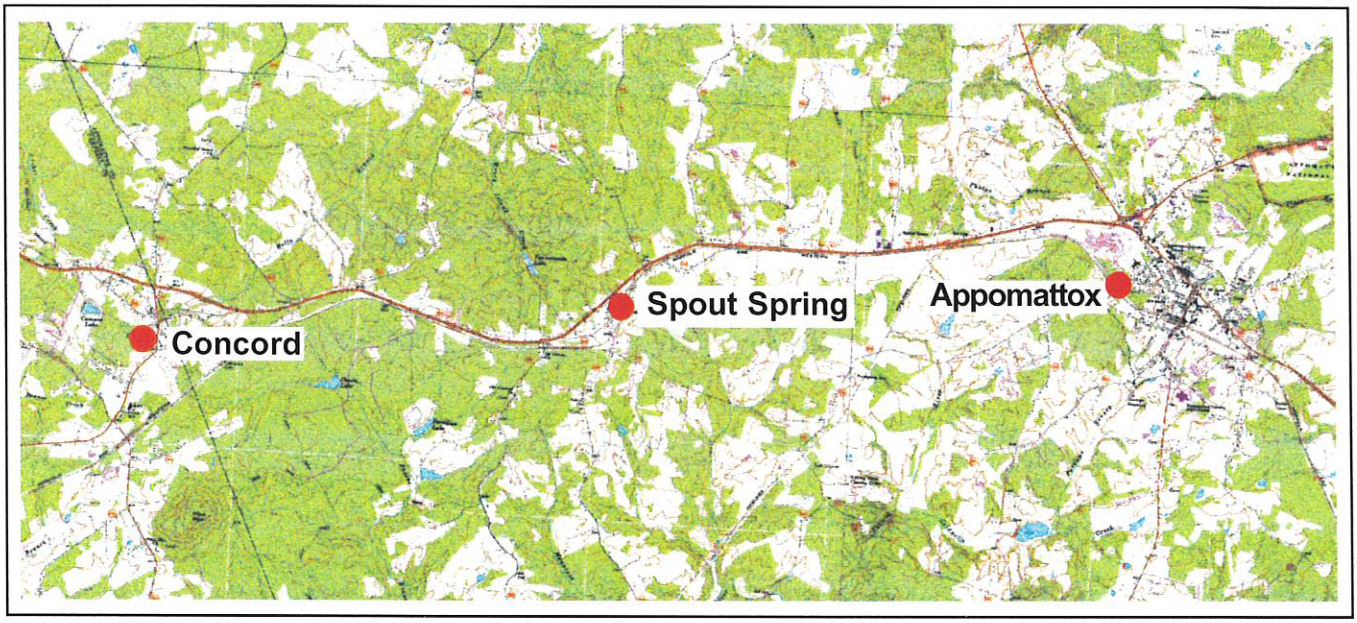
Water Source Study for the Appomattox Area



Wiley & Wilson
ARCHITECTS ENGINEERS PLANNERS
An Employee-Owned Company

Comm. No. 202150.00

August 2003

TAB

SCOPE

Wiley & Wilson was commissioned jointly by the County and Town of Appomattox to undertake an investigative study to provide and evaluate possible future development and water supply source scenarios to provide up to 2.0 million gallons per day (MGD) for a future water system. Included are alternatives for providing the area with a new water source versus the purchase and transmission of water through Campbell County from the City of Lynchburg. This study addresses the initial capital cost, operation, and maintenance costs for a comparative basis of each scenario.

PREVIOUS STUDIES

1. Comprehensive Water and Sewer Study for Town of Appomattox and Appomattox County, Wiley & Wilson, January 1991.
2. Feasibility Study for Water Services along Route 460 Corridor from City of Lynchburg to Town of Appomattox, Wiley & Wilson, January 1998.
3. 2003 Appomattox Community Development Plan (Final Draft)
4. The City of Lynchburg Water System Master Plan, Wiley & Wilson, June 2002.

Technical documents, regional studies, and data for the State of Virginia, which were applicable to the site and were used in estimation of site conditions, are noted in the text.

APPOMATTOX COUNTY WATER SYSTEMS

Currently, public water systems in Appomattox County are found only in and around the Towns of Appomattox and Pamplin. The Town of Pamplin serves approximately 100 customers. The Town of Appomattox relies on eight wells, two of which are chlorinated prior to distribution. The average daily usage is approximately 0.24 MGD. There are presently 650 residential connections, 6 manufacturing connections, 114 commercial connections, and 15 institutional connections.

The Town of Appomattox has a rated production capacity of 0.328 MGD, based on pumping capacity, and total storage of 1.10 MGD in two storage tanks.

With the exception of the Town of Pamplin and Holiday Lake State Park, both of which are on central wells, the remainder of the County has generally been rural and served by individual wells not requiring a central water system.

APPOMATTOX COUNTY GROWTH

As noted in the 2003 Community Plan, the Town of Appomattox water supply capacity would be insufficient for the planned industrial growth within the Appomattox Center for Business and Commerce as well as residential and commercial growth in and around the Town. Some of those demands would be along the developing Route 460 corridor, but would not extend to communities such as Spout Springs and Concord, which are currently supported by wells.

Development over the past decade within and outside of the Town of Appomattox has increased population and increased the taxing of the groundwater stores and/or the potential for well contamination, particularly in less monitored, non-central systems. Growth in the County and Town is addressed further in the following section on the Route 460 corridor.

LYNCHBURG TO APPOMATTOX WATERLINE

Transmission of water from Lynchburg through Campbell County along the Route 460 corridor to the Town of Appomattox has been considered for a number of years and was studied and reported previously in Reference 2. This study considered the corridor and a larger adjoining service area. The estimated demands along the corridor/service area from Reference 2 are provided in Table 1 below, along with an interim 20-year projection to year 2023. The ultimate demands include significant development in the service area adjoining the corridor.

Table 1
Water Demand Projections

Locality/User	1997 Demand* GPD	2023 Demand GPD	Ultimate Demand* GPD
Campbell County - Mt Athos			
BWX Technologies	650,000	1,000,000	1,000,000
Framatome	50,000	50,000	50,000
Subtotal	**700,000**	**1,050,000**	**1,050,000**
Campbell County - East of Mt Athos			
Thomas Terrace	30,000	36,606	36,606
Concord	28,500	45,000	45,000**
Industrial & Commercial	0	150,000	714,776
Subtotal	**58,500**	**231,606**	**796,382**
Appomattox County			
Growth (Res & Comm)	0	215,000	265,000
Appomattox Industry	0	300,000	981,320
Town of Appomattox	257,507	327,870	327,870
Subtotal	**257,507**	**842,870**	**1,574,190**
Total	**1,016,007**	**2,124,476**	**3,420,572**

* From Reference 2
**Value increased from 34,775 in Reference 2

In the current study the existing City of Lynchburg WATERCAD model for year 2010 was revised to include a transmission line to the Town of Appomattox. Demand and population projections for the City of Lynchburg are flat beyond year 2010, as shown in Table 2, which was extracted from Reference 4.

Table 2
Population Trend for the City of Lynchburg

Year	1990	2000	2010	2020
Population	66,049	65,269	65,050	65,050

The Lynchburg model includes the proposed Florida Avenue Pump Station in the City of Lynchburg and the 24-inch transmission line to a 16-inch Mt. Athos feed line. A schematic of the transmission line is depicted on Figure 1.

Table 1 flows were increased by 50 percent for the maximum day condition, as was used in the Lynchburg model and study. The transmission line was sized for both the 2023 and the ultimate demand flow conditions in Table 1, in addition to fireflow conditions adopted from Reference 2. The following were criteria for pipeline sizing:

1. Maximize pressures between 40 and 100 psi along the transmission route.
2. Provide minimum pressures of 20 psi for the fireflow requirement of 2000 GPM over 8 hours concurrent with the maximum day condition.
3. Filling of Appomattox tanks during maximum day.

The 2023 demand could be met through a 20-inch diameter line to a booster pump station in Concord and a 16-inch line from the station to connect with the existing 12-inch line in Appomattox. A second pump would be required in the booster pump station, located in Concord, to ensure fireflow protection. A backup pump and emergency power generator would be required in the booster station for emergency conditions, primarily due to the distance from the Appomattox storage tanks. It was found that through the provision of the second pump in the booster pump station that an additional storage tank along the line is not required to provide adequate pressures for the 2023

scenario. For demands exceeding those listed for 2023, a storage tank will be required near Spout Spring to ensure fireflow protection. A cost was not provided for this option since it would only be needed to serve the ultimate flows projected for both Campbell and Appomattox Counties.

The ultimate demand requires a 24-inch diameter line to a booster pump station in Concord and a 20-inch line from the station to connect with the existing 12-inch line in Appomattox. A 1 million gallon storage tank would be required at Spout Spring to ensure fireflow protection and pressures between Concord and Appomattox. The booster pump station would again require two pumps and a backup plus emergency power. The use of a 24-hour simulation model for balancing the Appomattox storage tanks permitted the selection between Concord and Appomattox of a 20-inch versus 24-inch line, as recommended in Reference 2. As noted above, the storage tank balance criteria results in some additional fire fighting capacity beyond 2,000 GPM. The storage tank would not be required to meet 2023 demands so that construction of the tank could be delayed until the demands materialize sometime after 2023.

Summary costs for this option are presented in the Section on Costs of Alternatives. Transmission line modeling details are provided in Appendix A while itemized costs are contained in Appendix D.

Cost of Water from City of Lynchburg

The rate that the Appomattox Area would have to pay for treated water from the City of Lynchburg is yet to be determined. However, the cost presumably would be comparable to what the City charges its other jurisdictions such as Campbell and Bedford Counties.

This cost in 1999 was approximately $1.32 per hundred cubic feet for water purchased from the City of Lynchburg. It is anticipated through current discussions that this figure may be closer to $1.50 per

hundred cubic feet in the near future. This would breakdown to a rate of $0.20 per 100 gallons, which compares to the current retail rate of $0.28 per 100 gallons in the Town of Appomattox.

APPOMATTOX SURFACE WATER RESOURCES

Nine prospective reservoir sites, including an existing dam, and a potential intake location on the James River, all within reasonable transmission distances of the Town, were considered for additional water supply. All transmission line routes and facilities are shown on Figure 2.

Reservoir Source Evaluation

Prospective reservoir sites were identified on the Appomattox River, Wreck Island Creek, Wolf Creek, Rough Creek, and Anderson Creek (the existing Holiday Lake Dam). The sites are shown on Figure 2 and summarized in Table 3 below:

Table 3
Prospective Reservoir Sites

Reservoir Site	Site Number	Drainage Area (sq. mi.)	Maximum Normal Pool			
			Water Surface Elevation (ft)	Dam Height (ft)	Surface Area (acres)	Storage (million gallons)
Appomattox River - Upper	1	4.8	730	53	207	1105
Appomattox River - Middle	2	12.7	635	55	134	805
Appomattox River - Lower	3	14.3	605	55	137	1001
Appomattox River - Confluence	4	14.7	590	55	142	1025
Wreck Island Stonewall Mill	5	39.5	540	37	229	852
Wreck Island Upper	6	35.3	540	22	163	559
Rough Creek	7	6.6	570	55	139	906
Wolf Creek	8	6.8	545	30	28	95
Holiday Lake	9	13.6	445	32	113	430

For comparison purposes the Maximum Normal Pool depths, which determine available storage, were chosen as 55 feet, except where local conditions such as damsite configuration or upstream road crossings would add significantly to the construction cost. Surface area and storage behind the dams were approximated using contours from the 1:24,000 USGS topographic mapping series, which have 10-foot contour intervals. Since contours of Holiday Lake were not available for this study, the storage was approximated using the relations from the other eight sites. This was considered sufficiently accurate for the objectives of this study phase where sites were sought for further consideration. The stage-storage curves derived for each reservoir site are contained in Appendix B.

Safe Yield for Prospective Reservoirs

Calculations of safe yield for each reservoir site were made through the use of a computerized water balance model, which requires representative inflows and reservoir storages. Since the creeks at the sites are ungaged, inflows were developed through review of regional USGS stream gage flow data. There are three USGS stream gages in the immediate area with flow records of sufficient length for potential use at the reservoir sites. The stream gages are Holiday Creek near Andersonville, VA, No. 02038850; Buffalo Creek near Hampden Sydney, VA, No. 02039000; and Appomattox River at Farmville, VA, No. 02039500. The period of record and catchment areas for the stream gaging stations are shown in Table 4.

Table 4
Appomattox Area USGS Stream Discharge Gages

Stream Gage	Stream Gage Station Name	Period of Record	Gage Drainage Area (sq. mi.)
2038850	Holiday Creek near Andersonville	1966-2002	8.53
2039000	Buffalo Creek near Hampden Sydney	1946-2002	69.7
2039500	Appomattox River at Farmville	1926-2002	303

Selection of the stream gaging station flow records for adjustment to reservoir inflows was made through inspection of the flow records, particularly during droughts. The primary droughts of record were 1930-31, 1969-71, and 2000-2003. All three basins experienced the same drought periods with similar monthly runoff per square mile, without significant variation for total drainage size. The stream gage for the Appomattox River at Farmville was selected for the reservoir yield analysis inflows since it has the longest period of record and exhibits similar drought characteristics to the other two gages. Further details on the selection process and runoff characteristics of the stream gages are presented in Appendix B. The daily stream gage flows were adjusted to inflows at the dam sites in direct proportion to basin drainage area.

Safe yield for the reservoir sites are determined through daily water balance model simulations including lake levels, inflows, seepage, evaporation, uncontrolled outflows during floods and outflows required for downstream aquatic maintenance. The reservoir safe yield is reduced by required releases for downstream flow maintenance. The water balance model simulation of safe yield for varying downstream release requirements, as a percent of mean annual flow (MAF), are shown in Table 5 below:

Table 5
Safe Yield Estimates for Prospective Reservoir Sites

Reservoir Site	Site Number	Drainage Area (sq. mi.)	Storage (MG)	Release= 20% MAF Safe Yield (MGD)	Release= 25% MAF Safe Yield (MGD)	Release= 30% MAF Safe Yield (MGD)
Appomattox River - Upper	1	4.8	1105	1.2	1.1	1.1
Appomattox River - Middle	2	12.7	805	2.3	2.2	2.1
Appomattox River - Lower	3	14.3	1001	2.8	2.6	2.4
Appomattox River - Confluence	4	14.7	1025	2.9	2.7	2.5
Wreck Island Stonewall Mill	5	39.5	852	4.0	3.5	3.1
Wreck Island Upper	6	35.3	559	3.2	2.7	2.4
Rough Creek	7	6.6	906	1.5	1.4	1.4
Wolf Creek	8	6.8	95	0.5	0.5	0.4
Holiday Lake	9	13.6	430	1.6	1.5	1.4

The table indicates significant variation in safe yields for varying minimum releases, particularly for the larger drainage areas.

For reservoirs with larger drainage areas and storage, the drought period determining safe yield was 2001 to 2003. For the smaller reservoirs, the 1969 through 1971 drought was the critical period.

Reservoir performance for Site 3 during the three main droughts, for the minimum 20 percent mean annual downstream release requirement, is shown on Figures 3, 4 and 5 for illustration purposes. The drawdown of the reservoir to a nearly empty condition during 2001 through 2003 shows that this drought period is the critical period which establishes reservoir safe yield.

Preferred Dam Sites

The reservoirs with drainage areas below 10 square miles produced lower than target yields, experienced problems refilling on an annual basis, and experienced multi- year non-refilling during the 1970's. As a result, these reservoirs were dropped from further consideration. Holiday Lake Dam was also dropped since a 7-mile transmission line is required and the major proportion of the storage shown in Table 3 is expected to be significantly less due to current reservoir use. Without full storage allocation, the reservoir yield would be reduced significantly from that shown in Table 3.

The Wreck Island Creek sites, although capable of higher yields, have some practical and economic concerns. Wreck Island Creek will require transmission lines in the order of 8 miles compared to 2 and 3 miles of length for Sites 2, 3, and 4 on the Appomattox River. Since the pipeline distance is much greater than the other sites and the inundated land has a number of landholders with current development, these sites were not favored.

At Site 4 on the Appomattox River above the Confluence with South Fork, the dam location does not provide sufficient space for the required spillway without substantial earth and rock moving costs. It was decided that the two remaining dam sites, Appomattox River – Middle (Site 2) and Appomattox River – Lower (Site 3) would provide the greatest return on investment and therefore detailed cost analyses are provided. These two sites and the layout of required facilities are shown in greater detail in Figure 6.

Spillway Sizing

Spillways for flood control introduce a significant cost to dam construction and must be sized in accordance with current dam safety criteria. Spillway dimensions and the ultimate height of the dam crest are determined by the location of and space for the spillway structure, the available reservoir storage, and the magnitude of the Spillway Design Flood (SDF). The magnitude of the SDF required for a structure is determined by the State Impounding Structures Regulations (4 VAC-50-20-50). The State Dam Class and SDF requirement are based on downstream hazard potential for the event of structure failure, maximum reservoir capacity (dam crest), and structure height.

This study did not undertake a dam break analysis to determine downstream inundation from a potential dam break due to the conceptual and preliminary design level of the study. In the absence of such analysis, the dam class has been estimated for the purpose of cost comparison in this study as Class II, and the SDF as the 1/2 Probable Maximum Flood (PMF). Details of the PMF calculation procedure and spillway size determination are contained in Appendix B. Prior to final design and construction, the downstream hazard potential from dam break assumed in this study must be confirmed through dam break analysis for the proposed structure. Additional dam safety criteria are applied to new structures based on current practice and standards.

Summary costs for reservoir alternatives at dam sites 2 and 3 are presented in the Section on Cost of Alternatives. Detailed costs are presented in Appendix D, while technical details for site selection and spillway sizing are contained in Appendix B.

HABITAT CONSIDERATIONS FOR DAMS

To date, there have not been any wetland designations in the prospective dam site locations. The Corps of Engineers requires this investigation within their permitting process. Additional costs and reservoir restrictions can be incurred if wetlands are deemed present within the reservoir area.

Downstream flow requirements from Virginia Department of Environmental Quality (VDEQ) have been estimated and incorporated in this study based on preliminary discussions with VDEQ. Although minimum storage and pool requirements have also been assumed in this study in determining safe yield, requirements beyond those assumed, should they occur, will reduce the safe yields determined in this study.

PERMITTING FOR DAMS

Permits will be required for the construction of new dams and the withdrawal of surface water using new diversion facilities. The regulatory agencies include the Corps of Engineers, the Virginia Department of Environmental Quality (VDEQ), the Virginia Marine Resource Commission (VMRC), and the Virginia Dam Safety Office of the Virginia Department of Conservation and Recreation (VDCR). The permits for the Corps, the VDEQ, and the VMRC can be obtained through a single permit application and joint permit process administered by the State for the three agencies. Sometimes, the agencies waive the requirement for the permits; however, the size and complexity of the projects described in this report, in our opinion and experience, would require an individual permit from each agency. A 30-day public notice and comment period would be required for these projects. One year or more should be allowed to complete the process. The permits are described below.

Corps of Engineers 404 Permit

The 404 permit is required for the placement of fill material into the waters of the United States. The definition of the waters of the United States would include all the streams in this study.

Virginia Department of Environmental Quality (VDEQ) Water Protection Permit

A Water Protection Permit is required to ensure the water quality in the state is not adversely impacted by the project. The Water Protection Permit 401 certification will establish surface water withdrawal criteria and downstream release requirements.

Virginia Marine Resources Commission (VMRC)

The VMRC requires a permit for encroachment on streambeds, which are considered to be the property of the State.

Virginia Department of Conservation and Recreation (VDCR) - Dam Safety

The dam safety section requires a permit for construction and operation of dams greater than 6 feet in height and over 50 acre-feet of storage. The design and construction of the dam must conform to the approved revised standards. The spillway size is determined by an evaluation of the downstream hazard, which is reflected in the SDF, as noted previously in the text. Reservoir and dam inspections would be required on a specified frequency for the life of the project.

Other

Permits will be required for construction site erosion and sedimentation control and construction of pipelines that are within or cross public right-of-ways.

JAMES RIVER INTAKE AND TRANSMISSION LINE

A potential intake was sited on the James River near Bent Creek and a line route chosen along Highway 26 to the Town. This routing would permit use of the highway right-of-way. The route and facilities are shown on Figure 2. Minimum flow estimates from records are used to establish allowable withdrawals. The 30-year minimum one-day flow (1Q30) is 260 cubic feet per second (167 MGD) estimated by the State Planning Studies[1]. This value was determined for unregulated conditions and does not include augmentation from Gathright Dam releases, which are in the order of 90 CFS. The removal of 2 MGD (3 CFS) for consumptive use represents only 1 percent of this minimum flow and is not anticipated to pose problems in obtaining a withdrawal permit.

The proposed transmission line along Route 26 requires 62,500 feet of 16-inch pipe to convey 2.0 MGD. The pump station located adjacent to the river would convey raw water to the water treatment plant. Transmission pipe pressures computed by the model indicate the best location of the water treatment plant to be between 2 and 2-1/2 miles from the river on the crest of the long grade coming up from the river. Treated water pumped from this location would provide pressures along the transmission line generally between 40 and 100 psi. A booster pump station would be located just north of the Town in order to boost pressures and fill the existing Town tanks, which have an overflow of elevation 997 feet. The approximate locations are shown in Figure 2. Technical details are contained in Appendix C. Summary and detailed costs for this option are presented in the Section on Costs of Alternatives, and Appendix D, respectively.

COSTS OF ALTERNATIVES

Order-of-magnitude construction costs are included for the transmission line from Lynchburg along the Route 460 corridor, two potential reservoir sites, and a James River intake and line. To the latter two options, the capital cost of a 2.0 MGD water treatment plant at $6 million plus operation and

maintenance costs of $1,000 per million gallons produced have been added. The operation and maintenance cost includes labor, chemicals, power, and repair/replacement. Cost of water from Lynchburg was discussed earlier and is not included in the Table below.

Table 6 summarizes the costs of the alternatives for review and comparison. A more detailed breakdown of the above costs is contained in Appendix D.

Table 6
Comparative Cost Data

Alternative	Campbell County Demand (MGD)	Appomattox County Demand/Yield (MGD)	Total Capital Cost (million $)	Capital Cost per MGD (million $)	Water Treatment Plant O&M Cost per MG ($/MG)*	Annual WTP Cost (million$)
460 Transmission Year 2023	0.23	0.84	$14.9	$13.9	0	0
460 Transmission Ultimate	0.80	1.52	$16.4	$7.1	0	0
Site 2 Reservoir	0	2.3	$15.40	$6.7	$1000	$0.84
Site 3 Reservoir	0	2.8	$15.7	$5.6	$1000	$1.02
James River Intake	0	2	$16.4	$8.2	$1000	$0.73

* Example: If the treatment facility produced 1.0 MGD, the annual O&M would be 365 x $1000 =$365,000. For 0.5 MGD, the annual O&M cost would be $182,500.
(Note: 1 MG = 133,690 ft^3)

1 James River Basin Comprehensive Water Resources Plan, Volume III, Virginia Department of Conservation and Economic Development, 1970

The reservoir yields provided in the above table are for downstream release requirements of 20 percent MAF. Additional releases would reduce yield ,as noted in the text, and increase the capital cost per million gallons for the reservoir alternative.

