Water Level Measurements

We did not encounter groundwater in any of our borings during or after drilling. Due to the relatively permeable, predominantly granular nature of the fill soils overlying the bedrock on this site, it is our opinion that the hydrostatic groundwater table was below the greatest depth of our SPT borings on the date of drilling. While diamond coring into bedrock, we used water as the drilling fluid. This masks the groundwater, which can be present in the bedrock, especially in zones of joints and seams. Thus, it is possible that groundwater may be present in the bedrock on this site. A discussion of the water level measurement methods is presented on the attached sheet entitled "Exploration/Classification Methods."

Based on published data from the U.S. Geological Survey, and our past experience in downtown St. Paul, the hydrostatic groundwater table is typically within the St. Peter Sandstone, at elevations of 10 feet to 20 feet SPCD, which corresponds to depths of about 75' to 85' below grade on this site.

Groundwater levels fluctuate seasonally and annually due to varying rainfall and snow melt, as well as other factors such as infiltration and runoff.

GEOTECHNICAL CONSIDERATIONS

The following geotechnical considerations are the basis for the recommendations presented later in this report.

Review of Soil/Rock Properties

Fill

When exposed to moisture and disturbed by traffic, the silty and clayey fill would have poor strength and stability. In our opinion, the existing fill was not placed in a controlled manner with the intent of supporting future structures, and the fill would have a moderate compressibility potential under the anticipated loads. The silty and clayey fill soils are moderately to highly frost susceptible and are estimated to have low to moderate permeabilities and are relatively slow draining soils. The presence of relatively shallow bedrock below the fill can also greatly impede the vertical migration of water infiltrating through the fill.

Limestone

In our opinion, the limestone of the Platteville Formation has a high strength and a low compressibility potential under the anticipated loads. The upper few feet of limestone is weathered at some of our borings locations and has a lower strength and higher compressibility than the underlying competent limestone. The Mifflin Member of the Platteville Formation can be very difficult to excavate. The limestone is generally judged to be slow draining; however, fractured and weathered zones within the limestone can allow rapid transmission of groundwater. The non-weathered portion of the limestone is not judged to be significantly frost susceptible. However, in our opinion, the weathered limestone would be considered moderately to highly frost susceptible.

Shale

In our opinion, the Glenwood Shale has a relatively high strength and a relatively low compressibility potential under the anticipated loads. However, the Glenwood Shale can undergo volume changes with changes in water content and due to elevated temperatures. When the water content in the shale increases, the shale can swell; the forces generated in swelling could lift light structures, possibly damaging foundations and floor slabs. Swelling of the shale has been a problem on some sites in the downtown St. Paul area. Swelling of the shale is generally more severe when the overburden soils and limestone are removed. Additionally, crystal formation within the shale has been observed in areas where temperatures and humidity levels are higher-than-normal. If the new structure will have equipment generating heat (e.g., high temperature boilers), please contact us for additional recommendations. The shale is judged to be slow draining and is at least moderately frost susceptible.

Sandstone

In our opinion, the St. Peter Sandstone has a high strength and a low compressibility potential under the anticipated loads. The sandstone is moderate to slow draining. The upper portion of the sandstone is generally slower draining due to its higher shale content and higher degree of cementation.

Approach Discussion

The depth to the top of bedrock varies significantly across the site, and it could be deeper or shallower than what we found in our borings. If the bedrock is deeper than what we found in our borings, the top of bedrock could be below the planned bottom of footings for the new parking ramp and addition. We recommend constructing all of the footings on bedrock to reduce the potential for differential settlement between footings bearing on bedrock and footings bearing on soil. In areas where the top of bedrock is lower than the anticipated bottom of footing elevation, the bottom of footing elevations and the heights of column piers and walls would vary with the elevation of bedrock. Strip footings would have to be stepped deeper to follow the bedrock, supported on horizontal benches at varying elevations.

Depending on the depth of bedrock, it is possible that the existing fill could extend deeper than the lower parking ramp slabs. If you choose to incur the risk of excessive total and differential floor slab settlement, then the existing fill soils could be left in place below the slabs. Where the existing fill is left in place under the slab, it should be surface-compacted with heavy towed or self-propelled vibratory roller, applying at least eight passes. If you cannot tolerate the risk of excessive floor slab settlement, then soil correction should be carried out under the entire footprint of the parking ramp where existing fill is encountered.

However, if the existing fill is left below the parking ramp slabs, the frost susceptibility of these soils must be considered. The existing silty and clayey fill soils on this site are judged to be moderately to highly frost susceptible. If a rigid pavement (i.e., a concrete slab-on-grade) is used for the lowest level of the unheated parking ramp, we recommend excavation of silty or clayey fill soils to a depth of at least 4' below the bottom of slab (or the top of competent bedrock), and replacement with non-frost-susceptible (NFS) granular soil. The purpose of this is to reduce the potential for the characteristic heave that can occur when silty or clayey soils freeze each winter. This heaving can raise the overlying slabs, possibly damaging the slabs. As an alternative to excavating and replacing the frost susceptible soils, you could consider placing a horizontal layer of insulation beneath the slab. Refer to the FROST ACTION subsection later in this report for additional recommendations.

We recommend that the foundations and utilities for the past buildings on this site be completely removed prior to construction of the new addition and parking ramp. The existing manhole discussed previously in the SURFACE OBSERVATIONS section of this report likely extends into bedrock, and it might be necessary to abandon the manhole in-place by filling the manhole with lean concrete. If the remnants of the past structures underlie the pavement areas, the old walls and columns should be cut off at least 2' below bottom of new base course to avoid "hard spots" under the new pavement that will be placed. We recommend that the bid documents contain a unit price line item for removal of old buried structures and utilities that cannot be seen from the surface but might be encountered.

