 to 6 MGD. Applying RORW to the BRDAs in excess of 6 MGD will require treatment and disposal of the RORW, now mixed with an unrelated waste material. Hence, the anticipated solution to arrive at a satisfactory beneficial use program is to deliver only 3 to 6 MGD to the of the reverse osmosis reject water to the BRDAs. This volume represents a small fraction of the 57 MGD of total reverse osmosis reject water produced by a desalination facility of the magnitude proposed by PCCA.

The results presented in Section 4 demonstrate a favorable result, indicating that the application of RORW to the bauxite residuals produces benefits. Tests resulted in the lowering of red mud pH below 9 with application ratios of 1:10 and higher.

In this scenario, the driver of the application rate is limited by the amount of evaporation that occurs in this system. The application rate is fixed by the evaporation rate, and the resulting parameter is the duration until a certain pH is met. Given that the jar test results showed that very high ratios beyond 1:10 were required to drop the pH below 9.0, it is expected that the duration to reach an acceptable pH is quite long.

Given the physical character of the in-situ bauxite residuals observed, simply pumping the reverse osmosis reject water onto the top of the residuals, where it would remain in a separate phase on top of the accumulated, consolidated residuals may result in little reaction. To demonstrate reaction and improvement of the red mud, it may be required to physically excavate and expose the accumulated material to the reverse osmosis reject water. It is anticipated that the residual will require high-energy mechanical mixing and conversion into a slurry with the reverse osmosis reject water as the base solution so that desired reaction can occur at an observable rate.

The method proposed is to use a floating dredge-type apparatus. Given the extreme dimensions of the beds (Bed 2 measures 4,800 feet by 10,400 feet), no on-shore system could be deployed to reach the center of the bed. A representative floating dredging system is illustrated in Figure 11. The moving cutter head at the articulated boom at the front excavates the submerged residual material in 3 dimensions, then pumps it to a different location, say 500 feet away.

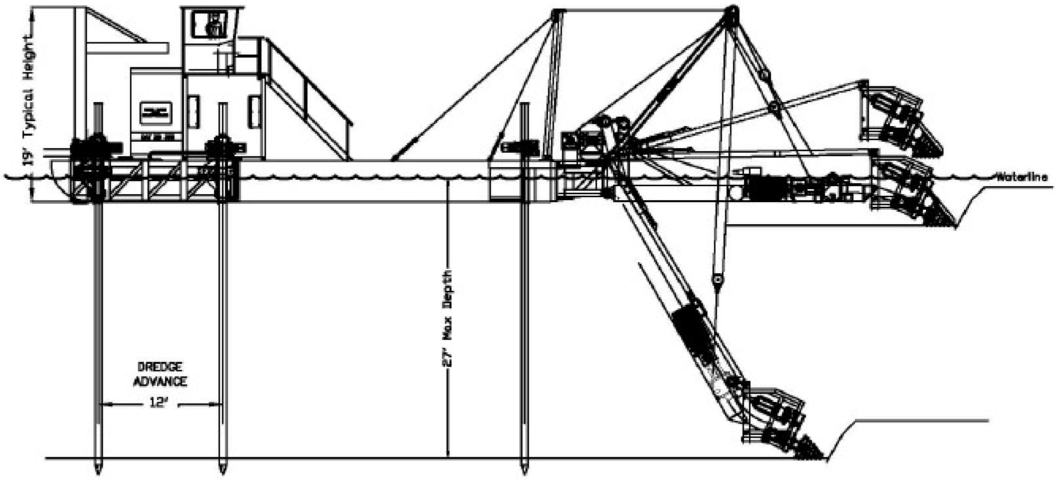


Figure 11. Schematic of Floating Dredge System

The dredging excavates the material and creates a mixing phenomenon with the inundating fluid, which in this case would be the reverse osmosis reject water. The dredging and pumping should create a slurry with fine particles, providing a greater exposure to and contact with the saline solution, and hence a better opportunity for the ions in the reverse osmosis reject water to react with the bauxite residual.

The slurry is pumped in a pipeline over a distance of 500 feet, then discharged back into the same impoundment, where the solids will settle out of the solution, likely over a large radius of distribution.

A representative implementation of this system would occur as follows.

After completion of the desalination facility, begin pumping reverse osmosis reject water to Bed 2 and Bed 3 in proportion to each bed's surface area. The salinity in Bed 2, with several feet of existing water above the deposited residuals, will gradually increase as the saline reject water mixes with the existing water, while evaporation is occurring. Bed 3 is effectively empty, so water pumped there will begin to cover the residuals while also evaporating.

