Short-Rotation Woody Biomass Sustainability Project: Pre- and Post-treatment Water Quality and Hydrology Data

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Version	Changes made
January 2016	Original version. Included pre-treatment water quality and hydrology data. Data accompanied Griffiths et al. 2016 JGR-Biogeosciences.
June 2017	Added post-treatment water quality data collected through October 2015 including pesticide data and water quality data from CFTs. Data accompanied Griffiths et al. 2017 Forest Ecology and Management.

Summary:
This dataset reports the pre-treatment hydrology and pre- and post-treatment water quality data from a watershed-scale experiment that is evaluating the effects of growing short-rotation loblolly pine for bioenergy on water quality and quantity in the southeastern U.S. The experiment is taking place on the Savannah River Site, near New Ellenton, South Carolina, USA. Beginning in 2010, water quality and hydrology were measured for two years in 3 watersheds (R, B, C). At the end of February 2012, 40% of two treatment watersheds (B, C) were harvested and loblolly pine seedlings were planted and managed for bioenergy (including multiple applications of herbicides and fertilizers). Water samples were collected from stream water (weekly), riparian groundwater (monthly), groundwater beneath the uplands (monthly), throughfall (weekly), and trenches that collected shallow subsurface flow (during storms), and these data are available for the pre- and post-treatment periods. Water samples were also collected from three concentrated flow tracks that formed in watersheds B and C in the post-treatment period. Water samples were analyzed for nitrate-N, ammonium-N, soluble reactive phosphorus (SRP), and dissolved organic carbon (DOC) concentrations. Stream water samples only were analyzed for total nitrogen and total phosphorus concentrations, and select samples (usually collected seasonally) were analyzed for pesticide concentrations. Water samples were also analyzed for stable isotopes of nitrate ($\delta^{15}N$, $\delta^{18}O$), and these data are available for the pre-

treatment period. Stream flow and trench flow were measured every 10-15 minutes, and these data are available for the pre-treatment period.

Associated manuscripts:
The pre-treatment data were presented in a manuscript (Griffiths et al. 2016) that utilized stable isotope of nitrate data to describe hydrological and biological drivers of watershed N cycling and sources of stream water nitrate in the 3 study watersheds.

Both the pre-treatment and post-treatment water quality data were presented in a manuscript (Griffiths et al. 2017) that examined the water quality responses to short-rotation pine production for bioenergy.

Griffiths, N.A., C.R. Jackson, J.J. McDonnell, J. Klaus, E. Du, and M.M. Bitew. 2016. Dual nitrate isotopes clarify the role of biological processing and hydrologic flowpaths on nitrogen cycling in subtropical low-gradient watersheds. JGR-Biogeosciences 131:422-437.

Griffiths, N.A., C.R. Jackson, M.M. Bitew, A.M. Fortner, K.L. Fouts, K. McCracken, and J.R. Phillips. 2017. Water quality effects of short-rotation pine management for bioenergy feedstocks in the southeastern United States. Forest Ecology and Management 400:181-198.

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Dataset description:
Study site:
This study took place in 3 watersheds in the National Environmental Research Park on the Department of Energy's Savannah River Site (SRS), near New Ellenton, South Carolina, USA. The study watersheds are located in the Upper Atlantic Coastal Plain, a region characterized by a humid subtropical climate. Additional information on the climate, geology, and ecology of the SRS can be found in Kilgo and Blake (2005).

The three adjacent study watersheds (watershed R: 45 ha; watershed B: 169 ha; watershed C: 117 ha) are part of the larger Fourmile Branch watershed. The uplands have a flat topography (2-3% slope) and well-drained sandy soils with a loamy to clayey subsoil. Vegetation was primarily minimally managed pine in the uplands (*Pinus palustris, P. taiga,* and *P. elliottii*) and hardwoods in the riparian zones. Streams are characterized as blackwater (i.e., high dissolved organic matter concentrations), with intermittent flow and a sandy benthic substrate. A more detailed site description can be found in Du et al. (2016), Griffiths et al. (2016, 2017), Jackson et al. (2016), and Klaus et al. (2015).

