LEESVILLE DEVELOPMENT DISCHARGE STUDY FINAL REPORT

SMITH MOUNTAIN PROJECT
FERC NO. 2210

PREPARED FOR:

APPALACHIAN POWER COMPANY
ROANOKE, VIRGINIA

PREPARED BY:

Kleinschmidt

www.KleinschmidtGroup.com

FEBRUARY 2015

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FERC NO. 2210

APPALACHIAN POWER COMPANY

1.0 INTRODUCTION AND BACKGROUND

1.1 PROJECT RELICENSING PROCESS AND BACKGROUND

Appalachian Power Company (Appalachian), owner and operator of the Smith Mountain Hydroelectric Project (FERC No. 2210)(Project), was issued a new project license by the Federal Energy Regulatory Commission (FERC) on December 15, 2009, as the previous license was due to expire on March 31, 2010. Under Section 401(a)(1) of the Clean Water Act (CWA), the Commission may not issue a license authorizing the construction or operation of a hydroelectric project unless the state water quality certifying agency either has issued water quality certification (certification) for the project or has waived certification by failing to act on a request for certification within a reasonable period of time, not to exceed one year. The CWA further provides that the state certification shall become a condition of the project license. Appalachian subsequently applied to the Virginia Department of Environmental Quality (VDEQ) for 401 certification on March 25, 2008. On October 31, 2008, VDEQ issued its certification for the Smith Mountain Project. The certification includes several project-specific conditions that were thus incorporated into the license issued by the Commission.

One of these project-specific conditions requires that Appalachian conduct a study to determine the relative effect of providing flows through project auto-cycling versus continuous releases at the Leesville dam. As such, the Leesville Development Discharge Study Plan was developed in consultation with state agencies and non-governmental organizations (NGOs) in early 2008, and filed with the VDEQ on February 27, 2009. A revised plan was filed with FERC on April 13, 2010 and the FERC issued its *Order Approving and Modifying Revised Leesville Auto-cycling vs. Continuous Release Study Plan* on October 13, 2010. The purpose of the study is to investigate

the relative difference in potential effects between these two operating conditions on bank erosion, recreation, public safety, water quality, and aquatic habitat in the Staunton River between Leesville Dam and the confluence with Goose Creek. In order to meet this objective, the following tasks were included within the study plan:

1. Contact and interview landowners with property along the river between Leesville Dam and the confluence of Goose Creek. Identify concerns pertaining to the current hourly autocycle operations;
2. Determine the magnitude of water level changes, as well as rates of rise and fall, occurring downstream of Leesville Dam as a result of hourly autocycling operations;
3. Evaluate effects on public safety and recreation, including angling, resulting from changes in water conditions associated with autocycling;
4. Assess changes in aquatic habitat associated with hourly autocycling compared to continuous flow, and assess fish and macroinvertebrate responses to hourly autocycling and continuous flow operations;
5. Evaluate erosion potential resulting from hourly autocycling as compared to continuous flow releases;
6. Determine effects of autocycling operations on dissolved oxygen levels;
7. Evaluate the effectiveness of re-vegetating shorelines as a bank stabilization measure at selected active erosion sites downstream of Leesville Dam; and
8. Conduct a feasibility evaluation on the ability to add a minimum flow unit to Leesville Dam.

The original schedule to conduct these study efforts was a four-year period beginning in 2010 and continuing through 2013. However, the Plan was not finalized until late 2010 thereby effectively eliminating the potential to conduct study efforts during 2010. Therefore, 2011 was the first year of the study. As such, the schedule was modified to allow for completion of all tasks through the course of the 2014 study season. Subsequent to the issuance of the project license in late 2009, Appalachian began preparations for conducting these various components described within the Study Plan in accordance with license conditions.

1.2 OVERALL STUDY RESULTS AND RECOMMENDATIONS

The overall study results are presented here so that they can be viewed collectively with regard to how they relate to one another. Individual Task Summaries are provided in Section 2.0 with supporting Task Reports included as attachments as appropriate. The Task Summaries and attachments provide detail of the methods and results for each Task as conducted during this study.

1.2.1 RESULTS

TASK 1 – PROPERTY OWNER SURVEYS

Property owners in the study area represent a mix of year-round residents and those who use their property for recreation. The commonality among the property owners however is the value they place on their property and the integral role that the river plays in that regard. Discussions between researchers and property owners during the course of the study illustrated the interest and concern for the river and how it is used. Many owners have been observers to the changes in project operations over the years and acknowledge that conditions have substantially improved but some concerns remain. As a result, 60% of the survey respondents indicated concerns regarding water level fluctuations affecting their shoreline property. Therefore, it is not surprising that 60% also would be willing to have shoreline protection measures evaluated on their property.

Recreation is an important use of the river by property owners and others as well. Water level fluctuations however; do not appear to prevent river users from pursuing their preferred recreational activities based on the survey. This applied to respondents who conducted their recreation within a mile of the dam where the magnitude of water levels fluctuation is the greatest.

TASK 2 – MAGNITUDE OF WATER LEVEL CHANGES

As would be expected, water level changes are greatest near the dam and become attenuated with distance. Near the dam, water levels fluctuate approximately 3.5 ft and rise at a rate of 0.65 ft / minute during a typical hourly autocycle but decrease substantially a relatively short distance downstream. In the vicinity of Goose Creek, fluctuations are less than 0.25 ft with a negligible rate of rise. This represents a substantial reduction in the downstream extent of water level fluctuations experienced during the 2-hour autocycle operations which were noticeable on data collected by the USGS Gage at Altavista, Virginia (Gage No. 02060500). Additionally, observations made during the Projects relicensing study indicate that water levels near Goose Creek fluctuated by approximately 2 ft during the 2-hour autocycle. Therefore, the change to hourly autocycling decreased the magnitude and downstream extent of water level fluctuations.

TASK 3 - EFFECTS ON PUBLIC SAFETY AND RECREATION

Based on responses to the property owners survey, river users are familiar with autocycling and are aware that the warning siren indicates water levels changes are about to occur. Respondents also indicated that they can hear the siren and plan their use of the river based on when the change will occur (i.e., wait for water levels to increase or decrease). As such, 86% indicated that water level changes do not prevent them from pursuing their preferred recreational activities. Likewise observations of fishermen at the fishing access area in the tailrace indicate that upon hearing the siren, fishermen move to a higher elevation. During the onset of generation, they may refrain from fishing until water levels reach their peak or until the end of the 9-minute generation period.

Safety components at the dam include the warning siren and signage. While all property owners indicated they can hear the siren from their property and are aware of its significance, several indicated that did not believe the siren was as loud as it used to be. Empirical data collected indicated that throughout the section of river where substantial water level changes occur, the siren is easily heard and appears to provide sufficient warning. The siren is not noticeable at the downstream portion of the study area but water level fluctuations are minimal in these areas. A somewhat surprising result of the survey was that 40% of the respondents were not aware of safety signage. This is likely due to owners accessing the river through their respective properties where signage does not exist. The evaluation of the signage conducted as part of the study indicated that the signage appeared to be consistent with other hydroelectric facilities.

While not directly related to autocycling, researchers did observe a potential concern when operations switch from autocycling to a continuous release as would occur during a higher flow event. As a courtesy, Appalachian informs a number of stakeholders (i.e., state resource agencies and lake associations) as well as media contacts to inform the public of potential for downstream flooding. However, there is potential for river users to become complacent to changes in water levels especially in downstream areas with minimal changes during autocycling. The downstream areas react differently however during a continuous release of higher flows. Water levels and velocity would increase more than during autocycling and have the potential to represent a hazard. Researchers observed such an occurrence by a number of recreationists utilizing an island area near the mouth of Goose Creek which can be a popular area

in the summer. It should be noted that such releases are not operational but are typically related to water management.

TASK 4 – AQUATIC HABITAT

Fish sampling conducted within the area from Leesville Dam to the confluence of Goose Creek documented 38 species. Species composition serves as an indicator of habitat characteristics and potential effects of autocycling on habitat. Additionally, assessment of sampled habitats indicate high quality habitat throughout the study reach In terms of habitat stability with regard to autocycling (i.e. pulsed releases), pools exhibit the most stability while riffle/run habitat would most likely be affected. Therefore, evaluation of life history requirements of the species documented provides an assessment of the overall suitability of the habitat most at risk to effects.

The presence of substantial numbers of fluvial dependent and fluvial specialist species in the fish assemblage below the Leesville Dam is indicative that the existing base flow and project operation (i.e. autocycling) adequately provides habitat services to the aquatic community for species that depend on riffle and run mesohabitats. In addition to these habitats being the most sensitive to flow fluctuations relative to pools and they are also most susceptible to effects from low flows. Spawning for most species would occur during the spring bioperiod; and most species are lithophyllic, nest building species. The persistence and abundance of these species indicates that the flow regime is adequately protective of that habitat function.

While not a direct component of this study, it is important to note that the federally endangered Roanoke logperch was documented within the study area. Declines of this species throughout its range are largely attributed to habitat degradation. In particular, sedimentation has eliminated areas of clean substrate and riffle/run habitat needed for this species. Previous fisheries survey downstream of Goose Creek did not document the presence of this species but the area between Leesville Dam and Goose Creek had not been surveyed. The researchers in this study believe it is likely that Roanoke logperch exist downstream of Leesville Dam due in part to the current operating regime which mobilizes fine sediments and helps to keep the substrate relatively free of sediment. Additionally, Leesville Dam acts as a sediment trap that limits upstream inputs.

TASK 5 – EROSION POTENTIAL

Understanding the behavior of complex systems such as the Roanoke River and using this understanding to achieve balance between multiple stakeholder demands is a challenging undertaking. A 2-D numerical model to simulate flow characteristics under the existing autocycling and the proposed continuous discharge scenarios was developed to forecast the effects and is an important tool for decision-making and impact assessment.

The 2-D hydrodynamic model was used to simulate steady and unsteady flow conditions in the Roanoke River from the Leesville Dam to the junction with Goose Creek. The model was calibrated to recorded water level and discharge conditions at the various locations on the river for the existing hourly autocycling conditions. It was found that autocycling increases the fluctuation in water levels, current speeds, and bed shear stress compared to the continuous release scenario. Consistent with field observations, the previously implemented 2-hour autocycling scenario is shown to have more influence on water levels, local discharge, current speeds, and erosion potential than the current hourly autocycling scenario.

Based on model results, it can be concluded that there is an increase in erosion potential under autocycling conditions compared to continuous release. However, this does not indicate an increase in current erosion rates, nor does it conclude that the stream bank is in fact actively eroding at an increased rate due to operations.

The increase in erosion potential is most evident near the dam and diminishes in the downstream direction with the impact being relatively minor at distances greater than about 1.3 mi downstream of the dam. The size of bed material that can be mobilized decreases while moving downstream, due to attenuating velocities. Autocycling has created a scour area just downstream of the dam where cobble and gravel is exposed. This scour area is no longer observed nor predicted to be seen 1.3 mi downstream from the dam based on model results.

No signs of active bank erosion were observed during the 2011 field survey of the study area. This supports the conclusion that the channel has adjusted to the altered flow regime and bank erosion is not a source of major sediment input downstream from Leesville Dam. In fact, the dam in combination with autocycling operations may be allowing for maintenance of relatively

sediment free substrate in the reach immediately downstream from the dam than would be seen under a continuous release scenario. There are two components that work toward this condition. First, the increased velocity from the peak discharge is able to keep the gravel-cobble substrate exposed in the study area by mobilizing fine sediments. Second, the dam and impoundment itself serve to trap sediment in the upstream section of the river thereby limiting the supply of sediment in the study area. Field observations and subsequent erosion pin measurements obtained during 2014, document erosion in the Leesville Dam to Goose Creek reach contrary to field observations made in 2011. It remains unclear as to the role operations is having on the observed erosion especially since erosion was documented even in the downstream portion of the study reach where minimal water level fluctuations occur. It must be remembered that erosion is a natural process that occurs on all rivers and is dependent on many processes such as stream flow along with the physical properties and structural arrangement of the sediment.

Bank pins were installed along the river banks as part of this study between Leesville Dam and Goose Creek during 2011 and from Goose Creek to Altavista in 2014. The intent of these installations was to provide a mechanism for quantifying erosion raters over a given time period. It would also potentially allow an estimate of the sediment originating from the river banks to be calculated. Therefore, subsequent measurements of these pins will allow for estimation of the rate at which the river banks may be eroding and comparison of areas impacted or not by water level fluctuations. A routine measurement schedule could help discern the difference between natural erosion caused by relatively stable flows or high flow events compared to autocycling operations.

TASK 6 – DISSOLVED OXYGEN

Dissolved oxygen (DO) was measured in the project forebay, tailrace, and in the Staunton River just upstream of the confluence of Goose Creek. Data indicates that DO levels meet the state requirements of 4 mg/l on an instantaneous basis and 5 mg/l on a daily average basis with few exceptions during typical autocycling operation. Continuous monitoring data further indicates that DO levels exhibit diurnal patterns typical of a riverine environment in the downstream portion of the study area. Therefore, hourly autocycling allows the project to meet DO discharge requirements.

TASK 7 – BANK STABILIZATION

An evaluation of bank stabilization techniques including the use of re-vegetating shoreline was conducted as part of Task 7. There are multiple techniques available and site characteristics typically define those most likely to be successful. The techniques provided illustrate those considered to be applicable to the Roanoke River downstream of Leesville Dam. It should be noted that to be effective, bank stabilization should be coordinated with land use practices.

TASK 8 – MINIMUM FLOW UNIT

Two potential configurations for a new minimum flow unit at the Leesville development, the estimated change in electricity generation and an opinion of construction costs for each configuration were investigated. The two minimum flow unit configurations considered are:

1. A new Kaplan unit in a new powerhouse downstream of the dam and existing powerhouse fed by a penstock from a new intake structure in the dam.
2. A new Kaplan unit in place of one of the existing large units.

The Kaplan units considered for this feasibility study have the ability to operate at discharge levels from 350 to 1200 cfs and eliminate the majority of the need to autocycle the large units (or the remaining unit in the second configuration).

Configuration 1 has the advantage of increasing the plant's capacity and number of units, thereby increasing unit availability. This increase in capacity is not required by the plant as one of the large units currently in operation is able to pass the average daily flow 98% of the time. Configuration 1 is expensive as compared to Configuration 2 due to the need for a new intake structure, penstock, powerhouse, and tailrace.

Configuration 2 has the advantage of lower construction cost by using the existing water conveyance structures for one of the units and not requiring an additional powerhouse or tailrace. However, the loss of one of the large units may create a small loss in the plant availability if the remaining large unit experienced a forced outage during a high flow period. Also, using the existing water passage for a new unit may decrease the efficiency of the new unit because the approach flow is not as well controlled as in a new station with a water passage built for the smaller unit.

There is no way to recover the cost associated with installing a minimum flow unit at the Leesville development. The addition of a minimum flow unit and the supporting facilities carry a high initial cost and would increase the development's operation and maintenance costs. These increased costs would lead to lower plant revenues due to decreased annual energy production.

Despite the fact that both minimum flow configurations would come at a high cost and provide no payback, Configuration 2 would provide the minimum flow capability at the lower capital cost and have marginally less negative effect on annual generation. Since both configurations that allow the plant to completely avoid autocycling are economically unfavorable a modified autocycling regime using the current units, if possible, may be a more favorable compromise.

1.2.2 RECOMMENDATIONS

Based on the data collected and observations from the researchers, the following recommendations are made for consideration.

- Provide a mechanism for property owners in the area between Leesville Dam and Goose Creek to meet with Appalachian representatives on an annual basis. This will allow for relationship building to discuss and resolve concerns.
- Continue to contact state and local agencies/organizations as well as the media to inform the public of changes autocycling to continuous release during periods of high flow.
- Consult with the USFWS and VDGIF to continue discussions pertaining to implications of Roanoke Logperch downstream of Leesville Dam.
- Monitor erosion pins throughout the Leesville Dam to Altavista reach on an annual basis with monitoring also occurring after high flow events for some agreed to period (e.g. three years).
- Conduct shoreline stabilization demonstration projects at two sites between Leesville Dam and Goose Creek in conjunction with property owners identified as interested participants.
- The current one hour autocycle regime should continue. Consideration however, should be given to tighter control of the release schedule each day.

2.0 INDIVIDUAL TASK SUMMARIES

2.1 TASK 1 – INTERVIEW ADJACENT LANDOWNERS TO IDENTIFY CONCERNS ASSOCIATED WITH HOURLY AUTOCYCLING

While initially planned as an early component of the study, this task was completed during 2014. During field efforts for other study tasks, researchers interacted with property owners as well as other river users. As such, it provided an opportunity to learn the area, experience autocycling and its potential effects and develop a better understanding of the various components of the study area. It also allowed researchers to better understand potential concerns. During these interactions, while formal interviews were not conducted, insights were developed on how property owners use the river, view autocycling and how to best develop interview questions.

2.1.1 METHODOLOGY

The first step in conducting the property owner interviews was to identify the various land parcels between Leesville Dam and Goose Creek on both the Campbell and Pittsylvania County sides of the river. This was accomplished by researching county records available at http://www.co.campbell.va.us and http://www.pittsylvaniacountyva.gov/.

A survey form with questions pertaining to how the property was utilized, recreational pursuits, and concerns about autocycling was developed. This survey along with the needed background information and a letter explaining the survey was sent to each property owner via U.S. mail. A copy of the materials provided is included as Attachment A. Additionally, each property owner whose telephone number could be located was called to confirm they had received the survey and their participation was requested. In order to facilitate ease of response, each property owner was provided with several options for responding depending on their personal preference. These options included:

- Fill out the hardcopy of the survey and return in the included envelope with pre-paid postage;
- Complete the survey on the online link provided; or
- Participate in a telephone interview.

Survey information was then summarized to provide a useful tool for decision making purposes with regard to autocycling or continuous flow releases.

2.1.2 RESULTS

There are 38 property parcels adjacent to the Staunton River between Leesville Dam and the mouth of Goose Creek. Of these, eight parcels are located in Campbell County and represented by six owners. Likewise, the 30 parcels located in Pittsylvania County have 24 owners. Three parcels near the dam are owned by Appalachian Power or their affiliates and are excluded from the survey. Therefore, a total of 28 and 7 non-Appalachian owned parcels are located in Campbell and Pittsylvania counties respectively.

