

5. RICHMOND AND EASTERN VIRGINIA REGION

The M5.8 earthquake on 27 August 2011 was strongly felt in the City of Richmond, located about 65 km southeast of the epicenter, and across most of Eastern Virginia. Throughout Tidewater, Williamsburg, Richmond, and surrounding counties, the average citizen reported audible sound, felt motion, fallen items from table-tops, and/or wall hangings out of kilter. However, little structural damage was reported anywhere in the region.

Where distress was noted, such distress was primarily related to architectural finishes (i.e., drywall or exterior cladding). In Goochland County, some measure of structural damage was observed. This was typically in the form of cracked foundation walls, which typically did not affect the use of the structure. In one instance, the structural damage resulted in a beam that needs to be fixed prior to occupancy.

Unfortunately, there were no M5.8 ground motions recorded in Richmond or Eastern Virginia. Reported intensities in Richmond were IV to V, much lighter than the VII to VIII that occurred in areas to the northeast, such as Washington, DC which is located twice as far from the epicenter. The relative lack of damage in Richmond and Eastern Virginia stands in contrast to the more significant damage seen in the epicentral region and parts of the Washington, DC area.

Regional reconnaissance involved limited site inspections by GEER team members guided largely by the observations of tens of other engineering professionals who reported very little in the way of ground failures. Primary attention was given to poor soil areas such as young alluvial deposits along rivers, creeks, and streams, including the James River. A summary of investigated sites is presented in Figure 5-1. Additional data for each site are available via the .kmz file on the GEER website.

Surficial Geology

Regional geology likely affected ground motion and amplification of seismic energy. A map showing the major geologic provinces overlain by the GEER study sites is provided in Figure 5-2. The metropolitan Richmond area is located on a southeastward azimuth from the M5.8 epicenter, a direction roughly perpendicular to the orientation of regional geologic structure and thrust faulting. This is in contrast to the Washington, DC area which is located on an azimuth parallel to these same structures. Heading toward Richmond from the Mineral area, the Piedmont residuum becomes covered by a mantle of “terrace deposits” prior to the eastward thickening of Coastal Plain deposits, which begin to appear in Richmond. Additionally the Piedmont between the epicenter and Richmond includes exposed Triassic-aged basins (lateral grabens) of sedimentary rocks.

The James River falls from non-tidal to tidal influence in the City of Richmond, approximately at the location of Interstate I-95. To the west of Interstate I-95, the stream bottom of the James River is typically bedrock – to the east the stream bottom is unconsolidated sediments of the Coastal Plain. Heading east from Richmond, the depth to bedrock increases by about 6 m/km (300 m in 50 km).

