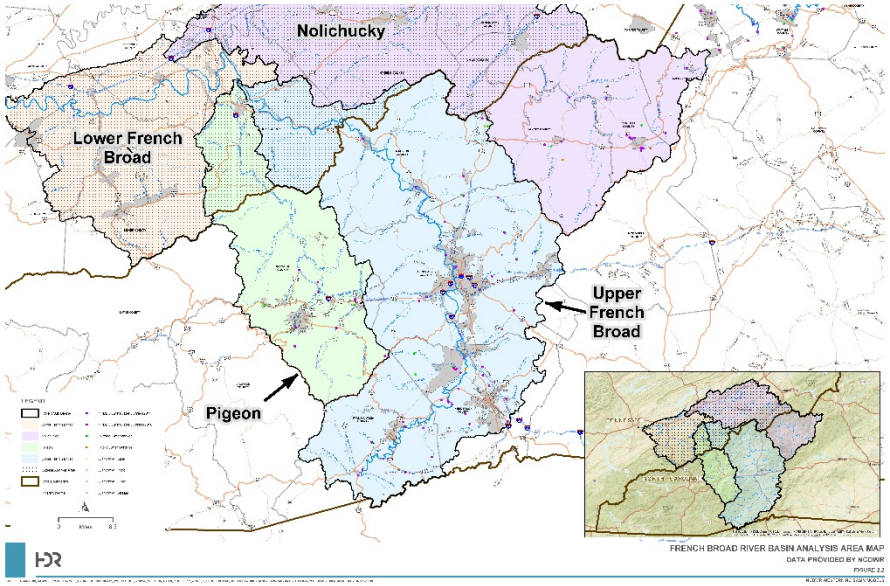
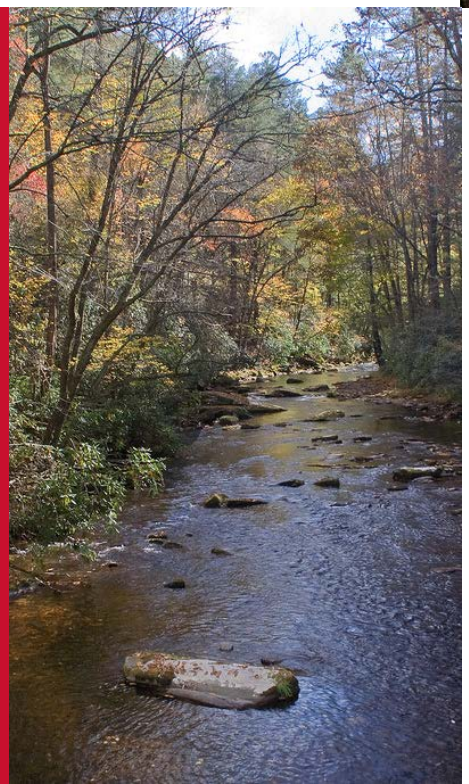
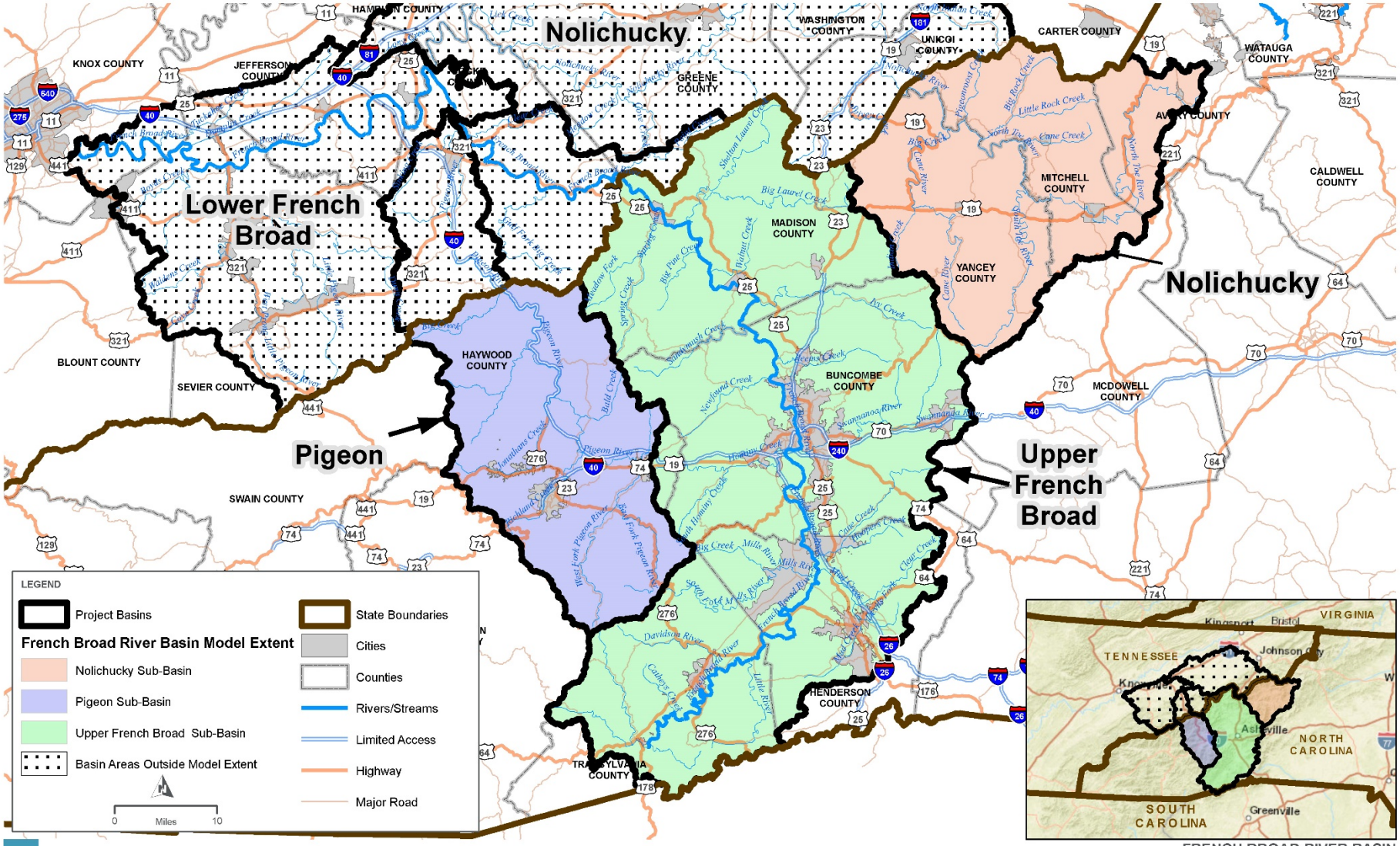




French Broad Hydrologic Model Stakeholder Meeting #2

Data Collection and Processing Review

October 1, 2018



FRENCH BROAD RIVER BASIN
MODEL EXTENT
FIGURE 1A

Data Collection Overview

Withdrawals and Returns

Introduction

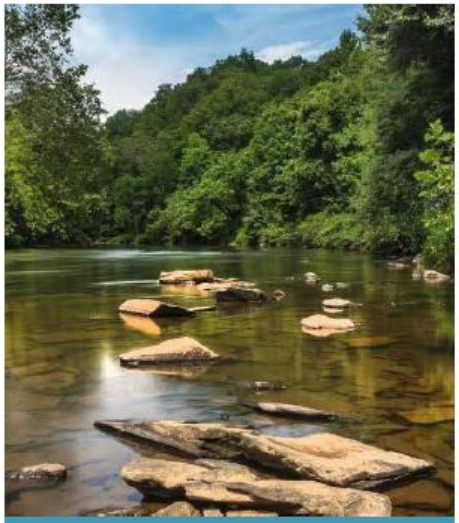
- Data focus:
  - Agriculture
  - Industrial
  - Municipal
  - 1930-2017
- Data Sources:
  - NC Division of Water Resources (NCDWR)
  - National Climactic Data Center (NCDC)
  - National Agricultural Statistics Service (NASS)
  - United States Department of Agriculture (USDA)
  - North Carolina Department of Agriculture (NCDA)
  - North Carolina Cooperative Extension Service (NCCES)
  - United States Geological Survey (USGS)
  - Municipal and Local Governments
  - Stakeholder input from April, 2018 kickoff
    - THANK YOU!

