SITE EVALUATION REPORT FOR THE WASTEWATER RECLAMATION TEST SITE
Colorado School of Mines, Golden, Colorado

Prepared by

Kathryn S. Lowe and Robert L. Siegrist
Environmental Science & Engineering Division
Colorado School of Mines, Golden, Colorado

June 5, 2002

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1.0 Introduction

Faculty and students within the Environmental Science & Engineering Division (ESE) and Geology and Geological Engineering Department (GE) at the Colorado School of Mines (CSM) are engaged in research and education related to onsite and alternative water and wastewater systems in collaboration with government organizations, private consulting firms, and private industry. To facilitate research and education, a domestic wastewater reclamation test site (WRTS) is being established on the CSM campus southwest of the Mines Park housing complex on the southwest corner of Highway 6 and 19th Street. The purpose of this test site is to facilitate research related to conventional and advanced unit operations and systems for onsite wastewater reclamation. It is also intended to facilitate education, both for undergraduate and graduate students as well as practitioners, regulators, and citizens. Test sites, such as the one proposed herein, have been established on university campuses across the U.S., but there are currently no facilities in Colorado or the Rocky Mountain region.

The establishment of the test site is comprised of two phases. Phase 1 was completed in July 1998 and involved the installation of a wastewater interception and treatment facility to support onsite pilot-scale experiments and laboratory research and teaching (Figure 1a). This Phase 1 wastewater interception and treatment system has been used as the source of septic tank effluent (STE) during laboratory testing over the past several years. The second phase involves establishment of a research area southwest of the Mines Park housing development with implementation planned to begin in June 2002 (Figure 1b). The primary technology elements of WRTS will include:

- In situ porous media biofilters (PMBs) for natural systems renovation based on continuous and intermittent gravity dosing, uniform pressurized distribution, and/or shallow subsurface drip irrigation approaches,
- Advanced treatment processes comprised of ex situ engineered porous media biofilters including peat, sand, textile, and/or foam media,
- Advanced treatment processes for nutrient removal via packed bed reactors including novel sorbents and fixed film bioreactors, and
- Pathogen removal in PMBs and by ultraviolet light irradiation for disinfection.

2.0 Site Suitability for Wastewater Infiltration

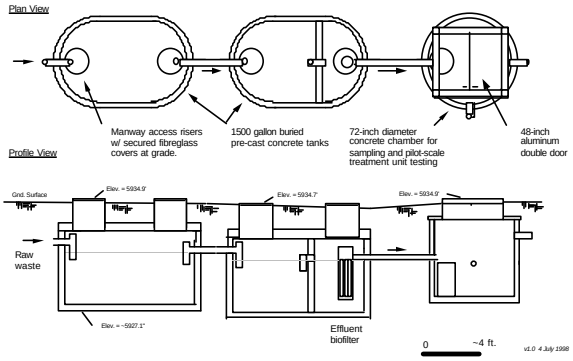
2.1 Site and Soil Conditions

The site selected for WRTS is located on CSM property in the SE1/4, SE1/4, Section 33, T3S, R70W. The site is currently undeveloped and in a natural state typical of the Rocky Mountain Front Range foothills. The land is covered primarily with native grasses, yucca, native shrubbery, and scattered small boulders. A small unnamed drainage trending southwest to northeast is parallel to the site approximately

50 ft (15 m) south of the southern site boundary. Two City of Golden water lines run north/south through the western portion of the site. There are no other disturbances to the surface or subsurface.

Natural site and soil features are critical to the design and performance of onsite wastewater treatment processes. These features were assessed through a site evaluation conducted between April 15, 2002 and May 9, 2002 during which time (1) soil profiles were inspected within two backhoe test pits, (2) nine soil borings were drilled and soil samples collected from ground surface to up to 22 ft (6.7 m) below ground surface, (3) seven shallow groundwater observation wells were installed, and (4) four percolation tests were performed. Subsurface soil lithology and color were recorded for soil samples collected from the boreholes. Additional soil sample analyses used for evaluation of site suitability include water content, total organic carbon, organic matter, pH, potassium, nutrients (total nitrogen, nitrate-nitrogen, ammonia-nitrogen, available potassium), percent sand/silt/clay, grain size distribution, and cation exchange capacity.

(a)



(b)

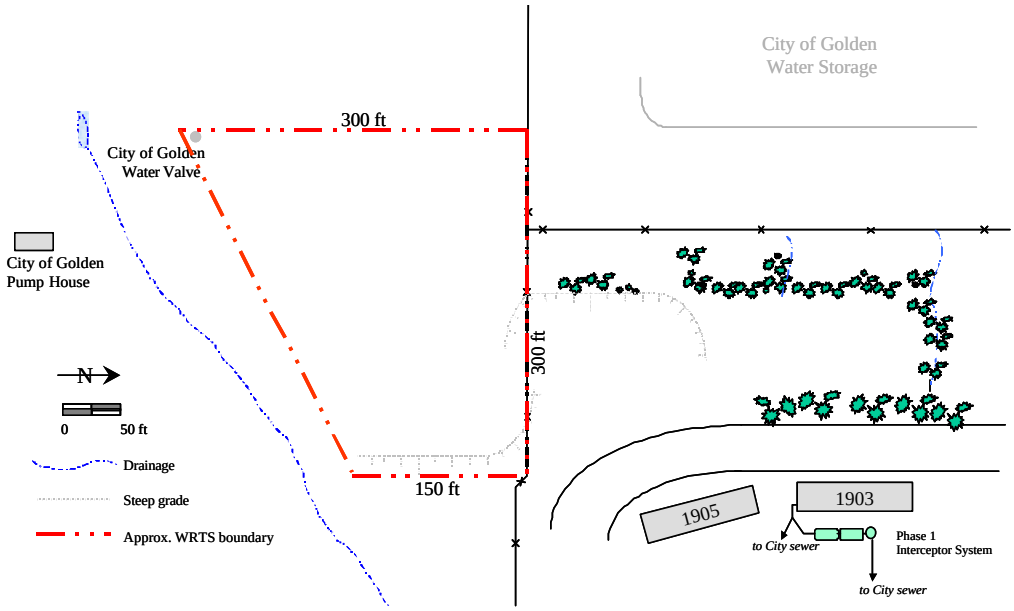


Figure 1. Mines Park Wastewater Reclamation Test Site; (a) Phase 1 Interception System and (b) Phase 2 proposed location.

2.2 Landscape Position and Drainage

The general topography across the site exhibits an easterly aspect with a slope of approximately 5 to 7 percent (see Appendix A). The slope increases gently across the site with a slightly greater slope along the eastern half of the site. The natural soil surface elevation within the proposed WRTS location is between the elevations of 5970 and 5980 feet (1820 to 1823 m) above mean sea level. Surface water drainage in the immediate area follows the landscape topography and is generally to the east-southeast toward the small unnamed drainage.

2.3 Soil Conditions

General soil characteristics for Mines Park were initially assessed from the U.S. Department of Agriculture Soil Conservation Survey (SCS) report (USDA 1983). Soils at Mines Park are reported to be primarily fine loamy soils (mixed, mesic Aridic Argiustolls). The parent materials are generally derived from igneous and metamorphic rocks of the mountains and sedimentary rocks of the foothills. The typical soil profile includes a neutral, grayish brown and dark grayish brown sandy loam surface layer (0-7 in., 0-18 cm), with a mildly alkaline, brown sandy clay loam (7-11 in., 18-28 cm) and moderately alkaline, very pale brown sandy loam (11-18 in., 28-46 cm) subsoil layer, and a substratum of mildly alkaline and moderately alkaline, very pale brown sandy loam and gravelly sandy loam (18-60 in., 46-152 cm). It is listed by SCS as having moderate permeability and an average depth to bedrock of 60 in. (1.5 m).

Morphologic inspection of the natural soil profiles exposed in two backhoe test pits and nine soil borings was conducted according to accepted procedures (USDA 1981; SSSA 1986; USEPA 1991). Locations of the backhoe test pits and soil borings are shown in Figure 2. Photographs of representative soil profiles are shown in Appendix A and the morphologic characteristics are summarized in Appendix B. These inspections revealed a varied soil profile between the western and northwestern areas of the site and the southeastern corner of the site.

