March 7, 2014

Mr. Robert McNeil, P.E., Director
Town of Millbury DPW
Department of Public Works
127 Elm Street
Millbury, MA 01527

RE: **Upstream Slope Evaluation**
Ramshorn Pond Dam Reconstruction
Millbury, Massachusetts
(PARE Project No. 13072.00/006)

Dear Mr. McNeil:

As requested, Pare Corporation (PARE) has completed additional evaluations of the alternatives for addressing the upstream slope stability and seepage concerns at the Ramshorn Pond Dam in Millbury, Massachusetts.

BACKGROUND

In November 2013, PARE submitted a Schematic Design Report with recommended approaches to address a number of deficiencies identified at the Ramshorn Pond Dam. The conceptual dam design presented within that report included the following significant improvements:

1. Replacement of the Low-level Outlet Pipe with a larger pipe to improve drawdown capacity and increase overall discharge capacity.
2. Replacement of the primary spillway with a new spillway located near the center of the embankment sized to provide adequate discharge capacity to meet the spillway design flood requirements. The spillway would include energy dissipation and scour protection to minimize the future potential for erosion of the channel at the downstream end of the spillway.
3. Replacement of the stormwater drainage system and the addition of sediment settling and detention infrastructure.
4. Replacement and relocation of the outlet control structure to an upstream location to provide safe, secure access for municipal operation and maintenance of the dam gate works and eliminate the existing condition of a charged pipe through the dam structure.
5. Replacement of the substandard upstream slope with a vertical cutoff wall to provide slope stability and seepage suppression.
6. Improvements to the downstream slope to meet slope stability requirements.
7. The addition of public access to Ramshorn Pond, a Massachusetts "Great Pond," via a limited parking/fishing area and canoe launch.

Upon review of the Schematic Design Report, the Ramshorn Pond Association (Association) criticized the Town's proposal for public access to the pond. The Association cited concerns that the costs associated with the proposed upstream wall at the dam was excessive for the purpose of providing public access. The Association requested that the Town of Millbury complete an alternatives analysis which would compare the proposed vertical cutoff wall option to a flattened slope option with appropriate seepage mitigation. The intent of the requested analysis is to

develop a more detailed understanding of the cost associated with each approach as well as the cost directly associated with providing public access.
To that end, PARE has developed slope stability and seepage models to analyze the two alternatives and develop a refined cost comparison. The scope of work included:

a. Developing upstream slope stability models based on in-situ soil materials that provide an embankment section that complies with current Commonwealth of Massachusetts Dam Safety Regulations for slope stability.
b. Developing seepage models based on in-situ soil materials and conceptual embankment geometry to calculate seepage factors of safety and compare against current Commonwealth of Massachusetts Dam Safety Regulations for seepage.
c. Developing opinions of probable cost for construction of the upstream slope and seepage improvements developed as part of the modeling (vertical cutoff wall versus slope with geomembrane).
d. Reviewing the environmental resource area impacts resulting from the slope and seepage improvement options (vertical cutoff wall versus slope with geomembrane) and developing opinions upon the permittability of each option. The review includes a discussion of additional permits that may be required as well as the impacts of those permits upon project schedule.
e. Developing an opinion of probable construction cost for the addition of public access and parking.

SEEPAGE & SLOPE STABILITY EVALUATIONS

PARE developed upstream slope stability and seepage models based on in-situ soil properties determined as part of previous evaluations, as presented in Table 1.

Table 1: Modeled Soil Properties

Layer	Classification	$(N_1)_{60}$ (bpf)	D_r[1] (%)	Angle of Internal Friction (º)	Saturated Unit Weight (lb/ft^3)[2]	K_{sat}[3] (ft/sec)	e[4]	w_{sat} (%)
1	Embankment Fill/SM	19	43.5	31	121.7	3.94-4	0.75	30
2	Loose Embankment Fill/SM	5	5	27	118.4	5.00e-4	0.89	30
3	Till/SW	63	95	40	139	3.28e-7	0.36	10
4	Sand (SM-SP)	27	55	33	128.4	3.28e-5	0.58	20
5	Weathered Rock	65	95	41	145.3	3.28e-8	0.27	10
6	Riprap	NA	NA	45	150	1	NA	NA

For the alternative of regrading the upstream slope, PARE completed an iterative slope analysis to find the critical slope meeting the factors of safety required by current Commonwealth of Massachusetts Dam Safety Regulations.