Data Collection & Processing

- Collect Water Withdrawal and Discharge Data
  - Identify applicable water users
  - Collect withdrawal & return data for users
  - Enter data into MS Excel database
  - Collect geographic information on withdrawal and return points
  - Reservoir operations (HydroLogics)
  - Data timeline = 1930 to 2017
- Process Data
  - “Hindcasting” forecasts of historic water use for withdrawals and returns where historic information is not available.
    - Water / Wastewater Utilities
    - Industrial
    - Power Generation
    - Agriculture / Irrigation

Data Documentation

- Deliverables
  - Withdrawal and discharge database
  - Summary report of water withdrawal & return data and hindcasting methodology
- Use of Data:
  - Develop inflow dataset
    - » Historical record of unimpaired (natural) river flow
  - Establish model nodes
  - Determine drainage areas to each node
  - Document monthly water demand for individual users
  - Determine agricultural water use needs across the basin



Data Collection Draft Report

French Broad and New/Watauga River Basin Models

Prepared for HydroLogics, Inc.

Western, North Carolina
September 19, 2018

Agricultural Data

Collection, Processing, & Results

Agriculture – Data Collection

- Quantify water use for:
  - Crop irrigation
  - Turf irrigation
  - Livestock watering
- Ag. Data Sources
  - National Agricultural Statistics Services (NASS)
    - Crops and Livestock Agricultural Survey (Ag Survey)
      - » Annual data
    - USDA Census of Agriculture (Census)
      - » Data every 5 years
  - NC Department of Agriculture (NCDA) Statistics
  - Agriculture Extension Agent Consultation
  - Dr. Ronald Sneed (retired professor NCSU)
  - US Geological Survey (USGS)

Agricultural Water Use Assumptions

- Crops evaluated
  - Tobacco
  - Turf
  - Golf courses
  - Nurseries (field and container/under cover)
  - Secondary crops (soybeans, cotton, corn, peanuts, irrigated pasture and hay)
  - Vegetables
  - Blueberries and Strawberries (no identified acreage from databases)
  - Orchards
- Livestock evaluated
  - Cattle (dairy and beef)
  - Chickens
  - Turkeys
  - Pigs
  - Horses
  - Other (alpacas, deer, duck, elk, goats, llamas, sheep, pheasants, etc.)

Crop Water Requirements

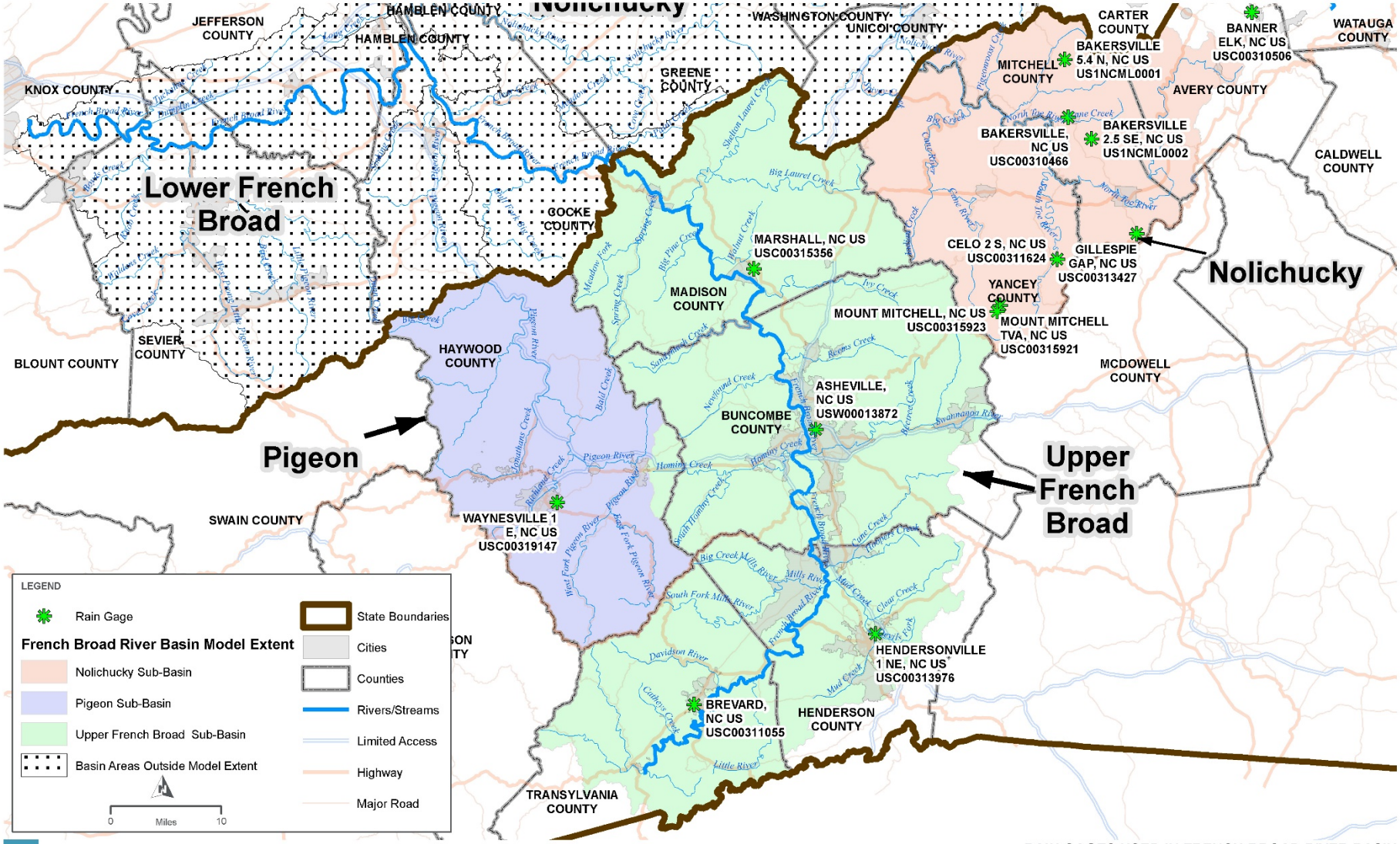
Crop	Start Date High	Start Date Mid	Start Date Low	Evapotranspiration
Tobacco	6-Jul	5-Jun	15-May	By Curve
Early Soybeans	14-Jun	1-Jun	16-May	By Curve
Late Soybeans	1-Aug	15-Jul	1-Jul	By Curve
Peanuts	N/A	1-Jun	15-May	By Curve
Cotton	N/A	1-Jun	15-May	By Curve
Corn	10-May	1-May	20-Apr	By Curve
	Dates	**Amount**	**Rest of Year**	
Pasture and Hay	15 May – 14 Oct	1"/week	none	
Turfgrass	28 Apr – 30 Sep	1.25"/ week	none	
Golf Courses	13 Apr – 17 Oct	0.57"/week	Tees & Greens 2.9% of total ac., 2"/week	
Nursery (container)	13 Jun – 12 Sep 1 Apr – 12 June 13 Sep – 31 Oct	0.75"/day 0.5"/day 0.5"/day	0.2"/day	
Nursery (field)	1 May – 14 Oct	1.25"/week	none	
Vegetables	15 April – 31 Aug 1 Sep – 14 Oct	1.25"/week 1"/week	none	
Blueberries	15 Apr -15 Jun 16 Jun – 30 Sep 28 Feb – 14 Apr	1.25"/week (production) 1.25"/week (protection) 1"/day for frost/freeze protection, highly variable		
Strawberries	2 Apr – 1 Jun 15 Sep – 30 Sep 1 Oct – 15 Nov 28 Feb – 1 Apr	1.25"/week (production) 1.25"/week (establishment) 1"/day (establishment) 1"/day for frost/freeze protection, highly variable		
Other fruit (Peaches, pecans, Apples, etc.)	15 Apr – 31 Aug 1 Mar – 14 Apr	1.25"/week (production) 0.16"/hr = 3.84"/day for frost/freeze protection		

