APPENDIX L
Karst Mitigation Plan

KARST MITIGATION PLAN

Prepared for:

Mountain Valley PIPELINE

Mountain Valley Pipeline

Suite 1700

625 Liberty Avenue

Pittsburgh, PA 15222-3111

February 2017

Revised September 12, 2017

Prepared by:

Draper Aden Associates
Engineering • Surveying • Environmental Services

DAA Project Number: B14188B-01

Draper Aden Associates (DAA) prepared this document (which may include drawings, specifications, reports, studies and attachments) in accordance with the agreement between DAA and MVP Gathering, LLC.

The standard of care for all professional engineering, environmental and surveying and related services performed or furnished by DAA under this Agreement are the care and skill ordinarily used by members of these professions practicing under similar circumstances at the same time and in the same locality. DAA makes no warranties, express or implied, under this Agreement in connection with DAA's services.

Conclusions presented are based upon a review of available information, the results of our field studies, and/or professional judgment. To the best of our knowledge, information provided by others is true and accurate, unless otherwise noted.

DAA's liability, hereunder, shall be limited to amounts due DAA for services actually rendered, or reimbursable expenses actually incurred.

Any reuse or modification of any of the aforementioned documents (whether hard copies or electronic transmittals) prepared by DAA without written verification or adaptation by DAA will be at the sole risk of the individual or entity utilizing said documents and such use is without the authorization of DAA. DAA shall have no legal liability resulting from any and all claims, damages, losses, and expenses, including attorney's fees arising out of the unauthorized reuse or modification of these documents. Client shall indemnify DAA from any claims arising out of unauthorized use or modification of the documents whether hard copy or electronic.

TABLE OF CONTENTS

1.0 INTRODUCTION

This **Karst Mitigation Plan** addresses the assessment and mitigation of potential hazards associated with land disturbance in karst terrain to support Mountain Valley Pipeline (MVP) construction, and post-construction monitoring. Hazards include the potential to impact sensitive karst features during construction, as well as potential hazards presented to pipeline construction and operation associated with karst terrain.

Karst feature assessment and mitigation efforts that are covered in this plan will take place within the limits of land disturbance (LOD) along the MVP alignment that is underlain by karst terrain. The LOD is identified in this Plan as an area within the MVP construction easement where ground cover is removed or where the grade is altered, through MVP construction activities (clearing and grubbing, trenching, blasting, boring or drilling). It is noted that MVP does not plan to utilize horizontal directional drilling (HDD) in karst terrain.

The post-construction monitoring portion of this Plan is designed to surveil the alignment for potential land subsidence that may be associated with an activated subsurface karst feature once reclamation actives are completed and the pipeline is brought into operation. Potential mitigation measures are also discussed in this Plan.

Karst terrain occurs from southern Summers County, West Virginia into Roanoke County, Virginia along an approximately 33-mile corridor (although karst terrain is not contiguous) within which the MVP alignment is proposed for construction (**Figure 1**). Note that karst terrain is not continuous throughout the karst zone illustrated in **Figure 1**. The Appalachian Plateau and Valley and Ridge geologic provinces are characterized by Mississippian to Ordovician age sedimentary bedrock, with folding and ancient thrust faulting resulting in a complicated distribution of rock types through this region. Siliciclastic sedimentary bedrock that does not form karst terrain is interbedded, or otherwise in contact with karst-forming carbonate bedrock.

The **Karst Hazards Assessment** (provided under separate cover) for the currently proposed MVP alignment in karst terrain included a desk top review using public and proprietary data sources extending a minimum of 0.25-mile from either side of the currently proposed MVP alignment. A more detailed assessment was made through field confirmation of karst features within a minimum

of 150 feet from the proposed MVP alignment on parcels where landowner permission was granted to access the property.

Avoidance of a karst feature constitutes the first and foremost recommendation for mitigating impact. If an identified karst feature cannot be reasonably avoided, or if a previously unidentified karst feature is encountered or forms during construction, this **Karst Mitigation Plan** provides recommendations for impact mitigation and feature stabilization.

MVP will deploy a **Karst Specialist (KS)** prior to, and during construction to confirm, monitor, and mitigate if necessary, existing karst features, and to assess and mitigate previously unidentified karst features that are encountered or observed to form during MVP land disturbance and construction.

