BIOLOGICAL ASSESSMENT FOR SHORTNOSE AND ATLANTIC STURGEONS

WILMINGTON TERMINAL TURNING BASIN EXPANSION

NORTH CAROLINA STATE PORTS AUTHORITY

October 26, 2018

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EXECUTIVE SUMMARY

The primary purpose and need of the North Carolina State Port Authority (NCSPA) at the Port of Wilmington (POW) is to expand the present turning basin to meet larger vessels calling on the port in the late fourth quarter of 2019 (Figure 1). In order to meet this need, the POW proposes to dredge the eastern and western sides of the present basin, deepening approximately 17.76 acres of shallow and deep unvegetated habitat to -45 feet (ft) Mean Low Low Water (MLLW), dredging 1.4 acres of coastal tidal marsh east of the channel, and installing a vertical submerged king or sheet pile tow wall along the eastern extents of the basin (Figures 2 and 3). Material will be placed in scows and hydraulically pumped to the Eagle Island confined disposal facility (CDF). There will be no impacts to the tidal marsh or Eagle Island disposal facility on the western side of the basin.

The international shipping community and clients that currently utilize the POW are expanding into a new class of freightliners to optimize shipping efficiency and global logistics. The new class of containerships are expected to be capable of carrying 14,000 Twenty-foot Equivalent Units (TEU) with an overall length of 1200-ft and a beam of 159-ft. Once the NCSPA clients transition to this new class of vessel, they will be calling on ports that currently have the facilities and capabilities to safely handle turning, berthing and unloading. To prevent the loss in clientele and subsequent revenue, the POW must adapt by expanding the current 1,400-ft turning basin to meet the needs of the future vessels. The proposed project includes a 1,524-ft turning basin elongated to 500-ft along the eastern side of the Cape Fear River (CFR) with a 1,612-ft long toe wall along the eastern edge of the project to stabilize the shoreline and maintain the basin width and navigable depth (Figure 2). This wall will be completely submerged, and additional H-piles will be installed in the recess of the sheet piles with solar powered navigation lights installed on top of the pile at EL+10-ft MLLW. This project requires construction dredging to -45 ft MLLW, which includes a two-ft over dredge to -44-ft MLLW and one-ft allowable over dredge for rock. The dredged basin will be maintained at -42-ft (+2 ft.). It is expected that total dredging quantities to be removed during this project will reach 560,000 cubic yards (CY), which includes 370,000 CY on the east side and 190,000 CY on the west side. It is currently proposed that the sediment will be disposed of at the Eagle Island CDF.

The Cape Fear River (CFR) supports a small population of Atlantic and shortnose sturgeons. Recent acoustic monitoring [North Carolina Department of Environment and Natural Resources (NCDENR) 2013] documented the occurrence of 46 Atlantic sturgeons (26 tagged, balance too small for tagging) and one shortnose sturgeon. While the likelihood of their presence in the affected areas is thought to be quite rare, past monitoring and collection efforts demonstrate they may occur in the harbor during their annual migrations up and down river (Personal communication, Chip Collier, North Carolina Division of Marine Fisheries 2013). Only adult and juvenile life stages could occur within the affected area, as eggs and larvae would not be present due to high salinities and lack of appropriate spawning habitat. Dredging effects on sturgeons may include abrasion of gills from sediment suspension, a temporary loss of the benthic community food source within the dredging footprint, and degradation in the benthic foraging habitat down current due to the deposition of suspended sediment. The severity of the biological effect of water quality changes on sturgeons depends upon the exposure magnitude, frequency, and duration for those parameters considered, as well as the species adapted tolerance.

Proposed mechanical dredging for the turning basin widening will result in the conversion of about 17.76 acres of sand/mud bottom habitat, which ranges in depth from zero ft mean low water (MLW), to a construction depth of -45-ft (-42-ft +2 ft, +1 ft) and 1.4 acres of coastal marsh. Sturgeon species likely use the project area and vicinity for feeding, resting, and as a potential pathway to upstream spawning areas (Moser and Ross 1993, Moser et al.1998). Other more recent tagging studies and monitoring by North Carolina Division of Marine Fisheries (NCDMF) further confirm the presence of sturgeons within the river near the port terminals (NCDENR 2013).

The proposed dredging area likely provides limited value as a forage area since the berthing area is dredged for maintenance on an annual basis and the adjacent shallow areas are greatly influenced by vessel movements, port operations, stormwater discharges etc. Recovery of benthic resources would likely require between six months and one year. Therefore, it is expected that the area will provide low value for benthic forage with or without the proposed deepening. The shallow habitat (1.68 acres of total) and the coastal marsh likely has a more diverse benthic community than what the recovered future benthic community will be like at deeper depths following dredging.

While this may represent a loss of potential foraging habitat for sturgeons, it is important to note that there are 37,800 acres of shallow water soft bottom habitat (<6 ft deep) and 188,549 acres of deeper soft bottom habitat (>6 ft deep) available for foraging within the CFR southern estuary (Deaton 2010). The area of proposed deepening of shallow water habitat (1.68 acres) accounts for 0.004 percent of available shallow water foraging habitat within the lower CFR. The widening will also impact 1.4 acres of tidal marsh, considered potential foraging habitat for sturgeon along the northwest corner of the Kinder Morgan property. This loss will account for 0.01 acres of the total Spartina dominated tidal marsh located in the lower CFR (unpublished data, Dial Cordy and Associates Inc. 2018).

Mechanical dredging through use of a clamshell bucket dredge will result in elevated total suspended solids (TSS) and turbidity levels for a short duration during dredging ranging from three to five months. Due to the small footprint during clamshell operations and because of tidal effects and the dynamic nature of sediment plumes, significant turbidity plumes are not anticipated. Dredging is not expected to result in depressed dissolved oxygen (DO) levels during dredging most of the year, other than during the late summer/early fall when water temperatures are higher and DO lower (Mallin 2013). Dissolved oxygen levels during the 1999 monitoring of agitation dredging at the POW were not depressed and did not go below five milligrams per liter or show any correlation to temperature or turbidity (NCDENR 2009, Law Engineering and Environmental Services, Inc. 1999). Maintaining the anadromous fish in-water construction moratorium from 1 February through 30 September of each year helps ensure that the potential summer DO sag is not further depressed by hydraulic dredging and thereby adversely affecting the behavior or health of sturgeons. Clamshell bucket dredging is allowable year round due to its potentially less adverse effect as compared to cutterhead hydraulic dredging.

The NCSPA has offered the following conservation measure to compensate for unavoidable effects and potential foraging habitat loss associated with the proposed project. This measure includes payment of $650,000 towards construction of the proposed modifications to the rock ramp weir fish passage at Lock and Dam #1. Along with the funds already secured, this additional contribution should allow construction to proceed in the next 12-18 months. This measure is only proposed if this project can be fully permitted and approved by all parties, including an informal Section 7 consultation letter from the National Marine Fisheries Service in less than 120 days from the initial date of application (26 October 2018)

Conservation measures to avoid and or minimize additional effects on managed and associated species within their associated Essential Fish Habitat in the project area includes the following:

- Turbidity booms will be deployed around dredging and pumping operations at all times to minimize movement of suspended sediments and turbidity.
- Turbidity booms will be monitored by the POW to ensure compliance with the above requirement.
- Best management practices will be used throughout construction to minimize turbidity and any indirect effects on managed and associated species.
- Observers will maintain watch on the dredge for sturgeons and manatee.
- No impacts to wetlands on the western shoreline will be impacted from this action.

Based on the information presented in this biological assessment, dredging 17.76 acres of unvegetated soft bottom habitat, dredging 1.4 acres of coastal wetland and installing a submerged tow wall for widening of the turning basin, may affect, but is not likely to adversely affect both species of sturgeon or critical habitat for Atlantic sturgeon. This applies to mechanical dredging only through use of clamshell/bucket dredge, as has been allowable with existing maintenance dredging permits for the POW. Conservation measures as proposed herein shall be implemented consistent with the terms presented in the above section.

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1.0 PROPOSED ACTION

The primary purpose and need of the North Carolina State Port Authority (NCSPA) at the Port of Wilmington (POW) is to expand the present turning basin to meet larger vessels calling on the port in the late fourth quarter of 2019 (Figure 1). In order to meet this need, the POW proposes to dredge the eastern and western sides of the present basin, deepening approximately 17.76 acres of shallow and deep unvegetated habitat to a construction depth of -45 feet (ft) MLLW), dredging 1.4 acres of coastal tidal marsh east of the channel, and installing a vertical submerged king or sheet pile tow wall along the eastern extents of the basin (Figures 2 and 3) Material will be placed in scows and hydraulically pumped to the Eagle Island confined disposal facility (CDF). There will be no impacts to the tidal marsh or Eagle Island disposal facility on the western side of the basin.

The international shipping community and clients that currently utilize the POW are expanding into a new class of freightliners to optimize shipping efficiency and global logistics. The new class of containerships are expected to be capable of carrying 14,000 Twenty-foot Equivalent Units (TEU) with an overall length of 1200-ft and a beam of 159-ft. Once the NCSPA clients transition to this new class of vessel, they will be calling on ports that currently have the facilities and capabilities to safely handle turning, berthing and unloading. To prevent the loss in clientele and subsequent revenue, the POW must adapt by expanding the current 1,400-ft turning basin to meet the needs of the future vessels. The proposed project includes a 1,524-ft turning basin elongated to 500-ft along the eastern side of the Cape Fear River (CFR) with a 1,612-ft long toe wall along the eastern edge of the project to stabilize the shoreline and maintain the basin width and navigable depth (Figure 2). This toe wall will consist of interlocking steel sheet pile with protective coatings that are 70-ft long and will be driven into the marl layer (see plans in Appendix A). This wall will be completely submerged, and additional H-piles will be installed in the recess of the sheet piles with solar powered navigation lights installed on top of the pile at EL+10-ft MLLW. This project requires dredging to -45 ft MLLW, which includes a two-ft over dredge to -44-ft MLLW and one-ft allowable paid over dredge for rock. It is expected that total dredging quantities to be removed during this project will reach 560,000 cubic yards (CY), which includes 370,000 CY on the east side and 190,000 CY on the west side. It is currently proposed that the sediment will be disposed of at the Eagle Island CDF. The current "Chevron" pier will need to be removed; however, the mooring dolphin for Berth 1 will remain. There will be no impacts to the existing slope on the Eagle Island Army Corps dredge disposal facility berm.

The NCSPA has confirmed that the authorized project depth of the CFR, -42 ft MLLW (+2), is acceptable for the larger ships that are expected to call at the POW next year. In addition, the dock structures and the ship-to-shore cranes that exist at the POW are adequately sized to receive the larger vessels that will begin to deploy in 2019. Failure to be able to service these vessels through constructing a 1,500 ft diameter basin could have a severe economic impact on the POW and State of North Carolina as early as next fall.

The construction schedule will require at least ten months for dredging and installation of the submerged tow wall. Ideally, it is preferable that dredging be allowed to proceed by 1 April 2019, with a summer 2019 deadline for partial completion and the fall of 2019 for full

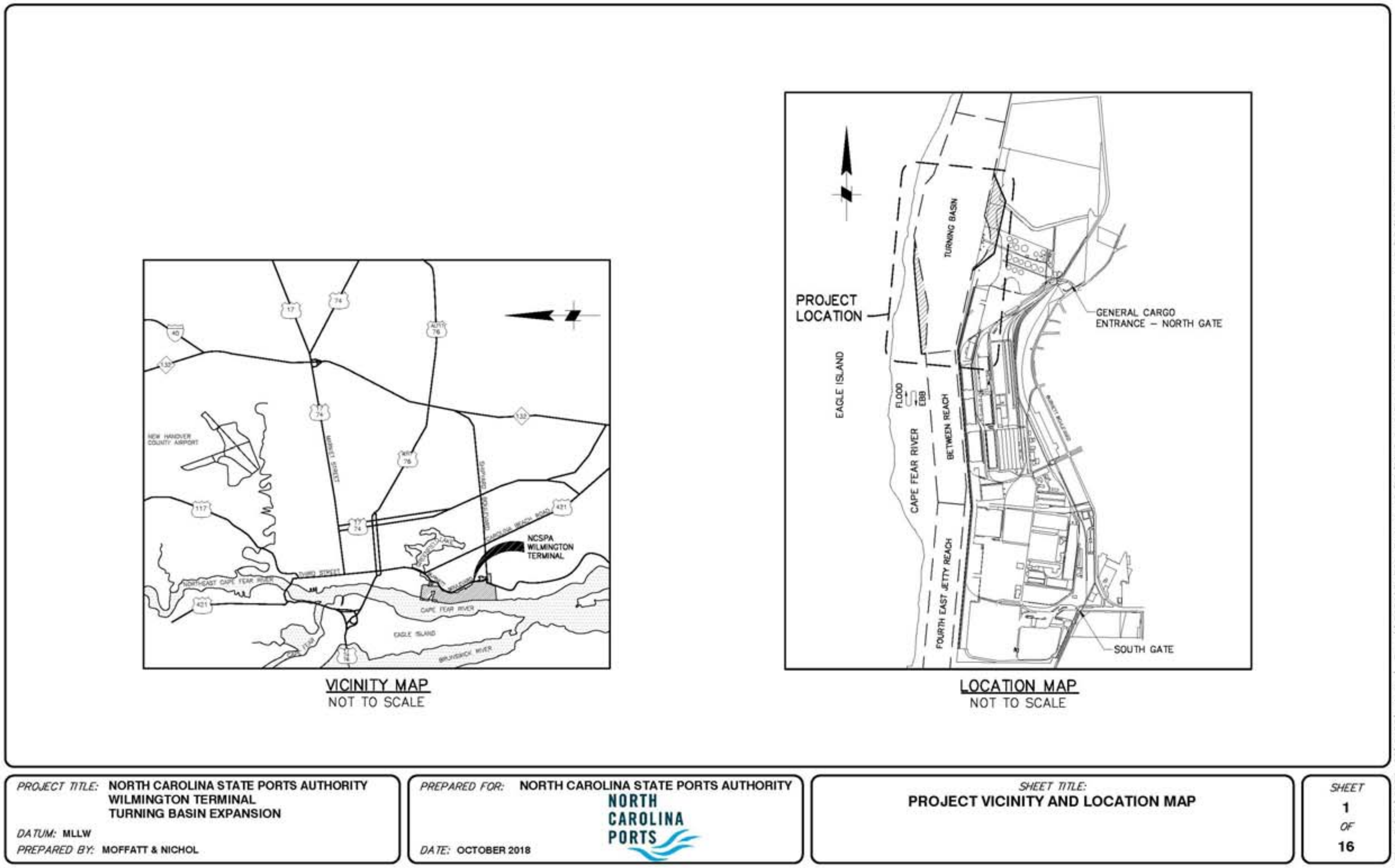

Figure 1. Location Map of Turning Basin Widening Project

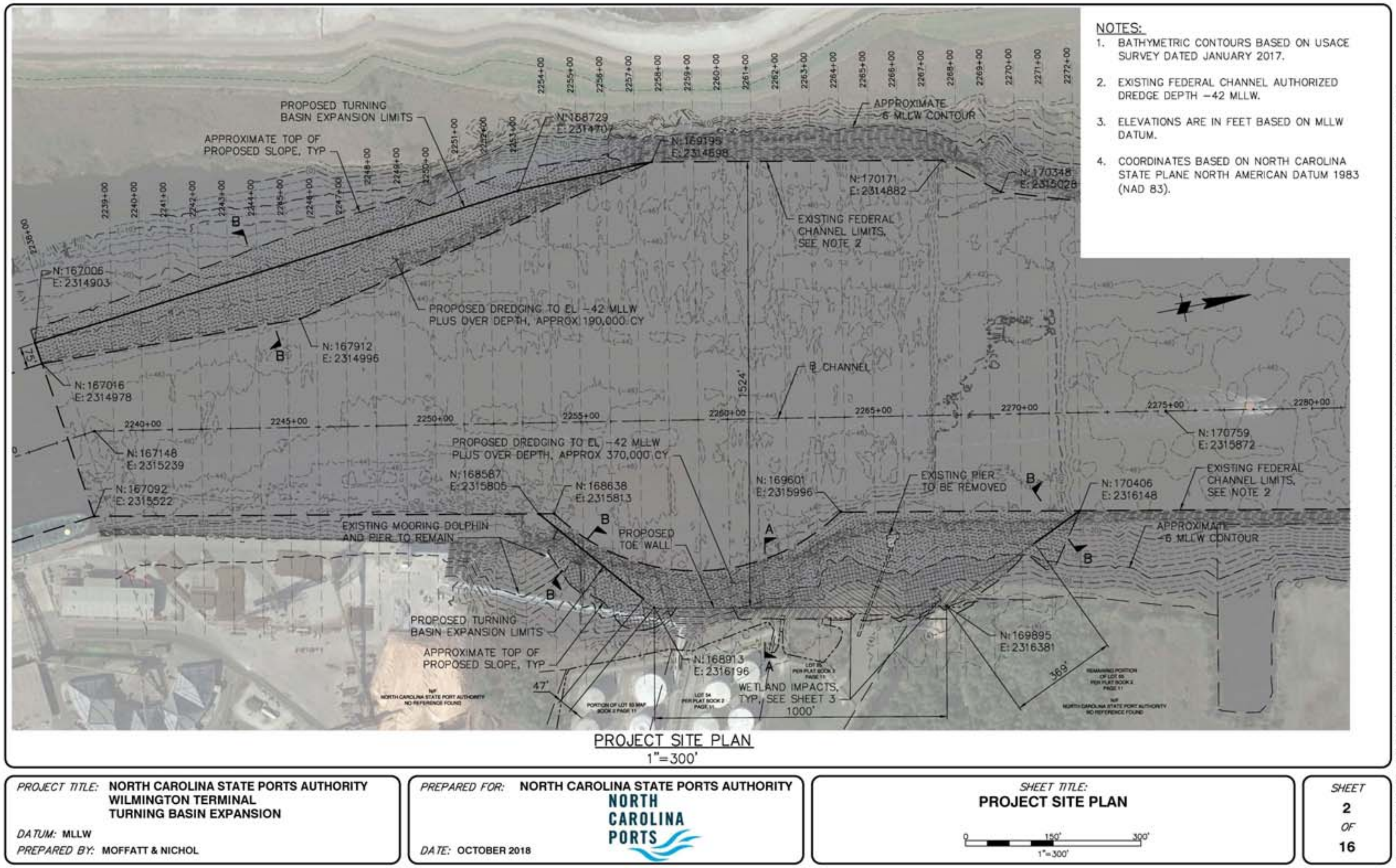

Figure 2. Project Site Plan for Turning Basin Expansion

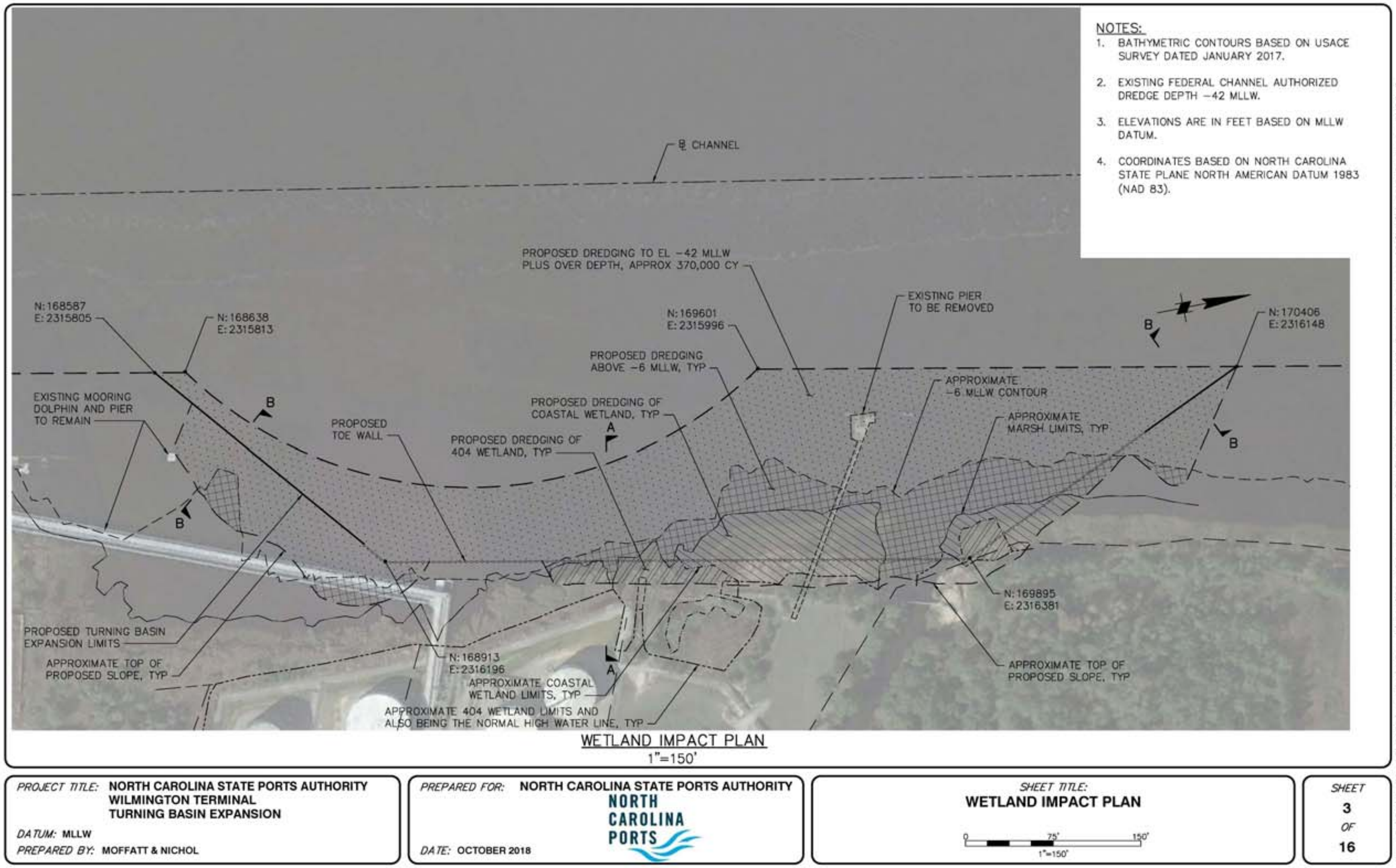

Figure 3. Wetland Impact Plan for Turning Basin Expansion

completion. Vessels plan on calling on the POW as early as late summer and more frequently after the first of the year.

1.1 Construction Methods

The proposed project includes mechanical dredging of sediment (barge-mounted crane equipped with an environmental bucket or a long reach excavator boom) from the east and west locations to widen the basin to 1,524 ft (Figures 2, 4, and Appendix A). Dredged material will be placed in scows and hydraulically pumped into the Eagle Island CDF. The toe wall will consist of an interlocking steel sheet pile with protective coatings that are 70-ft long and will be driven into the marl layer. This wall will be completely submerged, and additional H-piles will be installed in the recess of the sheet piles with solar powered navigation lights installed on top of the pile at EL+10- ft MLLW. Standard sheet pile installation equipment will be used for construction.

Figure 4. Photograph of Mechanical Dredging

The estimated quantity of sediments to be dredged is 360,000 CY on the east side of the channel and 190,000 CY on the west side. The east side will be dredged up to 49 ft from the present elevation, with an average of 23 ft. The west side will be cut up to 30 ft with an average around 15 ft (see plans in Appendix A). Prior to dredging on the east side of the channel, the toe wall will be constructed (Figure 2). Construction is estimated to take up to ten months to complete, with a projected partial completion date in Summer 2019 and final completion Fall 2019, in order to meet larger vessel calls starting late this summer. A variance for dredging in designated Primary Nursery Areas (PNAs) will be required from the North Carolina Division of Marine Fisheries (NCDMF) and North Carolina Division of Environment and Natural Resources (NCDENR). A summary of more construction details can be found in Appendix A.

1.2 Summary of Authorized Maintenance Dredging Activity

The NCSPA North Carolina Division of Coastal Management (NCDCM) Major Permit #47-78 (expiration date 12/31/19) has been modified a number of times since it was issued for allowing maintenance dredging, agitation dredging, and the recent expansion of the turning basin in 2015. Maintenance dredging of the POW harbor and turning basin annually by the Wilmington District United States Army Corps of Engineers (USACE) is on average one million CY. Supplemental dredging by the dredging contractor for the NCSPA averaged 31,000 CY between 2007 and 2012. Agitation dredging by the NCSPA averages 8,500 CY per year. The other private terminals are also authorized to conduct agitation dredging annually during the allowable environmental window.

The last widening of the turning basin was in 2016 to meet the needs of the container fleet at that time. The above NCDCM permit was modified and a USACE permit (SAW 2015-02235) was issued for this project. The basin was widened to 1,400 ft and material disposed of in the Eagle Island CDF. It was successfully completed as planned with no documented effects on sturgeon.

A large hydraulic cutterhead dredge, contracted by the USACE, is used annually for maintenance dredging of the harbor and turning basin. This includes annual dredging of quays/berths of the NCSPA and if time allows, contracted dredging of the private terminals. Disposal has historically been to the Eagles Island disposal area west of the POW. Both clamshell dredging and hydraulic cutterhead dredging are typically employed for new construction or berth dredging. However, these methods are also included in the maintenance dredging permits to allow for some flexibility in the use of the most cost effective method.

2.0 STATUS OF SHORTNOSE AND ATLANTIC STURGEONS IN THE CAPE FEAR RIVER

2.1 Status, Distribution, and Habitat

Shortnose Sturgeon

The most recent population estimate of shortnose sturgeons in the CFR is less than 50 individuals, based on analysis of tag/re-capture data by the Shortnose Sturgeon Recovery Team in 1995 [Personal communication, Mary Moser, University of North Carolina Wilmington (UNCW) 2013]. The shortnose sturgeon was listed as endangered throughout its range in 1967 under the Endangered Species Preservation Act of 1966 [a predecessor to the Endangered Species Act (ESA)]. The National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) later assumed jurisdiction for shortnose sturgeon under a 1974 government reorganization plan [38 Federal Register (FR) 413700]. No harvest or bycatch of shortnose sturgeon is allowed in state or federal waters. A fishing moratorium has been in place in state waters since 1991 for shortnose sturgeon.

