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Dominion™

March 31, 2006

Michael P. Murphy
Director – Division of Environmental Enhancement
Department of Environmental Quality
P.O. Box 10009
Richmond, Virginia 23240

Re: Federal Consistency Certification under Coastal Zone Management Act
Virginia Coastal Resources Management Program
North Anna Early Site Permit Application

Dear Mr. Murphy:

Your January 31, 2006 letter to me indicated there were remaining questions related to Virginia's Coastal Management Program review of the new cooling system design for the North Anna Early Site Permit project. Over the past several weeks, Dominion staff have met and discussed with DEQ and VDGIF representatives the information requested to ensure clarification and mutual understanding of the data needs. Attached are Dominion's responses to those questions.

We understand that the current stay of the federal consistency review process will end on March 31, 2006 as we mutually agreed in accordance with Federal Consistency Regulations at 15 CFR Part 930, Section 930.60(b). We request that the consistency review process be re-initiated in accordance with state procedures and be based on the information provided in the January 13, 2006 submittal to the Nuclear Regulatory Commission of the "Supplement to Address a Modified Approach to Unit 3 Cooling and to Ensure the Plant Parameter Envelope Remains Bounding," the information provided in this letter, and other data provided to the state over the past several weeks.

Please let Jud White (804-273-2948) or Tony Banks (804-273-2170) know of the schedule for completion of the Consistency Certification and if you have any further questions.

Sincerely,

Pamela Faggert

Pamela Faggert

cc: Ellie Irons – DEQ
Joe Hassell – DEQ
John Kauffman - VDGIF
Jack Cushing – NRC
Nitin Patel - NRC

Response to Questions in January 31, 2006 Letter from

Department of Environmental Quality to Dominion

1. DEQ's Division of Water Resources (DWR) awaits spreadsheets promised by Dominion on December 9, 2005, that show inflow, outflow, and change in storage components for the existing two units, and also for the existing two units with a new once-through cooling unit.

   a. DEQ-DWR requests a similar spreadsheet analysis for the new cooling system, operating the system (1) in maximum water conservation mode all the time and (2) in the mode contemplated by Dominion at the time of its November 18 meeting with state agencies.

   Response:

   (1) The spreadsheet analysis for the new cooling system operating in the maximum water conservation mode all the time is being provided with this submittal. (Electronic copy provided.) (2) Dominion previously provided the spreadsheets for the existing two units and for the existing two units with a new unit cooled by a closed-cycle system operating under the conceptual strategy presented at the November 18 and December 9, 2005 meetings.

   b. What would be the average additional consumptive use over the period of record that Dominion's consultant, Bechtel, used for each set of rules in a. above?

   Response:

   The average additional consumptive use in cubic feet per second (cfs) over the period of record (October 1978 to April 2003) used in the water budget model cases was:

(1) Maximum water conservation only	8.0 cfs
(2) Energy conservation/maximum water conservation	19.4 cfs

   These average values assume a station capacity factor of 96% and include 0.9 cfs for cooling station auxiliary heat loads in the water budget model cases.

2. DEQ-DWR asked how much additional storage would be required so as not to change the frequency and duration of the 20 cubic feet per second (cfs) minimum in-stream flow (MIF). Dominion answered this question by stating that 7 inches of additional storage would be required.

   Response:

   Dominion confirms that the frequency and duration of the 20 cfs MIF would not be greater than has been experienced with the existing two units if the additional storage above the normal pool level of 250 ft. msl were raised approximately 7 inches.

3. DEQ-DWR asked, in connection with question 2, what the impacts of the required amount (7 inches) of additional storage would be on fringe wetlands. The question was not answered. A seasonal spring surcharge in the volume of water stored of just a few inches may be part of a package allowing the permitting of the project. Accordingly, we request that Dominion make an analysis of the impacts of the required amount of the additional storage upon fringe wetlands and submit it for our review.

   Response:

   Dominion evaluated potential areas of Lake Anna shoreline wetlands that could be impacted by increasing the lake's normal water level from 250' MSL to 6" to 12" above normal level. The evaluations included

   - a review of the US FWS National Wetlands Inventory, and various Lake Anna topographical maps,
   - a physical survey by boat of the "best" estimate of areas that could be impacted, and
   - an aerial survey of uplake, low-gradient tributaries

   The conclusion is that a rise in water level of 6" to 12", because of the generally steep shoreline topography, would result in minimal changes to the types and amounts of wetlands other than to shift the prevailing vegetation in gradually sloping tributaries in an upland direction.

   The review of the US FWS National Wetlands inventory indicated the presence of broader wetland areas uplake, particularly in the tributary headwaters above the Route 208 Bridge.

   The physical boat survey included Freshwater Creek, Contrary Creek, and the main lake channel toward the dam. The survey began below the 208 bridge in Freshwater Creek. Typical vegetation included rushes and sedges with river birch grading to yellow poplar with increases in elevation. This area represents one in which increased lake level would be most evident due to the more gradually sloping shoreline. In many of the headwater lake tributaries, a successional shift, or movement in wetland vegetation in an upland direction with forest shrub/scrub transitioning to emergents, and emergents to submersed, would be expected. These shifts would likely develop over several years and depend on conditions such as soil type, water clarity and extent of canopy cover.

   Contrary Creek, although a gently sloping tributary, also had some shoreline areas with more abrupt channel bank elevations. Rushes were observed intermittently in these areas. Due to the altered shoreline in some areas, the lateral extent of flooding and resulting changes to the types and amounts of wetlands appear to be less than in the neighboring headwater, Freshwater Creek.

   Additional boat surveying of the main lake channel toward the dam, both upstream and downstream, showed shoreline topography of relatively steep banks. Some of these banks were nearly vertical gradients due to the effect of wind and wave action undercutting the banks. Several points and coves on either shoreline toward the dam confirmed that a lake level rise would likely result in little lateral or upland change within these areas. Much of the main lake

shoreline is more exposed to wind and wave action and would unlikely contain rooted vegetation.

Uplake, near the southern shore about one mile above the Route 208 bridge, there is an area of cleared and gently sloping land which would not be flooded by the postulated water level increase. There appeared to be dormant water willow in a protected area adjacent to this land.

A helicopter survey of the upper lake followed the boat survey, specifically to view the low gradient tributaries in both the North Anna and Pamunkey arms. The survey confirmed that changes associated with an increased water level would be most evident in these areas and result in the likely shift of wetland vegetation in an upland direction. Beaver activity was observed throughout these upper tributaries, with their dams already acting to flood and alter the wetland landscape. A direct result of the aerial survey was an identification of about 15 areas, ranging in size of approximately one-half acre to 25 acres, which could be impacted as described.

As a result of the evaluations described above, including ground-truthing points around the lake, the conclusion is that a 6" to 12" water level increase above the normal 250' MSL, depending on seasonal variation in precipitation and lake management, over time, would most likely result in little to no net loss of wetland areas impacted, with many areas remaining largely unchanged. Other areas, most notably the gradually sloping headwater tributaries, would exhibit an upland shift in the vegetation community concurrent with any sustained increase in normal water level.

Although the response above addresses shoreline wetlands impacts, other issues would need consideration with raising the normal lake level. Potential socioeconomic (recreational) impacts including usage of residential and marina docks, Lake Anna State Park, and enjoyment of local property and the recreational fishery would need to be evaluated. Additional hydrologic evaluations required would include the increased potential for localized flooding with higher downstream flows. These considerations are not associated with lowering the Lake Level Contingency Plan level, the other alternative DEQ requested Dominion to analyze. Lowering this level to about 247.5 ft from the current 248 ft level would eliminate the projected additional occurrences of the minimum (20 cfs) downstream flow. Further, the impact of changing the Lake Level Contingency Plan on the projected minimum level that would have been experienced during the drought of 2001 – 2002 would be small (0.1 ft).

4. DGIF requested that an Index of Hydrologic Analysis (IHA) be conducted using two scenarios: water conservation mode and energy conservation mode. Table 5.2-5 in the Supplement provides an analysis, but does not make clear the assumptions used in the calculations. Is the table computed using the proposed Dominion operating rules or some other rules? If it is computed using the operating rules proposed by Dominion, then DGIF will need only the analysis conducted using water conservation mode for the entire time. Low flows are most likely to occur during times when constraints may be present on maximum water conservation mode (dry cooling only),i.e., the times of greatest need from a fisheries perspective.

Response:

The IHA provided in the Supplement (Table 5.2-5) assumes the operating strategy proposed by Dominion that uses Energy Conservation and Maximum Water Conservation modes, depending on the level of Lake Anna. An IHA has been conducted assuming that the new cooling system is operated in Maximum Water Conservation all the time. This analysis uses the same methodology as was used to develop Table 5.2-5 in the ESP Supplement and is provided as Attachment 1.

5. DEQ-DWR indicates that the IHA analyses (question 5) are needed especially for the pre-dam condition. On December 9, Dominion wrote:

> Currently our resources are focused on completing the ESP supplement for submittal to the USNRC by January 13, 2006. After that effort is completed we will provide a schedule indicating when the pre-dam IHA can be supplied.

Response:

The IHA for the pre-dam condition is provided in Attachment 2.

6. According to DGIF, certain portions of Table 5.2-5 do not appear consistent with the proposed plant operation. For example, on page 115, in the post-impact period for November and December, the water loss at the 75% exceedance (50 and 63 cfs) is greater than the maximum evaporative water loss (37.8 cfs) listed in Table 3.1-9. Please clarify.

Response:

The difference in pre- and post-impact flow statistics can exceed the maximum evaporation rate for a given week since this flow is a function of both evaporative rate and change in storage in the reservoir. When the reservoir pool level is below 250 ft, inflow to the lake is used to satisfy minimum outflow requirements, make up evaporative losses and fill the reservoir with the excess. Once the reservoir level reaches 250 ft, the excess is released downstream. The pool levels trend lower with the addition of Unit 3 than the existing Units, creating more storage volume, which would require filling before the excess inflow is released.

7. Table 3.1-9 provides maximum make-up flow and evaporation rates. DGIF staff assumes that these will vary by ambient air temperature and that in some cases cooling needs can be met entirely by the dry tower. DGIF requests some type of monthly or seasonal analysis to aid in determining when cooling by evaporation is minimal and when the maximum values occur.

   Response:

   Dominion evaluated the proposed cooling system for evaporation rates over the period of record (October 1978 to April 2003). The average daily ambient temperature was used to estimate the average and maximum seasonal evaporation rates as follows:

		Unit 3 in EC/MWC	Unit 3 in Continuous MWC
Average Water Consumption From New Unit, cfs	December - February	16.6	0.8
	March - May	24.9	5.2
	June - August	24.7	19.9
	September - November	11.7	6.2
Maximum Water Consumption From New Unit, cfs	December - February	27.9	6.5
	March - May	32.6	22.8
	June - August	34.2	23.4
	September - November	33.3	22.5

Note that the average values are based on a station capacity factor of 96% and include evaporation from auxiliary heat loads. The maximum values are based on a station capacity factor of 100% and also include evaporation from auxiliary heat loads.

8. DGIF requested, in earlier correspondence, a chart that shows the timing and duration of flows at 20 cfs. This was provided in earlier documents, but does not appear in the Supplement. Figure 5.2-2 visually illustrates the duration of those events, but it is impossible to determine the duration with precision. We request that Dominion supply this chart and information.

   Response:

   The water budget model for the existing Units is based on a period of record (October 1978 to April 2003) and indicates that the outflow from the dam would be reduced to 20 cfs as follows:

Event	Dates	Duration
1	11/8/1998 – 12/26/1998	7 weeks
2	10/21/2001 – 12/16/2002	60 weeks

   Historically, during Event #1 above (11/8/1998 – 12/26/1998), the downstream flow was not reduced to 20 cfs, but maintained at a minimum of 40 cfs.

   The water budget model data for the existing Units and an additional unit operating under the proposed EC/MWC operating strategy projects the following dates when the flow would have been at a minimum of 20 cfs:

Event	Dates	Duration
1	09/13/1981 – 12/12/1981	13 weeks
2	10/17/1993 – 11/06/1993	3 weeks
3	10/18/1998 – 01/09/1999	12 weeks
4	08/15/1999 – 08/28/1999	2 weeks
5	09/30/2001 – 12/21/2002	64 weeks

   The water budget model data for new unit under the MWC-only operating strategy projects essentially the same data as for the EC/MWC operating strategy. This is due to the fact that the EC/MWC and MWC-only modes are equivalent below lake level 248 ft msl. Operating at MWC-only would have reduced the duration of Event #5 by about 1 week.

Following the numbered questions in VDEQ's letter dated January 31, 2006, the Department of Conservation and Recreation (DCR) expressed interest in Dominion's use of a dry tower for Unit 3. Dominion evaluated the use of 100% dry cooling for Unit 3 for the reactor technologies likely to be selected and found it was not economically feasible. Dominion is proposing a closed cycle cooling system that uses both dry and wet cooling to remove the thermal impact to the lake and significantly reduce water use for the proposed Unit.

Attachments

Attachment 1	Indicators of Hydrologic Alteration for the North Anna River, 100% Maximum Water Conservation Operation
Attachment 2	Indicators of Hydrologic Alteration for the North Anna River, Pre-Dam versus Post-Dam with Units 1 & 2 in Service
Attachment 3	DEQ's North Anna ESP Cooling Questions, Responses Provided on December 9, 2005, Revised to indicate updated information

Attachment 1

Indicators of Hydrologic Alteration Analysis
for
North Anna River
100% Maximum Water Conservation Operation
Existing Units versus Existing Units with Proposed Unit 3

Table 1: IHA Percentile Data for the North Anna River Near Partlow – 100% MWC Operation.

