

## CHAPTER 3 – ENGINEERING CONSIDERATIONS

### 3.1 Bicycle/Pedestrian Accommodations

Portions of the VT 2A corridor currently have bicycle and pedestrian facilities. In Essex Junction, there are five-foot wide sidewalks on both sides of VT 2A, except along the east side of the road south of Mill Street. In Williston, discontinuous segments of sidewalks or multi-use paths have been constructed parallel to VT 2A in the following locations:

- From the VT State Police Building to Taft Corner Shopping Center (East side)
- Near Wright Avenue (West side)
- From the Key Bank entrance to US 2 (West side)
- From US 2 to the Health Center at Williston (West side)
- In front of the Vermont State Employees Credit Union (East side)
- From Meadow Run Road to Mountain View Road (East side)
- From Hickory Hill Road to Industrial Avenue (West side)
- From Industrial Avenue to River Cove Road (West side)

In addition, the Town of Williston currently is planning to install segments of multi-use paths in the following locations:

- From Wright Avenue to the Key Bank entrance (West side)
- From River Cove Road to Overlook Park (West side)

As part of the alternatives that consider the reconstruction of VT 2A (Alternatives 2, 3, 18, 19, 22 and 23), these bicycle and pedestrian accommodations will be upgraded to provide a continuous path on at least one side of the VT 2A corridor for the entire length. The primary path will be located on the east side of VT 2A from Hurricane Lane to the Mountain View Road/Industrial Avenue intersection, then cross to the west side of VT 2A from this intersection northerly to the Winooski River crossing. The path will connect to the existing sidewalk on the west side of VT 2A in Essex Junction. Sidewalks or portions of multi-use paths will also be provided on the opposite side of the road where warranted and where they can reasonably be constructed without major construction cost or right-of-way impacts. Crosswalks will be provided to facilitate the safe crossing of bicyclists and pedestrians at all major intersections. In addition to the sidewalks and multi-use path, on-road bicycle use will be improved by the development of continuous four-foot wide shoulders along both sides of the corridor.

In the Circ corridor, there is an existing multi-use path that crosses the Circ corridor and provides connectivity between the Southridge and Coyote Run subdivisions on the east side of the corridor and the Allen Brook School and the Taft Farms subdivision on the west side. With the limited access and boulevard alternatives (Alternatives 16a, 16b, 16c, and 17), this east-west path would be reconstructed with an overpass above the Circ roadway. This raise in grade would require reconstruction of both approaches to the crossing. For the Circ Street (Alternatives 18, 19, and 23), the existing path would remain in place and intersect with the Circ Street at grade. The need and justification for a potential signalized crossing at this intersection would be studied as part of the final design process. In the north-south direction, Alternatives 16 and 17 would not have a multi-use path due to the limited right-of-way, the need for sufficient clear zone for safety purposes, and the difficulty of providing connection to the east-west path due to grade differentials. The Circ Street alternatives would include a north-south path with at-grade connection to the existing east-west path. Additional multi-use paths would be included along Mountain View Road and Redmond Road as part of all alternatives.

## 3.2 Public Transportation Accommodations

Public transportation facilities enhancement will be included in all of the alternatives. Enhancement of these services can be accomplished by many different measures, including increasing the frequency of the existing routes, modifying schedules to assist in efficient transfer between different routes, modifying routes to be more responsive to the users needs, adding new bus routes, providing convenient park and ride facilities, and improving bus waiting areas. Most of these measures are discussed more fully in the Transportation Technical Report.

Improvements to bus waiting areas could include the installation of better signing, installation of benches or shelters, and the construction of bus pull-outs. The first two measures will be incorporated into the final design of the corridor improvements. Bus pull-out areas are desired where frequent and lengthy bus stopping interferes with the flow of through traffic. This is especially problematic on the existing VT 2A corridor, where there is only one travel lane in each direction, and a bus stopping for passengers blocks all traffic in that direction. For Alternatives 2, 3, 18 and 19, the addition of another travel lane will reduce the complete blockage problem. For Alternatives 18, 19, 22 and 23, there will still be some locations where bus stops still will exist with only lane in each direction. Bus pull-outs would require the purchase of additional Right-of-Way and there is some reluctance for bus drivers to use them due to the difficulty of pulling back into the traffic stream. Bus pull-outs, where warranted, will be included in the final design of the VT 2A corridor for the preferred alternative.

## 3.3 Access Management

Access management consists of coordinating the location, number, spacing and design of access points to minimize site access conflicts and to maximize the traffic capacity and safety of a roadway. Typical access management measures could include:

- Limiting the number of driveways for a site
- Driveway consolidation
- Proper location of driveways relative to intersections and other driveways
- Placement of site driveways on a minor road rather than a major road
- Improved entrance driveway design, including proper turning radius, width and approach
- Cross-lot connections to reduce the movements onto the major road
- Back streets to encourage alternative routes away from the major road
- Median islands to limit the number and location of left turns on the major road
- Turn restrictions

An excellent example of good access management can be observed at the newly-developed commercial areas in the southerly portion of the VT 2A corridor. Rather than have a large number of individual curb cuts for the many stores in this area, access to VT 2A has been limited to just two locations – at the signalized intersections at Maple Tree Place/Marshall Avenue and at Connor Way/Wright Avenue. This layout reduces the number of conflict points for VT 2A traffic, allows cross-lot connections without unnecessary travel onto VT 2A, and provides improved design at the limited number of access points.

Access management is easiest to implement when there is proposed new development that is subject to site plan review. As part of the permitting process, the Town Planning Board can encourage good access management. Roadway reconstruction projects provide another opportunity to improve access management, but this requires cooperation with abutting property

owners. Improved access management measures should be incorporated into the final design of the preferred alternative to the greatest extent possible.

### **3.4 Alternatives Preliminary Layouts and Design Issues**

#### **3.4.1 VT 2A Corridor**

The VT 2A corridor is a highly developed commercial and residential roadway area. Consequently, all improvement alternatives followed the existing alignment. The existing profile was also matched to minimize difficulties with meeting existing driveway grades and nearby building elevations. This results in gradients in two locations (south of Allen Brook and south of the Winooski River) which exceed the recommended grade for this type of road.

The VT 2A alternatives required widening of the paved roadway to increase capacity. In general, this was accomplished by widening equally on both sides. Exceptions to this guideline included shifting the alignment to the east to avoid impacts to Morse Cemetery, and shifting the alignment to the west side at the Winooski River crossing, so that only one side of the bridge required alteration and so that the river pier required widening on one side only. The segment of VT 2A in Essex Junction has existing residential and commercial development closer to the edge of the roadway. Consequently, the lane widths, sidewalks and buffer strips were all reduced to minimize impacts in this densely developed area. The recommended layout for Alternative 2 is provided in Figures 3-1a through 3-1d in Volume II, and the recommended layout for Alternative 3 is provided in Figures 3-2a through 3-2d in Volume II.

For Alternative 22, in the three lane segment between Zephyr Road and James Brown Drive, the widening was designed on the east side only to minimize the impacts to the more dense residential development on the west side, to reduce the number of parcel acquisitions, and to maintain as much of the newly-constructed multi-use path as possible. North of James Brown Drive, the road will remain as a two lane roadway, and therefore the existing curbing and sidewalks will remain. Milling and overlay of the existing pavement would be provided for this section rather than the full depth reconstruction proposed for the remainder of the corridor. The recommended layout for Alternative 22 is provided in Figures 3-3a through 3-3d in Volume II.

#### **3.4.2 Circ Corridor**

VTrans has already acquired the right-of-way required for the Circ as previously designed. This alignment was reviewed and found to comply with the design criteria, and therefore the alignment provided the basis for the location for all study alternatives in the Circ corridor.

The original profile design was maintained for Alternatives 16a, 16b and 16c. For Alternative 17, the profile was modified in the vicinity of Mountain View Road to allow an at-grade intersection with Mountain View Road instead of the overpass design in Alternative 16. For the Circ Street alternatives (Alternatives 18, 19 and 23), the profile developed for the boulevard was maintained, except that the Circ Street ends at Mountain View Road. The recommended layout for Alternative 16 is provided in Figures 3-4a through 3-4d in Volume II, the recommended layout for the Circ Boulevard (Alternative 17) is provided in Figures 3-7a through 3-7d in Volume II, and the recommended layout for the Circ Street (Alternatives 18, 19 and 23) is provided in Figures 3-8a through 3-8d in Volume II.

## 3.5 Interchange and Intersection Options

### 3.5.1 Circ and I-89

This interchange represents the southerly starting point for the Circ Corridor and provides the important connection to the Interstate highway system. Since Alternatives 16a, 16b, and 16c present a limited access roadway for the Circ, a free-flowing interchange is desired to maintain the continuous movement of vehicles. The proposed trumpet interchange is an efficient interchange for this location as detailed in the original design and as shown in Figure 3-4a in Volume II.

The other alternatives in the Circ Corridor represent lower classification roadways with lower design and operating speeds. A free-flowing interchange such as a trumpet or cloverleaf is not needed for this connection. In fact, other interchange configurations, such as a diamond interchange, would provide a means to control the vehicular speeds as they travel from a freeway system (I-89) to an arterial or collector road. For this reason, all Circ alternatives except Alternatives 16a, 16b, and 16c provide a diamond interchange instead of the trumpet interchange selected for Alternatives 16a, 16b, and 16c. Either traffic signals or roundabouts could be constructed at the diamond ramp termini, however, roundabouts have been selected as the preferred intersection configuration at both of the ramp termini. (See Figure 3-7a, Volume II.)

On I-89, due to the close proximity of the new interchange for the Circ and the existing Exit 12 interchange, consideration was given to the traffic operations between these two interchanges. In the southbound direction, there would only be 600 feet between the end of the Exit 12 on-ramp and the start of the Circ off-ramp. In the northbound direction, there would only be 1000 feet between the end of the Circ on-ramp and the start of the Exit 12 off-ramp. These short distances could result in capacity and safety deficiencies due to the weaving and merging traffic flows. It was determined that improved operations would be obtained by the establishment of continuous auxiliary lanes between the ramps. These auxiliary lanes would allow traffic entering onto I-89 and getting off at the nearby exit to stay out of the mainline traffic flow on the two through lanes on I-89 and would increase the weaving capacity. The addition of these lanes would require minor widenings of approximately six feet, as the existing cross section consists of a four foot wide shoulder on the left side, two 12 foot wide travel lanes, and a ten foot wide shoulder on the right side (total paved width of 38 feet). With the auxiliary lane, the cross section would consist of a four foot wide shoulder on the left side, two twelve foot wide travel lanes, a 12 foot auxiliary lane, and a four foot wide shoulder on the right side (total paved width of 44 feet)

### 3.5.2 Circ and US 2

The original design for the Circ did not provide access to or from US 2. US 2 was to be reconstructed to pass over the Circ with a grade-separated structure. The decision to not construct an interchange at this location was based on several factors, including the close proximity to I-89, the wetland resource areas associated with Allen Brook in the vicinity, and the desire of the community to not encourage additional traffic onto US 2, especially in Williston Village.

The issue of whether to provide an interchange at this location was restudied during this DEIS. Traffic volume assignments were modeled to determine how traffic volumes would change if an interchange was constructed. A number of interchange configurations were considered, including a diamond interchange, a full cloverleaf interchange, and partial cloverleaf interchanges. The interchange configurations with ramps on the south side of US 2 were

eliminated due to the proximity to I-89, since they would create weaving deficiencies between the two interchanges. A partial cloverleaf with ramps on the north side of US 2 was studied as a reasonable alternative. (See Figure 3-5 in Volume II.) This alternative would have additional wetland impacts, would require additional right-of-way acquisition, include the acquisition of one residence, and would require widening of US 2 to accommodate the additional turning traffic.

For all other alternatives (Alternatives 17, 18, 19, and 23), an at-grade intersection would be provided for the Circ and US 2. This would eliminate the need to raise US 2 and provide an overpass. The at-grade intersection for the Circ and US 2 could either be a fully-actuated signal system or a roundabout.

### **3.5.3 Circ and Redmond Road/Mountain View Road**

The original design of the Circ (Alternative 16a) provided a new trumpet-shaped interchange and a new connector road to Redmond Road, providing a direct route to the IBM facility and to the Chittenden Solid Waste District (CSWD) as shown on Figure 3-4b in Volume II. The Circ would be raised over Mountain View Road with a grade-separated structure, thereby not allowing direct connection to Mountain View Road.

During this Preliminary Engineering Study, consideration was given to alternative configurations to the original design in this area. Of the several options considered, the most desirable appeared to be the development of a diamond interchange at Mountain View Road combined with the elimination of the Redmond Road Connector as shown on Figure 3-6 in Volume II. This alternative was designated Alternative 16c. This alternative would have one less structure and fewer wetland impacts compared to Alternatives 16a and 16b, but would place additional traffic volumes on Mountain View Road, and would require additional widening and two additional traffic signals on Mountain View Road. Additional right-of-way would be required on the south side of Mountain View Road. The new southbound on-ramp would be closer to the residential development of Brennan Woods, and the new northbound off-ramp would require a taking from the Catamount Golf Club, requiring the relocation and reconstruction of one fairway and green.

For Alternatives 17, 18, 19 and 23, an at-grade intersection would be provided for the Circ and Mountain View Road. This design could either be a fully-actuated signal system or a roundabout. This would eliminate the need to raise the profile of the Circ to pass over Mountain View Road. There would be no connector directly to Redmond Road, and all traffic destined to the IBM facility or the CCSWD facility would access these sites via Mountain View Road and Redmond Road. Improvements to these two roadway segments would be required to accommodate the increased volumes.

### **3.5.4 Signals vs. Roundabouts at Circ Corridor Intersections**

For all at-grade intersections associated with the Circ Alternatives, either signals or roundabouts could be designed. In most locations, some additional Right-of-Way may be required in the corners of each intersection should a roundabout be selected as the preferred intersection design.

## **3.6 Right-of-Way Requirements**

### **3.6.1 VT 2A Corridor**

Roadway widening for the VT 2A corridor with Alternatives 2, 3, 18, 19, 22 and 23 will require significant right-of-way acquisition to complete. The segment from I-89 to US 2 has been recently reconstructed and currently has 120 foot wide right-of-way . This will be sufficient to

construct most of the proposed improvements within the existing right-of-way. Additional slope easements will be required on many properties, but will be reduced where reasonable by the construction of retaining walls. Additional right-of-way would be required at certain intersections to accommodate additional turning lanes or roundabouts.

The segment from US 2 to Zephyr Road has a right-of-way that is 75 to 90 feet wide. The right-of-way in this segment would be widened to have a uniform 100 foot right-of-way for Alternatives 2, 3, 18, and 19 and would have a 120 foot right-of-way for Alternatives 22 and 23 to accommodate the raised median island.

The remainder of the corridor currently has a 66 foot right-of-way. For Alternatives 2, 3, 18, and 19, the right-of-way will be widened to 90 feet from Zephyr Road to the Winooski River, and then will be reduced to 80 feet in Essex Junction due to the reduced roadway dimensions in this area. For Alternatives 22 and 23, the three lane section between Zephyr Road and James Brown Drive will require an 80 foot right-of-way, while north of James Brown Drive, the existing two travel lanes will be maintained, and no additional right-of-way is required.

In addition to the strip takings for the roadway widening, acquisitions will be required for stormwater management areas designed to meet Vermont standards for control and treatment of roadway run-off.