Commence dredging operation in Bed 2, working slowly across the bed in a straightforward pattern. The dredging machine would have to be carefully operated and monitored to prevent damage to any low-permeability soil barrier on the bottom of the impoundment.

This dredging machine can excavate 300 cubic yards per hour. Given the processing rate, the 40-foot boom width of the proposed equipment, and the 12-foot depth of residuals in Bed 2, the dredging machine will advance at a rate of 17 feet per hour. Assuming that the dredger is operated for a standard 8-hour day, and knowing that Bed 2 has a short dimension of 4,800 ft, the dredger will require approximately 35 work days to make one pass along the short dimension.

Bed 2 is 10,400 feet long, which results in 260 40-foot passes. This indicates that the entire Bed 2 will require approximately 9,000 days to complete one entire pass across the entire bed. This is approximately 30 years. Of course, a larger dredge mechanism, operating more often, can reduce this time frame, but the magnitude of the task is to be noted. Multiple dredgers could be procured, including for Bed 3.

Perhaps a passive solution, of simply pumping reverse osmosis reject water to the two beds, to be allowed to evaporate, is a more appropriate and feasible solution.

6 Summary

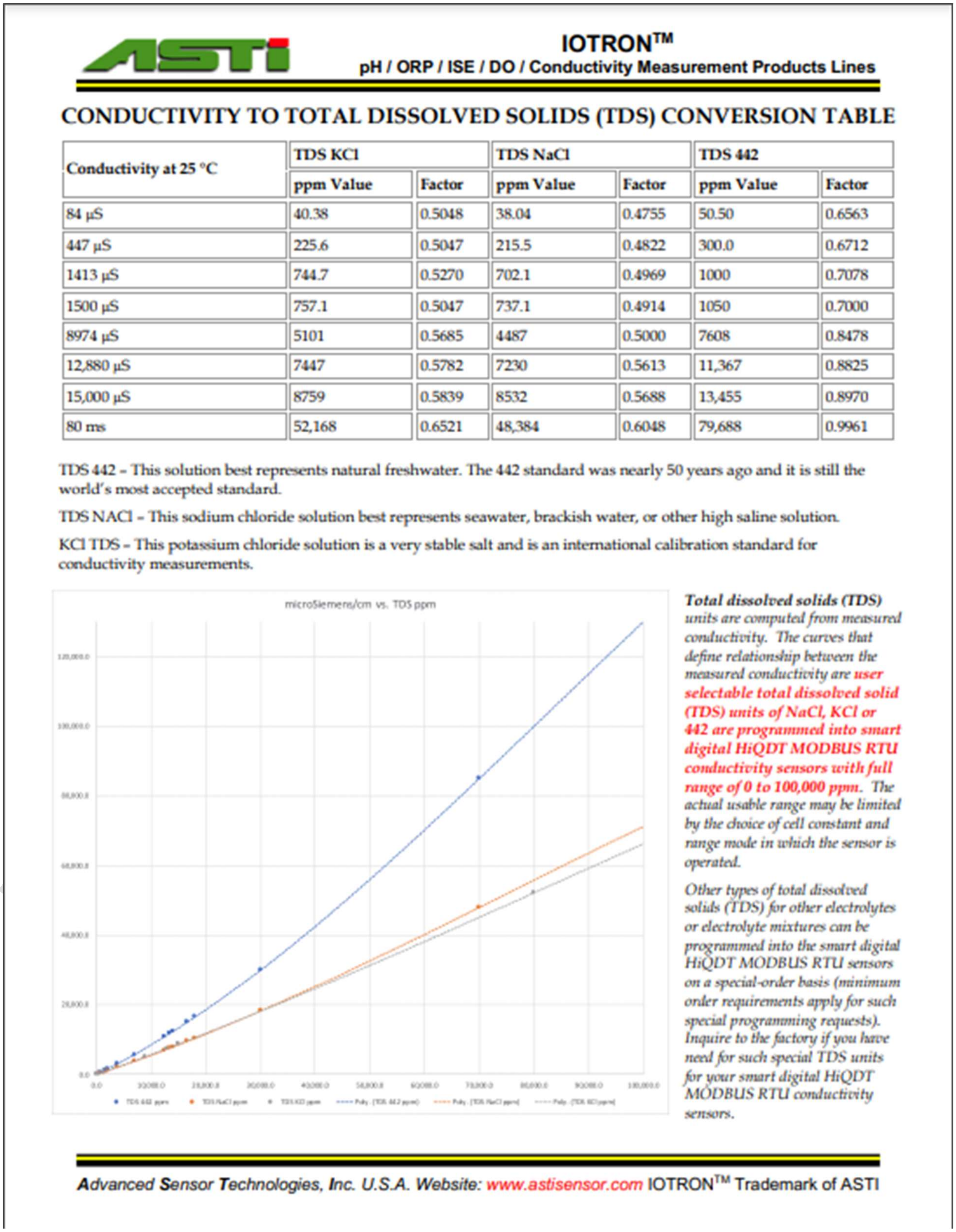
Parsons was provided many documents related to the condition and history of the site. Parsons visited the site, in particular beds 1 and 3, and provided sample containers. Samples from the two candidate BRDA beds were collected by the owner's personnel and delivered to the Parsons treatability laboratory.

