McIntyre Tract:
Year Four Monitoring Report

Brunswick County, NC

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1.0 Introduction

As part of the mitigation for unavoidable wetland impacts associated with the construction of the Wilmington Bypass by the North Carolina Department of Transportation, ECOBANK proposed to restore 12.3 acres of tidal cypress/gum swamp, 23.1 acres of tidal marsh/shrub scrub habitat, and 25.18 acres of tidal freshwater marsh at the McIntyre Tract in Brunswick County, North Carolina (Figure 1). In addition, ECOBANK proposed to enhance 79.68 acres of tidal marsh/shrub scrub. Details of this mitigation are located in the Revised Compensatory Mitigation Plan for the McIntyre Tract dated December 7, 2000.

Located along the Cape Fear River, this tract has been manipulated as a result of previous river transportation projects. Spoil material generated from dredging sections of the river had been placed on this tract over time, creating four upland islands throughout the site. In addition, an old railroad bed and an old roadbed were located on the tract. This fill material altered tidal amplitudes over a majority of the site. Therefore, the mitigation work at this site consisted primarily of re-contouring spoil islands, the railroad bed, and the old roadbed to the natural grade of adjacent wetlands and establishing meandering tidal sloughs within the tract, thereby reestablishing optimal tidal flushing. In addition, flooding breaks were established through an earthen berm on the southern end of the property, which restored both tidal freshwater marsh and tidal marsh/shrub scrub behind the berm. All graded areas were planted with appropriate vegetation. Trees were planted in the tidal cypress/gum swamp habitat and woody shrubs and herbaceous plants were planted in the tidal freshwater marsh and marsh/shrub scrub areas. Hydrological and vegetation monitoring will occur annually for a minimum of five years or until deemed successful, whichever is longer.

Because of this site's isolated location off of the Cape Fear River, the coordination of these mitigation activities was challenging. All mechanical equipment had to be barged over to the tract. In addition, approximately twenty employees working on grading and planting activities were transported to and from the site daily by boat. The mitigation project took approximately one month (working six days a week) to complete.

A majority of the construction activities were consistent with the mitigation plan. As stated in the Final Construction and Planting Report (July 2001), construction activities commenced at the McIntyre site on May 15, 2001 with the mobilization of equipment by barge and personnel by boat across the Cape Fear River to the McIntyre site. Grading activities began at several areas and consisted of removing spoil piles, recontouring existing spoil piles, constructing 8,850 linear feet of tidal sloughs, and constructing 11 tidal berm breaks. Grading was complete June 20, 2001. Proper elevations were maintained per the topographic map and verified using laser survey instrumentation. Installation of silt fences started on June 1 and the installation of over 3.5 miles of silt fence was completed by June 27. The silt fence crew also burned brush piles and did general site clean up. The trees and potted plants arrived on June 7. One shipment of herbaceous plants arrived on June 8 and the second shipment arrived on June 10. Two more shipments of herbaceous plants arrived on June 14. Tropical Storm Allison slowed the planting the week of June 10-15. Additional shipments were received on June 20 and 22, with the final shipments arriving on June 23. The planting crew started on June 10 and had all plantings done on June 27.

Because of the scope of the project and unforeseen circumstances, certain deviations from the plan were necessary. Changes to the original plan include the following:

1) Because the material excavated from the eastern section of the property was greater than anticipated, there were more spoil mounds along this slough than depicted in the figures from the mitigation plan. This excess material could not be shipped onto a barge because of its precarious location and it could not be burned because it was too wet. All spoil mounds within the tract were surveyed after construction and their size was subtracted from the mitigation acreage totals.

2) A GPS survey of the property was conducted after mitigation activities occurred and found that actual acreage values of the cypress/gum swamp, tidal marsh shrub scrub, and tidal freshwater marsh habitat types were less than the anticipated values. In August of 2001, sections of the cypress/gum swamp and the tidal freshwater marsh community types were extended to make up for this deficit. Vegetation sampling occurred throughout both the original and extended areas. However, the shrub scrub restoration habitat was unable to be enlarged (Table 1). The actual size of the shrub scrub restoration area is 17.02 acres (6.08 acres smaller than anticipated) and the actual size of the shrub scrub enhancement area is 85.76 acres (6.08 acres larger than anticipated).

Table 1. Planned and actual acreage for restoration and enhancement areas at McIntyre.

Habitat	Planned Acreage	Actual Acreage
Tidal Marsh / Shrub Scrub Restoration	23.1	**17.02**
Tidal Cypress/Gum Swamp Restoration	12.3	12.3
Tidal Freshwater Marsh Restoration	25.18	25.18
Tidal Marsh/Shrub Scrub Enhancement	79.68	**85.76**
Spoil Mounds	~ 5	2.74

3) Some of the planted vegetation arrived in unsuitable condition. To compensate for this, the nurseries shipped additional plants and plant species. In addition to the species listed in the mitigation plan, *Hibiscus moscheutos, Scirpus robustus, S. validus, S. americanus, and S. pungens* were planted. Although the mitigation plan stated that approximately 325,000 plants would be planted, over 345,000 were planted.

It should also be noted that during the third year of monitoring, 300 5-gallon bald cypress (*Taxodium distichum*) and 100 1-gallon water tupelo (*Nyssa aquatica*) trees were obtained from Bruton Nurseries (Fremont, NC) and planted in the cypress-gum areas since the vegetation success criterion was not met in this habitat type during the year two monitoring event. To improve the likelihood of success within the replanted area, the supplemental trees were older, planted in cooler weather, and the base of the trees was encircled with spoil material to provide a solid foundation.

Actions that have occurred throughout the fourth year of monitoring include general maintenance activities such as upkeep of the dock off of the Cape Fear River and the gauges located throughout the site and the reference areas.

2.0 Hydrology

Hydrological monitoring for all restoration and enhancement areas concentrated on matching tidal wetland hydrology of restored and enhanced sites to mature reference areas. Fourteen automated tide gauges were installed throughout the mitigation site and seven gauges were installed in reference marsh areas adjacent to the mitigation site (Figures 2 and 3). Each gauge within the McIntyre tract was assigned a reference gauge to which its data were compared

(Table 2). These assignments were based largely on similarities in proximity to the Cape Fear River and its tidal creeks, landscape position, and the surrounding vegetation. The hydrology success criterion for the site was the establishment of a hydroperiod that falls within 10% of the tidal amplitudes and duration of the reference areas. In addition, the salinity of the water at each restored gauge must match that of its corresponding reference gauge.

Table 2. List of reference gauges, the gauges at the McIntyre tract that correspond with them, and habitat type in which they are found. R = reference and E = enhancement.

Reference Gauge	Corresponding McIntyre Gauge	Habitat Type
1R	8, 9	Shrub Scrub Habitat
2R	12	Cypress Gum Swamp
3R	14E, 18E	Shrub Scrub Habitat
4R	19	Tidal Freshwater Marsh
5R*	7, 10, 15E, 17	Shrub Scrub Habitat
6R	11, 16	Tidal Freshwater Marsh
21R	13, 20	Tidal Freshwater Marsh

Note: 5R malfunctioned for most of 2004. 1R and 3R were used as substitute reference gauges for 7, 10, 15E, and 17 between October 2003 and September of 2004.

Gauges were installed between October of 2000 and July of 2001. Prior to September of 2001, most gauges were reading at different times and varied from four times a day to 48 times a day. In August of 2001, all gauges were programmed to read 24 times a day, at the top of each hour. Because each gauge's memory can store 520 readings, the gauges were reprogrammed to read 16 times a day (every 90 minutes) in January of 2002 in order to allow each gauge to be downloaded once a month. The elevation of each gauge as it relates to mean sea level (MSL; 1929 datum) and to the ground surface were determined by a local surveying company. Both of these elevation offsets are used in the graphing procedure (Appendix B). The salinity of water at each gauge is also measured and recorded at this time if standing water is present during the reading.

2.1 Tidal Cypress/Gum Swamp

Water reaches the tidal cypress/gum swamp during exceptionally high spring tidal cycles. Therefore, these areas are irregularly inundated. The hydrological success criterion for this habitat type is to match the tidal amplitude and salinities of the cypress/gum sections of the restoration site to the reference site. Gauge number 12 is

located within the restored cypress/gum habitat (located on the boundary of cypress/gum habitat and tidal freshwater marsh habitat; Figure 2). The gauge located within reference cypress/gum swamp habitat is number 2, which is found near the Wilmington Bypass Impact site (Rat Island; Figure 3).

2.1.1 Methods

In order to mathematically compare the tidal hydrology in restored cypress/gum areas to reference cypress/gum areas, the raw hydrology data collected by each gauge were first calibrated to MSL by adding its calculated offset. The difference between the corrected water level data from a McIntyre gauge and its corresponding reference gauge was taken for each hourly reading. The absolute value of this number was then divided by the reference gauge value to arrive at the percent difference of the two water level values. The average percent difference was then calculated for each month (Table 3).

The mitigation plan requires the salinity of the water within the restored cypress gum swamp habitat to match the salinity of the water at the reference cypress gum habitat. However, the word 'match' is not specific. The dictionary definition of the word is "to equal or be similar to another" (Merriam-Webster's Collegiate Dictionary, Tenth Edition; 1997). The definition of the word 'similar' is "having characteristics in common; strictly comparable". Therefore, some subjective interpretation of the salinity data was needed to determine if this criterion was achieved. Differences in salinity from one station to the next are inevitable due to upstream climatic conditions and the exact time at which each reading is taken. The time at which salinity data are read may vary from gauge to gauge by several hours due to the logistics of traveling to the various stations. This may result in different readings being taken at different tidal stages and could influence salinity. It is more meaningful to evaluate salinity *ranges* and *patterns* to determine how well the McIntyre site is matching the reference areas.

Salinity readings were taken monthly at each gauge location within the McIntyre tract and within the reference areas. For each habitat type, an average difference between salinity readings within the McIntyre tract and the reference areas was calculated. In addition, patterns of salinity fluctuations within the

McIntyre tract and corresponding reference areas were noted to determine if these fluctuations 'matched'.

Salinity values taken at the mitigation site and corresponding reference areas are listed in Table 4.

2.1.2 Results

Twelve months of hydrology and salinity data have been compiled and compared for this report (October of 2003 through September of 2004). During this time period, tidal amplitudes recorded at gauge 12 were within an average of 17.12% of the tidal amplitudes of reference gauge 2 (Table 3).

Table 3. Percent difference of tidal amplitudes between reference gauge 2R and its corresponding McIntyre gauge 12 within the cypress/gum swamp habitat in 2004.

Month	**2R vs. 12** % diff
Oct	16.76
Nov	18.18
Dec	18.97
Jan	22.83
Feb	20.82
Mar	20.90
Apr	13.77
May	16.93
Jun	13.67
Jul	14.73
Aug	13.63
Sep	14.28
Average	**17.12**

Between October of 2003 and September of 2004, the salinities of the gauge located within the restored cypress gum swamp habitat at McIntyre and its corresponding reference gauge ranged from 1 ppt to 5 ppt (Table 4). The average salinity difference for this habitat type was 1.1 ppt. In 2003, a similar range in salinity values was observed (0 ppt to 5 ppt) and the average difference in salinities was higher (2.2 ppt).

It should be noted that there are many gaps in salinity data because of varying tides during the readings. Because it took several hours to travel

throughout the site and read salinity, several locations were reached during low tide when no water is available to measure salinity.

Table 4. Salinity data for reference gauge 2R and its corresponding mitigation gauge 12 located in cypress/gum swamp habitat. Data given in parts per thousand (ppt).

Date	2R	12
10/1/03	5	3.5
11/05/03	-	-
12/02/03	-	-
1/27/04	3	2
2/19/04	*	*
4/13/04	4	3
5/12/04	5	4
6/18/04	*	*
7/06/04	3	-
8/23/04	2	1
9/25/04	-	2

Note: R = Reference gauge. - Could not read salinity because of low water level.

2.2 Tidal Marsh/Shrub Scrub

The hydrology criterion for this habitat type is to match the tidal amplitude and salinities of the tidal marsh/shrub scrub sections of the mitigation site to the reference sites, including the impact area at Rat Island. The gauges located within restored tidal marsh/shrub scrub habitat include numbers 7, 8, 9, 10, and 17 (Figure 3). Gauges 14E, 15E, and 18E are located within enhanced tidal marsh/shrub scrub habitat. Gauge numbers located within reference shrub scrub habitat are 1R, 3R and 5R (Figures 2 and 3).

2.2.1 Methods

In order to mathematically compare the tidal hydrology in restored and enhanced tidal marsh/shrub scrub areas and reference tidal marsh/shrub scrub areas, the raw hydrology data collected by each gauge were first calibrated to MSL by adding its calculated offset. The difference between the corrected water level data from a McIntyre gauge and its corresponding reference gauge was taken for each hourly reading. The absolute value of this number was then divided by the reference gauge value to arrive at the percent difference of the two water

level values. The average percent difference was then calculated for each month (Tables 5, 6, and 7).

The mitigation plan requires that the salinity of the water within the restored and enhanced tidal marsh/shrub scrub habitat "match" the salinity of the water at the reference tidal marsh/shrub scrub habitat. However, because the word 'match' is not specific, some subjective interpretation of the salinity data was needed to determine if this criterion was achieved. Differences in salinity from one station to the next are inevitable due to upstream climatic conditions and the tidal stage at the time of the reading. It is more meaningful to evaluate salinity *ranges* and *patterns* to determine how well the McIntyre site is matching the reference areas.

Salinity readings were taken monthly at each gauge location within the McIntyre tract and within the reference areas using a refractometer. An average difference between salinity readings taken from gauges within the tidal marsh/shrub scrub habitat at the McIntyre tract and the corresponding reference areas was calculated. In addition, patterns of salinity fluctuations within the McIntyre tract and corresponding reference areas were noted to determine if these fluctuations matched.

Salinity values taken at the mitigation site and corresponding reference areas are listed in Tables 8, 9, and 10.

2.2.2 Results

The average percent difference per month between the hydrology of gauges located in restored and enhanced shrub scrub habitat and the hydrology of gauges located in reference shrub scrub habitat was summarized in Tables 5, 6, and 7. It should be noted that Gauge 5R malfunctioned during the monitoring period. Because habitat at 1R and 3R is comparable to habitat at 5R, they were used as substitute reference gauges in this monitoring report. Three gauges documented an average percent difference within 10%. Gauges 8, 9, and 10 were within 9.7 %, 8.06%, and 9.43% of reference gauge 1R. Two gauges were slightly above the 10% criterion. Gauge 7 differed from reference gauge 3R by 11.63% and gauge 15E differed from reference gauge 1R by 10.84%. As in 2003, gauges

14E and 18E differed from their corresponding reference gauge (3R) by approximately 30%. Gauge 17 differed from its reference by 37.48%. As in previous years, all of these gauges except for Gauge 7 had, on average, higher water level readings than their corresponding reference gauge (see Appendix B).

Table 5. Percent differences of tidal amplitudes between reference gauge 1R and its corresponding McIntyre gauges within the tidal marsh/shrub scrub habitat.

Month	**1R vs. 8** (% diff)	**1R vs. 9** (% diff)
Oct	10.77	7.00
Nov	11.39	8.94
Dec	12.33	3.18
Jan	20.23	9.77
Feb	9.28	6.90
Mar	7.38	7.55
Apr	10.00	5.30
May	9.05	9.64
Jun	6.90	7.16
Jul	8.06	9.08
Aug	6.70	9.39
Sep	4.30	12.84
Average	**9.70**	**8.06**

R= Reference gauge.

Table 6. Percent differences of tidal amplitudes between reference gauge 3R and its corresponding McIntyre gauges within the tidal marsh/shrub scrub habitat.

Month	**3R vs. 14 E** (% diff)	**3R vs. 18E** (% diff)
Oct	23.76	21.38
Nov	25.72	22.06
Dec	40.84	35.18
Jan	42.89	39.56
Feb	40.21	35.76
Mar	32.45	28.86
Apr	33.22	27.84
May	35.31	23.60
Jun	36.36	27.36
Jul	50.68	62.82
Aug	36.02	37.48
Sep	*	*
Average	**36.13**	**32.90**

R= Reference gauge. E= Enhancement gauge. * 3R malfunctioned.

Table 7. Percent differences of tidal amplitudes between reference gauge 1R and its corresponding McIntyre gauges within the tidal marsh/shrub scrub habitat. Note that 1R and 3R are used as substitute reference gauges between October of 2003 and July of 2004 because 5R malfunctioned during this time period.

Month	**3R vs. 7** (% diff)	**1R vs. 10** (% diff)	**1R vs. 15E** (% diff)	**1R vs. 17** (% diff)
Oct	9.64	8.78	13.40	41.33
Nov	9.31	11.11	11.31	40.00
Dec	11.83	12.69	*	*
Jan	14.36	9.00	6.35	46.47
Feb	12.85	10.35	8.08	43.96
Mar	10.64	10.07	12.32	38.31
Apr	10.05	9.15	7.65	43.77
May	12.06	10.65	14.65	38.11
Jun	14.58	6.34	11.09	30.41
Jul	*	*	10.40	34.27
Aug	11.27	*	11.03	30.63
Sep	11.38	6.17	13.01	24.97
Average	**11.63**	**9.43**	**10.84**	**37.48**

R= Reference gauge. E= Enhancement gauge. * Gauge malfunctioned. Data lost.

Between October of 2003 and September of 2004, the salinities of gauges located within the restored and enhanced shrub scrub areas at McIntyre and their corresponding reference gauges were measured. It should be noted that there are many gaps in salinity data because of varying tides during the readings. Because it takes several hours to travel throughout the site and read salinity, several locations are reached during low tide when no water is available to measure salinity. Therefore, only limited data were measured and used in this analysis.

Salinity values for shrub scrub areas ranged from 0 ppt to 5 ppt in 2004. The average salinity difference for this habitat type was 0.9 ppt. Both the salinity range and average difference were similar to what was documented in 2003 (range: 0 ppt -5 ppt; avg. diff: 1.1 ppt). The data show that salinity patterns in restored, enhanced, and reference areas match. In general, as the reference salinity data increased on a particular day, the corresponding restored and enhanced salinity data also increased to match this fluctuation.

Table 8. Salinity data for reference gauge 1R and corresponding McIntyre gauges located in tidal marsh / shrub scrub habitat. Data are given in parts per thousand (ppt).

Date	1R	8	9
10/1/03	4	-	-
11/05/03	*	*	*
12/02/03	4	-	-
1/27/04	3	-	3
2/19/04	*	-	2
4/13/04	5	-	-
5/12/04	2	-	-
6/18/04	*	*	*
7/06/04	3	-	-
8/23/04	3	-	3
9/25/04	2	-	2

Note: R = Reference gauge. - Could not read salinity because of low water level. * Salinometer broken.

Table 9. Salinity data for reference gauge 3R and corresponding McIntyre gauges located in tidal marsh / shrub scrub habitat. Data are given in parts per thousand (ppt).

Date	3R	14E	18E
10/1/03	4	5	4
11/05/03	*	*	*
12/02/03	4	-	-
1/27/04	4	3	4
2/19/04	*	*	*
4/13/04	5	4	3
5/12/04	3	3	-
6/18/04	*	*	*
7/06/04	2	-	-
8/23/04	4	2	3
9/25/04	-	-	2

Note: R = Reference gauge. E = Enhancement gauge. - Could not read salinity because of low water level. * Could not read salinity because of broken refractometer.

Table 10. Salinity data for reference gauge 5R and corresponding McIntyre gauges located in tidal marsh / shrub scrub habitat. Data are given in parts per thousand (ppt).

Date	5R	7	10	15E	17
10/1/03	4	0	0	4	3
11/05/03	*	*	*	*	*
12/02/03	4	3	3	-	-
1/27/04	4	3	4	3	3
2/19/04	*	1	3	*	*
4/13/04	3	3	2	5	3
5/12/04	3	-	4	3	4
6/18/04	*	*	*	*	*
7/06/04	-	2	-	2	3
8/23/04	2	3	2	2	2
9/25/04	3	-	2	-	3

Note: R = Reference gauge. E = Enhancement gauge. - Could not read salinity because of low water level. * Could not read salinity because of broken refractometer.

2.3 Tidal Freshwater Marsh

Tidal amplitude and salinity data collected from restored sections of this habitat type between October of 2003 and September of 2004 were compared to similar areas within the reference site. The gauges located within restored tidal freshwater marsh habitat include numbers 11, 13, 16, 19, and 20. Gauge numbers located within reference freshwater marsh are 4R, 6R, and 21R.

2.3.1 Methods

In order to mathematically compare the tidal hydrology in restored tidal freshwater marsh areas and reference tidal freshwater marsh areas, the raw hydrology data collected by each gauge were first calibrated to MSL by adding its calculated offset. This places each gauge at MSL. The difference between the corrected water level data from a restored gauge and its corresponding reference gauge was taken for each hourly reading. The absolute value of this number was then divided by the reference gauge value to arrive at the percent difference of the two water level values. The average percent difference was then calculated for each month (Table 11).

The mitigation plan requires that the salinity of the water within the restored tidal marsh habitat "match" the salinity of the water at the reference tidal marsh habitat. Because the word 'match' is not specific, some subjective interpretation of the salinity data was needed to determine if this criterion was achieved. Differences in salinity from one station to the next are inevitable due to upstream climatic conditions and tidal stages at the time of the reading. It is more meaningful to evaluate salinity *ranges* and *patterns* to determine how well the McIntyre site is matching the reference areas.

Salinity readings were taken monthly at each gauge location within the McIntyre tract and within the reference areas using a refractometer. For each habitat type, an average difference between salinity readings within the McIntyre tract and the reference areas was calculated. In addition, patterns of salinity fluctuations within the restored tidal marsh habitat and corresponding reference areas were noted to determine if these fluctuations matched.

Salinity values taken at the mitigation site and corresponding reference areas are listed in Tables 12, 13, and 14.

2.3.2 Results

During the monitoring period, the average percent differences of water levels of most of the gauges located within the restored tidal freshwater marsh habitat compared closely to their relative reference gauges and were similar to results from previous years. Three of the five gauges in this habitat type were within 10% of their corresponding reference gauge. Gauge numbers 13 and 20 documented percent differences of 4.49% and 5.30% of reference gauge 21R and gauge 11 was within 8.03% of reference gauge 6R. The percent difference between gauge 19 and reference gauge 4R was 23.54%. The percent difference between gauge 16 and reference gauge 6R was 21.79%.

Table 11. Percent differences of tidal amplitudes between reference gauges and corresponding McIntyre gauges within the tidal freshwater marsh habitat.

Month	**4R vs. 19** (% diff)	**6R vs. 11** (% diff)	**6R vs. 16** (% diff)	**21R vs. 13** (% diff)	**21R vs. 20** (% diff)
Oct	21.50	*	*	3.54	9.59
Nov	19.96	7.80	18.22	6.39	8.66
Dec	25.22	7.63	23.90	3.84	7.49
Jan	24.38	8.36	22.85	2.46	7.35
Feb	26.19	6.11	20.52	2.95	5.91
Mar	24.06	7.22	19.35	2.32	4.41
Apr	20.73	7.03	19.28	2.97	3.53
May	19.77	*	18.30	7.69	2.64
Jun	32.45	*	*	*	*
Jul	21.26	*	*	4.41	3.34
Aug	21.86	14.46	22.84	7.16	3.32
Sep	25.13	*	30.89	5.68	2.05
Average	**23.54**	**8.03**	**21.79**	**4.49**	**5.30**

Between October of 2003 and September of 2004, the salinities of gauges located within the restored tidal freshwater marsh areas at McIntyre and their corresponding reference gauges ranged from 2 ppt to 9 ppt (Tables 12, 13, and 14). Average salinity difference for this habitat type was 1.0 ppt. These values are similar to what was measured in 2003 (range: 0 ppt to 5 ppt; avg. diff. 0.8 ppt), It should be noted that there are many gaps in salinity data because of varying tides

during the readings. Because it takes several hours to travel throughout the site and read salinity, several locations are reached during low tide when no water is available to measure salinity.

The data show that salinity patterns in restored and reference areas match. As the reference salinity data increased on a particular day, the corresponding restored salinity data also increased to match this fluctuation.

Table 12. Salinity data for reference gauge 4R and its corresponding mitigation gauge located in tidal freshwater marsh habitat. Data are given in parts per thousand (ppt).

Month	4R	19
10/1/03	5	-
11/05/03	*	*
12/02/03	-	3
1/27/04	3	4
2/19/04	*	*
4/13/04	5	9
5/12/04	-	3
6/18/04	*	*
7/06/04	2	-
8/23/04	3	3
9/25/04	2	3

Note: R = Reference gauge. - Could not read salinity because of low water level.
* Could not read salinity because of broken refractometer.

Table 13. Salinity data for reference gauge 6R and corresponding mitigation gauges located in tidal freshwater marsh habitat. Data are given in parts per thousand (ppt).

Date	6R	11	16
10/1/03	3	-	2
11/05/03	*	*	*
12/02/03	5	-	4
1/27/04	4	3	4
2/19/04	*	-	*
4/13/04	2	-	4
5/12/04	4	-	3
6/18/04	*	*	*
7/06/04	-	-	-
8/23/04	3	3	4
9/25/04	3	4	4

Note: R = Reference gauge. - Could not read salinity because of low water level.
* Could not read salinity because of broken refractometer.

Table 14. Salinity data for reference gauge 21R and corresponding mitigation gauges located in tidal freshwater marsh habitat. Data are given in parts per thousand (ppt).