Livestock Water Requirements

Livestock	Water Requirement	Duration
Beef Cattle	12 gal/day/head	All Year
Dairy Cattle	40 gal/day/head	All Year
Horses	12 gal/day/head	All Year
Pigs	4 gal/day/head	All Year
Chickens	9 gal/day/100 head	All Year
Turkeys	9 gal/day/50 head	All Year
Other animals (mainly goats, sheep)	2 gal/day/head	All Year

Agricultural Water Use Methodology

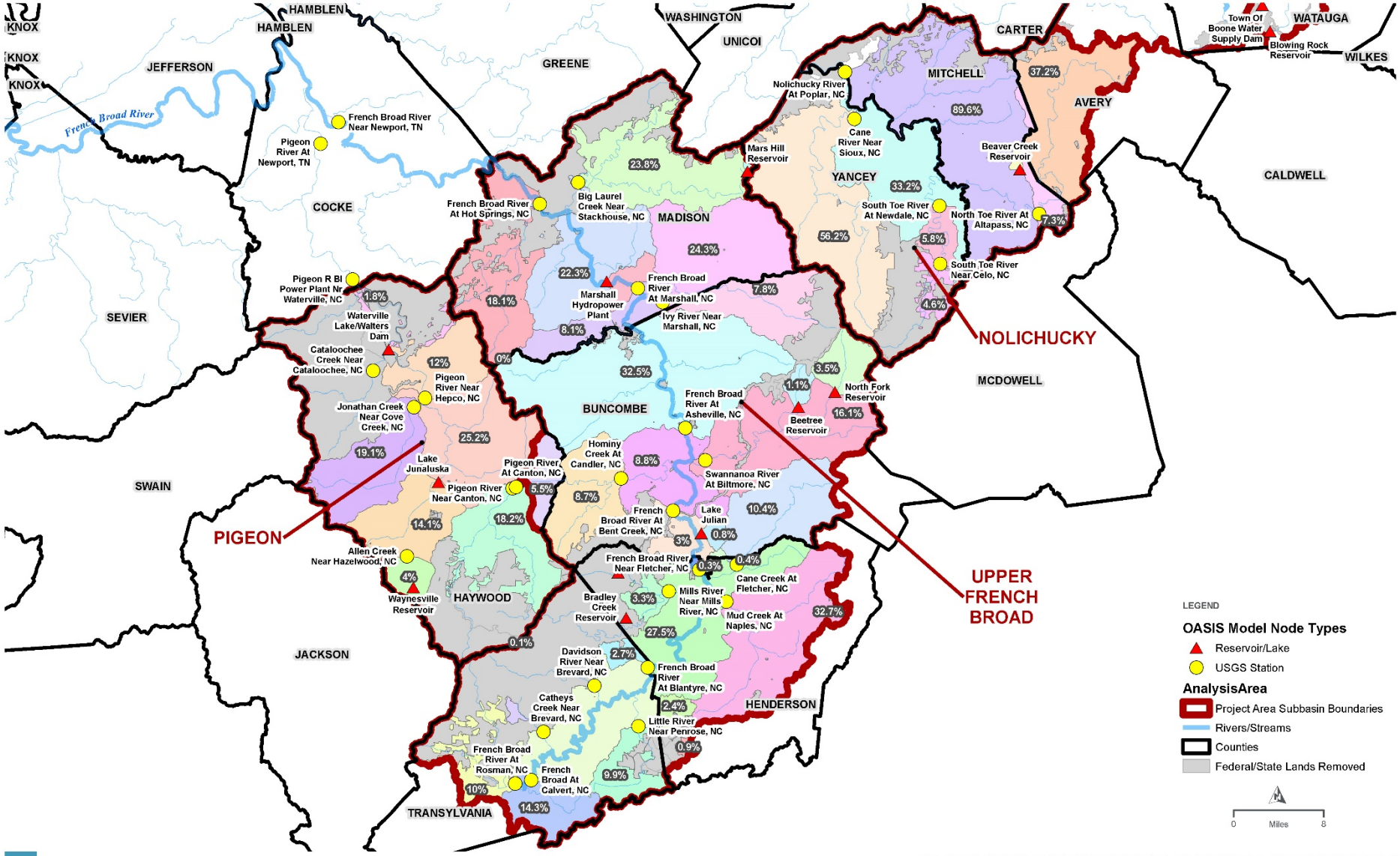
- Calculated to produce water use demand curve (daily values) from 1930-2017.
- Evapotranspiration curves
  - Used for movable irrigation (tobacco, soybeans, peanuts, cotton, corn, and nurseries in the open)
  - Irrigation level directly related to crop stress
  - Insufficient rainfall = irrigation
    - Rainfall data (1930-2017) from National Climactic Data Center (by county)
- Surface vs. Groundwater Use
  - USGS irrigation withdrawal data used (1995, 2000, 2005, 2010)
  - Surface vs. groundwater ratio to total irrigation developed
- Data Distribution
  - Assumed even distribution across counties, EXCEPT:
    - Cropped out Federal and State owned lands (national forests, state parks, etc.)
    - Where consultation with Ag. Extensions indicated an exception
  - Water use prorated to each OASIS node, based on drainage area



RAIN GAGES USED IN FRENCH BROAD RIVER BASIN

NCDC STATIONS

FIGURE 2A



FRENCH BROAD AREAS DRAINING TO OASIS MODEL NODES BY COUNTY

AGRICULTURE AND IRRIGATION AREA

FIGURE 2A

NCDWR WESTERN NC BASIN MODELS

Agricultural Water Use - Example

- Step 1: Identify Annual Irrigated Acreage and Livestock (by county and year)

COUNTY:	Yancey	1	2	3	4	5	6	7	8	9	10	11	12	13	14
STEP 1 : IDENTIFY ANNUAL IRRIGATED ACREAGE AND LIVESTOCK COUNT															
YEAR	COUNTY TOTAL	COUNTY AREA WITHIN PROJECT	IRRIGATED TOBACCO (Moveable)	TURF (Fixed)	GOLF (Fixed)	CONTAINER NURSERY (Fixed)	FIELD NURSERY (Fixed)	NURSERY - IN THE OPEN (Moveable)	NURSERY - UNDER PROTECTION (Fixed)	IRRIGATED COTTON (Moveable)	IRRIGATED EARLY SOY (Moveable)	IRRIGATED LATE SOY (Moveable)	IRRIGATED SOY (Moveable)	IRRIGATED CORN (Moveable)	IRRIGATED VEGETABLE (Fixed)	IRRIGATED PASTURE & HAY (Fixed)
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
2000	200,345	200,276	15.20	ND	150.00	ND	ND	140.80	0.13	ND	ND	ND	ND	ND	5.64	10.19
2001	200,345	200,276	14.60	ND	150.00	ND	ND	160.40	0.14	ND	ND	ND	ND	ND	5.82	10.59
2002	200,345	200,276	14.00	ND	150.00	ND	ND	180.00	0.14	ND	ND	ND	ND	ND	6.00	11.00
2003	200,345	200,276	14.00	ND	150.00	ND	ND	178.60	0.42	ND	ND	ND	ND	ND	8.80	11.00
2004	200,345	200,276	14.00	ND	150.00	ND	ND	177.20	0.70	ND	ND	ND	ND	ND	11.60	11.00
2005	200,345	200,276	14.00	ND	150.00	ND	ND	175.80	0.98	ND	ND	ND	ND	ND	14.40	11.00
2006	200,345	200,276	14.00	ND	150.00	ND	ND	174.40	1.26	ND	ND	ND	ND	ND	17.20	11.00
2007	200,345	200,276	14.00	ND	150.00	ND	ND	173.00	1.54	ND	ND	ND	ND	ND	20.00	11.00
2008	200,345	200,276	14.00	ND	150.00	ND	ND	191.80	1.45	ND	ND	ND	ND	ND	18.60	11.00
2009	200,345	200,276	14.00	ND	150.00	ND	ND	210.60	1.37	ND	ND	ND	ND	ND	17.20	11.00
2010	200,345	200,276	14.00	ND	150.00	ND	ND	229.40	1.28	ND	ND	ND	ND	ND	15.80	11.00
2011	200,345	200,276	14.00	ND	150.00	ND	ND	248.20	1.20	ND	ND	ND	ND	ND	14.40	11.00
2012	200,345	200,276	14.00	ND	150.00	ND	ND	267.00	1.11	ND	ND	ND	ND	ND	13.00	11.00
2013	200,345	200,276	14.00	ND	150.00	ND	ND	267.00	1.11	ND	ND	ND	ND	ND	13.00	11.00
2014	200,345	200,276	14.00	ND	150.00	ND	ND	267.00	1.11	ND	ND	ND	ND	ND	13.00	11.00
2015	200,345	200,276	14.00	ND	150.00	ND	ND	267.00	1.11	ND	ND	ND	ND	ND	13.00	11.00
2016	200,345	200,276	14.00	ND	150.00	ND	ND	267.00	1.11	ND	ND	ND	ND	ND	13.00	11.00
2017	200,345	200,276	14.00	ND	150.00	ND	ND	267.00	1.11	ND	ND	ND	ND	ND	13.00	11.00