RECOMMENDATIONS

Building Grading Procedures

Excavation

We recommend that the bituminous pavement be stripped from the footprint of the new addition. All remnants of previously razed structures and utilities should be completely removed from the footprint of the addition and parking ramp. After stripping the existing pavement and removing remnants of past structures from within the footprint of the parking ramp and addition, we recommend subcutting the overburden soils (i.e., existing fill) to the top of competent bedrock. Refer to Table A in the BEDROCK section of this report for estimated top of bedrock elevations. Please note that the estimated top of bedrock elevations in Table A represent the first occurrence of bedrock in our boring, which in some cases is weathered bedrock. Therefore, additional excavation could be required to remove weathered and/or highly fractured bedrock down to the underlying competent limestone bedrock.

We recommend that the footings be cast directly on competent limestone or sandstone bedrock, even if over-excavation has occurred. Based on a planned finished floor elevation of about 79 feet SPCD for the below grade parking level, the bottom of footings would likely fall within the Glenwood Shale and the lower level floor slab would be within about 2' of the top of the Glenwood Shale. The Glenwood Shale can undergo swelling upon increases in water content, therefore we recommend that the spread footings be lowered to bear in the St. Peter Sandstone below the shale, and that the Glenwood Shale be removed from below the lowest level floor slab of the parking ramp. For portions of the ramp without a lower level, the footings could bear in the competent limestone above the shale, and the shale would not have to be removed from under the floor slab.

Depending on the depth of bedrock, it is possible that the existing fill could extend below the basement floor slab of the addition and below the street level parking ramp slab. If you choose to incur the risk of excessive total and differential floor slab settlement, then the existing fill soils could be left in place under the slabs. Where the existing fill is left in place under the slab, it should be surface-compacted with heavy towed or self-propelled vibratory roller, applying at least eight passes. If you cannot tolerate the risk of excessive floor slab settlement, then soil correction should be carried out under the entire footprint of the parking ramp where existing fill is encountered. However, if the existing fill is left below the parking ramp slabs, the frost susceptibility of these soils must be considered. Refer to the FROST ACTION subsection later in this report for additional recommendations.

Bedrock Excavation

Excavations for the basement in the addition and the below grade level in the parking ramp will extend into the bedrock. The bedrock excavation will likely extend through the entire section of Platteville Limestone. The Mifflin Member of the Platteville Formation is a very dense limestone (with compressive strengths as high as 15,000 pounds per square inch) with widely spaced natural fractures. Excavation of the Platteville Formation typically requires hard rock excavation techniques such as line drilling and chipping with hammers. The Glenwood Shale has a lower compressive strength than the Platteville limestone, but excavation will still require hard rock excavation techniques.

The St. Peter Sandstone is generally weakly cemented, and all though it has a high strength when confined, the sandstone is easily erodible when unconfined and exposed to groundwater seepage. Footings for the parking ramp and the addition will likely bear in the St. Peter Sandstone. Depending on the depth of excavation into the sandstone, and the groundwater conditions at the time of construction, excavation support could be required to stabilize the exposed sandstone. This could include soil nails or rock bolts with wire mesh and a grouted face. The need for stabilization of the sandstone will have to be evaluated at the time of construction and the Contractor must include an appropriate budget for such protection.

Excavation Retention Systems

If the contractor elects to use an open cut for the basement excavations, the sideslopes in the overburden soils must be laid back at a safe angle to meet OSHA requirements. In our opinion, the predominantly granular fill soils, or interbedded granular and cohesive fill soils encountered on this site would be preliminarily classified as "Type C," and the slopes would be limited to no steeper than 1.5 horizontal:1 vertical (1.5H:1V). However, soil discontinuities or layering observed in the excavation sideslopes, such as silt or sand seams or shrinkage cracks, may necessitate slopes shallower than 1.5H:1V. The final decision on the OSHA soil types and safe slopes must be made by the contractor's "competent person," and cannot be defined in this report.

An unbraced excavation will likely not be possible along the existing streets and alleys (depending on the depth of overburden soils above the bedrock), and a temporary earth retention system could be required to provide a safe excavation. If a temporary earth retention system is chosen for some portions of the basement excavation, common methods for this type of construction in this area are driven or drilled soldier piles and wood lagging, or braced steel sheet piles. The toes of the piles must be installed deep enough to provide lateral retention at the base. This will likely require pre-drilling into the bedrock. The responsibility for the design of an open cut or a temporary retention system lies with the contractor.

The bedrock will typically stand at near-vertical angles; however, the final decision on safe bedrock slopes must be made by the contractor's "competent person," and cannot be defined in this report. Because the Platteville Limestone is fractured, the intersection of near vertical fractures with horizontal discontinuities such as bedding planes can cause blocks of rock to fall into the excavation. Rock anchors (or rock bolts) and/or shotcreting will likely be required to stabilize the exposed vertical rock face and provide a safe excavation. This type of stabilization would also likely be required adjacent to existing structures to reduce the potential for excessive settlement of the existing buildings during excavation of the below grade levels. This will have to be evaluated at the time of construction and the Contractor must include an appropriate budget for such protection.

Filling/Compaction

After removing the shale in the lower level floor slab of the parking ramp, new compacted granular fill could be placed up to the planned subgrade elevation. Granular fill could also be used to reestablish the planned floor slab subgrade elevation in the addition if over-excavation of the bedrock occurs under the floor slab. Granular fill placed under the lower level slab of the unheated parking ramp should be non-frost susceptible, as described in the FROST ACTION section of this report. For fill below the addition slab, we recommend using an imported granular soil with less than 20% passing the No. 200 sieve no gravel larger than 3", such as Mn/DOT 3149.2B1. If the Contractor proposes a different type of fill, a sample should be submitted to our laboratory for testing and review by a Geotechnical Engineer.