Seepage Analysis: PARE utilized GeoStudio Seep/W V.7.20 software to develop a steady-state seepage analysis using in-situ soil properties. Model parameters included the level of impoundment at an elevation of 630 feet (spillway crest) which represents the normal pool elevation. The tailwater was assumed to be free discharging at the toe of the dam at an elevation of 615 feet. Anisotropic embankment fill conditions were assumed with a conductivity

[1] Das, Principles of Geotechnical Engineering, 5th Edition, Table 2.4
[2] gsat = gdry + (e/(1+e))gw
[3] Holtz, Kovacs, and Sheahan, An Introduction to Geotechnical Engineering, 2nd Edition, Figure 7.7
[4] Department of the Navy, "NAVFAC DM-7.1, 1982 Ch. 3, Figure 7

ratio of 0.2. Soil conditions were modeled as saturated. Maximum pool conditions were not considered as part of this analysis. However, it was presumed that impacts of maximum pool loading would not impact the conclusions of this alternatives analysis.

Stability Analysis: PARE performed a stability analysis of various embankment slopes using GeoStudio Slope/W V.7.20 software. The porewater pressures and the phreatic surface generated from the seepage analysis were incorporated into the stability analysis. The entry and exit method was used to generate potential slip surfaces along with the Morgenstern-Price method used to compute the factor of safety for each potential slip surface. Model parameters included a minimum slip surface depth of two feet to minimize effects on the factor of safety from shallow surficial failures.

Loading conditions performed during this analysis followed current Commonwealth of Massachusetts Dam Safety Regulations for normal pool loadings. A surcharge load of 250 psf was applied to the middle 24.5 feet of the roadway area to simulate traffic loading during normal pool conditions. Traffic surcharges were not applied to sudden drawdown and earthquake loading cases. Maximum pool conditions were not evaluated as the hydrostatic forces associated with maximum pool conditions tend to stabilize the slope beyond conditions experienced during normal pool loading.

A seismic evaluation of the upstream slope was completed by applying a previously determined horizontal ground acceleration of 0.08g under steady state seepage conditions. A vertical coefficient was not applied.

The case of sudden drawdown was analyzed assuming near instantaneous and full drainage of the impoundment from the specified pool level, with no drainage from the embankment soils and full drainage of the riprap layer. It is acknowledged that this is a conservative representation as the embankment materials would partially drain during a sudden drawdown event. The actual rate of drawdown would be limited by the discharge capacity of the outlet structures. However, a staged drawdown analysis accounting for the limited drawdown rate was beyond the scope of this evaluation.

Model Results: The seepage model for all of the earthen slopes evaluated yielded factors of safety near 1.2 (See Table 2) as compared to an industry standard factor of safety of 5. The primary limiting factor to the seepage analysis is the existing dam embankment soil conditions. While regrading of the upstream slope provides additional soil layers to dissipate hydrostatic pressure through the embankment, the magnitude of this additional fill is not adequate to have a significant impact upon the calculated factor of safety at the downstream toe; as such, the various earthen slopes evaluated (from 2H:1V through 4H:1V) were all calculated to have similar low factors of safety of (1.2).

The modeling indicates that additional seepage remediation other than earth fill is required to control seepage through the dam and to achieve acceptable exit gradients at the downstream toe of the embankment. Options include an impermeable geomembrane under the earthen embankment slope or a vertical cutoff wall. Based upon conceptual evaluation, each of these options can be designed to provide the recommended seepage factor of safety of 5.

Table 2: Seepage and Stability Analysis Results

Upstream Slope Treatment Options	Calculated Factor of Safety (FOS)			
	Seepage Analysis	**Stability Analysis**		
	Seepage (FOS Recommended = 5)	Steady-State Seepage (FOS Required = 1.5)	Earthquake Loading (FOS Required > 1.0)	Sudden Drawdown (FOS Required = 1.2)
Earthen Slope				
2.00H:1V	1.2	1.4	1.1	n/d
2.25H:1V	1.2	1.5	1.1	1.0
2.50H:1V	1.2	1.5	1.1	1.1
2.75H:1V	1.2	1.7	1.2	1.1
3.00H:1V	1.2	1.8	1.3	0.9
4.00H:1V	1.2	2.3	1.6	1.2
2.25H:1V w membrane*	5.9	1.7	1.4	1.5
Vertical Cutoff Wall				
Vertical Cutoff Wall**	5.0	2.59	1.929	n/d

*Membrane extends from top of upstream slope to approximately 72-feet upstream of the dam toe
**The factor of safety was determined by a global failure of the slope around the wall; Wall embedment based upon allowable stress and seepage design.

