North Carolina Department of Environment and Natural Resources

Pat McCrory
Governor

John E. Skvarla, III
Secretary

Staff Summary
Roanoke River Basin Hydrologic Model
August 28, 2014

- Background
- Comments Received
- Response to Comments
- Demonstration of Roanoke River Basin Hydrologic Model Compliance with NC G.S. 143-355(o)
- Staff Recommendation
- Appendix - NC S.L. 2010-143

Background

In June 2012, the N.C. Division of Water Resources (DWR) contracted with Hydrologics, Inc. to develop a river basin hydrologic model for the Roanoke River basin to be used for water resource planning. The modeling software that was utilized to develop the model was Operational Analysis and Simulation of Integrated Systems (OASIS), which contains the following features:

a) A clickable map-base schematic with nodes representing reservoirs;
b) Withdrawals, dischargers, stream gages, and inflow locations;
c) Operation rules for reservoirs and water supply withdrawals;
d) Position analysis mode for real time operations;
e) Model runs that include both existing and future conditions scenarios;
f) A customized interface including an irrigation withdrawal update table and automatic safe yield analysis; and
g) Output options including USGS plots and 7Q10 statistics.

During the model building process, DWR held two public meetings in two locations within the Roanoke River basin. The main objective of these meetings was to seek and solicit input from the local water systems and the public in an effort to enhance the modeling process. The involvement of the local water systems ensured that the model was based on the most accurate data regarding withdrawals and discharges in the basin. In addition, training was offered for anyone interested in learning how to use the finished model. In December 2013, Hydrologics delivered the final model, and since that time DWR has conducted numerous exercises to validate the performance of the model.

In February 2014, the division published a public notice recommending that the Environmental

Management Commission consider approval of the Roanoke River Basin Hydrologic Model. This notice provided a 60-day public comment period, which ended on April 4, 2014. During the 60- day comment period, DWR received two comments, one from an individual and one from Duke Energy (attached). The individual comment contained information about a historical and topographical study of the Roanoke and its branches prepared by the Virginia Canals and Navigations Society. Duke's comment provided their water demand projections through 2060. These projections for future needs will be incorporated into model runs for the Roanoke basin plan.

Additional information and details about the Roanoke River Basin Hydrologic Model are available on the Division's website by going to: http://www.ncwater.org/Data_and_Modeling/Roanoke/.

Comments Received

Comment period: February 3 – April 4, 2014

Comments were received from:

- Virginia Canals & Navigations Society
- Duke Energy

Division of Water Resources, NC DENR
August 28, 2014

Email received on: Mon 2/10/2014 11:08 AM

I hope that those concerned with the Roanoke know about *The Roanoke/ Staunton River Atlas*, published by the Virginia Canals and Navigations Society, www.vacanals.org. This is an historical and topographical study of the Roanoke and its branches, and includes a river mileage system marked on standard USGS topo maps to help those working on the river to locate and correspond about historic sites as well as toxic spills, etc. I hope that those concerned with the river will use this as the standard mileage system instead of introducing another one.

The canal society has also published *The Dan River Atlas*.

William E. Trout, III

417 Phillips Street, Edenton, NC 27932

Bill@vacanals.org, 252-482-5946

Virginia Canals & Navigations Society, www.vacanals.org

Division of Water Resources, NC DENR
August 28, 2014

Email received on: Fri 4/4/2014 1:18 PM

This email and the attached Excel file provide Duke Energy's comments pursuant to the public notice of February 3, 2014, soliciting input on the Roanoke River Basin Hydrologic Model.

The Roanoke River Basin is a very important one to Duke Energy, as it is home to Belews Creek Steam Station, Dan River Combined Cycle Station, Rockingham Combustion Turbine Station, Roxboro Steam Station and Mayo Steam Station; in total approximately 20% of the company's electric generating capacity in the Carolinas.

We have reviewed the current inputs in NCDWR's model intended to represent the long-term amount of water use by our existing power plants. Since the model also considers water demand projections through 2060, it needs to include projections for our future needs.

Our input (see attached Excel file containing one datasheet for 2014-2039 and one datasheet for 2040-2060), requests NCDWR make the following changes in the model:

- Replace the outdated gross water withdrawal and return numbers assigned to our existing power plants with an updated set of figures.
- Adjust the model to account for the forced evaporation at Belews Creek Lake and Hyco Lake that occurs after the heated effluent is returned to the lake via the once-through cooling technology employed at Belews Creek and Roxboro Steam Stations.
- For planning purposes, add water demands to support hypothetical new combined cycle stations (two total) similar to the existing Dan River Combined Cycle Station at Belews Creek Lake and at Hyco Lake in 2040. Note we are not saying Duke Energy has specific plans to build new power plants at either of those locations; we are simply accounting for the water use that may reasonably be required to meet our customers' long-range needs. It's important to do this so the model does not assume basin-wide demands are too low in out years.

Thank you very much for the opportunity to review and comment on this important hydrologic model. If you have questions or need additional information, please call Phil Fragapane (704-382-4138) or me at 704-382-5942.

Sincerely,

Jeff Lineberger, PE

Director, Water Strategy & Hydro Licensing

Duke Energy

Response to Comments

The individual comment contained information about a historical and topographical study of the Roanoke and its branches prepared by the Virginia Canals and Navigations Society. Comment noted.

Duke's comment provided their water demand projections through 2060. These projections for future needs will be incorporated into model runs for the Roanoke basin plan.

Demonstration of Roanoke River Basin Hydrologic Model Compliance with NC G.S. 143-355(o)

The complete text of NC S.L. 2010-143, which added subsection (o) to NC G.S. 143-355, can be found in the Appendix.

