

APPENDIX B –
Finalized Inflow Data Development

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Section 1. Introduction

This report provides a detailed account of the inflow development for the Roanoke River Basin. The inflow record runs from January 1930 to December 2011.¹ There are 31 streamflow gages in the basin that are used in this project. These are listed in Table 1. These gages have at least 10 years of daily data with which to make valid statistical comparisons with other gages. Most of the gages have incomplete records; they either started after 1930 or ended before 2011. Some of the gages were used just to provide more data for *fillin* (see below) when computing statistics.

The inflow dataset is based on “unimpaired” gage flows. Gages only show the actual flow in the stream; they have no information about what the flow would have been without human intervention. “Impairments” are modifications of the natural flows due to change in reservoir storage (including evaporation and precipitation on the reservoir surface) and consumptive withdrawals of water (municipal, industrial, or agricultural). If water is withdrawn above a gage and returned to the river below the gage, the impairment is the entire withdrawal.

The next section describes the process used to compute daily flows and gains. Because of the noise in the data, it is important to look at the data at each step to find unrealistic values. These are noted later.

¹ A provisional record extends beyond December 2011, but this does not account for most of the actual impairments. Future updates will require impairment data for the inflow dataset to be considered finalized.

Section 2. Data and General Procedure

The first step in building the record is to compute the unimpaired gage flows. These computations are contained in the spreadsheet *inflow_unimpairment_rrbrom.xlsx* in the 'Inflow Spreadsheets' directory. The unimpaired gage data is summarized in the *unimpaired_summary.xlsx* file. Impairments in the basin accumulate as each downstream gage is included. For example, the impairments upstream of Kerr Lake include the impairments on the Upper Roanoke River, the Dan River, and the Smith River. The unimpairment of a gage is calculated as follows:

Unimpaired gage flow = gage flow + upstream water withdrawal (by agricultural, municipal, and industrial users) – upstream discharge (water or wastewater from municipal or industrial users, including power plants) + upstream change in reservoir storage + upstream evaporation on the reservoir surface - upstream precipitation on the reservoir surface.

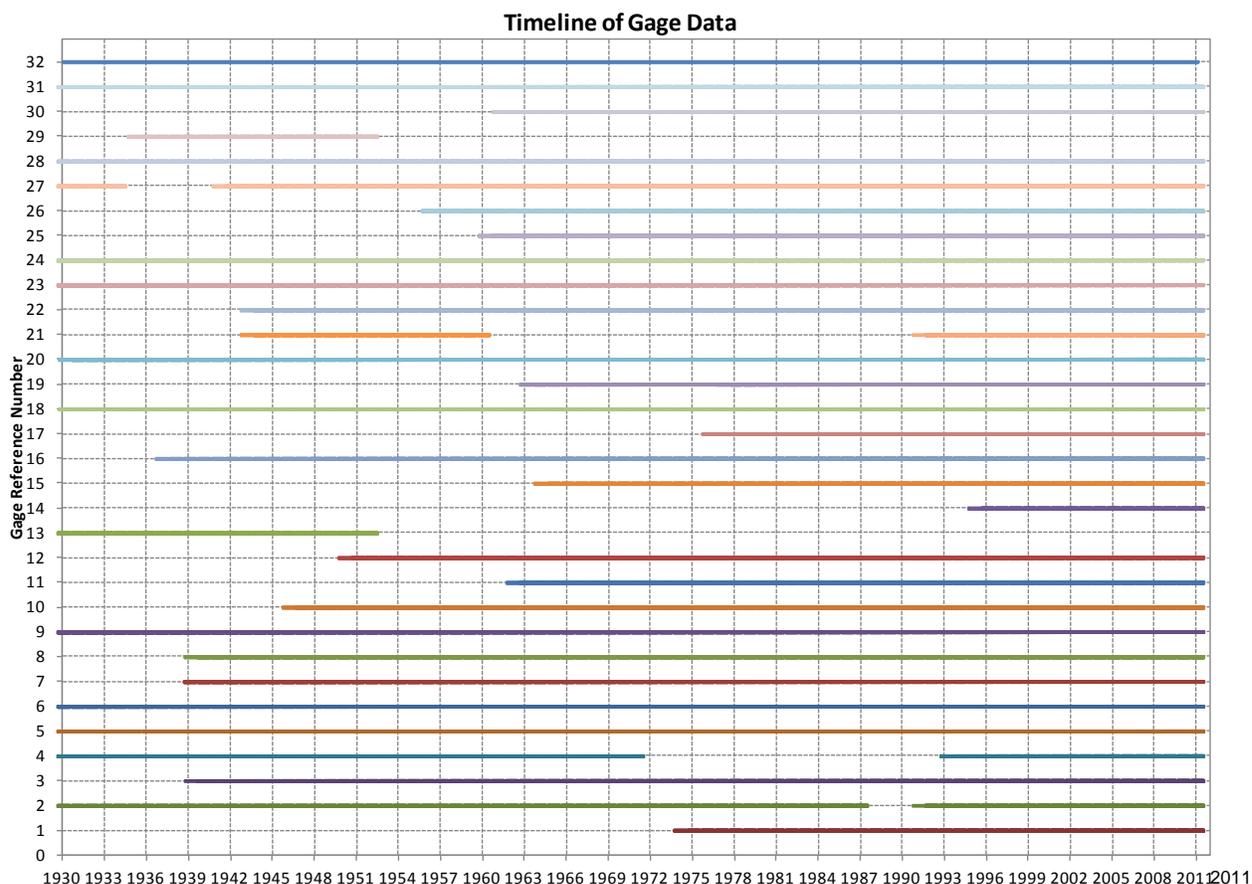
The discharge and withdrawal data were obtained by Moffatt and Nichol and NC DWR. The reservoir storage data were obtained by NC DWR from the reservoir owner/operator. Records for Philpott, Kerr, Gaston and Roanoke Rapids Reservoirs are available from the Army Corp of Engineers (Corps).

