Vermont Better Roads Grant Program Application

Please complete one application per category and/or project you are applying for. You may make copies of the application for multiple applications per category and/or multiple categories.

Please check the Category you are applying for:

- [ ] B. Correction of a Road Related Erosion Problem and/or Stormwater Mitigation Retrofit for both gravel and paved roads
- [ ] C. Correction of a Stream Bank or Slope Related Problem
- [x] D. Structure/culvert upgrades

Town/Organization: Bethel, VT

Project Name: Reconstruct Wingwall Prevent Scour Erosion

Road Name: Lilliesville Brook Road (Class 3) TH #: 31 Structure # (if applicable): 33

Road Type: Unpaved Please Select

Please Select

Watershed: White River

Please provide a thorough description of the problem (ex. Roadway has steep slope with no ditch which is causing roadway erosion):

Upstream wingwall deflecting (out of plane displacement) from deck/abuttment, erosion scouring/undermining at base of upstream abuttment, concrete cracking, spalling

Description of Project and how you plan to complete the work (ex. Stone line 500' of ditch by reshaping ditch and stone lining, working from the top of the project down to the bottom):

See attached DuBois & King report. Town will use recommended Option 2-Cantilever Wingwall Replacement Estimate.

Expected Effects (+ & -) on water quality (ex. Erosion will be eliminated by placing the stone ditch):

Concrete apron around abuttment will eliminate further erosion and scouring. Wingwall reconstruction will prevent collapse of structure and sloughing of bank and roadway into the stream

Distance from end of project to nearest water (stream, lake, or stormwater system that outlets directly to water). 0-50'

Progress to Date:
Engineering analysis, assessment and recommended solutions ($5,500.00)

Is there an emergency reason this project must be completed quickly? If yes, please explain:
Project is not an emergency at this time. However continued displacement of the wingwall could lead to failure.

Has this project been identified through a municipal road inventory, capital budget plan, tactical basin plan, culvert inventory, or other management plan? If yes, please list which.

(●) Yes: State Bridge Inspection ( ) No

Please list any professionals you may have contacted for assistance with this project (ANR River Management Engineer, Army Corps of Engineers, VTrans District Technical staff, Basin Planner etc.):
ANR River Management through DubBois & King.

Is the project located in the town "Right of Way?" Yes, No, Both (if "Both" please explain further).
Project will be within the existing 3 rod right-of-way.

Will the town road crew complete this work? Yes, No, Some (if "some" please explain further).
Project will be bid to contractors

Describe how the grant funds will be spent and/or attach a project budget:
Grant funds will be used to supplement State TH Structures grant.

How do you plan to meet the required 20% match on this grant?:
Match will be funded from General Fund

Requested Grant Amount ($20,000 max Category B, $40,000 max Categories C & D): $ 25,000.00

Estimated Total Project Cost (including 20% local match): $ 225,000.00

Estimated Completion Date: 11/01/2017

REQUIRED ATTACHMENTS:

- [x] Itemized Cost Estimate (labor, equipment, materials)
  (For assistance, call Better Backroads at 802-828-4585)
- [x] Project Location Map
  (Please show location of affected water; 1:12,000 USGS map, if possible)
- [x] Sketch of proposed erosion control measures, including:
  - [ ] Distances (ft.)
  - [ ] Estimate of waste & borrow quantities
  - [ ] Approx. location of town/other right-of-way and/or property lines
- [x] Photo(s) of the project area.
- [ ] Agreement for Entry and/or Deed of Easement (if project is outside Town ROW).
- [x] If project involves stream or river/road conflict, include documentation of consultation with a River Management Engineer.
- [ ] Other appropriate supporting documents.

By signing this application I certify that all the information provided is accurate to the best of my knowledge. We will comply with all the requirements of the grant including making our books available for audit if required.

SIGNATURE OF APPLICANT: (Must be Town Administrator/Manager or Select Board Chair)

Name: [signature] Title: Town Manager

Cost Estimate Worksheet

Town and Road Name: BR # 33, TH # 31 **Project Name:** Wingwall Replacement

Labor	Rate	# Hours	Total (Rate x Hours)
		Labor Total	

Equipment	Rate	# Hours	Total (Rate x Hours)
		Equipment Total	

Materials	Rate	Amount	Total (Rate x Amount)
		Materials Total	

Miscellaneous	Rate	Amount	Total (Rate x Hours)
See Cost Estimate in D & K study Option 2			225000
Cantilever Wingwall Replacement			
		Miscellaneous Total	225000
		Grand Total	2255000
		Match	5000

623276P1
March 30, 2016

Mr. Keith Arlund, Town Manager
Town of Bethel
134 South Main Street
Bethel, VT 05032

SUBJECT: Lilliesville Brook Road over Lilliesville Brook (Bridge #33)
Draft Engineering Assessment Study

Dear Mr. Arlund:

DuBois & King, Inc. (D&K) is providing this Draft Engineering Assessment Study that describes our investigations and subsequent evaluations of potential substructure repair alternatives for the subject bridge. The purpose of this report is to address the deficiencies raised by VTrans in their letter to you, dated October 23, 2015, so that the Town can decide on a preferred course of action.

Introduction

During a recent biennial inspection, the following problem was noted by the State of Vermont's Bridge Inspection Unit:

"Abutment #2 is partially undermined along its upstream half. A void roughly 10' long, extends in under the footing up to 4' to 5' in areas. The void continues under the upstream wingwall another 8'. The upstream wingwall is also cracked off and tipped out as much as 10" at its top. The undermining and wing damage needs attention."

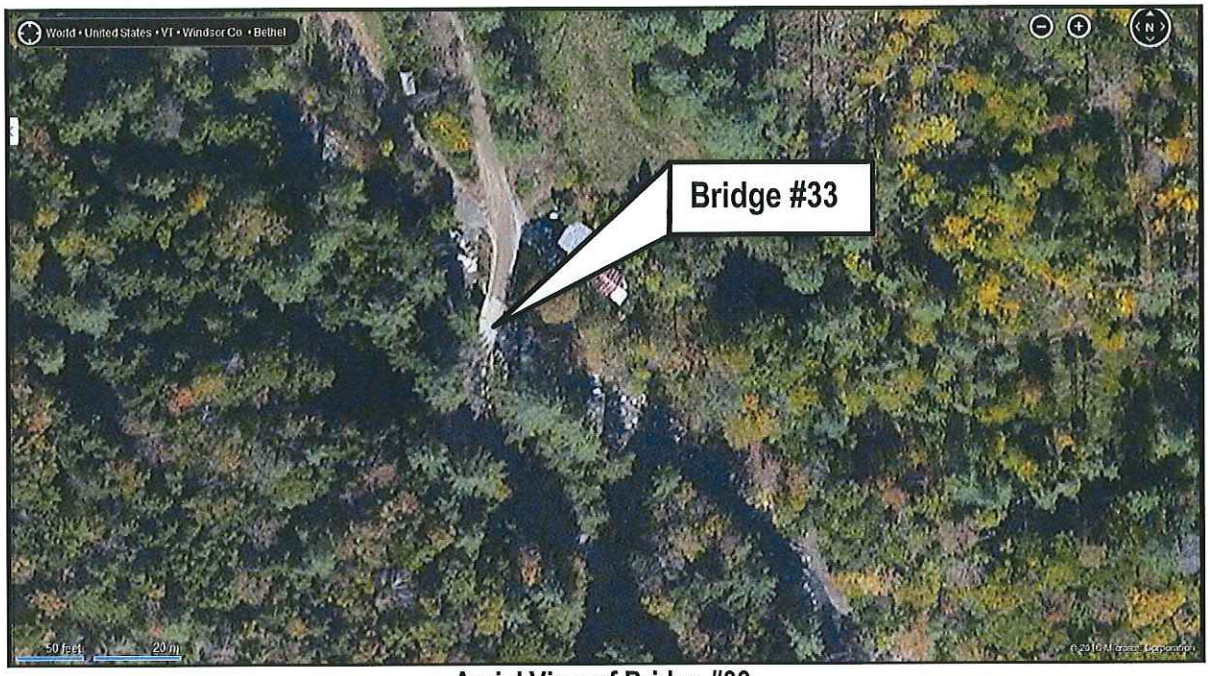
At the request of the Town, D&K engineers subsequently conducted a field review to observe the deficiencies first-hand. In order to get a better understanding of the site, D&K engineers have reviewed the previous bridge inspection reports prepared by VTrans, a Level II Scour Analysis for Bridge 33 (1996) performed by the USGS, and a Stream Geomorphic Assessment and River Corridor Plan Report (2014) prepared by the White River Partnership (WRP) and the Vermont Agency of Natural Resources (VTANR).

