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City of Charlottesville, Virginia
Ragged Mountain Project

B&V Project 168539
December 14, 2010

Ms. Lauren Hildebrand
Director of Utilities
City of Charlottesville
Department of Public Works
305 4th Street, N.W.
Charlottesville, VA 22903

Subject: REVISED Opinion of Probable Construction Costs for Modifying the Lower Ragged Mountain Dam
Ragged Mountain Project

Dear Ms. Hildebrand:

On August 30, 2010, Black & Veatch prepared a letter for the City of Charlottesville (City) that included an initial Opinion of Probable Construction Costs (OPCC) for three feasible upgrade alternatives for the Lower Ragged Mountain Dam (LRMD). The letter also included a brief description of the alternatives and assumptions supporting the OPCC.

On November 22, 2010, Black & Veatch met with representatives from the City, the Rivanna Water & Sewer Authority, Albemarle County, and the Independent Technical Review Team (ITRT) to discuss technical issues surrounding the potential raising of the LRMD. Discussions centered on the potential 51-ft dam raise (45-ft reservoir raise) while the other possible alternatives were not discussed. Based on the meeting and materials provided to the ITRT, the ITRT developed technical comments and prepared a letter report dated November 23, 2010.

Unfortunately, Black & Veatch did not receive the ITRT letter report until December 6th. Consequently, we are not able to respond to all of the comments provided in the letter report in the limited time available. However, in an effort to provide the City with a useful response as quickly as possible, Black & Veatch attempted to address some of the ITRT comments as interpreted from personal meeting notes as well as an unofficial letter report from the ITRT dated September 1st (received by Black & Veatch on November 23rd).

Our intent was to capture several of the major and potentially costly items to adjust the OPCC as necessary for further comparison to the cost estimate prepared for the New Ragged Mountain Dam (RMD). The revised OPCC is provided as Attachment A and the revised plan and profile of the 51-ft dam raise are provided in Attachments B and C, respectively. The following text briefly describes our response to some of the ITRT comments.

TECHNICAL COMMENTS FROM ITRT

For the sake of brevity, we attempted to summarize the ITRT comments with the Black & Veatch response following.

Foundation Excavation – *The assumed volume of foundation excavation should be revisited in consideration of the available geotechnical information.*

Black & Veatch reviewed applicable subsurface information illustrated on Drawing GDR-3 from the Geologic and Geotechnical Data Report, dated May 14, 2010 by Schnabel Engineering as well as the six test borings located in the LRMD footprint. Specifically, the following data points were referenced:

- Test borings BV1, BV2, BV3, BV 4 and test borings GF1 and GF2 (through the existing LRMD).
- Test borings GF-1, GF-2, GF-5, GF-6, GF-7, GF-17 and GF-14 (along the centerline of the proposed new RMD and downstream of the centerline).
- Test borings BD-03 and BD-07 (near the existing LRMD).
- Seismic refraction lines (geo-line 101, 102, 103, 104, 105, and 107).

The following conclusions were derived from the abovementioned data points:

- The depth below natural ground to a competent foundation surface in the valley bottom ranges between 5 and 15 feet.
- The depth to top of rock on the right abutment ranges between 20 and 45 feet.
- The depth to a competent foundation surface on the left abutment is affected by excavations made during the original construction of the LRMD. These excavations, evident on current topographic maps, removed some of the natural overburden material. As a result, the depth of overburden appears to range between 10 and 20 ft.

Excavation of the new raised LRMD footprint (RCC portion) was assumed to require removal of the existing earth buttress and all overburden material including an average of 15 ft of rock over the entire footprint. It is anticipated that some areas may require less than 5 ft of rock removal while others may require rock excavations of more than 20 ft to reach a competent surface. The total earth and rock excavation quantities are summarized in Attachment A.

Additional subsurface investigations consisting of test borings and geophysical surveys are needed to verify the abovementioned conclusions.

