Upper Neuse Watershed Planning Project

Technical Memorandum:

Documenting Key Assumptions in the Development of Landuse, Impervious Area, and Population Density Estimates for the Upper Neuse Basin: Year 2000, Year 2025, and Buildout

Prepared for

The Upper Neuse River Basin Association

By

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Purpose of Memo

Information about the distribution of landuse\landcover, total impervious area, and population densities is critical for determining the potential impacts of growth on the water resources of the Upper Neuse watershed. This information was obtained from a variety of sources and, wherever possible, incorporated into a GIS system to accurately represent the individual subwatersheds of the Upper Neuse system. A number of assumptions were required to interpret the available data in order to estimate the impacts of future growth. The following memo describes the process used to complete missing data and estimate model parameters. In addition, this memo briefly describes the major differences in the four modeling scenarios (Existing, 2025, Low Range Buildout, and High Range Buildout).

Documentation of Assumptions

Landuse/Landcover

Landuse/landcover information is a primary component of watershed modeling. This information describes the type and distribution of landcover within the watershed. Landuse/landcover data are used to determine the water runoff and contaminant washoff characteristics of the watershed. Each landcover may have different contaminant (e.g. sediment, nutrient) characteristics. Major changes in water quantity and quality can result from the conversion of rural landuses to more urbanized residential or commercial industrial lands. In addition, the distribution of landuses provides the basis for determining land available for future development.

Existing landuse information was generated from satellite imagery provided by the Triangle J Council of Governments (TJ COG). Data were summarized into 15 urban and rural classes for each of the 29 USGS 14-digit hydrological units that comprise the Upper Neuse watershed (Figure1, Table 1). Additional information used for the 2025 and buildout scenarios include the county and municipal boundaries, urban growth areas, critical and protected watershed boundaries, and zoning coverages. Where available, the realized density of new development was obtained from local planners. This provides a more realistic estimate of the potential growth within an area. Table 2 summarizes the residential densities used in the model setup.

Key Assumptions

- Urban growth boundaries are estimates of the areas that will be served by sewer and water utilities in the future. Roxboro and Durham have provided proposed urban growth boundaries. It is assumed that these boundaries represent the extent of future utility service for Durham and Roxboro. Local planning staffs were unable to provide estimated for future urban area growth for the other jurisdictions. Therefore, for this round of watershed modeling, it is assumed that no other expansion of urban areas will occur within the watershed.

- Land used for future development will be lost from the available forest and agricultural areas based upon the current distribution of these rural landuses. For example, if available forest land in a subwatershed is twice the amount of available agricultural land, then new development is assumed to replace twice as much forest land as agricultural land.

Table 1. Upper Neuse Basin Watershed Management Units

	Watershed Code	Land Area Acres	Land Area Square Miles	Primary Surface Waters
1	3020201010010	25,798	40.31	North Flat River, Chappels Creek
2	3020201010020	36,157	56.50	South Flat River, Alderidge Creek, Bushy Fork Creek
3	3020201010030	9,681	15.13	Flat River
4	3020201010040	23,659	36.97	Deep Creek, Rock Fork Branch
5	3020201010050	16,848	26.32	Lake Michie, Flat River, Dry Creek, Dial Creek
5A	10050A	12,086	18.88	Lake Michie Watershed Portion of HU
5B	10050B	4,762	7.44	Portion of HU that is downstream of Lake Michie
6	3020201020010	21,119	33.00	North Fork Little River, Buffalo Creek
7	3020201020020	25,024	39.10	South Fork Little River, Forrest Creek
8	3020201020030	5,316	8.31	South Fork Little River
9	3020201020040	15,683	24.50	Little River Reservoir, Little River
9A	20040A	10,439	16.31	Little River Reservoir Watershed Portion of HU
9B	20040B	5,244	8.19	Portion of HU that is downstream of Little River Reservoir
10	3020201030010	17,122	26.75	Lake Orange, West Fork Eno River, East Fork Eno River
11	3020201030020	25,176	39.34	McGowans Creek, Sevenmile Creek, Lake Ben Johnston
11A	30020A	21,191	33.11	Portion of HU Above Hillsborough Water Supply Intake
11B	30020B	3,985	6.23	Portion of HU Below Hillsborough Water Supply Intake
12	3020201030030	30,651	47.89	Eno River, Strouds Creek, Stoney Creek
13	3020201030040	18,061	28.22	Eno River, Crooked Creek
14	3020201030050	8,327	13.01	Eno River
15	3020201040010	18,302	28.60	Lake Butner (Holt), Knap of Reeds Creek, Camp Creek
16	3020201040020	11,475	17.93	Knap of Reeds Creek
17	3020201050010	23,528	36.76	Ellerbee Creek, Panther Creek
18	3020201050020	14,327	22.39	Little Lick Creek
19	3020201050030	14,096	22.02	Lick Creek
20	3020201050040	3,291	5.14	Surface of Falls Lake
21	3020201060010	30,194	47.18	Lake Rogers, Ledge Creek, Holman Creek
21A	60010A	11,125	17.38	Lake Rogers Watershed Portion of HU
21B	60010B	19,069	29.80	Portion of HU that is downstream of Lake Rogers
22	3020201060020	33,315	52.05	Beaverdam Creek, Smith Creek, Robertson Creek
23	3020201060030	3,733	5.83	Surface of Falls Lake
24	3020201065010	17,343	27.10	New Light Creek
25	3020201065020	15,202	23.75	Horse Creek
26	3020201065030	19,042	29.75	Upper Barton Creek
27	3020201065040	8,516	13.31	Cedar Creek
28	3020201065050	2,677	4.18	Surface of Falls Lake
TOTAL:		493,663	771.34	

