MEMORANDUM

DATE:	May 25, 2017
TO:	Pat Sweeney, President MPE Incorporated PO Box 2429 Park City, Utah 84060
FROM:	J. Lance Nielsen, P.E. Hansen, Allen & Luce, Inc. (HAL) 859 W. South Jordan Pkwy, Ste 200 South Jordan, Utah 84095
SUBJECT:	Treasure Project Interference Evaluation
PROJECT NO.:	344.150.100

PROFESSIONAL ENGINEER
5/25/2017
No. 354085-2202
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STATE OF UTAH

BACKGROUND

MPE Incorporated is developing a destination resort in Park City, Utah at the south end of Lowell Avenue. One component of the proposed development includes excavation of approximately 1 million cubic yards of material at the base of the hill southwest of Lowell Avenue and spreading it over three placement zones located up the hill from the development. The placement zones are shown on Figure 1.

The Treasure Project excavation area and placement zones are located within the current Drinking Water Source Protection (DWSP) zones for Park City's Spiro Tunnel (see Figure 1). Because of the historical mining activities in the area, concern has been expressed that placement of the excavated material may result in leaching of heavy metals into the groundwater and contamination of Park City's Spiro Tunnel drinking water source. The proposed excavation and placement zones are on the east side of Negro Hollow and the Spiro Tunnel is located within Thaynes Canyon as shown on Figure 1.

HAL was asked to evaluate the potential for the Treasure Project to interfere with Park City's Spiro Tunnel. This memorandum summarizes the results of the evaluation.

DATA SOURCES

Information for this evaluation was obtained from the following data sources.

1. AGEC. 2017. Email correspondence with Jim Nordquist on April 26, 2017 regarding geology near Treasure Project.
2. Baker, C.H. and D.L. Peterson. 1970. *Water Resources of the Heber-Kamas-Park City Area, North-Central, Utah*. Technical Publication No. 27. U.S. Geological Survey.
3. Bromfield, C.S. and M.D. Crittenden. 1971. *Geologic Map of the Park City East Quadrangle, Summit and Wasatch Counties, Utah*. Map GQ-852. U.S. Geological Survey.
4. Crittenden, M.D., F.C. Calkins, and B.J. Sharp. 1966. *Geologic Map of the Park City West Quadrangle, Utah*. Map GQ-535. U.S. Geological Survey.

5. Daly, Chris and George Taylor. 2009. *United States Average Annual Precipitation, 1961-1990*. Spacial Climate Analysis Service at Oregon State University. GIS dataset obtained from Utah AGRC website: www.agrc.utah.gov
6. Holmes, Walter F., Kendall R. Thompson, and Michael Enright. 1986. *Water Resources of the Park City Area, Utah with Emphasis on Ground Water*. Technical Publication No. 85. U.S. Geological Survey.
7. Utah Division of Water Rights. 2017. Well driller's logs for local wells. Online Water Rights Database. waterrights.utah.gov

HYDROGEOLOGIC EVALUATION

Bedrock formations in the vicinity of the Treasure Project and the Spiro Tunnel include the following, listed in relative age order from more recent to less recent. Descriptions are based on Bromfield and Crittenden (1971) and Crittenden et al (1966).

- Thaynes Formation (TRt) – Sandstone interbedded with shale and limestone
- Woodside Shale (TRw) – Shale with siltstone and very fine grained sandstone
- Park City Formation (Ppc) – Limestone and sandstone with a middle member consisting of shale.
- Weber Quartzite (IPw) – Quartzite and sandstone with some interbedded limestone and dolomite.
- Round Valley Formation (IPrv) – Limestone with sparse chert nodules.

In the area between the Treasure Project and the Spiro Tunnel, the bedrock formations dip to the north toward the Dutch Draw Syncline which plunges to the northeast. The Dutch Draw Syncline is located a couple of miles north of the map shown on Figure 1. There are multiple faults and folds in the overall area and the bedrock formations are significantly fractured and jointed. AGEC (2017) reports perpendicular joint systems in the Weber Quartzite that strike to the north and west. Groundwater flow through bedrock formations is likely primarily through joint systems. Joint systems in formations such as sandstone, limestone, and quartzite tend to remain open and provide for significant secondary porosity to convey groundwater flow. However, joints in mudstone and shale formations tend to heal over time and have a much lower ability to transmit water.