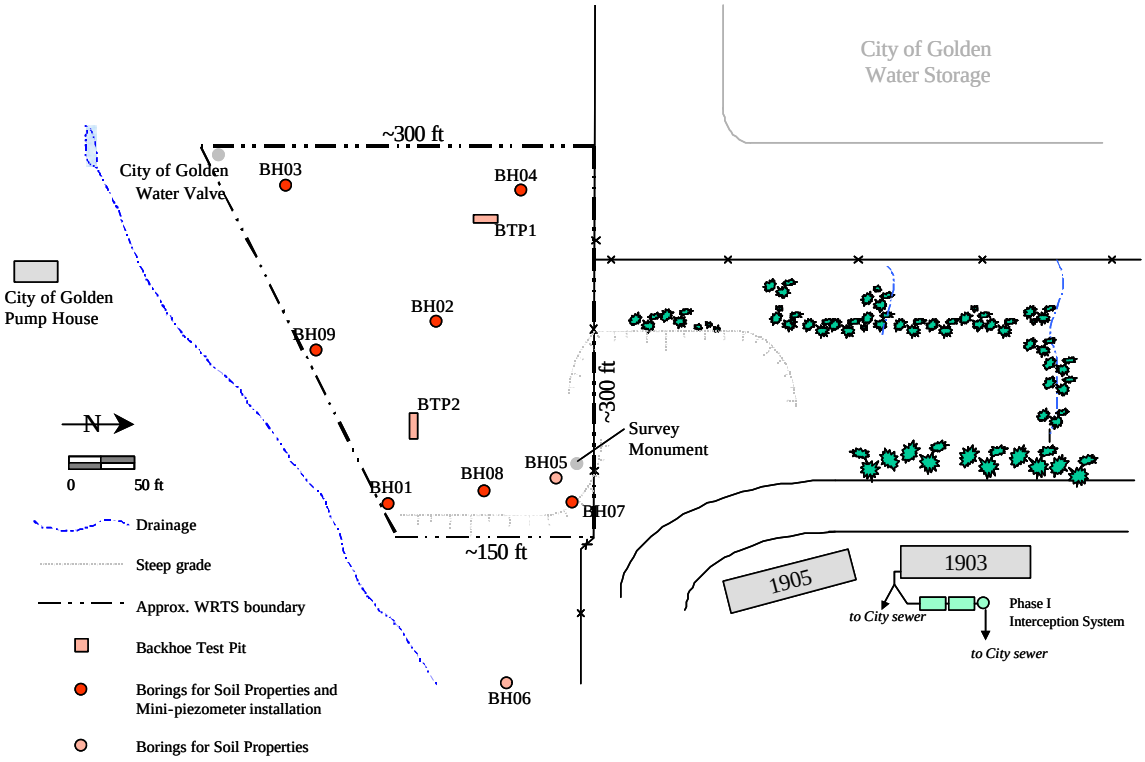


Figure 2. Soil Test Locations.

Backhoe test pit #1 (BTP1), located in the northwestern portion of the site, revealed soil conditions that are generally dominated by unconsolidated, sandy loam soils with little bedding structure and/or macropores. Roots were observed as deep as 3 ft (1 m) and a transition zone from sandy loam to highly weathered, friable igneous rock was observed at 5.5 ft (1.7 m) bgs. The soil matrix color of the sandy loam was generally in the 7YR4/4 range with soil mottling absent and of the weathered igneous rock generally in the 2.5YR5/4 range.

Backhoe test pit #2 (BTP2), located in the southeastern portion of the site, revealed a 6 inch layer of sandy loam underlain by highly fractured, weathered siltstone. Bedding planes in the siltstone ranged from 0.5 to 2.5 in. (1 to 6 cms) thick near the surface with bedding planes up to ~3 in. (8 cm) thick at 4 ft (1.2 m) bgs. The soil matrix color was generally in the 5YR6/4 range with soil mottling along root zones observed to a depth of 2 ft (60 cm) bgs. A transition zone from the weathered siltstone to weathered igneous rocks (poorly sorted subangular conglomerate with <3% schist, 40% silica, 55% feldspar (Kspar) and <2% hornblende) was observed at 4.5 ft (1.4 m) bgs.

Observations of subsurface lithology in the nine soil borings revealed similar soil conditions with sandy loam soils ranging from ~2 ft (60 cm) thick in the southwestern portion of the site to ~6 ft (1.8 m) thick in the northern portions of the site. The transition zone to weathered igneous rock was encountered at each location underlying the sandy loam. Samples of soil materials were collected from soil borings at 2 ft (60 cm) intervals and analyzed for water content, total organic carbon, organic matter, pH, potassium, nutrients (total nitrogen, nitrate-nitrogen, ammonia-nitrogen, available potassium), percent sand/silt/clay, grain size distribution, and cation exchange capacity.

Grain size distributions for the sand fraction were determined by sieving dry soil and weighing the various sand fractions. Results indicated that 9 to 52% (average 24%) of the soil was coarse sand to fine gravel (> 2mm), 46 to 85% (average 73%) was medium to fine sand (2mm to 0.075 mm), and 1.3 to 9% (average 3%) was silt and clay (<0.075 mm). The grain size distribution was very uniform across the site with a general trend of increasing sand particle size with depth. Summary statistics and representative grain size distribution graphs from BH03 are presented in Appendix C. To better define the silt and clay fractions, percent silt/sand/clay analysis was determined by hydrometer analysis. Results from this analysis revealed sandy loam soil texture across the site. Complete silt/sand/clay results are presented in Appendix C.

Total percent organic matter in the upper 10 ft of soils ranged from 0.1 to 1.4% (average 0.6%) with a general trend of decreasing organic matter with depth. Cation exchange capacity ranged between 2.5 and 22.1 meq/100 g dry soil (average 8.2 meq/100 g dry soil) and was relatively constant across the site. As expected, soils with higher clay content had a slightly higher cation exchange capacity. Other properties of interest include pH, total nitrogen (TN), ammonia-nitrogen (NH_4-N), nitrate-nitrogen (NO_3-N), available phosphorus and potassium (avail. P and K), and exchangeable calcium and magnesium (exch. Ca and Mg) and are summarized in Table 1.

2.4 Subsurface Drainage

No saturated conditions, either perched or continuous, were observed in the two backhoe test pits or 8 of 9 soils borings. In the southeastern corner (soil boring, BH01) of the site located closest to the unnamed surface drainage, continuously saturated conditions were observed at 16.5 ft (5 m) bgs during sampling of soil borings in April 2002. Shallow groundwater observation wells were installed at 7 soil boring locations. After installation, groundwater was present at two locations, BH01 at 9.44 ft (2.88 m) bgs and at BH08 at 14.37 ft (4.38 m) bgs. See Figure 2 for observation well locations. Soil moisture content, based on dry weight, was determined at each borehole location at 2 ft (60 cm) intervals to approximately

20 ft (6 m) bgs. Results indicated no marked change with depth (excluding BH01) across the site with most values ranging between 4 and 9%, dry weight basis. A complete listing of the soil moisture content results are included in Appendix C, Figure C.1 and Table C.1. While it is acknowledged that these groundwater observation wells were installed during an unusually dry year, mottling indicative of high groundwater was limited across the site. Mottling was observed in three of the nine borings all located in the southeast portion of the site at depths greater than 5 ft (1.5 m) bgs: BH01 at 10 ft (3 m) bgs, at BH02 at 6 ft (1.8 m) bgs and at BH08 at 7.5 ft (2.3 m) bgs.