Fill placed below the addition and parking ramp slabs should be placed in thin lifts and compacted to at least 95% of the maximum Standard Proctor dry density (ASTM: D 698). The fill should be placed in lifts thin enough to attain the specified compaction level throughout the entire lift thickness. This normally requires that fill be placed in loose lifts less than 8" thick.

Please refer to the standard data sheet at the end of this report entitled "Excavation and Refilling for Structural Support" for general information regarding excavation and fill placement for

Glenwood Shale. The Glenwood Shale can undergo swelling upon increases in water content. Therefore, we recommend that the spread footings be lowered to bear in the St. Peter Sandstone below the shale, or the structure could be supported on caissons bearing in the St. Peter Sandstone. Please contact us if you wish to pursue a caisson foundation so that we can provide additional recommendations.

As previously discussed, it is our opinion that footings bearing directly on competent St. Peter Sandstone could be proportioned for a maximum net allowable bearing capacity of up to 50 tsf. We anticipate that the footings for portions of the ramp without a below grade level would bear in the Platteville Limestone. Based on the conditions found in our borings, it is our opinion that the footings bearing in the competent limestone (i.e., below the zone of more highly fractured and weathered limestone directly below the overburden soils) could be proportioned for a maximum net allowable bearing capacity of up to 50 tsf. Where footings will bear in the limestone, but within 3' of the top of the Glenwood Shale, we recommend that the contact pressure on the footings be decreased to a maximum of 20 tsf.

The factor of safety with respect to bearing capacity for these designs would exceed 3. Based on these designs, we estimate that total post-construction building settlement would not exceed 1", with differential settlement less than ½" over a horizontal distance of 30'.

Existing Tunnels

There are known utility tunnels within the St. Peter Sandstone in this part of downtown St. Paul. Where footings bear in the Platteville Limestone at elevations at least 3' above the top of the Glenwood Shale, it is our opinion that the presence of the tunnels should not affect the foundations for this project. However, where footings bear in the limestone within 3' of the top of the Glenwood Shale, it might be necessary to lower the footings or extend drilled piers into the sandstone in areas where tunnels are known to exist. <u>Prior to construction, we strongly recommend that a detailed historical search of old underground utilities, sewers and tunnels, and mapping of old underground utilities and tunnels be completed in the area of the new parking ramp and restaurant addition</u>.

If tunnels exist in the area of the proposed footings, those footings would have to be lowered to bear within the sandstone at a depth that would allow for a 1 horizontal to 1 vertical (1:1) slope between the outside edge of the footing and the bottom outside edge of the tunnel invert. As an alternative to lower the spread footings, caissons (drilled piers) could be extended into the sandstone to provide the same 1:1 separation between the outside edge of the foundation and the tunnel invert

Building Floor Slabs

We recommend importing a 100% crushed concrete or crushed limestone Class 5 aggregate for the floor slab base in the lower level of the parking ramp. The purpose of the Class 5 crushed aggregate base below the parking ramp slab is to provide a firmer base and to allow the contractor to place a flatter slab; the Class 5 would also help the slab performance under traffic at joints in the slab. The minimum thickness of the Class 5 should be 6". The Class 5 aggregate base should be compacted to at least 98% of the maximum Standard Proctor dry density, or to meet the criteria for Mn/DOT dynamic cone penetrometer (DCP) tests. Refer to the BUILDING GRADING section of this report for additional recommendations on excavation and filling in floor slab areas.

For relative ease of compaction in confined spaces, we recommend that imported granular soils with less than 20% passing the No. 200 sieve (such as Mn/DOT 3149.2B1) be used as interior backfill around the new foundations and in underslab utility trenches inside the addition and parking ramp. Cohesive or semi-cohesive soil, or cobbles/ boulders should <u>not</u> be used for this backfill.

The backfill should be placed in thin lifts, with each lift mechanically compacted using manually-operated vibratory or impact equipment, to at least 95% of the maximum Standard Proctor dry density. The fill should be placed in lifts thin enough to attain the specified compaction level throughout the entire lift thickness. This normally requires that fill be placed in loose lifts less than 8" thick. We recommend not using heavy towed or self-propelled compactors within 4' of newly constructed foundation walls; such equipment can damage the new walls.

Based on a subgrade prepared with this type of backfill, and after general site grading, the floor slabs can be cast on-grade. For slabs cast on new compacted granular fill, we recommend using a modulus of subgrade reaction (k) of 220 pounds per cubic inch (pci) for design of the slabs. For slabs cast on Class 5 material, we recommend using a modulus of subgrade reaction of 260 pci. If the existing fill is to be left in place under the slabs, a modulus of 150 pci should be used.

We recommend placing a vapor retarder under the floor slab of the addition. The purpose of a vapor retarder is to reduce the potential for upward migration of water vapor from the soil into and through the concrete slab. Water vapor migrating upward through the slab can damage floor coverings, coatings, or sealers placed on the slab, or materials/packages stored on the slab, and contribute to excess humidity and possible microbial growth in a building. For additional recommendations on moisture and vapor protection of floor slabs, please refer to the standard sheet at the end of this report entitled "Floor Slab Moisture/Vapor Protection."

Frost Action

Unheated structures (such as the parking ramp) with slabs cast on subgrade soils consisting of primarily of silt or clay can experience slab heaving and cracking each winter when the soils freeze. To reduce the risk of slab heaving and cracking, we recommend excavation and replacement of silty or clayey soils to a depth of at least 4' below the bottom of slab, and replacement with non-frost-susceptible (NFS) granular soil. The NFS sand should be a sand or sand and gravel mix having less than 5% passing the No. 200 sieve and less than 40% passing the No. 40 sieve. The NFS sand should be placed in thin lifts and compacted to at least 95% of the maximum Standard Proctor dry density. We recommend placing drainpipes at the base of the NFS granular fill, connected to the site storm sewers to remove infiltrating water.

