CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

GEOTECHNICAL STUDY

Upchurch Annex
Salida, Colorado

Report Prepared for:

Mr. Tory Upchurch
2112 Ann Arbor Avenue
Austin, TX 78704

Project No. 21.6099
July 30, 2021

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COMMON ABBREVIATIONS

AASHTO......... **American Association of State Highway and Transportation Officials**
ABC................ **aggregate base course**
ACI .... **American Concrete Institute**
ADA .... **Americans with Disabilities Act**
ADSC .... **Association of Drilled Contractors**
AI .... **Asphalt Institute**
APM .... **asphalt paving material**
ASCE.............. **American Society of Civil Engineers**
ASTM .... **American Society for Testing and Materials**
AWWA .... **American Water Works Association**
bgs................. **below ground surface**
CDOT .... **Colorado Department of Transportation**
CBR................ **California Bearing Ratio**
CFR................ **Code of Federal Regulations**
CGS................ **Colorado Geological Survey**
CKD .... **cement of kiln dust stabilized subgrade**
CMU............... **concrete masonry unit**
CTB................ **cement treated base course**
deg .... **degree**
EDLA............. **equivalent daily load application**
e_m .... **edge moisture variation distance**
EPS .... **expanded polystyrene**
ESAL .... **equivalent single axle loads**
f'c .... **specified compressive strength of concrete at the age of 28 days**
F_a .... **seismic site coefficient**
FHWA .... **Federal Highway Administration**
FS .... **factor of safety**
F_v .... **seismic site coefficient**
GSA................ **global stability analysis**
GVW .... **gross vehicle weight**
IBC .... **International Building Code**
ICC-ES........... **International Code Council Evaluation Services, Inc.**
IRC .... **International Residential Code**
kip .... **1,000 pounds-force**
km .... **kilometer**
LTS .... **lime treated subgrade**
MDD .... **maximum dry density**
mg/L .... **milligrams per liter**
MGPEC........... **Metropolitan Government Pavement Engineers Council**
mm .... **millimeter**
Mr.................. **resilient modulus**
MSE .... **mechanically stabilized earth**
mV................. **millivolts**
NAPA .... **National Asphalt Pavement Association**
N_{DESIGN} .... **design gyrations**
OMC............... **optimum moisture content**

OSHA .... **Occupational Safety and Health Administration**
OWTS .... **onsite wastewater treatment system**
PCA .... **Portland Cement Association**
PCC .... **portland cement concrete**
pcf .... **pounds per cubic foot**
pci .... **pounds per cubic inch**
pH .... **power of hydrogen**
psf .... **pounds per square foot**
psi .... **pounds per square inch**
PT .... **post-tension**
S_s .... **mapped spectral accelerations for short periods**
UBC .... **Uniform Building Code**
USGS .... **United States Geological Survey**

1. PURPOSE

1.1 GENERAL

Cesare, Inc. (Cesare) performed a geotechnical study for the proposed subdivision to be located at the northeast corner of County Roads 140 and 141 in Salida, Colorado. The study was made to characterize existing subsurface conditions at the site and assist in determining design criteria for planning, site development, pavement sections, foundation systems, interior floor systems, exterior flatwork, surface and subsurface drainage adjacent to structures, and to present other pertinent geotechnical issues. Information gathered during the field exploration and laboratory testing is summarized in Figures 1 through 3 and Appendices A through C. Cesare's opinions and recommendations presented in this report are based on data generated during this field exploration, laboratory testing, and its experience.

1.2 SCOPE OF SERVICES

The scope of services performed is detailed in Cesare's Proposal Agreement No. SC210612 which was executed on June 22, 2021.

2. SUMMARY OF FINDINGS AND CONCLUSIONS

This section is intended as a summary only and does not include design details. The report should be read in its entirety and utilized for design.

- Subsurface conditions consist of less than 1 foot of topsoil over sandy gravels and gravelly sands with cobbles. No bedrock or groundwater was encountered to the full depths explored of 4 to 5 feet.
- Spread or pad type footings and slabs-on-grade are appropriate for this site.
- Good surface drainage should be established and positive drainage away from the structures, pavement, and other site improvements should be provided during construction and maintained throughout the life of the proposed structures.
- Pavement sections should consist of 3 inches of APM over 6 inches of ABC.

3. SITE CONDITIONS

The site is located northeast corner of County Roads 140 and 141 in Salida, Colorado. A vicinity map is shown in Figure 1. The site is about 5.6 acres and is currently undeveloped land. The site is bound by County Road 141A to the north, County Road 141 to the east, County Road 140 to the south and residential development to the east. A residence exists southwest of the property at the northeast corner of County Roads 140 and 141. The topography of the site is flat with a grade change of about 2% to the east. Vegetation onsite consists of grass and sagebrush. No bodies of water or bedrock outcrops were observed onsite.

4. PROPOSED CONSTRUCTION

The site will be developed into 10 single-family lots, 11 duplex lots, 2 triplex lots, and 1 lot for the Chaffee Housing Trust. The nature of construction of the structures is unknown. The structures will be serviced by offsite wastewater services. The lots will be accessed with a paved drive. Cesare assumes the drive will be paved with APM over ABC.

5. GEOLOGIC CONDITIONS

5.1 SURFICIAL DEPOSITS

The "Geology and mineral deposits of the Poncha Springs SE quadrangle, Chaffee County, Colorado" prepared for the USGS by Van Alstine, et al, dated 1974, indicates that surficial deposits onsite consist of:

- Terrace gravels

6. FIELD EXPLORATION

Cesare explored subsurface conditions on July 6, 2021 by excavating four exploratory pits at locations indicated in Figure 1. Exploratory pits were excavated 4 to 5 feet deep using a Bobcat E50 excavator. Graphical logs of the subsurface conditions observed, locations of sampling, and further explanation of the exploration are presented in Appendix A.

