STUDY OF

CUMULATIVE HYDROLOGIC IMPACTS

For

ALABAMA – COOSA – TALLAPOOSA (ACT)

RIVER BASIN

The Etowah Water and Sewer Authority
Paulding County Water System

September 30, 2014

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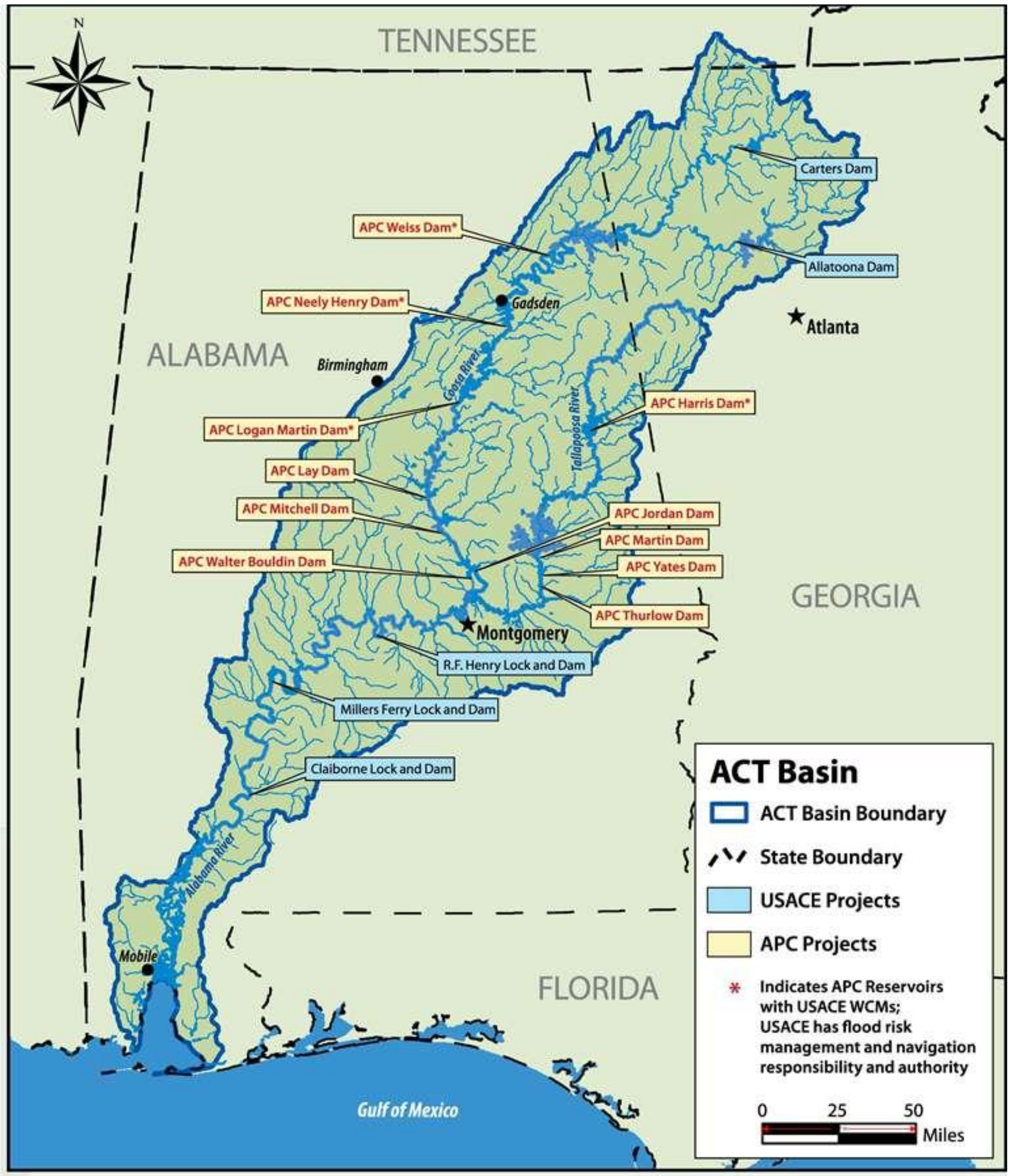

Figure A: Map of ACT River Basin
(Map courtesy of U.S. Army Corps of Engineers)

1.1 Purpose of Study

This study was commissioned jointly by the Paulding County Water System and the Etowah Water and Sewer Authority at the request of the U. S. Army Corps of Engineers for purposes of evaluating hydrologic impacts with projects for which 404 Permit applications are being evaluated. The purpose of this study is to demonstrate expected alterations to stream flow in the 22,800 square mile Alabama-Coosa-Tallapoosa (ACT) river basin system that would result from expected future increases in water supply demand in the State of Georgia, including construction and operation of three proposed water supply reservoirs located in the Georgia portion of the ACT basin. The proposed reservoirs include the Etowah Water & Sewer Authority's Russell Creek Reservoir in Dawson County, GA, Paulding County's Richland Creek Reservoir located below Lake Allatoona, and the Indian Creek Reservoir proposed by the Carroll County Water and Sewer Authority on the Little Tallapoosa River basin.

This analysis was conducted by HydroLogics, Inc. using the U. S. Army Corps of Engineers' August 2011 RES SIM model of the ACT basin. The Corps' model simulates stream flow and reservoir operation throughout the ACT river system over a 70-year time period from 1939 through 2008, taking into account daily variations of natural and man-made influences upon the river system such as stream flow, water withdrawals, water inputs, reservoir operations, etc. The model was expanded to analyze future conditions, including the aforementioned water supply reservoirs and associated returns.

The Corps' base model includes operating variables associated with existing federally-owned reservoirs as well as reservoirs owned by Alabama Power Company. The base model also accounts for existing withdrawals and discharges to the system. Using this baseline model, additional scenarios as described in Table 1 were analyzed to evaluate incremental and cumulative impacts of future water supply projects in the State of Georgia. The Hickory Log Creek Reservoir, which was completed subsequent to the 2008 base year, was added to the base separately from the three proposed water supply reservoirs listed in paragraph one. Future water withdrawals and wastewater discharges throughout Georgia's portion of the ACT basin were obtained from Georgia EPD for year 2040 (consistent with Georgia's water allocation request), and were combined with data for the three proposed water supply projects that were modeled under this study.

Evaluation of study output utilized the Corps of Engineers standardized excel spreadsheets for use with the RES SIM model. These spreadsheets were populated with results from model runs for each modeled scenario. The standardized Corps output format displays results for five pre-defined impact categories, including:

- Impacts to stream flow
- Impacts to hydroelectric power production capability
- Impacts to river navigation
- Impacts to drought operations on federally-controlled reservoirs
- Impacts to lake levels

The overview that follows is a summary of study findings for each of the five types of impacts when comparing future conditions *without* and *with* the three pending water supply projects.

1.2 Summary of Findings

The study findings are summarized as follows:

- Impacts of the three proposed water supply reservoirs to stream flow, hydropower, navigation, drought operations, pool levels, and recreation are very small, typically less than 1 percent of impact category. Impacts were small and both beneficial and non-beneficial.
- Non-beneficial impacts from the proposed water supply reservoirs typically occur during winter or spring periods of higher stream flow when the water supply reservoirs are refilling; whereas, benefits from the projects tend to occur during dry periods when stream withdrawals associated with the proposed water supply reservoirs will comply with Georgia regulations for low flow protection.
- The relocation of a portion of Paulding County's demand from Lake Allatoona to the Richland Creek Reservoir provides some benefit to Allatoona lake levels, hydropower generation, and flows in the downstream reach.

1.3 Modeled Scenarios

A description of the six modeled scenarios is included in Table 1.

Table 1. Modeled scenarios

Scenario I.D.	Description	Comments
1	Current demands as modeled by Corps, no additional reservoirs, present ACT operations manual	Run completed by the Corps ("Baseline")
2	Current demands as modeled by Corps, no additional reservoirs, proposed Allatoona operations manual	Run completed by the Corps ("Alt G"); Difference in #1 vs #2 shows impact of proposed Allatoona operation manual.
3	Same as #2 except Hickory Log Creek Reservoir (HLCR) is added	Difference in #3 vs #2 isolates implementation of HLCR as independent operation (per Corps directive)
4 (without projects 2040)	Same as #3 except with GA year 2040 water supply demand	Demonstrates effect of GA's 2040 Water Supply Demand projections and provides datum for contrasting Scenarios 5 and 6.
5 (with projects 2040)	Same as #4 except that three proposed reservoirs & their nodes are added to model with year 2040 demand	Demonstrates impacts of 3 new reservoirs in conjunction with 2040 water supply demands (Scenario 4) and cumulative impacts of GA future conditions.

Scenario I.D.	Description	Comments
6 (with projects full yield)	Same as #5 except that three proposed reservoirs & their nodes are operated at their requested yield	Demonstrates incremental impact of the full yield of the 3 water supply reservoirs projects and cumulative impacts in consideration of existing conditions. .

Scenario 1 represents current ACT conditions while Scenario 2 incorporates prospective operations within the ACT upon implementation of the Corps' proposed Water Control Manual update. Scenarios 3 through 6 incrementally incorporate operations of the Hickory Log Creek project plus the three proposed reservoir projects. The Hickory Log Creek Reservoir is constructed; however, it is not completely operational.

The incremental impacts of the proposed reservoirs are captured by comparing Scenarios 4 and 5 and Scenarios 4 and 6. Scenario 4 includes the proposed basin-wide operational changes for the water control manual update (the Corps of Engineer's run "Alt G"), HLCR operated as permitted (33 mgd of Cobb County Marietta Water Authority's Lake Allatoona withdrawal moved to the Canton node to be supported by HLCR releases), and the State of Georgia's Water Supply Request demand numbers throughout the state.[1] Scenario 5 incorporates the previous assumptions while adding the three proposed reservoirs to the model. Scenario 6 includes conditions established in the previous scenario with the Russell, Richland, and Indian Creek reservoirs operating at full capacity.[2] Therefore, the Scenario 4 vs 5 comparison shows the impact of operating the proposed reservoirs at the year 2040 conditions, while the Scenario 4 vs 6 comparison shows the impact of the operations of the proposed reservoirs at their fully-permitted capacity.

Figure 2 shows locations of river nodes used in the RES SIM model for existing conditions and Figure 3 shows model nodes with the proposed projects added to the model.

[1] The Alabama demands were not increased; they remain at the 2006 levels modeled by the Corps of Engineers.
[2] Safe yield levels were taken from previous studies.

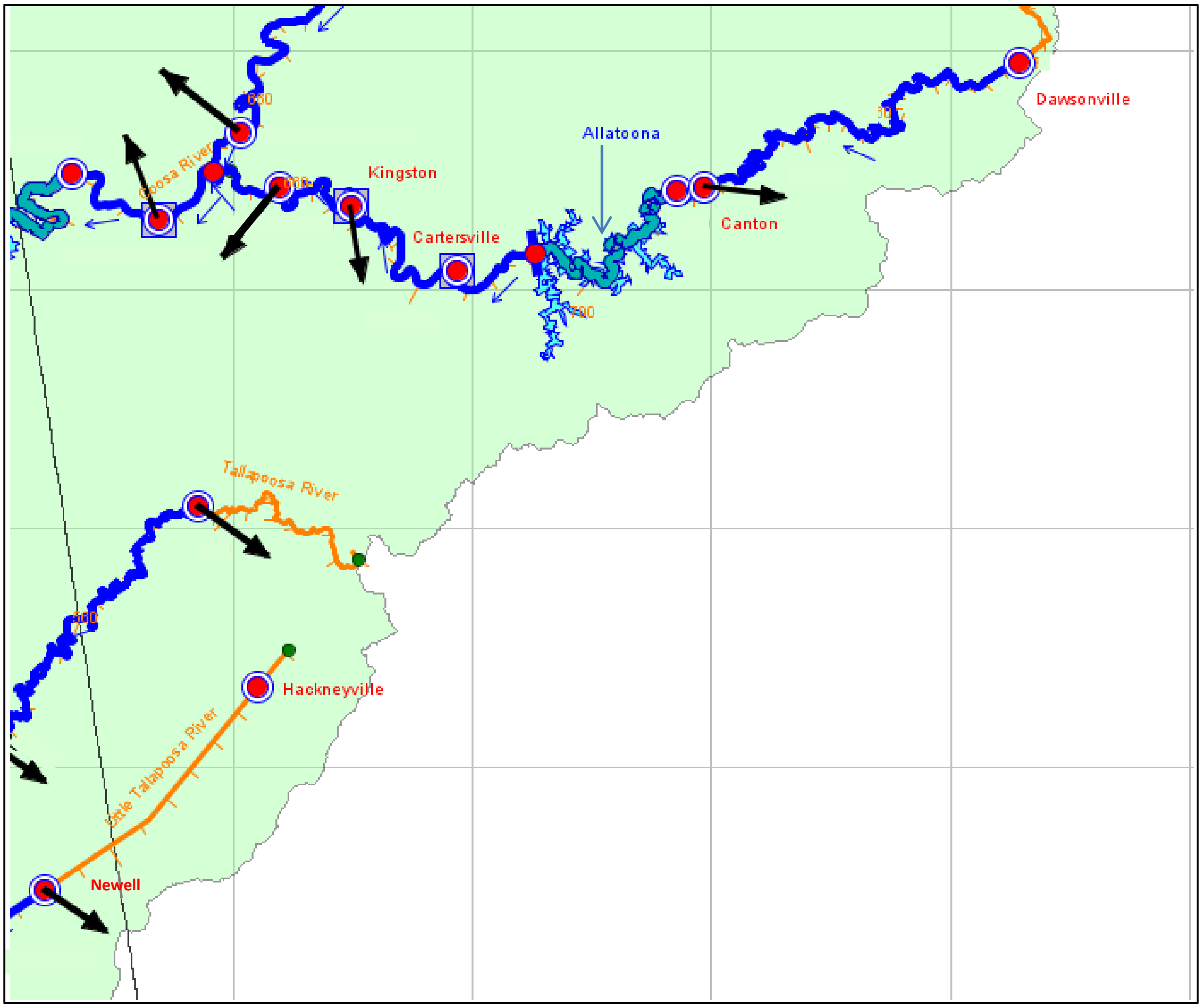

Figure B: River Nodes for Model – Existing Conditions

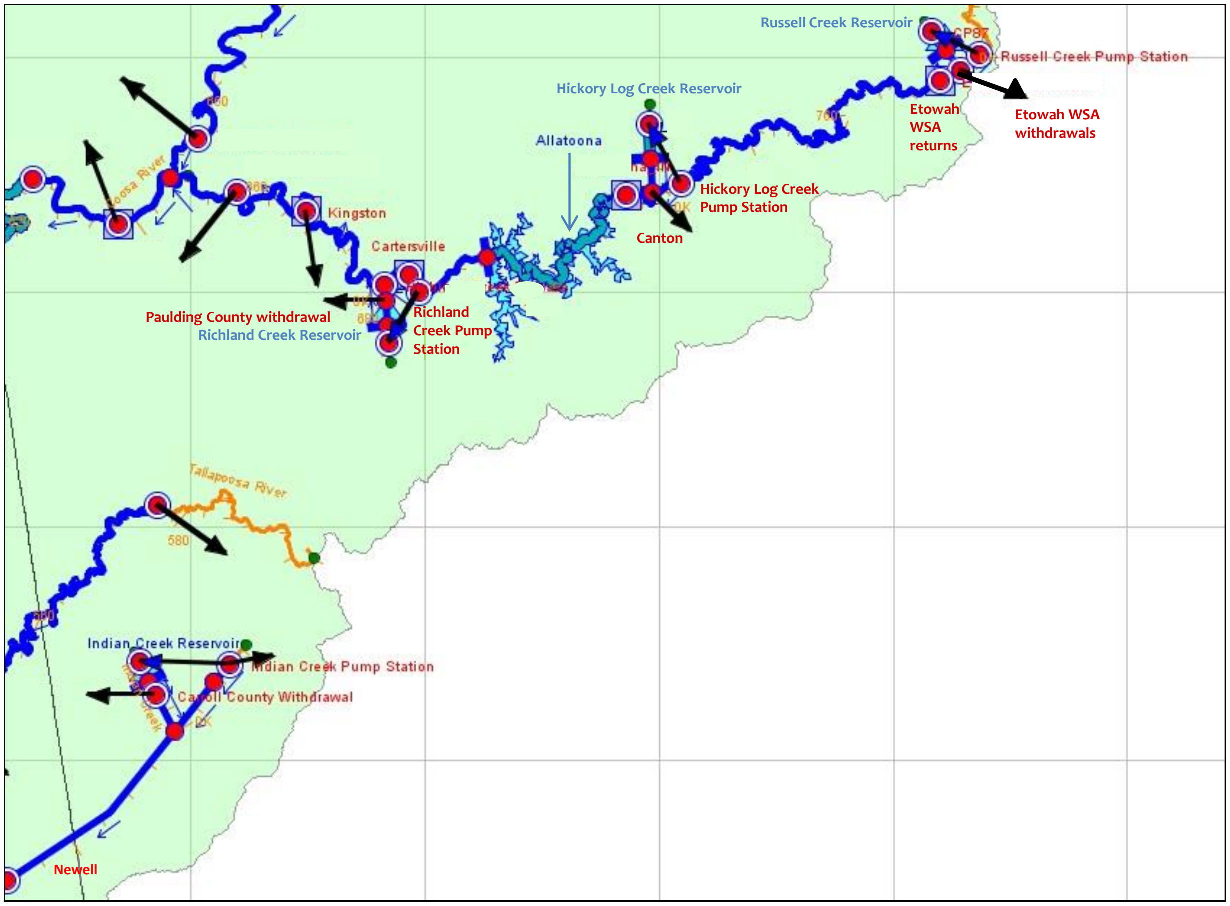

Figure C: River Nodes for Model – with Proposed Projects Added

Tables 2 and 3 provide a summary of water supply demands (withdrawals) and treated wastewater returns at each node in the model in the vicinity of proposed projects

Table 2
Water Supply Demand (Withdrawals) for Scenarios and Model Nodes

Model Node ID	Water Supplier ID	Scenario 1 Current Demands as modeled by Corps, present Allatoona oper.		Scenario 2 Current Demands as modeled by Corps, proposed Allatoona oper.		Scenario 3 Currrent Demands; Same as scenario 2 except HLCR is added		Scenario 4 Future demand (approx. year 2040) per EPD for GA; current demand for AL; HLCR included		Scenario 5 Future demand (approx. year 2040) per EPD for GA; current demand for AL; HLCR + 3 new reservoirs included		Scenario 6 Same as scenario 5 except ultimate future demand applied to 3 new reservoirs	
Etowah River		mgd	ref. note	mgd	ref. note	mgd	ref. note	mgd	ref. note	mgd	ref. note	mgd	ref.note
Dawsonville	Etowah WSA									9.2	13	11.5	13
	Total Dawsonville Node	**NA**	1	**NA**	1	**NA**	1	**NA**	1	**9.2**		**11.5**	
Canton:	City of Canton	2.7	2	2.7	2	2.7	2	13.5	7	13.5	7	13.5	7
	Other	20.5	2	20.5	2	20.5	2	48.8	8	39.6	14	39.6	14
	CCMWA	0		0		33	6	33	6	33	6	33	6
	Total Canton Node	**23.2**		**23.2**		**56.2**		**95.3**		**86.1**		**86.1**	
Allatoona:	CCMWA	34.5	3	34.5	3	1.5	6	73	9	49	15,16	56	17,18
	Cartersville	16.8	3	16.8	3	16.8	3	42	10	42	10	42	10
	Total Allatoona Node	**51.3**		**51.3**		**18.3**		**115**		**91**		**98**	
Richland Cr:	Paulding County	NA	4	NA	4	NA	4	NA	4	24	16	35	18
	Etowah through Cartersville node	**74.5**		**74.5**		**74.5**		**210.3**		**210.3**		**230.6**	
Little Tallapoosa River													
	Upstream of Indian Cr. Pump Station									7.89	11	7.89	11
	Indian Cr. Node									11	12	18	19
	Newell	6.1 (net)	5	6.1 (net)	5	6.1 (net)	5	18.89	11,12	0		0	
	Little Tallapoosa through Newell	**6.1 (net)**		**6.1 (net)**		**6.1 (net)**		**18.89**		**18.89**		**25.89**	

Table 3
Return Wastewater Flow for Scenarios and Nodes

Model Node ID	Wastewater Supplier ID	Scenario 1 Current Demands as modeled by Corps, present Allatoona oper.		Scenario 2 Current Demands as modeled by Corps, proposed Allatoona oper.		Scenario 3 Currrent Demands; Same as scenario 2 except HLCR is added		Scenario 4 Future demand (approx. year 2040) per EPD for GA; current demand for AL; HLCR included		Scenario 5 Future demand (approx. year 2040) per EPD for GA; current demand for AL; HLCR + 3 new reservoirs included		Scenario 6 Same as scenario 5 except ultimate future demand applied to 3 new reservoirs	
Etowah River		mgd	ref. note	mgd	ref. note	mgd	ref. note	mgd	ref. note	mgd	ref. note	mgd	ref.note
Etowah WSA returns (near Dawsonville)		NA	3	NA	3	NA	3	NA	3	4.5	5	5.6	5
	Total Etowah Node									**4.5**		**5.6**	
Canton	Etowah WSA							4.5	5				
	Cherokee WSA							9.6	6	9.6	6	9.6	6
	City of Jasper	0.5	1	0.5	1	0.5	1	1	6	1	6	1	6
	Total Canton Node	**0.5**		**0.5**		**0.5**		**15.1**		**10.6**		**10.6**	
Allatoona	Cobb County							23.8	6	23.8	6	23.8	6
	Cherokee & Fulton County							27.4	9	27.4	9	27.4	9
	Total Allatoona Node	**0**	2	**0**	2	**0**	2	**51.2**		**51.2**		**51.2**	
Richland	Paulding County									22.9	6	25.5	6
(pump station)	City of Emerson									1	6	1	6
	Bartow County									5.2	6	5.2	6
	Total Richland Node	**NA**	**3**	**NA**	**3**	**NA**	3	**NA**	3	**29.1**		**31.7**	
Cartersville	City of Cartersville							15.3	6	15.3	6	15.3	6
	Paulding County							22.9	6				
	City of Emerson							1	6				
	Bartow County							5.2	6				
	Total Cartersville Node	**NA**	**3**	**NA**	**3**	**NA**	3	**44.4**	3	**15.3**		**15.3**	
Kingston	Bartow & Other	**57.5 (net)**	**4**	**57.5 (net)**	**4**	**57.5 (net)**	4	5.92	10	5.92	10	5.92	10
	Total Etowah through Kingston	sum not given as some values are gross and some are net						**116.6**		**116.6**		**120.3**	
Little Tallapoosa River													
	Upstream of Indian Cr. P.S.									5.21	8	10	7
	Newell	6.1 (net)	4	6.1 (net)	4	6.1 (net)	4	5.21	8	0		0	
	Total Little Tallapoosa through Newell	**6.1 (net)**		**6.1 (net)**		**6.1 (net)**		**5.21**		**5.21**		**10**	

Reference notes for Water Supply Demand Spreadsheet.

- 1: No demands at the Dawsonville node.
- 2: 2006 actual withdrawal compiled by State of GA (GAreformatACT-Coosa-24-updated by Inchul-final version 2009-.xls).
- 3: Current limit is 56 mgd as modeled by COE in ResSim.
- 4: Node does not exist in current ResSim model (to be added with proposed reservoirs).
- 5: **Net** withdrawal at this node in current ResSim model (ACT_TOTALDEMANDS.dss).
- 6: 33 mgd of CCMWA's Allatoona demand is shifted to Canton node to be served by HLCR per Corps directive to model as permitted.(Safe Yield Analysis Hickory Log Creek Reservoir Canton, Georgia. Schnabel Engineering South, August 2005) .
- 7: MNGA District Water Supply Plan, pages 3-13 and B-4.
- 8: Canton node withdrawal from State's Water Supply Request (Zeng*) less City of Canton withdrawal.
- 9: CCMWA's ACT total = 106 mgd = 73 at Allatoona + 33 at HLCR. (corresponds to GA's Water Supply Request (Zeng) "Scenario C" , i.e. without RCR). CCMWA's 73 mgd incl 38 to CCMWA + 35 to Paulding.
- 10: 42 mgd City of Cartersville demand is from GA's Water Supply Request (Zeng) App. 2, pg. 11 for Cartersville demand.
- 11: GA State Water Plan total u/s of Newell is 18.89 mgd.....split est is 11 mgd for Carroll and 7.89 mgd u/s of Indian Cr. (see note 12).
- 12: 11 mgd derived from published study by Brown and Caldwell, *Summary of Water Supply Needs Analysis, Carroll County,* August 2008, slide 9 and 10, showing 2040 Carroll County total need (28mgd) versus existing supply capacity (17mgd); *Summary of Water Supply Needs Analysis, Carroll County*.
- 13: Proposed Russell Creek Water Supply Reservoir, demand forecast by Etowah WSA.
- 14: Canton node withdrawal from GA's Water Supply Request (Zeng) less Etowah WSA and City of Canton withdrawal.
- 15: Same as Scenario 4, except 24 mgd of Paulding demand is shifted to Richland Cr. Reservoir.
- 16: Same as Scenario 4, except 24 mgd of Paulding demand is shifted to Richland Cr. Reservoir.
- 17: Same as Scenario 5 by definition, (i.e. 2040 demands for all except 3 proposed projects).
- 18: Paulding demand shown at year 2060: 18mgd + 35 mgd = 53 mgd per Paulding 404 permit appl.
- 19: Indian Creek Reservoir yield of 18 mgd is per Carroll County 404 permit application.

Reference notes for Wastewater Return Spreadsheet.

- 1: Net withdrawal at this node in current ResSim model (ACT_TOTALDEMANDS.dss) showing 2006 actual withdrawals.
- 2: Permitted returns as modeled by COE in ResSim calculated from the modeld net demands (ACT_TOTALDEMANDS.dss).
- 3: Node does not exist in current ResSim model (to be added with proposed reservoirs).
- 4: Net withdrawal at this node in current ResSim model (ACT_TOTALDEMANDS.dss).
- 5: Forecast of 5.6 mgd in year 2050 is provided by Etowah WSA based on recent Wastewater Master Plan, scaled for 2040 in Scenarios 4.
- 6: Breakdown by system is derived from County total AAD per MNGA District Wastewater Mgt Plan, Appendix B (see tab WW return per dist plan by RLH Group).
- 7: Data provided by Carroll County.
- 8: State's Water Supply Request (Zeng*), Newell node.
- 9: State Water Plan, personal communication, W. Zeng (9/10/2013).
- 10: Bartow West WWTP + other. Difference between Water Supply Request and other returns.

1.4 Discussion of Key Findings

The below discussion summarizes results and displays key charts for each of the five impact categories for future conditions *without* the proposed reservoir projects (Scenario 4) and *with* the proposed reservoir projects (Scenarios 5 and 6). Key charts for Scenarios 2, 3, 4, 5, and 6 are contained in Appendix 1. The full suite of excel spreadsheets provided by the Corps of Engineers and populated with results from these three model runs is included in Appendix 2. The Corps' spreadsheets are limited to five scenarios in most cases, so Scenarios 2 through 6 were displayed and can be compared to either Scenario 1 (baseline) or Scenario 2 (Corps proposed operations).

The following narrative summarizes hydrologic impacts for Scenarios 4, 5, and 6. To aid in understanding the output, the following descriptive names are used for these three runs:

- *'without projects 2040'* = Scenario 4 (2040 demand without proposed reservoirs)
- *'with projects 2040'* = Scenario 5 (2040 demand with proposed reservoirs)
- *'with projects full yield'* = Scenario 6 (demand equal to full yield for proposed reservoirs)

1.4.1 Impacts to Stream Flow

1.4.1.1 Alabama River near Montgomery, AL

USGS Gage no. 02420000 on the Alabama River and referenced herein as 'Montgomery, AL' is the first node downstream of the confluence of the Coosa and Tallapoosa Rivers, and is therefore the most upstream node affected by all three proposed reservoir projects. Intuitively, impacts from Georgia withdrawals would be more pronounced at this upstream location and would be diminished progressively downstream as the river flow increases and because of buffering effects from multiple run-of-the-river reservoirs which are operated for power generation, flood control and navigation. Key findings from the RES SIM modeling include:

- The RES SIM model shows average flow at this location on the Alabama River is
  - 22,337 cfs for the *without projects 2040* run;
  - 22,337 cfs for the *with projects 2040* run; and
  - 22,308 cfs for the *with projects full yield* run.
- The without and with projects 2040 runs share the same net demands, so while the use of new storage may affect the timing of flows, the only difference in magnitude is and should be evaporation, which decreases the average flow by less than 1 cfs.
- The increase in net demands for the with projects full yield run is 29.1 cfs, which can be seen in the 0.1% decrease in average flow. Because of operations of the new projects to help meet the increased demand in the full yield run during dry times, the additional volume generally comes out of higher flows when the proposed reservoirs are refilling.
- The with projects runs reflect the fact that operation of the proposed water supply reservoirs will comply with Georgia regulations for low flow protection; thus, withdrawals will be curtailed and/or augmented by reservoir releases during drought periods to comply with

prescribed in-stream minimum flows. There is, therefore, little to no change in flows at this location.

Figure 1 shows the duration curve of flows at the Montgomery node; at the scale shown, stream flow for all three scenarios appear as a single line meaning there is no discernable difference between the scenarios with respect to stream flow. Figure 2 shows the same duration curve for the lowest 30% of flows, and even at this larger scale plot, the only discernable difference between the scenarios with respect to stream flow is the very lowest flow, which shows slightly higher flows without the projects than with. These lowest flows occur in January 1981, a particularly dry January. The difference in the one-day low flow occurs because of step functions in the hydropower and reservoir balancing rules that can cause large single-day differences in releases from very small differences in stages; the 7-day average flow that week is actually larger in the with project run. Figure 3 shows these low flows in the middle of January; the figure also shows that the lowest daily flows do not change very much between the scenarios.

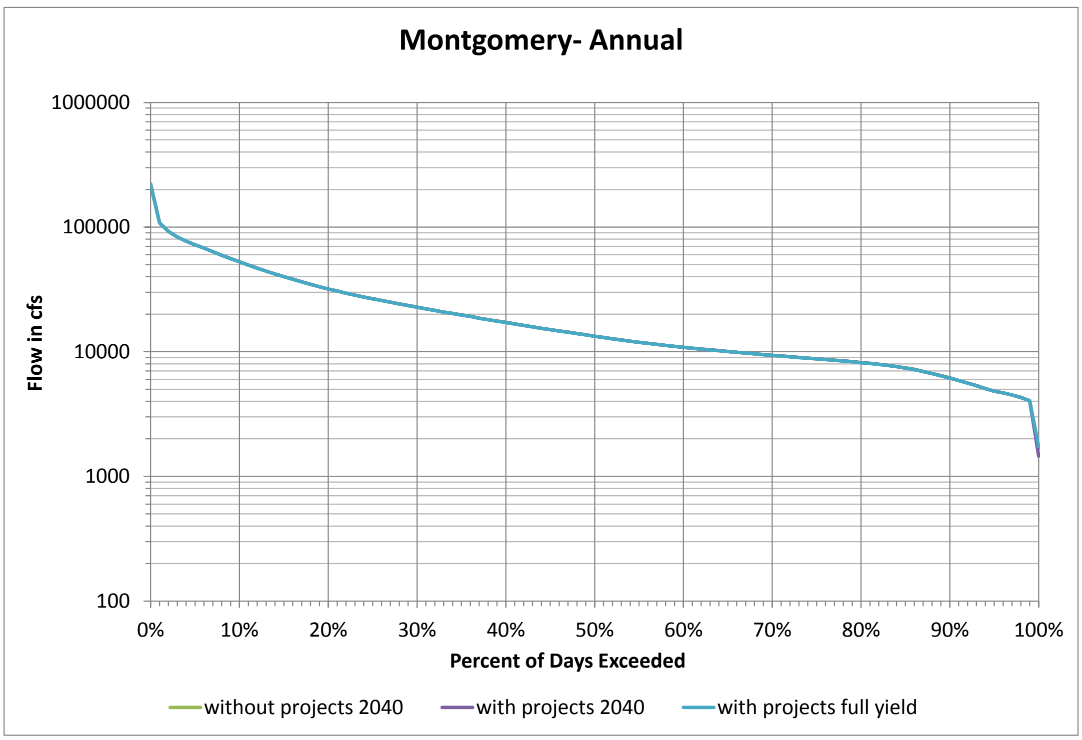

Figure 1. Duration curve of flows at Montgomery, AL.

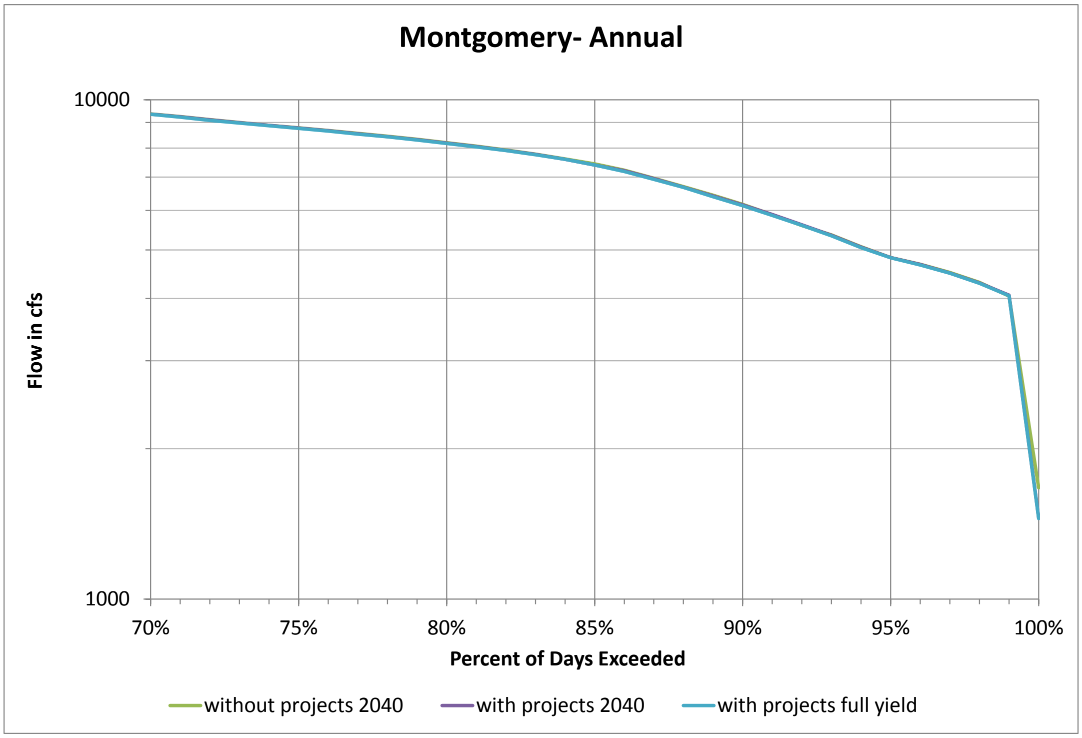

Figure 2. Duration curve of flows at Montgomery, AL, lowest 30% of flows.