	Pre-Impact period: 1979-2002 (24 years)						Post-Impact period: 2003-2026 (24 years)					
Statistic	10%	25%	50%	75%	90%	(75-25)/50	10%	25%	50%	75%	90%	(75-25)/50
Parameter Group #1												
October	40	40	40	78.7	259.4	0.9676	22.86	40	40	60.96	242.2	0.5241
November	30	40	103.5	272.7	364.9	2.249	20	40	64.05	240.1	337	3.125
December	30	40	195.5	332.2	524.7	1.495	30	40	183.3	292.5	523.9	1.377
January	40	97.57	380.1	528.9	780.3	1.135	40	56.19	379.3	528.1	779.6	1.244
February	40	165.3	344	592.2	1147	1.241	40	164.5	342.3	591.4	1146	1.247
March	106.5	198.5	480.3	712.5	1256	1.07	105	197.7	479.4	711.7	1256	1.072
April	45.67	145.6	300.2	448.2	1111	1.008	44.62	143.1	296.8	446.2	1109	1.022
May	40	76.4	152.3	317.7	500.9	1.585	40	66.35	140.5	304.6	492.4	1.696
June	40	40	48.55	111.4	273.7	1.47	40	40	46.97	93.31	254	1.135
July	40	40	40	63.38	331	0.5845	40	40	40	42.42	310.4	0.06055
August	40	40	40	89.55	207.9	1.239	40	40	40	54.34	189.1	0.3585
September	40	40	40	40	226.8	0	30	40	40	40	217.2	0
Parameter Group #2												
1-day minimum	30	40	40	40	40	0	20	25	40	40	40	0.375
3-day minimum	30	40	40	40	40	0	20	25	40	40	40	0.375
7-day minimum	30	40	40	40	40	0	20	25	40	40	40	0.375
30-day minimum	26	40	40	40	40	0	20	30.17	40	40	40	0.2458
90-day minimum	26.56	40	40	49.15	93.89	0.2287	20.14	27.56	40	42.47	85.92	0.3729
1-day maximum	269.2	1086	1642	2846	3961	1.072	268.8	949.9	1641	2835	3960	1.149
3-day maximum	261.7	1042	1614	2534	3681	0.9245	261.3	905.7	1613	2524	3680	1.003
7-day maximum	249.7	976.2	1572	2067	3240	0.6941	249.3	874.4	1570	2052	3239	0.75
30-day maximum	201.9	600.7	873.3	1317	1650	0.8197	201.5	591	867.8	1314	1650	0.8329
90-day maximum	120.9	410.5	597.9	795.9	1168	0.6445	109.5	398.9	595.8	793.1	1166	0.6615
Number of zero days	0	0	0	0	0	0	0	0	0	0	0	0
Base flow	0.07922	0.09787	0.1517	0.2468	0.6464	0.9818	0.07353	0.09876	0.1475	0.2139	0.4389	0.7806
Parameter Group #3												
Date of minimum	164.5	275	275	275	288	0	205	275	275	275	284	0
Date of maximum	338.5	37.5	85	169.8	275	0.3613	338.5	32.5	82	143	275	0.3019
Parameter Group #4												
Low pulse count	0	0	0	0	0.5	0	0	0	0	0	1	0
Low pulse duration	55	55	203.5	352	352	1.459	20	37.5	93.5	304	373	2.85
High pulse count	0.5	3	4	6	7.5	0.75	0.5	3	4	5.75	7	0.6875
High pulse duration	9	12.38	17.5	21.5	29.2	0.5214	9.3	11.88	16.5	20.5	29.2	0.5227
Parameter Group #5												
Rise rate	10.21	15.45	21.91	31.13	38.49	0.7159	14.37	18.84	24.06	30.87	37.14	0.5003
Fall rate	-35.83	-30.68	-14.76	-10.09	-6.361	-1.394	-36.53	-31.54	-15.21	-10.89	-5.375	-1.358
Number of reversals	2.5	13.5	18.5	21	24.5	0.4054	2	13	17	20.5	23.5	0.4412

Table 1: IHA Percentile Data for the North Anna River Near Partlow – 100% MWC Operation (continued).

	Pre-impact period: 1979-2002 (24 years)						Post-impact period: 2003-2026 (24 years)					
Statistic	10%	25%	50%	75%	90%	(75-25)/50	10%	25%	50%	75%	90%	(75-25)/50
EFC Monthly Low Flows												
October Low Flow	51.5	60.42	92.26	210.2	226.5	1.623	44.62	64.42	95.88	195.5	223.9	1.367
November Low Flow	54.35	84.52	160.9	219.7	310.5	0.8402	72.39	87.81	169.4	219.1	320.3	0.775
December Low Flow	53.84	81.38	192.4	240	320.4	0.8245	135.3	184.2	200.7	274.4	335.2	0.4495
January Low Flow	80.63	121.7	207.1	284.6	318	0.7868	62.57	113.8	209.1	283.9	318.2	0.8139
February Low Flow	52.27	129.1	223.5	269.9	316.1	0.6298	83.05	149.2	229.9	270.2	319.3	0.5265
March Low Flow	143.5	154.5	177.5	221	262.8	0.3751	142.1	151.4	174.8	218.3	261.9	0.383
April Low Flow	89.49	122.8	187.4	274.3	306.2	0.8086	87.88	124.3	189.5	267.8	295.8	0.7576
May Low Flow	54.74	85.28	142	196.3	236.6	0.7819	75.65	80.16	131.9	189.2	221.6	0.8268
June Low Flow	42.3	68.71	96.58	145.3	208.8	0.7926	64.69	78.39	85.26	132.5	200.7	0.6341
July Low Flow	42.1	50.38	70.63	113.8	233.3	0.8976	42.56	50.28	70.71	110.3	230.6	0.8482
August Low Flow	54.12	71.58	79.65	100.5	125	0.363	47.29	56.89	74.12	90.1	112.8	0.4481
September Low Flow	42.34	60.41	84.75	129.5	241.3	0.8153	49.34	51.85	70.22	143.2	164	1.301
EFC Flow Parameters												
Extreme low peak	34	40	40	40	40	0	30	40	40	40	40	0
Extreme low duration	8	22	36	127	421.4	2.917	8.7	18.5	53.5	132.3	251.8	2.126
Extreme low timing	125.8	165	185	233	257.6	0.1858	139.6	162	193.5	224	254.4	0.1694
Extreme low freq.	1	1	2	3	3.5	1	0	1	2	2	3	0.5
High flow peak	439.6	502.7	711.7	870.9	1005	0.5173	462.4	528.2	719.7	864.7	1033	0.4675
High flow duration	14.15	17	19.5	24.63	30.1	0.391	14	15.63	20.25	26	29.4	0.5123
High flow timing	0.9	39	97	161.9	219.2	0.3357	41.35	70.75	117	240.8	352.8	0.4645
High flow frequency	0.5	2	3	4	6	0.6667	0.5	1.25	3	4	5.5	0.9167
High flow rise rate	32.68	39.21	47.82	60.6	88.38	0.4474	23.65	31.83	45.29	72.24	99.9	0.8924
High flow fall rate	-101.1	-66.48	-42.56	-34.99	-28.96	-0.7397	-108	-62.85	-43.06	-33.99	-28.87	-0.6704
Small Flood peak	1717	2024	2450	2960	3207	0.3817	1716	1988	2330	2959	3206	0.4164
Small Flood duration	27.1	31	52.5	83	124.7	0.9905	27	36	53.75	92.88	126.4	1.058
Small Flood timing	20.25	51	102	186.4	298.7	0.3699	20.25	51	102	160.5	294.9	0.2992
Small Flood freq.	0	0	0	1	2	0	0	0	0	1	2	0
Small Flood riserate	23.39	57.35	97.13	144.1	168.8	0.8933	23.09	34.48	83.93	146	169.3	1.328
Small Flood fallrate	-351.5	-214.3	-121.6	-53.79	-29.48	-1.321	-351.9	-211.2	-121.8	-53.91	-26.57	-1.291
Large flood peak	4281	4281	4518	4756	4756	0.1051	4280	4280	4518	4755	4755	0.1051
Large flood duration	61	61	89	117	117	0.6292	61	61	89	117	117	0.6292
Large flood timing	32	32	44	56	56	0.06557	32	32	44	56	56	0.06557
Large flood freq.	0	0	0	0	0.5	0	0	0	0	0	0.5	0
Large flood rise	113.4	113.4	202.2	291.1	291.1	0.8787	113.4	113.4	202.2	291.1	291.1	0.8787
Large flood fall	-81.95	-81.95	-69.69	-57.43	-57.43	-0.3519	-81.95	-81.95	-69.69	-57.43	-57.43	-0.3518

Table 2: Non-Parametric IHA Scorecard for the North Anna River Near Partlow – 100% MWC Operation.

Statistic	Pre-impact period: 1979-2002 (24 years)	Post-impact period: 2003-2026 (24 years)
Watershed area	343	343
Mean annual flow	283	269
Mean flow/area	0.83	0.78
Annual C. V.	0.84	0.91
Flow predictability	0.45	0.45
Constancy/predictability	0.71	0.7
% of floods in 60d period	0.26	0.26
Flood-free season	3	3

	MEDIANS		COEFF. of DISP.		DEVIATION FACTOR		SIGNIFICANCE COUNT	
Statistic	Pre	Post	Pre	Post	Medians	C.D.	Medians	C.D.
Parameter Group #1								
October	40	40	0.9676	0.5241	0	0.4584	0.00	0.6957
November	103.5	64.05	2.249	3.125	0.3812	0.3896	0.7798	0.7598
December	195.5	183.3	1.495	1.377	0.062	0.07871	0.8318	0.7968
January	380.1	379.3	1.135	1.244	0.001907	0.09623	0.9499	0.7578
February	344	342.3	1.241	1.247	0.005017	0.005201	0.999	0.986
March	480.3	479.4	1.07	1.072	0.001758	0.001768	1	0.994
April	300.2	296.8	1.008	1.022	0.01149	0.0132	0.991	0.978
May	152.3	140.5	1.585	1.696	0.0774	0.07055	0.7227	0.8038
June	48.55	46.97	1.47	1.135	0.03252	0.2282	1	0.7177
July	40	40	0.5845	0.06055	0	0.8964	0.002002	0.6266
August	40	40	1.239	0.3585	0	0.7106	0.001001	0.5776
September	40	40	0	0	0		0.00	0.00
Parameter Group #2								
1-day minimum	40	40	0	0.375	0		0.00	0.00
3-day minimum	40	40	0	0.375	0		0.00	0.00
7-day minimum	40	40	0	0.375	0		0.00	0.00
30-day minimum	40	40	0	0.2458	0		0.00	0.00
90-day minimum	40	40	0.2287	0.3729	0	0.6306	0.01902	0.5676
1-day maximum	1642	1641	1.072	1.149	0.0005353	0.07179	1	0.8278
3-day maximum	1614	1613	0.9245	1.003	0.0007725	0.08508	1	0.8058
7-day maximum	1572	1570	0.6941	0.75	0.001261	0.08049	1	0.8388
30-day maximum	873.3	867.8	0.8197	0.8329	0.006325	0.01614	0.9089	0.961
90-day maximum	597.9	595.8	0.6445	0.6615	0.00353	0.02649	0.9139	0.952
Number of zero days	0	0	0	0			0.00	0.00
Base flow	0.1517	0.1475	0.9818	0.7806	0.02783	0.2049	0.9079	0.6927

Table 2: Non-Parametric IHA Scorecard for the North Anna River Near Partlow – 100% MWC Operation (continued).

Statistic	MEDIANS		COEFF. of DISP.		DEVIATION FACTOR		SIGNIFICANCE COUNT	
	Pre	Post	Pre	Post	Medians	C.D.	Medians	C.D.
Parameter Group #3								
Date of minimum	275	275	0	0	0		0.00	0.00
Date of maximum	85	82	0.3613	0.3019	0.01639	0.1645	0.7147	0.8248
Parameter Group #4								
Low pulse count	0	0	0	0			0.00	0.00
Low pulse duration	203.5	93.5	1.459	2.85	0.5405	0.953	0.6607	0.1802
High pulse count	4	4	0.75	0.6875	0	0.08333	0.3804	0.8008
High pulse duration	17.5	16.5	0.5214	0.5227	0.05714	0.002491	0.7838	0.996
Low Pulse Threshold	40							
High Pulse Level	348							
Parameter Group #5								
Rise rate	21.91	24.06	0.7159	0.5003	0.09811	0.3012	0.4314	0.3033
Fall rate	-14.76	-15.21	-1.394	-1.358	0.03008	0.02581	0.9359	0.9399
Number of reversals	18.5	17	0.4054	0.4412	0.08108	0.08824	0.5746	0.7918
EFC Low flows								
October Low Flow	92.26	95.88	1.623	1.367	0.03923	0.1578	0.8839	0.6877
November Low Flow	160.9	169.4	0.8402	0.775	0.05283	0.07756	0.9159	0.8739
December Low Flow	192.4	200.7	0.8245	0.4495	0.04316	0.4549	0.6677	0.4675
January Low Flow	207.1	209.1	0.7868	0.8139	0.009586	0.03438	0.9409	0.9119
February Low Flow	223.5	229.9	0.6298	0.5265	0.02862	0.164	0.9029	0.7648
March Low Flow	177.5	174.8	0.3751	0.383	0.01516	0.02106	0.9359	0.9329
April Low Flow	187.4	189.5	0.8086	0.7576	0.0112	0.06309	0.995	0.8388
May Low Flow	142	131.9	0.7819	0.8268	0.07102	0.05748	0.7538	0.8088
June Low Flow	96.58	85.26	0.7926	0.6341	0.1173	0.2	0.4474	0.7708
July Low Flow	70.63	70.71	0.8976	0.8482	0.00117	0.05497	0.99	0.951
August Low Flow	79.65	74.12	0.363	0.4481	0.06948	0.2344	0.4525	0.6126
September Low Flow	84.75	70.22	0.8153	1.301	0.1715	0.5963	0.5335	0.4965
EFC Parameters								
Extreme low peak	40	40	0	0	0		0.00	0.00
Extreme low duration	36	53.5	2.917	2.126	0.4861	0.271	0.1421	0.7307
Extreme low timing	185	193.5	0.1858	0.1694	0.04645	0.08824	0.5485	0.8288
Extreme low freq.	2	2	1	0.5	0	0.5	0.2262	0.2342
High flow peak	711.7	719.7	0.5173	0.4675	0.01123	0.09636	0.8879	0.7518
High flow duration	19.5	20.25	0.391	0.5123	0.03846	0.3103	0.4565	0.3984
High flow timing	97	117	0.3357	0.4645	0.1093	0.3835	0.9029	0.3534
High flow frequency	3	3	0.6667	0.9167	0	0.375	0.4905	0.4024
High flow rise rate	47.82	45.29	0.4474	0.8924	0.05279	0.9948	0.8268	0.02903
High flow fall rate	-42.56	-43.06	-0.7397	-0.6704	0.01158	0.09381	0.9329	0.9109

Table 2: Non-Parametric IHA Scorecard for the North Anna River Near Partlow -100% MWC Operation (continued).