The shortnose sturgeon inhabits large Atlantic coast rivers from the St. Johns River in northeastern Florida to the Saint John River in New Brunswick, Canada. Shortnose sturgeons occur primarily in slower moving rivers or nearshore estuaries associated with large river systems. Adults in southern rivers are estuarine anadromous, foraging at the freshwater-saltwater interface and moving upstream to spawn in the early spring. Shortnose sturgeons spend most of their life in their natal river systems and rarely migrate to marine environments. Spawning habitats include river channels with gravel, gravel/boulder, rubble/boulder, and gravel/sand/log substrates. Spawning in southern rivers begins in later winter or early spring and lasts from a few days to several weeks. Juveniles occupy the freshwater-saltwater interface, moving back and forth with the low salinity portion of the salt wedge during summer. Juveniles typically move upstream during the spring and summer and move downstream during the winter, with movements occurring above the freshwater-saltwater interface. In southern rivers, both adults and juveniles are known to congregate in cool, deep thermal refugia during the summer. Shortnose sturgeons are benthic omnivores, feeding on crustaceans, insect larvae, worms, and mollusks. Juveniles randomly vacuum the bottom and consume mostly insect larvae and small crustaceans. Adults are more selective feeders, feeding primarily on small mollusks (NMFS 1998).

Hall et al. (1991), Collins et al. (2001), the NCDENR, and the NCDMF (2013) used and are currently using telemetry studies to characterize the movements and habitats of the shortnose sturgeons in the Savannah and Cape Fear Rivers. According to Hall et al. (1991), spawning migrations in the Savannah River began in late January and continued through March. Spawning occurred above river kilometer (rkm) 161, and spawning fish were found to occupy the main channel in river bends where water velocity was high. Spawning areas were characterized by submerged timber with scoured sand, clay, and gravel substrate. Outside banks of the spawning areas were subject to continuous scouring, which prevented sediment accumulation. Maximum depths in the spawning areas ranged from 26 to 29 ft, and current velocities ranged from 1.7 to 3.4 ft/second at the surface, with an average bottom velocity of 2.6 ft/second. After spawning, fish moved downstream and returned to brackish water within two weeks of spawning. Data indicated that most or all sturgeons left the freshwater reaches of the river by early May. The freshwater-saltwater interface was identified as an apparent feeding ground for sturgeons, and sturgeons were found to occupy specific locations at rkm 39.6, rkm 36, and rkm 35.7 for extended periods (four to eight months). Depths in the feeding areas ranged from 20 to 35 ft, and salinities ranged from zero to six parts per thousand (ppt) depending on tidal stage. Foraging habitat substrate consisted of coarse sand and small gravel with some mud.

Collins et al. (2001) provided additional insight into seasonal movements by adults and juveniles in the Savannah River. Adults and juveniles migrated downstream when water temperatures dropped below 71.6 degrees Fahrenheit (°F) and upstream when temperatures rose above 71.6°F. During warmer months, adults and juveniles were concentrated in a segment of the river between rkm 46.5 and rkm 47.5. During cooler months, adults and juveniles occupied the area between rkm 34.3 and rkm 31.3 in the Front and Middle rivers. During this period, juveniles were concentrated in a small, deep area just inside the mouth of the Middle River. Habitat selection was apparently based on dissolved oxygen (DO), temperature, and salinity, and did not appear to be associated with substrate type. Mean salinities in the areas where juvenile shortnose sturgeons were found ranged from 1.4 ppt in the spring to 5.4 ppt in the winter. Dissolved oxygen levels at the juvenile sites ranged from 6.36 parts per million (ppm) in the summer to 8.36 ppm in the winter. Mean salinities in the areas where adult shortnose sturgeons were found ranged from 0.3 ppt in the summer to 8.6 ppt in the winter. Dissolved oxygen levels at the adult sites ranged from 6.45 ppm in the fall to 8.6 ppm in the winter.

Atlantic Sturgeon

The Atlantic sturgeon population in the CFR is suspected to be less than 300 spawning adults [Atlantic Sturgeon Status Review Team (ASSRT) 2007]. A recent estimate using side-scan sonar data to determine abundance for input into a count model and distance model indicates that abundance of individuals greater than one meter (m) total length (TL) was 73 for the count model and 76 for the distance model within the CFR (Flowers and Hightower 2015). The harvest of Atlantic sturgeons has been banned in state and federal waters since 1991. However, the Atlantic States Marine Fisheries Commission (ASMFC) has recognized that fishery management measures alone cannot sustain stocks of migratory fish species if sufficient quantity and quality of habitat is not available (ASMFC 1999).

On 6 February 2012, the NOAA's NMFS listed the Carolina distinct population segment of Atlantic sturgeons as endangered under the ESA, an action that triggers several additional conservation measures by federal and state agencies, private groups, and individuals (77 FR 5914). The historic range of the Atlantic sturgeons included estuarine and riverine systems from Labrador, Canada to the Saint Johns River in Florida. The historical distribution in the United States included approximately 38 rivers from Saint Croix River in Maine to the Saint Johns River in Florida, including spawning populations in at least 35 rivers. The current distribution in the United States includes 35 rivers, with spawning known to occur in at least 20 rivers.

Atlantic sturgeons spawn in freshwater, but spend most of their adult life in the marine environment. Spawning adults generally migrate upriver in the spring/early summer. A fall spawning migration may also occur in some southern rivers. Spawning is believed to occur in flowing water between the salt front and fall line of large rivers. Post-larval juvenile sturgeons move downstream into brackish waters, and eventually move to estuarine waters where they reside for a period of months or years. Subadult and adult Atlantic sturgeons emigrate from rivers into coastal waters, where they may undertake long range migrations. Migratory subadult and adult sturgeons are typically found in shallow (33-164 ft) nearshore waters with gravel and sand substrates. Although extensive mixing occurs in coastal waters, Atlantic sturgeons return to their natal river to spawn (ASSRT 2007).

Critical Habitat

Critical habitat has been proposed for designation for the Atlantic sturgeon (NOAA 2016), with much of the lower CFR being considered within critical habitat (Figure 5).

"The ESA requires that NOAA Fisheries designate critical habitat when a species is listed as threatened or endangered. Under the ESA, critical habitat is defined as geographic areas that are occupied by the species, and that contain features essential to the conservation of that species. Critical habitat can also include geographical areas that are not currently occupied by the species, but that are essential to its conservation.

Critical habitat does not create preserves or refuges. Instead, when a federal agency is carrying out funding or authorizing an activity that may affect the critical habitat, the federal agency works with NOAA Fisheries to avoid or minimize potential impacts to the species' habitat. The activity of the federal agency may need to be modified to avoid destroying or adversely modifying the critical habitat. The proposed designation of critical habitat does not include any new restrictions of management measures for recreational or commercial fishing operations."

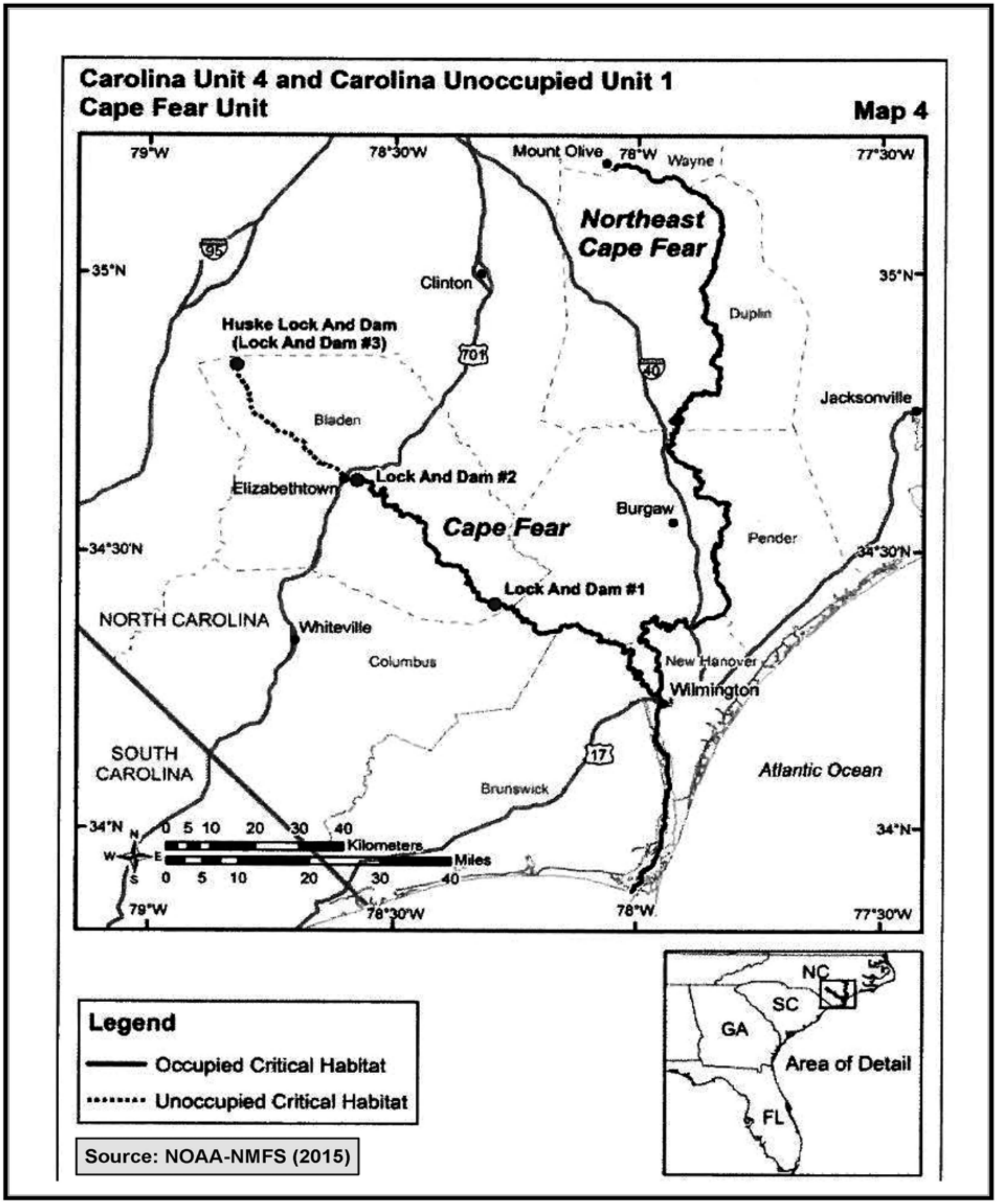

Figure 5. Atlantic Sturgeon Critical Habitat in the Cape Fear River System

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2.2 Threats

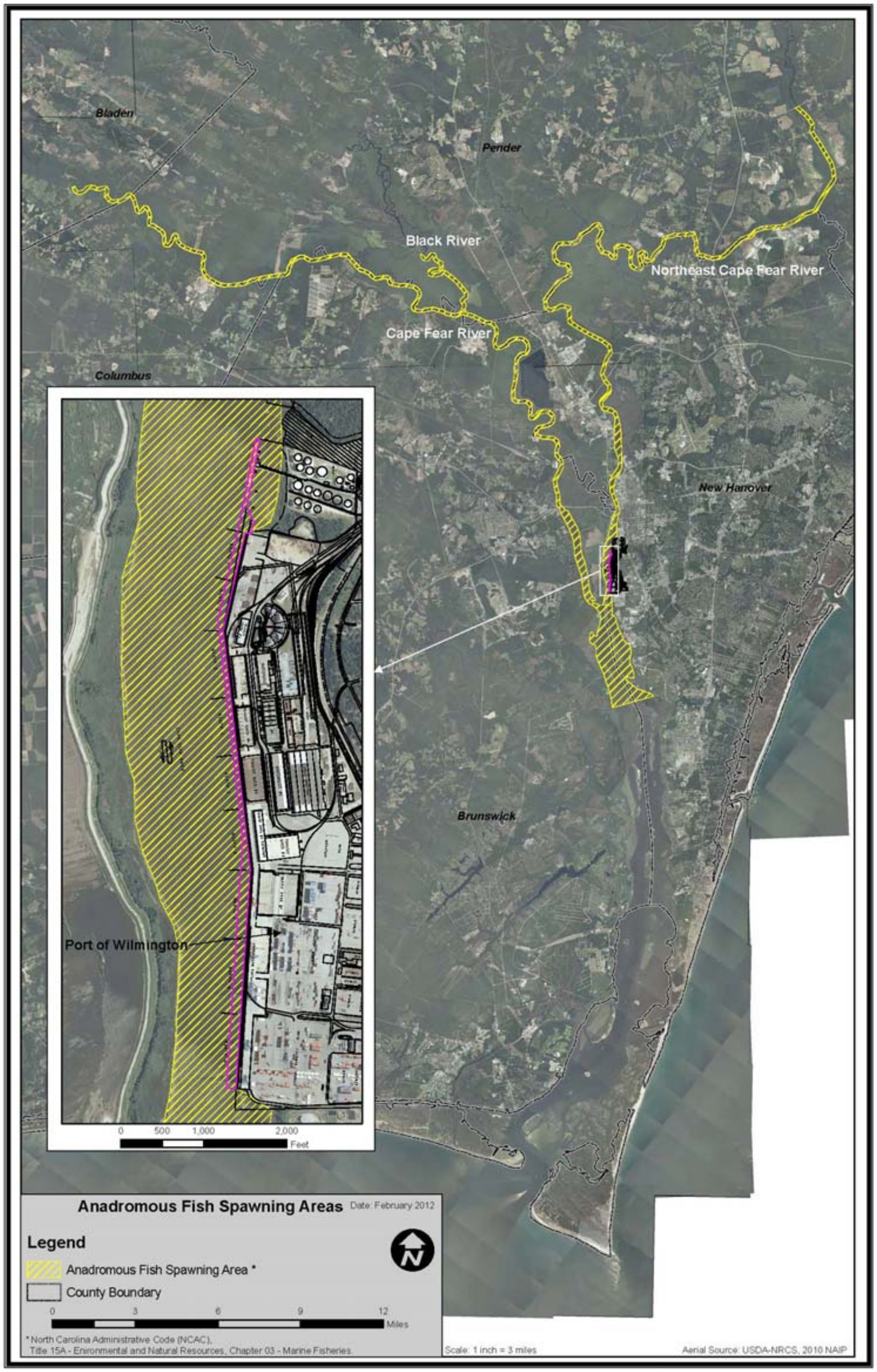
Historical overharvesting contributed to drastic declines in shortnose and Atlantic sturgeon populations. Commercial exploitation of shortnose sturgeons continued into the 1950s, and Atlantic sturgeons were commercially exploited throughout most of the 20th century (NMFS 1998, ASSRT 2007). Although directed commercial harvest is no longer permitted, by-catch mortality associated with other fisheries remains a major threat. By-catch mortality associated with the shad and shrimp fisheries and water quality degradation in nursery habitats are the primary threats currently facing southeastern sturgeon populations (Collins et al. 2000). Additional threats include dams, ship strikes, water withdrawal intake structures, and dredging (NMFS 1998, ASSRT 2007). Threats associated with dams include hydrological modifications, water quality degradation, and restriction of access to spawning and nursery areas. Ship strikes resulting in mortality are common. Most strikes have been attributed to large ocean going vessels, and most documented strikes have involved adult sturgeons. Sturgeons are susceptible to impingement and entrainment in water withdrawal intake structures associated with municipal water supply systems, power plants, and commercial facilities. Potential dredging effects include direct impacts on benthic habitats and food resources, hydrological modifications, turbidity and siltation, contaminant resuspension, and entrainment in the dredge intake pipeline.

2.2.1 Occurrence in the Project Area

Shortnose sturgeons were thought to be extirpated from North Carolina waters until an individual was captured in the Brunswick River in 1987 (Ross et al. 1988). Subsequent gill-net studies (1989-1993) resulted in the capture of five shortnose sturgeons, thus confirming the presence of a small population in the lower CFR (Moser and Ross 1995). In 1998, the NCDMF reported the capture of a shortnose sturgeon in western Albemarle Sound (Armstrong and Hightower 1999). Surveys in the Neuse River during 2001 and 2002 failed to capture any shortnose sturgeons (Oakley and Hightower 2007). Additional surveys have and are being performed annually in the Roanoke, Chowan, and Cape Fear River basins (NMFS 2010). It is unclear whether the lack of records from most North Carolina rivers is due to low abundance or the lack of directed survey effort.

Atlantic sturgeons were historically abundant in most North Carolina coastal rivers and estuaries. Populations are currently known from the Roanoke, Tar-Pamlico, Neuse, and Cape Fear River systems. Spawning is known to occur in the Roanoke, Tar-Pamlico, and Cape Fear River systems; and possibly in the Neuse River (ASSRT 2007). Laney et al. (2007) analyzed Atlantic sturgeon incidental capture data from winter tagging cruises off the North Carolina and Virginia coasts. Cruises conducted in nearshore ocean waters from Cape Lookout to Cape Charles, Virginia captured 146 Atlantic sturgeons between 1988 and 2006. Captures typically occurred over sand substrate in nearshore waters that were less than 59 ft deep. Laney et al. concluded that shallow nearshore waters off North Carolina represent a winter (January-February) aggregation site and an important area of winter habitat for Atlantic sturgeons.

Anadromous fish species' potential spawning areas, as designated by the State of North Carolina within the CFR system and near the NCSPA, are shown in Figures 5 and 6. Historic spawning grounds for both sturgeon species are above Lock and Dam #3 on the CFR (NCDMF



Source: NCDENR 2013

Figure 6. Anadromous Fish Spawning Areas within the Cape Fear River

2011, Anadromous Fish Spawning Area Maps). Only adult and juvenile life stages of the two sturgeon species may occur near the POW, predominately as adults migrate up and back down the river on their annual spawning run.

The NCDMF captured Atlantic and shortnose sturgeons during upstream migration in late-winter and early-spring of 2013 (NCDENR 2013). Following netting prior to spawn using sinking monofilament gill or trammel nets, telemetry tags were surgically implanted into captured individuals of both species. Vemco receivers were deployed in a passive array to relocate sturgeons within the CFR (Figure 7). Sturgeons were targeted using gillnets in the Brunswick River on 30 different events from January to June 2013. The average and range of water temperature, salinity, and DO during the sampling periods were 15.3 degrees Celsius (°C) (7.7°C to 21.5°C), 1.8 ppt (0.1 ppt to 4.6 ppt), and 9.9 milligram per liter (mg/L) (7.9 mg/L to 10.4 mg/L.), respectively.

During the study, 40 Atlantic sturgeons were captured, including four recaptures of fish which had previously been tagged during recent years (NCDENR 2013). Twenty-six of the Atlantic sturgeons were large enough to be implanted with sonic tags. Two of the recaptured Atlantic sturgeons had sonic tags from their initial capture. One of the recaptured fish, initially tagged 21 March 2011, showed no evidence or scarring from the prior surgery. Over the period this fish was tagged (718 days), it had grown 227 millimeters (mm) fork length (FL) and gained approximately 4.5 kilograms (kg). The other previously implanted fish had only been at large for 25 days.

By January 2013, 14 Atlantic sturgeons tagged in 2011, and 12 tagged in 2012 had emigrated from the CFR, with few sturgeons detected remaining within the system through February. A majority of the tagged Atlantic sturgeons (73%, 26 fish) which left the system in 2012 had returned to the CFR by June 2013 (Table 1), with most of the returns occurring during April. As of February 2013, 42 Atlantic sturgeons and one shortnose with sonic tags remained active within the CFR system.

Active spawning migration runs were noted during the past two years for a few tagged fish. One Atlantic sturgeon, which was previously captured and tagged as a running ripe male on 22 February 2012 migrating up the main stem of the CFR, was detected during 2013 migrating up the northeast branch of the CFR. First detected at the mouth of the CFR on 16 February 2013, this fish had migrated approximately 100 kilometers (km) up the northeast VGT over the course of the following 30 days. This fish then was detected over a 20km stretch between rkm 100 and 80 as observed in the previous year and was no longer in the river system after April.

A recent estimate, using side-scan sonar data for input into a count model and distance model, indicates that abundance of individuals greater than 1m TL was 73 for the count model and 76 for the distance model within the CFR (Flowers and Hightower 2015).

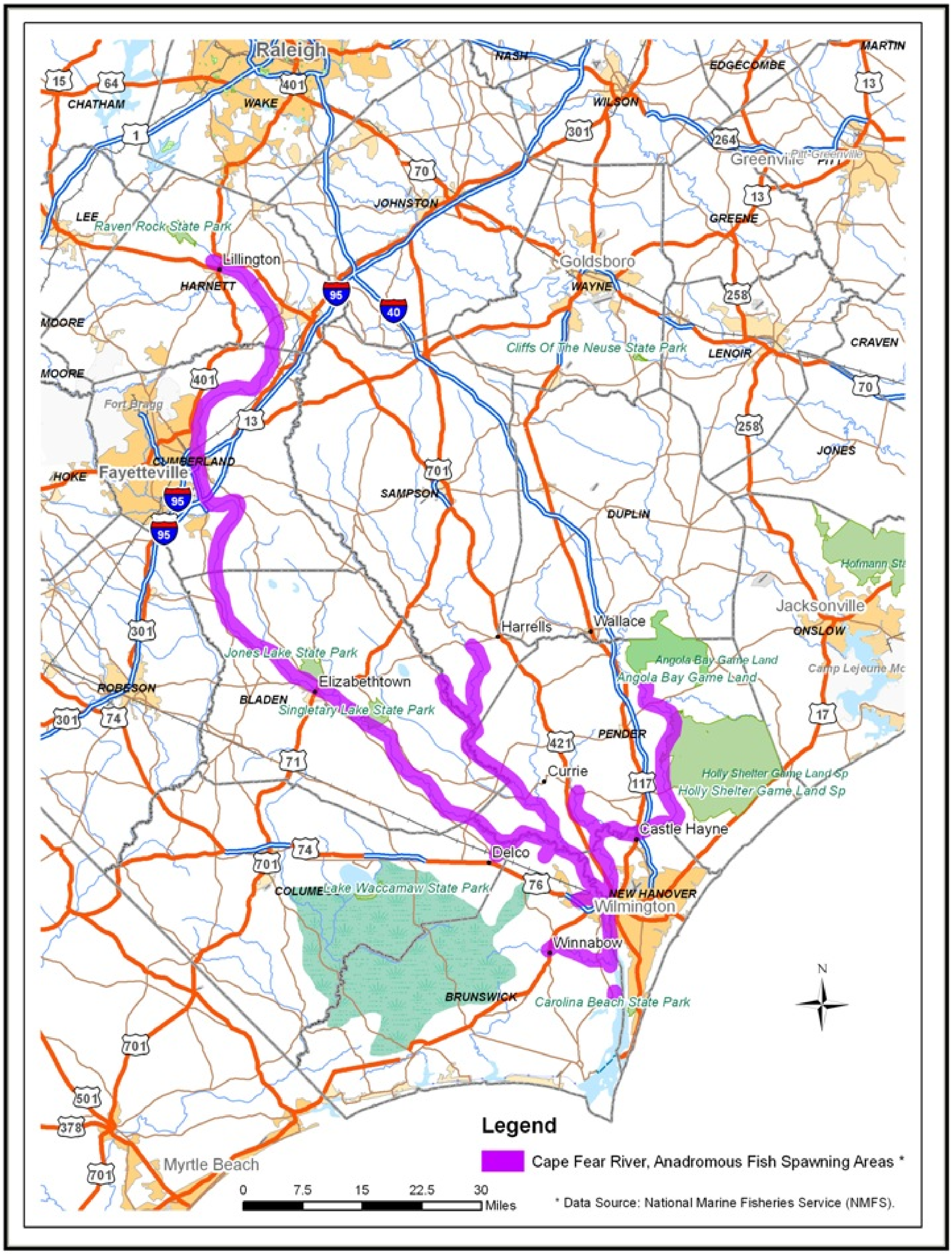


Figure 7. Cape Fear River, Anadromous Fish Spawning Areas

Table 1. Emigration and return dates for Atlantic Sturgeons implanted with sonic tags in the Cape Fear River.

Capture/ Release Date	FL (mm)	Sonic ID	Date Emigrated	Date Returned	Days at Large Outside Cape Fear River
10/11/2012	958	29704	11/20/2012	3/26/2013	126
3/30/2012	1146	29705	11/5/2012	5/1/2013	177
10/11/2012	934	29706	11/14/2012	4/18/2013	155
9/20/2012	1015	29707	10/28/2012	5/4/2013	188
3/30/2012	1265	29716	10/30/2012	4/21/2013	173
6/11/2012	975	29717	11/2/2012		
5/24/2012	951	29718	10/24/2012		
10/24/2012	1021	29723	11/19/2012	4/27/2013	159
9/27/2011	793	45122	11/2/2012	4/28/2013	177
10/4/2011	909	45126	11/6/2012	4/26/2013	171
10/4/2011	962	45127	10/25/2012	3/29/2013	155
2/22/2012	1970	45129	4/13/2012	2/15/2013	308
2/21/2012	960	45131	3/27/2012		
3/28/2012	1102	45132	11/23/2012		
3/28/2012	981	45133	11/12/2012	4/20/2013	159
4/15/2011	931	45154	11/1/2012	4/28/2013	178
3/30/2011	668	45155	12/1/2012	2/21/2013	82
3/31/2011	683	45156	11/1/2012	4/30/2013	180
4/19/2011	1030	45157	11/4/2012	5/6/2013	183
4/27/2011	1025	45158	11/5/2012	5/6/2013	182
4/6/2011	825	45161	11/18/2012	4/22/2013	155
5/18/2011	780	45162	3/20/2012		
5/25/2011	891	45167	10/30/2012		
9/21/2011	1105	45173	10/19/2012	6/12/2013	236
9/21/2011	784	45174	10/31/2012		
9/22/2011	1110	45176	10/24/2012	4/18/2013	176

Source: NCDENR 2013

The shortnose sturgeons which remained in the system from previous years continued to occur within the same stretch of river between the mouth of the Black River and upper entrance to the Brunswick River, with a run up to Lock and Dam #1 in March and back down in April to its typical range. To date, six Atlantic sturgeons tagged outside of North Carolina have been detected in the CFR (Table 2).

Table 2. Sturgeons collected, including original tagging location and recapture location, from the Cape Fear River Vemco Array, January 2013 through June 2013.

Species	Released Location	Detection Location	Number of Unique Individuals	Number of Detections	Number of Receivers
Atlantic Sturgeon	Cape Fear River, NC	Throughout Cape Fear System	46	215,321	18
Atlantic Sturgeon	Atlantic Coast, DE	Throughout Cape Fear System	4	1,216	13
Atlantic Sturgeon	Long Island Sound, CT	Lower Cape Fear River	1	93	4
Atlantic Sturgeon	Altamaha River, GA	Lower and Northeast Cape Fear	1	486	8
Shortnose Sturgeon	Cape Fear River, NC	Lower and Upper Cape Fear River	1	34,264	10
			159	591,584	21 Different Receivers

Source: NCDENR 2013

3.0 HABITAT IN ACTION AREA

Both species of sturgeon primarily forage on benthic invertebrates such as polychaetes, amphipods, bivalves, isopods, insects, and other crustaceans (Collins and Rourk 2008). Their preferential foraging habitat is unconsolidated substrates including sand and gravel, which often contain amphipods, small clams, polychaetes and oligochaete worms and insect larvae.