(o)(3) Model. - Each basinwide hydrologic model shall:

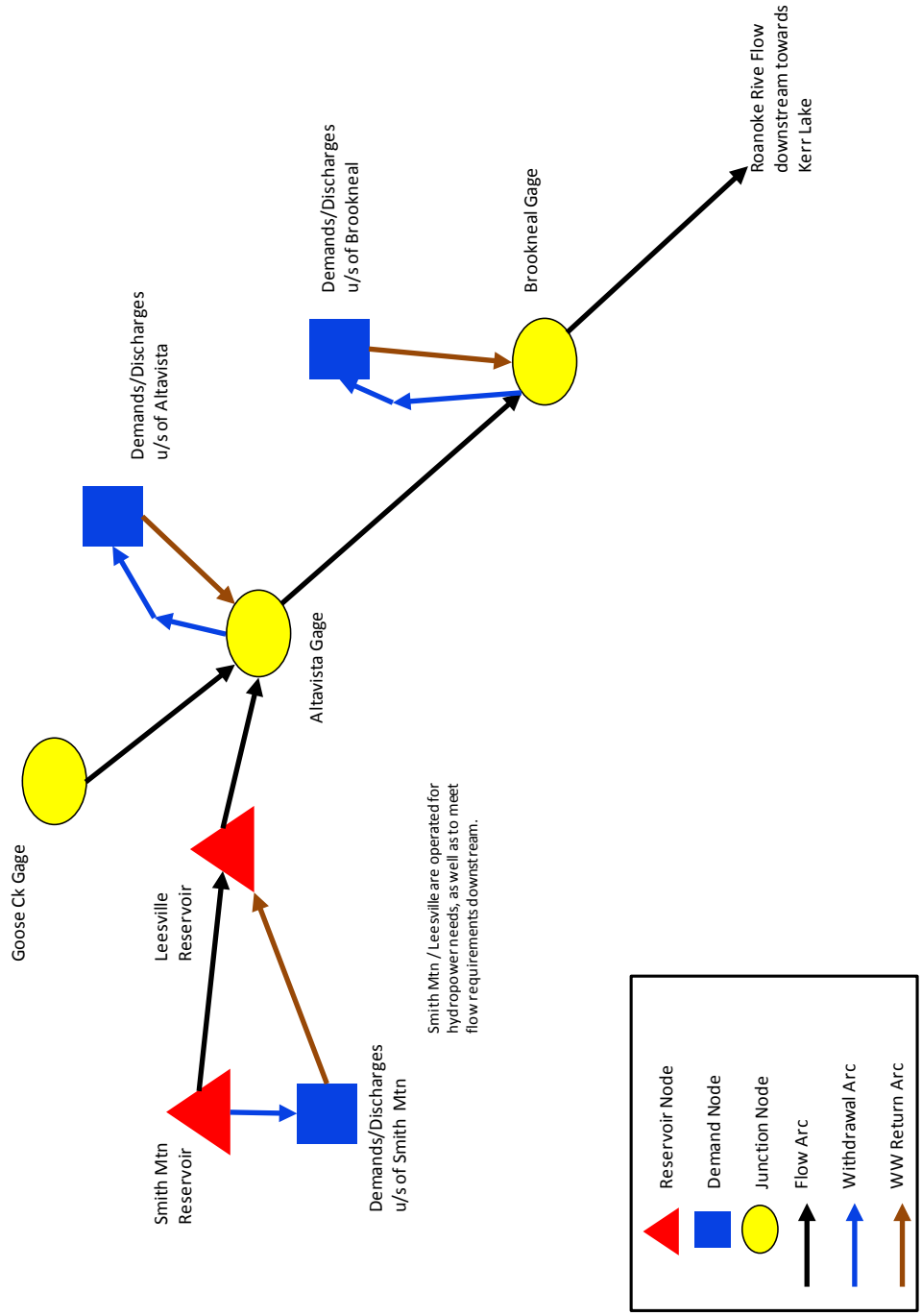
a. Include *(numbers added for reference; detailed information is provided for each)*

1) surface water resources within the river basin
2) groundwater resources within the river basin to the extent known
3) transfers into and out of the river basin that are required to be registered
4) other withdrawals
5) ecological flow
6) instream flow requirements
7) projections of future withdrawals
8) an estimate of return flows within the river basin
9) inflow data
10) local water supply plans
11) other scientific and technical information

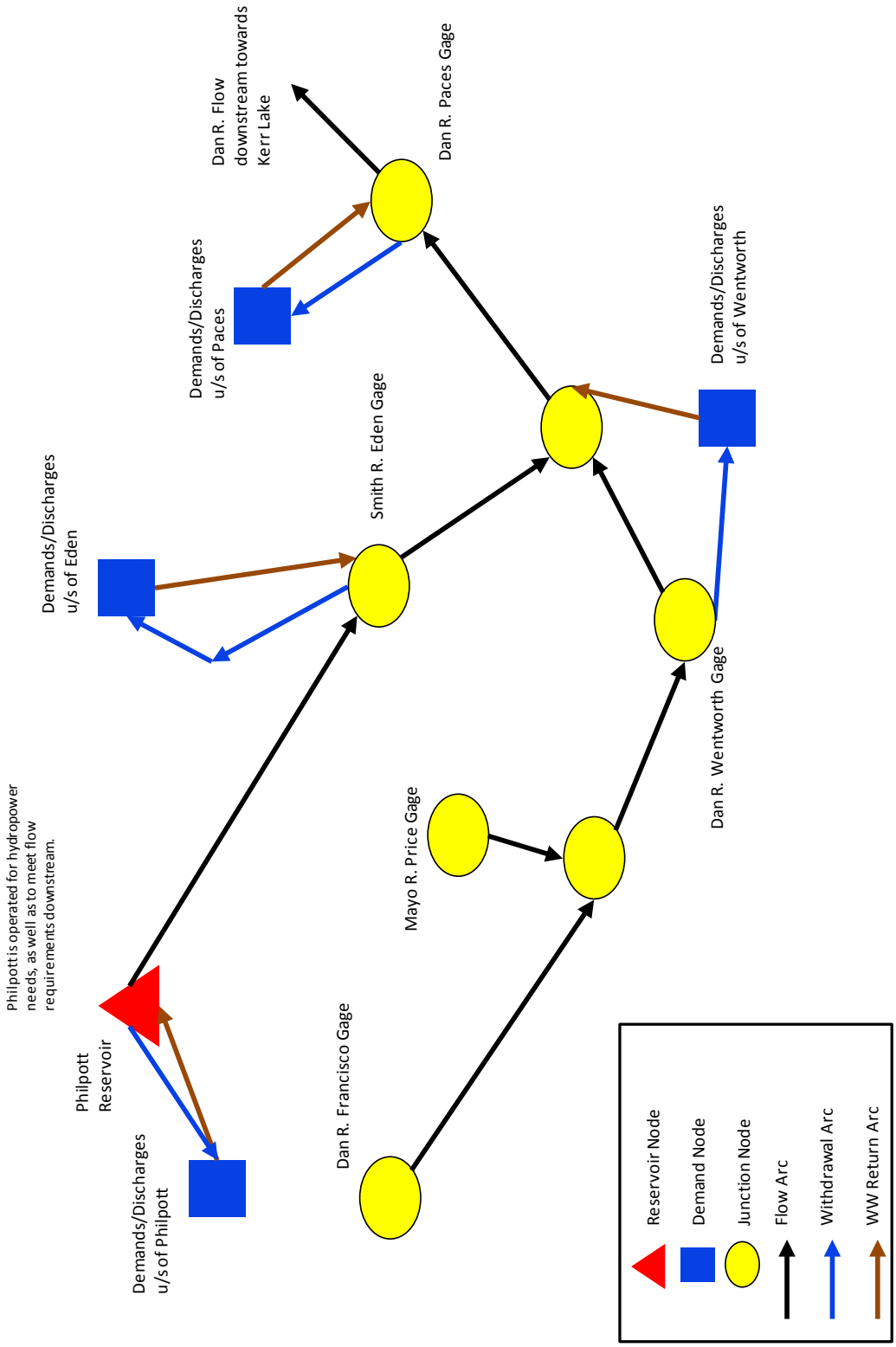
1) surface water resources within the river basin
DWR includes stream reaches and reservoirs that currently have or are projected to have a withdrawal or discharge of 100,000 gpd or will impact the flows for those reaches. 100,000 gpd is based on the current registration requirements. The following table and figures are a summary of the included streams and reservoirs.

