



25 Vaughan Mall, Unit 1  
Portsmouth, NH, 03801-4012  
Tel: 603-436-6192 Fax: 603-431-4733

## Technical Memorandum

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**DATE:** October 30, 2015  
**TO:** Glenn Smith, Town Administrator  
**FROM:** Daniel J. Rochette, P.E. and Erik B. Nichols EIT  
**RE:** 2016 Priority Road Evaluation - Final  
Northfield, New Hampshire

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### 1.0 INTRODUCTION

#### *1.1 Project Background*

The Town of Northfield (Town) is located in Merrimack County just southwest of Lake Winnisquam. The Town is a primarily rural community with a network of approximately 40 miles of roadways. These roads range in frequency of use and condition with a certain few in high need of repair. The Town has asked Underwood Engineers (UE) to provide an evaluation on 7.4 miles that the Town has identified as priorities for 2016. An opinion of costs will also be provided for budgetary purposes.

The 2016 priority roads of focus were selected by the Town as follows:

- Bay Hill Road – Approximately 1.6 miles
- Shaw Road – Approximately 0.85 miles
- Shaker Road – Approximately 2.5 miles
- Zion Hill Road – Approximately 1 mile
- Cofran Avenue, Howard Avenue, and Luneau Court – Approximately 0.66 miles
- Silver Lane – Approximately 0.82 miles.

To evaluate the roads, UE completed the following:

- Complete windshield survey to evaluate target roads.
- Develop repair strategies that are cost effective and appropriate for the Town.
- Provide construction details showing proposed repair strategies.

- Provide cost opinions for the recommended repair strategies.
- Target potential project areas of high priority.

### ***1.3 Previous Work***

UE understands that UNH completed an RSMS survey of the Town roads in 2012. This provided the Town with a snapshot of surface conditions by applying a PCI value but did not provide a prioritized strategy.

The Town has completed improvements recently including asphalt shims, overlays, ditch work, and full reconstruction (see summary of recent roadwork in Appendix C).

The Town also previously completed efforts to rank their roads to include traffic volume, emergency importance, etc. (Appendix C)

## **2.0 ROAD EVALUATION**

On May 24, 2015 UE completed a windshield survey of the target roads. This consisted of driving each road at low speeds (5-10 mph) to assess the surface conditions of each road and document certain physical characteristics (length, width, surface type). Each road was also documented on video and still photos.

### ***2.1 Road Observation***

There are many surface conditions to look at when assessing a road surface. These vary depending on the kind of surface the road has: pavement, gravel, concrete, or any other type of surface. Listed below are the common distresses looked for during the evaluation.

- **Asphalt Surface**
  - *Longitudinal / Transverse Cracking*
  - *Alligator Cracking*
  - *Edge Cracking*
  - *Patching / Potholes*
  - *Drainage*
  - *Roughness*
  - *Rutting*
- **Gravel Surface**
  - *Proper Crowning*
  - *Roadside Drainage*
  - *Corrugations*
  - *Dust*
  - *Potholes*
  - *Rutting*
  - *Loose Aggregate*



Although budget did not allow a detailed qualification of the distress, qualitative information was collected (Appendix B).

### 3.0 FINDINGS

Surface defects typically noted include alligator cracking, longitudinal/transverse cracking, edge cracking, and rutting, all of various severities. It should be noted that sub-surface investigations were not part of the evaluations. Any opinions rendered on subsurface conditions are based on the surface condition and previous experience with these types of roads. Further investigation including soil sampling may be warranted.


Based on site visits, visual evaluations and input from the Town, UE broke down each project area into sections (Figure 1) and prioritized each section's level of importance as shown in the tables in Appendix B. The priority ratings are described as follows:

**Table 1 – Road Assessments**

Priority Level	Description
1	High priority, immediate action recommended (years 1 and 2)
2	Medium priority, action to be taken within the next five years (years 3, 4, and 5)
3	Low priority, deformations are present, repair may be deferred beyond five years (year 6+)

Findings for the roads evaluated are generally summarized as follows:

**Table 2 – Road Evaluations**

<b>BAY HILL ROAD</b>	
<b>General Assessment</b> <ul style="list-style-type: none"><li>▪ <b>Traffic:</b> Moderate</li><li>▪ <b>Condition:</b> Severe cracking, rutting, shoulder erosion</li><li>▪ <b>Previous Work:</b> Asphalt shim</li><li>▪ <b>Priority Level:</b> 1, 2 and 3</li></ul>	



## SHAW ROAD

### General Assessment

- **Traffic:** Moderate
- **Condition:** Severe cracking, rutting, shoulder erosion
- **Previous Work:**
- **Priority Level:** 1, 2 and 3



## HOWARD AVENUE, LUNEAU COURT, AND COFRAN AVENUE

### General Assessment

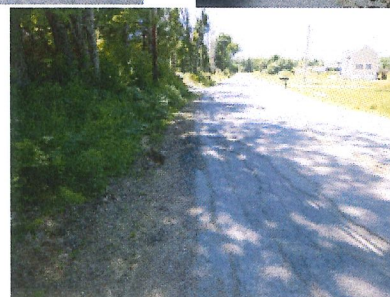
- **Traffic:** Low
- **Condition:** Severe cracking, rutting, shoulder erosion, sub-base failure
- **Previous Work:**
- **Priority Level:** 2 and 3



## ZION HILL ROAD

### General Assessment

- **Traffic:** Moderate
- **Condition:** Moderate cracking, rutting, shoulder erosion
- **Previous Work:** Spot Shim
- **Priority Level:** 1

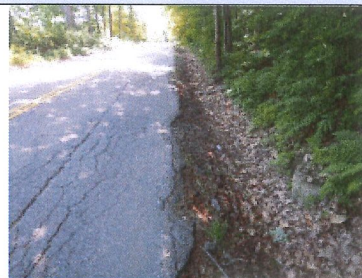




## SHAKER ROAD

### General Assessment

- **Traffic:** Moderate
- **Condition:** Severe cracking, rutting, shoulder erosion, trench repair needed
- **Previous Work:** Spot shim
- **Priority Level:** 2 and 3



## 4.0 PROPOSED REPAIRS

### 4.1 Repair Strategies

UE has provided in Appendix A typical construction details for road repair and drainage management used for the basis of this evaluation. Roadway repairs typically range from reclaimed base stabilization, to full roadway depth reconstruction, and added drainage management as described as follows:

- **Reclaimed Base Stabilization** – Is considered when the overall structure and shape of the road appears to be in good condition and the subbase does not appear to be failing (i.e. aged road which maintains a good crown). By pulverizing the existing asphalt and mixing it with existing base a more stable road structure is created that is not provided with an overlay. Drainage improvements are also typically added to prevent premature failure.
- **Full Depth Roadway Reconstruction** – This process is used when the roadway surface and base are failing. This process provides up to 20" of select gravel and 4" of pavement. Drainage improvements are also typically completed to prevent premature road failure.
- **Drainage Management** – How a road sheds water and drains is vital to a long service life as failures are typically a result of poor drainage conditions. Drainage improvements (underdrains, swales, culvert repair, and catch basins) should be completed on all roads, particularly prior to resurfacing.

### 4.2 Recommendations and Opinion of Costs

The roadways assessed by Underwood Engineers all express varying degrees of deformation and require appropriate repair. Specific areas on Bay Hill Road, Shaw Road, and Zion Hill Road

display significant roadway deformations that require immediate action as shown in Figure 1 (Appendix A) as Priority 1 areas. Recommendations and opinion of costs have been outlined below as a 5-year program (Tables 3 and 4) to summarize yearly budget needs (see Section 6).

Additional evaluations may be needed to narrow down the priority areas further. Soil investigations are also recommended to determine the most effective method of repair. The costs provided in Table 3 reflect a generalized approximation of costs needed to reconstruct the targeted areas and may differ upon actual roadway design.

Table 3 below highlights recommended repair strategies for high priority (priority 1) roadway sections where budget allocations should be considered for the next two years. Based on their deteriorating conditions and higher traffic volumes, these sections were determined to be high priority as a result of our assessment and input from the Town.

**Table 3 – Recommended Priority 1 Projects (Years 1 and 2)**

Area	Description	Unit	Costs
<b>Bay Hill Road Section 3 <sup>(1)</sup></b>	<ul style="list-style-type: none"> <li>Full Depth Reconstruction</li> <li>Drainage Improvements</li> </ul>	1,100 feet	\$ 155,000
<b>Shaw Road Section 1</b>	<ul style="list-style-type: none"> <li>Full Depth Reconstruction</li> <li>Drainage Improvements</li> </ul>	1,000 feet	\$ 128,000
<b>Zion Hill Road</b>	<ul style="list-style-type: none"> <li>Reclaimed Stabilized Base with stone added</li> <li>Full Depth Reconstruction (Remove and Rehandle)</li> <li>Drainage Improvements</li> </ul>	5,000 feet	\$ 536,000
<b>Shaker Road</b>	<ul style="list-style-type: none"> <li>Cross Drain Trench Repairs</li> </ul>	10	\$ 11,000
<b>Subtotal</b>		<b>7,100 feet</b>	<b>\$ 830,000</b>
Incidentals and Contingencies (15%):			\$ 124,500
Recommended Design and Construction Engineering (15%) <sup>(2)</sup> :			\$ 124,500
<b>TOTAL OPINION OF PROBABLE COSTS:</b>			<b>\$1,079,000</b>
<b>Annual Cost (years 1 and 2):</b>			<b>\$540,000</b>

1. Per request of the Town, additional analysis was completed on Bay Hill Road – Section 3 to review drainage improvement needs and to provide a construction budget. Findings for that section were summarized in a brief technical memorandum (Appendix D). The budget above has taken these findings into consideration.
2. See section 5 for additional discussion on rural road failures and the benefits of engineering.

Table 4 below provides recommendations for road sections categorized as Priority 2. These sections are still considered to be in poor condition, however repairs may not be as critical as Priority 1 sections. It is recommended these sections be considered priorities for repairs in the next five years.





