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June 21, 2007

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CONTRACT ID NO. 071225
ADDENDUM # 4

Subject: Jefferson County, NH 265-3 (018)
Letting June 22, 2007

(1) Added - Proposal Sheets - Notes - Pages 120(b)-120(tt) of 336
(2) Revised - Proposal Sheet - Certification of Bid Proposal - Last Page

Proposal revisions are available at http://transportation.ky.gov/contract/.

If you have any questions, please contact us at 502-564-3500.

Sincerely,

Steve Waddle
Director
Division of Construction Procurement

Enclosures
SW:ks

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THE OHIO RIVER
BRIDGES

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% INTRODUCTION

The Louisville Southern Indiana Ohio River Bridges (LSIORB) Project is being developed to improve cross9river mobility between Jefferson County, Kentucky and Clark County, Indiana. Section 4, one of six sections, is the East End Kentucky Approach and Connections to I9265. A key element of Section 4 is twin three9lane highway tunnels under the historic Drumanard Estate. The property is located on the north side of US Highway 42 (US 42) at the intersection with the Gene Snyder Freeway (also KY 841), as shown on Figure 1. This Contract consists of the excavation of an Exploratory Tunnel along the southbound alignment. The findings from the Exploratory Tunnel will be incorporated into the design of the twin tunnels to be constructed under a future contract.

The Indiana Department of Transportation (INDOT) and the Kentucky Transportation Cabinet (KYTC) are developing the LSIORB Project jointly, in coordination with the Federal Highway Administration (FHWA). Hatch Mott MacDonald (HMM) prepared this Geotechnical Baseline Report (GBR), the associated Geotechnical Data Report (GDR), and other Contract Documents for the Exploratory Tunnel under subcontract to H.W. Lochner (HWL), prime consultant for Section 4. Fuller, Mossbarger, Scott, and May Engineers, Inc (FMSM) performed field investigations for the Exploratory Tunnel, with assistance from HMM.

This GBR provides a baseline description of the anticipated subsurface conditions to be encountered during excavation of the Exploratory Tunnel; provides the basis for selection of initial support of the tunnel; and describes exploration and testing activities to be carried out during the work. The GBR is intended to assist bidders in evaluating the requirements for excavating and supporting the ground, controlling groundwater inflows, and identifying other important construction considerations.

Risks associated with subsurface conditions consistent with, or less adverse than, the baseline conditions represented in this GBR are allocated to the Contractor. Those risks associated with subsurface conditions more adverse than the baseline conditions are accepted by the Owner. The baseline conditions represent a contractual standard that the Owner and the Contractor agree to use when administering Subsection ,64+6'+6)9Differering Site Conditions of Division 1009General Provisions, Standard Specifications for Road and Bridge Construction, Edition of 2004, KYTC.

This report presents the design team's best judgement of soil, rock and groundwater conditions expected to be encountered in the surface and subsurface excavations for the Exploratory Tunnel. While the actual conditions encountered in the field are expected to be within the ranges discussed, the actual conditions encountered will likely vary from those presented in this report. The behavior of the geologic materials encountered in the surface and subsurface excavations will be influenced by the Contractor's selected equipment, means, methods, and level of workmanship.

It is highly recommended that Bidders engage a geotechnical engineer or engineering geologist to review thoroughly this GBR so that a complete understanding of the information presented in this report can be developed prior to submitting a bid.

Certain elements of the Contract are based on requirements that cannot be varied. These include, but are not limited to, the following:

,+ Ground support elements and unsupported length from the face as shown or noted on the Contract Drawings;

'ǂ Invert protection where shale is exposed in the tunnel invert as shown or noted on the Contract Drawings;
)ǂ Probe hole and associated water pressure testing to be carried out in advance of excavation;
4ǂ Locations, dimensions, and the concurrent excavation of the exploration bays while the tunnel heading is advanced, to facilitate timely geotechnical investigations within the tunnel;
7ǂ Spoil removal from the site as shown on the Contract Drawings;
-ǂ Removal and treatment requirements for groundwater and construction water;
8ǂ Access of the Engineer or his designated personnel to carry out mapping or geotechnical monitoring of exposed excavation surfaces;
3ǂ All geotechnical investigation activities to be performed within the exploratory tunnel;
*ǂ Limitations on allowable working hours; and
,6ǂ Limitations on blasting and vibration levels as definedǂ

A number of elements of the Contract are flexible, and afford the Contractor latitude in the selection of layout geometries, construction methods, equipment, and procedures, which are subject to the approval of the Engineer, and at no additional cost to the Cabinet. These include, but are not limited to, the following:

- Increased excavated width of the Exploratory Tunnel;
- Lowering of the tunnel invert; and
- Method of excavation (excluding TBM).

Any changes made by the Contactor for his own convenience or benefit shall be at the Contractor's own expense.

Certain drawings and figures contained in other documents in the Contract are referenced by the GBR as an aid to Bidders in understanding the elements of the work. Such drawings are not reproduced in the GBR.

' CONTRACT DESCRIPTION

'&% Introduction

The tunnel portion of Section 4 is oriented in a north9south direction near the City of Prospect, Kentucky. Access to the Exploratory Tunnel will be via an access ramp and a deep rock cut located at the southeastern end of the Contract site. The cut and access ramp is outside the scope of this GBR.

'&' Access Ramp

Prior to the Exploratory Tunnel access ramp construction, the existing KY 841 off9ramp is to be relocated by others to a position adjacent to the existing KY 841 on9ramp. The relocated KY 841 off9ramp will provide access and egress for haulage trucks for removal of tunnel spoil from the Contractor's working area, and will continue to provide access to US 42.

The site access to the Exploratory Tunnel Contractor's working area will be located at the former junction of the KY 841 off9ramp with US 42. The Contract Drawings illustrate the manner in which the Contractor will access and egress from the intersection area, and where the work can be staged. Access to the Exploratory Tunnel involves a downgrade as shown on the Contract Drawings.

'&+ Exploratory Tunnel

The Exploratory Tunnel will be 1,800 feet long, with a nominal cross9section measuring 12.3 feet high and 12.5 feet wide, as shown on Contract Drawings C9001 and C9007. The Exploratory Tunnel will be excavated within the future southbound highway tunnel through sedimentary rock formations consisting of limestones, shales, and dolomites. The limestones are known to exhibit karstic features resulting from the passage of water through soluble rock materials, leaving open and soil9filled channels in the rock mass. A total of five exploration bays will be excavated into the right (eastern) sidewall of the Exploratory Tunnel at the locations shown on Contract Drawings C9001 through C966-+

From the tunnel portal at Southbound Tunnel Station (SB) 50+00, the Exploratory Tunnel will trend northward at a 2.52% downward grade, cross beneath US 42, and then cross beneath the Drumanard Estate. The Exploratory Tunnel excavation shall not be permitted to daylight at its north end, but will terminate at SB 68+00. Therefore, the south portal will comprise the only access to the underground works.

Site investigations to be carried out by the Engineer and Contractor within the Exploratory Tunnel are described in Section 02 32 12 – Geotechnical Investigation in Exploratory Tunnel, of the Exploratory Tunnel Supplemental Specifications and shown on the Contract Drawings GI901 through GI912. The activities will include, but are not limited to, the following:

- A geologic mapping program throughout the Exploratory Tunnel. This work will be carried out through a combination of visual mapping, digital scanning survey of all excavated surfaces, and photo documentation+
- Observations regarding groundwater flow in and through the rock mass, and observed effects, on the regional groundwater table and on the ground surface.

- In situ measurements of rock properties, including slake durability.

- The recovery of rock samples for subsequent laboratory testing.

- Geophysical tests to investigate karstic void features within the rock mass, both within the tunnel and on the ground surface.

In addition, surface drilling of additional boreholes to install piezometers and extensometers at selected locations above the tunnel alignment will also be conducted.

Subsurface and surface investigations require the following work to be performed by the Contractor:

- An instrumentation program consisting of extensometers installed underground and surface measurements utilizing prismatic survey targets linked to robotic total station systems. The Exploratory Tunnel Supplemental Specifications also include the alternative of installing a series of robust survey stations on which theodolites can be re-established with precision. Such stations will also form the basis for the positioning of the digital scanning system, where used, for geologic mapping.

- Modification of existing standpipe wells to accommodate piezometers.

- Installation of piezometers within the exploratory tunnel and exploration bays

- Installation of tunnel convergence arrays

- Installation of rod extensometers within the exploratory tunnel and exploration bays

- Installation of cyclical wetting and drying chambers of Waldron shale in selected exploration bays

- Installation and testing of rock bolts under pull out loads

- Installation of flow gauge instruments in existing stream courses

- Installation of settlement monitoring points throughout the alignment to monitor any movements that could effect existing structures or utilities

- Installation of tilt meters on overhead utility poles

- Installation of crack gauges based on the finding of preconstruction surveys

- Survey monitoring to confirm stability of portal and tunneling beneath US 42.

- Drilling of investigation holes from the portal face

+ SOURCES OF GEOLOGIC INFORMATION

The primary sources of geotechnical data used in identifying and describing anticipated physical site conditions were exploration and testing that were completed specifically for the Contract. These included borings, surface mapping, surface geophysics, field tests, and laboratory tests. In addition, the following references and sources of information were reviewed:

,+ *Final Environmental Impact Statement (FEIS)*, signed by the Federal Highway Administration, Indiana Department of Transportation, Kentucky Transportation Cabinet, '66)+

'+ Louisville9Southern Indiana Ohio River Bridges Project Section 4 9 East End Kentucky Approach and I9265 Connections; Geotechnical Data Report, May 2006.

The principal sources of published information are two geologic maps of the region by Sparks and Zhang (2003) and Kepferle (1974). These show the bedrock outcrop locations, provide a description of the mapped units and the overall structural geologic setting, including the location of the Springdale anticline some 3 miles southwest of the planned tunnel site.

As will be discussed in later sections, two of the three formation units through which the tunnel is to be excavated, and other geologic units above and below the tunnel, exhibit karst. The published sources for evidence of karst in the region comprise:

,+ Groundwater Resources of Jefferson County, Kentucky, Carey, D. and Stickney, County Report 56, Series XII ISSN) 7595567, 2005.

'+ Karst occurrence in Kentucky, 1:500000 map Paylor, R. and Currens, J. Map and Chart 33 Series XII, 2001, KGS, UKY, Lexington, KY.

)+ Groundwater sensitivity regions of Kentucky, 1:500000 map and associated interpretation report, Kentucky Department For Environmental Protection, Division of water – Groundwater Branch, 1994.

+&% Overview of Investigation Program

+&%&% Borings

A total of 18 borings, labeled B91 through B918, have been performed to date in the vicinity of the future tunnels and the Exploratory Tunnel. Figure 1 indicates the location of the ten borings which are directly offset from the Contract alignment in the following sequence, progressing from south to north: B915, B9 12, B93, B911, B910, B99, B98, B95, B96, and B97, together with B916 some 3009feet south of the South Portal and B92, B914 and B91 which lie at or within 3009feet north of the planned north portal of the future tunnels. The remaining four borings B94, B913, B917 and B918 lie)669feet beyond the immediate vicinity of the Exploratory Tunnel located in the planned highway approach cuts. The boring logs and a plan and profile containing stick logs, are contained in the GDR.

+&%&' Field and Laboratory Testing

In situ field permeability packer tests were carried out in borings B915, B911, B99, B98, B96, B95, and B9 7. Testing of soil and rock samples was performed for the Contract. The data is presented in the GDR. Selected test results are summarized in this report in tables, or other forms where needed to substantiate characterization and behavior.

+&%&+ Surface Geophysics

Geophysical surveys were performed at the planned portal locations of the future tunnels. The following imaging technologies were employed:

- Conventional seismic refraction
- Gravity
- Self9potential
- Ground9penetrating radar
- Electrical resistivity
- Multi9channel surface wave analysis

The methods, results and data from these studies have been incorporated into profiles, descriptions and other aspects of the data interpretation and are described in the GDR.

Two of these surface9based methods, seismic refraction tomography and electric resistivity, will be utilized during the Exploratory Tunnel to further investigate the site. Additionally, electrical resistivity surveys will be carried out within the Exploratory Tunnel to investigate the nature of the ground beneath the Exploratory Tunnel invert.

The Contract Documents call for the Contractor to provide access and support services to specialist geophysical sub9contractors to carry out tests along the invert of the tunnel in two phases, in the locations shown on Contract Drawing GP966,+

3.1.4 Televiewer and Downhole Geophysical Surveying

A down9hole borehole televiewer and geophysical surveys were performed in boreholes B95, B96, B98, B9 10, and B911. Record logs of traverses using optical televiewer, 49pi density, neutron, and 39arm caliper tools in each of the five boreholes have been produced together with stereonet and rose plots of interpreted fracture/bedding orientation, tabulation of individual fracture/bedding orientation, and optical televiewer logs. The methods, results and data from these studies are described in the GDR.