In the laboratory, a bench-scale treatability study was performed, evaluating the reaction of the red mud and resulting liquid after application of the surrogate reject water. Beneficial results were observed. As predicted by the literature, application of the highly saline reject water did react with the red mud and result in a lowering of the pH, albeit at higher ratios than expected. The projected application ratios were above 1:10 to achieve a lowering of the pH to 9 or below. However, in this project the application rate is limited by the evaporation rate, which leads to a maximum of 6 MGD of reject water applied.

The reject water would remain a very difficult liquid to treat for discharge to a receiving water body. Trying to mechanically mix the red mud with the reject water would be costly and provide limited benefits to PCCA.

APPENDIX 1

CONDUCTIVITY TO TDS CONVERSION FACTORS



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CONDUCTIVITY TO TOTAL DISSOLVED SOLIDS (TDS) CONVERSION TABLE

Conductivity at 25 °C	TDS KCl		TDS NaCl		TDS 442	
	ppm Value	Factor	ppm Value	Factor	ppm Value	Factor
84 µS	40.38	0.5048	38.04	0.4755	50.50	0.6563
447 µS	225.6	0.5047	215.5	0.4822	300.0	0.6712
1413 µS	744.7	0.5270	702.1	0.4969	1000	0.7078
1500 µS	757.1	0.5047	737.1	0.4914	1050	0.7000
8974 µS	5101	0.5685	4487	0.5000	7608	0.8478
12,880 µS	7447	0.5782	7230	0.5613	11,367	0.8825
15,000 µS	8759	0.5839	8532	0.5688	13,455	0.8970
80 ms	52,168	0.6521	48,384	0.6048	79,688	0.9961

TDS 442 – This solution best represents natural freshwater. The 442 standard was nearly 50 years ago and it is still the world's most accepted standard.

TDS NACl – This sodium chloride solution best represents seawater, brackish water, or other high saline solution.

KCl TDS – This potassium chloride solution is a very stable salt and is an international calibration standard for conductivity measurements.

Total dissolved solids (TDS) *units are computed from measured conductivity. The curves that define relationship between the measured conductivity are* ***user selectable total dissolved solid (TDS) units of NaCl, KCl or 442 are programmed into smart digital HiQDT MODBUS RTU conductivity sensors with full range of 0 to 100,000 ppm****. The actual usable range may be limited by the choice of cell constant and range mode in which the sensor is operated.*

Other types of total dissolved solids (TDS) for other electrolytes or electrolyte mixtures can be programmed into the smart digital HiQDT MODBUS RTU sensors on a special-order basis (minimum order requirements apply for such special programming requests). Inquire to the factory if you have need for such special TDS units for your smart digital HiQDT MODBUS RTU conductivity sensors.