Date	21R	13	20
10/1/03	2	2	4
11/05/03	*	*	*
12/02/03	3	3	3
1/27/04	-	2	3
2/19/04	*	*	*
4/13/04	4	4	6
5/12/04	4	3	2
6/18/04	*	*	*
7/06/04	-	-	4
8/23/04	2	3	4
9/25/04	-	5	3

Note: R = Reference gauge. - Could not read salinity because of low water level. * Could not read salinity because of broken refractometer.

2.4 Pre-Construction Data vs. Post Construction Data

As a requirement of the McIntyre mitigation plan, hydrology data collected prior to mitigation in the tidal cypress/gum swamp habitat (Gauge 12), the tidal freshwater marsh habitat (Gauges 16, 19, and 20), and the shrub scrub enhancement areas (Gauges 14E and 18E) were to be compared to post-construction data collected from these gauges to prove that the mitigation activities did in fact provide additional flushing to these areas and increase average tidal amplitudes. This was especially important to document because the elevations of these areas were not altered during construction. Instead, several breaks were installed throughout the berm along the southern edge of the property and tidal creeks were created to increase flushing in these areas. Because this mitigation project was on a fast-paced schedule, only between three and five months of pre-construction hydrology data were collected.

It was determined that the tidal data had a skewed distribution with outliers, therefore, a nonparametric test (Wilcoxan) was performed. The two datasets for each gauge were compared and a p-value was formed. This value represented the probability that the post-construction data set was not significantly higher than the pre-construction data set (null hypothesis).

In this monitoring report, pre-construction data was compared to post-construction data collected during the year four monitoring period. Five of the six comparisons formed p-values less than .0001 (Table 15), which indicated that the post-construction data sets were significantly higher than the pre-construction data sets for

these gauges. Gauge 14E had a p-value of 0.0014, which is still considered significant (less than 0.05).

Post-construction data in 2002 were significantly higher than pre-construction data for all six gauges. In 2003, post-construction data were significantly higher for five of the six gauges. Based on these results, it can be concluded that the mitigation activities significantly increased tidal flushing within the cypress gum swamp, tidal freshwater marsh, and shrub scrub enhancement areas.

Table 15. Average pre-construction tidal amplitude, average post-construction tidal amplitude, and p-values for gauges located in tidal cypress gum habitat, tidal freshwater marsh habitat, and shrub scrub enhancement areas (see Appendix C for statistical analyses).

Gauge Number	Mean Pre-construction Tidal Amplitude (in)	Mean Post-construction (2004) Tidal Amplitude (in)	P-value
12	39.56	40.66	<.0001
16	38.04	44.02	<.0001
19	36.86	39.07	<.0001
20	36.30	43.52	<.0001
14E	33.46	34.15	.0014
18E	29.89	33.35	<.0001

2.5 Conclusions

The hydrology success criterion established in the mitigation plan required restored and enhanced hydrology to be within 10% of reference hydrology. Results of the year four monitoring resembled results from previous years, although there were some differences. Six gauges (8, 9, 10, 11, 13, and 20) met this criterion and nine gauges (7, 8, 9, 10, 11, 12, 13, 15E, and 20) were within 20%. Five gauges (14E, 16, 17, 18E, and 19) exceeded 20%. As in previous years, all McIntyre gauges except for gauge 7 had hydrology that was greater (or wetter) on average, than their corresponding reference gauges (see Appendix B). Gauge 7 is located along the slope of a tidal creek, in very sandy soils. Although this area is ponded much of the time, this gauge still had slightly lower readings, on average, than reference gauge 5R. This is because water is able to seep out of the sandy soils much quicker and more effectively than the muddier substrate located in the reference area. As the graphs show, high tides at gauge 7 are higher than gauge 5R, however low tides are lower as water quickly moves out of the soil and into the adjacent creek. The biggest difference was again between gauge 17 and its reference gauge, which was 37.48%. Gauge 17 is located along a tidal creek, just south of the

easternmost spoil pile. This area is extremely wet and is flooded a majority of the time. Data show that gauge 17 is much wetter than any other gauge at McIntyre or the reference areas.

In 2001 and 2002, nine of the fourteen gauges did not meet the hydrology success criterion established in the mitigation plan. In 2003 and in 2004, eight gauges did not meet this criterion. However, because all but one gauge (7) experienced wetter hydrology than the reference, the mitigation at McIntyre has achieved its ultimate goal of restoring and enhancing tidal flushing to this disturbed area. Frequent visits to the site during varying times of the tidal cycle indicate that the restored elevations of this tract and the tidal creeks are allowing water to inundate the site repeatedly during high tide and return to drier conditions during low tide (Appendix A). As stated in the previous monitoring reports, it appears that the hydrology success criterion of no greater than 10% difference between average tidal amplitudes of the McIntyre tract and the reference areas is too restrictive. Furthermore, when comparing hydrology data from two different reference gauges located at the impact site of Rat Island (2R and 3R) between October of 2003 and September of 2004, the average difference is 24.20% (Table 16). If the impact site itself cannot achieve the established success criterion, a more appropriate and realistic criterion may need to be developed by the agencies.

Table 16. Percent differences of tidal amplitudes between two reference gauges at the impact site (Rat Island).

Month	**2R vs. 3R** (% diff)
Oct	21.00
Nov	21.65
Dec	29.48
Jan	27.53
Feb	28.18
Mar	23.96
Apr	24.24
May	22.20
Jun	14.33
Jul	28.40
Aug	25.33
Sep	*
Average	**24.20**

* Gauge malfunctioned.

Salinity data taken at each gauge show that salinity readings within the McIntyre tract were similar to readings taken within reference areas. Salinity readings taken within the tract prior to construction resulted in values between 0 and 2 ppt. After construction (2001 and 2002), salinity values increased from between 5 and 16 ppt. However, salinity has since decreased to between 0 ppt and 6 ppt in 2003 and between 0 ppt and 9 ppt in 2004. The differences in salinity are likely due to differences in tidal flushing and precipitation from year to year.

Average salinity differences for the three habitat types at the McIntyre tract and the reference areas were 1.1 ppt (cypress/gum), 0.9 ppt (shrub scrub), and 1.0 ppt (freshwater marsh). Differences between readings taken on the same day may be a result of tidal cycles at the time of the readings and rainfall that occurred immediately prior to the readings (Appendix B). More important than the difference between values taken from the McIntyre tract and those taken from reference areas is the actual range of values. Values taken within the McIntyre tract ranged from 0 ppt – 9 ppt (post-project) while values taken within reference areas ranged from 2 ppt – 5 ppt (post-project).

Based on natural variation of salinity readings in any aquatic habitat, the salinity differences between the McIntyre site and reference areas are small enough to fulfill the salinity success criterion of 'matching'.

A comparison of pre-construction hydrology data and post-construction hydrology data determined that average post-construction tidal amplitudes were significantly higher than average pre-construction tidal amplitudes for all six gauges.

3.0 Vegetation

In June of 2001, wetland vegetation planting occurred within the three different types of habitat that were restored at the McIntyre site: tidal cypress/gum swamp, tidal marsh/shrub scrub, and tidal freshwater marsh. Trees were planted in the tidal cypress/gum swamp habitat, woody shrubs and herbaceous plants were planted in the tidal marsh/shrub scrub areas, and herbaceous plants were planted in the tidal freshwater marsh. Additional bald cypress and black gum trees were planted in the spring of 2003. Year four vegetation data were collected on August 17th and August 18th of 2004 (Appendix D).

3.1 Cypress/Gum Swamp

Within the 12.3 acres of restored cypress/gum habitat, bald cypress (*Taxodium distichum*) and swamp black gum (*Nyssa biflora*) trees were planted on a 20' spacing, which is approximately 120 trees per acre (Table 17). Although the mitigation plan stated that *N. aquatica* seedlings would be planted, because of limited nursery availability, *N. biflora* was used. The trees planted were obtained from a certified nursery and were received in one-gallon containers.

Table 17. Trees planted within restored cypress/gum swamp habitat at McIntyre in 2001.

Species Planted	Common Name	# Planted/acre	Total Planted
Taxodium distichum	Bald cypress	80	984
Nyssa biflora	Swamp black gum	40	492
Total		**120**	**1476**

3.1.1 *Methods*

Vegetation monitoring within the cypress/gum habitat comprised of establishing three circular plots, each one-tenth acre in size, within restored sections of this community type and counting all woody trees within these plots (Figure 3). According to the McIntyre Mitigation Plan, the minimum success criterion is to obtain survival of no less than 40 trees per acre, including volunteer cypress and gum.

3.1.2 *Results*

Although other woody species were observed within these plots, the bald cypress and black gum trees were the only species counted toward the 40 trees/acre success criterion.

When including all trees that were observed within each of the three plots, an average of 160 trees/acre was achieved. This is less than the 276.7 trees/acre observed in 2003 and was mostly due to a decrease in the number of volunteer shrubs occurring in Plot #1, such as *Baccharis halimifolia* and *Sapium sebiferum*. When including only the bald cypress and black gum species, the average number

was 83.3 trees/acre (Table 18). This value surpassed the success criterion of 40 trees/acre. Therefore, the cypress/gum swamp habitat achieved the vegetation success criterion for 2004.

Table 18. Species and number of trees observed within cypress/gum swamp vegetation monitoring plots in 2004.

Plot #	Species	Total Number	# Counted Towards Criterion
1	*Taxodium distichum* *Nyssa biflora* *Baccharis halimifolia* *Myrica cerifera* *Iva frutescens*	10 2 19 1 2	12
2	*Taxodium distichum* *Nyssa biflora*	7 1	8
3	*Taxodium distichum* *Nyssa biflora*	4 1	5
Total		47	25
Total/acre		**160**	**83.3**

3.2 Tidal Marsh/Shrub Scrub

Within the McIntyre tract, 17.02 acres of tidal marsh/shrub scrub habitat were restored. In these areas, a combination of woody shrubs and herbaceous plants were planted on a 2' spacing (Table 19). All planted vegetation was obtained from certified nurseries (Pinelands Nursery, Columbus NJ; Central Florida Lands & Timber Nursery, LLC, Mayo, FL; Horticultural Systems, Inc., Parrish, FL). Seedlings were 2" plugs and shrubs were shipped in one-gallon containers. No planting occurred within the 85.76 acres of shrub scrub enhancement.

Table 19. Shrubs and herbaceous plants planted within restored sections of the tidal marsh/shrub scrub habitat at McIntyre. Because some of the shipped plants arrived in unsuitable condition, the nursery shipped additional plants at no charge. Therefore, numbers planted exceeds values given in the mitigation plan.

Species Planted	Common Name	# Planted/acre	Total Planted
Myrica cerifera	Wax myrtle	110	2541
Iva frutescens	Marsh elder	70	1617
Baccharis halimifolia	Groundsel bush	11	250
Hibiscus moscheutos	Marsh mallow	86	2000
Spartina cynosuroides	Giant cordgrass	4620	106,722
Cladium jamaicense	Saw grass	4620	106,722
Spartina alterniflora	Smooth cordgrass	1650 (along tidal creeks only)	38,115
Scirpus pungens			28,600
Scirpus robustus	Salt marsh bulrush		4700
Scirpus americanus	Common three-square		4750
Scirpus validus	Soft-stemmed bulrush		5150
Total		**11,562**	**267,092**

3.2.1 *Methods*

Vegetation monitoring within the tidal marsh/shrub scrub habitat was performed using techniques developed by the National Marine Fisheries Service and the U.S. Army Corps of Engineers. The Braun-Blanquet (B-B) vegetation sampling technique was used to measure vegetation cover (Braun-Blanquet, 1965; see Appendix E). From the B-B method, cover values ranging between 0.1 and 5 are assigned to each species observed within a plot and are based on the species' density within that plot. Using the sum of the cover values generated from this method, measures of frequency, abundance, and density can be derived.

To collect vegetation data, 15.4 plots that were each $1m^2$ in size were sampled per acre. Since 17.02 acres of tidal marsh/shrub scrub habitat were restored, 263 plots were sampled. According to the mitigation plan, these plots were to be randomly located throughout restored sections of this habitat type. However, because a computer program that generated these random

latitude/longitude points could not be obtained, the location of plots was determined using a systematic sampling technique, with the consent of the Corps and NMFS. In the office, evenly-spaced transects (approximately 50' spacing) that ran north/south were marked onto a survey map of the site. Four teams each consisting of two people then walked these transects in the field and established a plot every fifty feet.

The vegetation success criterion is the survival of at least 70% of the planted seedlings for the first and each subsequent growing season. As stated on page 13 of the mitigation plan, both planted and volunteer emergent high marsh species (except *Phragmites australis* and *Typha angustifolia*) were counted towards this criterion. The final plant density success criterion is the establishment of 75% plant coverage by the end of the fifth growing season.

3.2.2 *Results*

Of the eleven species planted within this habitat type, all were observed within the sampling plots. An additional 31 species have volunteered into the site since planting occurred in June of 2001. The number of plots in which each species was observed and the sum of the B-B values for that species are given in Table 20.

Table 20. Number of occupied plots and sum of B-B values for each species observed in the tidal marsh/shrub scrub plots.

Species	# of Occupied Plots	Sum of BB
Amaranthus cannabinus	28	43.5
Asclepias incarnata	3	4
Aster subulatus	4	4.1
Baccharis halimifolia	30	64.7
Bacopa monnieri	15	14.5
Cicuta maculata	20	36.5
Cladium jamaicense	127	515.5
Cynodon dactylon	4	11.5
Cyperus spp.	8	4.5
Echinochloa walteri	4	5.1
Eleocharis spp.	2	7
Hibiscus moscheutos	3	1.6
Iva frutescens	1	2
Juncus bufonis	1	3
Juncus effusus	1	1
Juncus repens	1	0.5
Myrica cerifera	1	0.1
*Phragmites australis**	16	34.1
Pluchea rosea	49	60.7
Polyganum arifolium	1	2
Polyganum hydropiperoides	103	161.6
Polyganum pennsylvanicum	3	1.6
Pontederia cordata.	1	1
Sagittaria lancifolia	13	6.8
Sagittaria latifolia	1	3
Sapium sebiferum	1	1
Scirpus americanus	18	30.5
Scirpus pungens	14	32
Scirpus robustus	84	184.3
Scirpus validus	30	47.2
Setaria geniculata	3	2.2
Solidago spp.	13	13.3
Spartina alterniflora	16	42
Spartina cynosuroides	72	170.5
Taxodium distichum	1	0.1
*Typha angustifolia**	85	196.9
unknown	1	1
Zizania aquatica	2	7
2004 TOTAL	**679**	**1486.9**

*Not counted towards total.
Species listed in bold were planted.

National Marine Fisheries Service provided guidelines on how to analyze vegetation data collected using the B-B method in an emergent marsh mitigation site. Based on their protocol, survival (frequency) was estimated using the following formula:

Survival = # of occupied quadrats/total # of quadrats

The number of plots occupied by both planted and volunteer species (*except Phragmites australis* and *Typha angustifolia*) was counted (Table 20) and divided by the total number of plots sampled within this habitat type (263). This results in counting a plot more than once if more than one species exists within it. Furthermore, the NMFS formula assumes planting occurred on a $1m^2$ spacing (ie. one plant per plot). Instead, the tidal marsh/shrub scrub habitat was planted on a 2' spacing, which is approximately 2.72 plants per $1m^2$ plot. Therefore, the survival formula was modified to reflect this spacing:

*Survival = # of occupied quadrats/(total # of quadrats * 2.72)*

With this modification, the survival rate is 0.95 or 95% and represents the spacing of plants within the tidal marsh/shrub scrub habitat more accurately than the original formula. This value exceeds the survival success criterion of 70%. Therefore, the tidal marsh/shrub scrub habitat type meets the vegetation success criterion for 2004.

Although the density success criterion of 75% (a B-B value of 5) is not officially counted until the fifth year of monitoring, it was calculated this year to monitor progress. The NMFS formula to calculate density is:

Density = sum of B-B scale values/ total # of quadrats

Density within tidal marsh/shrub scrub habitat after year four monitoring is 5.7. In terms of B-B cover values, this average represents greater than 75% vegetative cover and already achieves the density success criterion.

3.3 Tidal Freshwater Marsh

A total of 25.18 acres of tidal freshwater marsh habitat was restored at McIntyre. Within these areas, herbaceous plant species were planted on a 4' spacing (Table 21). All planted vegetation was obtained from certified nurseries (Pinelands Nursery, Columbus NJ; Central Florida Lands & Timber Nursery, LLC, Mayo, FL; Horticultural Systems, Inc., Parrish, FL). All herbaceous plants were 2" plugs.

Table 21. List of herbaceous plants planted within restored sections of the tidal freshwater marsh habitat at McIntyre.

Species Planted	Common Name	# Planted/ac	Total Planted
Spartina cynosuroides	Giant cordgrass	1587	40,000
Cladium jamaicense	Saw grass	568	14,300
Scirpus americanus	Common three-square	568	14,300
Scirpus robustus	Salt marsh bulrush	284	6550
Scirpus validus	Soft-stemmed bulrush	111	2575
Total		**3118**	**77,725**

3.3.1 *Methods*

Vegetation monitoring within the tidal freshwater marsh areas followed the same protocol as within the tidal marsh shrub/scrub habitat. As with the tidal marsh shrub/scrub, 15.4 plots that were each $1m^2$ were established per acre. Because 25.18 acres of tidal freshwater marsh habitat were restored, 388 plots were counted.

The vegetation success criterion is the survival of at least 70% of the planted seedlings for the first and each subsequent growing season. Both planted and volunteer species (except *Phragmites australis* and *Typha angustifolia*) were counted towards this criterion. The final plant density success criterion is the establishment of 75% plant coverage by the end of the fifth growing season.

3.3.2 *Results*

Of the five species planted within this habitat type, all were observed within the sampling plots. An additional nineteen species have volunteered into the site since planting occurred in June of 2001, including cattails (*Typha*

angustifolia). Most of this habitat type previously consisted of cattail beds that were pressed to the ground with mechanical equipment prior to planting. The dead, prostrate cattails were not counted in the sampling efforts. However, new shoots that were located in these plots were counted in the field but were not included in the success criterion data. The number of plots in which each species was observed and the sum of the B-B values for that species are given in Table 22.

Table 22. Number of occupied plots and sum of B-B values for each species observed in the tidal freshwater marsh plots.

Species	# of Occupied Plots	Sum of B-B Values
Acer rubrum	1	0.1
Amaranthus cannabinus	1	1
Asclepias incarnata	1	0.5
Baccharis halimifolia	4	1.2
Bacopa monnieri	5	0.9
Cladium jamaicense	53	126
Cyperus spp.	6	8
Hydrocotyle spp.	9	8
Myrica cerifera	4	10
Osmunda regalis	14	14.1
*Phragmites australis**	2	9
Pluchea rosea	22	20.5
Polyganum hydropiperoides	21	19.2
Rosa palustris	1	0.5
Rubus spp.	5	11
Scirpus americanus	20	49
Scirpus pungens	46	72.7
Scirpus robustus	63	115.7
Scirpus validus	16	45.5
Spartina alterniflora	6	19
Spartina cynosuroides	11	14.1
Toxicodendron radicans	3	0.7
*Typha angustifolia**	381	1510.5
Unknown	3	1.6
Woodardia areolata	17	38.5
2004 TOTAL	**332**	**577.8**

*Not counted towards total. Planted species listed in bold.

Vegetation data collected within the tidal freshwater marsh habitat were analyzed using the same survival formula as in the tidal marsh/shrub scrub habitat. However, vegetation within this community type was planted on a 4' spacing. Therefore, the average number of plants located within any given $1m^2$ plot is 0.68. The revised formula is as follows:

*Survival = # of occupied quadrats/(total # of quadrats * 0.68)*

With this modification, the survival rate is 1.26 or 126%. This value greatly exceeds the survival success criterion of 70%. Therefore, the tidal freshwater marsh habitat type meets the vegetation success criterion for year four.

Although the density success criterion of 75% (a B-B value of 5) is not officially counted until the fifth year of monitoring, it was calculated this year to monitor progress. The NMFS formula to calculate density is:

Density = sum of B-B scale values/ total # of quadrats

Therefore, density within tidal freshwater marsh habitat after year four monitoring is 577.8/388, or 1.49. In terms of B-B cover values, this average represents between 1% and 5% vegetative cover. This value is still low but is steadily increasing from previous years.

3.4 Invasive Species

The scope and effect of invasive species throughout the McIntyre tract were evaluated in this fourth year monitoring report. Prior to any vegetation planting, the extent of *Phragmites australis* within the tract was determined to be mainly along its eastern section (near U.S. Highway 421) and in the middle of the tract near gauge 16 (Figure 3). The plants were sprayed twice in June of 2001 with an herbicide (see Appendix A). These areas were reevaluated during the vegetation monitoring in August of 2004 and it was determined that the plants were negatively affected by the herbicide but are continuing to grow. As in previous years, some individuals were observed within the monitoring transects mostly along the eastern section of the tract and their numbers are noted in Tables 21 and 22. Because of the well-known ability of *Phragmites australis* to withstand many forms of assault, we will continue to periodically monitor these areas and spray the plants with herbicide.

3.5 Conclusions

Year four vegetation monitoring was performed on August 17th and August 18th of 2004. This monitoring found all three habitat types, cypress gum tidal swamp, scrub shrub, and tidal freshwater marsh, to meet their respective vegetation success criterion.

In the cypress gum tidal swamp habitat, an average of 160 trees/acre was achieved. This is less than the 276.7 trees/acre observed in 2003 and is largely due to a decrease in the number of volunteer shrub species (*Baccharis halimifolia* and *Sapium sebiferum*) observed in Plot #1. When counting only the bald cypress and black gum species, the average was 83.3 trees/acre. This value surpasses the success criterion of 40 trees/acre. The supplemental planting that occurred in the spring of 2002 was instrumental in achieving this success.

The survival rate of planted and acceptable volunteer vegetation within the tidal scrub shrub habitat was 95%. This rate exceeded 100% because the formula includes volunteer herbaceous and woody species. Although this value exceeded the survival success criterion of 70%, it was a slight decrease from the 122% survival rate observed in 2003. The drop in survivorship was most likely due to an overall equilibration of species' density within the site. In fact, the density value observed in 2004 (5.7) was very similar to that observed in 2002 (5.8) and 2003 (5.6).

The survival rate of planted and acceptable volunteer vegetation within the tidal freshwater marsh habitat was 126%. As in 2003, this value greatly exceeded the survival success criterion of 70% largely because the cattails were repeatedly pushed down with lightweight equipment (i.e. trails for monitoring gauges) throughout the year, which allowed sunlight to penetrate to the ground. To ensure continued success, the cattails in the tidal freshwater marsh habitat will be periodically flattened to increase survivability of planted vegetation.

4.0 Summary

Both hydrology and vegetation success criteria were evaluated in this fourth year monitoring report at the McIntyre tract. This report compared fourteen automated gauges located within the McIntyre tract to seven automated gauges located within reference areas between October of 2003 and September of 2004. This comparison determined that six gauges (8, 9, 10, 11, 13, and 20) were within 10% of their reference gauge and nine gauges (7, 8, 9, 10, 11, 12, 13,

15E, and 20) were within 20%. Five gauges (14E, 16, 17, 18E, and 19) exceeded 20%. All McIntyre gauges except for gauge 7 had hydrology that was greater (or wetter) on average, than their corresponding reference gauges (see Appendix B). The biggest difference was again between gauge 17 and reference gauge 5R, which was 37.48%. Gauge 17 is located along a tidal creek, just south of the easternmost spoil pile. This area is extremely wet and is flooded a majority of the time. Data show that gauge 17 is much wetter than any other gauge at McIntyre or the reference areas.

The hydrology success criterion established in the mitigation plan required restored hydrology to be within 10% of reference hydrology. Six gauges meet this criterion and nine gauges are within 20%. However, all McIntyre gauges except for gauge 7 had hydrology that was greater (or wetter) on average, than that of the corresponding reference gauges (see Appendix B). Therefore, this mitigation has achieved its ultimate goal of restoring tidal flushing back to this area. Frequent visits to the site during varying times of the tidal cycle indicated that the restored elevations of this tract and the tidal creeks were allowing water to inundate the site during high tide and return to drier conditions during low tide. In addition, because planted wetland vegetation was surviving within the tract, it can be assumed that appropriate hydrology has been restored that was neither too wet nor too dry for the system. Although not all gauges met the hydrology success criterion of no greater than a 10% difference in tidal amplitudes between the McIntyre tract and the reference areas, the tract should not be considered a hydrological failure. In fact, when comparing two reference gauges (2R and 3R) located at the impact site, average tidal amplitude differences were approximately 24.20%. It appears that the established hydrology success criterion was too restrictive and did not allow for natural variation in amplitudes. A more appropriate and realistic success criterion may need to be developed by the agencies.

Salinity data taken at each gauge show that salinity readings within the McIntyre tract are similar to readings taken within reference areas. Average salinity differences for the three habitat types at the McIntyre tract and the reference areas were 1.1 ppt (cypress/gum), 0.9 ppt (shrub scrub), and 1.0 ppt (freshwater marsh). Values taken within the McIntyre tract ranged from 0 ppt – 9 ppt (post-project) while values taken within reference areas ranged from 2 ppt – 5 ppt (post-project). Based on natural variation of salinity readings in any aquatic habitat, the salinity differences between the McIntyre site and reference areas were small enough to fulfill the salinity success criterion of ‘matching’.

A comparison of pre-construction hydrology data and post-construction hydrology data determined that average post-construction tidal amplitudes were significantly higher than average pre-construction tidal amplitudes for five of the six gauges. Abnormally low tides were experienced within the project area during the post-construction data period, which was likely the reason that gauge 14E did not meet this objective in 2003.