Substrate in the Wilmington Harbor anchorage basin and within the dredging prisms of the terminal berths are similar, consisting of silts, clays, and small percentages of sands [Anamar Environmental Consulting, Inc. (Anamar) 2010, Table 3]. Sediment data from the proposed dredging area is limited; however, it is anticipated that grain-size distribution and the percent of fine fraction to be similar to those characterized within the Wilmington Harbor.

Table 3. Port of Wilmington sediment characterization.

Sediment Type	Sediment Gradation (mm)	POW Sediment (%)
Gravel	Particles ≥ 4.75	0.0
Sand	Particles ≥ 0.075 but ≤ 4.75	4.3
Silt	Particles ≤ 0.075	54.7
Clay	Particles ≤ 0.075	41.0

Source: Anamar 2010

Of the sediment tested within the Wilmington Harbor, the NCSPA terminal material had the highest percentage of silt and clay at 54.7% and 41.0%, respectively, with 4.3% sand (Anamar 2010).

The primary factors affecting the estuarine benthic community species occurrence, distribution and abundance includes sediment grain-size and organic content, sediment depositional rates, DO and salinity. Mallin et.al. (2000) described the infaunal benthic diversity and richness as constant, as sampled over a four-year period downstream of downtown Wilmington and the POW. These samples were dominated by a variety of taxa, including oligochaetes and amphipods (*Gammarus, Lembos*, and *Monoculodes* spp.) and by polychaetes (*Maranzellaria*, *Mediomastus*, and *Streblospio* spp.). These taxa were considered relatively opportunistic species typical of oligohaline to mesohaline areas. These species are considered proficient at recovering from bottom disturbances. Epibenthic species living on the sediment generally include gastropods, amphipods, and some insect larvae (Mallin et.al. 2000).

The fringing smooth cordgrass marsh located along portions of the shoreline that will be adversely impacted from dredging (Figure 3) provides foraging habitat as well for both species of sturgeon, preying on a wider diversity of benthic invertebrates than typically found in the unvegetated soft bottom habitat. Loss of the 1.4 acres of coastal tidal marsh and associated wetland habitat will directly affect the diversity and abundance of prey species foraged on by sturgeon. Diversity of benthic macroinvertebrates within the coastal wetlands is likely much higher than within the adjacent unvegetated mud bottom habitat. Of the 1.4 acres of wetland impact, 1.01 acres is solely the coastal marsh located in waters of the state beyond the property line (Figure 3).

The wetland impact area encompasses salt and brackish marshes on the contiguous tidal floodplain of the CFR. The tidal marshes form a continuous fringe along the river shoreline that is interrupted only by the mouth of Greenfield Creek. The landward boundary of tidal wetlands within the project area is marked by an existing man-made upland berm that extends continuously along the river shoreline and ties to a tidal gate across the mouth of Greenfield Creek. The berm functions as an artificial shoreline that has effectively reduced the width of the tidally influenced floodplain to approximately 100 ft. The normal high water mark and the Section 404 wetland-upland boundary are both located along the waterward toe of the berm. The tidal floodplain encompasses a mix of relatively natural salt/brackish marshes, disturbed brackish marshes consisting of dense common reed (*Phragmites australis*) stands on shallow fill deposits, and unvegetated tidal mud flats in shallow depressional areas. The entire area waterward of the berm toe, including the common reed stands, is inundated at high tide.

The natural tidal marshes consist predominantly of monospecific stands of smooth cordgrass (*Spartina alterniflora*). The smooth cordgrass marshes occur primarily on the relatively undisturbed lower portion of the tidal floodplain along the river. A few small areas of natural brackish marsh occur along the upper margins of the smooth cordgrass marshes. The brackish marshes are dominated by big cordgrass (*Spartina cynosuroides*) and other brackish species such as narrow-leaved cattail (*Typha angustifolia*), salt marsh aster (*Symphyotrichum tenuifolium*), bull-tongue arrowhead (*Sagittaria lancifolia*), and water primrose (*Ludwigia bonariensis*). Large dense monospecific stands of common reed occur on shallow fill deposits that generally extend waterward onto to the floodplain from the upland berm. The lower extent of the fill deposits and their associated common reed stands marks the boundary between Section 404 and Coastal Area Management Act coastal wetlands. Unvegetated tidal mud flats occur in very shallow linear depressions that appear to be natural features associated with tidal flow.

Although no direct benthic sampling has been conducted directly within the action area, it is highly likely that the benthic community includes species commonly preyed upon by sturgeons. Due to the consistent level of vessel activity and annual dredging at the NCSPA terminals, the benthic foraging habitat in these areas is probably significantly less diverse and abundant than reported by Mallin et al (2000) downstream of the POW, even when considering the rapid rate of recovery to disturbances by these opportunistic species common to this soft bottom habitat.

4.0 EFFECTS ON SHORTNOSE AND ATLANTIC STURGEONS

This section includes a discussion of known or probable effects of the proposed dredging methods and toe wall construction on water quality, the potential effects on sturgeon migration and foraging within the action area and the potential effects on sturgeon due to the loss of 1.4 acres of coastal marsh. Proposed dredging may have localized water quality effects on the estuarine water column during the short periods of time dredging occurs, including re-suspension of sediments and depression of DO concentrations near the bottom. The biological effect of these changes is more dependent upon the exposure, frequency, and duration of the events and in part on temperature and salinity in the water column. Since dredging would occur within a short period of time (April through September 2019), the negative effects on water quality would likely be minimal. Installation of the submerged tow wall is not likely to have any negative effect on sturgeon except during installation, when tow wall driving may result in minor acoustic impacts. Loss of coastal wetland marsh within the project area will result in loss of habitat for prey species commonly foraged on by sturgeon, including invertebrates and small demersal finfish. An analysis of dredging effects of construction of the tow wall is discussed below.

4.1 Project Effects on Suspended Sediments

The proposed action will have temporary effects from dredging on suspended sediment concentrations within the water column immediately above the bottom over the dredged area and within a plume downstream of the dredging activity for the ten-month project duration (April through September 2019). Effects of clamshell/bucket dredging on suspended sediment loading are described below.

Dredging is proposed to be accomplished through use of a clamshell/bucket dredge, transported by scow across the river and slurried to the CDF located on Eagle Island. Clamshell or mechanical dredging and its effects on water quality have been discussed in USACE (1983, 2008), Collins (1995), Barnard (1978), Hayes (1986), NMFS (1998, 2010) and Collins et al (2001). In general, this type of dredging generates a higher concentration of suspended material in the water column than by a hydraulic cutterhead dredge at the excavation location. Suspended sediment concentrations from clamshell dredging are more similar or slightly higher than that caused by I-beam agitation dredging; however, clamshell dredging results in a higher level of suspended sediments at or near the water surface than observed from I–beam dredging [Applied Technology and Management (ATM) 2002]. Total suspended solids (TSS) levels from clamshell dredging are similar to the natural TSS levels observed during spring tide events, but far less than would be observed following storm events. Depth averaged TSS concentrations at the dredge site were estimated to be 50 to 500 mg/L by Collins et al (2001). Increases in TSS during clamshell dredging are considered to be intermittent as the bucket moves through the water column. Re-suspended sediment concentrations of several hundred per liter in the water column close to the bucket as it dredges are quite common and are reduced close to background levels within several hundred feet of the point of operation.

4.2 Project Effects on Dissolved Oxygen

Mechanical dredging is not likely to result in a significant lowering of DO levels during construction within the action area. The vertical and horizontal mixing of bottom anoxic water during dredging likely raises the DO level within the plume, thereby maintaining DO levels above the state standard of 5.0 mg/L. Law Engineering and Environmental Services, Inc. (LAW) (1998, 1999a-f) implemented 11 water quality monitoring efforts associated with pre-, during-, and post-agitation dredging events from July 1998 to August 1999. The surface, mid-column, and bottom water quality sampling for turbidity, DO, and temperature indicated spatial and temporal variations in the immediate downstream vicinity of an active agitation dredging operation and at one berth downstream (approximately 800 ft) of the operation. The monitoring further revealed no substantial changes in temperature or DO as a result of the agitation (LAW 1999a-f). While the applicant is proposing mechanical dredging, this was the only recent on-site monitoring performed. It is expected, however, that the DO levels at the new dredged depth of –42 ft will be substantially lower than presently found in the action area. In addition, while dredging will take months to complete, the actual area of shallow water dredging is relatively small compared to the total area of shallow water soft bottom habitat present in the CFR southern estuary.

4.3 Dredging Effects on Sturgeons

A synopsis on the effects of dredging on sturgeons in the Savannah River for the Georgia Port Authority maintenance dredging program is provided in a Biological Assessment prepared by MG Associates (MGA) (2012) and by NOAA’s northeastern office (NMFS 2011) for proposed dredging in the Kennebec River.

Hydraulic or hopper dredging can lethally take sturgeons by entrainment in the dredge drag arms and impeller pumps (McCord 2005, NMFS 1998 and 2011). Mechanical dredges, such as clamshell dredges, have been documented to take shortnose sturgeons (Dickerson 2006). Indirect effects on sturgeons from mechanical and hydraulic dredging include a temporal loss of benthic organisms in benthic feeding areas, alteration of spawning migrations, and episodic deposition of re-suspended sediments in spawning habitat (NMFS 1998). McCord (2005) further evaluated the risks from dredging on sturgeons to also include reduced prey availability, increased turbidity and localized reduction in DO, and increased bioavailability of contaminants bound in the sediments. In a Biological Opinion prepared by the NMFS for proposed dredging in the Kennebec River, they cited similar conclusions as McCord (2005) on potential adverse effects, but downplayed the effects of burial of prey and sediment suspension on shortnose sturgeons (NMFS 2011). Due to the high mobility of sturgeons, it is very unlikely that large numbers of adult or juvenile sturgeons would be hit by a cutterhead (USACE 2010). Sturgeons are known to avoid dredging operations, as Hatin et al (2007) found following sampling Atlantic sturgeons before and after dredging operations. The NMFS (2011) concluded on the Kennebec River where entrainment of sturgeons has been observed that the effect is minor and not a significant threat to the species. The proposed mechanical dredging method for the POW action area involves considerable less risk than hopper or hydraulic dredging.

Since 1990, there have been only five shortnose sturgeons taken by hydraulic cutterhead dredges, as noted in the Environmental Impact Statement for Savannah Harbor deepening (USACE 2010). In addition, there has been no incidental take of either sturgeon species documented within the South Atlantic Division as a result of hydraulic cutterhead dredging.

Clamshell dredging, which may on occasion be used, has been found to be less harmful than either hydraulic or hopper dredging with no recorded incidental takes of sturgeons in the South Atlantic District by clamshell since 1990 USACE (2010) (note one sturgeon was found killed by entanglement in a net during the dredging operations, rather than by the dredge).

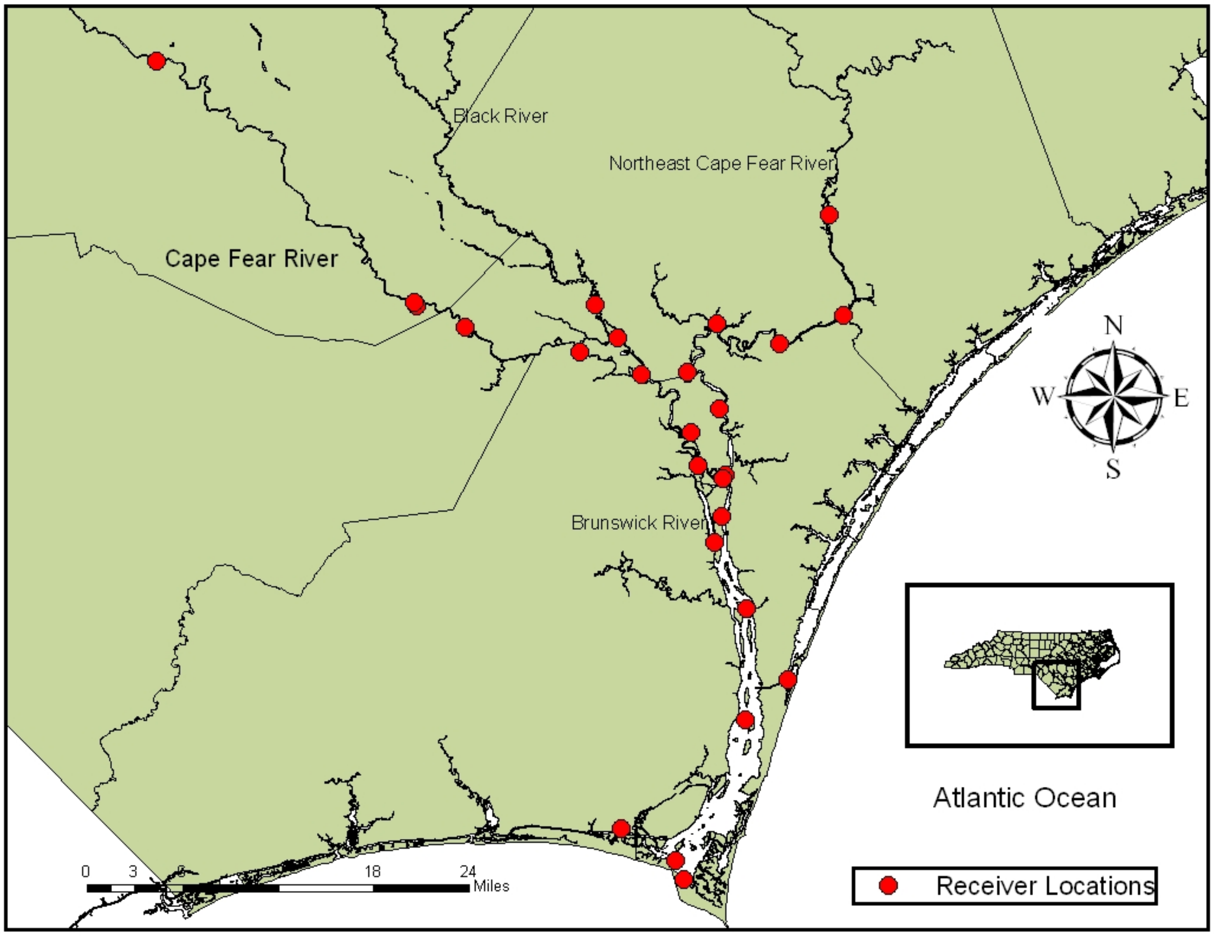
Sturgeon monitoring was performed during expansion of the Wilmington Harbor turning basin in 2016. No sturgeons were observed and there were no sturgeons injured during use of the clamshell dredge for this project.

4.4 Cape Fear River Sturgeon Vulnerability

Assessing the risk of dredging to sturgeons involves knowing the likelihood of their presence in the CFR near or adjacent to where dredging is proposed to be performed. As discussed above, the NCDMF sturgeon monitoring efforts have included the capture and implanting of Vemco telemetry tags into Atlantic and shortnose sturgeons during upstream migration in late-winter and early-spring and subsequent monitoring through June. A passive array of Vemco receivers were deployed and used to relocate sturgeons within the CFR (Figure 8). The habitat used by these individuals at different times of the year was described through water quality measurements, and depth and substrate profiles.

As the salinity in the POW harbor affected area is too high to support eggs and larvae as well as a lack of suitable spawning habitat, only juveniles and adults are a concern. Table 4 summarizes the seasonal occurrence of sturgeons based on the presence and vulnerable life stage within the affected area based on discussions with Chip Collier and Joe Facendola of NCDMF (Personal communication, December 2013). The CFR once supported thriving stocks of migratory fish including American shad, sturgeon and striped bass (Earll 1887, Chestnut and Davis 1975). Migratory fish populations within the CFR have declined substantially over the past two centuries (Smith and Hightower 2012). Based on this fact, the NCDMF has put forth extensive efforts to target sturgeons using gillnets in the Brunswick River, a small tributary of the CFR, on 30 different occasions from January to June 2013 (NCDENR 2013).

From January to June 2013, a total of 40 Atlantic sturgeons were captured, including four recaptures of fish previously tagged in the system. The fish ranged in size from 419 mm to



Source: NCDENR 2013

Figure 8. Locations of Vemco Receivers Deployed in the Cape Fear River, North Carolina, June 2013

Table 4. Vulnerability to dredging by season for sturgeons and striped bass.

Vulnerable Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Shortnose sturgeon												
Atlantic sturgeon												

Notes: White signifies low occurrence and vulnerability, gray: medium level of occurrence and vulnerability, dark blue: high level of occurrence and vulnerability

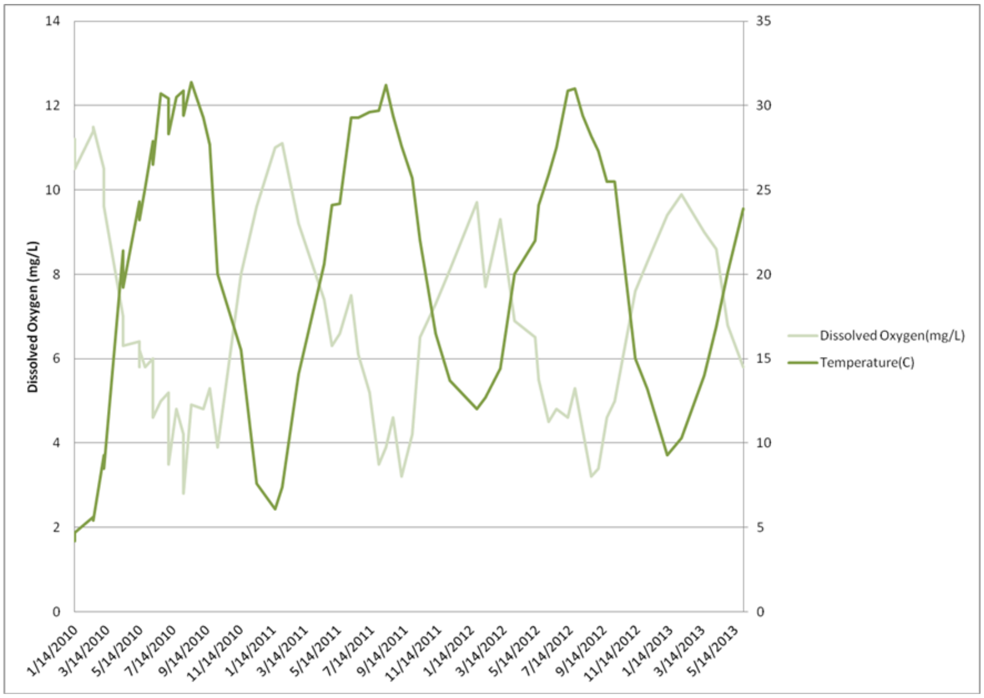
1,162 mm FL, with a mean FL of 794 mm. Twenty-six of the Atlantic sturgeons were implanted with sonic tags, with the remaining fish being too small. Two of the recaptured Atlantic sturgeons had received sonic tags during their initial capture. Through 2013, six Atlantic sturgeons tagged outside of North Carolina have been detected in the CFR array, and detection data have been shared with the appropriate tagging agencies. The Atlantic sturgeon population in the CFR is suspected to be less than 300 spawning adults; whereas, the most recent population estimate of shortnose sturgeons in the CFR is less than 50 individuals, based on analysis of tag/re-capture data by the Shortnose Sturgeon Recovery Team in 1995 (ASSRT 2007; Personal communication, Mary Moser, UNCW 2013).

4.5 Water Quality Effects on Sturgeons

The potential effects of elevated TSS, reductions in DO levels, and synergistic effects of changes in multiple parameters from dredging on sturgeon species are reviewed in this section.

The effects of depressed oxygen levels on life stages of sturgeons and other species has been studied by the Environmental Protection Agency (EPA) (2000) and Jenkins et al (1993). Harmful DO thresholds and tolerance levels for sturgeons were described as being below 4 mg/L. During summer, high water temperatures can actually exacerbate the negative effects of low DO on fish resulting in metabolic changes which decrease their ability to avoid low DO conditions which may be present during dredging (Secor and Niklitschek 2001).

The Lower Cape Fear Program has been monitoring water quality in the CFR since 1996, including Station M61 which is located at Channel Marker 61 at downtown Wilmington and the POW (Latitude N 34.19377, Longitude W 77.95725). As shown in Figure 9, there is a DO sag in the main river channel that begins below a paper mill discharge and persists into the mesohaline portion of the estuary, which includes Station M61 at the POW. This particular station does consistently fall below 5.0 mg/L on 33% or more of occasions sampled therefore resulting in some of the lowest DO levels in the mainstem of the river. Based on 2012 data, DO levels were lowest during summer months (<5 mg/L) including June (4.5), July (4.6), August (4.3), and September (3.4) and highest during winter months (>7 mg/L) including January through April, November and December. Discharge of high biological oxygen demand waste from the paper/pulp mill (Mallin et al. 2013), as well as inflow of blackwater from the northeast Cape Fear and Black Rivers, helps to diminish oxygen in the lower river and upper estuary. As the water reaches the lower estuary higher algal productivity, mixing and ocean dilution help alleviate oxygen problems (Mallin et al. 2013).



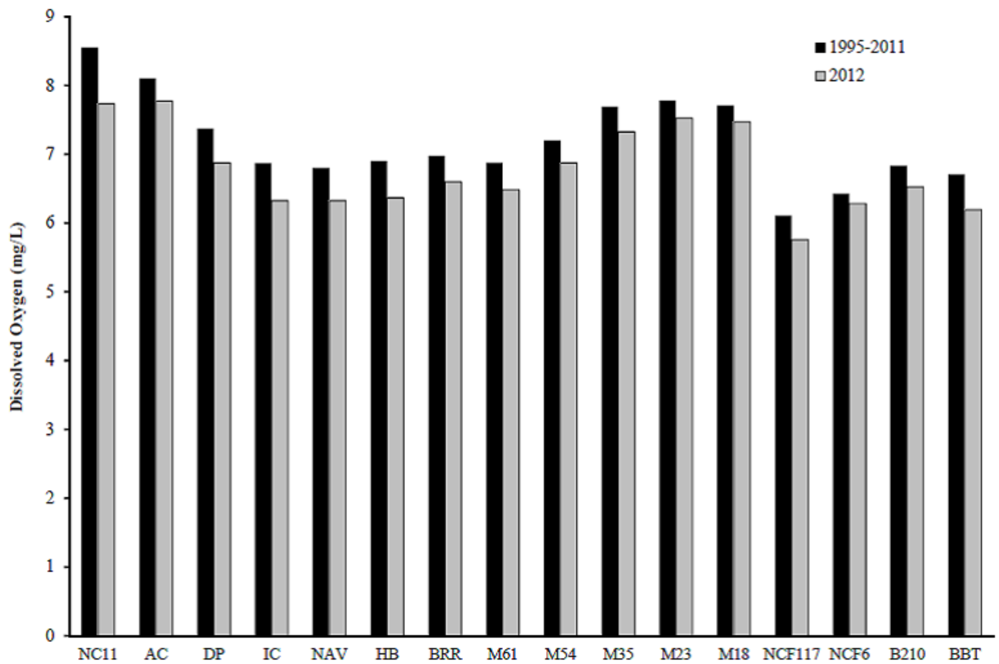
Source: Mallin et al 2013

Figure 9. Dissolved Oxygen and Temperature Data at Station M61

A long-term comparison of DO at Station M61 located near the POW is shown below for the period between 1995-2011 and for 2012. As shown, the average DO concentration at this station was slightly lower in 2012 as compared to the previous multi-year average (Figure 10).

Mechanical dredging may often increase the TSS present in the water column near the dredge site and often downstream during falling tides. Since there is no North Carolina state regulatory standard for TSS in estuarine waters or actual sampling data during dredging, this qualitative assessment can only be based on scientific literature and TSS monitoring efforts from other warm water estuaries. Turbidity, which is the measure of light scattering by particles in the water column and recorded as nephelometric turbidity units (NTU) is more commonly sampled due to its ease in sampling as compared to TSS. Turbidity will vary with the suspended sediment load and dissolved organic matter and plankton concentration. Turbidity increases can be correlated to rainfall, tidal stage, plankton blooms, dredging events, and other man induced events such as stormwater or other permitted discharges.

Total suspended solids data collected in the long term monitoring effort by Mallin (2013) is presented in Figure 10. Total suspended solids values for Station M61, located at the POW and sampled in 2012 by the Lower Cape Fear River Program ranged from 6.7 to 25.8 mg/L with station annual mean of 11.8 mg/L (Table 5). All samples were collected at the surface. Although TSS and turbidity both quantify suspended material in the water column, they do not always go hand in hand. High TSS does not mean high turbidity and vice versa. This anomaly may be explained by the fact that fine clay particles are effective at dispersing light and causing high turbidity readings, while not resulting in high TSS. On the other hand, large organic or



Source: Mallin et al 2013

Figure 10. Dissolved Oxygen at the Lower Cape Fear River Program Mainstem Stations, 1995-2011 and 2012

Table 5. Summary of TSS and Field Turbidity for Station M61, located at the POW.

Dates	Total Suspended Solids (mg/L)	Field Turbidity (NTU)
1/25/2012	9.4	8
2/9/2012	8.9	8
3/8/2012	11.7	13
4/3/2012	9.9	14
5/11/2012	11.1	7
6/5/2012	6.7	10
7/10/2012	15.5	9
8/7/2012	12.2	6
9/5/2012	8.5	5
10/4/2012	11.6	4
11/12/2012	25.8	19
12/4/2012	10.6	4

Source: Mallin et al. 2013

or inorganic particles may be less effective at dispersing light, yet their greater mass results in high TSS levels. While there is no North Carolina ambient standard for TSS, many years of data (1998 – present) from the lower Cape Fear watershed indicates that 25 mg/L can be considered elevated. The fine silt and clay in the upper to middle estuary sediments are most likely derived from the Piedmont and carried downstream to the estuary, while the sediments in the lowest portion of the estuary, such as the POW, are marine-derived sands (Benedetti et al. 2006).

Background turbidity (NTU), as shown on Figure 11 for Station M61 in the main channel at the POW for the period 1995-2011 as compared to 2012, shows a significant reduction. The ambient average for all field data collected from 1995 through 2011 for this station was close to 17 NTU, as compared to 8 NTU for the averaged data collected in 2012. However, given the year to year variability in rainfall up river, stormwater discharge etc. this might be expected.

Total suspended solids and turbidity affect fish in different ways, whereby suspended sediment can block gills and reduce growth rates and overall health, turbidity can reduce vision and indirectly affect behavior, feeding ability and predator avoidance. Applying turbidity standards during dredging practices and the industry's best management practices to minimize turbidity and suspended solids during dredging has reduced the risk level of that elevated suspended loads may have on sturgeons and other fish species.

