Carroll County
Alternatives Evaluation

Appendix B

Preliminary Evaluation of Reservoir Alternatives

6531-001-400

MALCOLM PIRNIE

REPORT

Preliminary Evaluation of Reservoir Alternatives in Support of Water Resources Element of Comprehensive Plan Carroll County, Maryland

Schnabel Reference 09150009

June 11, 2009

Prepared for:

MALCOLM PIRNIE

Prepared by:

Schnabel

Schnabel Engineering, LLC

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1.0 EXECUTIVE SUMMARY

Schnabel Engineering, LLC (Schnabel) was engaged by Malcolm Pirnie to perform a desktop study to update the evaluation of two potential reservoir sites (Gillis Falls and Union Mills) and the possible expansion of Piney Run Reservoir in support of the County's Master Plan. Our scope for this study included review of previous reports, site visits, updated cost estimates, and development of a summary letter report relative to the feasibility of constructing a dam at the considered sites.

For the expansion of Piney Run, a historic structure on the northeast shore of the reservoir would be impacted by an increase in dam height. However, assuming a spillway design flood of ½ probable maximum flood (½ PMF), a labyrinth spillway could be constructed that would enable passage of the ½ PMF within the existing spillway width, and allow a 4-ft increase in normal pool without raising of the dam. This increase in pool level provides a 0.46 mgd increase in safe yield (computed by Malcolm Pirnie).

As noted in the previous studies, either an earth dam or roller compacted concrete dam (RCC) could be constructed at both the Gillis Falls or Union Mills site. Cost estimates (2009 dollars) were developed for each option consisting of dam/reservoir construction (RCC dam assumed), stream mitigation, wetland mitigation, road/bridge relocations, and in the case of Union Mills, landfill improvements. The cost for constructing a dam to EL 610 at Gillis Falls was estimated to be on the order of $69M, while a dam to EL 610 at Union Mills[1] was estimated to be on the order of $57M. Relative to the amount of safe yield that could be attained at each site, the Union Mills site could provide significantly more safe yield, with a relative cost of $11.3M/mgd of safe yield versus $18.0M/mgd of safe yield for Gillis Falls. In addition, relative to the safe yield provided by each site, the Union Mills site would have significantly fewer impacts to the natural and human environments. Estimates for construction of the reservoirs to EL 630 were also conducted and yielded similar conclusions relative to these two sites.

Of the three sites considered herein and for the limited factors considered in this study, the apparent preferred alternative for development is the Union Mills Reservoir. Of these options, it appears to be the least environmentally damaging, practicable alternative capable of providing the water supply needs of the County for all considered growth scenarios.

Notwithstanding the preferred alternative noted above, permitting a reservoir in this region of the United States is an extremely difficult, expensive, time-consuming, and frustrating endeavor. If other surface water supply options are available to the County (such as water purchase from the City of Baltimore, or use of existing quarries for raw water storage), these options should be fully investigated as well. Such options may be more cost effective and permittable than a new reservoir project.

Additional field investigations are discussed in Section 5 of this report.

[1] Common elevations for Gillis Falls and Union Mills are coincidental.

2.0 INTRODUCTION

2.1 Authority

By contract dated January 27, 2009, Schnabel entered into a consultant agreement with Malcolm Pirnie, Inc. to assist with evaluations of water resource issues for the Water Resources Element (WRE) of Carroll County's Comprehensive Plan, required by State Law HB 1141.

2.2 Purpose

Schnabel was engaged by Malcolm Pirnie to perform a desktop study to update the evaluation of two potential reservoir sites (Gillis Falls and Union Mills) and the possible expansion of Piney Run Reservoir. The three reservoir sites are shown in Figure 1, Appendix A.

2.3 Scope

Our scope for this study included:

- Review of previous relevant reports
- Site visit to the three sites noted above
- Planning level construction cost estimates
- Letter Report, including feasible dam type for each site, major challenges to project development, photos of site visits

3.0 SITE DESCRIPTIONS

3.1 Piney Run Reservoir

Piney Run Reservoir is located in the southern portion of the county, about 1 mile north of Sykesville. The dam was constructed by Carroll County primarily as a drinking water supply for the southeastern portion of the county. It also provides flood control and recreation for local citizens. The reservoir was built in 1975 by the County under the Watershed Protection and Flood Prevention Act with the assistance of the US Department of Agriculture.

The existing volume of the reservoir is 1.97 billion gallons (BG) at normal pool EL 524. The normal surface area of the reservoir is 298 acres. A summary of the reservoir's pertinent data is presented in Section 4.

The drainage area to the reservoir is 10.43 square miles. The watershed is underlain primarily by schist, with lesser amounts of phyllite and gneiss. Land use is a mixture of agricultural, wooded and residential.

The dam impounding the reservoir is a 650-ft long earthen embankment with a maximum height of 73 ft. A standard NRCS covered riser and 36-inch conduit maintains the normal pool at EL 524 and provides discharge capacity for floods up to a 100-yr storm event. A 250-ft wide earthen emergency spillway at the right abutment (looking downstream) at EL 532 provides flood passage for floods in excess of a 100-yr event. The dam is classified as a "high hazard structure" according to MDE criteria; accordingly, the spillway design flood would be the probable maximum flood (See Section 4 for additional discussion).

A site visit was performed on February 27, 2009. Photos of the dam site and upstream area are included in Appendix B.

3.2 Gillis Falls Reservoir Site

In 1967, following a severe drought in the northeastern United States, the North Atlantic Basin Study proposed several water supply reservoirs of which Gillis Falls was one. In the 1970s and 1980s, the project progressed, and land was purchased as it became available. Since the early 1990s, the project has stalled due to environmental restrictions. A detailed chronology is contained in Reference 3.

The proposed Gillis Falls reservoir site is in the southern part of Carroll County. The site is just downstream of the confluence of Gillis Falls and Middle Run. The streams are tributary of the South Branch Patapsco River which drains to the Chesapeake Bay. This site was previously evaluated by Black & Veatch as part of the initial permitting effort for the reservoir (Reference 2).

The proposed reservoir would have a storage capacity of 4.15 BG and a surface area of 452 acres at a normal pool EL 610. A summary of the reservoir's pertinent data is presented in Section 4.

The drainage area to the reservoir is 17.4 square miles. The watershed is underlain primarily by schist and phyllite. Land use is a mixture of agricultural and wooded, with localized residential areas.

In Black & Veatch's 1989 Project Development Report, the proposed dam was an RCC structure with a maximum height of about 80 ft from the top of dam to the floodplain (about 95 ft from top of dam to rock foundation). The alternate location of the dam was based on a 1989 geotechnical report by Schnabel Engineering Associates (Reference 10). The dam would be classified as a "high hazard structure" according to MDE criteria; accordingly, the spillway design flood would be the probable maximum flood.

A site visit was performed on February 27, 2009. Photos of the dam site and upstream area are included in Appendix B.

3.3 Union Mills Reservoir Site

Union Mills is a proposed water supply reservoir site in the northern part of Carroll County. The site was envisioned as early as 1970 in the County Master Plan. The site is located about 4000-ft upstream of the confluence of Deep Run with Big Pipe Creek, which are tributary to the Monocacy River, and ultimately to the Potomac River.

Similar to Piney Run Dam, the site was originally contemplated to be a watershed dam, and in 1976 an environmental impact statement (EIS) was developed by the Soil Conservation Service (Reference 12). Accordingly, the dam was proposed as a multi-use reservoir for flood control, recreation, and water supply. This site was previously evaluated by the USDA as part of a watershed management plan for the Big Pipe Creek Watershed (Reference 11).

As originally proposed, the reservoir would have a storage capacity of 2.44 BG and a surface area of 298 acres at a normal pool EL 610. A summary of the reservoir's pertinent data is tabulated in Section 4.

The drainage area to the reservoir is 24.86 square miles. The watershed is underlain primarily by schist of the Marburg Formation. Land use is a mixture of agricultural and wooded, with localized residential areas.

In the southern part of the watershed, the John Owings Landfill lies adjacent to the proposed reservoir. The landfill was in private operation beginning about 1968, and in 1973 was purchased by the County, who operated the landfill until 1987. The site received commercial/residential refuse and dewatered sludge during that time. In 1993 an MDE-approved cap was installed to avoid further infiltration of water into the landfill. Monitoring wells around the site provide ground water quality data.

No geotechnical studies were performed for the Union Mills dam site. A brief overview of possible reservoir sizes was performed by Martin Covington, PE in 2006 (Reference 7).

A site visit was performed on February 27, 2009. Photos of the dam site and upstream area are included in Appendix B.

4.0 SURFACE WATER SUPPLY ALTERNATIVES

4.1 Raising of Piney Run Reservoir

The expansion of Piney Run Reservoir was evaluated as the first water supply alternative. During the site visit, it was observed that a historical structure (i.e., Waters Edge Farm) exists on the northeast shore of the reservoir, situated at roughly EL 541. Raising of the top of dam is not considered feasible, since it would place the historical structure below the crest level and therefore increase the potential for flooding during extreme events. Therefore, we assessed the potential to raise the pool level by 4 ft while maintaining the top of dam at EL 540.5. Table 4.1 summarizes pertinent data for the reservoir at the existing normal pool and the proposed 4-ft raise. A 4-ft raise would likely require modifications to the County Park and marina area.