Year four vegetation monitoring was performed in August of 2004. This monitoring found all three habitat types; cypress gum tidal swamp, scrub shrub, and the tidal freshwater marsh, to meet their respective vegetation success criterion.

In the cypress gum habitat, an average of 160 trees/acre was achieved. When including only the bald cypress and black gum species, the average was 83.3 trees/acre. This value surpassed the success criterion of 40 trees/acre.

The survival rate of planted and volunteer vegetation within the tidal scrub shrub habitat was 95%. Although this value exceeded the survival success criterion of 70%, it was a decrease from the 122% survival rate observed in 2003. This drop in survivorship was most likely due to an overall equilibration of species' density within the site. In fact, the density value observed in 2004 (5.7) was very similar to that observed in 2002 (5.8) and 2003 (5.6).

The survival rate of planted and volunteer vegetation within the tidal freshwater marsh habitat was 126%. As in 2003, this value greatly exceeded the survival success criterion of 70% largely because the cattails were repeatedly pushed down with lightweight equipment (i.e. trails for monitoring gauges) throughout the year, which allowed sunlight to penetrate to the ground. To ensure continued success, the cattails in the tidal freshwater marsh habitat will be periodically flattened to increase survivability of planted vegetation.

Based on the hydrology and vegetation data collected throughout the fourth year of monitoring, it has been determined that the McIntyre Tract is a mitigation success thus far.

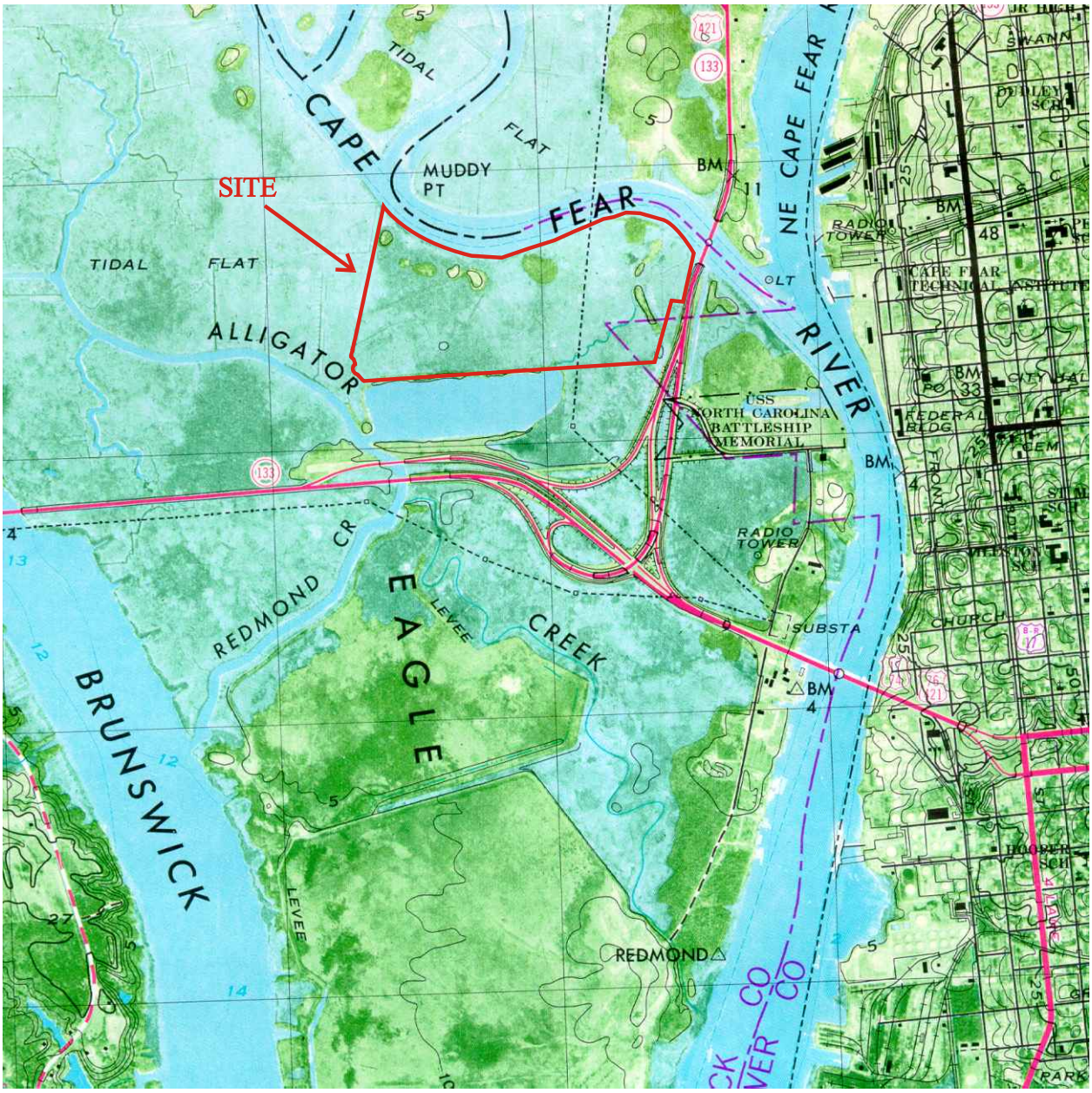

Figure 1. Vicinity map.

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December 2004

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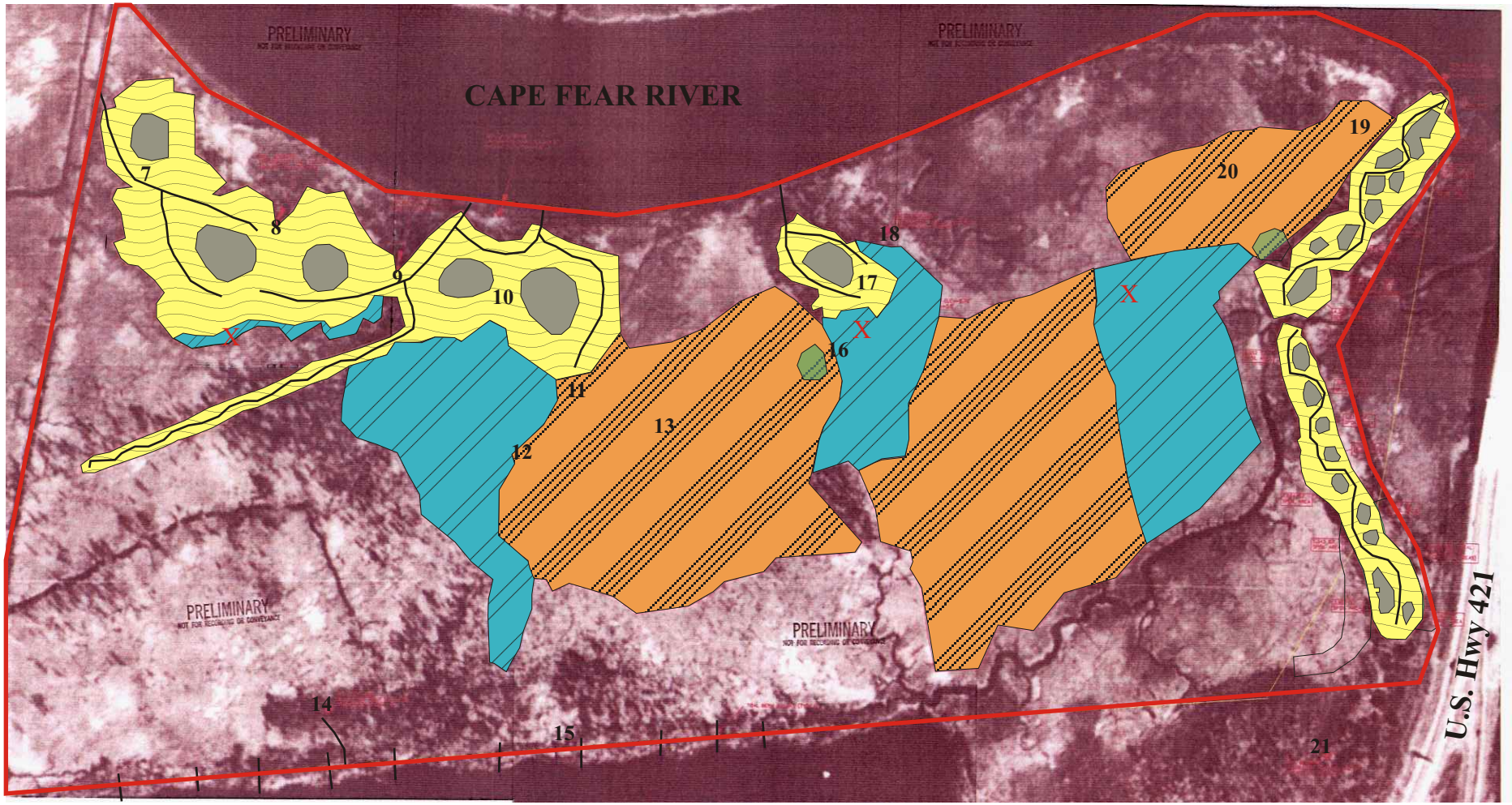
5 6 (Reference wells)



Restored Cypress/Gum Swamp (12.3 ac)
Restored Tidal Freshwater Marsh (25.12 ac)
Restored Tidal Marsh/Shrub Scrub (17.02 ac)
Spoil Pile (2.74 ac)
Areas sprayed with herbicide in 2001 to eliminate *Phragmites*

X Cypress/Gum Vegetation Plot
— Created Tidal Creek
Gauge Location
Project Boundaries

N

Note: All areas not otherwise marked within the project boundaries are classified as Tidal Marsh/Shrub Scrub Enhancement 85.72 ac).

SCALE: 1" = 400'

Figure 2. Site plan showing habitat types, gauge locations, created tidal creeks, and cypress/gum vegetation plots.

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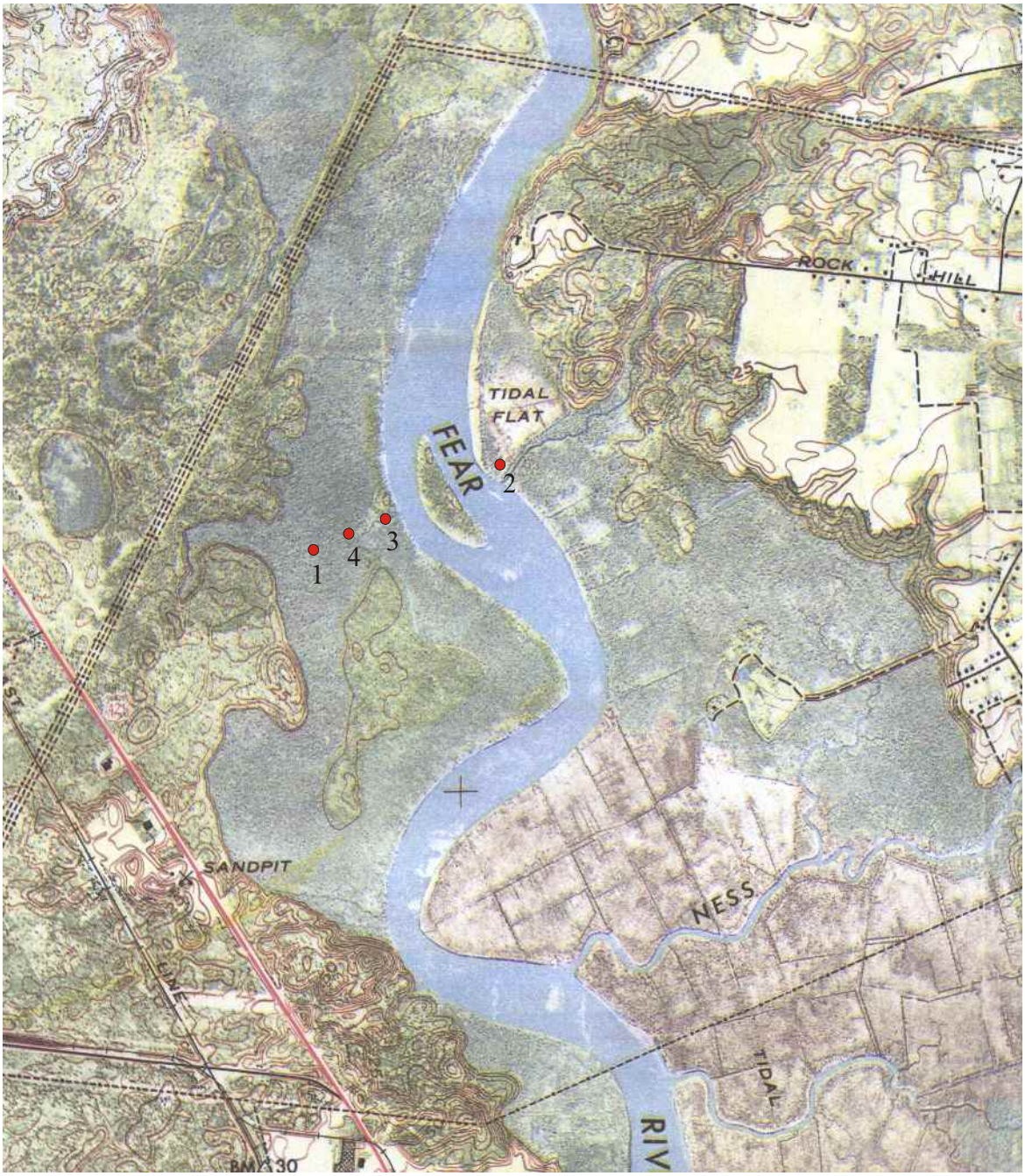

N

0 1000 2000 4000

SCALE 1" = 2000'

• Automated hydrology well

Figure 3. Location of wells at Rat Island (reference area/construction site).

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↓ View of McIntyre site from the Cape Fear River.

Tide gauge at McIntyre.
←

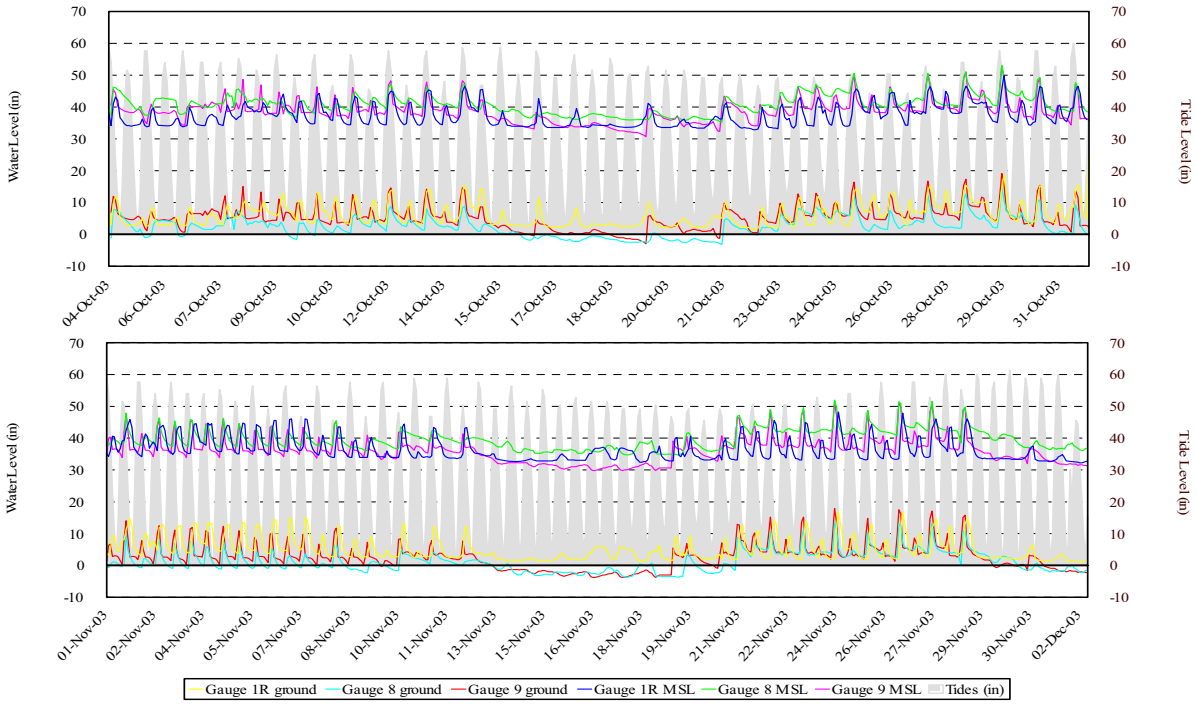
Appendix A. Pictures of site: Site monitoring performed in 2004.	***Land Management Group, Inc.*** **Environmental Consultants** Wilmington, N.C. December 2004	McIntyre Tract Wilmington Bypass Project Brunswick County, NC Year Four Monitoring Report

↓ Vegetation sampling within the freshwater marsh habitat at McIntyre.

Bald cypress tree within the cypress gum habitat.

←

Figure B.1. Hydrology Monitoring, Gauges 1R, 8, and 9



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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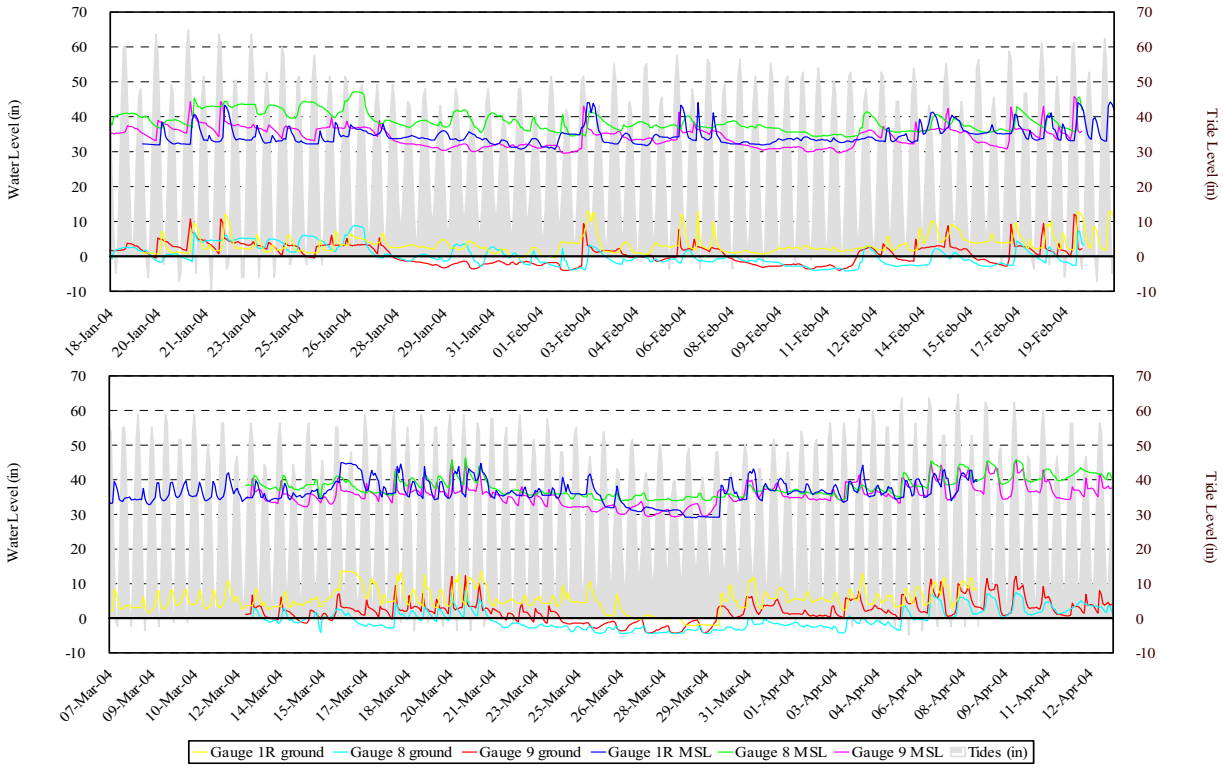
Figure B.1 contd. Hydrology Monitoring, Gauges 1R, 8, and 9



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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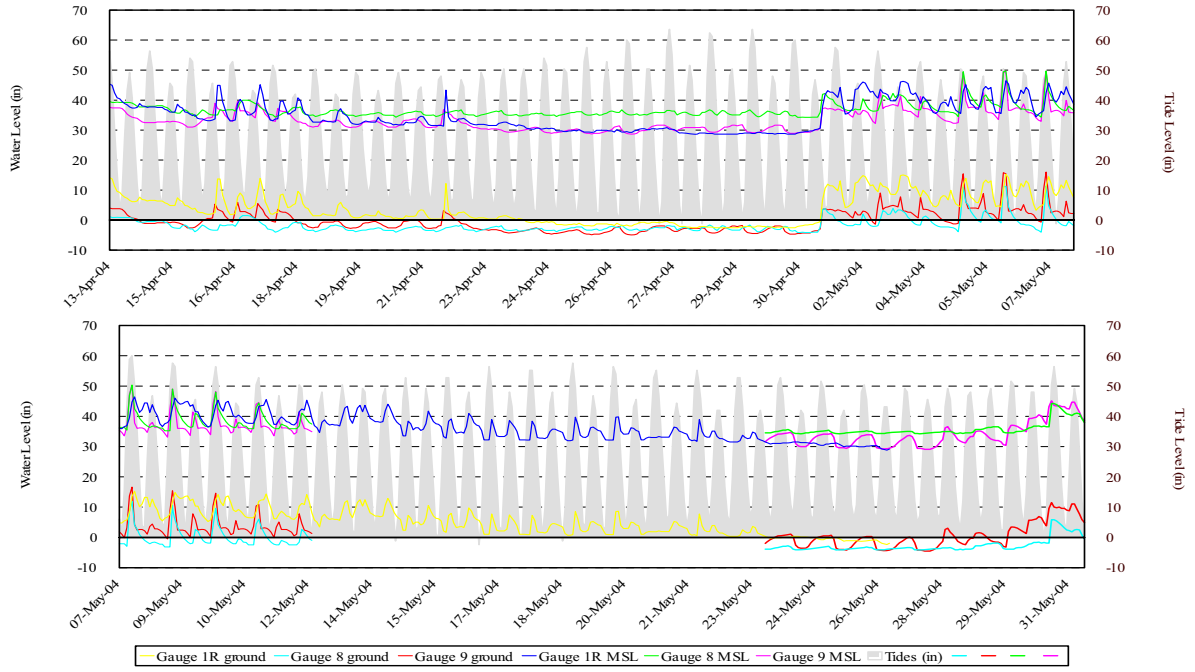
Figure B.1 contd. Hydrology Monitoring, Gauges 1R, 8, and 9



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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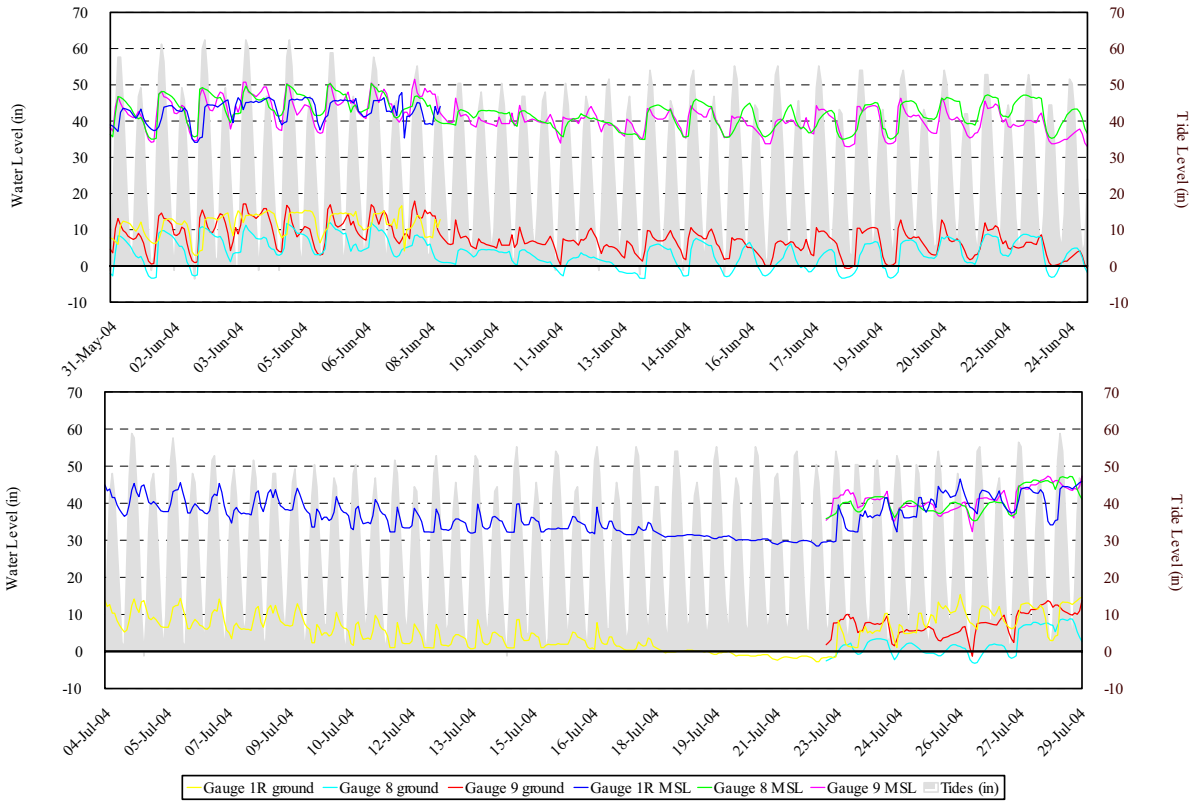
Figure B.1 contd. Hydrology Monitoring, Gauges 1R, 8, and 9



