Construction of Stabilized Grass Pull-Offs Using Geo-Technology Along the Gatlinburg Spur

Project PRA-FOOT 15A31
Great Smoky Mountains National Park
Foothills Parkway

Typical pre-construction pull-off on Gatlinburg Spur.

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BACKGROUND

The Gatlinburg Spur of the Foothills Parkway is a section of US 441 and US 321 that runs between the cities of Gatlinburg and Pigeon Forge, Tennessee. This section of US 441/321 is owned, regulated, and maintained by the National Park Service. The Gatlinburg Spur has no paved and very narrow grass shoulders. Grass shoulders are the standard design for park service roads and parkways for aesthetics and to minimize the impact of the roadway footprint on the environment. However, the Spur Road is not a typical park road because of the large volume of high-speed traffic generated by the tourist towns at either end. Because of the combination of high volumes of traffic, excessive speeds, changes in geometric configuration, and tourists unfamiliar with the roadway, the number of accidents in the area is high. When accidents occur along the Gatlinburg Spur Road there are very few areas where motorists can safely pull off the roadway until help arrives. Further, park rangers working these accidents have trouble finding areas to safely pull off the roadway. More common is the problem of pulling back onto the roadway once they become stuck in the mud of a soft soil shoulder. As a result, the National Park Service requested that the Eastern Federal Lands Highway Division (EFLHD) of the Federal Highway Administration (FHWA) design and construct a project to provide for safe and stable pull-off areas to be used by accident victims and park rangers.

SUBJECT PROJECT

The project designed by EFLHD involved construction of eight soil stabilized pull-off areas along the Gatlinburg Spur. The sites were designated by the National Park Service and were located in areas prone to re-occurring traffic accidents. They were typically at the beginning or end of a horizontal curve or near some feature restricting the shy zone (the space from the edge of the travel lane to the nearest impactable object). The pull-offs were spaced along the length of the Spur with four located on the northbound side and four located along the southbound side. The East Prong of the Little Pigeon River physically separates the northbound and southbound lanes of the Spur Road.

The typical configuration of all eight pull-offs was the same. They were approximately 70 feet long with a 30-foot taper on the approach, a 20-foot full width area, and a 20-foot taper on the exit end. The full width was approximately 13 foot. The pull-offs are only capable of holding two cars at most. The intent was to create a safe pull-off for emergency use and not to create a permanent parking area to be utilized by tourist and fishermen. The typical cross-section was an eight-inch deep inlay of a particular stabilization system on a 2% cross slope or on the grade of the adjacent travel lane. Several areas required fill to achieve the required grades.

Each area utilized a different stabilization method as an experiment to determine the best practice for future projects. All eight areas received a woven geotextile fabric on subgrade for separation. Backfill consisted of an aggregate-topsoil mixture. A combination of geocells, geoblocks, ring and grid, and/or fiberglass grids was used for stabilization. The pull-offs were then seeded for turf establishment to make them blend into the environment. The intent was to conceal their presence from the general public to prevent them from becoming parking areas.

STABILIZATION TECHNIQUES

Pull-Off Number One

Pull-off number one was used as a control lot (See Appendix B, Page 16). The area was excavated 8-inches deep and a separation geotextile was placed on subgrade. As specified in the *Special Contract Requirements for Project PRA-FOOT 15A31*[1], an engineered aggregate-topsoil (EAT) mixture was used to fill the initial 6-inch depth of the pull-off. Engineered aggregate-topsoil consists of a mixture of topsoil and AASHTO #57 stone. The #57 stone is added at 70% and the topsoil at 30% plus or minus 5% each. The intent of the larger stone content was to provide greater stability by means of intimate stone on stone contact. Just enough soil was added to fill the voids and allow for deep plant root establishment. Figure 1 shows the general size and shape of the pull-off at the top of the engineered aggregate-topsoil course.

An aggregate-topsoil mixture was used for the last 2-inchs of backfill as specified in the *Standard Specification for Roads and Bridges on Federal Highway Projects, FP-96*[2]. Aggregate-topsoil is a standard shoulder material for construction of park roads and parkways. It is a mixture of 50% topsoil and 50% AASHTO #57 stone plus or minus 10% respectively. The stone provides for stability and drainage in the mix. The topsoil is used as a binder for the open graded stone and a growing media for turf. This is the typical mix used for shoulders on all new projects and reconstruction projects designed by EFLHD. The aggregate-topsoil was then seeded for turf establishment to complete pull-off number one.

Figure 1. Pull-off number one used as the control lot.

Pull-Off Number Two

As with pull-off one, pull-off two was cut and filled to planned subgrade and a separation geotextile was placed. Pull-off number two required a perforated geosynthetic cellular confinement system or geocell as the base stabilizer (See Appendix B, Page 17). Geoweb by Presto Products Company was used for this project. As outlined in their website publication, *Geoweb Cellular Confinement System V-Series Material Specification*[3], Geoweb is produced from polyethylene and stabilized with carbon black to protect against ultraviolet (UV) degradation. The material is formed from strips of fabric, 6-inch wide for this application, and sown together to produce a honeycomb structure. Geoweb is delivered flat and is expanded by hand in accordion fashion to produce cells of desired dimension based on the application.

As shown in Figure 2 the Geoweb was expanded and cut to the desired shape. Once pinned in place, the Geoweb was then backfilled with engineered aggregate-topsoil. The remaining two inches were backfilled to grade with aggregate-topsoil and seeded for turf establishment.

Figure 2. Geoweb placement and backfill with engineered aggregate-topsoil.

Pull-Off Numbers Three and Four

Construction of pull-off three and four required the use of a porous cellular block panel or geoblock as the upper course (See Appendix B, Pages 18 and 19). The product chosen was also manufactured by Presto Products Company. As outlined in their website publication, *Geoblock System*[4], Geoblock is produced from recycled polyethylene and UV stabilized by carbon black to protect against ultraviolet degradation. As shown in Figure 3, the geoblocks are approximately 1.5 feet by 3 feet in area with a depth of 2 inches. They are molded into 3 inch by 3-inch cells with a 2-inch through hole in the bottom. The blocks are screwed together through tabs molded to the sides to cover the work area. The blocks are then cut to form the desired shape of the pull-off as shown in Figure 4.

Figure 3. Porous cellular block panels (geoblocks) placed in pull-offs #3 and #4.

Figure 4. Geoblock installed and cut to fit the pull-off at PA #3.

Pull-off number four used a 6-inch depth of engineered aggregate-topsoil on top of the separation geotextile as a base course for the geoblock. The 6-inch EAT was also used in pull-off number 3 but it was placed in the 6-inch deep geocell system. The geoblock itself was then backfilled with 2-inches of aggregate-topsoil to conceal the geoblock and to provide for turf establishment. Both areas were then completed with an application of seed and fertilizer.

