YADKIN RESERVOIR FISH AND AQUATIC HABITAT ASSESSMENT

JUNE 2005

YADKIN RESERVOIR FISH AND AQUATIC HABITAT ASSESSMENT

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1.0 INTRODUCTION

Alcoa Power Generating Inc. (APGI) is applying to the Federal Energy Regulatory Commission for a new license for the Yadkin Hydroelectric Project. The Project consists of four reservoirs (High Rock, Tuckertown, Narrows and Falls), dams, and powerhouses located on a 38-mile stretch of the Yadkin River in central North Carolina (Figure 1-1). The Project generates electricity to support the power needs of Alcoa's Badin Works and other aluminum operations or is sold on the open market.

In this study, the effect of the Yadkin Project reservoir operations on fish and aquatic habitat was evaluated. The existing aquatic habitat in the drawdown zones of High Rock and Narrows reservoirs were mapped and imported into an Arc View GIS database. At Tuckertown and Falls reservoirs, all the existing aquatic habitat in the littoral zone (the upper 2 ft of each reservoir) was mapped and imported into an Arc View GIS database. Additionally, the impacts of fluctuating water levels on aquatic habitat and aquatic biota in the four impoundments were evaluated.

2.0 BACKGROUND

As part of the relicensing process, APGI prepared and distributed, in September 2002, an Initial Consultation Document (ICD), which provided a general overview of the Project. Agencies, municipalities, non-governmental organizations and members of the public were given an opportunity to review the ICD and identify information and studies that were needed to address relicensing issues. To further assist in the identification of issues and data/study needs, APGI formed several Issue Advisory Groups (IAGs) to advise APGI on resource issues throughout the relicensing process. Through meetings, reviews and comments, the Fish and Aquatics IAG assisted in developing the Study Plans for the various resource issues, and will further review and comment on the findings resulting from the implementation of the study plans. This report presents the findings of the reservoir fish and aquatic habitat assessment studies, following implementation of the Final Study Plan, dated June 2003. The Final Study Plan, entitled Reservoir Fish and Aquatic Habitat Assessment is attached to this report as Appendix 1.

3.0 STUDY OBJECTIVES

On March 12 and April 9, 2003 the Fish and Aquatics IAG met to discuss study objectives for the Tailwater Fish and Aquatic Biota study. Over the course of those discussions and by written comments to the draft study plan received after the April 9, 2003 IAG meeting, the following objectives were identified for the final study plan, dated June 2003.

- Map the existing aquatic habitat in the existing and potential drawdown zones of High Rock and Narrows reservoirs and the littoral zones of Tuckertown and Falls reservoirs for inclusion in a GIS based (ARC View) database.
- Evaluate the impacts of fluctuating water levels under existing Project operations on the existing fishery and aquatic habitats in the four impoundments.

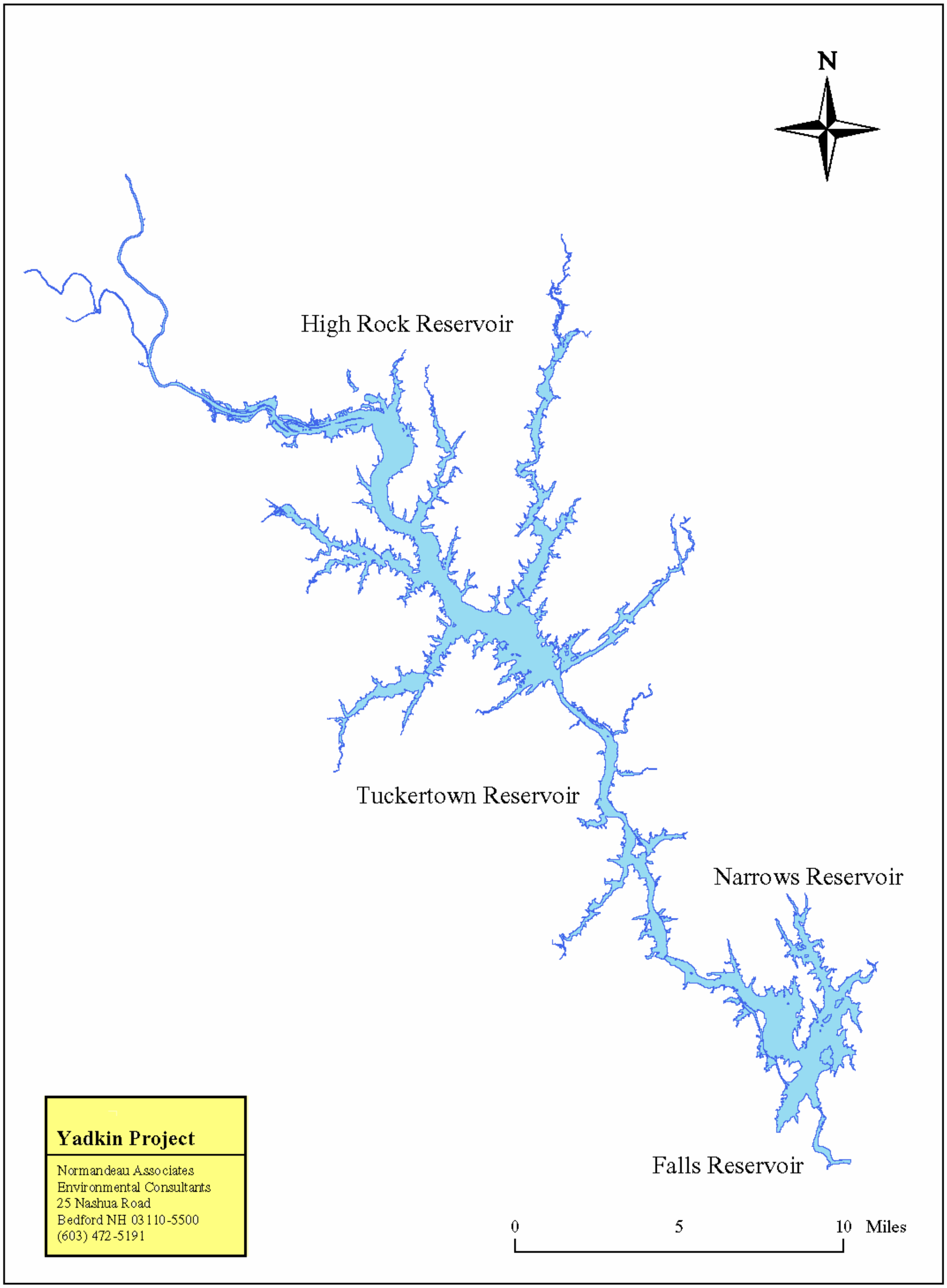

Figure 1-1. Yadkin project.

4.0 AQUATIC HABITAT SURVEYS

Intensive habitat surveys were conducted on High Rock, Tuckertown, Narrows and Falls Reservoirs between December 2003 and August 2004. Aquatic habitats were mapped within the existing drawdown zone of High Rock Reservoir, the littoral zone and a potential drawdown zone in Narrows Reservoir and within the littoral zones of both Tuckertown and Falls Reservoirs. The habitat surveys at High Rock and Narrows occurred during the winter months when the reservoirs were drawn down below 15 ft to assist in the habitat mapping. The habitat surveys on Tuckertown and Falls took place during the summer of 2004 while the two reservoirs were drawn down between 1 and 2 ft below full pool. Both Tuckertown and Falls have limited storage capacity and therefore do not experience the seasonal drawdowns that occur mostly at High Rock, and at times, Narrows reservoirs. During each survey, a digital video camera was used to film the entire shoreline of each reservoir, documenting the cover present. The methods outlined below were used on the habitat surveys conducted at each of the four reservoirs.

The following sections report the results of the four aquatic habitat surveys conducted on each reservoir. The report sections below provide a summary of what was mapped and exposed at certain reservoir elevations but it should be noted that the Arc View CD produced for each reservoir is the final work product. For High Rock, the amount of habitat exposed at any draw down level between full pool to approximately 16 ft below full pool can be calculated, and for Narrows, from full pool down to 14 ft. Additionally, habitat that may be added to a particular reservoir in the future can be included on the CD by qualified GIS personnel.

4.1 HABITAT MAPPING METHODS

A Trimble PRO-XRS Differential Global Positioning System (DGPS) connected to a laser rangefinder was used to map the different habitat types within the drawdown zone with sub-meter accuracy. The use of the DGPS and rangefinder in conjunction with one another allowed the field crew to delineate the perimeter of the habitat feature with multiple point readings to create a polygon. The habitat type of that given polygon could then be entered into the DGPS unit. Using the DGPS to create polygon shapes for each piece of habitat eliminated the need to manually record habitat dimensions. In turn, this reduced the amount of data post-processing required, after the fieldwork was completed.

Woody cover was entered into the DGPS as polygon shapes. Using the laser rangefinder and the DGPS, coordinates were traced along the perimeter of each downed tree to create a polygon. Similarly, piles of Christmas trees or areas of brush had GPS points taken to delineate the feature outline and were recorded as polygon shapes by the DGPS.

Rock substrate sometimes extended for hundreds of feet and in many cases, was a mixture of boulders, cobble, gravel and ledge. When substrate type was entered into the DGPS's data dictionary, the field crew selected the predominant substrate type for that particular polygon. For example, an area that was a mix of 75 % boulder, 20 % cobble and 5% gravel, would be entered into the DGPS as boulder habitat.

The mud/sand/clay substrate was the most dominant substrate encountered during the study. It was not mapped with the DGPS in the field. Instead, the field crew mapped all the other habitat types within the drawdown zone and any area within that zone that was not mapped, was lumped into the default category of mud/sand/clay substrate. This default substrate type was considered to be low value fish habitat when compared with woody cover and rock substrate. Substrate that did not provide good habitat, such as heavily embedded gravel, was not measured and was lumped with the default. There is however, limited habitat available for aquatic biota in the sand/embedded gravel/clay substrate. Most sections of it did have some rocks and pieces of woody debris scattered within the drawdown zone. In most cases it was not considered significant enough to map or the rock substrate was heavily embedded and considered a poor quality habitat.

Figure 4.1-1 is an example of what the data looks like in the ARCView format. By clicking the cursor on any habitat type shown on the screen, a table appears describing what type of habitat was selected, along with descriptive characteristics of that piece of habitat, such as its area in square feet or acres.

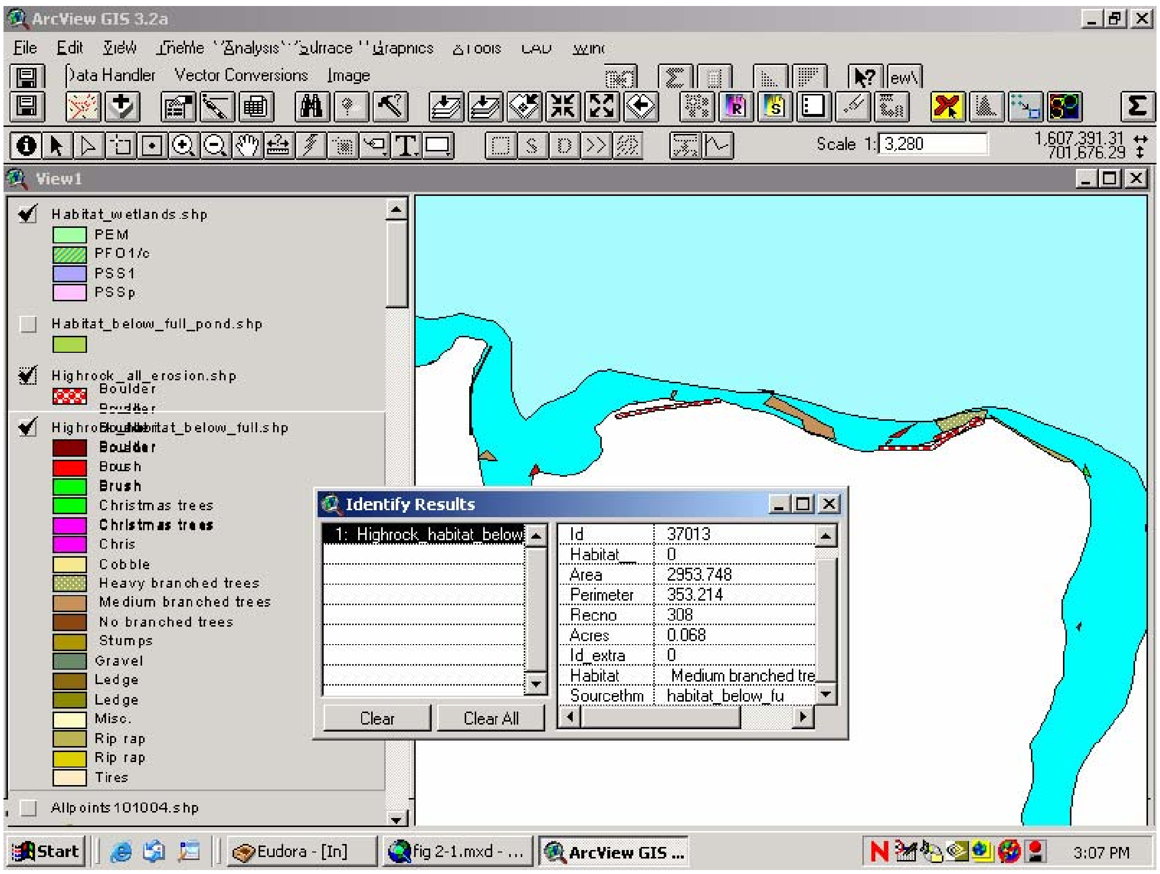

Figure 4.1-1. Example of Arcview File.

4.2 HIGH ROCK RESERVOIR

The High Rock development impounds a reservoir that has a drainage area of 3,973 square miles and has an available storage capacity of approximately 234,100 acre-feet at a full pool elevation of 623.9 feet (USGS Datum). The reservoir has a mean depth of 17 feet and a maximum depth of 62 feet. The High Rock Development is operated in a store-and-release mode. Normal daily fluctuation in water surface elevation due to operations is less than 1 ft, with a daily maximum of 2 to 4 ft. Seasonal drawdowns have averaged 8 ft in spring, 5 ft in summer, 10 ft in fall, and 12 ft in winter. The maximum annual drawdown typically occurs in late winter. The High Rock habitat field survey ran from January 20 through February 12, 2004. High Rock Reservoir's maximum full pond elevation is 623.9 feet (USGS Datum) with an average, annual drawdown of 13.5 feet (Figure 4.2-1). Water surface elevations during the field effort ranged from 619.6 to 605.1 with an average elevation of 610.1 ft. The drawdown assisted the field effort in that biologists were able to map habitat not only within the drawdown zone but also below the lower limit of that area (el. <612).

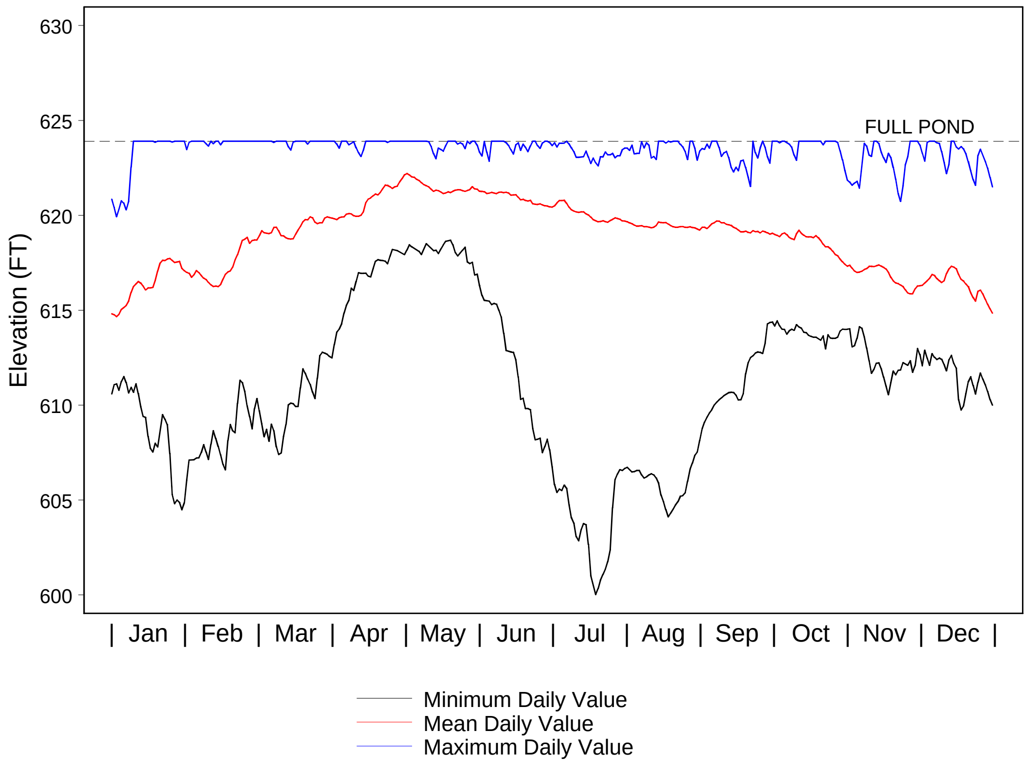

Figure 4.2-1. Minimum, Mean and Maximum Daily Water Elevations in the High Rock Reservoir for the Period of January 1, 1986 to December 31, 2003.High Rock Habitat Type Descriptions

Significant habitat types important to aquatic biota that were mapped during this study included:

1. aquatic vegetation
2. trees and woody debris (brush, fallen trees, standing trees, stumps)
3. Christmas trees added for habitat enhancement
4. docks
5. riprap
6. ledge, boulder, cobble, gravel
7. mud/sand/clay

Aquatic Vegetation

The data presented in this section was collected primarily through the use of overflight pictures taken during July and August of 2003 (NAI 2005c). After habitat types were mapped out on the collected photographs, biologists in the field were used to verify the wetland habitat types that were present. Four major wetland types of importance to aquatic biota were identified within High Rock Reservoir.

1. ***Palustrine Emergent:*** (PEM) Consisted mainly of water willow beds
2. ***Flood Plain Forest:*** (PFO1/c) Species composition within this wetland type can be very diverse. However, where this community type is present on the frequently flooded, shallow delta areas within High Rock, black willow is the dominant tree species. This habitat type is typically flooded only during high water events.
3. ***Shrub-Swamp:*** (PSS1) Shrub-swamp habitat on High Rock is dominated by loosely bunched stands of black willow seedlings.
4. ***Sparse Shrub-Swamp:*** (PSSp) Sparse shrub-swamp on High Rock can be found on the shallower bars that are beginning to seed in and is mainly composed of the widely scattered seedlings of black willow and buttonbush.

Woody Cover

Woody cover found within the 17-foot drawdown was split into several categories and mapped during the study. Naturally falling and intentionally cut trees (lap trees) lying within the drawdown zone were mapped. These downed trees were further categorized based on the size and amount of branches remaining on the tree. They were classified as heavy branching, medium branching or no branching (Figure 4.2-2). Christmas tree bundles added to the reservoir to provide and improve habitat for fish were also mapped (Figure 4.2-3). Other types of woody cover located and mapped in the drawdown zone included stumps, brush piles, and standing trees (Figure 4.2-3).

Substrate

All substrate types located within the drawdown zone were delineated and mapped during the field survey. These included ledge, boulder, cobble, gravel, and riprap (Figure 4.2-4; Figure 4.2-5). Substrate that did not provide good habitat for aquatic biota, such as heavily embedded gravel, was not measured and was included in the default (mud/sand/clay) substrate category. All habitats that were not mapped due to their not providing decent habitat for aquatic biota were put into the default category.

Docks

Docks were plotted from overflight pictures taken during 1997. Docks constructed after 1997 are not included in this report. Figure 4.2-5 shows examples of dock habitat from High Rock Reservoir. Yadkin estimates that approximately ___ docks were added since 1997.

Erosion

Areas of significant erosion were mapped during the field effort. "Significant erosion" was defined in the final study scope as areas that are observed to have active and ongoing erosion and observable impacts to important aquatic and terrestrial resources. Such areas included but were not necessarily limited to:

Photo A. Heavily branched tree overlying default habitat with stumps in foreground

Photo B. Medium branched tree overlying mixed cobble/gravel habitat.

Photo C. No branched tree on default habitat.

Figure 4.2-2. Some examples of different tree cover types mapped in High Rock Reservoir, including heavy, medium and no branched trees, January/February 2004.

Photo A. Stump habitat.

Photo B. Brush pile habitat.

Photo C. Christmas tree bundle habitat.

Figure 4.2-3. Some examples of different woody cover types mapped in High Rock Reservoir, including stumps, brush and Christmas trees, January/February 2004.

Photo A. Boulder and cobble habitat.

Photo B. Ledge habitat.

Photo C. Mixed gravel, cobble and boulder habitat.

Photo D. Gravel habitat

Figure 4.2-4. Some examples of different rocky substrate types mapped in High Rock Reservoir, including ledge, boulder, gravel and cobble, January/February 2004.

Photo A. Dock set over ledge habitat.

Photo B. Dock and rip-rap habitats.

Photo C. Rip-rap habitat.

Figure 4.2-5. Some examples of docks and rip-rap habitat mapped in High Rock Reservoir, January/February 2004.

- Areas where eroding shoreline has resulted in localized sediment deposits that are noticeably affecting water quality or aquatic habitats
- Areas where eroding shoreline has resulted in the loss of vegetation from a significant community or habitat type
- Areas where eroding shoreline are impacting public recreation facilities

4.2.1 Total Available Habitat in Drawdown Zone

High Rock Reservoir has 5,996 acres exposed during a 12-foot drawdown (el. 624 to el. 612). Of the 5,996 acres, 4,744 (79%) is mud/sand/clay substrate (Table 4.2-1). Four wetland cover types (Palustrine emergent, flood plain forest, shrub-swamp, and sparse shrub-swamp) cover 1,153 acres and comprise 19.2% of the habitat. Rock substrates (0.56%), woody cover (0.63%) and docks (0.50%) comprise the remaining habitat within the drawdown zone. The four wetland cover types, rock substrate, woody cover and docks represent quality habitat types that are beneficial to the success of aquatic biota.

Because of natural hydraulic controls, the planned drawdown did not dewater the upper section of High Rock that includes the lower Yadkin River and its confluence with the reservoir and habitat data collected in this section is presented separately (see Section 4.3.1).

Table 4.2-2 presents the 15 different habitat types mapped during the High Rock habitat survey along with the four wetland habitats that were added from aerial photographs. Mud/sand/clay is the dominant substrate present. Flood plain forest was the dominant wetland type and comprised 8.89% of the habitat. Sparse shrub-swamp was the next most abundant, covering 411 acres and comprising 6.86% of the habitat. Lesser amounts of shrub-swamp (193 acres; 3.2%) and palustrine emergent vegetation (15 acres; 0.25%) were also present. Next to the wetland habitat types, docks are the second most abundant form of quality habitat found within the drawdown zone, covering 29.88 acres and comprising 0.50% of the drawdown zone acreage. Medium branched trees are the dominant form of woody cover throughout the reservoir, comprising 0.50% of the acreage mapped. Christmas trees, brush, heavily branched trees, no branched trees, standing trees and stumps are all present in lesser amounts, throughout the reservoir. Rip-rap (0.24%) and boulders (0.18%) are the dominant rocky substrates present. Lesser amounts of cobble, gravel, and ledge can also be found within the drawdown zone.

Habitat available below the 12-foot drawdown contour (el. 612) was also mapped during the field survey (Table 4.2-2). During the survey, biologists mapped habitat between el. 612 and el. 605 (19 ft below full pool) in the main reservoir sections where the deeper water exists. The upper sections of the tributary arms were shallow and most were above el. 612. Excluding the default mud/sand/clay substrate, there was an additional 75.15 acres of habitat available below el. 612. Stumps were the dominant habitat type, accounting for 52% of the habitat available. Other woody cover types present included brush, Christmas trees, medium, heavily and no branched trees. Rip-rap was the dominant rocky substrate type that was mapped below the drawdown zone, accounting for 18 % of the habitat mapped there. Cobble, ledge, and boulders were also present.

Table 4.2-1. Total habitat available (in acres and %) within the drawdown zone of High Rock Reservoir with all woody cover and rock substrate types combined. [1]

Area exposed in drawdown zone		Mud/sand/clay (default) substrate		Rock substrate		Woody Cover		Docks		Wetlands	
acres	**%**	**acres**	**%**	**acres**	**%**	**acres**	**%**	**acres**	**%**	**acres**	**%**
5,996.23	100.00%	4,743.62	79.11%	33.42	0.56%	37.92	0.63%	29.88	0.50%	1152.84	19.23%

[1] Habitat mapped in the upper section of High Rock Reservoir that includes the lower Yadkin River and its confluence with the reservoir is presented separately because this area did not dewater during the planned drawdown. (See section 4.2.2.1)

Table 4.2-2. Habitat Types in Acres and Square Feet Mapped in the Drawdown Zone (el. 624 - 612) of High Rock Reservoir.

	Habitat Available in Drawdown Zone [1]			Acres of Habitat Below Drawdown Zone [2]
Habitat Type	**Acres**	**Square Feet**	**%**	
Mud/sand/clay	4,743.62	206,430,697.88	79.09%	---
Boulder	10.87	473,829.15	0.18%	10.38
Brush	2.37	103,872.54	0.04%	1.37
Christmas Trees	0.67	29,455.08	0.01%	0.39
Cobble	3.48	151,564.38	0.06%	2.52
Docks	29.88	1,300,180.00	0.50%	1.19
Gravel	0.00	114.07	0.00%	0.00
Heavily Branched Trees	1.44	62,380.67	0.02%	0.00
Ledge	4.59	200,183.56	0.08%	4.56
Medium Branched Trees	29.95	1,304,584.88	0.50%	1.37
No Branched Trees	0.49	8,117.29	0.01%	0.01
Rip-rap	14.49	621,295.77	0.24%	13.58
Stumps	2.98	129,412.55	0.05%	38.95
Tires	0.01	279.22	0.00%	0.00
Palustrine Emergent	15.09	657,338.33	0.25%	0.38
Flood Plain Forest	533.10	23,221,929.58	8.89%	0.00
Shrub-swamp	193.16	8,413,851.36	3.22%	0.45
Sparse shrub-swamp	411.49	17,924,204.30	6.86%	3.16
Total	5,997.65	261,033,290.61	100.00%	75.15

[1] Drawdown zone includes habitat between el. 624 down to el. 612, or the upper 12 feet of the drawdown zone.

[2] Habitat mapped below the drawdown zone extends below el. 612.

4.2.2 Major Sections of High Rock Reservoir

High Rock Reservoir was segmented into the different tributary arms to better compare the amount and types of habitat present in each area. Additionally, the main body of the reservoir was split into an upper and lower section for ease of analysis (Figure 4.2-6). Each tributary arm and main body section was then compared. Table 4.2-3 shows the full pond surface acreage and acreage within the 12 foot drawdown zone of each section.

4.2.2.1 Lower Yadkin River and Confluence Area

Locations of habitats mapped in the area of where the Yadkin River enters High Rock Reservoir are shown in Figure 4.2-7 (see attached CD). Unlike most of the main body and tributary arms of High Rock Reservoir, the effects of the drawdown were minimal in this area. The majority of the confluence area and lower Yadkin River showed very little effect and water surface elevation remained at nearly full bank during the 17-foot drawdown intended to assist with habitat mapping.

Figure 4.2-8 shows views from the upstream and downstream ends of this area. Minimal effects from the drawdown were evident from the confluence of the Yadkin and South Yadkin Rivers downriver to the confluence of the Yadkin and High Rock. Work done by PB Power has concluded that during high inflows to High Rock, a narrow river bend above the I-85 bridges along with a rapid rise in bottom elevations act as a hydraulic control. This hydraulic control helps to maintain the river at near full bank, and even though High Rock was drawn down 17 ft during the survey, inflow was enough (around 4,000 cfs) to keep this area watered up. As a result of the high water levels in this reach, the field crew was able to map only what was visible along the banks at or around the full pool elevation. A total of 2.94 acres of quality habitat were mapped in this area (Table 4.2-4). Woody cover was the predominant form of quality habitat present. Medium branched trees (1.44 acres; 48%) and heavy branched trees (1.36 acres; 46%) were the two dominant forms of quality habitat in area 1. Rip-rap (0.11 acres; 4%) was the dominant rocky substrate type present. Small amounts of brush, no branched trees and ledge were also present. The banks along the Yadkin River in this area were dominated by overhanging vegetation, which provide good habitat for aquatic biota (Figure 4.2-8). This vegetation was quantified and classified by the use of overflight photographs. Flood plain forest provides 580.27 acres of habitat along the lower Yadkin and within the confluence area (Table 4.2-4). Shrub-swamp and sparse shrub-swamp account for 85.92 and 79.91 acres respectively and are concentrated in the sandy delta area where the Yadkin River enters High Rock. Palustrine emergent vegetation covered 0.7 acres within this area of the reservoir.

4.2.2.2 Upper Main Reservoir

For analysis, the main reservoir was split into an upper and lower section. The upper section extended from approximately 2.25 miles below the Route 85 Bridge to the area just upstream from the confluence of Second Creek and the main reservoir (Figure 4.2-6). Locations of habitats mapped in the upper main reservoir are shown in Figure 4.2-9 (see attached CD). Within the entirety of the upper main reservoir, 63% is comprised of mud/sand/clay habitat (Table 4.2-5). Wetland habitats cover an additional 36% with flood plain forest being the dominant type. The remaining 1% of habitats mapped fell into the quality woody cover, rock substrate and dock habitat types.

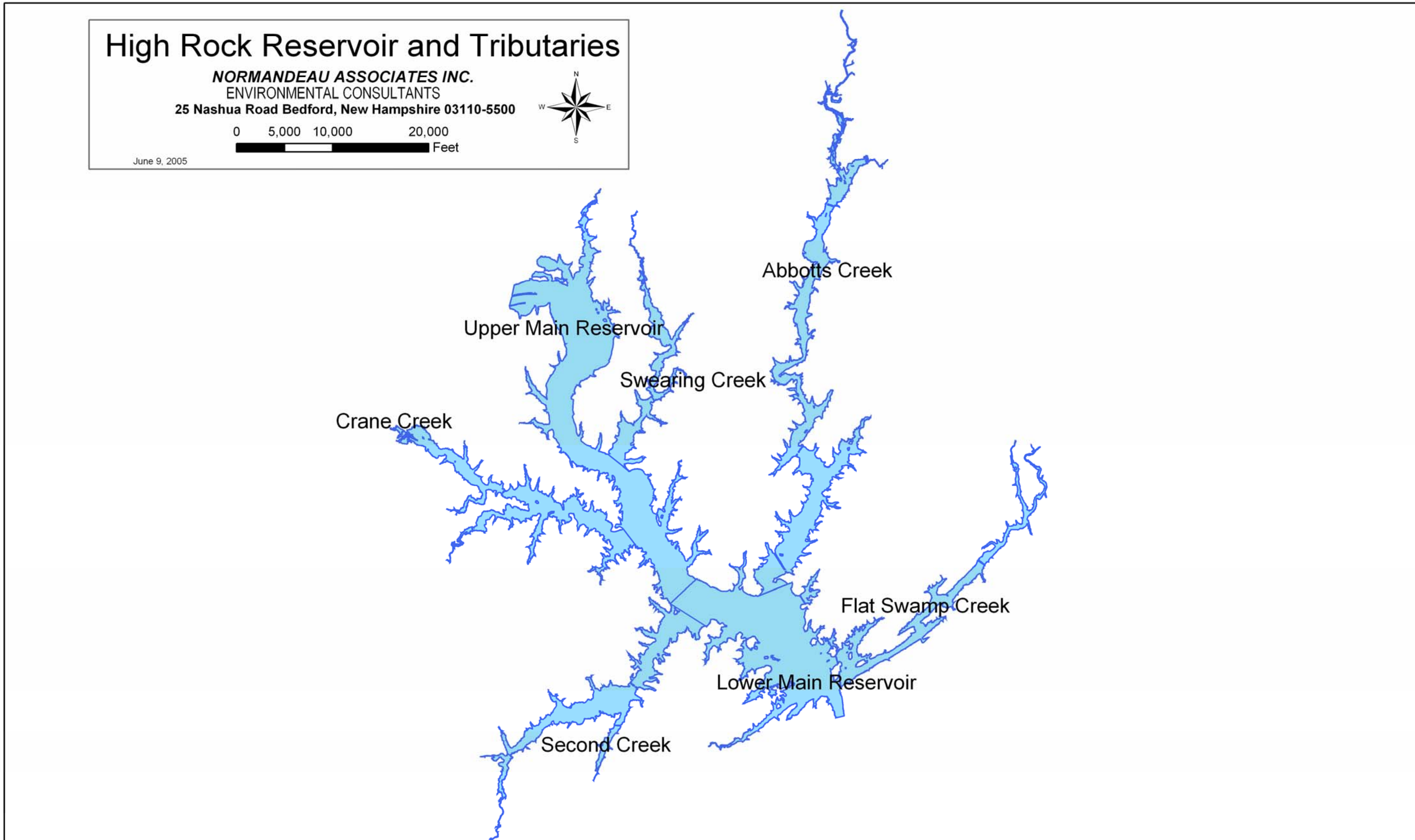

Figure 4.2-6. High Rock Reservoir segments for habitat analysis.

Table 4.2-3. Full pond surface and within drawdown zone acreage for High Rock Reservoir by section.

Section	Surface Acreage At Full Pond	Total Acreage within 12' Drawdown Zone (624'-612')
Lower Yadkin and Confluence Area	1,832.63	*** [1]
Upper Main Reservoir	3,859.68	2,024.04
Lower Main Reservoir	2,919.10	587.84
Crane Creek Tributary Arm	1,347.12	762.52
Swearing Creek Tributary Arm	638.81	429.97
Abbotts Creek Tributary Arm	2,271.17	1,165.48
Second Creek Tributary Arm	1,315.92	628.32
Flat Swamp Creek Tributary Arm	872.04	378.56

[1] No bathymetry at el. 612' to define the lower end of the drawdown zone and calculate an area.

Table 4.2-4. Habitat mapped within the Lower Yadkin River and its Confluence with High Rock Reservoir, January and February 2004.

Lower Yadkin Area	Available Habitat Elevation		% of Total Acreage
Habitat Type	Habitat Mapped (sq. feet)	Habitat Mapped (acres)	
Boulder	191.98	0.00	0.00%
Rip rap	4,623.96	0.11	0.01%
Brush	354.92	0.01	0.00%
Ledge	1,127.13	0.03	0.00%
Heavy branched trees	58,955.43	1.36	0.18%
Medium branched trees	62,836.81	1.44	0.19%
No branched trees	1,038.30	0.02	0.00%
Standing Trees	147.80	0.00	0.00%
Palustrine emergent [1]	30,361.00	0.70	0.09%
Flood plain forest [1]	25,276,467.00	580.27	77.39%
Shrub-swamp [1]	3,742,852.00	85.92	11.46%
Sparse shrub-swamp [1]	3,481,006.00	79.91	10.66%
Sum	**32,659,962.32**	**749.77**	**100.00%**

Surface Acreage at Full Pond
1,832.63

[1] Wetland habitats mapped by use of aerial photography. Rocky substrates and woody cover types mapped by DGPS and field crew.

Figure 4.2-7. Habitat types mapped in the Lower Yadkin River and Confluence Area.

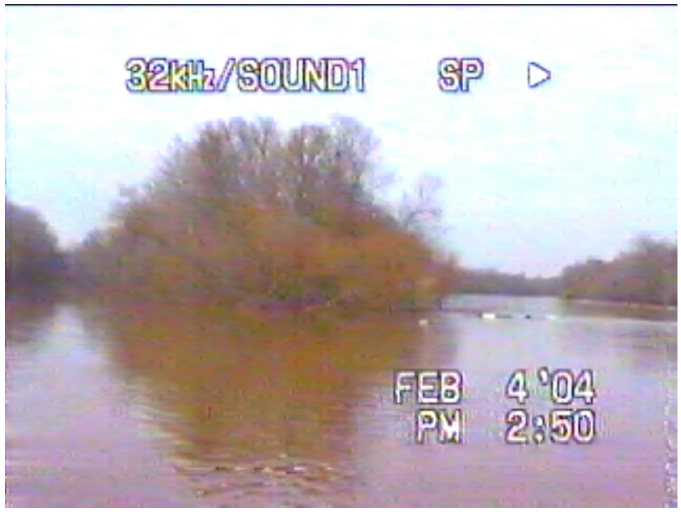

Photo A. Confluence of Yadkin and Little Yadkin Rivers at 17-foot drawdown showing water level at full-bank and the presence of overhanging vegetation.

Photo B. View looking downstream in the Lower Yadkin River area, showing water level at or near full pool during 17-foot drawdown.