7. LABORATORY TESTING

Cesare personnel returned samples obtained during field exploration to its laboratory where professional staff visually classified them and assigned testing to selected samples to evaluate pertinent engineering properties. Laboratory tests performed are listed in Table 7.1. Further discussion of laboratory testing and the laboratory test results are presented in Appendix B.

TABLE 7.1. Laboratory Testing Performed

Laboratory Test	To Evaluate
Grain size analysis	Grain size distribution for classification purposes.
Atterberg limits	Soil plasticity for classification purposes.
Water soluble sulfate content	Potential corrosivity of the soil on cementitious material.

8. SUBSURFACE CONDITIONS

Cesare's exploratory pits encountered

- Less than one foot of topsoil.
- Overburden soil consisting of gravelly sands and sandy gravels with cobbles, rounded to subrounded clasts, calcareous, slightly moist to moist and light brown to brown in color.
- No bedrock or groundwater were encountered to depths of 4 to 5 feet at the time of excavating.
- Exploratory Pits EP-1 and EP-2 caved at depths of 2 feet at the time of excavating.

The subsurface conditions encountered in Cesare's borings are reasonably consistent with those described in Section **5. GEOLOGIC CONDITIONS**. These observations represent conditions at the time of field exploration and may not be indicative of other times or other locations. A more complete description of the subsoil conditions encountered is shown in Appendix A.

Photo 1. View of typical soils encountered in the exploratory pits.

9. GROUNDWATER

Groundwater was not encountered to the maximum depth of exploration 5 feet at the time of excavation. Pits were backfilled at the completion of the observations. We do not anticipate groundwater to affect the construction or the development.

10. GEOLOGIC HAZARDS

The following subsections present a cursory review of geologic hazards. A detailed geologic hazards assessment was not the focus of Cesare's scope of services.

10.1 RADON

The U.S. Environmental Protection Agency map of radon zones indicates that virtually all of western Colorado, including Chaffee County, is in Zone 1 (www.epa.gov/radon/zonemap.html). Although there is no known safe level of radon, Zone 1 is the zone of highest risk for exposure to radon gas (i.e., greater than 4 picoCuries per Liter (pCi/L)). The CGS published a report that related geologic setting and building construction with radon levels (CGS 1991 Open-File Report 91-4). Residences with basements had higher levels of radon than residences built on grade on the same geologic material. The CGS is careful to state that radon potential can vary considerably within the same geologic unit due to the nonuniform distribution of uranium, secondary leaching, and the accumulation of uranium and other radioactive elements into other strata.

Based on levels of radon recorded in existing residences in the region and the presence of rock types that are known to produce radon, it is reasonable to assume that radon emission into buildings is occurring in the Salida area. The EPA, the Colorado Department of Public Health and Environment (CDPHE) Radiation Management Division, and the National Association of Home Builders (NAHB) recommend that all new residences constructed in Zone 1 include radon resistant features. These organizations also recommend that after the building is constructed, radon should be measured and if the results are greater than 4 pCi/L, the system should be upgraded from passive to active (usually by installing a fan). In the EPA publication titled, Building Radon Out: A Step-by-Step Guide on How to Build Radon-Resistant Homes (USEPA Office of Air and Radiation EPA/402-K-01-002, April 2001), three practical and inexpensive alternatives for passive, sub-slab depressurization systems are presented; gravel with vents, perforated pipes, or soil gas collection mats. Recommendations for passive and active design and construction techniques for reducing radon gas can be found on the EPA radon website www.epa.gov/radon or the CDPHE radon website www.cdphe.state.co.us/hm/rad/radon.

11. FOUNDATION RECOMMENDATIONS

11.1 SPREAD FOOTINGS

The proposed structures may be founded on conventional spread footings or pad type footings bearing on the sandy gravel/gravelly sand or on controlled, structural fill below frost depth and below any existing manmade fill in accordance with the following design recommendations:

a) A frost depth of 24 inches should be assumed for this area (Chaffee County Exhibit M to Ordinance 2018-2).
b) Footings bearing on the sandy gravels/gravelly sands should be designed for a maximum allowable soil bearing pressure of 3,000 psf based on dead load plus full live load. Footings bearing on controlled structural fill should be designed for a maximum allowable soil bearing pressure of 2,500 psf based on dead load plus full live load.
c) Continuous footings should have a minimum width of 14 inches and isolated pad type footings should have a minimum dimension of 18 inches.
d) Using the soil pressure recommended above, Cesare estimates the maximum settlement for the structure will be on the order of 1 inch, with differential settlement potentially on the order of 0.5 inches. Footings should be proportioned as much as practicable to reduce differential settlement.
e) Steel reinforcement for continuous concrete foundation walls should be designed to span localized settlements over a distance of 10 feet.
f) All soft or loose soil beneath footing areas should be redensified in place, or removed and replaced with properly compacted structural fill, suitable flow fill, or concrete prior to placement of footing concrete.
g) Particles greater than 12 inches in dimension should be removed from exposed footing subgrade.
h) Removal of cobbles and/or boulders from the soil at the foundation elevation can result in depressions. These resulting depressions can be backfilled with compacted onsite soil,

ABC or concrete.

i) All footing excavations should be observed by a Cesare representative prior to placement of concrete to determine if bearing conditions are consistent with those assumed to develop its recommendations.