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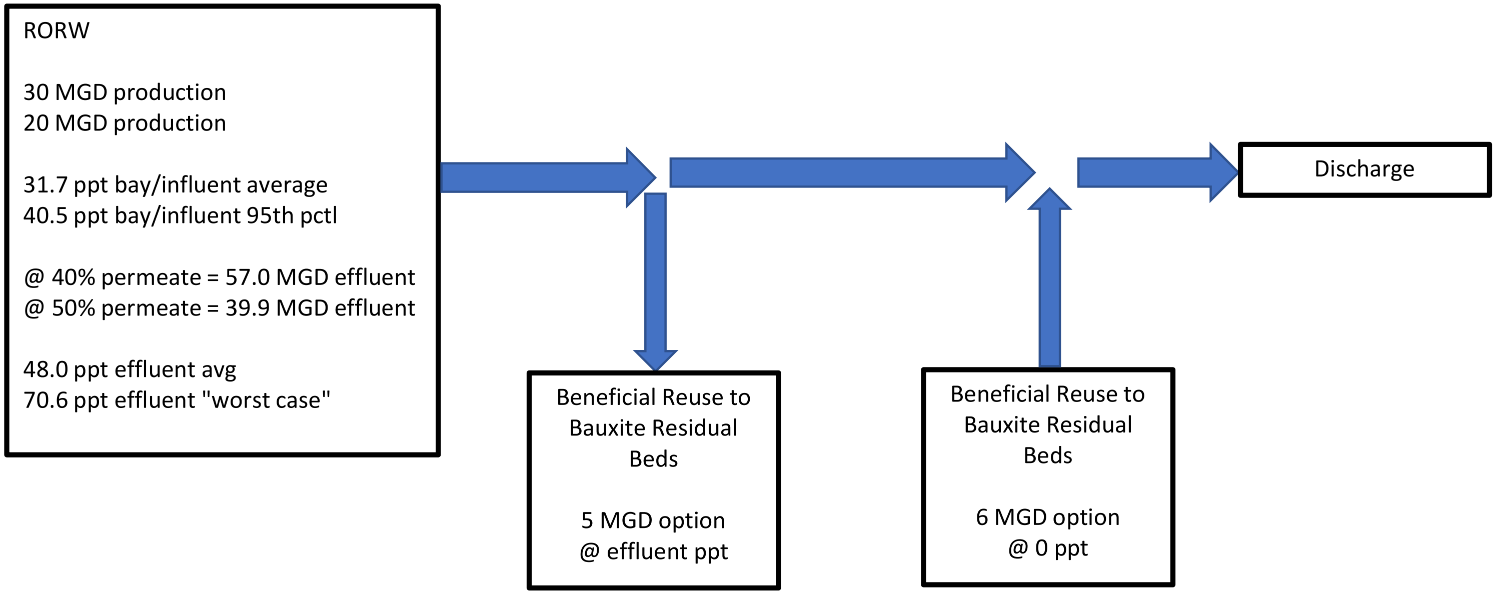
APPENDIX C

EFFLUENT SALINITY CALCULATIONS



RORW

30 MGD production
20 MGD production

31.7 ppt bay/influent average
40.5 ppt bay/influent 95th pctl

@ 40% permeate = 57.0 MGD effluent
@ 50% permeate = 39.9 MGD effluent

48.0 ppt effluent avg
70.6 ppt effluent "worst case"

Beneficial Reuse to
Bauxite Residual
Beds

5 MGD option
@ effluent ppt

Beneficial Reuse to
Bauxite Residual
Beds

6 MGD option
@ 0 ppt

Discharge

	RORW Produced, MGD	RORW Sent Away, MGD	RORW Disposed, MGD	Other Effluents Combined, MGD	Total Disposed, MGD	Salinity, g/L	**DISCHARGE, MGD @ g/L**
A Existing La Quinta Bay Discharge Concept	57.0		57.0		57.0	48.0	**57 @ 48**
B Bay Discharge with 2 Outfalls	57.0		57.0		57.0	48.0	**57 @ 48**
C La Quinta Discharge, 20 MGD Plant	38.0		38.0		38.0	48.0	**38 @ 48**
D Combined Effluent with Nearby Industry	57.0		57.0	6.0	63.0	43.4	**63 @ 43**
E Combined Effluent with Nearby Industry, 20 MGD Plant	38.0		38.0	6.0	44.0	41.5	**44 @ 41**
F Deep Well Injection Field	57.0	57.0					**0 @ 0**
G La Quinta Discharge with 25% Deep Well Injection	57.0	14.3	42.8		42.8	48.0	**43 @ 48**
H Evaporation – Natural	57.0	57.0					**0 @ 0**
I Evaporation – Thermal/Mechanical	57.0	57.0					**0 @ 0**
J Bauxite Residuals Beds - Full Flow	57.0	57.0					**0 @ 0**
K La Quinta Discharge, 5 MGD Reuse, 20 MGD Plant	38.0	5.0	33.0		33.0	48.0	**33 @ 48**
L La Quinta Discharge, Combined Effluent, 5 MGD Reuse	57.0	5.0	52.0	6.0	58.0	43.0	**58 @ 43**
M La Quinta Discharge, Combined Effluent, 5 MGD Reuse, 20 MGD	38.0	5.0	33.0	6.0	39.0	40.6	**39 @ 41**

