Water Supply Intakes Evaluation

Assessment of Potential Impacts Related to Modifications to Lock and Dam No. 1 Proposed by US Army Corps of Engineers

Prepared for:
City of Wilmington
and the
Lower Cape Fear Water and Sewer Authroity

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Our Ref.:
NC706027

Date:
January 24, 2007

Tables

Figures

Attachments: HEC-RAS Modeling Results

1. Introduction

The U.S. Army Corp of Engineers (COE) is pursuing the Wilmington Harbor Deepening project, which includes deepening of the harbor and relocation of a turning basin in the Northeast Cape Fear River. The feasibility report and final EIS for the Wilmington Harbor Deepening project were completed in June 1996, and the project has resulted in environmental issues that have required mitigation, including potential impacts to the endangered shortnose sturgeon. *The Biological Opinion* (BO) issued on August 3, 2000 stated, "The COE must construct a fish passage structure at Lock and Dam No.1 on the Cape Fear River." To address mitigation measures required for the Wilmington Harbor Deepening project, the COE is preparing a General Reevaluation Report (GRR) in which the COE will evaluate and recommend an alternative for providing fish passage at Lock and Dam No. 1.

The purpose of this report is to evaluate the proposed modifications to Lock and Dam No. 1 and assess potential impacts to the water supply intakes operated by the City of Wilmington (City) and the Lower Cape Fear Water and Sewer Authority (LCFWSA).

The scope of this report consists of the following:

- Determine the capacity of the existing water supply intakes.
- Evaluate the proposed modifications to Lock and Dam No. 1 to determine potential impacts on the capacity of the City's and LCFWSA's intakes.
- Qualitatively assess water quality impacts resulting from the potential migration of the "salt wedge" upstream after removal or modification of the dam.
- Determine if intake modifications are feasible to offset or compensate for adverse impacts on water supply intake capacity. Estimate water supply intake capacity after proposed modification is complete.
- Develop a conceptual design for recommended intake modifications and estimate construction costs.

2. Existing Facilities

2.1 City of Wilmington Raw Water Intake and Pump Station

The City of Wilmington obtains raw water from the Cape Fear River through its Kings Bluff raw water intake and pump station located upstream from Lock and Dam No. 1. The City's raw water supply facilities are shown in Figure 1. A site plan of the City's intake and pump station is shown in Figure 2. The Kings Bluff Pump Station was constructed in 1943 and has an effective capacity of 15 million gallons per day (MGD). A 14-ft wide canal conveys raw water from the Cape Fear River approximately 600-ft to the pump station wet well. The pump station is equipped with a traveling screen with 0.5-inch stainless steel mesh for removal of large debris. The intake channel leading to the traveling screen is 4-ft wide. The traveling screen was replaced in 1994.

At the backwater elevation under low flow conditions of 11.5 ft. msl, there is approximately 7.4 ft. of depth in the intake channel. The approach velocity is 0.78 ft./sec. New intakes permitted in North Carolina are required to have a maximum design approach velocity of 0.5 ft./sec. It is assumed that for any modifications to the intake and pump station, the approach velocity would need to meet the current standard.

The Kings Bluff pump station is equipped with three horizontal centrifugal pumps; a 15 mgd pump, a 16.5 MGD pump, and a 9 MGD pump. The 9 MGD pump is equipped with a diesel generator drive, and no other standby power is provided.

Raw water travels from the Kings Bluff Pump Station via a 30-inch pre-stressed concrete cylinder pipe approximately 21 miles, where it connects to two 24-inch cast iron pipelines. The two 24-inch cast iron lines convey raw water approximately 1.5 miles to two 48-inch raw water lines that are tunneled beneath the Cape Fear River and terminate at the Sweeney Water Treatment Plant (WTP) site.

2.2 LCFWSA Raw Water Intake and Pump Station

The LCFWSA owns and operates an intake and pump station, constructed in 1984, at Kings Bluff upstream from Lock and Dam No. 1. A site plan of the intake and pump station is shown in Figure 2.

The raw water intake includes three stainless steel, wedgewire tee screens each with a rated capacity of 15 MGD (Figure 3). A 48-inch intake pipe conveys raw water to the pump station wet well. The pump station is equipped with three vertical turbine pumps with two speed motors. The firm capacity of the pump station is 45 MGD. Two 2.7-MW diesel engine generators provide standby power.

Raw water is transported from the pump station via a 48-inch pipeline approximately 14 miles to a three million gallon ground storage tank located near the Brunswick County Water Treatment Plant. From the tank, the 48-inch raw water line travels a route along US Highway 421 approximately five miles to the meter vault that serves the City of Wilmington. This 48-inch pipeline also serves several industries along its route and has one section of 60-inch line that is approximately one mile long.

LCFWSA is proposing to construct an expansion of the existing pump station to increase firm pumping capacity to 100 MGD. The improvements include the following:

- (3) 27.5-MGD wedgewire intake screens
- 60-inch raw water intake pipeline (approximately 1,200 feet)
- New air backwash control building
- 3 new vertical turbine pumps (firm pumping capacity 55 MGD)

2.3 Lock and Dam No. 1

Lock and Dam No. 1 is located on the Cape Fear River at approximately river mile 39 (Figure 2). Lock and Dam No. 1 was constructed in 1915 at an elevation of 8 ft. msl and later modified in 1934 to increase the dam spillway to 11 ft. msl. The dam is a rock fill, timber crib dam with a 275-foot long concrete spillway. A bathymetric survey of the area upstream from Lock and Dam No. 1 was conducted by COE (Figure 4).

Lock and Dam No. 1 provides approximately 2.0 billion gallons of storage based on a backwater elevation of 11.5 ft. msl under low flow conditions and a minimum elevation of 7 ft. msl to maintain operation of the LCFWSA intake screens. This is an estimate based on the linear distance between Lock and Dam No. 1 and No. 2 and a rough approximation of the mean river channel width (based on the average channel width at 5 transects). Based on the rated capacity of the City's pump station of 15 MGD and of LCFWSA's pump station of 45 MGD, this would provide approximately 33 days of storage.

3. Evaluation of Proposed Modifications on Water Supply Intakes

3.1 General

Each proposed modification to Lock and Dam No. 1 is described in the following sections. COE conducted hydraulic modeling of each alternative to estimate the river stage following modification of Lock and Dam No. 1. COE used HEC-RAS to estimate river stage at a flow of 300 cubic ft. per second (cfs). COE selected 300 cfs as a conservative estimate of the low flow of the Cape Fear River at Lock and Dam No. 1.

Table 1 presents flow discharge statistics from a review of U.S. Geological Survey flow records at Lock and Dam No. 1 since construction of the Jordan Lake Dam. Table 2 shows the lowest flows recorded at Lock and Dam No. 1 since Jordan Lake was filled on February 4, 1982. Sixteen days of the top 30 lowest flows are during the drought of summer 2002. The four lowest flows are consecutive days (August 8-11, 2002).

TABLE 1. FLOW STATISTICS FOR CAPE FEAR RIVER AT LOCK AND DAM NO. 1

Period of Record	2/4/1982 to 1/1/2007
Maximum Flow (cfs)	47,600 (9/11/1996)
Mean Flow (cfs)	5,431
7Q10 Flow (cfs)	797
Minimum Flow (cfs)	179 (8/10/2002)

TABLE 2. LOW FLOWS FOR CAPE FEAR RIVER AT LOCK AND DAM NO. 1

Rank	Date	Flow (cfs)
1	8/10/2002	179
2	8/11/2002	230
3	8/9/2002	284
4	8/8/2002	361
5	11/11/2005	407
6	8/15/2002	408
7	11/12/2005	418
8	8/7/2002	430
9	8/12/2002	442
10	11/13/2005	447

The normal low-flow target for the Jordan Lake Dam is 600 cfs ±50 cfs at Lillington. The COE modified the Jordan Lake Dam low flow target at Lillington in response to the 2002 drought. The North Carolina Department of Environment and Natural Resources and the COE agreed to reduce the low-flow target in Lillington temporarily to conserve water during the 2002 drought (Table 3). The lowest flow target was based on maintaining a minimum flow of 200 cfs at Lock and Dam No. 1.