As an alternative to excavating the frost susceptible soils and replacing them with NFS fill, you could consider placing a horizontal layer of high quality insulation beneath the slab. The insulation should be a Type II expanded polystyrene (EPS), or approved equivalent, with a minimum compressive strength (ASTM: D1621) of 20 pounds per square inch (psi), a minimum rated R-value (ASTM: C177, C518) of 4.5R per inch, and a minimum density of 1.80 pounds per cubic foot. The insulation should be at least 4" thick and covered with a minimum 12" thick layer of compacted NFS soil (i.e., between the insulation and the slab). Additionally, insulation should be placed on all vertical faces of the interior and exterior foundation walls of the parking ramp to prevent backfill adfreezing. If you choose this alternative, please contact us so that we may provide additional design and construction recommendations after the foundation plan is available.

If the parking ramp is heated, then the NFS fill and/or insulation would not be required in the upper 4' of the parking ramp subgrade. Likewise, if a flexible pavement (i.e., bituminous pavement) is used on the at-grade level of the parking ramp, it would not be as critical to replace the existing silty and clayey fill soils with NFS fill or insulate the slab because flexible pavements generally experience less distress when the subgrade soils freeze and expand.

Pedestrian Tunnel

The preliminary design of this project includes a pedestrian tunnel connecting the new parking ramp to the new restaurant addition. Construction of the tunnel will require bedrock excavation. Refer to the BUILDING GRADING PROCEDURES section of this report for a discussion of bedrock excavation. We recommend that the tunnel slab be cast on a sand cushion placed over the exposed bedrock. A modulus of subgrade reaction of 220 pci may be used to design the tunnel slab. Refer to the STRUCTURE BACKFILLING section of this report for tunnel backfilling recommendations.

Structure Backfilling

We recommend placing a perimeter drainpipe completely around the outside of the basement walls for the addition and the parking ramp, as well as the pedestrian tunnel. The drainpipe should be surrounded with imported free-draining granular soil having less than 12% passing the

No. 200 sieve, such as Mn/DOT 3149.2B2. Silty or clayey soil must not be used for this backfill. The drainpipe should be connected to one or more sumps in the building so that infiltrating water can be removed. Our recommendations for drainage and backfilling the below grade portion of the building are provided on the attached standard sheet entitled "Basement/Retaining Wall Backfill and Water Control."

Where exterior entry slabs, sidewalks, aprons and patios abut the building and parking ramp, we recommend placing select non-frost susceptible (NFS) granular backfill around the exterior of the addition to reduce the potential for frost heave of the slabs and sidewalks. The NFS fill should be a sand or sand and gravel mix having less than 12% passing the No. 200 sieve and less than 40% passing the No. 40 sieve, such as Mn/DOT 3149.2B2. The fill should be placed in thin lifts and compacted to at least 95% of the maximum Standard Proctor dry density.

Exterior Drainage

The exterior drainage around the building and parking ramp must be carefully planned to prevent water from ponding against the buildings, and infiltrating and saturating the soils under patios, entry slabs, and sidewalks. We recommend a minimum slope of all surfaces abutting the buildings of at least 6" in the first 10' to promote surface water drainage away from the buildings. The roof drainage system should be designed to discharge away from the buildings. We also recommend not designing or building landscaped areas next to the structure where water can pond in decorative rock, while being prevented from flowing away from the building by adjacent sidewalks and/or driveways.

Underground Utility Construction

Installation of the underground utilities will likely require excavation of bedrock. Where bedrock is encountered in the utility trenches, we recommend that the rock be over-excavated a minimum of 6" below invert to allow for placement of granular pipe bedding. The contractor must be careful to avoid overbreak and fracturing of the bedrock below the invert elevation. If overbreak occurs below the pipe, the subgrade may appear stable when bedding is placed, but the bedding can migrate into the fractures/voids as surface water infiltrates through the trench backfill, causing settlement and misalignment of the pipes, and opening of the pipe joints.

Please refer to the standard data sheets at the end of this report entitled "Standard Recommendations for Utility Trench Backfilling" and "Bedding/Foundation Support of Buried Pipe" for additional recommendations on backfill materials and backfill placement.

Pavement Restoration

Based on our understanding of this project, pavement construction will be limited to restoring disturbed areas immediately adjacent to the building. Where the pavement will be restored, it is important that the new pavement section match the pavement section for the adjacent paved areas. If a sand subbase is present beneath the aggregate base course in the existing pavement, the new pavement section should also include a sand subbase of equal thickness so that relatively uniform drainage and frost heave characteristics are achieved. If a sand subbase is not present beneath the existing pavement, a sand subbase should not be placed in the repaired section to reduce the potential for differential frost heave across that segment of pavement. Similarly, the thickness of aggregate base course and bituminous pavement for the restored sections should be similar to the adjacent existing pavement. We recommend that you have an Engineer or Materials Technician on the site to document the existing pavement section during pavement restoration.

CONSTRUCTION CONSIDERATIONS

Potential Difficulties

Runoff Water and Groundwater in Excavations

Based on the conditions found in our borings, it is our opinion that the hydrostatic groundwater table would not be encountered in excavations for foundations or underground utilities for this project. However, it is possible that perched groundwater could be encountered in excavations on this site, including excavations into bedrock. Perched groundwater should not be dismissed as unimportant or inconsequential to the construction process. To allow observation of the excavation bottom, and to reduce the potential for soil disturbance and facilitate filling operations, we recommend that all free-standing water within the excavations be removed prior to proceeding with construction.

