December 6, 2011 839-04

Mr. Mark Conan
Plaid Pantries, Inc.
10025 SW Allen Boulevard
Beaverton, Oregon 97005-4124

Subject: **Work Plan for Supplemental Site Characterization**
Former Plaid Pantries Store #23
5210 East Fourth Plain Boulevard
Vancouver, Washington
Ecology VCP Project #SW1166

Dear Mr. Conan:

PNG Environmental, Inc. (PNG) is providing this work plan for additional characterization activities at the former Plaid Pantries Inc. (Plaid) Store #23 site located at 5210 East Fourth Plain Boulevard in accordance with comments provided by the Washington State Department of Ecology (Ecology) in a letter dated October 31, 2011. Additional tasks may be required to satisfy Ecology's administrative requirements for site closure. Supporting information is provided below.

BACKGROUND

The subject site is currently occupied by a commercial strip mall and paved parking lot area located along a commercial thoroughfare in Vancouver, Washington (Figure 1). The subject property is owned by M & P Properties. Plaid Pantries, Inc. (Plaid) was a tenant and operated the site as a retail gasoline station and convenience store between 1982 and early 2002. The Underground Storage Tank (UST) Site Number Plaid registered with Ecology was 11397. During Plaid's operations, only gasoline is known to have been stored and dispensed at the site. Leaded gasoline may have been dispensed at the site during phase-out of that product in the 1980s. PNG understands that Plaid did not store or dispense other hydrocarbons such as diesel fuel, bulk motor oil, or other bulk solvents at any time during its site operations.

Prior to Plaid's operations, the site was occupied continuously as a gasoline service station since the early 1960s. The nature and volume of fuel and other products used and stored at the site by others have not been determined by PNG, although the facility appears to have been operated as a Chevron station during much or all of its operations prior to Plaid. The pre-Plaid service station building was located near the southwestern margin of the existing site building and was demolished during site redevelopment in the early 1980s. Current and historic site infrastructure is illustrated on Figure 2.

ECOLOGY REQUEST FOR FURTHER ACTION

In an Opinion Letter dated October 31, 2011 (Attachment A), Ecology indicated that further site characterization and administrative actions are necessary to support Plaid's request for a No Further Action (NFA) determination. PNG wishes to clarify that the data needs and specific characterization efforts cited by Ecology are being required in support of a formal evaluation the

Remedial Investigation and Feasibility Study (RI/FS) and cleanup process and other administrative details provided under Chapter 173-340 WAC. The supplemental data gathering and clarification tasks as specified will enable Ecology to determine whether interim remedial actions undertaken by Plaid to date have adequately satisfied existing cleanup criteria.

PNG further notes that site cleanup actions to date are consistent with Ecology's definition of an "Interim Action" (WAC 173-340-430) because the following criteria were achieved:

- Emphasizes source-area contamination and related controls and does not directly address cleanup of downgradient and/or offsite portions of the plume. The need for additional offsite cleanup actions will be evaluated as part of the supplemental characterization. An interim action may satisfy the requirements of a complete cleanup action depending on its performance characteristics relative to final site cleanup goals.
- Source controls are "technically necessary to reduce a threat to human health or the environment by eliminating or substantially reducing one or more pathways for exposure to a hazardous substance."
- Corrects a problem "that may become substantially worse or cost substantially more to address if the remedial action is delayed." In particular, UST system removal and source-area treatment to date have been observed to provide effective contaminant removal and mitigation of plume migration. The completed source controls clearly satisfy this aspect of an interim action.
- Represents a remedial action capable of supporting further assessment, investigation, and design of a cleanup action if needed.

The interim actions completed to date were intended to result in a permanent solution and to achieve cleanup requirements as defined under MTCA. Although additional cleanup actions may ultimately be required subject to the findings of the planned characterization, we emphasize that the supplemental characterization tasks will indicate whether permanent cleanup was adequately achieved and whether or not further remedial actions are necessary.

Ecology's Opinion Letter comments are summarized below.

Site Characterization

Ecology has requested the following supplemental site characterization tasks be conducted.

- A geophysical survey of the subject property by GeoPotential, Inc. identified two subsurface anomalies that Ecology suspects may represent USTs from pre-Plaid site operations. Ecology requested characterization of both anomalies by physical examination and removal as feasible if USTs are confirmed to be present. If UST decommissioning is performed at the location of either of the anomalies, confirmation soil and groundwater samples will be required in accordance with the Opinion Letter.
- Analytical data indicates petroleum contaminated soil with contaminant concentrations exceeding the Model Toxics Control Act (MTCA) Method A cleanup levels (CULs) may remain in place at depths ranging from 10 to 15 feet below ground surface (bgs) at several locations. Ecology has requested the collection of confirmation soil samples from the vicinity of soil borings B-7/P2 at 15 to 16 feet bgs, B-6 at ten feet bgs, and B-13 at 15 feet bgs (see Figure 2). Contaminants of concern (COCs) at these locations are gasoline range hydrocarbons, BTEX, and lead.

- Although four consecutive quarterly groundwater monitoring events indicated COC concentrations in site groundwater were either below the applicable MTCA Method A CULs or not detected, Ecology noted a rebound effect in monitoring well MW-7 in September and December 2009. In addition, COC concentrations increased above the applicable MTCA Method A CULs when the depth to groundwater at that well was 14 feet bgs or greater. Groundwater depths during the last four quarterly monitoring events were shallower than 13.5 feet bgs. Consequently, Ecology requested sampling down-gradient wells MW-6 and MW-7 if depth to groundwater is greater than 14 feet bgs to confirm that the implemented remedy is permanent. If the groundwater table does not fall below 14 feet depth during a one-year quarterly monitoring period, no additional groundwater monitoring is necessary in this area and Ecology will accept the available groundwater data as representative of site conditions.
- PNG used an arbitrary vertical datum for this site investigation. Although the investigation was completed in 2010, effective June 2011 Ecology now requires the use of United States Geological Survey (USGS) datum as a basis for all elevations. Consequently, Ecology has requested calibration of site elevation data to a known USGS datum as required by WAC 173-340-840.

Establishment of Cleanup Standards

Ecology determined that the CULs and points of compliance established for the site do not meet certain administrative requirements of MTCA and must be specified as follows:

- Applicable MTCA Method A CULs for soil and groundwater shall be used to characterize the site.
- The point of compliance for protection of groundwater should be soil throughout the site.
- For soil CULs based on human exposure via direct contact or other exposure pathways where contact with the soil is required to complete the pathway, the point of compliance should be soils throughout the site from the ground surface to a depth of 15 feet bgs.
- The point of compliance for groundwater should be from the uppermost level of the saturated zone extending vertically to the greatest depth that could potentially be affected by the site.

Selection of Cleanup Actions

Ecology determined that the cleanup action selected for the site does not meet the certain administrative requirements of MTCA and must be specified as follows:

- The affected site media must be fully characterized prior to selecting any final cleanup action.
- For a site cleanup action to qualify for a no further action opinion, it must meet one or more of the minimum cleanup requirements in WAC 173-340-360(2).
- MTCA requires the use of permanent solutions to the maximum extent practicable. If permanent solutions are not part of the remedy, it will be necessary to develop a feasibility study based on the information collected in the characterization phase.

- The feasibility study should include all practicable methods of treatment in addressing the site cleanup. Monitored natural attenuation is a cleanup alternative that must be approved by Ecology before implementation.

Cleanup

Ecology determined that the cleanup performed at the site does not meet certain administrative standards for the site. This determination was based on the following:

- The site was not characterized to the extent now requested by Ecology prior to initiating cleanup activities.
- Soil sample analytical results indicated the petroleum contaminated soil was removed from the UST excavation; however, no confirmation soil sample was collected from the southwest corner of the UST excavation near soil boring B-6 where gasoline impacts were formerly identified.
- The conceptual site model (CSM) was not developed to the extent now requested by Ecology to define the site.

PROPOSED SCOPE OF WORK

PNG has developed the following scope of work to address site characterization data gaps identified by Ecology. Note that additional phases of work may be necessary to address Ecology's formal administrative requirements regarding CULs, points of compliance, selection of site cleanup actions through a feasibility study, and implementation of the selected cleanup action identified by the feasibility study, if required. Because of uncertainties regarding specific closure criteria, Plaid and PNG will coordinate site characterization findings with Ecology and will prepare separate work plan(s) for additional work that may be required at the completion of the proposed site characterization activities as described below.