1.1 Regulatory Framework

Land disturbance for natural gas pipeline construction and installation constitutes a construction practice that is regulated under federal and state laws for stormwater management and erosion and sediment control (ESC). Construction within karst terrain carries additional regulations to protect caves. The following summarizes the regulatory programs currently in-place in Virginia and West Virginia that will apply to pipeline construction in karst terrain.

In Virginia, ESC is governed by the Erosion & Sediment Control Law (§62.1-44.15:51 et seq) and the Erosion & Sediment Control Regulations (9VAC25-840) and falls under the purview of the Virginia Department of Environmental Quality (DEQ). Note that effective July 2, 2013, DEQ assumed stormwater permitting responsibilities from the Virginia Department of Conservation and Recreation. These laws and regulations serve to let the State regulate construction ESC in compliance with the Clean Water Act NPDES Permit program. Specifically, construction stormwater discharges are covered by the General VPDES permit for discharges of stormwater from construction activities, which requires that the Erosion Control/Stormwater regulations are followed for applicable sites. In normal cases, Erosion & Sediment Control regulations are triggered if land disturbance exceeds 10,000 square feet, and stormwater regulations are triggered if land disturbance exceeds one acre.

West Virginia also administers stormwater general permits through the West Virginia Department of Environmental Protection (DEP). Activities that disturb more than one (1) acre but less than three (3) acres are required to comply with the terms of the General Permit by completing a "Notice of Intent" form, while projects disturbing greater than three (3) acres must submit a site registration application form. For projects disturbing between three (3) and 99 acres, the form must be submitted to DEP at least 60 days prior to starting the project. Sites disturbing 100 acres or more, discharge to Tier 3 waters, have an initial grading construction phase of one (1) year or greater, or a common plan of development greater than 10 acres must submit the form at least 100 days prior to starting the project.

Virginia codified a law for protecting caves (the Virginia Cave Protection Act, Code of Virginia Section 10.1-1000 to 1008); there is no corresponding law that specifically protects karst.

The Virginia Department of Conservation and Recreation, a division of the Department of Environmental Quality, includes a Karst Protection Coordinator branch. Coordination with the Karst Protection Coordinator is described in more detail in this plan.

West Virginia also has a state law designed to protect caves (West Virginia Cave Protection Act, West Virginia Code - Chapter 20, Article 7A-1 through 7A-6) but does not address karst protection measures in general.

There are no specific laws or regulations governing blasting to remove shallow bedrock for pipeline trench construction. Nonetheless, a blasting plan will be prepared by the qualified blasting contractor and the Plan enforced to mitigate impacts to structures, sensitive features, and water resources in karst resulting from blasting.

1.2 Overview of Potential Karst Hazards

The term "karst" refers to a type of landform or terrain that is characterized by the presence of sinkholes, caverns, irregular "pinnacled" bedrock surface, and springs. The development of karst terrain is a result of the presence of soluble bedrock such as limestone, dolomite, marble or gypsum. Any landscape that is underlain by soluble bedrock has the potential to develop a karst terrain landform.

The most prevalent type of karst feature observed at the ground surface along the proposed MVP alignment in karst terrain (**Figure 1**) are sinkholes. Sinkholes fall into two broad categories, termed "vault-collapse" sinkholes, or "cover-collapse" sinkholes. Vault-collapse type sinkholes (i.e., where a cavern "vault" or roof has failed catastrophically) are relatively rare in karst terrain along the proposed MVP alignment. However, cover-collapse type sinkholes are more commonly observed.

Cover-collapse sinkholes typically develop by the raveling of overburden into solution channels within the bedrock mass, in which water is the transport medium for the movement of the fines. The natural raveling process is generally slow such that sinkhole development generally occurs over a long time span. However, various changes at a site can sometimes lead to the sudden and unanticipated development of sinkholes.

The most common changes that may initiate sinkhole development are:

1. Increase or redirection of overland or subsurface water flow paths, which accelerates the raveling of fines;
2. Removal of vegetation cover and topsoil (i.e., stripping and grubbing), which can reduce the cohesive strength of overburden that overlies a conduit; and
3. Sudden changes in the elevation of the water table (such as drought, over-pumping of wells, or quarry dewatering), which removes the neutral buoyancy of the water supporting a conduit plug, and may result in rapid collapse.