Figure 4.2-8. Confluence of Yadkin and Little Yadkin Rivers and just downstream during 17-ft drawdown, January/February 2004.

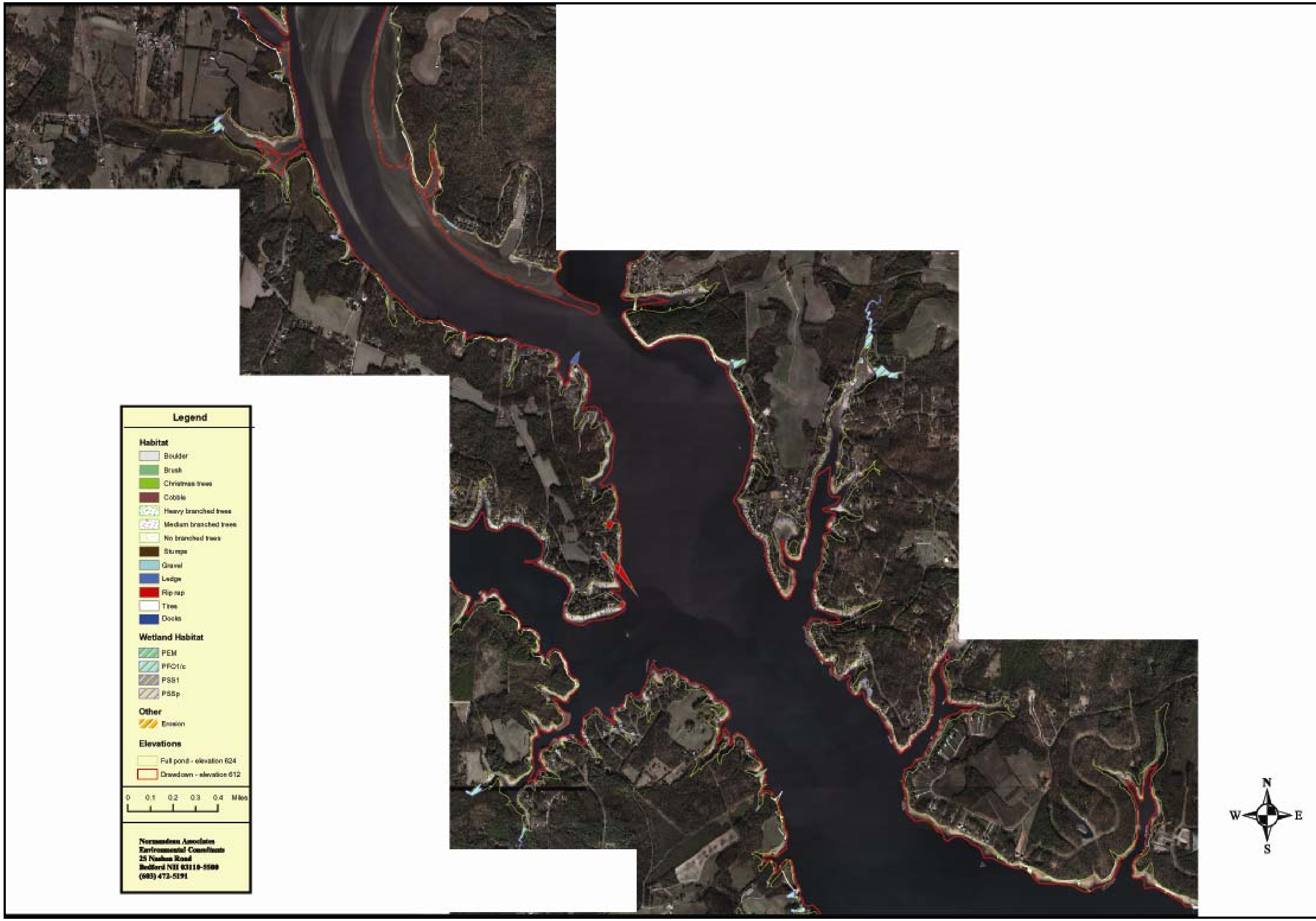

Figure 4.2-9. Habitat types mapped in the Upper Main Section of the High Rock Reservoir.

Table 4.2-5. Amount of habitat mapped in the Upper Main Reservoir, within (el. 624 down to 612) and 5 feet below the drawdown zone (el. 612 to 607).

Upper Main Reservoir

Habitat Type	Available Habitat: Habitat mapped within drawdown [1] (sq. feet)	Habitat mapped below drawdown [2] (sq. feet)	Habitat mapped within drawdown [1] (acres)	Habitat mapped below drawdown [2] (acres)	% of drawdown zone acreage
Boulder	5,953.39	11,291.58	0.14	0.26	0.01%
Cobble	11,980.79	12,820.55	0.27	0.30	0.01%
Ledge	2,210.64	64,664.86	0.05	1.49	0.00%
Rip rap	95,862.93	63,055.08	2.20	1.45	0.11%
Brush	22,246.33	12,266.69	0.50	0.28	0.02%
Heavy branched trees	6,528.92	32.15	0.15	0.00	0.01%
Medium branched trees	104,571.85	15,026.86	2.40	0.35	0.12%
No branched trees	3,215.22	325.37	0.07	0.01	0.00%
Christmas trees	356.49	23.86	0.01	0.00	0.00%
Stumps	11,635.34	26,031.75	0.27	0.60	0.01%
Docks	188,226.00	5,052.96	4.34	0.12	0.21%
Palustrine emergent	28,126.80	0.00	0.65	0.00	0.03%
Flood plain forest	7,999,341.89	132,614.14	183.64	0.00	9.07%
Shrub-swamp	6,667,502.88	0.00	153.07	0.45	7.56%
Sparse shrub-swamp	16,913,447.55	2,939,528.59	388.28	3.16	19.18%
Mud/sand/clay	56,106,361.83		1,288.01		63.64%
Sum	**88,167,568.85**	**3,282,734.44**	**2,024.04**	**8.47**	**100.00%**

Upper Main Reservoir	Surface Acreage		Reduction		
	At full pond	At 12' drawdown	acres	%	
	3,859.68	1,835.64	2,024.04	52.44	

[1] Habitat mapped between USGS elevations 624' to 612'.
[2] Habitat mapped below USGS elevation 612'.

A 12-foot drawdown in this area exposes 2,024 acres of total habitat (Table 4.2-5). Of the total exposed acreage, 63.6 % (1,288.03 acres) was classified as low quality mud/sand/clay habitat. Four wetland habitat types covered an additional 725.64 acres within the drawdown zone. Of these, sparse shrub-swamp was the most abundant, accounting for 53.5 % of total wetland acreage. Flood plain forest (25.3 %), shrub-swamp (21.1 %), and palustrine emergent (< 0.1 %) were present in lesser amounts. The remaining 10.4 acres were mapped as quality habitat types. Docks comprised 42% (4.34 acres) of the quality habitat available within the drawdown zone (Figure 4.2-10). Woody cover was dominated by medium branched trees, which accounted for 23% (2.4 acres) of the available quality habitat. Brush (0.5 acres; 5%), stumps (.027 acres; 3%), heavily and no branched trees (0.15 acres; 1% and 0.07 acres; 1% - respectively) were also present within the drawdown zone. A small area of Christmas trees (0.01 acres; <1) was also present. Rip-rap (2.20 acres; 21%) was the dominant rocky substrate in the upper main reservoir. Cobble (0.27 acres; 3%), boulder (0.14 acres; 1%) and ledge (0.05 acres; <1%) were the three other rocky substrate types available to aquatic biota.

An additional 8.47 acres of quality habitat were mapped in the five feet below the lower limit of the drawdown zone (el. 612 to 607) (Table 4.2-5). Sparse shrub-swamp was the dominant habitat type, covering 3.16 acres and accounting for 37.3 % of the habitat mapped below the drawdown. Shrub-swamp covered an additional 0.45 acres (4.0 %). Rocky substrate was the second dominant habitat type. Ledge (1.49 acres; 17 %) and rip-rap (1.45 acres; 17 %) were the two dominant rocky substrates present. Boulder (0.26 acres; 3%) and cobble (0.30 acres; 4 %) were present in smaller quantities. Stumps (0.60 acres; 7 %) were the most abundant woody cover type mapped in the area below the drawdown zone. Medium branched trees (0.35 acres; 4 %) and brush (0.28 acres; 3 %) were the second and third most dominant woody cover types in the upper main reservoir. Docks comprised 0.12 acres (3%) of the available quality habitat in the area mapped below the drawdown zone.

The average 12 ft drawdown reduces the water surface acreage of the upper main reservoir from 3,859.7 acres to 1,835.6 acres (52.44 % or 2,024.0 acres) (Table 4.2-5).

4.2.2.3 Lower Main Reservoir

For analysis, the main reservoir was split into an upper and lower section. The lower section extended from the area just upstream from the confluence of Second Creek and the main reservoir, down to the High Rock dam at the downstream end of the reservoir (Figure 4.2-6). Locations of habitats mapped in the lower main reservoir are shown in Figure 4.2-11 (see attached CD). Within the entirety of the lower main reservoir, 94% is comprised of mud/sand/clay habitat (Table 4.2-6). Wetland habitats cover an additional 2% with flood plain forest being the dominant type. The remaining 4% of habitats mapped fell into the quality woody cover, rock substrate and dock habitat types.

A 12-foot drawdown in this area exposes 587.84 acres of total habitat (Table 4.2-6). Of that total, 541.6 acres (92%) of the habitat was classified as mud/sand/clay habitat. An additional 46.2 acres were classified as wetland habitats, with 29.61 acres of flood plain forest being the most abundant type. Lesser amounts of sparse shrub-swamp (3.76 acres) were also present.

The remaining 12.8 acres were mapped as quality habitat types (Figure 4.2-12). Of the remaining habitat within the drawdown zone, rocky substrate was abundant with boulder (3.94 acres; 31%) and rip-rap (2.43 acres; 19%) being the most common. Ledge (0.30 acres; 2 %) and cobble (0.02 acres;

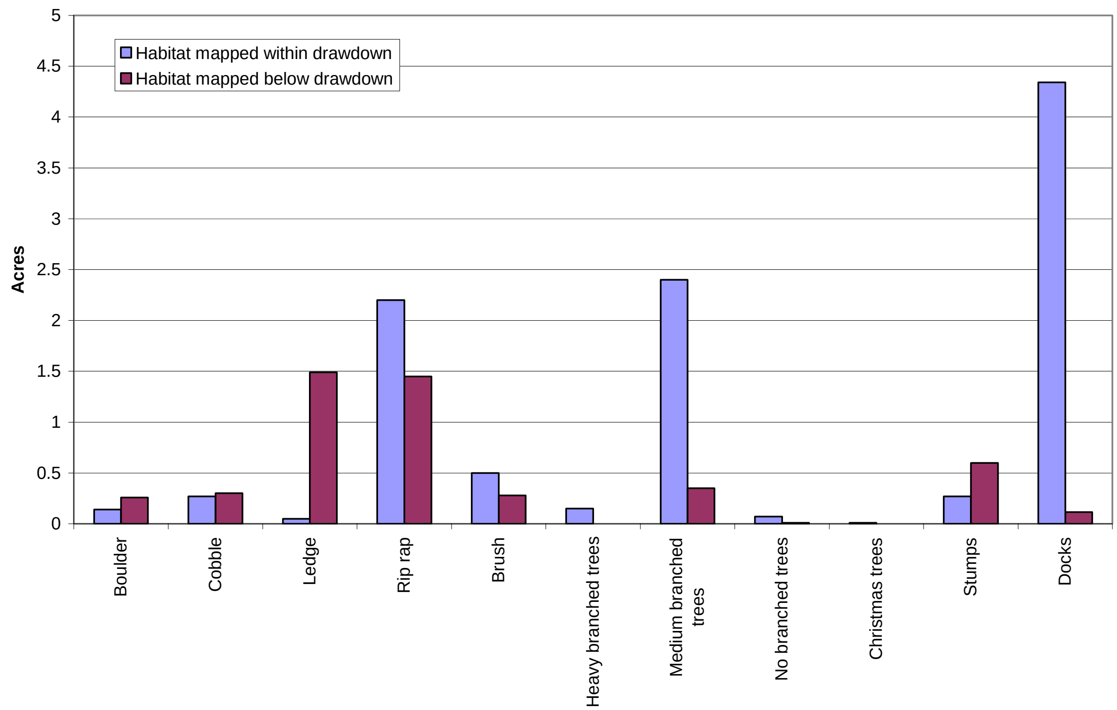

Figure 4.2-10. Habitat types mapped in the Upper Reservoir Area within the drawdown zone (el. 612-624) and 5-feet below (<el. 612) the drawdown zone. Wetland and mud/sand/clay habitat types are not included in this figure.

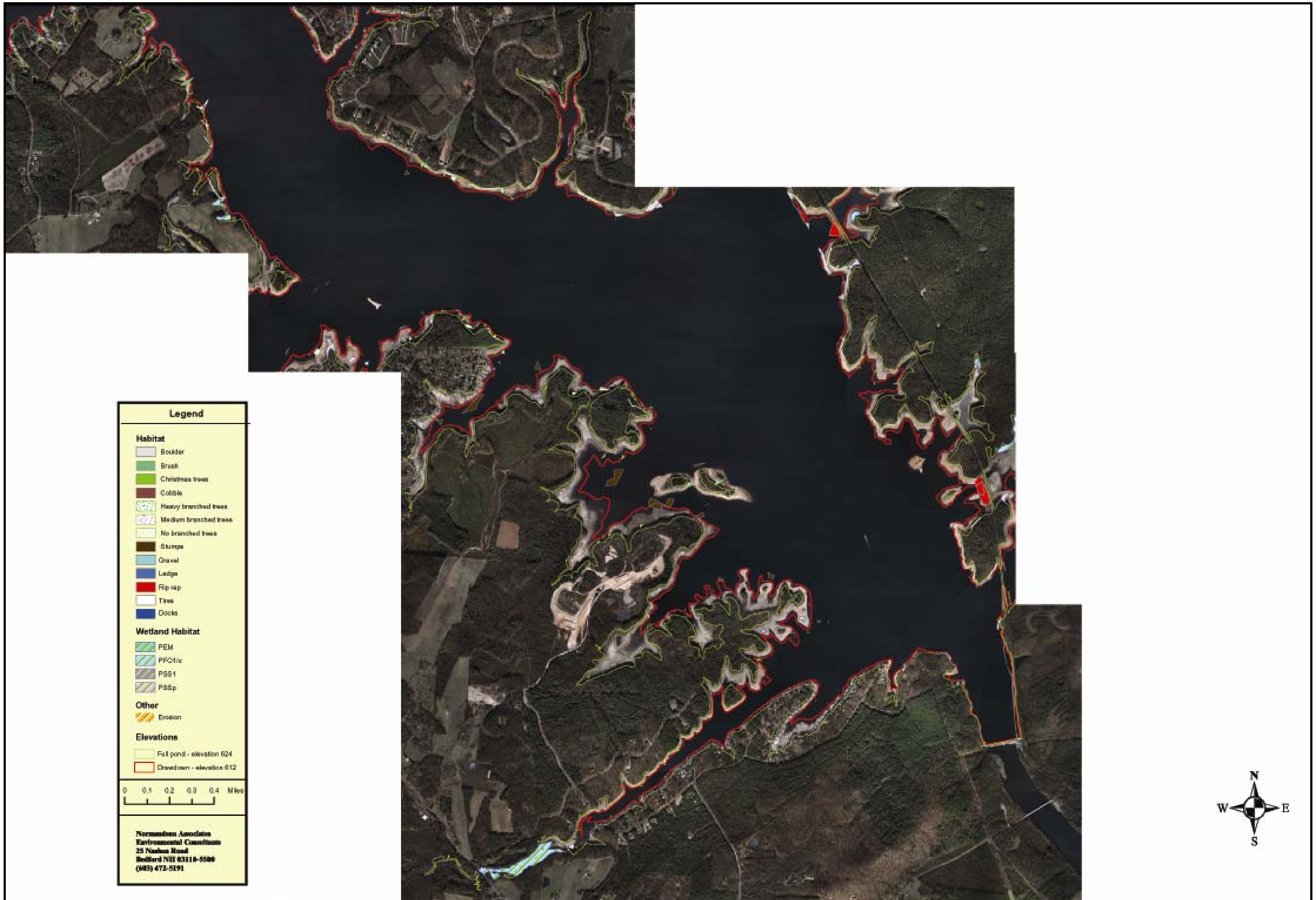

Figure 4.2-11. Habitat types mapped in the Lower Main Section of the High Rock Reservoir.

Table 4.2-6. Amount of habitat mapped in the lower main reservoir within the drawdown zone (el. 624 down to 612) and 5 feet below the drawdown zone (el. 612 to 607).

Lower Main Reservoir

	Available Habitat				
Habitat Type	Habitat mapped within drawdown [1] (sq. feet)	Habitat mapped below drawdown [2] (sq. feet)	Habitat mapped within drawdown [1] (acres)	Habitat mapped below drawdown [2] (acres)	% of drawdown zone acreage
Boulder	171,830.94	143,716.07	3.94	3.30	0.67%
Cobble	813.48	8,028.64	0.02	0.18	0.00%
Ledge	13,140.82	81,009.66	0.30	1.86	0.05%
Rip rap	105,847.49	103,624.09	2.43	2.38	0.41%
Brush	11,030.10	12,263.33	0.25	0.28	0.04%
Heavy branched trees	735.09	0.00	0.02	0.00	0.00%
Medium branched trees	111,588.36	15,272.08	2.56	0.35	0.44%
No branched trees	515.11	0.00	0.01	0.00	0.00%
Christmas trees	1,140.17	2,086.27	0.03	0.05	0.00%
Stumps	56,233.02	309,025.44	1.29	7.09	0.22%
Docks	85,813.20	4,356.00	1.89	0.10	0.32%
Flood plain forest	1,289,787.00	0.00	29.61	0.00	5.04%
Sparse shrub-swamp	163,769.78	0.00	3.76	0.00	0.64%
Mud/sand/clay	23,593,743.80		541.72		92.15%
Sum	**25,605,988.34**	**679,381.57**	**587.84**	**15.60**	**100.00%**

Lower Main Reservoir	**Surface Acreage**		**Reduction**		
	At full pond	**At 12' drawdown**	**acres**	**%**	
	2,919.10	2,331.26	587.84	20.14	

[1] Habitat mapped between USGS elevations 624' to 612'.
[2] Habitat mapped below USGS elevation 612'.

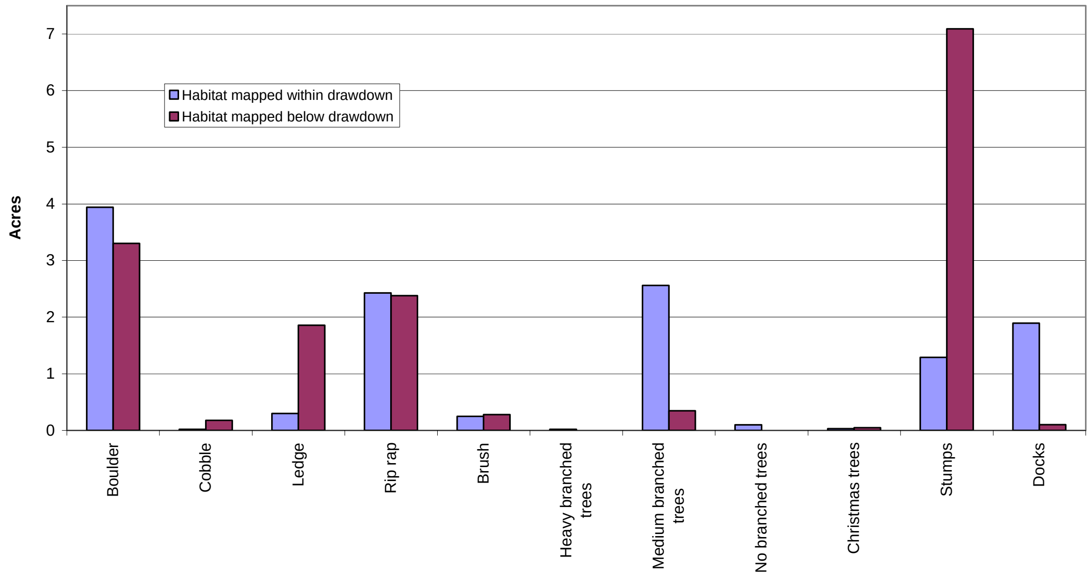

Figure 4.2-12. Habitat types mapped in the Lower Reservoir Area within the drawdown zone (el. 612-624) and 5-feet below (<el. 612) the drawdown zone. Wetland and mud/sand/clay habitat types are not included in this figure.

<1%) were present in lesser amounts. Medium branched trees were the dominant form of woody cover. They covered 2.56 acres and comprised 20 % of the available quality habitat. Stumps (1.29 acres; 10%), brush (0.25 acres; 2%), Christmas trees, heavy and no branched trees (all <1%) were also present. Docks made up 15% of the quality habitat, covering 1.89 acres.

An additional 15.6 acres of quality habitat were mapped within the five feet below the drawdown zone (el. 612 to 607) (Table 4.2-6). Of the woody cover present, the majority of it (7.1 acres; 46 % of the quality habitat) was stump habitat. Other woody cover type present included medium branched trees (0.35 acres; 2 %) and brush (0.28 acres; 2 %). Rocky substrate was dominated by rip-rap and boulders which accounted for 15 % (2.38 acres) and 21 % (3.30 acres), respectively, of quality habitat. Ledge (1.86 acres; 12 %) and cobble (0.18 acres; 1 %) were also present.

The average 12 ft drawdown reduces the water surface acreage of the lower main reservoir area from 2,781.01 acres to 2,196.98 acres (21.0 % or 584.0 acres) (Table 4.2-6).

4.2.2.4 Crane Creek Tributary Arm

Locations of habitats mapped in the Crane Creek Tributary arm are shown in Figure 4.2-13 (see attached CD).

Within the 12-foot drawdown zone in Lower Crane Creek, there was a total of 762.52 acres of exposed habitat (Table 4.2-7). Eighty-six percent (654 acres) of that exposed total was classified as mud/sand/clay substrate that is of low value to aquatic biota. An additional 96.2 acres was comprised of four types of wetlands, accounting for 13 % of the Crane Creek drawdown zone. Flood plain forest was the most abundant, covering 83.8 acres and accounting for 87 % of the total wetland habitat. Palustrine emergent, shrub-swamp and sparse shrub-swamp were also present. The

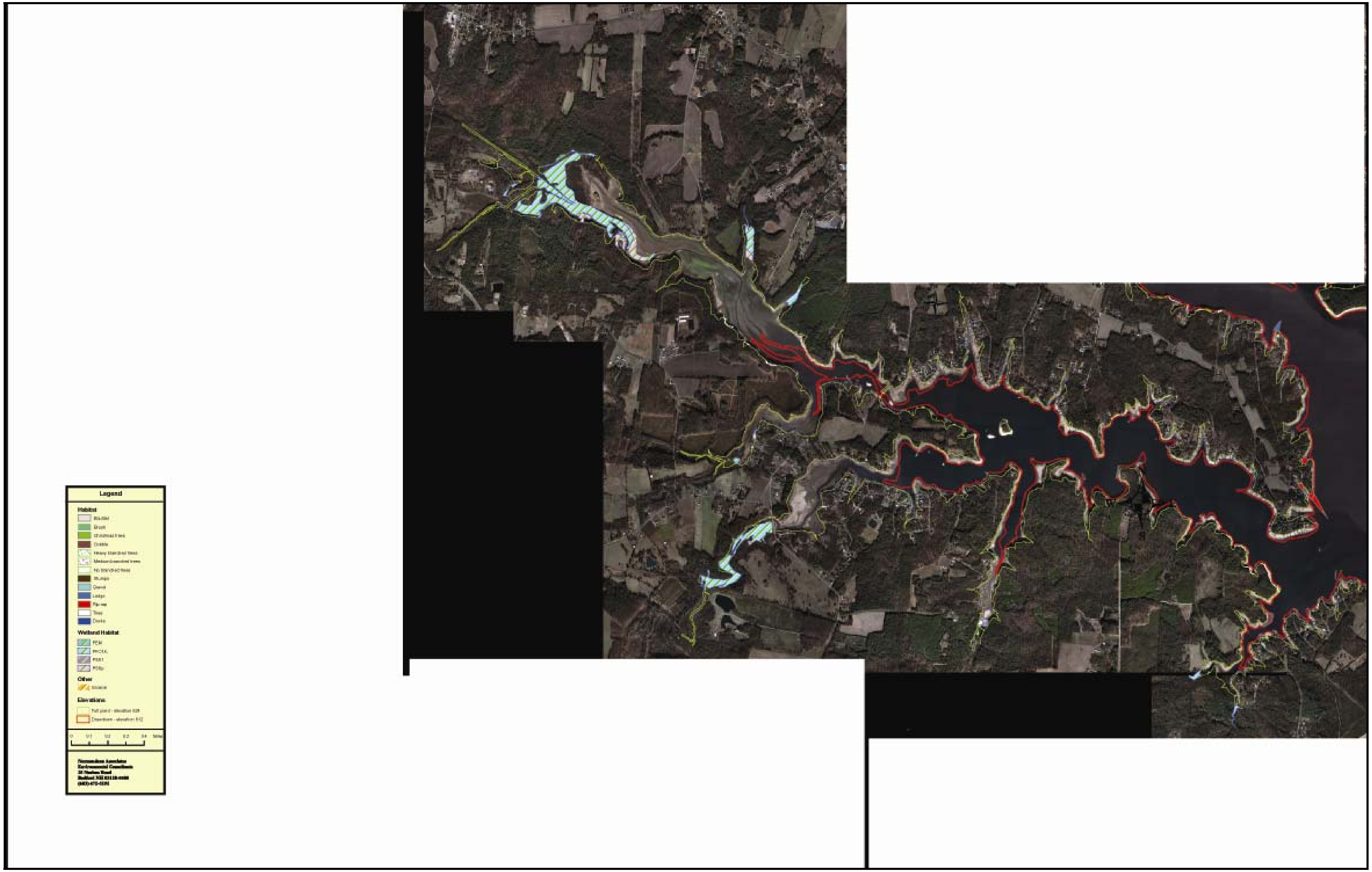

Figure 4.2-13. Habitat types mapped in the Crane Creek Tributary Arm.

Table 4.2-7. Amount of habitat mapped in Crane Creek Tributary Arm within the drawdown zone (el. 624 down to 612) and 5 feet below the drawdown zone (el. 612 to 607).

Crane Creek Tributary Arm

Habitat Type	Available Habitat: Habitat mapped within drawdown [1] (sq. feet)	Habitat mapped below drawdown [2] (sq. feet)	Habitat mapped within drawdown [1] (acres)	Habitat mapped below drawdown [2] (acres)	% of drawdown zone acreage
Boulder	48,779.33	31,670.65	1.12	0.72	0.15%
Cobble	52,394.83	41,207.59	1.20	0.95	0.16%
Ledge	277.71	0.00	0.01	0.00	0.00%
Rip rap	60,862.21	55.09	1.40	0.00	0.18%
Brush	4,526.92	2,230.35	0.10	0.05	0.01%
Heavily branched trees	17,738.54	0.00	0.41	0.00	0.05%
Medium branched trees	156,257.95	1,882.78	3.59	0.04	0.47%
No branched trees	212.50	0.00	0.01	0.00	0.00%
Christmas trees	3,732.33	87.12	0.08	0.00	0.01%
Stumps	5,830.36	16,173.19	0.13	0.37	0.02%
Docks	174,893.00	3,702.60	3.93	0.09	0.52%
Palustrine emergent	69,837.63	0.00	1.60	0.00	0.21%
Flood plain forest	3,650,008.66	0.00	83.79	0.00	10.99%
Shrub-swamp	20,025.09	0.00	0.46	0.00	0.06%
Sparse shrub-swamp	451,010.21	0.00	10.35	0.00	1.36%
Mud/sand/clay	28,499,015.73		654.33		85.81%
Sum	**33,215,402.99**	**97,009.37**	**762.52**	**2.22**	**100.00%**

Crane Creek Tributary Arm	**Surface Acreage**		**Reduction**		
	At full pond	**At 12' drawdown**	**acres**	**%**	
	1,347.12	584.60	762.52	56.60	

[1] Habitat mapped between USGS elevations 624' to 612'.
[2] Habitat mapped below USGS elevation 612'.

remaining 12.1 acres were comprised of quality habitat types (Figure 4.2-14). Of these 12.1 acres, 33% (4.0 acres) was comprised of docks. The remaining 67% was split between rocky substrates and woody cover. Rip-rap was the dominant rocky substrate, comprising 12% (1.4 acres) of the quality habitat within the drawdown zone. Cobble (1.2 acres; 10%) and boulder (1.12 acres; 9 %) were the next two most common rocky substrates in the Crane Creek tributary arm. The most abundant woody cover type was medium branched trees. They were responsible for 30 % (3.59 acres) of the quality habitat within the drawdown zone. Heavily branched trees (0.41 acres; 3%), brush (0.10 acres; 1 %), Christmas trees (0.08 acres; 1 %), stumps (0.13 acres; 1 %) and no branched trees (0.01 acres; <1 %) comprised the remainder of the woody cover in the drawdown area.

An additional 2.22 acres of quality habitat were mapped in the five feet below the lower limit of the drawdown zone (el. 612 to 607) (Table 4.2-7). Stumps (0.37 acres; 17%) were the dominant woody cover typs present. Medium branched trees (0.04 acres; 2 %), brush (0.05 acres; 2 %) and a small area of Christmas trees (<0.01 acres) were also available to aquatic biota. In addition to the woody cover, several rocky substrate types were also present. Boulder (0.72 acres; 33%) and cobble (0.95 acres; 43%) were present below the drawdown zone. There were no wetland habitats present below the drawdown zone.

The average 12 ft drawdown reduces the water surface acreage of the Lower Crane Creek tributary arm from 1,347.2 acres to 584.6 acres (56.6 % or 762.52 acres) (Table 4.2-7).

4.2.2.5 Swearing Creek Tributary Arm

Locations of habitats mapped in Swearing Creek tributary arm are shown in Figure 4.2-15 (see attached CD). Within Swearing Creek, there are 429.9 acres of total habitat that are exposed during an average 12 ft drawdown (Table 4.2-8). Of these 430 acres, 380 acres, or 88% was comprised of the low quality mud/sand/clay habitat. An additional 36 acres were covered by wetland habitat. Flood plain forest was the dominant wetland type, covering 28.6 acres of the drawdown zone. Shrub-swamp and sparse shrub-swamp habitat was also present in Swearing Creek Arm. The remaining 14.2 acres within the drawdown zone were classified and mapped as higher quality habitats (Figure 4.2-16). Docks were the dominant habitat within this section of High Rock Reservoir. They covered 4.2 acres and comprised 30% of the quality habitat in Swearing Creek. Rocky substrates and woody cover represented the remaining 70 % of the quality habitat. Rip-rap (2.58 acres; 18 %), ledge (1.12 acres; 8 %), cobble (0.12 acres; 1 %) and boulder (0.1 acres; 1%) were the rocky habitat types present. The woody cover in Swearing Creek was dominated by medium branched trees (4.79 acres; 37 %) and brush (0.73 acres; 5 %). Areas of Christmas trees, stumps and no-branched trees were also present.

An additional 0.77 acres of quality habitat was mapped within the five feet below the average drawdown level (el. 612 to 607) (Table 4.2-8). Rip-rap was the most abundant rocky habitat type, covering 0.21 acres (28%) of the additional habitat mapped. Woody cover was dominated by medium branched trees, which covered 0.17 acres and composed 22% of the quality habitat below the drawdown zone of Lower Swearing Creek. Docks were responsible for 0.14 acres (18%) of the habitat below the drawdown zone. Within the area below the drawdown, boulders, ledge, brush, and stumps provided additional quality habitat. There were no wetland habitats present in the mapped areas below the drawdown zone.

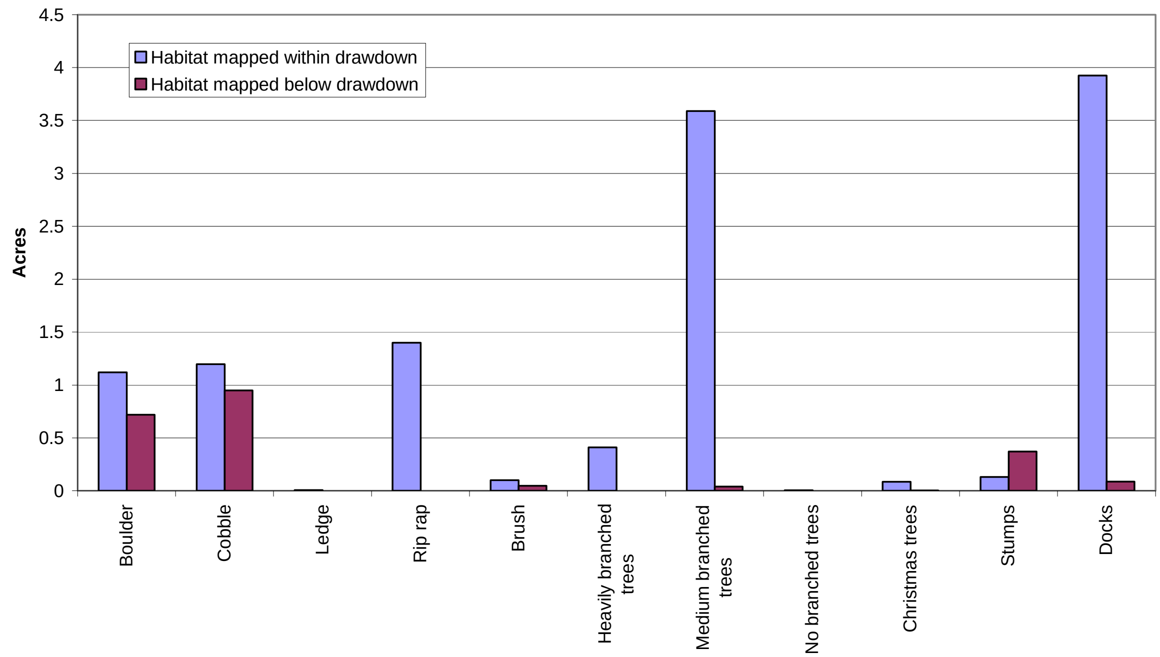

Figure 4.2-14. Habitat types mapped in the Lower Crane Creek Tributary Arm within the drawdown zone (el. 612-624) and 5-feet below (<el. 612) the drawdown zone. Wetland and mud/sand/clay habitat types are not included in this figure.

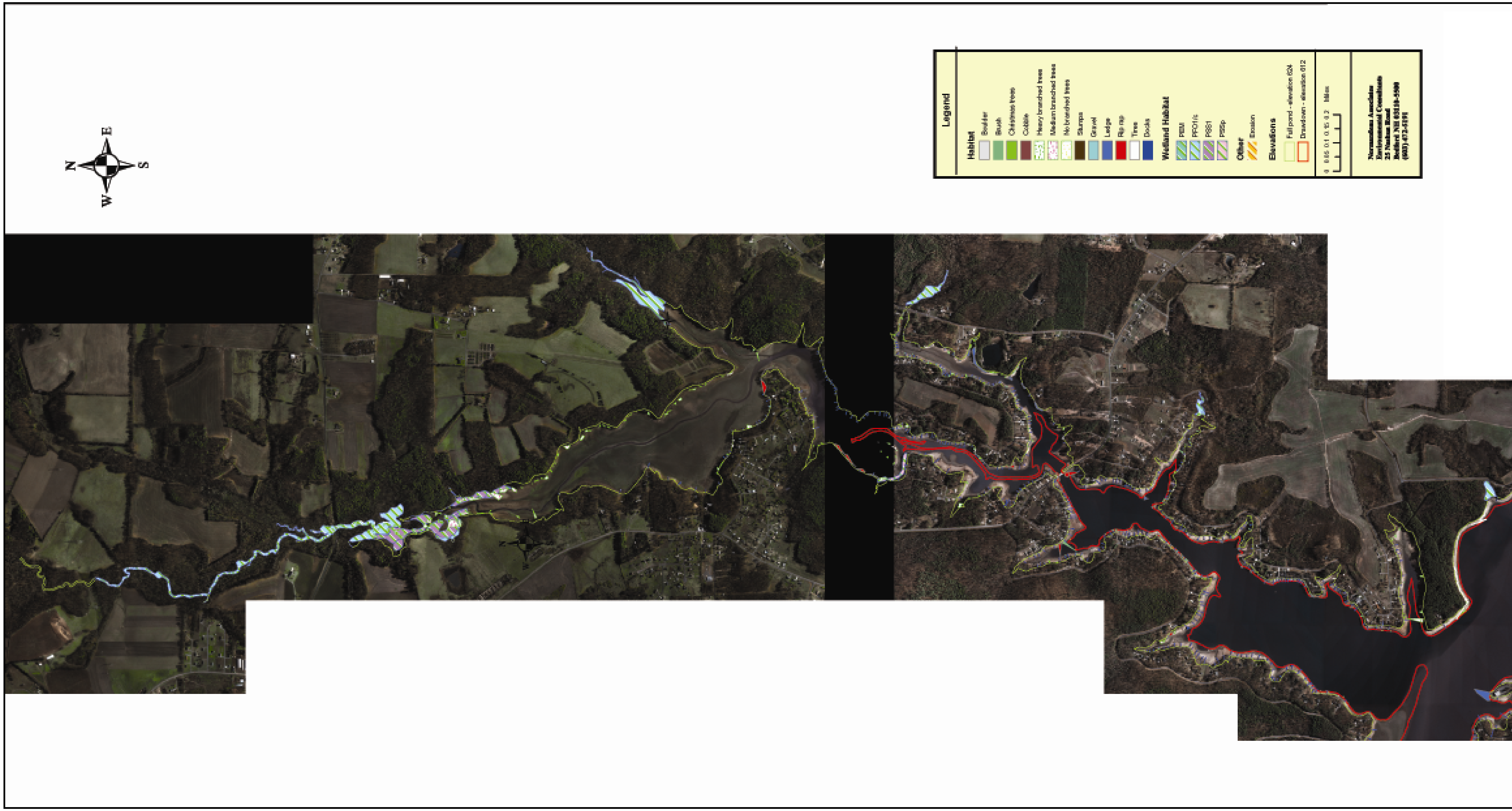

Figure 4.2-15. Habitat types mapped in the Swearing Creek Tributary Arm.