Responses were received from three of the owners representing four parcels in Campbell County and 12 of the owners representing 15 parcels in Pittsylvania County. The percent of non-Appalachian owned shoreline represented by respondents however is different. Owners representing approximately 61.7% of the Campbell County shoreline responded while 27.4% of the Pittsylvania County shoreline is represented by the owners who responded. The Pittsylvania shoreline contains a number of small residential lots whose owners accounted for the majority of the responses. The two Pittsylvania County property owners with the largest amount of shoreline, 52.2% combined, did not respond to the survey. These two properties are located at the downstream extent of the study reach. It is noteworthy that the majority of respondents utilized the hardcopy response option and several participated in phone interviews. Only one utilized the online survey option.

Survey results are provided at the end of this section and include responses to the standardized questions as well as comments provided. Overall, respondents viewed hourly autocycling as an improvement over the two-hour autocycle and the pre-autocycle operations. While there was agreement that improvements had been made, concerns about property losses due to erosion remain (60% of the respondents expressed this as a concern). Additionally, several other insights on the responses are noteworthy. They include:

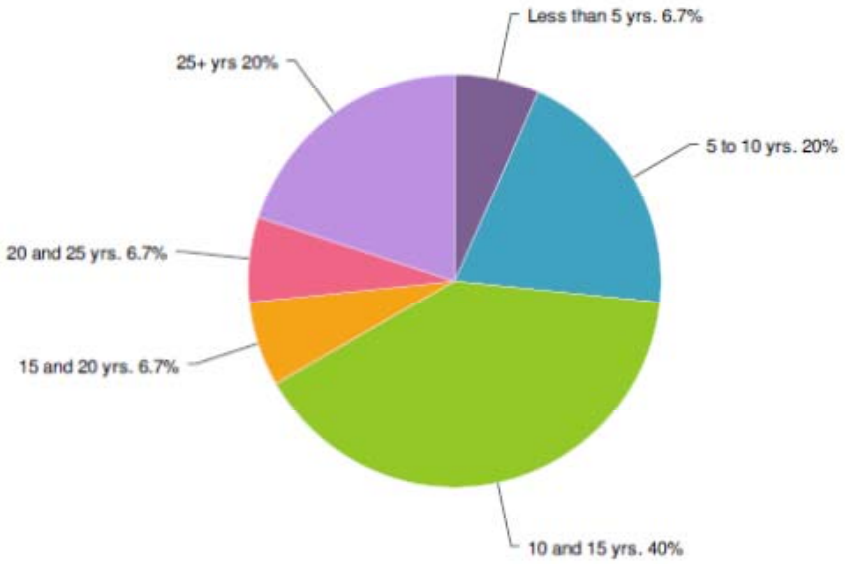
- A majority of respondents (73.3%) used the property all year long.
- The primary use for their property cited by the survey respondents was recreational, followed distantly by Agricultural.
- 73% of respondents have been property owners for 10 years or longer, meaning they have experienced both 2-hour and 1-hour cycles.
- Three respondents have been owners for more than 25 years and have experienced operations prior to the implementation of autocycling.

- Shore-based fishing, leisure activities, and paddling were the most popular forms of recreation.
- A majority (71.4%) of respondents participated in recreational activates within the first mile downstream of the Leesville Dam. This area represents the largest change in water level and velocity due to autocycling.
- 86% of respondents do not feel that hourly water level fluctuations affected their ability to pursue their preferred recreational activities.
- Of the nine respondents who recreate within 1 mile of Leesville Dam, 8 indicated they did not feel that hourly water level fluctuations affected their ability to pursue their preferred recreational activities.
- 100% of respondents can hear the sirens from their property and are aware that the sirens means water releases and increased water levels are about to begin.
- Only 60% of respondents however, are aware of the signage that warns of water level fluctuations (Note: this is likely due to accessing the river through their property.)
- 60% of respondents are concerned that water level fluctuations are affecting their shoreline due to erosion.
- 60% of respondents would consider having a portion of their shoreline property used to evaluate shoreline protection.

2.1.2.1 SURVEY RESPONSES

New Summary Report - 24 January 2015 (*Survey: Property Owners Survey)*

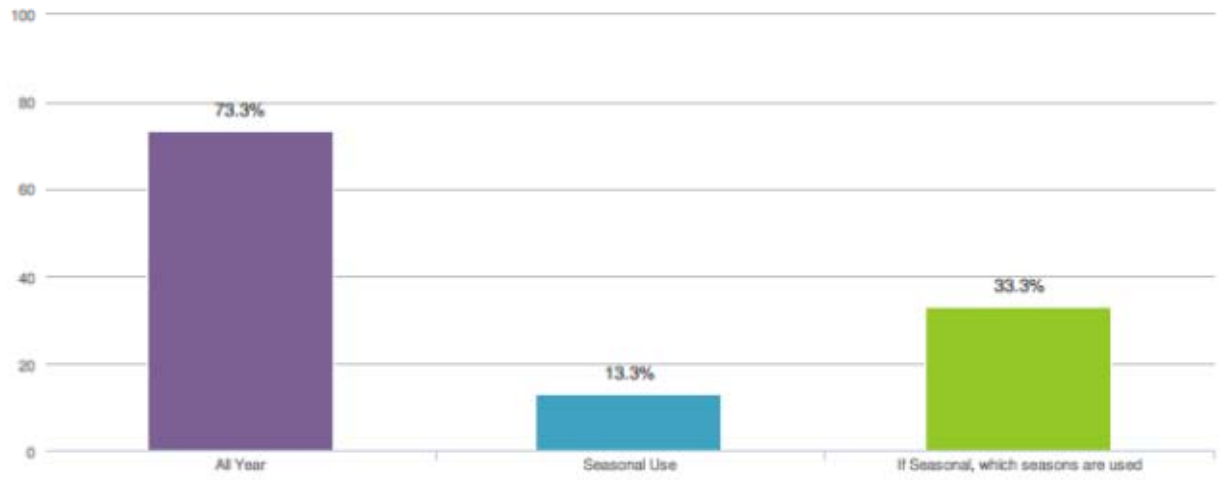
2. How long have you been a shoreline property owner in the area between the Dam and Goose Creek?



Less than 5 yrs.	6.7%		1
5 to 10 yrs.	20.0%		3
10 and 15 yrs.	40.0%		6
15 and 20 yrs.	6.7%		1
20 and 25 yrs.	6.7%		1
25+ yrs	20.0%		3
		Total	15

Statistics	
Sum	185.0
Average	13.2
StdDev	7.2
Max	25.0

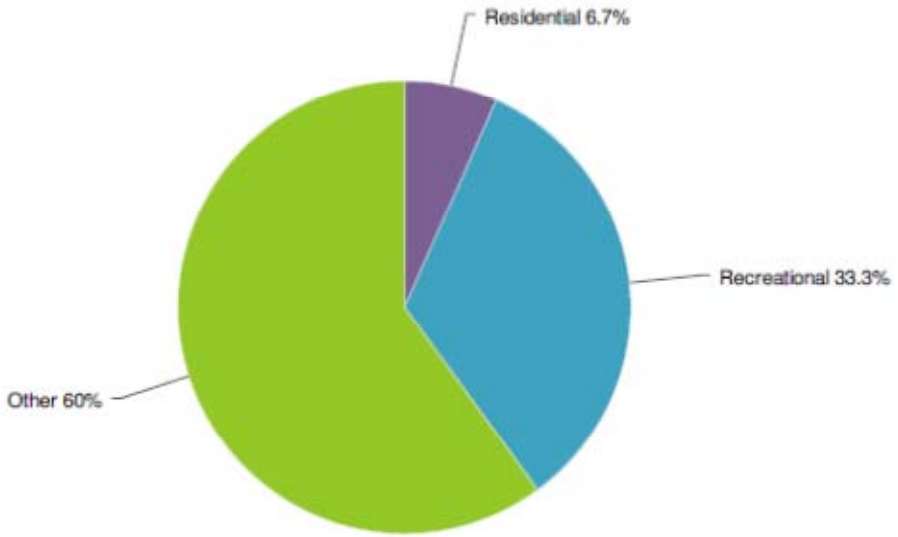
3. When do you use your property?



All Year	73.3%		11
Seasonal Use	13.3%		2
If Seasonal, which seasons are used	33.3%		5
		Total	15

Responses "If Seasonal, which seasons are used"	Count
Left Blank	10
In process of retiring and moving there	1
Spring- Fall	1
Summer	1
Summer - Fall	1
We have not been to the property in about 20 years	1

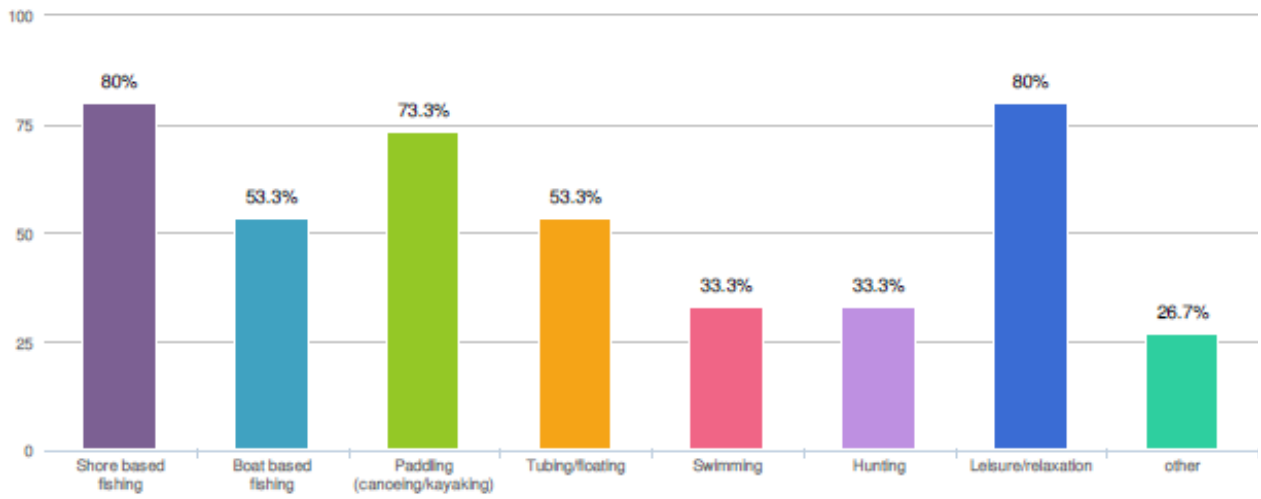
4. How do you use your property?



Residential	6.7%		1
Recreational	33.3%		5
Agricultural	0.0%		0
Other	60.0%		9
		Total	15

Responses "Other"	Count
Left Blank	6
Checked all: Residential, Recreational, Agricultural, Other: Timber	1
Recreational and agricultural	1
Recreational and loan use to friends and family	1
Residential and Recreational	2
all checked: Residential, Recreaiton, Agriculture, Other: Cattle Operation	1
raise cattle and grow hay	1
recreation and agriculture	1
residential and agricultural checked	1

5. What type of recreation do you participate in on the Staunton River?



Shore based fishing	80.0%		12
Boat based fishing	53.3%		8
Paddling (canoeing/kayaking)	73.3%		11
Tubing/floating	53.3%		8
Swimming	33.3%		5
Hunting	33.3%		5
Leisure/relaxation	80.0%		12
other	26.7%		4
		Total	15

Responses "other"	Count
Left Blank	11
None	1
Trail riding	1
Wading Fishing	1
walk out fishing	1

6. Please rank your top three recreational activities in terms of importance to you.

	Shore Based Fishing	Boat Based Fishing	Paddling	Tubing/floating	Power boating	Swimming	Hunting	Leisure/relaxation	Other	Response
Activity 1	3 21.4%	1 7.1%	3 21.4%	1 7.1%	0 0.0%	1 7.1%	1 7.1%	3 21.4%	1 7.1%	14
Activity 2	3 23.1%	2 15.4%	0 0.0%	1 7.7%	0 0.0%	2 15.4%	1 7.7%	3 23.1%	1 7.7%	13
Activity 3	3 23.1%	1 7.7%	1 7.7%	1 7.7%	0 0.0%	1 7.7%	2 15.4%	3 23.1%	1 7.7%	13

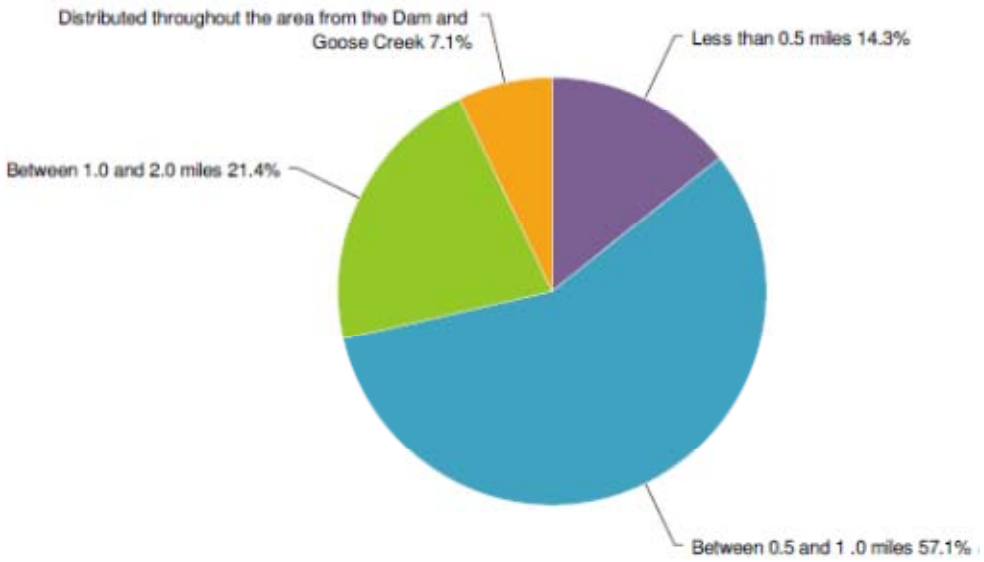
7. Do you feel that hourly water level fluctuations affect your ability to pursue your preferred recreational activities?

Yes	13.3%		2
No	86.7%		13
		Total	15

8. If you answered "Yes" to the above question, please provide a description of the effects. (If you answered "No", you can also add comments if desired.)

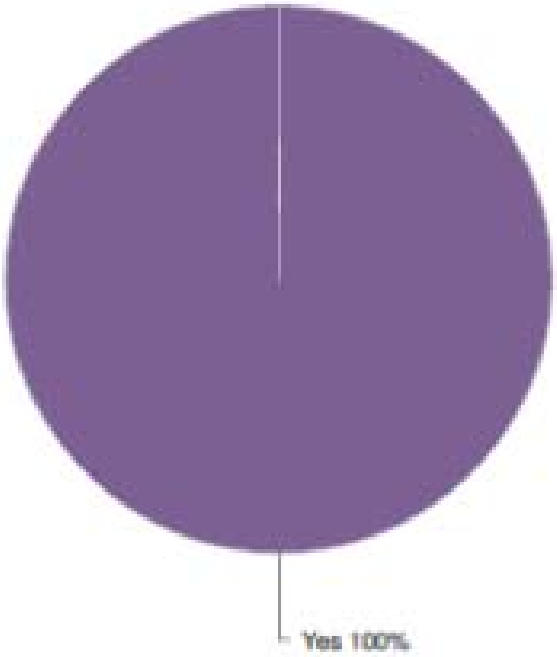
Count	Response
1	Bank washes
1	Has a distinct effect on riverbank erosion of soil
1	Just have to wait about 15 minutes for the flow to slow down.
1	You know the water flow and current change are coming you adjust and pay attention
1	like hourly the best of the 3 operations, people time their floats to be able to go with the surge
1	We just adjusted our swim/float time around water letting out. We swim/float when calm. Cannot during "let out" time.
1	I prefer the hourly release over the releases every 2 hours. It is better now in my opinion vs. pre-2009

9. What is the approximate distance from Leesville Dam where most of your recreational activities occur?



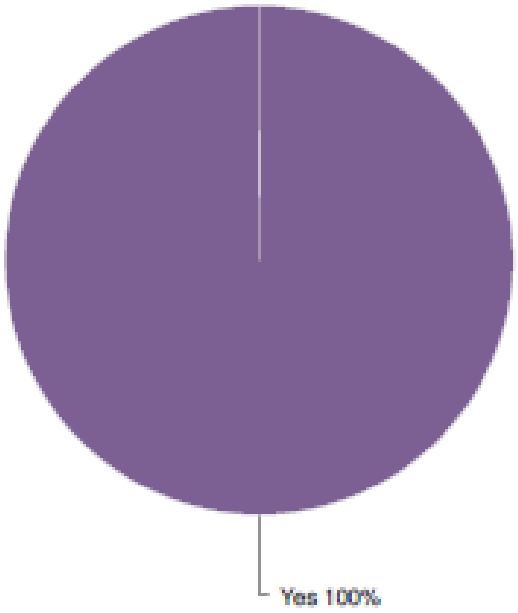
Less than 0.5 miles	14.3%	2
Between 0.5 and 1 .0 miles	57.1%	8
Between 1.0 and 2.0 miles	21.4%	3
Between 2.0 miles and the mouth of Goose Creek	0.0%	0
Distributed throughout the area from the Dam and Goose Creek	7.1%	1
	Total	14

10. The siren at the Dam sounds prior to water releases. Are you aware that the siren means water releases and increased water levels are about to begin?



