Division of Water Resources
Planning Section – Modeling & Assessment Branch (MAB)
Draft Monitoring Plan for Upper and Middle Cape Fear River Watersheds

This document outlines the monitoring plan for the upper and middle Cape Fear River (CFR) watersheds to support model development. This data will be used to support the development of a watershed model for the upper Cape Fear watershed (Deep River and Rocky River watersheds) and a water quality and hydrodynamic model for the middle Cape Fear River watershed (from confluence of the Haw River and Deep River down to Lock and Dam #1). An accompanying document titled "Cape Fear River Basin Nutrients and Dissolved Oxygen Modeling Plan" describes the purpose and goals for the model development.

The data to be collected will allow the DWR to develop the models to characterize water quality dynamics more accurately in the CFR basin. The goal is to collect enough site-specific information to reduce the uncertainties of estimating model parameters. This will increase confidence in model predictions and hopefully, avoid the need for additional modeling.

Please note that while this document notes which agencies are currently responsible for selected monitoring stations, this document does not assign the responsibility for the additional monitoring to those agencies. DWR will need to meet with the appropriate parties and determine cooperatively who will participate and to what extent.

Please let the MAB staff know immediately if some aspect of the study will be difficult or impossible to obtain.

Duration: 24 months, starting ASAP to include 2 summer seasons (May-September)

1. New Monitoring Stations

The following section details requested monitoring for new locations in the Cape Fear, Rocky, and Deep River watersheds. It is anticipated that DWR will be responsible for this portion of the study. Seven of the locations described below were included in a 2016 grant award to DWR from NFWF.

Spatial coverage: Table1 lists the nine watersheds (also shown in Figure 1) and their monitoring locations. Note that the list does not include existing ambient and coalition stations in the watersheds. Existing stations should continue to be monitored according to their established schedule as that data will also be used for modeling purposes.

Frequency: The proposed nine locations should be monitored once per month. These locations are critical points in the watershed for model calibration and validation.

Table 1. Proposed locations for routine monitoring.

Watersheds	Receiving River	Station Location		Road Crossing
		Longitude	Latitude	
Bush Creek	Deep River	-79.713	35.753	SR 2226
Brush Creek	Deep River	-79.583	35.602	SR 22 and 42
Richland Creek	Deep River	-79.619	35.608	SR 2873
Headwaters Rocky River	Rocky River	-79.493	35.802	SR1362
Landrum Creek	Rocky River	-79.275	35.688	NC 902
Bear Creek	Rocky River	-79.212	35.635	SR 2156
Gulf Creek	Cape Fear River	-79.027	35.566	SR#1916
Headwaters Locks Creek	Cape Fear River	-78.855	35.047	SR 1006
Carvers Creek	Cape Fear River	-78.404	34.453	NC 87

Parameters: The following parameters should be included in the monitoring for all locations listed above:

- Physical Parameters: depth, water temperature, dissolved oxygen, conductivity, and pH.
- Chemical and Sediment Parameters (grab samples): ammonia, Total Kjeldahl Nitrogen (TKN), nitrite & nitrate, total phosphorus, orthophosphorus, total suspended solids, turbidity, total organic carbon (TOC), and 5-day biological oxygen demand (BOD5).

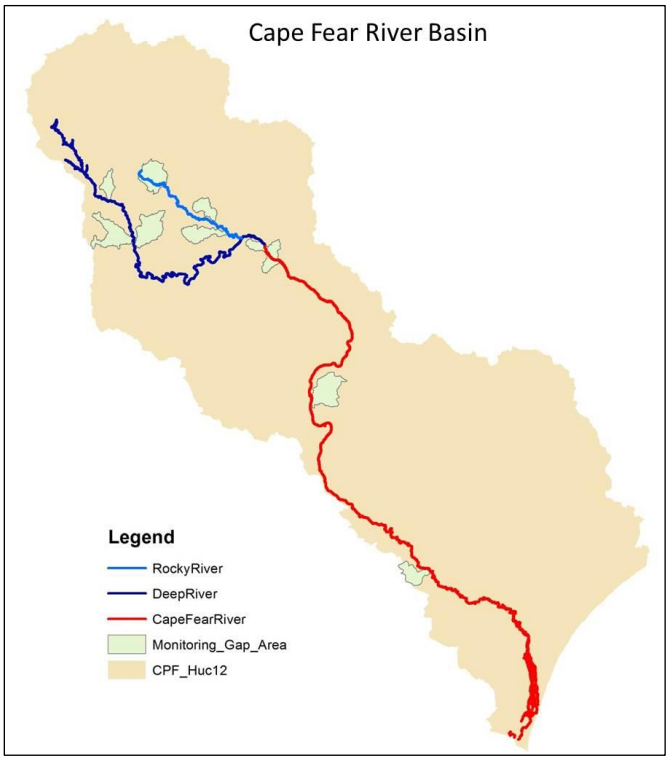

Figure 1. Proposed watershed locations for routine water quality monitoring study.