40% RO, 31.7 ppt average influent salinity 48.0 = effluent salinity

	RORW Produced, MGD	RORW Sent Away, MGD	RORW Disposed, MGD	Other Effluents Combined, MGD	Total Disposed, MGD	Salinity, g/L	**DISCHARGE, MGD @ g/L**
A Existing La Quinta Bay Discharge Concept	39.9		39.9		39.9	70.6	40 @ 71
B Bay Discharge with 2 Outfalls	39.9		39.9		39.9	70.6	40 @ 71
C La Quinta Discharge, 20 MGD Plant	26.6		26.6		26.6	70.6	27 @ 71
D Combined Effluent with Nearby Industry	39.9		39.9	6.0	45.9	61.4	46 @ 61
E Combined Effluent with Nearby Industry, 20 MGD Plant	26.6		26.6	6.0	32.6	57.6	33 @ 58
F Deep Well Injection Field	39.9	39.9					0 @ 0
G La Quinta Discharge with 25% Deep Well Injection	39.9	10.0	29.9		29.9	70.6	30 @ 71
H Evaporation – Natural	39.9	39.9					0 @ 0
I Evaporation – Thermal/Mechanical	39.9	39.9					0 @ 0
J Bauxite Residuals Beds - Full Flow	39.9	39.9					0 @ 0
K La Quinta Discharge, 5 MGD Reuse, 20 MGD Plant	26.6	5.0	21.6		21.6	70.6	22 @ 71
L La Quinta Discharge, Combined Effluent, 5 MGD Reuse	39.9	5.0	34.9	6.0	40.9	60.2	41 @ 60
M La Quinta Discharge, Combined Effluent, 5 MGD Reuse, 20 MGD	26.6	5.0	21.6	6.0	27.6	55.3	28 @ 55

50% RO permeate, 40.5 ppt influent (95th percentile)	70.6	= effluent salinity

APPENDIX D

COST ESTIMATES

Alt.	Description	Parameter	Units	Unit Cost	Cost
A	Existing La Quinta Bay Discharge Concept				
	Outfall pipeline, 54"	7,900	LF	900	7,110,000
	Add-on for construction in sea bed	1,700	LF	450	765,000
	Diffusers, 57 MGD	1	EA	5,000,000	5,000,000
	Pump station, outfall, 57 MGD x 400 HP	1	EA	4,000,000	4,000,000
B	Bay Discharge with 2 Outfalls				
	Outfall pipeline, 54"	7,900	LF	900	7,110,000
	Add-on for construction in sea bed	1,700	LF	450	765,000
	Diffusers, 28 MGD	2	EA	3,000,000	6,000,000
	Outfall pipeline, 36"	5,200	LF	750	3,900,000
	Add-on for construction in sea bed	5,200	LF	375	1,950,000
	Pump station, outfall, 57 MGD x 760 HP	1	EA	4,000,000	4,000,000
C	La Quinta Discharge, 20 MGD Plant				
	Outfall pipeline, 48"	7,900	LF	850	6,715,000
	Add-on for construction in sea bed	1,700	LF	425	722,500
	Diffusers, 38 MGD	1	EA	4,000,000	4,000,000
	Pump station, outfall, 38 MGD x 250 HP	1	EA	3,000,000	3,000,000
D	Combined Effluent with Nearby Industry				
	Outfall pipeline, 60"	7,900	LF	1,200	9,480,000
	Add-on for construction in sea bed	1,700	LF	600	1,020,000
	Diffusers, 63 MGD	1	EA	5,000,000	5,000,000
	Pump station, outfall, 63 MGD x 360 HP	1	EA	5,000,000	5,000,000
	Allowance for connection to GCGV effluent	1	EA	500,000	500,000
E	Combined Effluent with Nearby Industry, 20 MGD Plant				
	Outfall pipeline, 48"	7,900	LF	850	6,715,000
	Add-on for construction in sea bed	1,700	LF	425	722,500
	Diffusers, 44 MGD	1	EA	4,000,000	4,000,000
	Pump station, outfall, 44 MGD x 300 HP	1	EA	3,000,000	3,000,000
	Allowance for connection to GCGV effluent	1	EA	500,000	500,000
F	Deep Well Injection Field				
	Transmission pipeline, 18"	13,040	LF	120	1,564,800
	Transmission pipeline, 24"	9,780	LF	150	1,467,000
	Transmission pipeline, 30"	11,410	LF	290	3,308,900
	Transmission pipeline, 36"	9,780	LF	500	4,890,000
	Transmission pipeline, 42"	13,040	LF	700	9,128,000
	Transmission pipeline, 48"	8,150	LF	850	6,927,500
	Transmission pipeline, 60"	22,400	LF	1,200	26,880,000
	Pipeline easments	37,000	LF	5	185,000
	Pump station, transmission, 57 MGD x 2,200 HP	1	EA	6,000,000	6,000,000
	Well site acquisition	20	EA	25,000	500,000
	Deep well drilling and finishing	40	EA	2,500,000	100,000,000
	Injection well pump stations	40	EA	500,000	20,000,000
G	La Quinta Discharge with 25% Deep Well Injection				
	Transmission pipeline, 18"	5,000	LF	120	600,000
	Transmission pipeline, 24"	11,400	LF	150	1,710,000
	Transmission pipeline, 30"	22,400	LF	290	6,496,000
	Pipeline easments	22,400	LF	5	112,000
	Pump station, transmission, 14 MGD x 460 HP	1	EA	2,000,000	2,000,000
	Deep well drilling and finishing	10	EA	2,500,000	25,000,000
	Injection well pump stations	10	EA	500,000	5,000,000

