

STATE OF VERMONT  
AGENCY OF TRANSPORTATION

**Scoping Report**

FOR  
**Ludlow BF 013-3(16)**

**VT Route 100, BRIDGE 102 OVER UNNAMED BROOK**

August 18, 2020

---



Table of Contents

|   |           |
|---|-----------|
| <b>Table of Contents</b> .....                        | <b>2</b>  |
| <b>I. Site Information</b> .....                      | <b>3</b>  |
| Need.....   | 3         |
| Traffic.....  | 3         |
| Bicycle Usage.....                                    | 4         |
| Design Criteria .....                                 | 4         |
| Inspection Report Summary.....                        | 5         |
| Hydraulics .....                                      | 5         |
| Utilities .....                                       | 5         |
| Right of Way .....                                    | 6         |
| Resources.....  | 6         |
| Biological:.....                                      | 6         |
| Hazardous Materials:.....                             | 7         |
| Historic: .....                                       | 7         |
| Archaeological:.....                                  | 7         |
| Stormwater:.....                                      | 7         |
| <b>II. Safety</b> .....                               | <b>7</b>  |
| <b>III. Local Concerns</b> .....                      | <b>7</b>  |
| <b>IV. Maintenance of Traffic</b> .....               | <b>8</b>  |
| Option 1: Off-Site Detour.....                        | 8         |
| Option 2: Phased Construction.....                    | 9         |
| Option 3: Temporary Bridge .....                      | 9         |
| <b>V. Alternatives Discussion</b> .....               | <b>10</b> |
| No Action .....                                       | 10        |
| Rehabilitation .....                                  | 10        |
| Full Bridge Replacement On Alignment.....             | 12        |
| <b>VI. Alternatives Summary</b> .....                 | <b>14</b> |
| <b>VII. Cost Matrix</b> .....                         | <b>15</b> |
| <b>VIII. Conclusion</b> .....                         | <b>16</b> |
| <b>IX. Appendices</b> .....                           | <b>17</b> |
| Appendix A: Site Pictures .....                       | 18        |
| Appendix B: Town Map.....                             | 24        |
| Appendix C: Bridge Inspection Report.....             | 26        |
| Appendix D: Preliminary Hydraulics.....               | 28        |
| Appendix E: Preliminary Geotechnical Information..... | 31        |
| Appendix F: Natural Resources Memo .....              | 37        |
| Appendix G: Natural Resources ID.....                 | 39        |
| Appendix H: Archeology Memo.....                      | 41        |
| Appendix I: Historic Memo .....                       | 46        |
| Appendix J: Hazardous Sites Map .....                 | 52        |
| Appendix K: Crash Data .....                          | 54        |
| Appendix L: Utility Field Sketch .....                | 56        |
| Appendix M: Local Input.....                          | 59        |
| Appendix N: Operations Questionnaire .....            | 66        |
| Appendix O: Detour Routes.....                        | 69        |
| Appendix P: Plans .....                               | 72        |

## I. Site Information

Bridge 102 is a State-owned bridge located on VT Route 100 over an Unnamed Brook. The Bridge is located approximately 3.4 miles north of the junction with VT Route 103. The existing bridge conditions were gathered from a combination of a Site Visit, the Inspection Report, the Route Log and the existing Survey. See correspondence in the Appendix for more detailed information.

|                            |  |
|----------------------------|--|
| Roadway Classification     | Minor Arterial   |
| Bridge Type                | Aluminum Coated Corrugated Galvanized Metal Plate Pipe (ACCGMPP) |
| Culvert Length             | 55 feet  |
| Culvert Span               | 6 feet   |
| Average Cover over Culvert | 5 feet   |
| Year Built                 | Unknown  |
| Ownership                  | State of Vermont   |

### Need

Bridge 102 carries VT Route 100 across an unnamed brook. The following is a list of deficiencies of Bridge 102 and VT Route 100 in this location:

1. Bridge 102 is in poor condition. The last 15-feet of the pipe has heavy section loss along the invert from corrosion with numerous large holes through the invert.
2. The culvert clearspan does not meet the minimum bankfull width requirements.
3. There is a utility pole located behind the guardrail within the clearzone limits
4. VT Route 100 through the project area does not meet the minimum standards for width.

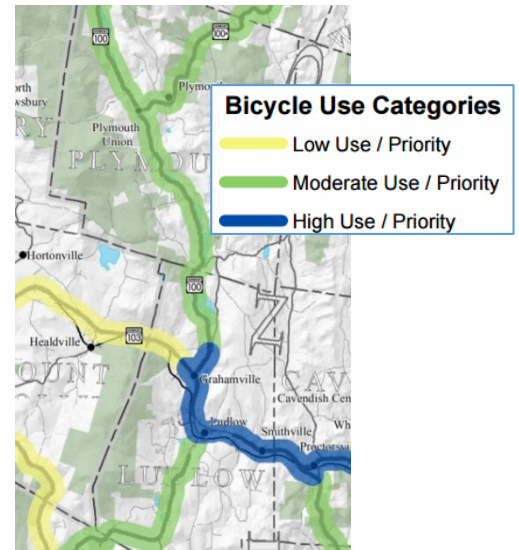
### Traffic

A traffic study of this site was performed by the Vermont Agency of Transportation. The traffic volumes are projected for the years 2024 and 2044.

| Traffic Data | 2024  | 2044  |
|--------------|-------|-------|
| AADT         | 2,300 | 2,600 |
| DHV          | 370   | 420   |
| ADTT         | 140   | 240   |
| %T           | 7.8   | 12.2  |
| %D           | 54    | 54    |

## Bicycle Usage

VT Route 100 through the project area has a moderate use/priority for bicycles. Per the Vermont State Standards, for a Minor Arterial with a design hourly volume of 420 vehicles per hour at 35 mph, the minimum required shared use shoulder width for bicycles is 4 feet. The current shoulder width through the project area is 2-feet. A minimum shoulder width of 4-feet will be recommended on the new bridge to meet minimum standards for shared-use.



## Design Criteria

The design standards for this bridge project are the Vermont State Standards, dated October 22, 1997. Minimum standards are based on an ADT of 2600, a DHV of 420, and a design speed of 35 mph for a Minor Arterial.

| Design Criteria                   | Source                              | Existing Condition  | Minimum Standard   | Comment         |
|-----------------------------------|-------------------------------------|---|--|-----------------|
| Approach Lane and Shoulder Widths | VSS Table 4.3                       | 11'2' (26')   | 11'5' (32')  | Substandard     |
| Bridge Lane and Shoulder Widths   | VSS Table 4.3                       | 11'4' (30') face-of-rail to face-of-rail  | 11'5' (32')  | Substandard     |
| Clear Zone Distance               | VSS Table 4.4                       | Utility Pole Within Clear Zone (within 1' of guardrail)   | 14' fill, 12' cut, 3'-7" behind guardrail  | Substandard     |
| Banking                           | VSS Section 4.13                    | 7%  | 8% (max)   |                 |
| Speed                             | VSS Section 4.3                     | 35 mph (Posted)   | 35 mph (Design)  |                 |
| Horizontal Alignment              | AASHTO Green Book, Table 3.10b      | R = 415   | R <sub>min</sub> = 417' @ e=7.6%   | Substandard     |
| Vertical Grade                    | VSS Table 4.5                       | -5.9%   | 6% (max) for level terrain   |                 |
| K Values for Vertical Curves      | VSS Table 4.1                       | K <sub>sag</sub> = 70   | 50 crest / 50 sag  |                 |
| Vertical Clearance                | VSS Section 4.8                     | No Issues Noted   | 14' 3" (min)   |                 |
| Stopping Sight Distance           | VSS Table 4.1                       | 330'  | 225'   |                 |
| Bicycle/Pedestrian Criteria       | VSS Table 4.7                       | 2' Paved Shoulder   | 4' Shoulder  | Substandard     |
| Bridge Railing                    | Structures Design Manual Section 13 | Heavy Duty Steel Beam   | TL-3   |                 |
| Hydraulics                        | VTrans Hydraulics Manual, Table 6.1 | <ul style="list-style-type: none"> <li>HW/D (Q<sub>50</sub>) = 0.79</li> <li>Clearspan: 6'</li> </ul> | <ul style="list-style-type: none"> <li>HW/D (Q<sub>50</sub>) &lt; 1.0</li> <li>Minimum Bank Full Width: 14'</li> </ul> | Substandard BFW |
| Structural Capacity               | Structures Design Manual, Ch. 3.4.1 | Poor Rated Culvert  | Design Live Load: HL-93  | Substandard     |



- There is a main utility line that runs along Route 100. One of the poles is located near the outlet of the culvert. The utility line contains single phase power and 3 communication lines.
- There are multiple service lines that cross over the culvert.

The relocation of aerial utilities will likely be necessary for construction.

### **Right of Way**

The existing Right-of-Way (ROW) is plotted on the Existing Conditions Layout sheet. There is a 3-rod ROW centered on VT Route 100 through the project area. The existing pipe inlet is located outside of the state-owned ROW. As such, it is anticipated that additional Right-of-Way will be required for all alternatives considered.

### **Resources**

The environmental resources present at this project are shown on the Existing Conditions Layout Sheet, and are as follows:

#### ***Biological:***

##### Wetlands

There are no wetlands in the project area.

The project area crosses an unnamed perennial stream. This stream is regulated by the US Army Corps of Engineers.

##### Wildlife Habitat

The riparian area of the unnamed stream likely provides a corridor for smaller terrestrial wildlife. The area around the culvert is developed and not the highest priority for wildlife movement. A larger structure will increase use of the structure.

The culvert currently provides partial aquatic organism passage. Aquatic organism passage will be required for this structure if it is replaced or repaired.

##### Rare, Threatened and Endangered Species (R/T/E)

The only listed species in the area is the federally threatened northern long-eared bat. The structure itself does not have suitable habitat.

##### Agricultural

The project area is mapped as statewide significant agricultural soils.

### ***Hazardous Materials:***

According to the Vermont Agency of Natural Resources (VANR) Vermont Hazardous Sites List, there is one hazardous waste site located within close proximity to the project, as identified on the map to the right.



### ***Historic:***

Bridge 102 is not historic.

One historic resource eligible for inclusion in the National Register of Historic Places (NRHP) was identified within a preliminary survey area, the former Ephraim T. Holt House at 1787 VT Route 100. This building is considered a Section 4(f) property. Impacts and project-related easements on this parcel should be avoided, if possible. See the historic resource ID in Appendix I for additional information.

### ***Archaeological:***

There are no known precontact archaeological sites within the project area.

There is one archaeologically sensitive area to the southeastern portion of the project area. Sensitivity is based on the apparent undisturbed nature of the field, proximity to a stream and the location within a natural travel corridor. See the archaeological resource ID in Appendix H for additional information.

### ***Stormwater:***

There are no stormwater or drainage concerns for this project.

## **II. Safety**

There have been 5 reported crashes along VT Route 100 within in the project area within the last 5-year period. One crash was located at the bridge within the project limits.

There have been 4 crashes in the last 5-year period along the local bypass route.

The bridge is not located within a high crash segment.

## **III. Local Concerns**

A Local Concerns Questionnaire was completed by the Town of Ludlow along with input from the Regional Planning Coordination with the following findings:

- The project is in the Lakes District, so the summer months are very busy. Winter months are also very busy due to traffic from ski resorts (Okemo and Killington). The slow season is April through May and mid-October (post Columbus Day weekend) through November.

- The project is in the very small hamlet of Tyson, which is mostly in Plymouth. Businesses that may be impacted in the area include the Tyson Store, Echo Lake Inn, and Inn at Water's Edge. Other businesses along the VT Route 100 corridor that might be impacted include Clear Lake Furniture, Green Mountain Sugarhouse and Tavola Italiana.
- While the VT Route 100 corridor is a popular bike route that experiences moderate use, there is not much pedestrian activity. However, the bridge is in the Lakes District with inns and a store close by, so there is likely some modest walking activity in the nearby area.

#### **IV. Maintenance of Traffic**

The Vermont Agency of Transportation developed an Accelerated Bridge Program in 2012, which focuses on expedited delivery of construction plans, permitting, and Right-of-Way, as well as accelerated construction of projects in the field. One practice that will help in this endeavor is closing bridges for portions of the construction period, rather than providing temporary bridges. In addition to saving money, the intention is to minimize the closure period with accelerated construction techniques and incentives to encourage contractors to complete projects early. The Agency will consider the closure option on projects where rapid reconstruction or rehabilitation is feasible. The use of prefabricated elements and systems for new bridges will also expedite construction schedules. This can apply to decks, superstructures, and substructures. Accelerated Bridge Construction should provide enhanced safety for the workers and the travelling public while maintaining project quality. The following options have been considered:

##### **Option 1: Off-Site Detour**

This option would close the bridge and reroute VT Route 100 traffic onto a signed detour route. The regional detour route would reroute VT Route 100 traffic onto US Route 4, to US Route 7, and VT Route 103, back to VT Route 100. This regional detour has an end-to-end distance of 53.6 miles. This detour adds 25.4 miles to the VT Route 100 through travel distance.

There is a local bypass route that may see an increase in traffic from local passenger cars if VT Route 100 is closed during construction. Local bypass routes are not signed detours but may experience higher traffic volumes during a road closure. The most likely local bypass route is as follows:

Local Bypass 1: VT Route 100 to Kingdom Road, Buswell Pond Road, Buswell Road, E Lake Road, and Red Bridge Road, back to VT Route 100 (4.6 miles end-to-end)

A map of the detour routes and possible local bypass route, which could see an increase in traffic, can be found in Appendix O.

*Advantages:* This option would eliminate the need for a temporary bridge or phased construction, which would significantly decrease cost and time of construction. Additionally, this option would have the least impacts to adjacent properties and cultural resources. This option reduces the time and cost of the project both at the development stage and construction.

*Disadvantages:* Traffic flow would not be maintained through the project corridor during construction.



## **Option 2: Phased Construction**

Phased construction is the maintenance of traffic on the existing bridge while building one lane at a time of the proposed structure. This allows keeping the road open during construction, while having minimal impacts to adjacent property owners and environmental resources.

While the time required to develop a phased construction project would remain the same, the time required to complete a phased construction project increases because some of the construction tasks have to be performed multiple times. In addition to the increased design and construction costs mentioned above, the costs also increase for phased construction because of the inconvenience of working around traffic and the effort involved in coordinating the joints between the phases. Another negative aspect of phased construction is the decreased safety of the workers and vehicular traffic, which is caused by increasing the proximity and extending the duration that workers and moving vehicles are operating in the same confined space. Phased construction is usually considered when the benefits include reduced impacts to resources and decreased costs and development time by not requiring the purchase of additional ROW.

Based on the current traffic volumes, it is acceptable to close one lane of traffic, and maintain one lane of traffic, both ways, with a traffic signal. There is approximately 5 feet of vertical fill over the existing culvert, which would need to be held back for phased construction.

*Advantages:* Traffic flow would be maintained through the project corridor during construction. Also, this option would have minimal impacts to adjacent properties.

*Disadvantages:* Phased construction generally involves higher costs and complexity of construction. Costs are usually higher and construction duration is longer, since many construction activities have to be performed two times. Additionally, since cars are traveling near construction activity, there is decreased safety. There would be some delays and disruption to traffic, since the road would be reduced to one-way traffic.

## **Option 3: Temporary Bridge**

From a constructability standpoint, a temporary bridge would be difficult to place on the downstream (west) side of VT Route 100. The Tyson Village Store is located in close proximity to the culvert, and a temporary bridge on that side of the road would be very close to the main building. The building foundation is located approximately 20-feet behind the guardrail. Additionally, on the downstream side, there are aerial utilities that would need to be relocated for a temporary bridge as well as an area of archaeological sensitivity. A temporary bridge on the upstream (east) side of VT Route 100 would be in close proximity to a historic 4(f) property on the eastern side of the road and would require some tree clearing. Both an upstream and downstream temporary bridge alignment would have limits outside the existing Right-of-Way.

Additional costs would be incurred to construct a temporary bridge, including the cost of fill for the approaches and the bridge itself, installation and removal of the temporary bridges and approaches, restoration of the disturbed area, and the time and money associated with the temporary Right-of-Way.

If a temporary bridge is chosen as the preferred method of traffic control, it should be a two-way bridge to accommodate the traffic volumes along VT Route 100. See the Temporary Roadway Layout Sheet in the Appendix.

Advantages: Traffic flow can be maintained along the VT Route 100 corridor.

Disadvantages: This option would require additional Right-of-Way acquisition. This option may have adverse impacts to surrounding cultural resources. There would be decreased safety to the workers and to vehicular traffic, because of cars driving near the construction site, and construction vehicles entering and exiting the construction site. This traffic control option would be more costly, and time consuming than an offsite detour. A number of trees would need to be cut down for this temporary condition.

## **V. Alternatives Discussion**

### **No Action**

This alternative is not recommended. The culvert is in poor condition and will continue to deteriorate if no action is taken. Heavy corrosion along with large holes have developed in the invert. The barrel will begin to distort if no action is taken. Something will have to be done to improve this culvert in the near future. In the interest of safety to the traveling public, the No Action alternative is not recommended. No cost estimate has been provided for this alternative since there are no immediate costs.

### **Rehabilitation**

This alternative involves the rehabilitation of the existing corrugated metal plate pipe.

Rehabilitation options considered:

- a: Invert Repair
- b: Pipe Liner
- c: Spray on Liner

All rehabilitation options would employ the use of hydroblasting or hydrodemolition to appropriately clean the existing pipe interior prior to rehabilitation. In addition to cleaning, the large rocks inside the culvert would need to be removed and some grouting would be needed to plug holes in the pipe and fill all voids on the outside of the pipe. The Preliminary Hydraulics Report indicates that a new interior pipe dimension that is maximized is preferred. Curing in dry conditions would be required in most cases, necessitating a re-routing of the stream flow during the work and for a prescribed curing period (usually 24 hours). A headwall with beveled inlets would be recommended for all rehabilitation alternatives.

Since the minimum hydraulic opening would be substandard for all options, and any rehabilitation will reduce the waterway area, it is assumed that an improved beveled inlet would be required for each option to optimize hydraulic performance and to funnel the stream into the culvert.

a. Invert Repair

Invert repair can be utilized on corrugated steel pipe, and typically consists of paving the invert or pouring a concrete invert. Much of the deterioration is located at the invert, making this a suitable repair for the culvert. This option involves removal of the degraded invert, and pouring a 2 to 3 inch thick section of concrete in its place. Additionally, there would need to be repair of any holes along the circumference of the pipe. This option would have the least impacts to the hydraulic capacity of the existing culvert. While this option is a good solution to the current degradation of the culvert invert, it adds little structural stability to the current structure. There has been no evidence of crushing or squashing, and as such, additional structural capacity is not required.

b. Pipe Liner:

A pipe liner involves inserting a culvert liner into the existing culvert, and grouting between the two. Sliplining can be done using several different types of pipe material including corrugated steel, aluminum, reinforced concrete, and polyethylene, and can restore the structural integrity of the culvert. The outside diameter of the pipe used for sliplining is generally specified to be at least 4 inches smaller than the inside diameter of the host pipe to allow the grout to be injected into the annular space between the two pipes. The reduced waterway would have a substandard bankfull width, and may not meet environmental standards. A liner option is anticipated to have the longest life expectancy of the rehabilitation alternatives, since the grout provides an increased structural capacity, prevents liner collapse, prevents fatigue failure, stabilizes the pipe, extends the design life from uncertainty to at least 30 years, and resists temperature changes.

c. Spray-On Liners

Spray-On liners provide a new rigid interior surface for the pipe and use either cementitious materials (polymer-enhanced cement mortar) or polyurea. These liners are spray applied either by hand or machine, although some users have had better quality control with hand-applied methods. Cementitious liners installed by these methods can provide full structural support, depending on thickness applied. Proper curing is essential to using spray-on liners to avoid bond failures. There could be water quality impacts associated with the application of these liners, their degree of impact related to selection of materials, and adherence to curing requirements. If a spray-on liner is selected, the polymer-enhanced cement mortar is recommended for environmental and safety reasons. Temporary Right of Way would need to be acquired to provide a staging area at each end to accomplish this alternative.

*Advantages:* A repair alternative would address the ongoing deterioration issues with the invert of the existing culvert without affecting traffic flow, and with minimum upfront costs. Additionally, it would have minimal impacts on resources.

*Disadvantages:* The rehabilitation alternative is only a repair and not a new structure. The life span of the repair work is estimated to be 15 to 30 years. Also, the existing culvert does not meet stream equilibrium standards, and the rehabilitation option would have a smaller hydraulic opening. Aquatic Organism Passage and wildlife connectivity would not be improved. It is assumed that for any rehabilitation alternative, temporary right-of-way will be necessary for the contractor's access to the ends of the culvert.

*Maintenance of Traffic:* The rehabilitation alternative has minimal effect on traffic. Traffic will remain open during the duration of the project, with the exception of intermittent lane closures for some construction activities.

## **Full Bridge Replacement On Alignment**

This option involves removing the existing Corrugated Galvanized Metal Plate Pipe and replacing it with a new precast structure having a waterway opening of at least 75 square feet and a span of 14 feet. Any new structure should have flared wingwalls at the inlet and outlet to make a smooth transition between the channel and the culvert.

The preliminary hydraulics report suggests several possible configurations for a new structure, including a new precast concrete box, or open bottom precast concrete frame or bridge with vertical face abutments.

Since there is approximately 5 feet of fill above the existing culvert, there would not be a considerable amount of earthwork. Due to the minimum required span and relatively shallow amount of fill, an open cut method of replacement is considered a more cost-effective solution than the available trenchless methods.

The various considerations under this option include: alignment, the bridge width and length, skew, superstructure type and substructure type.

### *a. Alignment*

Due to the many constraints at the project site, the current horizontal alignment will be considered even though it is substandard. By maintaining the existing alignments, impacts to resources and adjacent properties will be minimized. The substandard roadway/bridge widths will be brought up to standard for this option.

### *b. Bridge Width*

The existing roadway currently has 11-foot-wide lanes and 4-foot-wide shoulders which provides a rail-to-rail width of 30 feet. This does not meet the minimum standard of 32 feet as set forth in the Vermont State Standards. Since a new 75+ year bridge is being proposed, the bridge geometry should meet the minimum standards. A culvert that can accommodate a future 32-foot roadway width over bridge will be proposed.

### *c. Bridge Length and Skew*

The existing culvert has a span of 6-feet with no skew. This provides a clearspan normal to the channel of 6 feet.

The Hydraulics Section has recommended that any new structure should have a clearspan normal to the channel of 14 feet to meet the ANR bank full width requirements. Either a box or frame with a span of 14-feet or integral abutments with a bridge length of 40 feet would be appropriate. A skew of approximately 15-degrees will be recommended in order to match the site conditions.

*d. Structure Type*

The most common structure types for the recommended hydraulic opening are a 4-sided concrete box culvert, or a 3-sided open bottom concrete structure. A slab bridge with a similar hydraulic opening would also be acceptable at this site. A plate arch is not recommended, since it would have a reduced design life compared to a reinforced concrete structure.

- Concrete Box

It is preferred that the structure be a precast 4-sided concrete box culvert. This type of structure would provide protection against scour and undermining and would require less excavation than an open bottomed structure. Additionally, it would have a shorter construction duration compared to an opened bottom structure, since footings would not have to be placed six feet below the stream bed. The Preliminary Geotechnical Report indicates that this site may be a good location for a precast box. Borings should be taken early in the design process to verify in-situ conditions.

- Concrete Arch or Frame

This site is a good candidate for a prefabricated 3-sided concrete frame based on the minimum required span to meet hydraulic standards. A 3-sided concrete frame would have a 14-foot span to meet the minimum hydraulic standards. In order to accommodate a 32-foot-wide roadway, the proposed barrel length would be approximately 60 feet long. The culvert would have a skew of 15 degrees to the roadway to match the existing skew of the channel.

If an arch or frame is used, it should be founded either on bedrock or 6' minimum below the channel bottom, and full depth headwalls should be constructed at both the inlet and outlet ends.

The Preliminary Geotechnical Report indicates that no bedrock has been observed at the project site. While there are large boulders at both the inlet and outlet, these were likely placed for slope stabilization. Borings should be taken early on in design to verify the in-situ conditions.

*e. Substructure Type*

The Preliminary Geotechnical Report indicates that no bedrock has been observed at the project site. While there are large boulders at both the inlet and outlet, these were likely placed for slope stabilization. Borings should be taken early on in design to verify the in-situ conditions.

*f. Maintenance of Traffic:*

Either a temporary bridge, phased construction, or an offsite detour could be utilized for traffic control at this site.

*Advantages:* This alternative would address the structural deficiencies of the existing bridge, with a brand-new structure with a 75-year design life. This option would meet the minimum hydraulic standards and provide adequate AOP. This option would have minimal future maintenance costs.

*Disadvantages:* This alternative would require Right-of-Way acquisition and have impacts to adjacent properties. This option has the highest upfront costs.