Within the Savannah River, this assessment was based on a review of TSS exceedances above normal background levels (MGA 2011). For data collected in the harbor from 1999 through 2001 to define existing background TSS levels, the median background TSS levels ranged between 34 to 89 mg/L and have 90^{th} percentile concentrations between 69 and 456 mg/L (MGA 2011). Spring tide peaks monitored caused TSS peaks in excess of 100 mg/L at the surface and in excess of 500 mg/L near the bottom. Total suspended solids levels during storm events were at times in excess of 1,000 mg/L.

As discussed previously, LAW implemented 11 water quality monitoring efforts associated with pre-, during-, and post-agitation maintenance dredging events from July 1998 to August 1999. Turbidity data collected indicated re-suspended unconsolidated alluvial material tidally moved along the bottom and did not migrate into the mid and upper water columns before dispersion within the natural downstream flow. The monitoring further revealed no substantial changes in temperature or DO (LAW 1998 and 1999a-f). Suspended solids were not sampled during this study.

Demersal fish species, such as sturgeon, are in general more tolerant of high TSS and turbidity levels and therefore less susceptible to elevated TSS and turbidity levels from mechanical dredging. While eggs and larvae would be more susceptible to these conditions, they would not be present in this reach of the river. Adults and juvenile sturgeons would occur seasonally in the affected area, but could avoid exposure to plumes of suspended sediments caused by dredging. While gill abrasion is the most threatening potential direct effect on adults migrating through the plumes, it is not likely this would occur due to the small size of the resulting plume, thereby minimizing the temporal exposure to migrating sturgeons. There is little information on the lethal or sublethal effects of TSS on sturgeon species; however, it is suggested by O'Conner et al (1976) that the threshold for these species is much higher than would be experienced within the small plume field produced during hydraulic, mechanical or agitation dredging.

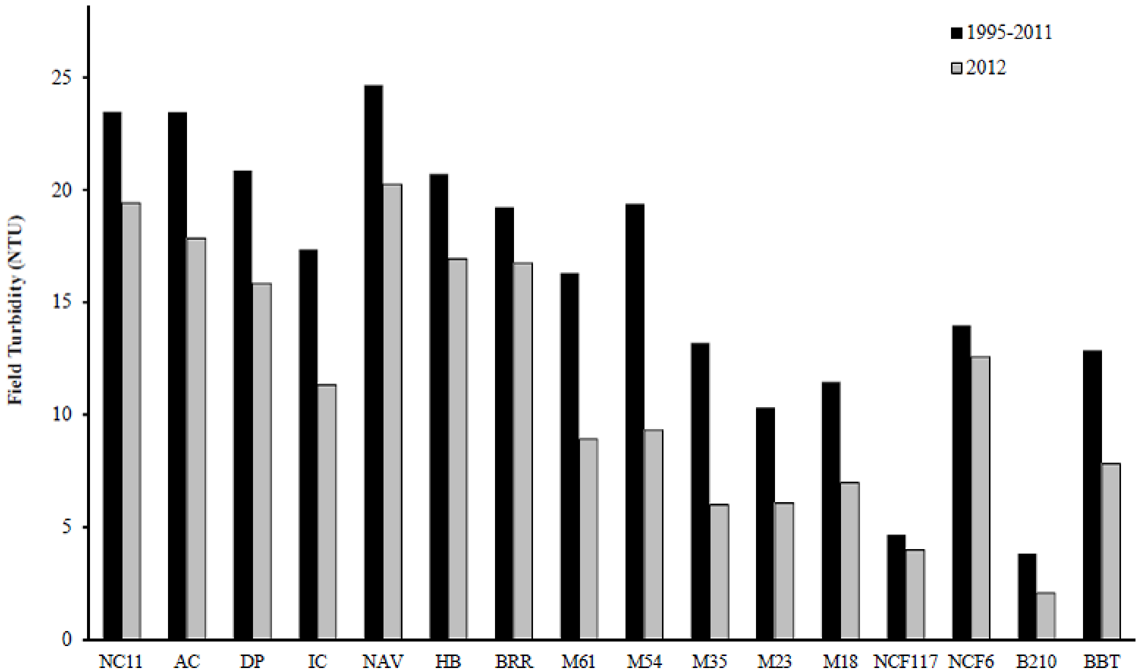


Figure 11. Field Turbidity at the Lower Cape Fear River Program Mainstem Stations, 1995-2011 and 2012

The synergistic effects of DO, TSS, and turbidity are not easy to understand. However, within the affected area of the CFR, the likely scenario would be a condition where anoxic fine material is suspended in the water column resulting in higher turbidity and lower DO. While this condition is easy to visualize, continuous monitoring in Savannah Harbor during dredging found no discernable relationship between DO and turbidity (MGA 2011). Clarkes' (2011) monitoring of bottom conditions upstream and downstream of a cutterhead dredge found a very minimal relationship between decreasing DO and increasing turbidity. Monitoring during agitation dredging in the CFR affected area also failed to find a relationship between these parameters (LAW 1999a-f). Therefore, since there appears to be little actual synergistic effect that has been detected for dredging in the above mentioned locations, it is not likely that there would be an adverse effect on sturgeon health while migrating through the affected area.

4.6 Foraging Habitat Loss Effects on Sturgeons

Proposed mechanical dredging for the turning basin widening will result in the conversion of about 17.76 acres of shallow and deep water unvegetated mud bottom habitat, and 1.4 acres of coastal wetland to navigable depth for the basin and for side slopes below and above the toe wall (Figures 2 and 3). Existing depths on the east side, where dredging is required, ranges from about - 5 ft MLLW to –40 ft MLLW, while existing depths on the west side where dredging is required ranges from 0 ft to –41 ft. Sturgeon species likely use the project area and vicinity for feeding, resting, and as a potential pathway to upstream spawning areas (Moser and Ross

1995, Moser et al.1998). Other more recent tagging studies and monitoring by NCDMF further confirm the presence of sturgeons within the river near the POW terminals (NCDENR 2013)

Atlantic sturgeons are benthic feeders and typically forage on benthic invertebrates including crustaceans, worms, and mollusks. The proposed dredging area likely provides limited value as a forage area since the berthing area is dredged for maintenance on an annual basis and the adjacent shallow areas are greatly influenced by vessel movements, port operations, and stormwater discharges etc. Recovery of benthic resources would likely, require between six months (Van Dolah et al.1979 and 1984, Clarke and Miller-Way 1992) to two years (Bonsdorff 1980, Ray 1997). Therefore, it is expected that the area will provide low value for benthic forage with or without the proposed deepening. The shallow habitat, though likely has a more diverse benthic community than what the recovered future benthic community will be like, at –42 ft MLW following dredging.

Loss of the 1.4 acres of coastal tidal marsh and associated wetland habitat will directly affect the diversity and abundance of prey species foraged on by sturgeon (Figure 3). Diversity of benthic macroinvertebrates within the coastal wetlands is likely much higher than within the adjacent unvegetated mud bottom habitat. Of the 1.4 acres of wetland impact, 1.01 acres is solely the coastal marsh located in waters of the state beyond the property line.

While this may represent a small loss of potential shallow foraging habitat for sturgeons, it is important to note that there is 37,800 acres of shallow water soft bottom habitat (<6 ft deep) and 188,549 acres of deeper soft bottom habitat (>6 ft deep) available for foraging within the CFR southern estuary (Deaton et. al. 2010). For the proposed project, a total of 1.68 acres of shallow water soft bottom habitat and 16.08 acres of deeper soft bottom will be deepened. This represents a loss of 0.004% of shallow water soft bottom habitat and 0.006% of deeper soft bottom habitat. Coastal tidal marsh habitat loss (1.4 acres) accounts for about 0.01 percent of the 12,733 acres of *Spartina alterniflora* dominant wetland present as of 2018 in the lower CFR [Dial Cordy and Associates Inc. (DC&A), unpublished data, 2018].

4.7 Temporary Water Quality Effects on Sturgeons

As discussed in prior sections of this report, dredging is not likely to result in any significant depression of DO levels due to sediment resuspension in the water column. While DO may be depressed somewhat, monitoring in the river has shown that it is not likely to fall to limits where lethal effects on sturgeons occur. Mechanical dredging will result in the production of plumes of suspended sediment where turbidity is higher along the bottom downstream for a short distance from the bottom impact. Sturgeons are known to seek areas of suitable water quality when encountering low DO conditions (Secor and Gunderson 1998). However, they are also known to adopt a sedentary behavior during periods of very low DO, which can prove fatal (NMFS 2011). Most fish in the affected area and the greater CFR are adapted to highly turbid estuarine waters, therefore gill abrasion and a short term loss of prey availability are not likely to be a commonly occurring event as a result of maintenance dredging.

4.8 Temporary Effects on Sturgeons' Foraging Habitat

Benthic habitat suitable for foraging by migrating sturgeons adjacent to the affected area will be temporarily disturbed through the suspension of bottom sediments and through the deposition of suspended sediments on the bottom downstream of the dredging. These foraging habitat effects will be short term due to the resilience and high rate of recovery afforded to benthic organisms occurring in these areas. Most of the benthic invertebrate species occurring in the affected area are opportunistic and will recover within six months or so following the disturbance (Van Dolah et al 1984). However, within the areas of coastal marsh dredged, the resulting unvegetated soft bottom habitat will not be colonized to the high diversity and abundance that was present prior to conversion. It is important to point out that the benthic habitat in the terminal quays and turning basin is already affected by ship and tug boat operations, annual maintenance dredging, stormwater discharge and other routine disturbances common to marine terminals.

While suitable benthic habitat for foraging may occur within the affected areas, sturgeons prefer shallower low flow areas for foraging where they will require less energy consumption during high temperature extremes. It is quite likely that high flow areas, as would occur within the affected area, would not be used for foraging; however, the area is designated PNA by the NCDMF, and as such may provide some foraging area for sturgeon species. In addition, the NCDMF sets nets to capture and tag sturgeons along the shoreline in the Cape Fear and Brunswick rivers, which is away from active port terminals and navigation channels.

5.0 CONCLUSIONS

The CFR supports a small population of Atlantic and shortnose sturgeons. Recent acoustic monitoring (NCDENR 2013) documented the occurrence of 46 Atlantic sturgeons (26 tagged, balance too small for tagging) and one shortnose sturgeon. While the likelihood of their presence in the affected areas is thought to be quite rare, past monitoring and collection efforts demonstrate they may occur in the harbor during their annual migrations up and down river (Personal communication, Chip Collier, NCDMF 2013). Only adult and juvenile life stages could occur within the affected area, as eggs and larvae would not be present due to high salinities and lack of appropriate spawning habitat. Dredging effects on sturgeons may include abrasion of gills from sediment suspension, a permanent loss of coastal marsh for foraging, a temporary loss of the benthic community food source within the dredging footprint, and degradation in the benthic foraging habitat down current due to the deposition of suspended sediment. The severity of the biological effect of water quality changes on sturgeons depends upon the exposure magnitude, frequency, and duration for those parameters considered, as well as the species adapted tolerance. Construction of the toe wall will only result in temporary impacts during construction and pile driving. Noise during construction will likely keep sturgeon away from the operations and from foraging close to shore during construction.

Mechanical dredging through use of a clamshell bucket dredge will result in elevated TSS and turbidity levels for a short duration during dredging ranging from five to six months. Due to the small footprint during clamshell operations and because of tidal effects and the dynamic nature of sediment plumes, significant turbidity plumes are not anticipated. Dredging is not expected to result in depressed DO levels during dredging most of the year, other than during the late summer/early fall when water temperatures are higher and DO lower (Mallin 2013). Dissolved oxygen levels during the 1999 monitoring of agitation dredging at the POW were not depressed and did not go below 5 mg/L or show any correlation to temperature or turbidity (NCDENR 2009, LAW 1999a-f). It should be noted the clamshell bucket dredging is allowable year round due to its potentially less adverse effect as compared to cutterhead hydraulic dredging.

6.0 CONSERVATION MEASURES

The NCSPA at the POW has successfully managed maintenance, agitation, and turning basin dredging for many years with strict adherence to environmental windows (unless high shoaling rates resulted in necessity to dredge), permit conditions, use of best management practices, and permit required monitoring. No incidental takes of sturgeon species have occurred during dredging operations. In 2014, the POW and other private terminals were granted approval to use agitation dredging as a temporal and cost-effective way to maintain navigable depth with their berths and quays. Recently, the POW was granted permits for use of both scour dredging and agitation dredging and for widening the turning basin in 2016.

For this proposed Turning Basin Widening project, the POW is asking for approval to dredge 17.76 acres of shallow unvegetated soft bottom habitat and 1.4 acres of tidal wetlands located with a PNA. This will result in the potential loss of shallow and deep water foraging habitat for juvenile and adult lifestages of sturgeon species. Indirect effects will be limited to altering fish movements during dredging, short-term effects due to generation of higher sediment loads and turbidity during dredging, and short-term impacts during construction of the submerged tow wall.

The NCSPA has offered the following conservation measure to compensate for unavoidable effects and potential foraging habitat loss associated with the proposed project and to avoid or minimize effects on sturgeon species. A payment of $650,000 towards construction of the proposed modifications to the Lock and Dam #1 rock ramp fish passage will be made to the North Carolina Department of Environmental Quality for their contracting to complete the project. Along with the funds appropriated by the North Carolina State legislature this past session, this should allow for completion of construction within one year of completion of the turning basin project. ***This measure is only proposed if this project can be fully permitted and approved by all parties, including a formal Section 7 consultation letter from the NMFS in less than 120 days from the initial date of application (26 October 2018***). A full description of this measure is provided below.

For compensation for Section 404 wetland impacts, the applicant is proposing to create three acres of tidal marsh in the lower CFR to compensate for losses of 1.4 acres of tidal wetlands located on the Kinder Morgan property (east side of river). A description of this measure is included in a separate Mitigation Plan prepared for impacts to Section 404 wetlands (DC&A 2018).

6.1 Project Description for Fish Passage Improvement for Lock and Dam #1 – Cape Fear River

Effective fish passage through navigation locks requires efficient attraction at the lower end of the lock, and passage is often restricted by low and intermittent (NMFS 2018). Although subsequent studies showed some passage of American shad and striped bass through the lock chamber, studies also indicated that a substantial proportion of the fish were not accessing upstream spawning areas (Smith and Hightower 2012). Furthermore, studies detected no passage by Atlantic or shortnose sturgeon. Subsequent efforts to augment the fish locking procedures included the construction of a steep pass fishway at Lock and Dam #1 in 1998; however, the structure proved to be ineffective for fish passage (Moser et al. 2000). The focus of subsequent efforts shifted to the design of a more effective, natural fishway structure that would benefit the full assemblage of anadromous species in the CFR. These efforts led to the design and construction of a nature-like, rock arch rapids fishway structure at Lock and Dam #1 during 2011/2012 (Figures 12 and 13). Construction of the rock arch rapids fulfilled a mitigation commitment made by the USACE in the August 2000 Finding of No Significant Impact for Preconstruction Modifications of Authorized Improvements for Wilmington Harbor (USACE 2000). This commitment was also included as a Term and Condition of the NMFS August 2000 Biological Opinion on the Wilmington Harbor Deepening Project.

Nature-like fishways are constructed with natural materials and are designed to approximate natural habitat conditions (slope, morphology, and hydraulics) within the river system (Aadland 2010, Parasiewicz et al. 1998). The rock arch rapids structure at Lock and Dam #1 incorporates a graduated slope of 3.3-5% to reduce flow rates and provides resting pools to support migrating fish. The fishway was designed by Dr. Luther Aadland of the Minnesota Department of Natural Resources using nature-like engineering principals that have been employed extensively at dams in the upper Midwest region. Post-construction performance criteria for fish passage structures are river-specific. Although standardized technical procedures for evaluating and determining success have not been established, assessments generally include evaluations of passage performance in terms of the percentage of fish passed over a given unit of time, as well as monitoring to assess the size of the population that is passing upstream (NOAA 2012). In the case of the rock arch structure at Lock and Dam #1, a general passage performance goal of 80% was established by fisheries experts through the pre-project interagency review team process.

Although the CFR once supported large spawning runs of anadromous fish, populations have declined substantially over the last two centuries (Smith and Hightower 2012). Although the river was highly productive for American shad at the beginning of the 20th Century, commercial landings are currently 87% lower than historical estimates (Stevenson 1899, Nichols and Louder 1970, and Smith and Hightower 2012). Of North Carolina's coastal rivers, the CFR is the least productive for striped bass. Due to low population numbers, a total harvest moratorium has been imposed on striped bass fishing in the CFR since 2008. The CFR striped bass population is maintained primarily by stocking, with essentially 100% of the population consisting of hatchery-reared individuals. Spawning populations of Atlantic and shortnose sturgeon in the CFR are estimated to number <300 and <50 individuals, respectively (ASSRT 2010, Moser and Ross 1995). Declines in anadromous fish populations are primarily attributable to the locks and

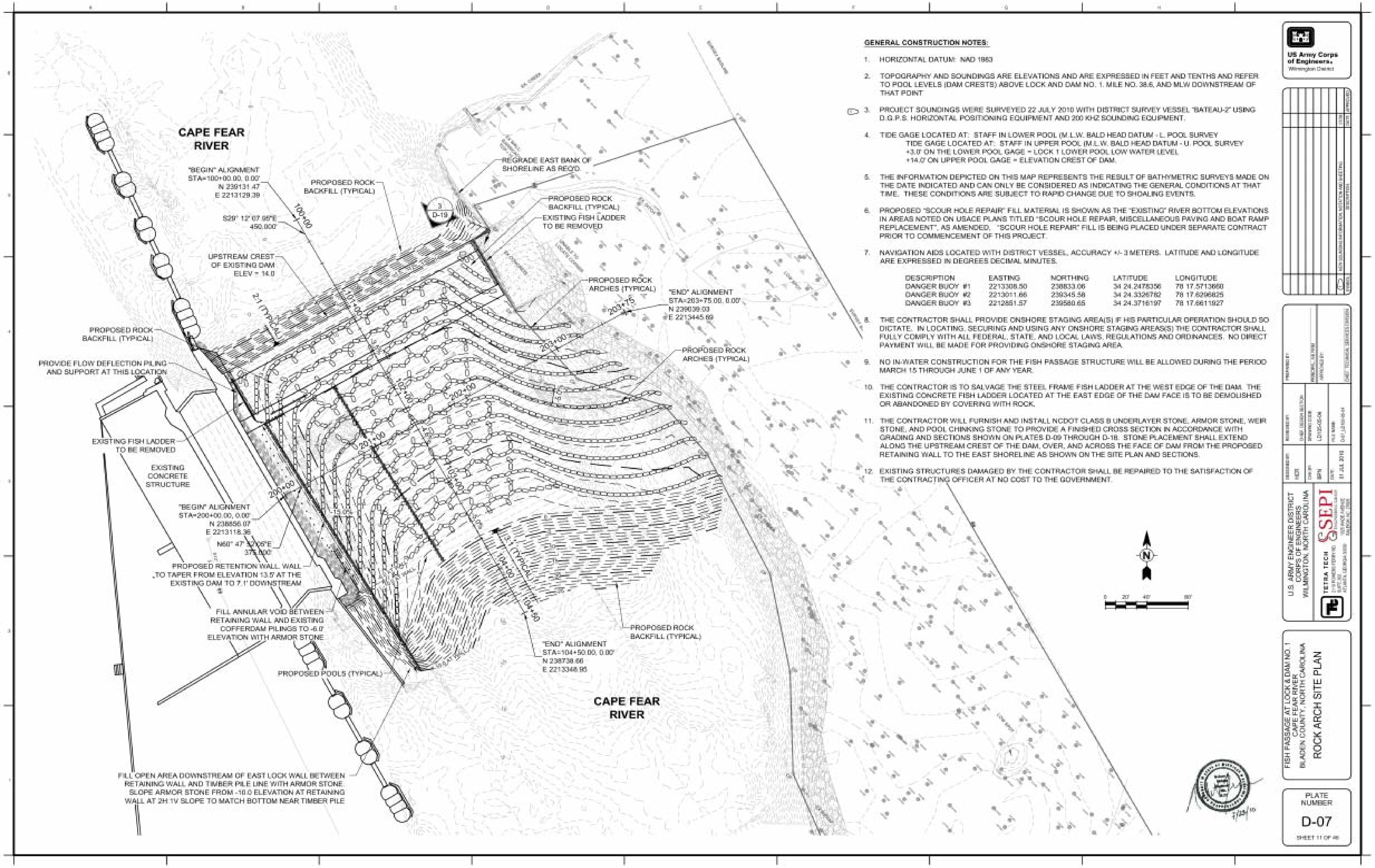


Figure 12. Existing Rock Arch Rapids Fish Ramp at Lock and Dam #1 on the Cape Fear River, North Carolina

Figure 13. Photo of Existing Rock Arch Rapids Fish Ramp at Lock and Dam

dams, which have disrupted the free-flowing river and blocked anadromous fish access to suitable upstream spawning habitats (Smith and Hightower 2012, Raabe 2014a).

Telemetry studies conducted to evaluate American shad usage of the rock arch fishway indicate American shad passage efficiency ranged from 53–65% and was consistent with prior estimates from locking procedures (Raabe 2014b). Electrofishing surveys have indicated catch rates have increased at the upper two locks and dams and decreased at Lock and Dam #1 over the last five years. These results show American shad are readily passing Lock and Dam #1 (NCDMF and NCWRC 2017). However, studies indicate that the structure as initially designed and constructed has had limited effectiveness in passing striped bass. Acoustic telemetry monitoring from 2013-2015 showed relatively low annual striped bass passage rates of 19-25% (Raabe 2017). The overall 2018 striped bass catch per unit effort in the CFR was reduced in relation to recent years; and as described above, it appears that the relatively small population is maintained almost entirely by stocking. The results of egg sampling during 2016 and 2017 were consistent with the low rates of adult passage at Lock and Dam #1. Striped bass eggs were concentrated below Lock and Dam #1 during both sampling years, with only a few eggs collected below Lock and Dam #2 and no eggs collected below Lock and Dam #3 (DC&A, unpublished data, 2017).

The primary purpose of the proposed modification to the fish passage at Lock and Dam #1 is to increase striped bass passage rates. The proposed action is needed to increase striped bass spawning success rates to levels that will ultimately lead to the restoration of a healthy, self-sustaining striped bass population in the CFR system. The restoration of self-sustaining anadromous fish populations has wide-ranging beneficial implications for the ecology of the

CFR system and the regional economy. Anadromous species play a critical role in sustaining the ecological integrity of major river systems through the transfer of ocean-derived primary production to a broad spectrum of higher trophic level organisms that are associated with inland freshwater systems. Local economies benefit from increased business related to revived recreational and commercial fishing opportunities (Hadley 2015). The economic implications of restored recreational and commercial anadromous fisheries in the CFR system are vast in geographic scope, spanning numerous counties across southeastern North Carolina.

Proposed plans (draft - not permitted) would involve the construction of three river-parallel fish pathways across the left, central, and right sections (Measures A-C) of the existing rock arch rapids (Figure 14). The proposed pathways were developed by the Cape Fear River Partnership and Dr. Luther Aadland, original designer of the rock arch rapids at Lock and Dam #1. The pathways have been designed to increase striped bass passage rates by reducing flow velocities, providing larger and deeper pools, and creating larger gaps in the rock weirs that separate the pools. Each pathway would consist of a linear series of staggered pools extending from the toe of the existing structure up to the dam crest. In order to reduce flow velocities and provide for a more even dispersal of energy, the slope of each pathway would be reduced in relation to the existing structure. The pools would be deepened in accordance with NOAA guidelines (NMFS 2018) to allow for multiple individuals and species to pass. Existing pool depths average 4’ and would be increased to an average of 6’ and would be connected through a staggered arrangement of 5.5-footwide gaps. Modifications would reduce the slope of the rock arch ramp from the existing graduated slope of ~3-5% to a uniform slope of ~3%, providing a more uniform loss of energy (Tetra Tech 2018).

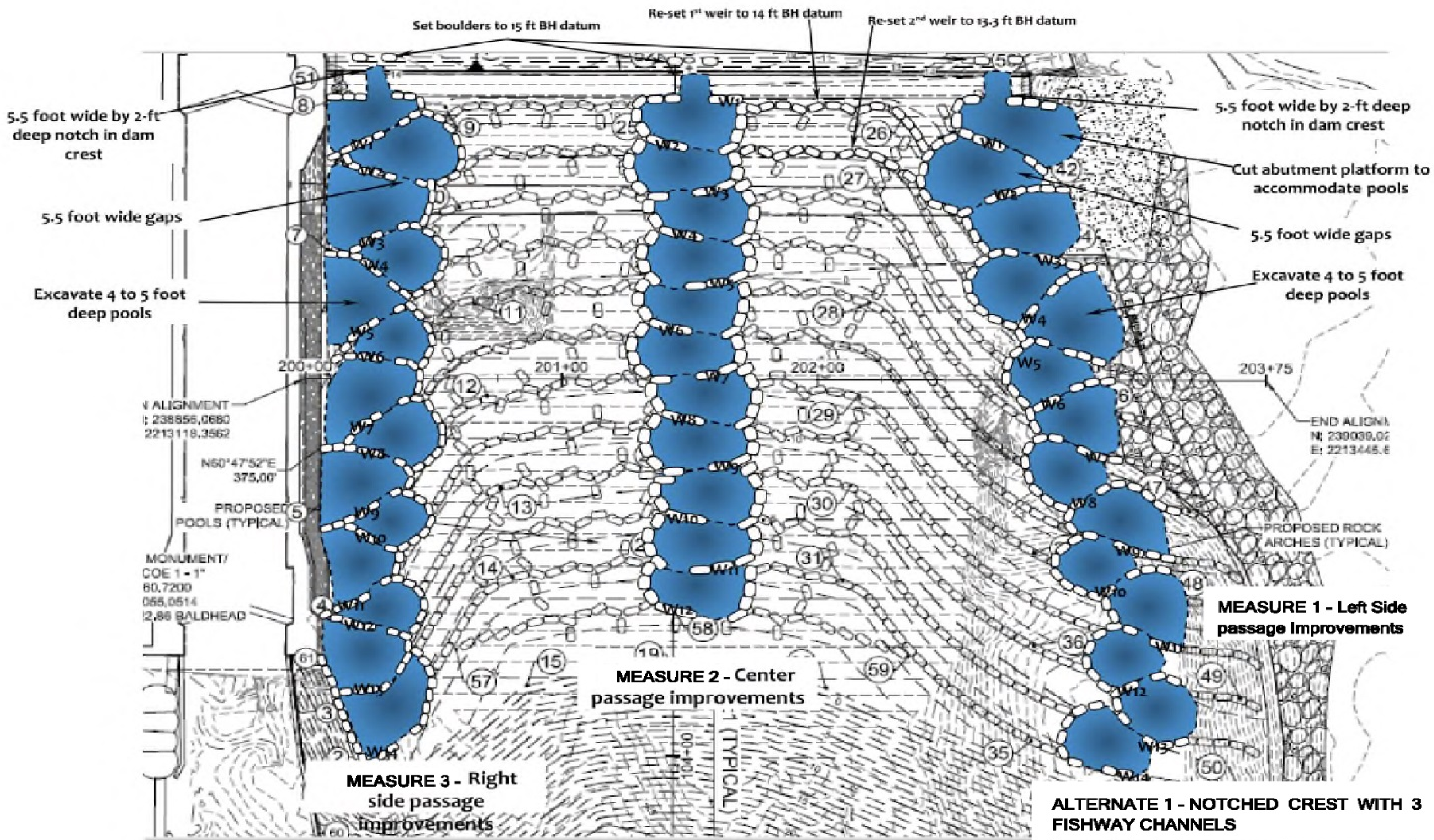


Figure 14. Preferred Alternative Upgrade Measures A-C

Measure A – Left Bank Fish Pathway

Measure A consists of creating a new fish pathway within the left side of the existing rock arch rapids. The new fish pathway would provide wider gaps (5.5 ft) and deeper resting pools (6'). These larger and deeper pools would be created by staggering them along a meandering sub-channel. Space for the sub-channel is available due to the high terrace along the left side of the rock arch rapids. In addition, the crest of the dam would be notched to supply flow at greater depth and to offer an attractive downstream entrance. The notch dimensions would be 5.5 ft wide and two ft deep and would minimize effects on the upstream head pond elevation during lowest flow conditions. Finally, the slope of the left abutment would be modified to provide the space needed for the pathway sub-channel and would support greater passage opportunities during high flow conditions. Currently, the abutment restricts the passage of migrating fish and striped bass have been observed immediately downstream. Abutment walls may also be responsible for trapping fish during receding high flows.