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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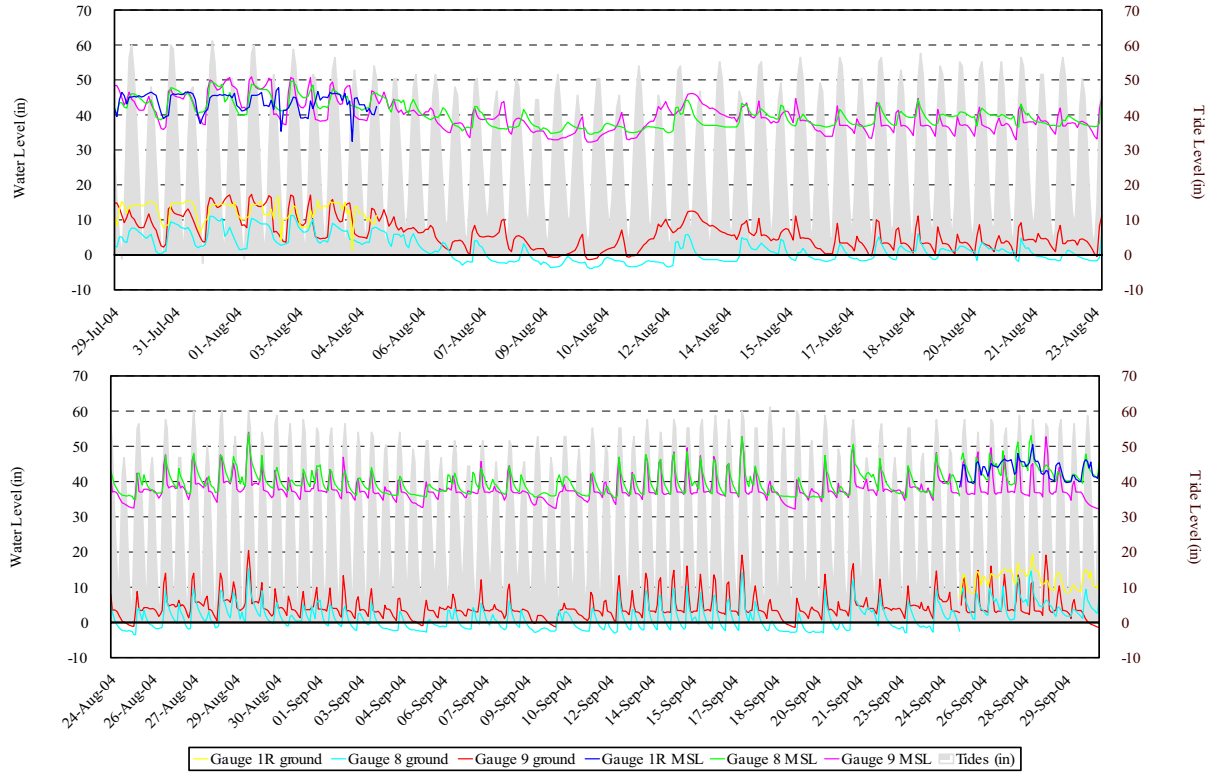
Figure B.1 contd. Hydrology Monitoring, Gauges 1R, 8, and 9



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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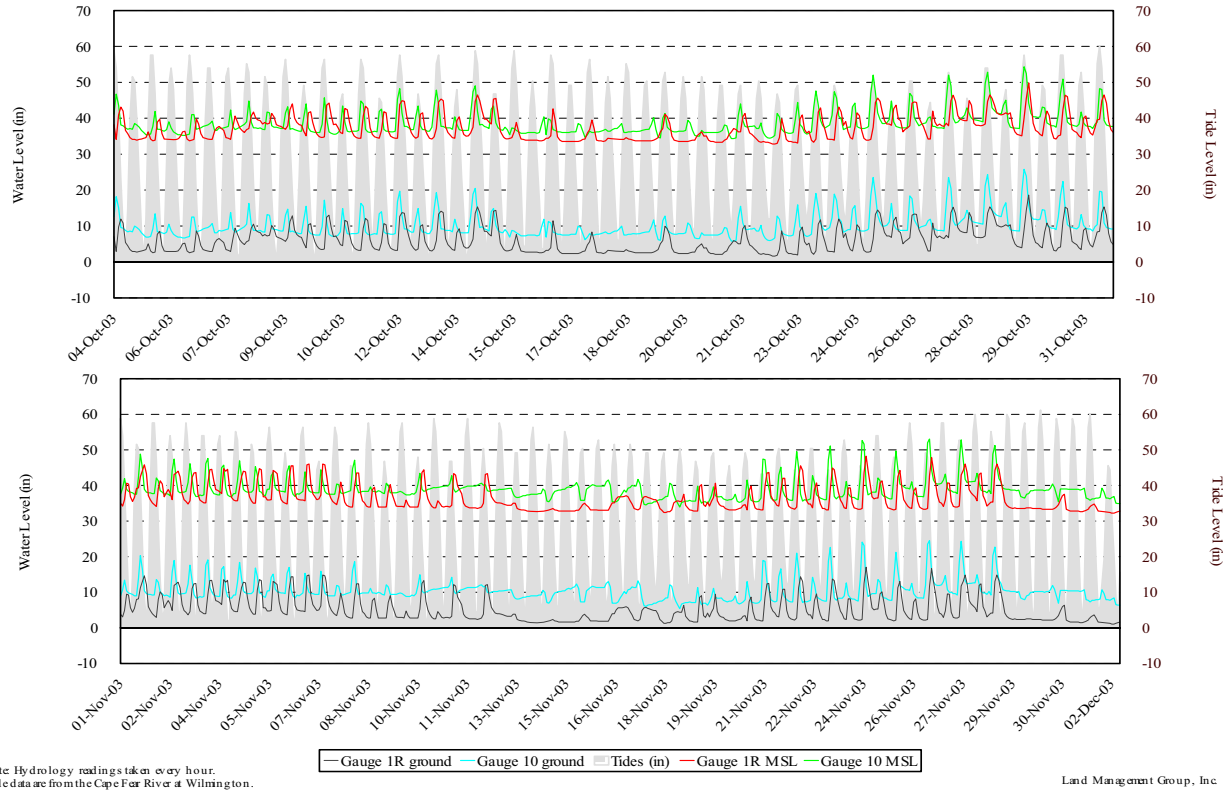
Figure B.2. Hydrology Monitoring, Gauges 1R and 10



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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Figure B.2 contd. Hydrology Monitoring, Gauges 1R and 10

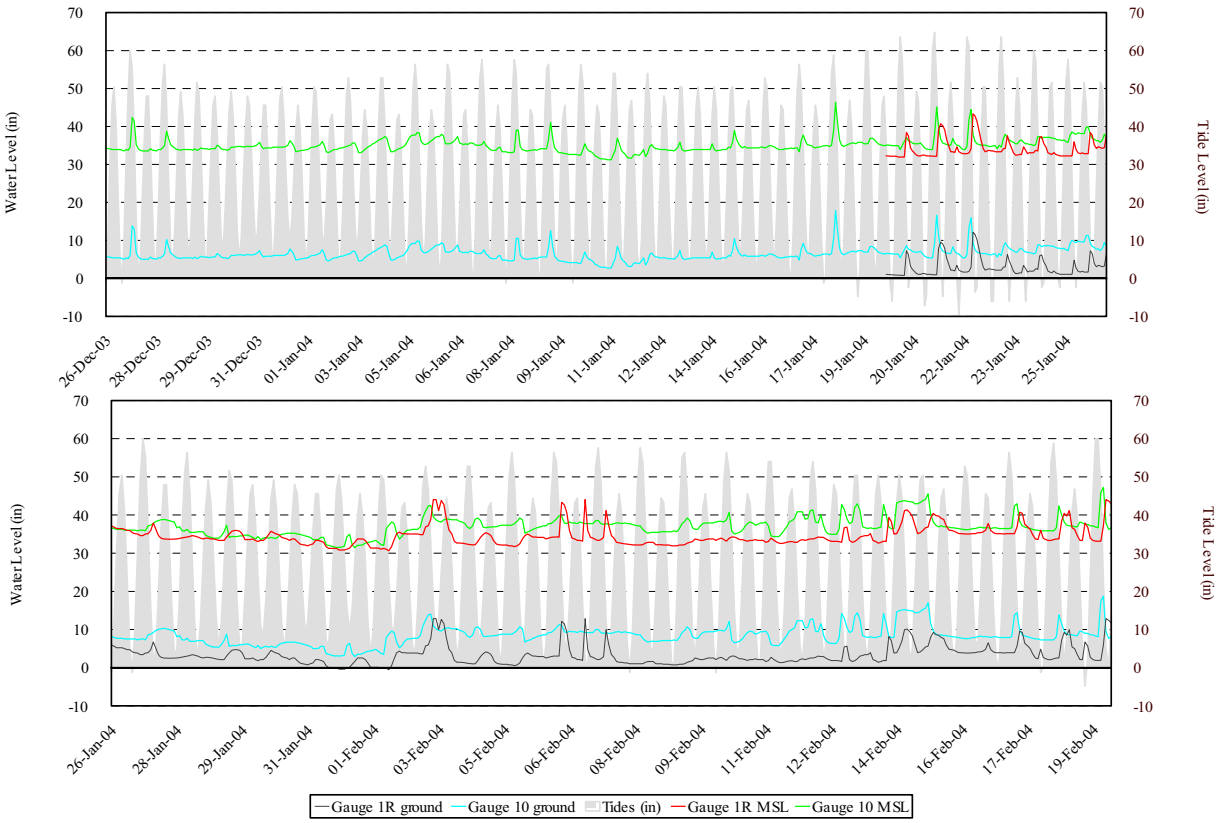


Figure B.2 contd. Hydrology Monitoring, Gauges 1R and 10

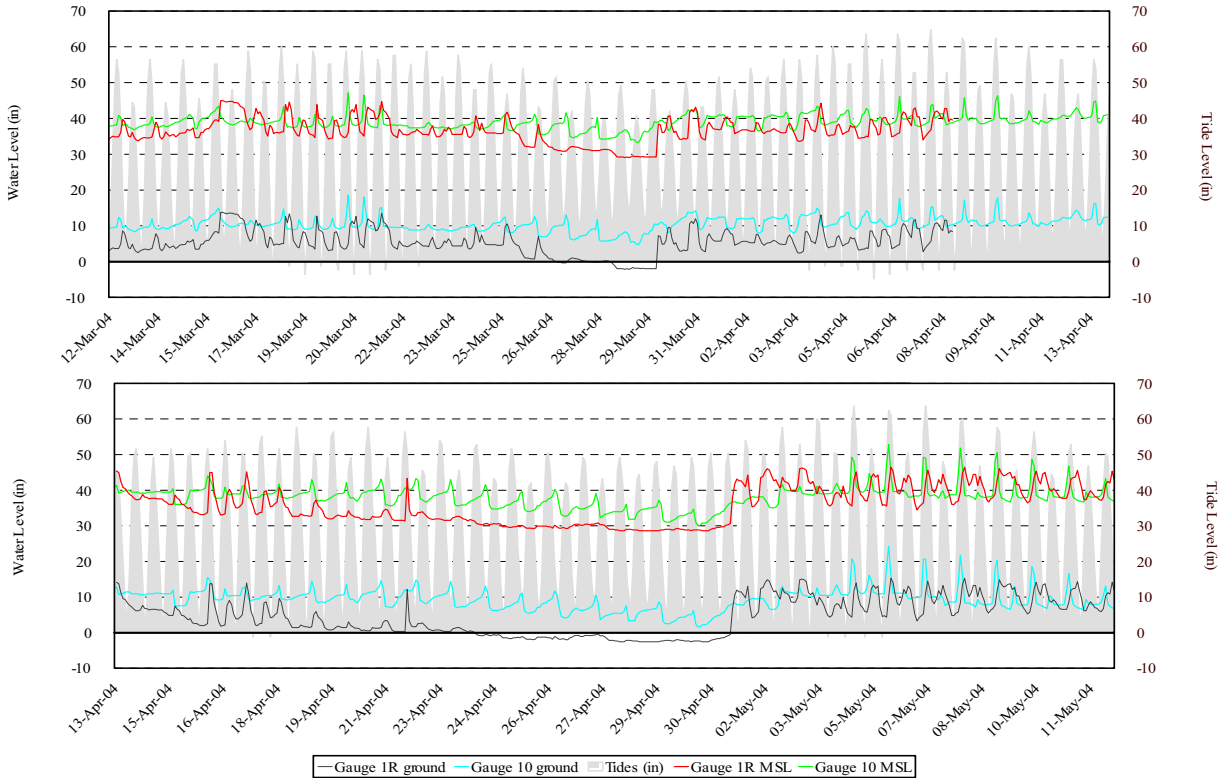


Figure B.2 contd. Hydrology Monitoring, Gauges 1R and 10

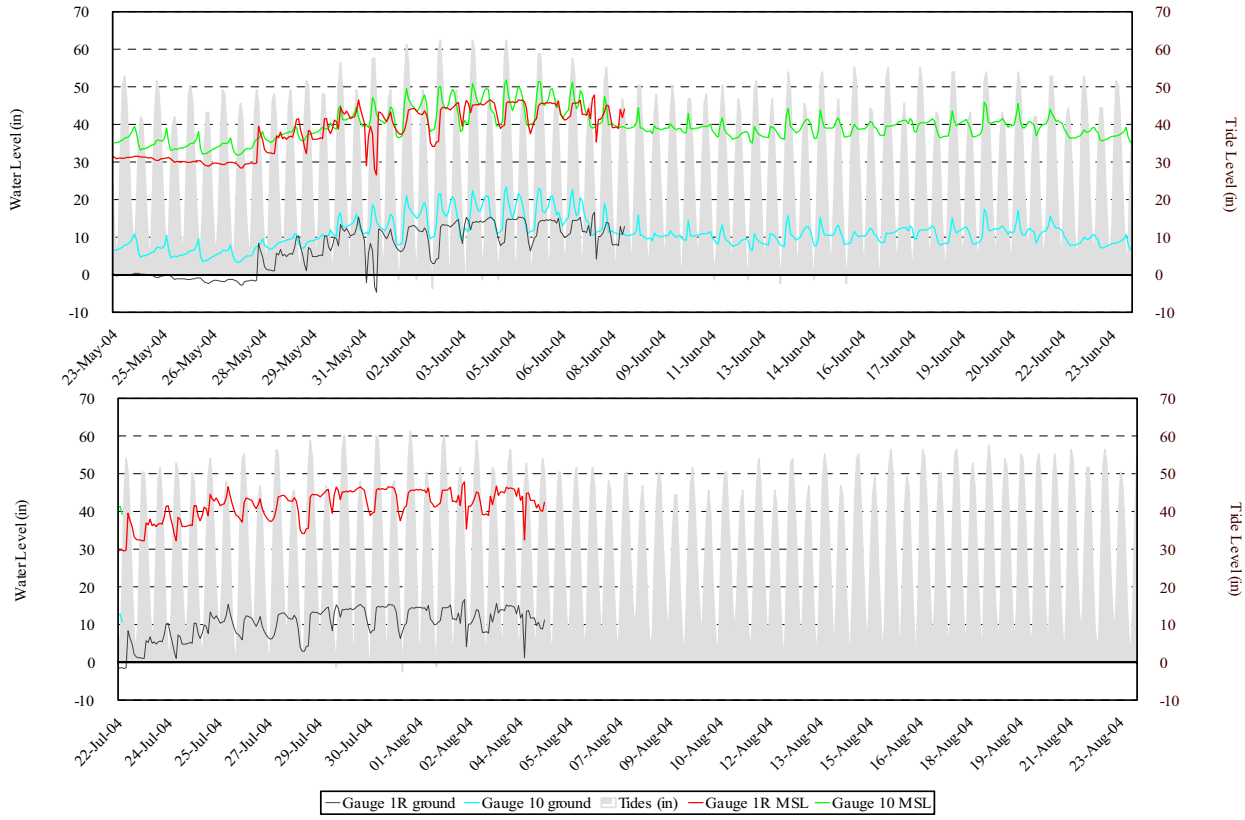


Figure B.2 contd. Hydrology Monitoring, Gauges 1R and 10

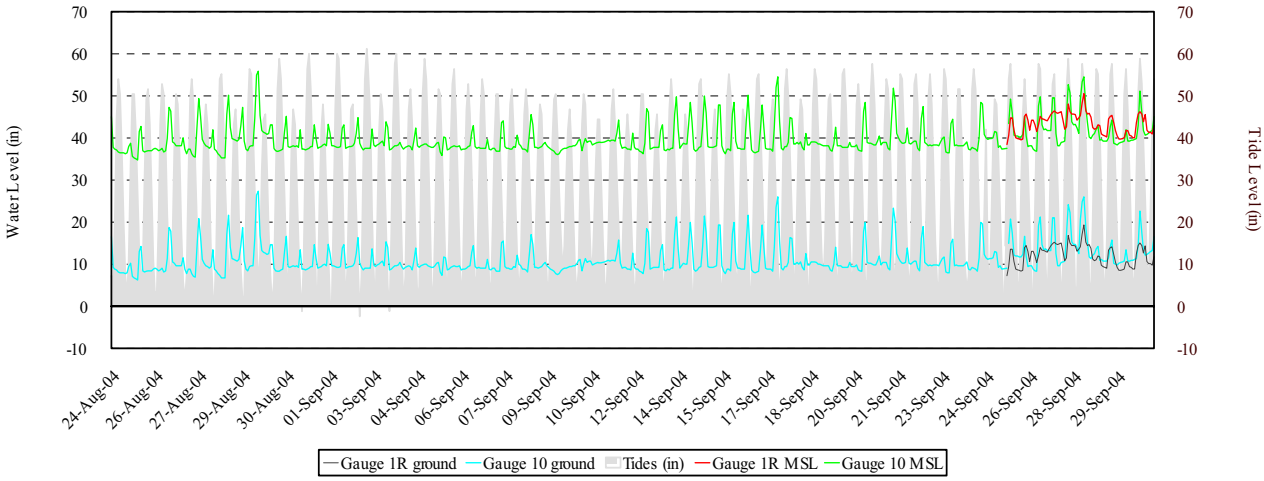
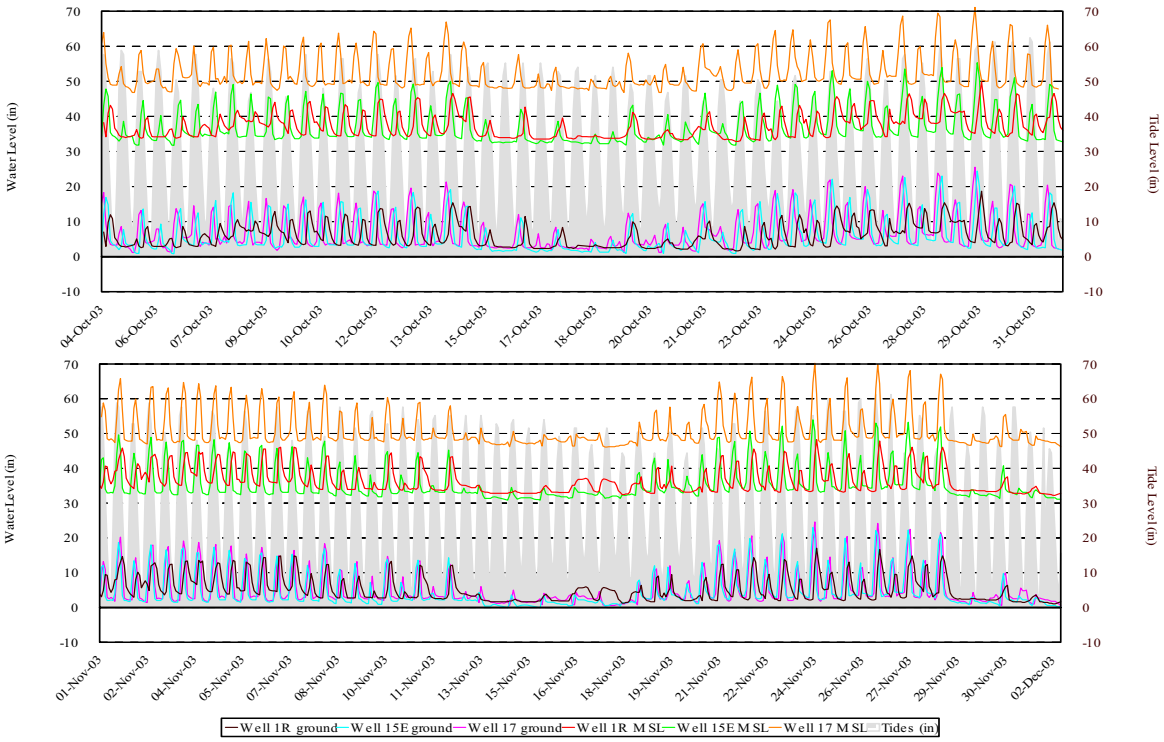


Figure B.3. Hydrology Monitoring, Gauges 1R, 15E, and 17



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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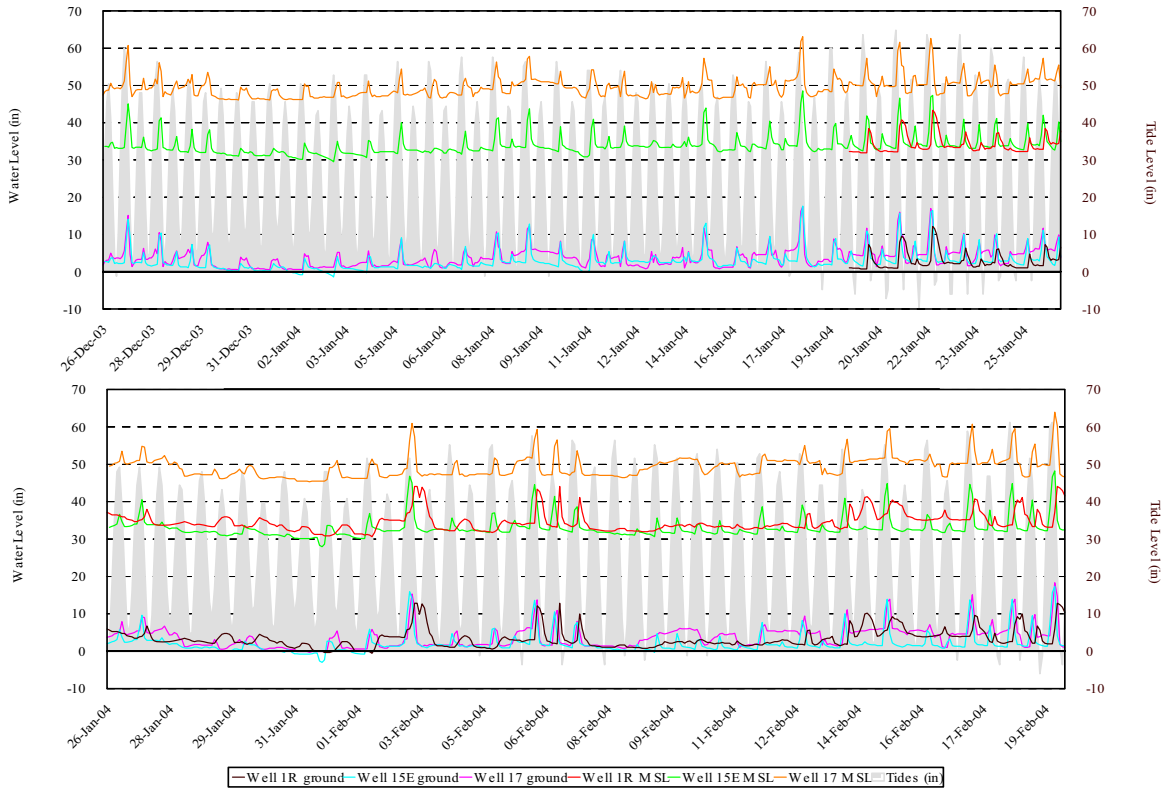
Figure B.3 contd. Hydrology Monitoring, Gauges 1R, 15E, and 17