We understand that the dam is currently classified as a "high hazard" structure, which means that there is significant potential for loss of life if the dam were to fail. For this hazard class and size structure, it is likely that the required spillway design flood would be the probable maximum flood (PMF). However, it is sometimes possible to reduce the spillway design flood to a fraction of the PMF based on an incremental inundation analysis. For the purposes of this report, we have assumed that the spillway design flood for Piney Run Dam could be reduced to approximately the ½ PMF. For a drainage area of 10.4 square miles, we estimate the PMF and ½ PMF inflows would be roughly 40,000 cfs and 20,000 cfs, respectively.

For a 4-ft increase in pool level, while maintaining flood discharges for all events up to the 100-year flood, the spillway riser and emergency spillway would also need to be raised by 4 ft. To safely pass the ½ PMF with 4.5 ft of overflow, an earth-cut spillway would need to be three times as wide as the existing, or roughly 750-ft wide. An alternative spillway that passes a large amount of flow with a relatively low depth of overflow is the labyrinth weir, which is zig-zagged in plan view. A conceptual layout of a labyrinth spillway that would essentially fit within the existing spillway width is shown in Figure 2. A 200-ft long armored channel and cutoff wall are included downstream of the weir to carry the flow past the toe of the dam and prevent headcutting erosion/breach of the emergency spillway.

Table 4.1 – Piney Run Reservoir – Summary of Pertinent Data*

Item	Piney Run (Existing)	Piney Run (Raised 4 Ft)
Volume (billion gal)	1.97	2.40
Surface Area (acres)	298	336
Normal Pool EL (ft)	524	528
Drainage Area (mi^2)	10.43	10.43
Estimated Safe Yield (mgd)	3.65	4.11
Average Min. Release (mgd)	1.0	1.0
Inundated Wetlands (acres)	N/A	12.6
Inundated Streams (miles)	N/A	1.05
Dam Height (ft)	73	73
Structure Impacts	N/A	N/A

* Data compiled by Malcolm Pirnie.

4.2 Gillis Falls Reservoir

The dam at Gillis Falls was envisioned by Black & Veatch to be an RCC structure (1989). Support for this assumption was provided by a geotechnical report by Schnabel Engineering Associates (SEA, 1989). Investigations in that report were performed at an upstream site. Due to high permeabilities revealed by packer testing in the right abutment, an alternate dam site was recommended about 1500-ft downstream of the original site. It is notable in SEA's report that rock quality based on recovery and rock quality designation (RQD) values was considered very poor. However, in-situ borehole pressure cell testing indicated a generally better quality rock mass, suitable for foundation support of either an earthfill or an RCC dam. Therefore, foundation grouting could be a significant cost item with the RCC dam.

In the Black & Veatch report, construction cost estimates were provided for both earth and RCC dams. The RCC dam was estimated to be about 10% less costly than the earthfill dam and structural spillway. For the purposes of this report, we have assumed construction of an RCC dam at the proposed site, with a normal pool at EL 610 and the top of dam at EL 620. For this layout, we estimated that the spillway would need to be approximately 400 ft wide to pass the PMF with 10 ft of overflow at the spillway (see Figures 3 and 5).

In conjunction with Malcolm Pirnie, Schnabel identified an expanded reservoir level at the same site that would be capable of providing additional safe yield. Table 4.2 summarizes pertinent data for the reservoir at the originally proposed and expanded elevations.

An additional smaller site was identified on Middle Run, which is a branch of the Gillis Falls Reservoir. To attain a similar volume, the Middle Run reservoir would need to be at a significantly higher elevation, and was noted to impact several dozen structures. Therefore, this alternative was excluded from further consideration.

Table 4.2 – Gillis Falls Reservoir – Summary of Pertinent Data*

Item	Originally Proposed EL 610	Possible Expansion EL 630
Volume (billion gal)	4.15	8.02
Surface Area (acres)	452	744
Normal Pool EL (ft)	610	630
Drainage Area (mi^2)	17.4	17.4
Estimated Safe Yield (mgd)	3.85	5.00
Average Min. Release (mgd)	5.45	5.45
Inundated Wetlands (acres)	177	225
Inundated Streams (miles)	10.1	14.2
Dam Height (ft above rock)	95	115
Structure Impacts (approx)	Aquaculture Facility; 5 homes	Aquaculture Facility; 16 homes

*Data compiled by Malcolm Pirnie, with the exception of dam height and structure impacts.

In addition, it should be noted that the Gillis Falls site at EL 610 and 630 would impact a total of about 2,500 and 4,000 LF of Tier II streams, respectively. One section of the Tier II stream is in the

vicinity of the dam site, and the other is in the uppermost arm of the reservoir. Impacts to these stream segments would add a further level of permitting effort and complexity to this site.

4.3 Union Mills Reservoir

As noted previously, the dam at Union Mills was originally conceived to be an earthen dam according to NRCS design criteria. Since the reservoir is no longer proposed as a multi-use watershed project, flood control does not need to be considered in the selection of project elevations. The dam may be constructed as either an earth embankment or RCC structure.

During the site visit, rock outcrops were observed at the steep left abutment (looking downstream). According to the County Soil Survey, rock depth in the central valley is anticipated to be on the order of 10 to 20-ft deep, and 2 to 6 ft at the abutments. The observed rock outcrops at the left abutment appeared to be moderately hard mica schist. Based on these observations, we have assumed construction of an RCC dam at the proposed site, with a normal pool at EL 610 and the top of dam at EL 625. For this layout, we estimated that the spillway would need to be approximately 350-ft wide to pass the PMF with 14 ft of overflow at the spillway (see Figures 4 and 5).

There is a low saddle area in the right abutment of the dam. We have assumed that this length of dam could be constructed with an earth embankment on the order of 10 to 15 ft in height.

In conjunction with Malcolm Pirnie, Schnabel identified an expanded reservoir level at the same site that would be capable of providing additional safe yield. Table 4.3 summarizes pertinent data for the reservoir at the originally proposed and expanded elevations.

Table 4.3 – Union Mills Reservoir – Summary of Pertinent Data*

Item	Originally Proposed EL 610	Possible Expansion EL 630
Volume (billion gal)	2.44	5.49
Surface Area (acres)	298	633
Normal Pool EL (ft)	610	630
Drainage Area (mi^2)	24.86	24.86
Estimated Safe Yield (mgd)	5.01	10.18
Average Min. Release (mgd)	2.5	2.5
Inundated Wetlands (acres)	114	165
Inundated Streams (miles)	8.4	15.1
Dam Height (ft above rock)	80	100
Structure Impacts (approx)	3 homes	4 homes; chicken house

* Data compiled by Malcolm Pirnie, with the exception of dam height and structure impacts.

It should also be noted that part of the Whittaker Chambers farm is located within the reservoir area. The farm was the scene of the famous "pumpkin patch" Cold War espionage case in the 1940s, and was declared a national historic landmark under the Reagan Administration. It is our understanding that the actual "pumpkin patch" site is not within the proposed pool area; however, portions of the Whittaker Chambers property along Big Pipe Creek would be flooded by the proposed reservoir.

The County would need to confirm that any impacts to the Whittaker Chambers Farm (National Historic Landmark) can be addressed.

4.3.1 Planning-Level Dam Construction Cost Estimates

For the assumed dam and spillway types discussed above, we developed estimated dam construction costs for each project. The cost estimates contained herein are to be considered "order of magnitude" according to the following categories of cost estimates developed by the American Association of Cost Engineers:

- ***Order-of-Magnitude Estimate:*** This is an estimate made without detailed engineering data. Some examples would be an estimate from cost capacity curves, an estimate using scale-up or scale-down factors, and an approximate ratio estimate. It is normally expected that this type of estimate would be accurate within +50 percent to -30 percent.

- ***Budget Estimate:*** "Budget" in this case applies to the owner's budget and not to the budget as a project control document. A budget estimate is prepared using flow sheets, layouts, and equipment details. An estimate of this type is accurate within +30 percent to -15 percent.

- ***Definitive Estimate:*** As the name implies, this is an estimate prepared from very defined engineering data. As a minimum, the data must include fairly complete plot plans and elevations, piping and instrumentation diagrams, one-line electrical diagrams, equipment data sheets and quotations, structural sketches, soil data and sketches of major foundations, building sketches, and a complete set of specifications. The "maximum" definitive estimate would be made from "Approved for Construction" drawings and specifications. A definitive estimate is accurate within +15 percent to -5 percent.

Cost estimates were developed based on quantities derived from the conceptual designs. Following are explanations of individual cost items warranting explanation.

- ***Mobilization and Demobilization:*** The cost for mobilization and demobilization includes the contractor's cost to mobilize equipment and personnel, acquire bonds and insurance, provide field offices, and other miscellaneous costs. Mobilization and demobilization were estimated to be about ten percent of the total construction cost.

