TECHNICAL SPECIFICATIONS

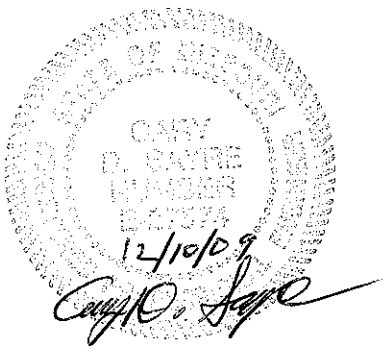
FOR

INTAKE STRUCTURE DESIGN
LITTLE OTTER CREEK LAKE

CALDWELL COUNTY, MISSOURI

NOVEMBER 2008
(Revised NOVEMBER 2009)

Project No. 05384.01



ALLSTATE CONSULTANTS
30601 HIGHWAY 5
P.O. BOX 156
MARCELINE, MO 64658
(660) 376-2941

ENGINEERING • PLANNING • SURVEYING • GEOTECHNICAL • INVESTIGATIVE

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840 INTAKE STRUCTURE - SUMMARY OF WORK

PART 1 – DESCRIPTION

a. General: The work to be completed consists of the installation of a new reinforced concrete intake structure, water piping, valving, handrails, grating, reinforcing steel, ladder, valve vault, drainage system, trash screens, and appurtenances, to be located at the proposed Little Otter Creek Lake in Caldwell County, Missouri. Incidental items such as excavation, demolition, concrete, placement, painting, testing, insurance, and all other appurtenances shall be provided for a complete and functional final product.

b. Site Use: The Contractor shall have full use of the site or easement area for construction practices and operation. The Owner shall also have use of the site to complete work and/or other Contractors or other professionals to complete work as required. The Contractor shall coordinate site use as necessary.

c. Contract: Parts not applicable to this job concerning funding agencies will be ignored.

d. Specifications: The project will be constructed under these bound specifications and shall be used in conjunction with the plans. Contractor shall include all necessary appurtenances to make the structure a complete and operable system. For the unit prices shown the Contractor shall include necessary items to make installation and operation complete.

e. Summary: In certain locations in the specifications, contract documents and on the plans, words, and language may be abbreviated. These abbreviations, words, and meanings shall be interpreted by the Engineer as required.

PART 2 – UTILITIES AND SUBSURFACE CONDITIONS

a. Utilities: The Contractor shall be responsible for locating safety and working around all utilities. Any damage to utilities, persons, equipment, or any other property shall be the responsibility of the Contractor. The pipe size and type shown may not be accurate but are believed to be true. The Contractor shall be responsible for all fittings, piping, and appurtenances at no cost to the Owner.

b. Testing and Exploration: Contractor shall be responsible for test drilling, probing, or other invasive or non-invasive types of investigations. The Owner shall be notified at least 24 hours in advance of any invasive testing.

PART 3 – PAYMENT

No extra payment will be due to the Contractor for testing, subsurface exploration, utility repairs, or other items associated with excavation and backfill, piping, or concrete work.

02008 DUCTILE IRON PIPE (DIP)

PART 1 – GENERAL

1. APPLICABLE STANDARDS

Unless indicated otherwise on the Plans, all materials (including testing procedures) and installations shall conform to the latest revision of the following standards:

a. AMERICAN WATERWORKS ASSOCIATION

1. C-101, C-106, C-108: (Cast Iron Pipe - referenced only as it pertains to existing facilities)
2. C-104 Cement Lining
3. C-110 Fittings
4. C-111 Gaskets
5. C-200, C-203, C-204, C-205, C-206, C-207, C-208, C-209, C-210, C-213 Steel Pipe
6. C-151 Ductile Iron Pipe
7. C-500, C-504, C-506, C-508, C-509: Valves
8. C-502 Hydrants
9. C-600 Pipelaying
10. C-651, C-652 Disinfection
11. C-700, C-701, C-702, C-704, C-706: Meters and Registration Systems
12. C-800 Service Lines

b. AMERICAN NATIONAL STANDARD INSTITUTE

1. A-21.1
2. A-21.6
3. A-21.10
4. A-21.11
5. A-21.51

c. AMERICAN SOCIETY OF TESTING MATERIALS

1. ASTM A-53
2. ASTM A-120
3. ASTM B-88
4. ASTM D-1598
5. ASTM D-1599
6. ASTM D-1693
7. ASTM D-1784
8. ASTM D-2241
9. ASTM D-2581
10. ASTM D-2937
11. ASTM D-3139
12. ASTM F-477

d. COMMERCIAL STANDARD

1. CS-256

e. NATIONAL SANITATION FOUNDATION

1. NSF No. 61. The NSF logo must be stamped on the pipe.

f. FEDERAL SPECIFICATIONS

1. WW-T-799

PART 2 - PIPE MAINS (POTABLE AND RAW WATER)

1. GENERAL

Pipelines in trenches, and piping inside structures, shall be complete with all fittings, valves, joints, and appurtenances. The interior of all pipe and appurtenances will be cleaned of foreign material; during installation, all openings will be temporarily closed to prevent the entrance of foreign material. Unless otherwise shown on the plans, all piping shall be ductile iron pipe.

2. DUCTILE IRON PIPE

a. Ductile Iron Pipe will comply with the requirements of AWWA C-151, Class 55 through the dam and Class 52 (minimum) in other locations as shown on the plans. All pipe, fittings, and specials shall be bituminous coated on the outside. The coating must be smooth, glossy, not brittle when cold nor sticky when hot, and must adhere to the pipe at all intermediate temperatures. The coating must be free of cracks, blisters, or visible holes. Skid marks and other abrasions to the pipe will be repaired or replaced prior to installation.

b. Joints for Ductile Iron Pipe shall be mechanical and restrained joint unless otherwise noted. Slip joints may not be used. Special joints such as restrained or ball and socket joints will be as noted on the Plans; joints shall conform to AWWA C-111.

c. Cement Lining for Ductile Iron Pipe and Fittings shall comply with AWWA C-104 and ANSI-21.4. The cement lining shall contain a bituminous seal coat, which after drying, shall have no deleterious affect upon the quality, taste, color, or odor of potable water.

d. Fittings shall conform to the requirements of AWWA C-110 or AWWA C-153. Fittings shall be supplied with transition gaskets as required for connection to PVC or other piping material. Mechanical joint fittings shall have standardized mechanical joint ends.

PART 3 - SPECIALS

a. In laying lines, ductile iron specials may be used in roadways or other crossings, and at locations as may be designated on the Plans or directed by the Engineer. These specials shall consist of tees, crosses, bends, etc.; these fittings shall be installed with the same care and attention as normal line fittings. These fittings shall be provided with iron plugs (or caps) at points where cross mains are not connected at the present time, or where anticipated future connections are proposed.

b. Pipes passing through walls and/or slabs shall be installed by cast in place of through-wall fittings, pipe sleeves. All through-wall piping, regardless of the method used, shall be cast in the concrete or grouted in formed openings with non-shrink grout. Pipe openings must be left watertight.

c. Flanged joints shall be used at all locations inside structures unless otherwise noted. Flanged fittings shall be short bodied ductile iron, and shall comply in all respects with AWWA C-110. Flange bolts shall be of the best quality, mild steel using square or hexagonal bolt heads, and hexagonal, cold pressed nuts. The diameter of the bolts shall conform to ASA Specifications for each size of flange, and the length shall be such that, after installation, the projection beyond the face of the nut will be between one-eighth (1/8) and three-eighths (3/8) inch.

d. Stainless steel anchors, bolts, and hardware shall be provided where shown on the plans.

e. The Contractor shall during the course of piping installation, provide and install a tracer wire alongside the transmission main.

f. Gaskets shall be of the best grade rubber or approved composition material, cut to fit standard flange drilling. Inside and outside diameters of the gasket shall be identical with those of the flange. Rubber gaskets shall comply with AWWA C-111 and ANSI 21.11 for ductile iron pressure pipe.

PART 4 - TRENCHING AND BACKFILLING

1. TRENCHING

a. In general, trench excavation for mains shall be by the open cut method. The Contractor shall determine the requirements of the manufacturer.

b. The depth of the trench shall be sufficient to provide at least forty-eight (48) inches and no more than seventy-two (72) inchs of cover material over the top of the pipe except through the dam. Special circumstances as may warrant additional cover material will be as noted on the Plans, or as directed by the Engineer.

c. Excavated material shall be deposited along the sides of the trench in such a workman like manner. Care shall be taken not to block natural watercourses which could cause flooding and damage to adjacent property. Any drains, culverts, or watercourses disturbed during the course of the work shall be replaced in as good a condition as they were prior to construction, and new materials shall be used to replace any broken or damaged by the Contractor during the progress of the work.

d. The Contractor shall not open more trench in advance of the pipe laying than is necessary to expedite the work.

e. Trenches shall generally be excavated to a uniform grade and in a straight line. Where changes in grade or alignment are necessary, such changes shall be gradual, and shall provide a uniform bed for the pipe. In no case will the change in vertical or horizontal alignment exceed the recommendations for pipe deflection specified by the manufacturer of the pipe being used. Drastic changes in horizontal or vertical alignment shall be accomplished through the use of bends or fittings as shown on the Plans, or as directed by the Engineer.

f. The Contractor must determine for himself, the location and size of any underground obstacles, piping, conduit, sewers, etc., and any underground utilities damaged shall be replaced to the original condition, at the Contractor's expense. Additionally, the Contractor shall determine the location and extent of any creek or ditch crossings which may be encountered, and shall include any necessary piping and/or fittings which may be required in the price bid for pipe installation. No additional payment will be made for these items unless they are specifically noted in the Proposal Form.

g. In the course of the trenching operation, the Contractor shall not cut fences without written permission from the property owner. Any fences damaged shall be replaced (or repaired to the original condition) at the Contractor's expense.

h. The Contractor must satisfy himself of the trenching conditions, which may be encountered during the progress of the work. Should rock be encountered during the excavation for the mains, valves, fittings, or specials, the same shall be considered to be included in the price bid for line installation, and no additional compensation for rock excavation will be made.

i. Rock greater than 1-inch will be excavated below the proposed water main to a depth of at least 6-inches and replaced with suitable bedding material.

j. Water mains shall not be installed in a trench containing water. Contractor shall be responsible for all trench safety procedures including trench boxes, dewatering equipment, and all associated equipment. Contractors shall use pumps, hoses, excavation equipment, rock, or any such means to keep piping out of water in a trench.

2. BACKFILLING

a. The line, when installed in the trench, shall be completely backfilled. The line, however, shall be tested for leakage when a water supply is available for such testing.

b. Backfilling shall closely follow completed installation of the main and appurtenances, but not until the installation has been inspected by the Engineer, and all connection locations recorded by the Contractor. In all cases, the pipe shall be backfilled the same day as laying except as specified further below; backfill material may be suitable earth material from the trench excavation. Care shall be taken to avoid damage to the pipe, or to producing unequal pressures thereon. No frozen material shall be used for backfill. Unless otherwise directed, backfill shall be compacted to at least ninety-five (95) percent of maximum density, as determined by standard compaction tests.

c. If trenches have not been properly filled, and settlement occurs, refilling shall be instituted as required to bring the surface to conformity with the surrounding ground surface.

PART 5 - INSTALLATION OF PIPELINES AND FITTINGS

a. In general, metal pipelines shall be installed to the alignment, both horizontal and vertical, as staked, graded, or otherwise determined, fixed or approved by the Engineer. All pipe shall be laid to horizontally straight lines between fittings, specials, or designated points. Except as otherwise specified or directed, the vertical alignment of all pipe will be on a straight line between valleys and summits, or to points of tangency of vertical curves or pipe bends where used.

b. At specified crossing points, or at special crossing locations, the pipe shall be laid to the grades indicated on the profile drawings, and as established by the Engineer. Grades thus established, either by means of offset grade stakes or direct levels, shall provide a minimum depth of cover of four (4) feet. The established grades will also provide for additional pipe depths where required for crossings, ground surface irregularities, for laying pipes on vertical curves within specified joint limits, and at drainage courses.

c. Pipe and accessories shall be handled in such a manner as to ensure installation in sound, undamaged condition. Special care will be taken not to injure the pipe coating. No other pipe or material of any kind shall be placed inside of any pipe or fitting.

d. Cutting shall be done in a neat, workmanlike manner by methods, which will not damage the pipe. Pipe shall be cut at ninety (90) degrees to centerline, with cut ends beveled or smoothed as required. Wheel cutters will be used whenever practicable. Unless otherwise authorized, all cutting shall be done by means of approved mechanical cutters.

e. Before installation, the pipe shall be inspected for defects, and rung with a light hammer to detect cracks. Any defective, damaged, or unsound pipe shall be rejected.

f. Unless permission is given by the Engineer, every joint shall be jointed in the trench, and the Contractor shall not lower into the trench, two (2) or more pipes joined together at the side of the trench, nor shall pipe be blocked up during jointing.

g. Valves, specials, and other appurtenances shall be placed as shown on the Plans, or as directed by the Engineer. Any omission of these appurtenances shall be corrected by the Contractor, and the same set as originally planned or ordered, without additional charge to the Owner. All fittings, specials, etc. shall be installed with concrete thrust blocking sized as noted on the Plans. Thrust blocking shall be set on undisturbed soil, and may be increased in size should unsatisfactory soil conditions occur. All fittings shall be wrapped with polyethylene (minimum 6-mil) prior to the placement of the blocking. Blocking used at crosses or tees, or at end of line caps or plugs, shall be so placed to not interfere with possible future connections or extensions.