**Table 3.1**  
**Right of Way Widths – VT 2A Corridor**

| Segment                           | Existing ROW | Proposed Alternatives 2 & 18 | Proposed Alternatives 3 & 19 | Proposed Alternatives 22 & 23 |
|-----------------------------------|--------------|------------------------------|------------------------------|-------------------------------|
| I – 89<br>To Taft Corner          | 120          | 120                          | 120                          | 120                           |
| Taft Corner<br>To Zephyr Rd.      | 75-90        | 100                          | 100                          | 120                           |
| Zephyr Rd.<br>To James Brown      | 66           | 90                           | 90                           | 80                            |
| James Brown<br>To Winooski River  | 66           | 90                           | 90                           | 66                            |
| Winooski River<br>To Five Corners | 66           | 80                           | 80                           | 66                            |

Notes: 1. All dimensions are in feet.  
2. Additional right-of-way is required at some intersections.

### 3.6.2 Circ Corridor

The right-of-way required for Alternative 16a was already acquired by VTrans as part of the original planned construction. Alternative 16b will require additional right-of-way for the new partial cloverleaf ramp in the northeast quadrant. Alternative 16c will require additional right-of-way for the construction of the new diamond ramps at Mountain View Road. The parcel on the southeast quadrant contains the Catamount Golf Club, and would require the relocation and reconstruction of one fairway and one green.

The existing right-of-way will also meet the requirements for Alternative 17 except at the I-89 interchange. Additional right-of-way is required in the southeast quadrant of the I-89 interchange to accommodate the southbound on-ramp for the preferred diamond interchange configuration.

For Alternatives 18, 19, and 23, the existing right-of-way will permit the construction of a new multi-use path within the right-of-way between US 2 and Mountain View Road. The existing right-of-way north of Mountain View Road would not be needed. Additional right-of-way is required in the southeast quadrant of the I-89 interchange to accommodate the southbound on-ramp for the preferred diamond interchange configuration.

## 3.7 Stormwater Management

### 3.7.1 Stormwater Management – VT 2A Corridor

#### **Introduction**

The VT 2A corridor, from I-89 to the Winooski River at the Williston/Essex Town line, has existing stormwater runoff collection measures that consist primarily of sheet flow over vegetated embankment slopes to open grassed swales and channel systems. Limited closed drainage collection systems exist along curbed portions of the roadways in locations adjacent to sidewalks or multi use paths. In Williston, the closed drainage segments include limited areas near the US 2 intersection, and the roadway segment adjacent to a new multi-use path from Meadow Run Road to River Cove Road. The portion of VT 2A in Essex Junction from the Winooski River to Five Corners has a closed drainage system for the entire segment.

The proposed VT 2A improvement alternatives will provide a widened roadway section with curbing and closed drainage systems throughout the corridor. Full depth reconstruction of existing roadway surfaces is proposed with all alternatives; therefore water quality treatment is required to treat stormwater runoff from all impervious roadway surfaces. Stormwater treatment practices have been developed along the corridor to provide water quality treatment, groundwater recharge, channel protection control (1 yr storm), overbank flood control (10 yr storm), and extreme flood control (100 yr storm) as required by the *Vermont Stormwater Management Manual (VTSWMM) Volume 1, April 2002, 5<sup>th</sup> printing*.

A portion of the VT 2A corridor (O'Brien Court to Sharon/Hillside Drive area) is within the Allen Brook drainage area, a watershed identified as impaired due to stormwater on the State of Vermont's 2006 303(d) List of Waters under the federal Clean Water Act. The stormwater discharge to Allen Brook is therefore regulated by and subject to the requirements of the Stormwater Management Rule for Stormwater-Impaired Waters.

#### **Existing Conditions**

Existing stormwater systems along the VT 2A corridor primarily consist of open drainage collection systems, with improved curb sections and closed drainage systems in locations adjacent to sidewalks and intersection areas.

The existing watersheds in the VT 2A corridor are depicted on Figure 3-9 in Volume II. The southern portion of the study roadway drains westerly toward unnamed tributaries to the Muddy Brook, the central portion to the Allen Brook watershed, and the northern portion drains into the Winooski River watershed.

The following addresses the specifics of the existing stormwater runoff systems along the VT 2A corridor which are shown on Figures 3-10a through 3.10d in Volume II.

- I-89 to Marshall Avenue - stormwater runoff sheet flows from the roadway surfaces to overland flow on embankment slopes and is collected by grassed swales. Runoff flows in a westerly direction toward an unnamed tributary to the Muddy Brook. There is a 36 inch cross culvert near the Vermont State Police building that directs the flow under VT 2A in an east-west direction.
- Marshall Avenue to US 2 - stormwater runoff sheet flows from the roadway surfaces to overland flow on embankment slopes and is collected by grassed swales. Portions of this segment drain into a stormwater management area that was constructed as part of the Maple Tree Place Shopping Center development. Overflow from this pond as well as surface drainage from some roadway areas is piped northerly along the west side of VT 2A and outlets to a grassed swale and grassed channel located between Helena Drive and Paul Street, then flows westerly towards Muddy Brook.
- US 2 to Paul Street - this segment contains a closed drainage section in which the stormwater is collected via catch basins and is connected to the closed drainage system described above.
- Paul Street to O'Brien Court- stormwater runoff sheet flows from the roadway surfaces to overland flow on embankment slopes and is collected by grassed swales. There is a 36 inch culvert near Knight Lane that directs runoff flow under VT 2A in an east-west direction. This flow is directed towards an existing stormwater management area behind the Williston Health Center.
- O'Brien Court to Allen Brook - stormwater runoff sheet flows from the roadway surfaces to overland flow on embankment slopes, is collected in grassed swales and directed to Allen Brook.
- Allen Brook to south of the intersection of Route 2A and Industrial Avenue/Mountain View Road – portions of this section are curbed with closed drainage systems which outlet via drain lines into Allen Brook on the east and west sides of the Allen Brook Bridge.
- Industrial Avenue/Mountain View Road to Hillside Drive - on the west side of the roadway there is a closed drainage system along the multi-use path, a curbed section of roadway. The closed system is piped westerly following Industrial Avenue and outlets to Allen Brook. The east side of the roadway is open drainage, with sheet flow runoff from the impervious roadway surface.
- Hillside Drive to James Brown Drive - on the west side of the roadway there is a closed drainage system along the multi-use path curbed roadway section from Hillside Drive to River Cove Drive. This system flows to the north and outlets into a swale just north of River Cove Road. This swale directs flow to an infiltration basin adjacent to the parking lot at First Quality Carpet/Lacillade Lumber Co. The east side of the roadway has open drainage with overland flow to several existing wetland pockets adjacent to the roadway. Overflow from these wetland areas continues to flow northerly along VT 2A, toward the Winooski River.
- James Brown Drive to north of Eastview Circle - stormwater runoff sheet flows from the roadway surface to overland flow on embankment slopes and is collected by grassed swales. Flow from the easterly side of the road crosses VT 2A in a four foot by five foot reinforced concrete box culvert, combines with the swale on the west side, and is conveyed northerly to the Winooski River in a channel located to the west of VT 2A.
- Eastview Circle to the Winooski River Bridge – this section has a closed drainage system with an outlet to the Winooski River on the east side of the bridge structure. On the bridge structure itself, scuppers direct stormwater from the roadway directly to the river.
- Winooski River Bridge to Mill Street – the roadway is curbed with a closed drainage system that outlets to the Winooski River on the east side of the bridge structure.

- Mill Street to the railroad crossing of VT 2A is a closed drainage system with outlet easterly down Mill Street to the Winooski River.
- From the railroad tracks to Five Corners intersection stormwater is collected in a closed drainage system along the curbed roadway. The closed drainage network carries stormwater north along Vermont 2A to Five Corners and then to the east along Maple Street. The system follows Elm, Jackson and Wisely Streets in the southeast direction before reaching an outlet point just south of the Central Vermont Railway tracks. An open channel carries the stormwater south a 48 inch corrugated metal pipe crossing the IBM Access Drive (River Street) before a direct outlet at the bank of the Winooski River.

### **Stormwater Treatment Standards**

Stormwater Treatment Practices and Sizing has been performed based on the requirements of the *VTSWMM* with drainage analysis prepared utilizing HydroCad TR-20 methodology and Bentley Flowmaster. Stormwater treatment standards and sizing criteria address Water Quality Treatment (WQv), Recharge (Rev), Channel Protection Control (CPv), Overbank Flood Control (Qp10) and Extreme Flood Control (Qp100) dependent on the on site soils types and receiving water. WQv treatment is required in all cases of runoff flow from the impervious areas, whereas Recharge is waived for drainage areas within hydrologic soil group type D soil areas, and Cpv, Qp10, Qp100 controls may be waived for smaller impervious areas as well as when the outlet is to waters with drainage basins over 10 square miles. Channel protection requires that extended detention of the post development 1-year, 24-hr event be detained for 12 hours in cold water fish habitat, which is the case for this section of roadway.

The existing predevelopment condition has been modeled as Meadow in good condition in accordance with the requirements of the *VTSWMM*. To minimize stormwater treatment practice sizing, it is anticipated that “clean offsite” runoff flows will bypass the roadway stormwater treatment measures, with only the roadway impervious areas treated. The goal of separation of offsite runoff will reduce flow quantities and therefore treatment measure sizing. In areas where existing stormwater treatment measures intercept existing roadway runoff, a diversion structure will be constructed to maintain existing base flows to the treatment measure (for example, the infiltration basin adjacent to First Quality Carpets/Lacillade Lumber parking lot). The site balancing procedure utilized by VTrans in the past has not been considered in this analysis since the procedure may be limited by VT Agency of Natural Resources (ANR), and will be reviewed in future drafts of the *VTSWMM*.

### **Allen Brook Impaired Watershed**

Approximately 3800 lf of the VT 2A corridor (O'Brien Court to Hillside Drive) is within the Allen Brook watershed area and is subject to the requirements of the Stormwater Management Rule for Stormwater-Impaired Waters. The rule establishes an interim and long term permit program for discharges of regulated stormwater to stormwater-impaired waters from new development, existing development, redevelopment and expansion of impervious surfaces. A TMDL study has not been completed for the watershed, therefore interim rules apply for impervious surfaces larger than one acre. The discharge shall meet the requirements of the 2002 *VTSWMM* and shall not increase the sediment load in the receiving water, otherwise referred to as no net increase, 100% Total Suspended Solids (TSS) removal. The *VTSWMM* stormwater practices are considered to achieve 80% TSS removal, leaving 20% TSS to offset. The 20% TSS offset soil loading can be determined and an offset provided by methods such as reduced winter sand application in the affected watershed as considered on the Circ AB, or through additional treatment of existing impervious surfaces or use of infiltration practices. The existing drainage area limits of Allen Brook along 2A are intended to remain similar to the existing condition, to avoid redirection of additional potentially sediment-laden runoff toward Allen Brook.

### **Stormwater Treatment Practices**

Stormwater treatment practice to be employed to treat, recharge groundwater and control stormwater runoff in the post development condition of Route 2A include stormwater ponds for treatment purposes and infiltration practices for recharge. Stormwater treatment practice information has been compiled from the *VTSWMM*, and for additional information refer to the current *VTSWMM*. Samples of these are presented in Appendix B.

Stormwater Ponds (*VTSWMM* section 2.7.1)

The Micropool extended detention pond is a pond that treats the majority of the water quality volume through extended detention and incorporates a micropool at the outlet of the pond to prevent sediment re-suspension. The variation of the pond can be used to provide channel protection volume as well as overbank and extreme flood control. A 10 acre minimum drainage area is recommended for this design. Refer to the Micropool example on Page B-1 as detailed by the *VTSWMM* and as shown in Appendix B.

### Stormwater Infiltration Practices

Infiltration practices typically cannot provide for control of channel protection, overbank flood and extreme flood volumes, except on very pervious, well draining sites. Assumptions regarding the distance to seasonal high water table (SHWT), porosity and infiltration rates were made in development of treatment practices. Field data will be required to determine actual site feasibility and design criteria for development of these stormwater treatment practices. Stormwater pretreatment is required prior to flow being directed to infiltration facilities.

Grass treatment channels or swales will be the primary practice utilized for this purpose, while other options include plunge pools and filter strips. Infiltration trenches and basins should be set back 35 feet from structures and septic systems. Refer to the Grassed Channel example on page B-2 as detailed by the *VTSWMM*.

The infiltration trench is an infiltration practice that stores the water quality volume in the void spaces of a gravel trench before it is infiltrated into the ground. Refer to the Infiltration Trench example on page B-3 as detailed by the *VTSWMM*.

The infiltration basin is an infiltration practice that stores the water quality volume in a shallow surface depression before it is infiltrated into the ground. Refer to the Infiltration Basin example on page B-4 as detailed by the *VTSWMM*.

### **Proposed Stormwater Facilities**

Reconstruction and widening along the VT 2A corridor will require the development of additional stormwater facilities to adequately collect, control and treat stormwater runoff. The widened roadway will be converted to a curbed roadway section with closed drainage systems for the entire length of the study area. Several new stormwater management areas will be developed to control and treat the stormwater runoff from the impervious roadway, multi-use path and sidewalk areas. The reconstruction project will provide an opportunity to treat not only the widened pavement areas, but will be designed to collect and treat the existing roadway surface areas as well.

Proposed stormwater control and treatment facilities are depicted on pages B-1 through B-4 in Appendix B. The facilities shown include existing and proposed ponds, stormwater management areas and major drainage systems. Individual catch basins and smaller pipes are not shown on these plans but would be part of the final design of the stormwater systems. Additional right-of-way would need to be acquired to construct some of these facilities. A summary of the proposed stormwater treatment measures for the VT 2A corridor is presented in Table 3.7.1 in Appendix C. The preliminary sizing for these facilities has been based on the design for Alternatives 2 and 18, which provides for four lanes of traffic for the entire corridor. Alternatives 3 and 19 would have similar facilities, with minor adjustments in the design due to the roundabouts and available land area. Alternatives 22 and 23 will have similar facilities in the southern portion, where a four-lane roadway is provided, but would have reduced facilities in the three-lane central section, and limited new stormwater facilities in the north section where the existing two-lane roadway will be maintained.

### **3.7.2 Stormwater Management – Circ AB Corridor**

#### **Project History**

An application for a Stormwater Discharge Permit for the project was initially filed and issued in 1988. The issued permit, No 1-0788, was amended several times to incorporate additional segments of the highway, with the final request filed in 1992 to incorporate Segments G/H. The initial permit was last amended and issued on March 20, 1999, incorporating all segments of the Circ A/B highway between I-89 in Williston and VT 2A in Essex (Segments A through F).

A new application was filed in February, 2002 for the segment of the highway between VT 117 in Essex and I-89 in Williston (Circ Segments A and B). The application was prepared following the 1997 procedures (rule in effect at the time the application was filed) and *The Vermont Stormwater Management Manual Public Review Draft*, dated August, 2001. Following both public and agency review, Discharge Permit No. 1-0788.0202 was issued on April 2, 2002. Due to concerns raised in an appeal of this issued permit, VTTrans elected to reapply for its Discharge Permit under the recently adopted new rules. Two new applications dated July 19, 2002 addressed the segment of the proposed highway, one concerning the roadway which discharges directly or indirectly to the Winooski River and Redmond Creek, and the other application concerning the portion which discharges directly or indirectly to Allen Brook.

