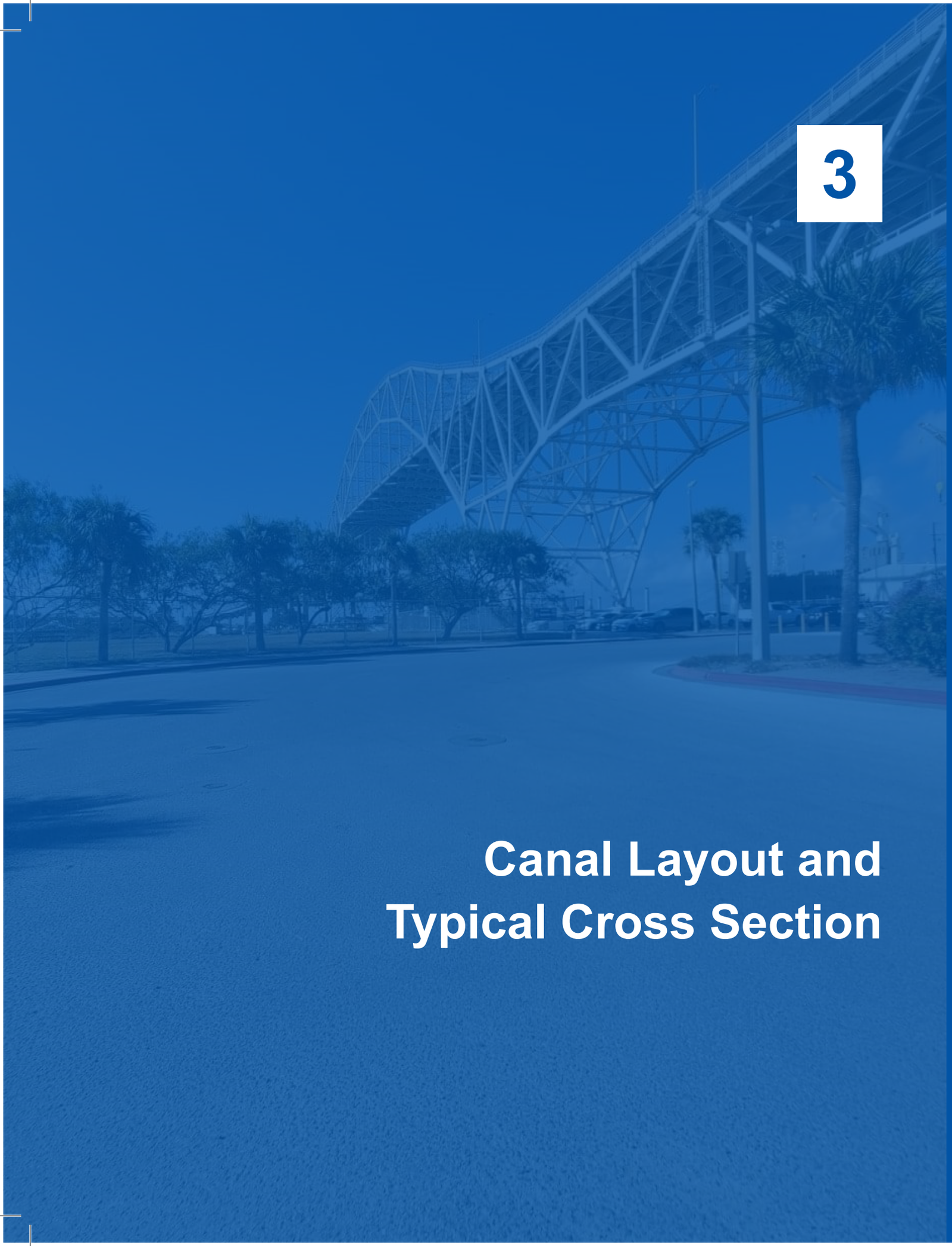

3

Canal Layout and Typical Cross Section

3 Canal Layout and Typical Cross Section

For the purposes of this study, LAN was scoped by the City of Corpus Christi to advance the concepts of design for Option 3 in the Urban Engineering North Beach Drainage Assessment Report (2018) (Project 19047A). Option 3 provided for a large bulkheaded rectangular shaped navigable canal generally located between Surfside Boulevard and Timon Boulevard.

The overarching objective with the advancement of the conceptual design was to investigate the project for its intended use of being navigable and a major drainage facility for the North Beach peninsula land area. Detailed design of the canal components was not included in LAN's scope of work.

3.1 Data Collection / Review

In addition to reviewing Urban's North Beach Drainage Assessment, LAN also took into consideration the concepts and initiatives previously adopted in master plans. LAN gathered and reviewed readily-available existing site improvement and land-use information on the North Beach area, including long and short-range plans, area development plans, capital improvement plans including streets and utility master plans. This task also included a review City of Corpus Christi Unified Development Codes and the following City-provided documents:

1. Downtown Area Development Plan, March 2018
2. North Beach Development Plan, November 2011
3. North Beach Redevelopment Initiative Specific Plan, March 2018
4. North Beach Eco-Park (City Planning Department Workshop), 2018
5. Harbor Bridge Replacement Project, Texas Department of Transportation (TxDOT)
6. Feasibility Assessment North Beach TxDOT Culvert Flooding Mitigation Project, HDR 2018
7. Urban Engineering North Beach Drainage Assessment Report (2018) (Project 19047A)

Part of the analysis of the canal, LAN considered the most appropriate locations for the canal entrance and exit to Corpus Christi Bay. This task was completed in conjunction with the water quality modeling with the intent to optimize the location for navigability and drainage. Two options were evaluated:

1. **Option 1** – Navigable access to the bay adjacent to the jetties on the North end of the peninsula.
2. **Option 2** – Navigable access to the bay through the beach, at the center of the project, at Burleson Avenue.

3.2 Option 1

Exhibits 4A and 4B show the general layout and features of Option 1, including:

1. Navigable access to the bay will be located adjacent to the North Beach Jetties. Jetty improvements could provide for reduction in sedimentation and siltation of canal.
2. Canal could be integrated into City of Corpus Christi Eco-Park concepts and adjacent wetlands.
3. Option 1 will require a bridge crossing at Beach Avenue. Section 6 of this report provides more detail.
4. Option 1 includes a 100-foot wide canal, rectangular bottom (un-lined), 10-foot deep (Mean Sea Level to bottom), concrete or steel sheet pile bulkhead.