Statistic	MEDIANS		COEFF. of DISP.		DEVIATION FACTOR		SIGNIFICANCE COUNT	
	Pre	Post	Pre	Post	Medians	C.D.	Medians	C.D.
Small Flood peak	2450	2330	0.3817	0.4164	0.04869	0.09086	0.6997	0.8388
Small Flood duration	52.5	53.75	0.9905	1.058	0.02381	0.06831	0.972	0.8849
Small Flood timing	102	102	0.3699	0.2992	0	0.1911	0.969	0.6106
Small Flood freq.	0	0	0	0			0.00	0.00
Small Flood riserate	97.13	83.93	0.8933	1.328	0.1359	0.4872	0.7407	0.3544
Small Flood fallrate	-121.6	-121.8	-1.321	-1.291	0.00175	0.02207	0.969	0.993
Large flood peak	4518	4518	0.1051	0.1051	0.0001723	0.0002433	0.6266	0.2783
Large flood duration	89	89	0.6292	0.6292	0	0	0.6266	0.03604
Large flood timing	44	44	0.06557	0.06557	0	0	0.6266	0.01001
Large flood freq.	0	0	0	0			0.00	0.00
Large flood rise	202.2	202.2	0.8787	0.8787	0.00002188	0.00003276	0.7578	0.1471
Large flood fall	-69.69	-69.69	-0.3519	-0.3518	0.00006339	0.0002528	0.6266	0.2783

Table 3: IHA Non-Parametric RVA Scorecard for the North Anna River Near Partlow – 100% MWC Operation.

Statistic	Pre-Impact period: 1979-2002				Post-Impact period: 2003-2026				RVA Boundaries		Hydrologic Alteration
	Medians	Coeff. of Dispersion	Minimum	Maximum	Medians	Coeff. of Dispersion	Minimum	Maximum	Low	High	(Middle Category)
Parameter Group #1											
October	40	0.9676	34.29	289.5	40	0.5241	20	278.5	40	40	-0.0625
November	103.5	2.249	20	701.8	64.05	3.125	20	699.7	40	233	0
December	195.5	1.495	20	658.3	183.3	1.377	20	657.5	44.53	259.2	0
January	380.1	1.135	20	835.7	379.3	1.244	20	834.9	151.3	465.2	-0.125
February	344	1.241	20	2688	342.3	1.247	20	2688	241.2	485.2	0
March	480.3	1.07	20	1353	479.4	1.072	20	1352	271.4	643.8	0
April	300.2	1.008	20	1388	296.8	1.022	20	1380	172.2	387.6	0
May	152.3	1.585	20	648.4	140.5	1.696	20	628.1	92.28	254.5	0
June	48.55	1.47	20	561.2	46.97	1.135	20	541.8	40	103.7	0.2
July	40	0.5845	20	486	40	0.06055	20	465.4	40	43.19	0.1333
August	40	1.239	20	331.1	40	0.3585	20	322.3	40	40	0
September	40	0	20	482.8	40	0	20	469.3	40	40	-0.05556
Parameter Group #2											
1-day minimum	40	0	20	40	40	0.375	20	40	40	40	-0.1818
3-day minimum	40	0	20	40	40	0.375	20	40	40	40	-0.1818
7-day minimum	40	0	20	40	40	0.375	20	40	40	40	-0.1818
30-day minimum	40	0	20	172.7	40	0.2458	20	159.4	40	40	-0.25
90-day minimum	40	0.2287	20	270.4	40	0.3729	20	252	40	41.69	-0.08333
1-day maximum	1642	1.072	40	4756	1641	1.149	20	4755	1283	2376	0
3-day maximum	1614	0.9245	40	4692	1613	1.003	20	4692	1233	2219	0
7-day maximum	1572	0.6941	40	4577	1570	0.75	20	4576	1136	1930	0.125
30-day maximum	873.3	0.8197	39.67	3432	867.8	0.8329	20	3432	657.3	1185	-0.125
90-day maximum	597.9	0.6445	40	1931	595.8	0.6615	20	1928	448.8	678.9	0
Number of zero days	0	0	0	0	0	0	0	0	0	0	0
Base flow	0.1517	0.9818	0.06759	1	0.1475	0.7806	0.042	1	0.1233	0.2036	0.125
Parameter Group #3											
Date of minimum	275	0	153	313	275	0	153	298	275	275	0
Date of maximum	85	0.3613	13	343	82	0.3019	13	343	80.5	217.5	0
Parameter Group #4											
Low pulse count	0	0	0	1	0	0	0	1	0	0	-0.09091
Low pulse duration	203.5	1.459	55	352	93.5	2.85	20	373	55	352	0
High pulse count	4	0.75	0	10	4	0.6875	0	9	3	5.75	0.1818
High pulse duration	17.5	0.5214	5	36	16.5	0.5227	4	36	13	18.41	-0.1111
The low pulse threshold is			40								
The high pulse level is			348								

Table 3: IHA Non-Parametric RVA Scorecard for the North Anna River Near Partlow – 100% MWC Operation (continued).

	Pre-Impact period: 1979-2002				Post-Impact period: 2003-2026				RVA Boundaries		Hydrologic Alteration
Statistic	Medians	Coeff. of Dispersion	Minimum	Maximum	Medians	Coeff. of Dispersion	Minimum	Maximum	Low	High	(Middle Category)
Parameter Group #5	21.91	0.7159	4.375	47.15	24.06	0.5003	10.54	57.66	16.08	28.33	0.2222
Rise rate	-14.76	-1.394	-36.47	-2.857	-15.21	-1.358	-37.97	-2.857	-24.11	-10.9	0
Fall rate	18.5	0.4054	0	25	17	0.4412	0	24	15	21	0
Number of reversals	21.91	0.7159	4.375	47.15	24.06	0.5003	10.54	57.66	16.08	28.33	0.2222

Assessment of Hydrologic Alteration

	Middle RVA Category			High RVA Category			Low RVA Category		
Statistic	Expected	Observed	Alter.	Expected	Observed	Alter.	Expected	Observed	Alter.
Parameter Group #1									
October	16	15	-0.0625	7	6	-0.1429	1	3	2
November	14	14	0	8	7	-0.125	2	3	0.5
December	8	8	0	8	7	-0.125	8	9	0.125
January	8	7	-0.125	8	8	0	8	9	0.125
February	8	8	0	8	8	0	8	8	0
March	8	8	0	8	8	0	8	8	0
April	8	8	0	8	8	0	8	8	0
May	8	8	0	8	8	0	8	8	0
June	15	18	0.2	8	5	-0.375	1	1	0
July	15	17	0.1333	8	6	-0.25	1	1	0
August	16	16	0	7	7	0	1	1	0
September	18	17	-0.05556	5	5	0	1	2	1
Parameter Group #2									
1-day minimum	22	18	-0.1818	0	0	0	2	6	2
3-day minimum	22	18	-0.1818	0	0	0	2	6	2
7-day minimum	22	18	-0.1818	0	0	0	2	6	2
30-day minimum	20	15	-0.25	1	1	0	3	8	1.667
90-day minimum	12	11	-0.08333	8	6	-0.25	4	7	0.75
1-day maximum	8	8	0	8	8	0	8	8	0
3-day maximum	8	8	0	8	8	0	8	8	0
7-day maximum	8	9	0.125	8	7	-0.125	8	8	0
30-day maximum	8	7	-0.125	8	8	0	8	9	0.125
90-day maximum	8	8	0	8	7	-0.125	8	9	0.125
Number of zero days	24	24	0	0	0	0	0	0	0
Base flow	8	9	0.125	8	7	-0.125	8	8	0

Table 3: IHA Non-Parametric RVA Scorecard for the North Anna River Near Partlow – 100% MWC Operation (continued).

Statistic	Middle RVA Category			High RVA Category			Low RVA Category		
	Expected	Observed	Alter.	Expected	Observed	Alter.	Expected	Observed	Alter.
Parameter Group #3									
Date of minimum	17	17	0	4	3	-0.25	3	4	0.3333
Date of maximum	8	8	0	8	7	-0.125	8	9	0.125
Parameter Group #4									
Low pulse count	22	20	-0.09091	2	4	1	0	0	0
Low pulse duration	2	2	0	22	1	-0.9545	0	1	0
High pulse count	11	13	0.1818	8	6	-0.25	5	5	0
High pulse duration	9	8	-0.1111	9	8	-0.1111	6	6	0
Parameter Group #5									
Rise rate	9	11	0.2222	8	8	0	7	3	-0.5714
Fall rate	9	9	0	8	6	-0.25	7	8	0.1429
Number of reversals	13	13	0	5	4	-0.2	6	7	0.1667

Attachment 2

Indicators of Hydrologic Alteration Analysis
For
North Anna River
Pre-Dam versus Post-Dam with Units 1 & 2 in Service

1. INTRODUCTION

Indicators of Hydrologic Alteration (IHA) have been calculated for the North Anna River to quantify the historical alterations to the hydrologic regime of the North Anna River downstream of the North Anna Dam as a consequence of impounding the river and operating the North Anna Power Station (NAPS). This calculation was undertaken at the request of the Virginia Department of Environmental Quality. This appendix describes the approach taken to calculate IHA, the hydrologic data used in the assessment, the results of the IHA calculation, and the main conclusions from this investigation.

2. APPROACH

To quantify the historical impacts to North Anna River streamflows due to the impoundment of the river to form Lake Anna and the operation of the existing NAPS, IHA have been calculated for streamflows downstream of the North Anna Dam under both pre- and post-impact conditions, and the Range of Variability Approach (RVA) has been applied to assess hydrologic alteration. These analyses have been performed using the methodology proposed by Richter et al. (References 1-3), which calculates statistical descriptions of the streamflow record and changes in these statistics for 33 hydrologic parameters. These parameters are organized into 5 groups that are intended to characterize the following:

- Magnitude of monthly water conditions
- Magnitude and duration of annual extreme water conditions
- Timing of annual extreme water conditions
- Frequency and duration of high and low pulses
- Rate and frequency of water condition changes

IHA have been calculated assuming that the pre-impact condition is defined to be the North Anna River prior to the closure and filling of Lake Anna in 1972 and operation of the existing NAPS. The post-impact condition is defined as the currently impounded Lake Anna with the existing NAPS in operation, which began in 1978. The IHA software package (Reference 4) has been used to perform the IHA and RVA analyses. The North Anna River streamflow data used for this analysis and the application of the IHA software package are described below.

3. STREAMFLOW DATA

Daily streamflow data published by the U. S. Geological Survey (USGS) and available for calculation of IHA for the North Anna River are summarized in Table 1. The locations of these stations are shown in Figure 1.

Table 1: North Anna River Daily Streamflow Data.

Station No.	Station Name	Drainage Area (mi^2)	Period of Record
1670400	North Anna River Near Partlow, VA[1]	344	1978-10-01 thru 1995-10-09
1671000	North Anna River Near Doswell, VA[2]	441	1929-04-01 thru 1988-09-30
1671020	North Anna River at Hart Corner Near Doswell, VA[3]	463	1979-10-01 thru 2004-09-30

[1] http://nwis.waterdata.usgs.gov/nwis/discharge/?site_no=01670400&agency_cd=USGS

[2] http://nwis.waterdata.usgs.gov/nwis/discharge/?site_no=01671000&agency_cd=USGS

[3] http://nwis.waterdata.usgs.gov/nwis/discharge/?site_no=01671020&agency_cd=USGS

In addition to these data, daily releases from the North Anna Dam have been estimated for the 1995-10-10 through 2003-04-10 period (Reference 5). These outflows were determined from historical lake level, gate opening, and hydroelectric operation records.

IHA were calculated at the Partlow station to reflect the impacts on the North Anna River as a consequence of constructing the North Anna Dam and operating NAPS. This gauging station is about 0.5 mile downstream of the North Anna Dam and has a drainage area of 344 mi^2 (versus 343 mi^2 for Lake Anna). Streamflows at this location are therefore representative of outflows from the North Anna Dam.