Sampling methods:
The pre-treatment period was designated as January 2010 through February 2012, and the post-treatment period was designated as after February 28, 2012. Water samples were collected from streams, riparian groundwater, groundwater beneath the uplands, interflow, concentrated flow tracks, and throughfall. Samples were not collected when the sites were dry (e.g., stream water sampling stopped because of a regional drought, no samples collected from throughfall samplers when there was no or little throughfall in a given week, etc).

Stream water samples were collected weekly at the outlet of each watershed and at an ephemerally flowing location upstream of the outlet. Stream water temperature was measured using a hand-held temperature and conductivity probe when the sample was collected. Riparian groundwater samples were collected monthly from two wells that were located near the watershed outlet ('intermittent'), and two wells that were located upstream ('ephemeral'). Groundwater was sampled monthly from 19 wells that were located across the 3 watersheds and within the larger Fourmile watershed (see Griffiths et al. 2017 for location of the wells). The well names (FHR = forest hydrology research) and well depths (from surface soil to well screen) were:

- watershed R (FHR004 [13.1 m], 005 [13.0 m], 010 [6.4 m])
- watershed B (FHR014 [14.2 m], 014D [25.6 m], 015 [16.6 m], 015D [37.6 m])
- watershed C (FHR001 [3.9 m], 011D [25.6 m], 012 [10.6 m], 013 [19.3 m], 013D [43.6 m], 016 [13.0 m], 016D [28.6 m])
- Fourmile watershed (FHR003 [2.7 m], 006 [10.5 m], 007 [5.4 m], 008 [6.8 m], 009 [12.4 m])

Shallow subsurface flow (i.e., interflow) was sampled from 5 trenches (1 per watershed in the established pine forest, and 1 each in watersheds B and C installed at the edge of the loblolly pine plantations and the riparian zone) that were constructed on contour within a hillslope. Multiple drains collected interflow from each trench face, and the drains emptied into v-notch weir boxes located downslope. A more detailed description of the trenches can be found in Du et al. (2016) and Jackson et al. (2016). Throughfall was collected in a funnel (200 cm^2) that was connected to a 3.8 L amber polypropylene bottle. Throughfall collectors were located under the canopy (3 throughfall collectors in watershed B, 3 in watershed C, 4 in watershed R). Sampling occurred weekly (when there was sufficient volume for water chemistry analysis), and water in all throughfall collectors in a given watershed was composited before collecting a sample. Sampling of concentrated flow tracks (CFTs) occurred weekly until the CFT dried up.

All water samples were brought back to the laboratory on ice, and filtered (0.7 μm) into clean polyethylene bottles (for nutrient and pesticide analyses) or amber glass vials (for DOC analysis). Stream water samples collected for total nitrogen and total phosphorus analysis were not filtered. Samples for all nutrient analyses were frozen at -20 °C until analysis, and samples for DOC and pesticides were refrigerated at 4°C until analysis.

Stream flow and trench flow:
Stream flow was measured every 15-minutes at a two-foot H-flume installed at the outlet of each watershed. Water level was measured using a pressure transducer and automated water sampler

(ISCO 6712, Teledyne ISCO, Lincoln, NE), and stream discharge was calculated based on the known configuration of the H-flume. Data were reported as mean daily discharge (L/s).

Trench flow (i.e., interflow) was measured every 10-minutes at multiple v-notch weir boxes that collected water from the trenched hillslope. Water level in each v-notch weir box was measured using a capacitance probe (Odyssey, Dataflow System, New Zealand), and outflow from all v-notch weir boxes for a given trench was summed to give the total hillslope interflow (L/s).

