Mountain Valley Pipeline Project

Docket No. CP16-10-000

Attachment DR5 Geology 1a

March 2017

Response:

Accession number 20161222-5394 (Commonwealth of Virginia) was submitted to the FERC by the Virginia Department of Conservation and Recreation (DCR), and included a comment letter from the Virginia Cave Board (VCB) that highlighted concerns over specific karst features in the vicinity of the proposed alignment. The VCB's primary focus in the letter was to encourage dye trace studies for many if not all of the karst areas crossed by the pipeline to determine subterranean flow paths. The VCB also suggested a more extensive inventory of karst features beyond the prescribed 0.25-mile buffer, particularly in zones of influence of surface runoff. Additionally, the VCB recommended continuous water quality monitoring to replace Mountain Valley's proposed pre-construction (grab) sampling discussed in the Water Resources Identification and Testing Plan.

The VCB questioned the 500-foot employed by Mountain Valley to identify water resources in karst terrain that are recommended for pre-construction testing. However, the 500-foot criterion is not a limiting buffer distance, but rather a guideline from which Mountain Valley may increase under certain karst conditions assessed by the Mountain Valley Karst Specialist Team (KST) and documented in the Karst Hazards Assessment (KHA) to select water resources that are further from a Project component. In several cases, Mountain Valley has identified springs to be monitored that are well beyond the 500-foot buffer distance from a Project component (e.g., spring on Kow Camp Road, Giles County, Virginia; KHA).

Mountain Valley's KST has an in-depth understanding of likely groundwater flow paths in the areas of concern identified by the VCB, based on the KST's combined 160-plus years of experience in assessing karst hydrogeology, particularly in the karst terrain traversed by the proposed alignment, in addition to the analysis of existing dye trace studies for the area and conducting electrical resistivity surveys along the proposed alignment in the Mount Tabor area. Therefore, Mountain Valley does not concur with the VCB's recommendation for completing extensive hydrologic research in the specified karst areas. The flow patterns can be extrapolated from existing knowledge of the areas. For example, the Mount Tabor sinkhole plain drains to Mill Creek Spring. There is no need to trace every sinkhole or sink point within the sinkhole plain.

Also, many of the small sinkholes on ridges and hilltops in the vicinity of the alignment have very limited catchment other than the sink themselves, and therefore possess limited risk to underlying karst hydrogeology.

The VCB identified several specific areas of karst terrain where dye tracing was suggested. These areas are listed below, with the Karst Hazards Assessment (Appendix A sheets identified illustrating the areas.

VCB-recommended Features or areas in Virginia along MVP for which hydrology studies (dye tracing) is advised:

- 201.66 (2 features) – (Sheet 10);
- 205.02 (Eight Point Cave) and 205.20 (High Voltage Cave) – (Sheet 13);
- 209.10 (Sheet 17) and 209.75 (Sheet 18);
- 215.24 (Sheet 23) and 216.22 (Sheet 24) and 216.52, 217.13 (Sheet 25) and 218.15 (Sheet 26);
- 223.33, 223.34, 223.46 (Sheet 28) –a single dye trace or possibly 2;
- 224.00 (Sheet 29);
- 226.20 (Sheet 31) -consistent with dye traces by DCR-DNH as cited;
- 226.89 (Sheet 32);
- 227.57 (Sheet 32); and
- 234.43, 234.73, 235.13 (Sheet 34).

Each area listed above is discussed in the following section, some areas are grouped together for continuity. The local karst hydrogeology is discussed, and recommendations are provided on whether, or what, additional information is recommended by Mountain Valley to provide additional confidence in characterizing the local hydrology with respect to the proposed pipeline construction. Maps associated with the discussion for each area are identified in that discussion, and found as Attachment DR5 Geology 1b.