Reference is made to the *Application for Stormwater Discharge Permit Winooski River and Redmond Creek Watersheds, Chittenden County Circumferential Highway (CCCH), Williston, VT* and the *Application for Stormwater Discharge Permit Allen Brook Watershed, Chittenden County Circumferential Highway (CCCH), Williston, VT* prepared for VTTrans July 19, 2002 by Dubois & King Inc.

#### **Overview**

The proposed Circ A/B corridor, from I-89 over the Winooski River to VT 117 in Essex, is located within an undeveloped state-owned right-of-way corridor. Existing runoff conditions consist of sheet flow over vegetated surfaces, shallow concentrated and channel flow to adjacent wetland areas and streams. Stream crossings occur at Allen Brook (Station 821+30), Redmond Creek (Station 692+80) and at the Winooski River (Station 673+00).

The proposed Circ A/B alternatives provide an uncurbed roadway section utilizing open drainage measures, flow over vegetated embankments to grass and stone collection swales and channels. A closed drainage network collects excess open channel and overland flow and

directs the stormwater runoff to several proposed detention ponds. Stormwater treatment practices have been developed along the corridor to provide water quality treatment, groundwater recharge, channel protection control (one year storm), overbank flood control (10 yr storm), and extreme flood control (100 yr storm) for impervious surfaces as required and outlined in the permit applications.

A portion of the Circ A/B corridor (southern end of project at I-89 to station 789+00) is within the Allen Brook drainage area, a watershed identified as impaired due to stormwater on the State of Vermont's 303(d) List of Waters under the federal Clean Water Act. The stormwater discharge to Allen Brook is therefore regulated by and subject to the requirements of the *Stormwater Management Rule for Stormwater-Impaired Waters*.

The southern portion of the Circ roadway corridor drains toward Allen Brook. The central portion discharges to wetland areas and Redmond Creek and the northern portion drains into tributaries of and to the Winooski River. The following addresses the specifics of the proposed stormwater runoff systems along the proposed Circ A/B corridor.

Construction of the Circ A/B corridor would begin at the VT 289 interchange and connects to the previously completed interchange and Segments C through F at VT 117. A southbound entrance ramp and northbound exit ramp would be constructed at the 117 interchange. A new bridge structure would be constructed across the Winooski River, VT 117 and the Central Vermont Railroad. South of the Winooski River bridge, the highway crosses the Williston landfill. An underpass would be incorporated at Station 683+00 to provide access to town property on both sides of the highway. At Station 693+00 the highway would cross Redmond Creek, which was designed to be conveyed in a 72 inch steel multi-plate structure. The highway passes behind the Hinesburg Sand and Gravel property and approaches the Redmond Road interchange. At Station 713+00 the highway divides into a full four-lane highway with a thirty-foot wide median separating the directional roadways. The highway then crosses Mountain View Road with twin bridges and descends more or less at existing grade towards Allen Brook. The Allen Brook crossing structure is a 25 foot span, 10 foot rise concrete box. The highway then climbs from Allen Brook and enters a full interchange with Interstate 89.

### **Stormwater Treatment Standards**

Stormwater Treatment Practices are outlined in the *Application for Stormwater Discharge Permit Winooski River and Redmond Creek Watersheds CCCH, Williston VT and Allen Brook Watershed, CCCH, Williston VT* prepared for VTrans July 19, 2002 by Dubois & King Inc. More detail of the applications is provided below in the Stormwater Treatment Practices section.

The stormwater management plan for the proposed project has been modified to comply with *The Vermont Stormwater Management Manual for Watershed Improvements*, dated April 2002. The stormwater analysis has been developed based on field reconnaissance, NRCS Soil Survey Maps, project design plans, photogrametric mapping and the SCS TR-20 hydrology method using the software package HydroCAD.

### **Proposed Stormwater Facilities for Circ A/B Corridor**

Stormwater facilities for Alternative 16a will replicate the original design to the greatest extent possible. Some of the proposed stormwater treatment areas will be relocated out of areas that have now been classified as wetlands. The proposed facilities will be refined for the other Circ alternatives, but will maintain the same basic concept. Stormwater runoff from the roadway impervious surfaces sheet flows across the pavement to vegetated embankments and is collected by grass lined swales. A network of grass lined collection swales, stone reinforced

ditches, and storm drains with catch basins and drop inlets convey stormwater from the roadway to detention ponds or other outlet locations. Detention ponds have been designed to contain and control stormwater for the channel protection volume (Cp), and overbank protection volume (Qp10) dependant on receiving water characteristics.

Treatment of the stormwater runoff from the impervious roadway surfaces throughout the proposed project will be achieved through vegetated buffers, grassed swales and overland flows. In addition to the methods of treatment noted, additional treatment is attained through sumps in the collection system catch basins and the channel protection (Cp) ponds which perform like extended detention dry ponds prior to release of stormwater to the receiving waters. Thus the level of treatment designed into the proposed project will meet or exceed the procedures outlined in the *2002 VSMMWI Manual*.

Recharge of stormwater for all highway impervious area on the Circ A/B roadway is achieved by sheet flow across vegetated embankments, extended detention and grass-lined swale flow.

Stormwater control will be accomplished by routing highway runoff through detention ponds prior to discharge. Planning for Cp, Qp10 and Qp100 flows were undertaken as a part of the design modification process. In general the systems have been designed to comply with the *2002 VSMMWI Manual*. A summary of drainage outlet points follows as outlined in the application, S/N location numbers refer to approximate stations which are shown on Figures 3-11a through 3.11d.

- Station 672 – Stormwater is collected from the new impervious areas (roadway) of the interchange of Route 289 and Route 117 via sheet flow off the roadway to a network of grass-lined swales, storm drains with drop inlets and stone reinforced ditches. Runoff is then routed through an existing sedimentation basin prior to discharging via an existing pipe under Route 117 into the Winooski River. Runoff from the bridge deck is discharge via scuppers.
- Station 675 – Stormwater from the roadway in this drainage area sheet flows off the roadway surface over a grassed embankment and is collected by grass lined swales. A network of grass lined collection swales, storm drains with drop inlets and stone reinforced ditches convey the stormwater to a sedimentation basin prior to discharging via a stone lined swale to the Winooski River. Runoff from the bridge is discharged via scuppers.
- Station 681 – Stormwater from the landfill roadway in this drainage area sheet flows off the roadway over grassed embankments and is collected by grass lined swales. The stormwater is further collected by storm drains that discharge onto a large stone apron that discharges to natural vegetated terrain. S/N 681 does not discharge to waters of the state.
- Station 692 – Stormwater from the landfill roadway in this drainage area sheet flows off the roadway over grassed embankments and is collected by grass lined swales. A network of grass lined collection swales, storm drains with drop inlets and stone reinforced ditches convey the stormwater through a detention pond designed for channel protection prior to discharging via a stone lined swale into Redmond Creek.
- Station 706 – S/N 706 intercepts offsite stormwater from an existing watershed between station 706+00 and 716+50. S/N 706 collects does not include proposed roadway runoff. The stone lined interceptor swale releases to a natural drainage way via a stone apron.
- Station 714 – Stormwater from the roadway sheet flows off the impervious roadway surfaces over grassed embankments and is collected by grass lined swales. A network

of grass lined collection swales, storm drains with drop inlets and stone reinforced ditches convey the stormwater through a detention pond. The detention pond also receives flow from the intercepted existing watershed between Stations 716+50 and 725+50. The pond has been designed for both channel protection and overbank protection.

- Station 749 – Stormwater is collected from the new impervious areas roadway of the Redmond Road interchange via a network of sheet flow and grass lined swales, storm drains with drop inlets and stone reinforced ditches. The stormwater collected is then routed through a detention basin designed for channel protection and overbank protection. The detention basin discharges through a 48 inch pipe to a stone apron that discharges into an existing swale. The swale will then convey the stormwater to a natural drainage channel on the west side of Redmond Road.
- S/N 756 – Stormwater from the Redmond Road relocation is collected through a network of grass lined swales to an existing drainage swale. Total impervious area is less than an acre.
- S/N 759 – Stormwater from the roadway in this drainage area is collected through sheet flow and a network of grass lined swales. The collected stormwater is discharged through a channel protection control structure before entering into an existing vegetated drainage way. The total impervious surface area is less than one acre, however, channel protection and overbank protection has been provided to address the additional drainage area routed to this location by the cut off swale up gradient of the highway.
- S/N 822 – Stormwater from the roadway in this drainage area sheet flows off the edge of pavement and is collected through a network of grass lined swales, storm drains with drop inlets and stone reinforced ditches. The collected stormwater is routed through a detention basin prior to discharging to Allen Brook via a stone spillway and ditch. The detention basin has been designed for channel protection, overbank protection (Qp10), and Extreme Flood Event (Qp100) were evaluated but control was not warranted.
- S/N 824 – Stormwater from the roadway in this drainage area sheet flows off the roadway, and is collected through a network of grass lined swales, storm drains with drop inlets and overland flow. A channel protection pond will be provided prior to discharging through an existing culvert under US Route 2 which discharges to Allen Brook.
- S/N 848 A, B & C – Stormwater from the Route 289/I-89 interchange sheets flows from the edge of pavement and is collected through a network of grass lined swales, storm drains with drop inlets and stone reinforced ditches. The collected stormwater, including the drainage diverted by the interceptor swales, is split and routed to three independent detention basins prior to discharging into natural drainage ways. Each of the detention basins has been designed for both channel protection and overbank protection for the control of their respective drainage areas.

### **Allen Brook Impaired Watershed**

Allen Brook is identified on the 2003 303(d) list as being impaired by stormwater runoff. In accordance with Act 109, the Stormwater Management Plan for the proposed highway has been designed in accordance with the April 2002 Vermont Stormwater Manual. The primary element of concern has been identified by the Agency of Natural Resources (ANR) as sediment. A detailed analysis, following the Federal Highway Administrative Methodology was performed to establish the sediment loading from the proposed highway on Allen Brook. This analysis projects sediment loading of between 0.06 to 1.14 cubic yards of sediment will be discharged to Allen Brook annually from the stormwater management system, which equates on the high side to less than two five gallon buckets annually. Thus the quantity of sediment being discharged to Allen Brook on an event basis will be insignificant.

Reference is made to the Application for Stormwater Discharge Permit Winooski River and Redmond Creek Watersheds and Allen Brook Watershed, Chittenden County Circumferential Highway (CCCH), Williston VT prepared for VTrans July 19, 2002 by Dubois & King Inc.

## **3.8 Utilities**

### **3.8.1 Introduction**

There are major utility systems along the VT 2A corridor. Many of these would be impacted by the widening and reconstruction of VT 2A. In addition, some of the existing utilities are in poor condition or are undersized for the demands of the growing population in this area. The reconstruction of VT 2A would be an opportune time to replace or update these facilities. There are several public and private utilities that provide service to the many commercial and residential customers in the Town of Williston and the Village of Essex Junction. Public utilities include drainage, water, and sewer systems. Private utilities include electrical, telephone, cable TV, and natural gas. All alternatives would require the alteration and replacement of some of these utilities, which will affect the cost and duration of the roadway reconstruction. The roadway reconstruction would include removal of existing pavement, replacement of adequate thicknesses of gravel materials, and full-depth placement of new pavement. The reconstruction process would provide an opportune time to replace old or under-sized utilities to eliminate the need to dig up the street for many years in the future.

All of the agencies responsible for the utilities in this corridor have been contacted to discuss their long-term needs for this area. Coordination with all of these agencies must be continued during the design process.

### **3.8.2 Water Supply System**

Along the VT 2A corridor there are existing water mains maintained by the Champlain Water District. The water system is split into a high and low service, with the limit of the high service along VT 2A from the southern end of the corridor to US 2, and the low service extending to the Winooski River. From the southerly study limit at Hurricane Lane north to the Vermont State Police Building there is a 10 inch diameter transite (AC) main along the east side of the roadway. From this point northerly to Taft Corners, a 12 inch diameter ductile iron main was recently replaced on the east side of the road. From Helena Drive to River Cove Road, there is a 12 inch diameter transite (AC) main on the west side of the road. A line also extends south along VT 2A from James Brown Drive to the adjacent hydrant location. Crossings exist in several locations along the VT 2A corridor.

The Williston Storage tank project to the south of the study area included the installation of a 12 inch diameter ductile iron main which was tied into the older 10-inch main at VT 2A. The section of 10 inch diameter should be replaced with a new 12 inch diameter ductile iron from the tank to the area near the Vermont State Police Building.

An older segment of 12 inch transite (AC) water main extends from Helena Drive to James Brown Drive and is reportedly in brittle condition. The main's location varies from along the edge of pavement to under the shoulder of the roadway in areas where widening has occurred in the past. This main should be replaced with a new 12 inch diameter ductile iron, and all service connections and crossings upgraded. A sleeve exists for the main crossing of Industrial

Ave/Mountain View Road, the main is in good condition but the sleeve will require extension dependant on intersection limits.

### **3.8.3 Sewer Collection System**

The existing sewer collection system runs along the VT 2A corridor to the Essex Junction Wastewater Treatment Facility on the north shore of the Winooski River. From Hurricane Lane south of the VT 2A/I-89 interchange to Taft Corners (Intersection of US 2) is a gravity flow 10 inch pvc main. A crossing at Taft Corners ties with a 12 inch pvc gravity main from the east and continues to just north of Knight Lane, at which point the line crosses to the west side of VT 2A. The system main remains several hundred feet to the west of VT 2A, before being ultimately pumped across the Winooski River to the treatment facility. Several crossings occur along the corridor tying adjacent developments to the main. A four inch pvc force main crosses at Meadow Run Road, a gravity service connection crosses just north of the intersection of VT 2A and Mountain View Rd/Industrial Ave. and an eight inch pvc gravity flow line crosses VT 2A near River Cove Road.

North of the Winooski River the sewer collection system is located within the existing pavement limits along the west side of VT 2A. The collection system flows to the treatment facility on the northern side of the Winooski River. The system crosses VT 2A at River St. /South St.

The sewer systems are reported to be in good conditions and therefore major reconstruction or replacement at the time of VT 2A reconstruction is not required. In the areas of full-depth roadway reconstruction, the top portion of many sewer manholes may require replacement or reconstruction. At the locations of crossings along VT 2A the existing lines will need to be updated to match adjacent line sizes, if they are of reduced size.

### **3.8.4 Natural Gas**

Vermont Gas has a six inch diameter main running on the west side of the VT 2A corridor. Although the gas main is reportedly in good condition, it is generally installed in a shallow trench (three to three and a half feet deep), and will create difficulties in maintaining the line and the many service connections during the full-depth reconstruction of the road. Significant portions of the line may need to be relocated or replaced to accommodate the construction activities.

### **3.8.5 Electrical Distribution**

Green Mountain Power has three phase overhead power distribution system running along the entire length of the VT 2A corridor. In Williston, the line is on the east side of the roadway, and then switches to the west side in Essex Junction. The poles are owned jointly with Verizon. The poles are generally about five-feet off the edge of the existing pavement and therefore widening of VT 2A would most likely require relocation of most of these poles. In addition to the overhead wires, there are some underground utilities that would also require relocation and adjustments as part of the VT 2A widening.

### **3.8.6 Telephone Systems**

Verizon owns and maintains the local communications systems on the VT 2A corridor. Much of the service is overhead and Verizon owns the utility poles jointly with Green Mountain Power. The overhead wiring would require relocation with the utility poles.