For the Route 26–James River alternative, the cost for an additional tank storage tank would be required for servicing demands along the route.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were made:

1. The scenarios were narrowed down to four alternatives which are basically of three types with two choices for the reservoir alternative.

2. The three alternatives and their cost are as follows:

    a. Reservoir with WTP – 15.4 million with an annual O&M of $1,000 per million gallons produced.
    b. James River with WTP - $16.4 million with an annual O&M of $1,000 per million gallons produced.
    c. Lynchburg – Appomattox Waterline - $16.4 million with $1.4 million delayed for 20 plus years brings the current total to $15.0 million.

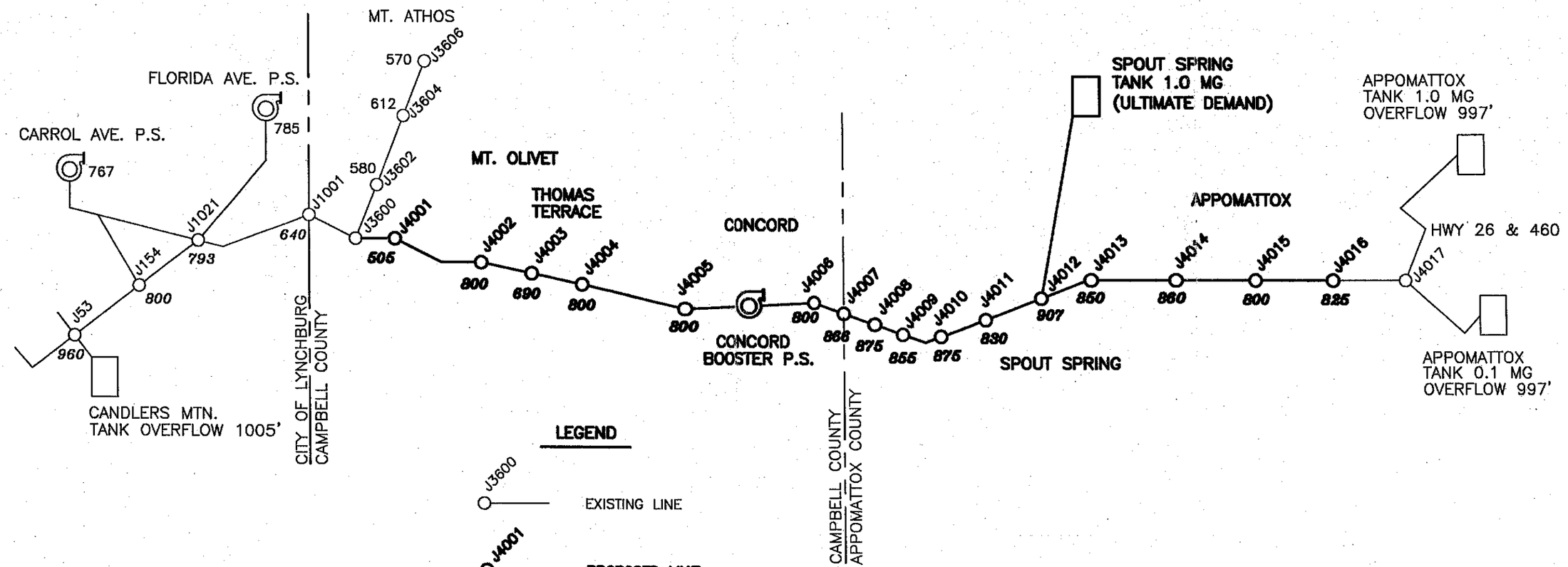
3. The three alternatives and costs provide varying yields with demands located in different locations, including some demand in Campbell County.

4. All three of the above alternatives are practicable and feasible. However, the Lynchburg – Appomattox waterline has several favorable characteristics:

    a. Low risk for future O&M and unforeseen expenses
    b. Provides immediate water service for the corridor from Concord to Appomattox for development due to the installed finished waterline.
    c. Provides for the potential utilization of more water than the other alternatives.

The following recommendations are made:

1. The scenario involving a waterline from the City of Lynchburg along the U.S. Route 460 corridor to portions of Campbell County and Appomattox should be pursued. This line would provide finished water from the City of Lynchburg, which in turn would be purchased by Campbell County and Appomattox.
2. Achievement of this project will require a considerable amount of funding; probably from a number of agencies. Appomattox, being the prime recipient of water, will need to take the lead and select an individual with considerable knowledge regarding the various agencies to pursue this funding.
3. It is also recommended that Appomattox seek the backing of both Campbell County and the City of Lynchburg for this project. This will make the project a regional objective and increase the potential for success.



APPOMATTOX AREA
WATER SOURCE STUDY
ROUTE 460 SCHEMATIC

DESIGNED BY:PTK	DRAWN BY: RAF	CHECKED BY:PTK
		PROJECT NO.: 202150
SCALE: NO SCALE		FILE NO.:460 SCHEMATIC.DWG
DATE: AUGUST 2003		SHEET FIGURE: 1

PROSPECTIVE DAM SITES
1. APPOMATTOX RIVER – UPPER
2. APPOMATTOX RIVER – MIDDLE
3. APPOMATTOX RIVER – LOWER
4. APPOMATTOX RIVER – CONFLUENCE
5. WRECK ISLAND STONEWALL MILL
6. WRECK ISLAND UPPER
7. ROUGH CREEK
8. WOLF CREEK
9. HOLIDAY LAKE

N

PROPOSED WATER TREATMENT PLANT AND PUMP STATION

JAMES RIVER AT BENT CREEK INTAKE AND PUMP STATION

HWY. 26 TRANSMISSION LINE

APPOMATTOX CO. CAMPBELL CO.

CONNECTION TO LYNCHBURG/CAMPBELL CO. WATER SYSTEM

CONNECTION TO EXISTING TOWN LINES

TOWN OF APPOMATTOX

HWY 460 TRANSMISSION LINE

APPOMATTOX CO. PRINCE EDWARD CO.

SCALE: 1" = 10,000'

10,000' 0 10,000'

APPOMATTOX AREA
WATER SOURCE STUDY
SYSTEM SCENARIO OVERVIEW

DESIGNED BY:PTK	DRAWN BY: RAF	CHECKED BY:PTK
		PROJECT NO.: 202150
SCALE: 1" = 10,000'		FILE NO.:
DATE: AUGUST 2003		SHEET FIGURE: 2

04Aug03

Fig. 3 Site 3 for Years 1930/32 Reservoir Performance - Yield =2.85 MGD

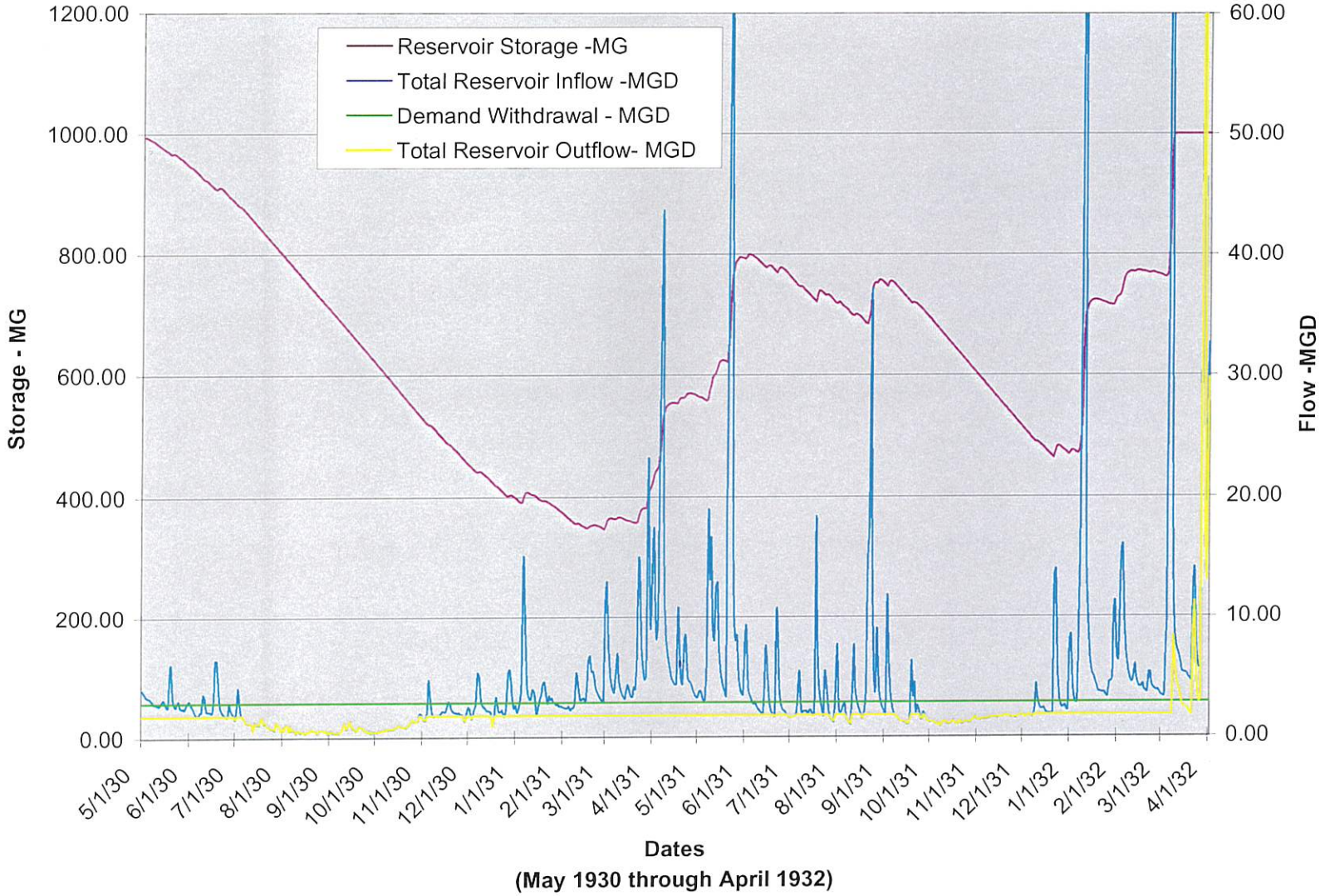


Fig. 4 Site 3 for Years 1969/71 Reservoir Performance - Yield =2.85 MGD

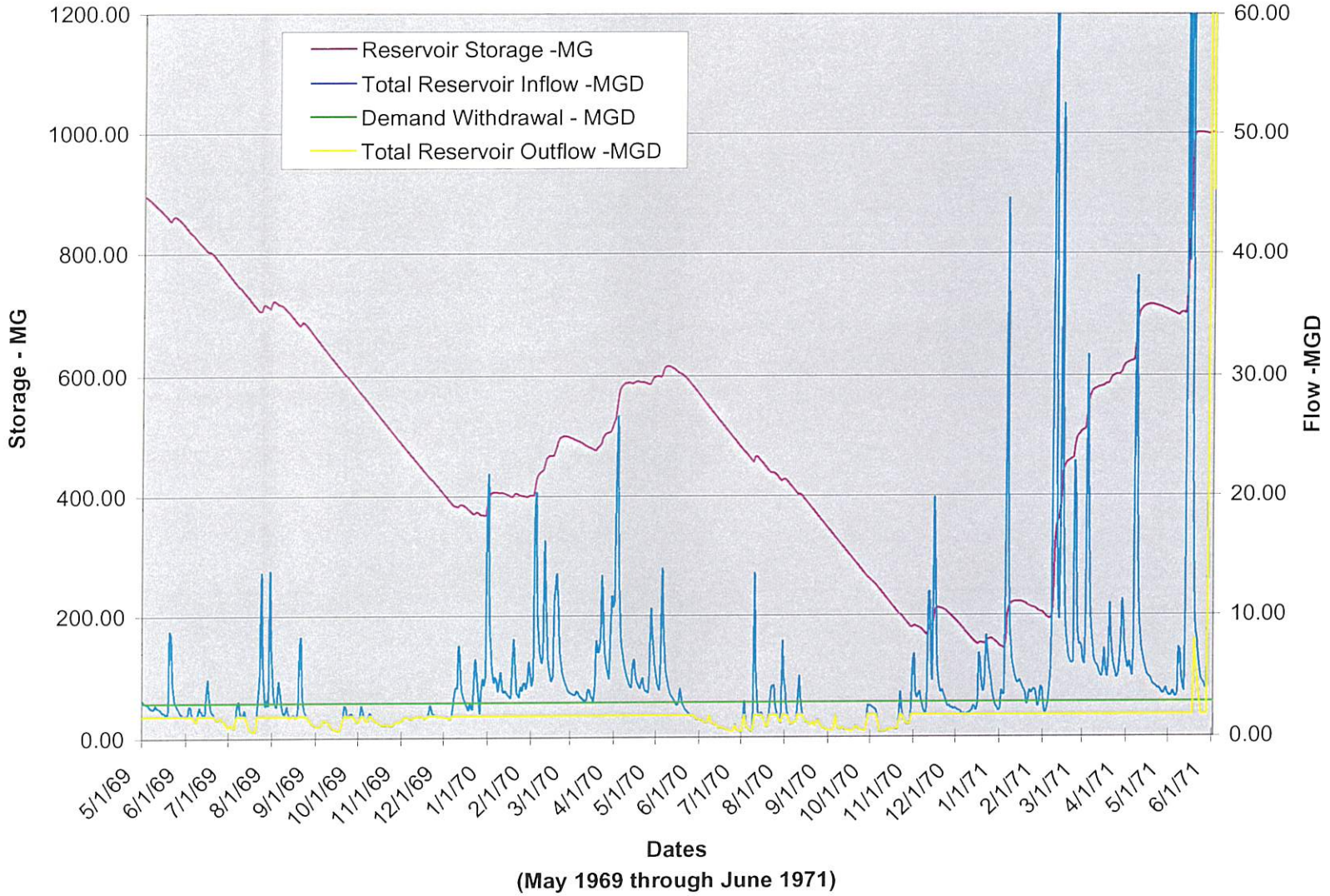
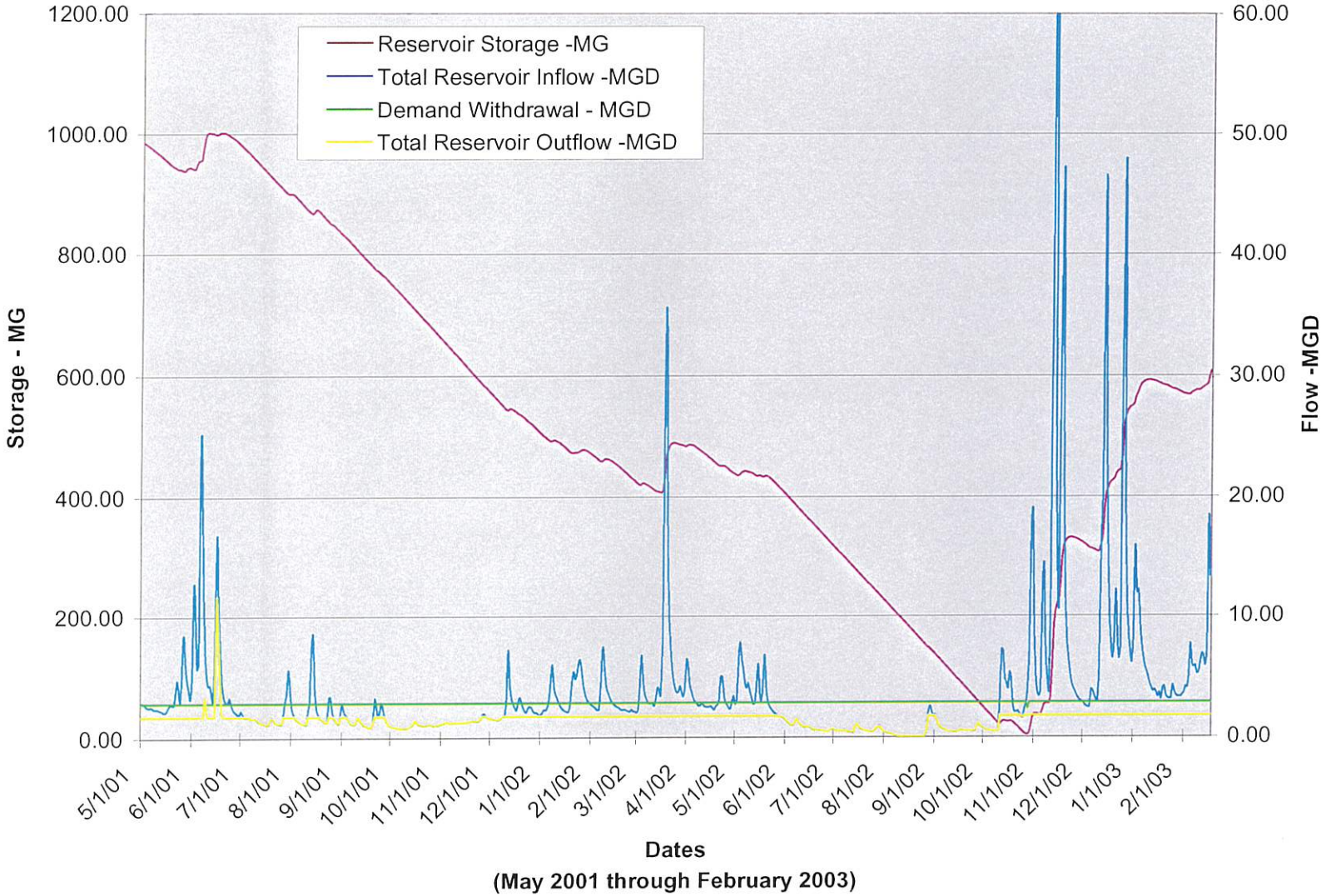
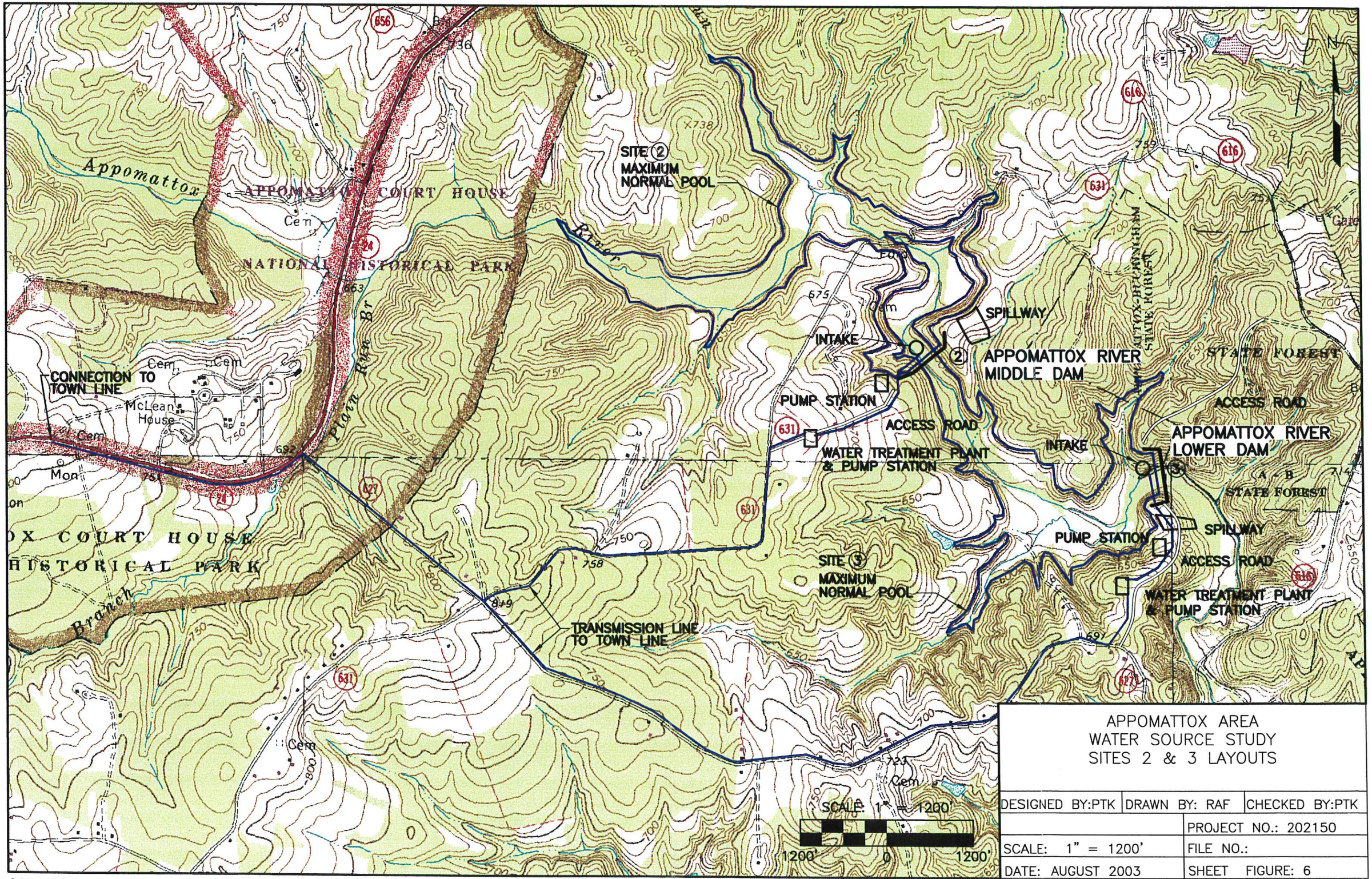


Fig. 5 Site 3 for Years 2001/03 Reservoir Performance - Yield =2.85 MGD





APPOMATTOX AREA
WATER SOURCE STUDY
SITES 2 & 3 LAYOUTS

DESIGNED BY:PTK	DRAWN BY: RAF	CHECKED BY:PTK
		PROJECT NO.: 202150
SCALE: 1" = 1200'		FILE NO.:
DATE: AUGUST 2003		SHEET FIGURE: 6

04Aug03

ROUTE 460 WATER TRANSMISSION CORRIDOR MODEL

The existing City of Lynchburg WATERCAD model for year 2010 was revised to include a transmission line along Route 460 connecting to the existing 12-inch line in the Town of Appomattox. The model includes the proposed Florida Street Pump Station in Lynchburg and the 24-inch transmission line to the Mt. Athos 16-inch feed line. The model schematic of the proposed line is shown on Figures 1 and 2 of the main report. The model demands generated from Table 1 in Tab 1 are contained in Table A-1.

Table A-1

Future Demand Allocation along Route 460 Corridor

Demand Node	2023		Ultimate	
	Avg Day (GPM)	Max Day (GPM)	Avg Day (GPM)	Max Day (GPM)
J-4001	0	0	0	0
J-4002	0	0	0	0
J-4003	15	23	50	75
J-4004	10	15	50	75
J-4005	35	53	150	225
J-4006	50	75	150	225
J-4007	50	75	150	225
J-4008	50	75	100	150
J-4009	50	75	100	150
J-4010	0	0	50	75
J-4011	70	105	100	150
J-4012	55	83	100	150
J-4013	40	60	65	98
J-4014	40	60	65	98
J-4015	50	75	100	150
J-4016	50	75	150	225
J-4017	180	270	228	342
Total	**745**	**1119**	**1608**	**2413**

The transmission line was sized to provide Table A-1 flows in addition to minimum pressures of 20 psi for the fireflow requirement of 2,000 GPM over 8 hours during maximum day condition, adopted from Reference 2. Simulation criteria are noted in the text in Tab 1.