Table 4.2-8. Amount of habitat mapped in Swearing Creek Tributary Arm within the drawdown zone (el. 624 down to 612) and 5 feet below the drawdown zone (el. 612 to 607).

Swearing Creek Tributary Arm

	Available Habitat				
Habitat Type	Habitat mapped within drawdown [1] (sq. feet)	Habitat mapped below drawdown [2] (sq. feet)	Habitat mapped within drawdown [1] (acres)	Habitat mapped below drawdown [2] (acres)	% of drawdown zone acreage
Boulder	4,098.17	261.51	0.09	0.01	0.02%
Cobble	5,101.18	0.00	0.12	0.00	0.03%
Gravel	114.07	0.00	0.00	0.00	0.00%
Ledge	48,959.89	5,417.03	1.12	0.12	0.26%
Rip rap	112,481.27	9,204.86	2.58	0.21	0.60%
Tires	38.14	0.00	0.00	0.00	0.00%
Brush	31,489.51	4,231.87	0.73	0.10	0.17%
Medium branched trees	208,693.10	7,311.10	4.79	0.17	1.11%
No branched trees	1,509.44	0.00	0.34	0.00	0.08%
Christmas trees	6,617.04	888.56	0.15	0.02	0.03%
Stumps	250.96	24.28	0.01	0.00	0.00%
Docks	167,183.00	6,185.52	4.29	0.14	1.00%
Flood plain forest	1,244,307.07	0.00	28.57	0.00	6.64%
Shrub-swamp	265,488.37	0.00	6.09	0.00	1.42%
Sparse shrub-swamp	64,355.28	0.00	1.48	0.00	0.34%
Mud/sand/clay	16,555,347.22		379.61		88.29%
Sum	**18,716,033.72**	**33,524.71**	**429.97**	**0.77**	**100.00%**

Swearing Creek Tributary Arm	**Surface Acreage**		**Reduction**		
	At full pond	**at 12' drawdown**	**acres**	**%**	
	638.81	208.84	429.97	67.31%	

[1] Habitat mapped between USGS elevations 624' to 612'.
[2] Habitat mapped below USGS elevation 612'.

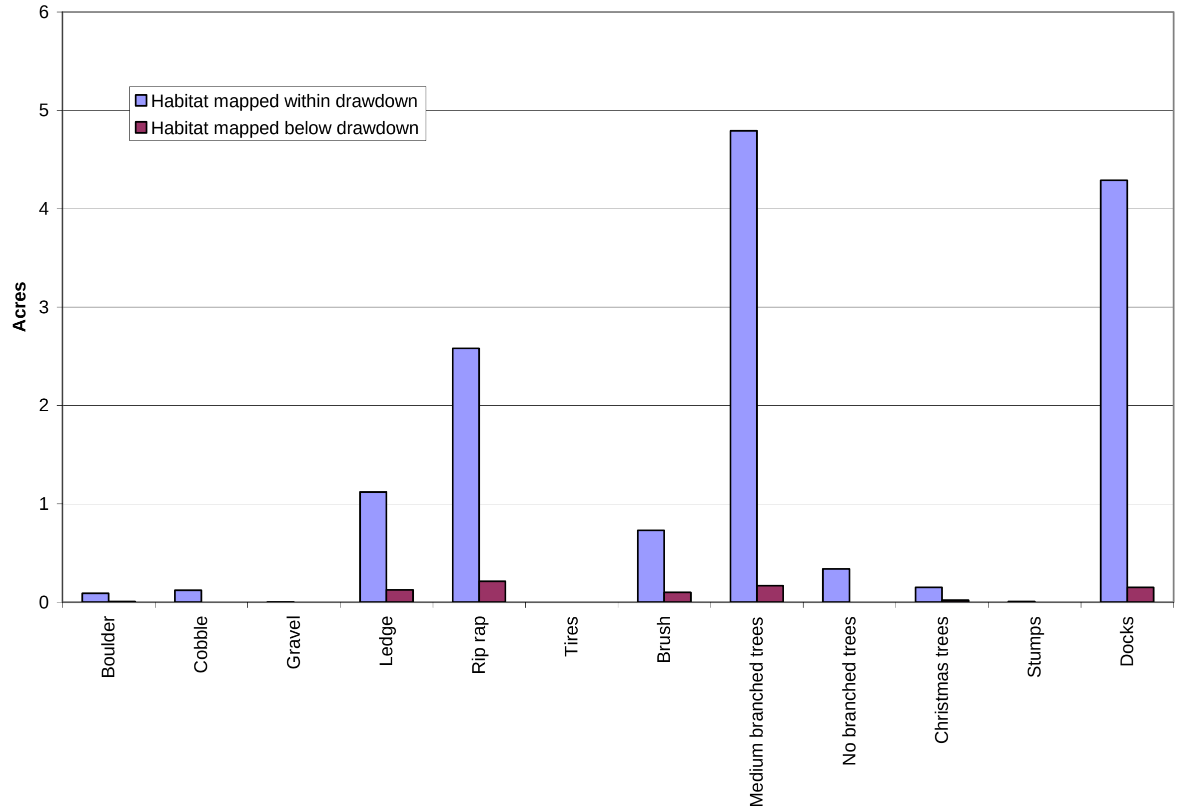

Figure 4.2-16. Habitat types mapped in the Swearing Creek Tributary Arm, within the drawdown zone (el. 612-624) and 5 feet below (<el. 612) the drawdown zone. Wetland and mud/sand/clay habitat types are not included in this figure.

The average 12 ft drawdown reduces the water surface acreage of the Swearing Creek tributary arm from 638.81 acres to 208.84 acres (67.3 % or 429.97 acres) (Table 4.2-8). Figure 4.2-17 shows the presence of water in the upper reach of Swearing Creek during the drawdown.

4.2.2.6 Abbott's Creek Tributary Arm

Locations of habitats mapped in Abbott's Creek tributary arm are shown in Figure 4.2-18 (see attached CD). Abbott's Creek has a total of 1,184.97 acres of habitat that are exposed during the average 12 ft drawdown (Table 4.2-9). Of the total exposed area, 939.69 acres or 79 %, was classified as mud/sand/clay. Palustrine emergent, flood plain forest, shrub-swamp, and sparse shrub-swamp combined to cover 223.8 acres of the drawdown zone. Flood plain forest was the dominant type, accounting for 81 % of the wetland habitat. The remaining 21.5 acres is comprised of higher quality habitats such as docks, rocky substrate and woody cover (Figure 4.2-19). Docks covered 9.96 acres and comprised 46 % of the quality habitat within this section of High Rock. Rocky substrate accounted for another 32% of the high quality habitat within this section. Rip-rap was the most abundant rocky substrate, covering 4.6 acres and representing 21% of the quality habitat. Boulder (1.1 acres; 5 %), ledge (0.7 acres; 3%), and cobble (0.4 acres; 2 %) comprised the remainder of the high quality rocky habitat within Lower Abbott's Creek. A total of 4.77 acres of woody cover (all

Photos A/B. Upper portion of Swearing Creek during 17-foot drawdown showing remaining channel.

Photo C. Upper portion of Abbots Creek during 17-ft drawdown showing remaining channel.

Photo D. Upper portion of Flatswamp Creek during 17-ft drawdown remaining channel.

Figure 4.2-17. Upper reaches of Swearing, Flat Swamp, and Abbott's Creeks showing presence of water during 17-ft drawdown.

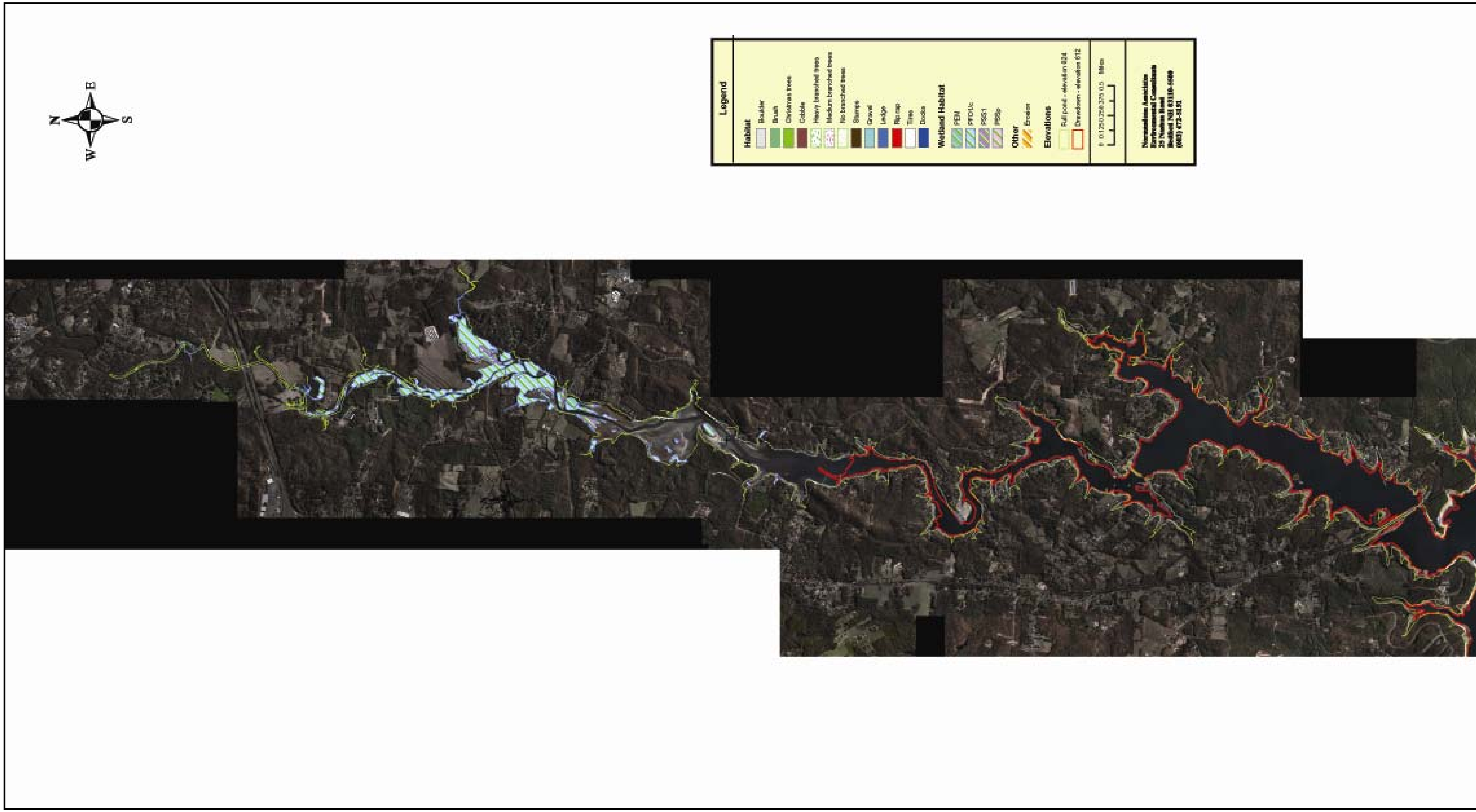

Figure 4.2-18. Habitat types mapped in the Abbotts Creek Tributary Arm.

Table 4.2-9. Amount of habitat mapped in Abbotts Creek Tributary Arm, within the drawdown zone (el. 624 down to 612), and 5 feet below the drawdown zone (el. 612 to 607).

Abbotts Creek Tributary Arm

	Available Habitat				
Habitat Type	Habitat mapped within drawdown [1] (sq. feet)	Habitat mapped below drawdown [2] (sq. feet)	Habitat mapped within drawdown [1] (acres)	Habitat mapped below drawdown [2] (acres)	% of drawdown zone acreage
Boulder	48,080.56	26,967.71	1.10	0.62	0.09%
Cobble	17,700.29	6,322.46	0.41	0.15	0.03%
Ledge	31,886.23	36,826.18	0.73	0.85	0.06%
Rip rap	198,821.39	353,474.38	4.57	8.11	0.39%
Brush	11,999.66	14,546.41	0.28	0.33	0.02%
Heavily branched trees	22,526.33	0.00	0.52	0.00	0.04%
Medium branched trees	163,939.51	12,618.54	3.76	0.29	0.32%
No branched trees	2,169.24	88.22	0.05	0.00	0.00%
Christmas trees	6,488.49	6,898.47	0.15	0.16	0.01%
Stumps	301.83	142,552.13	0.01	3.27	0.00%
Docks	397,267.00	15,768.70	9.96	0.36	0.84%
Palustrine emergent	507,297.23	0.00	11.64	0.00	0.98%
Flood plain forest	7,942,204.59	0.00	182.33	0.00	15.39%
Shrub-swamp	1,035,772.89	0.00	23.78	0.00	2.01%
Sparse shrub-swamp	261,241.12	0.00	6.00	0.00	0.51%
Mud/sand/clay	40,969,322.52		939.69		79.30%
Sum	**51,617,018.86**	**616,063.20**	**1,184.97**	**14.13**	**100.00%**

Abbots Creek Tributary Arm	**Surface Acreage**		**Reduction**		
	At full pond	**At 12' drawdown**	**acres**	**%**	
	2,271.17	1,105.69	1,184.97	52.17	

[1] Habitat mapped between USGS elevations 624' to 612'.
[2] Habitat mapped below USGS elevation 612'.

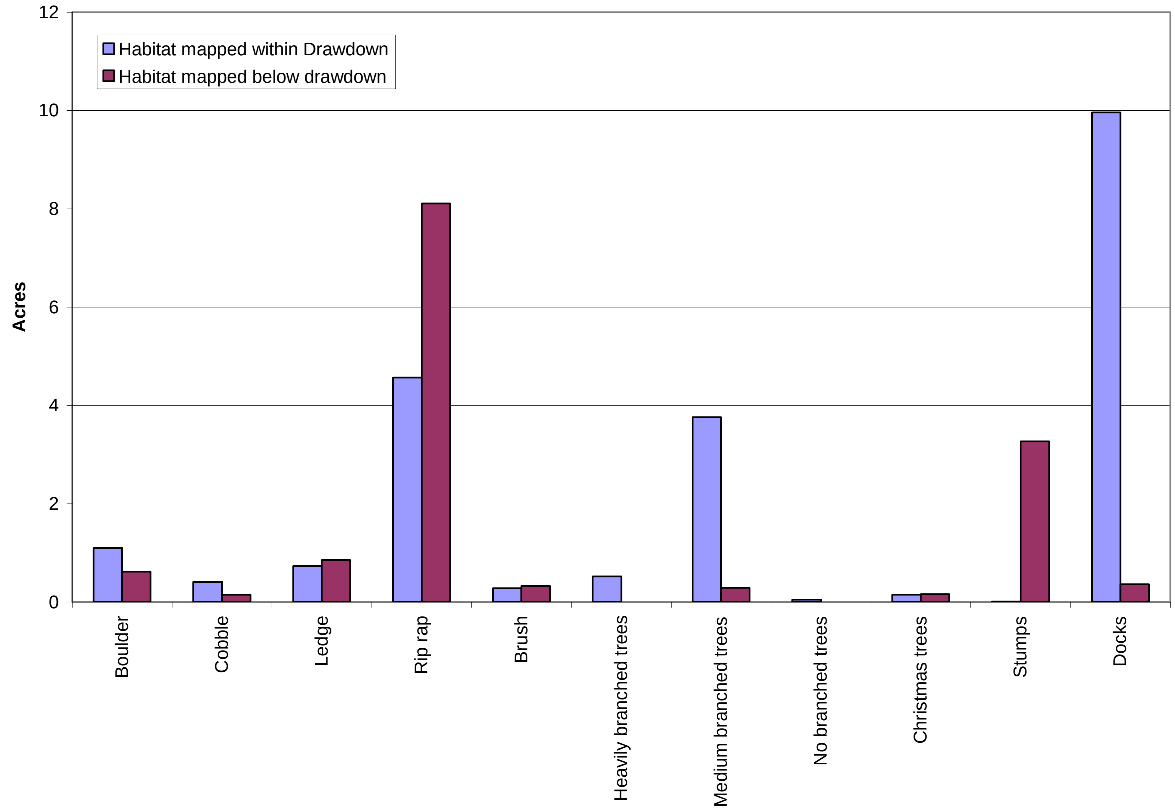

Figure 4.2-19. Habitat types mapped in the Abbotts Creek Tributary Arm, within the drawdown zone (el. 612-624) and 5 feet below (<el. 612) the drawdown zone. Wetland and mud/sand/clay habitat types are not included in this figure.

types combined) was located in the drawdown zone. Medium branched trees are the dominant woody cover type, covering 3.76 acres and comprising 17 % of the quality habitat available, followed by heavily branched trees (0.52 acres; 2%) and brush (0.28 acres; 1%),. Present in lesser quantities (<0.1 acres), were Christmas trees, no branched trees, and stumps.

An additional 14.13 acres of quality habitat were mapped within the five feet below the drawdown zone in Abbott's Creek (el. 612 to 607) (Table 4.2-9). Rip-rap covered 8.1 acres and made up 57% of this additional habitat. Another 23 % or 3.3 acres of additional habitat was stumps. The remaining 2.75 acres of quality habitat was a mix of rocky substrates (boulder, cobble, ledge), woody cover (brush, heavily branched, medium branched and no branched trees, Christmas trees) and docks. There were no wetland habitats within the mapped area below the drawdown zone. Figure 4.2-17 shows the presence of water in the upper reach of Abbott's Creek during the drawdown.

The average 12 ft drawdown reduces the water surface acreage of Lower Abbott's Creek from 2,271.17 acres to 1,105.69 acres (52.17 % or 1,184.97 acres) (Table 4.2-9).

Figure 4.2-20. Habitat types mapped in the Second Creek Tributary Arm..

Table 4.2-10. Amount of habitat mapped in Second Creek Tributary Arm, within the drawdown zone (el. 624 down to 612)and 5 feet below the drawdown zone (el. 612 to 607).

Second Creek Tributary Arm

Habitat Type	**Available Habitat** Habitat mapped within drawdown [1] (sq. feet)	Habitat mapped below drawdown [2] (sq. feet)	Habitat mapped within drawdown [1] (acres)	Habitat mapped below drawdown [2] (acres)	% of drawdown zone acreage
Boulder	2,811.77	206,794.98	0.06	4.75	0.01%
Cobble	10,949.56	0.00	0.25	0.00	0.04%
Ledge	0.00	10,501.88	0.00	0.24	0.00%
Rip rap	35,029.22	62,290.54	1.03	1.43	0.16%
Brush	19,650.61	12,078.70	0.45	0.28	0.07%
Heavily branched trees	5,874.19	0.00	0.14	0.00	0.02%
Medium branched trees	460,443.09	5,659.96	10.57	0.13	1.68%
No branched trees	112.32	0.00	0.00	0.00	0.00%
Christmas trees	10,190.55	7,086.36	0.23	0.16	0.04%
Stumps	30,267.94	1,186,563.93	0.70	27.24	0.11%
Tires	241.08	62.07	0.01	0.00	0.00%
Docks	144,619.00	9,147.60	3.62	0.21	0.58%
Palustrine emergent	46,107.78	0.00	1.06	0.00	0.17%
Flood plain forest	518,990.38	0.00	11.91	0.00	1.90%
Shrub-swamp	239,611.89	0.00	5.50	0.00	0.88%
Sparse shrub-swamp	234,150.14	0.00	5.38	0.00	0.86%
Mud/sand/clay	25,600,544.95		587.41		93.49%
Sum	**27,359,594.46**	**1,500,186.02**	**628.32**	**34.44**	**100.00%**

Second Creek Tributary Arm	**Surface Acreage**		**Reduction**		
	At full pond	**At 12' drawdown**	**acres**	**%**	
	1,315.92	687.60	628.32	47.75	

[1] Habitat mapped between USGS elevations 624' to 612'.
[2] Habitat mapped below USGS elevation 612'.

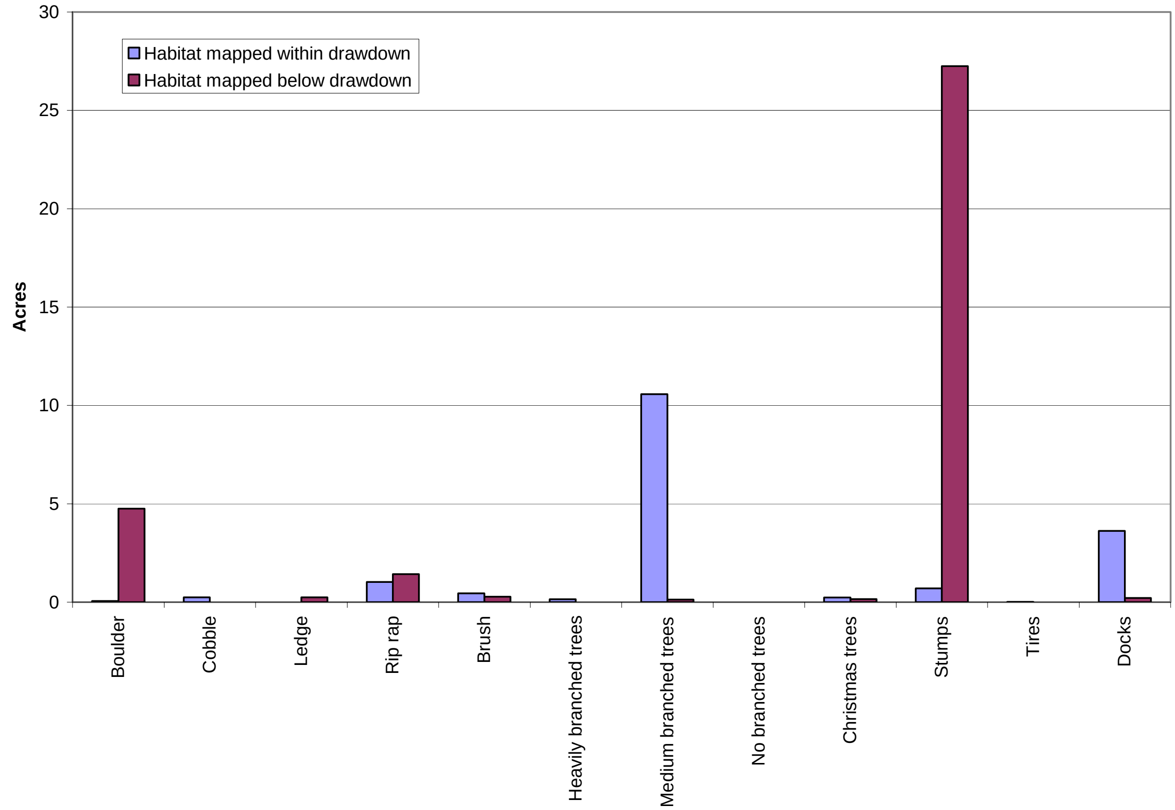

Figure 4.2-21. Habitat types mapped in the Second Creek Tributary Arm, within the drawdown zone (el. 612-624) and 5 feet below (<el. 612) the drawdown zone. Wetland and mud/sand/clay habitat types are not included in this figure.

4.2.2.7 Second Creek Tributary Arm

Locations of habitats mapped in Second Creek tributary arm are shown in Figure 4.2-20 (see attached CD). Within Second Creek tributary arm, there are 628.32 acres of total habitat that are exposed during an average 12 ft drawdown (Table 4.2-10). Of that, 93 % (587.4 acres) was categorized as mud/sand/clay. Four wetland habitat types combined to cover 23.85 acres of the drawdown zone. Flood plain forest was the dominant type accounting for 50 % of the wetland cover. Shrub-swamp (23 %) sparse shrub-swamp (22%) and palustrine emergent (5 %) were present in lesser amounts. The remaining 17.1 acres were mapped as quality habitat types (Figure 4.2-21). Docks accounted for 21% (3.62 acres) of the quality habitat. Woody cover habitat types were more abundant then rocky substrate types. The majority of woody cover present was made up of medium branched trees (10.57 acres; 62 %) and stumps (0.70 acres; 4 %). Lesser quantities of brush (0.45 acres), Christmas trees (0.23 acres) and heavily branched trees (0.14 acres) were also present. Most of the rocky substrate available in the drawdown zone was rip rap, accounting for 6 % (1.03 acres) of the quality habitat. Cobble (0.25 acres; 1 %) and boulder (0.06 acres; <1%) were also present in the drawdown zone.

An additional 34.44 acres of quality habitat were mapped at elevations lower the 612 feet (Table 4.2-10). Of that, 80% was comprised of stumps, which covered 27.24 acres. Other woody cover types present included heavily branched trees, medium branched trees and Christmas trees which each comprised less then 1% of the quality habitat mapped. Rocky substrate below the 612-foot elevation was dominated by boulder habitat (4.75 acres; 14%). Rip-rap (1.43 acres; 4%) and ledge (0.24 acres; <1%) habitat was also present. Docks were responsible for less then 1% of the quality habitat below the drawdown zone, covering only 0.21 acres. There were no wetland habitats present in the mapped area below the drawdown zone.

The average 12 ft drawdown reduces the water surface acreage of Second Creek tributary arm from 1,315.92 acres to 687.6 acres (47.75 % or 628.32 acres) (Table 4.2-10).

4.2.2.8 Flat Swamp Creek Tributary Arm

Locations of habitats mapped in Flat Swamp Creek tributary arm are shown in Figure 4.2-22 (see attached CD). Within Flat Swamp Creek tributary arm, there are 378.6 acres of total habitat that are exposed during an average 12 ft drawdown (Table 4.2-11). Of that total, 93 % of that is considered mud/sand/clay habitat. Three wetland types combined to cover 13.9 acres of the drawdown zone. Flood plain forest was the dominant type, covering 13.25 acres. Palustrine emergent and sparse shrub-swamp were present in lesser amounts. The remaining 13.3 acres were mapped as habitat types that are considered higher quality for aquatic biota (Figure 4.2-23). Rocky substrates provide the majority of the quality habitat within the drawdown zone of Flat Swamp Creek. Boulder (4.41 acres; 33%) and ledge (2.38 acres; 18 %) dominate while cobble (1.21 acres; 9 %) and rip-rap (0.28 acres; 2%) are available in lesser amounts. Medium branched trees are the dominant woody cover type, comprising 17 % (2.28 acres) of the drawdown zones quality habitat. Lesser amounts of stumps (0.57 acres; 4%), heavily branched trees (0.2 acres; 1%), and brush (0.07 acres; <1%) also provide some cover. Docks covered 1.84 acres within the Lower Flat Swamp Creek drawdown zone and were responsible for 14% of the quality habitat.

An additional 8.94 acres of quality habitat was mapped in the area below the drawdown zone (elevations <612) (Table 4.2-11). Rocky substrates were the most abundant, accounting for 65% of the quality habitat. Boulder (2.47 acres; 28%), ledge (1.68 acres; 19%), cobble (1.3 acres; 15%) and rip-rap (0.32 acres; 4%) habitats were all present. Stumps (2.11 acres; 24 %), were the most dominant form of woody cover. Lesser amounts of medium branched trees (0.56 acres; 6%), brush (0.16 acres; 2%) and Christmas trees (0.11 acres; 1%) were also available to aquatic biota. Docks covered 0.17 acres and accounted for 2% of the quality habitat mapped below the drawdown zone of the Flat Swamp Creek tributary arm. There were 0.03 acres of flood plain forest wetland habitat found within the mapped area below the drawdown zone. Figure 4.2-17 shows the presence of water in the upper reach of Flat Swamp Creek during the drawdown.

The average 12 ft drawdown reduces the water surface acreage of the Flat Swamp Creek tributary arm from 872.04 acres to 493.48 acres (43.4 % or 378.56 acres) (Table 4.2-11).

4.2.2.9 Habitat Differences Between Areas

Mud/sand/clay is the dominant substrate type in High Rock Reservoir, covering 79.09 % of the reservoirs 12-foot drawdown zone (Table 4.2-12). Its coverage is spread fairly evenly throughout the reservoir with a high of 93.5 % in the Second Creek tributary arm, to a low of 63.6 % in the upper section of the main reservoir body.

Wetland cover types combine to cover 19.2 % of the 12-foot drawdown zone (Table 4.2-13). Total coverage ranged from a high of 35.9 % in the upper main reservoir to a low of 3.7 % in Flat Swamp

Figure 4.2-22. Habitat types mapped in the Flat Swamp Creek Tributary Arm.

Table 4.2-11. Amount of habitat mapped in Lower Flat Swamp Creek Tributary Arm within the drawdown zone (el. 624 down to 612) and 5 feet below the drawdown zone (el. 612 to 607).

Flat Swamp Creek Tributary Arm

	Available Habitat				
Habitat Type	Habitat mapped within drawdown [1] (sq. feet)	Habitat mapped below drawdown [2] (sq. feet)	Habitat mapped within drawdown [1] (acres)	Habitat mapped below drawdown [2] (acres)	% of drawdown zone acreage
Boulder	192,275.00	107,673.43	4.41	2.47	1.17%
Cobble	52,624.26	56,687.69	1.21	1.30	0.32%
Ledge	103,708.27	73,111.70	2.38	1.68	0.63%
Rip rap	12,391.26	13,975.31	0.28	0.32	0.08%
Brush	2,929.42	7,160.00	0.07	0.16	0.02%
Heavily branched trees	8,977.60	697.45	0.21	0.02	0.05%
Medium branched trees	99,091.02	24,366.43	2.28	0.56	0.60%
No branched trees	383.47	42.01	0.01	0.00	0.00%
Christmas trees	930.01	5,068.07	0.02	0.11	0.01%
Stumps	24,893.12	91,728.94	0.57	2.11	0.15%
Tires	0.00	198.89	0.00	0.01	0.00%
Docks	80,150.40	7,405.20	1.84	0.17	0.49%
Palustrine emergent	5,968.90	0.00	0.14	0.00	0.04%
Flood plain forest	577,289.99	1,257.43	13.25	0.03	3.50%
Sparse shrub-swamp	21,680.46	0.00	0.50	0.00	0.13%
Mud/sand/clay	15,106,361.83		351.40		92.82%
Sum	**16,289,654.99**	**389,372.54**	**378.56**	**8.94**	**100.00%**

Flat Swamp	**Surface Acreage**		**Reduction**		
Creek Tributary Arm	**At full pond**	**At 12' drawdown**	**acres**	**%**	
	872.04	493.48	378.56	43.41	

[1] Habitat mapped between USGS elevations 624' to 612'.

[2] Habitat mapped below USGS elevation 612'.

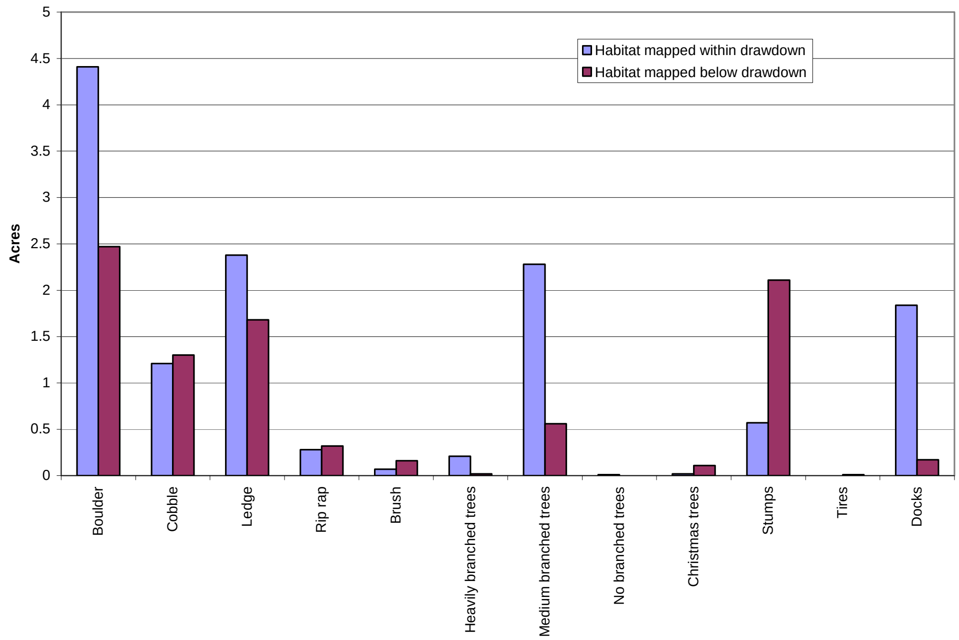

Figure 4.2-23. Habitat types mapped in the Flat Swamp Creek Tributary Arm, within the drawdown zone (el. 612-624) and 5 feet below (<el. 612) the drawdown zone. Wetland and mud/sand/clay habitat types are not included in this figure.

Table 4.2-12. Comparison of the Amount of Habitat Available in the Drawdown Zone (el. 624 to 612) of High Rock Reservoir by Major Tributary Arms and Main Reservoir Segments

Habitat Type	Flat Swamp Creek Tributary Arm [1]		Crane Creek Tributary Arm [1]		Swearing Creek Tributary Arm [1]		Abbott's Creek Tributary Arm [1]		Second Creek Tributary Arm [1]		Upper Main Reservoir		Lower Main Reservoir		Total Reservoir Combined	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Mud/sand/clay	351.40	92.83	654.33	85.81	379.61	88.29	939.69	79.30	587.41	93.49	1,288.01	63.64	541.72	92.15	4,742.17	79.09
Palustrine emergent	0.14	0.04	1.60	0.21	0.00	0.00	11.64	0.98	1.06	0.17	0.65	0.03	0.00	0.00	15.09	0.25
Flood plain forest	13.25	3.50	83.79	10.99	28.57	6.64	182.33	15.39	11.91	1.90	183.64	9.07	29.61	5.04	533.10	8.89
Shrub-swamp	0.00	0.00	0.46	0.06	6.09	1.42	23.78	2.01	5.50	0.88	153.07	7.56	0.00	0.00	188.90	3.15
Sparse shrub-swamp	0.50	0.13	10.35	1.36	1.48	0.34	6.00	0.51	5.38	0.86	388.28	19.18	3.76	0.64	415.75	6.93
Boulder	4.41	1.16	1.12	0.15	0.09	0.02	1.10	0.09	0.06	0.01	0.14	0.01	3.94	0.67	10.86	0.18
Brush	0.07	0.02	0.10	0.01	0.73	0.17	0.28	0.02	0.45	0.07	0.50	0.02	0.25	0.04	2.38	0.04
Christmas Trees	0.02	0.01	0.08	0.01	0.15	0.03	0.15	0.01	0.23	0.04	0.01	0.00	0.03	0.01	0.67	0.01
Cobble	1.21	0.32	1.20	0.16	0.12	0.03	0.41	0.03	0.25	0.04	0.27	0.01	0.02	0.00	3.48	0.06
Gravel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Docks	1.84	0.49	3.94	0.52	4.29	1.00	9.96	0.84	3.62	0.58	4.34	0.21	1.89	0.32	29.88	0.50
Heavily Branched Trees	0.21	0.06	0.41	0.05	0.00	0.00	0.52	0.04	0.14	0.02	0.15	0.01	0.02	0.00	1.45	0.02
Ledge	2.38	0.63	0.01	0.00	1.12	0.26	0.73	0.06	0.00	0.00	0.05	0.00	0.30	0.05	4.59	0.08
Medium Branched Trees	2.28	0.60	3.59	0.47	4.79	1.11	3.76	0.32	10.57	1.68	2.40	0.12	2.56	0.44	29.95	0.50
No Branched Trees	0.01	0.00	0.01	0.00	0.34	0.08	0.05	0.00	0.00	0.00	0.07	0.00	0.01	0.00	0.49	0.01
Rip-rap	0.28	0.07	1.40	0.18	2.58	0.60	4.57	0.39	1.03	0.16	2.20	0.11	2.43	0.41	14.49	0.24
Stumps	0.57	0.15	0.13	0.02	0.01	0.00	0.01	0.00	0.70	0.11	0.27	0.01	1.29	0.22	2.98	0.05
Tires	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Total	**378.56**	**100%**	**762.52**	**100%**	**429.97**	**100%**	**1,184.97**	**100%**	**628.32**	**100%**	**2,024.04**	**100%**	**587.84**	**100%**	**5,996.22**	**100%**

[1] Areas of habitat do not include the upper portions of tributary arms where bathymetry does not extend to el. 612.