Field Preparation Tasks

PNG proposes to perform the following specific tasks as part of this scope:

- Update the current Health and Safety Plan to guide field safety protocols, in accordance with rules established by the Occupational Safety and Health Administration and the Washington Industrial Safety and Health Act.
- Review site plans and as-built maps provided to PNG by Plaid.
- Request utility identification through the public Utility Notification Service. Contract with an experienced local firm in an effort to locate and map existing utilities within the work areas. This approach does not guarantee that unidentified conduits will not be encountered during drilling, but greatly minimizes the risk of doing so at depths where underground utilities are commonly present.

Physical Examination of Geophysical Anomalies

Physical examination of geophysical anomalies A and B (Figure 2) will include the following:

- Direct field operations using four-inch diameter air-knife excavation techniques at three locations within the mapped boundaries of each geophysical anomaly (Figure 3).

Air-knife excavations at each of the proposed locations will extend to below the suspected upper surface of each potential object at target depths of five feet bgs.

- To the extent possible, inspect and photograph the subsurface object at each geophysical anomaly location to identify and document the nature of the geophysical anomalies.
- Backfill air-knife excavations with bentonite and restore asphalt pavement at each proposed physical examination location.
- If USTs are positively identified at either (or both) of the geophysical anomaly locations, PNG will prepare and submit a separate work plan for UST decommissioning and confirmatory soil and groundwater sampling in accordance with Ecology guidance.

Confirmation Soil Sampling

Confirmation soil sampling at three locations in the former Plaid UST and pump island areas will include the following. Standard operating procedures (SOPs) for the specified logging and sampling tasks are attached.

- Direct field operations using direct-push Geoprobe drilling techniques to collect soil samples at three locations as requested by Ecology. As requested by Ecology, proposed boring locations B-22 through B-24 are illustrated on Figure 3 and are in the vicinity of Dames & Moore/Pemco soil boring B-7/P2 near the southwest property corner, PNG soil boring B-6 near the southwest corner of the former Plaid UST pit, and PNG soil boring B-13 near the west end of the southern pump island associated with pre-Plaid operations. Boring locations will be modified as necessary based on obstructions and/or utility locations.
  - Boring B-22 (B-7/P2 location) will be sampled in the interval between 15 and 16 feet bgs.
  - Boring B-23 (B-6 location) will be sampled at ten feet bgs.
  - Boring B-24 (B-13 location) will be sampled at 15 feet bgs.
  - Retrieve, examine, and log continuous soil cores during drilling at each location. Field screen soil samples for volatile organic vapors using a photo ionization detector (PID).
- Submit selected soil samples for laboratory analysis using the following analytical methods. At a minimum, one soil sample per boring collected at the specified depth will be analyzed as follows. Additional soil samples may be collected and analyzed based on field screening results and soil conditions observed.
  - Gasoline range hydrocarbons by Method NWTPH-Gx.
  - Volatile organic compounds (VOCs) by EPA Method 8260B.
  - Total lead by EPA Method 6020.

Wellhead Surveying

In accordance with Ecology's request, Plaid's seven-well network will be surveyed by a licensed Professional Land Surveyor to verify well locations and top of casing elevations relative to Mean Sea Level as determined by reference to a local USGS benchmark.

Confirmation Groundwater Monitoring

Confirmation of groundwater conditions at down-gradient monitoring wells MW-6 and MW-7 will include the following tasks. SOPs for the specified monitoring tasks are attached.

- Conduct quarterly depth to water measurements at monitoring wells MW-6 and MW-7 for a period of one year.
- Groundwater samples will not be collected for analysis if depth to water is shallower than 14 feet at these wells during any given quarterly event. If water depths of 14 feet bgs or greater are measured in either well, PNG will collect groundwater samples for laboratory analysis from both wells. If sampling is indicated, field tasks will include well purging, measuring standard groundwater monitoring data (depth to water and water quality stability parameters including dissolved oxygen, pH, temperature, conductivity, oxygen reduction potential, and dissolved [ferrous] iron), and collecting groundwater samples from both wells for laboratory analysis.
- If collected based on groundwater depth criteria, submit groundwater samples for laboratory analytical testing using the following analytical methods:
  - Gasoline range hydrocarbons by Method NWTPH-Gx.
  - VOCs by EPA Method 8260B.
  - Total (unfiltered) and dissolved (field filtered) lead by EPA Method 6000/7000 series.

Reporting

PNG will prepare interim status reports to document the various phases of planned characterization activities. At a minimum, we expect to issue reports summarizing the following scope elements. Note that to the extent possible, status reports will be combined in a single document for efficiency.

- Results of physical examination of geophysical anomalies A and B. A separate work plan document will be prepared to address decommissioning tasks if USTs are positively identified.
- Results of confirmation soil sampling at three locations in the former Plaid UST and pump island areas.
- Results of quarterly groundwater monitoring at wells MW-6 and MW-7.
- Revision of the Conceptual Site Model will be incorporated into a status report as requested by Ecology.
- All pertinent data will be uploaded to Ecology's Environmental Information Management (EIM) system.

PNG reports will include a summary of field work, an evaluation of the results (if samples are collected), site maps depicting monitoring locations and measured groundwater depths, tabulated analytical results and copies of all analytical reports and chain-of-custody documentation as appropriate, and recommendations for additional work if warranted.

Note that supplemental planning and/or reporting documents (such as more formal remedial investigation/feasibility study [RI/FS] reports) may be required, and the need for and scope of such documents will be discussed with Plaid and Ecology.

PNG's work scope is based on our experience at other similar sites and published Ecology guidance and other communications as referenced. We recommend that this work plan be discussed with and approved by Ecology before implementation.

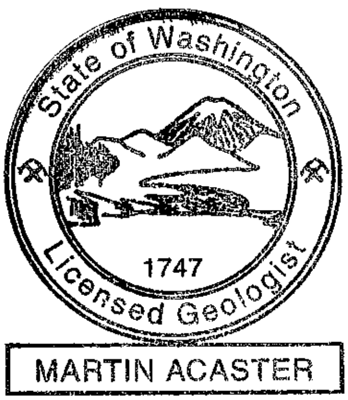
PNG appreciates this opportunity to present this proposal. If you have any questions, please call (503) 620-2387.

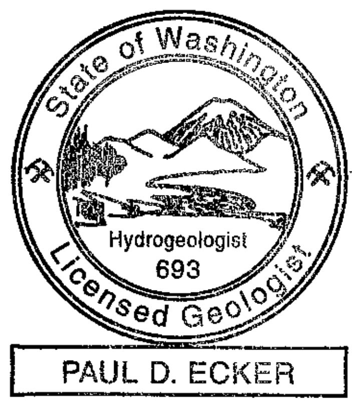
Sincerely,

PNG ENVIRONMENTAL, INC.

