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Technical Memorandum

To: Ben Scharenbroich
From: Jen Koehler, Lulu Fang, and Karen Chandler
Subject: City of Plymouth CIP Planning Assistance – Stormwater Improvements and Storage off Fernbrook Lane N
Date: November 18, 2024
Project: 23272078

Certification

I hereby certify that this memorandum 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.

Jennifer Koehler
PE #: 47500

11/18/2024
Date

1 Introduction

The City of Plymouth is concerned with existing flooding in the area around Fernbrook Lane N and Harbor Lane N and wants to explore the city's CIP opportunities to reduce flood risk in the area. These opportunities include storm sewer system capacity improvements and potential additional storage options on a 7.16-acre parcel (PIN: 2211822230017) located east of Fernbrook Lane N to provide flood storage, rate control, and (potentially) water quality improvements.

2 Existing Conditions Evaluation Summary

Barr previously completed an evaluation of existing conditions flooding in the project area for the City of Plymouth and the results are summarized in a separate memo dated 5/1/2024. We leveraged the modeling and information from that evaluation for this additional study and planning.

3 Proposed Conditions Evaluation Summary

3.1 Preliminary Assessment (Phase 1)

3.1.1 Data Collection and Review

3.1.1.1 Elevation Data

The existing grade on the parcel (per the 2011 Minnesota Department of Natural Resources LiDAR data) ranges from ~962 ft MSL to ~972 ft MSL. The existing invert of the storm sewer at the west side of the parcel is ~943 ft MSL and transitions to ~936 ft on the east side the parcel, so the existing storm sewer through this parcel is between 20 – 35 feet below the existing ground surface.

3.1.1.2 Soils and Groundwater Data

The United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) Web Soil Survey data indicate that the soils in the parcel area are primarily Rassett Sandy Loam, 2-6 % Slopes. This suggests that infiltration may be possible given the soil types (see Attachment A).

The City of Plymouth provided soil boring information collected as part of the construction of the Home2 Suites hotel on the parcels south of the Fernbrook Lane parcel of interest to better understand the potential soils at the site (Terracon, 2017; see Attachment B). This information is also useful to help evaluate if the soils could support infiltration or evaluate depth to groundwater.

The soil boring data provided suggests that the soils at the proposed bottom of construction storage (~939-943 ft MSL) would be silty sand with gravel (SM) which suggests that infiltration may be possible. However, the soil borings also indicated that the groundwater elevation could be around ~943 ft MSL +/- in the area. Given this, infiltration may not be possible but the construction of a wet pond that can provide some water quality benefits may still be an option. This should be confirmed by geotechnical investigations at the project site during future design phases.

Based on direction from City staff for this effort, we assumed that there is no known soil contamination in the project area at this time.

3.1.1.3 Critical Elevations

We leveraged the 2011 LiDAR data to estimate the critical elevation for habitable dwellings, assuming the lowest elevation along the building footprint is equivalent to the low opening. These elevations have not been confirmed by survey and we recommend that survey data be collected on these properties as the city moves into future phases of the project. We did not receive any information from the City of Plymouth about final floor elevation/as-built drawings for the potentially impacted structures in the project area as part of this effort. We also recommend that a survey of low openings, low floor, and finished floor elevations be performed as part of future design phases.

3.1.2 Preliminary Modeling

Barr used the existing conditions model that had been previously updated for the City of Plymouth for this project area to perform preliminary evaluation of an alternative that focused on upsizing conveyance along Juneau Lane N and Harbor Lane N to the proposed storage east of Fernbrook Lane N, with the following goals:

- Reduce floodingand number of impacted structures (with a focus on the habitable structures) in the study area watershed, meet rate control requirements for discharges to Plymouth Creek, and consider the ability to incorporate water quality treatment.
- By upsizing the system from the Plymouth Office Center Redevelopment site to the proposed pond (along Fernbrook Lane N), flooding on Fernbrook Lane N to the south by the low point north of Highway 55 may also be reduced.

We reviewed the results of the preliminary modeling with City staff in a meeting on 7/19/2024. During that meeting, city staff indicated they were comfortable proceeding with this alternative into Phase 2, with no need to evaluate other alternatives at this time.

3.2 Preferred Alternative (Phase 2)

Based on the selection of the preferred alternative by the City at the end of Phase 1, Barr refined the alternative and developed a concept level plan of the preferred alternative including the following:

- Estimated storage footprint
- Estimated land area needed as well as the estimated remaining developable area on the parcel of interest
- Estimated water quality improvement (assuming a wet pond)
- Developed preferred alternative concept layouts including pipe upsizing, estimated storage footprint, proposed inundation mapping in watershed area, and impacted structures for the Atlas 14, 10-year & 100-year 24-hour rainfall events

- Estimated planning level costs

Based on our conversation with City staff on 7/19/2024, we developed three preliminary grading plans to achieve the same amount of necessary storage, using the 2011 LiDAR topographic data and needed depth of the storage (see Figure 1). The following three options were evaluated:

- Option 1 assumes the City leverages the existing low area on the parcel to minimize excavation quantities.
- Option 2 assumes the City places the storage on the western portion of the parcel along Fernbrook Lane N, with the remaining developable area on the eastern half of the parcel. This generally encompasses the lower portion of the parcel.
- Option 3 assumes the City places the storage on the eastern portion of the parcel with the remaining developable area on the western half of the parcel. This generally encompasses the higher portion of the parcel and will require more excavation to implement the storage and replace downstream conveyance.

Barr refined the preliminary alternative modeling to reflect the proposed grading of each option. We used the refined model to finalize the estimated the approximate conveyance sizing and storage needed to meet the flooding and rate control requirements. The storage area contours, as generally shown in the figure, include the proposed top elevation to tie into the surrounding existing grade (elevation ~964/966), normal water level (NWL, at elevation ~943), and basin bottom (at elevation ~939). A summary of the approximate storage needs is included in Figure 1. Figure 2 and Figure 3 show the proposed upsized conveyance needed from Juneau Lane N and along Harbor Lane N to the proposed storage east of Fernbrook Lane, as well as inundation mapping and impacted structures in the watershed area for the Atlas 14, 10-year & 100-year 24-hour events, respectively.

We assumed that the total storage for the 100-year event would be contained between elevations 939 ft MSL and 954 ft MSL, to prevent tailwater impacts on the upstream storm sewer system and watershed areas. The portion of the basin from 939 ft MSL to 943 ft MSL is assumed to be a wet pond to provide water quality treatment due to the anticipated groundwater levels in the area.

We developed a basic P8 model based on storage option 1 assuming one contributing watershed with no additional treatment and the proposed pond is a wet pond. We assumed the depth of this wet pond at 4 feet, and that the pond would treat runoff from the entire area upstream of Fernbrook Lane N and the proposed storage parcel. The P8 model results showed the average annual total suspended solids (TSS) removal would be 6,330 lbs/year with a removal efficiency of 90% per year. and the average annual total phosphorus (TP) removal would be 13.8 lbs/year, with a removal efficiency of 60% per year. These modeled removal efficiencies suggest that the proposed water quality pond is sized appropriately for the contributing watershed.

We also developed planning- level costs, including engineering & design, construction (with contingency) due to the level of conceptual design (1- 10% design) and uncertainty. There are two difference cost estimates presented, the first combining drainage improvements (storage and conveyance) along with the estimated street/paving reconstruction costs and a second cost focused only on the drainage improvements.

The combined costs include the cost of the installation of upsized storm sewer mainlines, restoration of the street and other pavement along the upsized pipe segments, and construction of the proposed storage. This cost do not include any other utility work (e.g., water main, sanitary sewer, or private utility work) that may be required for the upsizing of the conveyance system. This costs also assume that any excavated material is considered clean and does not have any special disposal requirements.

However, based on final design, there may be an opportunity to utilize the material onsite as fill to create a future development area to help reduce overall costs. The cost of the project could be reduced if pipe upsizing is aligned with other roadway CIP projects or redevelopment of the private parcels located along the pipe conveyance. The second cost estimate does not include the cost of removal and restoration of the road.

Additionally, we based the pipe sizing on the sizing needed to protect habitable structures, using the estimated low building elevations per the 2011 LiDAR, not the actual surveyed low floor elevations. A future survey of the low openings and low floors may show that these building are higher than estimated and may result in a reduction in the required pipe sizes.

Land acquisition costs are not included in the planning level costs outlined above. However, based on the 2024 Hennepin County taxable market/land value, the 7.16-acre parcel is listed as $2,809,000. Based on the storage configurations summarized above, the City may be able to subdivide and resell ~4 acres for development following the construction of the stormwater management project.

Table 1 summarizes the proposed storage and land area requirements for the three different storage options shown in Figure 1. Table 1 also summarizes the estimated land acquisition cost and the planning level cost estimates for total engineering and construction with and without the road reconstruction cost. The road reconstruction cost could be shared with future roadway CIP projects or redevelopment of the private parcels to reduce the overall project.

Table 1 Summary of Preferred Alternative with and without Road Reconstruction Cost

Grading Option	Total Parcel Area (ac)	Storage Area (ac)	Remaining Developable Area (ac)	Water Quality Volume (ac-ft)	Flood Storage Volume (ac-ft)	Total Excavation Volume (ac-ft)	Land Acquisition Cost (2024$)[1]	Total Engineering and Construction Cost with Road Reconstruction (2024$, -30% / +50%)	Total Engineering and Construction Cost without Road Reconstruction (2024$, -30% / +50%)
Option 1	7.16	2.84	4.32	2.73	13.46	42.06	$2,809,000	$7.7 million ($5.3 - $11.5 million)	$5.6 million ($3.9 - $8.3 million)
Option 2	7.16	2.51	4.65	2.93	13.26	42.01	$2,809,000	$7.7 million ($5.4 - $11.5 million)	$5.6 million ($4.0 - $8.4 million)
Option 3	7.16	2.61	4.55	3.15	13.58	44.70	$2,809,000	$8.5 million ($6.0 - $12.8 million)	$6.2 million ($4.4 - $9.4 million)

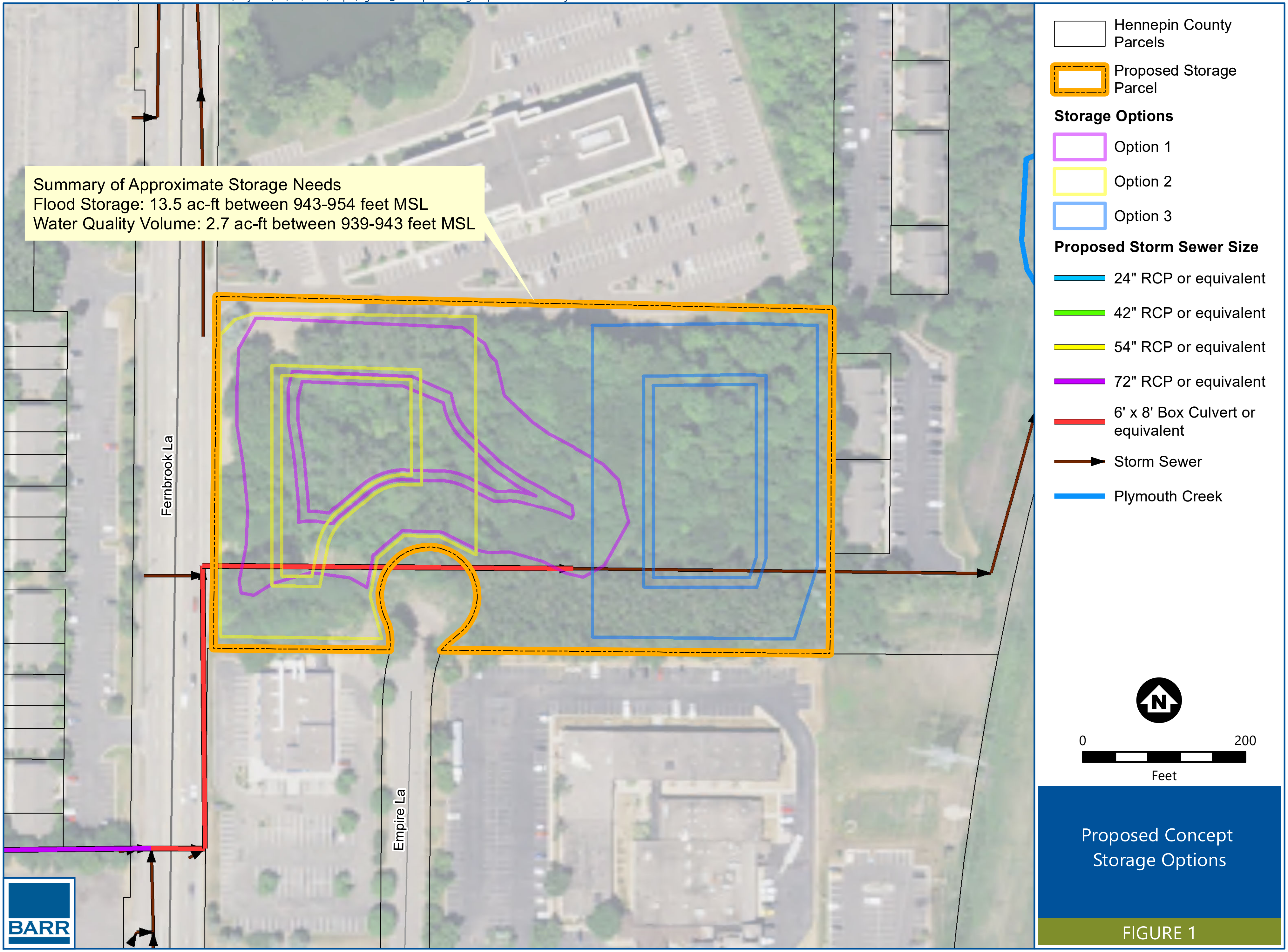
1: Land acquisition cost is based on purchase of entire 7.16-acre parcel

Table 2 summarizes the peak water surface elevations for the various subwatersheds within the study area during the Atlas 14 2-, 10-, and 100-year, 24-hour design storm events as well as the peak discharges to Plymouth Creek.