Table 1. Summary of Soil Properties.

	pH	Org. Mat. (%)	TN (ppm)	NH_4-N (ppm)	NO_3-N (ppm)	Avail. P (ppm)	Avail. K (ppm)	Exch. Ca (ppm)	Exch. Mg (ppm)	CEC (meq/ 100 g)
high	9.1	1.4	585.7	32.2	1.5	26.0	322.0	3770.0	440.0	22.1
low	5.2	0.1	6.8	1.9	0.5	1.0	50.0	310.0	70.0	2.5
average	7.3	0.5	124.0	5.2	0.7	4.4	117.3	1214.8	232.4	8.2
median	7.4	0.5	77.4	3.7	0.6	2.5	109.0	1005.0	230.0	6.8
std dev	1.01	0.33	138.41	4.93	0.19	4.80	46.62	791.94	113.31	4.67
CV	0.14	0.64	1.12	0.94	0.28	1.10	0.40	0.65	0.49	0.57

Percolation tests were conducted at four locations yielding the results summarized in Table 2. Tests were preformed on 4-in. (10 cm) diameter holes at a total depth of 3 ft. (1 m) below ground surface. Each hole was filled with water to at least 14 in. (36 cm) for 20 to 24 hrs, prior to testing. Following saturation of the test hole, the time for the water to drop 1 in. (2.5 cm) within the lower 6 inches (15 cm) of the hole was measured and recorded as the number of minutes per inch drop (min/in). Comparison of the individual rates and the average of all rates together to the boundary range of 5 and 60 min/in, indicates that the site is suitable for conventional soil absorption of STE. While it is widely recognized that conventional percolation tests are a poor measure of soil hydraulic capacity, tests were completed as required in the Jefferson County Regulations (Jefferson County 1999) and provide a relative measure of hydraulic capacity across the site.

Table 2. Summary of Percolation Test Results.

Location	Percolation Rate (min/in)	Average Percolation Rate (min/in)
BH01	10	15.5
BH03	16	
BH04	16	
BH09	20	

3.0 Test Site Design Considerations

Activities at the site will not present any disturbance to the local residents and odor, noise, or vector problems are not expected. Public and environmental risks associated with the proposed activities are negligible. The primary public risk is ingestion of untreated domestic wastewater effluent. However, this risk is non-existent at the site since all effluent will be released to the environment below ground; there will be no surface application of wastewater effluent. Also, planned access control (fencing, locking

caps, etc.) and adherence to minimum horizontal set-back distances will prevent exposure to the public and mitigate this potential risk. The primary potential environmental risk is the discharge of partially treated or untreated effluent to the ground surface or groundwater underlying the site. All testing involving delivery of wastewater effluent to the subsurface will be designed to achieve advanced treatment and satisfy the Jefferson County Regulations (Jefferson County 1999) which were developed to "preserve the environment and protect the public health and water quality…". Monitoring devices and sensors will be emplaced within and around unit operations and data will be collected from these manually as well as in an automated fashion including remote telemetry. All materials and methods used for installation will be industry standard and in accordance with any applicable local and State codes. All subsurface monitoring points will be installed with locking caps to prevent tampering.

4.0 Conclusions

Based on the site characteristics and soil conditions observed, the site was judged to be suitable for wastewater treatment and reclamation processes while satisfying the general goal of public health and environmental protection. It is important to note that the specific goal of the site evaluation described herein was to ensure that high groundwater, or low permeability of the subsurface native material would not diminish the soil treatment efficiency of proposed *in situ* test cells. Soil treatment research at the proposed site will be conducted using various configurations of small test cells ranging from 6-in. (15 cm) diameter *in situ* columns to ~2 ft (60 cm) wide by up to 7 ft (2.1 m) long test cells. An experimental design will be prepared describing specific details for each individual research activity.

5.0 References

Jefferson County. 1991. *Individual Sewage Disposal System Regulations.* Adopted by the Board of Health of Jefferson County, Colorado on November 17, 1998. Effective Date, January 1, 1999.

SSSA. 1986. *Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods, Second Edition.* Arnold Klute, Editor. American Society of Agronomy, Inc. and Soil Science Society of America, Inc. Madison, Wisconsin 53711.

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USEPA. 1991. *Description and Sampling of Contaminated Soils: A Field Pocket Guide*. EPA/625/12-91/002. United States Environmental Protection Agency. Center for Environmental Research Information, Cincinnati, Ohio 45268.

Appendix A Site Characteristics and Soil Conditions

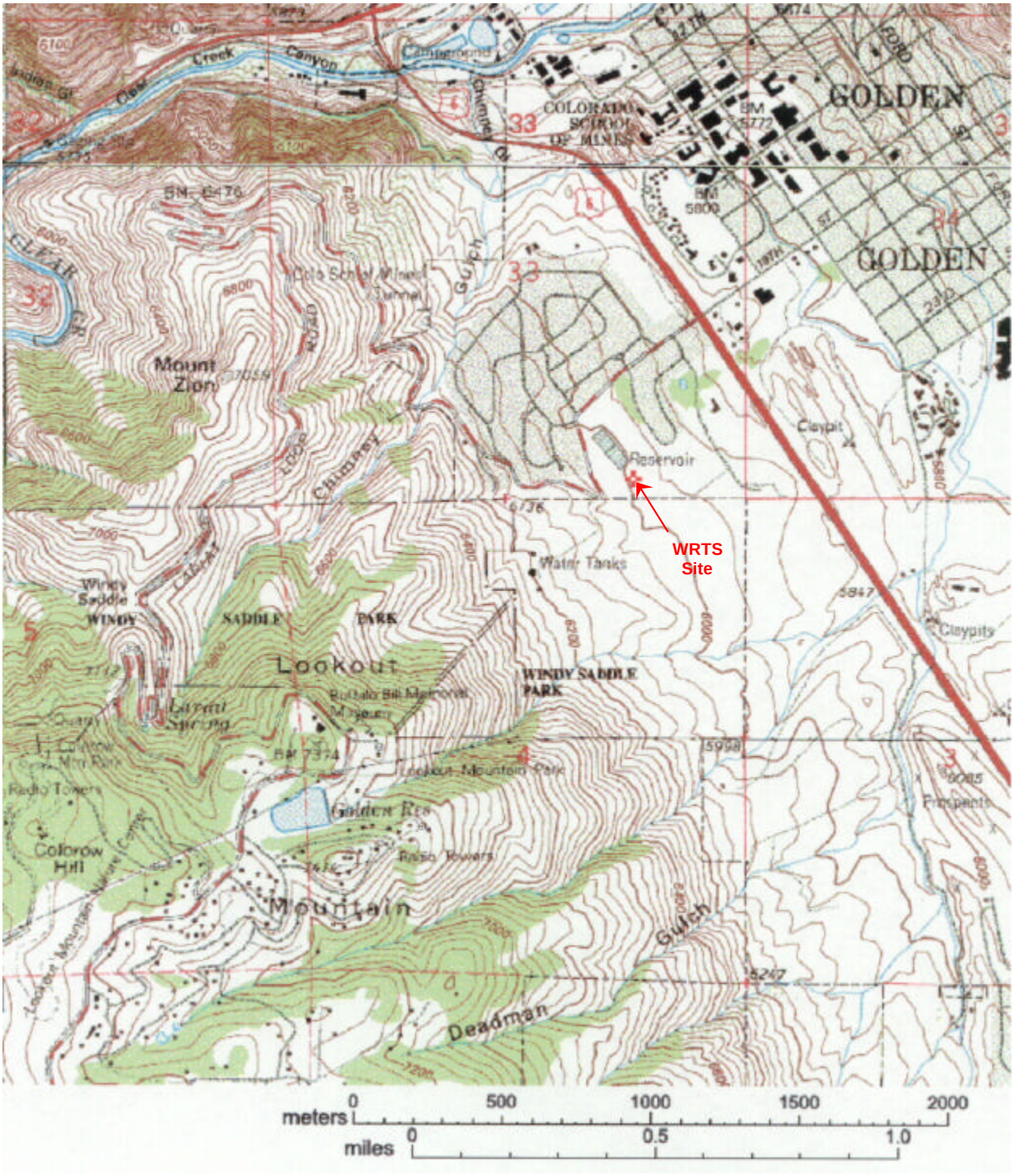


Figure A.1. Topographic map of the area surrounding the WRTS location.

Figure A.2. Photograph of Backhoe Test Pit #1, looking southwest (see Figure 2 for location).