Martin Acaster, L.G.
Senior Geologist

Paul Ecker, L.H.G.
Project Manager

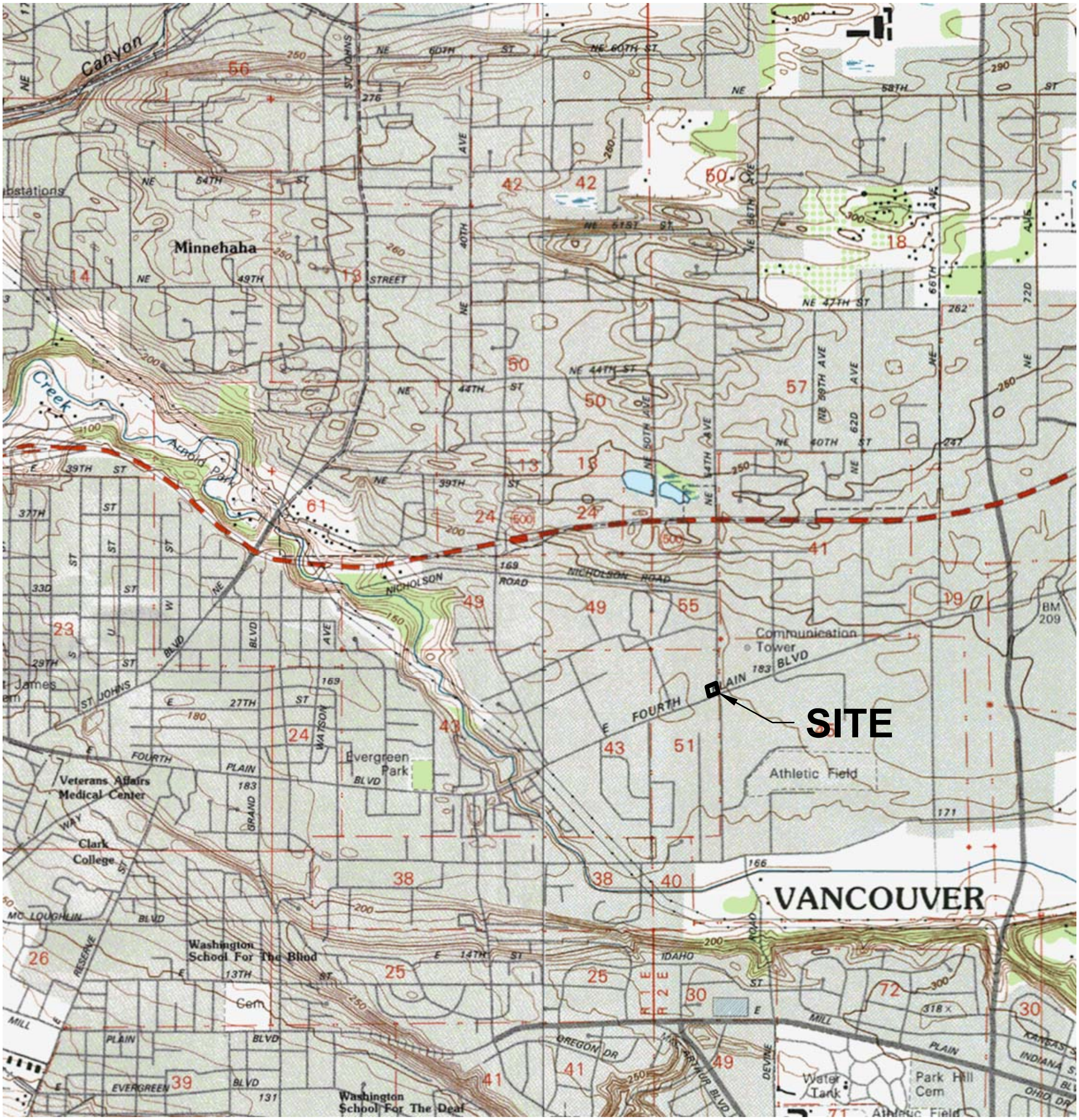


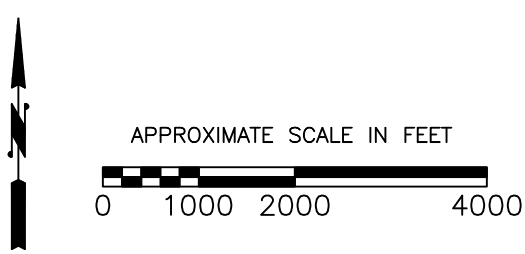


Attachments: Figure 1 – Site Vicinity Map
Figure 2 – Current and Historic Site Features
Figure 3 – Proposed Sampling Locations

Attachment A – Ecology Letter
Attachment B – PNG SOPs

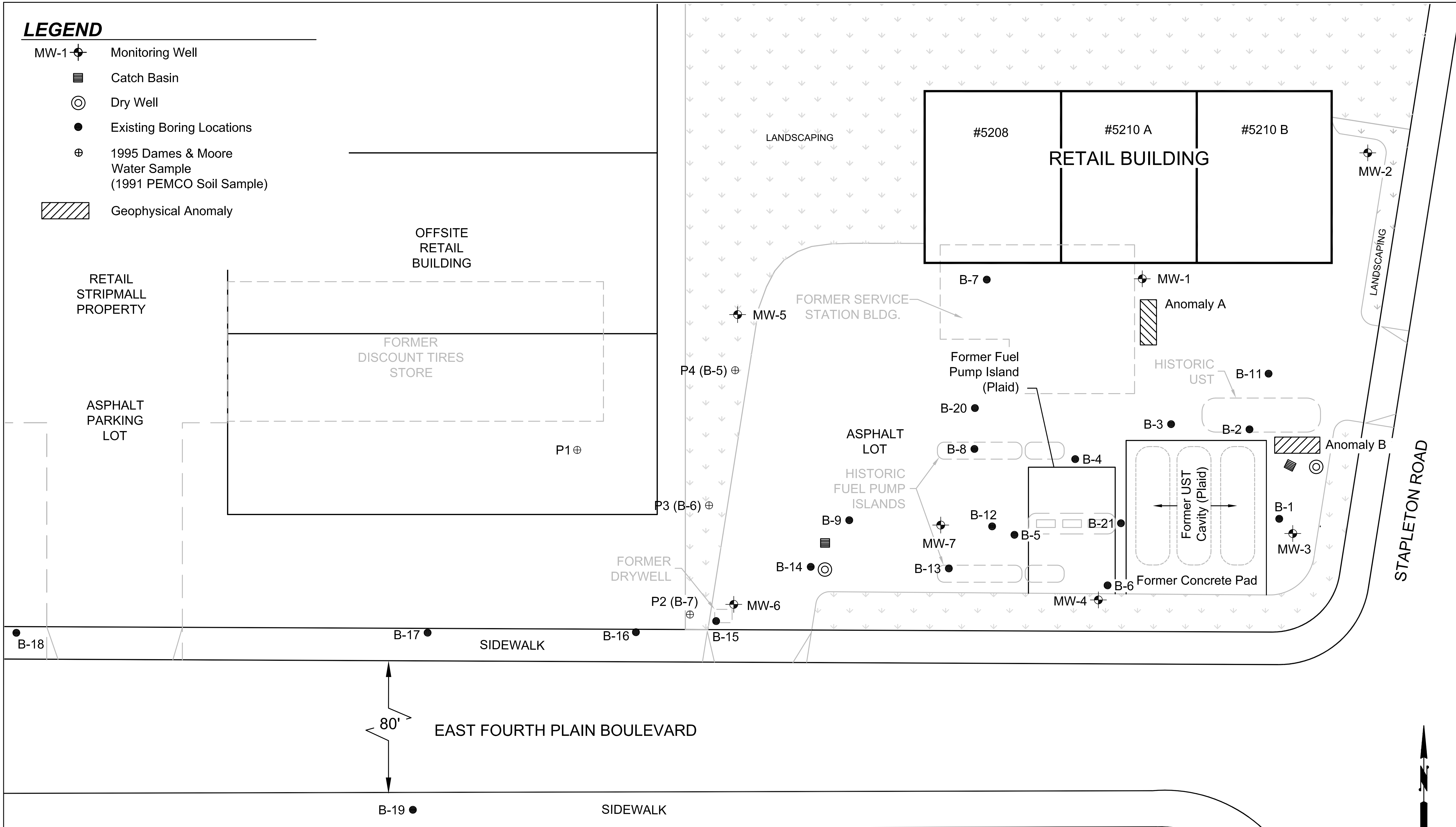
FIGURES





NOTE: USGS, Vancouver Washington / Oregon 7.5 Minute Quadrangle, 1990. Base map provided by MapTech.

PNG ENVIRONMENTAL, INC. 6665 SW Hampton St., Ste. 101 Tigard, OR 97223 TEL (503) 620-2387 FAX (503) 620-2977	DATE: 10-11-06 FILE NAME: 839-04 DRAWN BY: JJT APPROVED BY: PE	FORMER PLAID PANTRY #23 5210 E FOURTH PLAIN BLVD. VANCOUVER, WASHINGTON	SITE VICINITY MAP	Project No. 839-04 Figure No. 1



APPROXIMATE SCALE IN FEET

0 20 40

NOTE:
1. Site features are approximate.
2. Groundwater elevations measured relative to arbitrary 100.00 foot datum.