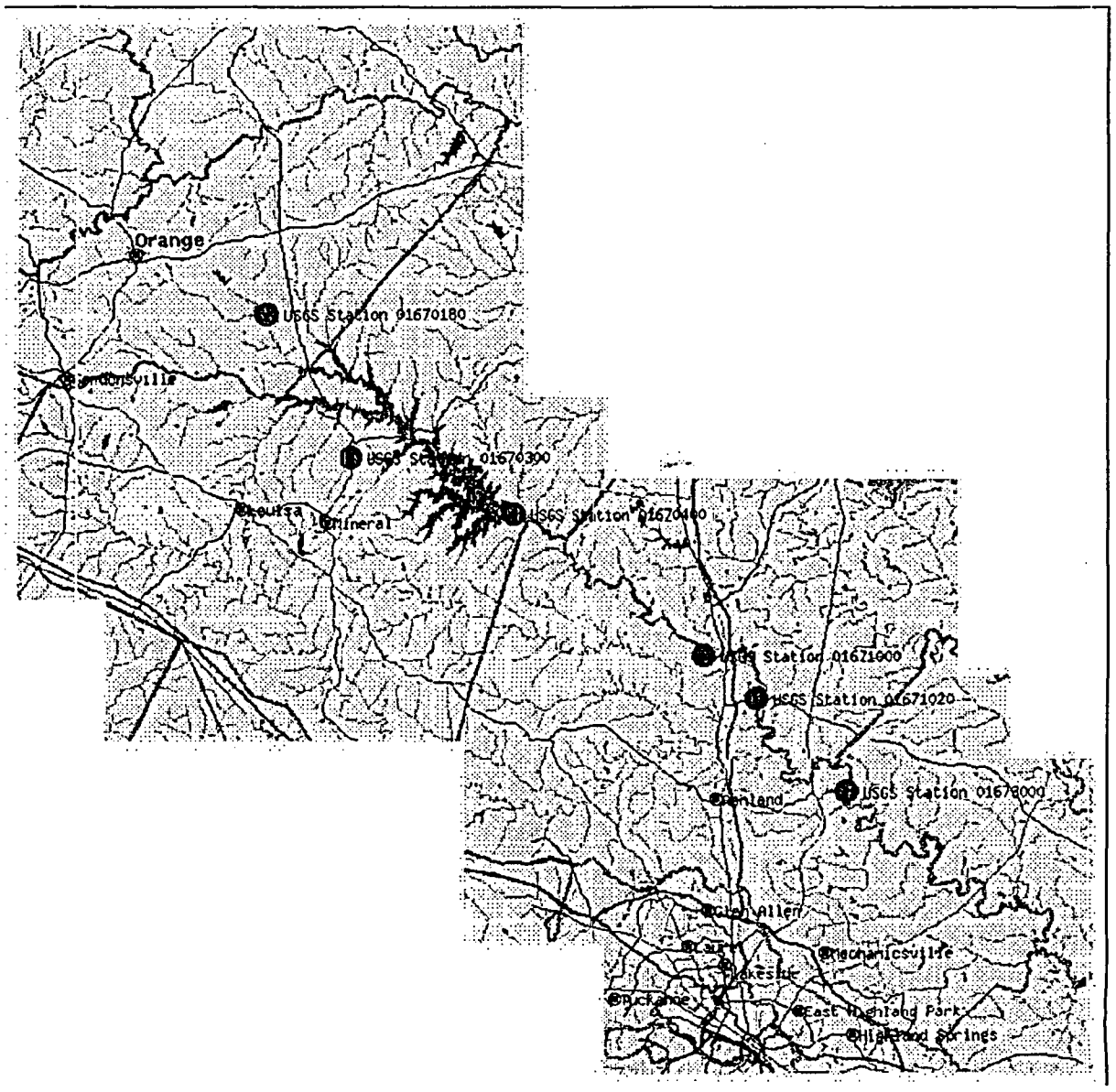

Figure 1: Locations of USGS Gauging Stations on the North Anna River.

3.1 Pre-impact Streamflows

Streamflow data from the North Anna River Near Doswell (drainage area = 441 mi^2) were used to represent pre-impact streamflows. Because the drainage area at the Doswell station is greater than that at the Partlow station, these data require correction (reduction) to be representative of flows at Partlow. The use of the drainage area ratio as a correction factor is a commonly used

method for scaling streamflow data. In this case the correction factor would be 344/441 = 0.780. Daily streamflows at Partlow can therefore be estimated by applying this correction factor to the daily streamflows at Doswell, i.e.,

$$Q_{Partlow} = 0.780\ Q_{Doswell}$$

This equation was used to estimate pre-impact daily streamflows at Partlow for the period prior to the closure and filling of Lake Anna in 1972.

3.2 Post-impact Streamflows

Streamflow data from the North Anna River Near Partlow were used to represent post-impact streamflows. Since this station is located directly downstream of the dam, there is no need to apply any correction factor to these data. The available period of record extends from 1978-10-01 through 1995-10-09, when the station was closed.

Because the 1997–2002 period included several drought years, it is desirable to include the effects of this dry period in the streamflow record. Two sources of data are available to extend the post-impact streamflow record at Partlow. The first includes the daily releases from the North Anna Dam from 1995-10-10 onward that were estimated using reservoir water level and gate opening records (Reference 5). The second includes the USGS streamflow record for the North Anna River Near Doswell Near Hart Corner, which is about 20 miles downstream of the North Anna Dam and has a drainage area of 463 mi^2. The correlation between daily streamflows at these two stations was examined using regression analysis. Assuming a linear relationship between Partlow and Hart Corner daily streamflow and taking the constant to be zero, the coefficient was determined for the concurrent period of record (1979-10-01 thru 1995-10-09). Results of the regression analysis, provided in Figure 2, indicate that that daily streamflow at Partlow is related to the daily streamflow at Hart Corner as follows

$$Q_{Partlow} = 0.730\ Q_{HartCorner}$$

with an r^2 value of 0.80. Even though the 0.730 coefficient value is close in magnitude to the ratio of the drainage areas for the two stations (i.e., 344/463 = 0.743), the relatively low r^2 value and lack of correlation in the low flow range evident in Figure 2 indicates that the above relationship is not suitable for extending the Partlow streamflow record, particularly with respect to estimating low flows. The lack of correlation is likely due to fact that streamflows at Partlow are regulated releases from the North Anna Dam, while the streamflows at Hart Corner reflect the regulated releases plus unregulated inflow from an additional 199 mi^2 of drainage area contributing to streamflows at the Hart Corner gauge. The dam releases estimated using reservoir

records (Reference 5) are expected to be more reliable for extending the Partlow streamflow record and were therefore used in the IHA analysis.

4. IHA AND RVA CALCULATION

IHA were calculated for the North Anna River downstream of the North Anna Dam using the daily streamflow data as described above. Table 2 summarizes the input data for the pre- and post-impact periods by water years. Note that the water year for any given year begins on October 1 of the previous calendar year and ends on September 30 of the present calendar year.

Table 2: Streamflow Data Used for IHA Calculation.

Period	Streamflow Record	Correction Factor
Pre-impact Period (water years 1930-1971)		
1929-10-01 thru 1971-09-30	North Anna River Near Doswell[1]	0.780
Post-impact Period (water years 1979-2002)		
1978-10-01 thru 1995-09-30	North Anna River Near Partlow[2]	Not applicable
1995-10-01 thru 2002-09-30	North Anna Dam releases[3]	Not applicable

[1] http://nwis.waterdata.usgs.gov/nwis/discharge/?site_no=01671000&agency_cd=USGS

[2] http://nwis.waterdata.usgs.gov/nwis/discharge/?site_no=01670400&agency_cd=USGS

[3] Reference 5

Results of the statistical analyses are summarized in Tables 3, 4 and 5. Table 3 summarizes the 10%, 25%, 50%, 75% and 90% percentiles for each of the 33 hydrologic parameters for pre- and post-impact conditions. Table 4 includes the results of the IHA analysis, provides the medians and coefficients of dispersion for each hydrologic parameter in a "scorecard" format, and quantifies changes in the IHA between the pre-impact and post-impact water regimes. Table 5 provides the results of the RVA analysis. In each of these tables, the IHA statistics have been calculated non-parametrically as recommended in the IHA User's Manual (Reference 5).

To illustrate changes to the low flow regime of the North Anna River under post-impact conditions, selected results of the analysis are presented graphically in Figures 3 through 8. Figure 3 plots the September monthly flows for pre- and post-impact conditions. September was chosen because it is the driest month of the year based on the median streamflow. These results indicate that while the median flow is not significantly different under pre- and post-impact conditions, there is generally less variability under post-impact conditions. Figures 4, 5, 6, 7 and 8 illustrate the 1-, 3-, 7-, 30- and 90-day minimum flows for pre- and post-impact conditions, respectively. These results indicate that the median minimum flows are greater under post-

impact conditions for flow durations ranging from 1 through 30 days, while the median 90-day minimum flow is less under post-impact conditions. There is less variability of the minimum flows for all durations.

5. CONCLUSIONS

The results in Tables 3–5 and Figures 3–8 indicate that the hydrologic regime of the North Anna River downstream of the North Anna Dam has been altered as a consequence of river impoundment and operation of NAPS. Some of the key results are summarized below.

- The median monthly flow for September, the driest month of the year, has not changed significantly with presence of the impoundment, whereas the variability in September monthly flows has decreased.
- The median 1-, 3-, 7- and 30-day minimum flows have increased while the median 90-day minimum flow has decreased with the presence of the impoundment; flow variability has decreased for all flow durations.
- The median date of minimum flow occurs 19 days later in the year with impoundment, while the median date of maximum flow occurs 22 days later in the year with the impoundment.

7. REFERENCES

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4. Indicators of Hydrologic Alteration, Version 7, User's Manual, The Nature Conservancy with Smythe Scientific Software and Totten Software Design, October 2005.

5. Bechtel Calculation No. 24830-003-G-018, "Water Budget Analysis and Lake Level Assessment," Dominion North Anna ESP Project, Rev 1, 2004.

Table 3: IHA Percentile Data for the North Anna River Near Partlow.

	Pre-impact period: 1930-1971 (42 years)						Post-impact period: 1979-2002 (24 years)					
Statistic	10%	25%	50%	75%	90%	(75-25)/50	10%	25%	50%	75%	90%	(75-25)/50
Parameter Group #1												
October	20	40	72	95.25	160.5	0.7674	40	41.5	49.5	59.25	119	0.3586
November	47.3	72.75	109.8	168.8	268.5	0.8747	40	45.38	57.5	173	254	2.22
December	66.7	105.3	156	227	290.2	0.7804	40	45.75	157	245	323	1.269
January	95.5	159	240	353	447.9	0.8083	40	52.5	250.5	407.5	537	1.417
February	142.4	200.3	307	405.3	484.8	0.6678	42.5	177.8	294.8	374.9	569.5	0.6688
March	195.1	223.8	312.5	400.3	546.5	0.5648	83.5	175.5	241.5	367	827.5	0.793
April	157.2	213.6	292.5	388	494.6	0.5962	48	173	204.5	361.5	816	0.9218
May	110.5	138.5	175.5	260.5	375.6	0.6952	40	56	162.5	249.5	353.5	1.191
June	70	80.5	106.3	148.8	204.4	0.6424	40	42.63	56.75	121.3	193.3	1.385
July	36.2	49.5	75.5	107.5	168.7	0.7682	40	41.25	53	65.75	179.5	0.4623
August	15.3	42	66.5	101.8	176.4	0.8985	40	40.5	52	59.5	95.5	0.3654
September	12.3	25.38	47	94.5	130.7	1.471	40	40.75	46.75	56.63	120	0.3396
Parameter Group #2												
1-day minimum	3	7.25	15	32.5	48.2	1.683	29	39.25	40	42	44	0.06875
3-day minimum	3	8.667	18.17	33.33	49.07	1.358	35.83	40	40	43.08	45.5	0.07708
7-day minimum	3.4	10.86	21.43	37.39	52.16	1.238	38.29	40	41.71	44.46	47	0.107
30-day minimum	7.857	17.39	36.57	60.68	88.26	1.184	37.67	40.46	44.25	49.92	54.27	0.2137
90-day minimum	20.62	36.13	72.87	95.38	122.7	0.8132	32.44	41.25	48.54	70.96	93.42	0.6122
1-day maximum	1898	2541	4142	4916	8274	0.5734	722	2943	4465	7153	8240	0.9429
3-day maximum	1380	1892	3105	4043	6413	0.6926	501.5	2258	3318	5483	7322	0.9719
7-day maximum	818.2	1191	1728	2641	3642	0.8389	326.7	1537	2363	3352	4658	0.7684
30-day maximum	469.3	628.1	886.9	1080	1519	0.509	226.2	643.9	949.2	1447	1836	0.8462
90-day maximum	333.5	449.8	585.9	671.8	807.3	0.3788	121.9	417.2	615	821	1195	0.6566
Number of zero days	0	0	0	0	0	0	0	0	0	0	0	0
Base flow	0.02178	0.03183	0.09145	0.1307	0.1671	1.081	0.08496	0.1025	0.1635	0.2446	0.695	0.8693
Parameter Group #3												
Date of minimum	226.2	232	257	275.8	287	0.1195	155.5	228.5	275.5	303	350.5	0.2036
Date of maximum	302.4	363	62.5	149.3	230	0.416	322.5	35.25	84	114.3	184	0.2158
Parameter Group #4												
Low pulse count	1.6	5	8	11	13	0.75	0.5	6	8	15	19.5	1.125
Low pulse duration	3.1	4.5	6.5	9.5	13	0.7692	2.3	3	4	5.625	14.05	0.6563
High pulse count	11	13.75	16	20.25	22.7	0.4063	0.5	9.5	14	21.25	25	0.8393
High pulse duration	2	2	3	3.5	4	0.5	2	2.375	4	5	5.85	0.6563
Parameter Group #5												
Rise rate	11.45	18.38	24.75	35.63	58.55	0.697	3	6.5	17	109.9	364	6.081
Fall rate	-28.35	-19	-15	-11	-9	-0.5333	-133	-72.75	-26.25	-10	-3	-2.39
Number of reversals	91	96	103.5	116.3	125	0.1957	14	58.5	109.5	129	138.5	0.6438

Table 3: IHA Percentile Data for the North Anna River Near Partlow (continued).