Pull-Off Numbers Five and Six

The next product used was a porous synthetic ring and grid system. Grasspave[2] produced by Invisible Structures, Incorporated was the product used (See Appendix B, Pages 20 and 21). In the *Grasspave*[2][5] publication it is reported that the ring and grid is produced from high density polyethylene and UV stabilized with a small percentage of carbon black. This product is delivered in 3-foot wide strips up to 30 feet long, typically. However, other larger sizes can be delivered for specific projects.

The ring is a 2-inch diameter pipe section 1-inch in height. The rings are held together by the grid to form Grasspave[2] as shown in Figure 5. The system is flexible enough that it can be rolled for delivery. Once delivered the typical sized pieces are easily snapped together to the desired size. The ring and grid is then cut to the required dimension.

Figure 5. The ring and grid is shown here after being snapped together at the joints.

The ring and grid was backfilled with AASHTO #89 stone as shown in Figure 6 and covered with aggregate-topsoil for turf establishment. As with the geoblock, the ring and grid was placed on 6 inches of EAT placed on separation geotextile. Pull-off six also utilized the 6-inch deep geocell while pull-off five did not.

a. Typical size of delivered product.

b. Ring and grid installed and cut to shape.

c. Backfill consisting of AASHTO #89 stone.

d. Aggregate-topsoil cover for turf establishment.

Figure 6. Ring and grid installation.

Pull-Off Numbers Seven and Eight

The last two pull-offs were stabilized using a fiberglass grating system (See Appendix B, Pages 22 and 23). Gridwalk manufactured by American Grating, LLC was the chosen product. As published in their report, *Gridwalk High Strength Molded Grating*[6] the grids can be produced from vinylester, polyester, ortho or phenolic resins based on the intended application. Vinylester was utilized for this particular application. The typical grid is produced in 4-foot by 12-foot sheets at 1-inch depth as shown in Figure 7. This product can be produced in various colors as needed.

Figure 7. The fiberglass grates for this project were one-inch deep and were delivered in 4' x 10' sheets. The panels for this project were pre-cut to the shape of the parking areas.

As recommended by the manufacturer, the grid was placed over a galvanized weld-wire fabric. A bed of AASHTO #89 stone was used to achieve fine grade for the grate and also to backfill the grate once placed. The grate sheets were fastened together with metal clips as they were set in place. After backfilling, the fiberglass grid was covered with 1-inch of aggregate-topsoil for turf establishment. Pull-off seven used a 6-inch depth of EAT as the base course. Pull-off eight also used the EAT but confined it with the 6-inch deep geocell for added stability. As was done in the other lots the system was then seeded and fertilized.

a. Pre-cut fiberglass grating system.

b. Grate placed on weld wire fabric and #89 stone.

c. Aggregate-topsoil covering grating system.

Figure 8. Installation of fiberglass grating system.

CONSTRUCTABILITY ISSUES

All of the methods other than the control lot were labor intensive. Systems with multiple components took longer to assemble. The size of the component materials effect production as well. Materials used for the control lot, (separation geotextile, EAT, aggregate-topsoil, and turf) were used in all the systems and are considered the basic components for this investigation. Following are some of the pros and cons of constructing each of the individual systems.

The geoweb was used in four of the systems as a base course stabilizer for the EAT. The geoweb was delivered in reasonably sized sections that could be handled by one person. It was fairly easy to place. Attachment of adjacent pieces was tedious and required a special stapler that was supplied by the manufacturer. Some effort was needed to stretch and pin the Geoweb in place for backfill. Backfilling was the most difficult part of the installation because the fabric of the web is easily overturned. Hand shoveling was required to properly backfill the web and could be overwhelming on a large project. However, once in place, properly backfilled, and compacted the Geoweb provided a stable base course.

The geoblocks used in two of the lots were easy to handle and place. Preparing the beds by cutting or filling to grade was the most difficult chore. Because the blocks are rigid the bed must be uniform to ensure continuous support for each geoblock panel. The use of the #89 stone as used for the other systems would have made the task easier. Connecting the geoblocks together was time consuming because of the degree of accuracy needed on the bed to mesh the block joints. Once in place, backfilling was easy and required only minimal raking and shoveling following placement by the backhoe.

The ring and grid was probably the easiest surface course system to place. The rolls were light and easy to handle. One person can place this system quickly. The flexibility of the ring and grid negated the need to fine grade the bed to the degree of the other systems. Once down the adjacent panels were easily snapped together by hand. Backfilling with the #89 stone was quick since the stone could be swept into place using a push broom. Covering the system with the aggregate-topsoil was similar to the other systems.

Finally, the fiberglass grate was similar to the geoblock when comparing the bedding requirements. However the grate bed was constructed of #89 stone which expedited bed construction. The grid was very rigid and in relatively large sheets requiring at least two people for placement. The addition of the welded wire fabric added to the time to construct as well. The use of the wire may have been excessive for this application. Attachment of adjacent panels was fairly easy and because of the large size of the panels fastener spacing can be increased. Backfill and cover was done just like with the ring and grid. The #89 stone was used for backfill while aggregate-topsoil was used as the cover. The biggest drawback with the fiberglass grating was with availability. This product was manufactured and shipped from California and required a long lead-time for delivery.

RECOMMENDATIONS

All of the systems appear to be viable. It would be fair to say that each has its place depending upon the desired application. Even the control lot would be sufficient for improving shoulder stability for most park service roads. However, the addition of one or more of the above systems may be warranted on high speed, high volume roads similar to the Gatlinburg Spur. For ease and speed of construction the ring and grid would be the logical choice followed by the geoweb, fiberglass grate and geoblock systems. A more in depth study is needed to determine strength and stability of each system.

Each of the systems appears to be functioning as intended for this project. As seen in Figure 9, the turf-covered pull-offs blend in well with their environment. All of the lots produced an acceptable stand of grass even though some utilized the clean #89 stone for backfill. Aesthetically pleasing, environmentally sensitive solutions are critical when constructing features for the National Park Service. Costs of each system can be found in Appendix A. Given the cost, construction requirements, and intended application the proper system can be chosen. As a result, it is recommended that one or more of these systems be tried when soil stabilization in an environmentally sensitive situation is required. Each system has its own strengths and weaknesses. Therefore, all of the systems warrant consideration for future use.

Figure 9. Typical completed parking area with turf established. Parking area #1 pictured. Parking areas blend well with the environment as can be seen when compared to pre-construction photo shown above.

REFERENCES

1. U S Department of Transportation, *Federal Highway Administration*, *Eastern Federal Lands Highway Division, Special Contract Requirements for Project PRA-FOOT*, Contract No. DTFH71-04-C-00009, Sterling, VA, July 27, 2004, J-19 thru J-40 pp.

2. U S Department of Transportation, *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects FP-96*, Federal Highway Administration, Washington, DC, 1996, 213-215 pp.

3. Presto Products Company, "Geoweb Cellular Confinement System V-Series Material Specification," World Wide Web, http://www.prestogeo.com/, May 13, 2003, 1-16 pp.