Surface Water Resources Discretely Modeled Roanoke River Basin Hydrologic Model	
Stream	**Reservoir**
Roanoke River	Smith Mountain
Roanoke River	Leesville
Goose Creek	
Smith River	Philpott Reservoir
Dan River	
Belews Creek	
Mayo River	
Smith River	
Hyco Creek	Hyco Lake
Mayo Creek	Mayo Reservoir
Roanoke River	John H Kerr Reservoir
Roanoke River	Lake Gaston
Roanoke River	Roanoke Rapids Lake
Roanoke River	

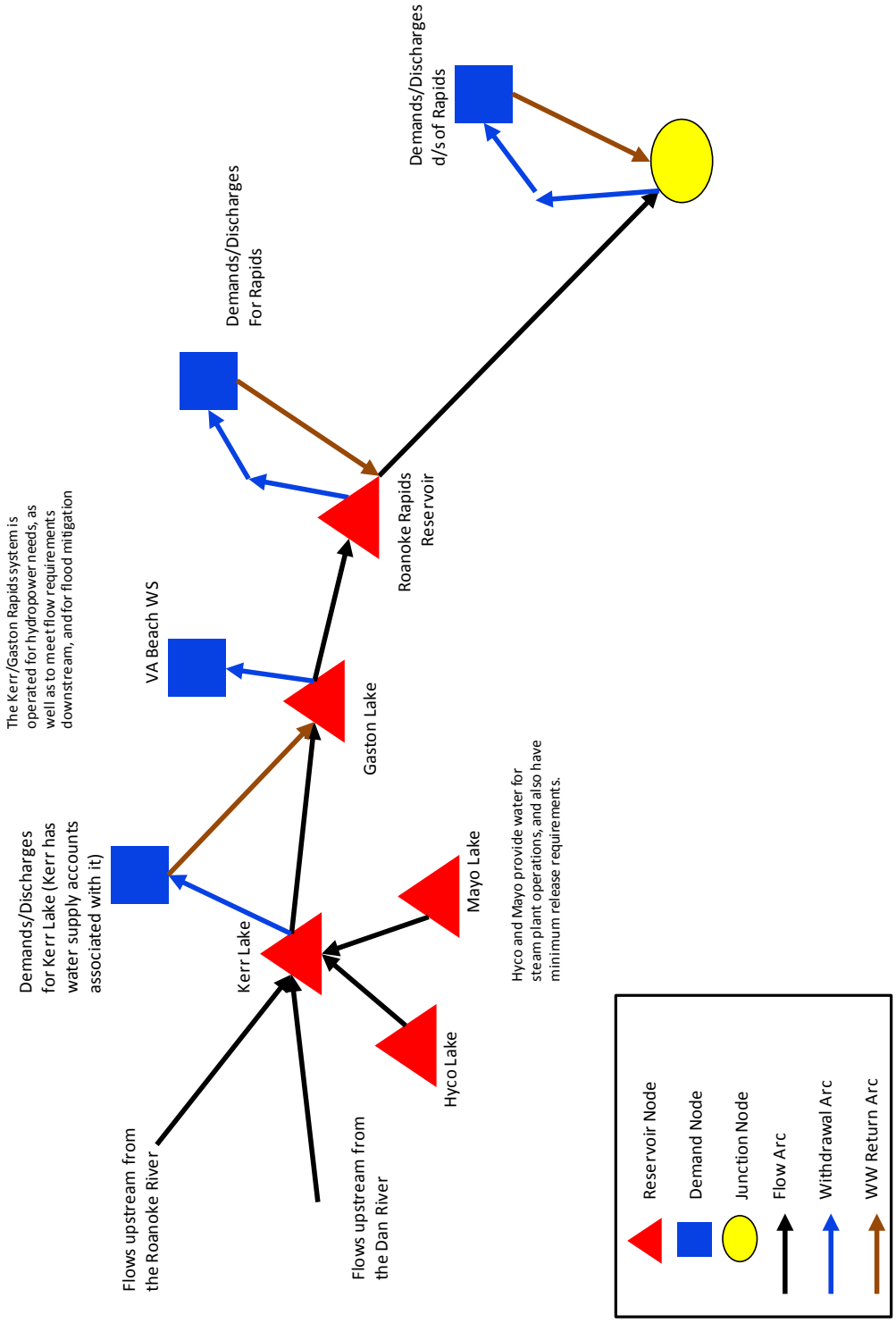
Flow Chart of Major Nodes in the Upper Roanoke Basin



Flow Chart of Major Nodes in the Dan/Smith River Basin



Flow Chart of Major Nodes in the Lower Roanoke River Basin



2) groundwater resources within the river basin to the extent known by the Department
Groundwater is currently not directly modeled. A common approach to understanding surface and groundwater interaction is to estimate base flows. DWR looks at changes in base flows to evaluate surface and groundwater interactions. Item 10) includes local water supply plans for systems that rely on groundwater.

3) transfers into and out of the river basin that are required to be registered under G.S. 143-215.22H
DWR includes registered interbasin transfers. The following table is a summary of interbasin transfers included in the model.

Interbasin Transfers
Roxboro
Kerr Lake Regional Water
Halifax (Co.)
VaBeach

4) other withdrawals
DWR includes known losses greater than 100,000 gpd. This includes reservoir evaporation, agricultural and golf course irrigation, public and self-supplied industrial withdrawals, and interbasin transfers. The following tables summarize reservoir evaporation, irrigation, and self-supplied industrial withdrawals that are included in the model.