12. LATERAL EARTH PRESSURES

12.1 FOUNDATION WALLS

Lateral pressures on walls depend on the type of wall, hydrostatic pressure behind the wall, type of backfill material, and allowable wall movements. Cesare recommends drain systems be constructed behind walls to reduce the potential for hydrostatic pressures to develop. Where anticipated/permissible wall movements are greater than 0.5% of the wall height, lateral earth pressures can be estimated for an "active" condition. Where anticipated wall movement is less than approximately 0.5% of the wall height or wall movement is constrained, lateral earth pressures should be estimated for an "at rest" condition. Recommended lateral earth pressures for onsite material are provided in Table 12.1.

The recommended values for lateral earth pressures provided in Table 12.1 are given in terms of an equivalent unit weight. The equivalent unit weight multiplied by the depth below the top of the ground surface is the horizontal pressure against the wall at that depth. The resulting pressure distribution is a triangular shape. These soil pressures are for horizontal backfill with no surcharge loading and no hydrostatic pressures. If these criteria cannot be met, Cesare should be contacted for additional criteria.

The unfactored or ultimate coefficients of sliding resistance between concrete and bearing soil are provided in Table 12.1.

TABLE 12.1. Lateral Earth Pressures and Coefficients of Sliding Resistance for Onsite Material

Backfill Material Type	Equivalent Unit Weight (pcf)			Coefficient of Sliding Resistance
	Active	At Rest	Passive	
3 inch minus on site sandy gravels/gravelly sands	40	55	300	0.70

12.2 THRUST BLOCK LOADS

The subsurface conditions at the proposed sewer and water line locations consist of sandy gravels and gravelly sands. Thrust blocks placed within this material should be designed for a maximum allowable lateral soil bearing pressure of 200 psf/feet of depth. For example, if the thrust block is placed 8 feet deep, then 200 (psf/feet) x 8 (feet) = 1,600 psf.

13. INTERIOR FLOORS

The natural sandy gravel/gravelly sand soil exhibited zero swell and collapse potential. Concrete slabs placed on this material or on properly placed structural fill comprised of this material do not require special considerations for accommodating movement as a result of expansive or collapsing soil.

Cobbles will be encountered at subgrade elevation. Particles greater than 6 inches in dimension should be removed prior to placing the interior floors.

13.1 SLAB-ON-GRADE CONSTRUCTION DETAILS

Cracking of slabs-on-grade can occur as a result of compressing of the supporting soil but also as a result of concrete curing stresses. If slab-on-grade floors are chosen, Cesare recommends that design and construction of all interior slab-on-grade floors incorporate the following considerations and precautions. These details will not reduce the amount of movement but are intended to reduce potential damage should some settlement of the supporting subgrade take place. The ACI Committee 302, "Guide for Concrete Floor and Slab Construction (ACI 302.R-96)" should be consulted regarding methods/techniques to reduce the occurrence of concrete shrinkage cracks and other potential issues associated with concrete finishing and curing.

a) A vapor barrier is recommended beneath concrete slabs-on-grade that will support equipment sensitive to moisture or will be covered with wood, tile, carpet, linoleum, or other moisture sensitive or impervious coverings. Location of the vapor barrier should be in accordance with recommendations provided by ACI 302.2R-06, "Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials." Further discussion of vapor barriers is presented in Appendix C.
b) Plumbing beneath slabs should be thoroughly pressure tested during construction for leaks prior to slab placement.
c) Backfill in the utility trenches beneath slabs should be compacted as specified in Section **17. STRUCTURAL FILL/BACKFILL SOIL.**
d) Plumbing and utilities that pass through the slab should be isolated from the slabs.
e) Provide frequent control joints in the slab. Refer to ACI 302.1R-15.
f) Use of load-transfer devices at construction and contraction joints is recommended when positive load transfer is required (See ACI 302.1R).

14. EXTERIOR FLATWORK

Flatwork supported on foundation wall backfill may settle and crack if the backfill is not properly moisture conditioned and compacted.

Exterior flatwork should be isolated from the structures. Exterior flatwork should be expected to move, although measures can be incorporated into construction to limit the movement or effects of the movement. Cesare recommends flatwork not be doweled into structure foundations, but rather supported on a haunch to limit settlement. The haunch should extend the full length of the slab.

Exterior flatwork, such as driveways and sidewalks, are normally constructed as slabs-on-grade. Porches and patios are increasingly constructed as structurally supported slabs, which in Cesare's opinion, is the most positive means of keeping slabs from moving and adversely affecting the operation of doors or means of egress. Cesare recommends that landings and slabs at egress doors, as well as porches and patios, be constructed as structurally supported elements if potential movement cannot be tolerated.

Simple decks that are not integral to the structure and can tolerate foundation movement can be constructed with less substantial foundations. A short pier or footing bottomed below frost depth can be used if movement is acceptable and if acceptable by local building requirements. Use of deeper foundation elements can reduce potential movement. Footings or short piers should not be underlain by wall backfill, due to risk of settlement. Inner edges of decks may be constructed on haunches and detailed such that movement of the deck foundations will not cause distress to the structure.

14.1 OVERHANGING ROOFS

Porches, patios, or decks with overhanging roofs that are integral to the structure, such that foundation movement cannot be tolerated, should be constructed with the same foundation type as the structure.