Alt.	Description	Parameter	Units	Unit Cost	Cost
	Outfall pipeline, 48"	7,900	LF	850	6,715,000
	Add-on for construction in sea bed	1,700	LF	425	722,500
	Diffusers, 43 MGD	1	EA	4,000,000	4,000,000
	Pump station, outfall, 43 MGD x 300 HP	1	EA	3,000,000	3,000,000
H	Evaporation – Natural				
	Land acquisition	36,000	AC	5,000	180,000,000
	Earthwork	5,600,000	CY	20	112,000,000
	Pump station, outfall, 57 MGD x 750 HP	1	EA	4,000,000	4,000,000
	Pump station, booster, 28 MGD x 600 HP	1	EA	3,000,000	3,000,000
	Transmission pipeline, 42"	74,000	LF	700	51,800,000
	Transmission pipeline, 60"	74,000	LF	1,200	88,800,000
I	Evaporation – Thermal/Mechanical				
	Evaporator process units	36	EA	15,000,000	540,000,000
	Add for slab, canopy	1	EA	10,000,000	10,000,000
K	La Quinta Discharge, 5 MGD Reuse, 20 MGD Plant				
	Pump station, transmission to mud beds, 5 MGD	1	EA	1,000,000	1,000,000
	Transmission pipeline to mud beds, 18"	10,500	LF	120	1,260,000
	Sludge dredge and equipment	1	EA	2,000,000	2,000,000
	Pump station, outfall, 33 MGD x 190 HP	1	EA	2,000,000	2,000,000
	Outfall pipeline, 48"	7,900	LF	850	6,715,000
	Add-on for construction in sea bed	1,700	LF	425	722,500
	Diffusers, 33 MGD	1	EA	3,000,000	3,000,000
L	La Quinta Discharge, Combined Effluent, 5 MGD Reuse				
	Allowance for connection to GCGV effluent	1	EA	500,000	500,000
	Pump station, transmission to mud beds, 5 MGD	1	EA	1,000,000	1,000,000
	Transmission pipeline to mud beds, 18"	10,500	LF	120	1,260,000
	Sludge dredge and equipment	1	EA	2,000,000	2,000,000
	Pump station, outfall, 58 MGD x 420 HP	1	EA	4,000,000	4,000,000
	Outfall pipeline, 54"	7,900	LF	900	7,110,000
	Add-on for construction in sea bed	1,700	LF	450	765,000
	Diffusers, 58 MGD	1	EA	3,000,000	3,000,000
M	La Quinta Discharge, Combined Effluent, 5 MGD Reuse, 20 MGD Plant				
	Allowance for connection to GCGV effluent	1	EA	500,000	500,000
	Pump station, transmission to mud beds, 5 MGD	1	EA	1,000,000	1,000,000
	Transmission pipeline to mud beds, 18"	10,500	LF	120	1,260,000
	Sludge dredge and equipment	1	EA	2,000,000	2,000,000
	Pump station, outfall, 39 MGD x 231 HP	1	EA	3,000,000	3,000,000
	Outfall pipeline, 48"	7,900	LF	850	6,715,000