Agricultural Water Use - Example

- Step 2: Annual Pattern of Daily Water Demand Rates (by crop and livestock type; by month and day)

COUNTY: Yancey

STEP 2: ANNUAL PATTERN OF DAILY WATER USE COEFFICIENTS BY CROP AND LIVESTOCK

TABLE ROW	MONTH	DAY	MONTH-DAY	IRRIGATED TOBACCO (Moveable) (in/day)	TURF (Fixed) (in/day)	GOLF (Fixed) (in/day)	CONTAINER NURSERY (Fixed) (in/day)	FIELD NURSERY (Fixed) (in/day)	NURSERY - IN THE OPEN (Moveable) (in/day)	NURSERY - UNDER PROTECTION (Fixed) (in/day)	IRRIGATED COTTON (Moveable) (in/day)	IRRIGATED EARLY SOY (Moveable) (in/day)	IRRIGATED LATE SOY (Moveable) (in/day)	IRRIGATED SOY (Moveable) (in/day)	IRRIGATED CORN (Moveable) (in/day)	IRRIGATED VEGETIBLE (Fixed) (in/day)	IRRIGATED PASTURE & HAY (Fixed) (in/day)
183	7	1	7-1	0.1669	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.0706	0.0995	0.0010	0.0503	0.2330	0.1786	0.1429
184	7	2	7-2	0.1725	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.0723	0.1030	0.0020	0.0525	0.2370	0.1786	0.1429
185	7	3	7-3	0.1800	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.0740	0.1065	0.0030	0.0548	0.2410	0.1786	0.1429
186	7	4	7-4	0.1875	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.0764	0.1100	0.0040	0.0570	0.2450	0.1786	0.1429
187	7	5	7-5	0.1950	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.0788	0.1150	0.0050	0.0600	0.2470	0.1786	0.1429
188	7	6	7-6	0.2006	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.0812	0.1200	0.0060	0.0630	0.2490	0.1786	0.1429
189	7	7	7-7	0.2063	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.0836	0.1250	0.0070	0.0660	0.2510	0.1786	0.1429
190	7	8	7-8	0.2119	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.0860	0.1300	0.0080	0.0690	0.2530	0.1786	0.1429
191	7	9	7-9	0.2175	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.0884	0.1350	0.0090	0.0720	0.2550	0.1786	0.1429
192	7	10	7-10	0.2225	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.0908	0.1400	0.0100	0.0750	0.2565	0.1786	0.1429
193	7	11	7-11	0.2275	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.0932	0.1450	0.0120	0.0785	0.2580	0.1786	0.1429
194	7	12	7-12	0.2325	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.0956	0.1500	0.0140	0.0820	0.2595	0.1786	0.1429
195	7	13	7-13	0.2340	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.0980	0.1550	0.0160	0.0855	0.2610	0.1786	0.1429
196	7	14	7-14	0.2355	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1009	0.1600	0.0180	0.0890	0.2625	0.1786	0.1429
197	7	15	7-15	0.2370	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1038	0.1643	0.0200	0.0921	0.2610	0.1786	0.1429
198	7	16	7-16	0.2385	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1067	0.1685	0.0220	0.0953	0.2595	0.1786	0.1429
199	7	17	7-17	0.2400	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1096	0.1728	0.0240	0.0984	0.2580	0.1786	0.1429
200	7	18	7-18	0.2417	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1125	0.1770	0.0260	0.1015	0.2565	0.1786	0.1429
201	7	19	7-19	0.2433	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1175	0.1813	0.0280	0.1046	0.2550	0.1786	0.1429
202	7	20	7-20	0.2450	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1225	0.1855	0.0300	0.1078	0.2533	0.1786	0.1429
203	7	21	7-21	0.2438	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1275	0.1898	0.0320	0.1109	0.2515	0.1786	0.1429
204	7	22	7-22	0.2425	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1325	0.1940	0.0340	0.1140	0.2498	0.1786	0.1429
205	7	23	7-23	0.2413	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1375	0.1983	0.0360	0.1171	0.2480	0.1786	0.1429
206	7	24	7-24	0.2400	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1450	0.2025	0.0380	0.1203	0.2463	0.1786	0.1429
207	7	25	7-25	0.2350	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1525	0.2060	0.0400	0.1230	0.2445	0.1786	0.1429
208	7	26	7-26	0.2300	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1600	0.2095	0.0420	0.1258	0.2428	0.1786	0.1429
209	7	27	7-27	0.2250	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1675	0.2130	0.0440	0.1285	0.2410	0.1786	0.1429
210	7	28	7-28	0.2194	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1750	0.2165	0.0460	0.1313	0.2393	0.1786	0.1429
211	7	29	7-29	0.2138	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1825	0.2200	0.0480	0.1340	0.2375	0.1786	0.1429
212	7	30	7-30	0.2081	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1900	0.2235	0.0500	0.1368	0.2340	0.1786	0.1429
213	7	31	7-31	0.2025	0.1786	0.0814	0.7500	0.1786	0.1786	0.7500	0.1975	0.2270	0.0525	0.1398	0.2305	0.1786	0.1429

Agricultural Water Use - Example

- Step 3: Unadjusted Total Water Demand (unadjusted for precipitation and groundwater use)

COUNTY: Yancey

STEP 3: UNADJUSTED TOTAL WATER DEMAND (UNADJUSTED FOR PRECIPITATION and GROUNDWATER USE)

YEAR	STEP 1 ROW	STEP 2 ROW	IRRIGATED TOBACCO (Moveable) (MGD)	TURF (Fixed) (MGD)	GOLF (Fixed) (MGD)	CONTAINER NURSERY (Fixed) (MGD)	FIELD NURSERY (Fixed) (MGD)	NURSERY - IN THE OPEN (Moveable) (MGD)	NURSERY - UNDER PROTECTION (Fixed) (MGD)	IRRIGATED COTTON (Moveable) (MGD)	IRRIGATED EARLY SOY (Moveable) (MGD)	IRRIGATED LATE SOY (Moveable) (MGD)	IRRIGATED SOY (Moveable) (MGD)	IRRIGATED CORN (Moveable) (MGD)	IRRIGATED VEGETIBLE (Fixed) (MGD)	IRRIGATED PASTURE & HAY (Fixed) (MGD)
7/1/2000	71	183	0.0689	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/2/2000	71	184	0.0712	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/3/2000	71	185	0.0743	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/4/2000	71	186	0.0774	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/5/2000	71	187	0.0805	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/6/2000	71	188	0.0828	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/7/2000	71	189	0.0851	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/8/2000	71	190	0.0874	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/9/2000	71	191	0.0898	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/10/2000	71	192	0.0918	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/11/2000	71	193	0.0939	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/12/2000	71	194	0.0960	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/13/2000	71	195	0.0966	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/14/2000	71	196	0.0972	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/15/2000	71	197	0.0978	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/16/2000	71	198	0.0984	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/17/2000	71	199	0.0991	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/18/2000	71	200	0.0997	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/19/2000	71	201	0.1004	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/20/2000	71	202	0.1011	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/21/2000	71	203	0.1006	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/22/2000	71	204	0.1001	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/23/2000	71	205	0.0996	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/24/2000	71	206	0.0991	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/25/2000	71	207	0.0970	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/26/2000	71	208	0.0949	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/27/2000	71	209	0.0929	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/28/2000	71	210	0.0905	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/29/2000	71	211	0.0882	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/30/2000	71	212	0.0859	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395
7/31/2000	71	213	0.0836	NA	0.3316	NA	NA	0.6827	0.0027	NA	NA	NA	NA	NA	0.0274	0.0395