Evaporation and precipitation data were collected by HydroLogics. Evaporation data are based on daily measurements from Kerr Lake station. When measurements are missing, daily measurements from Chapel Hill, NC, or a monthly pattern based on a study of Lake Michie in Durham, NC is used. Precipitation data are based on daily measurements from the following long-term stations; Philpott Dam, Kerr Dam, Chatham, Lynchburg, South Boston, and Clarksville. Data from the station closest to a reservoir are used to estimate the precipitation at the reservoir. When these data are missing, data from the next nearest station are used, and so on. For each reservoir, HydroLogics calculated a daily timeseries of net evaporation (or the difference between evaporation and precipitation) for the hydrologic record. These data are contained in spreadsheets in the "Evap-Precip" folder. These data are used to (1) estimate the historic change in reservoir storage due to net evaporation and (2) estimate net evaporation on the reservoir surface during OASIS model simulation.

HydroLogics unimpaired the streamflow data for eleven gages, which are highlighted in bold in Table 1. The other gages are on rivers where impairments are negligible or not quantified, or not required for the inflow methodology.

Table 1. List of Gages

USGS Number	Description	Period of Record	Ref No.	Ref. Name	Drain. Area
02056650	BACK CREEK NEAR DUNDEE, VA	07/1974-Present	1	Back	55.8
02068500	DAN RIVER NEAR FRANCISCO, NC	09/1924-Present	2	Fran	129
02071000	DAN RIVER NEAR WENTWORTH, NC	12/1939-Present	3	Went	1053
02070500	MAYO RIVER NEAR PRICE, NC	08/1929-Present	4	Nmayo	242
02070000	NORTH MAYO RIVER NEAR SPENCER, VA	10/1928-Present	5	Mayo	108
02074500	SANDY RIVER NEAR DANVILLE, VA	10/1929-Present	6	Sand	111
02072500	SMITH RIVER AT BASSETT, VA	10/1939-Present	7	Bass	259
02074000	SMITH RIVER AT EDEN, NC	10/1939-Present	8	Eden	538
02073000	SMITH RIVER AT MARTINSVILLE, VA	10/1929-Present	9	Mart	379
02072000	SMITH RIVER NEAR PHILPOTT, VA	10/1946-Present	10	Phil	215
02069700	SOUTH MAYO RIVER NEAR NETTLERIDGE, VA	10/1962-Present	11	SMayo	85.5
02075500	DAN RIVER AT PACES, VA	10/1950-Present	12	Pace	2587
02076000	DAN RIVER AT SOUTH BOSTON, VA	10/1923-09/1952	13	SBos	2762
02077200	HYCO CREEK NEAR LEASBURG, NC	08/196-Present	14	Hyco	45.9
02061500	BIG OTTER RIVER NEAR EVINGTON, VA	04/1937-Present	15	BOtt	315
02056900	BLACKWATER RIVER NEAR ROCKY MOUNT, VA	10/1976-Present	16	Bck	115
02059500	GOOSE CREEK NEAR HUDDLESTON, VA	10/1930-Present	17	Goos	188
02058500	PIGG RIVER NEAR SANDY LEVEL, VA	06/1963-Present	18	Pigg	351
02060500	ROANOKE RIVER AT ALTAVISTA, VA	10/1930-Present	19	Alta	1782
02054530	ROANOKE RIVER AT GLENVAR, VA	10/1991-Present	20	Glen	281
02054500	ROANOKE RIVER AT LAFAYETTE, VA	10/1943-Present	21	Lafa	254
02056000	ROANOKE RIVER AT NIAGARA, VA	10/1926-Present	22	Niag	509
02055000	ROANOKE RIVER AT ROANOKE, VA	02/1899-Present	23	Roan	384
02053800	S F ROANOKE RIVER NEAR SHAWSVILLE, VA	10/1960-Present	24	Shaw	109
02055100	TINKER CREEK NEAR DALEVILLE, VA	05/1956-Present	25	Tink	11.7
02064000	FALLING RIVER NEAR NARUNA, VA	10/1929-Present	26	Naru	165
02062500	ROANOKE RIVER AT BROOKNEAL, VA	10/1923-Present	27	Bknl	2404
02079000	ROANOKE RIVER AT CLARKSVILLE, VA	04/1935-09/1952	28	Clrk	7393
02079640	ALLEN CREEK NEAR BOYDTON, VA	10/1961-Present	29	Alln	53.5
02080500	ROANOKE RIVER AT ROANOKE RAPIDS, NC	01/1912-Present	30	RRap	8384
02045500	NOTTOWAY RIVER NEAR STONY CREEK, VA	10/1930-Present	31	Nott	577