5. Navigable Canal south of Burleson Avenue cannot be constructed until completion of Harbor Bridge Replacement Project. See Section 7 of this report for phasing considerations.
6. Option 1 includes a proposed 6-foot x 4-foot reinforced concrete box at the south end of the project at Breakwater Avenue, which discharges into Corpus Christi Bay adjacent to the USS Lexington; this structure could provide relief and circulation of water.

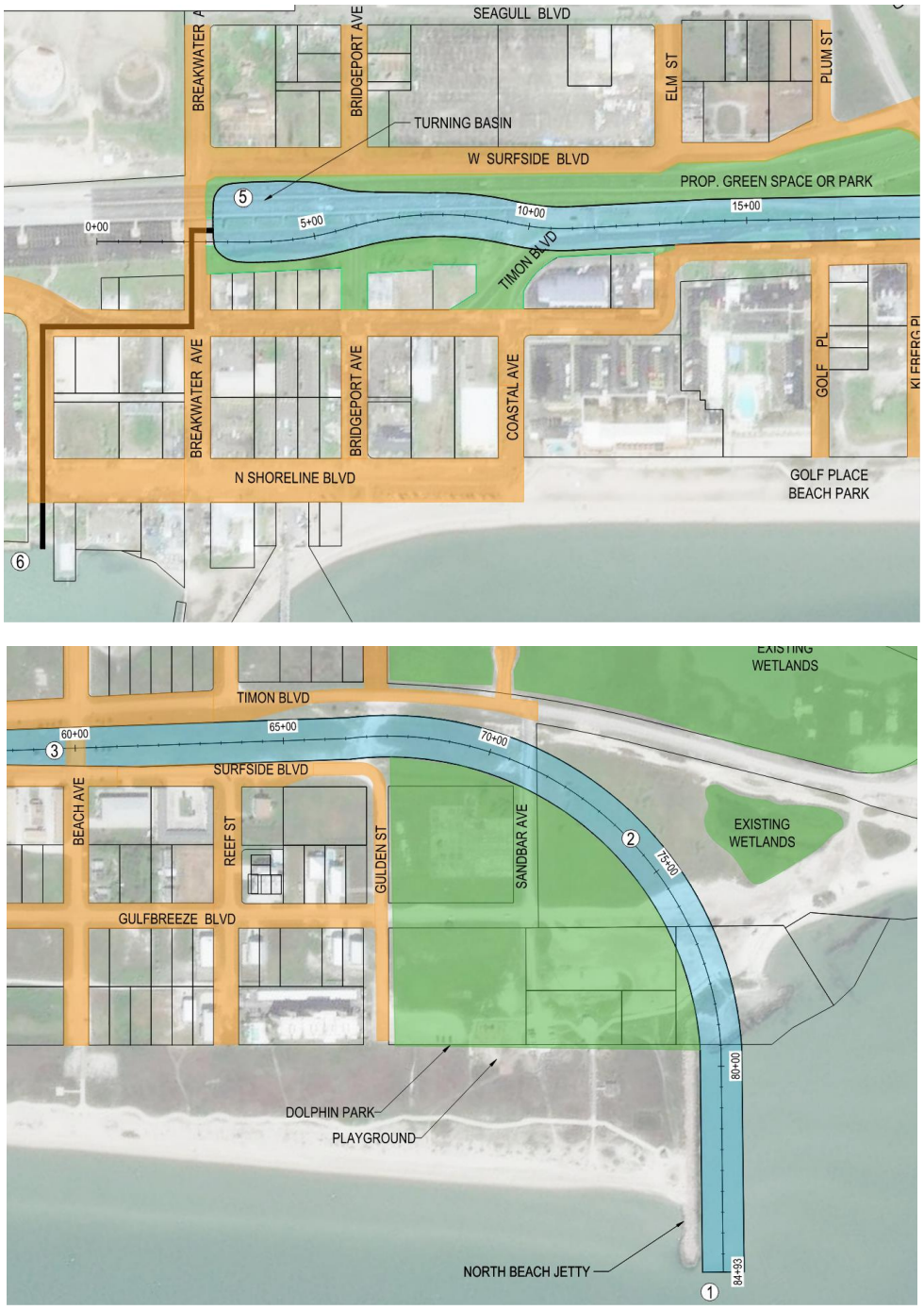

Figure 3-1 – Snapshots of Option 1 Layout

3.3 Option 2

Exhibits 5A and 5B show the general layout and features of Option 2, including:

1. Navigable access to the bay will be located through the beach at Burleson Avenue.
2. Option 2 does not provide for navigable access north of Beach Avenue. Beach Avenue includes an at-grade crossing. The canal transitions to an trapezoidal roadside ditch along Timon Boulevard and discharges through a box culvert into the existing wetlands area.
3. Option 2 includes a 90-foot wide canal, rectangular bottom (un-lined), 10-foot deep (Mean Sea Level to bottom), concrete or steel sheet pile bulkhead.
4. Navigable Canal south of Burleson Avenue cannot be constructed until completion of Harbor Bridge Replacement Project. See Section 7 of this report for phasing considerations.
5. Option 2 includes a proposed 6-foot x 4-foot reinforced concrete box at the south end of the project at Breakwater Avenue, which discharges into Corpus Christi Bay adjacent to the USS Lexington; this structure could provide relief and circulation of water.