- ***Erosion and Sediment Control:*** This includes erosion and sediment control measures to meet local regulations.

- ***Control of Water:*** This cost assumes the lake can be lowered for construction. It also includes costs to construct cofferdams, divert surface water past the construction area, and dewater the foundations as needed.

- ***Clearing and Grubbing:*** This includes costs to clear and grub trees within the work area.

- ***Reservoir Clearing:*** Cost for clearing trees from the reservoir area. No grubbing was considered necessary in the reservoir area.

- ***Stripping:*** Stripping of topsoil from the work area required to construct the structures listed herein.

- ***Excavation:*** Quantities include volumes of soil and rock to be excavated for dam and spillway foundations.

- ***Grout Curtain:*** The foundation for Gillis Falls is anticipated to be highly fractured. Although no geotechnical information is available for Union Mills, it was also anticipated to be highly fractured for estimating purposes. A grout curtain is specified to inject cement grout to fill foundation voids and reduce seepage beneath the dam. This item includes drilling, pump testing, and grout injection.

- ***Foundation Drains:*** The RCC dams were assumed to have drains drilled into the foundation for reduction of uplift.

- ***Select Fill:*** Quantities include drainage material under/adjacent to spillway slabs and walls. This material would consist of processed sand and aggregate.

- ***Riprap:*** Quantities include volumes required for placing riprap on the abutments, as well as downstream of the spillway.

- ***Earthfill:*** This includes costs to backfill the RCC dam and spillway structures.

- ***Topsoil and Seed:*** This includes placement of topsoil and permanent turf establishment in disturbed areas.

- ***Reinforced Concrete:*** Concrete quantities include volumes for the new concrete spillway and training walls (labyrinth spillway), and the stepped concrete overlay of the RCC spillway. The cost of concrete includes concrete, steel reinforcement, formwork, pumped delivery, and miscellaneous related items.

- ***Roller Compacted Concrete:*** Mass concrete for dam construction. Volume includes RCC above grade and extending 10 to 20 ft below grade, and an apron extending 40 ft downstream.

- ***Pre-Cast Concrete Panel System:*** includes the cost for pre-cast concrete panel, membrane backing, and heat welding of seams.

- ***Outlet Works/Intake Structure:*** Costs for constructing or modifying an intake structure for water supply withdrawals, and for drawdown requirements for the dam.

- ***Contingency:*** A contingency cost of 25% of the dam construction cost was included in the total cost to provide for margins of error in the study level cost and quantity estimates, to account for numerous smaller items not specified above, to accommodate a reasonable amount for field changes during construction, and to recognize the effects of bidding climate and material availability.

Unit prices for the above items were estimated based on similar dam construction projects completed within the past five years and adjusted for inflation. The anticipated engineering cost was added to

the dam construction cost for an estimated dam project cost. The itemized costs for the originally proposed and possibly expanded reservoirs are contained in Appendix C.

4.3.2 Comparative Project Cost Estimates

To assess the economic viability of each of the options discussed herein, we tabulated the primary project costs (except for land and impacted structures), as described below.

- ***Dam & Spillway:*** Computed as described above.

- ***Wetlands Mitigation:*** Costs for mitigating wetlands disturbed as part of the reconstruction of the embankment and reservoir. This unit cost can vary widely; an average value of $70,000 per acre was assumed for cost comparison.

- ***Stream Mitigation:*** Costs for mitigation of streams inundated by the proposed reservoir. This unit cost can vary widely; an average value of $250 per linear foot was assumed for cost comparison. This value assumes a large preservation component is part of the overall stream mitigation package.

- ***Road/Bridge Relocations:*** The cost for road and bridge relocations that may be required for construction of a new reservoir requires an in-depth planning study which is beyond the scope of this report. A nominal value was assumed for all options.

- ***Landfill Issues:*** At Union Mills, it may be necessary to construct additional mitigation measures to reduce the potential for contaminants to migrate from the landfill into the reservoir. This could take the form of a cutoff wall between the landfill and the reservoir, additional monitoring, enhanced seepage collection systems, or multiple measures.

The Comparative Project Costs for each option are tabulated below and also included in Appendix C.

Table 4.4 – Comparative Project Cost Estimates – Piney Run

Item	Raise Pool 4 Ft
Dam and Spillway	$4.2 M
Stream Mitigation	$1.4 M
Wetland Mitigation	$1.5 M
Road/Bridge Relocations	$0.4 M
Total	**$7.5 M**
Cost per MGD Safe Yield	**$16.3 M/mgd**

Table 4.5 – Comparative Project Cost Estimates – Gillis Falls

Item	Pool EL 610	Pool EL 630
Dam and Spillway	$32 M	$43 M
Stream Mitigation	$13 M	$19 M
Wetland Mitigation	$22 M	$28 M
Road/Bridge Relocations	$2 M	$2 M
Total	**$69 M**	**$92 M**
Cost per MGD Safe Yield	**$18.0 M/mgd**	**$18.3 M/mgd**

Table 4.6 – Comparative Project Cost Estimates – Union Mills

Item	Pool EL 610	Pool EL 630
Dam and Spillway	$28 M	$38 M
Stream Mitigation	$11 M	$20 M
Wetland Mitigation	$14 M	$20 M
Road/Bridge Relocations	$2 M	$2 M
Landfill Issues	$2 M	$2 M
Total	**$57 M**	**$82 M**
Cost per MGD Safe Yield	**$11.3 M/mgd**	**$8.0 M/mgd**

As can be seen in the cost estimates above, estimated mitigation costs are of similar magnitude as the dam construction cost in each case. For the purposes of site comparison, the assumption of an RCC dam at both Gillis Falls and Union Mills is reasonable for planning level estimates. In a difficult economy, cost competition may nominally favor the construction of an earthen dam, since there are more earthwork contractors than RCC contractors. If the County moves forward with either of the Union Mills or Gillis Falls option, an in-depth assessment of the two dam types should be performed based on geotechnical explorations and consideration of the economic climate.

5.0 CONCLUSIONS AND RECOMMENDED ACTIONS

5.1 Conclusions

For a reservoir site to be permittable according to Army Corps of Engineers' regulations, it must be the "least environmentally damaging practicable alternative." The site must also meet the threshold requirement of being capable of achieving the stated project purpose of providing the unmet water demand. Although the unmet water demand cannot be predicted with certainty at this time, it could fall within the range of safe yield available from individual reservoir options addressed in this letter report, depending on build-out assumptions and future regulatory policies concerning existing source appropriations. Based on these criteria, we conclude the following:

- The expansion of Piney Run would not be capable of significantly increasing supply and therefore would not meet a stated project purpose.
- The construction of Gillis Falls Reservoir would cost significantly more per mgd of safe yield than would the Union Mills Reservoir. It would also cause a greater level of environmental impacts for a given safe yield. Finally, Gillis Falls Reservoir would impact a greater number of structures, and would appear to cause more disruption to the human environment. For these reasons the Gillis Falls site appears to be less preferable and more difficult to permit.
- Of the three sites considered herein and for the limited factors considered in this study, the apparent preferred alternative is the Union Mills Reservoir. Of the three considered options, it appears to be the least environmentally damaging, practicable alternative capable of providing unmet water demand.
- Threatened and Endangered Species and Cultural Resources Impacts were not considered as part of this study, but should be assessed prior to final site selection.
- Notwithstanding the preferred alternative noted above, permitting a reservoir in this region of the United States is an extremely difficult, expensive, time-consuming, and frustrating endeavor. If other surface water supply options are available to the County (such as water purchase from the City of Baltimore, or use of existing quarries for raw water storage), these options should be fully investigated as well. Such options may be more cost effective and permittable than a new reservoir project.
- Other than the sites discussed herein, no other dam sites were identified that appeared capable of providing significant storage and safe yield for the County.

5.2 Recommended Field Investigations

The following additional investigations are recommended to better establish the feasibility of constructing a new reservoir at the potential reservoir sites:

- If not already completed, Threatened and Endangered Species surveys and Cultural Resource surveys should be conducted to identify any fatal flaws that could preclude development of the sites.