Bedrock Excavation

Excavations for the basement in the addition and the below grade level in the parking ramp will extend into the bedrock. Bedrock excavation will likely require hard rock excavating techniques such as line drilling and chipping hammers; in our opinion, the bedrock shall not be considered rippable. The highly fractured bedrock just below the overburden soils might be rippable with conventional equipment in some zones, but this would have to be evaluated with a test pit program. The boring logs must not be used to evaluate the rippability or excavatabilty of the bedrock. In this area, blasting is typically not considered a conventional method of rock removal due to potential vibration damage. Please notify us if the contractor plans to utilize blasting techniques for rock excavation.

Excavation Sidesloping

Excavations must have sideslopes in accordance with OSHA Regulations (Standards 29 CFR), Part 1926, Subpart P, "Excavations" (can be found on www.osha.gov). Even with the required OSHA sloping, surface runoff flowing over the slopes can possibly cause sideslope erosion which could require slope maintenance.

Observation and Testing

The recommendations in this report are based on the subsurface conditions found at our test boring locations. Since the soil and bedrock conditions can be expected to vary away from the boring locations, we recommend on-site observations by a Geotechnical Engineer, or the Engineer's representative, during construction to evaluate the effect of these potential changes.

As previously discussed, we strongly recommend that a detailed historical search of old underground utilities, sewers and tunnels, and mapping of old underground utilities and tunnels be completed in the area of the new parking ramp and restaurant addition prior to construction.

If tunnels exist on these sites, their presence will affect the design and construction of foundations for this project.

We recommend that all foundation bearing surfaces be observed by a Geotechnical Engineer immediately prior to concrete placement. We also recommend that the contractor drill a 5' deep probehole in the bedrock at each foundation location. The purpose of the probehole is to identify zones of unsuitable bedrock, or voids in the bedrock. Each probehole should be drilled in the presence of a Geotechnical Engineer or a Senior Materials Technician so that the bedrock conditions can be documented at each foundation location.

Soil density testing should also be performed on all fill placed at the site to document that our recommendations, and the specifications, for compaction and moisture, have been satisfied. Where fill material type is important, laboratory sieve analyses should be performed to document the actual fill meets the recommended gradation criteria. The building materials should also be tested in accordance with the project specifications and the building codes.

If the planned earth retention system will include driven piles, we recommend conducting a precondition survey of surrounding structures prior to the start of construction. We also recommend monitoring vibration on or near adjacent structures during the installation of the first few piles. Depending on the magnitude of the vibration encountered, it may be necessary to modify the pile driving system.

SUBSURFACE EXPLORATION

General

Our subsurface exploration program included drilling 11 Standard Penetration test (SPT) borings at this site between March 1 and 14, 2007. We cored the bedrock at six of the 11 borings. The approximate locations of the borings are shown on Figure 1 in the Appendix. We located the borings in the field by measuring from the existing buildings, using dimensions scaled from the site plan provided by ESG Architects. Our drill crew shot surface elevations at the borings referenced to the first floor slab of the existing restaurant building; this benchmark location is shown on Figure 1. According to the site plan, this benchmark is at elevation 85.23 feet SPCD. Before we drilled, we contacted Gopher State One Call to locate public underground utilities and Hance Utility Services to locate private underground utilities on this site.

SPT Borings

We drilled the SPT borings using 3-1/4" inside diameter hollow stem augers. We backfilled the SPT boreholes with soil cuttings to comply with current Minnesota Department of Health (MDH) regulations. Refer to the standard sheet entitled "Exploration/Classification Methods" for details on the drilling and sampling methods, the classification methods, and the water level measurement methods. A data sheet describing the USC System and the descriptive terminology and symbols used on the boring logs is also attached.

Rock Coring

We performed the rock coring in general accordance with ASTM: D2113, using an NQ wireline system. We backfilled the rock core borings with bentonite grout upon completion, to comply with MDH regulations.

In evaluating the quality of the rock sampled, one of two methods are used to quantify the rock quality. Typically, 5' increments are cored into the bedrock. The total length recovered (solid and fragmented) divided by the length of the core run establishes the percent recovery, which is shown on the logs under the "REC %" column heading.

From an engineering standpoint, a more useful determination of the bedrock quality is based on a modified core recovery procedure. This method, known as the rock quality designation (RQD), takes into account the number of fractures and soft zones within the bedrock based on the retrieved core samples. In calculating the modified core recovery using this method, only those sections of the retrieved core which are hard, solid, and 4" or longer (ignoring breaks due to handling) are combined and expressed as a percentage of the total core run length. The RQD value provides better indication of bedrock bearing capacity because soft layers/seams and highly jointed/fractured zones are taken into account in the bedrock quality determination.

LIMITATIONS

The data derived through the exploration program have been used to develop our opinions about the subsurface conditions at your site. However, because no exploration program can reveal totally what is in the subsurface, conditions between borings and between samples and at other times, may differ from conditions described in this report. The exploration we conducted identified subsurface conditions only at those points where we took samples or observed groundwater conditions. Depending on the sampling methods and sampling frequency, every soil layer may not be observed, and some materials or layers which are present in the ground may not be noted on the boring logs.

If conditions encountered during construction differ from those indicated by our borings, it may be necessary to alter our conclusions and recommendations, or to modify construction procedures, and the cost of construction may be affected.

The extent and detail of information about the subsurface condition are directly related to the scope of the exploration. It should be understood, therefore, that information can be obtained by means of additional exploration.

ASTM STANDARDS

When we refer to an ASTM Standard in this report, we mean that our services were performed in general accordance with that standard. Compliance with any other standards referenced within the specified standard is neither inferred nor implied.

STANDARD OF CARE

The conclusions contained in this report represent our professional opinions. We have endeavored to perform the engineering services for this project in a manner consistent with that level of skill and care ordinarily exercised by other members of our profession currently practicing in this area under similar budgetary and time constraints. No other warranty, express or implied is made.