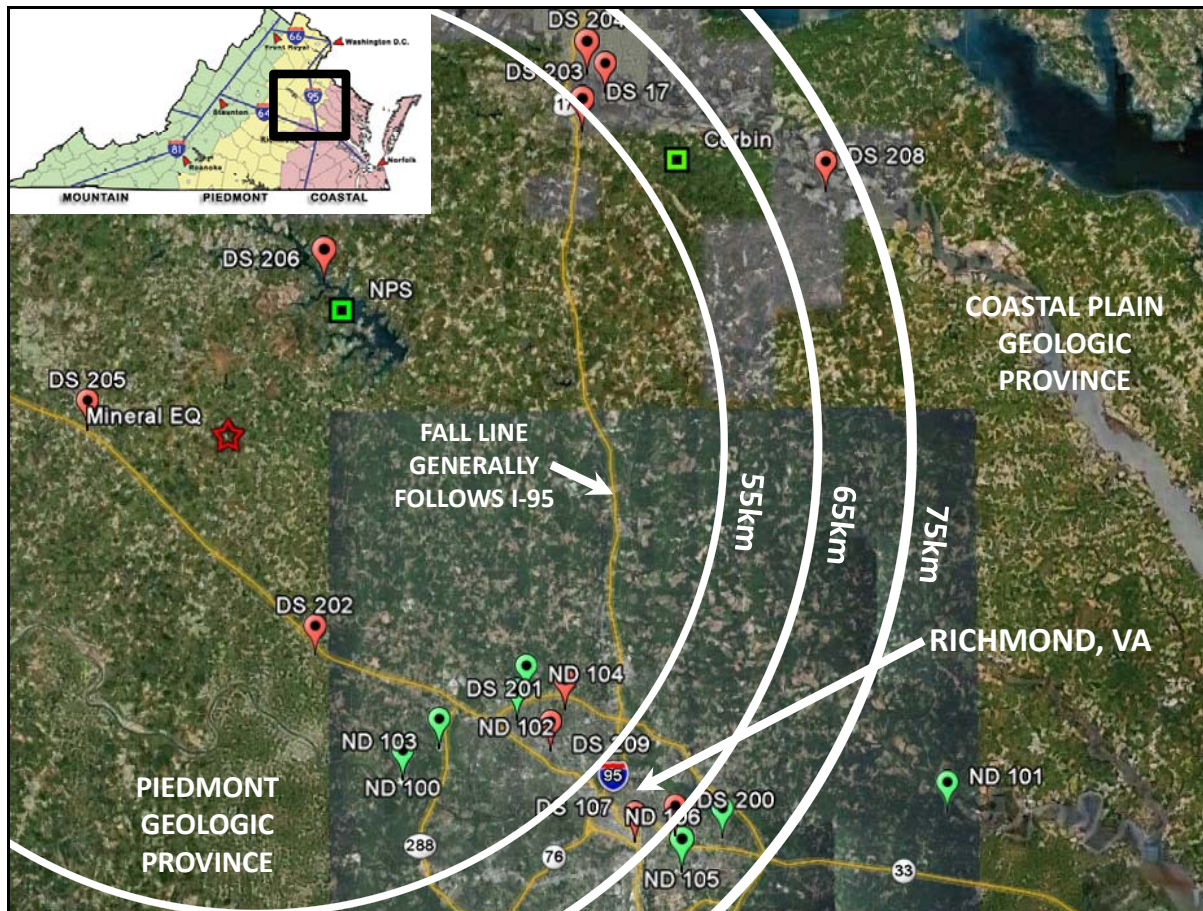


Figure 5-1 – Minor damage sites investigated by GEER in Richmond and Eastern Virginia.

Unconsolidated Coastal Plain sediments between the “Fall Zone” (i.e., approximately along Interstate I-95) and the Surry Scarp (i.e., a paleoshoreline in proximity to Williamsburg) typically include a transgressive and regressive sequence of overconsolidated clay and compact sand. The Miocene-age Calvert formation (sensitive marine clay) is widely present in Richmond and is widely used for belled caisson support of multi-story buildings (i.e., there is rarely the need to use the much deeper bedrock for foundation support within the city). The Bacon’s Castle formation (gravel grading upward into sand and sandy clayey silt) is widely present to the east of Richmond and atop the sensitive marine clay of the Calvert formation.

Normally consolidated clays, organic silt, and peat with interlayered very loose sands are typically found to the east of Williamsburg (i.e., east of the Surry Scarp). The lack of soft and loose Coastal Plain sediments in proximity to the earthquake’s epicenter and the thickening of the sediments toward the east are thought to be factors in limiting seismic damage in this region.