- As noted previously, estimated mitigation costs are of similar magnitude as estimated dam construction costs. If one of the sites evaluated in this report is found to be the preferred

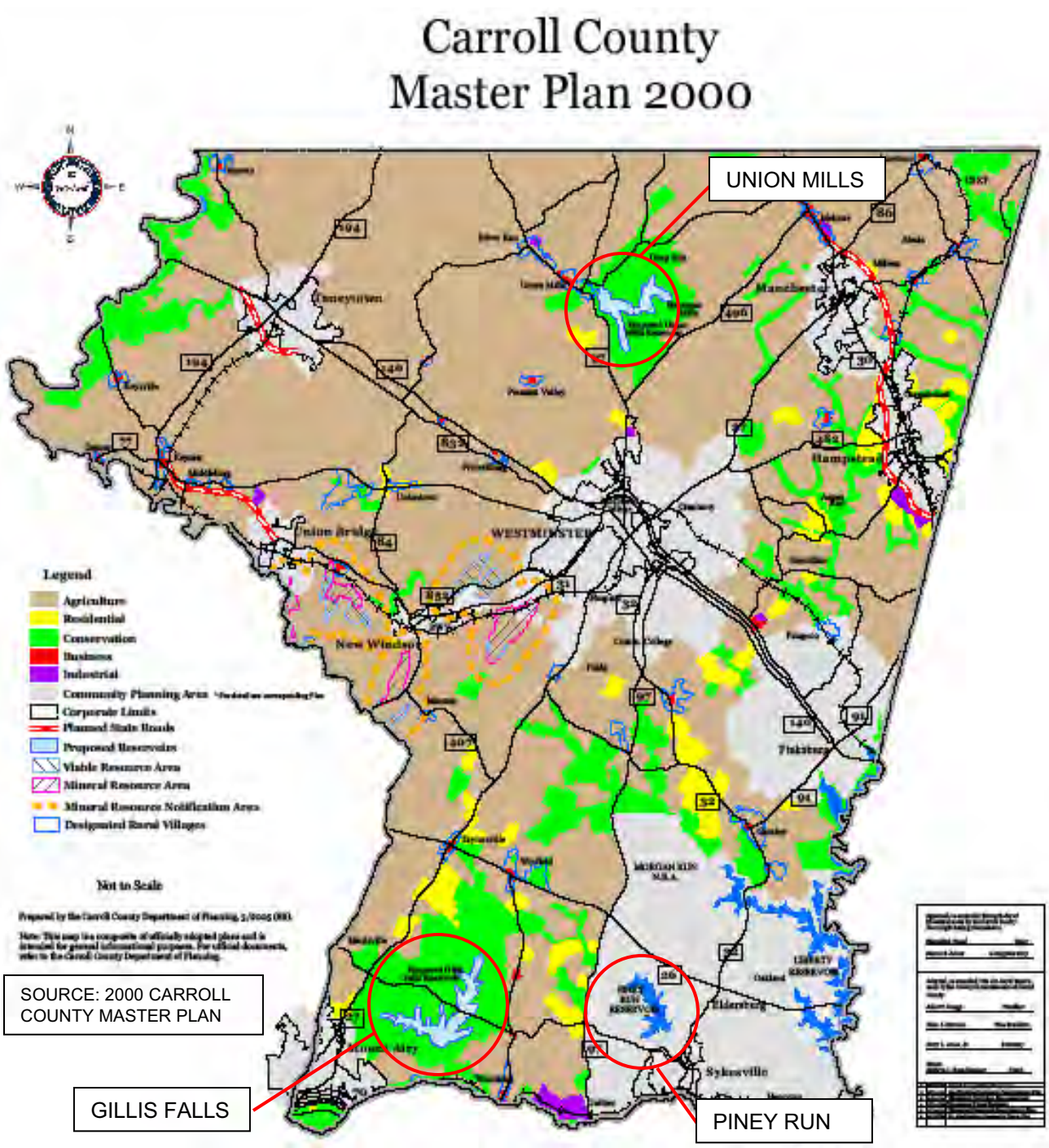
alternative for meeting the County's future demand, field investigations should be conducted to verify impacted stream and wetland quantities, and additional investigations should be pursued to identify potential mitigation sites. Judicious selection of potential mitigation sites can have a significant impact on mitigation costs. These preliminary studies would facilitate a more accurate planning level estimate of mitigation costs.

- At this point in the planning process, no subsurface investigations are recommended. Our desk-top study is considered valid for order of magnitude estimates and comparison of the sites. Following the environmental studies noted above, if one of the sites evaluated in this report is found to be the preferred alternative for meeting the County's future demand and is received more favorably by regulatory agencies, we recommend that a subsurface investigation be performed to better characterize the dam foundation, and identify the more favorable dam type for the site conditions. For the Gillis Falls or Union Mills site, an investigation consisting of 6 to 8 borings in conjunction with selected geophysical surveys would enable assessment of a rock profile along the dam and the general conditions anticipated for construction of the dam. If suitable rock is found to be significantly deeper than predicted, an earthen dam may prove to be more cost effective.

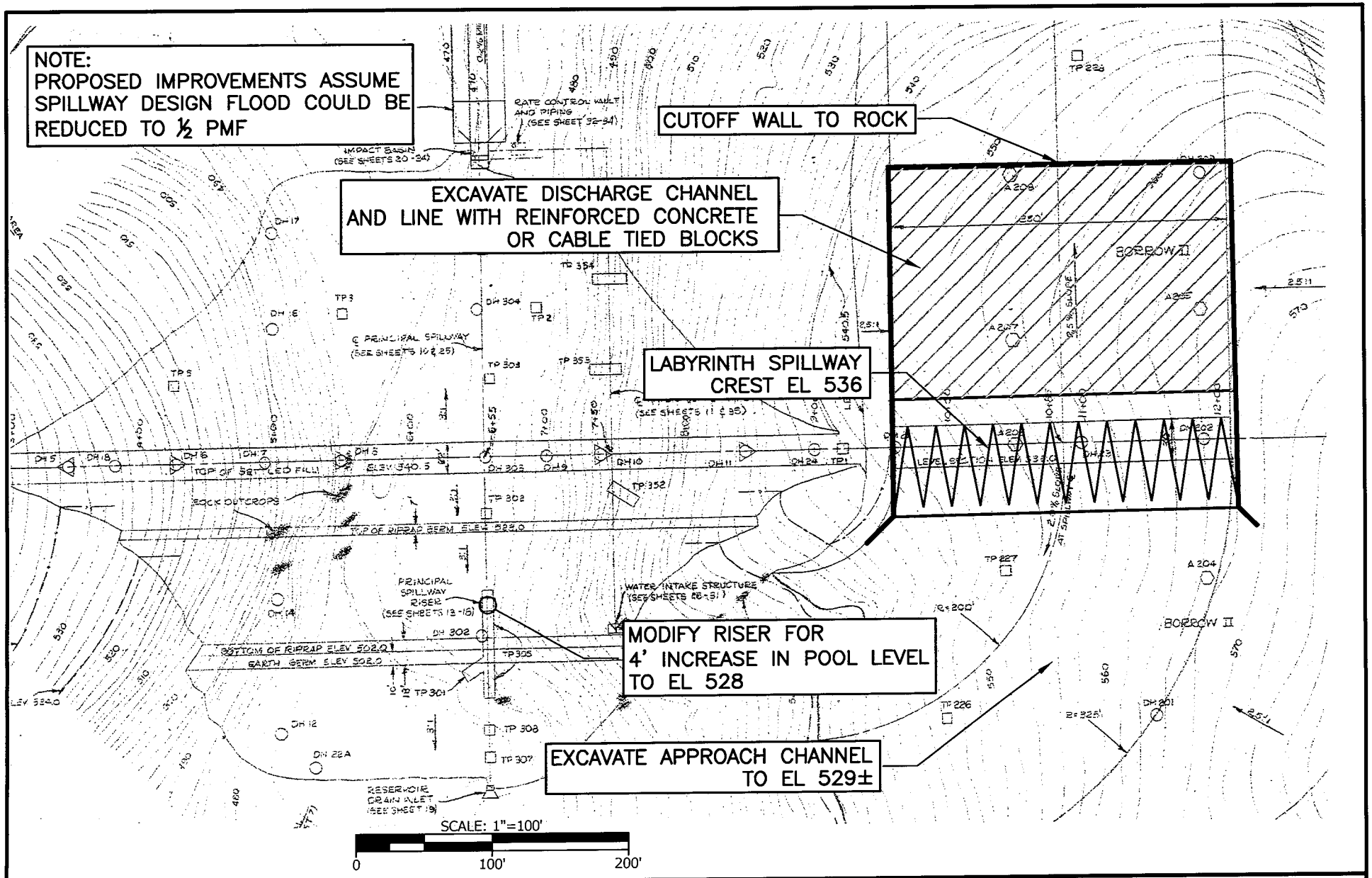
APPENDIX A

Figures

Site Location Plan, Figure 1
Piney Run Proposed Modifications for 4-ft Raise of Normal Pool, Figure 2
Gillis Falls RCC Dam Conceptual Layout, Figure 3
Union Mills RCC Dam Conceptual Layout, Figure 4
RCC Dam – Typical Sections, Figure 5



Schnabel Engineering	CARROLL COUNTY COMPREHENSIVE PLAN MARYLAND	SITE LOCATION PLAN FIGURE 1



Schnabel Engineering	CARROLL COUNTY COMPREHENSIVE PLAN MARYLAND	DRAWN BY: MJM	DATE: MAY 2009	PINEY RUN PROPOSED MODIFICATIONS FOR 4-FT RAISE OF NORMAL POOL
		CHECKED BY: JPH	SCALE: 1"=100'	PROJECT 09150009.00 FIGURE 2