## **VI. Alternatives Summary**

Based on the existing site conditions, bridge condition, and recommendations from hydraulics, there are several viable alternatives:

Based on the existing site conditions, culvert condition, and recommendations from hydraulics and others, the following alternatives are offered:

- Alternative 1: Culvert Rehabilitation with Traffic Maintained on Existing Culvert
  - a. Invert Repair
  - b. 60-inch Culvert Liner
  - c. Spray-On Culvert Liner
- Alternative 2a: New Prefabricated Box with Traffic Maintained on Offsite Detour
- Alternative 2b: New Prefabricated Box with Traffic Maintained with Phased Construction
- Alternative 2c: New Prefabricated Box with Traffic Maintained on a Temporary Roadway
- Alternative 3a: New Prefabricated 3-Sided Structure with Traffic Maintained on Offsite Detour
- Alternative 3b: New Prefabricated 3-Sided Structure with Traffic Maintained with Phased Construction
- Alternative 3c: New Prefabricated 3-Sided Structure with Traffic Maintained on a Temporary Roadway

A cost evaluation for each of the alternatives is shown below:

**VII. Cost Matrix<sup>1</sup>**

| Ludlow BF 013-3(16) |   | Do Nothing                     | Alternative 1              |                            |                            | Alternative 2          |                        |                        | Alternative 3                 |                        |                        |
|---------------------|---|--------------------------------|----------------------------|----------------------------|----------------------------|------------------------|------------------------|------------------------|-------------------------------|------------------------|------------------------|
|                     |   |                                | Culvert Rehabilitation     |                            |                            | New Precast Box        |                        |                        | New Precast 3-Sided Structure |                        |                        |
|                     |   |                                | a. Culvert Invert          | b. Pipe Liner              | c. Spray on Liner          | a. Offsite Detour      | b. Phased Construction | c. Temporary Bridge    | a. Offsite Detour             | b. Phased Construction | c. Temporary Bridge    |
| COST                | Bridge Cost                               | \$0                            | 102,000                    | 115,199                    | 135,000                    | 340,474                | 450,277                | 340,474                | 441,737                       | 584,197                | 441,737                |
|                     | Removal of Structure                      | \$0                            | 33,000                     | 33,000                     | 33,000                     | 33,000                 | 37,950                 | 33,000                 | 33,000                        | 37,950                 | 33,000                 |
|                     | Roadway                                   | \$0                            | 66,300                     | 71,580                     | 79,500                     | 176,998                | 292,601                | 176,998                | 197,251                       | 289,568                | 197,251                |
|                     | Maintenance of Traffic                    | \$0                            | 35,290                     | 35,290                     | 35,290                     | 189,300                | 359,100                | 204,040                | 189,300                       | 359,100                | 204,040                |
|                     | Construction Costs                        | \$0                            | 236,590                    | 255,069                    | 282,790                    | 739,772                | 1,139,927              | 754,512                | 861,288                       | 1,270,816              | 876,028                |
|                     | Construction Engineering & Contingencies  | \$0                            | 47,318                     | 89,274                     | 98,977                     | 221,932                | 284,982                | 226,354                | 258,386                       | 317,704                | 262,808                |
|                     | Accelerated Premium                       | \$0                            | 0                          | 0                          | 0                          | 29,591                 | 0                      | 0                      | 34,452                        | 0                      | 0                      |
|                     | Total Construction Costs w CEC            | \$0                            | 283,908                    | 344,343                    | 381,767                    | 991,295                | 1,424,909              | 980,866                | 1,154,126                     | 1,588,520              | 1,138,837              |
|                     | Preliminary Engineering <sup>2</sup>      | \$0                            | 70,977                     | 76,521                     | 84,837                     | 258,920                | 284,982                | 264,079                | 258,386                       | 254,163                | 262,808                |
|                     | Right of Way                              | \$0                            | 15,000                     | 15,000                     | 15,000                     | 15,000                 | 15,000                 | 50,000                 | 15,000                        | 15,000                 | 50,000                 |
|                     | Total Project Costs                       | \$0                            | 369,885                    | 435,864                    | 481,604                    | 1,265,215              | 1,724,891              | 1,294,945              | 1,427,513                     | 1,857,683              | 1,451,645              |
| Annualized Costs    | \$0                                       | 18,494                         | 14,529                     | 12,040                     | 16,870                     | 22,999                 | 17,266                 | 19,034                 | 24,769                        | 19,355                 |                        |
| TOWN SHARE          |   | No Local Share                 |                            |                            |                            |                        |                        |                        |                               |                        |                        |
| TOWN %              |   | No Local Share                 |                            |                            |                            |                        |                        |                        |                               |                        |                        |
| SCHEDULEING         | Project Development Duration <sup>3</sup> | N/A                            | 2 years                    | 2 years                    | 2 years                    | 2 years                | 2 years                | 2 years                | 2 years                       | 2 years                | 2 years                |
|                     | Construction Duration                     | N/A                            | 2 months                   | 2 months                   | 2 months                   | 3 months               | 8 months               | 8 months               | 3 months                      | 8 months               | 8 months               |
|                     | Closure Duration (If Applicable)          | N/A                            | N/A                        | N/A                        | N/A                        | 3 Days                 | N/A                    | N/A                    | 14 Days                       | N/A                    | N/A                    |
| ENGINEERING         | Typical Section - Roadway (feet)          | 30'                            | 30'                        | 30'                        | 30'                        | 32'                    | 32'                    | 32'                    | 32'                           | 32'                    | 32'                    |
|                     | Typical Section - Bridge (feet)           | 11'4' (30')                    | 11'4' (30')                | 11'4' (30')                | 11'4' (30')                | future 11'5' (32')     | future 11'5' (32')     | future 11'5' (32')     | future 11'5' (32')            | future 11'5' (32')     | future 11'5' (32')     |
|                     | Geometric Design Criteria                 | Substandard Shoulder Width     | Substandard Shoulder Width | Substandard Shoulder Width | Substandard Shoulder Width | Meets Minimum Standard | Meets Minimum Standard | Meets Minimum Standard | Meets Minimum Standard        | Meets Minimum Standard | Meets Minimum Standard |
|                     | Traffic Safety                            | Structurally Deficient Culvert | Improved                   | Improved                   | Improved                   | Improved               | Improved               | Improved               | Improved                      | Improved               | Improved               |
|                     | Alignment Change                          | N/A                            | No Change                  | No Change                  | No Change                  | No Change              | No Change              | No Change              | No Change                     | No Change              | No Change              |
|                     | Bicycle Access                            | Substandard Shoulder Width     | Substandard Shoulder Width | Substandard Shoulder Width | Substandard Shoulder Width | Meets Minimum Standard | Meets Minimum Standard | Meets Minimum Standard | Meets Minimum Standard        | Meets Minimum Standard | Meets Minimum Standard |
|                     | Pedestrian Access                         | N/A                            | No Change                  | No Change                  | No Change                  | No Change              | No Change              | No Change              | No Change                     | No Change              | No Change              |
|                     | Hydraulics                                | Substandard                    | Substandard Bankfull Width |                            |                            | Meets Minimum Standard |                        |                        | Meets Minimum Standard        |                        |                        |
|                     | Utilities                                 | No Change                      | Aerial Relocation          | Aerial Relocation          | Aerial Relocation          | Aerial Relocation      | Aerial Relocation      | Aerial Relocation      | Aerial Relocation             | Aerial Relocation      | Aerial Relocation      |
| OTHER               | ROW Acquisition                           | Yes                            | Yes                        | Yes                        | Yes                        | Yes                    | Yes                    | Yes                    | Yes                           | Yes                    | Yes                    |
|                     | Road Closure                              | No                             | No                         | No                         | No                         | Yes                    | No                     | No                     | Yes                           | No                     | No                     |
|                     | Design Life (years)                       | <10                            | 20                         | 30                         | 40                         | 75                     | 75                     | 75                     | 75                            | 75                     | 75                     |

<sup>1</sup> Costs are estimates only, used for comparison purposes.

<sup>2</sup> Preliminary Engineering costs are estimated starting from the end of the Project Definition Phase.

<sup>3</sup> Project Development Durations are starting from the end of the Project Definition Phase.

## VIII. Conclusion

We recommend **Alternative 2a**; a new precast concrete box with traffic maintained on an offsite detour during construction.

### Structure:

The existing culvert is in poor condition and has reached the end of its service life. The invert of the metal culvert has significant deterioration. Additionally, the culvert is hydraulically undersized warranting a full replacement with a larger structure.

The new culvert will be a 14-foot x 8.5-foot precast concrete box culvert, in order to meet the VTrans Hydraulic Section's recommendation. The new precast box will have bed retention sills placed along the bottom of the box, to allow for a natural channel bottom to form, accommodating aquatic organism passage. Sills should be 12-inches high at the edges of the box and 6 inches high in the center, creating a V-shape across the full width of the box. Sills should be spaced no more than 8 feet apart throughout the structure with one sill placed at both the inlet and the outlet. Since the precast culvert will have a closed bottom, it will be protected from scour. In order to satisfy the AOP needs, the culvert invert should be buried 36 inches and E-Stone Type III should be placed along the length of the channel bottom through the culvert, resulting in a 5.5-foot-high waterway opening. The new culvert should have headwalls that extend four feet below the channel bottom at the inlet and the outlet to prevent undermining.

### Traffic Control:

Traffic will be maintained on an offsite detour during a 3-day bridge closure. Due to the tight constraints of the bridge site, as well as archaeological and historic resources, this method of traffic control is preferred. The official State detour route has an end-to-end distance of 53.6 miles and adds 25.4 miles to the through route. The Average Daily Traffic volume is 2,300 vehicles per day. From a geometric standpoint, the Local Bypass Route, as described in Appendix O, could be considered an acceptable signed detour for passenger cars, pending the Town of Ludlow and the Town of Plymouth's approval.

The Local Bypass Route is as follows: VT Route 100 to Kingdom Road, Buswell Pond Road, Buswell Road, E Lake Road, and Red Bridge Road, back to VT Route 100. This local bypass route has an end-to-end distance of 4.6 miles.

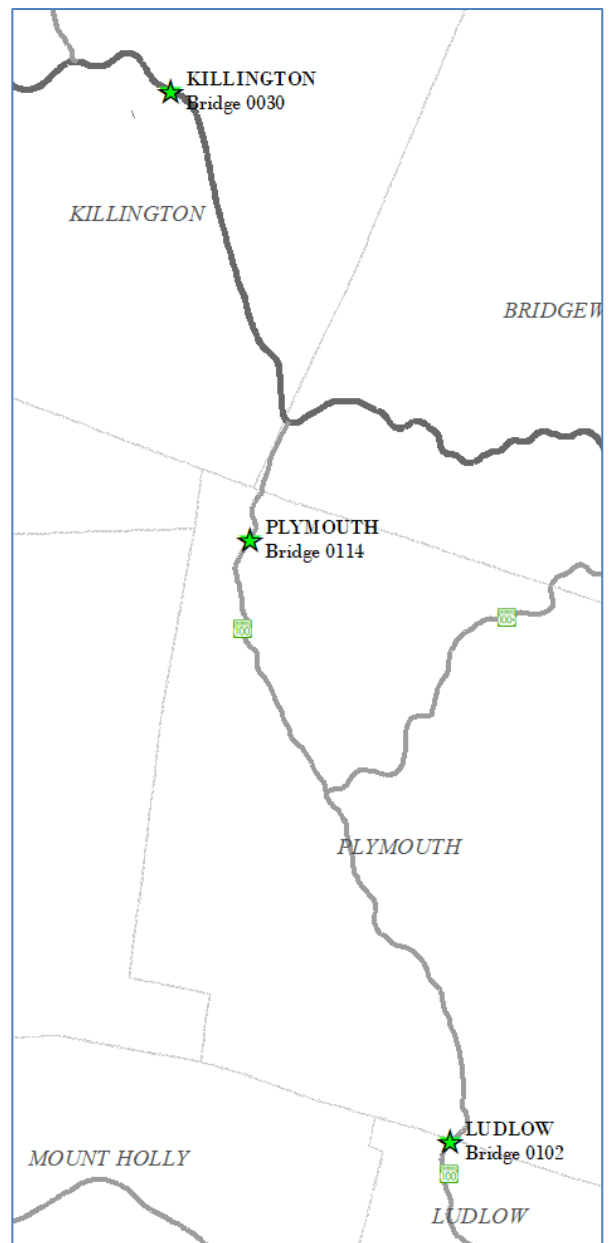


*Coordination with other projects:*

There are several projects in the State Highway Bridge Program within the project area that are currently in the scoping phase of project development. The projects are as follows:

- KILLINGTON BF 020-2(50) 19B207, US Route 4, Bridge 30 over unnamed brook.
- PLYMOUTH BF 013-3(17) 19B216, VT Route 100, Bridge 114 over Reservoir Brook.
- LUDLOW BF 013-3(16) 19B215, VT Route 100, Bridge 102 over unnamed brook.

Consideration should be given to bundling these projects for design and/or construction.



## IX. Appendices

- Appendix A: Site Pictures
- Appendix B: Town Map
- Appendix C: Bridge Inspection Report
- Appendix D: Preliminary Hydraulics
- Appendix E: Preliminary Geotechnical Information
- Appendix F: Natural Resources Memo
- Appendix G: Natural Resources ID
- Appendix H: Archeology Memo
- Appendix I: Historic Memo
- Appendix J: Hazardous Sites Map
- Appendix K: Crash Data
- Appendix L: Utility Field Sketch
- Appendix M: Community Input
- Appendix N: Operations Questionnaire
- Appendix O: Detour Maps
- Appendix P: Plans

## Appendix A: Site Pictures



Picture 1: Looking South over Bridge 102



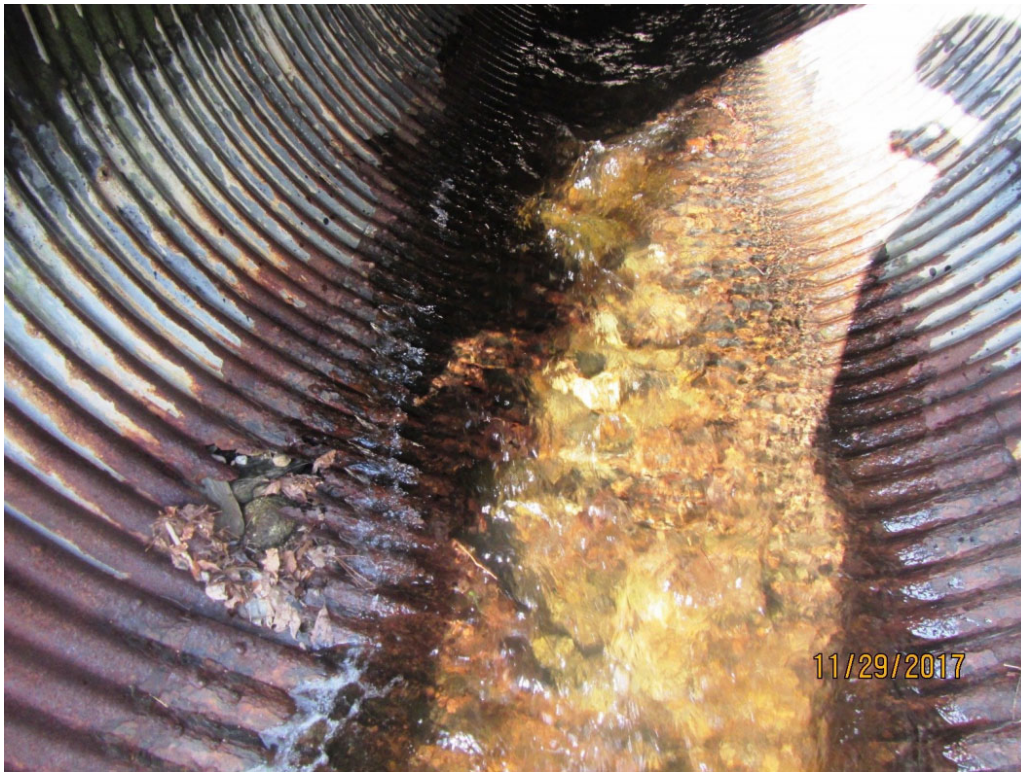
Picture 2: Looking North over Bridge 102



Picture 3: Looking Upstream from Bridge 102



Picture 4: Looking Downstream from Bridge 102



Picture 5: Culvert Barrel Condition



Picture 6: Culvert Inlet



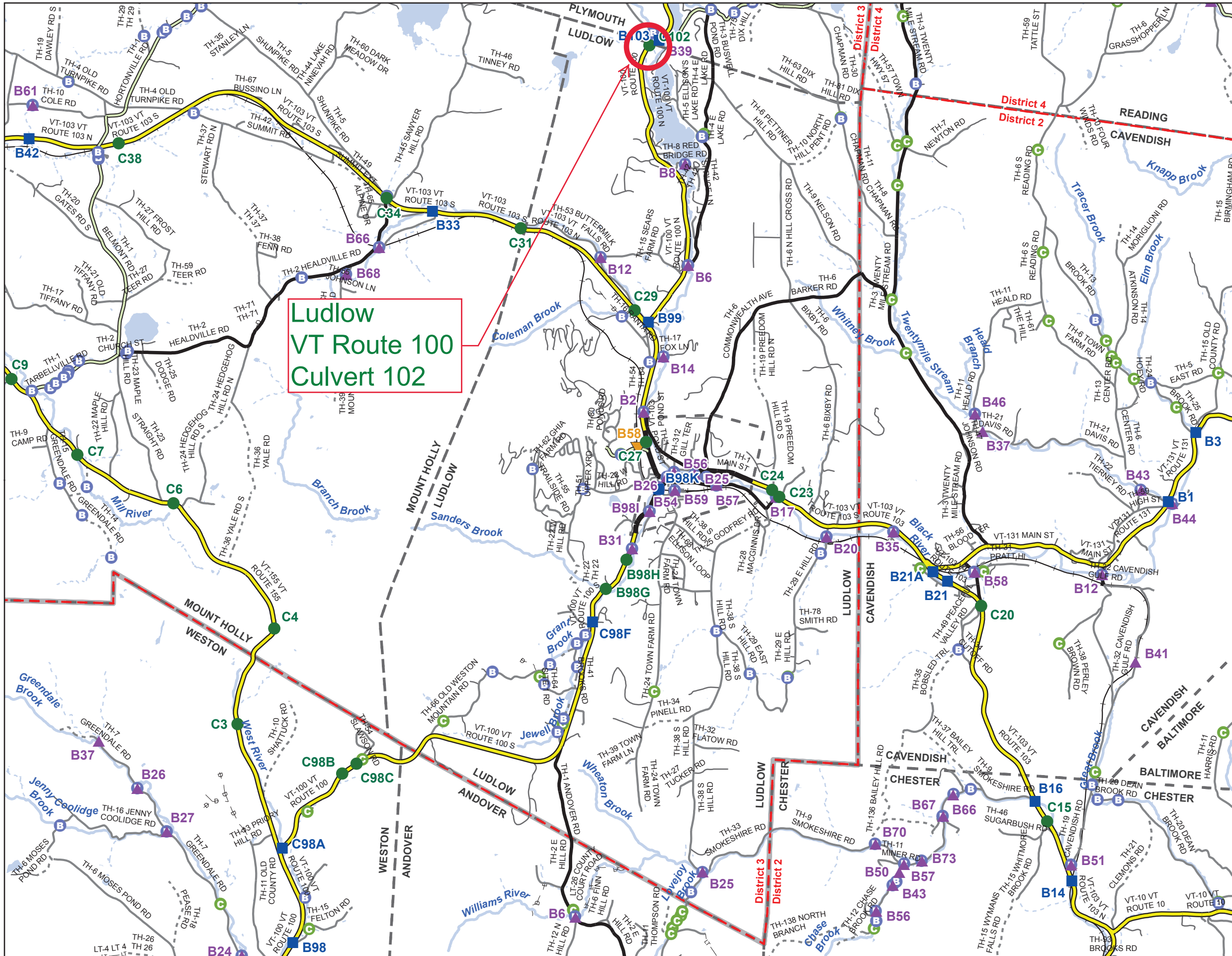
Picture 7: Culvert Outlet



Picture 8: Foundation on downstream side

## Appendix B: Town Map





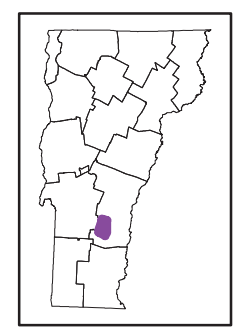
Ludlow  
VT Route 100  
Culvert 102

Scale: 1:65,700

- ★ INTERSTATE
- STATE LONG
- STATE SHORT
- ▲ TOWN LONG
- ▼ FASI/FAU
- ◆ BIKE PATH
- INTERSTATE
- STATE HIGHWAY
- CLASS 1
- CLASS 2
- CLASS 3
- CLASS 4
- - - LEGAL TRAIL
- - - PRIVATE
- - - DISCONTINUED
- FASI/FAU HWY
- MAINTENANCE DISTRICT
- POLITICAL BOUNDARY
- VTRANS REGION BOUNDARY
- NAMED RIVER-STREAM
- - - UNNAMED RIVER-STREAM
- Point from Local Bridge Data \*
- Point from Local Culvert Data \*

\* Points are from local town bridge and culvert inventories. Some points may overlap where VTrans has also conducted an inventory on the Town highway.  
Data source: VOBCT aka VTCulverts

Produced by:  
Mapping Section  
Division of Policy, Planning and  
Intermodal Development  
Vermont Agency of Transportation  
May 2017



**LUDLOW**  
COUNTY-TOWN CODE: 1410-0  
WINDSOR COUNTY  
DISTRICT #3  
District Long Name: Mendon District  
VTrans Four Region: Southwest

This map was funded in part through grants from the Federal Highway Administration, U.S. Department of Transportation. The representation of the authors expressed herein do not necessarily state or reflect those of the U. S. Department of Transportation.

**Appendix C: Bridge Inspection Report**

**STRUCTURE INSPECTION, INVENTORY and APPRAISAL SHEET**

Vermont Agency of Transportation ~ Structures Section ~ Bridge Management and Inspection Unit

Inspection Report for LUDLOW

bridge no.: 0102

District: 3

Located on: VT100 over BROOK

approximately 3.4 MI N JCT VT 103

Maintained By: STATE

**CONDITION**

Deck Rating: N NOT APPLICABLE  
Superstructure Rating: N NOT APPLICABLE  
Substructure Rating: N NOT APPLICABLE  
Channel Rating: 7 GOOD  
Culvert Rating: 4 POOR  
Federal Str. Number: 300013010214101

**AGE and SERVICE**

Year Built: 1919 Year Reconstructed: \_\_\_\_  
Type of Service On: 1 HIGHWAY  
Type of Service Under: 5 WATERWAY  
Lanes On the Structure: 02  
Lanes Under the Structure: 00  
Bypass, Detour Length (miles): 36  
ADT: 2400 Year of ADT: 1996

**GEOMETRIC DATA**

Length of Maximum Span (ft): 6  
Structure Length (ft): 6  
Lt Curb/Sidewalk Width (ft): 0  
Rt Curb/Sidewalk Width (ft): 0  
Bridge Rdwy Width Curb-to-Curb (ft): 0  
Deck Width Out-to-Out (ft): 0  
Appr. Roadway Width (ft): 31  
Skew: 0  
Bridge Median: 0 NO MEDIAN  
Feature Under: FEATURE NOT A HIGHWAY OR RAILROAD  
Min Vertical Underclr (ft): 06 FT 00 IN

**STRUCTURE TYPE and MATERIALS**

Bridge Type: ACCGMPP  
Number of Main Spans: 1  
Kind of Material and/or Design: 3 STEEL  
Deck Structure Type: N NOT APPLICABLE  
Type of Wearing Surface: N NOT APPLICABLE  
Type of Membrane: N NOT APPLICABLE  
Deck Protection: N NOT APPLICABLE

**CULVERT GEOMETRIC DATA and INDICATORS**

Culvert Barrel Length (ft): 55  
Average Cover Over Culvert (ft): 05  
Waterway Area Through Culvert (sq.ft.): 28  
Wingwall/Headwall Rating: N NOT APPLICABLE

**APPRAISAL**

Appr. Rdwy. Alignment: 8 EQUAL TO DESIRABLE CRITERIA

**INSPECTION**

Inspection Date: 122019 Inspection Frequency (months): 12

**INSPECTION SUMMARY and NEEDS**

12/06/2019 - Pipe is in poor condition due to heavy corrosion of the last ~ 25' of the invert. Pipe is not significantly long nor buried deep and full replacement is now the practical option; rather than repair. ~ MJ/MK

12/05/2018 - Pipe is in poor condition due to heavy corrosion of the last 15' of the invert. Concrete invert repair needed soon, to compensate, before deformation occurs. ~ MJ/MK

11/29/2017 Culvert is in poor condition and will need replacement in the near future due to the failing invert. ~FRE/JAS

10/15/12 The pipe is in fair to poor condition with 2"+ holes at the outlet end some as big as 1'. The guard rail needs to be fixed due to lack of cover around the guard rail. JM SH

Culvert is in fair condition. However the last 14' +/- of the invert have slotted holes. Pipe should be evaluated for a concrete invert or a sleeve. Inspected 10-8-08 ~MK

## Appendix D: Preliminary Hydraulics

**State of Vermont**  
**Structures and Hydraulics Section**  
One National Life Drive  
Montpelier, Vermont 05633-5001  
**vtrans.vermont.gov**

[phone] 802-371-7326  
[fax] 802-828-3566  
[ttd] 800-253-0191

*Agency of Transportation*

**TO:** Laura Stone, Structures, Scoping Engineer

**CC:** Nick Wark, Hydraulics Engineer

**FROM:** Jeff DeGraff, Hydraulics Project Engineer

**DATE:** June 2, 2020

**SUBJECT:** Ludlow BF 013-3(16) pin #19B215  
Ludlow, VT-100 Br102, over Unnamed Brook  
Site location: MM 8.436  
Coordinates: [43.463769, -72.706543](#)

We have completed our hydraulic study for the above referenced site, and offer the following for your use:

On 11/05/19 we met with ANR at the site. In an email on 11/13/19 they indicated a minimum span of 14-feet should be used to span bankfull width (BFW).

Design Storm Flow is 2% AEP (Q50).

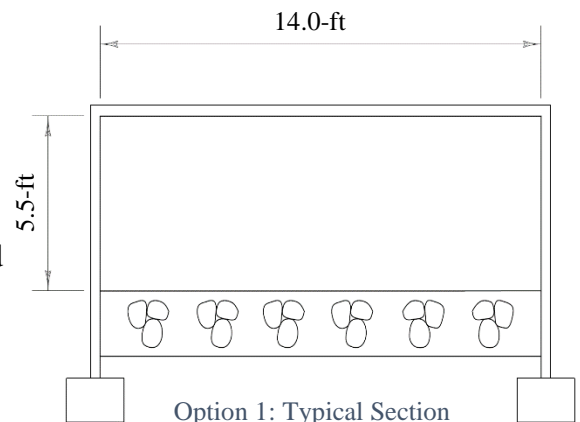
The following options were analyzed:

Existing Conditions: 6-ft Round ACCGMPP Culvert (Existing Conditions)

- Provides a Headwater to Depth ratio (HW/D) of 0.79 and 0.94 during the design and check storm event, respectively. Headwater depths of 4.78-ft and 5.63-ft were determined during the design and check storm event, respectively.
- The existing culvert meets the current hydraulic standards

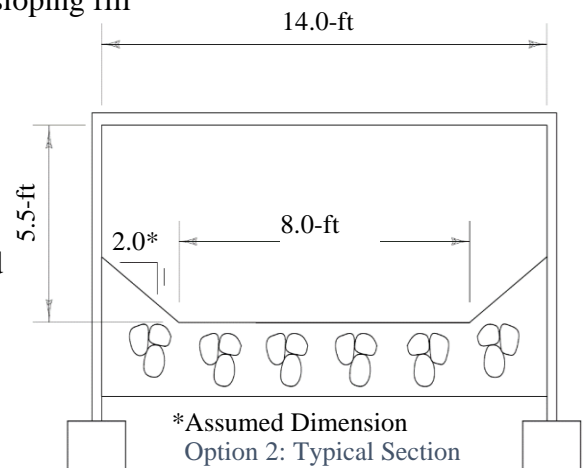
Option 1: Bridge (3-sided) 14-foot span x 5.5-foot clear height

- There is approximately 1.24 feet of freeboard at the design AEP providing a waterway area of 77.0 sq. ft, assuming a bottom slab elevation of 1079.8-ft
- E-Stone, Type III will need to be used to build the channel through this structure
- Stone Fill, Type III is to be used to protect any disturbed channel banks or roadway slopes at the structure's inlet and outlet
- Does not increase the 100-year base flood elevations
- Assumes no changes to the existing structure alignment/skew



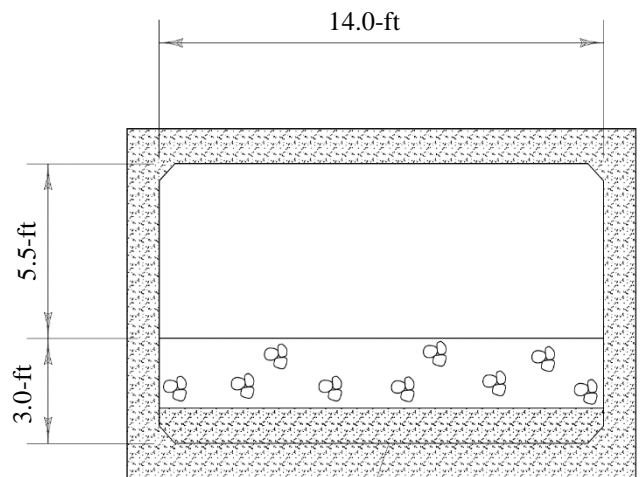
### Option 2: Bridge (3-Sided) 14-foot span x 5.5-foot clear height w/sloping fill

- There is approximately 1.18-feet of freeboard at the design AEP, providing a minimum waterway area of 75.0 sq. ft  $\pm$ , assuming a bottom slab elevation of 1079.8-ft
- E-Stone, Type III will need to be used to build the channel through this structure
- Stone Fill, Type III is to be used to protect any disturbed channel banks or roadway slopes at the structure's inlet and outlet
- Does not increase the 100-year base flood elevations
- Assumes no changes to the existing structure alignment/skew



### Option 3: Four-Sided Concrete Box (closed bottom) 14-foot span x 8.5-foot clear height

- There is approximately 1.24-feet of freeboard at the design AEP, assuming a bottom slab elevation of 1079.8-ft at the inlet
- Structure invert is to be buried 3-feet and provide a minimum waterway opening of 14-foot span x 5.5-foot clear height with a waterway area of 77.0 sq. ft.
- E-Stone, Type III will need to be used to build the channel through this structure
- Stone Fill, Type III is to be used to protect any disturbed channel banks or roadway slopes at the structure's inlet and outlet
- Bed retention sills should be added in the bottom of the structure. Sills should be 12 inches high at the edges of the box and 6 inches high in the center, creating a V-shape across the full width of the box. Sills should be spaced no more than 8 feet apart throughout the structure with one sill placed at both the inlet and the outlet
- Does not increase the 100-year base flood elevations
- Assumes no changes to the existing structure alignment/skew




This project is most likely to be replacement. A retrofit option may provide aquatic organism passage and may be considered during final if deemed a viable option. However, the existing crossing currently prohibits sediment continuity and hinders channel equilibrium. For these reasons, a replacement in-kind option is not recommended. If this is the preferred option, further environmental coordination is recommended.