Agricultural Water Use - Example

- Step 4: Weekly Precipitation Adjusted Water Demand Rates (variable irrigation (ET curves))

COUNTY: Yancey

STEP 4: WEEKLY PRECIPITATION ADJUSTED WATER USE COEFFICIENTS [VARIABLE IRRIGATION (ET CURVES)]

YEAR	STEP 2 ROW	Day in Week	WEEKLY PRECIPITATION	IRRIGATED TOBACCO	TURF	GOLF	CONTAINER NURSERY	FIELD NURSERY	NURSERY - IN THE OPEN	NURSERY - UNDER PROTECTION	IRRIGATED COTTON	IRRIGATED EARLY SOY	IRRIGATED LATE SOY	IRRIGATED SOY	IRRIGATED CORN	IRRIGATED VEGETIBLE	IRRIGATED PASTURE & HAY
				(Moveable)	(Fixed)	(Fixed)	(Fixed)	(Fixed)	(Moveable)	(Fixed)	(Moveable)	(Moveable)	(Moveable)	(Moveable)	(Moveable)	(Fixed)	(Fixed)
			(INCHES)	(in/day)	N/A	N/A	N/A	N/A	(in/day)	N/A	(in/day)	(in/day)	(in/day)	(in/day)	(in/day)	N/A	N/A
7/1/2000	183	7	*	0.0000	NA	NA	NA	NA	0.0143	NA	0.0000	0.0000	0.0000	0.0000	0.0030	NA	NA
7/2/2000	184	1	3.1350	0.0000	NA	NA	NA	NA	0.0000	NA	0.0000	0.0000	0.0000	0.0000	0.0000	NA	NA
7/3/2000	185	2	*	0.0000	NA	NA	NA	NA	0.0000	NA	0.0000	0.0000	0.0000	0.0000	0.0000	NA	NA
7/4/2000	186	3	*	0.0000	NA	NA	NA	NA	0.0000	NA	0.0000	0.0000	0.0000	0.0000	0.0000	NA	NA
7/5/2000	187	4	*	0.0000	NA	NA	NA	NA	0.0000	NA	0.0000	0.0000	0.0000	0.0000	0.0000	NA	NA
7/6/2000	188	5	*	0.0000	NA	NA	NA	NA	0.0000	NA	0.0000	0.0000	0.0000	0.0000	0.0000	NA	NA
7/7/2000	189	6	*	0.0000	NA	NA	NA	NA	0.0000	NA	0.0000	0.0000	0.0000	0.0000	0.0000	NA	NA
7/8/2000	190	7	*	0.0000	NA	NA	NA	NA	0.0000	NA	0.0000	0.0000	0.0000	0.0000	0.0000	NA	NA
7/9/2000	191	1	0.2900	0.1584	NA	NA	NA	NA	0.1371	NA	0.0398	0.0788	0.0000	0.0217	0.2073	NA	NA
7/10/2000	192	2	*	0.1584	NA	NA	NA	NA	0.1371	NA	0.0398	0.0788	0.0000	0.0217	0.2073	NA	NA
7/11/2000	193	3	*	0.1584	NA	NA	NA	NA	0.1371	NA	0.0398	0.0788	0.0000	0.0217	0.2073	NA	NA
7/12/2000	194	4	*	0.1584	NA	NA	NA	NA	0.1371	NA	0.0398	0.0788	0.0000	0.0217	0.2073	NA	NA
7/13/2000	195	5	*	0.1584	NA	NA	NA	NA	0.1371	NA	0.0398	0.0788	0.0000	0.0217	0.2073	NA	NA
7/14/2000	196	6	*	0.1584	NA	NA	NA	NA	0.1371	NA	0.0398	0.0788	0.0000	0.0217	0.2073	NA	NA
7/15/2000	197	7	*	0.1584	NA	NA	NA	NA	0.1371	NA	0.0398	0.0788	0.0000	0.0217	0.2073	NA	NA
7/16/2000	198	1	1.1650	0.0661	NA	NA	NA	NA	0.0121	NA	0.0000	0.0000	0.0000	0.0000	0.0933	NA	NA
7/17/2000	199	2	*	0.0661	NA	NA	NA	NA	0.0121	NA	0.0000	0.0000	0.0000	0.0000	0.0933	NA	NA
7/18/2000	200	3	*	0.0661	NA	NA	NA	NA	0.0121	NA	0.0000	0.0000	0.0000	0.0000	0.0933	NA	NA
7/19/2000	201	4	*	0.0661	NA	NA	NA	NA	0.0121	NA	0.0000	0.0000	0.0000	0.0000	0.0933	NA	NA
7/20/2000	202	5	*	0.0661	NA	NA	NA	NA	0.0121	NA	0.0000	0.0000	0.0000	0.0000	0.0933	NA	NA
7/21/2000	203	6	*	0.0661	NA	NA	NA	NA	0.0121	NA	0.0000	0.0000	0.0000	0.0000	0.0933	NA	NA
7/22/2000	204	7	*	0.0661	NA	NA	NA	NA	0.0121	NA	0.0000	0.0000	0.0000	0.0000	0.0933	NA	NA
7/23/2000	205	1	0.1900	0.2154	NA	NA	NA	NA	0.1514	NA	0.0957	0.1584	0.0029	0.0806	0.2260	NA	NA
7/24/2000	206	2	*	0.2154	NA	NA	NA	NA	0.1514	NA	0.0957	0.1584	0.0029	0.0806	0.2260	NA	NA
7/25/2000	207	3	*	0.2154	NA	NA	NA	NA	0.1514	NA	0.0957	0.1584	0.0029	0.0806	0.2260	NA	NA
7/26/2000	208	4	*	0.2154	NA	NA	NA	NA	0.1514	NA	0.0957	0.1584	0.0029	0.0806	0.2260	NA	NA
7/27/2000	209	5	*	0.2154	NA	NA	NA	NA	0.1514	NA	0.0957	0.1584	0.0029	0.0806	0.2260	NA	NA
7/28/2000	210	6	*	0.2154	NA	NA	NA	NA	0.1514	NA	0.0957	0.1584	0.0029	0.0806	0.2260	NA	NA
7/29/2000	211	7	*	0.2154	NA	NA	NA	NA	0.1514	NA	0.0957	0.1584	0.0029	0.0806	0.2260	NA	NA
7/30/2000	212	1	3.4600	0.0000	NA	NA	NA	NA	0.0000	NA	0.0000	0.0000	0.0000	0.0000	0.0000	NA	NA
7/31/2000	213	2	*	0.0000	NA	NA	NA	NA	0.0000	NA	0.0000	0.0000	0.0000	0.0000	0.0000	NA	NA

Agricultural Water Use - Example

- Step 5: Adjusted Total Ag Water Demand (adjusted for precipitation and irrigation (ET curves))

COUNTY: Yancey

STEP 5: ADJUSTED TOTAL WATER DEMAND (ADJUSTED FOR PRECIPITATION and GROUNDWATER USE)