The second step in the inflow development process is to fill in the missing flows and gains for each gage with missing records. This requires assembling a monthly record of unimpaired flows and gains based on the daily unimpaired data computed above. These flows and gains are fed into a program named *fillin* (developed by William Alley and Alan Burns of the USGS²). We will refer to these as “extended” flows and gains. This is done on a monthly basis because *fillin* only works with monthly data. The gages associated with the flows and gains used in the remainder of this document are shown in Table 2. The third step is to apportion the extended flows and gains to make sure that their volumes match downstream unimpaired gage flows. The monthly flows and gains are then disaggregated into daily values using local, unimpaired gages. These steps are described in detail in Section 3.

The last step in the process is to compute the OASIS nodal inflows based on the flows and gains computed above. This step is described in detail in Section 4.

Before undertaking these steps, we made some simplifications to certain gage records. On the Dan River near Francisco (129 sq. mi.), the nearby South Mayo River near Nettleridge gage

² “Mixed-Station Extension of Monthly Streamflow Records,” *Journal of Hydraulic Engineering*, ASCE, Vol. 109, No. 10, October 1983.

(85.5 sq. mi.) was used to fill a gap in the record by drainage area adjustment.

On the Mayo River near Price (242 sq. mi.), the following nearby gages were used to fill a gap in the record by drainage area adjustment; North Mayo River near Spencer (108 sq. mi.) and South Mayo River near Nettleridge (85.5 sq. mi.).

On the Dan River near Paces, two gages were combined into one. The Paces gage (2587 sq. mi) had a record from 1950-present; to extend the record back to 1930, the Dan River near South Boston gage (2762 sq. mi.) was scaled back by drainage area to form a complete record at Paces.

For Kerr Lake, the gage Roanoke River near Clarksville gage (7393 sq. mi.) was scaled up to the dam (7780 sq. mi.) to provide a flow record from 1935 – 1952. From 1952 – 2011, the computed net inflow to Kerr is used.

Table 2. Gages Where Flows and Gains Are Computed

Gage	Flow or Gain	Gain Calculation
Fran	Flow	
Mayo	Flow	
Went	Gain	Went flow – Mayo flow – Fran flow
Phil	Flow	
Eden	Gain	Eden flow – Phil flow
Paces	Gain	Paces flow – Eden flow – Went flow
Alta	Gain	DA adjustment of nearby gage
Bknl	Gain	Bknl flow – Alta gain
Hyc0	Flow	
Kerr	Gain	Kerr flow – Bknl flow – Paces flow
Gaston	Gain	DA adjustment of nearby gages
Rapids	Gain	DA adjustment of nearby gages
Haml	Gain	DA adjustment of nearby gages

Note that the gains at Wentworth, Eden, Paces and Kerr are calculated with consideration made to the time of travel (flow routing) along the Roanoke. See Section 6 for more information.

The inflows for Smith Mountain and Leesville (which are represented as a combined node in the RRBR0M model) are handled differently. They are based primarily on drainage area adjustments of upstream gages, including the Roanoke River, Pigg River, and Blackwater River gages, consistent with the approach taken by a previous consultant (Mead and Hunt) on earlier lake studies. Since drainage adjustment alone results in an under-estimation of flow (an average of 250 cfs based on mass plot pre-dam comparisons with the downstream Altavista gage), we scaled up the Mead and Hunt inflows by an average of 18 percent. We made further

adjustments to the inflows based on verification runs, in which we used the scaled-up Mead and Hunt inflows, assumed a dam leakage of 300 cfs (determined from similar mass plot analyses between pre-dam and post-dam Altavista gage flows and shared with USGS staff), and forced the model to match daily historic lake elevations. We computed the daily difference between computed and historic outflow (outflow error) and regressed those against the scaled-up Mead and Hunt inflows. The finalized inflows to Smith Mountain and Leesville are the sum of the scaled-up Mead and Hunt inflows plus the predicted outflow errors from the regression. These inflows were developed as part of the Smith Mountain/Leesville relicensing efforts in 2008. Since these inflows were used by HydroLogics to craft a low flow operating protocol for the new license, the inflow methodology was preserved.