As noted earlier, caves, pinnacled bedrock and karst springs are also observed within karst terrain underlying the proposed MVP alignment and are addressed later in this plan.

1.3 Karst Hazards Assessment

MVP deployed a **Karst Specialist** (KS) team to evaluate the karst terrain of southern West Virginia and southwestern Virginia through which the proposed MVP alignment will traverse. The KS team holds qualifications of, or work under the direction of, a professional geologist having direct work experience with karst hydrology and geomorphic processes. The KS team has over 70 years of combined direct field experience evaluating karst features in the vicinity of the proposed MVP alignment.

The KS team provided a detailed inventory in the **Karst Hazards Assessment** (provided under separate cover) of karst features within a minimum 0.25-mile of the centerline of the currently proposed MVP alignment and other Project components (e.g., access roads, temporary work spaces, etc.,). The KS team evaluated publicly available and proprietary karst feature data to inventory karst features. Direct field observations (where property access was granted) was used to confirm the desktop review and evaluate the terrain for additional, previously undocumented karst features.

Recommendations were provided to MVP on the locations of sensitive karst features, or areas that are particularly susceptible to karst formation but had limited mapping and field reconnaissance. For these specific karst areas, the KS team recommended that geophysical remote sensing techniques (e.g., electrical resistivity, ground penetrating radar, etc.,) be used, and if necessary invasive borings be completed, to further elucidate a karst feature or a discrete area suspected to have subsurface karst formations. In response to the karst feature assessment, MVP has made, and continues to make alignment adjustments to avoid sensitive karst areas. Alignment adjustments therefore reduce the corresponding recommendations for remote sensing and invasive boring evaluations.

The currently proposed alignment and associated Project components minimize risks related to karst hazards. As of the date of this report, there remains field reconnaissance to be completed on properties where access is currently denied. The KS team remains confident with the overall karst assessment and recommendations provided to MVP as related to the currently proposed alignment and associated Project components. At this time, additional generalized application of geophysics beyond that completed in the Mountain Tabor area of Montgomery County, Virginia, or borings,

etc., are not considered necessary by the KS team to provide additional data that are particularly reliable or actionable.

As noted, recommendations for avoiding major karst features were provided to MVP via the **Karst Hazards Assessment**, and proposed alignment adjustments were made. Karst features located in the final alignment will be minor in nature and extent (e.g., cover-collapse sinkholes). These features will be confirmed and monitored by the KS team prior to and during construction (discussed below) and if necessary stabilized. Formation of a significant karst feature during construction would be monitored and evaluated by the KS. Additional site evaluation (including geophysical remote sensing and invasive borings) may be recommended by the KS to evaluate potential that the feature serves as a conduit to groundwater and if necessary to support mitigation measures (discussed later in this report).

2.0 KARST TERRAIN INSPECTION PRIOR TO AND DURING CONSTRUCTION

MVP will deploy a KS team prior to tree clearing and complete a **Level 1** inspection of karst features in the LOD (see **Appendix A** for Karst Feature Inspection Form). The final MVP alignment for construction will have accommodated for karst feature avoidance recommendations. Therefore, a karst feature located within the LOD is likely to be minor in its extent and nature and a candidate for mitigation and stabilization prior to disturbance.

The KS will consult with MVP Construction to determine the recommended course of action prior to tree clearing in the vicinity of the feature. It is anticipated that the most common karst feature requiring mitigation for MVP construction will be cover-collapse sinkholes (discussed below). Karst feature stabilization would be completed in conjunction with recommendations from the appropriate state agency (Virginia Department of Conservation and Recreation, Karst Protection; West Virginia Department of Environmental Protection).

MVP will deploy an on-site KS team during construction activities (clearing and grubbing, trenching, blasting, boring or drilling) within karst terrain. The role of the KS is to observe construction activities to assist in limiting potential negative impacts, and to inspect, assess and if necessary mitigate karst features that are encountered or form during construction in conjunction with recommendations from the appropriate state agency (Virginia Department of Conservation and Recreation, Karst Protection; West Virginia Department of Environmental Protection).

Two or more KS will be available to conduct multiple inspections in karst terrain where MVP Construction crews may be working at different locations simultaneously.