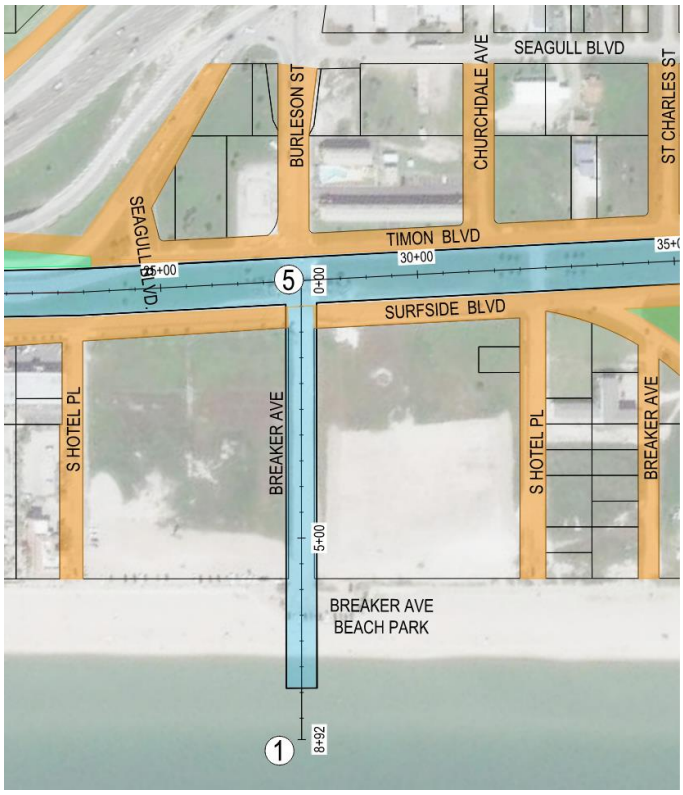

Figure 3-2 – Snapshot of Option 2 at Outfall to Bay

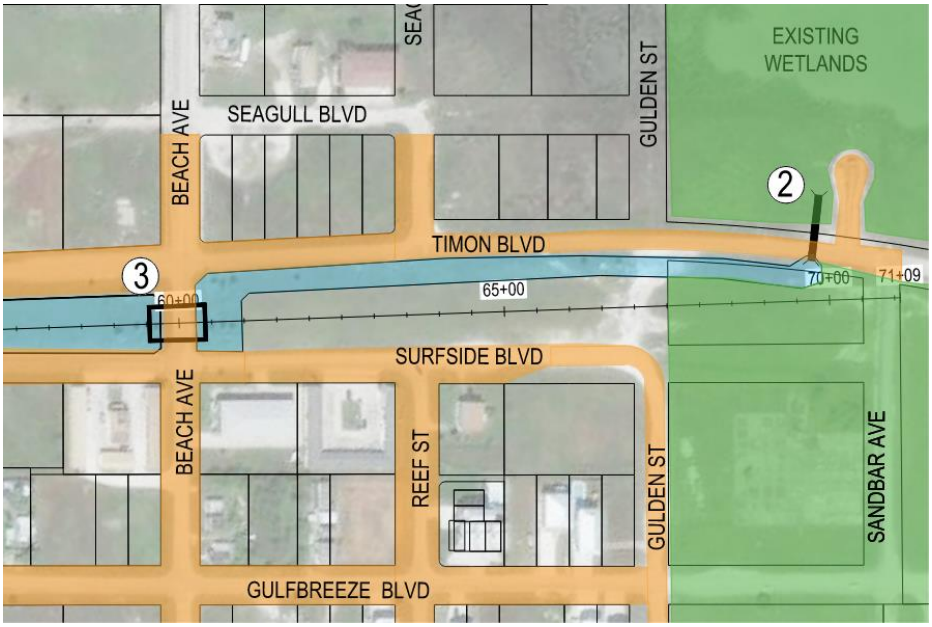

Figure 3-3 – Snapshot of Option 2 at Beach Avenue

3.4 Typical Cross Section

Figure 3-4 below is a typical canal cross section, also show in Exhibit 6:

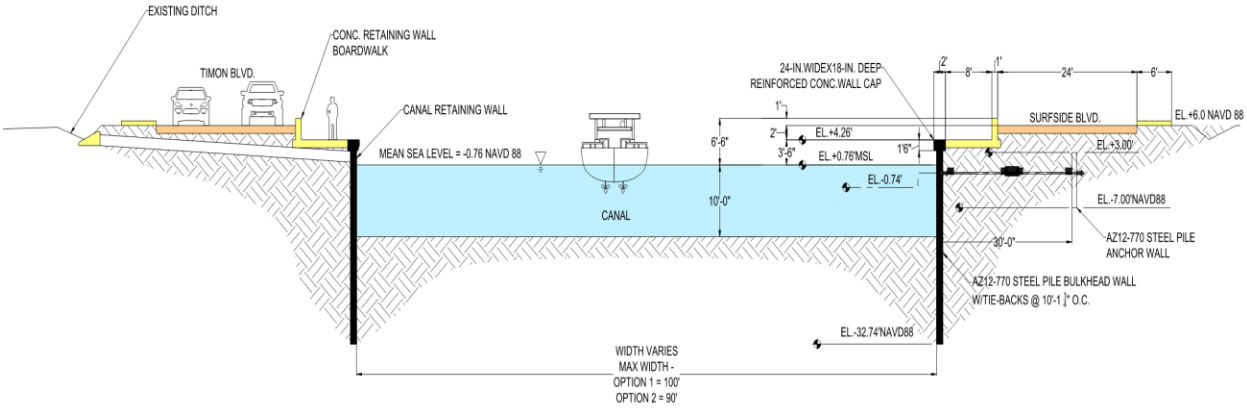

Figure 3-4 – Typical Cross Section

3.5 Design Craft / Navigability Constraints & Limitations

The proposed canal could be designed in the future to allow for navigability and access in and out of Corpus Christi Bay. LAN examined several considerations including: types of watercraft, watercraft dimensions (length, width, height above water, depth of craft / keel depth, and turning requirements for use on the proposed canal.

In general, there are three types of watercraft: cruising, watersports, and fishing. The below tables includes dimensions for many typical watercraft currently in use in or near the project area:

Type	Length Overall (ft)	Average Draft (ft)	Freeboard / Clearance above MSL (ft)	Beam Width (ft)
Cruising Sailboat	16 – 50	5 – 6	50 – 75	11 – 13
Catamaran	32 – 47	2 – 4	39 – 65	22 – 32
Cabin Cruiser	25 – 45	3 – 4	10 – 18	8 – 9
Motor Yacht	29 – 65	4 -5	14 – 15	11 – 14
Center Console	18 – 32	2	8 – 11	8 - 9

Table 3-1 – Type of Recreational Watercraft

The below table illustrates typical boat size versus draft depths:

Type	Length (ft)	Average Draft (ft)
Low Draft	< 32	< 3
Medium Draft	45- 65	4 – 5
Cabin Cruiser	25 – 45	3 – 4

Table 3-2 – Average Drafts / Length

Considerations for North Beach:

1. A 90-foot to 100-foot wide canal could accommodate most if not all recreational watercraft.
2. Ideal sub-types / classes of watercraft include: pontoon boats, bowriders, cabin cruisers, motor yachts, personal watercraft (jet ski, kayak, canoe), sport boats, walk-around boats.
3. Watercraft Limitations for the North Beach Canal include:
    a. Length – 50 -foot or less
    b. Clearance above water – less than 20-feet (Option 1 only)
    c. Keel depth – less than 10-feet
    d. Limit tall sailboats, large yachts requiring large turning radius, and sport and commercial fishing (outriggers)

Figure 3-5 on the next page shows typical turning movements for a craft that is 10-foot wide (beam width) by 50-foot long.