Table 4.2-13. Comparison of Dominant Habitat Types Mapped in the Major Tributary Arms and Main Reservoir Segments of High Rock Reservoir with Woody Cover and Rocky Substrate Types Combined.

	Flat Swamp Creek Tributary Arm [1]		Crane Creek Tributary Arm [1]		Swearing Creek Tributary Arm [1]		Abbotts Creek Tributary Arm [1]		Second Creek Tributary Arm [1]		Upper Main Reservoir		Lower Main Reservoir		Total Reservoir Combined	
Substrate Category	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Mud/sand/clay	351.40	92.83	654.33	85.81	379.61	88.29	939.69	79.30	587.41	93.49	1288.01	63.64	541.72	92.15	4742.17	79.09
Wetlands [1]	13.89	3.67	96.20	12.62	36.14	8.41	223.75	18.88	23.85	3.80	725.64	35.85	33.37	5.68	1152.84	19.23
Rock Substrate [2]	8.28	2.19	3.73	0.49	3.91	0.91	6.81	0.57	1.34	0.21	2.66	0.13	6.69	1.14	33.42	0.56
Woody Cover [3]	3.16	0.83	4.32	0.57	6.02	1.40	4.77	0.40	12.09	1.92	3.40	0.17	4.16	0.71	37.92	0.63
Docks	1.84	0.49	3.93	0.52	4.29	1.00	9.96	0.84	3.62	0.58	4.34	0.21	1.89	0.32	29.88	0.50

[1] Wetlands consists of the four wetland types mapped from overflight pictures.

[2] Rock substrate includes boulder, cobble, gravel, ledge and rip-rap combined.

[3] Woody cover includes, heavy, medium and no branch trees, Christmas trees, brush, and stumps combined.

Creek (Table 4.2-24). Overall, flood plain forest was the dominant wetland type mapped within the drawdown zone, covering 8.9 % of the total area. Sparse shrub-swamp was the second most abundant wetland type, accounting for 6.9 % of the habitat mapped within the drawdown zone. Shrub-swamp (3.1 %) and palustrine emergent (0.03 %) were present in lesser amounts.Rock substrates combine to cover 0.56 % of the 12-foot drawdown zone (Table 4.2-13). In the tributary arms, it ranged from 2.2 % of the total habitat in Flat Swamp Creek to 0.2 % in Second Creek. Overall, rip-rap was the dominant rock substrate in the reservoir, comprising anywhere from 0.6 % of the total habitat in Swearing Creek to 0.07 % in Flat Swamp Creek (Table 4.2-12). Boulders are the second most abundant rock substrate in the reservoir. While boulders comprised 1.2% of the habitat in Flat Swamp Creek, they were not as abundant in the other four tributary arms, with a high of 0.15 % in Crane Creek and a low of 0.01 % in Second Creek. Cobble (0.06%) was present in lesser amounts in each of the five tributary arms and both sections of the reservoir. Ledge (0.1%) was present in four of the five tributary arms and both sections of the reservoir. There was no ledge habitat present within the drawdown zone in Second Creek.

Woody cover types combined to cover 0.63% of the 12-foot drawdown zone (Table 4.2-13). Within the tributary arms, it ranged from a high of 1.9% of the habitat in Second Creek to a low of 0.6 % of the habitat in Crane Creek. Within the main body of the reservoir, only 0.2 % and 0.7% of the drawdown zone habitat in the upper and lower sections of the reservoir respectively, were woody cover. Reservoir-wide, medium branched trees were the most abundant form of woody cover, comprising 0.5 % of the total habitat within the 12-foot drawdown zone. Within the tributary arms, medium branched trees ranged from a high of 1.7 % of the habitat in the Second Creek tributary arm to a low of 0.3 % of the habitat in Abbott’s Creek tributary arm. Medium branched trees were responsible for 0.1 % of the habitat in the upper main reservoir and 0.4% of the habitat in the lower section of the main reservoir. Stumps were the second most abundant form of woody cover. They were present in 3 of the 5 tributary arms with a high of 0.2 % of available habitat in the Flat Swamp Creek tributary arm to a low of 0.06% of drawdown zone habitat in the Crane Creek tributary arm.

Docks provide 0.7 % of the available habitat in High Rock Reservoir (Table 4.2-13). They range from a high of 1.0 % of the available drawdown zone habitat in the Swearing Creek tributary arm to a low of 0.2 % of the available habitat in the upper portion of the main reservoir.

Table 4.2-14 shows the distribution of wetland habitat types within the main body of High Rock and all five tributary arms. Wetland habitat was present within all five tributary arms and the main body of the reservoir. Palustrine emergent vegetation, mainly consisting of water willow was present in four of the five tributary arms and in the upper half of the main reservoir. Flood plain forests were present in all five of the tributary arms and both the upper and lower sections of the main reservoir. Species composition within these forests is very diverse. However, where this community type is present on the frequently flooded, shallow delta areas within High Rock, black willow is the dominant tree species. Shrub-swamp habitat was present in four of the five tributary arms and the upper section of the main reservoir. Shrub-swamp habitat on High Rock is dominated by black willow seedlings. Sparse shrub-swamp habitat was present within all five tributary arms and both the upper and lower sections of the main reservoir body. Sparse shrub-swamp on High Rock can be found on the shallower bars that are beginning to seed in and is mainly composed of the widely scattered seedlings of black willow and buttonbush. Within the drawdown zone of High Rock, wetland vegetation (both aquatic and terrestrial) comprises 1,152.84 acres of habitat that is available to aquatic biota when water level conditions are ideal.

Table 4.2-14. Comparison of Wetland Habitat Types Mapped by Overflight, in the Major Tributary Arms and Main Reservoir Segments of High Rock Reservoir.

Wetland Habitat Type	Flat Swamp Creek Tributary Arm		Crane Creek Tributary Arm		Swearing Creek Tributary Arm		Abbotts Creek Tributary Arm		Second Creek Tributary Arm		Upper Main Reservoir		Lower Main Reservoir		Total Reservoir Combined	
	Acres	Sq. Feet	Acres	Sq. Feet	Acres	Sq. Feet	Acres	Sq. Feet	Acres	Sq. Feet	Acres	Sq. Feet	Acres	Sq. Feet	Acres	Sq. Feet
Palustrine Emergent	0.14	5,969	1.60	69,838	0.00	0	11.64	507,297	1.06	46,108	0.65	28,127	0.00	0	15.09	657,338
Flood Plain Forest	13.25	577,290	83.79	3,650,009	28.57	1,244,307	182.33	7,942,205	11.91	518,990	183.64	7,999,342	29.61	1,289,787	533.10	23,221,930
Shrub-swamp	0.00	0	0.46	20,025	6.09	265,488	23.78	1,035,773	5.50	239,612	153.07	6,667,503	0.00	0	188.90	8,228,401
Sparse Shrub-swamp	0.50	21,680	10.35	451,010	1.48	64,355	6.00	261,241	5.38	234,150	388.28	16,913,448	3.76	163,770	415.75	18,109,654
Sum	**9.97**	**434,280**	**55.83**	**2,432,103**	**32.92**	**1,434,130**	**215.65**	**9,393,711**	**60.12**	**2,619,099**	**626.69**	**27,298,321**	**11.99**	**522,085**	**1013.17**	**44,133,729**

4.2.2.10 Habitat within 2-foot Contour Intervals

Table 4.2-15 presents the total areas of each habitat type within two foot contour intervals for the drawdown zone of High Rock Reservoir (elevations 612-624, all tributary arms and reservoir sections combined). The contour with the greatest total area of habitat is the 624-622 elevations, with 408 acres of quality habitat. The 622-620, 620-618, and 618 to 616 contours all have between 222 and 240 acres of quality habitat within them. Sixty-seven percent of the mapped habitat is located within the top half of the current drawdown zone.

4.2.2.11 Erosion

Areas of erosion were present in all five tributary arms and both the upper and lower portions of the main reservoir (Figure 4.2-24). There were 136 sites showing erosion throughout the entire reservoir. These sites covered a total of 8.34 miles of shoreline (Table 4.2-16). Within the tributary arms, Abbott's Creek showed the greatest amount of erosion with a total of 1.47 miles of shoreline. Swearing Creek showed the least erosion, only 0.19 miles of shoreline. The upper portion of High Rock had 3.45 miles of eroded shoreline where as the lower portion of the reservoir had only 1.37 miles of eroded shore.

The upper reservoir had the greatest amount of exposed eroded habitat with a surface area of 2.74 acres. The lower portion of the reservoir had an additional 0.66 acres. Within the tributary arms, Abbott's Creek had the greatest eroded surface area (0.91 acres) while Swearing Creek had the least (0.08 acres).

4.3 TUCKERTOWN RESERVOIR

Tuckertown Reservoir covers 2,560 acres at full pool with a maximum and mean depth of 55 ft and 16 ft, respectively. The Tuckertown Reservoir is narrow relative to either adjacent High Rock or Narrows Reservoirs, and is mainly an enlargement of the old river channel with only a few small-to-moderately sized flooded tributary arms. The Tuckertown Development is operated as a run-of-river facility. Normal daily fluctuation in water surface elevation due to operations is less than 1 ft, with a daily maximum fluctuation of 1 to 3 ft (Yadkin ICD 2002). Annual drawdown is limited to 3 ft by the Yadkin FERC license, and the annual drawdown has averaged 2 ft historically. The Tuckertown Reservoir (Figure 4.3-1) habitat field survey ran from July 20 to 28, 2004. Tuckertown Reservoir's maximum full pond elevation is 564.7 feet. Fluctuations in reservoir water level average 2-feet during the annual cycle (Figure 4.3-2). Water surface elevations during the field effort ranged from 562.0 to 562.9 with an average elevation of 562.3 ft. The 2-foot drawdown assisted the field effort in that biologists were able to map habitat not only within the littoral zone but also habitats that visibly extended into the reservoir.

Tuckertown Habitat Type Descriptions

Significant habitat types important to aquatic biota that were mapped during this study included:

1. aquatic vegetation
2. trees and woody debris (brush, fallen trees, standing trees, stumps)
3. docks
4. riprap
5. ledge, boulder, cobble, gravel
6. mud/sand/clay

Table 4.2-15. Habitat within the High Rock Reservoir drawdown zone. Presented in 2-foot contour intervals.

	Elevation						
	624-622	622-620	620-618	618-616	616-614	614-612	<612
Habitat Type	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Boulder	1.23	0.92	1.42	2.19	2.67	2.52	11.46
Brush	0.33	0.36	0.51	0.27	0.37	0.60	1.39
Christmas	0.01	0.05	0.16	0.11	0.16	0.19	0.50
Cobble	0.28	0.33	0.58	0.60	1.02	0.69	2.54
Heavy	0.25	0.29	0.93	0.21	0.34	0.03	0.02
Medium	6.92	8.25	9.49	4.19	2.16	0.95	1.88
No Branch	0.06	0.04	0.06	0.01	0.02	0.01	0.01
Stumps	0.14	0.04	0.12	0.18	0.51	1.98	39.92
Gravel	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ledge	1.02	0.84	1.35	0.48	0.73	0.47	0.47
Misc	0.00	0.16	0.66	0.02	0.00	0.00	0.00
Riprap	2.54	2.29	2.64	2.49	2.09	2.50	9.06
Tires	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Palustrine emergent	2.38	7.55	3.22	0.70	0.71	0.00	0.00
Flood plain forest	353.64	141.07	53.11	31.23	9.74	2.43	0.03
Shrub-swamp	23.64	49.75	70.20	27.45	16.65	0.87	0.45
Sparse shrub-swamp	15.99	15.25	77.59	170.64	106.78	28.50	3.16
Docks	5.13	5.64	7.60	6.01	3.95	1.58	1.19
Total	413.54	232.83	229.64	246.76	147.88	43.32	72.07

Photo A. High Rock Reservoir bank erosion.

Photo B. High Rock Reservoir bank erosion.

Photo C. High Rock Reservoir bank erosion.

Figure 4.2-24. Examples of bank erosion on High Rock Reservoir during the habitat mapping survey, January/February 2004.

Table 4.2-16. Amount of erosion mapped by tributary arm and reservoir segment.

	Flat Swamp Creek Tributary Arm	Crane Creek Tributary Arm	Swearing Creek Tributary Arm	Abbotts Creek Tributary Arm	Second Creek Tributary Arm	Upper Main Reservoir	Lower Main Reservoir	All Areas Combined
Length of eroded shore (ft.)	4,377.17	4,244.25	1,019.99	7,785.24	1,108.37	18,235.87	7,257.19	44,028.08
Length of eroded shore (miles)	0.83	0.80	0.19	1.47	0.21	3.45	1.37	8.34
Area of eroded shore (sq. ft.)	13,928.31	18,090.38	3,631.95	39,807.43	8,141.21	119,577.10	28,800.56	231,976.94
Area of eroded shore (acres)	0.32	0.42	0.08	0.91	0.19	2.74	0.66	5.32

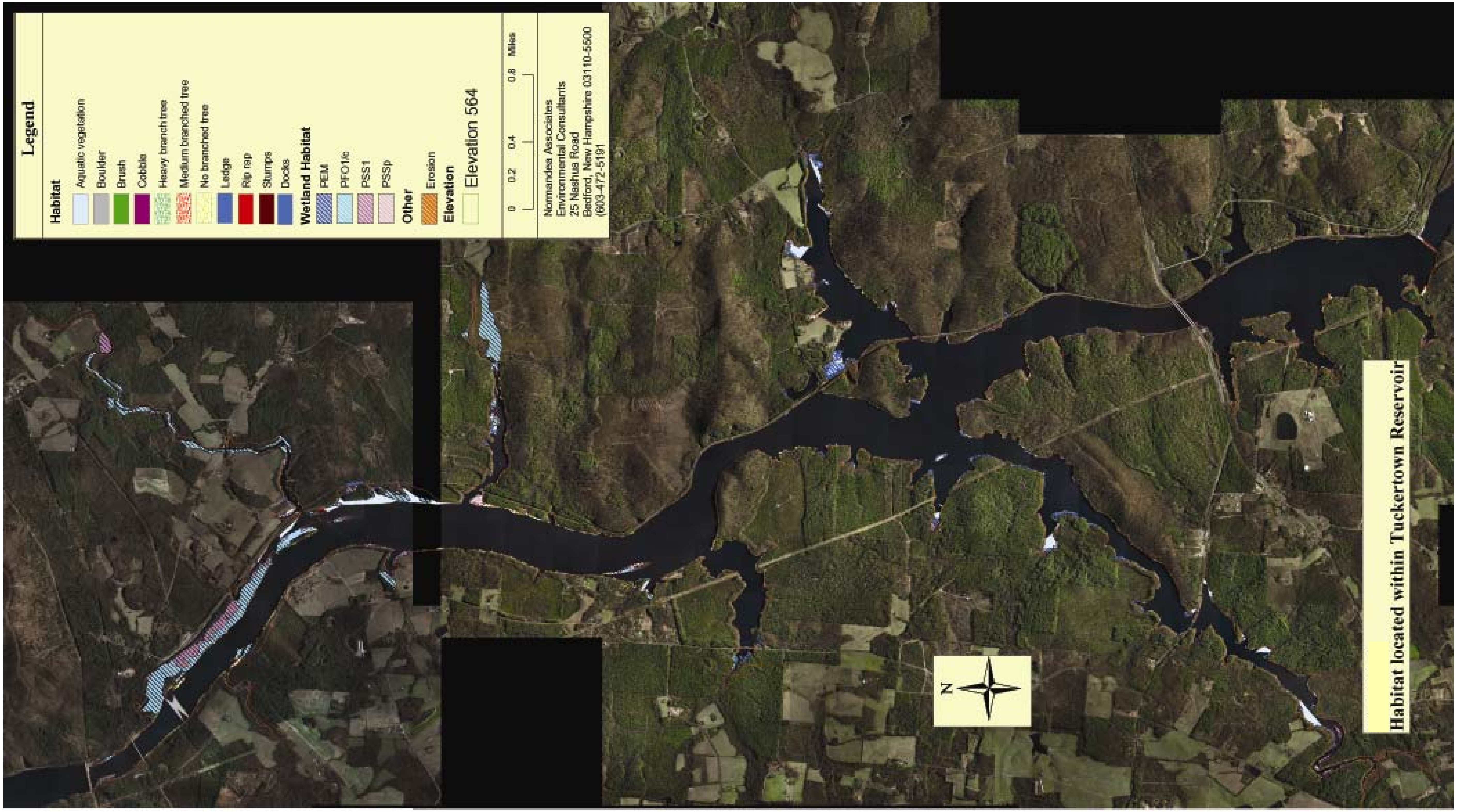

Figure 4.3-1 Habitat located within Tuckertown Reservoir.

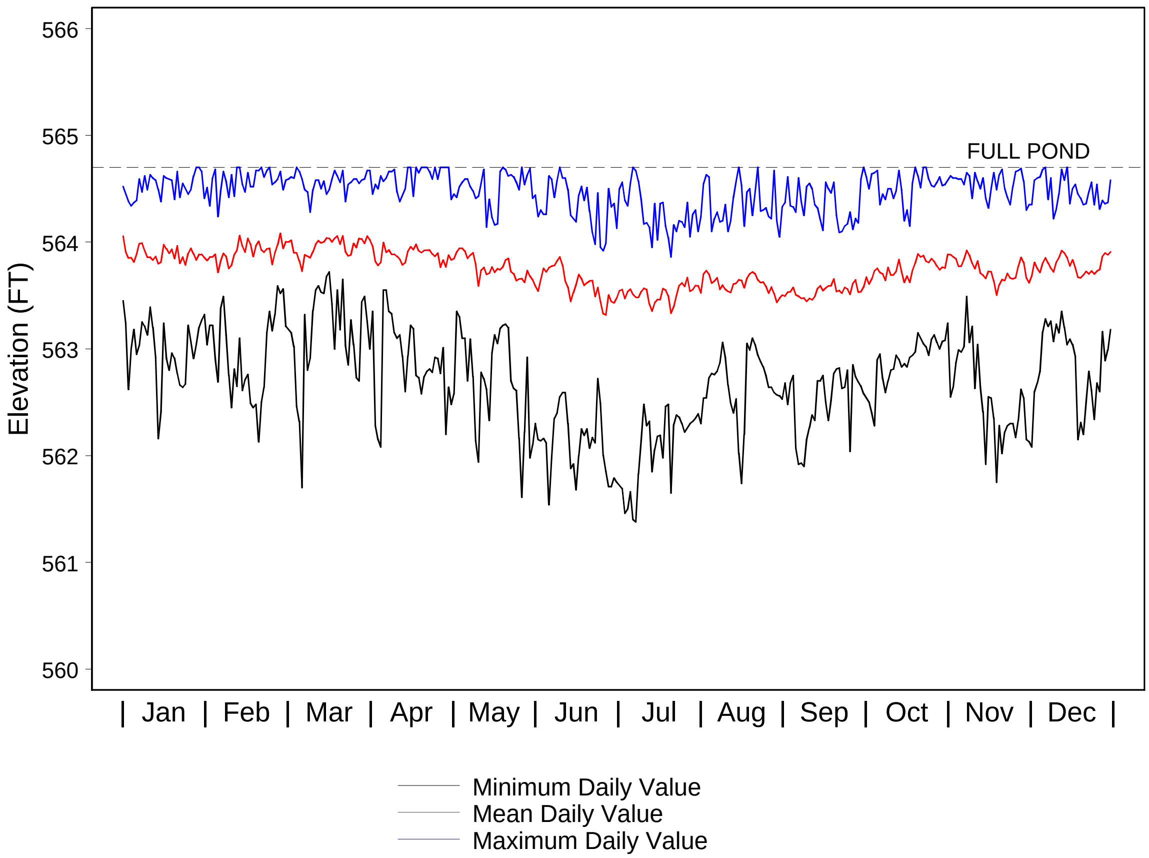

Figure 4.3-2. Minimum, Mean and Maximum Daily Water Elevations in the Tuckertown Reservoir for the Period of January 1, 1986 to December 31, 2003.

Aquatic Vegetation

Aquatic vegetation beds found during the July 2004 habitat survey were mapped. Figure 4.3-3 shows examples of the aquatic vegetation mapped by field biologists. In addition to data collected during the July 2004 habitat survey, additional wetland habitats were added through the analysis of overflight pictures taken during July and August of 2003. After habitat types were mapped out on the collected photographs, biologists in the field were used to verify the wetland habitat types that were present. Wetlands information collected through both methods is presented in this report. Five major wetland types of importance to aquatic biota within Tuckertown Reservoir were identified through overflight photograph analysis.

1. ***Palustrine Emergent:*** (PEM) Consisted mainly of water willow beds
2. ***Flood Plain Forest:*** (PFO1/c) Species composition within this wetland type can be very diverse. However, where this community type is present, black willow is the dominant tree species. This habitat type is typically flooded only during high water events.
3. ***Shrub-Swamp:*** (PSS1) Shrub-swamp habitat in Tuckertown is dominated by loosely bunched stands of black willow, buttonbush and sycamore seedlings.

Photo A:

Photo B:

Photo C:

Photo D:

Figure 4.3-3. Examples of aquatic vegetation mapped in Tuckertown Reservoir, July 2004.

4. ***Sparse shrub-Swamp*:** (PSSp) Sparse shrub-swamp habitat is comprised of widely scattered seedlings of black will and buttonbush.
5. ***Lacustrine Aquatic Bed***: (LAB) Comprised mainly of floating leaved or submerged aquatic plants. Dominant species within Tuckertown Reservoir is American elodea, a submerged aquatic.

Woody Cover

Woody cover found within the littoral zone was split into several categories and mapped during the study. Naturally falling and intentionally cut trees (lap trees) lying within the littoral zone were mapped. These downed trees were further categorized based on the size and amount of branches remaining on the tree. They were classified as heavy branching, medium branching or no branching (Figure 4.3-4). Other types of woody cover located and mapped in the littoral zone included stumps, and brush piles (Figure 4.3-4).

Substrate

All substrate types located within the littoral zone were delineated and mapped during the field survey. These included ledge, boulder, cobble, and riprap (Figure 4.3-5). Substrate that did not provide good habitat for aquatic biota, such as heavily embedded gravel, was not measured and was included in the default (mud/sand/clay) substrate category. All habitats that were not mapped due to their not providing decent habitat for aquatic biota were put into the default category.

Docks

Docks were plotted from overflight pictures taken during 1997. Docks constructed after 1997 are not included in this report. Figure 4.3-6 shows examples of dock habitat in Tuckertown Reservoir. Yadkin estimates that approximately ___ docks have been added since 1997.

Erosion

- Areas of significant erosion were mapped during the field effort. “Significant erosion” was defined in the final study scope as areas that are observed to have active and ongoing erosion
- and observable impacts to important aquatic and terrestrial resources. Such areas included but were not necessarily limited to:
- Areas where eroding shoreline has resulted in localized sediment deposits that are noticeably affecting water quality or aquatic habitats
- Areas where eroding shoreline has resulted in the loss of vegetation from a significant community or habitat type
- Areas where eroding shoreline are impacting public recreation facilities

4.3.1 Mapped Available Habitat

This section presents all habitats mapped at elevations below 564.2 feet. Within the Tuckertown Reservoir shape file, the 564.2 foot contour line was the closest available to the full pond value of 564.7 ft. The two-foot drawdown allowed for the field crew to map all habitat types providing quality cover for aquatic biota found within and just below the littoral zone.

Locations of habitats mapped in Tuckertown Reservoir are shown in Figure 4.3-1 (see attached CD). Although bathymetry below full pond was not available, based on the contour data and habitat mapped

Photo A: Heavy branched tree

Photo B: Medium and heavy branched trees

Photo C: Stumps

Photo D: Brush

Figure 4.3-4. Examples of woody cover types mapped in Tuckertown Reservoir, July 2004.

Photo A: Ledge and boulders

Photo B: Rip rap

Photo C: Cobble

Photo D: Boulder

Figure 4.3-5. Examples of rock substrate mapped in Tuckertown Reservoir, July 2004.

Photo A: Dock habitat

Photo B: Dock habitat

Photo C: Dock habitat

Figure 4.3-6. Examples of dock habitat mapped in Tuckertown Reservoir, July 2004.

above the full pond mark, NAI estimates that 76 % of the Tuckertown littoral zone is comprised of mud/sand clay while the remaining 24 % is quality habitat for aquatic biota.

Sixteen different types of high quality habitat were mapped below the full pond elevation of Tuckertown Reservoir, covering 175.9 acres (Table 4.3-1). Wetland habitats comprised the majority of the quality habitat, accounting for over 85% of the total mapped (Table 4.3-2). Aquatic vegetation mapped by the NAI field biologists covered 71.5 acres and comprised 40.6 % of the total habitat mapped. In addition, five major wetland habitat types were identified from aerial photographs and added into the GIS map after sufficient ground-truthing. Palustrine emergent vegetation, mainly water willow, covered 27.3 acres and comprised 15.5 % of the total habitat mapped. Flood plain forest, dominated by black willow trees, covered 24.4 acres and comprised 13.9 % of the total habitat. Lacustrine aquatic plant beds, comprised of floating and submerged aquatic plants covered 10.7 acres (6.1 % of total). Shrub-swamp (12.7 acres; 7.2 %) and sparse shrub-swamp (3.7 acres; 2.1 %) habitat types were also present in Tuckertown Reservoir. The total acreage covered by some wetland types may be underestimated. Due to a limited drawdown (2 ft) and low water clarity, areas of some wetland types (particularly palustrine emergent and lacustrine aquatic beds) may be more extensive than is visible from the surface.

Boulders were the dominant form of rock substrate found in Tuckertown Reservoir. They covered 4.43 acres and accounted for 2.5 % of the total habitat mapped. Cobble covered 1.1 acres and comprised 0.6 % of the habitat mapped. Lesser amounts of rip rap (0.3 acres; 0.2 %) and ledge (0.2 acres; 0.1 %) were mapped within the Tuckertown littoral zone.

Woody cover was dominated by medium branched trees. Medium branched trees covered 16.4 acres and were accountable for 9.3 % of the total habitat mapped in Tuckertown. Stumps were the second most abundant woody cover type, covering 2.7 acres and comprising 1.5 % of the total habitat. No branched trees (0.23 acres; 0.1 %), brush (0.12 acres; 0.1%), and heavy branched trees (0.08 acres; 0.04 %) were also present within the littoral zone area.

In addition to natural cover types, a small number of docks covered 0.16 acres and accounted for 0.1 % of the total quality habitat that was mapped in Tuckertown Reservoir below elevation 564.2’.

4.3.2 Erosion

There were 4 sites, varying in length from 21 to 106 feet, which showed signs of erosion throughout Tuckertown Reservoir (Figure 4.3-7). These sites covered a total of 0.05 miles of shoreline (Table 4.3-3). This represents 0.08 % of the total shoreline in Tuckertown Reservoir. A total area of 0.01 acres is eroded between the 4 sites mapped.

4.4 NARROWS RESERVOIR

Narrows Reservoir (Badin Lake) is the deepest of the four project impoundments and covers 5,355 acres at full pool. The reservoir is broad with two main basins, each with numerous coves and flooded tributary mouths. The maximum depth is 175 ft and the mean depth is 45 ft. The Narrows Development is usually operated as a run-of-river facility, but does have available storage to augment required minimum downstream releases in low flow periods. Normal daily fluctuation in water surface elevation due to operations is less than 1 ft with a daily maximum fluctuation of 1 to 2 ft (Yadkin 2002). The maximum average annual drawdown is approximately 3 ft. The Narrows Reservoir (Figure 4.4-1) habitat field survey ran from December 7 through December 21, 2003. Narrows Reservoir’s maximum full pond elevation is 509.8 feet with an average, annual drawdown of 2 feet (Figure 4.4-2). Water surface elevations during the field effort ranged from 493.2 to 501.7 with an average elevation of 495.4 ft. The

Table 4.3-1. Total amount of all habitat types mapped in Tuckertown Reservoir, below the full pond USGS elevation of 564.2'.

Tuckertown Reservoir	Available Habitat mapped below full pond [1]	
Type	**Square Feet**	**Acres**
Aquatic Vegetation [2]	3,112,900.87	71.46
Palustrine emergent [3]	1,187,706.01	27.27
Flood plain forest [3]	1,063,839.54	24.42
Shrub-swamp [3]	554,879.98	12.74
Sparse shrub-swamp [3]	160,072.84	3.67
Lacustrine Aquatic Bed [3]	467,065.74	10.72
Docks	7,138.04	0.16
Boulder	192,906.20	4.43
Cobble	45,817.79	1.05
Ledge	8,680.56	0.20
Rip rap	12,977.66	0.30
Brush	5,034.41	0.12
Heavy branched trees	3,352.79	0.08
Medium branched trees	713,945.70	16.39
No branched trees	10,023.41	0.23
Stumps	115,800.92	2.66
Sum	**7,662,142.43**	**175.89**

[1] Full pond elevation is equal to USGS 564.2'.
[2] Aquatic vegetation in this category was mapped by field crew using the laser rangefinder and DGPS.
[3] These wetland types were mapped through the use of aerial photographs.

Table 4.3-2. Habitat type by percentage of total mapped acreage in Tuckertown Reservoir, below the full pond USGS elevation of 564.2'.

Tuckertown Reservoir		
	Habitat Mapped Below Full Pond [1]	
Type	**Acres**	**% of Total [4]**
Aquatic Vegetation [2]	71.46	40.63%
Palustrine emergent [3]	27.27	15.50%
Flood plain forest [3]	24.42	13.88%
Shrub-swamp [3]	12.74	7.24%
Sparse shrub-swamp [3]	3.67	2.09%
Lacustrine Aquatic Bed [3]	10.72	6.09%
Docks	0.16	0.09%
Boulder	4.43	2.52%
Cobble	1.05	0.60%
Ledge	0.20	0.11%
Rip rap	0.30	0.17%
Brush	0.12	0.07%
Heavy branched trees	0.08	0.04%
Medium branched trees	16.39	9.32%
No branched trees	0.23	0.13%
Stumps	2.66	1.51%
Sum	**175.89**	**100.00%**

[1] Full pond elevation is equal to USGS 564.2'.
[2] Aquatic vegetation in this category was mapped by field crew using the laser rangefinder and DGPS.
[3] These wetland types were mapped through the use of aerial photographs.
[4] Percentages presented are of the quality habitat types mapped within the littoral zone only.
Does not include areas classified as low quality habitat (mud/sand/clay).

Photo A: Bank Erosion

Figure 4.3-7. Example of bank erosion mapped in Tuckertown Reservoir, July 2004.

Table 4.3-3. Amount of erosion mapped within Tuckertown Reservoir.

	Tuckertown Reservoir Erosion
Length of eroded shore (ft.)	261.00
Length of eroded shore (miles)	0.05
Area of eroded shore (sq. ft.)	535.34
Area of eroded shore (acres)	0.01

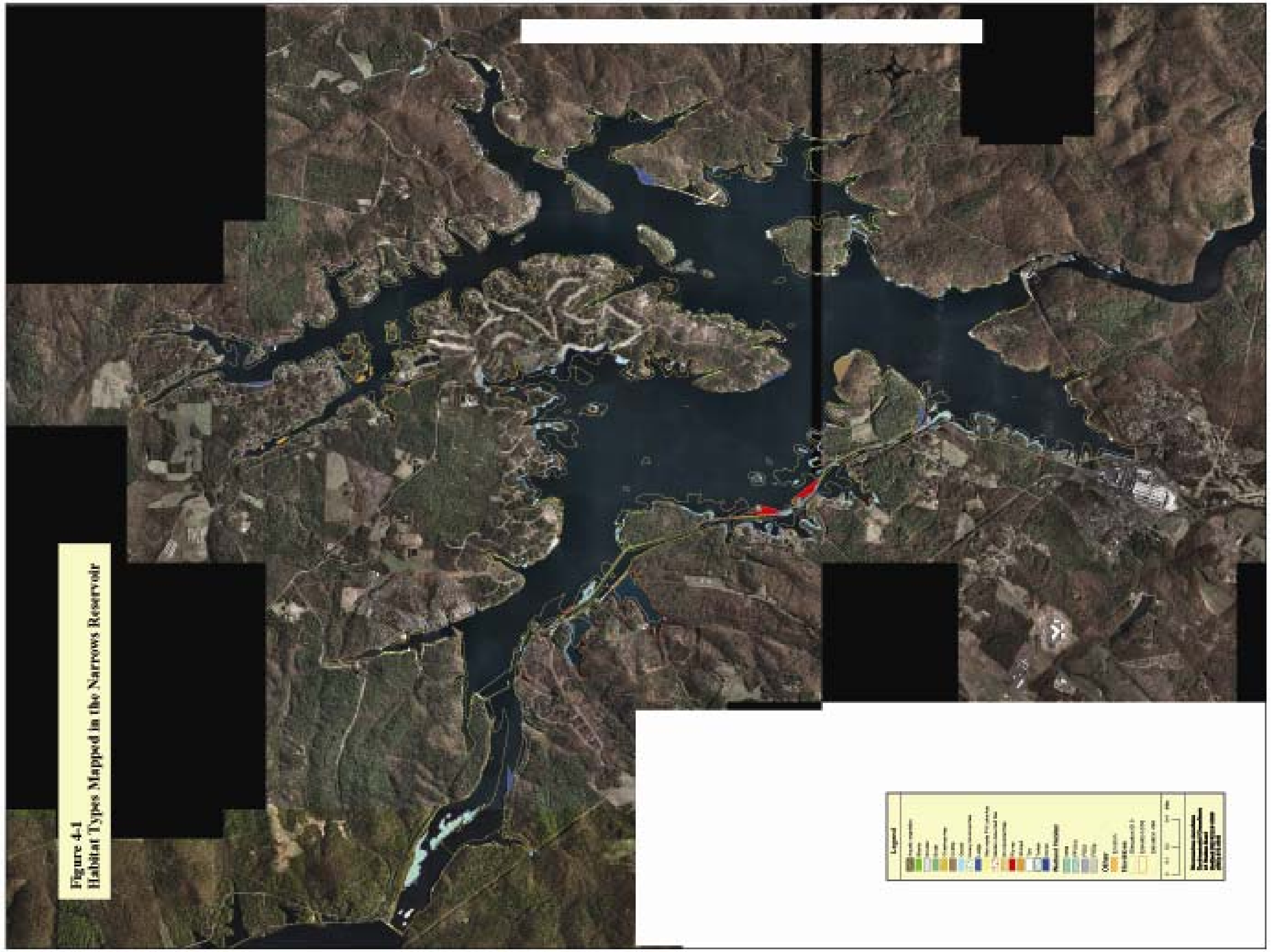

Figure 4.4-1 Habitat Types Mapped in the Narrows Reservoir.