Source: NRCS Hydrologic Unit Coverage Prepared By TJCOG (8/24/98)

Figure 1. Upper Neuse Basin Subwatersheds

Population Data

Another principal indicator of growth is the change in urban and rural population within the watershed. Population data plays two roles in the modeling process when more specific data is not available; 1) provides estimate of the number of new households in the watershed, 2) provides estimate of the number of septic systems. The number of new households is used to model the shift in landuse from agricultural and forest lands to urban or suburban landuses. The model represents these landuses differently with each having individual runoff and nutrient loading characteristics. Septic systems provide indirect loading on nutrients to the system.

A number of sources were used to estimate the population by subwatershed for the year 2000, the year 2025, and final buildout. The primary source of population data used for the analysis of Upper Neuse Basin is the Transportation Area Zone (TAZ) GIS coverage developed by the Triangle J Council of Governments. This coverage includes population and dwelling estimates for the period from 1995 – 2025 for the majority of the Upper Neuse watershed and is organized by TAZ blocks. These TAZ blocks range in size from less than an acre in urban areas to many square miles in more rural areas. The 1990 US Bureau of Census data was used to complete population data for areas not covered by the TAZ coverage. The 1990 Census data was also used to determine the percentage of households using septic, sewer, or other disposal methods.

Key Assumptions

- The TAZ coverage does not have complete population counts and dwelling estimates for Person and Granville counties. The 1990 census and county growth rate estimates are used to complete the missing information.

- The distribution of sewered and septic systems is estimated using the 1990 census data.

- It is assumed that no community systems will be allowed within the Upper Neuse watershed.

- All dwellings built within municipal and urban development zones are assumed to be sewered by 2025. The TAZ, municipal boundaries, and urban development zone coverages are used to determine the number of the new dwellings that will be provided with sewer and water.

- Based on available data, expansion of water and sewer services (areas within urban development zones) will occur for Durham and Roxboro.

- Zoning restrictions will be used to determine the area lost to urban development.

- The future population and number of dwellings in each subwatershed represented in the TAZ coverage are used for the 2025 projections. Where data are missing, estimates based upon the 1990 census data will be used. A linear growth rate based upon past county census data is assumed for these areas.

- Where available for rural (i.e. non-sewered) areas, realized density information will be used to estimate area converted to residential dwellings. Realized density reflects the actual lot sizes being developed due to soil, slope, and or other natural constraints to development. Zoning and density limits will be used to estimate conversion for all other cases. These conversions will not exceed a maximum density of 1 unit/acre (Table 2).

- It is assumed that the population density for future residential development occurs at the rate of 2.1 persons/dwelling.

Imperviousness

Imperviousness represents the amount of the land surface that rainfall does not penetrate. This parameter affects the quantity and velocity of runoff and the quantity of contaminant washoff. Imperviousness increases with the amount and density of development. Imperviousness estimates for the model are based upon the landuse/landcover and watershed imperviousness restrictions. Table 3 summarizes the applicable imperviousness limits for portions of the watershed subject to water supply protection ordinances.

Key Assumptions

- The model reflects local jurisdictions existing requirements for stormwater controls. For example, in certain watersheds stormwater controls are required for developments with impervious area greater than 24%. These BMPs are assumed to reduce the total nitrogen load by 22.5% and total phosphorus by 47.8%, based on typical observed removal efficiencies.