This assessment report provides a brief summary of the conditions as observed in the field and the findings noted in the previously prepared reports mentioned above. A range of repair options have been evaluated for this study, along with their associated probable costs and anticipated construction schedules. To aid in the determination of a recommended course of action, D&K have also discussed allowable options and permitting requirements with the VTANR River Management Engineer.

Site Visit and Existing Conditions

An initial site inspection was conducted on November 20, 2015 with a follow-up inspection performed on January 14, 2016. The inspections consisted of D&K engineers visiting the site and making visual observations of the existing bridge and wingwalls, roadway approaches, streambed conditions, site constraints, and confirming the findings of the most recent VTrans Bridge Inspection report. The site inspection concluded with a photo documentation of the entire site and surroundings.

Lilliesville Brook is a tributary of the White River and generally flows in the east-west direction at the site. For the purposes of this report, upstream is labeled West, downstream is labeled East, and Lilliesville Brook Road is considered to travel in the north-south direction with the abutments numbered from south to north. The deficiencies noted by VTrans and confirmed in the field are located on the upstream side of Abutment #2 (northwest corner of the bridge). The bridge is located approximately 0.6 miles north of the intersection of River Road and Lilliesville Brook Road in Bethel Vermont.



Aerial View of Bridge #33

Per the Structure Inventory and Appraisal (SI&A) sheet for the bridge, the bridge was originally built in 1930 and reconstructed in 2007. The original concrete abutments and wingwalls were retained during the 2007 superstructure replacement project. The new superstructure is comprised of six (6) 3'-0" wide precast prestressed concrete voided slabs spanning approximately 40 feet between abutments. The slabs are supported on cast-in-place concrete bridge seats that have been doweled into the tops of the original abutments. The latest bridge inspection report has coded the Deck and Superstructure as being in Very Good condition. The Substructure and Channel have been coded as being in Fair and Poor condition, respectively.

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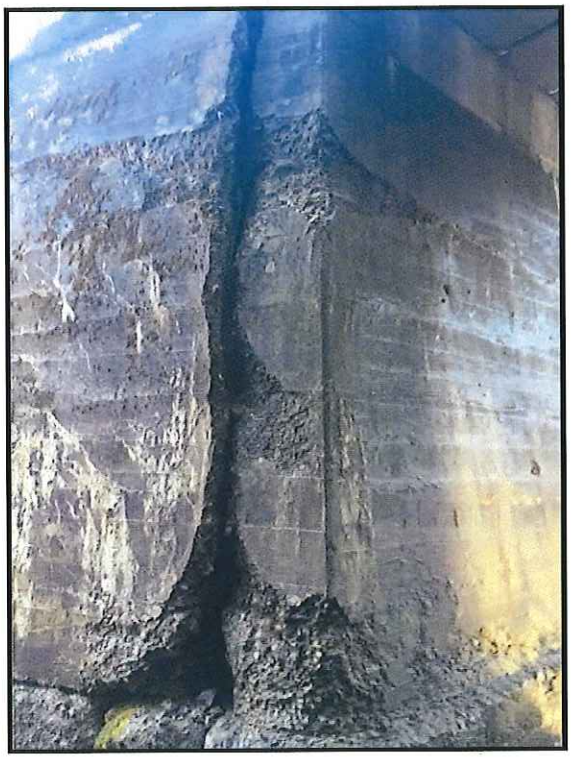
General View of Abutment #2 and Northwest Wingwall
Note: Superstructure replaced in 2007 and original substructure was retained.

No bridge plans, either for the original 1930 construction or the 2007 superstructure replacement project, were made available to D&K for this study. The make-up of the existing wingwalls, abutments, and their foundations is unknown. However, based on the site, original construction date, and height of the substructure, it is likely that the wingwalls and abutments are gravity-type substructures (mass concrete with battered stems) founded on spread footings without piles.

As previously mentioned, there is partial undermining occurring below the footing at the northwest corner of the bridge. The dimensions noted during the most recent VTrans inspection were confirmed at the time of the field visit; the area of the undermining extends for approximately 10 feet along the abutment and 8 feet along the northwest wingwall with penetrations of up to 5 feet. No exposed piles were observed below the bottom of footing at the undermined area.

Above the undermined area, severe cracking, spalling, and out-of-plane displacement of the northwest wingwall stem was observed at the interface with the abutment. Previous inspection reports prepared by VTrans have monitored the amount of separation present at the top of the wingwall. The rotation/separation of the wingwall stem was noted to be 5½" in May 2007; in October 2015 this displacement was noted to have increased to approximately 10".

Partial Undermining below the Abutment / Wingwall Footing



Cracking, Spalling, and Displacement of Northwest Wingwall at Interface with Abutment #2

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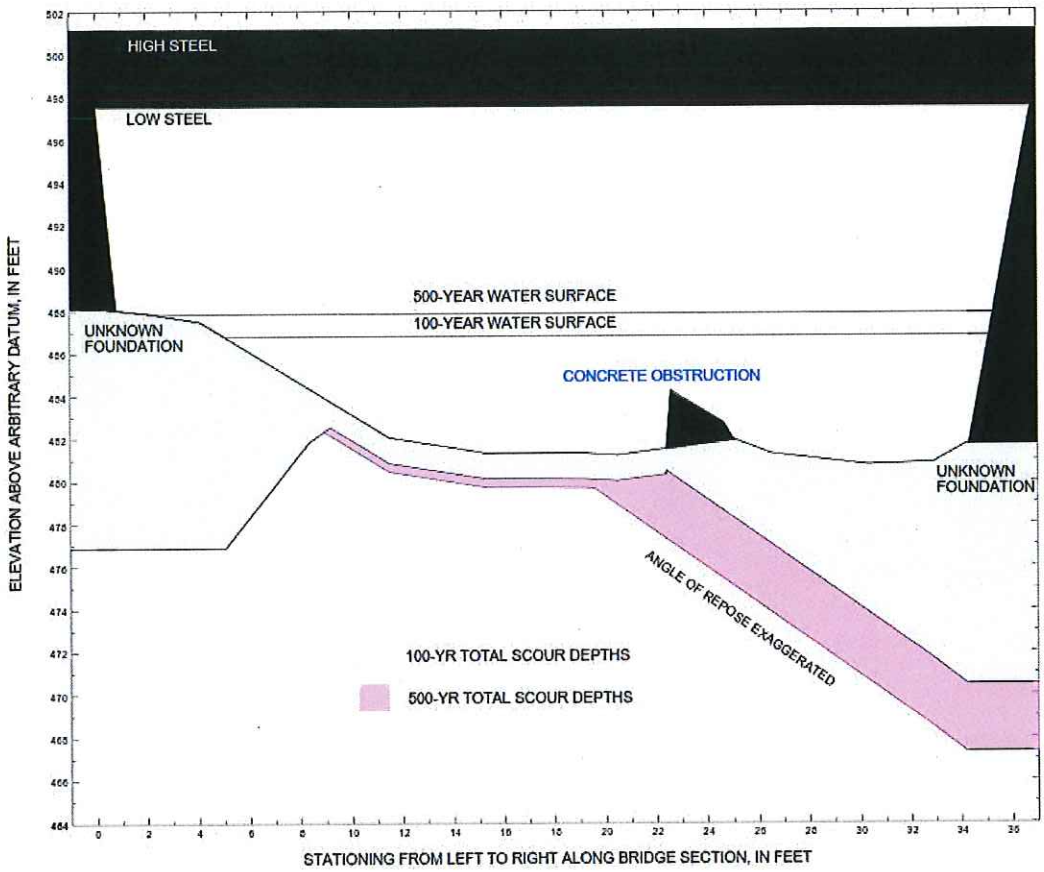
Potential Causes

In order to develop appropriate repair options at the site, D&K have made an attempt at identifying potential causes for the observed deficiencies.

Footing Undermining

A Level II Scour Analysis was performed for the subject bridge in 1996 by the U.S. Geological Survey. At that time no undermining was present underneath the footings. The analysis report calculated the potential scour depths and water velocities at the bridge due to the 100-year and 500-year storm events.



Scour Elevations for the 100-year and 500-year Discharges at the Bridge
(Figure from the 1996 Level II Scour Analysis Report)

The scour analysis report calculated the contraction scour depths as 1.2 feet and 1.6 feet for the 100-year and 500-year storms, respectively. Contraction scour of the main-channel bed occurs when water accelerates through an opening that is narrower than the channel upstream from the bridge. The calculated scour depths represent the amount that the entire streambed between the abutments will theoretically be lowered as a result of the flood events.