4. Presto Products Company, "Geoblock System," World Wide Web, http://www.prestogeo.com/, October 21, 2003, 1-16 pp.

5. Invisible Structures, Inc., "Grasspave^2," World Wide Web, http://www.invisiblestructures.com/, 1998, 1-17 pp.

6. American Grating, LLC, "Gridwalk High Strength Molded Grating," World Wide Web, http://www.amgrating.com/, January 2000, 1-7 pp.

APPENDIX A. UNIT COST FOR STABILIZED PULL-OFF SYSTEMS

Item Description	Pull-Off	Unit	Cost
Engineered Aggregate-Topsoil (EAT)	1	SQYD	$40.00
Perforated Geosynthetic Cellular Confinement	2	SQYD	$67.00
Porous Cellular Block panels, Type A	3	SQYD	$87.00
Porous Cellular Block panels, Type B*	4	SQYD	$132.00
Porous Synthetic Ring and Grid System, Type A	5	SQYD	$87.00
Porous Synthetic Ring and Grid System, Type B*	6	SQYD	$137.00
Fiberglass Grating System, Type A	7	SQYD	$75.00
Fiberglass Grating System, Type B*	8	SQYD	$122.00

* Type B systems utilized geoweb in their base course.

Note: Square yard prices include all components of a given system necessary to construct the respective pull-off. (i.e. geotextile, EAT, aggregate-topsoil, geo-product, etc.)

APPENDIX B. PLAN AND CROSS-SECTIONS FOR STABILIZED PULL-OFF SYSTEMS

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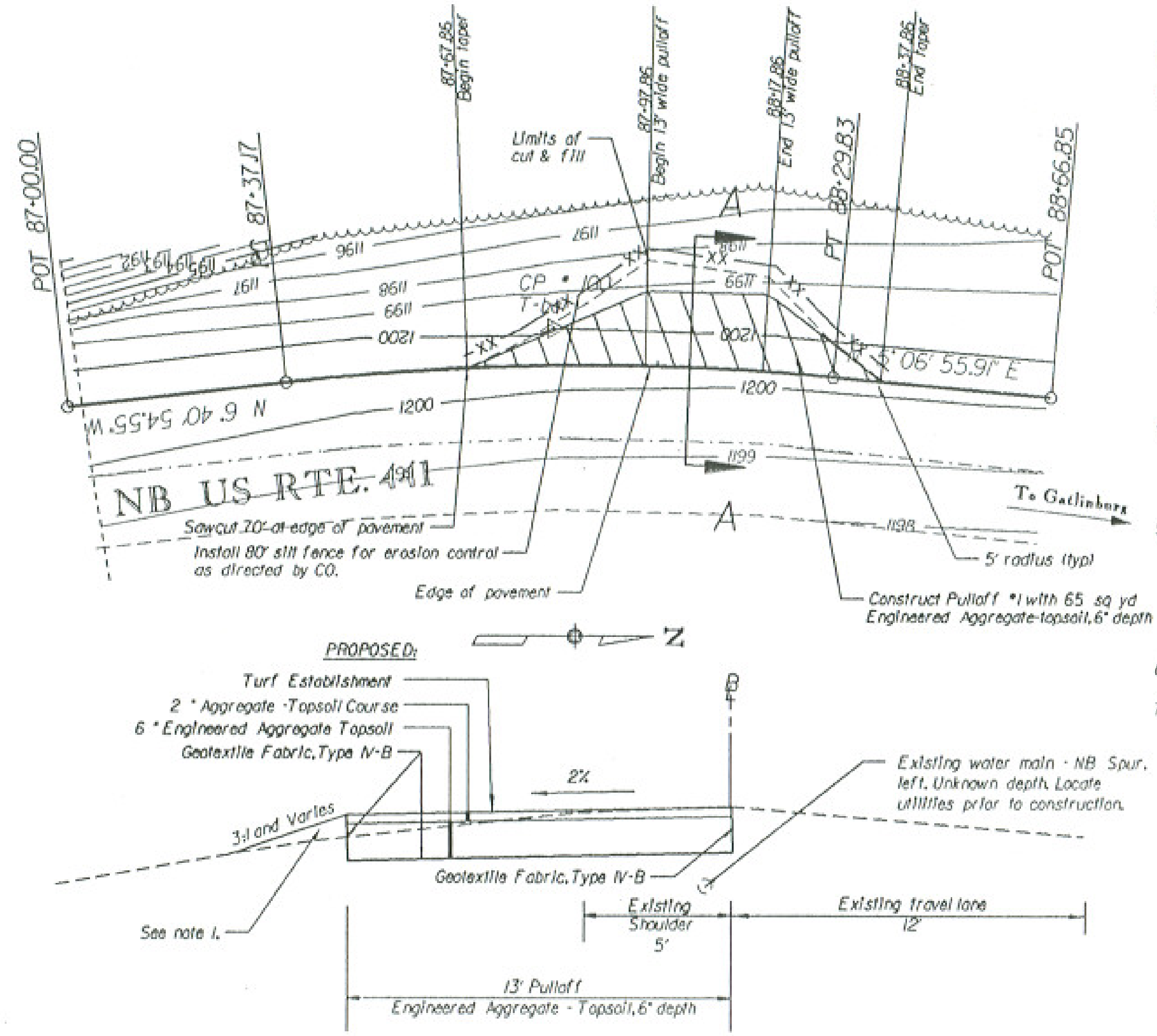

SECTION A-A
no scale

Note:

1. On 3:1 and varies shoulder slope place 2" aggregate topsoil over embankment material. Flatten shoulder slope to match existing as much as possible using excavated material for embankment.

2. Restore all disturbed areas to original condition. Use turf establishment on all disturbed areas.

3. Construct geotextile fabric IV-B according to manufacturers recommendations. Submit construction recommendations, details and material certifications to CO for approval 14 days prior to installation.

4. Erosion & Sediment Control Narrative: Install 80' silt fence before pulloff construction begins. Remove silt fence after turf is established.

5. Engineered aggregate-topsoil is a mix of predominantly *57 stone and just enough topsoil to fill the voids. Aggregate topsoil is a 50-50 mix of aggregate and topsoil intended as a growth medium for grass seed.

6. ℄ indicates survey baseline.

7. After all work is complete, restore the striping on the mainline pavement as follows: From beginning of taper to end of taper, paint over existing centerline and edge line striping with pavement marking type C for a total of 210 linear feet. Match existing paint color.