Options 1, 2 and 3 meet or surpass the current hydraulic standards, as well as minimum bankfull width criteria.

A preliminary scour analysis was performed as part of this study for Options 1 and 2 assuming a D50 of 12.7-mm (0.5 inch). Based on the analysis scour is not likely at this site. However, for preliminary design assume that the bottom of footing elevation is 6-ft below the streambed or founded on ledge. A final scour countermeasure design will be performed during final design.

Other similar sized structures could be considered for this site. If another alternative is considered, coordinate with the Hydraulics Unit to perform additional analyses.

Please contact us with any questions, or to check substructure configuration scenarios. 

## **Appendix E: Preliminary Geotechnical Information**

**To:** Nick Wark, P.E., P.I.I.T. Program Manager

*END*

*CEE*

**From:** Eric Denardo, P.E., Geotechnical Engineer, via Callie Ewald, P.E., Geotechnical Engineering Manager

**Date:** December 11, 2019

**Subject:** Ludlow BF 013-3(16) - Preliminary Geotechnical Information

**1.0 INTRODUCTION**

We have completed our preliminary geotechnical investigation for the replacement of Bridge No. 102 on VT Route 100 located approximately 3.4 miles north of the junction of VT Route 100 and VT Route 103. The subject project consists of replacing or rehabilitating the existing culvert. The existing structure is an asphalt coated corrugated galvanized metal plate pipe culvert. The project is currently in the scoping phase. This review included the examination of as-built record plans, historical in-house bridge boring files, water well logs and hazardous site information on-file at the Agency of Natural Resources, published surficial and bedrock geologic maps, and observations made from previous inspection reports and photos.

**2.0 SUBSURFACE INFORMATION**

**2.1 Published Geologic Data**

Published data indicates that soils at the site generally consist of Kame Terrace (Doll, 1970) underlain by Phyllite and Schist from the Tyson Formation (Ratcliffe, et. al, 2011).

The Agency of Natural Resources (ANR) documents and publishes all water wells that are drilled for residential or commercial purposes. Published online, these logs may provide general characteristics of the soil strata in the area. Nine water wells were located within an approximate 500-foot (ft) radius of the project. The well ID, depth to bedrock, and approximate distance from the project are summarized below. Bedrock was not reported in five of the wells and are omitted.

| Well ID   | Depth to Bedrock (ft) | Distance from Project (ft) |
|-----------|-----------------------|----------------------------|
| Tag 30282 | 82                    | 260                        |
| Tag 40954 | 320                   | 125                        |
| WRN 117   | 80                    | 465                        |
| Tag 106   | 70                    | 460                        |



The Geotechnical Engineering Section maintains a GIS based historical record of subsurface investigations, which contains electronic records for the majority of borings completed in the past 10 years. An exploration of this database revealed no projects within a half mile radius.

## **2.2 Hazardous Materials and Underground Storage Tanks**

The ANR Natural Resource Atlas also maps the location and information of known hazardous waste sites and underground storage tanks. The location of this project is not on the Hazardous Site List however, a hazardous site is located approximately 130 feet south of the bridge. The hazard is listed as contaminated soils due to abandoned underground gasoline storage tanks. Based on this limited information, it is possible that some level of contamination may exist on site.

## **2.3 Record Plans**

An investigation into records plans for the construction of the culvert was also a part of this research. No record plans were found in the State database.

## **3.0 FIELD OBSERVATIONS**

A site investigation was not conducted by Geotechnical Section staff however photos from bridge inspection reports and satellite imagery were reviewed to evaluate feasibility of boring operations and assess general site conditions as they relate to the proposed project.

Overhead utilities run parallel with VT 100 on the south eastern side of the roadway and cross above the culvert. There is a utility pole located next to the outlet of the culvert. The utilities and pole can be seen in Figure 3.1. A minimum safe distance from the drilling equipment will be required to be maintained during drilling operations and should be considered during the planning of any subsurface investigation. A boring on in the area of the inlet should not be affected by the overhead utilities however a boring near the outlet may need to be conducted farther away from the culvert. No exposed bedrock was apparent in any of the inspection photos however, boulders are present at both the inlet and outlet of the culvert. These boulders can be seen in Figures 3.2 and 3.3.



**Figure 3.1:** *Overhead utilities above culvert crossing VT RT 100. [Inspection photo dated 2017]*



**Figure 3.2:** *Large stones at the inlet of the culvert. [Inspection photo dated 2017]*



**Figure 3.3:** *Large stones observed at the outlet of the culvert. [Inspection photo dated 2017]*

#### **4.0 PRELIMINARY FOUNDATION ALTERNATIVES**

Based on the available existing information reviewed during this investigation, if a new structure is proposed, options for a replacement include a new corrugated galvanized metal plate pipe culvert, a reinforced concrete box culvert with new headwalls and wingwalls as needed, or a precast or steel arch with spread footings founded on soil or rock. Depth and condition of the foundation soils and/or bedrock will need to be identified during the subsurface investigation.

#### **5.0 PROPOSED SUBSURFACE INVESTIGATION**

If a full replacement of the culvert is selected, we recommend a minimum of two borings be advanced with one at the inlet and one at the outlet in order to more fully assess the subsurface conditions at the site including, but not limited to, the soil properties, groundwater conditions, and depth to bedrock (if applicable). If shallow bedrock is encountered, additional borings or probes should be advanced in the roadway along the proposed culvert alignment. Borings can likely be advanced in the roadway.

## **6.0 CLOSING**

When a design alternative as well as preliminary alignment has been chosen, the Geotechnical Engineering Section should be contacted to help design a subsurface investigation that efficiently gathers adequate information for the alternative chosen.

If you have any questions or would like to discuss this report, please contact us by phone at (802) 828-2561.

## **7.0 REFERENCES**

Doll, C. G., 1970, Surficial Geologic Map of Vermont, Vermont Geological Survey, Montpelier, VT.

Ratcliffe, N. M., Stanley, R. S., Gale, M. H., Thompson, P. J., Walsh, G. J., 2011, Bedrock Geologic Map of Vermont, Vermont Geological Survey, Montpelier, VT.

Vermont Agency of Natural Resources Department of Environmental Conservation, Natural Resources Atlas, [www.anr.vermont.gov/maps/nr-atlas%20](http://www.anr.vermont.gov/maps/nr-atlas%20), accessed 11/20/2019.

cc: Laura Stone, P.E., PIIT Project Engineer  
Electronic Read File  
Project File/CEE  
END

## **Appendix F: Natural Resources Memo**



## **Appendix G: Natural Resources ID**

**State of Vermont**  
**Program Development Division**  
One National Life Drive  
Montpelier, VT 05633-5001  
**vtrans.vermont.gov**

[phone] 802-279-2562  
[fax] 802-828-2334  
[ttd] 800-253-0191

*Agency of Transportation*

To: Project File  
From: James Brady, VTrans Environmental Biologist  
Date: November 12, 2019  
Subject: Ludlow BF 013-3 (16) - Natural Resource ID

I have completed my natural resource report for the above referenced project. My evaluation has included wetlands, wildlife habitat, agricultural soils and rare, threatened and endangered species.

#### **Wetlands/Watercourses**

There are no wetlands in the project area.

The project area crosses an unnamed perennial stream. This stream is regulated by the US Army Corps of Engineers.

#### **Wildlife Habitat**

The riparian area of the unnamed stream likely provides a corridor for smaller terrestrial wildlife. The area around the culvert is developed and not the highest priority for wildlife movement. A larger structure will increase use of the structure.

The culvert currently provides partial aquatic organism passage. Aquatic organism passage will be required for this structure if it is replaced or repaired.

#### **Rare, Threatened and Endangered Species**

The only listed species in the area is the federally threatened northern long-eared bat. The structure itself does not have suitable habitat.

#### **Agricultural Soils:**

The project area is mapped as statewide significant agricultural soils.

---



## **Appendix H: Archeology Memo**

**Brennan Gauthier**  
VTrans Senior Archaeologist  
Vermont Agency of Transportation  
Project Delivery Bureau  
Environmental Section  
1 National Life Drive  
Montpelier, VT 05633  
tel. 802-279-1460  
Brennan.Gauthier@Vermont.gov

To: Julie Ann Held, VTrans Environmental Specialist  
From: Brennan Gauthier, VTrans Senior Archaeologist  
Date: 9/30/2019  
Subject: Ludlow BF 013-3(16) Archaeological Resource Identification

Julie Ann,

I have completed my background research and field investigation for Bridge 102 along Vermont Route 100 in the town of Ludlow near the Tyson Store on the town line between Plymouth and Ludlow. Bridge 102 is a corrugated steel pipe that stretches for 55 feet below VT Route 100 carrying Tiny Pond Brook. This structure is currently rated a 3/10 and is considered to be in poor condition with a failing outlet. Although VTrans records suggest this structure was built in 1919, it is unclear that anything remaining from the original bridge is still present; the corrugated metal pipe appears to be from the 1970s based on observations from other culverts along Route 100.

Background review of known archaeological sites in the general project area shows that this portion of Ludlow and Plymouth was historically home to a blast furnace and associated worker housing. In fact, VT-WN-0051 is located several hundred meters to the north of the bridge location (*Figure 3*) and was home to a profitable blast furnace that operated in the area between 1837 and 1872. In fact, several pieces of blue furnace slag were observed in the stream channel during the initial field inspection. The current culvert is located directly adjacent to the Tyson Store, which does not appear on the 1870s Beers Map, but was likely constructed at some point in the late 19<sup>th</sup> century. This store was once a gas station and background research in the Vermont Agency of Natural Resource's public-facing website shows that there is a pair of 1000 gallon underground storage tanks still buried on site. The proximity to Bridge 102 is unknown, but I thought it would important to note this in order to avoid hazardous waste issues down the line.

There are no known precontact archaeological sites within the project area and only several within the same general travel corridor of Vermont Route 100. However, there is one archaeologically sensitive area to the southeastern portion of the project area that I've mapped into the archaeological geodatabase for inclusion in future plans. Sensitivity is based on the apparent undisturbed nature of the field, proximity to a stream and the location within a natural travel corridor. Please see *Figure 5* for a visualization of the sensitive area.

As always, feel free to reach out with any questions or concerns that may arise as part of this project. I can provide additional images or illustrations if desired.

Sincerely,



# Images and Illustrations

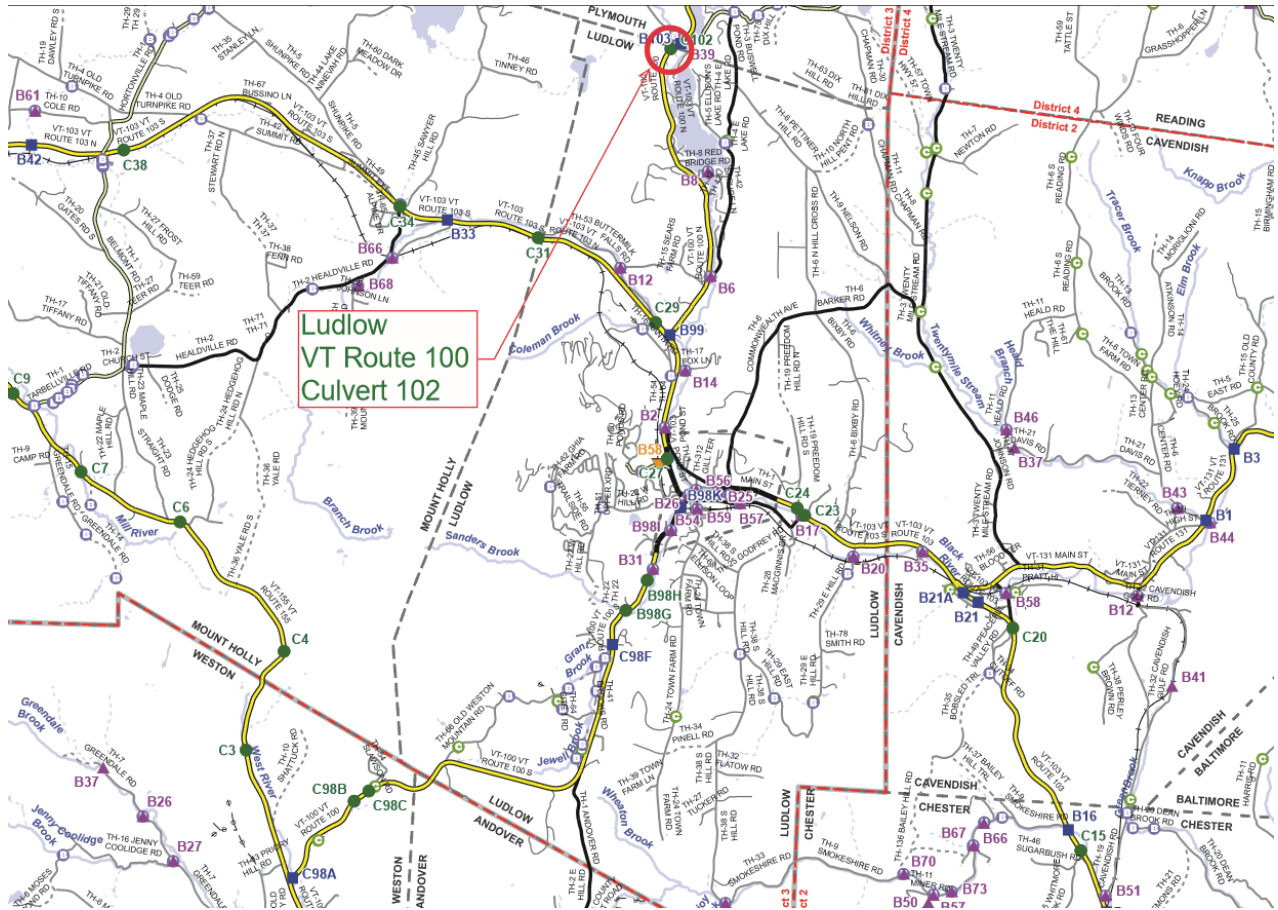


Figure 1: Project Location Map.

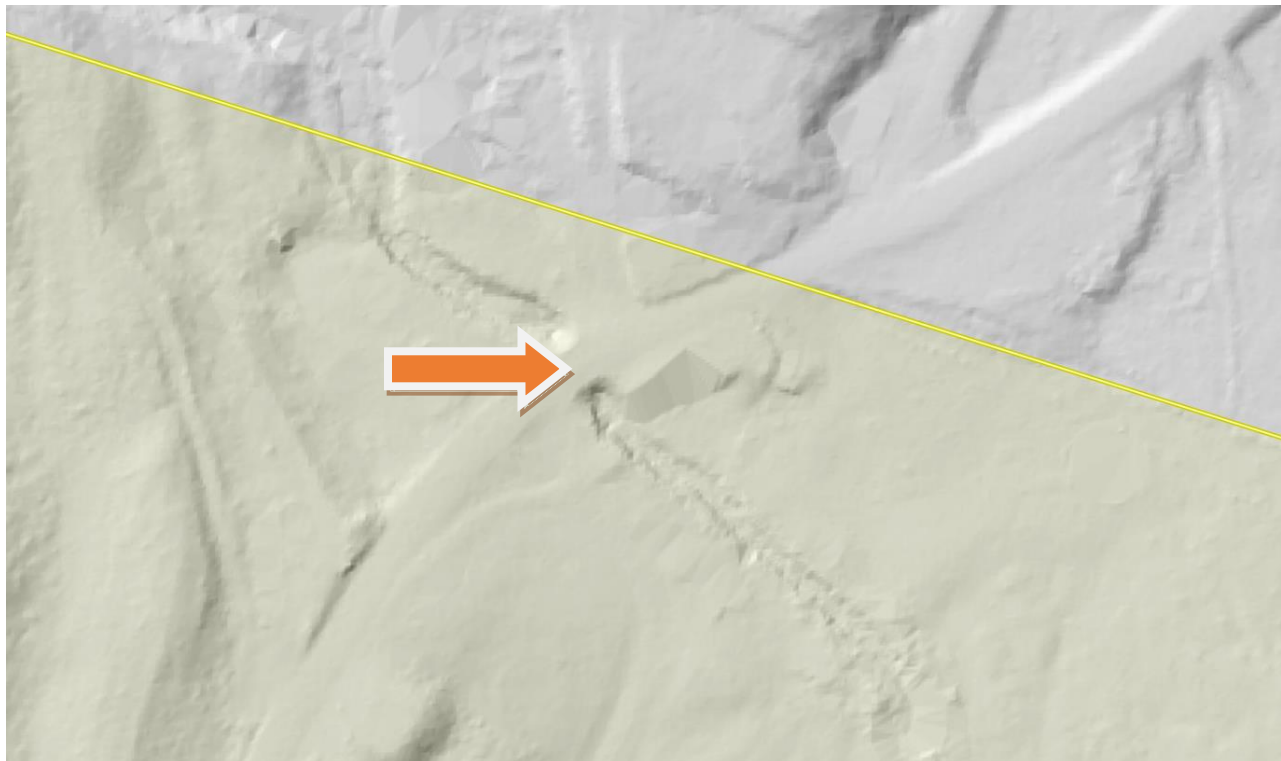


Figure 2: LiDAR View of Project Area.



Figure 3: VT-WN-0051 Site Proximity.

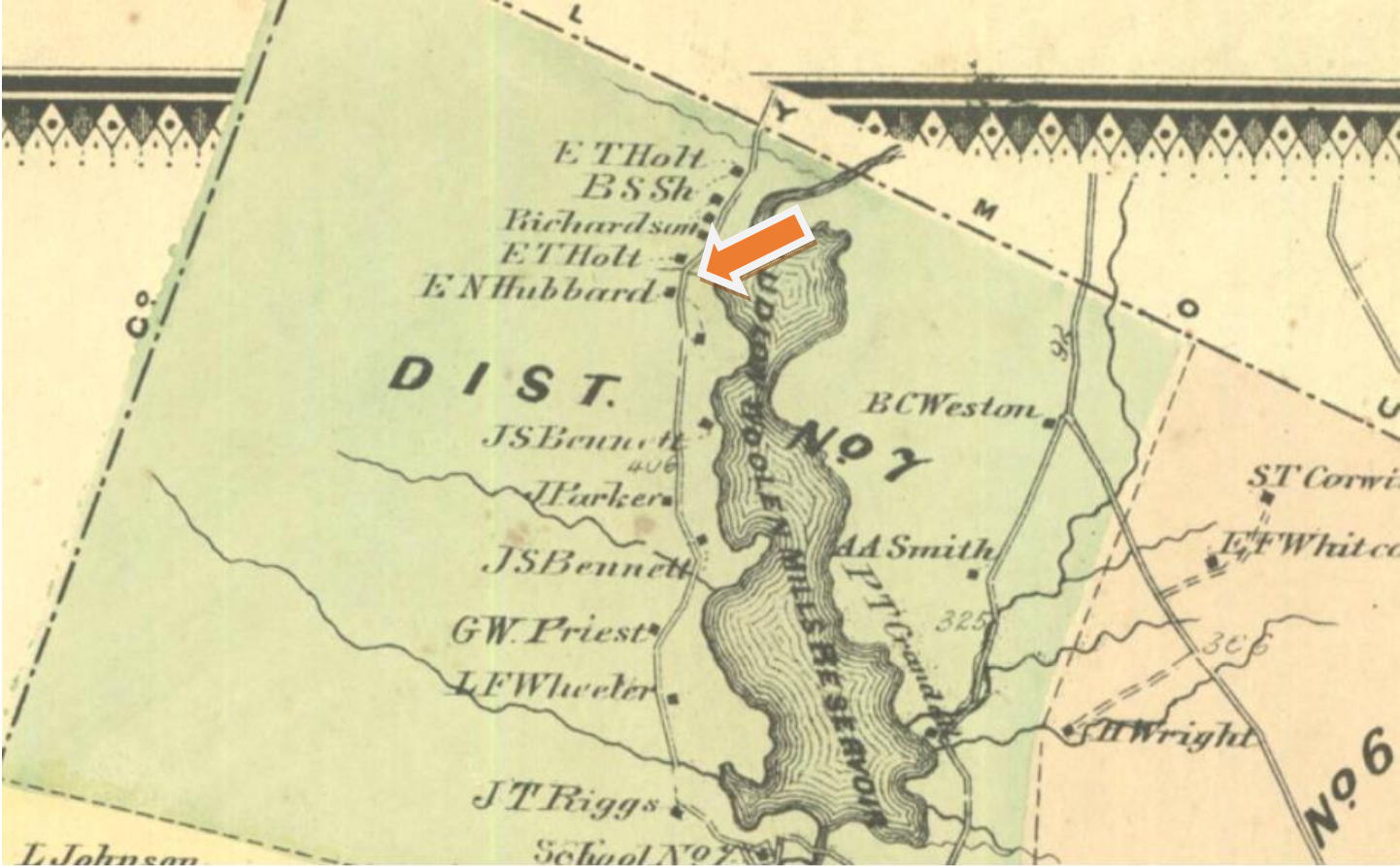


Figure 4: 1870s Map of Project Area.



Figure 5: Archaeologically Sensitive Area.

## **Appendix I: Historic Memo**



**Kyle Obenauer**  
*Historic Preservation Specialist*

Project Delivery Bureau - Environmental Section  
One National Life Drive  
Montpelier, VT 05633-5001

**Vermont Agency of Transportation**

kyle.obenauer@vermont.gov  
(802) 279-7040  
www.vtrans.vermont.gov

## **Historic Preservation Resource Identification Memo**

To: Julie Ann Held, VTTrans Environmental Specialist  
Cc: Brennan Gauthier, VTTrans Archaeologist

Date: November 12, 2019

**Subject: Ludlow BF 013-3(16)**

Julie Ann,

This Resource Identification effort is being undertaken to identify cultural resources within a broad preliminary survey area that could possibly be impacted by a future project at Bridge No. 102, which carries VT 100 over a brook near mile marker 8.43 in (Tyson) Ludlow, Windsor County, Vermont (*Figures 1-2*). Once a project has been defined at the conceptual design phase, VTTrans Cultural Resources staff will be able to determine a formal APE for purposes of Section 106 and 22 VSA § 14.

**One historic resource eligible for inclusion in the National Register of Historic Places (NRHP) was identified within a preliminary survey area, the former Ephraim T. Holt House at 1787 VT 100 (*Figure 8*).** This building has been mapped in ArcMap and is also considered a Section 4(f) property. Impacts and project-related easements on this parcel should be avoided, if possible.

Current records erroneously list that Bridge No. 102 was constructed in 1919. Likely installed sometime in the 1960s or 1970s, this structure is a deteriorated metal tube common in design, materials, and construction (*Figures 3-4*).

Several houses standing along both sides of the bridge inlet and outlet are individually listed in the Vermont State Register of Historic Places (*e.g. Figures 5-6*). Of these, the former Ephraim T. Holt house at 1787 VT 100 in Tyson appears individually eligible for inclusion in the NRHP under Criteria C (*Figure 8*). Constructed around 1865, this house is a good, increasingly rare example of a vernacular Classic Cottage with associated outbuildings. Child's Gazetteer of 1884 records that Holt was a blacksmith, veterinary, dentist, surgeon, farrier, wool grower and farmer of 175 acres.

None of the other State Register-listed buildings within the preliminary survey area appear to possess the significance necessary for individual inclusion in the NRHP. Due to intrusions and modifications to exterior cladding, fenestration, massing, and other features of the SR-listed buildings within a likely project area of potential effect, there does not preliminarily appear to be a significant concentration, linkage, or continuity of sites, buildings, structures, or objects that retain sufficient integrity for inclusion in the NRHP as a historic district. However, additional survey work would be necessary to more accurately make a definitive recommendation.

Please, let me know if there are any questions.

### Images

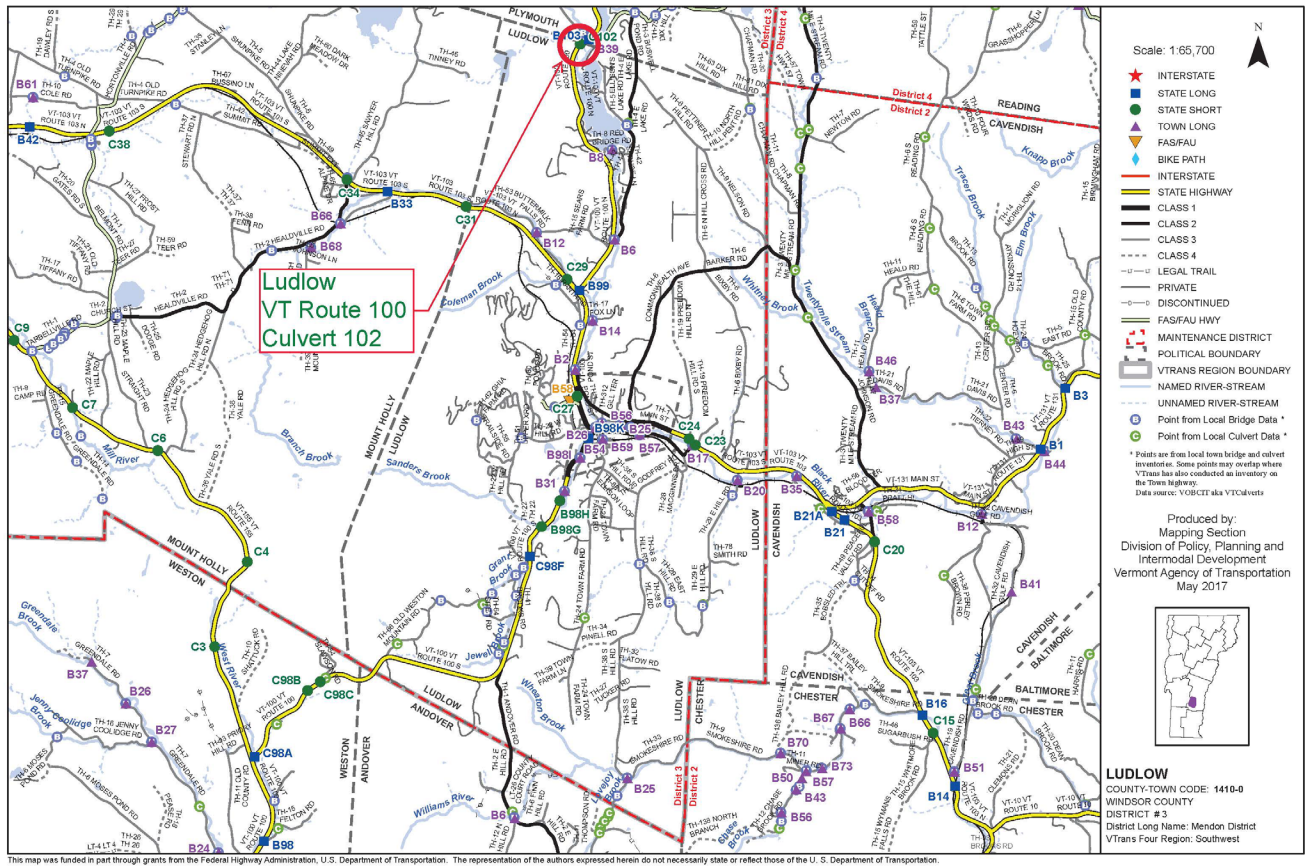


Figure 1. Bridge No. 102 Location



Figure 2. Preliminary Survey Area





*Figure 3. Bridge No. 102*



*Figure 4. Bridge No. 102 with Tyson Store in background.*



*Figure 5. SR-listed house at 1785 VT-100 in Ludlow. SR survey No. 1410-121.*



*Figure 6. SR-listed Tyron Store. SR survey No. 1410-120.*



*Figure 7. Ineligible building at outlet.*



*Figure 8. Former Ephraim T. Holt House, c. 1865. SR survey No. 1410-122.*

## **Appendix J: Hazardous Sites Map**



## LEGEND

- Landfills**
  - OPERATING
  - CLOSED
- Land Use Restrictions**
  - Class IV GW Reclass
  - Class VI GW Reclass
  - Deed Restriction
  - Easement
  - Land Record Notice
  - Other
- Hazardous Site
- Brownfields
- Salvage Yard
- Aboveground Storage Tank
- Underground Storage Tank (w/)
- Dry Cleaner
- Architectural Waste Recycling
- Urban Soil Background Areas
- Parcels (standardized)
- Parcels (non-standardized)
- Act250 Permits \*\*INCOMPLET
- VTRANS State and Town Long
- VTRANS State Short Structure
- Town Bridge
- Town Culvert
- Roads**
  - Interstate
  - Principal Arterial

1: 3,251

July 31, 2019



165.0 0 82.00 165.0 Meters

WGS\_1984\_Web\_Mercator\_Auxiliary\_Sphere

1" = 271 Ft. 1cm = 33 Meters

© Vermont Agency of Natural Resources

THIS MAP IS NOT TO BE USED FOR NAVIGATION

**DISCLAIMER:** This map is for general reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable. ANR and the State of Vermont make no representations of any kind, including but not limited to, the warranties of merchantability, or fitness for a particular use, nor are any such warranties to be implied with respect to the data on this map.