A listing of the proposed pipe sizes and lengths for the ultimate demand scenario are given in Table A-2.

Table A-2

Pipe Sizing along Hwy 460 Corridor

For Ultimate Demands

Pipe Label	From Node	To Node	Length (ft)	Diameter (in)	Material	Hazen- Williams C
P-4000	J-3600	J-4001	2,412	24	Ductile Iron	120
P-4001	J-4001	J-4002	9,387	24	Ductile Iron	120
P-4002	J-4002	J-4003	2,232	24	Ductile Iron	120
P-4003	J-4003	J-4004	3,863	24	Ductile Iron	120
P-4004	J-4004	J-4005	8,956	24	Ductile Iron	120
P-4005	J-4005	PMP-11	100	24	Ductile Iron	120
P-4006	J-4005	PMP-12	100	24	Ductile Iron	120
P-4007	PMP-11	J-4006	100	20	Ductile Iron	120
P-4008	PMP-12	J-4006	100	20	Ductile Iron	120
P-4009	J-4006	J-4007	3,127	20	Ductile Iron	120
P-4010	J-4007	J-4008	6,122	20	Ductile Iron	120
P-4011	J-4008	J-4009	7,575	20	Ductile Iron	120
P-4012	J-4009	J-4010	1,340	20	Ductile Iron	120
P-4013	J-4010	J-4011	2,500	20	Ductile Iron	120
P-4014	J-4011	J-4012	2,962	20	Ductile Iron	120
P-4015	J-4012	J-4013	5,290	20	Ductile Iron	120
P-4016	J-4013	J-4014	7,779	20	Ductile Iron	120
P-4017	J-4014	J-4015	2,625	20	Ductile Iron	120
P-4018	J-4015	J-4016	3,019	20	Ductile Iron	120

The ultimate demand requires a 24- inch diameter line to a booster pump station in Concord and a minimum 20-inch line from the station to connect with the existing 12-inch line in Appomattox. A 1.0 million gallon storage tank would be required at Spout Spring to ensure fireflow protection and adequate pressures between Concord and Appomattox. The storage tank at Spout Spring would not be required initially and would not be required to meet the demands that have been estimated for the year 2023.

The simulated ultimate demand pressures at selected nodes during average day and fireflow conditions are shown in Figures A-1 through A-8.

Figure A-1

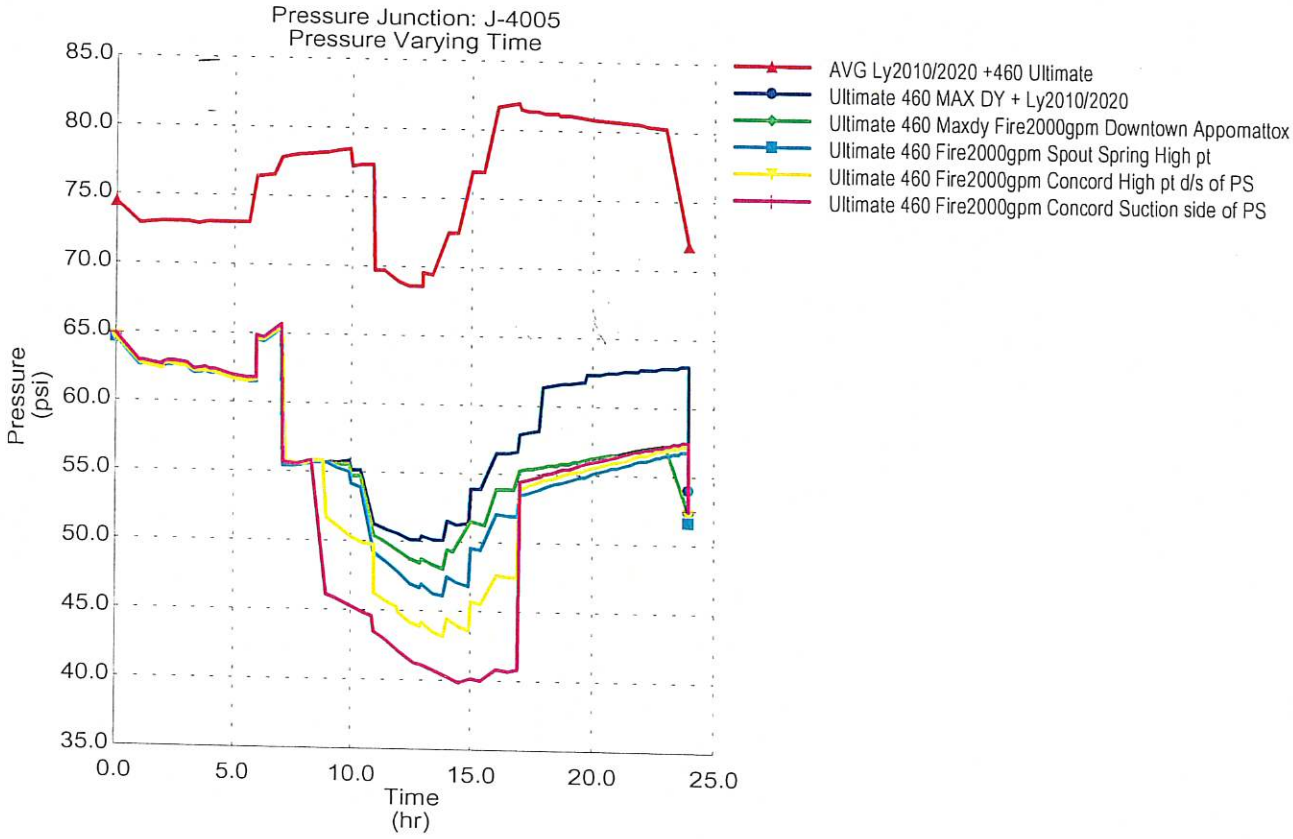


Figure A-2

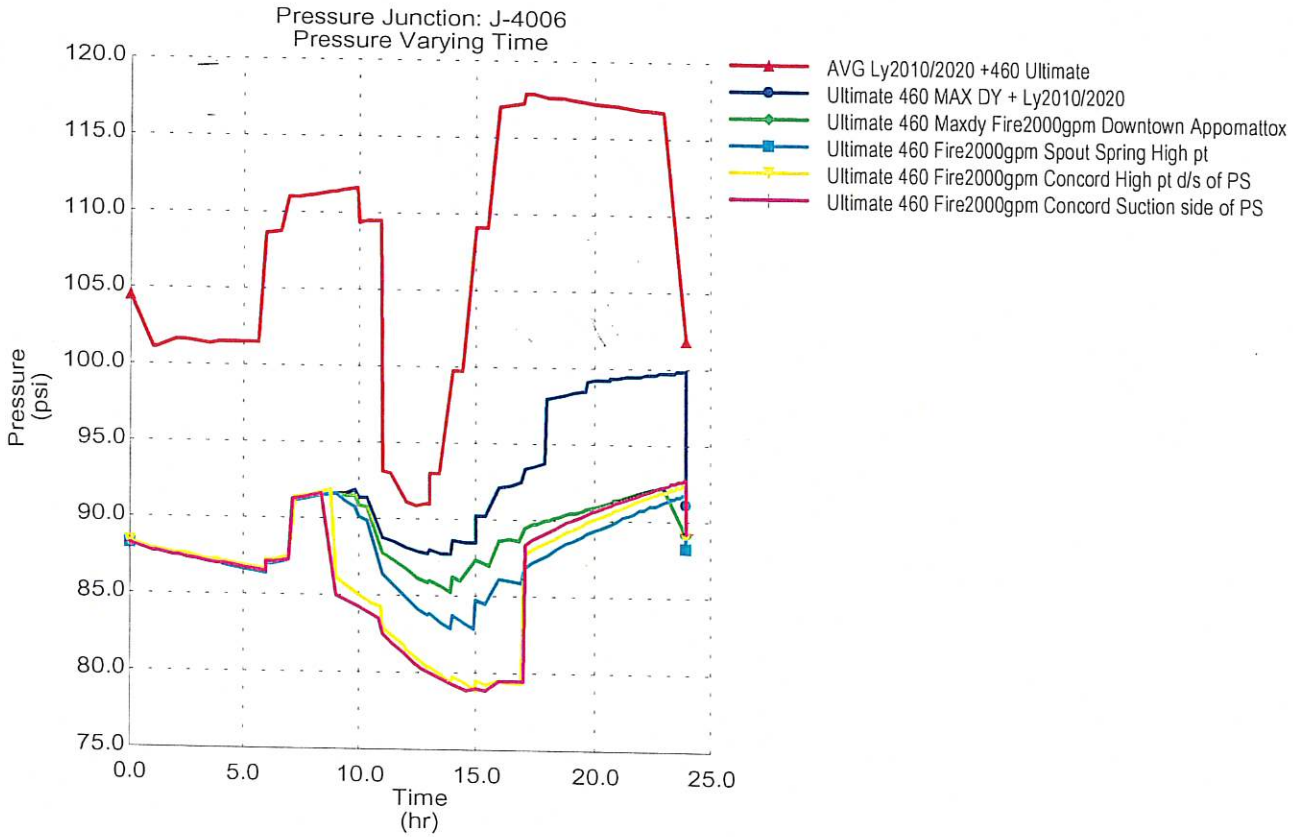

Pressure Junction: J-4006
Pressure Varying Time
120.0
115.0
110.0
105.0
100.0
95.0
90.0
85.0
80.0
75.0
Pressure (psi)
0.0
5.0
10.0
15.0
20.0
25.0
Time (hr)
AVG Ly2010/2020 +460 Ultimate
Ultimate 460 MAX DY + Ly2010/2020
Ultimate 460 Maxdy Fire2000gpm Downtown Appomattox
Ultimate 460 Fire2000gpm Spout Spring High pt
Ultimate 460 Fire2000gpm Concord High pt d/s of PS
Ultimate 460 Fire2000gpm Concord Suction side of PS

Figure A-3

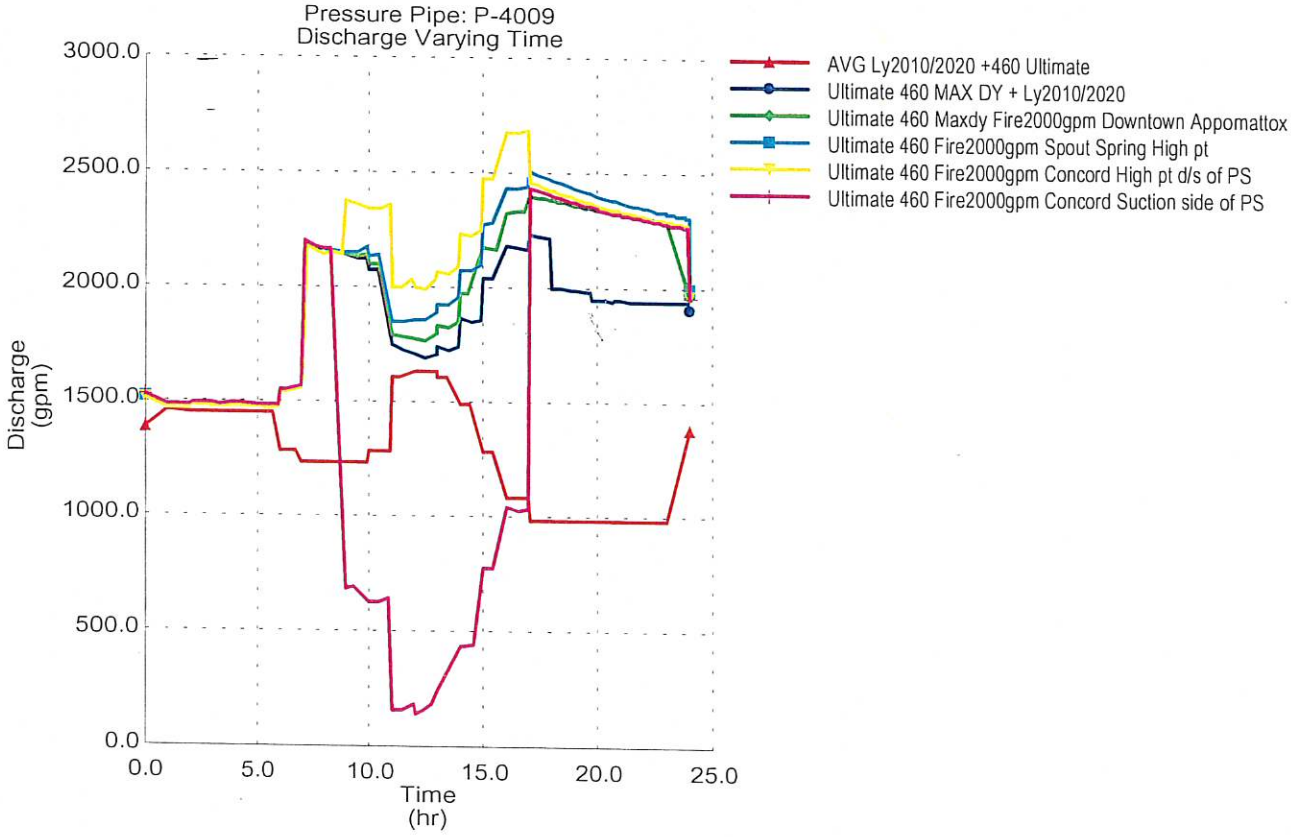


Figure A-4

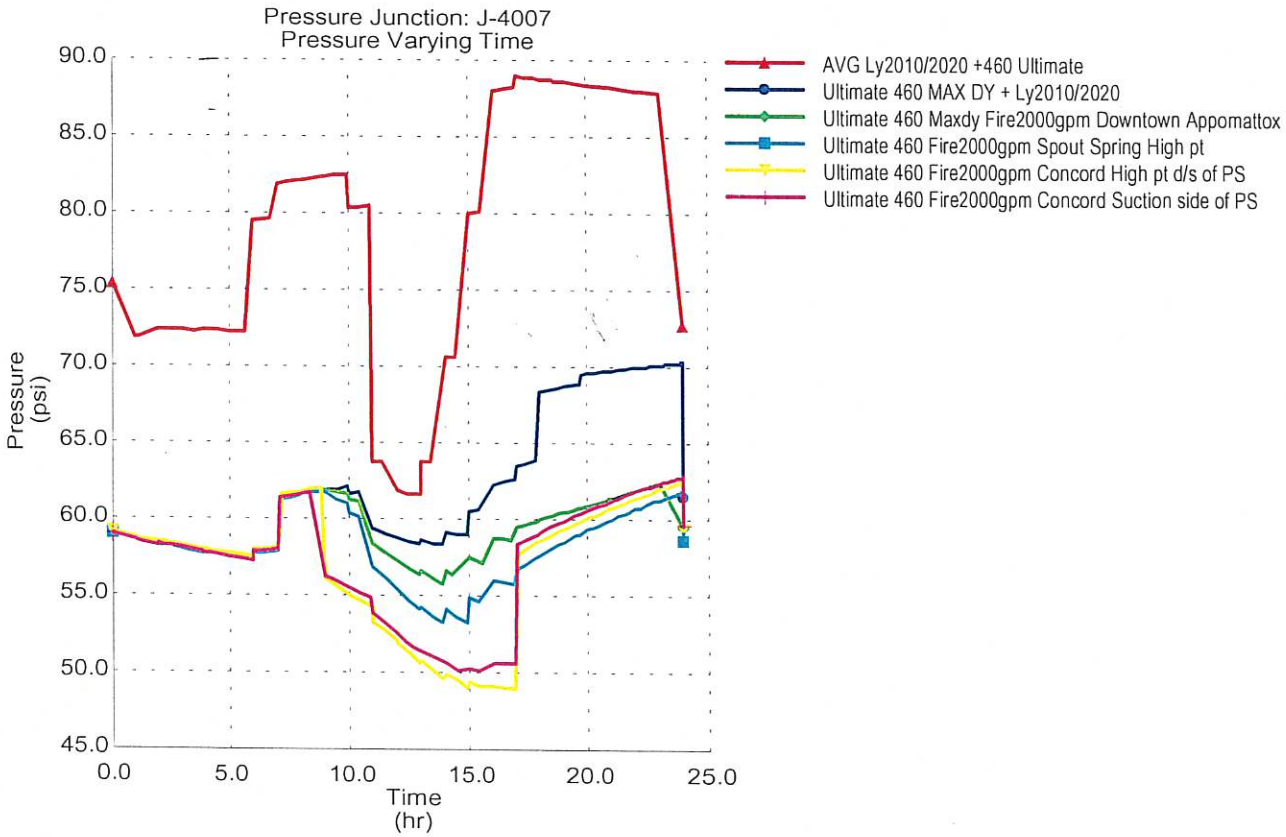

Pressure Junction: J-4007
Pressure Varying Time
Pressure (psi)
90.0
85.0
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
0.0
5.0
10.0
15.0
20.0
25.0
Time (hr)
AVG Ly2010/2020 +460 Ultimate
Ultimate 460 MAX DY + Ly2010/2020
Ultimate 460 Maxdy Fire2000gpm Downtown Appomattox
Ultimate 460 Fire2000gpm Spout Spring High pt
Ultimate 460 Fire2000gpm Concord High pt d/s of PS
Ultimate 460 Fire2000gpm Concord Suction side of PS

Figure A-5

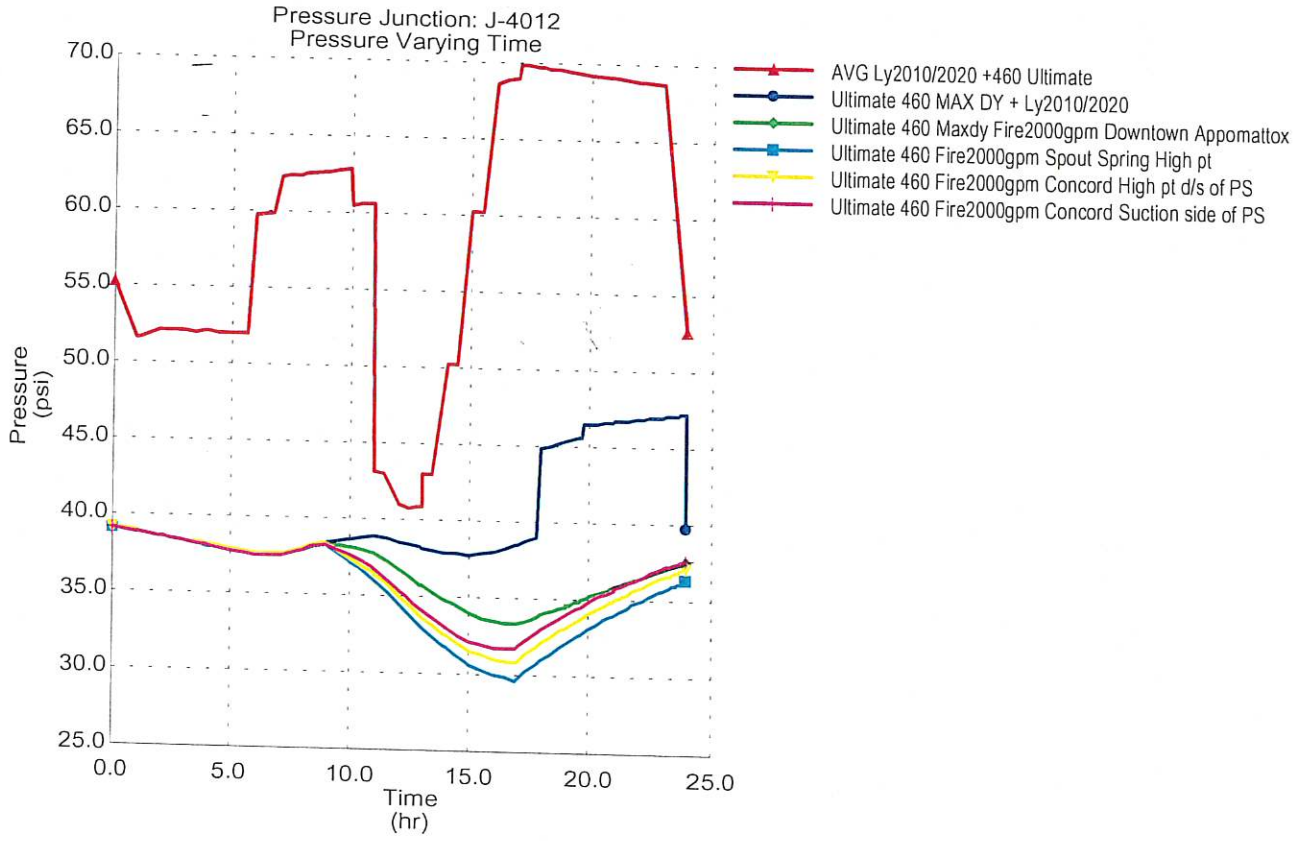


Figure A-6

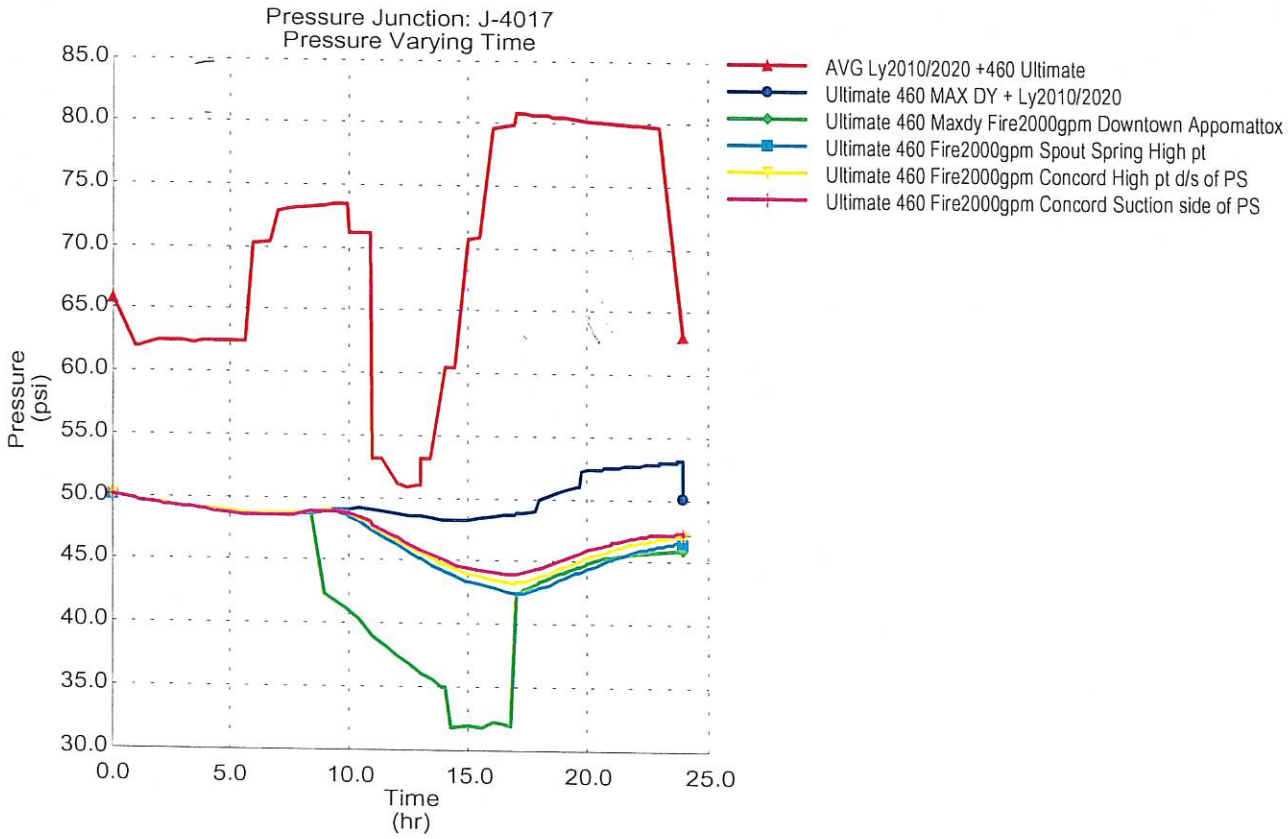

Pressure Junction: J-4017
Pressure Varying Time
Pressure (psi)
85.0
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
0.0
5.0
10.0
15.0
20.0
25.0
Time (hr)
AVG Ly2010/2020 +460 Ultimate
Ultimate 460 MAX DY + Ly2010/2020
Ultimate 460 Maxdy Fire2000gpm Downtown Appomattox
Ultimate 460 Fire2000gpm Spout Spring High pt
Ultimate 460 Fire2000gpm Concord High pt d/s of PS
Ultimate 460 Fire2000gpm Concord Suction side of PS