PART 6 - PRESSURE AND LEAKAGE TESTS

1. GENERAL

a. No part, section, or whole of the system, including services, shall be accepted unless, or until, the leakage determined under test pressure is less than the specified maximum. Averaging the amount of parts or sections of the system to determine the leakage for the whole system, will not be permitted, regardless of the test method used. The Engineer shall specify the type of test method to be used. A successful pressure test does not relieve the Contractor of his responsibilities under the terms of the Contract Agreement. The Contractor shall provide all additional metering equipment or appurtenances, unless otherwise directed, necessary for completion of system testing. The Contractor will also be responsible for purchasing, or otherwise obtaining, all water required for the initial (and all subsequent) flushing(s), disinfection, testing, filling, and any other necessary requirements relating to the testing procedures for the system. All water, materials, and appurtenances required for the testing shall be considered as incidental to the completion and acceptance of the system, and the costs for the same shall be included with the price bid for line construction.

b. Unless otherwise specified, test pressure will be double the operating pressure gradient at the lowest system elevation, or the pressure rating of the pipe plus fifty (50) psi, whichever is the lesser. The total test pressure shall not exceed any ASTM long-term test, which the pipe must pass. The duration of the test shall be two (2) hours, unless otherwise specified.

c. Sufficient backfill material shall be placed before filling the pipe with water and field testing, to prevent lifting of the pipe. If local conditions require that the trenches be backfilled immediately after pipe installation, testing may be carried out after backfilling has been completed; before placing the permanent surface. The entity supplying the water for tests shall be given seven (7) days advance notice by the Contractor.

d. The following procedures are based on the assumption that pressure and leakage tests will be performed at the same time. Each section of the line shall be slowly filled with water, and all air expelled by means of taps at high points **(such taps will not be considered as air release assemblies)**. Specified test pressure will be applied using a pump connected to the pipe in an Engineer approved manner. Test pressure must be maintained by additional pumping, as necessary, for the specified time, during which all exposed pipe, fittings, valves, and appurtenances will be carefully examined. All defective elements shall be replaced or repaired, and the test repeated until all visible leakage has been stopped, and the allowable leakage requirements have been met.

e. The Contractor shall furnish the gauges and measuring devices for the leakage test, pump, piping, valves, connections, and all other necessary apparatus, and shall furnish the necessary personnel to complete the test.

2. TEST METHOD NO. 1

The duration of each leakage test shall be two (2) hours, and during the test, the main shall be subjected to the pressure required above, or as specified in the purchaser's addendum to this standard. Leakage shall be defined as the quantity of water that must be supplied to the newly laid pipe, or any valved section thereof, to maintain the specified leakage test pressure after the pipe has been filled with water, and the air in the pipe line has been expelled. No installation will be accepted if the leakage is greater than that determined by the formula:

$L = (Nd \times \sqrt{P}) / 3,700$

"L" is the allowable leakage, in gallons per hour; "N" is the number of joints in the length of pipeline tested; "D" is the nominal diameter of the pipe, in inches; and "P" is the average test pressure during the leakage test, in pounds per square inch gauge.

3. TEST METHOD NUMBER TWO – REQUIRED FOR FmHA FINANCED PROJECTS

a. General: The test time period for this test shall be twenty-four (24) hours, and the line shall be considered to be acceptable only when the leakage determined under the test pressure (test pressure to be the working pressure of the pipe) is less than ten (10) gallons per inch of pipe diameter, per mile, per twenty-four (24) hours. The total test pressure shall not exceed any ASTM long-term test which the pipe must pass.

b. The Engineer may reduce:

1. The time of the pressure test to less than twenty-four (24) hours. Allowable leakage will be reduced in direct proportion to the test time;

2. If the test pressure is less than the pressure class of the pipe, allowable leakage will also be reduced in direct proportion to the reduction in test pressure, compared with the test pressure class of the pipe. Reduced test pressure will not be less than the pressure expected when the system, including service lines, is placed into service;

3. When both time and test pressure are reduced, allowable leakage will be calculated first for time, under Item 1. above. This calculated allowable leakage for reduced time will become the allowable leakage to be reduced when test pressure is reduced under Item 2. above.

c. Testing Procedures: Testing procedures shall not be attempted until at least seven (7) days have elapsed after the last thrust block has been cast, if cast with Portland cement, or at least three (3) days if high-early-strength cement is used.

PART 7 - RESPONSIBILITY FOR MATERIALS

1. RESPONSIBILITY FOR MATERIALS FURNISHED BY THE CONTRACOTR

The Contractor shall be responsible for all material furnished by him, and shall replace, at his expense, all such material found damaged or defective in manufacture. This shall include the furnishing of all material and labor required for the replacement of installed material discovered defective prior to the final acceptance of the work.

2. RESPONSIBILITY FOR MATERIALS FURNISHED BY THE OWNER

The Contractor's responsibility for material furnished by the Owner shall begin at the point of delivery to the Contractor. Materials already on the site shall become the Contractor's responsibility on the day of Award of the Contract. The Contractor shall examine all materials furnished by the Owner at the time and place of delivery to him, and shall reject all defective material. Any material furnished by the Owner, and installed by the Contractor without discovery of such defects will, if found defective prior to final acceptance of the work, be replaced with sound material by the Owner. The Contractor, however, shall, at his expense, furnish all labor, supplies, and facilities necessary to remove said defective material, and install the sound material in a manner satisfactory to the Engineer.

3. RESPONSIBILITY FOR SAFE STORAGE

The Contractor shall be responsible for the safe storage of material furnished by or to him, and accepted by him, which is intended for the work until such time that it has been incorporated in the completed project. The interior, as well as the sealing surfaces of all pipe, fittings, valves, and other appurtenances shall be kept free from dirt and foreign matter at all times. Valves and hydrants shall be drained, and stored in such a manner that they will be protected from freezing weather. Any material furnished by the Owner that becomes damaged after acceptance by the Contractor, shall be replaced by the Contractor, at his expense. Pipe stored outside for a period longer than two (2) months, shall be covered with canvas or other opaqued material, and arranged to provide for air circulation beneath the covering material. Clear plastic sheets shall not be used.

PART 8 - MEASUREMENT AND BASIS OF PAYMENT

a. Direct buried piping (including all necessary fittings) shall be paid for on a per lineal foot basis as indicated on the bid form.

b. All piping, valves, and fittings located within concrete structures including wall pipes/floor sleeves attached to structures shall be included in the lump sum bid of the particular structure.

c. See bid form for explanation.

02513 GATE VALVES

PART 1 - GENERAL

Contractor shall furnish and install gate valves located as shown on the plans and as specified herein. Valve installation shall include valve box, blocking, and all other related appurtenances. Valves shall be as manufactured by Mueller A-2360 Resilient Wedge, Clow, Pratt, or engineer approved equivalent.

PART 2 - CONSTRUCTION

a. Body Type: Gate valves shall be supplied with flanged joint ends complying with ANSI/AWWA C111. Valve body shall be iron.

b. Wedge: Gate valve shall be provided with resilient seated iron wedge, symmetrical, and fully encapsulated with molded rubber. No exposed iron. Wedge shall be extended to fit into guide channels in the valve body.

c. Stuffing Box: Gate valve shall be supplied with Triple O-Ring Seal Stuffing Box. Two upper and one lower rings.

d. Stem: Valve stem shall be non-rising equipped with two-inch wrench nut-open clockwise. Stem shall be machined from forged manganese bronze bar stock at the thrust collar.

e. Coating: Valve shall be fusion epoxy coated on interior and exterior surfaces. Epoxy coating shall meet or exceed all applicable requirements of ANSI/AWWA C550 and certified to ANSI/NSF 61.

f. Valves: Valve shall meet or exceed all applicable requirements of ANSI/AWWA C509.

g. Guide Cap Bearings: Protective guide cap bearings constructed of a polymer bearing material shall snap over each rubber encapsulated guide on the wedge providing a bearing interface between the wedge guides and the valve body's interior guide channel.

h. Anti-Friction Washers: Two (2) polymer washers (one above and one below the thrust collar) shall be incorporated into the valve design to reduce operating torque in both opening and closing directions.

i. Working Pressure: Maximum working pressure shall be 250 PSIG. Valve shall be hydrostatically tested at 500 PSIG.

j. Hardware: All nuts, washers, bolts, and appurtenances shall be stainless steel or other approved corrosion resistant material. Flange bolts and nuts shall be corrosion resistant but do not have to be stainless steel.

k. Stem Extensions: Stem extensions shall be supported by a bracket fastened securely to the concrete wall as shown on the plans.

02522 OPERATORS

PART 1 - GENERAL

Operators shall be provided at all valves, etc. as shown on the plans and/or specifications.

PART 2 – HANDWHEEL OPERATORS

a. Handwheel Operators shall have a cast bronze lift nut machined to accurately mate with the operating stem. Ball bearings shall be provided above and below the flange on the lift nut to take the thrust developed while opening and closing the gate. Bearings shall be housed in an enclosed weatherproof housing and shall be furnished with lubrication fittings. Each unit shall be fitted with a handwheel marked with direction of opening. Handwheels shall be of such diameter that handwheel pull shall not exceed forty (40) pounds on the rim. Handwheels shall be removable and shall be cast iron or fabricated steel. Protective stem covers may be mounted when required by the plans and/or specifications. Handwheel Operator shall be Waterman Industries, Inc. Type 2, Mueller, or equivalent.

b. Unless otherwise specified or shown on the plans, handwheel type lifts shall be provided without gear reduction. The crank operated type shall have single or double gear reduction depending upon the lift capacity required.

02536 MANHOLE RING AND COVER

PART 1 – GENERAL

a. Manhole ring and lid cover shall be provided complete and in place.

b. Castings shall be manufactured with a minimum tensile strength of 35,000 psi. This is in accordance with ASTM Specification A-48-83, Class 35B for gray iron. Through alloying higher tensile strengths can be produced when required.

PART 2 – FINISHED CASTINGS

a. Castings will be manufactured true to pattern within foundry limits. Published dimensions shall not deviate by +/-1/16-inch per foot.

b. All casting weights shown are averages. Published weights shall not deviate by +/-5 percent.

c. Castings shall be free of defects such as porosity, rough surfaces and shrinkage. All castings shall be cleaned by shotblasting.

d. All round castings of heavy-duty design shall be furnished with machined horizontal bearing surfaces.

e. All castings are furnished unpainted. Castings can be furnished with one coat of standard asphalt base paint. Please specify coating requirements when ordering.

PART 3 – TRAFFIC LOADS

a. Heavy Duty: For highway and street traffic. Suitable for H-20 load requirements of 16,000 lbs. Many castings are produced for much heavier traffic.

b. Medium Duty: For light traffic areas. Wheel loads not exceeding 2,000 lbs.

c. Light Duty: For non-traffic areas.

If required, proof load tests will be provided on any of the castings in the following pages. Proof load strength tests are performed in accordance with Fed. Spec. RR-F-621c.

PART 4 – MANUFACTURER

Manhole ring and cover shall be as manufactured by Deeter, Neenah, or equivalent.