AT&T also has an underground fiber optic cable for a portion of the corridor. The cable starts at Sharon Drive, on the west side of VT 2A and continues north, across the Winooski River to the railroad tracks in Essex Junction, then travels easterly along the railroad right-of-way. The cable

is contained in a four inch diameter plastic pipe was installed about 2000 by directional drilling and is located between four to ten feet below grade. Due to this method of installation, the roadway widening will not require major relocation of the cable. New cross pipes for drainage and other utilities will require coordination to avoid the fiber optic cable and pipe.

### **3.8.7 Cable**

Adelphia Cable maintains the cable service along the VT 2A corridor. The lines are located on the poles maintained by Green Mountain Power. Relocation of lines would be in conjunction with the pole relocations.

## **3.9 Structures Studies**

### **3.9.1 Introduction**

This section of the report presents an overview of the bridges associated with the ten alternatives being evaluated in the Draft Environmental Impact Statement for the Circ-Williston Transportation Project. For the VT 2A corridor, there are three locations studied: I-89 NB & SB over VT 2A, VT 2A over Allen Brook, and VT 2A over the Winooski River. For the Circ A/B corridor, there are six locations studied: Circ A/B over I-89 NB and SB, US 2 over the Circ A/B, Circ A/B over Mountain View Road, Circ A/B over Redmond Road Connector, Circ A/B over Redmond Creek and Circ A/B over the Winooski River/VT 117/Central Vermont Railroad. There are three other locations in the Circ A/B corridor that are not included in this structures study, since it is assumed that the structures as designed for the original Chittenden County Circumferential Highway project will be the preferred structure. These locations are Circ A/B over Allen Brook, the Williston Alternative Transportation Path over the Circ A/B corridor, and Circ A/B over the Landfill Access Road.

### **3.9.2 I-89 NB & SB Over VT 2A**

Possible improvements to VT 2A in the vicinity of I-89 Exit 12 include roadway widening and the addition of a multi-use path system. The current configuration of VT 2A provides four 11 foot travel lanes and two two-foot shoulders under the I-89 bridges. These dimensions are constrained by the existing piers for the I-89 structure over VT 2A. Since I-89 runs approximately east-west in this area, all orientation is according to true north. The proposed improvements to VT 2A are as follows:

- No Build option: Maintain the existing roadway width and lane configurations for VT 2A. This will be maintained for all alternatives except 2 and 18. For Alternatives 3, 19, 22, and 23, roundabouts would be constructed at the I-89 ramp terminals, and the existing four-lane section between the intersections could be retained, although the travel widths would be less than standard. A ten foot wide multi-use path would be constructed on the east side of VT 2A between the existing east abutment and east shoulder pier of the northbound and southbound bridge. Due to the 2:1 front slope between the abutment and shoulder pier, a retaining wall (oriented parallel to VT 2A) would be required to provide a level cross-section for the multi-use path under each structure. The existing five foot wide sidewalk between the west abutment and the west shoulder pier would be retained.
- VT 2A Widening: Alternatives 2 and 18 would include full reconstruction of VT 2A utilizing a five-lane roadway, consisting of five 12 foot wide lanes and two four foot wide shoulders. Also, a ten foot wide multi-use path would be constructed on the eastern edge of roadway, separated from the roadway by a five foot wide grass buffer zone. Where VT 2A passes under I-89, there would be at least a three foot wide buffer between the edge of the multi-use path and the face of the substructure unit. In accordance with Vermont State

Standards Table 3.4, 16 foot clear zones would be required (from edge of travel lane). The resulting minimum perpendicular distance between substructure units would be 98 feet. Due to the span arrangements of the existing structures, this option would entail full replacement of the existing I-89 bridges (see Figure 3-12a for more information).

### **Existing Bridges (Bridge Nos. 0061N & 0061S)**

The existing bridges, built in 1960, are identical. Each bridge is 154 feet long (CL-to-CL bearings at abutments), consisting of three simple spans (54 feet/ 59 feet/ 44 feet) of five rolled beams with a non-composite reinforced concrete deck and asphalt wearing surface. Each bridge carries I-89 over VT 2A with two 12-foot wide travel lanes and two three foot wide shoulders with a curb-to-curb width of 30 feet and an out-to-out width of 34 feet, ten inches. The abutments are reinforced concrete stub-type abutments supported on steel piles, situated at the top of 2:1 stone-paved slopes. The piers are reinforced concrete, two-column bents supported on spread footings. The horizontal alignment of I-89 is straight in the vicinity of Exit 12. Both bridges are situated on moderate crest vertical curves. The minimum vertical underclearance is 16 feet and 16 feet, seven inches for the northbound and southbound bridge respectively. There are no bridge-mounted utilities. Based on the latest routine inspection reports (May 25, 2004), both bridges are in good to fair condition.

### **Design Issues**

*Safety:* Reinforced concrete Jersey barriers are situated along the edge of VT 2A in the vicinity of the shoulder piers of the northbound and southbound bridge. While the barriers serve to protect motorists from the pier columns, there is a severe constriction in the roadway width under the bridges. Additionally, the bridges only provide one foot shoulders for motorists traveling on I-89. As cited in the latest inspection reports, the vertical underclearance, horizontal underclearance, and deck geometry were each rated as "Intolerable, Replacement Needed."

*Structure Maintenance:* The existing bridges each have three simple spans. Although this configuration was economical at the time of construction, the maintenance costs associated with multiple expansion joints can be burdensome. Additionally, the existing structures are nearly 50 years old. Although recent inspection reports suggest that the bridges are in good to fair condition, a structure of this age is susceptible to rapid deterioration.

*Structure Rehabilitation:* Recent inspection reports and as-built drawings of the bridges were obtained to assess the feasibility of the No Build Alternative. As mentioned above, the current deck geometry of the bridges is inadequate. Deck widening would resolve the substandard deck geometry, but would not resolve the substandard vertical and horizontal underclearances. Additionally, it is likely that the existing bridges, constructed in the 1960s, have a lead based paint system.

*Superstructure Options:* The replacement structures for I-89 Northbound and Southbound would be twin single-span bridges. Each structure would carry two 12 foot wide lanes, a ten foot wide outside shoulder, and a four foot wide inside shoulder. The out-to-out deck width for each bridge would be 40 feet, ten inches. The middle span of the existing northbound and southbound bridge is 59 feet, therefore allowing a relatively shallow structure depth. Due to existing vertical clearance constraints on VT 2A below the bridges, the profile of I-89 would need to be raised one foot, nine inches to accommodate the additional structure depth of the new single span bridges. The clear distance between faces of abutments for the VT 2A widening option would be 100 feet, ten inches (considering the 13 degree skew of the crossing). Assuming a span length of 105 feet (center-to-center of bearings at full-height abutments), the required structure depth for a steel plate girder bridge would approach five feet. Other structure options include New England Bulb

Tees (NEBTs), butted box beams, and rolled beams. NEBTs would be precluded due to structure depth requirements. A butted concrete box beam superstructure may be feasible upon further review during final design, but this option would be at the upper range of attainability based on the 105 foot span and considering the shallow structure depth requirement. The required span length would be beyond the practicable range for rolled beams. In order to minimize impacts to the profile of I-89 at the Exit 12 interchange, Grade 50W weathering steel plate girders would be used.

- Provide six Grade 50W plate girders at seven feet, four inches spacing, with balanced overhangs of two feet, one inch. Overall structure depth would be approximately five feet.

*Substructure Options:* As mentioned in the superstructure discussion above, structure depth would become a critical factor in the selection of bridge type and configuration. In order to minimize structure depth, full-height reinforced concrete cantilever abutments supported on spread footings would be constructed. Spread footings are assumed based on examination of the existing plans indicating the existing intermediate piers are supported on spread footings. To simplify construction phasing, U-back wingwalls would be used (see the discussion on construction phasing below).

The use of integral abutments situated on laid back slopes may be investigated in final design if the profile of I-89 is raised significantly to accommodate the increased structure depth associated with the longer spans. Site geometry meets the requirements necessary for consideration of integral abutments since existing plans with as-built quantities indicate an average pile length of approximately 31 feet. Although it is unclear if the piles were driven to refusal, it is likely that the soil profile is adequate to drive piles to their minimum embedment depth for integral abutment construction.

*Proposed Multi-use Path:* The alignment of the multi-use path has been placed on the eastern side of VT 2A, immediately adjacent to the northbound shoulder. The path would have a ten-foot buffer between the approach roadway shoulder and edge of path. To reduce structure lengths at the I-89 overpass, the buffer-zone would be reduced to five feet.

*Bridge Rails:* VTrans standard NETC 2-bar box beam rail with snow fence would be utilized for these bridges.

*Construction Phasing:* Phased construction utilizing a temporary bridge in the median of I-89 would be required in order to maintain traffic on I-89 during construction, assuming that the VT 2A widening option is selected. Traffic phasing would be as follows:

- Phase I: Construct a temporary bridge and detour roadway in the median of I-89.
- Phase II: Shift northbound traffic to the temporary structure. Demolish the existing northbound bridge and construct the replacement bridge and approaches.
- Phase III: Shift northbound traffic onto the newly constructed northbound bridge and shift southbound traffic onto the temporary bridge.
- Phase IV: Demolish the existing southbound bridge and construct the replacement bridge.
- Phase V: Shift southbound traffic onto the newly constructed southbound bridge. Remove the temporary bridge and proceed with improvements to VT 2A and the Exit 12 interchange.

*Utilities:* Based on existing plans, photos, and the latest project information, there are no bridge-mounted utilities anticipated at this location. Fascia-mounted sign structures may be required based on VTrans request.

### **Cost Estimation**

Structure costs were estimated based on information gathered from recent bid history in Vermont, with consideration for other regional data. Bridge construction costs for the existing Circ bridges were first updated by assigning current unit prices to the quantity estimates shown in the existing plans. An average cost of \$185 per square foot was established for all stringer-type bridges with cast-in-place concrete decks and typical reinforced concrete substructures based upon the results of the cost study. The square footage of a bridge is estimated as the out-to-out width of the bridge multiplied by the length of the grade separation (i.e. end of wingwall at Abutment 1 to end-of-wingwall at Abutment 2). See the Structures Study Figures for all cost information.

### **Recommendation**

Based on the geometrically substandard existing bridges at this site, new twin single-span bridges would be constructed. The superstructure would consist of single-span Grade 50W weathering steel plate girders with a cast-in-place concrete deck. The twin bridges would each have a span length of 105 feet (center-to-center of bearings at abutments), and an out-to-out deck width of 40 feet, ten inches. The substructure would consist of full-height reinforced concrete cantilever abutments with U-back wingwalls.

### **3.9.3 VT 2A over Allen Brook**

Improvements in the vicinity of VT 2A over Allen Brook include roadway widening and the addition of a multi-use path system. The existing bridge over Allen Brook carries two 12 foot wide travel lanes and two three foot wide shoulders with an overall bridge width of 31 feet, four inches. There are three roadway configurations for VT 2A over Allen Brook. These configurations are as follows (see Figure 3-12b for more information):

- No Build Alternative: Maintain the existing roadway width and overall bridge width at 31 feet, four inches.
- Alternative 2 and 3: Four-lane configuration which carries four 12 foot wide travel lanes and two four foot wide shoulders, and a ten foot wide multi-use path with a five foot wide buffer. The overall bridge width for this configuration would increase to 78 feet, ten inches.
- Alternative 22: A three-lane configuration which carries two 12 foot wide travel lanes, one 12 foot wide combined median and turn lane, two four foot wide shoulders and a 10 foot wide multi-use path with a five foot wide buffer. The overall width for this configuration would increase to 66 feet, ten inches.

### **Existing Bridge**

The existing bridge, built in 1936, is a 72 foot simple span steel rolled beam superstructure with a non-composite concrete deck and asphalt wearing surface. In 1976 the bridge was widened from approximately 24 feet to its current width of 31 feet, four inches. The existing concrete deck was retained with new fascia girders and concrete deck strips added. The original substructure elements are skeleton or "spill-through" abutments on spread footings. The widened substructure elements are cantilever type retaining walls on spread footings. The bottom of footing elevations of the 1976 construction are between 10 and 17 feet above footing elevations of the 1936 construction, therefore the widened substructure was constructed on the previously placed fill. The existing channel is trapezoidal in shape and protected with stone rip-rap at the water line. The structure carries a four chamber telephone duct bank, supported by inserts cast into the deck. A 12 inch diameter water line runs below the footings of the widened substructure and channel on the western side of the bridge.

### **Design Issues**

*Structure Rehabilitation:* April 2005 and July 2003 inspection reports and as-built drawings of the widening performed in 1976 were obtained to assess the feasibility of rehabilitation. Inspection reports noted the concrete deck was leaking in several bays and moderate to heavy rust had accumulated in those areas where the deck was leaking. A review of the existing plans indicate a number of undesirable structural and environmental details including several different beam spacing, two different beam sizes, and a lead based paint system.

The April 2005 inspection report noted a one and one half inch wide settlement crack in the west side of the south abutment cap under the exterior. As a result, the bridge was given “semi-critical” status and required repairs to correct ongoing settlement at the southwest corner of the bridge. Review of the existing plans and photos indicates that the settlement crack occurs at the construction joint between the 1936 and 1976 construction. The settlement is likely caused by inadequate bearing capacity or settlement of the fill materials on which the widening was constructed.

An analysis of the existing steel determined that the existing beams would be capable of supporting a new deck, wearing surface and HS 25 design loads in accordance with VTrans standards. However, reuse of superstructure components is not recommended due the amount of substructure rehabilitation required and costs associated with removal of the lead based paint system. Without the benefits of any physical testing or geotechnical design information it is unknown which of the existing substructure elements, if any, possess the load carrying capacity to support new dead and live loads.

A rehabilitation of the existing bridge would require a complete superstructure replacement and removal of the 1976 construction abutment widening. The remaining bridge substructure elements are approaching the end of their useful design life and may not provide an additional 75 years of service. Consequently, only replacement options for this structure were considered given the “semi-critical” repair status of VT 2A over Allen Brook and current state of disrepair.

*Proposed Multi-use Path:* The alignment of the multi-use path has been placed on the eastern side of the bridge, immediately adjacent to the northbound shoulder. Placing the multi-use path to the east side minimizes impacts to residences along the west side of VT 2A. The path will have a five foot buffer carried across the structure.

*Retaining Walls:* It is likely that both three and four lane roadway configurations would require construction of approximately 275 feet of retaining wall in areas where Allen Brook runs parallel to the roadway, near the current toe of slope. This retaining wall is required to minimize slope impacts to the Allen Brook channel and the flood plain. The roadway alignment could be shifted to the west to eliminate the need for a wall; however this is undesirable from a roadway geometry standpoint and would require the taking of several residences.

*Hydraulics/Abutment Orientation:* The existing bridge is a single span with a trapezoidal shaped channel cross section under the bridge. The existing channel has a significant curve to the east (immediately upstream) of the existing bridge of approximately 90 degrees. Inspection reports do not identify scour concerns or erosion of the channel bank under the structure. A review of the as-built plans show the existing structure low-chord is several feet above the 100 year flood. Proposed bridge alternatives increase the superstructure depth by approximately one foot, and would not restrict the current hydraulic opening. The proposed bridge would be constructed with a skew of approximately 10 degrees to better align the bridge with the channel below.