## NOTES

Map created using ANR's Natural Resources Atlas

## Appendix K: Crash Data

General Yearly Summaries - Crash Listing: State Highways and All Federal Aid Highway Systems

WHERE Year of Crash >= 2012 AND Year of Crash <= 2016

| * Reporting Agency/<br>Incident No. | City/Town | Mile<br>Marker | Crash Date | Time      | Weather                                | Contributing Circumstances   | Direction of Collision                  | Number<br>Of<br>Injuries | Number<br>Of<br>Fatalities | Number<br>Of<br>Untimely<br>Deaths | Direction | Road<br>Group        |
|-------------------------------------|-----------|----------------|------------|-----------|--|--|---|--------------------------|----------------------------|------------------------------------|-----------|----------------------|
| VT0140100/13LL00956                 | Ludlow    | 4.66           | 10/06/2013 | 00:21     | Clear                                  |  | Rear End                                | 0                        | 0                          | 0                                  | S, N      | SH                   |
| VT0140100/14LL01619                 | Ludlow    | 4.67           | 12/23/2014 | 16:38     | Rain                                   |  | Rear End                                | 0                        | 0                          | 0                                  | N         | SH                   |
| VT0140100/2016LL002958              | Ludlow    | 4.70           | 12/29/2016 | 17:27     | Snow                                   | Inattention, Driving too fast for conditions   | No Turns, Thru moves only, Broadside ^< | 0                        | 0                          | 0                                  | E, S      | SH<br>Class 1<br>TH  |
| VT0140100/14LL01394                 | Ludlow    | 5.03           | 11/01/2014 | 15:11     | Cloudy                                 | Operating vehicle in erratic, reckless, careless, negligent, or aggressive manner, Failure to keep in proper lane                  | Single Vehicle Crash                    | 1                        | 0                          | 0                                  | S         | SH                   |
| VT0140100/15LL00241                 | Ludlow    | 5.04           | 02/15/2015 | 16:18     | Clear                                  | Failed to yield right of way   | Left Turn and Thru, Broadside v<--      | 0                        | 0                          | 0                                  | W, S      | SH                   |
| VT0140100/15LL00756                 | Ludlow    | 5.26           | 06/18/2015 | 22:22     | Clear                                  | Swerving or avoiding due to wind, slippery surface, vehicle, object, non-motorist in roadway etc, No improper driving              | Single Vehicle Crash                    | 0                        | 0                          | 0                                  | N         | SH                   |
| VT0140000/12WNC0078                 | Ludlow    | 5.40           | 06/30/2012 | 13:26     | [No Weather]                           |  | [No Direction of Collision]             | 2                        | 0                          | 0                                  | N         | SH                   |
| VT0140100/12-LL-00653               | Ludlow    | 6.64           | 07/12/2012 | 16:45     | Clear                                  | Inattention  | Single Vehicle Crash                    | 0                        | 0                          | 0                                  | S         | SH                   |
| VT0140100/15LL00951                 | Ludlow    | 7.19           | 07/24/2015 | 00:24     | Clear                                  | Under the influence of medication/drugs/alcohol, Operating vehicle in erratic, reckless, careless, negligent, or aggressive manner | Single Vehicle Crash                    | 1                        | 0                          | 0                                  | N         | SH                   |
| VT0140100/15LL01261                 | Ludlow    | 7.21           | 09/26/2015 | 19:56     | Clear                                  | No improper driving  | Other - Explain in Narrative            | 0                        | 0                          | 0                                  | S         | SH                   |
| VT0140100/13LL00504                 | Ludlow    | 7.38           | 06/09/2013 | 12:18     | [No Weather]                           |  | [No Direction of Collision]             | 0                        | 0                          | 0                                  | N         | SH                   |
| VT0140100/15-LL-01398               | Ludlow    | 7.94           | 10/30/2015 | 08:13     | Cloudy                                 | Fatigued, asleep, Failure to keep in proper lane, No improper driving  | Head On                                 | 1                        | 0                          | 0                                  | N, S      | SH                   |
| VT0140100/13-LL-00317               | Ludlow    | UNK            | 04/08/2013 | 02:25     | Cloudy                                 | Distracted   | Single Vehicle Crash                    | 1                        | 0                          | 0                                  | N         | SH                   |
| VT0140100/15LL00161                 | Ludlow    | UNK            | 02/02/2015 | [No Time] | Snow                                   |  | Rear End                                | 0                        | 0                          | 0                                  | N         | SH                   |
| VTVSP1100/13D305358                 | Plymouth  | 0.34           | 12/14/2013 | 08:30     | [No Weather]                           |  | [No Direction of Collision]             | 0                        | 0                          | 0                                  |           | SH                   |
| VTVSP1100/14D304316                 | Plymouth  | 0.62           | 10/31/2014 | 07:13     | Clear                                  | Under the influence of medication/drugs/alcohol  | Single Vehicle Crash                    | 0                        | 0                          | 0                                  | S         | SH                   |
| VTVSP1100/15D304680                 | Plymouth  | 1.10           | 12/01/2015 | 12:54     | [No Weather]                           |  | [No Direction of Collision]             | 0                        | 0                          | 0                                  |           | SH                   |
| VT0140000/15WNC0216                 | Plymouth  | 1.10           | 12/01/2015 | 13:00     | Sleet, Hail (Freezing Rain or Drizzle) | Driving too fast for conditions  | Single Vehicle Crash                    | 0                        | 0                          | 0                                  | S         | SH                   |
| VT0140000/16WNC0299                 | Plymouth  | 1.45           | 11/11/2016 | 15:15     | Clear                                  | Failure to keep in proper lane, Fatigued, asleep, No improper driving  | Opp Direction Sideswipe                 | 0                        | 0                          | 0                                  | S, N      | SH<br>State<br>Owned |
| VT0140000/16WNC0234                 | Plymouth  | 1.88           | 08/24/2016 | 09:50     | Clear                                  |  | Other - Explain in Narrative            | 1                        | 0                          | 0                                  | S, N      | SH<br>State<br>Owned |
| VT0140000/14WNC0165                 | Plymouth  | 3.73           | 07/30/2014 | 10:30     | Clear                                  |  | Single Vehicle Crash                    | 0                        | 0                          | 0                                  | S         | SH                   |
| VT0140000/16WNC0051                 | Plymouth  | 4.11           | 02/13/2016 | 08:10     | Snow                                   |  | Head On                                 | 0                        | 0                          | 0                                  | S         | SH<br>State<br>Owned |

\*Crash occurred prior to the last Highway Improvement Project. This data should not be used in a crash analysis. UNK indicates Mile Marker is Unknown.

## **Appendix L: Utility Field Sketch**



**Ludlow BF 013-3(16)**  
*Existing Utilities within Project Limits*  
*Culvert 102, Ludlow*  
*Route 100, MM 8.43*

Aerial Utilities

Ludlow Electric (single phase), Comcast Communications, Ludlow TDS Telecom, and Vermont Telephone Company.

There is a main utility line that runs along Route 100. One of the poles is located near the outlet of the culvert. The utility line contains single phase power and 3 communication lines.

There are multiple service lines that cross over the culvert.

A utility relocation will likely be needed for the project.

Underground Utilities

VTel has an underground communication line that drops on a pole located southwest of the culvert and runs to a pedestal located just south of the culvert. The line ends at the pedestal.

Ludlow BF 013-3(16)  
Existing Utilities



## Appendix M: Local Input

## Local & Regional Input Questionnaire

---

### Project Summary

This project, BF 013-3(16), focuses on culvert 102 on VT Route 100 in Ludlow, Vermont. The culvert is deteriorating and is in need of either a major maintenance action or replacement. Potential options being considered for this project include a new liner applied to the interior of the existing culvert pipe, removal of the existing pipe or replacement with a new culvert placed in the same location. It is possible that VTrans will recommend a road closure and detour traffic away from the project site for the duration of the work. Efforts will be made to limit the detour to State roads.

### Community Considerations

1. Are there regularly scheduled public events in the community that will generate increased traffic (e.g. vehicular, bicycles and/or pedestrians), or may be difficult to stage if the bridge is closed during construction? Examples include annual bike races, festivals, parades, cultural events, weekly farmers market, concerts, etc. that could be impacted? If yes, please provide approximate date, location and event organizers' contact info.

Fourth of July parade, Memorial Day parade, 100 on 100 running event from Stowe to Ludlow (August 17<sup>th</sup> this year), winter ski traffic, little league parade

2. Is there a "slow season" or period of time from May through October where traffic is less or no events are scheduled?

The project is in the Lakes District, so summer is very busy. Winter is also very busy with ski traffic from Okemo and Killington. The slow season is April through May, mid-October (post Columbus Day weekend) through November.

3. Please describe the location of the Town garage, emergency responders (fire, police, ambulance) and emergency response routes that might be affected by the closure of the bridge, one-way traffic, or lane closures and provide contact information (names, address, email addresses, and phone numbers).

Emergency responders will be slowed down when responding to mutual aid calls in Plymouth. Municipal facilities are not located close to this project.

4. Are there businesses (including agricultural operations and industrial parks) or delivery services (fuel or goods) that would be adversely impacted either by a detour or due to work zone proximity?

The project is in the very small hamlet of Tyson, which is mostly in Plymouth. Businesses that may be impacted in the area include the Tyson Store, Echo Lake Inn, and Inn at Water's Edge. Other businesses along the VT Route 100 corridor that might be impacted include Clear Lake Furniture, Green Mountain Sugarhouse and Tavola Italiana.

## Local & Regional Input Questionnaire

---

5. Are there important public buildings (town hall, community center, senior center, library) or community facilities (recreational fields, town green, etc.) close to the project?

No, the project is on the edge of town, near the Ludlow/Plymouth town line.

6. What other municipal operations could be adversely affected by a road/bridge closure or detour?

Primarily emergency services.

7. Are there any town highways that might be adversely impacted by traffic bypassing the construction on other local roads? Please indicate which roads may be affected and their condition (paved/unpaved, narrow, weight-limited bridges, etc), including those that may be or go into other towns.

Yes, East Lake Road and Red Bridge Road would likely experience bypass traffic if the road is closed.

8. Is there a local business association, chamber of commerce, regional development corporation, or other downtown group that we should be working with? If known, please provide name, organization, email, and phone number.

Rotary, Jill Tofferi (Library), 802-228-8921

Okemo Valley Chamber of Commerce, Carol Lighthall, 802-228-5830,  
[clighthall@yourplaceinvermont.com](mailto:clighthall@yourplaceinvermont.com)

Springfield Regional Development Corp, Bob Flint, 802-885-3061,  
[bobf@springfielddevelopment.org](mailto:bobf@springfielddevelopment.org)

Town of Plymouth

9. Are there any public transit services or stops that use the bridge or transit routes in the vicinity that may be affected if they become the detour route?

Ludlow Municipal Transit, The Current and The Bus provide transit services in Ludlow. There are no fixed routes services that we are aware of along this section of VT Route 100.

### Schools

1. Where are the schools in your community and what are their yearly schedules (example: first week in September to third week in June)?

## Local & Regional Input Questionnaire

---

Ludlow Elementary School and Black River Middle/High School are both located along VT Route 103 in the Village of Ludlow. Both are in session from September through June. The Black River Middle/High School is closing in 2020.

2. Is this project on specific routes that school buses or students use to walk to and from school?

No, this is not a pedestrian route for school children.

3. Are there recreational facilities associated with the schools nearby (other than at the school)?

There are no school recreation facilities in the vicinity of this project.

### Pedestrians and Bicyclists

1. What is the current level of bicycle and pedestrian use on the bridge?

This is a popular bike route that experiences moderate use. There is not much pedestrian activity. It is in the Lakes District with inns and a store close by, so there is likely some modest walking activity in the area.

2. Are the current lane and shoulder widths adequate for pedestrian and bicycle use?

The project should maintain shoulder widths that are consistent with the roadway approaches.

3. Does the community feel there is a need for a sidewalk or bike lane on the bridge?

It is a popular bike route, so maintaining adequate shoulder widths is a priority for the community.

4. Is pedestrian and bicycle traffic heavy enough that it should be accommodated during construction?

There is not heavy use during early spring and late fall.

5. Does the Town have plans to construct either pedestrian or bicycle facilities leading up to the bridge? Please provide any planning documents demonstrating this (scoping study, master plan, corridor study, town or regional plan).

No, Ludlow has no plans in this vicinity.

6. In the vicinity of the bridge, is there a land use pattern, existing generators of pedestrian and/or bicycle traffic, or zoning that will support development that is likely to lead to significant levels of walking and bicycling?

The project is in located in the very small hamlet of Tyson. Tyson is not experiencing growth. We do not anticipate significant pedestrian traffic in this area. There is moderate bicycling activity as discussed above.

## Local & Regional Input Questionnaire

---

### Design Considerations

1. Are there any concerns with the alignment of the existing bridge? For example, if the bridge is located on a curve, has this created any problems that we should be aware of?

We are not aware of any alignment issues.

2. Are there any concerns with the width of the existing bridge?

No concerns.

3. Are there any special aesthetic considerations we should be aware of?

Nothing that we are aware of.

4. Does the location have a history of flooding? If yes, please explain.

We are not aware of flooding issues at this location. It is within an unmapped river corridor.

5. Are there any known Hazardous Material Sites near the project site?

Not that we are aware of.

6. Are there any known historic, archeological and/or other environmental resource issues near the project site?

There are no known resources in the vicinity that we are aware of, except for the stream itself and the lake it flows into.

7. Are there any utilities (water, sewer, communications, power) attached to the existing bridge? Please provide any available documentation.

There is no municipal water or sewer infrastructure in the vicinity. There may be a utility pole near the outlet. We are not aware of other infrastructure near to the structure.

8. Are there any existing, pending, or planned municipal utility projects (communications, lighting, drainage, water, wastewater, etc.) near the project that should be considered?

No projects are planned.

9. Are there any other issues that are important for us to understand and consider?

Winter ski traffic from Killington and Okemo.

## Local & Regional Input Questionnaire

---

### Land Use & Zoning

1. Please provide a copy of your existing and future land use map or zoning map, if applicable.

See the attached maps. Please be aware that the attached Future Land Use Map is a draft; the public hearing process to adopt the plan and this map is ongoing.

2. Are there any existing, pending or planned development proposal that would impact future transportation patterns near the bridge? If so, please explain.

None that we are aware of.

3. Is there any planned expansion of public transit or intercity transit service in the project area? Please provide the name and contact information for the relevant public transit provider.

None that we are aware of.

### Communications

1. Please identify any local communication outlets that are available for us to use in communicating with the local population. Include weekly or daily newspapers, blogs, radio, public access TV, Facebook, Front Page Forum, etc. Also include any unconventional means such as local low-power FM.

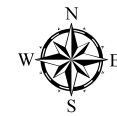
Email is the best to use for communication. Public access TV could be used too. Ludlow also has a Front Porch Forum.

2. Other than people/organizations already referenced in this questionnaire, are there any others who should be kept in the loop as the project moves forward?

Local businesses identified previously in this questionnaire as well as Okemo Mountain Resort and IMERYS Talc Plant.



# ZONING MAP OF LUDLOW VERMONT



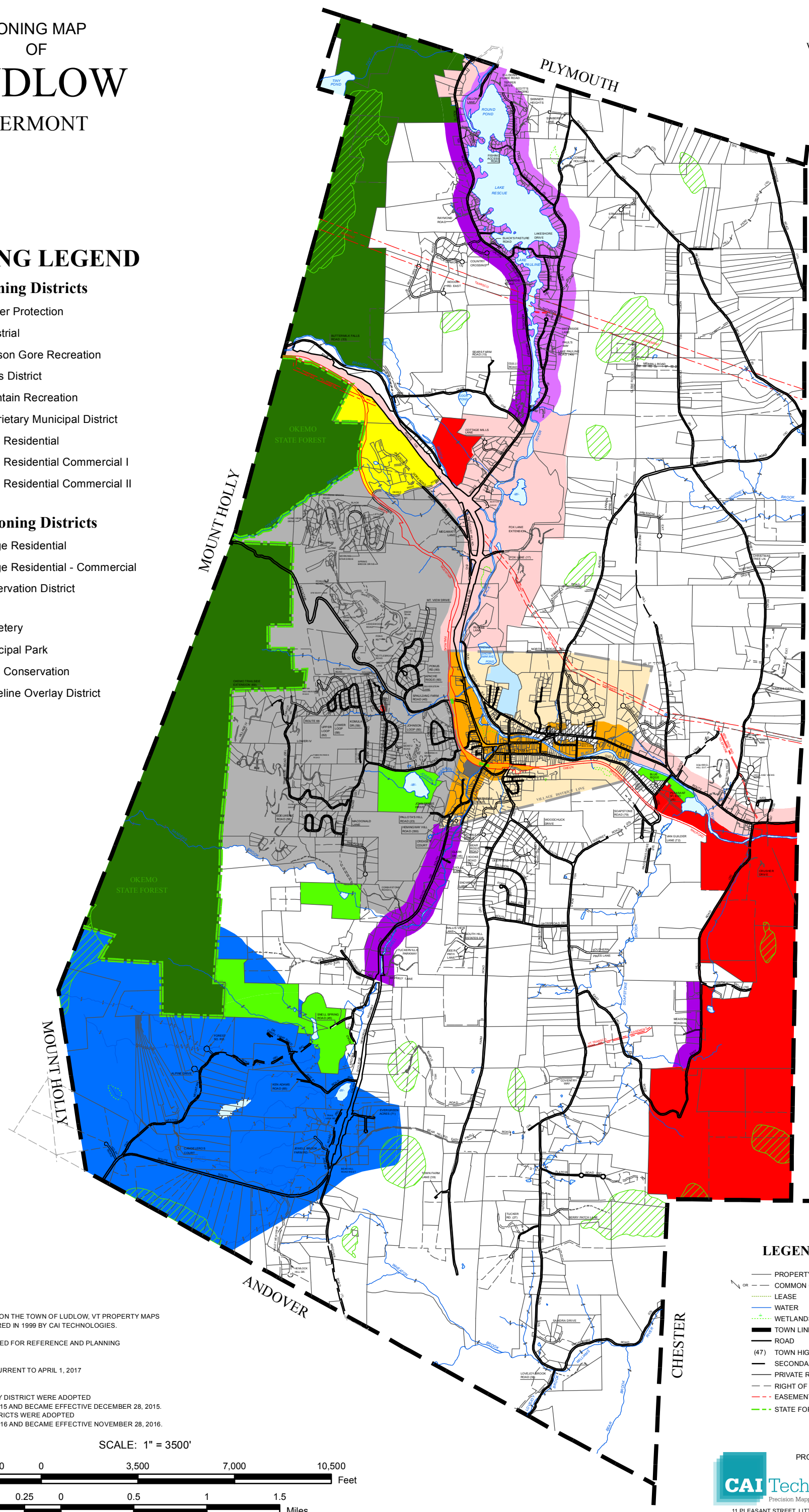
## ZONING LEGEND

### Town Zoning Districts

- Aquifer Protection
- Industrial
- Jackson Gore Recreation
- Lakes District
- Mountain Recreation
- Proprietary Municipal District
- Town Residential
- Town Residential Commercial I
- Town Residential Commercial II

### Village Zoning Districts

- Village Residential
- Village Residential - Commercial
- Preservation District
- Cemetery
- Municipal Park
- State Conservation
- Ridgeline Overlay District



## NOTES

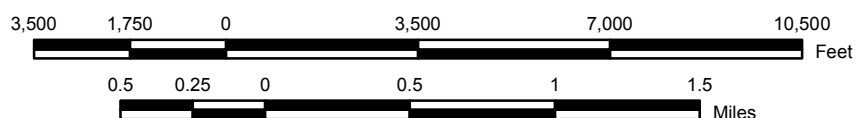
THIS MAP IS BASED ON THE TOWN OF LUDLOW, VT PROPERTY MAPS ORIGINALLY PREPARED IN 1999 BY CAI TECHNOLOGIES.

THIS MAP IS INTENDED FOR REFERENCE AND PLANNING PURPOSES ONLY.

PROPERTY LINES CURRENT TO APRIL 1, 2017

SOURCE DATA:  
 RIDGELINE OVERLAY DISTRICT WERE ADOPTED ON DECEMBER 7, 2015 AND BECAME EFFECTIVE DECEMBER 28, 2015.  
 TOWN ZONING DISTRICTS WERE ADOPTED ON NOVEMBER 7, 2016 AND BECAME EFFECTIVE NOVEMBER 28, 2016.

SCALE: 1" = 3500'



## LEGEND

- PROPERTY LINE
- COMMON OWNERSHIP
- LEASE
- WATER
- WETLANDS
- TOWN LINE
- ROAD
- (47) TOWN HIGHWAY NUMBER
- SECONDARY ROAD
- PRIVATE ROAD
- RIGHT OF WAY
- EASEMENT
- STATE FOREST

**Appendix N: Operations Questionnaire**

## Culvert Scoping Project BF 013-3(16) Operations Input Questionnaire

---

The Structures Section has begun the scoping process for BF 013-3(16), VT Route 100 Culvert 102, over an unnamed brook. This is a culvert constructed in 1919. The Structure Inspection, Inventory, and Appraisal Sheet (attached) rates the culvert as 4 (poor), and the channel as 7 (good). We are interested in hearing your thoughts regarding the items listed below. Leave it blank if you don't wish to comment on a particular item.

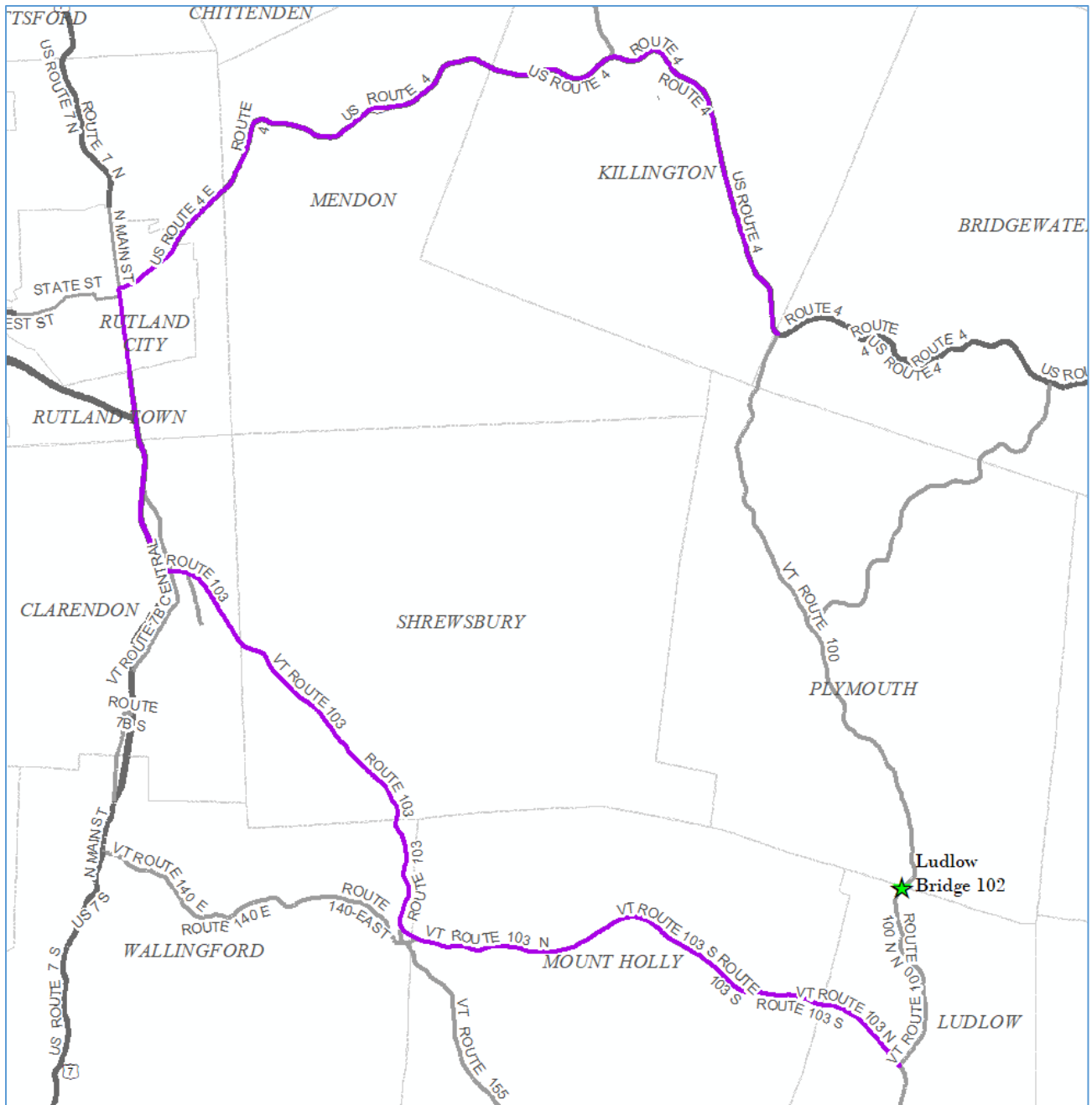
1. What are your thoughts on the general condition of this culvert and the general maintenance effort required to keep it in service? **The culvert is in poor condition. The District has repaired/armored the embankment several times but it keeps sloughing.**
2. What are your comments on the current geometry and alignment of the road over the culvert (curve, sag, banking, sight distance)? **All good.**
3. Do you feel that the posted speed limit is appropriate? **Yes.**
4. Is the current roadway width adequate for winter maintenance including snow plowing? **Yes.**
5. Are the railings constantly in need of repair or replacement? What type of railing works best for your district? (We are recommending more and more box beam guardrail on our culverts because of crash-worthiness and compatibility with accelerated projects). **Constantly....no. But the rail needs some attention now. Box beam would be a viable substitute.**
6. Are you aware of any unpermitted driveways within close proximity to the culvert? We frequently encounter driveways that prevent us from meeting railing and safety standards. **None that we are aware of.**
7. Are you aware of abutting property owners that are likely to need special attention during the planning and construction phases? These could be people with disabilities, elderly, or simply folks who feel they have been unfairly treated in the past. **The Tyson General store is adjacent to this culvert and part of it's parking area abuts the culvert.**
8. Do you find that extra effort is required to keep the slopes and river banks around the culvert in a stable condition? Is there frequent flood damage that requires repair? **Yes...refer to Question 1. There is not frequent flood damage.**
9. Does this culvert seem to catch an unusual amount of debris from the waterway? **No.**
10. Are you familiar with traffic volumes in the area of this project? **Yes.**