Seepage Mitigation – *To limit the quantity of water lost through seepage, the project should include a grout curtain below the existing dam; a grout curtain along the right abutment; and grouting of the existing dam.*

Based on discussions during the November 23rd workshop, water loss through the existing dam and underlying rock must be kept to a minimum. To reduce the quantity of seepage through and under the existing dam, grouting of the dam and foundation rock was added to the alternative. Grouting will be achieved using holes cored through the existing dam and into the foundation rock. The slightly angled core holes will begin at about elevation 630 ft from the downstream slope of the existing dam and extend to between 30 and 50 ft into the foundation rock under the dam heel.

In addition, seepage controls were included along the right abutment beyond the RCC section. Elements of the seepage barrier include a grout curtain extending about 30 ft into groutable rock and a slurry wall through the overburden material. Details regarding connection of the seepage barrier elements to one another and to the embankment portion of the raised dam have not yet been developed.

The OPCC provided in Attachment A reflects costs associated with these seepage control features.

Dam Section and Stability – *A stability analysis should be performed to assess the performance of the proposed dam raise. The crest width of the RCC section should be at least 20 ft wide. The quantity of RCC should be checked.*

Black & Veatch completed simple stability analyses of the proposed raised LRMD to verify the safety of the assumed geometry. The RCC crest width was increased to 20 ft for constructability. The spillway section was reduced from 100 ft wide to 50 ft wide based on hydrologic data provided in Schnabel Engineering's report entitled Preliminary Design Report, dated May 14, 2010.

A maximum cross section with a 20 ft wide crest, a 25 ft high chimney section, and a 90 ft wide base at elevation 570 ft, was developed. The base width is equivalent to a 0.7H:1V downstream slope. It was assumed that the entire base is horizontal at elevation 570 ft; although, actual base geometry will be considerably more undulating. Attachment B illustrates the assumed maximum section.

Considerations in the analyses included RCC lift joint strength, bedrock interface strength, and bedrock strength among other items. The post-tensioned anchors proposed to support the existing dam during construction were not considered in the stability of the raised structure. Stability

analyses were performed for the RCC chimney section, lift joint at elevation 641 ft (top of existing dam), maximum raised section without drains, and maximum raised section with drains.

Our approach to the stability analysis considered:

- Using a shear strength with both friction angle and cohesion for roller compacted concrete (RCC) lift joints where the typical safety factors required are 3.0 for normal operation, 2.0 for unusual, typically flood and ice load, and 1.0 for extreme, which is the earthquake case.
- Using a zero cohesion shear strength for the bedrock/RCC interface, where the required safety factors are typically 1.5 for the worst static case, and 1.3 if the worst static case is the probable maximum flood (PMF).
- That base cracking was not acceptable for the normal case, but is acceptable under the unusual load cases, as long as the crack stabilizes and the safety factor and bearing stresses are acceptable.
- Based on the results of direct shear tests provided in Gannett Fleming's Draft Geotechnical Report dated August 19, 2008, and what was seen at the interfaces of BV-1, BV-2, and BV-3, a friction angle of 55 degrees with zero cohesion was selected for the interface shear strength beneath both portions of the dam.

The maximum cross section was first evaluated without drains. A linear headwater to tailwater distribution was taken from the heel of the existing dam to the toe of the RCC. The stability analysis results indicate that the maximum section has acceptable bearing stresses and safety factors without drains, using the normal and PMF loadings.

Notwithstanding the stability results assuming no drains, the constructed alternative will include drains through the existing dam, and use box drains beneath the RCC. As a result, the safety factors for all loading conditions increased considerably.

Based on the analyzed cross section, the total quantity of RCC required is estimated at approximately 54,900 cubic yards. If the project proceeds into design, it may be possible to optimize the cross section to reduce the quantity of RCC while satisfying required safety factors.

Outlet Works – *the existing outlet works is not reliable and does not have the required capacity to meet future use demands.*

Based on conversations during the November 22nd meeting, the outlet works has the following requirements:

- A 36-inch diameter pipe to provide the necessary capacity to the water treatment plant.