*Bridge Rails:* A VTrans standard NETC box beam rail would be utilized for this bridge. The standard four-bar section would be used on the side where the multi-use path is located; the two-bar section would be used elsewhere on the bridge.

*Integral Abutments:* The site geometry and hydraulic conditions meet the requirements necessary for consideration of an integral abutment bridge at this site. The current channel configuration would also not require an increase in span length; therefore structure depth and hydraulic freeboard would not be impacted. Existing plans and performance of the original substructure indicate adequate foundation soils near the channel elevation; however they give no indication related to depth of refusal. A geotechnical investigation would be required to determine if pile lengths set fourth by VTrans are suitable for consideration of an integral approach.

*Construction Phasing:* For both three-lane and four-lane configurations, the additional bridge width required is approximately equal on both sides of the existing structure. Traffic analysis has determined that one-way alternating traffic controlled by a signal is not acceptable, and two-way traffic must be maintained at all times throughout construction. The narrow width of the existing bridge allows for only a small portion to be removed at one time and still maintain two-way traffic. In addition, the spill through abutments have only two columns near the exterior girders. This permits only a small portion of the abutment to be removed and still retain structural adequacy.

For the three-lane configuration, it would be possible to construct the bridge in the following sequence:

- Phase I: Remove the outer portion of the existing bridge on the eastern side, and then construct the easternmost section of the proposed bridge, retaining walls and approaches. Maintain two lanes of traffic on existing bridge.
- Phase II: Move northbound traffic to the new portion of proposed structure. Remove the western portion of existing bridge, shift southbound traffic to eastern side of the remaining structure formerly occupied by northbound traffic. Construct westernmost portion of the new bridge.
- Phase III: Shift southbound traffic to newly constructed portion of proposed bridge, remove remaining portions of existing bridge and construct middle portion of new bridge.
- Phase IV: Shift both traffic lanes to the east, construct sidewalk for multi-use path.

This phasing configuration would result in two bonded longitudinal deck joints. A significant amount of shoring would be required to protect excavations during construction. These factors would significantly impact bridge construction and life cycle costs. The cost of phased construction would need to be weighed against the costs and construction benefits of providing a temporary bridge.

The width of the four-lane configuration, coupled with the multi-use path and buffer allow for approximately 32 feet of the new structure to be built while maintaining traffic on the existing bridge. The construction sequence for this configuration would be:

- Phase I: Remove approximately five feet of the existing bridge to on the east side of VT 2A. Maintain two lanes of traffic on existing bridge. Construct approximately 32 feet of the proposed bridge, retaining walls and approaches to the east.
- Phase II: Shift traffic to the new structure in two 12 foot lanes. Remove the remaining portions of existing bridge and construct the western segment of the new structure.
- Phase III: Shift traffic to the west and construct the multi-use path.

This phasing configuration would be preferred over that required for the three lane option, as it eliminates the need for bridge construction between traffic lanes and provides the contractor with

a larger work area. The number of braced excavations and traffic shifts would be minimized, reducing costs.

*Utilities:* Existing telephone utilities supported by the superstructure and water line buried below the bridge and channel would be relocated to the new structure. It is recommended that the water line below the channel be abandoned and removed below new construction to eliminate concerns of damage to the new structure or utility. Depending on superstructure type, utilities would be supported between girder bays or cantilevered on the exterior of the bridge.

### **Superstructure Option**

Due to the semi-critical classification of the structure and components which must be repaired, structure rehabilitation and widening is not a viable option. Consequently, removal and complete replacement of the existing bridge structure is recommended. The following comparisons are based on a new single-span structure with a 72 foot span length. This span length does not pose any significant or unusual constructability requirements for any of the load-carrying member types. The proposed abutments are skewed slightly to conform to the alignment of the stream channel, minimizing channel re-construction.

The span length of this structure is such that rolled steel beams, steel plate girders, New England bulb tee (NEBT) pre-stressed concrete girders, and pre-stressed concrete box beams are all viable superstructure types. Rolled beams with a reinforced concrete deck would be the recommended alternative based on economy of cost and familiarity of construction with local contractors likely to perform the work.

The distance from the low chord of the structure to ordinary low water level is not known at this time. Provided that the requirements of the VTrans structures manual are met, rolled steel beams would utilize Grade 50W painted weathering steel for all configurations. Utilities are easily mounted within the beam bays on cross frames for this superstructure type.

*Four-Lane Configuration:* The preliminary cross-section for this configuration would utilize 14, Grade 50W painted rolled beams spaced at approximately 5 feet, 9 inches with approximately two foot overhangs. The total structure depth would be approximately four feet.

*Three-Lane Configuration:* The preliminary cross section for this configuration would utilize 12, Grade 50W painted rolled beams spaced at approximately five feet, eight inches with two feet, three inch overhangs. Similar to the four-lane option, the total structure depth would be approximately four feet.

### **Cost Estimation**

Structure costs were estimated based on information gathered from recent bid history in Vermont, with consideration for other regional data. Bridge construction costs for the existing Circ bridges were first updated by assigning current unit prices to the quantity estimates shown in the existing plans. An average cost of \$185 per square foot was established for all stringer-type bridges with cast-in-place concrete decks and typical reinforced concrete substructures based upon the results of the cost study. The square footage of a bridge is estimated as the out-to-out width of the bridge multiplied by the length of the grade separation (i.e. end of wingwall at Abutment 1 to end-of-wingwall at Abutment 2). See the Structures Study Figures for all cost information.

### **Recommendation**

Due to existing superstructure and substructure poor overall condition, widening the existing bridge is not considered a viable option and therefore a complete bridge replacement would be recommended.

The superstructure would be cast-in-place reinforced concrete deck supported by painted weathering steel rolled beams spaced at five feet, eight inches for a three lane configuration and five feet, nine inches for a four-lane configuration.

The bridge would be skewed to align with Allen Brook below to minimize channel re-grading and associated impacts.

The span length would be appropriate for either conventional or integral abutment substructures.

### **3.9.4 VT 2A and Multi-use Path Over the Winooski River**

Improvements in the vicinity of VT 2A over the Winooski River include minor roadway widening and lane re-configuration along with the addition of a multi-use path. The ten foot wide path is required to improve and encourage bicycle and pedestrian transit throughout the corridor. The existing bridge and roadway in the vicinity of the crossing provides a five feet, six inch sidewalk along the western edge of the roadway. Roadway alternatives at this location include the No-Build Alternative and a four-lane configuration. Lane and shoulder widths achieved for each option are heavily dependent on the method of widening. Additionally, the decision to construct a separate multi-use path bridge also impacts lane and shoulder widths. These width restrictions are detailed in Figures 3-12c and 3-12d and are summarized below.

- No Build Alternative: Maintain existing roadway width of 44 feet and overall width of 52 feet, two inches. Lane widths do not change. See Existing Typical Section.
- Four Lane Option: The preferred lane configuration for Alternatives 2 and 3 is four 12 foot lanes, two four foot shoulders, and the ten foot wide multi-use path located on the west side of VT 2A. If the existing vehicular bridge is not widened but existing sidewalk is removed, four 11 foot lanes and two two-foot, nine inch shoulders would be provided. This configuration would be provided for all four lane options where a separate multi-use path bridge is provided. See discussion below for lane widths when the existing bridge is widened.

#### **Existing Vehicular Bridge**

The existing vehicular bridge was constructed in 1987 to replace a single span truss structure formerly at the site. The current bridge is a two-span, continuous curved steel plate girder system acting composite with the concrete deck. The bridge carries two 12 foot wide travel lanes, two ten foot shoulders, and a five feet, six inch sidewalk. The overall width is 52 feet, two inches. Provisions for a telephone duct bank and gas line are included in the westernmost girder bay. Substructure elements are cast-in-place concrete. Abutments and wingwalls are cantilever retaining walls bearing on rock. The pier is a wall-type pier with a hammerhead cap, also founded on rock. Substructure elements are approximately parallel to river flow. The river channel at the crossing is predominantly ledge and widens to both sides immediately downstream of the crossing. Immediately upstream of the crossing is hydroelectric dam. The inspection report dated March 2005 noted the bridge is in overall good condition.

#### **Structure Options-Widened Bridge Structure**

Two approaches were evaluated for accommodating the additional travel lanes and multi-use path, a sidewalk cantilevered from the existing bridge superstructure and a more extensive widening. This more extensive widening would include additional steel plate girders and deck along with extensions of the pier abutment walls and new wing walls. For either widening option,

the existing three-bar bridge rail would be removed and replaced with the standard NETC box beam rail, since it is possible that VT 2A would become part of the National Highway System.

### **Cantilevered Sidewalk Option**

The cantilever sidewalk option would provide a reduced width roadway and sidewalk / multi-use path of five feet along the western side of VT 2A (see figure 3), and would be used with the four lane configuration. The sidewalk would be separated from vehicular traffic by the existing bridge rail, which must be maintained in place to withstand vehicular impact loads. Sidewalk railing would be a pedestrian rail satisfying pedestrian loading.

The sidewalk floor would be cast-in-place reinforced concrete deck supported by rolled steel sections attached to the western exterior girder by connection plates which would be either bolted or welded in the field to the girder. Since this option would be attached to the superstructure, only minor modifications to the abutments and approaches would be required.

### **Design Issues – Cantilevered Sidewalk**

*Roadway/Path Width over Bridge:* As discussed above, the preferred roadway and multi-use path widths cannot be accommodated with this option. The cantilevered sidewalk option would be restricted to the five foot width shown.

*Structural Capacity of Existing Members:* As described above the existing bridge is a curved girder superstructure. Curved girder superstructure designs are typically controlled by the exterior girder and typically carry the largest lateral loads, have the largest the deflections, and are the longest spans of the group. Although no detailed analysis has been performed on this structure to determine available capacity, it is likely the applied loads of the cantilever sidewalk would stress the girder beyond acceptable limits. Additionally, field welding and bolting of plates to the existing girders is not recommended in applicable design codes as this can shorten service life and limit load carrying capacity, therefore, this option would not be recommended.

### **Full Bridge Widening Option**

Full bridge widening would provide the desired roadway and multi-use path widths for the four lane option. Widening would occur to the west of VT 2A and would be accomplished by extending the bridge deck, adding curved steel plate girders, and widening both abutments and the pier. This method of widening the bridge is commonly performed on girder type bridges.

### **Design Issues – Full Bridge Widening**

*Roadway/Path Width over Bridge:* For the four lane option, the widening would be approximately 16 feet, six inches and would require two additional curved girders. The multi-use path typically has a five foot buffer between the roadway and path. The buffer has been eliminated from the bridge structure to minimize structure costs.

*Structural Capacity of Existing Members:* Curved girder bridges are subject to loads which require analysis of the bridge structure as a single unit. The addition of exterior girders would have to be carefully analyzed to avoid overstressing existing components of the new structure, including cross frames. Substructure components would also need to be analyzed to determine the effect of a widening as described above.

*Approach Slopes:* Approach embankments for the structure were constructed at a two-to-one slope, however the additional width required for the four lane configurations may require one-and-one-half-to-one side slopes to minimize impacts to the adjacent Overlook Park and the electric substation property.

*Construction Access:* The mountainous topography and shallow depth to bedrock create difficult access to the river for pier widening. This must be taken into consideration when further developing the widened pier geometry.

*Hydraulics / Pier Location:* Inspection reports indicate no evidence of scour at the existing bridge. A review of the existing plans indicates the flood of record (which occurred in 1927) reached elevation 244 feet, which is above the 100 year flood elevation of approximately 235 feet. Since the widening is occurring on the exterior of the curve, all new superstructure components would have adequate clearance above the design flood. Widening the existing pier would have a very small, if any impact on river hydraulics.

*Construction Phasing:* A portion of the existing deck on the west side, and bridge rail on both sides would need to be removed to construct the widened bridge and install new NETC bridge rails. The most appropriate traffic control would be to provide one lane of traffic in each direction, replace the eastern bridge rail and brush curb, then shift lanes from the west side of the bridge to the northbound travel lane and shoulder. This would allow the Contractor to work in part from the bridge deck itself, allowing the bridge to be widened in a two phases.

### **Structure Options-Separate Bridge Structure**

An alternative to widening the existing bridge structure would be to accommodate the multi-use Path on a separate bridge carrying only cyclists and pedestrians. Single span and two-span options were considered. Two-span options would place a pier in the Winooski River parallel to and in line with the vehicular bridge pier to minimize hydraulic restrictions. Single span options were evaluated in the event construction of a pier is infeasible or environmentally unacceptable. Two-span options considered are a conventional prefabricated steel truss and a steel plate girder superstructure. Single span options include a prefabricated steel cable-stayed bridge. For all structure options, structural steel would be Grade 50 weathering steel. Due to the proximity of the hydroelectric dam just upstream of the crossing, VTTrans bridge policy requires structural steel to be painted at this location. The required elevation and location of the abutments are such that structure depth would not affect river hydraulics at the crossing. Vertical profiles for all options are equal and therefore would require the same amount of earthwork and length of retaining wall.

A review of the existing plans show depth to ledge is shallow, therefore all abutment options would be cast-in-place concrete. The shallow depth of ledge is beneficial for all structure options as deep foundations are not required. Alignment of substructure components for the two-span options would be skewed to match the existing vehicular pier. Single span options do not require a pier therefore abutments could be set normal to the path. The approaches would be earth fill sections. Wingwalls and retaining walls constructed using a mechanically stabilized earth (MSE) system would be the most cost effective solution. Conventional cast-in-place concrete walls would also provide an acceptable solution.

### **Prefabricated Truss Option**

The prefabricated truss option evaluated is a two-span continuous structural steel half-through system. Span lengths are equal at 165 feet, for a total bridge length of 330 feet. As mentioned above, cantilevered cast-in-place concrete abutments with footings on rock are assumed, with a total abutment height estimated at 30 feet. The approximate bridge skew is 20 degrees. The preliminary superstructure cross section utilizes a five inch composite metal and concrete floor deck to minimize dead loads. The overall structure height is approximately nine feet with a clear inside width of 10 feet. The bridge panels would consist of wood rub-rails, toe plates, and vertical safety pickets spaced at six inches. Rub and hand rails would be mounted to the inside of the truss.

### **Steel Girder Option**

The steel girder option evaluated is a two-span continuous welded plate girder system. Similar to the prefabricated truss, this option has two equal spans of 165 feet for a total bridge length of 330 feet. Substructure proportions and skew angle are essentially equal to the prefabricated (prefab) truss option. The initial configuration identified for this option utilizes two hybrid steel plate girders spaced at seven feet, supporting an eight and one half inch thick concrete deck with three foot overhangs. The bridge will be visible to motorists on the vehicular bridge; therefore girders constructed with a parabolic haunch would have aesthetic and structural merit. The total beam depth for this configuration is approximately six feet, three inches with a total structure depth of seven feet, six inches. A total face-to-face rail width of ten feet and an overall bridge width of 13 feet would be used. A standard or custom design pedestrian rail with balusters would be incorporated with this option.

### **Prefabricated Cable-Stayed Truss Option**

The prefabricated cable-stayed truss option utilizes a steel half-through truss system suspended by cables extending to steel bent towers at the abutments. The total span for this structure is 330 feet. Tower bents are approximately 80 feet tall supported vertically by cast-in-place concrete abutments and horizontally by cables tied to concrete counterweights anchored into bedrock. Abutment skew is set normal to the path, as a pier is not required for this option. The overall superstructure height is six feet with a clear inside width of ten feet. The bridge panels would consist of wood rub-rails, toe plates, and vertical safety pickets spaced at six inches. This option does not require permanent or temporary impacts to the Winooski River and would be seen as signature structure connecting the communities of Williston and Essex Junction.