Figure A-7

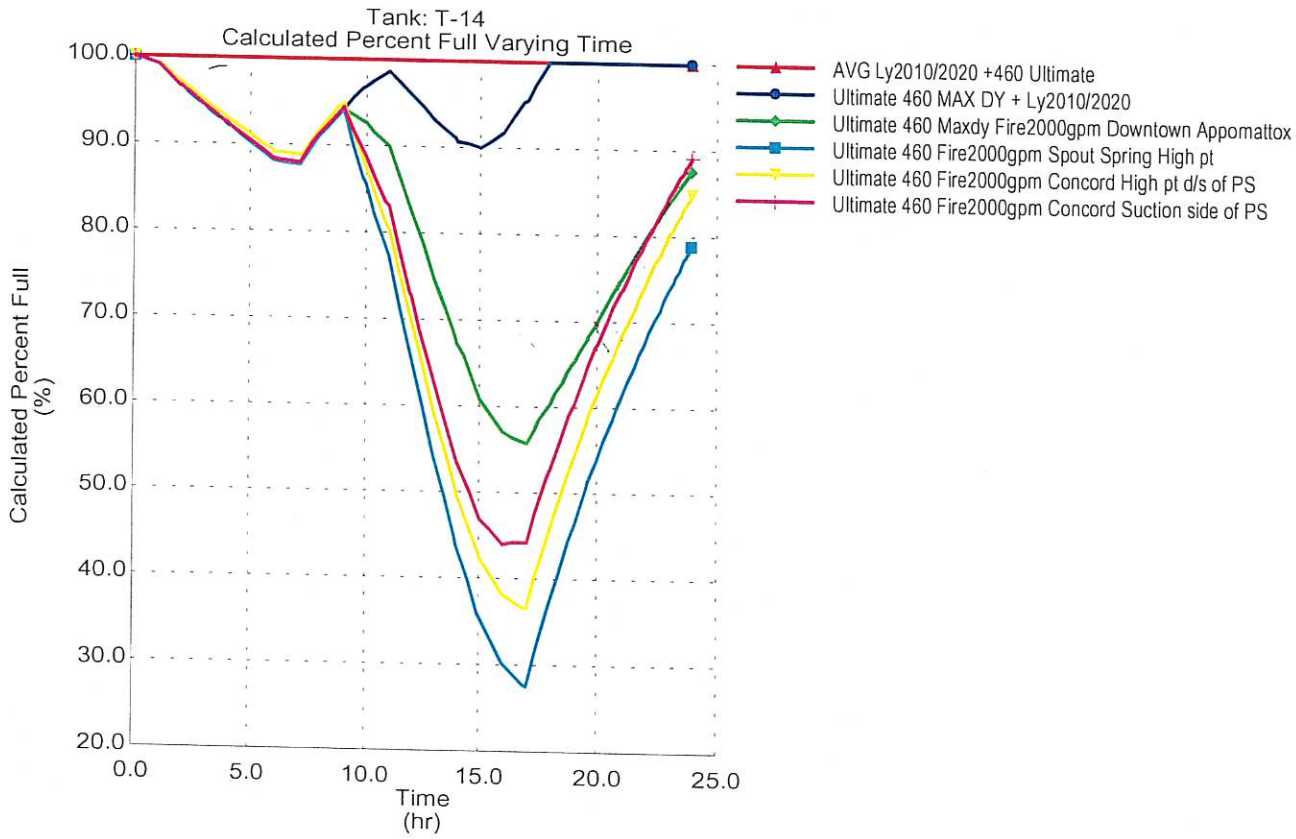
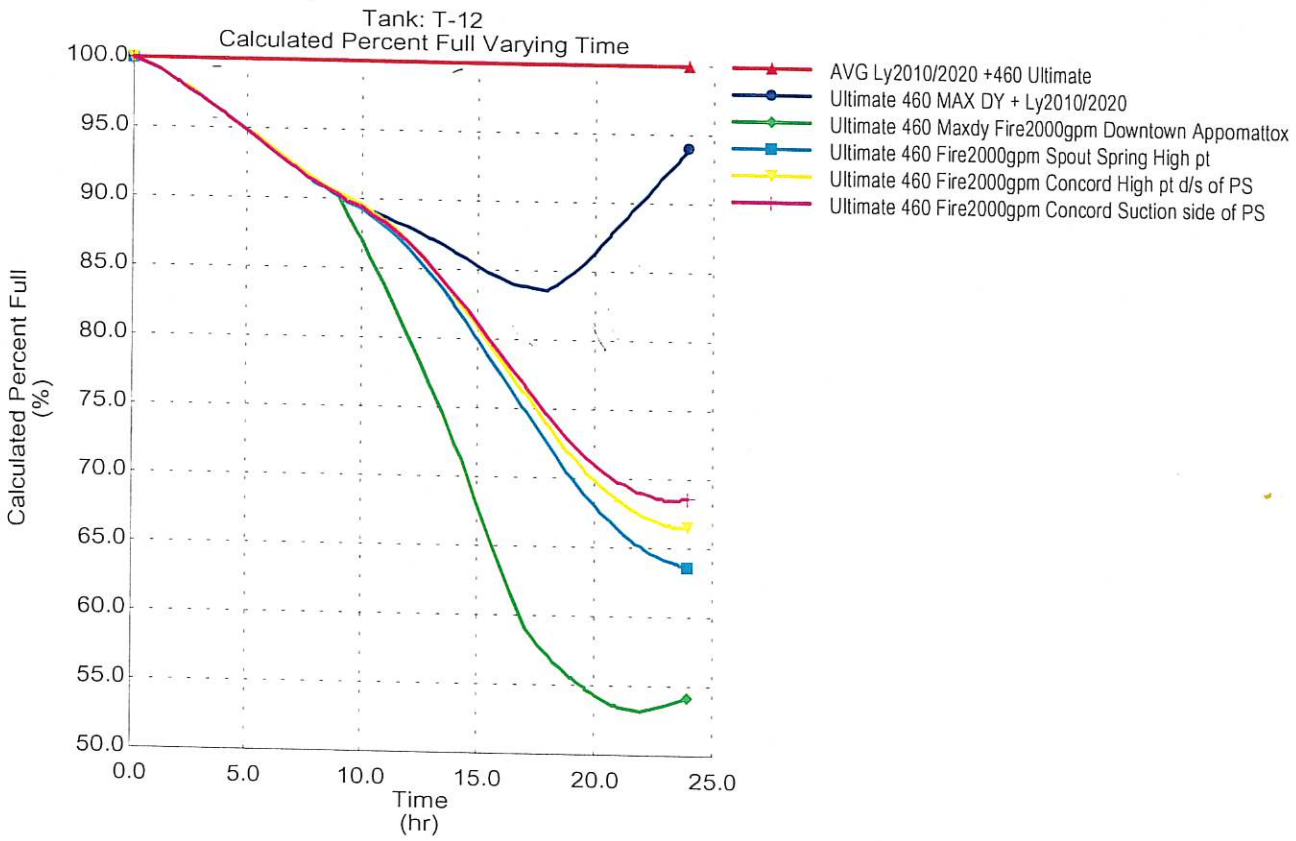


Figure A-8



SAFE YIELD AT PROSPECTIVE RESERVOIR SITES

Calculations of safe yield for each reservoir site were made through the use of a computerized water balance model, which requires representative inflows and reservoir storages. Representative reservoir inflows were determined by review of regional USGS stream flow data. There are three USGS stream gages in the immediate area with records of sufficient length for potential use at the reservoir sites. The gages are Holiday Creek near Andersonville, VA, 02038850 (drainage area 8.53 square miles), Buffalo Creek near Hampden Sydney, VA, 02039000 (drainage area 69.7 square miles), and Appomattox River at Farmville, VA, 02039500 (drainage area 303 square miles). The characteristics of the stream gaging stations are shown in Table B-1.

Table B-1
USGS Stream Gage Basin Characteristics

Stream Gage	Station Name	Record Period	Drainage Area (sq. mi.)	Forested Area (%)	Basin Mean Elevation (ft.)	Main Channel Slope (ft/mi)	Main Channel Length (mi)
2038850	Holiday Creek Near Andersonville	1966-2002	8.53	99	700	58.8	5.2
2039000	Buffalo Creek near Hampden Sydney	1946-2002	69.7	99	490	12.5	10.7
2039500	Appomattox River at Farmville	1926-2002	303	75	490	9.2	37.4
Dam Site 3	Appomattox River - Lower Dam	N/A	14.3	90	690	66.5	5.2

Selection of the stream gaging station records for adjustment to reservoir inflows was made through inspection of the gage records, particularly during droughts. The primary droughts for this region, for these size basins, as revealed in Tables B-2, B-3, and B-4, were 1930-31, 1968-71, and 2000-2002.

The tables show that all three basins experienced the same drought periods with similar monthly runoff per square mile, without significant variation for runoff per square mile for total drainage area. Flow records for Holiday Creek near Andersonville diverged from the other stations during the low

flows in 2001. This was considered as a potential gage zeroing problem and this station was removed from further consideration. Based on these results, the stream gage for the Appomattox River at Farmville was selected for the reservoir yield analysis inflows, and adjusted to the dam sites in direct proportion to basin area.

Areas and storage behind the dams were approximated using the 1:24,000 USGS topographic mapping series, which have 10-foot contour intervals. The stage-storage curves derived for the dam sites are presented in Table B-5.

Reservoir safe yield is determined through daily water balance model simulations including lake levels, inflows, seepage, evaporation, uncontrolled outflows during floods and aquatic release requirements. Reservoir safe yield is reduced by releases for downstream flow requirements. The spreadsheet model and equations are shown in Figures B-1 and B-2, respectively.

The inflows and reservoir levels for 1926-2003 for Site 2 are shown on Figure B-3. Several drought periods in which the reservoir does not fill in the same 12-month period are shown. In some cases this phenomenon extends for 3 years. The 1960's experienced prolonged periods of reduced inflows. The extent of the drought and impact on reservoir yield for Site 2 are shown in Figures B-4, B-5, and B-6 to show the worst droughts. To date, for reservoirs of this storage capability and drainage area in Appomattox County, the period 2001 to 2003 is the worst drought and determines reservoir safe yield.

SPILLWAY DESIGN FLOOD

Spillway dimensions and the ultimate height of the dam crest are determined by the location of and space for the spillway structure, the available reservoir storage, and the magnitude of the Spillway Design Flood (SDF). The requisite SDF magnitude for the structure is determined by the State Impounding Structures Regulations (4 VAC-50-20-50). The State Dam Class and SDF requirement

are based on downstream hazard potential for the event of structure failure, maximum reservoir capacity (dam crest), and structure height.

This study did not undertake a dam break analysis to determine downstream inundation from potential dam break due to its conceptual and preliminary design level. In the absence of such study, the dam class has been estimated for the purpose of cost comparison in this study as Class II and the SDF as the 1/2 PMF. Prior to construction, the downstream hazard potential from dam break must be confirmed through dam break analysis for the proposed structure.

The Spillway Design Flood for Sites 2 and 3 was computed using standard procedures contained in Government publications[1,2]. The Probable Maximum Precipitation and the Probable Maximum Flood for these sites were computed using the government HMR52 and HEC-1 Flood Hydrograph computer programs[2,3], respectively.

Hydrologic characteristics of Appomattox River basin were compared to that of similar basins where experience and model calibrations for extreme events have been acquired. Time to peak and infiltration rate characteristics were within the range of these referenced studies. The Site 2 and Site 3 basin time of concentrations were computed as 2.8 and 3.4 hours, respectively, as shown in Table B-6. The drainage basin and time of concentration paths for Site 3 are shown on Figure B-7.

The computed PMF and 1/2 PMF peak hourly inflows to Site 2 reservoir were 50,800 and 25,400 cubic feet per second (CFS), respectively. The respective inflow peaks for Site 3 were 51,000 and 25,500 CFS. The two reservoirs require a 230-foot wide concrete spillway to route the 1/2 PMF, or SDF, outflow.

[1] HMR52, Probable Maximum Storm (Eastern United States), User's Manual, HEC, US Army Corps of Engineers, September 1984.
[2] Hydrometeorological Report No. 51, Probable Maximum Precipitation estimates, United States East of the 105th Meridian, National weather Service, June 1978.
[3] HEC-1, Flood Hydrograph Package, User's Manual, HEC, US Army Corps of Engineers, September 1990.

Table B-2
Monthly Streamflow Unit Discharge for USGS02038850

USGS 02038850 HOLIDAY CREEK NEAR ANDERSONVILLE, VA

Appomattox County, Virginia
Hydrologic Unit Code 02080207
Latitude 37°24'55", Longitude 78°38'10" NAD27
Drainage area 8.53 square miles 8.53
Gage datum 472.97 feet above sea level NGVD29

YEAR	Monthly mean daily streamflow, in ft³/s												Next Calendar Year		Average (ft³/s)		Runoff/square mile		YEAR START
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Jul-Dec	Jul-Feb	Jul-Dec	Jul-Feb	
1966					4.32	1.63	0.61	1	4.74	6.45	2.79	6.26	7.7	7.29	3.1	4.1	0.367	0.478	1966
1967	7.7	7.29	7.77	4.37	4.87	6.42	3.7	7.21	2.6	3.33	3.46	16.4	10.4	5.99	5.3	5.9	0.620	0.696	1967
1968	10.4	5.99	9.16	6.06	9.96	3.97	2.41	2.19	1.08	1.96	4.28	3.13	5.96	5.51	2.2	2.9	0.253	0.344	1968
1969	5.96	5.51	13.6	5.47	4.53	3.17	6.34	3.94	2.32	2.64	2.49	6.49	6.43	9.35	3.5	4.4	0.409	0.518	1969
1970	6.43	9.35	6.53	7.25	5	2.19	2.85	1.41	0.81	2.08	4.39	3.62	6.42	13.2	2.2	3.8	0.255	0.444	1970
1971	6.42	13.2	8.46	9.5	36	7.43	3.27	4.06	5.68	25.6	12.9	8.48	9.12	20.9	8.6	9.9	1.009	1.163	1971
1972	9.12	20.9	11.1	9.89	24	70.2	15.3	6.83	5.23	23.7	24.7	19.9	18.2	21.4	13.7	15.0	1.608	1.760	1972
1973	18.2	21.4	22.7	32.6	13.4	8.83	5.46	24.9	7.25	5.51	4.32	25.6	16.6	14.5	10.5	11.6	1.234	1.363	1973
1974	16.6	14.5	12.3	13.8	13.9	13.1	4.96	6.85	16.9	4.12	4.91	8.22	10.8	12.1	6.6	7.6	0.769	0.892	1974
1975	10.8	12.1	34.2	11.1	7.79	5.78	13.6	4.08	28.9	6.29	7.61	11.7	14.7	10.4	10.3	10.8	1.206	1.266	1975
1976	14.7	10.4	10.6	10.9	7.83	5.29	4.14	2.95	3.34	19.8	7.63	10.3	7.53	7.48	6.9	7.1	0.812	0.827	1976
1977	7.53	7.48	9.39	10.2	5.82	3.3	1.76	1.23	1.39	2.49	7.59	8.43	30.5	7.17	3.3	6.8	0.384	0.793	1977
1978	30.5	7.17	15.4	20.6	19.6	6.5	4.71	3.76	2.83	2.63	4.02	5.73	18.2	28.7	3.4	7.7	0.398	0.900	1978
1979	18.2	28.7	16.4	12.7	6.54	15.1	5.04	7.8	19.5	12.3	10.2	7.92	16.9	9.1	9.0	9.9	1.050	1.157	1979
1980	16.9	9.1	14.7	14	8.47	4.46	5.89	2.63	1.99	2.67	3.69	2.99	3.05	7.98	2.9	3.4	0.334	0.398	1980
1981	3.05	7.98	4.12	4.46	2.93	1.92	2.44	1.53	1.95	4.55	2.4	5.52	7.13	17	2.6	4.6	0.310	0.542	1981
1982	7.13	17	10.8	7.4	5.05	18.9	4.16	3.2	2.1	3.51	4.57	6.83	4.08	10.2	3.5	4.3	0.410	0.499	1982
1983	4.08	10.2	13.3	19.6	7.84	4.7	2.49	1.62	1.1	3.02	8.83	11	7.2	15.1	4.0	5.5	0.471	0.647	1983
1984	7.2	15.1	21.9	19.7	9.87	4.47	4.95	6.21	2.52	3.51	4.12	4.97	6.48	11.9	3.8	4.9	0.443	0.576	1984
1985	6.48	11.9	5.81	4.44	6.19	5.53	3.01	14.7	2.29	3.41	32.3	6.99	5.69	10.2	8.9	8.7	1.046	1.018	1985
1986	5.69	10.2	7.49	5.31	3.79	1.91	0.98	1.66	1.21	1.23	2.69	6.68	5.79	10.9	2.1	3.4	0.243	0.399	1986
1987	5.79	10.9	9.36	21.1	5.81	2.23	1.37	0.58	13.9	1.98	5.56	6.64	7.03	6.42	4.3	4.8	0.499	0.562	1987
1988	7.03	6.42	5.5	6.8	8.69	3.52	2.36	2.33	1.7	1.93	4.93	2.16	2.4	5.38	2.2	2.5	0.258	0.299	1988
1989	2.4	5.38	11.1	7.67	19	6.35	5.51	3.73	14.4	11.1	9.32	7.84	17.2	12.6	7.4	9.1	0.868	1.061	1989
1990	17.2	12.6	17.3	13.6	13.7	6.75	3.84	3.02	2.14	6.92	5.02	7.4	12.4	7.84	4.1	5.4	0.477	0.634	1990
1991	12.4	7.84	15.3	11.2	9.01	8.32	9.02	5.84	3.06	3.09	3.99	8.35	6.31	8.11	4.8	5.3	0.563	0.622	1991
1992	6.31	8.11	8.22	8.46	6.21	6.44	3.47	2.55	6.66	4.08	10.5	13.3	14.5	12.8	5.8	7.5	0.679	0.880	1992
1993	14.5	12.8	35.6	16.1	9.84	9.74	4.17	3.33	2.76	2.82	18	16.3	15.4	33.9	6.8	10.5	0.793	1.234	1993
1994	15.4	33.9	37.9	13.3	8.19	14.2	8.2	8.96	3.93	3.91	4.5	4.02	11.5	7.94	4.8	5.9	0.565	0.691	1994
1995	11.5	7.94	9.51	6.16	8.69	11.7	6.55	2.41	3.4	10.6	8.32	8.34	19.3	15.5	5.7	8.2	0.666	0.966	1995
1996	19.3	15.5	14.4	13.1	10.6	5.77	4.44	6.38	36.8	8.77	8.49	19.4	13.4	13.5	12.0	12.3	1.406	1.443	1996
1997	13.4	13.5	13.7	11.4	8.15	4.64	5.81	2.92	2.69	4.02	8.29	6.7	24.9	36.9	4.4	10.0	0.511	1.176	1997
1998	24.9	36.9	27.5	25.2	13.8	6.17	2.87	3.67	1.37	2.09	3.02	3.7	11.5	5.86	2.4	3.8	0.282	0.444	1998
1999	11.5	5.86	8.01	6.79	6.15	2.95	1.72	0.88	7.7	3.01	3.96	5.09	5.12	7.61	3.2	3.9	0.373	0.452	1999
2000	5.12	7.61	5.69	9.01	4.38	2.62	1.8	1.4	3.03	1.72	2.96	2.78	3.39	2.22	2.0	2.1	0.229	0.251	2000
2001	3.39	2.22	12.2	5.74	3.63	2.93	1	0.46	0.32	0.44	0.83	1.47	2.07	2.05	0.6	1.0	0.076	0.112	2001
2002	2.07	2.05	4.61	3.16	2.64	0.56	0.44	0.28	0.44	2.04									
Mean of monthly streamflows	10.9	12.4	13.9	11.6	9.54	8.03	4.45	4.39	6.1	5.91							0.608	0.764	1966-2001

Table B-3
Monthly Streamflow Unit Discharge for USGS02039000

USGS 02039000 BUFFALO CREEK NEAR HAMPDEN SYDNEY, VA

Prince Edward County, Virginia
Hydrologic Unit Code 02080207
Latitude 37°15'25", Longitude 78°29'12" NAD27
Drainage area 69.70 square miles 69.7
Gage datum 339.19 feet above sea level NGVD29