## Culvert Scoping Project BF 013-3(16) Operations Input Questionnaire

---

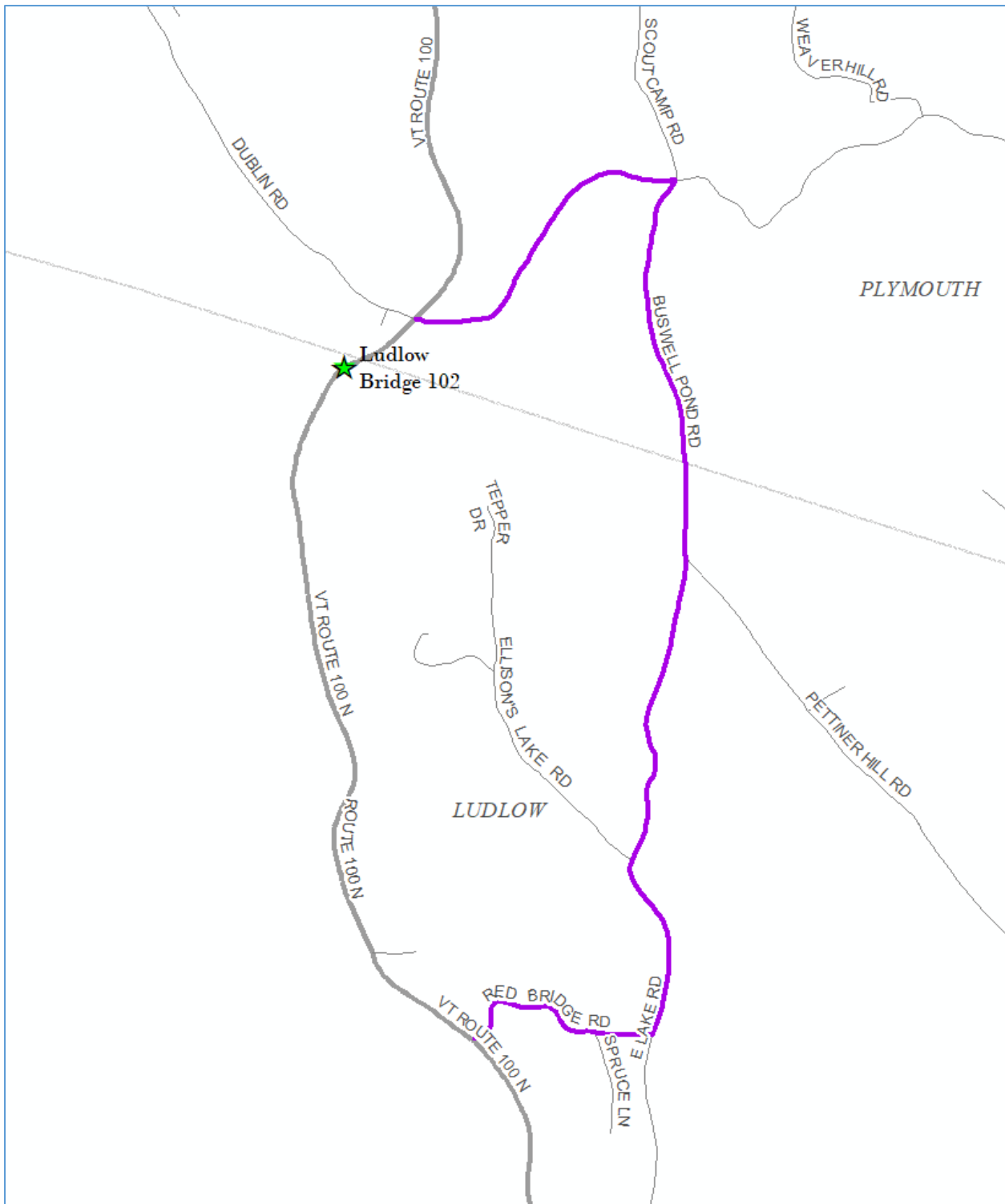
11. Do you think a closure with off-site detour and accelerated construction would be appropriate? Do you have any opinion about a possible detour route, assuming that we use State route for State projects and any route for Town projects? Are there locations on a potential detour that are already congested that we should consider avoiding? **A detour route would be very lengthy. V100 to U004 to U007 to V103 to V100 (and reverse).**
  
12. Please describe any larger projects that you have completed that may not be reflected on the attached Appraisal sheet, such as deck patches, paving patches, railing replacement with new type, steel coating, etc. **N/A**
  
13. Are there any drainage issues that we should address on this project? **No.**
  
14. Are you aware of any complaints that the public has about issues that we can address on this project? **No.**
  
15. Is there anything else we should be aware of? **I believe this pipe was damaged during TS Irene and currently is s programmed project?**

## **Appendix O: Detour Routes**



**Detour Route:** VT Route 100, to US Route 4, US Route 7, and VT Route 103, back to VT Route 100

- 53.7 Miles end-to-end
- 14.1 Miles Through-Route
- 39.6 Miles Detour Route
- 25.5 Miles Added



**Local Bypass Route:** VT Route 100 to Kingdom Road, Buswell Pond Road, Buswell Road, E Lake Road, and Red Bridge Road, back to VT Route 100 (4.6 miles end-to-end)

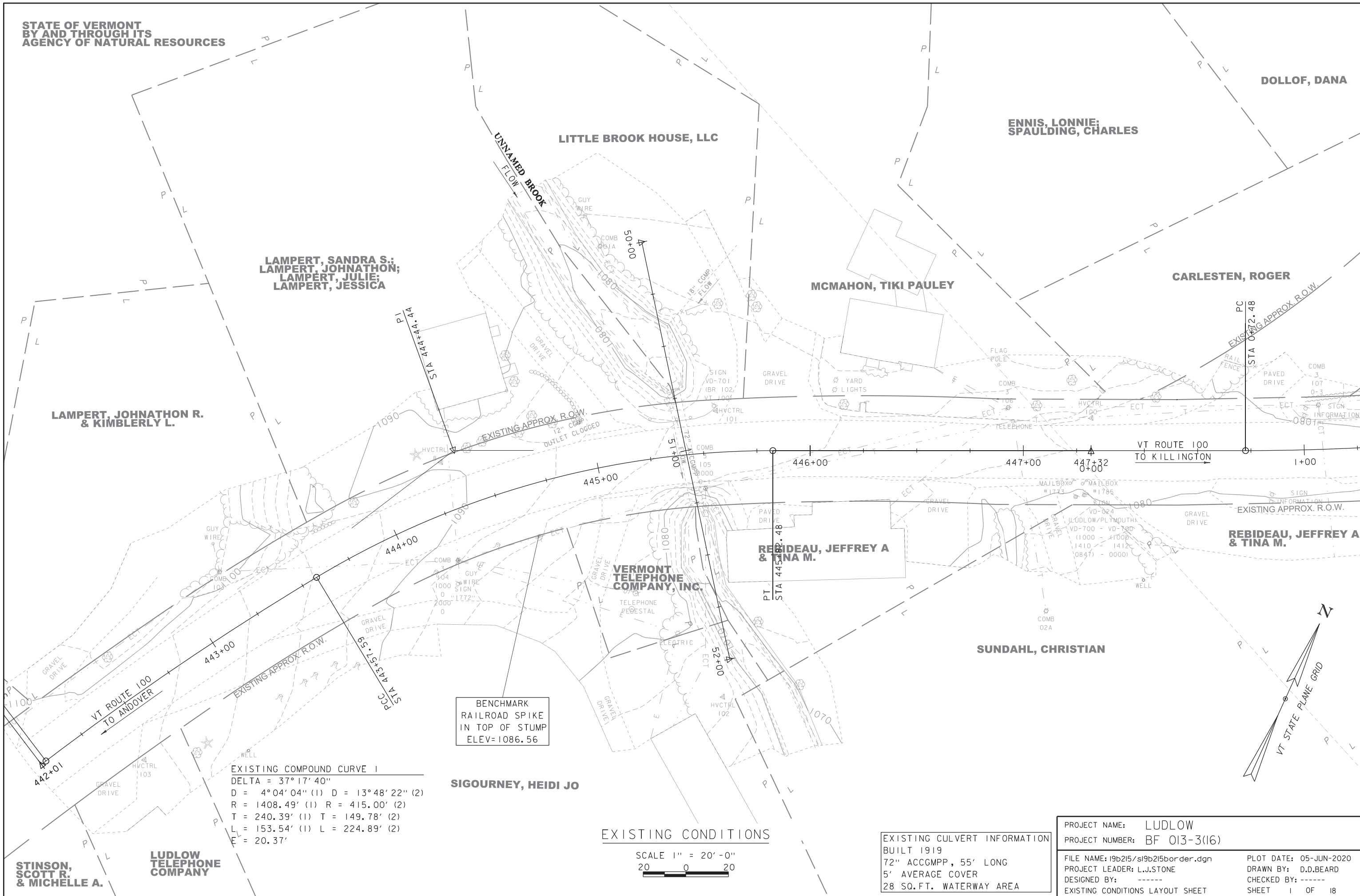
- 4.6 Miles end-to-end
- 1.7 Miles Through-Route
- 2.9 Miles Detour Route
- 1.2 Miles Added

## Appendix P: Plans

### INDEX OF SHEETS

| SHEET NO. | SHEET DESCRIPTION  |
|-----------|--|
| 1         | Existing Conditions Layout                                   |
| 2         | Existing Profile Sheet                                       |
| 3         | VT Route 100 Typical Sections                                |
| 4         | Alternative 1 (Culvert Rehabilitation) Typical Sections      |
| 5         | Alternative 1 (Culvert Rehabilitation) Profile               |
| 6         | Alternative 1 (Culvert Rehabilitation) Slip-Liner Layout     |
| 7         | Alternative 1 (Culvert Rehabilitation) Spray-On Liner Layout |
| 8         | Alternative 2 (New Precast Box) Typical Sections             |
| 9         | Alternative 2 (New Precast Box) Profile                      |
| 10        | Alternative 2 (New Precast Box) Layout                       |
| 11        | Alternative 3 (New 3-Sided Arch or Frame) Typical Sections   |
| 12        | Alternative 3 (New 3-Sided Arch or Frame) Profile            |
| 13        | Alternative 3 (New 3-Sided Arch or Frame) Layout             |
| 14        | Upstream Temporary Bridge Layout                             |
| 15        | Downstream Temporary Bridge Layout                           |
| 16        | Phasing Typical Sections                                     |
| 17        | Phase 1 Layout   |
| 18        | Phase 2 Layout   |





LAMPERT, SANDRA S.;  
LAMPERT, JOHNATHON;  
LAMPERT, JULIE;  
LAMPERT, JESSICA

LITTLE BROOK HOUSE, LLC

ENNIS, LONNIE;  
SPAULDING, CHARLES

DOLLOF, DANA

MCMAHON, TIKI PAULEY

CARLESTEN, ROGER

LAMPERT, JOHNATHON R.  
& KIMBLERLY L.

REBIDEAU, JEFFREY A  
& TINA M.

VERMONT  
TELEPHONE  
COMPANY, INC.

SUNDAHL, CHRISTIAN

SIGOURNEY, HEIDI JO

STINSON,  
SCOTT R.  
& MICHELLE A.

LUDLOW  
TELEPHONE  
COMPANY

EXISTING COMPOUND CURVE 1  
DELTA = 37° 17' 40"  
D = 4° 04' 04" (1) D = 13° 48' 22" (2)  
R = 1408.49' (1) R = 415.00' (2)  
T = 240.39' (1) T = 149.78' (2)  
L = 153.54' (1) L = 224.89' (2)  
E = 20.37'

BENCHMARK  
RAILROAD SPIKE  
IN TOP OF STUMP  
ELEV= 1086.56

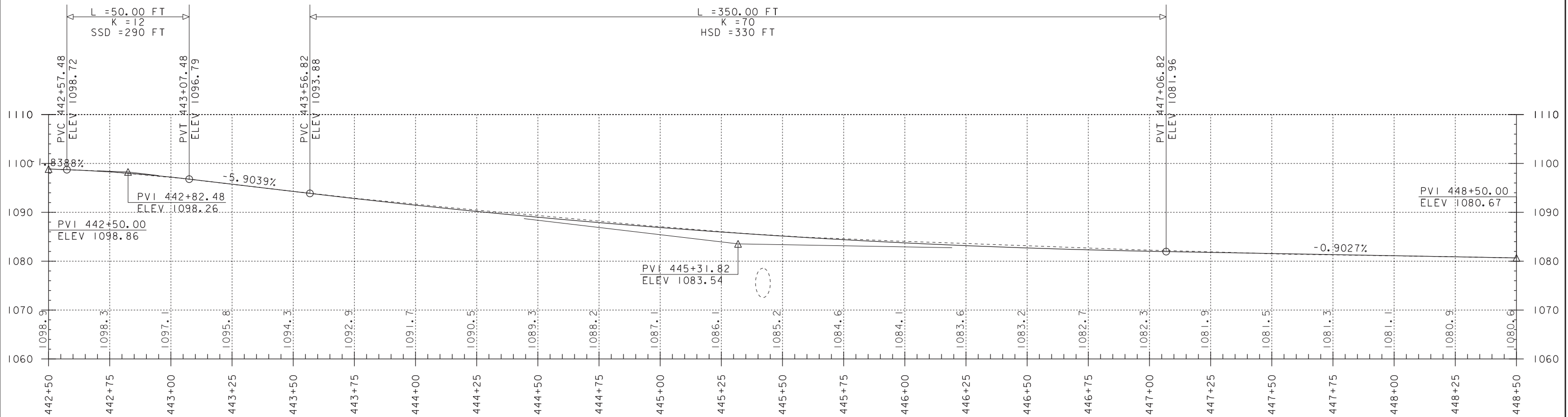
EXISTING CONDITIONS

SCALE 1" = 20' - 0"  
20 0 20

EXISTING CULVERT INFORMATION  
BUILT 1919  
72" ACCGMPP, 55' LONG  
5' AVERAGE COVER  
28 SQ. FT. WATERWAY AREA

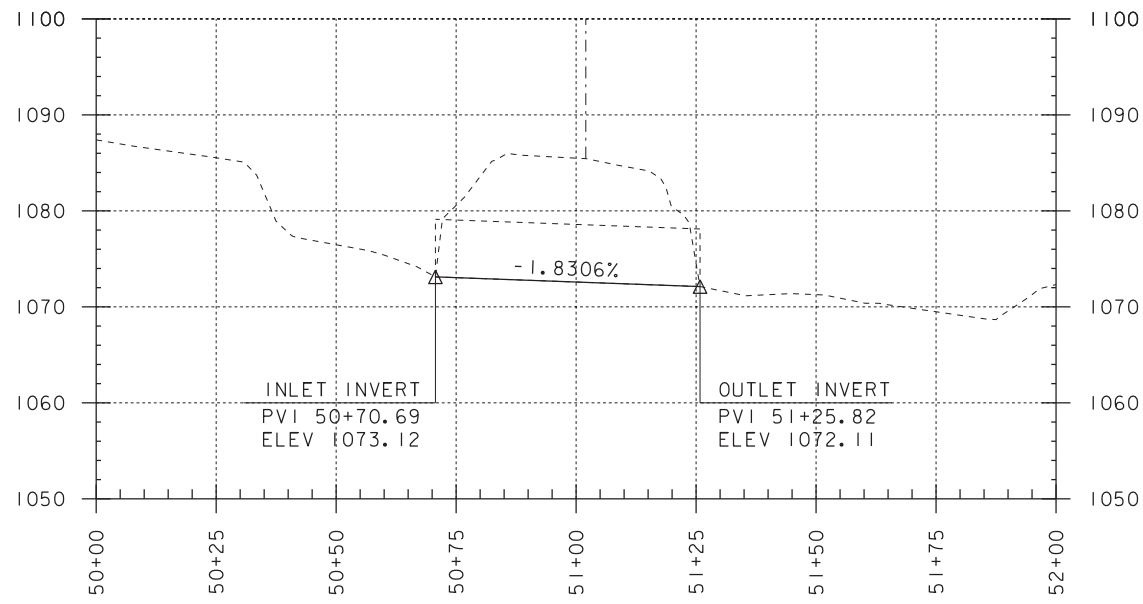
PROJECT NAME: LUDLOW  
PROJECT NUMBER: BF 013-3(16)  
FILE NAME: I9b215/sb9b215border.dgn  
PROJECT LEADER: L.J.STONE  
DESIGNED BY: -----  
EXISTING CONDITIONS LAYOUT SHEET

PLOT DATE: 05-JUN-2020  
DRAWN BY: D.D.BEARD  
CHECKED BY: -----  
SHEET 1 OF 18



VT ROUTE 100 PROFILE

SCALE: HORIZONTAL 1"=20'-0"  
VERTICAL 1"=10'-0"

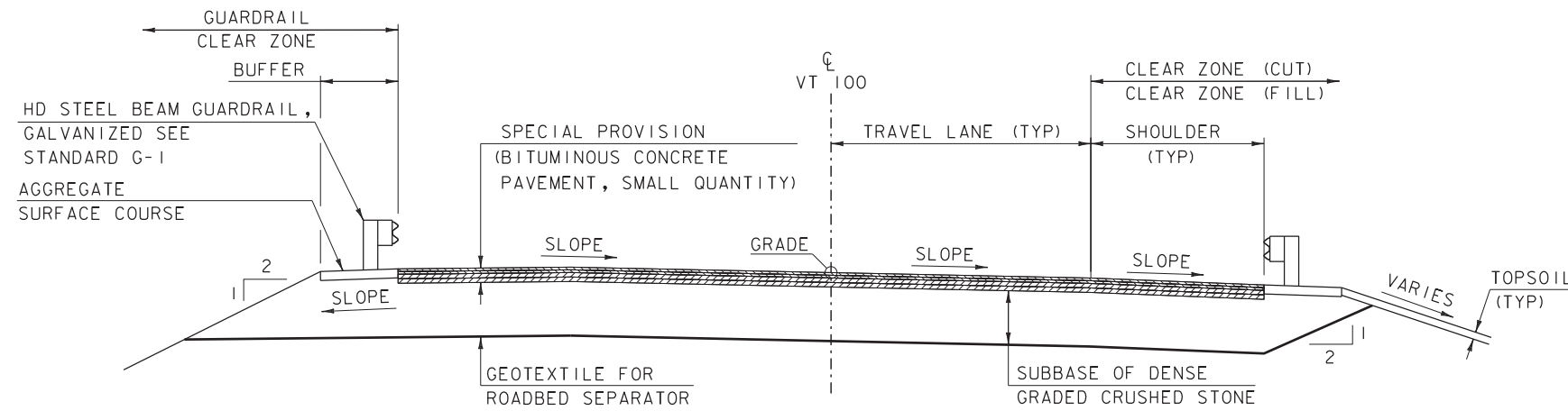


CULVERT 102 PROFILE

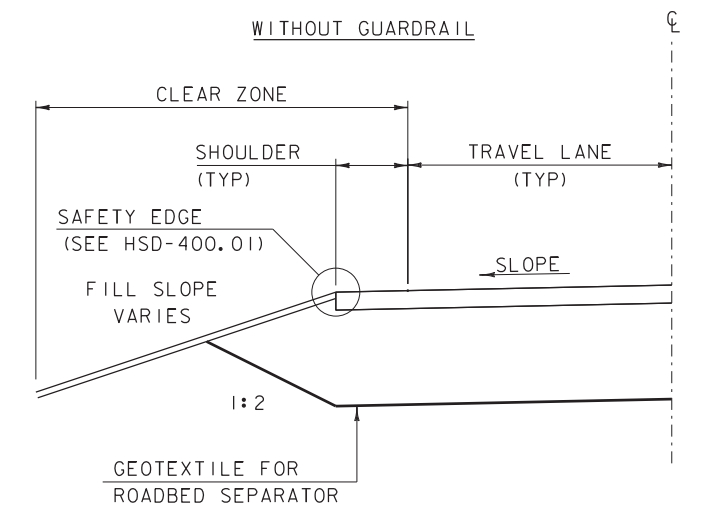
SCALE: HORIZONTAL 1"=20'-0"  
VERTICAL 1"=10'-0"

NOTE:  
GRADES SHOWN TO THE NEAREST TENTH ARE EXISTING GROUND ALONG CL  
GRADES SHOWN TO THE NEAREST HUNDREDTH ARE FINISH GRADE ALONG CL

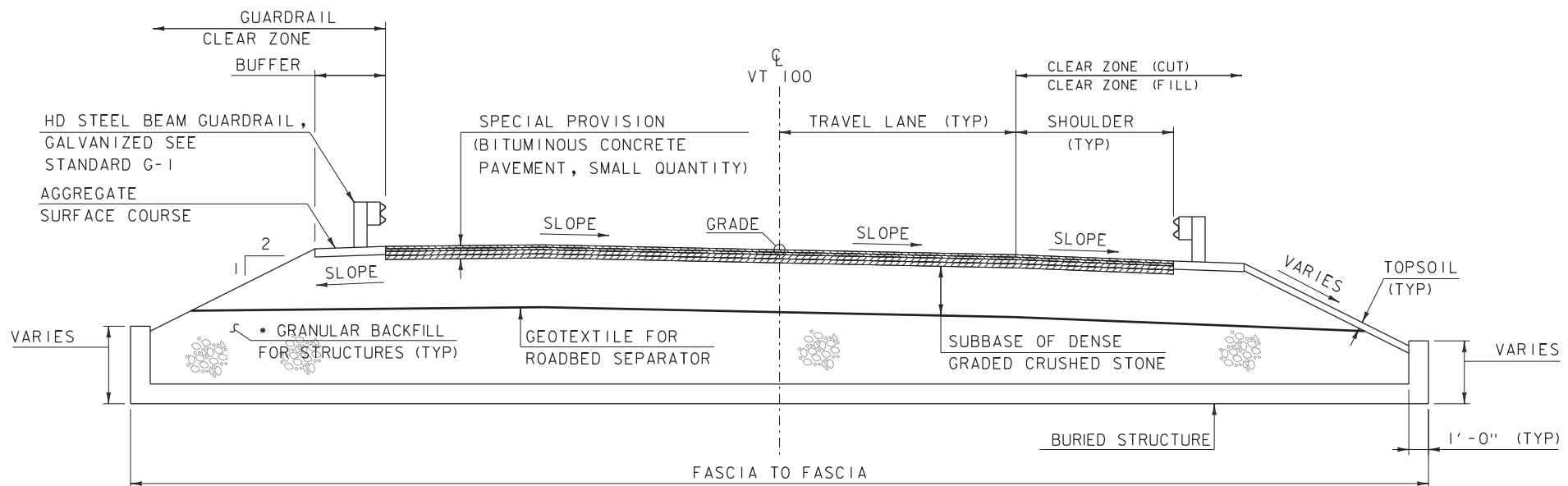
|                                      |                        |
|--------------------------------------|------------------------|
| PROJECT NAME: LUDLOW                 | PLOT DATE: 05-JUN-2020 |
| PROJECT NUMBER: BF 013-3(16)         | DRAWN BY: D.D.BEARD    |
| FILE NAME: I9b215/sb9b215profile.dgn | CHECKED BY: -----      |
| PROJECT LEADER: L.J.STONE            | SHEET 2 OF 18          |
| DESIGNED BY: -----                   |                        |
| PROFILE SHEET                        |                        |



**VT ROUTE 100 TYPICAL SECTION**  
SCALE: 1/4" = 1'-0"



**ROADWAY TYPICAL SECTION**  
NOT TO SCALE



**VT ROUTE 100 BURIED STRUCTURE TYPICAL SECTION**  
SCALE: 1/4" = 1'-0"

**ROAD TYPICAL INFORMATION**

|                   | LEFT   |        | RIGHT  |        |
|-------------------|--------|--------|--------|--------|
|                   | WIDTH  | SLOPE  | WIDTH  | SLOPE  |
| TRAVEL LANE       | 11'-0" | VARIES | 11'-0" | VARIES |
| SHOULDER          | 5'-0"  | VARIES | 5'-0"  | VARIES |
| BUFFER            | 3'-7"  | -0.060 | 3'-7"  | -0.060 |
| FILL SLOPE        | ---    | VARIES | ---    | VARIES |
| CLEAR ZONE (CUT)  | 12'-0" | ---    | 12'-0" | ---    |
| CLEAR ZONE (FILL) | 14'-0" | ---    | 14'-0" | ---    |
| CLEAR ZONE (RAIL) | 3'-7"  | ---    | 3'-7"  | ---    |

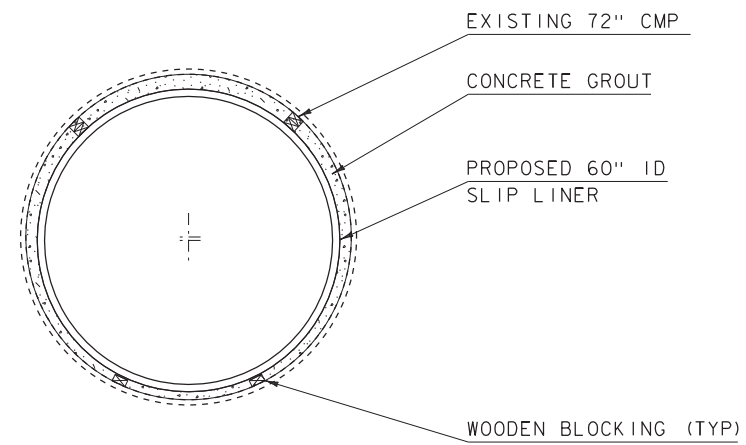
**MATERIAL INFORMATION**

|                | THICKNESS | TYPE  |
|----------------|-----------|---|
| WEARING COURSE | 1 1/2"    | SPECIAL PROVISION (BITUMINOUS CONCRETE PAVEMENT, SMALL QUANTITY) (TYPE IVS) |
| BINDER COURSE  | 1 1/2"    | SPECIAL PROVISION (BITUMINOUS CONCRETE PAVEMENT, SMALL QUANTITY) (TYPE IVS) |
| BASE COURSE #2 | 2 1/2"    | SPECIAL PROVISION (BITUMINOUS CONCRETE PAVEMENT, SMALL QUANTITY) (TYPE IIS) |
| BASE COURSE #1 | 2 1/2"    | SPECIAL PROVISION (BITUMINOUS CONCRETE PAVEMENT, SMALL QUANTITY) (TYPE IIS) |
| BUFFER         | 8"        | AGGREGATE SURFACE COURSE  |
| SUBBASE        | XX"       | SUBBASE OF DENSE GRADED CRUSHED STONE                                       |
| TOPSOIL        | 4"        | TOPSOIL   |

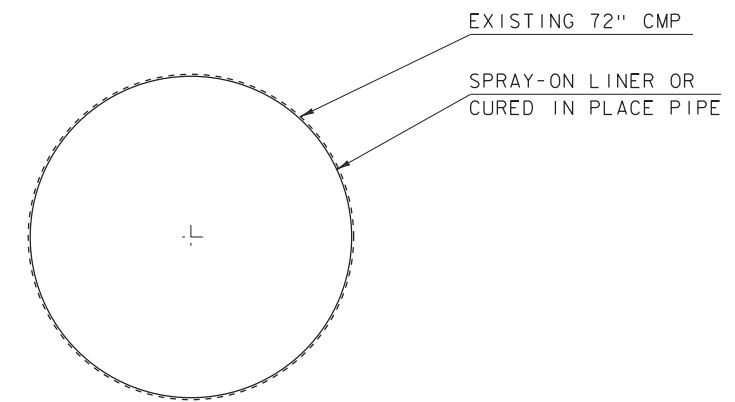
TACK COAT: EMULSIFIED ASPHALT IS TO BE APPLIED AT A RATE OF 0.025 GAL/SY BETWEEN SUCCESSIVE COURSES OF PAVEMENT AND 0.080 GAL/SY ON COLD PLANED SURFACES AS DIRECTED BY THE ENGINEER.

| MATERIAL TOLERANCES<br>(IF USED ON PROJECT) |          |
|---|----------|
| SURFACE                                     |          |
| - PAVEMENT (TOTAL THICKNESS)                | +/- 1/4" |
| - AGGREGATE SURFACE COURSE                  | +/- 1/2" |
| SUBBASE                                     | +/- 1"   |
| SAND BORROW                                 | +/- 1"   |

