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Of Counsel:
Richard Lowerre

April 8, 2019

Ms. Bridget Bohac,
Chief Clerk, MC-105
Texas Commission on Environmental Quality
P.O. Box 13087
Austin, Texas 78711

http://www14.tceq.texas.gov/epic/eComment/

Re: Comments and Request for Contested Case Hearing on the Application by the Port of Corpus Christi Authority of Nueces County for TPDES Permit No. WQ0005253000 for a Desalination Facility in Port Aransas, Texas

Dear Ms. Bohac:

On behalf of the Port Aransas Conservancy ("PAC") and a number of owners of property in Port Aransas, I am filing this letter and the attached set of comments and issues in support of their request for a contested case hearing for the above referenced application. The PAC and the landowners also incorporate by reference their prior comments and those of the City of Port Aransas and the Coastal Conservation Association for the purposes of any determination of whether they are "affected persons," and for any determination of the issues to be addressed in a contested case hearing.

Please use my name, mailing address, and phone number above for all communications with the PAC and these individuals on this matter.

The Port Aransas Conservancy is a non-profit corporation with members who live or own property in or near the City of Port Aransas. The members include James and Tammy King, Sam and Sarah Steves, Edward and Nancy Steves, Jack and Valerie Guenther, Mary Abell, and Bill and Kathy Mays Johnson, all of whom are clearly affected by the proposed desalination facility. The purpose of the PAC is to foster a balance of conservation and economically sustainable uses for Port Aransas and its surrounding neighborhood and waterways while recognizing that their community and economy is dependent on tourism and fisheries within a healthy barrier island coastal ecosystem. The Conservancy requests a contested case hearing and to be named a party in the contested case hearing to represent its members.

The individual landowners and their interests are identified below. Each of them requests a contested case hearing and to be named as a party to the hearing. These individuals are willing to be aligned with each other and to be aligned with the PAC.

James and Tammy King own property at 1004 Private Road C, Port Aransas, Texas 78373, which is located in a private marina between the Corpus Christi Ship Channel and Channelview Drive near the University of Texas Marine Institute. Their property is within one-half mile of the proposed desalination facility, and within about one-quarter mile of the proposed outfall. They also own Bay Tree

Condominium, 900 Station Street, Unit B 13-14, Port Aransas, Texas 78373, which is located within the Clines-Bay Tree Marina with direct access into the Corpus Christi Ship Channel, and is also within one-half mile of the proposed facility.

The King family has owned a number of homes over the years in Port Aransas, and they use their current home on Private Road C frequently as a second home and retreat for their family and friends. There, the Kings have a boat barn located on their property where their family keeps three boats which are used regularly for recreation, fishing, and accessing the bays, estuaries and the gulf through the waters of the ship channel. They also keep several kayaks that are used for flats fishing in the Lighthouse Lakes next to Harbor Island and other estuaries in the region. The private marina has a home owners association in which the Kings own an interest. That marina owns common land along the ship channel where owners fish and recreate.

The Kings use their Bay Tree Condominium as an investment property with rentals in the HOA's rental pool, as well as for guests and friends who visit Port Aransas. There are a number of boat slips, a lighted fishing pier, a fish cleaning station, a swimming pool, and a common area on the marina. It is possible to see the lighthouse in Lydia Ann Channel from the condominium. The property is also used for boat access to the entire area bay system and the Gulf of Mexico for recreation and fishing.

Sam and Sarah Steves own 231 Port A, LLC, which owns property directly across the ship channel from the outfall and the desalination plant. They own five separate properties that are listed as one and identified as property No. 27 on the original adjacent landowner map in the application. That property includes 243 Turtle Cove and 231 Turtle Cove, Port Aransas, Texas 78373 both of which are adjacent to the ship channel.

Edward and Nancy Steves co-own the property at 243 Turtle Cove.

The Steves' families or their guests are commonly at their properties in Port Aransas weekly, although, like the other individuals, their uses of their properties have been recently curtailed because of the damage caused by Hurricane Harvey. The Steves, their families and their guests historically have fished from their property in the ship channel. They have taken their kayaks, their bay boat and their ocean boat through the ship channel into the bays and into the ocean. They intend to use their property for such recreational activities in the future.

Mary Abell is the general partner for Abell Realty Limited Partnership, which owns 224 Turtle Cove, Port Aransas, Texas 78373, shown as property No. 33 on the applicant's original adjacent landowner map. It is adjacent to the water and is directly across from Harbor Island. Ms. Abell is an avid angler and fishes from the jetty on her property and from her boat which she takes through the ship channel. She is also a duck hunter and has hunted near Harbor Island in Lydia Ann Channel.

Jack Guenther Sr., Jack Guenther Jr. and Valerie Guenther own the properties at 201 and 221 Turtle Cove, Port Aransas, Texas 78373, which are shown as property No. 35 on the applicant's original adjacent landowner map. Despite owning property shown on the map, the Guenthers did not receive mailed notice of the application. Their properties are adjacent to the ship channel and are directly across from the proposed facility. The properties are in the name of Guenther Life Insurance Trust, and Jack Guenther Jr. is the Trustee. The properties are used by the Guenthers and their families for recreation, including fishing and boating in the ship channel and in the bays and Gulf of Mexico.

Bill and Kathy Mays Johnson own several condominiums at Clines Landing, specifically Units #410 and #217. Both units are close to, if not within, one-quarter mile from the location of the proposed discharge facilities in the ship Channel. The Johnsons use their properties regularly and own a boat there which they use for fishing. The also fish from in front of their properties in the ship channel. The Johnsons did not receive mailed notice of the application.

In brief, the Port Aransas Conservancy and the individuals listed above oppose the proposed permit and the associated desalination facility, because these increase the risks of damage to the environment from which the Conservancy's members and the individuals draw many of the benefits of property ownership on and near the channel. Furthermore, this increased risk adversely impacts their property values, the economic basis for the area (tourism), and the general marine environment.

Sincerely,

Richard Lowerre

Cc:

Mr. Vic McWherter, Office of Public Interest Counsel, TCEQ, via email:vic.mcwherter@tceq.texas.gov

Ms. Sarah L. Garza, director of Environmental Planning, Port of Corpus Christi Authority of Nueces County, Texas, P.O. Box 1541, Corpus Christi, Texas 78403

Mr. Charles Maguire, Director of the Water Division, EPA, Region 6, 1445 Ross Avenue, Suite 1200, Dallas, Texas 75202

Comments and Issues That Need to Be Addressed

The desalination facility proposed by the Port of Corpus Christi Authority of Nueces County (hereinafter, POCC) would, if authorized, have significant impacts on the marine environment, the economic foundations of the area, nearby private landowners and the public. POCC has not, however, provided TCEQ and the public with the information needed to evaluate the impacts of the proposed desalination facility.

In summary, because of the lack of experience by POCC and TCEQ with the type of facility proposed and the complexity of the issues, TCEQ should require POCC to present significant additional information, including independent modeling, on the potential impacts of the proposed treatment, based on a more complete presentation of the facility and factors that will affect its operations and the quality of the wastewaters to be discharged. The additional analysis should be based on a number of factors discussed below, including but not limited to:

1. the specific locations, elevations and design of the intake structures, since those factors will affect the composition of source water;[1]
2. the details of the desalination process: for example, whether the facility would be designed for a 40% recovery RO process or a 50% recovery RO process; the composition of the 22% (assuming 40% RO recovery) of the effluent containing “coagulants” and “flocculants” and bleach (sodium hypochlorite), and the plan for managing effluent when facility operations (40% recovery RO process) are producing fewer than 35 MGD of product water;[2]
3. the range of conditions that will affect how the discharge will move and disperse with the tides, during slack tides, with differing temperatures and stratification of the water column, and the existing conditions at the discharge locations now;
4. the foreseeable changes in the contours and ship traffic load of the channel in which the discharge structure is proposed;
5. the actual impacts on the nearby property owners, including reduced property values, nuisance odors, and other nuisance conditions that will result from POCC’s operations; and
6. the actual impacts on the economic health of the affected community, including the level of tourism that will be lost due to the location of the facility.

In addition, TCEQ should either return the Application to POCC or require POCC to correct errors in the Application and require a showing of plans to actually construct the facility. As discussed below, it appears that POCC is speculating in this permitting process, possibly so it can sell the permit in the future. Moreover, the revisions to the Application should include the

[1] An example of the analysis needed is provided in “Identification and Characterization of Potential Environmental Impacts Mitigation Measures Related to Intake and Discharge Facilities of Seawater Desalination Plants Variable Salinity Desalination Demonstration Project,” for the City of Corpus Christi. 10 July 2015, By Greg Stunz (intakes) and Paul Montagna (discharges) Harte Research Institute for Gulf of Mexico Studies, Texas A&M University-Corpus Christi, a copy of which is attached.

[2] See the Application’s “Brine Discharge Mixing Analysis,” Figure 7 and Table 10.

conflicts and cumulative impacts of POCC's other proposed projects, such as dredging the ship channel to a depth of 75 feet or more and its proposal to construct a port at the location of the discharge structures for the desalination facility.

Comments on Procedures:

1. Speculation.

   POCC has stated in essence that it has no current plans to construct a desalination plan, but that it expects a future need. It has admitted in the Application that it has not even begun the process to obtain the Section 404 permit from the U.S. Army Corps of Engineers that it will need.

   Yet, TCEQ and the public will be required to expend resources on this project which may never be needed or constructed. Worse, the POCC may be seeking a permit that it can sell in the future, if there is a need.

   Moreover, POCC is working on proposals for dredging of the ship channel deeper than it is now and for the construction of a new port facility for very large crude carriers or "VLCCs," which will be at the location of the discharge structures for the desalination facility. Thus, POCC will have to amend any permit it would receive in this proceeding to address the conflict with the port with the discharge location and depth. The change in locations will affect the mixing zone and impacts and nearby marine communities.

   TCEQ should return the Application to POCC or require amendments to the Application for POCC's failure to present these facts, which constitute misrepresentations or omissions of material facts, in violation of the agency rules at 30 TAC § 305.66.

2. Lack of needed Application requirements.

   The Application by the POCC may be the first Application for a seawater desalination facility in Texas. As a result, TCEQ has not developed for desalination permits the type of requirements it has for many other Applications for TPDES permits.

