Geologic Resources Inventory Scoping Summary
Stones River National Battlefield, Tennessee

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June 29, 2009

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The Geologic Resources Inventory (GRI) provides each of 270 identified natural area National Park System units with a geologic scoping meeting and summary (this document), a digital geologic map, and a geologic resources inventory report. The purpose of scoping is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and monitoring and research needs. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity to discuss park-specific geologic management issues, and if possible include a site visit with local experts.

The National Park Service held a GRI scoping meeting for Stones River National Battlefield on March 23, 2009 at the Tennessee Division of Geology offices in Nashville, Tennessee followed by a site visit at the park on March 24, 2009. Tim Connors (NPS-GRD) facilitated the discussion of map coverage and Lisa Norby (NPS-GRD) led the discussion regarding geologic processes and features at the battlefield. Geologists from the Tennessee Division of Geology presented a brief geologic overview of the battlefield and surrounding area. Participants at the meeting included NPS staff from the park, Geologic Resources Division, and Cumberland Piedmont Network, geologists from the Tennessee Division of Geology, and cooperators from Colorado State University (see table 2). This scoping summary highlights the GRI scoping meeting for Stones River National Battlefield including the geologic setting, the plan for providing a digital geologic map, a prioritized list of geologic resource management issues, a description of significant geologic features and processes, lists of recommendations and action items, and a record of the meeting participants.

Park and Geologic Setting

Originally established as a national military park on March 3, 1927 and managed by the War Department until August 10, 1933, Stones River National Battlefield in Rutherford County, central Tennessee preserves the scene of the American Civil War battle that took place over three days from December 31, 1862 to January 2, 1863. The NPS manages 287.31 ha (709.96 ac) (with fee ownership of approximately 260 ha [650 ac]) over several dispersed sites at Stones River including the General Bragg Headquarters, General Rosecrans Headquarters, Redoubt Brannan, and Curtain Wall No. 2 sites. The park is a relatively flat karst plain in Murfreesboro, Tennessee within the Inner Basin of the Central Basin physiographic province.

Exposed within the Stones River area are four Middle Ordovician geologic units: Lebanon Limestone (Olb-not exposed within park boundaries), Ridley Limestone (Ord), and the Pierce and Murfreesboro Limestones (Opm-presence questioned by the Tennessee Division of Geology staff). These are among the oldest exposed rocks in Tennessee deposited within a large, shallow, open marine basin when the North American continent was situated in the equatorial latitudes. The Ridley Limestone contains massive limestone with some shale and chert rich layers locally whereas the Pierce and Murfreesboro Limestones are fine-grained to cryptocrystalline limestone with some thin shale partings and lenses of dark chert. Outcrop exposures within the park are weathering deeply and are limited in area. Soil development is scant and soils are thin over the level terrain of

the sinkhole plain. The West Fork Stones River cuts through the northern area of the park with moderate slopes flanking the river's riparian area.

Geologic Mapping for Stones River National Battlefield

During the scoping meeting, Tim Connors (NPS-GRD) showed some of the main features of the GRI's digital geologic maps, which reproduce all aspects of paper maps, including notes, legend, and cross sections, with the added benefit of being GIS compatible. The NPS GRI Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation for the GRI Program and allows for rigorous quality control. Staff members digitize maps or convert digital data to the GRI digital geologic map model using ESRI ArcGIS software. Final digital geologic map products include data in geodatabase and shapefile format, layer files complete with feature symbology, FGDC-compliant metadata, an Adobe Acrobat PDF help document that captures ancillary map data, and a map document that displays the map, and provides a tool to access the PDF help document directly from the map document. Final data products are posted at http://science.nature.nps.gov/nrdata/. The data model is available at http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm.

When possible, the GRI Program provides large scale (1:24,000) digital geologic map coverage for each park's area of interest, which is often composed of the 7.5-minute quadrangles that contain park lands (fig. 1). Maps of this scale (and larger) are useful to resource managers because they capture most geologic features of interest and are spatially accurate within 12 m (40 ft). The process of selecting maps for management begins with the identification of existing geologic maps (table 1) and mapping needs in the vicinity of the park. Scoping session participants then select appropriate source maps for the digital geologic data or develop a plan to obtain new mapping, if necessary.