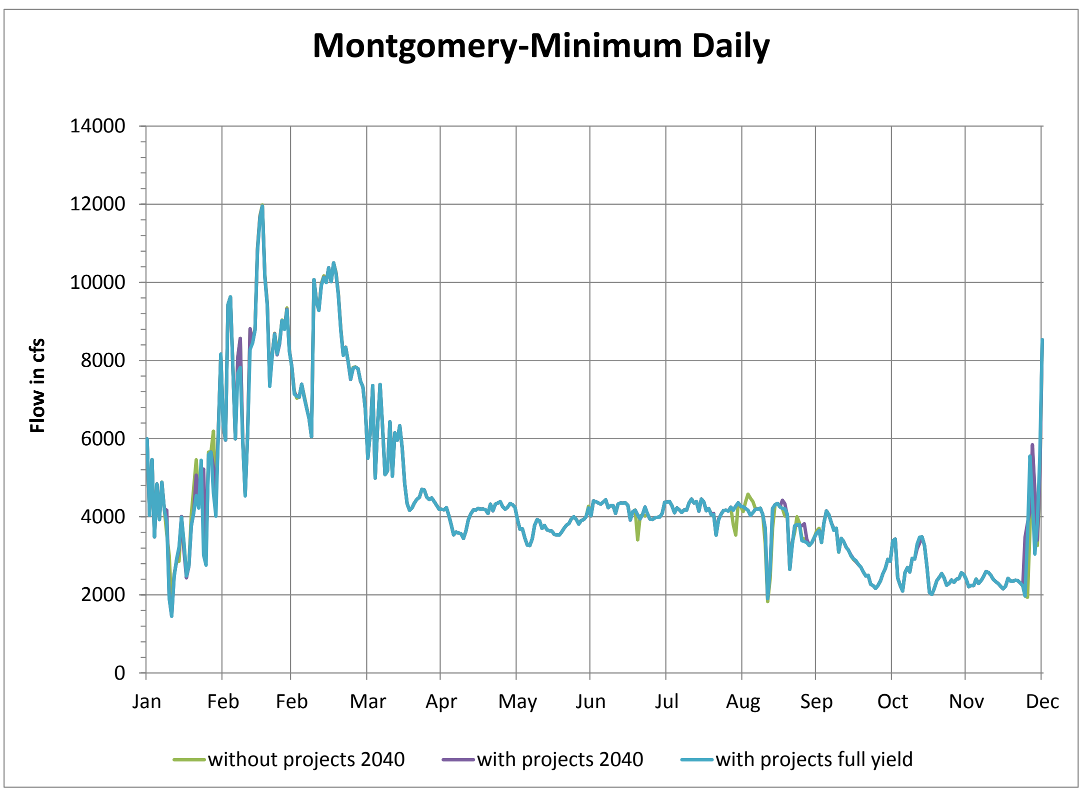

Figure 3. Minimum daily flows at Montgomery, AL

Figure 4 and Figure 5 illustrate potential shifts in the seasonality of low flows; Figure 4 shows the 75th percentile (lowest 25%) of flows for each month, and Figure 5, the 90th percentile (lowest 10%). These displays show no discernable differences.

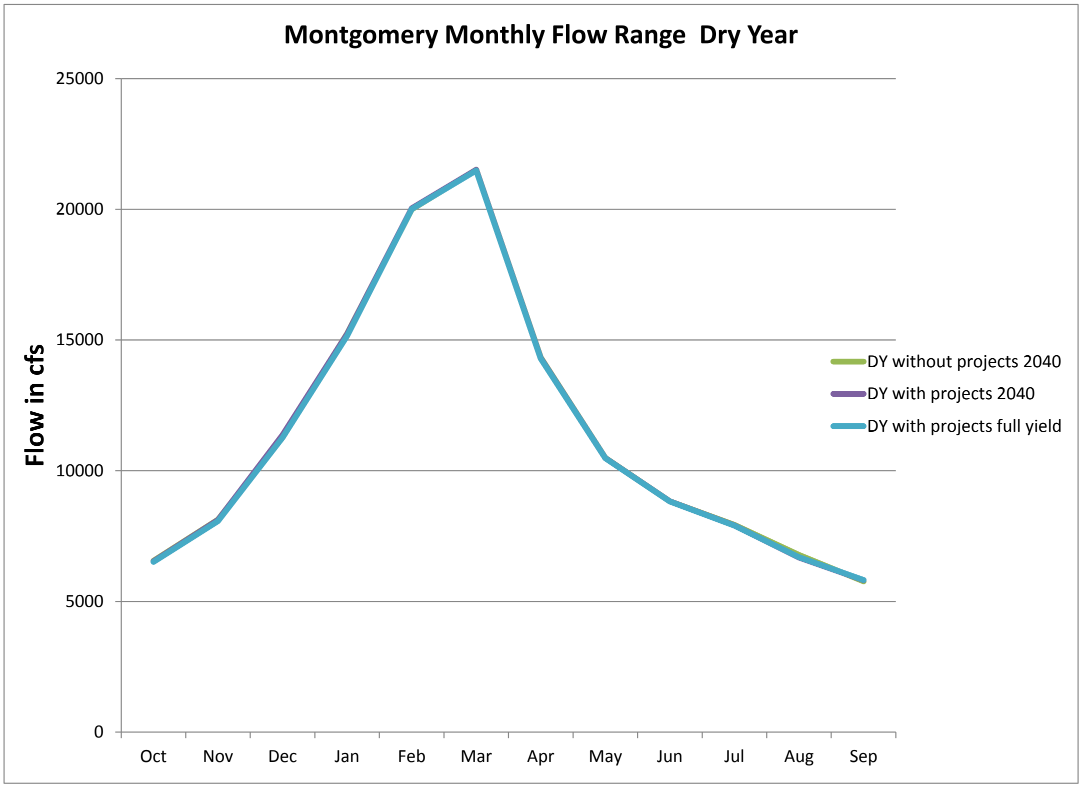

Figure 4. Monthly Flow Range at "Dry" level (lowest 25%) at Montgomery, AL.

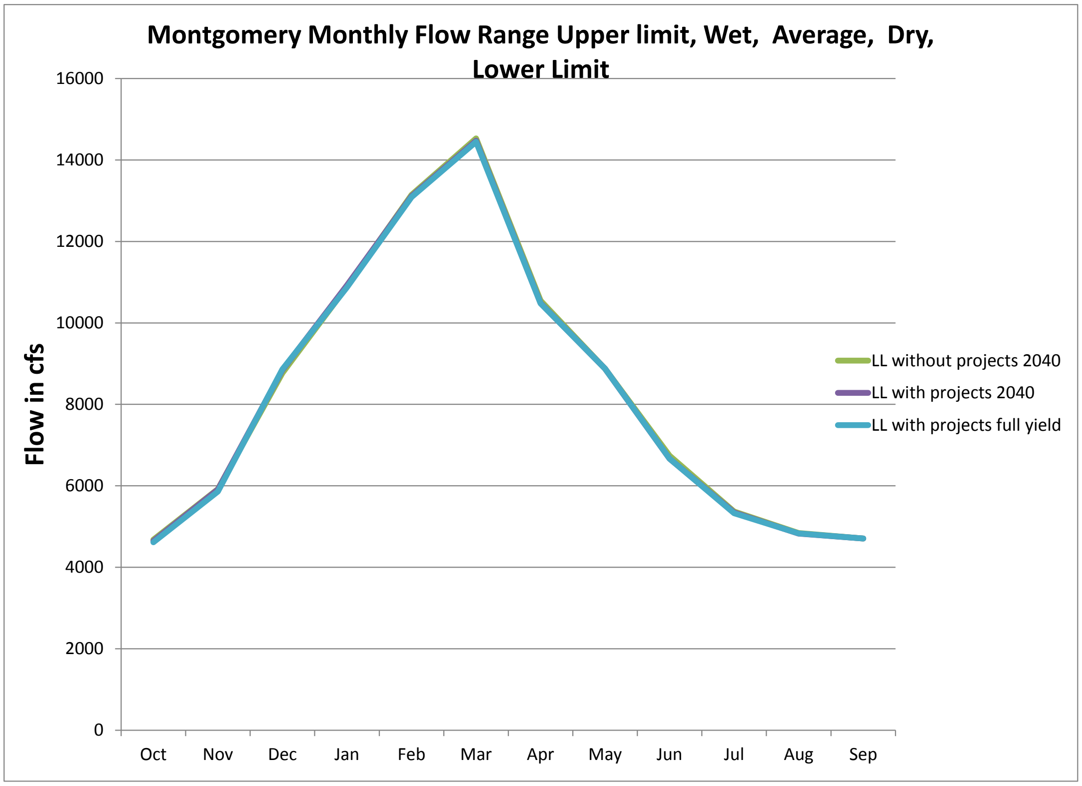

Figure 5. Monthly Flow Range at "Lower Limit" level (lowest 10%) at Montgomery, AL.

1.4.1.2 Etowah River near Lake Allatoona

USGS Gage no. 02394000 on the Etowah River downstream of Lake Allatoona and referenced herein as 'Allatoona' is downstream of the Russell Creek project but upstream of the Richland Creek project. This node is influenced by both the addition of the proposed projects as well as the relocation of much of Paulding County's demand from Lake Allatoona to Richland Creek Reservoir. Key findings from the RES SIM modeling include:

- The average flow at this location on the Etowah River is:
    - 1541 cfs for the without projects 2040 run;
    - 1578 cfs for the with projects 2040 run; and
    - 1565 cfs for the with projects full yield run
- The average flow difference between the without and with projects 2040 runs is equal to 37 cfs, which is also the quantity of Paulding County demand shifted from Lake Allatoona to Richland Creek (evaporation from Russell Creek is less than 1 cfs).
- The increase in net demands for with projects full yield run is 12.7 cfs (1.8 cfs for Etowah WSA and 10.9 cfs for Paulding County from Lake Allatoona), which can be seen in the 0.8% decrease in average flow.

Figure 6 shows the duration curve of flows at the Allatoona node. The flows are higher in the *with projects* runs because of the demand shift discussed above: the Etowah River reach between the Allatoona and Kingston nodes and the Little Tallapoosa near Indian Creek Reservoir are the only reaches in the model that have different net upstream consumptive use in the two 2040 runs. A small difference can also be seen in flow between the *with project 2040* and *full yield* runs.

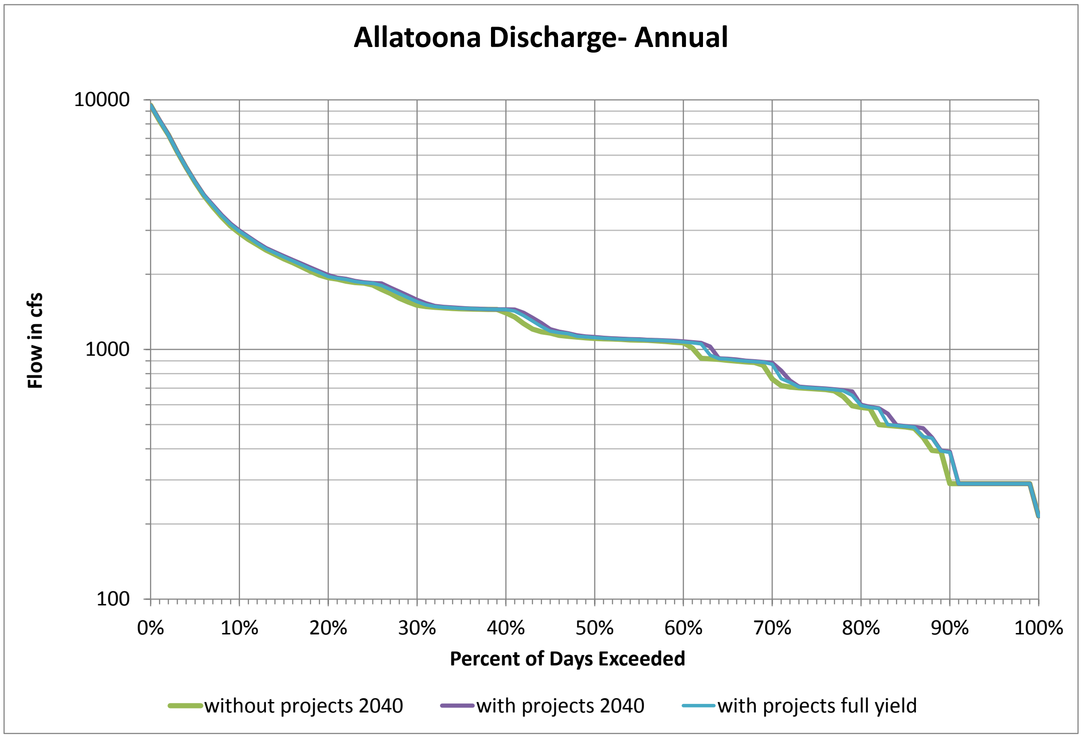

Figure 6. Duration curve of flows at Allatoona.

Figure 7 and Figure 8 illustrate shifts in the seasonality of low flows; Figure 7 shows the 75th percentile (lowest 25%) of flows for each month, and Figure 8, the 90th percentile (lowest 10%). The increase in flows resulting from the relocation of 37 cfs of Paulding County's demand is evident in most months. The increase in flow is much higher than 37 cfs because Lake Allatoona's release is determined by the number of hydropower generation hours, which changes abruptly at the "power zone" stage thresholds. Less withdrawal from Lake Allatoona in the *with project* scenarios translates to higher stages in Lake Allatoona, which means more hours of hydropower releases. The benefit in river flows is more apparent at the 75th percentile level than the 90th percentile level and in the winter and spring.

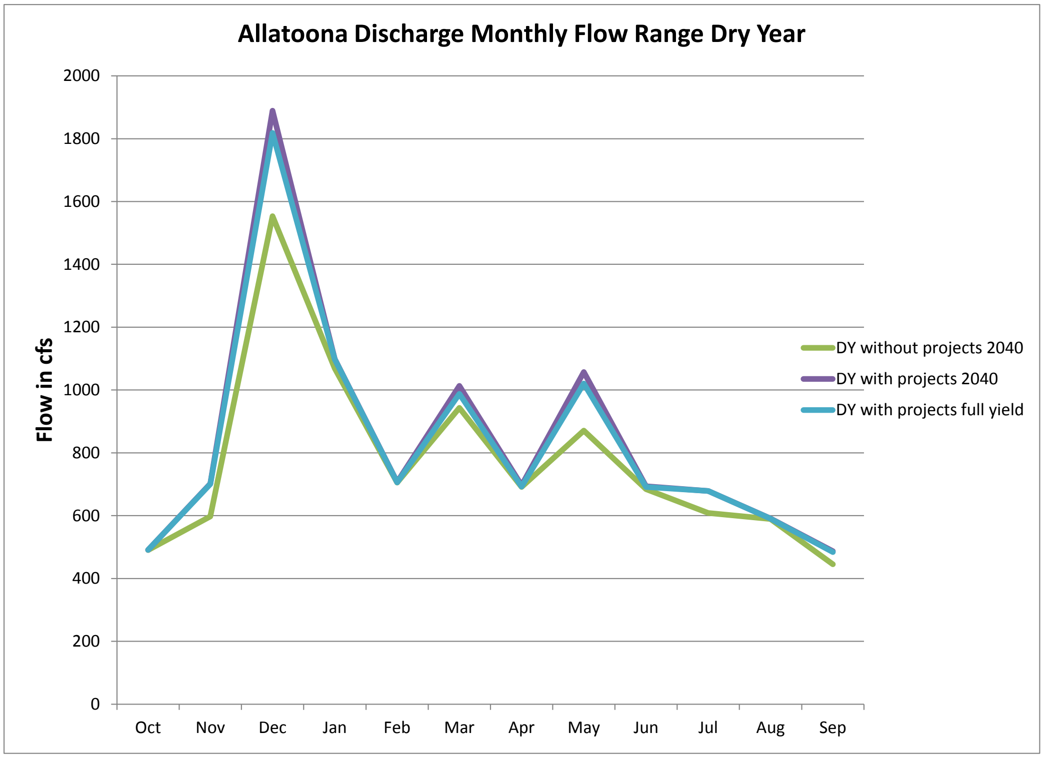

Figure 7. Monthly Flow Range at "Dry" level (lowest 25%) at Allatoona.

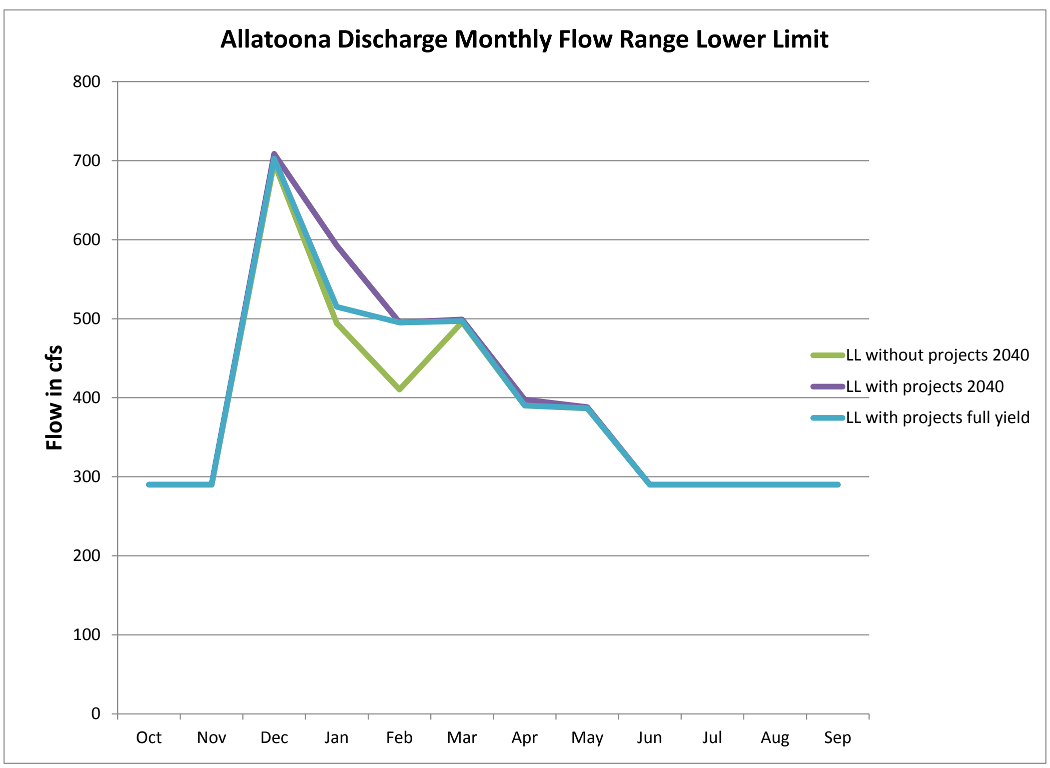

Figure 8. Monthly Flow Range at "Lower Limit" level (lowest 10%) at Allatoona.

1.4.1.3 Coosa River near Rome, GA

USGS Gage no. 02397000 on the Coosa River near Rome, Georgia and referenced herein as 'Rome Coosa' is the most downstream node on the Coosa River before it crosses from Georgia into Alabama. Approximately 95% of Georgia's ACT basin water demand is located in the Coosa portion of the basin, including future needs associated with the Richland Creek and Russell Creek projects. Key findings from the RES SIM modeling include:

- The average flow at this location on the Coosa River is:
    - 6196.3 cfs for the without projects 2040 run;
    - 6195.7 cfs for the with projects 2040 run; and
    - 6170.2 cfs for the with projects full yield run
- The without and with projects 2040 runs share the same net demands, so while the use of new storage may affect the timing of flows, the only difference in magnitude is and should be evaporation, which decreases the average flow by 0.007%.
- The increase in net demands for with projects full yield run is 25.5 cfs, which can be seen in the 0.4% decrease in average flow. Because of operations of the new projects to help meet the increased demand in the full yield run during dry times, the additional volume generally comes out of higher flows when the proposed reservoirs are refilling. The with projects runs reflect the fact that operation of the proposed water supply reservoirs will comply with Georgia regulations for low flow protection; thus, withdrawals will be curtailed and/or augmented by reservoir releases during drought periods to comply with prescribed in-stream minimum flows. Conversely, refilling of the reservoirs will dictate higher withdrawal rates during periods of higher stream flows.

Figure 9 shows the duration curve of flows at the Rome Coosa node; at the scale shown, stream flow for all three scenarios appear as a single line meaning there is no discernable difference between the scenarios with respect to stream flow. Figure 10 shows the same duration curve for the lowest 25% of flows. At this larger scale plot, a slight decrease in flow can be seen for the *with projects full yield* run of about 15 to 30 cfs.

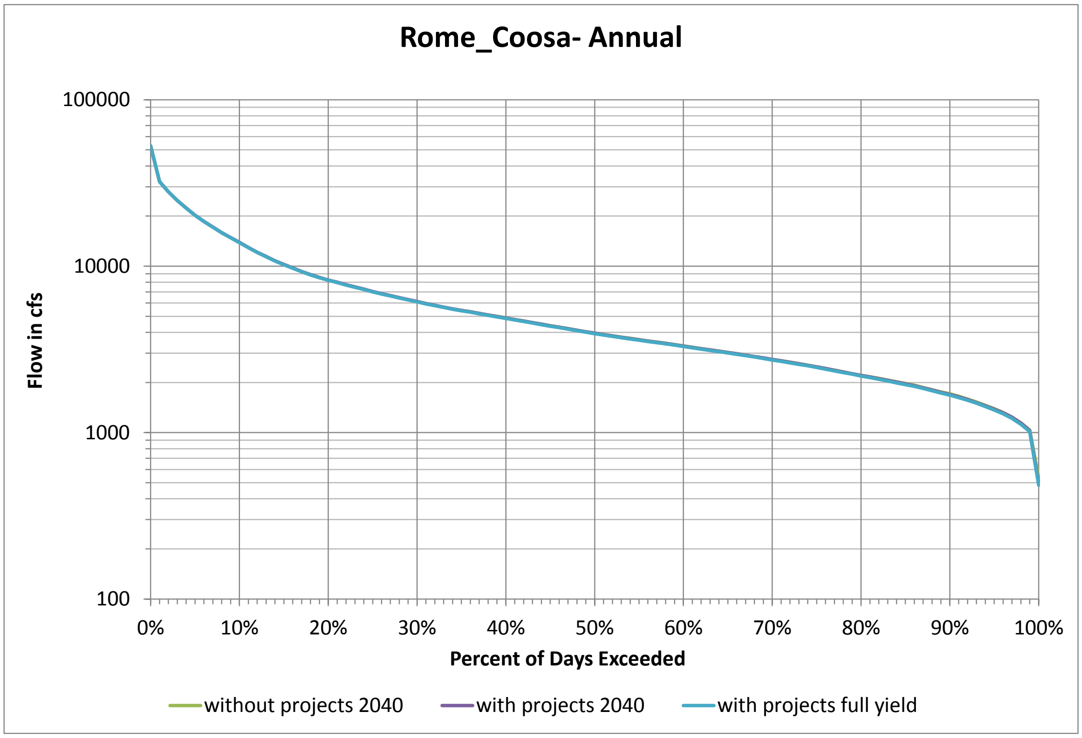

Figure 9. Duration curve of flows at Rome Coosa.

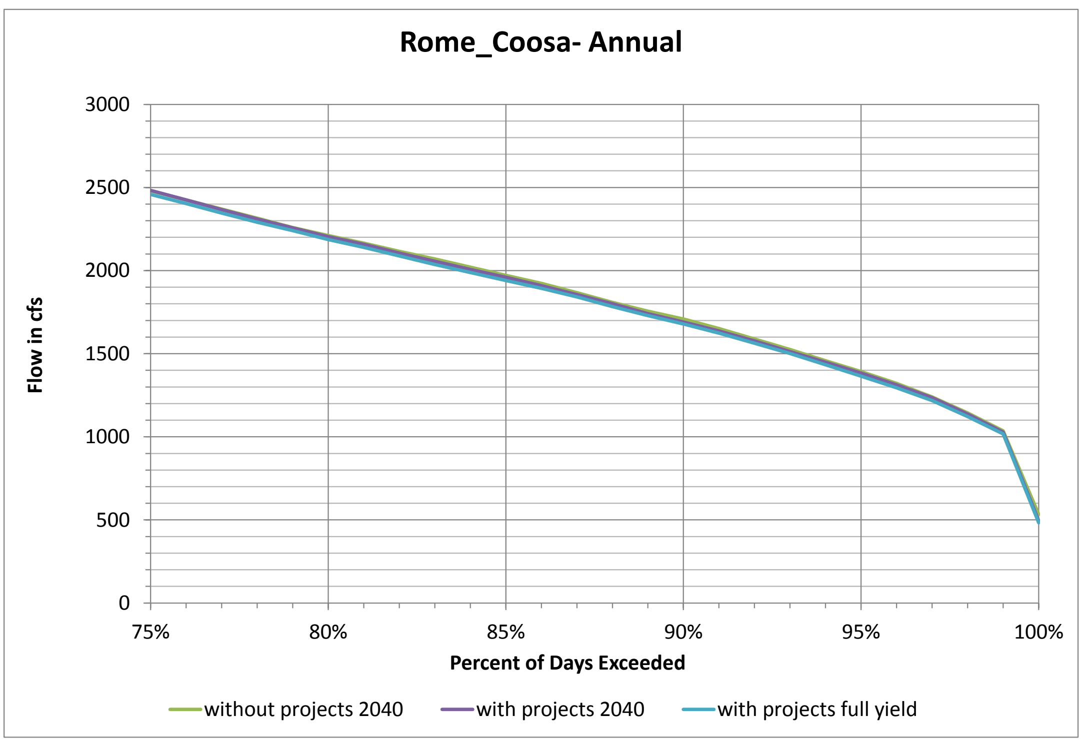

Figure 10. Duration curve of flows at Rome Coosa, lowest 25% of flows.

Figure 11 and Figure 12 illustrate shifts in the seasonality of low flows; Figure 11 shows the 75th percentile (lowest 25%) of flows for each month, and Figure 12, the 90th percentile (lowest 10%). These displays show no discernable differences between the scenarios, with the exception of a small difference in December: flows in the *with projects 2040* Scenario are slightly higher than the other two scenarios. These higher flows occur because Allatoona stages tend to be slightly higher in the *with projects* runs than the *without project*s run (0.2 ft on average) as a result of much of Paulding County's withdrawal moving downstream. When this small stage difference happens to straddle the hydropower action zones in the lake (as it does in December 1939), the number of hours of hydropower generated is reduced in one run but not the other, resulting in about 700 cfs flow difference between the scenarios.

The month with the largest reduction at the 90th percentile level between the *without projects 2040* run and *with projects full yield* run was selected for further examination. The duration curve for this month, April, is shown in Figure 13 and Figure 14. At the 90th percentile level, the *without projects 2040* run flows are 3355 cfs and the *with projects full yield* run flows are 3300 cfs, a decrease of 54.5 cfs or 1.6%.

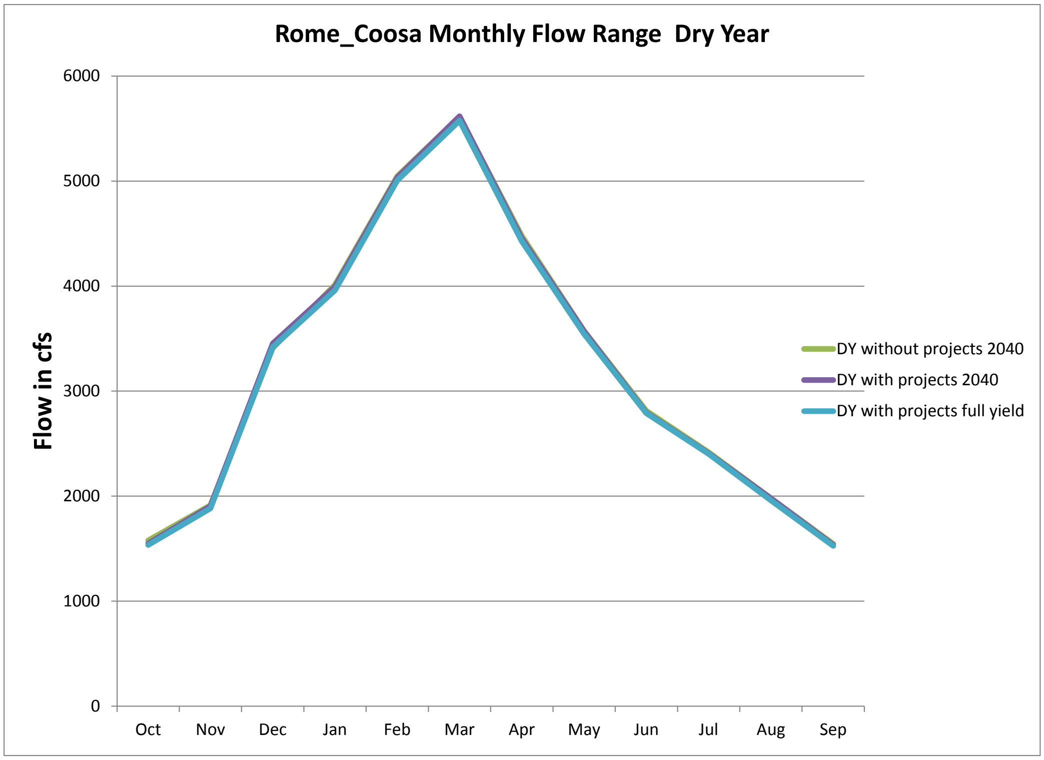

Figure 11. Monthly Flow Range at "Dry" level (lowest 25%) at Rome Coosa.

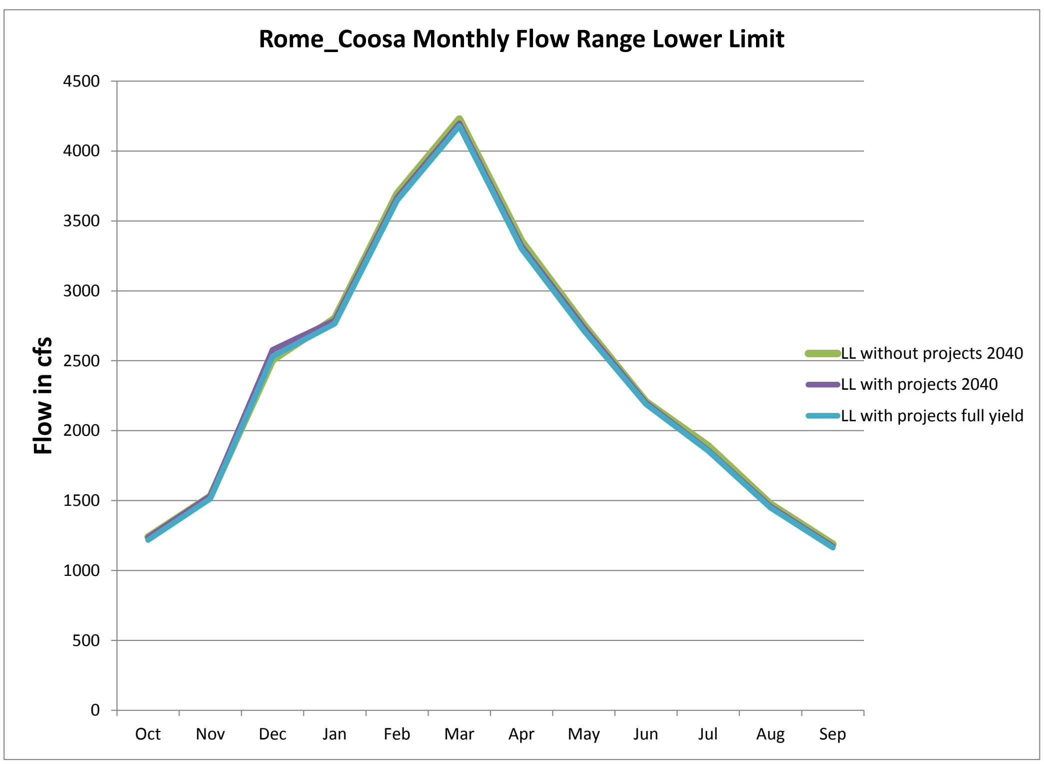

Figure 12. Monthly Flow Range at "Lower Limit" level (lowest 10%) at Rome Coosa.

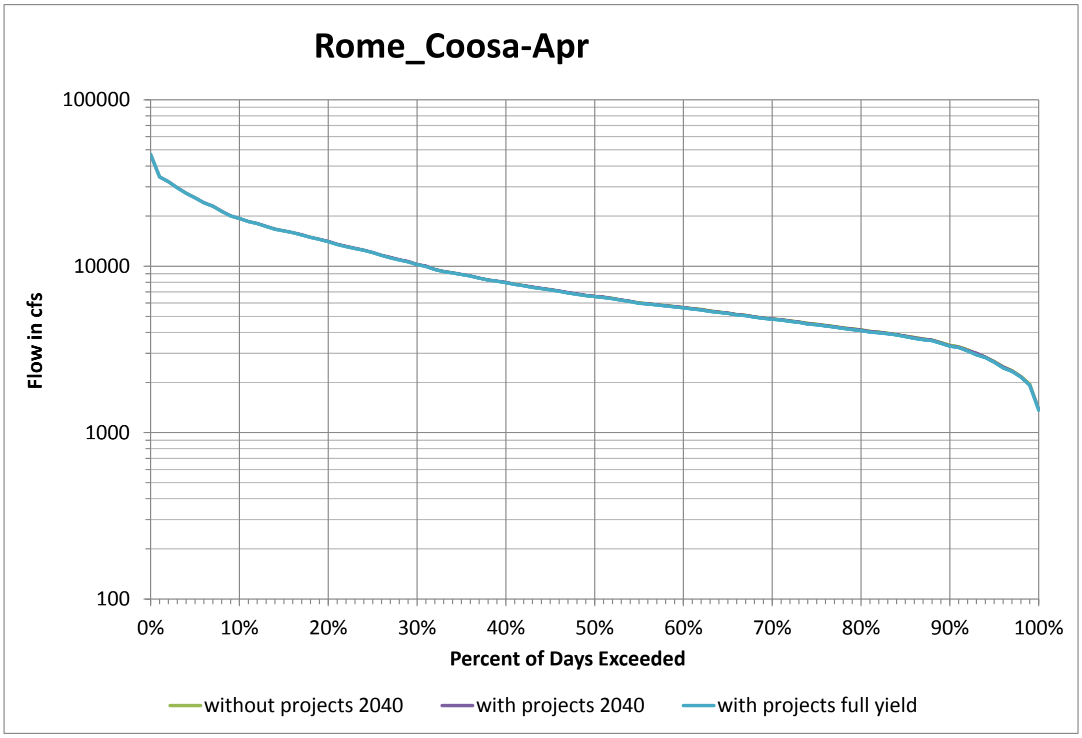

Figure 13. Duration curve of flows in April at Rome Coosa.