2.1 Level 1 Inspection of a Karst Feature

A **Level 1 Inspection** of a karst feature will entail observation and documentation of the following ground and feature characteristics:

1. soil subsidence;
2. rock collapse;
3. sediment filling;
4. swallet (sinking stream) or notable increased surface water infiltration;
5. spring / seep / flooding;
6. cave or void space;

7. clogging; and/or other changes in morphology or function that might indicate potential impact to the epikarst stratum caused by the work.

The inspection will be recorded on a Karst Feature Inspection Form (**Appendix A**), including digital photographs, GPS coordinates and reference to the nearest MVP milepost.

If any of the representative changes listed above are observed at a karst feature, the KS will complete a **Level 2 Inspection** (discussed below).

2.2 Level 2 Inspection of a Karst Feature

The **Level 2 Inspection** will be conducted as follows, and recorded on a Karst Feature Inspection Form provided in **Appendix A**.

The KS will examine the suspected karst feature to identify potential connectivity to the subterranean environment and risk for impacting groundwater quality. The choice of characterization methods will be proposed to MVP by the KS, and will include any combination of (but not be limited to):

1. visual assessment and physical inspection;
2. geophysical survey;
3. track drill probes;
4. infiltration or dye trace testing; or
5. other techniques utilized to facilitate subsurface characterization of karst features.

If the karst feature does not appear to have connectivity to the subterranean environment and risk for impacting groundwater quality, the KS will provide MVP Construction with a recommendation on stabilization measures for the feature (see Section 3.5 of this Plan), and construction activities will continue after the feature is stabilized.

If it is determined that the feature has connectivity to the subterranean environment and potential to impact groundwater, the KS will consult with MVP Construction regarding appropriate mitigation. Mitigation activities would be conducted in conjunction with recommendations from the appropriate state agency (Virginia Department of Conservation and Recreation, Karst Protection; West Virginia Department of Environmental Protection). In addition:

- As requested by Virginia DCR, The KS will contact Mr. Wil Orndorff, DCR Karst Protection (540-230-5960; Wil.Orndorff@dcr.virginia.gov) to alert DCR of a newly discovered karst feature and proposed mitigation activities. DCR may request to review the feature prior to further disturbance.
    - If the karst feature is observed in West Virginia, it is recommended that the KS also contact Mr. Jon Bosley, Program Manager, WVDEP Stormwater Permitting (304-926-0499, ext. 1059; Jon.M.Bosley@wv.gov).

A weekly **Level 1 Inspection** of the stabilized or mitigated feature will be completed and documented by the KS on a Karst Feature Inspection Form (**Appendix A**) while construction activities (clearing and grubbing, trenching, blasting, boring or drilling) are on-going within 150 feet of the feature.

Mitigation or stabilization activities will be documented upon completion in a report prepared by the KS, to be delivered to MVP.

3.0 MANAGEMENT OF NEWLY IDENTIFIED KARST FEATURES

If a suspected karst feature is intercepted during work activities, or forms within the LOD during construction activities (clearing and grubbing, trenching, blasting, boring or drilling), the KS will conduct a combined **Level 1** and **Level 2 Inspection** of the feature.

Suspected karst features include:

1. Sinkhole;
2. Spring;
3. Bedrock enclosed conduit(s) or void;
4. Solution pocket that extend beyond visual examination range (and therefore may be open);
5. Soil void;
6. Highly fractured karst bedrock;

The KS will follow the procedural outlines listed above for **Level 1** and **Level 2 Inspections**.

3.1 Sinkhole Stabilization

Sinkholes are common surficial geomorphic expressions of karst terrain. If a sinkhole is located within the proposed LOD and cannot be reasonably avoided, the sinkhole will be stabilized prior to construction in accordance with recommendations provided by the KS, and in conjunction with recommendations from the appropriate state agency (Virginia Department of Conservation and Recreation, Karst Protection; West Virginia Department of Environmental Protection).

A weekly **Level 1 Inspection** (described below) of the stabilized feature will be completed and documented by the KS (see **Appendix A** for Karst Feature Inspection Form) while construction activities (clearing and grubbing, trenching, blasting, boring or drilling) are on-going within 150 feet of the feature.

Mitigation activities will be documented upon completion in a report prepared by the KS, to be delivered to MVP.

See the following sections of this report for activities to be followed under this Mitigation Plan for karst features other than sinkholes that are located within the MVP LOD.