**Table 4 – Recommended Priority 2 Projects (years 3, 4, and 5)**

Area	Description	Unit	Costs
<b>Bay Hill Road Sections 4 and 5</b>	<ul style="list-style-type: none"> <li>Full Depth Reconstruction</li> <li>Drainage Improvements</li> </ul>	4,600 feet	\$ 392,000
<b>Shaw Road Sections 2 and 3</b>	<ul style="list-style-type: none"> <li>Full Depth Reconstruction</li> <li>Drainage Improvements</li> </ul>	1,600 feet	\$ 185,000
<b>Luneau Court</b>	<ul style="list-style-type: none"> <li>Reclaimed Stabilized Base (Process in Place)</li> <li>Drainage Improvements</li> </ul>	300 feet	\$ 17,000
<b>Cofran Avenue</b>	<ul style="list-style-type: none"> <li>Full Depth Reconstruction</li> <li>Reclaimed Stabilized Bas with Stone Added</li> <li>Drainage Improvements</li> <li>Curbing</li> </ul>	2,000 feet	\$ 182,000
<b>Shaker Road Sections 2-9</b>	<ul style="list-style-type: none"> <li>Reclaimed Stabilized Base</li> <li>Full Depth Reconstruction</li> <li>Guard Rail</li> <li>Drainage Improvements</li> </ul>	12,200 feet	\$ 1,062,000
<b>Subtotal</b>		<b>20,700 feet</b>	<b>\$ 1,838,000</b>
Incidentals and Contingencies (15%):			\$ 276,000
Recommended Design and Construction Engineering (15%):			\$ 276,000
<b>TOTAL OPINION OF PROBABLE COSTS:</b>			<b>\$2,390,000</b>
<b>Annual Cost (years 3-5):</b>			<b>\$800,000</b>

The values shown in Tables 3 and 4 represent a budgetary cost for recommended repair strategies. A breakdown of costs for the entire road length and priority areas can be found in Appendix B. UE recommends including an additional 15% for any incidentals and contingencies that may arise during a project, and 15% for engineering services.

Engineering budget provided is based on providing contract documents for bidding and periodic construction phase services only. Additional discussion with the Town may be needed to review the engineering level of effort.

In addition to the budgets provided above Underwood Engineers recommends completion of a Town wide road evaluation to further prioritize required work and to aid in implementation of a 20 year capital improvement plan and appropriate budget schedule. The budget cost previously provided to the Town is \$50,000 to complete this work. See Appendix E for the draft scope of these services.

## 5.0 BENEFITS OF ENGINEERING

Road failures are primarily caused by poor subsurface conditions, poor drainage conditions, and the increased traffic volumes. Historically, rural roadways were not constructed to the same standards as today. Roads today are engineered and reconstructed using the appropriate gravel and pavement thickness required to support today's traffic volumes. Drainage improvements are



also important as standing water in and around roadway gravels will lead to premature deterioration. Though routine maintenance (crack sealing, ditch cleaning, shoulder leveling, etc.) should be completed on a regular basis, a properly constructed and maintained roadway will not need significant maintenance (overlays) for at least ten years and rehabilitation will not be required for at least twenty years.

Engineering services typically fall into two categories, Design Phase and Construction Phase, and generally include the following but can be tailored to meet a specific Town's need:

- Design Phase
  - Subsurface Investigations
  - Topographic Survey within Town ROW
  - Preparation of Construction Drawings
  - Preparation of Project Manual (i.e. Contract Documents)
    - Contract
    - Project Unit Prices
    - General Conditions
    - Project Specifications
    - QA/QC Requirements
  - Providing suggested easement documents
  - Assistance with Project Bidding
- Construction Phase
  - Site observation to confirm conformance with Contract Documents
  - Review and Preparation of Pay Applications
  - Review and Approval of Change Orders
  - Project Close Out
    - Punchlist
    - Warranty Period
    - Contract Close Out Documents
  - Record Drawings

## 6.0 SUMMARY

We recommend the following yearly budget over the next 5 years to complete the scope of recommended repairs and engineering as outlined above. It may be possible for the Town to adjust these budget numbers in the future based on the results and findings of a Town wide road evaluation (budgeted below as the Report Phase, \$50,000).

**Table 5 – Recommended Yearly Budgets (5 years)**

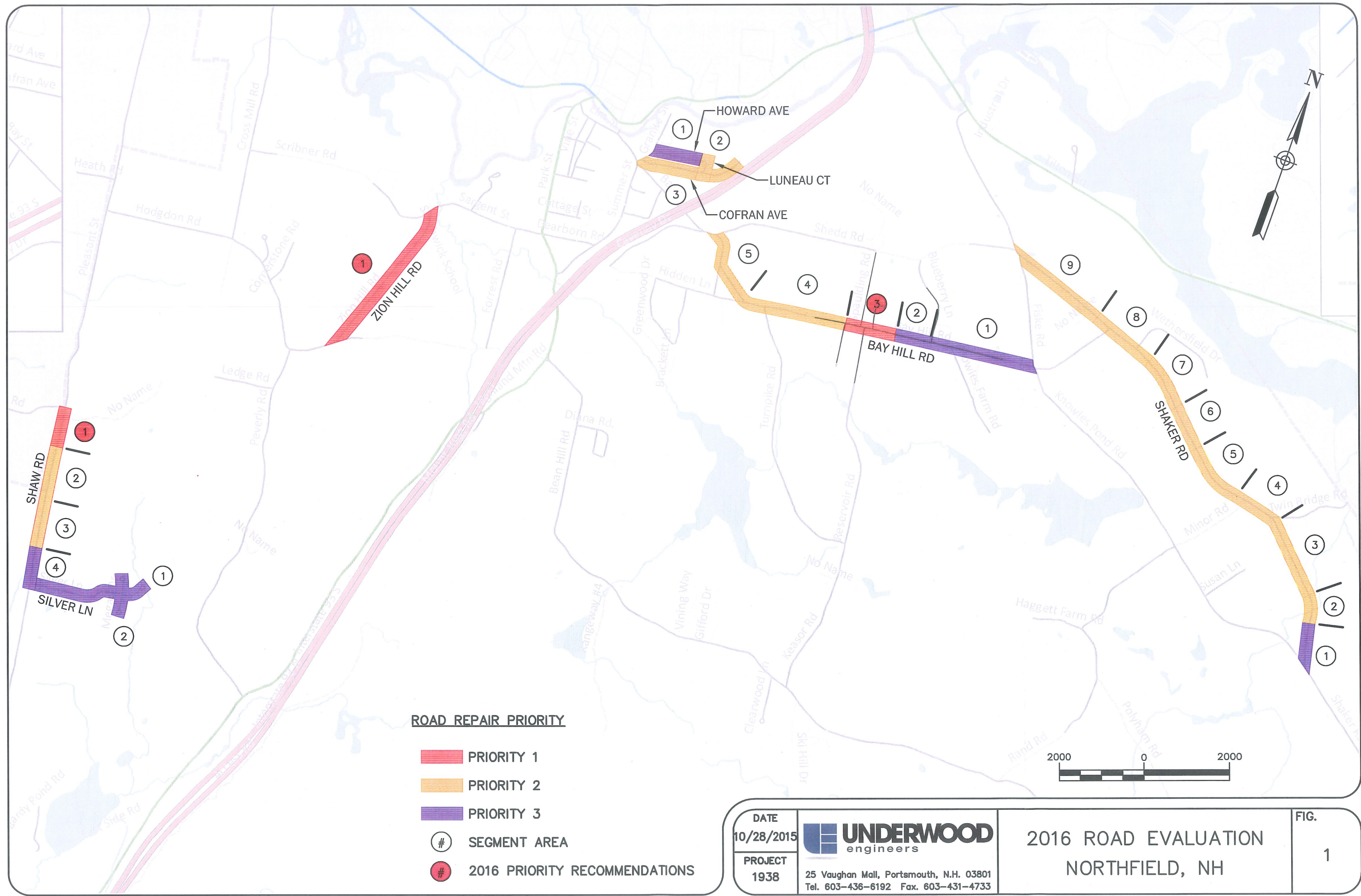
	2016	2017	2018	2019	2020
Construction and Contingencies	\$ 478,000	\$ 478,000	\$ 708,000	\$ 708,000	\$ 708,000
Eng. Design and Construction	\$ 62,000	\$ 62,000	\$ 92,000	\$ 92,000	\$ 92,000
Engineering (Report Phase)	\$ 50,000				
Total Recommended Budget	\$ 590,000	\$ 540,000	\$ 800,000	\$ 800,000	\$ 800,000



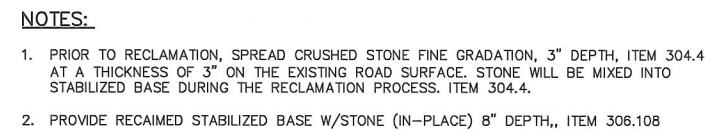
## **Appendix A**

### **Figures**

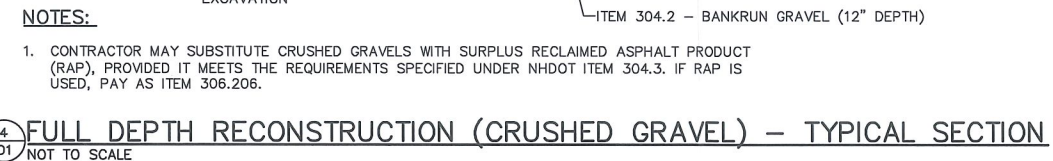
H:\Real Numbers\Northfield, NH\1938-2016 Roadway Evaluation\Drawings\1938 figure.dwg, Fig 1, 10/28/2015 4:02:01 PM, rmg








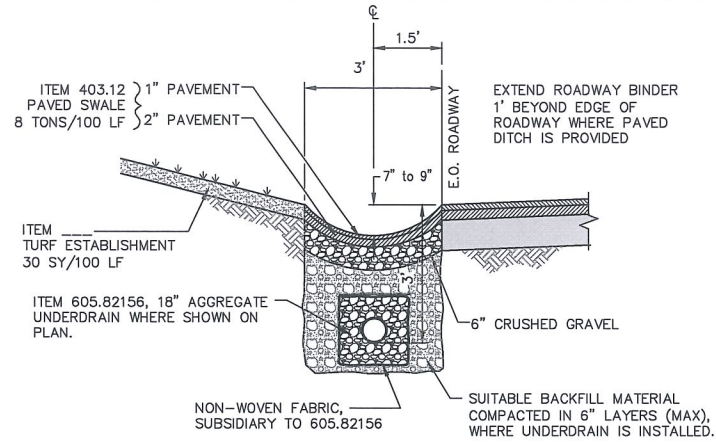
2 RECLAIMED STABILIZED BASE (STONE ADDED) – TYPICAL SECTION  
D1 NOT TO SCALE



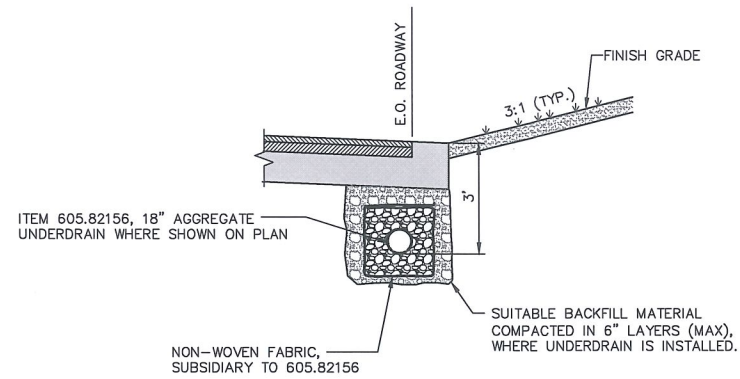
1. ALL ROADWAYS WILL, GENERAL, BE CONSTRUCTED AT THE EXISTING LINE AND GRADE UNLESS SHOWN OTHERWISE ON THE DRAWINGS OR DIRECTED BY THE ENGINEER. LINE GRADING FOR ROADWAY, SHOULDER, SLOPES AND DITCHES SHALL CONFORM TO THE REQUIREMENTS OF SECTION 214 OF THE NHDOT STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION (LATEST ADDITION). RECLAIMED BASE MATERIAL MAY BE USED FOR SHOULDER LEVELING.
2. DEPTH FOR COMMON EXCAVATION ASSUMES THAT PROPOSED FINISH GRADES GENERALLY MATCH EXISTING GRADE.
3. QUANTITIES SHOWN IS FOR ROAD WITH A PAVED WIDTH OF 24'