Table 1. GRI Mapping Plan for Stones River National Battlefield

Covered Quadrangles	Relationship to the park	Citation	Format	Assessment	GRI Action
Walterhill	Intersects the park boundary	Wilson, C. W., Jr. 1964. Geologic Map and Mineral Resources Summary of the Walterhill Quadrangle. Scale 1:24,000. Geologic Quadrangle Map 315 NW. Nashville, TN: Tennessee Division of Geology	digital	The digital map has not been finalized yet, but the digitization is done and available to the GRI.	Obtain GIS shapefiles digitized by the Tennessee Division of Geology and convert to GRI Geology-GIS Geodatabase Data Model
Murfreesboro	Intersects the park boundary	Wilson, C. W., Jr. 1965. Geologic Map and Mineral Resources Summary of the Murfreesboro Quadrangle. Scale 1:24,000. Geologic Quadrangle Map 315 SW. Nashville, TN: Tennessee Division of Geology	digital	The digital map has not been finalized yet, but the digitization is done and available to the GRI.	Obtain GIS shapefiles digitized by the Tennessee Division of Geology and convert to GRI Geology-GIS Geodatabase Data Model

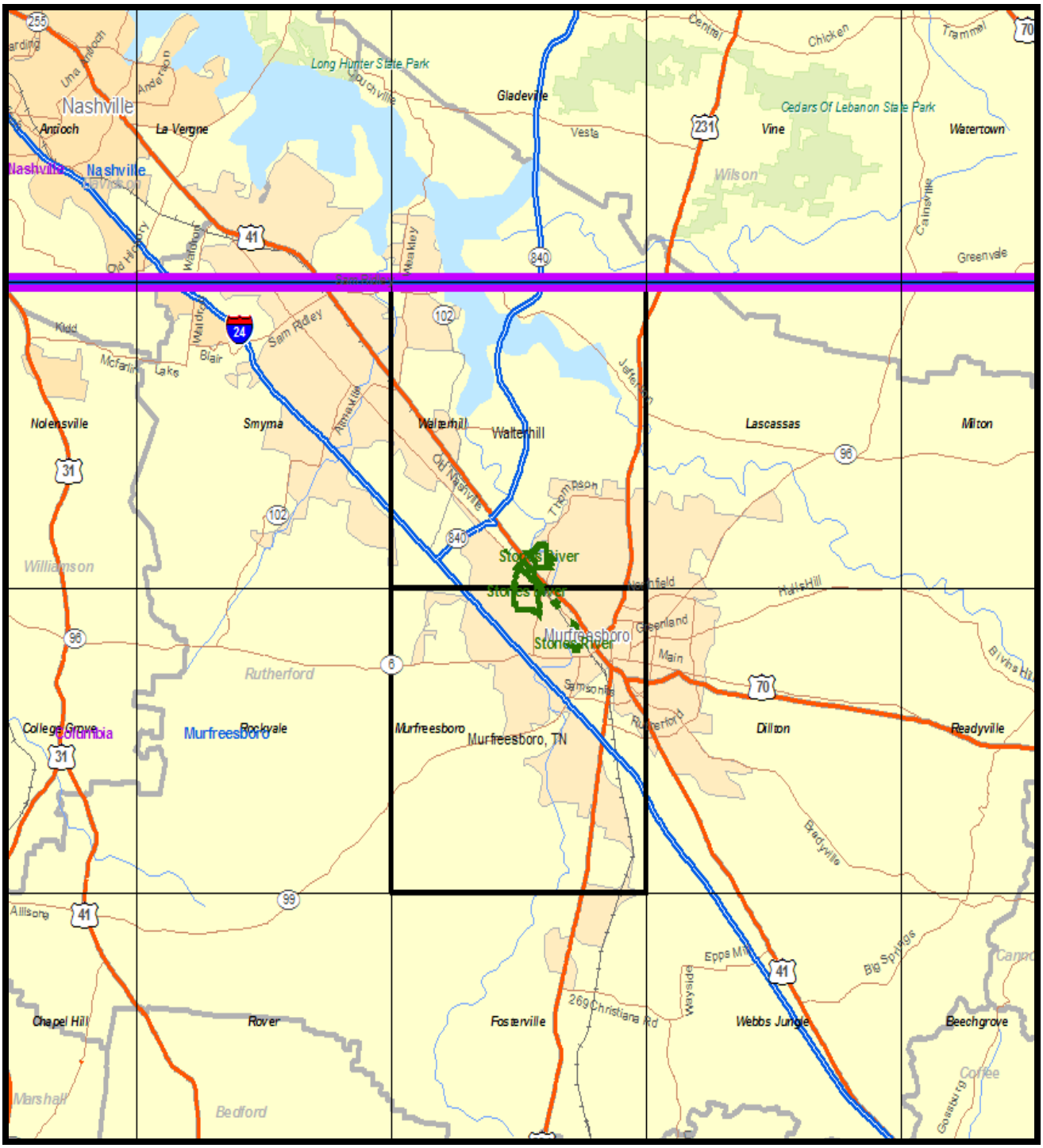

Figure 1. Area of interest for Stones River National Battlefield, Tennessee. The 7.5-minute quadrangles are labeled in black; names and lines in blue indicate 30-minute by 60-minute quadrangles, whereas names and lines in purple indicate 1x2 degree quadrangles. Green outlines indicate national battlefield boundaries.

Map coverage is available at the 1:24,000 scale for all of the areas of interest for Stones River National Battlefield. According to Mike Hoyal of the Tennessee Division of Geology, there may be some discrepancy among geologic units on the maps due to the undulating nature of units in the

vicinity of the park. The Pierce-Murfreesboro contact is questionable along the West Fork Stones River. These units are lumped together. The GRI GIS-mapping team should confirm current park boundary with the base cartography group.

Geologic Resource Management Issues

The scoping session for Stones River National Battlefield provided the opportunity to develop a list of geologic features and processes, which will be further explained in the final GRI report. During the meeting, participants prioritized the most significant issues as follows:
(1) Historic mineral resource development and disturbed lands
(2) Karst hazards, and
(3) Flooding and fluvial processes.

Other geologic resource management issues discussed include seismicity, and slope processes.

Historic mineral resource development and disturbed lands

The park originally covered 141 ha (350 ac) in the 1920s. Much of that area had been cultivated farmland. The park occasionally permits hay cutting on 15 ha (38 ac) of tenable hay land. Special use permits for crops cover 5-6 fields over 14 ha (35 ac). The park is incrementally converting much of the open area to native grasses (7-8 species) to manage the cultural landscape of the battlefield.