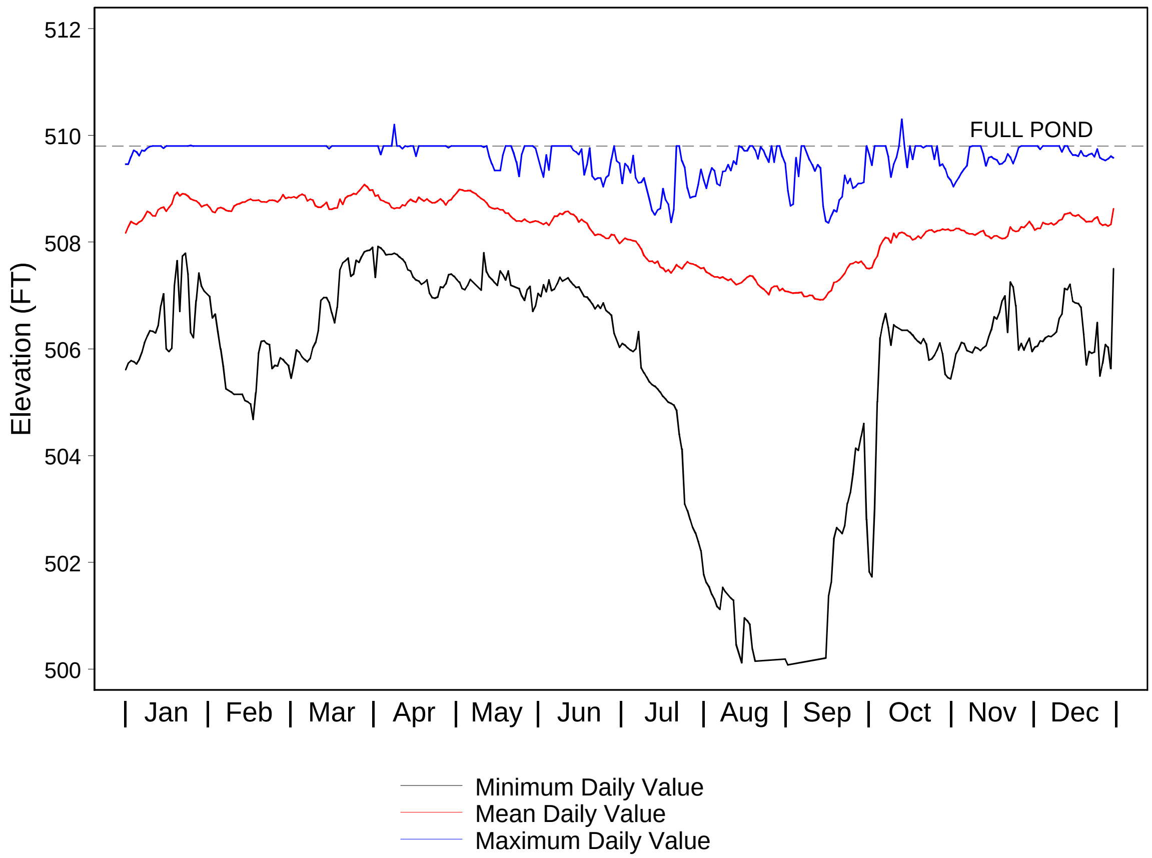

Figure 4.4-2. Minimum, Mean and Maximum Daily Water Elevations in the Narrows Reservoir for the Period of January 1, 1986 to December 31, 2003.

drawdown assisted the field effort in that biologists were able to map habitat not only within the 2-foot littoral zone but also well below, in what could potentially be a drawdown zone.

Narrows Habitat Type Descriptions

Significant habitat types important to aquatic biota that were mapped during this study included:

1. aquatic vegetation
2. trees and woody debris (brush, fallen trees, standing trees, stumps)
3. Christmas trees added for habitat enhancement
4. docks
5. riprap
6. ledge, boulder, cobble, gravel
7. mud/sand/clay

Aquatic Vegetation

The data presented in this section was collected through the use of overflight pictures taken during July and August of 2003. After habitat types were mapped out on the collected photographs, biologists in the field were used to verify the wetland habitat types that were present. Three major wetland types of importance to aquatic biota were identified within Narrows Reservoir.

1. ***Palustrine Emergent:*** (PEM) Consisted mainly of water willow beds
2. ***Flood Plain Forest:*** (PFO1/c) Species composition within this wetland type can be very diverse. However, where this community type is present, black willow is the dominant tree species. This habitat type is typically flooded only during high water events.
3. ***Shrub-Swamp:*** (PSS1) Shrub-swamp habitat on Narrows is dominated by loosely bunched stands of black willow seedlings.
4. ***Lacustrine Aquatic Beds:*** (LAB) Lacustrine aquatic beds in Narrows Reservoir consisted of floating leaved or submerged aquatic plants.

In addition to the wetland acreage mapped through aerial photography, there were additional areas of palustrine emergent (water willow) vegetation added to the final acreage total. The following explanation was taken from Section 5.4 of the 2005 NAI Draft Study Report entitled *Wetland and Riparian Habitat Assessment.*

In the 2004 NAI study, the distribution of water willow on Narrows was delineated as part of the cover type mapping. As described in the vegetation mapping methods section (Section 5.2), emergent and submergent vegetation communities were mapped on all four reservoirs from true color aerial photographs flown in mid-summer 2003, at a scale of 1:9600. Field verification of the mapped limits and species composition of the cover types occurred throughout the growing season 2004. While the aerial photography was suitable for identifying the larger beds, it was less effective for detecting small or narrow stands of emergent vegetation. These are beds that were typically less than 6 feet wide, or occurred under trees overhanging the shoreline. To compensate for this difficulty, the cover type maps were supplemented in the field by a more quantitative assessment that estimated the percentage of the shoreline which supported water willow. As the shoreline was traveled, the percentage of the shoreline that supported water willow was noted in general categories: 0%, 1-20%, 21-40%, 41-60%, 61-80%, and >80%. Almost 80% of the shoreline of Narrows was reviewed for this purpose. In the office, the perimeter of the shoreline falling into each category was measured. The beds were assumed to be 5 feet wide, and therefore the acreage of water willow formed by these small beds could be estimated. These small beds are not shown on the cover type maps, but add an additional 92 acres of emergent wetlands on Narrows, or slightly more then the total mapped from aerials.

This additional palustrine emergent vegetation was presented in this habitat report within the total reservoir analysis but because it was not shown on the ArcView cover type maps, it could not be broken down as being within the littoral zone (elevation 510-508), drawdown zone (elevation 508-494), or below the drawdown zone (elevations <494). Therefore it is excluded from analysis in sections 4.4.1, 4.4.2, and 4.4.3 of this report.

Woody Cover

Woody cover found within the littoral and potential drawdown zones was split into several categories and mapped during the study. Naturally falling and intentionally cut trees (lap trees) lying within the drawdown zone were mapped. These downed trees were further categorized based on the size and amount of branches remaining on the tree. They were classified as heavy branching, medium branching or no branching. Christmas tree bundles added to the reservoir to provide and improve habitat for fish were also mapped. Other types of woody cover located and mapped in the drawdown zone included stumps, brush piles, and standing trees (Figure 4.4-3).

Rock Substrates

All substrate types located within the littoral and potential drawdown zone were delineated and mapped during the field survey. These included ledge, boulder, cobble, gravel, and riprap (Figure 4.4-4; Figure 4.4-5). Substrate that did not provide good habitat for aquatic biota, such as heavily embedded gravel, was not measured and was included in the default (mud/sand/clay) substrate category. All habitats that were not mapped due to their not providing decent habitat for aquatic biota were put into the default category.

Docks

Docks were plotted from overflight pictures taken during 1997. Docks constructed after 1997 are not included in this report. Figure 4.4-5 shows examples of dock habitat from Narrows Reservoir. Yadkin estimates that approximately ___ docks have been added since 1997.

Erosion

Areas of significant erosion were mapped during the field effort. “Significant erosion” was defined in the final study scope as areas that are observed to have active and ongoing erosion and observable impacts to important aquatic and terrestrial resources. Such areas included but were not necessarily limited to:

Areas where eroding shoreline has resulted in localized sediment deposits that are noticeably affecting water quality or aquatic habitats

- Areas where eroding shoreline has resulted in localized sediment deposits that are noticeably affecting water quality or aquatic habitats
- Areas where eroding shoreline has resulted in the loss of vegetation from a significant community or habitat type
- Areas where eroding shoreline are impacting public recreation facilities

4.4.1 Total Available Habitat

Locations of habitats mapped in Narrows Reservoir are shown in Figure 4.4-1 (see attached CD). The total habitat available within the upper 16 feet of Narrows Reservoir is shown in Table 4.4-1. Mud/sand/clay was the dominant substrate present within the mapped area of the reservoir, accounting for 74.85 % of all habitat mapped. This substrate type is of low value to aquatic biota as it provides little in the way of cover and protection. Four wetland types covered 265.1 acres and comprised 17.6 % of the habitat within the upper 16 feet of Narrows Reservoir. Rock substrates (70.25 acres; 4.7 %), woody cover (27.9 acres; 1.85 %), and docks (15.53 acres; 1.03 %) accounted for the remaining habitat and provided 113.7 acres of quality habitat for aquatic biota.

4.4.2 Littoral Zone

This section looks at the habitat mapped within the littoral zone, or the upper two feet of elevation within Narrows Reservoir (elevations 510 to 508). The low quality mud/sand/clay substrate is the dominant cover type within the Narrows Reservoir littoral zone (Table 4.4-2). Wetland cover is abundant within the littoral zone. Flood plain forest is the most abundant of the wetland habitat types, covering 28.63

Photo A. Heavily branched tree over cobble and gravel.

Photo B. Medium branched tree over cobble and gravel.

Photo C. Stump habitat.

Photo D. Christmas trees and brush piles anchored by cinder blocks.

Figure 4.4-3. Examples of woody cover habitat types mapped within Narrows Reservoir during December 2003.

Photo A. Mixed boulder/cobble substrate.

Photo B. Boulder pile habitat.

Photo C. Mixed boulder cobble gravel habitat.

Photo D. Ledge habitat.

Figure 4.4-4. Examples of rocky substrate habitat types mapped within Narrows Reservoir during December 2003.

Photo A. Rip-rap habitat near a railroad trestle.

Photo B. Dock habitat.

Figure 4.4-5. Examples of rip-rap and dock habitat types mapped within Narrows Reservoir during December 2003.

Table 4.4-1. Total habitat available (in acres and %) within the upper 16 feet of Narrows Reservoir with all woody cover, rock substrate and wetland types combined. [1]

Mud/Sand/Clay (Default) Substrate		Rock Substrate		Woody Cover		Docks		Wetlands [2]	
Acres	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
1,127.15	74.85%	70.25	4.66%	27.91	1.85%	15.53	1.03%	265.08	17.60%

[1] The upper 16 feet of elevation comprises both the littoral zone (el 510-508') and the potential drawdown zone (el 508-494') in Narrows Reservoir.
[2] Wetlands includes an additional 92 acres of PEM habitat added after completion of aerial photograph analysis (See Section 4.4 for explanation), the default substrate has been adjusted accordingly.

Table 4.4-2. Percentage by type of all habitats mapped within the 2-ft littoral zone[2] of Narrows Reservoir.

Habitat Type	Square Feet	Acres	% of Total
Lacustrine Aquatic Beds [1]	297,268.19	6.82	3.52%
Palustrine Emergent [1,4]	1,021,151.61	25.46	13.14%
Flood Plain Forest [1]	1,259,772.76	28.63	14.78%
Shrub-swamp [1]	38,969.60	1.29	0.67%
Docks	95,096.58	2.19	1.13%
Misc. Man-made [3]	0.69	0.00	0.00%
Boulder	91,746.85	2.10	1.09%
Cobble	84,319.04	1.93	1.00%
Gravel	7,859.49	0.18	0.09%
Ledge	36,148.04	0.83	0.43%
Rip-rap	38,156.66	0.88	0.45%
Brush	45.90	0.00	0.00%
Christmas Trees	389.05	0.01	0.00%
Heavy Branched Trees	69,007.24	1.58	0.82%
Medium Branched Trees	72,312.28	1.65	0.85%
No Branched Trees	1,247.26	0.03	0.01%
Stumps	0.00	0.00	0.00%
Mud/Sand/Clay	5,541,439.77	120.40	62.15%
Total	**8,357,662.81**	**193.98**	**100.00%**

[1] These wetland habitat types were mapped from aerial photographs.
[2] Littoral zone represents habitat found between the 510 and 508 elevations.
[3] Miscellaneous man-made includes blocks, toilets, PVC-structures, tires, etc.
[4] Does not include PEM acreage added post aerial photograph analysis (See Section 4.4 for explanation).

acres and comprising 14.8 % of the littoral zone. Palustrine emergent wetlands (mainly water willow beds) are the second most abundant wetland type, covering 25.46 acres and composing 13.1 % of the littoral zone. As mentioned in Section 4.4, an additional 92 acres of palustrine emergent habitat was added during the ground-truthing process that took place after the aerial photography analysis. Because this data is not available in the ArcView cover type maps, the percentage of that acreage present in the littoral, potential drawdown and areas below the potential drawdown could not calculated. Lacustrine aquatic beds accounted for 3.5 % of the habitat in the littoral zone. Rock substrates within the littoral zone are dominated by boulder (2.1 acres; 1.1%) and cobble (1.93 acres; 1.0 %). Rip-rap (0.88 acres; 0.5 %), ledge (0.83 acres; 0.4 %) and gravel (0.18 acres; 0.1 %) are present in lesser amounts in the littoral zone. Medium branched trees (1.65 acres; 0.9%) and heavy branched trees (1.58 acres; 0.8 %) are the two dominant forms of woody cover. Small amounts of brush, Christmas trees, and no branched trees were found and mapped within the littoral zone. Docks covered an additional 2.19 acres of the littoral zone, accounting for 1.1 % of the habitat present there.

A two foot change in water surface elevation in Narrows Reservoir will dewater the littoral zone and reduce the water surface acreage from a full pond value of 5,887.3 acres to 5,695.16 acres, a loss of 192.4 acres or 3.26 % (Table 4.4-3).

Table 4.4-3. Water surface area reductions within Narrows Reservoir.

Narrows Reservoir	Surface Acreage			Reduction			
	At Full Pond	At 2' Drawdown	At 16' Drawdown	Full Pond to 2' Drawdown		Full Pond to 16' Drawdown	
	(El 510')	(El 508')	El (494')	Acres	%	Acres 1	%
	5,887.30	5,695.16	4,382.46	192.14	3.26%	1,504.84	25.56%

[1] Area that would be dewatered if a 16' drawdown was implemented at Narrows Reservoir.

4.4.3 Potential Drawdown Zone

Water levels at Narrows were dropped sixteen feet in order to evaluate the potential impacts associated with increasing the annual drawdown at Narrows Reservoir, similar to that currently done at High Rock Reservoir. This section looks at the habitat within this zone (between elevations 508 and 494) that would be affected if this drawdown regime was to be implemented at Narrows Reservoir. Of note here is that the bathymetry provided assumes that there is no flow being released from the dam on the downstream end of High Rock Reservoir. The 494' contour line stops approximately 3,600 feet shy of the High Rock Reservoir dam, leaving an area that is suggested to be dewatered. However, this area is not dewatered as flow is continuously moving down system from High Rock. Of the area mapped within the potential drawdown zone in

Narrows Reservoir, 83.3 % was classified as low value mud/sand/clay habitat (Table 4.4-4). Emergent wetland habitat (mainly water willow beds) was the second most abundant habitat type, covering 53.83 acres and accounting for 4.08 % of the total habitat mapped. As mentioned in Section 4.4, an additional 92 acres of palustrine emergent habitat was added during the ground-truthing process that took place after the aerial photography analysis. Because this data is not available in the ArcView cover type maps, the percentage of that acreage present in the littoral, potential drawdown and areas below the potential drawdown could not calculated. In addition to Palustrine emergent habitat, lacustrine aquatic beds were present, covering 51 acres and accounting for 3.9 % of the potential drawdown zone. Two other wetland types, flood plain forest (3.9 acres; 0.3 %) and shrub-swamp (1.1 acres; 0.1 %) were also present within the potential drawdown zone. Rock substrate within the potential drawdown zone was dominated by both boulder (25.4 acres; 1.9 %) and cobble (22.9 acres; 1.7 %). Ledge (6.6 acres; 0.5 %), rip-rap (5.2 acres; 0.4 %) and gravel (4.3 acres; 0.3 %) were also available for aquatic biota, within the potential drawdown zone. Woody cover was dominated by medium branched trees which covered 10.4 acres and comprised 0.8 % of the available habitat. Heavy branched trees (8.7 acres; 0.7 %) and stumps (5.0 acres; 0.4 %) were also abundant within the potential drawdown zone. Lesser amounts of brush (0.3 acres; 0.02 %), no branched trees (0.2 acres; 0.01 %) and Christmas trees (0.2 acres; 0.01 %) were also present within the potential drawdown zone. An additional 13.34 acres of the potential drawdown zone was covered by docks. These accounted for 1.01 % of the total habitat between the 508 and 494 foot elevations.

An annual drawdown in Narrows reservoir, similar to that done at High Rock, would reduce the water surface acreage from a full pond value of 5,887.3 acres to 4,382.46 acres, a loss of 1,504.84 acres or 25.56 % (Table 4.4-3).

4.4.4 Additional Mapped Habitat

Where suitable conditions existed, biologists mapped habitats as far into the water as possible below the base of the potential drawdown zone (< el. 494) (Table 4.4-5). This provided an additional 24.42 acres of high quality habitat within Narrows Reservoir. Of this additional habitat, 82.7 % was comprised of rock substrates. Rip-rap covered 7.73 acres and accounted for 31.7 % of the additional habitat. Ledge (5.47 acres; 22.3 %), cobble (3.87 acres; 15.8 %) and boulder (3.02 acres; 12.4 %) substrates were also present in the area below the potential drawdown zone. Medium branched trees were the dominant woody cover type, accounting for 9.3 % of the habitat and covering 2.26 acres. Stumps (1.37 acres; 5.6 %) and heavy branched trees (0.27 acres; 1.1 %) also comprised a significant portion of the woody cover present. Lesser amounts of Christmas trees and no branched trees were also mapped. Wetland habitat mapped below the potential drawdown zone was limited. Only 0.2 acres (0.8 % of total habitat) of palustrine emergent, flood plain forest, and shrub-swamp habitats were found in areas below the potential drawdown

Table 4.4-4. Percentage by type of all habitats mapped within the potential drawdown zone[2] of Narrows Reservoir.

Habitat Type	Square Feet	Acres	% of Total
Lacustrine Aquatic Beds [1]	2,219,286.56	50.95	3.86%
Palustrine Emergent [1,4]	2,344,986.24	54.89	4.16%
Flood Plain Forest [1]	194,834.31	3.94	0.30%
Shrub-swamp [1]	47,144.42	1.10	0.08%
Docks	580,620.84	13.34	1.01%
Misc. Man-made [3]	3,172.07	0.06	0.00%
Boulder	1,107,651.24	25.41	1.93%
Cobble	999,350.46	22.92	1.74%
Gravel	185,445.83	4.26	0.32%
Ledge	287,138.41	6.57	0.50%
Rip-rap	225,363.12	5.17	0.39%
Brush	10,949.33	0.25	0.02%
Christmas Trees	6,204.21	0.15	0.01%
Heavy Branched Trees	378,087.58	8.67	0.66%
Medium Branched Trees	454,095.61	10.42	0.79%
No Branched Trees	8,053.65	0.18	0.01%
Stumps	216,958.12	4.97	0.38%
Mud/Sand/Clay	52,923,757.67	1,098.75	83.28%
Total	**59,973,813.11**	**1,312.00**	**100.00%**

[1] These wetland habitat types were mapped from aerial photographs.
[2] Drawdown zone represents habitat found between the 508 and 494 elevations.
[3] Miscellaneous man-made includes blocks, toilets, PVC-structures, tires, etc.
[4] Does not include PEM acreage added post aerial photograph analysis (See Section 4.4 for explanation).

Table 4.4-5. Amount of habitat mapped in Narrows Reservoir within the littoral zone (el. 510 to 508 ft), the possible drawdown zone (el. 508 to 494 ft), and the area below the possible drawdown zone (el. <494 ft).

	Available Habitat Elevation					
	Littoral Zone (El. 510 - 508 ft)		Possible Drawdown Zone (El. 508 - 494 ft)		Habitat Extending Below Drawdown (<494 ft)	
Habitat Type	**Sq. Feet**	**Acres**	**Sq. Feet**	**Acres**	**Sq. Feet**	**Acres**
Lacustrine Aquatic Beds [1]	297,268.19	6.82	2,219,286.56	50.95	0.00	0
Palustrine Emergent [1,3]	1,102,151.61	25.46	2,344,986.24	54.89	2,447.57	0.06
Flood Plain Forest [1]	1,259,772.76	28.63	194,834.31	3.94	1,490.59	0.03
Shrub-swamp [1]	38,969.60	1.29	47,144.42	1.10	4,714.59	0.11
Docks	95,096.58	2.19	580,620.84	13.34	11,764.06	0.27
Misc. Man-made [2]	0.69	0.00	3,172.07	0.06	0.00	0.00
Boulder	91,746.85	2.10	1,107,651.24	25.41	131,635.70	3.02
Cobble	84,319.04	1.93	999,350.46	22.92	168,726.55	3.87
Gravel	7,859.49	0.18	185,445.83	4.26	4,349.62	0.10
Ledge	36,148.04	0.83	287,138.41	6.57	238,128.52	5.47
Rip-rap	38,156.66	0.88	225,363.12	5.17	336,731.94	7.73
Brush	45.90	0.00	10,949.33	0.25	35.57	0.00
Christmas Trees	389.05	0.01	6,204.21	0.15	1,774.41	0.04
Heavy Branched Trees	69,007.24	1.58	378,087.58	8.67	12,004.58	0.27
Medium Branched Trees	72,312.28	1.65	454,095.61	10.42	98,507.62	2.26
No Branched Trees	1,247.26	0.03	8,053.65	0.18	922.09	0.02
Stumps	0.00	0.00	216,958.12	4.97	59,770.38	1.37
Mud/Sand/Clay	5,541,439.77	120.40	52,923,757.67	1098.75	---	---
Sum	**6,037,768.84**	**193.98**	**57,386,848.13**	**1312.00**	**1,064,351.05**	**24.42**

[1] These wetland habitat types were mapped from aerial photographs.
[2] Miscellaneous man-made includes blocks, toilets, PVC-structures, tires, etc.
[3] Does not include PEM acreage added post aerial photograph analysis (See Section 4.4 for explanation).

zone. As mentioned in Section 4.4, an additional 92 acres of palustrine emergent habitat was added during the ground-truthing process that took place after the aerial photography analysis. Because this data is not available in the ArcView cover type maps, the percentage of that acreage present in the littoral, potential drawdown and areas below the potential drawdown could not calculated. An additional 0.27 acres of docks, accounting for 1.1% of the total habitat mapped below the drawdown zone, were also present.

4.4.5 Habitat Within 2-foot Contour Intervals

Table 4.4-6 presents the acreage of each habitat type within two foot contour intervals for the littoral and potential drawdown zone of Narrows Reservoir (elevations 510-494). The contour with the greatest total area of habitat is the 510-508 elevations (current littoral zone), with 71.4 acres of quality habitat. Quality habitat declines as you move down through the 2-foot contours within the potential drawdown zone. Seventy-seven percent of the mapped habitat is located within the top half of the potential drawdown zone.

4.4.6 Erosion

There were 33 sites, varying in length from 53 to 792 feet, which showed signs of erosion in Narrows Reservoir (Figure 4.4-6). These sites covered a total of 2.15 miles of shoreline (Table 4.4-7). This represents 2.2 % of the total shoreline in Narrows Reservoir. A total area of 0.92 acres is eroded between the 33 sites mapped.

4.5 FALLS RESERVOIR

Falls Reservoir is a small, narrow impoundment that covers 204 acres at full pool. The reservoir is located on the Yadkin River approximately one mile above its confluence with the Uhwarrie River, forming the Pee Dee River. Maximum depth is 52 ft and mean depth is 27 ft. Falls Reservoir has a comparatively straight, steep shoreline with only one moderately sized, flooded tributary arm. Daily water level fluctuations due to the run-of-river operation mode normally range 0-2 ft, with a maximum fluctuation up to 4 ft. No seasonal drawdowns occur due to limited storage capacity. The Falls Reservoir (Figure 4.5-1) habitat field survey ran from July 28 to 29, 2004. Falls Reservoir's maximum full pond elevation is 332.8 feet. Seasonal fluctuations in water level average in range from 0-2 feet (Figure 4.5-2). Water surface elevations during the field effort ranged from 330.3 to 330.7 with an average elevation of 330.5 ft. The 2-foot drawdown assisted the field effort in that biologists were able to map habitat not only within the littoral zone but also habitats that visibly extended into the reservoir.

Falls Habitat Type Descriptions

Significant habitat types important to aquatic biota that were mapped during this study included:

1. aquatic vegetation
2. trees and woody debris (brush, fallen trees, stumps)
3. rock substrates (boulder, cobble)
4. mud/sand/clay

Table 4.4-6. Habitat within the littoral and potential drawdown zone of Narrows Reservoir. Presented in 2-foot contour intervals.

	Elevation							
	510-508	508-506	506-504	504-502	502-500	500-498	498-496	496-494
Habitat Type	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Lacustrine Aquatic Beds	6.82	10.72	12.38	10.71	8.04	5.45	2.60	1.04
Palustrine Emergent	25.46	29.72	17.98	5.41	1.28	0.33	0.12	0.05
Flood plain forest	28.63	2.63	0.70	0.19	0.09	0.09	0.23	0.01
Shrub-swamp	1.29	0.51	0.29	0.14	0.06	0.05	0.03	0.03
Docks	2.18	3.40	4.04	3.89	1.54	0.63	0.22	0.09
Misc. Man-made*	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03
Boulder	2.10	2.42	4.51	4.41	4.73	3.96	3.18	2.20
Brush	0.00	0.04	0.04	0.03	0.04	0.03	0.04	0.02
Christmas tree	0.01	0.01	0.01	0.00	0.01	0.04	0.04	0.04
Cobble	1.93	3.26	3.88	3.88	3.59	3.43	2.91	1.97
Gravel	0.18	0.49	0.73	0.70	0.70	0.69	0.62	0.33
Heavy branched tree	1.58	2.76	2.35	1.43	0.94	0.61	0.36	0.21
Ledge	0.83	0.94	1.28	1.23	0.86	0.91	0.78	0.56
Medium branched tree	1.65	3.07	2.78	1.84	1.07	0.63	0.50	0.54
No branched tree	0.03	0.02	0.02	0.03	0.03	0.04	0.03	0.02
Rip rap	0.88	1.07	1.16	1.12	0.69	0.39	0.38	0.37
Stumps	0.00	0.01	0.06	0.47	0.49	0.53	1.60	1.82
Total	73.57	61.07	52.20	35.49	24.14	17.82	13.65	9.33

Table 4.4-7. Amount of erosion mapped within Narrows Reservoir.

	Narrows Reservoir Erosion
Length of eroded shore (ft.)	11,368.31
Length of eroded shore (miles)	2.15
Area of eroded shore (sq. ft.)	40,220.29
Area of eroded shore (acres)	0.92

Photo A: Bank Erosion

Photo B: Bank Erosion

Photo C: Bank Erosion

Figure 4.4-6 Examples of erosion mapped within Narrows Reservoir during December 2003.

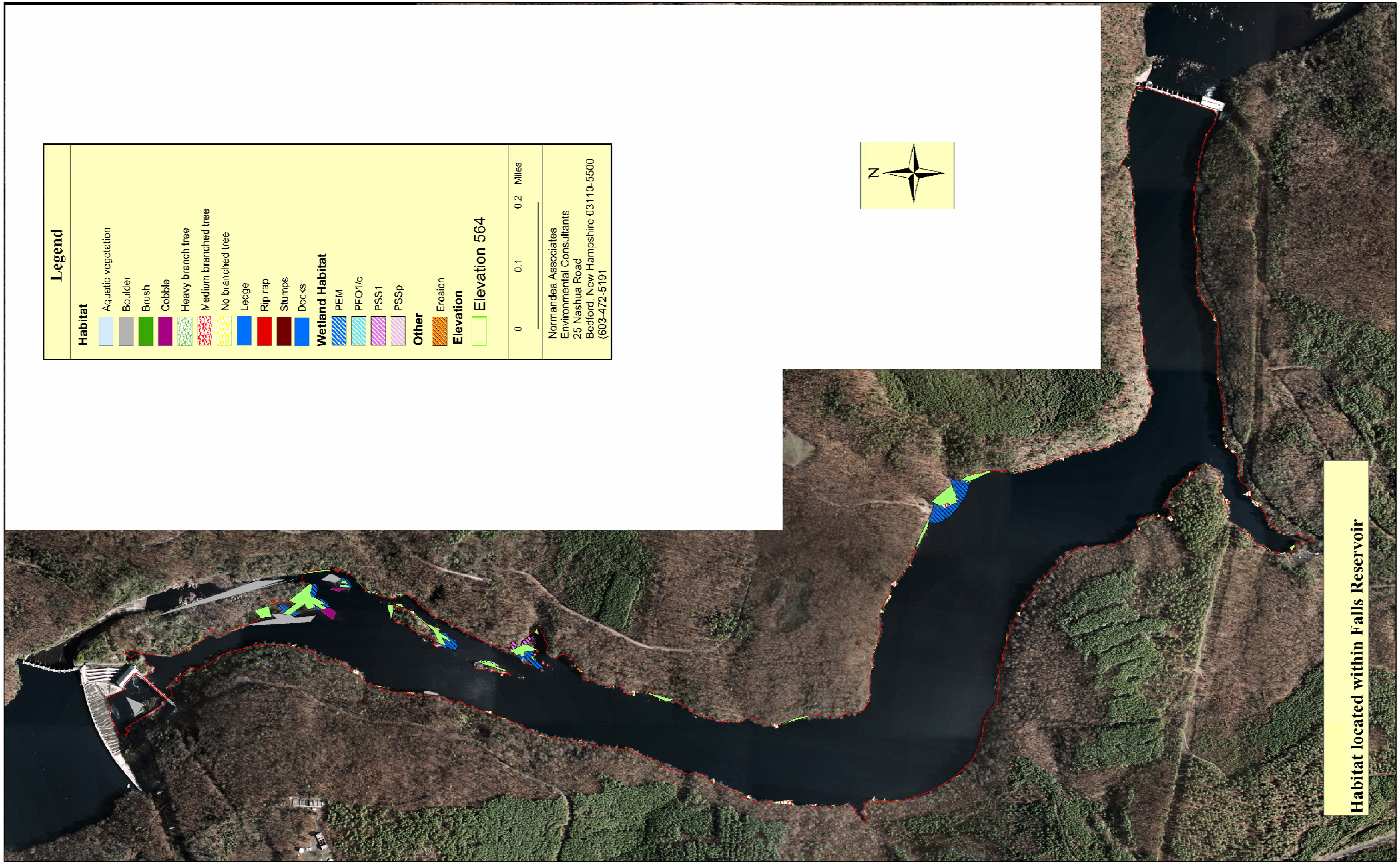

Figure 4.5-1. Habitat located within Falls Reservoir.

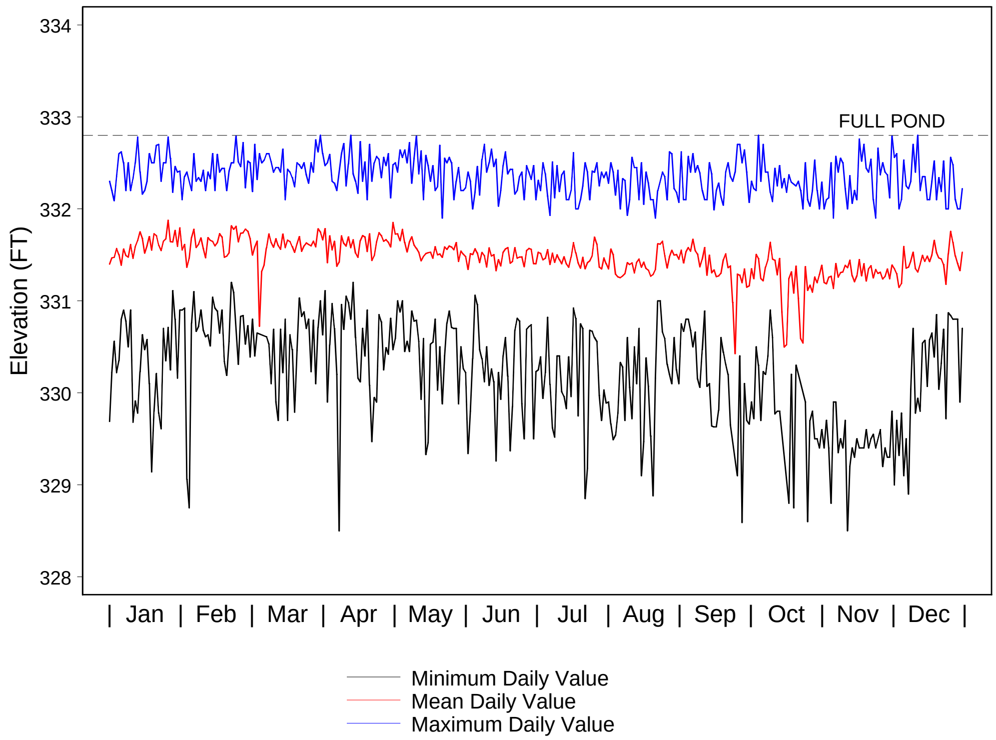

Figure 4.5-2. Minimum, Mean and Maximum Daily Water Elevations in the Falls Reservoir for the Period of January 1, 1986 to December 31, 2003.

Aquatic Vegetation

Aquatic vegetation beds found during the July 2004 habitat survey were mapped. Figure 4.5-3 shows examples of the aquatic vegetation mapped by NAI biologists. In addition to data collected during the survey, additional wetland habitats were added through the analysis of overflight pictures taken during July and August of 2003. After habitat types were mapped out on the collected photographs, biologists in the field were used to verify the wetland habitat types that were present. Wetlands information collected through both methods is presented in this report. Three major wetland types of importance to aquatic biota within Falls Reservoir were identified through the analysis of overflight photographs.

1. ***Palustrine Emergent:*** (PEM) Consisted mainly of water willow beds
2. ***Flood Plain Forest:*** (PFO1/c) Species composition within this wetland type can be very diverse. However, where this community type is present, black willow is the dominant tree species. This habitat type is typically flooded only during high water events.
3. ***Shrub-Swamp:*** (PSS1) Shrub-swamp habitat in Falls is dominated by loosely bunched stands of black willow, buttonbush and sycamore seedlings.

Woody Cover

Woody cover found within the littoral zone was split into several categories and mapped during the study. Naturally falling and intentionally cut trees (lap trees) lying within the littoral zone were mapped. These downed trees were further categorized based on the size and amount of branches remaining on the tree.

Photo A: Aquatic Vegetation

Figure 4.5-3. Example of aquatic vegetation mapped in Falls Reservoir, July 2004.

They were classified as heavy branching, medium branching or no branching. Other types of woody cover located and mapped in the littoral zone included stumps and brush piles (Figure 4.5-4).

Substrate

All substrate types located within the littoral zone were delineated and mapped during the field survey. These included boulder and cobble (Figure 4.5-5). Substrate that did not provide good habitat for aquatic biota, such as heavily embedded gravel, was not measured and was included in the default (mud/sand/clay) substrate category. All habitats that were not mapped due to their not providing decent habitat for aquatic biota were put into the default category.

Erosion

Areas of significant erosion were mapped during the field effort. "Significant erosion" was defined in the final study scope as areas that are observed to have active and ongoing erosion and observable impacts to important aquatic and terrestrial resources. Such areas included but were not necessarily limited to:

- Areas where eroding shoreline has resulted in localized sediment deposits that are noticeably affecting water quality or aquatic habitats
- Areas where eroding shoreline has resulted in the loss of vegetation from a significant community or habitat type
- Areas where eroding shoreline are impacting public recreation facilities

Photo A: Medium branched tree

Photo B: Medium branched tree

Photo C: No branched tree

Figure 4.5-4. Examples of woody cover types mapped in Falls Reservoir, July 2004.

Photo A: Boulder

Photo B: Cobble and boulder

Figure 4.5-5. Examples of rock substrate mapped in Falls Reservoir, July 2004.

4.5.1 Mapped Available Habitat

This section presents all habitats mapped at elevations lower then 331.0 feet. Within the Falls Reservoir shape file, the 331.0 foot contour line was the closest available to the full pond value of 332.8 ft. The two-foot drawdown allowed for the field crew to map all habitat types providing quality cover for aquatic biota found within and just below the littoral zone.

Although bathymetry below full pond was not available, based on the contour data and habitat mapped above the full pond mark, NAI estimates that 85 % of the Falls littoral zone is comprised of mud/sand clay while the remaining 15 % is quality habitat for aquatic biota.