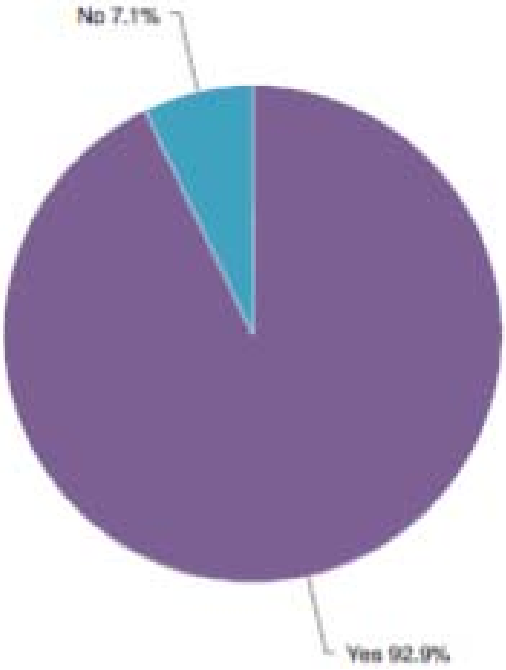
Yes	100.0%		15
No	0.0%		0
		Total	15

11. Can you hear the siren from your shoreline property?



Yes	100.0%		15
No	0.0%		0
		Total	15

12. Can you hear the siren from the river areas you recreate?



Yes	92.9%		13
No	7.1%		1
		Total	14

13. Are you aware of the signage that warns of water level fluctuations?

Yes	60.0%		9
No	40.0%		6
		Total	15

14. Are you concerned that water level fluctuations are affecting your shoreline?

Yes	60.0%		9
No	40.0%		6
		Total	15

15. If you answered yes to Question #13, please describe your concerns.

Count	Response
1	During heavy rains only
1	N/A
1	The bank/shore is sand. Few rocks and trees. Water pushes it back
1	Waster running breaks shore line, washing it away
1	You can see the soil go downstream every time the level rises
1	erosion of shore on property. Lost 5-10 feet of shoreline.
1	stable now
1	I think it is imperative that Appalachian use stone along my shoreline and riverbank to minimize EROSION!!
1	I know the 2 hr let out really affected it. We lost 6 ft of shoreline in just a few years. I am concerned about losing shoreline because we have lost quite a bit in the time we have had the property. It still washed away the shore but better than every 2 hours. I think a continuous release would be best.

16. Water releases have changed over the years. Prior to 1988, the volume, duration, and schedule of water releases varied considerably. Beginning in 1988, water was typically released for approximately 18 minutes every 2 hours. In 2009, the water release schedule was changed to occur for approximately 9 minutes every hour (i.e. Hourly Autocycling). Based on your experience, please provide your thoughts and/or observations on these changes.

Count	Response
1	Continues to erode away the riverbank and soil at the shoreline
1	I like it better with a 1 hour release.
1	I think every hour is best.
1	It makes it hard to have a fixed dock
1	N/A
1	Prefer 9 minute every hour
1	We adjusted our activities to the release schedule.
1	We were not on the land over most of this period. Didn't even realize things had changed in 2009
1	constant low level flow best
1	My people have not reported any changes recently. We had a lot of shoreline lost pre-1988, but since then things have been a lot better
1	While the 2-hour release gave more time to fly fish while wading, it did more damage to the shoreline.
1	floods are less now than before dam. ...a mess, extensive shore restoration on property. ...has adjusted. Send link of river resources
1	Do not see how it could make a difference. Power is important. River will change with the time and weather.
1	It is better now vs. 2009 and prior. The 18 minute release caused water levels to be too high and causes more erosion.

17. Would you consider having a portion of your shoreline property used to evaluate shoreline protection?

Yes	60.0%		9
No	40.0%		6
		Total	15

18. If you have any additional comments regarding the operation of Leesville Dam, please provide them below.

Count	Response
1	"Appalachian has done a great job in avoiding any flooding"!!
1	Please leave as is now. release 9 minutes/hour. Thanks and good luck.
1	The old siren needs to be used again. The current whistle is inaudible if a breeze is blowing.
1	hope the dam don't break. Doing better now than in the beginning.
1	Data entry note: for Q 17: This depends on what you mean by "used" you can set up monitor equipment for a year or two if you like.
1	We own 1 mile of river off Taylor's Ford Road. Pre- 1988 the dam destroyed all the life in the river. It is not a good place to live or do recreation now.
1	like the improvement to the public area at the dam. Data entry note: for Question 17: official, no, not liable, not responsible for...people "pass thru"
1	data entry note: For question 9 they checked: Between 0.5 and 1.0 miles, and Distributed throughout the area from the Dam and Goose Creek
1	Continue to keep it safe for all. Keep the politics fair/equal between the river residents and lake residents. I love and respect the river. Data entry note: for question 11: However it isn't as load as in years past.
1	The siren is not as loud as it used to be. Please contact to discuss shoreline protection evaluations first (i.e. before implementing).
1	I wish water could be on a constant basis (small release) rather than the heavy release every hour.

2.2 TASK 2 – DETERMINE BOTH THE MAGNITUDE OF WATER LEVEL CHANGES AND RATE OF CHANGE DUE TO HOURLY AUTOCYCLING

The objective of the water level component of the Leesville Development Discharge Study, otherwise called Task 2, is to characterize the rates and magnitude of water level change resulting from hourly autocycling operations at Leesville Dam. While a summary for this effort is provided below, a more detailed report on study efforts is provided in Attachment B.

Water levels were monitored by utilizing in-situ water level data loggers to provide a quantitative evaluation of water level changes within the geographic study area. Level loggers were installed at six locations along a 3.5-mile stretch of river between Leesville Dam and Goose Creek. A level logger was also deployed at one location within Goose Creek in order to assess any backwatering effects caused as a result of hydro operations (Figure 2-1). Initial deployment occurred on June 7 and 8, 2011, with subsequent data downloads occurring on June 14, 15, and 16, 2011, July 13, 2011, and August 16, 2011.

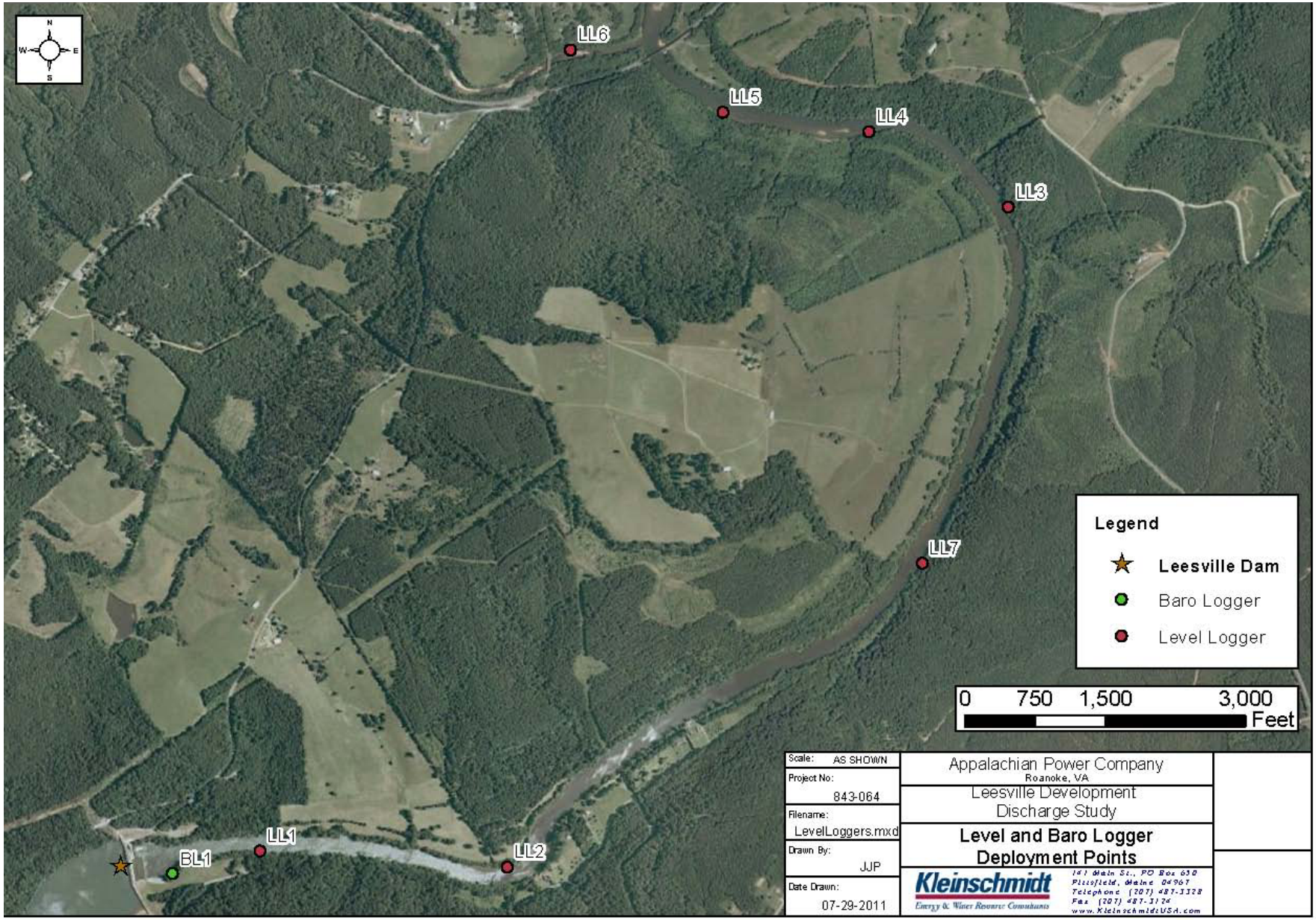


FIGURE 2-1. LEESVILLE LEVEL LOGGER DEPLOYMENT POINTS.

2.2.1 MAGNITUDE OF WATER LEVEL CHANGES

The initial study plan called for two monitors to be placed in Goose Creek but due to an oversight, only one monitor was used. When implementing the study plan, field biologists endeavored to deploy each level logger based on agreed upon locations, as understood at the time of deployment. Moreover, field biologists positioned each logger utilizing their best judgment as to where the loggers would likely collect the most conclusive resulting data and most accurately depict water level fluctuations within the study reach. It has subsequently become apparent that in doing so, the second level logger in Goose Creek was inadvertently left out of the study. Nevertheless, when reviewing resulting Goose Creek data, it is apparent that both the rate of rise and the magnitude of rise are very minimal for all three of the 24-hour analysis periods. This can be viewed in Figures 6 through 11 of the report (Attachment B), as well as in Appendices A-1 through A-3 of the report. Furthermore, the data collected at Level Logger 6, within Goose Creek, tracks very closely to the data collected at Level Logger 5, located within the Staunton River approximately 3.25 miles downstream of the base of Leesville Dam. It can be assumed that any additional level loggers placed closer to the mouth of Goose Creek would also track very similarly to both Level Logger 5 and Level Logger 6. Furthermore, it can be surmised that any additional level loggers placed upstream of Level Logger 6 within Goose Creek would experience even more negligible rates of rise and decreasing fluctuations resulting from Leesville operations. Even though it is unfortunate that this deployment error was made, any additional level logger in this location would have likely not provided any beneficial information in addition to what has already been collected.)

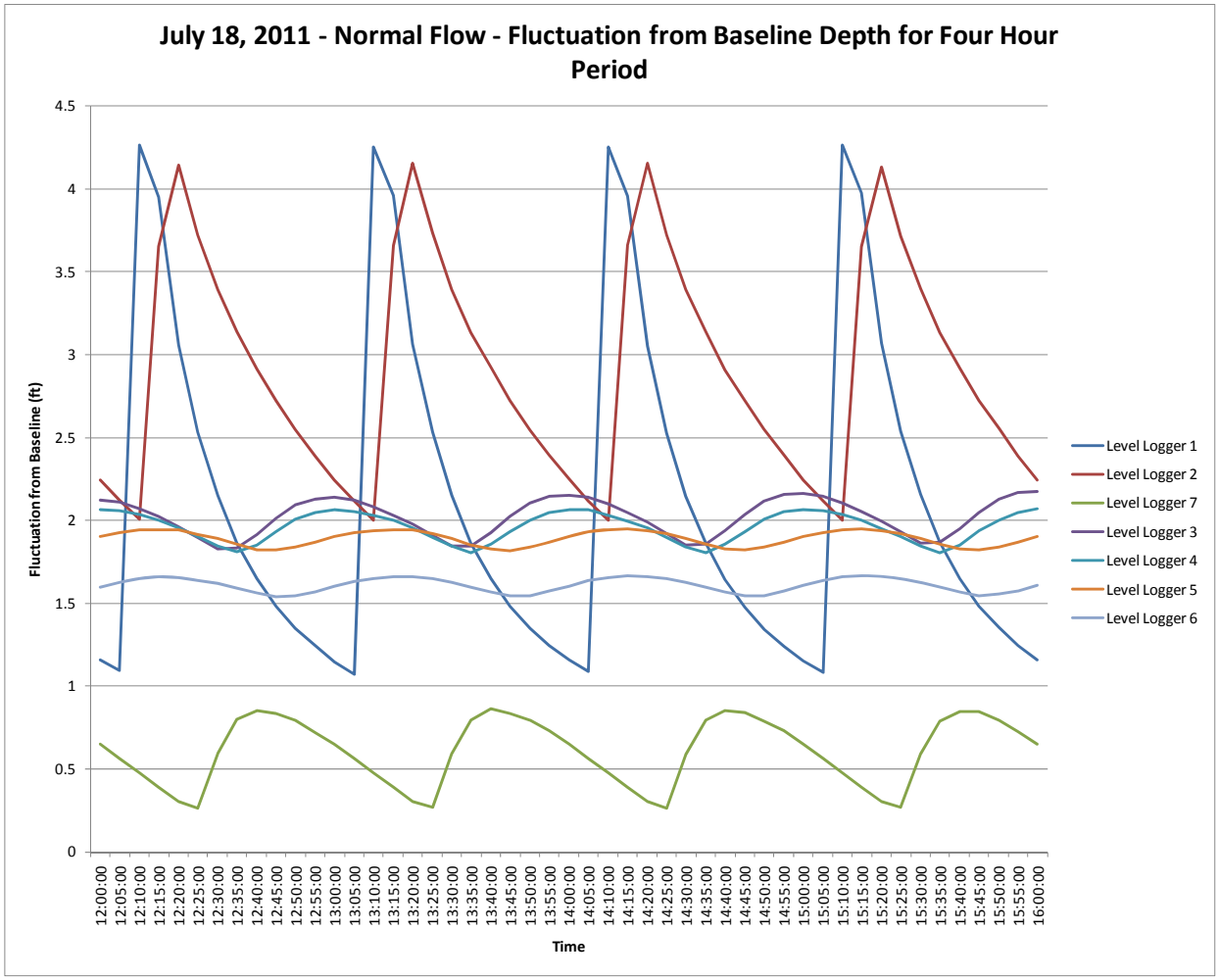
In order to quantify the magnitude of water level changes resulting from autocycling operations, a representative normal, high and low flow day was chosen using average daily flow data provided at the USGS gage at Altavista. These include: July 18, 2011 (normal); July 10, 2011 (high); and, August 11, 2011 (low). Flow data collected at Altavista indicates that there were relatively few instances where flows dipped below 800 cfs during June, July and August of 2011. However, August 11, 2011 represents one of the lowest average daily flows experienced during the study period.

2.2.1.1 MAGNITUDE AND RATE OF RISE AND FALL UNDER NORMAL FLOWS

July 18, 2011 was considered representative of a normal flow day experienced during the study period. Water level fluctuations from the loggers' baseline depth readings are presented in Figure 2-2, below. The baseline water depth at deployment varied slightly depending on logger location. Generally, loggers were deployed, and subsequently redeployed, at approximately 17 to 27 inches below the water surface. It should also be noted that the stretch of the Staunton River in which LL7 was placed was very shallow in nature, with rocky/boulder substrates. This in turn affected the depth at which the logger could be placed. Although all data obtained at this logger is still applicable to this study, Figure 2-2 does demonstrate the difference in placement depth.

Rate of rise during the analysis period is depicted in Figure 2-3. As is expected, both the magnitude of water level fluctuations and rate of change decrease as distance from the dam increases. An approximately 3.5-foot water level increase is seen at LL1 (near the dam) after the onset of autocycle operations. This was shown to occur at a rate of approximately 0.65 feet/minute. Water level changes due to autocycling operations appear to be fairly attenuated as flows reach LL5 located toward the downstream end of the study reach. Less than a 0.25-foot water level fluctuation is observed at LL5 over the period of analysis, with a negligible rate of rise. LL6, which was placed within Goose Creek, also tracks very similarly to LL5 under normal flow conditions.

Approximations of water arrival time can be obtained from the data. Flows peak at LL1 approximately 10 minutes after the start of autocycling operations at Leesville Dam. As expected, the time when peak flows are observed increase with distance from the dam. The slight fluctuations in water level experienced at LL5 and LL6, as described above, occur approximately 60 and 75 minutes after the onset of autocycle operations, respectively. It takes approximately one hour from the commencement of autocycling operations for water levels to reach their low levels at all locations. Again this is expected due to the hourly autocycle sequence.



** Please see discussion above regarding baseline depth and Level Logger 7.*

FIGURE 2-2. STAUNTON RIVER FLUCTUATION FROM BASELINE DEPTH READINGS FROM 12:00 TO 16:00 HOURS UNDER NORMAL FLOWS.

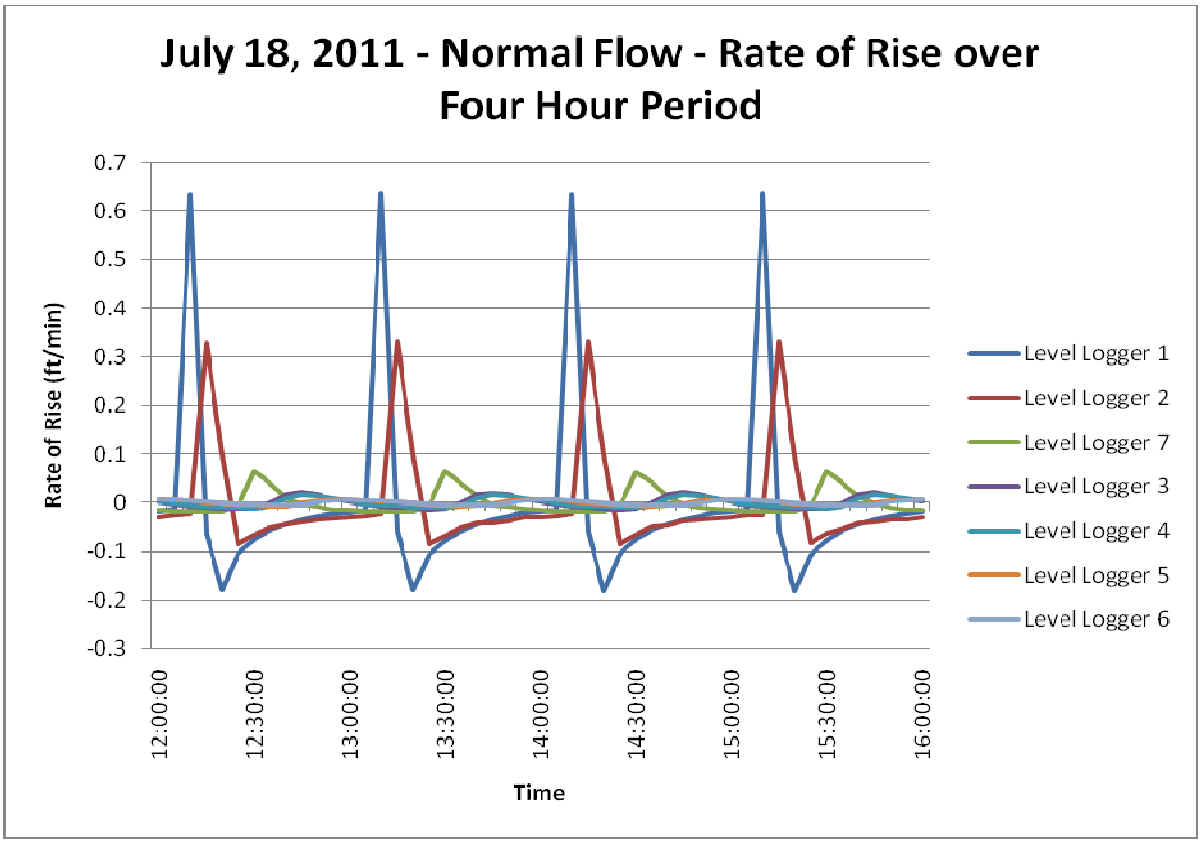


FIGURE 2-3. RATE OF RISE UNDER NORMAL FLOW CONDITIONS IN FEET/MINUTE.