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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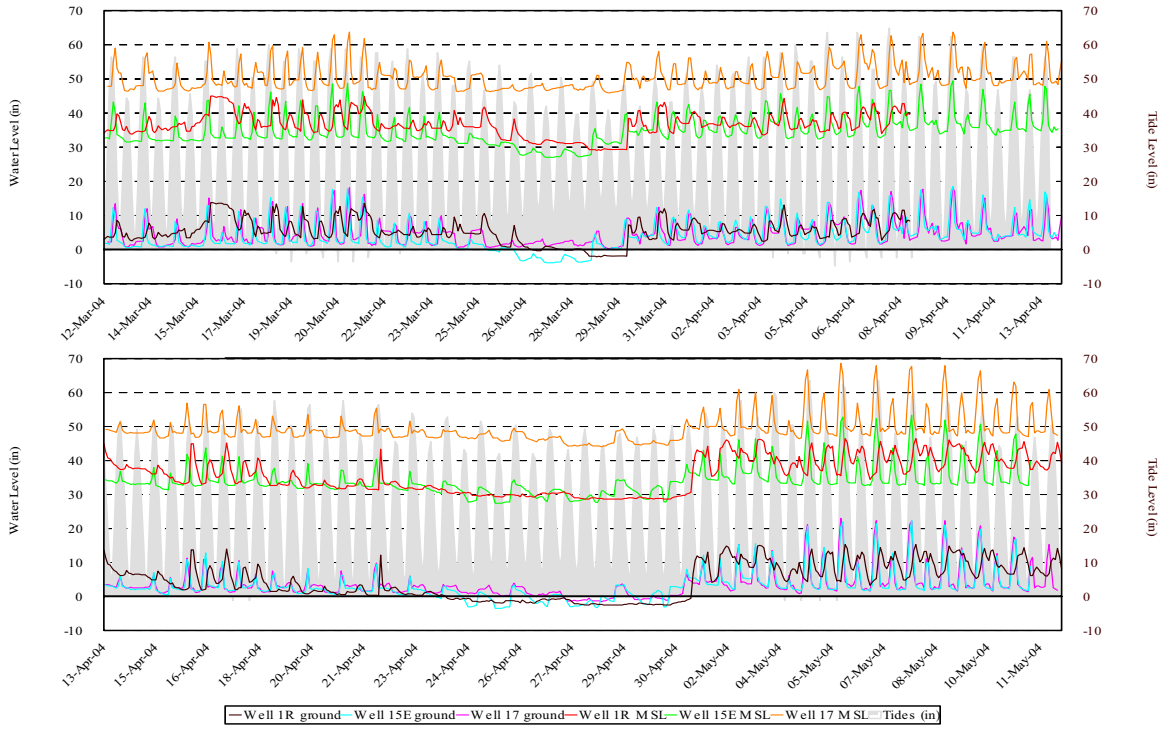
Figure B.3 contd. Hydrology Monitoring, Gauges 1R, 15E, and 17



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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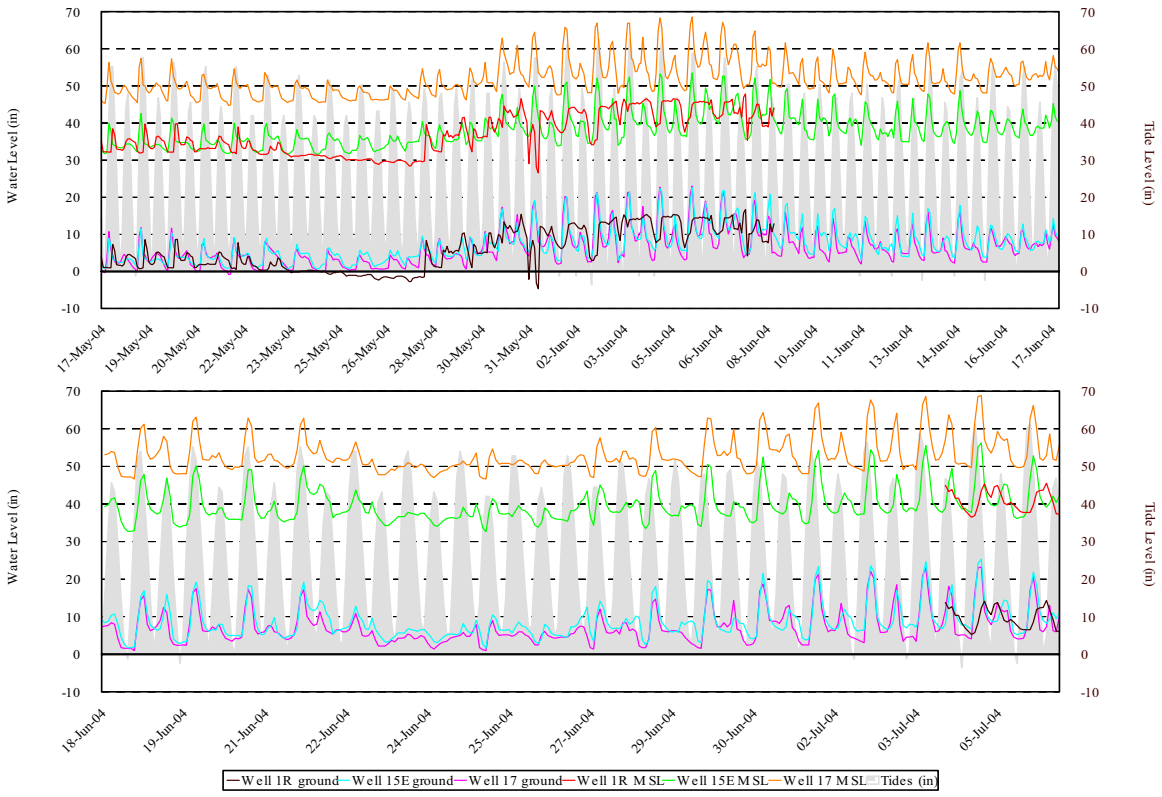
Figure B.3 contd. Hydrology Monitoring, Gauges 1R, 15E, and 17



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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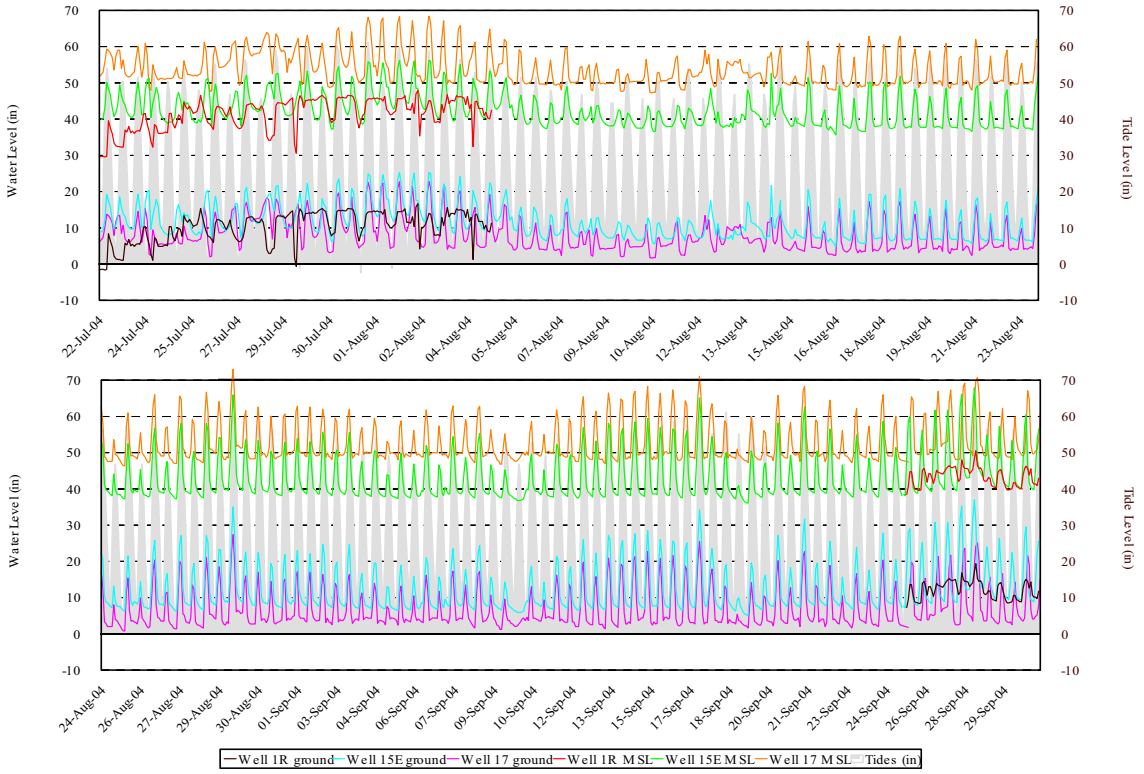
Figure B.3 contd. Hydrology Monitoring, Gauges 1R, 15E, and 17



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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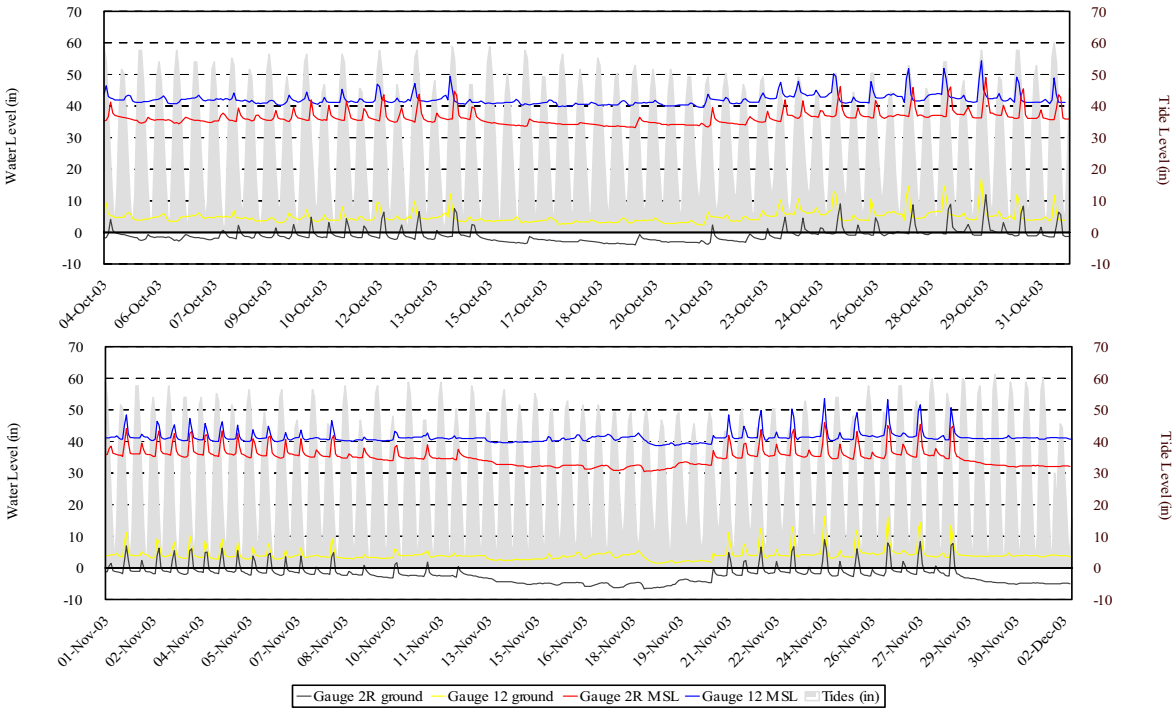
Figure B.4. Hydrology Monitoring, Gauges 2R and 12

Cypress Gum Swamp



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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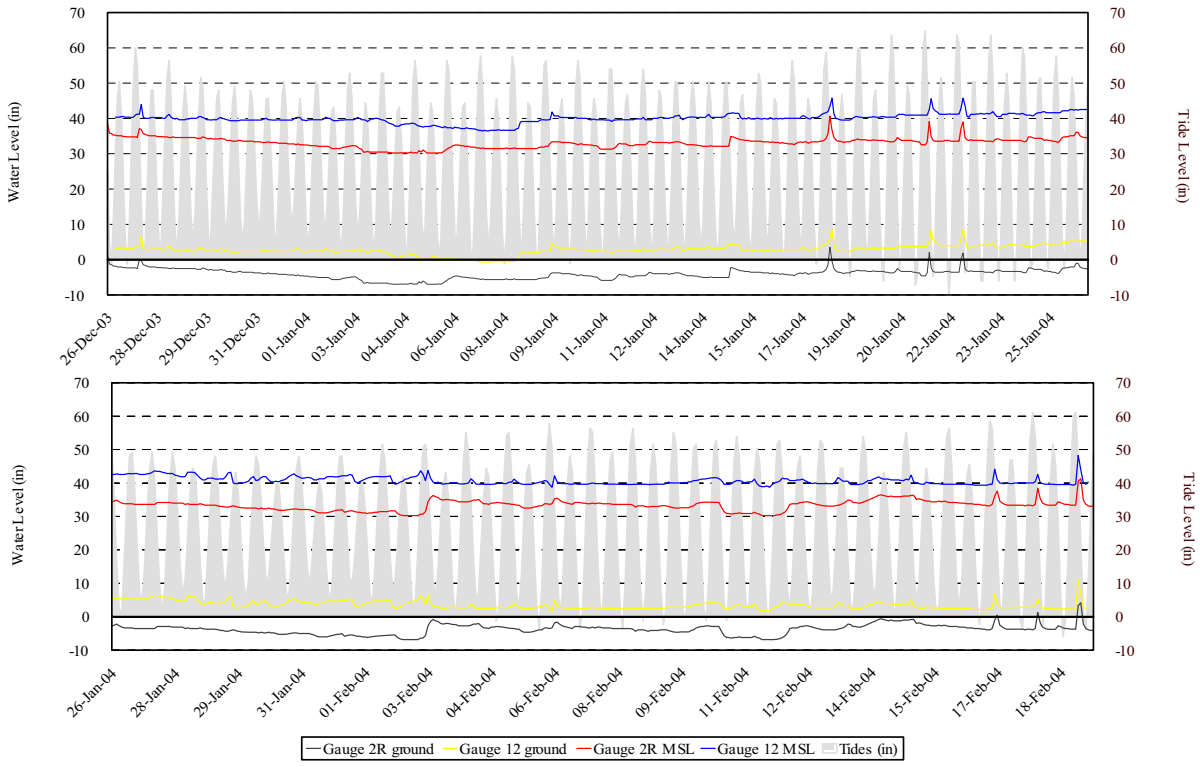
Figure B.4 contd. Hydrology Monitoring, Gauges 2R and 12

Cypress Gum Swamp



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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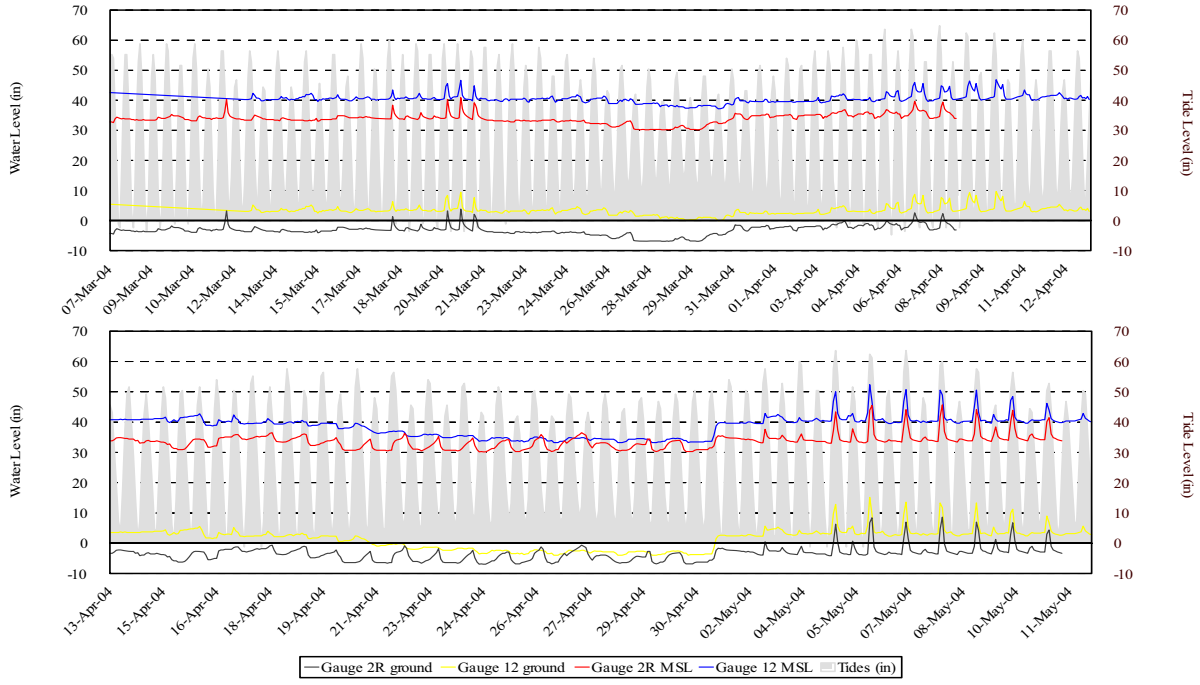
Figure B.4 contd. Hydrology Monitoring, Gauges 2R and 12
Cypress Gum Swamp



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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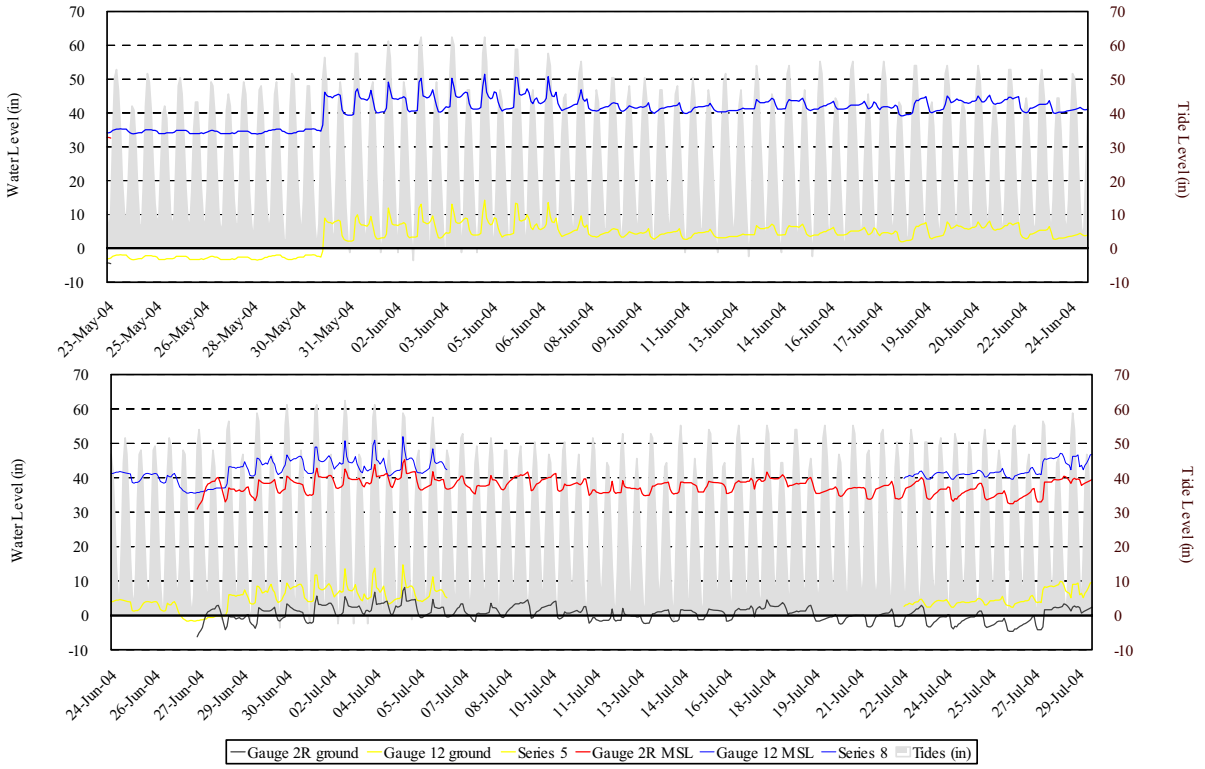
Figure B.4 contd. Hydrology Monitoring, Gauges 2R and 12
Cypress Gum Swamp



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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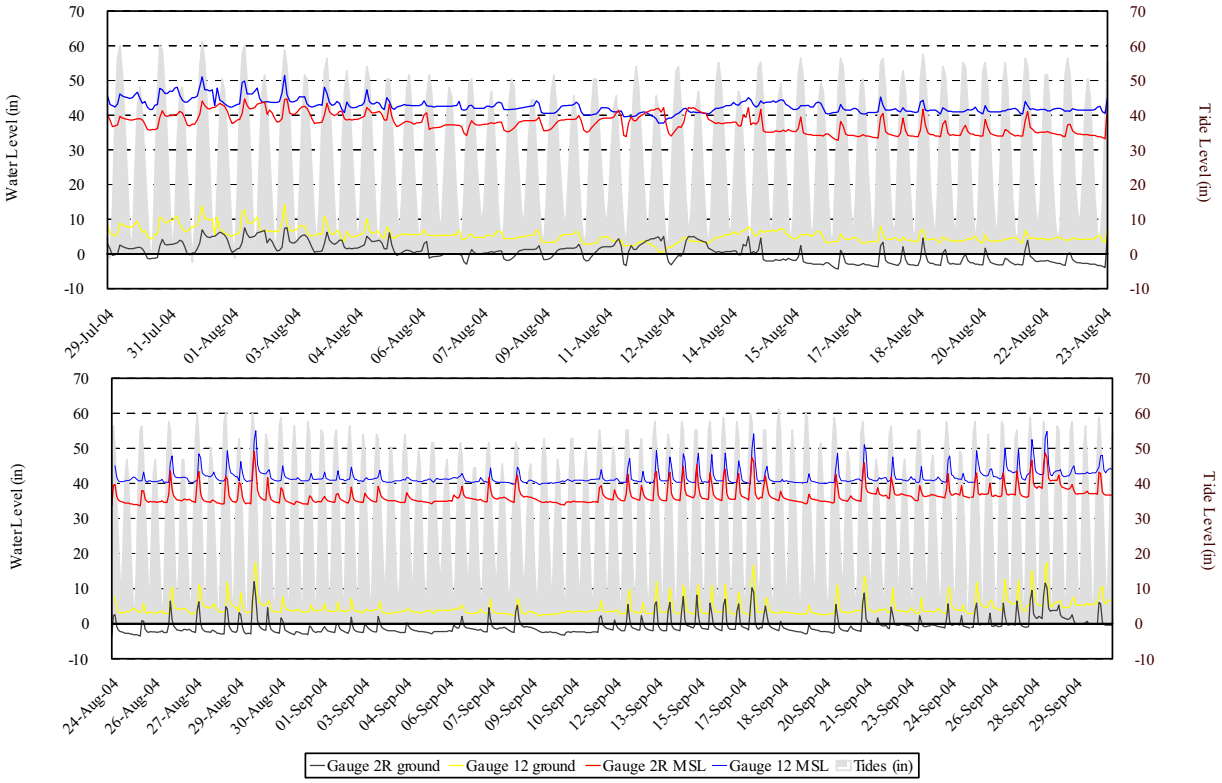
Figure B.4 contd. Hydrology Monitoring, Gauges 2R and 12

Cypress Gum Swamp



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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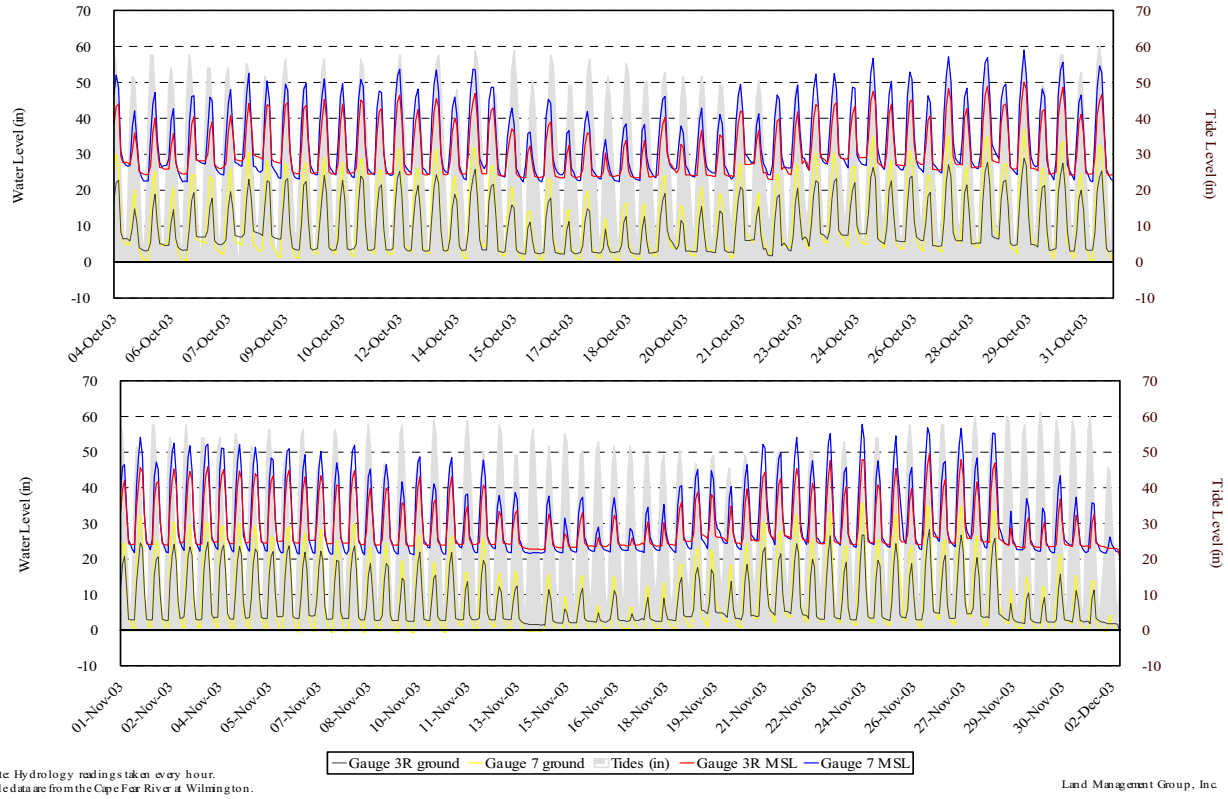
Figure B.5. Hydrology Monitoring, Gauges 3R and 7