- The ability to drain the reservoir in a reasonable time period.
- The ability to withdraw water from different depths depending on water quality.
- The ability to access the water above the dead storage.

Regarding the questions concerning the condition of the existing intake tower and gates, we suggest satisfying these needs through construction of a new intake tower located on the left abutment adjacent to the existing dam as shown on Attachment C. The tower would be attached to the upstream face of the RCC and include three 36-inch diameter intake levels (controlled with sluice gates) with the lowest at about elevation 630 ft. An intake at elevation 630 ft will allow access to approximately 89 percent of the reservoir volume with the remaining 11 percent providing dead storage. A 36-inch diameter pipe would extend through the RCC dam, along the left abutment and connect to existing piping.

With the addition of a new sluice gate on the upstream side of the existing 18-inch diameter outlet pipe and removal of existing gates, the existing tower could permit access to water below elevation 630 ft in periods of severe drought although at a lower discharge rate (e.g. through the existing 18-inch diameter pipeline).

OPCC REVISIONS

The original August 30th OPCC was developed by dividing the project into numerous items and pricing each item through a single lump sum amount or estimating quantities and unit prices. For ease of comparison with the New RMD estimate, appropriate items, unit prices, and lump sum costs from previous cost estimates were used in preparation of the Black & Veatch OPCC. The referenced cost estimates are identified in Attachment A.

Considering our response to the issues described in this letter, we adjusted the quantities for many items based on a more detailed evaluation as well as adding new items as appropriate. The revised OPCC shown in Attachment A indicates a range of construction costs from $13.5M to $19.5M as compared to the August 30th OPCC range of $12.7M to $18.3M. Although additional effort has been spent to further the conceptual design of the LRMD raise, Black & Veatch continues to assigned an accuracy of -10 percent to +30 percent on the OPCC. Thus, the OPCC is carrying a “contingency” of about $4.5M for the estimated $15M project.

A few other comments regarding the OPPC are summarized below:

- Similar to previous estimates for the new RMD, this OPCC does not consider costs associated with environmental restoration or modifications to the I-64 embankment.
- Changes to the Virginia dam safety regulations may permit a slightly smaller spillway design flood for the raised LRMD. The change would result in smaller inflows to the

LRMD and, therefore, a lower water surface elevation during the storm. A lower water surface elevation would result in a slightly lower crest elevation. The cost reduction associated with the change, although small, is not yet considered.

- A July 27, 2010 memorandum from the Rivanna Water & Sewer Authority describes the methodology behind lowering the new Ragged Mountain Reservoir level about 3 ft while retaining the required storage volume. Development of a new stage-storage curve for the Lower Ragged Mountain Reservoir may indicate that a lower reservoir level is also applicable to the upgraded LRMD. The cost reduction associated with a lower crest elevation is not considered.

The revised OPCC presented in this letter is based on data generated by others as well as preliminary engineering analyses performed by Black & Veatch. Additional studies and field investigations are needed to verify several major elements of the alternatives including seepage control measures and foundation conditions.

Should you have any questions or need clarification, please do not hesitate to contact me at 301-921-8244 or at zamenskyg@bv.com.

Very truly yours,
BLACK & VEATCH

Gregory A. Zamensky, P.E.
Regional Practice Leader
Dams, Levees and Reservoirs Practice

Attachments A – Alternative 1 OPCC REVISED
B – Alternative 1 Plan and Section
C – Alternative 1 Profile

cc: File
Rich Gorny, Black & Veatch
Doug Brinkman, Black & Veatch

ATTACHMENT A
REVISED OPINION OF PROBABLE CONSTRUCTION COSTS
LOWER RAGGED MOUNTAIN DAM RAISE
ALTERNATIVE 1: 45-FT RESERVOIR RAISE (51-FT DAM RAISE)