Statistic	Pre-impact period: 1930-1971 (42 years)						Post-impact period: 1979-2002 (24 years)					
	10%	25%	50%	75%	90%	(75-25)/50	10%	25%	50%	75%	90%	(75-25)/50
EFC Monthly Low Flows												
October Low Flow	41	47.5	71	90.25	119.9	0.6021	40	41.5	49.5	57.75	62.5	0.3283
November Low Flow	48	72.75	102	129.5	199.2	0.5564	40	44.5	54	71	173	0.4907
December Low Flow	64.8	92	127	167	224.1	0.5906	40	46.13	68.5	176.8	199.2	1.907
January Low Flow	79.6	127	179	234.8	261.4	0.602	41.2	53	113.5	188	212.5	1.189
February Low Flow	106.8	139.5	196	252	267.2	0.574	40	56	156	215.5	264	1.022
March Low Flow	147.8	189.4	231.3	267.3	290.2	0.3368	42.4	63.5	158	186.8	227.2	0.7801
April Low Flow	139.9	163	232	263.5	287.2	0.4332	58.25	68.25	151.5	187.8	261.8	0.7888
May Low Flow	104.1	125	156.5	196.9	236	0.4593	40	55	70	143	176.6	1.257
June Low Flow	67.6	73.5	99.5	133.1	147	0.5992	40	42	53	64	97	0.4151
July Low Flow	43.15	47.25	63.5	95.13	109.9	0.7539	40	41	52.5	61	128.8	0.381
August Low Flow	35.6	45.75	59.75	79.25	127	0.5607	40	42	50	58	88.8	0.32
September Low Flow	34.1	42	54.25	88.63	110	0.8594	40	42	47	55.5	63	0.2872
EFC Flow Parameters												
Extreme low peak	12	16.75	20.5	25	27	0.4024	20	20	20	20	20	0
Extreme low duration	1	2	5.5	8.75	17	1.227	1	1	85.75	170.5	170.5	1.977
Extreme low timing	207	231.3	249.5	267	286.5	0.09768	245.5	245.5	275.3	305	305	0.1626
Extreme low freq.	0	0	2	4	5	2	0	0	0	0	0.5	0
High flow peak	330.3	386.1	446.8	529.8	647.9	0.3215	264.2	355.1	538.5	640	1377	0.529
High flow duration	3	3.5	4	5	5.5	0.375	3	3	4.5	5.5	7.35	0.5556
High flow timing	53.15	82.75	113.8	188.5	228.8	0.2889	31.45	60.63	83	118	184	0.1568
High flow frequency	14	16	19	22	24.7	0.3158	0.5	11.25	14.5	20.75	26.5	0.6552
High flow rise rate	108.9	129.6	166.1	195	230.8	0.3935	122	137.7	230	304	357	0.7231
High flow fall rate	-139.1	-102.2	-90.54	-77.67	-70.46	-0.2713	-280.8	-173.9	-122.5	-97.53	-86.34	-0.623
Small Flood peak	4281	4409	4641	5693	7495	0.2767	4255	4615	5940	6741	8060	0.358
Small Flood duration	7.8	10.5	24.25	50.5	120.7	1.649	8	10.75	19	31.88	56.5	1.112
Small Flood timing	324	0.75	47	153.8	252.1	0.418	13.5	32.63	122	203.3	322.5	0.4662
Small Flood freq.	0	0	0	1	1	0	0	0	1	1	2	1
Small Flood riserate	257.3	450.4	853.5	1549	2555	1.287	405.1	655.2	1093	2249	3087	1.458
Small Flood fallrate	-1032	-642.4	-333.9	-99.59	-60.86	-1.626	-1136	-826.7	-439.5	-299.6	-197.4	-1.199
Large flood peak	8580	8775	11430	17590	18960	0.7713	8330	8330	9165	10000	10000	0.1822
Large flood duration	8	9.75	18	22.5	23	0.7083	26	26	27	28	28	0.07407
Large flood timing	118	146.8	233.5	276.8	291	0.3552	57	57	73	89	89	0.08743
Large flood freq.	0	0	0	0	0.7	0	0	0	0	0	0.5	0
Large flood rise	1034	1305	2166	7626	9431	2.918	1103	1103	1901	2700	2700	0.8402
Large flood fall	-2690	-2345	-1069	-519.3	-417.1	-1.709	-519	-519	-415.5	-311.9	-311.9	-0.4984

Table 4: Non-Parametric IHA Scorecard for the North Anna River Near Partlow.

Statistic	Pre-impact period: 1930-1971 (42 years)	Post-impact period: 1979-2002 (24 years)
Watershed area	344	344
Mean annual flow	291.9	284.3
Mean flow/area	0.85	0.83
Annual C. V.	0.49	0.64
Flow predictability	0.39	0.49
Constancy/predictability	0.62	0.76
% of floods in 60d period	0.23	0.22
Flood-free season	3	5

	MEDIANS		COEFF. of DISP.		DEVIATION FACTOR		SIGNIFICANCE COUNT	
Statistic	Pre	Post	Pre	Post	Medians	C.D.	Medians	C.D.
Parameter Group #1								
October	72	49.5	0.7674	0.3586	0.3125	0.5327	0.1131	0.1421
November	109.8	57.5	0.8747	2.22	0.4761	1.537	0.06406	0.002002
December	156	157	0.7804	1.269	0.00641	0.6261	0.976	0.08008
January	240	250.5	0.8083	1.417	0.04375	0.7532	0.9259	0.06607
February	307	294.8	0.6678	0.6688	0.0399	0.001549	0.5686	0.998
March	312.5	241.5	0.5648	0.793	0.2272	0.404	0.1261	0.1481
April	292.5	204.5	0.5962	0.9218	0.3009	0.5462	0.04204	0.08709
May	175.5	162.5	0.6952	1.191	0.07407	0.713	0.4254	0.06306
June	106.3	56.75	0.6424	1.385	0.4659	1.157	0.01401	0.00
July	75.5	53	0.7682	0.4623	0.298	0.3983	0.1111	0.1451
August	66.5	52	0.8985	0.3654	0.218	0.5933	0.1071	0.09009
September	47	46.75	1.471	0.3396	0.005319	0.7691	0.9499	0.1071
Parameter Group #2								
1-day minimum	15	40	1.683	0.06875	1.667	0.9592	0.00	0.05506
3-day minimum	18.17	40	1.358	0.07708	1.202	0.9432	0.00	0.04705
7-day minimum	21.43	41.71	1.238	0.107	0.9467	0.9136	0.00	0.05205
30-day minimum	36.57	44.25	1.184	0.2137	0.2101	0.8194	0.02002	0.07508
90-day minimum	72.87	48.54	0.8132	0.6122	0.3339	0.2472	0.1031	0.3013
1-day maximum	4142	4465	0.5734	0.9429	0.07798	0.6444	0.4875	0.1822
3-day maximum	3105	3318	0.6926	0.9719	0.06888	0.4032	0.6907	0.2472
7-day maximum	1728	2363	0.8389	0.7684	0.3675	0.08395	0.05205	0.7518
30-day maximum	886.9	949.2	0.509	0.8462	0.07022	0.6625	0.5986	0.1061
90-day maximum	585.9	615	0.3788	0.6566	0.04959	0.7332	0.5726	0.06707
Number of zero days	0	0	0	0			0.00	0.00
Base flow	0.09145	0.1635	1.081	0.8693	0.7877	0.1957	0.00	0.6166

Table 4: Non-Parametric IHA Scorecard for the North Anna River Near Partlow (continued).

Statistic	MEDIANS		COEFF. of DISP.		DEVIATION FACTOR		SIGNIFICANCE COUNT	
	Pre	Post	Pre	Post	Medians	C.D.	Medians	C.D.
Parameter Group #3								
Date of minimum	257	275.5	0.1195	0.2036	0.1011	0.7029	0.1421	0.02503
Date of maximum	62.5	84	0.416	0.2158	0.1175	0.4811	0.4845	0.1321
Parameter Group #4								
Low pulse count	8	8	0.75	1.125	0	0.5	0.7948	0.1361
Low pulse duration	6.5	4	0.7692	0.6563	0.3846	0.1469	0.03804	0.7157
High pulse count	16	14	0.4063	0.8393	0.125	1.066	0.1131	0.01602
High pulse duration	3	4	0.5	0.6563	0.3333	0.3125	0.003003	0.1552
Low Pulse Threshold	76							
High Pulse Level	296							
Parameter Group #5								
Rise rate	24.75	17	0.697	6.081	0.3131	7.725	0.08709	0.00
Fall rate	-15	-26.25	-0.5333	-2.39	0.75	3.482	0.00	0.003003
Number of reversals	103.5	109.5	0.1957	0.6438	0.05797	2.291	0.3814	0.001001
EFC Low flows								
October Low Flow	71	49.5	0.6021	0.3283	0.3028	0.4548	0.05806	0.1662
November Low Flow	102	54	0.5564	0.4907	0.4706	0.118	0.05806	0.6667
December Low Flow	127	68.5	0.5906	1.907	0.4606	2.229	0.01401	0.00
January Low Flow	179	113.5	0.602	1.189	0.3659	0.9759	0.01001	0.01301
February Low Flow	196	156	0.574	1.022	0.2041	0.7813	0.1071	0.04505
March Low Flow	231.3	158	0.3368	0.7801	0.3168	1.316	0.007007	0.003003
April Low Flow	232	151.5	0.4332	0.7888	0.347	0.8209	0.02402	0.03303
May Low Flow	156.5	70	0.4593	1.257	0.5527	1.737	0.00	0.00
June Low Flow	99.5	53	0.5992	0.4151	0.4673	0.3073	0.002002	0.2743
July Low Flow	63.5	52.5	0.7539	0.381	0.1732	0.4947	0.1111	0.1201
August Low Flow	59.75	50	0.5607	0.32	0.1632	0.4293	0.09109	0.2272
September Low Flow	54.25	47	0.8594	0.2872	0.1336	0.6658	0.1792	0.0951
EFC Parameters								
Extreme low peak	20.5	20	0.4024	0	0.02439	1	0.7107	0.08609
Extreme low duration	5.5	85.75	1.227	1.977	14.59	0.6106	0.00	0.4484
Extreme low timing	249.5	275.3	0.09768	0.1626	0.1407	0.6643	0.005005	0.1872
Extreme low freq.	2	0	2	0	1	1	0.00	0.00
High flow peak	446.8	538.5	0.3215	0.529	0.2054	0.6455	0.05205	0.05105
High flow duration	4	4.5	0.375	0.5556	0.125	0.4815	0.03504	0.5115
High flow timing	113.8	83	0.2889	0.1568	0.168	0.4574	0.07107	0.3183
High flow frequency	19	14.5	0.3158	0.6552	0.2368	1.075	0.006006	0.009009
High flow rise rate	166.1	230	0.3935	0.7231	0.3845	0.8375	0.00	0.01802
High flow fall rate	-90.54	-122.5	-0.2713	-0.623	0.3534	1.297	0.00	0.008008

Table 4: Non-Parametric IHA Scorecard for the North Anna River Near Partlow (continued).

Statistic	MEDIANS		COEFF. of DISP.		DEVIATION FACTOR		SIGNIFICANCE COUNT	
	Pre	Post	Pre	Post	Medians	C.D.	Medians	C.D.
Small Flood peak	4641	5940	0.2767	0.358	0.2799	0.2934	0.07808	0.4394
Small Flood duration	24.25	19	1.649	1.112	0.2165	0.3259	0.5766	0.5636
Small Flood timing	47	122	0.418	0.4662	0.4098	0.1152	0.5475	0.7237
Small Flood freq.	0	1	0	1			0.00	0.00
Small Flood riserate	853.5	1093	1.287	1.458	0.281	0.1332	0.4515	0.8088
Small Flood fallrate	-333.9	-439.5	-1.626	-1.199	0.3161	0.2621	0.3043	0.5546
Large flood peak	11430	9165	0.7713	0.1822	0.198	0.7638	0.4715	0.3974
Large flood duration	18	27	0.7083	0.07407	0.5	0.8954	0.1171	0.2432
Large flood timing	233.5	73	0.3552	0.08743	0.877	0.7538	0.2432	0.1812
Large flood freq.	0	0	0	0			0.00	0.00
Large flood rise	2166	1901	2.918	0.8402	0.1222	0.7121	0.7558	0.5175
Large flood fall	-1069	-415.5	-1.709	-0.4984	0.6112	0.7083	0.4294	0.3003

Table 5: IHA Non-Parametric RVA Scorecard for the North Anna River Near Partlow.

Statistic	Pre-impact period: 1930-1971				Post-impact period: 1979-2002				RVA Boundaries		Hydrologic Alteration
	Medians	Coeff. of Dispersion	Minimum	Maximum	Medians	Coeff. of Dispersion	Minimum	Maximum	Low	High	(Middle Category)
Parameter Group #1											
October	72	0.7674	4	426	49.5	0.3586	40	320	48	79.81	0.4
November	109.8	0.8747	20	310.5	57.5	2.22	20	408.5	84.79	145.3	-0.875
December	156	0.7804	29	630	157	1.269	20	543	120	208.9	-0.4167
January	240	0.8083	51	778	250.5	1.417	20	690	181.7	327.6	-0.5
February	307	0.6678	64	881	294.8	0.6688	20	2395	210.6	362.6	0.25
March	312.5	0.5648	108	630	241.5	0.793	20	1796	269.5	376.7	-0.25
April	292.5	0.5962	119	523	204.5	0.9218	20	1220	243.7	326.8	-0.75
May	175.5	0.6952	88	569	162.5	1.191	20	359	149	220.2	-0.3
June	106.3	0.6424	57	424	56.75	1.385	20	199	82.5	131.3	-0.7667
July	75.5	0.7682	20	525	53	0.4623	20	352	54.19	98.81	0
August	66.5	0.8985	9	380	52	0.3654	20	173	48	88.24	0.2833
September	47	1.471	3	169	46.75	0.3396	20	187	37.29	79.91	1.625
Parameter Group #2											
1-day minimum	15	1.683	1	101	40	0.06875	20	46	9.19	27.81	-0.75
3-day minimum	18.17	1.358	1.667	104.3	40	0.07708	20	50	10.4	31.27	-0.875
7-day minimum	21.43	1.238	1.857	117.3	41.71	0.107	20	52	12.08	36.11	-0.875
30-day minimum	36.57	1.184	3.467	122.2	44.25	0.2137	20	90.03	23.09	48.91	1
90-day minimum	72.87	0.8132	6.744	223.6	48.54	0.6122	20	265	47.5	91.6	0.375
1-day maximum	4142	0.5734	1092	18960	4465	0.9429	40	10000	2899	4648	0.25
3-day maximum	3105	0.6926	886.7	16100	3318	0.9719	40	7667	2090	3606	0
7-day maximum	1728	0.8389	541.7	8467	2363	0.7684	40	5423	1314	2175	-0.125
30-day maximum	886.9	0.509	337.9	2187	949.2	0.8462	34.67	3698	671.3	987.3	-0.125
90-day maximum	585.9	0.3788	249.3	1207	615	0.6566	24.89	1931	477.2	637.5	-0.25
Number of zero days	0	0	0	0	0	0	0	0	0	0	-7.947E-08
Base flow	0.09145	1.081	0.009916	0.2081	0.1635	0.8693	0.06773	0.9383	0.04014	0.1133	0
Parameter Group #3											
Date of minimum	257	0.1195	184	301	275.5	0.2036	17	358	246.2	273.8	-0.875
Date of maximum	62.5	0.416	1	365	84	0.2158	12	335	87.28	233.8	0.375
Parameter Group #4											
Low pulse count	8	0.75	0	21	8	1.125	0	25	6.19	10	-0.2344
Low pulse duration	6.5	0.7692	3	18	4	0.6563	2	266	5.43	8.5	-0.6719
High pulse count	16	0.4063	7	25	14	0.8393	0	27	15	17.81	-0.8833
High pulse duration	3	0.5	2	5	4	0.6563	2	11	2.095	3	-0.7941
The low pulse threshold is			76								
The high pulse level is			296								

Table 5: IHA Non-Parametric RVA Scorecard for the North Anna River Near Partlow (continued).