### **Design Issues-Separate Bridge Structure**

*Path Horizontal and Vertical Alignment:* Preliminary horizontal alignment options place the multi-use path to the west of the vehicular bridge, on the same side as the existing sidewalk. The horizontal alignment consists of a tangent section over the Winooski River with reverse curves at the approaches. Abutments are located approximately 21 feet beyond wingwall ends of the vehicular bridge to allow abutment construction to occur beyond the channel limits. Due to the existing curvature, the minimum distance between existing and new structures at mid-channel is approximately 32 feet. This alignment results in an overall bridge length of 330 feet

The Americans with Disabilities Act mandates the maximum constant grade for a pedestrian way shall not exceed five percent without a landing area. This criterion was considered when establishing the preliminary vertical alignment for the proposed bridge. An average deck elevation of 273 was used, which is slightly above the average deck elevation of the vehicular bridge. This elevation provides vertical tangents less than five percent; however it results in fills of approximately 20 feet at both abutments. A retaining wall would be required to maintain the vehicular access to the electric substation at the northwestern corner of the project. See the *Approach Slopes* section below for additional discussion.

*Path Width over Bridge:* The proposed multi-use path cross section is comprised of a ten foot paved section and two foot gravel shoulders for a total width of 14 feet. It has become increasingly common to carry only the paved width of the path over the bridge to reduce construction costs, therefore a rail-to-rail width of ten feet is used for all options.

*Bridge Deck Thickness:* The prefabricated truss superstructure alternatives utilize a five inch composite concrete and metal deck system to minimize dead loads. The preliminary design for the steel girder assumed the use of an eight and one half inch cast-in-place concrete deck, which

is standard for Vermont bridges. We would recommend revising the deck thickness to six inches should a non-proprietary system be selected for use at this bridge crossing. This reduction in dead load would allow for a more economical superstructure configuration.

*Hydraulics / Pier Location:* The existing vehicular bridge pier is located approximately at the center of the Winooski River channel, and is parallel to river flow. Since the existing ground at the proposed abutments is above elevation 244, all bridge structure options would have adequate clearance above the design flood. The proposed river pier would be located directly in line with and parallel to the existing vehicular bridge pier. Pier construction at this location and orientation would minimize impact to river hydraulics.

*Construction Access:* Access to the river channel for construction of a pier would be required for two span structure options. The presence of the vehicular bridge and hydroelectric dam to the east, as well as swift river currents, mountainous topography and shallow depth to bedrock will make access difficult and should be considered during selection of the bridge span arrangement.

*Approach Slopes:* The multi-use path would require the construction of 325 feet of fill embankment adjacent to the existing vehicular bridge fill slopes. The south approach would be constructed using earth fill and two-to-one slopes, and would have only minimal impacts as the slope limits tie into existing ground before the Overlook Park parking area. The north approach slope runs near the paved access drive of the electric substation parcel. This approach, if built with two-to-one fill slopes, would have unacceptable impacts to the access drive, which cannot be relocated due to orientation of loading docks and natural slopes. A retaining wall approximately 200 feet in length would be required as part of the northwest wingwall to maintain access to the substation.

*Aesthetics:* The proximity of the proposed pedestrian bridge to the vehicular bridge and to Overlook Park makes it highly visible to motorists and pedestrians. In addition, the bridge crosses a major river and the town line of Essex Junction and Williston. Improving the aesthetics of the bridge may be of interest to VTrans and the towns of Williston and Essex Junction.

### **Cost Comparison**

Widened structure costs were estimated based on information gathered from recent bid history in Vermont, with consideration for other regional data. An average square foot cost of \$185 per square foot was determined as the base cost of construction for this bridge, and then increased to \$350 per square foot to account for perceived site difficulty, restricted work areas, traffic control and complexity of the structure. The square footage of a bridge is estimated as the out-to-out width of the bridge multiplied by the length of the grade separation (i.e. end of wingwall at Abutment 1 to end-of-wingwall at Abutment 2). See the Structures Study Figures for all cost information.

The separate bridge option cost comparisons consider the bridge costs of the structure only, on a per square foot basis and does not include approach embankments and retaining walls, as they are the same size, length and proportion among all options. Costs per square foot for prefabricated options are supplemented and verified by preliminary pricing information furnished by the Steadfast Bridge Company. Costs for all structure types assume conventional cantilevered concrete abutments.

### **Recommendation**

The recommended option would be to provide the full bridge widening by adding girders and modifying the substructure and approaches. This option is the most feasible structural option and

provides a bridge structure that accommodates the preferred lane widths, while minimizing environmental impacts to the Winooski River.

### **3.9.5 Circ over I-89 NB & SB**

For each of the proposed Circ configurations, an overpass structure would be required to carry the Circ over existing I-89 at the proposed Exit 11A interchange. The current configuration of I-89 in the vicinity of future Exit 11A consists of a northbound and southbound barrel each carrying two 12 foot wide travel lanes with shoulders. The barrels are on a straight horizontal alignment and are separated by a grass median. The anticipated overpass structure would be a two-span bridge with a pier located in the median. The proposed configuration of the Circ is dependent on the selected highway alternative; however the anticipated structures are nearly identical in span configuration and structure type for each of the various Circ configurations (Limited Access Highway, Circ Boulevard, and Circ Street). The following options are evaluated at the Circ/I-89 interchange.

#### **Limited Access Highway Option:**

The structure would carry two 16-foot lanes of opposing traffic, two five foot, four inch outside shoulders, two 4-foot inside shoulders, and a two foot wide concrete median barrier. The overall bridge width for this configuration would be 56 feet, eight inches. The bridge would function as an on-ramp and off-ramp for I-89 Southbound. Due to the geometry of the trumpet interchange, the entire bridge would be situated on a horizontal curve, with a constant profile grade of 4.6 percent (See Structures Study Figure 5 for more information). Aside from minor adjustments to the roadway profile at this location, this configuration would be identical to the layout proposed in the bridge design effort in 1988. See the discussion on "Existing Plans" below.

#### **Circ Boulevard and Circ Street Options:**

The structure would be required to carry four 12 foot wide lanes, two five feet, four inch wide outside shoulders, two three foot wide inside shoulders, and a two foot wide concrete median barrier. The overall bridge width for this configuration would be 70 feet, eight inches. The future Exit 11A interchange would be a diamond interchange with roundabouts for the Boulevard and Street options. The bridge would be situated on a straight horizontal alignment, with a constant profile grade of 4 percent (See Figure 3-12f for more information).

#### **Existing Plans**

Although never constructed, the Circ roadway segment over I-89 was previously designed in 1988 as part of the original Circumferential Highway design. The bridge would be situated on a horizontal curve and would carry the on-ramp and off-ramp for I-89 Southbound at future Exit 11A. The bridge would carry two 16 foot lanes of opposing traffic, two five foot, four inch wide outside shoulders and a two foot wide concrete barrier centered in a 10-foot wide median. The overall bridge width for this configuration would be 56 feet, 8 inches.

The bridge design would consist of a two-span continuous curved steel plate girder superstructure supported on full-height reinforced concrete cantilever abutments with U-back wingwalls. Structure depth and span lengths would be optimized to provide approximately 16 foot, six inch vertical clearance. The structure is fixed at the pier located in the median of I-89. The overall bridge length between bearings at abutments is 253 feet, 10 inches (128 feet, two inches/125 feet, eight inches). Abutments are situated at the toe of 2:1 slopes and set outside the I-89 clear zone.

#### **Design Issues**

*Superstructure Options:* For all possible bridge configurations, steel plate girders are the only feasible option as the required span lengths are outside the range of rolled beams. Concrete superstructure options would require splice technology and close spacing for the given span configuration. Furthermore, the curved superstructure for the Limited Access Highway option precludes the use of precast concrete girders. Based on these circumstances and existing plans, the proposed bridge would incorporate steel plate girders. This crossing meets the criteria for Grade 50W weathering steel based on the guidelines set forth in the *Vermont Structures Manual*. Girders would be composite with a reinforced concrete deck. The following beam configurations are recommended:

- Limited Access Highway option: Provide six Grade 50W plate girders at nine feet, nine inches spacing, with balanced overhangs of approximately four feet. Overall structure depth would be approximately seven feet.
- Circ Boulevard and Circ Street options: Provide nine Grade 50W plate girders at eight feet, one inch spacing with balanced overhangs of three feet. Overall structure depth would be approximately six and a half feet.

*Substructure Options:* Substructure elements would be aligned parallel to I-89 creating slight bridge skews (ranging from 8 to 15 degrees for the different options). Based on aesthetics and previous design methodology for the project, U-back wingwalls would be used. The curved alignment of the Limited Access Highway option precludes the use of integral abutments. For the Circ Boulevard and Circ Street options, the site does not preclude the use of integral abutments, but the bridge length would approach the maximum integral abutment bridge length of 330 feet as recommended in the *Vermont Structures Manual*. Lengthening the bridge would also require an adjustment to the structure depth and roadway profile. Integral abutments may be further investigated through final design. Boring logs from the existing bridge plans indicate a soil profile suited for spread footings, with adequate depth to bedrock for proper pile fixity if integral abutments are used.

- All options: Provide full-height reinforced concrete cantilever abutments supported on spread footings with U-back wingwalls.

*Bridge Rails:* For all bridge options, standard NETC two-bar box beam rail with snow fence will be utilized.

*Construction Phasing:* Phased construction is not required at this location. Regardless of the selected highway alternative, the new overpass will be constructed in a single phase with minimal impacts to I-89 below.

*Utilities:* Based on existing plans and the latest project information, there are no bridge-mounted utilities anticipated at this location. Bridge-mounted drainage structures may be necessary dependent upon additional analyses. Fascia-mounted sign structures may be required based on VAOT request.

### **Cost Estimation**

Structure costs were estimated based on information gathered from recent bid history in Vermont, with consideration for other regional data. Bridge construction costs for the existing Circ bridges were first updated by assigning current unit prices to the quantity estimates shown in the existing plans. An average cost of \$185 per square foot was established for all stringer-type bridges with cast-in-place concrete decks and typical reinforced concrete substructures based upon the results of the cost study. The square footage of a bridge is estimated as the out-to-out width of

the bridge multiplied by the length of the grade separation (i.e. end of wingwall at Abutment 1 to end-of-wingwall at Abutment 2). See the Structures Study Figures for all cost information.

### **Recommendation**

Limited Access Highway option: The superstructure would consist of two-span continuous curved steel plate girders supported on full-height reinforced concrete cantilever abutments and a reinforced concrete pier located in the median of I-89. The span configuration would provide nearly balanced spans with a total bridge length of 253 feet, ten inches (center-to-center of bearings at abutments). The out-to-out bridge width would be 56 feet, eight inches.

Circ Boulevard and Circ Street options: The superstructure would consist of two-span continuous steel plate girders supported on full-height reinforced concrete cantilever abutments and a reinforced concrete pier located in the median of I-89. The span configuration would provide balanced spans with a total bridge length of 250 (center-to-center of bearings at abutments). The out-to-out bridge width would be 70 feet, eight inches.

### **3.9.6 US 2 Over Circ**

An overpass structure would be required to carry US 2 over the Circ corridor for several of the proposed Circ configurations (alternatives 16a, 16b, and 16c). The current configuration of US 2 in the vicinity of future Circ consists of an at-grade roadway running approximately east-west. The anticipated overpass structure would be a single-span bridge with abutments located outside of the Circ clear zone. Only Limited Access Highway alternatives are considered in this discussion. The Circ Boulevard (Alternative 17) and Circ Street (Alternatives 18, 19, and 23) options propose an at-grade intersection at US 2; therefore no structure study is required for those alternatives. The anticipated structure configuration for the Limited Access Highway alternatives is dependent on the type of interchange at US 2. The following options are evaluated at the US 2/Circ interchange.

Limited Access Highway, No Connection at US 2: In this alternative, US 2 would be carried over Circ with no connection. The configuration of Circ at this location would consist of two 12 foot eastbound lanes, two 12 foot westbound lanes, eight-foot outside shoulders, four-foot inside shoulders, and a 12 foot median. US 2 over Circ would consist of two 12 foot lanes and two eight-foot shoulders. The overall bridge width for this configuration would be 44 feet. The structure would be situated entirely on a crest vertical curve (See Figure 3-12e for more information). This configuration would be identical to the layout proposed in the bridge design effort in 1988. See the discussion on "Existing Plans" below.

Limited Access Highway, Partial Cloverleaf at US 2: In this alternative, there would be a partial cloverleaf interchange at US 2. The configuration of Circ at this location would consist of three 12 foot eastbound lanes, three 12 foot westbound lanes, four foot outside shoulders, four foot inside shoulders, and a 12 foot median. US 2 over Circ would consist of four 12 foot lanes and two six foot shoulders. The overall bridge width for this configuration would be 64 feet. The structure would be situated entirely on a crest vertical curve (See Figure 3-12f for more information). It should be noted that additional pipe/culvert structures would be required to carry the partial cloverleaf ramp structures over Allen Brook for this option.

### **Existing Plans**

Although never constructed, US 2 over Circ was previously designed in 1988 as part of the original Circ Highway design effort. The bridge would carry two 12 foot lanes of opposing traffic and two eight-foot shoulders. The overall bridge width for this configuration would be 44 feet.

The bridge design consists of a single-span steel plate girder superstructure supported on full-height reinforced concrete cantilever abutments with U-back wingwalls. The structure would provide approximately 17 feet vertical clearance over proposed Circ. The length between bearings at abutments is 146 feet. Abutments are situated at the toe of 2:1 slopes and set outside the Circ clear zone.

### **Design Issues**

*Superstructure Options:* For all possible bridge configurations, steel plate girders are the only practicable option as the required span lengths are outside the range of rolled beams. A New England Bulb Tee option would be cost prohibitive due to close beam spacing required to meet the span requirement. Based on these circumstances and existing plans, the proposed bridge would incorporate steel plate girders. This crossing meets the criteria for Grade 50W weathering steel based on the guidelines set forth in the Vermont Structures Manual. Girders would be composite with a reinforced concrete deck. The following beam configurations are recommended:

- No Connection at US 2: Provide five Grade 50W plate girders at nine feet, three inches spacing, with balanced overhangs of three feet, six inches. Overall structure depth would be approximately seven feet, ten inches.
- Partial Cloverleaf at US 2: Provide seven Grade 50W plate girders at nine feet, eight inches spacing with balanced overhangs of three feet. Overall structure depth would be approximately seven feet, ten inches.

*Substructure Options:* Substructure elements would be aligned parallel to future Circ creating a bridge skew of approximately four degrees. Based on aesthetics and previous design methodology for the project, U-back wingwalls would be used. According to subsurface explorations conducted in 1988, the soil profile consists mainly of varying clays and silts. Based on these conditions, a deep foundation would be used at this site. The profile of US 2 over Circ is optimized to provide adequate vertical clearance for span lengths coinciding with the use of full height abutments. During final design, it may be possible to investigate the use of integral abutments situated on laid back slopes; however, the span length would approach 190 feet which would force a deeper structure depth and a profile adjustment for US 2.

All options: Provide full-height reinforced concrete cantilever abutments on pile-supported footings with U-back wingwalls.