The stability analyses for upstream slope sections flatter than 2.25H:1V yielded factors of safety above the required minimum values for steady state seepage and earthquake loading (See Table 2). Factors of safety for sudden drawdown from normal pool were only met for slopes flatter than 3H:1V; however, the simplified models developed as part of this evaluation represent a conservation method for evaluating sudden drawdown cases. As such, while the results of the sudden drawdown case were considered as part of this evaluation, they were not considered critical factors.

As part of this analysis, impacts of an upstream membrane upon slope stability were also considered. The presence of the membrane provides a barrier to seepage water entering the embankment, significantly lowering the phreatic surface within the embankment. The lowered phreatic surface greatly reduces the pore water pressure within the embankment, thereby increasing the slope stability factors of safety. Based upon the analysis with the membrane in place, the existing slope angle (2.25H:1V) provides a stable cross section under the loading cases considered.

The impact of the proposed toe drain rehabilitation was also considered as part of this evaluation. The toe drain provides a means by which to lower the phreatic surface within the embankment by providing a drainage system within the embankment. However, the effectiveness of the drain is partially limited by the configuration of the dam in the area of the outlet. Based upon conceptual evaluations, the rehabilitation of the toe drain will increase the calculated factor of safety against seepage from 1.2 (as determined for existing conditions as part of the Schematic Design Report) to near 2.0. However, the toe drain does not provide adequate mitigation to increase this factor to the recommended value of 5.

Preliminary design of the upstream cutoff wall was completed to determine required embedment depths. The cutoff wall was determined to require a tip elevation near El. 621 to meet stability requirements. However, this tip elevation was refined through iterative seepage analyses to find a tip elevation which satisfies both stability and seepage requirements. Based upon this analysis, the tip elevation for the sheet pile wall is approximated to be near El. 608 at the maximum dam embankment section.

PERMITTING IMPLICATIONS

Given the presence and locations of the various wetland resource areas in the project vicinity, a number of environmental permits will be required for the work to address the upstream slope stability and embankment seepage, regardless of the ultimate design approach. Based upon schematic designs, an upstream wall for slope stability would require fewer impacts in the pond than would a geomembrane installation. Improvements to the upstream side of dam, particularly impacts below the normal pool level, could be minimized through the implementation of the upstream wall approach. However, the impermeable geomembrane solution would require disturbance along the entire upstream slope and at least an additional 75 feet of the pond bottom past the toe of the slope, significantly expanding the impact area. This expansion would result in a total project disturbance of approximately 1 acre of wetlands. Projects that affect 1 acre or more of wetlands require an Individual Permit (IP) from the US Army Corps of Engineers, which can be time consuming and expensive with no certainty of approval. The IP process includes a full public interest review, analysis of alternatives (including the wall option), and a Public Notice/Comment period.

CONCLUSIONS AND DISCUSSION

Based upon the evaluations completed as part of this study, both the Vertical Upstream Wall (Option 1) and an Earthen Slope with Geomembrane (Option 2) present technically feasible approaches to stabilize the upstream side of the dam and remediate seepage concerns to provide a repaired dam meeting dam safety regulations and industry design standards. The two options conceptually include the following:

> **Option 1: Vertical Upstream Wall –** Remove existing riprap from the top of the slope above the wall alignment. Install a driven sheet pile wall along the upstream side of the dam to a depth adequate to provide seepage resistance. Based upon conceptual design, this will require a tip elevation near 608 at the maximum embankment section.
>
> To complete the work associated with Option 1, a drawdown of the impoundment is anticipated to be required to allow for the removal of riprap along the top of the slope and the installation of the wall. The drawdown associated with the wall is anticipated to be shallow (i.e., 2 to 4 feet) and last on the order of 2 to 3 weeks.
>
> **Option 2: Earthen Slope with Geomembrane –** Remove and stockpile existing stone riprap from the entire upstream slope. Excavate, grade, and install geomembrane or other impermeable layer (PVC, HDPE) along the entire slope and to a distance of roughly 75 feet upstream of the upstream toe of the embankment. Provide suitable bedding and membrane protection layers along the upstream slope. Furnish and install geotextile and bedding stone. Reinstall stockpiled stone riprap.
>
> To complete the work associated with Option 2, a drawdown of the impoundment will be required to allow for the removal of riprap along the entire slope, excavate to grades necessary for geomembrane installation, backfill of the geomembrane, and reconstruction of the upstream slope protection. The drawdown is anticipated to be more than 10-feet and last a duration of more than 1 month, if not longer. In conjunction with the draw down, a temporary cofferdam will also be required to prevent the need to drain the impoundment an additional 8-feet, which likely would not be permittable.