Several areas of the park have been affected by extraction sites and industrial uses. An old oil and gas well, converted to a water well, is within the park boundary. Several manmade ponds, known as "hog or cattle ponds" also exist within the park. Following a 1991 boundary expansion, concrete debris in the northern portion of the park was excavated and covered over at the site of a former concrete truck cleanout dump. This site was restored in 1995(?). The park is currently in the process of remediating and restoring another dump site at the Jones-Farrer tracts (fig. 2). The King tract was an area mined for soil that subsequently became a dump. The park is obtaining funding to mitigate this area. The city of Murfreesboro used the Redoubt Brannan site and adjacent city land as a city dumpsite. The dump was removed approximately 12 years ago.

A 1920s-1930s era tour road in the park has affected some of the park's cedar glade areas by altering surface run-off. A new tour road in the planning stages at Stones River National Battlefield will reuse the eastern portion of the existing tour road while the historic west side will be converted to a paved trail. Other areas of the park will be used for the new tour road, a visitor use trail, and parking areas. A new main park entrance is proposed for construction on Thompson Lane. A new entrance to the McFadden Farm section of the park north of Highway 41/Broad Street is also proposed for Thompson Lane. Historic McFadden Lane/Van Cleve Lane south of Old Nashville Highway is proposed for use as part of the tour road. This area has active sinkholes. The park is in the process of obtaining project funding for road improvements.

The Lebanon Limestone, northwest of the park, has been mined for aggregate and building stone. Two large, water filled quarries adjacent to the Old Nashville Highway near General Rosecrans Headquarters are just outside the park boundary. It is unknown how this quarrying is affecting the hydrogeologic system at the park.

Karst hazards

According to the geologic hazards map of Rutherford County, TN presented by the Tennessee Division of Geology, the karst features at the battlefield are pervasive in the park. The Ordovician limestone units (Lebanon, Ridley, Pierce, and Murfreesboro limestones) are conducive to karst formation on the highland rim and central basin in Tennessee. The opening to Rebel Yell Cave, created by karst processes is unmarked and surrounded by a steep, unstable, rubble-covered sinkhole (fig. 3). Even though the cave opening has been partially sealed with rebar, the entrance could pose a visitor safety hazard. Van Cleve Lane south of Old Nashville Highway has been damaged by sinkhole formation.