4.0 MEASURES TO AVOID IMPACTS TO THE KARST AQUIFER AND ENVIRONMENT

The following procedures will be used during pipeline construction activities (clearing and grubbing, trenching, blasting, boring or drilling) to limit potential impact to karst features and related water resources.

1. Protect known and/or future mapped recharge areas of cave streams and other karst features (see **Karst Hazards Assessment** provided under separate cover to identify the relevant construction area where these features are located) by following relevant conservation standards, specifically those pertaining to stream and wetland crossings, erosion and sediment control, and spill prevention, containment, and control.
2. MVP construction activities (clearing and grubbing, trenching, blasting, boring or drilling) will be conducted in a manner that minimizes alteration of existing grade and hydrology of karst features:
    a. In linear excavations adjacent to karst features, spoils will be stockpiled and managed up-slope of the excavation, and runoff controlled according to the MVP project-specific stormwater management and ESC Plan (under separate cover).
    b. Surface water control measures, including, but not limited to diversion (direct water flow into trench or off right-of-way areas past the area of concern), detention or collection and transportation, will be utilized to prevent construction-influenced surface water from free flowing into karst features.
    c. Karst features will not be utilized for the disposal of water.
3. Blasting will be conducted in a manner that will not compromise the structural integrity or alter the karst hydrology of known or inferred subsurface karst structures. If rock is required to be hammered or blasted, the following parameters will be adhered to:
        a. The excavation will be carefully inspected for voids or other openings, or signs of enhanced secondary porosity.
        b. If the rock removal intercepts an open or clay-filled void, cave, or other signs of enhanced secondary porosity, see previous section of this plan for **Level 1** and **Level 2 Inspections**.
        c. Blasting will be conducted by a qualified blasting contractor, in accordance with the contractors written and approved blasting plan.

d. If a track drill is used to prepare the hole(s) for the explosive charge(s) and the boring encounters an open or clay-filled void, cave, or other signs of enhanced secondary porosity, see previous section of this plan for **Level 1** and **Level 2 Inspections**.

4. Comply with requirements of project Spill Prevention, Control, and Countermeasures Plan (SPCC) prepared by Contractor (under separate cover). The following general guidelines will be incorporated into the SPCC for construction practices in karst terrain:

   a. To reduce the risk of groundwater contamination, equipment will not be parked or left idling for extended periods of time (more than 12 hours), refueled or serviced within 100 feet of any karst feature.
   b. Equipment refueling will not be performed within flagged or marked buffer areas of streambeds, sinkholes, fissures, or areas draining into these or other karst features, except by hand-carried cans (5 gallon maximum capacity) when necessary.
   c. Equipment servicing and maintenance areas will be sited outside of flagged or marked buffer areas of streambeds, sinkholes, fissures, or areas draining into these or other karst features.
   d. Prevent runoff resulting from construction equipment washing operations to directly enter any karst feature by locating these operations outside of the buffer area.
   e. Hazardous materials, chemicals, fuels, lubricating oils, and petroleum products will not be stored within 100 feet of any karst feature.
   f. All equipment will be checked by a construction inspector daily for leaks prior to beginning work in karst areas. If any leaks are observed, or damaged or defective equipment is discovered, drip pans and other containment will be deployed immediately and the equipment removed or repaired as soon as practical.
   g. If a reportable spill (reportable volume will be defined in the project-specific SPCC Plan) occurs within a karst feature or water body, refer to the project-specific SPCC Plan.

5. The intent of ESC and related Best Management Practices (BMPs) is to confine project-related disturbance to the LOD, protect sensitive karst features, and minimize erosion and enhance revegetation in those areas. In addition to ESC BMPs for standard pipeline construction, which includes specifications by regulatory agencies, additional BMPs will be implemented as specified by the KS.

6. Discharge of hydrostatic testing water in karst areas will be avoided if practicable. If circumstances require hydrostatic testing water to be discharged in karst areas, the KS will recommend a discharge location in consideration of the following guidelines:
   a. Do not discharge hydrostatic testing water directly into flagged or marked buffer areas of karst features or channels or surface features that flow towards karst feature(s).
   b. Where possible, discharge hydrostatic test water down-gradient of karst features unless on-the-ground circumstances (e.g., manmade structures, terrain, and other sensitive resources) prevent such discharge.
      i. If those circumstances occur, discharge water into uplands greater than 500 feet from flagged or marked buffer areas of karst features unless on-the ground circumstances (e.g. manmade structures, terrain, other sensitive resources) prevent such discharge.
      ii. If i.) above is not practicable, discharge water as far from flagged or marked karst features as practical and utilize additional sediment and water flow control devices to minimize effects.
   c. Control the rate and volume of discharge to prevent land erosion, sediment mobilization and ponding of water.