Chemical analysis:
Nitrate concentrations were measured using the cadmium reduction method, ammonium concentrations were measured using the phenol hypochlorite method, and soluble reactive phosphorus (SRP) concentrations were measured using the molybdate-blue method (APHA 2005) on a SEAL Analytical AA3 autoanalyzer. Dissolved organic carbon (DOC) concentrations were measured using the high-temperature combustion catalytic oxidation method on a Shimadzu TOC-L CSH/CSN analyzer. Unfiltered stream water samples were analyzed for total nitrogen (TN) and total phosphorus (TP) concentrations using the combustion oxidation and chemiluminescence detection method on a Shimadzu TOC-L CSH/CSN analyzer, and the persulfate digestion and molybdate-blue method on a SEAL Analytical AA3 autoanalyzer, respectively. Stable isotopes of nitrate were measured using the denitrifier method with *Pseudomonas aureofaciens* bacteria (Sigman et al. 2001, Casciotti et al. 2002) at the UC Davis Stable Isotope Facility. Analysis was conducted on all water samples with a nitrate concentration >14 μg N/L. The ratios of $^{15}N/^{14}N$ and $^{18}O/^{16}O$ in N_2O were measured on a Thermo Finnigan Gas Bench and PreCon trace gas concentration system with a ThermoScientific Delta V Plus isotope-ratio mass spectrometer. The pesticides sulfometuron methyl, imazapyr, glyphosate, and fipronil were analyzed using Ultra Performance Liquid Chromatography at the OMIC USA Inc., analytical facility. See Griffiths et al. (2016, 2017) for additional details.

Data files and data dictionary:
All data are in 10 comma separated (.csv) files. Missing values (including samples that were not collected) are reported as -9999.

File 1: SRWBS_pre- and post-treatment_throughfall_chem.csv
File 2: SRWBS_pre- and post-treatment_interflow_chem.csv
File 3: SRWBS_pre- and post-treatment_groundwater_chem.csv
File 4: SRWBS_pre- and post-treatment_rip_groundwater_chem.csv
File 5: SRWBS_pre- and post-treatment_stream_chem.csv
File 6: SRWBS_pre- and post-treatment_pesticides.csv
File 7: SRWBS_post-treatment_CFT_chem.csv
File 8: SRWBS_pre-treatment_nitrate_isotopes.csv
File 9: SRWBS_pre-treatment_stream_flow.csv
File 10: SRWBS_pre-treatment_trench_flow.csv

File 1: SRWBS_pre- and post-treatment_throughfall_chem.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	DATE	YYYYMMDD	Measurement date.	
2	TIME	HH:MM	Measurement time (24-h clock).	
3	WATERSHED		Watershed (R, B, or C).	
4	NH4_CONC	µg N/L	Ammonium-N concentration.	Ammonium-N concentrations were measured using the phenol-hypochlorite method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are reported.
5	NO3_CONC	µg N/L	Nitrate-N concentration.	Nitrate-N concentrations were measured using the cadmium reduction method. Detection limit is 2.0 µg N/L. Concentrations below the detection limit (DL) are reported.
6	SRP_CONC	µg P/L	Soluble reactive phosphorus concentration.	Soluble reactive phosphorus concentrations were measured using the molybdate-blue method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are reported.
7	DOC_CONC	mg C/L	Dissolved organic carbon concentration.	Dissolved organic carbon concentrations were measured using the high-temperature combustion catalytic oxidation method.

File 2: SRWBS_pre- and post-treatment_interflow_chem.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	DATE	YYYYMMDD	Measurement date.	
2	TIME	HH:MM	Measurement time (24-h clock).	
3	WATERSHED		Watershed (R, B, or C).	
4	NH4_CONC	µg N/L	Ammonium-N concentration.	Ammonium-N concentrations were measured using the phenol-hypochlorite method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are reported.
5	NO3_CONC	µg N/L	Nitrate-N concentration.	Nitrate-N concentrations were measured using the cadmium reduction method. Detection limit is 2.0 µg N/L. Concentrations below the detection limit (DL) are reported.
6	SRP_CONC	µg P/L	Soluble reactive phosphorus concentration.	Soluble reactive phosphorus concentrations were measured using the molybdate-blue method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are reported.
7	DOC_CONC	mg C/L	Dissolved organic carbon concentration.	Dissolved organic carbon concentrations were measured using the high-temperature combustion catalytic oxidation method.