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Section 3. Computation of Extended Gage Flows and Reach Gains

All the computations outlined in this section are done on monthly data, which reduces noise and is required for statistical hydrology programs like *fillin*. Noisy data occurs when time of travel differences occur or when the impairment data create artificial variation in the flows.

First, the actual gains are determined from the unimpaired gage flows. These computations are done with the DSSVue script, *compute_gain.py*. Next, *fillin* is run to compute the extended flows and gains for the gages with missing records. Note that *fillin* preserves the actual flows and gains where they exist. These extended flows and gains are then “scaled.” The objective of scaling is to ensure that the sum of filled-in flows upstream of a gage with an actual record equals the actual unimpaired flow at that gage. The *fillin* program does not ensure this for two reasons. First, it utilizes only a single correlated record for each value generated, thus ignoring sums, and second, it works with log transforms, and not actual flows.

Here is an example. We want to compute the unimpaired gain at Wentworth (reference name for Dan River near Wentworth gage) from 1929 – 1939 when the Wentworth gain was not in place. As a result, we have no actual gain at Went. We extended the gain at Went using *fillin*. Now we want to adjust those extended values so that the sum of the flows at Fran, Mayo and Phil and the gains at Eden, Went and the remaining gain down to Paces match the unimpaired flow at Paces. So we say that we maintain the Paces flow less the known inflows to Fran, Mayo, and Phil by scaling with the sum of the Went, Eden and Paces extended gains. The calculation is:

$$\text{Scaled Went extended gain} = (\text{Pace flow} - \text{Phil flow} - \text{Mayo flow} - \text{Fran flow}) * (\text{Went extended gain}) / (\text{Pace extended gain} + \text{Went extended gain} + \text{Eden extended gain})$$

The companion calculation for the flow at Paces is:

$$\text{Scaled Pace extended gain} = (\text{Pace flow} - \text{Phil flow} - \text{Mayo flow} - \text{Fran flow}) * (\text{Pace extended gain}) / (\text{Pace extended gain} + \text{Went extended gain} + \text{Eden extended gain})$$

Thus the sum of the actual unimpaired flows/gains (Phil, Mayo, Fran) and the scaled gains (Eden, Went and Pace) equals the unimpaired gage flow at Paces, or

$$\text{Fran flow} + \text{Phil flow} + \text{Mayo flow} + \text{Went scaled gain} + \text{Eden scaled gain} + \text{Pace scaled gain} = \text{Paces unimpaired gain}$$

In this way we ensure that the total volume of all the flows and gains, be they actual or extended, upstream from a given gage match the unimpaired flow at the gage, preserving the unimpaired gaged flows.

The DSSVue script used to do these calculations is *scale_flow_gain.py*. The output is the file

scale_flow_gain.dss, which contains monthly flows and gains.

The next step is to disaggregate the monthly flows into daily flows. This is done using flows for a daily, unimpaired gage that is local or has similar drainage area (call it a “reference gage”) along with our monthly flows. We multiply the monthly value by the ratio of that day’s flow to that month’s flow at the reference gage. The disaggregation formula is:

$$\begin{aligned} \text{daily ratio} &= \text{daily reference value} / \text{monthly reference value} \\ \text{daily computed value} &= \text{monthly computed value} * \text{daily ratio} \end{aligned}$$

Two DSSVue scripts are used to do this step: *convert_month_to_day.py* and *disaggregate.py*. DSSVue cannot work on two records with different time steps, so the first step is to convert the monthly value to daily. For example, the flow at Fran for January 1930 is 207 cfs; converting the monthly flow to daily gives 207 cfs for each day in the month. The first script converts the monthly flows to daily flows for each location where we need them. The second script computes the daily flows and gains as shown above.

It is important to note that we are not trying to replicate history in computing the OASIS inflows; rather, we are trying to build daily flows whose variation is *representative* of history while preserving unimpaired gaged flows as “ground truth”.

Note that actual daily values of unimpaired gage *flows* are often maintained in the script files. Actual daily *gains* between gages are generally not maintained due to their “noise”, so the script files aggregate them monthly and then disaggregate them back to daily values using a locally unimpaired gage. Therefore, actual flows and gains on a monthly basis are maintained, but generally the former will only be maintained on a daily basis.