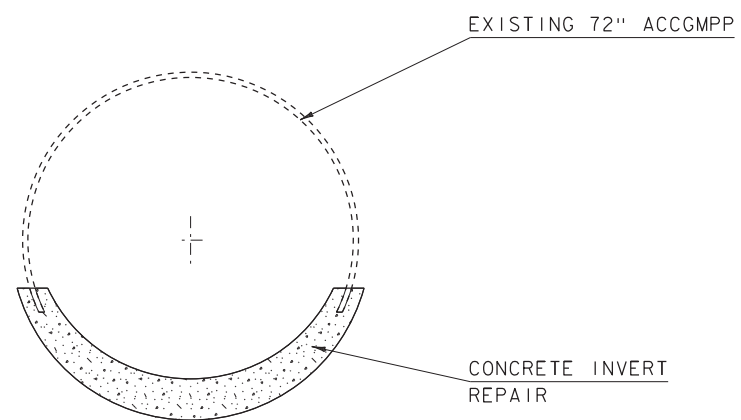
|                                  |                        |
|----------------------------------|------------------------|
| PROJECT NAME: LUDLOW             | PLOT DATE: 05-JUN-2020 |
| PROJECT NUMBER: BF 013-3(16)     | DRAWN BY: D.D.BEARD    |
| FILE NAME: I9b215/s19b215+yp.dgn | CHECKED BY: -----      |
| PROJECT LEADER: L.J.STONE        | SHEET 3 OF 18          |
| DESIGNED BY: -----               |                        |
| TYPICAL SECTION SHEET 1          |                        |



CULVERT LINER TYPICAL SECTION

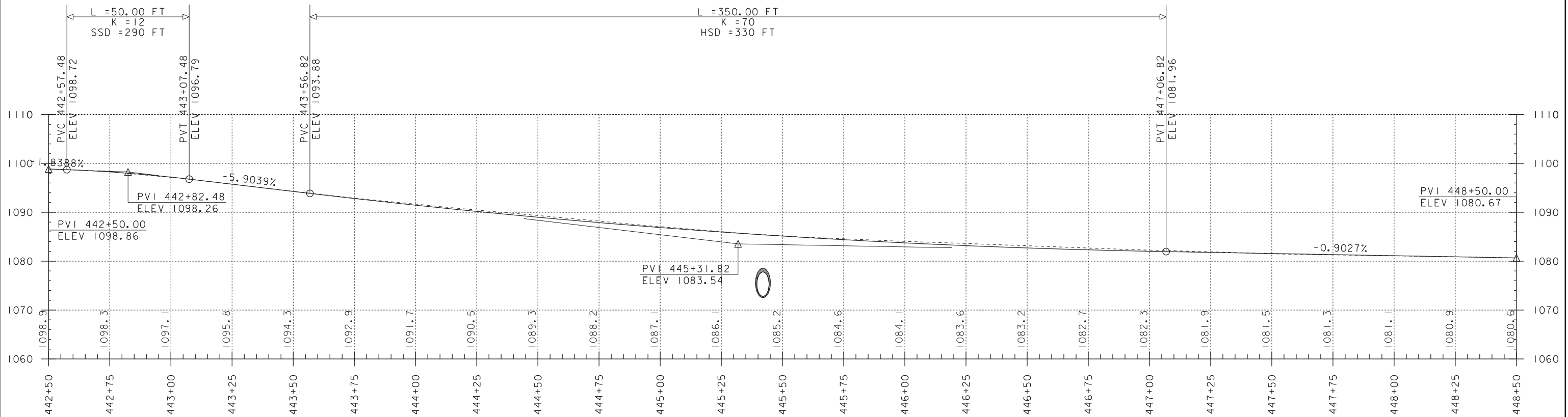


SPRAY-ON CULVERT LINER TYPICAL SECTION



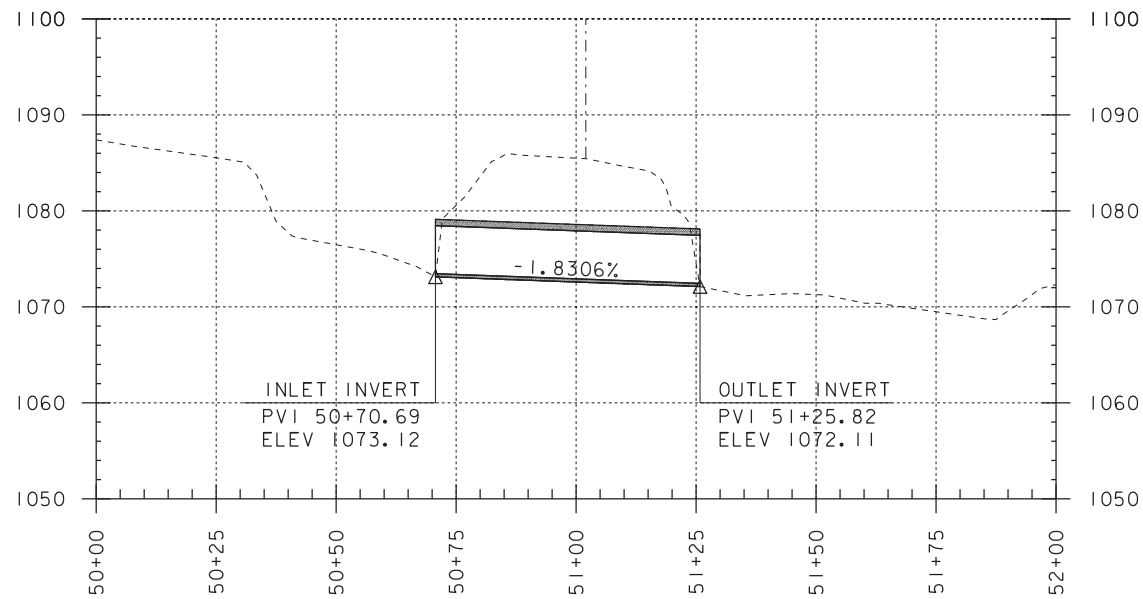
INVERT REPAIR TYPICAL SECTION

|                                       |                        |
|---------------------------------------|------------------------|
| PROJECT NAME: LUDLOW                  | PLOT DATE: 05-JUN-2020 |
| PROJECT NUMBER: BF 013-3(16)          | DRAWN BY: D.D.BEARD    |
| FILE NAME: I9b215/s19b215+typical.dgn | CHECKED BY: -----      |
| PROJECT LEADER: L.J.STONE             | SHEET 4 OF 18          |
| DESIGNED BY: -----                    |                        |
| REHABILITATION TYPICAL SECTIONS       |                        |



**VT ROUTE 100 PROFILE**

SCALE: HORIZONTAL 1"=20'-0"  
VERTICAL 1"=10'-0"



**CULVERT 102 REHABILITATION PROFILE**

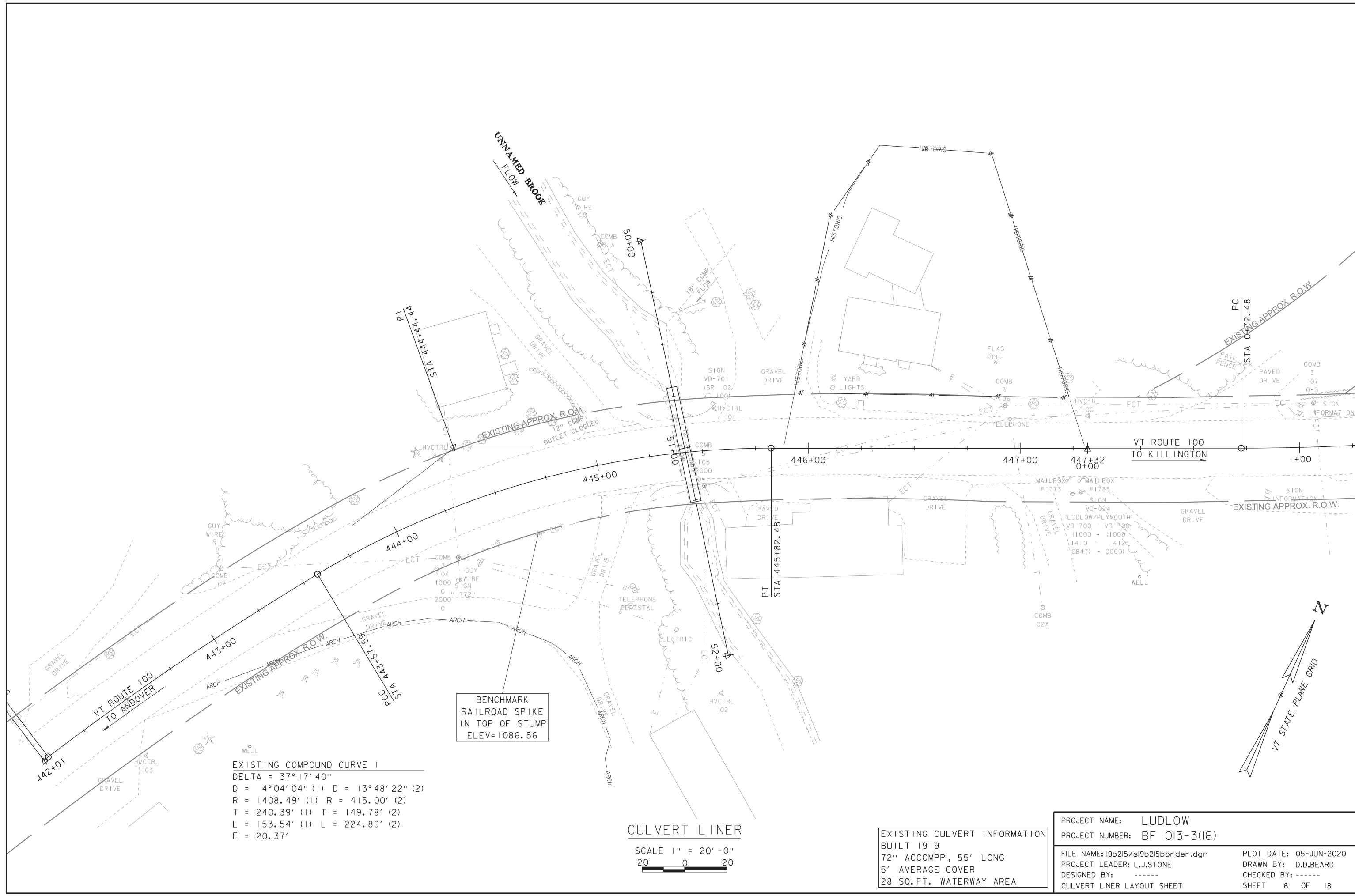
SCALE: HORIZONTAL 1"=20'-0"  
VERTICAL 1"=10'-0"

NOTE:  
GRADES SHOWN TO THE NEAREST TENTH ARE EXISTING GROUND ALONG CL  
GRADES SHOWN TO THE NEAREST HUNDREDTH ARE FINISH GRADE ALONG CL

PROJECT NAME: LUDLOW  
PROJECT NUMBER: BF 013-3(16)

FILE NAME: I9b215/sb9b215profile.dgn  
PROJECT LEADER: L.J.STONE  
DESIGNED BY: -----  
REHABILITATION PROFILE SHEET

PLOT DATE: 05-JUN-2020  
DRAWN BY: D.D.BEARD  
CHECKED BY: -----  
SHEET 5 OF 18



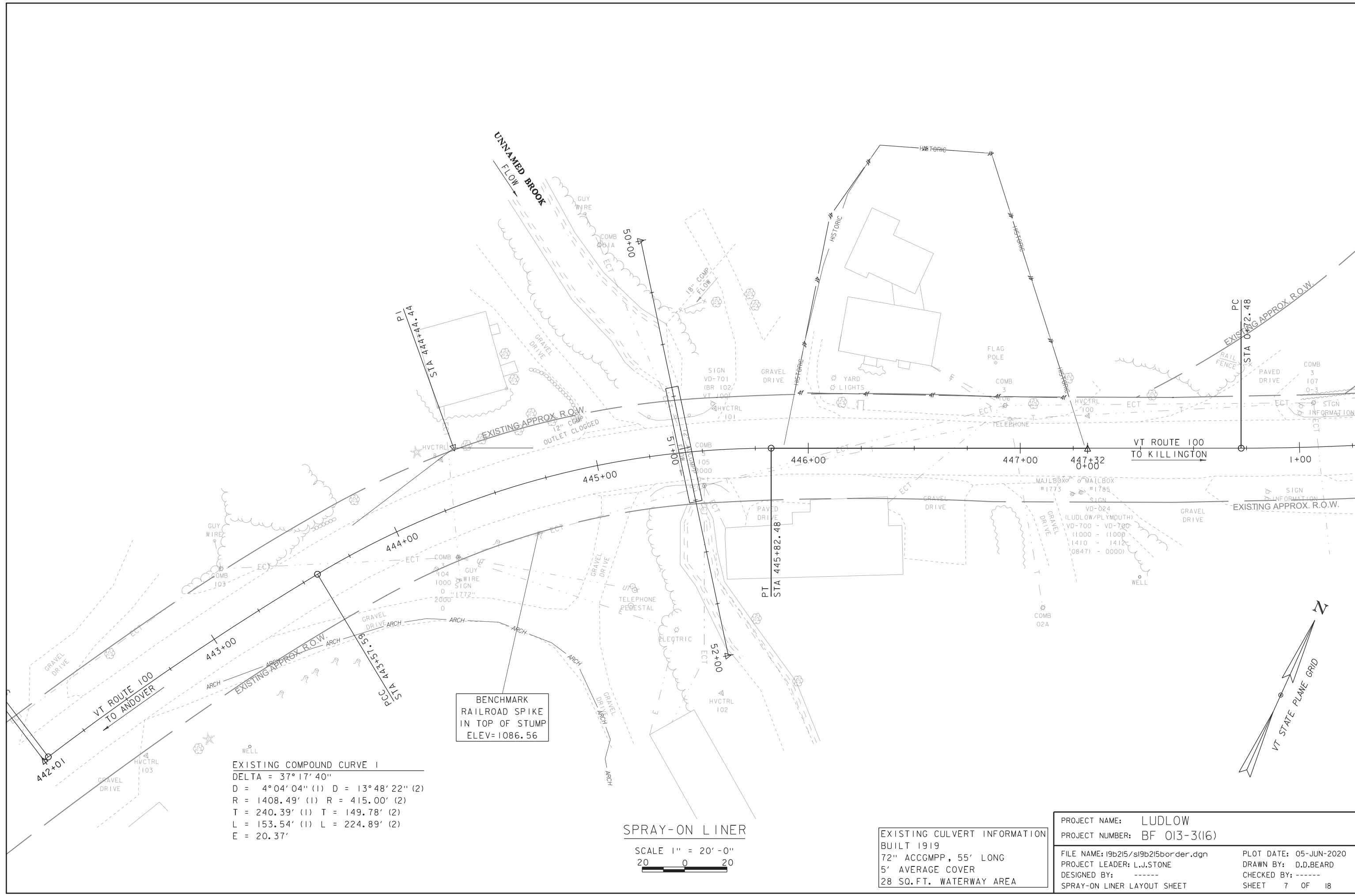
EXISTING COMPOUND CURVE 1  
 DELTA = 37° 17' 40"  
 D = 4° 04' 04" (1) D = 13° 48' 22" (2)  
 R = 1408.49' (1) R = 415.00' (2)  
 T = 240.39' (1) T = 149.78' (2)  
 L = 153.54' (1) L = 224.89' (2)  
 E = 20.37'

BENCHMARK  
 RAILROAD SPIKE  
 IN TOP OF STUMP  
 ELEV= 1086.56

CULVERT LINER  
 SCALE 1" = 20'-0"  
 20 0 20

EXISTING CULVERT INFORMATION  
 BUILT 1919  
 72" ACCGMP, 55' LONG  
 5' AVERAGE COVER  
 28 SQ. FT. WATERWAY AREA

|                                     |                        |
|-------------------------------------|------------------------|
| PROJECT NAME: LUDLOW                | PLOT DATE: 05-JUN-2020 |
| PROJECT NUMBER: BF 013-3(16)        | DRAWN BY: D.D.BEARD    |
| FILE NAME: I9b215/s19b215border.dgn | CHECKED BY: -----      |
| PROJECT LEADER: L.J.STONE           | SHEET 6 OF 18          |
| DESIGNED BY: -----                  |                        |
| CULVERT LINER LAYOUT SHEET          |                        |



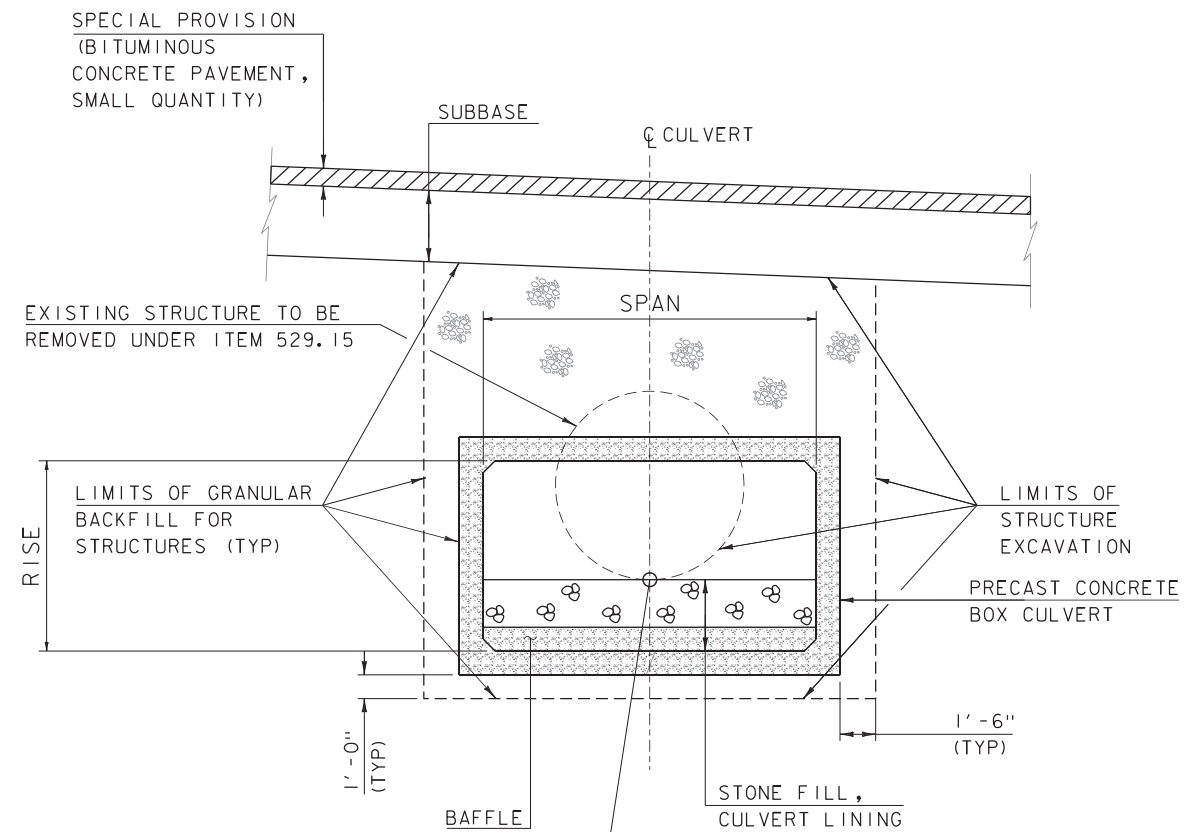
EXISTING COMPOUND CURVE 1  
 DELTA = 37° 17' 40"  
 D = 4° 04' 04" (1) D = 13° 48' 22" (2)  
 R = 1408.49' (1) R = 415.00' (2)  
 T = 240.39' (1) T = 149.78' (2)  
 L = 153.54' (1) L = 224.89' (2)  
 E = 20.37'

BENCHMARK  
 RAILROAD SPIKE  
 IN TOP OF STUMP  
 ELEV= 1086.56

SPRAY-ON LINER  
 SCALE 1" = 20'-0"  
 20 0 20

EXISTING CULVERT INFORMATION  
 BUILT 1919  
 72" ACCGMP, 55' LONG  
 5' AVERAGE COVER  
 28 SQ. FT. WATERWAY AREA

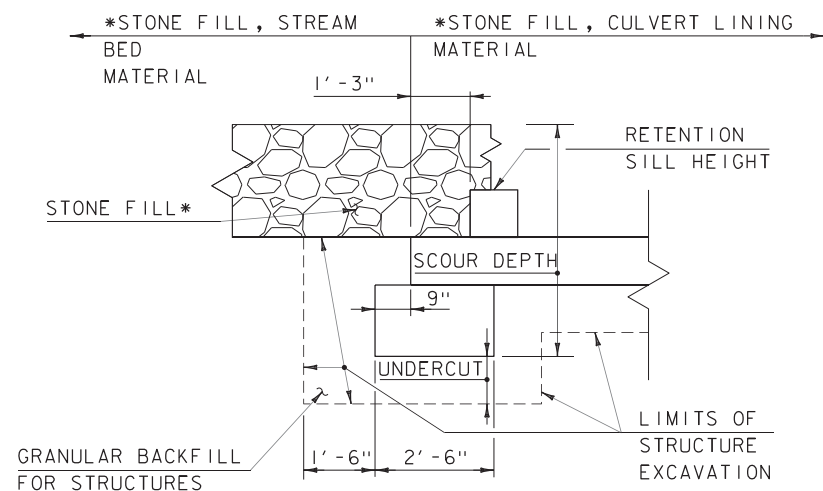
|                                     |                        |
|-------------------------------------|------------------------|
| PROJECT NAME: LUDLOW                | PLOT DATE: 05-JUN-2020 |
| PROJECT NUMBER: BF 013-3(16)        | DRAWN BY: D.D.BEARD    |
| FILE NAME: I9b215/s19b215border.dgn | CHECKED BY: -----      |
| PROJECT LEADER: L.J.STONE           | SHEET 7 OF 18          |
| DESIGNED BY: -----                  |                        |
| SPRAY-ON LINER LAYOUT SHEET         |                        |



|        |        |
|--------|--------|
| SPAN   | 11'-0" |
| RISE   | 10'-0" |
| LENGTH | 55'-0" |

**CULVERT TYPICAL SECTION**

NOT TO SCALE



**CUTOFF WALL TYPICAL SECTION**

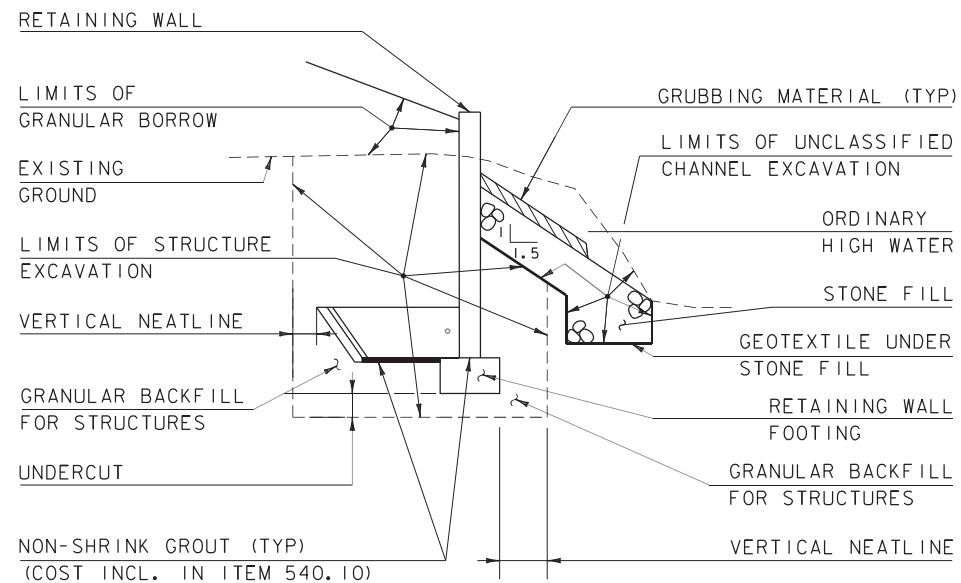
NOT TO SCALE

NOTE:

THE CUTOFF WALL MAY BE OMITTED IF THE DEPTH OF CULVERT LINING MATERIAL PLUS THE THICKNESS TO THE BOTTOM OF THE BOX MEETS OR EXCEEDS THE LISTED SCOUR DEPTH.

**CUTOFF WALL - CRITICAL DIMENSIONS**

|                       | DIMENSION |
|-----------------------|-----------|
| SCOUR DEPTH           | 4'-0"     |
| RETENTION SILL HEIGHT | 1'-0"     |
| UNDERCUT              | 1'-0"     |

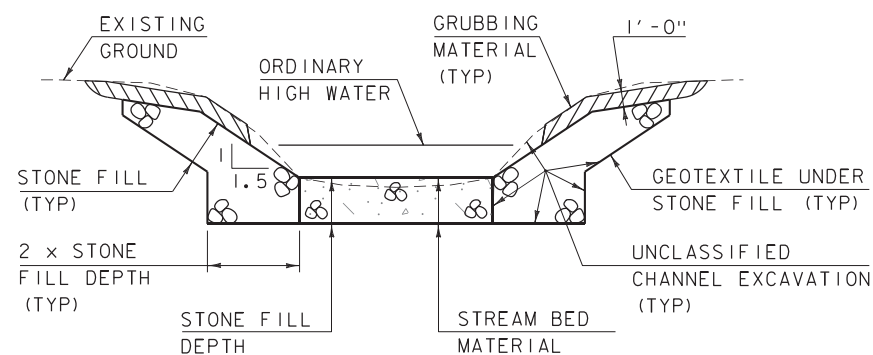


**RETAINING WALL EARTHWORK TYPICAL SECTION**

NOT TO SCALE

NOTE:

TOP OF RETAINING WALL FOOTING SHALL BE AT OR BELOW BOTTOM OF BOX CULVERT.



**TYPICAL CHANNEL SECTION**

(NOT TO SCALE)

- 1) WHENEVER CHANNEL SLOPE INTERSECTS ROADWAY SUBBASE, GRUBBING MATERIAL SHALL BEGIN AT THE BOTTOM OF SUBBASE.
- 2) THE CONTRACTOR SHALL CREATE A LOW FLOW CHANNEL IN THE STREAM BED MATERIAL AS DIRECTED BY THE ENGINEER.
- 3) GRUBBING MATERIAL SHALL BE PLACED UNDERNEATH STRUCTURES WHERE THERE IS MORE THAN 6 FEET VERTICALLY FROM ORDINARY HIGH WATER (OHW) TO THE BOTTOM OF SUPERSTRUCTURE AND MORE THAN 6 FEET HORIZONTALLY FROM OHW LINE TO FRONT FACE OF ABUTMENT. THIS MATERIAL SHALL START JUST ABOVE THE OHW ELEVATION AND TERMINATE 3 FEET HORIZONTALLY FROM THE FRONT FACE OF THE ABUTMENT. THIS MATERIAL SHALL NOT BE PLACED UNDERNEATH DOWNSPOUTS. SEE THE CHANNEL SECTIONS FOR ADDITIONAL DETAILING.