05600 ALUMINUM I-BAR GRATING

PART 1 - DESCRIPTION OF WORK

a. General: The contractor shall provide all labor, materials, equipment and necessary appurtenances as required to furnish and install aluminum grating, platforms, framework, mounting hardware, clips, fasteners, and incidentals. Under normal usage, the systems shall be designed such that no spare parts or preventive maintenance shall be required.

b. Codes: Fabrication and installation shall be in compliance with all applicable codes, standards, and ordinances including ASTM, ANSI, OSHA, and NAAMM. Installation shall be in accordance with manufacturer's instructions. Where possible, field measurements shall be obtained prior to factory fabrication. Protective neoprene backing or other engineer approved materials shall be used in locations where the aluminum reacts in a negative or corrosive manner with the adjoining surfaces (ie: steel, concrete, etc.)

c. Walking Surfaces: All walking surfaces shall contain holes that allow draining such that liquids will not pool.

d. Fall Protection: OSHA approved fall protection device and correspondence harnesses with lanyards shall be included, cables, clamps, nuts, bolts, and hardware shall be stainless steel.

e. Maximum: Grating shall be aluminum alloy, swage locked I-bar grating type. Grating shall be able to withstand a uniform load of at least 100 lb/sq. ft. and a concentrated load of at least 390 lb. Maximum clear span deflection at these loads shall be 0.25 inch. The maximum clear span deflection of 0.25 inch shall be for any clear span shown on the plans. Maximum fiber stress shall be 12,000 psi.

f. Manufactured: Grating shall be manufactured by KLEMP, IKG Borden, or approved equivalent.

g. Material: Aluminum.

h. Type: Swage-Locked I-bar as shown on the plans.

i. Description: Panel shall consist of equally spaced extruded aluminum bearing bars, positioned and locked by swaged cross rods to provide permanent lock. Bearing bars shall be on 1 3/16-inch centers and cross rods shall be on 4-inch centers.

PART 2 - FABRICATION

a. Main bars shall be vertical within a tolerance of 0.10-inch per inch of depth.

b. Longitudinal bow (before fastening to supports) shall be less than 1/200 of the length.

c. Transverse bow before fastening to supports shall be less than d-inch in 3 feet.

d. Crossbars shall not deviate from a straight line perpendicular to the main bars by more than 3/16-inch in 3 feet.

e. Crossbars shall match crossbars of adjacent sections to form a continuous pattern of straight lines.

f. Panel width and length tolerances shall be plus or minus 1/4- inch.

g. Provide all openings in grating as required for installation of all piping, wiring and equipment installed under this Contract.

h. Band all openings 4 inches and larger with a metal bar same size as main bearing bar.

i. Trim-band open end of grating at head of a ladder, manway openings, hinged sections, and grating panels with metal bar same size as main bearing bar.

PART 3 - MANUFACTURERS

Aluminum I-Bar grating shall be provided by one of the following manufacturers:

Dravo Corporation, Pittsburgh, Pennsylvania.
IKG Industries.
Klemp Corporation, Chicago, Illinois.
Borden Metal Products Company, Elisabeth, New Jersey.
Or Approved equivalent.

PART 4 - INSTALLATION

a. All aluminum products shall be installed according to manufacturer's instructions.

b. All mounting hardware shall be stainless steel or aluminum. All finished surfaces shall be smooth and free of voids and rough spots.

PART 5 - PACKING, SHIPPING AND HANDLING

a. All materials shall be banded to skids or placed in boxes to prevent damage.

b. Examine all components upon arrival. Notify manufacturer of any damage immediately. Store all components under roof if possible. If stored outside, keep under tarp or suitable cover.

c. Any damaged materials will not be accepted.

PART 5 - SHOP DRAWINGS

a. Shop drawings are required to show how the grating, framework, and appurtenances will be installed complete and in place. Shop drawings shall show attachment of fasteners and clips. Shop drawings shall indicate which portions will be factory fabricated and which portions will be field fabricated. Cross sections showing elevations for the installed systems shall be shown in the shop drawings.

b. Contractor shall submit the manufacturer's specifications, load tables, and standard installation details.

c. Where applicable, contractor shall take field measurements prior to final preparation of shop drawings or factory fabrication to ensure proper fitting of the system.

05613 HANDRAILS

PART 1 - GENERAL

a. The contractor shall provide all labor, materials, equipment and necessary appurtenances as required to furnish and install handrails, kick plates, platforms, mounting hardware, clips, fasteners, and incidentals. Under normal usage, the systems shall be designed such that no spare parts or preventive maintenance shall be required.

b. Fabrication and installation shall be in compliance with all applicable codes, standards, and ordinances including ASTM, ANSI, OSHA, and NAAMM. Installation shall be in accordance with manufacturer's instructions. Where possible, field measurements shall be obtained prior to factory fabrication. Protective neoprene backing or other engineer approved materials shall be used in locations where the aluminum reacts in a negative or corrosive manner with the adjoining surfaces (ie: steel, concrete, etc.)

c. Handrails and kick plates shall be installed at all stairways, ships ladders and other locations shown on the plans or as codes and regulations require.

d. Handrails shall be 1 ½ inch diameter schedule 40 aluminum pipe with smooth mill finish. Fittings shall be including stainless steel non-welded, mechanical connection type machine screws, lock washers, structural adhesive, and threaded tubular rivets.

e. Posts and top rails shell run in continuous lengths; providing a continuous smooth top surface.

f. All mounting flanges shall be similar in design and shape unless required for a specific use.

g. All handrail systems shall be manufactured by Julius Blum & Co., Non Welded Connectorail System, or Approved Equivalent.

PART 2 - INSTALLATION

a. All aluminum products shall be installed according to manufacturer's instructions.

b. All mounting hardware shall be stainless steel or aluminum. All finished surfaces shall be smooth and free of voids and rough spots.

PART 3 - PACKING, SHIPPING AND HANDLING

a. All materials shall be banded to skids or placed in boxes to prevent damage.

b. Examine all components upon arrival. Notify manufacturer of any damage immediately. Store all components under roof if possible. If stored outside, keep under tarp or suitable cover.

c. Any damaged materials will not be accepted.

PART 4 - SHOP DRAWINGS

a. Shop drawings are required to show how the framework, handrails, kick plates, Fittings, and appurtenances will be installed complete and in place. Shop drawings shall show attachment of fasteners and clips. Shop drawings shall indicate which portions will be factory fabricated and which portions will be field fabricated. Cross sections showing elevations for the installed systems shall be shown in the shop drawings.

b. Contractor shall submit the manufacturer's specifications, load tables, and standard installation details.

c. Where applicable, contractor shall take field measurements prior to final preparation of shop drawings or factory fabrication to ensure proper fitting or the system.

APPENDIX:

Geotechnical Report

Proposed Water Supply Intake Structure
Little Otter Creek LO-1 Lake Project
Caldwell County, Missouri

January 19, 2009

Project No. 05384.01

For
Caldwell County Commission
Kingston, Missouri

Prepared By:

Allstate Consultants, LLC
Columbia, Missouri

allstate consultants llc
Engineering • Planning • Surveying • Investigative • Geotechnical

January 19, 2009

Caldwell County Commission
49 East Main Street
Kingston, Missouri 64650

Attention: Mr. Dale Hartley
Presiding Commissioner

RE: Geotechnical Report
Proposed Water Supply Intake Structure
Little Otter Creek LO-1 Lake Project
Caldwell County, Missouri
Allstate Project No. 05384.01

Dear Mr. Hartley:

We have completed the subsurface exploration, laboratory testing and geotechnical engineering report for the proposed water supply intake structure to be constructed in conjunction with the Little Otter Creek LO-1 Lake Project southeast of Hamilton in Caldwell County Missouri. The accompanying geotechnical report presents the findings of the subsurface exploration, the results of the laboratory tests and our engineering recommendations regarding the design and construction of the foundations, walls and backfill for the proposed water supply intake structure.

It has been a pleasure to be of service during the initial phase of this project. If you have any questions regarding this geotechnical report, or if we may be of further service during the design or construction phases, please feel free to contact our office.

Sincerely,

Allstate Consultants, LLC

William A. Barrow

William A. Barrow, P.E., R. G.
Geotechnical Manager
Missouri: E-16978

WAB
Enclosures

3312 LeMone Industrial Blvd. • Columbia, MO 65201 • 573/875-8799 • Fax: 573/875-8850
119 S. Main • Marceline, MO 64658 • 660/376-2941 • Fax: 660/376-3492

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GEOTECHNICAL REPORT

PROPOSED WATER SUPPLY INTAKE STRUCTURE
LITTLE OTTER CREEK LO-1 LAKE PROJECT
CALDWELL COUNTY, MISSOURI

ALLSTATE PROJECT NO. 05384.01
JANUARY 19, 2009

INTRODUCTION

Allstate Consultants, LLC has completed the subsurface exploration for the proposed water supply intake structure to be constructed as a part of the Little Otter Creek LO-1 Lake Project planned southeast of Hamilton in Caldwell County, Missouri as shown on the Site Location Plan in the Appendix.

Three (3) soil test borings, designated TB-1, TB-2 and TB-3, were performed to depths of approximately 3 to 5 feet below the existing ground surface at the proposed water intake structure site. Test boring TB-3 was extended into the underlying bedrock to a depth of 35 feet beneath the existing ground surface using a rock core barrel and a diamond bit to obtain cores of the bedrock. Laboratory tests were performed on soil samples recovered from the borings and the soil samples and rock cores were visually classified. The Test Boring Logs, Rock Core Reports with core photographs and a Test Boring Location Plan are included in the Appendix.

The purpose of this geotechnical engineering report is to describe the subsurface conditions encountered in the borings, evaluate the field and laboratory test data and provide recommendations regarding the design and construction of the foundation, walls and backfill for the proposed water supply intake structure.

GENERAL PROJECT DESCRIPTION

The proposed water intake structure will be constructed concurrently with the NRCS's Little Otter Creek Dam and Reservoir near the City of Hamilton in Caldwell County, Missouri. The Little Otter Creek LO-1 project is a proposed multi-purpose reservoir and high hazard earth embankment dam to be located in the Little Otter Creek Watershed approximately 3 miles southeast of Hamilton and some 2 miles south of US Highway 36 as shown on the Site Location Plan.

Design information provided by NRCS indicates the earth dam will have a length of about 2500 feet and a maximum height of about 82 feet. The dam crest, to be established at elevation 872 feet, will rise some 72 feet above the Little Otter Creek's

existing valley floor which has an average ground surface elevation of about 800 feet. At the permanent pool elevation of 855 feet, the earth embankment will impound a reservoir with a total drainage area of 4,825 acres and a water surface area of approximately 362 acres.

We understand the proposed dam will utilize nearly 1 million cubic yards of earth borrow material and will extend from approximate station 8+00 on the left (east) abutment to station 33+20 feet at the auxiliary spillway to be excavated into the right (west) abutment. The grass lined auxiliary spillway will have a crest elevation of 860.7 feet. The principal spillway riser will be located at approximate station 19+85 and about 100 feet upstream of the dam centerline and will have a spillway crest elevation of 855 feet. The spillway outlet pipe will consist of a 30 inch reinforced concrete pipe (RCP).

The proposed earth embankment will have 3H to 1V side slopes; a downstream stability berm with a 4H to 1V side slope and an internal drainage system consisting of a chimney drain and downstream blanket drain.

WATER INTAKE STRUCTURE DESCRIPTION

The proposed water intake structure will be located approximately 225 feet upstream of dam centerline station 15+65 and will consist of a rectangular reinforced concrete drop inlet having inside plan dimensions of about 6 feet by 6 feet. The structure will be provided with screened intake pipes having control valves and extending through the side walls at varying levels between the normal pool elevation at 855 feet and the mud line at approximate elevation 836 feet. A ductile iron outlet pipe will be provided near the base of the intake structure at approximate elevation 820 feet to supply raw water to a proposed water treatment plant to be located downstream of the new earth dam and reservoir.

Plans are to support the water intake structure on a mat foundation bearing on bedrock just outside the upstream toe of the proposed embankment dam. The outlet pipe will extend through and be constructed concurrently with the earth dam using NRCS pipe installation, backfill compaction, and downstream internal drainage specifications as agreed to during our meeting with representatives of NRCS on December 4, 2008.

Allstate designers indicate the inside bottom of the intake structure will be established near elevation 820 feet and the top of the structure will extend some 8 feet above normal water supply pool to approximate elevation 863 feet. Preliminary structural design work indicates a reinforced concrete intake structure of this description will require a reinforced mat foundation having approximate plan dimensions of 18.5 feet by 18.5 feet and a thickness of about 4 feet to accommodate buoyancy forces when the intake valves are closed. Before filling, the intake structure will have a dead weight of about 550 kips

and will apply a gross bearing pressure of less than 2000 psf to the supporting foundation strata. The net bearing pressure will be somewhat lower when consideration is given to the weight of the soil and rock that will be excavated and not replaced during backfilling around the intake structure.

We understand the water intake structure will also be subjected to lateral loading from wind, seismic activity and other potential sources.

GENERALIZED GEOLOGY OF DAM SITE

Available NRCS geologic and soil mechanics reports indicate the valley floor of the dam site is underlain by approximately 12 to 15 feet of recent clayey and sandy alluvium; the abutments by thin clayey colluvium over limited glacial deposits and the surrounding uplands by thin weathered loess deposits over as much as 30 feet of Pre-Illinoian glacial till.