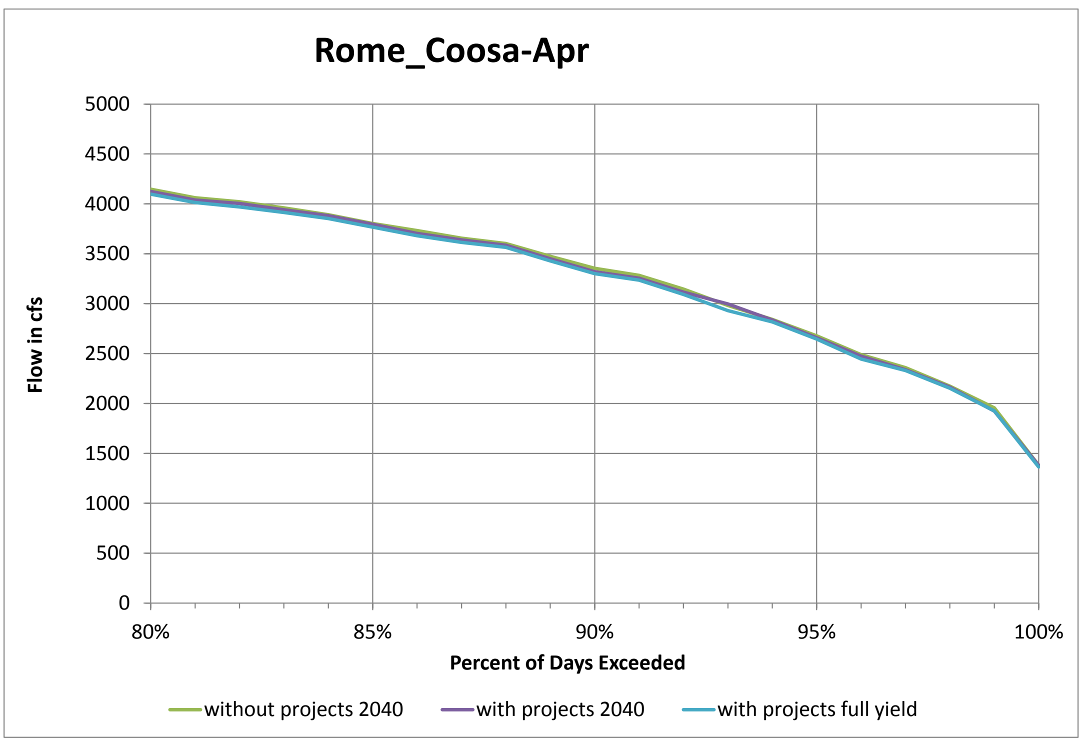

Figure 14. Duration curve of flows in April at Rome Coosa, lowest 20% of flows.

1.4.1.4 Tallapoosa River near Wadley, AL

USGS Gage no. 02414500 on the Tallapoosa River and referenced herein as 'Wadley' is the river node location included in the Corps of Engineers' spreadsheet that is closest to the Little Tallapoosa River, and therefore the most upstream location affected by Indian Creek Reservoir. Key findings from the RES SIM modeling include:

- The average flow at this location on the Tallapoosa River is
    - 2535.4 cfs for *without projects 2040* run;
    - 2535.1 cfs for *with projects 2040* run; and
    - 2531.9 cfs for *with projects full yield* run.
- The *without* and *with projects 2040* runs share the same net demands, so while the use of new storage may affect the timing of flows, the only difference in magnitude is and should be evaporation, which decreases the average flow by 0.01%.
- The increase in net demands for *with projects full yield* run is 3.4 cfs, which can be seen in the 0.1% decrease in average flow. Because of operations of the new projects to help meet the increased demand in the full yield run during dry times, the additional volume generally comes out of higher flows when the proposed reservoirs are refilling. The *with projects* runs reflect the fact that operation of the proposed water supply reservoirs will comply with Georgia regulations for low flow protection; thus, withdrawals will be curtailed during drought periods to comply with prescribed in-stream minimum flows. Conversely, refilling of the reservoirs will dictate higher withdrawal rates during periods of higher stream flows.

Figure 15 shows the duration curve of flows at the Wadley node; at the scale shown, stream flow for all three scenarios appear as a single line meaning there is no discernable difference between the scenarios with respect to stream flow. Figure 16 shows the same duration curve for the lowest 20% of flows and even at this larger scale plot there is little discernable difference between the scenarios with respect to stream flow, with the exception of slightly higher flows in the *with projects* reflecting reservoir releases at low flows.

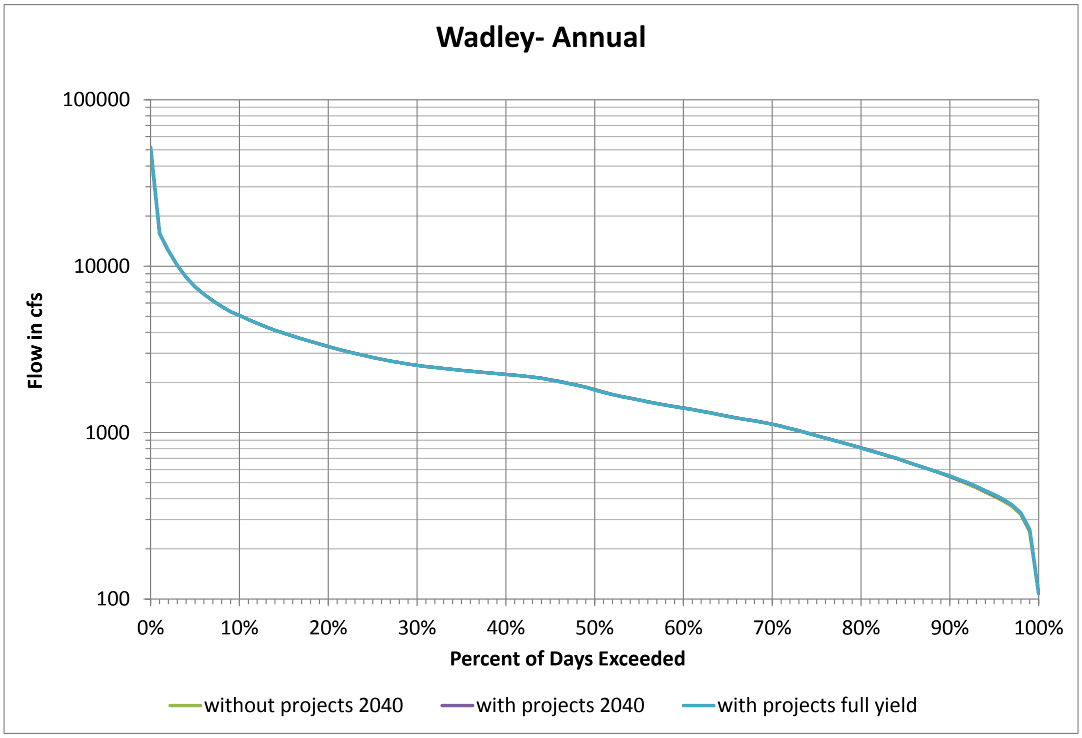

Figure 15. Duration curve of flows at Wadley.

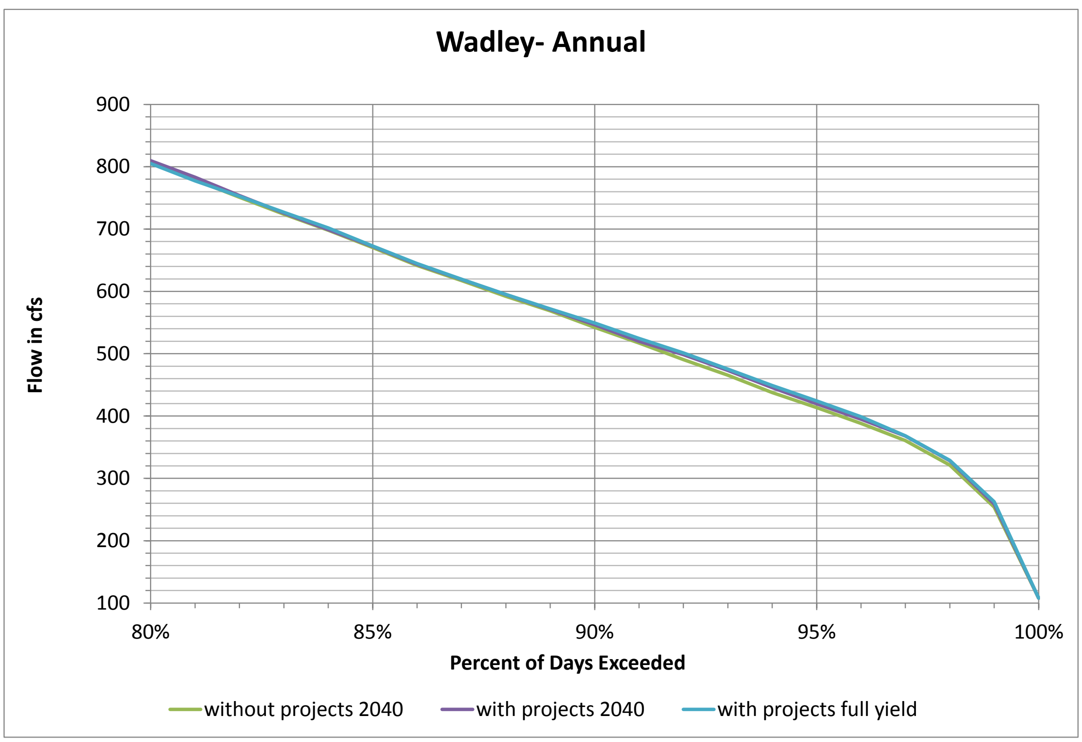

Figure 16. Duration curve of flows at Wadley, lowest 20% of flows.

Figure 17 and Figure 18 illustrate shifts in the seasonality of low flows; Figure 17 shows the 75th percentile (lowest 25%) of flows for each month, and Figure 18, the 90th percentile (lowest 10%). These displays show no discernable differences, with the exception of slightly higher values for the *with projects 2040* scenario in December; storage was used frequently (23 of 70 simulated years) in December to support withdrawals.

While December showed an increase in flow with the projects at the 75th percentile level, it was also the month with the largest reduction in flow at the 90th percentile level between the *without projects 2040* run and *with projects full yield* run. The duration curve for this month, December, is shown in Figure 19 and Figure 20. At the 90th percentile level, without projects 2040 run flows are 584 cfs and with projects full yield run flows are 574 cfs, a decrease of of 10 cfs or 1.7%.

Figure 20 also shows higher flows in some of the percentiles for the full yield demands compared with the 2040 demands. This counterintuitive result occurs because the return flows to the Little Tallapoosa River are quite a bit higher for the full yield demands, and while the higher withdrawals are supported by reservoir storage, the higher returns are made directly to the river, increasing flows.

In months other than January, April, and December, the flows in *with projects full yield* run are higher than those in *without projects 2040* run because storage in the proposed reservoir allows for curtailment of river withdrawals during low stream flow conditions. For example, in August (Figure 21 and Figure 22) at the 90th percentile level, the *without projects 2040* run flows are 448 cfs and the *with projects full yield* run flows are 461 cfs, an increase (i.e. beneficial impact) of 13 cfs or 2.9%. As Figure 17 to Figure 22 illustrate, seasonal shifts in flow are very small.

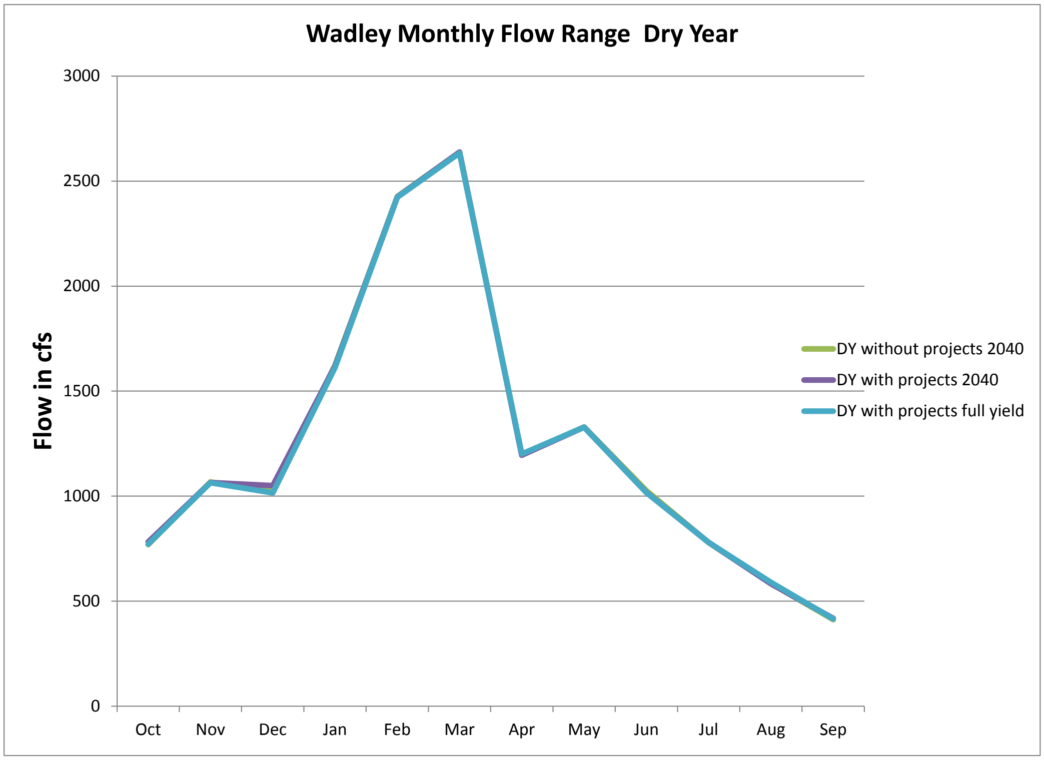

Figure 17. Monthly Flow Range at "Dry" level (lowest 25%) at Wadley.

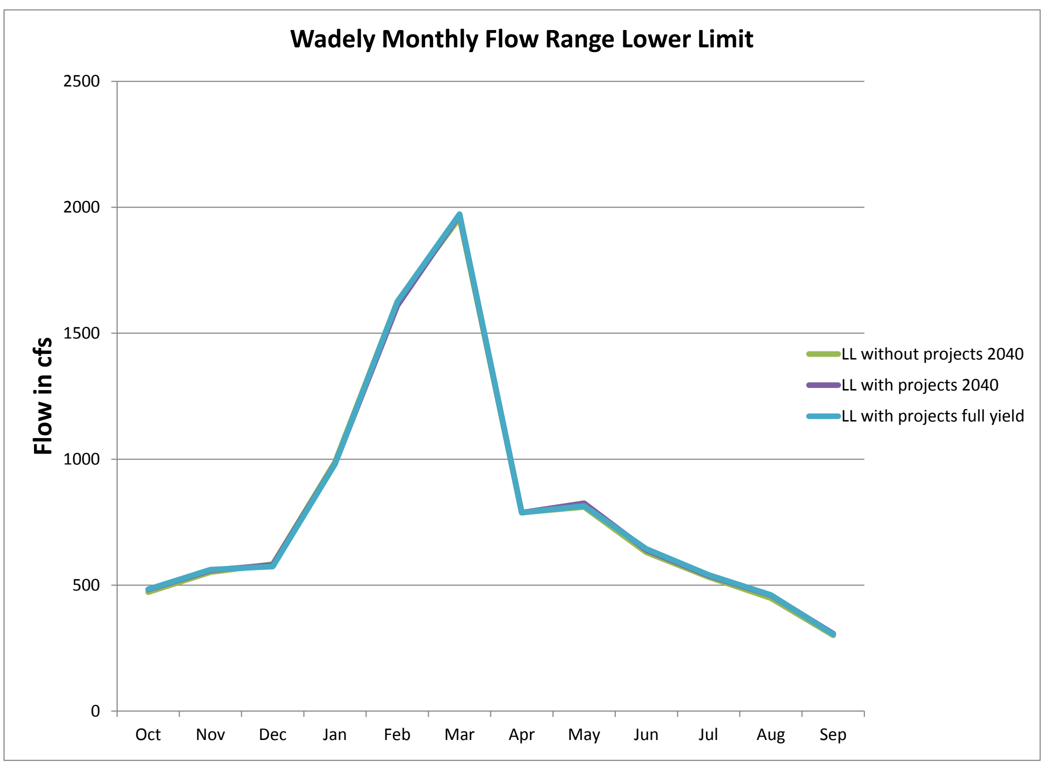

Figure 18. Monthly Flow Range at "Lower Limit" level (lowest 10%) at Wadley.

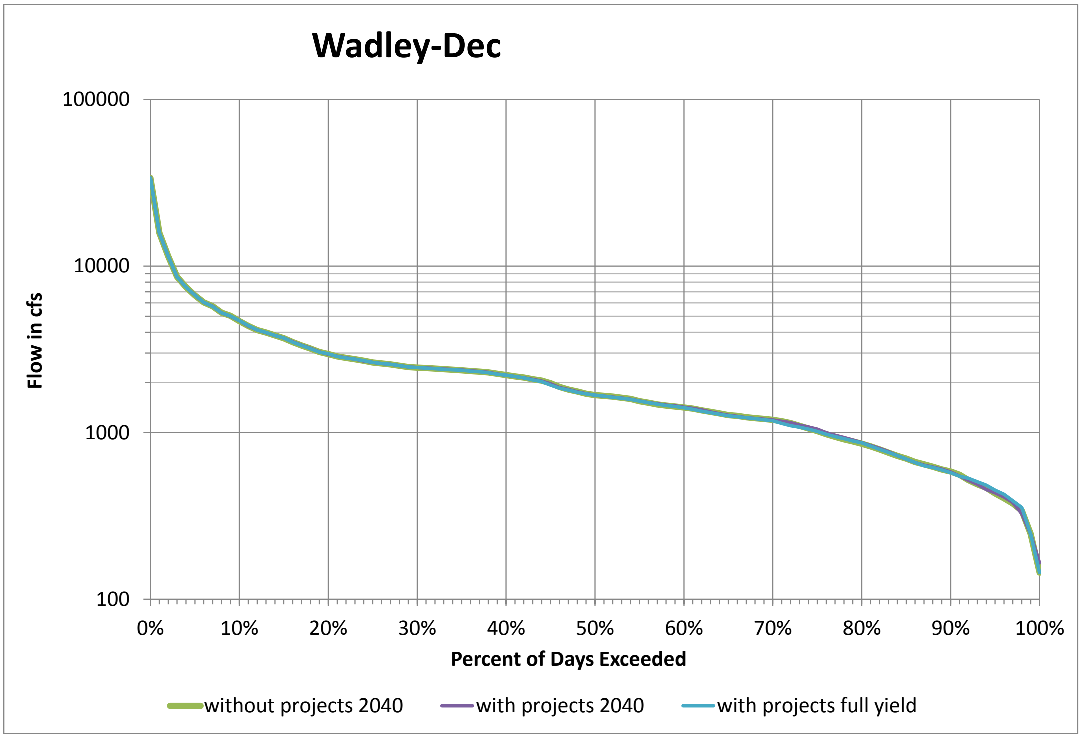

Figure 19. Duration curve of flows in December at Wadley.

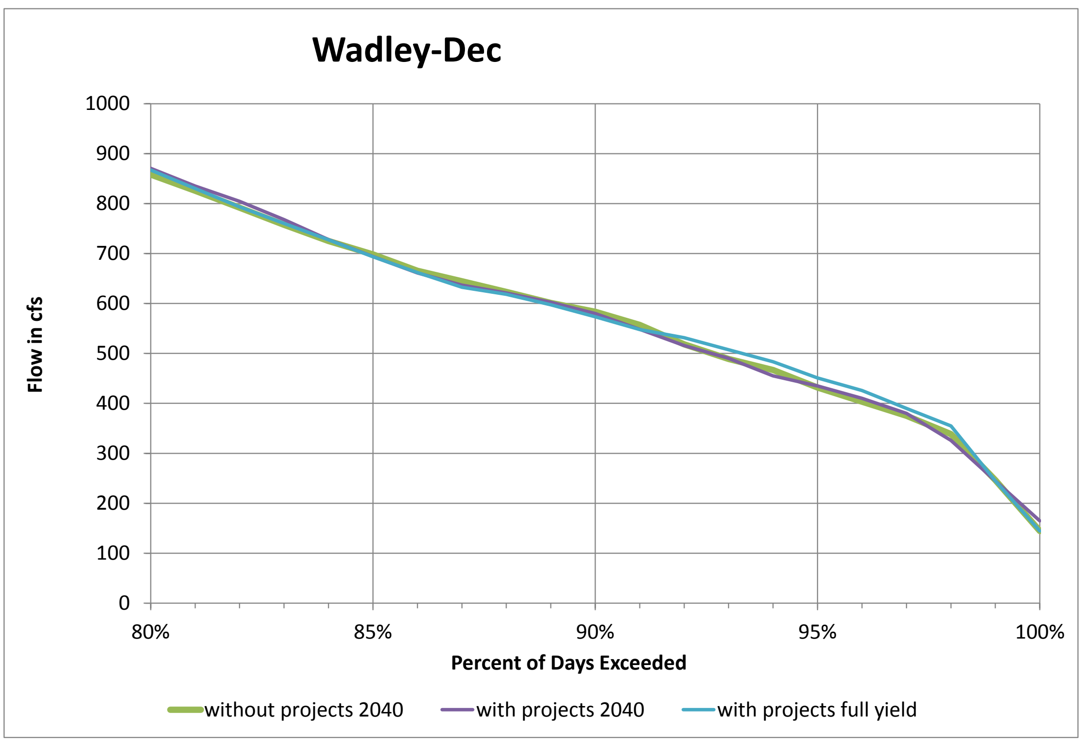

Figure 20. Duration curve of flows in December at Wadley, lowest 20% of flows.

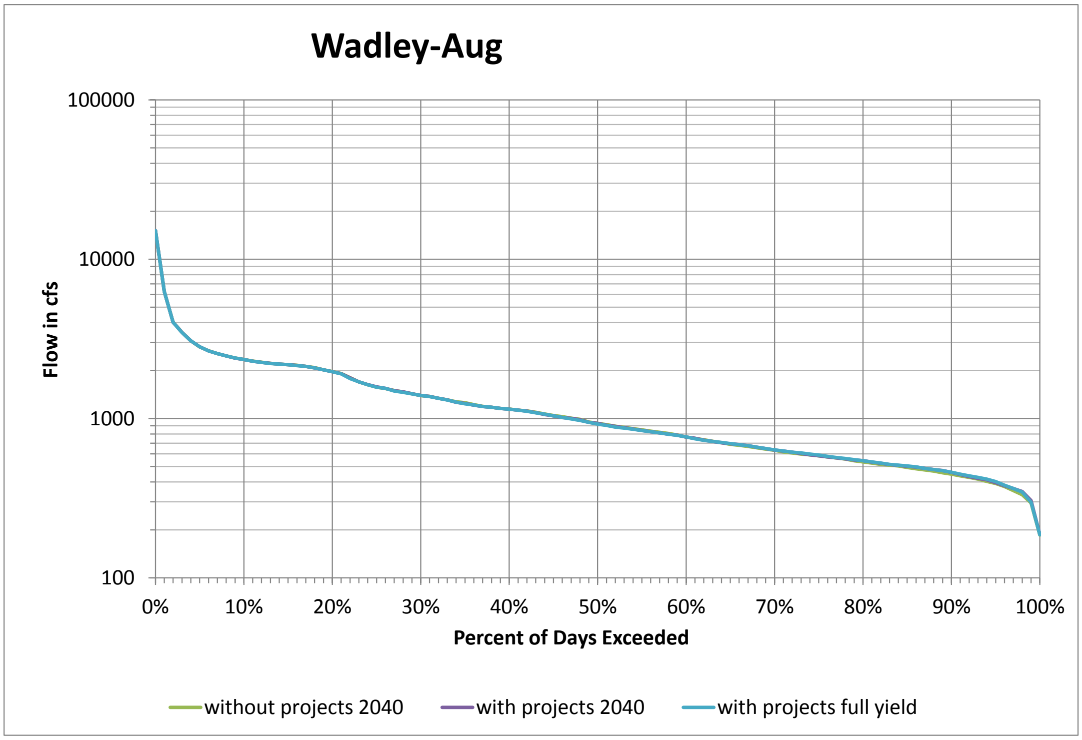

Figure 21. Duration curve of flows in August at Wadley.

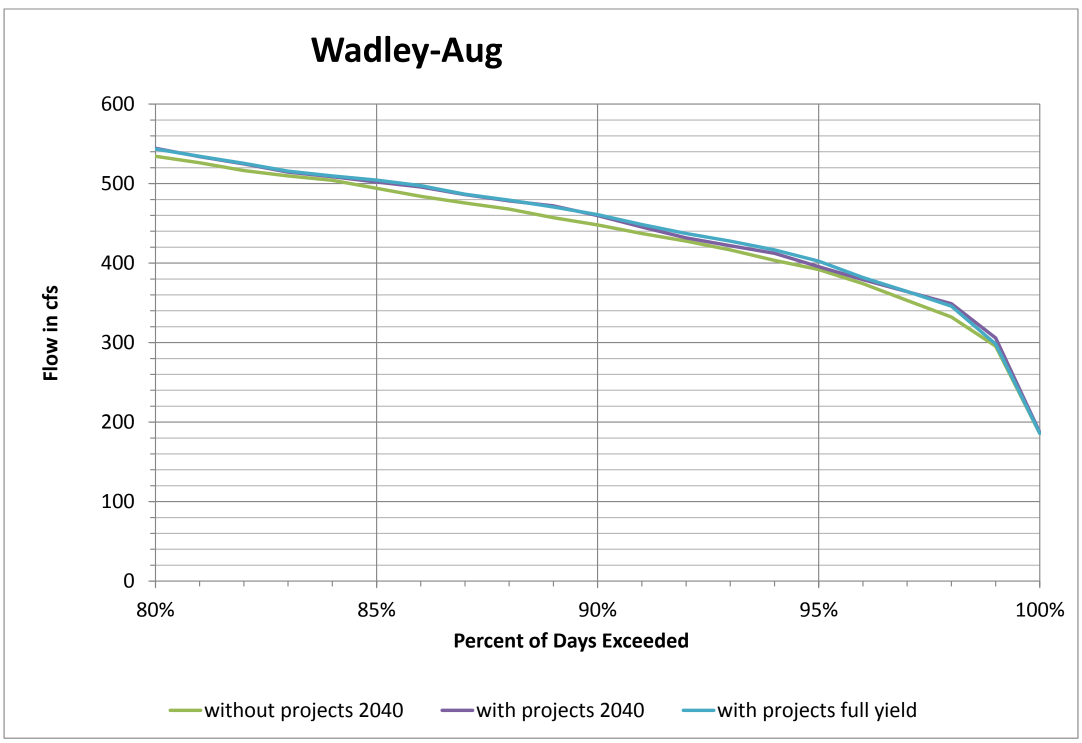

Figure 22. Duration curve of flows in August at Wadley, lowest 20% of flows.

1.4.2 Impacts to Hydropower

Monthly hydropower generation at each power-generating reservoir in the ACT basin is shown in Figure 23 to Figure 29. With the exception of Allatoona, which is discussed below, differences in potential power generation between scenarios are always much less than 1%. On a monthly basis, there is either no change or less a 1% decrease in energy generation for the *with projects full yield* run compared to *without projects 2040* run; Martin, however, shows a small increase in generation (less than 1%) in May through August.

For Allatoona, the relocation of much of Paulding County's withdrawal from the lake to the downstream reach results in more water going through the turbines. The result is an increase in generation of about 3000 MWh/year or 3% for the *with projects 2040* run and 2000 MWh/year or 2% for the *with projects full yield* run. The increase in generation tends to be higher in the summer and fall months (3-8% for *with projects 2040*) and lower in the winter and spring months (2-3% for *with projects 2040*), as shown in Figure 23.