Table 2 Summary of Peak Water Surface Elevations (WSE) and Peak Discharges to Plymouth Creek for the Atlas 14 2, 10, and 100-year, 24-hour Design Storm Events

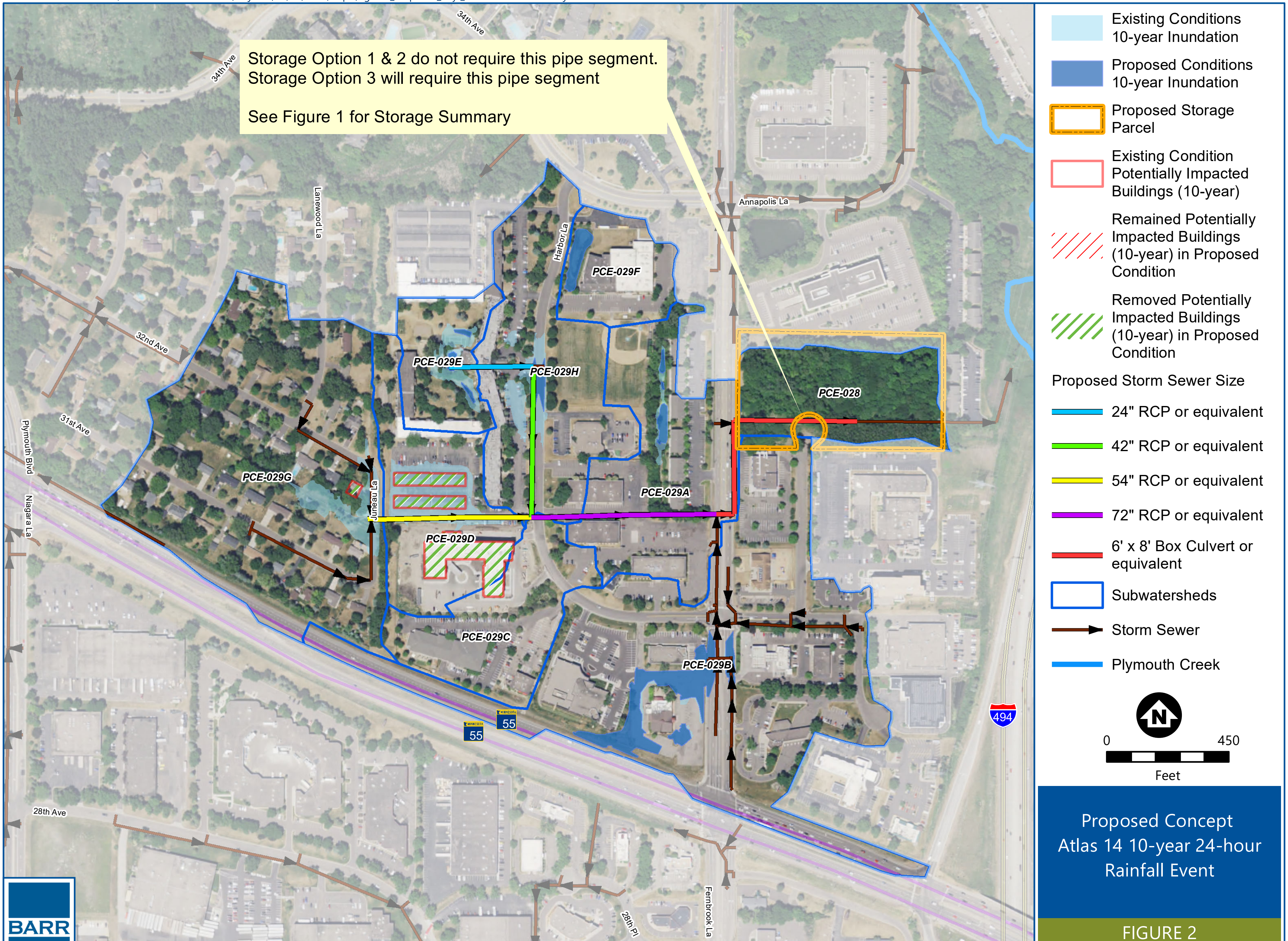
Subwatersheds	2-year 24-hour Peak WSE		10-year 24-hour Peak WSE		100-year 24-hour Peak WSE	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
PCE-029A	950.75	949.62	951.88	950.63	954.35	954.33
PCE-029B	955.44	955.14	956.54	956.43	957.38	957.35
PCE-029C	953.83	951.71	954.81	952.85	956.63	954.68
PCE-029D	956.27	953.09	956.96	954.30	957.50	956.23
PCE-029E	955.96	953.78	956.59	955.26	956.98	956.44
PCE-029F	956.51	956.44	957.34	957.18	958.89	958.79
PCE-029G	957.83	954.15	959.17	955.18	960.83	957.96
PCE-029H	954.48	952.94	955.18	954.03	956.87	955.23
Total Flow to Plymouth Creek (cfs)	97	71	105	91	121	107

Barr Footer: ArcGIS 10.9.1, 2024-08-13 05:15 File: I:\Projects\23\27\2078\Maps\Figure1_Concept – Storage Options.mxd User: jak2



Proposed Concept Storage Options

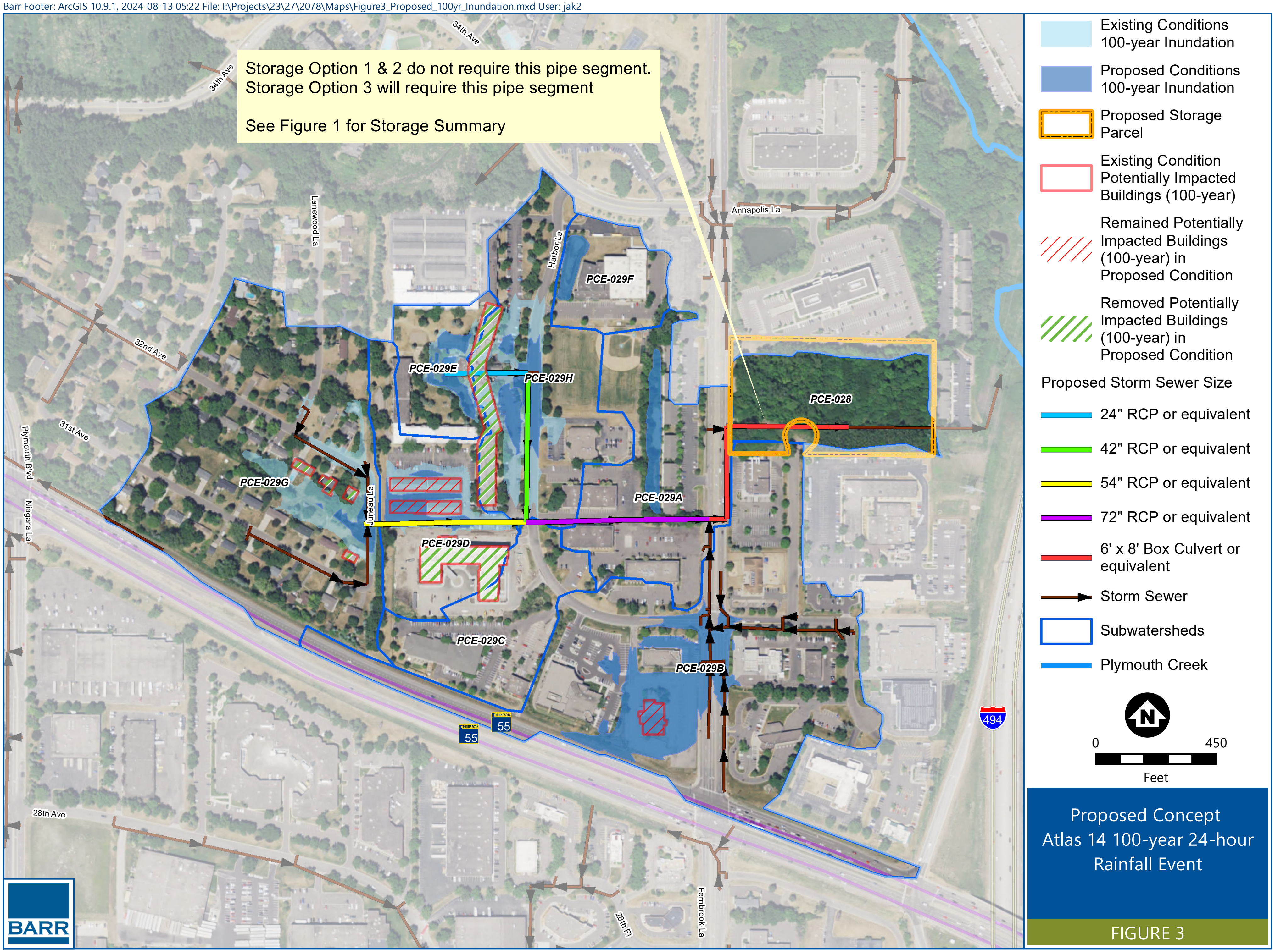
FIGURE 1



Proposed Concept
Atlas 14 10-year 24-hour
Rainfall Event

FIGURE 2

Barr Footer: ArcGIS 10.9.1, 2024-08-13 05:22 File: I:\Projects\23\27\2078\Maps\Figure3_Proposed_100yr_Inundation.mxd User: jak2



Attachment A: USDA Soil Survey Data

Soil Map—Hennepin County, Minnesota
(Fernbrook Parcel, Plymouth, MN)

Map Scale: 1:1,490 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 20, 40, 80, 120

Feet: 0, 50, 100, 200, 300

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Hennepin County, Minnesota
Survey Area Data: Version 19, Sep 10, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 29, 2023—Sep 13, 2023

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
L3B	Rasset sandy loam, 2 to 6 percent slopes	9.6	100.0%
Totals for Area of Interest		**9.6**	**100.0%**

Attachment B: Geotechnical Investigation for Home2 Suites site (Terracon, 2017)

Home2 Hotel
Empire Lane
Plymouth, Minnesota

February 9, 2017

Terracon Project No. MP175002

Prepared for:

Plymouth Hotel Group, LLC

Eden Prairie, Minnesota

Prepared by:

Terracon Consultants, Inc.

Minneapolis, Minnesota

February 9, 2017

Plymouth Hotel Group, LLC
100 Prairie Center Drive, Suite 210
Eden Prairie, Minnesota 55344

Attn: Mr. Greg Timm
P: 919-489-9743

Re: Geotechnical Engineering Report
Home2 Hotel
Empire Lane
Plymouth, Minnesota
Terracon Project No. MP175002

Dear Mr. Timm:

Terracon Consultants, Inc. (Terracon) is pleased to submit our Geotechnical Engineering Report for the proposed Home2 Hotel in Plymouth, Minnesota. This report presents the results of our subsurface exploration and provides geotechnical recommendations for earthwork, design and construction of foundations, and floor slab and pavement subgrade preparation, and thickness recommendations for pavements.

If you have any questions regarding this report, or if we may be of further service to you, please contact us.

Sincerely,
Terracon Consultants, Inc.

Brett W. Larsen, P.E.
Geotechnical Engineer

Brett E. Bradfield, P.E.
Senior Engineering Consultant

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.

Date: 2/28/2017

Brett W. Larsen
Reg. No. 52573

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EXECUTIVE SUMMARY

Terracon completed a subsurface exploration and performed geotechnical engineering services for the proposed Home2 Hotel in Plymouth, Minnesota. Nine (9) borings were performed within the proposed building and pavement areas to depths of about 15 to 30 feet below existing ground surface (bgs). Geotechnical findings, professional opinions, and recommendations presented in this report are summarized below.

- Fill comprised of sand, silty and clayey sand, and lean clay was encountered in all of the borings to depths of about 3½ to 9 feet bgs.
- Excavations for spread footing foundations should extend to suitable fill materials that are tested and evaluated during construction, and if necessary beneath existing fill that is found to not exhibit structural fill characteristics. Overexcavations of limited depths below footings or mechanical densification of loose soils would also be required where low strength native soils are encountered at or just below the planned bearing elevations.
- Provided that alternatives discussed to aid in reducing risks associated with support above existing fill will be acceptable to the owner, it is our opinion that the proposed slabs and pavements could be supported on existing fill materials that are tested and evaluated and prepared as detailed in this report.
- We suggest documentation of original fill placement (i.e., grading plans, compaction test reports, etc.) be provided to Terracon for review and to supplement the opinions presented in this report. If the owner is cautious of risks associated with support of structural elements above existing fill, the building site development would involve extending all foundation elements beneath the existing fill, and more extensive to complete removal of the existing fill layers to expose suitable native soils, followed by replacement with new structural fill below slabs and pavements.
- Generally, the on-site soils appear suitable for use/reuse as general site grading fill; however, some processing should be anticipated.

The professional opinions and recommendations presented in this report are based on evaluation of data developed by testing discrete samples obtained from widely spaced borings. Site subsurface conditions have been inferred from available data, but actual subsurface conditions will only be revealed by excavation. So that variations in subsurface conditions which may affect the design can be addressed as they are encountered, we recommend that Terracon be retained to observe excavation and perform tests during the site preparation, earthwork and foundation construction phases of the project.

This executive summary should not be separated from or used apart from this report. This report presents professional opinions and recommendations based on our understanding of the project at the time this report was prepared. The report limitations are described in the section **5.0 GENERAL COMMENTS**.

GEOTECHNICAL ENGINEERING REPORT
HOME2 HOTEL
EMPIRE LANE
PLYMOUTH, MINNESOTA

Terracon Project No. MP175002

February 9, 2017

1.0 INTRODUCTION

Terracon Consultants, Inc. (Terracon) has completed a subsurface exploration and performed geotechnical engineering services for the proposed Home2 Hotel in Plymouth, Minnesota. Nine (9) borings were performed at the site to depths of approximately 15 to 30 feet below existing ground surface (bgs). Terracon performed these services in general accordance with Terracon Proposal No. PMP175002, dated January 6, 2017.

Site Vicinity Map (Exhibit A-1), Boring Location Plan (Exhibit A-2), and logs of the borings (Exhibit A-4) are included in Appendix A. This report presents the results of our subsurface exploration and provides geotechnical information and recommendations relative to the items listed below.

- subsurface soil conditions
- earthwork and site preparation
- pavement design considerations
- foundation design and construction
- floor slab subgrade preparation
- frost considerations

2.0 PROJECT INFORMATION

2.1 Site Location and Description

Item	Description
Location	■ This project site is located at the northeast corner of Empire Lane and Harbor Lane in Plymouth, Minnesota.
Existing conditions	■ The site is developed with an existing hotel structure which is surrounded by asphalt pavements.
Existing topography	■ The site appears to be relatively flat with up to 2 feet of relief within the proposed building area.

2.2 Project Understanding

Item	Description
Proposed building	■ Five story structure with sidewalks and main building entrances along the southern portion of the building. ■ The building will have a footprint of approximately 13,000 square feet with plan dimensions of approximately 200 feet by 65 feet.

Item	Description
Finished floor elevation, FFE	■ Not available at this time; assumed within 2 feet of existing grades.
Maximum loads (assumed)	■ Columns: 500 kips ■ Walls: 7 kips per linear foot ■ Slabs: 150 psf
Pavements	■ Automobile parking areas are planned primarily to the east and west of the proposed building. ■ We understand that these pavements could be asphalt or concrete.
Grading	■ Site grading plans were not provided. ■ We have considered that cuts and fills in the planned building and pavement areas will be no more than 2 feet.
Free-standing retaining walls	■ None anticipated.
Below-grade areas	■ None anticipated.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

Subsurface conditions at the boring locations can be generalized as follows:

Stratum	Approximate Depth to Bottom of Stratum (bgs)	Material Encountered	Comments / Consistency / Relative Density
Surface Materials	Approximately 4 inches of asphalt pavement at Borings 1 through 7 Approximately 3 to 6 inches topsoil and root zone at Borings 8 and 9		
1	3½ to 9	Existing Fill – Silty Sand Clayey Sand and Sandy Lean Clay [1]	With gravel and cobbles, dark gray to brown SPT N-values: ■ typically 21 to 44 bpf ■ 2 to 16 bpf in Borings 3, 8 and 9
2	18½ to 24 [2]	Sandy Lean Clay	Stiff
3	Not determined [3]	Silty Sand	Medium dense to dense

1. Layers of sandy lean clay within existing fill at Borings 1, 2, 4, 5 and 7.
2. Borings 8 and 9 were terminated at a depth of 15 feet bgs in Stratum 2
3. Borings 1 through 7 were terminated in this stratum at a depth of 30 feet bgs.

Conditions encountered at each boring location are indicated on the individual boring logs in Exhibit A-4. The stratification lines shown on the boring logs and profile represent the approximate boundaries between soil and bedrock types. In-situ, transitions between materials may be gradual.

3.2 Groundwater

The borings were observed during drilling and shortly after completion of drilling operations for the presence and level of groundwater. Groundwater was not observed during drilling operations.

Groundwater observations provide an approximate indication of the groundwater conditions existing on the site at the time the observations were made. A longer time may be required to develop representative water level in the boreholes, since there could be potential for perched conditions to develop. Longer-term observations using cased holes or piezometers, sealed from the influence of surface water, would be required for a better evaluation of the groundwater conditions on this site.

Fluctuations of the groundwater levels will likely occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structures may be different than indicated on the boring logs. The possibility of groundwater level fluctuations and perched water should be considered when developing the design and construction plans for the project.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

The following recommendations are based upon the data obtained in our field and laboratory programs, project information provided to us, and on our experience with similar subsurface and site conditions.

4.1 Geotechnical Considerations

Existing fill was encountered at all borings. Based on site history, we have considered that the fills were likely placed during overall site development of the nearby existing hotel and adjacent lots. The fill encountered at the borings was generally comprised of sand soils. Moisture contents of samples of the fill encountered in the borings ranged from 4 to 22 percent, and the standard penetration test N-values typically ranged from 21 to 44 blows per foot (bpf), although lower N-values were encountered in sample intervals within the fill at Borings 3, 8 and 9. Documentation regarding placement of the original fill at this site, if available, should be provided for Terracon's review to supplement the comments and recommendations included in this report.