As documented within this letter, the installation of a vertical cutoff wall (Option 1) and regrading of the upstream slope with the installation of an impermeable geomembrane for seepage mitigation (Option 2) are both technically feasible approaches. However, the wall option has the added benefit of significantly reduced wetland impacts and would therefore likely be viewed by the regulatory agencies as a preferred approach. Should the impermeable geomembrane approach be selected, it is likely that project permitting would be more extensive, expensive, and time consuming with reduced expectations for success.

Based upon the options considered, PARE recommends continuing to pursue the design, permitting, and construction of Option 1: Vertical Upstream Wall. This recommendation is based upon a number of considerations, including:

- Durability (Design Life): A driven upstream wall, particularly if the schematic design option of an in-filled composite sheeting is selected, will provide a solution with a minimum design life of 50 years. While the membrane would also provide an acceptable design life, the membrane is more susceptible to failure due to punctures, tears, or other damage resulting from the evolutionary nature of dams.
- Permitting: The vertical upstream wall provides an alternative with significantly lower impacts to land under Ramshorn Pond. This reduced impact as compared to Option 2 should prove beneficial in the permitting process.
- Scheduling / Drawdowns: The extent and duration of water control, diversion, and drawdown will be significant less for Option 1 as compared to Option 2. While a project phasing approach has not been developed, it is anticipated that Option 1 will require minimal drawdown of the impoundment. Option 2 would require extensive and prolonged drawdown of the impoundment along with additional requirements for cofferdam and diversion to enable the installation of the membrane.

OPINIONS OF PROBABLE COST

For the purposes of this evaluation of the opinion of probable cost for Options 1 and Option 2, PARE has assumed that the scope of the work required to implement improvements along the upstream side of the dam is independent from the costs associated with completing the remainder of the proposed scope of repair work. As such, the following opinions of cost have been developed assuming that the upstream slope work is a discrete scope of work that is not significantly impacted by the remainder of the scope items. The conceptual opinions of probable cost have been developed for the two options and do not include general construction project requirements. The costs shown herein are based on a limited investigation and are provided for general information only. This should not be considered an engineer's estimate, as actual construction costs may be somewhat less or considerably more than indicated. For more detailed information utilized for the development of the opinions of probable cost, refer to attached Opinion of Probable Cost worksheet.

	Option 1: Vertical Upstream Wall	**Option 2: Slope with Geomembrane**
Base Scope of Work (Crest, Downstream Slope, Spillway, Low Level Outlet, General Requirements)	$ 640,000	$ 640,000
Upstream Slope Repairs	$ 710,000	$ 670,000
Public Access	$ 70,000	$ 116,000
Subtotal	$ 1,420,000	$ 1,426,000
Contingencies (25%), Bonds (3%)	$ 400,000	$ 400,000
Total Construction Opinion of Cost	$ 1,820,000	$ 1,826,000
Engineering & Design	$ 65,000	$ 65,000
Permitting	$ 35,000	$ 45,000 (est)
Bid & Construction Phase Services (budget)	$ 60,000	$ 60,000
Total Project Opinion of Cost	$ 1,980,000	$ 1,996,000

We trust that this letter report and attachments meets your needs at the current time. Should you have any questions please feel free to contact me at 508.543.1755 or via email at aorsi@parecorp.com.

Sincerely,
Pare Corporation

Allen R. Orsi, P.E.
Managing Engineer

Jeffrey Costa
Engineer

Attachments:
- Figure 1: Upstream Regrading Sketch
- Figure 2: Upstream Regrading Section
- Opinions of Probable Cost

