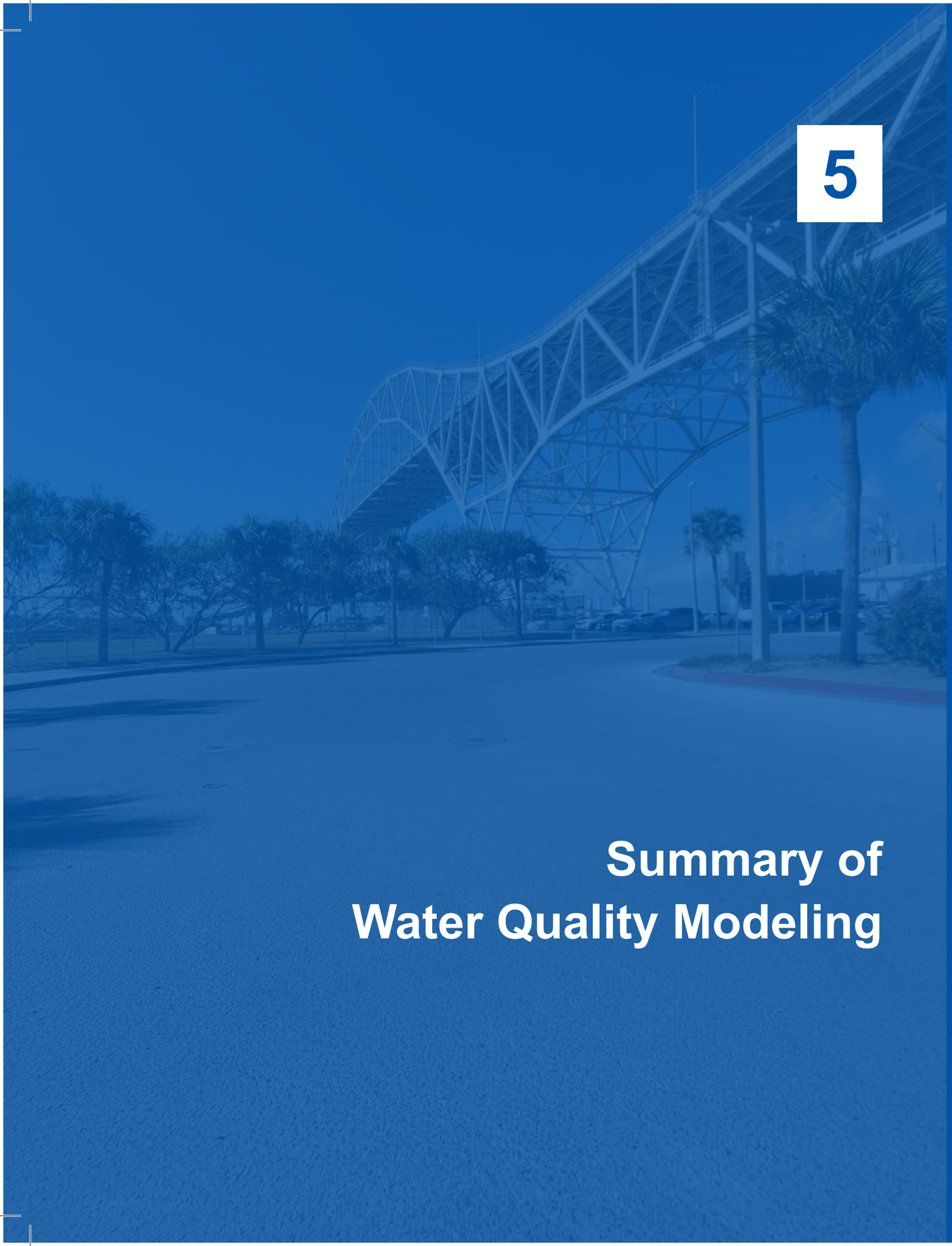

5

Summary of Water Quality Modeling

5 Summary of Water Quality Modeling

Modeling was conducted to help evaluate tidal exchange between the proposed North Beach Navigable Canal (NBC) and the Corpus Christi Bay (CCB), and to evaluate Water Quality (WQ) conditions that may occur in the NBC under various design layouts.

This modeling effort started with the selection of a suitable program to conduct WQ modeling. Then, required data to develop the model were collected and analyzed, and a suitable simulation period was selected that represents a worst-case WQ condition. Models were then developed, and simulations conducted based on the options of the proposed canal layouts. Finally, the modeling results were analyzed and findings were summarized.

Appendix B includes a detailed analysis and results of the water quality modeling.