- Imperviousness of all new development will not exceed the limit specified in the watershed regulations. Outside urban areas served by sewer and water, residential development will not exceed a maximum density of 1 unit/acre (12% imperviousness).

- Areas that are allowed to reach 36% imperviousness without curbs and gutters are considered to be equivalent to 24% imperviousness.

- Where no density limits apply, the maximum imperviousness for residential areas will not exceed 50%.

Withdrawals and Discharges

The withdrawals and point source discharges within the basin are also modeled to maintain the hydrological balance and account for nutrient loadings from direct discharges. Tables 4 through 9 present the assumed withdrawals and discharge characteristics within the watershed.

Key Assumptions

- The 1998 – 2000 Discharge Monitoring Records are assumed to be representative of typical point source discharges.

- The High Range Buildout discharges are based upon the Low Range projections and are assumed to have a linear relationship to population.

Modeling Scenarios

Four scenarios were developed to estimate the water runoff and nutrient loading characteristics within the watershed.

Existing

The existing scenario represents current conditions (Year 2000) within the Upper Neuse Basin. Census data, TAZ information, and satellite imagery are used to develop the impacts for the model.

2025

The 2025 scenario uses estimates of changes in population and dwellings from the TAZ coverage to develop changes in landuse and number of septic systems. The major assumptions used to develop the 2025 model are as follows:

- Where available, realized densities provided by municipal and county governments will be used to determine the total area lost to development in non-sewered areas. If realized densities are not available, zoning restrictions will be used to estimate rural land lost to development.

- All areas zoned as non-residential (commercial, industrial, etc.) are assumed to be built out by 2025. Where applicable, non-residential growth with a maximum impervious area of 70% will be allowed up to a limit of 5% of the total watershed area.

Low Range Buildout

The Low Range Buildout scenario represents a moderate estimate of the potential future development within the watershed. The assumptions used for this scenario are based on realized residential densities and zoning.

- All forest and agricultural land not protected from development is assumed to be converted to residential or non-residential lands based upon zoned use. Fifteen percent of the available land is assumed to remain as undeveloped land (e.g. unbuildable, community open space).

- Where available, realized densities provided by municipal and county governments will be used to determine the total area lost to development in non-sewered areas. If realized densities are not available, zoning restrictions will be used to estimate rural land lost to development.

- The lesser of the realized lot size or density limit will be used to estimate the final number of dwellings. Density may not exceed 1 unit/ac.

- All development is regulated by the *low option* specified in the watershed regulations.

High Range Buildout

The High Range Buildout scenario represents a worst case estimate of the potential future development within the watershed. The assumptions used for this scenario are based on maximum development as allowed by zoning.

- All forest and agricultural land not protected from development is assumed to be converted to residential or non-residential lands based upon zoned use. Fifteen percent of the available land is assumed to remain as undeveloped land.

- Development will be based upon zoning restrictions to determine the maximum allowable urban and rural density.

- All landuses will develop to the maximum allowed imperviousness.

- All development is regulated by the *high option* specified in the watershed regulations. This option allows higher development densities and imperviousness limits and may require storm water controls.

Table 2. Upper Neuse River Basin Summary of Residential Density Assumptions

Jurisdiction	Watersheds	Urban Zoned (Units/ac)	Rural Zoned (Units/ac)	Rural Realized (Units/ac)
Butner	5A, 5B, 15,16, 21A	1.0[3]	0.5[3]	-
Creedmoor	21A, 21B, 22	2.0[3]	1	-
Durham	3,4,5A, 5B, 6, 7, 8, 9A, 9B, 13, 14, 15, 16, 17, 18, 19, 20, 21A, 21B, 23, 24, 25, 26	2.0[3]	0.5[3]	0.5[3]
Franklin	24, 25	2.0[2]	1.45[2]	-
Granville	5A, 5B, 11B, 12, 15, 16, 17, 20, 21A, 21B, 22, 23, 24, 25	1.74[2]	1.09[3]	0.2[4]
Hillsborough	11B, 12	9.0[3]	0.5 – 1[3]	3[3]
Orange	2, 3, 6, 7, 8, 10, 11A, 11B, 12, 13	-	0.2 – 1[4]	.34[1]
Person	1, 2, 3, 4, 5A, 6, 15	2.0[2]	1[2]	-
Raleigh	25, 26, 27	1.0[3]	1[3]	0.5[4]
Roxboro	1	2.0[2]	1[2]	-
Stem	21A	1.74[2]	1.09[2]	-
Wake County	18, 19, 20, 21B, 22, 23, 24, 25, 26, 27, 28	0.5 – 1.0[3]	0.5 – 1[3]	0.5[3]
Wake Forest	25	0.5 – 1.0[3]	0.5 - 1[3]	-