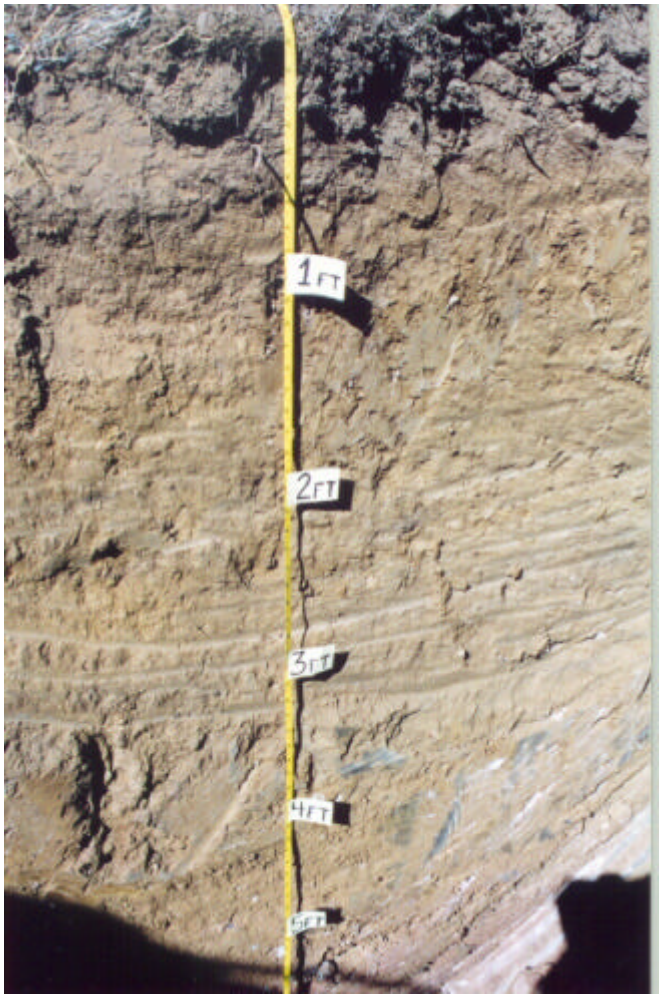


Figure A.3. Photograph of Soil Profile at Backhoe Test Pit #1 (west side of pit).

Figure A.4. Photograph of Backhoe Test Pit #2, looking northeast (see Figure 2 for location).

Figure A.5. Photograph of Soil Profile at Backhoe Test Pit #2 (north side of pit) with close-up of transition zone.

Appendix B. Summarized Soil Profile Descriptions

Table B.1. Backhoe Test Pit 1, Soil Profile Description.

Colorado School of Mines
Environmental Science and Engineering Division
1500 Illinois Street
Golden, Colorado 80401-1887
Phone: 303-274-3427 Fax: 303-273-3413

Project: WRTS Site Evaluation — Ground Surface Elevation:
Site/Location: Backhoe Test Pit #1 (BTP1) — Described by: Kathryn Lowe
Date: 09-May-02 — Page 1 of 1

Depth (bgs)	Soil Texture	Structure / Consistency	Color	Soil Hydrologic Parameters	Remarks
1	Sandy clay loam	Unconsolidated, tight, limited macropores	10YR3/3	dry	No mottling observed in pit
2	Sandy clay loam	Unconsolidated, tight, limited macropores	7YR4/4	dry	
3	Sandy clay loam	Unconsolidated, tight, limited macropores	7YR4/4	dry	
4	Sandy clay loam	Unconsolidated, tight, limited macropores	7YR4/4	dry	
5	Sandy clay loam	Unconsolidated, tight, limited macropores	7YR4/4	dry	
5.5	Not applicable	Poorly consolidated, very friable	2.5YR5/4	dry	Clear interface between soils; weathered igneous rock (conglomerate)
6	Not applicable	Poorly consolidated, very friable	2.5YR5/4	dry	weathered igneous rock (conglomerate)
7	Not applicable	Poorly consolidated, very friable	2.5YR5/4	dry	weathered igneous rock (conglomerate)
8	Not applicable	Poorly consolidated, very friable	2.5YR5/4	dry	weathered igneous rock (conglomerate)

Table B.2. Backhoe Test Pit 2, Soil Profile Description.

Colorado School of Mines
Environmental Science and Engineering Division
1500 Illinois Street
Golden, Colorado 80401-1887
Phone: 303-274-3427 Fax: 303-273-3413

Project: WRTS Site Evaluation — Ground Surface Elevation:
Site/Location: Backhoe Test Pit #2 (BTP2) — Described by: Kathryn Lowe
Date: 09-May-02 — Page 1 of 1

Depth (bgs)	Soil Texture	Structure / Consistency	Color	Soil Hydrologic Parameters	Remarks
0.5	Sandy clay loam	Unconsolidated, tight, limited macropores	10YR5/6	dry	No mottling observed in pit
1	Sandy loam	Highly fractured with bedding planes ~0.5 to 5.5 inches thick	5YR6/4	dry	weathered siltstone
2	Sandy loam	Highly fractured with bedding planes ~0.5 to 5.5 inches thick	5YR6/4	dry	mottling along root zones in top 2ft of pit; weathered siltstone
3	Sandy loam	Highly fractured with bedding planes ~0.5 to 5.5 inches thick	5YR6/4	dry	weathered siltstone
4	Sandy loam	Highly fractured with bedding planes ~0.5 to 5.5 inches thick	5YR6/4	dry	weathered siltstone
4.5	Sandy loam	Fractured with bedding planes ~2 to 5 inches thick	7.5YR5/6	dry	Clear interface between soils, but not contiguous across pit; weathered siltstone / weathered igneous rock (conglomerate)
5	Not applicable	Fractured with bedding planes ~2 to 5 inches thick	7.5YR5/6	dry	weathered siltstone / weathered igneous rock (conglomerate)
6	Not applicable	Fractured with bedding planes ~2 to 5 inches thick		dry	weathered igneous bedrock (poorly sorted, subangular, <3% schist, 40% silica, 55% feldspar (Kspar), and <2% hornblend)
					Total depth of test pit, 6 ft bgs - bedrock

Table B.3. Borehole 1, Soil Profile Description.

Colorado School of Mines
Environmental Science and Engineering Division
1500 Illinois Street
Golden, Colorado 80401-1887
Phone: 303-274-3427 Fax: 303-273-3413

Project: WRTS Site Evaluation Ground Surface Elevation: _____
Site/Location: Borehole 01 (BH01) Described by: Kathryn Lowe
Date: 16-Apr-02 Page 1 of 1

Depth (bgs)	Sample Type	Color	Soil Hydrologic Parameters	Soil Texture	Structure / Consistency / Morphology
2	core	10YR5/6	dry	very fine-medium gravelly sandy clay loam	loose, subangular
4	core	10YR6/3	dry	fine-medium gravelly sandy loam	loose, subangular
6	core	10YR7/4	dry	very fine-medium gravelly sandy loam	friable, poorly sorted, subangular; weathered igneous
8	core	10YR7/4	dry	very fine-medium gravelly sandy loam	friable, poorly sorted, subangular; weathered igneous
10	cuttings	5YR4/4	dry	sandy loam	mottled, poorly sorted, subangular
12	core	5YR4/4 & 5GY7/	dry	sandy loam	mottled, poorly sorted, subangular
14	cuttings	2.5YR3/4	dry	sandy loam	poorly sorted, subangular
16	cuttings	2.5YR4/4	wet	sandy loam	poorly sorted, subangular

Table B.4. Borehole 2, Soil Profile Description.

Colorado School of Mines
Environmental Science and Engineering Division
1500 Illinois Street
Golden, Colorado 80401-1887
Phone: 303-274-3427 Fax: 303-273-3413

Project: WRTS Site Evaluation Ground Surface Elevation: _____
Site/Location: Borehole 02 (BH02) Described by: Kathryn Lowe
Date: 16-Apr-02 Page 1 of 1

Depth (bgs)	Sample Type	Color	Soil Hydrologic Parameters	Soil Texture	Structure / Consistency / Morphology
2	core	5YR4/4	dry	fine gravelly sandy clay loam	loose
4	core	5YR4/4	dry	fine gravelly sandy loam	loose, poorly sorted, subangular
6	core	5YR4/4 & 10Y7/	dry	fine gravelly sandy loam	mottled (predominately grey with some red), friable, poorly sorted, subangular; weathered igneous
8	core	5YR4/3	dry	sandy loam	loose, poorly sorted, subangular
10	cuttings	5YR4/3	dry	sandy loam	poorly sorted, subangular
12	cuttings	7.5YR7/2	dry	sandy loam	poorly sorted, subrounded
14	cuttings	7.5YR7/2	dry	sandy loam	poorly sorted, subrounded
16	cuttings	2.5YR6/3	dry	sandy loam	rounded to subrounded
18	cuttings	5YR5/4	dry	sandy loam	subangular

Table B.5. Borehole 3, Soil Profile Description.

