White Paper – Background and Technical Details of the Port's Efforts to Permit A Desalination Plant
August 20, 2018

This white paper is to provide a detailed overview of the permits the Port of Corpus Christi Authority (PCCA) is obtaining in an effort to assist the City of Corpus Christi in adding desalination as a sustainable water supply to the Region's water portfolio which currently consists entirely of surface water supply (Grimsbo, 2018).

Background

Stakeholders in our area have been talking for decades about desalination as a possible option for enhancing the resiliency of our water supply. In 2015, a draft report prepared by Freese and Nichols, Inc., that to date has not been finalized, determined that desalination was in fact an appropriate water source for our area and could be constructed while keeping water supply reasonably priced. The effort by the Stakeholder Group slowed as discussions became centered around non-curtailable water contracts, site selection for future plants, and analysis of the region's current supply of water verses current and future consumption.

The Port Commissioners became concerned that the supply of water for our region, while appearing to be adequate during rainy seasons, could be greatly impacted by another severe drought as was experienced in our region in 2013. Further, construction of a desalination plant is a protracted process and is thus not an immediate solution. First and foremost, a desalination plant requires a significant permitting effort prior to commencing construction. Therefore, the Port Commission directed staff to identify and negotiate a contract with a consultant possessing appropriate qualifications to assist the PCCA with development of the permit applications necessary for construction so the permits would be available when needed for construction of a desalination facility. PCCA staff interviewed various consultants and determined Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) to be most qualified (David R. Hoffman, Port of Corpus Christi Permitting - Desalination Plant, 2017). On April 18, 2017, the Port Commission approved a Professional Engineering Services Contract with Amec Foster Wheeler and then a subsequent Professional Engineering Services Contract on June 19, 2018 with Wood Environment & Infrastructure, Inc. (Wood), formerly Amec Foster Wheeler, for development of the long lead permits necessary for commencing construction of a desalination plant. The proposed site locations are on PCCA-owned property at La Quinta and Harbor Island.

General Desalination Plant Configuration Details

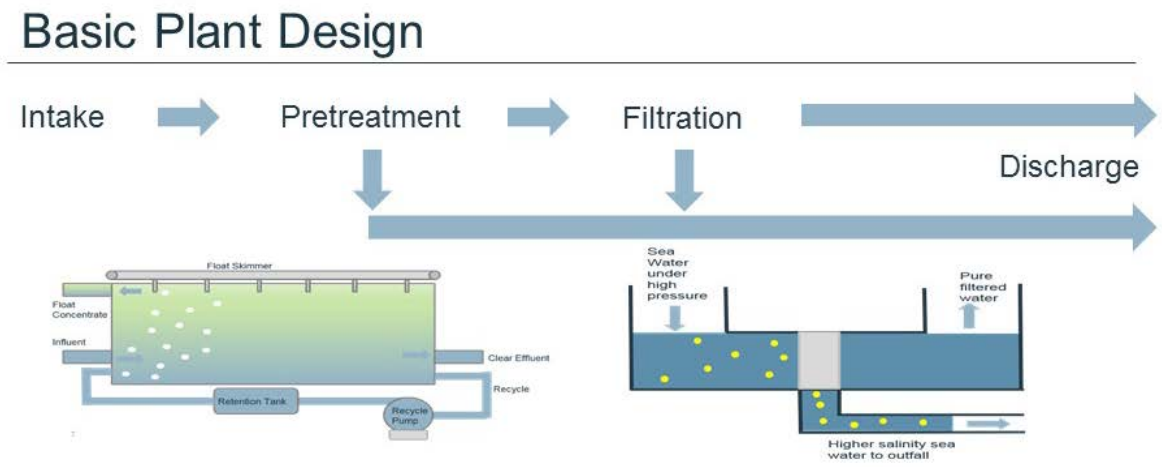
A desalination plant essentially removes the salt and other components from seawater in order that it can be used for industrial or potable water purposes. The process used to remove the salts and other components is a multi-phase filtering process that ends with

reverse osmosis. Reverse osmosis utilizes an ultra-fine membrane through which the water is forced to filter it. Reverse osmosis desalination is different than thermal desalination in that the latter uses heat to evaporate water and leaves behind the salt. The proposed desalination technology discussed by stakeholders for Corpus Christi and the PCCA permit applications was all based on reverse osmosis. A good review of the reverse osmosis desalination process can be found at https://adventure.howstuffworks.com/survival/gear/reverse-osmosis-desalinators3.htm.