Item	Description	Units	Quantity	Unit Price	Extension	Notes/Reference
1	Mobilization & Demobilization					
	a. General (6.5%)	LS	1	$ 892,000	$ 892,000	Percentage of total cost
	b. Bonds & Insurance (3%)	LS	1	$ 412,000	$ 412,000	Percentage of total cost
2	Care & Diversion of Water					
	a. Erosion and Sediment Control	LS	1	$ 150,000	$ 150,000	
	b. Foundation Dewatering/Water Control	LS	1	$ 200,000	$ 200,000	
3	Clearing & Grubbing					
	a. Dam, buttress, access road	AC	2	$ 6,000	$ 12,000	Unit price Ref. 1,3
4	Reservoir Clearing	AC	100	$ 8,000	$ 800,000	Quantity Ref. 1, Unit price Ref. 3
5	Demolition of Existing Structures					
	a. Miscellaneous Structures	LS	1	$ 10,000	$ 10,000	Quantity and unit price Ref. 1, 3
	b. Removal of Upper Dam	LS	1	$ 200,000	$ 200,000	Quantity and unit price Ref. 1, 3
	c. Removal of Old Piping	LS	1	$ 50,000	$ 50,000	Quantity and unit price Ref. 1, 3
6	Excavation					
	a. Unclassified Excavation (buttress and abutments)	CY	50000	$ 5	$ 250,000	Unit price Ref. 1, 3, quantity updated
	b. Rock Excavation	CY	17000	$ 20	$ 340,000	Unit price Ref. 1, 3, quantity updated
7	Foundation Preparation					
	a. Rock Trimming	CY	1700	$ 75	$ 128,000	Unit price Ref. 1, 3
	b. Foundation Cleaning	SY	4000	$ 40	$ 160,000	Unit price Ref. 1, 3, quantity updated
	c. Concrete preparation (existing dam face)	SY	2000	$ 40	$ 80,000	High pressure water and air
8	Foundation Drilling & Grouting					
	a. Grout Curtain Below RCC Dam	SF	14400	$ 25	$ 360,000	Unit price Ref. 1, 3, quantity updated
	b. Abutment Seepage Treatment (grout, slurry wall)	LS	1	$ 300,000	$ 300,000	Grout curtain and slurry wall
	c. Curtain Below/Through Existing Dam	SF	22800	$ 25	$ 570,000	From angled holes on d/s slope (drilling, grout)
9	Post-tensioned Anchors	LF	1600	$ 350	$ 560,000	Extending only through existing LRMD into rock
10	Fill					
	a. Common Earth (shell fill, backfill)	CY	12000	$ 4	$ 48,000	Unit price Ref. 1, 3
	b. Select Fill (Core)	CY	1300	$ 6.5	$ 8,000	Unit price Ref. 1, 3
	c. Filter/Drain	CY	2500	$ 65	$ 163,000	Unit price Ref. 1, 3
11	Slope Protection (earth section, right abutment)					
	a. Class 1 Riprap	CY	1200	$ 80	$ 96,000	Unit price Ref. 1, 3, quantity updated
	b. Riprap Bedding	CY	300	$ 45	$ 14,000	Unit price Ref. 1, 3, quantity updated
12	Conventional Concrete					
	a. Structural Concrete (retaining walls, stilling basin)	CY	185	$ 750	$ 139,000	Unit price Ref. 1, 3, quantity updated