Colorado School of Mines
Environmental Science and Engineering Division
1500 Illinois Street
Golden, Colorado 80401-1887
Phone: 303-274-3427 Fax: 303-273-3413

Project: WRTS Site Evaluation
Ground Surface Elevation:
Site/Location: Borehole 03 (BH03)
Described by: Kathryn Lowe / Brett Chambers
Date: 16-Apr-02
Page 1 of 1

Depth (bgs)	Sample Type	Color	Soil Hydrologic Parameters	Soil Texture	Structure / Consistency / Morphology
2	core	7.5YR4/6	dry	sandy clay loam	loose
4	core	10YR5/4	dry	sandy loam	loose
6	core	10YR5/4	dry	fine gravelly sandy loam	tight, well sorted, subangular
8	core	7.5YR4/4	dry	medium gravelly sandy loam	friable, poorly sorted, subangular (clay layer at 7.75 ft - 7.5YR4/6); weathered igneous
10	core	2.5YR4/4	moist	fine gravelly sandy loam	friable, poorly sorted, subangular; weathered igneous
12	core	10YR4/4	dry	medium gravelly sandy loam	loose, poorly sorted, subangular
15	cuttings	5YR4/4	dry	sandy loam	poorly sorted, subangular
16	cuttings	5YR5/4	dry	sandy loam	poorly sorted, subangular
18	cuttings	2.5YR4/6	dry	sandy loam	poorly sorted, subangular
20	cuttings	5YR5/4	dry	sandy loam	poorly sorted, subangular
22	cuttings	2.5YR5/6	dry	sandy loam	poorly sorted, subangular

Table B.6. Borehole 4, Soil Profile Description.

Colorado School of Mines
Environmental Science and Engineering Division
1500 Illinois Street
Golden, Colorado 80401-1887
Phone: 303-274-3427 Fax: 303-273-3413

Project: WRTS Site Evaluation
Ground Surface Elevation:
Site/Location: Borehole 04 (BH04)
Described by: Kathryn Lowe / Brett Chambers
Date: 17-Apr-02
Page 1 of 1

Depth (bgs)	Sample Type	Color	Soil Hydrologic Parameters	Soil Texture	Structure / Consistency / Morphology
2	core	10YR4/6	dry	fine gravelly sandy clay loam	tight
4	core	10YR5/6	dry	sandy clay loam	
6	core	10YR5/6	dry	fine gravelly sandy clay loam	
8	core	10YR5/8	dry	sandy loam	loose, poorly sorted, subangular
10	core	10YR4/6	moist	sandy loam	loose, poorly sorted, subangular
11.5	core	7.5YR5/6	moist	sandy loam	loose, poorly sorted, subangular
14	core	7.5YR4/6	moist	sandy loam	loose, poorly sorted, subangular
16	core	5YR4/4	dry	fine gravelly sandy loam	friable, poorly sorted, subangular; weathered igneous
18	cuttings	7.5YR4/4	dry	fine gravelly sandy loam	poorly sorted, subangular
20	cuttings	5YR4/4	dry	sandy loam	poorly sorted, subangular
22	cuttings	5YR4/4	dry	sandy loam	poorly sorted, subangular

Table B.7. Borehole 5, Soil Profile Description.

Colorado School of Mines
Environmental Science and Engineering Division
1500 Illinois Street
Golden, Colorado 80401-1887
Phone: 303-274-3427 Fax: 303-273-3413

Project: WRTS Site Evaluation — Ground Surface Elevation: _____
Site/Location: Borehole 05 (BH05) — Described by: Kathryn Lowe / Brett Chambers
Date: 17-Apr-02 — Page 1 of 1

Depth (bgs)	Sample Type	Color	Soil Hydrologic Parameters	Soil Texture	Structure / Consistency / Morphology
2	core	5YR5/6	dry	fine-medium gravelly sandy clay loam	poorly sorted
4	core	7.5YR5/6	dry	sandy clay loam	poorly sorted
6	core	7.5YR6/6	dry	sandy loam	loose, poorly sorted, subangular
7	core	2.5YR5/4	dry	sandy loam	loose, poorly sorted, subangular
8	cuttings	2.5YR6/4	dry	sandy loam	poorly sorted, subangular
10	cuttings	7.5YR7/3	dry	sandy loam	poorly sorted, subangular

Table B.8. Borehole 6, Soil Profile Description.

Colorado School of Mines
Environmental Science and Engineering Division
1500 Illinois Street
Golden, Colorado 80401-1887
Phone: 303-274-3427 Fax: 303-273-3413

Project: WRTS Site Evaluation — Ground Surface Elevation: _____
Site/Location: Borehole 06 (BH06) — Described by: Kathryn Lowe / Brett Chambers
Date: 17-Apr-02 — Page 1 of 1

Depth (bgs)	Sample Type	Color	Soil Hydrologic Parameters	Soil Texture	Structure / Consistency / Morphology
2	core	10YR5/6	dry	medium gravelly sandy loam	poorly sorted, subangular
4	cuttings	10YR6/4	dry	fine gravelly sandy loam	poorly sorted, subangular
6	cuttings	10YR6/6	dry	fine gravelly sandy loam	poorly sorted, subangular
8	cuttings	10YR7/4	dry	fine gravelly sandy loam	poorly sorted, subrounded
10	cuttings	7.5YR6/4	dry	sandy loam	subrounded

Table B.9. Borehole 8, Soil Profile Description.

Colorado School of Mines
Environmental Science and Engineering Division
1500 Illinois Street
Golden, Colorado 80401-1887
Phone: 303-274-3427 Fax: 303-273-3413

Project: WRTS Site Evaluation — Ground Surface Elevation: _____
Site/Location: Borehole 08 (BH08) — Described by: Kathryn Lowe / Brett Chambers
Date: 18-Apr-02 — Page 1 of 1

Depth (bgs)	Sample Type	Color	Soil Hydrologic Parameters	Soil Texture	Structure / Consistency / Morphology
2	core	5YR5/6	dry	fine-medium gravelly sandy clay loam	loose; some weathered igneous
4	core	5YR5/6	dry	fine-medium gravelly sandy loam	loose; some weathered igneous
6	core	5YR4/4	dry	very medium gravelly sandy clay loam	poorly sorted, subangular
7.5	core	7.5YR6/4	dry	fine gravelly sandy loam	mottled, poorly sorted, subangular
9	cuttings	5YR7/3	dry	sandy loam	well sorted, subangular
10	cuttings	5YR6/3	dry	sandy loam	well sorted, subangular
12	cuttings	2.5YR6/3	dry	sandy loam	subrounded
14	cuttings	5YR5/4	dry	sandy loam	poorly sorted, subrounded
16	cuttings	7.5YR5/4	dry	sandy loam	subrounded
18	cuttings	5YR5/4	dry	sandy loam	subrounded
20	cuttings	5YR6/3	dry	sandy loam	well sorted, subrounded

Table B.10. Borehole 9, Soil Profile Description.

Colorado School of Mines
Environmental Science and Engineering Division
1500 Illinois Street
Golden, Colorado 80401-1887
Phone: 303-274-3427 Fax: 303-273-3413

Project: WRTS Site Evaluation — Ground Surface Elevation: _____
Site/Location: Borehole 09 (BH09) — Described by: Kathryn Lowe
Date: 18-Apr-02 — Page 1 of 1

Depth (bgs)	Sample Type	Color	Soil Hydrologic Parameters	Soil Texture	Structure / Consistency / Morphology
2	core	5YR4/3	dry	sandy clay loam	loose
4	core	7.5YR5/6	dry	sandy loam	loose
6	cuttings	7.5YR5/4	dry	sandy loam	poorly sorted, subangular
8	cuttings	5YR4/3	dry	sandy loam	poorly sorted, subrounded
10	cuttings	5YR3/3	dry	loam	poorly sorted, subangular
12	cuttings	7.5YR5/4	dry	sandy loam	poorly sorted, subrounded
14	cuttings	5YR5/4	dry	sandy loam	poorly sorted, subrounded
16	cuttings	5YR4/4	dry	sandy loam	poorly sorted, subrounded
18	cuttings	5YR4/4	dry	sandy loam	poorly sorted, subrounded
20	cuttings	5YR4/4	dry	sandy loam	poorly sorted, subrounded

Appendix C Soil Analyses Data

Figure C.1. Soil Water Content with Depth.