4 GEOLOGIC SETTING

4.1 Regional Geology

The Exploratory Tunnel alignment is located near the northern boundary of Jefferson County beneath rolling topography with ground surface elevations ranging from 515 feet to 595 feet above mean sea level (MSL). The site is located about one mile southeast of the Ohio River, which has an elevation of approximately 420 feet near the confluence with Harrods Creek. In general, the ground elevations are higher in the southern half of the alignment near US 42 and decrease towards the north. The topography along the Exploratory Tunnel alignment is shown on Contract Drawings C9001 through C9006.

As presented in various Kentucky Geological Survey documents, the Exploratory Tunnel and the future tunnels are located in the Outer Bluegrass Physiographic Province. In the Contract area, steep sloped hills and valleys covered with a veneer of residual soil and underlain by interbedded shale and limestone/dolomite layers characterize this Province. The Contract area is also located along the northeastern edge of the Cincinnati Arch, an area of regional uplift such that the limestone and shale layers dip (tilt) gently downwards towards the north9northwest at an angle of less than 10 degrees from horizontal. Refer to the GDR for additional discussion.

4.2 Regional Soil Conditions

According to a Soil Survey of Jefferson County, Kentucky (Zimmerman, 1966) the soils across the Contract site belong to the Crider Series. They are reported as: "well9drained soils found in sinks and on wide, level ridges with short side slopes." The upper 30 inches is comprised primarily of loess (windblown silt) and the underlying material formed primarily as residuum from the parent limestone. The thickness of the overburden soils is reported in the reference to range from 3 feet to 14 feet.

However, as discussed in the GDR, this layer of loess, reportedly up to 30 inches thick, could not be distinguished within the site borings conducted on the Drumanard Estate. This survey concluded the soils encountered in boring B96, namely soft to stiff lean clay and silt with trace to some sand and fine gravel, could be taken as representative of soils within the Drumanard Estate. Equally, the GDR concluded the soils observed along the Contract alignment did not appear as well drained as reported in the references, and ponding of water at surface following rains or snow melt9off was observed.

4.3 Regional Rock Types

Rock was encountered in the borings advanced for the Exploratory Tunnel. The rock formations encountered in the borings are presented in order from the shallowest to deepest and include:

- Jeffersonville/Sellersburg Limestone (Undifferentiated)[1]
- Louisville Limestone[1]
- Waldron Shale
- Laurel Dolomite
- Osgood Formation
- Brassfield Limestone
- Saluda Dolomite Member of the Drakes Formation

[1] Comprise Upper Limestones

Only the Louisville Limestone, the Waldron Shale, and the Laurel Dolomite (at the northern end of the alignment) will be encountered in the Exploratory Tunnel excavations.

Details, including the borehole logs of core drilling of these rock types, are provided in the GDR. Core recovery will be required in these rocks from the boreholes scheduled in the Contract. Summary descriptions of the rock units from Sparks and Zhang (2003) are given in Appendix A. Of particular mention, Sparks and Zhang (2003) comment that:

NSlope instability in the shale-dominant units affects construction and engineering projects. The high clay content in the Waldron Shale, Osgood Formation, ... can lead to foundation failure under roads and buildings. Water saturation will cause the clay minerals in these shales to shrink and swell, which results in heaving and movement of sediments. Roads built on these sediments should have adequate drainage to channel water away, and buildings may need pilings down to bedrock. Slope cuts should not be over-steepened, because these clay-rich units are prone to slumping. The clay content renders the soil relatively impermeable, and percolation rates are too low for adequate septic-tank drainage."

Measures to cope with these shale9dominant units are described later in this report+

4.4 Bedrock Profile and Karst

The location of the Exploratory Tunnel and adjacent area is known to be prone to karstic development. Paylor and Currens (2002) define the term karst as, "a terrain that is generally underlain by limestone or dolomite, where the topography is formed mainly by dissolving rock. Karst landscapes are commonly characterized by sinkholes, sinking streams, closed depressions, subterranean drainage, large springs, and caves." According to their geologic map of Karst Occurrence in Kentucky, the location of the Exploratory Tunnel and immediately adjacent areas are, "underlain by bedrock with high potential for karst development."

Oher published works exist which suggest that the Contract site is prone to karst development. Carey and Stickney (2005) define the area surrounding the Contract site as karst prone. Likewise, other sources suggest karst features. For example, Sparks and Zhang (2003) state that sinkholes occur occasionally in the Louisville Limestone and Laurel Dolomite; Kepferle et al. (1971) also state that sinks develop in the Louisville Limestone on uplands.

4.5 Hydrogeologic Setting

In the vicinity of the Contract area, the notes of Hydrogeology in Geologic Map of the Louisville 30 x 60 minute Quadrangle (Thomas Sparks and Qinhua Zhang Geologic Map 4 Series Xii, 2003, UKY KGS) note:

"Most groundwater in the Louisville Quadrangle is obtained from wells less than 100 feet deep in shallow alluvial deposits or fractured bedrock. Some Ohio River alluvial wells in Jefferson and Oldham counties may produce as much as 1000 gallons per minute. Springs are common in many of the carbonate units in the area, such as Louisville Limestone, Laurel Dolomite, and Drakes formation"

Alluvial deposits adjacent to the Ohio River, such as those referenced above, near the mouth of Harrods Creek have surface elevations of 430 feet to 440 feet, on the order of 50 feet below the lowest invert elevation of the Exploratory Tunnel.

As noted in (Kepferle, 1974) water from wells in the limestone is highly mineralized; calcium carbonate concentrations average about 580 parts per million (ppm) and with sulfates average about 450 ppm. No groundwater sampling or chemical testing has been conducted in the current investigation program.

The area of the tunnel alignment has been categorized as having a Hydrogeologic Sensitivity Rating of 4, on a scale ranging from 1 (low) through 5 (high) (Ray et al, 1994), which defines the ease and speed with which a (waterborne or liquid phase) contaminant can move into and within a groundwater system.

This information indicates that there is a high potential for hydraulic conductivity and that infiltration will increase due to localized rainfall runoff or stream catchment flow.

4.6 Tectonic Setting

The U.S. Geological Survey (USGS) seismic risk maps place the Contract alignment in Zone 2, an area capable of producing earthquakes of greater than 7.0 on the Richter Scale. The New Madrid Fault Zone, the source of three of the most powerful earthquakes in recorded US history (in 1811 and 1812), is located about 250 miles southwest of the Contract site. No faults have been identified at the Contract site.

4.7 In-situ Stress

Available reports suggest that the site lies within a thrust fault regime zone of the Mid9Continent Region. Horizontal stresses are anticipated to be greater than vertical stresses, though studies disagree on the direction of the maximum principal stress. Testing to investigate the state of stress will be carried out by others in boreholes drilled from the surface during the work to measure the in9 situ state of stress. Historical details are presented in the GDR. The Contract includes supplemental support provisions to address stress9induced deformations, should they occur.

0 RELEVANT PHYSICAL AND MAN-MADE CONDITIONS

0&% Soil Deposits

As presented in the GDR, the borings encountered naturally deposited soil as well as soil placed as fill. Soil samples were collected through auger cuttings or by split spoon sampling. Only one boring, B96, above the tunnel alignment was sampled using a split spoon sampler. The soils encountered in this boring were soft to stiff lean clay and silt with trace to some sand and fine gravel. These are assumed to be representative of soils within the Drumanard Estate. By visual examination of auger cuttings, native soil was encountered in all of the borings advanced. The soil appears to be orange9brown lean clay to silty clay (Unified Soil Classification System symbol CL) with thinner lenses of silt and possibly sand. The soils observed along the Contract alignment do not appear well drained; ponding of water at the surface following rains or snow melt9off was observed.

0&' Soil = Rock Interface

Auger "refusal" : the point past which the hollow stem augers cannot physically be advanced 9 typically indicates the presence of the unweathered bedrock profile. Refusal occurred within a foot of when rock was first observed in a boring. If present at all, a weathered horizon of rock is estimated to be less than two feet thick.

The soil-rock interface is generally sub9parallel with the ground surface and occurs at depths between 3 and 16 feet in those holes located on or immediately adjacent to the Drumanard Estate (B911, B910, B99, B-8, B96, B95, and B97). However, at least four sinkholes were mapped on the surface along the Drumanard Estate, with several smaller sinks noted along the I971 and US 42 road cuts and in the triangular shaped property at the intersection of KY 841 and US 42. The locations of some of these features are shown on Figure 1, as is the location of a spring and a sinking stream present on the Drumanard Estate.

The boreholes as drilled may have intersected the over9deepened profile of such surface karstic solution features, or represent a soil depth overlying a limestone unaffected by the solution process. Evidence of surface karstic solutioning, as exposed in near9by road cuts, ranges in depth from 10 feet to 25 feet. The rock interface with the natural soil was observed in cuts along US 42 and KY 841, and in the northern part of the unnamed stream that crosses the Drumanard Estate, and is estimated to be less than 5 feet, deeper where cover is thickest.

0&+ Louisville Limestone

The Louisville Limestone observed in the borings advanced for this Contract consists of a light gray, slightly weathered to fresh, medium strong to strong, fine9to medium9grained interbedded dolomitic limestone and dolomite with thin (<1/2 inch) interbeds of dark gray shaley limestone. Beds are randomly spaced from less than one foot to over five feet. Stylolites and macrofossils are rare. It exhibits only a thin, weathered rock zone, within 2 feet the rock becomes slightly weathered to fresh.

Voids, typically measuring less than 9 inches high were encountered in the Louisville Limestone in borings B95, B97, B98 above the planned tunnel and B913, and B914, which are outside of the North Portal. The voids, when present, typically occur in the upper five to ten feet of the boring adjacent to the soil9rock interface. During the drilling, it was noted that in many of the borings, the drilling fluid circulation was lost in the upper five to ten feet of the rock mass, indicating that such voids may be connected.

The characteristics and properties for the Louisville Limestone were evaluated through core log inspection, down hole tests, and laboratory tests. All of the laboratory test results are summarized on Table 5 of the GDR. Discontinuity spacings, RQD, Unconfined Compressive Strength, Brazilian Tensile Strength, Axial Point Load, Diametral Point Load, Cerchar Abrasivity, and Punch Penetration results are summarized in Table 1 and shown on Figure 4 in histogram format, with baseline averages indicated.

In borings located near the alignment, the formation thickness ranges from 26.8 feet to 39.4 feet. In the borings offset from the tunnel alignment (65 feet to 175 feet), the formation thickness ranges from 12 feet to 60 feet.

Properties	**Table 1 - Louisville Limestone Range of Property Values**		
	Minimum Value	Maximum Value	Baseline Average Value
Discontinuity Spacing (ft) From Borehole Televiewer	6+67	, ,+,	,
RQD	, *	, 66	* '
Unconfined Compressive Strength (psi) Sample No.	,›-)3 B-3	'7›*76 B-,)-4	, '›-*6
Split (Brazilian) Tensile Strength (psi) Sample No.	4 , 4 B-, , -1	,›347 B-, 3-4	,›, 66
Axial Point Load (psi) Sample No.	)) ' B-, 8-6	,›447 B-6-9	3-6
Diametral Point Load (psi) Sample No.	,)6 B-7-, 6	,›38 , B-6-9	376
Cerchar Abrasivity Index Sample No.	6+8 B-7-, '	, B-, '-8	6+*
Punch Penetration (kip/in) Sample No.	*) B-, 3-4	,)4 B-, '-9	, ' ,

5.4 Waldron Shale

The Waldron Shale observed in the borings and road cuts consists of medium to dark gray, very fine to fine9grained, fresh, weak to locally medium strong, thinly bedded shale with thin fine9grained dolomite interbeds. As described below, the shale demonstrates variable slake durability. Three competent samples that could be prepared were subjected to petrographic analysis. The analyses of these more competent samples indicate that that they are comprised of clay size and silt size particles of dolomite with 2 to 3 percent quartz. Limestone and dolomite beds up to 4 inches thick are locally present in the Waldron Shale, typically near the base of the formation. Limestone and dolomite materials will demonstrate a higher Mohs Hardness than the shale, as further described in the GDR. The limestone and dolomite beds can be expected to demonstrate strength properties characteristic of the underlying Laurel Dolomite. Both the upper contact of the Waldron Shale with the Louisville Limestone and the lower contact with the Laurel Dolomite are sharp and well defined features.

When freshly removed from ground, the shale core was recovered in "sticks" up to 2 feet in length. However, when allowed to air9dry for periods as short as one to three days, the shale core was observed to part along sub9horizontal planes into pieces ranging from 0.5 to 2 inches thick. This "poker9chip" behavior is reflective of strain relief of lateral in9situ stress.