SIGNATURES

Report Prepared by:

American Engineering Testing, Inc.

Chad A. Underwood, PE, PG
Senior Geotechnical Engineer

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota

Print Name: Chad A. Underwood

Signature:

Date: 4/24/07 License #: 43026

Report Reviewed by:

American Engineering Testing, Inc.

Steven D. Koenes, PE
Principal Engineer

EXCAVATION AND REFILLING FOR STRUCTURAL SUPPORT

EXCAVATION

Excavations for structural support at soil boring locations should be taken to depths recommended in the geotechnical report. Since conditions can vary, recommended excavation depths between and beyond the boring locations should be evaluated by geotechnical field personnel. If ground water is present, the excavation should be dewatered to avoid the risk of unobservable, poor soils being left in-place. Excavation base soils may become disturbed due to construction traffic, ground water or other reasons. Such soils should be subcut to underlying undisturbed soils. Where the excavation base slopes steeper than 4:1, the excavation bottom should be benched across the slope parallel to the excavation contour.

Soil stresses under footings spread out with depth. Therefore, the excavation bottom and subsequent fill system should be laterally oversized beyond footing edges to support the footing stresses. A lateral oversize equal to the depth of fill below the footing (i.e., 1:1 oversize) is usually recommended. The lateral oversize is usually increased to 1.5:1 where compressible organic soils are exposed on the excavation sides. Variations in oversize requirements may be recommended in the geotechnical report or can be evaluated by the geotechnical field personnel.

Unless the excavation is retained, the backslopes should be maintained in accordance with OSHA Regulations (Standards - 29 CFR), Part 1926, Subpart P, "Excavations" (found on www.osha.gov). Even with the required OSHA sloping, ground water can induce sideslope raveling or running which could require that flatter slopes or other approaches be used.

FILLING

Filling should proceed only after the excavation bottom has been approved by the geotechnical engineer/technician. Approved fill material should be uniformly compacted in thin lifts to the compaction levels specified in the geotechnical report. The lift thickness should be thin enough to achieve specified compaction through the full lift thickness with the compaction equipment utilized. Typical thicknesses are 6" to 9" for clays and 12" to 18" for sands. Fine grained soils are moisture sensitive and are often wet (water content exceeds the "optimum moisture content" defined by a Proctor test). In this case, the soils should be scarified and dried to achieve a water content suitable for compaction. This drying process can be time consuming, labor intensive, and requires favorable weather.

Select fill material may be needed where the excavation bottom is sensitive to disturbance or where standing water is present. Sands (SP) which are medium to coarse grained are preferred, and can be compacted in thicker lift thicknesses than finer grained soils.

Filling operations for structural support should be closely monitored for fill type and compaction by a geotechnical technician. Monitoring should be on a full-time basis in cases where vertical fill placement is rapid; during freezing weather conditions; where ground water is present; or where sensitive bottom conditions are present.

EXCAVATION/REFILLING DURING FREEZING TEMPERATURES

Soils that freeze will heave and lose density. Upon thawing, these soils will not regain their original strength and density. The extent of heave and density loss depends on the soil type and moisture condition; and is most pronounced in clays and silts. Foundations, slabs, and other improvements should be protected from frost intrusion during freezing weather. For earthwork during freezing weather, the areas to be filled should be stripped of frozen soil, snow and ice prior to new fill placement. In addition, new fill should not be allowed to freeze during or after placement. For this reason, it may be preferable to do earthwork operations in small plan areas so grade can be quickly attained instead of large areas where much frost stripping may be needed.

FLOOR SLAB MOISTURE/VAPOR PROTECTION

Floor slab design relative to moisture/vapor protection should consider the type and location of two elements, a granular layer and a vapor membrane (vapor retarder, water resistant barrier or vapor barrier). In the following sections, the pros and cons of the possible options regarding these elements will be presented, such that you and your specifier can make an engineering decision based on the benefits and costs of the choices.

GRANULAR LAYER

In American Concrete Institute (ACI) 302.1R-04, a "base material" is recommended over the vapor membrane, rather than the conventional clean "sand cushion" material. The base layer should be a minimum of 4 inches (100 mm) thick, trimmable, compactible, granular fill (not sand), a so-called crusher-run material. Usually graded from 1½ inches to 2 inches (38 to 50 mm) down to rock dust is suitable. Following compaction, the surface can be choked off with a fine-grade material. We refer you to ACI 302.1R-04 for additional details regarding the requirements for the base material.

In cases where potential static water levels or significant perched water sources appear near or above the floor slab, an under floor drainage system may be needed wherein a draintile system is placed within a thicker clean sand or gravel layer. Such a system should be properly engineered depending on subgrade soil types and rate/head of water inflow.

VAPOR MEMBRANE

The need for a vapor membrane depends on whether the floor slab will have a vapor sensitive covering, will have vapor sensitive items stored on the slab, or if the space above the slab will be a humidity controlled area. If the project does not have this vapor sensitivity or moisture control need, placement of a vapor membrane may not be necessary. Your decision will then relate to whether to use the ACI base material or a conventional sand cushion layer. However, if any of the above sensitivity issues apply, placement of a vapor membrane is recommended. Some floor covering systems (adhesives and flooring materials) require installation of a vapor membrane to limit the slab moisture content as a condition of their warranty.

VAPOR MEMBRANE/GRANULAR LAYER PLACEMENT

A number of issues should be considered when deciding whether to place the vapor membrane above or below the granular layer. The benefits of placing the slab on a granular layer, with the vapor membrane placed below the granular layer, include **reduction** of the following:

- Slab curling during the curing and drying process.
- Time of bleeding, which allows for quicker finishing.
- Vapor membrane puncturing.
- Surface blistering or delamination caused by an extended bleeding period.
- Cracking caused by plastic or drying shrinkage.