DWG NO D1		STANDARD DETAILS		 <b>UNDERWOOD</b> engineers  25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733	<table><tr><td>Drawn/Chk. — RMG</td><td>△</td></tr><tr><td>Designed — EBN</td><td>△</td></tr><tr><td>Checked —</td><td>△</td></tr><tr><td>Approved —</td><td>△</td></tr><tr><td>Date — JUL/2015</td><td>△</td></tr><tr><td>Book No. —</td><td>△</td></tr><tr><td>Project No. — 1938</td><td>△</td></tr><tr><td>Dwg. ID 1938-DETAILS</td><td>△</td></tr><tr><td>Scale — AS-SHOWN</td><td>△</td></tr></table>	Drawn/Chk. — RMG	△	Designed — EBN	△	Checked —	△	Approved —	△	Date — JUL/2015	△	Book No. —	△	Project No. — 1938	△	Dwg. ID 1938-DETAILS	△	Scale — AS-SHOWN	△	<table><tr><td colspan="2">REVISIONS</td><td>APP'D</td></tr><tr><td>NO.</td><td colspan="2"></td></tr></table>	REVISIONS		APP'D	NO.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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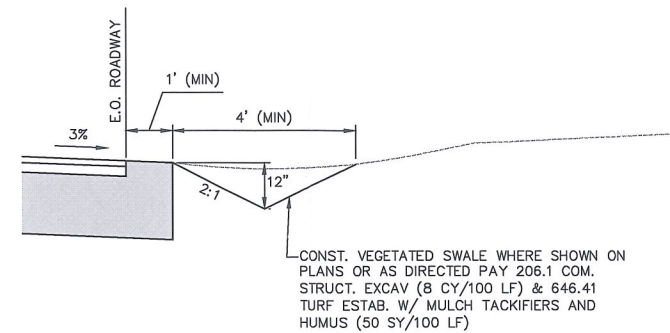




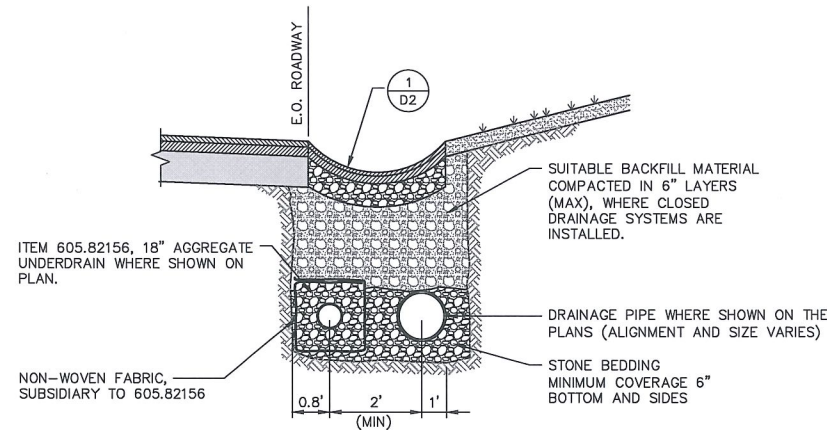
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PAVED DITCH DETAIL W/ UNDERDRAIN  
NOT TO SCALE



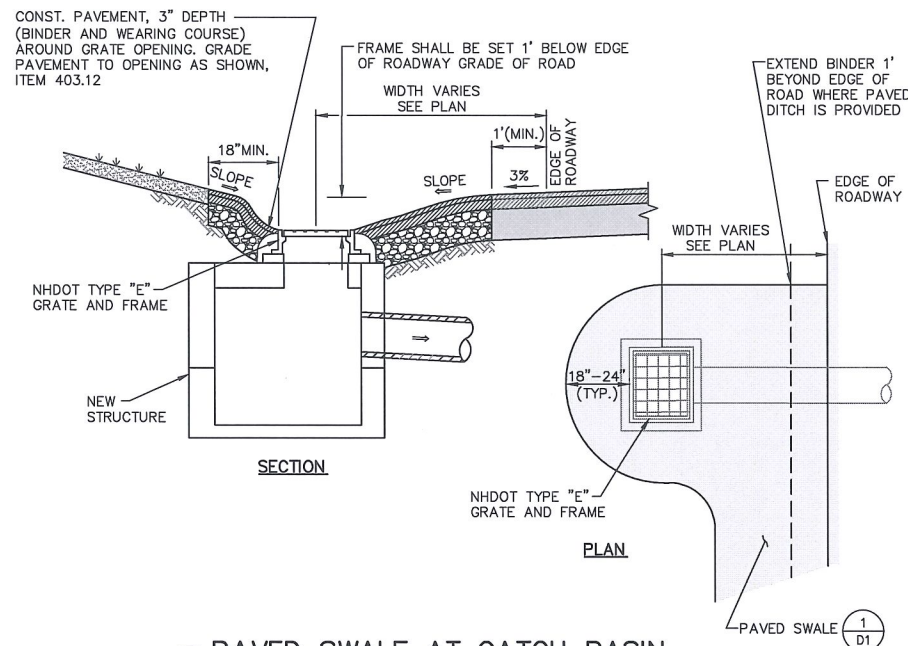
4  
D2  
TYPICAL ROAD DETAIL W/ UNDERDRAIN  
NOT TO SCALE



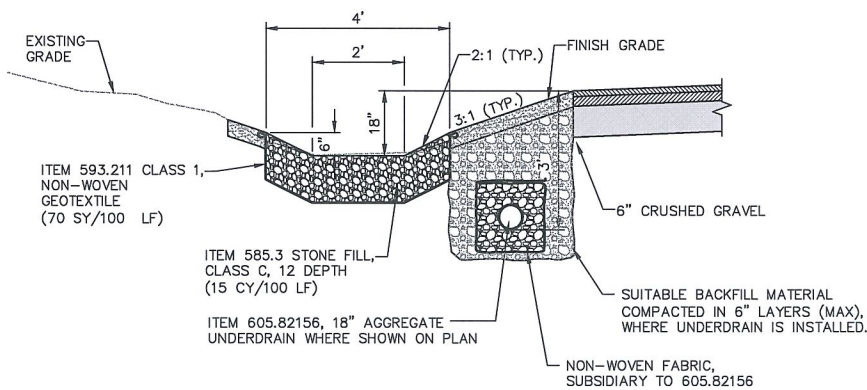
7  
D2  
VEGETATED SWALE DETAIL (12" DEPTH)  
NOT TO SCALE



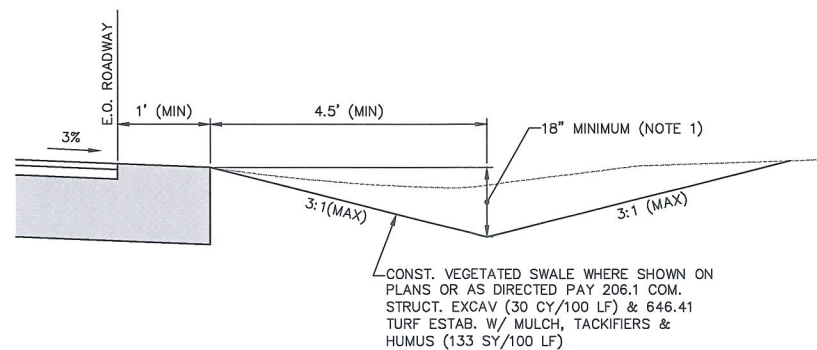
2  
D2  
TYPICAL TRENCH DETAIL W/ DRAIN & UNDERDRAIN  
NOT TO SCALE



5  
D2  
PAVED SWALE AT CATCH BASIN  
NOT TO SCALE



3  
D2  
STONE LINED DITCH  
NOT TO SCALE



6  
D2  
VEGETATED SWALE DETAIL (18" DEPTH)  
NOT TO SCALE

NOTES:

1. DEPTH OF DITCH TO BE 18", EXCEPT AT APPROACH CHANNEL TO CULVERTS. INCREASE DEPTH TO 2' AT APPROACH TO DRIVEWAY CULVERTS OR TO INVERT, WHICHEVER IS GREATER.

ISSUE FOR	BIDDING	CONSTRUCTION	RECORD DRAWING
By	By	By	By
Date	Date	Date	Date
APPROVED	APPROVED	APPROVED	APPROVED
DATE	DATE	DATE	DATE
NO.	NO.	NO.	NO.