Measure A meets NOAA guidelines for depth and flow requirements for low flow conditions and maintains satisfactory flow at the fish channel entrance. Furthermore, it provides improved access for fish even when the head pond is lower. The lower channel slope and greater depth between weirs create deeper pools and reduce velocities, allowing improved fish passage for the full spectrum of native fish species. Abutment removal facilitates the passage of congregating striped bass and eliminates an existing fish trap.

Measure B – Center Fish Pathway

Measure B incorporates facets of the left and right bank improvements (Measures A and C) yet lacks significant slope reduction and offers limited space for increased pool size. Consequently, modification benefits in this location would be limited to greater gap width and depth.

Measure C – Right Bank Fish Pathway

Measure C is similar to the left bank fishway improvement (Measure A); however, it would be located along the right side within the rock arch rapids adjacent to the lock chamber wall. Limited space in this location restricts potential slope reduction resulting in a final slope of ~3.2%. The benefits associated with Measure C are similar to Measure A, although pool size and velocity reduction would be limited by the confined location and steeper slope.

The modification to Lock and Dam #1 fish passage is presently being designed and going through the regulatory approval process with state and federal agencies. Construction costs are estimated to be in the order of one million dollars, based on most recent estimates. Funds presently available for construction include about $350,000. By providing up to $650,000 in additional funds, the Cape Fear River Watch will be able to schedule construction and likely secure the remaining amount of funds needed from the state or other federal agencies (NOAA, USFWS).

Conservation measures to avoid and or minimize additional effects on managed and associated species in the project area includes the following:

- Turbidity booms will be deployed around dredging and pumping operations at all times to minimize movement of suspended sediments and turbidity.
- Turbidity booms will be monitored by the POW to ensure compliance with the above requirement.
- Best management practices will be used throughout construction to minimize turbidity and any indirect effects on managed and associated species.
- Due to the performance of mechanical dredging during the higher activity and migration period of the year for sturgeon, the applicant agrees to place an observer on the clamshell barge to observe for sturgeon either entrained in the bucket dredge or injured/killed during dredging. Weekly reports will be provided to the NCDENR and NMFS as to weekly observations.
- Construction of the toe wall will serve to minimize future erosion and subsidence of sediment into the channel and mirrors the amount of material needing dredged.

7.0 EFFECTS DETERMINATION

Based on the information presented in this biological assessment for dredging 17.76 acres of unvegetated soft bottom habitat; dredging 1.4 acres of coastal wetland, and installing a submerged tow wall for widening of the turning basin may affect, but is not likely to adversely affect both species of sturgeon or critical habitat for Atlantic sturgeon. This applies to mechanical dredging only through use of clamshell/bucket dredge, as has been allowable with existing maintenance dredging permits for the POW. Conservation measures as proposed herein shall be implemented consistent with the terms presented in the above section.

8.0 REFERENCES

Aadland, L. P. 2010. Reconnecting Rivers: Natural Channel Design in Dam Removal and Fish Passage. Minnesota Department of Natural Resources. St. Paul. pp. 43.

Anamar Environmental Consulting, Inc. 2010. Northeast Cape Fear River Turning Basin and North Carolina State Port Authority Maintenance Dredging Wilmington Harbor, North Carolina. Evaluations Pursuant to Section 103 Marine Protection, Research and Sanctuaries Act of 1972, as Amended. August 2010.

Applied Technology and Management. 2002. "Agitation Dredge Evaluation, Savannah Harbor Ecosystem Restoration Project." Technical report prepared for US Army Corps of Engineers Savannah District by Applied Technology and Management. June 17, 2002.

Atlantic States Marine Fisheries Commission. 1999. Amendment 1 to the Inter-state Fishery Management Plan for shad and river herring. Atlantic States Marine Fisheries Commission, Fishery Management Report No.35, Washington, DC.

Atlantic Sturgeon Status Review Team. 2007. Status Review of Atlantic sturgeon (Acipenser oxyrinchus oxyrinchus). Report to National Marine Fisheries Service, Northeast Regional Office. February 23, 2007. 174 pp.

Armstrong, J. L. and J. E. Hightower. 1999. Potential for restoration of the Roanoke River population of Atlantic sturgeon. Applied Ichthyology 18:475-480.

Barnard, W. 1978. Prediction and Control of Dredged Material Dispersion around Dredging and Open-water Pipeline Disposal Operations. Technical Report DS-78-13. U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, Vicksburg, MS. August, 1978.

Benedetti, M. M., M. J. Raber, M. S. Smith, and L. A. Leonard. 2006. Mineralogical indicators of alluvial sediment sources in the Cape Fear River basin, North Carolina. *Physical Geography* 27:258-281.

Bonsdorff, E. 1980. Macrozoobenthic recolonization of dredged brackish water bay in SW Finland. Ophelia Supplement 1: 145-155.

Chestnut, A. and H. Davis. 1975. Synopsis of Marine Fisheries of North Carolina. Part 1: Statistical Information, 1880-1973. North Carolina Sea Grant Award No. UNC-SG-75-12. 425 p.

Clarke, D. 2011. Analysis of Savannah Harbor Water Quality Compliance Monitoring. Dredging Operations Technical Support Program. US Army Corps of Engineers, Vicksburg MS.

Clarke, D. G. and T. Miller-Way. 1992. An environmental assessment of the effects of open-water disposal of maintenance dredged material on benthic resources in Mobile bay, Alabama. Miscellaneous Paper No. D-92-1. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Collins, M. A. 1995. Dredging-Induced Near-Field Resuspended Sediment Concentrations and Source Strengths. Miscellaneous paper D-95-2. Prepared for U.S. Army Corps of Engineers; monitored by U. S. Army Engineer Waterways Experiment Station. Prepared by Michael A. Collins; School of Engineering and Applied Science; Southern Methodist University. August 1995.

Collins, M. R., D. C. Walling, L. E. Zimmerman, R. F. Van Dolah. 2000. Savannah Harbor Biological Monitoring: Fish, Shellfish, and Benthos. Final report to U.S. Environmental Protection Agency, Atlanta, GA.

Collins, M. R., Post, W. C., and D. C. Russ. 2001. Distribution of shortnose sturgeon in the lower Savannah River: Results of research conducted 1999-2000. Final Report to Georgia Ports Authority. South Carolina Department of Natural Resources. 21 pp. plus appendices.

Collins, M. R. and A. Rourk. 2008. Shortnose and Atlantic sturgeon age-growth, status, diet and genetics. South Carolina Dept. of Natural Resources , Charleston, SC, USA. Final report to National Fish and Wildlife Foundation. Project #2006-0087-09.

Deaton, A. S., W. S. Chappell, K. Hart, J. O'Neal, and B. Boutin. 2010. North Carolina Coastal Habitat Protection Plan. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries, NC. 639 p.

Dickerson, D. 2006. Observed takes of sturgeon and turtles from dredging operations along the Atlantic Coast. Supplemental data provided by U.S. Army Engineer R&D Center Environmental Laboratory, Vicksburg, Mississippi

Earll, E. R. 1887. North Carolina and its Fisheries. Goode, G. B. The Fisheries and Fisheries Industry of the United States. Section II, 475-497 pp. A geographical review of the fisheries industries and fishing communities for the year 1880. Volume II. United States Commission of Fish and Fisheries. Government Printing Office, Washington, D.C.

Environmental Protection Agency. 2000. Ambient aquatic life water quality criteria for dissolved oxygen (saltwater): Cape Cod to Cape Hatteras. Office of Water. Report number EPA-822-R-00-012. 48 pp.

Flowers, H. J., and J. E. Hightower. 2015. Estimating Sturgeon Abundance in the Carolinas Using Side-Scan Sonar. *Maritime and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 7:1-9, 2015.

Hadley, J. 2015. An Economic Analysis of Recreational and Commercial Fisheries Occurring in the Middle and Lower Cape Fear River, North Carolina. North Carolina Department of Environment and Natural Resources. Division of Marine Fisheries. 2015.

Hall, J. W., T. I. J. Smith, and S. D. Lamprecht. 1991. Movements and habitats of shortnose sturgeon Acipenser brevirostrum in the Savannah River. Copeia (3): 695-702.

Hatin, D., S. Lachance, and D. Fournier. 2007. Effect of dredged sediment deposition on use by Atlantic sturgeon and lake sturgeon at an open-water disposal site in the St. Lawrence estuarine transition zone. Pages 235-256 in J. Munro, D. Hatin, J.E, Hightower, K. McKown, K.J. Sulak, A.W. Kahnle, and F. Caron (eds.) Anadromous sturgeons: habitats, threats and management. American Fisheries Society, Symposium 56, Bethesda, Maryland.

Hayes, D. F. 1986. "Guide to Selecting a Dredge for Minimizing Resuspension of Sediment," Effects of Dredging Techcnical Notes EEDP-09-01, Army Engineer Waterways Experiment Station, Vicksburg, MS.

Jenkins, W. E., T. I. J. Smith, L. Heyward, and D. M. Knott. 1993. Tolerance of shortnose sturgeon, Acipenser brevirostrum, juveniles to different salinity and dissolved oxygen concentrations. Proc. Ann. Conf. of Southeast Fish and Wildlife Agencies. 47:476-484.

Law Engineering and Environmental Services, Inc. (LAW). August 1998. Agitation Sled Dredging Water Quality Assessment Berth 1 and 2, Port of Wilmington. Report Date 18 August 1998; Sample Events 6-7 July 1998 and 11-12 July 1998.

LAW. January 1999a. Agitation Sled Dredging Water Quality Assessment Berth 1 and 2, Port of Wilmington. Report Date 1 January 1999; Sample Dates 16-20 November 1998, 3 December 1998, and 5 December 1998.

LAW. February 1999b. Agitation Sled Dredging Water Quality Assessment Berth 1 and 2, Port of Wilmington. Report Date 4 February 1999; Sample Dates 14-15 January 1999.

LAW. February 1999c. Agitation Sled Dredging Water Quality Assessment Berth 1 and 2, Port of Wilmington. Report Date 18 February 1999; Sample Dates 1-2 February 1999.

LAW. March 1999d. Agitation Sled Dredging Water Quality Assessment Berth 1 and 2, Port of Wilmington. Report Date 8 March 1999; Sample Date 27 February 1999.

LAW. June 1999e. Agitation Sled Dredging Water Quality Assessment Berth 1 and 2, Port of Wilmington. Report Date 7 June 1999; Sample Dates 17-20 May 1999 and 24-27 May 1999.

LAW. August 1999f. Agitation Sled Dredging Water Quality Assessment Berth 1 and 2, Port of Wilmington. Report Date 25 August 1999; Sample Dates 9-13 August 1999.

Laney, R. W., J. E. Hightower, B. R. Versak, M. F. Mangold, W. W. Cole Jr, and S.E. Winslow. 2007. Distribution, habitat use, and size of Atlantic sturgeon captured during cooperative winter tagging cruises, 1988–2006. Am. Fish. Soc. Symp. 56, 167–182.

Mallin, M. A., M. R. McIver, and J. F. Merritt. 2013. *Environmental Assessment of the Lower Cape Fear River System, 2012.* CMS Report No. 12-03, Center for Marine Science, University of North Carolina at Wilmington, Wilmington, N.C.

Mallin. A. Michael, M. H. Posey, M. R. McIver, S. H. Ensign, T. Alphin, M. Williams, M. Moser, and J. Merritt. 2000. Environmental Assessment Of The Lower Cape Fear River System, 1999-2000. 4.0 Benthic Community Patterns in the Lower Cape Fear River System. Center for Marine Science, University of North Carolina at Wilmington. Accessed March 2012. Available on line at http://www.uncw.edu/cms/aelab/LCFRP/ and http://www.uncw.edu/cms/aquaticecology/Laboratory/LCFRP/WQ%20Reports/99-00/Report.htm

McCord, J. W. 2005. Species Account for Shortnose and Atlantic Sturgeon. SCDNR. 20 pp.

MG Associates (MGA). 2011. Summary of Available Turbidity, Suspended Sediment, and Dissolved Oxygen Monitoring Data, Lower Savannah River Estuary, Georgia. Report prepared for Georgia Ports Authority. November 2011.

MGA. 2012. Biological Assessment for Shortnose and Atlantic Sturgeons, Maintenance Dredging in the Upper Savannah River Estuary, Georgia. Prepared for Georgia Ports Authority, Savannah, GA. October 12, 2012.

Moser, M. L. and S. W. Ross. 1995. Habitat use and movements of shortnose and Atlantic sturgeons in the Lower Cape Fear River, North Carolina. Transactions of the American Fisheries Society 124:225-234.

Moser M. L., J. B. Bichy, and S. B. Roberts. 1998. Sturgeon distribution in North Carolina. Center for Marine Science Research. Final Report to U.S. ACOE, Wilmington District, NC.

Moser, M. L., A. M. Darazsdi, and J. R. Hall. 2000. Improving passage efficiency of adult American shad at low-elevation dams with navigation locks. *North American Journal of Fisheries Management* 20:376-385.

National Marine Fisheries Service (NMFS). 1998. Recovery Plan for Shortnose Sturgeon, Acipenser brevirostrum. Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. 104 pp.

NMFS. 2010. Final Amendment 3 to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan. Highly Migratory Species Management Division. Office of Sustainable Fisheries. National Marine Fisheries Service. Silver Spring, MD. March 2010. Accessed March 2012. Available online at http://www.nmfs.noaa.gov/sfa/hms/FMP/AM3_FEIS/Chapter_11.pdf.

NMFS. 2011. Biological Opinion on Maintenance Dredging of the Lower Kennebec River. Northeast Region. 73 pp.

NMFS, Southeast and Northeast Regions. 2018. Diadromous Fish Passage: A Primer on Technology, Planning, and Design for the Atlantic and Gulf Coasts.

National Oceanic and Atmospheric Administration. 2016. "NOAA issues proposed rules designating Atlantic sturgeon critical habitat." June 2, 2016. Available at: http://www.noaa.gov/noaa-issues-proposed-rules-designating-atlantic-sturgeon-critical-habitat.

Nichols, P. R., and D. E. Louder. 1970. Upstream Passage of Anadromous Fish Through Navigation Locks and Use of the Stream for Spawning and Nursery Habitat Cape Fear River, N.C., 1962-1966. (Circular No. 352). Washington, D.C.

North Carolina Department of Environment and Natural Resources (NCDENR), Division of Water Quality. 2009. Ambient Monitoring System Report Cape Fear River Basin – August 2009. AMS-1.

NCDENR, Division of Marine Fisheries. 2013. Research and Management of Endangered and Threatened Species in the South East: Riverine Movements of Shortnose and Atlantic Sturgeon. Semi-annual progress report under Account #P24019087211 (NOAA Award #NA10NMF4720036).

North Carolina Division of Marine Fisheries. 2011. Primary Nursery Areas Maps. Accessed March 2012. Available online at http://www.ncfisheries.net/maps/FNA_maps/ map27.pdf, dated March 2011.

Oakley, N C. and J. E. Hightower. 2007. Status of shortnose sturgeon in the Neuse River, North Carolina. American Fisheries Society Symposium 56:273-284.

O'Connor, J. M., D. A. Neumann, and J. A. Sherk, Jr. 1976. Lethal effects of suspended sediments on estuarine fish. Technical Paper 76-20. US Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, VA. 38 pp.

Parasiewicz, P., J. Ebberstaller, S. Weiss, and S. Schmutz. 1998. Conceptual guidance for nature-like bypass channel, in: M. Jungwirth, S. Schmutz, S. Weiss (eds.). Fish Migration and Fish Bypasses, Fishery News Books, Blackwell Sciences, Oxford.

Raabe, J. K. 2014a. Evaluation of Fish Passage Following Installation of a Rock Arch Rapids at Lock and Dam #1, Cape Fear River, North Carolina. Proceedings of the International Conference on Engineering and Ecohydrology for Fish Passage. June 09, 2014. UMass Amherst.

Raabe, J. K. 2014b. Characterizing Habitat Suitability for American Shad in the Yadkin-Pee Dee River. Final Report. North Carolina Cooperative Fish and Wildlife Research Unit. Raleigh, NC.

Raabe, J. K., T. Ellis, J. Hightower, and J. Facendola. 2017. 147th meeting AM Fish Society.

Ray, G. 1997. Benthic Characterization of Wilmington Harbor and Cape Fear Estuary, Wilmington, North Carolina. Final Report Prepared for the U.S. Army Corps of Engineers – Wilmington District. US Army Engineers Waterways Experiment Station, Vicksburg, MS.

Ross, S. W., F. C. Rohde, and D. G. Lindquist. 1988. Endangered, threatened, and rare fauna of North Carolina, part 2. A re-evaluation of the marine and estuarine fishes, North Carolina Biological Survey, Occasional Papers 1988-7 Raleigh, North Carolina.

Secor, D. H., and T. E. Gunderson. 1998. Effects of hypoxia and temperature on survival, growth, and respiration of juvenile Atlantic sturgeon, Acipenser oxyrinchus. Fishery Bulletin 96:603-613.

Secor, D. H., and E. J. Niklitschek. 2001. Hypoxia and sturgeons: report to the Chesapeake Bay Program Dissolved Oxygen Team. Technical Report Series No. TS 314-01-CBL. 24 pp.

Smith, J. A. and J. E. Hightower. 2012. Effect of low-head lock and dam structures on migration and spawning of American shad and striped bass in the Cape Fear River, North Carolina. Transactions of the American Fisheries Society 141:402-413.

Stevenson, C. H. 1899. The shad fisheries of the Atlantic Coast of the United States. Rep. U.S. Comm. Fish., Pt.24, 1898: 101-269.

Tetra Tech, Inc. 2018. Cape Fear Lock and Dam 1 Fish Passage CFD Model. Final Technical Report. May 2018.

United States Army Corps of Engineers (USACE). 1983. Dredging and Dredged Material Disposal. Engineer Manual 1110-2- 5025. Washington D.C.

USACE. 2008. The Four Rs of Environmental Dredging: Resuspension, Release, Residual, and Risk. Engineer Research and Development Center. ERDC/EL TR-08-4.

USACE. 2010. Biological Assessment of Threatened and Endangered Species for the Proposed Savannah Harbor Expansion Project. Appendix B to the Environmental Impact Statement. 196 pp.

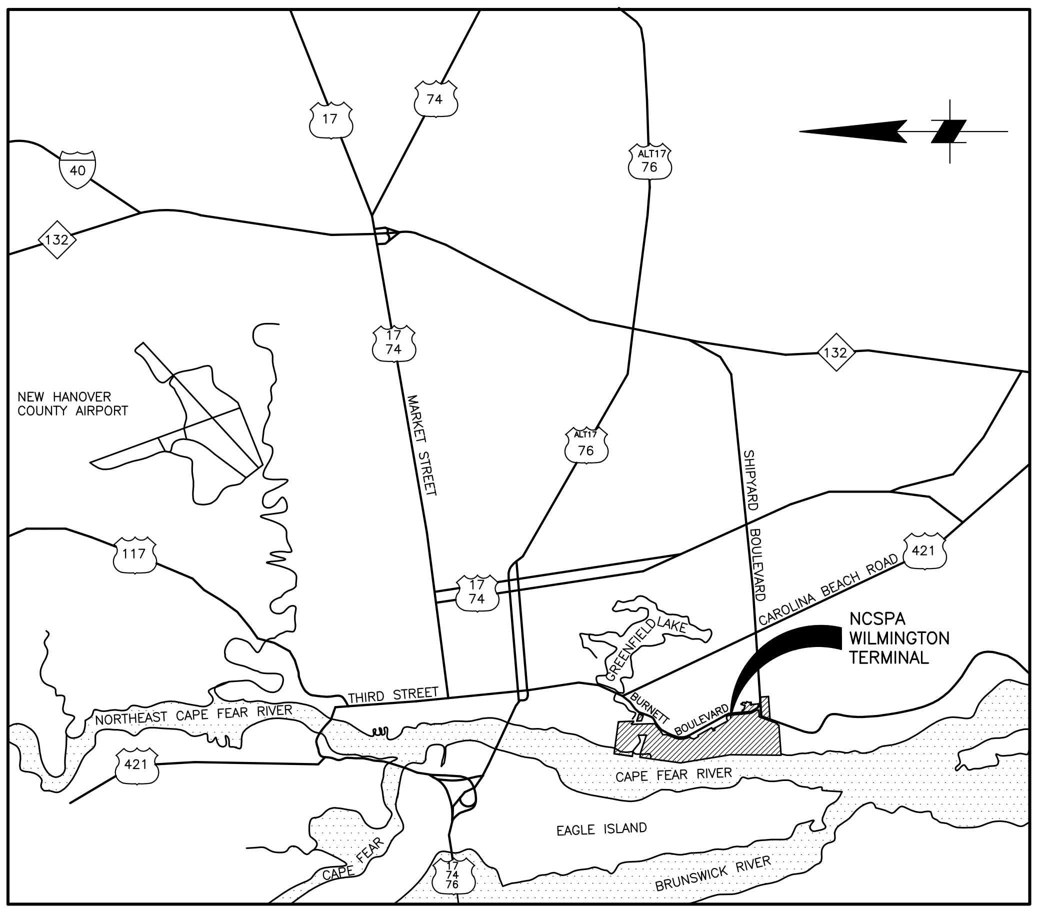
USACE, Wilmington District. 2000. Finding of No Significant Impact, Preconstruction Modifications of Authorized Improvements, Wilmington Harbor, North Carolina, August 2000.

Van Dolah, R. F., D. R. Calder, D. M. Knott, and M. S. Maclin. 1979. Effects of dredging and unconfined disposal on macrobenthic communities in Sewee Bay, South Carolina. Tech. Rep. 39. South Carolina Marine Resources Center, Charleston, SC.

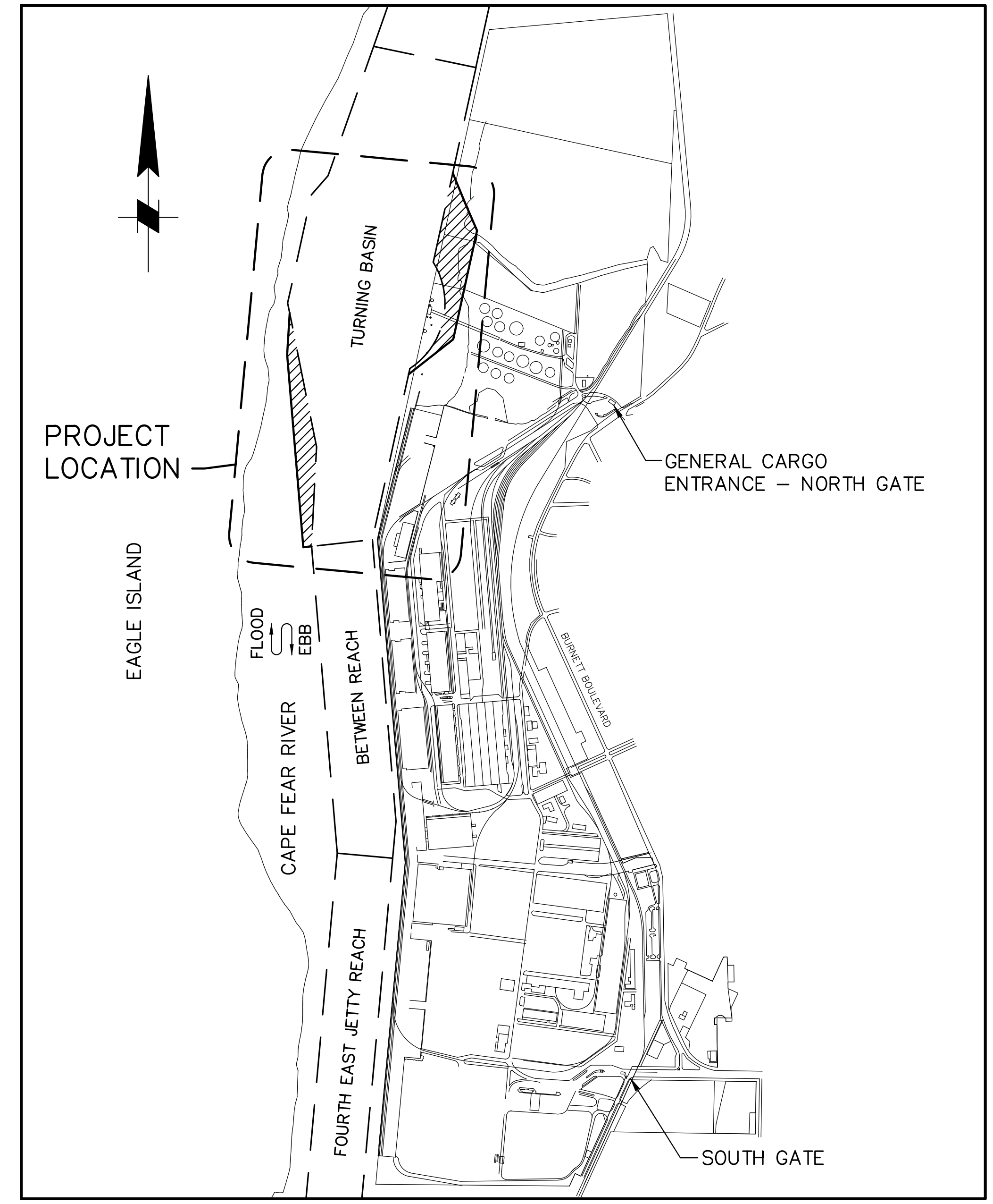
Van Dolah, R. F., D. R. Calder, and D. M., Knott. 1984. Effects of dredging and open water disposal on benthic macroinvertebrates in a South Carolina estuary. Estuaries 7:28-37.