	b. Downstream Facing Concrete (spillway section)	CY	650	$ 450	$ 293,000	Unit price Ref. 2, quantity updated
	c. Upstream Facing Concrete	CY	2000	$ 250	$ 500,000	18 inch thick concrete face
	d. Dental Concrete	CY	1350	$ 250	$ 338,000	Unit price Ref. 1, 3
13	Steel Reinforcing Bars (170 lbs / cy)	LB	142000	$ 0.80	$ 114,000	Unit price Ref. 1, 3
14	Roller Compacted Concrete					
	a. RCC In-place	CY	54900	$ 85	$ 4,667,000	Unit price Ref. 2, quantity updated
	b. RCC Trial Placement	LS	1	$ 150,000	$ 150,000	Unit price Ref. 2
	c. Grout Enriched RCC (downstream facing)	CY	4000	$ 90	$ 360,000	Contractor input on cost
15	Bedding Mix	LS	1	$ 150,000	$ 150,000	Price reduced from Ref. 2 value, smaller footprint
16	Dam Construction Joints	LS	1	$ 100,000	$ 100,000	Unit price Ref. 2
17	Drilled Foundation Drains	LF	3000	$ 40	$ 120,000	Unit price Ref. 2, quantity updated
18	Outlet Works Modifications	LS	1	$ 50,000	$ 50,000	New gate on u/s side of 18-inch pipe
19	Instrumentation	LS	1	$ 200,000	$ 200,000	Unit price Ref. 2
20	Rock Lined Swale	LF	1500	$ 60	$ 90,000	Quantity and unit price Ref. 1
21	Utilty Relocation	LS	1	$ 125,000	$ 125,000	Unit price escalated from Ref. 4
22	Landscaping and Site Restoration	LS	1	$ 100,000	$ 100,000	
23	Roadways					
	a. Reservoir Drive Upgrades	LS	1	$ 250,000	$ 250,000	Quantity and unit price Ref. 1, 3
	b. Traffic Control	LS	1	$ 150,000	$ 150,000	Quantity and unit price Ref. 1, 3
	c. Roadway Surfacing	SY	7000	$ 12	$ 84,000	Quantity and unit price Ref. 1, 3
	d. Access Road Improvements	LS	1	$ 200,000	$ 200,000	Quantity and unit price Ref. 1, 3
24	Intake Tower and 36-inch Pipe (open cut at El. 630 ft)					
	a. Furnish and Install Pipe	LF	450	$ 280	$ 126,000	Unit price Ref. 1, 3
	b. Rock Removal	CY	150	$ 200	$ 30,000	Unit price Ref. 1, 3
	c. Sluice Gates	EA	3	$ 30,000	$ 90,000	Vendor estimate
	d. Tower Concrete, Trash Racks, Backfill Concrete	LS	1	$ 150,000	$ 150,000	8'x8' tower, slab
	e. Pipe Connection	LS	1	$ 10,000	$ 10,000	Unit price Ref. 1, 3
25	Unlisted Items (5%)	LS	1	$ 634,000	$ 634,000	
	Subtotal - Construction Costs			$	15,023,000	
	Construction Cost Variance (-10%)			$	13,521,000	
	Construction Cost Variance (+30%)			$	19,530,000	
26	Engineering Services					
	a. Geotechnical Study, Engineering Design (10%)	LS	1	$ 1,502,000	$ 1,502,000	
	b. Construction Oversight (12%)	LS	1	$ 1,803,000	$ 1,803,000	