**UNDERWOOD**  
engineers

25 Vaughan Mall, Portsmouth, N.H. 03801  
Tel. 603-436-6192 Fax. 603-431-4733

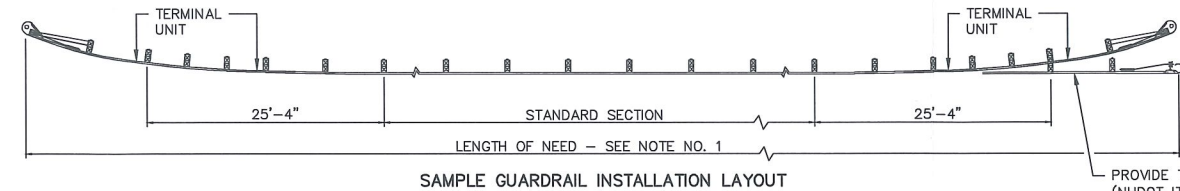
STANDARD DETAILS  
2016 ROADS EVALUATION  
TOWN OF NORTHFIELD  
NORTHFIELD, NEW HAMPSHIRE



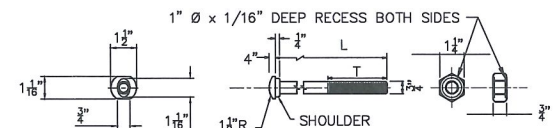
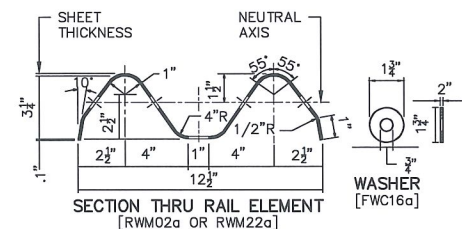
PIPE I.D.	Wt (INCHES)	Wp (INCHES)
1-21 INCHES	84	108
24-30 INCHES	96	120
> 30 INCHES	108	132



1. BEDDING: BEDDING FOR PIPES SHALL CONSIST OF PREPARING THE BOTTOM OF THE TRENCH TO SUPPORT THE ENTIRE LENGTH OF THE PIPE AT A UNIFORM SLOPE AND ALIGNMENT. CRUSHED GRAVEL (NHDOT ITEM 304.3) OR CRUSHED STONE SHALL BE USED TO BED THE PIPE TO THE ELEVATION SHOWN ON THE DRAWINGS.
2. COMPACTION: ALL BACKFILL SHALL BE COMPACTED AT OR NEAR OPTIMUM MOISTURE CONTENT BY PNEUMATIC TAMPERS, VIBRATORY COMPACTORS OR OTHER APPROVED MEANS. BACKFILL BENEATH PAVED SURFACES SHALL BE COMPACTED TO NOT LESS THAN 95 PERCENT OF AASHTO T99, METHOD C (STANDARD PROCTOR).
3. SUITABLE MATERIAL: IN ROADS, ROAD SHOULDERS, WALKWAYS AND TRAVELED WAYS, SUITABLE MATERIAL FOR TRENCH BACKFILL SHALL BE THE NATURAL MATERIAL EXCAVATED DURING THE COURSE OF CONSTRUCTION, BUT SHALL EXCLUDE DEBRIS; PIECES OF PAVEMENT; ORGANIC MATTER; TOP SOIL; ALL WET OR SOFT MUCK, PEAT, OR CLAY; ALL EXCAVATED LEDGE MATERIAL; ROCKS OVER 6 INCHES IN LARGEST DIMENSION; FROZEN EARTH AND ANY MATERIAL WHICH, AS DETERMINED BY THE ENGINEER, WILL NOT PROVIDE SUFFICIENT SUPPORT OR MAINTAIN THE COMPLETED CONSTRUCTION IN A STABLE CONDITION. IN SEEDER AREAS, SUITABLE MATERIAL SHALL BE AS DESCRIBED ABOVE, EXCEPT THAT THE ENGINEER MAY PERMIT THE USE OF TOP SOIL, LOAM, ROCKS UNDER 12", FROZEN EARTH OR CLAY, IF HE/SHE IS SATISFIED THAT THE COMPLETED CONSTRUCTION WILL BE ENTIRELY STABLE AND PROVIDED THAT EASY ACCESS TO THE PIPE WILL BE PRESERVED.
4. BASE COURSE AND PAVEMENT: SHALL MEET THE REQUIREMENTS OF THE NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION'S LATEST EDITION OF THE STANDARD SPECIFICATIONS FOR HIGHWAYS AND BRIDGES - DIVISIONS 300 AND 400 RESPECTIVELY.
5. DRAINAGE PIPE: PIPE MATERIALS SHALL BE EITHER POLYVINYL CHLORIDE (PVC) REINFORCED CONCRETE (RC) OR CORRUGATED POLYETHYLENE (CPE). THE OWNER RESERVES THE RIGHT TO DETERMINE WHICH PIPE MATERIALS ARE USED FOR THE PROJECT.
6. W=MAXIMUM ALLOWABLE TRENCH WIDTH: FOR ROCK EXCAVATION, FOR ORDERED EXCAVATION BELOW GRADE AND HANDLING OF EXCAVATED CONTAMINATED SOILS. FOR PIPES 15 INCHES NOMINAL DIAMETER OR LESS, W SHALL BE NO MORE THAN 36 INCHES. FOR PIPES GREATER THAN 15 INCHES IN NOMINAL DIAMETER, W SHALL BE 24 INCHES PLUS PIPE OUTSIDE DIAMETER (O.D.)
7. THE DIMENSIONS SHOWN SHALL BE CONSIDERED MAXIMUM PAVEMENT PAYMENT WIDTHS FOR 0'-10" DEEP CONSTRUCTION. Wt AND Wp SHALL BE INCREASED BY 4'-0" FOR TRENCHES 10'-10" TO 15" AND BY 8'-0" FOR TRENCHES 15' TO 20' IN DEPTH.

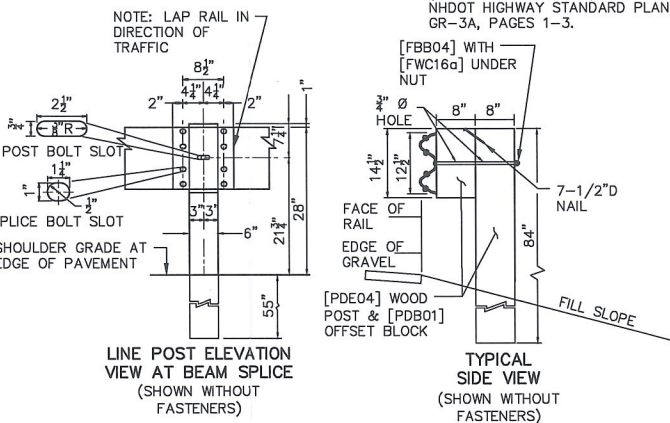


## SAMPLE GUARDRAIL INSTALLATION LAYOUT



DESIGNATOR	L	T	INTENDED USE
FBB01	1½"	FULL LENGTH THREAD	RAIL SPLICE BOLTS
FBB02	2"	1'-9"	POST BOLT (STEEL POSTS)
FBB03	10½"	4'-0"	POST BOLT
FBB04	18½"	4'-0"	POST BOLT (WOOD POSTS)
FBB05	25½"	4'-0"	POST BOLT (DOUBLE-FACED RAIL)

3/4 INCH BUTTON HEAD BOLT AND RECESSED NUT  
[FBB01-05]



RECTANGULAR PLATE WASHER  
[FWR03] (6 REQ'D)  
(SEE NOTE NO. 3)

3 NHDOT BEAM GUARDRAIL STANDARD SECTION WOOD POST & HARDWARE DETAILS  
D3 NOT TO SCALE



- ### GENERAL NOTES:
1. LENGTH OF NEED IS THE TOTAL LENGTH OF GUARDRAIL AS SHOWN ON PLANS.
  2. DESIGNATIONS PROVIDED IN BRACKETS [ ] REFERENCE STANDARD ELEMENTS DETAILED IN A GUIDE TO STANDARDIZED HIGHWAY BARRIER HARDWARE, 1995, AASHTO-AGC-ARTBA JOINT HARDWARE COOPERATIVE COMMITTEE.
  3. THE RECTANGULAR PLATE WASHER [FWR03] IS USED ONLY FOR 38.1 FEET OF STANDARD SECTION UPSTREAM OF A TERMINAL UNIT TYPE G-2 (SEE STANDARD NO. GR-5).
  4. USE 12.8 FOOT LENGTH RAIL ELEMENT IN CURVES OF LESS THAN 333.3 FEET RAIL RADIUS.
  5. ALL DIMENSIONS SUBJECT TO MANUFACTURER'S TOLERANCES.
  6. USE [PDE02] 6.1 FEET LONG POSTS WHEN FILL SLOPE IS 4:1 OR FLATTER AND/OR WHEN FIELD CONDITIONS DICTATE (E.G., LEDGE FILLS), AS DETERMINED BY THE ENGINEER.
  7. WHEN GUARDRAIL IS INSTALLED BEHIND CURB, EITHER 6 FEET BEHIND SLOPE CURB OR A CURBED RAMP OR AT THE BACK OF SIDEWALK WITH BARRIER CURB, THE RAIL HEIGHT SHALL BE SET FROM THE GRADE AT THE FACE OF RAIL.

[illegible]

## Appendix B

### Opinion of Probable Costs



BAY HILL ROAD = Approximately 1.66 Miles (8,770 feet)								
Area	Description	Existing Condition	Priority	Proposed Construction	Unit Cost per foot	Length (ft)	Cost	Total Cost
1	From Fiske Rd west bound to Blueberry Ln, relatively flat at first then uphill.	Fairly good, appears recently paved, longitudinal cracking appears. Minor cracking at shoulder pavement interface	3	(2/D1) Stabilized Base with Stone added	\$64.00	2,500	\$160,000	\$160,000
2	From Blueberry Ln to peak of Bay Hill Road (end of newer pavement).	Hill levels out, more E.O.P cracking, ditch on left hand side, as hill crests and begins downward slope more cracking appears.	3	(2/D1) Stabilized Base with Stone added	\$64.00	615	\$39,360	\$39,360
3	From Crest of hill to Spaulding Rd	Alligator cracking evident on leftside, road uneven due to frost heaves, heavy shoulder erosion at EOP. Sub-base collapse evident, rutting appears. Heavy longitudinal crackin appears near Drake Rd as well as rutting and alligator cracking. Roadway worsens towards Reservoir Rd.	1	(5/D1) Full Depth Recon (remove and rehandle)	\$92.00	1,060	\$97,520	\$155,320
				See Appendix D for drainage improvement costs	\$57.80	1,000	\$57,800	
4	From Spaulding Rd to Hidden Lane	Road begins to level out, road deformations lessen, transitional and longitudinal cracking occurs, rutting does appear on leftside, heavier rutting near woodlawn ave. heavy aligator cracking in spots as well as heavy longitudinal cracking. Potholes begin appearing	2	(5/D1) Full depth Recon (remove and rehandle)	\$92.00	2,695	\$247,940	\$247,940
5	Hidden Lane to Bay Street	Alligator cracking and longitudinal cracks continue, roadway fairly level. High EOP cracking at shoulder, potholes and rutting, large potholes near WB Hill Rd.	2	(3/D1) Reclaimed stabilized base.	\$65.00	1,900	\$123,500	\$144,500
				Stone Lined Ditch w/o Underdrain	\$14.00	1,500	\$21,000	
SUBTOTAL								\$747,120
Incidentals and Contingencies (15%)								\$112,068
Recommended Design and Construction Engineering (15%)								\$112,068
TOTAL OPINION OF PROBABLE COSTS								\$971,256