YEAR	Monthly mean daily streamflow, ln ft³/s												Next Calendar Year		Average (ft³/s)		Runoff/square mile		YEAR START
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Jul-Dec	Jul-Feb	Jul-Dec	Jul-Feb	
1946										38.2	47.5	48.3	115	49.1	19	33	0.275	0.475	1946
1947	115	49.1	107	87.6	48.5	33.6	31.1	28.3	36.8	71.8	97.5	52.9	64.6	142	45	58	0.653	0.826	1947
1948	64.6	142	124	139	78.3	77.1	44.4	51.7	29.6	57.7	111	143	112	112	63	73	0.900	1.052	1948
1949	112	112	84.7	73.6	87.1	41.7	45.9	34.4	30.6	46.8	87.4	51.9	53.4	75	42	47	0.609	0.675	1949
1950	53.4	75	103	51.6	92.8	62.7	128	60.8	83.2	49.6	52.3	106	62.5	79.2	69	69	0.988	0.993	1950
1951	62.5	79.2	83.3	90.6	51.1	42.5	37.3	32.4	25.4	23.9	82.6	156	112	94.2	51	63	0.736	0.898	1951
1952	112	94.2	138	107	61.2	36.7	51.8	50.9	65.8	30.6	198	73.9	107	105	67	75	0.961	1.082	1952
1953	107	105	136	83.8	51	37.2	23.4	18.9	21.3	25.7	28.1	53.7	126	54.2	25	39	0.352	0.561	1953
1954	126	54.2	92.7	57.5	61.6	43.1	18.8	11.8	8.6	29.2	38	79.9	34.5	72.8	27	32	0.384	0.464	1954
1955	34.5	72.8	96.8	85.9	45	27.8	43	260	60.7	44.1	37.5	32.8	31.7	88.2	69	67	0.987	0.955	1955
1956	31.7	88.2	74.7	84.5	42.2	29.2	27.7	16.2	15.6	27	44.5	46.3	46.4	110	25	36	0.364	0.523	1956
1957	46.4	110	74.3	85.6	27.4	68.4	14.5	21	47.4	27.6	96	94.7	108	140	43	60	0.616	0.865	1957
1958	108	140	110	122	114	49.6	31.9	52.3	24.6	39.5	36.4	108	57.4	48.3	42	44	0.604	0.638	1958
1959	57.4	48.3	46	86.5	32.3	24.6	18.1	16	17	36	41.7	54.1	50.9	159	26	43	0.376	0.612	1959
1960	50.9	159	97.3	142	84	37.8	22.5	26	31	27	29.5	35.6	38.4	142	25	38	0.353	0.548	1960
1961	38.4	142	94.4	94.6	86.9	77.6	44.7	134	45.7	65.6	49	140	132	128	69	82	0.989	1.179	1961
1962	132	128	137	131	66.4	93	83.3	37.4	34.2	34.5	73	51.1	81.8	71.9	45	52	0.644	0.744	1962
1963	81.8	71.9	180	52.7	42.4	28	23.9	15.9	14.7	17	40.3	36.9	97.8	105	21	39	0.305	0.553	1963
1964	97.8	105	63.3	51.9	35.4	20.7	19.1	13.7	17.2	30.3	26.5	56.2	48.3	98	23	34	0.336	0.486	1964
1965	48.3	98	103	52.3	31.2	22.8	51	17.3	17.7	18.5	20.2	18.7	25.3	102	21	29	0.295	0.423	1965
1966	25.3	102	76.2	31.3	40.1	30.7	15.5	18.8	25.9	47.9	28.6	35.1	69.7	64.2	25	34	0.353	0.485	1966
1967	69.7	64.2	60.8	29.4	36.9	36.1	20.9	53.1	17	19.1	23.6	94.3	67.8	36.9	33	37	0.471	0.534	1967
1968	67.8	36.9	80.5	33.6	42.4	31.2	20.6	18.7	7.04	13	34.4	29.3	48.9	53.8	18	25	0.253	0.357	1968
1969	48.9	53.8	114	37.5	23.4	18.1	26.1	17.1	10.6	13.7	14.6	29.2	37.2	64.9	16	23	0.230	0.336	1969
1970	37.2	64.9	45.5	65.5	31.5	11.2	14	11.1	6.67	9.94	45.5	25.1	48.1	107	16	29	0.230	0.416	1970
1971	48.1	107	60.9	52.7	119	52.5	27.7	71.5	101	365	102	63.4	82.3	130	105	105	1.505	1.505	1971
1972	82.3	130	76.8	125	142	294	119	59.8	44.1	194	185	132	125	169	105	114	1.510	1.636	1972
1973	125	169	155	218	96.2	60.7	45.4	43.2	34.8	36.4	38.4	130	113	98.5	47	60	0.677	0.860	1973
1974	113	98.5	92.7	102	77.5	59.4	46.1	53.4	160	35.5	38.3	62.7	106	102	56	67	0.810	0.958	1974
1975	106	102	296	109	57.9	43.3	126	48.1	160	66.1	55.3	80.3	139	75.9	77	84	1.099	1.200	1975
1976	139	75.9	63.7	63.5	52.4	36.2	24.9	14.6	19.5	149	55.3	95.9	51.5	55.5	52	52	0.742	0.747	1976
1977	51.5	55.5	84.4	81.4	37.6	26.7	14.4	9.02	10.3	28.9	54.4	69.4	313	45.6	27	61	0.383	0.877	1977
1978	313	45.6	176	183	173	60.9	45.4	78	33.9	32.2	48.7	81.1	165	295	46	85	0.658	1.219	1978
1979	165	295	138	116	61.9	68	34.9	44	168	130	102	67.1	159	77.1	78	87	1.117	1.248	1979
1980	159	77.1	152	129	67.7	35.5	36.1	18.5	18.8	31.5	36.4	24.8	27.7	66.3	24	29	0.342	0.410	1980
1981	27.7	66.3	37.5	49	25.6	31.9	26.5	18	36.2	46.4	25.3	52.5	82.8	139	29	47	0.422	0.670	1981
1982	82.8	139	88.5	44.3	64	93.6	51.4	27.7	18.5	35.6	51	90.9	52.5	105	40	48	0.567	0.685	1982
1983	52.5	105	183	256	106	43.8	28.4	19	14.9	37.4	81.7	140	119	105	46	60	0.661	0.867	1983
1984	119	105	207	149	66.6	38.5	55.8	53	27.9	38.3	41.3	51.1	75.7	105	36	49	0.551	0.710	1984
1985	75.7	105	40.7	30.3	30.4	22.1	20.1	148	30.1	44.2	315	70.2	48.2	88.5	89	85	1.281	1.213	1985
1986	48.2	88.5	74.9	42.6	37.9	21.1	15.8	41.4	20.3	21.8	36.6	89.4	94.4	137	32	50	0.464	0.719	1986
1987	94.4	137	128	187	45.6	32	24.3	12.5	75.8	39.6	52.8	85.1	84.4	60.4	41	48	0.594	0.692	1987
1988	84.4	60.4	47.6	56	78.6	34.5	21.9	29.1	22.7	24.1	60.3	38.2	38.5	82.5	28	35	0.402	0.500	1988
1989	38.5	82.5	105	104	171	96.2	129	43.6	82	69.1	77.1	59.9	146	116	66	80	0.947	1.151	1989
1990	146	116	82.2	125	111	63.7	32	31.3	21.8	76.5	49.3	73.5	126	65.8	41	53	0.586	0.762	1990
1991	126	65.8	142	77.4	47.9	35.1	29.4	41.8	24.2	24.6	31.7	51.1	60.4	60.1	29	36	0.418	0.514	1991

Table B-3 continued
Monthly Streamflow Unit Discharge for USGS02039000

USGS 02039000 BUFFALO CREEK NEAR HAMPDEN SYDNEY, VA (Cont'd)

1992	60.4	60.1	64.6	62.7	46.2	50.7	27.5	25.3	49.5	34	63.1	100	151	85	43	59	0.615	0.853	1992
1993	151	85	324	168	72.6	53.9	35.9	26.4	21.6	24	144	147	90.8	171	57	73	0.818	1.041	1993
1994	90.8	171	261	86.5	59.3	55.6	42.9	55.2	39.8	30.6	64.7	38.9	78.6	57.5	39	45	0.559	0.650	1994
1995	78.6	57.5	83.1	39.4	66.1	113	62.8	19.8	25.8	83	70.9	44.5	155	133	44	66	0.631	0.943	1995
1996	155	133	97.1	79.5	82.3	37.7	35.7	56.9	163	57.8	57.5	157	99.4	119	75	83	1.082	1.185	1996
1997	99.4	119	127	111	66.6	42.1	26	18.9	18.5	26.1	48.5	48.5	213	231	27	69	0.383	0.987	1997
1998	213	231	192	133	116	47.5	28.5	29.4	16.3	17.9	23.3	35.4	105	51.7	22	34	0.311	0.491	1998
1999	105	51.7	66.5	45.5	39.7	17	17.6	9	46.6	35.8	38.4	35.5	62.3	71.8	26	35	0.374	0.501	1999
2000	62.3	71.8	87.5	97.3	41.3	29.7	22.3	17.3	20.8	16.9	20	21.3	30.1	30.4	17	20	0.244	0.285	2000
2001	30.1	30.4	96.9	43.8	23.7	68.9	17.7	20.9	15.3	11.6	15.5	23.4	35.1	28.6	15	19	0.215	0.268	2001
2002	35.1	28.6	58.2	26.3	27.8	10	6.40	4.30	7.51										
																	0.611		1946-2001
																	0.625	0.791	1966-2001
Mean of monthly streamflows	90.4	98.8	112	91.7	65.4	49.9	38.7	40	40.7	49	62.8	70.7							

Table B-4
Monthly Streamflow Unit Discharge for USGS02039500

USGS 02039500 APPOMATTOX RIVER AT FARMVILLE, VA

Cumberland County, Virginia
Hydrologic Unit Code 02080207
Latitude 37°18'25", Longitude 78°23'20" NAD27
Drainage area 303.00 square miles
Gage datum 281.93 feet above sea level NGVD29

303

YEAR	Monthly mean daily streamflow, in ft^3/s												Next Calendar Year		Average (ft^3/s)		Runoff/square mile		YEAR START
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Jul-Dec	Jul-Feb	Jul-Dec	Jul-Feb	
1926				230	106	71.4	119	95.5	49.6	75.8	165	409	155	298	131	151	0.434	0.499	1926
1927	155	298	180	291	116	76	87.2	252	79.5	289	376	476	280	392	224	247	0.739	0.817	1927
1928	280	392	313	586	180	133	98.6	946	547	160	143	168	200	379	296	293	0.975	0.968	1928
1929	200	379	529	573	249	205	199	80.5	56.7	249	270	272	300	405	162	202	0.534	0.668	1929
1930	300	405	213	224	101	87.3	44.2	19.6	21.8	30.3	69.8	90.8	126	118	40	57	0.131	0.190	1930
1931	126	118	226	318	392	121	105	187	82.5	37.8	51	103	424	195	81	132	0.269	0.436	1931
1932	424	195	627	249	251	82.8	44.3	24.5	27.5	397	606	549	495	406	236	283	0.778	0.933	1932
1933	495	406	260	577	252	218	158	102	75.8	52.8	74.3	125	129	114	84	93	0.279	0.305	1933
1934	129	114	614	247	172	172	83.9	101	368	258	349	679	520	491	263	316	0.868	1.042	1934
1935	520	491	568	902	265	290	327	216	653	137	379	305	1,170	713	287	431	0.948	1.423	1935
1936	1,170	713	805	474	189	228	131	205	106	139	119	226	1,223	509	133	295	0.439	0.975	1936
1937	1,223	509	306	875	424	294	360	398	291	666	274	218	388	255	317	319	1.046	1.052	1937
1938	388	255	448	265	187	850	426	200	134	127	202	333	306	723	204	269	0.675	0.888	1938
1939	306	723	648	276	153	223	449	243	109	130	239	153	232	815	190	259	0.627	0.854	1939
1940	232	815	280	585	186	156	179	1,782	149	128	322	232	336	182	402	372	1.328	1.228	1940
1941	336	182	233	380	152	147	290	71.1	50.3	41	68.7	108	135	194	91	106	0.299	0.351	1941
1942	135	194	216	118	203	120	189	608	122	551	184	402	331	788	296	351	0.978	1.158	1942
1943	331	788	501	333	261	133	104	48.9	49.5	61.6	152	118	220	387	76	125	0.252	0.411	1943
1944	220	387	936	498	228	95.1	103	189	869	287	195	350	506	460	284	327	0.936	1.079	1944
1945	506	460	328	347	282	153	191	175	873	180	236	676	451	602	332	374	1.097	1.233	1945
1946	451	602	387	304	694	229	316	224	129	162	169	181	578	188	170	218	0.560	0.719	1946
1947	578	188	521	419	193	127	104	77.2	150	253	475	209	346	671	181	250	0.597	0.825	1947
1948	346	671	578	692	297	290	171	359	107	258	454	864	547	478	318	360	1.049	1.189	1948
1949	547	478	347	328	356	181	387	154	122	222	438	226	244	379	222	240	0.732	0.793	1949
1950	244	379	399	212	431	187	334	185	383	176	164	382	254	370	233	249	0.768	0.822	1950
1951	254	370	375	415	183	148	148	123	102	78.7	266	793	679	444	217	293	0.717	0.966	1951
1952	679	444	688	412	212	110	128	193	288	104	426	248	423	370	198	241	0.652	0.795	1952
1953	423	370	549	365	226	131	92.5	62.4	85.8	88.9	90.8	221	505	217	92	152	0.304	0.501	1953
1954	505	217	367	270	255	162	68	58.8	45.2	110	134	296	126	333	102	129	0.338	0.425	1954
1955	126	333	480	315	190	111	134	802	162	124	121	105	102	317	208	207	0.688	0.685	1955
1956	102	317	292	309	143	112	97.6	57.5	83.3	93	202	203	183	497	105	154	0.348	0.509	1956
1957	183	497	321	406	112	169	52.6	57.9	144	76.8	336	386	477	496	150	223	0.496	0.736	1957
1958	477	496	478	625	513	235	116	159	90.5	110	114	309	235	186	129	147	0.426	0.485	1958
1959	235	186	201	370	131	87.1	109	67.8	65.6	171	174	216	213	719	115	188	0.380	0.621	1959
1960	213	719	437	520	399	156	90.3	139	192	97.5	105	125	179	694	107	175	0.353	0.579	1960
1961	179	694	445	499	384	289	168	294	218	397	216	642	552	518	278	334	0.918	1.102	1961
1962	552	518	678	539	241	371	263	124	123	101	222	180	314	284	145	179	0.479	0.589	1962
1963	314	284	655	191	160	98.9	77.5	51.1	63.5	50.2	122	119	353	468	69	142	0.228	0.470	1963
1964	353	468	253	211	123	66.9	64	42.6	55.7	87.3	79.2	158	158	417	70	115	0.231	0.381	1964
1965	158	417	464	199	115	73.7	127	52.8	56.1	73.5	66.2	61.6	96.3	430	63	104	0.207	0.344	1965
1966	96.3	430	330	107	153	84	40.5	72.5	114	209	98.8	124	304	270	94	136	0.312	0.450	1966
1967	304	270	244	119	138	122	84	167	57.6	62.7	68.7	438	324	151	127	152	0.418	0.500	1967
1968	324	151	301	128	197	167	58.9	54.6	16.7	32.1	117	99.8	166	203	54	82	0.179	0.271	1968
1969	166	203	446	153	95.2	65.5	97.1	85.9	42.2	45.2	57.4	127	174	266	65	98	0.216	0.324	1969
1970	174	266	178	238	120	29.5	83	49.2	25.7	46.2	164	108	209	509	68	129	0.225	0.427	1970
1971	209	509	270	249	788	263	76.7	197	270	1,190	386	256	418	678	341	384	1.126	1.269	1971

Table B-4 continued
Monthly Streamflow Unit Discharge for USGS02039500

USGS 02039500 APPOMATTOX RIVER AT FARMVILLE, VA (Cont'd)

1972	418	678	324	374	674	1,865	518	194	152	804	877	626	548	792	455	500	1.500	1.649	1972
1973	548	792	689	1,088	373	227	163	266	139	169	166	665	572	435	226	287	0.745	0.946	1973
1974	572	435	397	448	348	304	164	195	674	126	151	240	393	405	221	259	0.728	0.855	1974
1975	393	405	1,475	368	200	139	517	208	971	227	249	297	725	350	352	394	1.162	1.301	1975
1976	725	350	273	344	225	161	106	66.1	86.2	729	283	429	251	228	244	243	0.807	0.804	1976
1977	251	228	310	377	165	101	53.1	44.2	42.9	83.7	263	308	1,429	239	114	276	0.375	0.911	1977
1978	1,429	239	750	849	872	223	162	276	132	89.8	178	278	863	1,402	160	367	0.529	1.212	1978
1979	863	1,402	665	528	235	410	149	218	733	558	493	311	784	311	351	396	1.158	1.307	1979
1980	784	311	632	537	323	133	156	81.5	62.8	90.5	158	114	111	259	95	114	0.313	0.375	1980
1981	111	269	126	183	101	109	104	99.1	107	208	99	243	337	703	124	207	0.408	0.684	1981
1982	337	703	441	191	211	558	159	136	76.7	134	196	311	171	448	145	179	0.480	0.592	1982
1983	171	448	734	1,155	436	160	95.1	74.4	58.1	131	386	571	437	553	189	254	0.622	0.839	1983
1984	437	553	1,022	788	306	139	200	261	93.5	151	189	190	287	455	156	201	0.514	0.665	1984
1985	287	455	167	129	161	106	73.3	738	91.9	115	1,287	281	177	387	368	348	1.215	1.150	1985
1986	177	387	287	161	132	69	47.9	140	64.7	57	130	343	309	509	112	175	0.371	0.579	1986
1987	309	509	369	893	169	87.2	66.7	33.5	464	92.9	277	326	329	241	179	202	0.591	0.668	1987
1988	329	241	167	219	379	117	74.2	86	64.8	64.9	193	119	134	364	86	120	0.284	0.396	1988
1989	134	364	541	377	799	279	346	117	417	343	332	215	674	574	253	334	0.835	1.101	1989
1990	674	574	433	583	412	257	129	144	78.7	289	164	306	594	293	160	223	0.527	0.735	1990
1991	594	293	660	347	243	135	228	144	92.9	71.9	106	242	266	268	127	157	0.420	0.520	1991
1992	266	268	317	309	220	234	105	86.6	156	119	283	484	652	476	177	261	0.583	0.862	1992
1993	652	476	1,518	713	300	295	127	104	92.6	92.1	648	627	450	842	241	327	0.797	1.078	1993
1994	450	842	1,442	430	297	384	239	285	138	120	221	142	377	275	164	200	0.542	0.659	1994
1995	377	275	372	178	321	455	357	84.8	97.8	356	318	256	779	606	211	316	0.696	1.043	1995
1996	779	606	449	363	336	148	168	252	1,140	326	285	961	486	545	447	462	1.475	1.523	1996
1997	486	545	538	430	257	153	138	91.8	84.7	106	219	198	1,032	1,251	120	339	0.396	1.120	1997
1998	1,032	1,251	1,034	773	596	199	110	140	68.6	69	84.8	136	474	214	87	144	0.289	0.476	1998
1999	474	214	311	177	200	67.5	65.3	44.8	266	149	157	191	267	327	125	161	0.411	0.533	1999
2000	267	327	299	428	166	129	85.8	71.1	111	60.8	78.3	99.3	141	140	72	87	0.239	0.288	2000
2001	141	140	561	215	105	220	60.2	75.8	53.3	33	45.5	80.3	116	97.1	50	62	0.165	0.206	2001
2002	116	97.1	214	105	119	28.2	19.6	12.2	22.5	101									
																	0.602	0.768	1926-2001
																	0.601	0.787	1966-2001
Mean of monthly streamflows	402	438	483	407	273	208	160	192	194	191	243	301	291						

Table B-5
Stage Storage Relationships
for Prospective Appomattox County Damsites

Appomatox River - Upper Site 1 *Drainage Area=4.8 Sq. Mi*

ELEV (Ft MSL)	SURFACE AREA (ACRES)	STORAGE INCREMENT (AF)	LIVE STORAGE (ACRE-FT)	LIVE STORAGE (MG)	RESERVOIR FEATURE	SURFACE AREA SOURCE
677.0	0.0	0.0	0.0	0.0	Toe	USGS Mapping
680.0	1.2	1.2	1.2	0.4		USGS Mapping
690.0	14.0	64.3	65.5	21.4		USGS Mapping
700.0	36.2	242.4	307.9	100.3		USGS Mapping
710.0	70.6	524.5	832.4	271.2		USGS Mapping
720.0	120.0	942.1	1774.6	578.2		USGS Mapping
730.0	207.2	1616.3	3390.8	1104.9	U/S Limit	USGS Mapping

Appomatox River - Middle Site 2 *Drainage Area=12.7 Sq. Mi*

ELEV (Ft MSL)	SURFACE AREA (ACRES)	STORAGE INCREMENT (AF)	LIVE STORAGE (ACRE-FT)	LIVE STORAGE (MG)	RESERVOIR FEATURE	SURFACE AREA SOURCE
580.0	0.0	0.0	0.0	0.0	Toe	USGS Mapping
590.0	6.2	20.8	20.8	6.8		USGS Mapping
600.0	23.1	137.8	158.6	51.7		USGS Mapping
610.0	38.2	303.4	462.0	150.5		USGS Mapping
620.0	66.6	517.5	979.4	319.2		USGS Mapping
630.0	110.7	877.2	1856.6	605.0		USGS Mapping
635.0	133.6	609.9	2466.5	803.7	U/S Limit	USGS Mapping
640.0	158.6	729.6	3196.1	1041.5		USGS Mapping

Appomatox River - Lower Site 3 *Drainage Area=14.3 Sq. Mi*

ELEV (Ft MSL)	SURFACE AREA (ACRES)	STORAGE INCREMENT (AF)	LIVE STORAGE (ACRE-FT)	LIVE STORAGE (MG)	RESERVOIR FEATURE	SURFACE AREA SOURCE
550.0	0.0	0.0	0.0	0.0	Toe	USGS Mapping
560.0	12.5	41.5	41.5	13.5		USGS Mapping
570.0	34.8	227.0	268.5	87.5		USGS Mapping
580.0	56.9	454.0	722.5	235.4		USGS Mapping
590.0	82.9	694.6	1417.1	461.8		USGS Mapping
600.0	120.4	1010.3	2427.4	791.0		USGS Mapping
605.0	137.3	643.6	3070.9	1000.7		USGS Mapping
610.0	160.2	742.8	3813.8	1242.7		USGS Mapping
615.0	180.0	849.9	4663.7	1519.7		Estimate

Table B-5 continued
Stage Storage Relationships
for Prospective Appomattox County Damsites

Appomatox River - Confluence Site 4 *Drainage Area=14.7 Sq. Mi*

ELEV (Ft MSL)	SURFACE AREA (ACRES)	STORAGE INCREMENT (AF)	LIVE STORAGE (ACRE-FT)	LIVE STORAGE (MG)	RESERVOIR FEATURE	SURFACE AREA SOURCE
535.0	0.0	0.0	0.0	0.0	Toe	USGS Mapping
540.0	1.7	2.8	2.8	0.9		USGS Mapping
550.0	15.1	72.6	75.4	24.6		USGS Mapping
560.0	45.7	290.1	365.5	119.1		USGS Mapping
570.0	76.9	606.3	971.8	316.7		USGS Mapping
580.0	108.6	923.1	1894.9	617.4		USGS Mapping
590.0	142.4	1251.2	3146.0	1025.1	U/S Limit	USGS Mapping
600.0	190.3	1657.7	4803.7	1565.3		USGS Mapping