   For example, TCEQ's Application includes special requirements for aquaculture, including the identification of features in and around the proposed site, including nursery habitat, bird roosts, recreational use and other such activities or conditions that may be impacted. Likewise, TCEQ's Application has special requirements for power plants and other facilities using cooling water. Those Applications must include information on location and design of intake structures to allow evaluation of the impacts on the environment. Such requirements are added because of the legal and practical requirements for TCEQ's analyses of the impact of facilities seeking TPDES permits. TCEQ is authorized to require the submission of any "other information as reasonably may be required by the executive director for an adequate understanding of the project or operation. . ."[3]

[3] 30 TAC §305.45. Contents of Application for Permit.

Because of the lack of experience with seawater desalination facilities, the scale of the proposed project, the sensitivity of the receiving waters, and the precedent that will be set by this Application, TCEQ should require the type of additional information it has required for aquaculture along the Texas coast, for cooling water intake structures, and for types of facilities that provide analogous risks to marine communities.

3. Errors in the Application.

POCC's Application has numerous errors, i.e., misrepresentations of material facts, for which TCEQ is authorized to deny or revoke the permit.[4] Moreover, the representations in the Application, including the errors, would be incorporated into the permit if it is issued. TCEQ should require POCC to make significant amendments to the Application.

For example, the Application erroneously states that there are no sea grasses or oyster beds in the vicinity, in other words, that could be affected.[5] The Application references an old FEMA map for its floodplain analysis,[6] knowing that after hurricane Harvey those maps are outdated and that the area of the facility has flooded and will flood again during 100-year flood events.

Likewise, POCC did not check the boxes for the characteristics of the water body, including the fact that the area receives agricultural runoff, is used for fishing, contact recreation, navigation, picnic park activities and other such uses.[7]

The Application does not include information required in TCEQ rules, including a map "which shows the facility and **each of its intake and discharge structures** and any other structure or location regarding the regulated facility and associated activities."[8]

Of particular concern for public participation are the errors in identifying potentially affected persons who should receive mailed notice. TCEQ advised POCC at least twice that it had not properly identified the affected landowners for purposes of mailed public notice. After two attempts to correct the problem, the Application continues to be in error. Part of this problem is identifying the distance from the facility to landowners who could be affected and should receive mailed notice. TCEQ rules require the distance to be from the "proposed point or point of discharge."[9] Those points apparently could be placed be anywhere in the ship channel 300 to 600 feet from the shore of Harbor Island,[10] although the Application indicates elsewhere that it will likely be approximately 300 feet from the shore.

[4] 30 TAC §305.66.

[5] Technical Report, page 45.

[6] Technical Report, page 2.

[7] Technical Report, page 47.

[8] 30 TAC §305.45(a)(6).

[9] *Id.*, Subsection D.

[10] Appendix A, page 10 (Brine Discharge Mixing Analysis).

In any case, there are many affected landowners within one quarter of a mile from the facility and points of discharge, even more within the one-half mile distance that, at a minimum, should have been used because of the collection and storage of sludge that will be a significant source of odors. The one mile radius should have been the proper area for such mailed notice, given all the impacts on nearby properties.

In addition, the Application has other errors, e.g., reporting at one point that the temperature of the receiving water could be 14-32 degrees Fahrenheit and elsewhere 13 to 34 degrees Celsius. The Application also fails to provide information or provides false information on a number of issues: the presence of sea grasses and oyster reefs, the fact that the salinity data are not from the area where the intake structures will be, and the plans promoted by POCC to dredge the ship channel to 75 feet, if not more, and build a new port at the location of the discharge structures. POCC apparently has even provided incorrect coordinates for the location of its facility.

4. Improper public notice.

As a result of failure to provide a correct landowner map and list, a number of landowners never received notice of the Application. As with the individual commenters here, many owners of these residences use them as vacation homes or rentals and do not live in Port Aransas where newspaper notice would be published. The requirement for mailed notice is a jurisdictional matter, and failure of POCC to comply with the requirements should result in, at least, an amendment to the Application and new public notice. Moreover, the delay in the Application process has potentially resulted in changes in ownership of properties that will be affected, again denying owners notice of this opportunity to comment and of the future opportunity to request a contested case hearing.

5. Antidegradation: absence of analysis and required data.

The TCEQ's "tier 2" antidegradation provision, found in 30 TAC § 307.5(b)(2), prohibits effluent discharges that would lower the quality of fishable/swimmable waters, such as the waters to which POCC proposes to discharge, by more than a *de minimis* extent, unless certain justifications are provided. POCC has not provided the justifications, and it has not provided the data necessary for it or TCEQ to conduct the necessary antidegradation analysis.

In particular, the POCC Technical Report is badly deficient in its description of the receiving waters for the discharge. Worksheet 4.0 of the Technical Report does not indicate the width of the receiving water to which Attachment 6 (at Attachment 3) and Attachment 9 show the discharge. (Neither of these attachments reflects a diffuser, while, elsewhere (see, the SPIF), there is described a 300-foot extension to a diffuser.) The proximity of grasses and oyster reefs to the outfall point is not provided. On page 4, in the Process Design Basis and Narrative portion of the Application, POCC claims effluent will increase the ambient salinity concentration less than 1% beyond the initial mixing zone.[11] POCC deems this increase "insignificant," but POCC presents no data or analysis to support that conclusion, and it is not at all clear what POCC means when it talks of "salinity." Table 2 certainly reflects very large differences between background water and effluent concentrations of chemicals and ions such as magnesium, sulfate, nitrate, silicon dioxide and boron.

The Application includes no information regarding the assimilative capacity of the receiving waters, either with or without the VLCC port or the deepened channel. The State's water quality standards implementation procedures (RG-194) specify that the applicable date for establishing baseline water quality conditions is November 28, 1975, in accordance with 40 CFR Part 131 (EPA standards regulation). POCC has provided no information concerning conditions in the vicinity of the proposed effluent discharge in 1975 and, as noted, POCC has provided no antidegradation analysis based on any baseline date, in any event.

Comments on Impacts:

6. Impacts from the design and location of the intake structures.

Because the location and design of the intake structure will affect the make-up of both the water subject to desalination and the discharged water, TCEQ should require POCC to present in its Application both the location of the intake structures and their design. Neither was provided in the Application and neither has been taken into account in the modeling of the desalination operations and resulting concentration of the salts and other constituents of the water taken in for desalination.

The location and design of the intake structures are significant for a number of reasons, including but not limited to:

1. the difference in the salinity depending upon the location in a bay, in the ship channel or in the ocean, and

2. the quantity of entrained larvae, eggs and other organic materials that move with the water, that cannot swim from or be screened out of the water that is taken in and, thus, affect desalination operations. The extent of such organic material will not only affect the populations of fish and shell fish but also affect the characteristics of the sludge and the extent of nuisance odors from handling the sludges. Location of the intake is significant because, during the ebb tides, significant numbers of larvae will pass through the ship channel and past any intake structures there. A significant percentage of those larvae and eggs will again move by the intake structure during neap tides.

Considerations of the impacts of intake structures are required during evaluations of discharge permits for steam electric power plants and other facilities using taking in large

[11] The claim of 1% salinity increase is, itself, an unsupportable generalization, given the range of concentrations modeled across the various scenarios for RO efficiency and output product flow rates. Also, the decision to use the ZID as the figure of merit for effluent salinity analysis is not explained. The decision to reconfigure the shape of the perimeter of the ZID from circular to rectangular is also not justified.

quantities of water for cooling purposes. The justification used there for requiring evaluations of the intake structures on the aquatic and marine communities is valid for the intake for seawater desalination facilities.

The list of species whose eggs and/or larvae move through the tidal inlet in their passage from offshore spawning areas to the estuarine nursery sites is provided below. This life-cycle strategy is often referred to as "Estuarine Dependent Marine Species" and, while the details differ among species, the general concept is the same: the larvae (which may range from neutrally buoyant to weakly swimming stages) are exposed to entrainment from an intake system located in the inlet. If a similar intake system were placed farther up in the estuary, the larvae of these same species are less vulnerable to entrainment since they either settle to the bottom or have at least grown to a stage where they might actually swim away from a properly designed intake, thus avoiding impingement:

White Shrimp
Brown Shrimp
Blue Crab
Red Drum (redfish)
Atlantic Croaker
Sand Trout
Gulf Menhaden
Striped Mullet
White Mullet
Southern Flounder

Other species spawn inside the estuary as well as nearshore or even in the inlets. Thus, their populations could be affected by the intake structures, but they will also be affected by the discharges discussed below. Those additional species include:

Black Drum
Spotted Seatrout (speckled trout)
Silver Perch
Anchovy
Sheepshead
Scaled Sardine
Atlantic Threadherring.

7. <u>Impacts due to the design for desalination and treatment of the water to be discharged.</u>

The Application materials repeatedly note that the optimum design of the facility varies as a function of the RO efficiency achieved and the MDG product, i.e., saleable "fresh" water, output. As far as commenters can determine, neither POCC nor TCEQ properly evaluated the chemical composition or plume dispersion characteristics of the water that will be discharged under the target facility operating scenario or, certainly, during facility startup, shutdown and intermediate maintenance conditions.

One issue is the failure to consider the constituents in the source water, and those chemicals added to enhance desalination, prevent or remove scale in the pipes and other equipment, and for water treatment processes before the water is discharged. While the permit may only need a limited number or limits on representative constituents in the discharge, POCC should be required to identify all constituents that could change water quality or adversely affect the benthic and other marine communities. POCC should be required to have background levels in the receiving waters for all such constituents near the bottom of the ship channel, where the denser brines are likely to settle. They should also have plans for monitoring them before release and also in the mixing zone to verify the theoretical modeling.

That monitoring of the actual mixing zone is also important because of the assumptions about the conditions at the discharge locations and the issue of the size and shape of the mixing zone. The change from circles or spheres to rectangles or boxes for the shape is an issue. There is no justification for either, especially given the changes in the flows of the tides, temperature variations and ship movements. For example, the conditions in the ship channel at slack tides and the variation in stratification of the water column was also not properly taken into effect. There is also the issue of the proposed deepening of the channel.

Without significant more work, the impacts of the effluent cannot be properly evaluated or properly monitored. There is also no plan for adequate monitoring to determine if the modeling or other evaluations represent what will actually occur, on average or during conditions of maximum impacts.

8. Direct impacts from the design and location of the discharge structures.

While it is likely that the location and design of the discharge structures will change if the facility is ever constructed, the proposal for the location in the Application demonstrates the problems.

The proper modeling of the mixing zone and area of most significant impact was not done due to the changing bathymetry of the ship channel, the movement of large ships through the channel, and the structures currently located or to be located in and around that mixing zone.