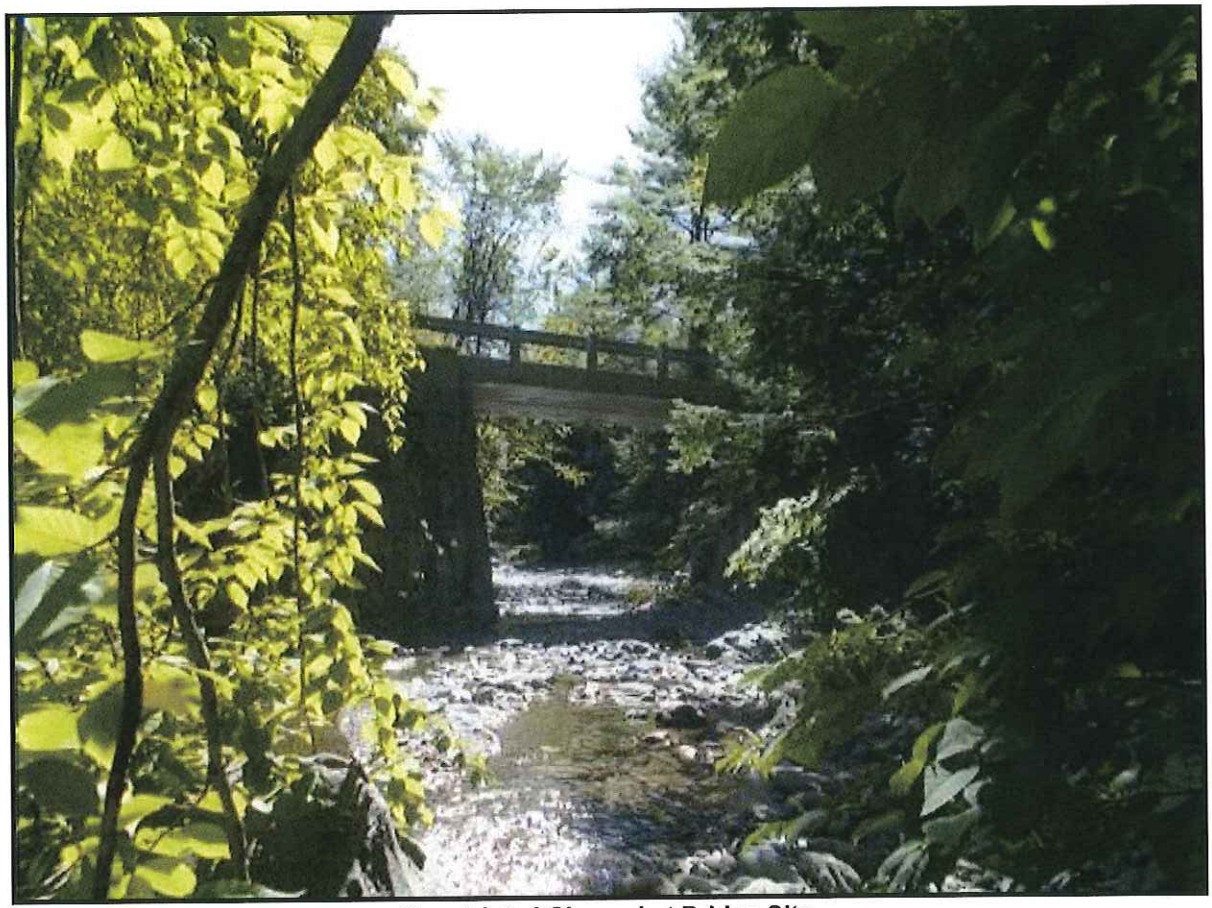
Local abutment scour depths were calculated in the report to be 10.0 feet and 12.8 feet for the 100-year and 500-year storms, respectively. Local scour is additional streambed degradation localized around flow obstructions (such as bridge abutments) and is caused by hydraulic

vortices or eddies which can lift up sediment and create scour holes. The scour report had calculated the local abutment scour as being very deep but it is important to note that the analysis assumed an infinite depth of erosive material below the footings. In all likelihood, bedrock is located above the calculated abutment scour depths. The standard computations for local abutment scour are also generally recognized as being overly conservative.

The calculated water velocities were found to be swift through the site during flood events; 12.1 ft/s for the 100-year storm and 12.9 ft/s for the 500-year storm.

Inspection data dating back to 2007 is available for this bridge; undermining of the footing was noted in both the 2009 and 2011 inspection reports (before Tropical Storm Irene). After Tropical Storm Irene, the observed undermining had worsened. The 2013 inspection noted: *"Immediate repairs are needed to correct the undermining of abutment 2 and it's upstream wingwall, and anti-scour protection added."*

A Stream Geomorphic Assessment and River Corridor Plan Report prepared in December 2014 noted that the stream dynamics at the bridge site indicate hourglass/Venturi effect and that the hydraulic opening at the bridge is insufficiently wide. The angle of the bridge alignment (abutments not in line with the banks) further reduces the effective width of the hydraulic opening.



Constricted Channel at Bridge Site
(Photo from the 2014 Stream Geomorphic Assessment and River Corridor Report)

The original cause of the observed undermining at the northwest corner of the bridge is likely due to local scour resulting from the poor alignment of the bridge in respect to the channel and a constricted hydraulic opening which produces swift water velocities. The undermining of the footing was undoubtedly exacerbated by Tropical Storm Irene which heavily damaged sections of Lilliesville Brook in August 2011.

Wingwall Displacement

It is difficult to say with any certainty what has caused the observed separation of the wingwall stem without available plans or without implementing a testing program. It may be caused by a number of potential factors:

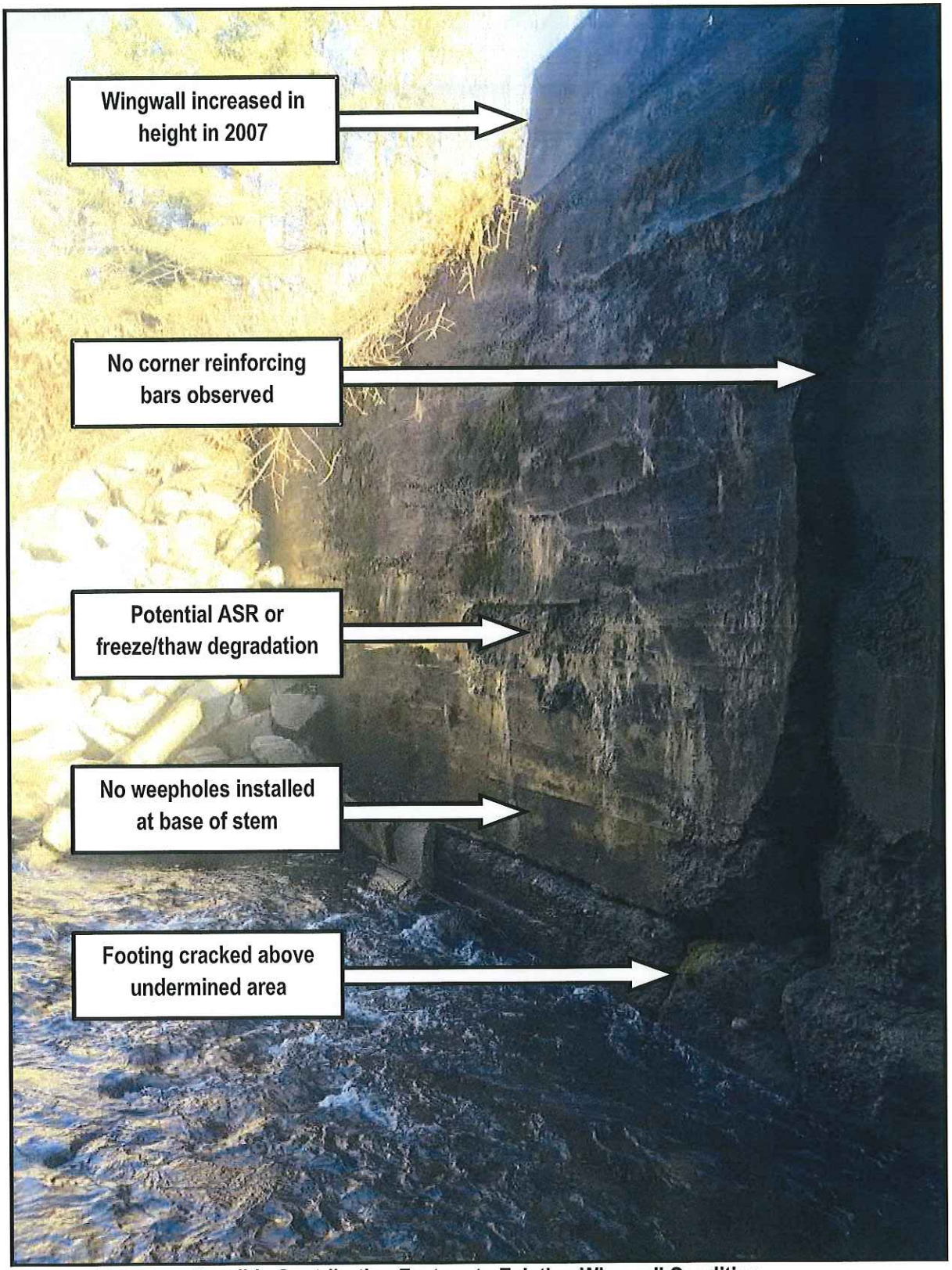
- The wingwall footing was observed to be cracked at the undermined area and the wingwall may have rotated or shifted due to lack of support below.