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FOOTHILLS PARKWAY

CONSTRUCTION PLANS
PULLOFF

SCALE IN FEET

REG	STATE	PROJECT	SHEET NO.
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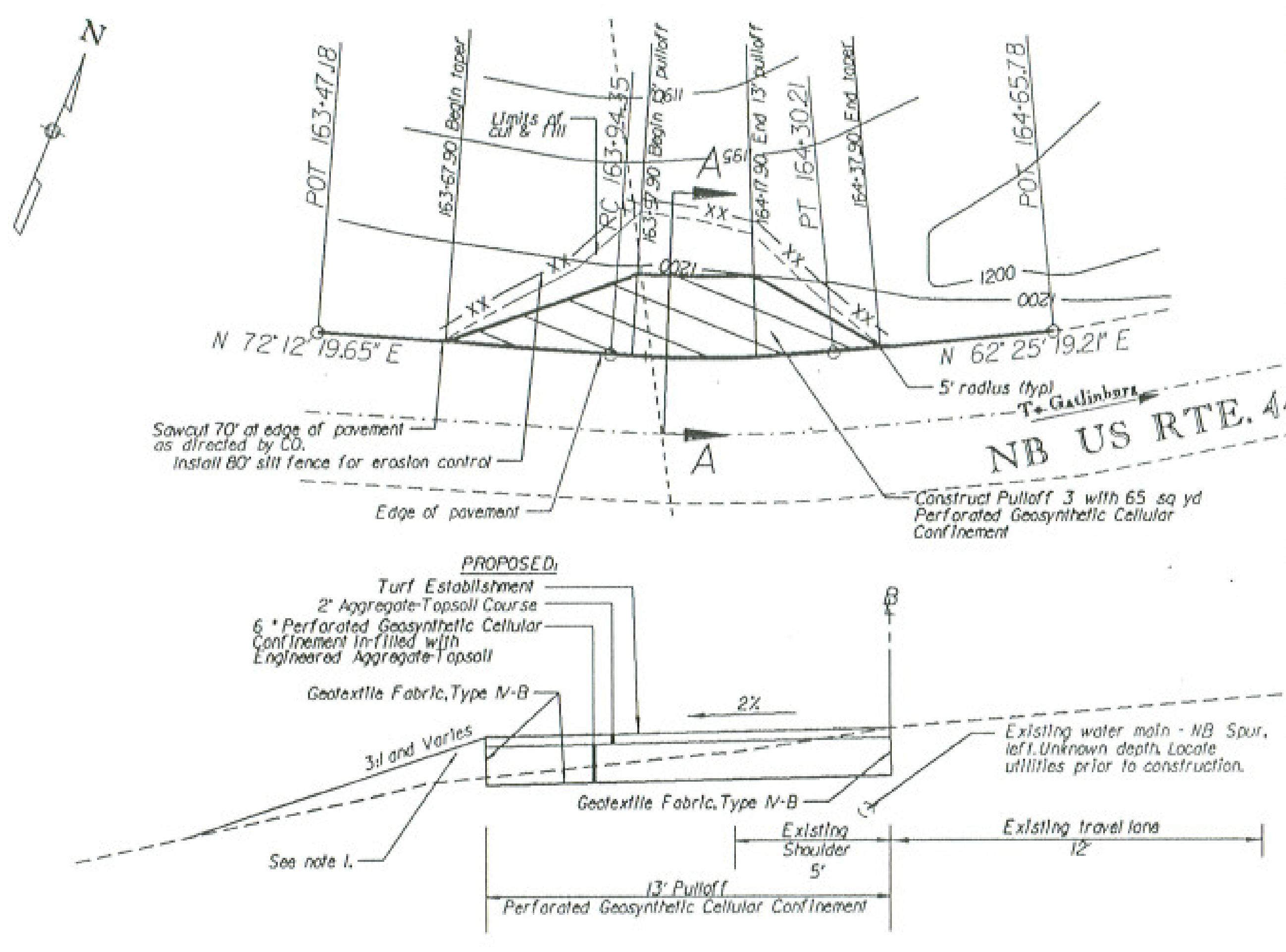

SECTION A-A
no scale

Note:

1. On 3:1 and varies shoulder slope place 2" aggregate topsoil over embankment material. Flatten shoulder slope to match existing as much as possible using excavated material for embankment.
2. Restore all disturbed areas to original condition. Use turf establishment on all disturbed areas.
3. Construct perforated geosynthetic cellular confinement system according to manufacturers recommendations. Submit construction recommendations, details and material certifications to CO for approval 14 days prior to installation.
4. Erosion & Sediment Control Narrative: Install 80' silt fence before pulloff construction begins. Remove silt fence after turf is established.
5. Engineered aggregate-topsoil is a mix of predominantly #57 stone and just enough topsoil to fill the voids. Aggregate topsoil is a 50-50 mix of aggregate and topsoil intended as a growth medium for grass seed.
6. ℄ Indicates survey baseline.
7. After all work is complete, restore the striping on the mainline pavement as follows: From beginning of taper to end of taper, paint over existing centerline and edge line striping with pavement marking type C for a total of 210 linear feet. Match existing paint color.

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CONSTRUCTION PLANS
PULLOFF

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REG	STATE	PROJECT	SHEET NO.
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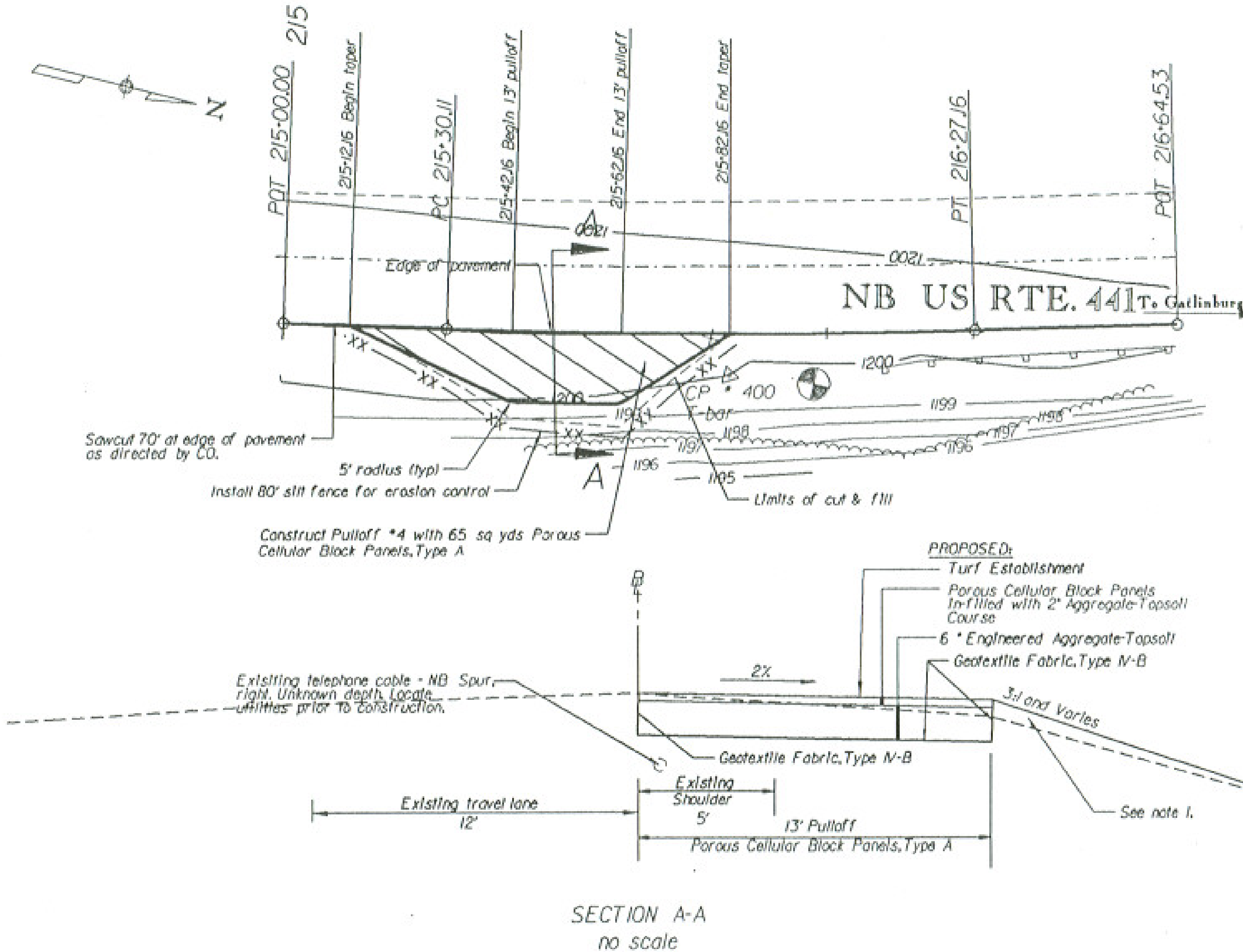