TABLE 3. JORDAN LAKE DAM OPERATIONS DURING 2002 DROUGHT

Date Implemented	Low-Flow Target at Lillington
June 17, 2002	500 cfs, ±50 cfs
June 27, 2002	450 cfs, ±50 cfs
July 1, 2002	400 cfs, ±50 cfs
July 3, 2002	350 cfs, ±50 cfs
July 8, 2002	300 cfs, ±25 cfs
July 15, 2002	275 cfs, ±25 cfs
July 29, 2002	250 cfs, 25 cfs
August 19, 2002	Flow at Lock & Dam #1 ≥ 200 cfs, then 200 cfs, ±25 cfs Flow at Lock & Dam #1 < 200 cfs, then 250 cfs, ±25 cfs
October 22, 2002	600 cfs, ±50 cfs (normal target)

Given that there are only three days during the 25-year period of record with flows less than 300 cfs, the selection of 300 cfs as a threshold is considered a reasonable flow for evaluation of the impacts on water supply.

The sections below describe each modification to Lock and Dam No. 1 that COE is evaluating, including estimated river stages following the modification. The estimated river stages demonstrate impacts on the water supply intakes operated by the City and LCFWSA.

3.2 Alternative 1 – Removal of Lock and Dam No. 1

3.2.1 Description

In this alternative, the COE would remove Lock and Dam No. 1 entirely. This action requires the U.S. Congress to de-authorize the project. COE has indicated that this alternative is possible, as Lock and Dam No. 1 was authorized solely for commercial navigation. There is no commercial traffic on this portion of the Cape Fear River, and COE indicates that due to the lack of traffic the navigation channel upstream from Lock and Dam No. 1 has not been maintained since 1992.

3.2.2 Potential Impacts on Intake Capacity

Based on COE's modeling, removal of Lock and Dam No. 1 would lower the backwater elevation behind Lock and Dam No. 1 to 2.39 ft. msl at a river flow of 300 cfs. Figure 5 shows the schematics of the City's and LCFWSA's intakes, which demonstrate the impact of this alternative. The HEC-RAS model output for this alternative is shown in Attachment A. At a water surface elevation of 2.39 ft. msl, both the City's and LCFWSA's existing water supply intakes would no longer be operational. No storage would be available under low flow conditions.

3.2.3 Potential Impacts on Water Quality

The other concern about complete dam removal is the potential for migration of the salt wedge upstream during low flow conditions. If the salt wedge migrates up to the water supply intakes, it would render these intakes non-operational for the City's as well as LCFWSA's customers, as neither system is equipped with treatment systems capable of removing chlorides, bromides, and Total Dissolved Solids.

COE has collected an extensive database of water quality data for the Cape Fear River in the reach between Lock and Dam No. 1 and Wilmington. ARCADIS has reviewed the available water quality data collected by the North Carolina Division of Water Quality and the U.S. Geological Survey (USGS). Most of the water quality data was collected at sites two to nine miles downstream from Lock and Dam No. 1 and do not provide much insight into the potential for salt migration.

ARCADIS also obtained water quality data from International Paper, which operates a water treatment facility near Reigelwood, North Carolina. This facility is approximately nine miles downstream from Lock and Dam No. 1. Water quality data figures collected during the 2002 drought were considered to be a worst-case scenario, since the 2002 drought was the most severe drought on record for eastern North Carolina. Table 4 summarizes chloride concentrations in the drinking water produced by the International

Paper facility. International Paper does not collect chloride data in the raw water; however, this facility uses conventional surface water treatment with alum coagulation so that finished water data should closely resemble raw water concentrations. The maximum concentration of chlorides was 72 mg/L during the peak of the 2002 drought. The U.S. Environmental Protection Agency (USEPA) does not enforce a primary standard for chlorides in drinking water. The USEPA does set National Secondary Drinking Water Standards, which are non-enforceable guidelines, for chlorides of 250 mg/L.

TABLE 4. WATER QUALITY DATA FOR CAPE FEAR RIVER AT REIGELWOOD

Date	Chlorides (mg/L)		
	Minimum	Maximum	Average
June 2002	46	56	52
July 2002	51	69	61
August 2002	51	71	60
September 2002	36	72	57
October 2002	28	51	41

Source: International Paper, Reigelwood, North Carolina

Note: Chloride data reflected finished water concentrations from International Paper's surface water treatment plant.

No bromide data was available for the International Paper facility or any other site near Lock and Dam No. 1. Bromides are not regulated by USEPA either. However, bromide is converted to bromate via ozonation. The City's Sweeney Water Treatment Plant uses ozonation for oxidation of raw water and for disinfection of settled water. No other water plant in the area currently uses ozonation. Bromate is regulated by USEPA with a maximum contaminant level of 0.01 mg/L. Since no bromide data was available, bromide concentrations at the International Paper facility were estimated based on the available chloride data. The composition of seawater is fairly consistent for a wide range of salinities, thus evaluating the ratio of chloride to bromide should provide a good approximation of bromide levels at the International Paper facility. In seawater, chloride concentrations would typically be 19,345 mg/kg and bromide levels would typically be 66 mg/kg. If chloride levels were 72 mg/L, then bromide levels would be approximately 0.25 mg/L. Bromide levels of 0.25 mg/L would likely result in bromate levels exceeding the USEPA primary standard of 0.01 mg.L, depending upon a wide range of factors.

Given that chloride levels did not approach USEPA's secondary standard under these conditions at Reigelwood, it is not expected that removal of the dam would result in a significant increase in chloride concentrations at the water supply intakes operated by the City and LCFWSA, located approximately 9 miles upstream. However, deepening of the harbor channel could affect the range of tidal influence in the

Cape Fear River, particularly under certain conditions, such as drought conditions coinciding with the storm surge associated with a hurricane. While there is insufficient data to make a definitive determination, removal of Lock and Dam No. 1 could result in increased bromide levels, which would have a negative water quality impact on the City of Wilmington water treatment facilities.

3.3 Alternative 2 – Modification of Spillway Elevation to 2.0 ft. msl

3.3.1 Description

In this alternative, the COE would lower the spillway to 2.0 ft. msl. This modification allows for fish passage under normal spring flows. COE has indicated in meetings that the benefit of this alternative, as compared to Alternative 1, is that it would provide a small pool for water supply under low flow conditions.

3.3.2 Potential Impacts on Intake Capacity

Based on COE's modeling, lowering of Lock and Dam No. 1 to an elevation of 2.0 ft msl would reduce the backwater elevation to 2.54 ft. msl at 300 cfs. Schematics of the City's and LCFWSA's intakes and the impact of this alternative are shown in Figure 5. The HEC-RAS model output for this alternative is shown in Attachment B. With a water surface elevation of 2.54 ft msl, both the City's and LCFWSA's existing water supply intakes would no longer be operational. The backwater elevation under Alternative 1 was 2.39 ft msl. By lowering the dam to 2.0 ft. msl, it increases the backwater elevation by only 2 inches as compared to Alternative 1; therefore, practically no storage would be available under low flow conditions.

3.3.3 Potential Impacts on Water Quality

Similar to Alternative 1, the lowering the spillway to elevation 2.0 ft msl is not expected to result in significantly higher chloride concentrations. However, bromide levels could increase which would have a negative water quality impact for the City of Wilmington.

3.4 Alternative 3 – Modification of Spillway Elevation to 8.0 ft. msl

3.4.1 Description

In this alternative, the COE would lower the spillway to 8.0 ft. msl, which is the elevation of the original dam, and could be achieved by removing the 3-foot cap installed in 1934. This modification would be completed in conjunction with construction of a bypass channel or a rock ramp (fish ladder). COE indicates that the purpose of lowering the spillway to 8.0 ft msl in conjunction with one of the other alternatives is to reduce construction costs.

3.4.2 Potential Impacts on Intake Capacity

Based on COE's modeling, lowering the spillway to 8.0 ft. msl would lower the water surface elevation to 8.49 ft. msl at a river flow of 300 cfs. Schematics of the City's and LCFWSA's intakes are shown in Figure 5 which demonstrate the impact of this alternative. The HEC-RAS model output for this alternative is shown in Attachment C.

A backwater elevation of 8.49 ft. msl results in approximately 2.5 ft. of submergence over LCFWSA's intake screens. Based on a pumping capacity of 45 MGD, the water level in the pump wet well would be approximately 3.2 ft msl. This is below the minimum submergence required for the existing pumps. Reducing the backwater elevation to 8.5 ft. msl under low flow conditions would reduce pump station capacity to approximately 30 MGD.