15. EXCAVATIONS

Conventional earthmoving equipment should be adequate to excavate the onsite soil. The sandy gravels and gravelly sands will collapse. All excavations should be properly sloped and/or braced, and local and federal safety codes observed. Slopes and other areas void of vegetation should be protected against erosion. If temporary shoring is required, a contractor specializing in design and construction of shoring should be contacted.

It is the contractor's responsibility to provide safe working conditions and comply with the regulations in OSHA Standards-Excavations, 29 CFR Part 1926. The following guidelines are provided for planning purposes. Sloping and shoring requirements must be evaluated at the time of construction by the contractor's competent person as defined by OSHA. OSHA classifications for various material types and the steepest allowable slope configuration corresponding to those classifications are shown in Table 15.1.

TABLE 15.1. Allowable Slope Configuration for Onsite Material

Material Type	OSHA Classification	Steepest Allowable Slope Configuration*
On site sands and gravels	Type C	1-1/2:1

* Units horizontal to units vertical. The values shown apply to excavation less than 20 feet in height. Conditions can change and evaluation is the contractor's responsibility.

The classifications and slope configurations in Table 15.1 assume that excavations are above the groundwater table, there is no standing water in the excavations, and there is no seepage from the slope into the excavations, unless otherwise specified. The above classifications and slope configurations assume that the material in the excavations is not fractured, adversely bedded, jointed, nor left open to desiccate, crack, or slough, and are protected from surface runoff. There are other considerations regarding allowable slope configurations that the contractor is responsible for, including proximity of equipment, stockpiles, and other surcharge loads to the excavation. The contractor's competent person is responsible for all decisions regarding slope configuration and safety conditions for excavations.

Excavations should not undermine existing foundation systems of structures or infrastructure, unless they are adequately protected. At a minimum, new excavations should not intersect a line drawn on a 34 degree angle down and away from the bottom edge of the existing foundation systems or bottom edge of infrastructure. If this condition cannot be met, shoring or staged excavations may be required. If shoring is required, a condition survey of the adjacent structures is recommended before construction starts and upon completion of construction. In Cesare's experience, condition surveys include, but may not be limited to, photographs of any distress to adjacent structures.

Permanent slopes should be no steeper than 2:1 and should be revegetated or otherwise protected from erosion.

16. STRUCTURAL FILL/BACKFILL SOIL

Where fill/backfill soil is necessary, the suitable onsite inorganic soil may be used below, around, and above the structure. At this site, unsuitable material is defined as topsoil, organics, trash, ash, frozen material, hard lumps, and clods, and particles that are larger than 3 inches. Existing onsite fill material can be reused for structural fill/backfill, provided it is free of unsuitable material. If unsuitable material is encountered in the existing fill, it cannot be reused as fill/backfill. Recommendations for fill/backfill placement are:

a) Clods or lumps shall be broken down to a maximum size of 3 inches. Pieces that are larger than 3 inches shall be removed from the fill/backfill.
b) Fill/backfill material should be placed in loose lifts and compacted in accordance with Table 16.1.
c) Maximum loose lift thickness shall be 12 inches depending on the type of equipment used to apply compactive effort and shall be reduced if the specified compaction cannot be obtained with the equipment used.
d) Fill/backfill should not be placed if material is frozen or if the surface upon which fill/backfill is to be placed is frozen.
e) Fill/backfill material should be placed and spread in horizontal lifts of uniform thickness in a manner that avoids segregation.
f) Placement surface should be kept free of standing water, debris, and unsuitable material during placement and compaction of fill/backfill material.
g) Fill/backfill maximum allowable particle size is 3 inches. Do not incorporate oversize material in the fill/backfill that is incapable of being broken down by the equipment and methods being employed to process and compact the fill/backfill. Process and compact material in the lift, as necessary, to produce the specified fill/backfill characteristics. If oversize particles remain in the lift after processing and compacting, remove oversize material to produce a fill/backfill within specified requirements.

TABLE 16.1. Compaction Specifications

Material Type (General)	AASHTO Classification	Moisture Content (%)	Relative Compaction (%)	Compaction Standard
Onsite minus 3 inch material	A-1, A-2-4, A-2-5, A-3, A-4, A-5	±3% of OMC	≥95%	Standard Proctor (ASTM D698)

* If fill thickness greater than 20 feet is planned, additional requirements may apply.

16.1 IMPORT FILL

Material imported for structural fill should be tested and approved for use onsite by the project geotechnical engineer prior to hauling to the site. Proctor and classification tests should be conducted to determine if the fill meets required specifications. Fill material should meet the specifications in Table 16.2.

TABLE 16.2. Import Fill Specifications

Soil Parameter	Specification
Maximum particle size	3 inch
Percent finer than No. 200 sieve	20% maximum
Liquid limit	40% maximum
Plasticity index	15% maximum

17. SUBSURFACE DRAINAGE

Groundwater was not encountered during this study. If basements, crawlspaces, or first floors are below surrounding grade, it will be excavated into relatively impervious material. This creates a depression around the structure that is backfilled with soil. Infiltration through the backfill from precipitation and runoff can collect in this depression and create a perched water condition that can cause foundation and floor slab problems, including water in the below grade areas.

Cesare recommends that any basement, crawlspace, or portion of the first floor that will be below surrounding grade be provided with an exterior perimeter subsurface drainage system. The system shall be sloped to drain to a suitable gravity outlet or a sump. A pump shall be installed if a sump is used. The drainage system shall consist of perforated, machine slotted, or equivalent rigid plastic pipe placed around the perimeter of the basement or crawlspace foundation. Pipes with a smooth interior are recommended. Pipes that are corrugated on the interior can become obstructed more easily than pipes with smooth interiors and may be more difficult to clean. A recommended drain schematic is shown in Figure 3.