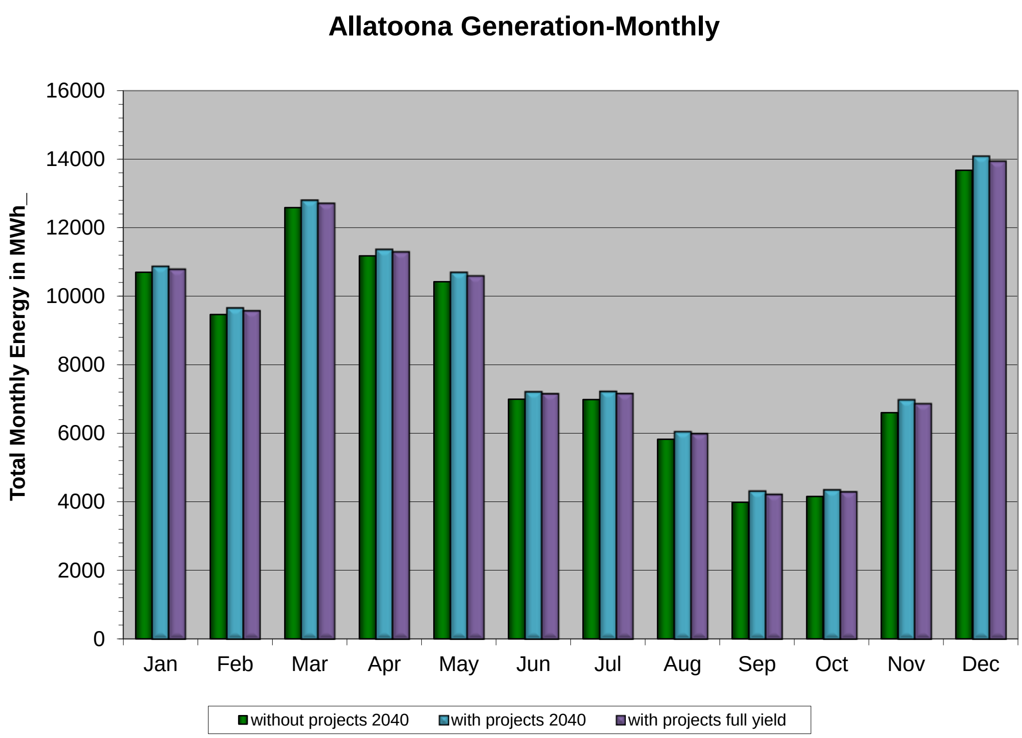

Figure 23. Monthly energy generation, Allatoona

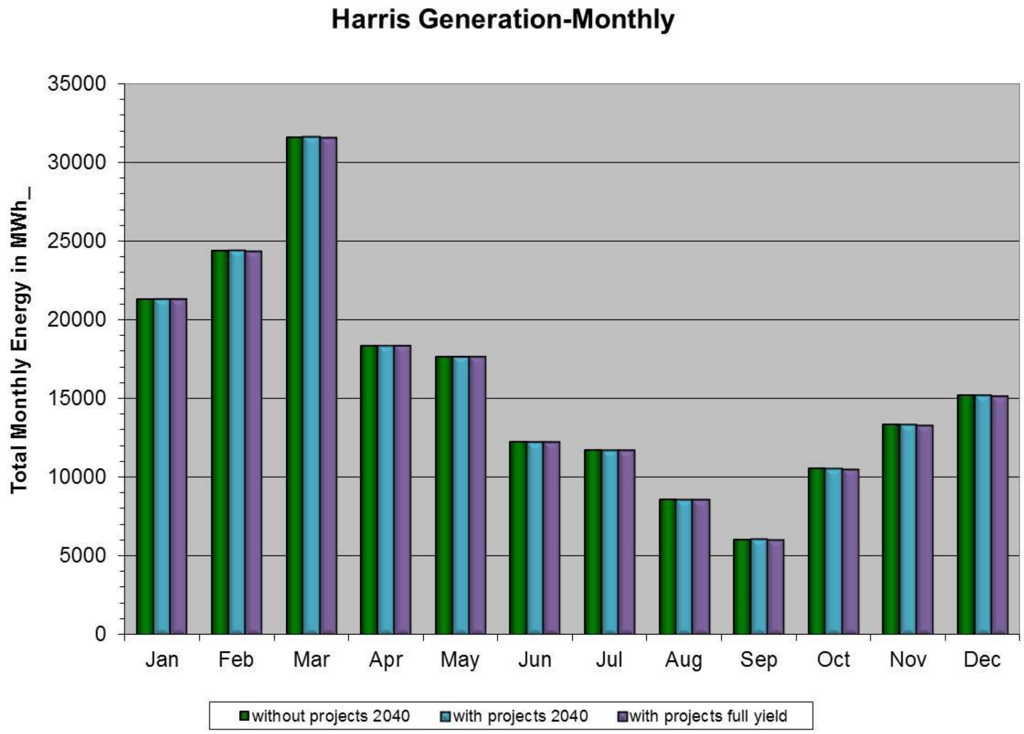

Figure 24. Monthly energy generation, Harris

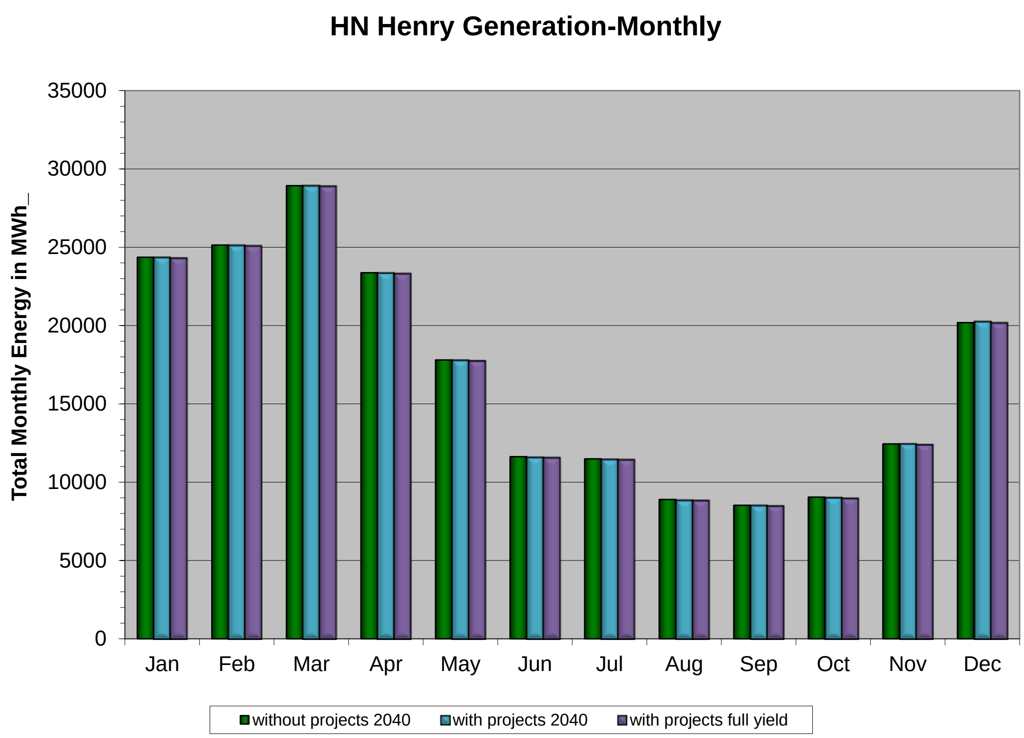

Figure 25. Monthly energy generation, H.N. Henry

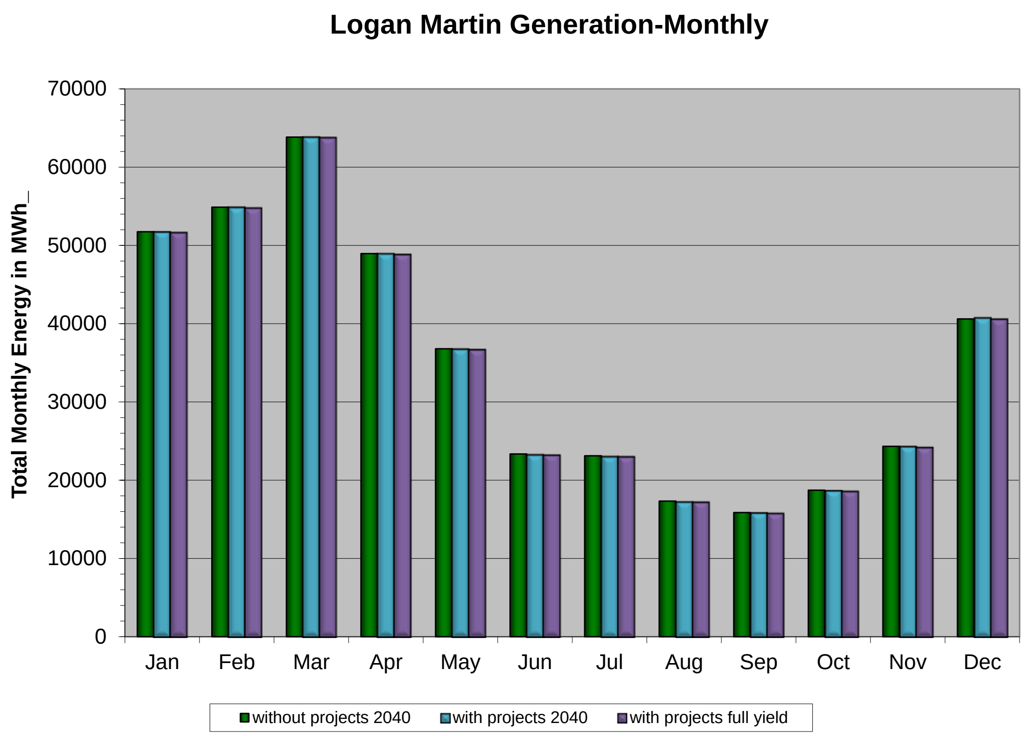

Figure 26. Monthly energy generation, Logan Martin

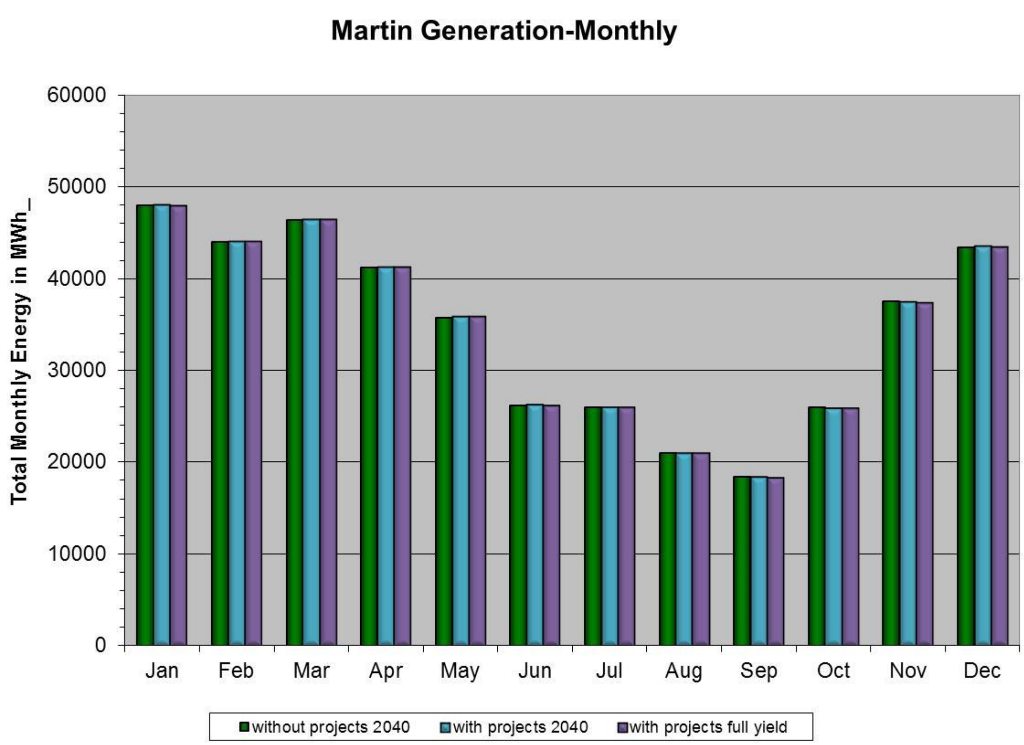

Figure 27. Monthly energy generation, Martin

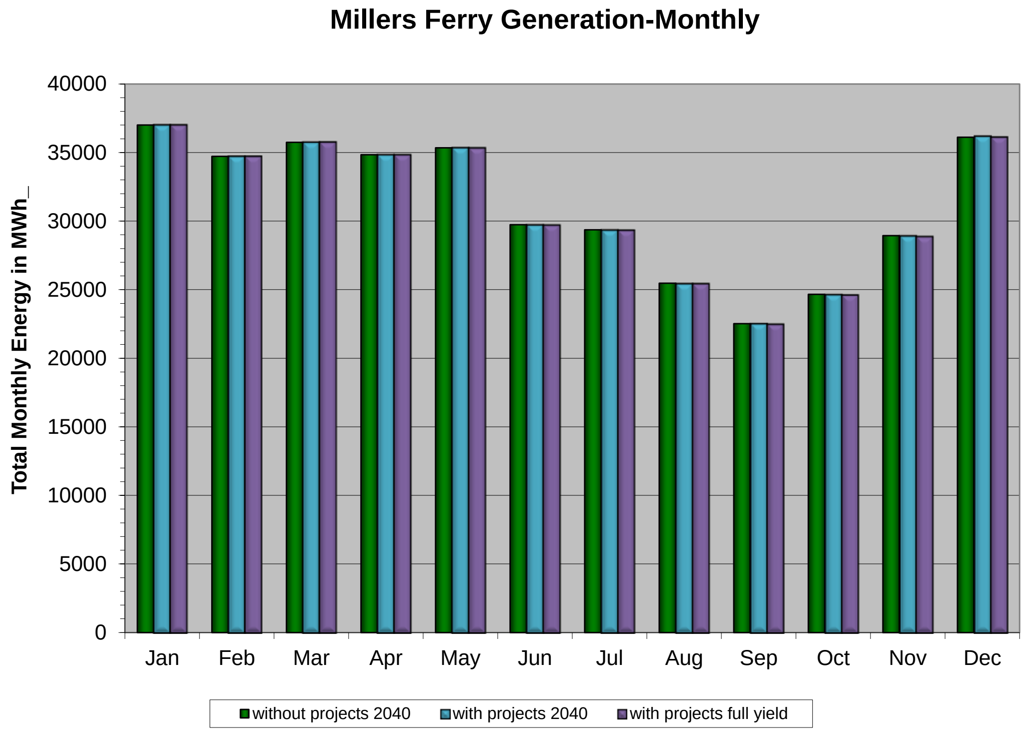

Figure 28. Monthly energy generation, Millers Ferry

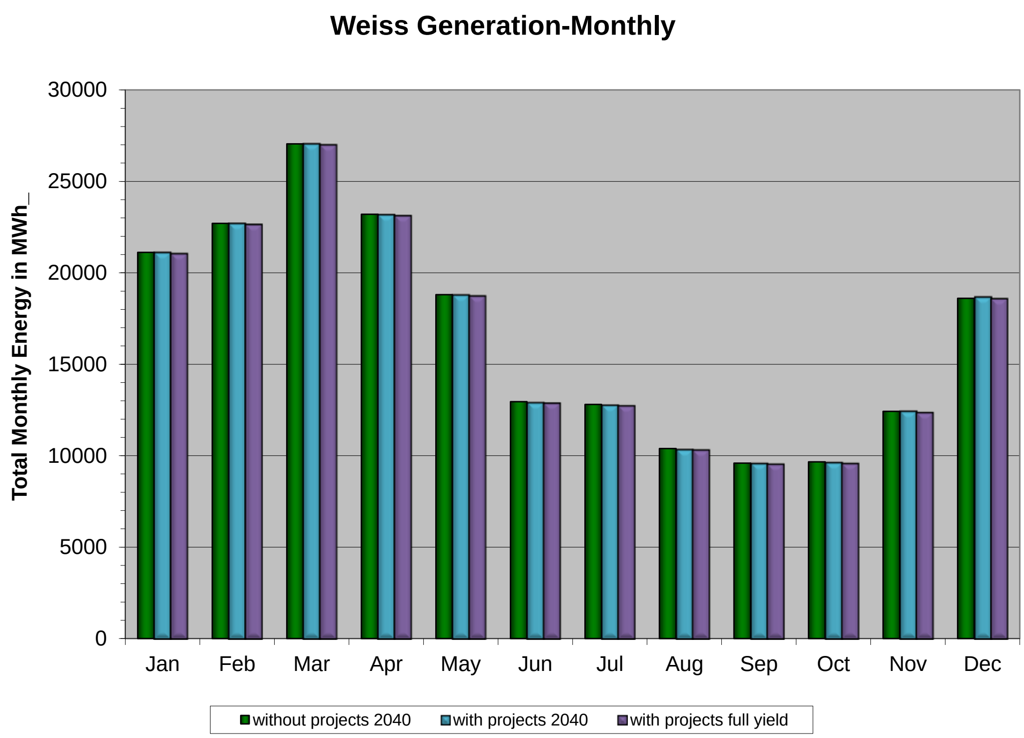

Figure 29. Monthly energy generation, Weiss

1.4.3 Impacts to Navigation

Figure 30 and Figure 31 show the percentage of time navigation targets (7.5 and 9 feet, respectively) are met by month. For most months, there is no change, and when differences do occur, they are always less than 1%. For example, in November, the time with a 7.5 foot channel in November decreases from 71.8% to 71.5% between the *2040 without projects* run and *full yield* run, while in July, the time with a 7.5 foot channel increases from 80.6% to 80.7% between the without projects run and with projects runs.

Figure 32 and Figure 33 show the number of years that target navigation depths (7.5 and 9 feet, respectively) are maintained for the full month. Small shifts in the timing of flows below the navigation thresholds, especially around the first of the month can result in a particular year being counted in one run and not another. For example, in November 1960, the lowest flow is just above the threshold in the *without projects* run and just below in the *with projects* runs (see Figure 34). Overall, the impacts to navigation are minor and both beneficial and non-beneficial shifts occur with the addition of the projects.

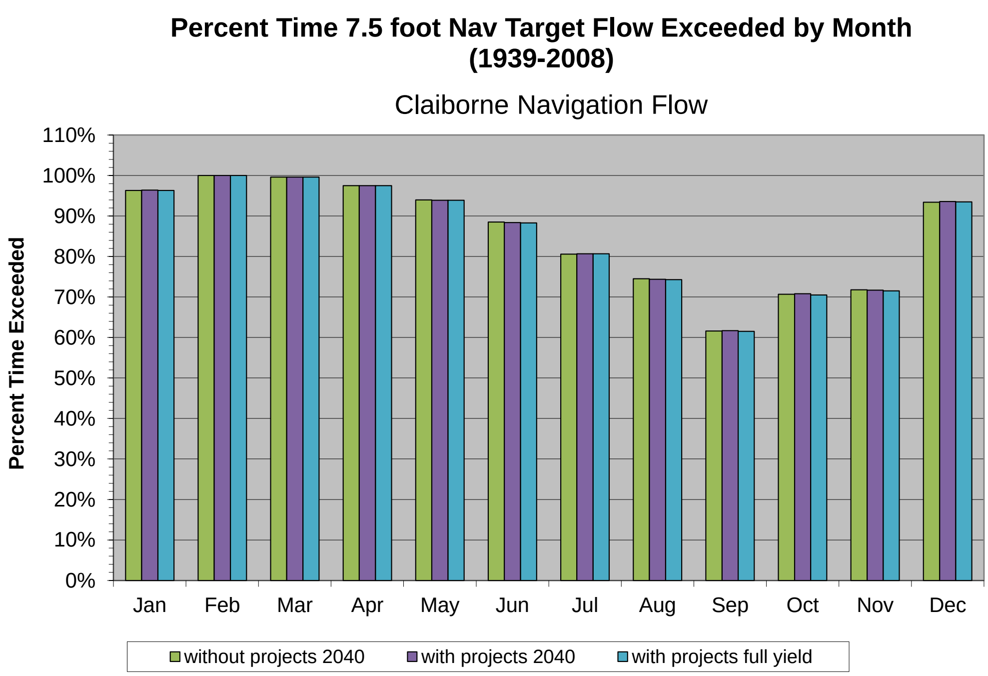

Figure 30. Percent of time 7.5 foot navigation target is exceeded by month

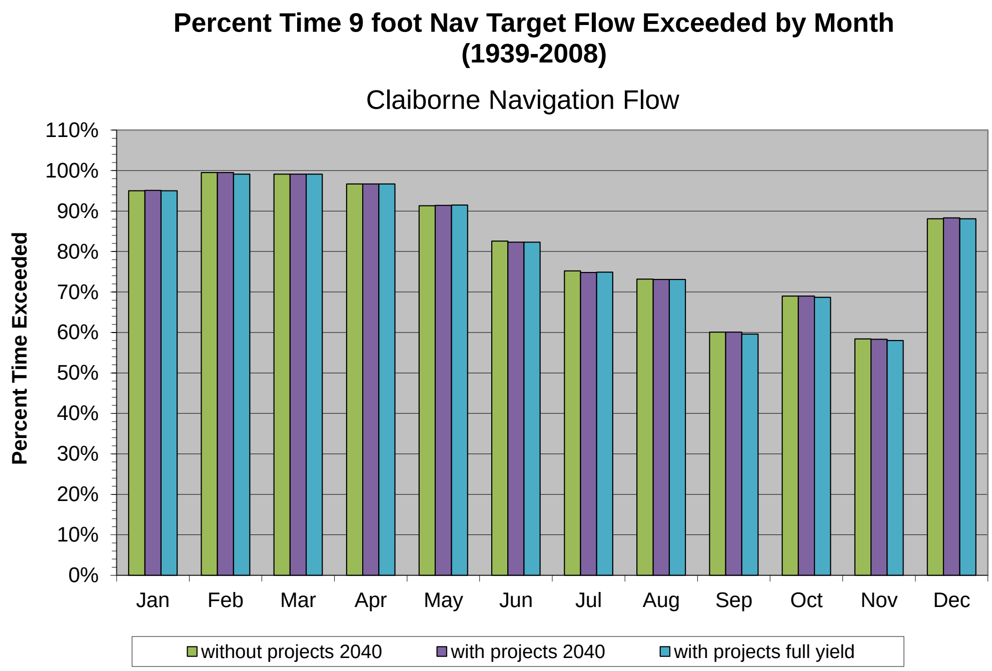

Figure 31. Percent of time 9 foot navigation target is exceeded by month

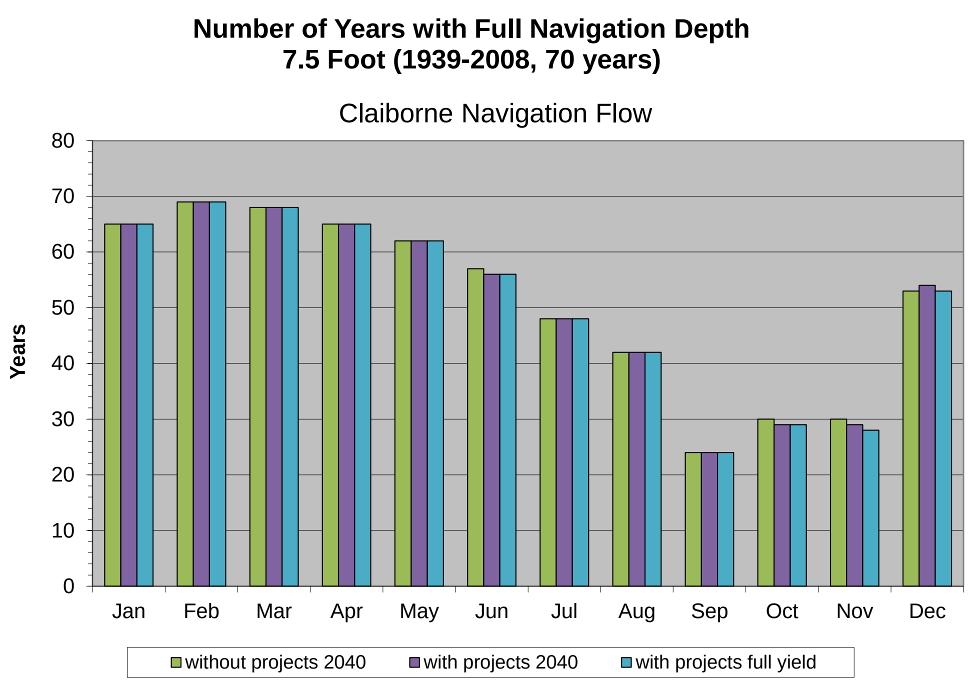

Figure 32. Number of years 7.5 foot navigation depth is maintained for the full month[3]

[3] Small differences in flow can lead to full year differences; see Figure 34 for an example.

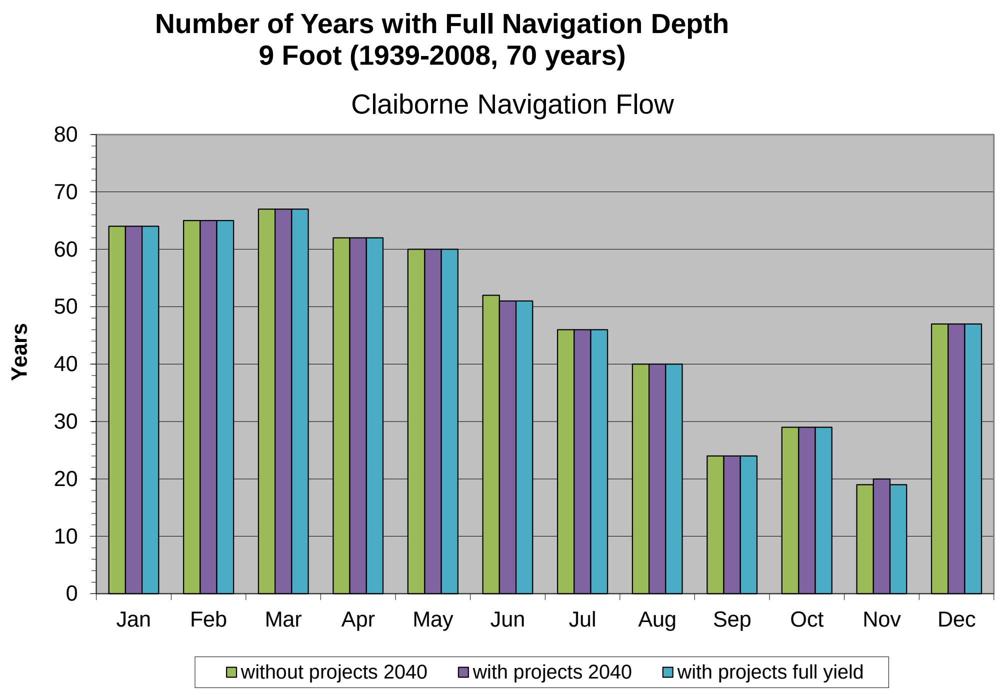

Figure 33. Number of years 9 foot navigation depth is maintained for the full month

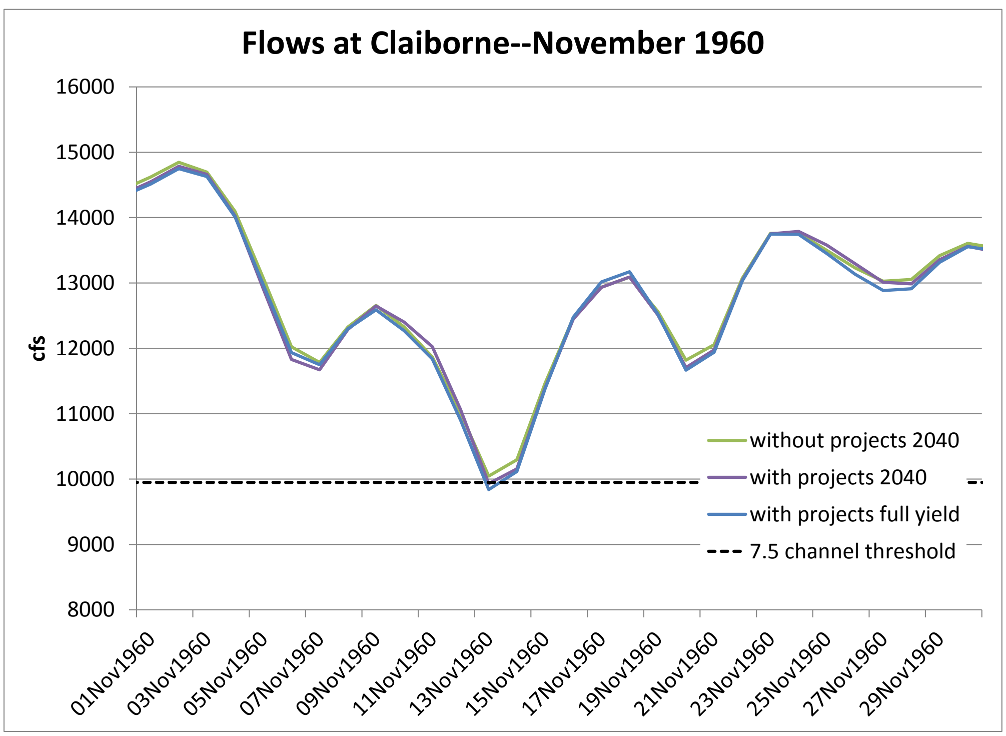

Figure 34. Claiborne flows in November 1960, a month in which full navigation depth is achieved in the *without projects* runs but not the *with projects* runs in Figure 32.

1.4.4 Impacts to Drought Operations

There are three different triggers that determine drought operation levels. The first is the Basin Inflow Trigger. Figure 35 shows a 0.1% shift in the amount of time the Basin Inflow Trigger is in the “low” versus “normal” condition, with more time in the normal condition with the projects. This small shift is probably not indicative in an actual change of conditions for two reasons. First, in the equation for calculating the Basin Inflow condition, the (unregulated) flow upstream of Allatoona is subtracted out of the Etowah River component of basin inflow: because much of Paulding County’s withdrawal shifts from Lake Allatoona to the downstream reach when the projects are added, the Etowah Basin Inflow term is higher for the with project runs. We are not clear on the reasoning behind subtracting out the Allatoona and upstream component of Basin Inflow, but if this calculation were based on Kingston instead, the results might be different. Second, one of the unregulated flow terms used in the calculation (JordanIN_UNREG) shows a surprising difference between scenarios. While, the flows between the scenarios are different by the expected amounts (consumptive use), the unregulated flows, on the other hand, show a 69 cfs *increase* in the *with projects 2040* run compared to *without projects 2040* run, and 44 cfs increase in the *with projects full yield* run compared to the *without projects 2040* run.

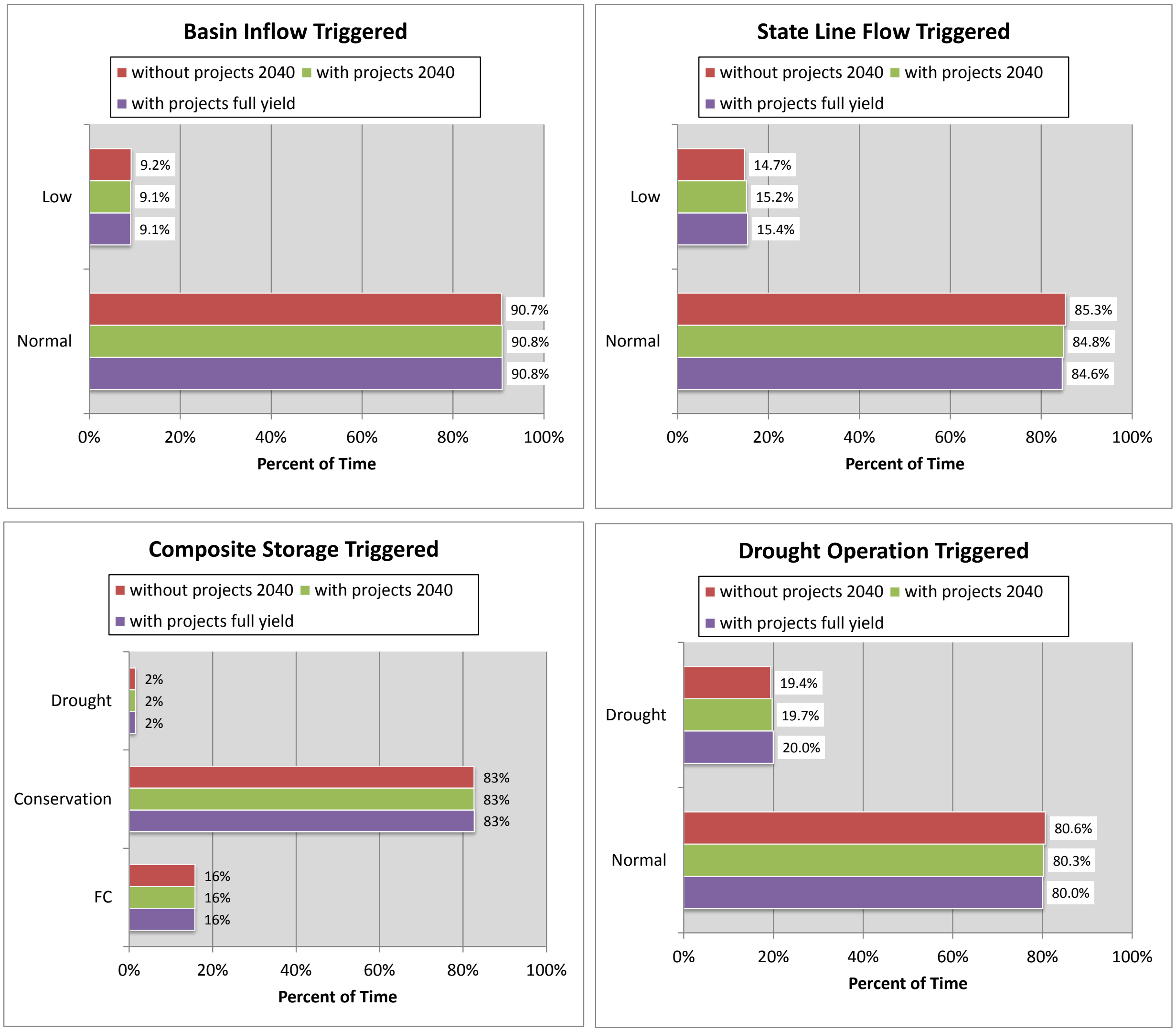

Figure 35. Drought operation triggers

The second trigger is the State Line Flow Trigger, which marks time when flow at Rome-Coosa is below the low State Line Flow criteria. Figure 35 shows a 0.5-0.7% increase in time in the low condition with the addition of the projects. Because the trigger is only changed twice a month, a small difference in the flows can change the trigger for a full two weeks. As an example, on February 1, 2000 of the simulations, the *with and without projects 2040* runs State Line Flow Trigger is off, while the *full yield* run's triggers remain on, as shown in Figure 36.

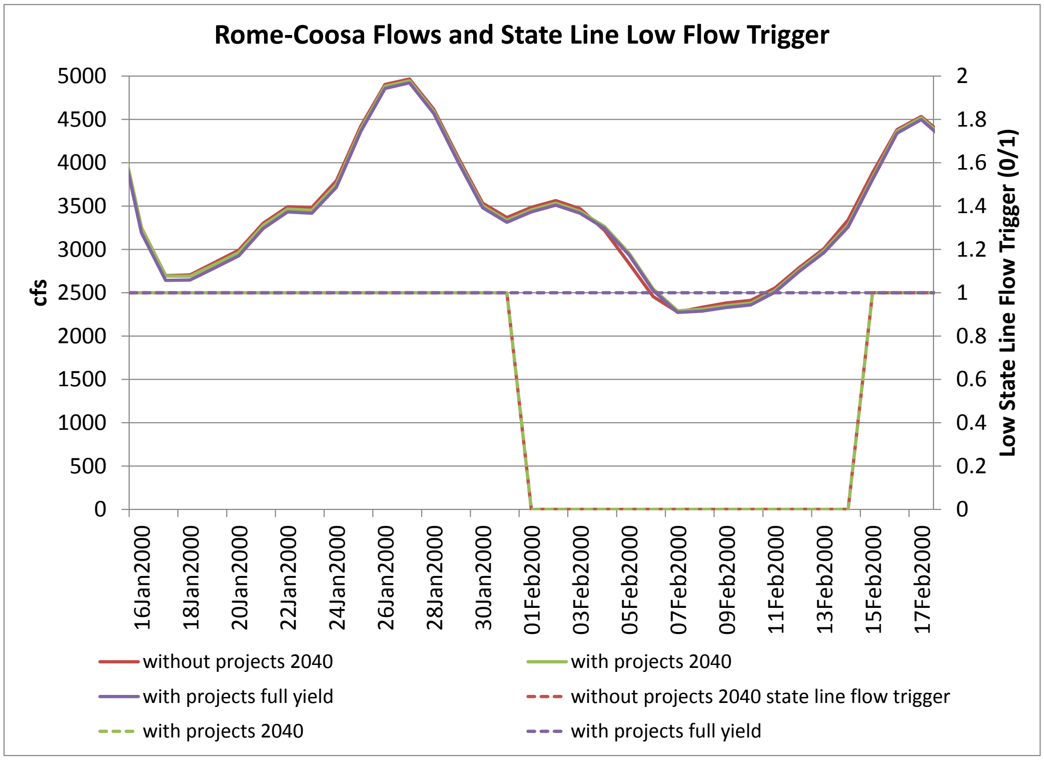

Figure 36. Flows at Rome Coosa and the Low State Line Flow Trigger

The third and final trigger looks at composite storage: the Composite Storage Trigger is unchanged with the addition of the projects (Figure 35). These three triggers are added together to determine the drought level (Figure 35 and Figure 37). The *with project* scenarios show a 0.4-0.7% increase in time spent in Drought Level 1 (one trigger below normal conditions) and a 0.1% decrease in time spent in Drought Level 2 (two triggers below normal conditions). There is no difference in Drought Level 3. Note that the issues raised in regard to the individual triggers also affect the Drought Operations Trigger.

Figure 38 shows the percentage of time the system is in various operations. All three scenarios spend the majority of the time in “9 ft channel” operation (about 70%). The with projects scenarios show a decrease of 0 to 0.3% in time spent in “9 ft channel” operation. There is a decrease of 0.2 to 0.3% in time spent in “7.5 ft channel” operation and a decrease of 0.1% in “7Q10” operations.

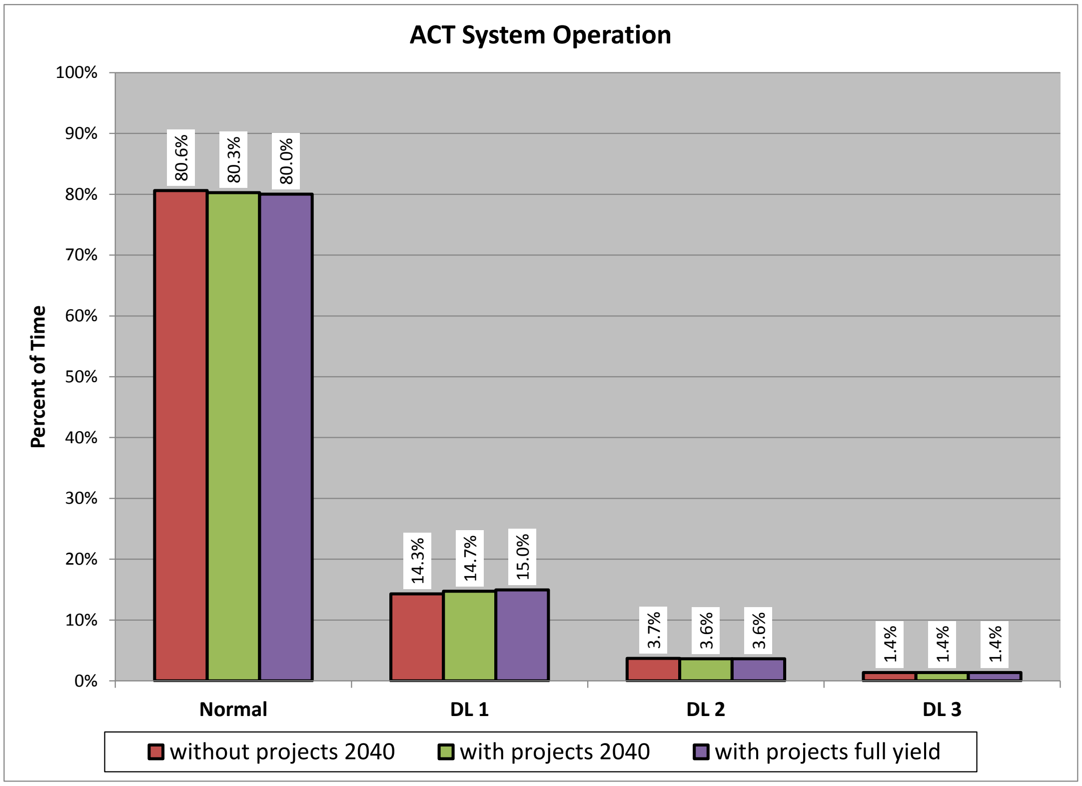

Figure 37. Drought levels

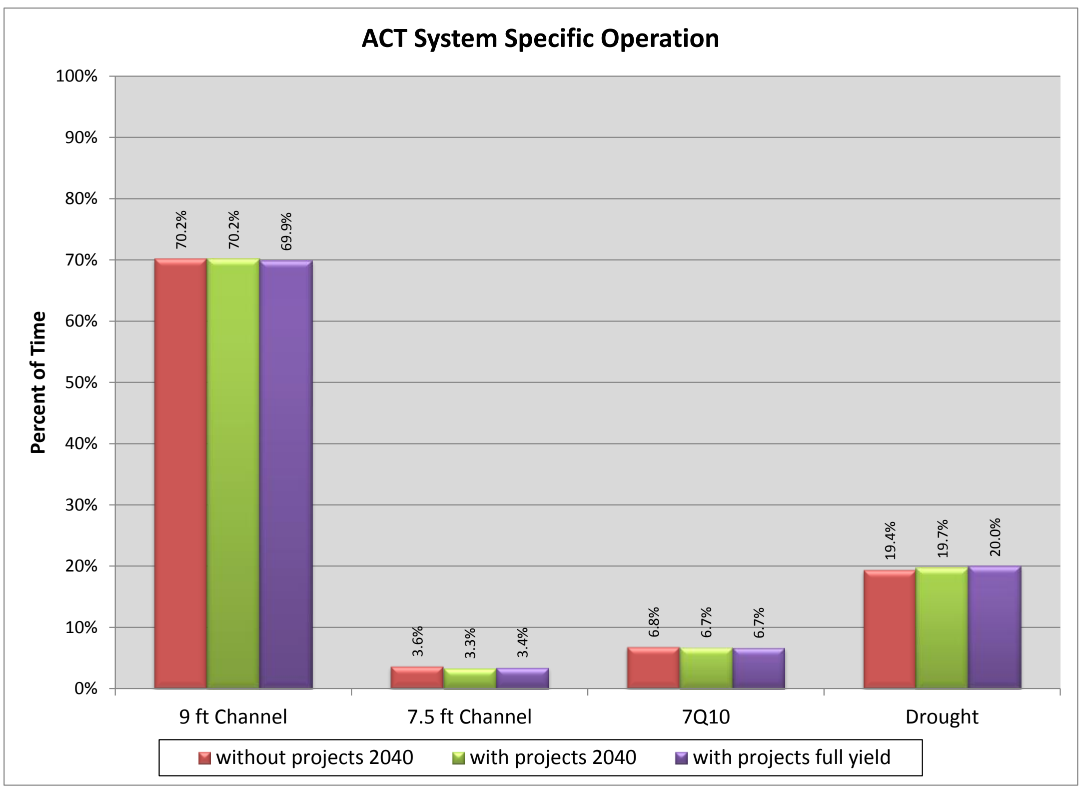

Figure 38. ACT system specific operation

1.4.5 Impacts to Pool Levels

The only reservoir with impacts to pool levels is Lake Allatoona. By relocating much of Paulding County's withdrawal from the lake to Richland Creek Reservoir, Allatoona's stage remains approximately 0.2 ft higher on average. This can be seen in Figure 39 and Figure 40. The pool still drops below the recreation impacts levels in all years (Figure 41), but there is a small improvement in summer recreation levels with the projects (Figure 42).