Evaporation
SmithMtn
Leesville
Philpott
Hyco
Mayo
Kerr
Gaston
R. Rapids

Agricultural and Golf Course Irrigation

Counties	IrrTobacco	Turf	Golf	ContNurs	FieldNurs	IrrCotton	IrrEarlySoy	IrrLateSoy	IrrCorn	IrrVeg	IrrPas&Hay	IrrPeanut	IrrBlueberry	IrrStrawberry	IrrFruit
Halifax (VA), Patrick (VA)	x			x	x				x	x	x			x	x
Forsyth, Rockingham, Stokes	x	x	x	x	x		x	x		x			x	x	x
Caswell, Pittsylvania (VA)	x			x	x					x					x
Caswell, Person	x	x		x	x					x				x	
Bedford (VA), Botetourt (VA), Floyd (VA), Franklin (VA), Montgomery (VA), Pittsylvania (VA), Roanoke (VA)	x			x	x				x	x	x		x	x	x
Campbell (VA)	x				x				x	x	x				
Appomattox (VA), Campbell (VA), Pittsylvania (VA)	x		x		x				x	x	x		x	x	x
Granville, Vance, Charlotte (VA), Halifax (VA), Pittsylvania (VA)	x			x	x				x	x	x			x	x
Warren, Brunswick (VA), Mecklenburg (VA)	x			x	x				x	x	x				x
Halifax, Northampton	x	x				x	x	x	x	x	x				
Halifax, Northampton	x	x				x	x	x	x	x	x				

Industrial Withdrawals
Belews Consump. Loss
Belews Creek Steam Station
Dan River Steam Station
Dan River Steam Consump. Loss
Roxboro Consump. Loss
Roxboro Steam Electric
Mayo Consump. Loss
Mayo Steam Electric
Rapids Mill
Dominion Altavista
Burlington Ind.
Dominion Pittsylvania
Old Dominion Clover
Hanes
MeckCogen

5) ecological flow
DWR's models do include ecological flows that are part of an existing permit requirement or part of the operational plan of federal projects, such as COE or TVA reservoirs. Ecological flows included in the model are a subset of instream flow requirements. See item 6).

6) instream flow requirements
DWR's models do include instream flow requirements that are part of an existing permit requirement or part of the operational plan of federal projects, such as COE or TVA reservoirs. The following table is a summary of the instream flow requirements included in the model.

Instream Flow Requirements	
Node	Type
Phillpott	Special Operation Policy
Hyco	Special Operation Policy
Mayo	Special Operation Policy
Roanoke Rapids Bypass	Special Operation Policy
Roanoke Rapids Spawning Release	Follows Spawning Target Release Pattern
Leesville Release	Special Operation Policy
Kerr	Special Operation Policy
Gaston	Special Operation Policy

7) projections of future withdrawals
DWR develops model scenarios for current and 50-year projected withdrawals in 10-year increments. See the table in item 8).

8) an estimate of return flows within the river basin
DWR develops return flow estimates based on historical withdrawal discharge patterns. The following table includes the water use projections and return flow ratios based on the 2010 local water supply plans (LWSP). These values are updated periodically based on LWSP updates. The projections are for long-range planning only and their inclusion in the model should not be interpreted as approval for expansion or for the installation of new facilities. (WWR=Water Withdrawal Registration, NPDES=National Pollutant Discharge Elimination System, CCPCUA=Central Coastal Plain Capacity Use Area)

Withdrawal and Return Flow Projections						
Roanoke River Basin Hydrologic Model						
Withdrawer or Discharger	**2010 Million Gallons / Day**	**2020 Million Gallons / Day**	**2030 Million Gallons / Day**	**2040 Million Gallons / Day**	**2050 Million Gallons / Day**	**2060 Million Gallons / Day**
Western Virginia WA Withdrawal	14.295	14.766	15.251	15.722	16.193	16.678
Western Virginia WA Return Flow	14.363	14.836	15.324	15.797	16.270	16.758
Salem Withdrawal	5.520	5.520	5.520	5.520	5.520	5.520
Salem Return Flow	5.546	5.546	5.546	5.546	5.546	5.546
Ferum Return Flow	0.154	0.154	0.154	0.154	0.154	0.154
Ronile Return Flow	0.105	0.105	0.105	0.105	0.105	0.105
Montgomery County Return Flow	0.073	0.073	0.073	0.073	0.073	0.073
Shawsville Return Flow	0.067	0.067	0.067	0.067	0.067	0.067
Rocky Mount Withdrawal	1.013	1.211	1.416	1.614	1.812	2.017
Rocky Mount Return Flow	1.247	1.491	1.743	1.987	2.231	2.482
Bedford Withdrawal	0.871	1.005	1.143	1.277	1.411	1.549
Bedford Return Flow	0.842	0.971	1.105	1.234	1.364	1.497
Altavista Withdrawal	1.771	1.850	1.930	2.009	2.087	2.168
Altavista Return Flow	2.424	2.532	2.642	2.749	2.857	2.967
Dominion Altavista	3.196	3.196	3.196	3.196	3.196	3.196
Dominion Altavista Return Flow	0.589	0.589	0.589	0.589	0.589	0.589
Brookneal Withdrawal	0.156	0.172	0.189	0.205	0.221	0.238
Brookneal Return Flow	0.114	0.126	0.138	0.150	0.162	0.174
Dominion Pittsylvania Withdrawal	10.847	10.847	10.847	10.847	10.847	10.847
Dominion Pittsylvania Return	0.925	0.925	0.925	0.925	0.925	0.925