PNG ENVIRONMENTAL, INC.
6665 SW Hampton St., Ste. 101
Tigard, OR 97223
TEL (503) 620-2387
FAX (503) 620-2977

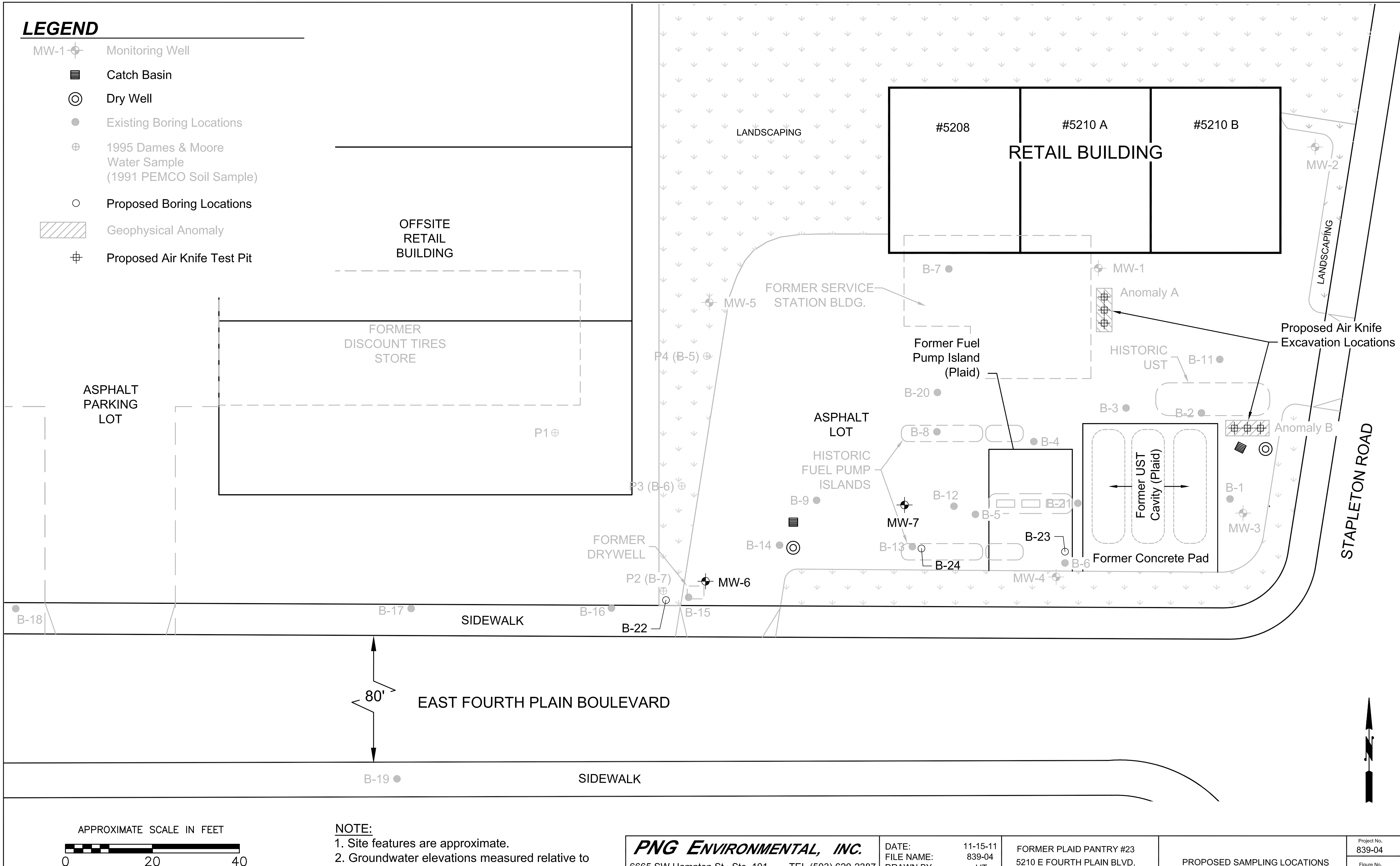
DATE:	11-15-11
FILE NAME:	839-04
DRAWN BY:	JJT
APPROVED BY:	PE

FORMER PLAID PANTRY #23
5210 E FOURTH PLAIN BLVD.
VANCOUVER, WASHINGTON

CURRENT AND HISTORIC SITE FEATURES

Project No. 839-04

Figure No. 2



NOTE:
1. Site features are approximate.
2. Groundwater elevations measured relative to arbitrary 100.00 foot datum.

PNG ENVIRONMENTAL, INC.	DATE: 11-15-11	FORMER PLAID PANTRY #23	PROPOSED SAMPLING LOCATIONS	Project No. 839-04
6665 SW Hampton St., Ste. 101 TEL (503) 620-2387	FILE NAME: 839-04	5210 E FOURTH PLAIN BLVD.		Figure No. 3
Tigard, OR 97223 FAX (503) 620-2977	DRAWN BY: JJT	VANCOUVER, WASHINGTON		
	APPROVED BY: PE			

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ATTACHMENT A
Ecology Letter

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47775 • Olympia, Washington 98504-7775 • (360) 407-6300

October 31, 2011

Mr. Terry Pyle
Plaid Pantries, Inc
10025 SW Allen Boulevard
Beaverton, Oregon 97005

Re: Further Action at the following Site:

- **Site Name:** Plaid Pantry 23
- **Site Address:** 5210 East Fourth Plain Boulevard, Vancouver, Washington
- **Facility/Site No.:** 78978458
- **VCP Project No.:** SW1166

Dear Mr. Pyle:

The Washington State Department of Ecology (Ecology) received your request for an opinion on your independent cleanup of the Plaid Pantry 23 facility (Site). This letter provides our opinion. We are providing this opinion under the authority of the Model Toxics Control Act (MTCA), Chapter 70.105D RCW.

Issue Presented and Opinion

Is further remedial action necessary to clean up contamination at the Site?

YES. Ecology has determined that further remedial action is necessary to clean up contamination at the Site.

This opinion is based on an analysis of whether the remedial action meets the substantive requirements of MTCA, Chapter 70.105D RCW, and its implementing regulations, Chapter 173-340 WAC (collectively "substantive requirements of MTCA"). The analysis is provided below.

Description of the Site

This opinion applies only to the Site described below. The Site is defined by the nature and extent of contamination associated with the following releases:

- Total petroleum hydrocarbons in the gasoline-range (TPH-G) into the Soil and Groundwater.
- Volatile Organic Compounds (VOCs) into the Soil and Groundwater.
- Metals into the Groundwater.

Enclosure A includes a detailed description and diagram of the Site, as currently known to Ecology.

Please note a parcel of real property can be affected by multiple sites. At this time, we have no information that the parcel(s) associated with this Site are affected by other sites.

Basis for the Opinion

This opinion is based on the information contained in the following documents:

1. PNG Environmental, Inc., **Environmental Assessment, Plaid Pantry No. 23, 5210 East Fourth Plain Boulevard, Vancouver, Washington,** dated November 5, 1997.

2. PNG Environmental, Inc., **Site Check, Plaid Pantries #23, 5210 East Fourth Plain Boulevard, Vancouver, Washington,** dated March 31, 1998.

3. PNG Environmental, Inc., **Site Characterization Report, Plaid Pantry No. 23, 5210 East Fourth Plain Boulevard, Vancouver, Washington,** dated April 9, 2002.

4. GeoPotential Environmental & Exploration Geophysics, **Subsurface Mapping Survey,** dated March 2005.

5. Rengenesis [Proposal], **Application of ORC Advanced to Accelerate Natural Attenuation of Contaminants of Concern (COCs) at the Former Plaid Pantry Site, Vancouver, Washington,** dated April 6, 2005.

6. PNG Environmental, Inc., **Site Investigation Report, September 26, 2005, Plaid Pantry # 23,** dated September 26, 2005 (PNG 2005).

7. PNG Environmental, Inc., **UST Decommissioning and Site Assessment Report, Former Plaid Pantry #23, 5210 East Fourth Plain Boulevard, Vancouver, Washington,** dated January 24, 2007.

8. PNG Environmental, Inc., **In-Situ Remedial Actions and Monitoring Summary Report, January – December 2009, Plaid Pantries Store # 23, Vancouver, Washington,** dated February 20, 2009.