Wreck Island Stonewall Mill Site 5 *Drainage Area=39.5 Sq. Mi*

ELEV (Ft MSL)	SURFACE AREA (ACRES)	STORAGE INCREMENT (AF)	LIVE STORAGE (ACRE-FT)	LIVE STORAGE (MG)	RESERVOIR FEATURE	SURFACE AREA SOURCE
503.0	0.0	0.0	0.0	0.0	Toe	USGS Mapping
510.0	9.0	21.0	21.0	6.8	Road 608	USGS Mapping
520.0	38.9	41.2	62.2	20.3		USGS Mapping
530.0	128.1	792.0	854.2	278.3		USGS Mapping
540.0	228.7	1759.9	2614.0	851.8	Max U/S	USGS Mapping

Wreck Island Upper Site 6 *Drainage Area=35.3 Sq. Mi*

ELEV (Ft MSL)	SURFACE AREA (ACRES)	STORAGE INCREMENT (AF)	LIVE STORAGE (ACRE-FT)	LIVE STORAGE (MG)	RESERVOIR FEATURE	SURFACE AREA SOURCE
508.0	0.0	0.0	0.0	0.0	Toe	USGS Mapping
510.0	1.2	0.8	0.8	0.3	Road 608	USGS Mapping
520.0	16.3	41.2	42.0	13.7		USGS Mapping
530.0	84.4	459.3	501.3	163.4		USGS Mapping
540.0	162.6	1213.8	1715.1	558.9	Max U/S	USGS Mapping

Table B-5 continued
Stage Storage Relationships
for Prospective Appomattox County Damsites

Rough Creek Site 7 *Drainage Area=6.6 Sq. Mi*

ELEV (Ft MSL)	SURFACE AREA (ACRES)	STORAGE INCREMENT (AF)	LIVE STORAGE (ACRE-FT)	LIVE STORAGE (MG)	RESERVOIR FEATURE	SURFACE AREA SOURCE
515.0	0.0	0.0	0.0	0.0	Toe	USGS Mapping
520.0	0.9	1.5	1.5	0.5		USGS Mapping
530.0	10.7	49.0	50.5	16.5		USGS Mapping
540.0	36.0	221.1	271.6	88.5		USGS Mapping
550.0	65.5	500.2	771.8	251.5		USGS Mapping
560.0	99.7	820.0	1591.8	518.7	45 Foot	USGS Mapping
570.0	138.8	1187.2	2779.0	905.6	55 Foot	USGS Mapping
580.0	191.9	1646.5	4425.5	1442.1	Max U/S	USGS Mapping

Wolf Creek Site 8 *Drainage Area=6.8 Sq. Mi*

ELEV (Ft MSL)	SURFACE AREA (ACRES)	STORAGE INCREMENT (AF)	LIVE STORAGE (ACRE-FT)	LIVE STORAGE (MG)	RESERVOIR FEATURE	SURFACE AREA SOURCE
515.0	0.0	0.0	0.0	0.0	Toe	USGS Mapping
520.0	1.0	1.7	1.7	0.5		USGS Mapping
530.0	6.3	32.7	34.4	11.2		USGS Mapping
540.0	21.6	131.9	166.3	54.2		USGS Mapping
545.0	28.4	124.6	290.9	94.8	Max U/S	USGS Mapping
550.0	38.4	166.4	457.2	149.0		USGS Mapping

Table B-6
Basin Time of Concentration

Appomattox Site 1- Time of Concentration

A= 8134 acres = 12.71 square miles
Southern Piedmont Region q(2)= 122(A)^0.635
q(2)= 613.0449 at dam
Max Path Elev = 895
Min Path Elev = 580
Path Fall = 315
SL (ft/mi)= 60.69851

Tc Area=	0.727905	Tc Area=	1.833577	Tc Area=	2.470365	Tc Area=	3.910096
q(2) (cfs)=	99.71882	q(2) (cfs)=	179.2895	q(2) (cfs)=	216.6522	q(2) (cfs)=	290.0005
SL (ft/mi)=	69.01961	SL (ft/mi)=	50.19807	SL (ft/mi)=	46.06325	SL (ft/mi)=	32.22132

Sheet Flow			*Shallow concentrated flow*		*Channel flow 1*		*Channel flow 2*		*Channel flow 3*		*Channel flow 4*		*Lake 1*		*Lake 2*		*Total*
						3:1ss		3:1ss		3:1ss		3:1ss					
Descript	range	gravel,urba	Descript	grassed waterway	Descript	Trapezoid	Descript	Trapezoid	Descript	Trapezoid	Descript	Trapezoid	Descript	lake	Descript	lake	
Upper El	895	880	Upper El	860	Upper El	800	Upper El	760	Upper El	700	Upper El	660	Upper El	630	Upper El	600	
Lower El	880	860	Lower El	800	Lower El	760	Lower El	700	Lower El	660	Lower El	630	Lower El	600	Lower El	580	
Delta h (ft)	15	20	Delta h (ft)	60	Delta h (ft)	40	Delta h (ft)	60	Delta h (ft)	40	Delta h (ft)	30	Delta h (ft)	30	Delta h (ft)	20	280
L (ft)	295	339	L (ft)	2720	L (ft)	3060	L (ft)	6311	L (ft)	4585	L (ft)	4916	L (ft)	5470	L (ft)	2689	27401
slope	0.051	0.059	slope	0.022	slope	0.013	slope	0.010	slope	0.009	slope	0.006	slope	0.005	slope	0.007	0.010
n	0.13	0.02			Q2est(cfs)	99.72	Q2est(cfs)	179.29	Q2est(cfs)	216.65	Q2est(cfs)	290.00					
P2 (in)	3.5	3.5			n	0.1	n	0.1	n	0.1	n	0.1					
				Compare	w or b (ft)	6	w or b (ft)	7.6	w or b (ft)	8.2	w or b (ft)	9.1					
n' from T 5-7				from f 15-2	d (ft)	2.83	d (ft)	3.78	d (ft)	4.13	d (ft)	5.12					
				2.3	X-Sc A(ft2)	41.01	X-Sc A(ft2)	71.59	X-Sc A(ft2)	85.04	X-Sc A(ft2)	120.63					
				0.37	Pw (ft)	23.9	Pw (ft)	31.51	Pw (ft)	34.32	Pw (ft)	40.58					
				from f 15-2	R (ft)	1.72	R (ft)	2.27	R (ft)	2.48	R (ft)	2.97					
v(effective)	0.360	1.755	v (fps)	2.2	v (fps)	2.44	v (fps)	2.51	v (fps)	2.55	v (fps)	2.41	v (fps)	21.98	v (fps)	17.94	
Tt	**0.23**	**0.05**	Tt	**0.34**	Tt	**0.35**	Tt	**0.70**	Tt	**0.50**	Tt	**0.57**	Tt	**0.07**	Tt	**0.04**	**2.85**

Appomattox Site 6- Time of Concentration

A= 8134 acres = 14.3 square miles
Southern Piedmont Region q(2)= 122(A)^0.635
q(2)= 660.6907 at dam
Max Path Elev = 895
Min Path Elev = 550
Path Fall = 345
SL (ft/mi)= 66.47933

Tc Area=	0.727905	Tc Area=	1.833577	Tc Area=	2.470365	Tc Area=	3.910096	Tc Area=	4.65024
q(2) (cfs)=	99.71882	q(2) (cfs)=	179.2895	q(2) (cfs)=	216.6522	q(2) (cfs)=	290.0005	q(2) (cfs)=	323.7477
SL (ft/mi)=	69.01961	SL (ft/mi)=	50.19807	SL (ft/mi)=	46.06325	SL (ft/mi)=	32.22132	SL (ft/mi)=	28.95795

Sheet Flow			*Shallow concentrated flow*		*Channel flow 1*		*Channel flow 2*		*Channel flow 3*		*Channel flow 4*		*Channel flow 5*		*Lake 2*		*Total*
						3:1ss		3:1ss		3:1ss		3:1ss		3:1ss			
Descript	range	gravel,urba	Descript	grassed waterway	Descript	Trapezoid	Descript	Trapezoid	Descript	Trapezoid	Descript	Trapezoid	Descript	Trapezoid	Descript	lake	
Upper El	895	880	Upper El	860	Upper El	800	Upper El	760	Upper El	700	Upper El	660	Upper El	630	Upper El	600	
Lower El	880	860	Lower El	800	Lower El	760	Lower El	700	Lower El	660	Lower El	630	Lower El	600	Lower El	580	
Delta h (ft)	15	20	Delta h (ft)	60	Delta h (ft)	40	Delta h (ft)	60	Delta h (ft)	40	Delta h (ft)	30	Delta h (ft)	30	Delta h (ft)	20	280
L (ft)	295	339	L (ft)	2720	L (ft)	3060	L (ft)	6311	L (ft)	4585	L (ft)	4916	L (ft)	5470	L (ft)	2689	27401
slope	0.051	0.059	slope	0.022	slope	0.013	slope	0.010	slope	0.009	slope	0.006	slope	0.0055	slope	0.007	0.010
n	0.13	0.02			Q2est(cfs)	99.72	Q2est(cfs)	179.29	Q2est(cfs)	216.65	Q2est(cfs)	290.00	Q2est(cfs)	323.75			
P2 (in)	3.5	3.5			n	0.1	n	0.1	n	0.1	n	0.1	n	0.1			
				Compare	w or b (ft)	6	w or b (ft)	7.6	w or b (ft)	8.2	w or b (ft)	9.1	w or b (ft)	9.5			
n' from T 5-7				from f 15-2	d (ft)	2.83	d (ft)	3.78	d (ft)	4.13	d (ft)	5.12	d (ft)	5.35			
				2.3	X-Sc A(ft2)	41.01	X-Sc A(ft2)	71.59	X-Sc A(ft2)	85.04	X-Sc A(ft2)	120.63	X-Sc A(ft2)	136.69			
				0.37	Pw (ft)	23.9	Pw (ft)	31.51	Pw (ft)	34.32	Pw (ft)	40.58	Pw (ft)	43.34			
				from f 15-2	R (ft)	1.72	R (ft)	2.27	R (ft)	2.48	R (ft)	2.97	R (ft)	3.15			
v(effective)	0.360	1.755	v (fps)	2.2	v (fps)	2.44	v (fps)	2.51	v (fps)	2.55	v (fps)	2.41	v (fps)	2.37	v (fps)	17.94	
Tt	**0.23**	**0.05**	Tt	**0.34**	Tt	**0.35**	Tt	**0.70**	Tt	**0.50**	Tt	**0.57**	Tt	**0.64**	Tt	**0.04**	**3.42**

Figure B-1
Water Balance Model

Appomattox Reservoir Study

user inputs *primary (initial) linked inputs*

APPOMATTOX RIVER AT FARMVILLE, VA

Base Gauge station used for Inflow:	USGS 02039500
Mean Annual Flow at gauge (cfs)	291
gauge station drainage area (acres):	193920
Site parameters for this Run	Site2-OptionA
Reservoir drainage area (acres):	8134
Inflow Adjustment Factor (AF)	0.042
Reservoir Surface Area (acres):	89
Max Reservoir Volume @ El 6.3 (acre-ft):	2467
Avg Reservoir Volume @ El 4.0 (acre-ft)	1233
Min Reservoir Volume @ El 2.0 (acre-ft):	5
Reservoir Live Storage for Run (acre-ft):	2462
Reservoir Live Storage for Run (MG):	802

Consistent Units Columns

Unit Conversio	cfs	Inches/day	(MGD)	*(acre-ft/day)*
	1		0.64632	1.983
	1.547		1	3.069
	0.504		0.3258	1.000
Seepage:	0.032		0.020	0.063
Lake Evaporation- Lake Preci		1		7.422
April - Oct (1980)		0.0186	0.045	0.138
Nov - March (1980/81)		-0.0015	-0.004	-0.011
April - Oct (1954)		0.0201		
Nov - March (1954/55)		-0.0064		

Site 2 (Appomatox Middle) Storage Options:

	Max Reservoir Volume (acre-ft):		Surface Area
Option A	2466.5	Reservoir @ El 635	133.6
Option B	1856	Reservoir @ El 630	110.7
Option C	979	Reservoir @ El 620	66.6

Min Reservoir Volume (acre-ft):
5 Reservoir @ El 585
0 Reservoir @ El 580

Site 1 (Appomattox Upper) Storage Options:

	Max Reservoir Volume (acre-ft):		Surface Area
Option A	3391	Reservoir @ El 730	207.2
Option B	1775	Reservoir @ El 720	120
Option C	832.4	Reservoir @ El 710	70.6

Min Reservoir Volume (acre-ft):
5 Reservoir @ El 682
0 Reservoir @ El 677

Run parameters for Proposed Sites	Site1-OptionA	Site1-OptionB	Site1-OptionC	Site2-OptionA	Site2-OptionB	Site2-OptionC	Site3-OptionA	Site3-OptionB	Site4-OptionA	Site4-OptionB	Site5-OptionA
Reservoir Drainage Area (acres)	3062	3062	3062	8134	8134	8134	9152	9152	9395	9395	25282
Inflow Adjustment Factor (AF)	0.016	0.016	0.016	0.042	0.042	0.042	0.047	0.047	0.048	0.048	0.130
Reservoir Surface Area = 2/3 Full Area (acres)	138	80	47	89	74	44	93	80	95	72	152
Full Pool Res. Volume @ El (acre-ft):	3391	1775	832	2467	1856	979	3071	2427	3146	1895	2614
Avg Reservoir Volume = 1/2 Full Vol (acre-feet)	1695	887	416	1233	928	490	1535	1214	1573	948	1307
Min Reservoir Volume @ El (acre-ft):	5	5	5	5	5	5	10	10	3	3	12
Site # Live Storage for Run (acre-ft):	3386	1770	827	2462	1851	974	3061	2417	3143	1892	2602

	(MGD)	*(acre-ft/day)*	*FishRelease*
Pipeline Demand:	2.3	7.059	0.200 MAF

					Reservoir Inflow = USGS station flow x AF1 (cfs)	*Reservoir Inflow (acre-ft/day)*	*Lake Evaporation Less Precip (acre-ft/day)*	*Seepage (acre-ft/day)*	*Requested Pumpage (acre-ft/day)*	*Streamflow Withdrawal (acre-ft/day)*	*Initial Reservoir Storage (acre-ft)*	*Projected Reservoir Storage Change (acre-ft/day)*	*Reservoir Storage After Restrictions (acre-ft)*	*Actual Reservoir Storage Change (acre-ft/day)*	*Actual Reservoir Pumpage (acre-ft/day)*	*Period Accumulated Pumpage (acre-ft/day)*
Blank Line - Do not Remove																
1926	4	1	4/1/26	280	11.7	23.30	0.14	0.06	7.06	4.84	2466.50	11.19	2466.50	0.00	7.06	7.06
1926	4	2	4/2/26	204	8.6	16.97	0.14	0.06	7.06	4.84	2466.50	4.87	2466.50	0.00	7.06	14.12
1926	4	3	4/3/26	156	6.5	12.98	0.14	0.06	7.06	4.84	2466.50	0.88	2466.50	0.00	7.06	21.18
1926	4	4	4/4/26	150	6.3	12.48	0.14	0.06	7.06	4.84	2466.50	0.38	2466.50	0.00	7.06	28.24
1926	4	5	4/5/26	162	6.8	13.48	0.14	0.06	7.06	4.84	2466.50	1.38	2466.50	0.00	7.06	35.29
1926	4	6	4/6/26	156	6.5	12.98	0.14	0.06	7.06	4.84	2466.50	0.88	2466.50	0.00	7.06	42.35
1926	4	7	4/7/26	150	6.3	12.48	0.14	0.06	7.06	4.84	2466.50	0.38	2466.50	0.00	7.06	49.41
1926	4	8	4/8/26	162	6.8	13.48	0.14	0.06	7.06	4.84	2466.50	1.38	2466.50	0.00	7.06	56.47
1926	4	9	4/9/26	198	8.3	16.47	0.14	0.06	7.06	4.84	2466.50	4.37	2466.50	0.00	7.06	63.53
1926	4	10	4/10/26	174	7.3	14.48	0.14	0.06	7.06	4.84	2466.50	2.37	2466.50	0.00	7.06	70.59
1926	4	11	4/11/26	162	6.8	13.48	0.14	0.06	7.06	4.84	2466.50	1.38	2466.50	0.00	7.06	77.65
1926	4	12	4/12/26	328	13.8	27.29	0.14	0.06	7.06	4.84	2466.50	15.19	2466.50	0.00	7.06	84.71

Figure B-1 (continued)
Water Balance Model

Site 5 (Wreck Island Lower) Storage Options:

20 % MAF	Max Reservoir Volume (acre-ft):	Surface Area
2.3	2614 Reservoir @ El 540	228.7
1.95	854 Reservoir @ El 530	128.1
	62 Reservoir @ El 520	38.9

Min Reservoir Volume (acre-ft):
12 Reservoir @ El 508
0 Reservoir @ El 503

Site 7 (Rough Creek) Storage Options:

20 % MAF	Max Reservoir Volume (acre-ft):	Surface Area
4.05	4425 Reservoir @ El 580	191.9
1.9	2779 Reservoir @ El 570	138.8
	1592 Reservoir @ El 560	99.7

Min Reservoir Volume (acre-ft):
2 Reservoir @ El 520
0 Reservoir @ El 515

Site 4 (Appomattox Confluence) Storage Options:

20 % MAF	Max Reservoir Volume (acre-ft):	Surface Area	20 % MAF
1.7	3146 Reservoir @ El 590	142.4	1.7
1.5	1895 Reservoir @ El 580	108.6	1.5

Min Reservoir Volume (acre-ft):
3 Reservoir @ El 540
0 Reservoir @ El 535

Doesn't fill

Site 6 (Wreck Island Upper) Storage Options:

Max Reservoir Volume (acre-ft):	Surface Area
1715 Reservoir @ El 540	162.6
501 Reservoir @ El 530	84.4
42 Reservoir @ El 520	16.3

Min Reservoir Volume (acre-ft):
5 Reservoir @ El 512
0 Reservoir @ El 508

Site 3 (Appomatox Lower) Storage Options:

Max Reservoir Volume (acre-ft):	Surface Area
3071 Reservoir @ El 605	140
2427 Reservoir @ El 600	120.4

Min Reservoir Volume (acre-ft):
10 Reservoir @ El 555
0 Reservoir @ El 550

Site 9 (Holiday Dam) Storage Options:

Max Reservoir Volume (acre-ft):	Surface Area	
1332 Reservoir @ El 445	113	1.6

Min Reservoir Volume (acre-ft):
5 Reservoir @ El 415
0 Reservoir @ El 412

Site5-OptionB	Site5-OptionC	Site6-OptionA	Site6-OptionB	Site6-OptionC	Site7-OptionA	Site7-OptionB	Site8	Site9		Casad Resrvr	S Reservoir
25282	25282	22561	22561	22561	4239	4239	4361	8697		1853	28067
0.130	0.130	0.116	0.116	0.116	0.022	0.022	0.022	0.045		0.010	0.145
85	26	108	56	11	128	93	20	75		150	500
854	62	1715	501	42	4425	2779	291	1332		8890	10500
427	31	858	251	21	2213	1390	146	666		4445	5250
12	0	5	5	5	2	2	2	5		10	500
842	62	1710	496	37	4423	2777	289	1327		8880	10000

PLOTTING

Reservoir Outflow including Seepage (acre-ft/day)	*Drawdown Period Accumulated Withdrawal (acre-ft/day)*	*Accumulated Days of Withdrawal (acre-ft/day)*	*Reservoir Status*	*End of Reservoir Withdrawal*	*Reservoir Drawdown Warning*	*date*	*Reservoirs Total Inflow (MG)*	*Pumpage Withdrawal (MGD)*	*Reservoir Vol (MG)*	*Reservoir Outflow including Seepage (MGD)*	*Streamflow Withdrawal (MGD)*
16.10	0.00	0	-	-	-	4/1/1926	7.59	2.30	803.59	5.24	1.58
9.78	0.00	0	-	-	-	4/2/1926	5.53	2.30	803.59	3.18	1.58
5.78	0.00	0	-	-	-	4/3/1926	4.23	2.30	803.59	1.88	1.58
5.28	0.00	0	-	-	-	4/4/1926	4.07	2.30	803.59	1.72	1.58
6.28	0.00	0	-	-	-	4/5/1926	4.39	2.30	803.59	2.05	1.58
5.78	0.00	0	-	-	-	4/6/1926	4.23	2.30	803.59	1.88	1.58
5.28	0.00	0	-	-	-	4/7/1926	4.07	2.30	803.59	1.72	1.58
6.28	0.00	0	-	-	-	4/8/1926	4.39	2.30	803.59	2.05	1.58
9.28	0.00	0	-	-	-	4/9/1926	5.37	2.30	803.59	3.02	1.58
7.28	0.00	0	-	-	-	4/10/1926	4.72	2.30	803.59	2.37	1.58
6.28	0.00	0	-	-	-	4/11/1926	4.39	2.30	803.59	2.05	1.58
20.09	0.00	0	-	-	-	4/12/1926	8.89	2.30	803.59	6.55	1.58

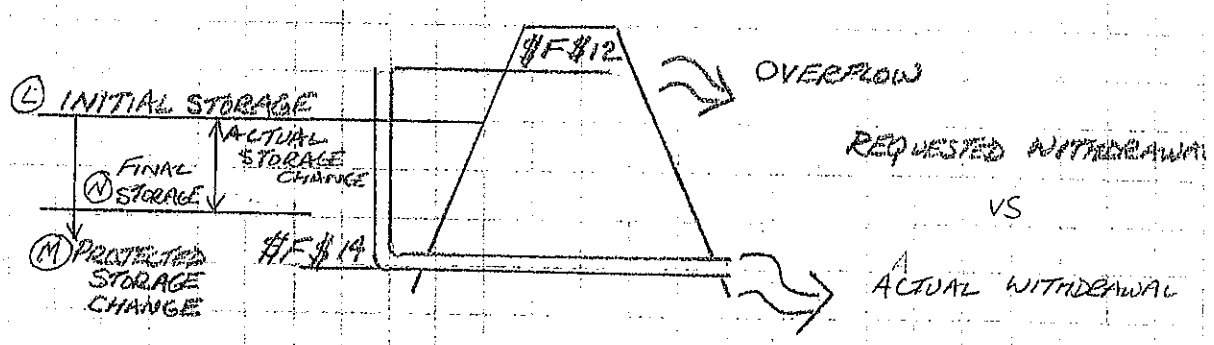
FIGURE B-2

RESERVOIR WATER BALANCE MODEL EQUATIONS

Wiley & Wilson Architects . Engineers . Planners

DESIGN CALCULATIONS

PROPOSED RESERVOIR



PROJECTED SITE STORAGE CHANGE

(M) = G − H − I − J − K

G: INFLOW; H: EVAPORATION; I: SEEPAGE; J: DEMAND WITHDRAWAL; K: STREAMFLOW WITHDRAWAL

SITE STORAGE AFTER RESTRICTIONS

(N) IF((L+M) > #F#12, #F#12, IF((L+M) < #F#14, #F#14, (L+M)))

#F#12: MAX LEVEL; #F#14: MIN LEVEL

ACTUAL RESERVOIR STORAGE CHANGE

(O) N − L

N: FINAL STORAGE; L: INITIAL STORAGE

ACTUAL RESERVOIR DEMAND WITHDRAWAL (PUMPAGE)