The soil strata lying beneath the abutments and valley floor are underlain by Pennsylvanian beds of shale and limestone of the Lower Kansas City and Upper Pleasanton Groups. NRCS rock core borings and test trenches excavated at the dam site indicate the abutment soils are generally underlain by (from youngest to oldest) the Lower Kansas City, Fontana Shale, Winterset Limestone, Stark Shale, Upper and Lower Galesburg Shales, Bethany Falls Limestone, Hushpuckney Shale, Middle Creek Limestone, Elm Branch Shale, Sniabar Limestone, Mound City Shale and the Upper Pleasanton, Shale Hill Formation. Valley exploration by the NRCS indicates the alluvium is typically underlain by the Sniabar Limestone, Mound City Shale and the underlying Shale Hill Formation.

FIELD EXPLORATION AND LABORATORY TESTING PROCEDURES

Test borings for the water intake structure were located on the site by Allstate Consultants using the site plan we developed for the client and traditional surveying methods. Ground surface elevations at the boring locations were also determined during this survey. Approximate test boring locations are shown on the Test Boring Location Plan in the Appendix.

Test borings were performed using a track-mounted CME 550 rotary drilling rig. Solid stem, continuous flight augers were used to advance the borings and a rotary diamond core bit was used to core the rock. At relatively close vertical intervals, the augers were removed from the borehole and soil samples were obtained using split-barrel sampling methods. Standard Penetration Tests (SPT) were performed during the split-barrel sampling procedure. Rock coring was performed in the underlying bedrock in Test Boring TB-3 only.

As the borings were advanced, the drill crew recorded the results of the subsurface exploration on field boring logs. Information reported on the field logs included, the number, type, depth, recovery, penetration resistance and/or calibrated hand penetrometer reading for each sample. The field logs also included visual descriptions of the recovered soil and rock samples; the driller's interpretation of subsurface conditions between samples based on field observations and the drill crew's groundwater observations. Recovered soil samples were sealed to reduce moisture loss and transported to the laboratory for further testing and classification.

Split-barrel samples were tested in the laboratory to determine the field water content. The unconfined compressive strength of some of the samples was estimated using a calibrated hand penetrometer. These values are provided with an asterisk on the test boring logs. The strength estimated using this device is approximate and was considered accordingly during our analysis.

On completion of laboratory testing, the soil samples were described and classified in general accordance with the Unified Soil Classification System (USCS) using visual-manual procedures. USCS Group Letter Symbols and Group Names were also assigned based on visual-manual estimates. The results of the laboratory tests are shown on the test boring logs. Rock core samples were also visually classified in the laboratory.

The final Test Boring Logs and Rock Core Report included in this report present the results of the field exploration and the laboratory testing program. The final logs delineate the soil and rock strata encountered in the borings and represent the geotechnical engineer's interpretation of subsurface conditions at the boring locations. These interpretations were developed from a review of the field boring logs with modifications based on the laboratory test results and on visual observations of the recovered samples as well as a review of subsurface information made available by the NRCS from the dam site exploration. Graphical symbols depicting the soil and rock strata are shown on the boring logs for illustrative purposes. It should be recognized that differing soil and/or rock types could be present between samples and between borings.

The Test Boring Log Notes included in the Appendix describe the symbols used on the Test Boring Logs and provide additional information regarding sampling procedures; soil and rock descriptions and classification; Standard Penetration Tests; laboratory test results; the consistency of fine grained soils; the relative density of coarse grained soils; bedrock quality and borehole water level observations. The Unified Soil Classification System is also described in the Appendix and a legend is included relating the graphical symbols used on the boring logs to the USCS Group Letter Symbols and Group Names and to the principal rock types encountered in the project area.

SITE DESCRIPTION

The proposed water intake structure will be located on gently rising upland terrain on the east side of the Little Otter Creek valley some 1500 feet north of County Highway 130 (Jefferson Drive). By general legal description, the site lies in the northeast quarter of the southeast quarter of Section 32, Township 57 North, and Range 27 West in Caldwell County, Missouri.

The proposed structure will be situated on the left abutment approximately 225 feet upstream of dam centerline station 15+65 just outside the upstream toe of the proposed earth embankment as shown on the Test Boring Location Plan.

At the time of exploration, the intake structure site was covered with perennial grass, small brush and a few surrounding trees and appeared to be in a relatively undeveloped condition. The surrounding upland terrain sloped gently from the north and east to the intake structure site situated just above the valley slope near elevation 834 to 836 feet.

A few feet south and several feet west of the upland site, the sloping terrain declined more steeply toward a small tributary on the south with a flow line elevation at 812 to 816 feet and to the Little Otter Creek floodplain on the west near elevation 800 feet. Small outcrops of the Winterset Limestone were observed at approximate elevations 824 to 828 feet on the vegetated valley slopes just south and southwest of the intake structure site.

SUBSURFACE CONDITIONS

Subsurface conditions encountered at the individual boring locations are indicated on the Test Boring Logs. Stratification lines shown on these logs represent approximate boundaries between soil and rock types. In-situ, the change between material types may be more gradual. Based on a review of the Test Boring Logs, subsurface conditions at the project site can be characterized as follows:

Soil and Rock Conditions

Test Borings TB-1, TB-2, and TB-3 encountered some 4 inches of topsoil over thin deposits of native post-glacial soil and underlying Pennsylvanian bedrock similar to that encountered in the NRCS borings. Beneath the topsoil, TB-1 to TB-3 encountered surficial deposits of stiff to very stiff, fat clay with gravel and dense, clayey gravel. These weathered clayey and gravelly deposits extended to auger refusal at depths of 3 to 5 feet in the borings and were underlain by weathered Pennsylvanian limestone.

Test Boring TB-3 was extended into the underlying bedrock to a depth of 35 feet beneath the existing ground surface using a rock core barrel and a diamond bit.

Beneath the soil cover, rock coring encountered the Winterset Limestone. The Winterset Formation consisted of a moderately hard, light gray, weathered limestone with thin clay and shale seams and occasional high angle joints. The jointed and medium bedded, Winterset Limestone extended to a depth of approximately 15 feet (approx. el. 820 feet) and was underlain by the Stark Shale composed of a soft to moderately hard, black fissile shale with phosphate lenses observed along bedding planes.

Below the Stark Shale, at a depth of about 19 feet (approx. el. 816 feet), rock coring encountered a dark gray claystone with limestone nodules. This soft claystone unit appeared to be a facies of the Upper Galesburg Shale Formation. At a depth of about 22 feet (approx. el. 813 feet) TB-3 penetrated the claystone and encountered weathered shaley limestone of the Lower Galesburg Formation. This soft to moderately hard, predominantly limestone unit was fractured, appeared to be highly solutioned and contained greenish gray shale infilling throughout.

At a depth of about 27 feet (approx. el. 808 feet), TB-3 penetrated the Lower Galesburg unit and encountered the Bethany Falls Limestone. This massive unit consisted of a moderately hard, light gray, nodular limestone with occasional thin shale partings. Boring TB-3 was terminated in the Bethany Falls Formation at a depth of about 35 feet (approx. el. 800 feet) beneath the existing ground surface. Photographs of the rock cores are included in the Appendix.

Groundwater Conditions

Groundwater was not observed in the soil borings during drilling and sampling. Water was introduced into boring TB-3 during rock coring and water levels observed in this boring during the brief exploration period would have been influenced by the added drilling water.

It should be recognized that short term water level observations in open boreholes, drilled into low permeability soils, may not represent actual groundwater conditions in these materials. In fact, a considerable length of time may be required for a groundwater level to be detected and to stabilize in an open borehole extending into materials similar to those encountered in the test borings at this site.

Installation and long term observation of piezometers or groundwater observation wells, screened in the hydrologic units of interest and sealed to prevent the entrance of surface water, would be required to more accurately characterize and evaluate groundwater

levels and fluctuations in these levels in this geologic setting. While these services can be provided if requested, they are beyond the scope of this investigation.

Groundwater levels often vary across a project site and typically fluctuate at individual locations with variations in seasonal and climatological conditions. Perched water tables can develop and groundwater levels encountered during construction can be influenced by alterations in site grades, other construction activities, modifications to adjacent sites and factors not readily evident at the time the borings are performed.

During construction, groundwater levels may be higher or lower than the levels reported on the boring logs. The likelihood of fluctuating groundwater levels during construction and the rise in lake water levels during reservoir filling and future high water events should be appropriately considered during development of design and construction plans for this project.

GEOTECHNICAL EVALUATION AND RECOMMENDATIONS

Geotechnical Evaluation

We understand proposed plans are to support the proposed water intake structure on a mat foundation bearing at approximate elevation 816 feet. Exploration indicates, this plan will require excavation of approximately 3 to 5 feet of clayey and gravelly overburden; some 10 feet of jointed and medium bedded Winterset Limestone; and about 4 feet of soft to moderately hard, black fissile shale to reach the design bearing elevation.

In our opinion, excavation of the soil and rock units described above and support of the intake structure on a mat foundation as proposed is feasible. However, at approximate elevation 816 feet the bearing material will consist of a soft, dark gray, claystone commonly known as the Upper Galesburg Shale. Claystones are often prone to swelling, heave and loss of strength on saturation and the unit could give rise to foundation stability issues after reservoir filling. For these reasons, we recommend the dark gray claystone be removed from beneath the entire footprint of the proposed mat foundation down to the top of the Lower Galesburg Formation consisting of weathered shaley limestone at approximate elevation 812 feet. We recommend the foundation be lowered to accommodate this deeper bearing elevation or the over-excavation to elevation 812 feet be filled with lean concrete so that the mat foundation can bear at the current design elevation of 816 feet.

The Winterset Limestone is jointed and medium bedded and it may be possible to remove some of this material with a track hoe and a rock bucket with rock teeth. However, it is likely that excavation of most of this material will require use of a rock

chipper or other means of rock excavation. Blasting is not recommended since this may compromise the integrity of the bedrock surrounding and underlying the intake structure. Track hoe excavation of the black fissile shale and underlying claystone may be feasible with a rock bucket. Evaluation of safe excavation slopes and/or recommendations for support of excavations are beyond the scope of this report.

Detailed foundation, compacted backfill and lateral earth pressure recommendations are presented in the sections that follow:

Water Intake Structure Foundation

We recommend the proposed water supply intake structure be supported by a reinforced concrete mat foundation that either bears on the weathered shaley limestone of the Lower Galesburg Formation at approximate elevation 812 feet or on lean concrete that extends down from the plan bearing elevation to the top of the Lower Galesburg Formation at approximate elevation 812 feet.

A mat foundation bearing on the weathered shaley limestone at approximate elevation 812 feet or on lean concrete that extends down from the current plan bearing elevation to the top of the Lower Galesburg Formation at approximate elevation 812 feet could be proportioned using a net allowable total load design bearing pressure of up to 5000 psf. The net allowable bearing pressure refers to the pressure at the mat bearing level in excess of the minimum surrounding overburden pressure.

We recommend the bottom of the foundation excavation be observed by the geotechnical engineer of record during construction. To protect the shaley limestone from exposure; potential cycles of freezing and thawing; and deterioration after excavation, we recommend the foundation excavation be over-deepened at least 4 to 6 inches and provided with a protective mud mat of lean concrete extending across the full width of the foundation excavation unless the lean concrete fill is going to be placed immediately after the excavation is observed. The protective mud mat, if used, should be placed within a few hours of excavation and observation of the bearing surface by the geotechnical engineer of record and prior to exposure to drying or wetting environments and/or freezing temperatures.

The water intake structure should also be designed to resist flotation due to buoyancy forces that will develop when intake valves are closed and the reservoir is impounding water. It is likely that uplift resistance considerations will control the size and thickness of the proposed mat foundation resulting in a net applied bearing pressure that is much lower than the recommended net allowable bearing pressure of up to 5000 psf.

In computing resistance to flotation a total unit weight of 145 pcf should be used for that portion of the concrete intake structure extending above the high water level. For that portion of the concrete structure extending below the high water level, we recommend a buoyant unit weight of 85 pcf be used to resist flotation. For controlled compacted backfill placed directly above the footprint of the mat foundation, flotation can be resisted using a buoyant unit weight of 60 pcf for that portion of the controlled compacted clay backfill placed directly above the foundation. An appropriate factor of safety should be employed to resist flotation.