Run-off from external developments that surround the entire park has impacted the water quality within and around the park. Characteristically high infiltration rates and permeability of karst landscapes result in little to no adsorption of contaminants. This area of Tennessee is experiencing the fastest population growth in the state (100,000 Murfreesboro city residents in 2009 compared to 45,000 in 1992). The U.S. Geological Survey completed water quality testing in the late 1990s and found volatile organic compounds in elevated concentrations at park locations such as Battlefield (McFadden) Spring. Dye tracing has discovered direct conduits from industrial sites to areas beneath the park. The park is a level one water quality NPS Inventory and Monitoring program target.

Flooding and fluvial processes

As the name suggests, West Fork Stones River is the primary fluvial feature at the battlefield. Natural fluvial processes cause the river to migrate along its course, which may impact park resources. In the 1970's the park installed rock riprap along 91 m (300 ft) of the shoreline to stabilize the riverbank (at tour route stop 6 downstream from McFadden's Ford). The riprap blends in relatively well with nearby rock outcrops of the Ridley Formation and provides areas for fishing (fig. 4). The park is uncertain whether they should remove this riprap to allow the river to return to its natural configuration and processes.

Typical of karst landscapes is the rapid response in local waterways to precipitation events and at Stones River National Battlefield this effect is exacerbated by the presence of surrounding development. During heavy rains, West Fork Stones River rises rapidly due to increased runoff caused by less infiltration due to the presence of impervious surfaces associated with development. Roads and railroads are elevated, affecting the hydrogeologic system. Areas around the highway and near the cemetery also have increased runoff. Drain and fill work near the cemetery has been done to mitigate flooding and standing water in these areas. Local development, including the construction of a large drain from a large development known as the Gateway and the Avenues outdoor mall south of the park may actually prevent some major flooding at the park.

An ongoing problem affecting the park area is the long-term drought in the southeastern U.S. It is unclear how the hydrogeologic system and the park ecosystem may change in response to less precipitation. As climate changes, more severe weather events could alter runoff and erosion thereby impacting fluvial processes and sediment loads in park streams and rivers.

Other geologic resource management issues

Seismicity

According to geologists from the Tennessee Division of Geology, Stones River National Battlefield is within an area of relatively low seismic risk (zone 1). However, there are frequent seismic events in the area. Though not likely, potential hazards associated with seismicity that could threaten park resources include liquefaction within water saturated, unconsolidated floodplain deposits. Seismic shaking, if strong enough, could damage park infrastructure including buildings, roads, trails, monuments, and bridges.

Slope processes

Landslide hazards exist within Rutherford County, but the gentle slopes at the national battlefield preclude serious risk for slope failure. Over time, erosion could subdue and diminish some of the cultural resources at the battlefield including earthworks. The park planted native, warm season grasses in an attempt to stabilize the earthworks. Other areas that could experience erosion and slumping are the riverbanks.

Figure 2. Reclamation area within Stones River National Battlefield. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Figure 3. Entrance to the Rebel Yell Cave. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Figure 4. Riprap along West Fork of Stones River near tour stop 6. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Features and Processes

Karst features

The Ordovician limestone units at Stones River National Battlefield are prone to karst processes. At the battlefield, these units are deeply weathered and display characteristic karst features including caves, sinkholes, subtle closed depressions, and springs. Rebel Yell Cave is the only known and named cave on Stones River National Battlefield property. Rebel Yell Cave is at least 6-9 m (20-30 ft) deep. Dye traces link Rebel Yell Cave with Snail Shell Cave which is known as one of the most biologically significant cave sites in the southeastern United States. Snail Shell Cave is approximately 7.5 km (4.7 mi) to the southwest of Rebel Yell Cave.

The landscape is a sinkhole plain with many karst features prominent in the subsurface, often controlling soil distribution at the surface. The plain is internally drained with springs emerging and draining almost immediately. At least two springs occur within the park including Battlefield (McFadden) Spring. King Pond is spring fed. There are also five or six small, ephemeral wetlands overlying aquitard layers within the park.