The characteristics and properties for the Waldron Shale were obtained through core log inspection, down hole tests, and laboratory tests. In particular, samples of the shale were subjected to Slake Durability testing (Kentucky Method 6497,)902) to quantify the tendency of the shale to degrade with time. All of the laboratory test results are summarized on Table 5 of the GDR. Discontinuity spacings, RQD, Unconfined Compressive Strength, Brazilian Tensile Strength, Axial Point Load, Diametral Point Load, and Slake Durability results are summarized in Table 2 and shown on Figure 5 in histogram format, with baseline averages indicated. The total formation thickness was observed in all of the borings to range from 10.4 feet to 12.6 feet.

Properties	Table 2 - Waldron Shale Range of Property Values		
	Minimum Value	Maximum Value	Baseline Average Value
Discontinuity Spacing (ft) From Borehole Televiewer	6+,	4+*	,
RQD	*6	,66	*-
Unconfined Compressive Strength (psi) Sample No.	,>*'4 B-2	*>)*6 B-,'-3	7>*66
Split (Brazilian) Tensile Strength (psi) Sample No.	4'7 B-,6-8	873 B-,7-5	766
Axial Point Load (psi) Sample No.	,7, B-6-,*	*36 B-9-4	466
Diametral Point Load (psi) Sample No.	88 B-,'-7	8,7 B-9-4	'-6
Slake Durability Index Sample No.	,7+, B-6-8	*8+' B-8-8	37

0&0 **Laurel Dolomite**

The Laurel Dolomite is described in the published literature as comprised of dolomite with a shale interbed in the lower third of the unit. As observed in the borings in the tunnel horizon, the Laurel Dolomite is comprised of the following three large9scale layers:

,+ Layer #1: The upper and thickest part is a light gray to tan, fine9 to medium9grained, medium strong to strong interbedded limestone, dolomitic limestone and dolomite. The rock mass is thin to thick bedded with few to no macrofossils or stylolites. A brown colored 5 to 10 foot thick zone of non9interconnected pits (<0.1 inch across) is present near the lower part of this sub9unit. The thickness of this sub9 nit ranges from about 38 to 51 feet.

'+ Layer #2: An interbed of dark gray, very fine grained, fresh, weak to medium strong, thinly bedded shale. This sub9unit is typically one to seven feet thick.

)+ Layer #3: A basal part of dark gray, fine9 to very fine9grained, fresh, medium strong to strong limestone and shaley limestone. This sub9unit is approximately four to nine feet thick.

Only the upper part of the Laurel Dolomite, that is, the interbedded limestone, dolomitic limestone and dolomite comprising Layer #1, will be encountered in the Exploratory Tunnel.

The characteristics and properties for the Laurel Dolomite were obtained through core log inspection, down hole tests, and laboratory tests. All of the laboratory test results are summarized on Table 5 of the GDR. Discontinuity spacings, RQD, Unconfined Compressive Strength, Brazilian Tensile Strength, Axial Point Load, Diametral Point Load, Cerchar Abrasivity, and Punch Penetration results are summarized in Table 3 and shown on Figure 6 in histogram format, with baseline averages indicated.

Properties	Table 3 -Laurel Dolomite Range of Property Values		
	Minimum Value	Maximum Value	Baseline Average Value
Discontinuity Spacing (ft) From Borehole Televiewer	6+,	3+7	,+'
RQD	78	,66	*8
Unconfined Compressive Strength (psi) Sample No.	3>,*6 B-,4-6	'4>4,6 B-,49,6	,7>-76
Split (Brazilian) Tensile Strength (psi) Sample No.	-7, B-2-2a	,>-74 B-,7-6	,>6)7
Axial Point Load (psi) Sample No.	''4 B-5-4	,>8*' B-9-,6	**6
Diametral Point Load (psi) Sample No.	), B-,,-9	,>7-8 B-,69,6	*)6
Cerchar Abrasivity Index Sample No.	6+7 B-,7-3	,+4 B-,'-4	6+*
Punch Penetration (kip/in) Sample No.	*- B-,7-3	,-7 B-,7-5	,)7

0&* Karstic Features

At least four sinkholes were mapped on the surface along the Drumanard property with several smaller sinks along the U.S. 42 road cuts, and in the triangular shaped property at the intersection of KY 841 and U.S. 42. The locations of some of these features are shown on Figure 1, as are the locations of a spring (or seep) and a sinking stream present on the Drumanard Estate. The largest of the sinkholes observed measures approximately 50 feet in diameter and on the order of 10 feet deep relative to the surrounding ground surface. Areas of small sinkholes with a cumulative length of up to 600 feet were also observed in local rock cuts.

For the purpose of this GBR, a karstic feature measuring from 6 inches to 2 feet maximum in size (length, width, height) is defined as a “solution channel”; a karstic feature measuring from 2 feet to 10 feet in advance length, width and height is defined as a “karstic void”.

Solution channels have been observed at the base of Louisville Limestone immediately above the limestone shale contact. Examples are shown in photographs of roadcuts along I-71 contained in

Appendix B of the GDR. Solution channels can be identified at spacings estimated from 50 feet to several hundreds of feet apart. The examples illustrated had an estimated outflow of 5 to 10 gallons per minute while the majority of the exposure exhibited a dry or damp condition. It is considered that these flow channels could be examples, at a lower elevation, of the karst features which were encountered in the upper elevations of the Louisville Limestone (boreholes B95, B97, B98, B913, and B914) associated with water loss from the boreholes and consistent with solution channels near the soil rock interface. Suggested measures for dealing with solution channels are discussed in Section 7 and illustrated in Contract Drawing S9667+

Where the rock cover is shallow, especially at the north end of the tunnel alignment, the Exploratory Tunnel design anticipates karst voids that will warrant grouting coupled with special support measures drilled above the tunnel roof prior to the advancement of the tunnel heading. Provisions have been included in the design of the Exploratory Tunnel to address these conditions, should they be encountered. These measures are discussed in Section 7 and illustrated in Contract Drawings S9009 and S-6,6+

0&3 Rock Mass Discontinuities

The rock mass can generally be described as having three main joint sets, with the near vertical joint set being highly variable. Joint orientations have been evaluated from the geotechnical logs, from borehole televiewer surveys, and from surface mapping. By considering the stereonet plots, televiewer surveys, and surface mapping on a regional basis, orientation estimates were developed for the tunnel alignment, as summarized in Table 4 below.

Stereonet plots of the vertical joints and sub9horizontal discontinuities (bedding planes) are presented in Figure 11 of the GDR.

Table 4 = Orientations of Main Joint Sets

Set No.	Description	Dip (degrees)	Dip Direction (degrees)
,	Sub9horizontal	0 to 10	0 to 360
'	Sub9vertical	85 to 90	100 to 110 (280 to 290)
)	Sub9vertical	85 to 90	010 to 025 (190 to 205)
4	Sub9vertical	85 to 90	050 to 060 (230 to 240)
7	Sub9vertical	85 to 90	325 to 340 (145 to 160)

Other joints, which fall outside of the above joint set ranges, are categorized as random+

In general the joints observed in all formations encountered in the borings are tight to partly open with little to no infilling. Many of the joints in the road cuts, with the exception of the Louisville Limestone along I971 at Milepost 12.0 and 12.3 and the Jeffersonville/Sellersburg Limestone at the U.S. 42 road cuts, appear to also be tight to partly open with little to no infilling or staining.

Many of the joints at the three aforementioned sites have been enlarged by solutioning. The majority of these joints are near the ground surface where surface water penetrated the ground and enlarged the joints.

Spacings between sub9horizontal bedding planes and joints have been evaluated from the logs of the recovered core, and from borehole televiewer surveys of boreholes. This information is shown on Figures 4, 5, and 6. For each of the rock units the wider spacings noted in the borehole logs reflect only those that caused breakage of the core, whereas the televiewer detected all bedding features. The televiewer data is considered to be the more indicative of defects that will influence rock breakage during excavation, and are therefore to be anticipated for baseline purposes.

0&. **Groundwater Conditions**

The hydrogeology of the Contract area was investigated through a combination of surficial geologic mapping, surface9based geophysical investigations, borings, observation wells, downhole geophysics, and in situ packer permeability tests. Given the number of karst features and the poorly developed stream pattern observed across the site, the hydrogeology of the tunnel area is typical of an early stage of karst development. Although a significant amount of water may move vertically through some partly open vertical joints, the geomorphology, the results of downhole geophysical tests, and demonstrated hydraulic effects of voids during drilling, indicate that groundwater movement is controlled mainly by flow through discrete solution channels.

Borings were advanced to investigate the conditions at the following key geologic features:

- The soil9rock interface
- The contact between the Louisville Limestone and the Waldron Shale
- The limestone formations above the Waldron Shale
- The Waldron Shale formation
- The limestone formations below the Waldron Shale

Based upon observations made during drilling, and water levels recorded during dry and wet weather periods, groundwater levels vary greatly across the site. A number of wells suggest the presence of a perched water table approximately 6 to 15 feet below the ground surface, which equates to approximately 12 to 40 feet above the crown of the Exploratory Tunnel. It is considered that this could result from a perched condition at the soil/rock interface. However, other wells showed no evidence of a perched condition. Thus, the presence of a perched water table at the soil/rock interface cannot be definitely established.

Other observation wells were installed into the Laurel Dolomite. The observation well data, considered in total, suggest that there are two aquifers present across the site, one that is perched above the Waldron Shale, and one that exists within the lower Laurel Dolomite. The upper aquifer is likely to have a water table ranging from approximately 10 to 50 feet above the crown of the Exploratory Tunnel. The lower aquifer is expected to lie in the range of elevation 427 feet to 509 feet, or approximately 50 feet below to 20 feet above the invert of the Exploratory Tunnel.

Packer tests were conducted in selected borings to assess the rock mass permeability. The tests were assessed using the method described by Houlsby to produce a likely permeability value over the test zone. The majority of the tests indicate a permeability ranging from $2.3\text{x}10^{93}$ cm/s to $7.4\text{x}10^{9-}$ cm/s. However, a test conducted in Boring B96 approximately six feet below the invert of the Exploratory Tunnel indicates a substantially higher permeability value of 1.2×10^{93} cm/s. It is concluded that the former tests reflect the mass permeability of the intact rock units, whereas the latter test encountered a vertical feature as documented in the core logs.

It is believed that because a majority of the boreholes were drilled vertically, few vertical discontinuities were physically intersected in the boreholes. Perhaps more importantly, none of the borings encountered solution channels thought to exist in the Louisville Limestone at or just above the contact with the underlying Waldron Shale. It is these undetected features that can be expected to generate the majority of the groundwater inflow during tunnel excavation. Because of the likely connection to the ground surface, inflows along such solution features can be expected to increase during wet weather periods.

Expected groundwater inflows during tunnel excavation are addressed in Section 7.

It is anticipated most of the flow will come from discrete locations and will decrease from an initial higher rate to a steady state, and will eventually reduce to zero if the source is a natural cistern. If the source of inflow is an active solution channel or a vertical joint, the inflow can be expected to increase in response to rainfall precipitation events.

Inflow during a significant precipitation event is more likely to be a concern. It is uncertain how much recharge area an active solution channel might drain. Consequently, solution channels encountered during tunneling will be either channeled to maintain flow across the tunnel as detailed on Contract Drawing S9005, or monitored during precipitation events to determine whether special measures will be required to address the inflow.

0&6 **Gas**

In the Louisville area naturally occurring gas (primarily methane) has rarely been encountered, and where present, it is found at random and variable intervals in the bedrock. Regionally, natural gas has rarely been encountered in the soil.

Gas was encountered in two readings taken in Boring B911 at a depth of 35 feet and Boring B912 at a depth of 25 feet. The Lower Explosive Limit (LEL) readings recorded were for 2 and 3 parts per million (ppm) respectively. Both of these readings were recorded while drilling in the Jeffersonville/Sellersburg Limestone. The field staff noted no odor or sign of gas venting from the borehole at the time these readings were taken.

The gas level indicators also indicated levels of Carbon Monoxide (CO) up to 6 ppm in Borings B911 and B-12. However, some of the readings registered were negative numbers and cast doubt as to the validity of the positive CO readings.

Gas was encountered in borings advanced along the Ohio River for the Riverbank Filtration Tunnel which is located about 8,000 feet north of the Exploratory Tunnel portal as described in the GDR. These borings were drilled in deeper and older formations than those encountered along the tunnel alignment. The source of the gas is not known nor is the geologic mechanism for the gas entrapment.

Based on these results, the Exploratory Tunnel Supplemental Specifications have been developed on the basis that the tunnel is classified as Potentially Gassy, in accordance with OSHA regulations.

0&%/ **Surface Structures and Utilities**

With the exception of the intersection of KY 841 and U.S. 42, the land surrounding the Exploratory Tunnel and access ramp alignments is either developed for residential use or is listed on the National Register of Historic Places (NRHP). Contract Drawing G9008 defines the approximate property lines and respective property owners.