File 3: SRWBS_pre- and post-treatment_groundwater_chem.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	DATE	YYYYMMDD	Measurement date.	
2	TIME	HH:MM	Measurement time (24-h clock).	
3	WATERSHED		Watershed (R, B, C, or Fourmile).	
4	WELL_ID		Well ID (FHR001, 003, 004, 005, 006, 007, 008, 009, 010, 11D, 12, 013, 13D, 014, 14D, 015, 15D,	

			016, 16D).	
5	NH4_CONC	µg N/L	Ammonium-N concentration.	Ammonium-N concentrations were measured using the phenol-hypochlorite method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are reported.
6	NO3_CONC	µg N/L	Nitrate-N concentration.	Nitrate-N concentrations were measured using the cadmium reduction method. Detection limit is 2.0 µg N/L. Concentrations below the detection limit (DL) are reported.
7	SRP_CONC	µg P/L	Soluble reactive phosphorus concentration.	Soluble reactive phosphorus concentrations were measured using the molybdate-blue method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are reported.
8	DOC_CONC	mg C/L	Dissolved organic carbon concentration.	Dissolved organic carbon concentrations were measured using the high-temperature combustion catalytic oxidation method.

File 4: SRWBS_pre- and post-treatment_rip_groundwater_chem.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	DATE	YYYYMMDD	Measurement date.	
2	TIME	HH:MM	Measurement time (24-h clock).	
3	WATERSHED		Watershed (R, B, or C).	
4	WELL_ID		Well ID (IW1, IW2). Wells located in the intermittent (I) sites.	
5	NH4_CONC	µg N/L	Ammonium-N concentration.	Ammonium-N concentrations were measured using the phenol-hypochlorite method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are reported.
6	NO3_CONC	µg N/L	Nitrate-N concentration.	Nitrate-N concentrations were measured using the cadmium reduction method. Detection limit is 2.0 µg N/L. Concentrations below the detection limit (DL) are reported.
7	SRP_CONC	µg P/L	Soluble reactive phosphorus concentration.	Soluble reactive phosphorus concentrations were measured using the molybdate-blue method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are reported.
8	DOC_CONC	mg C/L	Dissolved organic carbon concentration.	Dissolved organic carbon concentrations were measured using the high-temperature combustion catalytic oxidation method.

File 5: SRWBS_pre- and post-treatment_stream_chem.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	DATE	YYYYMMDD	Measurement date.	
2	TIME	HH:MM	Measurement time (24-h clock).	
3	WATERSHED		Watershed (R, B, or C).	
4	WATER_TEMP	°C	Stream water temperature measured in the field when the water quality sample was collected.	Hand-held temperature and conductivity probe.
5	NH4_CONC	µg N/L	Ammonium-N concentration.	Ammonium-N concentrations were measured using the phenol-hypochlorite method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are

				reported.
6	NO3_CONC	µg N/L	Nitrate-N concentration.	Nitrate-N concentrations were measured using the cadmium reduction method. Detection limit is 2.0 µg N/L. Concentrations below the detection limit (DL) are reported.
7	SRP_CONC	µg P/L	Soluble reactive phosphorus concentration.	Soluble reactive phosphorus concentrations were measured using the molybdate-blue method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are reported.
8	DOC_CONC	mg C/L	Dissolved organic carbon concentration.	Dissolved organic carbon concentrations were measured using the high-temperature combustion catalytic oxidation method.
9	TN_CONC	µg N/L	Total nitrogen concentration.	Total nitrogen-N concentrations were measured using the combustion oxidation and chemiluminescence detection method.
10	TP_CONC	µg P/L	Total phosphorus concentration.	Total phosphorus-P concentrations were measured using the persulfate digestion and molybdate-blue method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are reported.

File 6: SRWBS_pre- and post-treatment_pesticides.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	DATE	YYYYMMDD	Measurement date.	
2	TIME	HH:MM	Measurement time (24-h clock).	
3	WATERSHED		Watershed (R, B, C, or Fourmile).	
4	SAMPLE TYPE		Sample type (CFT, gw, rip_gw, stream, stream_storm, interflow).	
5	SITE_ID		Site ID for CFT (CFT0, CFT3), groundwater (FHR001, 003, 004, 005, 006, 007, 008, 009, 010, 011, 11D, 012, 013, 13D, 014, 14D, 015, 15D, 016, 16D), riparian groundwater (I = intermittent, E = ephemeral), stream (I = intermittent, E = ephemeral).	
6	GLYPHOSATE_CONC	µg/L	Glyphosate concentration.	Glyphosate concentration was measured using Ultra Performance Liquid Chromatography at the OMIC USA Inc., analytical facility. Detection limit was 2 µg /L.
7	IMAZAPYR_CONC	µg/L	Imazapyr concentration.	Imazapyr concentration was measured using Ultra Performance Liquid Chromatography at the OMIC USA Inc., analytical facility. Detection limit was 2 µg /L.
8	SULFO_CONC	µg/L	Sulfometuron methyl concentration.	Sulfometuron methyl concentration was measured using Ultra Performance Liquid Chromatography at the OMIC USA Inc., analytical facility. Detection limit was 1 µg /L. A level of 'trace' is a qualitative result below the detection limit.
9	FIPRONIL_CONC	µg/L	Fipronil concentration.	Fipronil concentration was measured using Ultra Performance Liquid Chromatography at the OMIC USA Inc., analytical facility. Detection limit was 1 µg /L.