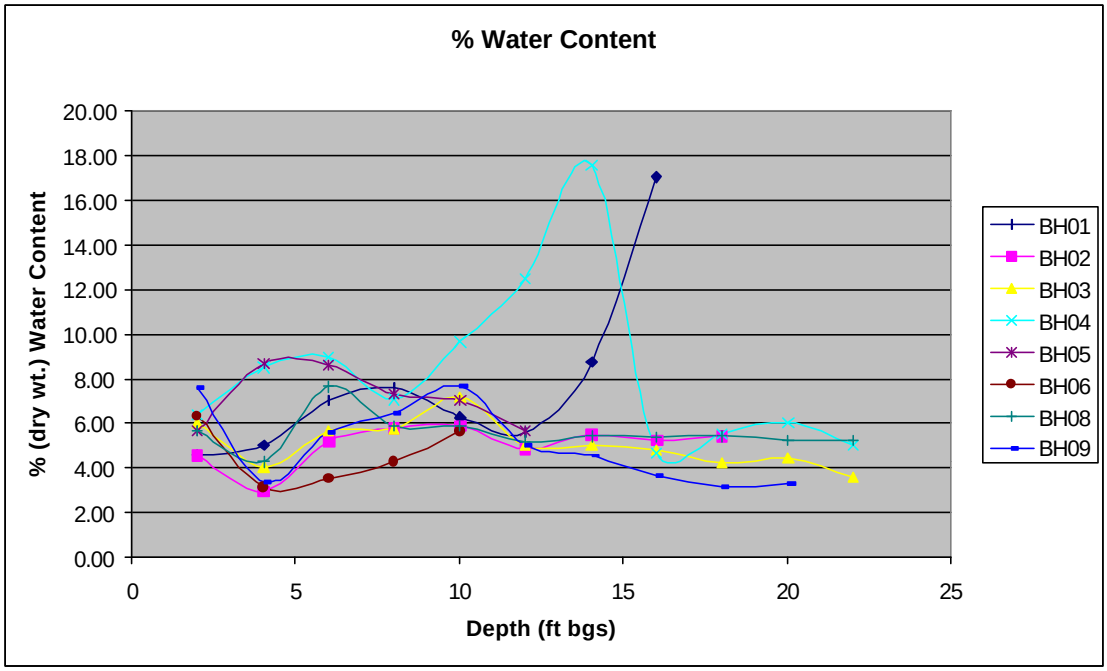


Table C.1. Summary of % Water Content Results.

Depth (ft bgs)	% (dry wt.) Water Content							
	BH01	BH02	BH03	BH04	BH05	BH06	BH08	BH09
2	4.6	4.6	6.0	6.4	5.6	6.3	5.7	7.6
4	5.0	3.0	4.0	8.5	8.7	3.1	4.3	3.4
6	7.0	5.2	5.7	9.0	8.6	3.5	7.6	5.6
8	7.6	5.8	5.8	7.1	7.0	4.3	5.9	6.4
10	6.3	5.9	7.2	9.7	5.6	5.7	5.2	7.7
12	5.6	4.9	5.0	12.5	-	-	5.4	5.0
14	8.8	5.5	-	17.5	-	-	5.4	4.6
16	17.0	5.3	4.8	4.7	-	-	5.4	3.7
18	-	5.4	4.2	5.6	-	-	5.3	3.2
20	-	-	4.4	6.1	-	-	5.3	3.3
22	-	-	3.6	5.0	-	-	-	-

Notes: No samples collected from BH07 which was located within 3 ft of BH05.
- indicates no sample collected at that interval.

Table C.2. Summary of Organic Matter Results.

Depth (ft bgs)	% Organic Matter							
	BH01	**BH02**	**BH03**	**BH04**	**BH05**	**BH06**	**BH08**	**BH09**
2	0.7	1.1	1.4	1.0	0.8	1.3	0.8	1.2
4	0.3	0.5	0.6	0.8	0.6	0.6	0.3	0.3
6	0.3	0.4	0.4	0.6	0.5	0.5	0.5	0.2
8	0.3	0.3	0.4	0.5	0.5	0.3	0.2	0.2
10	0.3	0.2	0.1	0.7	0.1	0.8	0.1	0.4

Notes: Samples collected below 10 ft were not submitted for analysis. No samples collected from BH07 which was located within 3 ft of BH05.

Table C.3. Summary of Cation Exchange Capacity Results.

Depth (ft bgs)	Cation Exchange Capacity (meq/100g dry soil)							
	BH01	**BH02**	**BH03**	**BH04**	**BH05**	**BH06**	**BH08**	**BH09**
2	8.6	8.9	12.1	11.3	11.2	5.3	7.7	1.8
4	5.7	6.9	8.8	13.1	22.1	4.0	6.6	3.9
6	4.9	6.6	9.1	13.6	8.2	4.3	21.6	3.5
8	3.6	2.5	6.4	15.0	5.7	2.7	5.2	6.3
10	13.4	4.1	3.4	10.8	2.9	6.6	12.8	13.4

Notes: Samples collected below 10 ft were not submitted for analysis. No samples collected from BH07 which was located within 3 ft of BH05.

Table C.4. Summary of % Sand/Silt/Clay Results.

Depth (ft bgs)	% Sand / % Silt / % Clay (dry wt.)							
	BH01	**BH02**	**BH03**	**BH04**	**BH05**	**BH06**	**BH08**	**BH09**
2	64/ 14/ 22	70/ 9/ 21	48/ 23/ 29	59/ 17/ 24	63/ 8/ 29	69/ 12/ 19	69/ 9/ 22	58/ 13/ 29
4	72/ 12/ 16	75/ 7/ 18	68/ 16/ 16	60/ 12/ 28	62/ 14/ 24	76/ 10/ 14	69/ 12/ 19	77/ 10/ 13
6	73/ 13/ 14	66/ 18/ 16	70/ 13/ 17	61/ 15/ 24	69/ 13/ 18	75/ 11/ 14	59/ 17/ 24	74/ 15/ 11
8	75/ 14/ 11	77/ 11/ 12	75/ 10/ 15	69/ 13/ 18	69/ 14/ 17	74/ 13/ 13	74/ 13/ 13	66/ 21/ 13
10	72/ 14/ 14	70/ 15/ 15	68/ 17/ 15	63/ 17/ 20	58/ 26/ 16	73/ 11/ 16	73/ 14/ 13	45/ 38/ 17

Notes: Samples collected below 10 ft were not submitted for analysis. No samples collected from BH07 which was located within 3 ft of BH05.

Table C.5. Summary of percent sand fraction based on dry sieve analysis.

	Count	**Min.**	**Max.**	**Ave.**	**Median**	**Std. Dev.**	**CV**	**Var.**
% > 2mm (coarse sand)	17	8.7%	51.7%	23.9%	22.8%	0.097	0.404	0.0093
% Sand	17	46.3%	84.9%	73.3%	74.6%	0.089	0.122	0.0080
% Silt & Clay	17	1.3%	9.2%	2.8%	2.3%	0.018	0.639	0.0003

Soil sample intervals included in summary statistics are: BH01, 6 and 8 ft bgs; BH02, BH03 and BH04, 2, 4, 6, and 8 ft bgs; and BH05, BH08 and BH09, 4 ft bgs.

Table C.6. Summary statistics for sand grain size distribution based on dry sieve analysis.