Based on information provided by AGEC (2017), the Treasure Project excavation area is located over the Weber Quartzite and material excavated for the project would be from this formation. The three placement zones are located primarily over the outcroppings for the lower portions of the Park City Formation which includes a middle shale member (see Figure 2).

Based on the underground water claim for the Spiro Tunnel, the first half-mile of the tunnel penetrates the Thaynes Formation. The following approximately one mile penetrates the Woodside Shale. The next approximately one mile of tunnel is through the various members of the Park City formation (see Figure 3).

Based on HAL experience, groundwater flow through bedrock formations typically moves from areas of high recharge to low recharge through fracture and joint systems unless there is a barrier to groundwater flow. Examples of groundwater flow barriers include fault gouge zones or confining formations such as mudstones or shales. Based on Daly and Taylor (2009), average annual precipitation in the area is highest at the top of the mountains to the southwest from the Treasure Project and drops to the northeast toward Park City. Geologic mapping in the area does not show any barriers to groundwater flow that would prevent water from flowing to the northeast. Therefore, the groundwater flow direction in the bedrock formations is primarily from southwest to northeast. This is supported by information provided in water resources publications by Baker and Peterson (1970) and Holmes et al (1986).

Cross-sections were developed to show the relationship of the placement zones relative to the bedrock formations and the Spiro Tunnel. The cross-section locations are included on Figure 1 with the actual cross-sections shown on Figures 2 and 3. Figure 2 demonstrates that the entire Woodside Shale formation is located between the placement zones for the Treasure Project and the tunnel. This formation primarily consists of shale which would act as a barrier to groundwater flow. Therefore, it is unlikely that groundwater from the Treasure Project placement zones could travel through the Woodside Formation perpendicular to the groundwater flow direction.

The Spiro Tunnel does penetrate the Park City Formation at least a mile and a half southwest of the tunnel opening. However, in order for groundwater from the Treasure Project placement areas to enter the tunnel through this formation, it would have to travel more than a mile upgradient which is not hydraulically possible.

Although the DWSP zone delineated for the Spiro Tunnel includes the Treasure Project placement areas, there is compelling hydrogeologic evidence that groundwater from this area could never reach the tunnel. It is believed that the zone boundary was expanded to the south in an effort to be conservative and maximize protection of groundwater. From a hydrogeologic standpoint, HAL believes the eastern boundary of the DWSP zone should be moved west to the outcropping of the Woodside Shale as shown on Figure 1.

WATER QUALITY

Concern has been expressed that placement of excavated material will result in a higher leaching rate of heavy metals as precipitation infiltrates through the placed material. Technically, there will be an increase in surface area exposure to water from this placed material. However, the excavated and placed material will only undergo mechanical breaking and crushing and heavy metals will still be chemically bound within the rock formation. The excavated materials will be from the Weber Quartzite formation. Generally, quartzite is relatively inert and does not leach large amounts of heavy metals into groundwater. An increase in surface area exposure may slightly increase the potential for leaching, but the increase would be expected to be negligible. Additionally, the placed material will be unsaturated and the exposure time to water as it moves through the placed material will be relatively short. This would also limit the potential for leaching.