The invert elevation of City of Wilmington's intake is 4.06 ft. msl. With water surface elevation of 8.49 ft. msl, there would be approximately 4.4 ft. of depth through the traveling screen. At the rated capacity of the City's pump station, the approach velocity would be approximately 1.31 ft./sec. In order to meet the maximum approach velocity of 0.5 ft./sec required in North Carolina, the capacity of the City's pump station would be reduced to 5.7 MGD.

- Backwater Elevation at 300 cfs: 8.49 ft. msl
- Intake Invert Elevation: 4.06 ft. msl
- Water depth through intake: 4.4 ft.
- Intake/traveling screen width: 4.0 ft.
- Area: 17.6 sq.ft.
- Approach Velocity at 15 MGD: 1.31 ft./sec.
- Capacity at Maximum Permitted Approach Velocity: 5.7 MGD

Another issue to consider is suction lift with the City's horizontal centrifugal pumps. The existing pumps were not designed for suction lift. Accounting for headlosses through the traveling screen and suction piping, the pumps would be required to lift approximately 4 to 6 ft. when the river is at 8.49 ft. msl. The existing pumps may not be able to achieve this level of suction lift without cavitation.

With a backwater elevation of 8.5 ft msl, Lock and Dam No. 1 would provide approximately 660 million gallons of storage under low flow conditions based on a minimum elevation of 7 ft. msl to maintain operation of the LCFWSA intake screens. Based on the rated capacity of the City pump station of 15 MGD and of LCFWSA's pump station of 45 MGD; this would provide approximately 11 days of storage.

3.4.3 Potential Impacts on Water Quality

This alternative is not expected to have an impact on water quality since the dam would remain in place.

3.5 Alternative 4 – Construction of Bypass Channel Around Dam

3.5.1 Description

In this alternative, a bypass constructed around the dam would divert approximately 10% of the spring flow (5,000-6,000 cfs). The design diversion of 10% is the recommended flow for successful fish passage. Actual flow diversion would range from 8 to 11%. A conceptual design has not been developed for a fish bypass channel at Lock and Dam No. 1. However, COE has indicated that the fish bypass would be similar to one planned for the New Savannah Bluff Lock and Dam located on the Savannah River approximately 13 miles downstream from the City of Augusta, Georgia. The low headwater design elevation at New Savannah Bluff is 1.0 foot below the existing low headwater elevation.

3.5.2 Potential Impacts on Intake Capacity

If a fish bypass channel for Lock and Dam No. 1 were constructed similar in design and the headwater elevation were reduced by one foot at low flows, then the headwater elevation at Lock and Dam No. 1 would be 10.5 ft. msl. This would provide for 4.5 ft. of submergence over the LCFWSA intake screens, which is sufficient to protect the screens from floating debris and boat traffic. Based on a pumping capacity of 45 MGD, the water level in the pump wet well would be approximately 5.6 ft msl. This is approximately one foot above the minimum submergence required for the existing pumps. Therefore, no reduction in capacity is expected for the LCFWSA intake and pump station.

With a headwater elevation of approximately 10.5 ft. msl at low flows, there would be approximately 6.1 ft. of depth through the traveling screen at the City's intake. This would result in an approach velocity of 1.0 ft./sec, which exceeds the maximum velocity for new intakes. At the maximum permitted approach velocity of 0.5 ft/sec, the intake capacity is reduced to 12.0 MGD.

- Assumed Backwater Elevation at 300 cfs: 10.49 ft. msl
- Intake Invert Elevation: 4.06 ft. msl
- Water depth through intake: 6.1 ft.
- Intake/traveling screen width: 4.0 ft.
- Area: 24.1 sq.ft.
- Approach Velocity at 15 MGD: 1.0 ft./sec
- Capacity at Maximum Permitted Approach Velocity: 12.0 MGD

Accounting for headlosses through the traveling screen and suction piping, the pumps would be required to lift approximately 2 to 4 ft. when the river is at 10.5 ft. msl. The existing pumps may be able to operate with higher suction lift. Field tests should be conducted to confirm if the existing pumps could operate satisfactorily given the existing sump conditions. A priming system may be needed to ensure the pump is primed, as the water level in the sump would be below the centerline of the pump impeller.

3.5.3 Potential Impacts on Water Quality

This alternative is not expected to have an impact on water quality, as the dam would remain in place.

3.6 Alternative 5 – Construction of Natural Fish Bypass

3.6.1 Description

In this alternative, a bypass would be constructed around the dam designed to divert approximately 10% of the spring flow (5,000-6,000 cfs). In Alternative 4, the fish bypass channel would have a short run and be located in the immediate vicinity around the dam. In this alternative, the fish bypass design would resemble a natural stream. The fish bypass would simulate a meandering stream and would extend approximately 1,500 ft. upstream from Lock and Dam No. 1. COE has contracted Zapata Engineering to develop a conceptual design for the natural fish bypass. The plans call for a 60-ft. wide natural channel with an invert elevation of 8.5 ft. msl. Based on modeling conducted by Zapata Engineering, the headwater elevation at 338 cfs would be 12.5 ft. msl. The water surface elevation under low flow conditions at the water supply intakes has not been determined for this alternative. The natural fishway would be designed with a gate such that stop logs could be installed during low flow conditions, which would restrict flow bypass and ensure flow over the dam. COE has not determined the minimum flow threshold that would trigger installation of stop logs. Based on conversations with COE staff, the flow target would exceed 300 cfs. Assuming that flow over the dam does not drop below 300 cfs, the backwater elevation under low flow conditions would be similar to existing (11.5 ft msl). However, this alternative requires additional operation and maintenance by COE staff to monitor river flows and to install and maintain stop logs.

COE is concerned about fish migration during the springtime. COE has indicated that water supply would take priority in the event of low flow conditions occurring simultaneously with the typical fish migration season. The City and LCFWSA should secure a long-term commitment from COE regarding the terms and conditions under which the fish bypass and stop logs would be operated if this alternative is selected by COE.

3.6.2 Potential Impacts on Intake Capacity

Since COE has indicated that stop logs would be installed to restrict flow bypass under low flow conditions, then the minimum backwater elevation would be approximately 11.5 ft. msl, identical to the

existing conditions at Lock and Dam No. 1; therefore, no impacts on intake capacity are expected based on the operating conditions stated by the COE.

3.6.3 Potential Impacts on Water Quality

This alternative is not expected to have an impact on water quality, as the dam would remain in place.

3.7 Alternative 6 – Construction of Rock Ramp Cascade on Downstream Side of Dam

3.7.1 Description

In this alternative, rock would be placed on the downstream face of Lock and Dam No. 1, creating a fish ladder and taking the lock out of service, which would require the U.S. Congress to deauthorize the project. The spillway would not require modification in this alternative; the headwater elevation at low flows would be the same as the existing depth (11.5 ft.).

3.7.2 Potential Impacts on Intake Capacity

As the headwater elevation at low flows would not change, there would be no change in intake capacity.

3.7.3 Potential Impacts on Water Quality

This alternative is not expected to have an impact on water quality, as the dam would remain in place.

3.8 Summary of Potential Impacts

Potential impacts on the water supply intakes operated by the City and LCFWSA by the proposed modifications to Lock and Dam No. 1 are summarized in Table 5.

TABLE 5. SUMMARY OF POTENTIAL IMPACTS

Alternative	Water Surface Elevation at Low Flow (ft msl)	Impact on City's Intake Capacity	Impact on LCFWSA's Intake Capacity	Number of Days Storage in Backwater Pool
Existing	11.49	15 MGD	45 MGD	33
Alternative 1 Remove Lock and Dam No. 1	2.34	No longer operational		0
Alternative 2 Lower Spillway to 2.0 ft msl	2.49	No longer operational		0
Alternative 3 Lower Spillway to 8.0 ft msl	8.49	Intake = 5.7 MGD Reduces suction head on pumps	Reduce capacity to ~20 MGD	11
Alternative 4 Fish Bypass Channel (Spillway at 11.0 ft)	10.49 (assumed)	Intake = 12 MGD Reduces suction head on pumps	Reduce capacity to ~30 MGD	26
Alternative 5 Natural Fish Bypass (Spillway at 11.0 ft)	11.49	None (assuming stop logs installed under low flow conditions)		33
Alternative 6 Rock Ramp (Spillway at 11.0 ft)	11.49	None	None	33

4. Mitigation of Impacts on Water Supply Intakes

4.1 General

Another objective of this evaluation is to assess options for mitigating impacts to the City's and LCFWSA's water supply intakes. For alternatives impacting intake capacity, conceptual designs were developed to mitigate impacts of modifications to Lock and Dam No. 1. Opinions of probable construction cost were developed based on a 30% contingency, 15% markup for engineering and technical services, and an estimate for environmental review (SEPA) and permitting. Costs related to easement or property acquisition, operation and maintenance, temporary bulk water purchases, or any costs related to modifying Lock and Dam No. 1 were not included.