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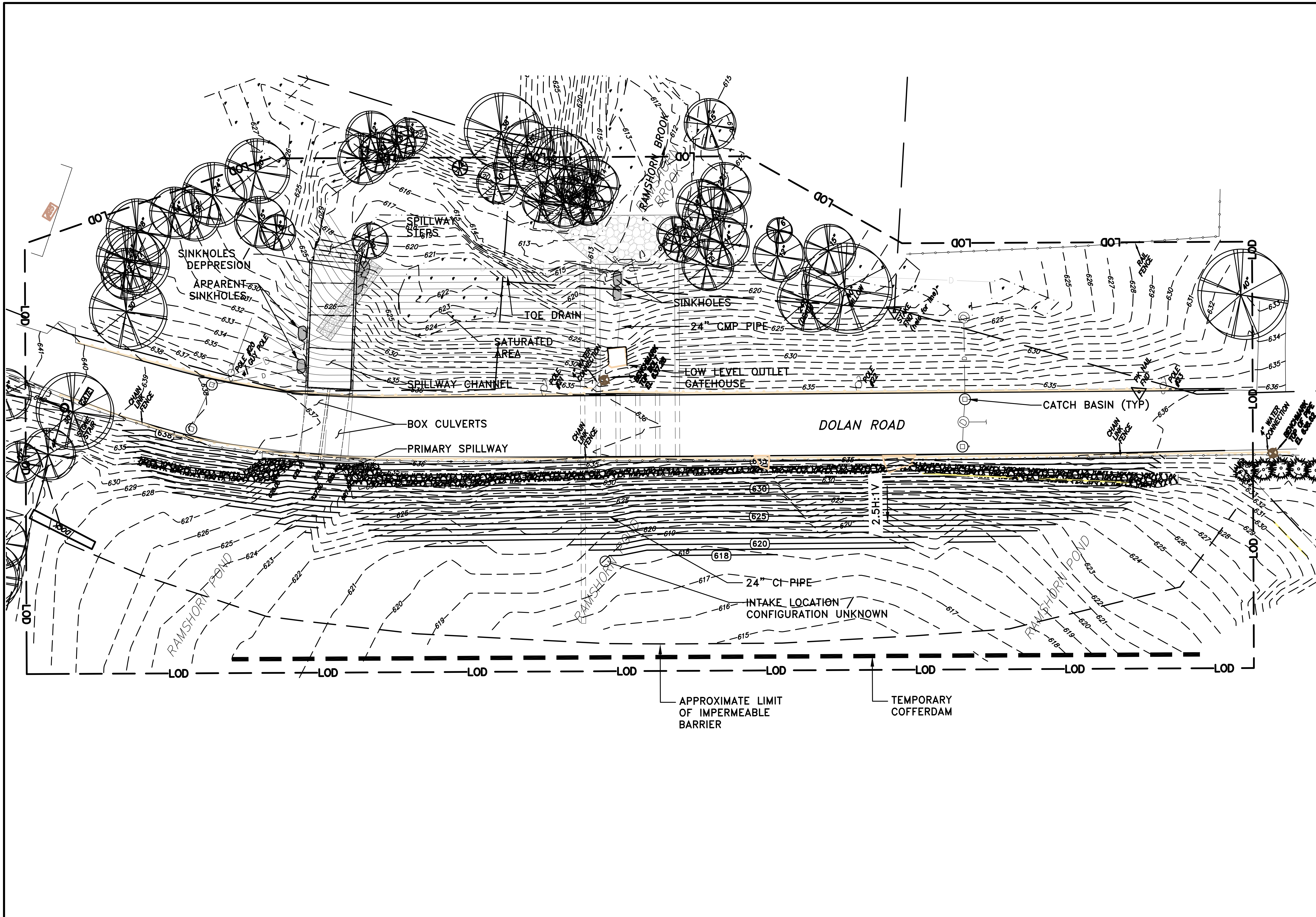

PARE

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508-543-1755

SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

RAMSHORN POND DAM
MA00145 / 3-14-186-21
MILLBURY, MASSACHUSETTS
TOWN OF MILLBURY PUBLIC WORKS

REVISIONS:

PROJECT NO.:	13072.00
DATE:	FEBRUARY 2014
SCALE:	1" = 40'
DESIGNED BY:	JMC
CHECKED BY:	ARO
DRAWN BY:	LMC
APPROVED BY:	JMB