Note:

1. On 3:1 and varies shoulder slope place 2" aggregate topsoil over embankment material. Flatten shoulder slope to match existing as much as possible using excavated material for embankment.

2. Restore all disturbed areas to original condition. Use turf establishment on all disturbed areas.

3. Construct porous cellular block panel system according to manufacturers recommendations. Submit construction recommendations, details and material certifications to CO for approval 14 days prior to installation.

4. Erosion & Sediment Control Narrative: Install 80' silt fence before pulloff construction begins. Remove silt fence after turf is established.

5. Engineered aggregate-topsoil is a mix of predominantly *57 stone and just enough topsoil to fill the voids. Aggregate topsoil is a 50 - 50 mix of aggregate and topsoil intended as a growth medium for grass seed.

6. ℄ Indicates survey baseline.

7. After all work is complete, restore the striping on the mainline pavement as follows: From beginning of taper to end of taper, paint over existing centerline and edge line striping with pavement marking type C for a total of 310 linear feet. Match existing paint color.

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CONSTRUCTION PLANS
PULLOFF

SCALE IN FEET

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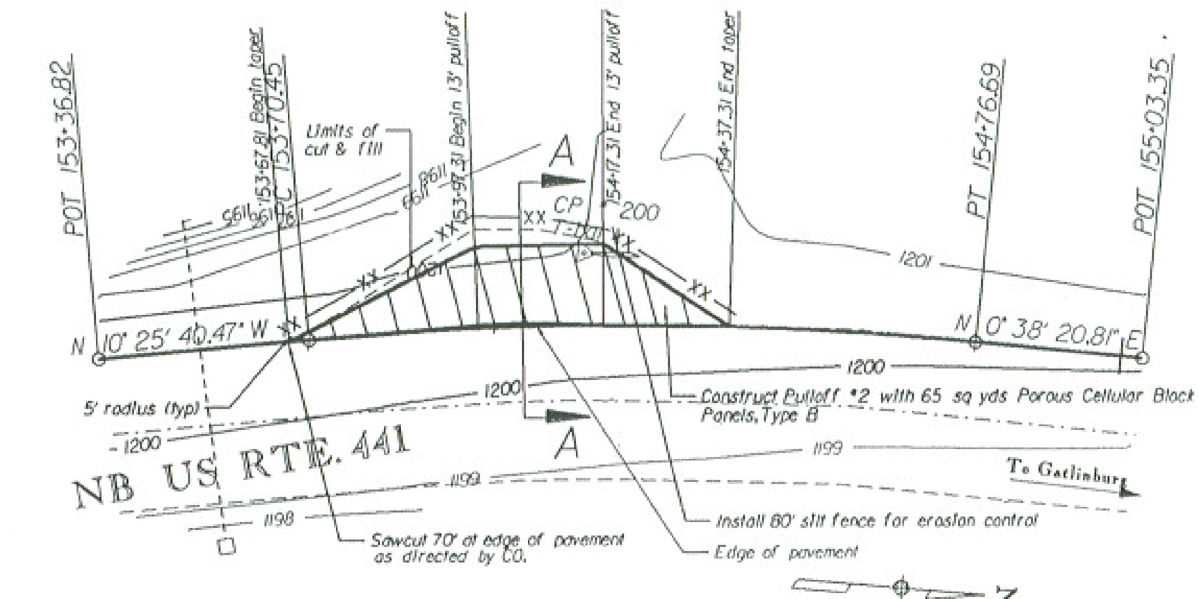

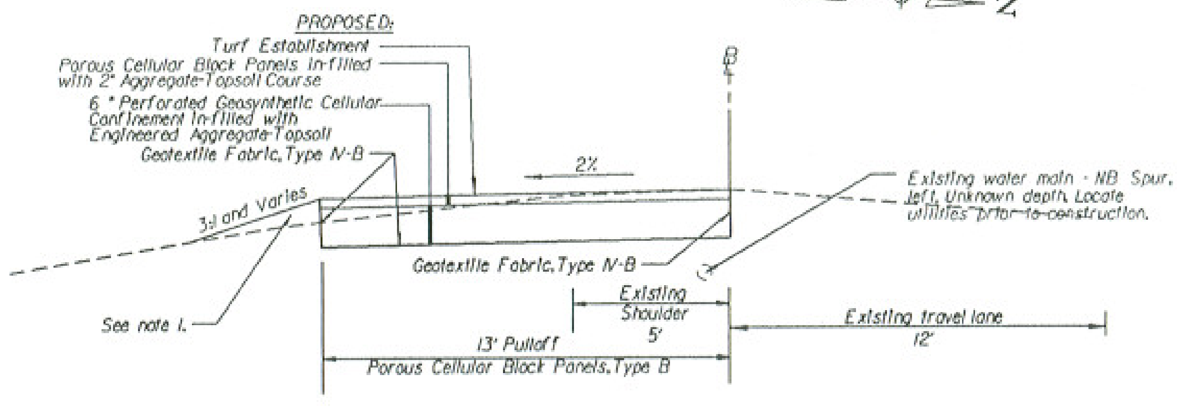

SECTION A-A
no scale

Note:

1. On 3:1 and varies shoulder slope place 2" aggregate topsoil over embankment material. Flatten shoulder slope to match existing as much as possible using excavated material for embankment.