2. Existing Monitoring Stations

The following section details requested additional monitoring needs from existing monitoring stations.

2.1 Deep River, Rocky River

Monitoring stations for the Deep and Rocky Rivers are shown in Figure 2 (stations with additional monitoring needs are underlined). All stations in the Deep River and Rocky River watersheds should be monitored at least monthly year-round for the following parameters:

- Physical Parameters: depth, secchi depth (where composite samples are collected), water temperature, dissolved oxygen, conductivity, and pH.
- Chemical and Sediment Parameters (grab samples): ammonia, TKN, nitrite & nitrate, total phosphorus, total suspended solids, and turbidity. These parameters should be collected according to appropriate protocol currently applied at each station (i.e. grab or composite photic zone sampling).

The six stations listed below in Table 2 and underlined in Figure 2 have been identified for additional monitoring as follows:

- Frequency: twice/month during summer months (May – September), monthly during non-summer months, with the exception of BOD5, which should be collected monthly. DWR will review BOD5 data after the first year of collection, if the majority of BOD5 data is below detection limit for any station, there will be no requirement for a second year for BOD5 or BOD20 or 30.
- Physical Parameters: depth, secchi depth (where composite samples are collected), water temperature, dissolved oxygen, conductivity, and pH.
- Chemical and Sediment Parameters (grab samples): ammonia, TKN, nitrite & nitrate, total phosphorus, orthophosphorus, chlorophyll-*a*, total suspended solids, turbidity, TOC, and BOD5. For all stations except for B5575000, long term BOD (BOD20 or BOD30, depending on lab resources) should be collected once per year. These parameters should be collected according to appropriate protocol currently applied at each station (i.e. grab or composite photic zone sampling).

Table 2. Stations identified for additional summer sampling

Station ID	Waterbody	Location Description	Agency	Intended Use
B4800000*	Deep River	Deep Riv at SR 2122/2128 Worthville Rd at Worthville	UCFRBA	Headwater
B5480000*	Bear Creek	Bear Creek at NC 705 at Robbins	DWR	Tributary Input
B5575000	Deep River	Deep Riv at NC 42 at Carbonton	DWR	Calibration
B6040300*	Deep River	Deep Riv at SR 1011 Old US 1 nr Moncure	DWR	Calibration
B5950000*	Rocky River	Rocky Riv at US 64 near Siler City	UCFRBA	Calibration
B6000000*	Rocky River	Rocky Riv at NC 902 nr Pittsboro	DWR	Calibration

* Includes BOD20 or BOD30 (depending on lab resources) once per year.

Watershed Storm Event Monitoring: Monitoring during high flow storm events provides important information to help support modeling efforts characterizing nutrient loading during storm events. Monitoring during high flow events is necessary to perform hydrograph analysis with respect to watershed characteristics such as ground water recharge, vegetation cover, soil type, and topography.

Monitoring is requested for each station listed above in Table 2 for two high flow events during summer months each year over the two-year study period, for a total of four high flow events per station. Each high flow event should include three sampling events to capture as best as possible (considering travel times and safety concerns) the rising limb, peak flow, and falling limb of the hydrograph.

Parameters: The following parameters should be included in the monitoring for storm events:

- Physical Parameters: depth, water temperature, dissolved oxygen, conductivity, and pH.
- Chemical and Sediment Parameters (grab samples): ammonia, TKN, nitrite & nitrate, total phosphorus, orthophosphorus, total suspended solids, turbidity, BOD5, and TOC. BOD5 is optional depending on time of collection and holding time issues.