The remainder of this section shows the details in how the records were extended and disaggregated. This is the short hand used in the remainder of this document:

d/s = downstream
u/s = upstream
DA = drainage area
F = actual or scaled flow at a gage
XF = “extended” flow at a gage as computed by *fillin* when actual flows do not exist
G = actual or scaled gain, or inflow, between two locations, which is the difference of u/s gage F and d/s gage F
XG = extended gain between two locations as computed by *fillin* when actual gains do not exist

Dan River near Wentworth GAIN (Went), 10/1929 – 11/1939

$$10/29 - 09/39 \text{ WentG} = (\text{PaceF} - \text{PhilFr} - \text{MayoF} - \text{FranFr}) * \text{WentXG} \\ / (\text{PaceXG} + \text{WentXG} + \text{EdenXG})$$

$$10/39 - 11/39 \text{ WentG} = (\text{PacesF} - \text{PhilFr} - \text{MayoF} - \text{FranFr} - \text{EdenG}) * \text{WentXG} \\ / (\text{PaceXG} + \text{WentXG})$$

$$12/39 - 12/11 \text{ WentG} = \text{WentF} - \text{FranF} - \text{MayoF}$$

Disaggregate using Fran.

Smith River near Eden GAIN (Eden), 10/1929 – 09/1939

$$10/29 - 09/39 \text{ EdenG} = (\text{PaceF} - \text{PhilFr} - \text{MayoF} - \text{FranFr}) * \text{EdenXG} \\ / (\text{PaceXG} + \text{WentXG} + \text{EdenXG})$$

$$10/39 - 12/11 \text{ EdenG} = \text{EdenF} - \text{PhilF}$$

Disaggregate using Mayo.

Dan River near Paces GAIN (Pace), 10/1929 – 11/1939

$$10/29 - 09/39 \text{ PaceG} = (\text{PaceF} - \text{PhilFr} - \text{MayoF} - \text{FranFr}) * \text{PaceXG} \\ / (\text{PaceXG} + \text{WentXG} + \text{EdenXG})$$

$$10/39 - 11/39 \text{ PaceG} = (\text{PacesF} - \text{PhilFr} - \text{MayoF} - \text{FranFr} - \text{EdenG}) * \text{PaceXG} \\ / (\text{PaceXG} + \text{WentXG})$$

$$12/39 - 12/11 \text{ PaceG} = \text{PaceF} - \text{EdenF} - \text{WentF}$$

Disaggregate using Sandy River nr Danville.

Roanoke River near Brookneal GAIN (Bknl), 10/1929 – 09/1930

$$10/29 - 09/30 \text{ BknlG} = (\text{RapdF} - \text{KerrF} - \text{PaceFr}) * \text{BknlXG} \\ / (\text{BknlXG} + \text{KerrXG} + \text{RapdXG})$$

$$10/30 - 12/11 \text{ BknlG} = \text{BknlF} - \text{AltaF}$$

Disaggregate using Goose Ck.

Kerr Lake GAIN (Kerr), 10/1929 – 03/1935

$$10/29 - 09/30 \text{ KerrG} = (\text{RapdF} - \text{KerrF} - \text{PaceFr}) * \text{KerrXG} \\ / (\text{BknlXG} + \text{KerrXG} + \text{RapdXG})$$

$$10/30 - 03/35 \text{ KerrG} = (\text{RapdF} - \text{KerrF} - \text{PaceFr} - \text{BknlG}) * \text{KerrXG} \\ / (\text{KerrXG} + \text{RapdXG})$$

$$04/35 - 12/11 \text{ KerrG} = \text{KerrF} - \text{BknlF} - \text{PaceF}$$

Disaggregate using Mehr.

The result of the computations in this section is a set of monthly and daily flows and gains at each of the locations shown in Table 2.

Section 4. Computing Inflows at OASIS Nodes from the Flows and Gains

This section describes the computation of inflows at OASIS nodes from flows and gains at gages described above. The computations are done “on the fly” during an OASIS run called “Compute_Inflows” using ratios of drainage area (total or incremental) as shown in Table 3 below. The computations are included in an OCL file called *set_inflows.ocl* and are listed below.