UPSTREAM
REGRADING SKETCH

FIGURE NO.: 1

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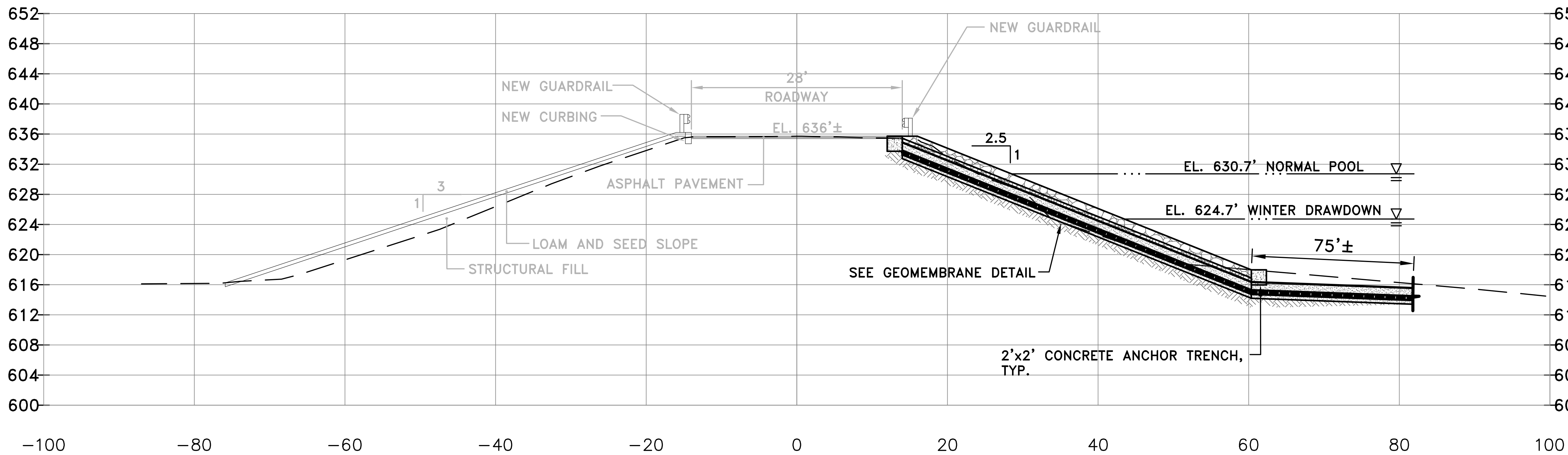
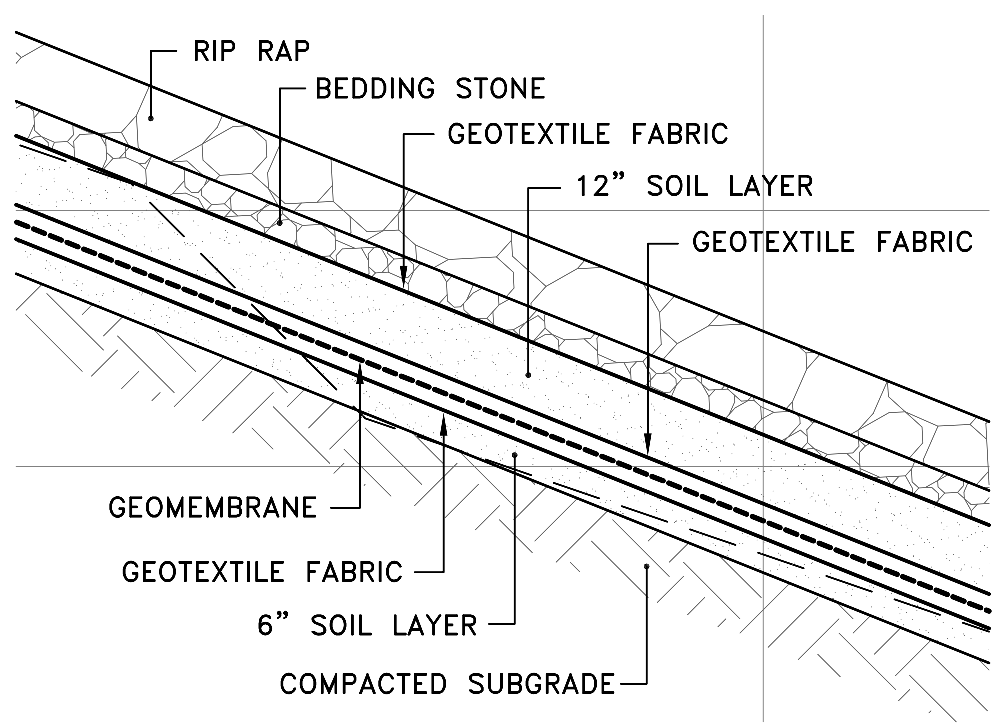


UPSTREAM SLOPE CONCEPTUAL SECTION

SCALE: 1"=15'



CONCEPTUAL GEOMEMBRANE DETAIL

NOT TO SCALE

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SCALE ADJUSTMENT GUIDE

0" 1"

BAR IS ONE INCH ON ORIGINAL DRAWING.