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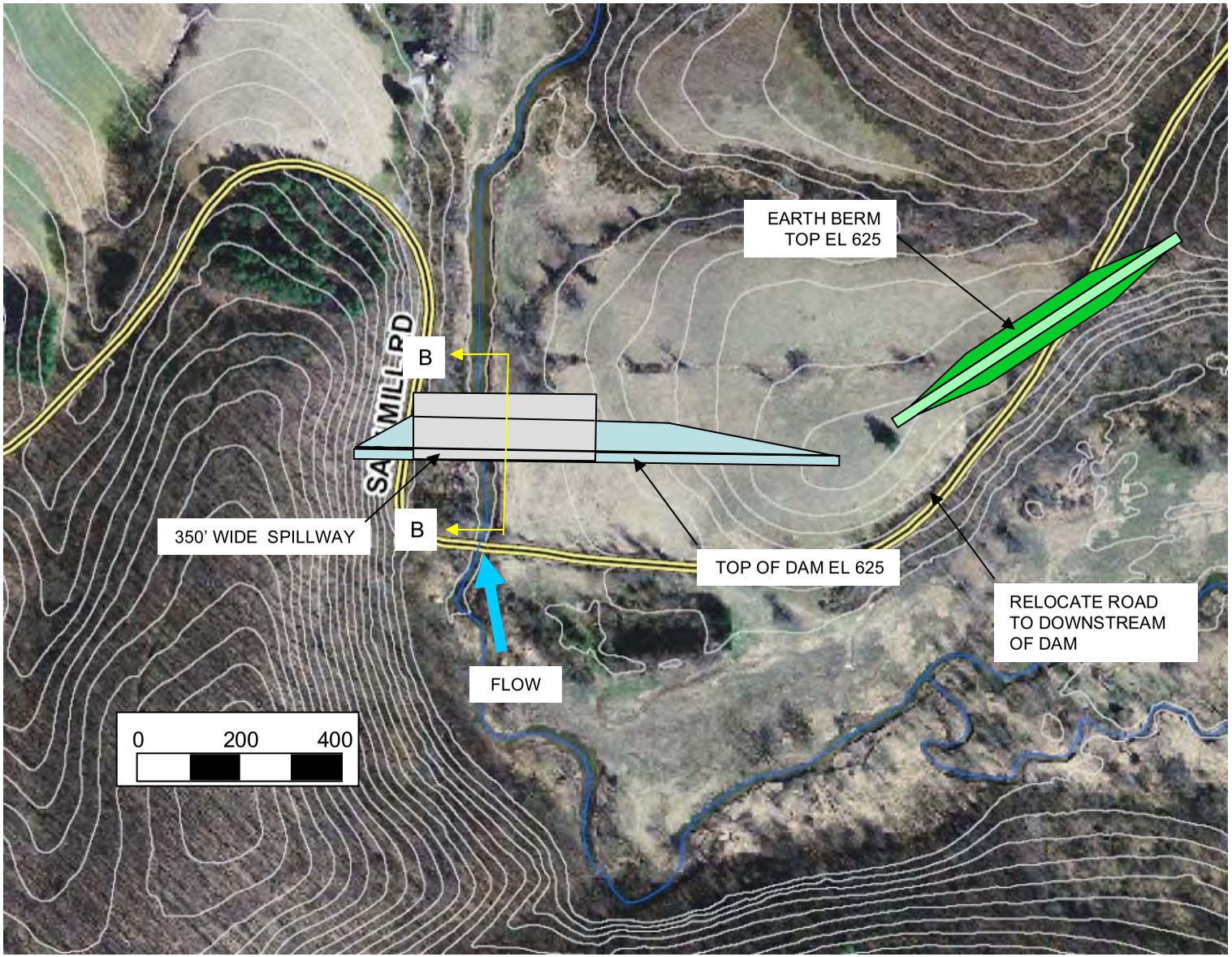
CARROLL COUNTY
COMPREHENSIVE PLAN
MARYLAND

GILLIS FALLS
RCC DAM CONCEPTUAL LAYOUT
FIGURE 3



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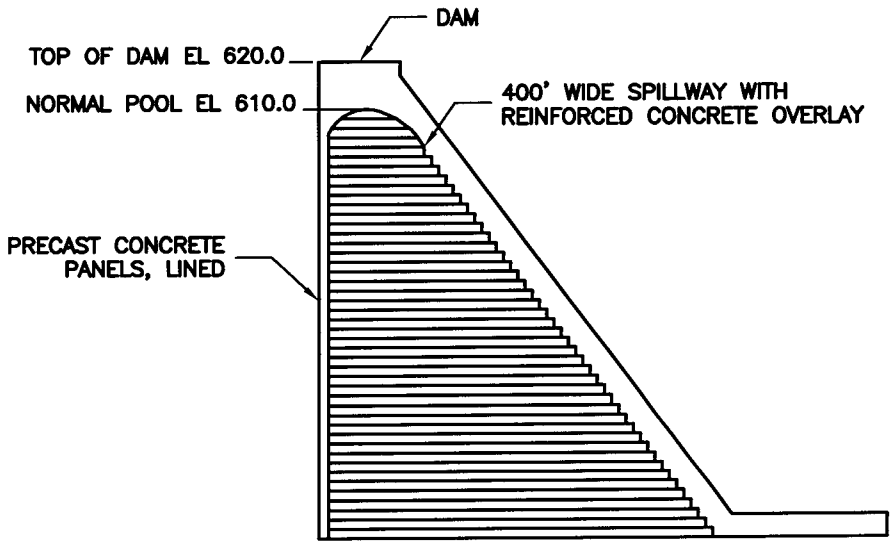
CARROLL COUNTY
COMPREHENSIVE PLAN
MARYLAND

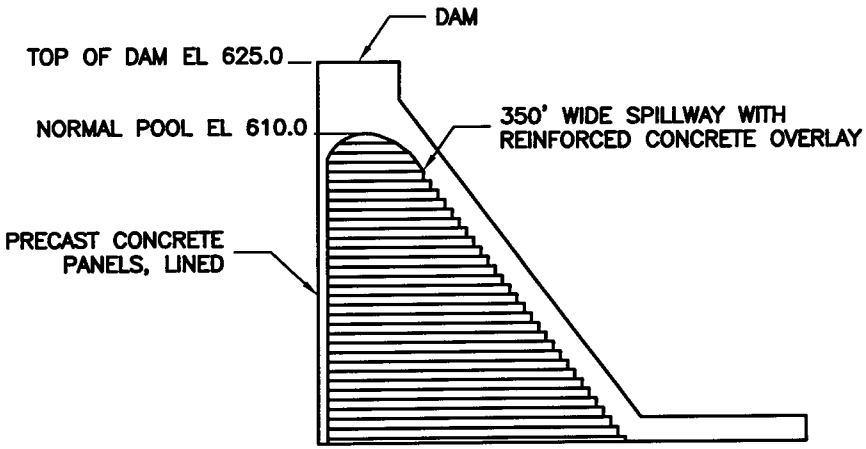
UNION MILLS
RCC DAM CONCEPTUAL LAYOUT
FIGURE 4



A GILLIS FALLS SECTION

SCALE: 1"=40'

0 40' 80'



B UNION MILLS SECTION

SCALE: 1"=40'

0 40' 80'

Schnabel Engineering	CARROLL COUNTY COMPREHENSIVE PLAN MARYLAND	DRAWN BY: MJM	DATE: MAY 2009	RCC DAM-TYPICAL SECTIONS
		CHECKED BY: JPH	SCALE: AS SHOWN	PROJECT 09150009.00 FIGURE 5