VCB item: 201.66 (2 features) – (Sheet 10)
See Figure 1 of 7 in Attachment DR5 Geology 1b

The VCB references a group of sinkholes straddling and adjacent to Big Stoney Creek Road near MP 201.66. These sinkholes lie along a small hill between the New River and Butt Mountain. The larger of the sinkholes is about 25 acres in size and is bisected by Big Stoney Creek Road (State Route.635). This road is used extensively by trucks associated with the active mining operations for the Lhoist Chemical lime plant, Kimballton, Virginia. The ground surface of these sinks in the vicinity of the alignment is covered by sandstone colluvium. The location is also between two high voltage transmission lines. A second large abandoned stone quarry, Klotz Quarry, is located one mile southwest.

The subsurface flow direction from the vicinity of these sinkholes is most likely along strike to the southwest toward the New River. This southerly groundwater flow would likely intersect the Dry Branch subterranean flow. Dry Branch sinks in its bed just over a mile south-southeast and resurges at a spring on the New River. This was dye traced by the DCR in 2002 (see map 1).

The VCB also mentions nearby access roads. The access road in the vicinity of the sinkholes follows Hoot Owl Road, which serves a residence and is the access to an APCO electric substation adjacent to the alignment at MP-201.4. The other access road mentioned by the VCB, near MP 200.50, is along an existing road in the Lhoist limestone quarries. Negligible impacts are anticipated from the use of these existing roads.

Based on field observations, the geologic setting, strike and dip of the bedrock, and proximity of a previous dye trace, little additional information would be provided with

respect to the overall understanding of the local karst hydrogeology by tracing these sinks or others in this general vicinity.

VCB item: 205.02 (Eight Point Cave) and 205.20 (High Voltage Cave) – (Sheet 13)
Figure 2 of 7 in Attachment DR5 Geology 1b

The VCB calls out a location where the proposed alignment crosses the southwest ridge of Doe Mountain and where it overlies limestone that outcrops near the top of the ridge. In very typical fashion for Giles County where the bedrock strata tend to dip southeast into the mountain, two caves have formed near the geologic contact of the Moccasin siliciclastic sedimentary formation and the conformably underlying limestone. However, at this location there is limited contributing watershed because of the high position on the ridge. The proposed alignment deviates to avoid these features, then bypasses a third cave feature as the alignment progresses southeast down the mountain side.

Groundwater flow in this area is most likely to the southwest along bedrock strike toward Little Stoney Creek. It is likely that the subterranean flow discharges into the alluvial deposits underlying the creek, from which it could flow southerly in alluvium to the nearby New River, or it could flow along a prominent west-trending lineament to Klotz Spring. A dye trace conducted by DCR in 2002 from a swallet on the west side of Little Stony Creek confirms some degree of flow along this lineament, which lies along the contact of the limestone and the overlying Eggleston formation.

This assessment of flow is based on existing knowledge, decades of experience studying karst hydrogeology in this area, previous DCR dye testing, and sound fundamentals of hydrogeology. Dye trace study is not needed to confirm what is the most reasonable assessment of subterranean groundwater flow.

The Mountain Valley KST identified a water supply spring in the dolomite near Kow Camp Road approximately 1,900 feet south of and 100 feet topographically below the proposed alignment stream crossing at MP 205.3. Mountain Valley will be contacting the property owner in mid-2017 to request permission to conduct pre-construction testing of the spring as part of the Water Supply Identification and Testing Plan.

VCB item: 209.10 (Sheet 17), 209.75 (Sheet 18)
Figure 3 of 7 in Attachment DR5 Geology 1b

The VCB notes two sinkholes features in the vicinity south of Cave Hill Road. The first is a large, dry, forest floored and unaltered sink near MP 209.10. The second is a collection of sinks near MP 209.80, some of which have been partially filled with field rock over the decades as a result of traditional pasture clearing. These locations are just south of the well-known Pighole Cave (Mountain Valley completed a major realignment of the proposed route to avoid Pighole Cave, and is now 1600 feet south and downgradient of the cave). Pighole Cave is a 428-foot deep vertical cave (total vertical extent). The lowest point of Pighole Cave is at an elevation of approximately 1,865 feet above mean sea level (AMSL) where a small stream disappears under the wall and can no longer be humanly followed. This confirms that local groundwater base level is at least

lower than this point and there is a downward flow gradient well below the sinkholes identified by the VCB and toward Sinking Creek at an elevation of approximately 1,800 feet AMSL. The regional subterranean flow pattern is to the west-southwest along strike towards the New River, more or less trending with the direction of Sinking Creek.