NAI biologists mapped 7.2 acres of habitat below the full pond mark that was considered to be of high quality to aquatic biota (Table 4.5-1). Wetland habitat types accounted for almost 70 % of the 7.2 acres of quality habitat mapped in the Falls Reservoir littoral zone (Table 4.5-2). Palustrine emergent vegetation, consisting mainly of water willow, covered 2.8 acres of the littoral zone and accounted for 39.1 % of the total quality habitat mapped. This wetland type was one of three that were mapped by the use of aerial photographs. Flood plain forest (0.1 acres; 1.7 %) and shrub-swamp (0.3 acres; 4.0 %) were the two other habitat types to be mapped from aerial photographs. The remainder of the aquatic vegetation was mapped by the field crew during July. These areas combined to cover 1.8 acres and account for 25.1 % of the habitat mapped. Rock substrate was present in the form of boulders and cobble. Boulders were the more abundant of the two, covering 1.1 acres of the littoral zone and comprising 14.7% of the habitat mapped. Smaller amounts of cobble (0.2 acres; 2.9 %) were present in areas of the littoral zone. Medium branched trees were the dominant form of woody cover within the Falls Reservoir littoral zone. They covered 0.9 acres and accounted for 12.3 % of the quality habitat. Small amounts of stumps (0.01 acres; 0.7 %) and no branched trees (0.01 acres; 0.1 %) were also found in Falls Reservoir.

4.5.2 Erosion

No areas of “significant erosion” were identified in Falls Reservoir during the July 2004 habitat survey.

5.0 IMPACTS OF YADKIN RESERVOIR OPERATIONS ON AQUATIC BIOTA AND HABITAT IN THE FOUR IMPOUNDMENTS

5.1 HIGH ROCK RESERVOIR

5.1.1 Impacts of Current Project Operations on Aquatic Biota and Habitat in High Rock

Project operations at High Rock that have the greatest impact on aquatic biota and habitat are the fluctuating water levels. Ecological changes associated with fluctuations in reservoir water levels can generally be divided into three categories – effects on fish habitat, effects on supporting trophic levels and the effects on fish populations, such as reproduction and behavior (Culver et al 1980). The shallow littoral zone is the most important area of a reservoir from the standpoint of aquatic biota (fish, aquatic insects, etc) and higher aquatic plants. The littoral zone is where most fish spawn, where their young find food and cover and where the larger predators frequent for feeding opportunities. Before analyzing the impacts of operations on aquatic biota and habitat, this section first presents data on High Rock Reservoirs current hydrologic regime, water quality and fish populations.

Table 4.5-1. Total amount of all habitat types mapped in Falls Reservoir, below the full pond USGS elevation of 331'.

Falls Reservoir

	Available Habitat Mapped Below Full Pond [1]	
Type	**Square Feet**	**Acres**
Aquatic Vegetation [2]	65,055.86	1.49
Palustrine emergent [3]	86,684.10	1.99
Flood plain forest [3]	2,177.99	0.05
Shrub-swamp [3]	7,405.17	0.17
Boulder	45,579.41	1.05
Cobble	9,028.30	0.21
Medium branched trees	34,428.00	0.79
No branched trees	118.11	0.00
Stumps	217.01	0.01
Sum	**250,693.95**	**5.75**

[1] Full pond elevation is equal to USGS 331.0'.
[2] Aquatic vegetation in this category was mapped by field crew using the laser rangefinder and DGPS.
[3] These wetland types were mapped through the use of aerial photographs.

Table 4.5-2. Habitat type by percentage of total mapped acreage in Falls Reservoir, below the full pond USGS elevation of 331'.

Falls Reservoir

	Habitat Mapped Below Full Pond [1]	
Type	**Acres**	**% of Total [4]**
Aquatic Vegetation [2]	1.49	25.97%
Palustrine emergent [3]	1.99	34.66%
Flood plain forest [3]	0.05	0.83%
Shrub-swamp [3]	0.17	2.87%
Boulder	1.05	18.21%
Cobble	0.21	3.60%
Medium branched trees	0.79	13.76%
No branched trees	0.00	0.05%
Stumps	0.01	0.09%
Sum	**5.75**	**100.00%**

[1] Full pond elevation is equal to USGS 331.0'.
[2] Aquatic vegetation in this category was mapped by field crew using the laser rangefinder and DGPS.
[3] These wetland types were mapped through the use of aerial photographs.
[4] Percentages presented are of the quality habitat types mapped within the littoral zone only. Does not include areas classified as low quality habitat (mud/sand/clay).

5.1.2 Existing Hydrologic Regime in High Rock

High Rock Reservoir is the largest of the four project impoundments, and covers 15,180 acres with a maximum and mean depth of 62 ft and 17 ft, respectively. High Rock features five major flooded tributary arms, several smaller ones, and a lengthy convoluted shoreline (411.3 miles). Its large size enables High Rock Reservoir to serve as the main storage and water regulation reservoir for the Yadkin-Pee Dee system downstream. The High Rock Development is operated in a store-and-release mode. Normal daily fluctuation in water surface elevation due to operations is less than 1 ft, with a daily maximum of 2 to 4 ft (Yadkin ICD 2002). Seasonal drawdowns have averaged 8 ft in spring, 5 ft in summer, 10 ft in fall, and 12 ft in winter. The maximum annual drawdown typically occurs in late winter.

Daily water levels in the High Rock reservoir over the 18-year period of record are plotted in Figure 4.2-1. Full-pond elevations have occurred during all months of the year, though more frequently during spring. Water levels in the reservoir were generally highest during the spring and declined as summer progressed, with the lowest daily values observed in July and August. Out of the four reservoirs in the Yadkin system, High Rock exhibited the greatest range in elevation on an annual basis (Table 5-1). On the shorter time scales, however, elevations varied to a similar or lesser extent than in the other reservoirs, and declined to zero at the weekly and daily time scales.

5.1.3 High Rock Water Quality

This section provides a brief review of High Rock's water quality, however, a more detailed assessment of the reservoirs water quality is in Normandeau's recent water quality report (NAI 2005b). High Rock Reservoir is classified as a eutrophic system with a hydraulic retention time that ranges from 3 to 30 days, depending on river flows and dam release schedules (NCDWQ 1998). The reservoir is very turbid with large concentrations of suspended sediments and poor water clarity which causes a shallow photic zone. The average Secchi depth reading in High Rock Reservoir is about a half meter, which means that light penetration and algal productivity is limited to the top one meter (~ 3 ft). Because it is the furthest upstream of the four developments, High Rock receives the heaviest load of sediment from the rivers and creeks that flow into it compared to the other three reservoirs. The heavy sediment load carries greater concentrations of nutrients, including high concentrations of phosphorus and total nitrogen that can support nuisance algae blooms. The availability of nutrients in High Rock has created a large standing crop of algae, as indicated by the large chlorophyll *a* concentrations, a surrogate measure for algal biomass.

The large standing crop of algae and the shallow photic zone tend to produce near-saturated to supersaturated oxygen levels in the photic zone, but as the micro-organisms settle into the underlying water, respiration and decomposition quickly deplete oxygen concentrations, creating anoxic conditions. This oxygen depletion in High Rock occurs during the warmer months and extends from the reservoir bottom up to the lower limit of the photic zone. In a typical year, lower dissolved oxygen levels first appear around May and extend through October or November. Surface dissolved oxygen concentrations below 5 mg/l occurred in mid-summer of 1999 and 2001 and briefly in 2002 because of the drought. Reduced flows promoted intense algal production which caused the low surface dissolved oxygen (NAI 2005b).

Table 5-1. Summary of Water Elevation (FT) Statistics in the Yadkin Reservoirs Based on Daily Data (1986-2003)[a] and Hourly Data (1997-2003)[b]. Elevations Referenced to the USGS Datum.

Time Scale	RESERVOIR AND NORMAL FULL POND ELEVATION							
	High Rock (623.9 FT)		Tuckertown (564.7 FT)		Narrows (509.8 FT)		Falls (332.8 FT)	
	Statistic	Date(s)	Statistic	Date(s)	Statistic	Date(s)	Statistic	Date(s)
Annual Range[a]								
Minimum	8.83	1990	1.60	1988	2.19	1989	2.60	1994
Mean	13.49		2.42		4.09		5.90	
Maximum	23.62	2002	3.30	2000	11.92	2002	17.83	1998
Monthly Range[a]								
Minimum	0.88	Jun-99	0.25	*	0.30	Feb-98	0.57	Jul-87
Mean	4.38		1.22		1.50		2.01	
Maximum	15.66	Feb-89	2.90	Mar-91	8.07	Oct-95	17.67	Mar-98
Monthly Elevation[a]								
Minimum	599.86	Jul-02	561.38	Jul-00	497.82	Aug-02	314.80	*
Mean	618.87		563.75		508.23		331.47	
Maximum	623.90	*	564.70	*	510.30	Oct-90	332.80	*
Weekly Range[a]								
Minimum	0.00	*	0.00	*	0.00	*	0.00	*
Mean	1.62		0.60		0.59		1.13	
Maximum	10.35	29-31 Dec-96	2.90	3-9 Mar-91	8.07	1-7 Oct-95	17.51	1-7 Mar-98
Weekly Elevation[a]								
Minimum	599.86	14-20 Jul-02	561.38	2-8 Jul-00	497.82	25-31 Aug-02	314.80	*
Mean	618.84		563.75		508.22		331.47	
Maximum	623.90	*	564.70	*	510.30	14-20 Oct-90	332.80	*
Daily Range[b]								
Minimum	0.00	*	0.00	*	0.00	*	0.00	*
Mean	0.38		0.32		0.20		1.09	
Maximum	4.02	15 Feb-97	2.68	14 Jun-00	1.60	21Mar-03	17.51	6 Mar-98
Daily Elevation[b]								
Minimum	599.82	20 Jul-02	561.38	8-9 Jul-00	497.71	31 Aug-02	314.80	*
Mean	618.28		563.70		508.22		331.54	
Maximum	623.90	**	564.77	10 Jan-00	509.91	29 Aug-02	332.90	20 Mar-03

* Occurred more than once during period of record.

** Occurred multiple times between 24 April and 4 May 1997, 28-31 January 1998, 5-7 February 1998, 10-13 March 1998, 18-25 April 1998, 8-12 May 1998, and on several dates in March, April, July, August and September of 2003

5.1.4 Existing Management and Fisheries Data for High Rock

NAI sampled fish in the tailwaters of High Rock, Tuckertown, Narrows, and Falls during 2003-2004 and the results of that effort are presented in a companion report entitled *Yadkin Tailwater Fish and Aquatic Biota Assessment* (NAI 2005a). NAI did not sample for fish in High Rock Reservoir during the 2003 and 2004 field seasons. However, High Rock and the other three Project reservoirs have been sampled for fish species recently by the North Carolina Wildlife Resources Commission (NCWRC) biologists and by consultants retained by Yadkin. Most of the sampling conducted by NCWRC has focused on selected game fish, such as crappie (Dorsey 2000; Nelson and Dorsey 2005) and largemouth bass (Dorsey 2001; Dorsey 2002). Reconnaissance-level fish sampling was conducted on the four reservoirs by Dames and Moore (D&M) in 1996 and 1997 for use in developing Yadkin's Shoreline Management Plan (SMP). Additionally, Carolina Power & Light (CP&L) biologists under contract to Yadkin conducted an intensive year-long electrofishing and gill net survey on the four reservoirs in 2000. During the effort, CP&L also collected fish scales from three species, blueback herring, striped bass, and white bass for age and growth analyses. Table 5-2 presents a cumulative species list for all four reservoirs compiled from NAI, NCWRC, and CP&L work within the project reservoirs. The combined total from these studies represents 51 species and 3 hybrids found within the four project reservoirs.

High Rock Reservoir is actively managed by the NCWRC as a warm water fishery. Major sport fisheries exist for largemouth bass, black and white crappie, striped bass, and several species of catfish. The NCWRC currently regulates game species through a combination of size and creel restrictions. Table 5-3 shows the historic stocking records from the NCWRC for the project reservoirs. Striped bass fingerlings are stocked into High Rock at a rate of 5 per acre, or about 79,000 fish per year. The number of striped bass fingerlings stocked into the reservoir was doubled in 2003 to compensate for potential losses incurred during the severe drought in 2002.

Table 5-4 shows historic sampling efforts of the NCWRC within three of the four project reservoirs. Summarized past studies indicate that High Rock Reservoir is supporting at least 36 species of game and non-game fish species and two hybrids, representing all trophic levels (Table 5-3). In 2000, Carolina Power and Light (CP&L) conducted a baseline fisheries study on High Rock Reservoir and captured 28 fish species and two hybrids in the reservoir using gill nets and a boat electrofishing unit. Data collected during this study can be found in Appendix 2, Table 2-1. Gizzard shad, bluegill, threadfin shad, largemouth bass and black crappie comprised the five most abundant species captured by electrofishing, making up 84% of the total catch. Threadfin shad, white perch, channel catfish, black crappie and gizzard shad were the five species most commonly captured in gill nets, and these five species made-up 91% of the total gill net catch. Gizzard shad and threadfin shad had the highest CPUE's for electrofishing whereas threadfin shad and white perch had the highest gillnet CPUE. CP&L conducted age and growth analysis on 41 striped bass and 24 white bass captured within High Rock Reservoir and the results of this analysis can be found in Appendix 2 (Tables 2-2 & 2-3). High Rock striped bass ranged in age from 1 to 8 years and the white bass ranged in age from 1 to 5 years.

The NCWRC examined the health and status of the crappie populations in High Rock during 2000 (Dorsey 2000a). A total of 924 black crappie and 160 white crappie were captured by trap net and examined during this study. Relative weight scores averaged 94 for black crappie and 89 for white crappie, which is close to the ideal relative weight range of 95 to 100 reported in the literature. The mean total length for black crappie was 214 mm and of those collected, 57% were greater then the 203 mm minimum size limit. Additionally, 84% of white crappie collected were bigger than the minimum limit.

Table 5-2. Compiled species list for all four project reservoirs

Scientific Name	Common Name	High Rock	Tuckertown	Narrows	Falls
Alosa aestivalis	Blueback Herring		C	B,C	B,C
Alosa pseudoharengus	Alewife		B		
Ameiurus melas	Black bullhead	A	B		
Ameiurus nebulosus	Brown bullhead	A,B	A,B	A,B	
Amia calva	Bowfin	A,B			C
Aphredoderus sayanus	Pirate perch				
Carassius auratus	Goldfish	A,B	C	B	
Carpiodes cyprinus	Quillback	A,B	A,B,C	A,C	
Catostomus commersoni	White sucker	A		A	
Cyprinus carpio	Common carp	A,B	A,B,C	A,B,C	B,C
Cyprinella analostana	Satinfin shiner		B,C	C	C
Dorosoma cepedianum	Gizzard shad	A,B	A,B,C	A,B,C	B,C
Dorosoma petenense	Threadfin shad	A,B	A,B,C	A,B,C	B,C
Erimyzon oblongus	Creek chubsucker	A,B	A,B,C	A,B,C	
Esox americanus	Redfin pickerel			A	
Esox niger	Chain pickerel			A	
Etheostoma nigrum	Johnny Darter		B		
Etheostoma olmstedi	Tesselated darter		C		
Gambusia holbrooki	Eastern mosquitofish		B	A,B	B
Hybognathus regius	Eastern Silvery Minnow		C		
Ictalurus brunneus	Snail bullhead			B	C
Ictalurus catus	White catfish	A,B	A,B,C	A,B,C	B,C
Ictalurus furcatus	Blue catfish		B,C	B,C	B,C
Ictalurus natalis	Yellow bullhead			A,B	
Ictalurus platycephalus	Flat bullhead	A	B	B	C
Ictalurus punctatus	Channel catfish	A,B	A,B,C	A,B,C	B,C
Ictiobus bubalus	Smallmouth buffalo	A	C	A	B,C
Lepisosteus osseus	Longnose gar	A,B	B,C	A,B,C	C
Lepomis auritus	Redbreast sunfish	A,B	A,B,C	A,B,C	B,C
Lepomis cyanellus	Green sunfish	A,B	A,B,C	A,B,C	B,C
Lepomis gibbosus	Pumpkinseed	A,B	B,C	A,B,C	B
Lepomis gulosus	Warmouth	A,B	A,B,C	A,B,C	B,C
Lepomis macrochirus	Bluegill	A,B	A,B,C	A,B,C	B,C
Lepomis microlophus	Redear sunfish	A,B	A,B,C	A,B,C	B,C
Micropterus salmoides	Largemouth bass	A,B	A,B,C	A,B,C	B,C
Minytrema melanops	Spotted sucker	B			
Morone americana	White perch	A,B	A,B,C	A,B,C	B,C
Morone chrysops	White bass	A,B	A,B,C	A,B,C	C
Morone saxatilis	Striped bass	A,B	A,B,C	A,B,C	B,C
Moxostoma anisurum	Silver redhorse	A	B,C	A,C	C
Moxostoma macrolepidotum	Shorthead redhorse	B	B,C	A,B,C	B,C
Moxostoma pappillosum	V-lip redhorse	A	A	A	
Nocomis leptocephalus	Bluehead chub			B	
Notemigonus crysoleucas	Golden shiner	A,B	B	A,B,C	B,C
Notropis hudsonius	Spottail shiner		C		
Perca flavescens	Yellow perch	A,B	A,B,C	A,B,C	B,C
Pomoxis annularis	White crappie	A,B	B,C	A,B,C	B,C
Pomoxis nigromaculatus	Black crappie	A,B	A,B,C	A,B,C	B,C
Pylodictis olivaris	Flathead catfish	A,B	A,B,C	B,C	B,C
Scartomyzon spp.	Brassy jumprock	A			
	Striped bass x White bass	B	B,C	B,C	
	Carp x Goldfish	B			
	Sunfish Hybrid			B	B

A - Source = NCWRC Surveys (taken from Fisheries and Wildlife Management Plan for the Yadkin-PeeDee River Basin (NCWRC 2004))
B - Source = Carolina Power and Light 2000 Survey
C - Source = Normandeau Associates Inc. 2003/2004 Tailwater Surveys

Table 5-3. North Carolina Wildlife Resources Commission Stocking Records for High Rock, Tuckertown, Narrows, Falls and Tillery Reservoirs

Waterbody	Species	Years Stocked
High Rock Reservoir	Bluegill	1950,51,55,57-60
	Crappie	1941
	Largemouth bass	1949-59,61,62
	Smallmouth bass	1966,67
	Striped bass	1959-61,63,65-67,69,70,75,77-79,81-87,90,92-95,98-03
	Threadfin shad	1961,63,65
	Walleye	1950,54
	White bass	1954
Tuckertown Reservoir	Striped bass	1977-79,81-85,87-90,92-95,98-03
Narrows (Badin) Reservoir	Bluegill	1949-51,58,60
	Largemouth bass	1949-53,55-58,61,82
	Striped bass	1971,72,75,77-79,81-87,89,91,93-03
	Walleye	1954
	White bass	1954
Falls Reservoir	Bluegill	1958,60
	Largemouth bass	1953,58,60
Lake Tillery	Bluegill	1949-51,60,63
	Largemouth bass	1949-53,55-58,61
	Northern pike	1958,61
	Sauger	1963
	Striped bass	1965,66,75,78,79,81-87,90,92,93-95,97-03

*From Fisheries and Wildlife Management Plan for the Yadkin-Pee Dee River Basin (NCWRC 2004)

Table 5-4. Fisheries sampling efforts conducted on impoundments within the Yadkin-Pee Dee River Basin, by the North Carolina Wildlife Resources Commission (1972 -2001).

			Gear Type				
Reservoir	**Year(s) Data Collected**	**Source**	**CR**	**EF**	**GN**	**TP**	**CS**
High Rock	1992	NCWRC				x	
	1999	NCWRC		x			
	2000	NCWRC				x	
	2001	NCWRC		x			
Tuckertown	1977	NCWRC	x				
	1987-89	NCWRC				x	
	1988	NCWRC					x
	1988-90	NCWRC					x
	1993	NCWRC				x	
	1994	NCWRC				x	
	1995	NCWRC		x			
	1998	NCWRC				x	
	1998	NCWRC		x			
Narrows	1972-73, 80-81	NCWRC					x
	1972-73, 80,82,84	NCWRC	x				
	1980	NCWRC					x
	1982	NCWRC			x		
	1983-84, 90, 95	NCWRC		x			
	1987-89	NCWRC				x	
	1989, 93-95, 98	NCWRC				x	
	1990	NCWRC					x
	1990, 95	NCWRC		x			
	1990, 96-97	NCWRC			x		
	1998	NCWRC		x			
	2000	NCWRC				x	
	2001	NCWRC		x			
Tillery	1989-90, 99	NCWRC				x	
	1997	NCWRC		x			

CR = Cove rotenone
EF = Electrofishing
GN = Gill net
TP = Trap net
CS = Creel survey

* From Fisheries and Wildlife Management Plan for the Yadkin-Pee Dee River Basin (NCWRC 2004).

Length at age calculations indicated that both species reached harvestable size in 1.5 years. With good catch rates, growth rates, and a large percentage of the populations at or over the minimum size, the black and white crappie populations within High Rock were in good condition in 2000.

A follow up survey to assess population characteristics in the High Rock crappie populations was conducted in 2003, following the severe drought conditions observed in 2002 (Nelson & Dorsey 2005). A total of 328 black crappies and 92 white crappies were captured by trapnet and examined. Differences between the 2000 and 2003 crappie populations were observed. The percentage of fish greater than the 203 mm minimum size limit was lower in both black (12%) and white crappie (37%) during the 2003 sampling, indicating a loss of larger individuals in the population that may have been caused by the severe drought. The average relative weight score for black crappie was 98, a slight increase from the average value (94) reported for 2000, indicating the remaining fish did not have a problem securing enough food. Mean total length for black crappie captured in 2003 (186 mm) was lower than the 2000 average. The average relative weight for white crappie decreased to 83 from the 89 value reported in 2000, suggesting a problem securing enough food. Similar to 2000 findings, length at age calculations indicated that both species are reaching harvestable size in 1.5 to 2 years.

Largemouth bass length and weight data collected by the NCWRC in High Rock during 1999, 2001 and 2003, was used to calculate relative weight, total length and CPUE values. Calculated relative weight values for largemouth bass were 100 (1999), 98 (2001), and 101 (2003) and were within or just above the recommended ideal range of 95 to 100 reported for this fish. These relative weight values were consistent over the 5 year period that encompassed the severe drought. The average total length of largemouth bass in High Rock reservoir shows an upward trend. Prior to the drought (1999), mean total length was 335 mm, compared to 344 mm during the drought (2001) and 390 mm during the post-drought (2003). It appears as if some of the smaller individuals were lost during the low water period, perhaps due to the increased predation associated with drawdowns. Average largemouth bass CPUE for the three years of sampling were 51 (1999), 78 (2001), and 44 (2003). The high CPUE value for 2001 could be associated with a large number of fish being forced into a smaller area of water due to the drought conditions.

5.1.5 Impacts of Current Project Operations on Habitat in High Rock

Fluctuating water levels have the greatest impact on habitat found in High Rock Reservoir. Impacts from the drawdown include exposing high quality habitat types such as wetlands, rock substrate, woody cover and docks. These high quality habitat types cannot be used by aquatic biota for up to 8 months a year due to the annual draw downs. Additionally, the sediment exposed during the drawdown is subject to erosion, desiccation and in the winter, freezing. These processes may reduce aquatic plant stands that would provide cover and food for various aquatic biota and increase sediment loading during large storm events (NAI 2005c).

For a complete summary of the findings from the High Rock habitat survey see section 4.2 of this report. Within the average 12 ft drawdown zone of High Rock Reservoir, poor quality mud and sand accounted for 79.1 % (4,7427 acres) of the total habitat. The remaining 20.9 % of habitat exposed at a 12 ft drawdown was classified as high quality and of this, four wetland habitat types accounted for 19.2 % (1,1523 acres). The wetland habitat types mapped included palustrine emergent (0.25%), flood plain forest (8.89 %), shrub-swamp (3.22 %) and sparse shrub-swamp (6.86 %). The remaining 101 acres (1.7%) of high quality habitat mapped in High Rock's drawdown zone included rock substrate (0.56 %) woody cover (0.63 %) and docks (0.50 %).

An additional 747 acres of wetland habitat types were mapped in the lower Yadkin River area that were not included in the 1,013 acres of wetlands reported above (see Section 4.3.1 and Figure 4-3). The lower Yadkin River section of the reservoir was above elevation 612 or the 12 ft drawdown mark (full pool is el. 624) and because of incomplete bathymetry in some areas, this reach was treated separately. This section of the reservoir is mostly riverine in nature, and unlike most of the main body and tributary arms of High Rock Reservoir, the effects of the planned 17 ft drawdown during the winter of 2004 were minimal. The majority of this area remained at or near full bank during the drawdown. A narrow bend in the river upstream of the I-85 Bridge coupled with a rapid rise in bottom elevations in this area act as a hydraulic control. During periods of high inflow, this hydraulic control helps maintain the river at or near full bank even during periods of low water in the reservoir. Inflow to High Rock Reservoir during the planned drawdown period was approximately 4,000 cfs and this was enough to keep water elevations within 2 ft of full bank in this reach.

Wetland habitat types mapped in the drawdown zone of High Rock reservoir (not including the lower Yadkin River area mentioned above) are the dominant high quality habitat type, making up 92% of the high quality habitat present. The vast majority of these wetland habitats are located within the upper six ft of the reservoir and in most areas of High Rock (excluding the upper reservoir area) they are unavailable to aquatic biota for approximately 8 months a year. Flood plain forest represents 46% (533.1 acres) of the wetlands mapped in High Rocks drawdown zone, but it should be noted that this habitat type is typically only flooded during high water events. Most of the flood plain forest habitat type is found in the upper reservoir, especially on the shallow delta areas located in the upper Main Reservoir area and in the upper regions of the major tributary arms.

The most extensive areas of wetland habitats found in High Rock are located in the lower Yadkin River and confluence area (747 acres), where the Yadkin River enters the reservoir and the upper Main Reservoir section (627 acres), located just downstream (see Sections 4.3.1 & 4.3.2). The lower Yadkin River and confluence area is very important to the aquatic biota in High Rock because it resists dewatering when inflows are low, even when the reservoir water levels are below full pond.

5.1.6 Impacts of Current Project Operation on Aquatic Biota in High Rock

A major impact to the existing fish community and aquatic habitats from Project operations on High Rock Reservoir are fluctuations in water level. Because High Rock is operated as a store-and-release reservoir, seasonal fluctuations are greater there than in the other three reservoirs. Water levels in the reservoir are highest during the spring season and decline as summer progresses. During the 18-year period (1986-2003), High Rock reservoir reached its maximum mean water surface elevation during the first week of May (Figure 4.2-1). After peaking during early May, the mean daily elevation value decreases as the late spring and summer progress. Daily fluctuations in water elevations can also impact aquatic biota in High Rock Reservoir but the impacts are minor compared to seasonal drawdowns. Daily fluctuations in High Rock are usually less than one foot with maximum daily values of one to four feet. However, daily fluctuations during the spawning season (April and May) are rare because the reservoir is being refilled at this time.

Table 5-5 presents the spawning times for fish species found within the four Yadkin reservoirs and shows that many of the management species identified by NCWRC, such as largemouth bass, black and white crappies, sunfish species (bluegill, pumpkinseed, redbreast, redear) begin spawning during April and May. The key for these species and other shallow water spawners is to have the reservoir stable during their spawning season so the fish eggs do not become dewatered. Many fish species probably begin

Table 5-5. Spawning times for fish species found in Falls, Narrows, Tuckertown and Highrock Resevoirs (From Menhinick, 1991) * Species captured by CP&L sampling in 2000

Common Name	J	F	M	A	M	JN	JL	A	S	O	N	D	Range	Temperature	Substrate
Longnose gar													3Apr-4May		shallow, heavy vegetation
Bowfin													2Mar-4May	16-19 °C	
Gizzard shad													1May-2Jun		shallow water
Threadfin shad													Apr-Sep	21 °C	shallow shorelines, bolders,logs debris
Blueback herring													Mar		
Alewife *													Mar		
Common carp													Mar-Jun		shallow,submerged vegetation
Goldfish													Mar-May		submerged vegetation
Golden shiner													4Apr-1Aug	68-80F	submerged vegetation
Bluehead chub *													Apr-Jun		
Eastern silvery minnow													Mar-May		
Satinfin shiner													3Apr-1Jul		
Spottail shiner													4Apr-4May		
Spotted sucker													2Apr-3May	12.2-19.4 °C	shallow gravel shoals
White sucker													2Mar-4Apr	10 °C	gravel areas
Quillback													4Apr-3May		
Creek chubsucker													Mar-1May	17-18 °C	gravel substrate, slow water
Smallmouth buffalo													1Mar-2Jun	15-16 °C	1-6m submerged vegetation
Silver redhorse													Mar-1Apr	14-15 °C	gravel shoal areas
Shorthead redhorse													2Apr-2May	14 °C	gravel shoals (15-21cm)
Flathead catfish													Jun-2Jul		spawning shelters
Blue catfish													Apr-May		
Channel catfish													4May-1Jul	22-30 °C	spawning shelters
Yellow bullhead													Apr-2May		
Flat bullhead													Jun-Jul	21-24 °C	
Snail bullhead													4Mar-1Jun		
White catfish													3May-3Jun		
Black bullhead *													2Apr-2Jun		gravel substrate
Brown bullhead *													Apr-1May	21 °C	
Eastern mosquitofish *													Apr-Aug		
White perch													1Mar-2Apr		
Striped bass													3Mar-4Apr	15 °C	mid-water, eggs must stay suspended
White bass													Mar-4Apr		mid-water- demersal eggs
Redbreast sunfish													4Apr-Jun		nests in sandy substrate

(continued)

Table 5-5. (Continued)

Common Name	J	F	M	A	M	JN	JL	A	S	O	N	D	Range	Temperature	Substrate
Warmouth													2May-Aug		shallow, silty debris near cover
Green sunfish													1May-Aug		sunny areas near cover
Bluegill													1May-Oct		shallow gravel substrate
Pumpkinseed													1May-Oct		shallow water, less the 1m
Redear sunfish													May-Aug		shallow water
Largemouth bass													1May-Jun		firm substrate along shallow edges
Smallmouth bass													Apr-1Jun	15-18 ^{o}C	coarse gravel, less then 1m
White crappie													1Apr-1Jun		shallow protected areas near brush
Black crappie													1Apr-1Jun		shallow protected areas near brush
Yellow perch													2Feb-Mar		vegetation, brush, sand and gravel
Tesselated darter													Mar-May		
Johnny darter *													1Apr-2May		clear areas under submerged objects

spawning at lower water surface elevations in years when the reservoir is not filled on time, and in most cases, this will not negatively impact spawning success. However, if the water becomes too deep during the spawning process, centrarchids (sunfish and bass) have been known to abandon their nests.

To minimize impacts to the spawning populations of High Rock Reservoir, it is beneficial to have water levels raised to their maximum level by late March or early April. This will allow fish species requiring shallow areas in the vicinity of natural covers access to the wetland habitats that are responsible for 91% of the high quality habitat within the current drawdown zone. The majority of this wetland habitat is flood plain forest and sparse shrub-swamp habitats that are located near the full pond water line. In order for these habitats to be of use to the fish community for spawning and subsequent protection for young-of-year fish, water levels in High Rock should be brought to full pool by early April and maintained at a stable level into the summer months. This type of reservoir management is important for several of the game fish species such as largemouth bass, crappie and sunfishes (bluegill, redear, and redbreast). These species require shallow areas of water near brushy cover to spawn.

Gizzard and threadfin shad, which form a large percentage of the fish community and the primary forage base in High Rock, also rely on stable, shallow water to successfully spawn. Threadfin shad will gather in spawning groups in areas of shallow water along the shoreline where they deposit adhesive, demersal eggs on the bottom substrate, rocks and logs. Gizzard shad also require shallow water for group spawning. Water levels in High Rock Reservoir need to be brought to full pond for early spring in order to flood the quality habitat that is present.

The impacts of seasonal reservoir hydrology and water level manipulation on the recruitment and success of two important game fish, largemouth bass and crappie, have been well studied. When managing for largemouth bass, year class strength has shown to be enhanced by the spring flooding of the littoral zone (Miranda et al. 1984; Fisher and Zale 1992; Reinert et al. 1997). However, while spring flooding does enhance year class strength, largemouth bass year class strength in Normandy Reservoir (Tennessee) was not fixed until late in the season and was dependent upon how much water was in the system throughout the summer (Sammons and Bettoli 2000). Lower water levels during the summer months led to decreased survival and abundance of young-of-year largemouth bass (Reinert et al. 1997; Sammons et al. 1999). Lower water levels reduce the shoreline cover available to age-0 largemouth bass, increasing predation and decreasing feeding efficiency. Reduced habitat at low water levels has been shown to limit carrying capacity for age-0 bass (Irwin et al. 1997). In Jordan Lake (North Carolina), good year class success was not linked to high mean water or inversely linked to low mean water, but it was found that seasons with high instability of water levels during the spawning period yielded the poorest year classes of bass (Jackson and Noble 2000). Kohler et al. (1993) reported that extreme fluctuations in Illinois reservoirs were disruptive to largemouth bass spawning activities. While spawning behavior may be interrupted by short-term fluctuations in water level, hatching of young-of-year largemouth will continue as long as the eggs do not become dewatered (Phillips et al. 1995; Sammons et al. 1999). As initiation of spawning has been related to the first day at full pool (Normandy Reservoir, Tennessee), it is suggested that the best management strategy for largemouth bass is to reach full pool early in the spring and to maintain that level for ninety days (Sammons et al. 1999). This allows for increased growth, survival, year-class strength (Sammons et al. 1999) and for more harvestable sized bass in less time (Sammons and Bettoli 2000).

Water level manipulation also plays a role in the success of crappie spawning. Black and white crappie make use of brushy cover in the littoral zone for spawning. Successful crappie recruitment appears to be related to high inflows entering the reservoir just prior to the spring spawning season (Maceina and

Stimpert 1998; Sammons et al. 2000; Maceina 2003). It is suggested that crappie respond to these inflows with increased spawning activity as it may mimic the natural flooding that would ordinarily trigger these fish to spawn (Maceina and Stimpert 1998). Crappie recruitment was higher in tributary storage impoundments in Tennessee during years of high reservoir discharge in the pre-spawn period (Sammons et al. 2002). High rates of reservoir flushing during the late spring and early summer can negatively effect the survival of crappie fry (Pope et al. 1996; Maceina and Stimpert 1998). Crappie fry have been documented as moving from the littoral zone to the limnetic zone at a length of 50-60 mm (O'Brien et al. 1984). It is this occupation of the limnetic zone during the post larval stages that could lead to mortality as fish are pushed out of the reservoir during periods of high water flow (Beam 1983). In addition to being removed from the system, high flow increases turbidity and decreases zooplankton, limiting the food availability and feeding efficiency of the larval fish (O'Brien 1984). While the exact mechanism driving the relationship between high winter flows and recruitment in crappie is still unclear (Sammons et al. 2002), manipulating and raising water levels both before and during the spawning season can increase crappie production along with that of other littoral spawners (Maceina 2003). Management for largemouth bass and crappie can coincide with one another. Conditions that produce high discharge in the late winter, which are beneficial for crappie, usually lead to above average pool levels in the late spring and summer. Maintaining these pool levels throughout the late summer to increase the success of young-of-year bass will not have an effect on crappie fry as they have already moved off into the limnetic zone (Sammons and Bettoli 2000).

In addition to fish spawning, project operations also exert effects on the macroinvertebrate community of High Rock Reservoir. Aquatic insects are negatively impacted by the current drawdown regime that dewaters the littoral zone. In studies conducted on mainstem Missouri River impoundments, it was reported that aquatic macroinvertebrates took 40 days after inundation to re-colonize exposed substrate (Benson 1973).

The current game fish populations in High Rock depend on the large forage base provided by threadfin and gizzard shad. These two fish species combined make up nearly 50% of the fish captured in High Rock Reservoir and are doing well because they are taking advantage of the large standing crop of plankton produced in the reservoir (see Section 5.1.3 above). Predators such as largemouth bass, crappies, striped bass, catfish and other species depend on the large numbers of shad for food, especially since macroinvertebrate production is low due to the seasonal drawdowns.