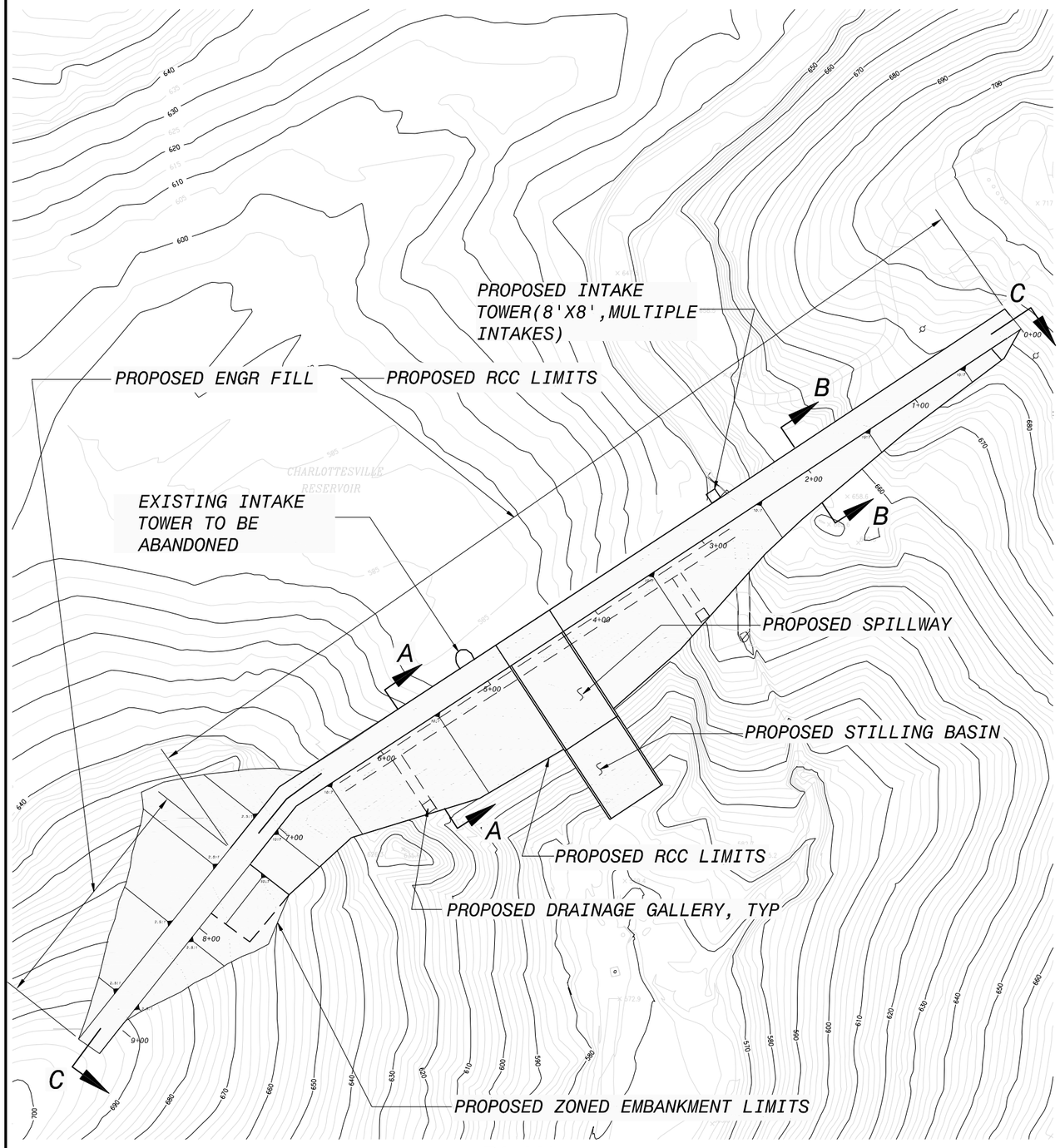
References

[1] RMD, Earthen Embankment Dam, Preliminary Opinion of Cost, Schnabel Engineering, May 10, 2010

[2] Appendix B, Package 2 Ragged Mountain RCC New Dam, Schnabel Engineering, September 19, 2008

[3] Earthen Dam Phased Construction Assessment Report, Schnabel Engineering, July 19, 2010

[4] Feasbility Study for Upgading the Ragged Mountain Dams, Gannett Fleming, Feburary 28, 2003