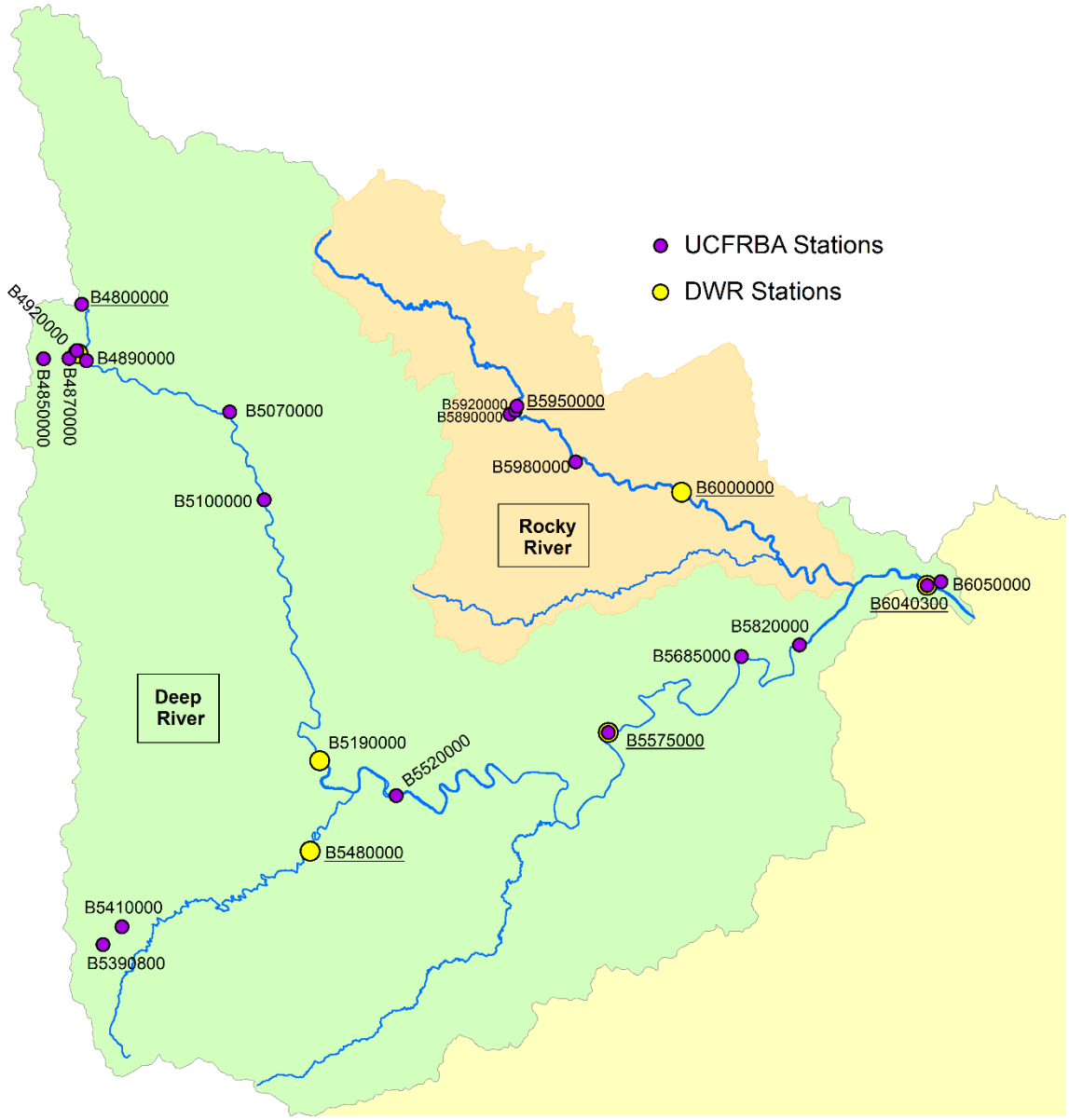

Figure 2. Deep River and Rocky River Monitoring Stations. Stations with additional monitoring needs are underlined.

2.2 Cape Fear River Mainstem

All stations in the Cape Fear River watershed should be monitored at least monthly year-round for the following parameters:

- Physical Parameters: depth, secchi depth (where composite samples are collected), water temperature, dissolved oxygen, conductivity, and pH.
- Chemical and Sediment Parameters: ammonia, TKN, nitrite & nitrate, total phosphorus, total suspended solids, and turbidity. These parameters should be collected according to appropriate protocol currently applied at each station (i.e. grab or composite photic zone sampling).