APPENDIX A

PERMIT PLANS/DRAWINGS



VICINITY MAP
NOT TO SCALE



LOCATION MAP
NOT TO SCALE

PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY**
WILMINGTON TERMINAL
TURNING BASIN EXPANSION

DATUM: **MLLW**

PREPARED BY: **MOFFATT & NICHOL**

PREPARED FOR: **NORTH CAROLINA STATE PORTS AUTHORITY**

NORTH CAROLINA PORTS

DATE: **OCTOBER 2018**

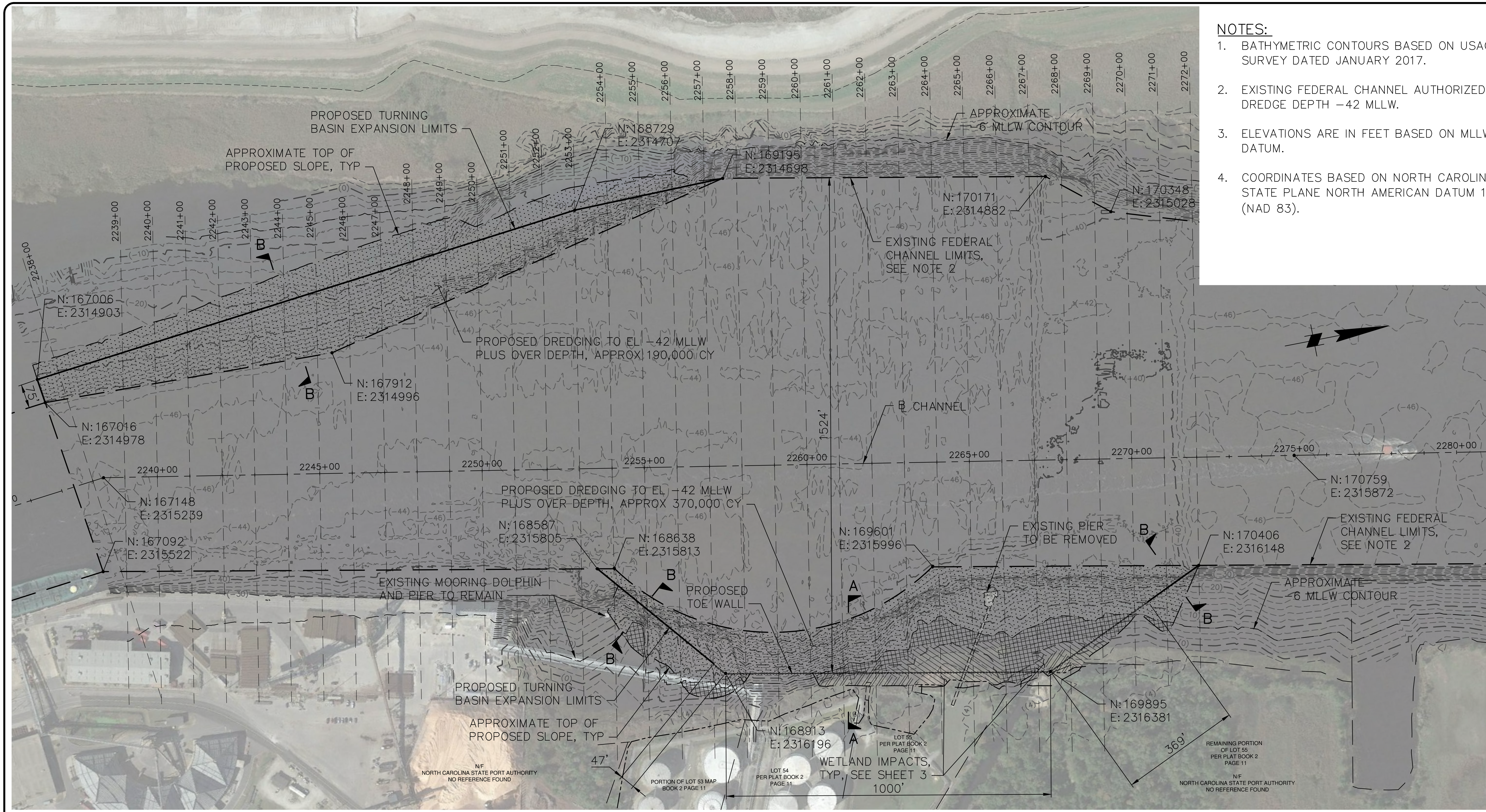
SHEET TITLE:
PROJECT VICINITY AND LOCATION MAP

SHEET **1** *OF* **16**

File: Q:\RA\9232-08\CADD_Active_Permit\923208-P01; Plotted: 10/24/2018 12:16 PM by KOONS, DAVE; Saved: 10/23/2018 11:49 AM by DKOONS

NOTES:

1. BATHYMETRIC CONTOURS BASED ON USACE SURVEY DATED JANUARY 2017.
2. EXISTING FEDERAL CHANNEL AUTHORIZED DREDGE DEPTH −42 MLLW.
3. ELEVATIONS ARE IN FEET BASED ON MLLW DATUM.
4. COORDINATES BASED ON NORTH CAROLINA STATE PLANE NORTH AMERICAN DATUM 1983 (NAD 83).

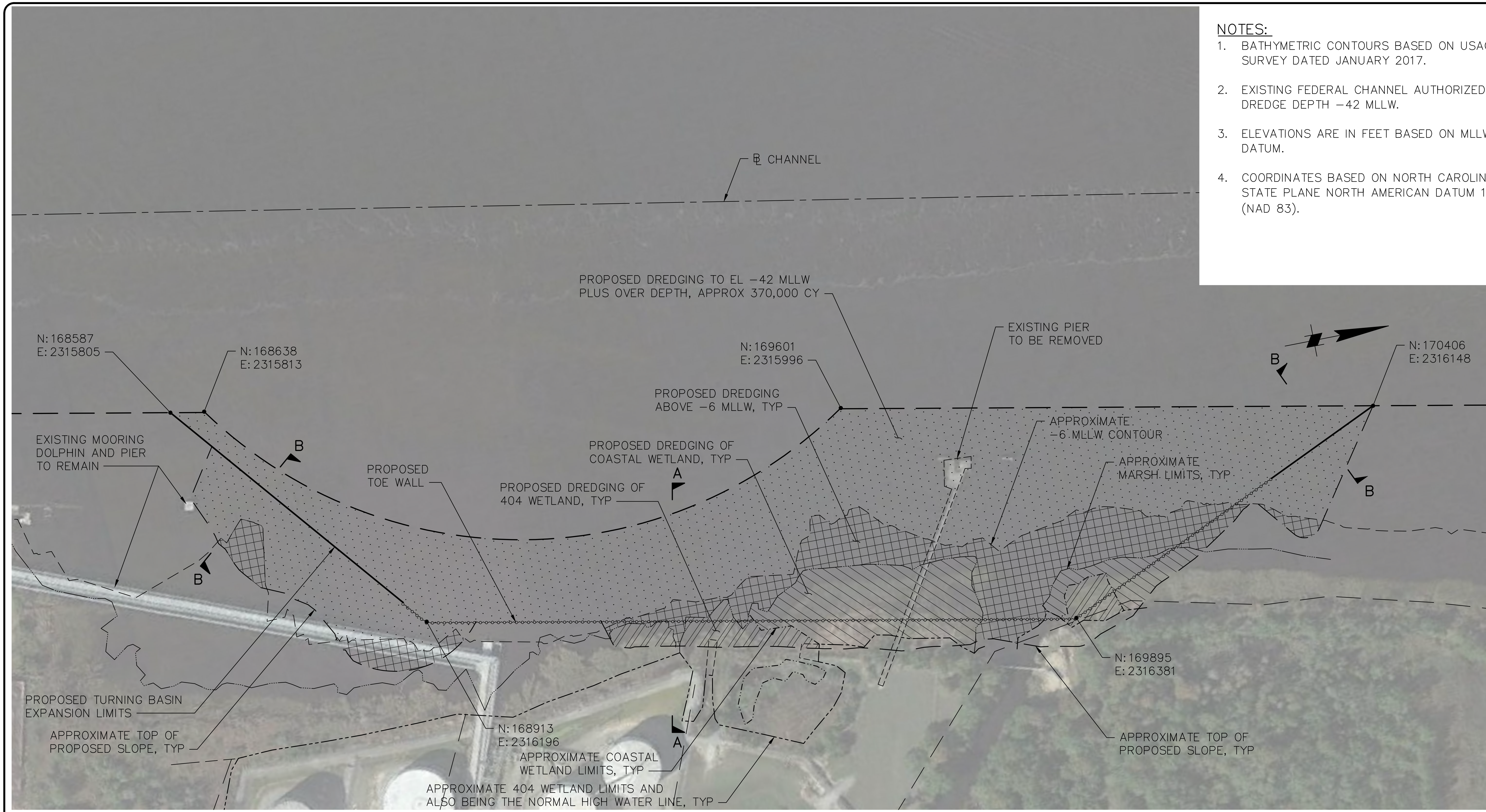


PROJECT SITE PLAN

1"=300'

PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY WILMINGTON TERMINAL TURNING BASIN EXPANSION** *DATUM:* **MLLW** *PREPARED BY:* **MOFFATT & NICHOL**	*PREPARED FOR:* **NORTH CAROLINA STATE PORTS AUTHORITY** NORTH CAROLINA PORTS *DATE:* **OCTOBER 2018**	*SHEET TITLE:* **PROJECT SITE PLAN** 0 150' 300' 1"=300'	SHEET **2** OF **16**

File: Q:\RA\9232-08\CADD_Active_Permit\923208-P02; Plotted: 10/24/2018 12:16 PM by KOONS, DAVE; Saved: 10/24/2018 11:17 AM by DKOONS



NOTES:

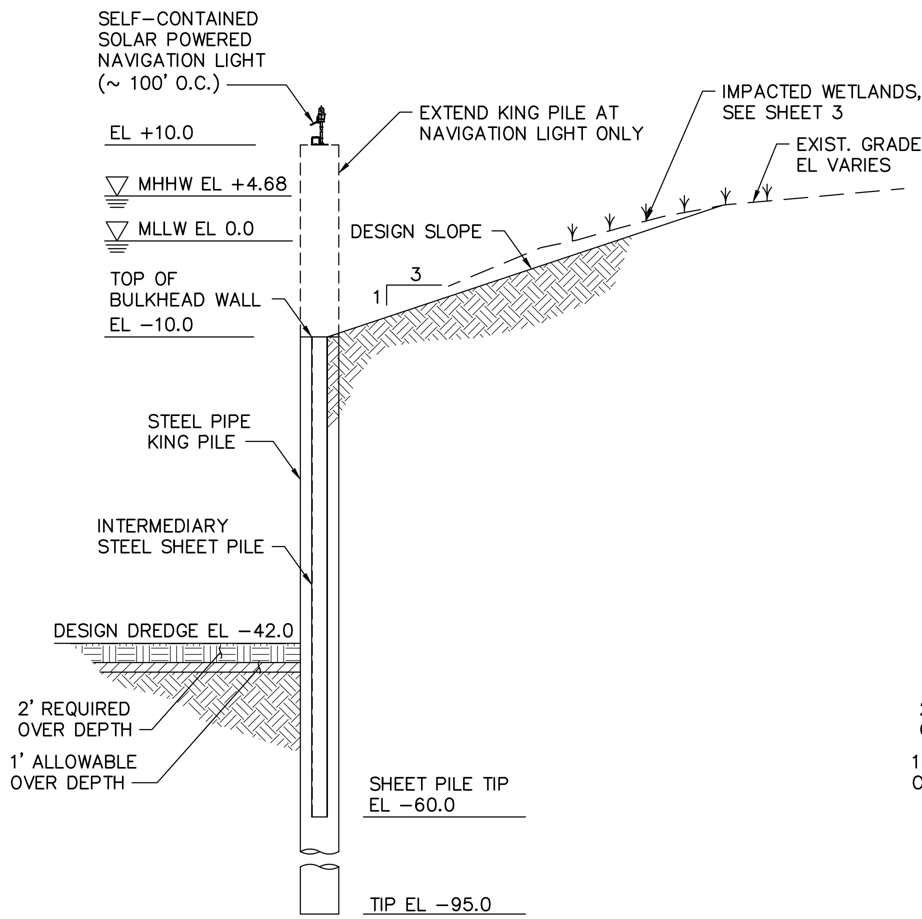
1. BATHYMETRIC CONTOURS BASED ON USACE SURVEY DATED JANUARY 2017.
2. EXISTING FEDERAL CHANNEL AUTHORIZED DREDGE DEPTH −42 MLLW.
3. ELEVATIONS ARE IN FEET BASED ON MLLW DATUM.
4. COORDINATES BASED ON NORTH CAROLINA STATE PLANE NORTH AMERICAN DATUM 1983 (NAD 83).

WETLAND IMPACT PLAN

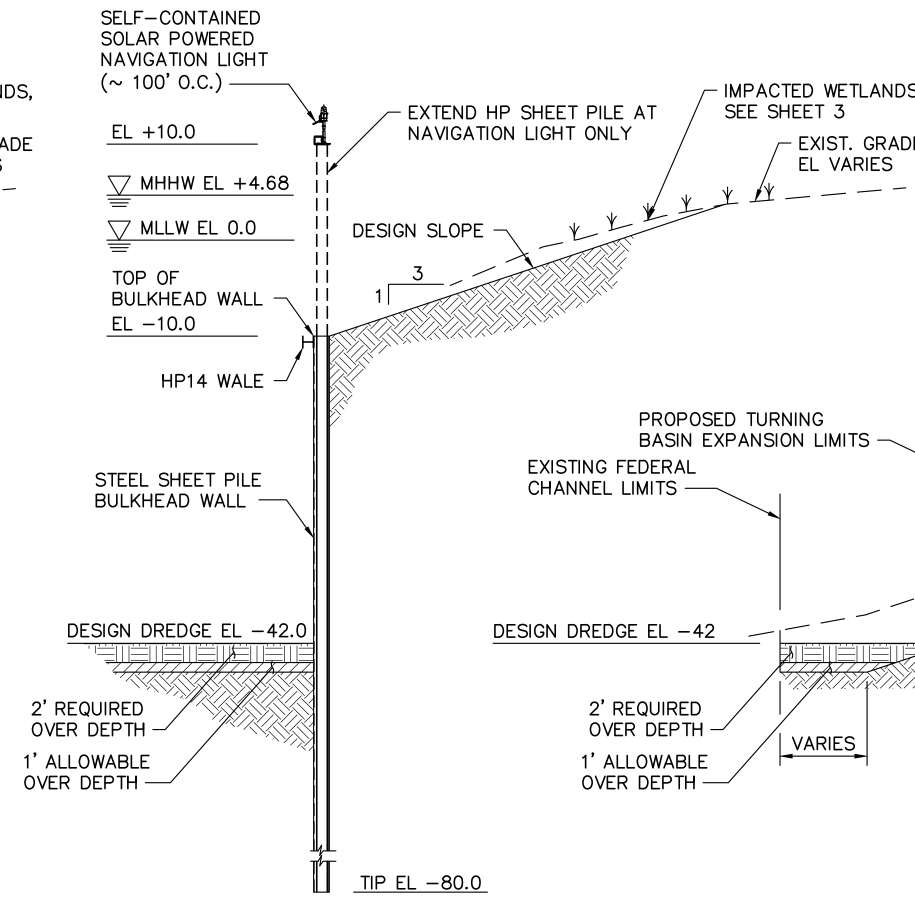
1"=150'

File: Q:\RA\9232-08\CADD_Active_Permit\923208-P03; Plotted: 10/24/2018 12:16 PM by KOONS, DAVE; Saved: 10/24/2018 10:52 AM by DKOONS

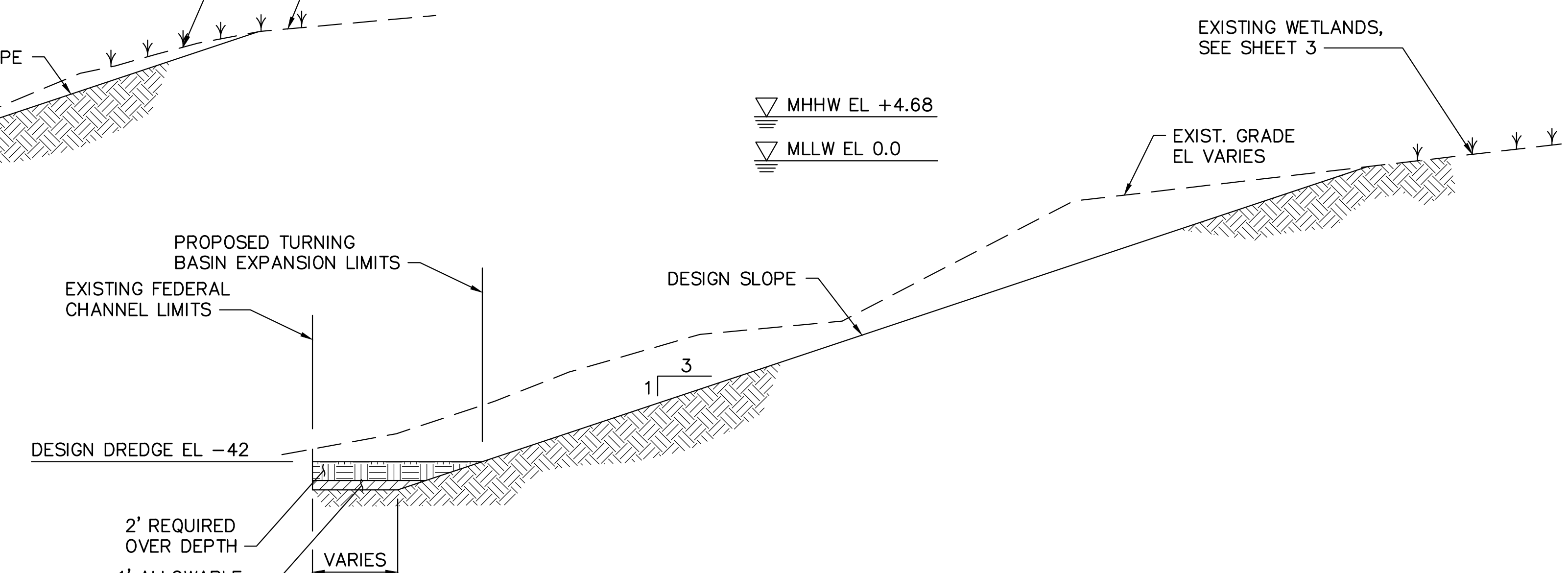
PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY WILMINGTON TERMINAL TURNING BASIN EXPANSION** *DATUM:* **MLLW** *PREPARED BY:* **MOFFATT & NICHOL**	*PREPARED FOR:* **NORTH CAROLINA STATE PORTS AUTHORITY** NORTH CAROLINA PORTS *DATE:* **OCTOBER 2018**	*SHEET TITLE:* **WETLAND IMPACT PLAN** 0 75' 150' 1"=150'	*SHEET* **3** *OF* **16**



SECTION A–A
KING PILE WALL
1"=20'



SECTION A–A
SHEET PILE WALL ALTERNATIVE
1"=20'



SECTION B–B
1"=20'

PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY**
WILMINGTON TERMINAL
TURNING BASIN EXPANSION

DATUM: **MLLW**

PREPARED BY: **MOFFATT & NICHOL**

PREPARED FOR: **NORTH CAROLINA STATE PORTS AUTHORITY**

NORTH CAROLINA PORTS

DATE: **OCTOBER 2018**

SHEET TITLE:
TYPICAL SECTIONS

0 10' 20'
1"=20'

SHEET
4
OF
16

File: Q:\RA\9232-08\CADD_Active_Permit\923208-P04; Plotted: 10/24/2018 12:16 PM by KOONS, DAVE; Saved: 10/23/2018 11:49 AM by DKOONS

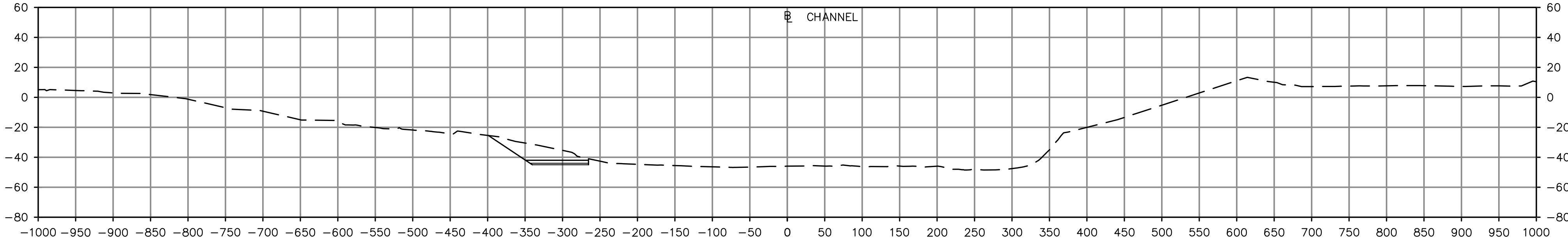
NOTES:

1. BATHYMETRIC CONTOURS BASED ON USACE SURVEY DATED JANUARY 2017.
2. ELEVATIONS ARE IN FEET BASED ON MLLW DATUM.

LEGEND

- – – – – – – – APPROXIMATE EXISTING GRADE
- ———————— PROPOSED DREDGING

2238+00



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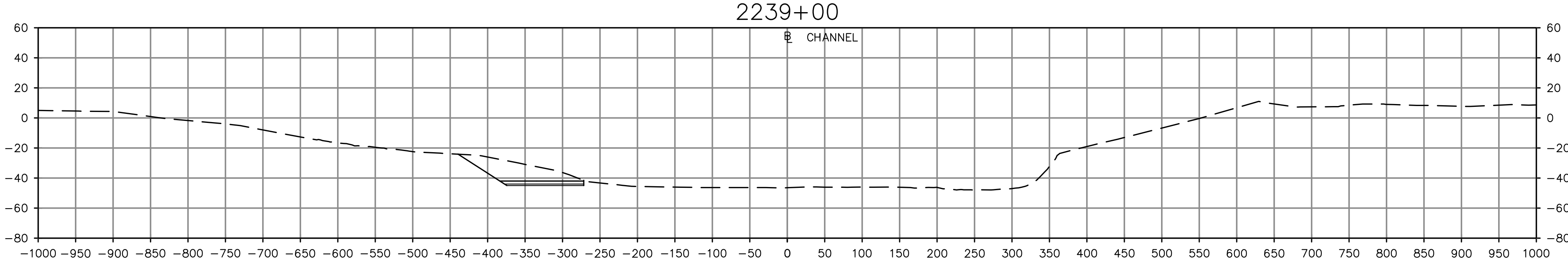
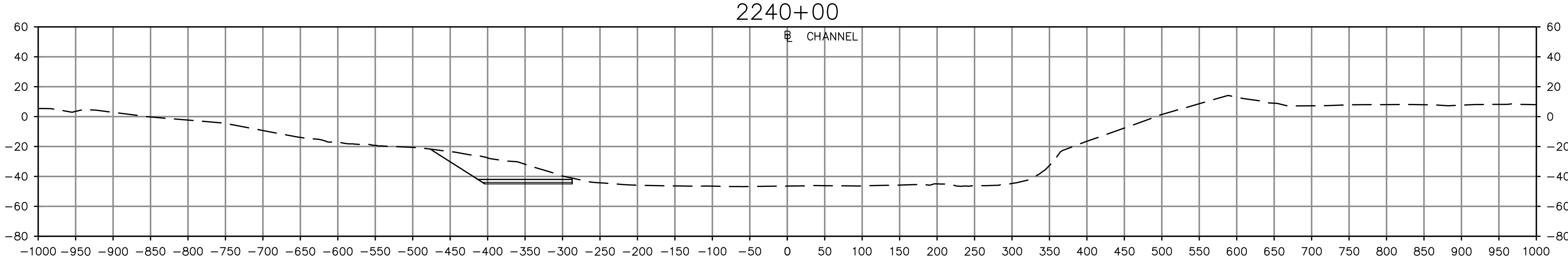


2240+00



PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY**
WILMINGTON TERMINAL
TURNING BASIN EXPANSION

DATUM: **MLLW**

PREPARED BY: **MOFFATT & NICHOL**

PREPARED FOR: **NORTH CAROLINA STATE PORTS AUTHORITY**

NORTH CAROLINA PORTS

DATE: **OCTOBER 2018**

SHEET TITLE:
CROSS SECTIONS
1 OF 12

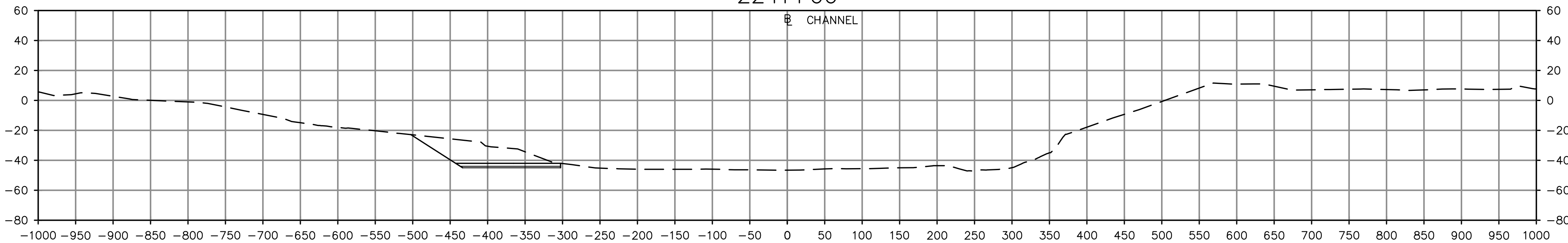
0 100' 200'
1"=200' HORIZONTAL

0 50' 100'
1"=100' VERTICAL

SHEET
5
OF
16

File: Q:\RA\9232-08\CADD_Active_Permit\923208-P05; Plotted: 10/24/2018 12:16 PM by KOONS, DAVE; Saved: 10/23/2018 10:37 AM by DKOONS