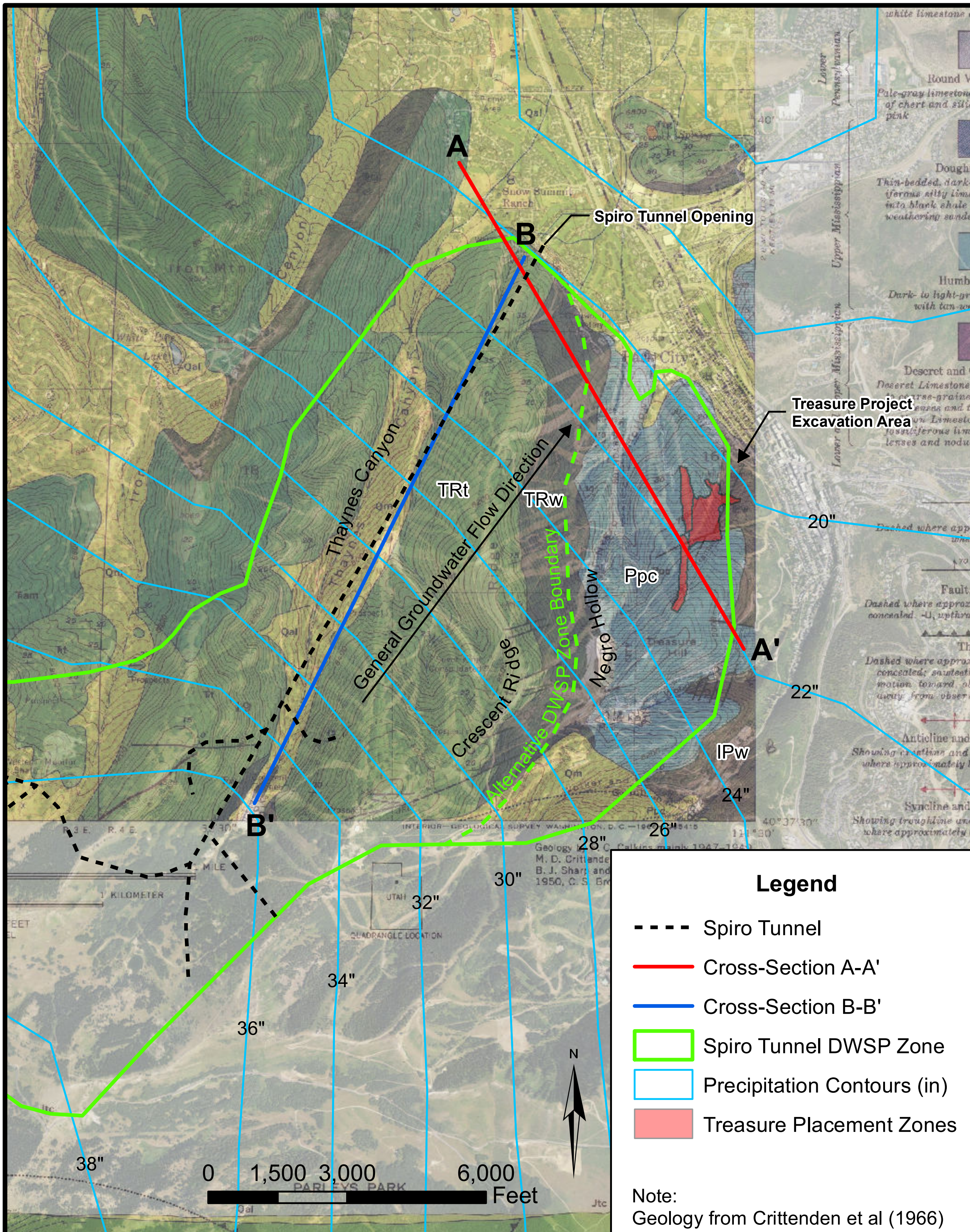
In the case of mine tailings, where the rock has undergone chemical alterations through mine processing, the chemical bond between the metals and the rock has been broken, which frees the metals to rapidly dissolve into water as it passes through the tailings. This will not be the case for the Treasure Project. Therefore, placing excavated quartzite material at the proposed placement zones is not likely to have a significant effect on groundwater quality and is not likely to affect any of Park City's other drinking water sources.