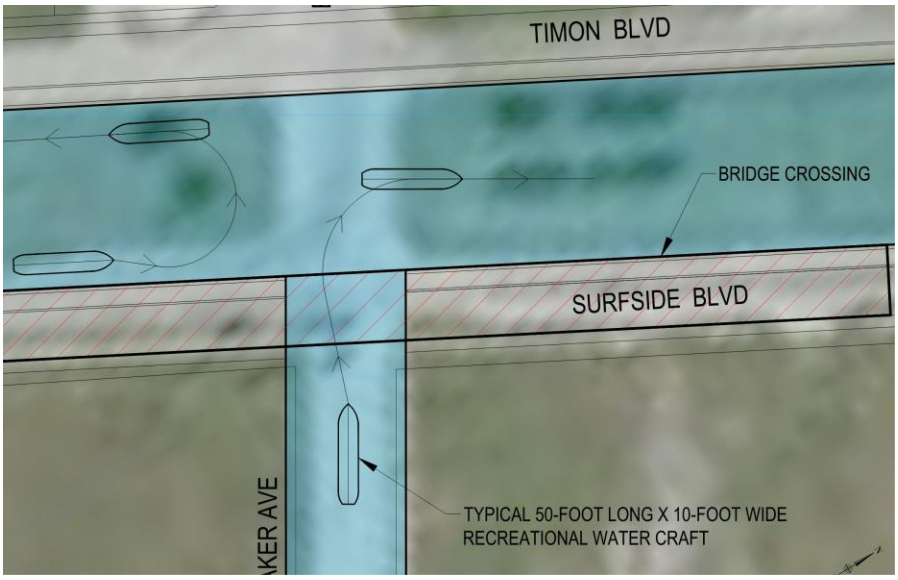

Figure 3-5 – Typical Craft Turning Movements

3.6 Bulkhead Requirements

3.6.1 Anchored Bulkhead Wall

The new bulkhead and anchor wall system should be designed to accommodate the appropriate lateral and surcharge loadings associated with future landside improvements including but not limited to the boardwalk and H-10 traffic loading from the roads parallel to the bulkhead. The new bulkhead and tieback system should be designed to accommodate a navigable canal with a channel depth of 10' from MSL.

The new bulkhead wall should be designed to accommodate new stormwater outfall structures that will penetrate the wall at and below water level.

3.6.2 Geotechnical Engineering Recommendations

Tolunay-Wong Engineers, Inc. (TWEI) performed the geotechnical study (TWEI Report No. 26074) for the proposed bulkhead wall in order to explore and evaluate the soil conditions, and to provide geotechnical recommendations for the design and construction of the proposed bulkhead structure. Refer to the attached geotechnical report for additional information.

3.6.3 Soil Erosion Susceptibility

According to the Geotechnical report, the cohesionless granular soils (sands, silty sands, clayey sands) which were encountered above depths of 23-ft to 28-ft in the borings for this study are primarily fine-grained sands, some with abundant fine seashell fragments. These materials will be prone to erosion by becoming part of the water column when subjected to wave action as well as large water velocities below the water surface due to turbulent flow (eddies, jets, etc.). Protection methods against erosion could consider installation of hardscape (cast-in-place concrete or precast concrete articulated block), riprap, soil cement, grout filled mattresses or other streambed armoring measures. However, actual assessment of erosion will require analysis of stream equilibrium condition which is beyond the scope of services at this time.

3.6.4 Bulkhead Wall Design

The recommended soil parameters for the design of the new bulkhead wall for short-term, long-term loading conditions are presented in Appendix D of this report.

3.6.5 Bulkhead Wall System

Two types of bulkhead wall systems should be considered for the North Beach project. LAN performed preliminary analyses for both type of wall systems:

a. Cantilever Walls: Cantilever walls are usually used as floodwall or as earth retaining walls with low wall heights (10 to 15 feet or less).
b. Anchored Walls: An anchored wall is required when the height of the wall exceeds the height suitable for a cantilever or when lateral deflections are a consideration.

Approximate retained height is 13'-6" without consideration of any erosion/scour of the streambed. Currently, detailed analysis of erosion/scour is beyond the scope of services. However, considering erosion potential of streambed soil, our analyses of sheet pile walls accounted for erosion of the sands to a depth of 2-ft below the proposed streambed. Upon detailed erosion/scour analysis, this will be revisited and either the protection of the streambed or revisions to the bulkhead wall design would likely be required in accordance with the erosion/scour analysis results.

Anchored sheet pile walls are proposed for this project after preliminary analysis. Anchored sheet pile walls derive their support by two means: passive pressure on the front of the embedded portion of the wall and anchor tie rods near the top of the piling. This method is suitable for heights up to about 35 feet, depending on the soil conditions. The overall stability of anchored sheet pile walls and the stresses in the members depends on the interaction of a number of factors, such as the relative stiffness of the piling, the depth of piling penetration, the relative compressibility and strength of the soil, the amount of anchor yield, etc.

There are several materials which can be used for anchored sheet pile walls. The design must consider the possibility of material deterioration and its effect on the structural integrity of the system. Most permanent structures are constructed of either steel or concrete. Concrete is capable of providing a long service life under normal circumstances but has relatively high initial costs when compared to steel sheet piling. They are more difficult to install than steel piling. Long-term field observations indicate that steel sheet piling provides a long service life when properly designed. Allowance for subsequent installation of cathodic protection in the design can be considered should excessive corrosion occur. Detailed study of corrosion protection requires field soil corrosivity testing as recommended in ASTM STP1000 which is beyond the scope of services at this time.