The Drumanard Estate Gardens and Buildings are registered on the National Register of Historical Places. The Register inventory lists 55 acres, 6 buildings, 3 structures, and two objects consisting of the following:

- Gardens, trees, and plantings designed by nationally renowned landscape architects that cannot be disturbed or damaged by construction9related blast vibrations or lowering of the groundwater table
- The Drumanard buildings, which are located some 440 feet west of the Exploratory Tunnel alignment
- Other historic structures on the Estate that are located from 140 feet to 400 feet from the alignment

Another historic structure is the Allison Barrickman House, which is located immediately south of KY 841 and the Exploratory Tunnel portal access ramp area. The property falls within a 5009foot offset from the Contract site.

Two residential communities located near the site include the Bridgepointe subdivision located northeast of the Exploratory Tunnel alignment and the Shadow Wood subdivision located northwest of the northern terminus of the Exploratory Tunnel.

Utilities, power line poles and buried fiber optics are present in an easement running parallel to the north side of U.S. Route 42 between the highway and the Drumanard Estate property line. The approximate locations of these utilities as well as near9surface culverts are shown on the Contract Drawing IM966'+

0&%% Previous Construction Experience

Previous experience with rock excavation in the Contract vicinity is limited to the road cuts exposed within the Jeffersonville Limestone on US 42 and KY 841. New rock cuts have been exposed (in late 2006, early 2007) in order to relocate the KY 841 off ramp and widen US 42. These new exposures have not been subject to inspection or assessment in this report or the GDR.

0&%' Interpretation of Baseline Values

With regard to variations in material properties and characteristics, and rock mass parameters, a claim for additional compensation will only be considered with regard to such material properties and characteristics, and rock mass parameters, for the entire tunnel alignment. No claim will be considered to have merit or reasonable basis if predicated solely on a portion of the tunnel alignment.

* ANTICIPATED GROUND CONDITIONS

*&% Lithologies by Tunnel Reach

The Exploratory Tunnel has been divided into four reaches that reflect changes in the rock formation(s) expected to be encountered during tunnel excavation. This assessment is based upon an interpolation of contours at the top and base of the Waldron Shale as encountered in certain boreholes, as indicated on Figures 2 and 3.

*&' Rock Mass Conditions and Classification

To determine the quality and condition of the rock, and to classify the expected ground conditions, two Rock Mass Classification systems were used: the Q9system as originally proposed by Barton, Lien & Lunde (1974), with a further update by Grimstad and Barton (1993); and the Rock Mass Rating classification system (RMR), as developed by Bieniawski (1989). A key parameter common to both classifications is the Rock Quality Designation (RQD) (Deere, D.U. and Deere, D. W., 1984). Data and baseline values of RQD are summarized in Figures 4, 5, and 6 for the three rock units, respectively. It is noted that RQD was assessed as the core was recovered immediate from the boreholes. The tendency of the Waldron Shales to form "poker chips" thereafter is not reflected in the RQD values shown on Figure 5. This effect can be expected to reduce the RQD values from the high 90s logged to below 25. The lower values were included in the rock mass classification assessments described below.

*&'&% Rock Mass Classification, Q-Value

The key parameters for assessing Q9Value include: RQD, Joint set number (Jn), Joint roughness number (Jr), Joint alteration number (Ja), Joint water reduction factor (Jw), and Stress Reduction Factor (SRF). Reviewing the rock core, core photographs and boring logs parameter values were selected, and then choosing the appropriate value of the various parameters as described in Barton (1974, 1993). Q was then computed by Equation 1 below. The term 'RQD/Jn' in Equation 1 is intended to reflect rock block size. The term 'Jr/Ja' is an indicator of the inter9block shear strength, and Jw/SRF is a representation of the active in9situ stress:

Equation 1: $Q = (RQD/Jn) \times (Jr/Ja) \times (Jw/SRF)$

The rock classification systems based on different Q values are summarized in Table 5. The estimated Q values for the three rock types within the tunnel horizon are summarized on Table 6. The Q values range from a low of 0.07 (Extremely Poor) in the Waldron Shale to a maximum of 17 (Good) in the Louisville Limestone+

Numeric mean Q values were estimated to be 6.1 (Fair) for the Louisville Limestone, 0.4 (Very Poor) for the Waldron Shale, and 6.6 (Fair) for the Laurel Dolomite. It is noted that much interpretation is required to estimate the input parameters when determining Q values. The value range extends from 0.001 to 1000, and is logarithmic in nature. Thus, each classification category reflects a broad range in Q value.

Furthermore, the original classification was developed for deeper, more confined excavations than the planned excavation, which lies close to the rock surface in an environment that could be adversely influenced by karst9related groundwater inflows and levels of near9surface in situ stress. Because of the subjective and variable nature of the estimated Q values, it is the general ground classification that is considered indicative of the anticipated conditions, not the precise Q values. The Q values were utilized to develop the tunnel initial support systems shown on the Contract Drawings.

Table 5 = Q Rock Mass Classification System (After Grimstad & Barton, 1993)	
A	**Classification**
400 – 1,000 ,669466 469,66 ,6946	Exceptionally Good Extremely Good Very Good Good
4+69,6+6 ,+694+6 6+,9,+6	Fair Poor Very Poor
6+6,96+, 6+66,96+6,	Extremely Poor Exceptionally Poor

Table 6 = Rock Mass Q-Values for Project Site Formation Types			
Formation Type	Range of Q Value		
	Lower Value	Upper Value	Mean Value
Louisville Limestone	)	,8	-+,
Waldron Shale	6+68	,	6+4
Laurel Dolomite	4	3	-+-

*&'&' Rock Mass Rating, RMR

The parameters used to evaluate RMR are Intact Strength 9 (by Point Load Strength Index and Unconfined Compressive Strength, UCS), RQD, spacing of discontinuities, condition of discontinuities and their orientation to planned direction of drive, and groundwater conditions.

Similar to Q, RMR values were evaluated for each rock unit. For each assessed rock unit, the parameters shown in the Rock Mass Rating System were evaluated and their individual ratings summed to determine the overall RMR values. The RMR classification system and estimated RMR values are summarized in Tables 7 and 8.

Both Q and RMR will be evaluated in the field to determine the actual support system requirements to be installed.

Table 7 = RMR Rock Mass Rating Classification System (after Bieniawski, 1989)	
RMR	**Classification**
100 – 81	Very good rock
80 – 61	Good rock
60 – 41	Fair rock
40 – 21	Poor rock
20 – 0	Very poor rock

Table 8 = Rock Mass Rating (RMR) Values for Project Site Formation Types			
Formation Type	Range of RMR Value		
	Minimum	Maximum	Mean
Louisville Limestone	)-	86	-)
Waldron Shale	)-	-4	77
Laurel Dolomite	)4	8,	-)

3 DESIGN AND CONSTRUCTION CONSIDERATIONS

3&% Method of Tunnel Excavation

This GBR has been prepared with the anticipation that the tunnel will be excavated using drill and blast methods. Alternative methods including roadheaders or impact hammers coupled with line drilling of the profile will also be considered, subject to approval by the Engineer.

3&' Tunnel Alignment

As indicated on the Contract Drawings, the Exploratory Tunnel has been selected to trend along the alignment of the future southbound highway tunnel, and is located within the upper portion of the highway tunnel cross9section.

3&+ Tunnel Support Design

Utilizing the rock mass quality assessments of Q and RMR discussed in Section 6, tunnel support types were developed to address the range of ground conditions anticipated in the Exploratory Tunnel. Tunnel support measures generally consist of pattern rock bolts and welded wire fabric installed in the roof and sidewalls. These measures may be augmented with shotcrete and invert concrete protection where the tunnel encounters poorer rock mass conditions. The rock bolts are to consist of fiberglass bars to facilitate future highway excavation. Requirements for rock support elements are contained in the Exploratory Tunnel Supplemental Specifications.

Typical tunnel support types are Type I, II, and III, as shown on Contract Drawing S9003. These support types will be determined based on the actual ground classifications. Type IV, which is a mandatory support type, was developed to provide unclassified support where the tunnel crosses beneath Highway 42. This support type is to be installed independent of the assessed rock mass classification. A fifth type, Type EBC, was developed to support the wider span exploration bays as shown on Contract Drawing S9 004. Type EBC support includes pattern rock bolts and welded wire fabric on the arch and walls, as well as shotcrete as directed by the Engineer. Type EBC support shall be augmented with additional shotcrete and invert concrete protection where the tunnel encounters poorer rock mass conditions.

The initial 30 feet of tunnel from the portal will require a mandatory support pattern, Type P, as shown on Contract Drawings S9001 and S-002 and specified in Exploratory Tunnel Supplemental Specification 31 72 13.

To address localized conditions as well as karst features, the Exploratory Tunnel Supplemental Specifications include provisions for the installation and payment of supplemental rock bolts, welded wire fabric, shotcrete, steel ribs, canopy tubes and self9drilling rock bolts, all as directed by the Engineer in the field.

Figures 2 and 3 show the baseline usage of the various support types along the four tunnel reaches. The Exploratory Tunnel Supplemental Specifications designate the means by which ground support requirements will be assessed by the Contractor and agreed between both the Contractor and Engineer as excavation proceeds. With regard to variations within specific reaches, or elements of work based upon such variations, a claim for additional compensation will only be considered with regard to total support quantties as given in Figures 2 and 3 for the entire tunnel alignment. No claim will be considered to have merit or reasonable basis if predicated solely on a portion of the tunnel alignment.

Rock mass behavior during tunneling will be influenced by the characteristics of the rock mass, including joint and other discontinuity spacings, their orientations with respect to the tunnel axis, spacings relative to the tunnel and exploration bay spans, and amount of groundwater inflow. The degree of difficulty that the Contractor will face in excavating the tunnel and the exploratory bays will also depend upon the method and type of construction e.g. drill and blast, blast vibration restrictions, the round length excavated, control of perimeter look9out angles, the timely installation of support when required to stabilize deteriorating rock materials, and the muck handling and pumping systems employed particularly in those sections where shale will be exposed in the tunnel+

Blocks formed by bedding planes and other sub9horizontal discontinuity surfaces will be prone to fallout when they are cut by near9vertical adversely oriented discontinuities. Joint surfaces can be expected to be open, or will contain clay, rock fragments, or gouge material resulting from solution effects of ground water flow in the limestone. As discussed in the GDR, zones of closely spaced vertical joints have been observed in nearby road cuts at fifty to several hundred feet intervals.

Due to the closely jointed nature of the rock mass, and the well9defined bedding planes that have been observed, block fallout can be expected to occur in all excavations. Block fallouts are expected to include the following:

- Slab fallout that occurs during blasting or scaling caused by the tendency for rock to break back to sub9horizontal discontinuities+
- Progressive failure by gradual loosening and fallout of small blocks of rock. This failure mode is likely to occur in shales if initial support is not installed immediately after the tunnel is excavated+
- Block failure in the sidewalls due to undermining by a softened shale invert condition.

A certain degree of overbreak should be anticipated, notwithstanding the application of good workmanship and the use of proper controlled blasting and other excavation procedures. Contract Drawing numbers C9007 and C9008 designate the excavation lines for the Exploratory Tunnel and exploration bay enlargements including:

- Excavation
- An allowance for initial support
- The minimum dimension which all ground support elements shall lie outside

The risks and costs associated with overbreak volumes from the designated excavation line as shown on drawings C9007 and C9008 are the responsibility of the Contractor+

7.4 Tunneling Conditions by Reach

Four reaches, R1 through R4, were developed to reflect the rock type(s) anticipated to be encountered along the tunnel alignment. These Reaches are illustrated on Figures 2 and 3 which show the estimated percentages of the different initial support types to be installed within each reach, in the tunnel entrance portal, in the section of tunnel beneath Highway 42, and in the five exploration bays. Details of these support measures, as well as the tunnel support measures at the portal, are shown on the Contract Drawings.

Reach 1

Reach 1 is estimated to extend from SB 50+00 to SB 52+50. It is expected that Reach 1 will encounter the Louisville Limestone in the invert, walls and roof. The beginning 30' of Reach 1 is the portal design for the exploratory tunnel. Towards the end of the reach, shale can be expected to be encountered in the invert. The rock mass is intersected by a sub9horizontal joint system with variable spacing averaging about 1 foot. The vertical joints based on mapping of existing rock exposures are randomly spaced at 2 to 10 feet and typically within 10 degrees of vertical. Groundwater inflow is to be expected. Rock mass permeability in this reach are on the order of $1.0x10^{98}$ cm/s, however the permeability of vertical joints is expected to be on the order of 1+6/ ,$6^{9)}$ cm/s.