4.2 Alternatives 1 and 2

Both alternatives 1 and 2 would render the water supply intakes operated by the City and LCFWSA no longer operational; both intakes would be dry. The backwater elevations for alternatives 1 and 2 are 2.39 ft msl and 2.54 ft msl, respectively. There are no modifications that could allow the use of either the City's or LCFWSA's existing pump stations at these water surface elevations. The only option would be to abandon the existing intakes and pump stations and construct new facilities designed based on the new low water level. Based on the bathymetric survey conducted by the COE, water depths at a water level of approximately 2.4 ft. would be limited. On the western side of the Cape Fear River, water depths would be zero to two ft. This depth is too shallow to use wedgewire tee screens to provide the required intake capacity. Deeper water (up to 4.5 ft.) would be available on the eastern bank of the river although access to this deeper water would be problematic. Dredging of the river bottom to increase water depth is technically feasible, but would present a significant permitting challenge. If the dam is removed, then this area may be considered tidally influenced. Obtaining a dredging permit in a tidal area would be challenging. Therefore, a feasible alternative to provide the required intake capacity (up to 60 MGD initially and up to 105 MGD in the future) at a water depth of only 2 ft. may not exist.

4.3 Alternative 3

In this alternative, Lock and Dam No. 1 would not continue to operate; therefore, there would be no comercial traffic, only recreational traffic. Under low flow conditions, the top of the intake screens would be 2.5 ft. below the water level. Given proper signage and buoys, this is sufficient submergence to protect from damage from floating debris and boat traffic.

However, the capacity of the LCFWSA intake and pump station would be reduced to approximately 20 MGD in order to maintain wet well levels above the minimum pump submergence (4.5 ft msl). Headlosses through the existing intake screens and pipeline are high, which is likely due to excessive siltation in the intake pipeline. LCFWSA cannot take this pipeline out of service for maintenance. LCFWSA is currently

planning to construct a 60-inch pipeline and three 27.5-MGD intake screens for a future capacity of 100 MGD. The second intake pipeline will allow LCFWSA to take the existing line out of service for cleaning. It is recommended that the hydraulic design of future improvements account for siltation in the intake line. Siltation is unavoidable due to the high turbidities in the Cape Fear River and the intake pipeline design, which may tend to trap sediments in the portion of the line beneath the river.

To alleviate the limitation on pump capacity resulting from a water level lowered to 8.5 ft msl, a new raw water intake pipeline and additional intake screens would be required. To reduce headlosses to maintain wet well levels above the minimum pump submergence, an additional 66-inch pipeline and intake screens would be required. Refer to Figure 6 for a schematic of the proposed modifications. The estimated construction cost for these improvements is $3.63 million.

The City's intake capacity would be reduced significantly. To meet the maximum permitted approach velocity for water supply intakes, the traveling screen should be removed and replaced with two wedgewire intake screens (15 MGD each). The intake screens should be located in the main river channel to ensure sufficient flow for cleaning. Mounting intake screens in the existing intake channel would not allow for sufficient cleaning since there is no flow to carry dirt and debris removed following air burst cleaning. Therefore, a new 42-inch intake pipe should be installed along the bank of the existing channel into the main river channel where water depth is approximately 10 ft at low water level.

The existing raw water pumps may not be capable of the additional suction lift associated with a 3-foot drop in water level and additional headlosses related to the intake screens and intake pipeline. Under these conditions, the existing pumps would be required to have a suction lift of approximately 5 to 6 feet. Satisfactory operation of the pumps is a function of the intake and sump conditions and difficult to determine without conducting field tests. For purposes of this evaluation, it was assumed that new pumps designed for the new suction conditions would be installed along with a priming system to ensure vacuum lift, as shown in Figure 6. The estimated construction cost for these improvements is $2.99 million.

4.4 Alternative 4

In this alternative, the intake screens would be 4.5 ft below the water level under low flow conditions. Given proper signage and buoys, this is sufficient submergence to protect from damage from floating debris and boat traffic. However, the capacity of the LCFWSA intake and pump station would be reduced to approximately 20 MGD in order to maintain wet well levels above the minimum pump submergence (4.5 ft msl). To alleviate the limitation on pump capacity, a new raw water intake pipeline and additional intake screens would be required in addition to the 60-inch pipeline and three 27.5-MGD intake screens currently planned for a future capacity of 100 MGD. To reduce headlosses to maintain wet well levels above the minimum pump submergence, an additional 36-inch pipeline and intake screens would be required. Refer to Figure 6 for a schematic of the proposed modifications. The estimated construction cost for these improvements is $2.64 million.

The City's intake capacity would be reduced significantly. To meet the maximum permitted approach velocity for water supply intakes, the traveling screen should be removed and replaced with two wedgewire intake screens (15 MGD each) similar to the improvements shown for Alternative 3. Refer to Figure 6 for a schematic of the proposed modifications.

The existing raw water pumps may be capable of the additional suction lift associated with a one-foot drop in water level and additional headlosses related to the intake screens and intake pipeline. Under these conditions, the existing pumps would be required to have a suction lift of approximately two to three feet. Field tests conducted would confirm if the existing pumps operate under the new suction conditions. For purposes of this evaluation, it is assumed the existing pumps operate satisfactorily with an installed priming system to ensure vacuum lift. The estimated construction cost for these improvements is $2.47 million.

4.5 Summary of Improvements

Table 6 summarizes the proposed improvements to mitigate impacts associated with modifications to Lock and Dam No. 1. No cost estimates were developed for Alternatives 1 and 2 since no feasible modifications are available at this site.

TABLE 6. SUMMARY OF CONCEPTUAL COST OPINIONS FOR MITIGATING IMPACTS

Alternative	Proposed Improvement	Conceptual Cost Opinion (in millions)
Alternative 1 Remove Lock and Dam No. 1	No modifications feasible at this site	No cost estimates developed
Alternative 2 Lower Spillway to 2.0 ft msl	No modifications feasible at this site	No cost estimates developed
Alternative 3 Lower Spillway to 8.0 ft msl	▪ LCFWSA: 66-inch intake pipeline and 3 new screens ▪ City: Replace traveling screen with 2 wedgewire screens and 42-inch intake pipe. Replace existing pumps and install priming system.	$3.63 $2.99 Total = $6.62
Alternative 4 Fish Bypass Channel	▪ LCFWSA: 36-inch intake pipeline and 3 new screens ▪ City: Replace traveling screen with 2 wedgewire screens and 42-inch intake pipe. Install priming system on existing pumps.	$2.64 $2.47 Total = $5.11
Alternative 5 Natural Fish Bypass (Spillway at 11.0 ft)	No proposed modifications (assumes stop logs installed under low flow conditions)	N/A
Alternative 6 Rock Ramp on downstream side of dam (Spillway at 11.0 ft)	No proposed modifications	N/A

5. Summary and Recommendations

The water supply intakes operated by the City of Wilmington and the Lower Cape Fear Water and Sewer Authority are both located in the upstream pool created by Lock and Dam No. 1. The increased depth in the river is critical for the reliable operation of the intakes for the following reasons:

- The increased water depth is required to maintain submergence of intake structures under low flow or drought conditions.
- The barrier in the river provides protection against adverse water quality impacts that may be associated with tidal waters and upstream migration of salt wedge.