CONCLUSIONS

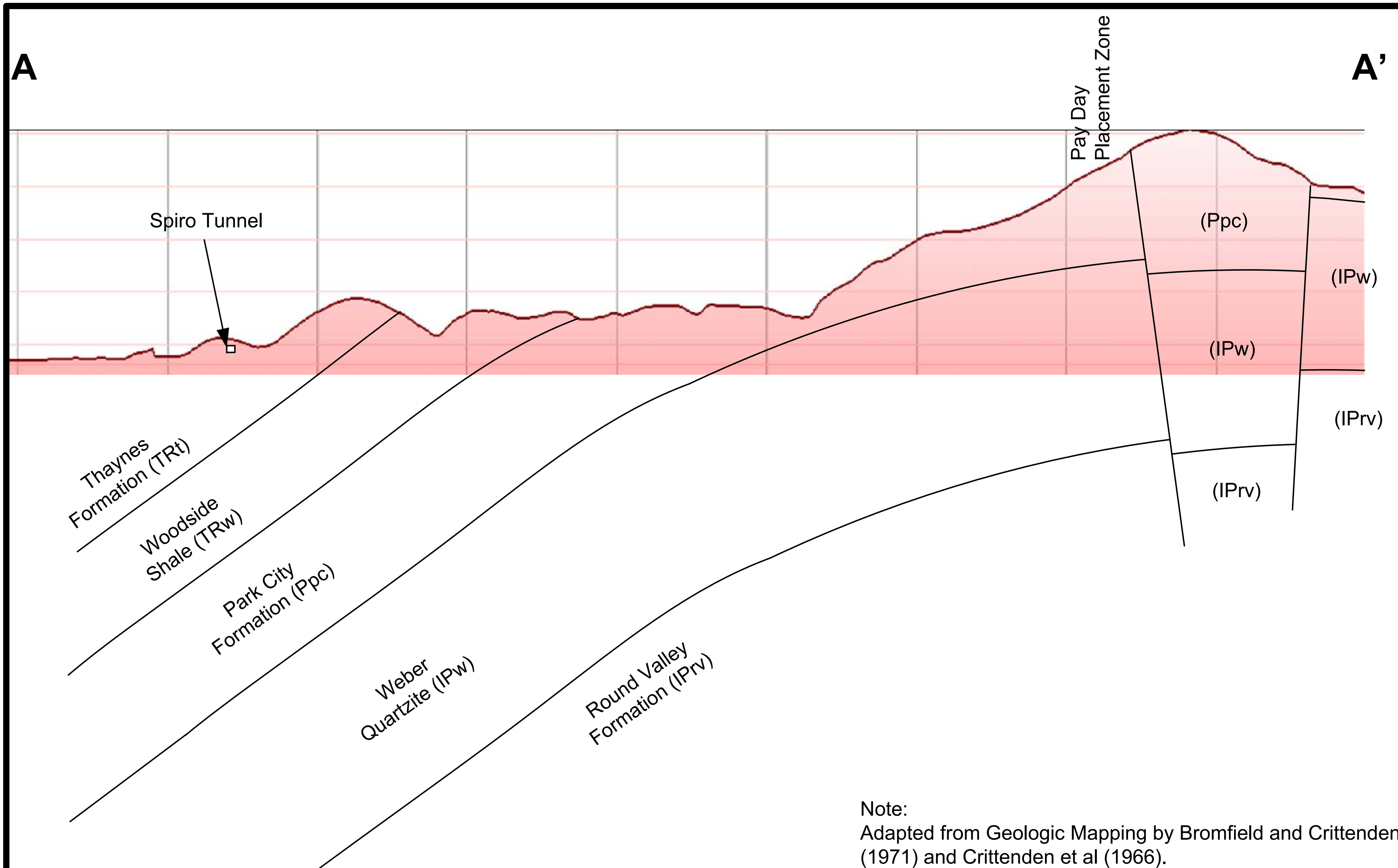
Based on the available data, it is our opinion that the Treasure Project will have no hydrologic or water quality impact on the Spiro Tunnel for the following reasons:

- High recharge volume at the top of the mountains to the southwest of the Treasure Project causes a groundwater flow gradient from southwest to northeast.
- There are no barriers to groundwater flow moving from southwest to northeast.
- Groundwater flows unimpeded to the northeast toward Park City.
- The location of the Treasure Project is more than a mile southeast from the opening of the Spiro Tunnel which is lateral to the groundwater flow gradient.
- There is a thick shale formation (Woodside Shale) that separates the Treasure Project from the Spiro Tunnel.
- Excavated and placed quartzite material will only undergo mechanical breaking and crushing and metals will still be chemically bound to rock materials.
- Placed material will not undergo chemical processing.
- Placed material will be unsaturated limiting the exposure time to groundwater which reduces the potential for leaching.
- Quartzite material is relatively inert to groundwater and is unlikely to result in dissolution of large amounts of metals.