Alt.	Description	Parameter	Units	Unit Cost rate	Cost $/year
A	Existing La Quinta Bay Discharge Concept				
	Outfall pumping	400	HP	588	235,164
	Low-skill laborers	2	EA	30,000	60,000
	High-skill laborers	2	EA	100,000	200,000
	Equipment, materials, spare parts	1	EA	100,000	100,000
B	Bay Discharge with 2 Outfalls				
	Outfall pumping	760	HP	588	446,812
	Low-skill laborers	2	EA	30,000	60,000
	High-skill laborers	2	EA	100,000	200,000
	Equipment, materials, spare parts	1	EA	100,000	100,000
C	La Quinta Discharge, 20 MGD Plant				
	Outfall pumping	250	HP	588	146,977
	Low-skill laborers	2	EA	30,000	60,000
	High-skill laborers	2	EA	100,000	200,000
	Equipment, materials, spare parts	1	EA	100,000	100,000
D	Combined Effluent with Nearby Industry				
	Outfall pumping	360	HP	588	211,648
	Low-skill laborers	2	EA	30,000	60,000
	High-skill laborers	2	EA	100,000	200,000
	Equipment, materials, spare parts	1	EA	100,000	100,000
E	Combined Effluent with Nearby Industry, 20 MGD Plant				
	Outfall pumping	300	HP	588	176,373
	Low-skill laborers	2	EA	30,000	60,000
	High-skill laborers	2	EA	100,000	200,000
	Equipment, materials, spare parts	1	EA	100,000	100,000
F	Deep Well Injection Field				
	Transmission pumping	2,200	HP	588	1,293,402
	Injection pumping	7,600	HP	588	4,468,115
	Low-skill laborers	5	EA	30,000	150,000
	High-skill laborers	4	EA	100,000	400,000
	Equipment, materials, spare parts	1	EA	500,000	500,000
G	La Quinta Discharge with 25% Deep Well Injection				
	Outfall pumping	300	HP	588	176,373
	Low-skill laborers	3	EA	30,000	90,000
	High-skill laborers	4	EA	100,000	400,000
	Equipment, materials, spare parts	1	EA	100,000	100,000
	Transmission pumping	460	HP	588	270,439
	Injection pumping	1,900	HP	588	1,117,029
	Low-skill laborers	5	EA	30,000	150,000
	High-skill laborers	4	EA	100,000	400,000
	Equipment, materials, spare parts	1	EA	500,000	500,000
H	Evaporation – Natural				
	Transmission pumping	1,350	HP	588	793,678

Alt.	Description	Parameter	Units	Unit Cost	Cost
	Low-skill laborers	10	EA	30,000	300,000
	High-skill laborers	2	EA	100,000	200,000
	Equipment, materials, spare parts	1	EA	200,000	200,000
I	Evaporation – Thermal/Mechanical				
	Energy cost for evaporators	750,000,000	kW-hr	0.09	67,500,000
K	La Quinta Discharge, 5 MGD Reuse, 20 MGD Plant				
	Transmission pumping	264	HP	588	155,208
	Outfall pumping	180	HP	588	105,824
	Low-skill laborers	6	EA	30,000	180,000
	High-skill laborers	4	EA	100,000	400,000
	High-skill dredge operators	4	EA	125,000	500,000
	Equipment, materials, spare parts	1	EA	100,000	100,000
L	La Quinta Discharge, Combined Effluent, 5 MGD Reuse				
	Transmission pumping	264	HP	588	155,208
	Outfall pumping	386	HP	588	226,933
	Low-skill laborers	6	EA	30,000	180,000
	High-skill laborers	4	EA	100,000	400,000
	High-skill dredge operators	4	EA	125,000	500,000
	Equipment, materials, spare parts	1	EA	100,000	100,000
M	La Quinta Discharge, Combined Effluent, 5 MGD Reuse, 20 MGD Plant				
	Transmission pumping	264	HP	588	155,208
	Outfall pumping	231	HP	588	135,807
	Low-skill laborers	6	EA	30,000	180,000
	High-skill laborers	4	EA	100,000	400,000
	High-skill dredge operators	2	EA	125,000	250,000
	Equipment, materials, spare parts	1	EA	200,000	200,000