Node 100 (Smith Mtn Res)	SM_Lee Flow
Node 210 (Goose Ck)	GCrk Flow
Node 220 (Altavista)	Alta Gain
Node 240 (Brookneal)	Bknl Gain
Node 304 (Joyce Mill)	Fran Flow * 72.4 / 129
Node 306 (Francisco)	Fran Flow * 56.6 / 129
Node 308 (Moores Spring)	Went Gain * 101 / 924
Node 314 (Madison)	Went Gain * 370 / 924
Node 330 (Wentworth)	Went Gain * 453 / 924
Node 320 (Mayo)	Mayo Flow
Node 300 (Philpott Res)	Phil Flow
Node 340 (Eden)	Eden Gain
Node 349 (Paces)	Pace Gain
Node 360 (Hyco Lake)	Hyco Flow * 189 / 49.9
Node 380 (Mayo Lake)	Hyco Flow * 52.2 / 49.9
Node 400 (Kerr Lake)	Kerr Gain – inflow360 – inflow380
Node 600 (Gaston Lake)	Gast Gain
Node 700 (RRapids Res)	Rapd Gain
Node 800 (Hamilton)	Haml Gain

Table 3. List of Drainage Areas (in square miles)

Reservoirs			Gages		
Description	Total Drainage Area	Incremental Drainage Area	Description	Total Drainage Area	Incremental Drainage Area
Smith Mt/Leesville	1507	1507	Goose Creek Huddleston	188	188
Philpott	212	212	Roanoke River Altavista	1782	87
Hyc0	189	189	Roanoke River Brookneal	2404	622
Mayo	52.2	52.2	Dan River Joyce Mill	72.4	72.4
Kerr	7780	2443	Dan River Francisco	129	56.6
Gaston	8319	539	Dan River Moores Spring	230	101
Roanoke Rapids	8375	56	Dan River Madison	499	269
			Mayo River Price	242	242
			Dan River Wentworth	1053	924
			Smith River Eden	550	338
			Dan River Paces	2692	1089

Section 5. Error Checking and Inflow Filtering

As noted in Section 1, because of the noisy data, a lot of error checking is necessary. These are some of the errors that can occur. Often the available impairment data is only available on a monthly average basis, which can cause issues when applying to daily gage flows.

- Negative unimpaired gage flow. These are physically impossible and should be corrected unless the value is small, say between 0 and -10 cfs, because the impact is negligible.
- Negative gains. These are sometimes legitimate. However, there are times when a flood hits a gage at the very end of the month, while not arriving at the gage downstream until the beginning of the next month. This can cause a highly negative gain in the first month and a highly positive gain the next month. These should be corrected.
- There are pathological cases where the scaling can cause one gage to have a large positive flow, while the adjacent gage has a large negative flow. This can occur when the two extended values are similar in magnitude but opposite in sign. These need to be adjusted.
- For this work, the changes are tracked in the file *hand_mods_rrbrom.xlsx*.

No daily adjustments were made for the basin. Monthly flows were adjusted in the “month_unimp” sheet of *hand_mods_rrbrom.xlsx*. Revisions were done for Paces, Brookneal, and Kerr gains in the *unimpaired.dss*.

An example of a negative monthly gain occurred on September 2005 at Paces; a large inflow at the end of the month upstream did not travel down to Paces until the beginning of the next month:

	<u>09/2005</u>	<u>10/2005</u>
WentF	498 cfs	1126 cfs
EdenF	349 cfs	704 cfs
PaceF	806 cfs	2143 cfs

This leads to values of -41 cfs and 313 cfs for the Paces gain in September and October, respectively. A manual adjustment was then made by adding 100 cfs to the Paces flow in September, and subtracting 100 cfs from the Paces flow in October, which eliminates the negative gain in September and maintains the total volume over the two month period.

To prevent model infeasibility from provisional inflows (see Appendix C), unrealistic releases from upstream reservoirs, or unrealistic water supply shortages, we added code in the OCL to filter remaining daily negative inflows. The negative inflow is “stored” until there is a sufficiently positive inflow to release the accumulated negative flows, thereby preserving mass over a multi-day period.

Since the negative inflows are generally very small and infrequent, the filtering has negligible impact on being able to match the monthly unimpaired gage flow.

To test that all flows, gains, and drainage areas have been properly accounted for, we check that the “reconstituted,” unimpaired gage flows match the actual unimpaired gage flows. In this case, reconstituted means that the flow at a given gage is computed by summing the appropriate upstream flows and gains. File *gage_compe.xlsx* compares the actual monthly unimpaired gage flows with the computed values from *flows_gains_month.dss*. To test that all the drainage areas have been properly accounted for, file *model_comp.xlsx* compares the same actual unimpaired gage flows to the gage flows reconstituted from the computed OASIS inflows.