9. PNG Environmental, Inc., **Groundwater Monitoring Summary Report, January 2009 – March 2010,** dated April 12, 2010.

10. PNG Environmental, Inc., **Final Site Characterization and Closure Report, Plaid Pantries Store # 23, Vancouver, Washington,** dated March 4, 2011.

Those documents are kept in the Central Files of the Southwest Regional Office of Ecology (SWRO) for review by appointment only. You can make an appointment by calling the SWRO resource contact at (360) 407-6365.

This opinion is void if any of the information contained in those documents is materially false or misleading.

Analysis of the Cleanup

Ecology has concluded that **further remedial action** is necessary to clean up contamination at the Site. That conclusion is based on the following analysis:

1. **Characterization of the Site.**

Ecology has determined your characterization of the Site is not sufficient to establish cleanup standards and select a cleanup action. The Site is described above and in **Enclosure A.**

The Site is located at 5210 East Fourth Plain Boulevard in Vancouver, Washington. The Site was operated as a Plaid Pantry convenience store and refueling station from 1982 to 2002. Plaid Pantry operated three gasoline underground storage tanks (USTs) at the Site during that time: one 10,000-gallon and two 12,000-gallon single-wall steel tanks with single-wall distribution piping. From 1998 to 2002, when the USTs were removed from service, the USTs were out of compliance with *WAC 173-360-310 Upgrading requirements for existing UST systems* by not being upgraded with a lining and/or cathodic protection.

In 1991, PEMCO conducted an environmental assessment of the adjacent, down-gradient Gramor parcel west of the Site and found VOC soil contamination. Laboratory analytical results for boring B-7 indicated benzene was present in the soil at 1.9 milligrams per kilogram (mg/kg) and above the MTCA Method A Soil Cleanup Level (CUL) for unrestricted land uses of 0.03 mg/kg; TPH-G was not analyzed for. A follow on investigation by Dames and Moore in 1995 found benzene in groundwater at 290 micrograms per liter (µg/L) and total xylenes at 1,300 µg/L. MTCA Method A Groundwater CULs for benzene and total xylenes were 5 µg/L and 1,000 µg/L, respectively, and there was no mention if TPH-G was analyzed for (see Figure 3, Table 1, and Table 2). The consultant determined that the parcel was not the source of the contamination and notified the Ecology. In January 1997, Ecology notified Plaid Pantry that their Site was placed on the *Confirmed and Suspected Contaminated Sites* list.

In November 1997, PNG Environmental, Inc. (PNG) provided an Environmental Assessment of the Site and concluded that there could be multiple off-Site sources to explain the contamination on the Gramor parcel. In February 1998, PNG conducted a Site Check of the Plaid Pantry parcel and concluded there were TPH-G and VOCs present in the groundwater at location boring B-5. Analytical results indicated total lead was also present in the groundwater at three locations, all above the MTCA Method A CUL of 15 µg/L; the highest lead concentration was 317 µg/L at B-1. Also during their investigation, the driller penetrated a fuel distribution line at the location of B-6. The investigation advanced at total of six borings using direct-push methods and found TPH-G and VOCs in the Site soil at one location, B-6, at 10 feet below ground surface (bgs). PNG estimated a release of eight gallons of gasoline. The B-6 soil sample had the highest reported TPH-G soil concentration at the Site with a concentration of 4,400 mg/kg; the MTCA Method A Soil CUL for TPH-G was 30 mg/kg due to benzene being present at the Site (see Figure 3, Table 1, and Table 2). PNG installed two soil vapor extraction (SVE) wells at B-6 to remediate petroleum-contaminated soil (PCS). Ecology was notified of a leaking UST (LUST) at the Site (LUST identification number 4379070).

From 2002 to 2010, PNG conducted activities at the Site, including a Site Characterization in 2005, UST decommissioning activities (removing three USTs and associated piping) in 2006, in-situ remedial actions by injecting oxygenating compounds in solution into the subsurface in June 2008, and groundwater monitoring activities from 2007 to 2010. During the UST decommissioning and removal, three USTs and associated piping were removed and disposed of. PNG collected soil samples from the excavation pit side walls and floor. The excavation soil samples submitted for analysis indicated the contamination was removed (see Figure 5).

The 2008 in-situ remedy action involved the injection of 3,125 pounds of a RegenOx®/ORC-A[dvanced]™ mix of material blended with 5,000 gallons of water into 35 locations in the southwestern corner of the parcel. The oxygen reducing compound (ORC) mix was injected between 10 feet and 20 feet bgs (see Figure 4). The injection was conditionally rule authorized under an Ecology Underground Injection Control Program Well registration Letter dated May 1, 2008, which authorized the injection of ORC blended material into the subsurface and required the meeting of groundwater quality standards under Chapter 173-200 WAC.

From 2007 to 2010, PNG conducted quarterly groundwater monitoring at six monitoring wells on the Site. The last four quarters indicated the constituents of concern (COCs) were at all wells were either not detected at the laboratory reporting limit or were not detected above their applicable MTCA Method A CUL (see Table 2).

Based on a review of the available information, Ecology has the following comments:

1. In April 2002, North Creek Analytical, Inc. (NCA) performed a forensic analysis of soil and water samples from the Site to differentiate similarities and differences of the samples to establish dates of the releases for samples collected from MW1 and B12. NAC found that there appeared to be at least two separate release events temporally separated by 10 years; however, NCA could not make a determination as to whether the releases were attributable to separate sources. The forensic analysis also discussed the presence of gasoline range organics at 121 parts per billion (ppb) and

tetrachloroethene at 1.81 ppb in the groundwater at MW-1. Tetrachloroethene is a notable COC often associated with parts cleaning operations. Although this halogenated hydrocarbon is not found in commercial gasoline, diesel, or lube oil, it is often a contaminant of waste oil.

The findings of the March 2005 *Subsurface Mapping Survey* (found in Appendix A in PNG 2005) indicated there were two large subsurface anomalies, one metal object (MO) and one ground penetrating radar (GPR) anomaly (see Figure 3[IM]). GPR and hand-held metal detectors identified the MO, and the size of the MO was estimated to be 11 feet long by 3 feet wide; it was located near monitoring well MW-1 (just outside the footprint of the former service station). There was no narrative discussing the GPR anomaly; however, it was identified in Figure 3[IM] as being near the historic service station UST location.

During the 2005 UST removal, a single, uncapped, steel fuel distribution pipe was uncovered at the bottom of the UST excavation pit. It was attributed to being part of the historic UST system; the pipe was reported to enter into the excavation's north sidewall in the general direction towards the historic UST and GPR location. PNG reported the pipe to have been severed and removed, and the remaining portion capped in place in the northern excavation wall.

WAC 173-340-740 (b) requires a cleanup action be conducted to address all areas where the concentration of hazardous substances in the soil exceeds cleanup levels at the relevant point of compliance. The information discussed above indicates that the area around MW-1 was not thoroughly characterized nor was any remedial action applied at that location. TPH-G soil contamination above the MTCA cleanup level remains at MW-1. The source of that contamination was not determined. The information seems to indicate the MO as a potential source near MW-1 and future releases cannot be ruled out. Per WAC 173-360-395, if previously closed or abandoned USTs pose a current or potential threat to human health and the environment, Ecology can require that the UST be decommissioned and/or removed. The Ecology database does not contain any information on the historic USTs.

Available information indicates characterization of the MO near MW-1 and the GPR anomaly are warranted. The true nature of both anomalies should characterized by physical examination, and if they are confirmed as the historic UST and waste oil tank, they should be removed per WAC 173-360-395.

Analytical data also indicates PCS above the MTCA Method A CULs remains at 15 feet bgs at the Site. TPH-G and benzene were identified above their applicable MTCA Method A CULs. Areas of concern are B7/P2, where the benzene concentration in the soil was above the MTCA CUL, and B-6[1] and B-13, where the TPH-G concentration was above the MTCA CUL. Soil sample analytical results indicated the PCS was removed from the UST excavation; however, no confirmation soil sample was collected from the southwest corner of the UST excavation near B-6, the location with the highest TPH-G concentration. Confirmation soil samples should be collected from B7/P2 at 15 to 16 feet bgs, B-6 at 10 feet bgs, and B-13 at 15 feet bgs. The COCs for the soil at these locations will be TPH-G, BTEX, and lead.