Reach 2

Reach 2 is estimated to extend from SB 52+50 to SB 57+50. At the beginning of Reach 2, the Louisville Limestone is anticipated to be encountered in the Exploratory Tunnel roof and walls, with Waldron Shale encountered in the invert. As the reach progresses northward, the Waldron Shale is anticipated to rise relative to the downward9sloped tunnel drive, such that at the end of the reach, Louisville Limestone is anticipated to be encountered only in the crown and the upper 50% of the walls, with Waldron Shale anticipated to be encountered in the invert and lower 50% of the walls. The shale in this reach is typically weaker than the overlying Louisville Limestone. The presence of two dissimilar rock formations in the heading at the same time will need to be addressed in the Contractor's excavation procedures to avoid over excavation of the weaker shale. The rock mass is intersected by the same sub9horizontal and vertical joint system as in Reach 1. Groundwater inflow is to be expected. Rock mass permeability measurements range from $1.0x10^{98}$ cm/s to $1.6x10^{97}$ cm/s, however the permeability of vertical joints is expected to be on the order of $1.0x10^{9)}$ cm/s.

Reach 3

Reach 3 is estimated to extend from SB 57+50 to SB 61+00. At the beginning of Reach 3, Louisville Limestone is anticipated to be encountered for the top 50% of the wall and crown, with Waldron Shale comprising the invert and lower 50% of the walls. At the end of the reach, Louisville Limestone is anticipated to be in the crown only, with Waldron Shale in 100% of the tunnel walls and invert. The shale in this reach is shown as being of variable slake durability (results from B910 samples vs. B911 samples). As in Reach 2, the shale will be weaker than the overlying Louisville Limestone. Because the shales will eventually occupy the full wall height, the potential for overbreak is greater than in Reach 2. Again, the presence of two dissimilar rock formations in the heading at the same time will need to be addressed in the Contractor's excavation procedures to avoid over excavation of the weaker shale. The Louisville Limestone will be intersected by the same sub9horizontal and vertical joint system as in Reaches 1 and 2, however closer and weaker bedding planes are expected in the shale. Also, thin (on the order of 4 inches thick) layers of limestone and dolomite observed to occur in the lower portion of the shale can be expected to make the excavation of the shale more difficult. Groundwater inflow is to be expected. Rock mass permeability measurements in this reach range from $1.0x10^{98}$ cm/s to $1.3x10^{94}$ cm/s, however the permeability of vertical joints is expected to be on the order of $1.0x10^{9)}$ cm/s.

Reach 4

Reach 4 is estimated to extend from SB 61+00 to SB 68+00, the terminus of the Exploratory Tunnel. At the beginning of Reach 4, it is anticipated that Waldron Shale will be encountered in the roof and the majority of the walls, with Laurel Dolomite in the invert and only a small portion of the walls. As the tunnel moves towards the north, Waldron Shale is anticipated in the roof and approximately the upper 50% of the walls, with Laurel Dolomite anticipated in the invert and approximately the lower 50% of the walls. Because the true top elevation for the Waldron Shale is unconfirmed along this reach, it should be expected that the upper limestone will also be encountered in the roof for limited distances and will be intersected by the same sub9horizontal and vertical joint system as in Reaches 1, 2 and 3. Because of the substantial presence of the Waldron Shale, this reach is anticipated to require 100% Type III support. Groundwater inflow is to be expected. Permeability values measured in the shale for this reach range from 2.8x10^{9-} cm/s to 1.1x10^{94} cm/s, however artesian conditions are anticipated where vertical joints in the underlying Laurel Dolomite are encountered.

Invert

Due to the tendency of the Waldron Shale to degrade, wherever the shale is encountered, invert concrete is to be placed as required by Exploratory Tunnel Supplemental Specifications, Section 31 71 16.01 and Section 31 71 23. This requirement will pertain to both the tunnel and the Exploration Bays. The payment provisions anticipate invert concrete for approximately 800 feet of the tunnel, between approximately Stations SB 52+50 and SB 60+50.

Karstic Features

When solution channels are encountered, they will be addressed in the following ways:

,+ Probe drilling (discussed below) to detect their existence in advance of encountering them in the heading. If encountered by probe drilling, formation grouting in advance of the heading could take place+

'+ If interrupted by the tunnel cross9section, a solution channel exposed on one sidewall of the excavation can be re9connected o the continuing solution channel on the opposite sidewall as shown on Contract Drawing S9005 and Exploratory Tunnel Supplemental Specifications Section 31 71 29 - Control and Removal of Tunnel Water+

)+ Where re9connection of solution channels is not feasible, such inflow will be addressed by secondary grouting behind the tunnel face if sustained inflow exceeds flow levels as defined in Exploratory Tunnel Supplemental Specifications Section 31 71 26 9 Probe Drilling and Grouting and Contract Drawings S9007 and S9663+

Solution channels can be expected to be encountered anywhere along the Exploratory Tunnel alignment. As a baseline, expect that 20 such channels will be encountered and that 50% will exhibit flow when encountered. Individual solution channels can be expected to be spaced as closely as 10 feet and as widely as hundreds of feet. Observations suggest that these solution channels will occur more frequently at the base of the limestone above the Waldron shale interface, and at the top of the Dolomite just below the shale contact+

The potential for encountering karstic voids is the greatest in the Louisville Limestone, particularly in the roof in areas of low ground cover, and near the contact with the underlying Waldron Shale. Where karstic voids are encountered, the Contractor can expect increased difficulties associated with:

- Soil infilling of the encountered voids
- Flush flows associated with stored groundwater in the voids and any connecting joints and solution channels
- Support of openings that extend beyond the normal excavation profile

- Support of the rock mass adjacent to such voids

Ground support design for karstic voids will be dependent on actual site conditions encountered. Contract Drawings S9009 and S-010 show suggested procedures and methods requiring installation of 409feet canopy tubes for dealing with a single feature. For baseline purposes, bid items have been included in the Exploratory Tunnel Supplemental Specifications and Schedule of Bid Items to account for two (2) karstic voids measuring from 2 feet to 10 feet in advance length, width and height.

Groundwater Inflows

Groundwater inflows are anticipated to occur in all reaches during the work and groundwater control measures will need to be instituted along the alignment. Groundwater inflows during tunnel excavation will be measured in terms of heading inflows and long9term inflows. The Exploratory Tunnel Supplemental Specifications contain the requirement details by which groundwater inflow measurements will be made.

The heading is defined as a zone extending 20 feet back from the face of excavation. Heading inflows are groundwater inflows (exclusive of the Contractor's construction water) measured and captured 20 feet back from the face of excavation, and conveyed to the portal. Heading inflows can be expected to occur anywhere along the tunnel, will be manifested initially as a peak flow rate from a specific feature or feature(s), and will decay over time as the storage of groundwater associated with that feature or features is depleted. For baseline purposes, the Contractor should expect to encounter 10 heading inflow events up to a peak inflow rate of 100 gallons per minute (gpm), during the work. The rate of decay can be expected to vary. For baseline purposes, assume that the time for peak inflows to decay to $1/20^{th}$ of the peak flow rate will range from 24 to 72 hours, and average 48 hours.

In an effort to reduce the impacts of heading inflows in the downgrade Exploratory Tunnel drive, the Contractor should have an available pumping capacity capable of handling 100 gallons/minute within a maximum distance of 20 feet behind the tunnel face in addition to that required for his construction needs and that required for fire fighting capacity. All water pumped from the tunnel is required to be treated prior to discharge, in accordance with Exploratory Tunnel Supplemental Specifications Section 31 71 29.

Long term inflows are defined as the flow rate of ground water removed at the tunnel portal (exclusive of the Contractor's construction water) that derives from inflows and seepage occurring from the tunnel perimeter behind the heading. For baseline purposes, the Contractor is responsible for capturing, piping, pumping, treating, and disposing of up to 15 gpm of long term inflows at all times during the work. Long term inflows are in addition to any heading inflows that may occur. Long9term inflows will enter the tunnel through a variety of means, including discontinuities such as joints, bedding planes, and solution channels.

3&0 Tunnel Mapping

The Engineer will also carry out tunnel mapping and inspection during excavation using both the Q and RMR rock mass classification systems to evaluate tunneling and groundwater conditions and to confirm the Contractor's recommendation or assess the need for additional tunnel support. The Contractor will be required to provide access in the heading on a regular basis, and to allow for uninterrupted access for tunnel mapping.

3&* Probe Drilling

Probe drilling is required to be carried out continually along the entire tunnel alignment. The purpose for probe drilling is to assess the nature of the ground, particularly the presence of karstic features above the tunnel roof, and to identify the potential for groundwater inflows ahead of the face. Exploratory Tunnel Supplemental Specifications Section 31 71 26 and Contract Drawing S9007 contain the requirements for probe drilling along the tunnel alignment. All probe holes are to be tested for methane and explosive gases in accordance with Exploratory Tunnel Supplemental Specifications Section 01 35 00.

3&3 Formation Grouting

Grouting is required to control groundwater inflows and to control tunnel stability in locations of low ground cover. Grouting will be instituted in order to reduce the potential for the depletion of perched groundwater that serves vegetation on the Drumanard Estate. Control of grouting pressures and volumes will be critical to effective grouting where overburden is low. Criteria, procedures, and requirements for probe drilling and grouting are presented in Exploratory Tunnel Supplemental Specifications Section 31 71 26.

The baseline estimate for grouting ahead of the face per Contract Drawing S9008 is defined as follows:

- Single Cover Grouting: 109percent of tunnel length
- Double Cover Grouting: 59percent of tunnel length
- Primary and secondary pattern of grout holes will be required.

Post excavation grouting shall be carried out as directed by the Engineer at locations within the tunnel where groundwater continues to form a permanent inflow into the completed tunnel. For baseline purposes, assume a total of 40' length of tunnel will require post excavation grouting+

The need for both pre and post excavation tunnel grouting can be expected in any location along the tunnel.

3&. Gas and Ventilation

The Contractor is to assume that the tunnel will be classified as "Potentially Gassy" in accordance with 29 CFR OSHA 19269800. Monitoring for gas is required in accordance with prevailing Federal and State regulations and Exploratory Tunnel Supplemental Specifications Section 01 35 00.

3&6 Highway 42

The Exploratory Tunnel Supplemental Specifications require that Highway 42 remain in operation during tunnel construction but that traffic is stopped temporarily during periods of blasting beneath and in proximity to the highway. Monitoring of vibration and surface settlement must be carried out in accordance with specification requirements‡

. INSTRUMENTATION AND EXPLORATION REQUIREMENTS

.&% Introduction

The Contract Drawings and Exploratory Tunnel Supplemental Specifications contain the requirements for ground performance instrumentation, settlement monitoring, vibration monitoring, and planned geotechnical investigations. The Contractor is responsible for completing the procurement, installation and maintenance of all instruments and readout units or data9loggers.

.&' Piezometers

Standpipe piezometers have been installed in existing boreholes as shown on Contract Drawings IM9002 and IM9603. Automatic readout devices are required to be installed and maintained by the Contractor in selected standpipe wells.

.&+ Stream flow Measurements

Automatic flowmeters will be installed by the Contractor to monitor stream flows across the Drumanard Estate as shown on Contract Drawings IM9002. Outflow of water from the tunnel will be monitored at the tunnel portal. The Contractor is required to install and maintain the instrumentation.

8.4 Rainfall Measurements

The Contractor is required to establish and maintain an automatic rain gauge adjacent to the Contractor's working area**.** This will provide correlation to stream flow and potential run9off quantities.

.&0 Blast Vibration Monitoring and Pre-Construction and Post Construction Condition Surveys

All blasting and vibration monitoring and condition survey activities shall be in conformance with requirements set forth in Special Notes for Blasting and Vibration.

.&* Ground Settlement

Review and alert levels have been specified in Exploratory Tunnel Supplemental Specification 31 09 13 for settlement markers and surface monitoring points shown on IM9002 for US Highway 42.

.&3 Excavation Deformations

Convergence monitoring and monitoring of ground displacement with rod and wire extensometers are required at selected locations within the tunnel and Exploration Bays during excavation. Convergence monitoring locations and anchor points are to be located in accordance with Contract Drawings GI9003 through GI9009.

.&. Cyclical Wetting and Drying Chambers of Waldron Shale

Cyclical Wetting and Drying Chamber consisting of a perforated water sprayer or pipe mounted to a rigid frame shall be installed as described in Exploratory Tunnel Supplemental Specification 02 32 13 and shown on contract Drawings GI9610 through GI9012. Cyclical wetting and drying tests on the Waldron Shale shall consist of spraying water through the perforated sprayer for the period specified followed by a specified drying period to allow the rock surface to dry or to a cycle duration as instructed by the Engineer.

.&6 Geophysical Investigations

Resistivity and refraction tomography surveys are to be carried out by the Engineer along traverse lines as shown on Contract Drawing GP9001. Two parallel resistivity survey lines are to be conducted in the invert of the Exploratory Tunnel as detailed on Contract Drawing GP9001.The Contractor is to provide access so that the survey is complete and preliminary analysis is developed prior to the commencement of exploratory drilling within the adjacent Exploration Bay.