PCCA and Coastal Bend Bays and Estuaries Program (CBBEP) staff were provided the opportunity in April 2017 to tour the Carlsbad Desalination Plant in Carlsbad, California. This is a 50 Million Gallon per day (MGD) plant located in San Diego County. Additional information on the desalination process can be found on their web page at https://www.carlsbaddesal.com.

As shown in Figure 1, in a reverse osmosis desalination process, seawater is drawn in through an intake structure and undergoes pretreatment and filtration through reverse osmosis. The purified water is then sent through a water distribution system for consumption and the concentrated high-salinity sea water (brine) is directed back to the bay system. Proper mixing of brine in the bay system is necessary to avoid impacts on marine life and the environment.

FIGURE 1 - OVERVIEW OF DESALINATION PROCESS



Permitting Overview

There are several permits necessary for construction and operation of a desalination plant. Permitting also requires an entity to demonstrate control or ownership of the property on which the proposed site is to be located. Following are the list of long lead permits that are necessary in order to commence construction of a plant, not including the associated infrastructure (David R. Hoffman, Project Update Memo, 2017) (Correspondence From City of Corpus Christi to Freese Nichols, Inc., 2017):

- Texas Commission on Environmental Quality (TCEQ) Marine Seawater Desalination Permit (TCEQ-20775/20776) for discharges offshore or TCEQ Texas Pollution Discharge Elimination System (TPDES) (TCEQ-10411) for discharges nearshore[1].
- TCEQ Water Rights Permits (Texas Water Code Chapters 5, 11, and 12) for withdrawal of surface water for any purpose.
- U.S. Army Corp of Engineers (COE) Section 404 Standard Permit, Section 10 of the Rivers and Harbors Act of 1899 for structures in water of the United States.