If any USTs are confirmed present, they will need to be characterized and decommissioned; confirmation soil and groundwater samples will be needed. Due to the potential for the MO anomaly to be a former waste oil UST, the soil and groundwater should be analyzed for applicable constituents listed on MTCA Table 830-1. The COCs for the Site groundwater near MW-1 will be TPH-G, TPH-D, TPH-O, benzene, toluene, ethylbenzene, and total xylenes (BTEX), ethylene dibromide (EDB) (via EPA Method 8011), ethylene dichloride (EDC), methyl tertiary-butyl ether (MTBE), total lead, carcinogenic polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and halogenated VOCs. The COCs for the Site soil around MW-1 will be TPH-G, TPH-D, TPH-O, BTEX, and lead. If EDB, EDC, MTBE, carcinogenic PAHs, PCBs, and halogenated VOCs are present in the groundwater then those COCs will have to be evaluated for also. The COCs for the Site groundwater near the historic UST location will be TPH-G, TPH-D, TPH-O, BTEX, EDB (via EPA Method 8011), EDC, MTBE, and total lead. The COCs for the Site soil around the historic UST location will be TPH-G, TPH-D, TPH-O, BTEX, and lead. If EDB, EDC, MTBE are present in the groundwater then those COCs will have to be evaluated for also.

2. PNG provided four quarters of groundwater analytical results where COC concentrations were below the applicable MTCA Method A CULs or not detected; however, Ecology noted that COC concentrations at MW-7 indicated a rebound effect in September and December 2009. There was also a demonstrated pattern where COC concentrations increased above the applicable MTCA Method A CULs when the depth to groundwater at that well was measured at 14 feet bgs or deeper. Groundwater sampling events for the last four quarters were above 13.50 feet bgs and followed the variable concentration pattern consistently displayed at the well. Ecology recommends that downgradient wells MW-6 and MW-7 be sampled again

[1] Because of the limited release of TPH-G caused by the push probe penetration into the fuel distribution pipeline at the B-6 location, PNG singularly remediated the soil at this location via a SVE system; however, no operational or performance reports, field logs, results tables, SVE well installation logs, analytical results, or soil confirmation samples were provided to Ecology for review to demonstrate compliance with MTCA. Once a remedial action is determined to have remediated the Site media to comply with the MTCA cleanup standards, Ecology requires that confirmation sample analytical results demonstrate the affected media concentrations are below the applicable MTCA CULs before a no further action opinion will be provided.

when the groundwater depth is below 14 feet bgs to confirm that the implemented remedy is permanent (see Table 2, Table 4, and Figure 9). Ecology recognizes the variable nature of the groundwater table and suggests that the depth to water be evaluated for the next year, if the groundwater table does not reach the desired depth, Ecology will accept the available groundwater data as representative of Site conditions.

Please note that Ecology requires *at least* four consecutive quarters of clean groundwater monitoring analytical results to demonstrate compliance with the MTCA cleanup regulations. The reason for this is to determine any seasonal variations or long-term patterns in the contaminant concentration fluctuations, so that Ecology can determine whether the implemented remedy is permanent.

3. PNG used an arbitrary vertical datum for this Site investigation. MTCA requires the use of United States Geological Survey (USGS) datum as a basis for all elevations. Please calibrate all elevation points used in the investigation to a known USGS datum point per *WAC 173-340-840 General Submittal Requirements.*

4. Please provide Ecology with an updated work plan for the remedial activities identified above for review and approval to ensure that the proposed activities will likely meet the substantive requirements of MTCA.

5. MTCA requires the submittal of three copies of a plan or report. Please submit two bound hard copies and one electronic copy (portable document format [pdf]) for future plans or reports provided to Ecology for review per *WAC 173-340-840 General Submittal Requirements.*

6. In accordance with *WAC 173-340-840(5)* and Ecology Toxics Cleanup Program *Policy 840 (Data Submittal Requirements)*, all data generated for Independent Remedial Actions shall be submitted simultaneously in both a written and electronic format. For additional information regarding electronic format requirements, see the website http://www.ecy.wa.gov/eim. Be advised that according to the policy, any reports containing sampling data that are submitted for Ecology review are considered incomplete until the electronic data has been entered. Please ensure that data generated during on-site activities is submitted pursuant to this policy. **Data must be submitted to Ecology in this format for Ecology to issue a No Further Action determination.** Please be sure to submit all soil and groundwater data collected to date, as well as any future data, in this format. Data collected prior to August 2005 (effective date of this policy) is not required to be submitted; however, you are encouraged to do so if it is available. Be advised that Ecology requires up to two weeks to process the data once it is received.

2. Establishment of cleanup standards.

Ecology has determined the cleanup levels and points of compliance you established for the Site do not meet the substantive requirements of MTCA.

Applicable MTCA Method A CULs for soil and groundwater shall be used to characterize the Site. Standard points of compliance are being used for the Site. The point of compliance for protection of groundwater will be established in the soils throughout the Site. For soil cleanup levels based on human exposure via direct contact or other exposure pathways where contact with the soil is required to complete the pathway, the point of compliance shall be established in the soils throughout the Site from the ground surface to 15 feet bgs. In addition, the point of compliance for the groundwater is established throughout the Site from the uppermost level of the saturated zone extending vertically to the lowest most depth that could potentially be affected by the Site.

3. Selection of cleanup action.

Ecology has determined the cleanup action you selected for the Site does not meet the substantive requirements of MTCA.

The affected Site media must be fully characterized prior to selecting any final cleanup action. For a Site cleanup action to qualify for a no further action opinion, it must meet one or more of the minimum cleanup requirements in WAC 173-340-360(2). MTCA requires the use of permanent solutions to the maximum extent practicable. If permanent solutions are not part of the remedy, it will be necessary to develop a feasibility study based on the information collected in the characterization phase. The feasibility study should include all practicable methods of treatment in addressing the Site cleanup. Please note that monitored natural attenuation is a cleanup alternative that must be approved by Ecology before implementation.

4. Cleanup.

Ecology has determined the cleanup you performed does not meet any cleanup standards at the Site.

The Site was not fully characterized prior to initiating cleanup activities. PNG decommissioned and removed three USTs from the Site. PNG excavated approximately 590 tons of PCS from the Site and disposed of it the Wasco County Landfill in Oregon. PNG applied ORCs to the UST excavation floor and sidewalls prior to backfilling the excavation. Finally, PNG injected approximately 3,000 pounds of ORCs into subsurface soil and groundwater to help remove residual groundwater impacts. Soil sample analytical results indicated the PCS was removed from the UST excavation; however, no confirmation soil sample was collected from the southwest corner of the UST excavation near B-6, the location with the highest TPH-G concentration.

After a review of the available data, Ecology determined the CSM was not developed enough to define the Site nor did the analytical data define the Site. MTCA defines a Site as wherever the contamination has come to lie. Laboratory analytical results indicated a source of the Site contamination near the Plaid Pantry USTs or fuel dispenser pad; however, there was speculation that more than one source was responsible for the Site contamination. A review of the groundwater gradient history would suggest the UST excavation or fuel pad was an unlikely source for the soil contamination at MW-1.

Limitations of the Opinion

1. Opinion does not settle liability with the state.

Liable persons are strictly liable, jointly and severally, for all remedial action costs and for all natural resource damages resulting from the release or releases of hazardous substances at the Site. This opinion **does not**:

- Resolve or alter a person's liability to the state.
- Protect liable persons from contribution claims by third parties.

To settle liability with the state and obtain protection from contribution claims, a person must enter into a consent decree with Ecology under RCW 70.105D.040(4).

2. Opinion does not constitute a determination of substantial equivalence.

To recover remedial action costs from other liable persons under MTCA, one must demonstrate that the action is the substantial equivalent of an Ecology-conducted or Ecology-supervised action. This opinion does not determine whether the action you performed is substantially equivalent. Courts make that determination. *See* RCW 70.105D.080 and WAC 173-340-545.

3. State is immune from liability.

The state, Ecology, and its officers and employees are immune from all liability, and no cause of action of any nature may arise from any act or omission in providing this opinion. *See* RCW 70.105D.030(1)(i).