Among the more interesting karst features at the national battlefield are limestone pavements and karst karren ("cutters"). These are wide, weathered joints in the limestone pavements (fig. 5). Joints preferentially eroded away by channeling runoff and entraining organic debris, which promoted soil development and subsequent microbial activity (CO_2 produced) that increased solubility of the limestone. Between the karrens are limestone "pinnacles". These karst features hindered troop and artillery movement during the Civil War battle, but also provided soldiers with shelter from enemy fire. At the Slaughter Pen, the joints are in deeply weathered Ridley Limestone oriented in sets at ≈90° angles and are over 1 m (3 ft) deep (fig. 5).

Weathered limestone also controlled plant distribution in the Stones River area. Unique cedar glade habitats exist in the southern part of the park where weathered limestone gravel covers the ground surface with very little, to no soil development (1/4 in. maximum soil depth) (fig. 6). The glades lend their name to a soil type (the Gladesville soil) characterized by a thin veneer of soil and rocks. These glades host endemic, rare and endangered species including the Tennessee purple coneflower and Pyne's ground-plum.

Historically in Rutherford County, if the land was at all arable, farmers used it for fields or pastures, whereas forested areas generally have limestone rock outcrops and thin soils (cedar brakes or thickets). Trees grow in weathered karst karrens, possibly contributing to increasing the gaps in the rock.

Geologic connections with the battle at Stones River

As mentioned elsewhere, the rough karst terrain at Stones River impeded troop and artillery movement and provided "shelters of convenience" for soldiers trying to avoid enemy fire. The cedar glades were open areas that allowed easy passage of troops during the battle. Geology likely influenced the location of the shallow McFadden's Ford that was a turning point in the battle.

Paleontological resources

According to the NPS Paleontological Inventory for Stones River National Battlefield, fossil resources are documented within the park, presenting opportunities for resource management including field surveys, inventory, and monitoring, education, and interpretation. The Middle Ordovician Ridley Limestone, underlying most of the land within the park, contains coiled-shell cephalopods (noticed within the park) as well as sponges, bryozoans, brachiopods, gastropods (noted elsewhere, but possibly within the park). In the park area, the Pierce and Murfreesboro Limestones contain bryozoans, brachiopods, ostracodes, and gastropods.

Within the Ordovician limestone at Stones River, quick field surveys by the Tennessee Division of Geology staff, Stones River National Battlefield staff, and the GRI field trip revealed the presence of bryozoans, gastropods, cephalopods, and a large trilobite. Some coral was present in cedar glades along with remnant chert clasts. Caves within the park could contain Pleistocene fossilized remains.

Unique features

As mentioned elsewhere in this scoping summary, cedar glades within the park are globally unique and rare habitats. These weathered, limestone gravel laden open areas at first appear devoid of appreciable flora. They were clear at the time of battle leading some soldiers to write about “empty fields”. The tour road at the park currently passes through several cedar glades. Posted signs attempt to keep visitors from trampling and degrading the glades, but it is unclear at this time what impact the roads have on these fragile ecosystems.

Figure 5. Karst karren amidst a forest at Stones River National Battlefield. Photograph is by Lisa Norby (NPS-GRD).

Figure 6. Cedar glade at Stones River National Battlefield. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Recommendations

1. Consult geologists and cave and karst specialists when designing new tour roads and restoration project to avoid potential issue with karst processes and features.

Action Items

1. GRI report writer will use White (1988) "Geomorphology and Hydrology of Karst Terrains" as a reference.
2. GRI report writer will obtain a copy of the 1999 GMP for the park to use in preparation of the final geologic report.
3. GRI team will contact Dave Steenson (NPS-GRD) regarding the concrete area reclamation project at the Jones-Farrer site.
4. GRI report author will obtain 1990s U.S. Geological Survey water quality report to use in preparation of the final geologic report.

References

Meiman, J. 2005. Cumberland Piedmont Network Water Quality Report: February 2005, Stones River National Battlefield. Atlanta, GA: National Park Service, Southeast Region.

U.S. Geological Survey. 2001. Level One Water-Quality Inventory and Monitoring: Stones River National Battlefield, Tennessee. Nashville, TN: U.S. Geological Survey.

Hunt Foster, R. and others. 2009 (in prep). Paleontological Inventory of Stones River National Battlefield. National Park Service.

Table 2. Scoping Meeting Participants

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