Withdrawal and Return Flow Projections						
Roanoke River Basin Hydrologic Model						
Withdrawer or Discharger	**2010 Million Gallons / Day**	**2020 Million Gallons / Day**	**2030 Million Gallons / Day**	**2040 Million Gallons / Day**	**2050 Million Gallons / Day**	**2060 Million Gallons / Day**
Flow						
Boxley Withdrawal	0.161	0.161	0.161	0.161	0.161	0.161
Campbell County Withdrawal	1.961	2.167	2.374	2.580	2.787	2.993
Keysville Withdrawal	0.311	0.311	0.311	0.311	0.311	0.311
Keysville Return Flow	0.263	0.263	0.263	0.263	0.263	0.263
Old Dominion Clover Withdrawal	11.557	11.557	11.557	11.557	11.557	11.557
Old Dominion Clover Return Flow	1.646	1.646	1.646	1.646	1.646	1.646
Belews Consump. Loss Withdrawal	14.813	14.813	14.813	14.813	14.813	14.813
Belews Creek Steam Station Withdrawal	1259.100	1259.100	1259.100	1259.100	1259.100	1259.100
Belews Creek Steam Station Return Flow	1256.582	1256.582	1256.582	1256.582	1256.582	1256.582
Madison Withdrawal	0.644	2.036	2.449	2.906	3.225	3.655
Abington Return Flow	0.130	0.130	0.130	0.130	0.130	0.130
Stuart Withdrawal	0.309	0.309	0.309	0.309	0.309	0.309
Stuart Return Flow	0.254	0.254	0.254	0.254	0.254	0.254
Mayodan Withdrawal	0.666	1.153	1.276	1.413	1.569	1.632
Mayodan Return Flow	0.920	1.592	1.762	1.952	2.167	2.255
Dan River Steam Station Withdrawal	184.700	184.700	184.700	184.700	184.700	184.700
Dan River Steam Station Return Flow						
Dan River Steam Consump. Loss Withdrawal	2.302	2.302	2.302	2.302	2.302	2.302
Eden	7.650	7.442	7.552	7.662	7.775	7.842
Miller Coors Return Flow	1.663	1.663	1.663	1.663	1.663	1.663
Corning Return Flow	0.100	0.100	0.100	0.100	0.100	0.100
Schoolfield Return Flow	0.199	0.199	0.199	0.199	0.199	0.199
South Boston Return Flow	1.315	1.315	1.315	1.315	1.315	1.315
Clarksville Withdrawal	0.252	0.254	0.256	0.258	0.260	0.262
Clarksville Return Flow	0.298	0.301	0.303	0.305	0.308	0.310
Roxboro Consump. Loss	11.360	11.360	11.360	11.360	11.360	11.360

Withdrawal and Return Flow Projections						
Roanoke River Basin Hydrologic Model						
Withdrawer or Discharger	**2010 Million Gallons / Day**	**2020 Million Gallons / Day**	**2030 Million Gallons / Day**	**2040 Million Gallons / Day**	**2050 Million Gallons / Day**	**2060 Million Gallons / Day**
Withdrawal						
Roxboro Steam Electric Withdrawal	1012.567	1012.567	1012.567	1012.567	1012.567	1012.567
Roxboro Steam Electric Return Flow	1006.745	1006.745	1006.745	1006.745	1006.745	1006.745
Roxboro Withdrawal	2.463	4.938	5.186	5.434	5.683	5.833
Roxboro Return Flow	2.023	4.057	4.260	4.464	4.669	4.792
Mayo Consump. Loss Withdrawal	5.206	5.206	5.206	5.206	5.206	5.206
Mayo Steam Electric	13.400	13.400	13.400	13.400	13.400	13.400
Mayo Steam Electric Return Flow	6.434	6.434	6.434	6.434	6.434	6.434
Kerr Lake Regional Water Withdrawal	6.180	10.330	12.726	15.268	16.410	18.118
Kerr Lake Regional Water Return Flow	2.587	4.325	5.328	6.392	6.870	7.586
Mecklenburg Cogeneration Withdrawal	2.414	2.433	2.453	2.472	2.492	2.512
Mecklenburg Cogeneration Return Flow	0.917	0.924	0.932	0.939	0.946	0.954
Roanoke River Serv Auth Withdrawal	1.225	1.235	1.245	1.254	1.264	1.274
Roanoke River Serv Auth Return Fow	0.054	0.055	0.055	0.056	0.056	0.056
South Hill Return Flow	0.925	0.925	0.925	0.925	0.925	0.925
Virginia Beach Withdrawal	36.800	41.366	46.070	50.636	55.265	59.978
Roanoke Rapids SD Withdrawal	5.006	5.987	6.002	6.021	6.012	6.002
Roanoke Rapids SD Return Flow	3.772	4.512	4.523	4.538	4.531	4.523
Kapston Kraft Paper Corp. Withdrawal	17.500	17.500	17.500	17.500	17.500	17.500
Kapston Kraft Paper Corp. Return Flow	19.884	19.884	19.884	19.884	19.884	19.884
Weldon Withdrawal	4.370	4.546	4.673	4.788	4.899	4.992
Weldon Return Flow	0.656	0.682	0.701	0.719	0.735	0.749
Rich Square Return Flow	0.169	0.169	0.169	0.169	0.169	0.169
Caledonia Return Flow	0.173	0.173	0.173	0.173	0.173	0.173

Withdrawal and Return Flow Projections						
Roanoke River Basin Hydrologic Model						
Withdrawer or Discharger	**2010 Million Gallons / Day**	**2020 Million Gallons / Day**	**2030 Million Gallons / Day**	**2040 Million Gallons / Day**	**2050 Million Gallons / Day**	**2060 Million Gallons / Day**
Lewiston Mill Return Flow	2.404	2.404	2.404	2.404	2.404	2.404
Enterprise Farms Withdrawal	1.763	1.763	1.763	1.763	1.763	1.763
Williamston Return Flow	0.944	0.944	0.944	0.944	0.944	0.944
Windsor Return Flow	0.538	0.538	0.538	0.538	0.538	0.538
Domtar Paper Co. Return Flow	57.691	57.691	57.691	57.691	57.691	57.691
Plymouth Return Flow	0.497	0.497	0.497	0.497	0.497	0.497
Martinsville Withdrawal	1.937	1.937	1.937	1.937	1.937	1.937
Martinsville Return Flow	3.463	3.463	3.463	3.463	3.463	3.463
CPFilms Inc Withdrawal	1.048	1.048	1.048	1.048	1.048	1.048
CPFilms Inc Return Flow	1.821	1.821	1.821	1.821	1.821	1.821
Henry County Withdrawal	3.301	3.301	3.301	3.301	3.301	3.301
Danville Withdrawal	6.367	6.367	6.367	6.367	6.367	6.367
Danville Return Flow	6.219	6.219	6.219	6.219	6.219	6.219
Danville Industrial WTP Withdrawal	0.001	0.001	0.001	0.001	0.001	0.001
Gretna Withdrawal	0.204	0.208	0.213	0.217	0.221	0.225
Gretna Return Flow	0.238	0.243	0.248	0.253	0.258	0.263
Chatham Withdrawal	0.415	0.424	0.433	0.441	0.450	0.459
Chatham Return Flow	0.299	0.305	0.312	0.318	0.324	0.330

9) inflow data

Inflow records are developed using USGS stream gage data adjusted for historical withdrawals, discharges, and changes in reservoir storage. The following tables list the stream flow gages used to create the model inflows.