Contact Information

Thank you for choosing to clean up the Site under the Voluntary Cleanup Program (VCP). After you have addressed our concerns, you may request another review of your cleanup. Please do not hesitate to request additional services as your cleanup progresses. We look forward to working with you.

For more information about the VCP and the cleanup process, please visit our web site: www.ecy.wa.gov/programs/tcp/vcp/vcpmain.htm. If you have any questions about this opinion, please contact me by phone at (360) 407-7404 or e-mail at erad461@ecy.wa.gov.

Sincerely,

Eugene Radcliff

Eugene Radcliff, L.G.
Site Manager
SWRO Toxics Cleanup Program

GER/ksc:Plaid Pantry 23 FA Opinion

Enclosures (10): A – Description and Diagrams of the Site

Figure 1	Site Vicinity Map
Figure 3[IM]	2005 Mapping Survey Interpretation Map
Figure 3	Historical Site Features
Figure 4	ISCO Injection Locations
Figure 5	UST Decommissioning Confirmation Soil Sample Locations (October 2006)
Figure 7	Groundwater Elevation Contour Map for September 2010
Figure 9	Gasoline & Benzene in Groundwater
Table 1	Soil Analytical Results
Table 2	Groundwater Analytical Results Summary
Table 4	Groundwater Elevation Data for MW-7 [modified]

By certified mail: (7009 3410 0000 1272 3670)

cc: Ms. Louise Piacentini and Mr. Gene McIntosh, C/O M & P Properties
Mr. Bryan DeDoncker, Clark County Health
Mary Shaleen-Hansen – Ecology
Mr. Scott Rose – Ecology
Ms. Dolores Mitchell – Ecology (without enclosures)

ATTACHMENT B
PNG SOPs

STANDARD OPERATING PROCEDURE
LOGGING OF SOIL BOREHOLES
SOP 1

The following procedures are used for completing the Soil Boring Log Form (Figure 1-1). These procedures, which must be used for PNG projects where soil boring techniques are performed during field exploration, establish the minimum information that must be recorded in the field to adequately characterize soil boreholes.

These procedures are adapted from ASTM D-2488-84 (attached). Field staff is encouraged to examine ASTM D-2488-84 in its entirety. This standard operating procedure (SOP) has made minor modifications to emphasize environmental investigations as opposed to geotechnical investigations (for which the standards were written). Because environmental projects are each unique and because job requirements can vary widely, the minimum standards presented may need to be supplemented with additional technical descriptions or field test results. However, all soil boring field logs, regardless of special project circumstances, must include information addressed in this SOP to achieve the minimum acceptable standards required by PNG.

HEADING INFORMATION

- Project Number: Use the standard contract number.
- Client: Identify the name of the client and the project site location.
- Location: If stationing, coordinates, mileposts, or similar are applicable identify the location of the project. If this information is not available, identify the facility (i.e., 20 ft NE of Retort #1).
- Drilling Method: Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger, cable tool) and the name of the drill rig (e.g., Mobil B 61, CME 55).
- Diameter: Provide the diameter of the borehole. If the borehole has variable diameters, provide the depth interval for each diameter.
- Sampling Method: Identify the type of sampler(s) used (e.g., standard split spoon, Dames & Moore sampler, grab).
- Drilling Contractor: Provide the name of the drilling contractor.
- PNG Staff: Enter the name(s) of PNG staff performing logging and sampling activities.
- Water Level Information: Provide the date, time, depth to static water, and casing depth. Generally, water levels should be taken each day before resuming drilling and at the completion of drilling. If water is not encountered in the boring, this information should be recorded.
- Boring Number: Provide the boring number. A numbering system should be developed prior to drilling that does not conflict with other site information, such as previous drilling or other sampling activities.
- Sheet: Number the sheets consecutively for each boring and continue the consecutive depth numbering.
- Drilling Start and Finish: Provide the drilling start and finish dates and times.

For consecutive sheets provide, at a minimum, the job number, the boring number, and the sheet number.

TECHNICAL DATA

- Sampler Type: Provide the sampler type (e.g., SS = split spoon, DM = Dames & Moore split spoon, G = grab).
- Depth of Casing: Enter the depth of the casing below ground surface immediately prior to sampling.
- Driven/Recovery: Provide the length that the sampler was driven and the length of sample recovered in the sampler. This column would not apply to grab samples.
- Sample Number/Sample Depth: Provide the sample number. The sample numbering scheme should be established prior to drilling. One method is to use the boring number and consecutive alphabetical letters. For instance, the first sample obtained from boring MW-4 would be identified as 4A and the second would be identified as 4B, and so on. Another method for sample identification is naming the boring number with the depth. For example, the sample from Boring 1 at 10 ft would be labeled B1-10'. The depth of the sample is the depth of the casing plus the length to the middle of the recovered sample to the nearest 0.1 ft. Typically, split spoon samplers are 18 in. long. Samples should be obtained from the middle of the recovered sample. The depth of the sample with the casing at 10 ft would then be 10.7 ft.
- Number of Blows: For standard split spoon samplers, record the number of blows for each 6 in. of sampler penetration. A typical blow count of 6, 12, and 14 is recorded as 6/12/14. Refusal is a penetration of less than 6 in. with a blow count of 50. A partial penetration of 50 blows for 4 in. is recorded as 50/4". For nonstandard split spoons (e.g., 5-ft tube used for continuous sampling), total blows will be recorded.
- Blank Columns: Two blank columns are provided. Project managers are encouraged to use these columns for site-specific information, usually related to the contaminants of concern. Examples for a hydrocarbon site would be sheen and PID readings of the samples.
- Depth: Use a depth scale that is appropriate for the complexity of the subsurface conditions. The boxes located to the right of the scale should be used to graphically indicate sample locations as shown in the example.
- Surface Conditions: Describe the surface conditions (e.g., paved, 4-in. concrete slab, grass, natural vegetation and surface soil, oil-stained gravel).
- Soil Description: The soil classification and definition of soil contacts should follow the format described in SOP-2, *Field Classification of Soil*.
- Comments: Include all pertinent observations. Drilling observations might include drilling chatter, rod-bounce (boulder), sudden differences in drilling speed, damaged samplers, and malfunctioning equipment. Information provided by the driller should be attributed to the driller. Information on contaminants might include odor, staining, color, and presence or absence of some indicator of contamination. Describe what it is that indicates contamination (e.g., fuel-like odor, oily sheen in drill cuttings, yellow water in drill cuttings).

Designation: D2488 – 09a

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (either intact or disturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids
D1452 Practice for Soil Exploration and Sampling by Auger Borings
D1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils
D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
D2113 Practice for Rock Core Drilling and Sampling of Rock for Site Investigation
D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved June 15, 2009. Published July 2009. Originally approved in 1966. Last previous edition approved in 2009 as D2488 – 09. DOI: 10.1520/D2488-09A.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve.

fine—passes a No. 40 (425-μm) sieve and is retained on a No. 200 (75-μm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols.*