	Count	Min.	Max.	Ave.	Median	Std. Dev.	CV	Var.
d10	17	0.075	0.21	0.16	0.17	0.039	0.252	0.002
d25	17	0.160	0.45	0.30	0.28	0.082	0.278	0.007
d30	17	0.180	0.68	0.37	0.32	0.128	0.351	0.016
d50	17	0.370	1.10	0.70	0.68	0.215	0.309	0.046
d60	17	0.500	1.20	0.88	0.90	0.214	0.244	0.046
d75	17	0.810	1.60	1.21	1.10	0.227	0.188	0.051

Soil sample intervals included in summary statistics are: BH01, 6 and 8 ft bgs; BH02, BH03 and BH04, 2, 4, 6, and 8 ft bgs; and BH05, BH08 and BH09, 4 ft bgs.

Table C.7. Sand grain size distribution by dry sieve analysis, BH03 at 2 ft bgs.

Colorado School of Mines
Environmental Science and Engineering Division
1500 Illinois Street
Golden, Colorado 80401-1887
Phone: 303-274-3427 Fax: 303-273-3413

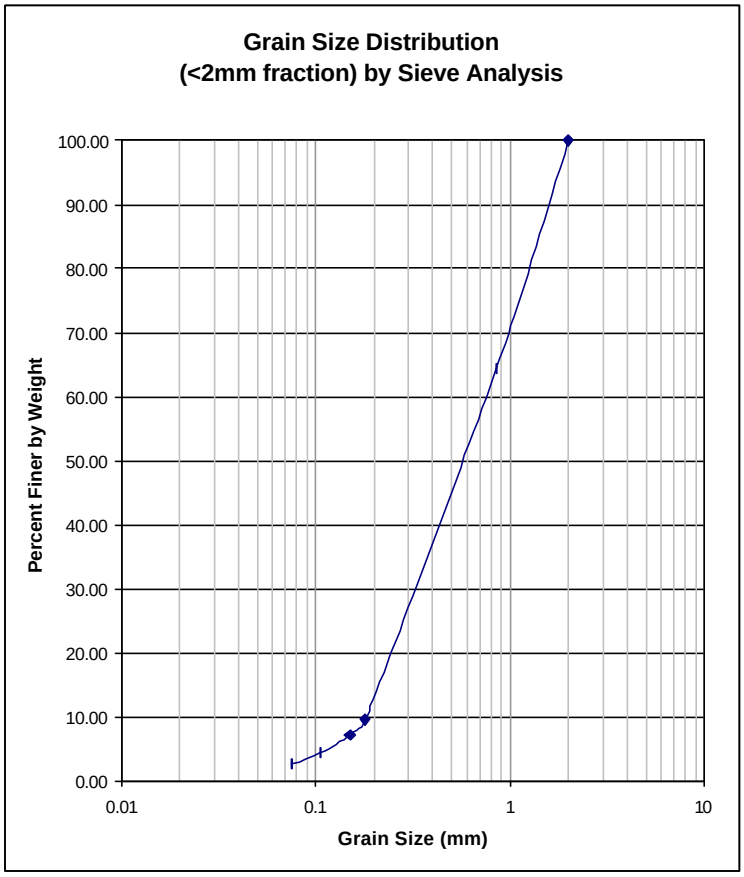
Project: WRTS Site Evaluation
Location: BH03, 2ft bgs
Date: 14-May-02
Analyses by: Brett Chambers

USDA Classification

Size (mm)	Fraction	Mass (g)	Percent
>2.0	Gravel		
2.0-1.0	Very Coarse Sand		
1.0-0.5	Coarse Sand		
0.5-0.25	Medium Sand		
0.25-0.1	Fine Sand		
0.1-0.05	Very Fine Sand		
0.05-0.002	Silt		
<0.002	Clay		
	Total		
> 2mm	Coarse sand		
2-0.05	Sand		
<0.05	Silt + Clay		

Unified Classification

Sieve No.	Size (mm)	Fraction	Mass (g)	Percent
#10	>2.0	Coarse Sand	15.03	12.8%
#20	2.0-0.85	Medium Sand	36.36	31.0%
#80	0.85-0.18	Fine Sand	56.08	47.8%
#100	0.18-0.15	Fine Sand	2.42	2.1%
#140	0.15-0.106	Fine Sand	2.87	2.4%
#200	0.106-0.075	Fine Sand	1.82	1.6%
-	< 0.075	Silt + Clay	2.66	2.3%
-	-	-	-	-
		Total	117.24	100.0%
	> 2mm	Coarse sand	15.03	12.8%
	2 - 0.075	Sand	99.55	84.9%
	<0.075	Silt + Clay	2.66	2.3%



Summary Statistics

d10	0.18
d25	0.28
d30	0.32
d50	0.58
d60	0.74
d75	1.10

Table C.8. Sand grain size distribution by dry sieve analysis, BH03 at 4 ft bgs.

Colorado School of Mines
Environmental Science and Engineering Division
1500 Illinois Street
Golden, Colorado 80401-1887
Phone: 303-274-3427 Fax: 303-273-3413

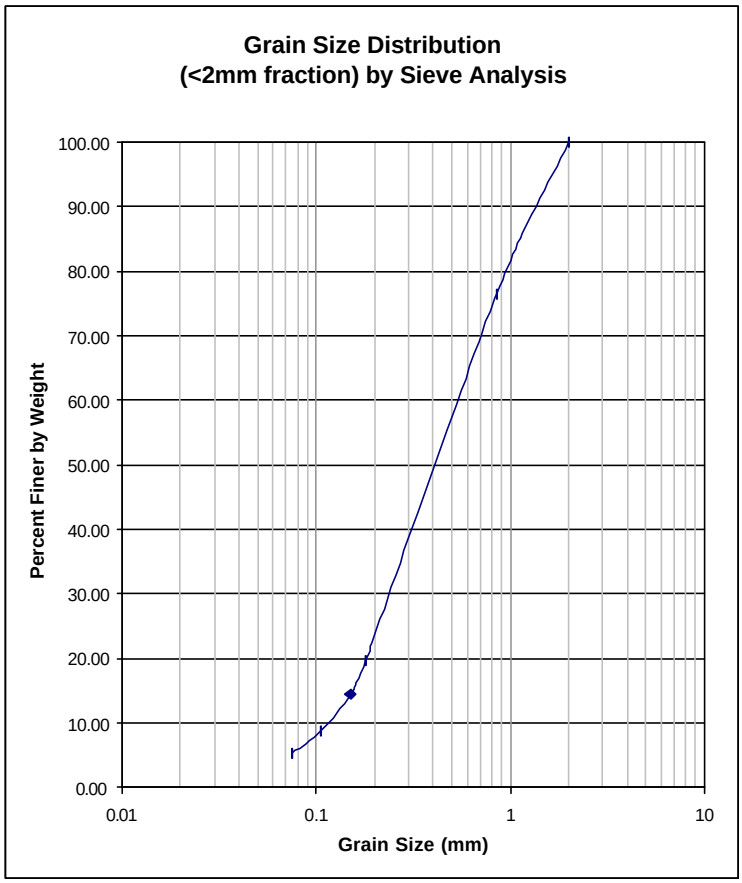
Project: WRTS Site Evaluation
Location: BH03, 4ft bgs
Date: 14-May-02
Analyses by: Brett Chambers

USDA Classification

Size (mm)	Fraction	Mass (g)	Percent
>2.0	Gravel		
2.0-1.0	Very Coarse Sand		
1.0-0.5	Coarse Sand		
0.5-0.25	Medium Sand		
0.25-0.1	Fine Sand		
0.1-0.05	Very Fine Sand		
0.05-0.002	Silt		
<0.002	Clay		
	Total		
> 2mm	Coarse sand		
2-0.05	Sand		
<0.05	Silt + Clay		

Unified Classification

Sieve No.	Size (mm)	Fraction	Mass (g)	Percent
#10	>2.0	Coarse Sand	20.29	15.4%
#20	2.0-0.85	Medium Sand	26.17	19.9%
#80	0.85-0.18	Fine Sand	63.22	48.0%
#100	0.18-0.15	Fine Sand	5.87	4.5%
#140	0.15-0.106	Fine Sand	6.23	4.7%
#200	0.106-0.075	Fine Sand	3.99	3.0%
-	< 0.075	Silt + Clay	5.85	4.4%
-	-	-	-	-
		Total	131.62	100.0%
	> 2mm	Coarse sand	20.29	15.4%
	2 - 0.075	Sand	105.48	80.1%
	<0.075	Silt + Clay	5.85	4.4%



Summary Statistics

d10	0.11
d25	0.20
d30	0.23
d50	0.40
d60	0.52
d75	0.81

Table C.9. Sand grain size distribution by dry sieve analysis, BH03 at 6 ft bgs.