Sources:
[1] TJ COG, 2000
[2] Kerr-Tar Council of Governments, 2000
[3] UNRBA Regulatory Review and Assessment, 1999
[4] Best Professional Judgment
[5] TAZ Density Estimates

Table 3. Upper Neuse River Basin Summary of Maximum Imperviousness Assumptions

Jurisdiction	Area Designation	Watershed	Zoning Class	% Imp (Low)	% Imp (High)	Comments
Butner	Critical	WS-II (Ledge Creek) WS-III (Flat River) WS-IV (Falls Lake)	Resid.	6% 12% 24%	24% 30% 50%	
			Non-Resid.	70%	70%	Limit of 5% of watershed
	Protected	WS-II (Ledge Creek) WS-III (Flat River) WS-IV (Falls Lake)	Resid.	12% 24% 36%	30% 50% 70%	
			Non-Resid.	70%	70%	Limit of 5% of watershed
Creedmoor	Critical		Resid.	6%	6%	
			Non-Resid.	6%	6%	
	Protected		Resid.	12% - 24%	12% - 24%	Zoning dependent
			Non-Resid.	70%	70%	Limit of 5% of watershed
Durham	Critical	WS-II (Little River Reservoir) WS-III (Flat River) WS-IV (Eno River)	Resid.	6% 6-9% 24%	6% 6-9% 24%	Not Permitted
			Non-Resid.	Special	Special	Requires special use permit
	Protected	WS-II (Little River Reservoir) WS-III (Flat River) WS-IV (Eno River)	Resid.	6% 6-9% 12%[a]-24%[b]	6% 6-9% 70%[b]	
		WS-II (Little River Reservoir) WS-III (Flat River) WS-IV (Eno River)	Non-Resid.	6%[a] 6-9%[a] 12%[a] - 24%[b]	 70%[b] 70%[b]	Not permitted without utilities in the Little River Reservoir watershed
Franklin	Critical	WS-IV (Falls Lake)	Resid.	24%	24%	Assumed to be same as Granville County
		WS-IV (Falls Lake)	Non-Resid.	70%	70%	Assumed to be same as Granville; limit of 5% of watershed

Jurisdiction	Area Designation	Watershed	Zoning Class	% Imp (Low)	% Imp (High)	Comments
	Protected	WS-IV (Falls Lake)	Resid.	24%	24%	Assumed to be same as Granville
		WS-IV (Falls Lake)	Non-Resid.	70%	70%	Assumed to be same as Granville; limit of 5% of watershed
Granville	Critical	WS-II (Ledge Creek) WS-III (Flat River) WS-IV (Falls Lake)	Resid.	6% 24% 24%	6% 24% 24%	Stormwater management required for subdivisions
			Non-Resid.	70%	70%	Limit of 5% of watershed
	Protected	WS-II (Ledge Creek) WS-III (Flat River) WS-IV (Falls Lake)	Resid.	12% 24% 24%	12% 24% 24%	Stormwater management required for subdivisions
			Non-Resid.	70%	70%	Limit of 5% of watershed
Hillsborough	Critical		Resid.	6%	6%	Stormwater management required to meet watershed district guidelines
			Non-Resid.	6%[c], 24%[d]	6%[c], 24%[d]	Stormwater management required to meet watershed district guidelines
	Protected		Resid.	12%, 30%[c]	12%, 30%[c]	Stormwater management required to meet watershed district guidelines
			Non-Resid.	70%	70%	Stormwater management required to meet watershed district guidelines; limit of 5% of watershed