The benefits of placing the vapor membrane over the granular layer include the following:

- A lower moisture emission rate is achieved faster.
- Eliminates a potential water reservoir within the granular layer above the membrane..
- Provides a "slip surface", thereby reducing slab restraint and the associated random cracking.

If a membrane is to be used in conjunction with a granular layer, the approach recommended depends on slab usage and the construction schedule. The vapor membrane should be placed above the granular layer when:

- Vapor sensitive floor covering systems are used or vapor sensitive items will be directly placed on the slab.
- The area will be humidity controlled, but the slab will be placed before the building is enclosed and sealed from rain.
- Required by a floor covering manufacturer's system warranty.

The vapor membrane should be placed below the granular layer when:

- Used in humidity controlled areas (without vapor sensitive coverings/stored items), with the roof membrane in place, and the building enclosed to the point where precipitation will not intrude into the slab area. Consideration should be given to slight sloping of the membrane to edges where draintile or other disposal methods can alleviate potential water sources, such as pipe or roof leaks, foundation wall damp proofing failure, fire sprinkler system activation, etc.

There may be cases where membrane placement may have a detrimental effect on the subgrade support system (e.g., expansive soils). In these cases, your decision will need to weigh the cost of subgrade options and the performance risks.

BASEMENT/RETAINING WALL BACKFILL AND WATER CONTROL

DRAINAGE

Below grade basements should include a perimeter backfill drainage system on the exterior side of the wall. The exception may be where basements lie within free draining sands where water will not perch in the backfill. Drainage systems should consist of perforated or slotted PVC drainage pipes located at the bottom of the backfill trench, lower than the interior floor grade. The drain pipe should be surrounded by properly graded filter rock. A filter fabric should then envelope the filter rock. The drain pipe should be connected to a suitable means of disposal, such as a sump basket or a gravity outfall. A storm sewer gravity outfall would be preferred over exterior daylighting, as the latter may freeze during winter. For non-building, exterior retaining walls, weep holes at the base of the wall can be substituted for a drain pipe.

BACKFILLING

Prior to backfilling, damp/water proofing should be applied on perimeter basement walls. The backfill materials placed against basement walls will exert lateral loadings. To reduce this loading by allowing for drainage, we recommend using free draining sands for backfill. The zone of sand backfill should extend outward from the wall at least 2', and then upward and outward from the wall at a 30° or greater angle from vertical. As a minimum, the sands should contain no greater than 12% by weight passing the #200 sieve, which would include (SP) and (SP-SM) soils. The sand backfill should be placed in lifts and compacted with portable compaction equipment. This compaction should be to the specified levels if slabs or pavements are placed above. Where slab/pavements are not above, we recommend capping the sand backfill with a layer of clayey soil to minimize surface water infiltration. Positive surface drainage away from the building should also be maintained. If surface capping or positive surface drainage cannot be maintained, then the trench should be filled with more permeable soils, such as the Fine Filter or Coarse Filter Aggregates defined in MnDOT Specification 3149. You should recognize that if the backfill soils are not properly compacted, settlements may occur which may affect surface drainage away from the building.

Backfilling with silty or clayey soil is possible but not preferred. These soils can build-up water which increases lateral pressures and results in wet wall conditions and possible water infiltration into the basement. If you elect to place silty or clayey soils as backfill, we recommend you place a prefabricated drainage composite against the wall which is hydraulically connected to a drainage pipe at the base of the backfill trench. High plasticity clays should be avoided as backfill due to their swelling potential.

LATERAL PRESSURES

Lateral earth pressures on below grade walls vary, depending on backfill soil classification, backfill compaction and slope of the backfill surface. Static or dynamic surcharge loads near the wall will also increase lateral wall pressure. For design, we recommend the following ultimate lateral earth pressure values (given in equivalent fluid pressure values) for a drained soil compacted to 95% of the Standard Proctor density and a level ground surface.

	Equivalent Fluid Density	
Soil Type	**Active (pcf)**	**At-Rest (pcf)**
Sands (SP or SP-SM)	35	50
Silty Sands (SM)	45	65
Fine Grained Soils (SC, CL or ML)	70	90

Basement walls are normally restrained at the top which restricts movement. In this case, the design lateral pressures should be the "at-rest" pressure situation. Retaining walls which are free to rotate or deflect should be designed using the active case. Lateral earth pressures will be significantly higher than that shown if the backfill soils are not drained and become saturated.

FREEZING WEATHER EFFECTS ON BUILDING CONSTRUCTION

GENERAL

Because water expands upon freezing and soils contain water, soils which are allowed to freeze will heave and lose density. Upon thawing, these soils will not regain their original strength and density. The extent of heave and density/ strength loss depends on the soil type and moisture condition. Heave is greater in soils with higher percentages of fines (silts/clays). High silt content soils are most susceptible, due to their high capillary rise potential which can create ice lenses. Fine grained soils generally heave about 1/4" to 3/8" for each foot of frost penetration. This can translate to 1" to 2" of total frost heave. This total amount can be significantly greater if ice lensing occurs.

DESIGN CONSIDERATIONS

Clayey and silty soils can be used as perimeter backfill, although the effect of their poor drainage and frost properties should be considered. Basement areas will have special drainage and lateral load requirements which are not discussed here. Frost heave may be critical in doorway areas. Stoops or sidewalks adjacent to doorways could be designed as structural slabs supported on frost footings with void spaces below. With this design, movements may then occur between the structural slab and the adjacent on-grade slabs. Non-frost susceptible sands (with less than 12% passing a #200 sieve) can be used below such areas. Depending on the function of surrounding areas, the sand layer may need a thickness transition away from the area where movement is critical. With sand placement over slower draining soils, subsurface drainage would be needed for the sand layer. High density extruded insulation could be used within the sand to reduce frost penetration, thereby reducing the sand thickness needed. We caution that insulation placed near the surface can increase the potential for ice glazing of the surface.