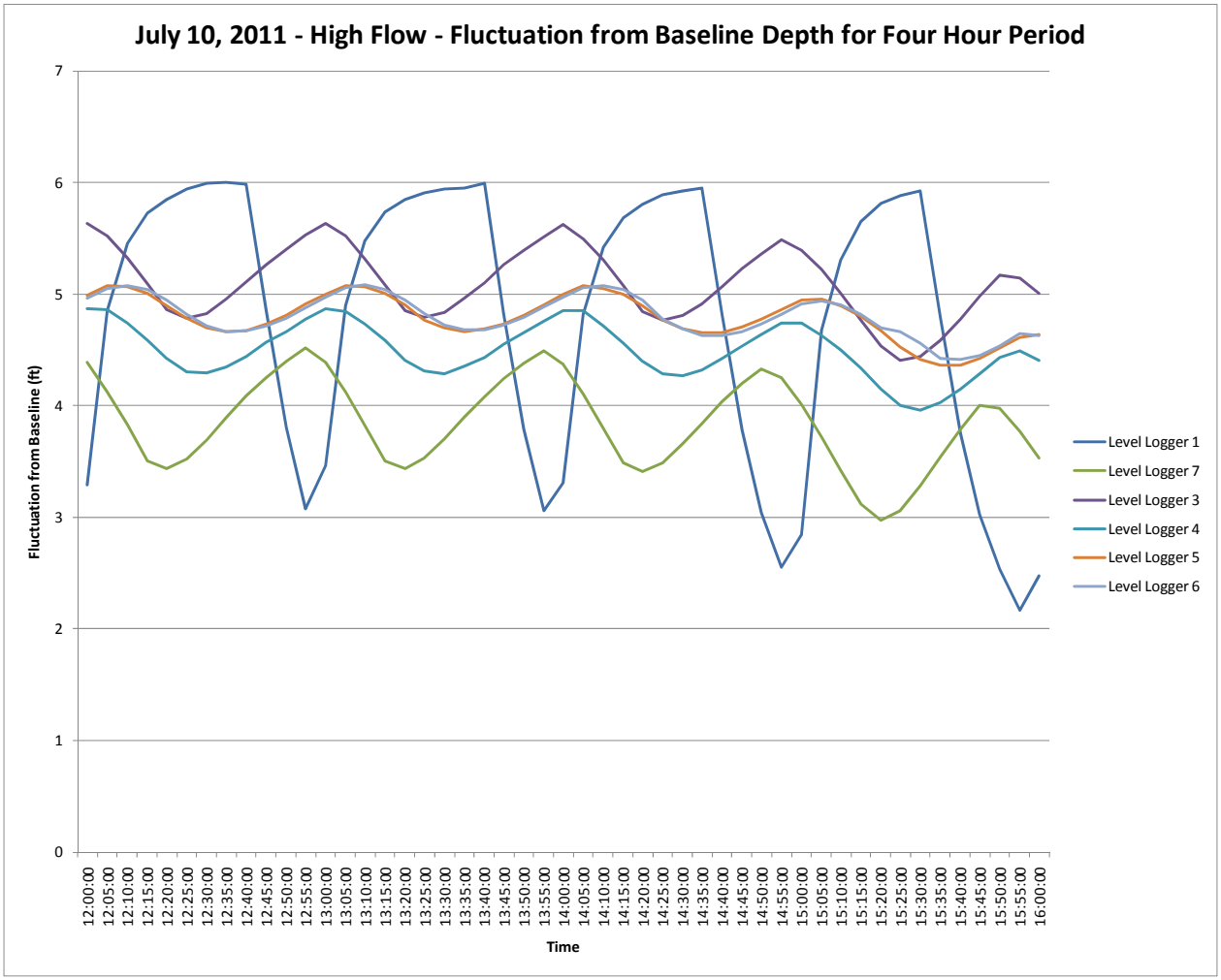
2.2.1.2 MAGNITUDE AND RATE OF RISE AND FALL UNDER HIGH FLOWS

July 10, 2011 was chosen as representative of a high flow day, as flows at Altavista averaged 2,700 cfs, peaking between 12:00 and 16:00 hours. As with the normal flow analyses, a four hour period from 12:00 hours to 16:00 hours was chosen as a representative flow period. Unfortunately, data from LL2 is unavailable for this time period as the logger was lost subsequent to the June 15 download. Therefore, no data from the LL2 location is depicted within Figures 2-4 and 2-5.

Water level fluctuations from the loggers' baseline depth readings are presented in Figure 2-4, below. Rate of rise during the analysis period is depicted in Figure 2-5. With the exception of LL1, the high flows appear to show a greater fluctuation than autocycling operations under normal flow conditions. An approximately 3.0-foot water level increase is seen at LL1, as opposed to a 3.5-foot water level increase under normal flow conditions. The rate of rise

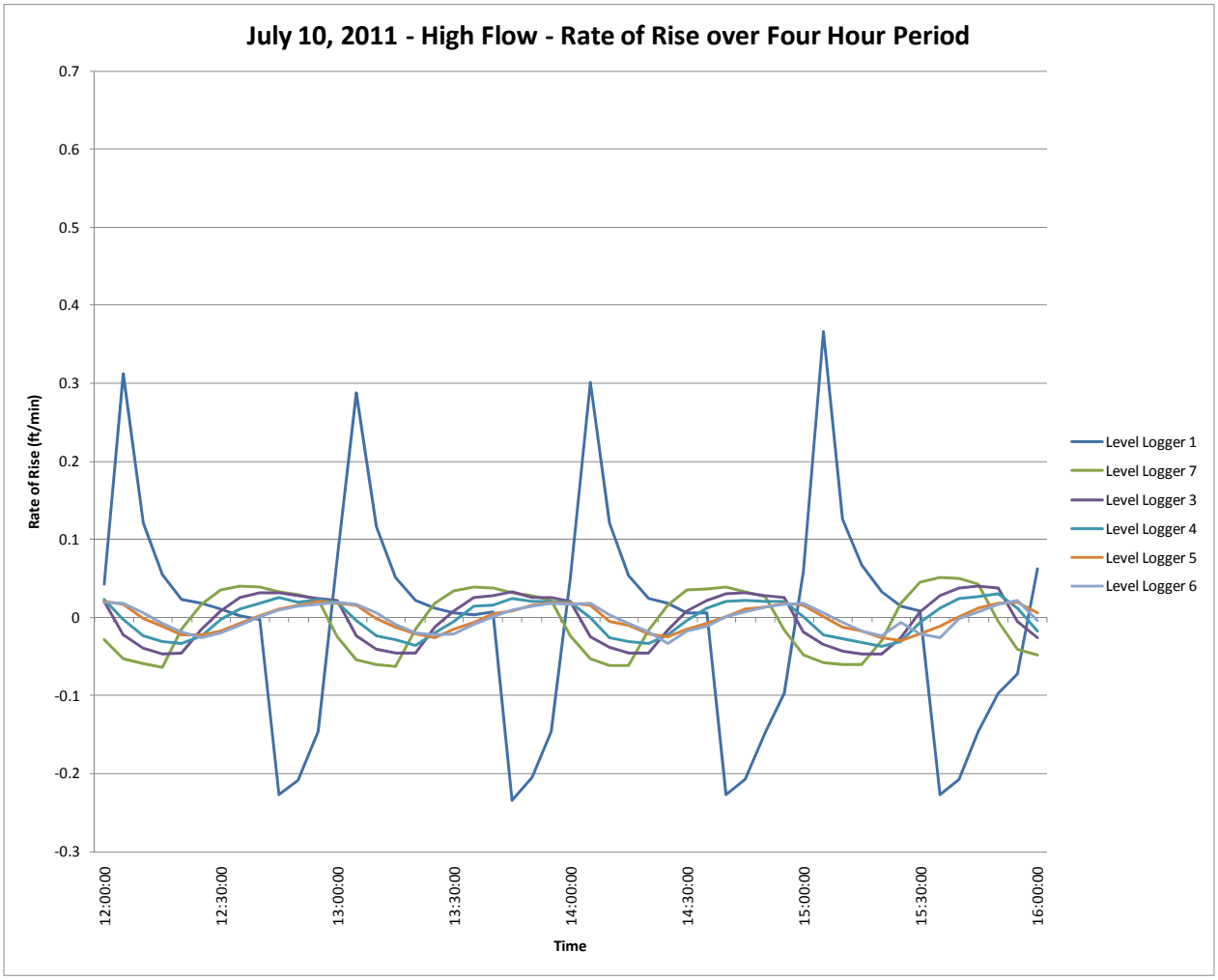
observed at LL1 is approximately 0.3 feet/minute under high flow conditions. Less than a 0.5-foot water level fluctuation is observed at LL5 and LL6 over the period of analysis, with a rate of rise less than 0.1 feet/minute.

With regards to water arrival time, flows are observed to peak slightly later, and remain higher for a longer period of time under the observed high flow conditions. The flows at LL1 peak around 35 minutes after the onset of autocycling operations. River flows peak approximately hourly at the downstream locations. It takes approximately 50 minutes from the onset of autocycling operations for water levels to reach their lowest level at all locations.



** Please see discussion regarding Level Logger 2, above.*

FIGURE 2-4. STAUNTON RIVER FLUCTUATION FROM BASELINE DEPTH READINGS FROM 12:00 TO 16:00 HOURS UNDER HIGH FLOWS.



** Please see discussion regarding Level Logger 2, above.*

FIGURE 2-5. RATE OF RISE UNDER HIGH FLOW CONDITIONS IN FEET/MINUTE.

2.2.1.3 MAGNITUDE AND RATE OF RISE AND FALL UNDER LOW FLOWS

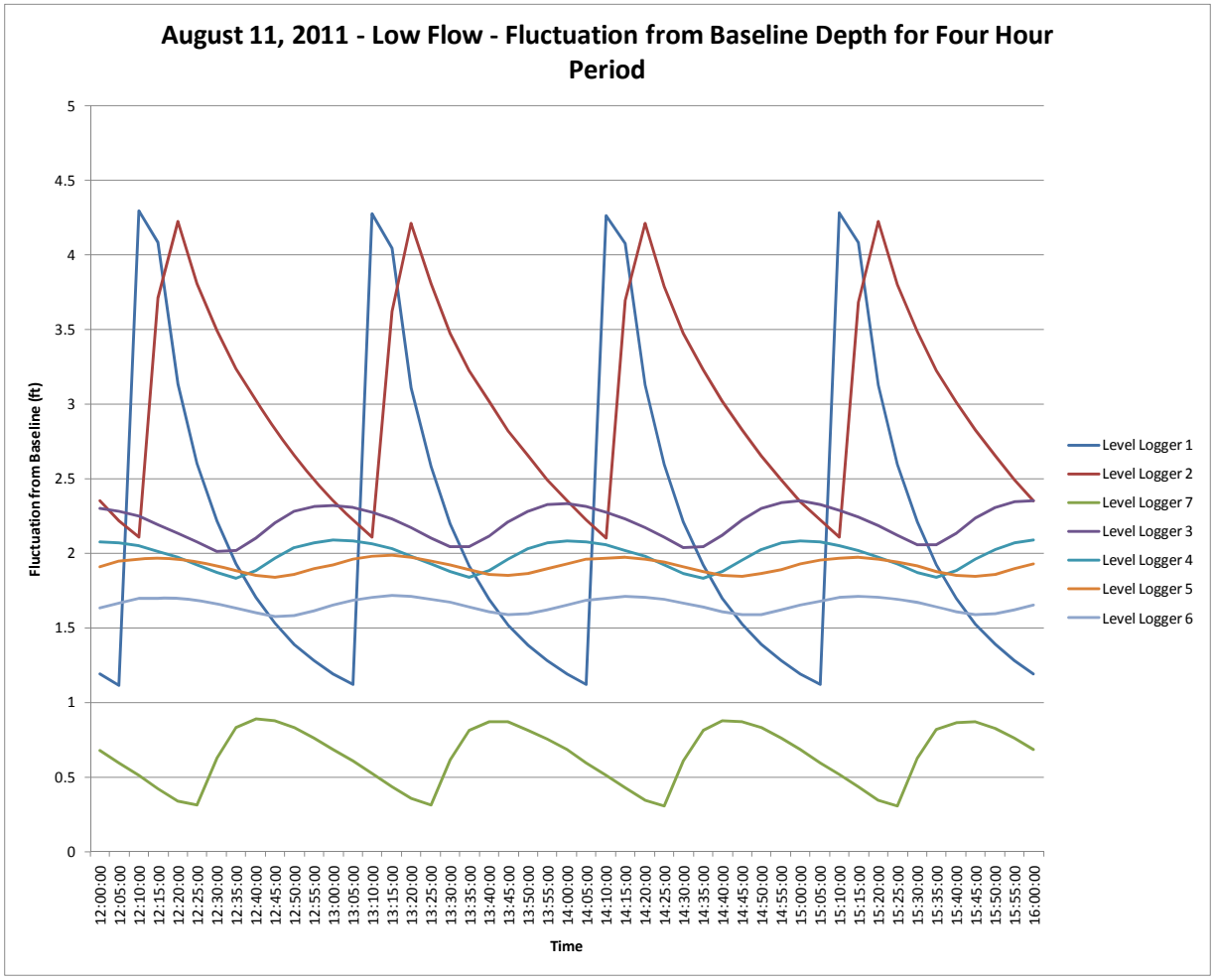
Although true low flow conditions were not experienced during the study period, August 11, 2011 was chosen as representative of the lowest flows experienced during that time. Daily flows, as reported by USGS at Altavista, averaged 790 cfs. As such, results for this time period track very similarly to the July 18 normal flow event. As with the above flow events, a 4-hour time period, from 12:00 hours to 16:00 hours, was analyzed in order to more readily quantify and visually portray the data.

Water level fluctuations from the loggers' baseline depth readings are presented in Figure 2-6, below. Rate of rise during the same analysis period is depicted in Figure 2-7. An approximately

3.5-foot water level increase is seen at LL1, at a rate of approximately 0.65 feet/minute. Water levels at the location of LL2 were shown to rise approximately 2.25 feet at a rate of about 0.30 feet/minute. River flows at LL7 were shown to have contributed to a 0.6-foot water level fluctuation from baseline depth, at a rate of less than 0.1 feet/minute. Water level fluctuations of approximately 0.25-foot or less and negligible rates of rise were observed at all four downstream level loggers (LL3, LL4, LL5 and LL6).

Approximations of water arrival are estimated from the data and are similar to those observed at normal autocycle conditions. Flows peak at LL1 approximately 10 minutes after the start of autocycling operations at Leesville Dam. It takes approximately one hour from the commencement of autocycling operations for water levels to return to low levels at all locations.

In summary, both the magnitude of water level fluctuations and rate of change decrease as distance from the dam increases. Under typical autocycle conditions, an approximately 3.5-foot water level increase occurs near the dam after the onset of autocycle operations. This was shown to occur at a rate of approximately 0.65feet/minute. Water level changes due to autocycling are less than a 0.25-foot near Goose Creek, with a negligible rate of rise.



*

Please see discussion regarding baseline depth and Level Logger 7 included in Section 2.2.1.1.

FIGURE 2-6. STAUNTON RIVER FLUCTUATION FROM BASELINE DEPTH READINGS FROM 12:00 TO 16:00 HOURS UNDER LOW FLOWS.