The recommendations provided in the following sections are intended to help reduce risks associated with supporting the foundations, floor slab and pavements on tested and evaluated existing fill. Risks associated with support above existing fill that has not been placed in controlled and tested conditions include potential uneven settlement, and these risks cannot be eliminated without complete removal and replacement of existing fill. All foundation excavations could be extended to suitable native soils beneath existing fill and any dark colored soil layers containing organics (where encountered) to reduce the risks of settlement.

If the owner has information on the grading work that was performed for site development and can accept some potential risk for support of foundations, slabs and pavements over a limited portion of existing fill, along with the recommended testing and evaluation program during construction, there would be an alternative to conducting stability evaluations and corrections of the exposed soils and replace zones of fill materials that do not exhibit structural fill characteristics with new structural fill to provide more uniformity in subgrade conditions to support the foundations, slabs and pavements.

If low strength or loose native soils are encountered at or near the planned bearing elevations, overexcavation to a limited depth below the footings will be needed, followed by replacement with granular structural fill to bearing elevations. It might be possible to mechanically densify loose native sand soils to improve the bearing conditions without a need to perform overexcavations, but field testing would be necessary.

We recommend additional tests and observations be conducted during construction. As mentioned, there could be risks associated with supporting foundations, slabs and pavements over existing fill materials that exhibit variable composition and quality. However, we suggest that a thorough observation and testing program be performed during construction to evaluate exposed soils and implement any corrections as deemed necessary.

4.2 Earthwork

Recommendations for site preparation, excavation, subgrade preparation, and placement of structural fill for the project are provided in the following sections.

4.2.1 Site Preparation

Construction areas should be stripped of pavement materials, vegetation, topsoil and any unsuitable materials (e.g., demolition debris, construction debris, desiccated soil, frozen soil, etc.) from the site surface within planned construction areas. All utilities that are planned to be abandoned/demolished should be completely removed along with associated bedding materials from within the proposed building area. If not possible, the abandoned utility lines should be thoroughly grouted and plugged with flowable fill.

It might be possible to reuse existing fill soils and the native on-site soils that are stripped or removed in excavated portions of the site as structural fill provided they meet the requirements in section **4.2.2 Structural Fill Requirements**, i.e., do not include rubble, debris or organic matter. We recommend that Terracon be retained to assist in evaluating exposed subgrades during earthwork so that unsuitable materials, if any, are removed at the time of construction.

If the owner and designers would prefer to reduce some of the risks for support above existing fill, we suggest that following the stripping and general cuts to rough grades, that the on-site existing fill soils be removed to depths of at least 1 foot below the planned subgrade for floor slabs and pavements, and the zone subsequently be replaced with new structural fill after recommended subgrade stability evaluations. The placement of a new section of structural fill would aid in providing relatively uniform subgrade support directly below the grade supported elements.

After stripping and completing cuts to designated levels, we recommend scarifying the exposed site soils to a depth of 12 inches, adjusting the moisture contents to recommended levels and then compacting. It should then be possible to evaluate the stability of the soil subgrade by proofrolling or thoroughly observing subgrade stability during the compaction process. Clay soil subgrades should be proofrolled with a loaded tandem axle dump truck having a gross weight of at least 20 tons. Sand soil areas could be proofrolled and evaluated with a smooth drum vibratory roller having a gross weight of at least 10 tons. Weak areas detected during proofrolling should be removed and replaced with new structural fill.

If subgrades become disturbed by precipitation and/or construction activity, the subgrade should additionally be improved before the floor slabs are placed. Stabilization measures will need to be employed should unstable subgrade conditions develop. Improvement methods are influenced by schedule, weather, the size of the disturbed area, and the nature of the disturbance. Improvement methods include but are not limited to:

- **Scarification and Compaction** – Soils can be scarified, moisture conditioned (i.e., dried or moistened), and compacted. The success of this procedure depends primarily upon favorable weather and sufficient time to manipulate the soils. Even with adequate time and favorable weather, stable subgrades may not be achieved if the thickness of the unstable material is greater than about 1 to 1½ feet.

- **Undercutting and Replacement with Crushed Stone/Aggregate** – The use of crushed stone, crushed concrete, and/or gravel to replace loose soils could improve subgrade stability. To limit depths of potential undercuts, the use of a geotextile or geogrid could also be considered after underground work, such as utility construction, is completed. The specifications provided by the reinforcement product manufacturer should be verified prior to material purchase/delivery and placement at the site.

4.2.2 Structural Fill Material Requirements

Structural fill should meet the following material property requirements:

Fill Type [1]	Soil Classification	Acceptable Location for Placement
On-site soils	Sandy lean clay (CL) [2] Fill – Sand and Silty sand with cobbles and gravel [3]	■ Below floor slabs and pavements ■ Below foundations if placed during mass grading on stable subgrades ■ Sand soils can also be used below foundations in overexcavations

Fill Type [1]	Soil Classification	Acceptable Location for Placement
Imported cohesive soil	CL [2]	■ Below floor slabs and pavements ■ Below foundations if placed during mass grading on stable subgrades
Imported granular material [3]	GW, GP, GM, GC SW, SP, SM, SC	■ Below foundations in overexcavations ■ Below grade-supported floor slabs (granular soils should contain <15% passing No. 200 sieve) ■ Backfill around structures ■ Free-draining zones below slabs (granular soils should contain <6% passing No. 200 sieve)
Unsuitable material [4]	CH, MH, OL, OH, PT	■ Green (non-structural) locations

1. Structural fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation prior to use on this site.
2. If low plasticity fine-grained soils are planned for use as structural fill, by our definition, these materials should have a liquid limit of 45 or less and a plasticity index of 23 or less (ASTM D 4318).
3. Cobbles and rock larger than 3-inches should be removed from material which will be re-used as structural fill.
4. Specific material requirements will need to be satisfied based on the intended use. Specific material requirements will also need to be satisfied based on near-surface native soils such that fill soils are similar to the native subgrade soils.

Appropriate laboratory tests, including standard Proctor (ASTM D698) moisture-density relationship tests, and Atterberg Limits for cohesive soils should be performed on proposed fill materials prior to their use as structural fill. Further evaluation of any on-site soils or off-site fill materials should be performed by Terracon prior to their use in compacted fill sections.

4.2.3 Compaction Requirements

Item	Description
Fill lift thickness	■ 9 inches or less in loose thickness when heavy, self-propelled compaction equipment is used ■ 4 inches in loose thickness when hand equipment (e.g., jumping jack, vibratory plate compactor, etc.) is used
Compaction of cohesive material [1, 2]	■ At least 95%
Moisture content of cohesive material	■ -2% to +3% of optimum
Compaction of granular material [1, 2, 3]	■ At least 98%
Moisture content of granular material [4]	■ Workable moisture levels

1. Compaction values and moisture contents are relative to standard Proctor maximum dry density and optimum moisture content (ASTM D 698).
2. We recommend structural fill be tested for moisture content and compaction during placement. If the results of the in-place density tests indicate the specified moisture or compaction limits have not

Item	Description
	been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved. 3. If the granular material is a coarse sand or gravel, is of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D 4253 and D 4254). 4. Specifically, the moisture content of the granular material should be at a level to achieve compaction without the granular material bulking during placement or pumping when proofrolled.

4.2.4 Utility Trench Backfill

All trench excavations should be made with sufficient working space to permit construction, including backfill placement and compaction.

Utility trenches are a common source of water infiltration and migration. Utility trenches constructed in cohesive soils that penetrate beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate below the building. We recommend constructing an effective “trench plug” of either low permeability clay soil or flowable fill or cohesive structural fill that extends at least 5 feet out from the face of the building exteriors. If clay soils are used for the plug, the material should be compacted at or above the soil’s optimum water content. The “trench plug” fill should be placed to completely surround the utility line and any granular envelope, and be compacted or placed in accordance with recommendations in this report. Care should be taken as to not damage the in-place utility.

4.2.5 Grading and Drainage

The site should be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Accumulated water should be promptly removed to reduce the potential softening of prepared subgrades. The soil types observed in the borings are easily eroded by surface water, so appropriate erosion control measures should be provided.

Dewatering of excavations will be required where seepage is encountered, and a dewatering plan should be addressed in advance of construction. It should be possible to remove accumulations of water within excavations in cohesive soils using a system of sump pits and pumps. More extensive dewatering systems, such as deeper sumps or well points, will be required where excavations extend below groundwater levels in the sand soils. Groundwater levels should be maintained at least 2 feet below the anticipated base of excavations. The contractor is responsible for employing appropriate dewatering methods to control seepage, remove standing water, maintain site drainage, and facilitate construction.

Slope final surrounding grades away from the proposed structures on all sides to prevent ponding of water. Gutters and downspouts that drain water a minimum of 10 feet beyond the footprint of the proposed building are recommended. This can be accomplished through the use of downspout extensions or flexible pipes that are designed to attach to the end of the downspout. Flexible pipe should only be used if it is daylighted in such a manner that it gravity-drains collected water.

4.2.6 Earthwork Construction Considerations

As a minimum, all temporary excavations should be sloped or braced as required by Occupational Safety and Health Administration (OSHA) regulations to provide stability and safe working conditions. Temporary excavations will probably be required during grading operations and installation of utilities. Contractors, by their contract, are usually responsible for designing and constructing stable, temporary excavations and they should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of the grade-supported slabs. Construction traffic over the completed subgrade should be avoided to the extent practical.

If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompacted prior to grade-supported slab construction.

By conducting this exploration and site characterization, Terracon is in a beneficial position to observe and evaluate subsurface conditions exposed during construction and to then compare the findings of the exploration and develop resolutions if variations are present. Terracon should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during the following phases: subgrade preparation, proofrolling, placement and compaction of controlled compacted fills, backfill of excavations into the completed subgrade, and finished grade prior to construction of grade-supported slabs.

4.2.7 Weather Related Earthwork Considerations

Construction of subgrades and aggregate bases during below freezing weather would require the use of clean, crushed rock that can be compacted without moisture conditioning. If open graded aggregate bases are used, we recommend the use of a separation geotextile between the crushed rock and on-site soils to help prevent fines migration.

Soil, aggregate base, and floor slab materials should not be placed on frozen ground. For construction in the spring, we recommend that placement of the floor slab be delayed until frost is thawed from the complete soil profile. In the project locale, during the period between November 15 and April 1, the ground temperature should be anticipated to be below freezing. Full ground thaw typically occurs in mid-April to late May in this locale, and is generally documented through the lifting of weight restrictions on trucks by MnDOT.

4.2.8 Frost Considerations

The soils on this site are frost susceptible, and water that infiltrates beneath slabs and shallow groundwater can be detrimental to the performance of the slabs. If frost action needs to be eliminated in critical areas, then we recommend the use of structural slabs (e.g., structural stoops in front of building doors), as is common practice in the state of Minnesota. It is our opinion that placing non-frost susceptible material in large areas under exterior slabs would be exceedingly expensive and an unusual design and construction procedure in Minnesota. Strong consideration should be given to the potential frost effect in the transition areas between doorways and slabs.

The following recommendations are provided to help reduce potential frost heave:

- Providing surface drainage away from the building and slabs and toward the site storm drainage system;
- Grading silty or clayey subgrades such that groundwater potentially perched in overlying more permeable subgrades, such as sand or aggregate base, slopes toward the site drainage system;
- Placing non-frost susceptible fill as backfill around stoops; and
- Placing a 3:1 (Horizontal: Vertical) transition zone between non- or low-frost susceptible soils and other soils.

Non-frost susceptible fill should consist of the sand or gravel soils with less than 3% passing the No. 200 sieve, along with provisions to drain subsurface water from the base of the non-frost susceptible fill areas.

4.3 Spread Footing Foundations

Based on the materials encountered in the borings and our analyses, it is our opinion that the proposed building could be supported on spread footings bearing on:

- Existing fill materials that are tested and evaluated to exhibit structural fill characteristics to depths of at least 2 feet below the base of foundations;
- Suitable native stiff sandy lean clay soils;
- New structural fill placed extending to native soils; or
- Granular structural fill extending to native soils in overexcavations of existing fill and unsuitable low strength or native soils containing organics.

Overexcavations used to remove existing fill or unsuitable native soils should be performed as described in section **4.3.2 Spread Footing Foundation Construction Considerations**.

The soils encountered in foundation excavations should be observed and tested by Terracon personnel at each column footing and at regular intervals along continuous footings. Design recommendations for spread footing foundations for the proposed building prepared in accordance with the recommendations in this report are presented in the following sections.

4.3.1 Spread Footing Foundation Design Recommendations

Recommendations for spread footing foundation design are provided in the table below.

Description	Value
Suitable bearing materials	■ Tested and evaluated existing fill ■ Native stiff consistency clay ■ Structural fill extending to suitable native soils ■ Granular structural fill using the overexcavation and backfill procedure per section **4.3.2**
Net allowable bearing pressure [1]	3,000 psf
Minimum footing widths	■ Wall footings: 18 inches ■ Column footings: 30 inches
Minimum embedment below finished grade for frost protection	■ For continuously heated structures [2]: 3½ feet ■ For non-heated structures [3]: 5 feet
Estimated total settlement [4]	1 inch or less
Estimated differential settlement [5]	■ ¾ inch or less between columns ■ ¾ inch or less over 40 feet along walls
Ultimate passive pressure [6, 7] (equivalent fluid density)	■ For cohesive soil backfill or foundations cast against site clay soils: 280 pcf ■ For granular backfill materials placed adjacent to footings: 360 pcf [8]
Ultimate coefficient of sliding friction	Footings on suitable bearing material: 0.40

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. This value considers that any unsuitable native or existing fill materials, or low strength or low density soils will be undercut and replaced with structural fill to designated depths where encountered.
2. Minimum embedment applies to perimeter footings beneath continuously heated structures. Minimum embedment may also reduce the effects of seasonal moisture variations in the subgrade soils. Where interior footings will not be subject to freezing weather and large moisture fluctuations during or after construction, the minimum embedment below top of slab could be reduced to 1½ feet.
3. Minimum embedment applies to perimeter footings beneath unheated structures and appurtenances or foundations that may be exposed to cold temperatures during construction.
4. The foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of structural fill, and the quality of the earthwork operations. Settlement of foundations supported above existing fill that is not thoroughly tested and evaluated could exceed these estimates.
5. Frequent control joints in the structure and sufficiently flexible connections are recommended to accommodate possible differential settlement.
6. Use of passive earth pressures requires that either the sides of the excavation for the spread footing foundation are nearly vertical and the concrete is placed neat against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face. Passive resistance in the upper 5 feet of the soil profile in exterior locations should be neglected due to frost effects.
7. Some horizontal movement of the foundation must occur to mobilize passive resistance.
8. Use of the granular fill values for passive resistance requires that the granular soils adjacent to the footing extend beyond the limits of 60° with respect to vertical from the base of foundation.

4.3.2 Spread Footing Foundation Construction Considerations

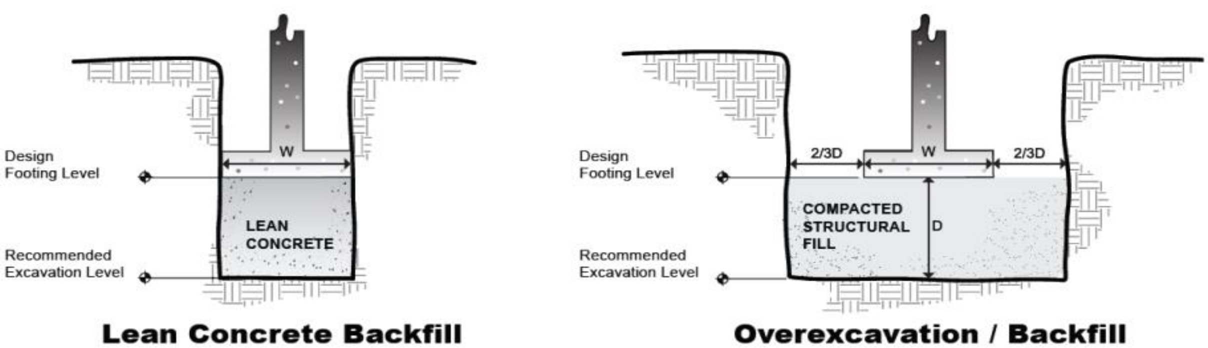
Where unsuitable bearing soils are encountered in footing excavations, the excavations could be extended deeper to suitable soils, and the footings could bear directly on suitable soils at the lower level or on lean concrete backfill placed in the excavations from suitable soils back to the design footing level.