List of Gages for Roanoke Basin

USGS Number	Description
2068500	**DAN RIVER NEAR FRANCISCO, NC**
2071000	**DAN RIVER NEAR WENTWORTH, NC**
2070500	**MAYO RIVER NEAR PRICE, NC**
2074000	**SMITH RIVER AT EDEN, NC**

List of Gages for Roanoke Basin

USGS Number	Description
2075500	DAN RIVER AT PACES, VA
2076000	DAN RIVER AT SOUTH BOSTON, VA
2077200	HYCO CREEK NEAR LEASBURG, NC
2060500	ROANOKE RIVER AT ALTAVISTA, VA
2062500	ROANOKE RIVER AT BROOKNEAL, VA
2079000	ROANOKE RIVER AT CLARKSVILLE, VA
2080500	ROANOKE RIVER AT ROANOKE RAPIDS, NC

10) local water supply plans

Local water supply plans from the systems in the following table were used as the data source for identifying historical, current, and projected water supply sources, demands, and discharges. It includes systems that rely on purchased water, surface water, and groundwater. (The table in item 8) summarizes the local water supply plan information. Smaller systems may be included in the modeled systems in item 8).)

Local water supply systems used to develop the Roanoke River Basin Hydrologic Model	
ID #	**Name**
04-08-085	Bertie County RWS
02-35-025	Bunn
02-79-040	Dan River Water Inc
02-85-020	Danbury, Town Of
02-79-010	Eden
02-35-030	Franklin County
04-42-030	Halifax
04-42-040	Halifax County
04-59-025	Hamilton

Local water supply systems used to develop the Roanoke River Basin Hydrologic Model	
ID #	**Name**
04-66-010	Jackson
04-59-030	Jamesville
02-91-010	Kerr Lake Regional Water
02-91-015	Kittrell WA
02-35-108	Lake Royale SD
04-08-020	Lewiston-Woodville
04-42-028	Littleton
02-79-030	Madison
02-79-025	Mayodan
02-17-015	Milton
02-93-020	Norlina
04-66-113	Northampton - Gaston
04-66-110	Northampton - Lake Gaston
04-66-108	Northampton - Milwaukee
04-66-045	Northampton - Progressive
02-39-010	Oxford
04-94-010	Plymouth
04-08-040	Powellsville
04-66-020	Rich Square
04-42-010	Roanoke Rapids SD
02-73-010	Roxboro
04-08-050	Roxobel
04-42-015	Scotland Neck

Local water supply systems used to develop the Roanoke River Basin Hydrologic Model	
ID #	**Name**
02-85-025	Stokes County WASA
02-79-035	Stoneville
02-85-015	Walnut Cove
40-93-005	Warren Co- Northampton
02-93-015	Warren County
40-93-006	Warren County - Halifax
02-93-010	Warrenton
04-42-020	Weldon
04-59-010	Williamston
04-08-010	Windsor
02-17-010	Yanceyville
02-35-020	Youngsville

11) other scientific and technical information the Department deems relevant

The two key additional technical add-ons are inclusion of the drought plans (water shortage response plans for water systems and low inflow protocols for hydropower projects) and conditional streamflow forecasts. Conditional forecasts are generated based on a function built into the OASIS model. The following table is a summary of the drought plans included in the model.

Water Shortage Response Plan Summary for Major Water Systems	
Water System	Source
Franklinton	City Pond: on Cedar Creek/Taylor Creek
Eden	Dan River
KLRWS	Kerr Lake
Mayodan	Mayo River
Weldon	Rrapids

(o)(3) Model. - Each basinwide hydrologic model shall:

b. Be designed to simulate the flows of each surface water resource within the basin that is identified as a source of water for a withdrawal registered under G.S. 143-215.22H in response to different variables, conditions, and scenarios. The model shall specifically be designed to predict the places, times, frequencies, and intervals at which any of the following may occur:

1. Yield may be inadequate to meet all needs.
2. Yield may be inadequate to meet all essential water uses.
3. Ecological flow may be adversely affected.

Demonstration that the model is capable of simulating flows and predicting adequacy and adverse effects is accomplished through validation. Validation is an evaluation of model performance, i.e., whether the model possesses a satisfactory range of accuracy consistent with its intended application. Validation refers to the processes and techniques that are used to assure that the model represents the real system to a sufficient level of accuracy. Validation compares simulated system output with real system observations. Validation is evaluated through qualitative and quantitative measures, involving both graphical comparisons and statistical tests.

Statistical test results and graphical comparisons for the Roanoke River Basin Hydrologic Model are provided in the following table and figures.