SHAW ROAD = Approximately 0.81 Miles (4,277 feet)								
Area	Description	Existing Condition	Priority	Proposed Construction	Unit Cost per Foot	Length (ft)	Cost	Total Cost
1	From Giles Road heading South to 36 Shaw Rd.	Large longitudinal cracking at center of road and EOP, potholes and aligator cracking appear immediately, rutting occurs, very large longitudinal cracks appear around 1000' and heavy rutting continues.	1	(4/D1) Full depth reconstruction (crushed gravel)	\$100.00	1,000	\$100,000	\$128,000
				(3/D2) Stone Lined Ditch	\$40.00	700	\$28,000	
2	From 36 Shaw Rd to 71 Shaw Rd	Road begins to level out, minor rutting and minor longitudinal cracking, shoulder deterioration on RT, alligator cracking increases. Heavy rutting appears on LT near 55 Shaw Rd. Shoulder in poor condition LT. Potholes increases with rutting. Heavy longitudinal cracks	2	(5/D1) Full depth reconstruction	\$92.00	875	\$80,500	\$105,000
				(3/D2) Stone Lined Ditch without UD	\$14.00	1,750	\$24,500	
3	From 71 Shaw Rd to 91 Shaw Rd	Cracking lessens near 71 Shaw Rd, begins downward slope, alligator cracking continues, room for shoulder work. Longitudinal cracking and rutting along both EOPs, rutting and longitudinal cracking increases.	2	(5/D1) Full depth reconstruction	\$92.00	755	\$69,460	\$80,030
				(3/D2) Stonlined Ditch without UD. Install on one side of road	\$14.00	755	\$10,570	
4	From 91 Shaw Rd to Silver	Road deformation lessens, occasional longitudinal cracking, alligator cracking minor rutting occurs	2	(2/D1) Reclaimed stabilized base (stone added)	\$64.00	1,647	\$105,408	\$105,408
SUBTOTAL								\$418,438
Incidentals and Contingencies (15%)								\$62,766
Recommended Design and Construction Engineering (15%)								\$62,766
TOTAL OPINION OF PROBABLE COSTS								\$543,969



ZION HILL ROAD = Approximately .95 miles (5,016 feet)								
Area	Description	Existing Condition	Priority	Proposed Construction	Unit Cost per Foot	Length (ft)	Cost	Total Cost
1	Southbound from Sargent Rd to Hodgdon Road	Road deformations, longitudinal cracking and EOP cracking, RT shoulder needs drainage, small potholes visible, alligator cracking continues, EOP breakdown, rutting occurs, occasional large Longitudinal cracks appear,	1	(2/D1) Reclaimed Stabilized Base with Stone Added	\$64.00	3,516	\$225,024	\$535,524
				(5/D1) Full Depth Reconstruction (Remove and Rehandle)	\$92.00	1,500	\$138,000	
				Drainage Improvements <sup>1</sup>	\$57.50	3,000	\$172,500	
1. Linear Foot costs based on Bay Hill Road Drainage Evaluation Costs								\$535,524
SUBTOTAL								\$535,524
Incidentals and Contingencies (15%)								\$80,329
Recommended Design and Construction Engineering (15%)								\$80,329
TOTAL OPINION OF PROBABLE COSTS								\$696,181

COFRAN AND HOWARD AVENUES = Approximately .57 miles (3,010 feet)								
Area	Description	Existing Condition	Priority	Proposed Construction	Unit Cost per Foot	Length (ft)	Cost	Total Cost
1	Howard Avenue	Minor deformations, some alligator cracking at EOP, longitudinal cracking at center	3	(2/D1) Reclaimed Stabilized Base with Stone Added	\$64.00	1,226	\$78,464	\$149,664
				(1/D2) Paved Ditch with underdrain	\$35.00	1,000	\$35,000	
				(2/D3) Storm Drain Trench	\$40.00	800	\$32,000	
				(4/D3) Cape Cod Berm	\$14.00	300	\$4,200	
2	Luneau Court	Major Road deformation, Alligator cracking throughout, collapsed subbase, future drainage needed.	2	(1/D1) Reclaimed Stabilized Base (Process in Place)	\$56.00	300	\$16,800	\$16,800
3	Cofran Avenue	Major road deformations east of Luneau Court, Alligator cracking and rutting, subbase failure, West of Luneau less rutting longitudinal cracking some subbase issues and transitional cracking	2	(5/D1) Full Depth Reconstruction (Remove and Rehandle)	\$92.00	550	\$50,600	\$181,832
				(2/D1) Reclaimed Stabilized Base with Stone Added	\$64.00	1,438	\$92,032	
				(1/D2) Paved Ditch with underdrain	\$35.00	1,000	\$35,000	
				(4/D3) Cape Cod Berm	\$14.00	300	\$4,200	
SUBTOTAL							\$348,296	
Incidentals and Contingencies (15%)							\$52,244	
Recommended Design and Construction Engineering (15%)							\$52,244	
TOTAL OPINION OF PROBABLE COSTS							\$452,785	

SILVER LANE = Approximately .82 miles (4,315 feet)								
Area	Description	Existing Condition	Priority	Proposed Construction	Unit Cost per Foot	Length (ft)	Cost	Total Cost
1	Silver Lane	Minor road deformations, alligator cracking throughout, EOP deterioration and cracking worsening near intersection with Megan Dr.	3	(2/D1) Reclaimed Stabilized Base with Stone Added	\$64.00	3,064	\$196,096	\$196,096
2	Megan Drive and Sarah Lane	Alligator cracking throughout and occasional potholes	3	(2/D1) Reclaimed Stabilized Base with Stone Added	\$64.00	1,251	\$80,064	\$80,064
								<b>SUBTOTAL</b> \$276,160
								<b>Incidentals and Contingencies (15%)</b> \$41,424
								<b>Recommended Design and Construction Engineering (15%)</b> \$41,424
								<b>TOTAL OPINION OF PROBABLE COSTS</b> \$359,008



SHAKER ROAD = Approximately 2.36 Miles (12,460 feet)								
Area	Description	Existing Condition	Priority	Proposed Construction	Unit Cost per Foot	Length (ft)	Cost	Total Cost
1	Westbound from Knowles Pond to 585 Shaker Rd.	Alligator cracking, Longitudinal cracks at center of road, minor rutting begins to appear	3	(2/D1) Reclaimed Stabilized Base with Stone Added	\$64.00	820	\$52,480	\$52,480
2	585 Shaker to end of Guard Rail	Rd Condition worsens as approaches bend with guardrails (GR), Alligator cracking continues at center of road, room for shoulder work, rutting increases in GR area	2	(5/D1) Full Depth Reconstruction (Remove and Rehandle)	\$92.00	800	\$73,600	\$163,600
				Guard Rail	\$300.00	300	\$90,000	
3	End of Guard Rail to Twin Bridge Rd	Alligator cracking at center of road, low spots at center of road, Rutting occurs and slowly increases on LT, LT has longitudinal cracking and road	2	(2/D1) Reclaimed Stabilized Base with Stone Added	\$64.00	2,276	\$145,664	\$145,664
4	Twin Bridge Rd to 400 Shaker Rd	Initially Rd in fairly good condition, minor alligator cracking at center, Drain trench repair needed near 400 Shaker Rd, Alligator cracking increases, rutting begins to occur	2	(2/D1) Reclaimed Stabilized Base with Stone Added	\$64.00	1,000	\$64,000	\$65,100
				(1/D3) Cross Drain Trench Repair	\$1,100.00	1	\$1,100	
5	400 Shaker Rd To 411 Shaker Road	Road begins to go uphill, minor deformation at culvert crossing, constant alligator cracking at center of road, occasional rutting and EOP cracking especially on LT.	2	(2/D1) Reclaimed Stabilized Base with Stone Added	\$64.00	700	\$44,800	\$45,900
				(1/D3) Cross Drain Trench Repair	\$1,100.00	1	\$1,100	
6	411 Shaker Rd to 349 Shaker Rd	Increased rutting and longitudinal cracking on LT, occasional rutting on RT, Road begins to level out, appears several patches have been installed, possible 3 trench repairs	2	(5/D1) Full Depth Reconstruction (Remove and Rehandle)	\$92.00	1,690	\$155,480	\$158,780
				(1/D3) Cross Drain Trench Repair	\$1,100.00	3	\$3,300	
7	349 Shaker Rd to 300 Shaker Rd	Alligator and longitudinal cracking continues, rutting is occasional, shoulder drainage needed. Large pothole near 300 Shaker	2	(2/D1) Reclaimed Stabilized Base with Stone Added	\$64.00	1,000	\$64,000	\$126,960
				(5/D1) Full Depth Reconstruction (Remove and Rehandle)	\$92.00	380	\$34,960	
				(3/D2) Stone Lined Ditch without UD	\$14.00	2,000	\$28,000	
8	300 Shaker Rd to 231 Shaker Road.	Road initially in good shape, longitudinal cracking appears on LT, large longitudinal crack on RT with potholes, heavy rutting on the LT, RT looks in fairly good shape, shoulder drainage needed on LT, at least 5Trench repairs needed, heavy rutting has been patched recently	2	(5/D1) Full Depth Reconstruction (Remove and Rehandle)	\$92.00	1,300	\$119,600	\$178,500
				(2/D1) Reclaimed Stabilized Base with Stone Added	\$64.00	550	\$35,200	
				(1/D3) Cross Drain Trench Repair	\$1,100.00	5	\$5,500	
				(3/D2) Stone Lined Ditch without UD	\$14.00	1,300	\$18,200	
9	231 Shaker Road to	Alligator cracking in center of roadand on LT EOP, large potholes from Alligator cracking breaking apart, trench repair, minor rutting	2	(2/D1) Reclaimed Stabilized Base with Stone Added	\$64.00	2,500	\$160,000	\$177,300
				(3/D2) Stone Lined Ditch without UD	\$14.00	1,000	\$14,000	
				(1/D3) Cross Drain Trench Repair	\$1,100.00	3	\$3,300	
SUBTOTAL								\$1,114,284
Incidentals and Contingencies (15%)								\$167,143
Recommended Design and Construction Engineering (15%)								\$167,143
TOTAL OPINION OF PROBABLE COSTS								\$1,448,569

**Appendix C**  
**Town Road Rankings and Summary of Previous**  
**Work**





## ROAD RANKINGS

### Scale Notes

Traffic	1 = Minimal	2	3	4	5 = High Volume
Role in Emerg. Response Network	1 = Minor	2	3	4	5 = Critical
Condition in 2013	1 = Good	2	3	4	5 = Poor
Annual Operating Cost	1 = Minimal	2	3	4	5 = Extensive

**Traffic** is a measure of road use, using actual traffic count figures whenever available and estimates from the Highway Superintendent and Police Chief when traffic counts are unavailable.