The bearing soils should be observed and tested by Terracon personnel and prepared in accordance with the recommendations in this report. Deepened foundation excavations through existing fill should extend to suitable native soils. It is possible that the initial native soils encountered in some areas might contain organic material or exhibit relatively low strength. Where low strength native clay soils exhibiting estimated unconfined compressive strengths of 2,000 psf or less are encountered within 2 feet of the design footing level, the overexcavations should be continued to the following depths below the design footing level that are equal to at least:

- 100% of the width of continuous footings;
- 50% of the width of isolated column footings; or
- 2 feet, whichever is greatest

The overexcavations could be ended at the above mentioned depths if low strength native soils are still present at these depths.

Overexcavation for compacted structural fill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing base elevation. The overexcavation should then be backfilled up to the footing base elevation with well-graded granular material (e.g., approved granular materials containing less than 10% passing the No. 200 sieve) placed and compacted as recommended in section **4.2.3 Compaction Requirements** of this report. Lean concrete could be used to backfill the foundation



NOTE: Excavations in sketches shown vertical for convenience. Excavations should be sloped as necessary for safety.

overexcavations if low strength soils are still present at the maximum overexcavation depths listed above, and widening of the footing excavations would still be required. The overexcavation and backfill procedure is illustrated in the adjacent figure.

The base of all foundation excavations should be free of water and loose soil prior to placing structural fill or concrete. Structural fill should be placed soon after excavating to reduce bearing soil disturbance, and concrete should be placed soon after completion of the structural fill placement. Should the materials at bearing level become excessively dry, disturbed or saturated, or frozen, the affected material should be removed and structural fill should be properly placed prior to placing concrete.

Care should be taken during excavation and construction of footings to minimize disturbance to bearing soils. Lean concrete mud-mats or a layer of compacted crushed aggregate could be placed over bearing soils to reduce disturbance to foundation soils during construction. Concrete should be placed soon after excavating to reduce bearing soil disturbance.

4.4 Floor Slabs

4.4.1 Floor Slab Design Recommendations

Item	Description
Floor slab support [1, 2]	Prepared according to section **4.2 Earthwork**.
Aggregate base course [3]	At least 4 inches of free draining granular material
Modulus of subgrade reaction (for point load conditions)	150 pounds per square inch per inch (psi/in) where at least 4 inches of aggregate base are present below the floor slab

1. Floor slabs and foundations support substantially different loads so foundations and floors often settle differently. The design should consider the potential for differential settlement of walls and floors.
2. We recommend subgrades be maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become desiccated prior to construction of floor slabs, the affected material should be removed or the materials scarified, moistened, and recompacted. Upon completion of grading operations in the building areas, care should be taken to maintain the recommended subgrade moisture content and density prior to construction of the building floor slabs.
3. The floor slab design should include a capillary break, comprised of free-draining, compacted, granular material containing less than 5% passing the U.S. No. 200 sieve.

Where appropriate, saw-cut control joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations refer to the ACI Design Manual.

The use of a vapor retarder should be considered beneath concrete slabs on grade that will be covered with moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer and slab contractor should refer to ACI 302 and ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

4.4.2 Floor Slab and Exterior Slab Construction Considerations

Refer to section **4.2.8 Frost Considerations** if provisions to reduce potential movements of exterior slabs is necessary.

On most project sites, the site grading is generally accomplished early in the construction phase. However as construction proceeds, the subgrade may be disturbed due to utility excavations, construction traffic, desiccation, rainfall, etc. As a result, the floor slab subgrade may not be suitable for placement of base rock and concrete and corrective action may be required.

We recommend the area underlying the floor slab be rough graded and then thoroughly proofrolled prior to final grading and placement of base rock, if the areas are accessible to this type of equipment. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the affected material with properly compacted fill. All floor slab subgrade areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to placement of the base rock and concrete.

4.5 Pavements

4.5.1 Pavement Subgrade Preparation

Similar to conditions discussed in section **4.4.2 Floor Slab and Exterior Slab Construction Considerations**, subgrade disturbances and surface irregularities often develop in the initially prepared pavement subgrades as construction proceeds. As a result, the pavement subgrades should be carefully evaluated as the time for pavement construction approaches.

Prior to placement of pavement materials, we recommend the moisture content and density of the top 12 inches of the subgrade be adjusted to recommended levels. This is also an appropriate time for repairing deep subgrade deficiencies. Areas not in compliance with the required ranges of moisture or density should be moisture conditioned and recompacted.

Proofrolling and repair of subgrade deficiencies should be performed within two days prior to commencement of actual paving operations. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted fills. If a significant precipitation event occurs after the evaluation or if the surface becomes disturbed, the subgrade should be reviewed by qualified personnel immediately prior to paving. The subgrade should be in its finished form at the time of the final review.

4.5.2 Pavement Design Considerations

Pavement thickness can be determined in general accordance with the Minnesota Department of Transportation (MnDOT), which generally follows AASHTO (1993) guidelines, Asphalt Institute and/or other methods if specific wheel loads, axle configurations, frequencies, and desired pavement life are provided. The following references were utilized to formulate recommended pavement sections for the proposed facility:

- American Concrete Institute (ACI) <u>ACI 330R-08 – Guide for the Design and Construction of Concrete Parking Lots</u>; and
- Minnesota Asphalt Paving Association (MAPA).

Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

- Final grade adjacent to parking lots and drives should slope down from pavement edges at a minimum 2%;
- The subgrade and the pavement surface should have a minimum ¼-inch per foot slope to promote proper surface drainage;
- Install pavement subsurface drainage surrounding areas anticipated for frequent wetting (e.g., intake structures, wash racks);
- Install joint sealant and seal cracks immediately; and
- Seal all landscaped areas in, or adjacent to pavements to reduce moisture migration to subgrade soils.

4.5.3 Pavement Design Recommendations

Opinions of pavement thicknesses are based on the subsurface conditions encountered at the borings, general characterization of the subgrade, our experience on similar projects, and consider that the subgrade is proofrolled, tested, and evaluated as recommended in this report. Testing such as CBR, resilient modulus, etc. was not part of our scope of service for this project to evaluate the support characteristics of the subgrade; however, these can be performed upon request. The thickness of pavements for these scenarios should be in accordance with local city or county ordinances.

Thickness recommendations for ***Standard Duty*** sections based on primarily light passenger vehicle (gross weight less than 4 tons) traffic, and the occasional truck traffic are according to ACI Traffic Category A. As part of the layout design of the project we recommend the designer use signs and preventive structures to restrict heavy truck traffic from entering these areas.

The following tables summarizes the estimated minimum portland cement concrete (PCC) and asphaltic cement concrete (ACC) pavement thicknesses for the anticipated traffic conditions for the facility. A schematic of these sections is provided in Appendix D. These sections are based on the subsurface conditions encountered at the borings and our experience on similar projects, and consider that all materials are placed on a subgrade prepared and evaluated as recommended in this report.

Pavement Area	PCC over Granular Base (inches) [1, 2, 3]	ACC over Granular Base (inches) [1, 2, 4]
Parking stalls (for automobiles and light vehicles)	5 over 4	4 over 6
Standard Duty	6 over 4	5 over 8
Refuse collection pads, service/delivery areas and facility entrance aprons [5]	7 over 4	Not recommended

Pavement Area	PCC over Granular Base (inches) [1, 2, 3]	ACC over Granular Base (inches) [1, 2, 4]

1. Pavement materials, mix design, and construction should conform to the current Minnesota Department of Transportation (MnDOT) Standard Specifications for Construction.
2. The granular base course materials should be placed on a stable subgrade and compacted to at least 98 percent of the material's standard Proctor maximum dry density. Considers the subgrade is sloped to promote drainage and is prepared in accordance with section **4.2 Earthwork**.
3. PCC pavement concrete should have a 28 day compressive strength of at least 4,000 psi.
4. A minimum surface course thickness of 2 inches is recommended with ACC pavements.
5. Trash container pads and slabs at main entrances and exits should be at least 7 inches PCC, and the trash container pads should be large enough to support the container and the tipping axle of the collection truck, and turning maneuvers of heavy vehicles.

Thicker pavement sections could be used to reduce maintenance and extend the expected service life of the pavements.

We recommend using PCC pavements in areas of anticipated concentrated loads (e.g., loading docks) and areas with repeated turning or maneuvering of trucks (e.g., entrance aprons). We also recommend PCC pavement sections include sufficient reinforcing steel and dowels at joints to resist potential flexure and to provide load transfer across transverse joints and to reduce differential movement between pavement slabs.

Construction traffic on the pavements was not considered in developing the recommended minimum pavement thicknesses. If the pavements will be subject to traffic by construction equipment/vehicles, the pavement thicknesses should be revised to consider the effects of the additional traffic loading.
PCC pavements require properly designed and constructed longitudinal joints (parallel to traffic) and transverse joints (perpendicular to traffic) to provide satisfactory performance.

Pavements should be sloped to provide rapid drainage of surface water. Water should not be allowed to pond on or adjacent to the pavements. Ponding of water adjacent to the pavements could contribute to significant moisture increases in the subgrade soils and subsequent loss of strength and/or possible heaving leading to premature pavement deterioration.

4.5.4 Pavement Drainage

Subsurface drainage systems (i.e., a permeable base and subdrains) below pavement areas generally prolong the life of a pavement and help to prevent infiltrated surface water from becoming trapped below pavements. Saturation of the pavement subgrade could result in a reduction of subgrade strength (rutting) and/or possible heaving. The use of a granular base will also reduce the potential for frost action.

As described in the previous section, subsurface drainage systems should be considered for any potential low elevation or poorly drained areas, and in vicinity of any landscaping systems with sprinklers. The pavement subgrade should slope toward the subdrain lines.

Typical components for pavement subsurface drainage design are provided in the table below.

Item	Description
Pavement aggregate base	A minimum of 4 inches of material meeting the specifications for MnDOT base aggregate.
Subdrain pipe	■ Minimum 4-inch diameter ■ Pipe perforations should be appropriately sized to prevent free-draining granular material from entering the subdrain pipe ■ Pipe invert should be at least 5 feet below proposed grade ■ Subdrain lines should be sloped to provide positive gravity drainage to a reliable discharge point ■ Embedded in at least 4 inches of trench backfill material
Subdrain trench backfill [1]	■ Free-draining granular material encapsulated with non-woven geotextile filter fabric (Contech C60NW or equivalent)

1. The subdrain trench backfill should extend up to and be hydraulically connected to the recommended aggregate base layer below the pavements.

4.5.5 Pavement Maintenance

The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore preventive maintenance should be planned and provided for through an on-going pavement management program. Preventive maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment. Preventive maintenance consists of both localized maintenance (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Preventive maintenance is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements. Prior to implementing any maintenance, additional engineering observation is recommended to determine the type and extent of preventive maintenance. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction, subgrade preparation, and other earth-related construction phases of the project.

Support of foundations, floor slabs and pavements on or above existing fill soils is discussed in this report. However, even with the recommended construction testing services, there is an inherent risk for the owner that compressible fill or unsuitable material within or buried by the fill will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill but can be reduced by performing additional testing and evaluation.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The geotechnical scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A
FIELD EXPLORATION

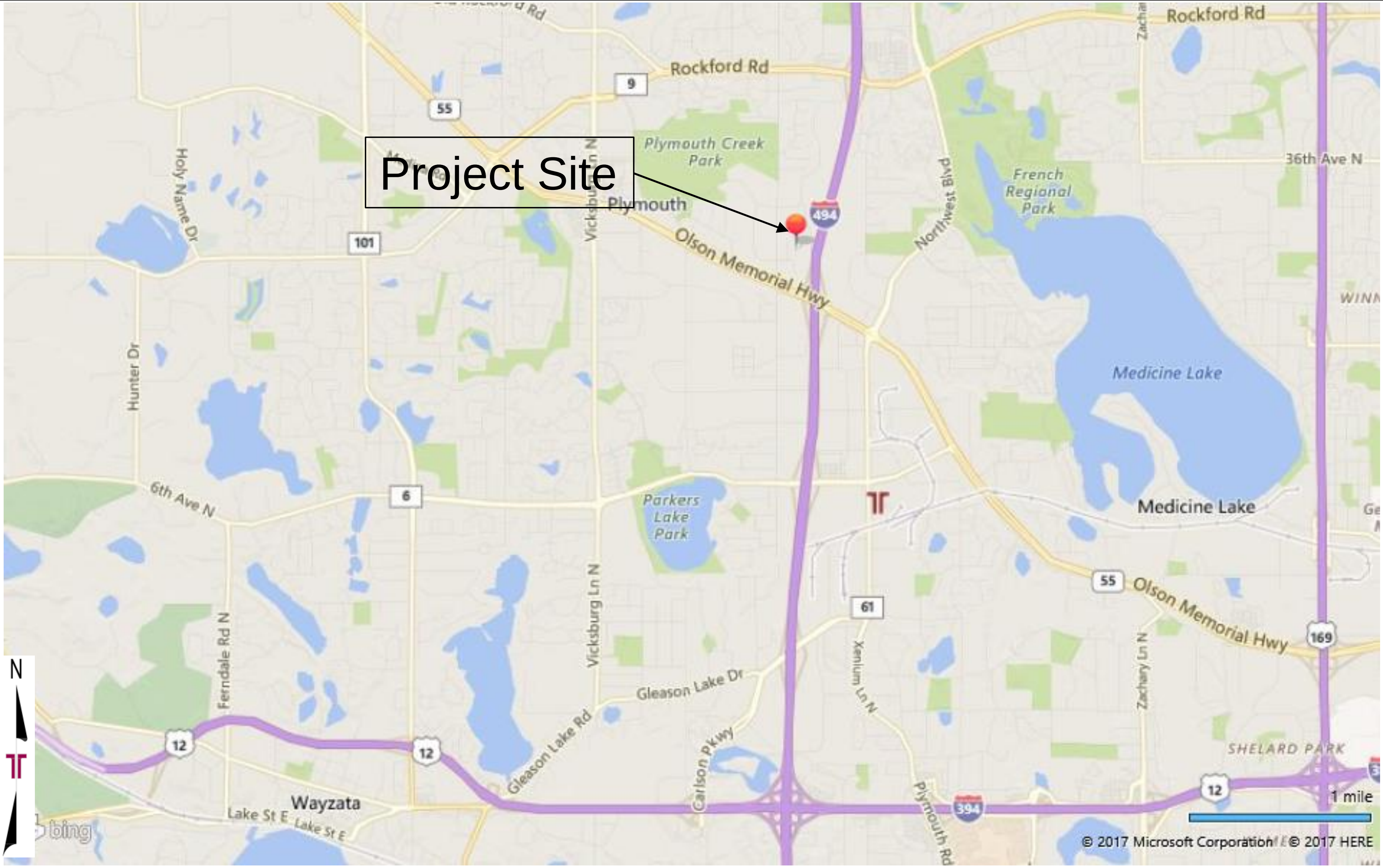


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager: BWL	Project No. MP175002	Terracon Consulting Engineers & Scientists	SITE VICINITY MAP
Drawn by: BWL	Scale: N.T.S		Home2 Hotel Empire Lane Plymouth, Minnesota
Checked by: BEB	File Name: MP175002-A	13400 15th Avenue NE Minneapolis, Minnesota 55441	
Approved by: BEB	Date: February 2017	PH. [763] 489-3100 FAX. [763] 489-3101	

Exhibit

A-1

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager: BWL	Project No. MP175002	Terracon Consulting Engineers & Scientists	BORING LOCATION PLAN
Drawn by: BWL	Scale: N.T.S	13400 15th Avenue NE Minneapolis, Minnesota 55441	Home2 Hotel Empire Lane Plymouth, Minnesota
Checked by: BEB	File Name: MP175002-A	PH. [763] 489-3100 FAX. [763] 489-3101	Exhibit
Approved by: BEB	Date: February 217		A-2

Field Exploration Description

A Boring Location Plan indicating the approximate boring locations is included as Exhibit A-2. The borings were staked by Terracon personnel using a handheld GPS unit at approximate structure locations transposed from site diagrams provided. The as-drilled boring locations were recorded by field personnel using a handheld GPS unit, and these coordinates are provided on each boring log. The ground surface elevations were interpreted from LIDAR maps of the area. The ground surface elevations indicated on the logs are approximate and have been rounded to the nearest foot. Locations and elevations of the borings are accurate only to the degree implied by the means and methods used to define them.