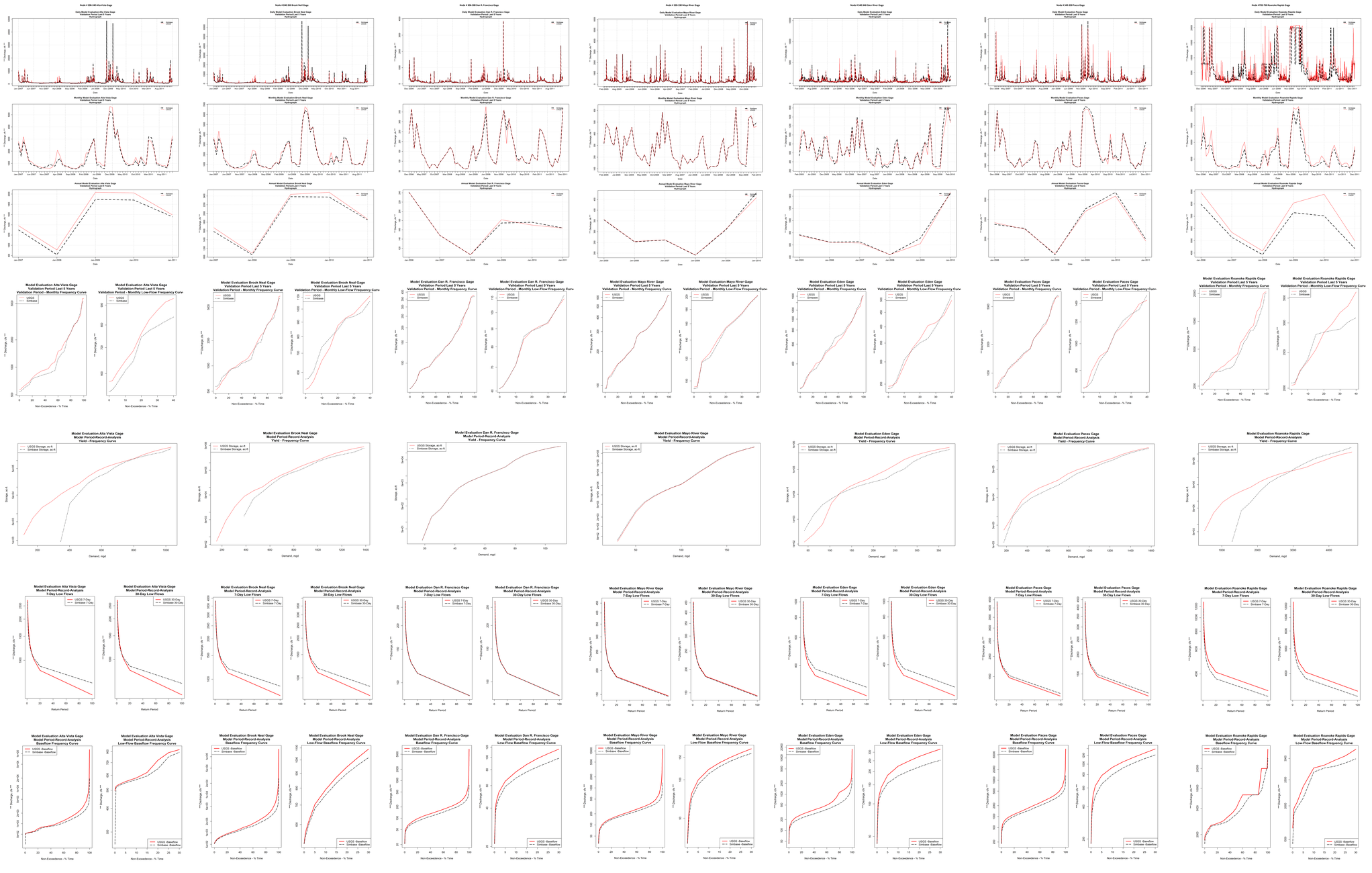
Goodness-Of-Fit Statistics
Summary Table - Roanoke Basin Gage Flow

Gages / GOF Results	Last 5 Years Data			Drought Period Comparison		
	Monthly			Data Source	Total, Days	% Difference ≤ ± 25%
	NSE > 0.5	RSR ≤ 0.70	PBIAS ≤ ± 25%			
220 Alta Vista Gage	0.9584	0.2024	-6.1	USGS	307	
	Satisfactory	Satisfactory	Satisfactory	Simbase	366	19
240 Brook Neal Gage	0.9743	0.159	-3.1	USGS	555	
	Satisfactory	Satisfactory	Satisfactory	Simbase	620	12
306 Dan River, Francisco Gage	0.9831	0.1289	0	USGS	730	
	Satisfactory	Satisfactory	Satisfactory	Simbase	698	-4
320 Mayo Gage at Mayo River	0.9986	0.0369	-0.2	USGS	512	
	Satisfactory	Satisfactory	Satisfactory	Simbase	518	1
340 Eden Gage at Smith River	0.9285	0.2653	3.5	USGS	332	
	Satisfactory	Satisfactory	Satisfactory	Simbase	319	-4
349 Dan River at Paces Gage	0.9862	0.1165	1.7	USGS	549	
	Satisfactory	Satisfactory	Satisfactory	Simbase	518	-6
720 Roanoke River at	0.8862	0.3346	-12.3	USGS	564	

Division of Water Resources, NC DENR
August 28, 2014

Goodness-Of-Fit Statistics Summary Table - Roanoke Basin Gage Flow						
Gages / GOF Results	Last 5 Years Data			Drought Period Comparison		
	Monthly			Data Source	Total, Days	% Difference ≤ ± 25%
	NSE > 0.5	RSR ≤ 0.70	PBIAS ≤ ± 25%			
Roanoke Rapids Gage	Satisfactory	Satisfactory	Satisfactory	Simbase	248	-56

01 Graphical Analysis : For Last 5 years Data



(o)(3) Model. - Each basinwide hydrologic model shall:
c. Be based solely on data that is of public record and open to public review and comment.

Flow records used in modeling are from streamflow data collected by the U.S. Geological Survey at gaging stations throughout the basin. The withdrawal and discharge information is from various DWR databases such as the local water supply plan, withdrawal registration and NPDES. All of these databases are publicly available. For example, future demand scenarios were derived from data submitted by local government water systems and other large community water systems as part of their local water supply plans.

During the model building process, DWR held two public meetings. The main objective of these meetings was to seek and solicit additional input from the local water systems and the public in an effort to enhance the modeling process. The involvement of the local water systems ensured that the model was based on the most accurate data regarding withdrawals and discharges in the basin.

In February 2014, the Division published a public notice recommending that the Environmental Management Commission consider approval of the Roanoke River Basin Hydrologic Model. This notice provided a 60-day public comment period, which ended on April 4, 2014.

The model, modeling report, and supplemental information are available on DWR's web site. Anyone may obtain an account to run the model through an email or phone request.

(o)(5) Interstate cooperation. - To the extent practicable, the Department shall work with neighboring states to develop basinwide hydrologic models for each river basin shared by North Carolina and another state.

The Commonwealth of Virginia has supplied data and reviewed the model. The State of North Carolina and the Commonwealth of Virginia have agreed to use this model for joint Roanoke River Basin water supply planning.

(o)(6) Approval and modification of hydrologic models. -
a. Upon completion of a hydrologic model, the Department shall:
1. Submit the model to the Commission for approval.
2. Publish in the North Carolina Register notice of its recommendation that the Commission approve the model and of a 60-day period for providing comment on the model.
3. Provide electronic notice to persons who have requested electronic notice of the notice published in the North Carolina Register.
b. Upon receipt of a hydrologic model, the Commission shall:
1. Receive comment on the model for the 60-day period noticed in the North Carolina Register.
2. Act on the model following the 60-day comment period.

All of these requirements will be met when the Commission acts on the model.

(o)(6) d. A hydrologic model is not a rule, and Article 2A of Chapter 150B of the General Statutes does not apply to the development of a hydrologic model.

The model is not a rule.

(o)(8) Construction of subsection. - Nothing in this subsection shall be construed to vary any existing, or impose any additional regulatory requirements, related to water quality or water resources.

The model is for planning purposes only, and will not be used to regulate water quantity or quality.