File 7: SRWBS_ post-treatment_CFT_chem.csv

Column	Heading	Units/ Format	Description	Measurement Method

1	DATE	YYYYMMDD	Measurement date.	
2	TIME	HH:MM	Measurement time (24-h clock).	
3	WATERSHED		Watershed (B or C).	
4	CFT_ID		CFT ID (CFT0, CFT3, CFT4).	
5	NH4_CONC	µg N/L	Ammonium-N concentration.	Ammonium-N concentrations were measured using the phenol-hypochlorite method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are reported.
6	NO3_CONC	µg N/L	Nitrate-N concentration.	Nitrate-N concentrations were measured using the cadmium reduction method. Detection limit is 2.0 µg N/L. Concentrations below the detection limit (DL) are reported.
7	SRP_CONC	µg P/L	Soluble reactive phosphorus concentration.	Soluble reactive phosphorus concentrations were measured using the molybdate-blue method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are reported.
8	DOC_CONC	mg C/L	Dissolved organic carbon concentration.	Dissolved organic carbon concentrations were measured using the high-temperature combustion catalytic oxidation method.

File 8: SRWBS_pre-treatment_nitrate_isotopes.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	DATE	YYYYMMDD	Measurement date.	
2	TIME	HH:MM	Measurement time (24-h clock).	
3	WATERSHED		Watershed (R, B, or C).	
4	SAMPLE TYPE		Sample type (deep_gw, rip_gw, stream, throughfall, interflow).	
5	WELL_ID		Well ID for both deep groundwater (FHR001, 003, 004, 005, 006, 007, 008, 009, 11D, 12D, 13D, 14D, 15D, 16D) and riparian groundwater (IW1, IW2, EW1, EW2; I = intermittent, E = ephemeral).	
6	D15N	‰	Stable isotope of nitrate $\delta^{15}N$.	Stable isotope of nitrate $\delta^{15}N$ and $\delta^{18}O$ were measured using the denitrifier method with *Pseudomonas aureofaciens* bacteria at the UC Davis Stable Isotope Facility. All samples with a nitrate concentration >14 µg N/L were analyzed for stable isotopes of nitrate.
7	D18O	‰	Stable isotope of nitrate $\delta^{18}O$.	Same as above.

File 9: SRWBS_pre-treatment_stream_flow.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	DATE	YYYYMMDD	Measurement date.	
2	WATERSHED		Watershed (R, B, or C).	
3	DISCHARGE	L/s	Mean daily discharge measured at the outlet of each watershed.	Stream flow was measured every 15-minutes at a two-foot H-flume installed at the outlet of each watershed. Water level was measured using a pressure transducers and automated water sampler (ISCO 6712, Teledyne ISCO, Lincoln, NE), and stream discharge was calculated based on the known configuration of

				the H-flume.

File 10: SRWBS_pre-treatment_trench_flow.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	DATE	YYYYMMDD	Measurement date.	
2	TIME	HH:MM	Measurement time (24-h clock).	
3	WATERSHED		Watershed (R or C).	
4	DISCHARGE	L/s	Interflow measured every 10-minutes.	Trench flow (i.e., interflow) was measured every 10-minutes at multiple v-notch weir boxes that collected water from the trenched hillslope. Water level in each v-notch weir box was measured using a capacitance probe (Odyssey, Dataflow System, New Zealand), and outflow from all v-notch weir boxes for a given trench was summed.

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