Effects of Alternative Water Level Regimes on High Rock

One of the study objectives was to evaluate the effects of alternative water elevations on aquatic biota and habitat in High Rock Reservoir. The evaluation was conducted using several simplified water level regimes that were developed to encompass the range of operational alternatives that are being considered in the relicensing (Figure 5-1). The water level alternatives evaluated included:

- ***High Rock*** – three alternative water level regimes:
  - *Alternative 1 – Near-Full Year Round*; reservoir maintained within 3 feet of full pond year round;
  - *Alternative 2 – Extended Near Full Season*; a 10-foot average drawdown, similar to existing conditions but a longer full pond period, refilling in March rather than April and drawing down in November rather than mid-September;

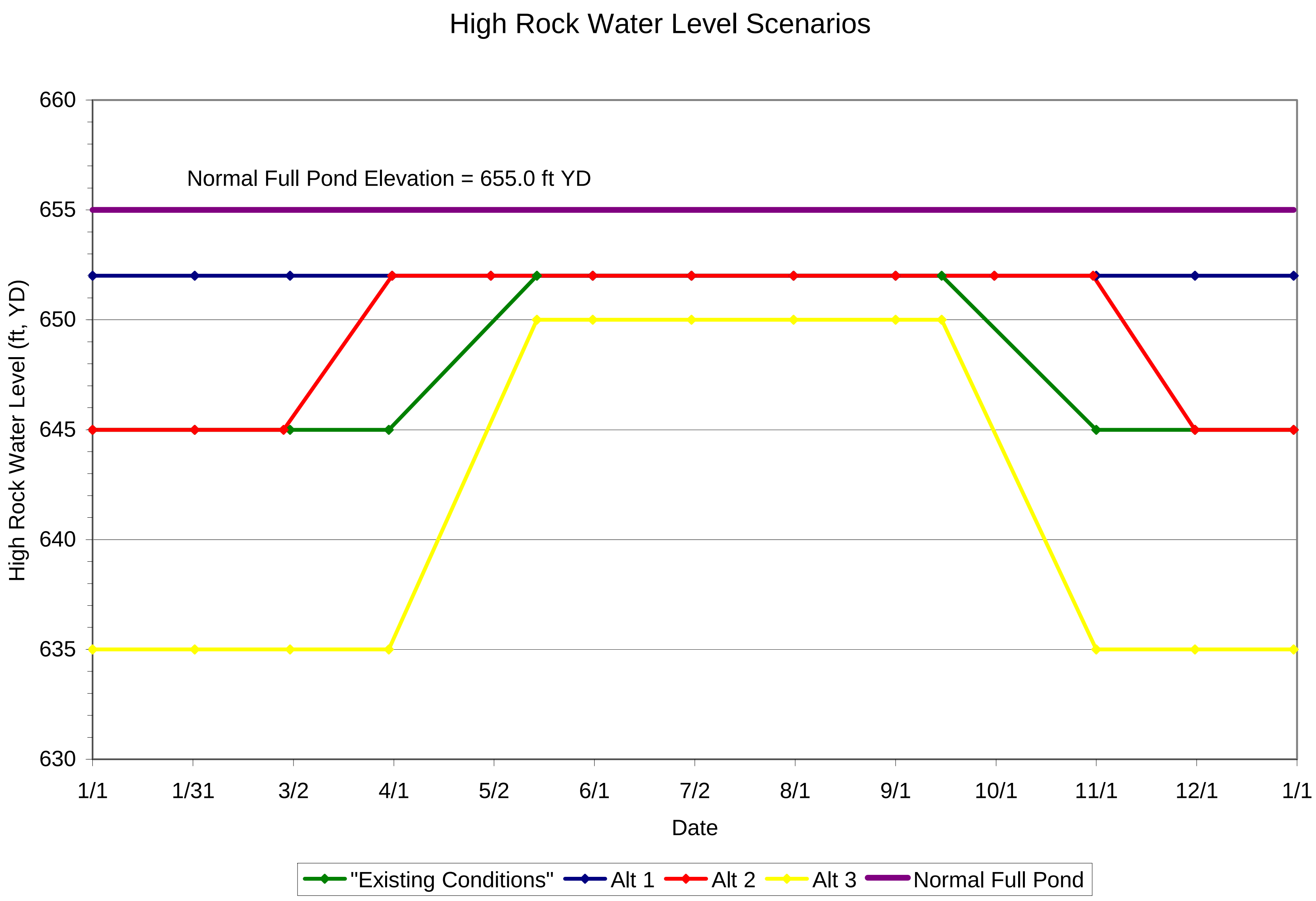

Figure 5-1. High Rock water level scenarios provided by APGI.

- *Alternative 3 – Additional Use of Storage*; drawing down 20 feet on average, with the same refill and drawdown schedule as existing, but refilling to within 5 feet of full pond (618.9 feet USGS, 650.0 feet Yadkin datum).

Alternative 1

A stable water level at near-full pond year round would give fish and other aquatic biota access to existing high quality habitat types such as wetlands, woody cover, docks and rock habitats found in the shallow, upper reaches of the tributary coves and along the reservoirs shoreline. It would also result in the development of emergent wetlands and aquatic beds that are rare under High Rocks current drawdown regime. These aquatic beds and emergent wetlands would provide cover and feeding opportunities for many species of fish and macroinvertebrates. The sunfish species such as bluegill, pumpkinseed, redbreast and redear would benefit from a relatively stable full pool situation. Other important forage and game fish species that would probably increase in abundance from a near-full pond scenario would be gizzard shad, threadfin shad and black and white crappies. Aquatic biota such as macroinvertebrates (aquatic insects) would benefit from a near- full pond scenario and would soon colonize the shallow littoral zone that they are currently excluded from most of the year due to the drawdowns. The aquatic insect populations that would colonize the littoral zone would provide a primary food source for many species of fish and other aquatic biota.

A near-full pool water elevation in High Rock year round may also have some negative effects on the existing fishery. The current drawdown regime has benefited the larger predators such as largemouth bass and striped bass by drawing the young fish out of their protective cover each fall and winter, making them more vulnerable to predation. This has kept some of the sunfish populations in check, preventing them from overpopulating the reservoir, which can result in stunted fish populations with fewer harvestable fish available. Under alternative 1, the current species composition would change, but it is difficult to predict the final outcome. For instance, it is not known if largemouth bass or striped bass would be negatively impacted by a near-full pond situation. Both predators depend on the large forage base provided by threadfin and gizzard shad and under alternative 1, these forage species would probably increase in abundance. This increase in these forage fish might offset the lost foraging opportunities that the current drawdown provides each fall and winter. Undesirable fish species, such as carp, that are detrimental to native fish populations (Etnier and Starnes 1993) would also benefit from a near-full pond scenario and could rapidly overpopulate the reservoir. Carp, already abundant in High Rock, would take advantage of the feeding and spawning opportunities provided by the predicted increase in aquatic vegetation, one of their preferred foods. They were ranked sixth in abundance in both electrofishing and gill net catches in the fisheries study conducted by CP&L in 2000 (Appendix 2, Table 2-1). Carp spawn during the spring in shallow water, laying their eggs amongst submerged vegetation. Since a large female can produce more than 2 million eggs per season, they could rapidly overpopulate the reservoir under ideal conditions.

As mentioned above, alternative 1 would result in the development of emergent wetlands and aquatic beds along much of the shoreline. However, it is also likely to have the adverse impact of eliminating much of the black willow that has colonized the delta area located in the upper reservoir region, downstream of the I-85 bridge (NAI 2005c – Section 10). Emergents such as water willow could colonize some of these areas, but the delta area is likely to be less stable and more subject to shifting sediment during large flood events.

Alternative 2

An extended near full pond that's refilled in March and drawn down an average of 10 ft in November would be an improvement for fish populations in High Rock when compared to existing project operations. Current operations begin refilling the reservoir in April and draw it down an average of 13.5 ft beginning in mid-September. Filling the reservoir in March will improve the spawning conditions for important management species such as largemouth bass and black and white crappies and many other fish that spawn in shallow water during April and May (see Section 5.1.6). Also, extending the full pond season until November will help increase the survival rates of young of the year fish. The smaller fish will have access to shoreline cover for a longer time period during the critical growing period, enabling most to grow to a larger size before the pond is drawn down. The larger size gives the fish a better chance to avoid the predators during the winter months. Although alternative 2 would improve survival of more young of the year fish compared to the current drawdown scenario, it would still provide the benefit of preventing certain fish species such as sunfish and carp from becoming severely overpopulated. The percent composition of the current fish populations in the lake would probably remain the same, because alternative 2 is similar to the current drawdown regime. Game fish such as black crappie, bluegill and largemouth bass would continue to dominate the catches, because they have done well under the current drawdown regime. Gizzard and threadfin shad, the primary forage fishes in the reservoir, would also continue to do well under alternative 2, given their high abundance under the current drawdown regime.

The shorter winter drawdown proposed for alternative 2 would likely enhance emergent wetland development around High Rock, with water willow potentially becoming the dominate species. Water willow is able to tolerate the fluctuating water levels on Narrows and may be able to persist in some areas during a winter drawdown in High Rock. Black willow beds in the delta region of upper High Rock may decline somewhat, however, they would probably persist given that periodic exposure to inundation during the growing season occurs now under the current drawdown regime.

Alternative 3

This alternative would be the most detrimental to fish and aquatic biota in High Rock Reservoir. Refilling the lake to within 5 ft of full pond keeps most of the high quality habitat found along the shoreline exposed because most of the existing wetland habitat is located within the upper 5 to 6 ft. Refilling the reservoir beginning in April would mean that in some years water elevations would not be high enough for spawning fish and their young to take advantage of the existing wetland habitats found along the upper shoreline. Additionally, drawing the reservoir down 20 ft each fall would bring water levels down to where they were during the severe drought of 2002. Although hard to quantify, this severe a drawdown would cause higher mortalities among young fish compared to the existing drawdown. This alternative would also be most detrimental to the existing wetlands around High Rock. The black willow stands on the delta area would probably thrive and expand; however, many of the remnant in-pond wetlands around the periphery of the reservoir would be less stable. The combination of a long winter drawdown, a lower average water level and periodic full pond levels would create a difficult environment for emergent wetlands to persist or colonize. Woody species such as black willow and button bush might be able to tolerate the extreme conditions and expand around the shoreline, but their potential as fish habitat would be limited by the lower average drawdown level, and in wet years, the higher water levels could result in considerable dieback of these woody species.

5.2 NARROWS RESERVOIR

5.2.1 Impacts of Project Operations on Aquatic Biota and Habitat in Narrows

Fluctuations in water elevations have the greatest impacts to aquatic biota and habitat in Narrows Reservoir. Since the average annual drawdown in Narrows is currently 2 to 3 ft compared to 13.5 ft in High Rock, the impacts are not as severe. For instance, the current drawdown in Narrows has allowed the growth and persistence of extensive water willow beds in the reservoir, whereas this wetland habitat type is rare in High Rock due to the greater drawdown and because it extends through the winter. Another impact of Project operations on aquatic biota in Narrows is the quality of the water discharged from Tuckertown Reservoir into Narrows. The low dissolved oxygen concentrations that are drawn from Tuckertown Reservoir via the turbines during the warm months of the year negatively impact aquatic biota in Narrows (NAI 2005a; NAI 2005b). Before analyzing the impacts of operations on aquatic biota and habitat, this section first presents data on Narrows current hydrologic regime, water quality and fish populations.

5.2.2 Existing Hydrologic Regime in Narrows

Narrows Reservoir (Badin Lake) is the deepest of the four project impoundments and the second largest reservoir in the Project area, covering 5,355 acres at full pool. The reservoir is broad and can be divided into two large basins, each with numerous coves and flooded tributary mouths. Narrows receives most of its flow from Tuckertown Reservoir and average residence time in the reservoir is estimated at 2.1 days. Maximum depth is 175 ft near the dam and mean depth is 45 ft, which is more than double that of the other three reservoirs. With its deeper water, Narrows is the only Project reservoir where a true hypolimnion develops (>4ºC difference between surface and bottom waters). The Narrows Development is usually operated as a run-of-river facility, but it does have available storage to augment required minimum downstream releases in low flow periods. Normal daily fluctuation in water surface elevation due to operations is less than 1 ft with a daily maximum fluctuation of 1 to 2 ft (Yadkin 2002). The maximum average annual drawdown is approximately 3 ft.

The Narrows reservoir showed a greater degree of seasonal change compared to the Tuckertown and Falls reservoirs, but less than that observed in the High Rock reservoir (Figure 4.4-2). Late winter and late summer minima occurred, with the reservoir being fullest from early spring through early summer.

5.2.3 Water Quality in Narrows

Water quality in Narrows is considered good; it has greater water clarity and lower concentrations of suspended solids, nutrients and algal biomass than the two upstream reservoirs and better surface dissolved oxygen conditions than Falls Reservoir which lies downstream (NAI 2005b). The surface waters are less turbid than the upstream reservoirs, but the photic zone is still relatively shallow, with averages ranging from 2.4 to 3.4 meters. Nutrient concentrations in Narrows are lower than in High Rock and Tuckertown Reservoirs, but at times they are still at levels that can produce nuisance algal blooms. However, such blooms are likely to occur at a lower frequency in Narrows than in the two upstream reservoirs. NCDWQ (1998) classified Narrows Reservoir as eutrophic/mesotrophic and determined that it supports intended uses.

Unlike the upstream reservoirs, Narrows Reservoir exhibits strong thermal stratification beginning in May and persisting until December or January. Dissolved oxygen concentrations in the upper four or five meters are usually greater than 5 mg/l; below five meters, dissolved oxygen concentrations <5 mg/l persist from June through September. Complete mixing of the reservoir usually occurs in December or January and dissolved oxygen concentrations are similar throughout the water column until stratification returns in late spring. Low dissolved oxygen concentrations less than 5.0 mg/l were frequently observed from June through October in the Tuckertown tailwater (upper section of Narrows Reservoir) and periodically in May and November from the discharge of water with low dissolved oxygen concentration from Tuckertown Reservoir (NAI 2005b) .

5.2.4 Existing Management and Fisheries Data for Narrows

Narrows reservoir is currently maintained by the NCWRC as a warm water fishery. Largemouth bass and both crappie species are managed with both size and creel limits. Narrows Reservoir is also known for its fishery for large catfish, especially blue catfish. A state record, 83-pound blue catfish was caught in Narrows Reservoir during May of 2003. Blue catfish do not currently receive game status from NCWRC but future management plans for the species may be investigated due to the popularity of this fishery. Table 5-3 shows the historic stocking records for Narrows Reservoir by the NCWRC. Striped bass are currently stocked into Narrows at a rate of 11.6 fish per acre, or about 62,000 fingerlings per year.

A summary of past studies in Narrows Reservoir (Table 5-2) indicates that the reservoir is supporting at least 43 species of game and non-game fish species, representing all trophic levels. Table 5-4 shows the historic sampling efforts of the NCWRC within three of the four project reservoirs. The 2000 CP&L study documented thirty-five species and two hybrids within the reservoir. Appendix 2 (Table 2-7) shows the percent compositions and CPUE's for each of those species, by gear type. Bluegill, gizzard shad, threadfin shad, yellow perch and largemouth bass comprised the five most abundant species captured by electrofishing. White perch, striped bass, gizzard shad, channel catfish, and white catfish were the five species most commonly captured in gill nets. Bluegill and gizzard shad had the highest CPUE's for electrofishing whereas white perch and striped bass had the highest gillnet CPUE. NAI sampled in the Tuckertown tailwater (upper reach of Narrows Reservoir) during 2003-2004 and catches during this effort were similar to the 2000 CP&L study. Bluegill and gizzard shad had the highest electofishing CPUE and white perch and channel catfish dominated the gill net catches (NAI 2005a). CP&L conducted age and growth analysis on 225 striped bass and 41 white bass captured within Narrows Reservoir in 2000. The results of this analysis can be found in Appendix 2 (Tables 2-8 & 2-9). Striped bass from this sample ranged in age from 1 to 6 years, while white bass ages ranged from 1 to 3 years. In some years, summertime dissolved oxygen levels have dropped low enough to cause significant kills of striped bass in Narrows Reservoir (NCWRC 2004).

The NCWRC examined the health and status of the black crappie population in Narrows Reservoir during the fall of 2000 (Dorsey 2000b). A total of 151 black crappie were captured by trapnet and examined, and of these, 93% were greater then the 203 mm minimum size limit. The average relative weight for black crappie was 97 and the mean total length was 261 mm. Ages of captured fish ranged from 0 to 7 years, with 90% of fish being age-2 or younger. Crappie in Narrows Reservoir reached harvestable size in 1.5 years. Previous NCWRC studies, along with this one, have documented a crappie population in Narrows Reservoir made up of a small number of fast-growing fish. Without identifying a mechanism to increase overall population density, it is doubtful that angler catch rates will increase on Narrows Reservoir (Dorsey 2000b). A follow up survey to assess population characteristics in the Narrows Reservoir crappie populations was conducted in 2003 (Nelson & Dorsey 2005). A total of 252 black crappies and 30 white crappies were captured by trapnet and examined. Minimal differences between the 2000 and 2003 crappie populations were observed. The percentage of fish greater than the 203 mm minimum size limit was lower in 2003 (80%) than during 2000 (93%). The average relative weight score for black crappie increased to 98 while the mean total length decreased slightly to 243 mm. Similar to 2000 findings, length at age calculations for Narrows Reservoir black crappie indicate that fish within this population are reaching harvestable size in 1 to 1.5 years. NAI conducted fish surveys in the project tailwaters in 2003-2004 and the results of this effort can be found in the tailwater fish report (NAI 2005a). The average relative weight of black crappie collected in the Tuckertown tailwater (upper segment of Narrows Reservoir) during this study was 93, slightly lower than the ideal range of 95 to 105 reported for this fish.

Largemouth bass were examined during spring of 2001 by the NCWRC (Dorsey 2002). Proportional stock density (PSD) values for bass captured by electrofishing during this study was 80, exceeding the species ideal range of 40 to 70. This indicates that some of the large quality bass are experiencing low mortality and this is probably due to catch and release fishing practices. The mean relative weight score of these bass was 91, slightly lower than the recommended range of 95 to 100. During the Tuckertown tailwater fish survey in 2003-2004, largemouth bass PSD values averaged 84 across three seasons and average relative weight for the same group of fish was 101, exceeding the ideal range for both values, indicating the bass were in very good condition (NAI 2005a). Twelve percent of 60 largemouth bass captured in Narrows in 2001 that were sent to a USFWS testing center tested positive for Largemouth Bass Virus. Largemouth bass virus typically affects adult fish and causes them to lose their equilibrium and float at the water surface. First detected in Florida, the disease has been documented in several bodies of water throughout the eastern United States. Although fish kills have occurred in some of the infected populations of largemouth bass, there have been no documented changes in the total numbers of fish after die-offs associated with largemouth bass virus. Additionally, this virus has also been found in populations of largemouth bass and other species while showing no overt signs of the disease (Grizzle and Brunner 2003).

5.2.5 Impacts of Current Project Operations on Habitat in Narrows

Fluctuating water levels have the greatest impact on aquatic habitat in Narrows Reservoir by dewatering high quality habitat types that cannot be used by aquatic biota at certain times of the year. The current drawdown regime averages 2 to 3 ft and the impacts to habitat within this drawdown zone is discussed in detail in Section 4.4.2 and is summarized here. Within the average 2 ft drawdown or littoral zone (el. 510 to 508), the dominant habitat type is the low quality mud/sand substrate that covers 120.42 acres, or 62% of the littoral zone (see Table 4.4-2). Wetland cover is abundant in the littoral zone, with flood plain forest being the dominant type, covering nearly 29 acres, or 14.8% of the littoral zone. Palustrine emergent wetlands (mainly water willow) are the second most abundant type, covering 25.5 acres (13%) of the littoral zone. An additional 92 acres of palustrine emergent wetlands was added during the ground-truthing process after the aerial photographs were analyzed. Because this wetland habitat data was not available for the ArcView cover maps, the percentage of that acreage present in the littoral zone or the amount that exists below this contour level could not be accurately calculated (see Section 4.4). However, some of the 92 acres not included in the ArcView maps does exist within the littoral zone, so the amount of water willow habitat type reported above is under estimated. Nearly all the water willow beds are within 5 to 6 ft of full pond. High quality rock habitat exposed in the littoral zone included boulder (2.1 acres: 1.1%), cobble (1.9 acres; 1%), riprap (0.9 acres; 0.5%), ledge (0.83 acres; 0.4 %) and gravel (0.18 acres; 0.1 %) Medium branched trees (1.7 acres; 0.9%) and heavy branched trees (1.6 acres; 0.8 %) are the two dominant forms of woody cover. Small amounts of brush, Christmas trees, and no branched trees were found and mapped within the littoral zone. Docks covered an additional 2.19 acres of the littoral zone, accounting for 1.13 % of the habitat present there.

A two foot change in water surface elevation in Narrows Reservoir will dewater the littoral zone and reduce the water surface acreage from a full pond value of 5,887.3 acres to 5,695.2 acres, a loss of 192.4 acres or 3.3 % (Table 4.4-3).

5.2.6 Impacts of Current Project Operations on Aquatic Biota in Narrows

Although currently not as severe as High Rock Reservoir, the degree of seasonal change in water levels is greater in Narrows Reservoir than in either Falls or Tuckertown. Management for important game species in Narrows Reservoir is similar to that for High Rock. Largemouth bass, crappie and other shallow water spawners require water levels to be at or near full pool by early spring and to be held there into the early summer. As described in the current literature (see section 5.1.6 for summary) crappie respond to inflow of water into the reservoir as a trigger to commence spawning. Water levels reaching and maintaining a full pond level are beneficial to many of the centrarchids who require flooded quality habitat to spawn and whose young rely on the same flooded habitat for cover and food. Figure 4.4-2 displays the minimum, mean and maximum daily water surface elevations in Narrows for the period of January 1, 1986 to December 31, 2003. On average, reservoir levels were highest in late March through April and then declined to a September low. This early spring refill in late March benefited the shallow water spawners such as largemouth bass, crappies and sunfish species. The early refill probably benefited the gizzard shad and threadfin shad as well, because these fish also rely on shallow areas being watered up early in the spring. Refill generally occurred through the fall and winter, with reservoir maxima at full pool almost continuously from mid-January through early May, and this provided young fish with ample cover, increasing their chances to survive the winter. The lowest water levels observed during the period of record occurred between July and September 2002 during the severe drought. Narrows was drawn down nearly 10 ft during the drought, but this was an unusual event. In most years, fish and aquatic biota had access to the water willow beds and other cover available along the lakes shoreline.

The emergent wetlands on Narrows are more extensive but lower in species diversity than those found on Tuckertown. Water willow formed the vast majority of the emergent community, with other species being low in number and distribution. Aquatic beds were abundant in the four small ponds west of the railroad bed on the west side of Narrows. These areas are connected to the main reservoir and fluctuate with the reservoir, but the aquatics appear able to persist in the dry years and expand in wet years. Current Project operations such as a smaller drawdown compared to High Rock and no winter drawdown period have allowed these important wetland areas to persist. Water willow is an important wetland cover type for fish and other aquatic biota and a recent study identified 17 fish species that use emergent wetlands in the course of the year, more than any other shallow water habitat type (Touchette et al. 2001). This wetland habitat type provides spawning habitat for many fish species (crappies, sunfish, etc.), nursery habitat for young, cover for small resident species and foraging opportunities for larger predators.

Daily fluctuations in water elevations can also impact aquatic biota in Narrows Reservoir but the impacts are minor compared to seasonal drawdowns. Daily fluctuations in Narrows are usually less than one foot with maximum daily values of one to two feet. However, daily fluctuations during the spawning season (April and May) are rare because the reservoir is being refilled at this time. For a review of the impacts of low dissolved oxygen concentrations on aquatic biota, see Section 7.0 of the NAI Tailwater Fish and Aquatic Biota Assessment (NAI 2005a). In the Tuckertown tailwater (Narrows Reservoir), in 2004, an average water year, average daily dissolved oxygen concentrations were below 5 mg/l on 75 days.

5.2.7 Effects of Alternative Water Level Regimes on Aquatic Biota in Narrows

One of the study objectives was to evaluate the effects of alternative water elevations on aquatic biota in Narrows Reservoir. At Narrows, the alternative water level regime being looked at includes winter drawdowns that may increase to 15 ft, and summer fluctuations that may become more routine and deeper (5 to 10 ft), compared to the present 2 to 3 ft fluctuations.

Implementing a drawdown regime in Narrows Reservoir similar to that in High Rock would negatively influence the available high quality wetland habitat types. A 14-foot drawdown would expose 1,392 acres of wetland and other habitat types (see section 4.4.3 for full details). Of that acreage, a total of 173 acres are palustrine emergent habitat comprised mainly of water willow and it would also expose the additional 92 acres of water willow that was found during the ground-truthing field trip that was not included in the ArcView maps (see section 4.4). This perennial aquatic plant would be exposed to freezing and desiccation during the winter which would reduce the acreage of this habitat type in Narrows Reservoir. For a full report on the status of water willow in Narrows Reservoir see the Draft Wetland and Riparian Habitat Assessment (NAI 2005c). Summer fluctuations of 5 to 10 ft may also negatively impact aquatic biota by limiting the ability of fish to use the emergent wetlands. Currently, water levels remain within 2 ft of full pool, and thus continue to inundate the lower portion of the water willow beds. If water levels drop below approximately 5 ft in Narrows, most of the water willow observed in 2004 would be unavailable to fish and other aquatic biota such as macroinvertebrates. Although water willow is clearly tolerant of the current summer water level fluctuations, the combination of a winter drawdown and greater summer fluctuations could exceed this species tolerance and result in a decline. Because fish and other aquatic biota depend on the habitat provided by water willow, they would likely decline in abundance along with the loss of water willow.

5.3 TUCKERTOWN RESERVOIR

5.3.1 Impacts of Project Operations on Aquatic Biota and Habitat in Tuckertown

Fluctuations in water elevations, although minor compared to the other three reservoirs, does have a limited impact on aquatic biota and habitat in Tuckertown Reservoir. The largest impact of Project operations on aquatic biota in Tuckertown is the quality of the water discharged from High Rock Reservoir. The low dissolved oxygen levels that are drawn from High Rock Reservoir via the turbines during the warm months of the year negatively impact aquatic life in Tuckertown Reservoir (see NAI 2005a; NAI 2005b). Before analyzing the impacts of operations on aquatic biota and habitat, this section first presents data on Tuckertown Reservoirs current hydrologic regime, water quality and fish populations.

5.3.2 Hydrologic Regime in Tuckertown

Tuckertown Reservoir covers 2,560 acres at full pool with a maximum and mean depth of 55 ft and 16 ft, respectively. The Tuckertown Reservoir is narrow relative to either High Rock or Narrows Reservoirs, and is mainly an enlargement of the old river channel with only two small tributary arms. The Tuckertown Development is operated as a run-of-river facility and average residence time in the reservoir is estimated at 21.8 hours. Normal daily fluctuation in water surface elevation due to operations is less than 1 ft, with a daily maximum fluctuation of 1 to 3 ft (Yadkin ICD 2002). Annual drawdown is limited to 3 ft by the Yadkin FERC license, and has averaged 2 ft historically.

Daily elevations in the Tuckertown reservoir exhibited a less distinct seasonality compared to the High Rock reservoir (Figure 4.3-2), although minimum elevations on the monthly, weekly, and daily time scales also occurred during July. Overall, elevations within the Tuckertown reservoir were the most stable and exhibited the smallest range of variation of each of the four reservoirs, on all time scales except for the daily range.

5.3.3 Water Quality in Tuckertown

Water quality in Tuckertown Reservoir is generally considered fair and is similar to the water quality found in the lower portion of High Rock Reservoir, which provides almost all of its flow (NAI 2005b). The short residence time (~22 hours) does not allow sufficient time for biological and physical processes to change water quality appreciably. In general, it is a relatively turbid reservoir with a shallow photic zone. As observed in High Rock, nutrient concentrations are at levels that can promote nuisance algae blooms and algal biomass remains at high levels. Although the suspended solids concentrations are much lower than High Rock Reservoir, they are still greater than levels typically seen in reservoirs (Wetzel 2001). Water transparency is low, and the reservoir exhibits only weak stratification near the dam in the summer. Dissolved oxygen depletion in deeper water typically extends from May through October or November, but anoxic conditions are usually limited to the summer months and depths below 5 meters. Dissolved oxygen in the upper five meters of the water column varied considerably among the sampling years. Low dissolved oxygen concentrations (<5mg/l) at the surface were observed during the summer and occasionally in early fall in 1999, 2000, 2001 and briefly in October 2002 (NAI 2005b). However, in 2003 low dissolved oxygen levels were not observed in the upper 5 meters and bottom dissolved oxygen levels remained above 3 mg/l throughout the year, and this was attributed to the high flows experienced in 2003. Low dissolved oxygen levels in the High Rock tailwater (upper section of Tuckertown Reservoir) are common during the warm months. In 2004, an average water year, average daily dissolved oxygen concentrations were below 5 mg/l on 107 days in the High Rock tailwater, the upper end of the Tuckertown impoundment (see NAI 2005b, Table 2.4-3). NCDWQ classified Tuckertown Reservoir as eutrophic and determined that it supports designated uses (NCDWQ 1998).

5.3.4 Existing Management and Fisheries Data for Tuckertown

The NCWRC currently manages Tuckertown reservoir as a warm water fishery. Largemouth bass and black crappie are managed by size and creel limits on anglers. Table 5-3 shows the historic stocking records for Tuckertown Reservoir. Currently, striped bass fingerlings are stocked into Tuckertown at a rate of 5 per acre or about 13,000 fish per year. The striped bass fishery within Tuckertown Reservoir has not done as well as it has in High Rock and Narrows Reservoirs and the reason is not known.

A summary of past studies (Table 5-2) indicates that the reservoir is supporting at least 42 species of game and non-game fish species, representing all trophic levels. Table 5-4 shows the historic sampling efforts of the NCWRC within three of the four project reservoirs. A comprehensive fish study was conducted on Tuckertown Reservoir by CP&L in 2000 and 36 species and one hybrid were captured within the reservoir by electrofishing and gillnetting. Appendix 2 (Table 2-4) shows the percent composition and CPUE for each fish species captured, by gear type. Bluegill, threadfin shad, gizzard shad, largemouth bass and common carp comprised the five most abundant species captured by electrofishing. Threadfin shad, white perch, channel catfish, black crappie and gizzard shad were the five species most commonly captured in gill nets. Bluegill and threadfin shad had the highest CPUE's for electrofishing whereas threadfin shad and white perch had the highest gillnet CPUE. NAI sampled for fish in the High Rock tailwater (Tuckertown Reservoir) seasonally during 2003-2004 and the composition of the catches were similar to the CP&L study (NAI 2005a). Bluegill, gizzard shad, largemouth bass, and common carp dominated the electrofishing catches during the 2003-2004 tailwater fish study and in gill nets, white perch, channel catfish, and gizzard shad were the dominant fish.

CP&L conducted age and growth analysis on 85 striped bass and 19 white bass captured within Tuckertown Reservoir in 2000. The results of this analysis can be found in Appendix 2 (Tables 2-5 & 2-6). The striped bass and white bass captured in Tuckertown ranged in age from 1 to 5 years.

The NCWRC examined the health and status of crappie populations in Tuckertown Reservoir during the fall of 2001(Dorsey 2001b). A total of 222 black crappies and 124 white crappies were captured by trapnet and examined. Sixty-eight percent of black crappie and 71% of white crappie were less than the 203 mm minimum limit. Mean length at age values indicated that both species reached harvestable size by age two. The average relative weight for black crappie was 87 and for white crappie it was 82 and both values were lower than the ideal range of 95 to 105, indicating a problem securing enough food. Length frequencies show a high percentage of fish below the minimum harvestable length for both species, which may indicate a stunted population. The report suggested that the minimum size limit stay in place for now but if future studies show similar population characteristics that the size limit be lifted to reduce the number of small crappies and increase harvestable sized fish.

Black crappie captured in the High Rock tailwater (upper Tuckertown Reservoir) during the recent tailwater fish study conducted by NAI in 2003-2004 exhibited similar relative weights and length frequency distributions as the CP&L study (NAI 2005a). Average relative weight of black crappie across three seasons of sampling was 80, which is lower than the recommended range of 95 to 105 reported for this fish and lower than the relative weight of 87 calculated by NCWRC (Dorsey 2001b). It suggests the black crappies are having a problem securing enough food. Length frequency distribution of black crappies captured during the NAI tailwater fish study demonstrated that many of the fish collected were below the harvestable size, similar to the NCWRC results in 2001.

Largemouth bass were examined during spring of 2002 by the NCWRC (Dorsey 2002). Proportional stock density (PSD) and relative stock density (RSD) values for bass captured by electrofishing were 68 and 36, respectively; the PSD value exceeded the ideal range of 40 to 70 and the RSD value was on the high end of the ideal range of 10 to 40 reported in the literature. These values indicate that there are numerous large bass available and that they are experiencing low mortalities, suggestive of catch and release fishing practices. The mean relative weight score of these bass was 93, which is slightly lower than the ideal range of 95 to 100. Based on these three values, the largemouth bass population in Tuckertown Reservoir was in very good condition in 2002. Twenty-two percent of the 50 largemouth bass sent to a USFWS testing center, tested positive for Largemouth Bass Virus.

During the recent 2003-2004 High Rock tailwater fish study (upper Tuckertown Reservoir), largemouth bass average PSD and RSD values were 89 and 58, respectively, and both these values exceeded the ideal range reported for this fish (NAI 2005a). This means the larger sized, quality bass are experiencing low mortalities. Average relative weight for these same fish was 102 and this value exceeds the ideal range of 95 to 100. Based on these values, the condition of largemouth bass in Tuckertown during the 2003-2004 study was excellent.

5.3.5 Impacts of Current Project Operations on Habitat in Tuckertown

Project operations that have the greatest impact on habitat in Tuckertown Reservoir are the fluctuating water levels. The Tuckertown Development is operated as a run-of-river facility and normal daily fluctuation in water surface elevation due to operations is less than 1 ft, with a daily maximum fluctuation of 1 to 3 ft (Yadkin ICD 2002). Annual drawdown is limited to 3 ft by the Yadkin FERC license, and the annual drawdown has averaged 2 ft historically. Figure 4.3-2 shows the minimum, mean and maximum daily water elevations at Tuckertown between 1986 and 2003. Water elevations were relatively stable during most of the period of record, especially during the spring spawning period (April-May). There were instances when minimum daily water levels fell a couple of feet during the April and May period, and these instances could have impacted fish nesting in shallow water. Keeping the reservoir water levels stable during April and May will help improve spawning conditions. Overall, elevations within the Tuckertown reservoir were the most stable and exhibited the smallest range of variation of each of the four reservoirs, therefore impacts due to fluctuating water levels were minor compared to High Rock and Narrows Reservoirs.

Available high quality habitat mapped within Tuckertown's two foot drawdown zone and periodically exposed due to the fluctuating water levels consisted of 151.7 acres (83% wetland cover types, 17% quality substrates). For a detailed review of the habitat mapped in Tuckertown Reservoir, see Section 4.3 above. Wetland habitats comprised the majority of the quality habitat, accounting for over 85% of the 151.73 acres mapped (Table 4.3-2). Aquatic vegetation mapped by the NAI field biologists covered 71.46 acres and comprised 47.1% of the total habitat mapped. In addition, five major wetland habitat types were identified from aerial photographs and added into the GIS map after sufficient ground-truthing. Palustrine emergent vegetation, mainly water willow, covered 15.61 acres and comprised 13.05 % of the total habitat mapped. Flood plain forest, dominated by black willow trees, covered 19.8 acres and comprised 13.05 % of the total habitat. Lacustrine aquatic plant beds, comprised of floating and submerged aquatic plants covered 7.62 acres (5.02 % of total). Shrub-swamp (8.52 acres; 5.62 %) and sparse shrub-swamp (3.15 acres; 2.07 %) habitat types were also present in Tuckertown Reservoir. The total acreage covered by some wetland types may be underestimated. Due to a limited drawdown (2 ft) and low water clarity, areas of some wetland types (particularly palustrine emergent and lacustrine aquatic beds) may be more extensive than is visible from the surface.

High quality rock habitat found in the littoral zone included boulders, cobble, riprap and ledge and combined made-up 5.8 acres or 3.9% of the available high quality habitat. Woody cover was dominated by medium branched trees, which covered 16.4 acres, or 10.8 % of the total habitat mapped in the littoral zone. Stumps, no branched trees, brush and heavy branched trees combined for an additional 3.1 acres. In addition to natural cover types, a small number of docks covered 0.16 acres and accounted for 0.1 % of the total quality habitat that was mapped in Tuckertown Reservoir below elevation 564.2.

5.3.6 Impacts of Current Project Operations on Aquatic Biota in Tuckertown

Fluctuating water levels at Tuckertown Reservoir impact aquatic biota that occupy the littoral zone in the lake. Figure 4.3-2 displays the minimum, mean and maximum daily water surface elevations in Tuckertown Reservoir for the period of January 1, 1986 to December 31, 2003. Water elevations were relatively stable during most of the period of record, especially during the spring spawning period (April-May). However, there were instances when minimum daily water levels dropped a couple of feet during the April and May period, and these instances could have impacted fish nesting in shallow water. Keeping the reservoir water levels stable during April and May will help improve spawning conditions and it is more important to not have quick drops in water elevation after fish have laid their eggs. An increase in water elevation will not negatively impact fish as long as it's not more than several feet. See Section 5.1.6 for a complete review of the impacts of fluctuating water levels on fish and aquatic biota.

Overall, water elevations within the Tuckertown reservoir were the most stable and exhibited the smallest range of variation of each of the four reservoirs and therefore impacts due to fluctuating water levels were minor compared to High Rock and Narrows Reservoirs.