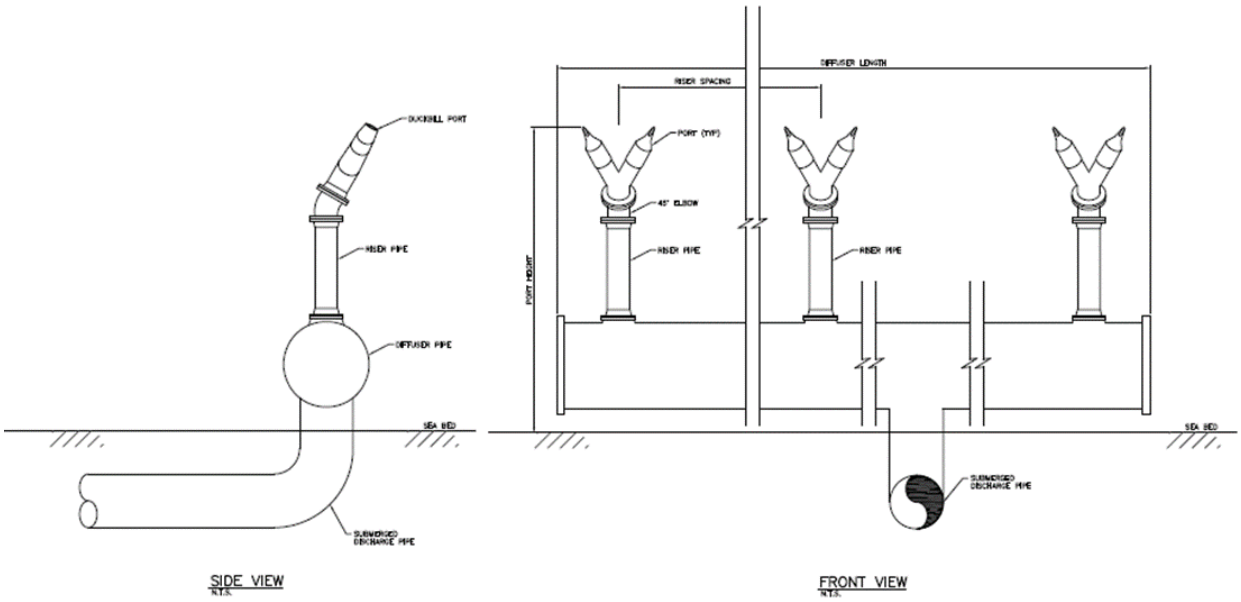
Permitting Strategy

Due to the nature of the permits required, the elements required for the individual permits, and the sequencing of the development of the information needed for the application, the PCCA determined it was necessary to pursue the TPDES permit for both locations first prior to the water rights or the COE permits. On July 26, 2017, PCCA and Amec Foster Wheeler met with TCEQ staff to determine the appropriate permitting mechanism. Freese and Nichols completed a feasibility study for the City of Corpus Christi, and considerations for intake and outfall structures and associated pipelines concluded inshore discharge as the most feasible alternative. During the meeting with TCEQ staff, the TPDES permit route was determined to be the most appropriate permit application process for the discharge.

The permit applications for each property were prepared in 2017. The permit applications were initiated with the intent for a 10 million gallon a day (MGD) plant at La Quinta and a 20 MGD plant at Harbor Island. Upon further discussions with stakeholders about the region's water capacity and projected needs, the applications were modified for a 30 MGD and a 50 MGD plant at La Quinta and Harbor Island, respectively. The plants would not be constructed to full capacity initially; instead they would be constructed in incremental phases. The intake and discharge structures, however, would be permitted and sized for the full buildout for efficiency and planning purposes. An effluent diffuser was proposed for both locations to aid in dissipation of the brine discharge back into the bay system. Figure 2 below illustrates diffuser technology.

[1] Offshore is defined as 3 or more miles seaward of any Texas Coast and nearshore is defined as less than three miles seaward from any Texas Coast. (Rogers, 2016)

FIGURE 2 - OVERVIEW OF DIFFUSER TECHNOLOGY



Prior to submittal, the final TPDES permit applications were reviewed with various stakeholders, including staff and/or members of Port Industry, City of Corpus Christi, San Patricio Municipal Water District, Coastal Bend Bays & Estuaries Program, and Corpus Christi Economic Development Corporation, Freese and Nichols, Arroyo Consulting, and third-party desalination vendors.

On March 20, 2018, two TPDES permit applications were submitted to the TCEQ for review following a pre-application meeting with TCEQ staff members. The administrative completeness and request for the first public notice for the permit application for the La Quinta permit application was received on April 20, 2018. Public notice for the La Quinta property was initiated on May 17, 2018, and lasted 30 days. The administrative completeness and request for the public notice for the Harbor Island permit application was received on June 26, 2018. Public notice for the Harbor Island property was initiated on July 25, 2018. Upon completion of the public notice process, PCCA will submit additional information as requested by the TCEQ to clarify and address public comments on both permits and will work with the TCEQ staff in review of the draft TPDES permit. A second public notice is expected following development of the draft permit.

Subsequent to the La Quinta public notice, PCCA and Wood began meeting with the Texas Parks & Wildlife Department (TPWD) and other stakeholders on both permit applications. Planning for the final location of diffusers and the intake structures and the correct type of intake structure was initiated in June with the approval of the contract with Wood by the Port Commission. Wood is explicitly tasked with identifying design alternative(s) that will avoid significant impacts to bay flora, fauna, and habitats. This process is ongoing and will conclude with the development of the water rights permit application and the information necessary to start the COE permit application process.

Given the potential concerns with the intake structure development, PCCA and Wood have already scheduled meetings with TPWD, University of Texas Marine Science Institute, and the Coastal Bend Bays & Estuaries Program and are currently coordinating meetings with other organizations such as the Harte Research Institute, Coastal Conservation Association, and Saltwater-Fisheries Enhancement Association. The intent of these meetings is to get input in the design of the intake structure prior to developing the permit applications. The Port is committed to incorporating the best available science from the local research community into the planning and design of this facility.