Thus, the discharge cannot be evaluated for the likely impacts, including toxic and other impacts from:

- the concentrated brine;
- other constituents of the discharge, including contaminants and organic material in the water taken into the facility and those used for desalination and wastewater treatment process, including Sodium Hypochlorite (NaOCl) chlorine, the chemicals in the coagulants and flocculants which are not identified in the Application and any other chemicals added in the desalination, descaling, and treatment process;
- the temperature of the discharged waters;

- the level of dissolved oxygen in the discharged waters;
- the levels of nutrients in the discharged waters;
- degradation of water quality beyond *de minimus* (the anti-degradation standards); and
- the toxicity of the discharged wastewater.[12]

The potential ranges of constituents and conditions of the discharge waters need to be evaluated for the impacts on benthic communities, benthic organisms in the water column, and on the large marine communities, fish and shellfish. They also need to be evaluated for adverse effects on habitat, including sea grasses in the area.

9. Indirect impacts on fish and wildlife, including endangered species.

With the improper evaluation of the direct impacts of the discharges of wastewaters, the Application does not provide a basis for evaluating the indirect impacts to fish and wildlife species that are dependent on the species which will be directly affected by entrainment through the intake structures and by the quality of the waters that are discharged.

10. Failure of TCEQ to perform or require a proper consistency evaluation under the Texas Coastal Management Program.

Because of the lack of information to evaluate impacts on marine communities and on surrounding properties, TCEQ was not able to perform a proper consistency evaluation and did not properly determine that the proposed project is consistent with goals and policies of the Texas Coastal Management Program, including the purposes of the Program:

- to protect, preserve, restore and enhance the diversity, quality, quantity, functions and values of coastal natural resource areas;
- to ensure sound management of all coastal resources by allowing for compatible economic development and multiple human uses of the coastal zone;
- to ensure and enhance planned public access to and enjoyment of the coastal zone in a manner that is compatible with private property rights and other uses of the coastal zone; and
- to balance the benefits from economic development and multiple human uses of the coastal zone.

This problem is highlighted by the recommendations in the report of the Texas Parks and Wildlife Department and General Land Office of 2018 to the Texas Legislature, Joint Marine Seawater Desalination Study.[13]

[12] POCC should have been required to provide the results of toxicity tests or information on the results of such tests done at similar facilities.

[13] *Available at:* https://tpwd.texas.gov/publications/pwdpubs/media/hb2031dz.pdf

11. Impacts on recreation and the economic foundations of the area.

Likewise, the failure of POCC to provide the needed information and modeling or analysis limits the ability of TCEQ and the public to evaluate properly the impacts on recreational and commercial fishing, on other recreational use of the ship channel, on tourism and on use and enjoyment of nearby residential and commercial properties. Port Aransas is heavily dependent on eco-tourism, with over 5 million visitors per year coming to the area for fishing, bird watching and enjoying the beach.

12. Impacts from POCC's facility siting and location of pipelines.

POCC has not shown that the location of its facility, including the desalination facility, the intake structures and related pipelines, and the discharge structure and related pipelines were properly located to avoid adverse impacts on wetlands, the release of contaminants in the sediments or on land, and cultural resources from historic use of and around Harbor Island.

13. Impacts of nuisance conditions.

POCC has not addressed the extent of or controls for the nuisance conditions its operations will create, including odors, noise and light. The desalination facility is in the city limits of Port Aransas, and the nuisance conditions will affect many more people than are within one-quarter of a mile from the facility. It does not appear that the POCC has made any effort to identify potential nuisance conditions by looking at other seawater desalination facilities or made any effort, such as proper sludge management, to address such conditions.

Comments on Permit Conditions:

Because of POCC's lack of experience with desalination facilities, the relatively new development and use of desalination technologies for marine waters, and the lack of experience by TCEQ in regulating such facilities, the recommendations below are, in some cases, above and beyond TCEQ current practices for standard industrial wastewater facilities. They are, however, justified by the unique nature of this proposal.

14. Waste streams.

Under the 40% RO efficiency and 50 MGD product output scenario, roughly 22% of the effluent to be discharged is generated before the reverse osmosis stage of the desalination process. This part of the discharge is laden with additives that will be used to prepare the intake water for the RO stage treatment. The permit needs to be revised to clearly restrict the waste streams that can be treated or discharged, without a major amendment. Those waste streams should be limited to those that will be created for the specific desalination process proposed in the Application. Any change in the desalination process, including addition of chemicals not listed in the Application and the future use of the discharge pipeline or outfalls for other waste streams, should be strictly prohibited.

15. Discharge location and limits.

The permit needs to specify the location to which each discharge structure is limited so that monitoring of the location and discharges can be done.

The permit needs to be revised to prohibit discharge of chemicals not identified specifically in the Application, and to set strict numerical limits on all constituents that are used at the facility or that may be found in the wastewaters and that could affect the marine environment, including but not limited to:

- heavy metals;
- scale prevention, descaling and other chemicals used for cleaning in the facility or of the intake and discharge structures and related pipelines;
- chemicals use to facilitate desalination; and
- contaminants that may be found in the sediments or water in the location of the intake structures during or after construction of the structures.

The permit needs to be revised to specify and limit the quantities of wastewaters discharged during conditions not modeled for the Application, including conditions of lower than normal low tides and movement of ships past the discharge that affect the mixing or other conditions assumed in evaluating the impacts of discharges.

16. Monitoring.

The permit needs to be revised to require monitoring on all constituents in the wastewaters which could affect the marine environment or sufficient representative constituents, including heavy metals, organic chemicals and nutrients.

Given the precedent setting nature of the POCC application and the lack of experience with the type of discharges proposed, the permit should include provisions for periodic monitoring of water quality to determine if water quality standards are being met and if the discharges are creating adverse impacts on fish, shellfish, sea grasses and benthic communities. These monitoring requirements or opportunities should be available for enforcement by the City of Port Aransas, Nueces County as well as TCEQ, and thus needs to be set out in detail in the Application or the permit.

17. Reporting.

The permit needs to be revised to require timely reporting of all results of monitoring of the intake waters, the discharged water, the receiving waters and toxicity.

The permit needs to be revised to require timely reporting of any violations of any permit condition on the discharge limits, and on monitoring or reporting requirements or any other condition that will allow TCEQ and the City of Port Aransas to address the conditions as soon as needed to avoid adverse impacts.

18. Contingency plans.

POCC should be required to prepare specific and detailed plans for dealing with hurricanes and other significant storm events. Those plans should address the risks of damage to intake and discharge structures and the related pipelines; the risks of damage to the desalination facilities, including sludge storage areas or tanks; or the risks of damage to other equipment which could result in the release of wastewaters at locations other than the authorized discharge locations or in any significant untreated or inadequately wastewaters released from the discharge structures.

APPENDIX A

TM 2.1 – Identification and Characterization of Potential Environmental Impacts Mitigation Measures Related to Intake and Discharge Facilities of Seawater Desalination Plants

Variable Salinity Desalination Demonstration Project
City of Corpus Christi

10 July 2015

By Greg Stunz (intakes) and Paul Montagna (discharges)
Harte Research Institute for Gulf of Mexico Studies
Texas A&M University-Corpus Christi

Introduction

A preliminary overview of the potential environmental impacts and mitigation measures of several pre-determined sites as potential locations for intake and discharge facilities of seawater desalinization plants has been conducted. Below is a summary of those results. Also included in these analyses are matrices that further detail how the recommendations were derived, and there are lists of common species that would likely be impacted based on the current literature available. Certainly, as candidate site selection is conducted and refined, detailed assessments of species and habitat impacts as well as thorough site-specific analyses would need to be performed.

Intake Site Assessment

When considering locations for a desalinization intake site, multiple factors have to be examined. From an ecological standpoint, the biggest concerns are related to impacts that the desalination plant would have on the resident fauna. Two factors that have the most impact are impingement and entrainment. Impingement of larger fish, marine mammals, and sea turtles can reduce the spawning stock biomass due to an increased mortality rate. In addition, entrainment of smaller ichthyoplankton and eggs can reduce recruitment. Despite the known ecological impacts that construction of a desalinization plant creates, directed sampling pre- and post-construction would need to be conducted in order to measure the actual environmental impacts to the selected site. While specific detailed mitigation measures are beyond the scope of this report, all sites with the exception of 2A and 2B (the most environmentally diverse locations) would likely have similar mitigation measures.

Specifically for this study, six candidate intake assessment locations were chosen by Freese and Nichols, Inc. The Harte Research Institute, specifically the Fisheries and Ocean Health Lab was contracted to identify potential environmental impacts of specific intake structures listed for the following locations: two chosen near Broadway WWTP, two near the La Quinta Channel Extension, one offshore in the Gulf of Mexico, and one in the Viola Turning Basin in the Inner Harbor (Figure 1). In the following assessment, the key environmental intake topics of concern will be discussed:

- Impingement of marine life on screens
- Entrainment of marine life in desalinization plant
- Impacts on seagrass and other sensitive marine areas
- Visual impacts and disturbance of coastal uses
- Impacts on coastal wetlands
- Other environmental issues

Overall Recommendations: This section summarizes our opinions on the proposed designs and locations, focusing on those that would minimize the impact to resident fauna and limit degradation or loss of high quality habitat. Under the current proposed plan, the preferred intake type would be either the subsurface directional drilled or subsurface infiltration gallery intakes. Logistical limitations prevent all sites as candidates for these subsurface methods, and our recommendation considers these limitations. While benthic organisms would be impacted during the creation of the subsurface system, once created there would be no freestanding source from which fauna could be impinged or entrained. When taking into account both the sites proposed and the intake types at those locations, a directional drilled intake would be recommended at site 3A as the overall preferred location/intake type. Since the location is outside of Corpus Christi Bay, there would be less impact on ship navigation during construction. This site and intake type combination also would likely have the lowest overall effect on mortality (construction and daily operations). However, we do make alternative recommendations and provide our opinion on the pros and cons of each location. Overall, we recommend the following sites and intake type combinations (in order of preference):

1. Site 3A as a directional drilled intake
2. Site 3A as an infiltration gallery intake
3. Site 1A as a directional drilled intake
4. Site 1A as an infiltration gallery intake
5. Site 3A as a wedgewire intake
6. Site 1A as a wedgewire intake
7. Site 4A as an onshore open intake
8. Site 1B as an onshore open intake
9. Site 2A as an offshore directional drilled intake
10. Site 2A as an offshore infiltration gallery
11. Site 2B as an onshore surface intake

These recommendations are based strictly from an ecological perspective, and in some cases and may not be feasible for the specific plant designs proposed here. Specifically, subsurface intakes are effective if the installation requires less than 15 million-gallon-per-day (mgd) intake capacities (WateReuse Association 2011). For the current intake location assessment, the target capacity is 50 mgd. Given this, while subsurface intakes are ideal regarding their minimal impact to the local biota, they may also be impractical in this specific scenario. If the final design of the plant requires 50 mgd, the following sites and intake type combinations are recommended (in order of preference, omitting subsurface options):

1. Site 3A as a wedgewire intake
2. Site 1A as a wedgewire intake
3. Site 4A as an onshore open intake
4. Site 1B as an onshore open intake
5. Site 2B as an onshore surface intake

Site Specifics Recommendations

The following is a site by site breakdown of the potential environmental impacts due to the construction of a desalinization intake. An intake selection matrix (Table 1) contains site-specific details and other criteria used to determine these recommendations. A list of the marine nekton species in Corpus Christi Bay that could potentially be impacted has also been included (Table 2). Clearly, as facilities siting becomes more refined, detailed assessments would be needed to further elucidate site-specific impacts. These recommendations are presented by site number and not in order of preference.