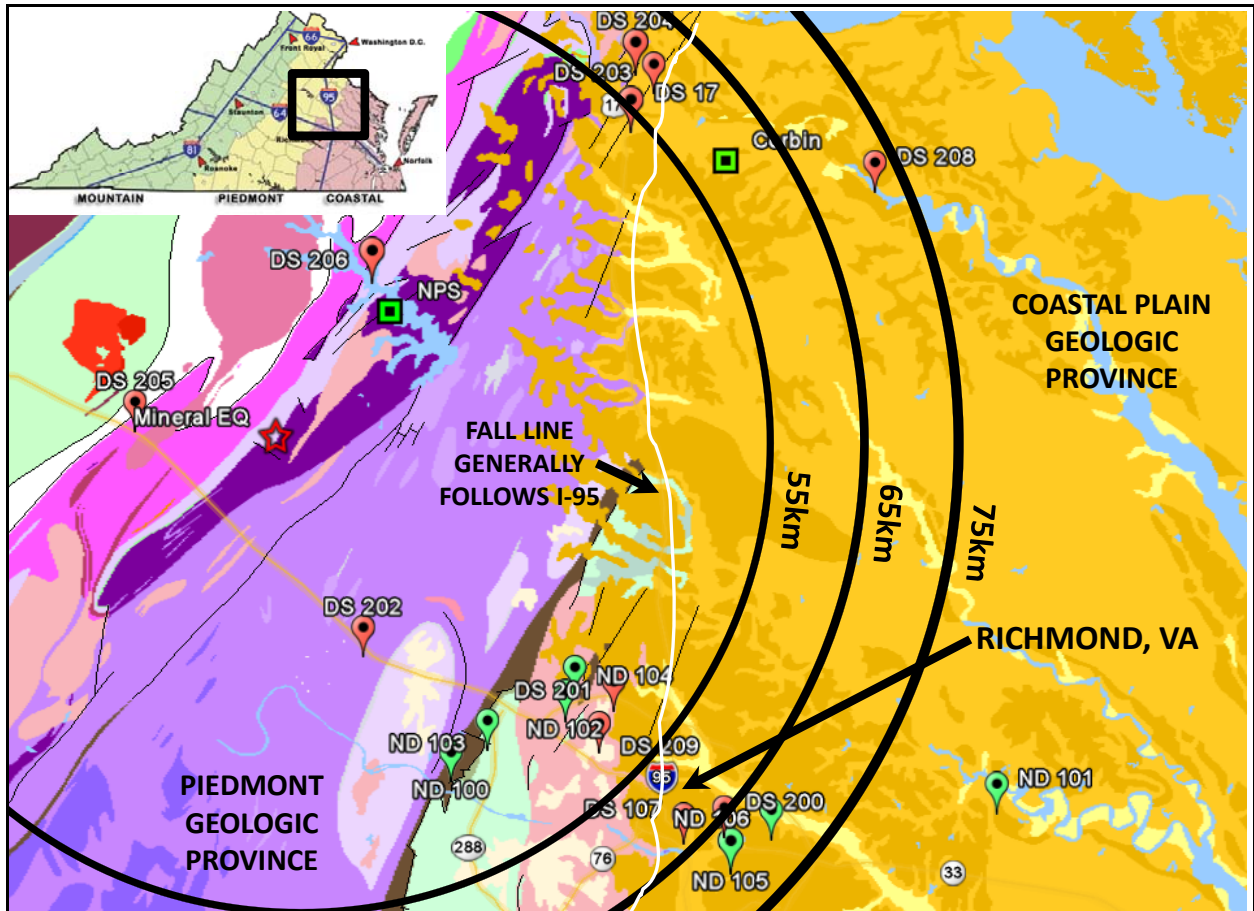


Figure 5-2 – Surficial geology overlain by GEER study sites in Richmond and Eastern Virginia.

Liquefaction

There were no reports of sand boils in the Richmond and Eastern Virginia Region, although it is possible that small features may have been overlooked. Field observations of saturated, loose sand along the Pamunkey River (in the vicinity of White House Landing, New Kent County, Virginia – 37.5640, -77.0462) did not result in findings of sand boils. Luck Stone Corporation (prominent aggregate supplier) owns a ~700 acre environmental banking facility in this vicinity and the geologic professional that measures ground water levels (i.e., who transects the site on a regular basis) did not identify the presence of sand boils. Additionally, calls to WSSI (Wetland Studies and Solutions, Inc., Gainesville, Virginia) alerted their staff to look for sand boil features on their wetland banks. Their wetland banks are primarily in the Piedmont (i.e., where loose

sand is confined to riparian alluvium) and their field staff did not observe sand boils during their ongoing field work.

River Bank Slumps

Through conversations with the staff of the James River Park System, no observations of river bank slumps or sand boils were noted in Richmond or to the east.

Rockfalls

The study area of Richmond and Eastern Virginia includes a few rock outcrops and rock cuts. No rock falls were associated with the earthquake within this region.

Luck Stone Corporation did not report loss of support within their pits or other geologic hazards stemming from the earthquake. Luck Stone did report that the earthquake triggered their monitoring systems used to monitor blasting-induced vibrations. Luck Stone uses a third party to perform seismic monitoring and their consultant has assembled the results from about ~200 monitoring stations triggered by the event. Such monitoring stations are located in quarry sites owned by various aggregate producers and will be available to the GEER team when compiled.

Bridges

Following the earthquake, Virginia Department of Transportation (VDOT) mobilized over 300 personnel to perform inspections on eight tunnels and over 700 bridges. The VDOT inspection program included the 238 structures that were identified in a 1994 study of earthquake-sensitive structures. The initial VDOT inspection program included an assessment of unusual orientation/movement (i.e., variation in sight-lines at deck joints or along the length of the structure); bearings at abutments and piers; signs of distress to the structure or substructure; and, utilities attached to the structure. From this initial review, four structures were identified for in-depth inspections. While no bridges were found to be structurally unfit for continued use, VDOT noted the following:

- Courthouse Road (Route 208) over South Anna River (37.98064, -78.04818) – Slight longitudinal movements;
- Courthouse Road (Route 208) over Interstate I-64 (37.94017, -78.10846) – Slight longitudinal movements;
- Parish Road (Route 683) over Interstate I-64 (37.89477, -78.04297) – Concrete spalling of barrier end wall;
- Courthouse Road (Route 1) over Hazel Run (38.28778, -77.48687) – Pier column cracking up to 15 mm wide (this is a City of Fredericksburg bridge).