Technical Details of the Proposed Discharges

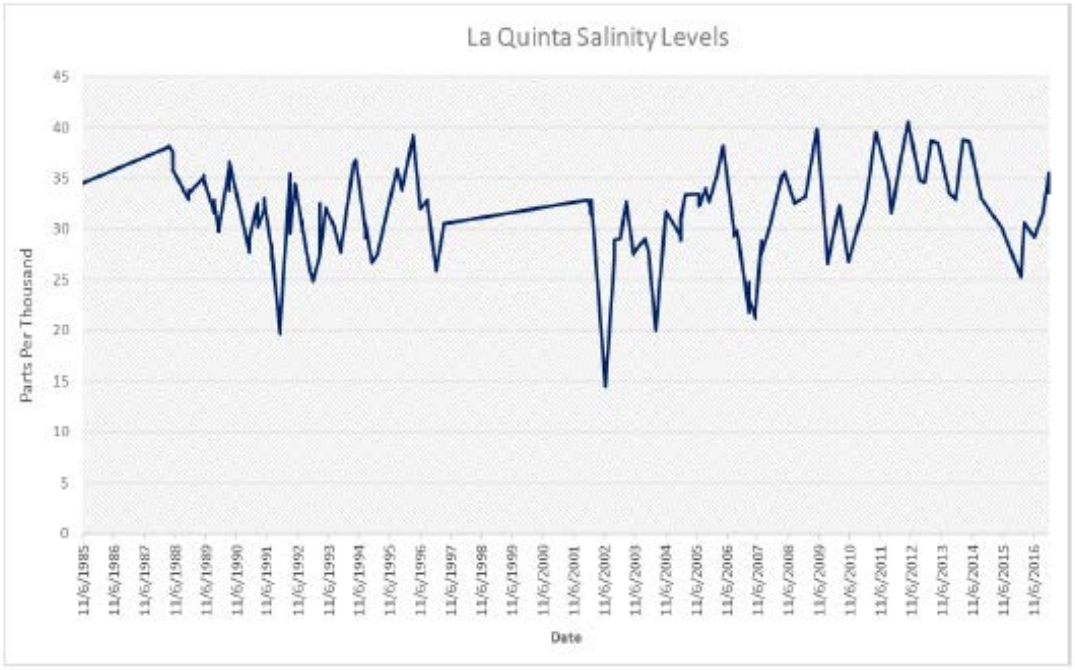
The TPDES permit applications for the 30 MGD and 50 MGD desalination plants at La Quinta and Harbor Island, respectively, were developed based on an estimated 40% - 50% efficiency of the reverse osmosis process. There is no chemical or thermal pollution introduced in the reverse osmosis desalination process and any biofoulants used in the process are expected to be neutralized before reverse osmosis; the only pollutant in the discharge is brine. Below is a table outlining the discharge volumes associated with the two desalination plants.

TABLE 1. DESALINATION FACILITY WATER BALANCE

FACILITY	***INTAKE (MGD)***	***TREATED WATER (MGD)***	***RO REJECT (MGD)***	***SLUDGE TO LANDFILL (MGD)***	***OTHER WASTEWATER (MGD)***	***TOTAL WASTEWATER DISCHARGE (MGD)***
La Quinta	90.4	30	45	3.1	12.3	**57.3**
Harbor Island	150.7	50	75	5.1	20.6	**95.6**

Salinity is the measure of how much salt is present in a unit of water. The average sea water salinity in Corpus Christi Bay is 30 parts per thousand (ppt). However, the salinity level is highly variable, ranging from 15 to 40 ppt, due to erratic rainfall patterns and variable freshwater inflows. The below Figure 3 demonstrates the variable salinity over time based on data obtained from Buoy 13409 near La Quinta (TCEQ, 2017).

FIGURE 3 – VARIABLE SALINITY DATA FOR CORPUS CHRISTI BAY



Note: Data from Buoy 13409

In addition to increased salinity, any naturally occurring metals present in the intake water will become concentrated in the brine discharge. No issues with metals are expected, however; it is customary for TCEQ to require sampling and analyses after startup to confirm no issues exist. PCCA and Wood are prepared to perform sampling and analysis as a permit condition at the beginning of the discharge and throughout the operation of the plants.