The borings were drilled with a track-mounted rotary drill rig using continuous flight hollow-stem augers to advance the boreholes. Samples were obtained using split-barrel sampling procedures.

In the split-barrel sampling procedure, a standard 2-inch (outside diameter) split-barrel sampling spoon is driven into the ground with an automatic 140-pound hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the standard penetration resistance value (N). These “N” values are indicated on the boring logs at the depths of occurrence. The samples were sealed and transported to the laboratory for testing and classification.

The drill crew prepared a field log of each boring. The field logs included visual classifications of the materials encountered during drilling as well as the driller’s interpretation of the subsurface conditions between samples. The boring logs included as Exhibit A-4 represent our interpretation of the subsurface conditions at the boring locations based on field and laboratory data and observation of the samples.

BORING LOG NO. 1

PROJECT: Home2 Hotel

CLIENT: Plymouth Hotel Group, LLC
Eden Prairie, Minnesota

SITE: Empire Lane
Plymouth, Minnesota

LOCATION See Exhibit A-2

Latitude: 4

Parking lot is ~963 ft MSL

~GW below surface = 22 ft

GW at ~941 ft MSL

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.3	App									
	1.0	**FIL**									
		FIL				X	9-18-13 N=31		11		
						X	5-9-12 N=21		4		
	6.5		958.5+/-	5							
		SANDY LEAN CLAY (CL), trace gravel, brown, stiff				X	2-4-6 N=10		21		
				10		X	3-5-7 N=12		21		
				15		X	4-7-8 N=15		18		
	19.0		946+/-								
		SILTY SAND (SM), with gravel, brown, dense		20		X	6-5-9 N=14		6		
					dry cave in at 22'						
				25		X	9-21-26 N=47		4		
						grab			2		
	30.0		935+/-	30							
		Boring Terminated at 30 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-30': Hollow-stem auger

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from LIDAR Maps

Notes:

WATER LEVEL OBSERVATIONS
No free water observed
dry cave in at 22'

Terracon
13400 15th Ave N
Plymouth, MN

Boring Started: 1/27/2017	Boring Completed: 1/27/2017
Drill Rig: 825	Driller: BB
Project No.: MP175002	Exhibit: A-4

BORING LOG NO. 2

PROJECT: Home2 Hotel

CLIENT: Plymouth Hotel Group, LLC
Eden Prairie, Minnesota

SITE: Empire Lane
Plymouth, Minnesota

LOCATION See Exhibit A-2

Latitude: 45.0146° Longitude: -93.4587°

Approximate Surface Elev: 965 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	Approx. 4" Asphalt	964.5+/-								
2.5	**FILL - SANDY LEAN CLAY**, dark gray	962.5+/-				15-17-14 N=31		7		
6.5	**FILL - SILTY SAND**, with gravel and cobbles, brown	958.5+/-	5			5-17-17 N=34		6		
18.5	**SANDY LEAN CLAY (CL)**, trace gravel, brown, stiff	946.5+/-	10			4-6-8 N=14		22		
							3350	19	102	45-16-29
			15			3-5-7 N=12		18		
30.0	**SILTY SAND (SM)**, with gravel, brown, medium dense to dense	935+/-	20			4-9-15 N=24		3		
			25			8-16-24 N=40		3		
			30			6-50/3"		3		
	Boring Terminated at 30 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-30': Hollow-stem auger

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from LIDAR Maps

Notes:

WATER LEVEL OBSERVATIONS
No free water observed
dry cave in at 21.5'

Terracon
13400 15th Ave N
Plymouth, MN

Boring Started: 1/26/2017	Boring Completed: 1/26/2017
Drill Rig: 825	Driller: BB
Project No.: MP175002	Exhibit: A-4

BORING LOG NO. 3

PROJECT: Home2 Hotel

CLIENT: Plymouth Hotel Group, LLC
Eden Prairie, Minnesota

SITE: Empire Lane
Plymouth, Minnesota

LOCATION See Exhibit A-2

Latitude: 45.0144° Longitude: -93.459°

Approximate Surface Elev: 965 (Ft.) +/-

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	Approx. 4" Asphalt	964.5+/-								
1.0	**FILL - CLAYEY SAND**, gray	964+/-								
	FILL - SILTY SAND, with gravel and cobbles, dark brown				X	7-6-5 N=11		18		
					X	2-1-1 N=2		17		
			5							
					X	6-5-11 N=16		13		
9.0	**SANDY LEAN CLAY (CL)**, trace gravel, gray-brown, stiff	956+/-			X	5-5-8 N=13		22		
			10							
					Shelby tube		2460	23	106	
			15							
					X	5-6-8 N=14		15		
			20							
				dry cave in at 22'						
24.0	**CLAYEY SAND (SC)**, with gravel, brown, medium dense	941+/-			X	8-6-11 N=17		13		
25.0	**SILTY SAND (SM)**, trace gravel, brown, dense	940+/-	25							
30.0		935+/-	30		X	7-11-23 N=34		3		
	Boring Terminated at 30 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-30': Hollow-stem auger

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from LIDAR Maps

Notes:

WATER LEVEL OBSERVATIONS
No free water observed
dry cave in at 22'

Terracon
13400 15th Ave N
Plymouth, MN

Boring Started: 1/26/2017	Boring Completed: 1/26/2017
Drill Rig: 825	Driller: BB
Project No.: MP175002	Exhibit: A-4

BORING LOG NO. 4

PROJECT: Home2 Hotel

CLIENT: Plymouth Hotel Group, LLC
Eden Prairie, Minnesota

SITE: Empire Lane
Plymouth, Minnesota

LOCATION See Exhibit A-2

Latitude: 45.0143° Longitude: -93.4592°

Approximate Surface Elev: 965 (Ft.) +/-

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	Approx. 4" Asphalt	964.5+/-								
1.0	**FILL - SANDY LEAN CLAY**, gray	964+/-								
	FILL - SANDY LEAN CLAY, with gravel and cobbles, dark brown				X	14-24-20 N=44		17		
					X	4-6-26 N=32		16		
6.5		958.5+/-	5							
	FILL - SILTY SAND, with gravel, brown				X	16-20-16 N=36		5		
9.0		956+/-								
	SANDY LEAN CLAY (CL), trace gravel, gray-brown, stiff				X	12-6-7 N=13		24		
			10							
					X	4-4-6 N=10		19		
18.5		946.5+/-	15							
	CLAYEY SAND (SC), with gravel, brown, medium dense				X	5-9-10 N=19		11		
20.0		945+/-	20							
	SILTY SAND (SM), trace gravel, brown, medium dense to dense			dry cave in	X	7-13-21 N=34		3		
			25							
					X	5-10-10 N=20		2		
30.0		935+/-	30							
	Boring Terminated at 30 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-30': Hollow-stem auger

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from LIDAR Maps

Notes:

WATER LEVEL OBSERVATIONS
No free water observed

dry cave in at 24.5'

Terracon
13400 15th Ave N
Plymouth, MN

Boring Started: 1/25/2017	Boring Completed: 1/25/2017
Drill Rig: 825	Driller: BB
Project No.: MP175002	Exhibit: A-4

BORING LOG NO. 5

PROJECT: Home2 Hotel

CLIENT: Plymouth Hotel Group, LLC
Eden Prairie, Minnesota

SITE: Empire Lane
Plymouth, Minnesota

LOCATION See Exhibit A-2

Latitude: 45.0144° Longitude: -93.4587°

Approximate Surface Elev: 965 (Ft.) +/-

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	Approx. 4" Asphalt	964.5+/-								
1.0	**FILL - SANDY LEAN CLAY**, gray-brown	964+/-								
	FILL - SILTY SAND, with gravel, brown				X	12-17-15 N=32		9		
					X	8-12-14 N=26		7		
6.5		958.5+/-	5							
	SANDY LEAN CLAY (CL), trace gravel, gray-brown, stiff to very stiff				X	3-5-7 N=12		23		
					X	9-12-14 N=26		18		
			10							
					X	3-6-7 N=13		17		
18.5		946.5+/-	15							
	SILTY SAND (SM), trace gravel, brown, dense to very dense				X	8-35-32 N=67		2		
			20	dry cave in at 20.5'						
					X	9-15-23 N=38		4		
			25							
30.0		935+/-	30		X	9-18-26 N=44		4		
	Boring Terminated at 30 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-30': Hollow-stem auger

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from LIDAR Maps

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

dry cave in at 20.5'

Terracon
13400 15th Ave N
Plymouth, MN

Boring Started: 1/27/2017	Boring Completed: 1/27/2017
Drill Rig: 825	Driller: BB
Project No.: MP175002	Exhibit: A-4

BORING LOG NO. 6

PROJECT: Home2 Hotel

CLIENT: Plymouth Hotel Group, LLC
Eden Prairie, Minnesota

SITE: Empire Lane
Plymouth, Minnesota

LOCATION See Exhibit A-2

Latitude: 45.0144° Longitude: -93.4599°

Approximate Surface Elev: 965 (Ft.) +/-

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	Approx. 4" Asphalt	964.5+/-								
	FILL - SILTY SAND, with gravel, brown				X	15-12-9 N=21		5		
3.5		961.5+/-								
	SANDY LEAN CLAY (CL), trace gravel, gray-brown, stiff to very stiff				X	4-3-3 N=6		22		
			5							
					X	3-4-5 N=9		22		
					X	3-5-6 N=11				
			10							
				dry cave in at 11.5'						
					X	3-4-5 N=9		18		
15.0		950+/-	15							
	Boring Terminated at 15 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-15': Hollow-stem auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from LIDAR Maps

Notes:

WATER LEVEL OBSERVATIONS
No free water observed

dry cave in at 11.5'

Terracon
13400 15th Ave N
Plymouth, MN

Boring Started: 1/25/2017	Boring Completed: 1/25/2017
Drill Rig: 825	Driller: BB
Project No.: MP175002	Exhibit: A-4

BORING LOG NO. 7

PROJECT: Home2 Hotel

CLIENT: Plymouth Hotel Group, LLC
Eden Prairie, Minnesota

SITE: Empire Lane
Plymouth, Minnesota

LOCATION See Exhibit A-2

Latitude: 45.0143° Longitude: -93.4586°

Approximate Surface Elev: 965 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	Approx. 4" Asphalt	964.5+/-								
	FILL - SANDY LEAN CLAY, trace gravel, dark brown				Split spoon	9-15-8 N=23		14		
3.5		961.5+/-								
	SANDY LEAN CLAY (CL), trace gravel, brown, stiff to very stiff				Split spoon	3-3-4 N=7		21		
			5		Shelby tube		4490	22	105	43-17-26
					Split spoon	8-5-6 N=11		18		
			10	dry cave in at 12.5'						
15.0		950+/-	15		Split spoon	3-5-8 N=13		19		

Boring Terminated at 15 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-15': Hollow-stem auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from LIDAR Maps

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

dry cave in at 12.5'

Terracon
13400 15th Ave N
Plymouth, MN

Boring Started: 1/25/2017	Boring Completed: 1/25/2017
Drill Rig: 825	Driller: BB
Project No.: MP175002	Exhibit: A-4

BORING LOG NO. 8

PROJECT: Home2 Hotel

CLIENT: Plymouth Hotel Group, LLC
Eden Prairie, Minnesota

SITE: Empire Lane
Plymouth, Minnesota

LOCATION See Exhibit A-2

Latitude: 45.0146° Longitude: -93.4581°

Approximate Surface Elev: 965 (Ft.) +/-

GRAPHIC LOG	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	Approx. 6" Topsoil **FILL - CLAYEY SAND**, trace gravel, dark brown			X	3-2-2 N=4		22		
				X	2-9-10 N=19		18		
	4.5 — 960.5+/-								
	SANDY LEAN CLAY (CL), trace gravel, brown, stiff to very stiff	5							
				X	11-10-5 N=15		23		
		10		X	5-25-6 N=31				
			(dry cave in at 13')						
				X	3-3-6 N=9		18		
	15.0 — 950+/-	15							
	Boring Terminated at 15 Feet								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-15': Hollow-stem auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from LIDAR Maps

Notes:

WATER LEVEL OBSERVATIONS
No free water observed
dry cave in at 13'

Terracon
13400 15th Ave N
Plymouth, MN

Boring Started: 1/25/2017	Boring Completed: 1/25/2017
Drill Rig: 825	Driller: BB
Project No.: MP175002	Exhibit: A-4

BORING LOG NO. 9

PROJECT: Home2 Hotel

CLIENT: Plymouth Hotel Group, LLC
Eden Prairie, Minnesota

SITE: Empire Lane
Plymouth, Minnesota

LOCATION See Exhibit A-2

Latitude: 45.0151° Longitude: -93.458°

Approximate Surface Elev: 965 (Ft.) +/-

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	Approx. 3" Topsoil **FILL - CLAYEY SAND**, trace gravel, dark brown				Split spoon	3-3-3 N=6		14		
3.3		961.5+/-								
	FILL - SILTY SAND, with gravel, brown				Split spoon	3-3-5 N=8		16		
6.5		958.5+/-	5							
	SANDY LEAN CLAY (CL), trace gravel, brown, medium stiff				Split spoon	2-2-4 N=6		21		
					Split spoon	2-3-4 N=7		24		
			10	Cave in						
					Hand sample			22		
15.0		950+/-	15							
	Boring Terminated at 15 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-15': Hollow-stem auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from LIDAR Maps

Notes:

WATER LEVEL OBSERVATIONS
No free water observed

dry cave in at 13'

Terracon
13400 15th Ave N
Plymouth, MN

Boring Started: 1/25/2017	Boring Completed: 1/25/2017
Drill Rig: 825	Driller: BB
Project No.: MP175002	Exhibit: A-4

APPENDIX B
LABORATORY TESTS

Laboratory Test Summary

Samples obtained during the field program were visually classified in the laboratory by a geotechnical engineer. A testing program was conducted on selected samples, as directed by the geotechnical engineer, to aid in classification and evaluation of engineering properties required for analyses.

The lab tests listed below were performed on samples from the project site.

- ASTM D2216 – "Moisture Content"
- ASTM D4318 – "Atterberg Limits"
- ASTM D 7263 – "Unit Weight"
- ASTM D 2166 – "Unconfined Compression"

Results of the laboratory tests are presented on the boring logs located in Appendix A. Laboratory test results were used to classify the soils encountered as generally outlined by the Unified Soil Classification System.

The samples were classified in the laboratory based on visual observation, texture and plasticity (ASTM D2487 and ASTM D2488), and the laboratory testing described above. The descriptions of the soils indicated on the boring log are in general accordance with the General Notes in Appendix C and the Unified Soil Classification System (USCS), both summarized and included as Exhibits C-1 and C-2 in Appendix C.

Procedural standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

Samples will be stored for a period of 30 days subsequent to submittal of this report and will be discarded after this period, unless we are notified otherwise.