The mat foundation will likely be subjected to transient lateral forces due to wind, water, and seismic loading. For lateral loads of short duration, horizontal sliding can be resisted by an allowable base adhesion of 500 psf acting on the bottom contact area of that portion of the foundation that is in compression and by an allowable passive resistance of 1500 psf acting on the vertical face of the foundation element in the direction perpendicular to the lateral load. These allowable values are for native materials similar to those encountered in the rock core boring TB-3 that are not weakened by blasting, softened by freezing and thawing cycles nor disturbed by other construction activity prior to placement of the mat foundation. The allowable passive resistance is valid for a rock formed mat foundation placed directly against the relatively undisturbed vertical face of the in-situ rock or for controlled compacted clay backfill placed between the foundation and rock and compacted strictly as recommended in this report. Passive resistance should not be relied upon within 3 feet of finished grade.

Surface water and/or perched groundwater may enter foundation excavations during construction. In our opinion, water entering foundation excavations from these sources should be promptly removed using sump pumps and/or gravity drainage ditches.

The bearing surface of all foundation excavations should be free of water and loose or unsuitable material prior to placing protective lean concrete mud mats, lean concrete fill in over-excavations and/or structural concrete. Mud mats, lean concrete fill, reinforcement and structural concrete should be placed soon after excavation to minimize disturbance of the bearing surface of the supporting strata. Should the bearing materials become disturbed, frozen, or damaged, the impacted material should be removed to suitable material prior to placing concrete. The geotechnical engineer of record should be retained to observe and test the foundation bearing materials during construction.

A mat foundation designed and supported on bedrock as recommended in this report is expected to experience a total settlement on the order of 1 inch or less.

Controlled Compacted Backfill for Water Intake Structure

We recommend the water intake structure be backfilled with controlled, compacted clay backfill to provide relatively uniform and predictable earth pressures on all sides of the proposed structure. Clay borrow materials proposed for use as wall backfill should be free of organic matter and debris and should consist of lean clay soils having a liquid limit less than 50, a plasticity index less than 30 and a relatively low volume change potential. Highly plastic or fat clays, weathered shales and claystones, and lean clays with low moisture contents are not recommended for use as wall backfill material.

Soil used for controlled, compacted backfill for the water intake structure should be placed in lifts of 8 inches or less in loose thickness and should be compacted with appropriate equipment to at least 95 % of the materials standard Proctor maximum dry density as established by ASTM D 698. The moisture content of suitable lean clay soils at the time of placement and compaction should be within the range of the optimum moisture content to 4 % above the optimum moisture content as determined by the standard Proctor test. Where hand operated, compaction equipment is utilized in confined spaces adjacent to intake structure foundations and walls, 4 to 6 inch thick lifts may be required.

We recommend the individual lifts of compacted clay backfill be brought up evenly around the structure so as to reduce the potential for development of unbalanced lateral loads. As the controlled compacted backfill is placed, we recommend that additional controlled compacted clay site fill be added as necessary around the lower sides of the structure in such a manner that either native soil or controlled compacted clay fill extends out from the structure at elevation 836 feet for a horizontal distance of at least 30 feet in all directions. Beyond this 30 foot distance, the controlled compacted fill on the south and west sides of the structure should slope down to either the earth dam on the south or the existing natural grade on the west at a slope no steeper than 3 horizontal to 1 vertical. Controlled compacted fill placed against existing native slopes or the earth dam slopes should be placed on properly stripped and prepared subgrades and should be adequately benched into the existing slopes in such a manner that the potential for development of a plane of weakness or slippage is significantly reduced. The compacted clay backfill and surrounding site fill should be placed in such a manner that adequate surface drainage is provided away from the structure during construction.

Lateral Earth Pressures on Below Grade Walls

The walls of the proposed water intake structure will extend at least 35 feet beneath normal pool at elevation 855 feet and some 16 feet beneath existing grade at elevation 836 feet and will be subject to lateral earth and water pressures.

Below grade concrete walls that are provided with appropriate lateral support are commonly designed for the "at rest" lateral earth pressure. This earth pressure is the minimum lateral pressure that should be used to design properly braced below grade walls that experience essentially no wall rotation. Additional lateral earth pressures can develop that exceed the "at rest" earth pressure. The actual earth pressures developed will depend on the structural design, wall bracing and restraint, construction sequence and methods, backfill compaction procedures and the shear strength of the wall backfill.

Lean clay soils meeting the requirements of this report are suitable for use as wall backfill, if these soils are free of organic matter and debris. For the "at rest" condition, a full reservoir and saturated lean clay backfill, we recommend the below grade walls be designed for full hydrostatic pressure from the high reservoir level down to the mud line and a combined earth and hydrostatic pressure equivalent to that of a fluid exerting a lateral pressure of at least 100 pounds per cubic foot (pcf) per foot of wall height below the mud line (estimated at the existing ground surface elevation of 836 feet).

The above minimum design earth pressure does not include a factor of safety and assumes the wall backfill will consist of controlled, compacted lean clay fill placed in horizontal lifts and compacted as recommended in this report. The recommended minimum design earth pressure does not include the additional lateral stress that can develop during compaction of the wall backfill or due to heavy construction equipment that may be operated too close to walls or other surcharge loads that may be placed above or below finished grade.

Additional Considerations

The outlet pipe for the water intake structure will extend through and be constructed concurrently with the proposed earth dam using NRCS pipe installation, backfill compaction, and downstream internal drainage specifications as discussed during Allstate's meeting with representatives of NRCS on December 4, 2008.

The outlet pipe will be subjected to settlement and elongation due to settlements and horizontal deformations during construction, reservoir filling and over the life of the embankment dam. The outlet pipe and pipe joints should be designed with sufficient flexibility to accommodate these movements. Although evaluation of outlet pipe settlement and elongation is beyond the scope of this report, further analysis of anticipated pipe movements could be performed during the design stage if requested.

In our opinion, the outlet pipe should extend out of the side of the intake structure rather than through the bottom as shown on some of the preliminary design drawings since a bottom discharging pipe may be subjected to additional concentrated stresses due to the substantial weight of the structure. Additionally, the outlet pipe should be bedded in

concrete; provided with carefully placed and compacted, moist (standard proctor optimum to 4 % above) clay backfill, and installed with an appropriate zone of sand backfill connected to the internal drainage system in the downstream portion of the pipe's embankment penetration in accordance with NRCS specifications.

CONCLUSION AND LIMITATIONS

The authorized geotechnical engineering services have been completed. The resulting geotechnical recommendations included in this report provide a basis for development of foundation and wall designs for the proposed water intake structure. We recommend the geotechnical engineer of record review the final project plans, specifications and foundation submittals so that we can comment on and assist in the interpretation and implementation of our geotechnical recommendations. Allstate Consultants should also be retained during construction of this project to provide geotechnical observation and testing services for foundations and controlled compacted clay backfill.

The evaluations, analyses and recommendations provided in this report are based on the subsurface conditions encountered in the test borings performed at the locations indicated on the Test Boring Location Plan and from other information discussed in this report. Our geotechnical report does not consider variations that could occur between boring locations or changes that may occur due to the passage of time, the modifying effects of weather or adjacent construction activities. The character and extent of such variations may not become evident until or after construction. Should variations be identified, we should be notified immediately so that further evaluations and additional recommendations can be developed.

The scope of our geotechnical engineering services does not include either specifically or by implication any environmental evaluation of this site nor identification of contaminated or hazardous materials or conditions. Further, we have performed no assessment of the possible presence of bacteria or fungi nor the potential for development of problems associated with mold. If the owner or client is concerned about the potential for such issues, other environmental studies should be performed.

This geotechnical report has been prepared for the exclusive use of our client for specific application to this project only and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended to be made. During construction, site safety, excavation support, and dewatering will be the responsibility of others. Should changes occur in the nature, design or location of the proposed project, as described in this report, the evaluations, recommendations and conclusions contained herein shall not be considered valid unless Allstate Consultants reviews the changes and provides written verification or modification of the conclusions of this report.

NOT TO SCALE

PREPARED BY:

ALLSTATE CONSULTANTS
3312 LEMONE INDUSTRIAL BLVD.
COLUMBIA, MISSOURI 65201
Phone (573) 875-8799
Fax (573) 875-8850

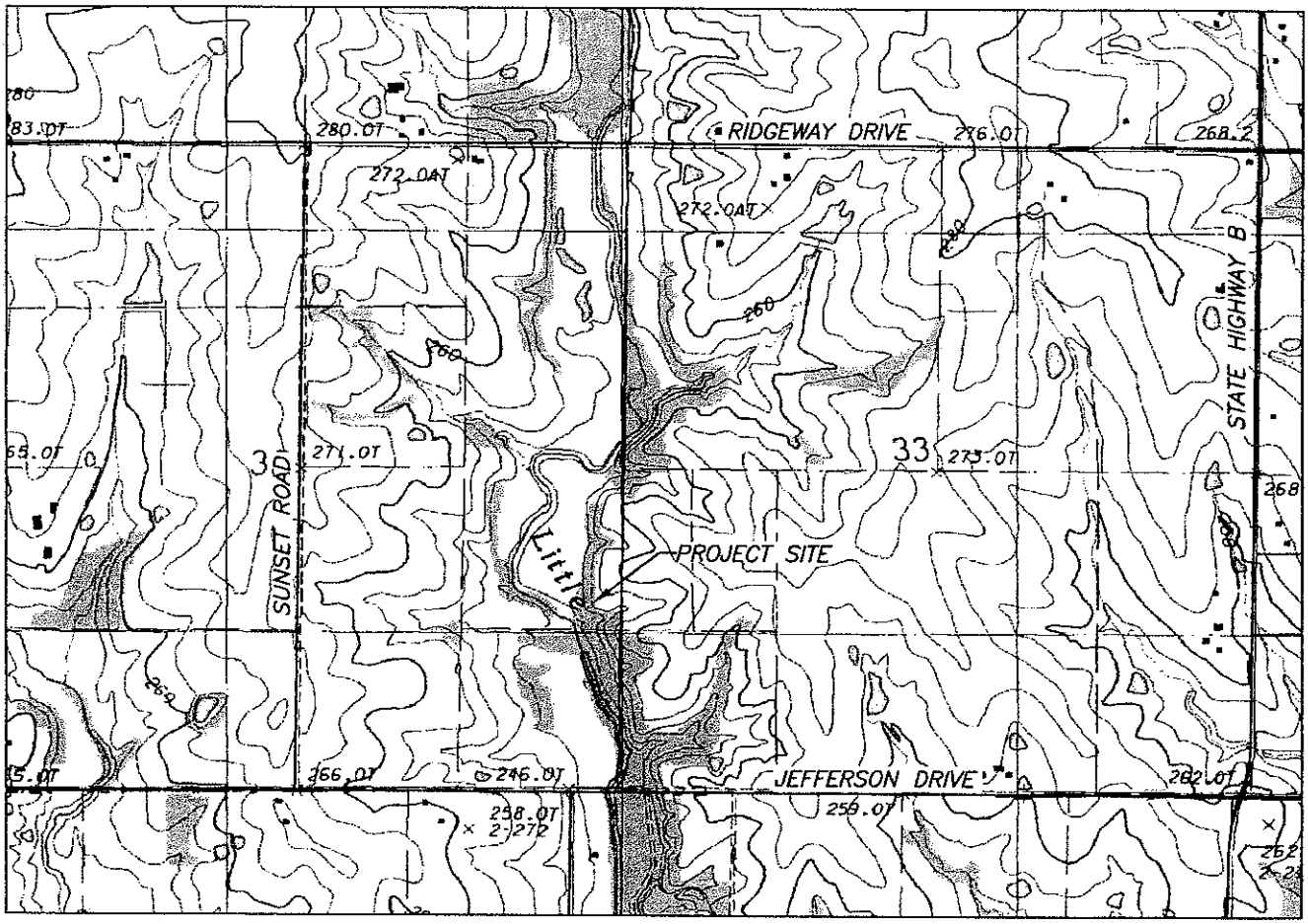
DATE: JANUARY 19, 2009

USGS SITE LOCATION MAP
PROPOSED WATER INTAKE STRUCTURE
LITTLE OTTER CREEK LO-1 LAKE PROJECT
CALDWELL COUNTY, MO

DRAWN BY:	PROJECT MGR:	PROJECT NUMBER:
CCM	W.A.B.	05384.01

N

NOT TO SCALE



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COLUMBIA, MISSOURI 65201
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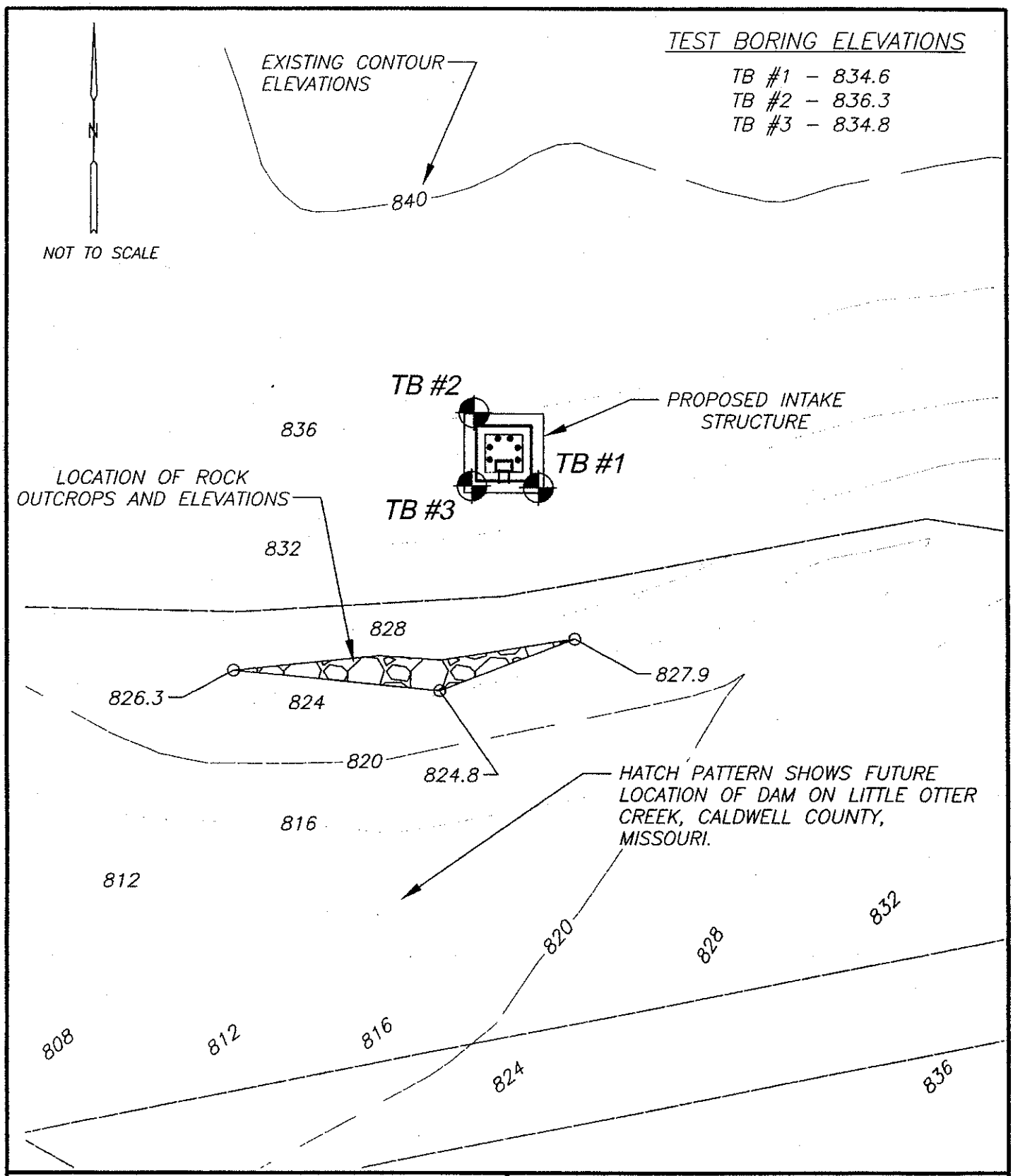
CCM	W.A.B.	05384.01



ALLSTATE CONSULTANTS
30601 HIGHWAY 5
MARCELINE, MO 64658
(660) 376-2941
ENGINEERING • PLANNING • SURVEYING • GEOTECHNICAL • INVESTIGATIVE

BORING LOCATION PLAN
INTAKE STRUCTURE DESIGN
LITTLE OTTER CREEK LAKE

CALDWELL COUNTY, MISSOURI

DRAWN BY:	PROJECT MGR:	PROJECT NUMBER:
C.A.P.	W.A.B.	05384.01

TEST BORING LOG

TEST BORING NO. 1

PROJECT: LITTLE OTTER CREEK LAKE-WATER INTAKE STRUCTURE — CLIENT: CALDWELL COUNTY COMMISSION

SITE LOCATION: CALDWELL COUNTY, MISSOURI — PROJECT NO: 05384.01

DEPTH (feet)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY (inches)	USCS SYMBOL	GRAPHICAL SYMBOL	MATERIAL DESCRIPTION	SPT BLOW COUNTS (Blows/6")	PLASTIC LIMIT PL / FIELD WATER CONTENT / LIQUID LIMIT LL (10 20 30 40 50 60)	DRY UNIT WEIGHT pcf	UNCONFINED COMPRESSIVE STRENTH psf
						Approx. Surface Elevation: 834.6				
0						4" TOPSOIL				
	1	SS	18	CH		FAT CLAY, With Gravel, Brown, Stiff, CH	8/8/7	• 25.1		*2500
	2	SS	13	CH		4.3 Grading Yellow Brown 830.3	12/14/50-1"	• 22.3		*3500
5						AUGER REFUSAL AT 4.3 FT				
10										
15										
20										
25										
30										
35										

Note: Stratification lines represent approximate boundaries between soil and rock types. In-situ, the transition between strata may be gradual. Rock classification estimated from disturbed samples. Coring and lab analyses may reveal other rock types. * Based on Calibrated Hand Penetrometer.

DRILLING CONTRACTOR: PALMERTON AND PARRISH

DRILLING METHOD: CME 550 WITH 3 3/8" CONTINUOUS FLIGHT AUGERS

DEPTH WATER FIRST ENCOUNTERED: NONE WD ▽

DEPTH TO WATER AFTER BORING COMPLETION (AB): NONE AB ▼

DEPTH TO WATER HOURS AFTER BORING COMPLETION: ▼

ALLSTATE CONSULTANTS, LLC

BORING COLUMBIA, MISSOURI

STARTED: 11/04/08

COMPLETED: 11/04/08 TEST BORING NO. 1

LOG APPROVED BY: WAB PAGE 1 OF 1

TEST BORING LOG
TEST BORING NO. 2

PROJECT: LITTLE OTTER CREEK LAKE-WATER INTAKE STRUCTURE — **CLIENT:** CALDWELL COUNTY COMMISSION

SITE LOCATION: CALDWELL COUNTY, MISSOURI — **PROJECT NO:** 05384.01

DEPTH (feet)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY (inches)	USCS SYMBOL	GRAPHICAL SYMBOL	MATERIAL DESCRIPTION	SPT BLOW COUNTS (Blows/6")	PLASTIC LIMIT PL / FIELD WATER CONTENT / LIQUID LIMIT LL (10 20 30 40 50 60)	DRY UNIT WEIGHT pcf	UNCONFINED COMPRESSIVE STRENTH psf
						Approx. Surface Elevation: 836.3				
	1	SS	15	GC		CLAYEY GRAVEL, Light Brown Mottled Orange,	14/41/50-3"	• 8.4		
2.8						Dense, GC 833.5				
						AUGER REFUSAL AT 2.8 FT				
5										
10										
15										
20										
25										
30										
35										

Note: Stratification lines represent approximate boundaries between soil and rock types. In-situ, the transition between strata may be gradual. Rock classification estimated from disturbed samples. Coring and lab analyses may reveal other rock types. * Based on Calibrated Hand Penetrometer.

DRILLING CONTRACTOR: PALMERTON AND PARRISH

DRILLING METHOD: CME 550 WITH 3 3/8" CONTINUOUS FLIGHT AUGERS

DEPTH WATER FIRST ENCOUNTERED: NONE WD ▽

DEPTH TO WATER AFTER BORING COMPLETION (AB): NONE AB ▼

DEPTH TO WATER HOURS AFTER BORING COMPLETION: ▼

ALLSTATE CONSULTANTS, LLC

BORING COLUMBIA, MISSOURI

STARTED: 11/04/08

COMPLETED: 11/04/08 — **TEST BORING NO. 2**

LOG APPROVED BY: WAB — **PAGE 1 OF 1**

TEST BORING LOG
TEST BORING NO. 3

PROJECT: LITTLE OTTER CREEK LAKE-WATER INTAKE STRUCTURE — **CLIENT:** CALDWELL COUNTY COMMISSION

SITE LOCATION: CALDWELL COUNTY, MISSOURI — **PROJECT NO:** 05384.01

DEPTH (feet)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY (inches)	USCS SYMBOL	GRAPHICAL SYMBOL	MATERIAL DESCRIPTION	SPT BLOW COUNTS (Blows/6")	PLASTIC LIMIT PL / FIELD WATER CONTENT / LIQUID LIMIT LL (10 20 30 40 50 60)	DRY UNIT WEIGHT pcf	UNCONFINED COMPRESSIVE STRENTH psf
						Approx. Surface Elevation: 834.8				
						FAT CLAY, With Gravel,				
	1	SS	18	CH		Trace Roots, Light Brown,	11/14/8	• 27.7		*3000
						Stiff to Very Stiff, CH				
	2	SS	18	CH		Grading Yellow Brown	2/10/7	• 23.0		*4500
5						5 AUGER REFUSAL AT 5.0 FT 829.8				
	R1	N Q	29			WEATHERED LIMESTONE, Light Gray, With Thin Shale & Clay Seams, Jointed, Medium Bedded, Moderately Hard	REC-97% RQD-75%			
10	R2	NQ	59			Note: Occasional High Angle Joints (Winterset Limestone)	REC-98% RQD-65%			
15	R3	NQ	59			15 Grading Dark Gray Shale 819.8	REC-98% RQD-70%			
						SHALE, Black, Fissile, With Phosphate Lenses, Soft to Moderately Hard,				
20	R4	NQ	60			19 (Stark Shale) 815.8	REC-100% RQD-22%			
						CLAYSTONE, Dark Gray, With Limestone Nodules, Soft				
						22.2 (Upper Galesburg Shale) 812.6				
25	R5	NQ	60			WEATHERED SHALEY LIMESTONE, Light Gray, Jointed, Fractured, Highly Solutioned, With Greenish Gray Shale Infilling,	REC-100% RQD-18%			
						27 Soft to Moderately Hard 807.8				
30	R6	NQ	60			LIMESTONE, Light Gray, Massive But Nodular, With Occasional Thin Shale Partings, Moderately Hard (Bethany Falls Limestone)	REC-100% RQD-83%			
35	R7	N Q	26			35 BOTTOM OF BORING 799.8	REC-87% RQD-87%			

Note: Stratification lines represent approximate boundaries between soil and rock types. In-situ, the transition between strata may be gradual. Rock classification from visual observations. Lab analyses may reveal other rock types. * Based on Calibrated Hand Penetrometer.

DRILLING CONTRACTOR: PALMERTON AND PARRISH

DRILLING METHOD: CME 550 WITH 3 3/8" CONTINUOUS FLIGHT AUGERS

DEPTH WATER FIRST ENCOUNTERED: NONE WD ▽

DEPTH TO WATER AFTER BORING COMPLETION (AB): NONE AB ▼

DEPTH TO WATER HOURS AFTER BORING COMPLETION: ▼

ALLSTATE CONSULTANTS, LLC

BORING COLUMBIA, MISSOURI

STARTED: 11/04/08

COMPLETED: 11/04/08 — **TEST BORING NO. 3**

LOG APPROVED BY: WAB — **PAGE 1 OF 1**

ROCK CORE REPORT
TEST BORING NO. 3

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: Caldwell County Commission
Project: Little Otter Creek Lake -Water Intake Structure
Location: Caldwell County, Missouri

Report Date: 11/20/2008
Project No.: 05384.01

CORING INFORMATION

Date Cored: November 4, 2008
Method: NQ core barrel and diamond bit
Boring No.: TB-3

Run No.:		Length:	Depth:
R1		30 in.	5.0'-7.5'
R2		60 in.	7.5'-12.5'
R3 (Part)		30 in.	12.5'-15.0'