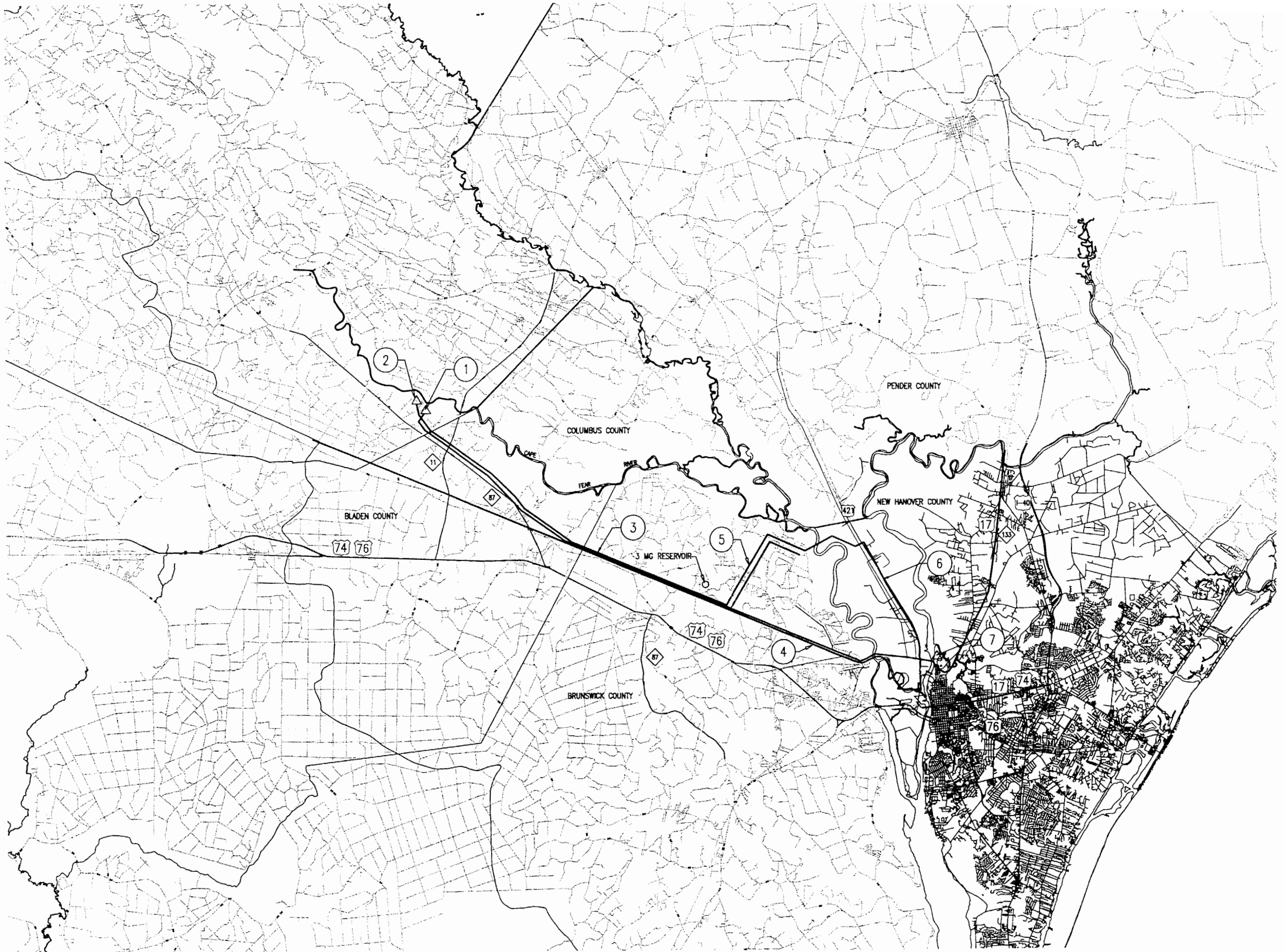
Much of southeastern North Carolina has benefited from this reliable water supply for over 65 years. Both the City's and LCFWSA's water supply facilities were designed based on the current spillway elevation of Lock and Dam No. 1. The findings and conclusions of this report are summarized below:

- **Any modification to the height of the spillway at Lock and Dam No. 1 will have a significant impact on the water supply infrastructure operated by the City and the LCFWSA.**
- **Complete removal of Lock and Dam No. 1 would render both the City's and LCFWSA's water intake and pumping facilities non-operational. Furthermore, the resulting water depth in the river would make it very difficult to construct and operate a reliable water supply intake.**
- **Lowering the water level at the water supply intakes will reduce both the City's and the LCFWSA's raw water intake and pumping capacity.**
- **Lowering the water level at the water supply intakes will also reduce the raw water storage in the river from 33 days to approximately 26 days for a 1-foot drop in water level and to 11 days for a 3-foot drop in water level at current capacities.**
- **For either an adjacent diversion channel (Alternative 4) or a natural fishway (Alternative 5), maintaining the current water level (11.5' MSL) during low flows will require the use of stop logs and continuous monitoring and operation during low flows. The added requirement to monitor and operate the bypass channel during low flows would reduce the overall reliability of the intake and pumping facilities.**
- **We recommend that the COE select the rock ramp on the downstream face of the dam with no modification to the height of the dam (Alternative 6). This alternative is the only alternative that will not impact the reliability of the water supply for the City's and LCFWSA's customers.**

6. References

Weaver, Curtis; and B. Pope. "Low-Flow Characteristics and Discharge Profiles for Selected Streams in the Cape Fear River Basin, North Carolina, Through 1998." *USGS Water-Resources Investigation Report 01-4094*. 2001.

Weaver, Curtis. "The Drought of 1998–2002 in North Carolina — Precipitation and Hydrologic Conditions." *Scientific Investigations Report 2005–5053*.



REV. ISSUED DATE DESCRIPTION

CITY OF WILMINGTON NORTH CAROLINA

LOWER CAPE FEAR WATER AND SEWER AUTHORITY

ARCADIS

ARCADIS G&M OF North Carolina, Inc.
801 Corporate Center Drive, Suite 300
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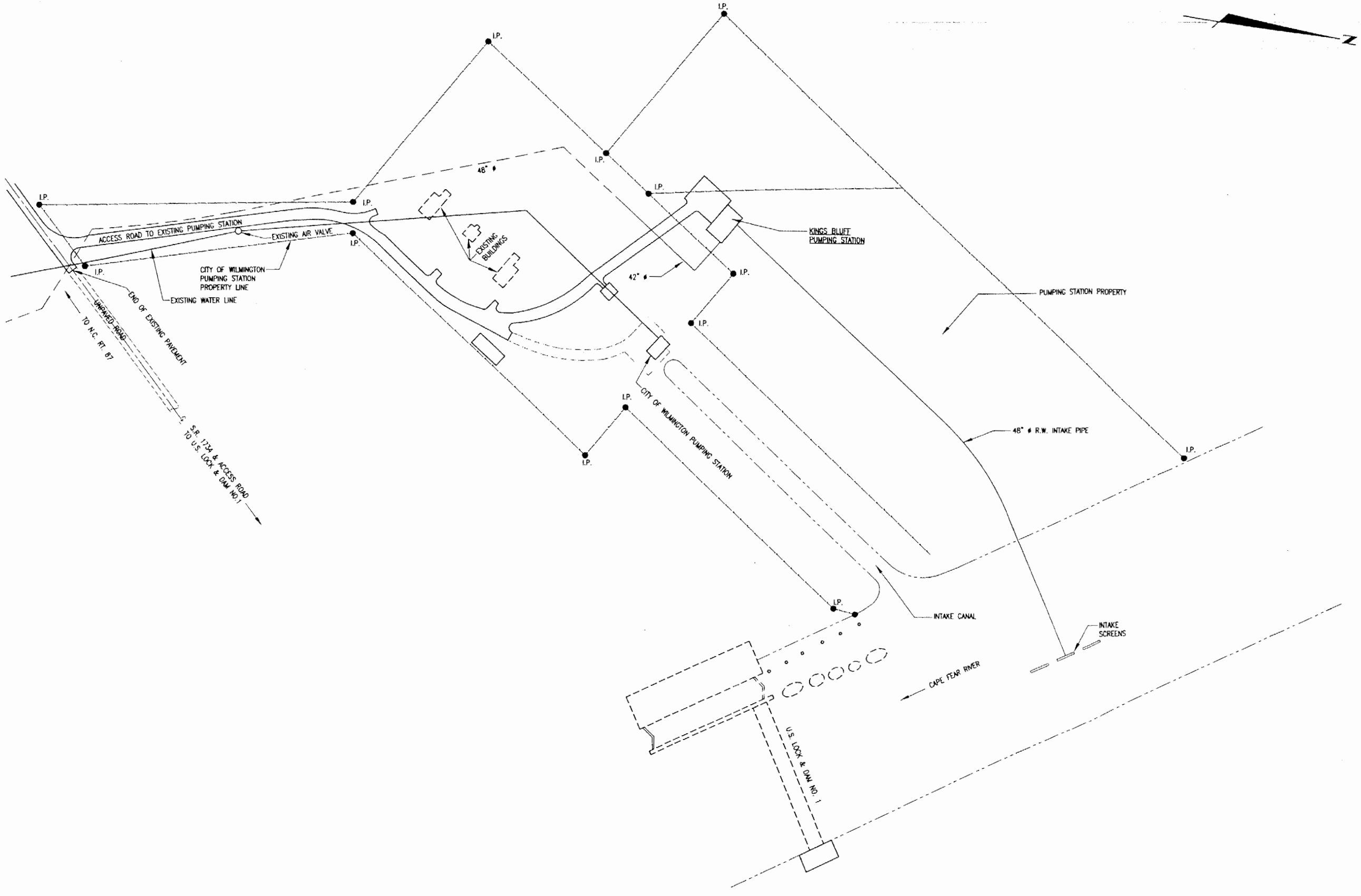
CITY OF WILMINGTON AND THE LOWER CAPE FEAR WATER AND SEWER AUTHORITY WATER SUPPLY INTAKE EVALUATION