In 1981 Saunders, et. al. traced a sinking stream, just northeast of this area, near Mountain Lake Road. A trace during low flow went to the resurgence of Sinking Creek on the New River to the west-southwest. A trace during high flow went to Bell Spring, also on the New River but slightly farther north. These springs are over four miles away from our site of discussion. During dry periods Sinking Creek flows underground from a point just west of its crossing with US-460 and it resurges about a mile upstream on the New River on its wet weather surface flow path junction with the New River. Bell Spring is about a half mile downstream of the Sinking Creek surface flow junction on the New River. An interpretation of this high/low flow condition difference is that the lower conduit flow network closer to the New River becomes full and the water flows over a drainage divide to the north and the next outlet downstream, which is Bell Spring.

The KST suggest that the Saunders et al (1981) traces would have passed several hundred feet below the MVP alignment en route to known resurgence.

A dye trace study is not needed to confirm what is already the most reasonable conclusion about subterranean groundwater flow paths as shown by previous dye studies. And, as noted, the proposed alignment entails excavating an approximate 10-foot ditch that would be 200 or more feet above the flow path identified in the Saunders et al (1981) trace. Practically speaking, little information would be gained by tracing these sinkholes relative to pipeline construction, and proper dye studies would likely be focused two miles to the west of the MVP route.

Literature Cited

Saunders, J.W.; Ortiz, R.K.; and Koerschner III, W.F., 1981, Major groundwater flow directions in the Sinking Creek and Meadow Creek drainage basins of Giles and Craig Counties, Virginia, USA., in Beck, B.F. (editor), Proceedings of the Eighth International Congress of Speleology, Bowling Green, Kentucky, July 18-24, 1981.

VCB item: 215.24 (Sheet 23), 216.22 (Sheet 24), 216.52, 217.13 (Sheet 25), 218.15 (Sheet 26)
Figure 4 of 7 in Attachment DR5 Geology 1b

The proposed alignment follows the northwest flank of Sinking Creek Mountain, in the lowland valley underlain by dolomite or limestone depending upon its position, and is generally 100 to 200 feet in elevation above Sinking Creek (i.e., the localized groundwater discharge zone) (see Sheet 23 of 37). The exception to this relative positioning of the proposed alignment is the major alignment adjustment that avoids the Canoe Cave and associated spring near MP 214.9 (Sheet 23 of 37 of the Mountain Valley Karst Hazards Assessment). Mountain Valley followed the recommendation of FERC

and adopted a re-route of the proposed alignment centerline to avoid Canoe Cave by 950 feet (Sheet 23 of 37).

There is effectively no risk for disturbing the physical portions of the cave since the construction right of way (ROW) is separated by approximately 800 feet from the mapped extent of the cave (Figure 4). The extent of Canoe Cave was confirmed as recently as 2016 by field mapping conducted by the Virginia Department of Conservation and Recreation. The cave trends northeast and along bedrock strike approximately 600 feet (Figure 4). A large buffer of undisturbed land (approximately 800 feet) will be maintained between the edge of the construction right-of-way and the Canoe Cave. Furthermore, the proposed alignment in the vicinity of Canoe Cave is situated on previously cleared farmland such that additional tree-clearing will not be necessary near the cave and spring and this greatly reduces the potential for impact to the local hydrology.