LAN performed preliminary analysis to compare both: Steel Sheet Piling and Prestressed Concrete Sheet Piling. Preliminary analysis resulted in AZ12-770 steel sheet piling (19.31 psf weight) and 10 inch thick x 24 inch prestressed concrete sheet piling (125 psf weight). Here the piling is driven into some soft soil layers based on limited boring data available. Past experience indicates concrete pile can induce settlement (due to its own weight) in soft foundation materials. In this case the water tightness of the wall will probably be lost. Also, prestressed concrete piling may not be readily available in all localities.

LAN has developed preliminary details of an idealized bulkhead wall system using steel sheet piling, shown in Figures 3-6 and 3-7 below:

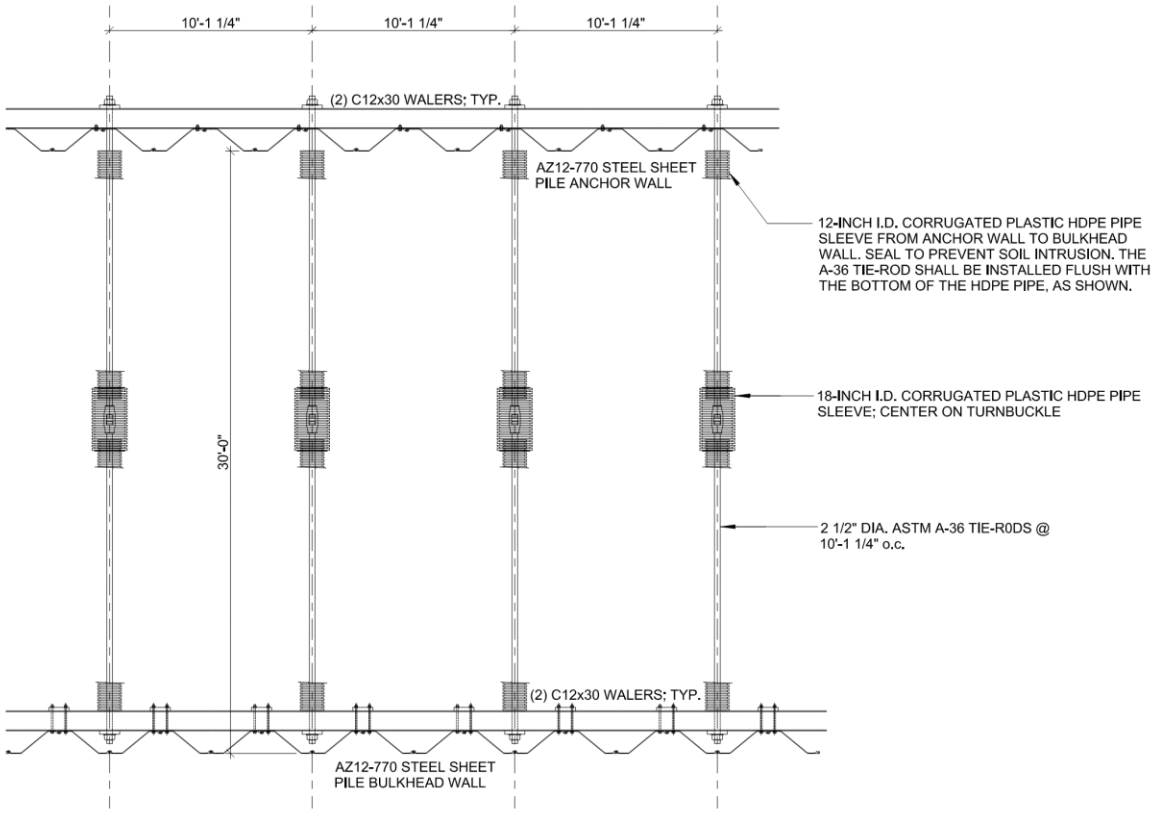

Figure 3-6 – Bulkhead Wall System Plan View

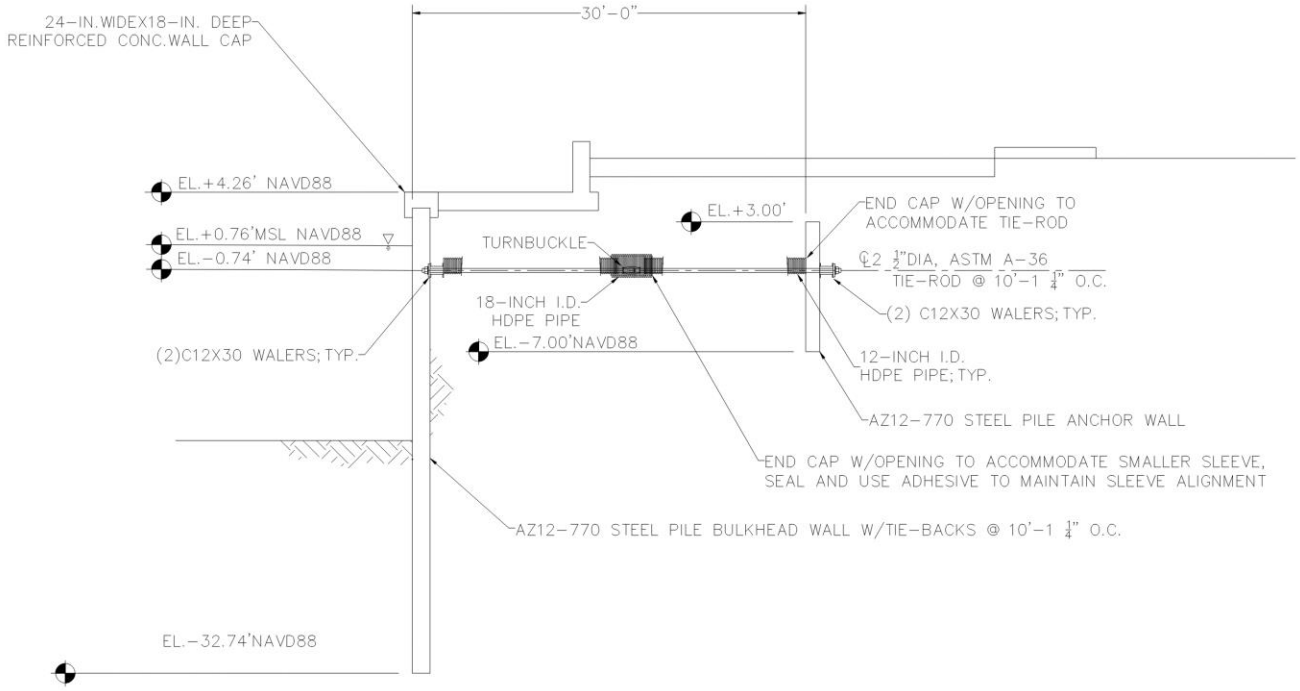

Figure 3-7 – Bulkhead Wall System – Cross Section

NOTES

1. OPTION 1 NAVIGABLE ACCESS IN AND OUT OF CANAL WILL BE ADJACENT TO NORTH BEACH JETTIES. JETTY IMPROVEMENTS COULD PROVIDE FOR REDUCTION IN SEDIMENTATION AND SILTATION OF CANAL.
2. NAVIGABLE CANAL COULD BE INTEGRATED INTO ECO-PARK WATER FEATURES AND WETLAND AREAS AND STILL PROVIDE FOR NAVIGABILITY IN THIS SECTION.
3. OPTION 1 WILL REQUIRE A BRIDGE CROSSING AT BEACH AVENUE. BRIDGE APPROACHES ARE APPROXIMATELY 180-FEET LONG ON EAST AND WEST SIDES, BRIDGE LENGTH = XX; LOW CHORD = 20.76 NAVD-88 (20-FOOT OF CLEARANCE ABOVE MEAN SEA LEVEL). SEE EXHIBIT GX.