YEAR	IRRIGATED TOBACCO (Moveable) (MGD)	TURF (Fixed) (MGD)	GOLF (Fixed) (MGD)	CONTAINER NURSERY (Fixed) (MGD)	FIELD NURSERY (Fixed) (MGD)	NURSERY - IN THE OPEN (Moveable) (MGD)	NURSERY - UNDER PROTECTION (Fixed) (MGD)	IRRIGATED COTTON (Moveable) (MGD)	IRRIGATED EARLY SOY (Moveable) (MGD)	IRRIGATED LATE SOY (Moveable) (MGD)	IRRIGATED SOY (Moveable) (MGD)	IRRIGATED CORN (Moveable) (MGD)	IRRIGATED VEGETIBLE (Fixed) (MGD)	IRRIGATED PASTURE & HAY (Fixed) (MGD)
7/1/2000	--	NA	0.3316	NA	NA	0.0392	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/2/2000	--	NA	0.3316	NA	NA	--	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/3/2000	--	NA	0.3316	NA	NA	--	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/4/2000	--	NA	0.3316	NA	NA	--	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/5/2000	--	NA	0.3316	NA	NA	--	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/6/2000	--	NA	0.3316	NA	NA	--	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/7/2000	--	NA	0.3316	NA	NA	--	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/8/2000	--	NA	0.3316	NA	NA	--	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/9/2000	0.0470	NA	0.3316	NA	NA	0.3767	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/10/2000	0.0470	NA	0.3316	NA	NA	0.3767	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/11/2000	0.0470	NA	0.3316	NA	NA	0.3767	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/12/2000	0.0470	NA	0.3316	NA	NA	0.3767	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/13/2000	0.0470	NA	0.3316	NA	NA	0.3767	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/14/2000	0.0470	NA	0.3316	NA	NA	0.3767	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/15/2000	0.0470	NA	0.3316	NA	NA	0.3767	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/16/2000	0.0196	NA	0.3316	NA	NA	0.0334	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/17/2000	0.0196	NA	0.3316	NA	NA	0.0334	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/18/2000	0.0196	NA	0.3316	NA	NA	0.0334	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/19/2000	0.0196	NA	0.3316	NA	NA	0.0334	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/20/2000	0.0196	NA	0.3316	NA	NA	0.0334	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/21/2000	0.0196	NA	0.3316	NA	NA	0.0334	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/22/2000	0.0196	NA	0.3316	NA	NA	0.0334	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/23/2000	0.0639	NA	0.3316	NA	NA	0.4159	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/24/2000	0.0639	NA	0.3316	NA	NA	0.4159	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/25/2000	0.0639	NA	0.3316	NA	NA	0.4159	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/26/2000	0.0639	NA	0.3316	NA	NA	0.4159	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/27/2000	0.0639	NA	0.3316	NA	NA	0.4159	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/28/2000	0.0639	NA	0.3316	NA	NA	0.4159	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/29/2000	0.0639	NA	0.3316	NA	NA	0.4159	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/30/2000	--	NA	0.3316	NA	NA	--	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284
7/31/2000	--	NA	0.3316	NA	NA	--	0.0020	NA	NA	NA	NA	NA	0.0197	0.0284

Agricultural Water Use - Example

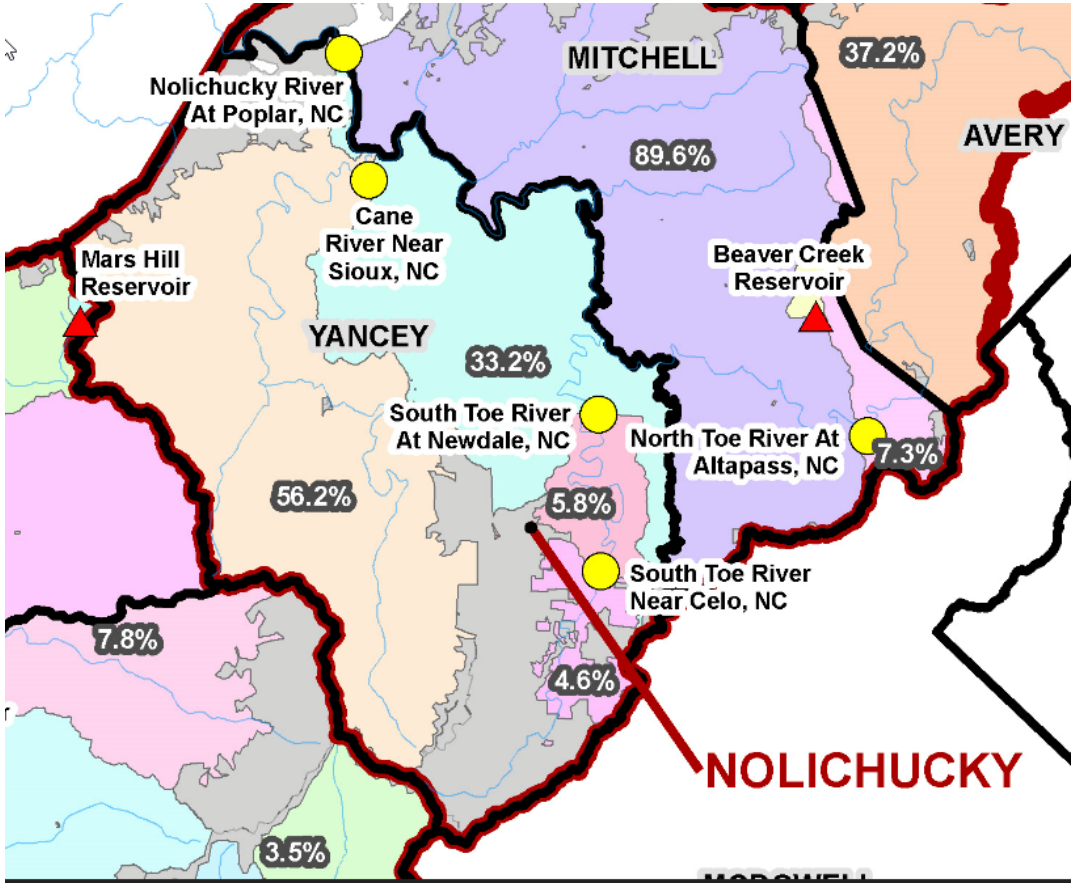
- Step 6: County Ag Water Use Summary Total

COUNTY: Yancey

STEP 6: COUNTY SUMMARY TOTALS				
YEAR	TOTAL FIXED CROP WATER USE (Fixed) (MGD)	TOTAL LIVESTOCK (Livestock) (MGD)	TOTAL MOVABLE IRRIGATION (Moveable) (MGD)	TOTAL AGRICULTURAL WATER USE (MGD)
7/1/2000	0.44	0.06	0.04	0.54
7/2/2000	0.44	0.06	--	0.50
7/3/2000	0.44	0.06	--	0.50
7/4/2000	0.44	0.06	--	0.50
7/5/2000	0.44	0.06	--	0.50
7/6/2000	0.44	0.06	--	0.50
7/7/2000	0.44	0.06	--	0.50
7/8/2000	0.44	0.06	--	0.50
7/9/2000	0.44	0.06	0.42	0.92
7/10/2000	0.44	0.06	0.42	0.92
7/11/2000	0.44	0.06	0.42	0.92
7/12/2000	0.44	0.06	0.42	0.92
7/13/2000	0.44	0.06	0.42	0.92
7/14/2000	0.44	0.06	0.42	0.92
7/15/2000	0.44	0.06	0.42	0.92
7/16/2000	0.44	0.06	0.05	0.55
7/17/2000	0.44	0.06	0.05	0.55
7/18/2000	0.44	0.06	0.05	0.55
7/19/2000	0.44	0.06	0.05	0.55
7/20/2000	0.44	0.06	0.05	0.55
7/21/2000	0.44	0.06	0.05	0.55
7/22/2000	0.44	0.06	0.05	0.55
7/23/2000	0.44	0.06	0.48	0.98
7/24/2000	0.44	0.06	0.48	0.98
7/25/2000	0.44	0.06	0.48	0.98
7/26/2000	0.44	0.06	0.48	0.98
7/27/2000	0.44	0.06	0.48	0.98
7/28/2000	0.44	0.06	0.48	0.98
7/29/2000	0.44	0.06	0.48	0.98
7/30/2000	0.44	0.06	--	0.50
7/31/2000	0.44	0.06	--	0.50

Agricultural Water Use - Example

- Step 7: Ag Water Use Distribution
  - Crop out federal and state owned lands
  - County area draining to each OASIS node
  - Ag water use by sub-basin part (parts defined by sub-basin & county intersections draining to OASIS nodes)
  - Total ag water use for each OASIS node