SHEET TITLE

RAW WATER PUMPING AND TRANSMISSION FACILITIES AREA MAP

FIGURE 1



Date\Time : Tue, 09 Jan 2007 - 3:04pm
Path\Name : O:\WWA\106822_Wilm-LCFWSA_Intake\WWA\LCFWSA\FIGURE 2 General Plan.dwg
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REV. ISSUED DATE DESCRIPTION

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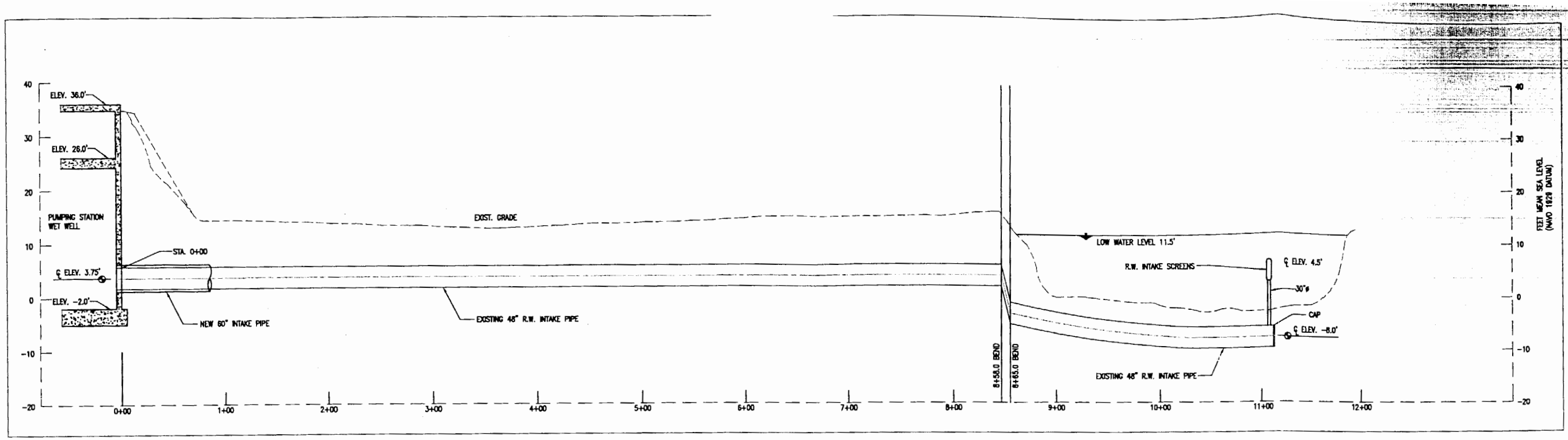
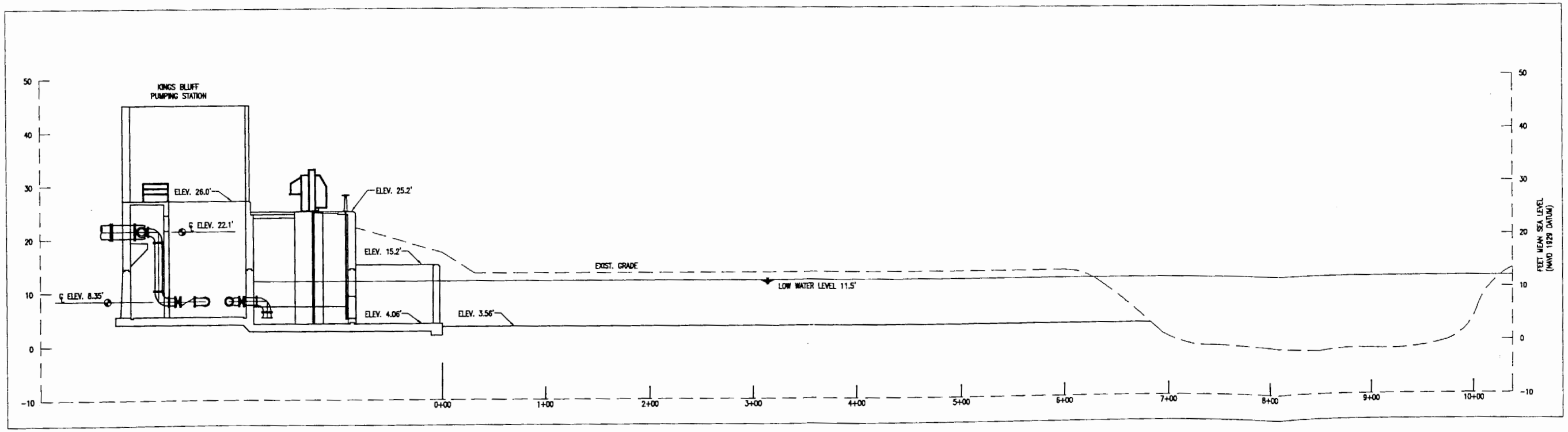
CITY OF WILMINGTON AND THE LOWER CAPE FEAR WATER AND SEWER AUTHORITY
WATER SUPPLY INTAKE EVALUATION

SHEET TITLE
SITE PLAN

FIGURE 2



LOWER CAPE FEAR WSA RAW WATER INTAKE AND PUMP STATION



CITY OF WILMINGTON KINGS BLUFF RAW WATER PUMP STATION AND INTAKE CANAL

NOTES:
1. HORIZONTAL SCALE IS APPROXIMATE

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Date\Time : Tue, 09 Jan 2007 - 10:54am
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Layout Tab: Layout1