- No weepholes are present at the base of the wingwall stem and the potential build-up of excessive hydrostatic pressure behind the wall may have caused the observed cracking/separation of the wingwall stem.

- The recent superstructure replacement project has increased the height of the retained fill that the wingwall must support. Note that the force exerted on retaining walls increases exponentially with an increase in wall height. It is likely that no measures were taken to increase the structural capacity of the existing substructure for the new increased loads.

- The abutment-wingwall stem interface is typically constructed monolithically and the nature of the cracking suggests that an expansion joint was never present between the wingwall and abutment stem. However, no corner reinforcing bars were found extending from the wingwall stem into the abutment concrete. The potential lack of these corner reinforcing bars may have led to a shear friction failure at the wingwall-abutment interface.

- The existing substructure concrete is approximately 86 years old and has gone through numerous freeze-thaw cycles and may also be chemically degrading through a process known as alkali-silica reaction (ASR). Common visual symptoms of ASR damage are map-cracking, surface discolorations, gel exudation at cracks, and expansion causing deformation, relative movement, or displacement; the majority of these symptoms are present at the northwest wingwall. ASR damage can also reduce the resistance of concrete to cyclic freezing and thawing which may be accelerating the deterioration of the concrete.



Possible Contributing Factors to Existing Wingwall Condition

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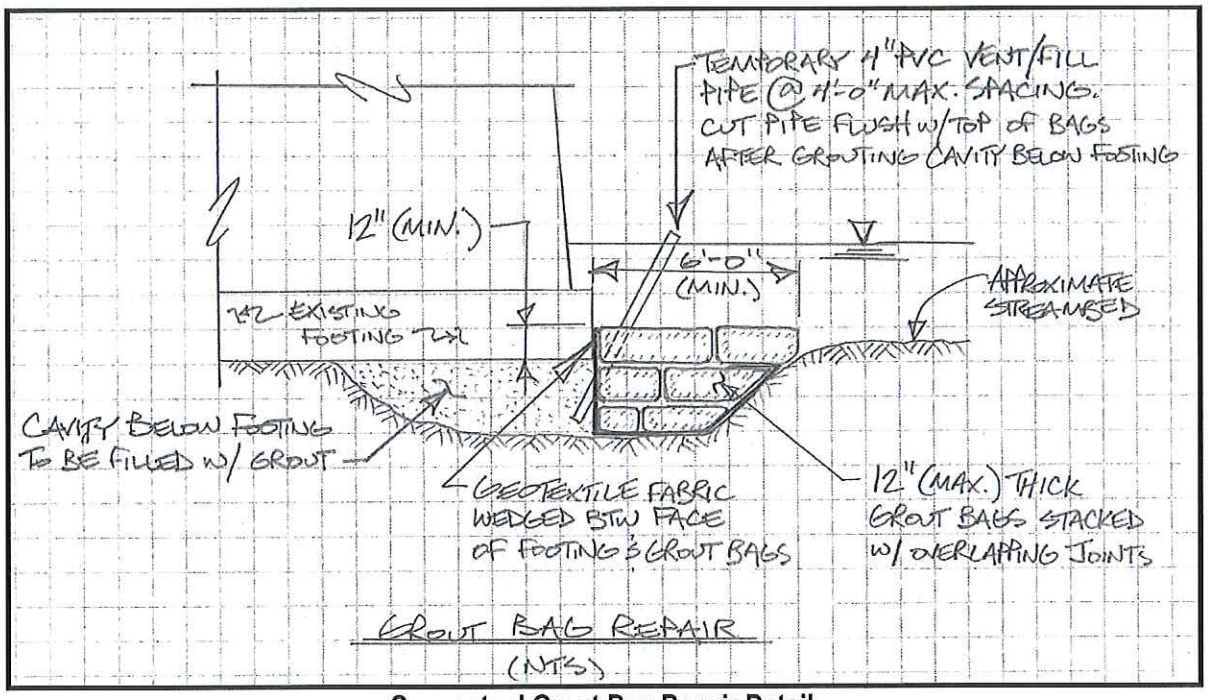
Repair Options

A range of potential remediation options to address the observed deficiencies and their probable causes are presented below. Preliminary construction costs are based on assumed quantities, discussions with local contractors, VTrans Average Price Lists, and similar projects designed by D&K.

Footing Undermining Repair Option 1 - Grout Bags

Grout bags are fabric shells that are filled with concrete and are typically used for the repair of scour holes underneath footings. Properly-installed grout bags reduce scour depth to a degree generally comparable with riprap, and they are one of the cheapest and simplest types of armoring against streambed erosion. They are ideal for small bridges in remote locations, where it may be difficult to bring in equipment for the placement of riprap.



Conceptual Grout Bag Repair Detail

This type of repair does not require the use of heavy equipment and does not require work to be performed in the dry, which helps reduce costs. Loose streambed material in the scour hole is removed by hand and a geotextile fabric is laid down to prevent the leaching of streambed materials prior to installing the grout bags. The grout bags are then stacked, overlapping the joints of the preceding layer, along the face of the abutment and wingwall footing in front of the undermined area. Once the grout bag installation is complete, grout is pumped through vent/fill pipes to completely fill the undermined area. The pipes are then cut flush with the top of the bags after the pumping operation is completed to prevent debris from getting caught up on the pipes in the future.

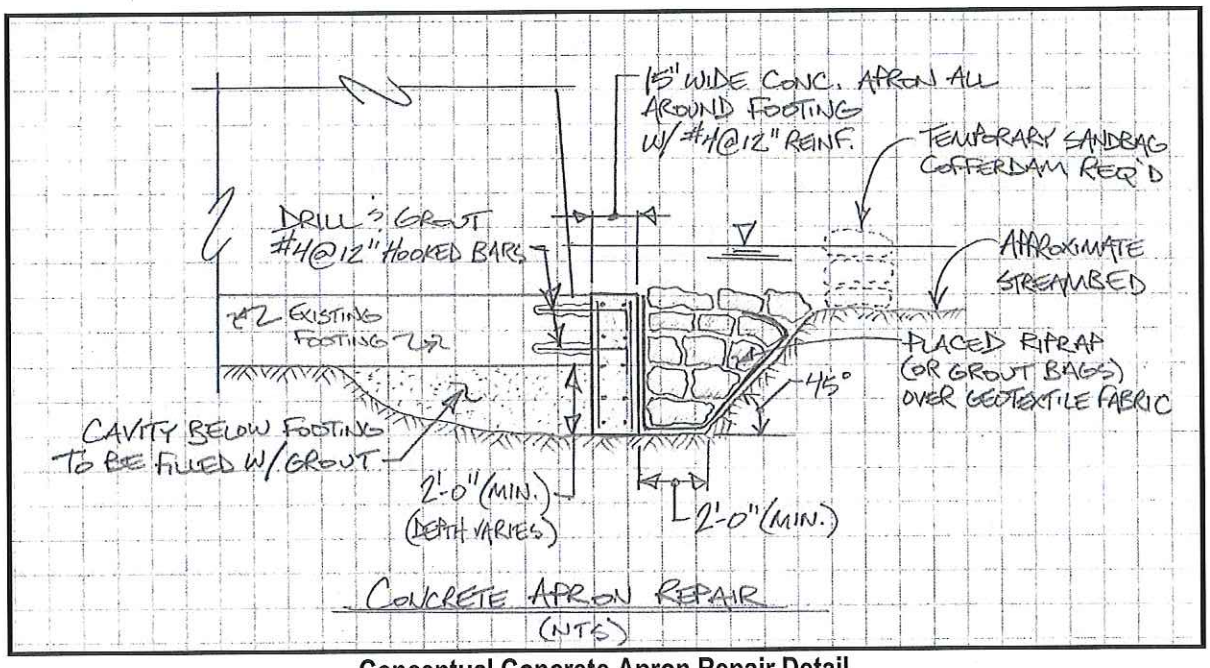
It should be noted that grout bag repairs such as this are generally recommended for design flood velocities that are below 10 ft/s and for computed total scour depths (contraction scour + local scour) of less than 6 feet. As previously mentioned, the calculated local abutment scour depths

derived in the Level II Scour Analysis are well in excess of 6 feet but they may be overly conservative numbers since bedrock is likely close to the bottom of the existing footings. The calculated flood velocities at the site for the 100-year and 500-year storms, however, may be too swift for this type of repair to be considered a permanent solution without regular monitoring and maintenance. Periodic inspection and/or future repairs may be required since there would be the possibility that some grout bags may get swept away in the flow during high storm events.