RAMSHORN POND DAM
MA00145 / 3-14-186-21
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DESIGNED BY:	JMC
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APPROVED BY:	JMB

UPSTREAM
REGRADING SECTION

FIGURE NO.: 2

Z:\JOBS\13 Jobs\13072.00 Ramshorn Pond Dam Design & Permitting\dwg\Upstream Slope Evaluation Figures\FIG 2 SLOPE SECTION.dwg

PARE CORPORATION

PROJECT : Ramshorn Pond Dam Repairs
SUBJECT: Opinion of Probable Cost
COMPUTATIONS BY: JMC
CHECKED BY: ARO

PROJECT NUMBER: 13072.00
DATE: February 2014
DATE: February 2014

Upstream Slope with Geomembrane

Item	Quantity	Unit		Unit Price		Total	Source/Notes
Regrade Upstream Slope							
Remove Existing Riprap	1500	TON	$	50.00	$	75,000.00	RSMEANS Heavy Construction 02 41 13.70 400
Control of water (cofferdam)	7500	SF	$	24.00	$	180,000.00	RSMEANS Heavy Construction 31 41 16.10 1300
Place & Compact Fill to 2.5H:1V	310	CY	$	15.00	$	4,650.00	Recent Project Costs
Imported Fill	310	CY	$	45.00	$	13,950.00	Recent Project Costs
Regrade Pond Bottom	2000	SY	$	2.20	$	4,400.00	RSMEANS Heavy Construction 31 22 16, finish grading
				Subtotal		**$278,000.00**	
Geomembrane							
Geotextile	11000	SY	$	8.00	$	88,000.00	RSMEANS Heavy Construction 31 32 19.16 1510/recent costs
Stone Cushion	1000	TON	$	45.00	$	45,000.00	Recent Project Costs/Engineers Judgment
Core Trench Excavation	150	CY	$	8.00	$	1,200.00	RSMEANS Heavy Construction 31 23 16.13
Core Trench Backfill with Concrete	150	CY	$	400.00	$	60,000.00	Engineers Judgment
Membrane	51000	SF	$	0.60	$	30,600.00	410*117*5% overlap
Membrane mobilization	1	LS	$	6,000.00	$	6,000.00	
Penetrations	1	EA	$	200.00	$	200.00	Low Level Outlet
Attachment to Concrete	50	LF	$	65.00	$	3,250.00	
Membrane Labor	10	DAY	$	2,500.00	$	25,000.00	RSMEANS Heavy Construction/Engineers Judgment
Prevailing Wage Markup	35000	SF	$	0.20	$	7,000.00	
				Subtotal		**$266,250.00**	
Riprap Protection							
Riprap	1700	Ton	$	-	$	-	Assume reuse
Anchor Stone	350	Ton	$	55.00	$	19,250.00	Recent Project Costs
Upstream Bedding Stone	450	Ton	$	45.00	$	20,250.00	Recent Project Costs
				Subtotal		**$39,500.00**	
Widen Crest near LLO/Spillway							
Structural Fill and Backfill	110	CY		$90.00		$9,900.00	Recent Project Cost
				Subtotal		**$9,900.00**	
Parking Spot							
Signage	1	EA		$1,000.00		$1,000.00	Engineers Judgment
Pavement for 1 Parking Spot	5	SY		$22.00		$110.00	RSMEANS Heavy Construction 32 12 16.13.0200
Line striping	1	STALL		$15.00		$15.00	RSMEANS Heavy Construction 32 17 23
				Subtotal		**$1,125.00**	

PARE CORPORATION

PROJECT : Ramshorn Pond Dam Repairs
SUBJECT: Opinion of Probable Cost
COMPUTATIONS BY: JMC
CHECKED BY: ARO