**Role of Emergency Response Network** is a measure of the degree to which the road is a central part of the response network as determined by the Police Chief and Highway Superintendent, including the degree to which the road serves as a collector in addition to providing residential and commercial access

**Condition in 2013** is a measure of the road surface condition at the current time.

**Annual Operating Cost** is a measure of the cost of maintaining the road above and beyond what is required for regular winter maintenance.

STREET	SURFACE	LENGTH	Traffic 1	Role in Emg Resp. Network 1	Road Conditions 3	Operating Cost 2	Ranking as of 4.16.2014
Bay Hill Rd	Asphalt	1.20	4.5	4.5	4	4	29
Rand Rd	Asphalt	0.60	2	2	5	5	29
Cofran Av	Asphalt	0.47	2	2	5	5	29
Silver Ln	Asphalt	0.58	1.5	2	5	5	28.5
Zion Hill Rd	Asphalt	0.95	5	4.5	3.5	4	28
Watson St	Asphalt	0.09	1	1.5	5	5	27.5
Bean Hill Rd #2	Asphalt	1.00	3.5	3.5	4	4	27
Knowles Pond Rd	Asphalt	1.80	3	3	4	4	26
Reservoir Rd #2	Asphalt	0.49	2.5	2.5	5	3	26
Lineau Ct	Asphalt	0.05	1.5	1.5	5	4	26
Shaker Rd #2	Asphalt	2.00	4.5	4.5	3.5	3	25.5
Sarah Ln	Asphalt	0.12	1	2	4	5	25
Arch St	Asphalt	0.27	2.5	3.5	5	2	25
Vine St	Asphalt	0.28	3	3	5	2	25
Blueberry Ln	Asphalt	0.40	1	1.5	4	5	24.5
Megan Dr	Asphalt	0.13	1	1.5	4	5	24.5
Shaw Rd	Asphalt	0.80	3	3	4	3	24
Shaw Rd	Unpaved	1.28	3	3	4	3	24
Holmes Av	Asphalt	0.15	2.5	2.5	5	2	24
Memorial St	Asphalt	0.07	2	3	5	2	24
Ledge Rd	Unpaved	0.27	2	2.5	3	5	23.5
Shaker Rd	Unpaved	0.72	1.5	2	4	4	23.5
Howard Av	Asphalt	0.24	2	2.5	5	2	23.5
Ayers Rd	Unpaved	0.39	3	3	3	4	23
Wethersfield Dr	Asphalt	0.46	2	2	3	5	23
Peeverly Rd	Asphalt	1.71	3	3	3.5	3	22.5
Summer St	Asphalt	0.67	4.5	4.5	2.5	3	22.5
Elm St	Asphalt	0.23	3.5	4	3	3	22.5
Oak Hill Rd #1	Asphalt	0.80	3.5	4	3	3	22.5

STREET	SURFACE	LENGTH	Traffic 1	Role in Emg Resp. Network 1	Road Conditions 3	Operating Cost 2	Ranking as of 4.16.2014
Oak Hill Rd #2	Asphalt	1.20	3.5	4	3	3	22.5
Woodlawn Av	Asphalt	0.19	1	1.5	4	4	22.5
Drake Dr	Asphalt	0.15	1	1.5	4	4	22.5
Bean Hill Rd	Unpaved	0.51	2	3	3	4	22
Keasor Rd	Unpaved	0.53	2.5	2.5	3	4	22
Sargent St	Asphalt	0.52	4.5	4.5	3	2	22
Cottage St	Asphalt	0.15	1.5	1.5	5	2	22
Oak St	Asphalt	0.11	3	3.5	3	3	21.5
Rand Rd	Unpaved	0.40	2	2	3	4	21
Knowles Farm Rd	Unpaved	0.42	1.5	1.5	4	3	21
Granite St	Asphalt	0.27	2.5	3	3	3	20.5
Turnpike Rd	Asphalt	1.22	2.5	2.5	3	3	20
Union Rd	Asphalt	0.58	3.5	3.5	3	2	20
Stevens Rd	Unpaved	0.61	1.5	1.5	3	4	20
Diana Dr	Asphalt	0.40	2	2	4	2	20
Cross Mill Rd	Asphalt	1.21	4.5	4.5	2	2	19
Hodgdon Rd	Asphalt	1.16	4.5	4.5	2	2	19
Scribner Rd	Asphalt	0.34	2.5	3	3	2	18.5
Keasor Rd	Asphalt	0.17	2.5	2.5	3	2	18
W B Hill Rd	Asphalt	0.14	2	2	2	4	18
Haggett Farm Rd	Unpaved	0.23	1.5	1.5	3	3	18
Dearborn St	Asphalt	0.24	3.5	3.5	2	2	17
Twin Bridge Rd	Asphalt	0.36	3.5	3.5	2	2	17
Reservoir Rd #1	Asphalt	0.50	2.5	2.5	2	3	17
Greenwood Dr	Asphalt	0.59	2	2	3	2	17
Glines Park Rd	Asphalt	0.21	1.5	1.5	3	2	16
Forrest Rd #1	Asphalt	0.60	2.5	2.5	2	2	15
Scribner Rd	Unpaved	0.12	1	1	2	3	14
CONDITION 1 ROADS							
Shaker Rd #1	Asphalt	1.20	4.5	4.5	1	3	18
Bay St	Asphalt	0.40	4.5	4.5	1	3	18
Bean Hill Rd. frm. SAR	Asphalt	1.20	4.5	4.5	1	3	18
Fellows Hill Rd	Asphalt	0.92	3.5	3	1	3	15.5
Fiske Rd	Asphalt	0.50	4.5	4.5	1	1	14
Bay Hill Rd Ext.	Asphalt	0.40	3	4	1	2	14
Susan Ln	Asphalt	0.21	1.5	2	1	3	12.5
Fiddlers Choice Rd	Unpaved	0.45	1	1.5	1	3	11.5
Shedd Rd	Unpaved	0.21	1	1	1	3	11
Shedd Rd	Asphalt	0.74	2.5	2.5	1	1	10
Hidden Ln	Asphalt	0.42	1.5	1.5	1	2	10
Gale Av	Asphalt	0.14	1.5	1.5	1	1	8
Hill St	Asphalt	0.12	1.5	1.5	1	1	8
Johnson Rd	Asphalt	0.18	2	1	1	1	8
Johnson Rd	Unpaved	0.11	2	1	1	1	8



STREET	SURFACE	LENGTH	Traffic 1	Role in Emg Resp. Network 1	Road Conditions 3	Operating Cost 2	Ranking as of 4.16.2014
Riverside Rd	Asphalt	0.24	1.5	1.5	1	1	8
Tallwood Dr	Asphalt	0.17	1.5	1.5	1	1	8
Clearwood Ln	Asphalt	0.25	1	1.5	1	1	7.5
Gibson Mill Rd	Asphalt	0.10	1	1.5	1	1	7.5
View St	Asphalt	0.08	1	1.5	1	1	7.5
Caveney Dr	Unpaved	0.48	1	1	1	1	7
Cornerstone Rd	Asphalt	0.20	1	1	1	1	7
Forrest Rd #2	Unpaved	0.10	1	1	1	1	7
Forrest Rd #3	Unpaved	0.10	1	1	1	1	7
Kimball St	Asphalt	0.08	1	1	1	1	7
Lambert Rd	Unpaved	0.24	1	1	1	1	7

## Summary of recent road work

Road ranking has not been updated since 2014 work was done

STREET	SURFACE	LENGTH	Last Repair or Recon	Work Done	Traffic 1	Role in Emerg Response Network	Road Conditions 3	Operating Cost 4	Ranking as of 4.16.2014
Bay Hill Rd	Asphalt	1.20	2014	Partial grader shim	4.5	4.5	4	4	29
Rand Rd	Asphalt	0.60	2014	Repave	2	2	5	5	29
Cofran Av	Asphalt	0.47			2	2	5	5	29
Silver Ln	Asphalt	0.58			1.5	2	5	5	28.5
Zion Hill Rd	Asphalt	0.95	2011	Spot shim	5	4.5	3.5	4	28
Watson St	Asphalt	0.09			1	1.5	5	5	27.5
Bean Hill Rd #2	Asphalt	1.00	2014	Partial grader shim	3.5	3.5	4	4	27
Knowles Pond Rd	Asphalt	1.80			3	3	4	4	26
Reservoir Rd #2	Asphalt	0.49	2012	Grind/Repave	2.5	2.5	5	3	26
Lineau Ct	Asphalt	0.05			1.5	1.5	5	4	26
Shaker Rd #2	Asphalt	2.00	2012	Spot shim	4.5	4.5	3.5	3	25.5
Sarah Ln	Asphalt	0.12			1	2	4	5	25
Arch St	Asphalt	0.27			2.5	3.5	5	2	25
Vine St	Asphalt	0.28			3	3	5	2	25
Blueberry Ln	Asphalt	0.40			1	1.5	4	5	24.5
Megan Dr	Asphalt	0.13			1	1.5	4	5	24.5
Shaw Rd	Asphalt	0.80			3	3	4	3	24
Shaw Rd	Unpaved	1.28			3	3	4	3	24
Holmes Av	Asphalt	0.15			2.5	2.5	5	2	24
Memorial St	Asphalt	0.07			2	3	5	2	24
Ledge Rd	Unpaved	0.27			2	2.5	3	5	23.5
Shaker Rd	Unpaved	0.72			1.5	2	4	4	23.5
Howard Av	Asphalt	0.24			2	2.5	5	2	23.5
Ayers Rd	Unpaved	0.39			3	3	3	4	23
Wethersfield Dr	Asphalt	0.46			2	2	3	5	23
Peverly Rd	Asphalt	1.71			3	3	3.5	3	22.5
Summer St	Asphalt	0.67			4.5	4.5	2.5	3	22.5
Elm St	Asphalt	0.23			3.5	4	3	3	22.5
Oak Hill Rd #1	Asphalt	0.80			3.5	4	3	3	22.5
Oak Hill Rd #2	Asphalt	1.20	2012	Overlay	3.5	4	3	3	22.5
Woodlawn Av	Asphalt	0.19			1	1.5	4	4	22.5
Drake Dr	Asphalt	0.15			1	1.5	4	4	22.5
Bean Hill Rd	Unpaved	0.51			2	3	3	4	22
Keasor Rd	Unpaved	0.53			2.5	2.5	3	4	22
Sargent St	Asphalt	0.52			4.5	4.5	3	2	22
Cottage St	Asphalt	0.15			1.5	1.5	5	2	22
Oak St	Asphalt	0.11			3	3.5	3	3	21.5
Rand Rd	Unpaved	0.40			2	2	3	4	21
Knowles Farm Rd	Unpaved	0.42			1.5	1.5	4	3	21
Granite St	Asphalt	0.27			2.5	3	3	3	20.5
Turnpike Rd	Asphalt	1.22			2.5	2.5	3	3	20
Union Rd	Asphalt	0.58			3.5	3.5	3	2	20
Stevens Rd	Unpaved	0.61			1.5	1.5	3	4	20
Diana Dr	Asphalt	0.40			2	2	4	2	20
Cross Mill Rd	Asphalt	1.21	2010	shim/overlay	4.5	4.5	2	2	19
Hodgdon Rd	Asphalt	1.16	2010/2011	shim/overlay	4.5	4.5	2	2	19
Scribner Rd	Asphalt	0.34			2.5	3	3	2	18.5