.&%/ Exploratory Investigation Drilling

Exploratory borings with core recovery will be drilled within each Exploration Bay as detailed in Contract Drawing GI9002. Geophysical logging of these holes are required. Piezometers are to be installed as detailed on Contract Drawings.

Exploration probe holes with no recovery are also required, as detailed in Contract Drawing GI9001. Crosshole tomography holes will be required as per Exploratory Tunnel Supplemental Specification 02 32 13 and illustrated on Contract Drawing GI966,+

.&%% Record of Exposed Tunnel Geology

The Contractor will be required to carry out geologic mapping and digital tunnel photography in accordance with Exploratory Tunnel Supplemental Specification 02 32 13. Such work will need to be scheduled concurrent with ongoing tunnel excavation work.

6 LIMITATIONS

The interpretations and assessments contained in this report are based upon the available information from limited surface mapping, borings, in situ tests and laboratory tests. The geologic environment of the overburden at the site and of the bedrock along the tunnel alignment is complex, and as such, no amount of pre‐construction information will convey as detailed an understanding as will exist following excavation. The range of expected site and construction conditions presented in this report is established as a baseline to be used by all bidders in preparing their bids. The expected conditions were developed with the standard of care commonly applied as the state of the practice in the profession. No warranty is included; either expressed or implied that the actual conditions encountered will conform to the baseline conditions described herein.

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GEOTECHNICAL BASELINE REPORT

APPENDIX A

Appendix A:

In Geologic Map of the Louisville 30 x 60 minute Quadrangle (Thomas Sparks and Qinhua Zhang Geologic Map 4 Series Xii, 2003, UKY KGS) provide a summary description of the mapped geologic members and units encountered Contract area and recovered in cores from the site investigation program. It is reproduced below for reference and comparison purposes.

Devonian

SELLERSBURG AND JEFFERSONVILLE LIMESTONES-

Unit composed of Sellersburg and Jeffersonville Limestones, as well as some New Albany Shale in Owen 7.5-minute quadrangle. Sellersburg Limestone includes Beechwood and Silver Creek Limestone Members. Beechwood Limestone, coarse to very coarse fossil fragments and whole fossils in matrix of silt-size lime mud or very finely crystalline calcite; locally cherty; very thin- to thin-bedded. Silver Creek Limestone, dolomitic, argillaceous; cryptogramed to micrograined; bedding laminated to crosslaminated. Jeffersonville Limestone, fossil fragments in matrix of spary calcite or calcareous mudstone; pyritic; locally dolomitic; scattered banded chart in thin irregular stringers. Abundant whole fossils include large colonial corals in lower part and brachiopods in upper part. Unit is unconfomable with underlying Louisville Limestone.

JEFFERSONVILLE LIMESTONE-

Limestone, fine to very coarse fossil fragments and whole fossils in matrix of silt- to clay-size lime mud or crystalline calcite, Unit is mapped separately in La Grange and Crestwood 7.5-minute quadrangles.

Silurian

LOUISVILLE LIMESTONE-

Dolomitic limestone, dolomite, and minor shale. Dolomitic limestone, micrograined to fine-grained; very thin- to thick-bedded; styfolitic; abundant large fossil fragments and whole fossils. Dolomite, calatic, very fine- to fine-grained with abundant, very coarse-grained fossil fragments. Fossils include brachiopods, stromatolites, and corals. Unit mapped in west part of the quadrangle; dolomitization increases from north to south.

WALDRON SHALE--Shale, clayey, dolomitic; bedding obscure, sparse fossils; poorly exposed.

LAUREL DOLOMITE >

Dolomite and minor shale. Dolomite composed of two types: (1) micrograined to very finely crystalline; characterized by even beds commonly 0.1 to 1 m thick; contains calcite m irnagular patches; locally contains thin discontinuous chert layers and nodules; fossils, including crinoid columnals and rare brachiopods; forms upper part of unit; and (2) massive, porous, mottled, thick- to very thickbedded, bedding obscure; contains clasts of colorless calcite; forms lower part of unit. Shale, dolomitic, laminated, fossils rare or absent, occurs in middle or lower part of unit.

OSGOOD AND BRASSFIELD FORMATIONS-

Unit composed of Osgood and Brassfield Formations. Osgood Formation, shale, dolomite, and dolomitic mudstone. Shale, dolomitic; laminated, poorly fissile; in part distinct 3- to 8-cm-thick even beds, indistinct where weathered. Dolomite, generally very fine-grained, thin-to thickbedded with thin shale or dolomitic mudstone partings; rare fossils. Dolomitic mudstone, thin-bedded; locally present. Osgood Formation is conformable but may ~ be locally unconformabie with the underlying Brassfietd Formation. Brassfield Formation, limestone and dolomite. Limestone, fine- to coarse-grained; locally crossbedded; contains whole and broken fossils and scattered thin lenses of porcelaneous chert. Dolomite, calcitic and similar to the limestone, occurring as both medium- to coarse-grained and very fine-grained types. Limestone and dolomite interbedded and intergraded. Basal contact unconformable.

BRASSFIELD FORMATION-

Limestone and dolomite. Limestone, fine- to mediumgrained, well-sorted; consists mostly of erinoid and bryozoan fragments cemented by spany calcite; slightly phosphatic and glauconftic. Dolomite, finely crystalline; contains abundant vugs. Unit grades from limestone at base to dolomite at top.

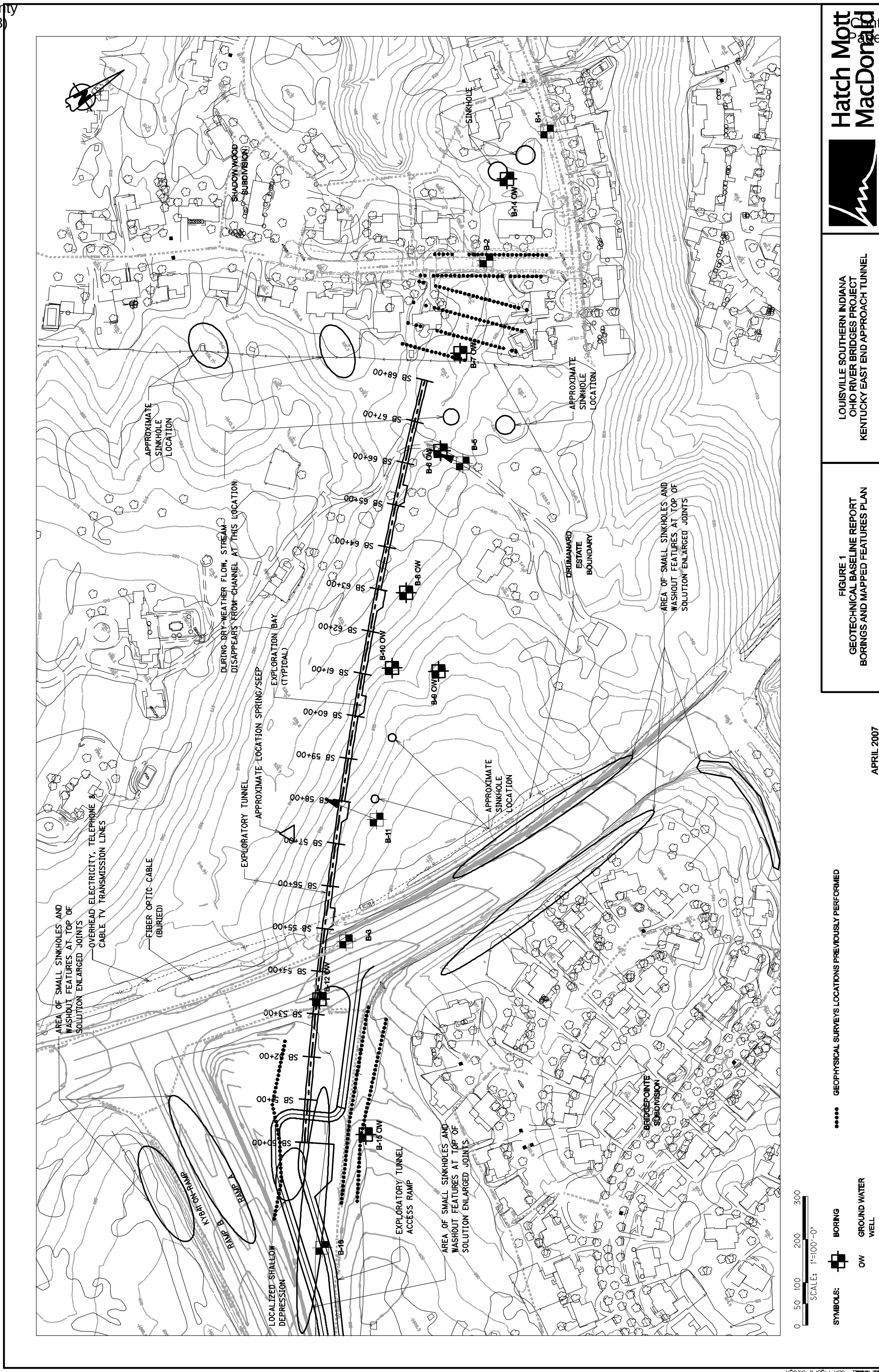
Ordivician

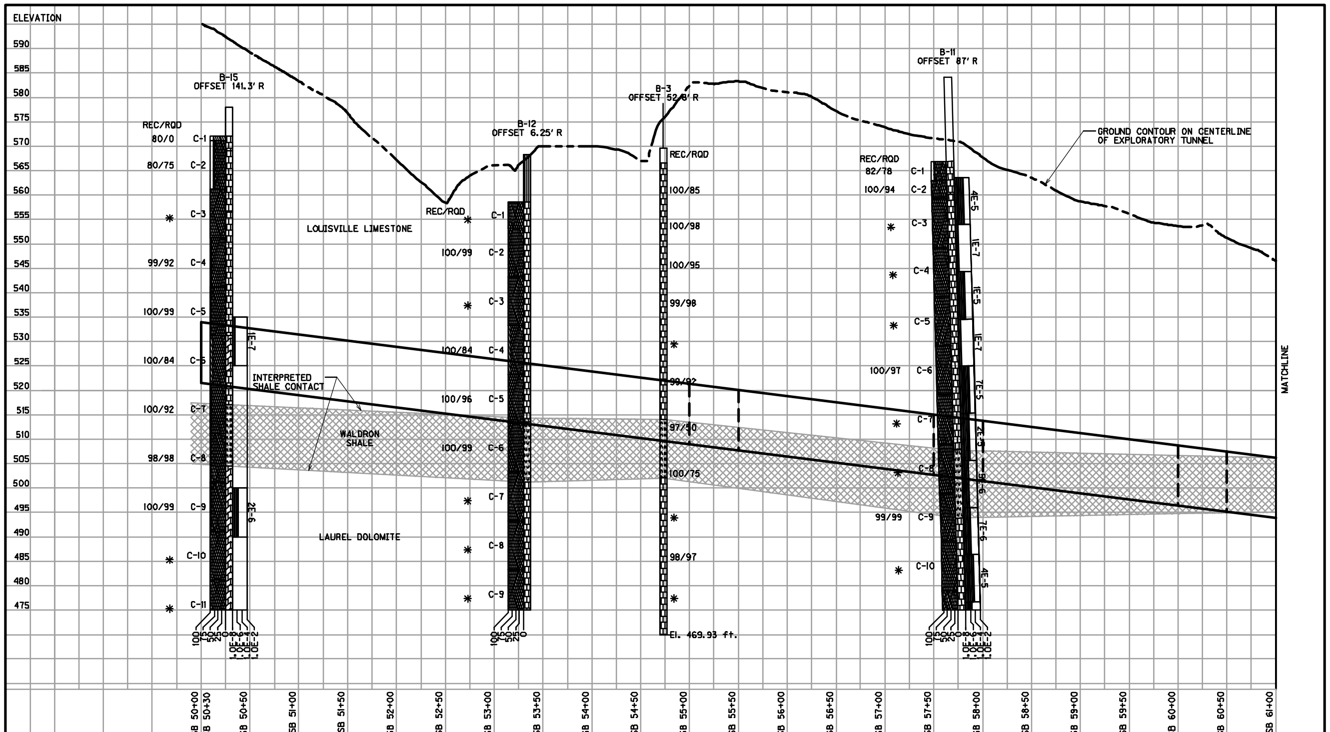
DRAKES FORMATION-

Unit consists of three members: in ascending order, they are the

- *Rowland,*
- *Bardstown, and*
- *Saluda Dolomite Members.*

Dolomite, limestone, shale,and mudstone. Dolomite, very fine- to fine-grained with medium- to coarse-grained beds near top locally, partly calcareous, sparsely fossiliferous; worm burrows, mud cracks, and ripple marks present; thin- to thick-bedded. Limestone, micrograined to coarse-grained, locally doiomitic, partly argillaceous and silty; commonly fossiliferous, abundant colonial corals; thin- to thick-bedded. Shale, calcareous, locally carbonaceous, partly dolomftic. Mudstone, commonly dolomitic, locally calcareous, occurs interbedded with other units; thin- to thick-bedded.