Site 1: Near Broadway WWTP

Site 1A is located in the Corpus Christi Bay near Inner Harbor with submerged wedgewire, subsurface filtration gallery, or subsurface directional drilled intakes as the proposed types.

- **Impingement of marine life on screens**
  Constructing a submerged wedgewire intake would have a greater potential for impinging marine fauna as compared to a subsurface intake. A subsurface intake (either filtration gallery or directional drilled) would have the least amount of overall mortality since it does not protrude from the seafloor, so there is no concern of impingement for this type of intake.

- **Entrainment of marine life in desalinization plant**
  The wedgewire intake would likely increase marine life mortality on a daily operating basis as opposed to a subsurface intake because there is a greater potential for impinging marine fauna. With a subsurface intake the water is drawn

through the sand/gravel so most of the larvae and eggs in the water column would not filter through the seafloor and are not at risk for entrainment.

- **Impacts on seagrass and other sensitive marine areas**
  This location does not appear to have any type of limiting habitat (i.e., seagrasses) that would negatively impact the resident benthic fauna. If a subsurface intake was constructed it is possible that the motile species would be able to avoid the area during construction and potentially re-settle upon its completion.

- **Visual impacts and disturbance of coastal uses**
  Since it is submerged offshore, either of the intake options (wedgewire or submerged) present no concern regarding visual disturbances and minimal concern regarding navigational disturbances (e.g. shrimp trawls) in this area.

- **Impacts on coastal wetlands**
  There are no concerns about coastal wetlands due to the intake being submerged and offshore based on NWI maps for the surrounding area.

- **Other environmental issues**
  No other environmental issues have currently been identified at this time.

Site 1B is located in the Corpus Christi Bay Turning Basin - proposed to be an onshore surface intake using traveling screens.

- **Impingement of marine life on screens**
  The onshore traveling screen intake would impact the surrounding marine fauna. Depending on construction location and depth, fish and invertebrates are likely to become impinged in the screen and occasional cleaning would be necessary to ensure proper operation. The use of fish buckets would help limit this problem, but there are still problems with macroalgae potentially fouling the screens.

- **Entrainment of marine life in plant**
  Larval fish, eggs, and plankton would be entrained in a traveling screen intake. However, the habitat quality in this area is likely already impacted by industrialization, so it is unlikely that the mortality from entrainment would be enough to substantially impact any local populations.

- **Impacts on seagrass and other sensitive marine areas**

Due to the highly industrialized area it is unlikely to have any type of sensitive habitat types (i.e., seagrasses) to an extent that would negatively impact the resident benthic fauna, so it is possible that the motile species would be able to avoid the area during construction and potentially re-settle upon completion.

- **Visual impacts and disturbance of coastal uses**
  As with all surface intakes, this unit (or building housing the unit) would be visible. Most of the area surrounding the proposed site is heavily industrialized so despite the construction of the new intake, the general aesthetics of the area would not change. One other consideration is the addition of any debris or sedimentation to the barge canal during construction. A portion of the canal might need to be narrowed or closed, which could create problems for ships attempting to unload/load cargo in the surrounding area.

- **Impacts on coastal wetlands**
  While the shoreline would be impacted, there wetlands in the area are approximately 75 m from the so there would a slight potential for impacts on coastal wetlands.

- **Other environmental issues**
  No other environmental issues have currently been identified at this time.

Site 2: La Quinta Channel Extension

Site 2A is located west of Spoil Island with suggested intake types that include submerged infiltration gallery and submerged directional drilled. Follow-up inquires by Freese and Nichols, Inc. included a possible wedgewire screen intake at this site. For the same reasons as described below, this intake type would also be least favorable among the other site locations.

- **Impingement of marine life on screens**
  No concerns due to submerged intakes. For a wedgewire intake there would be a greater potential for impinging marine fauna as compared to a subsurface intake.

- **Entrainment of marine life in plant**
  No concerns due to submerged intakes. The wedgewire intake would have higher marine life mortality on a daily operating basis as opposed to a subsurface intake

- **Impacts on seagrass and other sensitive marine areas**

During construction, the mortality of benthic organisms would be subject to the greatest change in this system because of physical disturbance to the bottom sediments. The Spoil Island area is known to have seagrass habitats, sensitive for economically important species of sciaenids (e.g. red drum, spotted seatrout) and paralichthys (flounders). This area is also adjacent to sensitive fish nursery habitat and other areas that are important for a variety of marine life, including possible feeding areas for sea turtles and nesting sites for colonial waterbirds. Thus, these physical and geographical concerns lead to some reservations about these areas as candidate sites.

- **Visual impacts and disturbance of coastal uses**
  Since it is submerged, any of the intake options (infiltration gallery, directional drilled, or wedgewire intake) present no concern regarding visual disturbances and minimal concern regarding navigational disturbances (e.g. shrimp trawls) in this area. However, during construction of the infiltration gallery the shipping channel would be affected, since pipes need to be laid down in order to bring the water from the intake to the plant. A directional drill intake might be a better option since drilling can occur without impact to the shipping channel.

- **Impacts on coastal wetlands**
  While the area is not considered coastal wetlands, there are concerns about negatively impacting the seagrass and Spoil Island habitat if an intake were to be placed in this area.

- **Other environmental issues**
  Spoil Island has the potential to be a feeding and resting place for migrating birds, including the federally endangered Piping Plover (*Charadrius melodus)*. Altering the island or surrounding shoreline area could decrease the suitability for this area to provide necessary resources for migrating birds.

Site 2B is an onshore surface intake located on the shoreline of the channel extension.

- **Impingement of marine life on screens**
  With the close proximity to seagrasses, it is likely that a traveling screen intake would be a source of mortality for recreationally important species such as sciaenids and paralichthys.

- **Entrainment of marine life in plant**

In this location, larval fish, eggs, and plankton would become entrained. This area has the potential to for impacting the recruitment of recreationally important species (e.g. sciaenids and paralichthys) due to the relatively high habitat quality of the surrounding area.

- **Impacts on seagrass and other sensitive marine areas**
  This location is in close proximity to seagrass. Since many species use seagrass beds as recruitment areas, this site would not be recommended for development. Like site 2A, this area is also adjacent to some of the most sensitive fish nursery habitat and other areas that are important for a variety of marine life. Thus, these physical and geographical concerns lead to some reservations about these areas as candidate sites.

- **Visual impacts and disturbance of coastal uses**
  As with all surface intakes, this unit (or building housing the unit) would be visible. A portion of the canal might need to be narrowed or closed, which could create problems for ships attempting to unload/load cargo in the surrounding area.

- **Impacts on coastal wetlands**
  Approximately 60 acres of the entire shoreline at this location is classified as estuarine and marine wetlands according to the NWI map. Creating a surface intake would impact coastal wetlands by the need to create the intake system on the shoreline.

- **Other environmental issues**
  No other environmental issues have currently been identified.

Site 3: Mustang or Padre Islands

Site 3A is proposed to be located 2 miles offshore, with proposed intake types including submerged wedgewire, submerged infiltration gallery, and submerged directional drilled.

- **Impingement of marine life on screens**
  Constructing a submerged wedgewire intake would have greater potential for impinging marine fauna compared to a subsurface intake. Since this location is outside of Corpus Christi Bay, there is a greater variety of species that may become impinged in the intake. Although there would be mortality associated with the construction of a subsurface intake (either filtration gallery or directional drilled) there is no concern about impingement since it does not protrude from the seafloor. It is our opinion that this area would have the least impact based on our

criteria; however, it is also the least studied. If chosen, further detailed assessment would need to be performed at this area.

- **Entrainment of marine life in plant**
  The wedgewire intake would have the greatest potential for marine life mortality on a daily operating basis, compared to a subsurface intake where water that is drawn into the sediment is used. Since the water from a subsurface intake is drawn through the sand/gravel, larvae and eggs in the water column would not filter through the seafloor and would not be at risk for entrainment.

- **Impacts on seagrass and other sensitive marine areas**
  During construction, the benthic organisms would be the most likely effected in this system because of the physical disturbances to the bottom. This location does not appear to have any type of limiting habitat (i.e., seagrasses) that would negatively impact the resident benthic fauna, so it is possible that the motile species would be able to avoid the area during construction and potentially re-settle once construction is complete.

- **Visual impacts and disturbance of coastal uses**
  Since it is submerged offshore, either of the intake options (wedgewire or submerged) present no concern regarding visual disturbances and minimal concern regarding navigational disturbances (e.g. shrimp trawls) in this area.

- **Impacts on coastal wetlands**
  Since this site is outside of Corpus Christi Bay, there are no concerns about negative impacts on coastal wetland.

- **Other environmental issues**
  No other environmental issues have currently been identified.

Site 4: ON Stevens WTP

This site is proposed to be located in the Viola Turning Basin, a heavily industrialized area at the end of the Corpus Christi Turning Basin. The proposed intake at this location is an onshore traveling screen surface.

- **Impingement of marine life on screens**
  This location is at the end of the Viola Turning Basin, which is not a favorable habitat for most species of recreational importance. Impingement would be a concern, but it is likely to be of mostly lower trophic level species (e.g. anchovies,

silversides) which can be found throughout the Corpus Christi Bay system. The potential for macroalgae to become impinged is a concern as well.

- **Entrainment of marine life in plant**
  The abundance of eggs, larval fish, or plankton that get entrained in the surface intake likely would not be as high as the other sites, since the location is so far from any source of inflow. This water may already be slightly more saline than other locations due to evaporation and extended flushing cycles, making it a harsher environment than the other listed sites.