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Section 6. Time of Travel / Flow Routing

To account for time of travel between points along the main stem of the Roanoke River, flow routing has been incorporated into both the development of inflows, and the handling of flows within the model. The time of travel or lag coefficients were furnished by the Corp of Engineers. The time of travel reaches consist of Francisco to Wentworth, Philpott to Eden, Wentworth/Eden to Paces, Paces/Brookneal to Kerr, and Rapids to Hamilton. Flow routing for the development of inflows is handled in *inflow_unimpairment_rrbrom.xlsx*. Flow routing within the model is handled in the OCL file *routing.ocl*. The routing equations used for each gain are as follows:

Routed Francisco flow = yesterday's flow

Wentworth gain = Wentworth flow - yesterday's Francisco Flow

Routed Philpott flow/release = yesterday's flow/release

Eden gain = Philpott flow – yesterday's Philpott flow/release

Routed Brookneal Flow = [flow(-2 days) + flow(-1 day)] / 2

Routed Paces Flow = yesterday's flow

Kerr gain = Kerr flow - previous two day average of Brookneal flows – yesterday's Paces flow

Routed Rapids release = [flow(-5 days) + flow(-4 day)] / 2

Hamilton gain = Hamilton Flow – 2 day Rapids release, lagged 3 days

Note that the computation of gains may include subtracting the flows from tributaries in the reach (see Section 3), which are not routed.

The daily routed timeseries are averaged monthly; the monthly flows are used to compute gains for the above mentioned reaches by subtracting from the monthly downstream un-routed flow. No routing is necessary when disaggregating to daily flows since gains are disaggregated using a representative local unimpaired gage flow.

For inflow development, upstream flows are routed before being subtracted from the downstream flow to compute a gain. In the model runs, routing is handled using a routing reservoir, which holds back upstream flows for the appropriate amount of time before releasing downstream.

Section 7. Extending the Record Beyond December 2011

As mentioned earlier, the finalized inflow record ends on December 31, 2011. This section describes how to finalize updates to the record when new records (including impairments) become available. This is not to be confused with *provisional* updates used to facilitate real-time forecasting, which are done directly from the model interface using the Update Record tab. Let us assume that we are adding data from January 1, 2012 to December 31, 2012. Note that we are only adding to the record. We are not changing any of the values prior to January 2012.

1. Assemble the new data for the gage records in Table 4 below and place in the files *gage_day.dss* and *gage_month.dss*.
2. Compute the impairments at each gage and add them to the gage flows. This has been done in the unimpairment spreadsheets described earlier (called *inflow_unimpairment_rrbrom.xlsx*). Next put the daily unimpaired flows into the spreadsheet *unimpaired_summary.xlsx* to compute the monthly unimpaired flows using a spreadsheet pivot table.
3. Append the new unimpaired flows to the *unimpaired.dss* file (monthly averages) and to the *unimpaired_daily.dss* file (daily data) where appropriate. Note that the Bknl, Fran, Went, Phil, Eden, and Pace flows need to include both routed (indicated in the “F-Part” of the DSS record) and unrouted records.
4. Copy the following files into the folder *c:\Program Files\HecDssVue* (assuming the DSSVue has been installed in the default location). Update the *fillin.cf* so the ending year is 2012.

fillin.cf
fillin.exe
gage_day.dss
gage_month.dss
path_list.dat
unimpaired.dss
unimpaired_daily.dss

5. Copy the following files in folder of *c:\Program Files\HEC\HecDssVue\HecDssVue\scripts*. If extending the record to a year beyond 2011, be sure to change the ending years in the script from either '11 or 2011 to the appropriate year. Use the script files from the folder “scripts_2012”, in which this change has already been made.

compute_gain.py
convert_day_to_month.py
convert_month_to_day.py
disaggregate.py
scale_flow_gain.py

6. Transfer the monthly flows from *unimpaired.dss* to *hand_mods.xlsx*. Here perform necessary modifications to remove negative gains from the records, following the examples of previous modifications. Then paste the modified flows and routed flows back into *unimpaired.dss* and *extend_flow_gain.dss*.
7. Execute the script *01_compute_gain.py*. This reads from file *unimpaired.dss*, computes all the gains, and writes to the files *extend_flow_gain.dss*, *scale_flow_gain.dss*, and *fillin_input.dss*.
8. Close DSSVUE, and execute *fillin* by double-clicking it. This updates the file *extend_flow_gain.dss* with filled-in flows. Thus, this file is a combination of the actual unimpaired values and extended values.
9. Open up DSSVue again, execute the script *02_scale_flow_gain.py*, which does the calculations described in Section 3. This reads from file *extend_flow_gain.dss* and updates file *scale_flow_gain.dss*.
10. Import the appropriate flows and gains from *scale_flow_gain.dss* into *hand_mod.xlsx* and perform hand modifications to remove negative flows and gains. Paste modified flows/gains back into *scale_flow_gain.dss*.
11. Execute the script *03_convert_month_to_day.py*. This reads from files *gage_month.dss* and *scale_flow_gain.dss* to generate a daily record from the monthly records. The daily records are used to disaggregate the flows, as shown in Section 3. File *month_day.dss* is written.
12. Execute the script *04_disaggregate.py* to convert the monthly flows and gains at the gages to daily. File *flow_gain.dss* is produced; this file has the data that are read by OASIS.
13. Execute the script *05_convert_day_to_month.py* to convert the daily flows and gains at the gages into monthly values. The purpose of this step is to import the monthly flows and gains into *gage_comp.xlsx* to ensure that all the accounting has been properly done.
14. Enter the Smith Mountain inflows as “SM_Lee/flow” into *flows_gains.dss*. These flows are automatically calculated from the provisional inflow update described in Appendix C and be found in a *basedata.dss* under the record “100/inflow” once it has been provisionally updated through at least December 31, 2012.
15. Execute the OASIS run called “Compute_Inflows”, beginning Jan 1, 2012 and ending December 31, 2012. This run contains a file called “set_inflows.ocl” that assigns inflows to the OASIS nodes.