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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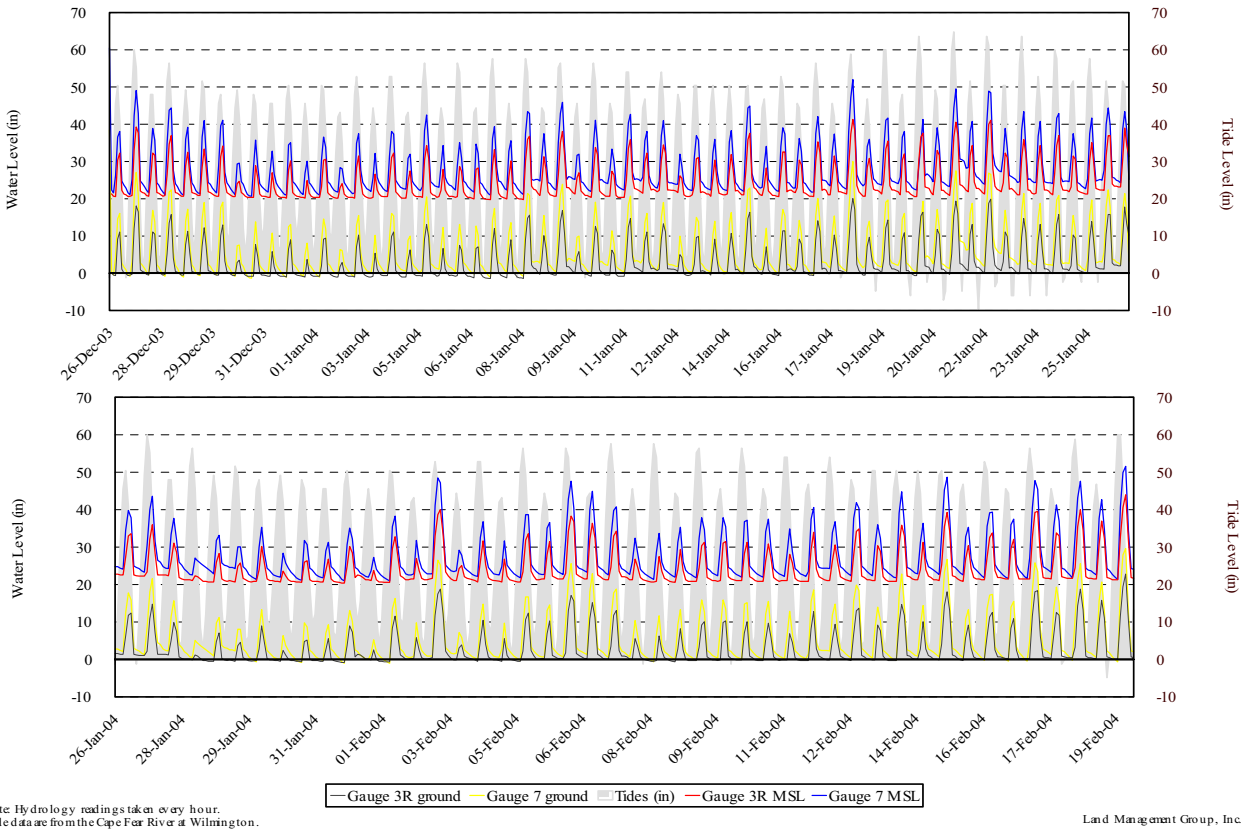
Figure B.5 contd. Hydrology Monitoring, Gauges 3R and 7



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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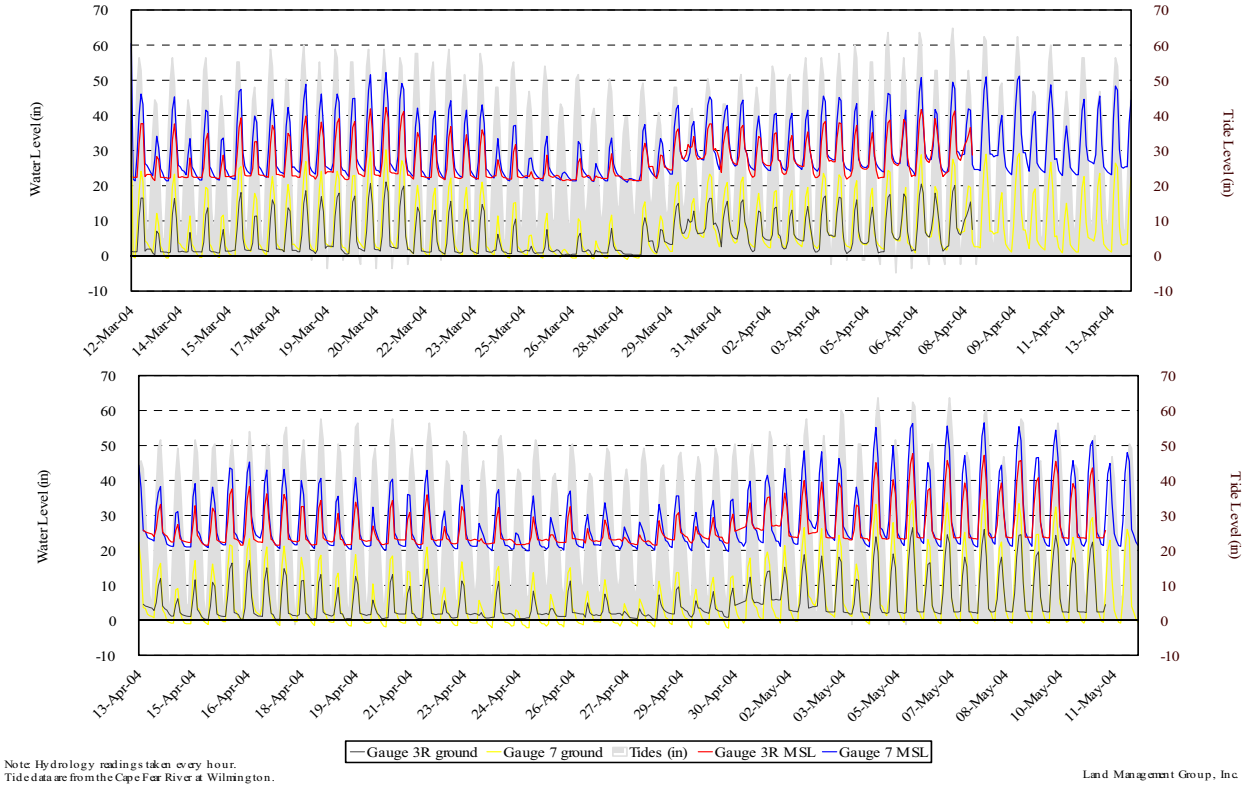
Figure B.5 contd. Hydrology Monitoring, Gauges 3R and 7



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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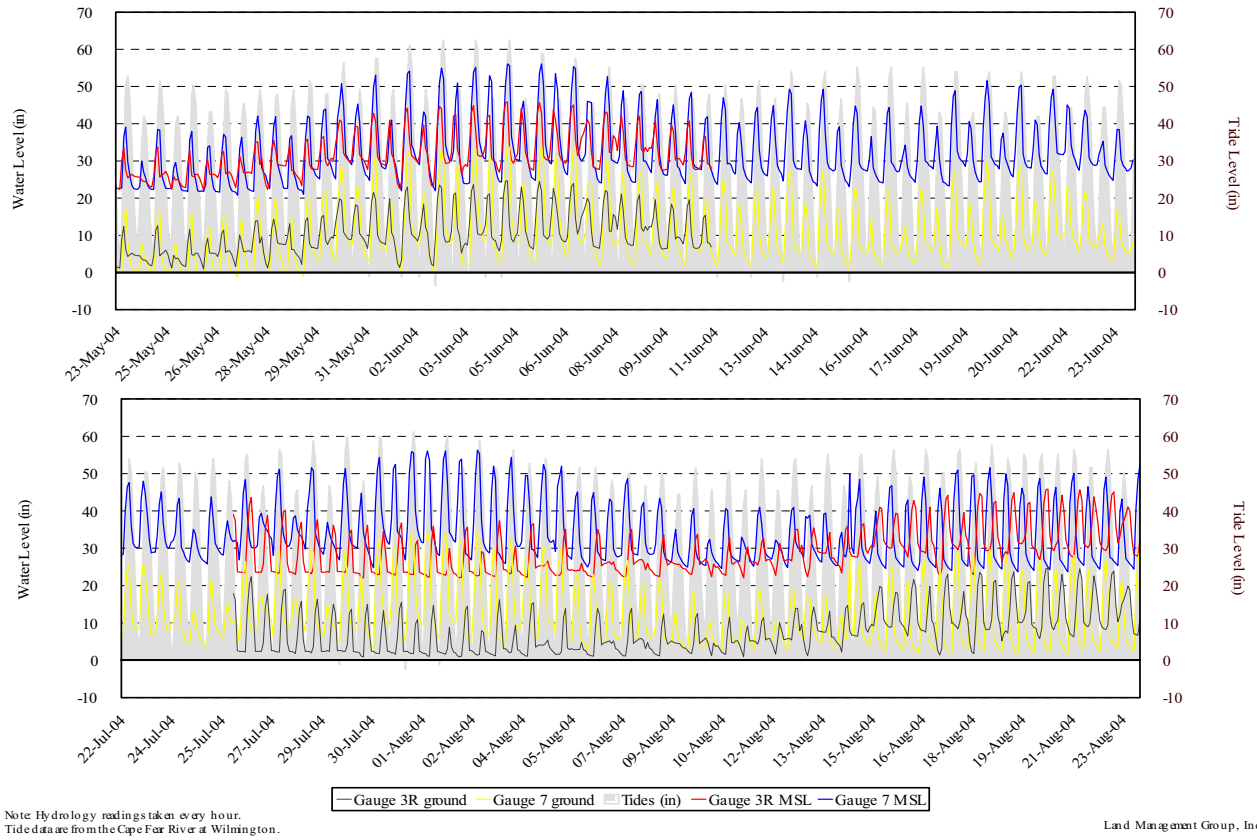
Figure B.5 contd. Hydrology Monitoring, Gauges 3R and 7



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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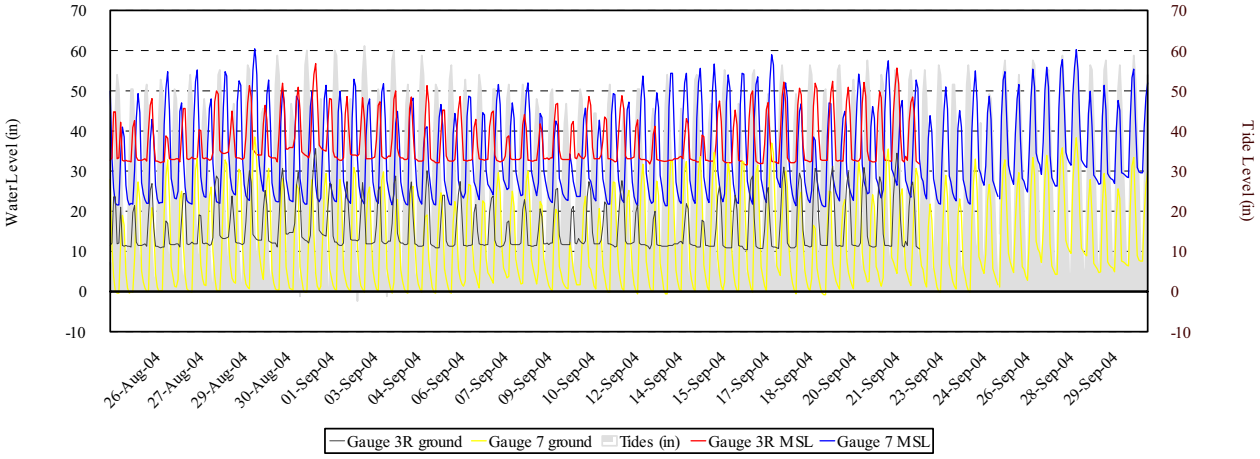
Figure B.5 contd. Hydrology Monitoring, Gauges 3R and 7



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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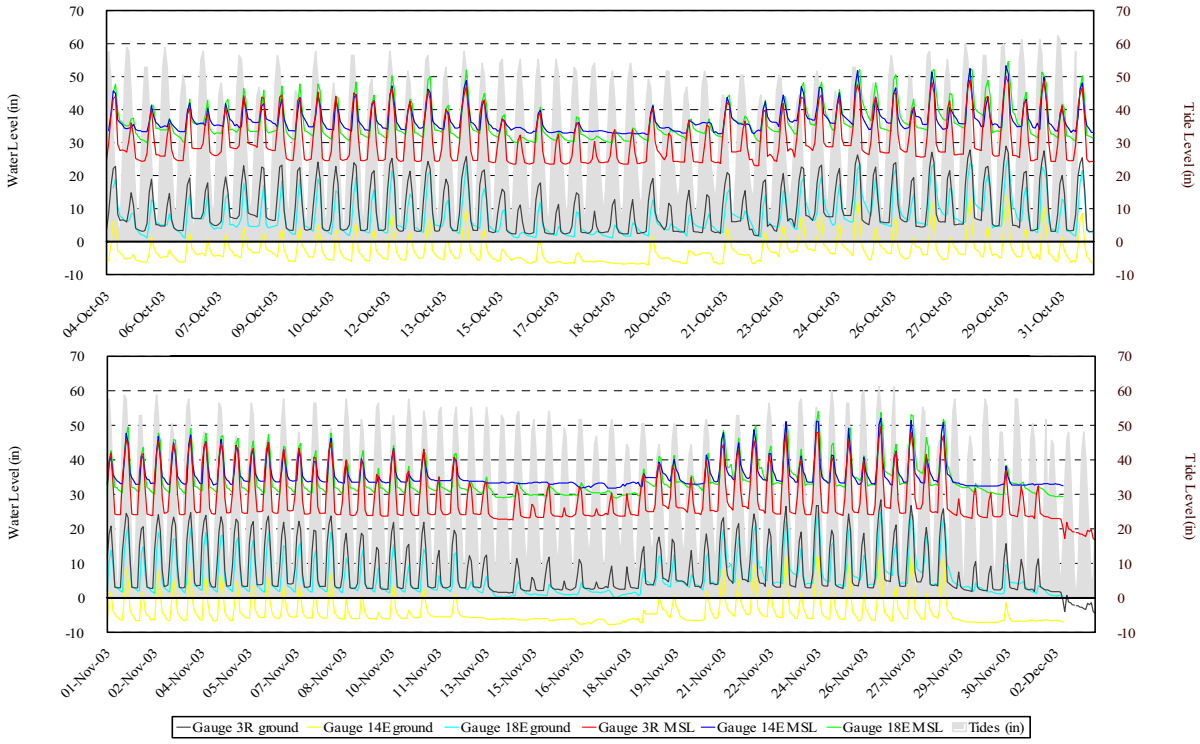
Figure B.6. Hydrology Monitoring, Gauges 3R, 14E, and 18E



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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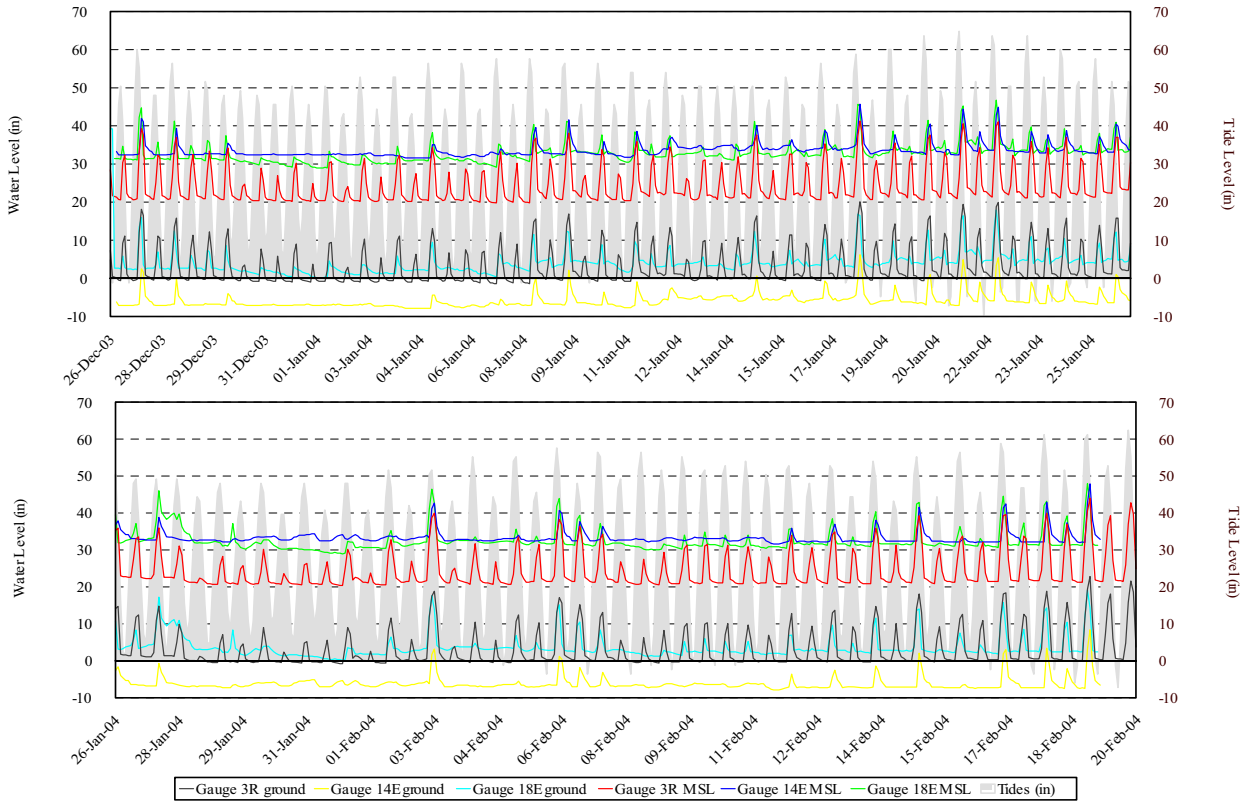
Figure B.6 contd. Hydrology Monitoring, Gauges 3R, 14E, and 18E



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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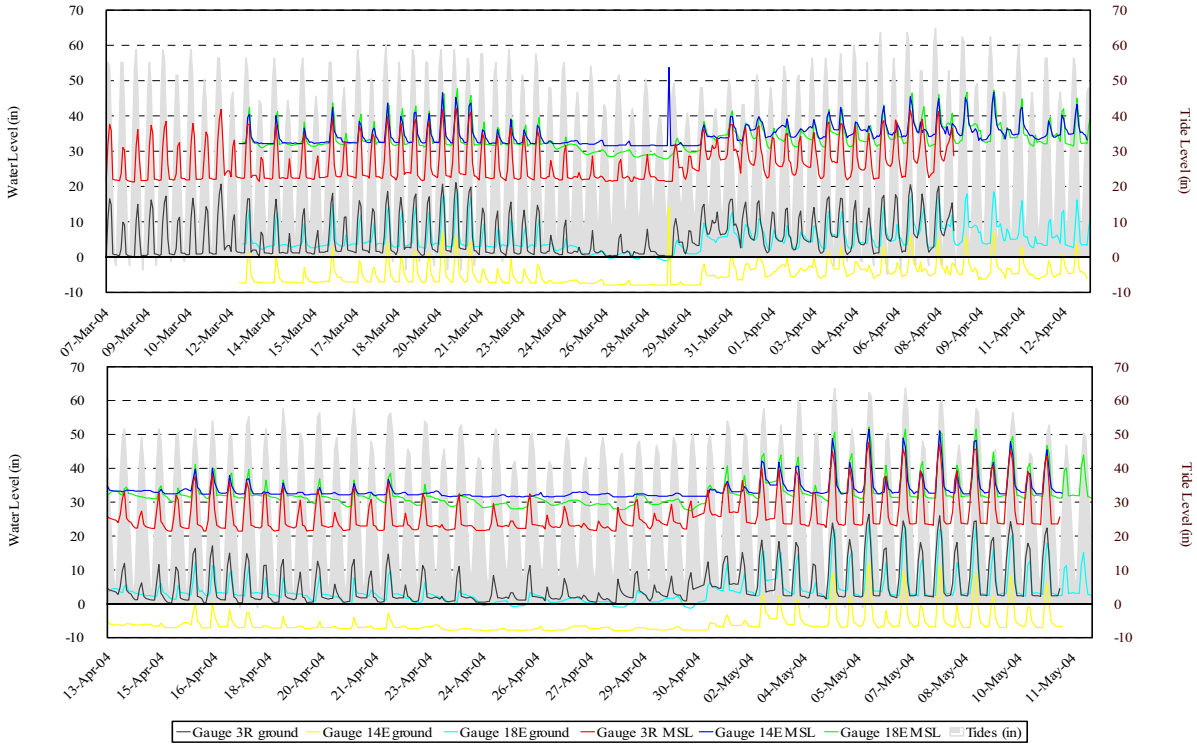
Figure B.6 contd. Hydrology Monitoring, Gauges 3R, 14E, and 18E



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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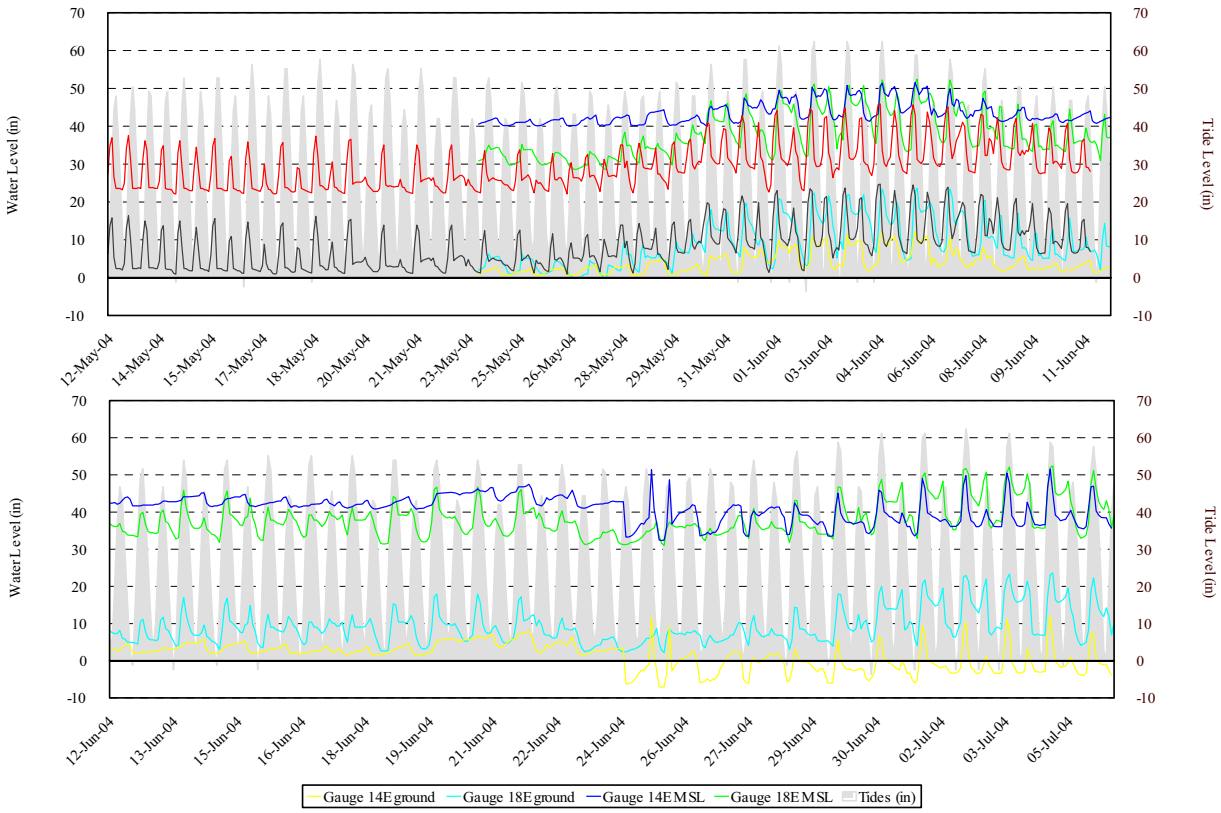
Figure B.6 contd. Hydrology Monitoring, Gauges 3R, 14E, and 18E