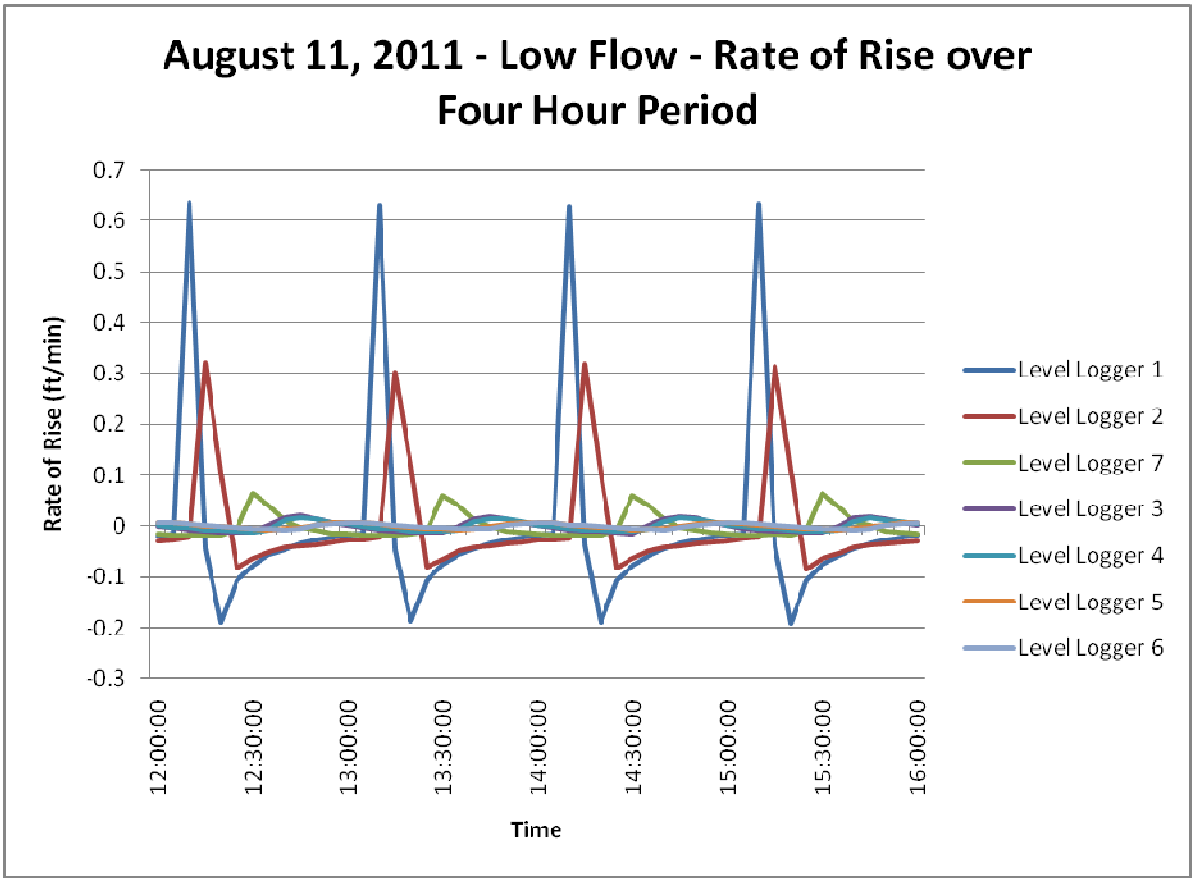


FIGURE 2-7. RATE OF RISE UNDER LOW FLOW CONDITIONS IN FEET/MINUTE.

2.3 TASK 3 – ASSESSMENT OF AUTOCYCLING ON PUBLIC SAFETY AND RECREATION

As part of the study, a qualitative evaluation of the public safety measures in place at the Leesville development – specifically the siren warning system and associated signage was conducted. The assessment includes the entire study reach, from Leesville Dam downstream to its confluence with Goose Creek. This assessment occurred during periods of higher anticipated recreational use, between April 1 and October 31, and also during periods of maximum foliage that could inhibit sound travel as distance from the siren increases.

Step 1 of this study included a qualitative and quantitative evaluation of the Leesville Development audio warning system. The audibility of the siren system was assessed at 12 sites along the 3.5-mile stretch of river. Data collected includes sound measurements of the siren at each location as well as qualitative observations from the researchers conducting the field effort. GPS coordinates of siren monitoring locations were also recorded.

Step 2 of this study included a qualitative evaluation of public safety and informational signage. Visible public safety and informational signs on the Leesville dam and between the dam and the river confluence with Goose Creek were photo documented and GPS coordinates were recorded. The adequacy of existing signage was assessed – again qualitatively – and compared to FERC's Part 8 and Part 12 regulations, as well as *Safety Signage at Hydropower Projects* (FERC 2001), and *Guidelines for Public Safety at Hydropower Projects* (FERC 1992).

Results of the acoustical testing and signage documentation are provided in Attachment C.

2.4 TASK 4 – ASSESS CHANGES IN AQUATIC HABITAT ASSOCIATED WITH HOURLY AUTOCYCLING COMPARED TO CONTINUOUS FLOW

2.4.1 FISH HABITAT AND COMMUNITY

The aquatic sampling plan called for sampling of fisheries and macroinvertebrate communities as well as conducting a habitat evaluation. The initial study plan for fisheries sampling included using electrofishing and seining at three locations during April, June, August, and October. Consultation with Scott Smith of VDGIF indicated that based on VDGIF experience, April sampling was unlikely to be productive and suggested that the sampling regime be modified to include four sampling locations and eliminate the April sample. This suggestion was adopted. It was also suggested that researchers consider eliminating the seining component of the study effort. However, researchers opted to continue to use seining as a sampling method. A report on 2011 Aquatic sampling efforts is provided in Attachment D. The aquatic community and habitat data obtained was used to evaluate potential effects of project operations as discussed below.

The Instream Flow Needs IFIM study conducted on the Roanoke River between Leesville Dam and Clarkton, Virginia (Appalachian Power Company, 2007) was used as the basis for establishing a habitat-based base flow downstream of the Leesville development. This flow is released from Leesville Dam via hourly autocycling. One objective of the current study is to assess the potential effects of autocycling on aquatic habitat. This was done by evaluating the aquatic community present within the study area.

In general, the river reach from Leesville Dam to Brookneal has a moderate to low gradient with diverse physical habitat including shallow riffles, long runs, and deep pools and contains

numerous island complexes and the substrate is composed primarily of bedrock and boulders, with relatively large areas of cobble and gravel, except for pools which are predominantly sand (Appalachian Power Co., 2007). Habitat mapping conducted as part of the IFIM study revealed that pools and glides were the dominant habitat types in the Leesville-Altavista segment (78%), most runs (13%) ranged between 4-5 ft deep and pools were typically 6-8 ft deep but ranged up to 13 ft deep (Appalachian Power Co., 2007). Riffles occupy only 9% of this reach (Table 2-1). While the IFIM study did not include the river segment from Leesville Dam to the confluence of Goose Creek, habitat composition is similar. Pools and glides are the dominant habitat type with runs and riffles comprising a relatively small (<25%) of the area. The release of water through autocycling varies water depth and velocity on an hourly basis as described in sections 2.2 and 2.5 of this report. As such, the characteristics of each habitat type also change. Spatially, these changes are most noticeable near the dam but are not noticeable near the confluence of Goose Creek. From a habitat perspective, pools are affected the least while riffles have the potential to be affected the most. Therefore, aquatic species requiring or preferring riffle habitat also have the greatest potential to be affected.

TABLE 2-1. SUMMARY OF MAJOR MESOHABITAT TYPES IN THE ROANOKE RIVER BETWEEN LEESVILLE AND ALTAVISTA (*APPALACHIAN POWER CO., 2007*).

MESOHABITAT TYPE	PERCENTAGE
Pool	47
Glide	31
Run	13
Riffle	9

The Roanoke River fish assemblage survey (Smith, et al., 2011) conducted in river segment from Leesville Dam to the Confluence of Goose Creek, the study area for this effort provides a characterization of the fish community and reflects habitat use in the study area. Smith et al. (2011) included a Qualitative Habitat Evaluation Index (QHEI) survey of habitat quality and complexity. The QHEI values consistently scored greater than 80, indicating very good overall cover, substrate and channel suitability. In particular, as a result of the Leesville Dam trapping sediment to some degree, there was a limited amount of siltation or imbeddedness due to fine sediment.

Various ecological indicator tools can be used to analyze the fish assemblage response to stressors and restoration efforts. The Index of Biotic Integrity (IBI) model (Karr, 1981) evaluates responses to water quality and physical habitat perturbations using a variety of parameters including tolerant *vs.* sensitive indicator species, and metrics such as species richness. For examples, the species richness of a reference site can serve as a measure of the change in ecological condition. In general, in a relatively degraded stream, a low number of resident fish species and a high proportion of tolerant species can indicate a stressed environment (Armstrong, et al. 2001). The Roanoke River fish assemblage reflects a relatively rich species array (N= 39) comprised of cyprinid, catostomid, centrarchids, percid, morone and alosid families.

The Target Fish Community (TFC) approach indexes the fish community composition as a response to flow restoration or perturbation (Bain and Meixler, 2008). Species habitat requirements are organized into three macrohabitat use classes: macrohabitat generalists, fluvial dependents, and fluvial specialists (Bain and Meixler, 2008). Macrohabitat generalists, such as largemouth bass, use a broad range of habitat and are able to complete their life cycle in lakes, reservoirs, and streams and can be considered as similar to "tolerant" species in an IBI context. Fluvial specialists, such as jumprock, are fish species that require flowing-water habitats throughout life and are comparable to "sensitive" species in an IBI model. Fluvial dependents, such as white suckers, require access to streams or flowing-water habitats for a specific life stage, but may be found in other habitats during other life stages.

Development of a Roanoke River IBI or TFC model ultimately requires analysis of fish data from several ecologically healthy Reference River sites that are geomorphically and zoogeographically similar to the designated segment of the Roanoke River. Populating the model requires input from local fisheries experts to assure that the species composition of the proposed fish community model is consistent with the fish fauna expected to naturally occur within the area. Although reference data development to establish a Roanoke River TFC model are beyond the scope of this study, some interpretation of data can still be made by reviewing the distribution of species among the TFC habitat use guilds. An unimpaired riverine fish assemblage would be expected to have fluvial dependent, fluvial specialist and generalist species all represented; conversely an assemblage lacking fluvial specialist species would be almost

entirely comprised of generalists, and an indicator that fluvial habitat suitability such as riffles and runs is inadequately available.

Table 2-2 classifies fish assemblage data from Smith, et al (2011) according to TFC habitat use guilds, based on 2011 data obtained during the late spring and summer bioperiods. The timing of these collections should account for abundance influenced by within-year reproduction as well as seasonally occurring low flow summer water quality and habitat use conditions. Because it is a single year of data, the extent to which inter-annual variability in fish abundance influences relative abundance of various species is unknown, and thus proportional accuracy of each species contribution to various habitat use guilds is unknown. However, taken as a whole, these data broadly indicate an assemblage comprised of 61% habitat generalist, 29% fluvial specialist and 9% fluvial dependent species.

Given the amount of mesohabitat comprised pool and slow moving glide it is not surprising that approximately 60 % of the fish fauna are comprised of generalist species dominated by various centrarchids, white perch and cyprinid species. However, the fact that approximately 30% of the community is comprised of fluvial specialist species indicates that fluvial habitat quality is consistently available to facilitate spring spawning and summer growth for those species dependent on riffle and run habitat, even though it represents a relatively small component of the available mesohabitat. Riffles are the mesohabitat most sensitive to flow fluctuations (Dunne and Leopold, 1978; Annear, et al. 2002). Sustained flow over riffles is important for maintaining macroinvertebrate communities, fish passage, spawning, egg incubation, feeding, and protective cover for fish (Annear, et al. 2002), and for maintaining dissolved oxygen levels in downstream reaches.

TABLE 2-2. CLASSIFICATION OF FISH SPECIES IN THE ROANOKE RIVER NEAR ALTAVISTA BASED ON DATA FROM SMITH (2011) TO TARGET FISH COMMUNITY HABITAT USE GUILDS *(G = GENERALIST, FS = FLUVIAL SPECIALIST, FD = FLUVIAL DEPENDENT)*.

SPECIES	TOTAL	TFC HABITAT CLASS	
Bluegill	298	G	
Redbreast	168	G	
White Perch	106	G	
Rock Bass	61	G	
Spottail Shiner	59	G	
Largemouth Bass	50	G	
Bluntnose Minnow	45	G	
Channel Catfish	35	G	
Smallmouth Bass	31	G	
Swallowtail Shiner	29	G	
Satinfin Shiner	24	G	
Yellow Perch	19	G	
Bull Chub	14	G	
Common Carp	12	G	
Green Sunfish	8	G	
Gizzard Shad	7	G	
Redear Sunfish	3	G	
Pumpkinseed	2	G	
Black Crappie	2	G	
White Bass	1	G	
Longnose Gar	1	G	
Hybrid x Sunfish	1	G	
Green Sunfish x Bluegill	1	G	61%
Shorthead Redhorse	186	FS	
Notchlip Redhorse	71	FS	
Golden Redhorse	71	FS	
Chainback Darter	39	FS	
Roanoke Darter	36	FS	
Black Jumprock	20	FS	
Northern Hog Sucker	18	FS	
Walleye	15	FS	
Johnny Darter	7	FS	
Roanoke Log Perch	3	FS	29%
Quillback	6	FD	
Str. Bass x Wh. Bass	1	FD	
Comely Shiner	59	FD	
White Shiner	57	FD	
Striped Bass	17	FD	
White Sucker	11	FD	9%

CONCLUSION

The presence of significant numbers of fluvial dependent and fluvial specialist species in the fish assemblage below the Leesville Dam is indicative that the existing base flow and project operation (i.e. autocycling) adequately provides habitat services to the aquatic community for species that depend on riffle and run mesohabitats. These habitats are the most sensitive to flow fluctuations relative to pools and could be vulnerable during periods of recurring low base flow, such as may be present at the low point of the autocycle. Spawning for most species would occur during the spring bioperiod; and most species are lithophyllic, nest building species. The persistence and abundance of these species indicates that the flow regime is also adequately protective of that habitat function.

2.4.2 AQUATIC ASSESSMENT

The information provided in the following subsections summarizes the aquatic community data collected within the study reach.

Fisheries sampling (electrofishing and seining) was conducted twice during the 2011 field season in the 3.5 mile reach below the Leesville Project. Fisheries sampling was conducted at four locations in June and August. The October sample was cancelled due to reasons described below.

The four electrofishing stations were also sampled for qualitative habitat (QHEI). The sites were positioned downstream from the Leesville Dam and included one site in the tailwater section (Station 1) and three sites further downstream (Stations 2, 3, and 4) (see electrofishing map, Figure 2-8). Initially the survey design included 150 m electrofishing reach lengths. Following an initial review of the data from the first sampling pass and based on our experiences in similar riverine settings, it was determined that 500 m reach lengths would result in sufficient sampling effort and habitat coverage to better represent the fish assemblage and available habitat. Also, the increase in sampled area more appropriately conforms to the QHEI methodology. Therefore, the size of the sampling areas were increased.

2.4.2.1 ELECTROFISHING

A total of 1,469 individual fish among 36 species and three hybrids (see species list) were collected over 2.6 km of total electrofishing sampling effort in June and August 2011. The average catch was 560.9 fish/km and 152.2 kg/km respectively. Species richness increased between the June and August sampling passes and is attributable to lengthening the electrofishing zones from 0.15 km to 0.50 km in length. Species richness increased by 4 (20%) at Station 1 and Station 4 and by 11 species (100% and 85%, respectively) at Station 2 and 3. The addition of species when both passes were combined ranged from 2 to 7 when compared to the August sampling pass. Relative numbers and biomass were highly varied between June and August with no clear patterns between passes.

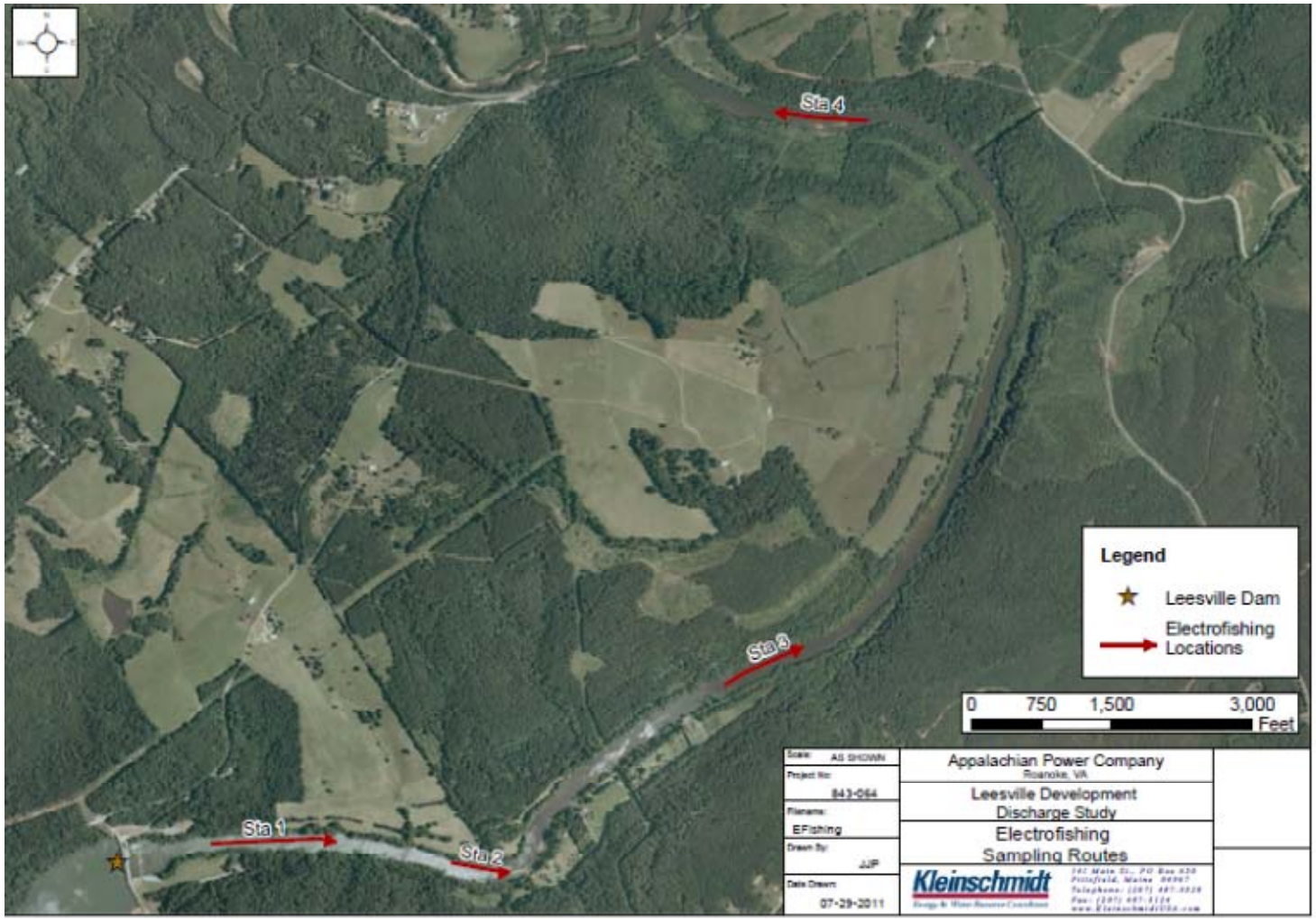


FIGURE 2-8. LEESVILLE ELECTROFISHING SAMPLING ROUTES.

2.4.2.2 SEINING

Seining samples were conducted at three locations (see seining map, Figure 2-9) within each electrofishing zone during June and August. A total of 125 fish were collected with seven species being represented (Table 2-3).