4. OPTION 1 - SEE TYPICAL SECTION, NAVIGABLE CANAL IS TYPICALLY 100-FOOT WIDE.
5. NAVIGABLE CANAL SOUTH OF BURLESON CANNOT BE CONSTRUCTED UNTIL COMPLETION OF HARBOR BRIDGE REPLACEMENT PROJECT. SEE SECTION 7 OF REPORT REGARDING PHASING CONSIDERATIONS.
6. PROPOSED 6-FOOT X 4-FOOT REINFORCED CONCRETE BOX ON SOUTH END OF CANAL COULD PROVIDE RELIEF AND CIRCULATION OF WATER.

LEGEND
- HARBOR BRIDGE
- ROADS
- GREEN SPACE / PARKS
- CANAL

NEW HARBOR BRIDGE (US 181)

US HWY 181

E CAUSEWAY BLVD

SEAGULL BLVD

COASTAL AVE

BREAKWATER AVE

BRIDGEPORT AVE

ELM ST

PLUM ST

BURLESON ST

CHURCHDALE AVE

ST CHARLES ST

TOURIST AVE

TURNING BASIN

W SURFSIDE BLVD

PROP. GREEN SPACE OR PARK

TIMON BLVD

SURFSIDE BLVD

0+00 5+00 10+00 15+00 20+00 25+00 30+00 35+00

GOLF PL

KLEBERG PL

PAUL PL

S HOTEL PL

BREAKER AVE

SURFSIDE BLVD

SURFSIDE PARK

N SHORELINE BLVD

GOLF PLACE BEACH PARK

BREAKER AVE BEACH PARK

SURFSIDE BEACH

TEXAS STATE AQUARIUM

USS LEXINGTON

CORPUS CHRISTI BAY

SECTION A - A

EXHIBIT 4A - OPTION 1 LAYOUT (SOUTH)

0 80 160
SCALE: 1"=80'

CONSULTANT'S PROJECT NO.
130-10937-000

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A LEO A DALY COMPANY
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PROGRAM MANAGEMENT
500 N. Shoreline Blvd., Suite 905
Corpus Christi, Texas 78401

CITY of CORPUS CHRISTI
TEXAS
Department of Engineering Services

NORTH BEACH
NAVIGABLE CANAL

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CITY PROJECT # 20277
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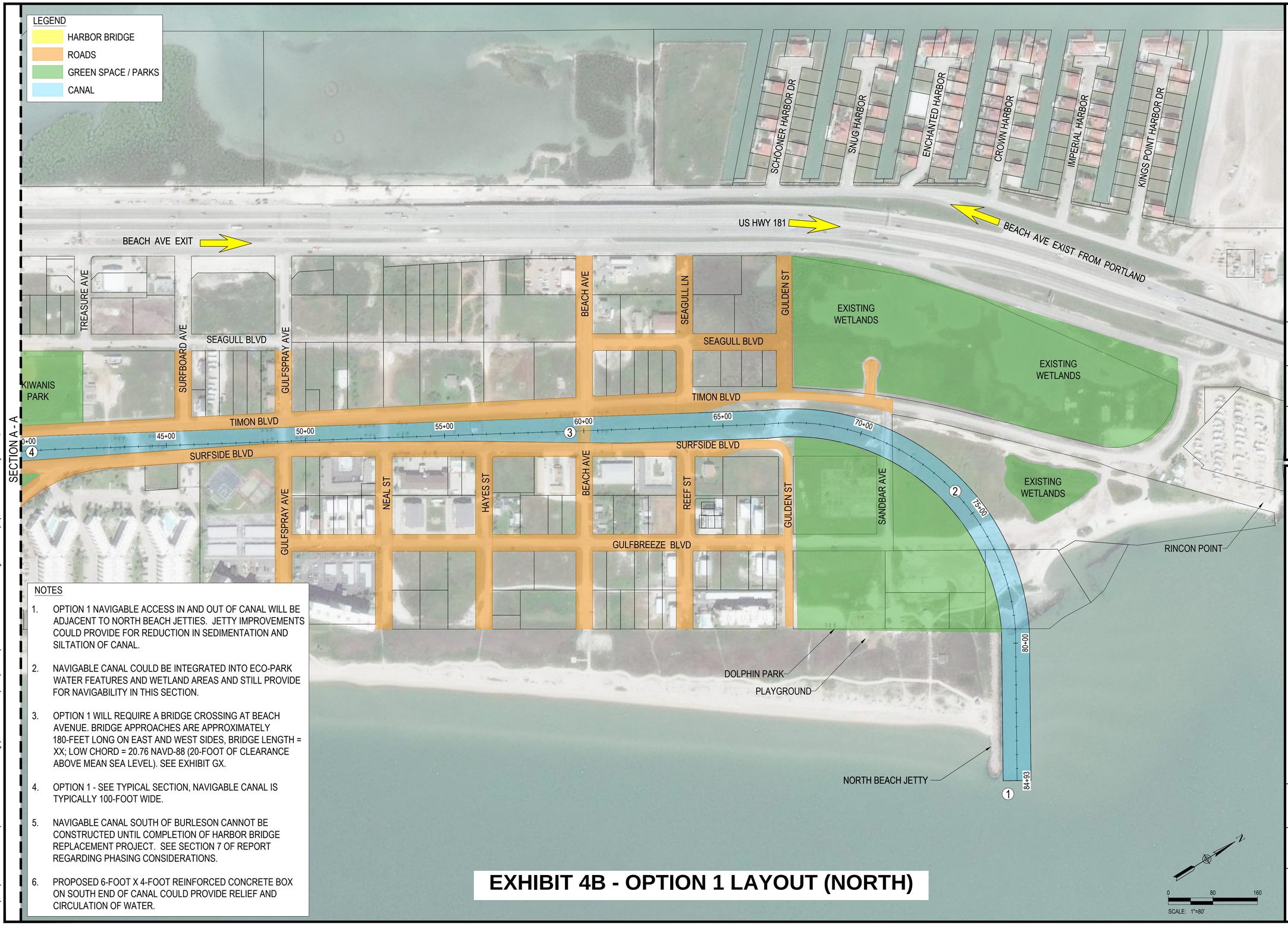