- **Impacts on seagrass and other sensitive marine areas**
  This location does not appear to have any seagrass in the surrounding area.

- **Visual impacts and disturbance of coastal uses**
  As with all surface intakes, this unit (or building housing the unit) would be visible after construction. This channel was created as a shipping lane, so most of the area is already industrialized.

- **Impacts on coastal wetlands**
  Depending on location, there are approximately 30 acres of freshwater emergent wetlands that might be impacted during the creation of the surface intake.

- **Other environmental issues**
  No other environmental issues have currently been identified.

Discharge Facilities Assessment

When considering the locations for desalination plant discharge facilities, several factors need to be considered. The addition of brine concentrate can have environmental impacts on the marine community. As a result, the salinity tolerance of marine organisms need to be considered when determining the locations for Corpus Christi desalination plant discharge locations (Figure 2). Changes in salinity and temperature can have deleterious effects on many marine species, particularly those in early developmental stages. See Table 3 for a list of the marine species of bottom dwellers in Corpus Christi Bay that could potentially be impacted. Specifically for this study, five candidate discharge assessment locations were chosen by Freese and Nichols, Inc.

The Harte Research Institute, more specifically the Ecosystem Studies and Modeling Lab was contracted to identify potential environmental impacts of specific discharge structures to the surrounding environment.

Biomass, abundance, and diversity of the benthic community can be affected by salinity changes (Montagna et al. 2002, Van Diggelen 2014). The average salinity in the Corpus Christi Bay system since 1987 is about 35 ± 7 ppt. The estuarine macrobenthic community of Corpus Christi Bay would not likely be affected by a salinity increase within this range (Table 4, Montagna et al. 2013). However, brine plumes can create hypoxic or anoxic zones which disturb benthic communities and organisms in the water column. It is known that there is an interaction between salinity and dissolved oxygen (DO) concentration in Corpus Christi Bay, such that benthic communities decline dramatically as salinity increases to around 42 ppt and DO decreases to around 3 mg/L (Ritter and Montagna 1999). This effect could be heightened due to depressions in the bay bottom that are scattered throughout Corpus Christi Bay, which constrain mixing of bottom water, leading to hypoxia (Nelson 2012). In contrast the average DO in Corpus Christi Bay is 6.3 mg/L. Directed sampling before and after the construction of a discharge facility would be recommended in order to determine the actual environmental impacts to the selected sites.

Some of the proposed discharge sites are recorded as having evidence of contaminant-induced degradation of sediment quality from storm-water outfalls. Sampling would need to be conducted post-construction to monitor if there is any change in contaminant-induced degradation of sediment quality (Carr et al. 2000).

In the assessment the following key environmental intake issues will be discussed:

- Salinity tolerance of identified marine organisms in the mixing zone
- Marine organism salinity tolerances
- Target acceptable discharge salinity
- Mixing of brine concentrate and ambient seawater issues
- Ion imbalance of brine concentrate and ambient seawater mixing issues
- Toxicity of brine concentrate and ambient seawater mixing issues
- Estimate maximum velocity at edge of mixing zone safe for aquatic life
- Concentrate disposal impacts, diffusion, and transport

Overall recommendations: To limit the environmental impacts on resident fauna, it is our opinion that the preferred discharge type would be either submerged jet diffusers or a submerged pipe. Submerged jet diffusers would be the quickest method for dilution of effluent and the preferred way to avoid hypoxia. We recommend site 3A with submerged jet diffusers as the preferred location for a discharge facility. This combination would have the least environmental impact because the discharge would be entering into a deeper and more dynamic body of water. This site and discharge type combination also appears to have the lowest overall effect on mortality (construction and daily). Overall we recommend the following sites and discharge type combinations (in order of preference):

1. Site 3A as submerged jet diffusers
2. Site 3A as a submerged pipe
3. Site 1B as submerged jet diffusers
4. Site 1B as a submerged pipe
5. Site 4A as a surface open discharge pipe
6. Site 1A as a surface open discharge pipe – drainage ditch
7. Site 2A as submerged jet diffusers
8. Site 2A as a submerged pipe

The following is a site by site assessment of the key environmental issues from construction and operation of discharge facilities. Discharge selection matrix (Table 5) contains site-specific details and other criteria regarding to how these recommendations were determined.

Site 1: Near Broadway WWTP

Discharge location 1A is located in the Inner Harbor of Corpus Christi Bay. Corpus Christi Inner Harbor has been subject to refinery process water effluent discharge for over fifteen years. The proposed type of discharge infrastructure is a surface open discharge pipe – drainage ditch. Brine concentrate in an open-air ditch could evaporate further and become even more saline. Considering salinity alone, a discharge salinity of 2.0 parts per thousand (ppt) above ambient salinity (Table 4) would not have an effect on the marine community in the Inner Harbor. However, the conclusion from Hodges' 2015 report is that desalination brine in the ship channel would likely result in extended periods of hypoxia and anoxia. This location does not appear to have seagrass or other limiting habitat.

- **Salinity tolerance of identified marine organisms in the mixing zone**
  The salinity tolerance of marine organisms in the mixing zone is between approximately 28 and 42 ppt, with an average around 35 (Table 4).

- **Marine organism salinity tolerances**
  The Corpus Christi Bay system has natural salinities ranging from 28 - 42 ppt, with an average around 35 ppt (Van Diggelen and Montagna 2016). We know that the resident marine species can tolerate salinities within this range; however, further studies are needed to determine the effects of a localized salinity increase greater than 42 ppt.

- **Target acceptable discharge salinity**
  The target acceptable discharge salinity would need to be 35 - 42 ppt (Table 4), just above the average salinity of the bay system.

- **Mixing of brine concentrate and ambient seawater issues**
  It is unknown how the mixing of warm brine concentrate would affect the bay system, but it could lead to hypoxia. It would be recommended that the concentrate be brought as close as possible to ambient seawater temperature before being released.

- **Ion imbalance of brine concentrate and ambient seawater mixing issues**
  The concentration of copper, calcium, chlorine, and anti-scalants in the brine concentrate would need to be determined before its impact can be assessed. Fish, plankton, and benthic fauna can experience toxic effects from the bioaccumulation of metals. Research is needed to verify the potential impacts of brine concentrate mixing with seawater.

- **Toxicity of brine concentrate and ambient seawater mixing issues**
  Warm temperatures of brine plumes may affect marine species, particularly animals in early developmental stages. This site does not appear to have seagrass habitat, so there is little concern for brine concentrate affecting sensitive nursery grounds.

- **Estimate maximum velocity at edge of mixing zone safe for aquatic life**
  At the seafloor there are sluggish currents ranging from 0.01 - 0.25 meters per second (m/s) (Powell et al. 2007). The current velocity in Corpus Christi Bay is variable and wind driven at the surface. Current speed is probably very sluggish at this particular site. Brine discharged at a high velocity would promote more mixing but could negatively impact flora and fauna. We estimate the maximum velocity at the edge of mixing zone safe to aquatic life to be no more than 0.5 m/s (Powell et al. 2007).

- **Concentrate disposal impacts, diffusion and transport**
  The target acceptable discharge salinity would need to be close to 35 ppt, and no higher than 42 ppt. Field and laboratory studies would need to be conducted to investigate the environmental impacts of warm brine plumes with high concentration of heavy metals. A brine plume at this site would probably lead to hypoxia.

Discharge location 1B is located in Corpus Christi Bay in the Ship Channel near Harbor Bridge. The proposed types of discharge infrastructure are submerged pipe and submerged jet diffusers. This site has previously been described as a depositional zone for material coming from the Inner Harbor (Carr et al. 1998). A submerged pipe would release a brine plume at the sediment surface of the bay. This pipe would be subject to fouling by sessile marine organisms such as serpulid worms and tunicates. Discharge location 1B may experience more wind-driven mixing than location 1A, potentially mixing up the brine plume released from a submerged pipe. However, hypoxia could still develop from the brine plume. Submerged jet diffusers are an alternative discharge type that prevents the formation of dense brine plumes. Turbidity from jet diffusers can cause developmental and filtration problems in bivalves because it is generally known that filter feeders can be clogged in highly turbid environments.

- **Salinity tolerance of identified marine organisms in the mixing zone**
  The salinity tolerance of marine organisms in the mixing zone is between approximately 28 and 42 ppt, with an average around 35.

- **Marine organism salinity tolerances**
  The Corpus Christi Bay system has natural salinities ranging from 28 - 42 ppt, with an average around 35 ppt. We know that the resident marine species can tolerate salinities within this range; however, further studies are needed to determine the effects of a localized salinity increase greater than 42 ppt.

- **Target acceptable discharge salinity**
  The target acceptable discharge salinity would need to be 35 - 42 ppt. It would be easier to reach the target acceptable discharge salinity using submerged jet diffusers.

- **Mixing of brine concentrate and ambient seawater issues**
  It is unknown how the mixing of warm brine concentrate would affect the bay system. It would be recommended that the concentrate be brought as close as possible to ambient seawater temperature before being released. A submerged pipe would create a brine plume at the sediment surface, which could lead to hypoxia if not thoroughly mixed in. Submerged jet diffusers would be the preferred option to achieve optimal mixing of brine concentrate and seawater.

- **Ion imbalance of brine concentrate and ambient seawater mixing issues**
  The concentration of copper, calcium, chlorine, and anti-scalants in the brine concentrate would need to be determined before its impact can be assessed. Fish, plankton, and benthic fauna can experience toxic effects from the bioaccumulation of metals. Sessile organisms would be subject to stress from ion imbalance as they cannot relocate. Submerged jet diffusers would be the preferred option to promote mixing and dilution of brine concentrate and seawater.

- **Toxicity of brine concentrate and ambient seawater mixing issues**
  Warm temperatures of brine plumes may affect marine species, particularly animals in early developmental stages. This site does not appear to have seagrass habitat, so there is little concern for brine concentrate affecting sensitive nursery grounds at this site. Research is needed to verify the toxicological effects of brine concentrate mixing with seawater.

- **Estimate maximum velocity at edge of mixing zone safe for aquatic life**
  We estimate the maximum velocity at the edge of mixing zone safe to aquatic life to be no more than 0.5 m/s (Powell et al. 2007). Although marine life would only be exposed to diffuser jet turbulence for short bursts of time, on the order of seconds, we recommend conducting laboratory studies to determine a velocity that minimizes shear stress mortality (Foster et al. 2013).