Table 3 and Figure 3 below show stations that have been identified for additional monitoring (which includes an increase of monitoring frequency and additional monitoring parameters) as follows:

- Frequency: twice/month during summer months (May-September), monthly during non-summer months, with the exception of BOD5 and phytoplankton, which should be collected monthly. DWR will review BOD5 data after the first year of collection, if the majority of BOD5 data is below detection limit for any station, there will be no requirement for a second year for BOD5 or BOD20 or 30.
- Physical Parameters: depth, secchi depth (where composite samples are collected), water temperature, dissolved oxygen, conductivity, and pH. These parameters should be collected according to appropriate protocol currently applied at each station, but should include depth profiles behind the impoundments.
- Chemical and Sediment Parameters: ammonia, TKN, nitrite & nitrate, total phosphorus, total suspended solids, and turbidity. Stations identified for additional parameter collection (orthophosphorus, chlorophyll-*a*, TOC, BOD5, long-term BOD (BOD20 or BOD30, depending on lab resources) and monthly collection of phytoplankton assemblage) are identified in Table 3. These parameters should be collected according to appropriate protocol currently applied at each station (i.e. grab or composite photic zone sampling).

Monitoring needs for additional parameters are shown in Table 3 as List 1 and List 2. “Phyto” is added at stations where phytoplankton assemblage needs to be collected monthly. “LTBOD” is added at stations where long-term BOD (BOD20 or BOD30, depending on lab resources) should be collected once per year. The parameters that correspond to List 1 and List 2 are as follows:

- Additional Parameters List 1: OrthoP, Chla, TOC, BOD5
- Additional Parameters List 2: OrthoP, Chla, TOC

The addition of orthophosphorus, chlorophyll-a, TOC, BOD5, and phytoplankton assemblage to the monitoring plan reflects model needs and lessons learned from previous modeling exercises. Table 3 identifies the intended use of the additional information for model development. If these parameters are not collected, they will need to be estimated based on literature values or assumed and this will increase model uncertainty.

Table 3. Critical Middle Cape Fear Monitoring Stations identified for additional monitoring.

Station ID	Location Description	Additional Parameters[1]	Flow Gage	Agency	Intended Use
B6040300	Deep Riv at SR 1011 Old US 1 near Moncure	List 1 & LTBOD	02102000	DWR[2]	Headwater (MCF); Calibration (UCF)
B4050000	Haw Riv below Jordan Dam Near Moncure	List 1 & LTBOD	02098198	DWR	Headwater
B6160000	CFR - Bridge at NC 42	List 1 & Phyto	210215985	MCFRBA	Calibration
B6204000	Buckhorn Crk Near SR 1921	List 1 & LTBOD	02102192	MCFRBA	Tributary input
B6215000	CFR - Captains Landing	List 1 & LTBOD		MCFRBA	Calibration
B6370000	CFR - US 401 Lillington	List 2	2102500	DWR[3]	Calibration
B6830000	Upper Little River at SR 2021 Titan Roberts Rd	List 1 & LTBOD		DWR[3]	Tributary Input
B7319100	Lower Little River at SR 1609 near Walkertown	List 1 & LTBOD		MCFRBA	Tributary Input
B7500000	CFR - I-95	List 2		MCFRBA	Calibration
B7600000	Cape Fear Riv at NC 24 at Fayetteville	List 1 & LTBOD	2104000 (stage only)	DWR	Calibration
B8230000	Rockfish Creek at NC 87	List 1 & LTBOD		MCFRBA	Tributary input
B8290000	CFR - Above L&D 3 DuPont Water Intake	List 1 & Phyto, LTBOD		MCFRBA	Calibration
B8300000	CFR - Below L&D 3 nr Tar Heel	List 2	2105500	DWR	Calibration
B8339000	CFR - Above L&D 2	List 1 & Phyto, LTBOD		MCFRBA	Calibration
B8340000	CFR - Below L&D 2 nr Elizabethtown	List 2		DWR	Calibration
B8348000	CFR - SR 1730, Elwell Ferry Road (Boat)	List 2		MCFRBA	Calibration
B8349000	CFR - Above L&D 1	List 1 & Phyto, LTBOD	2105769	MCFRBA	Calibration
B8350000	CFR - Below L&D 1 Cape Fear Riv at Lock 1 nr Kelly	List 2	2105769	DWR	Outflow Confirmation

1. List 1: OrthoP, Chla, TOC, BOD5; List 2: OrthoP, Chla, TOC; Phyto: phytoplankton assemblage; LTBOD: BOD20 or BOD30, depending on lab resources.
2. Co-located DWR and UCFRBA station, additional monitoring is assigned to DWR.
3. Co-located DWR and MCFRBA station, additional monitoring is assigned to DWR.