2. Restore all disturbed areas to original condition. Use turf establishment on all disturbed areas.

3. Construct porous cellular block panels according to manufacturers recommendations. Submit construction recommendations, details and material certifications to CO for approval 14 days prior to installation.

4. Erosion & Sediment Control Narrative: Install 80' silt fence before pulloff construction begins. Remove silt fence after turf is established.

5. Engineered aggregate-topsoil is a mix of predominantly #57 stone and just enough topsoil to fill the voids. Aggregate topsoil is a 50-50 mix of aggregate and topsoil intended as a growth medium for grass seed.

6. B Indicates survey baseline.

7. After all work is complete, restore the striping on the mainline pavement as follows: From beginning of taper to the end of taper, paint over existing centerline and edge line striping with pavement marking type C for a total of 210 linear feet. Match existing paint color.

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CONSTRUCTION PLANS
PULLOFF

SCALE IN FEET

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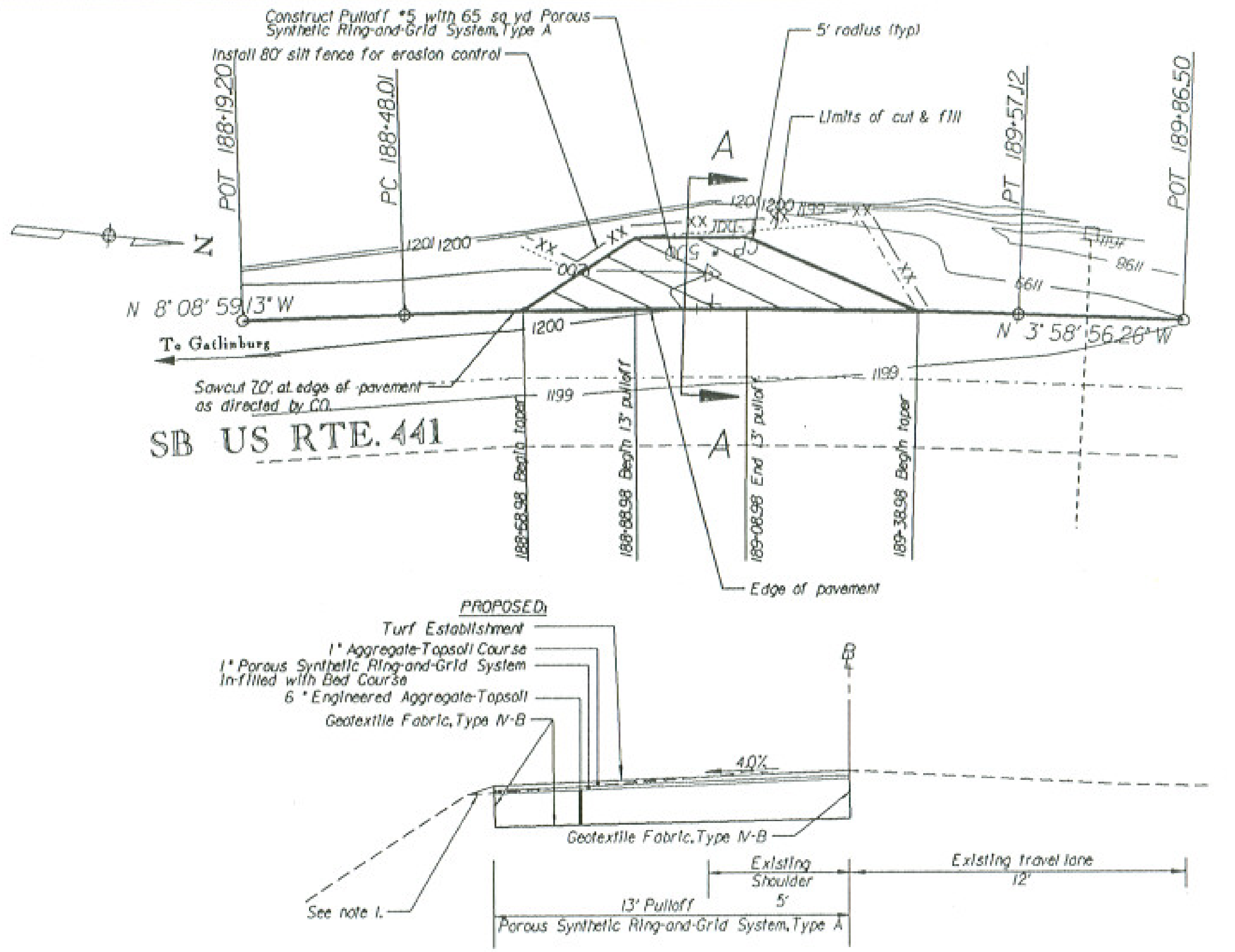

SECTION A-A
no scale

Note:

1. On shoulder slope place 1" aggregate topsoil over embankment material. Stay out of ditch as much as possible. Use excavated material for embankment.

2. Restore all disturbed areas to original condition. Use turf establishment on all disturbed areas.

3. Construct porous synthetic ring and grid system according to manufacturers recommendations. Submit construction recommendations, details and material certifications to CO for approval 14 days prior to installation.

4. Erosion & Sediment Control Narrative: Install 80' silt fence before pulloff construction begins. Remove silt fence after turf is established.

5. Engineered aggregate-topsoil is a mix of predominantly #57 stone and just enough topsoil to fill the voids. Aggregate topsoil is a 50-50 mix of aggregate and topsoil intended as a growth medium for grass seed.

6. ℄ Indicates survey baseline.

7. After all work is complete, restore the striping on the mainline pavement as follows: From beginning of taper to end of taper, paint over existing centerline and edge line striping with pavement marking type C for a total of 210 linear feet. Match existing paint color.