- **Concentrate disposal impacts, diffusion, and transport**
  The target acceptable discharge salinity would need to be close to 35 ppt, and no higher than 42 ppt. Field and laboratory studies would need to be conducted to investigate the environmental impacts of warm brine plumes with high concentration of heavy metals. A brine plume at this site could lead to hypoxia. Submerged jet diffusers would be the preferred option to achieve optimal mixing of brine concentrate and seawater.

Site 2: La Quinta Channel Extension

Discharge location 2A is located southwest of La Quinta Channel Extension in Corpus Christi Bay. The proposed types of discharge infrastructure are submerged pipe and submerged jet diffusers. Nearby tidal flats, salt marshes, and seagrass beds are inhabited by protected bird species and used as recruitment areas by recreationally important fish species. Green sea turtles, bottlenose dolphins, and manatees have been observed in La Quinta Channel. Hypoxia or anoxia would occur as a result of submerged pipe brine plume discharge. This site would have the most severe environmental impacts and would not be recommended for the construction of a discharge facility.

- **Salinity tolerance of identified marine organisms in the mixing zone**
  The salinity tolerance of marine organisms in the mixing zone is between approximately 28 and 42 ppt, with an average around 35.

- **Marine organism salinity tolerances**
  The Corpus Christi Bay system has natural salinities ranging from 28 - 42 ppt, with an average around 35 ppt. We know that the resident marine species can tolerate salinities within this range; however, further studies are needed to determine the effects of a localized salinity increase greater than 42 ppt.

- **Target acceptable discharge salinity**
  The target acceptable discharge salinity would need to be 35 - 42 ppt. It would be easier to reach the target acceptable discharge salinity using submerged jet diffusers.

- **Mixing of brine concentrate and ambient seawater issues**
  Submerged jet diffusers dilute and disperse brine through rapid mixing, decreasing the possibility or extent of hypoxic zones.

- **Ion imbalance of brine concentrate and ambient seawater mixing issues**
  The concentration of copper, calcium, chlorine, and anti-scalants in the brine concentrate would need to be determined before its impact can be assessed. Fish, plankton, and benthic fauna can experience toxic effects from the bioaccumulation of metals. Sessile organisms would be subject to stress from ion imbalance as they cannot relocate. Submerged jet diffusers would be the preferred option to promote mixing and dilution of brine concentrate and seawater.

- **Toxicity of brine concentrate and ambient seawater mixing issues**
  Warm temperatures of brine plumes may affect marine species, particularly those in early developmental stages. This site has seagrass habitat that is potentially a recruitment area for many estuarine species. Discharge from a submerged pipe could be particularly detrimental by causing hypoxia. Submerged jet diffusers could create turbidity, affecting the phytoplankton community and shading out seagrass. A discharge facility at this site could have severe environmental impacts. More research is needed to verify the toxicological effects of brine concentrate mixing with seawater.

- **Estimate maximum velocity at edge of mixing zone safe for aquatic life**
  If the submerged jet diffuser was installed at the bottom of the 35 foot trench, as proposed, a velocity of 2 - 3 fps at the edge of the mixing zone would be acceptable. However, if the submerged jet diffuser was installed at the average seafloor depth of about 3 meters, there could be severe environmental impacts, as mentioned above. We estimate the maximum velocity at the edge of mixing zone safe to aquatic life to be no more than 0.5 m/s (Powell et al. 2007). Although marine life would only be exposed to diffuser jet turbulence for short bursts of time, on the order of seconds, we recommend conducting laboratory studies to determine a velocity that minimizes shear stress mortality (Foster et al. 2013).

- **Concentrate disposal impacts, diffusion, and transport**
  The target discharge salinity would need to be close to 35 ppt, and no higher than 42 ppt. Field and laboratory studies would need to be conducted to investigate the environmental impacts of warm brine plumes with high concentration of heavy metals. A brine plume at this site would probably lead to hypoxia. A submerged pipe is also subject to fouling by sessile marine organisms such as serpulid worms and tunicates. Submerged jet diffusers

would be the preferred option to achieve optimal mixing of brine concentrate and seawater.

Site 3: Mustang Island or Padre Island

Discharge location 3A is located 2 miles offshore of either Mustang Island or Padre Island. The proposed types of discharge infrastructure are submerged pipe or submerged jet diffusers. This is the preferred choice for a discharge site because the brine effluent would be rapidly mixed into the ambient seawater and have the least environmental impact. Kemp's ridley, loggerhead, green and leatherback turtles as well as bottlenose dolphins have been recorded at this site. It is unlikely that these species would be affected by the discharge.

- **Salinity tolerance of identified marine organisms in the mixing zone**
  The salinity tolerance of marine organisms in the mixing zone is between approximately 32 and 36 ppt, with an average of 35 ppt.

- **Marine organism salinity tolerances**
  The Gulf of Mexico has natural salinities ranging from 32 - 36 ppt, with an average around 35 ppt. We know that the resident marine species can tolerate salinities within this range; however, further studies are needed to determine the effects of a localized salinity increase greater than 36 ppt.

- **Target acceptable discharge salinity**
  The target acceptable discharge salinity would need to be 35 - 38 ppt. It would be easier to reach the target acceptable discharge salinity using submerged jet diffusers.

- **Mixing of brine concentrate and ambient seawater issues**
  The discharge of brine concentrate from a submerged pipe is expected to mix well with ambient seawater. Submerged jet diffusers would be the preferred option for quickest dilution and least environmental impact.

- **Toxicity of brine concentrate and ambient seawater mixing issues**
  It is not anticipated that there would be issues with brine concentrate toxicity at this site. Effluent would be thoroughly mixed in through wind-driven mixing and tidal currents.

- **Ion imbalance of brine concentrate and ambient seawater mixing issues**
  The concentration of copper, calcium, chlorine, and anti-scalants in the brine concentrate would need to be determined before its impact can be assessed. Fish, plankton, and benthic fauna can experience toxic effects from the bioaccumulation of metals. Sessile organisms would be subject to stress from ion imbalance as they cannot relocate.

Submerged jet diffusers would be the preferred option to promote mixing and dilution of brine concentrate and seawater.

- **Estimate maximum velocity at edge of mixing zone safe for aquatic life**
  The average current velocity near Bob Hall Pier is between 0.5 and 1.0 m/s. The current velocity offshore at this discharge site changes every day. We estimate the maximum velocity at the edge of mixing zone safe to aquatic life to be no more than 1.5 m/s (Powell et al. 2007).

- **Concentrate disposal impacts, diffusion and transport**
  The target discharge salinity would need to be close to 35 ppt, and no higher than 36 ppt. Field and laboratory studies would need to be conducted to investigate the environmental impacts of warm brine plumes with high concentration of heavy metals. A submerged pipe is also subject to fouling by sessile marine organisms such as serpulid worms and tunicates. Submerged jet diffusers would be the preferred option to achieve optimal mixing of brine concentrate and seawater.

Site 4: ON Stevens WTP

Discharge location 4A is at the Tule Lake Turning Basin in the Inner Harbor of Corpus Christi Bay. The proposed discharge infrastructure is a surface open discharge pipe. Considering salinity alone, a discharge salinity of 2.0 ppt above ambient salinity would not have an effect on the marine community in the Inner Harbor. However, the conclusion from Hodges' 2015 report is that desalination brine released in the ship channel would likely result in extended periods of hypoxia and anoxia. This location does not appear to have seagrass or other limiting habitat.

- **Salinity tolerance of identified marine organisms in the mixing zone**
  The salinity tolerance of marine organisms in the mixing zone is between approximately 28 and 42 ppt, with an average around 35 ppt.

- **Marine organism salinity tolerances**
  The Corpus Christi Bay system has natural salinities ranging from 28 - 42 ppt, with an average around 35 ppt. We know that the resident marine species can tolerate salinities within this range; however, further studies are needed to determine the effects of a localized salinity increase greater than 42 ppt.

- **Target acceptable discharge salinity**
  The target acceptable discharge salinity would need to be 35 - 42 ppt.

- **Mixing of brine concentrate and ambient seawater issues**

A surface open discharge pipe would release brine concentrate directly into the bay. The dense concentrate would settle at the bottom of the harbor and cause hypoxia.

- **Ion imbalance of brine concentrate and ambient seawater mixing issues**
  The concentration of copper, calcium, chlorine, and anti-scalants in the brine concentrate would need to be determined before its impact can be assessed. Fish, plankton, and benthic fauna can experience toxic effects from the bioaccumulation of metals. Sessile organisms would be subject to stress from ion imbalance as they cannot relocate.

- **Toxicity of brine concentrate and ambient seawater mixing issues**
  Warm temperatures of brine plumes may affect marine species, particularly animals in early developmental stages. This site does not appear to have seagrass habitat or recreational fish species, so there is little concern for brine concentrate affecting sensitive nursery grounds.

- **Estimate maximum velocity at edge of mixing zone safe for aquatic life**
  At the seafloor there are sluggish currents ranging from 0.01 - 0.25 m/s. The current velocity in Corpus Christi Bay is variable and wind driven at the surface. Current speed is probably very sluggish at this particular site. Brine discharged at a high velocity would promote more mixing but could negatively impact flora and fauna. We estimate the maximum velocity at the edge of mixing zone safe to aquatic life to be no more than 0.5 m/s (Powell et al. 2007).

- **Concentrate disposal impacts, diffusion, and transport**
  The target acceptable discharge salinity would need to be close to 35 ppt, and no higher than 42 ppt. Field and laboratory studies would need to be conducted to investigate the environmental impacts of warm brine plumes with high concentration of heavy metals. A brine plume at this site would probably lead to hypoxia.