Hatch Mott MacDonald
LOUISVILLE SOUTHERN INDIANA
OHIO RIVER BRIDGES PROJECT
KENTUCKY EAST END APPROACH TUNNEL
FIGURE 1
GEOTECHNICAL BASELINE REPORT
BORINGS AND MAPPED FEATURES PLAN
APRIL 2007
GEOPHYSICAL SURVEYS LOCATIONS PREVIOUSLY PERFORMED
SYMBOLS:
BORING
OW GROUND WATER WELL
SCALE: 1"=100'-0"
SHADOW WOOD SUBDIVISION
BRIDGEPOINTE SUBDIVISION
DRUMANARD ESTATE BOUNDARY
APPROXIMATE SINKHOLE LOCATION
EXPLORATORY TUNNEL
EXPLORATORY TUNNEL ACCESS RAMP
EXPLORATION BAY (TYPICAL)
APPROXIMATE LOCATION SPRING/SEEP
DURING DRY-WEATHER FLOW, STREAM DISAPPEARS FROM CHANNEL AT THIS LOCATION
AREA OF SMALL SINKHOLES AND WASHOUT FEATURES AT TOP OF SOLUTION ENLARGED JOINTS
OVERHEAD ELECTRICITY, TELEPHONE & CABLE TV TRANSMISSION LINES
FIBER OPTIC CABLE (BURIED)
LOCALIZED SHALLOW DEPRESSION
KY841 ON-RAMP
RAMP A
RAMP B



INVERT ELEVATION	521.42	521.18	515.26	508.96	507.70	502.66	501.40	496.36	495.00	493.84

LITHOLOGY	LOUISVILLE LIMESTONE	LOUISVILLE LIMESTONE OVER WALDRON SHALE	LOUISVILLE LIMESTONE OVER WALDRON SHALE (OVER LAUREL DOLOMITE)
REACH	REACH R1	REACH R2	REACH R3

ANTICIPATED INITIAL ROCK SUPPORT	+P	REACH R1: 80% TYPE I 5% TYPE II 15% TYPE III	TYPE IV (MANDATORY)	EBC	REACH R2: 0% TYPE I 80% TYPE II 20% TYPE III	EBC	REACH R3A: 0% TYPE I 45% TYPE II 55% TYPE III	EBC	REACH R3B: SEE NOTE 3
SUPPLEMENTAL SUPPORT	4.5 PERCENT OF TOTAL TUNNEL LENGTH								

NOTES:

1. ONLY UPPER SECTION OF BOREHOLE RECORD SHOWN ON SECTION. FOR FULL DETAILS OF GEOTECHNICAL RECORDS REFER TO GDR.
2. FOR SUPPORT TYPE I, II, III AND IV REFER TO DRAWING S-003. FOR SUPPORT TYPE EBC REFER TO DRAWING S-004.
3. ANTICIPATED LENGTH OF INITIAL TUNNEL SUPPORT IN TUNNEL REACH R3 EXCLUDING EXPLORATION BAY COMPRISES: 0% TYPE I, 45% TYPE II, 55% TYPE III IN TWO TUNNEL SUB-SECTIONS R3A AND R3B.

LEGEND:

+P - PRESCRIBED SUPPORT SPECIFIED FOR TUNNEL PORTAL AS PER DWG S-001 AND S-002.
* C-# - DENOTES (100% CORE RECOVERY/100% RQD) FOR NUMBERED CORE RUN
B-24 - BORING NUMBER
- SOIL OVERBURDEN
- RECOVERY
- ROCK QUALITY DESIGNATION (RQD)
- LIMESTONE
- DOLOMITE
- SHALE - NON-DURABLE
- SHALE - DURABLE
- LEAN CLAY
- SILT
- FILL
- ASPHALT
- LEAN CLAY WITH SILT - SILT WITH TRACE CLAY
C-2 - CORE SAMPLE NUMBER
SPT-3(4) - SPLIT SPOON SAMPLE-SAMPLE NUMBER (BLOWCOUNT)
- REC AND RQD (%)
7E-5 - PERMEABILITY (CM/S)

HORIZONTAL: 0 30 60 120 180 SCALE: 1"=60'-0"

VERTICAL: 0 6 12 18 24 SCALE: 1"=12'-0"

FILE NAME: GBR Figure 02.dgn

APRIL 2007

FIGURE 2
GEOTECHNICAL BASELINE REPORT
GEOTECHNICAL PROFILE AND DETAILS
FOR TUNNEL AND EXPLORATION BAYS
SHEET 1 OF 2

LOUISVILLE SOUTHERN INDIANA
OHIO RIVER BRIDGES PROJECT
KENTUCKY EAST END APPROACH TUNNEL

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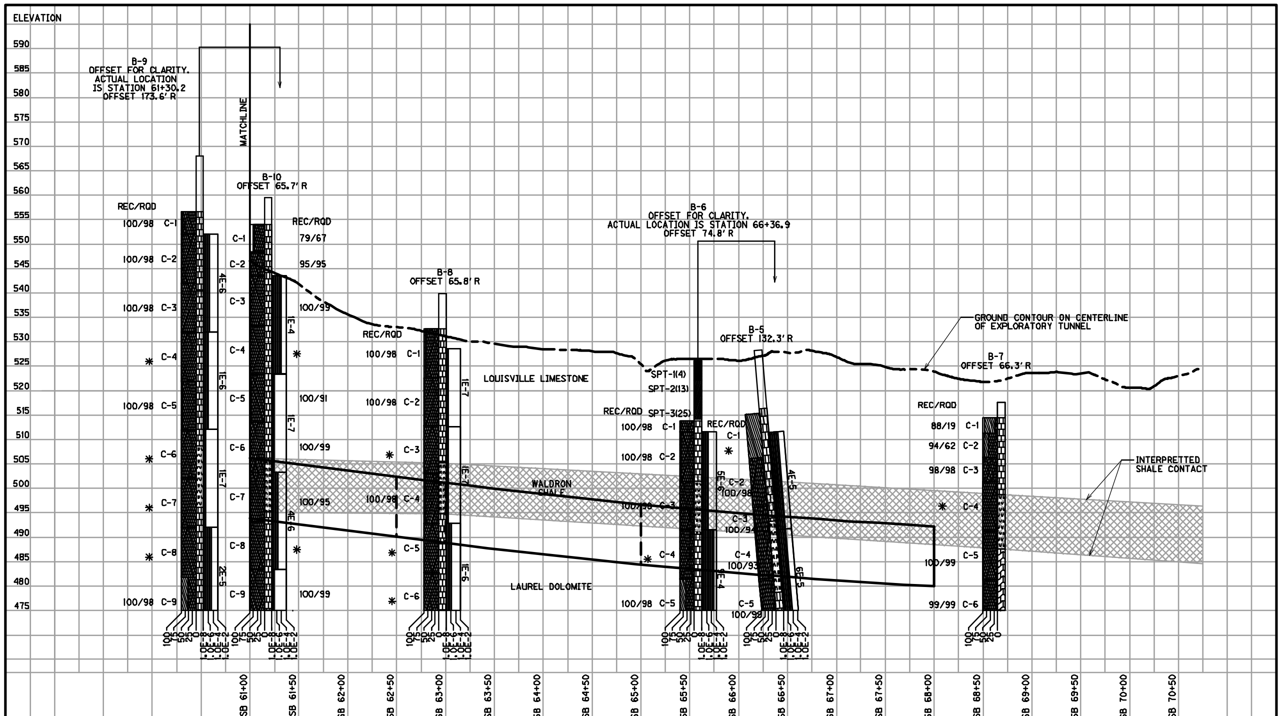

INVERT ELEVATION	493.84 / 490.06	488.81	484.43	483.51	479.95
LITHOLOGY	WALDRON SHALE OVER LAUREL DOLOMITE				
REACH	REACH R4				
ANTICIPATED INITIAL ROCK SUPPORT	REACH R4A: 0% TYPE I 0% TYPE II 100% TYPE III	EBC	REACH R4B: 0% TYPE I 0% TYPE II 100% TYPE III	EBC	REACH R4C: 0% TYPE I 0% TYPE II 100% TYPE III
SUPPLEMENTAL SUPPORT	4.5 PERCENT OF TOTAL LENGTH				

NOTES:

1. ONLY UPPER SECTION OF BOREHOLE RECORD SHOWN ON SECTION. FOR FULL DETAILS OF GEOTECHNICAL RECORDS REFER TO GDR.
2. FOR SUPPORT TYPE I, II, III AND IV REFER TO DRAWING S-003. FOR SUPPORT TYPE EBC REFER TO DRAWING S-004.

LEGEND:

- ✱ C-# DENOTES (100% CORE RECOVERY/100% RQD) FOR NUMBERED CORE RUN
- B-24 - BORING NUMBER
- SOIL OVERBURDEN
- RECOVERY
- ROCK QUALITY DESIGNATION (RQD)
- LIMESTONE
- DOLOMITE
- SHALE - NON-DURABLE
- SHALE - DURABLE
- LEAN CLAY
- SILT
- FILL
- ASPHALT
- LEAN CLAY WITH SILT - SILT WITH TRACE CLAY
- C-2 - CORE SAMPLE NUMBER
- SPT-3(4) - SPLIT SPOON SAMPLE-SAMPLE NUMBER (BLOWCOUNT)
- REC AND RQD (%)
- PERMEABILITY (CM/S)

HORIZONTAL: 0 30 60 120 180 SCALE: 1"=60'-0"

VERTICAL: 0 6 12 18 24 SCALE: 1"=12'-0"

FILE NAME: GBR Figure 03.dgn

APRIL 2007

FIGURE 3
GEOTECHNICAL BASELINE REPORT
GEOTECHNICAL PROFILE AND DETAILS
FOR TUNNEL AND EXPLORATION BAYS
SHEET 2 OF 2

LOUISVILLE SOUTHERN INDIANA
OHIO RIVER BRIDGES PROJECT
KENTUCKY EAST END APPROACH TUNNEL

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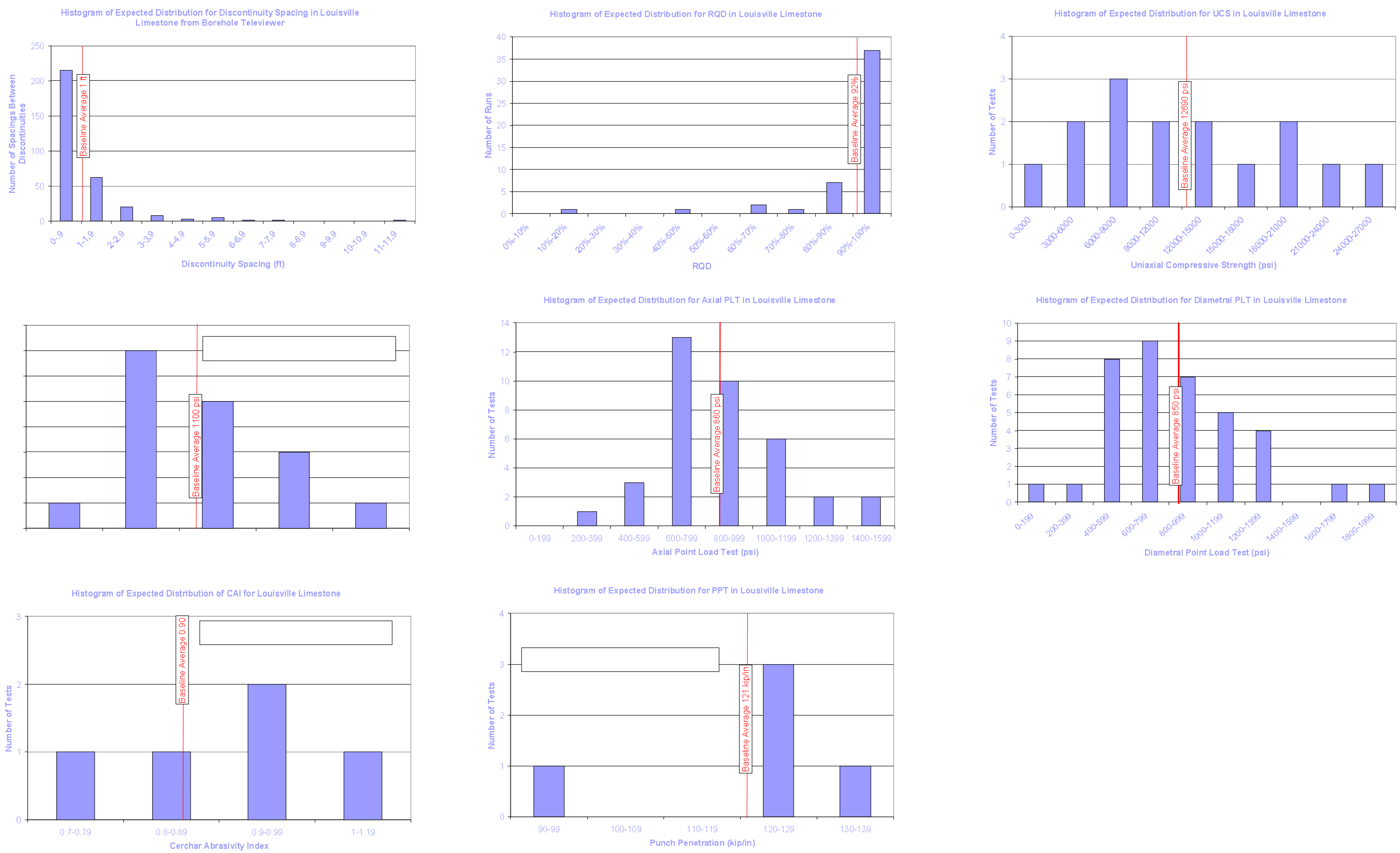