The cave encounters subsurface pools of standing water at the approximate elevation of the spring (Figure 4). These pools located in Canoe Cave are at the elevation of the spring, appear to represent the local water table, and are likely connected to the subterranean karst flow regime of the localized catchment for Canoe Cave. The air-filled section of Canoe Cave (i.e., between the entrance and the above-referenced water pools) does not host perennial flowing water.

The proposed route is topographically lower than the spring associated with Canoe Cave and crosses the spring outflow approximately 370 feet downstream of the spring itself (see Figure 4). As with numerous springs along Sinking Creek, it represents the local groundwater base level or water table of the local karst drainage networks. Allogenic recharge to the karst system(s) in the vicinity of Canoe Cave is typically found topographically higher on Sinking Creek Mountain, at the upper limestone contact (Figure 4). The proposed alignment construction entails an approximately 7-foot to 10-foot narrow excavation that is downslope and downgradient hydrologically from Canoe Cave and spring and as such will not affect the cave or spring (see enclosed Figure 4).

The following discussion presents an assessment of the larger karst catchment and potential allogenic recharge to Canoe Cave and the associated spring. While the surficial karst features observed in the area of Canoe Cave and its catchment (i.e., sink holes, losing streams) are important contributors to the local groundwater hydrology and possible recharge to the cave, there is a larger groundwater hydrologic system underlying this area that receives recharge from the catchment (i.e., not all precipitation that falls on the catchment necessarily recharges Canoe Cave and spring).

The following discussion summarizes Mountain Valley's hydrogeologic assessment of the karst terrain northwest of Sinking Creek Mountain that is part of the Canoe Cave catchment.

Approximately 6,400 feet northeast of Canoe Cave, along bedrock strike, there is a small insurgence cave in the limestone approximately 240 feet southeast of the alignment,

Sinking stream #1, near MP-216.2 (Figure 4). This feature was discovered during field reconnaissance completed as part of Mountain Valley's Karst Hazards Assessment. It is most likely the primary source of water for the spring near Canoe Cave. This area is potentially near the upstream edge of the majority catchment for the spring near Canoe Cave because just further northeast is another spring near Steele Acres Road. Presumably, this spring near Steele Acres Road would drain the catchment that is further northeast of the Canoe Cave and spring catchment (i.e., a separate catchment) and includes an insurgence near MP-218.1 (Figure 4), which is near the point where the alignment turns southeast to cross Sinking Creek Mountain. With this understanding of the larger karst catchment relative to Canoe Cave, the proposed pipeline construction is topographically and hydrologically lower than the primary (allogenic) water sources that feed the springs along the flank of the mountain. Therefore, the location of the proposed alignment relative to the catchment results in negligible risks to karst features and hydrology related to Canoe Cave and spring.

Additional contribution to the spring located west of Canoe Cave comes from several small sinkholes along the upper limestone contact between the general area of Canoe Cave and the aforementioned insurgence at MP-216.2 (Figure 4). These sinkholes were observed during initial field reconnaissance for Mountain Valley's Karst Hazards Assessment. No sink openings or surface water flow to the sinks was observed during field reconnaissance; however, the geographic and geologic location suggests that these are points of infiltration for precipitation (allogenic recharge) that may contribute to Canoe Cave and spring. However, these sinkhole locations are topographically and hydrologically above the proposed alignment (i.e., pipeline construction will not adversely affect hydrology recharging the Canoe Cave and spring) (Figure 4).