Statistic	Pre-Impact period: 1930-1971				Post-Impact period: 1979-2002				RVA Boundaries		Hydrologic Alteration
	Medians	Coeff. of Dispersion	Minimum	Maximum	Medians	Coeff. of Dispersion	Minimum	Maximum	Low	High	(Middle Category)
Parameter Group #5											
Rise rate	24.75	0.697	7	102.5	17	6.081	2	1008	21.1	29.91	-0.875
Fall rate	-15	-0.5333	-36	-6	-26.25	-2.39	-136	-2	-17.41	-11.19	-0.375
Number of reversals	103.5	0.1957	81	141	109.5	0.6438	3	145	98.19	113	-0.4167

Assessment of Hydrologic Alteration

Statistic	Middle RVA Category			High RVA Category			Low RVA Category		
	Expected	Observed	Alter.	Expected	Observed	Alter.	Expected	Observed	Alter.
Parameter Group #1									
October	8.571	12	0.4	8	2	-0.75	7.429	10	0.3462
November	8	1	-0.875	8	7	-0.125	8	16	1
December	8.571	5	-0.4167	8	8	0	7.429	11	0.4808
January	8	4	-0.5	8	9	0.125	8	11	0.375
February	8	10	0.25	8	6	-0.25	8	8	0
March	8	6	-0.25	8	5	-0.375	8	13	0.625
April	8	2	-0.75	8	9	0.125	8	13	0.625
May	8.571	6	-0.3	8	7	-0.125	7.429	11	0.4808
June	8.571	2	-0.7667	8	5	-0.375	7.429	17	1.288
July	8	8	0	8	4	-0.5	8	12	0.5
August	8.571	11	0.2833	8	3	-0.625	7.429	10	0.3462
September	8	21	1.625	8	2	-0.75	8	1	-0.875
Parameter Group #2									
1-day minimum	8	2	-0.75	8	22	1.75	8	0	-1
3-day minimum	8	1	-0.875	8	23	1.875	8	0	-1
7-day minimum	8	1	-0.875	8	23	1.875	8	0	-1
30-day minimum	8	16	1	8	7	-0.125	8	1	-0.875
90-day minimum	8	11	0.375	8	2	-0.75	8	11	0.375
1-day maximum	8	10	0.25	8	10	0.25	8	4	-0.5
3-day maximum	8	8	0	8	11	0.375	8	5	-0.375
7-day maximum	8	7	-0.125	8	12	0.5	8	5	-0.375
30-day maximum	8	7	-0.125	8	10	0.25	8	7	-0.125
90-day maximum	8	6	-0.25	8	10	0.25	8	8	0
Number of zero days	24	24	-7.947E-08	0	0	0	0	0	0
Base flow	8	8	0	8	16	1	8	0	-1

Table 5: IHA Non-Parametric RVA Scorecard for the North Anna River Near Partlow (continued).

Statistic	Middle RVA Category			High RVA Category			Low RVA Category		
	Expected	Observed	Alter.	Expected	Observed	Alter.	Expected	Observed	Alter.
Parameter Group #3									
Date of minimum	8	1	-0.875	8	15	0.875	8	8	0
Date of maximum	8	11	0.375	8	4	-0.5	8	9	0.125
Parameter Group #4									
Low pulse count	9.143	7	-0.2344	6.857	10	0.4583	8	7	-0.125
Low pulse duration	9.143	3	-0.6719	7.429	3	-0.5962	7.429	16	1.154
High pulse count	8.571	1	-0.8833	8	10	0.25	7.429	13	0.75
High pulse duration	9.714	2	-0.7941	6.286	15	1.386	8	5	-0.375
Parameter Group #5									
Rise rate	8	1	-0.875	8	9	0.125	8	14	0.75
Fall rate	8	5	-0.375	8	6	-0.25	8	13	0.625
Number of reversals	8.571	5	-0.4167	7.429	11	0.4808	8	8	0

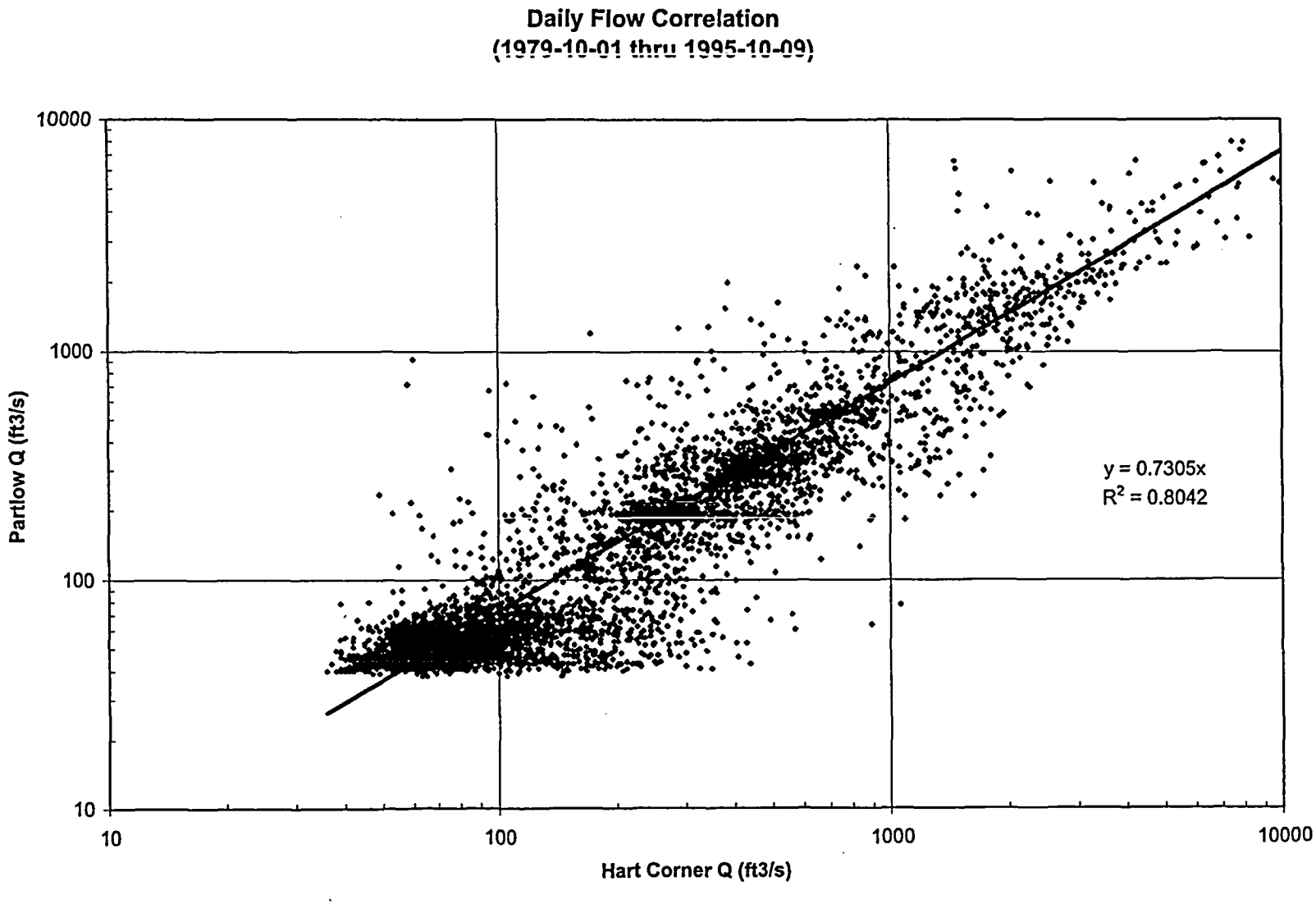

Figure 2: Correlation in North Anna River Daily Flows Observed at the Partlow and Hart Corner Gauging Stations.

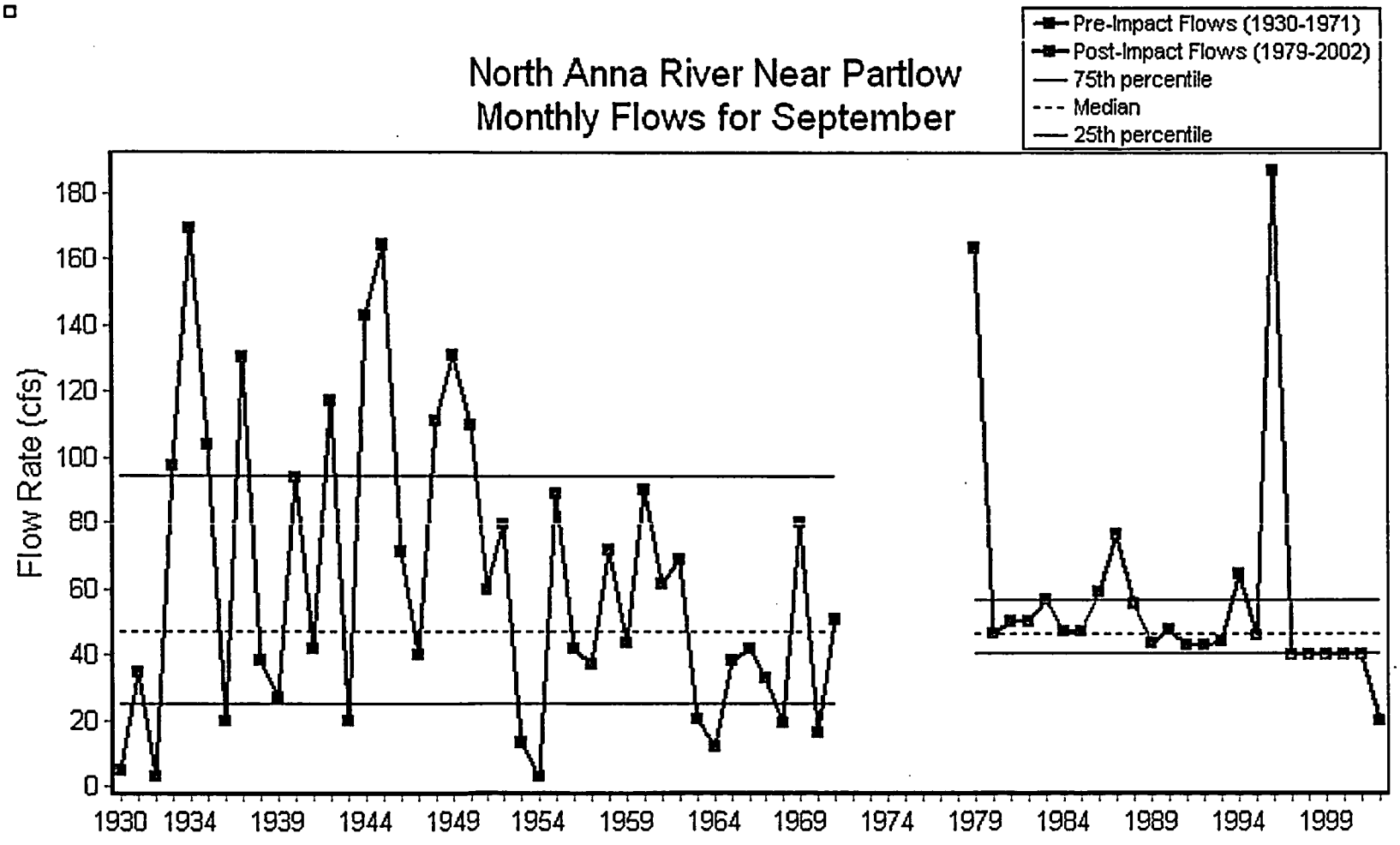

Figure 3: September Monthly Flows for the North Anna River Near Partlow.

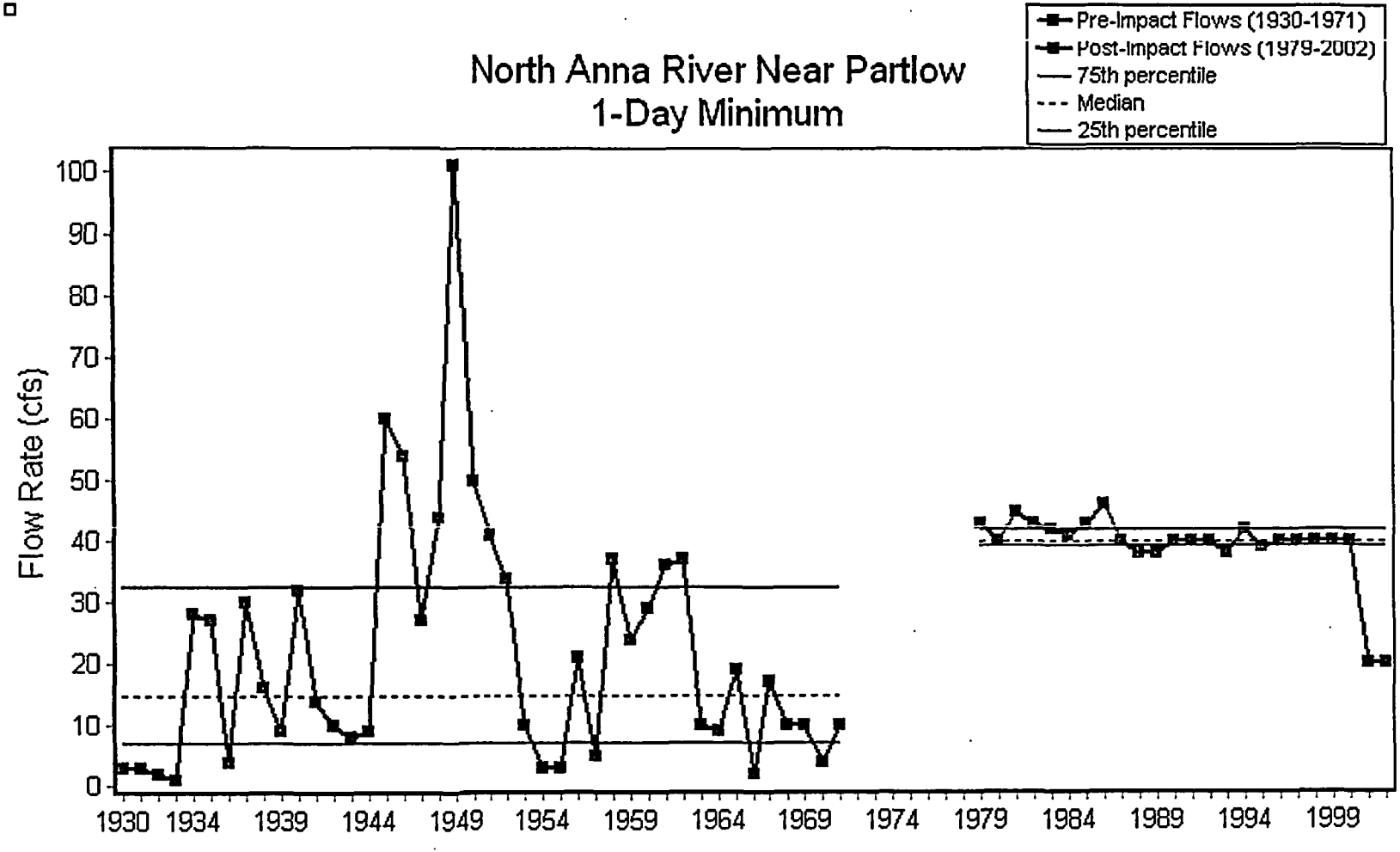

Figure 4: 1-day Minimum Low Flows for the North Anna River Near Partlow.