18. SURFACE DRAINAGE

Good drainage and surface water management is important. Performance of site improvements, such as foundations, floors, hardscape, and pavement are often adversely affected by failing to establish and/or maintain good site drainage. Grades must be adjusted to provide positive drainage away from the structure, pavement, and other site improvements during construction and maintained throughout the life of the proposed facility. The following drainage precautions are recommended:

a) Ground surface around the perimeter foundation walls should be sloped to drain away from the structure in all directions. Current building codes require a minimum slope of 6 inches in the first 10 feet (5%) of the structure. At the completion of construction, Cesare recommends a continuous slope away from foundations of 12 inches in the first 10 feet (10%), where site constraints permit. Cesare recommends that concrete and pavement adjacent to structures slope at a rate of at least 2% away from the structure or as otherwise required by ADA criteria. Maximum grades practical should be used for paving and flatwork to prevent areas where water can pond.
b) Joints that occur at locations where paving or flatwork abuts the structure should be properly sealed with flexible sealants and maintained.

c) Ground surface should be sloped so water will not pond between or adjacent to structures and other site improvements. Curbs, sidewalks, paths, plants, or other improvements should not block, impede, or otherwise disrupt surface runoff. Use of chases and weep holes to promote drainage is encouraged. Landscape edging should be perforated or otherwise constructed in a manner to prevent ponding of surface water, especially in the vicinity of the backfill soil.
d) Drainage swales should be located as far away from the foundation as practicable.
e) If site constraints do not allow for the recommended slopes, the project civil engineer shall provide a method for drainage that is equivalent to the recommendations herein. Water should not be allowed to pond adjacent to or near foundations, flatwork, or other improvements.
f) Roof downspouts and other water collection systems should discharge onto pavements or extend away from the structure well beyond the limits of the backfill zone using downspout extensions, appropriately sized splash blocks, or other means. Buried downspout extensions are discouraged as they can be difficult to monitor and maintain.
g) Irrigation directly adjacent to the structure is discouraged and should be minimized. Sprinkler lines, zone control boxes, and sprinkler drains shall be located outside the limits of the foundation backfill. Sprinkler systems should be placed so that the spray from the heads, under full pressure, does not fall within 5 feet of the foundation walls.
h) Plants, vegetation, and trees that require moderate to high water usage are discouraged and should not be located within 5 feet of foundation walls.
i) Plantings that are desired within 5 feet of the foundation should be placed in watertight planters/containers.
j) The project civil engineer shall perform measurements to document that positive drainage, as described in this section or as otherwise designed by the project civil engineer is achieved. Maintenance of surface drainage is imperative subsequent to construction and is the responsibility of the owner and/or tenant.

19. PAVEMENT RECOMMENDATIONS

19.1 DESIGN CRITERIA

The pavement recommendations contained in this report are based on the AASHTO 1999 and the design parameters indicated in Table 19.1.

TABLE 19.1. Pavement Design Parameters

Design Parameter	Value
Design period (years)	20
Initial serviceability (ρ_s)	4.5
Terminal serviceability (ρ_t)	2.0
Serviceability loss, (ρ_s-ρ_t)	2.5
Reliability, Z_r (%)	80
Overall standard deviation, S_o (APM)	0.44
Total 18 kip ESAL's/EDLA • Automobile parking • Drive lanes and entry drives	 35,000 70,000
Subgrade strength	

• R-value (gravelly sands, estimated)	67
Strength coefficients for: a. APM b. ABC	 0.44 0.12

Deviation from the parameters shown in Table 19.1 will require a revision to the recommended pavement section thicknesses. If the subgrade becomes saturated, the pavement is not properly maintained, and/or the actual traffic is greater than the values used in the design, the design service life will be reduced.

19.2 PAVEMENT THICKNESSES

The current at grade soil has an estimated R-value of 67. This soil provides good support of pavement systems. The recommended pavement sections are shown on Table 19.2.

TABLE 19.2. Recommended Pavement Section Thicknesses

Traffic Area	Alternate	APM (in)	ABC (in)	PCC (in)
Parking lots	APM+ABC	3.0	6.0	--
Drive lanes	APM+ABC	3.0	6.0	--
Trash dumpster	PCC	--	--	6.0

19.3 TRASH DUMPSTER APPROACHES

Approaches to trash dumpsters typically experience a greater frequency of distress due to higher loading conditions. To reduce the risk of increased maintenance, Cesare recommends paving these areas with concrete. CDOT Class P portland cement concrete is recommended. Cesare recommends control joints spaced at a maximum spacing of 12 feet, and at least one control joint transverse and longitudinal to each approach. The approach to the trash dumpster should be large enough to include the collection truck's runup braking distance and its front wheels should fully bear on the slab when emptying the dumpster.

19.4 SUBGRADE PREPARATION AND PAVEMENT CONSTRUCTION

19.4.1 Pavement Subgrade

The entire subgrade should be proof rolled a maximum of 24 hours prior to paving with a loaded 988 front end loader or similar heavy rubber tired vehicle (GVW of 50,000 pounds with 18 kip per axle at tire pressures of 90 psi) to detect any soft or loose areas. All areas exhibiting unstable subgrade conditions, such as rutting, pumping, or excessive movement should be overexcavated to a firm soil layer or to a maximum depth of 2 feet, whichever is shallowest, and replaced with suitable compacted fill. If unstable subgrade conditions persist, Cesare should be contacted for consultation. Soft spots should be stabilized prior to placement of pavement sections. Positive drainage off paved surfaces should be provided.