Other sinkholes in the Canoe Cave catchment and adjacent areas were considered for this analysis. Near MP 215.0, and continuing along just north of the Canoe Cave and spring are a few sinkholes (Figure 4). The largest sinkhole, which is also the one closest to the Canoe Cave spring contains farm refuse, apparently deposited in the sinkhole over many years. The other sinkholes are much smaller and are situated well away from the proposed alignment. Another insurgence identified as Sinking stream #2 near 216.5 (Figure 4) also contains many years of farm refuse, scrap metal, and old tires. However, a constructed ditch (presumably for farm use) directs water away from Sinking stream #2 (Figure 4). Sinkholes further to the northeast, toward the Giles and Montgomery County line at MP 217.0 (Figure 4) likely accumulate wet weather recharge and will be avoided or mitigated as specified in the Karst Mitigation Plan. Another karst feature of note is the insurgence at MP 218.1 (Figure 4), located approximately 50 feet lower in elevation and down a steep ravine just beyond the point where the alignment turns south to cross Sinking Creek mountain. As a sinking stream feature, water flowing underground near this location will rapidly seek the local water table, which is approximately 100 to 200 feet lower than the ground surface and will not be affected by pipeline construction.

The Mountain Valley KST's detailed understanding of Canoe Cave karst hydrology means that in the highly unlikely event of construction-related release of fluid or

sediment the likely receptors to be monitored and mitigated are known (i.e., there is no need to conduct a dye trace study). In addition to understanding the local karst hydrology, Mountain Valley will conduct pre-construction outreach directly to property owners along the alignment to request information on springs and wells in the local catchments, and request permission to conduct pre-construction water quality and quantity testing. Through these measures, Mountain Valley will possess an accurate accounting of water supply locations for future monitoring in needed. Furthermore, in the unlikely event of a release, Mountain Valley will immediately implement mitigation measures specified in the Karst Mitigation Plan, SPCC Plan, and E&S Plan to prevent infiltration or migration of construction related fluid or sediment from the limit of disturbance and entering the karst or a karst feature, thus protecting the subsurface karst environment.

In summary, the proposed alignment poses negligible risk for impacts to Canoe Cave and spring, and other related karst features and resources in the vicinity due to the location of the proposed alignment being both topographically and hydrologically below (at lower elevations) than these karst features.

VCB item: 223.33, 223.34, 223.46 (Sheet 28) –a single dye trace or possibly 2.
Figure 5 of 7 in Attachment DR5 Geology 1b

The VCB identifies an area of concern containing sinkholes just south of Mount Tabor Road. In late 2016 DCR conducted a dye trace from a sinkhole in this vicinity but just north of the road. The trace flowed southwest paralleling a sinkhole lineament to Slussers Chapel Cave and related hydrologic complex thus extending the proven subsurface catchment to this saddle between Mill Creek and Dry Run surface watersheds.

The sinkholes in question are within a few hundred feet of each other and the DCR dye trace, thus it is highly likely the flow pattern will be the same. The elevation change from the DCR dye input to the spring is approximately 400 feet, though it passes through Slussers Chapel Cave achieving a depth range of about 315 feet at that location. Based on knowledge of karst development demonstrated by the caves of the area, the KST reasonably interprets that water infiltrating the bedrock in this vicinity will also drop rapidly downward toward base groundwater level.

Based on this evidence, which expands and confirms the understanding of subterranean flow in the Mount Tabor area by the KST, additional dye trace studies are unnecessary and redundant, especially immediately adjacent to a recent study.

VCB item: 224.00 (Sheet 29)
Figure 5 of 7 in Attachment DR5 Geology 1b

Small sinkholes with little or no catchment area are located near the top of the hills and ridges near MP 224 identified by the VCB. These small sinkholes are almost indiscernible in the LiDAR data. They likely represent more of a coarse bedrock surface than a well-developed karst process. This is also the location of recent high-grade logging operations and is just beyond the DCR Slussers Chapel Conservation Site. Precipitation

that does not flow on the surface to lower elevations will enter the ground in a diffuse manner. The alignment carefully avoids the sinkhole(s) in this area and Mountain Valley anticipates no impact to the karst environment as a result of crossing the ridge at this location. Practically speaking, little information would be gained by attempting to trace these sinkholes relative to pipeline construction.