Staff Recommendation

Based on compliance with NC G.S. 143-355(o), public comment, and staff certification of the model, the Division recommends that the EMC approve the Roanoke River Basin Hydrologic Model.

APPENDIX - NC S.L. 2010-143

GENERAL ASSEMBLY OF NORTH CAROLINA
SESSION 2009

SESSION LAW 2010-143
HOUSE BILL 1743

AN ACT TO DIRECT THE DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES TO DEVELOP BASINWIDE HYDROLOGIC MODELS, AS RECOMMENDED BY THE ENVIRONMENTAL REVIEW COMMISSION.

The General Assembly of North Carolina enacts:

SECTION 1. G.S. 143-350 reads as rewritten:

"**§ 143-350. Definitions.**

As used in this Article:

…

(3) "Essential water use" means the use of water necessary for firefighting, health, and safety; water needed to sustain human and animal life; and water necessary to satisfy federal, State, and local laws for the protection of public health, safety, welfare, the environment, and natural resources; and a minimum amount of water necessary to ~~maintain~~ support and sustain the economy of the State, region, or area.

…."

SECTION 2. G.S. 143-355 is amended by adding a new subsection to read:

"(o) Basinwide Hydrologic Models. - The Department shall develop a basinwide hydrologic model for each of the 17 major river basins in the State as provided in this subsection.

(1) Definitions. - As used in this subsection:

a. "Ecological flow" means the stream flow necessary to protect ecological integrity.

b. "Ecological integrity" means the ability of an aquatic system to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to prevailing ecological conditions and, when subject to disruption, to recover and continue to provide the natural goods and services that normally accrue from the system.

c. "Groundwater resource" means any water flowing or lying under the surface of the earth or contained within an aquifer.

d. "Prevailing ecological conditions" means the ecological conditions determined by reference to the applicable period of record of the United States Geological Survey stream gauge data, including data reflecting the ecological conditions that exist after the construction and operation of existing flow modification devices, such as dams, but excluding data collected when stream flow is temporarily affected by in-stream construction activity.

e. "Surface water resource" means any lake, pond, river, stream, creek, run, spring, or other water flowing or lying on the surface of the earth.

(2) Schedule. - The Department shall develop a schedule for basinwide hydrologic model development. In developing the schedule, the Department shall give priority to developing hydrologic models for river basins or portions of river basins that are experiencing or are likely to experience water supply shortages, where the ecological integrity is threatened or likely to become threatened, or for which an existing hydrologic model has not been developed by the Department or other persons or entities.

(3) Model. - Each basinwide hydrologic model shall:

a. Include surface water resources within the river basin, groundwater resources within the river basin to the extent known by the Department, transfers into and out of the river basin that are required to be registered under G.S. 143-215.22H, other withdrawals, ecological flow, instream flow requirements, projections of future withdrawals, an estimate of return flows within the river basin, inflow data, local water supply plans, and other scientific and technical information the Department deems relevant.

b. Be designed to simulate the flows of each surface water resource within the basin that is identified as a source of water for a withdrawal registered under G.S. 143-215.22H in response to different variables, conditions, and scenarios. The model shall specifically be designed to predict the places, times, frequencies, and intervals at which any of the following may occur:

1. Yield may be inadequate to meet all needs.
2. Yield may be inadequate to meet all essential water uses.
3. Ecological flow may be adversely affected.

c. Be based solely on data that is of public record and open to public review and comment.

(4) Ecological flow. - The Department shall characterize the ecology in the different river basins and identify the flow necessary to maintain ecological integrity. The Department shall create a Science Advisory Board to assist the Department in characterizing the natural ecology and identifying the flow requirements. The Science Advisory Board shall include representatives from the Divisions of Water Resources and Water Quality of the Department, the North Carolina Wildlife Resources Commission, the North Carolina Marine Fisheries Commission, and the Natural Heritage Program. The Department shall also invite participation by the United States Fish and Wildlife Service; the National Marine Fisheries Service; representatives of organizations representing agriculture, forestry, manufacturing, electric public utilities, and local governments, with expertise in aquatic ecology and habitat; and other individuals or organizations with expertise in aquatic ecology and habitat. The Department shall ask the Science Advisory Board to review any report or study submitted to the Department for consideration that is relevant to characterizing the ecology of the different river basins and identifying flow requirements for maintenance of ecological integrity. The Department shall consider such other information, including site specific analyses, that either the Board or the Department considers relevant to determining ecological flow requirements.

(5) Interstate cooperation. - To the extent practicable, the Department shall work with neighboring states to develop basinwide hydrologic models for each river basin shared by North Carolina and another state.

(6) Approval and modification of hydrologic models. -

a. Upon completion of a hydrologic model, the Department shall:

1. Submit the model to the Commission for approval.
2. Publish in the North Carolina Register notice of its recommendation that the Commission approve the model and of a 60-day period for providing comment on the model.
3. Provide electronic notice to persons who have requested electronic notice of the notice published in the North Carolina Register.

b. Upon receipt of a hydrologic model, the Commission shall:

1. Receive comment on the model for the 60-day period noticed in the North Carolina Register.
2. Act on the model following the 60-day comment period.

c. The Department shall submit any significant modification to an approved hydrologic model to the Commission for review and approval under the process used for initial approval of the model.

d. A hydrologic model is not a rule, and Article 2A of Chapter 150B of the General Statutes does not apply to the development of a hydrologic model.

(7) Existing hydrologic models. - The Department shall not develop a hydrologic model for a river basin for which a hydrologic model has already been developed by a person or entity other than the Department, if the Department determines that the hydrologic model meets the requirements of this subsection. The Department may adopt a hydrologic model that has been developed by another person or entity that meets the requirements of this subsection in lieu of developing a hydrologic model as required by this subsection. The Department may make any modifications or additions to a hydrologic model developed by another person or entity that are necessary to meet the requirements of this subsection.

(8) Construction of subsection. - Nothing in this subsection shall be construed to vary any existing, or impose any additional regulatory requirements, related to water quality or water resources.

(9) Report. - The Department shall report to the Environmental Review Commission on the development of basinwide hydrologic models no later than November 1, of each year."

SECTION 3. The first report required by G.S. 143-355(o), as enacted by Section 2 of this act, is due no later than November 1, 2011.

SECTION 4. This act is effective when it becomes law.

In the General Assembly read three times and ratified this the 8th day of July, 2010.

s/ Walter H. Dalton
President of the Senate
s/ Joe Hackney
Speaker of the House of Representatives
s/ Beverly E. Perdue
Governor
Approved 1:52 p.m. this 22nd day of July, 2010