Figures 5-3 through 5-7 show representative observations from VDOT bridge inspections.



Figure 5-3 Courthouse Road over South Anna River - displacement of railing (37.98064, -78.04818).



Figure 5-4 Courthouse Road over South Anna River - bearing displacement (37.98064, -78.04818).



Figure 5-5 Parish Road over Interstate I-64 –spalling (37.89477, -78.04297).



Figure 5-6 Route 1 over Hazel Run- horizontal cracks at Column 4, Pier 1 (38.28778, -77.48687).



Figure 5-7 Route 1 over Hazel Run – horizontal crack at Column 3, Pier 1.

Power

There was no reported loss of power within the Richmond and Eastern Virginia Region as a result of the earthquake.

Water

There was no reported loss of water within Richmond and Eastern Virginia Region as a result of the earthquake.

Railroad

There were no reports of railroad damage within the Richmond and Eastern Virginia Region as a result of the earthquake.

Dams

There were no reports of damage to embankment dams within the Richmond and Eastern Virginia Region as a result of the earthquake.

Slopes

There were no reports of slope movements or failures within the Richmond and Eastern Virginia Region as a result of the earthquake.

Landfills

Calls to Allied Waste (owners and operators of the Old Dominion Landfill at 37.5077, -77.3744) indicate that there were no observations of distress or unusual effects stemming from the earthquake. This facility was designed in accordance with current regulations, which include considerations for seismic events.

Calls to Henrico County (owners of their own landfill facility at 37.6807, -77.5652) indicate that there were no observations of distress or unusual affects stemming from the earthquake. This facility was also designed in accordance with the current regulations.

Buildings and Foundations

Limited structural damage was observed in buildings of the Richmond and Eastern Virginia region. In preparation of this brief summary, calls to the Virginia Department of General Services show that structural damage was not noted in any of their buildings. There was one observation of distress in an architectural item – the exterior cladding of the State Corporation Commission building (37.5366, -77.4322) realized minor cracking. This is a non-structural building component that may have become compressed against the stair well of the building during ground motion. Calls to local consulting structural engineers and building owners show that multiple building condition surveys did not disclose structural damage as a result of the earthquake. These building condition surveys include areas west of Richmond, such as “West Creek” (37.6281, -77.6613) and “Innsbrook” (37.6556, -77.5821) office parks. In some instances, minor drywall cracking was noted. One such observation was noted at a warehouse building in Fredericksburg, Virginia (38.2723, -77.4619) where drywall cracking was noticed at the mezzanine level.

In Port Royal, Virginia, the St. Peter's Church experienced some measure of distress from the earthquake. Discussions with local structural engineers indicate that minor cracking was noted on the parapet wall.

Goochland County

Goochland County completed inspections of 28 properties, including private residences, cell phone towers, churches and commercial buildings. For the case of residences, there were typical reports of foundation and stress cracks. There was only one instance (5735 Broad Street Road, Maidens, Virginia at 37.7201, -77.8259) where the residence was deemed "do not occupy" owing to chimney shifting, concern about brick veneer failure and loss of support in a basement beam.

Henrico County

Henrico County completed inspections of 13 residential properties, based on citizen concerns. Typical findings include, "possible aggravation of existing foundation issues," blockwork cracking, brick veneer cracks and in one instance a slab-on-grade crack that resulted in in-slab water-line leakage (37.6664, -77.5173). At the location of 3245 Gurley Road (37.6259, -77.5356) the inspection report notes cracking in concrete masonry unit and/or brick basement walls and chimneys.

Henrico County officials also completed inspections of their public office and school buildings. Of these self-performed inspections, some apparent cracking was noted in the masonry walls at the Technical Center of Highland Springs High School (37.5402, -77.3241). Some of these cracks appeared to be possibly earthquake related while many appeared to be related to settlement and temperature cracking. County inspectors also noted some masonry cracks in each of the three stairwells of the Eastern Henrico School Administration Building (37.5544, -77.3829). All of these masonry cracks were minor in nature and require raking out the mortar joint and re-pointing as a repair procedure.

City of Richmond

The City of Richmond responded to calls from citizens in the aftermath of the earthquake. The City has not provided a listing of their inspections; however, of those inspections the extent of damage was slight, and no homes were deemed unsafe to occupy.