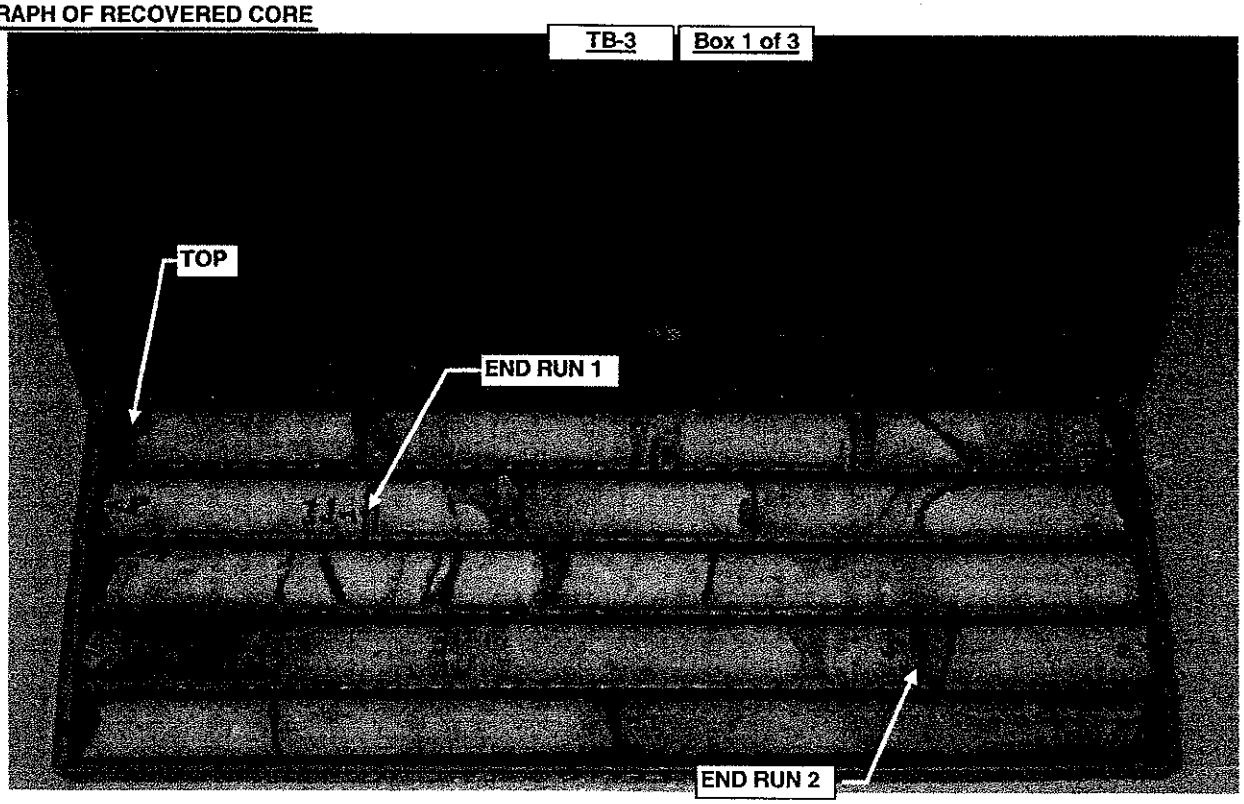
MATERIAL INFORMATION

Description: (5.0'-15.0') **WEATHERED LIMESTONE,** Light Gray, with Thin Shale & Clay Seams, Jointed, Medium Bedded, Moderately Hard, Occasional High Angle Joints

Depth: 5.0 feet to 15.0 feet (EL. 829.8' to 819.8')
Recovery: 9 feet 9 inches

Recovery Ratio:		RQD:	
R1: 97 %		R1: 75 %	
R2: 98 %		R2: 65 %	
R3: 98 %		R3: 70 %	

PHOTOGRAPH OF RECOVERED CORE



Comments:

ROCK CORE REPORT
TEST BORING NO. 3

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: Caldwell County Commission
Project: Little Otter Creek Lake -Water Intake Structure
Location: Caldwell County, Missouri

Report Date: 11/20/2008
Project No.: 05384.01

CORING INFORMATION

Date Cored: November 4, 2008
Method: NQ core barrel and diamond bit
Boring No.: TB-3

Run No.:		Length:	Depth:
	R3 (Part)	30 in.	15.0'-17.5'
	R4	60 in.	17.5'-22.5'
	R5 (Part)	30 in.	22.5'-25.0'

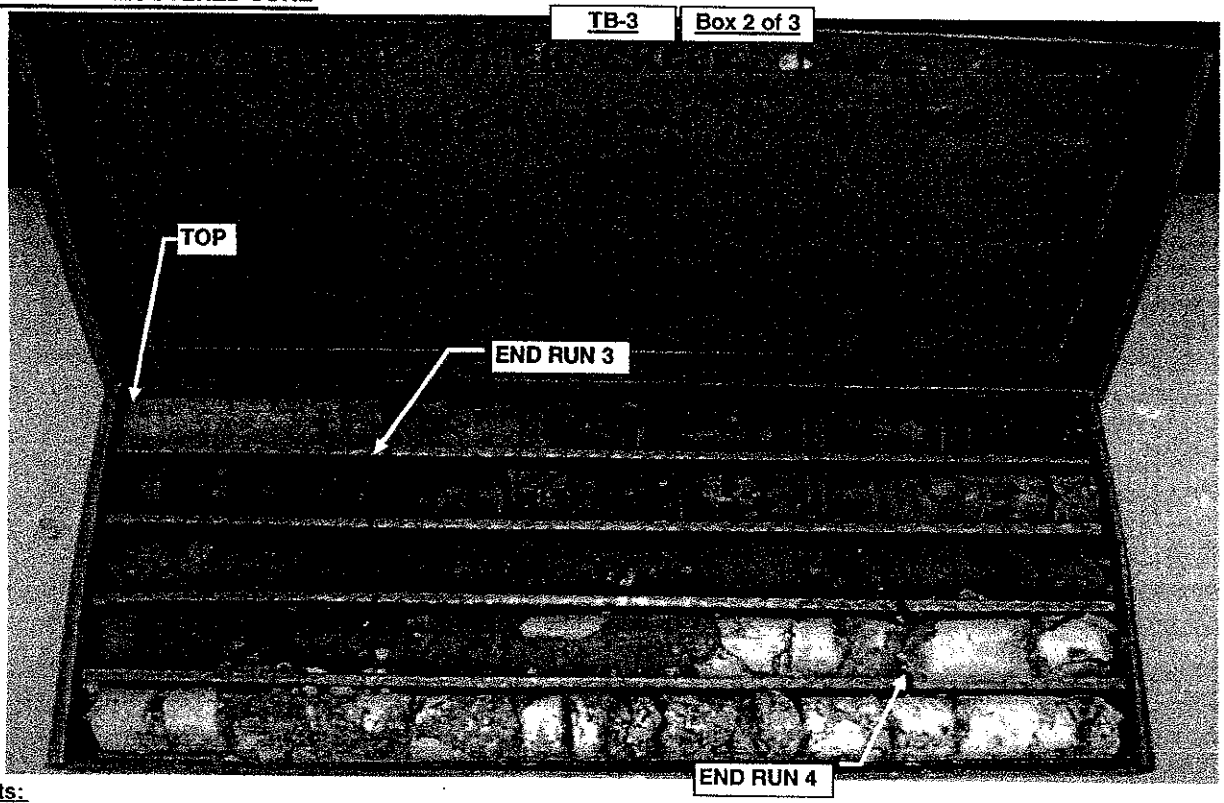
MATERIAL INFORMATION

Description: (15.0'-19.0') **SHALE,** Black, Fissile, Soft to Moderately Hard
(19.0'-22.2') **CLAYSTONE,** Dark Gray, with Limestone Nodules, Soft
(22.2'-25.0') **WEATHERED LIMESTONE,** Light Gray, Jointed, Fractured, Highly Solutioned, with Greenish Gray Shale Infilling, Soft to Moderately Hard

Depth: 15.0 feet to 25.0 feet (EL. 819.8' to 809.8')
Recovery: 9 feet 11 inches

Recovery Ratio: R3: 98% R4: 100% R5: 100%
RQD: R3: 70% R4: 22% R5: 18%

PHOTOGRAPH OF RECOVERED CORE



Comments:

ROCK CORE REPORT
TEST BORING NO. 3

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: Caldwell County Commission
Project: Little Otter Creek Lake -Water Intake Structure
Location: Caldwell County, Missouri

Report Date: 11/20/2008
Project No.: 05384.01

CORING INFORMATION

Date Cored: November 4, 2008
Method: NQ core barrel and diamond bit
Boring No.: TB-3

Run No.:		Length:	Depth:
	R5 (Part)	30 in.	25.0'-27.5'
	R6	60 in.	27.5'-32.5'
	R7	30 in.	32.5'-35.0'

MATERIAL INFORMATION

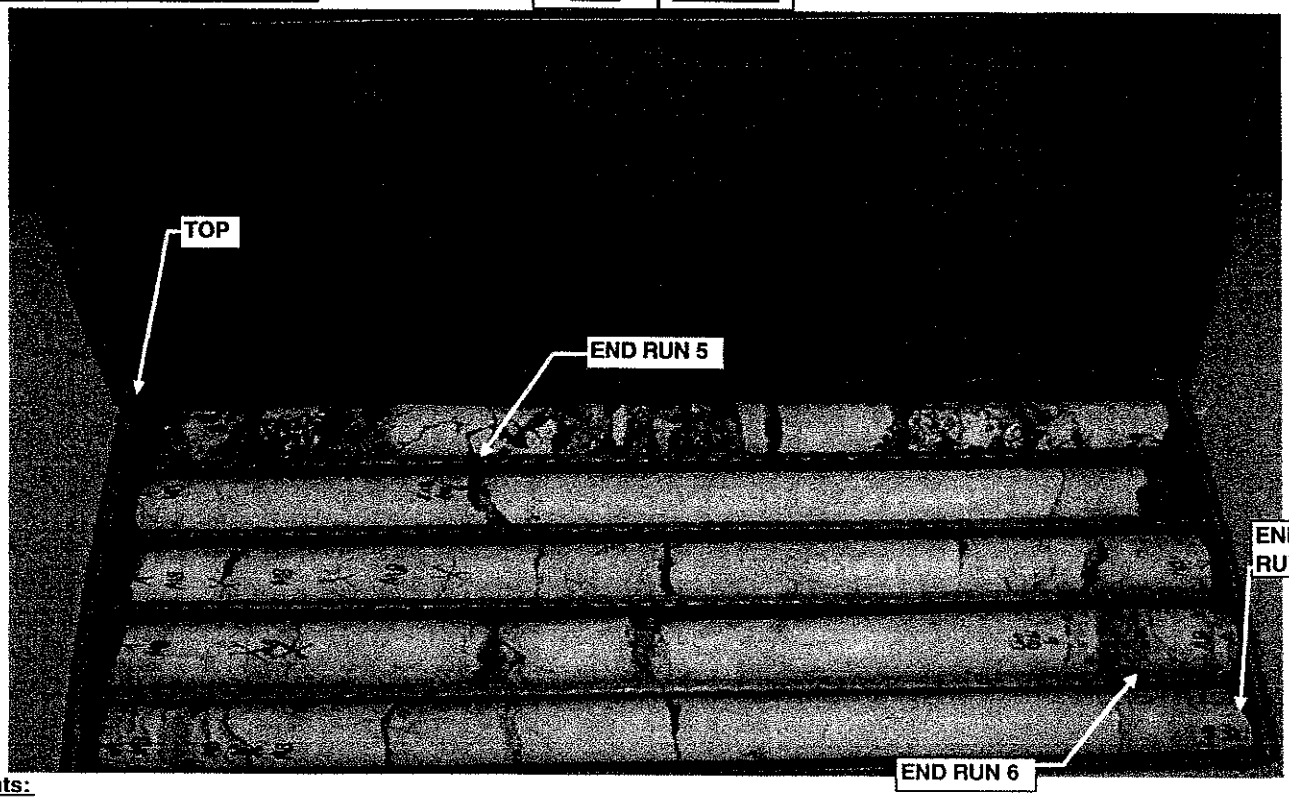
Description: (25.0'-27.0') **WEATHERED LIMESTONE,** Light Gray, Jointed, Fractured, Highly Solutioned, with Greenish Gray Shale Infilling, Soft to Moderately Hard (27.0'-35.0') **LIMESTONE,** Light Gray, Massive but Nodular, with Occasional Thin Shale Partings, Moderately Hard

Depth: 25.0 feet to 35.0 feet (EL. 809.8' to 799.8')
Recovery: 9 feet 8 inches

Recovery Ratio: R5: 100% R6: 100% R7: 87%
RQD: R5: 18% R6: 83% R7: 87%

PHOTOGRAPH OF RECOVERED CORE

TB-3 | Box 3 of 3



Comments:

TEST BORING LOG NOTES

SAMPLE TYPE

SHELBY TUBE SAMPLE – Obtained by pushing a standard 3 inch OD thin-walled tube sampler using the hydraulic stroke of the drilling rig.

SPLIT-SPOON SAMPLE – Obtained by driving a standard 2 inch OD by 1 3/8 inch ID split-barrel sampler during performance of a Standard Penetration Test (SPT).