**MATERIAL INFORMATION**

|                                 | THICKNESS | TYPE           |
|---------------------------------|-----------|----------------|
| STONE FILL                      | 4'-0"     | TYPE 4         |
| STONE FILL, CULVERT LINING      | 4'-0"     | E-STONE TYPE 4 |
| STONE FILL, STREAM BED MATERIAL | 4'-0"     | E-STONE TYPE 4 |

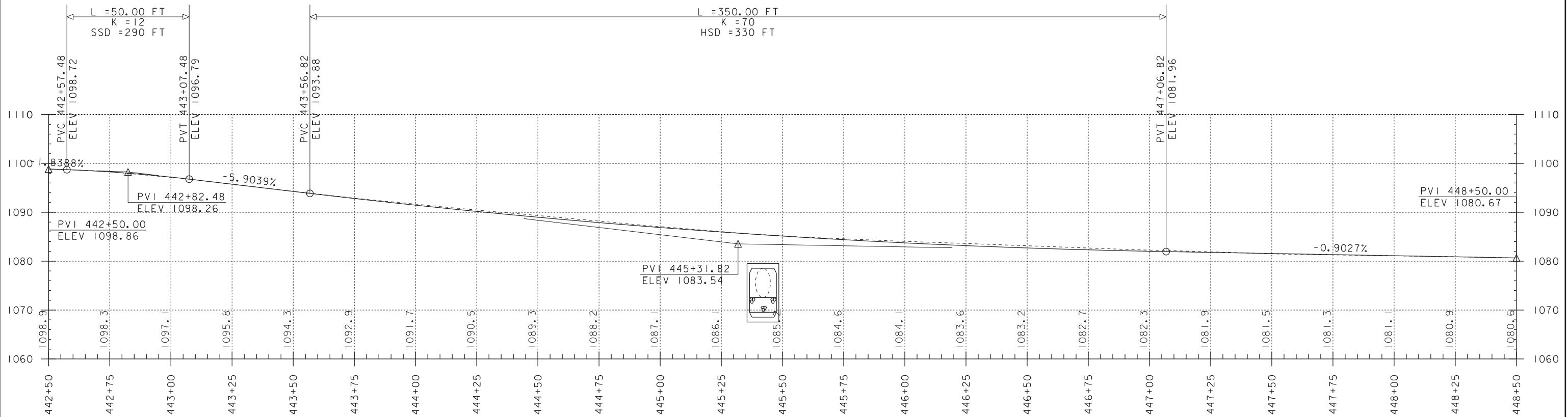
**RETAINING WALL - ASSUMED DIMENSIONS**

| LEVELING PAD      |           |
|-------------------|-----------|
| WIDTH             | DIMENSION |
| WIDTH             | 2'-6"     |
| TOE               | 0'-9"     |
| HEEL              | 0'-9"     |
| THICKNESS         | 1'-0"     |
| UNDERCUT          | 1'-0"     |
| WALL              |           |
| THICKNESS         | 1'-0"     |
| HEIGHT            | VARIES    |
| EXCAVATION LIMITS |           |
| VERTICAL NEATLINE | 1'-6"     |
| UNDERCUT          | 1'-0"     |

PROJECT NAME: LUDLOW  
PROJECT NUMBER: BF 013-3(16)

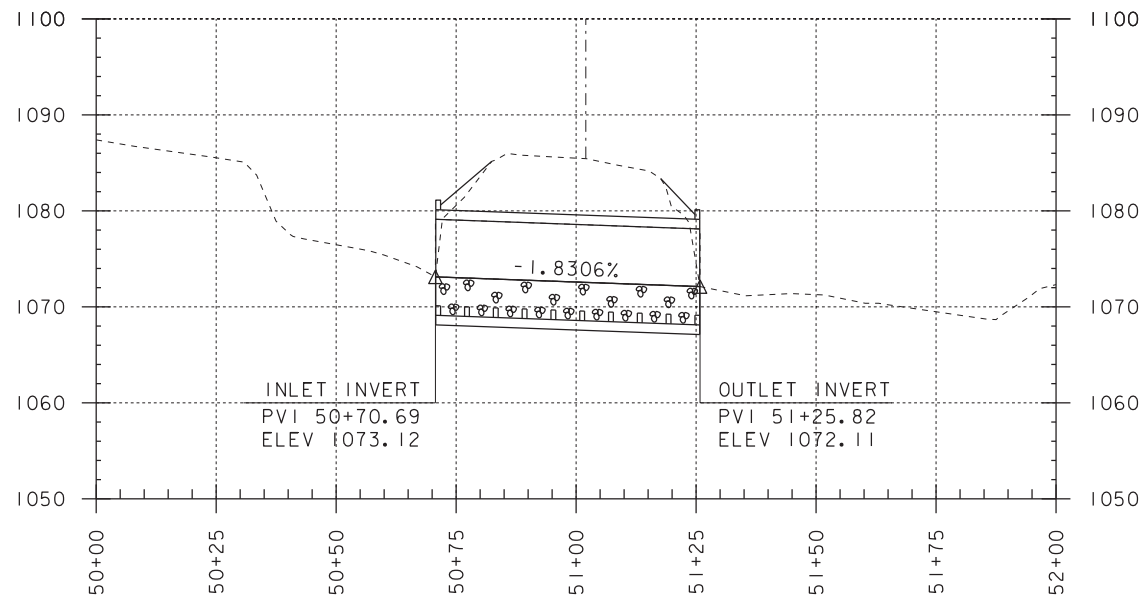
FILE NAME: I9b215/s19b215+yp.dgn PLOT DATE: 05-JUN-2020  
PROJECT LEADER: L.J.STONE DRAWN BY: D.D.BEARD  
DESIGNED BY: ----- CHECKED BY: -----  
PRECAST STRUCTURE TYPICAL SECTION SHEETSHEET 8 OF 18





**VT ROUTE 100 PROFILE**

SCALE: HORIZONTAL 1"=20'-0"  
 VERTICAL 1"=10'-0"

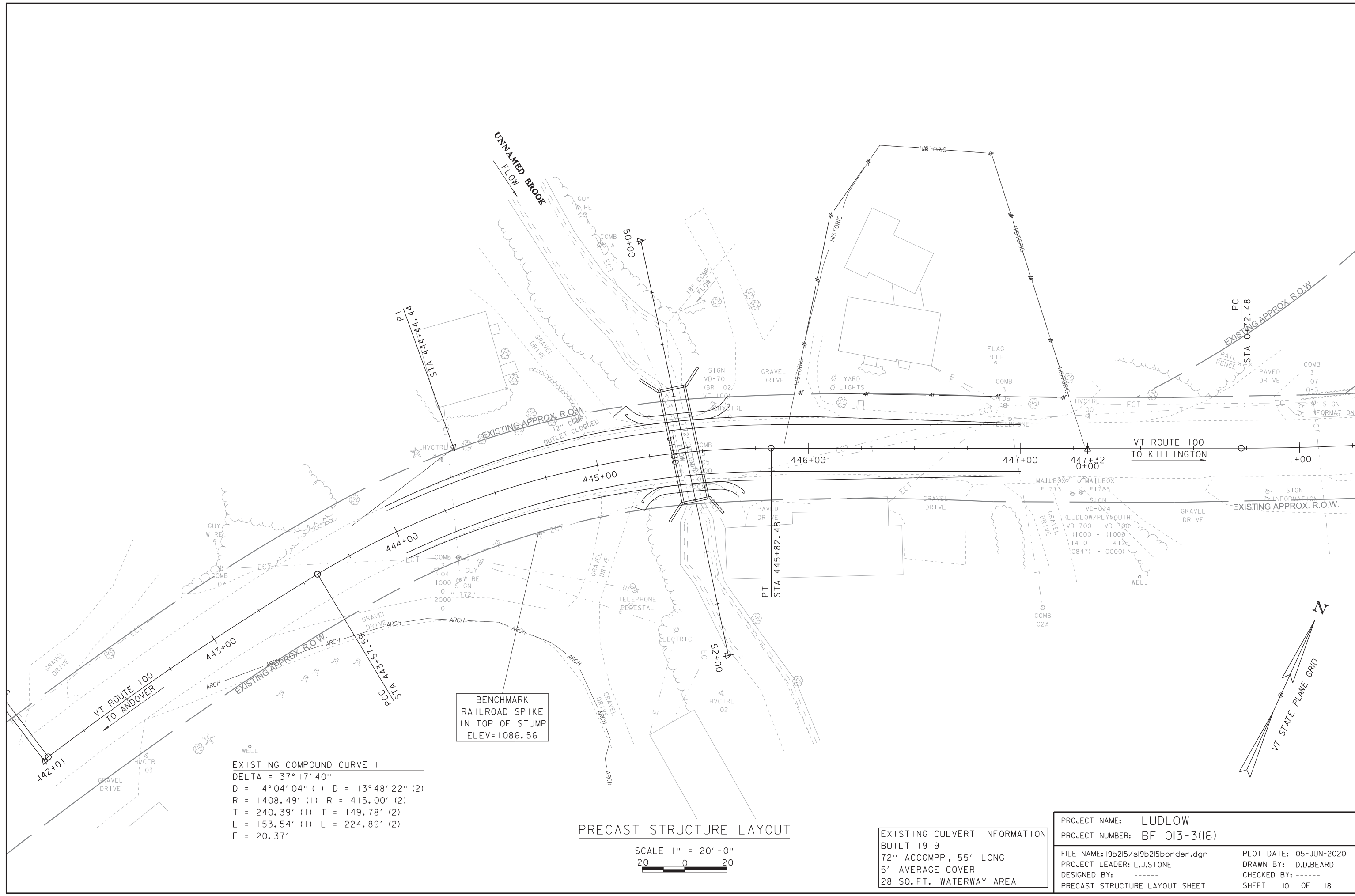


**CULVERT 102 PRECAST STRUCTURE PROFILE**

SCALE: HORIZONTAL 1"=20'-0"  
 VERTICAL 1"=10'-0"

NOTE:  
 GRADES SHOWN TO THE NEAREST TENTH ARE EXISTING GROUND ALONG CL  
 GRADES SHOWN TO THE NEAREST HUNDREDTH ARE FINISH GRADE ALONG CL

|                                      |                                 |
|--------------------------------------|---------------------------------|
| PROJECT NAME: LUDLOW                 | PLOT DATE: 05-JUN-2020          |
| PROJECT NUMBER: BF 013-3(16)         | DRAWN BY: D.D.BEARD             |
| FILE NAME: I9b215/sb9b215profile.dgn | CHECKED BY: -----               |
| PROJECT LEADER: L.J.STONE            | SHEET 9 OF 18                   |
| DESIGNED BY: -----                   | PRECAST STRUCTURE PROFILE SHEET |



EXISTING COMPOUND CURVE 1  
 DELTA = 37° 17' 40"  
 D = 4° 04' 04" (1) D = 13° 48' 22" (2)  
 R = 1408.49' (1) R = 415.00' (2)  
 T = 240.39' (1) T = 149.78' (2)  
 L = 153.54' (1) L = 224.89' (2)  
 E = 20.37'

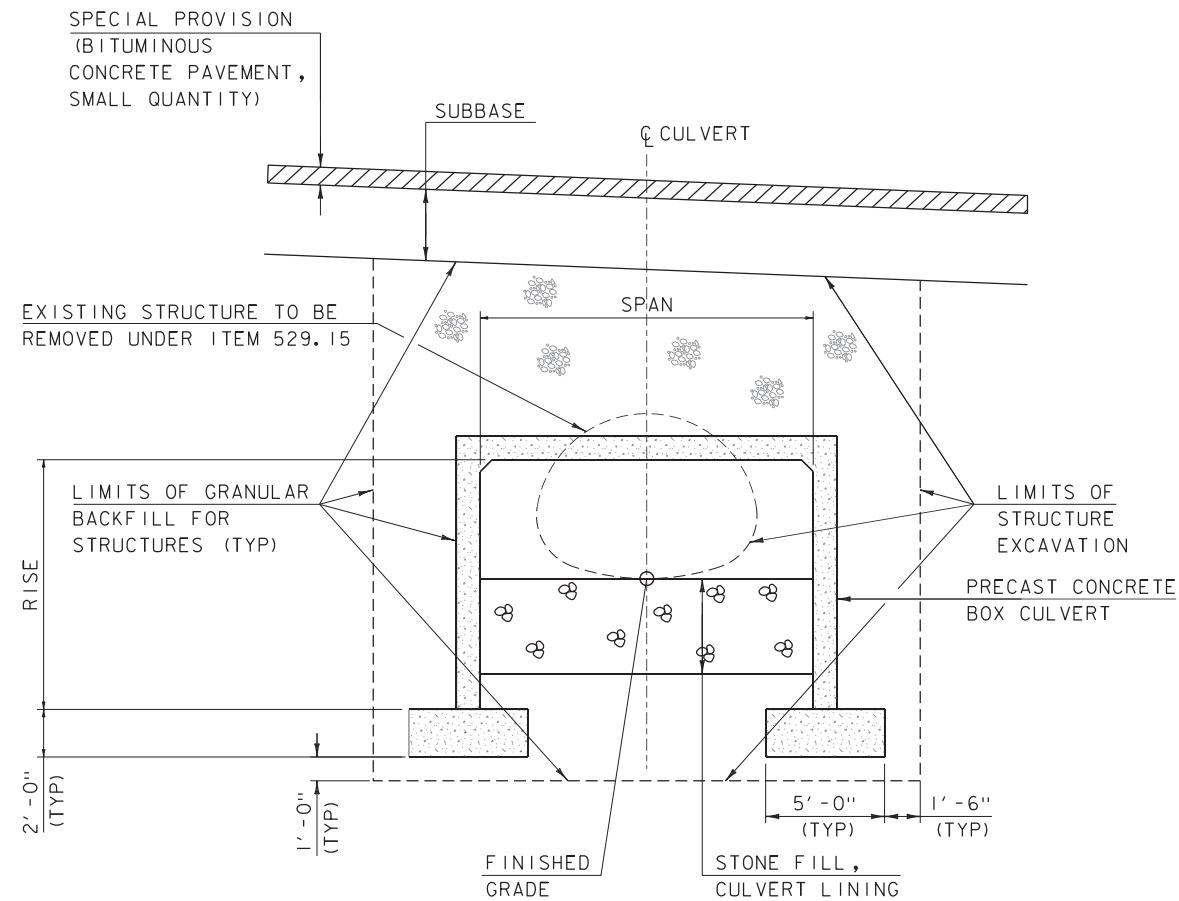
BENCHMARK  
 RAILROAD SPIKE  
 IN TOP OF STUMP  
 ELEV= 1086.56

PRECAST STRUCTURE LAYOUT

SCALE 1" = 20'-0"  
 20 0 20

EXISTING CULVERT INFORMATION  
 BUILT 1919  
 72" ACCGMP, 55' LONG  
 5' AVERAGE COVER  
 28 SQ. FT. WATERWAY AREA

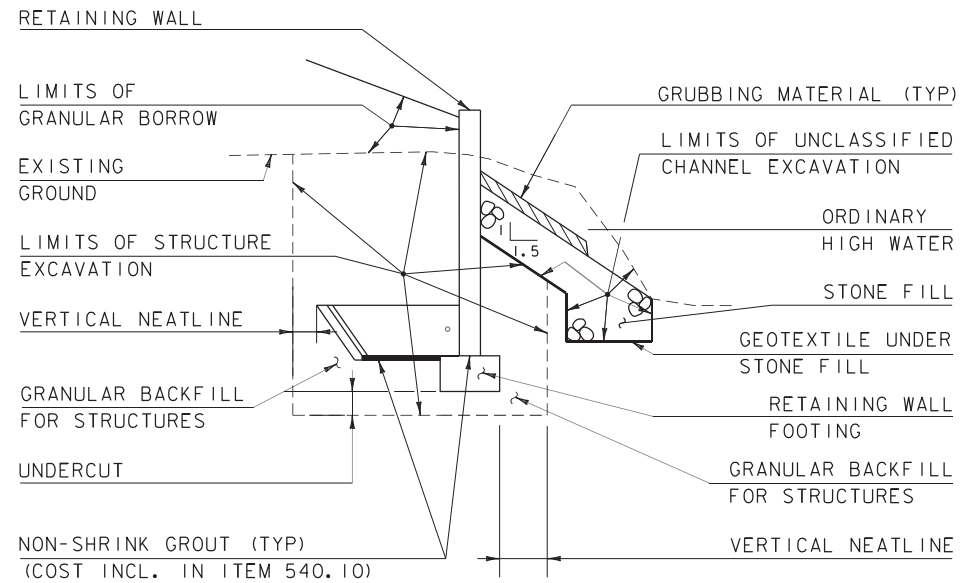
|                                |                          |             |             |
|--------------------------------|--------------------------|-------------|-------------|
| PROJECT NAME:                  | LUDLOW                   | PLOT DATE:  | 05-JUN-2020 |
| PROJECT NUMBER:                | BF 013-3(16)             | DRAWN BY:   | D.D.BEARD   |
| FILE NAME:                     | I9b215/s19b215border.dgn | CHECKED BY: | -----       |
| PROJECT LEADER:                | L.J.STONE                | SHEET       | 10 OF 18    |
| DESIGNED BY:                   | -----                    |             |             |
| PRECAST STRUCTURE LAYOUT SHEET |                          |             |             |



|        |          |
|--------|----------|
| SPAN   | 12' - 0" |
| RISE   | 10' - 0" |
| LENGTH | 55' - 0" |

**CULVERT TYPICAL SECTION**

NOT TO SCALE

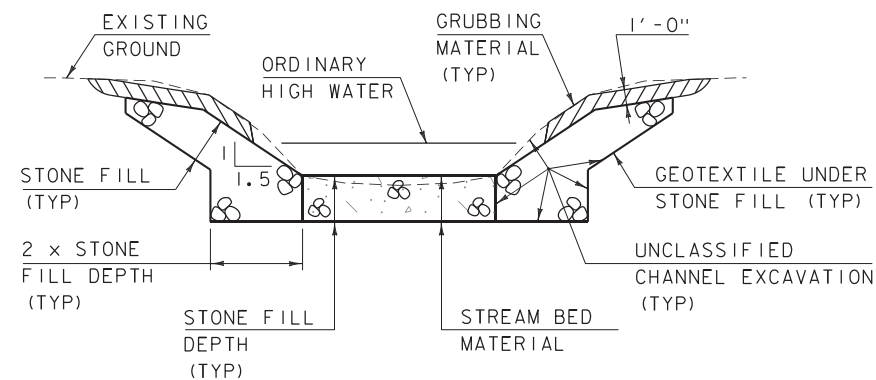


**RETAINING WALL EARTHWORK TYPICAL SECTION**

NOT TO SCALE

NOTE:

TOP OF RETAINING WALL FOOTING SHALL BE AT OR BELOW BOTTOM OF BOX CULVERT.



**TYPICAL CHANNEL SECTION**

(NOT TO SCALE)

- 1) WHENEVER CHANNEL SLOPE INTERSECTS ROADWAY SUBBASE, GRUBBING MATERIAL SHALL BEGIN AT THE BOTTOM OF SUBBASE.
- 2) THE CONTRACTOR SHALL CREATE A LOW FLOW CHANNEL IN THE STREAM BED MATERIAL AS DIRECTED BY THE ENGINEER.
- 3) GRUBBING MATERIAL SHALL BE PLACED UNDERNEATH STRUCTURES WHERE THERE IS MORE THAN 6 FEET VERTICALLY FROM ORDINARY HIGH WATER (OHW) TO THE BOTTOM OF SUPERSTRUCTURE AND MORE THAN 6 FEET HORIZONTALLY FROM OHW LINE TO FRONT FACE OF ABUTMENT. THIS MATERIAL SHALL START JUST ABOVE THE OHW ELEVATION AND TERMINATE 3 FEET HORIZONTALLY FROM THE FRONT FACE OF THE ABUTMENT. THIS MATERIAL SHALL NOT BE PLACED UNDERNEATH DOWNSPOUTS. SEE THE CHANNEL SECTIONS FOR ADDITIONAL DETAILING.

**MATERIAL INFORMATION**

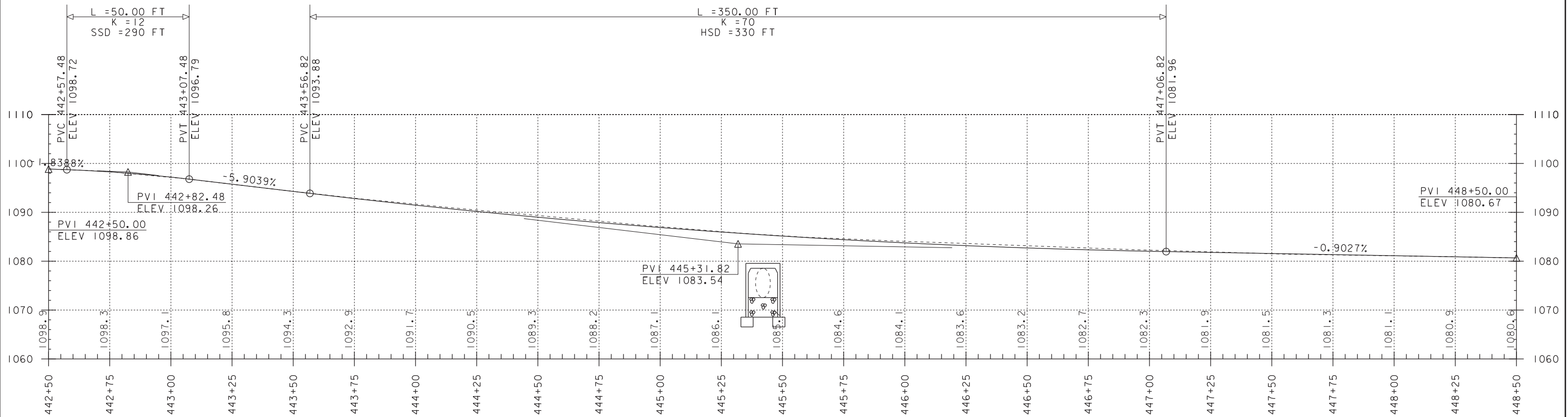
|                                 | THICKNESS | TYPE           |
|---------------------------------|-----------|----------------|
| STONE FILL                      | 4' - 0"   | TYPE 4         |
| STONE FILL, CULVERT LINING      | 4' - 0"   | E-STONE TYPE 4 |
| STONE FILL, STREAM BED MATERIAL | 4' - 0"   | E-STONE TYPE 4 |

**RETAINING WALL - ASSUMED DIMENSIONS**

| LEVELING PAD      |           |
|-------------------|-----------|
| WIDTH             | DIMENSION |
| WIDTH             | 2' - 6"   |
| TOE               | 0' - 9"   |
| HEEL              | 0' - 9"   |
| THICKNESS         | 1' - 0"   |
| UNDERCUT          | 1' - 0"   |
| WALL              |           |
| THICKNESS         | 1' - 0"   |
| HEIGHT            | VARIES    |
| EXCAVATION LIMITS |           |
| VERTICAL NEATLINE | 1' - 6"   |
| UNDERCUT          | 1' - 0"   |

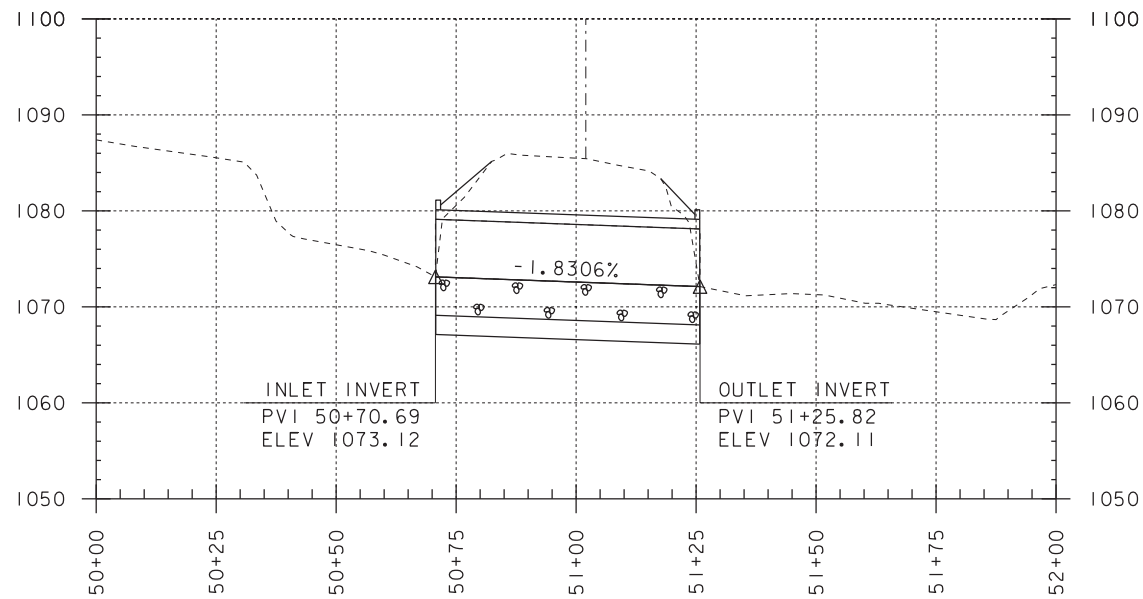
PROJECT NAME: LUDLOW  
PROJECT NUMBER: BF 013-3(16)

FILE NAME: I9b215/s19b215+yp.dgn PLOT DATE: 05-JUN-2020  
PROJECT LEADER: L.J.STONE DRAWN BY: D.D.BEARD  
DESIGNED BY: ----- CHECKED BY: -----  
3-SIDED STRUCTURE TYPICAL SECTION SHEET SHEET 11 OF 18



VT ROUTE 100 PROFILE

SCALE: HORIZONTAL 1"=20'-0"  
VERTICAL 1"=10'-0"



CULVERT 102 3-SIDED STRUCTURE PROFILE

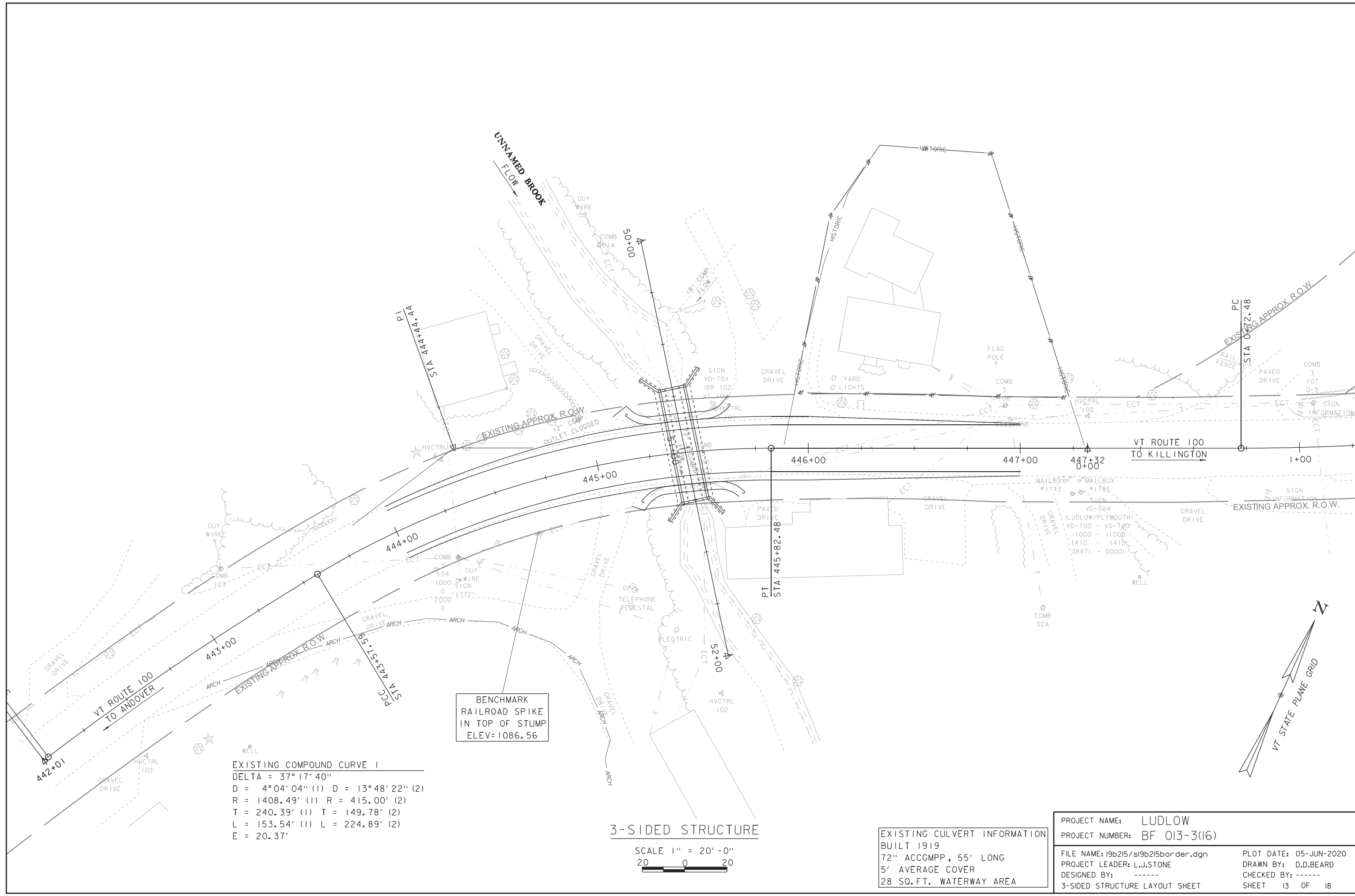
SCALE: HORIZONTAL 1"=20'-0"  
VERTICAL 1"=10'-0"