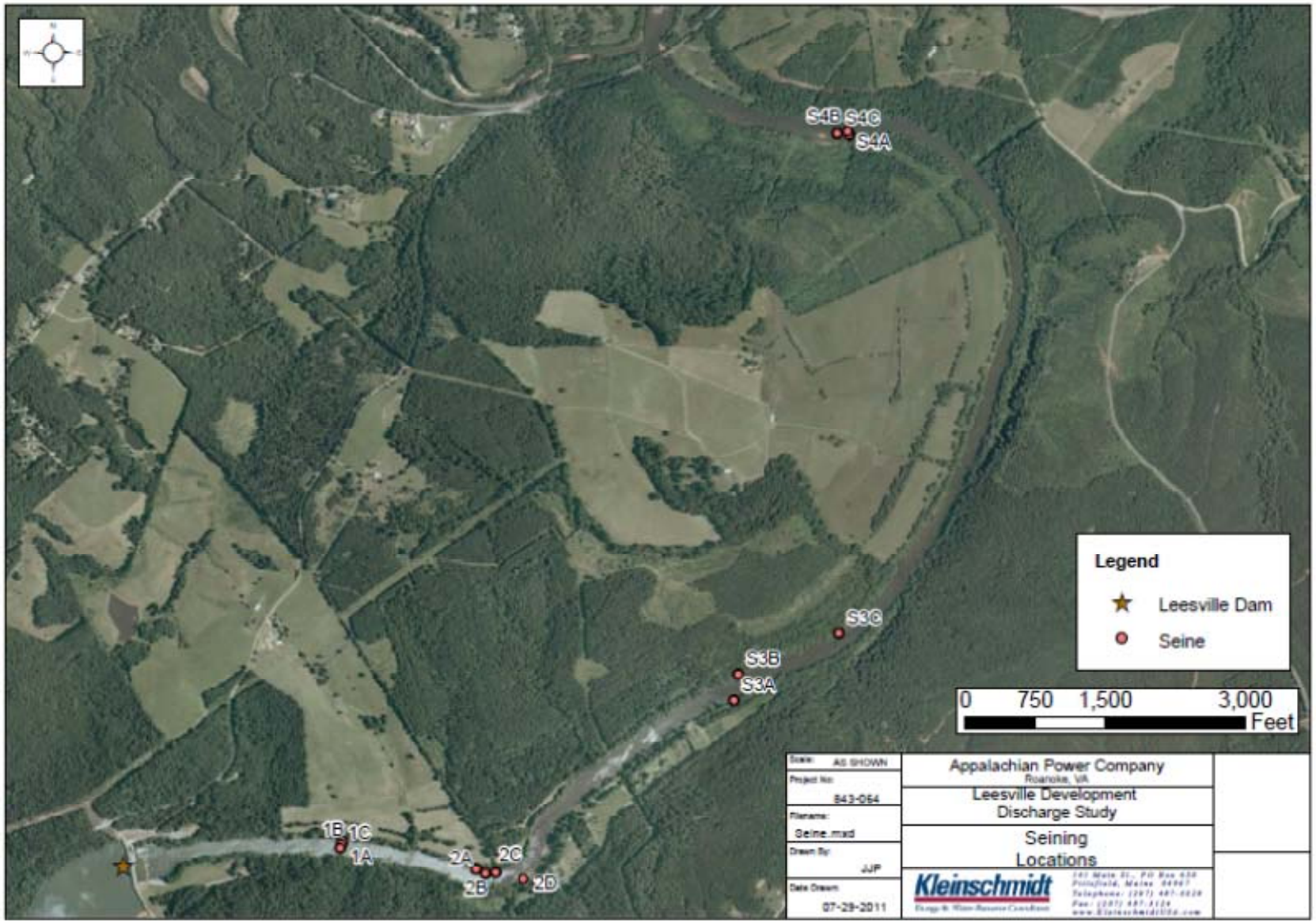


FIGURE 2-9. LEESVILLE SEINING LOCATIONS.

TABLE 2-3. SPECIES LIST AND TOTAL FISH COLLECTED FOR BOTH THE JUNE AND AUGUST SAMPLES.

SPECIES	ELECTROFISHING	SEINING	TOTAL
Longnose Gar	1		1
Quillback	6		6
Gizzard Shad	7		7
Golden Redhorse	71		71
Shorthead Redhorse	186		186
Notchlip Redhorse	71		71
Northern Hog Sucker	18		18
White Sucker	11		11
Black Jumprock	20		20
Spottail Shiner	26	33	59
Bull Chub	14		14
Bluntnose Minnow	45		45
Common Carp	12		12
Comely Shiner	14	45	59
Satinfin Shiner	10	14	24
White Shiner	57		57
Swallowtail Shiner	10	19	29
Channel Catfish	35		35
Striped Bass	17		17
White Bass	1		1
Str. Bass x Wh. Bass	1		1
Black Crappie	2		2
White Perch	106		106
Rock Bass	61		61
Smallmouth Bass	31		31
Largemouth Bass	50		50
Green Sunfish	7	1	8
Bluegill	297	1	298
Pumpkinseed	2		2
Redear Sunfish	3		3
Redbreast	168		168
Green Sunfish x Bluegill	1		1
Hybrid x Sunfish	1		1
Walleye	15		15
Yellow Perch	19		19
Johnny Darter	7		7
Chainback Darter	39		39
Roanoke Darter	24	12	36
Roanoke Log Perch	3		3
	1,469	**125**	**1,594**

During the August 2011 sample, three Roanoke Logperch (*Percina rex*) were collected at two different sampling locations. Roanoke Logperch is a federally endangered species and this is the first documented account of this species in this portion of the Roanoke River during recent years. All three Roanoke Logperch were collected in habitat consisting of bedrock crevices. Due to the collection of this endangered species and after consultation with resource agencies the October sample was cancelled. Since that time, appropriate consultation with the United States Fish and Wildlife Service as well as the VDGIF has occurred. Additional sampling has been postponed indefinitely.

2.4.3 MACROINVERTEBRATE SAMPLING

The requirements for the macroinvertebrate portion of Task 4 called for two sampling methods. Kick net sampling (qualitatively) and Hester-Dendy sampling (quantitatively) was performed during the months of July and August at four locations on the Roanoke River below the Leesville Dam (Figure 2-10). Both the kick net and Hester-Dendy samples were collected at the same locations.

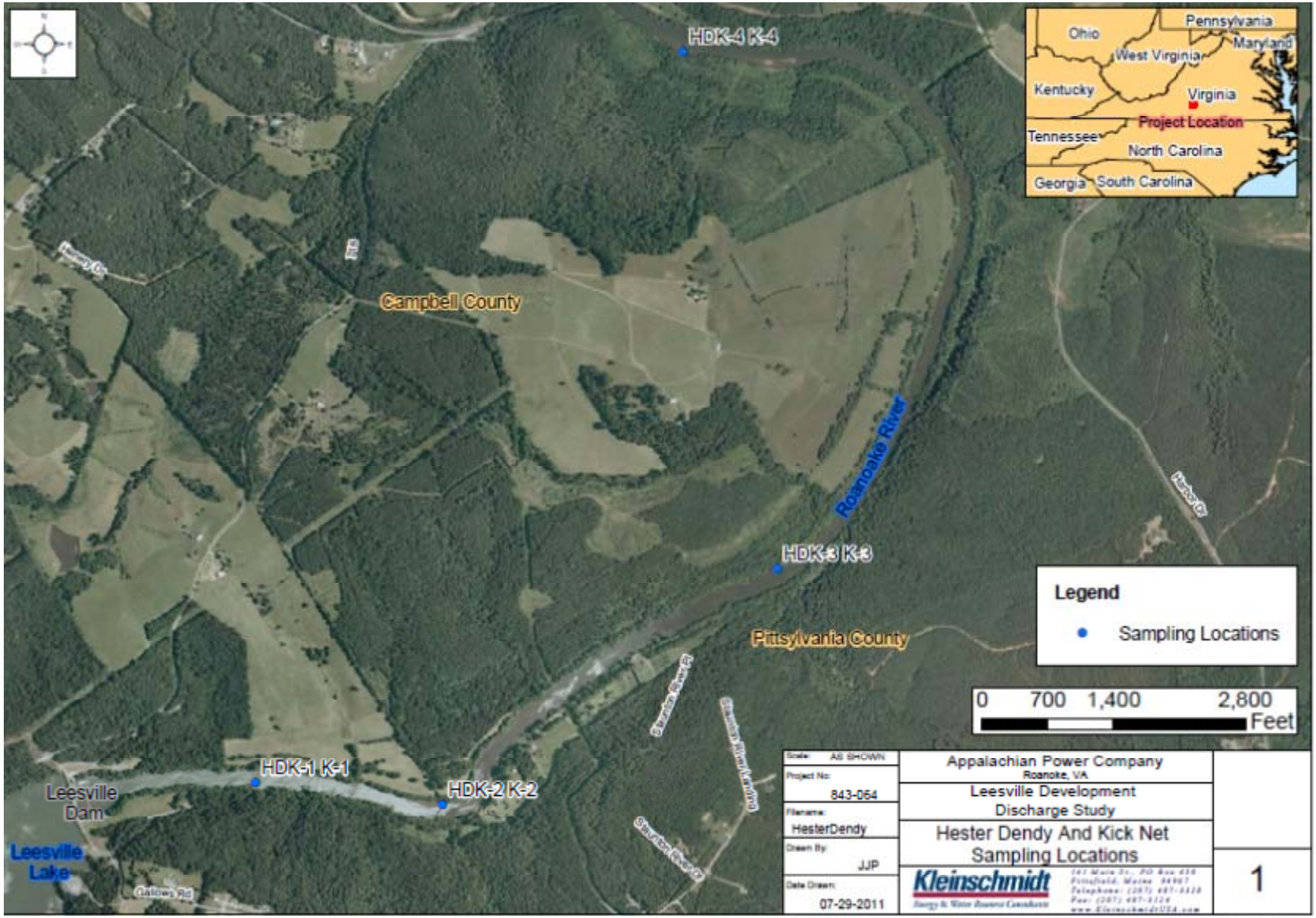


FIGURE 2-10. SAMPLING LOCATIONS FOR HESTER-DENDY AND KICK NETS.

KICK NET SAMPLES

Kick net samples were collected using a bottom aquatic kick net which was rectangular in shape and had a stainless steel frame with a 500 micron mesh net with an opening of 10” x 18”. Within each location, five areas were disturbed by kicking bottom sediment from upstream to down towards the collection net. Once the sediment cleared the area and the water was clear of any suspended sediment or organisms the net was removed from the water. All sediment was sieved through a 500 micron sieve and all organisms were preserved using 70% ethanol. All organisms were sent to the lab for sorting and identification and the Index of Biotic Integrity (IBI) was calculated using EPA’s 1999 Rapid Bioassessment Protocols (RBP). Seven metrics were utilized to characterize the biological integrity of the benthic habitat sampled.

On July 13, 2011, kick net samples were performed at the four selected locations. A total of 829 organisms were collected at the four locations. *Cheumatopsyche* was the most abundant species at all locations. Table 2-4 shows the type and number of organisms collected, for each kick net, at each location as well as the IBI indices for each location.

TABLE 2-4. BENTHIC MACROINVERTEBRATE DATA (NUMBERS PER KICK SAMPLE AND IBI INDICES) COLLECTED ON THE ROANOKE RIVER IN LEESVILLE, VIRGINIA ON JULY 13, 2011.

TAXON	TOLERANCE VALUE[2]	FUNCTIONAL FEEDING CATEGORY[3]	NO. COLLECTED IN SAMPLE[1]								ALL SAMPLES	
			SAMPLE NO. K-1		SAMPLE NO. K-2		SAMPLE NO. K-3		SAMPLE NO. K-4		MEAN	
			NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT
Coleoptera												
Dineutus	4	PR							2	1.0	0.5	0.2
Dubiraphia	6	SC							4	2.1	1.0	0.5
Hydroporus	4	PR							1	0.5	0.3	0.1
Optioservus	4	SC					2	0.9			0.5	0.2
Diptera												
Antocha	3	CG	2	1.1	2	0.9	2	0.9			1.5	0.7
Chironomidae	6	CG	40	21.1	69	32.4	32	13.8	19	9.8	40.0	19.3
Dasyhelea	6	CG							3	1.5	0.8	0.4
Hemerodromia	6	PR					2	0.9	3	1.5	1.3	0.6
Simulium	6	FC			38	17.8	72	31.0	4	2.1	28.5	13.8
Tipula	4	SH					1	0.4			0.3	0.1
Ephemeroptera												
Baetis	6	CG					2	0.9	2	1.0	1.0	0.5
Ephemerella	1	CG			1	0.5					0.3	0.1
Maccaffertium	3	SC							3	1.5	0.8	0.4
Tricorythodes	4	CG			2	0.9	2	0.9	5	2.6	2.3	1.1
Hydracarina	7	PR	32	16.8	12	5.6			2	1.0	11.5	5.5
Megaloptera												
Nigronia	2	PR							1	0.5	0.3	0.1
Mollusca												
Corbicula	4	FC	1	0.5	1	0.5	1	0.4	11	5.7	3.5	1.7
Ferrissia	7	SC							1	0.5	0.3	0.1
Helisoma	6	SC	1	0.5							0.3	0.1
Leptoxis	7	SC	21	11.1	6	2.8	27	11.6	74	38.1	32.0	15.4
Musculium	8	FC	9	4.7	1	0.5					2.5	1.2
Physa	8	SC	1	0.5	4	1.9			6	3.1	2.8	1.3
Pisidium	8	FC	2	1.1							0.5	0.2
Nematoda	9	CG	2	1.1							0.5	0.2
Nemertea												
Prostoma	6	PR							1	0.5	0.3	0.1
Odonata												
Gomphus	5	PR	1	0.5					2	1.0	0.8	0.4
Oligochaeta												
Naididae	10	CG							1	0.5	0.3	0.1
Tubificidae	7	CG	2	1.1	4	1.9			3	1.5	2.3	1.1

TABLE 2-4. ***(CONTINUED)***

TAXON	TOLERANCE VALUE[2]	FUNCTIONAL FEEDING CATEGORY[3]	NO. COLLECTED IN SAMPLE[1]								ALL SAMPLES	
			SAMPLE NO. K-1		SAMPLE NO. K-2		SAMPLE NO. K-3		SAMPLE NO. K-4		MEAN	
			NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT
Trichoptera												
Ceratopsyche	5	FC					2	0.9			0.5	0.2
Cheumatopsyche	6	FC	45	23.7	59	27.7	60	25.9	14	7.2	44.5	21.5
Helicopsyche	3	SC					2	0.9			0.5	0.2
Hydropsyche	5	FC							1	0.5	0.3	0.1
Hydroptila	6	SC	20	10.5	5	2.3	2	0.9	3	1.5	7.5	3.6
Lepidostoma	1	SH					1	0.4			0.3	0.1
Micrasema	2	SH							1	0.5	0.3	0.1
Mystacides	4	CG							2	1.0	0.5	0.2
Neophylax	3	SC					2	0.9	2	1.0	1.0	0.5
Oecetis	8	PR	4	2.1			2	0.9	6	3.1	3.0	1.4
Protoptila	1	SC					1	0.4	1	0.5	0.5	0.2
Psychomyia	2	CG			2	0.9			8	4.1	2.5	1.2
Triaenodes	6	SH							2	1.0	0.5	0.2
Turbellaria												
Dugesia	9	PR	7	3.7	7	3.3	17	7.3	6	3.1	9.3	4.5
TOTAL NUMBER			**190**	**100.0**	**213**	**100.0**	**232**	**100.0**	**194**	**100.0**	**207.3**	**100.0**
METRICS												
Taxonomic Richness			16		15		19		31		42	
Shannon Diversity, base			1.68		0.81		1.75		1.32		1.54	
Modified Hilsenhoff Biotic Index			6.6		6.1		6.2		6.1		6.2	
EPT Index			3		5		10		13		17	
Percent Ephemeroptera			0.0		1.4		1.7		5.2		2.1	
Percent Dominant Taxon			23.7		32.4		31.0		38.1		21.5	
(Identity)			*(Cheumatopsyche)*		*(Chironomidae)*		*(Simulium)*		*(Leptoxis)*		*(Cheumatopsyche)*	
Percent Chironomidae			21.1		32.4		13.8		9.8		19.3	

[1] 200 organism subsample sorted from a kick net sample collected at each location.

[2] Modified Hilsenhoff Biotic Index. Source is the Pennsylvania Department of Environmental Protection.

[3] PR=Predator; CG=Collector/Gatherer; FC=Filterer/Collector; SC=Scraper; SH=Shredder. Source is the Pennsylvania Department of Environmental Protection.

HESTER-DENDY SAMPLES

Hester-Dendy sample plates were deployed at four locations along the Roanoke River below the Leesville Dam (Figure 2-10) on July 13, 2011. Three duplicate round Hester-Dendy plate samplers were deployed at each location. Each sampler consist of fourteen 7.5 cm diameter hardboard plates, spaced by eight single spacers, one double spacer, two triple spacers, and two quadruple spacers.

Samplers were deployed for 34 days and when retrieved at the end of the sampling period, were placed into a 5-gallon bucket. Each of the fourteen plates was then removed and scraped using a small plastic scraper. All contents from the three samplers at a given location were combined. All contents within the 5-gallon bucket were then sieved through a 500 micron sieve and preserved in 70% ethanol for laboratory sorting and identification. The Index of Biotic Integrity (IBI) was calculated using EPA's 1999 Rapid Bioassessment Protocols (RBP). Seven metrics were utilized to characterize the biological integrity of the benthic habitat sampled.

A total of 886 organisms were collected and identified from the four locations. The dominant taxon was *Cheumatopsyche* at three of the four locations and *Leptoxis carinata* was the dominant taxon at the fourth. Total number of organisms collected per location and IBI indices can be found in Table 2-5.

TABLE 2-5. BENTHIC MACROINVERTEBRATE DATA (NUMBERS PER HESTER-DENDY SAMPLE AND IBI INDICES) COLLECTED ON THE ROANOKE RIVER IN LEESVILLE, VIRGINIA FROM JULY 13 THROUGH AUGUST 16, 2011.