5.0 POST-CONSTRUCTION MONITORING

After pipeline construction and land reclamation are completed, Mountain Valley will implement a monitoring program within karst terrain to surveil for potential land subsidence that may be associated with activation of a subsurface karst feature. The monitoring program will provide early-warning detection of subtle ground movement and trigger Mountain Valley's post-construction landform evaluation and mitigation procedures in karst terrain, as described below. Recommendations for mitigation are discussed in Section 5.3, below. More specific mitigation measures will depend upon the results of the monitoring program, and the Mountain Valley KS team's field observations on actual conditions.

Mountain Valley will construct the pipeline with safeguards to prevent impacts to, and from, karst terrain, as discussed above. Mountain Valley does not consider it sound practice to establish a construction area that requires repeated interim measures to maintain stability.

5.1 Light Detection and Ranging (LiDAR) Surveys

Mountain Valley will utilize aerial Light Detection and Ranging (LiDAR) surveys on a prescribed periodic basis (discussed below) to monitor the ROW for changes in ground topography that could be indicators of potential land subsidence due to activation of a subsurface karst feature.

LiDAR works by emitting multiple laser pulses over the same area, such that some pulses are reflected off intermediate surfaces (i.e. variable height vegetation, buildings, power lines, etc.) and some of the pulses find the underlying ground surface. The resulting data are processed to classify data that represent the ground surface (i.e., generate a bare Earth model), providing a detailed topographic and geomorphic landform model to detect subtle changes in ground morphologies.

A progression of LiDAR data collected over time over the ROW in karst terrain will be compared to previous surveys in order to identify whether subtle landform chances are occurring that could correspond with possible land subsidence. The sequential LiDAR models of the area of concern will be configured as a "heat map" to more clearly identify changes in geomorpholgy. If ground subsidence is perceived via LiDAR monitoring (analysis is discussed below), direct inspection by the Mountain Valley KS team will take place to assess the potential for sinkhole or other karst

feature formation. The intent is to mitigate subtle landform movements before a larger failure could occur.

5.2 Monitoring Schedule

Mountain Valley will conduct semiannual aerial LiDAR monitoring of the ROW in karst terrain during an initial two-year period after construction is complete, rendering four (4) sequential LiDAR surveys during the first two years after construction. This spans a critical period of time post-construction to confirm that land reclamation is established, and that karst terrain underlain by the ROW is stable. Continued monitoring described below will confirm these conclusions over the long-term.

If karst terrain in the ROW is demonstrated to be stable by sequential LiDAR monitoring data for the initial two years of semiannual monitoring (described above), the frequency of LiDAR survey will be reduced to annually for another two consecutive years. This will provide six (6) LiDAR monitoring events over the span of four years in order to detect potential land subsidence.

If the ROW in karst terrain is demonstrated to be stable by sequential LiDAR monitoring data for the combined four years of monitoring (i.e., the initial two years of semiannual monitoring, followed by two years of annual monitoring), the frequency of LiDAR surveys will be further reduced to a five-year periodicity throughout the life of the pipeline.

As each new sequential LiDAR survey is completed (see monitoring schedule above), the data will be processed and compared to all historical LiDAR data for the ROW available at the time to produce a "heat map" of potential ground movement over time.

If karst terrain reclamation is required in the ROW, Mountain Valley will remediate the area per the KS team's recommendations, and include the repaired area specifically in its routine monitoring schedule to document that land stability was achieved.

5.3 Slope Stability Mitigation Measures

If land subsidence is detected by the LiDAR monitoring program, Mountain Valley will engage the Mountain Valley KS team to complete field inspection and verification and confirm actual

conditions and governing reasons for the topographic changes. Recommendations for remedial measures will be provided to Mountain Valley based on the KS team inspection observations.