The estimated construction cost for this repair option is $30,000. The construction duration would be approximately 1 week.

Footing Undermining Repair Option 2 - Concrete Apron

Another potential scour repair option would be the addition of a cast-in-place concrete apron which would be doweled into the toe of the existing footing. The existing scour hole behind the new apron would be filled with grout, similarly to the grout bag repair option. Further investigations may be warranted at the site to determine how far down the apron should extend, but ideally, the apron would extend down to ledge if it is located close to the streambed surface. For the purposes of this report, the proposed concrete apron was assumed to extend down a minimum of 2 feet below the bottom of footing elevation. This depth would provide adequate protection for the computed channel contraction scour depths calculated in the Level II Scour Analysis; additional riprap placed in front of the apron and on the upstream channel bank would provide protection against bridge local scour.



Conceptual Concrete Apron Repair Detail

One of the disadvantages of this option is that it would require the use of a temporary sandbag cofferdam (or similar water control device) to allow for work to be performed in the dry. Streambed excavations would also be required to attain the proper depth for the apron and to permit enough space to install riprap (or alternatively, grout bags) in front of the apron for added scour protection. Since this is a more invasive repair option, it would be recommended to extend the apron along the entire perimeter of the existing abutment and wingwall footing (instead of

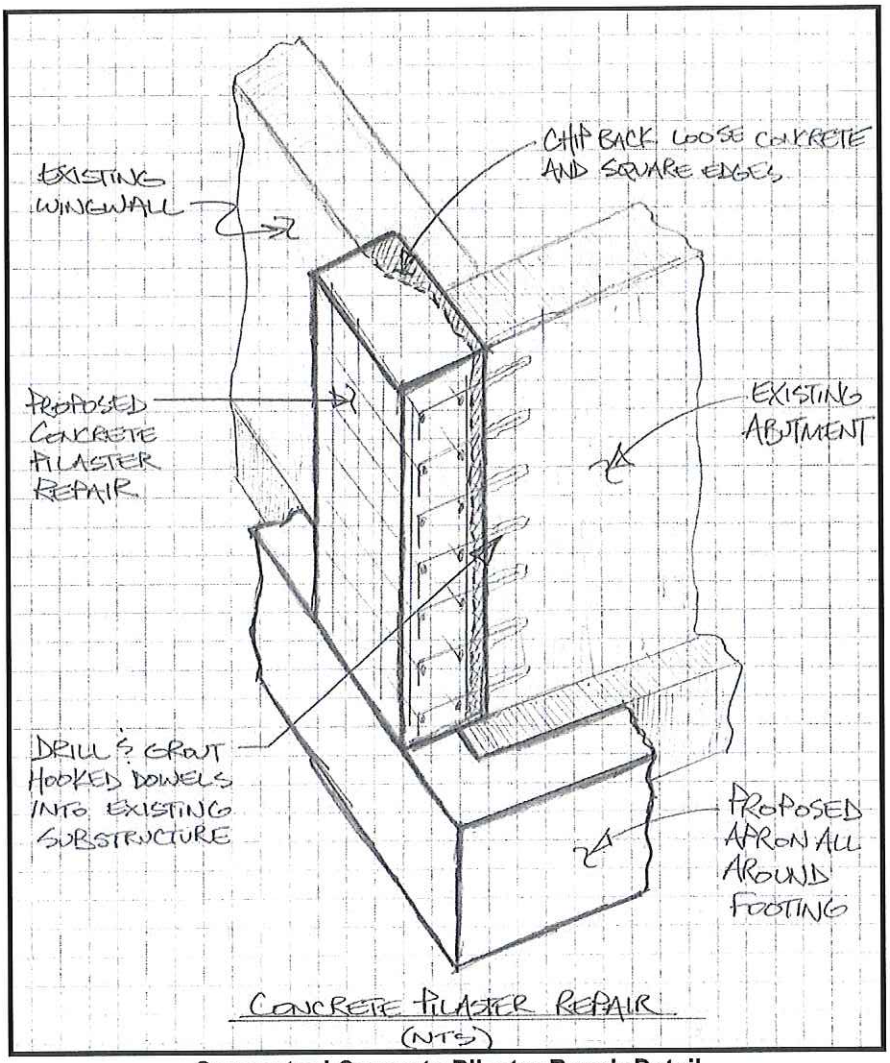
just at the existing scour hole location) to provide a more complete repair and help reduce the potential for maintenance or repairs in the future.

This alternative would provide for a more permanent repair than the grout bag repair option. The concrete apron would be physically attached to the substructure and would not get washed away during flood events. If needed, the protective riprap in front of the apron could be cheaply repaired or re-placed after flood events.

The estimated construction cost for this repair option is $55,000. The construction duration would be approximately 1 month.

Wingwall Repair Option 1 - Concrete Pilaster

One potential repair option for the cracked and spalled northwest wingwall stem would be to remove all existing loose, cracked, or delaminated concrete at the wingwall-abutment interface and to build out a full-height cast-in-place concrete pilaster repair as illustrated below.



Conceptual Concrete Pilaster Repair Detail

This option involves sawcutting neat edges around the repair area and chipping back the face of the wingwall and abutment concrete until sound concrete is encountered. Hooked reinforcing dowels would be drilled and grouted into the existing substructure to help anchor the new concrete. The chipped-back concrete surface would be cleaned and prepared, and an epoxy bonding compound would be applied prior to placing fresh concrete in order to improve the bond of the new concrete to the old.

Repairs of this kind are commonly used to patch deteriorating concrete elements. Due to the observed out-of-plane displacement of the wingwall stem relative to the abutment, it would be preferred to build-out the patch as conceptually shown rather than leaving the repair patch flush with the face of the wingwall stem. This type of approach would provide some added strength at the corner interface between the wingwall and abutment. If this repair concept were ultimately chosen, it would be recommended that the concrete apron repair be used in conjunction to address the scour issues under the footing. The new pilaster concrete would then be able to be supported at its base by the new apron concrete.

The advantages of this type of repair are its relative low cost and that the bridge could remain in service while the work is being performed. The pilaster repair would remove the deteriorated concrete at the wingwall-abutment interface and would prevent the loss of the roadway backfill material through the existing crack; however, the long-term performance of this repair cannot be assured. Due to the unknown cause of the wingwall cracking and the observed relative displacement, it would be possible that the pilaster would crack in the future or that the wingwall beyond the repair limits would start to crack or fail in a similar fashion. A patch repair such as this could not be adequately designed to resist the earth pressure and vehicular surcharge loads that are present and the existing wingwall concrete would be relied upon for structural integrity. This option would also not address any potential internal chemical processes that may be degrading the existing concrete.