PROJECT NUMBER: 13072.00
DATE: February 2014
DATE: February 2014

Upstream Slope with Geomembrane

Item	Quantity	Unit	Unit Price	Total	Source/Notes
Wall Near Spillway/LLO					
Install PVC Sheetpile Wall with Concrete and Steel	50	LF	$1,300.00	$65,000.00	Spoke to Shawn from Truline 12395916234, 36' tall (12 exposed 24 below)--no labor
Labor and Crane	2	DAY	$4,000.00	$8,000.00	3 Laborers, Crane Operator, Oiler, and Crane
			Subtotal	**$73,000.00**	
			Total Without Access	**$670,000.00**	
Public Access					
Widen Crest for Parking					
Structural Fill and Backfill	160	CY	$90.00	$14,400.00	Recent Project Cost
Pavement for 5 Parking Spots	26	SY	$22.00	$572.00	RSMEANS Heavy Construction 32 12 16.13.0200
Line striping	5	STALL	$15.00	$75.00	RSMEANS Heavy Construction 32 17 23
Handicap Painting	1	EA	$45.00	$45.00	RSMEANS Heavy Construction 32 17 23
Signage	2	EA	$1,000.00	$2,000.00	Engineers Judgment
Concrete Ramp	13	CY	$750.00	$9,750.00	Recent Project Costs
			Subtotal	**$26,842.00**	
Handicap Accessible Ramp					
Structural Fill and Backfill	700	CY	$90.00	$63,000.00	Recent Project Cost
Railings	140	LF	$120.00	$16,800.00	RSMEANS Heavy Construction 05 52 13.50
			Subtotal	**$79,800.00**	
Canoe Launch					
Fill for Canoe Launch	100	CY	$90.00	$9,000.00	RSMEANS Heavy Construction 31 23 23.13/Recent Project Cost
			Subtotal	**$9,000.00**	
			Total	**$115,642.00**	
			Total With Access	**$790,000.00**	

PROJECT : Ramshorn Pond Dam Repairs

SUBJECT: Opinion of Probable Cost

COMPUTATIONS BY: JMC

CHECKED BY: ARO

PROJECT NUMBER: 13072.00

DATE: February 2014

DATE: February 2014

Upstream Sheetpile Wall

Item	Quantity	Unit	Unit Price	Total	Source/Notes
Cost of Wall					
Remove Existing Riprap	1500	TON	$50.00	$75,000.00	RSMEANS Heavy Construction 02 41 13.70 400
Install PVC Sheetpile Wall with Concrete and Steel	410	LF	$1,300.00	$533,000.00	Spoke to Shawn from Truline 12395916234, 36' tall (12 exposed
Labor and Crane	12	DAY	$4,000.00	$48,000.00	3 Laborers, Crane Operator, Oiler, and Crane
			Subtotal	**$656,000.00**	
Cost of Fill Behind Wall					
Backfill Behind Sheetpile Wall	600	CY	$45.00	$27,000.00	RSMEANS Heavy Construction 31 23 23.13
Structural Fill	600	CY	$45.00	$27,000.00	Recent Project Costs
Loam and Seed	560	SY	$6.00	$3,360.00	RSMEANS Heavy Construction 33 01 30.16
			Subtotal	**$57,360.00**	
Parking Spot					
Signage	1	EA	$1,000.00	$1,000.00	Engineers Judgment
Pavement for 1 Parking Spot	5	SY	$22.00	$110.00	RSMEANS Heavy Construction 32 12 16.13.0200
Line striping	1	STALL	$15.00	$15.00	RSMEANS Heavy Construction 32 17 23
			Subtotal	**$1,125.00**	
Total				**$710,000.00**	
Public Access					
Concrete Gravity Wall	40	CY	$600.00	$24,000.00	Engineers Judgment
Install PVC Sheetpile Wall with Concrete and Steel	8	LF	$1,300.00	$10,400.00	Spoke to Shawn from Truline 12395916234, 36' tall (12 exposed 24 below)--no labor
Labor and Crane	1	DAY	$4,000.00	$4,000.00	3 Laborers, Crane Operator, Oiler, and Crane
Concrete Ramp	13	CY	$750.00	$9,750.00	Recent Project Costs
Railings	140	LF	$120.00	$16,800.00	RSMEANs Heavy Construction 05 52 13.50
Pavement for 5 Parking Spots	26	SY	$22.00	$572.00	RSMEANS Heavy Construction 32 12 16.13.0200
Line striping	5	STALL	$15.00	$75.00	RSMEANS Heavy Construction 32 17 23
Handicap Painting	1	EA	$45.00	$45.00	RSMEANS Heavy Construction 32 17 23
Signage	2	EA	$1,000.00	$2,000.00	Engineers Judgment
Fill for Canoe Launch	100	CY	$90.00	$9,000.00	RSMEANS Heavy Construction 31 23 23.13/Recent Project Cost
Fill From Ramp	-70	CY	$90.00	-$6,300.00	RSMEANS Heavy Construction 31 23 23.13/Recent Project Cost
			Subtotal	**$70,342.00**	
Total Including Public Access				**$780,000.00**	