Once Mountain Valley has received recommendations from the KS team, Mountain Valley will contact Mr. Wil Orndorff, DCR Karst Protection (540-230-5960; Wil.Orndorff@dcr.virginia.gov) to alert DCR of potential karst feature activation and proposed mitigation activities. DCR may request to review the feature prior to further disturbance. If the karst feature is observed in West Virginia, Mountain Valley will also contact Mr. Jon Bosley, Program Manager, WVDEP Stormwater Permitting (304-926-0499, ext. 1059; Jon.M.Bosley@wv.gov). WVDEP may request to review the feature prior to further disturbance.

Once Mountain Valley has received recommendations from the KS team, and notified the agency(ies), Mountain Valley will implement planned remedial activities. Specific remedial measures will depend upon the nature and extent of potential land subsidence. Examples of potential redial measures could include:

- If subsidence is confirmed in surficial backfill in the ROW (which may or may not be associated with subsurface karst), enhanced backfill compaction (or replacement with engineered materials), enhanced water management, and aggressive revegetation will be implemented.

- If subsidence in native earth material outside of the ROW is confirmed, the KS team inspectors will provide recommendations to Mountain Valley for remediation measures such as sinkhole stabilization measures discussed earlier in this Plan.

- If subsidence may have resulted in pipe stress, a stress relief excavation may be required to allow the pipeline to rebound to the non-stress condition prior to subsidence. Stress relief excavations typically start in the middle of the area where land movement is observed, and extend in either direction until no rebound is observed, and generally continue for a minimum of an additional 50 feet. Surveys may be required during the excavation work to track pipeline rebound, and to confirm before and after pipeline location and elevation. Stress relief excavations would only be contemplated for relatively large-scale movement scenarios.

- Mountain Valley may also consider installing strain gauges on the pipeline during stress-relief excavation. The strain gauges would monitor potential accumulated pipeline strain in the future if land subsidence continues. Strain gauge monitoring would be conducted manually on a yearly basis, unless LiDAR monitoring under the post-remediation timeframe continues to identify large-scale slope movement, in which case the strain gauges will be monitored on a six-month basis. Strain gauges would only be contemplated for relatively large-scale movement scenarios.

Mountain Valley Pipeline Project

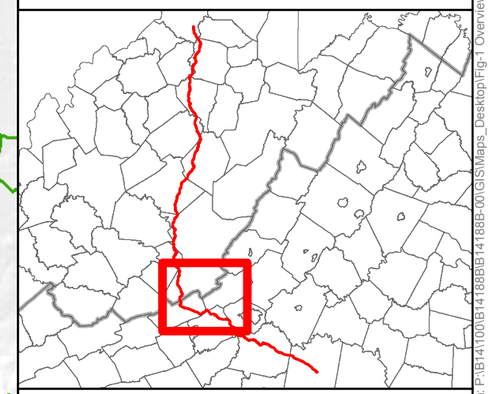
Mountain Valley PIPELINE

FIGURE NUMBER 1
Karst Zones

Draper Aden Associates
Engineering • Surveying • Environmental Services

Legend

- MVP Proposed Route with Mile Posts
- MVP Alternates / Previous Variations
- Limestone
- Dolomite
- Karst Features



Karst Regions adapted from 1968 Geological Map of West Virginia. 1:250,000. West Virginia Geological and Economic Survey.
Digital Representation of the 1993 Geologic Map of Virginia; 1:500,000
U.S. Geological Survey, 2003; (Virginia Division of Mineral Resources Publication 174)
Geologic Map of Giles County, Virginia, 1986. Ed. E.K.Rader and T.M.Gathright II

Document Path: P:\B141\100\B141888B\B141888B-00\GIS\Maps_Desktop\Fig-1 Overview Karst Zones v6.mxd

Summers
Greenbrier
Greenbrier
Greenbrier
Alleghany
Monroe
Mercer
Mercer
Giles
Pulaski
Craig
Botetourt
Montgomery
Roanoke
Salem
Alt.110
Alt.110
Alt.110J
Alt.110R
Alt.110R
Alt.200
Alt.200
Alt.Mt Tabor
Alt.93
Alt.87
Alt.135
MVP October 2016 Proposed Route

N
1:225,000
NAD 1983 UTM 17N
0 2 4 6 8 Miles

Service Layer Credits:
Background hillshade: Shuttle Radar Topography Mission 90m DEM; NASA