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Auger	Split Spoon
Shelby Tube	Macro Core
Ring Sampler	Rock Core
Grab Sample	No Recovery

WATER LEVEL

- Water Initially Encountered
- Water Level After a Specified Period of Time
- Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance. Includes gravels, sands and silts.			**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, psf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

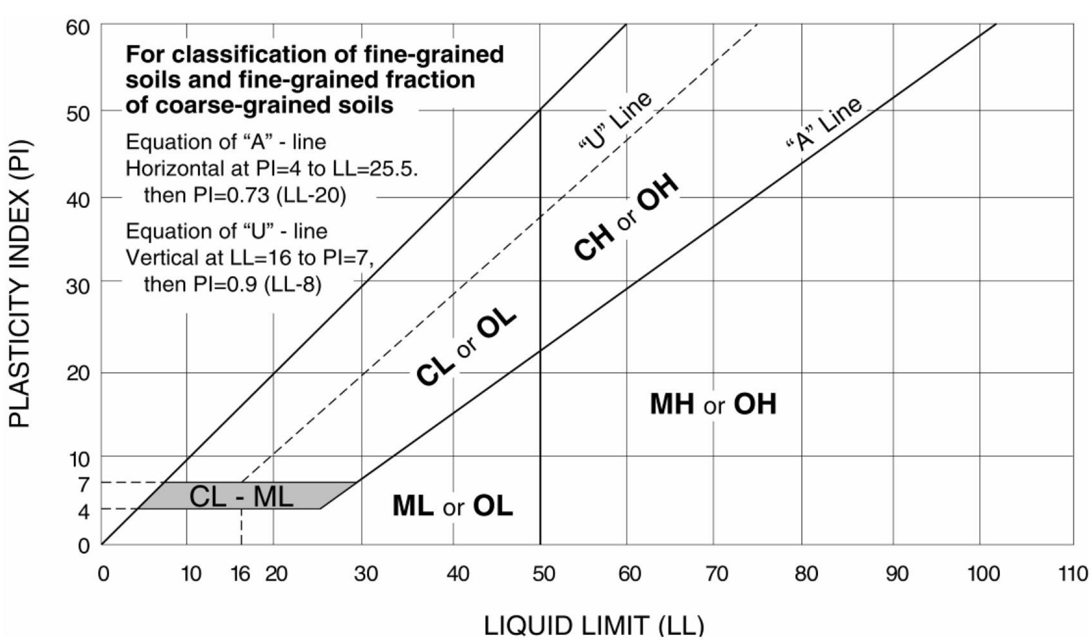
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



Terracon

Attachment C: Planning Level Cost Estimates

PREPARED BY: BARR ENGINEERING COMPANY

	SHEET:	1	OF	1
	CREATED BY:	XF2	DATE:	9/23/2024
	CHECKED BY:	JAK2	DATE:	9/23/2024
	APPROVED BY:		DATE:	
ISSUED:			DATE:	
ISSUED:			DATE:	
ISSUED:			DATE:	

ENGINEER'S OPINION OF PROBABLE PROJECT COST

PROJECT: Plymouth CIP Planning Assistance

LOCATION: City of Plymouth

PROJECT #: 23272078.00

OPINION OF COST - SUMMARY

Engineer's Opinion of Probable Project Cost

Plymouth CIP Planning - Conveyance and Fernbrook Storage - Grading Option 1 (No Roadwork)

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
	Mobilization/Demobilization (10%)	LS	1	$505,613.73	$505,613.73	1,2,3,4,5,6
	Traffic and Pedestrian Safety Control Measures (5%)	LS	1	$240,768.44	$240,768.44	1,2,3,4,5,6
	Construction Layout and Staking (2%)	LS	1	$94,419.00	$94,419.00	1,2,3,4,5,6
	Sediment and Erosion Control (2%)	LS	1	$92,567.64	$92,567.64	1,2,3,4,5,6
	Construction Fencing	LF	7,460	$5.71	$42,584.17	1,2,3,4,5,6
	Clearing and Grubbing Trees/Shrubs less than 12" Diameter	AC	7.2	$15,000.00	$108,000.00	1,2,3,4,5,6
	Removal and Disposal of Tree Stump 12 inch to 24 inch Diameter	EA	20	$350.00	$7,000.00	1,2,3,4,5,6
	Removal and Disposal of Tree 24 inch to 36 inch Diameter	EA	10	$2,805.91	$28,059.07	1,2,3,4,5,6
	Remove Storm Sewer	LF	3,123	$35.00	$109,305.00	1,2,3,4,5,6
	Remove Storm Structures	EA	10	$1,218.33	$12,183.25	1,2,3,4,5,6
	Sawcut Bituminous Pavement (Full Depth)	LF	0	$6.00	$0.00	1,2,3,4,5,6
	Remove and Dispose Pavement (Bituminous & Concrete)	SY	0	$10.00	$0.00	1,2,3,4,5,6
	Sawcut, Remove and Dispose of Curb & Gutter (P)	LF	0	$8.00	$0.00	1,2,3,4,5,6
	Import Topsoil Borrow and Placement (6")	CY	4,453	$35.10	$156,271.02	1,2,3,4,5,6
	Common Excavation, Haul, & Disposal Offsite (Clean)	CY	67,857	$32.00	$2,171,413.11	1,2,3,4,5,6
	Bituminous Utility Patch Type A (includes subgrade Class V)	SY	0	$125.25	$0.00	1,2,3,4,5,6
	Curb & Gutter (Driveway and Street)	LF	0	$35.00	$0.00	1,2,3,4,5,6
	ADA Pedestrian Ramps	EA	0	$3,500.00	$0.00	1,2,3,4,5,6
	Concrete Walk (P)	SY	0	$118.84	$0.00	1,2,3,4,5,6
	Aggregate Base (CV), Class 5 - Concrete Walk	TON	0	$45.89	$0.00	1,2,3,4,5,6
	24" RCP Pipe Sewer	LF	310	$136.12	$42,195.65	1,2,3,4,5,6
	24" RCP FES	EA	1	$2,195.05	$2,195.05	1,2,3,4,5,6
	24" RCP Trash Rack	EA	0	$1,800.00	$0.00	1,2,3,4,5,6
	27" RCP Pipe Sewer	LF	0	$188.62	$0.00	1,2,3,4,5,6
	27" RCP FES	EA	0	$2,545.51	$0.00	1,2,3,4,5,6
	42" RCP Pipe Sewer	LF	570	$306.25	$174,562.50	1,2,3,4,5,6
	42" RCP FES	EA	1	$3,175.00	$3,175.00	1,2,3,4,5,6
	42" FES Trash Rack	EA	1	$4,862.50	$4,862.50	1,2,3,4,5,6
	48" RCP Pipe Sewer	LF	354	$538.61	$190,667.94	1,2,3,4,5,6
	48" RCP FES	EA	0	$5,704.12	$0.00	1,2,3,4,5,6
	48" FES Trash Rack	EA	0	$4,800.00	$0.00	1,2,3,4,5,6
	54" RCP Pipe Sewer	LF	280	$431.25	$120,750.00	1,2,3,4,5,6
	54" RCP FES	EA	0	$4,350.00	$0.00	1,2,3,4,5,6
	54" FES Trash Rack	EA	0	$7,921.25	$0.00	1,2,3,4,5,6
	72" RCP Pipe Sewer	LF	694	$665.85	$462,099.90	1,2,3,4,5,6
	72" RCP FES	EA	0	$6,000.00	$0.00	1,2,3,4,5,6
	72" FES Trash Rack	EA	0	$11,325.00	$0.00	1,2,3,4,5,6
	72" H x 96" W BOX CULVERT	LF	456	$969.00	$441,864.00	1,2,3,4,5,6
	72" H x 96" W BOX CULVERT FES	EA	1	$8,371.88	$8,371.88	1,2,3,4,5,6
	48" Diameter RC Drainage Structure, Complete	EA	2	$6,500.00	$13,000.00	1,2,3,4,5,6
	60" Diameter RC Drainage Structure, Complete	EA	3	$9,500.00	$28,500.00	1,2,3,4,5,6
	72" Diameter RC Drainage Structure Complete	EA	3	$20,034.06	$60,102.19	1,2,3,4,5,6
	96" Diameter RC Drainage Structure Complete	EA	0	$32,643.75	$0.00	1,2,3,4,5,6
	108" Diameter RC Drainage Structure Complete	EA	0	$49,218.75	$0.00	1,2,3,4,5,6
	120" Diameter RC Drainage Structuren Complete	EA	3	$58,200.00	$174,600.00	1,2,3,4,5,6
	Native Restoration including ECB (includes some tree replacement but not pond area)	AC	2	$100,000.00	$152,000.00	1,2,3,4,5,6
	Turf Seeding with HydroMulch (remainder of parcel)	AC	4	$25,000.00	$100,000.00	1,2,3,4,5,6
	Class I Rip Rap	TON	68	$215.00	$14,620.00	1,2,3,4,5,6
	CONSTRUCTION SUBTOTAL				$5,562,000	1,2,3,4,5,6,7,8
	CONSTRUCTION CONTINGENCY (25%)				$0	1,4,8
	ESTIMATED CONSTRUCTION COST				$5,562,000	1,2,3,4,5,6,7,8
	PLANNING, ENGINEERING, & DESIGN (25%)				$0	
	ESTIMATED TOTAL PROJECT COST				**$5,562,000**	1,2,3,4,5,6,7,8
ESTIMATED ACCURACY RANGE		**-30%**			$3,894,000	1,2,3,4,5,6,7,8
		50%			$8,343,000	1,2,3,4,5,6,7,8

Notes

[1] Quantities based on Design Work Completed (1-5%).

[2] Unit Prices Based on Information Available at This Time including recently bid projects.

[3] Limited Soil Boring and Field Investigation Information Available.

[4] This design level (Class 4, 1 - 10% design completion per ASTM E 2516-11) cost estimate is based on concept designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -30% to

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES

+50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[5] Estimate assumes that projects will not be located on contaminated soil.

[6] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following construction.

[7] Furnish and Install pipe cost per linear foot includes all trenching, bedding, backfilling, compaction, and disposal of excess materials

[8] Estimate costs are reported to nearest thousand dollars.

	PREPARED BY: BARR ENGINEERING COMPANY		SHEET:	1	OF	1
			CREATED BY:	XF2	DATE:	9/23/2024
ENGINEER'S OPINION OF PROBABLE PROJECT COST			CHECKED BY:	JAK2	DATE:	9/23/2024
PROJECT:	Plymouth CIP Planning Assistance		APPROVED BY:		DATE:	
LOCATION:	City of Plymouth	ISSUED:			DATE:	
PROJECT #:	23272078.00	ISSUED:			DATE:	
OPINION OF COST - SUMMARY		ISSUED:			DATE:	

Engineer's Opinion of Probable Project Cost

Plymouth CIP Planning - Conveyance and Fernbrook Storage - Grading Option 1

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
	Mobilization/Demobilization (10%)	LS	1	$697,711.67	$697,711.67	1,2,3,4,5,6
	Traffic and Pedestrian Safety Control Measures (5%)	LS	1	$332,243.65	$332,243.65	1,2,3,4,5,6
	Construction Layout and Staking (2%)	LS	1	$130,291.63	$130,291.63	1,2,3,4,5,6
	Sediment and Erosion Control (2%)	LS	1	$127,736.89	$127,736.89	1,2,3,4,5,6
	Construction Fencing	LF	7,460	$5.71	$42,584.17	1,2,3,4,5,6
	Clearing and Grubbing Trees/Shrubs less than 12" Diameter	AC	7.2	$15,000.00	$108,000.00	1,2,3,4,5,6
	Removal and Disposal of Tree Stump 12 inch to 24 inch Diameter	EA	20	$350.00	$7,000.00	1,2,3,4,5,6
	Removal and Disposal of Tree 24 inch to 36 inch Diameter	EA	10	$2,805.91	$28,059.07	1,2,3,4,5,6
	Remove Storm Sewer	LF	3,123	$35.00	$109,305.00	1,2,3,4,5,6
	Remove Storm Structures	EA	10	$1,218.33	$12,183.25	1,2,3,4,5,6
	Sawcut Bituminous Pavement (Full Depth)	LF	5,328	$6.00	$31,968.00	1,2,3,4,5,6
	Remove and Dispose Pavement (Bituminous & Concrete)	SY	6,940	$10.00	$69,400.00	1,2,3,4,5,6
	Sawcut, Remove and Dispose of Curb & Gutter (P)	LF	2,315	$8.00	$18,520.00	1,2,3,4,5,6
	Import Topsoil Borrow and Placement (6")	CY	4,453	$35.10	$156,271.02	1,2,3,4,5,6
	Common Excavation, Haul, & Disposal Offsite (Clean)	CY	67,857	$32.00	$2,171,413.11	1,2,3,4,5,6
	Bituminous Utility Patch Type A (includes subgrade Class V)	SY	6,940	$125.25	$869,235.00	1,2,3,4,5,6
	Curb & Gutter (Driveway and Street)	LF	2,315	$35.00	$81,025.00	1,2,3,4,5,6
	ADA Pedestrian Ramps	EA	4	$3,500.00	$14,000.00	1,2,3,4,5,6
	Concrete Walk (P)	SY	5,144	$118.84	$611,348.63	1,2,3,4,5,6
	Aggregate Base (CV), Class 5 - Concrete Walk	TON	1,372	$45.89	$62,965.65	1,2,3,4,5,6
	24" RCP Pipe Sewer	LF	310	$136.12	$42,195.65	1,2,3,4,5,6
	24" RCP FES	EA	1	$2,195.05	$2,195.05	1,2,3,4,5,6
	24" RCP Trash Rack	EA	0	$1,800.00	$0.00	1,2,3,4,5,6
	27" RCP Pipe Sewer	LF	0	$188.62	$0.00	1,2,3,4,5,6
	27" RCP FES	EA	0	$2,545.51	$0.00	1,2,3,4,5,6
	42" RCP Pipe Sewer	LF	570	$306.25	$174,562.50	1,2,3,4,5,6
	42" RCP FES	EA	1	$3,175.00	$3,175.00	1,2,3,4,5,6
	42" FES Trash Rack	EA	1	$4,862.50	$4,862.50	1,2,3,4,5,6
	48" RCP Pipe Sewer	LF	354	$538.61	$190,667.94	1,2,3,4,5,6
	48" RCP FES	EA	0	$5,704.12	$0.00	1,2,3,4,5,6
	48" FES Trash Rack	EA	0	$4,800.00	$0.00	1,2,3,4,5,6
	54" RCP Pipe Sewer	LF	280	$431.25	$120,750.00	1,2,3,4,5,6
	54" RCP FES	EA	0	$4,350.00	$0.00	1,2,3,4,5,6
	54" FES Trash Rack	EA	0	$7,921.25	$0.00	1,2,3,4,5,6
	72" RCP Pipe Sewer	LF	694	$665.85	$462,099.90	1,2,3,4,5,6
	72" RCP FES	EA	0	$6,000.00	$0.00	1,2,3,4,5,6
	72" FES Trash Rack	EA	0	$11,325.00	$0.00	1,2,3,4,5,6
	72" H x 96" W BOX CULVERT	LF	456	$969.00	$441,864.00	1,2,3,4,5,6
	72" H x 96" W BOX CULVERT FES	EA	1	$8,371.88	$8,371.88	1,2,3,4,5,6
	48" Diameter RC Drainage Structure, Complete	EA	2	$6,500.00	$13,000.00	1,2,3,4,5,6
	60" Diameter RC Drainage Structure, Complete	EA	3	$9,500.00	$28,500.00	1,2,3,4,5,6
	72" Diameter RC Drainage Structure Complete	EA	3	$20,034.06	$60,102.19	1,2,3,4,5,6
	96" Diameter RC Drainage Structure Complete	EA	0	$32,643.75	$0.00	1,2,3,4,5,6
	108" Diameter RC Drainage Structure Complete	EA	0	$49,218.75	$0.00	1,2,3,4,5,6
	120" Diameter RC Drainage Structuren Complete	EA	3	$58,200.00	$174,600.00	1,2,3,4,5,6
	Native Restoration including ECB (includes some tree replacement but not pond area)	AC	2	$100,000.00	$152,000.00	1,2,3,4,5,6
	Turf Seeding with HydroMulch (remainder of parcel)	AC	4	$25,000.00	$100,000.00	1,2,3,4,5,6
	Class I Rip Rap	TON	68	$215.00	$14,620.00	1,2,3,4,5,6
	CONSTRUCTION SUBTOTAL				$7,675,000	1,2,3,4,5,6,7,8
	CONSTRUCTION CONTINGENCY (25%)				$0	1,4,8
	ESTIMATED CONSTRUCTION COST				$7,675,000	1,2,3,4,5,6,7,8
	PLANNING, ENGINEERING, & DESIGN (25%)				$0	
	ESTIMATED TOTAL PROJECT COST				**$7,675,000**	1,2,3,4,5,6,7,8
ESTIMATED ACCURACY RANGE		**-30%**			$5,373,000	1,2,3,4,5,6,7,8
		50%			$11,513,000	1,2,3,4,5,6,7,8

Notes

[1] Quantities based on Design Work Completed (1-5%).