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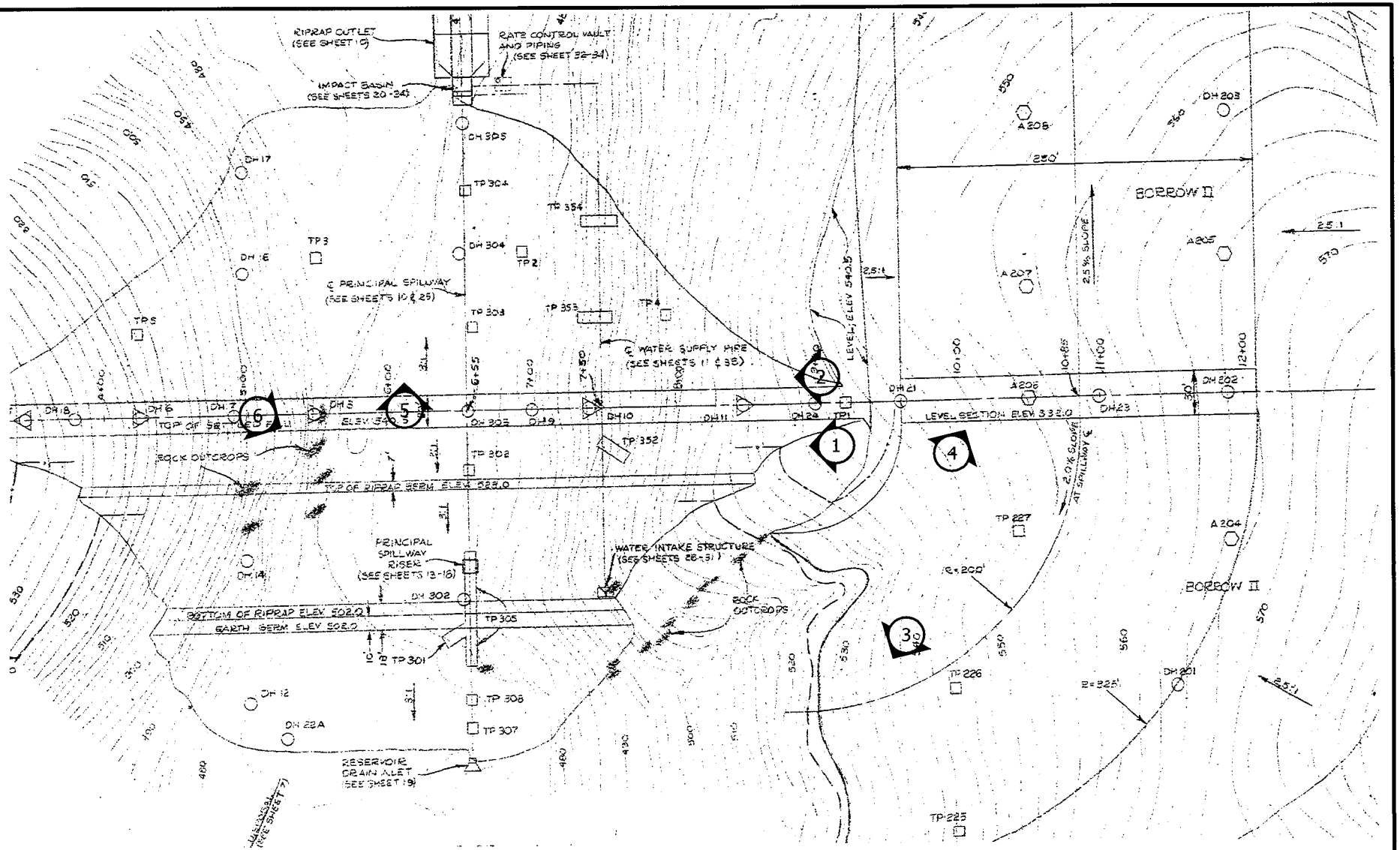
APPENDIX B

Photographs



SCALE: 1"=100'

0 100' 200'

REFERENCE: Rummel, Klepper, and Kahl, 1972 provided the base plan for this drawing.

Schnabel Engineering	CARROLL COUNTY COMPREHENSIVE PLAN MARYLAND	DRAWN BY: MJM	DATE: MAY 2009	PINEY RUN PHOTO LOCATION PLAN 1
		CHECKED BY: JPH	SCALE: 1"=100'	PROJECT 09150009.00

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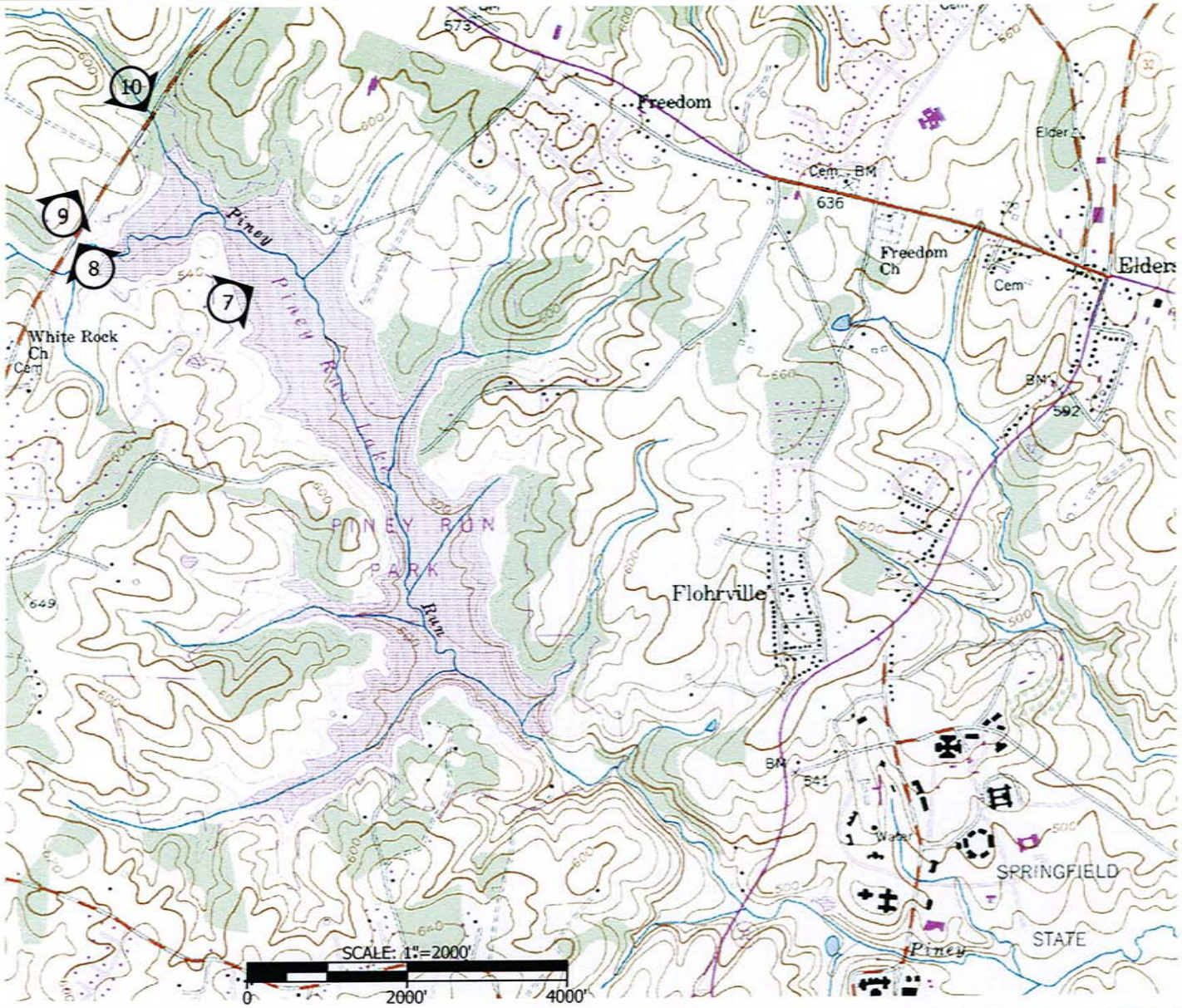

Schnabel Schnabel Engineering	CARROLL COUNTY COMPREHENSIVE PLAN MARYLAND	DRAWN BY: MJM	DATE: MAY 2009	PINEY RUN PHOTO LOCATION PLAN 2
		CHECKED BY: JPH	SCALE: 1"=2000'	PROJECT 09150009.00

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Photo 1 – View upstream from emergency spillway.

Photo 2 – Downstream view of emergency spillway.

Photo 3 – Overview of upstream slope of dam.

Photo 4 – Overview of downstream slope of dam.

Photo 5 – Overview of impact basin at toe of dam.

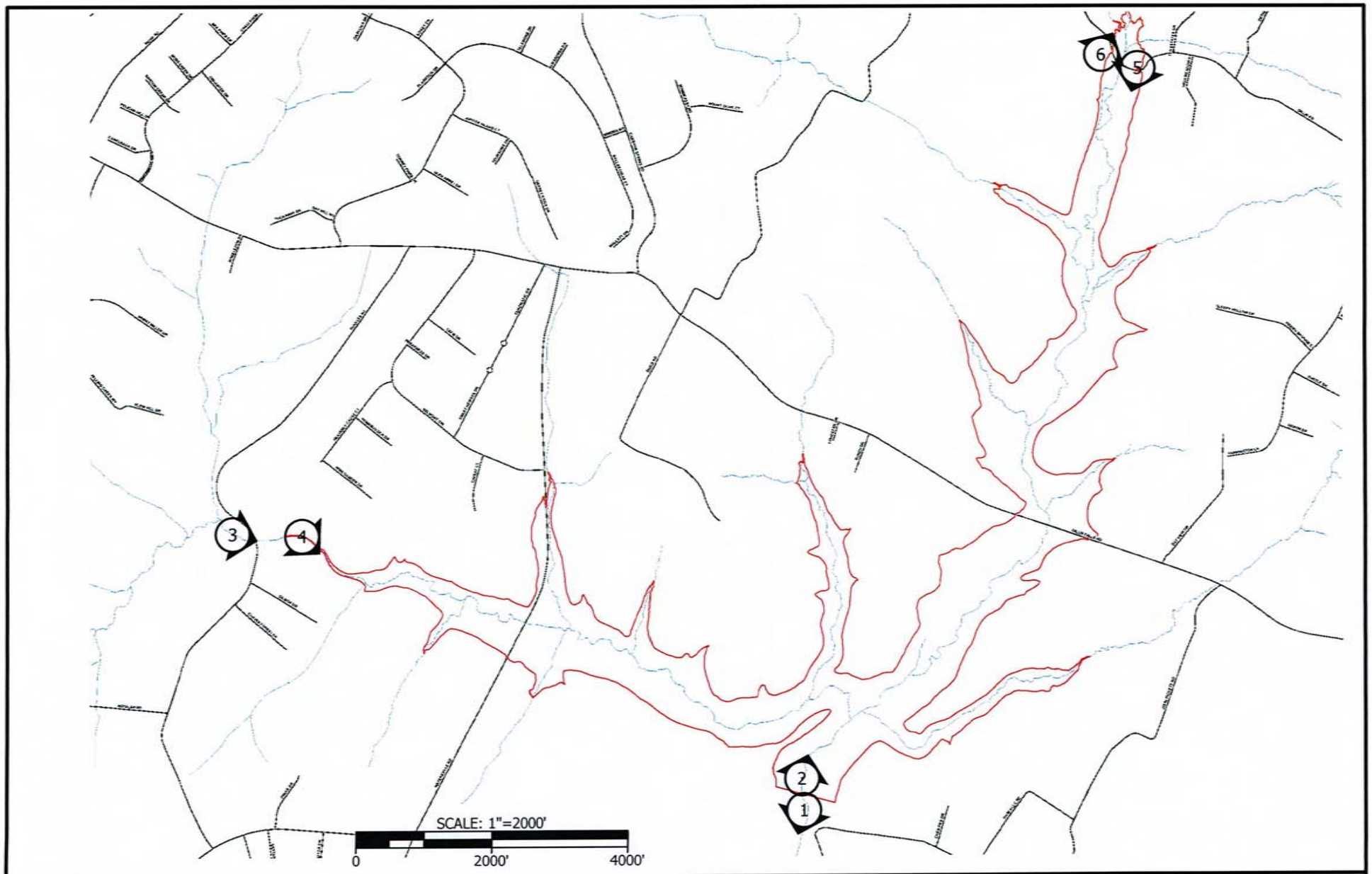
Photo 6 – Intake structure and pedestrian bridge.