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CONSTRUCTION PLANS
PULLOFF

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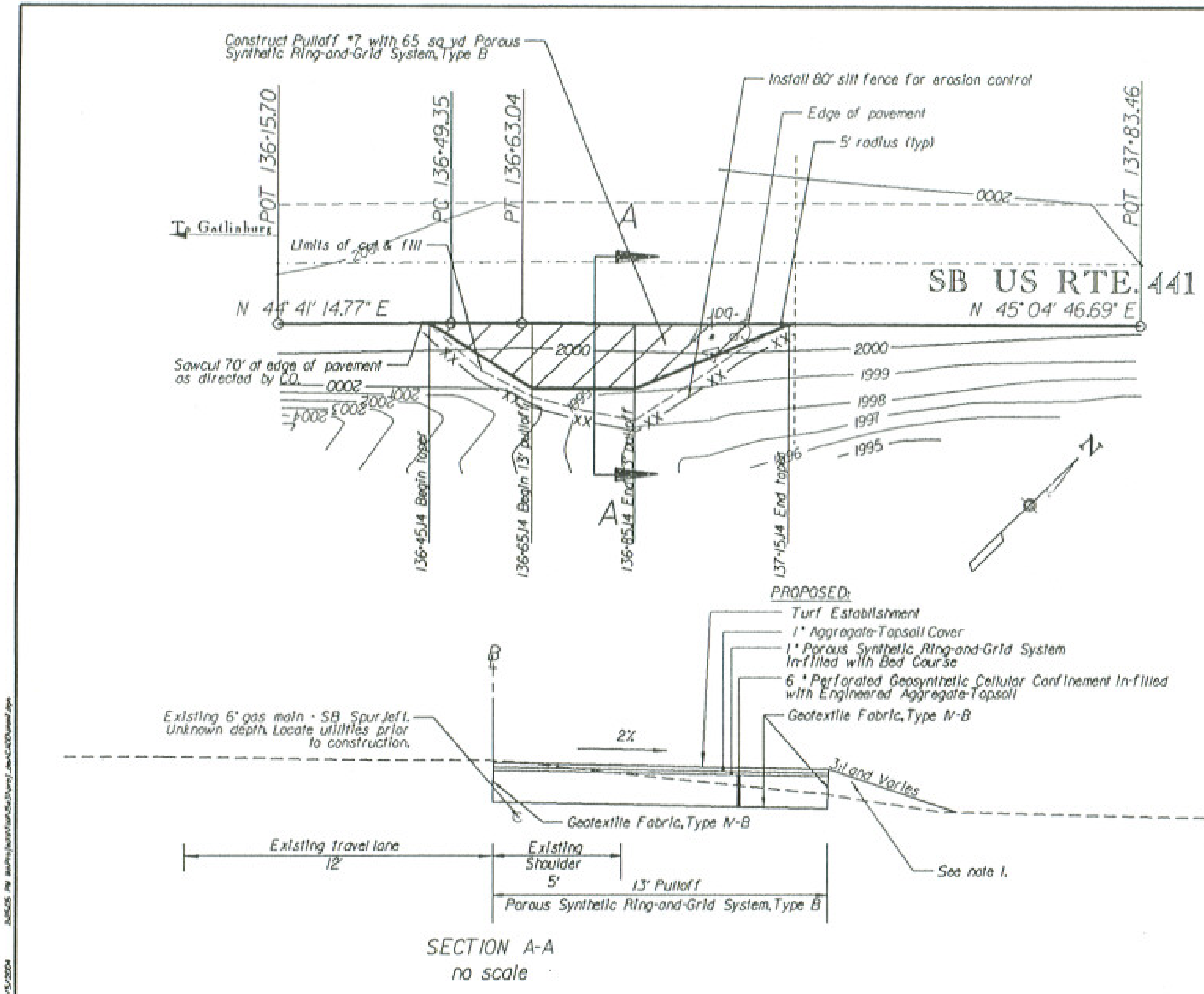

Note:

REG	STATE	PROJECT	SHEET NO.
SE	TN	PRA-FOOT (5A3)	87

1. On 3:1 and varies shoulder slope place 1" aggregate topsoil over embankment material. Flatten shoulder slope to match existing as much as possible using excavated material for embankment
2. Restore all disturbed areas to original condition. Use turf establishment on all disturbed areas.
3. Construct porous synthetic ring and grid system according to manufacturers recommendations. Submit construction recommendations, details and material certifications to CO for approval 14 days prior to installation.
4. Erosion & Sediment Control Narrative: Install 80' silt fence before pulloff construction begins. Remove silt fence after turf is established.
5. Engineering aggregate-topsoil is a mix of predominantly *57 stone and just enough topsoil to fill the voids. Aggregate topsoil is a 50-50 mix of aggregate and topsoil intended as a growth medium for grass seed.
6. ℄ indicates survey baseline.
7. After all work is complete, restore the striping on the mainline pavement as follows: From beginning of taper to end of taper, paint over existing centerline and edge line striping with pavement marking type C for a total of 210 linear feet. Match existing paint color.

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CONSTRUCTION PLANS
PULLOFF

SCALE IN FEET

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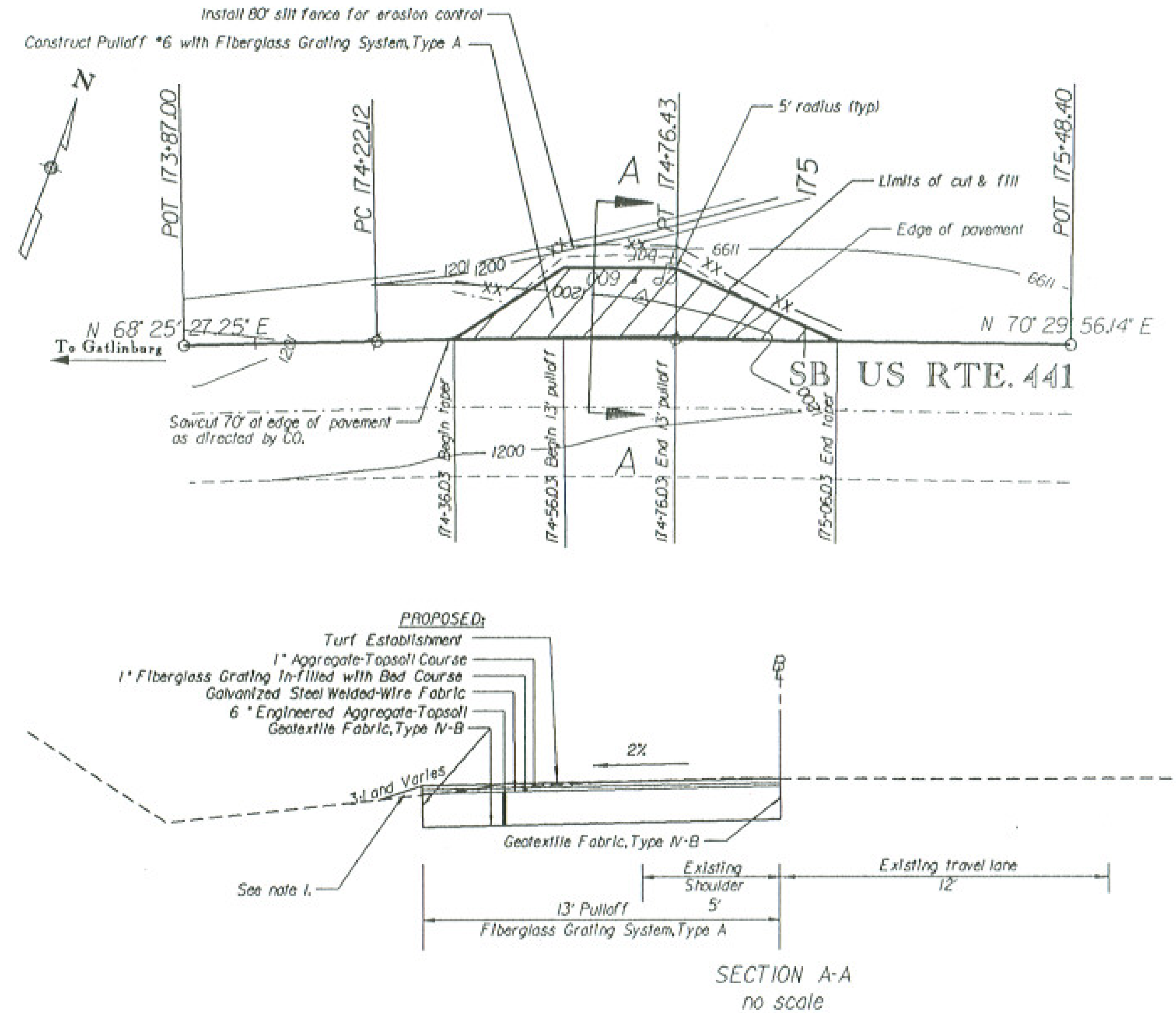

Note:

1. On 3:1 and varies shoulder slope place 1" aggregate topsoil over embankment material. Flatten shoulder slope to match existing as much as possible using excavated material for embankment.