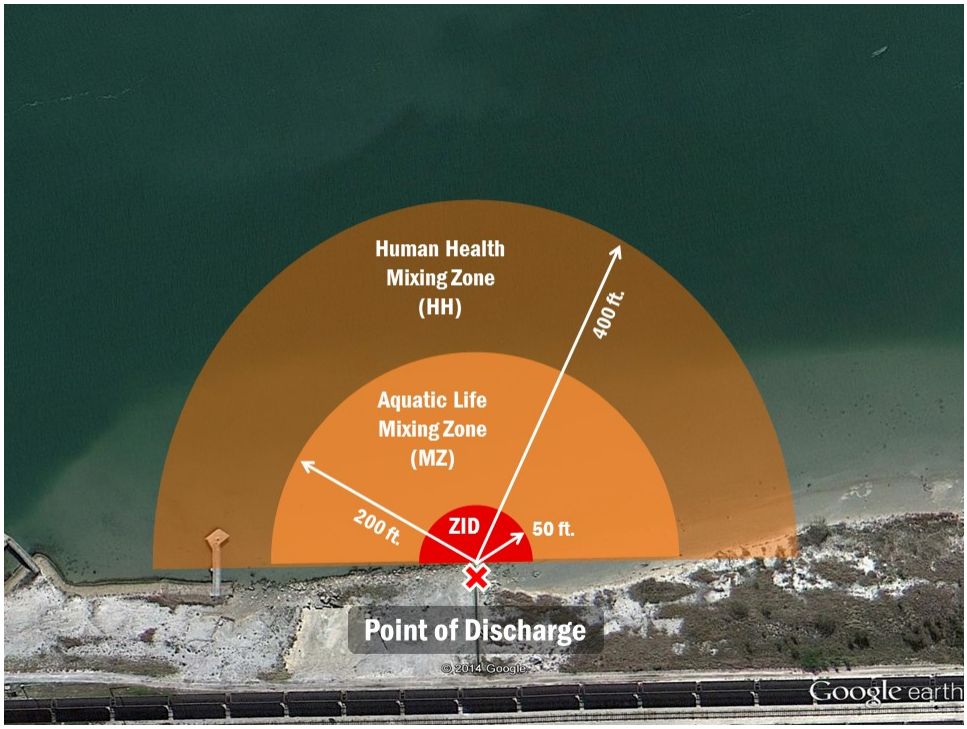
Brine discharges, if not managed properly, may create a salt water lens that can sink to the floor of the receiving water body due to density difference. When vertical mixing of the water column is limited, surface exchange of oxygen is also limited. As a result, oxygen may be depleted (hypoxia) or absent (anoxia) in certain zones of the water column. These conditions represent a reduction in available habitat and may impact flora and fauna. Some of the other documented impacts associated with improperly managed brine discharges into seawater are (Pilar Palomar and Inigo J. Losado, 2011):

- Impacts on plankton by causing a drop in osmotic pressure
- Impacts on fish
- Impacts on seagrasses and algae due to turbidity of the brine presence.

Due to the depth of the channel in which both proposed discharges would occur and the fact that sea grasses cannot survive at these water depths, the impacts to sea grasses do not apply in this situation. Ecosystem impacts from the discharge will be further mitigated by targeting previously impacted location alternatives with relatively diminished habitat value and/or high flow rates which, in combination with the use of diffuser

technology, will reduce the potential for salinity impacts (Sabine Lattermann and Thomas Hopner, 2013). A study completed in association with the variable salinity desalination demonstration project by the City of Corpus Christi, also concluded that the issues of brine discharge when using an outfall pipe were least favorable in the area of La Quinta because of the risk of creating a hypoxic zone around the discharge, but this was completely mitigated through the use of a diffuser (Greg Stunz (Intakes) and Paul Montagna (Discharges), 2015).

Modeling of the brine discharge was conducted by Wood using the TCEQ approved CORMIX® Model which is a proprietary program used for mixing zone analysis. The CORMIX®Model was also subsidized by the U.S. Environment Protection Agency. The CORMIX® Model establishes three different zones for evaluating the mixing of the discharge in the receiving water: zone of initial dilution (ZID), aquatic life mixing zone (MZ), and human health mixing zone (HHMZ). Figure 4 below provides an example representation of the mixing zones and the associated distances for such mixing zones as per TCEQ guidance for modeling discharges. The ZID is a small area immediately adjacent to the point of discharge and discharges in this area are not to be lethal to aquatic organisms and may not impede migration of aquatic organisms. Within the MZ, the acute aquatic life criteria apply and chronic aquatic life criteria apply at the edge of the MZ. Within the HHMZ, chronic aquatic life criteria and human health criteria apply at the edge of the HHMZ. Further, with regard to acute and chronic criteria, this relates to a measurement of acute and chronic toxicity. Acute toxicity is a representation of the adverse effects of a substance from either single exposure or multiple exposures over a short duration and chronic toxicity is a representation of the adverse effects of a substance resulting from long term exposures. (Borski, 2016)