Photo 7 – Historical structure on east side of reservoir.

Photo 8 – View of road culvert at White Rock Road.

Photo 9 – View east at White Rock Road.

Photo 10 – View towards reservoir at White Rock Road.



Schnabel Schnabel Engineering	CARROLL COUNTY COMPREHENSIVE PLAN MARYLAND	DRAWN BY: MJM	DATE: MAY 2009	GILLIS FALLS PHOTO LOCATION PLAN
		CHECKED BY: JPH	SCALE: 1"=2000'	PROJECT 09150009.00

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Photo 1 – View downstream at dam site.

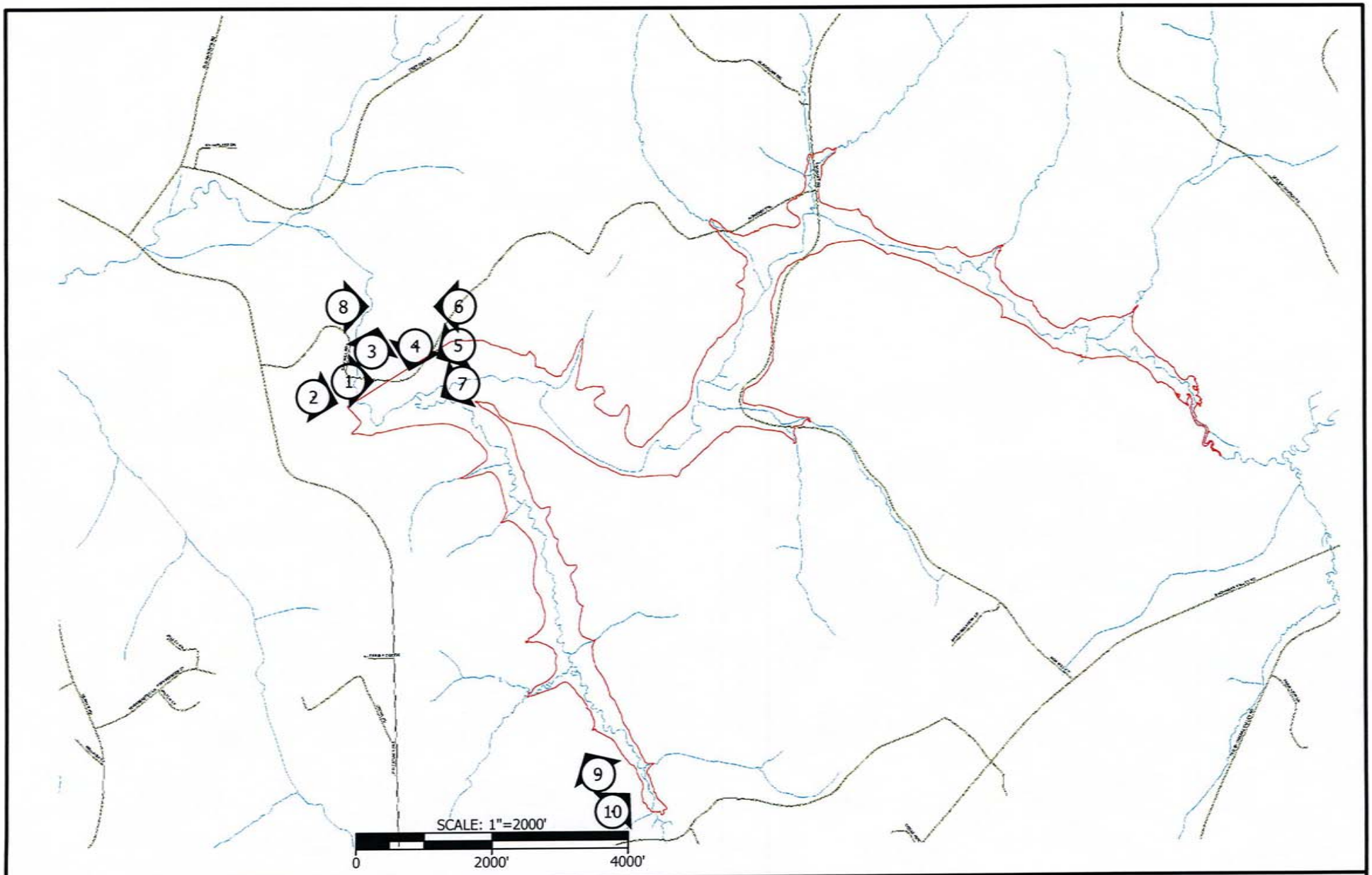
Photo 2 – View Upstream at dam site.

Photo 3 – View of road culvert at Runkles Road.

Photo 4 – Aquaculture business at Runkles Road.

Photo 5 – View downstream at Gillis Road.

Photo 6 – View upstream at Gillis Road.



Schnabel Schnabel Engineering	CARROLL COUNTY COMPREHENSIVE PLAN MARYLAND	DRAWN BY: MJM	DATE: MAY 2009	UNION MILLS PHOTO LOCATION PLAN
		CHECKED BY: JPH	SCALE: 1"=2000'	PROJECT 09150009.00

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Photo 1 – View across bridge at Saw Mill Road at dam site.

Photo 2 – View upstream from Saw Mill Road at dam site.

Photo 3 – View downstream from Saw Mill Bridge at dam site.

Photo 4 – View of valley slope downstream of dam site.

Photo 5 – View along proposed dam centerline from right abutment.

Photo 6 – View downstream from right abutment.

Photo 7 – View along steep valley slope upstream of proposed earth berm.

Photo 8 – View across valley to right abutment.

APPENDIX C

Cost Estimates

Piney Run Reservoir Raise 4 Ft
Comparative Project Cost Estimate
Carroll County, Maryland

Work	Quantity	Unit	Unit Price	Amount
Dam and Spillway	1	LS	$4,210,000	$4,210,000
Stream Mitigation	1.05	Mile	$1,320,000	$1,386,000
Wetlands Mitigation*	22	Acre	$70,000	$1,540,000
Road/Bridge Improvements	1	LS	$350,000	$350,000
	Total			**$7,486,000**
	Added Safe Yield (mgd)			**0.46**
	Cost Per MGD Safe Yield			**$16,270,000**

*Assumes an average wetland mitigation ratio of 1.75:1

Gillis Falls Reservoir EL 610
Comparative Project Cost Estimate
Carroll County, Maryland

Work	Quantity	Unit	Unit Price	Amount
Dam & Spillway	1	LS	$32,410,000	$32,410,000
Stream Mitigation	10.1	Mile	$1,320,000	$13,332,000
Wetlands Mitigation	310	Acre	$70,000	$21,700,000
Road/Bridge Relocations	1	LS	$2,000,000	$2,000,000
	Total			**$69,442,000**
	Safe Yield (mgd)			**3.85**
	Cost Per MGD Safe Yield			**$18,040,000**

*Assumes an average wetland mitigation ratio of 1.75:1

Gillis Falls Reservoir EL 630
Comparative Project Cost Estimate
Carroll County, Maryland