5.1 Constituents Modeled

To evaluate WQ conditions, a CE-QUAL-W2 model was developed to simulate the following WQ constituents:

- Water temperature, Salinity, Dissolved oxygen (DO),
- Total suspended solids (TSS), Carbonaceous biochemical oxygen demand (CBOD),
- Nutrients (nitrogen and phosphorus), and Chlorophyll a.

With a canal system, the target WQ constituent would be Dissolved Oxygen (DO) because poor tidal exchange in a canal can substantially reduce DO levels that might cause fish kill. DO is selected because it is necessary to support aquatic life and therefore one of the most important indicators of WQ. DO is also regulated in the Texas Surface Water Quality Standards (TSWQS) and enforced by the Texas Commission on Environmental Quality (TCEQ).

5.2 TCEQ Criteria

As listed in Table 5-1, the current (2018) TSWQS includes a 5.0 and 3.0 mg/L Mean DO criteria for Corpus Christi Bay and the Inner Harbor, respectively. A DO criterion of 5.0 mg/L requires the minimum average DO over any 24-hour period to be at least 5.0, which requires the calculation of 24-hour moving-average DO levels. The criterion also includes a minimum 4.0 mg/L that cannot extend beyond eight hours per each 24-hour day, which is the reason why how long the low DO levels would last needs to be determined. Similarly, the DO standard for the Inner Harbor is 3.0 and 2.0 mg/L for the mean and minimum levels, respectively.

Segment No.	WQ Segment Names (Water Bodies)	Aquatic Life Use	DO Criteria (mg/L)	
			Mean	Minimum
2481	Corpus Christi Bay	Exceptional	5.0	4.0
2484	Corpus Christi Inner Harbor	Intermediate	3.0	2.0

- Dissolved oxygen means are applied as a minimum average over a 24-hour period.
- 24-hour minimum dissolved oxygen concentrations are not to extend beyond eight hours per 24-hour day.
Source: TSWQS (2018).

Table 5-1 – TCEQ Criteria

While most surface WQ monitoring collect surface DO levels when comparing against the criteria, sampling conducted with TCEQ in Corpus Christi Ship Channel involved collecting DO profiles along the ship channel depth and comparing depth-average DO levels to the criteria.

TCEQ also uses QUAL-TX models to simulate DO, and the models are depth-average models. Therefore, water-column average DO was used to demonstrate compliance with the criteria.

5.3 Model Development

Both navigable canal layout options were modeled. Each option included an upstream box culvert (at Breakwater Boulevard) connecting the south end of the proposed canal to Corpus Christi Bay to help improve circulation in the canal.

As a result, a total of four combinations were modeled:

- Option 1 Layout without an upstream culvert – North outfall to Corpus Christi Bay,
- Option 1 Layout with an upstream culvert,
- Option 2 Layout without an upstream culvert – Beach outfall to Corpus Christi Bay, and
- Option 2 Layout with an upstream culvert.

Further detail related to the development of the water quality models can be found in Appendix B.

5.4 Modeling Results

Results from CE-QUAL-W2 modeling were analyzed and compared against the DO criteria in TSWQS to answer the following questions:

- What is the lowest DO level?
- What is the duration of the low DO period?
- What is the distance of low DO along the proposed canal?

To answer these questions, DO timeseries at the water surface and the canal bottom were reviewed and analyzed. In addition, the water-column average DO and the longitudinal DO profiles were analyzed evaluated. With many model segments and layers and each layer/segment has output timeseries per WQ constituent from two-month-long continuous simulation, lots of model output data were processed and analyzed.

5.4.1 Options without Culvert

Appendix B presents detailed results at the upstream end (Segment 2) of Option 1 layout without an upstream culvert. It shows the 24-hour moving average DO levels at the surface and bottom of the segment as well as the water column average DO levels.

Appendix B shows that during the simulation period and under the simulated conditions, the minimum average DO levels at both surface and water-column under Option 1 layout would be **slightly below the 5.0 mg/L criterion**, and the bottom DO levels would be below the criterion frequently.

For evaluating if DO would be below the minimum 4.0 mg/L criterion and the duration of the low DO periods, Appendix B show that the surface and water column DO levels would be expected

to be higher than the 4.0 mg/L criterion but the bottom DO would drop below the 4.0 level with 39 hours being the longest duration below the criterion.

5.4.2 Options with Culvert

Appendix B also shows similar CE-QUAL-W2 modeling results for the other NBC layout options with culverts added for improved circulation. In addition, the CE-QUAL-W2 model output were evaluated to locate the time and location of the lowest 24-hour moving average water-column DO. Then, longitudinal water-column average DO profiles along the entire canal at the time of the lowest DO level were generated.