TAXON	TOLERANCE VALUE[2]	FUNCTIONAL FEEDING CATEGORY[3]	NO. COLLECTED IN SAMPLE[1]								ALL SAMPLES	
			SAMPLE NO. HDK-1		SAMPLE NO. HDK-2		SAMPLE NO. HDK-3		SAMPLE NO. HDK-4		MEAN	
			NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT
Coleoptera												
Dineutus	4	PR					1	0.4			0.3	0.1
Macronychus	2	SC					3	1.3	2	1.0	1.3	0.6
Diptera												
Antocha	3	CG			1	0.4					0.3	0.1
Chironomidae	6	CG	14	6.6	30	12.6	9	3.8	19	9.8	18.0	8.1
Simulium	6	FC			1	0.4	4	1.7	2	1.0	1.8	0.8
Ephemeroptera												
Baetis	6	CG					7	2.9	1	0.5	2.0	0.9
Isonychia	3	CG							11	5.7	2.8	1.2
Maccaffertium	3	SC					3	1.3	9	4.6	3.0	1.4
Tricorythodes	4	CG			2	0.8			6	3.1	2.0	0.9
Megaloptera												
Corydalus	4	PR							2	1.0	0.5	0.2
Nigronia	2	PR							1	0.5	0.3	0.1
Mollusca												
Leptoxis carinata	7	SC	6	2.8			20	8.3	108	55.7	33.5	15.1
Physa	8	SC	1	0.5							0.3	0.1
Odonata												
Argia	6	PR							1	0.5	0.3	0.1
Oligochaeta												
Naididae	10	CG							1	0.5	0.3	0.1
Plecoptera												
Acroneuria	0	PR							1	0.5	0.3	0.1
Trichoptera												
Brachycentrus	1	FC							2	1.0	0.5	0.2
Cheumatopsyche	6	FC	144	67.6	204	85.4	180	75.0	7	3.6	133.8	60.4
Hydropsyche	5	FC					3	1.3	12	6.2	3.8	1.7
Lepidostoma	1	SH							1	0.5	0.3	0.1
Micrasema	2	SH					9	3.8	2	1.0	2.8	1.2
Oecetis	8	PR	3	1.4			1	0.4	4	2.1	2.0	0.9
Psychomyia	2	CG			1	0.4					0.3	0.1
Turbellaria												
Dugesia	9	PR	45	21.1					2	1.0	11.8	5.3
TOTAL NUMBER			**213**	**100.0**	**239**	**100.0**	**240**	**100.0**	**194**	**100.0**	**221.5**	**100.0**

TABLE 2-5. ***(CONTINUED)***

TAXON	TOLERANCE VALUE[2]	FUNCTIONAL FEEDING CATEGORY[3]	NO. COLLECTED IN SAMPLE[1]								ALL SAMPLES	
			SAMPLE NO. HDK-1		SAMPLE NO. HDK-2		SAMPLE NO. HDK-3		SAMPLE NO. HDK-4		MEAN	
			NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT
METRICS												
Taxonomic Richness			6		6		11		20		24	
Shannon Diversity, base			0.96		0.50		1.05		1.78		1.48	
Modified Hilsenhoff Biotic Index			6.7		6.0		5.8		6.0		6.1	
EPT Index			2		3		6		11		12	
Percent Ephemeroptera			0.0		0.8		4.2		13.9		4.4	
Percent Dominant Taxon			67.6		85.4		75.0		55.7		60.4	
(Identity)			*(Cheumatopsyche)*		*(Cheumatopsyche)*		*(Cheumatopsyche)*		*(Leptoxis carinata)*		*(Cheumatopsyche)*	
Percent Chironomidae			6.6		12.6		3.8		9.8		8.1	

[1] 200 organism subsample sorted from a Hester-Dendy sample collected at each location.

[2] Modified Hilsenhoff Biotic Index. Source is the Pennsylvania Department of Environmental Protection.

[3] PR=Predator; CG=Collector/Gatherer; FC=Filterer/Collector; SC=Scraper; SH=Shredder. Source is the Pennsylvania Department of Environmental Protection.

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2.5 TASK 5 – EVALUATE EROSION POTENTIAL AND SEDIMENT INPUTS RESULTING FROM HOURLY AUTOCYCLE AS COMPARED TO CONTINUOUS FLOW RELEASES

Understanding the behavior of complex systems such as the Roanoke River and using this understanding to achieve balance between multiple stakeholder demands is a challenging undertaking. Developing numerical models of the existing system and using these models to forecast the effects of different discharge regimes is an important tool for decision-making and impact assessment. As such, a 2-D numerical model to simulate flow characteristics under the existing autocycling and the proposed continuous discharge scenarios was developed and the results are included in Attachment E.

A two-dimensional hydrodynamic model was used to simulate steady and unsteady flow conditions in the Roanoke River from the Leesville Dam to the junction with Goose Creek. The model was calibrated to recorded water level and discharge conditions at the various locations on the river for the existing hourly autocycling conditions. It was found that autocycling increases

the fluctuation in water levels, current speeds, and bed shear stress compared to the continuous release scenario. The previously implemented 2-hour autocycling scenario is shown to have more influence on water levels, local discharge, current speeds, and erosion potential than the current hourly autocycling scenario.

Based on model results, it can be concluded that there is an increase in erosion potential under autocycling conditions compared to continuous release. However, this does not indicate an increase in current erosion rates, nor does it conclude that the stream bank is in fact actively eroding at an increased rate due to operations. Erosion is a natural process that occurs on all rivers and is dependent on many processes such as stream flow along with the physical properties and structural arrangement of the sediment.

The increase in erosion potential is most evident near the dam and diminishes in the downstream direction with the impact being relatively minor at distances greater than about 1.3 mi downstream of the dam. The size of bed material that can be mobilized decreases while moving downstream, due to attenuating velocities. Autocycling has created a scour area just downstream of the dam where cobble and gravel is exposed. This scour area is no longer observed nor predicted to be seen 1.3 mi downstream from the dam based on model results.

No signs of active bank erosion were observed during the 2011 field survey of the study area. This supports the conclusion that the channel has adjusted to the altered flow regime and bank erosion is not a source of major sediment input downstream from Leesville Dam. In fact, the dam in combination with autocycling operations may be allowing for maintenance of relatively sediment free substrate in the reach immediately downstream from the dam than would be seen under a continuous release scenario. There are two components that work toward this condition. First, the increased velocity from the peak discharge is able to keep the gravel-cobble substrate exposed in the study area by mobilizing fine sediments. Second, the dam and impoundment itself serve to trap sediment in the upstream section of the river thereby limiting the supply of sediment in the study area.

Bank pins were installed along the river banks as part of this study. The intent of these installations was to provide a mechanism for quantifying erosion raters over a given time period.

It would also potentially allow an estimate of the sediment originating from the river banks to be calculated. Therefore, subsequent measurements of these pins will allow for estimation of the rate at which the river banks may be eroding. This would also serve as analytical testing of our contention that the banks are stable in this reach and they are not a significant source of sediment.

This area of clean substrate and stable channel morphology downstream from the dam leads to the conclusion that the source of sediment causing potential sedimentation and habitat disruption issues further downstream is due to other sources such as tributary inputs (e.g. Goose Creek) and/or surrounding land use practices. Further study would be required to fully understand the sediment sourcing throughout the region in order to mitigate any hotspots of sediment supply to this system.

2.5.1 HYDROGRAPHIC SURVEY

As bathymetric data was unavailable, a hydrographic survey of the Roanoke River and Goose Creek was conducted. The purpose of this survey was to collect cross section elevation data of the channel bottom. The survey was conducted using both a handheld depth finder as well as an Acoustic Doppler Current Profiler (ADCP). The handheld depth measurements were taken from a canoe and each had a GPS coordinate associated with it. The ADCP data was collected using a Teledyne RD Instruments StreamPro and provided water depth data in addition to discharge and velocity data. Cross section surveys were conducted at each water level logger location to support hydraulic analyses and modeling. The cross section data will be merged with topographic data using GIS in order to represent the channel bathymetry in the study area. Figure 2-11 shows the locations of surveyed cross sections.

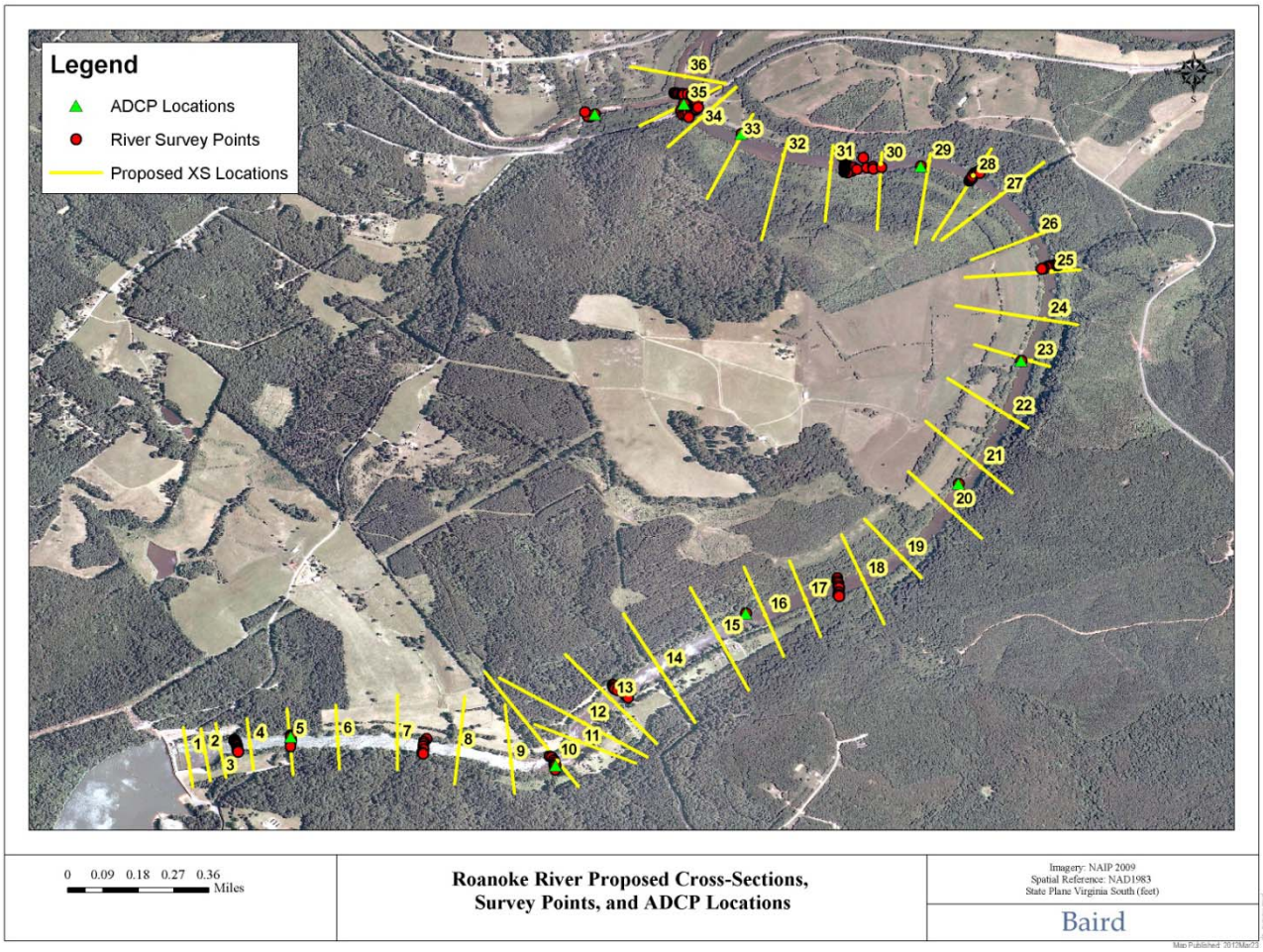

FIGURE 2-11. ROANOKE RIVER HYDROGRAPHIC SURVEY.

2.5.2 DISCHARGE DATA

Discharge measurements were taken using the Teledyne RD Instruments StreamPro ADCP. An ADCP instrument was used in order to collect both discharge and velocity data throughout the water column. ADCP data was collected at locations where water level recorders were deployed and where additional cross section elevation data was needed. Following the manufacturer's recommendation, ADCP data were collected at each cross section until there were four measurements within 5% error of each other. These data will be used for calibration of the 2D river model, to develop stage/discharge relationships at each data logger location, and to provide support for feasibility testing of vegetative measures to enhance bank stabilization. Figure 2-11 shows the locations discharge measurements were taken.

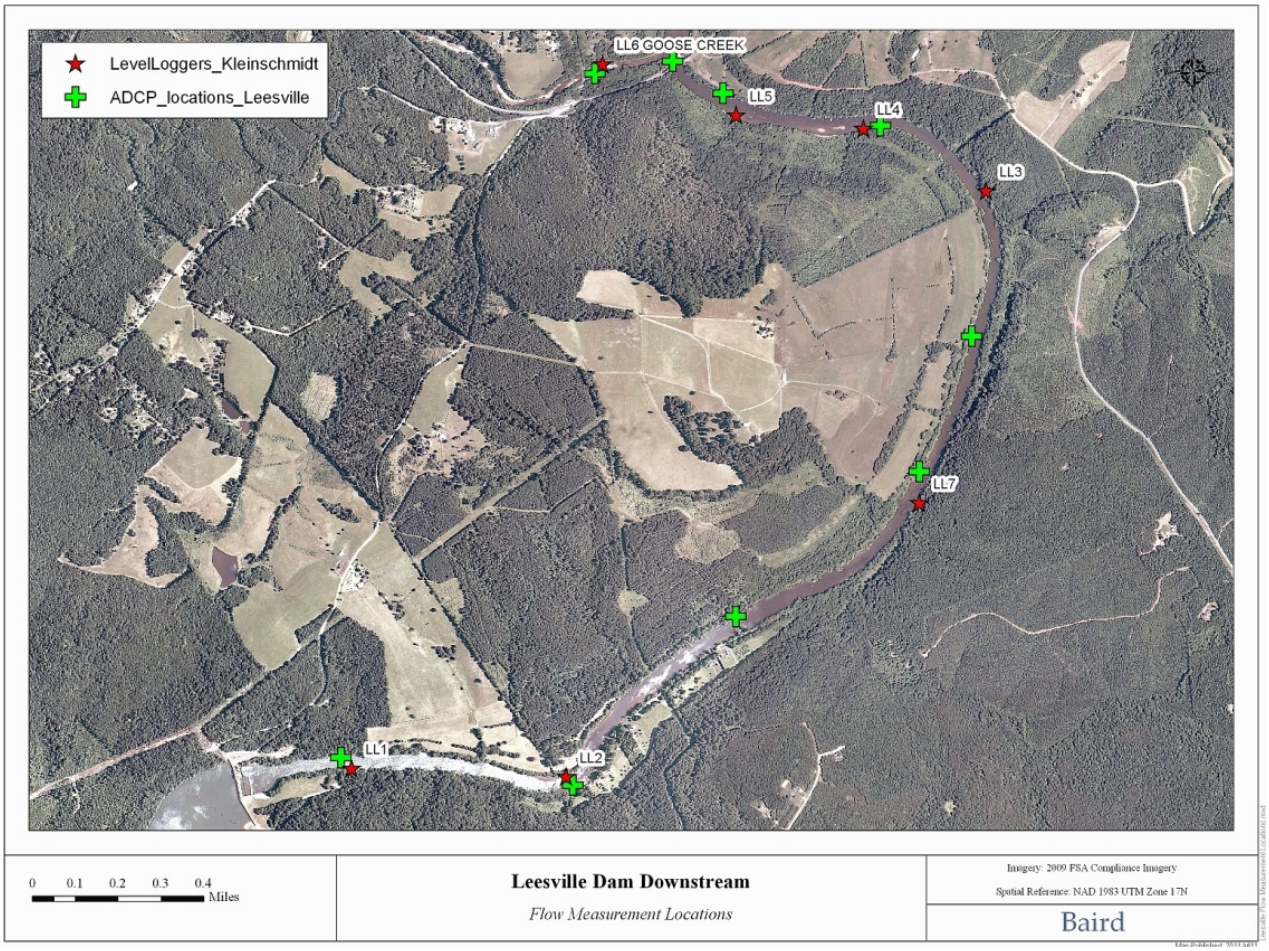

FIGURE 2-12. LOCATION OF LEVEL LOGGERS AND ADCP MEASUREMENTS.

2.5.3 WATER LEVEL LOGGERS

Water level loggers were deployed in early June of 2011 to accurately determine the magnitude of water level changes, as well as rates of rise and fall, occurring downstream of Leesville Dam as a result of hourly autocycling operations. The level loggers were set to record barometric pressure and water depth every five to fifteen minutes. Figure 2-12 shows the locations level loggers were deployed.

As the normal target flows downstream of Leesville vary by month and include flow from the watershed, the hourly autocycle will also vary. Therefore, the data must be collected over the range of normal expected operation. Due to the dynamic nature of autocycling, the data will not be definitively correlated to a given flow at an exact point in time, but it will be highly representative of what is occurring.

2.5.4 EROSION PIN INSTALLATION

Erosion pins were installed along the Roanoke River to monitor erosion rates occurring on the banks downstream of the dam in order to evaluate erosion potential and sediment inputs resulting from hourly autocycling as compared to continuous flow releases. The erosion pins were installed along the Roanoke River in the second week of June 2011. The lengths of the pins sticking out of the ground and the distance from water surface were measured as a reference point upon installation. Installation of the pins allows them to be revisited and measured to further characterize bank erosion. A total of 130 pins were installed to accurately represent the channel and provide redundancies in case pins are lost or stolen. Figure 2-13 shows the locations where erosion pins were installed. An additional 100 pins were installed between Goose Creek and Altavista during August 2014.

FIGURE 2-13. EROSION PIN LOCATIONS.

2.6 TASK 6 – DETERMINE EFFECTS OF AUTOCYCLING ON DISSOLVED OXYGEN LEVELS

2.6.1 DISSOLVED OXYGEN MONITORING

During 2011, water quality parameters were only monitored in association with aquatic community sampling. During 2012, however, water quality data was collected mid-July through mid-September. Water quality was monitored in the forebay, in the discharge, and at a downstream location just upstream of Goose Creek to determine the effect of autocycling on dissolved oxygen levels. The complete water quality monitoring report is provided as Attachment F.

A continuous data monitor was deployed just upstream of the Goose Creek confluence. Data was collected at 10-minute intervals using a stationary monitor during a 2-month period from mid July through mid September. The frequent data collection was used to ensure that data was representative of the full range of autocycling conditions during summer months when DO issues typically occur. Additional water quality data was collected in the forebay (profile data) and in the Project discharge on a weekly basis to complement the data collected downstream. Data was analyzed to determine if state water quality standards were being achieved on a consistent basis through hourly autocycling. Dissolved oxygen standards consist of achieving 4 mg/l on an instantaneous basis and 5 mg/l as a daily average.