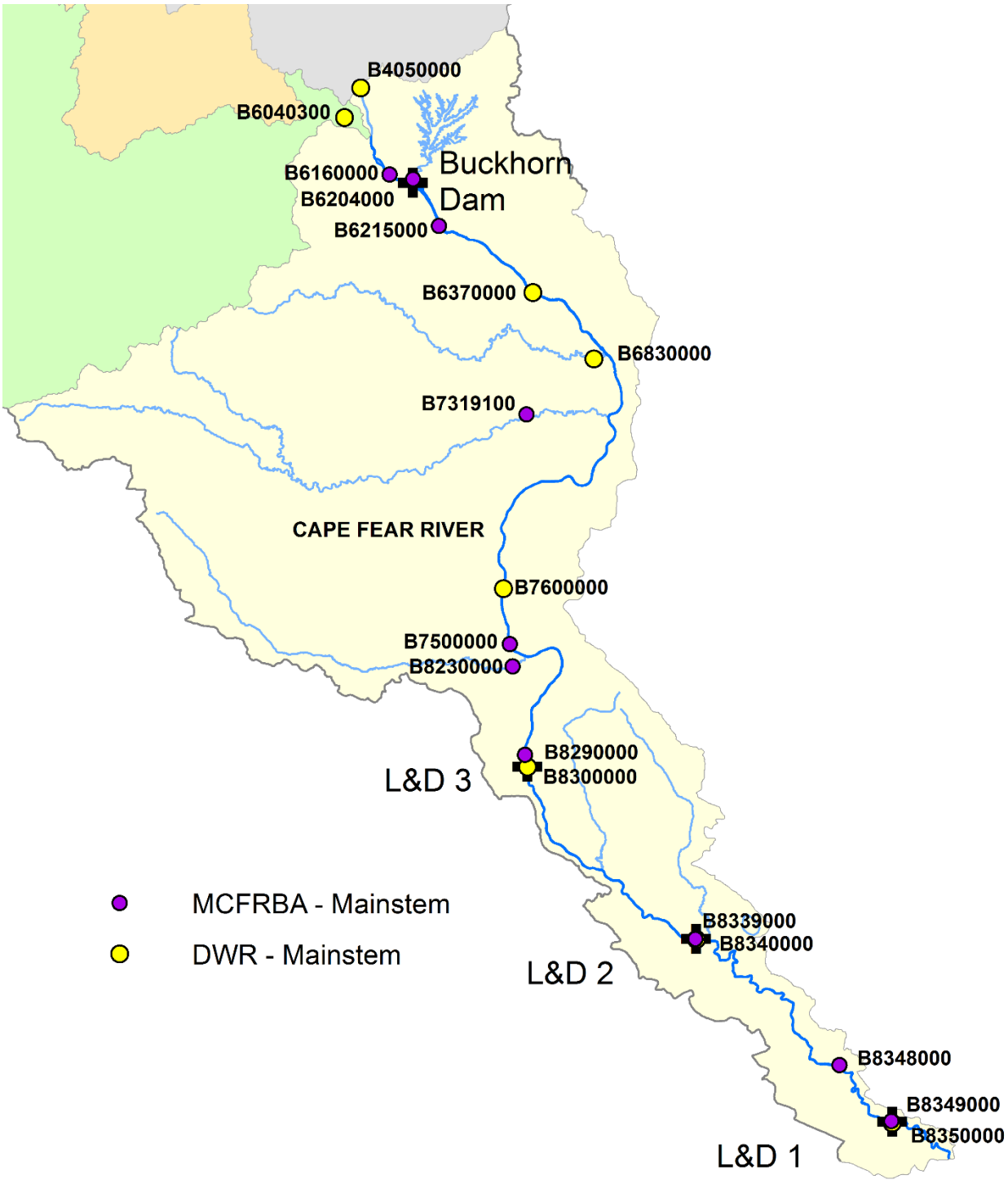

Figure 3. Mainstem Cape Fear River - Monitoring stations selected for additional monitoring

3. Special Studies

A number of special studies have been identified to support modeling of the Cape Fear River. These are described below.