*Bridge Rails:* For all bridge options, standard NETC two-bar box beam rail snow fence would be utilized.

*Construction Phasing:* Phased construction would be required in order to maintain traffic on US 2 during construction. Traffic phasing would be as follows:

- Phase I: Construct a temporary at-grade roadway parallel to US 2 in the vicinity of Circ.
- Phase II: Shift traffic to the temporary detour and construct the bridge on the proposed alignment.
- Phase III: Shift traffic onto the new bridge and construct Circ.

*Utilities:* Based on existing plans and the latest project information, there are no bridge-mounted utilities anticipated at this location. Fascia-mounted sign structures may be required based on VAOT request.

### **COST ESTIMATION**

Structure costs were estimated based on information gathered from recent bid history in Vermont, with consideration for other regional data. Bridge construction costs for the existing Circ bridges were first updated by assigning current unit prices to the quantity estimates shown in the existing plans. An average cost of \$185 per square foot was established for all stringer-type bridges with cast-in-place concrete decks and typical reinforced concrete substructures based upon the results of the cost study. The square footage of a bridge is estimated as the out-to-out width of the bridge multiplied by the length of the grade separation (i.e. end of wingwall at Abutment 1 to end-of-wingwall at Abutment 2). See the Structures Study Figures for all cost information.

### **RECOMMENDATION**

No Connection at US 2 (Alternative 16a and 16c): The single-span superstructure would consist of steel plate girders supported on full-height reinforced concrete cantilever abutments. The total bridge length would be 146 feet (center-to-center of bearings at abutments). The out-to-out bridge width would be 44 feet.

Partial Cloverleaf at US 2 (Alternative 16b): The single-span superstructure would consist of steel plate girders supported on full-height reinforced concrete cantilever abutments. The total bridge length would be 150 feet (center-to-center of bearings at abutments). The out-to-out bridge width would be 64 feet.

### **3.9.7 Circ Over Mountain View Road**

Overpass structures would be required to carry Circ Eastbound and Westbound over Mountain View Road for the Limited Access Highway option (Alternatives 16a and 16b). The anticipated overpass structures would be a single-span bridges with abutments located outside of the Mountain View Road clear zone. The configurations of Circ and Mountain View Road are dependent upon the selected interchange option at this location. The following options are evaluated at the Circ/Mountain View Road interchange:

- Limited Access Highway, Trumpet Interchange at Redmond Road (Alternatives 16a and 16b): In this alternative, Circ would be carried over Mountain View Road with no immediate connection at Mountain View Road (See Figure 3-12h for more information). Motorists would transition between Mountain View Road and Circ via the trumpet interchange at Redmond Road. This configuration would be identical to the layout proposed in the bridge design effort in 1988. See the discussion on “EXISTING PLANS” below.
- Limited Access Highway, Diamond Interchange at Mountain View Road (Alternative 16c): In this alternative, Circ would be carried over Mountain View Road as part of a diamond interchange at Mountain View Road (See Figure 3-12i for more information). This option would require a longer crossing due to the additional width requirements for Mountain View Road in the vicinity of the diamond interchange.

### **Existing Plans**

Although never constructed, Circ over Mountain View Road was previously designed in 1988 as part of the original Circ Highway design effort. Circ in the vicinity of Mountain View Road would follow a constant one percent grade, and would be situated entirely on a gentle horizontal curve. Due to the width of the median between the eastbound and westbound roadways, it would be most economical to construct the bridges with an open median. Although two separate superstructures would be constructed, the median is narrow enough to justify the use of continuous abutments. The abutments would be oriented parallel to the alignment of Mountain View Road causing a slight skew angle of less than two degrees. The horizontal alignment of Mountain View Road would follow its existing alignment which is straight in the vicinity of the Circ crossing. The cross section of Mountain View Road would consist of two 12 foot lanes of

opposing traffic, two six foot shoulders, and a ten-foot multi-use path separated from the edge of shoulder by a four-foot buffer zone.

The eastbound and westbound superstructure would each carry three 12 foot lanes and two five feet, four inch wide shoulders, and would consist of a curved cast-in-place concrete deck supported on straight steel plate girders. The two superstructures would share full-height reinforced concrete cantilever abutments with U-back wingwalls. The structure would provide approximately 16 feet, 11 inch vertical clearance over proposed Redmond Road Connector. The length between bearings at abutments would be 92 feet. Abutments are situated at the toe of 2:1 slopes and set outside the clear zone for Mountain View Road.

### **Design Issues**

*Superstructure Options:* The bridge configuration shown in the existing documents for Circ over Mountain View Road would be appropriate for the Circ alternative utilizing a trumpet interchange at Redmond Road Connector. Although the relatively short span length for this option could employ rolled beams or concrete beams, corridor-wide consistency and methodology used in the existing plans would make steel plate girders the recommended superstructure alternative.

For the diamond interchange option (Alternative 16c), the configuration of Mountain View Road would be widened to accommodate the additional turn lanes required for the intersections. The cross section of Mountain View Road under Circ would consist of five 12 foot lanes, two six foot shoulders, and a ten-foot multi-use path separated from the edge of shoulder by a four-foot buffer zone. The length between bearings at abutments would be approximately 125 feet. At this length, rolled beams would not be feasible. Again, corridor-wide structure consistency combined with methodology used in the existing plans would make steel plate girders the recommended superstructure alternative.

This crossing meets the criteria for Grade 50W weathering steel based on the guidelines set forth in the Vermont Structures Manual. Girders would be composite with a reinforced concrete deck. The following beam configurations are recommended:

- Limited Access Highway, Trumpet Interchange at Redmond Road: The eastbound and westbound superstructure would be identical, each consisting of six Grade 50W plate girders at eight feet, ten inch spacing, with variable-width overhangs (approximately three feet, six inch maximum). Overall structure depth would be approximately five feet, four inches.
- Limited Access Highway, Diamond Interchange at Mountain View Road: The eastbound and westbound superstructure would be identical, each consisting of five Grade 50W plate girders at nine feet spacing, with variable-width overhangs (approximately three feet, six inch maximum). Overall structure depth would be approximately five feet, eight inches.

*Substructure Options:* According to subsurface explorations conducted in 1987, the soil profile consists mainly of silty sand and sandy silt. Based on these findings, a shallow foundation would be used at this site. Based on aesthetics and previous design methodology for the project, U-back wingwalls would be used. As mentioned above, the eastbound and westbound superstructures would be supported on shared abutments. Due to the width of the shared abutments, expansion joints would be required to control cracking due to transverse thermal expansion. Although this site would be suited for integral abutments situated on laid back slopes, the transverse expansion joint would complicate the detailing of such a structure.

Provide full-height reinforced concrete cantilever abutments supported on spread footings with U-back wingwalls for both Circ alternatives.

**Bridge Rails:** For all bridge options, standard NETC two-bar box beam rail with snow fence will be utilized.

**Construction Phasing:** Phased construction is not required at this location. The proposed structure would be constructed with minimal impacts to Mountain View Road below.

**Utilities:** Based on existing plans and the latest project information, there are no bridge-mounted utilities anticipated at this location. Fascia-mounted sign structures may be required based on VAOT request.

### **Cost Estimates**

Structure costs were estimated based on information gathered from recent bid history in Vermont, with consideration for other regional data. Bridge construction costs for the existing Circ bridges were first updated by assigning current unit prices to the quantity estimates shown in the existing plans. An average cost of \$185 per square foot was established for all stringer-type bridges with cast-in-place concrete decks and typical reinforced concrete substructures based upon the results of the cost study. The square footage of a bridge is estimated as the out-to-out width of the bridge multiplied by the length of the grade separation (i.e. end of wingwall at Abutment 1 to end-of-wingwall at Abutment 2). See the Structures Study Figures for all cost information.

### **Recommendations**

Limited Access Highway, Trumpet Interchange at Redmond Road (Alternatives 16a and 16b): The eastbound and westbound superstructure would each consist of a curved cast-in-place concrete deck supported on straight steel plate girders. The two single-span superstructures would share full-height reinforced concrete cantilever abutments on spread footings with U-back wingwalls. The total bridge length would be 92 feet (center-to-center of bearings at abutments, measured along the construction chord). The eastbound and westbound superstructure would each have an out-to-out deck width of 50 feet, eight inches.

Limited Access Highway, Diamond Interchange at Mountain View Road (Alternative 16c): The eastbound and westbound superstructure would each consist of a curved cast-in-place concrete deck supported on straight steel plate girders. The two single-span superstructures would share full-height reinforced concrete cantilever abutments on spread footings with U-back wingwalls. The total bridge length would be 125 feet (center-to-center of bearings at abutments, measured along the construction chord). The eastbound and westbound superstructure would each have an out-to-out deck width of 42 feet, eight inches.

### **3.9.8 Circ over Redmond Road Connector**

Overpass structures would be required to carry Circ Eastbound and Westbound over Redmond Road Connector for the Limited Access Highway option utilizing a trumpet interchange at Redmond Road (Alternatives 16a and 16b). The anticipated overpass structures would be a single-span bridge with abutments located outside of the Redmond Road Connector clear zone.

Limited Access Highway, Trumpet Interchange at Redmond Road (Alternatives 16a and 16b). : In this alternative, Circ would be carried over Redmond Road connector (See Structures Study Figure 3-12h for more information). This configuration would be identical to the layout proposed in the bridge design effort in 1988. See the discussion on “Existing Plans” below.

### **Existing Plans**

Although never constructed, Circ over Redmond Road Connector was previously designed in 1988 as part of the original Circ Highway design effort. Circ in the vicinity of Redmond Road

Connector would follow a constant one percent grade, and would be situated entirely on a gentle horizontal curve. Due to the width of the median between the eastbound and westbound roadways, it would be most economical to construct the bridges with an open median. Although two separate superstructures would be constructed, the median is narrow enough to justify the use of shared abutments. The abutments would be oriented tangential to the alignment of Redmond Road Connector causing a skew angle of approximately 26 degrees. The horizontal alignment of Redmond Road Connector would be sharply curved at this location. The cross section of Redmond Road Connector would consist of two 16 foot lanes of opposing traffic, two four foot inside and outside shoulders, and a 16 foot median.

The eastbound and westbound superstructure would each consist of a curved cast-in-place concrete deck supported on straight steel plate girders. The eastbound superstructure would carry two 12 foot wide lanes, a five feet, four inch wide inside shoulder, and a nine foot, four inch wide outside shoulder. The westbound superstructure would carry three 12 foot lanes and two five foot, four inches wide shoulders. The overall deck widths for this configuration would be 42 feet, eight inches and 50 foot, eight inches for eastbound and westbound respectively. The two superstructures would share full-height reinforced concrete cantilever abutments with U-back wingwalls. The structure would provide approximately 16 feet, five inches vertical clearance over proposed Redmond Road Connector. The length between bearings at abutments is 140 feet. Abutments are situated at the toe of 2:1 slopes and set outside the clear zone for Redmond Connector Road.

### **Design Issues**

*Superstructure Options:* For all possible bridge configurations, steel plate girders would be the recommended girder type as the required span lengths are outside the range of rolled beams. A New England Bulb Tee option would be cost prohibitive due to close beam spacing required for the span length. Based on these circumstances and existing plans, the proposed bridge would incorporate steel plate girders. This crossing meets the criteria for Grade 50W weathering steel based on the guidelines set forth in the Vermont Structures Manual. Girders would be composite with a reinforced concrete deck. The following beam configurations are recommended:

Circ Eastbound superstructure: Provide five Grade 50W plate girders at 9 feet spacing, with variable-width overhangs (approximately three feet, six inches maximum). Circ Westbound superstructure: Provide six Grade 50W plate girders at eight feet, ten inch spacing, with variable-width overhangs (approximately three feet, six inches maximum). Overall structure depth would be approximately seven feet, nine inches.

*Substructure Options:* As mentioned above, the eastbound and westbound superstructures would be supported on shared abutments. Due to the width of the shared abutments, expansion joints would be required to control cracking due to transverse thermal expansion. Although this site would be suited for integral abutments situated on laid back slopes, the transverse expansion joint would complicate the detailing of such a structure. Substructure elements would be aligned tangential to future Redmond Road Connector creating a bridge skew of approximately 26 degrees, precluding the use of integral abutments according the Vermont Structures Manual. Based on aesthetics and previous design methodology for the project, U-back wingwalls would be used. According to subsurface explorations conducted in 1987, the soil profile consists mainly of silty sand and sandy silt. Based on these findings, a shallow foundation would be used at this site.

Provide full-height reinforced concrete cantilever abutments supported on spread footings with U-back wingwalls.

**Bridge Rails:** For all bridge options, standard NETC two-bar box beam rail with snow fence will be utilized.

**Construction Phasing:** Phased construction is not required at this location. Circ and Redmond Road Connector would both be constructed without live traffic.

**Utilities:** Based on existing plans and the latest project information, there are no bridge-mounted utilities anticipated at this location. Fascia-mounted sign structures may be required based on VAOT request.

### **Cost Estimation**

Structure costs were estimated based on information gathered from recent bid history in Vermont, with consideration for other regional data. Bridge construction costs for the existing Circ bridges were first updated by assigning current unit prices to the quantity estimates shown in the existing plans. An average cost of \$185 per square foot was established for all stringer-type bridges with cast-in-place concrete decks and typical reinforced concrete substructures based upon the results of the cost study. The square footage of a bridge is estimated as the out-to-out width of the bridge multiplied by the length of the grade separation (i.e. end of wingwall at Abutment 1 to end-of-wingwall at Abutment 2). See the Structures Study Figures for all cost information.

### **Recommendation**

Limited Access Highway, Trumpet Interchange at Redmond Road (Alternatives 16a and 16b): The eastbound and westbound superstructure would each consist of a curved cast-in-place concrete deck supported on straight steel plate girders. The two single-span superstructures would share full-height reinforced concrete cantilever abutments with U-back wingwalls. The total bridge length would be 140'-0" (center-to-center of bearings at abutments, measured along the construction chord). The overall deck widths for this configuration would be 42'-8" and 50'-8" for eastbound and westbound respectively.

### **3.9.9 Circ over Redmond Creek and Wildlife Corridor**

Circ Segment B, which would continue from Mountain View Road to VT 289, crosses Redmond Creek approximately 2000 feet south of the Winooski River. The preferred lane configuration for both the Limited Access and Boulevard options are identical in this location with two lanes in each direction. Smaller shoulders and narrower median would make the Boulevard option approximately 16 feet narrower at this location. A structure is required at this location to provide an adequate hydraulic opening for Redmond Creek, and to provide a crossing location for wildlife. The anticipated structure type is dependent on the requirements of the wildlife corridor as outlined below and would be a concrete box structure or a bridge structure.

### **Existing Plans**

Plans previously produced for the VTrans in 1988 and updated in 2003 identify a 72 inch diameter corrugated galvanized steel plate pipe at this location. The total pipe length was based on a limited access configuration of Circ B with two-to-one fill slopes at the crossing location. The total pipe length was identified at 302 feet with straight cast-in-place gravity headwalls. No provisions for a wildlife corridor were included with the aforementioned design.

### **Design Issues**

**Wildlife Corridor:** At the direction of the VTrans, provisions for a wildlife corridor will be included at this crossing. The VTrans *Structures Design Manual* outlines the requirements for cattle pass structures as a 96 inch diameter corrugated aluminum arch plate pipe with a paved invert. Since the crossing is intended for both water and wildlife. The minimum recommended width of the

wildlife corridor would be ten feet, located on the north side of Redmond Creek. With allowances for the wildlife corridor and the stream, the total recommended clear width for the structure is 14 feet.