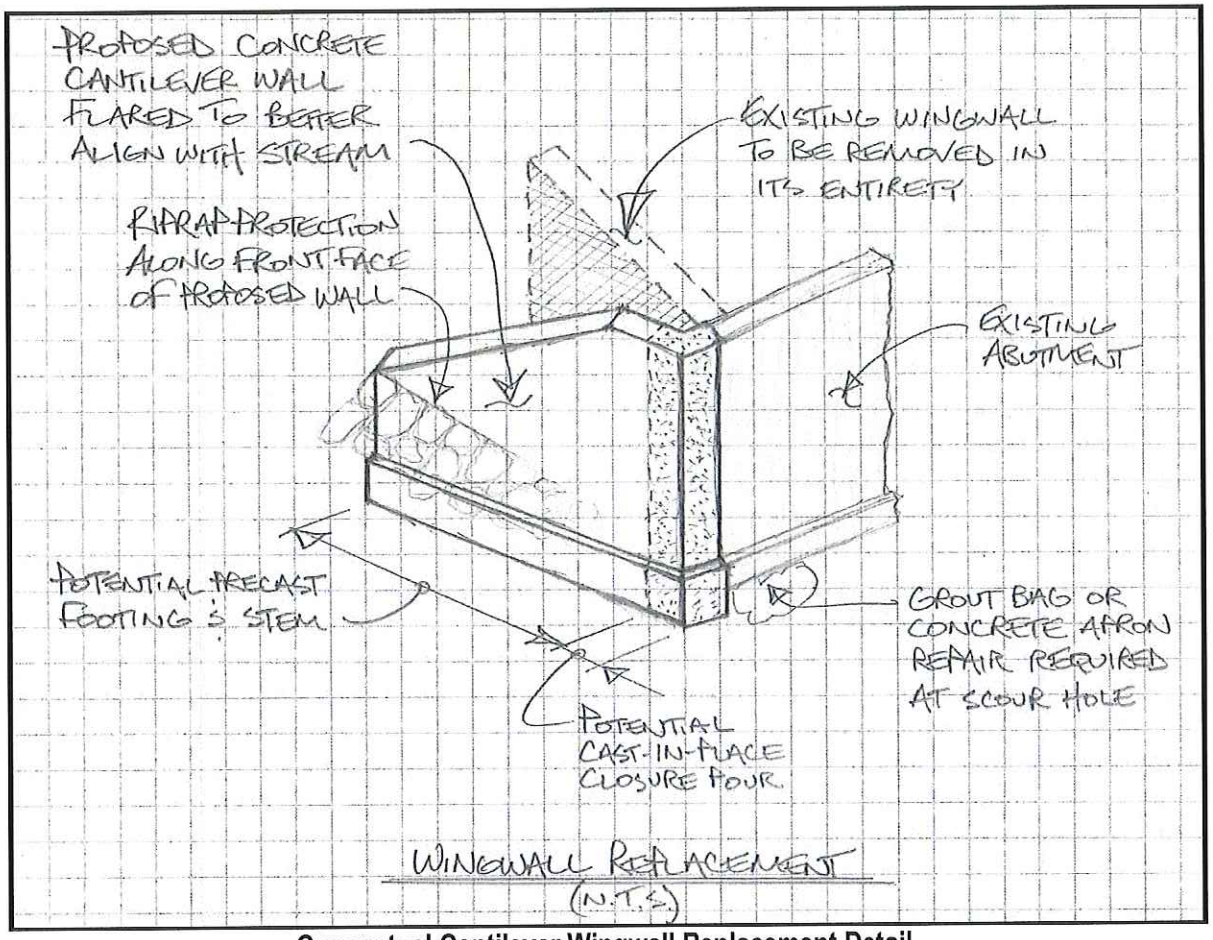
The estimated construction cost for this repair option is $20,000. Note that this is the cost for the pilaster repair alone and does not include additional costs for addressing the footing undermining. If this repair were performed in conjunction with the concrete apron repair (as would be recommended for this alternative), the total cost would be approximately $75,000 and the construction duration would be approximately 6 weeks.

Wingwall Repair Option 2 – Cantilever Wingwall Replacement

Because of the deteriorating condition of the existing concrete and since the original cause for the observed displacement and severe cracking of the northwest wingwall is unknown, it would be desirable to replace the wingwall in its entirety. A proposed concrete cantilever wall could be connected to the end of the existing abutment with dowels (similarly to the pilaster repair option), and the new wingwall could be flared to be more in line with the channel which would reduce the magnitude of local scouring at that corner of the bridge.

Since the existing roadway is only one lane wide and extensive approach roadway excavation would be required to perform the work, the bridge would need to be closed for the duration of the wingwall replacement. A temporary detour route would need to be established for this option, likely using Whittier Road and Gay Hill Road. To accelerate construction and minimize the duration of the temporary detour, it may be possible to use precast footing and stem elements in the design to avoid lengthy cure times in the field for cast-in-place concrete. There would

likely need to be a cast-in-place closure pour to provide a positive connection between the new wingwall and the existing abutment but the feasibility of having a completely independent wingwall with an expansion joint present at the abutment may also be a possibility which would help shorten the bridge closure duration.



Conceptual Cantilever Wingwall Replacement Detail

The main advantage of the complete wingwall replacement option is that this is a long-term solution that would not depend on the questionable re-use of the existing wingwall concrete for structural integrity. The realignment of the proposed wingwall to better suit the stream conditions will help reduce potential future scour by having a less abrupt transition in the channel. Soil borings will need to be taken to properly design the new wingwall and to help determine the elevation of bedrock at the site. If bedrock is located near the existing streambed surface, the proposed wingwall footing will extend down and be keyed into the ledge to enhance safety against scour.

The estimated construction cost for this replacement option is $225,000. This price includes assumed costs for survey, geotechnical investigations, engineering, traffic maintenance, and all labor and materials necessary for the wingwall replacement. The price also includes the performance of concrete apron repairs to address the abutment footing undermining, however the grout bag repair option would also be a suitable repair. The construction duration for this option would be approximately 2 months.

DuBois & King inc.

Other Wingwall Repairs Considered

Several other wingwall repair methods were considered for this report and are briefly described below. There is currently insufficient available information on the existing substructure concrete and soil conditions to adequately design the majority of these repairs or confirm their viability. These repair concepts are not recommended by D&K at this time unless original design plans are made available and/or subsurface investigations and material testing programs are implemented.

Wingwall Tie-Back Anchoring

Tie-back systems are commonly used to repair walls that have deflected outwards. Steel rods, prestressing tendons, or helical piles are all commonly used types of tie-backs and can be designed to anchor into soil, rock, or concrete deadmen (mass concrete poured near the roadway surface). Horizontal walers or similar devices are used to distribute the tie-back force to the face of the failing retaining wall. The design of a successful tie-back system that prevents future wall movement is extremely reliant upon an accurate understanding of the substructure geometry and the soil properties at the site. The anchorage point for a tie-back system also needs to be located outside of the soil failure plane for the element; at this particular bridge site, a suitable anchorage point within the roadway embankment fill may not be available due to the proximity of the wingwall on the other side of the abutment. Note too, that additional concrete repairs would be required in conjunction with the installation of a tie-back system. The purpose of the tie-backs is only to prevent wall movements; the existing cracking/spalling that is present would need to be patched and repaired as well.

Example of Wall Tie-Back Anchoring System

(Left photo shows installation of the tie-backs through cored holes in the wall; Right photo shows the finished wall with horizontal walers in place to distribute the tie-back force along the face of the wall)

Steel H-Pile Buttress

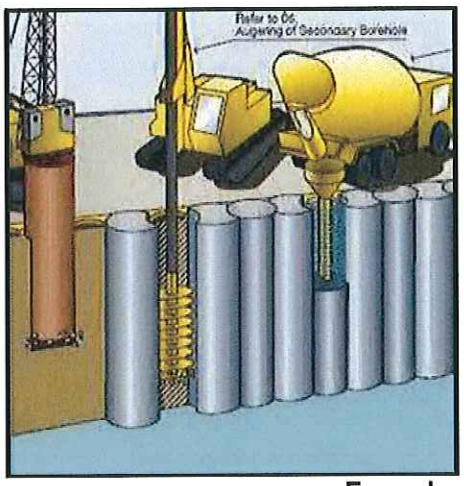
Another potential option to secure the deflected wingwall would be the installation of vertical steel H-pile buttresses. Due to the assumed high elevation of ledge, the steel piles would be installed into cored holes in the bedrock just in front of the face of the existing wingwall. The piles would extend along the full-height of the wingwall and the piling would be sized to have sufficient stiffness to resist any future outward movements of the wingwall. Similarly to tie-back systems, the proper design of the H-pile buttresses would be reliant on a more complete understanding of the existing substructure and soil conditions and additional concrete repairs would also be required.

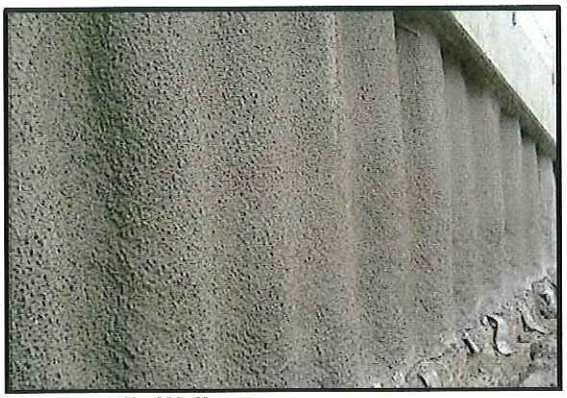
Example of Steel H-Pile Buttress

(Tilted retaining wall repaired with 3 steel H-piles which have been faced with masonry to hide repair)

Secant Pile Wall

Secant pile walls are composed of a series of drilled shafts constructed in such a way that the shafts overlap each other to form a wall. These types of walls are extremely stiff and the drills used for their construction can advance a cased hole through man-made and natural obstructions, including reinforced concrete and rock. A new secant wall could be installed directly through the existing wingwall concrete at the bridge. The distinct advantages of this option would be that approach roadway excavations would not be required to construct the new wall and the existing wingwall would not be relied upon for its structural integrity in the final condition. These types of wall installations, however, are not usually used for small projects such as this due to their very high costs and the large equipment required to perform the work.