REV. ISSUED DATE DESCRIPTION

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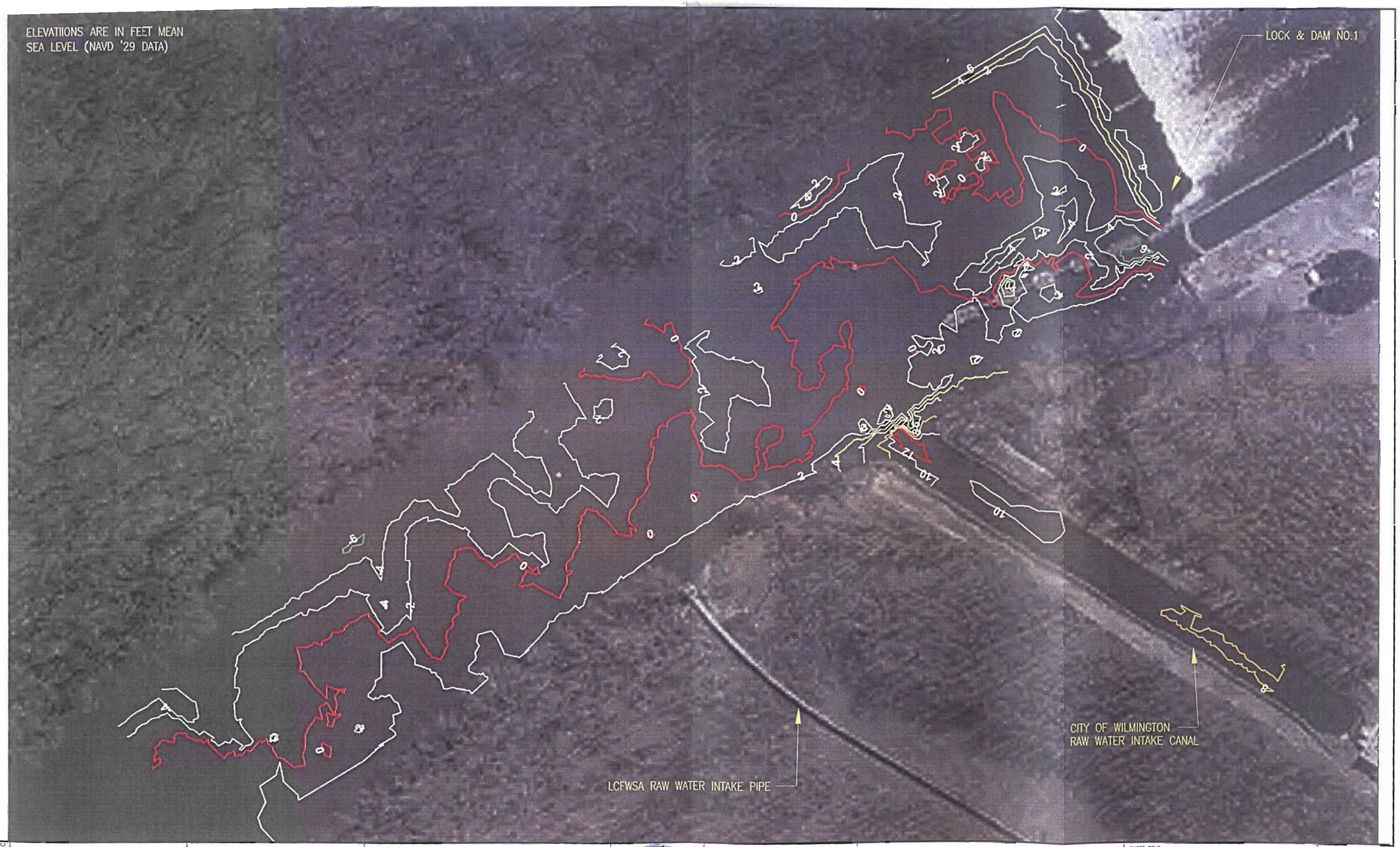
CITY OF WILMINGTON AND THE LOWER CAPE FEAR WATER AND SEWER AUTHORITY WATER SUPPLY INTAKE EVALUATION

SHEET TITLE

EXISTING RAW WATER INTAKE AND PUMPING FACILITIES

FIGURE 3

ELEVATIIONS ARE IN FEET MEAN SEA LEVEL (NAVD '29 DATA)



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Current Plotstyle Bylayer
Layout Tab Layout1

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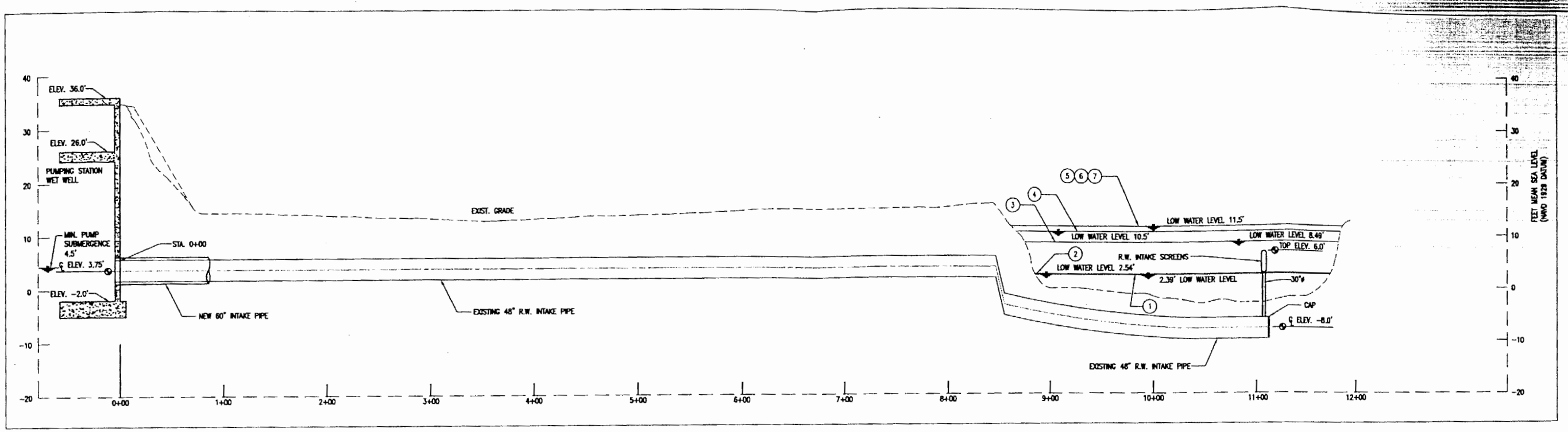
CITY OF WILMINGTON AND THE LOWER CAPE FEAR WATER AND SEWER AUTHORITY WATER SUPPLY INTAKE EVALUATION

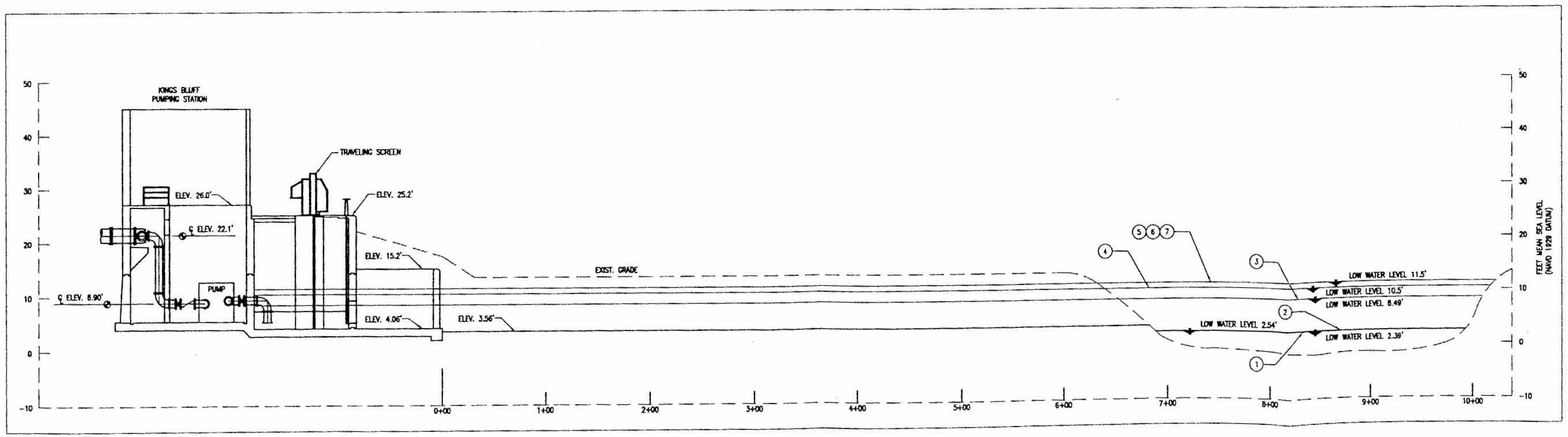
SHEET TITLE

CAPE FEAR RIVER BOTTOM ELEVATIONS – LOCK & DAM #1

FIGURE 4



LOWER CAPE FEAR WSA RAW WATER INTAKE AND PUMP STATION



CITY OF WILMINGTON KINGS BLUFF RAW WATER PUMP STATION AND INTAKE CANAL

NOTES:
1. HORIZONTAL SCALE IS APPROXIMATE

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Current Pen Assignments : ByDefault