Impacts on other pool levels are essentially zero. The three reservoir node locations included in the Corps of Engineers' spreadsheet that are closest to the projects are shown: 1) the reservoir node closest to the confluence of the Coosa and Tallapoosa Rivers, and therefore the most upstream location affected by all three projects, is the node entitled 'RF Henry'; 2) the reservoir node closest to the confluence of the Coosa and Etowah Rivers, and therefore the most upstream location affected by the Russell and Richland Creek projects, is the node entitled 'Weiss'; and 3) the reservoir node closest to the confluence of the Little Tallapoosa and Tallapoosa Rivers, and therefore the most upstream location affected by the Indian Creek project, is the node entitled 'Harris'. For each location, annual duration curves of pool elevation and number of years the pools fall below important levels are shown in Figure 43 to Figure 54.

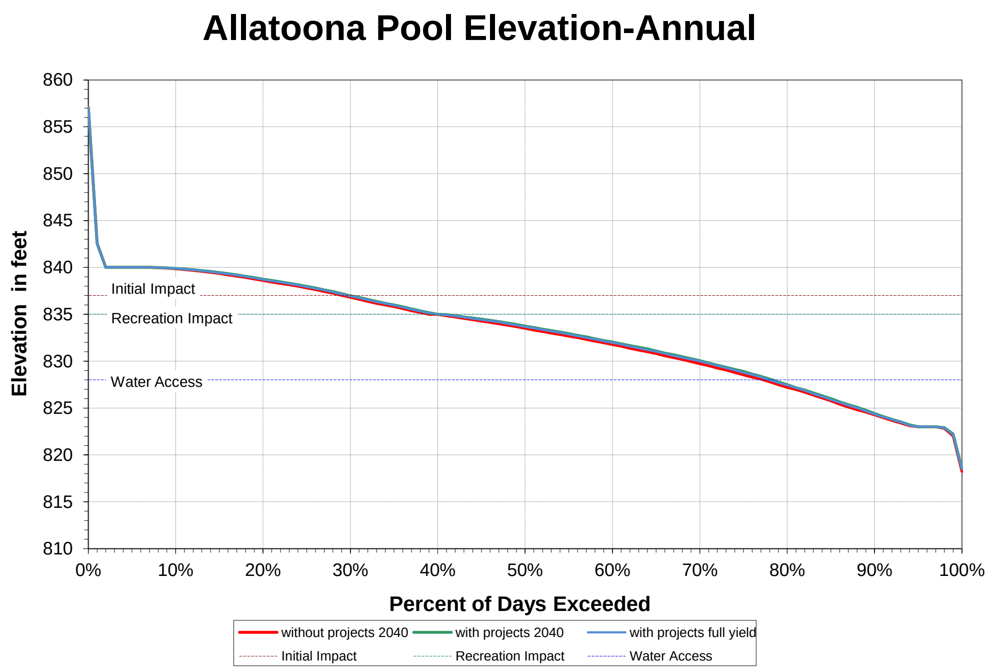

Figure 39. Pool elevations, Allatoona

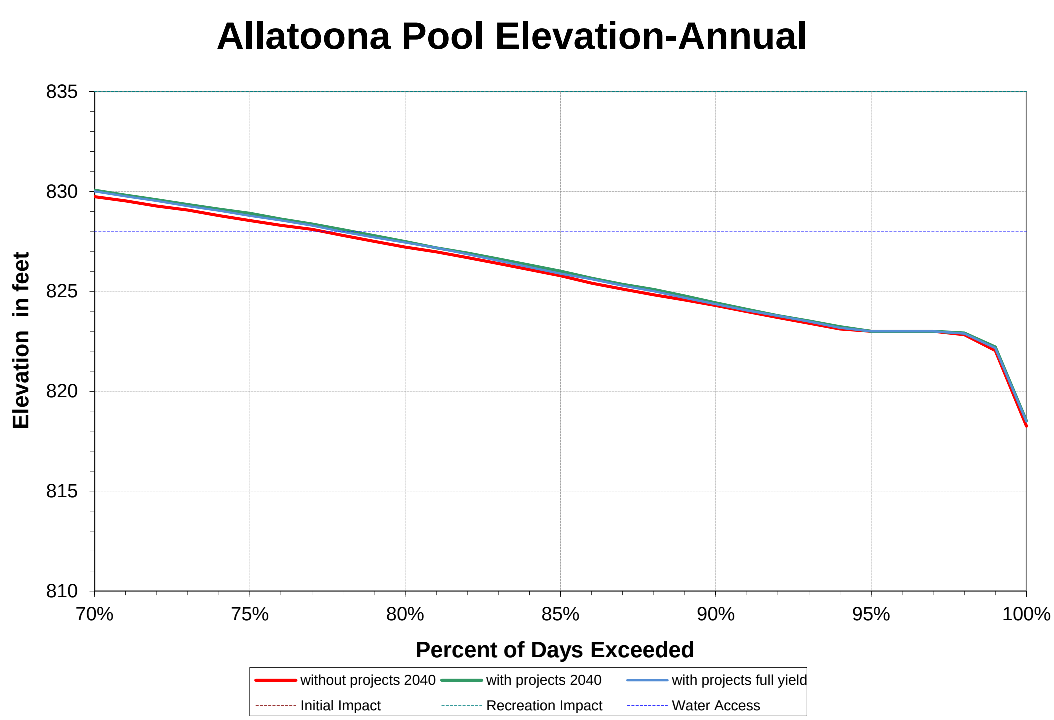

Figure 40. Pool elevations, lowest 30%, Allatoona

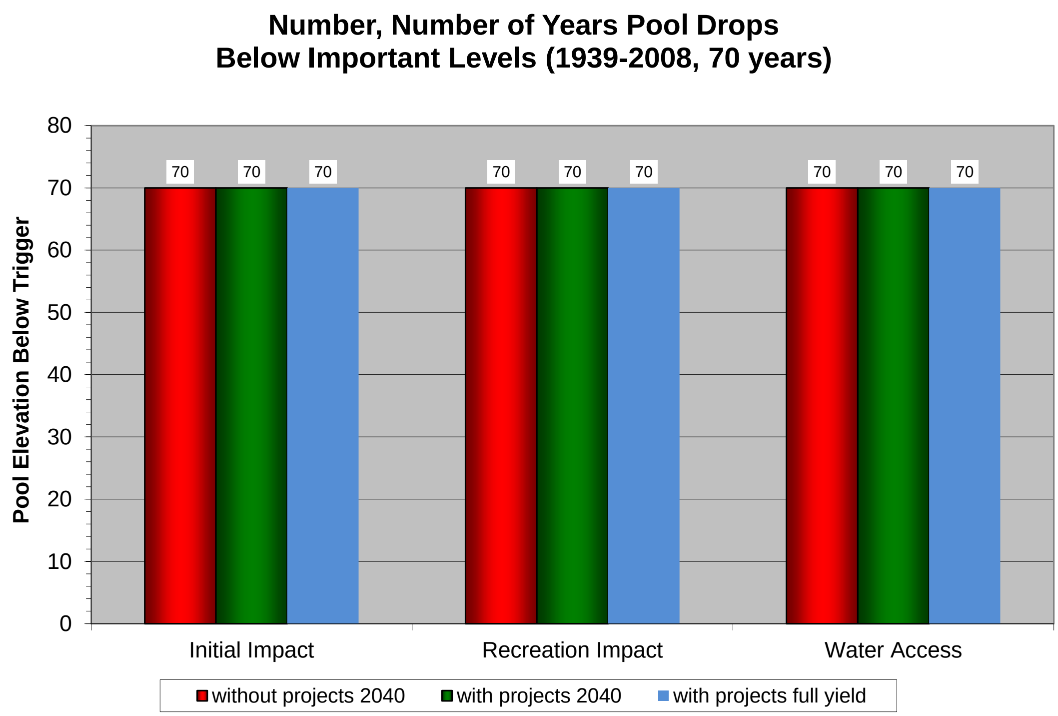

Figure 41. Number of years pool drops below important levels, Allatoona

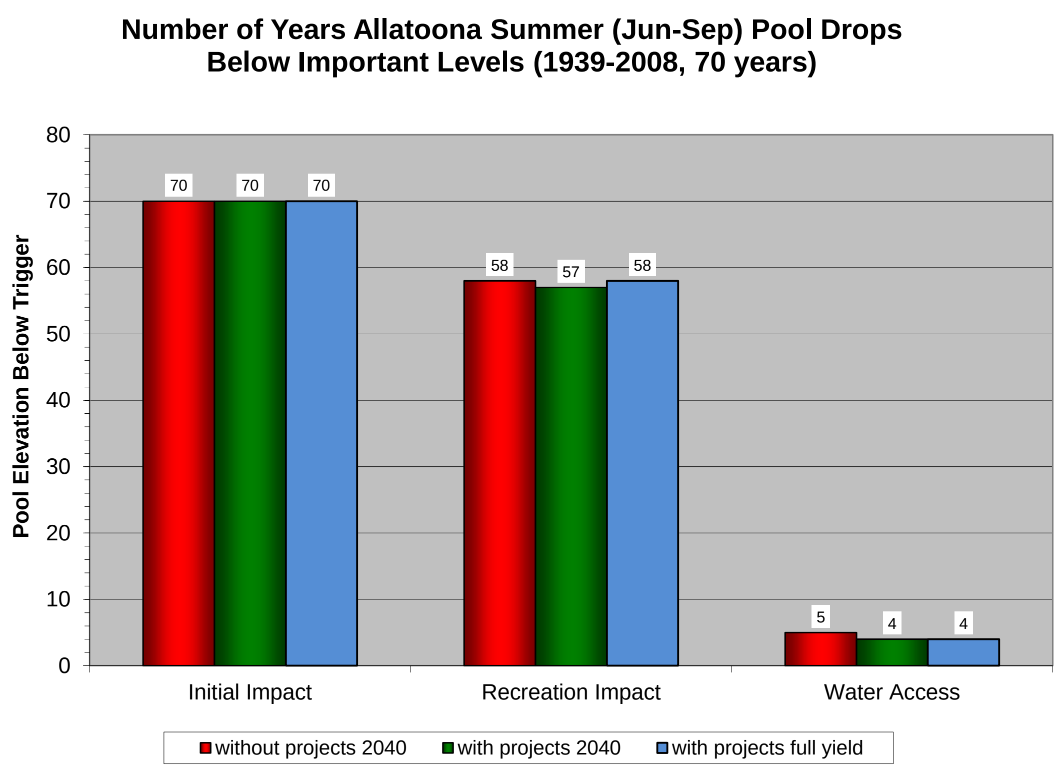

Figure 42. Recreation impact, Allatoona

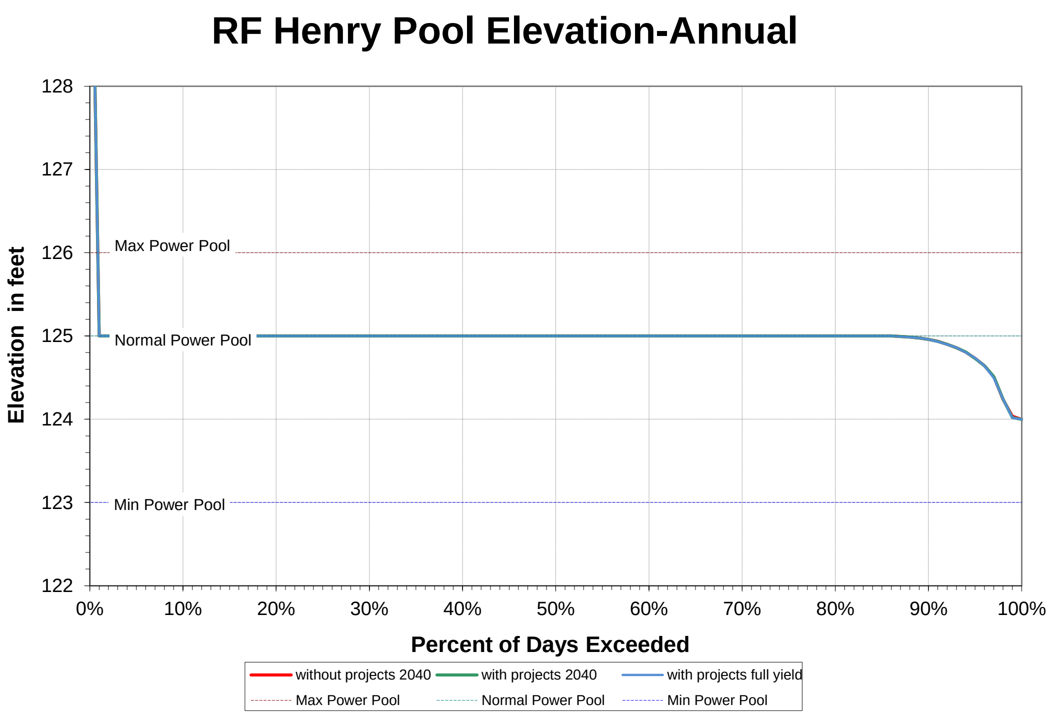

Figure 43. Pool elevations, R.F. Henry

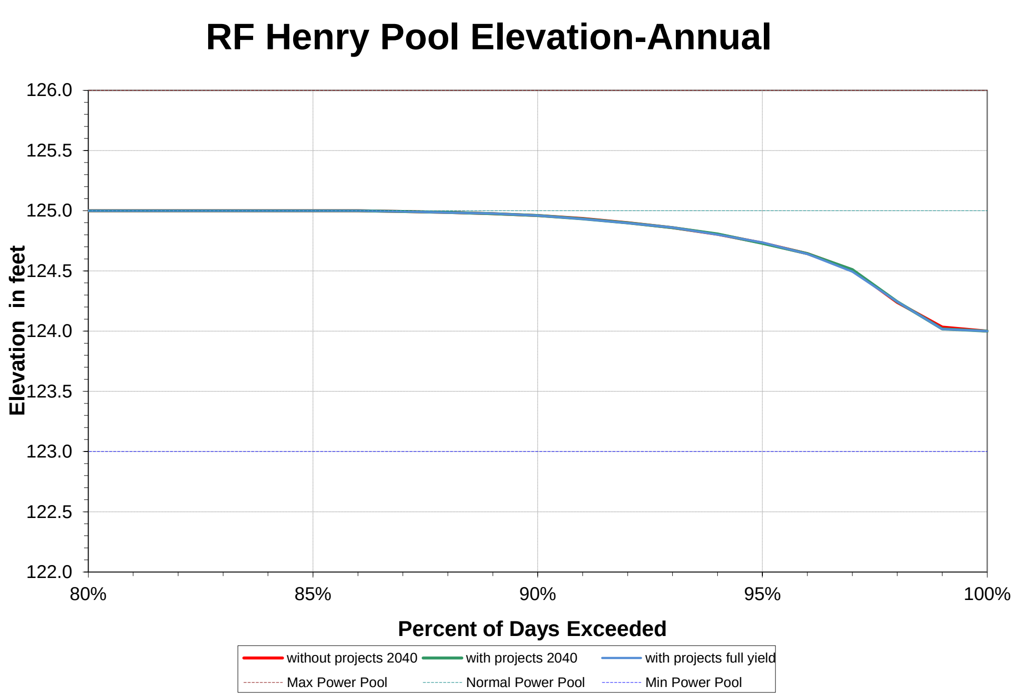

Figure 44. Pool elevations, lowest 20%, R.F. Henry

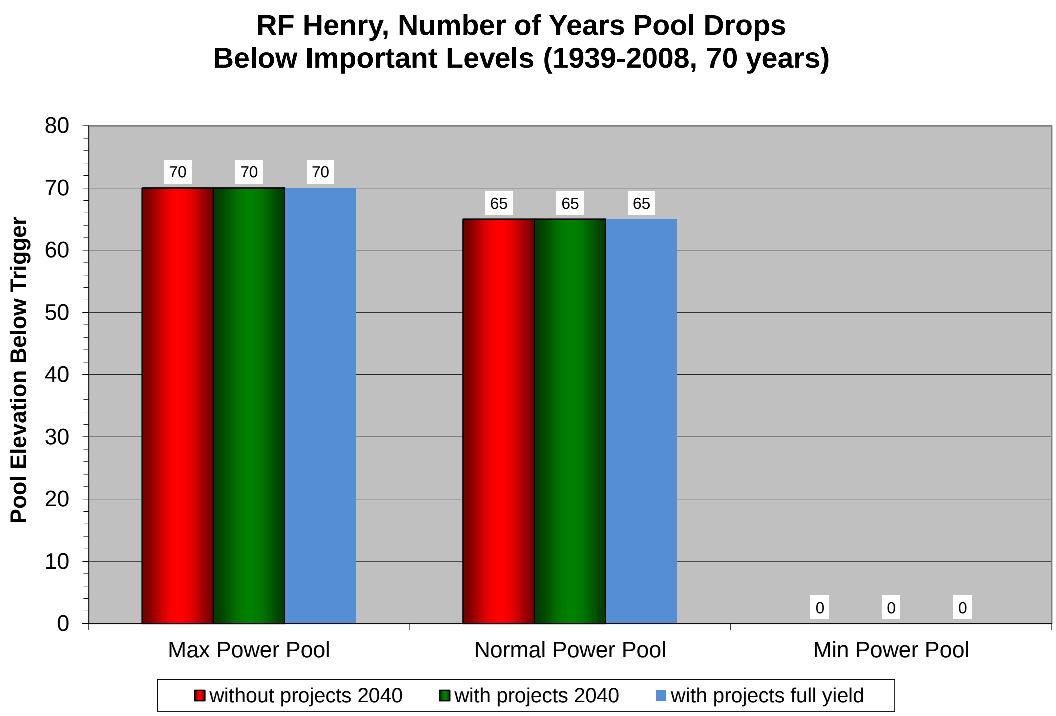

Figure 45. Number of years pool drops below important levels, R.F. Henry

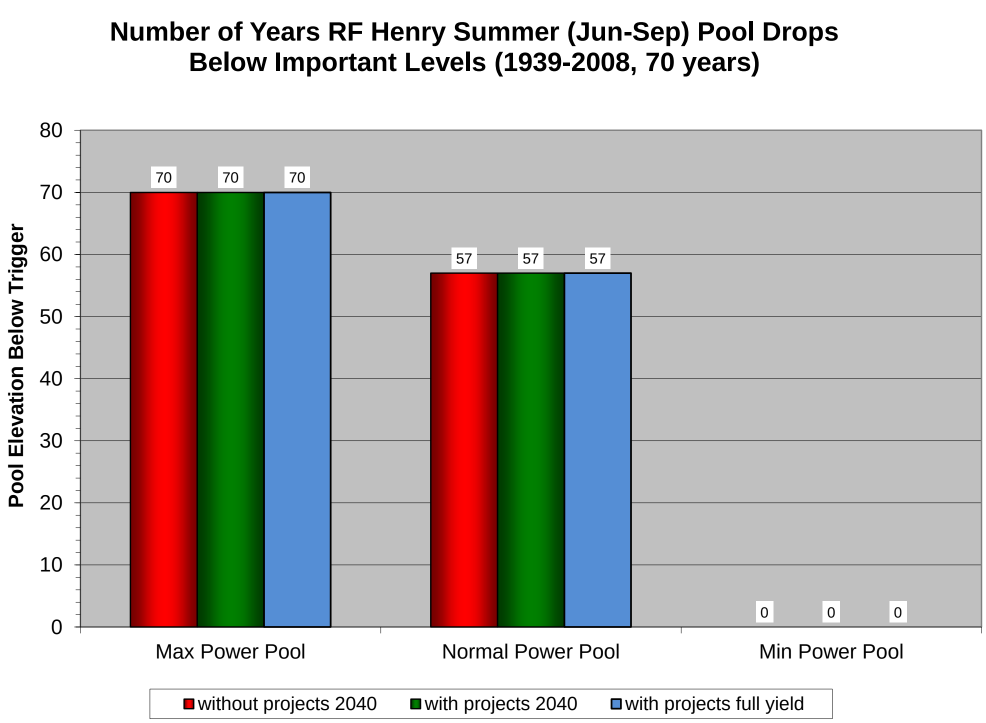

Figure 46. Recreation impact, R.F. Henry

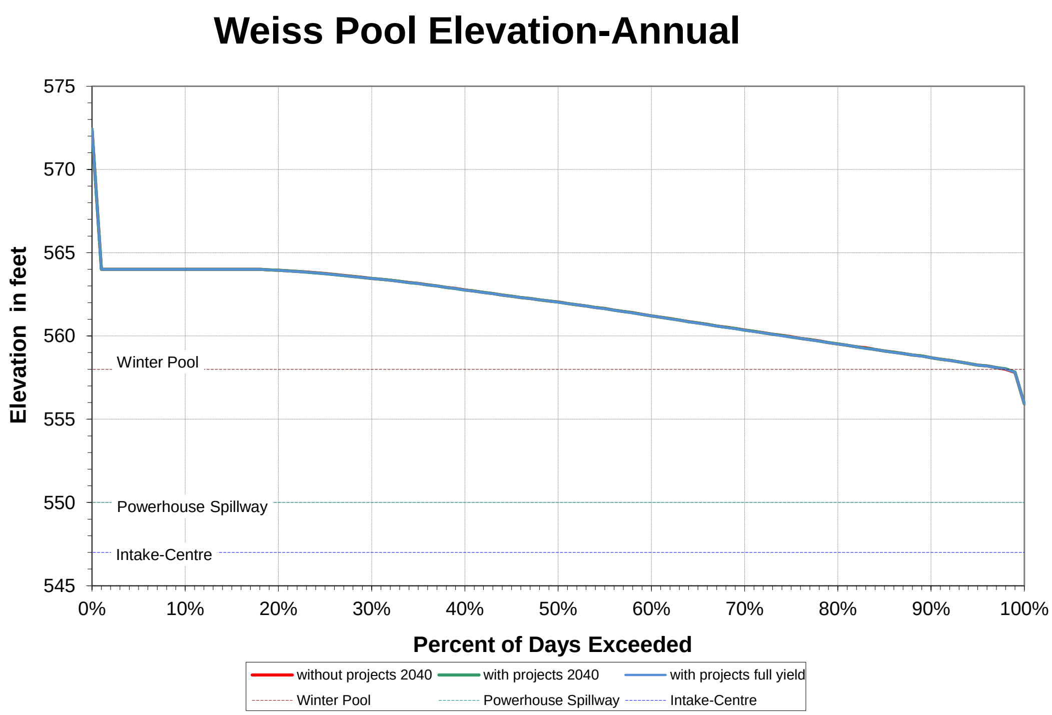

Figure 47. Pool elevations, Weiss

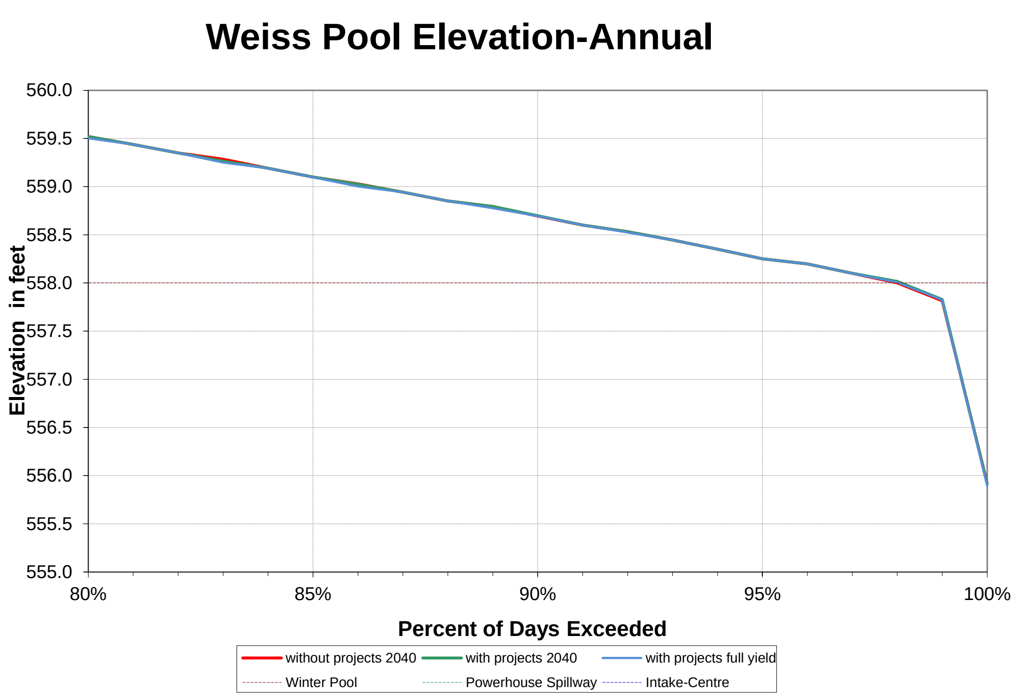

Figure 48. Pool elevations, lowest 20%, Weiss

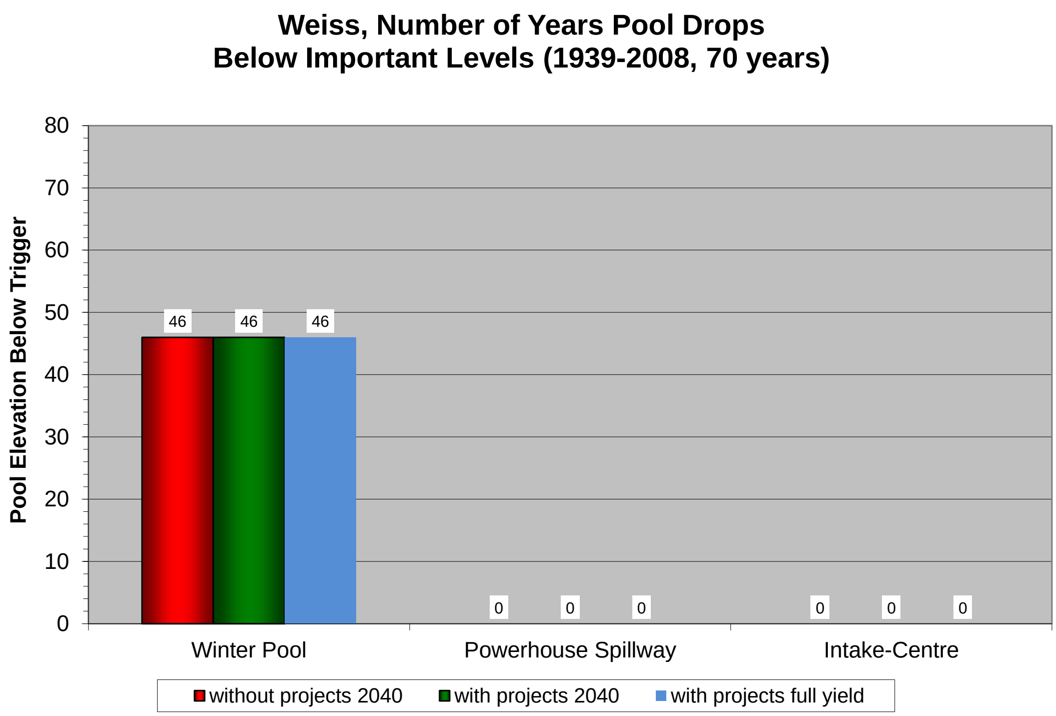

Figure 49. Number of years pool drops below important levels, Weiss

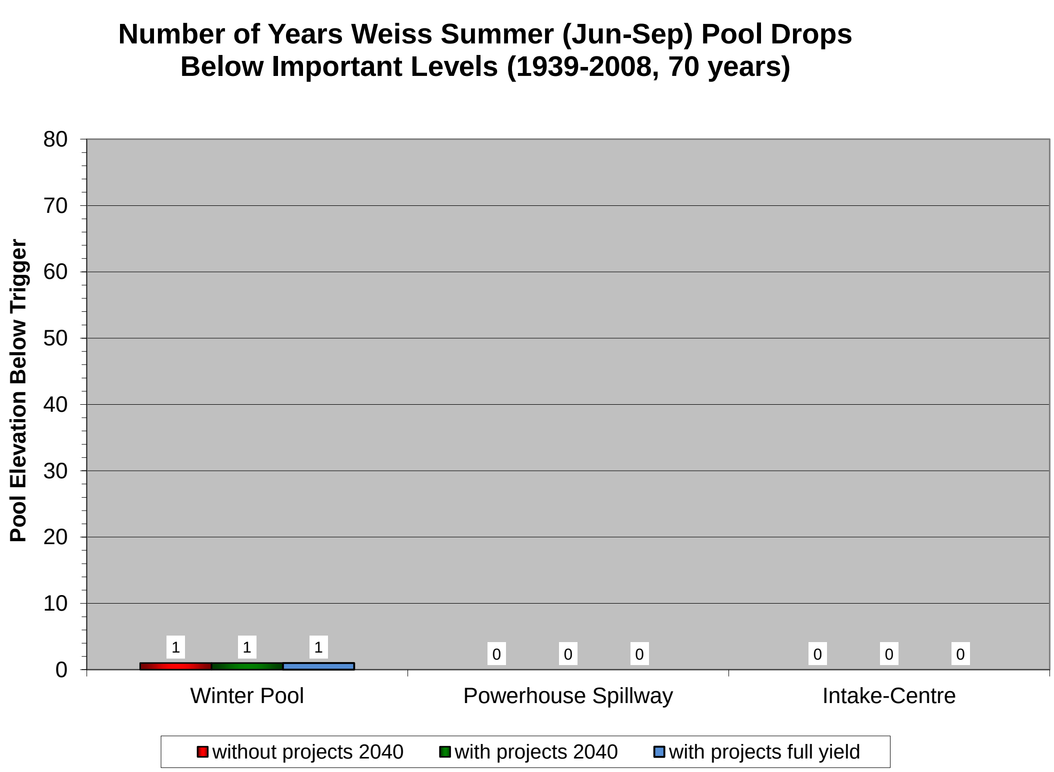

Figure 50. Recreation impact, Weiss

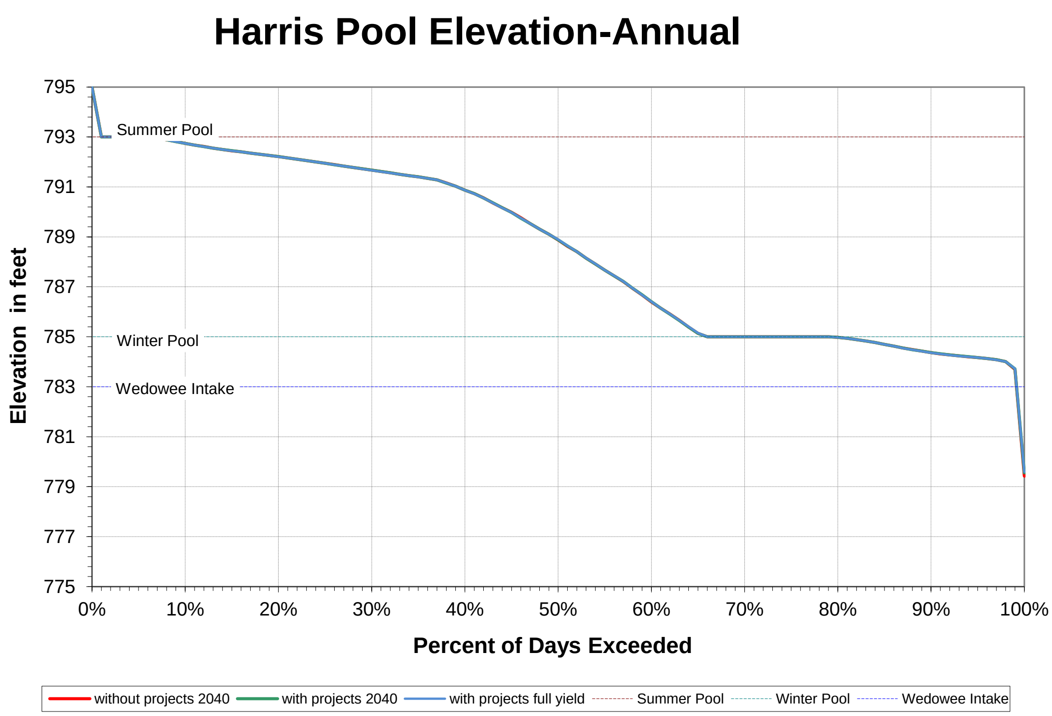

Figure 51. Pool elevations, Harris

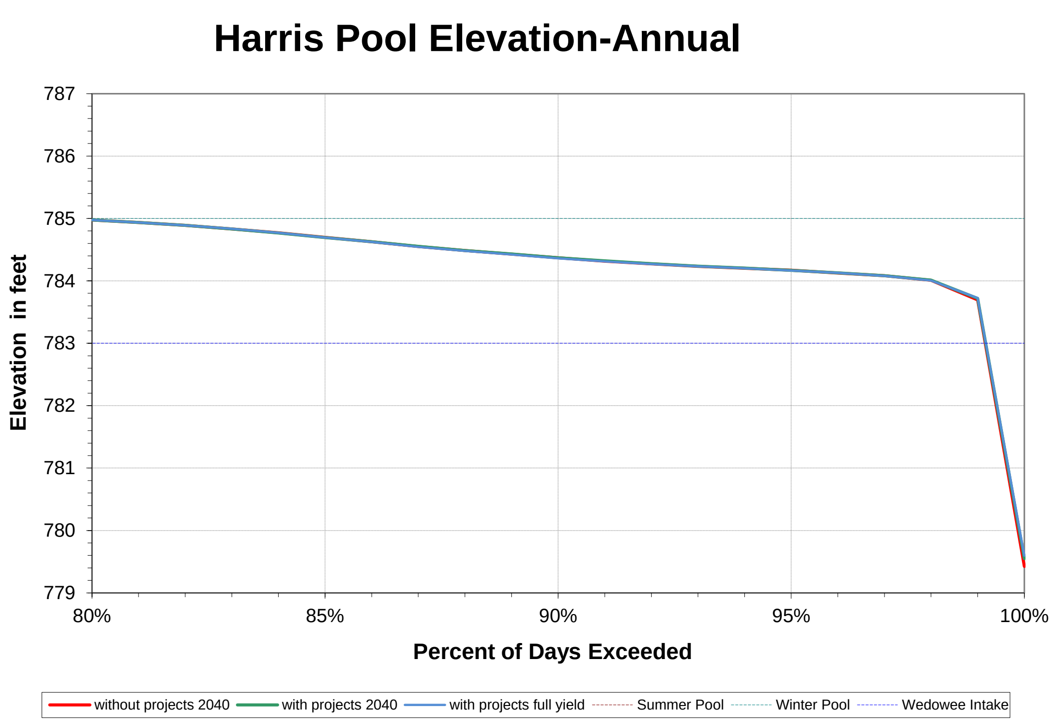

Figure 52. Pool elevations, lowest 20%, Harris

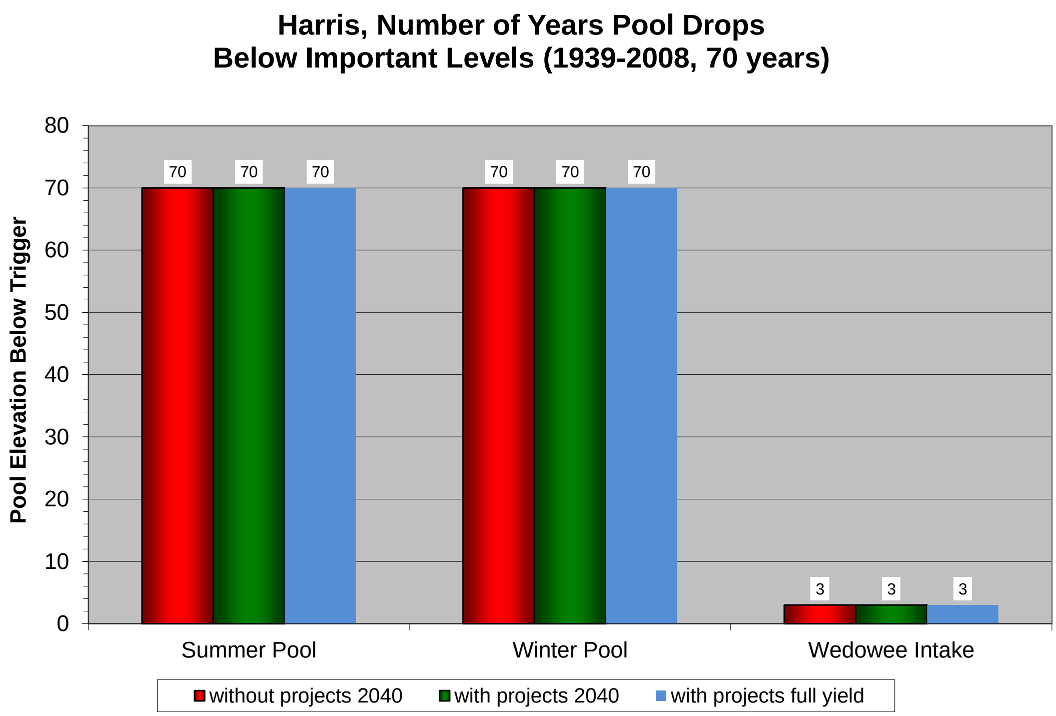

Figure 53. Number of years pool drops below important levels, Harris

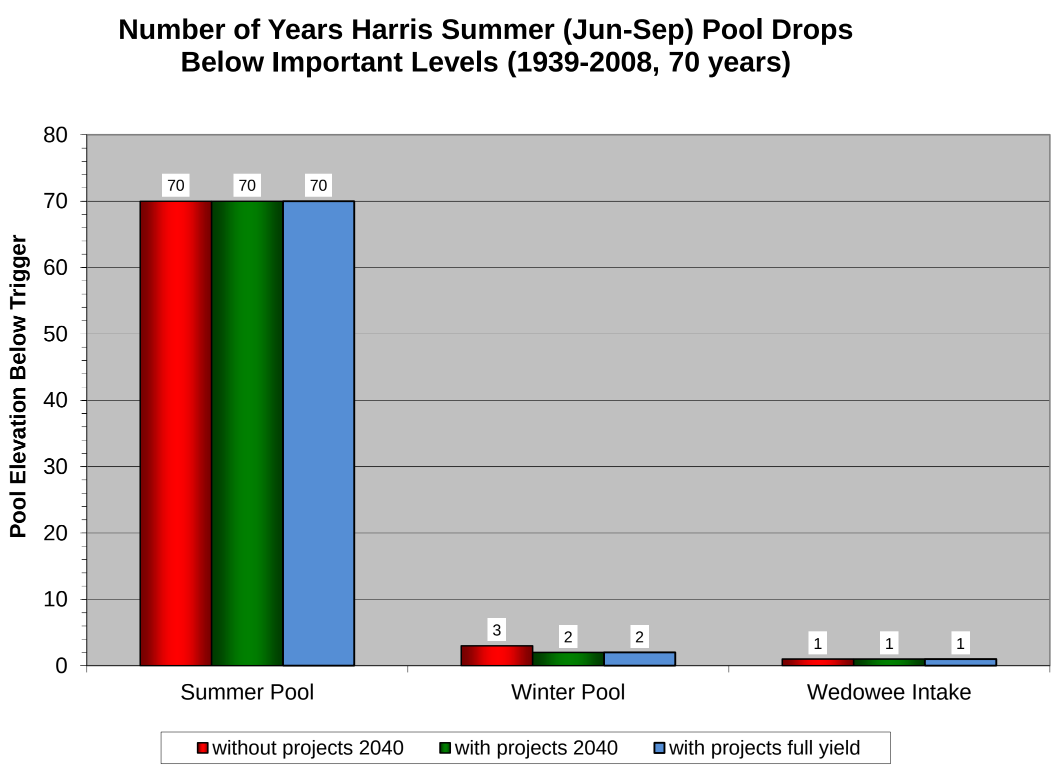

Figure 54. Recreation impact, Harris

1.5 Conclusion

The impacts of the three projects to stream flows, hydropower, navigation, drought operations, pool levels, and recreation are very small and, when they occur at all, the impacts are beneficial as well as non-beneficial. The beneficial impacts result from the relocation of withdrawals and the fact that stream withdrawals associated with the proposed water supply reservoirs will comply with Georgia regulations for low flow protection and this curtailment and/or augmentation of stream withdrawals during drought periods is beneficial to stream flow when compared to what stream flow would be during drought conditions without the proposed reservoir projects. The non-beneficial impacts observed herein are often not a result of the proposed water supply projects; rather, they occur as a byproduct of minor timing or magnitude changes crossing operational thresholds of the Corps' or APC's reservoirs. Statistical thresholds, such as the first of the month or pool elevations which trigger certain reservoir operations, can magnify impacts. Overall, both beneficial and non-beneficial impacts are well within the error of the model.

Report Addendum

The Army Corps of Engineers requested an additional set of runs to complete their review. These runs use a different assumption for withdrawals from Lake Allatoona: rather than assuming future demands (approximately year 2040), CCMWA and Cartersville withdrawals are set to their current contract amounts. Table1a shows the net demands from the original runs.[4] Table 2a shows the net demands from the new runs, which are delineated by the suffix "a". The difference can be seen for Lake Allatoona only, in the highlighted cells.

Limiting the Allatoona withdrawals results in a gap between the projected CCMWA and Cartersville demands and the modeled demands. Identifying replacement sources is beyond the scope of this project. There are some scenarios that show *less* than the contract amount from Lake Allatoona; this happens when a portion of CCMWA's withdrawal is moved to Hickory Log Creek Reservoir or Richland Creek Reservoir. Scenarios 4a and 5a provide an example. In Scenario 4a, the contract limits of 34.5 and 16.8 mgd are taken from the lake. CCMWA returns its projected 23.8 mgd for a net withdrawal of 27.5 (shown in Table 2a). In Scenario 5a, 24 mgd of CCMWA's withdrawal is relocated to Richland Creek Reservoir. This leaves 10.5 mgd for CCMWA in Lake Allatoona, for a total net withdrawal of 10.5 (CCMWA) + 16.8 (Cartersville) – 23.8 (CCMWA returns) = 3.5 mgd (shown in Table 2a). By maintaining the same net withdrawals in Scenarios 4a and 5a, the impact of the new projects can be assessed. Scenario 6a then takes the projects to their projected yield so that the impact of the ultimate withdrawal can also be assessed.

The results from the new runs do not differ greatly from the original runs, but some of the details have changed. Here, we provide any information that differs from the original report and either updated plots or pointers to the relevant plots in the submitted spreadsheets (Appendix 2a). The sections and figure numbers parallel those in the original report.

The narrative summarizes hydrologic impacts for Scenarios 4a, 5a, and 6a. To aid in understanding the output, the following descriptive names are used for these three runs:

- *'without projects 2040a'* = Scenario 4a (2040/contract demand without proposed reservoirs)
- *'with projects 2040a'* = Scenario 5a (2040/contract demand with proposed reservoirs)
- *'with projects full yield a'* = Scenario 6a (demand equal to full yield for proposed reservoirs)

[4] Gross withdrawals and returns can be found in Table 2 and Table 3 of the original report along with reference notes explaining the demand sources for the original runs.

Table 1a
Net Withdrawal for Scenarios and Model Nodes

Model Node ID	Water Supplier ID	Scenario 1 Current Demands as modeled by Corps, present Allatoona oper.		Scenario 2 Current Demands as modeled by Corps, proposed Allatoona oper.		Scenario 3 Currrent Demands; Same as scenario 2 except HLCR is added		Scenario 4 Future demand (approx. year 2040) per EPD for GA; current demand for AL; HLCR included		Scenario 5 Future demand (approx. year 2040) per EPD for GA; current demand for AL; HLCR + 3 new reservoirs included		Scenario 6 Same as scenario 5 except ultimate future demand applied to 3 new reservoirs	
Etowah River		mgd	ref. note	mgd	ref. note	mgd	ref. note	mgd	ref. note	mgd	ref. note	mgd	ref. note
Dawsonville	Etowah WSA	0		0		0		0		4.7		5.9	
Canton	City of Canton, CCMWA (Scen 3-6), other	22.7		22.7		55.7		80.2		75.5		75.5	
Allatoona:	CCMWA & Cartersville	51.5		51.5		18.5		91.2		67.2		74.2	
	Cherokee & Fulton County (returns only)							-27.4		-27.4		-27.4	
Richland Creek pump station	Paulding & Bartow County, City of Emerson (returns only)	NA		NA		NA		NA		-29.1		-31.7	
Cartersville	City of Cartersville (Also, Paulding & Bartow County, City of Emerson for Scen 4a) (returns only)	NA		NA		NA		-44.4		-15.3		-15.3	
Richland Creek Reservoir	Paulding County	NA		NA		NA		NA		24		35	
Kingston	Bartow & Other	57.5		57.5		57.5		68.6		68.6		68.6	
	Etowah through Kingston node	**131.7**		**131.7**		**131.7**		**168.2**		**168.2**		**184.8**	
Little Tallapoosa River													
	Upstream of Indian Cr. Pump Station									-5.21		-10	
	Indian Cr. Node									7.89		7.89	
	Newell	6.1		6.1		6.1		-5.21		11		18	
	Little Tallapoosa through Newell	**6.1**		**6.1**		**6.1**		**-5.21**		**13.68**		**15.89**	

Table 2a
Net Withdrawal for Alternative Scenarios and Model Nodes