19.4.2 Subbase and Aggregate Base Course

Subbase and ABC should meet the following requirements:

- C ABC material should be approved prior to construction and should subsequently be tested as the material is being placed.

- ABC should have a minimum R-value of 77.
- ABC material should be compacted to a minimum of 95% of the MDD as determined by the modified Proctor test, ASTM D1557.

19.4.3 Pavement

Pavement construction shall be in accordance with the following recommendations and criteria:

- APM shall meet the requirements in the CDOT *Standard Specifications for Road and Bridge Construction*, Section 400.
- Asphalt binder grade shall be PG 58-28, N_{Design} of 50 or 75.
- Approved APM material should Grade SX and be placed in the maximum lifts of 3 inches.
- APM shall be compacted to 92% to 96% of the maximum theoretical density within 0.3% of the optimum asphalt content as determined by ASTM D2041.
- APM placement specifications should follow CDOT specifications and industry standards as recommended by the NAPA and the AI.
- Portland cement concrete should be obtained from an approved mixture design with minimum properties meeting a CDOT Class P mixture.
- Portland cement concrete placement specifications should follow industry standards as recommended by the ACI and the PCA.
- Positive drainage off paved surfaces should be provided.

Construction material should be approved prior to use and should subsequently be tested as this material is being placed.

20. SOIL CHEMICAL TESTING

20.1 SULFATE EXPOSURE

Water soluble sulfate contents of 0.00% were measured on samples collected from Exploratory Pit EP-1 from depths of 1 to 2 feet. Results are summarized in Appendix B. The PCA publication titled, *Design and Control of Concrete Mixtures*, 2002 and the ACI publication titled, *Building Code Requirements for Structural Concrete and Commentary*, consider this range negligible for water soluble sulfate exposure.

21. GEOTECHNICAL RISK

The concept of risk is an important aspect of any geotechnical study. The primary reason for this is that the analytical methods used by geotechnical engineers are generally empirical and must be tempered by engineering judgment and experience, therefore, the solutions or recommendations presented in any geotechnical study should not be considered risk free, and more importantly, are not a guarantee that the interaction between the soil and the proposed construction will perform as predicted, desired, or intended. The engineering recommendations presented in the preceding sections constitute Cesare's best estimate of those measures that are necessary to help the structure/pavement perform in a satisfactory manner based on the information generated during this study, training, and experience in working with these conditions.

22. LIMITATIONS

This document has been prepared as an instrument of service for the exclusive use of Mr. ory

Upchurch for the specific application to the project as discussed herein and has been prepared in accordance with geotechnical engineering practices generally accepted in the state of Colorado at the date of its preparation. No warranties, either expressed or implied, are intended or made. This document should not be assumed to contain information for other parties or other purposes.

The findings of this study are valid as of the date its preparation. Changes in the conditions of a property can occur with the passage of time, whether due to natural processes or the works of people on this or adjacent properties. Standards of practice evolve in engineering and changes in applicable or appropriate standards may occur, whether they result from legislation or the broadening of knowledge. Accordingly, the findings of this study may be invalidated wholly or partially by changes outside of Cesare's control, therefore, this study is subject to review and should not be relied upon without such review after a period of 3 years.

In the event that changes, including but not limited to, the nature, type, design, size, elevation, or location of the project or project elements as outlined in this report are made, the conclusions and recommendations contained in this report shall not be considered valid unless Cesare reviews the changes and either confirms or modifies the conclusions of this report in writing.

Cesare should be retained to review final plans and specifications that are developed for proposed construction to judge whether the recommendations presented in this report and any addenda have been appropriately interpreted and incorporated in the project plans and specifications as intended.

The exploration locations for this study were selected to obtain a reasonably accurate depiction of underground conditions for design purposes and these locations are often modified based on accessibility and the presence of underground or overhead utility conflicts. Variations from the soil conditions encountered are possible. These variations may necessitate modifications to Cesare's design recommendations, therefore, Cesare should be retained to observe subsurface conditions, once exposed, to evaluate whether they are consistent with the conditions encountered during Cesare's exploration and that the recommendations of this study remain valid. If parties other than Cesare perform these observations and judgements, they must accept responsibility to judge whether the recommendations in this report remain appropriate.

Cesare's scope of services for this report did not include either specifically, or by implication, any environmental assessment of the site or identification of contaminated or hazardous material or conditions. Additionally, none of the services performed in connection with this study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not, of itself, be enough to prevent mold from growing in or on the structures involved.

At a minimum, Cesare should be retained during construction to observe and/or test:

- completed excavations.
- placement and compaction of fill.
- proposed import or onsite fill material.
- placement and compaction of pavement subgrade, subbase, base course and asphalt.

Cesare offers many other construction observations, materials engineering, and testing services and can be contacted to discuss further.