3.1 Sediment Oxygen Demand/Nutrient Flux

DWR requested that EPA conduct sediment oxygen demand/nutrient flux studies behind the major impoundments of the Cape Fear River (Buckhorn Dam, Locks and Dams 1, 2, and 3). This study was performed in June 2017 and the final report was provided to DWR in November 2017.

3.2 Bathymetry

In 2015, DWR started to collect bathymetric data in the middle Cape Fear River to support model development. Figure 4 shows the detailed bathymetric data that have been collected in part of the region. However, due to resource limitation as well as accessibility issues by boat, bathymetric information in a large portion of the middle Cape Fear River below Buckhorn Dam and a small portion above L&D 1 (gray area in Figure 4) are still not available. Additional cross-sectional bathymetrical surveys in those regions would be helpful.

3.3 Others as Identified by the Nutrient Criteria Development Science Advisory Council

There may be other special studies identified by the Nutrient Criteria Development Science Advisory Council as they begin to evaluate causal and response variables for nutrient criteria for the Cape Fear River. These will likely be short term studies and will be dependent on available resources.

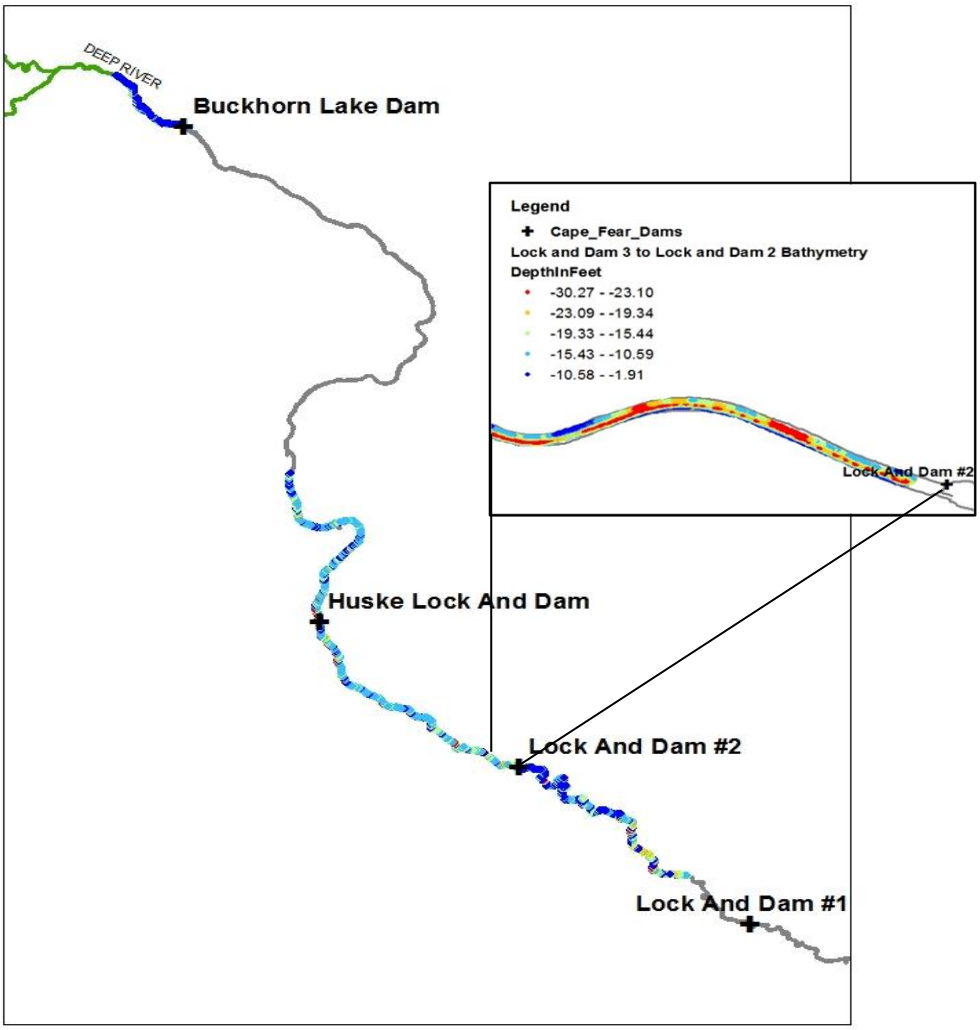

Figure 4. Bathymetric data (indicated by the red to blue dots) collected in the middle Cape Fear River.