Then go to the run folder, open the *output.dss* file, click View → Refresh Catalog. Select all of the inflow nodes (i.e, those which have a pathname labeled inflow) and convert from acre feet (af) to cubic feet per second (cfs) by doing the following: click Utilities → Math Functions. On

the Arithmetic tab, select Divide from the pull down menu, click the Data Set radio button, and highlight all of the inflow records, click the Constant radio button and enter 1.9835 into the field, and then press the Compute button at the bottom of the window. Once the computation has completed, close the Math Functions window and click Yes when prompted to save the changes. Now select all of the inflow records and click Edit → Tabular Edit, and change all of the units to cfs, and all of the units Type to PER-AVER. Close the editing window and save your changes.

Next select all of the records, and copy and append to the *basedata.dss* file in the basedata folder. The basedata file will now contain this finalized data from January 1, 2012 to December 31, 2012. This basedata file will be used for all future runs.

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Table 4. Gages Used to Extend the Record Beyond December 2011

USGS Number	Description	Period of Record	Ref. Name	Drain. Area
02056650	BACK CREEK NEAR DUNDEE, VA	07/1974-Present	Back	55.8
02068500	DAN RIVER NEAR FRANCISCO, NC	09/1924-Present	Fran	129
02071000	DAN RIVER NEAR WENTWORTH, NC	12/1939-Present	Went	1053
02070500	MAYO RIVER NEAR PRICE, NC	08/1929-Present	Nmayo	242
02070000	NORTH MAYO RIVER NEAR SPENCER, VA	10/1928-Present	Mayo	108
02074500	SANDY RIVER NEAR DANVILLE, VA	10/1929-Present	Sand	111
02072500	SMITH RIVER AT BASSETT, VA	10/1939-Present	Bass	259
02074000	SMITH RIVER AT EDEN, NC	10/1939-Present	Eden	538
02073000	SMITH RIVER AT MARTINSVILLE, VA	10/1929-Present	Mart	379
02072000	SMITH RIVER NEAR PHILPOTT, VA	10/1946-Present	Phil	215
02069700	SOUTH MAYO RIVER NEAR NETTLERIDGE, VA	10/1962-Present	SMayo	85.5
02075500	DAN RIVER AT PACES, VA	10/1950-Present	Pace	2587
02077200	HYCO CREEK NEAR LEASBURG, NC	08/196-Present	Hyco	45.9
02061500	BIG OTTER RIVER NEAR EVINGTON, VA	04/1937-Present	BOtt	315
02056900	BLACKWATER RIVER NEAR ROCKY MOUNT, VA	10/1976-Present	Blck	115
02059500	GOOSE CREEK NEAR HUDDLESTON, VA	10/1930-Present	Goos	188
02058500	PIGG RIVER NEAR SANDY LEVEL, VA	06/1963-Present	Pigg	351
02060500	ROANOKE RIVER AT ALTAVISTA, VA	10/1930-Present	Alta	1782
02054530	ROANOKE RIVER AT GLENVAR, VA	10/1991-Present	Glen	281
02054500	ROANOKE RIVER AT LAFAYETTE, VA	10/1943-Present	Lafa	254
02056000	ROANOKE RIVER AT NIAGARA, VA	10/1926-Present	Niag	509
02055000	ROANOKE RIVER AT ROANOKE, VA	02/1899-Present	Roan	384
02053800	S F ROANOKE RIVER NEAR SHAWSVILLE, VA	10/1960-Present	Shaw	109
02055100	TINKER CREEK NEAR DALEVILLE, VA	05/1956-Present	Tink	11.7
02064000	FALLING RIVER NEAR NARUNA, VA	10/1929-Present	Naru	165
02062500	ROANOKE RIVER AT BROOKNEAL, VA	10/1923-Present	Bknl	2404
02079640	ALLEN CREEK NEAR BOYDTON, VA	10/1961-Present	Alln	53.5
02080500	ROANOKE RIVER AT ROANOKE RAPIDS, NC	01/1912-Present	RRap	8384
02045500	NOTTOWAY RIVER NEAR STONY CREEK, VA	10/1930-Present	Nott	577