Work	Quantity	Unit	Unit Price	Amount
Dam & Spillway	1	LS	$43,000,000	$43,000,000
Stream Mitigation	14.2	Mile	$1,320,000	$18,744,000
Wetlands Mitigation*	394	Acre	$70,000	$27,580,000
Road/Bridge Relocations	1	LS	$2,000,000	$2,000,000
	Total			**$91,324,000**
	Safe Yield (mgd)			**5.00**
	Cost Per MGD Safe Yield			**$18,260,000**

*Assumes an average wetland mitigation ratio of 1.75:1

Union Mills Reservoir EL 610
Comparative Project Cost Estimate
Carroll County, Maryland

Work	Quantity	Unit	Unit Price	Amount
Dam & Spillway	1	LS	$27,750,000	$27,750,000
Stream Mitigation	8.4	Mile	$1,320,000	$11,088,000
Wetlands Mitigation*	200	Acre	$70,000	$14,000,000
Address Landfill Issues	1	LS	$2,000,000	$2,000,000
Road/Bridge Relocations	1	LS	$2,000,000	$2,000,000
	Total			**$56,838,000**
	Safe Yield (mgd)			**5.01**
	Cost Per MGD Safe Yield			**$11,340,000**

*Assumes an average wetland mitigation ratio of 1.75:1

Union Mills Reservoir EL 630
Comparative Project Cost Estimate
Carroll County, Maryland

Work	Quantity	Unit	Unit Price	Amount
Dam & Spillway	1	LS	$37,700,000	$37,700,000
Stream Mitigation	15.1	Mile	$1,320,000	$19,932,000
Wetlands Mitigation*	289	Acre	$70,000	$20,230,000
Address Landfill Issues	1	LS	$2,000,000	$2,000,000
Road/Bridge Relocations	1	LS	$2,000,000	$2,000,000
	Total			**$81,862,000**
	Safe Yield (mgd)			**10.18**
	Cost Per MGD Safe Yield			**$8,040,000**

*Assumes an average wetland mitigation ratio of 1.75:1

Piney Run Dam
Raise Normal Pool 4 ft
Carroll County, Maryland

COST ESTIMATE

Work	Quantity	Unit	Unit Price	Amount
Mobilization and Demobilization	1	LS	$300,000	$300,000
Erosion and Sediment Control	1	LS	$10,000	$10,000
Control of Water	1	LS	$10,000	$10,000
Demolition	1	LS	$5,000	$5,000
Clearing and Grubbing	2.0	Acre	$10,000	$20,000
Stripping	5.0	Acre	$5,000	$25,000
Common Excavation	14,000	CY	$15	$210,000
Rock Excavation	1,000	CY	$100	$100,000
Select Fill	2,500	CY	$60	$150,000
Riprap		CY	$100	$0
Articulated Concrete Blocks	50,000	SF	$15	$750,000
Topsoil & Seed	2.0	Acre	$15,000	$30,000
Drain pipe	700	LF	$25	$17,500
Structural Concrete	1,500	CY	$750	$1,125,000
Riser & Intake Modifications	1	LS	$100,000	$100,000

Values Rounded to Nearest $1000

Subtotal		$2,853,000
25% Contingency		$713,000
Est. Total Const. Cost		**$3,566,000**
Engineering	**18%**	**$641,880**
Est Total Dam Cost		**$4,210,000**

Gillis Falls Dam
RCC Dam - Normal Pool EL 610
Carroll County, Maryland

COST ESTIMATE

Work	Quantity	Unit	Unit Price	Amount
Mobilization and Demobilization	1	LS	$2,000,000	$2,000,000
Erosion and Sediment Control	1	LS	$300,000	$300,000
Control of Water	1	LS	$800,000	$800,000
Reservoir Clearing	450	Acre	$4,000	$1,800,000
Clearing and Grubbing	8	Acre	$10,000	$80,000
Stripping	7	Acre	$5,000	$35,000
Common Excavation	45,000	CY	$10	$450,000
Rock Excavation	2,000	CY	$100	$200,000
Grout Curtain	1	LS	$1,000,000	$1,000,000
Foundation Drains	3,000	LF	$75	$225,000
RCC	110,000	CY	$80	$8,800,000
Reinforced Concrete	3,100	CY	$700	$2,170,000
Unreinforced Concrete	2,800	CY	$450	$1,260,000
PreCast Panel System	63,000	SF	$25	$1,575,000
Outlet Works	1	LS	$1,000,000	$1,000,000
Backfill	20,000	CY	$10	$200,000
Topsoil & Seed	8	Acre	$10,000	$80,000

Values Rounded to Nearest $1000

Subtotal		$21,975,000
25% Contingency		$5,494,000
Est. Total Const. Cost		**$27,469,000**
Engineering	**18%**	**$4,944,420**
Est Total Dam Cost		**$32,410,000**

Gillis Falls Dam
RCC Dam - Normal Pool EL 630
Carroll County, Maryland

COST ESTIMATE

Work	Quantity	Unit	Unit Price	Amount
Mobilization and Demobilization	1	LS	$2,000,000	$2,000,000
Erosion and Sediment Control	1	LS	$350,000	$350,000
Control of Water	1	LS	$900,000	$900,000
Reservoir Clearing	745	Acre	$4,000	$2,980,000
Clearing and Grubbing	12	Acre	$10,000	$120,000
Stripping	12	Acre	$5,000	$60,000
Common Excavation	60,000	CY	$10	$600,000
Rock Excavation	4,000	CY	$100	$400,000
Grout Curtain	1	LS	$1,200,000	$1,200,000
Foundation Drains	4,000	LF	$75	$300,000
RCC	165,000	CY	$75	$12,375,000
Reinforced Concrete	4,000	CY	$700	$2,800,000
Unreinforced Concrete	3,500	CY	$450	$1,575,000
PreCast Panel System	75,000	SF	$25	$1,875,000
Outlet Works	1	LS	$1,200,000	$1,200,000
Backfill	30,000	CY	$10	$300,000
Topsoil & Seed	12	Acre	$10,000	$120,000

Values Rounded to Nearest $1000

Subtotal		$29,155,000
25% Contingency		$7,289,000
Est. Total Const. Cost		**$36,444,000**
Engineering	**18%**	**$6,559,920**
Est Total Dam Cost		**$43,000,000**

Union Mills
RCC Dam - Normal Pool EL 610
Carroll County, Maryland

DAM COST ESTIMATE

Work	Quantity	Unit	Unit Price	Amount
Mobilization and Demobilization	1	LS	$2,000,000	$2,000,000
Erosion and Sediment Control	1	LS	$350,000	$350,000
Control of Water	1	LS	$800,000	$800,000
Reservoir Clearing	300	Acre	$4,000	$1,200,000
Clearing and Grubbing	10	Acre	$10,000	$100,000
Stripping	10	Acre	$5,000	$50,000
Common Excavation	35,000	CY	$10	$350,000
Rock Excavation	2,000	CY	$100	$200,000
Grout Curtain	1	LS	$1,000,000	$1,000,000
Foundation Drains	3,000	LF	$75	$225,000
RCC	83,000	CY	$85	$7,055,000
Reinforced Concrete	2,500	CY	$700	$1,750,000
Unreinforced Concrete	2,400	CY	$450	$1,080,000
PreCast Panel System	50,000	SF	$25	$1,250,000
Outlet Works	1	LS	$1,000,000	$1,000,000
Backfill	30,000	CY	$10	$300,000
Topsoil & Seed	10	Acre	$10,000	$100,000

Values Rounded to Nearest $1000

Subtotal		$18,810,000
25% Contingency		$4,703,000
Est. Total Const. Cost		**$23,513,000**
Engineering	**18%**	**$4,232,340**
Est Total Dam Cost		**$27,750,000**

Union Mills
RCC Dam - Normal Pool EL 630
Carroll County, Maryland

DAM COST ESTIMATE

Work	Quantity	Unit	Unit Price	Amount
Mobilization and Demobilization	1	LS	$2,000,000	$2,000,000
Erosion and Sediment Control	1	LS	$350,000	$350,000
Control of Water	1	LS	$800,000	$800,000
Reservoir Clearing	633	Acre	$4,000	$2,532,000
Clearing and Grubbing	15	Acre	$10,000	$150,000
Stripping	15	Acre	$5,000	$75,000
Common Excavation	50,000	CY	$10	$500,000
Rock Excavation	2,000	CY	$100	$200,000
Grout Curtain	1	LS	$1,200,000	$1,200,000
Foundation Drains	3,000	LF	$75	$225,000
RCC	130,000	CY	$78	$10,140,000
Reinforced Concrete	3,700	CY	$700	$2,590,000
Unreinforced Concrete	3,000	CY	$450	$1,350,000
PreCast Panel System	68,000	SF	$25	$1,700,000
Outlet Works	1	LS	$1,200,000	$1,200,000
Backfill	40,000	CY	$10	$400,000
Topsoil & Seed	15	Acre	$10,000	$150,000

Values Rounded to Nearest $1000

Subtotal		$25,562,000
25% Contingency		$6,391,000
Est. Total Const. Cost		**$31,953,000**
Engineering	**18%**	**$5,751,540**
Est Total Dam Cost		**$37,700,000**

APPENDIX D

References

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