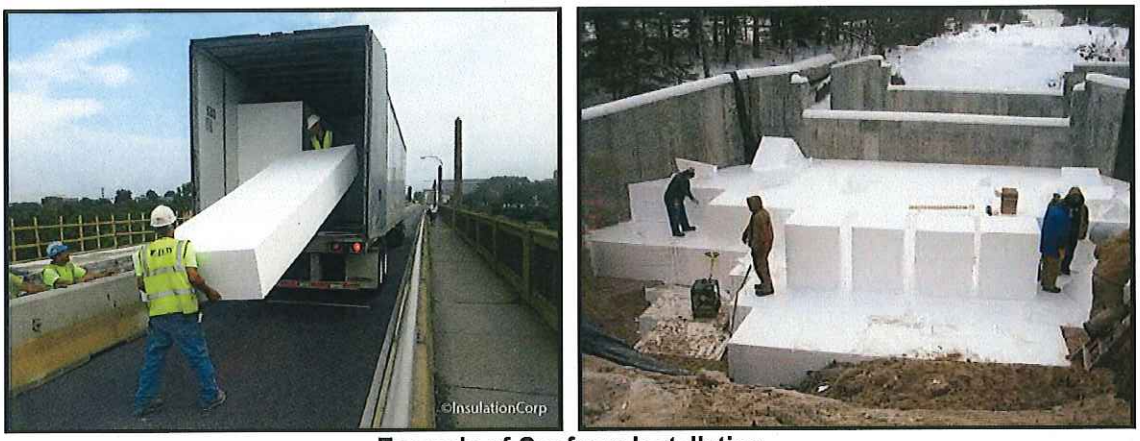
Example of Secant Pile Walls

(Left photo shows installation of the drilled shafts; Right photo shows a finished wall with shotcreted finish)

DuBois & King inc.

Geofoam Embankment Fill

Geofoam is a manufactured expanded polystyrene product that is frequently used as a substitution for standard roadway embankment fill. Geofoam comes in large lightweight blocks and can be quickly installed without the need for large equipment or specialty tools. The installation of these blocks behind retaining structures greatly reduces the lateral force on a wall and still provides equal strength as compacted soil. The installation of the geofoam blocks would require a complete closure of the road to perform excavations, and a drainage system would need to be installed to prevent problems with built-up hydrostatic pressure or buoyancy. The magnitude of the lateral forces on the wingwall would be greatly reduced with this option and this in turn would decrease the likelihood of future movements; however, the existing wingwall displacement and concrete deficiencies would still need be addressed. Given the need for large excavations to install the blocks, it would likely be a more prudent solution to completely replace the existing wingwall instead.



Example of Geofoam Installation

(Lightweight blocks frequently used as roadway embankment at bridge approaches)

Conclusion and Recommendations

D&K have reviewed available background data for the bridge and have performed site visits to confirm the concerns raised by VTrans inspection staff. The field-measured wingwall displacements as noted in previous inspection reports have been increasing over the last few years and the wingwall concrete shows signs of deterioration throughout. Previous scour analyses and river studies have confirmed the bridge's scour susceptibility and the current size of the scour hole under the footing warrants immediate action.

Based on these findings, D&K recommends fully replacing the existing wingwall with a new reinforced concrete cantilever wingwall. It is recommended that the proposed wingwall be flared to better align with the existing channel and that riprap protection be placed in front of the new wingwall and along the upstream embankment. Alternative methods for repairing the wingwall were examined but the majority of these options rely in some part on the questionable structural integrity of the existing wingwall concrete. Due to a lack of original plans, the structural adequacy of these potential repair designs would ultimately be uncertain.

To address the ongoing scour below the footing, it is recommended that either of the Footing Undermining Repair Options described in this report (grout bags or concrete apron repairs) be implemented. The grout bag repair option is a cheaper alternative and could be quickly installed in the interim before construction of a new wingwall commences. Alternatively, the concrete apron repair concept would provide for more complete scour protection along the perimeter of the footing, but it would be better suited for concurrent installation with the new wingwall since there would be potential cost savings associated with the concrete work and control of water during construction.

Once you have reviewed the above information, if you have any questions, please do not hesitate to contact me at (802) 728-3376. I would be happy to meet with you or other representatives of the Town to elaborate on any aspect of our assessment. DuBois & King, Inc. appreciates the opportunity to continue assistance to the Town on this project.

Very truly yours,
DuBOIS & KING, INC.

Evan P. Detrick

Evan P. Detrick, P.E.
Transportation Division Director

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Footing Undermining Repair Option 1 - Grout Bags Estimate

QUANTITIES

Plan Area of Grout Bags in Front of Footing = 144.0 SF

(Assumes constant 6 ft width of repair; 10 ft length along abutment and 8 ft along the wingwall)

Assumed Number of Grout Bag Layers = 3 EA

Total Area of Grout Bags = 432.0 SF

Area of Geotextile Fabric = 30.3 SY

(Assumes 3 ft vertical portion, 6 ft wide, and additional 3 ft for overlap with grout bags)

Volume of Grout to Fill Cavity = 3.1 CY

(Assumes 18 in average depth and 4 ft average depth of penetration)

ESTIMATED COST SUMMARY

ITEM	QUANTITY	UNIT	UNIT COST	COST
Grout Bags	432.0	SF	$ 35.00	$ 15,120.00
Geotextile Fabric	30.3	SY	$ 5.00	$ 151.67
Grout to Fill Cavity	3.1	CY	$ 300.00	$ 933.33
Mobilization/Demobilization	1	LS	$ 2,500.00	$ 2,500.00
			Materials & Installation Subtotal =	$ 18,705.00
			Design & Construction Administration =	$ 5,000.00
			20% Contingency =	$ 3,741.00
			Σ =	$ 27,446.00
			SAY,	**$30,000**

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Footing Undermining Repair Option 2 - Concrete Apron Estimate

QUANTITIES

Assumed Total Length of Concrete Apron Repair =	50	FT
Assumed Thickness of Concrete Apron =	15	IN
Assumed Height of Concrete Apron =	4	FT
Total Volume of Concrete Apron =	9.3	CY
Assumed Reinforcement Weight/FT of Concrete Apron =	15	LB/FT
(Assumes #4@12" EW/EF in apron and #4 hooked bars doweled into top and bottom of concrete footing)		
Total Weight of Reinforcement =	750.0	LB
Total Length of Drilling and Grouting Hooked Bars =	100.0	FT
(Assumes 12" embedment for #4 hooked bars installed at top and bottom of existing footing)		
Total Area of Epoxy Bonding Compound =	100.0	SF
Area of Geotextile Fabric =	66.7	SY
(Assumes 4 ft vertical portion, 2 ft wide along base, and additional 6 ft for diagonal portion and overlap with riprap)		
Volume of Grout to Fill Cavity =	3.1	CY
(Same quantity as for Grout Bag Repair Option)		
Assumed Cross-Sectional Area of Riprap =	16	SF
Total Volume of Riprap =	29.6	CY
Assumed Average Cross-Sectional Area of Streambed Excavation =	12	SF
Total Volume of Excavation =	22.2	CY

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Footing Undermining Repair Option 2 - Concrete Apron Estimate

QUANTITIES (CONT'D)

For the purpose of developing a unit cost for the water control structure, assume Portadam product (or similar) will be used. Per ACOE data (2005 dollars), the cost per linear foot for Portadam 3' high frames, liner, and hardware is $71.30 (cost includes all materials and labor necessary for installation).