NOTES

1. OPTION 1 NAVIGABLE ACCESS IN AND OUT OF CANAL WILL BE ADJACENT TO NORTH BEACH JETTIES. JETTY IMPROVEMENTS COULD PROVIDE FOR REDUCTION IN SEDIMENTATION AND SILTATION OF CANAL.
2. NAVIGABLE CANAL COULD BE INTEGRATED INTO ECO-PARK WATER FEATURES AND WETLAND AREAS AND STILL PROVIDE FOR NAVIGABILITY IN THIS SECTION.
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5. NAVIGABLE CANAL SOUTH OF BURLESON CANNOT BE CONSTRUCTED UNTIL COMPLETION OF HARBOR BRIDGE REPLACEMENT PROJECT. SEE SECTION 7 OF REPORT REGARDING PHASING CONSIDERATIONS.
6. PROPOSED 6-FOOT X 4-FOOT REINFORCED CONCRETE BOX ON SOUTH END OF CANAL COULD PROVIDE RELIEF AND CIRCULATION OF WATER.

EXHIBIT 4B - OPTION 1 LAYOUT (NORTH)

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Corpus Christi, Texas 78401

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Department of Engineering Services

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CITY PROJECT # 20277
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NOTES

1. OPTION 1 NAVIGABLE ACCESS IN AND OUT OF CANAL WILL BE THROUGH THE BEACH AT BREAKER / BURLESON AVENUES. NEW JETTIES COULD BE CONSTRUCTED FOR REDUCTION IN SEDIMENTATION AND SILTATION OF CANAL.
2. OPTION 2 DOES NOT PROVIDE NAVIGABLE ACCESS NORTH OF BEACH AVENUE. FOR DRAINAGE AND CIRCULATION, THE CANAL WILL TRANSITION TO A ROADSIDE DITCH AND DISCHARGE INTO THE EXISTING WETLANDS AREA.
3. BEACH AVENUE AT-GRADE CROSSING COULD INCLUDE 3 - 10X10 RCB'S.
4. OPTION 2 - SEE TYPICAL SECTION, NAVIGABLE CANAL IS TYPICALLY 90-FOOT WIDE.
5. BURLESON STREET IS CLOSED AT THE CANAL. RELOCATION OF NORTH BEACH ENTRY GATE TO BEACH AVENUE.
6. NAVIGABLE CANAL SOUTH OF BURLESON CANNOT BE CONSTRUCTED UNTIL COMPLETION OF HARBOR BRIDGE REPLACEMENT PROJECT. SEE SECTION 7 OF REPORT REGARDING PHASING CONSIDERATIONS.
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LEGEND
- HARBOR BRIDGE
- ROADS
- GREEN SPACE / PARKS
- CANAL

NEW HARBOR BRIDGE (US 181)
US HWY 181
E CAUSEWAY BLVD
COASTAL AVE
SEAGULL BLVD
BREAKWATER AVE
BRIDGEPORT AVE
ELM ST
PLUM ST
BURLESON ST
CHURCHDALE AVE
ST CHARLES ST
TOURIST AVE
TURNING BASIN
W SURFSIDE BLVD
PROP. GREEN SPACE OR PARK
TIMON BLVD
SEAGULL BLVD
SURFSIDE BLVD
0+00
5+00
10+00
15+00
20+00
25+00
30+00
35+00
1
4
5
6
7
8+92
N SHORELINE BLVD
GOLF PL
KLEBERG PL
PAUL PL
S HOTEL PL
BREAKER AVE
SURFSIDE PARK
GOLF PLACE BEACH PARK
BREAKER AVE BEACH PARK
SURFSIDE BEACH
TEXAS STATE AQUARIUM
USS LEXINGTON
CORPUS CHRISTI BAY
SECTION A - A

EXHIBIT 5A - OPTION 2 LAYOUT (SOUTH)

0 80 160
SCALE: 1"=80'