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Figure 1. Intake Assessment Locations

Figure 2. Discharge Assessment Locations

Table 1. ***Intake type and site location recommendations. A total impact score is given for each intake and the sites are color coded by recommendation level.***

Intake Matrix	Site 3A Mustang or Padre Islands	Site 1A CC Bay by CC Harbor	Site 4A Viola Turning Basin	Site 1B CC Turning Basin, Inner Harbor	Site 2A West of Spoil Island	Site 2B Shoreline near La Quinta Channel
Subsurface Intake			N/A	N/A		N/A
Impingement of Marine Life	0	0	N/A	N/A	0	N/A
Entrainment of Marine Life	0	0	N/A	N/A	0	N/A
Impacts on Submerged Aquatic Vegetation	2	2	N/A	N/A	3	N/A
Impacts on Other Sensitive Marine Areas	0	0	N/A	N/A	3	N/A
Visual Impacts	0	0	N/A	N/A	2	N/A
Disturbances of Coastal Uses	1	2	N/A	N/A	2	N/A
Impacts on Coastal Wetlands	0	0	N/A	N/A	3	N/A
Other Environmental Issues	0	0	N/A	N/A	2	N/A
Total Impact Score	**3**	**4**	N/A	N/A	**15**	N/A
Off-shore, Open Intake			N/A	N/A		N/A
Impingement of Marine Life	2	2	N/A	N/A	3	N/A
Entrainment of Marine Life	2	2	N/A	N/A	3	N/A
Impacts on Submerged Aquatic Vegetation	2	2	N/A	N/A	3	N/A
Impacts on Other Sensitive Marine Areas	0	0	N/A	N/A	3	N/A
Visual Impacts	0	0	N/A	N/A	2	N/A
Disturbances of Coastal Uses	1	2	N/A	N/A	2	N/A
Impacts on Coastal Wetlands	0	0	N/A	N/A	3	N/A
Other Environmental Issues	0	0	N/A	N/A	2	N/A
Total Impact Score	**7**	**8**	N/A	N/A	**21**	N/A
On-shore, Open Intake	N/A	N/A			N/A	
Impingement of Marine Life	N/A	N/A	3	3	N/A	3
Entrainment of Marine Life	N/A	N/A	3	3	N/A	3
Impacts on Submerged Aquatic Vegetation	N/A	N/A	1	1	N/A	3
Impacts on Other Sensitive Marine Areas	N/A	N/A	0	0	N/A	3
Visual Impacts	N/A	N/A	2	2	N/A	3
Disturbances of Coastal Uses	N/A	N/A	0	1	N/A	3
Impacts on Coastal Wetlands	N/A	N/A	2	2	N/A	3
Other Environmental Issues	N/A	N/A	0	0	N/A	2
Total Impact Score	N/A	N/A	**11**	**12**	N/A	**23**

Impact Factor:
- 0 - No Impact
- 1 - Minimal Impact
- 2 - Moderate Impact
- 3 - Severe Impact

Recommendation Key (based on the impact factor scores)
- Preferred
- Alternative
- Least Favorable
- Not Applicable

Table 2. ***Preliminary list of fish and invertebrates that could potentially be impacted by local intake systems. Further study is needed before a site specific list can be created.***

Fish		**Crustaceans**	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
American Halfbeak	*Hyporhamphus meeki*	Blue Crab	*Callinectes sapidus*
Atlantic Brief Squid	*Lolliguncula brevis*	Gulf Crab	*Callinectes similis*
Atlantic Bumper	*Chloroscombrus chrysurus*	Brown Shrimp	*Farfantepenaeus aztecus*
Atlantic Croaker	*Micropogonias undulatas*	Pink Shrimp	*Farfantepenaeus duorarum*
Bay Anchovy	*Anchoa mitchilli*	White Shrimp	*Litopenaeus setiferus*
Black Drum	*Pogonias cromis*	Cleaner Shrimp	*Hippolytidae*
Blue Fish	*Pomatomus saltatrix*	Grass Shrimp	*Palaemonidae*
Code Goby	*Gobiosoma robustum*	Mysid Shrimp	*Mysidae*
Darter Goby	*Ctenogobius boleosoma*		
Feather Blenny	*Hypsoblennius hentz*		
Green Goby	*Microgobius thalassinus*		
Gulf Flounder	*Paralichthys albigutta*		
Gulf Menhaden	*Brevoortia patronus*		
Hogchoaker	*Trinectes maculatas*		
Inshore Lizardfish	*Synodus foetens*		
Ladyfish	*Elops saurus*		
Lizardfish	*Synodontidae sp.*		
Naked Goby	*Gobiosoma bosc*		
Pinfish	*Lagodon rhomboides*		
Pipefish	*Syngnathidae sp.*		
Puffer Fish	*Tetradontidae sp.*		
Red Drum	*Sciaenops ocellatus*		
Sand Seatrout	*Cynoscion arenarius*		
Sea Robin	*Triglidae sp.*		
Shrimp eel	*Ophichthus gomesii*		
Silver Perch	*Bairdiella chrysoura*		
Silversides	*Menidia sp.*		
Skilletfish	*Gobiesox strumosus*		
Southern Flounder	*Paralichthys lethostigma*		
Spot Croaker	*Leiostomus xanthurus*		
Spotfin Mojarra	*Eucinostomus argenteus*		
Spotted Seatrout	*Cynoscion nebulosus*		
Striped Mullet	*Mugil cephalus*		
Stripped Burrfish	*Chilomycterus schoepfi*		
Tarpon	*Megalops atlanticus*		

Table 3. ***Marine species list of bottom dwellers for Corpus Christi Bay. Adapted from Table 12 of Sediment Quality Assessment of Storm Water Outfalls and other Selected Sites in the Corpus Christi Bay National Estuary Program Study Area. Corpus Christi Bay National Estuary Program - CCBNEP-32, September 1998.***

Phylu	**Class/Order**	Species
Anthozoa		unidentified Anthozoans
Turbellaria		unidentified Turbellaria
Nermertinea		*Phoronis architecta*
Mollusca	Gastropoda	*Acteocina canaliculata*
		Cyclinella tenuis
		Crepidula sp
		Crepidula plana
		unidentified Vitrinellidae
		Caecum pulchellum
		Nassarius acutus
		Nassarius vibex
		Anachis obesa
		Pyrgiscus sp.
	Pelecypoda	unidentified Pelecypoda
		Nuculana acuta
		Aligena texasiana
		Mysella planulata
		Mulinia lateralis
		Abra aequalis
		Cumingia tellinoides
		Tagelus divisus
		Anomalocardia auberiana
		Chione cancellata
		Lyonsia hyalina floridana
		Periploma margaritaceum
Annelida	Polychaeta	*Malmgreniella taylori*
		Paleanotus heteroseta
		Paramphinome jeffreysii
		Mystides rarica
		Eteone heteropoda
		Cabira incerta
		Ancistrosyllis groenlandica
		Sigambra sp.
		Gyptis vittata
		Microphthalmus abberrans
		Syllis cornuta
		Exogone sp.
		Brania clavata
		Sphaerosyllis sp. A

Phylu	**Class/Order**	Species
Annelida	Polychaeta	unidentified Syllidae
Annelida	Polychaeta	*Ceratonereis irritabilis*
		Laeonereis culveri
		unidentified Nereidae
		Glycinde solitaria
		Lysidice ninetta
		Diopatra cuprea
		Onuphis eremita
		Lumbrineris parvapedata
		Drilonereis magna
		Schistomeringos rudolphi
		Schistomeringos sp. A
		Polydora ligni
		Paraprionospio pinnata
		Apoprionospio pygmaea
		Prionospio heterobranchia
		Scolelepis texana
		Spiophanes bombyx
		Spio pettiboneae
		Polydora socialis
		Streblospio benedicti
		Polydora caulleryi
		Polydora sp.
		Magelona pettiboneae
		Magelona phyllisae
		Magelona rosea
		Spiochaetopterus costarum
		Tharyx setigera
		Cossura delta
		Haploscoloplos foliosus
		Scolopus rubra
		Haploscoloplos sp.
		Naineris sp. A
		Aricidea fragilis
		Cirrophorus lyra
		Aricidea catharinae
		Paraonis fulgens
		Armandia agilis
		Armandia maculata
		Capitella capitata
		Notomastus latericeus
		Notomastus cf. latericeus

Phylu	**Class/Order**	Species
Annelida	Polychaeta	*Mediomastus ambiseta*
		unidentified Capitellidae
Annelida	Polychaeta	*Branchioasychis americana*
		Clymenella torquata
		Asychis elongata
		Euclymene sp. B
		Axiothella mucosa
		Axiothells sp. A
		unidentified Maldanidae
		Isolda pulchella
		Melinna maculata
		unidentified Terebellidae
		Fabricia sp. A
		Chone sp.
		Megalomma bioculatum
		Pomatoceros americanus
		Eupomatus dianthus
		Eupomatus protulicola
Oligochaeta		unidentified Oligochaetes
Sipuncula		*Phascolion strombi*
Crustacea	Branchiopoda	*Latonopsis occidentalis*
	Ostracoda	*Sarsiella texana*
		Sarsiella zostericola
	Copepoda	*Pseudodiaptomus coronatus*
	Branchiura	*Argissa hamatipes*
	Malacostraca	*Pagurus annulipes*
		Pagurus longicarpus
		Pinnixa sp.
		Megalops
	Cumacea	*Leptocuma* sp.
	Amphipoda	unidentified Amphipoda
		Ampelisca sp. B
		Ampelisca abdita
		Synchelidium americanum
		Erichthonias brasiliensis
		Corophium ascherusicum
		Corophium louisianum
		Microprotopus sp.
		Grandidierella bonnieroides
		Batea catharinensis
		Listriella clymenellae
		Caprellidae sp.

Phylu	**Class/Order**	Species
	Amphipoda	*Amphilochus* sp.
Crustacea	Isopoda	*Xenanthura brevitelson*
		Idotea montosa
Crustacea	Tanaidacea	*Leptochelia rapax*
Echinodermata	Ophiuroidea	unidentified Ophiuroidea
	Holothuroidea	*Thyome mexicana*
Chordata	Urochordata	unidentified Ascidiacea
	Hemichordata	*Schizocardium* sp.

Table 4. Selected references for salinity effects on estuarine macrobenthic and epibenthic organisms.