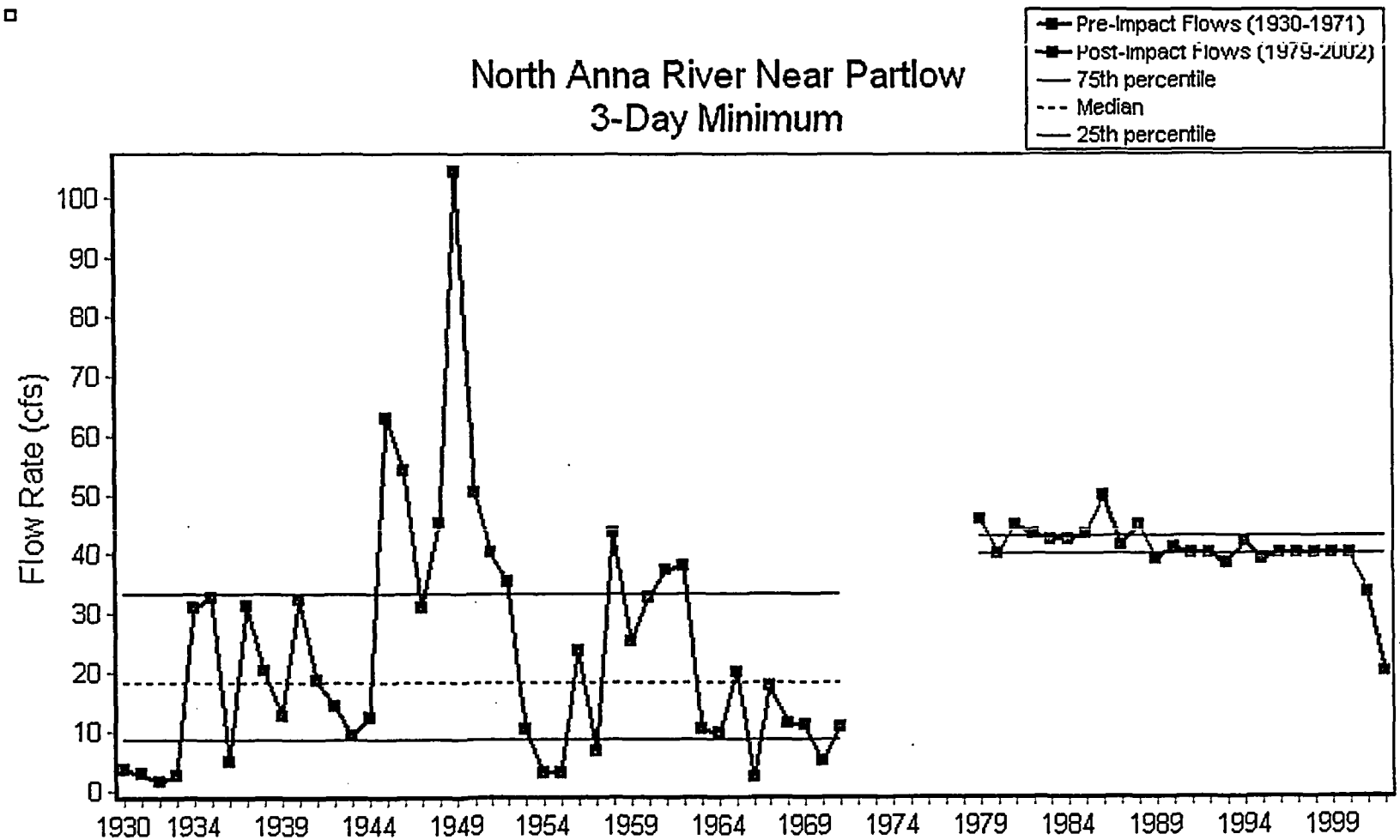

Figure 5: 3-day Minimum Low Flows for the North Anna River Near Partlow.

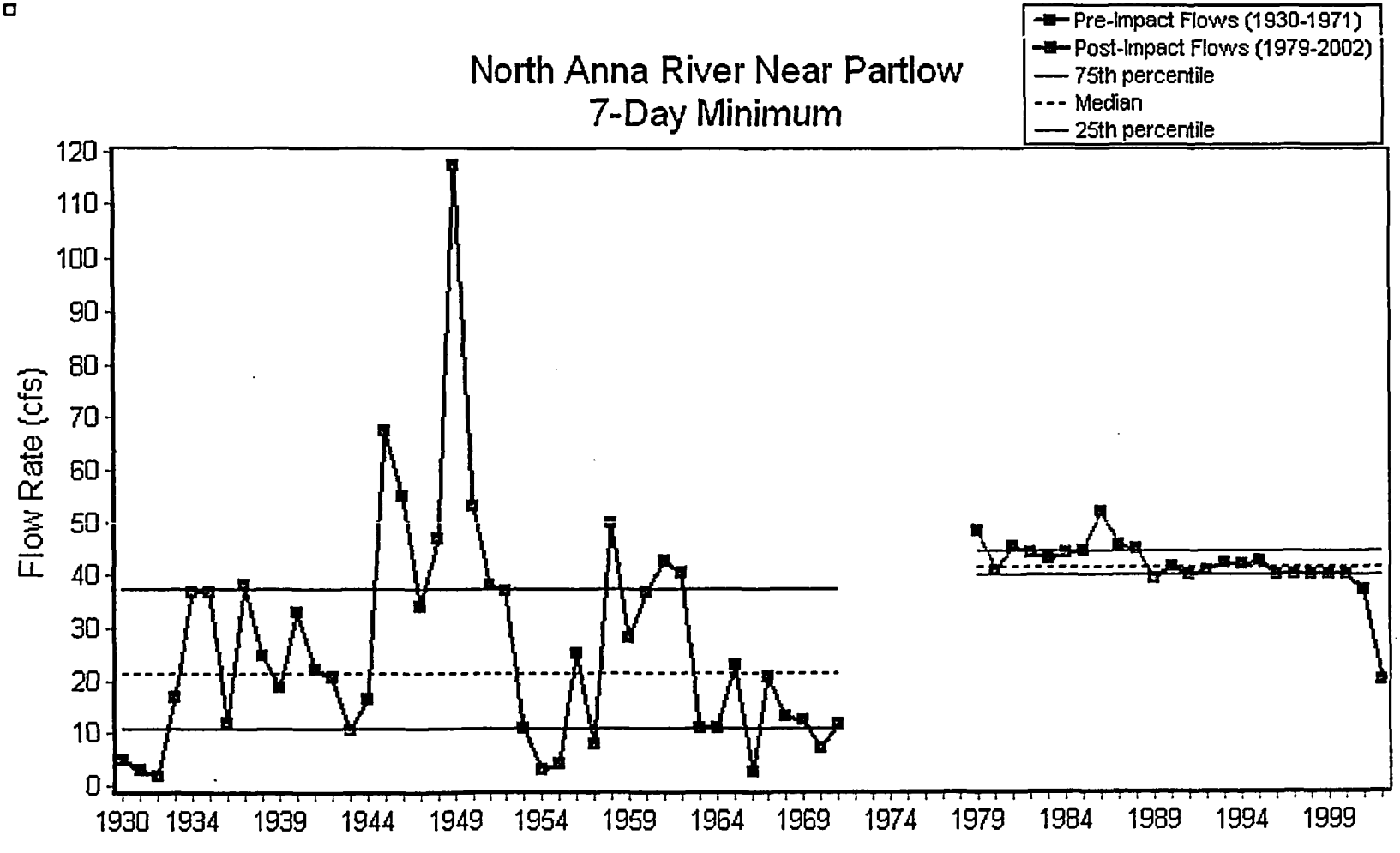

Figure 6: 7-day Minimum Low Flows for the North Anna River Near Partlow.

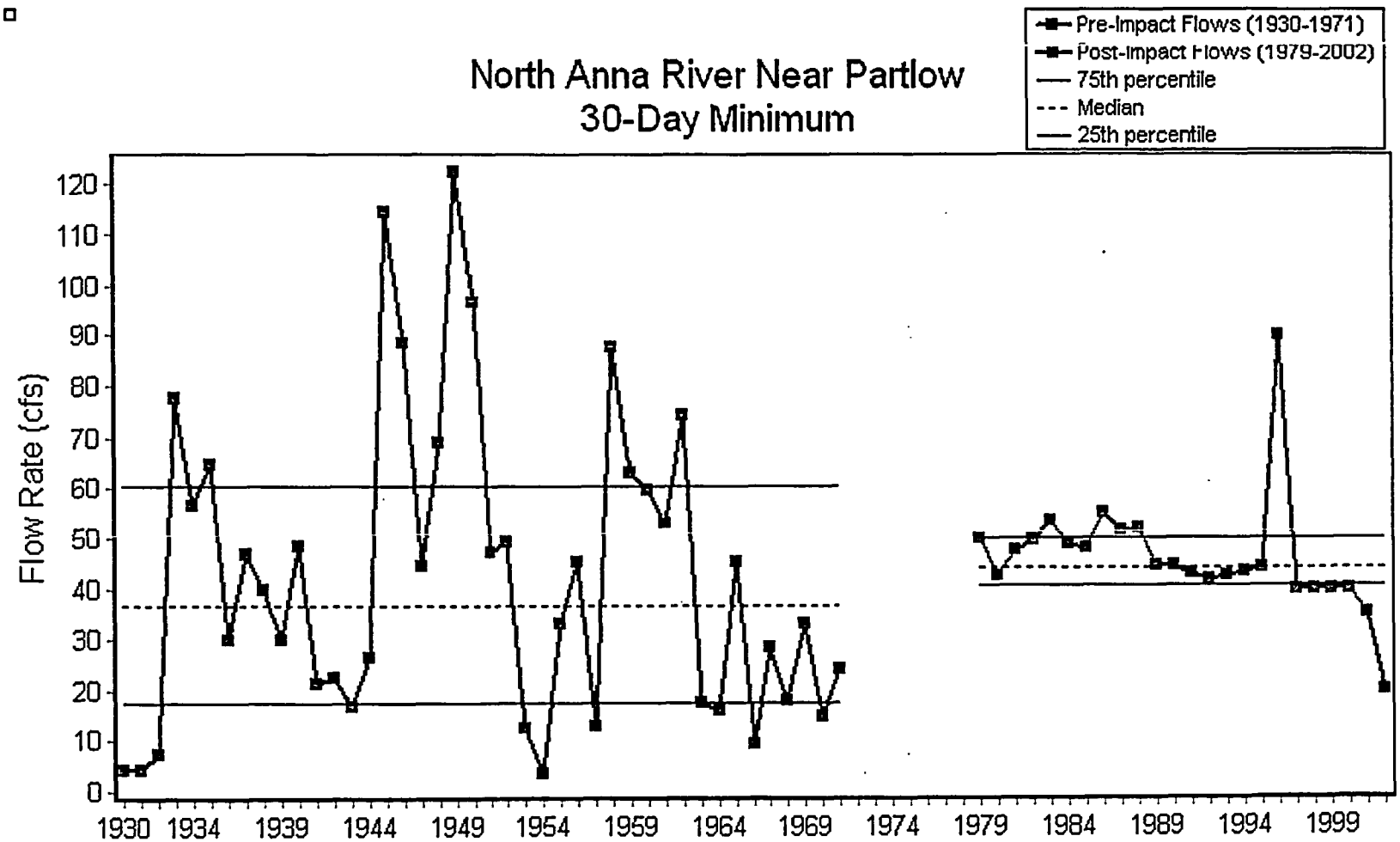

Figure 7: 30-day Minimum Low Flows for the North Anna River Near Partlow.