Municipal and Industrial Data

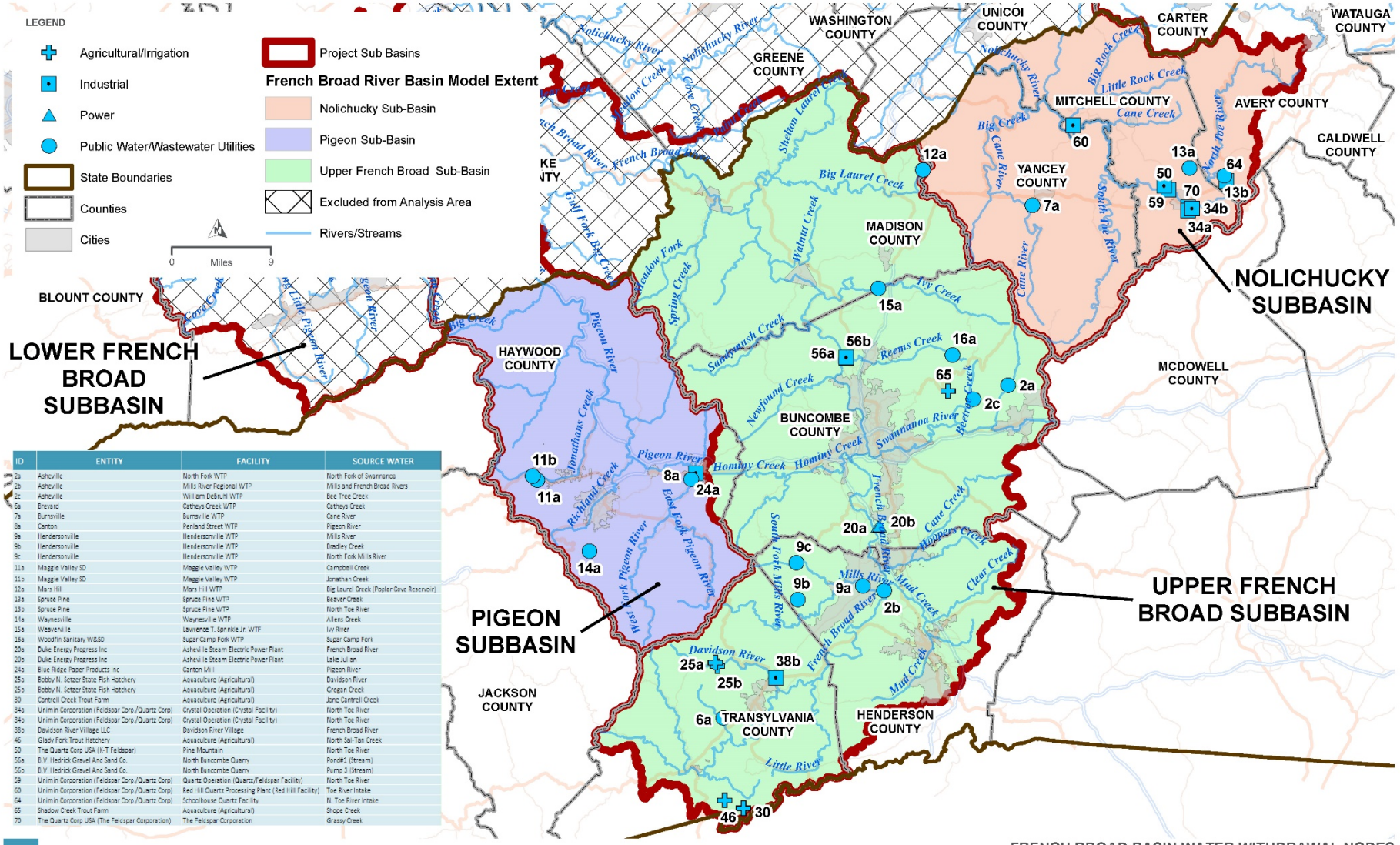
Collection, Processing, & Results

Municipal and Industrial Withdrawals – Data Collection

- Quantify water use for:
  - Municipal (public & private) water systems
  - Industries
    - Manufacturing
    - Mining
    - Power
    - Recreational*
- Data Sources
  - NCDWR Local Water Supply Plans (Public Water Utilities)
    - Data for 1997, 2002, and 2006-2017
  - NCDWR Water Withdrawal and Transfer Registration (Private Water Utilities and Industries)
    - Data for 1999, 2001-2006, & 2007-2017*
  - Individual Water Users
    - Fill in data gaps
    - Focus on 1930-1997 prior to NCDWR records
    - Provide anecdotal information (facility start and end dates)

Municipal and Industrial Withdrawals – Data Processing

- Data Compilation
  - 1930-1960: limited data
  - 1970-present: more available/accurate data
  - Only entities withdrawing ≥ 100,000 gpd (annual average day basis)
    - Or projected (through NC Local Water Supply Plans) to withdraw ≥ 100,000 gpd (through 2060)
- Data Processing
  - Monthly time series for OASIS model
  - Based on facility start and end dates
  - Hindcasting missing/non-reported data
    - Developed record for 1930-2017
    - Water suppliers: Population data (U.S. Census)
    - Industries: GDP for NC (U.S. Bureau of Economic Analysis)
  - Monthly demand
    - Most recent 5 years of data
    - Used for each unique model node



ID	ENTITY	FACILITY	SOURCE WATER
2a	Asheville	North Fork WTP	North Fork of Swannanoa
2b	Asheville	Mills River Regional WTP	Mills and French Broad Rivers
2c	Asheville	William DeBruhl WTP	Bee Tree Creek
6a	Brevard	Catheys Creek WTP	Catheys Creek
7a	Burnsville	Burnsville WTP	Cane River
8a	Canton	Penland Street WTP	Pigeon River
9a	Hendersonville	Hendersonville WTP	Mills River
9b	Hendersonville	Hendersonville WTP	Bradley Creek
9c	Hendersonville	Hendersonville WTP	North Fork Mills River
11a	Maggie Valley SD	Maggie Valley WTP	Campbell Creek
11b	Maggie Valley SD	Maggie Valley WTP	Jonathan Creek
12a	Mars Hill	Mars Hill WTP	Big Laurel Creek (Poplar Cove Reservoir)
13a	Spruce Pine	Spruce Pine WTP	Beaver Creek
13b	Spruce Pine	Spruce Pine WTP	North Toe River
14a	Waynesville	Waynesville WTP	Allens Creek
15a	Weaverville	Lawrence T. Sprinkle Jr. WTF	Ivy River
16a	Woodfin Sanitary WBSD	Sugar Camp Fork WTP	Sugar Camp Fork
20a	Duke Energy Progress Inc	Asheville Steam Electric Power Plant	French Broad River
20b	Duke Energy Progress Inc	Asheville Steam Electric Power Plant	Lake Julian
24a	Blue Ridge Paper Products Inc	Canton Mill	Pigeon River
25a	Bobby N. Setzer State Fish Hatchery	Aquaculture (Agricultural)	Davidson River
25b	Bobby N. Setzer State Fish Hatchery	Aquaculture (Agricultural)	Grogan Creek
30	Cantrell Creek Trout Farm	Aquaculture (Agricultural)	Jane Cantrell Creek
34a	Unimin Corporation (Feldspar Corp./Quartz Corp)	Crystal Operation (Crystal Facility)	North Toe River
34b	Unimin Corporation (Feldspar Corp./Quartz Corp)	Crystal Operation (Crystal Facility)	North Toe River
38b	Davidson River Village LLC	Davidson River Village	French Broad River
46	Glady Fork Trout Hatchery	Aquaculture (Agricultural)	North Sal-Tar Creek
50	The Quartz Corp USA (K-T Feldspar)	Pine Mountain	North Toe River
56a	B.V. Hedrick Gravel And Sand Co.	North Buncombe Quarry	Pond#1 (Stream)
56b	B.V. Hedrick Gravel And Sand Co.	North Buncombe Quarry	Pumo 3 (Stream)
59	Unimin Corporation (Feldspar Corp./Quartz Corp)	Quartz Operation (Quartz/Feldspar Facility)	North Toe River
60	Unimin Corporation (Feldspar Corp./Quartz Corp)	Red Hill Quartz Processing Plant (Red Hill Facility)	Toe River Intake
64	Unimin Corporation (Feldspar Corp./Quartz Corp)	Schoolhouse Quartz Facility	N. Toe River Intake
65	Shadow Creek Trout Farm	Aquaculture (Agricultural)	Shope Creek
70	The Quartz Corp USA (The Feldspar Corporation)	The Feldspar Corporation	Grassy Creek