APPENDIX A - KARST FEATURE INSPECTION FORM

Page 1 of 2

Date:_____ Karst Specialist:_____ MVP Milepost:_____

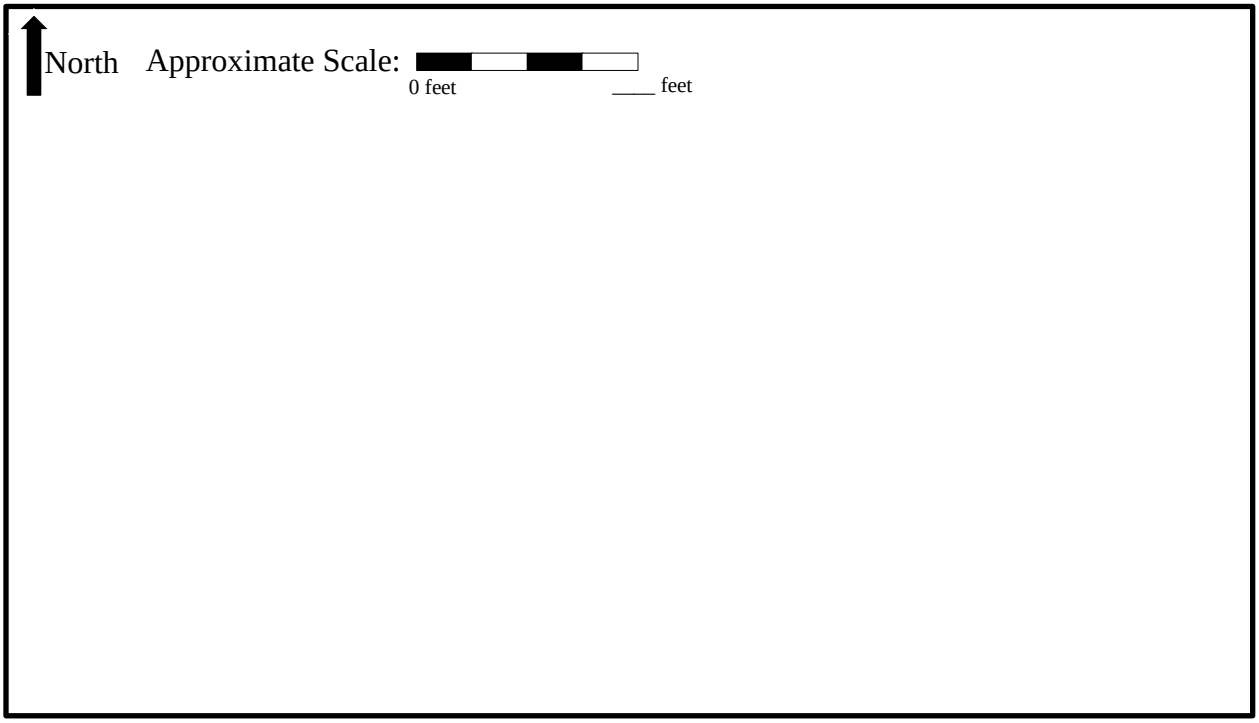
GPS Coordinates (X, Y; coordinate system):_____

Digital image documentation:

Photo #	View toward (circle):	Description:
	North South East West	
	North South East West	
	North South East West	
	North South East West	

Continue on next page if necessary.

Sketch:



Appendix A - Karst Feature Inspection Form **Page 2 of 2**

Level 1 Inspection: Check characteristics observed:

____ soil subsidence ____ rock collapse ____sediment filling

____ swallet / notable increased surface water infiltration ____spring / seep or flooding

____ clogging; and/or other changes in morphology or function that might indicate potential impact to the epikarst stratum caused by the work.
Description:_____
_____
_____

Recommend Level 2 Inspection? (circle one) **Yes / No**

Level 2 Inspection: Check inspection method(s):

_____ visual assessment _____ geophysical survey _____ track drill probes

_____ infiltration or dye trace testing

_____ other: _____

Mitigation recommended? (circle one) **Yes / No**

Summarize recommended mitigation method(s):

_____
_____
_____
_____

KS contact Wil Orndorff, DCR (540-230-5960)? **Yes / No** Date_____ Time_____

DCR Inspection requested? (circle one) **Yes / No**

KS contact Jon Bosley, WVDEP Stormwater Permitting (304-926-0499, ext. 1059)? **Yes / No**
Date_____ Time_____

WVDEP Inspection requested? (circle one) **Yes / No**

Notes:
_____
_____