2241+00



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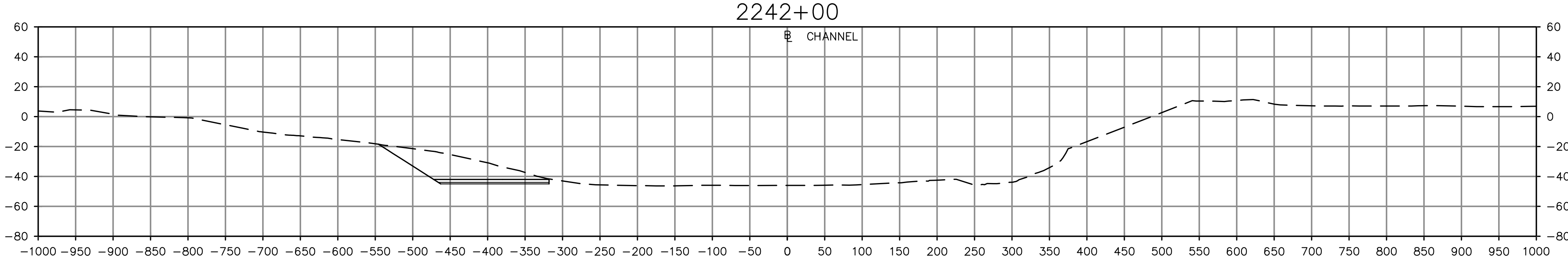

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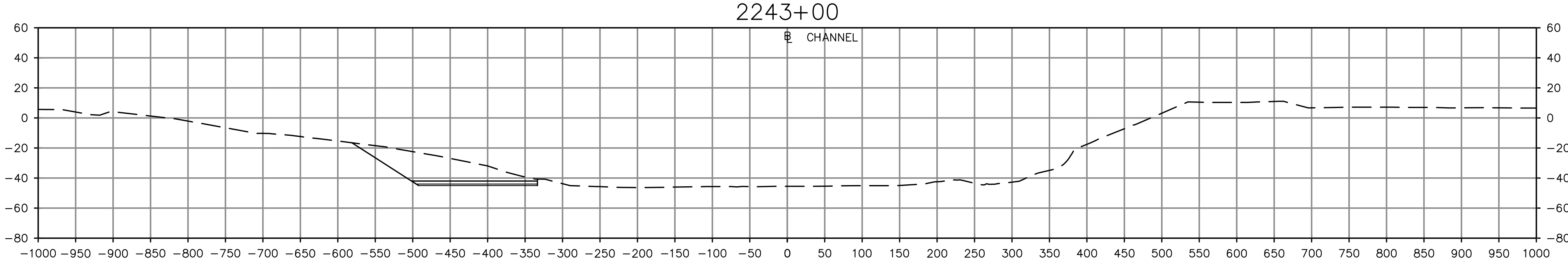


NOTES:

1. BATHYMETRIC CONTOURS BASED ON USACE SURVEY DATED JANUARY 2017.
2. ELEVATIONS ARE IN FEET BASED ON MLLW DATUM.

LEGEND

— — — — — — APPROXIMATE EXISTING GRADE

———————— PROPOSED DREDGING

PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY WILMINGTON TERMINAL TURNING BASIN EXPANSION**

DATUM: **MLLW**

PREPARED BY: **MOFFATT & NICHOL**

PREPARED FOR: **NORTH CAROLINA STATE PORTS AUTHORITY**

DATE: **OCTOBER 2018**

SHEET TITLE: **CROSS SECTIONS 2 OF 12**

0 100' 200' 1"=200' HORIZONTAL

0 50' 100' 1"=100' VERTICAL

SHEET **5** OF **16**

File: Q:\RA\9232-08\CADD_Active_Permit\923208-P06; Plotted: 10/24/2018 12:16 PM by KOONS, DAVE; Saved: 10/23/2018 10:37 AM by DKOONS

NOTES:

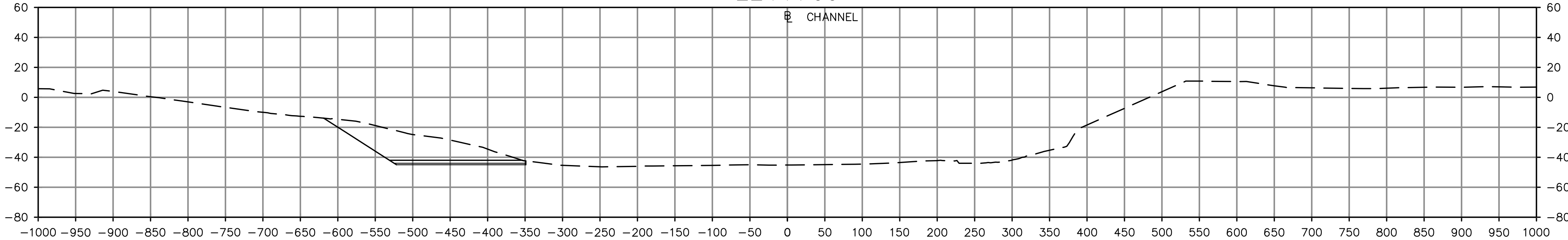
1. BATHYMETRIC CONTOURS BASED ON USACE SURVEY DATED JANUARY 2017.
2. ELEVATIONS ARE IN FEET BASED ON MLLW DATUM.

LEGEND

— — — — — — — APPROXIMATE EXISTING GRADE

——————————— PROPOSED DREDGING

2244+00



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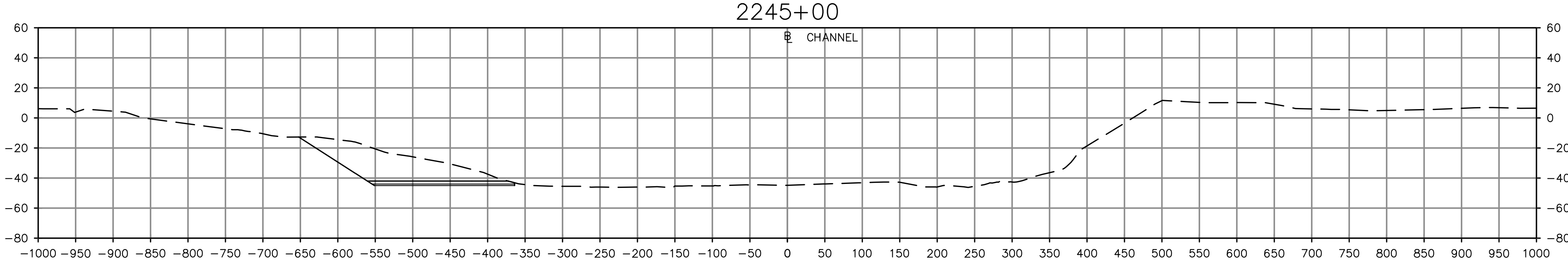

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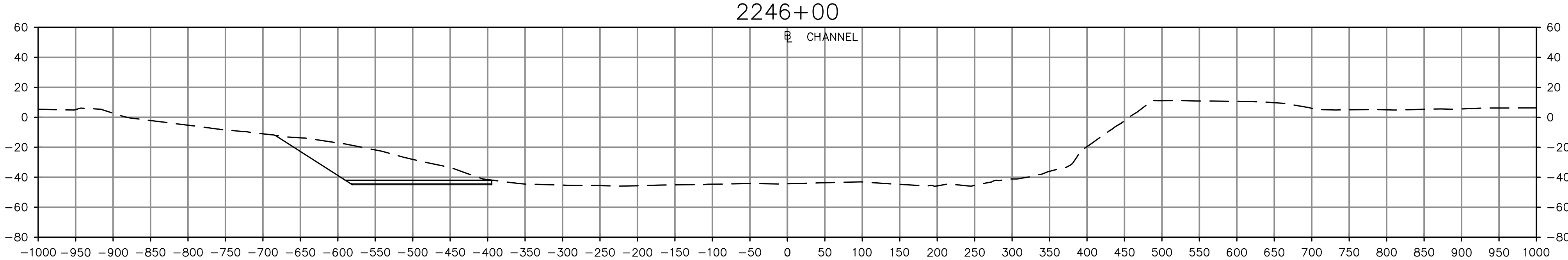


PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY**
WILMINGTON TERMINAL
TURNING BASIN EXPANSION

DATUM: **MLLW**

PREPARED BY: **MOFFATT & NICHOL**

PREPARED FOR: **NORTH CAROLINA STATE PORTS AUTHORITY**

NORTH CAROLINA PORTS

DATE: **OCTOBER 2018**

SHEET TITLE:
CROSS SECTIONS
3 OF 12

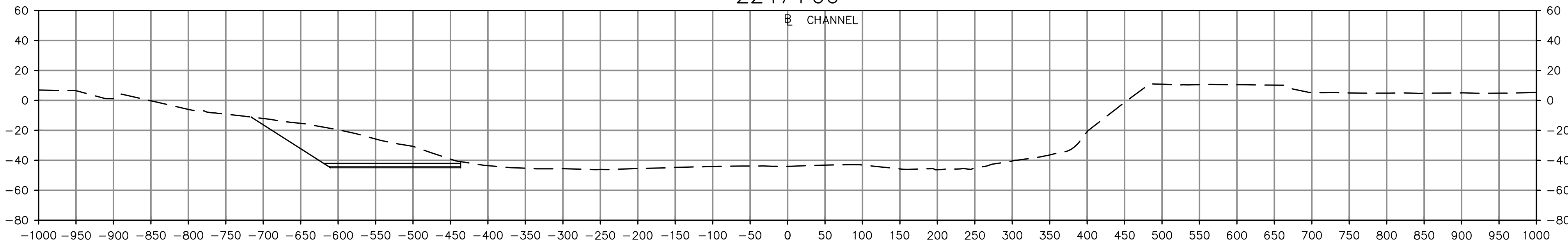
0 100' 200' — 1"=200' HORIZONTAL

0 50' 100' — 1"=100' VERTICAL

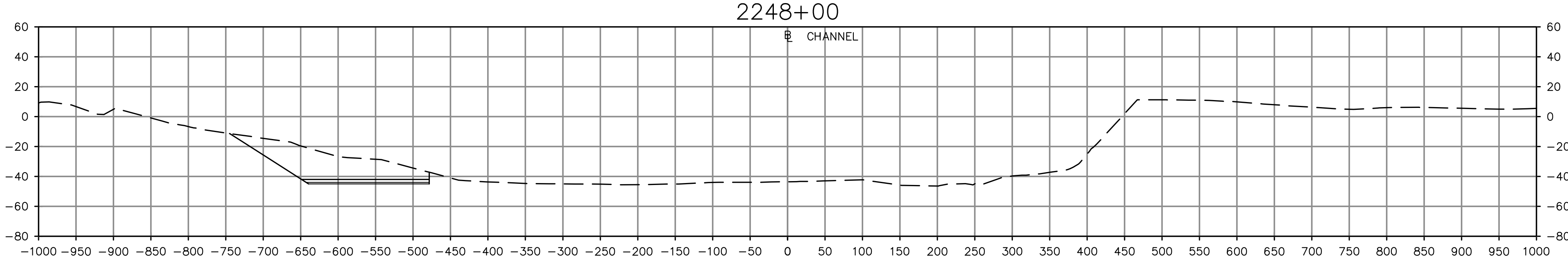
SHEET **7** *OF* **16**

File: Q:\RA\9232-08\CADD_Active_Permit\923208-P07; Plotted: 10/24/2018 12:17 PM by KOONS, DAVE; Saved: 10/23/2018 10:37 AM by DKOONS

2247+00



2248+00



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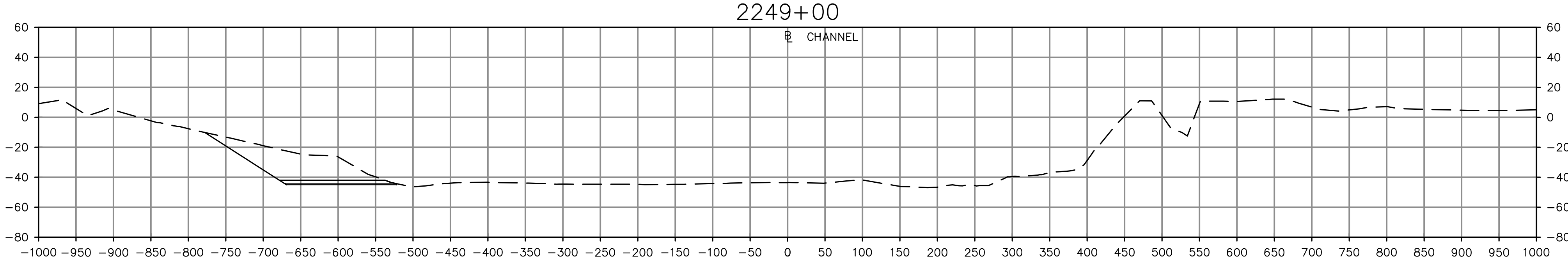


NOTES:

1. BATHYMETRIC CONTOURS BASED ON USACE SURVEY DATED JANUARY 2017.
2. ELEVATIONS ARE IN FEET BASED ON MLLW DATUM.

LEGEND

APPROXIMATE EXISTING GRADE

PROPOSED DREDGING

PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY WILMINGTON TERMINAL TURNING BASIN EXPANSION**

DATUM: **MLLW**

PREPARED BY: **MOFFATT & NICHOL**

PREPARED FOR: **NORTH CAROLINA STATE PORTS AUTHORITY**

DATE: **OCTOBER 2018**

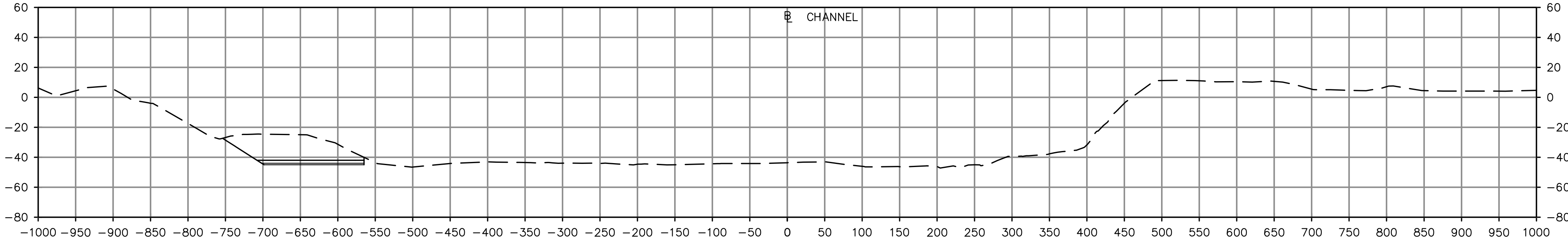
SHEET TITLE: **CROSS SECTIONS 4 OF 12**

0 100' 200' 1"=200' HORIZONTAL

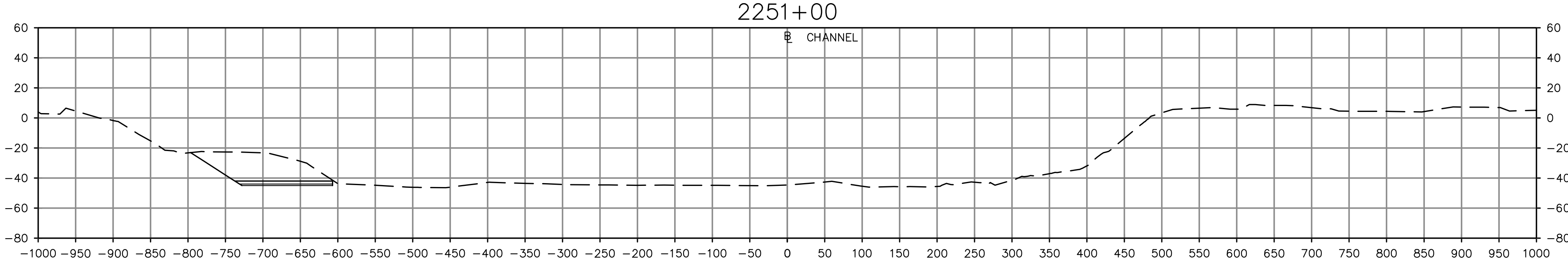
0 50' 100' 1"=100' VERTICAL

SHEET **8** *OF* **16**

2250+00



2251+00



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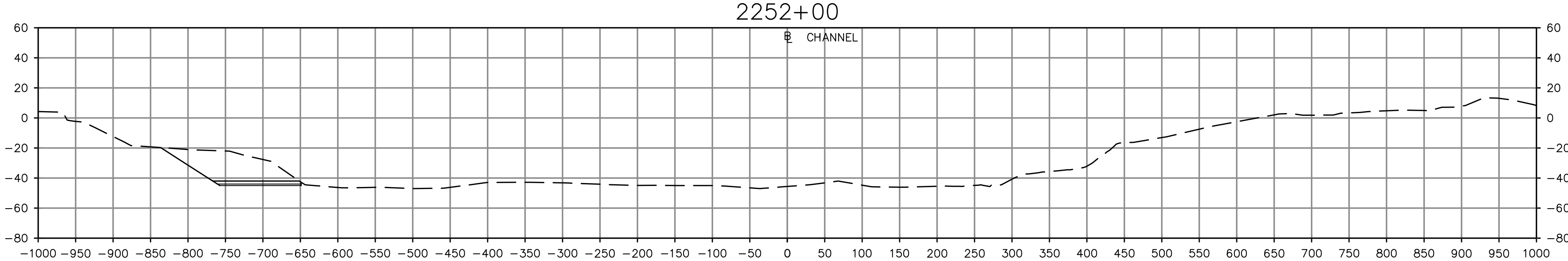


NOTES:

1. BATHYMETRIC CONTOURS BASED ON USACE SURVEY DATED JANUARY 2017.
2. ELEVATIONS ARE IN FEET BASED ON MLLW DATUM.

LEGEND

APPROXIMATE EXISTING GRADE

PROPOSED DREDGING

PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY WILMINGTON TERMINAL TURNING BASIN EXPANSION**

DATUM: **MLLW**

PREPARED BY: **MOFFATT & NICHOL**

PREPARED FOR: **NORTH CAROLINA STATE PORTS AUTHORITY**

NORTH CAROLINA PORTS

DATE: **OCTOBER 2018**

SHEET TITLE:

CROSS SECTIONS

5 OF 12

0 100' 200'

1"=200' HORIZONTAL

0 50' 100'

1"=100' VERTICAL

SHEET

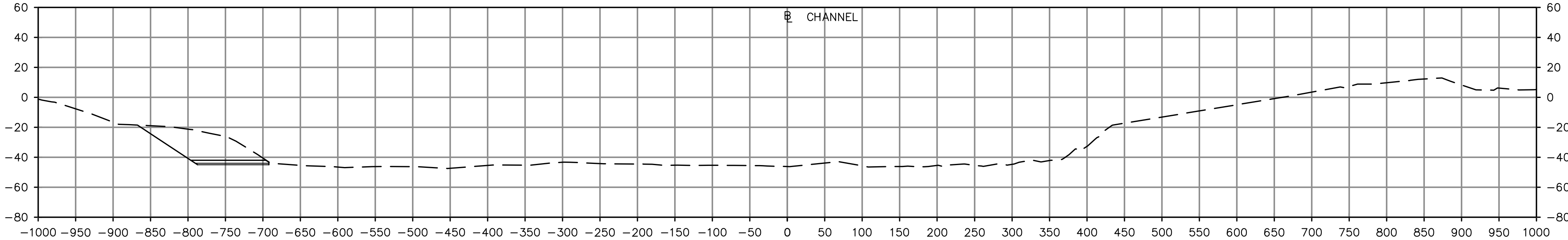
9

OF

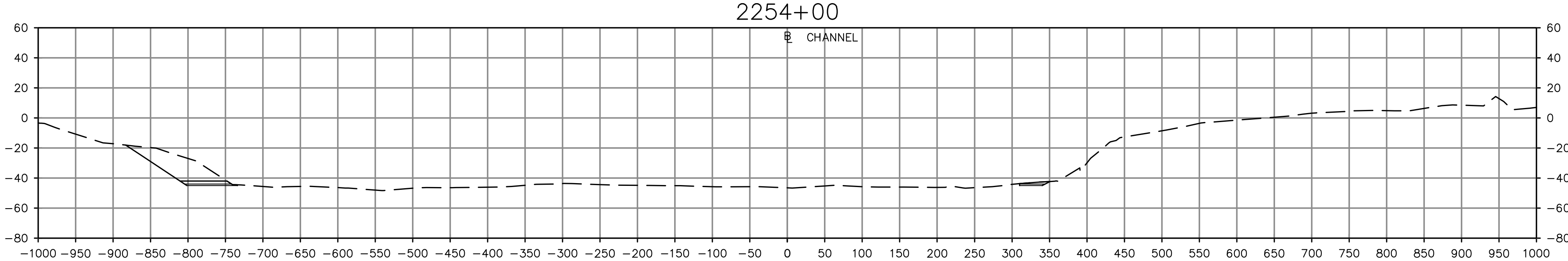
16

File: Q:\RA\9232-08\CADD_Active_Permit\923208-P09; Plotted: 10/24/2018 12:17 PM by KOONS, DAVE; Saved: 10/23/2018 10:38 AM by DKOONS

2253+00



2254+00



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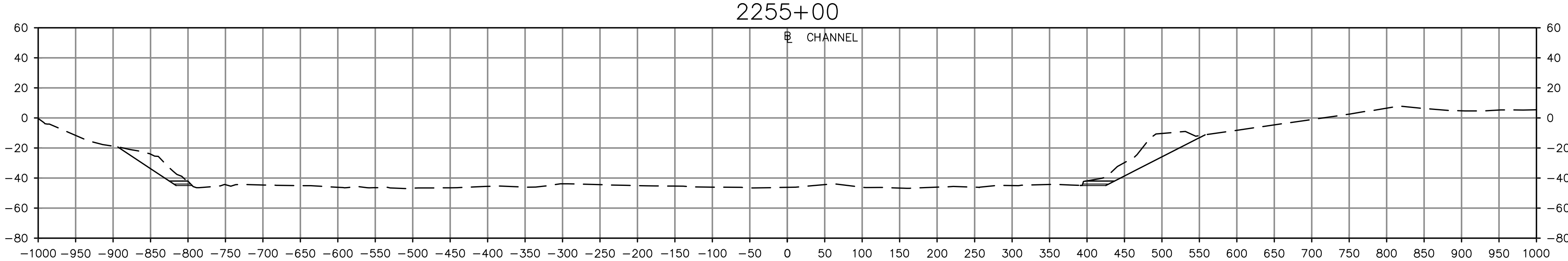


NOTES:

1. BATHYMETRIC CONTOURS BASED ON USACE SURVEY DATED JANUARY 2017.
2. ELEVATIONS ARE IN FEET BASED ON MLLW DATUM.

LEGEND:

— — — — — APPROXIMATE EXISTING GRADE

———————— PROPOSED DREDGING

PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY**
WILMINGTON TERMINAL
TURNING BASIN EXPANSION

DATUM: **MLLW**

PREPARED BY: **MOFFATT & NICHOL**

PREPARED FOR: **NORTH CAROLINA STATE PORTS AUTHORITY**

NORTH CAROLINA PORTS

DATE: **OCTOBER 2018**

SHEET TITLE:
CROSS SECTIONS
6 OF 12

0 100' 200'
1"=200' HORIZONTAL

0 50' 100'
1"=100' VERTICAL

SHEET
10
OF
16

NOTES:

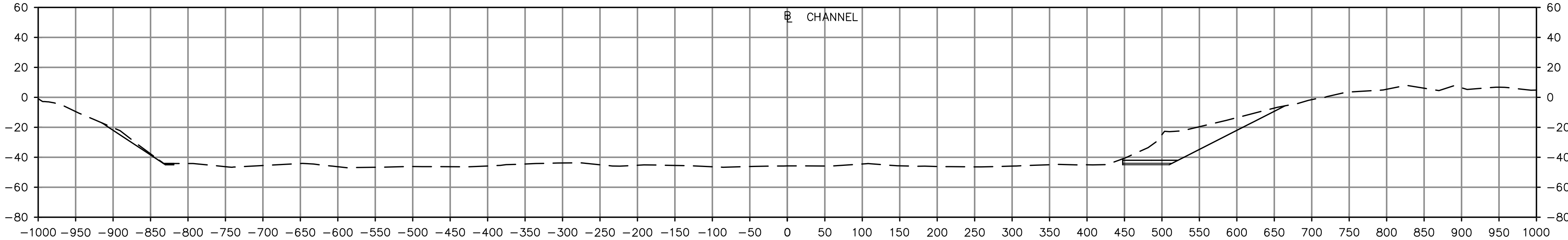
1. BATHYMETRIC CONTOURS BASED ON USACE SURVEY DATED JANUARY 2017.
2. ELEVATIONS ARE IN FEET BASED ON MLLW DATUM.