Profile data was collected in the Leesville Dam forebay on ten occasions. Data was collected at 1-m intervals for DO, temperature, and pH. Surface values ranged from 5.15 to 9.8 mg/L DO, 23.17 to 28.95°C, and 6.3 to 7.98 pH. Summary statistics for each sampling event are presented in Table 2-6 for each constituent. Results demonstrated that the Leesville Dam Forebay exhibited chemical stratification for DO and thermal stratification during the sampling period. However, the Forebay was relatively isothermal by September 19, 2012 suggesting that fall turnover began around that time.

Ten profiles were also collected in the Leesville Dam Tailrace at 1-m intervals for DO, temperature, and pH. Surface values ranged from 3.9 to 6.9 mg/L DO, 22.79 to 25.41°C, and 5.9 to 7.3 pH. Summary statistics for each sampling event are presented in Table 2-7 for each constituent. The Leesville Dam Tailrace did not exhibit stratification for DO, temperature, or pH

for all but one of the sampling events. Chemical stratification for DO was observed during the September 12, 2012 event when the Project turbines were not operating and spill was occurring. Likewise, a minor thermal stratification was also observed during that sampling event. During the September 12, 2012 event when Project operations were shut down, DO concentrations in the bottom half of the water body dropped to below 2 mg/L due to the fact that this area was isolated from the spillway and did not receive flowing water. While the Project was operating, DO was generally greater than 4 mg/L at all depths except for six individual DO readings. These readings represented a portion of the water column on September 6, 2012 (5 of 11 readings) and September 19, 2012 (1 of 10 readings).

Continuous DO and temperature data were collected at the downstream location from July 17 through September 19, 2012. Additionally, continuous pH data was collected beginning August 14, 2012. Summary statistics of instantaneous data are presented in Table 2-8 and daily average data is summarized in Table 2-9. The large majority of DO data is above the minimum with 1.8% of instantaneous DO values below the minimum value of 4 mg/L. All pH values were within the range of VDEQ standards of 6.0-9.0. No temperature values exceeded the maximum of 31°C. With the exception of four days in August, the minimum daily average DO criterion of 5 mg/l was achieved.

The continuous data shows clear diurnal fluctuations for DO, temperature, and pH and would be expected for this type of system. All three constituents vary together, with the highest values peaking after midday and the lowest values occurring during the night. The diurnal pattern also continued for all three constituents during the period when the project turbines were non-operational (i.e., water was released through spill) on September 12th and 13th. The daytime DO values were somewhat higher during the non-operational time, while the nighttime DO values were similar to those observed during operations. There did not appear to be any substantial difference in temperature or pH during the period when the project was non-operational.

TABLE 2-6. FOREBAY SUMMARY STATISTICS BY EVENT.

EVENT	TEMPERATURE			DISSOLVED OXYGEN			pH		
	MIN	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX	MEAN
7/17/2012	19.79	27.89	23.34	0.42	9.08	4.70	6.68	7.27	7.05
7/24/2012	20.06	27.69	23.47	0.18	8.92	3.45	7.15	8.20	7.51
8/01/2012	20.62	28.43	24.49	0.92	8.75	5.18	6.30	7.27	7.06
8/06/2012	20.30	28.65	24.19	0.35	9.03	4.06	7.22	8.54	7.65
8/14/2012	21.33	28.95	25.02	0.35	9.95	4.28	7.03	8.28	7.42
8/21/2012	21.84	26.12	23.91	0.11	8.48	3.70	7.09	8.17	7.58
8/30/2012	22.01	28.43	24.28	0.96	8.91	3.60	6.89	8.41	7.48
9/06/2012	22.06	26.75	23.63	0.54	7.11	2.48	7.08	8.11	7.44
9/12/2012	21.98	26.85	23.54	0.22	7.65	2.65	7.08	7.87	7.41
9/19/2012	21.81	23.17	22.58	0.19	5.16	3.61	6.99	7.30	7.17
ALL	19.79	28.95	23.85	0.11	9.95	3.77	6.30	8.54	7.38

TABLE 2-7. TAILRACE SUMMARY STATISTICS BY EVENT.

EVENT	TEMPERATURE			DISSOLVED OXYGEN			pH		
	MIN	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX	MEAN
7/17/2012	23.41	23.76	23.63	5.47	6.85	5.96	6.44	6.65	6.56
7/24/2012	24.10	24.95	24.24	4.64	5.81	5.01	6.53	7.18	6.92
8/01/2012	24.29	24.45	24.40	5.16	6.20	5.41	6.90	7.18	7.07
8/06/2012	24.73	24.95	24.83	5.01	6.22	5.39	6.20	7.17	6.83
8/14/2012	25.27	25.45	25.38	5.16	6.94	5.49	5.91	6.78	6.58
8/21/2012	24.02	24.34	24.17	4.44	5.44	4.80	6.92	7.16	7.07
8/30/2012	23.92	24.27	24.07	4.55	5.60	5.03	7.03	7.19	7.14
9/06/2012	23.67	24.01	23.83	3.41	4.60	3.97	6.99	7.15	7.10
9/12/2012	23.14	23.96	23.48	1.45	6.92	3.71	7.15	7.38	7.26
9/19/2012	22.63	22.82	22.72	3.91	4.44	4.20	7.22	7.26	7.23
ALL	22.63	25.45	24.08	1.45	6.94	4.90	5.91	7.38	6.97

TABLE 2-8. DOWNSTREAM LOCATION WEEKLY SUMMARY STATISTICS.

WEEK OF:	TEMPERATURE			DISSOLVED OXYGEN			pH		
	MIN	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX	MEAN
07/17/12	22.58	26.60	24.21	5.1	8.0	6.4	-	-	-
07/23/12	23.06	26.42	24.39	3.4	7.1	5.3	-	-	-
07/30/12	23.24	26.92	24.76	4.0	7.9	5.7	-	-	-
08/06/12	23.96	26.68	25.18	4.6	7.6	5.8	-	-	-
08/13/12	23.34	26.97	24.78	3.7	7.3	5.3	7.51	8.03	7.69
08/20/12	22.63	25.82	24.03	3.6	7.3	5.2	7.09	7.90	7.33
08/27/12	22.89	25.90	24.28	4.4	7.3	5.6	7.17	7.67	7.41
09/03/12	22.67	25.68	24.18	4.3	7.4	5.5	7.19	7.75	7.41
09/10/12	21.37	24.99	22.89	4.6	9.3	6.1	7.24	7.96	7.44
09/17/12	21.82	23.25	22.61	4.6	7.3	5.8	7.30	7.62	7.42
ALL	21.37	26.97	24.13	3.37	9.33	5.67	7.09	8.03	7.45

TABLE 2-9. DOWNSTREAM LOCATION SUMMARY STATISTICS FOR DAILY AVERAGES.

WEEK OF:	DAILY AVERAGE DISSOLVED OXYGEN		
	MIN	MAX	MEAN
07/17/12	6.1	6.9	6.5
07/23/12	5.0	6.0	5.4
07/30/12	5.2	6.0	5.7
08/06/12	5.8	5.9	5.8
08/13/12	4.4	5.7	5.3
08/20/12	4.7	5.8	5.2
08/27/12	5.4	5.8	5.6
09/03/12	5.2	5.7	5.5
09/10/12	5.5	6.8	6.1
09/17/12	5.6	5.9	5.8

Additionally, a withdrawal zone model, based on forebay temperature profiles and discharge temperatures was developed. The original intent of the model was to establish a tool that can provide insights on the differences in withdrawal zone as it relates to discharge rate should chronic non-compliance events be documented. While chronic non-compliance events were not documented, the model can be used to assess potential differences in DO should operational conditions that affect the withdrawal zone be considered.

2.7 TASK 7 – EVALUATE THE EFFECTIVENESS OF RE-VEGETATING SHORELINES AS A BANK STABILIZATION MEASURE AT SELECTED ACTIVE EROSION SITES DOWNSTREAM OF LEESVILLE DAM

The purpose of this task is to identify potential measures for bank stabilization and locations with project stakeholders where demonstration projects could be developed. The results of that effort are provided in Attachment G.

Hydropower operations can be a direct or indirect cause of river bank erosion, as their operation reduces sediment supply and changes water flow regimes. Water level fluctuations may lead to bank erosion in both natural and altered flow regimes making it is necessary to investigate the erosion mechanisms taking place in order to determine the relative roles of the hydropower project influences versus natural erosion. Additionally, it is important to determine which methods can be appropriately used to mitigate erosion along the river reach immediately downstream of the hydropower project. While it is important to protect the streambanks, it is also important to maintain the natural integrity of the project area, as the river is an important recreational and ecological asset to the community. Attachment G presents findings of erosion observations in the study area, along with potential streambank stabilization approaches that may be employed to mitigate bank erosion issues.

2.8 TASK 8 – CONDUCT A FEASIBILITY EVALUATION ON THE ABILITY TO ADD A MINIMUM FLOW UNIT TO LEESVILLE DAM

2.8.1 INTRODUCTION

Two potential configurations for a new minimum flow unit at the Leesville development, the estimated change in electricity generation and an opinion of construction costs for each configuration were investigated. A detailed report is provided in Attachment H. The Leesville development is a traditional hydroelectric project but Leesville Dam also impounds the lower reservoir of the Smith Mountain Hydroelectric Project. Therefore, water levels in Leesville Lake fluctuate by 13 feet on a routine basis and with the exception of high flow conditions; most of the discharge from Leesville is geared towards meeting minimum flow requirements for ecological and recreational purposes. Minimum flow requirements, which vary by month and by hydrologic conditions, are achieved by pulsing (autocycling) the two existing turbine units. The existing units are not capable of continuous operation at the relatively low discharge volumes

associated with the minimum flow requirements. Therefore, autocycling each hour is conducted such that the minimum flow requirement is achieved on an average hourly basis.

The implementation of hourly autocycle operations was initiated in December of 2009. Prior to that time, minimum flow requirements were achieved using a 2-hour autocycle. The change in operations was implemented in order to mitigate the magnitude of pulsed releases for environmental and recreational benefits. A typical 2-hour autocycle consisted of operating the units for approximately 18 to 20 minutes every other hour. Compared to hourly autocycling, the development discharged twice as long during each pulse. Subsequently, the non-discharge time was decreased from approximately 100 minutes to 50 minutes under the hourly autocycle operational plan. As a result of these changes, the magnitude of water level fluctuations are substantially reduced (i.e., the highest water levels are reduced and the lowest water levels are increased) while achieving a given minimum flow. Additionally, the variation in water levels due to autocycling is attenuated over a much shorter distance.

2.8.2 METHODS AND RESULTS

After a review of existing information and the confirmation of existing site hydrology and operational records, two conceptual level minimum flow configurations were developed. The first is a vertical Kaplan turbine located in a new powerhouse fed by a new penstock connecting to an intake structure on the dam. The second is a vertical Kaplan of the same size as the first configuration in place of one of the existing turbine units. The Kaplan units considered for this feasibility study have the ability to operate at discharge levels from 350 to 1200 cfs and eliminate the majority of the need to autocycle the large units (or the remaining unit in the second configuration).

Energy models were completed for both minimum flow configurations to estimate their impact on the Leesville Development's annual energy production. These energy models work to capture the effects of the change in the physical arrangement, performance, and the operational regime for the new continuous discharge units. The opinions of construction cost for both configurations then provide comparative costs that together with the change in energy production allows for evaluation of the minimum flow configurations.

Average daily flows were analyzed to create a flow duration curve. This flow duration curve revealed that one of the existing units with 4500 cfs capacity would be able to pass the entire river flow 98% of the time. The ability of one of the existing units to pass the required flow for such a large percentage of the time is why the configuration of replacing one of the large units was explored in this feasibility study. This flow duration curve also assisted in sizing the minimum flow unit. Additionally, a net head curve was created from historical data for use in the energy model.

In order to be effective, the minimum flow configurations explored needed to be able to pass a wide range of flows in order to eliminate as much autocycling as possible. The site has approximately 70 ft of net head and generally experiences flows between 350 cfs and 4500 cfs. A minimum flow unit that could cover a broad range of flows near the low end of the river flow was selected to effectively reduce the number of days where one large unit is run in an hourly autocycle. A Vertical Kaplan minimum flow unit was selected to pass between 350 cfs and 1200 cfs. The daily flows are below 350 cfs only 5% of the time and above 1200 cfs 31% of the time. This translates into the minimum flow unit being able to pass all river flow 64% of the time. The ability to pass nearly all of the lower flows will mean that the minimum flow unit is able to run near continuously. During periods of higher flow above the minimum flow unit's range the development could be operated in an hourly autocycle mode to pass only the flow above the minimum flow unit's range or all of the flow with the minimum flow unit shut down. The selected minimum flow unit will also have the effect of reducing the apparent river fluctuations as the autocycle releases will occur only during periods of relatively high flow.

As shown in the conceptual drawings in Attachment H, the two minimum flow unit configurations considered are:

1. A new Kaplan unit in a new powerhouse downstream of the dam and existing powerhouse fed by a penstock from a new intake structure in the dam (shown on Drawings 1 through 3).
2. A new Kaplan unit in place of one of the existing large units (shown on Drawing 4).

Configuration 1 has the advantage of increasing the plant's capacity and number of units, thereby increasing unit availability. This increase in capacity is not required by the plant as one of the large units currently in operation is able to pass the average daily flow 98% of the time.

Configuration 1 is expensive as compared to Configuration 2 due to the need for a new intake structure, penstock, powerhouse, and tailrace.

Configuration 2 has the advantage of lower construction cost by using the existing water conveyance structures for one of the units and not requiring an additional powerhouse or tailrace. However, the loss of one of the large units may create a small loss in the plant availability if the remaining large unit experienced a forced outage during a high flow period. Also, using the existing water passage for a new unit may decrease the efficiency of the new unit because the approach flow is not as well controlled as in a new station with a water passage built for the smaller unit.

Based on the plant data collected and the new conceptual configurations an energy model was developed. During the autocycling operation the current units run at maximum efficiency during operation. This leads to high overall plant efficiency. The minimum flow units would follow the average daily flow and therefore often operate at efficiencies lower than the existing units. Also, due to the high capacity of the plant, spilling water in excess of plant capacity currently occurs on a very infrequent basis. This means that very little energy is available for recovery from the additional generating capacity provided by a minimum flow unit in Configuration 1. In Configuration 2, powerhouse capacity would be reduced. Due to this reduced capacity spilling flow would occur more often than in existing conditions or with Configuration 1. A combination of these factors causes both of the minimum flow configurations to result in a net loss of energy. The decreased predicted annual energy output in shown in Table 2-10 below.

TABLE 2-10. ENERGY MODEL RESULTS.

ANNUAL GENERATION (MWH)	PRESENT ARRANGEMENT	NEW POWERHOUSE	REPLACE EXISTING UNIT
Modeled	47,136	45,260	46,636
Decrease vs. Present		310	109
Percent Decrease vs. Present		.66%	.23%

A more detailed summary of the energy model results that includes monthly energy comparisons is included in Attachment H.

Both minimum flow unit configurations offer unique construction challenges. Configuration 1 requires a section be cut in the dam. As such a large cofferdam attached to the front of the dam would be required. Additionally, it would be critical that the design of the intake does not interfere with the function of the rock anchors currently in place at the dam. A conceptual design includes a new FRP penstock that runs underneath the access road to the new powerhouse and is provided in Attachment H. These challenges on top of the normal challenges of complex hydroelectric facility construction that include increased design and permitting costs would make the new powerhouse configuration carry a large cost risk.

Configuration 2, the new minimum flow unit in place of one of the existing larger units would make the construction process considerably shorter but would have its own challenges of integrating a new unit into the old water passage. Concrete and steel modifications would be made to the generator deck, head cover area, and stay ring area to accommodate the new, smaller unit and its associated distributor.

The opinion of probable construction cost for each configuration is shown in Table 2-11 below. The costs for the hydroelectric equipment were taken from recent projects of similar size and configuration on a price per power output basis. The opinion of probable cost worksheets are included as Attachment H.

TABLE 2-11. OPINION OF PROBABLE COST.

CONFIGURATION	DESCRIPTION	OPINION OF PROBABLE COST
Configuration 1	New powerhouse with new Kaplan Turbine	$19,848,000
Configuration 2	New Kaplan Turbine to replace existing larger unit	$14,755,000

For use in comparison the dollar per kW of installed capacity is shown in Table 2-12. This metric is commonly used for comparison of hydroelectric developments.

TABLE 2-12. OPINION OF PROBABLE COST IN DOLLARS PER KW.

CONFIGURATION	DESCRIPTION	OPINION OF PROBABLE COST (DOLLARS PER KW)
Configuration 1	New powerhouse with new Kaplan Turbine	$3,100
Configuration 2	New Kaplan Turbine to replace existing larger unit	$2,300

Comparing the cost opinion for overall cost and cost per installed kW shows the large differential between installing the minimum flow unit in a new powerhouse and installing the minimum flow unit in place of an existing turbine.

2.8.3 CONCLUSIONS

There is no way to recover the cost associated with installing a minimum flow unit at the Leesville development. The addition of a minimum flow unit and the supporting facilities carry a high initial cost and would increase the development's operation and maintenance costs. These increased costs would lead to lower plant revenues due to decreased annual energy production. The addition of a minimum flow unit may decrease the maintenance costs on the existing units (or remaining unit in Configuration 2) but this reduction would be minimal. It is possible that the reduced use of the existing units could actually add cost as the idle or stored unit's condition could deteriorate due to lack of use.

Despite the fact that both minimum flow configurations would come at a high cost and provide no payback Configuration 2 would provide the minimum flow capability at the lower capital cost and have marginally less negative effect on annual generation.

Since both configurations that allow the plant to completely avoid autocycling are economically unfavorable, and the current autocycle operations appear to have resulted in improvements downstream of the plant, the existing one-hour autocycle regime utilizing the current units should continue. A modified autocycle arrangement where the units would run off peak efficiency could result in more even river flows. However, this type of modified autocycle would create a reduction in annual power generation and have some associated increase in operations and maintenance costs because the units would be run off their optimal efficiency point. Therefore, the current one-hour autocycle regime should continue into the future.