The largest impact of Project operations on aquatic biota in Tuckertown is the quality of the water coming out of High Rock Reservoir. The low dissolved oxygen levels that are drawn from High Rock Reservoir via the turbines during the warm months of the year negatively impact aquatic life in Tuckertown Reservoir (see NAI 2005a; NAI 2005b). For a review of the impacts of low dissolved oxygen levels on fish and aquatic biota, see Section 7.0 of Normandeau's Tailwater Fish and Aquatic Biota Assessment (NAI 2005a). In the High Rock tailwater (upper Tuckertown Reservoir) in 2004, which was an average water year, average daily dissolved oxygen concentrations were below 5 mg/l on 107 days. The short residence time (~22 hours) does not allow sufficient time for biological and physical processes to change water quality. Water coming in from High Rock is generally turbid and nutrient concentrations are at levels that can promote nuisance algae blooms and algal biomass remains at high levels. Although the suspended solids concentrations are much lower than High Rock Reservoir, they are still greater than levels typically seen in reservoirs (Wetzel 2001).

5.3.7 Effects of Alternative Water Level Regimes on Aquatic Biota in Tuckertown

Only one alternative is under evaluation for Tuckertown Reservoir and this involves increasing the short-term water level fluctuations to 3-5 ft compared to the current 1-2 ft. This alternative could negatively impact fish that spawn in shallow water (2-4 ft deep) during the spring, such as largemouth bass, crappies and sunfish species. Refer to Section 5.1.6 for a complete review of impacts to fish species caused by fluctuating water levels.

This alternative could have the effect of reducing the diversity and possibly the extent of emergent wetlands and aquatic beds found in Tuckertown, which are very important to the fish and other aquatic biota in the reservoir. Species diversity of the aquatic plants would be reduced because the zonation which currently exists within the emergent marsh would be disrupted. Although water willow would probably expand because it is tolerant of fluctuations, it would do so at the detriment of other species such as pickerelweed that cannot tolerate water fluctuations. Aquatic beds could also decline if the fluctuations were prolonged enough for them dehydrate. However, some reduction in the aquatic bed productivity and extent is to be expected, especially toward the upper limit of aquatic bed growth.

5.4 FALLS RESERVOIR

5.4.1 Impacts of Project Operations on Aquatic Biota and Habitat in Falls

Fluctuations in water elevations, although minor when compared to High Rock and Narrows Reservoirs, do have a limited impact on the aquatic biota of Falls Reservoir. The largest Project impact from operations on the Falls Reservoir aquatic biota is the quality of water discharged from Narrows Reservoir. The mid-water discharge from Narrows Reservoir includes cooler anoxic water that lowers temperature, pH and dissolved oxygen levels throughout Falls Reservoir (NAI 2005b). Before analyzing the impacts of operations on aquatic biota and habitat, this section first presents data on Falls Reservoirs current hydrologic regime, water quality, and fish populations.

5.4.2 Hydrologic Regime in Falls

Falls Reservoir is a small, narrow impoundment that covers 204 acres at full pool. The reservoir is located on the Yadkin River approximately one mile above its confluence with the Uhwarrie River, forming the Pee Dee River. Maximum depth is 52 ft and mean depth is 27 ft. Falls Reservoir has a comparatively straight, steep shoreline with only one moderately sized, flooded tributary arm. Daily water level fluctuations due to the run-of-river operation mode normally range 0-2 ft, with a maximum fluctuation up to 4 ft. No seasonal drawdowns occur due to limited storage capacity.

Although water levels in the Falls reservoir showed the highest degree of daily, weekly, and monthly variability (Table 5-1), overall there was no discernable seasonal pattern apparent in the long term daily records (Figure 4.5-2). Extreme low water events in March 1998, September 1993, and mid-October 1988 were the source of the most of the minimum values observed on each time scale examined.

5.4.3 Water Quality in Falls

Water quality in Falls Reservoir is characterized by the absence of stratification and the clearest water of the project reservoirs. It receives almost all of its inflow from Narrows Reservoir. The mid-water discharge from Narrows includes cooler anoxic water that lowers the temperature, pH, and dissolved oxygen levels throughout Falls Reservoir. Falls Reservoir has the lowest concentrations of solids, nutrients, and algal biomass of the four project reservoirs. Short residence time (estimated at 1.7 hours) along with the deep epilimnetic water (thought to have low algal biomass) discharged into the system from Narrows, combine to inhibit the development of significant algal production (NAI 2005b). Surface dissolved oxygen concentrations range from 3 to 11 mg/l with low dissolved oxygen conditions typically extending from the bottom to within a meter or two of the surface between June and October. Low dissolved oxygen conditions (<5 mg/l) have been occasionally observed at the surface, however, anoxic conditions have not been observed (NAI 2005b).

5.4.4 Existing Management and Fisheries Data for Falls

Falls Reservoir is actively managed by the NCWRC as a warm water fishery. Sport fish present include largemouth bass, crappie, catfishes, and striped bass. The NCWRC currently regulates several game species in Falls Reservoir through a combination of size and creel restrictions. Table 5-3 shows the historic stocking records from the NCWRC for the project reservoirs. Striped bass are not currently stocked in Falls Reservoir and individuals caught in the reservoir are most likely recruited from upstream.

A summary of past studies (Table 5-2) indicates that the reservoir is supporting at least 32 species of game and non-game fish species, representing all trophic levels. Prior to the 2003-2004 NAI study, the most recent comprehensive study conducted on Falls Reservoir, evaluating species composition, was performed by CP&L in 2000. Twenty-five species and one hybrid were captured within the reservoir by electrofishing and gillnetting. Appendix 2 (Table 2-10) shows the percent compositions and CPUE's for each of those species, by gear type. Bluegill, largemouth bass, redbreast sunfish, warmouth and white catfish comprised the five most abundant species captured by electrofishing. White perch, gizzard shad, blue catfish, channel catfish, and white catfish were the five species most commonly captured in gill nets.

Several of the dominant species captured by NAI in the Narrows tailwater (Falls Reservoir) by electrofishing (bluegill, largemouth bass, and redbreast sunfish) and gillnets (white perch, gizzard shad, blue catfish, and channel catfish) were the same as those recorded during the 2000 CP&L survey (NAI

2005a). Bluegill, largemouth bass and redbreast sunfish had the highest CPUE's for electrofishing whereas white perch and gizzard shad had the highest gillnet CPUE.

During the 2003-2004 Narrows tailwater fish study (upper Falls Reservoir) largemouth bass average PSD and RSD values were 88 and 60, respectively. Both of these values exceeded the ideal range reported for the species (NAI 2005a). Average relative weight for this species was 97, within the ideal range of 95 to 100 for this species. Based on the above values, the condition of largemouth bass in Falls reservoir during the 2003-2004 NAI study was excellent.

5.4.5 Impacts of Project Operation on Habitat in Falls

Project operations that have the greatest impact on habitat in Falls Reservoir are the fluctuating water levels. Similar to Tuckertown, Falls Development is operated as a run-of-the river facility. Falls Reservoir is operated with a normal daily fluctuation of 0 to 2 feet and a maximum daily fluctuation of 3 to 4 feet (Yadkin ICD 2002). Figure 4.5-2 shows the minimum, mean and maximum daily water elevations at Falls between 1986 and 2003. Water elevations were relatively stable during the period of record, particularly during the spring spawning period (April and May). There were instances where the mean daily water elevation dropped and this could impact fish nesting in shallow water habitats within Falls Reservoir.

Available high quality habitat mapped within the two foot drawdown zone at Falls Reservoir totaled 5.75 acres (65 % wetland cover types, 35 % quality substrates). This high quality habitat is periodically exposed due to fluctuating water levels. For a detailed review of the habitat mapped in Falls Reservoir, see Section 4.5 above. Aquatic vegetation mapped by NAI field biologists during the field study covered 1.49 acres and accounted for nearly 26 % of the habitat mapped. In addition, three major wetland habitat types were identified from aerial photographs and added into the GIS map after sufficient ground-truthing. Palustrine emergent vegetation, mainly water willow, covered 1.99 acres and comprised 34.66 % of the total habitat mapped. Shrub-swamp (0.17 acres; 2.87 %) and flood plain forest (0.05 acres; 0.83 %) habitat types were also present in Falls Reservoir. The total acreage covered by some wetland types may be underestimated. Due to a limited drawdown (2 ft) and low water clarity, areas of some wetland types (particularly palustrine emergent) may be more extensive than is visible from the surface.

High quality rock habitat found in the littoral zone included boulders and cobble and combined, made-up 1.26 acres or 21.81 % of the available high quality habitat. Woody cover was dominated by medium branched trees, which covered 0.79 acres, or 13.76 % of the total habitat mapped in the littoral zone. Stumps and no branched trees combined for an additional 0.14 % of the habitat mapped.

5.4.6 Impacts of Project Operations on Aquatic Biota in Falls

Fluctuating water levels in Falls Reservoir showed the highest degree of daily, weekly and monthly variability of the four Project reservoirs (Figure 4.5-2). Daily water level fluctuations due to the run-of-river operation normally range 0-2 ft, with a maximum fluctuation up to 4 ft. Impacts to aquatic biota caused by fluctuating water levels would occur in the 1-4 ft daily drawdown zone along the shoreline. Macroinvertebrates would be impacted in this zone, but since fluctuations are only a few feet, aquatic insects and mussels can still colonize the available habitat just below the impacted zone.

Impacts of fluctuating water levels on the fish population in Falls Reservoir include the short term loss of cover within the 1 to 4 ft daily impact zone and possible interference with some fishes spawning requirements. Fish species that may be impacted by fluctuating water levels include sunfish species (bluegill, redbreast sunfish), largemouth bass and gizzard shad – all species that spawn in water depths of 4 ft or less. However, successful spawning of all these fish in Falls Reservoir have been documented in recent fish studies. Bluegill, redbreast sunfish and largemouth bass were among the top five species captured electrofishing in the reservoir and gizzard shad was second in abundance in the gill net catches. These four species had young of the year, juvenile and adult fish amongst the catches, indicating successful spawning. The impacts of fluctuating water levels on their recruitment are probably minimal.

Another impact of Project operations on aquatic biota in Falls is the quality of the water coming out of Narrows Reservoir. The low dissolved oxygen levels that are drawn from Narrows Reservoir via the turbines during the warm months of the year negatively impact aquatic life in Falls Reservoir (see NAI 2005a; NAI 2005b). For a review of the impacts of low dissolved oxygen levels on fish and aquatic biota, see Section 7.0 of Normandeau's Tailwater Fish and Aquatic Biota Assessment (NAI 2005a). In the Narrows tailwater (upper Falls Reservoir) in 2004, which was an average water year, average daily dissolved oxygen concentrations were below 5 mg/l on 75 days.

5.4.7 Effects of Alternative Water Level Regimes on Aquatic Biota in Falls

There are no alternative hydrologic regimes being proposed for Falls Reservoir.

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APPENDIX 1

Yadkin Project (FERC No. 2197)
Reservoir Fish and Aquatic Habitat Assessment

Final Study Plan
June, 2003

Background

Alcoa Power Generating Inc. (APGI) is the licensee for the Yadkin Hydroelectric Project. The Yadkin Project is currently licensed by the Federal Energy Regulatory Commission (FERC) as Project No. 2197. This license expires in 2008 and APGI must file a new license application with FERC on or before April 30, 2006 to continue operation of the Project.

The Yadkin Project consists of four reservoirs, dams, and powerhouses (High Rock, Tuckertown, Narrows, and Falls) located on a 38-mile stretch of the Yadkin River in central North Carolina. The Project generates electricity to support the power needs of Alcoa's Badin Works, to support its other aluminum operations, or is sold on the open market.

As part of the relicensing process, APGI prepared and distributed, in September 2002, an Initial Consultation Document (ICD), which provides a general overview of the Project. Agencies, municipalities, non-governmental organizations and members of the public were given an opportunity to review the ICD and identify information and studies that are needed to address relicensing issues. To further assist in the identification of issues and data/study needs, APGI has formed several Issue Advisory Groups (IAGs) to advise APGI on resource issues throughout the relicensing process. IAGs will also have the opportunity to review and comment on Draft Study Plans. This Draft Study Plan has been developed in response to comments on the ICD and through discussions with the Fish and Aquatics IAG, to provide additional necessary information for consideration in the relicensing process.

Issues

The following issue was raised during initial consultation regarding reservoir fisheries and aquatic habitat at the Yadkin Project:

- Evaluate the effects of Yadkin Project reservoir operations on fish and aquatic habitat

Study Objectives

On March 12, 2003 the Fish and Aquatics IAG met and discussed objectives for the reservoir fishery and aquatic habitat study. Over the course of those discussions the following objectives were identified for the study.

- Map the existing aquatic habitat in the existing and potential drawdown zones of High Rock and Narrows reservoirs and the littoral zones of Tuckertown and Falls reservoirs for inclusion in a GIS based (ARC View) database.
- Evaluate the impacts of fluctuating water levels under existing Project operations on the existing fishery and aquatic habitats in the four impoundments.

A draft study plan for the Yadkin Reservoir Fish and Aquatic Habitat Assessment was prepared by Normandeau Associates and distributed electronically to the Fish and Aquatics IAG on April 4, 2003 for review prior to the April 9, 2003 IAG meeting held in Badin, NC. Comments from the April 9 meeting have been incorporated into this final study plan. Comments at the meeting included discussions on the difficulties of doing the proposed habitat assessment by boat on High Rock during low water because of the shallow water encountered, especially in the tributary arms. Another comment was that the draft habitat study plan lacked sufficient detail on the habitat types that would be mapped and what the final report and Arc View file would contain. Comments on the proposed mapping of significant erosion along the reservoir were also discussed at the April 9th IAG meeting, including what constituted significant erosion and the impacts of potential erosion on affected resources. It was agreed that those Participants that were not familiar with Normandeau Associates *Santeetlah Reservoir Aquatic Habitat Study* would be given a copy as an example of the type of habitat survey and the work product (Arc View) that Normandeau Associates will provide for the proposed Yadkin Reservoirs Habitat surveys.

A revised draft study plan was distributed to the IAG in May, 2003 and IAG members and no additional comments were received.

Methods-Habitat Surveys

The habitat mapping portion of the study will be conducted by Normandeau Associates Inc. (NAI) and will entail the following:

- Significant aquatic habitat will be mapped in the drawdown zones of High Rock and Narrows in one foot contour intervals during the fall/early winter of 2003 after the reservoirs have been drawn down. In order to document habitat conditions in the typical 10-15 foot drawdown zone within High Rock Reservoir, Normandeau will attempt to map habitat in High Rock with at least a 10 ft drawdown. A drawdown greater than these may be possible to achieve for study purposes, but it is important to recognize that factors such as weather and incoming flows that are beyond the control of Yadkin can create conditions under which significant drawdowns of the two reservoirs are not possible. At Narrows, Normandeau will attempt to map habitat to a depth of 15 ft in order to evaluate the potential resource impacts associated with increasing the annual drawdown of Narrows Reservoir, similar to that currently done at High Rock.

- At High Rock, Normandeau Associates plans to conduct the habitat survey in two parts – the first effort will focus on the shallow tributary arms when the drawdown is approximately 5 ft below full pond in late summer or early fall (depending on the bathymetry in the various coves/tributary arms). This will enable the field crew to work mostly from a boat in the shallower areas, which would not be possible during a full 10 to 15 ft drawdown. The second effort will occur after High Rock is drawn down at least 10 ft, and at this time the remaining habitat in the main body of the reservoir and in the deeper areas of the tributary arms will be mapped. Field crews may also conduct the Narrows habitat survey in two trips, but this may not be necessary because the reservoir is generally deeper than High Rock and the area exposed at a 15 ft drawdown is expected to be significantly less than at High Rock.

- Habitat will be mapped in the littoral zones of Tuckertown and Falls Reservoirs (using the same methods cited above) during the fall/early winter of 2004. Because these two reservoirs have limited storage capability and do not have significant seasonal drawdowns, attempts will be made to coordinate and conduct these surveys when the reservoirs are down approximately 2 to 3 ft below high water (if feasible).

- Habitat surveys at all four reservoirs will be conducted using a Trimble GPS unit coupled with a laser scope, digital movie camera, laptop computer and Hydro Pro software. The laser scope will enable a crew to pinpoint and outline important habitat features to sub-meter accuracy so that habitat area can be calculated. Habitat types will include, but not be limited to stream confluences, aquatic vegetation, woody debris (natural and cut), structures (piers, docks, marinas, etc.), rock habitat – gravel, cobble, boulder and ledge, and sand/clay habitat. Stream confluences will be filmed at drawdown to document access between the tributaries and the reservoir and any blockage will be pinpointed with the Trimble GPS.

- Aquatic vegetation will be mostly lacking during the fall/winter period when this habitat work is planned, therefore most of the mapping of aquatic vegetation habitat types will be done during the proposed wetland and terrestrial studies during spring and summer, using a combination of stereo overflights and ground truthing. This effort will quantify the major water willow beds and other aquatic plants present. Once this data is collected and mapped, it will be imported into the Arc View habitat data file for each reservoir.

- Woody habitat types that will be mapped include downed trees (natural fall or cut), brush piles, stumps, standing timber and man-made fish habitat such as Christmas trees. Downed trees will be further broken down by their size and the amount of branches remaining on them, such as bare tree trunk, medium branched and heavily branched trees. Also, trees that were cut by agencies and cabled together to provide fish habitat will be differentiated from those that fell naturally or were cut illegally.

- Docks and piers will also be layered into the Arc View data file for each reservoir and this work (including the area of the docks in square feet) has already be completed by PB Power on High Rock using overflight pictures from a 2002 survey.

- All substrate types within the drawdown zone will be delineated and mapped, including sand/clay (or mud), gravel, cobble, boulder, ledge and rip-rap. Substrate that does not provide good habitat, such as heavily imbedded gravel (imbedded >75%) will not be measured. The predominant substrate type (mud or sand/clay) will not be mapped by the field crew, but will instead become the “default substrate”. All habitat types except this category will be mapped, and all other habitat of lower value that is not mapped will fall into this category.

- All habitat data from the four reservoirs will be imported into an ARC View data file after it’s collected, so the amount of aquatic habitat (acres and ft^2) can be calculated. Bathymetry in all four reservoirs will be presented in 1 ft contour intervals.

- During the habitat surveys, the entire shoreline of all four reservoirs will be filmed with a digital movie camera connected to the Trimble GPS unit. Areas of significant erosion and their extent will be located with the GPS system (latitude/longitude), filmed during this survey and their locations included in the Arc View data file for each reservoir. Significant erosion will include areas that are observed to have active and ongoing erosion and observable impacts to important aquatic and terrestrial resources. Such areas will include but are not necessarily limited to:
    - areas where eroding shoreline has resulted in localized sediment deposits that are noticeably affecting water quality or aquatic habitats

- o areas where eroding shoreline has resulted in the loss of vegetation from a significant plant community or habitat type.
- o areas where eroding shoreline are impacting public recreation facilities

Methods – Reservoir level fluctuation evaluation

The reservoir fluctuation evaluation portion of the study will also be conducted by Normandeau and will entail the following:

- Evaluate effects of current Project operations and water level fluctuations on existing fishery and aquatic habitats, including impacts to fish species of management concern during the spawning season and impacts due to daily and seasonal drawdowns. Fish species evaluated will primarily include all those that spawn in the littoral zone, such as largemouth bass, sunfish species (bluegill, pumpkinseed etc). Other fish, such as the forage species that are pelagic spawners (threadfin and gizzard shad, blueback herring) will also be evaluated. The habitat surveys discussed above will be used to quantify impacts of fluctuations on fish and aquatic habitats. Other Project operations that could affect aquatic biota such as stranding (after generation ceases) and water quality (especially dissolved oxygen and temperature) will also be evaluated as part of this study.
- Evaluate effects of alternative reservoir fluctuations, such as reduced drawdown zone, seasonal changes to rule curve (fill reservoir sooner or hold full longer, etc.)
    - o Assess existing water level fluctuation and drawdown data for the reservoirs, calculate median, mean low and mean high water levels from long term data sets and prepare a graph for a 12-month cycle to assess impacts (this data will also be used for wetlands evaluation).
    - o Use existing fishery data (species lists) collected by NCWRC, Yadkin consultants (recent Progress Energy fish sampling in four reservoirs) and fisheries data that will be collected during the proposed tailwater fisheries sampling beginning in August 2003 to conduct this evaluation.

Data Collection and Reporting Schedule

Data collection for the habitat surveys on High Rock and Narrows Reservoirs are planned for the fall and early winter in 2003 and the habitat data collection for the Tuckertown and Falls Reservoirs is planned for the fall/early winter in 2004. Results of the habitat surveys and reservoir fluctuation evaluations for the four impoundments will be reported in draft and final study reports. A draft study report of the habitat surveys on High Rock and Narrows Reservoirs will be prepared and distributed to the Fish and Aquatics IAG for review and comment by the 1st quarter of 2004, approximately two to three months after the completion of data collection. A draft study report for the Tuckertown and Falls Habitat survey will be prepared and distributed to the Fish and Aquatics IAG by the 1st quarter of 2005, approximately 2 months after data collection. IAG comments will be addressed in a final habitat study report for all four reservoirs that will be distributed to the IAG in March 2005. Interim results, such as draft habitat maps of the reservoirs, may be shared with the IAG as such information becomes available, prior to completion of the draft study report. The draft Reservoir Level Fluctuation report for High Rock and Narrows will be prepared and distributed to the IAG for review and comment by the 2nd quarter of 2004, about three months after the draft Habitat survey report for these two reservoirs is turned in. The draft Reservoir

Level Fluctuation report for Tuckertown and Falls Reservoirs will be distributed to the IAG for review and comment by the 2nd quarter of 2005, about two months after the draft habitat survey for these reservoirs is turned in (draft habitat survey reports are needed in order to complete the draft reservoir fluctuation reports). Final Reservoir Level Fluctuation reports for the four reservoirs will be distributed to the IAG for review and comment by the 2nd quarter of 2005.

APPENDIX 2

Appendix Table 2-1. Percent Composition and CPUE of Fish Species collected in High Rock Reservoir by electrofishing and gill nets in 2000 (CP&L)

Species	Electrofishing (fish per hour)		Gill Nets (fish per 24 hour set)	
	% Comp	CPUE	% Comp	CPUE
Black crappie	7.53%	15.17	10.77%	10.94
Bluegill	21.92%	44.17	0.86%	0.87
Bowfin	0.00%	0.00	0.02%	0.02
Brown bullhead	0.00%	0.00	0.09%	0.09
Channel catfish	0.91%	1.83	11.29%	11.46
Common carp	3.80%	7.67	1.33%	1.35
Common carp x goldfish hybrid	0.00%	0.00	0.38%	0.39
Creek chubsucker	0.00%	0.00	0.02%	0.02
Flathead catfish	0.50%	1.00	0.65%	0.66
Gizzard shad	28.04%	56.50	5.61%	5.70
Golden shiner	0.74%	1.50	0.23%	0.23
Goldfish	0.74%	1.50	0.29%	0.30
Green sunfish	0.50%	1.00	0.00%	0.00
Largemouth bass	7.69%	15.50	0.54%	0.55
Longnose gar	0.00%	0.00	0.27%	0.27
Pumpkinseed	0.66%	1.33	0.05%	0.05
Quillback	0.33%	0.67	1.10%	1.12
Redbreast sunfish	0.17%	0.33	0.00%	0.00
Redear sunfish	0.17%	0.33	0.05%	0.05
Shiner unid. (notropis)	0.00%	0.00	0.02%	0.02
Shorthead redhorse	0.91%	1.83	1.13%	1.14
Spotted sucker	0.17%	0.33	0.00%	0.00
Striped bass	1.08%	2.17	0.83%	0.85
Striped x white bass hybrid	0.00%	0.00	0.09%	0.09
Threadfin shad	19.02%	38.33	37.19%	37.77
Warmouth	0.00%	0.00	0.07%	0.07
White bass	0.00%	0.00	0.54%	0.55
White catfish	0.25%	0.50	1.04%	1.05
White crappie	2.89%	5.83	0.77%	0.78
White perch	1.16%	2.33	24.69%	25.07
Yellow perch	0.83%	1.67	0.09%	0.09

Appendix Table 2-2. Aged subsamples of striped bass captured in High Rock Reservoir in 2000.

Length Group	Female - Age								Male - Age								Unknown- Age							
(mm)	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
200-209																	2							
210-219																	5							
230-239	1																							
240-249	1																							
250-259	1																2							
260-269	1																1							
270-279																	1							
330-339		1																						
370-379		1									1													
410-419											3													
420-429											1													
440-449			2								1													
450-459										1														
460-469											1													
470-479											1													
510-519											2													
550-559			1																					
560-569											1													
580-589											1													
640-649					1																			
670-679													1											
680-689					1																			
850-859														1										
870-879																						2		
890-899								1																
900-909																								1

Appendix Table 2-3. Aged subsamples of white bass captured in High Rock Reservoir in 2000.

Length Group	Female - Age								Male - Age								Unknown- Age							
(mm)	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
180-189																	1							
210-219									1															
230-239		1																						
240-249										1								1						
250-259		1									1													
270-279			2																					
280-289																		1						
290-299		1									1													
320-320			1																					
330-329												1							1	1				
350-359			1																1					
360-369			1								1	1												
380-389					1																			
390-399					1															1				

Appendix Table 2-4. Percent Composition and CPUE of Fish Species collected in Tuckertown Reservoir by electrofishing and gill nets in 2000 (CP&L)

	Electrofishing (fish per hour)		Gill Nets (fish per 24 hour set)	
Species	**% Comp**	**CPUE**	**% Comp**	**CPUE**
Black crappie	0.91%	4.25	6.83%	5.43
Blue catfish	0.00%	0.00	0.02%	0.02
Bluegill	51.19%	240.13	0.76%	0.60
Channel catfish	0.37%	1.75	8.95%	7.11
Common carp	2.56%	12.00	0.94%	0.75
Creek chubsucker	0.00%	0.00	0.06%	0.05
Flathead catfish	0.00%	0.00	1.14%	0.91
Gizzard shad	6.16%	28.88	7.45%	5.92
Golden shiner	0.43%	2.00	0.06%	0.05
Green sunfish	0.40%	1.88	0.00%	0.00
Largemouth bass	4.74%	22.25	0.78%	0.62
Longnose gar	0.00%	0.00	0.18%	0.14
Pumpkinseed	0.45%	2.13	0.14%	0.11
Quillback	0.00%	0.00	0.06%	0.05
Redbreast sunfish	0.13%	0.63	0.00%	0.00
Redear sunfish	0.85%	4.00	0.00%	0.00
Redhorse unid.(moxostoma)	0.00%	0.00	0.02%	0.02
Satinfin shiner	0.03%	0.13	0.00%	0.00
Shorthead redhorse	0.08%	0.38	0.46%	0.37
Silver redhorse	0.03%	0.13	0.06%	0.05
Striped bass	0.00%	0.00	1.66%	1.32
Striped x white bass hybrid	0.00%	0.00	0.06%	0.05
Threadfin shad	28.83%	135.25	44.78%	35.60
Warmouth	0.75%	3.50	0.26%	0.21
White bass	0.03%	0.13	0.32%	0.25
White catfish	0.00%	0.00	0.16%	0.13
White crappie	0.40%	1.88	0.60%	0.48
White perch	0.88%	4.13	24.20%	19.24
Yellow perch	0.80%	3.75	0.04%	0.03

Appendix Table 2-5. Aged subsamples of striped bass captured in Tuckertown Reservoir in 2000.

Length Group (mm)	Female - Age								Male - Age								Unknown- Age							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
190-199																	5							
200-209	1																3							
210-219																	3							
220-229									2															
230-239																	3							
240-249	1																2							
250-259																		1						
370-379																		1						
380-389			1																1					
390-399		1																						
400-409			1																4					
410-419			2															1	3					
420-429		1								3								1						
430-439		2	1								2							1						
440-449		1								2								1	1					
450-459		1	1							1								1						
460-469		1								1	2													
470-479											1								1					
480-489				1							2								2					
490-499			1								2									1				
500-509											1													
510-519				1								1												
520-529											1													
530-539			1																					
540-549																			1					
560-569			1	1																				
580-589				1								1												
590-599				1																				
610-619												1												
630-639													1											

Appendix Table 2-6. Aged subsamples of white bass captured in Tuckertown Reservoir in 2000.

Length Group (mm)	Female - Age								Male - Age								Unknown- Age							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
210-219																	1							
220-229	1																1							
250-259	1																							
260-269	1								1															
280-289		1																						
300-309										1														
310-319																		1						
320-329											1													
330-339			1									1												
340-349												1								1				
350-359												2												
360-369												1												
390-399				1																				
400-409					1																			

Appendix Table 2-7. Percent Composition and CPUE of Fish Species collected in Narrows Reservoir by electrofishing and gill nets in 2000 (CP&L)

Species	Electrofishing (fish per hour)		Gill Nets (fish per 24 hour set)	
	% Comp	CPUE	% Comp	CPUE
Black crappie	0.10%	0.25	0.94%	0.51
Blue catfish	0.00%	0.00	1.06%	0.57
Blueback herring	0.00%	0.00	0.14%	0.08
Bluegill	33.23%	83.38	0.23%	0.12
Brown bullhead	0.55%	1.38	0.06%	0.03
Channel catfish	0.60%	1.50	5.89%	3.16
Common carp	1.30%	3.25	0.26%	0.14
Creek chubsucker	0.00%	0.00	0.03%	0.02
Flat bullhead	0.50%	1.25	1.20%	0.64
Flathead catfish	0.05%	0.13	0.31%	0.17
Gizzard shad	19.63%	49.25	7.00%	3.76
Golden shiner	0.15%	0.38	0.00%	0.00
Green sunfish	0.30%	0.75	0.00%	0.00
Largemouth bass	6.58%	16.50	1.11%	0.60
Pumpkinseed	0.85%	2.13	0.14%	0.08
Redbreast sunfish	4.24%	10.63	0.06%	0.03
Redear sunfish	1.59%	4.00	0.11%	0.06
Shorthead redhorse	0.10%	0.25	0.66%	0.35
Snail bullhead	0.80%	2.00	0.83%	0.44
Striped bass	0.10%	0.25	8.15%	4.37
Striped x white bass hybrid	0.00%	0.00	0.40%	0.21
Sunfish (hybrid)	0.05%	0.13	0.00%	0.00
Threadfin shad	13.35%	33.50	3.17%	1.70
Warmouth	0.60%	1.50	0.26%	0.14
White bass	0.00%	0.00	1.23%	0.66
White catfish	2.54%	6.38	3.60%	1.93
White crappie	0.45%	1.13	0.29%	0.15
White perch	1.49%	3.75	62.75%	33.67
Yellow perch	10.86%	27.25	0.11%	0.06

Appendix Table 2-8. Aged subsamples of striped bass captured in Narrows Reservoir in 2000.

Length Group (mm)	Female - Age								Male - Age								Unknown- Age							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
100-109																	1							
200-209																	3							
210-219																	1							
220-229																	1							
240-249																	2							
260-269	1																2	1						
270-279	1																3							
280-289	3								1								3							
290-299										1							2							
300-309									1															
310-319																		3						
330-339																		1						
340-349																	1	1						
350-359		3								2								1						
360-369		3								3	1													
370-379		1								2								2	2					
380-389		6								1	1							2						
390-399		3									4								1					
400-409		3								2								4						
410-419		2								2								6						
420-429		1								2	1							1	1					
430-439		3								1								3	3					
440-449		2	1							2								3	2					
450-459		2	2							5	1													
460-469		5	1							2								2						
470-479		2	1							3	1	1						2						
480-489			4							1	4								1					
490-499			2								3								3					
500-509			1								1								3					
510-519				1							2	1							4	1				
520-529			1								1								3					
530-539			1	1								2							2					
540-549											1	2							1					
550-559			1								1									1				
560-569												2								1				
570-579												1												
580-589			1	2								2								1	1			
590-599				1								2							1					
600-609			1	1																1				
610-619												1								1				
620-629																				1				
640-649																				1				
660-669				1							1													
720-729																						1		

Appendix Table 2-9. Aged subsamples of white bass captured in Narrows Reservoir in 2000.

Length Group (mm)	Female - Age								Male - Age								Unknown- Age							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
200-209	1																							
210-219																	1							
230-239																	2							
240-249									4															
250-259	2																2							
260-269									2								2							
270-279			1															2						
280-289										1	1													
310-319		1								2								1	2					
320-329			2							1									2					
330-339			1																3					
340-349																		1						
350-359											1													
360-369			1																					
370-379																		1						
400-409			1																					

Appendix Table 2-10. Percent Composition and CPUE of Fish Species collected in Falls Reservoir by electrofishing and gill nets in 2000 (CP&L)

Species	Electrofishing (fish per hour)		Gill Nets (fish per 24 hour set)	
	% Comp	CPUE	% Comp	CPUE
Black crappie	0.00%	0.00	0.72%	0.10
Blue catfish	0.21%	0.25	12.80%	1.84
Blueback herring	0.00%	0.00	1.45%	0.21
Bluegill	36.19%	43.25	1.21%	0.17
Channel catfish	3.35%	4.00	10.14%	1.46
Common carp	1.46%	1.75	0.48%	0.07
Eastern mosquitofish	0.21%	0.25	0.00%	0.00
Flathead catfish	0.21%	0.25	3.14%	0.45
Gizzard shad	9.21%	11.00	13.04%	1.88
Golden shiner	0.21%	0.25	0.00%	0.00
Green sunfish	1.88%	2.25	0.00%	0.00
Largemouth bass	12.34%	14.75	1.69%	0.24
Pumpkinseed	0.21%	0.25	0.00%	0.00
Redbreast sunfish	12.34%	14.75	0.24%	0.03
Redear sunfish	1.46%	1.75	0.24%	0.03
Shorthead redhorse	0.00%	0.00	3.38%	0.49
Smallmouth buffalo	0.21%	0.25	0.00%	0.00
Striped bass	0.00%	0.00	0.72%	0.10
Sunfish (hybrid)	0.21%	0.25	0.00%	0.00
Threadfin shad	0.21%	0.25	0.00%	0.00
Warmouth	10.67%	12.75	0.97%	0.14
White catfish	7.53%	9.00	8.70%	1.25
White crappie	0.00%	0.00	0.48%	0.07
White perch	1.05%	1.25	40.34%	5.81
Yellow perch	0.84%	1.00	0.24%	0.03

APPENDIX 3

Comment Summary

Copies of the Fish and Aquatics Habitat Assessment Study Draft Report were distributed to the Fish and Aquatics Issues Advisory Group (IAG) in March, 2005. The Draft Report was then summarized and discussed at a Fish and Aquatics IAG meeting held April 5, 2005. Additionally, the IAG was given until May, 2005 to submit additional comments. Table 1 below is a summary of the comments received and responses to the comments.

Source of Comment	Comment	Response
Chris Goudreau, NC Wildlife Resources Commission, 4/5/05 F&A IAG meeting	Requested that the final report include a summary table showing the quality habitats found in each 2 ft contour interval in all four Project reservoirs.	Tables summarizing the acreage of each type of quality habitat found within the 2 ft contours for High Rock (624'-612') and Narrows (510'-494') were added to the Final report as Tables 4.2-15 and 4.4-6). Because Tuckertown and Falls Reservoirs fluctuate very little under existing Project operations, only the quality habitats found in the littoral zone (about 2-3 ft), below the full pond elevation of the reservoirs were mapped. Therefore, it was not possible to estimate the total amount of habitat available in 2 ft contours for these two reservoirs.
Chris Goudreau, NC Wildlife Resources Commission, 4/5/05 F&A IAG meeting	Requested that the Final report provide an estimate for the mud/sand/clay habitat within the littoral zones of Tuckertown and Falls Reservoirs.	Sections 4.3.1 and 4.5.1 of the Final report have been edited to include this estimate.
Darlene Kucken, NC Division of Water Quality, email dated 4/29/05	A species listed in the document (*Carpiodes carpio*, River carpsucker) is not found in the Yadkin River basin.	The record of this species included in the draft report was the result of a keypunch error. The fish was actually a Quillback. The Final report has been corrected and the reference to the River carpsucker removed.
Darlene Kucken, NC Division of Water Quality, email dated 4/29/05	The report should address the loss of connectivity of tributary streams and their fish fauna due to the presence of the reservoirs.	This issue will be addressed in a separate study report on Habitat Fragmentation which is being prepared as part of the Yadkin Project relicensing process.
Darlene Kucken, NC Division of Water Quality, email dated	The report should address the impacts/abundances of exotic	NAI contacted NCDWQ about this issue and at the time the

4/29/05	fish species within the reservoirs, particularly in the Abbott's Creek arm of High Rock.	Final report was prepared was awaiting a reply from NCDWQ staff as to what exotic species are of interest.