For example, the longitudinal DO profile for Option 1 without an upstream culvert indicates that Segments 2 to 5 have DO levels below the 5.0 mg/L criterion. With about 200 ft per segment, a total of four segments would be about 800 ft of canal near the south end of the proposed canal not meeting the criterion.

5.4.3 Summary of Results

The CE-QUAL-W2 modeling results for the NBC layout options are summarized in Table 5-2 to allow comparison of the options. The results shows that at the south end of the canal, the surface and water-column DO can meet the 5.0 mg/L criterion only for the options with an upstream box culvert. Without the culvert, both options would not meet the criterion.

The results listed in Table 5-2 also show that **only Option 1 with an upstream culvert would meet the minimum DO not longer than 8-hour duration criterion**.

This would be the recommended option from the viewpoint of meeting DO criteria if the 5.0 mg/L criterion were adopted for the proposed canal.

Canal Layout	**Option 1**		Option 2		Remarks
With U/S Culvert	No	**Yes**	No	Yes	Culvert becomes Segment 2, so the most u/s segment become Segment 3
CE-QUAL-W2 Segment No.	2	3	2	3	
Water Depth	Min 24-hr Moving Avg DO (mg/L)				Criteria: DO ≥ 5.0 mg/L
Surface	4.72	**5.36**	4.97	**5.44**	
Bottom	0.76	3.65	0.15	2.65	
Water Column	4.66	**5.24**	4.81	**5.16**	
Water Depth	Duration (hours) of DO < 4.0 mg/L				Criteria: Duration ≤ 8 hours
Surface	0	0	0	0	
Bottom	39	**7**	132	13	
Water Column	0	0	0	0	

Table 5-2 – TCEQ Criteria

5.5 Total Suspended Solids (TSS)

Sedimentation modeling of the North Beach Navigable Canal was not performed as part of this Phase. With the finding that the existing storm sewers are clogged indicating substantial sediment loads from the drainage area, it is recommended that future modeling include watershed loading

modeling to generate runoff flow and sediment loads from the drainage area into the canal during storm events. Such watershed loading modeling may involve continuous pollutant build-up and wash off simulations, or it may involve applying acceptable Event Mean Concentrations (EMC) to runoff volumes simulated by HEC-HMS or other watershed hydrologic models. Once the runoff loads are determined, then the CE-QUAL-W2 models developed under this Phase can be modified to simulate the transport of the runoff sediment loads in the proposed NBC.

5.6 Bacteria

Similar to TSS, conducting bacteria simulations was not included in the current scope but the CE-QUAL-W2 modeling does include bacteria simulations during dry weather conditions. Per TSWQS, the indicator bacteria for contact recreation in tidal water is enterococci with a criterion of 35 bacteria per deciliter (#/dL). Figure B-32 in Appendix B shows the CE-QUAL-W2 output surface, water column average, and bottom enterococci levels at the upstream end of Option 1 layout without culvert. The model assumed initial and boundary enterococci concentrations of 10 #/dL. With first-order decay, the enterococci level at the upstream end of the proposed NBC Option 1 layout dropped to small values after a few days, indicating substantial reduction of bacteria levels from the bay to the upstream end of the canal.

On the other hand, with a culvert connected to the bay, the bacteria level mostly maintained at the bay boundary concentration of 10 #/dL, as shown in Figure B-33. Similar to TSS, the simulation of indicator bacteria was conducted for dry weather conditions only with no stormwater runoff effects. With bacteria levels typically high during storm events, it is recommended that watershed runoff modeling be conducted under Phase 2 to evaluate the bacteria levels in the canal during and after the storm events. It is especially important if the Option 2 layout were to be adopted because Option 2 will outfall onto an existing recreational beach area, and bacteria loads during and after storm events may substantially raise the bacteria levels in the beach water impacting the recreational use of the beach.

5.7 Trash / Floatables

Trash and floatables can be a major concern to the proposed NBC because they would create WQ and aesthetic issues, clog storm sewers and bridge/culvert openings, and sometimes cause boat traffic safety concerns. LAN conducted a study in 2015 for the Cole Park watershed of the City to identify potential sources of floatables that may result in stormwater runoff; evaluate current inlet protection measures; and identify “upstream”, “midstream” and “downstream” management measures for floatables controls. The 2015 study found substantial floatables in the Cole Park drainage area and in the storm sewer systems. Similar floatable conditions would be likely for the North Beach area, and substantial floatables might be washed into the proposed NBC during storm events. Depending of the sizes of the storm events, amount of the floatables might be washed out to CCB but substantial amount of floatable might remain inside the canal for a period of time after each storm event.