PLAN

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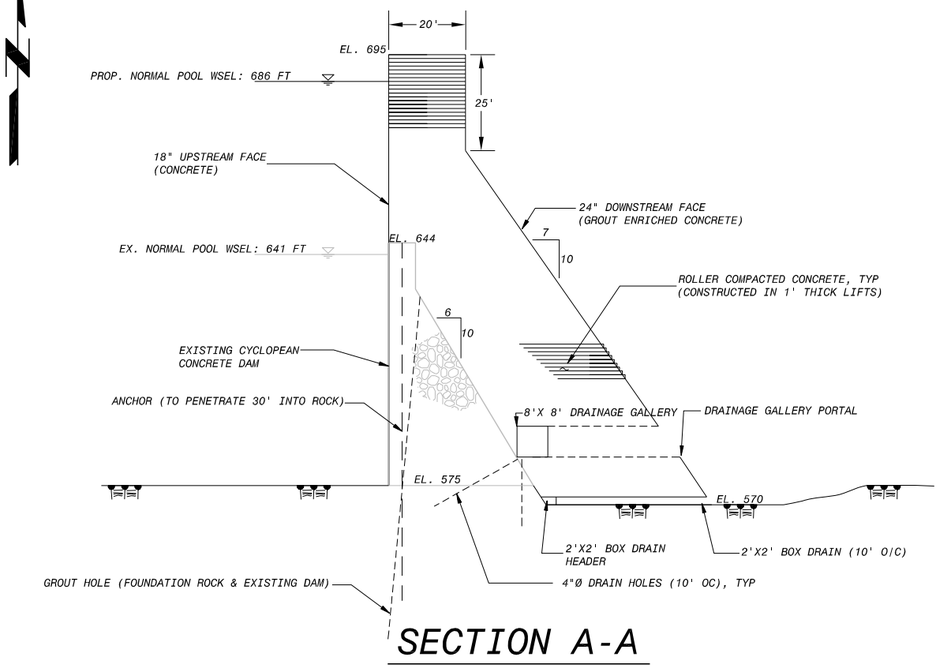
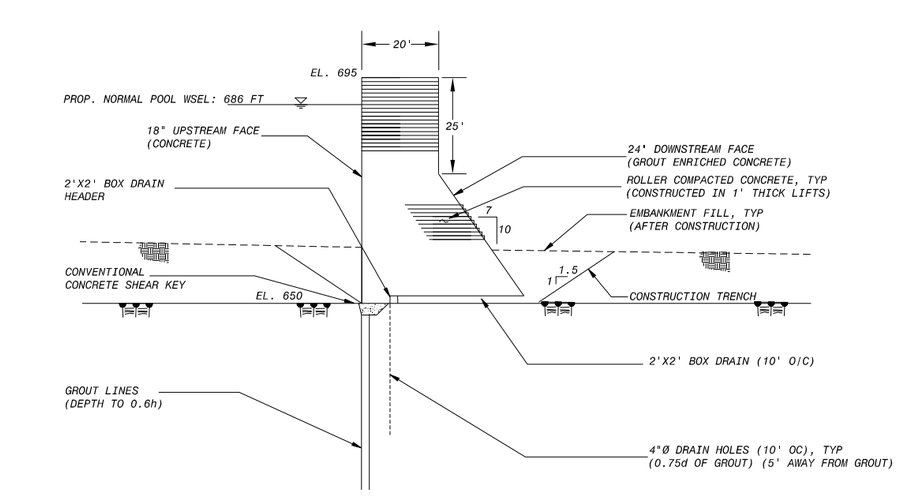


SECTION A-A

PROPOSED CS ALONG EXISTING CYCLOPEAN DAM



SECTION B-B

PROPOSED CS ALONG PROPOSED ABUTMENT EXTENSION

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XREF4:
XREF5:
DWG VER:

BLACK & VEATCH
Black & Veatch Corporation
Gaithersburg, Maryland

RAGGED MOUNTAIN DAM STUDY

ALTERNATIVE 1 PLAN AND SECTIONS

DESIGNED:	GZ
DETAILED:	TH
CHECKED:	GZ
APPROVED:	RG
DATE:	08/25/2010

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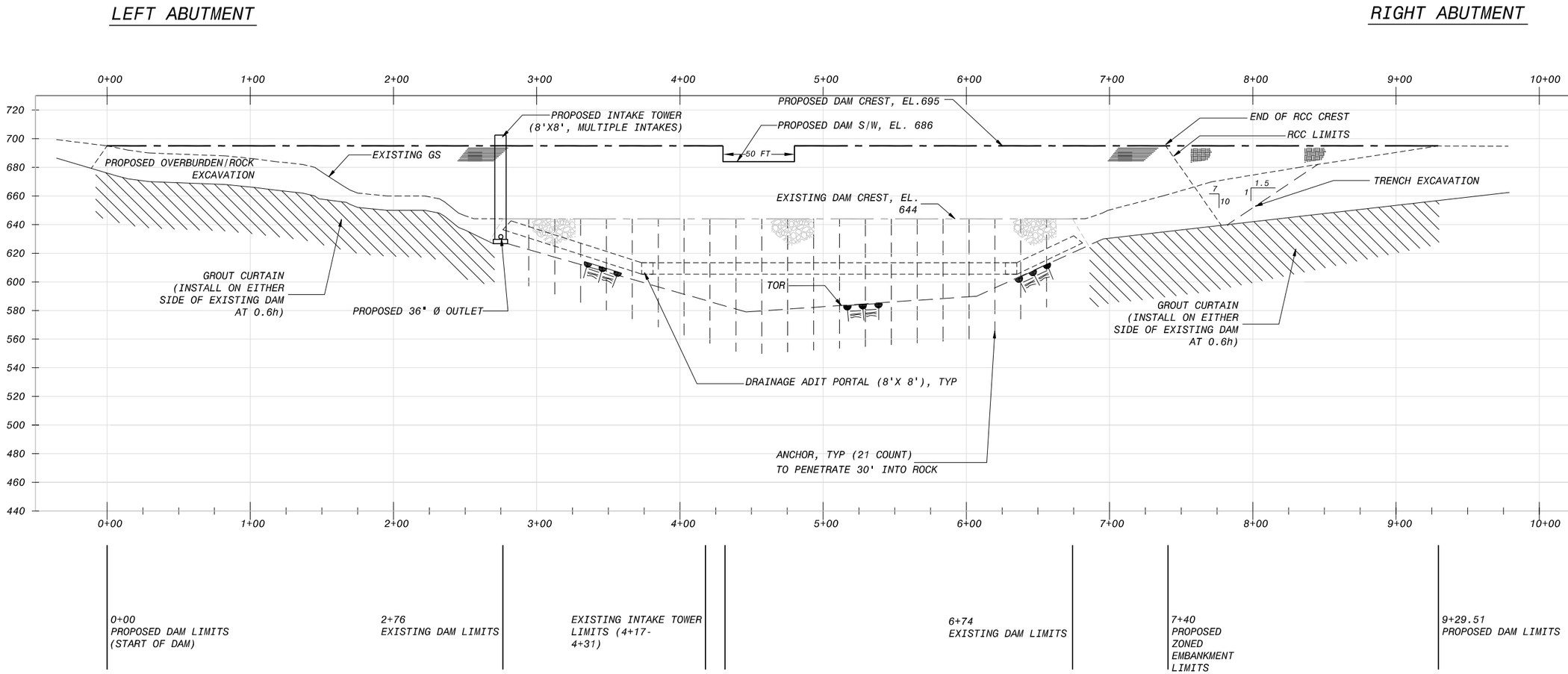
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE

PROJECT NO. 168539

ATTACHMENT A



DAM PROFILE ALONG CENTERLINE

40' 20' 0 40' 80'

1"=40'

SECTION C-C OF ATTACHMENT A

PRELIMINARY - NOT FOR CONSTRUCTION

NO.	BY	CK.	APP	DATE	REVISIONS AND RECORD OF ISSUE
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DWG VER:

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Gaithersburg, Maryland

RAGGED MOUNTAIN DAM STUDY

ALTERNATIVE 1 PROFILE

DESIGNED:	GZ
DETAILED:	TH
CHECKED:	GZ
APPROVED:	RG
DATE:	08/25/2010

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IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE

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ATTACHMENT B