CONTINUOUS SAMPLE - Obtained by inserting a 3 inch OD by 2 ¼ ID continuous split-barrel sampler into the lead section of a hollow stem auger string and advancing the sampler with the hollow stem auger as the auger penetrates into the underlying soil.

ROCK CORE SAMPLE - Obtained by coring the rock with an NX size core barrel and diamond bit. The NX size core is approximately 2 1/8 inches in diameter. An NQ size core is approximately 2 inches in diameter.

SOIL AND ROCK DESCRIPTIONS AND CLASSIFICATION

Soil samples are described and classified in general accordance with the Unified Soil Classification System (USCS) using visual-manual procedures. All USCS Group Letter Symbols and Group Names are based on visual-manual estimates except where accompanied by results of Atterberg limits tests and grain size analyses. A brief description of the USCS is attached.

Fine-grained soils are also described in terms of their consistency and coarse-grained soils in terms of their in-place relative density. For fine-grained soils, the consistency is based on the unconfined compressive strength (Table 1). For coarse-grained soils the relative density is related to the N value determined from the Standard Penetration Test (Table 2).

Rock strata penetrated by flight augers or rock bits and intermittently sampled with a split-barrel sampler are described and classified based on drilling performance and visual observation of disturbed samples. Rock cores may reveal other rock types.

Rock core samples, obtained with a core barrel and diamond bit, are visually described and classified based on lithology, bedding, structure, degree of weathering, and hardness. All rock descriptions and classifications are based on visual observations. Petrographic analyses may indicate other rock types. Rock core recovery is expressed as the ratio of the length of core recovered to the length of the core run. Rock Quality Designation (RQD) is the ratio of the total length of the pieces of core that are hard, sound and 4 inches or longer to the length of the core run. Both core recovery and RQD are expressed as a percentage.

Soil and rock strata, delineated on the boring log, represent the geotechnical engineer's interpretation of subsurface conditions at the boring location. The interpretation is developed from the field boring log with modifications based on the laboratory test results and visual observations of the soil and rock samples. Graphical symbols depicting the soil and rock strata are shown on the boring logs for illustrative purposes. Different soil or rock types could be present between samples. A legend relating the graphical symbols to the USCS Group Letter Symbols and Group Names and the principal rock types encountered in the project area is attached. Stratification lines shown on the boring logs represent approximate boundaries between the various soil and rock types. In-situ, the transition between the soil and rock strata may be gradual.

STANDARD PENETRATION TEST

A standard split-barrel sampler (2 inch OD by 1 3/8 inch ID) is driven 18 inches into the soil by a 140 pound hammer repeatedly dropped from a height of 30 inches. The hammer blows are recorded for each 6 inches of penetration and the penetration resistance or N Value is considered the number of blows required for the final 12 inches of sampler penetration. Blows per 6 inch interval are recorded as 8/18/23 etc. under the Test Boring Log heading *SPT Blow Counts*. Where the sampler penetrated less than 6 inches under 50 hammer blows for one of the intervals, the results are recorded as 8/18/50-3".

LABORATORY TEST RESULTS AND SYMBOLS

PLASTIC LIMIT (PL) - Water content at which a soil will just begin to crumble when rolled into a thread approximately 1/8 inch in diameter. Generally represents the water content below which the soil develops cracks upon significant deformation.

LIQUID LIMIT (LL) - Water content at which a pat of soil, cut by a groove of standard dimensions, will flow together for a distance of ½ inch under the impact of 25 blows in a standard liquid limit apparatus. Generally represents the water content above which the soil is in suspension and has minimal shear strength.

FIELD WATER CONTENT - Water content of the soil or rock at depth indicated at time of exploration. The water content may fluctuate with seasonal and climatological conditions and may be altered by excavation, exposure and other construction activities or by conditions not apparent during exploration.

- Relationship between plastic limit (PL), field water content, and liquid limit (LL). The plasticity index, (PI), is the difference between the liquid and plastic limits. In general, the higher the liquid limit and PI, the more a soil is inherently prone to volume change. However, soils with lower liquid limits and PI's can also experience volume change.

Soils having field water contents approaching the liquid limit typically have low shear strength and high compressibility. Soils having water contents near the plastic limit typically have higher shear strength and lower compressibility.

UNCONFINED COMPRESSIVE STRENGTH

_ The load per unit area at which an unconfined cylindrical specimen of soil will fail in a simple, quick compression test without lateral support. Expressed in pounds per square foot on the boring log.

* Indicates unconfined compressive strength estimated using a calibrated hand penetrometer.

TABLE 1

CONSISTENCY OF FINE-GRAINED SOILS

UNCONFINED COMPRESSIVE STRENGTH, Qu, psf	CONSISTENCY
Less than 500 psf	Very Soft
500 - 1,000	Soft
1,000 - 2,000	Medium
2,000 - 4,000	Stiff
4,000 - 8,000	Very Stiff
Above - 8,000	Hard

TABLE 2

RELATIVE DENSITY OF COARSE-GRAINED SOILS

SPT N VALUE Blows/ft.	RELATIVE DENSITY
0 - 4	Very Loose
4 - 10	Loose
10 - 30	Medium Dense
30 - 50	Dense
Above 50	Very Dense

TABLE 3

ROCK QUALITY DESIGNATION RQD

RQD (%)	ROCK QUALITY
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 – 100	Excellent

WATER LEVEL SYMBOLS AND OBSERVATIONS:

WS or WD - Borehole water level observation *While Sampling* or *While Drilling* - ▽

AB - Borehole water level observation *After Boring* completion - ▼

24 Hrs AB – Water level observation *24 Hrs After Boring* completion or other such time as recorded on the boring log. - ▼

WCI - *Wet Cave In*

DCI - *Dry Cave In*

Borehole water level measurements were made at the times and under the conditions indicated on the boring logs. Groundwater levels may vary across the site and will fluctuate with seasonal and climatological conditions. Groundwater levels may also be altered by site grading and/or other construction activities. Borehole water level measurements in highly pervious soils may represent groundwater conditions in these units at the time of the observations. In semi-pervious and fine-grained soils, short term water level measurements in borings may not represent actual groundwater conditions. Long term observations of piezometers, screened in the hydrologic units of interest, and sealed from the influence of surface water are typically required to evaluate groundwater conditions and fluctuations in groundwater levels in low permeability soils.

SOIL AND ROCK SYMBOLS FOR BORING LOGS

SOIL SYMBOLS

GRAPHICAL SYMBOL	USCS Group Symbol	USCS Group Name
	GW	Well-graded gravel
	GP	Poorly graded gravel
	GM	Silty gravel
	GC	Clayey gravel
	SW	Well-graded sand
	SP	Poorly graded sand
	SM	Silty sand
	SC	Clayey sand
	CL	Lean clay
	ML	Silt
	CL-ML	Silty Clay
	OL	Organic clay / Organic silt
	CH	Fat clay
	MH	Elastic silt
	OH	Organic clay / Organic silt
	PT	Peat

ROCK SYMBOLS

GRAPHICAL SYMBOL	MAJOR ROCK TYPE
	SILTSTONE
	SHALE
	SANDSTONE
	LIMESTONE
	DOLOMITE
	COAL
	UNDERCLAY
	CLAYSTONE

OTHER SYMBOLS

	CL	Lean Clay, with Sand and Gravel (Glacial Drift)
	CH	Fat Clay, with Sand and Gravel (Glacial Drift)

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UNIFIED SOIL CLASSIFICATION SYSTEM

Soil Classification Chart

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name
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]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[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]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[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 / Liquid limit - not dried < 0.75	OL	Organic clay[K,L,M,N] / 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 / Liquid limit - not dried < 0.75	OH	Organic clay[K,L,M,P] / Organic silt[K,L,M,Q]
HIGHLY ORGANIC SOILS		Primarily organic matter, dark in color, and organic odor		PT	Peat

Footnotes

[A] Based on the material passing the 3-in. (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] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains $\geq$ 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 $\geq$ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched 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 $\geq$ 30% plus No. 200, predominantly sand, add "sandy" to group name.

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

[N] PI $\geq$ 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.

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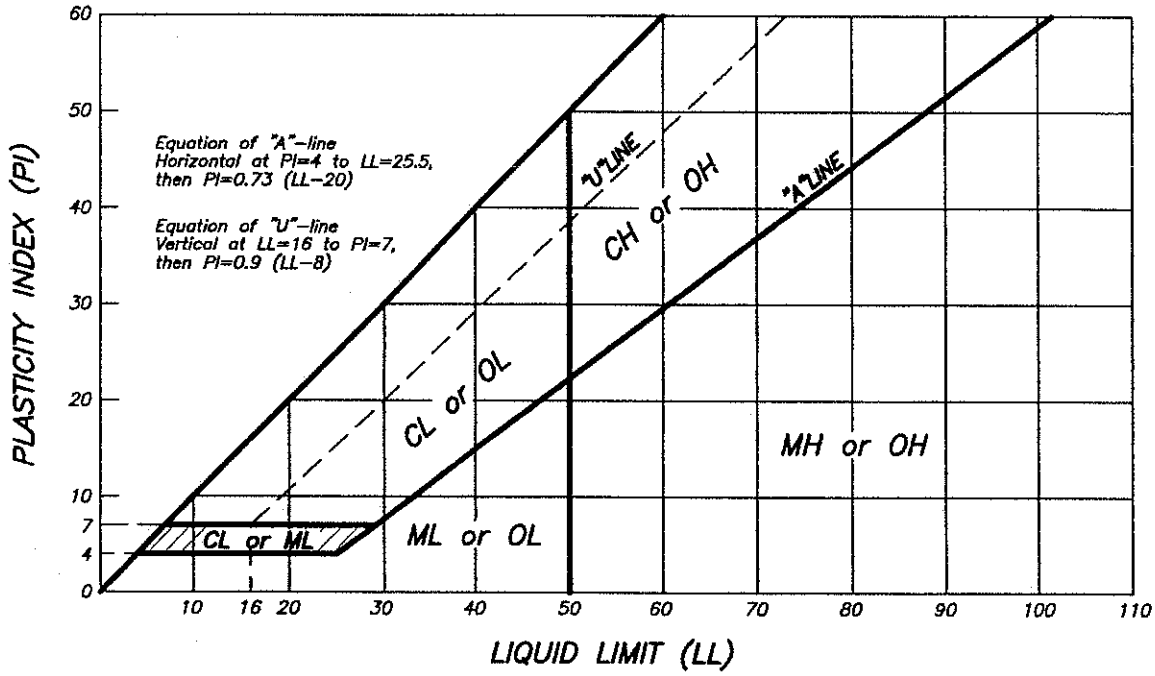
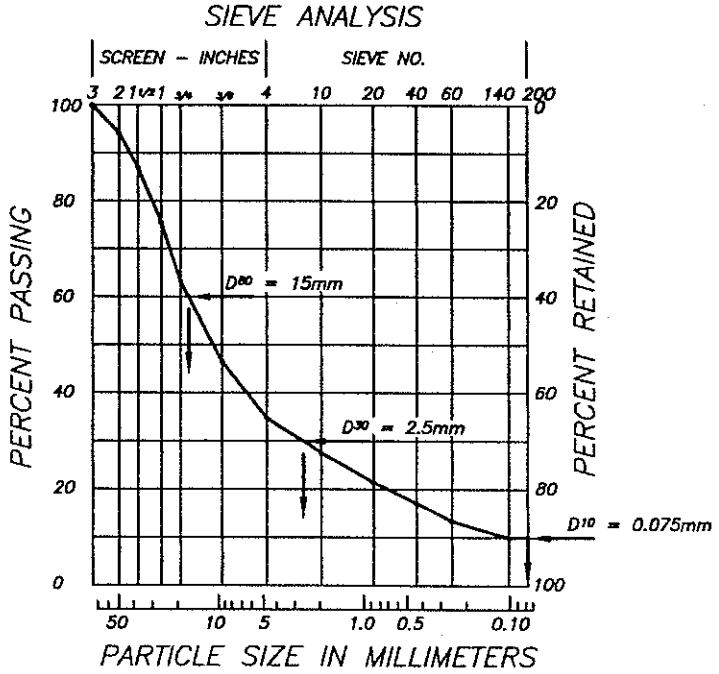
UNIFIED SOIL CLASSIFICATION SYSTEM



PLASTICITY CHART FOR CLASSIFICATION OF FINE-GRAINED SOILS AND FINE-GRAINED FRACTION OF COARSE-GRAINED SOILS.



$$Cu = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200$$

$$Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$$

Cumulative Particle-Size Plot

FOR CLASSIFICATION OF COARSE-GRAINED SOILS WITH 12% OR LESS FINES.

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(573) 875-8799