Therefore, excavation of quartzite material from the Treasure Project and placement of this material at the proposed placement zones poses no risk to Park City's public drinking water supplies.



HANSEN ALLEN & LUCE INC ENGINEERS	MPE INCORPORATED TREASURE PROJECT INTERFERENCE EVALUATION	Study Area Map	FIGURE 1



Note:
Adapted from Geologic Mapping by Bromfield and Crittenden (1971) and Crittenden et al (1966).

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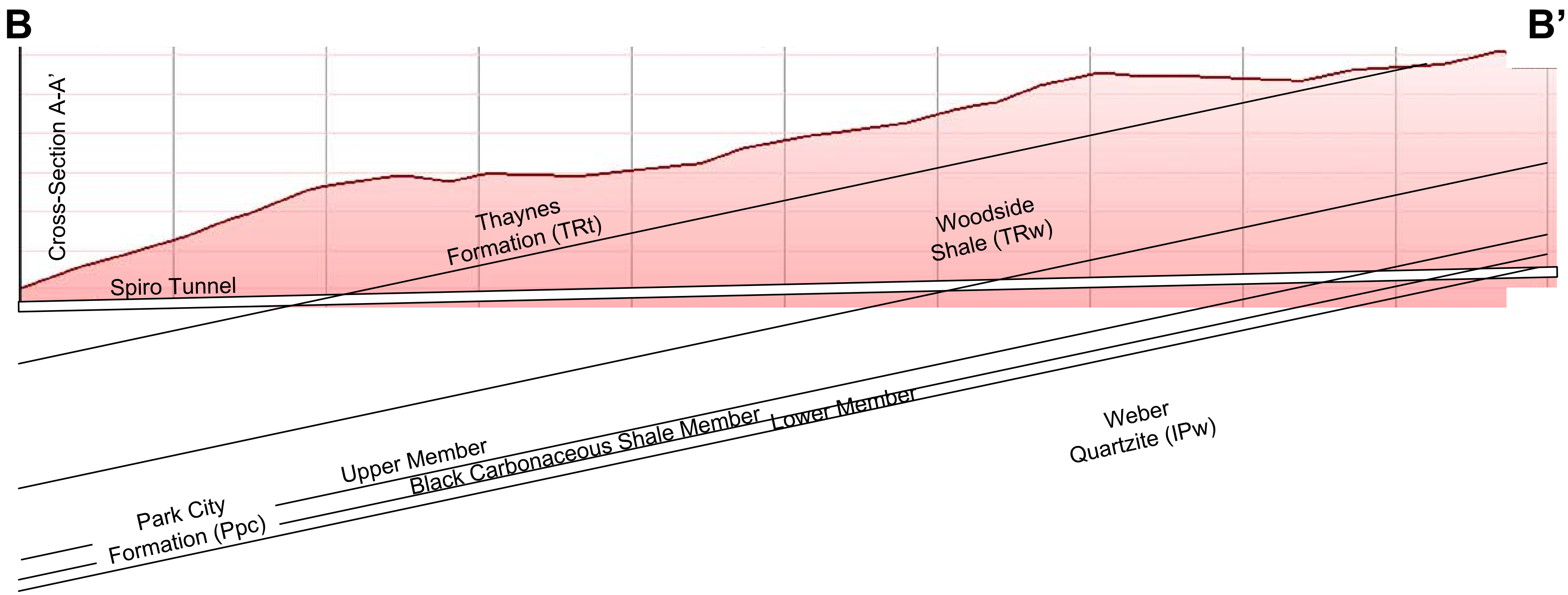
ENGINEERS

MPE Incorporated

Treasure Project Interference Evaluation

Conceptual Geologic Cross-Section A-A'

Figure
2



Note:
Adapted from Geologic Mapping by Bromfield and Crittenden (1971) and Crittenden et al (1966) and based on bedrock formation information listed on the Underground water claim for the Spiro Tunnel.

HANSEN ALLEN & LUCE INC ENGINEERS	**MPE Incorporated** **Treasure Project Interference Evaluation**	**Conceptual Geologic Cross-Section B-B'**	Figure **3**