W:\2021\SCB\21.6099.A Upchurch Annex\ACAD\Boring Location Map.dwg 7/30/2021 8:37 AM

BACKGROUND IMAGE FROM GOOGLE EARTH

PROJECT NO:	21.6099		
PROJECT NAME:	Upchurch Annex		
DRAWN BY:	ZLM	CHECKED BY:	DRD
DWG DATE:	07.30.21	REV. DATE:	--

FIGURE 1
Vicinity Map

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BACKGROUND IMAGE FROM GOOGLE EARTH

PROJECT NO:	21.6099		
PROJECT NAME:	Upchurch Annex		
DRAWN BY:	ZLM	CHECKED BY:	DRD
DWG DATE:	07.30.21	REV. DATE:	--

FIGURE 2
Site Plan and Location of Exploratory Pits

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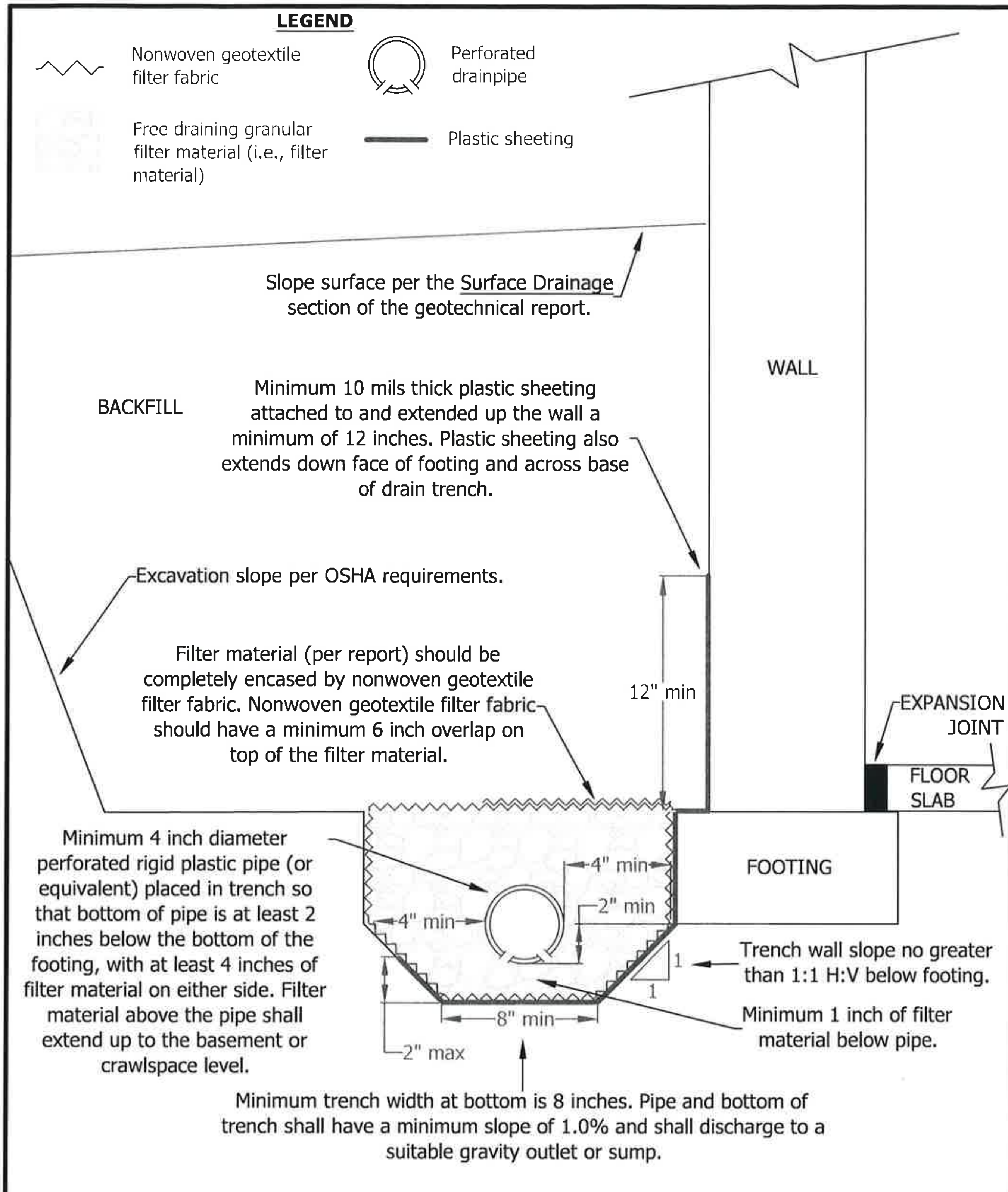

FIGURE 3

Typical Exterior Perimeter Drain - Footing

PROJECT NO:	21.6099		
PROJECT NAME:	Upchurch Annex		
DRAWN BY:	YES	CHECKED BY:	DRD
DWG DATE:	08.08.18	REV. DATE:	07.28.21

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APPENDIX A

Field Exploration

PROJECT NAME Upchurch Annex
PROJECT NUMBER 21.6099
CESARE REP. D.Duran
DATE STARTED 7/6/2021
DATE COMPLETED 7/6/2021
CO STATE PLANE
EXPLORATORY PIT ID EP-1
PIT ELEVATION ft.
PIT LOCATION
EXCAVATOR COMPANY
TYPE OF EXCAVATOR Bobcat E50

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
			Topsoil	0.75	0.0						
			SAND, gravel, cobbles in a silt matrix, calcareous, slightly moist, light brown (SM; A-1-b).	2		Bulk			28-23-5	13	
			GRAVEL, sand, cobbles with silt, poorly graded, rounded to subrounded clasts, moist, brown (GP-GM; A-1-a).	5	2.5 / 5.0						

Pit excavated to 5 feet

LEGEND

WATER LEVEL AT TIME OF EXCAVATION

DEPTH OF REFUSAL

BULK SAMPLE

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PROJECT NAME	Upchurch Annex	EXPLORATORY PIT ID	EP-2
PROJECT NUMBER	21.6099	PIT ELEVATION	ft.
CESARE REP.	D.Duran	PIT LOCATION	
DATE STARTED	7/6/2021	EXCAVATOR COMPANY	
DATE COMPLETED	7/6/2021	TYPE OF EXCAVATOR	Bobcat E50
CO STATE PLANE			