Approximate Length of Water Control Structure =	50	FT
Assumed Cost per Foot for Water Control Structure (adjusted for inflation) =	100	$/FT
Duration of Work =	30	DAYS
Cost per Day for Pumping (RSMeans) =	250	$/DAY
Dewatering Basin Cost =	2500	$
Total Cost for Control of Water =	15000	$

ESTIMATED COST SUMMARY

ITEM	QUANTITY	UNIT	UNIT COST	COST
Apron Concrete	9.3	CY	$ 1,000.00	$ 9,259.26
Steel Reinforcement	750.0	LB	$ 2.50	$ 1,875.00
Drilling and Grouting	100.0	FT	$ 30.00	$ 3,000.00
Epoxy Bonding Compound	100.0	SF	$ 5.00	$ 500.00
Geotextile Fabric	66.7	SY	$ 5.00	$ 333.33
Grout to Fill Cavity	3.1	CY	$ 300.00	$ 933.33
Riprap	29.6	CY	$ 75.00	$ 2,222.22
Streambed Excavation	22.2	CY	$ 50.00	$ 1,111.11
Control of Water	1	LS	$ 15,000.00	$ 15,000.00
Mobilization/Demobilization	1	LS	$ 3,500.00	$ 3,500.00
			Materials & Installation Subtotal =	$ 37,734.26
			Design & Construction Administration =	$ 8,000.00
			20% Contingency =	$ 7,546.85
			Σ =	$ 53,281.11
			SAY,	**$55,000**

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Wingwall Repair Option 1 - Concrete Pilaster Estimate

QUANTITIES

Assumed Total Length of Concrete Pilaster Repair =	4	FT
Assumed Thickness of Concrete Pilaster =	2	FT
Assumed Height of Concrete Pilaster =	15	FT
Total Volume of Concrete Pilaster =	4.4	CY
Assumed Reinforcement Weight/FT of Height of Concrete Pilaster =	20	LB/FT
(Assumes #4@12" EW/EF and #4 hooked bars doweled into abutment and wingwall stems)		
Total Weight of Reinforcement =	300.0	LB
Total Length of Drilling and Grouting Hooked Bars =	45.0	FT
(Assumes 12" embedment for #4 hooked bars installed into abutment and wingwall stems)		
Total Area of Epoxy Bonding Compound =	60.0	SF
Assumed Volume of Concrete Excavation =	1.5	CY

ESTIMATED COST SUMMARY

ITEM	QUANTITY	UNIT	UNIT COST	COST
Pilaster Concrete	4.4	CY	$ 1,000.00	$ 4,444.44
Steel Reinforcement	300.0	LB	$ 2.50	$ 750.00
Drilling and Grouting	45.0	FT	$ 30.00	$ 1,350.00
Epoxy Bonding Compound	60.0	SF	$ 5.00	$ 300.00
Reinforced Concrete Excavation	1.5	CY	$ 2,000.00	$ 3,000.00
Mobilization/Demobilization	1	LS	$ 2,500.00	$ 2,500.00
			Materials & Installation Subtotal =	$ 12,344.44
			Design & Construction Administration =	$ 5,000.00
			20% Contingency =	$ 2,468.89
			Σ =	$ 19,813.33
			SAY,	**$20,000**

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Wingwall Repair Option 2 - Cantilever Wingwall Replacement Estimate

QUANTITIES

Assumed Length of Proposed Wingwall =	20	FT
Assumed Average Thickness of Proposed Wingwall Stem =	2.75	FT
Assumed Height of Proposed Wingwall Stem =	15.00	FT
Assumed Thickness of Proposed Wingwall Footing =	2.00	FT
Assumed Width of Proposed Wingwall Footing =	10.00	FT
Total Volume of Proposed Wingwall Concrete =	45.4	CY
Assumed Total Reinforcement Weight =	4500	LB
Total Length of Drilling and Grouting Bars in Existing Stem and Footing =	50.0	FT
(Assumes 12" embedment for #5 bars installed at existing abutment)		
Assumed Plan Area of Riprap in Front of Wingwall =	250	SF
Assumed Riprap Thickness =	4	FT
Total Volume of Riprap =	37.0	CY
Assumed Length of Existing Wingwall =	20	FT
Assumed Average Thickness of Existing Wingwall Stem =	5.25	FT
(Assumes 18" wide at top with 2:12 front face batter and 4:12 backface batter)		
Assumed Average Height of Existing Wingwall Stem =	15.00	FT
Assumed Thickness of Existing Wingwall Footing =	2.00	FT
Assumed Width of Existing Wingwall Footing =	10.00	FT
Total Volume of Existing Wingwall Concrete to be Excavated =	73.1	CY
Assumed Volume of Roadway Embankment Excavation for Removal of Existing Wingwall =	250	CY
Assumed Volume of Streambed Excavation for Proposed Wingwall Construction =	45	CY
Assumed Volume of Roadway Embankment Fill =	300	CY
(Includes both granular borrow for roadway and granular borrow for backill for structures)		

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Wingwall Repair Option 2 - Cantilever Wingwall Replacement Estimate

QUANTITIES (CONT'D)

Note that the developed cost for this wingwall replacement option will include performing concrete apron repairs to address the existing scour hole below the footing. The previously calculated concrete apron repair cost will be adjusted here to account for the presence of the proposed wingwall. The quantities will be assumed to be roughly 2/3 of those previously calculated. The assumed lump sum cost for the apron repairs devloped below reflect potential savings in the concrete and reinforcing costs If performed concurrently with the wingwall replacement.

ITEM	QUANTITY	UNIT	UNIT COST	COST
Apron Concrete	6.2	CY	$ 900.00	$ 5,555.56
Steel Reinforcement	500.0	LB	$ 2.25	$ 1,125.00
Drilling and Grouting	66.7	FT	$ 30.00	$ 2,000.00
Epoxy Bonding Compound	66.7	SF	$ 5.00	$ 333.33
Geotextile Fabric	44.4	SY	$ 5.00	$ 222.22
Grout to Fill Cavity	2.1	CY	$ 300.00	$ 622.22
Riprap	19.8	CY	$ 75.00	$ 1,481.48
Streambed Excavation	14.8	CY	$ 50.00	$ 740.74
			Σ =	$ 12,080.56
			SAY,	$13,000

For the purpose of developing a unit cost for the water control structure, assume Portadam product (or similar) will be used. Per ACOE data (2005 dollars), the cost per linear foot for Portadam 3' high frames, liner, and hardware is $71.30 (cost includes all materials and labor necessary for installation).

Approximate Length of Water Control Structure =	75	FT
Assumed Cost per Foot for Water Control Structure (adjusted for inflation) =	100	$/FT
Duration of Work =	60	DAYS
Cost per Day for Pumping (RSMeans) =	250	$/DAY
Dewatering Basin Cost =	2500	$
Total Cost for Control of Water =	25000	$

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Wingwall Repair Option 2 - Cantilever Wingwall Replacement Estimate

ESTIMATED COST SUMMARY

ITEM	QUANTITY	UNIT	UNIT COST	COST
Proposed Wingwall Concrete	45.4	CY	$ 900.00	$ 40,833.33
Steel Reinforcement	4500.0	LB	$ 2.25	$ 10,125.00
Drilling and Grouting	50.0	FT	$ 30.00	$ 1,500.00
Riprap	37.0	CY	$ 75.00	$ 2,777.78
Existing Concrete Wingwall Excavation	73.1	CY	$ 400.00	$ 29,259.26
Roadway Embankment Excavation	250.0	CY	$ 20.00	$ 5,000.00
Streambed Excavation	45.0	CY	$ 50.00	$ 2,250.00
Roadway Embankment Fill	300.0	CY	$ 25.00	$ 7,500.00
Concrete Apron Repairs	1	LS	$ 13,000.00	$ 13,000.00
Control of Water	1	LS	$ 25,000.00	$ 25,000.00
Survey	1	LS	$ 2,000.00	$ 2,000.00
Borings and Geotechnical Investigations	1	LS	$ 5,000.00	$ 5,000.00
Traffic Maintenance	1	LS	$ 5,000.00	$ 5,000.00
EPSC Measures	1	LS	$ 5,000.00	$ 5,000.00
* Miscellaneous	1	LS	$ 1,000.00	$ 1,000.00
Mobilization/Demobilization	1	LS	$ 10,000.00	$ 10,000.00

* Miscellaneous items include epoxy bonding compound, damp-proofing, water repellent, weephole drainage, etc.

Materials & Installation Subtotal =	$ 165,245.37
Design & Construction Administration =	$ 25,000.00
20% Contingency =	$ 33,049.07
Σ =	$ 223,294.44

SAY, $225,000

Additional Budget Information Bethel Category D Application

The purpose of this application is to supplement anticipated funding the State of Vermont Town Highway Structures grant from VTrans.

Total Estimated Cost of the project:	225,000	
TH Structures Grant (if approved)	175,000	
Structures Grant Match (10%)	17,500	(General Fund)
Balance Required	32,500	
Category D Grant Request	25,000	
Town Match	7,500	(General Fund)