Model Node ID	Water Supplier ID	Scenario 1 Current Demands as modeled by Corps, present Allatoona oper.		Scenario 2 Current Demands as modeled by Corps, proposed Allatoona oper.		Scenario 3 Currrent Demands; Same as scenario 2 except HLCR is added		Scenario 4a Contract Demands for Allatoona Lake; future demand (approx. year 2040) per EPD elsewhere for GA; current demand for AL; HLCR included		Scenario 5a Contract Demands for Allatoona Lake*; future demand (approx. year 2040) per EPD elsewhere for GA; current demand for AL; HLCR + 3 new reservoirs included		Scenario 6a Same as scenario 5a except ultimate future demand applied to 3 new reservoirs**	
Etowah River		mgd	ref. note	mgd	ref. note	mgd	ref. note	mgd	ref. note	mgd	ref. note	mgd	ref. note
Dawsonville	Etowah WSA	0		0		0		0		4.7	10	5.9	10
Canton	City of Canton, CCMWA (Scen 3-6), other	22.7	1	22.7	1	55.7	4	80.2	5	75.5	11	75.5	11
Allatoona:	CCMWA & Cartersville	51.3	2	51.3	2	18.3	4	27.5	2	3.5	12	10.5	15
	Cherokee & Fulton County (returns only)							-27.4	6	-27.4	6	-27.4	6
Richland Creek pump station	Paulding & Bartow County, City of Emerson (returns only)	NA		NA		NA		NA		-29.1	7	-31.7	16
Cartersville	City of Cartersville (Also, Paulding & Bartow County, City of Emerson for Scen 4a) (returns only)	NA		NA		NA		-44.4	7	-15.3	7	-15.3	7
Richland Creek Reservoir	Paulding County	NA		NA		NA		NA		24	12	35	17
Kingston	Bartow & Other	57.5	3	57.5	3	57.5	3	68.6	8	68.6	8	68.6	8
Etowah through Kingston node		**131.5**		**131.5**		**131.5**		**104.5**		**104.5**		**121.1**	
Little Tallapoosa River													
	Upstream of Indian Cr. Pump Station									2.68	13	-2.11	18
	Indian Cr. Node									11	14	18	19
	Newell	6.1	3	6.1	3	6.1	3	13.68	9	0		0	
Little Tallapoosa through Newell		**6.1**		**6.1**		**6.1**		**13.68**		**13.68**		**15.89**	

Reference notes for Water Supply Demand Spreadsheet.

- 1: 2006 actual withdrawal compiled by State of GA (GAreformatACT-Coosa-24-updated by Inchul-final version 2009-.xls).
- 2: Allatoona permit limit (net withdrawal at this node in ACT_WCM-Aug2011 ResSim modeling)
- 3: Net withdrawal at this node in ACT_WCM-Aug2011ResSim modeling (found in ACT_TOTALDEMANDS.dss).
- 4: As in Scenario 2, but 33 mgd of CCMWA's Allatoona demand is shifted to Canton node to be served by HLCR per Corps directive to model HLCR as permitted. (Safe Yield Analysis Hickory Log Creek Reservoir Canton, Georgia. Schnabel Engineering South, August 2005).
- 5: Includes City of Canton (MNGA District Water Supply Plan, pages 3-13 and B-4), 33 mgd of CCMWA's Allatoona demand (shifted to Canton node to be served by HLCR), other withdrawals (Canton node withdrawal from State's Water Supply Request less City of Canton withdrawal), Etowah WSA returns (provided by Etowah WSA based on recent Wastewater Master Plan, scaled for 2040), Cherokee WSA and City of Jasper returns (derived from County total AAD per MNGA District Wastewater Mgt Plan, Appendix B).
- 6: State Water Plan, personal communication, W. Zeng (9/10/2013).
- 7: Derived from County total AAD per MNGA District Wastewater Mgt Plan, Appendix B.
- 8: Bartow West WWTP + other, calculated as difference between Water Supply Request and other returns
- 9: Withdrawal from GA State Water Plan; return from State's Water Supply Request, Newell node.
- 10: Etowah WSA 2040 net demand predictions
- 11: As in Scenario 4a, but without Etowah WSA's net demand (relocated upstream near Dawsonville).
- 12: As in Scenario 4a, but with 24 mgd of Paulding County's demand relocated from Lake Allatoona to Richland Creek Reservoir.
- 13: Newell demand from Scenario 4a split into Indian Creek Reservoir demand (see note 14) and other.
- 14: Derived from published study by Brown and Caldwell, Summary of Water Supply Needs Analysis, Carroll County, August 2008, slide 9 and 10, showing 2040 Carroll County total need (28mgd) versus existing supply capacity (17mgd).
- 15: As in Scenario 4a, but with additional 7 mgd of Paulding County Demands based on year 2060 projections, Paulding 404 permit appl.
- 16: As in Scenario 5a, but with increase in Paulding County returns derived from County total AAD per MNGA District Wastewater Mgt Plan, Appendix B.
- 17: Paulding demand shown at year 2060: 18mgd (Richland Creek Reservoir) + 35 mgd (Lake Allatoona) = 53 mgd per Paulding 404 permit appl.
- 18: As in Scenario 5a, but with increased returns from Carroll County.
- 19: Indian Creek Reservoir yield of 18 mgd is per Carroll County 404 permit application.

*Less Paulding County's relocated demand to Richland Creek Reservoir

**Also, 7 MGD additional demand in Lake Allatoona for Paulding County re 404 permit appl.

1.4.1a Impacts to Stream Flow

1.4.1.1a Alabama River near Montgomery, AL

Key findings from the RES SIM modeling include:

- The RES SIM model shows average flow at this location on the Alabama River is
    - 22,436 cfs for the *without projects 2040a* run;
    - 22,435 cfs for the *with projects 2040a* run; and
    - 22,406 cfs for the *with projects full yield a* run.
- The without and with projects 2040 runs share the same net demands, so while the use of new storage may affect the timing of flows, the only difference in magnitude is and should be evaporation, which decreases the average flow by less than 1 cfs.
- The increase in net demands for the with projects full yield run is 29.1 cfs, which can be seen in the 0.1% decrease in average flow. Because of operations of the new projects to help meet the increased demand in the full yield run during dry times, the additional volume generally comes out of higher flows when the proposed reservoirs are refilling.

Figure 1a shows the duration curve of flows at the Montgomery node; at the scale shown, stream flow for all three scenarios appear as a single line meaning there is no discernable difference between the scenarios with respect to stream flow. Figure 2a shows the same duration curve for the lowest 30% of flows, and even at this larger scale plot, there is no discernable difference. Figure 3a shows that the lowest daily flows do not change very much between the scenarios.

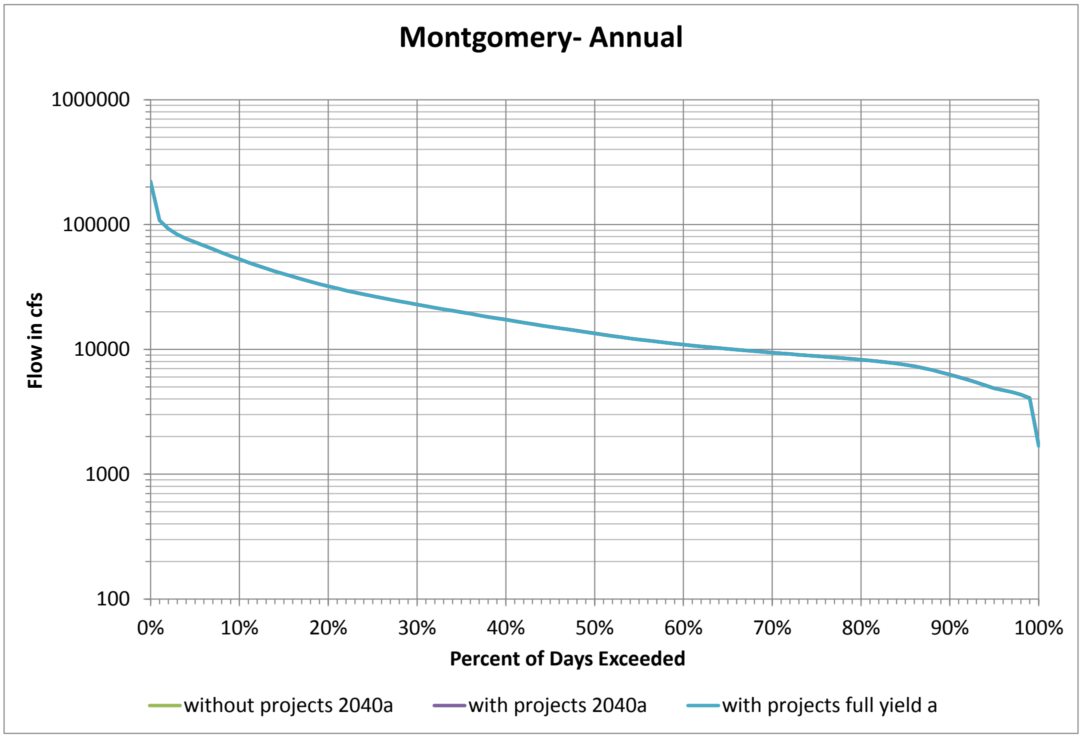

Figure 1a. Duration curve of flows at Montgomery, AL.

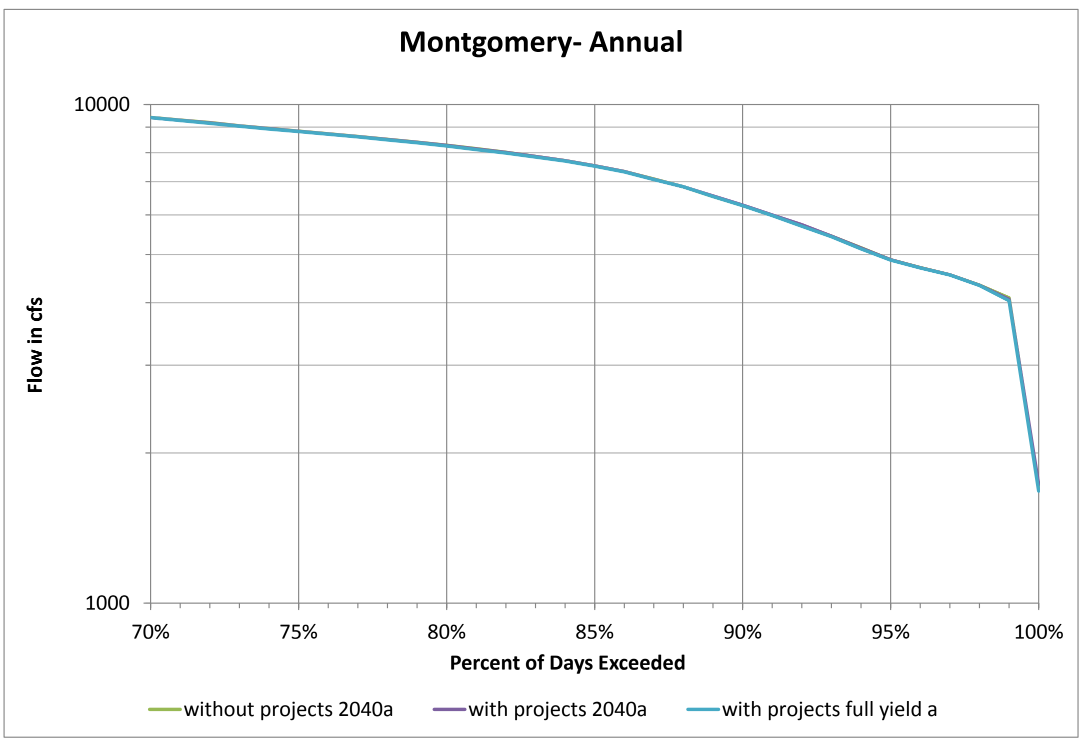

Figure 2a. Duration curve of flows at Montgomery, AL, lowest 30% of flows.

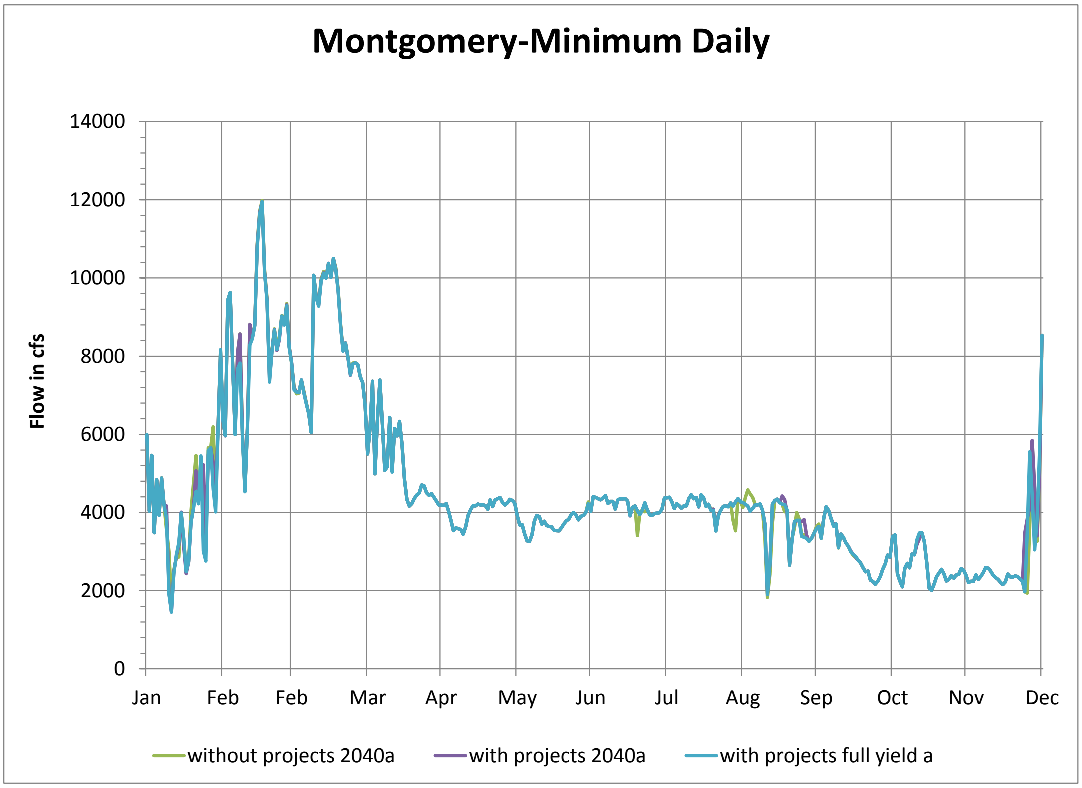

Figure 3a. Minimum daily flows at Montgomery, AL

Figure 4a and Figure 5a illustrate potential shifts in the seasonality of low flows; Figure 4a shows the 75th percentile (lowest 25%) of flows for each month, and Figure 5a, the 90th percentile (lowest 10%). These displays show no discernable differences.

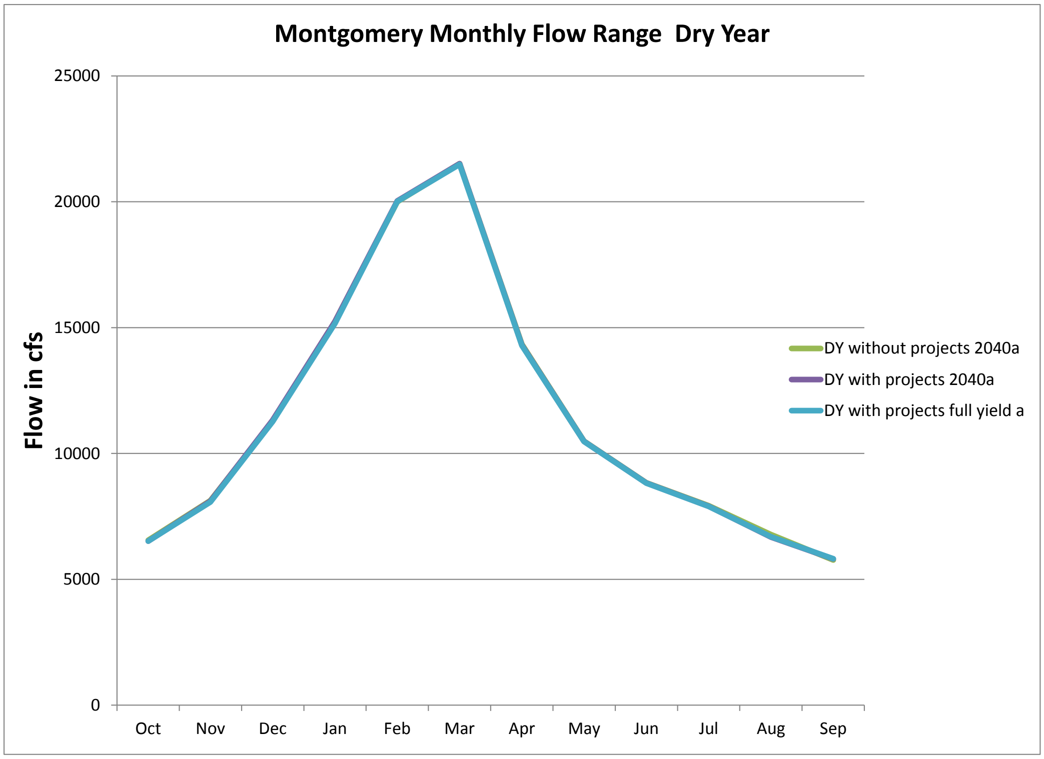

Figure 4a. Monthly Flow Range at "Dry" level (lowest 25%) at Montgomery, AL.

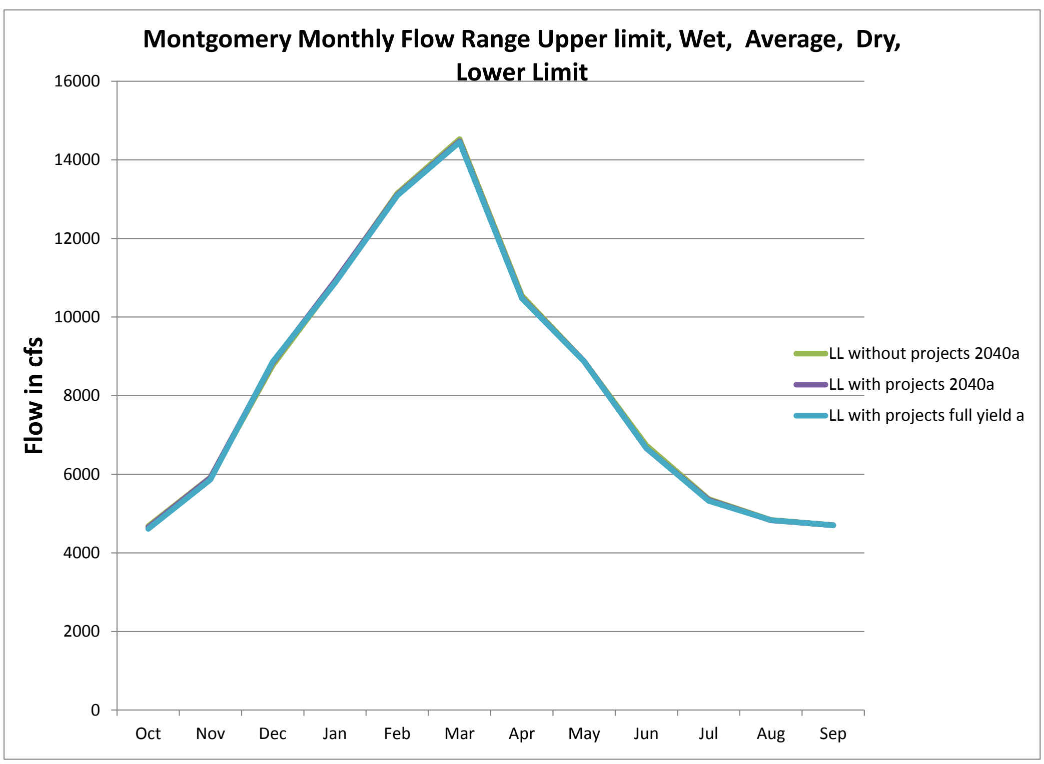

Figure 5a. Monthly Flow Range at "Lower Limit" level (lowest 10%) at Montgomery, AL.

1.4.1.2a Etowah River near Lake Allatoona

USGS Gage no. 02394000 on the Etowah River downstream of Lake Allatoona and referenced herein as 'Allatoona' is downstream of the Russell Creek project but upstream of the Richland Creek project. This node is influenced by both the addition of the proposed projects as well as the relocation of much of Paulding County's demand from Lake Allatoona to Richland Creek Reservoir. Key findings from the RES SIM modeling include:

- The average flow at this location on the Etowah River is:
  - 1639 cfs for the *without projects 2040a* run;
  - 1676 cfs for the *with projects 2040a* run; and
  - 1663 cfs for the *with projects full yield a* run
- The average flow difference between the *without* and *with projects 2040* runs is equal to 37 cfs, which is also the quantity of Paulding County demand shifted from Lake Allatoona to Richland Creek (evaporation from Russell Creek is less than 1 cfs).
- The increase in net demands for *with projects full yield* run is 12.7 cfs (1.8 cfs for Etowah WSA and 10.9 cfs for Paulding County from Lake Allatoona), which can be seen in the 0.8% decrease in average flow.

Figure 6a shows the duration curve of flows at the Allatoona node. The flows are higher in the *with projects* runs because of the demand shift discussed above: the Etowah River reach between the Allatoona and Kingston nodes and the Little Tallapoosa near Indian Creek Reservoir are the only reaches in the model that have different net upstream consumptive use in the two 2040 runs. A small difference can also be seen in flow between the *with project 2040* and *full yield* runs.

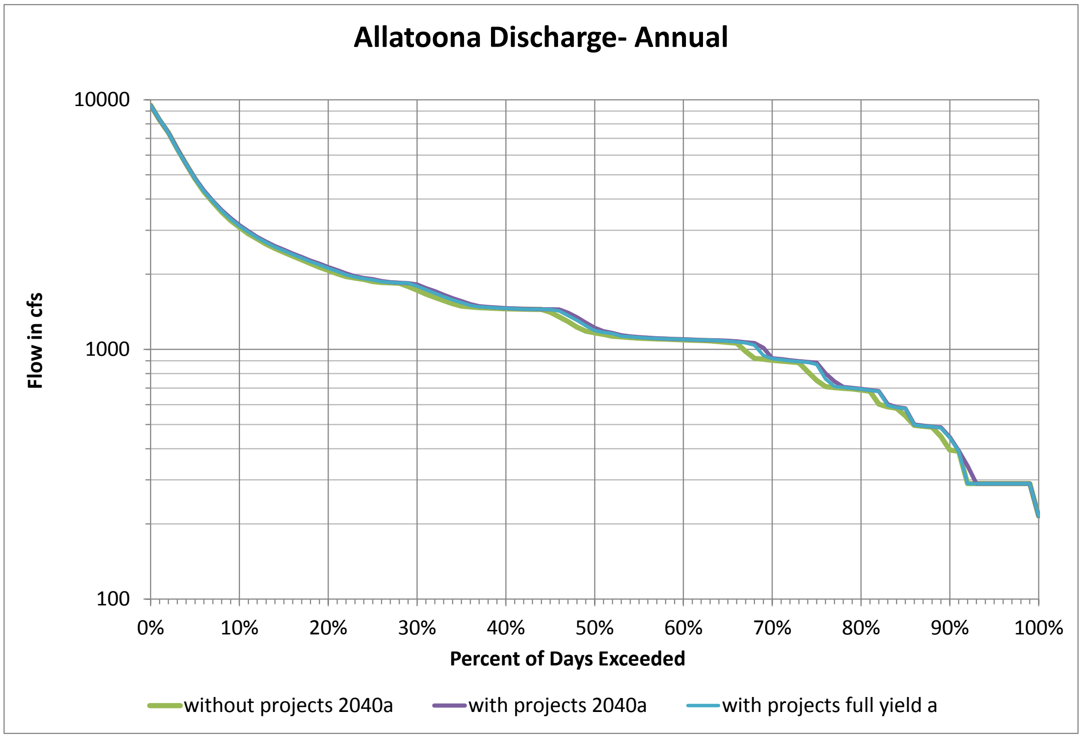

Figure 6a. Duration curve of flows at Allatoona.