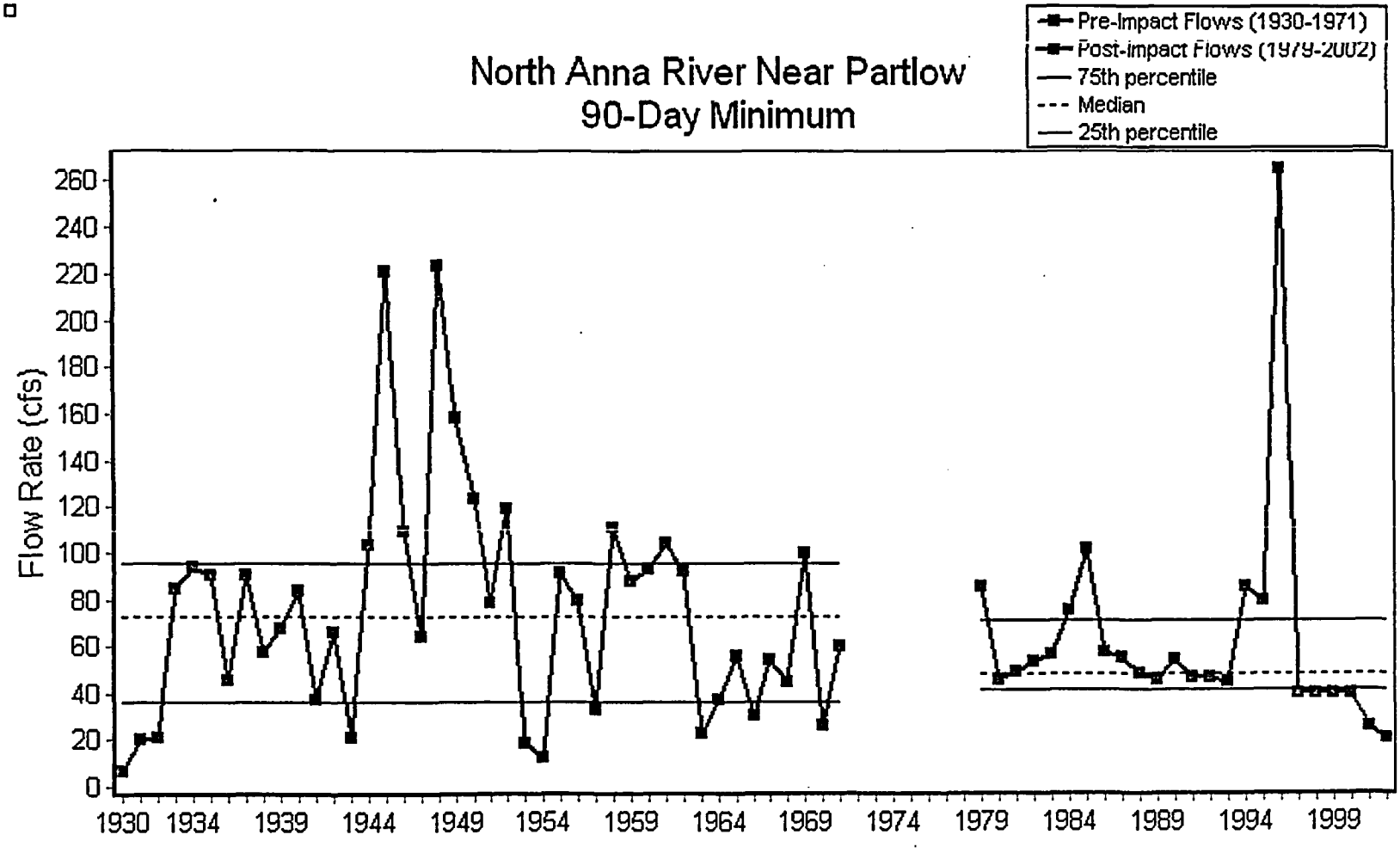

Figure 8: 90-day Minimum Low Flows for the North Anna River Near Partlow.

DEQ's North Anna ESP Cooling Questions

Responses Provided on December 9, 2005

Revised to indicate updated information as of 03/31/2006

Received from Mr. Joseph Hassell [DEQ-DWR] on 11/22/2006

1. At the meeting on November 18, 2005, Dominion presented some new figures. Specifically Dominion said that the new cooling system would cost $200 million dollars, would use 20 MW of electricity to power the fans and would result in maximum drawdown of 244.5 and a drawdown 2 feet or greater 6.8% of the time. To make such statements, Dominion has contemplated the size, operating rules and design of the cooling system.

   Discuss the assumptions that went into these conclusions. Specifically:

   a. When does Dominion operate in water conservation mode? Is it as soon as the water level drops below the crest of the spillway?

   b. When does Dominion operate in energy conservation mode? Is it as soon as outflow exceeds 40 cfs, i.e., as soon as water the water level returns to 250 feet msl?

   c. What is the cooling capacity of the new system

      i. How many units are there

      ii. What is the average heat rejection capacity per unit (wet and dry)

      iii. What are the ambient air and water temperature conditions used in answering 1.c.ii.

   The system and operating assumptions are for a conceptual cooling system design that is used for the purpose of evaluating potential effects of the closed cooling system. Final design parameters, details and operating strategy will be developed during the design phase of the plant. The design concept that is the basis of these answers is used to assess potential impact and project feasibility.

   The conceptual operating strategy would place the cooling system in the water conservation mode whenever the lake level falls below 250 ft. The transition to water conservation mode occurs after a period of time (assumed to be seven days for purposes of analysis) when the operating staff is allowed to attempt to return lake level to 250 ft by reducing the downstream release in accordance with dam operating rules. If this cannot be accomplished during the allowed time, the water conservation mode is entered. The system is assumed to remain in water conservation mode until the lake level is returned to at least 250 ft.

   The energy conservation mode is assumed to be in effect when the lake level is at or above 250 ft.

   The cooling system utilizes a combination of wet and dry cooling towers. The basic design conceptual performance is for one-third of the heat to be rejected by dry towers and two-thirds of the heat by wet towers during the worst ambient conditions for cooling tower performance. 100 dry units and 42 wet units are required. Ten additional wet units are provided to enable the system to reject all the heat using wet units in the energy conservation mode of operation, resulting in a total of 52 wet units.

The average heat rejection per unit at maximum design conditions in the water conservation mode is:

Type	Average Heat Rejection per unit(cell) (million Btu/hr)
Dry Tower Unit	33.7
Wet Tower Unit	157.8

The maximum design conditions assumed are:

Dry Tower

Air Temperature	95 °F Dry Bulb, 79 °F Wet Bulb (non-coincident)
Water Temperature In	129.7 °F
Water Temperature Out	119.7 °F

Wet Tower

Air Temperature	79 °F Wet Bulb
Water Temperature In	119.7 °F
Water Temperature Out	100 °F

2. You mentioned that in energy conservation mode – "Dry cooling will be reduced with reliance mostly on wet towers for heat removal." What does "mostly" mean? Is it possible to remove 100% of the waste heat through wet cooling, if so under what range water temperature and ambient air conditions can this occur? If the cooling process is operating under maximum energy conservation mode, how much energy is used to operate just the wet cooling process vs. the dry cooling process? You said that 20 MW was needed to run the fans. How much energy is used just to run the pumps? You said in Maximum Water Conservation mode that one third of the heat will be removed by energy conservation.

   The energy conservation mode assumes that 100% of the heat rejection is accomplished using wet towers. A small amount of heat transfer is achieved in the dry coolers as the water passes through the tubes when the fans are off; however, the analysis does not take credit for this benefit. To provide 100% cooling using wet towers, ten additional units are provided. The maximum design conditions remain the same as indicated above for the wet towers.

   In the energy conservation mode (100% wet cooling assumed), about 11 MW are required to operate the fans. The power required to operate the dry towers to provide one-third of the heat removal would be 15 MW. These dry towers would be operated in the maximum water conservation mode.

   The pumps that force water through the cooling tower system are the Circulating Water pumps. The power requirement for these pumps is determined by factors that will be developed during the final design phase of the project. Generally speaking, the power required to force the water through the Main Condenser, the cooling tower field and connecting piping and to lift it over the elevation change is all to be determined. A rough

estimate of this power required is 22 MW. It should be noted that pumps of this type are common to power generation facilities that utilize a steam cycle, whether they are nuclear or fossil-fueled.

In the maximum water conservation mode, one-third of the heat removal is achieved using the dry towers at the maximum ambient conditions stated above. It is possible, under some ambient conditions to remove 100% of the heat using the dry towers. This is discussed in #5.

3. On average how much waste heat is produced by unit three when it is operating under full power?

   The estimated average waste heat produced by Unit 3 when it is operating is 1×10^{10} Btu/hr (2928 MWth). An additional 88 MWth of intermittent capacity is assumed for auxiliary plant cooling systems.

4. What is the maximum amount of waste heat that the wet cooling towers are capable of dispersing without using the fans? If the wet cooling towers are capable of dispersing all the waste heat without using the fans what are the ambient air and water conditions that allow this to take place.

   The wet towers are not normally operated with the fans off. The fans are required to provide the necessary airflow to cool the circulating water. There is some heat rejection in the dry towers when the fans are off, but this has not been estimated or included in the cooling tower evaluation.

5. What is the maximum amount of waste heat that can be dispersed by using just the fans, what are the ambient air and water conditions that allow this to take place?

   Assuming that this refers to the dry towers, 100% of the heat can be rejected using only the dry towers when the air temperature falls below 74 °F dry bulb. This results in a water temperature out of the towers of 100 °F, which while acceptable as a maximum, is not desirable from a long term plant efficiency standpoint. Below about 61 °F dry bulb, 100% of the heat can be rejected using dry towers alone while providing an acceptable cooling water temperature for long term plant operation.

6. You modeled your new cooling system enough to say that closed cooling would result in the lake being at less than 6.8% of the time versus 5.2% of the time historically. Was your assumption that the minimum release would be 20 cfs when lake elevations were below 248 feet msl and 40 cfs when storage levels were above msl?

   This is correct. The model assumes existing dam operating rules where the minimum release rate is 20 cfs if the lake level is below 248 ft and 40 cfs for lake levels of 248 ft and greater. The percent of time the dam release would be at 20 cfs is 7.3%.

7. What would the trigger level elevation on the lake have to be so that 20 cfs occurs no more than 5.2% of the time?

   With Unit 3 using the cooling system under the assumed operating conditions, the lower Contingency Plan level at which 20 cfs is the minimum allowed release would have to be 247.5 ft.

8. The Department of Game and Inland Fisheries has asked what increase in storage would be required to keep the frequency of mif of less than 40 cfs discharges at 5.2% of the time. Estimate how many acres of fringe wetlands and linear feet of stream such an increase in storage would flood.

   The estimated increase in storage to keep the frequency of flows less than 40 cfs equivalent to existing is 0.6 ft or about 7 inches. Dominion is not at this time proposing any increase to the normal pool level. Dominion has provided the requested estimate as response to Question 3 of the VDEQ letter dated January 31, 2006.

9. In January 2005 Dominion sent DEQ a spreadsheet created by Bechtel that showed inflow outflow and change in storage components for the existing two units and for the existing two units with a new once through cooling unit. Please produce a similar spreadsheet analysis for your new cooling system operating the system in maximum water conservation mode all the time and in the mode in which you had in mind when you met with us on November 18, 2005. What would be the average additional consumptive use over the period of record that Bechtel used for each set of rules?

   The requested spreadsheets will be provided for DEQ's use after they have been verified in early January 2006. The average consumptive use for the operating strategy previously presented is 18.5 cfs. An additional 0.9 cfs would be consumed for auxiliary plant heat loads. Using the maximum water conservation mode all the time results in an average consumption of 8.0 cfs, including consumption for auxiliary loads.

10. What is the maximum amount of water that must be supplied to unit 3 in terms of gallons per minute? What is the maximum amount of water that must be supplied to unit three in gallons per day? What are the ambient air and water temperature and any other relevant assumptions (e.g. no dry cooling) that you used to calculate these values?

    The maximum rate of water supply for Unit 3 (including auxiliary plant cooling and net of blowdown) for the energy conservation mode is 37.2 cfs. This is 24 MGD, if this rate is sustained for a full 24-hour period with no dry cooling and the maximum ambient conditions noted above in the response to #1. Sustaining makeup rates at this maximum for 24 hours would never be expected to occur. The model calculates consumption based on the average daily temperature and assumes the system is operating under those conditions all day. This consumption is then reported as a weekly average. The largest calculated weekly average consumption rate, considering all the data analyzed is 22.1 MGD.

11. How does Dominion plan to provide water to unit 3? Describe the construction processes that would be used to revive the old intake or build a new one or if you have another plan please describe that.

    There are no firm plans for how the intake structure would be provided. Dominion expects to use the abandoned Unit 3 and 4 intake area. The existing cofferdam would likely remain intact until the pump house and intake structures are constructed. An opening in the cofferdam would then be created of sufficient size to allow water to enter the bay at very low velocity. The inlet structure and screening whether constructed at the cofferdam (upstream of the pump house) or at the pump house intake will incorporate designs that significantly limit entrainment. If the intake structure is at the pump house, the cofferdam may be removed after construction of the pump house/intake structure is completed.

Received from Mr. John Kauffman [DGIF] on 11/22/2005

1. What increase in storage above elevation 250 would replicate the reduction of flows to 20 cfs to the same frequency as estimated for current conditions- 1/2 ft? 1 ft? Would a change in operating rules to water conservation all the time have any impact on the duration and frequency of flows of 20 cfs? We would also like to see a chart that provides the timing and duration of reduced flows.

   An increase in storage level of 0.6 ft (about 7 inches) above 250 ft would replicate the reduction of flows to 20 cfs to the same frequency as estimated for current conditions. Changing the operating rules to water conservation all the time would have little impact on the duration and frequency of flows of 20 cfs. This is due to the way the water budget model assumes that all flow into the lake that is not lost through natural or forced evaporation is released from the dam for lake levels above 250 ft. If the lake level falls below 250 ft, the model assumes the release rate is 40 cfs. The only difference between the water conservation and energy conservation models below 250 ft is the time period allowed to attempt to raise lake level before the water conservation mode is entered. This represents seven days at the differential consumption rate between the energy conservation mode and water conservation modes. The resulting analytical impact on lake level and time at reduced flows is small.

   The table of timing and duration of flows of 20 cfs is provided in Dominion's response to Question 8 of the VDEQ letter dated January 31, 2006. This table is provided instead of the hydrograph.

2. We are concerned about increased number of days when flows are 40 cfs because of evaporative cooling in the proposed Unit 3. Please conduct a Index of Hydrologic Analysis as was done in the draft EIS for the proposed Unit 3 changes. Please perform that analysis under two operating scenarios: a) as proposed in your November fact sheet and b) operating under water conservation rules the entire time. This would give us an idea of the potential amount of water saved as a result of increasing the utilization of the dry towers. As requested in earlier letters we would also like to see an IHA analysis of flows prior to the dam being built.

   The IHA that was performed for the ESP Application is being revised for inclusion in the ESP supplement using the proposed conceptual operating rules. An additional IHA is being performed assuming the water conservation mode is in operation at all times. These will be provided to DEQ in early January, 2006.

The MWC-only and Pre-dam analyses are provided in Attachments 1 and 2, respectively.