Due to the fact that floatables only stay/float on water surface, typical WQ models including CE-QUAL-W2 cannot simulate floatables directly. While special program can be developed to simulate floatables, e.g. the program developed by LAN’s WQ modeling lead, Dr. Yu-Chun Su, to simulate the transport of floating debris in the ocean, the effort would be time-consuming and costly. However, the CE-QUAL-W2 model has the capability to perform tracking of neutrally buoyant particles to estimate typical residence time within the modeled water body.

Using the Option 1 layout without an upstream culvert, a simulation was conducted by releasing 100 neutrally buoyant particles onto the surface of the upstream segment at the beginning of the simulation. Using the particle tracking function of CE-QUAL-W2, the residence time (time for the particle to leave the canal at the downstream outfall boundary due to tidal action during dry weather) was found to range from 1.5 to 21.7 days with an average of 7.4 days.

Thus, under this Option 1 layout, floatables/trash may stay in the canal for a little over a week on average during dry weather after a storm event. It is recommended that the City incorporates "upstream", "midstream" and "downstream" management measures for floatables controls when overhauling the existing storm sewer system to minimize input of floatables into the proposed NBC. The City may also consider developing and implementing a maintenance program to monitor and clean up floatables/trash in the canal.

5.8 Nutrients / Algae

Based on CE-QUAL-W2 model output, nutrient levels (NH3-N, NO23-N, ortho-P) at the upstream end of the Option 1 canal layout with or without an upstream culvert would all be expected to be at low levels. For the with upstream culvert case, the culvert would allow additional tidal exchange so the nutrients would mostly be maintained at the bay concentration levels.

For algae simulation, Appendix B shows that the chlorophyll *a* level would be between 20 and 30 micrograms per liter (ug/L) at the upstream end of the Option 1 canal layout without an upstream culvert. These modeling results are within reasonable range because, as shown in Figures B-11 and B-12, the Inner Harbor chlorophyll *a* data are mostly below 10 ug/L but there are also some values in the 20s or 30s.

With a culvert connecting the proposed NBC to the bay, the chlorophyll *a* level was mostly at the bay level, as shown in Appendix B. Similar to the TSS plots, there is a sudden drop to 0 of the surface chlorophyll *a* on 08/12/2019 in Figure B-40 and on 07/16/2019 and 08/09/2019 in Figure B-41. These sudden drops appear to be output issues of the CE-QUAL-W2 program and not errors in the calculations.

5.9 Water Quality Conclusions and Recommendations

The modeling results show that both Option 1 and 2 layouts with an upstream culvert may meet the 5.0 mg/L DO criterion better. Additionally, the modeling results show bottom low DO levels that could be a concern of complying with the DO criteria.

If non-compliance were found by TCEQ, the water body may be put on the impaired water-body or the 303(d) list that may then trigger Total Maximum Daily Load (TMDL) studies, enforcement actions, and potentially lawsuit by environmental groups. Not being able to meet DO criteria would also affect the environmental permitting of the project.

To achieve compliance with DO criteria, one potential option is to negotiate with TCEQ for the canal to be classified as an Intermediate Aquatic Life Use water quality segment. This would allow the canal to have a lower DO criterion similar to the 3.0 mg/L level for the Inner Harbor. The

proposed canal is not an open bay so it could be considered similar to a ship channel. Following the completed CE-QUAL-W2 modeling effort, the following list of items are recommended:

1. Negotiate with TCEQ to classify the NBC as a water body similar to Inner Harbor with a lower DO criterion.
2. Monitoring sediment accumulation in the canal once the canal has been constructed, including the collection of samples for organic and toxicity analyses.
3. Monitor surface and bottom DO, SOD, $CBOD_5$, and algae levels once the canal has been constructed.
4. Conduct CMS-Flow / sediment transport modeling to evaluate potential sediment shoaling rates in the canal and annual maintenance dredging requirements.
5. Conduct watershed loading modeling to generate runoff flow and sediment loads from the drainage area into the canal during storm events.
6. Conduct watershed runoff modeling to evaluate the bacteria levels in the canal during and after the storm events.
7. Conduct watershed runoff modeling to evaluate its effects on DO levels in the canal during and after storm events.
8. With potentially high volume of trash/floatables in stormwater runoff and the CE-QUAL-W2 particle tracking showing floatables/trash potentially staying in the canal for a little over a week on average during dry weather after a storm event, the City may incorporate “upstream”, “midstream” and “downstream” management measures for floatables controls when overhauling the existing storm sewer system to minimize input of floatables into the proposed NBC. The City may also consider developing and implementing a maintenance program to monitor and clean up floatables/trash in the canal.