STREET	SURFACE	LENGTH	Last Repair or Recon	Work Done	Traffic 1	Role in Emerg Response Network	Road Conditions 3	Operating Cost 4	Ranking as of 4.16.2014
Keasor Rd	Asphalt	0.17			2.5	2.5	3	2	18
W B Hill Rd	Asphalt	0.14			2	2	2	4	18
Haggett Farm Rd	Unpaved	0.23			1.5	1.5	3	3	18
Dearborn St	Asphalt	0.24			3.5	3.5	2	2	17
Twin Bridge Rd	Asphalt	0.36			3.5	3.5	2	2	17
Reservoir Rd #1	Asphalt	0.50			2.5	2.5	2	3	17
Greenwood Dr	Asphalt	0.59			2	2	3	2	17
Glines Park Rd	Asphalt	0.21			1.5	1.5	3	2	16
Forrest Rd #1	Asphalt	0.60			2.5	2.5	2	2	15
Scribner Rd	Unpaved	0.12			1	1	2	3	14
CONDITION 1 ROADS									
Shaker Rd #1	Asphalt	1.20			4.5	4.5	1	3	18
Bay St	Asphalt	0.40	2010	shim/overlay	4.5	4.5	1	3	18
Bean Hill Rd. frm. SAR	Asphalt	1.20	2012	Reconstruction	4.5	4.5	1	3	18
Fellows Hill Rd	Asphalt	0.92	2013	Grind/Repave	3.5	3	1	3	15.5
Fiske Rd	Asphalt	0.50	2013	Reconstruction	4.5	4.5	1	1	14
Bay Hill Rd Ext.	Asphalt	0.40	2012	shim/overlay	3	4	1	2	14
Susan Ln	Asphalt	0.21	2013	Grind/Repave	1.5	2	1	3	12.5
Fiddlers Choice Rd	Unpaved	0.45			1	1.5	1	3	11.5
Shedd Rd	Unpaved	0.21			1	1	1	3	11
Shedd Rd	Asphalt	0.74	2013	Grind/Repave	2.5	2.5	1	1	10
Hidden Ln	Asphalt	0.42			1.5	1.5	1	2	10
Gale Av	Asphalt	0.14			1.5	1.5	1	1	8
Hill St	Asphalt	0.12			1.5	1.5	1	1	8
Johnson Rd	Asphalt	0.18			2	1	1	1	8
Johnson Rd	Unpaved	0.11			2	1	1	1	8
Riverside Rd	Asphalt	0.24			1.5	1.5	1	1	8
Tallwood Dr	Asphalt	0.17			1.5	1.5	1	1	8
Clearwood Ln	Asphalt	0.25			1	1.5	1	1	7.5
Gibson Mill Rd	Asphalt	0.10			1	1.5	1	1	7.5
View St	Asphalt	0.08			1	1.5	1	1	7.5
Caveney Dr	Unpaved	0.48			1	1	1	1	7
Cornerstone Rd	Asphalt	0.20			1	1	1	1	7
Forrest Rd #2	Unpaved	0.10			1	1	1	1	7
Forrest Rd #3	Unpaved	0.10			1	1	1	1	7
Kimball St	Asphalt	0.08			1	1	1	1	7
Lambert Rd	Unpaved	0.24			1	1	1	1	7

**Appendix D**  
**Bay Hill Road Section 3 Drainage Analysis**





25 Vaughan Mall, Unit 1  
Portsmouth, NH, 03801-4012  
Tel: 603-436-6192 Fax: 603-431-4733

## Technical Memorandum

**DATE:** September 9, 2015  
**TO:** Glenn Smith, Town Administrator  
**FROM:** Daniel J. Rochette, P.E. and Erik B. Nichols EIT  
**RE:** Bay Hill Road Section 3 Drainage Analysis  
Northfield, New Hampshire

### INTRODUCTION

Underwood Engineers recently submitted a draft technical memorandum on July 30, 2015. After meeting with the Town's CIP Committee on August 19, 2015, the Town requested Underwood Engineers (UE) further evaluate Section 3 of Bay Hill Rd (approximately 1000 feet) with drainage improvements and provide an estimated opinion of costs for repairing the section.

This drainage evaluation builds off of the previous assessment of Bay Hill Road and has provided additional drainage improvements to Section 3 upon further analysis.

### BAY HILL ROAD: SECTION 3

Section 3 of Bay Hill Road begins approximately 600 feet west of Blueberry Lane and extends to the intersection of Spaulding Road. The section drops approximately 60 feet over its 1,000 foot length with limited drainage systems on both sides of the road. The roadway is in poor condition with alligator cracking, severe longitudinal cracking and rutting due to subbase failure and poor drainage. The intersection of Bay Hill Road and Reservoir Road appears to contain the most severe section of road deficiencies. The basis of these observations is from visual inspection, using past engineering experience. No subbase investigations were performed.

### DRAINAGE EVALUATION

Bay Hill's Section 3 lies within a 1 acre watershed that is mostly grass and pavement from the road. Using a 10 year-24 hour storm event, the peak runoff that can generate from within the watershed is approximately 2 CFS. It appears that existing drainage systems should be improved in order to prolong the lifespan of the road.



25 Vaughan Mall, Unit 1  
Portsmouth, NH, 03801-4012  
Tel: 603-436-6192 Fax: 603-431-4733

## PROPOSED IMPROVEMENTS

UE proposes the following drainage improvements in addition to the road improvements described in the July 30<sup>th</sup> Draft Memo:

- Paved swales with underdrain and storm drain
- Catch basins
- Stone lined ditches
- Vegetated swales
- New culvert at Reservoir Road with stabilized inlet and outlet. An 18" diameter pipe has been assumed for budgeting. However a 15" pipe may be adequate following further evaluation.

Stone lined ditches would be used appropriately wherever space will allow. In portions of the road where space is limited the use of paved swales and catch basins would be ideal for collecting and conveying stormwater away from the road with as little encroachment on neighboring properties as possible.

To address the Town's concerns about runoff flowing to Reservoir Road, an 18" culvert can be installed to convey the collected stormwater under Reservoir Road into an existing drainage area via new stone ditch. The attached **Figure 1** displays the locations of the proposed drainage improvements. Additionally, the Town may want to consider pursuing a drainage easement for the re-routing of runoff flows.

To aid in providing a better finished product, UE recommends completing the drain improvements with the road improvements to better establish grading required. Particularly for paved swales which tie into the shoulder of the roadway.

## ESTIMATED OPINION OF COSTS

The estimated opinion of costs for the Section 3 improvements are summarized as follows (See attached detailed breakdown):

**Table 1 – Estimated Opinion of Costs for Bay Hill Road Section 3 (Length Approx. 1,000 feet)**

Proposed Improvement	Cost
Full Depth Road Reconstruction (Remove and Rehandle)	\$ 98,000
Drainage Improvements	\$57,000
<b>Subtotal</b>	<b>\$155,000</b>
Incidentals and Contingencies (15%)	\$ 23,000
Recommended Design and Construction Engineering (15%)	\$ 23,000
<b>TOTAL OPINION OF PROBABLE COSTS</b>	<b>\$201,000</b>





25 Vaughan Mall, Unit 1  
Portsmouth, NH, 03801-4012  
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The values shown in Table 1 above represent a budgetary cost to reconstruct the roadway and provide drainage improvements based on the unit costs provided in the report. Refined costs would be established after design. UE recommends including an additional 15% for any incidentals and contingencies that may arise during a project, and 15% for engineering budgeting.

Engineering budget is based on providing survey and design services as well as contract documents for bidding and periodic construction phase services only.

Please do not hesitate to contact us with any questions you may have regarding this evaluation.