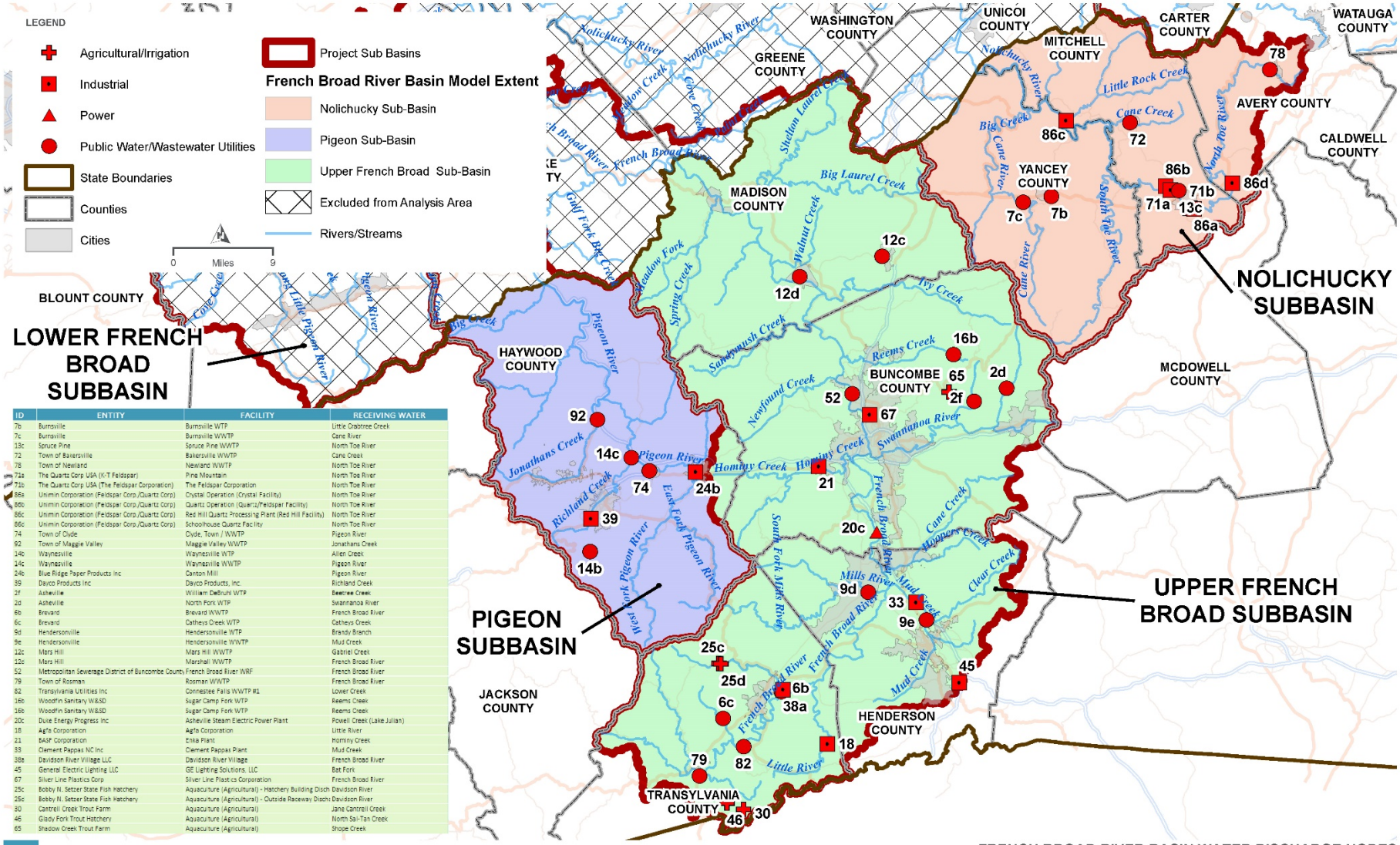
FRENCH BROAD BASIN WATER WITHDRAWAL NODES
FLOW MODIFICATION POINTS
FIGURE 4A

Municipal and Industrial Discharges – Data Collection

- Quantify water use for:
  - Municipal (public & private) water systems
  - Industries
    - Manufacturing
    - Mining
    - Power
    - Recreational
- Data Sources
  - NPDES records from NCDWR
    - 1994-2017
  - Individual dischargers
    - Fill in data gaps
    - Focus on 1930-1994 prior to NCDWR records
    - Provide anecdotal information (e.g. facility start and end dates, expansions, etc.)

Municipal and Industrial Discharges – Data Processing

- Data Compilation
  - 1994-present: more available/accurate
  - 1930-1993 data calculated/estimated if not provided
  - Only entities discharging ≥ 100,000 gpd (annual average day basis)
- Data Processing
  - Monthly time series for OASIS model
  - Based on facility start and end dates
  - Hindcasting missing/non-reported data
    - Developed record for 1930-2017
    - Public wastewater discharges: Linear interpolation
    - Industries: GDP for NC (U.S. Bureau of Economic Analysis)
  - Monthly discharge patterns (similar to withdrawal approach)



ID	ENTITY	FACILITY	RECEIVING WATER
7b	Burnsville	Burnsville WTP	Little Crabtree Creek
7c	Burnsville	Burnsville WWTP	Cane River
13c	Spruce Pine	Spruce Pine WWTP	North Toe River
72	Town of Bakersville	Bakersville WWTP	Cane Creek
78	Town of Newland	Newland WWTP	North Toe River
71a	The Quartz Corp USA (K-T Feldspar)	Pine Mountain	North Toe River
71b	The Quartz Corp USA (The Feldspar Corporation)	The Feldspar Corporation	North Toe River
86a	Unimin Corporation (Feldspar Corp./Quartz Corp)	Crystal Operation (Crystal Facility)	North Toe River
86b	Unimin Corporation (Feldspar Corp./Quartz Corp)	Quartz Operation (Quartz/Feldspar Facility)	North Toe River
86c	Unimin Corporation (Feldspar Corp./Quartz Corp)	Red Hill Quartz Processing Plant (Red Hill Facility)	North Toe River
86d	Unimin Corporation (Feldspar Corp./Quartz Corp)	Schoolhouse Quartz Facility	North Toe River
74	Town of Clyde	Clyde, Town / WWTP	Pigeon River
92	Town of Maggie Valley	Maggie Valley WWTP	Jonathans Creek
14b	Waynesville	Waynesville WTP	Allen Creek
14c	Waynesville	Waynesville WWTP	Pigeon River
24b	Blue Ridge Paper Products Inc	Canton Mill	Pigeon River
39	Dayco Products Inc	Dayco Products, Inc.	Richland Creek
2f	Asheville	William DeBruhl WTP	Beetree Creek
2d	Asheville	North Fork WTP	Swannanoa River
6b	Brevard	Brevard WWTP	French Broad River
6c	Brevard	Catheys Creek WTP	Catheys Creek
9d	Hendersonville	Hendersonville WTP	Brandy Branch
9e	Hendersonville	Hendersonville WWTP	Mud Creek
12c	Mars Hill	Mars Hill WWTP	Gabriel Creek
12d	Mars Hill	Marshall WWTP	French Broad River
52	Metropolitan Sewerage District of Buncombe County	French Broad River WRF	French Broad River
79	Town of Rosman	Rosman WWTP	French Broad River
82	Transylvania Utilities Inc	Connestee Falls WWTP #1	Lower Creek
16b	Woodfin Sanitary W&SD	Sugar Camp Fork WTP	Reems Creek
16b	Woodfin Sanitary W&SD	Sugar Camp Fork WTP	Reems Creek
20c	Duke Energy Progress Inc	Asheville Steam Electric Power Plant	Powell Creek (Lake Julian)
18	Agfa Corporation	Agfa Corporation	Little River
21	BASF Corporation	Enka Plant	Hominy Creek
33	Clement Pappas NC Inc	Clement Pappas Plant	Mud Creek
38a	Davidson River Village LLC	Davidson River Village	French Broad River
45	General Electric Lighting LLC	GE Lighting Solutions, LLC	Bat Fork
67	Silver Line Plastics Corp	Silver Line Plastics Corporation	French Broad River
25c	Bobby N. Setzer State Fish Hatchery	Aquaculture (Agricultural) - Hatchery Building Disch	Davidson River
25c	Bobby N. Setzer State Fish Hatchery	Aquaculture (Agricultural) - Outside Raceway Discha	Davidson River
30	Cantrell Creek Trout Farm	Aquaculture (Agricultural)	Jane Cantrell Creek
46	Glady Fork Trout Hatchery	Aquaculture (Agricultural)	North Sal-Tan Creek
65	Shadow Creek Trout Farm	Aquaculture (Agricultural)	Shope Creek

FRENCH BROAD RIVER BASIN WATER DISCHARGE NODES

FLOW MODIFICATION POINTS

FIGURE 5A

Questions???

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