(Taken from Power Point Presentation by Jeff Borski)

The modeling for the PCCA permit applications used the salinity data referenced earlier in this paper and concluded that through the implementation of a diffuser, as proposed in the PCCA's applications, it is possible to achieve the target mixing performance at the selected design production rate and at the 40-50% recovery rate. Specifically, the salinity of approximately 1% of background (background is 30 ppt, one percent is 30.3 ppt) could be accomplished within the ZID (at 50 feet from the diffuser) for both the Harbor Island and La Quinta locations (Wood Environment and Infrastructure Solutions, Inc., 2018).

TCEQ has identified the target mixing performance, required to be achieved and demonstrated through modeling, which are 2.5% at the ZID, 1% at the MZ, and 0.80% at the HHMZ. Table 2 and 3 below demonstrate the actual modeled mixing results, which are below the required TCEQ target mixing rates, for the various diffuser design alternatives for Harbor Island and La Quinta, respectively.

TABLE 2 - EFFLUENT PERCENTAGES AT ZID, MZ, AND HH MIXING ZONES (%) IN HARBOR ISLAND PLANT DIFFUSER AT 50% RO RECOVERY

Design Alternative	***Initial Dilution***	***Aquatic Mixing Zone***	***Human Health Mixing Zone***
1	1.01	0.534	0.467
2	1.01	0.536	0.467
3	1.01	0.575	0.504
4	1.01	0.541	0.472
5	1.01	0.575	0.504

TABLE 3 - EFFLUENT PERCENTAGES AT ZID, MZ, AND HH MIXING ZONES (%) IN LA QUINTA PLANT DIFFUSER AT 50% RO RECOVERY

Design Alternative	***Initial Dilution***	***Aquatic Mixing Zone***	***Human Health Mixing Zone***
3	1.00	0.693	0.605
4	0.998	0.693	0.605
6	1.00	0.690	0.604

As demonstrated above, when a diffuser is used to discharge the brine at an appropriate rate to optimize mixing within the ZID, impacts to plankton, fish, and adjacent shallow areas of sea grasses are non-existent. This is further substantiated by the conservative assumptions used to model the performance of the diffuser at both locations.

Some additional considerations for mitigation measures include preventative measures for red tide occurrences caused by red algal blooms as well as further dilution of the brine prior to discharge. Red tide outbreaks in the bay system could create potential health exposure issues if drawn in through the intake structure. This is typically mitigated operationally through shut down of the plant during red tide outbreaks. Another mitigation

measure to dilute the brine prior to discharge is to co-mingle the discharge with other nearby permitted wastewater discharges. For planning and permitting purposes, it is most efficient to plan for the worst-case discharge in the event that the co-mingled sources have variable daily discharge rates.

Finally, the TPWD expresses a concern over using salinity and current data that doesn't represent the entire water column. The use of the collected surface water data that was used in PCCA permit applications had limitations. Publicly available current data was also used in the permit in the absence of actual data. In addition, a significantly lower current rate was utilized to be conservative. However, to address both of these concerns, PCCA is attempting to find additional sources for actual salinity and current data at depth. PCCA and Wood are awaiting additional salinity data from Conrad Blutcher Institute that is being obtained through another project and will request data from University of Texas Marine Science Institute, if available, for the currents. These data for salinity and current across the full water column will then be incorporated into the CORMIX model.

Next Steps

PCCA and Wood will continue to work with TCEQ staff in addressing public comments received during the Public Notice for both permit applications for the discharge.

PCCA and Wood will also continue to reach out to stakeholders to identify the concerns related to the intake structure and obtain available research and studies. This information will inform the development of the proposed intake structures and subsequent water rights permit application to the TCEQ. The coordination with stakeholders on the intake structures for both La Quinta and Harbor Island is expected to continue through mid-October with final development of the draft permit applications by early November. As before with the discharge permits, the draft permit applications will be reviewed with key stakeholders prior to submitting to the TCEQ.

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