Figure 7a and Figure 8a illustrate shifts in the seasonality of low flows; Figure 7a shows the 75th percentile (lowest 25%) of flows for each month, and Figure 8a, the 90th percentile (lowest 10%). The increase in flows resulting from the relocation of 37 cfs of Paulding County's demand is evident in some months. The increase in flow is much higher than 37 cfs because Lake Allatoona's release is determined by the number of hydropower generation hours, which changes abruptly at the "power zone" stage thresholds. Less withdrawal from Lake Allatoona in the *with project* scenarios translates to higher stages in Lake Allatoona, which means more hours of hydropower releases.

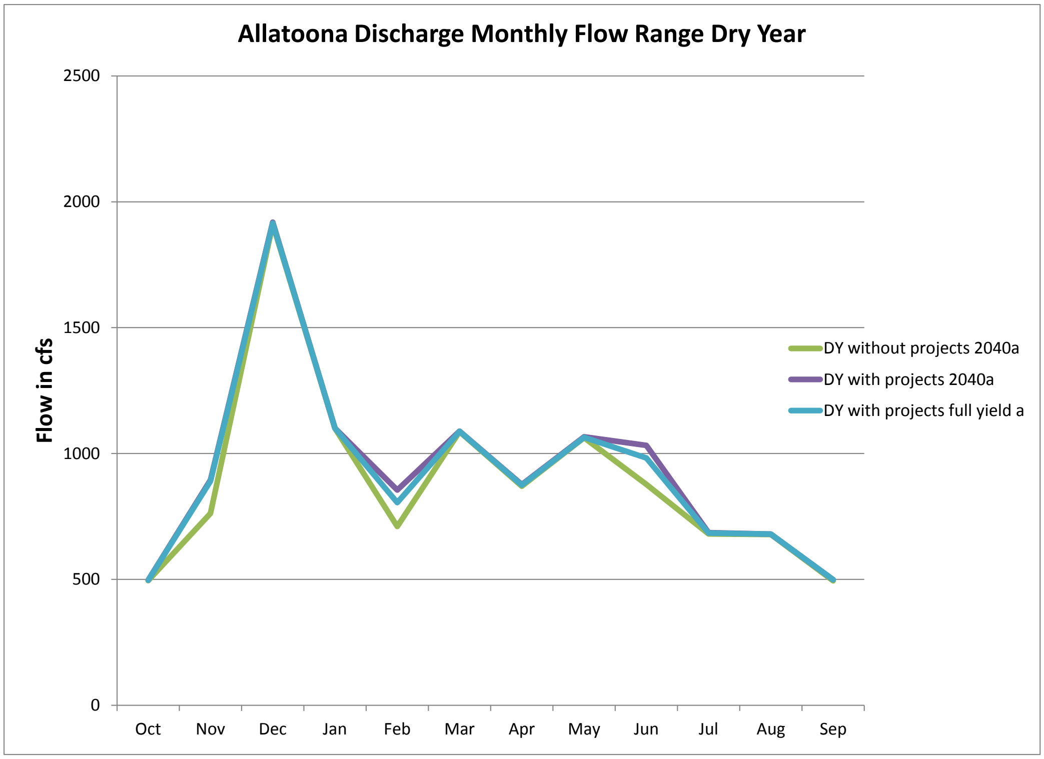

Figure 7a. Monthly Flow Range at "Dry" level (lowest 25%) at Allatoona.

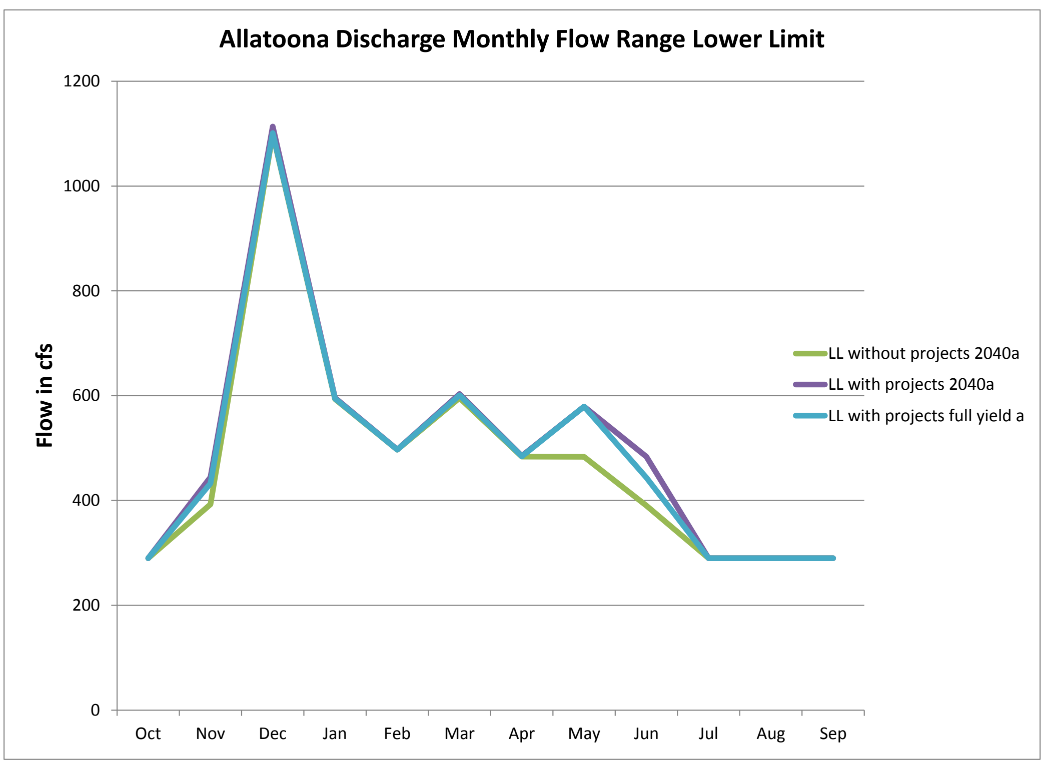

Figure 8a. Monthly Flow Range at "Lower Limit" level (lowest 10%) at Allatoona.

1.4.1.3aCoosa River near Rome, GA

USGS Gage no. 02397000 on the Coosa River near Rome, Georgia and referenced herein as 'Rome Coosa' is the most downstream node on the Coosa River before it crosses from Georgia into Alabama. Approximately 95% of Georgia's ACT basin water demand is located in the Coosa portion of the basin, including future needs associated with the Richland Creek and Russell Creek projects. Key findings from the RES SIM modeling include:

- The average flow at this location on the Coosa River is:
    - 6294.6 cfs for the *without projects 2040a* run;
    - 6294.1 cfs for the *with projects 2040a* run; and
    - 6268.5 cfs for the *with projects full yield a* run
- The *without* and *with projects 2040a* runs share the same net demands, so while the use of new storage may affect the timing of flows, the only difference in magnitude is and should be evaporation, which decreases the average flow by 0.008%.
- The increase in net demands for *with projects full yield* run is 25.5 cfs, which can be seen in the 0.4% decrease in average flow. Because of operations of the new projects to help meet the increased demand in the full yield run during dry times, the additional volume generally comes out of higher flows when the proposed reservoirs are refilling. The *with projects* runs reflect the fact that operation of the proposed water supply reservoirs will comply with Georgia regulations for low flow protection; thus, withdrawals will be curtailed and/or augmented by reservoir releases during drought periods to comply with prescribed in-stream minimum flows. Conversely, refilling of the reservoirs will dictate higher withdrawal rates during periods of higher stream flows.

Figure 9a shows the duration curve of flows at the Rome Coosa node; at the scale shown, stream flow for all three scenarios appear as a single line meaning there is no discernable difference between the scenarios with respect to stream flow. Figure 10a shows the same duration curve for the lowest 25% of flows.

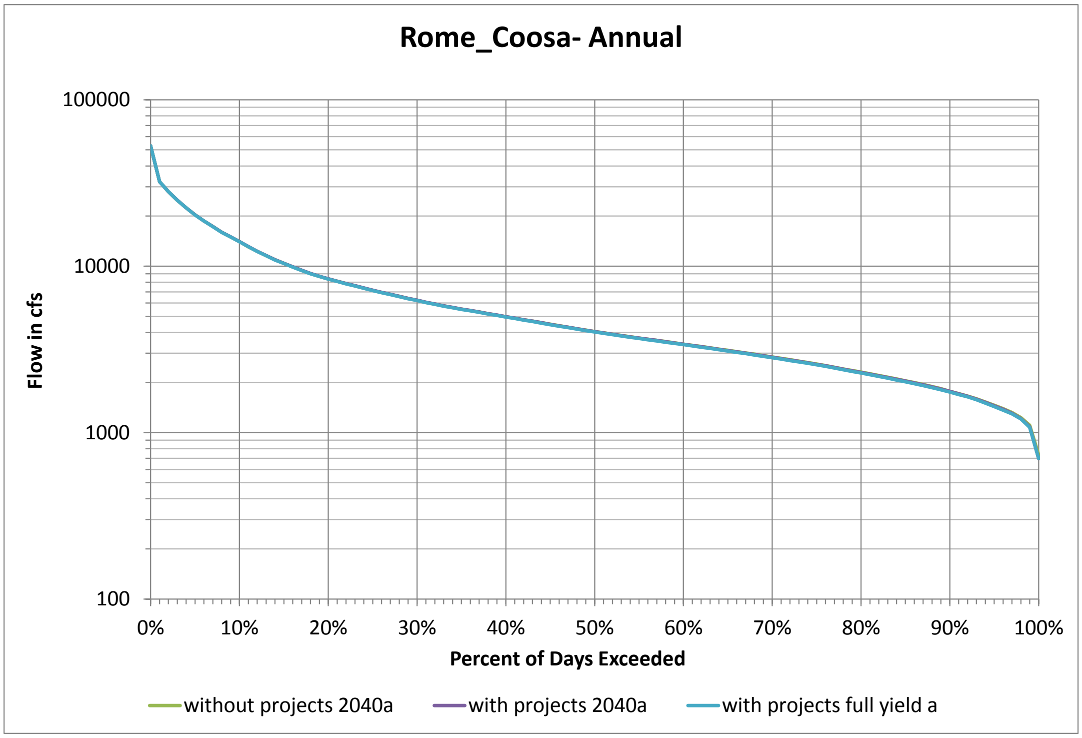

Figure 9a. Duration curve of flows at Rome Coosa.

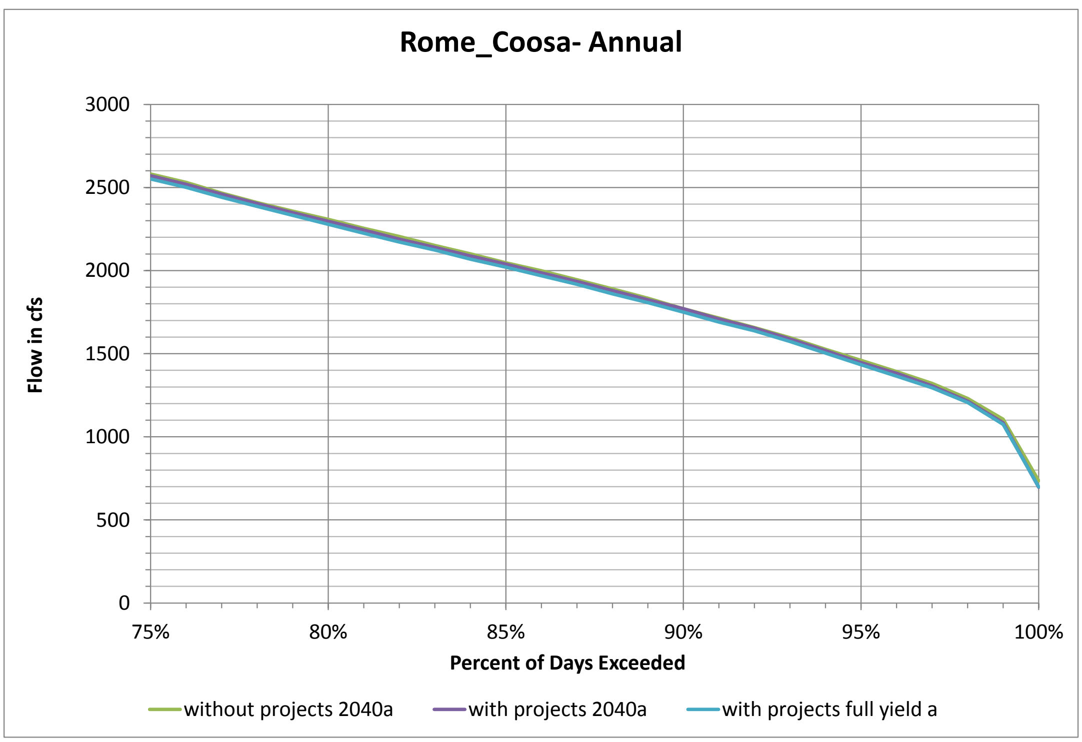

Figure 10a. Duration curve of flows at Rome Coosa, lowest 25% of flows.

Figure 11a and Figure 12a illustrate shifts in the seasonality of low flows; Figure 11a shows the 75th percentile (lowest 25%) of flows for each month, and Figure 12a, the 90th percentile (lowest 10%). These displays show no discernable differences between the scenarios, with the exception of a small difference in December: flows in the *with projects 2040a* Scenario are slightly higher than the other two scenarios. These higher flows occur because Allatoona stages tend to be slightly higher in the *with projects* runs than the *without project*s run (0.2 ft on average) as a result of much of Paulding County's withdrawal moving downstream. When this small stage difference happens to straddle the hydropower action zones in the lake (as it does in November/December 1939), the number of hours of hydropower generated is reduced in one run but not the other, resulting in about 700 cfs flow difference between the scenarios.

The month with the largest reduction at the 90th percentile level between the *without projects 2040a* run and *with projects full yield a* run was selected for further examination. The duration curve for this month, March, is shown in Figure 13a and Figure 14a. At the 90th percentile level, the *without projects 2040* run flows are 4240 cfs and the *with projects full yield* run flows are 4195 cfs, a decrease of 45 cfs or 1%.

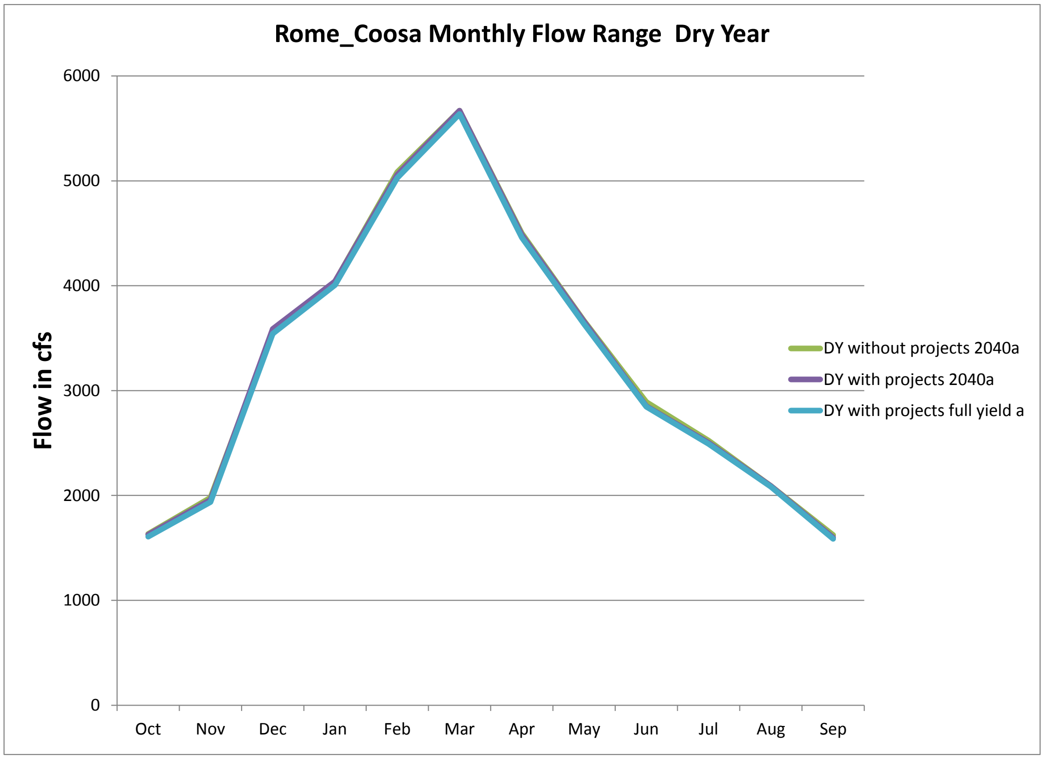

Figure 11a. Monthly Flow Range at "Dry" level (lowest 25%) at Rome Coosa.

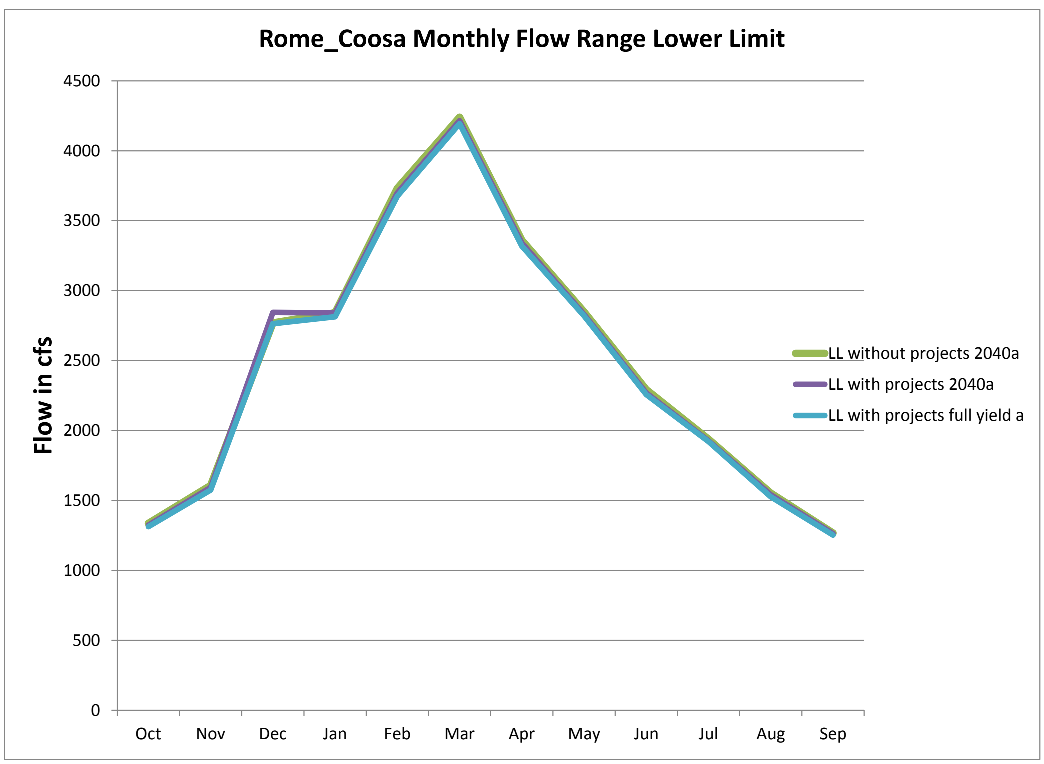

Figure 12a. Monthly Flow Range at "Lower Limit" level (lowest 10%) at Rome Coosa.

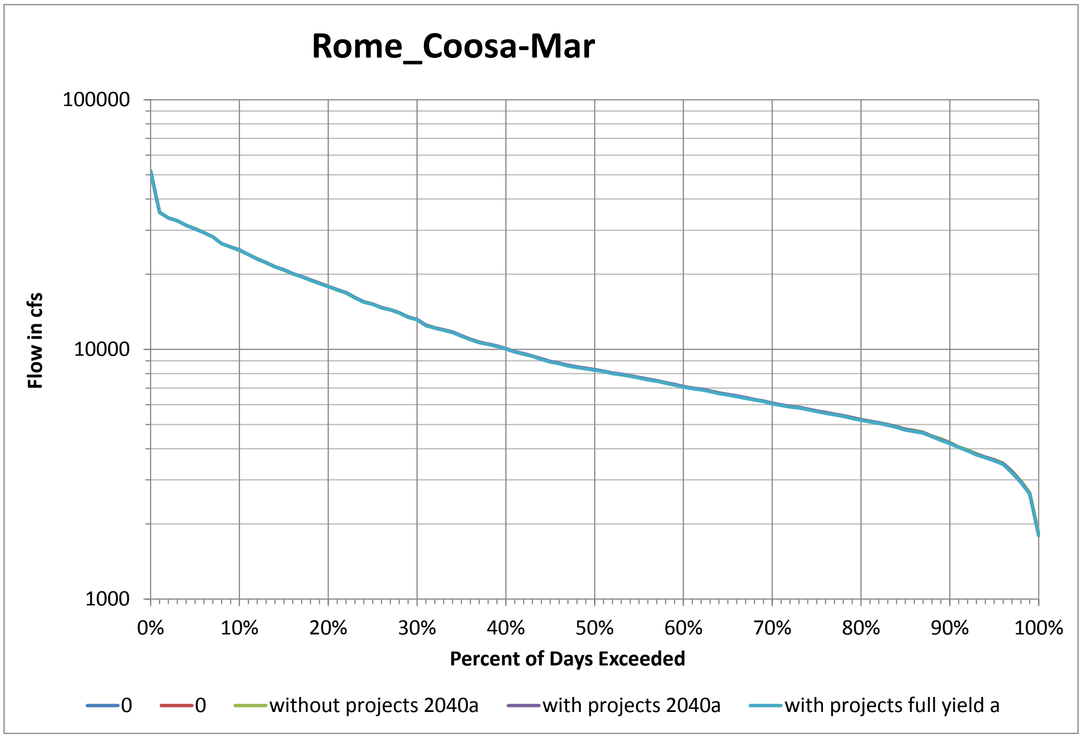

Figure 13a. Duration curve of flows in April at Rome Coosa.

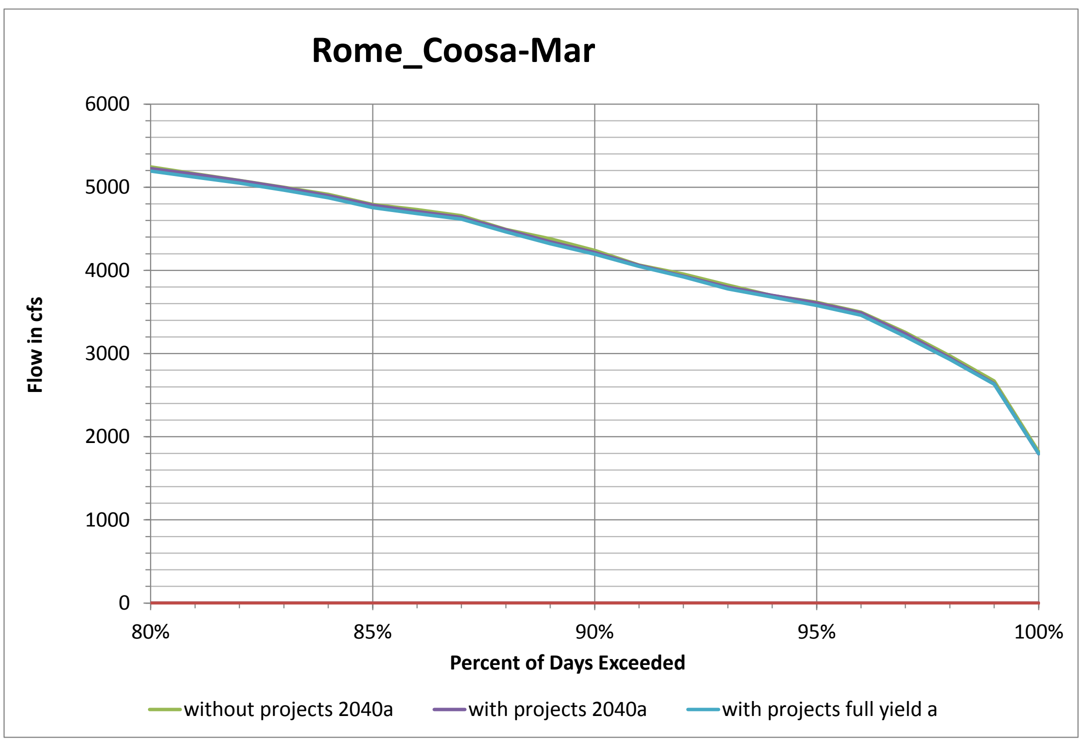

Figure 14a. Duration curve of flows in March at Rome Coosa, lowest 20% of flows.

1.4.1.4aTallapoosa River near Wadley, AL

USGS Gage no. 02414500 on the Tallapoosa River and referenced herein as 'Wadley' is the river node location included in the Corps of Engineers' spreadsheet that is closest to the Little Tallapoosa River, and therefore the most upstream location affected by Indian Creek Reservoir. Key findings from the RES SIM modeling include:

- The average flow at this location on the Tallapoosa River is
  - 2535.4 cfs for *without projects 2040a* run;
  - 2535.1 cfs for *with projects 2040a* run; and
  - 2531.9 cfs for *with projects full yield a* run.
- The *without* and *with projects 2040* runs share the same net demands, so while the use of new storage may affect the timing of flows, the only difference in magnitude is and should be evaporation, which decreases the average flow by 0.01%.
- The increase in net demands for *with projects full yield* run is 3.4 cfs, which can be seen in the 0.1% decrease in average flow. Because of operations of the new projects to help meet the increased demand in the full yield run during dry times, the additional volume generally comes out of higher flows when the proposed reservoirs are refilling. The *with projects* runs reflect the fact that operation of the proposed water supply reservoirs will comply with Georgia regulations for low flow protection; thus, withdrawals will be curtailed during drought periods to comply with prescribed in-stream minimum flows. Conversely, refilling of the reservoirs will dictate higher withdrawal rates during periods of higher stream flows.

There were no changes to the Tallapoosa section of the model between the original runs and the runs reported in this section, so additional information can be found in Section 1.4.1.4 and the spreadsheet POR_WadleyFlowlDuration_Mar2011_CumImpactStudy.xls.

1.4.2a Impacts to Hydropower

Monthly hydropower generation at each power-generating reservoir in the ACT basin can be found in the submitted spreadsheets (Appendix 2a) in the folder "POR_ACT_Hydropower_Analysis_Mar2011_CumImpactStudy". With the exception of Allatoona, which is discussed below, differences in generation between scenarios are much less than 1%.

For Allatoona, the relocation of much of Paulding County's withdrawal from the lake to the downstream reach results in more water going through the turbines. The result is an increase in generation of about 3000 MWh/year or 3% for the *with projects 2040a* run and 2000 MWh/year or 2% for the *with projects full yield* a run. The increase in generation tends to be higher in the summer and fall months (2-7% for *with projects 2040a*) and lower in the winter and spring months (about 2% for *with projects 2040a*).

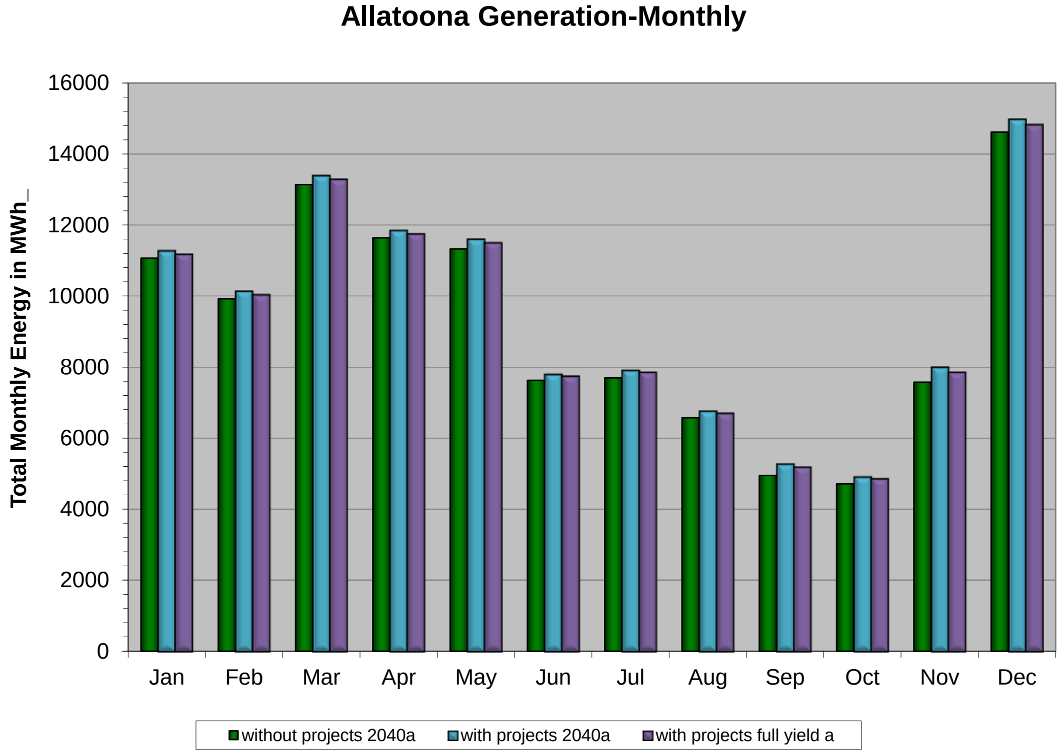

Figure 23a. Monthly energy generation, Allatoona

1.4.3a Impacts to Navigation

Figure 30a and Figure 31a show the percentage of time navigation targets (7.5 and 9 feet, respectively) are met by month. For most months, there is no change, and when differences do occur, they are always less than 1%. For example, in November, the time with a 7.5 foot channel in November decreases from 71.8% to 71.4% between the *2040 without projects a* run and *full yield a* run, while in July, the time with a 7.5 foot channel increases from 80.6% to 80.7% between the without projects run and with projects runs.

Figure 32a and Figure 33a show the number of years that target navigation depths (7.5 and 9 feet, respectively) are maintained for the full month. Small shifts in the timing of flows below the navigation thresholds, especially around the first of the month can result in a particular year being counted in one run and not another. For example, in November 1958, the lowest flow is just above the threshold in the *2040a* runs and just below in the *full yield* run (see Figure 34a). Overall, the impacts to navigation are minor, and both beneficial and non-beneficial shifts occur with the addition of the projects.

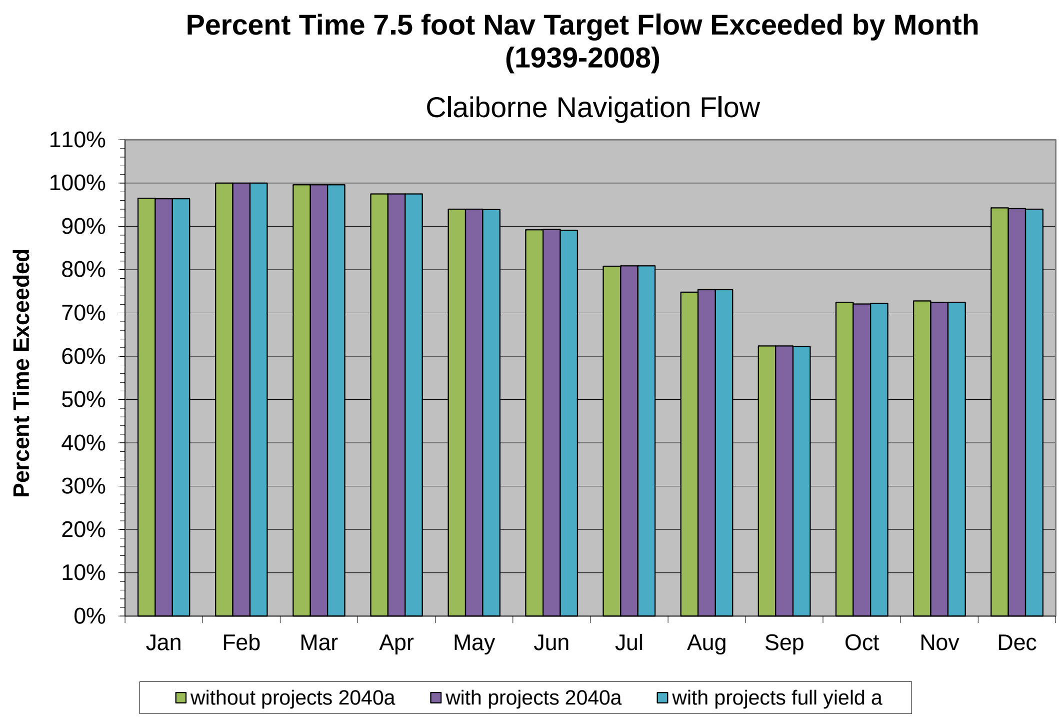

Figure 30a. Percent of time 7.5 foot navigation target is exceeded by month

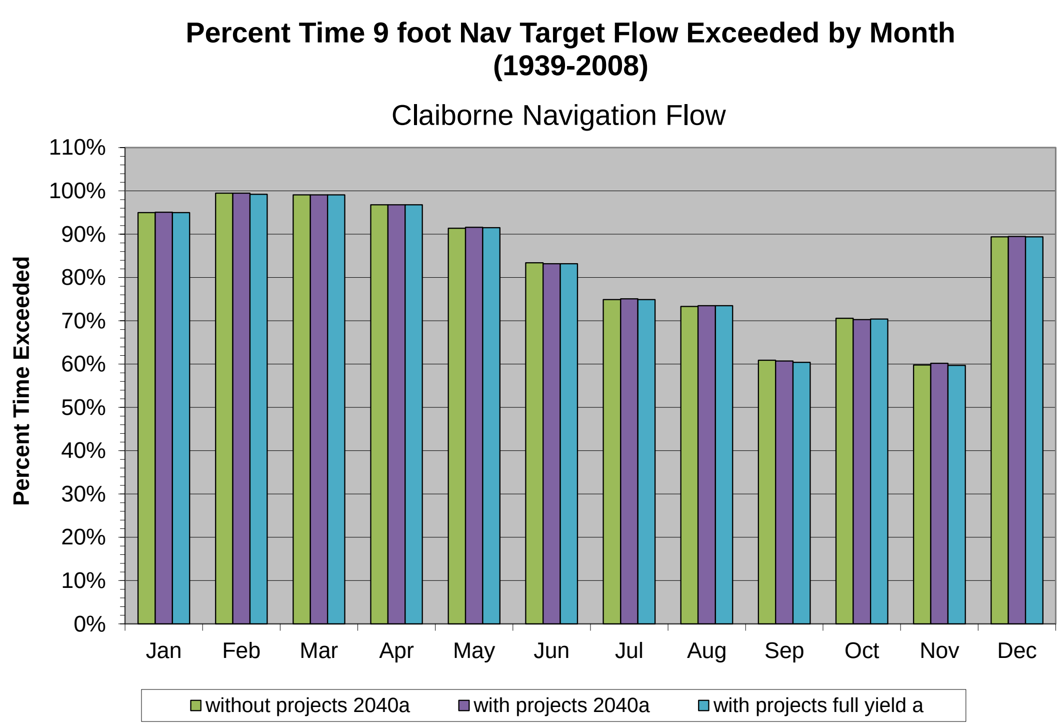

Figure 31a. Percent of time 9 foot navigation target is exceeded by month

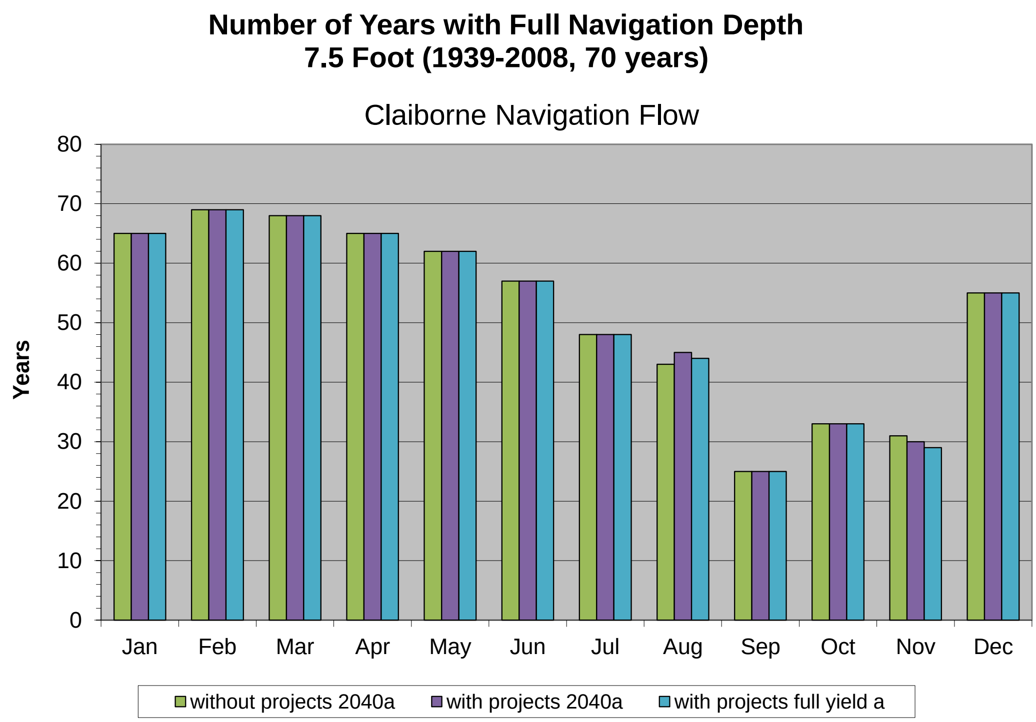

Figure 32a. Number of years 7.5 foot navigation depth is maintained for the full month[5]

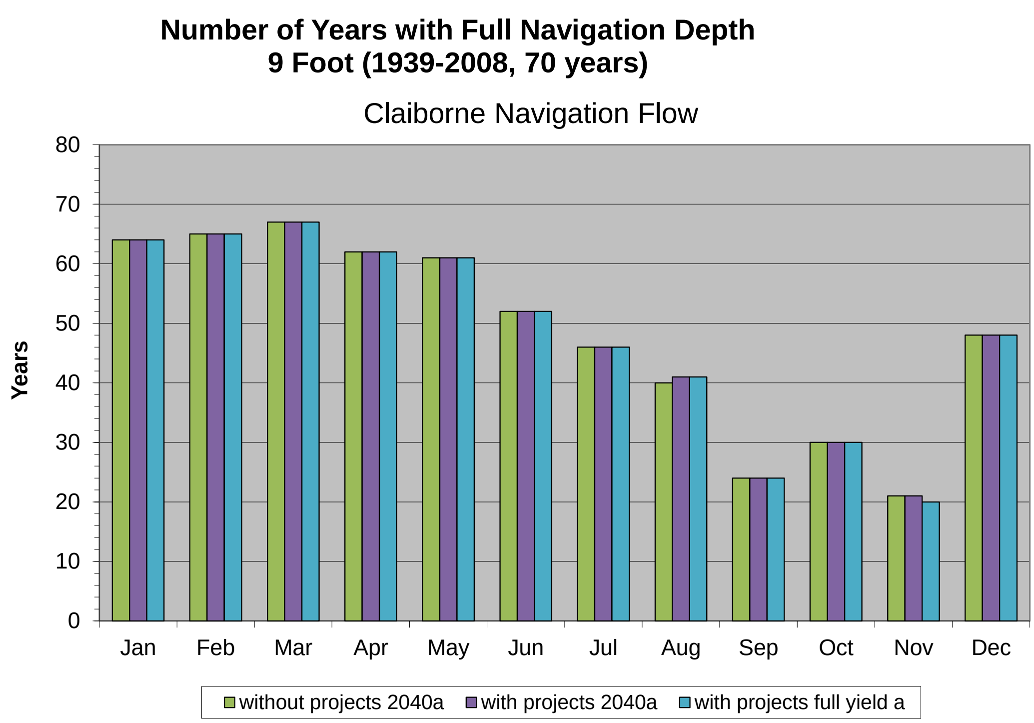

Figure 33a. Number of years 9 foot navigation depth is maintained for the full month

[5] Small differences in flow can lead to full year differences; see Figure 34a for an example.