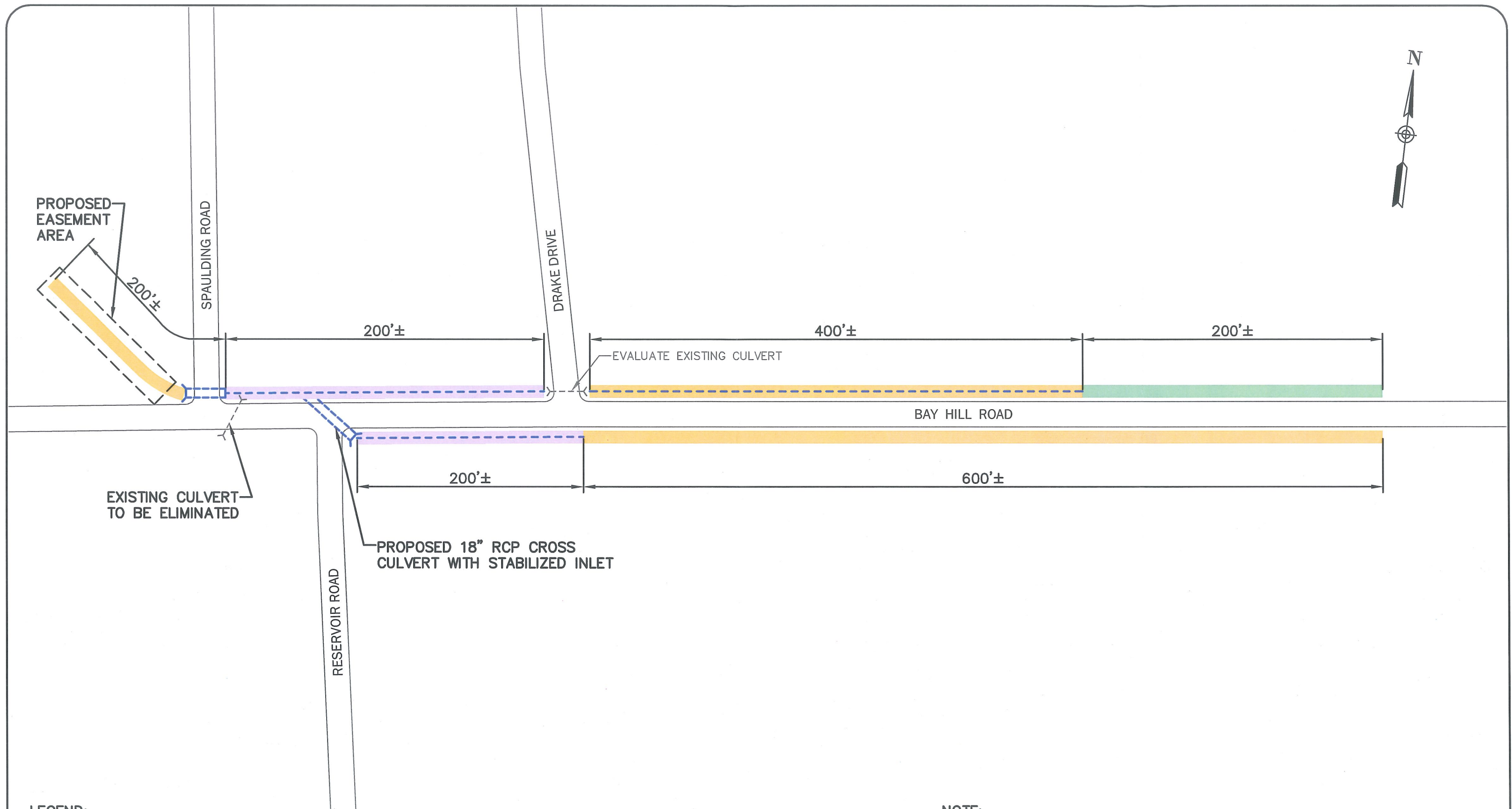
DRAFT

Bay Hill Section 3 Road Reconstruction Estimate (Previously Provided)								
Area	Description	Existing Condition	Priority	Proposed Construction	Unit Cost per foot	Length (ft)	Cost	Total Cost
3	From Crest of hill to Spaulding Rd	Alligator cracking evident on leftside, road uneven due to frost heaves, heavy shoulder erosion at EOP. Sub-base collapse evident, rutting appears. Heavy longitudinal crackin appears near Drake Rd as well as rutting and alligator cracking. Roadway worsens towards Reservoir Rd.	1	(5/D1) Full Depth Recon (remove and rehandle)	\$92.00	1,060	\$97,520	\$97,520
							SUBTOTAL	\$97,520
							Incidentals and Contingencies (15%)	\$14,628
							Recommended Design and Construction Engineering (15%)	\$14,628
							TOTAL OPINION OF PROBABLE COSTS	\$126,776

Bay Hill Section 3 Drainage Improvements								
Area	Description	Existing Condition	Priority	Proposed Construction	Unit Cost per foot	Length (ft)	Cost	Total Cost
3	From Crest of hill to Spaulding Rd	Alligator cracking evident on leftside, road uneven due to frost heaves, heavy shoulder errosion at EOP. Sub-base collapse evident, rutting appears. Heavy longitudinal crackin appears near Drake Rd as well as rutting and alligator cracking. Roadway worsens towards Reservoir Rd.	1	(3/D2) Stone Lined Ditch	\$14.00	900	\$12,600	\$57,400
				(3/D2) Stone Lined Ditch w/UD	\$40.00	400	\$16,000	
				(7/D2) Vegetated Swale (12" Depth)	\$4.00	200	\$800	
				(2/D2) Paved Swale w/ UD and Storm Drain	\$65.00	400	\$26,000	
				18" RCP Culvert	\$2,000.00	1	\$2,000	
SUBTOTAL							\$57,400	
Incidentals and Contingencies (15%)							\$8,610	
Recommended Design and Construction Engineering (15%)							\$8,610	
TOTAL OPINION OF PROBABLE COSTS							\$74,620	



H:\Real Numbers\Northfield, NH\1938-2016 Roadway Evaluation\Drawings\1938 figure.dwg, Fig 1 - Drain Improve, 10/28/2015 4:13:46 PM, rmg



**LEGEND:**

- STONE-LINED DITCH WITH UNDERDRAIN
- STONE-LINED DITCH WITHOUT UNDERDRAIN
- PAVED SWALE WITH UNDERDRAIN AND STORM DRAIN
- VEGETATED SWALE

**NOTE:**

ALL NOTED LENGTHS ARE APPROXIMATE AND NOT VERIFIED.

REVISED: 10/28/2015

DATE  
9/9/15  
PROJECT  
1938

**UNDERWOOD**  
engineers  
25 Vaughan Mall, Portsmouth, N.H. 03801  
Tel. 603-436-6192 Fax. 603-431-4733

BAY HILL ROAD SECTION 3  
DRAINAGE IMPROVEMENTS  
2016 ROAD EVALUATION  
NORTHFIELD, NH

FIG.  
1

**Appendix E**  
**Town Wide Road Evaluation Scope and Opinion of**  
**Cost**



ENGINEERING SERVICES REQUEST  
AUTHORIZATION TO PROCEED

To: Underwood Engineers, Inc.  
25 Vaughan Mall  
Portsmouth, New Hampshire 03801

File No.:  
ESR No.: 1  
Description: *Roadway CIP*

From: Town of Northfield  
21 Summer St  
Northfield, New Hampshire 03276

Date: March 19, 2015

Owner's Contact(s) (this project): Glenn Smith, Town Administrator  
Engineer's Contact(s) (this project): Dan Rochette, P.E., Project Manager

Under agreement for Professional Services as Consulting Engineer for the Town of Northfield, (Underwood File # \_\_\_\_\_), you are authorized to proceed with the following work:

**Description / Instructions:**

Underwood Engineers, Inc. will provide professional engineering services for the evaluation of the Town's Class V roads and development of roadway CIP for planning and budgeting as described in the RFQ for qualification packages received by the Town on November 21, 2014:

***Task 1 – Data Review, Collection, and Inspection***

Underwood Engineers understands the Town has previously completed RSMS evaluations in 2002 and 2012. Work will build on the information available in those evaluations including the following:

- Work with the Town to gain an understanding of goals and priorities. This will include a kickoff meeting to determine project goals.
- Review and discuss existing data available with the Town.
  - 2002 RSMS Evaluation
  - 2012 RSMS Evaluation
  - CIP budgets
  - Previous CIP work complete
- Review previous RSMS evaluation completed
  - Evaluate differences between the 2002 and 2012 RSMS evaluations
- Develop a cataloging system (spreadsheet) to summarize the characteristics and condition of each road. We understand the Town has previously provided a traffic and importance rating for each road and this information will be used.
- Review available traffic data to determine the traffic impacts to various roads.
- Complete a visual inspection of each road within the Town to confirm findings from the 2012 RSMS evaluation:
  - Single pass windshield survey (5 mph) to review findings and update previous RSMS information (paved and gravel)
    - a. Travel surface condition
    - b. Road shoulder condition
    - c. Type and character of drainage system (closed or surface)
    - d. Note traffic observed (light, medium, high, high percentage of heavy loads).

## **ESR #1**

Northfield, NH

March 9, 2015

Page 2 of 3

### ***Task 2 – Subsurface investigations***

- Coordinate and observe one (1) day of subsurface investigations on high priority roads (approximately 15 borings)
  - Depth of exploration will generally be 6'
  - Procure spoon samples (3 per boring) for evaluation.
  - Complete up to 10 gradations from samples
- Summarize findings in final report

### ***Task 3 – Evaluation and Assessment***

Based on the data collection phase, Underwood Engineers will complete an assessment of the Town's roads. Work will include:

- Develop a rating system that will describe suggested improvements. Rating system will incorporate categories previously used by the Town (i.e. traffic and emergency response needs). All road will be classified into the following categories (suggested funding sources shown):
  - Deferred Maintenance (no work needed)
  - Routine Maintenance (budget item)
  - Preventative Maintenance (budget item)
  - Rehabilitation (capital project – warrant article)
  - Reconstruction (capital project – warrant article)
- Develop opinions of unit costs for the annual operation and maintenance costs.
- Develop opinions of unit costs for the capital projects.
- Develop total costs for O&M and capital projects.
- Provide assistance in reviewing load limits, if appropriate.
- Evaluate the Town's current maintenance budget as it relates to the recommended costs above.
- Provide a life-cycle cost analysis of various repair strategies to assess the cost-effectiveness of different approaches.
- Develop a capital improvements plan (5-year) with rankings for road repair.
- Develop a conceptual 20-year repair plan for road repair strategies. The intent of this item is to show the recurring repair/maintenance needs for a 20-year period.
- Provide a brief (clear and concise) report with recommendations. It is anticipated that the report will include the following:
  - Executive summary
  - Summary narrative for each road and/or road segment (1 page summary with typical picture).
  - Overall (overlay) map of the Town's road system using USGS mapping (or composite tax maps) as the base map. Road repair strategies shall be presented on the maps for public display.
  - Recommended road repair sequence.
  - Summary of opinion of costs (O&M and capital)
- Underwood will provide a draft of the above report and will attend one (1) CIP meeting to review draft report, focusing on budget and maintenance strategies prior to finalizing report.



- Compile inventory location of visible cross culverts and drainage structures (CB and DMH's) located within tolerances of available hand held GPS units.
- Generally observe condition of Town owned bridges and provide a brief narrative
- Provide a schematic work plan depicting locations of culverts, drainage structures and Town owned bridges identified.
- Provide summary of finding in report described in Task 3

- Prepare a PowerPoint presentation for public meetings to include the following:
  - Overall road conditions
  - Prioritized repair strategy
  - Budget impacts
- Attend public meetings as necessary to present findings to the public.
- Two (2) meetings are anticipated.

- Summary Report
- Display boards for public meeting
- PowerPoint presentation for public meeting (suitable for Town website)

- Topographic or boundary survey services
- Design Engineering Services
- Design Review Services
- Geotechnical or subsurface services (except as noted above)
- Construction Engineering Services
- Traffic Control to be provided by Town if required

\$\_\_\_\_\_ in accordance with the established hourly rates for personnel assigned plus reimbursable expenses for the services identified above. Billings for services will be monthly and will be due Underwood Engineers, Inc. within 30 days of the billing date.

Suggested budgets, as used herein, are best estimates by Underwood Engineers. The budgets are based on available information and prior to a detailed research on the Project. Budgets are not intended to be fixed prices but are reasonable estimates of average costs to complete projects of similar size. Engineer will not exceed the budget without written authorization.

Keith Pratt, P.E. Date  
President Underwood Engineers, Inc.