*Riparian Corridor:* A wildlife biological review conducted for the Circ identified Redmond Creek as a potential amphibious animal habitat. Based on the soil type of the creek bed, the minimum recommended undisturbed natural bottom width would be 50 feet with a preferred width of 100 feet. This undisturbed width requirement precludes the use of a buried structure. The creek width at the crossing is approximately 13 feet, allowing flexibility in location of the designated wildlife corridor.

*Hydraulics:* The previously proposed culvert was sized based on the 50-year design flood and provided a hydraulic opening of approximately 28.3 square feet. It is expected the dimensional requirements of the wildlife corridor would control the design and provide a minimum cross sectional area in the range of 200 square feet, likely adequate for the 100-year design flood.

### **Structure Options**

For both Limited Access and Boulevard options, the Circ profile grade line is approximately 60 feet above existing ground at the crossing, requiring large embankment fill sections with 2:1 side slopes. A buried structure (concrete box option) length is dependent on roadway width, side slopes and depth the structure is buried. Similarly, the elevation difference between existing ground and the Circ profile grade has an impact on span length. Bridge options at this location would be stub abutments on piles due to the depth of fill. To minimize span length, embankment slopes below the structure would be 1.5:1 and protected by stone rip-rap. Three structure options are provided based on dimensional criteria for the wildlife and/or riparian corridor and hydraulic criteria of the waterway. For bridge options, standard NETC two-bar box beam rail would be utilized. Construction phasing and traffic control would not be required for this crossing since no live traffic is present at this time. Box culvert options would tie into the creek at the inlets and outlets, requiring water diversion structures. Bridge options would not require water diversion structures as the structure does not interfere with Redmond Creek.

#### **Wildlife Corridor - Concrete Box Option (Figure 3-12j)**

Roadway width and depth of fill above the structure resulted in a culvert length of 260 feet. A 10 foot wide wildlife corridor is provided on a natural material shelf above Redmond Creek. A clear height of 12 feet is provided. Cast-in-place construction is identified for this structure due to its physical size and weight.

#### **Wildlife Corridor - Bridge Structure (Figure 3-12k)**

The span length for this bridge option is 158 feet, and was determined utilizing by the 25 foot approximate width provided for Redmond Creek and the wildlife corridor, and extending 1.5:1 side slopes up to proposed grade. For all possible bridge configurations, the total bridge width is 49 feet, ten inches. At this span length, steel plate girders are the only practicable option as they exceed the range of rolled beams. A New England Bulb Tee option would be cost prohibitive due to close beam spacing required to meet the span requirement. Based on these criteria, seven plate girders with a spacing of seven feet, three inches would be required. Openness ratios do not apply to this option.

Substructure elements would be aligned parallel to Redmond Creek creating a bridge skew of approximately 10 degrees. The depth of embankment at the site precludes the use of cantilever abutments and spread footings on soil. Stub abutments on piles would be the

recommended substructure type for this bridge, due to the irregularity of embankment fill materials.

#### **Riparian Corridor - Bridge Structure (Figure 3-12I)**

The span length for this bridge option is 177 feet, and was determined utilizing the 50 foot width provided for Redmond Creek and the riparian corridor, and extending 1.5:1 side slopes up to proposed grade. For all possible bridge configurations the total bridge width is 49 feet, ten inches. At this span length, steel plate girders are the only practicable option as they are outside the range of rolled beam and New England Bulb Tee options. Based on these criteria, six plate girders with a spacing of eight feet, nine inches would be required.

Similar to the wildlife corridor option, substructure elements would be aligned parallel to Redmond Creek creating a bridge skew of approximately 10 degrees. Also similar to the wildlife corridor option, stub abutments on piles would be the recommended substructure type for this bridge.

#### **Cost Estimation**

Structure costs were estimated based on information gathered from recent bid history in Vermont, with consideration for other regional data. Bridge construction costs for the existing Circ bridges were first updated by assigning current unit prices to the quantity estimates shown in the existing plans. An average cost of \$185 per square foot was established for all stringer-type bridges with cast-in-place concrete decks and typical reinforced concrete substructures based upon the results of the cost study. The square footage of a bridge is estimated as the out-to-out width of the bridge multiplied by the length of the grade separation (i.e. end of wingwall at Abutment 1 to end-of-wingwall at Abutment 2). See the Structures Study Figures in Volume II for all cost information.

#### **Recommendation**

The Wildlife Corridor Concrete Box Option – A concrete box can be constructed with adequate openness ratio to meet the wildlife corridor requirements. The box culvert will be a significant upgrade over the original design in terms of reduced length and increased hydraulic capacity. The box culvert will have both lower initial cost and lower long-term maintenance cost.

### **3.9.10 Circ over Winooski River, VT 117, and Central Vermont Railroad**

Existing VT 289 ends at the intersection with VT 117, at north bank of the Winooski River. A structure would be required at this location to carry Circ Segment B over the Winooski River, VT 117, and Central Vermont Railroad. The preferred lane configuration for both the Limited Access and Boulevard options are similar in this location. Eastbound and westbound traffic would each be carried on a section consisting of two 12 foot travel lanes in each direction. The Boulevard option (Alternative 17) would have reduced width shoulders, resulting in a narrower width cross section on the bridge structure.

#### **Existing Plans**

Although never constructed, Circ over Winooski River was previously designed in 1988 as part of the original Circ Highway design effort. The bridge was designed as the first barrel of a divided highway. The structure would carry two 11 foot lanes of opposing traffic, an 11 foot acceleration lane for eastbound traffic, and 11 foot deceleration lane for westbound traffic, and two two foot shoulders. The plans proposed a single bridge with an out-to-out deck width of 52 feet.

The bridge design consists of a five-span continuous steel plate girder superstructure supported on mid-height reinforced concrete cantilever abutments with U-back wingwalls supported on spread footings. Intermediate piers consist of reinforced concrete two-column bents. The

proposed span configuration would provide span lengths of 145 feet-185 feet-220 feet-185 feet-145 feet. Pier 1, 2, and 3, located within flooded area for the 100 year event, would be supported on drilled shafts, while Pier 4 would be supported on a spread footing. The structure would provide approximately 16 feet, 4 inches vertical clearance over VT 117, and approximately 24 feet over Central Vermont Railroad.

Traffic volume data determined during this EIS indicates that this bridge structure will require a full four lanes of traffic for the 2030 design conditions. Rather than reducing the lane widths and eliminating the median between the two travel directions, it is recommended that the two structures be included for both Alternatives 16 and 17 (see Figure 3-12m).

### **Design Issues**

*Superstructure Options:* Steel plate girders are the only feasible option based on the length of the crossing and the desire to minimize the number of piers situated in the river. Concrete superstructure options would require splice technology and close spacing for the given span configuration. Based on these circumstances and existing plans, the proposed bridge would incorporate steel plate girders. This crossing meets the criteria for Grade 50W weathering steel based on the guidelines set forth in the Vermont Structures Manual. Girders would be composite with a reinforced concrete deck. The following beam configuration is recommended:

*Eastbound Bridge:* Provide six Grade 50W plate girders at seven feet, four inch spacing, with balanced overhangs of three feet. Out-to-out bridge width would be 42 feet, eight inches. Overall structure depth would be approximately seven feet, six inches.

*Westbound Bridge:* Identical to Eastbound Bridge.

*Substructure Options:* Substructure elements would be aligned approximately parallel to Winooski River and VT 117 creating a skew of approximately 15 degrees. Based on aesthetics and previous design methodology for the project, U-back wingwalls would be used. The bridge length precludes the use of integral abutments (maximum length is 330 feet as recommended in the Structures Manual). The boring logs from the subsurface exploration conducted in 1986 indicate primarily silty sand and till over bedrock. As recommended in the previous design plans, the river piers (Piers 1, 2, and 3) would be supported on drilled shaft foundations. Drilled shafts are appropriate to reduce scour susceptibility and support the high loads associated with long interior spans. Elsewhere, spread footings are recommended.

Provide mid-height reinforced concrete cantilever abutments supported on spread footings with U-back wingwalls. Provide two-column reinforced concrete piers with drilled shaft foundations at Piers 1, 2, and 3, and a spread footing at Pier 4.

*Bridge Rails:* Standard NETC two-bar box beam rail with snow fence will be utilized.

*Construction Phasing:* Phased construction is not required at this location.

*Utilities:* Based on existing plans and the latest project information, there are no bridge-mounted utilities anticipated at this location. Due to the structure length, bridge-mounted drainage structures may be necessary. Fascia-mounted sign structures for signage on VT 117 may be required based on VAOT request.

### **Cost Estimation**

Structure costs were estimated based on information gathered from recent bid history in Vermont, with consideration for other regional data. Bridge construction costs for the existing Circ bridges were first updated by assigning current unit prices to the quantity estimates shown in the existing plans. An average cost of \$185 per square foot was established for all stringer-type bridges with cast-in-place concrete decks and typical reinforced concrete substructures based upon the results of the cost study. The square footage of a bridge is estimated as the out-to-out width of the bridge multiplied by the length of the grade separation (i.e. end of wingwall at Abutment 1 to end-of-wingwall at Abutment 2). See the Structures Study Figures for all cost information.

### **Recommendation**

The eastbound and westbound superstructures would each consist of a cast-in-place reinforced concrete deck supported on straight steel plate girders utilizing Grade 50W structural steel. The twin five-span superstructures would share mid-height reinforced concrete cantilever abutments on spread footings with U-back wingwalls. The intermediate piers would consist of adjacent two-column reinforced concrete piers with drilled shaft foundations at Piers 1, 2, and 3, and a spread footing at Pier 4. The total bridge length would be 880 feet (center-to-center of bearings at abutments). The eastbound and westbound superstructures would each have an out-to-out deck width of 42 feet, eight inches, consisting of six girders spaced at seven feet, four inches with symmetric three foot overhangs.

## **3.10 Construction Staging**

### **3.10.1 VT 2A Corridor**

Due to the very heavy traffic volumes, the narrow roadway width, the limited Right-of-Way and the proximity of existing buildings, construction along the VT 2A corridor will require significant coordination with all involved parties to minimize the impacts of the project. The need to maintain safe work areas for construction personnel and equipment while also providing traffic flow for through traffic and local access for the businesses and residences will require staged construction operations that will lengthen the required construction period and increase the cost of the reconstruction.

The reconstruction of VT 2A will present an opportunity to provide an adequate and uniform pavement structure to this important arterial. Portions of the road were constructed many years ago and do not provide adequate pavement and base materials to meet the requirement of current and future traffic loads. In addition, widening and utility work has been completed over the years, leading to different base conditions in various portions of the roadway. Therefore, full-depth reconstruction of the roadway is planned. This will require removal of all existing pavement and base and sub-base materials and placement of free-draining gravels and a uniform thickness of bituminous concrete pavement. As described in Section 3.8, deficient utility systems also will be upgraded as part of the construction.

The widening of VT 2A is planned to be centered on the existing centerline of the roadway, with equal widening on each side. One notable exception to this alignment is in the vicinity of Morse Cemetery, where a shift in the alignment to the east is required to avoid impacts to the cemetery. Another exception is at the Winooski River crossing, where the widening will take place only on the west side of the existing bridge to limit the area of impact to the resource area and to reduce construction cost. The existing profile of VT 2A will be generally maintained in order to minimize issues with matching the existing grade at the many access drives and to minimize utility relocation problems.

The construction sequencing and staging will be established during the final design process for the selected alternative with input from town officials, abutting property interests, and utility agencies. Generally, widening would take place on one side, then traffic detoured onto that side while widening and construction is completed on the other side. Due to the heavy traffic volumes during the day, some construction work such as cross-trenching for drainage lines and other utilities would require night-time operations.

Staged construction would also be necessary for the reconstruction of the three bridges on the VT 2A corridor at I-89, Allen Brook, and over the Winooski River. The construction sequencing for these structures is described in Section 3.9.

### **3.10.2 Circ Corridor – Alternatives 16a, 16b, and 16c**

Since the Circ A/B corridor is to be constructed on new alignment, the need for staged construction and the disruption to existing traffic flow will be significantly less than for the VT 2A corridor improvements. The main segments of the Circ roadway can be constructed without interference to existing traffic flow except at the crossing of existing roadways such as US 2 and Mountain View Road.

It is anticipated that the Circ roadway would be constructed in two stages, with the southerly portion (Circ A) from I-89 to Redmond Road beginning first, and the northern portion (Circ B), including the Winooski River bridge beginning second, with both segments to be completed at the same time.

At the interchange of the Circ roadway and I-89, a temporary detour for I-89 traffic is planned to permit the construction of the new bridge structure over I-89. Prior to the bridge installation, a 2300 foot long temporary detour road would be constructed for northbound I-89 traffic to travel around the construction zone. This detour road would be removed after the bridge is completed.

At US 2, the Circ would be constructed close to the existing ground elevation and US 2 would be constructed over the Circ A/B roadway. This would require the construction of a structure over the Circ with filled approaches on US 2. Since the alignment of US 2 will be close to the existing alignment, a temporary detour is planned for US 2 traffic flow. An 1800 foot long temporary detour road would be constructed to the north of the existing US 2 alignment, the traffic flow diverted to the detour, and the new overpass and filled approaches constructed. The traffic flow on US 2 would be re-directed onto the new overpass and the temporary detour road removed.

The existing multi-use path near Allen Brook School would be raised on an overpass over the Circ. The alignment at the crossing over the Circ would be along the existing alignment. In order to maintain the usage of the multi-use path during the construction of the overpass, a temporary detour would be constructed to the north of the existing path alignment. After the overpass is completed, the new path would be opened for use and the temporary detour removed. Construction of the overpass early in the construction sequence for the Circ project would allow continued use of the path during the construction of the Circ itself.

The Circ roadway would also be constructed with new structures over Mountain View Road and VT 117. Both of these structures can be constructed with minimal disruptions to the traffic flow on these cross streets.

### **3.10.3 Circ A/B Corridor – Alternative 17**

For the Boulevard alternative (Alternative 17), construction staging for the interchange at I-89 would be similar to the staging for Alternatives 16a, a6b, and 16c as described above, with a temporary detour roadway for northbound I-89 traffic. At US 2, there would be an at-grade intersection, and therefore the temporary detour of US 2 would not be required. Widening of US 2 to accommodate the additional lanes required for the signalized intersection would be accomplished by standard roadway widening techniques, with widening of one side, re-directing traffic onto the new widened surface to facilitate widening on the other side. The multi-use path would pass over the Circ Boulevard, and the construction staging could proceed similar to the sequence described for Alternative 16 above.

At the intersection of Mountain View Road, the Circ Boulevard will intersect with Mountain View Road with an at-grade intersection. Roadway widening would be required for Mountain View Road and would be accomplished by standard roadway widening techniques.

#### **3.10.4 Circ Corridor – Alternatives 18, 19, and 23**

For Alternatives 18, 19, and 23, construction at I-89, at US 2, and at Mountain View Road would be similar to Alternative 17, except the Circ Street would terminate at Mountain View Road. For these alternatives, the multi-use path would cross the Circ Street at-grade, and therefore a temporary detour of the path would not be necessary since the existing profile of the path would be maintained.