[2] Unit Prices Based on Information Available at This Time including recently bid projects.

[3] Limited Soil Boring and Field Investigation Information Available.

[4] This design level (Class 4, 1 - 10% design completion per ASTM E 2516-11) cost estimate is based on concept designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -30% to

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES

+50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

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[6] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following construction.

[7] Furnish and Install pipe cost per linear foot includes all trenching, bedding, backfilling, compaction, and disposal of excess materials

[8] Estimate costs are reported to nearest thousand dollars.

	PREPARED BY: BARR ENGINEERING COMPANY		SHEET:	1	OF	1
BARR			CREATED BY:	XF2	DATE:	9/23/2024
ENGINEER'S OPINION OF PROBABLE PROJECT COST			CHECKED BY:	JAK2	DATE:	9/23/2024
PROJECT:	Plymouth CIP Planning Assistance		APPROVED BY:		DATE:	
LOCATION:	City of Plymouth	ISSUED:			DATE:	
PROJECT #:	23272078.00	ISSUED:			DATE:	
OPINION OF COST - SUMMARY		ISSUED:			DATE:	

Engineer's Opinion of Probable Project Cost

Plymouth CIP Planning - Conveyance and Fernbrook Storage - Grading Option 2 (No Roadwork)

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
	Mobilization/Demobilization (10%)	LS	1	$506,453.09	$506,453.09	1,2,3,4,5,6
	Traffic and Pedestrian Safety Control Measures (5%)	LS	1	$241,168.14	$241,168.14	1,2,3,4,5,6
	Construction Layout and Staking (2%)	LS	1	$94,575.74	$94,575.74	1,2,3,4,5,6
	Sediment and Erosion Control (2%)	LS	1	$92,721.31	$92,721.31	1,2,3,4,5,6
	Construction Fencing	LF	7,460	$5.71	$42,584.17	1,2,3,4,5,6
	Clearing and Grubbing Trees/Shrubs less than 12" Diameter	AC	7.2	$15,000.00	$108,000.00	1,2,3,4,5,6
	Removal and Disposal of Tree Stump 12 inch to 24 inch Diameter	EA	20	$350.00	$7,000.00	1,2,3,4,5,6
	Removal and Disposal of Tree 24 inch to 36 inch Diameter	EA	10	$2,805.91	$28,059.07	1,2,3,4,5,6
	Remove Storm Sewer	LF	3,123	$35.00	$109,305.00	1,2,3,4,5,6
	Remove Storm Structures	EA	10	$1,218.33	$12,183.25	1,2,3,4,5,6
	Sawcut Bituminous Pavement (Full Depth)	LF	0	$6.00	$0.00	1,2,3,4,5,6
	Remove and Dispose Pavement (Bituminous & Concrete)	SY	0	$10.00	$0.00	1,2,3,4,5,6
	Sawcut, Remove and Dispose of Curb & Gutter (P)	LF	0	$8.00	$0.00	1,2,3,4,5,6
	Import Topsoil Borrow and Placement (6")	CY	4,517	$35.10	$158,535.81	1,2,3,4,5,6
	Common Excavation, Haul, & Disposal Offsite (Clean)	CY	67,776	$32.00	$2,168,831.79	1,2,3,4,5,6
	Bituminous Utility Patch Type A (includes subgrade Class V)	SY	0	$125.25	$0.00	1,2,3,4,5,6
	Curb & Gutter (Driveway and Street)	LF	0	$35.00	$0.00	1,2,3,4,5,6
	ADA Pedestrian Ramps	EA	0	$3,500.00	$0.00	1,2,3,4,5,6
	Concrete Walk (P)	SY	0	$118.84	$0.00	1,2,3,4,5,6
	Aggregate Base (CV), Class 5 - Concrete Walk	TON	0	$45.89	$0.00	1,2,3,4,5,6
	24" RCP Pipe Sewer	LF	310	$136.12	$42,195.65	1,2,3,4,5,6
	24" RCP FES	EA	1	$2,195.05	$2,195.05	1,2,3,4,5,6
	24" RCP Trash Rack	EA	0	$1,800.00	$0.00	1,2,3,4,5,6
	27" RCP Pipe Sewer	LF	0	$188.62	$0.00	1,2,3,4,5,6
	27" RCP FES	EA	0	$2,545.51	$0.00	1,2,3,4,5,6
	42" RCP Pipe Sewer	LF	570	$306.25	$174,562.50	1,2,3,4,5,6
	42" RCP FES	EA	1	$3,175.00	$3,175.00	1,2,3,4,5,6
	42" FES Trash Rack	EA	1	$4,862.50	$4,862.50	1,2,3,4,5,6
	48" RCP Pipe Sewer	LF	354	$538.61	$190,667.94	1,2,3,4,5,6
	48" RCP FES	EA	0	$5,704.12	$0.00	1,2,3,4,5,6
	48" FES Trash Rack	EA	0	$4,800.00	$0.00	1,2,3,4,5,6
	54" RCP Pipe Sewer	LF	280	$431.25	$120,750.00	1,2,3,4,5,6
	54" RCP FES	EA	0	$4,350.00	$0.00	1,2,3,4,5,6
	54" FES Trash Rack	EA	0	$7,921.25	$0.00	1,2,3,4,5,6
	72" RCP Pipe Sewer	LF	694	$665.85	$462,099.90	1,2,3,4,5,6
	72" RCP FES	EA	0	$6,000.00	$0.00	1,2,3,4,5,6
	72" FES Trash Rack	EA	0	$11,325.00	$0.00	1,2,3,4,5,6
	72" H x 96" W BOX CULVERT	LF	456	$969.00	$441,864.00	1,2,3,4,5,6
	72" H x 96" W BOX CULVERT FES	EA	1	$8,371.88	$8,371.88	1,2,3,4,5,6
	48" Diameter RC Drainage Structure, Complete	EA	2	$6,500.00	$13,000.00	1,2,3,4,5,6
	60" Diameter RC Drainage Structure, Complete	EA	3	$9,500.00	$28,500.00	1,2,3,4,5,6
	72" Diameter RC Drainage Structure Complete	EA	3	$20,034.06	$60,102.19	1,2,3,4,5,6
	96" Diameter RC Drainage Structure Complete	EA	0	$32,643.75	$0.00	1,2,3,4,5,6
	108" Diameter RC Drainage Structure Complete	EA	0	$49,218.75	$0.00	1,2,3,4,5,6
	120" Diameter RC Drainage Structuren Complete	EA	3	$58,200.00	$174,600.00	1,2,3,4,5,6
	Native Restoration including ECB (includes some tree replacement but not pond area)	AC	2	$100,000.00	$160,000.00	1,2,3,4,5,6
	Turf Seeding with HydroMulch (remainder of parcel)	AC	4	$25,000.00	$100,000.00	1,2,3,4,5,6
	Class I Rip Rap	TON	68	$215.00	$14,620.00	1,2,3,4,5,6
	CONSTRUCTION SUBTOTAL				$5,571,000	1,2,3,4,5,6,7,8
	CONSTRUCTION CONTINGENCY (25%)				$0	1,4,8
	ESTIMATED CONSTRUCTION COST				$5,571,000	1,2,3,4,5,6,7,8
	PLANNING, ENGINEERING, & DESIGN (25%)				$0	
	ESTIMATED TOTAL PROJECT COST				**$5,571,000**	1,2,3,4,5,6,7,8
ESTIMATED ACCURACY RANGE		**-30%**			$3,900,000	1,2,3,4,5,6,7,8
		50%			$8,357,000	1,2,3,4,5,6,7,8

Notes
[1] Quantities based on Design Work Completed (1-5%).
[2] Unit Prices Based on Information Available at This Time including recently bid projects.
[3] Limited Soil Boring and Field Investigation Information Available.
[4] This design level (Class 4, 1 - 10% design completion per ASTM E 2516-11) cost estimate is based on concept designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -30% to

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES

+50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[5] Estimate assumes that projects will not be located on contaminated soil.

[6] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following construction.

[7] Furnish and Install pipe cost per linear foot includes all trenching, bedding, backfilling, compaction, and disposal of excess materials

[8] Estimate costs are reported to nearest thousand dollars.

	PREPARED BY: BARR ENGINEERING COMPANY		SHEET:	1	OF	1
			CREATED BY:	XF2	DATE:	9/23/2024
ENGINEER'S OPINION OF PROBABLE PROJECT COST			CHECKED BY:	JAK2	DATE:	9/23/2024
PROJECT:	Plymouth CIP Planning Assistance		APPROVED BY:		DATE:	
LOCATION:	City of Plymouth	ISSUED:			DATE:	
PROJECT #:	23272078.00	ISSUED:			DATE:	
OPINION OF COST - SUMMARY		ISSUED:			DATE:	

Engineer's Opinion of Probable Project Cost

Plymouth CIP Planning - Conveyance and Fernbrook Storage - Grading Option 2

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
	Mobilization/Demobilization (10%)	LS	1	$698,833.01	$698,833.01	1,2,3,4,5,6
	Traffic and Pedestrian Safety Control Measures (5%)	LS	1	$332,777.63	$332,777.63	1,2,3,4,5,6
	Construction Layout and Staking (2%)	LS	1	$130,501.03	$130,501.03	1,2,3,4,5,6
	Sediment and Erosion Control (2%)	LS	1	$127,942.19	$127,942.19	1,2,3,4,5,6
	Construction Fencing	LF	7,460	$5.71	$42,584.17	1,2,3,4,5,6
	Clearing and Grubbing Trees/Shrubs less than 12" Diameter	AC	7.2	$15,000.00	$108,000.00	1,2,3,4,5,6
	Removal and Disposal of Tree Stump 12 inch to 24 inch Diameter	EA	20	$350.00	$7,000.00	1,2,3,4,5,6
	Removal and Disposal of Tree 24 inch to 36 inch Diameter	EA	10	$2,805.91	$28,059.07	1,2,3,4,5,6
	Remove Storm Sewer	LF	3,123	$35.00	$109,305.00	1,2,3,4,5,6
	Remove Storm Structures	EA	10	$1,218.33	$12,183.25	1,2,3,4,5,6
	Sawcut Bituminous Pavement (Full Depth)	LF	5,328	$6.00	$31,968.00	1,2,3,4,5,6
	Remove and Dispose Pavement (Bituminous & Concrete)	SY	6,940	$10.00	$69,400.00	1,2,3,4,5,6
	Sawcut, Remove and Dispose of Curb & Gutter (P)	LF	2,315	$8.00	$18,520.00	1,2,3,4,5,6
	Import Topsoil Borrow and Placement (6")	CY	4,517	$35.10	$158,535.81	1,2,3,4,5,6
	Common Excavation, Haul, & Disposal Offsite (Clean)	CY	67,857	$32.00	$2,171,413.11	1,2,3,4,5,6
	Bituminous Utility Patch Type A (includes subgrade Class V)	SY	6,940	$125.25	$869,235.00	1,2,3,4,5,6
	Curb & Gutter (Driveway and Street)	LF	2,315	$35.00	$81,025.00	1,2,3,4,5,6
	ADA Pedestrian Ramps	EA	4	$3,500.00	$14,000.00	1,2,3,4,5,6
	Concrete Walk (P)	SY	5,144	$118.84	$611,348.63	1,2,3,4,5,6
	Aggregate Base (CV), Class 5 - Concrete Walk	TON	1,372	$45.89	$62,965.65	1,2,3,4,5,6
	24" RCP Pipe Sewer	LF	310	$136.12	$42,195.65	1,2,3,4,5,6
	24" RCP FES	EA	1	$2,195.05	$2,195.05	1,2,3,4,5,6
	24" RCP Trash Rack	EA	0	$1,800.00	$0.00	1,2,3,4,5,6
	27" RCP Pipe Sewer	LF	0	$188.62	$0.00	1,2,3,4,5,6
	27" RCP FES	EA	0	$2,545.51	$0.00	1,2,3,4,5,6
	42" RCP Pipe Sewer	LF	570	$306.25	$174,562.50	1,2,3,4,5,6
	42" RCP FES	EA	1	$3,175.00	$3,175.00	1,2,3,4,5,6
	42" FES Trash Rack	EA	1	$4,862.50	$4,862.50	1,2,3,4,5,6
	48" RCP Pipe Sewer	LF	354	$538.61	$190,667.94	1,2,3,4,5,6
	48" RCP FES	EA	0	$5,704.12	$0.00	1,2,3,4,5,6
	48" FES Trash Rack	EA	0	$4,800.00	$0.00	1,2,3,4,5,6
	54" RCP Pipe Sewer	LF	280	$431.25	$120,750.00	1,2,3,4,5,6
	54" RCP FES	EA	0	$4,350.00	$0.00	1,2,3,4,5,6
	54" FES Trash Rack	EA	0	$7,921.25	$0.00	1,2,3,4,5,6
	72" RCP Pipe Sewer	LF	694	$665.85	$462,099.90	1,2,3,4,5,6
	72" RCP FES	EA	0	$6,000.00	$0.00	1,2,3,4,5,6
	72" FES Trash Rack	EA	0	$11,325.00	$0.00	1,2,3,4,5,6
	72" H x 96" W BOX CULVERT	LF	456	$969.00	$441,864.00	1,2,3,4,5,6
	72" H x 96" W BOX CULVERT FES	EA	1	$8,371.88	$8,371.88	1,2,3,4,5,6
	48" Diameter RC Drainage Structure, Complete	EA	2	$6,500.00	$13,000.00	1,2,3,4,5,6
	60" Diameter RC Drainage Structure, Complete	EA	3	$9,500.00	$28,500.00	1,2,3,4,5,6
	72" Diameter RC Drainage Structure Complete	EA	3	$20,034.06	$60,102.19	1,2,3,4,5,6
	96" Diameter RC Drainage Structure Complete	EA	0	$32,643.75	$0.00	1,2,3,4,5,6
	108" Diameter RC Drainage Structure Complete	EA	0	$49,218.75	$0.00	1,2,3,4,5,6
	120" Diameter RC Drainage Structuren Complete	EA	3	$58,200.00	$174,600.00	1,2,3,4,5,6
	Native Restoration including ECB (includes some tree replacement but not pond area)	AC	2	$100,000.00	$160,000.00	1,2,3,4,5,6
	Turf Seeding with HydroMulch (remainder of parcel)	AC	4	$25,000.00	$100,000.00	1,2,3,4,5,6
	Class I Rip Rap	TON	68	$215.00	$14,620.00	1,2,3,4,5,6
	CONSTRUCTION SUBTOTAL				$7,687,000	1,2,3,4,5,6,7,8
	CONSTRUCTION CONTINGENCY (25%)				$0	1,4,8
	ESTIMATED CONSTRUCTION COST				$7,687,000	1,2,3,4,5,6,7,8
	PLANNING, ENGINEERING, & DESIGN (25%)				$0	
	ESTIMATED TOTAL PROJECT COST				**$7,687,000**	1,2,3,4,5,6,7,8
	ESTIMATED ACCURACY RANGE	**-30%**			$5,381,000	1,2,3,4,5,6,7,8
		50%			$11,531,000	1,2,3,4,5,6,7,8

Notes

[1] Quantities based on Design Work Completed (1-5%).