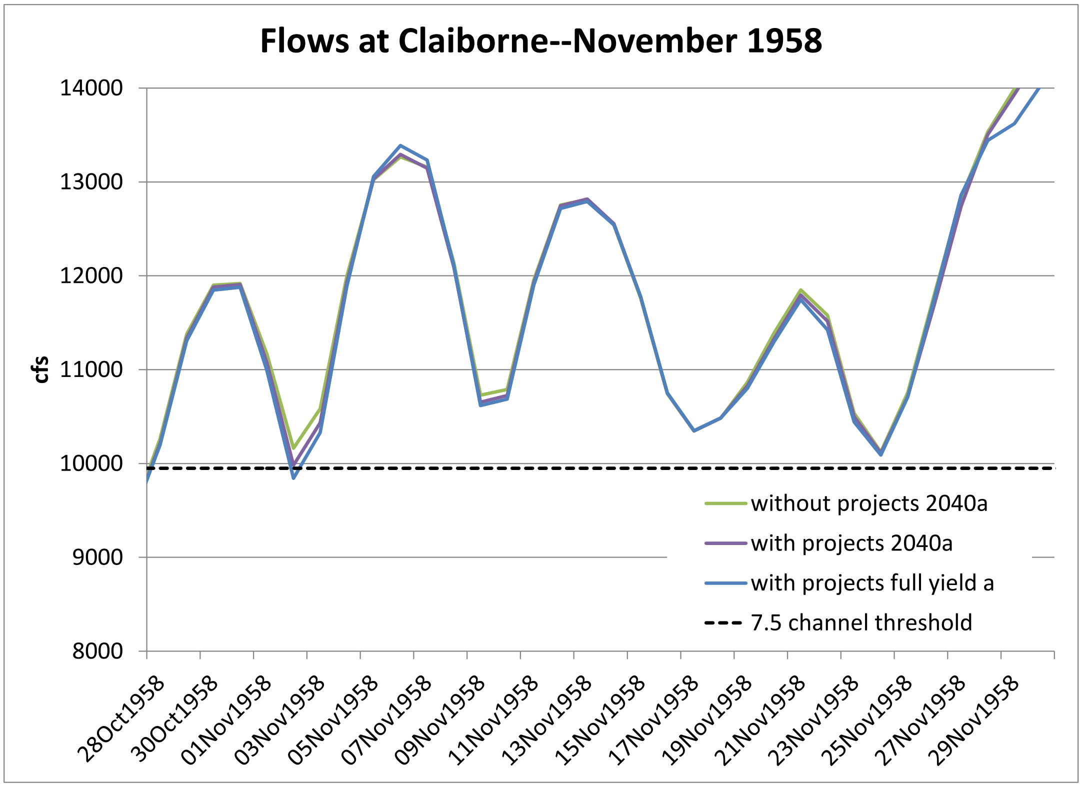

Figure 34a. Claiborne flows in November 1958, a month in which full navigation depth is achieved in the *2040a* runs but not the *full yield a* run in Figure 32a.

1.4.4a Impacts to Drought Operations

There are three different triggers that determine drought operation levels. The first is the Basin Inflow Trigger. Figure 35a shows a 0.2% shift in the amount of time the Basin Inflow Trigger is in the "low" versus "normal" condition, with more time in the normal condition with the projects. This small shift is probably not indicative in an actual change of conditions for two reasons. First, in the equation for calculating the Basin Inflow condition, the (unregulated) flow upstream of Allatoona is subtracted out of the Etowah River component of basin inflow: because much of Paulding County's withdrawal shifts from Lake Allatoona to the downstream reach when the projects are added, the Etowah Basin Inflow term is higher for the *with project* runs. We are not clear on the reasoning behind subtracting out the Allatoona and upstream component of Basin Inflow, but if this calculation were based on Kingston instead, the results might be different. Second, one of the unregulated flow terms used in the calculation (JordanIN_UNREG) shows a surprising difference between scenarios. While, the flows between the scenarios are different by the expected amounts (consumptive use), the unregulated flows, on the other hand, show a 69 cfs *increase* in the *with projects 2040a* run compared to *without projects 2040a* run, and 44 cfs increase in the *with projects full yield a* run compared to the *without projects 2040a* run.

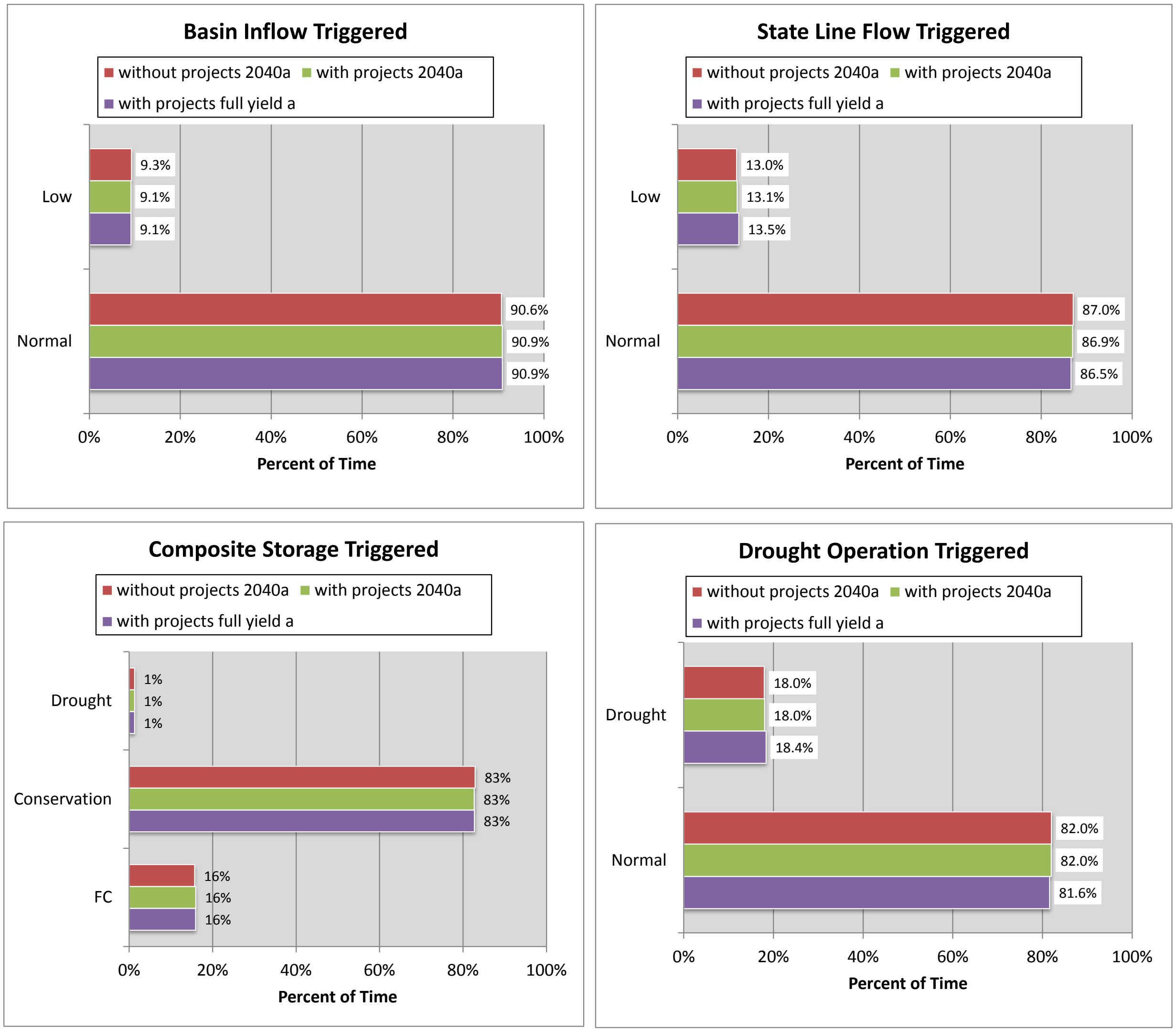

Figure 35a. Drought operation triggers

The second trigger is the State Line Flow Trigger, which marks time when flow at Rome-Coosa is below the low State Line Flow criteria. Figure 35a shows a 0.1-0.5% increase in time in the low condition with the addition of the projects. Because the trigger is only changed twice a month, a small difference in the flows can change the trigger for a full two weeks. As an example, on February 1, 2000 of the simulations, the *with and without projects 2040a* runs State Line Flow Trigger is off, while the *full yield* run's triggers remain on despite very small difference in flows, as shown in Figure 36a.

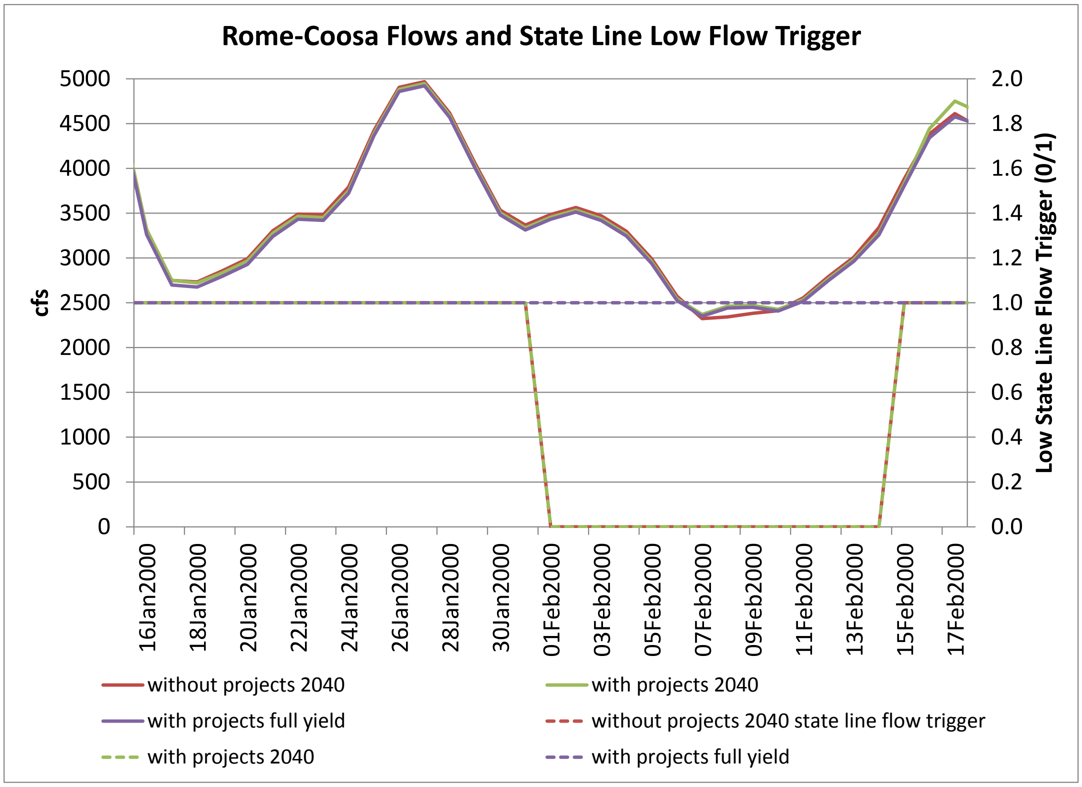

Figure 36a. Flows at Rome Coosa and the Low State Line Flow Trigger

The third and final trigger looks at composite storage: the Composite Storage Trigger is unchanged with the addition of the projects (Figure 35a). These three triggers are added together to determine the drought level (Figure 35a and Figure 37a). The *with project* scenarios show a 0.3-0.6% increase in time spent in Drought Level 1 (one trigger below normal conditions) and a 0.1% decrease in time spent in Drought Level 2 (two triggers below normal conditions). There is no difference in Drought Level 3. Note that the issues raised in regard to the individual triggers also affect the Drought Operations Trigger.

Figure 38a shows the percentage of time the system is in various operations. All three scenarios spend the majority of the time in “9 ft channel” operation (about 71%). The *with projects* scenarios show a decrease of 0.1 to 0.2% in time spent in “9 ft channel” operations. There is a decrease of 0 to 0.1% in time spent in “7.5 ft channel” operations.

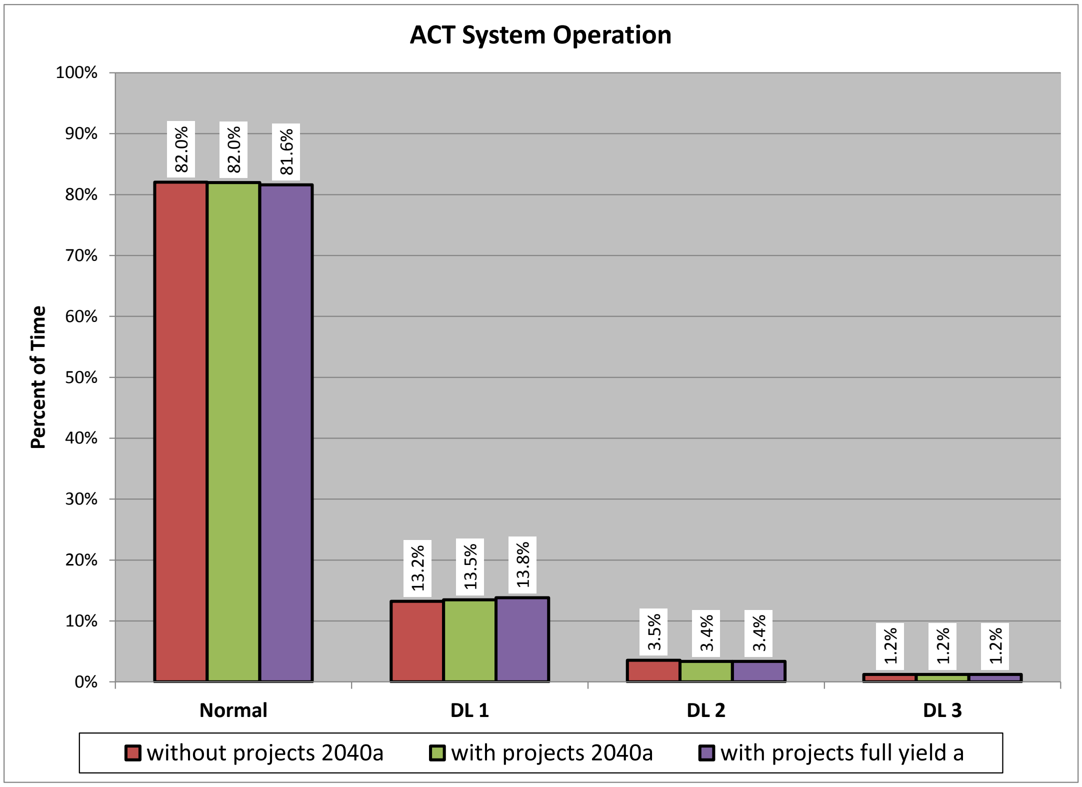

Figure 37a. Drought levels

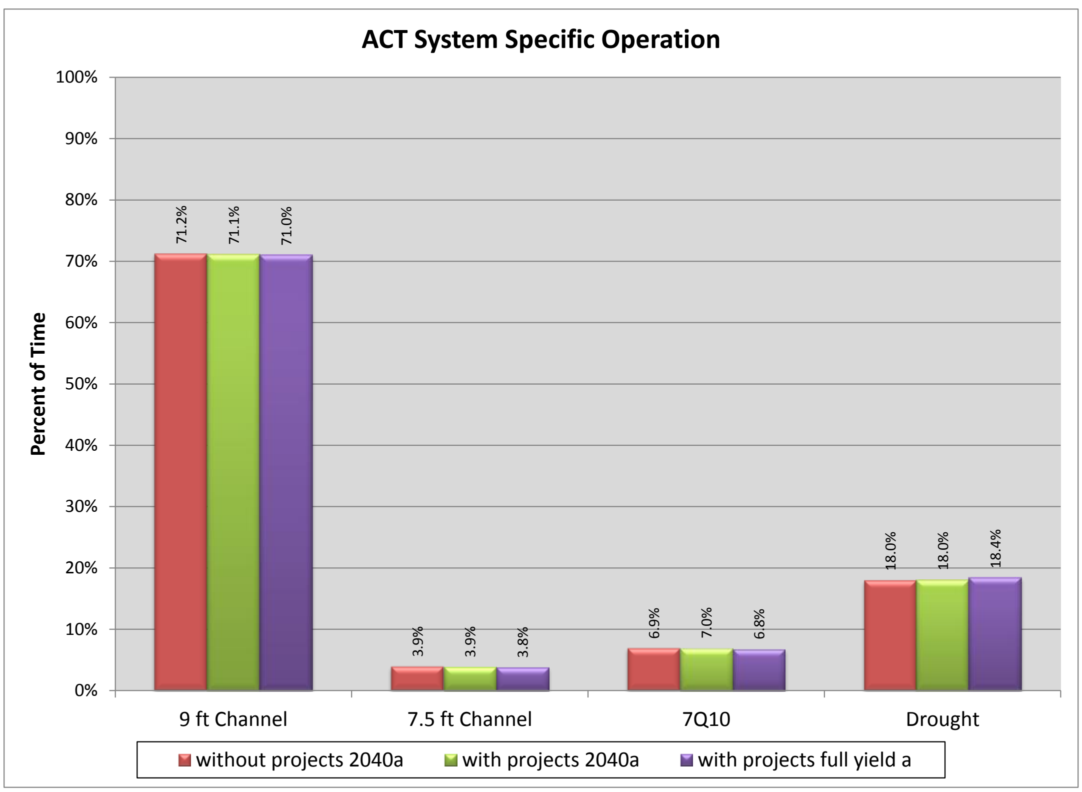

Figure 38a. ACT system specific operation

1.4.5a Impacts to Pool Levels

The only reservoir with impacts to pool levels is Lake Allatoona. By relocating much of Paulding County's withdrawal from the lake to Richland Creek Reservoir, Allatoona's stage remains approximately 0.2 ft higher on average. This can be seen in Figure 39a and Figure 40a. The pool still drops below the recreation impacts levels in all years (Figure 41a), but there is a small improvement in summer recreation levels with the projects (Figure 42a).

Impacts on other pool levels are essentially zero; results can be found in the folder POR_ACT_PoolElevation_Analysis_Mar2011_CumImpactStudy of Appendix 2a.

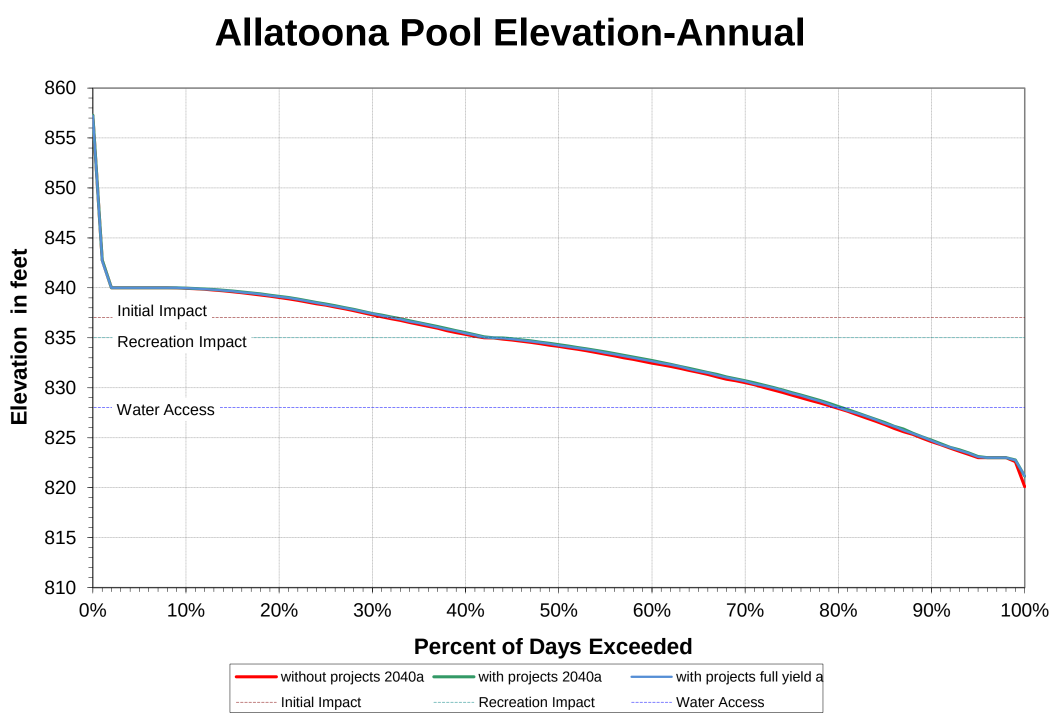

Figure 39a. Pool elevations, Allatoona

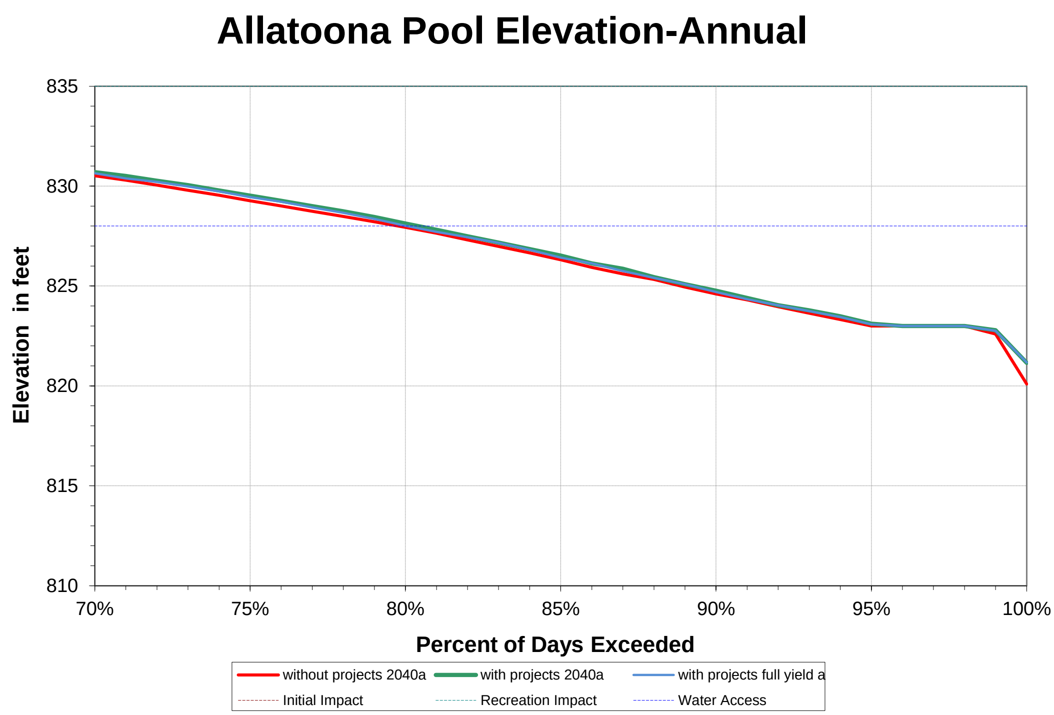

Figure 40a. Pool elevations, lowest 30%, Allatoona

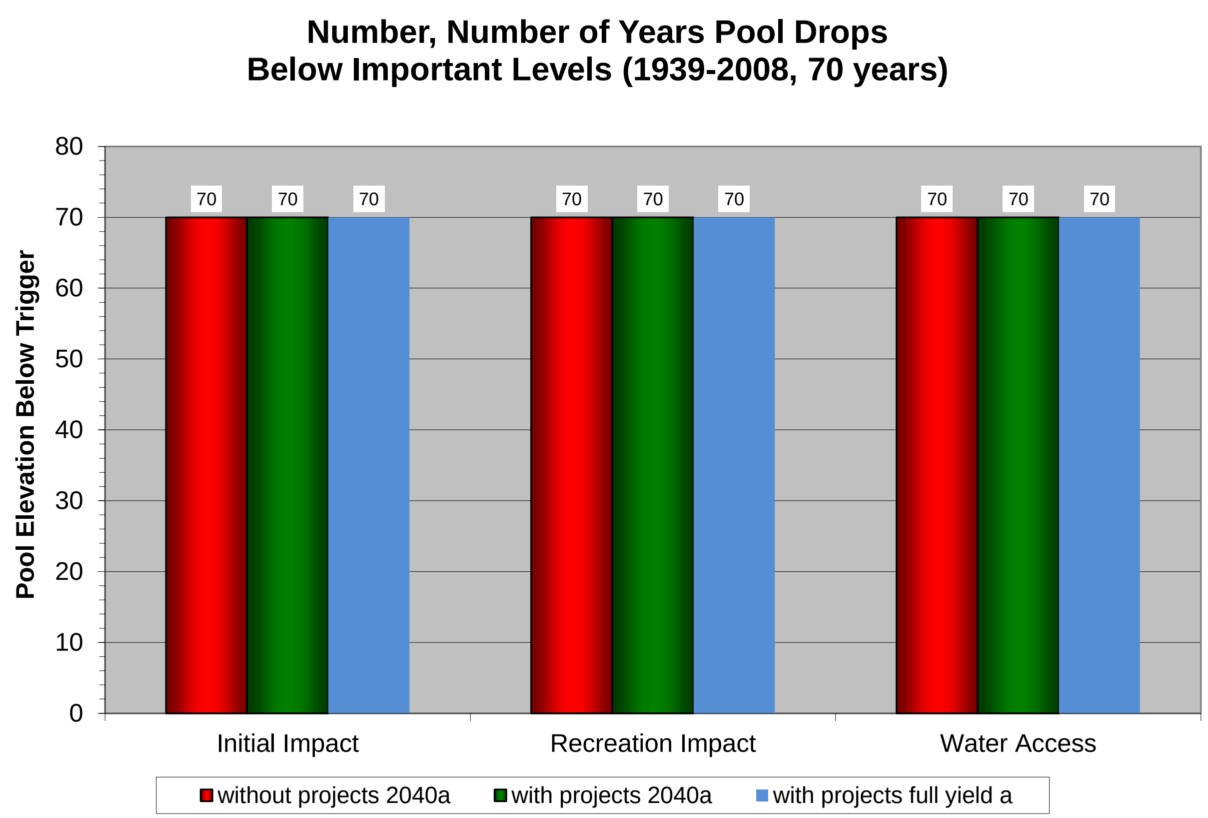

Figure 41a. Number of years pool drops below important levels, Allatoona

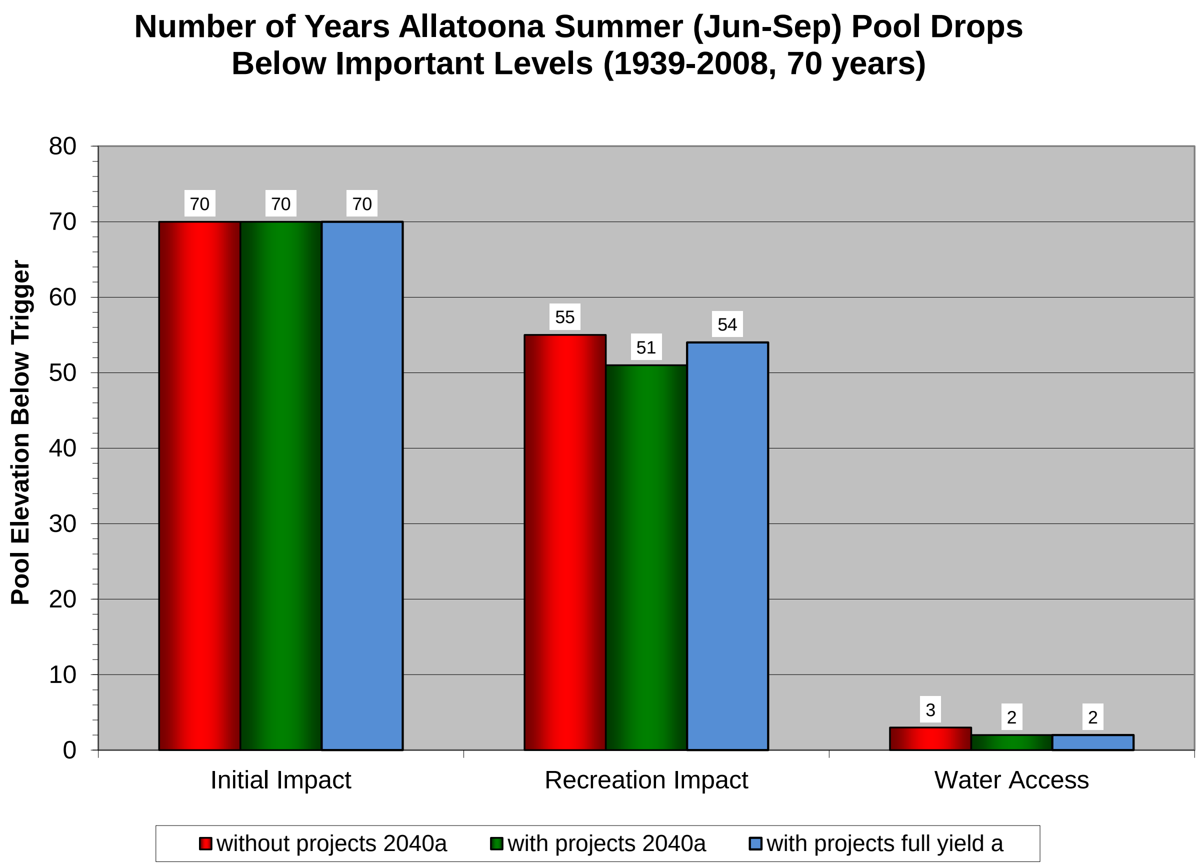

Figure 42a. Recreation impact, Allatoona

1.5a Conclusion

The impacts of the three projects to stream flows, hydropower, navigation, drought operations, pool levels, and recreation are very small and, when they occur at all, the impacts are beneficial as well as non-beneficial. The beneficial impacts result from the relocation of withdrawals and the fact that stream withdrawals associated with the proposed water supply reservoirs will comply with Georgia regulations for low flow protection, and this curtailment and/or augmentation of stream withdrawals during drought periods is beneficial to stream flow when compared to what stream flow would be during drought conditions without the proposed reservoir projects. The non-beneficial impacts observed herein are often not a result of the proposed water supply projects; rather, they occur as a byproduct of minor timing or magnitude changes crossing operational thresholds of the Corps' or APC's reservoirs. Statistical thresholds, such as the first of the month or pool elevations which trigger certain reservoir operations, can magnify impacts. Overall, both beneficial and non-beneficial impacts are well within the error of the model.