Colorado School of Mines
Environmental Science and Engineering Division
1500 Illinois Street
Golden, Colorado 80401-1887
Phone: 303-274-3427 Fax: 303-273-3413

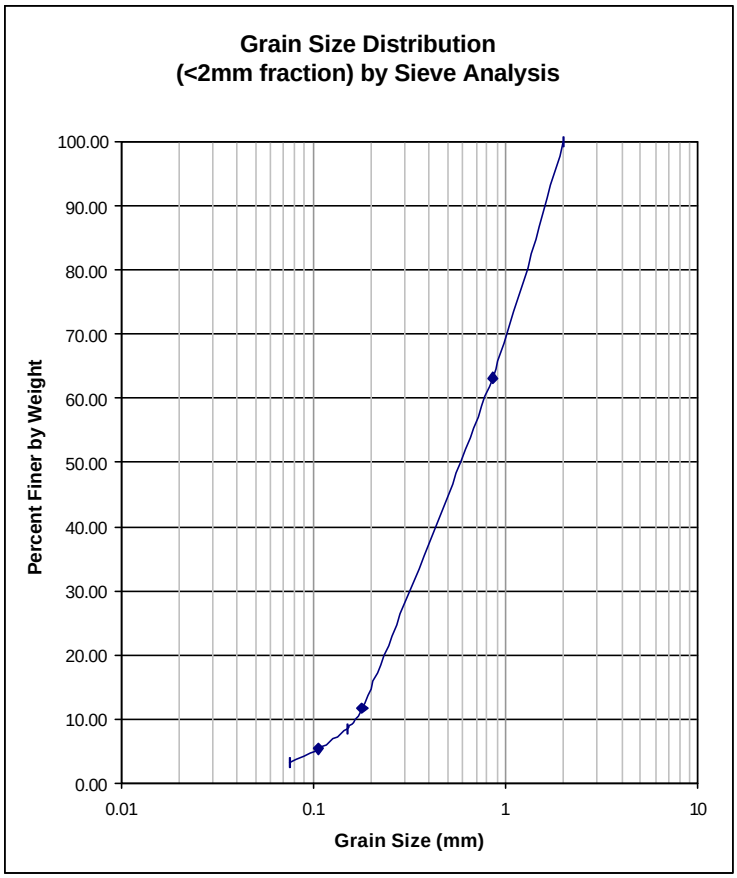
Project: WRTS Site Evaluation
Location: BH03, 6ft bgs
Date: 14-May-02
Analyses by: Brett Chambers

USDA Classification

Size (mm)	Fraction	Mass (g)	Percent
>2.0	Gravel		
2.0-1.0	Very Coarse Sand		
1.0-0.5	Coarse Sand		
0.5-0.25	Medium Sand		
0.25-0.1	Fine Sand		
0.1-0.05	Very Fine Sand		
0.05-0.002	Silt		
<0.002	Clay		
	Total		
> 2mm	Coarse sand		
2-0.05	Sand		
<0.05	Silt + Clay		

Unified Classification

Sieve No.	Size (mm)	Fraction	Mass (g)	Percent
#10	>2.0	Coarse Sand	29.97	22.8%
#20	2.0-0.85	Medium Sand	37.27	28.4%
#80	0.85-0.18	Fine Sand	52.11	39.7%
#100	0.18-0.15	Fine Sand	3.17	2.4%
#140	0.15-0.106	Fine Sand	3.23	2.5%
#200	0.106-0.075	Fine Sand	2.07	1.6%
-	< 0.075	Silt + Clay	3.35	2.6%
-	-	-	-	-
		Total	131.17	100.0%
	> 2mm	Coarse sand	29.97	22.8%
	2 - 0.075	Sand	97.85	74.6%
	<0.075	Silt + Clay	3.35	2.6%



Summary Statistics	
d10	0.17
d25	0.27
d30	0.31
d50	0.58
d60	0.77
d75	1.10

Table C.10. Sand grain size distribution by dry sieve analysis, BH03 at 8 ft bgs.

Colorado School of Mines
Environmental Science and Engineering Division
1500 Illinois Street
Golden, Colorado 80401-1887
Phone: 303-274-3427 Fax: 303-273-3413

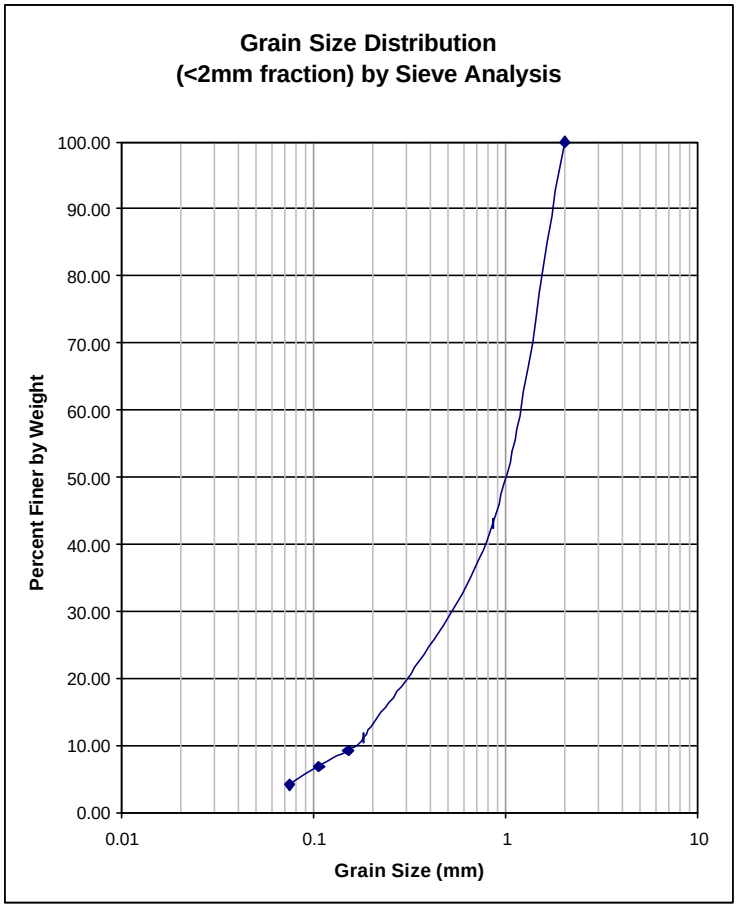
Project: WRTS Site Evaluation
Location: BH03, 8ft bgs
Date: 14-May-02
Analyses by: Brett Chambers

USDA Classification

Size (mm)	Fraction	Mass (g)	Percent
>2.0	Gravel		
2.0-1.0	Very Coarse Sand		
1.0-0.5	Coarse Sand		
0.5-0.25	Medium Sand		
0.25-0.1	Fine Sand		
0.1-0.05	Very Fine Sand		
0.05-0.002	Silt		
<0.002	Clay		
	Total		
> 2mm	Coarse sand		
2-0.05	Sand		
<0.05	Silt + Clay		

Unified Classification

Sieve No.	Size (mm)	Fraction	Mass (g)	Percent
#10	>2.0	Coarse Sand	62.43	51.7%
#20	2.0-0.85	Medium Sand	33.19	27.5%
#80	0.85-0.18	Fine Sand	18.63	15.4%
#100	0.18-0.15	Fine Sand	1.04	0.9%
#140	0.15-0.106	Fine Sand	1.38	1.1%
#200	0.106-0.075	Fine Sand	1.64	1.4%
-	< 0.075	Silt + Clay	2.41	2.0%
-	-	-	-	-
		Total	120.72	100.0%
	> 2mm	Coarse sand	62.43	51.7%
	2 - 0.075	Sand	55.88	46.3%
	<0.075	Silt + Clay	2.41	2.0%



Summary Statistics

d10	0.16
d25	0.40
d30	0.51
d50	1.00
d60	1.10
d75	1.30