[2] Unit Prices Based on Information Available at This Time including recently bid projects.

[3] Limited Soil Boring and Field Investigation Information Available.

[4] This design level (Class 4, 1 - 10% design completion per ASTM E 2516-11) cost estimate is based on concept designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -30% to

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES

+50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[5] Estimate assumes that projects will not be located on contaminated soil.

[6] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following construction.

[7] Furnish and Install pipe cost per linear foot includes all trenching, bedding, backfilling, compaction, and disposal of excess materials

[8] Estimate costs are reported to nearest thousand dollars.

PREPARED BY: BARR ENGINEERING COMPANY

	SHEET:	1	OF	1	
	CREATED BY:	XF2	DATE:	9/23/2024	
ENGINEER'S OPINION OF PROBABLE PROJECT COST	CHECKED BY:	JAK2	DATE:	9/23/2024	
PROJECT: Plymouth CIP Planning Assistance	APPROVED BY:		DATE:		
LOCATION: City of Plymouth	ISSUED:		DATE:		
PROJECT #: 23272078.00	ISSUED:		DATE:		
OPINION OF COST - SUMMARY	ISSUED:		DATE:		

Engineer's Opinion of Probable Project Cost

Plymouth CIP Planning - Conveyance and Fernbrook Storage - Grading Option 3 (No Roadwork)

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
	Mobilization/Demobilization (10%)	LS	1	$567,237.68	$567,237.68	1,2,3,4,5,6
	Traffic and Pedestrian Safety Control Measures (5%)	LS	1	$270,113.18	$270,113.18	1,2,3,4,5,6
	Construction Layout and Staking (2%)	LS	1	$105,926.74	$105,926.74	1,2,3,4,5,6
	Sediment and Erosion Control (2%)	LS	1	$103,849.74	$103,849.74	1,2,3,4,5,6
	Construction Fencing	LF	7,460	$5.71	$42,584.17	1,2,3,4,5,6
	Clearing and Grubbing Trees/Shrubs less than 12" Diameter	AC	7.2	$15,000.00	$108,000.00	1,2,3,4,5,6
	Removal and Disposal of Tree Stump 12 inch to 24 inch Diameter	EA	20	$350.00	$7,000.00	1,2,3,4,5,6
	Removal and Disposal of Tree 24 inch to 36 inch Diameter	EA	10	$2,805.91	$28,059.07	1,2,3,4,5,6
	Remove Storm Sewer	LF	3,591	$35.00	$125,685.00	1,2,3,4,5,6
	Remove Storm Structures	EA	10	$1,218.33	$12,183.25	1,2,3,4,5,6
	Sawcut Bituminous Pavement (Full Depth)	LF	0	$6.00	$0.00	1,2,3,4,5,6
	Remove and Dispose Pavement (Bituminous & Concrete)	SY	0	$10.00	$0.00	1,2,3,4,5,6
	Sawcut, Remove and Dispose of Curb & Gutter (P)	LF	0	$8.00	$0.00	1,2,3,4,5,6
	Import Topsoil Borrow and Placement (6")	CY	4,517	$35.10	$158,535.81	1,2,3,4,5,6
	Common Excavation, Haul, & Disposal Offsite (Clean)	CY	72,116	$32.00	$2,307,707.23	1,2,3,4,5,6
	Bituminous Utility Patch Type A (includes subgrade Class V)	SY	0	$125.25	$0.00	1,2,3,4,5,6
	Curb & Gutter (Driveway and Street)	LF	0	$35.00	$0.00	1,2,3,4,5,6
	ADA Pedestrian Ramps	EA	0	$3,500.00	$0.00	1,2,3,4,5,6
	Concrete Walk (P)	SY	0	$118.84	$0.00	1,2,3,4,5,6
	Aggregate Base (CV), Class 5 - Concrete Walk	TON	0	$45.89	$0.00	1,2,3,4,5,6
	24" RCP Pipe Sewer	LF	310	$136.12	$42,195.65	1,2,3,4,5,6
	24" RCP FES	EA	1	$2,195.05	$2,195.05	1,2,3,4,5,6
	24" RCP Trash Rack	EA	0	$1,800.00	$0.00	1,2,3,4,5,6
	27" RCP Pipe Sewer	LF	0	$188.62	$0.00	1,2,3,4,5,6
	27" RCP FES	EA	0	$2,545.51	$0.00	1,2,3,4,5,6
	42" RCP Pipe Sewer	LF	570	$306.25	$174,562.50	1,2,3,4,5,6
	42" RCP FES	EA	1	$3,175.00	$3,175.00	1,2,3,4,5,6
	42" FES Trash Rack	EA	1	$4,862.50	$4,862.50	1,2,3,4,5,6
	48" RCP Pipe Sewer	LF	354	$538.61	$190,667.94	1,2,3,4,5,6
	48" RCP FES	EA	0	$5,704.12	$0.00	1,2,3,4,5,6
	48" FES Trash Rack	EA	0	$4,800.00	$0.00	1,2,3,4,5,6
	54" RCP Pipe Sewer	LF	280	$431.25	$120,750.00	1,2,3,4,5,6
	54" RCP FES	EA	0	$4,350.00	$0.00	1,2,3,4,5,6
	54" FES Trash Rack	EA	0	$7,921.25	$0.00	1,2,3,4,5,6
	72" RCP Pipe Sewer	LF	694	$665.85	$462,099.90	1,2,3,4,5,6
	72" RCP FES	EA	0	$6,000.00	$0.00	1,2,3,4,5,6
	72" FES Trash Rack	EA	0	$11,325.00	$0.00	1,2,3,4,5,6
	72" H x 96" W BOX CULVERT	LF	870	$969.00	$843,030.00	1,2,3,4,5,6
	72" H x 96" W BOX CULVERT FES	EA	1	$8,371.88	$8,371.88	1,2,3,4,5,6
	48" Diameter RC Drainage Structure, Complete	EA	2	$6,500.00	$13,000.00	1,2,3,4,5,6
	60" Diameter RC Drainage Structure, Complete	EA	3	$9,500.00	$28,500.00	1,2,3,4,5,6
	72" Diameter RC Drainage Structure Complete	EA	3	$20,034.06	$60,102.19	1,2,3,4,5,6
	96" Diameter RC Drainage Structure Complete	EA	0	$32,643.75	$0.00	1,2,3,4,5,6
	108" Diameter RC Drainage Structure Complete	EA	0	$49,218.75	$0.00	1,2,3,4,5,6
	120" Diameter RC Drainage Structuren Complete	EA	3	$58,200.00	$174,600.00	1,2,3,4,5,6
	Native Restoration including ECB (includes some tree replacement but not pond area)	AC	2	$100,000.00	$160,000.00	1,2,3,4,5,6
	Turf Seeding with HydroMulch (remainder of parcel)	AC	4	$25,000.00	$100,000.00	1,2,3,4,5,6
	Class I Rip Rap	TON	68	$215.00	$14,620.00	1,2,3,4,5,6
	CONSTRUCTION SUBTOTAL				$6,240,000	1,2,3,4,5,6,7,8
	CONSTRUCTION CONTINGENCY (25%)				$0	1,4,8
	ESTIMATED CONSTRUCTION COST				$6,240,000	1,2,3,4,5,6,7,8
	PLANNING, ENGINEERING, & DESIGN (25%)				$0	
	ESTIMATED TOTAL PROJECT COST				**$6,240,000**	1,2,3,4,5,6,7,8
ESTIMATED ACCURACY RANGE		**-30%**			$4,368,000	1,2,3,4,5,6,7,8
		50%			$9,360,000	1,2,3,4,5,6,7,8

Notes

[1] Quantities based on Design Work Completed (1-5%).

[2] Unit Prices Based on Information Available at This Time including recently bid projects.

[3] Limited Soil Boring and Field Investigation Information Available.

[4] This design level (Class 4, 1 - 10% design completion per ASTM E 2516-11) cost estimate is based on concept designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -30% to

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES

+50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[5] Estimate assumes that projects will not be located on contaminated soil.

[6] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following construction.

[7] Furnish and Install pipe cost per linear foot includes all trenching, bedding, backfilling, compaction, and disposal of excess materials

[8] Estimate costs are reported to nearest thousand dollars.

BARR	PREPARED BY: BARR ENGINEERING COMPANY		SHEET:	1	OF	1
			CREATED BY:	XF2	DATE:	9/23/2024
ENGINEER'S OPINION OF PROBABLE PROJECT COST			CHECKED BY:	JAK2	DATE:	9/23/2024
PROJECT:	Plymouth CIP Planning Assistance		APPROVED BY:		DATE:	
LOCATION:	City of Plymouth	ISSUED:			DATE:	
PROJECT #:	23272078.00	ISSUED:			DATE:	
OPINION OF COST - SUMMARY		ISSUED:			DATE:	

Engineer's Opinion of Probable Project Cost

Plymouth CIP Planning - Conveyance and Fernbrook Storage - Grading Option 3

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
	Mobilization/Demobilization (10%)	LS	1	$775,471.69	$775,471.69	1,2,3,4,5,6
	Traffic and Pedestrian Safety Control Measures (5%)	LS	1	$369,272.24	$369,272.24	1,2,3,4,5,6
	Construction Layout and Staking (2%)	LS	1	$144,812.64	$144,812.64	1,2,3,4,5,6
	Sediment and Erosion Control (2%)	LS	1	$141,973.18	$141,973.18	1,2,3,4,5,6
	Construction Fencing	LF	7,460	$5.71	$42,584.17	1,2,3,4,5,6
	Clearing and Grubbing Trees/Shrubs less than 12" Diameter	AC	7.2	$15,000.00	$108,000.00	1,2,3,4,5,6
	Removal and Disposal of Tree Stump 12 inch to 24 inch Diameter	EA	20	$350.00	$7,000.00	1,2,3,4,5,6
	Removal and Disposal of Tree 24 inch to 36 inch Diameter	EA	10	$2,805.91	$28,059.07	1,2,3,4,5,6
	Remove Storm Sewer	LF	3,591	$35.00	$125,685.00	1,2,3,4,5,6
	Remove Storm Structures	EA	10	$1,218.33	$12,183.25	1,2,3,4,5,6
	Sawcut Bituminous Pavement (Full Depth)	LF	6,156	$6.00	$36,936.00	1,2,3,4,5,6
	Remove and Dispose Pavement (Bituminous & Concrete)	SY	7,980	$10.00	$79,800.00	1,2,3,4,5,6
	Sawcut, Remove and Dispose of Curb & Gutter (P)	LF	2,729	$8.00	$21,832.00	1,2,3,4,5,6
	Import Topsoil Borrow and Placement (6")	CY	4,517	$35.10	$158,535.81	1,2,3,4,5,6
	Common Excavation, Haul, & Disposal Offsite (Clean)	CY	67,857	$32.00	$2,171,413.11	1,2,3,4,5,6
	Bituminous Utility Patch Type A (includes subgrade Class V)	SY	7,980	$125.25	$999,495.00	1,2,3,4,5,6
	Curb & Gutter (Driveway and Street)	LF	2,729	$35.00	$95,515.00	1,2,3,4,5,6
	ADA Pedestrian Ramps	EA	4	$3,500.00	$14,000.00	1,2,3,4,5,6
	Concrete Walk (P)	SY	6,064	$118.84	$720,678.36	1,2,3,4,5,6
	Aggregate Base (CV), Class 5 - Concrete Walk	TON	1,617	$45.89	$74,209.52	1,2,3,4,5,6
	24" RCP Pipe Sewer	LF	310	$136.12	$42,195.65	1,2,3,4,5,6
	24" RCP FES	EA	1	$2,195.05	$2,195.05	1,2,3,4,5,6
	24" RCP Trash Rack	EA	0	$1,800.00	$0.00	1,2,3,4,5,6
	27" RCP Pipe Sewer	LF	0	$188.62	$0.00	1,2,3,4,5,6
	27" RCP FES	EA	0	$2,545.51	$0.00	1,2,3,4,5,6
	42" RCP Pipe Sewer	LF	570	$306.25	$174,562.50	1,2,3,4,5,6
	42" RCP FES	EA	1	$3,175.00	$3,175.00	1,2,3,4,5,6
	42" FES Trash Rack	EA	1	$4,862.50	$4,862.50	1,2,3,4,5,6
	48" RCP Pipe Sewer	LF	354	$538.61	$190,667.94	1,2,3,4,5,6
	48" RCP FES	EA	0	$5,704.12	$0.00	1,2,3,4,5,6
	48" FES Trash Rack	EA	0	$4,800.00	$0.00	1,2,3,4,5,6
	54" RCP Pipe Sewer	LF	280	$431.25	$120,750.00	1,2,3,4,5,6
	54" RCP FES	EA	0	$4,350.00	$0.00	1,2,3,4,5,6
	54" FES Trash Rack	EA	0	$7,921.25	$0.00	1,2,3,4,5,6
	72" RCP Pipe Sewer	LF	694	$665.85	$462,099.90	1,2,3,4,5,6
	72" RCP FES	EA	0	$6,000.00	$0.00	1,2,3,4,5,6
	72" FES Trash Rack	EA	0	$11,325.00	$0.00	1,2,3,4,5,6
	72" H x 96" W BOX CULVERT	LF	870	$969.00	$843,030.00	1,2,3,4,5,6
	72" H x 96" W BOX CULVERT FES	EA	1	$8,371.88	$8,371.88	1,2,3,4,5,6
	48" Diameter RC Drainage Structure, Complete	EA	2	$6,500.00	$13,000.00	1,2,3,4,5,6
	60" Diameter RC Drainage Structure, Complete	EA	3	$9,500.00	$28,500.00	1,2,3,4,5,6
	72" Diameter RC Drainage Structure Complete	EA	3	$20,034.06	$60,102.19	1,2,3,4,5,6
	96" Diameter RC Drainage Structure Complete	EA	0	$32,643.75	$0.00	1,2,3,4,5,6
	108" Diameter RC Drainage Structure Complete	EA	0	$49,218.75	$0.00	1,2,3,4,5,6
	120" Diameter RC Drainage Structuren Complete	EA	3	$58,200.00	$174,600.00	1,2,3,4,5,6
	Native Restoration including ECB (includes some tree replacement but not pond area)	AC	2	$100,000.00	$160,000.00	1,2,3,4,5,6
	Turf Seeding with HydroMulch (remainder of parcel)	AC	4	$25,000.00	$100,000.00	1,2,3,4,5,6
	Class I Rip Rap	TON	68	$215.00	$14,620.00	1,2,3,4,5,6
	CONSTRUCTION SUBTOTAL				$8,530,000	1,2,3,4,5,6,7,8
	CONSTRUCTION CONTINGENCY (25%)				$0	1,4,8
	ESTIMATED CONSTRUCTION COST				$8,530,000	1,2,3,4,5,6,7,8
	PLANNING, ENGINEERING, & DESIGN (25%)				$0	
	ESTIMATED TOTAL PROJECT COST				**$8,530,000**	1,2,3,4,5,6,7,8
ESTIMATED ACCURACY RANGE		**-30%**			$5,971,000	1,2,3,4,5,6,7,8
		50%			$12,795,000	1,2,3,4,5,6,7,8

Notes

[1] Quantities based on Design Work Completed (1-5%).

[2] Unit Prices Based on Information Available at This Time including recently bid projects.

[3] Limited Soil Boring and Field Investigation Information Available.

[4] This design level (Class 4, 1 - 10% design completion per ASTM E 2516-11) cost estimate is based on concept designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -30% to

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES

+50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[5] Estimate assumes that projects will not be located on contaminated soil.

[6] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following construction.

[7] Furnish and Install pipe cost per linear foot includes all trenching, bedding, backfilling, compaction, and disposal of excess materials

[8] Estimate costs are reported to nearest thousand dollars.