VCB item: 226.20 (Sheet 31) -consistent with dye traces by DCR-DNH as cited.
Figure 6 of 7 in Attachment DR5 Geology 1b

A large sinkhole located east of the alignment near MP 226.3 is called out by the VCB. The alignment traverses the edge of the catchment for this sinkhole. The sinkhole is approximately 500 feet in elevation above the base level flow pattern that was identified by DCR dye traces. The KST suggests that precipitation received by the sinkhole and general karst infiltration in this area will ultimately join these identified flow patterns and discharge at Old Mill Cave Spring, Dam Spring, or Hancock Spring. This is the most reasonable interpretation of subterranean flow based upon the KST's decades of experience, and would make dye tracing at this location of limited value. Mountain Valley anticipates negligible impact to the karst environment resulting from crossing the hill at this location.

VCB item: 226.89 (Sheet 32)
Figure 6 of 7 in Attachment DR5 Geology 1b

At this location the VCB highlights a linear sinkhole feature that trends toward a small spring that was of concern with the close proximity of the previous FERC 4.0.0 proposed alignment. The current proposed alignment is about 2000 feet northeast further away but still crosses the aligned set of sinkholes. These sinkholes are formed along bedrock strike adjacent to a narrow and unmapped shale stratum. This shale layer likely acts as an impervious barrier that guides subsurface flow along the carbonate-shale contact to the southwest to discharge at the small spring. The location where the current alignment crosses the lineament it is at an elevation approximately 100 feet higher than the spring. Construction activities here are much less likely to impact the spring than if they were immediately above the spring. The KST believes that groundwater would flow along this lineament to the spring and possibly to the base level discharge point which is Hancock Spring. This is the most reasonable flow interpretation, based on decades of experience. Dye tracing this sinkhole alignment to the spring would provide little relevant information in the context of pipeline construction.

VCB item: 227.57 (Sheet 32)
Figure 6 of 7 in Attachment DR5 Geology 1b

On the southeast side of the North Fork of the Roanoke River is the final karst-forming carbonate outcrop in the Mount Tabor – Catawba Road area where a small surface stream sinks at the contact between the Edinburg Limestone and the non-carbonate Bays Formation. Subterranean water is expected to flow southwest, generally in alignment with three sinkholes and through Johnsons Cave, to discharge at Johnsons Cave Spring

on the North Fork of the Roanoke River. The total estimated direct line flow distance of the localized network is approximately 2,500 feet.

The alignment crosses this small stream in non-karst terrain approximately 930 feet uphill from the swallet. During wet periods this stream overflows its sink point and continues to the River by overland flow. Thus, during construction, there may not be flowing water and/or there is ample distance for appropriate erosion and sediment control measures. Similarly, a potential wet weather swallet was observed just west of MP 227.55. This streambed was dry at the time of field visit by the KST.

At the time of field visit on October 21, 2015 this west stream at MP-227.55 was dry and the east stream was flowing. The USGS shows both streams as intermittent. During very wet periods both streams overflow their sink points and continue to the North Fork of the Roanoke River by overland flow as is evidenced by observing the stream beds. The sink point locations are below the contact between the Edinburg limestone and the non-carbonate Bays formation. For both sink points the KST suggests the subterranean water flows westerly along strike and coincident with the aligned sinkholes, through Johnsons Cave, and out at Johnsons Cave Spring.

The KST suggests that the surface and subsurface flow patterns described above are the most reasonable interpretation of local conditions. Dye tracing the swallet described above would provide little relevant information in the context of pipeline construction, and would only confirm what is a relatively uncomplicated karst setting.