(P) IF((L+M) > N, J, IF(J − (O − M) < Ø, Ø, (J − (O − M))))

(L+M): PROJECTED STORAGE; N: FINAL STORAGE; J: REQUEST; J − (O − M): REDUCED REQUEST; Ø: IF NOT ENOUGH WATER; (O − M): DIFF ACTUAL − PROJECTED STORAGE

PERIOD ACCUMULATED DEMAND WITHDRAWAL

(Q) IF(P > Ø, SUM(Q_{PREV} + P), IF(P_{PREV} > Ø, SUM(Q_{PREV} + P), IF(P_{PREV_2} = Ø, Ø, S…

RESERVOIR OUTFLOW INCLUDING SEEPAGE

(R) IF((G − H − I − P − K + L) < #F#12, I+K, I+K+(G − H − I − P − K + L − #F#12))

G: INFLOW; H: EVAP; I: SEEPAGE; P: PUMPAGE; K: STREAM WITHD; L: INIT STORAGE; G − H − I − P − K + L: PROJECTED RES STORAGE; #F#12: MAX LEVEL

DOWNSTREAM STREAMFLOW WITHDRAWAL

(K) IF((G − #M#32 × #F#6 × #F#10 − #L#3)) > 0, (#M#32 × #F#6 × #F#10 + #L…

Project APPOMATTOX AREA SOURCE STUDY Comm. No. 20250.00

By P.T. KEENAN Date APRIL 2003 Sheet No. FIG B-2

Fig. B-3 Site 2 Reservoir Performance - Yield =2.3 MGD

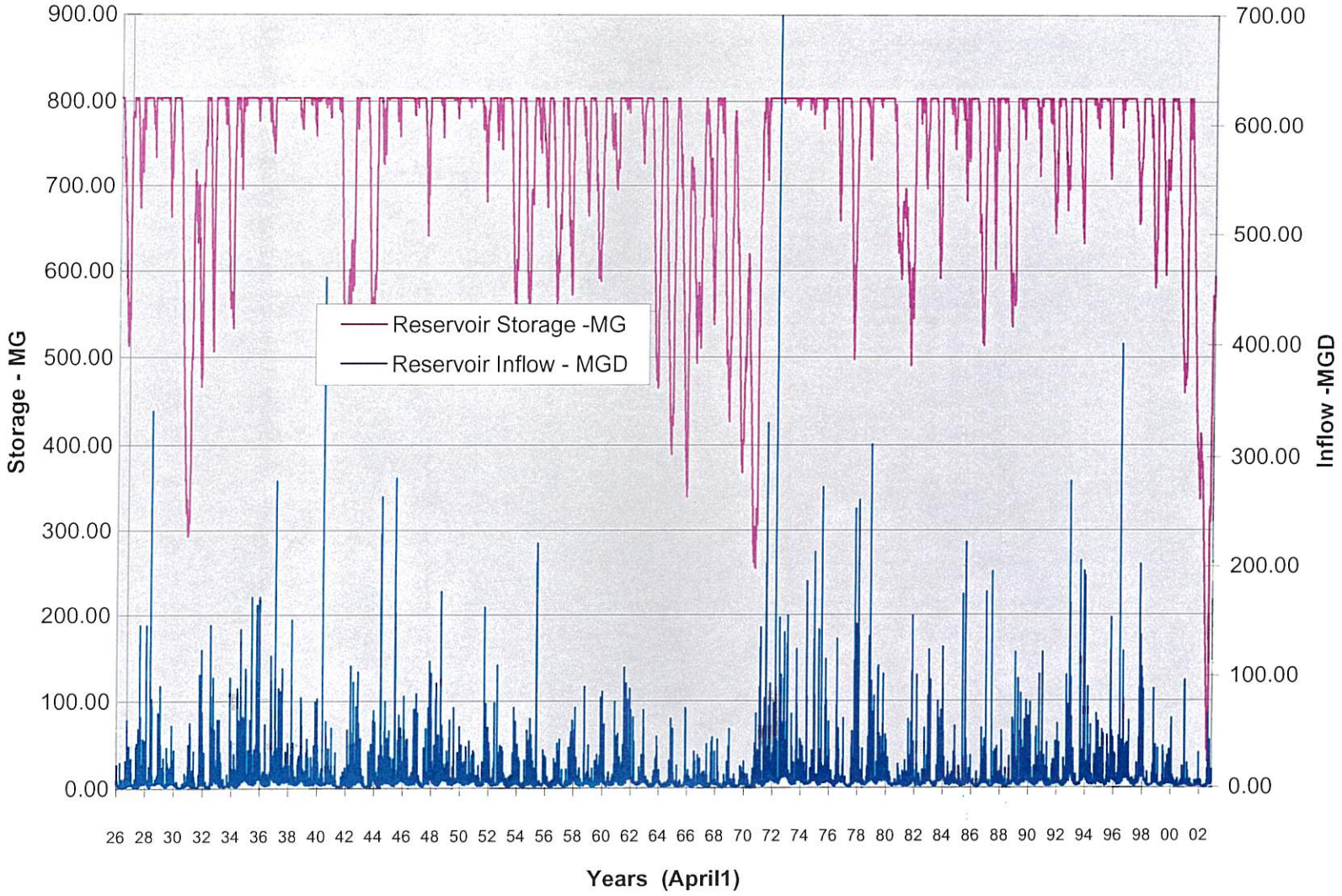


Fig. B-4 Site 2 for Years 1930/32 Reservoir Performance - Yield =2.3 MGD

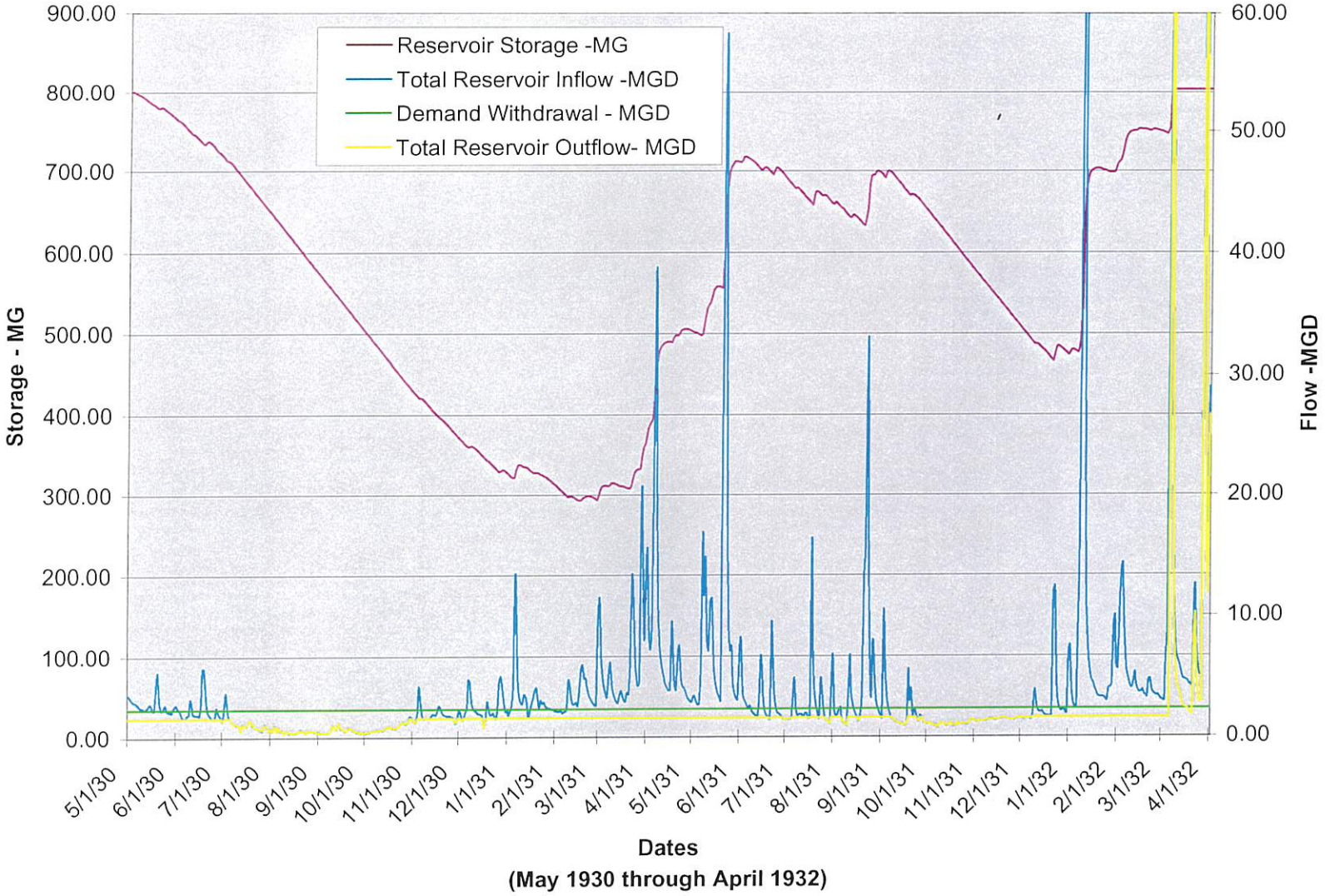


Fig. B-5 Site 2 for Years 1969/71 Reservoir Performance - Yield =2.3 MGD

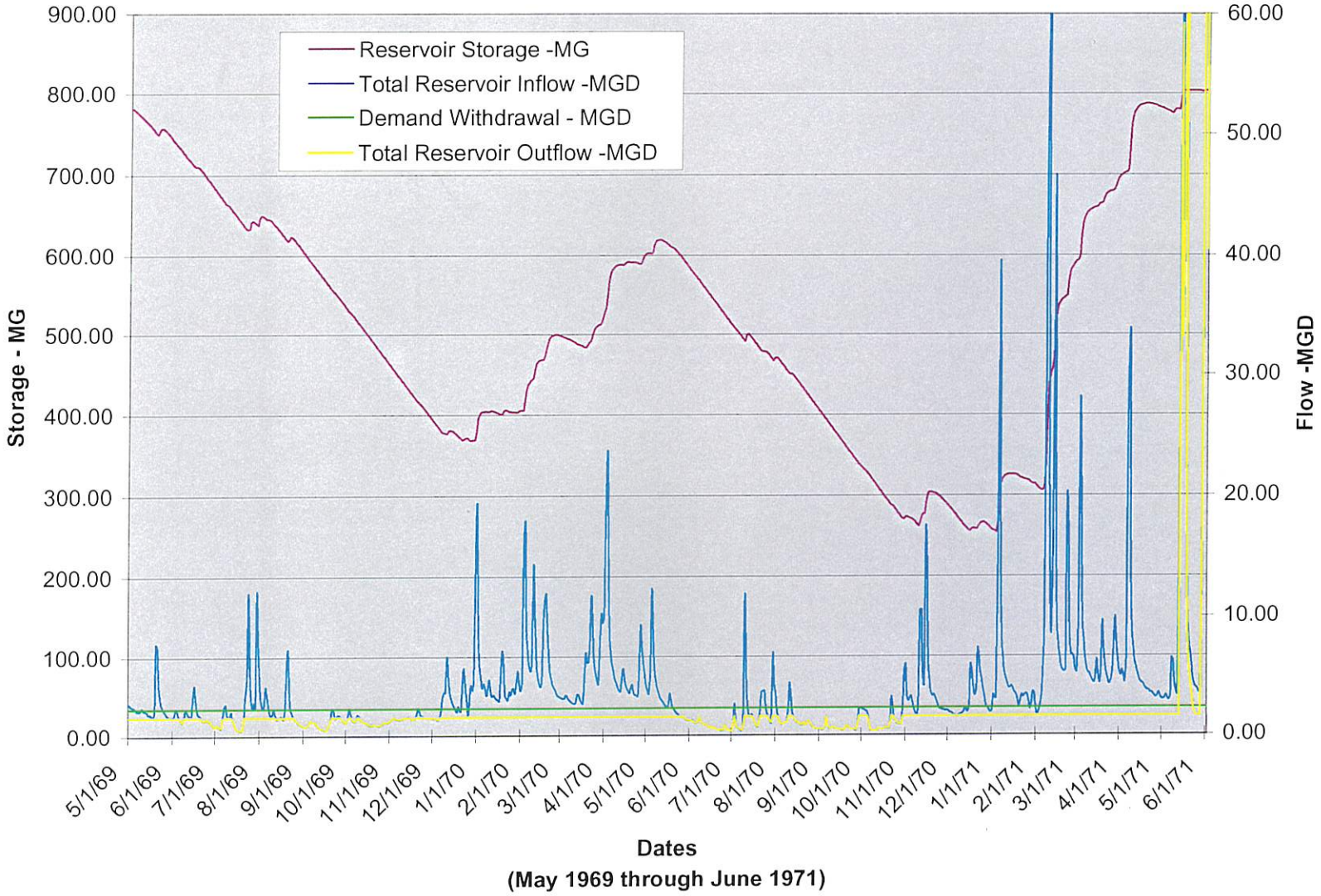
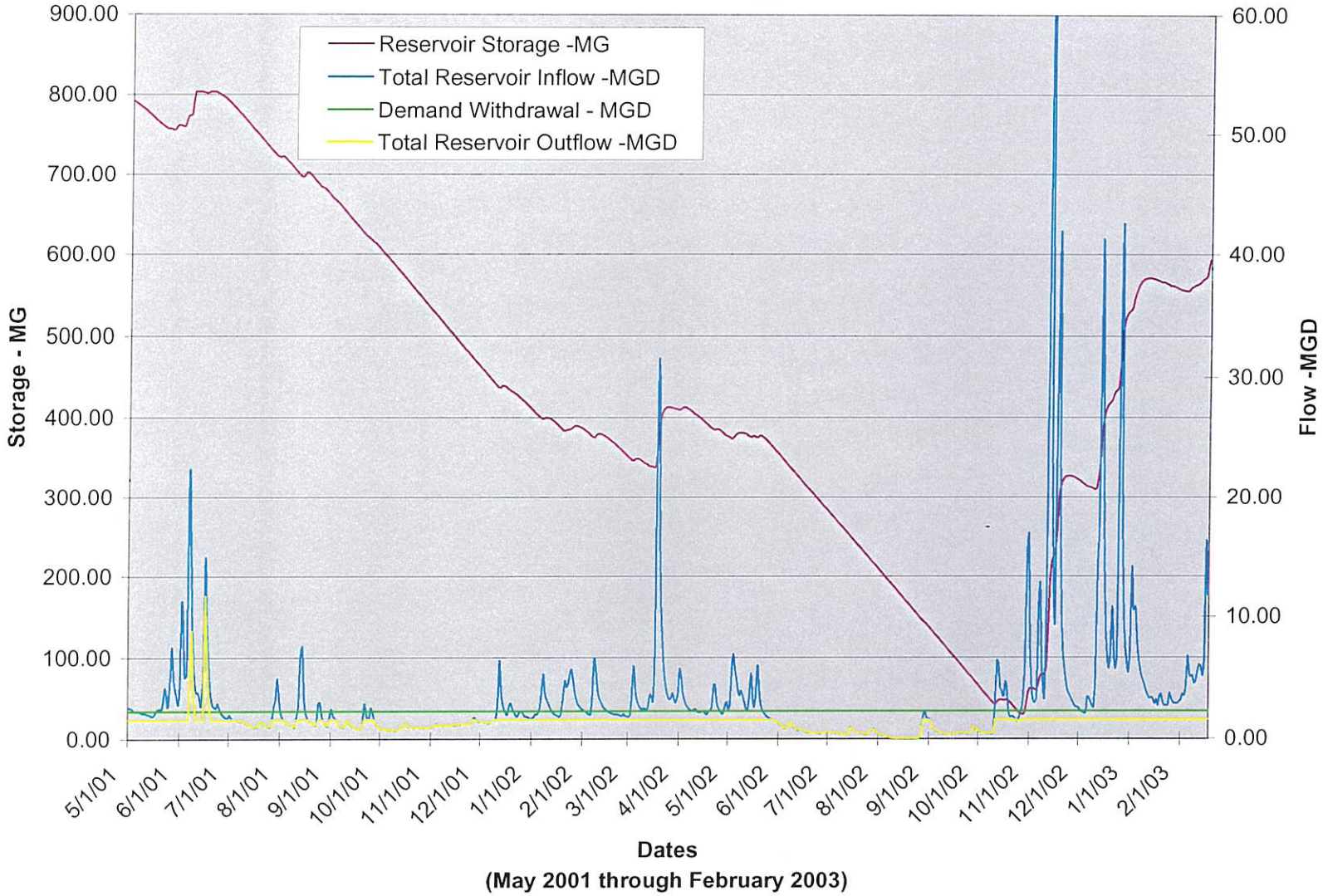


Fig. B-6 Site 2 for Years 2001/03 Reservoir Performance - Yield =2.3 MGD



SEGMENT TRAVEL TIME
① = 0.23 hrs
② = 0.05 hrs
③ = 0.34 hrs
④ = 0.35 hrs
⑤ = 0.70 hrs
⑥ = 0.50 hrs
⑦ = 0.57 hrs
⑧ = 0.64 hrs
⑨ = 0.04 hrs

WATERSHED BOUNDARY
14.3 SQUARE MILES

BASIN TIME OF CONCENTRATION
= 3.42 HOURS

SITE 3
APPOMATTOX RIVER
LOWER

TOWN OF
APPOMATTOX

APPOMATTOX COURT HOUSE
NATIONAL HISTORICAL PARK

APPOMATTOX-BUCKINGHAM
STATE FOREST

Vera

SCALE: 1" = 2500'

2500' 0 2500'

N

APPOMATTOX AREA
WATER SOURCE STUDY
BASIN TIME OF CONCENTRATION
SITE 3

DESIGNED BY:PTK	DRAWN BY: RAF	CHECKED BY:PTK
		PROJECT NO.: 202150
SCALE: 1" = 2500'		FILE NO.:
DATE: AUGUST 2003		FIGURE: B-7

04Aug03

JAMES RIVER WATER INTAKE AND TRANSMISSION LINE

An intake was sited on the James River at Bent Creek and a line route chosen along Route 26 to the Town as Shown on Figure 2 in Tab 1. This routing would permit use of the highway right of way. An intake, pump station, and water treatment plant would be located at the river end of the transmission line. The line would carry treated water to permit supply to communities and users in route. A small tank, not included in the construction cost, would be required to serve customers along the Route 26 corridor.

To assure appropriate line sizing a WATERCAD model was created. The proposed transmission line along Route 26 requires 62,500 feet of 16-inch pipe to convey 2.0 MGD. Pressures computed by the model, as shown in Table C-1, indicate the best location of the water treatment plant to be approximately 2 miles south of the river along Route 26 (at J-3). A booster pump station would be required to boost pressures and fill the existing Town storage tanks (overflow elevation of 997 feet) and would be located near the intersection of Route 659 and Route 26 (J-13), which is northwest of the existing 1.0 MG tank.

Table C-1

James River Transmission Line Trial Hydraulic Characteristics

Hwy 26 16 Inch Line from James River to Town

	Label	Elevation (ft)	Zone	Type	Demand (gpm)	Pattern	Demand (Calculated) (gpm)	Calculated Hydraulic Grade (ft)	Pressure (psi)	Needed Fire Flow (gpm)	Location Description
J-2	J-2	455	Zone-1	Demand	0	Fixed	0	895.64	190.65	0	
J-3	J-3	652	Zone-1	Demand	0	Fixed	0	887.68	101.97	0	Proposed Water Treatment Plant
J-4	J-4	645	Zone-1	Demand	0	Fixed	0	880.29	101.8	0	
J-5	J-5	600	Zone-1	Demand	0	Fixed	0	875.95	119.39	0	
J-6	J-6	740	Zone-1	Demand	0	Fixed	0	872.63	57.38	0	Junction Mill Rd (Hwy 611)
J-7	J-7	665	Zone-1	Demand	0	Fixed	0	868.34	87.97	0	
J-8	J-8	761	Zone-1	Demand	0	Fixed	0	863.29	44.25	0	Junction Hwy 663
J-9	J-9	748	Zone-1	Demand	0	Fixed	0	848.49	43.48	0	Oakville - Junction 608
J-10	J-10	585	Zone-1	Demand	0	Fixed	0	840.75	110.65	0	North Creek crossing
J-11	J-11	720	Zone-1	Demand	0	Fixed	0	835.63	50.03	0	
J-12	J-12	685	Zone-1	Demand	0	Fixed	0	833.61	64.3	0	
J-13	J-13	740	Zone-1	Demand	0	Fixed	0	828.64	38.35	0	Proposed Booster PS
J-14	J-14	795	Zone-1	Demand	0	Fixed	0	826.5	13.63	0	Junction Hwy 659

Label	From Node	To Node	Length (ft)	Diameter (in)	Material	Hazen-Williams C	Minor Loss Coefficient	Discharge (gpm)	Upstream Structure Hydraulic Grade (ft)	Downstream Structure Hydraulic Grade (ft)	Pressure Pipe Headloss (ft)	Headloss Gradient (ft/1000ft)	Velocity (ft/s)
P-1	R-1	PMP-1	681	16	Ductile Iro	120	0	1,390.51	395	394.09	0.91	1.33	2.22
P-2	PMP-1	J-2	5,072.00	16	Ductile Iro	120	0	1,390.51	902.41	895.64	6.76	1.33	2.22
P-3	J-2	J-3	5,971.00	16	Ductile Iro	120	0	1,390.51	895.64	887.68	7.96	1.33	2.22
P-4	J-3	J-4	5,546.00	16	Ductile Iro	120	0	1,390.51	887.68	880.29	7.39	1.33	2.22
P-5	J-4	J-5	3,257.00	16	Ductile Iro	120	0	1,390.51	880.29	875.95	4.34	1.33	2.22
P-6	J-5	J-6	2,489.00	16	Ductile Iro	120	0	1,390.51	875.95	872.63	3.32	1.33	2.22
P-7	J-6	J-7	3,221.00	16	Ductile Iro	120	0	1,390.51	872.63	868.34	4.29	1.33	2.22
P-8	J-7	J-8	3,789.00	16	Ductile Iro	120	0	1,390.51	868.34	863.29	5.05	1.33	2.22
P-9	J-8	J-9	11,097.00	16	Ductile Iro	120	0	1,390.51	863.29	848.49	14.79	1.33	2.22
P-10	J-9	J-10	5,810.00	16	Ductile Iro	120	0	1,390.51	848.49	840.75	7.75	1.33	2.22
P-11	J-10	J-11	3,835.00	16	Ductile Iro	120	0	1,390.51	840.75	835.63	5.11	1.33	2.22
P-12	J-11	J-12	1,519.00	16	Ductile Iro	120	0	1,390.51	835.63	833.61	2.02	1.33	2.22
P-13	J-12	J-13	3,725.00	16	Ductile Iro	120	0	1,390.51	833.61	828.64	4.97	1.33	2.22
P-14	J-13	J-14	1,609.00	16	Ductile Iro	120	0	1,390.51	828.64	826.5	2.15	1.33	2.22
P-15	J-14	FCV-1	4,504.00	16	Ductile Iro	120	0	1,390.51	826.5	820.49	6	1.33	2.22
P-16	FCV-1	T-1	371	16	Ductile Iro	120	0	1,390.51	820.49	820	0.49	1.33	2.22

Label	Elevation (ft)	Pump Power (Hp)	Shutoff Head (ft)	Shutoff Discharge (gpm)	Design Head (ft)	Design Discharge (gpm)	Maximum Operating Head (ft)	Maximum Operating Discharge (gpm)	Control Status	Intake Pump Grade (ft)	Discharge Pump Grade (ft)	Discharge (gpm)	Pump Head (ft)	Calculated Water Power (Hp)	Downstream Pipe	Upstream Pipe
PMP-1	400		600	0	490	1,480.00	250	2,200.00	On	394.09	902.41	1,390.51	508.31	178.45	P-2	P-1

The following Table D-1 and the attached supporting data reflect an order-of-magnitude construction cost estimate for the four primary alternatives recommended in this study. Total costs of these alternatives are somewhat similar. However, all the alternatives except Route 460 waterline require considerable operation and maintenance cost. Also, the tank for the Route 460 waterline could be delayed for more than 20 years making this alternative possibly the least costly.