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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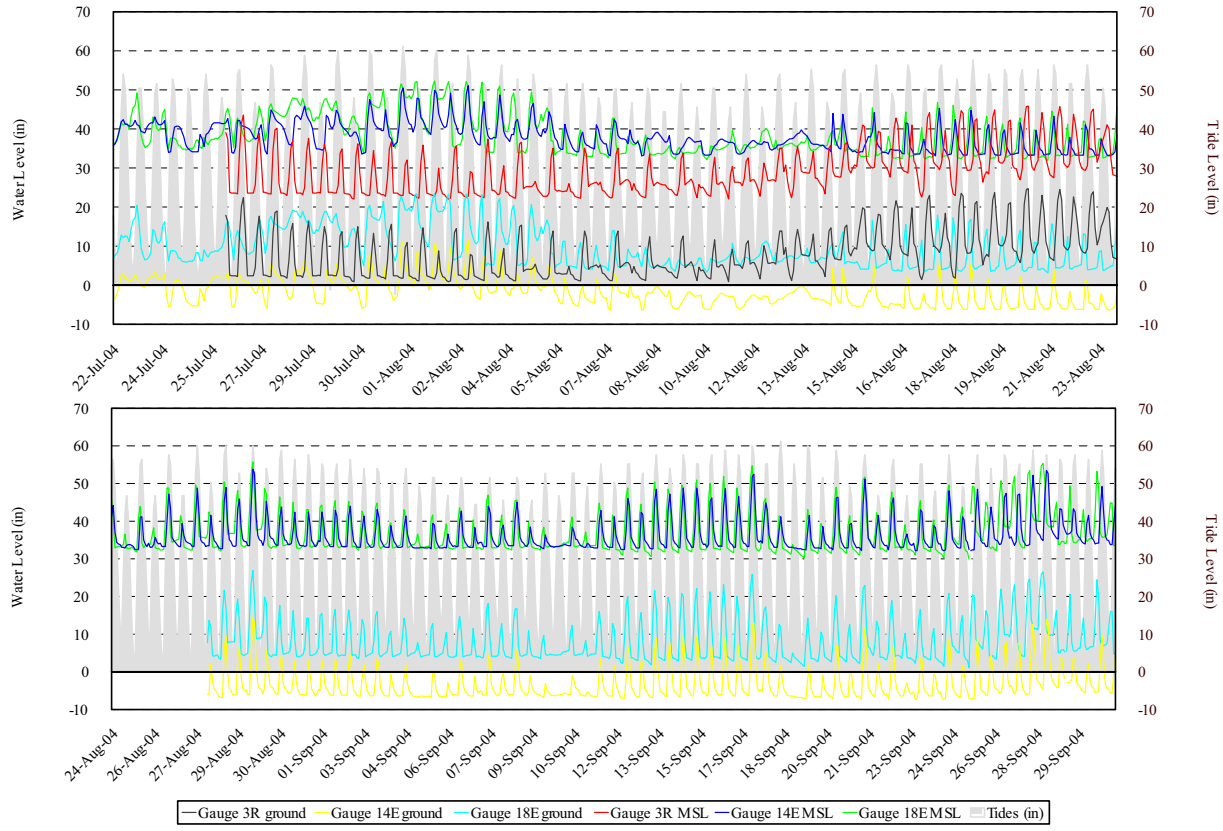
Figure B.6 contd. Hydrology Monitoring, Gauges 3R, 14E, and 18E



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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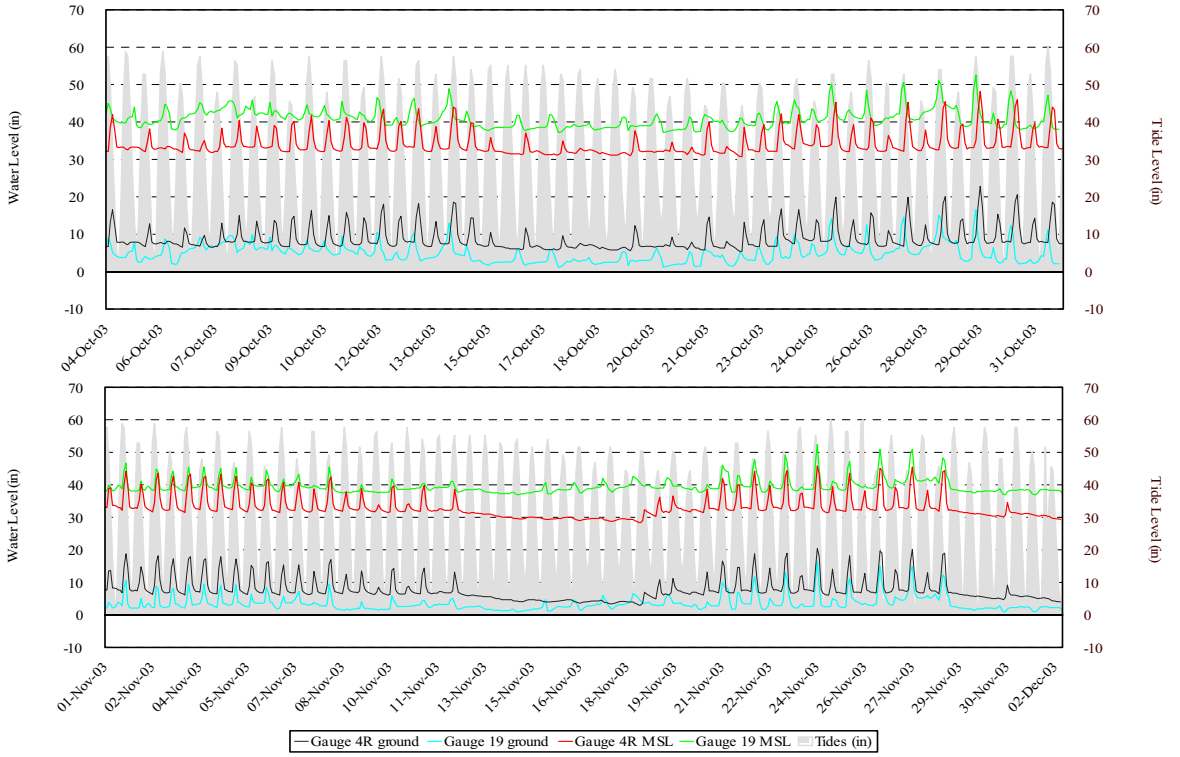
Figure B.7. Hydrology Monitoring, Gauges 4R and 19



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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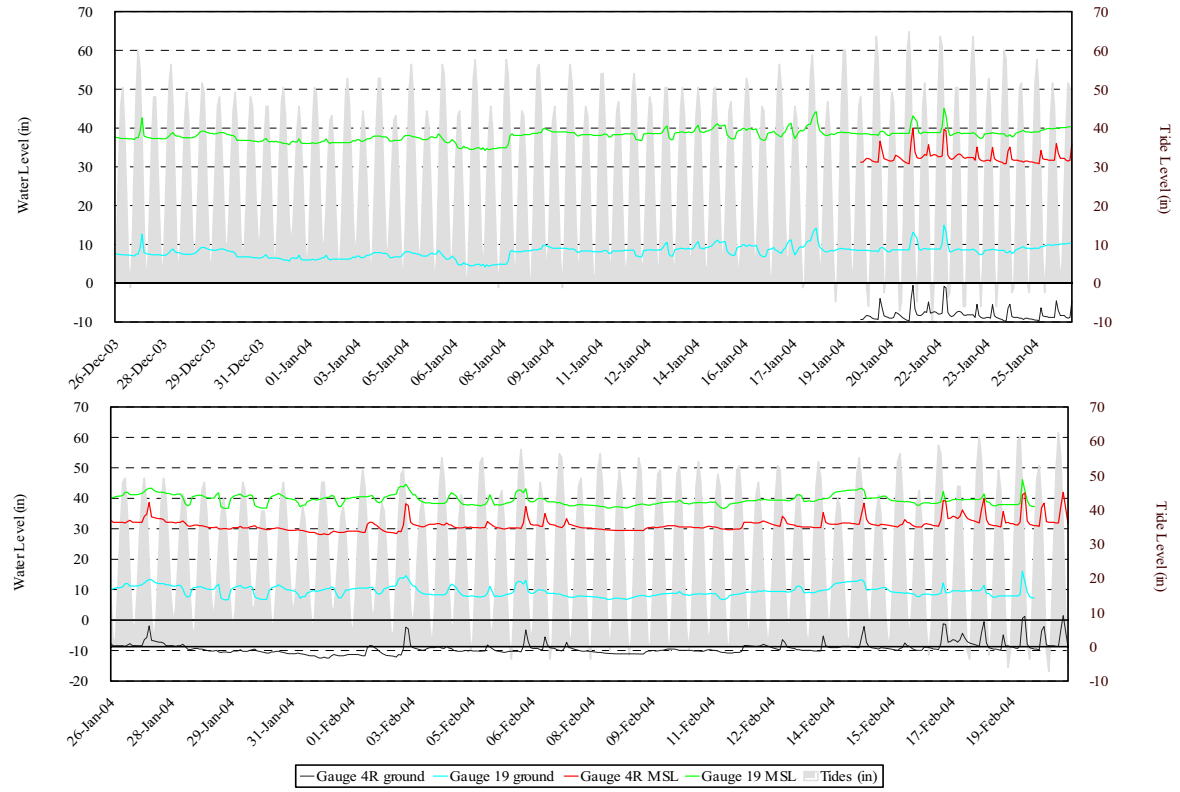
Figure B.7 contd. Hydrology Monitoring, Gauges 4R and 19



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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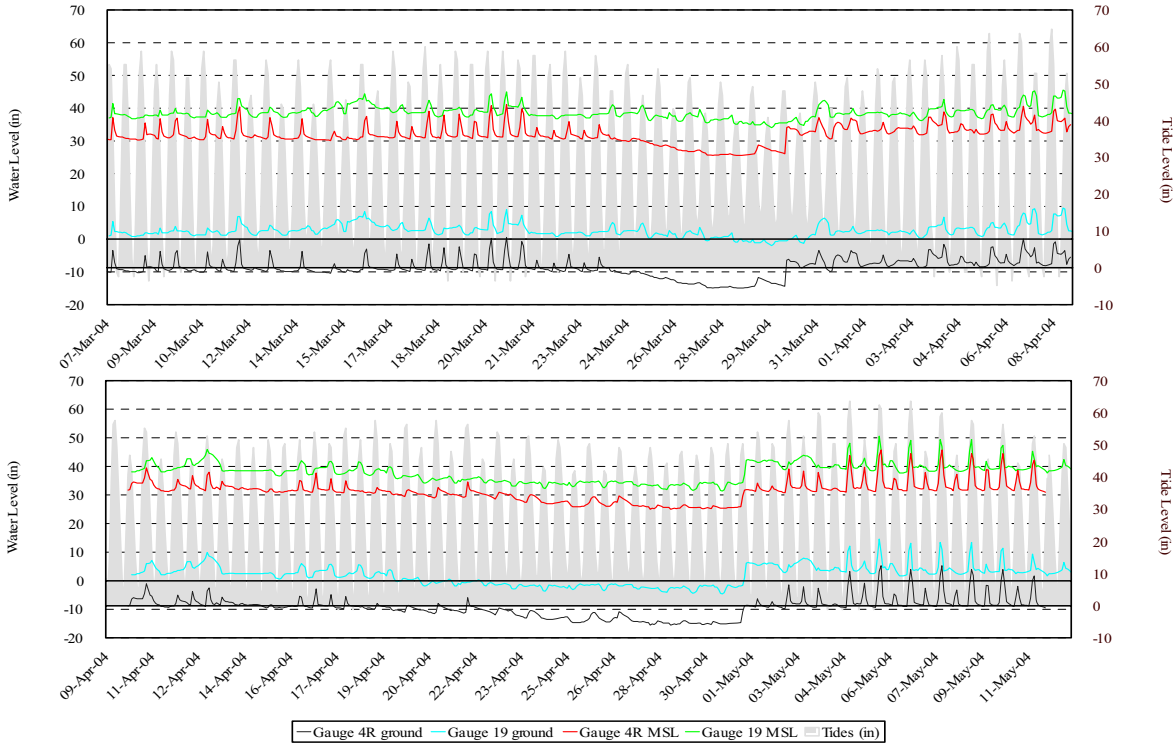
Figure B.7 contd. Hydrology Monitoring, Gauges 4R and 19



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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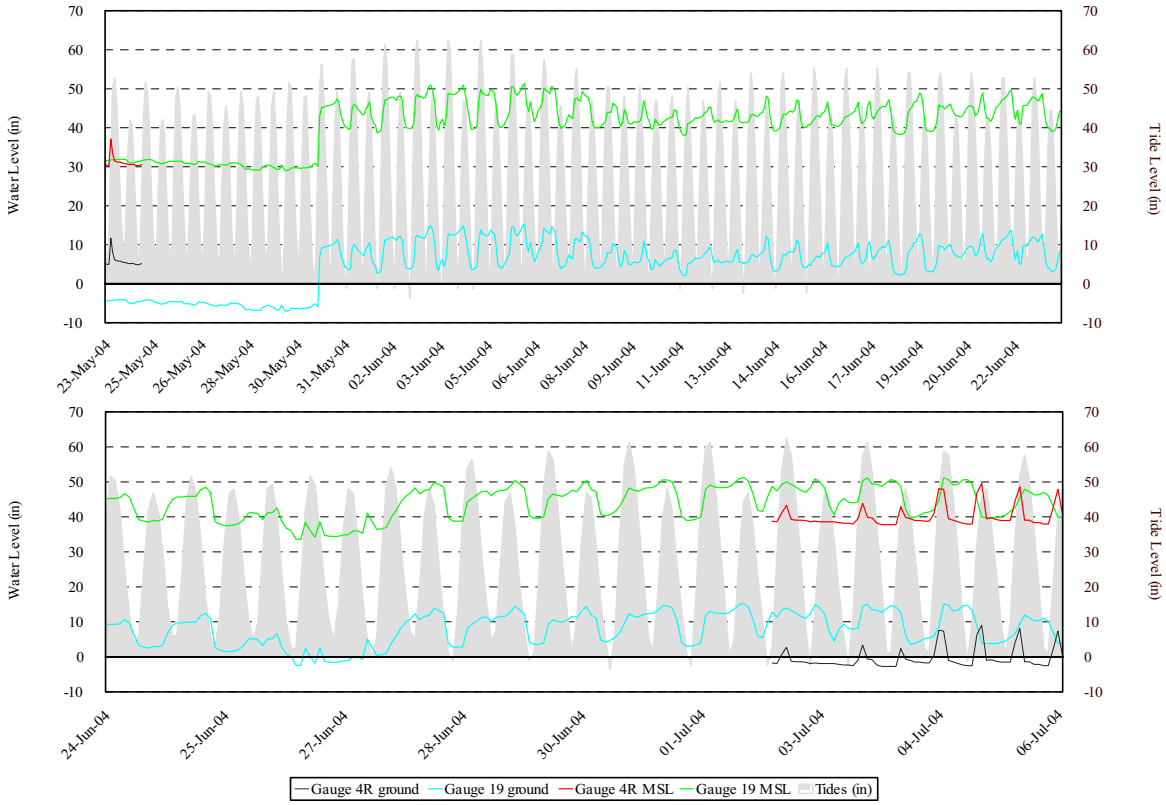
Figure B.7 contd. Hydrology Monitoring, Gauges 4R and 19



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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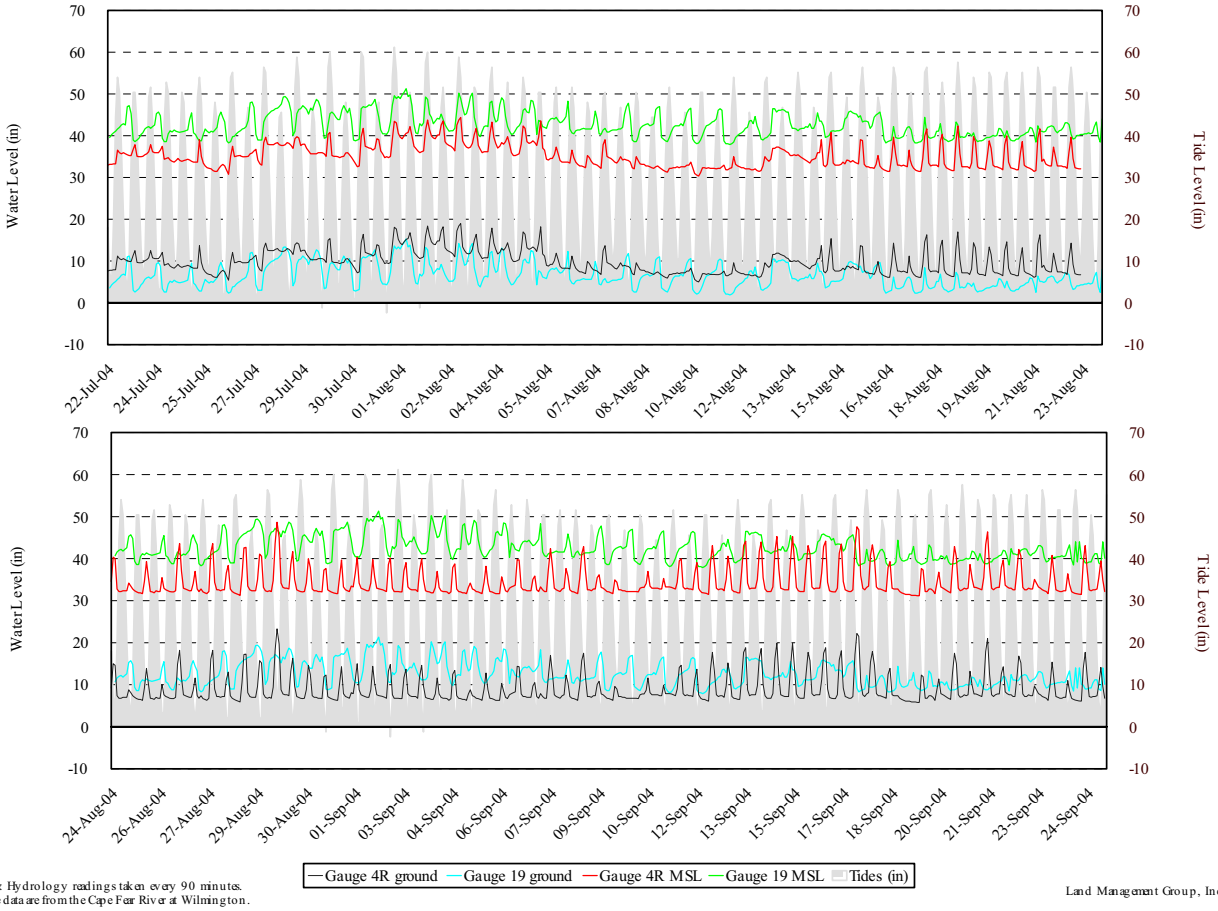
Figure B.7 contd. Hydrology Monitoring, Gauges 4R and 19



Note: Hydrology readings taken every 90 minutes.
Tide data are from the Cape Fear River at Wilmington.

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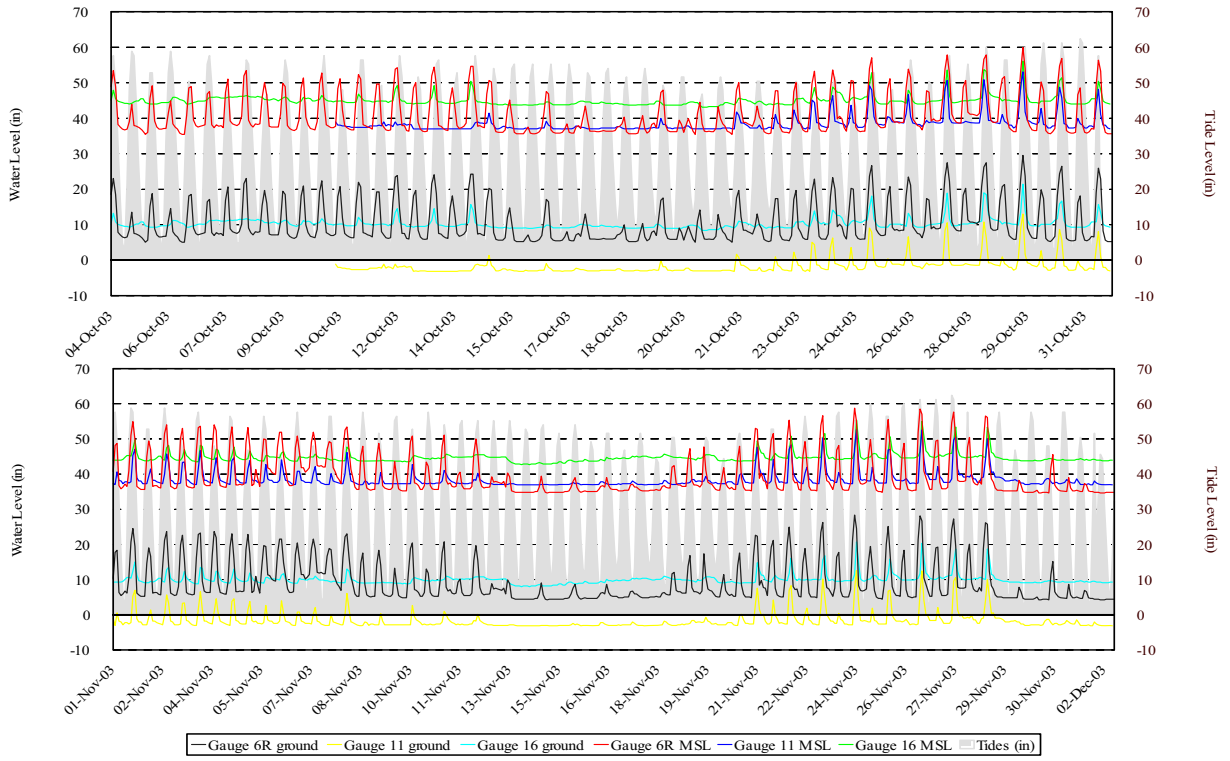
Figure B.8. Hydrology Monitoring, Gauges 6R, 11, and 16



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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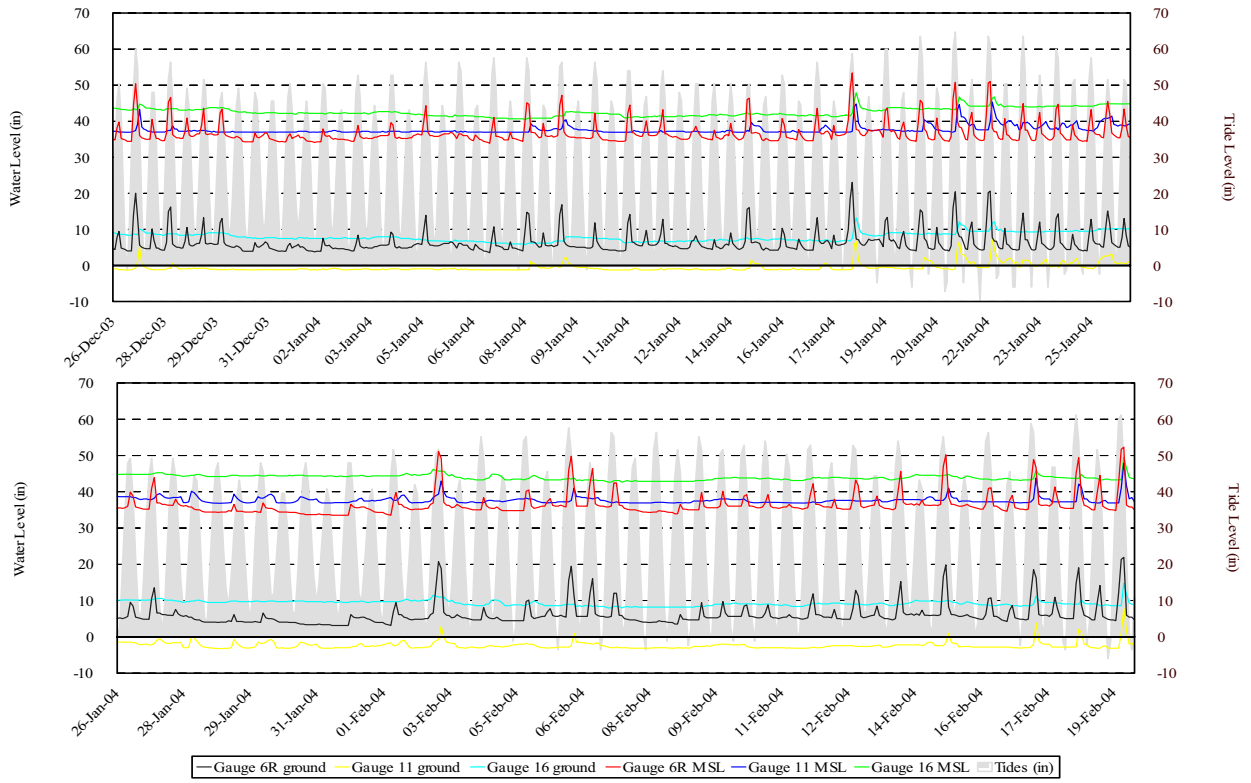
Figure B.8 contd. Hydrology Monitoring, Gauges 6R, 11, and 16