VCB item: 234.43, 234.73, 235.13 (Sheet 34)
Figure 7 of 7 in Attachment DR5 Geology 1b

The VCB's final area of interest regards a small section of Elbrook limestone observed by the KST between Interstate-81 and the Roanoke River. In particular, at MP 234.43 a very small stream swallet was observed on July 15, 2016 approximately 140 feet southeast of the proposed alignment within a topographic drainage alongside Cannery Road. In wet weather, this drainage joins a small intermittent stream approximately 600 feet further to the southeast. This stream includes drainage from storm water culverts under and alongside Interstate-81. In this vicinity, the proposed alignment parallels a high voltage electric power line corridor as it crosses a short section of karst exhibiting numerous small sinkholes that likely indicate a pinnacle/cutter type bedrock surface. These sinkholes are on the scale of three to six feet in diameter and approximately one foot deep. These sinkholes are not revealed in Montgomery County's 2015 high resolution LiDAR data. The proposed alignment continues to the southeast and was routed to avoid several sinkholes before traversing the Norfolk Southern Railroad, the Roanoke River, and US Route 11.

The sinkholes in the area are formed on the top of a small ridge and have little or no catchment beyond their edges. Precipitation infiltration therefore is predominantly diffuse from the surface to the local water table. At present no springs are known to exist along the base of the ridge. The KST suggests that attempting to demonstrate a flow path from

the top of the ridge to the flood plain along the river at the base of the ridge would provide little or no useful information in the context of pipeline construction.

Practical issues concerning dye tracing:

There are several practical problems associated with many of VCB's suggestions for dye tracing. Foremost is access to dye injection and monitoring locations. Most of the property owners in the areas under discussion by VCB are reticent to allow access to their property, and would likely be less inclined to allow repeated visits for dye trace monitoring studies. Many of the sinkholes noted by the VCB are in forested areas located far from roads, therefore access for a water truck to facilitate injection of dye would be limited. Furthermore, for several of the areas there are no known springs and many properties would have to be contacted in order to search for such locations to monitor for dye emergence. Some of the large known springs that act as major karst resurgences are likewise on other properties quite distant from MVP activities. In addition to these obstacles, the potential benefit is limited for assessing pipeline construction issues. It is also noted that dye traces are not always conclusive and more likely than not would provide no clear resolution to the VCB's stated concerns.

The VCB-suggested Sinking Creek Mountain Variation:

The VCB suggested that the proposed alignment from approximately MP-214.7 to MP-218.1, which traverses pastureland on the low north-west flank of Sinking Creek Mountain be moved over the ridge and onto the National Forest on the southeast side of Sinking Creek Mountain. Mountain Valley considers this suggestion to not be viable from an engineering and construction standpoint due to side slope conditions. Mountain Valley seeks to minimize tree clearing along the proposed alignment, as well as minimize changes to current land use, which would be required to establish the route in the National Forest.

The VCB recommends more stringent watershed basin delineation:

The Mountain Valley KST provided a discussion above on the most reasonable interpretation of surface and subsurface flow directions in karst terrain areas of concern pointed out by the VCB. Those portions of watersheds (above or below ground) that are upgradient from the proposed alignment, with respect to flow, are not at risk. Mountain Valley suggests that formal watershed basin delineation would provide little relevant information in the context of pipeline construction.

The VCB recommends additional water source testing:

The Water Supply Identification and Testing Plan establishes the criteria for property owner outreach, data gathering and testing of water sources (including springs) along the proposed alignment, including karst terrain. The Plan is currently being implemented in the northern and southern extents of the proposed alignment. In the karst areas of the alignment, property owner outreach and water source identification, assessment and testing will commence in mid-2017. This Plan directs Mountain Valley to complete a comprehensive and relevant water resource assessment and testing program. Many

property owners have not granted Mountain Valley permission to access their property, which is also anticipated for water resource testing.

The VCB charges the DEIS does not document channels terminating in swallets:

Please refer to the table provided below that identifies karst swallets more than 500 feet from the proposed alignment and spring outlet.