LEGEND

— — — — — APPROXIMATE EXISTING GRADE

———— PROPOSED DREDGING

2256+00



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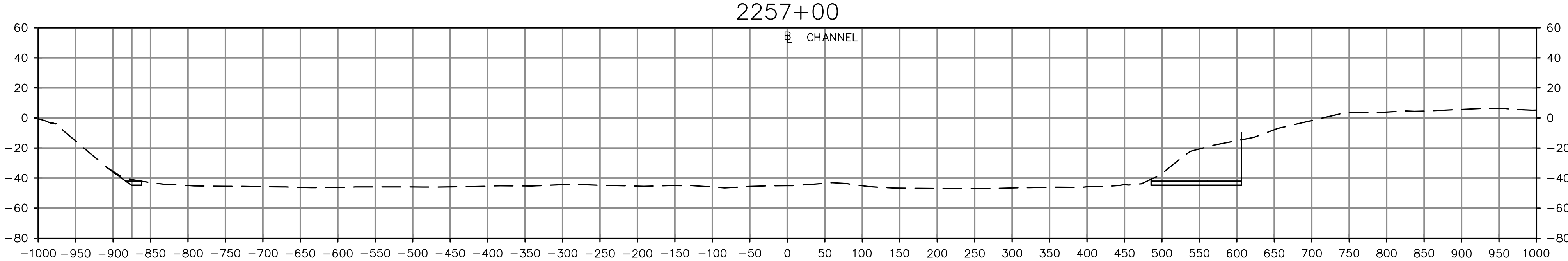

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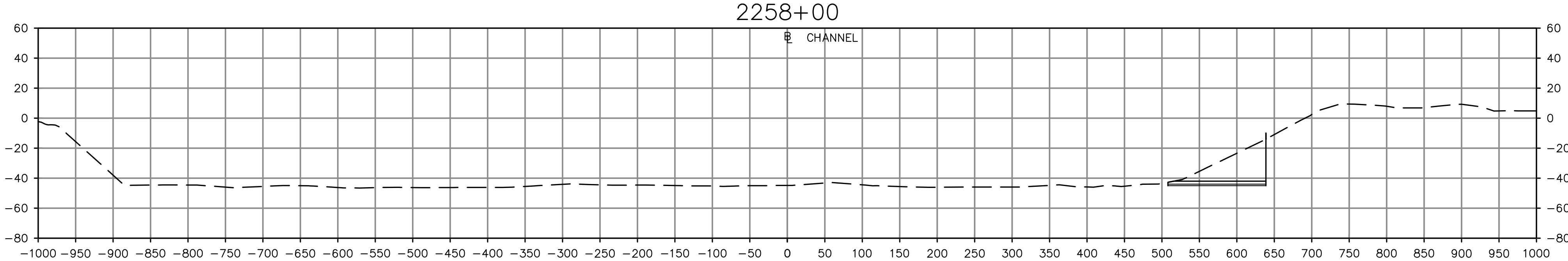


PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY WILMINGTON TERMINAL TURNING BASIN EXPANSION**

DATUM: **MLLW**

PREPARED BY: **MOFFATT & NICHOL**

PREPARED FOR: **NORTH CAROLINA STATE PORTS AUTHORITY**

NORTH CAROLINA PORTS

DATE: **OCTOBER 2018**

SHEET TITLE: **CROSS SECTIONS 7 OF 12**

0 100' 200' — 1"=200' HORIZONTAL

0 50' 100' — 1"=100' VERTICAL

SHEET **11** *OF* **16**

File: Q:\RA\9232-08\CADD_Active_Permit\923208-P11; Plotted: 10/24/2018 12:17 PM by KOONS, DAVE; Saved: 10/23/2018 10:38 AM by DKOONS

NOTES:

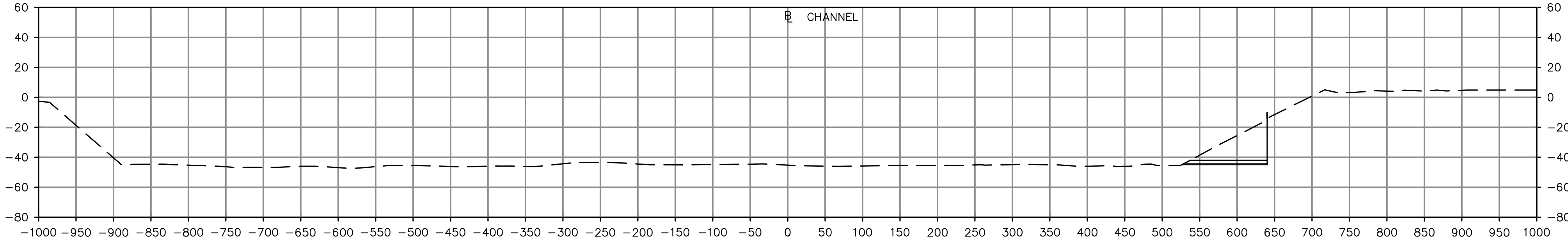
1. BATHYMETRIC CONTOURS BASED ON USACE SURVEY DATED JANUARY 2017.
2. ELEVATIONS ARE IN FEET BASED ON MLLW DATUM.

LEGEND

– – – – – – APPROXIMATE EXISTING GRADE

———— PROPOSED DREDGING

2259+00



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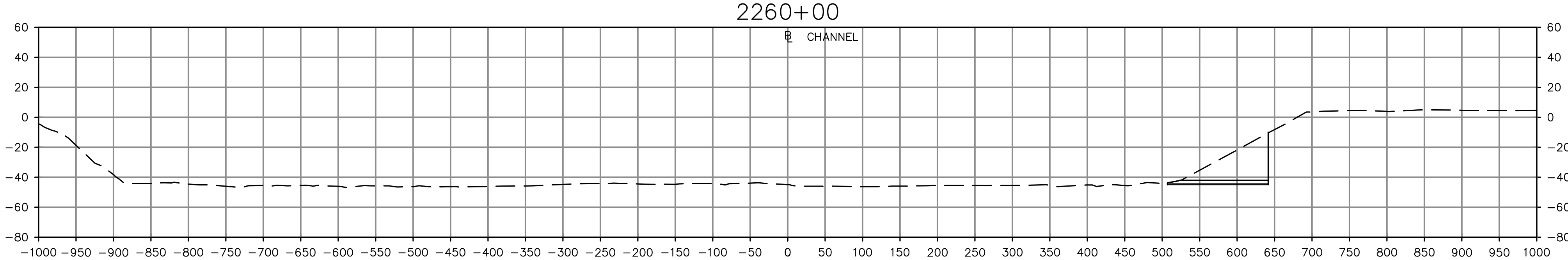

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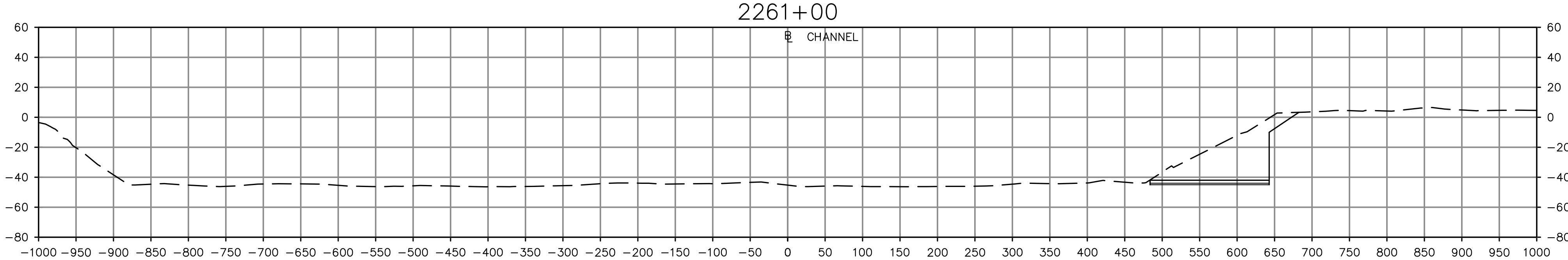


PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY WILMINGTON TERMINAL TURNING BASIN EXPANSION**

DATUM: **MLLW**

PREPARED BY: **MOFFATT & NICHOL**

PREPARED FOR: **NORTH CAROLINA STATE PORTS AUTHORITY**

NORTH CAROLINA PORTS

DATE: **OCTOBER 2018**

SHEET TITLE:

CROSS SECTIONS 8 OF 12

0 100' 200'

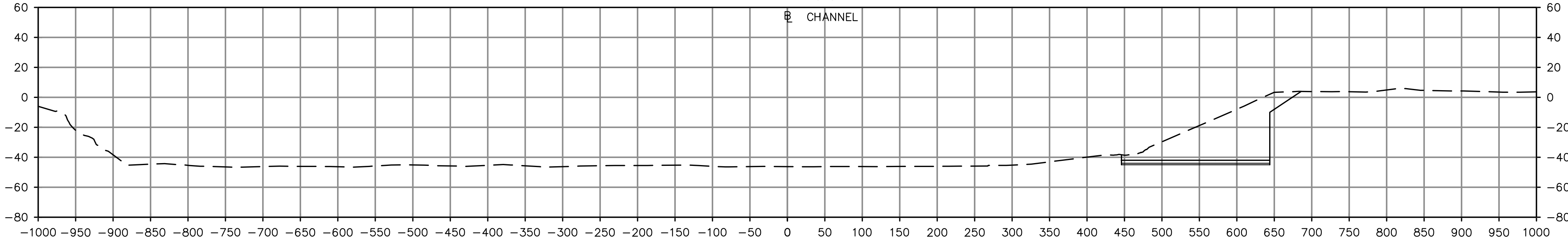
1"=200' HORIZONTAL

0 50' 100'

1"=100' VERTICAL

SHEET **12** *OF* **16**

2262+00



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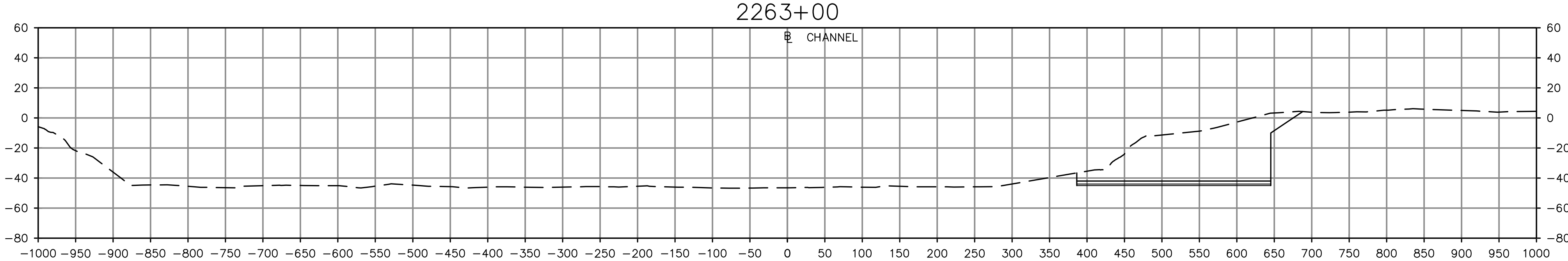

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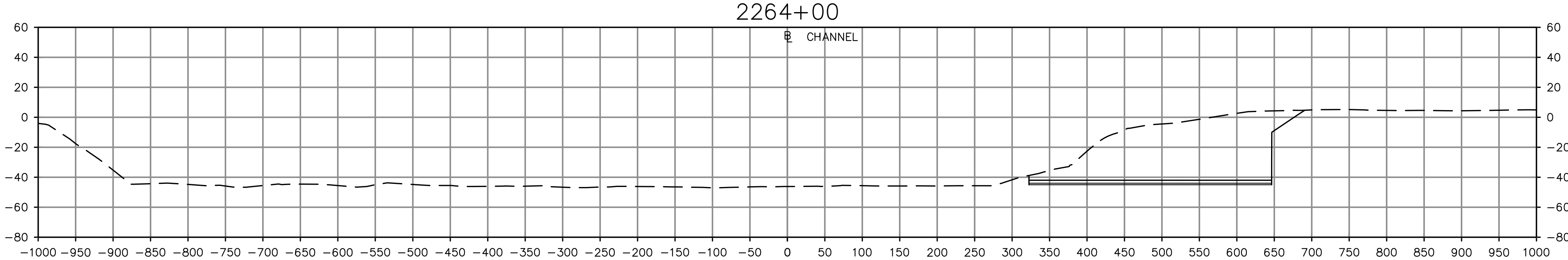


NOTES:

1. BATHYMETRIC CONTOURS BASED ON USACE SURVEY DATED JANUARY 2017.
2. ELEVATIONS ARE IN FEET BASED ON MLLW DATUM.

LEGEND

— — — — — — — APPROXIMATE EXISTING GRADE

———————— PROPOSED DREDGING

PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY**
WILMINGTON TERMINAL
TURNING BASIN EXPANSION

DATUM: **MLLW**

PREPARED BY: **MOFFATT & NICHOL**

PREPARED FOR: **NORTH CAROLINA STATE PORTS AUTHORITY**

NORTH CAROLINA PORTS

DATE: **OCTOBER 2018**

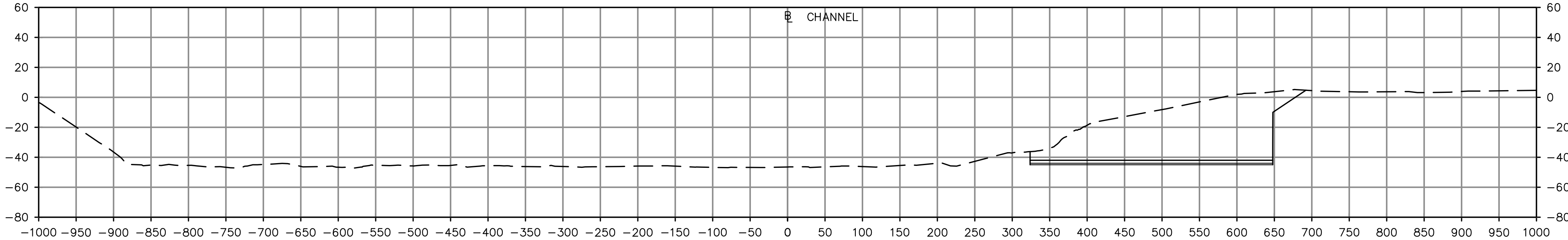
SHEET TITLE:
CROSS SECTIONS
9 OF 12

0 100' 200'
1"=200' HORIZONTAL

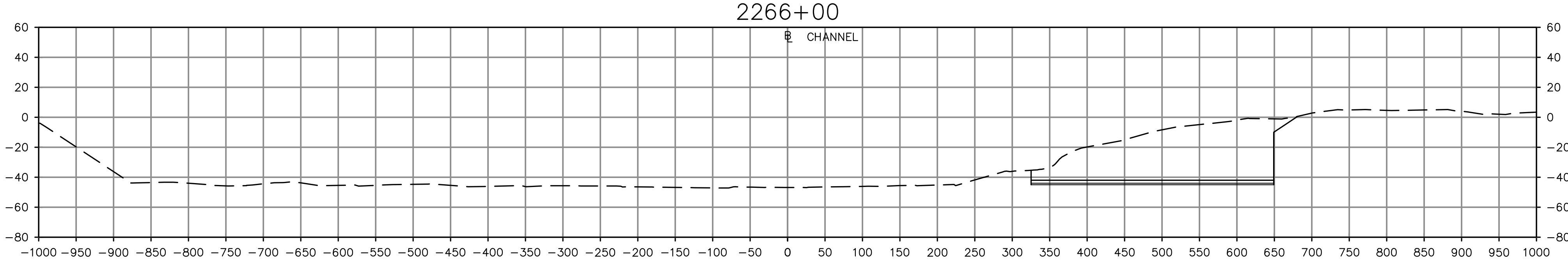
0 50' 100'
1"=100' VERTICAL

SHEET **13** *OF* **16**

2265+00



2266+00



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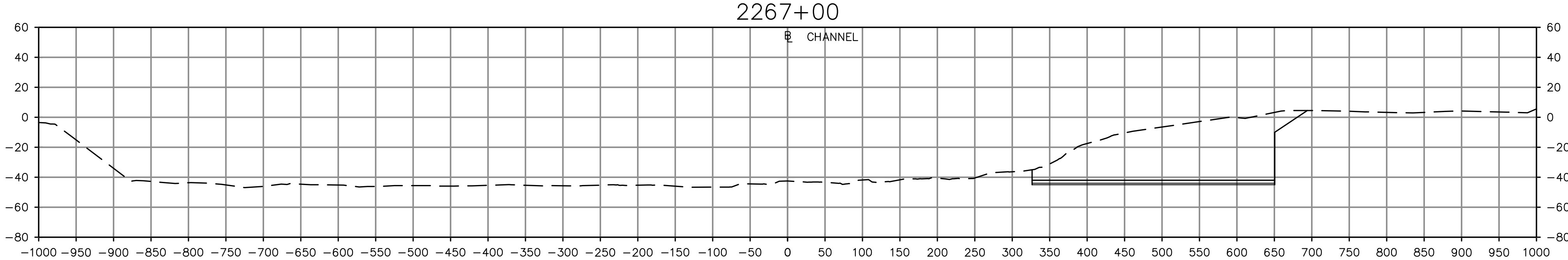


NOTES:

1. BATHYMETRIC CONTOURS BASED ON USACE SURVEY DATED JANUARY 2017.
2. ELEVATIONS ARE IN FEET BASED ON MLLW DATUM.

LEGEND

— — — — — APPROXIMATE EXISTING GRADE

———— PROPOSED DREDGING

PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY WILMINGTON TERMINAL TURNING BASIN EXPANSION**

DATUM: **MLLW**

PREPARED BY: **MOFFATT & NICHOL**

PREPARED FOR: **NORTH CAROLINA STATE PORTS AUTHORITY**

NORTH CAROLINA PORTS

DATE: **OCTOBER 2018**

SHEET TITLE:

CROSS SECTIONS 10 OF 12

0 100' 200'
1"=200' HORIZONTAL

0 50' 100'
1"=100' VERTICAL

SHEET **14** *OF* **16**

File: Q:\RA\9232-08\CADD_Active_Permit\923208-P14; Plotted: 10/24/2018 12:17 PM by KOONS, DAVE; Saved: 10/23/2018 10:39 AM by DKOONS

NOTES:

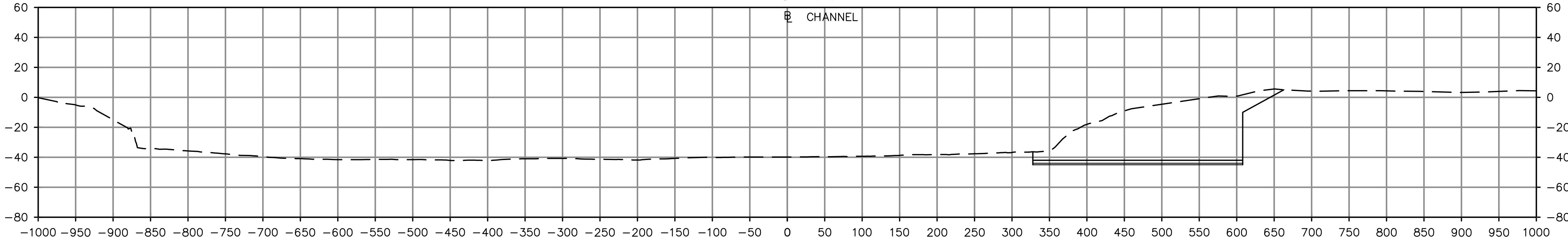
1. BATHYMETRIC CONTOURS BASED ON USACE SURVEY DATED JANUARY 2017.
2. ELEVATIONS ARE IN FEET BASED ON MLLW DATUM.

LEGEND

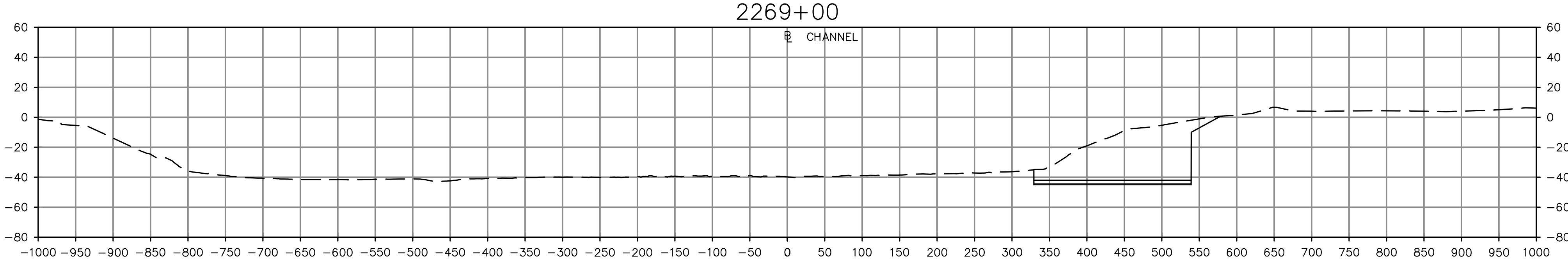
— — — — — — APPROXIMATE EXISTING GRADE

———————— PROPOSED DREDGING

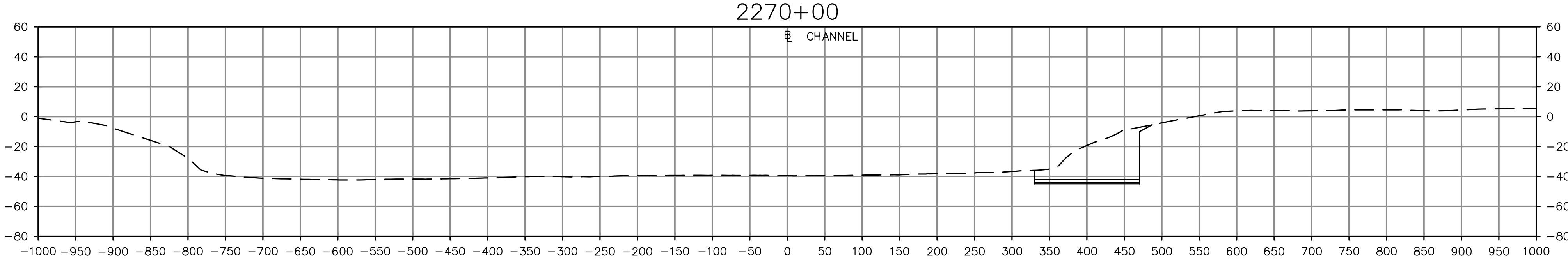
2268+00



2269+00



2270+00



PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY WILMINGTON TERMINAL TURNING BASIN EXPANSION**

DATUM: **MLLW**

PREPARED BY: **MOFFATT & NICHOL**

PREPARED FOR: **NORTH CAROLINA STATE PORTS AUTHORITY**

NORTH CAROLINA PORTS

DATE: **OCTOBER 2018**

SHEET TITLE:

CROSS SECTIONS

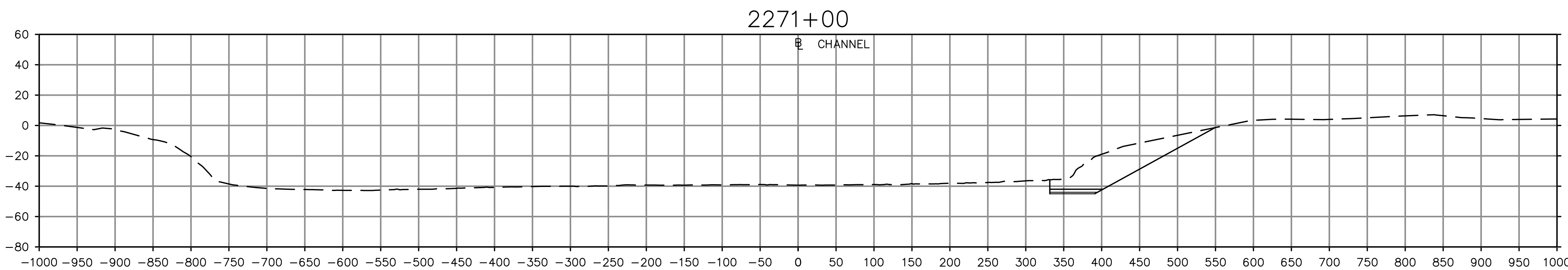
11 OF 12

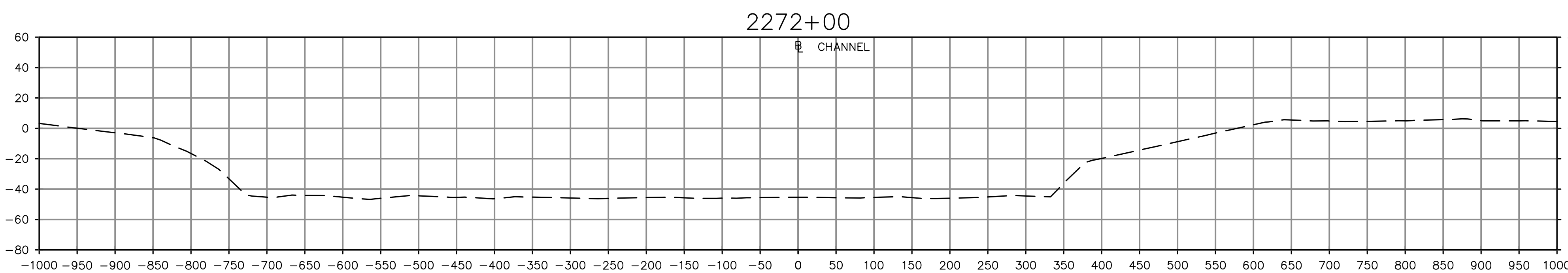
0 100' 200' 1"=200' HORIZONTAL

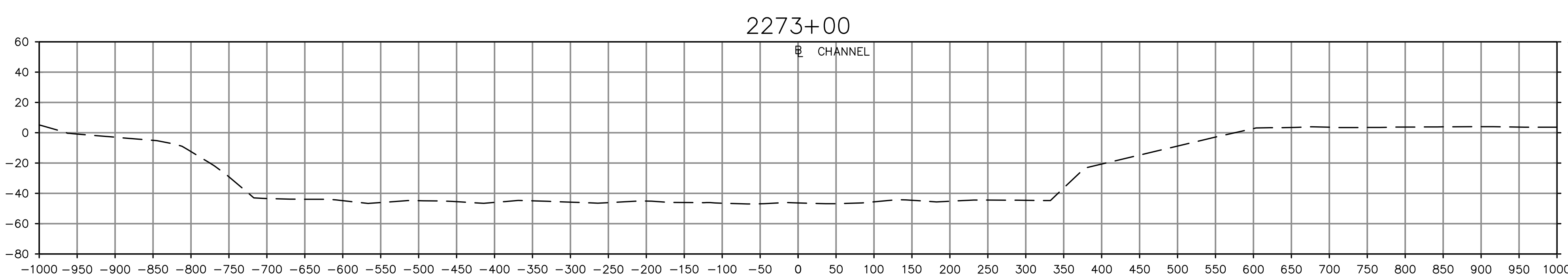
0 50' 100' 1"=100' VERTICAL

SHEET **15** *OF* **16**

File: Q:\RA\9232-08\CADD_Active_Permit\923208-P15; Plotted: 10/24/2018 12:17 PM by KOONS, DAVE; Saved: 10/23/2018 10:39 AM by DKOONS







NOTES:

1. BATHYMETRIC CONTOURS BASED ON USACE SURVEY DATED JANUARY 2017.
2. ELEVATIONS ARE IN FEET BASED ON MLLW DATUM.

LEGEND

— — — — — — — — APPROXIMATE EXISTING GRADE

———————— PROPOSED DREDGING

PROJECT TITLE: **NORTH CAROLINA STATE PORTS AUTHORITY WILMINGTON TERMINAL TURNING BASIN EXPANSION**

DATUM: **MLLW**

PREPARED BY: **MOFFATT & NICHOL**

PREPARED FOR: **NORTH CAROLINA STATE PORTS AUTHORITY**

NORTH CAROLINA PORTS

DATE: **OCTOBER 2018**

SHEET TITLE:

CROSS SECTIONS 12 OF 12

0 100' 200' 1"=200' HORIZONTAL

0 50' 100' 1"=100' VERTICAL

SHEET **16** *OF* **16**

File: Q:\RA\9232-08\CADD_Active_Permit\923208-P16; Plotted: 10/24/2018 12:17 PM by KOONS, DAVE; Saved: 10/23/2018 10:39 AM by DKOONS