The possible effects of adfreezing should be considered if clayey or silty soils are used as backfill. Adfreezing occurs when backfill adheres to rough surfaced foundation walls and lifts the wall as it freezes and heaves. This occurrence is most common with masonry block walls, unheated or poorly heated building situations and clay backfill. The potential is also increased where backfill soils are poorly compacted and become saturated. The risk of adfreezing can be decreased by placing a low friction separating layer between the wall and backfill.

Adfreezing can occur on exterior piers (such as deck, fence or other similar pier footings), even if a smooth surface is provided. This is more likely in poor drainage situations where soils become saturated. Additional footing embedment and/or widened footings below the frost zones (which includes tensile reinforcement) can be used to resist uplift forces. Specific designs would require individual analysis.

CONSTRUCTION CONSIDERATIONS

Foundations, slabs and other improvements which may be affected by frost movements should be insulated from frost penetration during freezing weather. If filling takes place during freezing weather, all frozen soils, snow and ice should be stripped from areas to be filled prior to new fill placement. The new fill should not be allowed to freeze during transit, placement or compaction. This should be considered in the project scheduling, budgeting and quantity estimating. It is usually beneficial to perform cold weather earthwork operations in small areas where grade can be attained quickly rather than working larger areas where a greater amount of frost stripping may be needed. If slab subgrade areas freeze, we recommend the subgrade be thawed prior to floor slab placement. The frost action may also require reworking and recompaction of the thawed subgrade.

BEDDING/FOUNDATION SUPPORT OF BURIED PIPE

GENERAL

This page addresses soil bedding and foundation support of rigid pipe, such as reinforced concrete, and flexible pipe, such as steel and plastic. This does not address selection of pipe based on loads and allowable deflections, but rather addresses the geotechnical/soil aspects of uniform pipe support. Bedding/foundation support needs relate to local conditions directly beneath and to the sides of the pipe zone, which may be influenced by soft in-situ ground conditions or by soil disturbance due to soil sensitivity or ground water. Bedding relates to granular materials placed directly beneath the bottom of the pipe (usually 4" to 6" thick), which is intended to provide increased support uniformity. We refer to foundation soils as thicker layers of sands and/or gravels (beneath the bedding zone) intended to provide increased foundation strength support, usually needed due to soft, unstable and/or waterbearing conditions.

GRANULAR BEDDING

With circular pipes, high local loads (approaching point loads) develop if pipes are placed on hard surfaces. Load distribution is improved by placing granular bedding materials beneath the pipe, which are either shaped to match the pipe bottom or are placed without compaction to allow "settling in." The bedding should be placed in such a manner that the pipe will be at the proper elevation and slope when the pipe is laid on the bedding. Common bedding material is defined in Mn/DOT Specification 3149.2F, Granular Bedding. Published documents recommend rigid pipes having a diameter of 12" to 54" be placed on a bedding thickness of 4", which increases to 6" of bedding for pipe diameters ranging from 54" to 72". Beyond a 72" diameter, the bedding thickness can be equal to the pipe outside diameter divided by 12. Typically, the need for bedding under small diameter pipes (less than 12") depends on the pipe designer's specific needs, although in obvious point loads situations (bedrock, cobbles, significant coarse gravel content), bedding is recommended. Note that bedding should also account for larger diameter bells at joints.

FOUNDATION FILL

Positive uniform strength is usually compromised in soft or unstable trench bottom conditions. In this case, deeper subcuts and foundation fill placement is needed beneath the pipe. In moderate instability conditions, improvement can likely be accomplished with a thicker bedding layer. However, in more significant instability situations, particularly where ground water is present, coarser materials may be needed to provide a stronger foundation. Thicker gravel layers can also be a favorable media from which to dewater. The following materials would be appropriate for stability improvement, with the coarser materials being appropriate for higher instability/ground water cases.

- Fine Filter Aggregate – Mn/DOT Specification 3149.2J
- Coarse Filter Aggregate – Mn/DOT Specification 3149.2H

When using a coarser material which includes significant void space, we highly recommend enveloping the entire gravel layer within a geotextile fabric. The gravel material includes open void space, and the fabric acts as a separator which minimizes the intrusion of fines into the open void space. If an additional granular bedding sand is used above foundation gravel, the fabric would also prevent downward infiltration of bedding sand into the rock void space.

Although it is preferred to not highly compact thin granular bedding zones directly beneath the pipe center, it is desirable to compact the foundation materials to prevent more significant pipe settlement. We recommend foundation fill be compacted to a minimum of 95% of the Standard Proctor density (ASTM:D698). It is not possible to test coarse rock fill, although this material should still be well compacted/ tamped.

Often, pipes entering structures such as catch basins, lift stations, etc., enter the structure at a higher elevation than the structure bottom, and are therefore placed on the structure backfill. Fill beneath these pipes should be considered foundation fill. Depending on the flexibility of the connection design, it may be necessary to increase the minimum compaction level to reduce differential settlements, particularly with thicker fills.

SIDE FILL SUPPORT

If the pipe designer requires support from the side fill, granular bedding should also be placed along the sides of the pipe. In poor soil conditions, the sand fill may need to be placed laterally up to two pipe diameters on both sides of the pipe. With rigid pipe, compacted sand placement up to the spring line (within the haunch area) is usually sufficient. With flexible pipe, side fill should be placed and compacted at least to the top of the pipe. For positive support, it is very important to properly compact the sands within the haunch area.