Authors	**Organism(s) Studied**	**Study Location**	**Salinity Tolerance Results**
Chadwick & Feminella (2001)	Burrowing mayfly *Hexagenia limbata*	USA (Alabama)	Laboratory bioassays showed that *H. limbata* nymphs could survive elevated salinities (LC50 of 6.3 ppt at 18 °C, 2.4 ppt at 28 °C). Similar growth rates at 0,2,4, & 8 ppt.
Saoud & Davis (2003)	Juvenile brown shrimp *Farfantepenaeus aztecus*	USA (Alabama)	Growth significantly higher at salinities of 8 & 12 ppt than at salinities of 2 and 4 ppt.
Tolley et al. (2006)	Oyster reef communities of decapod crustaceans & fish	USA (Florida)	Upper stations (~20 ppt) and stations near high-flow tributaries (6-12 $m^3 s^{-1}$) were typified by decapod *Eurypanopeus depressus* & gobiid fishes. Downstream stations (~30 ppt) and stations near low-flow tributaries (0.2-2 $m^3 s^{-1}$) were typified by decapods *E*
Montagna et al. (2008a)	Southwest Florida mollusc communities	USA (Florida)	*Corbicula fluminea*, *Rangia cuneata*, & *Neritina usnea* only species to occur < 1 psu. *R. cuneata* good indicator of mesohaline salinity zones with tolerence to 20 psu. Gastropod *N. usnea* common in fresh to brackish salinities. *Polymesoda caroliniana*
Montague & Ley (1993)	Submersed vegetation & benthic animals	USA (Florida)	Mean salinity ranged from ~11-31 ppt. Standard deviation of salinity was best environmental correlate of mean plant biomass and benthic animal diversity. Less biota at stations with greater fluctuations in salinity. For every 3 ppt increase in standard

Authors	**Organism(s) Studied**	**Study Location**	**Salinity Tolerance Results**
Rozas et al. (2005)	Estuarine macrobenthic community	USA (Louisiana)	Increased density and biomass with increases in freshwater inflow and reduced salinities. Salinity ranged from 1-13 psu.
Finney (1979)	Harpacticoid copepods *Tigriopus japonicus*, *Tachidius brevicornis*, *Tisbe sp.*	USA (Maryland)	All species tested for response to salinities from 0-210 ppt. *Tigriopus* became dormant at 90 ppt died at 150 ppt. *Tachidius* became dormant at 60 ppt, died at 150 ppt. *Tisbe* died shortly after exposure to 45 ppt.
Kalke & Montagna (1991)	Estuarine macrobenthic community	USA (Texas)	Chironomid larvae & polychaete *Hobsonia florida*: increased densities after freshwater inflow event (1-5 ppt). Mollusks *Mulinia lateralis & Macoma mitchelli:* increased densities & abundance during low flow event (~20 ppt). *Streblospio benedicti* & *Medioma*
Keiser & Aldrich (1973)	Postlarval brown shrimp *Penaeus aztecus*	USA (Texas)	Shrimp selected for salinities between 5-20 ppt.
Montagna et al. (2002b)	Estuarine macrobenthic community	USA (Texas)	Macrofauna increased abundances, biomass & diversity with increased inflow; decreased during hypersaline conditions. Macrofaunal biomass & diversity had nonlinear bell-shaped relationship with salinity: maximum biomass at ~19 ppt
Zein-Eldin (1963)	Postlarval brown shrimp	USA (Texas)	In laboratory experiments with temperatures 24.5-26.0 °C, postlarvae grew equally well in salinities of 2-40 ppt.

Authors	**Organism(s) Studied**	**Study Location**	**Salinity Tolerance Results**
	Penaeus aztecus		
Zein-Eldin & Aldrich (1965)	Postlarval brown shrimp *Penaeus aztecus*	USA (Texas)	In laboratory experiments with temperatures < 15 °C, postlarval survivial decreased in salinities < 5 ppt.
Allan et al. (2006)	Caridean shrimp *Palaemon peringueyi*	South Africa	At constant salinity of 35 ppt, respiration rate increased with increased temperature. At constant temperature of 15 °C, respiration rate increased with increased salinity.
Ferraris et al. (1994)	Snapping shrimp *Alpheus viridari*, Polychaete *Terebellides parva*, sipunculan *Golfingia cylindrata*	Belize	Organisms subjected to acute, repeated exposure to 25, 35, or 45 ppt. *A. viridari* hyperosmotic conformer at decreased salinity, but osmoconformer at increased saliniry. *G. cylindrata* always osmoconformer. *T. parva* always osmoconformer; decreased survival.
Lercari et al. (2002)	Sandy beach macrobenthic community	Uruguay	Abundance, biomass, species richness, diversity & evenness significantly increased from salinity of ~6 ppt to salinity of ~25 ppt.
Chollett & Bone (2007)	Estuarine macrobenthic community	Venezuela	Immediately after heavy rainfall (~25 psu), spionid polychaetes showed large increases in density & richness versus normal values (~41 psu).

Authors	Organism(s) Studied	Study Location	Salinity Tolerance Results
Dahms (1990)	Harpacticoid copepod *Paramphiascella fulvofasciata*	Germany (Helgoland)	After 2 hours, no mortality in salinities of 25-55 ppt. Almost all displayed dormant behavior < 20 ppt and > 55 ppt.
McLeod & Wing (2008)	Bivalves *Austrovenus stutchburyi* & *Paphies australis*	New Zealand	Sustained exposure (> 30 d) to salinity < 10 ppt significantly decreased survivorship.
Rutger & Wing (2006)	Esturaine macroinfaunal community	New Zealand	Infaunal community in low salinity regions (2-4 ppt) showed low species richness & abundance of bivalves, decapods, & Orbiniid polychaetes, but high abundance of amphipods & Nereid polychaetes compared to higher salinity regions (12-32 ppt).
Drake et al. (2002)	Estuarine macrobenthic community	Spain	Species richness, abundance, and biomass decreased in the upstream direction, positively correlated with salinity. Highly significant spatial variation in macrofaunal communities along the salinity gradient. Salinity range: 0-40 ppt.
Normant & Lamprecht (2006)	Benthic amphipod *Gammarus oceanicus*	Baltic Sea	Low salinity basin (5-7 psu). Physiological performance examined from 5-30 psu. Feeding & metabolic rates decreased with increasing salinity; nutritive absorption increased. Faeces productoin & ammonia excretion rates decreased strongly from lowest to

Table 5. Discharge matrix

Discharge Matrix		Site 3A Mustang or Padre Islands	Site 1B CC Turning Basin, Inner Harbor	Site 4A Tule Lake Turning Basin	Site 1A CC Bay by CC Harbor	Site 2A SW of La Quinta Channel
Surface Open Discharge Drainage Ditch						
	Marine Species in Estimated Mixing Zone	N/A	N/A	N/A		N/A
	Organisms in Water Column	N/A	N/A	N/A	1	N/A
	Bottom Dwellers	N/A	N/A	N/A	1	N/A
	Endangered Species	N/A	N/A	N/A	0	N/A
	Salinity Tolerance of Identified Organisms in Mixing Zone	N/A	N/A	N/A	2	N/A
	Target Acceptable Discharge Salinity	N/A	N/A	N/A	3	N/A
	Mixing of Brine Concentrate and Ambient Seawater Mixing Issues	N/A	N/A	N/A	2	N/A
	Ion Imbalance of Brine Concentrate and Ambient Seawater Mixing Issues	N/A	N/A	N/A	2	N/A
	Toxicity of Brine Concentrate and Ambient Seawater Mixing Issues	N/A	N/A	N/A	3	N/A
	Estimate Maximum Velocity at Edge of Mixing Zone, Safe to Aquatic Life	N/A	N/A	N/A	1	N/A
	Other Environmental Issues	N/A	N/A	N/A	2	N/A
	Total Impact Score	N/A	N/A	N/A	17	N/A
Off-shore, Submerged Pipe Discharge						
	Marine Species in Estimated Mixing Zone			N/A	N/A	
	Organisms in Water Column	0	1	N/A	N/A	3
	Bottom Dwellers	1	1	N/A	N/A	3
	Endangered Species	0	0	N/A	N/A	1
	Salinity Tolerance of Identified Organisms in Mixing Zone	1	1	N/A	N/A	3
	Target Acceptable Discharge Salinity	1	1	N/A	N/A	3
	Mixing of Brine Concentrate and Ambient Seawater Mixing Issues	0	2	N/A	N/A	3
	Ion Imbalance of Brine Concentrate and Ambient Seawater Mixing Issues	0	1	N/A	N/A	3
	Toxicity of Brine Concentrate and Ambient Seawater Mixing Issues	1	2	N/A	N/A	3
	Estimate Maximum Velocity at Edge of Mixing Zone, Safe to Aquatic Life	0	1	N/A	N/A	2
	Other Environmental Issues	1	1	N/A	N/A	3
	Total Impact Score	5	11	N/A	N/A	27
Impact Factor:				Recommendation Key (based on the impact factor scores)		
0 - No Impact				Preferred		
1 - Minimal Impact				Alternative		
2 - Moderate Impact				Least Favorable		
3 - Severe Impact				Not Applicable		

Table 5 (cont). Discharge matrix

Discharge Matrix	Site 3A Mustang or Padre Islands	Site 1B CC Turning Basin, Inner Harbor	Site 4A Tule Lake Turning Basin	Site 1A CC Bay by CC Harbor	Site 2A SW of La Quinta Channel
Off-shore, Submerged Jet Diffusers Discharge					
Marine Species in Estimated Mixing Zone			N/A	N/A	
Organisms in Water Column	0	1	N/A	N/A	3
Bottom Dwellers	1	1	N/A	N/A	3
Endangered Species	0	0	N/A	N/A	1
Salinity Tolerance of Identified Organisms in Mixing Zone	1	1	N/A	N/A	3
Target Acceptable Discharge Salinity	1	1	N/A	N/A	3
Mixing of Brine Concentrate and Ambient Seawater Mixing Issues	0	2	N/A	N/A	3
Ion Imbalance of Brine Concentrate and Ambient Seawater Mixing Issues	0	1	N/A	N/A	3
Toxicity of Brine Concentrate and Ambient Seawater Mixing Issues	1	2	N/A	N/A	3
Estimate Maximum Velocity at Edge of Mixing Zone, Safe to Aquatic Life	0	1	N/A	N/A	2
Other Environmental Issues	1	1	N/A	N/A	3
Total Impact Score	5	11	N/A	N/A	27
Surface Open Discharge Pipe					
Marine Species in Estimated Mixing Zone	N/A	N/A		N/A	N/A
Organisms in Water Column	N/A	N/A	1	N/A	N/A
Bottom Dwellers	N/A	N/A	1	N/A	N/A
Endangered Species	N/A	N/A	0	N/A	N/A
Salinity Tolerance of Identified Organisms in Mixing Zone	N/A	N/A	2	N/A	N/A
Target Acceptable Discharge Salinity	N/A	N/A	2	N/A	N/A
Mixing of Brine Concentrate and Ambient Seawater Mixing Issues	N/A	N/A	3	N/A	N/A
Ion Imbalance of Brine Concentrate and Ambient Seawater Mixing Issues	N/A	N/A	2	N/A	N/A
Toxicity of Brine Concentrate and Ambient Seawater Mixing Issues	N/A	N/A	3	N/A	N/A
Estimate Maximum Velocity at Edge of Mixing Zone, Safe to Aquatic Life	N/A	N/A	2	N/A	N/A
Other Environmental Issues	N/A	N/A	1	N/A	N/A
Total Impact Score	N/A	N/A	17	N/A	N/A
Impact Factor:				Recommendation Key (based on the impact factor scores)	
0 - No Impact				Preferred	
1 - Minimal Impact				Alternative	
2 - Moderate Impact				Least Favorable	
3 - Severe Impact				Not Applicable	