TABLE D-1
APPOMATTOX AREA
WATER SOURCE STUDY
CONSTRUCTION COST SUMMARY

Lynchburg-Appomattox Water Line	
Transmission Line - 24" + 20"	$14,460,623
Booster Pump Station	$497,894
Sub-Total (Through 2023)	$14,958,517
1.0 MG Elevated Tank	$1,400,000
Total (After 2023)	**$16,358,517**
James River Water	
Intake and Pump Station	$1,000,541
Transmission Line - 16"	$8,948,310
2.0 MGD Water Treatment Plant	$6,000,000
Booster P.S. near Town	$497,894
Total	**$16,446,745**
Reservoir Site 2 - Middle Appomattox River	
Dam	$6,687,913
Intake & Pump Station	$750,341
2.0 MGD Water Treatment Plant	$6,000,000
Transmission Line - 16"	$1,948,968
Total	**$15,387,222**
Reservoir Site 3 - Lower Appomattox River	
Dam	$6,357,550
Intake & Pump Station	$750,341
2.0 MGD Water Treatment Plant	$6,000,000
Transmission Line - 16"	$2,572,229
Total	**$15,680,120**

TABLE D-2
Lynchburg to AppomattoxTransmission Line
Cost Estimate

APPOMATTOX AREA

Water Source Study
Lynchburg to Appomattox Transmission Line
Transmission Line- 24" & 20"
Cost Estimate - April 2003

#	Item	Quantity	Unit	Unit Price	Item Cost
A	CONSTRUCTION COSTS				
1	24 INCH DIP	27050	L.F.	$125	$3,381,250
3	24 INCH GATE VALVES	10	EA.	$13,500	$135,000
4	24 INCH AIR RELEASE VALVES	14	EA.	$1,500	$21,000
5	24 INCH BLOW OFF VALVES	10	EA.	$1,400	$14,000
6	20 INCH DIP	42539	L.F.	$91	$3,871,049
7	20 INCH GATE VALVES	15	EA.	$9,500	$142,500
8	20 INCH AIR RELEASE VALVES	21	EA.	$1,500	$31,500
9	20 INCH BLOW OFF VALVES	15	EA.	$1,400	$21,000
10	ROCK EXCAVATION	10000	LF	$128	$1,280,000
11	36 INCH CASING PIPE BORED	1100	L.F.	$350	$385,000
12	CONCRETE ENCASEMENT @ STREAM XINGs	320	L.F.	$240	$76,800
13	GRAVEL SURFACING	1200	S.Y.	$10	$12,000
14	STAKEOUT	1	L.S.	$56,000	$56,000
15	EROSION CONTROL	1	L.S.	$60,000	$60,000
16	SEEDING	15	AC.	$3,000	$45,000
17	FIRE HYDRANTS	70	EA	$3,000	$210,000
18	MOBILIZATION	1	L.S.	$300,000	$300,000
	SUBTOTAL				$10,042,099
	CONSTRUCTION CONTINGENCY @20%				$2,008,420
	TOTAL CONSTRUCTION COST				$12,050,519
B	RELATED COSTS				
1	TECHNICAL SERVICES (SURVEY, ENGINEERING, TESTING, CONSTRUCTION ADMINISTRATION & INSPECTION				$2,410,104
	TOTAL				$14,460,623

TABLE D-3
Booster Pump Station
Cost Estimate

APPOMATTOX AREA

Water Source Study
Booster Pump Station
Cost Estimate - April 2003

#	Item	Quantity	Unit	Unit Price	Item Cost
A	CONSTRUCTION COSTS				
1	PUMP AND PUMP MOTOR	3	EA	$20,000	$60,000
2	3 PHASE ELECTRICITY	1	LS.	$41,400	$41,400
3	HVAC BUILDING ELECTRICAL	1	LS	$16,000	$16,000
4	CHECK VALVE	3	EA.	$1,470	$4,410
5	ELECTRIC CHECK VALVE & PUMP DIRECTOR	3	EA.	$14,600	$43,800
6	AIR & VACUUM RELEASE VALVE	1	EA.	$750	$750
7	SURGE RELIEF VALVE	1	EA.	$2,700	$2,700
8	TRANSIT TIME METER	1	EA	$6,700	$6,700
9	TELEMETER & CONTROL SYSTEM	1	LS	$40,000	$40,000
10	HEADER & OUTLET PIPE	1	EA	$4,000	$4,000
11	STRUCTURE CONCRETE/ROOF/DOORS/WINDOWS	1	L.S.	$60,000	$60,000
12	FENCING	160	L.F.	$100	$16,000
13	DRIVEWAY/PARKING	1	L.S.	$10,000	$10,000
14	SITE GRADING, EROSION CONTROL & SEEDING	1	L.S.	$5,000	$5,000
15	SITE ACQUISITION	1	L.S.	$20,000	$20,000
15	MOBILIZATION	1	L.S.	$15,000	$15,000
	SUBTOTAL				$345,760
	CONSTRUCTION CONTINGENCY @ 20%				$69,152
	TOTAL CONSTRUCTION COST				$414,912
B	RELATED COSTS				
1	TECHNICAL SERVICES (SURVEY, ENGINEERING, TESTING, CONSTRUCTION ADMINISTRATION & INSPECTION				$82,982
	TOTAL				$497,894

TABLE D-4
James River Intake and Pump Station
Cost Estimate

APPOMATTOX AREA

Water Source Study
James River Intake and Transmission Line
James River Intake and Pump Station
Cost Estimate - April 2003

#	Item	Quantity	Unit	Unit Price	Item Cost
A	CONSTRUCTION COSTS				
1	FINE MESH RIVER INTAKE AND SUPPORTS	2	EA.	$6,750	$13,500
2	RIVER & SHORE COFFERDAM	1	LS	$200,000	$200,000
3	AIRBURST INTAKE LINE CLEANING	1	EA.	$22,500	$22,500
4	16 INCH INTAKE LINE	200	L.F.	$74	$14,800
5	16x36 EXPANDER/REDUCER	1	EA.	$3,500	$3,500
6	36 INCH WETWELL SLUICE GATE	1	EA.	$12,000	$12,000
7	DEWATERING PUMP	1	EA.	$2,100	$2,100
8	PUMP AND PUMP MOTOR	2	EA.	$30,000	$60,000
9	3 PHASE ELECTRICITY	1	EA	$55,880	$55,880
10	HVAC BUILDING ELECTRICAL	1	LS	$16,000	$16,000
11	CHECK VALVE	2	EA.	$1,470	$2,940
12	ELECTRIC CHECK VALVE & PUMP DIRECTOR	2	EA.	$14,600	$29,200
13	AIR & VACUUM RELEASE VALVE	1	EA.	$750	$750
14	SURGE RELIEF VALVE	1	EA.	$2,700	$2,700
15	TRANSIT TIME METER	1	EA	$6,700	$6,700
16	16 INCH HEADER & OUTLET PIPE	1	LS	$2,000	$2,000
18	TELEMETER & CONTROL SYSTEM	1	LS	$40,000	$40,000
19	PS STRUCTURE EXCAVATION/HAULING	2300	CY	$25	$57,500
20	PS STRUCTURE CONCRETE	120	CY	$400	$48,000
21	PS ROOFING, DOORS & WINDOWS	1	LS	$20,000	$20,000
22	FENCING	120	L.F.	$100	$12,000
23	CLEAR & GRUB	2	AC.	$3,000	$6,000
24	SITE GRADING, EROSION CONTROL & SEEDING	2	AC.	$1,500	$3,000
25	ACCESS ROAD	250	L.F.	$75	$18,750
26	SITE ACQUISITION	1	LS	$20,000	$20,000
27	MOBILIZATION	1	LS	$25,000	$25,000
	SUBTOTAL				$694,820
	CONSTRUCTION CONTINGENCY @20%				$138,964
	TOTAL CONSTRUCTION COST				$833,784
B	RELATED COSTS				
1	TECHNICAL SERVICES (SURVEY, ENGINEERING, TESTING, CONSTRUCTION ADMINISTRATION & INSPECTION				$166,757
	TOTAL				$1,000,541

TABLE D-5
James River Water Transmission Line
Cost Estimate

APPOMATTOX AREA

Water Source Study
James River Intake and Transmission Line
16 Inch Pipeline - James River to WTP
Cost Estimate - April 2003

#	Item	Quantity	Unit	Unit Price	Item Cost
A	CONSTRUCTION COSTS				
1	16 INCH DIP CLASS	62496	L.F.	$74	$4,624,704
3	16 INCH ISOLATION GATE VALVES	20	EA.	$9,225	$184,500
4	16 INCH AIR RELEASE VALVES	30	EA.	$1,500	$45,000
5	16 INCH BLOW OFF VALVES	18	EA.	$1,400	$25,200
6	ROCK EXCAVATION	10000	LF	$96	$956,000
7	36 INCH CASING PIPE BORED	350	L.F.	$350	$122,500
8	CONCRETE ENCASEMENT @ STREAM XINGs	400	L.F.	$240	$96,000
9	GRAVEL SURFACING	720	S.Y.	$10	$7,200
10	STAKEOUT	1	L.S.	$48,000	$48,000
11	EROSION CONTROL	1	L.S.	$60,000	$60,000
12	SEEDING	15	AC.	$3,000	$45,000
13	MOBILIZATION	1	L.S.	$300,000	$300,000
	SUBTOTAL				$6,214,104
	CONSTRUCTION CONTINGENCY @20%				$1,242,821
	TOTAL CONSTRUCTION COST				$7,456,925
B	RELATED COSTS				
1	TECHNICAL SERVICES (SURVEY, ENGINEERING, TESTING, CONSTRUCTION ADMINISTRATION & INSPECTION				$1,491,385
	TOTAL				$8,948,310

TABLE D-6
Reservoir Site 2 (Middle Appomattox River) Dam
Cost Estimate

APPOMATTOX AREA

Water Source Study
Reservoir Source Evaluation
Site 2 (Middle Appomattox River) Dam
Cost Estimate - April 2003

A. CONSTRUCTION COST

		QUANTIT	UNIT	UNIT PRICE	COST
1	MOBILIZATION	1	L.S	$200,000.00	$200,000
2	STREAM DIVERSION	1	L.S.	$25,000.00	$25,000
3	STRIP - STOCKPILE & REPLACE TOPSOIL	21450	C.Y.	$4.00	$85,800
4	CLEAR RESERVOIR SITE (elev 640)	160	AC.	$1,200.00	$192,000
5	DEWATERING	1	EA.	$30,000.00	$30,000
6	CUT OFF TRENCH	3470	C.Y.	$6.00	$20,820
7	FLOOD SPILLWAY EXCAVATION (soil)	41610	C.Y.	$4.00	$166,440
8	FLOOD SPILLWAY EXCAVATION (rock- blast &haul)	20800	C.Y.	$20.00	$416,000
9	FLOOD SPILLWAY & CHUTE	1690	C.Y.	$200.00	$338,000
10	GROUT CAP	60	C.Y.	$120.00	$7,200
11	EMBANKMENT	280600	C.Y.	$4.00	$1,122,400
12	U/S RIPRAP	4570	C.Y.	$40.00	$182,800
13	DROP SPILLWAY	100	C.Y.	$400.00	$40,000
14	LOW LEVEL DRAIN INLET STRUCTURE	20	C.Y.	$400.00	$8,000
15	36 INCH LOW LEVEL DRAINSITE	50	L.F.	$160.00	$8,000
16	120 INCH OUTLET PIPE	300	L.F.	$700.00	$210,000
17	OUTLET/WATER INTAKE STRUCTURE	300	C.Y.	$400.00	$120,000
18	D/S SPILLWAY EROSION PROTECTION (riprap)	11710	C.Y.	$40.00	$468,400
19	CHIMNEY DRAIN MATERIAL (4')	5000	C.Y.	$20.00	$100,000
20	TOE & CHIMNEY DRAIN	980	L.F.	$20.00	$19,600
21	SEEDING	10	AC.	$2,500.00	$25,000
22	EROSION AND SEDIMENT CONTROL	1	L.S.	$30,000.00	$30,000
23	ACCESS ROAD	2500	L.F.	$60.00	$150,000
24	SOIL, MATERIALS TESTING	1	L.S.	$20,000.00	$20,000
25	SITE ACQUISITION	175	AC.	$1,600.00	$280,000
26	16 INCH PIPING TO WTP	1970	L.F.	$45.00	$88,650
	SUBTOTAL				$4,354,110
	CONTINGENCY @ 20%				$870,822
	TOTAL CONSTRUCTION COST				$5,224,932

B. RELATED COSTS

1	ENGINEERING, PERMITTING & CONSTRUCTION MANAGEMENT @20%	$1,044,986
2	ENVIRONMENTAL MITIGATION @8% PLUS or MINUS	$417,995
	TOTAL	$6,687,913

NOTE: COSTS DO NOT INCLUDE 3 PHASE POWER FROM POWER COMPANY

TABLE D-7
Reservoir Site 2 Transmission Line to Town
Cost Estimate

APPOMATTOX AREA

Water Source Study
Reservoir Source Evaluation
16 Inch Pipeline - Site 2 Damsite WTP to Route 24
Cost Estimate - April 2003

#	Item	Quantity	Unit	Unit Price	Item Cost
A	CONSTRUCTION COSTS				
1	16 INCH DIP CLASS 350	14900	L.F.	$74	$1,102,600
2	16 INCH ISOLATION VALVES	6	EA.	$9,225	$55,350
3	16 INCH AIR RELEASE VALVES	9	EA.	$1,500	$13,500
4	16 INCH BLOW OFF VALVES	6	EA.	$1,400	$8,400
5	ROCK EXCAVATION	1000	LF	$96	$95,600
6	36 INCH CASING PIPE BORED	100	L.F.	$350	$35,000
7	CONCRETE ENCASEMENT @ STREAM XINGs	40	L.F.	$240	$9,600
8	GRAVEL SURFACING	100	S.Y.	$10	$1,000
9	STAKEOUT	1	L.S.	$7,400	$7,400
10	EROSION CONTROL	1	L.S.	$10,000	$10,000
11	SEEDING	5	AC.	$3,000	$15,000
12	MOBILIZATION	1	L.S.	$50,000	$50,000
	SUBTOTAL				$1,353,450
	CONSTRUCTION CONTINGENCY @ 20%				$270,690
	TOTAL CONSTRUCTION COST				$1,624,140
B	RELATED COSTS				
1	TECHNICAL SERVICES (SURVEY, ENGINEERING, TESTING, CONSTRUCTION ADMINISTRATION & INSPECTION				$324,828
	TOTAL				$1,948,968

TABLE D-8
Reservoir Raw Water Intake and Pump Station
Cost Estimate

APPOMATTOX AREA

Water Source Study
Reservoir Source Evaluation
Damsite Raw Water Intake & PS
Cost Estimate - April 2003

#	Item	Quantity	Unit	Unit Price	Item Cost
A	CONSTRUCTION COSTS				
1	FINE MESH RIVER INTAKE AND SUPPORTS	2	EA.	$6,750	$13,500
2	SHORE COFFERDAM	2500	SF	$20	$50,000
3	AIRBURST INTAKE LINE CLEANING	1	EA.	$22,500	$22,500
4	16 INCH INTAKE LINE	200	L.F.	$74	$14,800
5	16x36 EXPANDER/REDUCER	1	EA.	$3,500	$3,500
6	36 INCH WETWELL SLUICE GATE	1	EA.	$12,000	$12,000
7	DEWATERING PUMP	1	EA.	$2,100	$2,100
8	PUMP AND PUMP MOTOR	2	EA.	$30,000	$60,000
9	3 PHASE ELECTRICITY	1	EA	$55,880	$55,880
10	HVAC BUILDING ELECTRICAL	1	LS	$16,000	$16,000
11	CHECK VALVE	2	EA.	$1,470	$2,940
12	ELECTRIC CHECK VALVE & PUMP DIRECTOR	2	EA.	$14,600	$29,200
13	AIR & VACUUM RELEASE VALVE	1	EA.	$750	$750
14	SURGE RELIEF VALVE	1	EA.	$2,700	$2,700
15	TRANSIT TIME METER	1	EA	$6,700	$6,700
16	16 INCH HEADER & OUTLET PIPE	1	LS	$2,000	$2,000
18	TELEMETER & CONTROL SYSTEM	1	LS	$40,000	$40,000
19	PS STRUCTURE EXCAVATION/HAULING	2300	CY	$25	$57,500
20	PS STRUCTURE CONCRETE	120	CY	$400	$48,000
21	PS ROOFING, DOORS & WINDOWS	1	LS	$20,000	$20,000
22	FENCING	120	L.F.	$100	$12,000
23	CLEAR & GRUB	2	AC.	$3,000	$6,000
24	SITE GRADING, EROSION CONTROL & SEEDING	2	AC.	$1,500	$3,000
25	ACCESS ROAD	250	L.F.	$60	$15,000
26	MOBILIZATION	1	LS	$25,000	$25,000
	SUBTOTAL				$521,070
	CONSTRUCTION CONTINGENCY @20%				$104,214
	TOTAL CONSTRUCTION COST				$625,284
B	RELATED COSTS				
1	TECHNICAL SERVICES (SURVEY, ENGINEERING, TESTING, CONSTRUCTION ADMINISTRATION & INSPECTION				$125,057
	TOTAL				$750,341

TABLE D-9
Reservoir 3 (Middle River Lower) Dam
Cost Estimate

APPOMATTOX AREA

Water Source Study
Reservoir Source Evaluation
Site 3 (lower Appomattox River) Dam
Cost Estimate - April 2003

A. CONSTRUCTION COST

		QUANTIT	UNIT	UNIT PRICE	COST
1	MOBILIZATION	1	L.S	$200,000.00	$200,000
2	STREAM DIVERSION	1	L.S.	$25,000.00	$25,000
3	STRIP - STOCKPILE & REPLACE TOPSOIL	22650	C.Y.	$4.00	$90,600
4	CLEAR RESERVOIR SITE (elev 610)	160	AC.	$1,200.00	$192,000
5	DEWATERING	1	EA.	$30,000.00	$30,000
6	CUT OFF TRENCH	3250	C.Y.	$6.00	$19,500
7	FLOOD SPILLWAY EXCAVATION (soil)	15700	C.Y.	$4.00	$62,800
8	FLOOD SPILLWAY EXCAVATION (rock- blast &haul)	3950	C.Y.	$20.00	$79,000
9	FLOOD SPILLWAY & CHUTE	2930	C.Y.	$200.00	$586,000
10	GROUT CAP	56	C.Y.	$120.00	$6,720
11	EMBANKMENT	327890	C.Y.	$4.00	$1,311,560
12	U/S RIPRAP	6420	C.Y.	$40.00	$256,800
13	DROP SPILLWAY	100	C.Y.	$400.00	$40,000
14	LOW LEVEL DRAIN INLET STRUCTURE	20	C.Y.	$400.00	$8,000
15	36 INCH LOW LEVEL DRAINSITE	50	L.F.	$160.00	$8,000
16	120 INCH OUTLET PIPE	300	L.F.	$700.00	$210,000
17	OUTLET/WATER INTAKE STRUCTURE	300	C.Y.	$400.00	$120,000
18	D/S SPILLWAY EROSION PROTECTION (riprap)	1340	C.Y.	$40.00	$53,600
19	CHIMNEY DRAIN MATERIAL (4')	5000	C.Y.	$20.00	$100,000
20	TOE & CHIMNEY DRAIN	980	L.F.	$20.00	$19,600
21	SEEDING	10	AC.	$2,500.00	$25,000
22	EROSION AND SEDIMENT CONTROL	1	L.S.	$30,000.00	$30,000
23	ACCESS ROAD	4500	L.F.	$60.00	$270,000
24	SOIL, MATERIALS TESTING	1	L.S.	$20,000.00	$20,000
25	SITE ACQUISITION	180	AC.	$1,600.00	$288,000
26	16 INCH PIPING TO WTP	1930	L.F.	$45.00	$86,850

SUBTOTAL	$4,139,030
CONTINGENCY @ 20%	$827,806
TOTAL CONSTRUCTION COST	$4,966,836

B. RELATED COSTS

1 ENGINEERING, PERMITTING & CONSTRUCTION MANAGEMENT @20%	$993,367
2 ENVIRONMENTAL MITIGATION @8% PLUS or MINUS	$397,347
TOTAL	$6,357,550

NOTE: COSTS DO NOT INCLUDE 3 PHASE POWER FROM POWER COMPANY

TABLE D-10
Reservoir Site 3 Transmission Line
Cost Estimate

APPOMATTOX AREA

Water Source Study
Reservoir Source Evaluation
16 Inch Pipeline - Site 3 Damsite WTP to Route 24
Cost Estimate - April 2003

#	Item	Quantity	Unit	Unit Price	Item Cost
A	CONSTRUCTION COSTS				
1	16 INCH DIP CLASS 350	19730	L.F.	$74	$1,460,020
2	16 INCH ISOLATION VALVES	6	EA.	$9,225	$55,350
3	16 INCH AIR RELEASE VALVES	9	EA.	$1,500	$13,500
4	16 INCH BLOW OFF VALVES	6	EA.	$1,400	$8,400
5	ROCK EXCAVATION	1000	LF	$96	$95,600
6	36 INCH CASING PIPE BORED	150	L.F.	$350	$52,500
7	CONCRETE ENCASEMENT @ STREAM XINGs	40	L.F.	$240	$9,600
8	GRAVEL SURFACING	90	S.Y.	$10	$900
9	STAKEOUT	1	L.S.	$11,400	$11,400
10	EROSION CONTROL	1	L.S.	$14,000	$14,000
11	SEEDING	5	AC.	$3,000	$15,000
12	MOBILIZATION	1	L.S.	$50,000	$50,000
	SUBTOTAL				$1,786,270
	CONSTRUCTION CONTINGENCY @ 20%				$357,254
	TOTAL CONSTRUCTION COST				$2,143,524
B	RELATED COSTS				
1	TECHNICAL SERVICES (SURVEY, ENGINEERING, TESTING, CONSTRUCTION ADMINISTRATION & INSPECTION				$428,705
	TOTAL				$2,572,229

Wiley & Wilson

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