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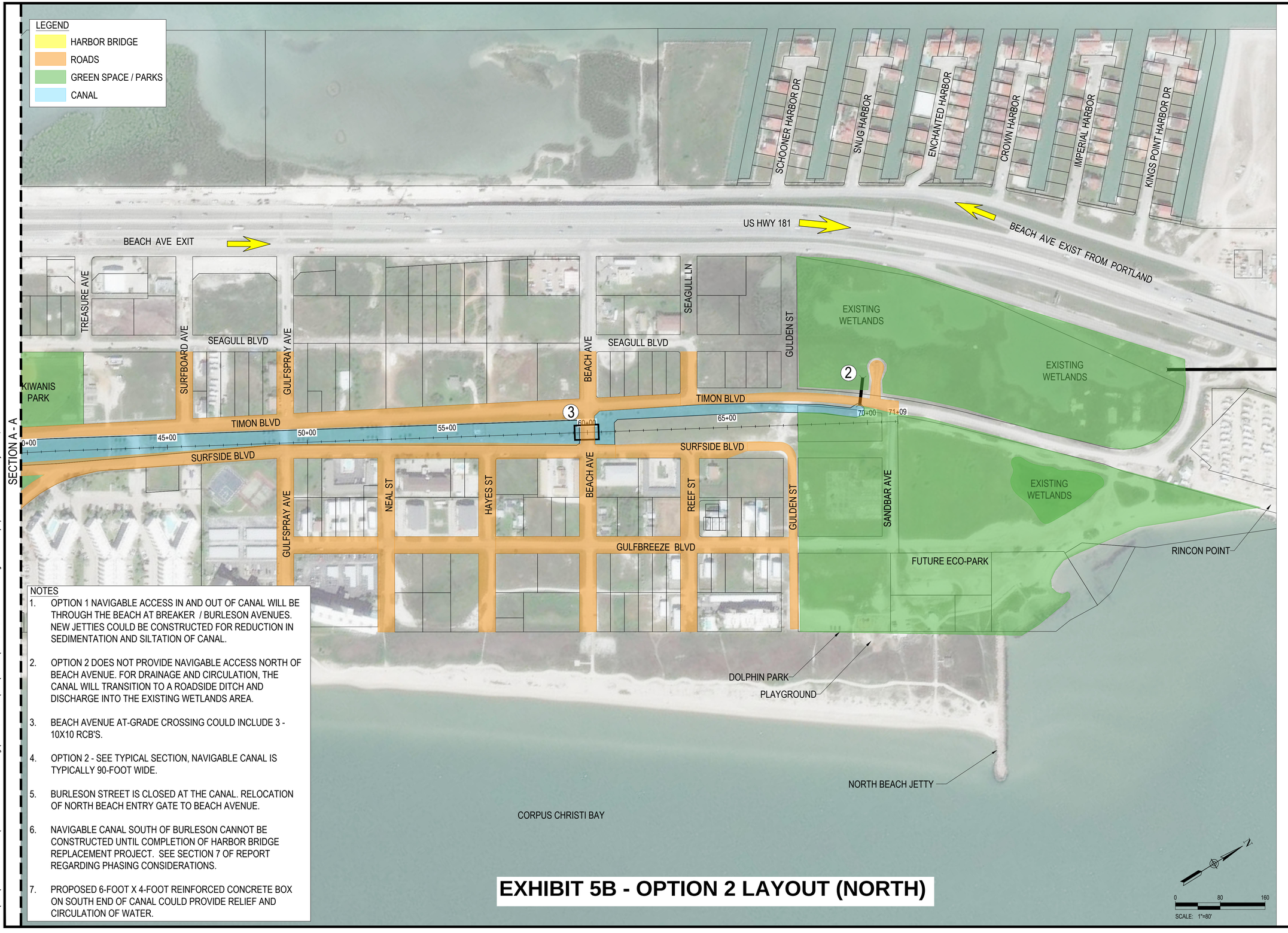

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2. OPTION 2 DOES NOT PROVIDE NAVIGABLE ACCESS NORTH OF BEACH AVENUE. FOR DRAINAGE AND CIRCULATION, THE CANAL WILL TRANSITION TO A ROADSIDE DITCH AND DISCHARGE INTO THE EXISTING WETLANDS AREA.
3. BEACH AVENUE AT-GRADE CROSSING COULD INCLUDE 3 - 10X10 RCB'S.
4. OPTION 2 - SEE TYPICAL SECTION, NAVIGABLE CANAL IS TYPICALLY 90-FOOT WIDE.
5. BURLESON STREET IS CLOSED AT THE CANAL. RELOCATION OF NORTH BEACH ENTRY GATE TO BEACH AVENUE.
6. NAVIGABLE CANAL SOUTH OF BURLESON CANNOT BE CONSTRUCTED UNTIL COMPLETION OF HARBOR BRIDGE REPLACEMENT PROJECT. SEE SECTION 7 OF REPORT REGARDING PHASING CONSIDERATIONS.
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EXHIBIT 5B - OPTION 2 LAYOUT (NORTH)

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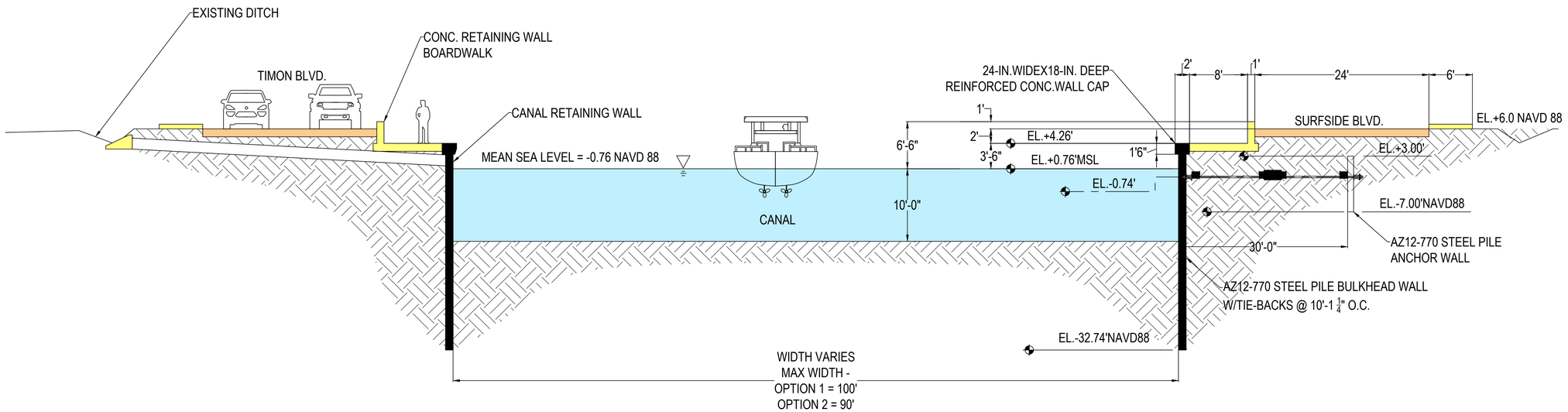

EXHIBIT 6 - TYPICAL CANAL CROSS SECTION

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SCALE: 1"=8'

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