NOTE:  
GRADES SHOWN TO THE NEAREST TENTH ARE EXISTING GROUND ALONG CL  
GRADES SHOWN TO THE NEAREST HUNDREDTH ARE FINISH GRADE ALONG CL

PROJECT NAME: LUDLOW  
PROJECT NUMBER: BF 013-3(16)

FILE NAME: I9b215/sb9b215profile.dgn  
PROJECT LEADER: L.J.STONE  
DESIGNED BY: -----  
3-SIDED STRUCTURE PROFILE SHEET

PLOT DATE: 05-JUN-2020  
DRAWN BY: D.D.BEARD  
CHECKED BY: -----  
SHEET 12 OF 18



EXISTING COMPOUND CURVE 1  
 DELTA = 37° 17' 40"  
 D = 4° 04' 04" (1) D = 13° 48' 22" (2)  
 R = 1408.49' (1) R = 415.00' (2)  
 T = 240.39' (1) T = 149.78' (2)  
 L = 153.54' (1) L = 224.89' (2)  
 E = 20.37'

BENCHMARK  
 RAILROAD SPIKE  
 IN TOP OF STUMP  
 ELEV= 1086.56

3-SIDED STRUCTURE

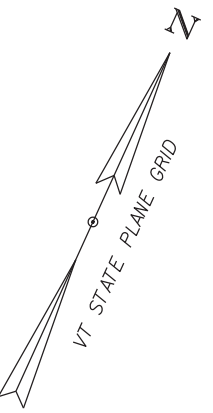
SCALE 1" = 20'-0"  
 20 0 20

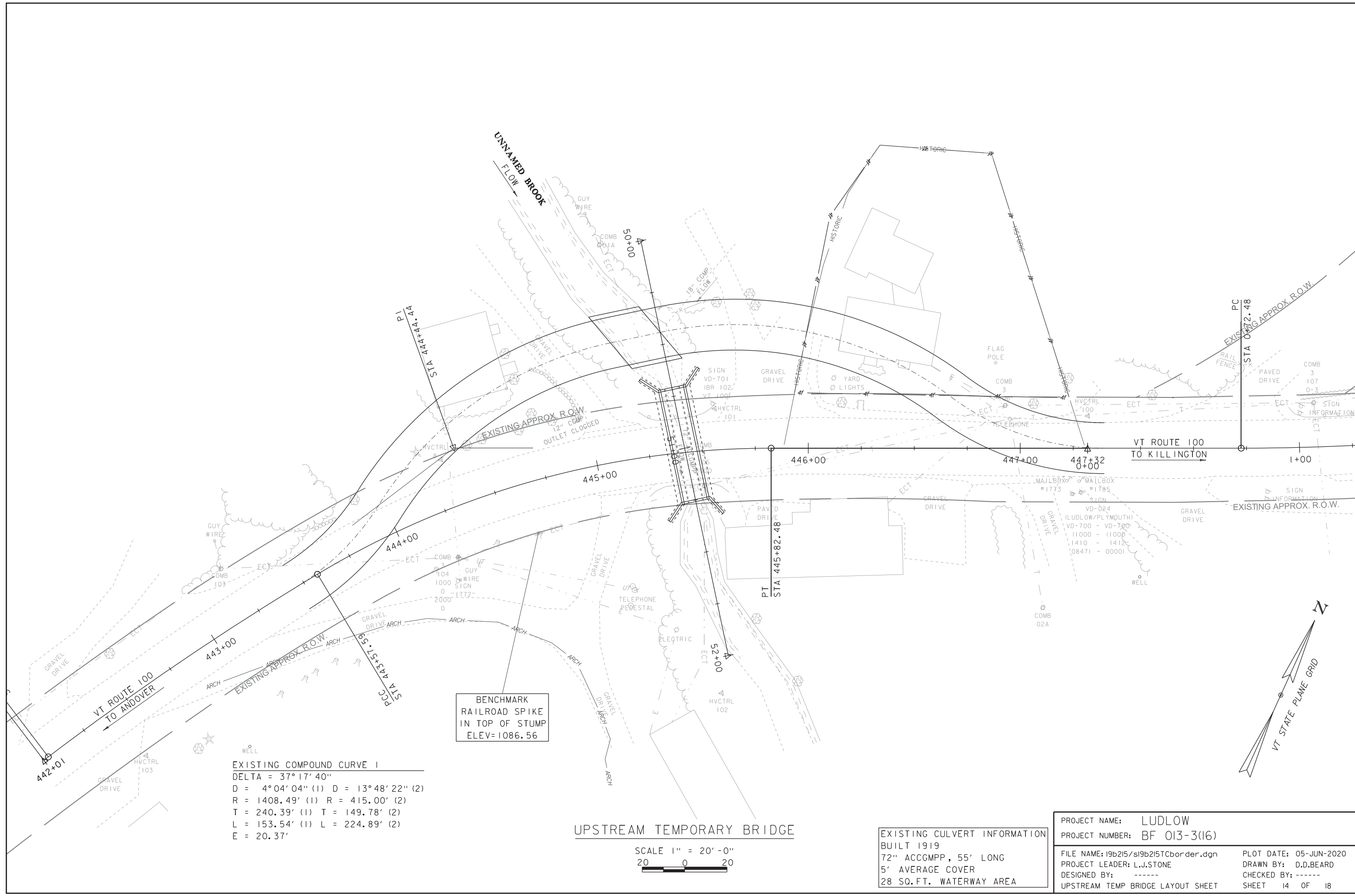
EXISTING CULVERT INFORMATION  
 BUILT 1919  
 72" ACCGMP, 55' LONG  
 5' AVERAGE COVER  
 28 SQ. FT. WATERWAY AREA

PROJECT NAME: LUDLOW  
 PROJECT NUMBER: BF 013-3(16)

FILE NAME: I9b215/s19b215border.dgn  
 PROJECT LEADER: L.J.STONE  
 DESIGNED BY: -----  
 3-SIDED STRUCTURE LAYOUT SHEET

PLOT DATE: 05-JUN-2020  
 DRAWN BY: D.D.BEARD  
 CHECKED BY: -----  
 SHEET 13 OF 18





EXISTING COMPOUND CURVE 1  
 DELTA = 37° 17' 40"  
 D = 4° 04' 04" (1) D = 13° 48' 22" (2)  
 R = 1408.49' (1) R = 415.00' (2)  
 T = 240.39' (1) T = 149.78' (2)  
 L = 153.54' (1) L = 224.89' (2)  
 E = 20.37'

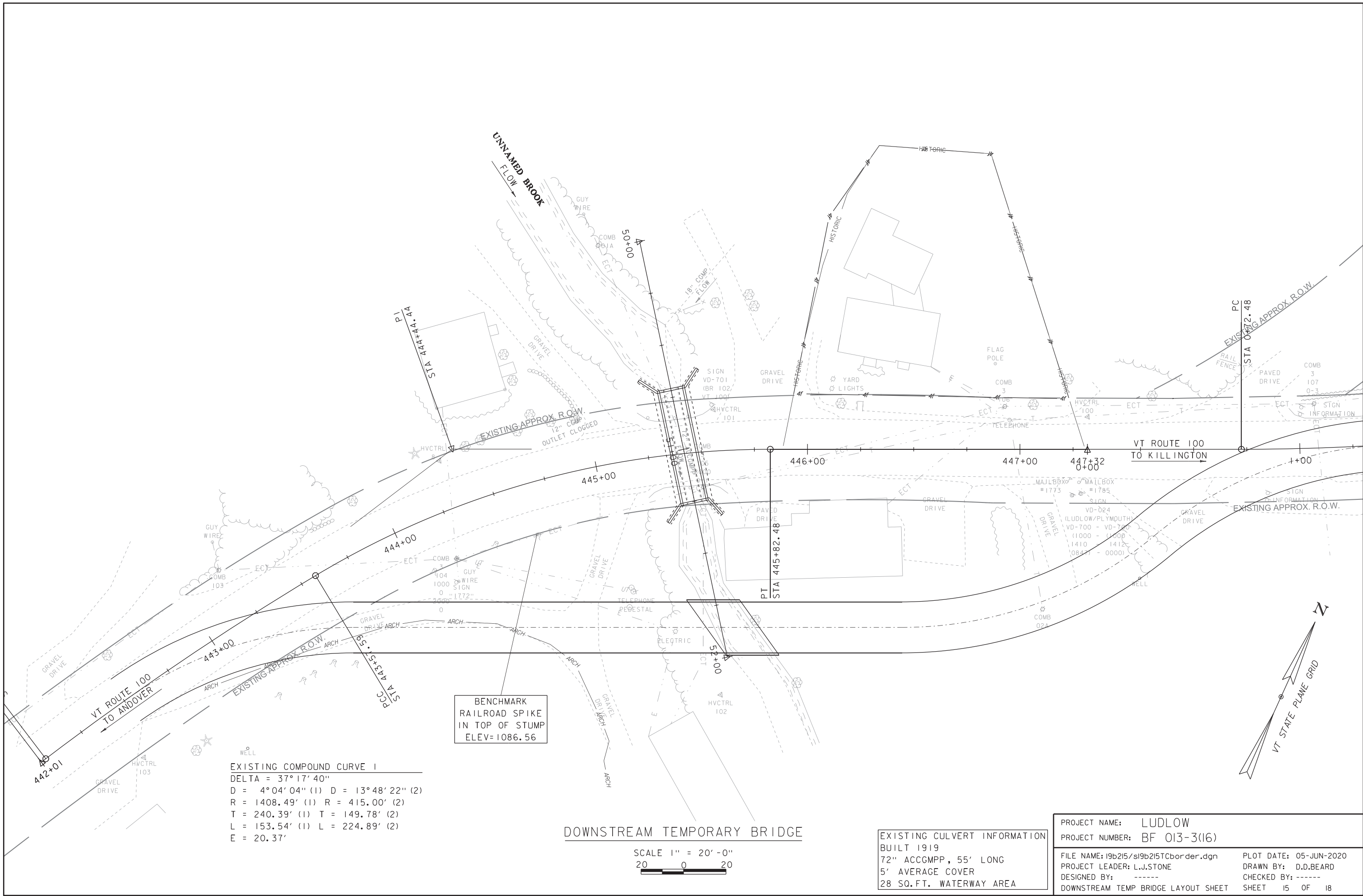
BENCHMARK  
 RAILROAD SPIKE  
 IN TOP OF STUMP  
 ELEV= 1086.56

UPSTREAM TEMPORARY BRIDGE

SCALE 1" = 20' - 0"  
 20 0 20

EXISTING CULVERT INFORMATION  
 BUILT 1919  
 72" ACCGMP, 55' LONG  
 5' AVERAGE COVER  
 28 SQ. FT. WATERWAY AREA

|                                   |                            |             |             |
|-----------------------------------|----------------------------|-------------|-------------|
| PROJECT NAME:                     | LUDLOW                     | PLOT DATE:  | 05-JUN-2020 |
| PROJECT NUMBER:                   | BF 013-3(16)               | DRAWN BY:   | D.D.BEARD   |
| FILE NAME:                        | I9b215/s19b215TCborder.dgn | CHECKED BY: | -----       |
| PROJECT LEADER:                   | L.J.STONE                  | SHEET       | 14 OF 18    |
| DESIGNED BY:                      | -----                      |             |             |
| UPSTREAM TEMP BRIDGE LAYOUT SHEET |                            |             |             |



EXISTING COMPOUND CURVE 1  
 DELTA = 37° 17' 40"  
 D = 4° 04' 04" (1) D = 13° 48' 22" (2)  
 R = 1408.49' (1) R = 415.00' (2)  
 T = 240.39' (1) T = 149.78' (2)  
 L = 153.54' (1) L = 224.89' (2)  
 E = 20.37'

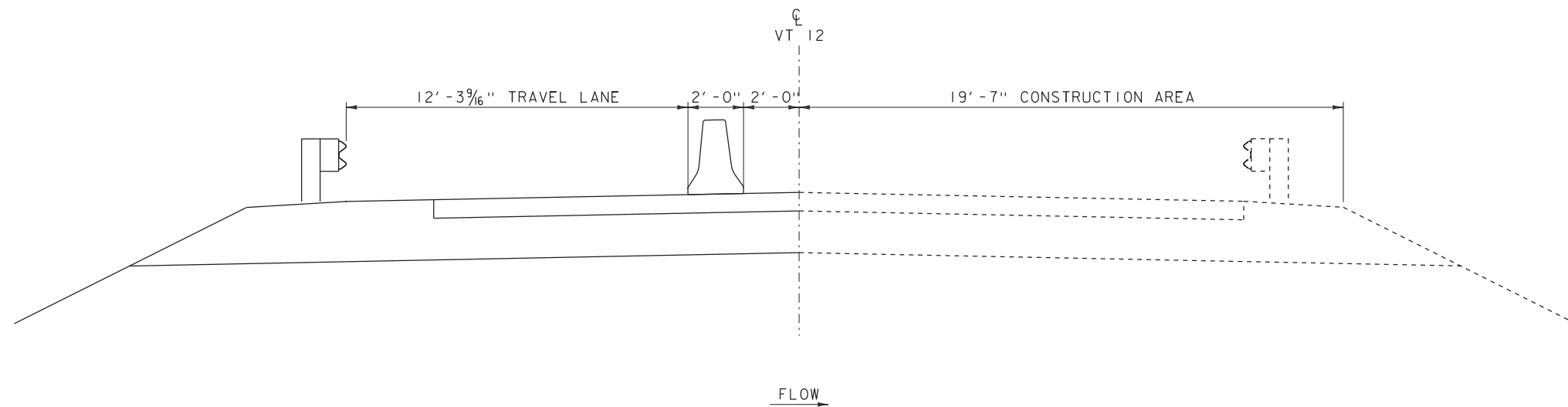
BENCHMARK  
 RAILROAD SPIKE  
 IN TOP OF STUMP  
 ELEV= 1086.56

DOWNSTREAM TEMPORARY BRIDGE

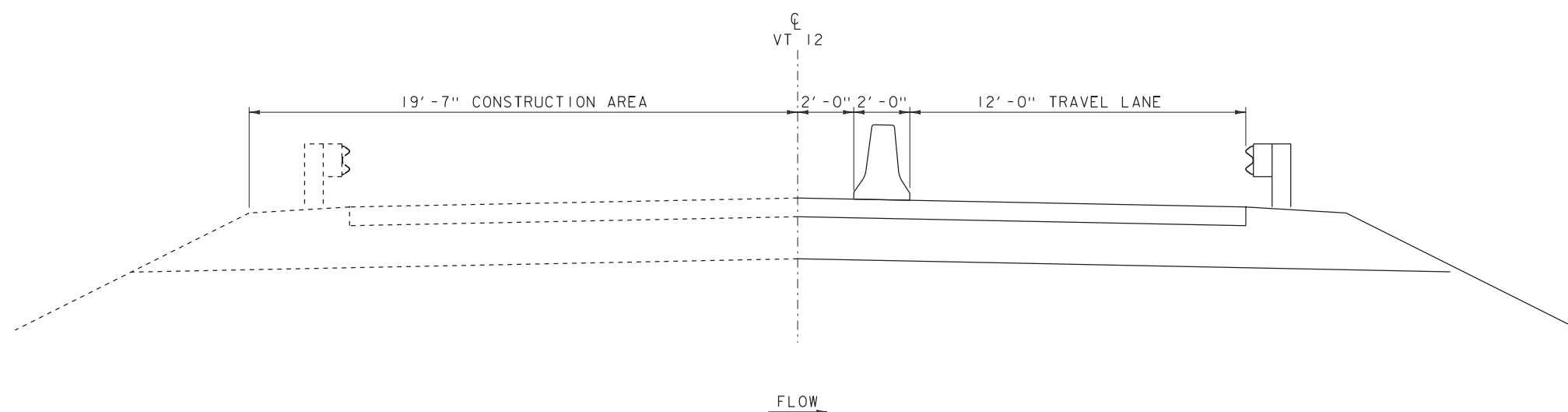
SCALE 1" = 20' - 0"  
 20 0 20

EXISTING CULVERT INFORMATION  
 BUILT 1919  
 72" ACCMPP, 55' LONG  
 5' AVERAGE COVER  
 28 SQ. FT. WATERWAY AREA

|                 |                            |                                     |                |
|-----------------|----------------------------|-------------------------------------|----------------|
| PROJECT NAME:   | LUDLOW                     | PLOT DATE:                          | 05-JUN-2020    |
| PROJECT NUMBER: | BF 013-3(16)               | DRAWN BY:                           | D.D.BEARD      |
| FILE NAME:      | I9b215/s19b215TCborder.dgn | CHECKED BY:                         | -----          |
| PROJECT LEADER: | L.J.STONE                  | DOWNSTREAM TEMP BRIDGE LAYOUT SHEET | SHEET 15 OF 18 |



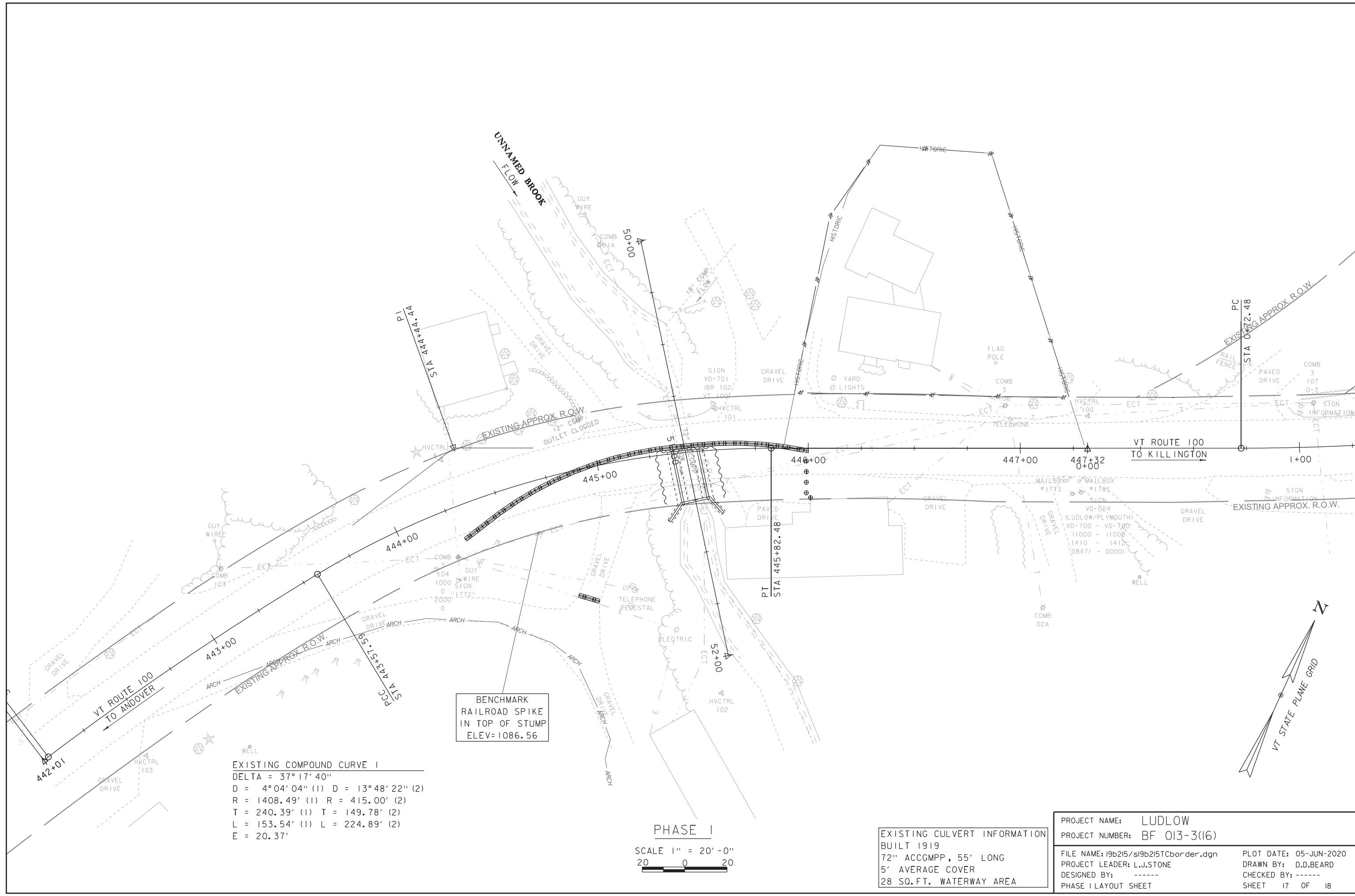
PHASE 1 TYPICAL SECTION  
SCALE 3/8" = 1' - 0"



PHASE 2 TYPICAL SECTION  
SCALE 3/8" = 1' - 0"

|                                      |                        |
|--------------------------------------|------------------------|
| PROJECT NAME: LUDLOW                 | PLOT DATE: 05-JUN-2020 |
| PROJECT NUMBER: BF 0241(55)          | DRAWN BY: D.D.BEARD    |
| FILE NAME: I9b215\sb9b215traffic.dgn | CHECKED BY: -----      |
| PROJECT LEADER: L.J.STONE            | SHEET 16 OF 18         |
| DESIGNED BY: -----                   |                        |
| PHASING TYPICAL SECTIONS             |                        |





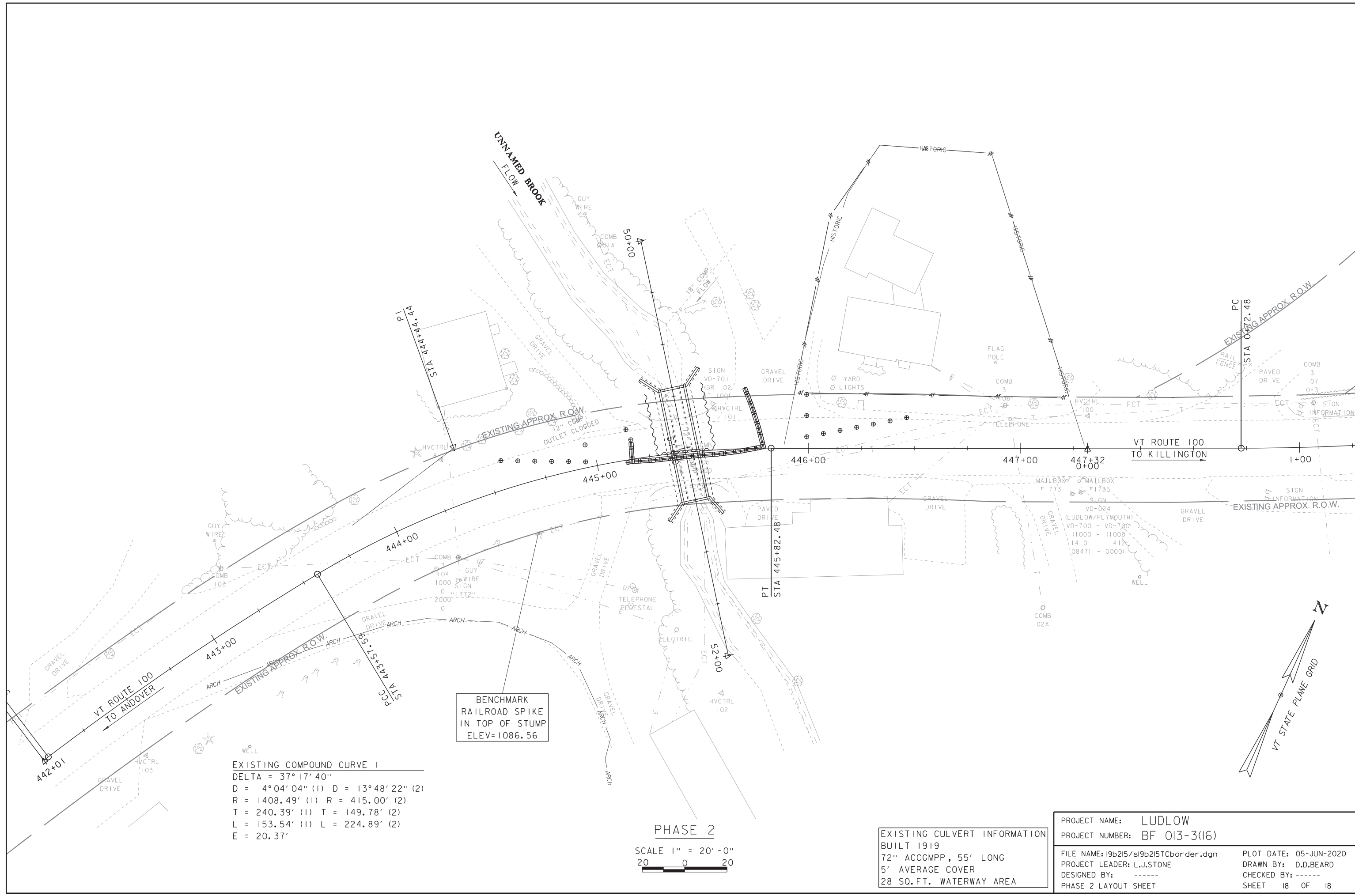
EXISTING COMPOUND CURVE 1  
 DELTA = 37° 17' 40"  
 D = 4° 04' 04" (1) D = 13° 48' 22" (2)  
 R = 1408.49' (1) R = 415.00' (2)  
 T = 240.39' (1) T = 149.78' (2)  
 L = 153.54' (1) L = 224.89' (2)  
 E = 20.37'

BENCHMARK  
 RAILROAD SPIKE  
 IN TOP OF STUMP  
 ELEV= 1086.56

PHASE I  
 SCALE 1" = 20' - 0"  
 20 0 20

EXISTING CULVERT INFORMATION  
 BUILT 1919  
 72" ACCGMP, 55' LONG  
 5' AVERAGE COVER  
 28 SQ. FT. WATERWAY AREA

|                                       |                        |
|---------------------------------------|------------------------|
| PROJECT NAME: LUDLOW                  | PLOT DATE: 05-JUN-2020 |
| PROJECT NUMBER: BF 013-3(16)          | DRAWN BY: D.D.BEARD    |
| FILE NAME: I9b215/s19b215TCborder.dgn | CHECKED BY: -----      |
| PROJECT LEADER: L.J.STONE             | SHEET 17 OF 18         |
| DESIGNED BY: -----                    |                        |
| PHASE I LAYOUT SHEET                  |                        |



EXISTING COMPOUND CURVE 1  
 DELTA = 37° 17' 40"  
 D = 4° 04' 04" (1) D = 13° 48' 22" (2)  
 R = 1408.49' (1) R = 415.00' (2)  
 T = 240.39' (1) T = 149.78' (2)  
 L = 153.54' (1) L = 224.89' (2)  
 E = 20.37'

BENCHMARK  
 RAILROAD SPIKE  
 IN TOP OF STUMP  
 ELEV= 1086.56

PHASE 2  
 SCALE 1" = 20' - 0"  
 20 0 20

EXISTING CULVERT INFORMATION  
 BUILT 1919  
 72" ACCGMP, 55' LONG  
 5' AVERAGE COVER  
 28 SQ. FT. WATERWAY AREA

|                                       |                        |
|---------------------------------------|------------------------|
| PROJECT NAME: LUDLOW                  | PLOT DATE: 05-JUN-2020 |
| PROJECT NUMBER: BF 013-3(16)          | DRAWN BY: D.D.BEARD    |
| FILE NAME: I9b215/s19b215TCborder.dgn | CHECKED BY: -----      |
| PROJECT LEADER: L.J.STONE             | SHEET 18 OF 18         |
| DESIGNED BY: -----                    |                        |
| PHASE 2 LAYOUT SHEET                  |                        |