Jurisdiction	Area Designation	Watershed	Zoning Class	% Imp (Low)	% Imp (High)	Comments
Orange	Critical	WS-IV (Eno River)	Resid.	6%	6%	
		WS-IV (Eno River)	Non-Resid.	6%	6%	
	Protected	WS-II (Little River Reservoir) WS-III (Flat River) WS-IV (Eno River)	Resid.	6% 12% 24%	6% 12% 24%	
		WS-II (Little River Reservoir) WS-III (Flat River) WS-IV (Eno River)	Non-Resid.	12% 70% 70%	12% 70% 70%	
Person	Critical		Resid.	6%	6%	
			Non-Resid.	6%	6%	
	Protected	WS-II (Little River Reservoir) WS-III (Flat River)	Resid.	12% 24%	12% 24%	
			Non-Resid.	70%	70%	Limit 5% of watershed
Raleigh	Secondary		Resid.	12%[a], 24%[b], 30%[b,d]	12%[a], 24%[b], 30%[b,d]	
			Non-Resid.	12%[a], 24%[b], 30%[b,d]	12%[a], 24%[b], 30%[b,d]	
Roxboro	Critical		Resid.	6%	6%	
			Non-Resid.	6%	6%	
	Protected	WS-II (Little River Reservoir) WS-III (Flat River)	Resid.	12% 24%	12% 24%	
			Non-Resid.	70%	70%	Limit 5% of watershed
Stem	Critical	WS-II (Ledge Creek) WS-III (Flat River) WS-IV (Falls Lake)	Resid.	6% 24% 24%	6% 24% 24%	
			Non-Resid.	70%	70%	Limit 5% of watershed
	Protected	WS-II (Ledge Creek) WS-III (Flat River) WS-IV (Falls Lake)	Resid.	12% 24% 24%	12% 24% 24%	
			Non-Resid.	70%	70%	

Jurisdiction	Area Designation	Watershed	Zoning Class	% Imp (Low)	% Imp (High)	Comments
Wake County		All	Resid.	6 – 24%	6 – 24%	Imperv. restriction by zone: R-80W (6%), R-40W (24%)
			Non-Resid.	6 – 24%	6 – 24%	Requires special permit.
Wake Forest		All	Resid.	6%, 12%[a], 24%[b]	6%, 12%[a], 24%[b]	
			Non-Resid.	6%, 12%[a], 24%[b]	6%, 12%[a], 24%[b]	

[a] Without utilities
[b] With utilities
[c] Without stormwater controls
[d] With stormwater controls

Table 4. 1998 – 2000 Point Source Discharge Characteristics

Point Source	Flow (MGD)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (kg)	Total Phosphorus (kg)
Durham NS	9.27	4.29	0.17	55,008.2	2,115.7
Hillsborough	0.98	11.10	0.82	15,009.5	1,112.9
Butner	2.11	14.71	1.79	42,852.9	5,223.3

Source: 1998 – 2000 NPDES Discharge Monitoring Records

Table 5. Current Drinking Water Withdrawals

Withdrawal	Flow (MGD)	Flow (hm^3/yr)
Lake Johnston/Corporation Lake (Hillsborough/OAWS)	2.6	3.6
Lake Michie (Durham)	15.0	20.7
Little River Reservoir (Durham)	15.0	20.7
Lake Holt (Butner)	2.6	3.6
Lake Rogers (Creedmoor)	0.25	0.35

Source: TJ COG, 2000

Table 6. 2025 Point Source Discharge Characteristics

Point Source	Flow (MGD)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (kg)	Total Phosphorus (kg)
Durham NS	15.05	3.5	0.17	72,829.6	3,433.4
Hillsborough	3.00	3.5	0.82	14,517.5	3,413.7
Butner	6.50	3.5	1.79	31,454.6	16,113.8

Source: TJ COG, 2000

Table 7. 2025 Drinking Water Withdrawals

Withdrawal	Flow (MGD)	Flow (hm^3/yr)
Lake Johnston/Corporation Lake (Hillsborough/OAWS)	4.2	5.8
Lake Michie (Durham)	17.0	23.5
Little River Reservoir (Durham)	20.0	27.7
Lake Holt (Butner)	3.1	4.3
Lake Rogers (Creedmoor)	0.32	0.44

Source: TJ COG, 2000

Table 8. Buildout Point Source Discharge Characteristics

Point Source	Flow (MGD)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (kg)	Total Phosphorus (kg)
Durham NS	20.00	3.5	0.17	96,783.5	4,562.7
Hillsborough	9.08	3.5	0.82	43,915.5	10,326.4
Butner	10.00	3.5	1.79	48,391.7	24,790.4

Source: TJ COG, 2000

Table 9. Drinking Water Withdrawals at Buildout

Withdrawal	Flow (MGD)	Flow (hm^3/yr)
Lake Johnston/Corporation Lake (Hillsborough/OAWS)	5.5	7.6
Lake Michie (Durham)	20.0	27.7
Little River Reservoir (Durham)	20.0	27.7
Lake Holt (Butner)	12.0	16.6
Lake Rogers (Creedmoor)	0.80	1.11

Source: TJ COG, 2000