2. Restore all disturbed areas to original condition. Use turf establishment on all disturbed areas.

3. Construct fiberglass grating system according to manufacturers recommendations. Submit construction recommendations, details and material certifications to CO for approval 14 days prior to installation.

4. Erosion & Sediment Control Narrative: Install 80' silt fence before pulloff construction begins. Remove silt fence after turf is established.

5. Engineered aggregate-topsoil is a mix of predominantly #57 stone and just enough topsoil to fill the voids. Aggregate topsoil is a 50-50 mix of aggregate and topsoil intended as a growth medium for grass seed.

6. ℄ indicates survey baseline.

7. After all work is complete, restore the striping on the mainline pavement as follows: From beginning of taper to end of taper, paint over existing centerline and edge line striping with pavement marking type C for a total of 210 linear feet. ~~Match existing paint color.~~

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CONSTRUCTION PLANS
PULLOFF

SCALE IN FEET

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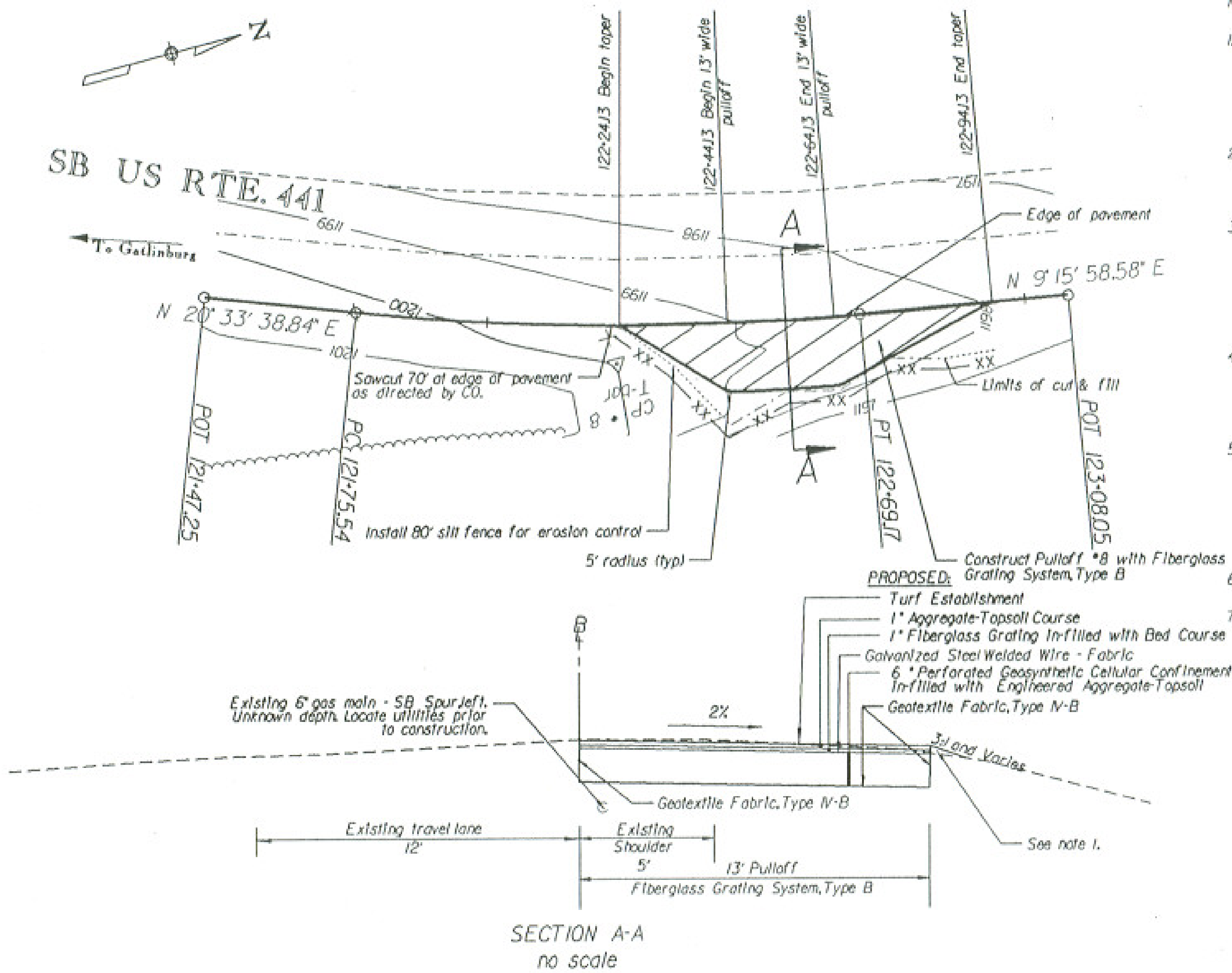

Note:

1. On 3:1 and varies shoulder slope place 2" aggregate topsoil over embankment material. Flatten shoulder slope to match existing as much as possible using excavated material for embankment.

2. Restore all disturbed areas to original condition. Use turf establishment on all disturbed areas.

3. Construct fiberglass grating system according to manufacturers recommendations. Submit construction recommendations, details and material certifications to CO for approval 14 days prior to installation.

4. Erosion & Sediment Control Narrative: Install 80' silt fence before pulloff construction begins. Remove silt fence after turf is established.

5. Engineered aggregate-topsoil is a mix of predominately #57 stone and just enough topsoil to fill the voids. Aggregate topsoil is a 50-50 mix of aggregate and topsoil intended as a growth medium for grass seed.

6. ℄ Indicates survey baseline.

7. After all work is complete, restore the striping on the mainline pavement as follows: From beginning of taper to end of taper, paint over existing centerline and edge line striping with pavement marking type C for a total of 210 linear feet. Match existing paint color.

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION
STERLING, VIRGINIA

GREAT SMOKY MOUNTAINS NATIONAL PARK
FOOTHILLS PARKWAY

CONSTRUCTION PLANS
PULLOFF

SCALE IN FEET