APRIL 2007

FIGURE 4
GEOTECHNICAL BASELINE REPORT
PROPERTIES OF LOUISVILLE LIMESTONE

LOUISVILLE SOUTHERN INDIANA
OHIO RIVER BRIDGES PROJECT
KENTUCKY EAST END APPROACH TUNNEL

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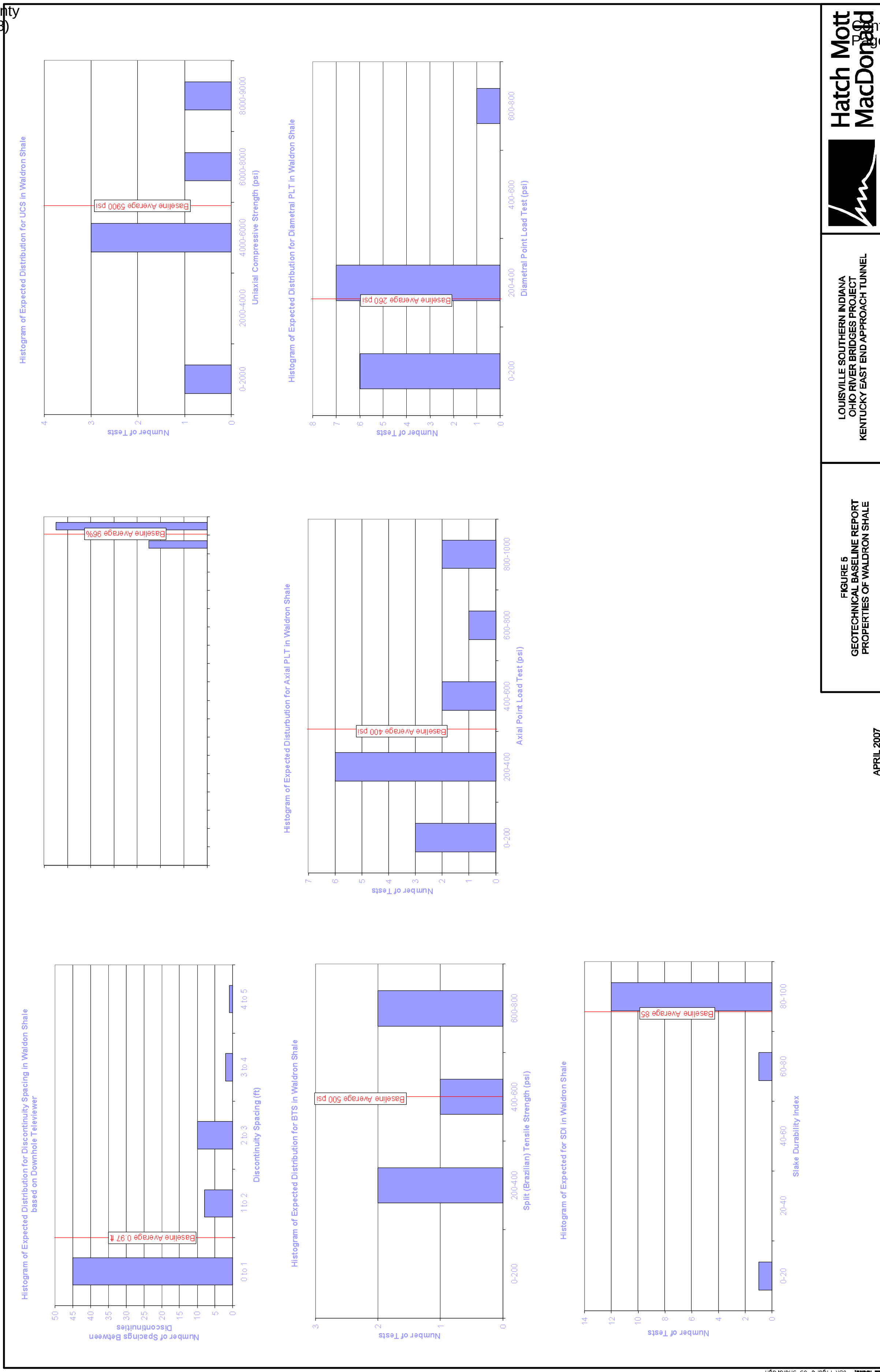
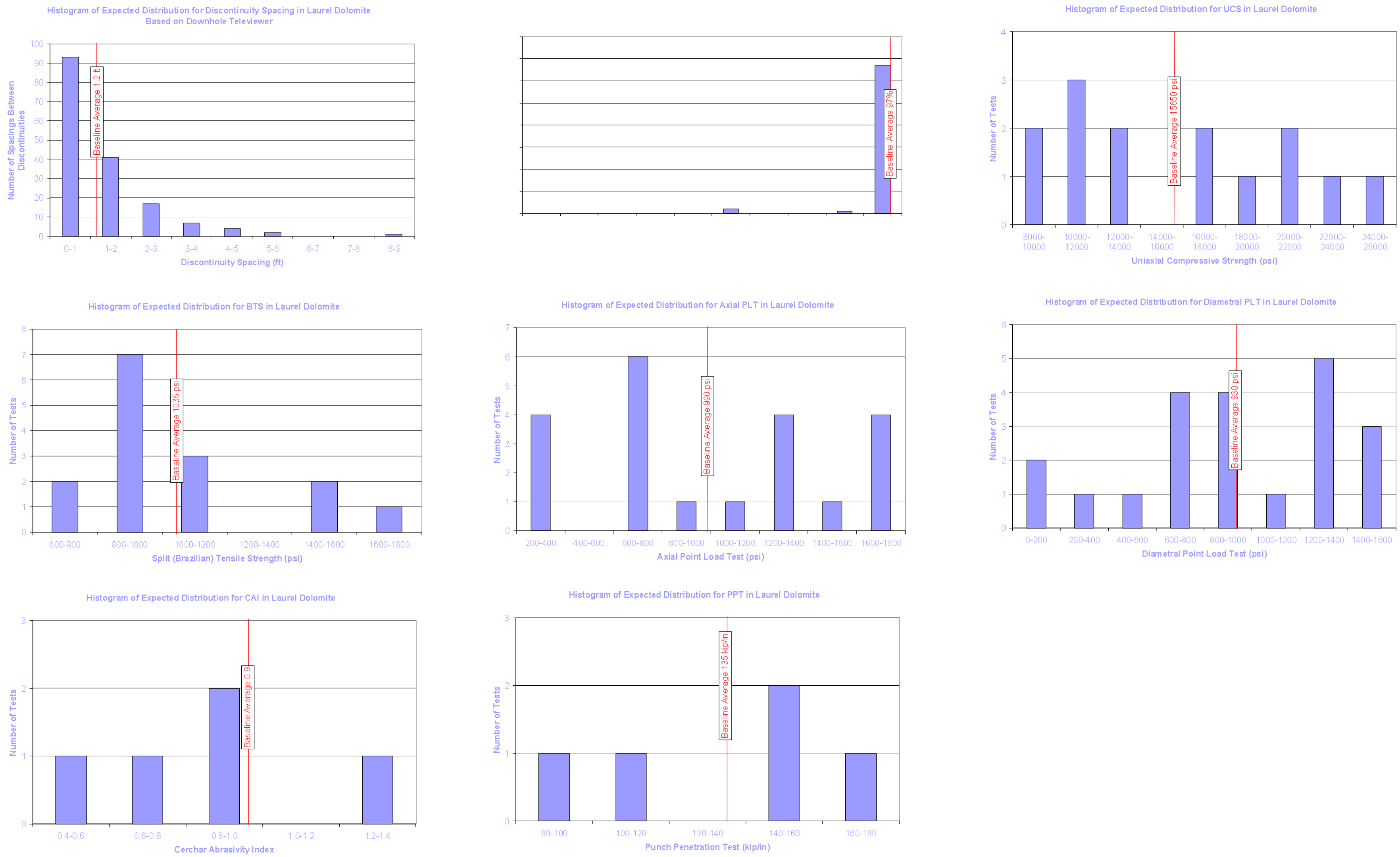
FILE NAME: GBR Figure 04 Limestone.dgn


Hatch Mott MacDonald
LOUISVILLE SOUTHERN INDIANA
OHIO RIVER BRIDGES PROJECT
KENTUCKY EAST END APPROACH TUNNEL
FIGURE 5
GEOTECHNICAL BASELINE REPORT
PROPERTIES OF WALDRON SHALE
APRIL 2007
Histogram of Expected Distribution for UCS in Waldron Shale
Uniaxial Compressive Strength (psi)
Number of Tests
Baseline Average 5900 psi
0-2000
2000-4000
4000-6000
6000-8000
8000-9000
Histogram of Expected Distribution for Diametral PLT in Waldron Shale
Diametral Point Load Test (psi)
Baseline Average 260 psi
0-200
200-400
400-600
600-800
Baseline Average 96%
Histogram of Expected Disturbution for Axial PLT in Waldron Shale
Axial Point Load Test (psi)
Baseline Average 400 psi
0-200
200-400
400-600
600-800
800-1000
Histogram of Expected Distribution for Discontinuity Spacing in Waldon Shale based on Downhole Televiewer
Discontinuity Spacing (ft)
Number of Spacings Between Discontinuities
Baseline Average 0.97 ft
0 to 1
1 to 2
2 to 3
3 to 4
4 to 5
Histogram of Expected Distribution for BTS in Waldron Shale
Split (Brazilian) Tensile Strength (psi)
Baseline Average 500 psi
0-200
200-400
400-600
600-800
Histogram of Expected Distribution for SDI in Waldron Shale
Slake Durability Index
Baseline Average 85
0-20
20-40
40-60
60-80
80-100



FILE NAME: GBR Figure 06 Dolomite.dgn

APRIL 2007

FIGURE 6
GEOTECHNICAL BASELINE REPORT
PROPERTIES OF LAUREL DOLOMITE

LOUISVILLE SOUTHERN INDIANA
OHIO RIVER BRIDGES PROJECT
KENTUCKY EAST END APPROACH TUNNEL

Hatch Mott MacDonald

CERTIFICATION OF BID PROPOSAL / DBE

We (I) propose to furnish all labor, equipment and materials necessary to construct and/or improve the subject project in accordance with the plans, the Transportation Cabinet's Standard Specifications for Road and Bridge Construction, current edition, special provisions, notes applicable to the project as indicated herein and all addenda issued on this project subsequent to purchase of proposal.

We (I) attach a bid proposal guaranty as provided in the special provisions in an amount not less than 5% of the total bid. We agree to execute a contract in accordance with this bid proposal within 15 calendar days after the receipt of the notice of award for the project.

We (I) have examined the site of proposed work, project plans, specifications, special provisions, and notes applicable to the project referred to herein. We understand that the quantities shown herein are estimated quantities subject to increase or decrease as provided in the specifications.

We (I) acknowledge receipt of all addendum(s) (if applicable) and have made the necessary revisions to the bid proposal. We have considered all addendum(s) in the calculation of the submitted bid and applied the updated bid items, which are included.

- Addendum # 1 – Plan & Proposal – May 30, 2007
- Addendum # 2 – Proposal – Wage Rates and Bid Items - June 6, 2007
- Addendum # 3 - Proposal – Revised Notes - June 12, 2007
- Addendum # 4 – Proposal – Added Note - June 21, 2007

"The bidder certifies that it has secured participation by Disadvantaged Business Enterprises ("DBE") in the amount of ______ percent of the total value of this contract and that the DBE participation is in compliance with the requirements of 49 CFR 26 and the policies of the Kentucky Transportation Cabinet pertaining to the DBE Program."

____

Name of Contracting Firm

BY: ____ ______________________

Authorized Agent (Signature) Title

______________________________________ ____________________ ________ ________

Address City State Zip Code

____

Telephone Number

When two or more organizations bid as a joint venture, enter names of each organization and an authorized agent for each organization must sign above.