Downgradient Karst Swallets Identified More Than 500 feet from the Proposed Alignment and Spring Outlet

County	Swallet Name	MP	Approximate Distance (miles)	Spring / Resurgence
Giles	Sink on Dry Branch	202.3	0.6	Klotz Spring (traced DCR)
Giles	Losing stream and/or sinks	207.2	1	Bell Spring (most likely)
Giles	Losing stream and/or sinks	207.4	0.8	Bell Spring (most likely)
Giles	Losing stream and/or sinks	207.8	1	Bell Spring (traced DCR)
Giles	Sinks of Sinking Creek	211.1	3	Rise of Sinking Creek (traced, Saunders)
Giles	Swallet in sinkhole filled with farm refuse	216.5	0.13	Spring at Steele Acres Road (most likely as only 370 feet away)
Montgomery	Slussers Chapel Cave	221.9	0.6	Mill Creek Spring (traced DCR)
Montgomery	Mill Creek sink point 1	222.4	0.4	Mill Creek Spring (traced DCR)
Montgomery	Mill Creek sink point 2	222.85	0.12	Mill Creek Spring (traced DCR)
Montgomery	Swallet near Johnsons Cave	227.7	0.17	Johnsons Cave Spring (most likely)

The VCB charges that the DEIS fails to adequately identify karst features:

The VCB states in its letter:

> "*FERC relies upon the applicant's desktop review of publicly available data to identify 94 instances of karst features within Summers and Monroe Counties, West Virginia and Giles, Craig, and Montgomery Counties, Virginia. That review is limited to areas within ¼ mile of the MVP Filing Alignment. FERC describes these features as "sinkholes, caves, and caverns." That level of review is far too narrow and fails to account for portions of the karst system beyond mapped caves and the most obvious surface features. Because the DEIS fails to identify and assess impacts to the broader karst system, it does not comply with NEPA."*

The KST established a 0.25-mile karst review buffer (noted as the secondary karst buffer in the Karst Hazards Assessment) as a guideline. In some locations, it is more than enough to adequately catalogue and describe karst. In other locations, the KST included features well beyond the 0.25-mile buffer. Some notable examples of karst delineation beyond the 0.25-mile buffer are features in the Mount Tabor area such as Slussers Chapel Cave, Mill Creek Spring, Old Mill Cave Spring, as well as insurgences on Dry Branch. Beyond just sinkholes and caves, the KST observations have included water insurgences (swallets), losing streams, resurgences (springs), seeps, and small limestone quarries. The KST also identified faults and fractures in the field along with various contacts between geologic units. Throughout the Project the KST considered the full extent of the karst

hydrologic system and based the assessments on the KST's combined decades of experience in assessing karst terrain in the areas traversed by the proposed alignment.

In conclusion, based on the nature of construction, controls to be implemented by Mountain Valley, and on the nature of karst terrain, Mountain Valley considers the primary risk to karst hydrology (this is generally applied to all karst terrain, for any construction project) to be potential sediment release and transport along autogenic recharge pathways. In the vicinity of the valley floor northwest and parallel to Sinking Creek Mountain (the larger karst catchment is shown in Figure 4), several alignment adjustments were made to avoid sinkholes, swallet, and losing streams to the extent possible. Where a flowing stream is crossed by the proposed alignment that may subsequently sink into karst terrain, stringent stream crossing measures will be taken to ensure that the stream is not degraded (this applies to any location in karst terrain). The Mountain Valley Karst Mitigation Plan, and karst-specific Erosion and Sediment Control Plan specify avoidance and mitigation measures to prevent sediment release to karst features. To put this in the proper perspective, sediment migration in karst terrain occurs routinely with every precipitation event, regardless of the presence of the pipeline. Mountain Valley will take all reasonable and necessary actions to prevent any additional sediment migration in karst terrain from construction beyond what is already naturally occurring.

Mountain Valley will deploy the KST as construction inspectors in karst terrain during all phases of construction where karst terrain traversed by the proposed pipeline. The KST will monitor construction to ensure that karst features are identified and protected during construction and in the highly unlikely event of a construction-related fluid or sediment release.