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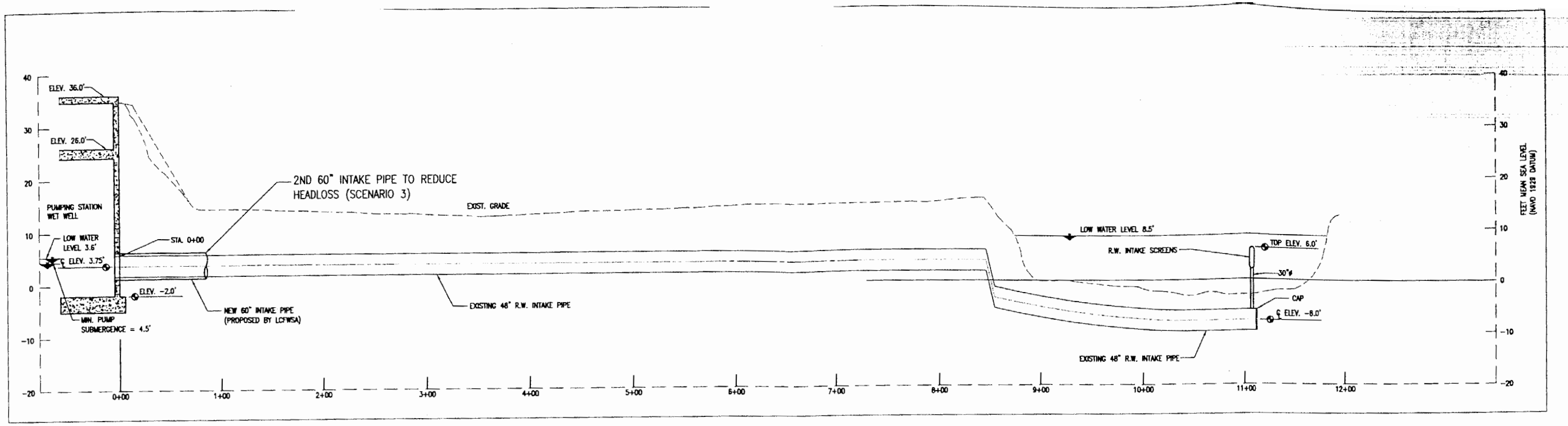
CITY OF WILMINGTON AND THE LOWER CAPE FEAR WATER AND SEWER AUTHORITY WATER SUPPLY INTAKE EVALUATION

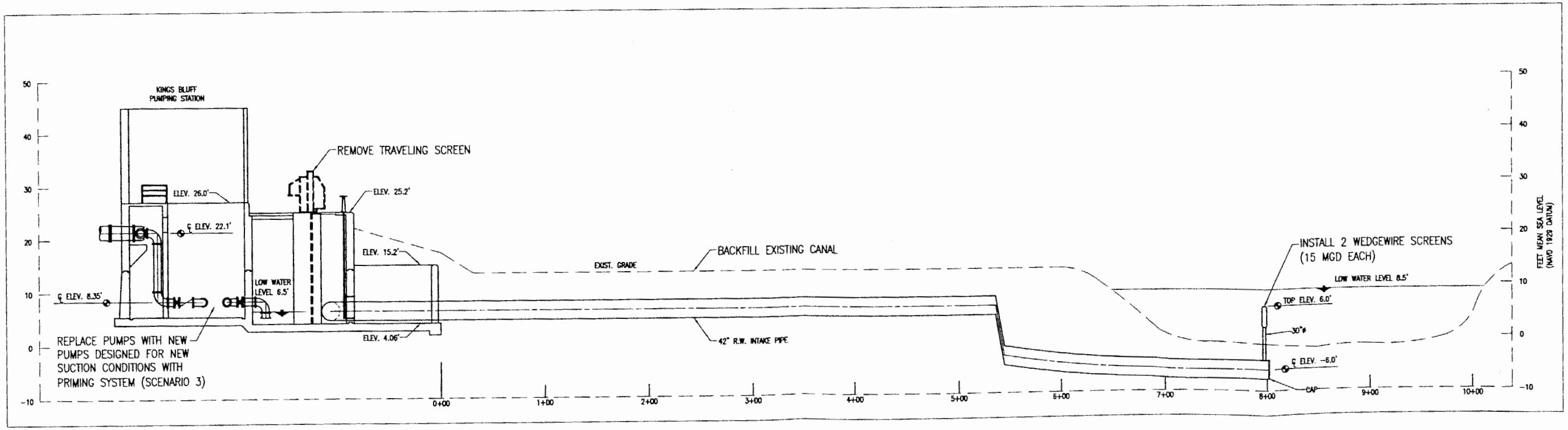
SHEET TITLE

MODIFIED RAW WATER INTAKE AND PUMPING FACILITIES

FIGURE 5



LOWER CAPE FEAR WSA RAW WATER INTAKE AND PUMP STATION



CITY OF WILMINGTON KINGS BLUFF RAW WATER PUMP STATION AND INTAKE CANAL

NOTES:
1. HORIZONTAL SCALE IS APPROXIMATE

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CITY OF WILMINGTON NORTH CAROLINA

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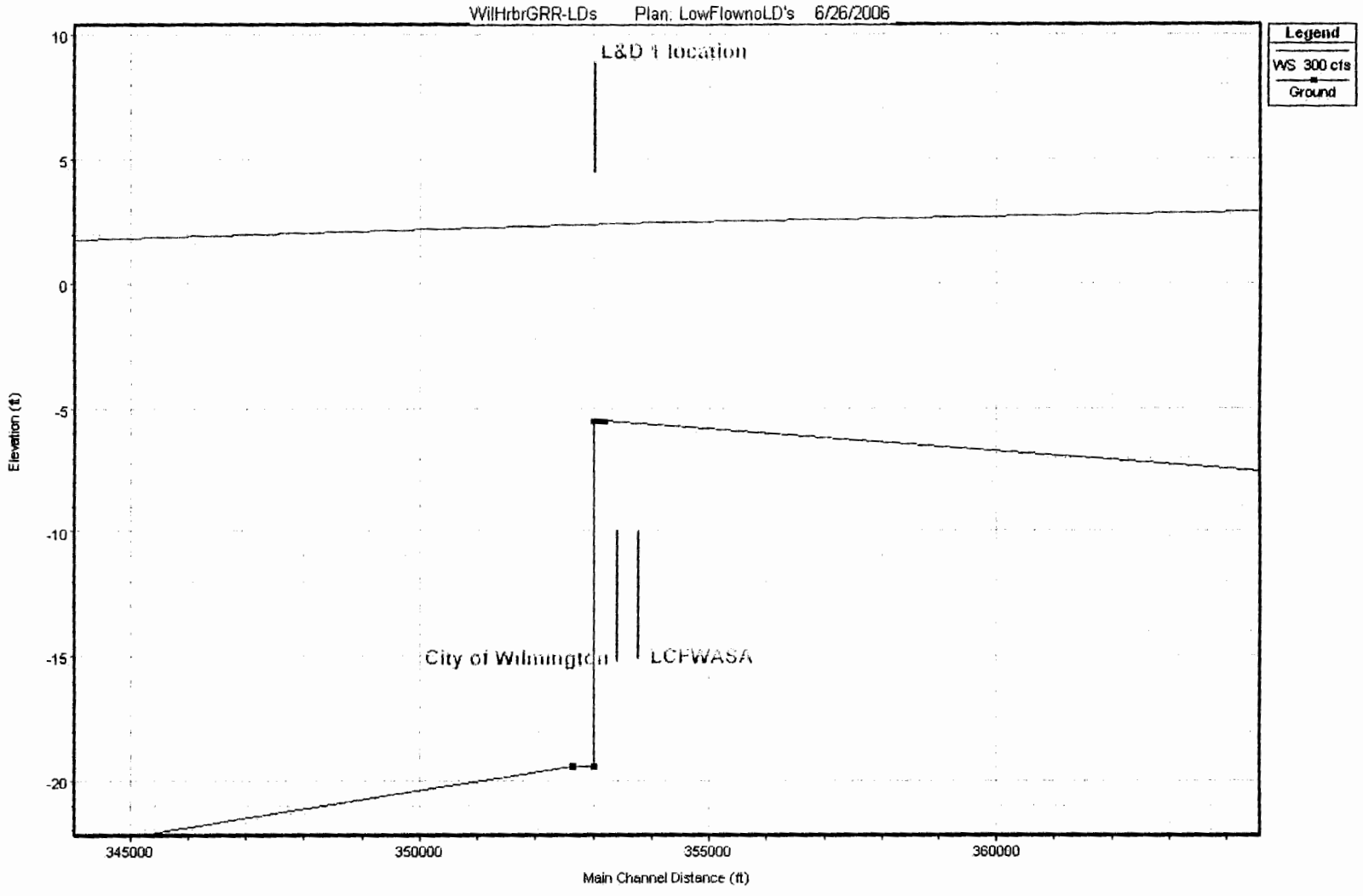
SHEET TITLE
SCENARIOS 3 & 4 CONCEPT DESIGN FOR PUMP STATION & INTAKE IMPROVEMENTS

FIGURE 6

Attachment A: Removal of Lock & Dam No. 1



Attachment B: Spillway lowered to 2.0' MSL