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft) / MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
		Topsoil	0.75	0.0						
		SAND, gravel, cobbles in a silt matrix, calcareous, slightly moist, light brown (SM; A-1-b).	2.25		Bulk sample			21-21-1	6	
		GRAVEL, sand, cobbles with silt, poorly graded, rounded to subrounded clasts, moist, brown (GP-GM; A-1-a).	5	2.5	Bulk sample					
		Pit excavated to 5 feet		5.0						

LEGEND

▼ WATER LEVEL AT TIME OF EXCAVATION

↑ DEPTH OF REFUSAL

☒ BULK SAMPLE

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

PROJECT NAME	Upchurch Annex	EXPLORATORY PIT ID	EP-3		Page 1 of 1
PROJECT NUMBER	21.6099	PIT ELEVATION	ft.		
CESARE REP.	D.Duran	PIT LOCATION			
DATE STARTED	7/6/2021	EXCAVATOR COMPANY			
DATE COMPLETED	7/6/2021	TYPE OF EXCAVATOR	Bobcat E50		
CO STATE PLANE					

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft) / MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
		Topsoil	0.75	0.0						
		GRAVEL, sandy, cobbles with silt, poorly graded, rounded to sub rounded clasts, calcareous, slighty moist to moist, light brown to brown (GP-GM; A-1-a).	5	2.5	Bulk sample			NV-NP-NP	5	
		Pit excavated to 5 feet		5.0						

LEGEND

▼ WATER LEVEL AT TIME OF EXCAVATION

↑ DEPTH OF REFUSAL

BULK SAMPLE

CESARE, INC.
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PROJECT NAME	Upchurch Annex	EXPLORATORY PIT ID	EP-4	Page 1 of 1
PROJECT NUMBER	21.6099	PIT ELEVATION	ft.	
CESARE REP.	D.Duran	PIT LOCATION		
DATE STARTED	7/6/2021	EXCAVATOR COMPANY		
DATE COMPLETED	7/6/2021	TYPE OF EXCAVATOR	Bobcat E50	
CO STATE PLANE				

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
			Topsoil	1	0.0						
			GRAVEL, sandy, cobbles with silt, poorly graded, rounded to sub rounded clasts, calcareous, slighty moist to moist, light brown to brown (GP-GM; A-1-a).	4	2.5	Bulk sample					

Pit excavated to 4 feet

LEGEND

▼ WATER LEVEL AT TIME OF EXCAVATION

↑ DEPTH OF REFUSAL

BULK SAMPLE

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APPENDIX B

Laboratory Testing

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SUMMARY OF LABORATORY TEST RESULTS

Upchurch Annex

Project No. 21.6099

Sample Location		Water Soluble Sulfates (%)	Gradation			Atterberg Limits		Material Type
Pit	Depth (feet)		Gravel (%)	Sand (%)	Silt/ Clay (%)	Liquid Limit (%)	Plasticity Index (%)	
EP-1	1 to 2	0.00	43	44	13	28	5	(SM) Silty sand with gravel; A-1-b
EP-2	1 to 5		51	43	6	22	1	(GP-GM) Poorly graded gravel with silt and sand; A-1-a
EP-3	2 to 5		50	45	5	NV	NP	(GP-GM) Poorly graded gravel with silt and sand; A-1-a

NV=No Value; NP= Non-plastic

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APPENDIX C

Vapor Barriers

VAPOR BARRIERS

If it is determined that a vapor retarder/barrier is warranted, Cesare recommends that the vapor barrier comply with ASTM E1745, and if moisture sensitive flooring will be utilized, have a permeance below 0.01 perms before and after mandatory conditioning testing. The vapor retarder/barrier should be installed per ASTM E1643 and the design professional should consider project specific requirements in specification verbiage. See the ACI Committee 302, "Guide for Concrete Floor and Slab Construction (ACI 302.R-96)" for additional discussion and guidance regarding the use of vapor retarders/barriers beneath floor slabs.

The 2018 IBC, Section 1805.2 Dampproofing states that where hydrostatic pressure will not occur, as determined by Section 18-03.5.4, floors shall be dampproofed in accordance with this section.

Section 1805.2 Floors, states,

> "*Dampproofing materials for floors shall be installed between the floor and the base course required by Section 1805.4.1, except where a separate floor is provided above a concrete slab. Where installed beneath the slab, dampproofing shall consist of not less than 6-mil (0.006 inch; 0.152 mm) polyethylene with joints lapped not less than 6 inches (152 mm), or other approved methods or materials. Where permitted to be installed on top of the slab, damp proofing shall consist of mopped-on bitumen, not less than 4-mil; (0.004 inch; 0.102 mm) polyethylene, or other approved methods or materials. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer's installation instructions*".

Section 1805.4.1 Floor Base Course, states,

> *"Floors of basements, except as provided for in Section 1805.1.1 shall be placed over a floor base course not less than 4 inches (102 mm) in thickness that consists of gravel or crushed stone containing no more than 10 percent of material that passes through a No. 4 (4.75mm) sieve."*

Cesare recommends that the architect be consulted regarding the need for a vapor retarder or vapor barrier. Decision to include a vapor retarder/barrier beneath the slab is dependent on the sensitivity of floor coverings and building use to moisture.