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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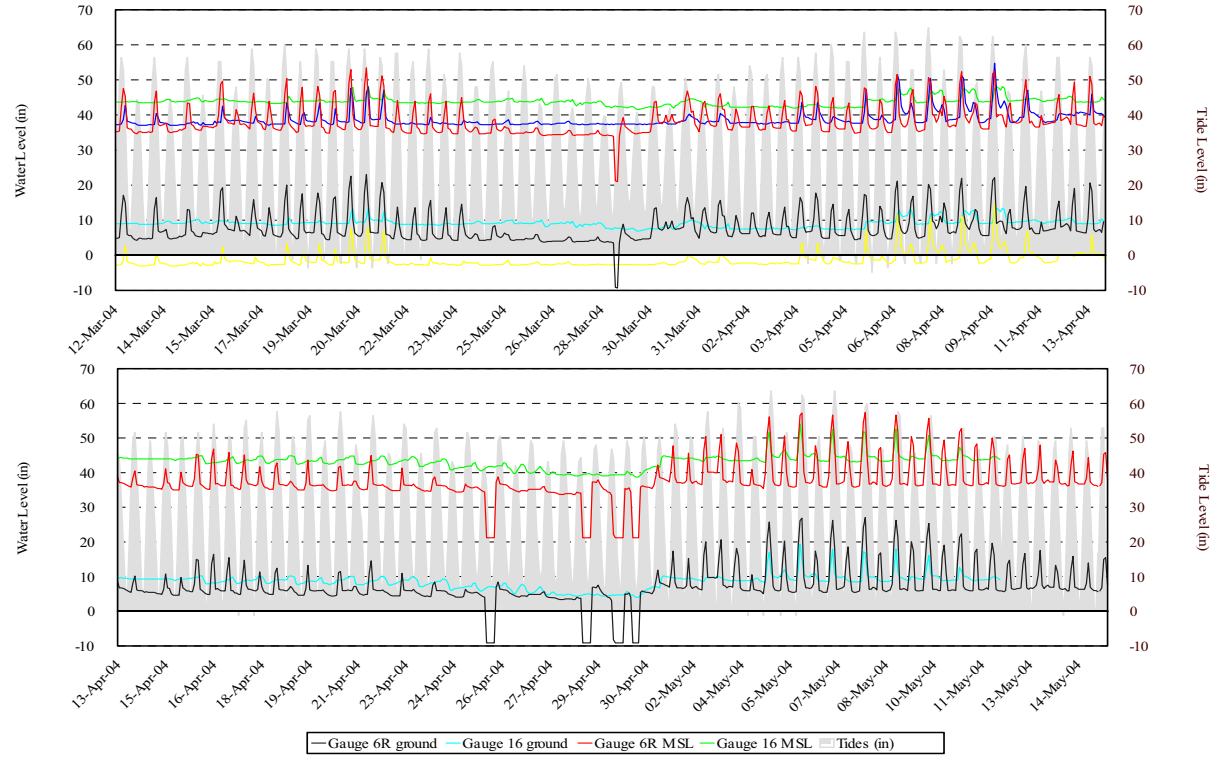
Figure B.8 contd. Hydrology Monitoring, Gauges 6R, 11, and 16



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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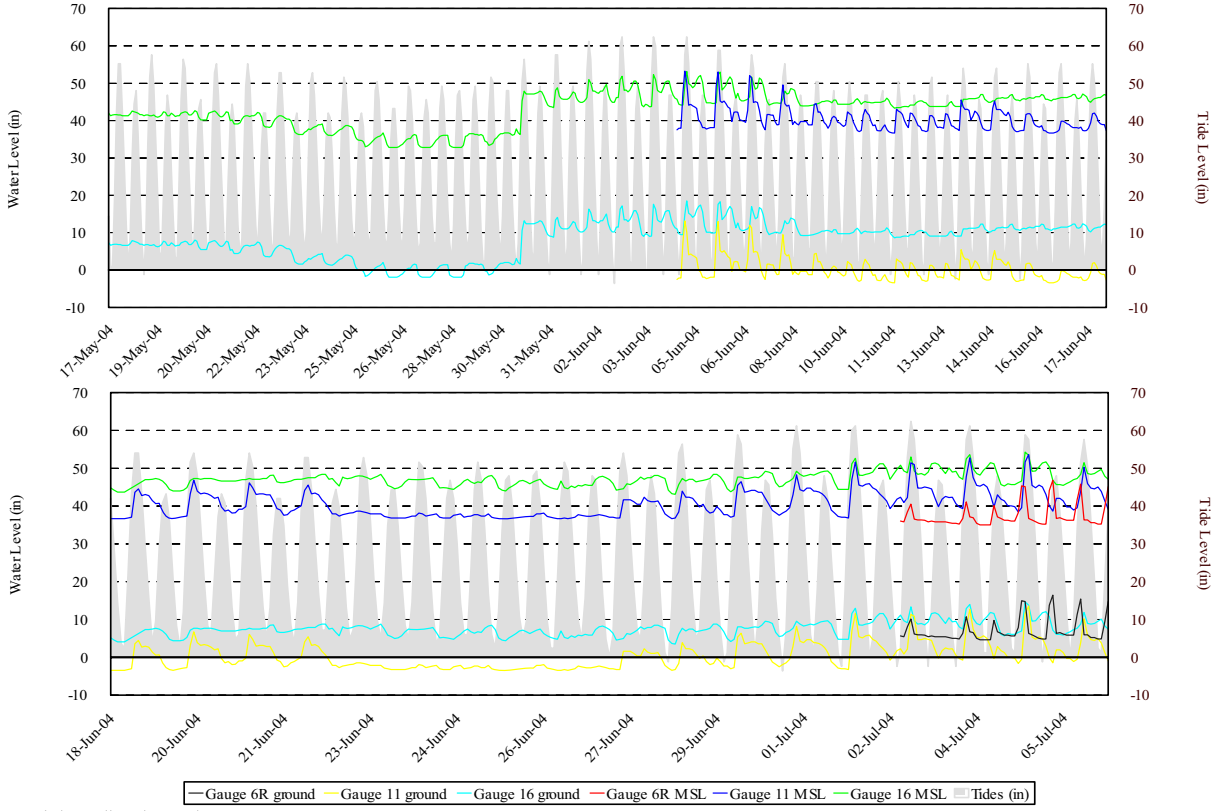
Figure B.8 contd. Hydrology Monitoring, Gauges 6R, 11, and 16



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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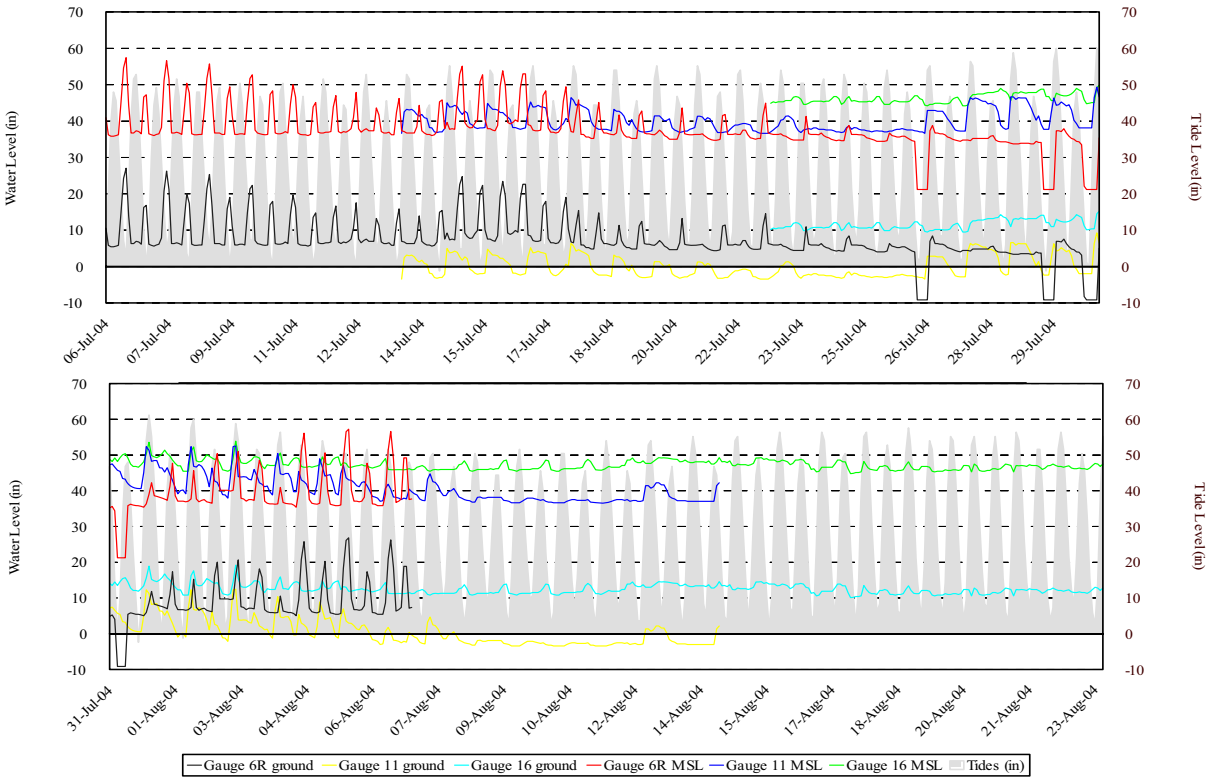
Figure B.8 contd. Hydrology Monitoring, Gauges 6R, 11, and 16



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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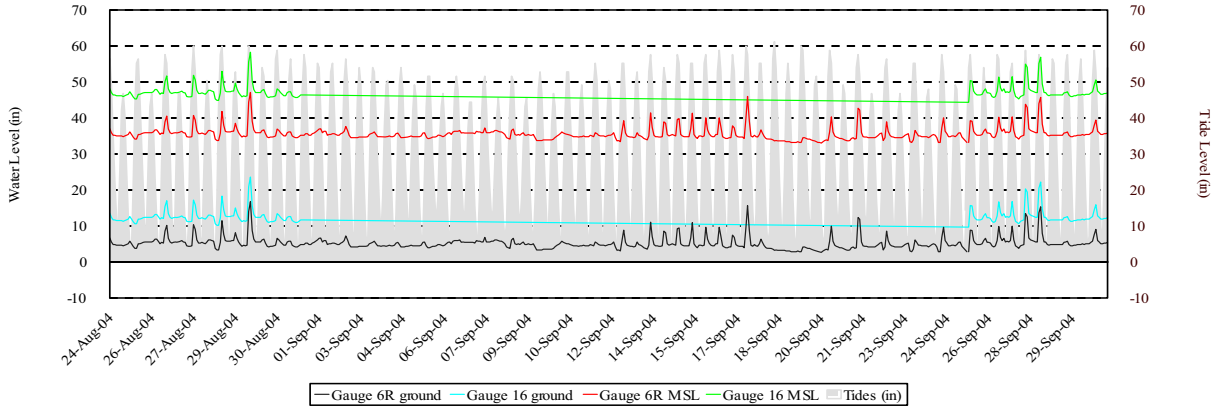
Figure B.8 contd. Hydrology Monitoring, Gauges 6R, 11, and 16



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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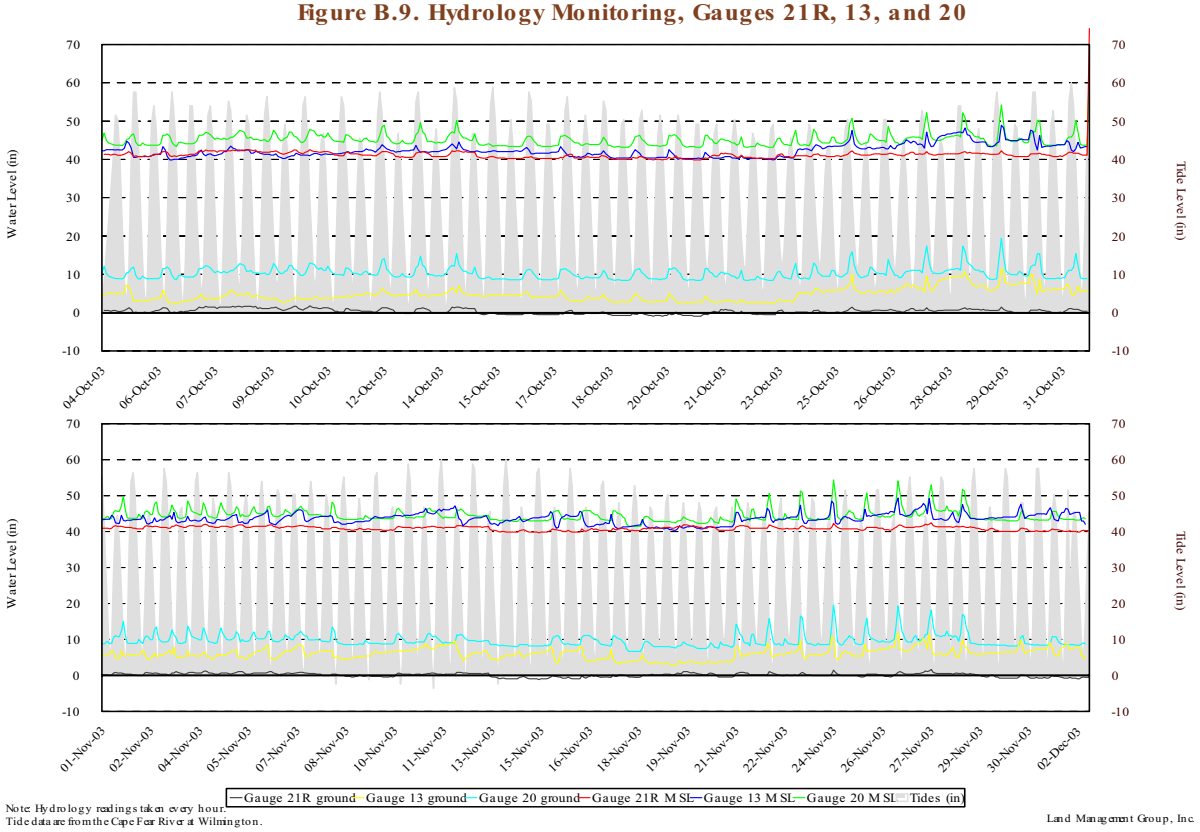
Figure B.9. Hydrology Monitoring, Gauges 21R, 13, and 20



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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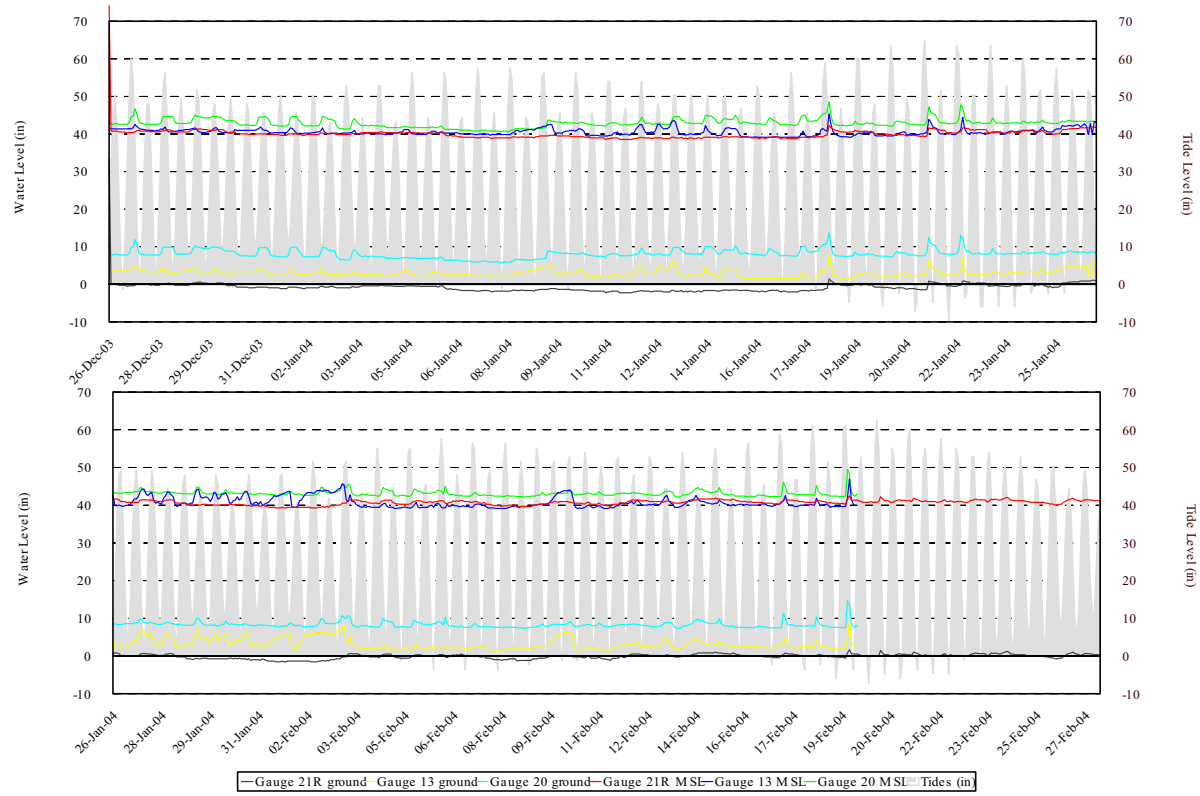
Figure B.9 contd. Hydrology Monitoring, Gauges 21R, 13, and 20



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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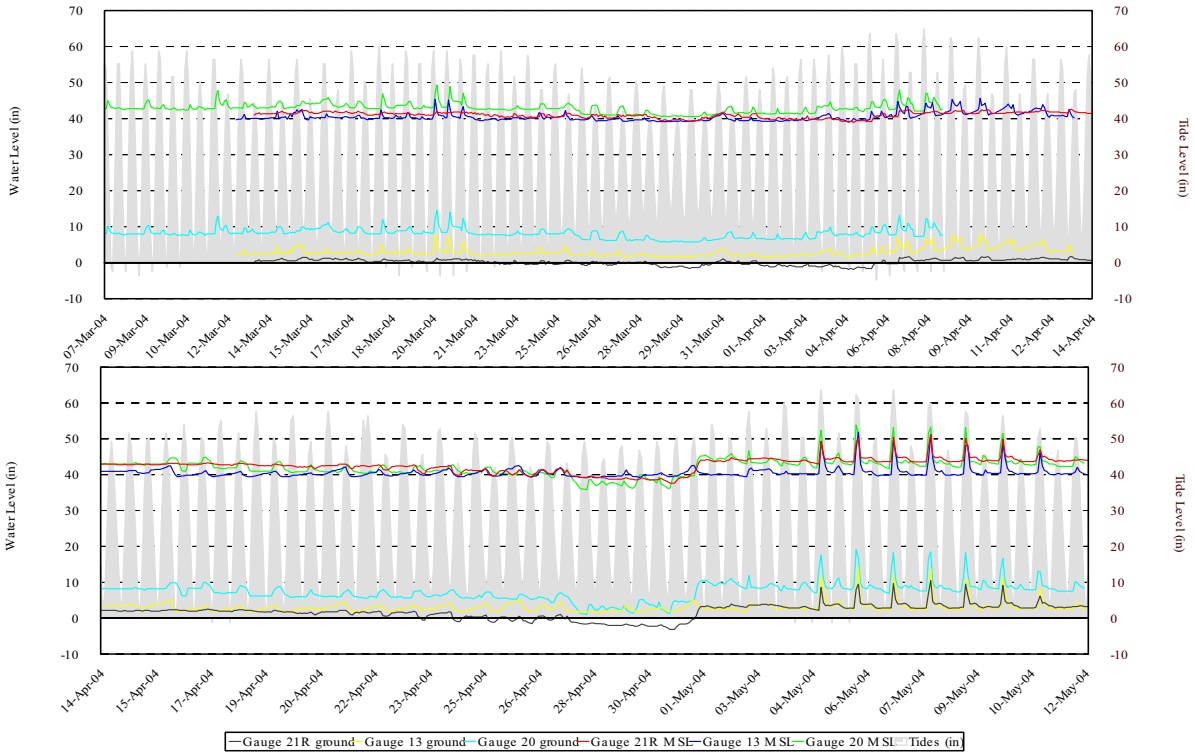
Figure B.9 contd. Hydrology Monitoring, Gauges 21R, 13, and 20



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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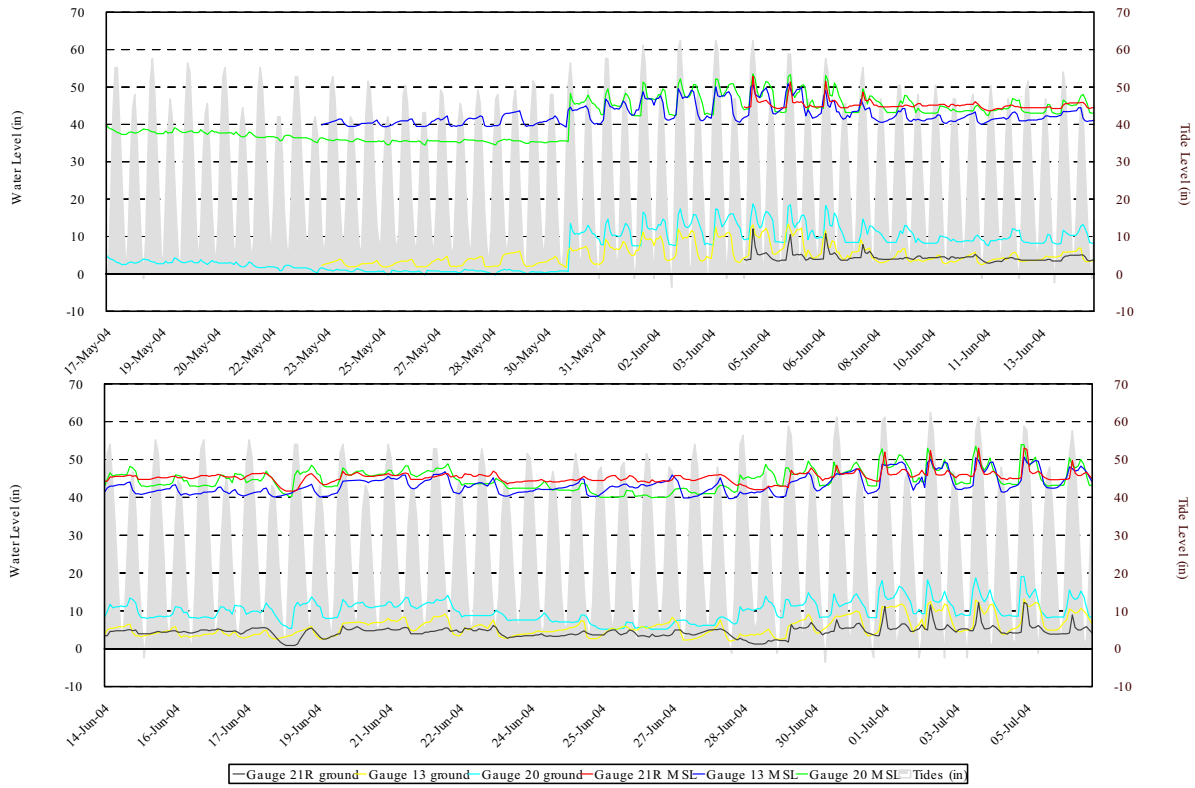
Figure B.9 contd. Hydrology Monitoring, Gauges 21R, 13, and 20



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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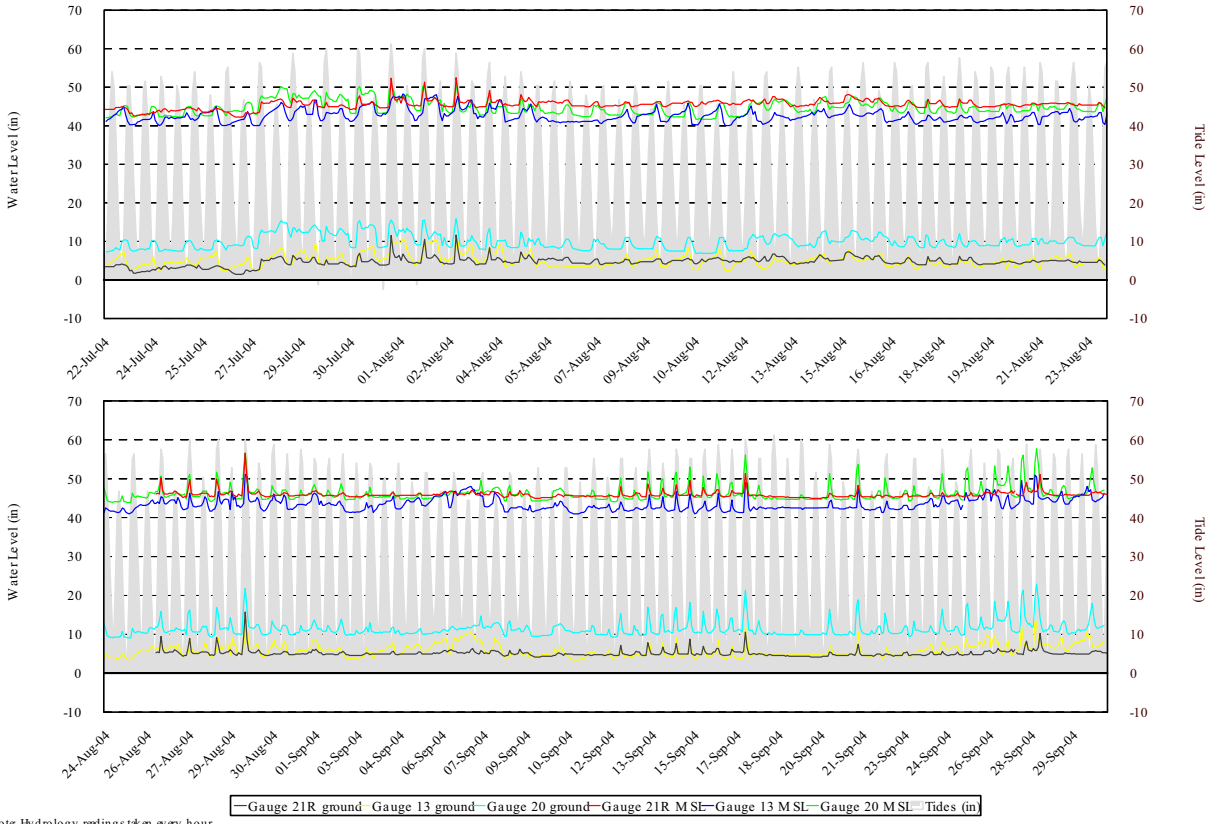
Figure B.9 contd. Hydrology Monitoring, Gauges 21R, 13, and 20



Note: Hydrology readings taken every hour.
Tide data are from the Cape Fear River at Wilmington.

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