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

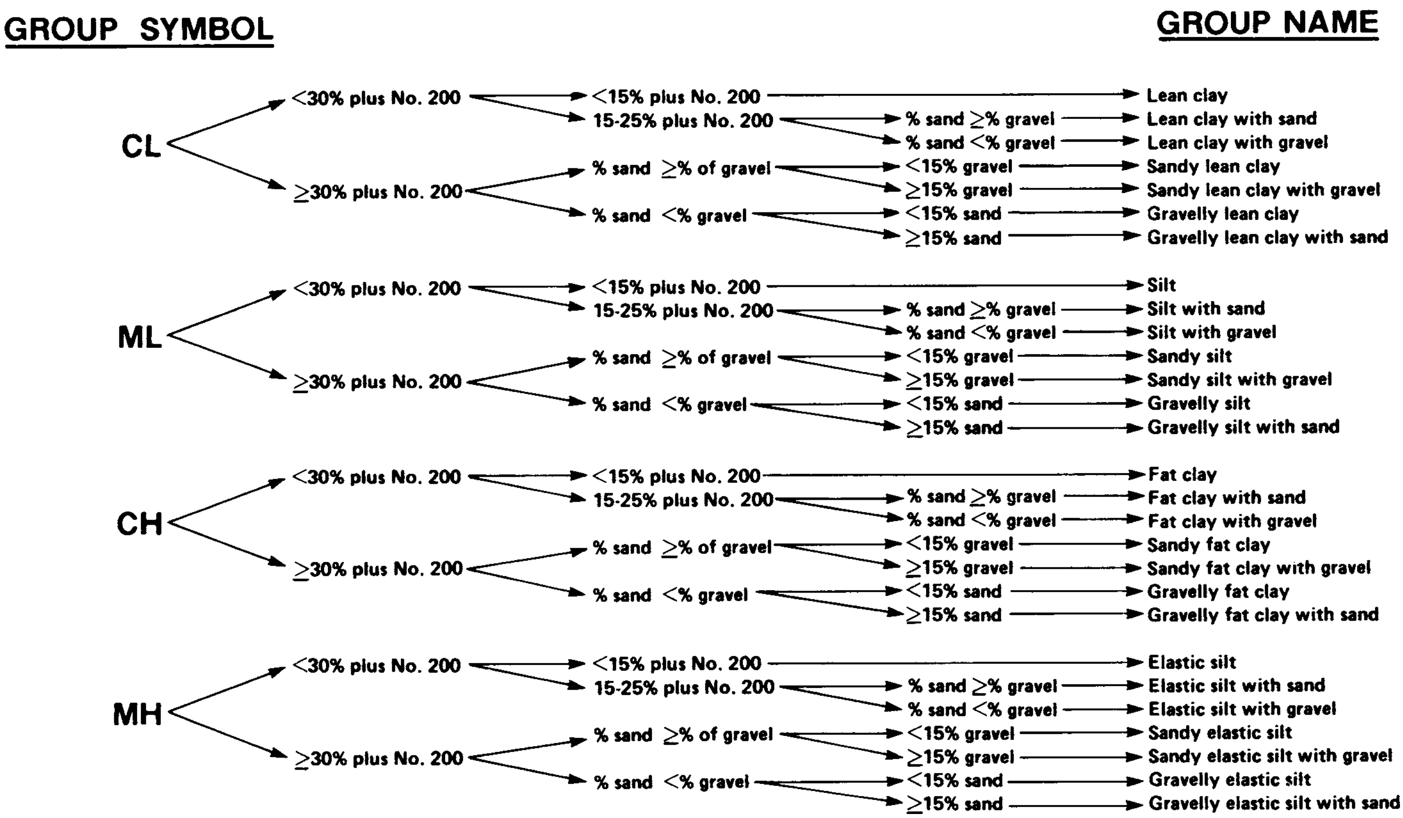
5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

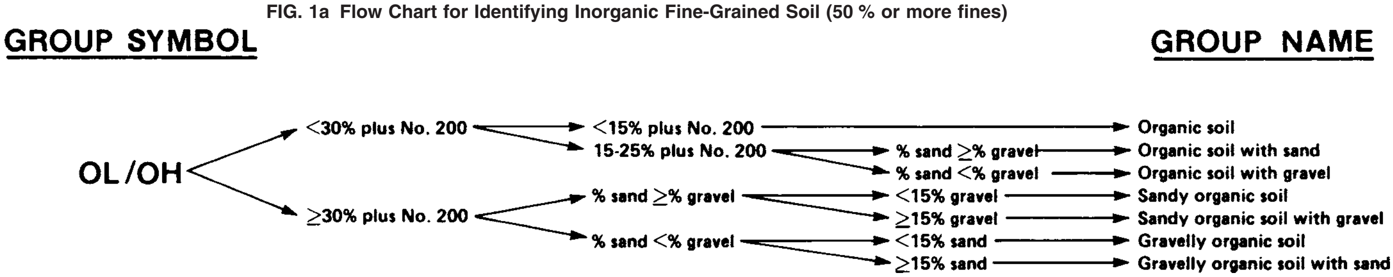
5.7 This practice may be used in combination with Practice D4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D3740 provides a means for evaluating some of those factors.



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

6. Apparatus

6.1 *Required Apparatus*:

6.1.1 *Pocket Knife or Small Spatula*.

6.2 *Useful Auxiliary Apparatus*:

6.2.1 *Test Tube and Stopper* (or jar with a lid).

6.2.2 *Hand Lens*.

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

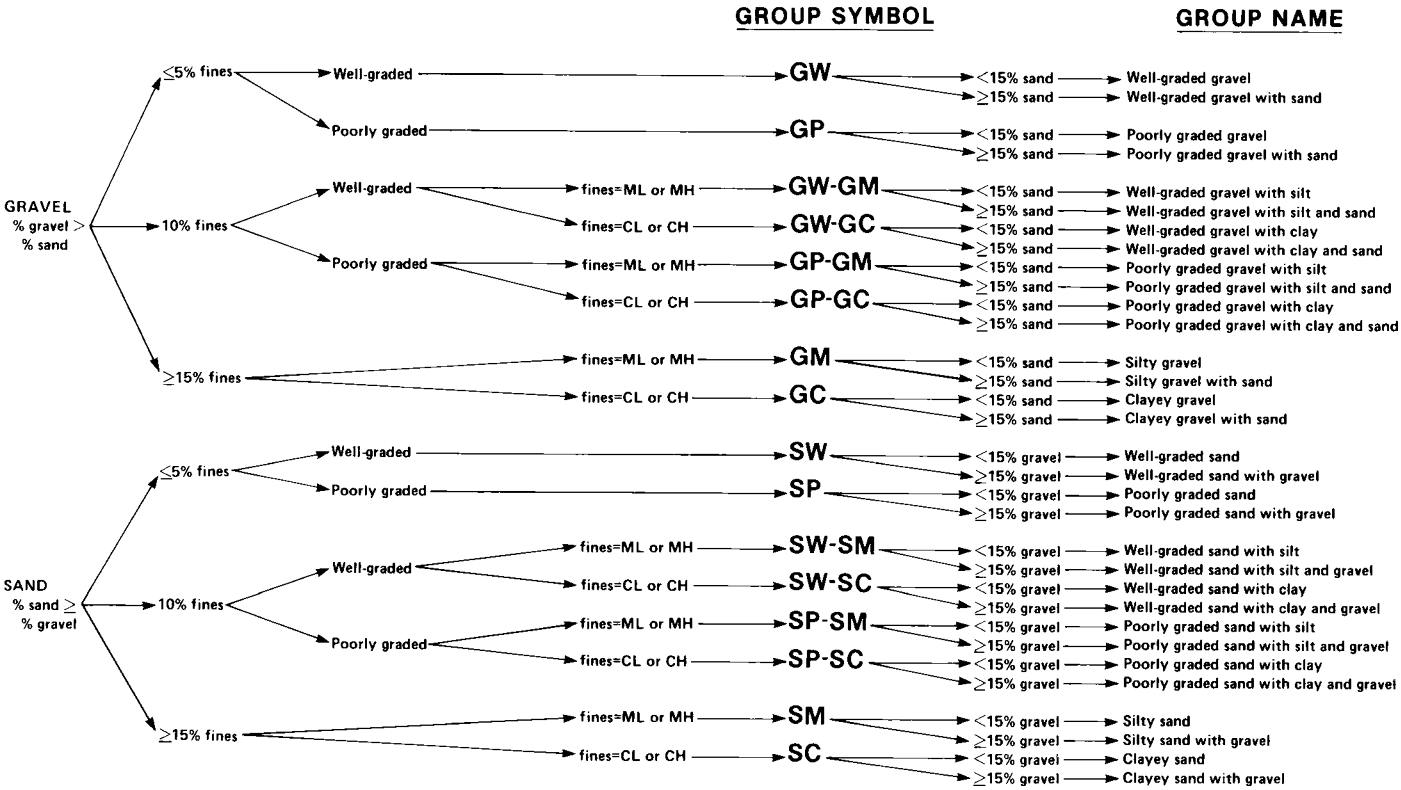
9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D1452, D1587, or D2113, or Test Method D1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (3⁄8 in.)	200 g (0.5 lb)
19.0 mm (3⁄4 in.)	1.0 kg (2.2 lb)
38.1 mm (11⁄2 in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table

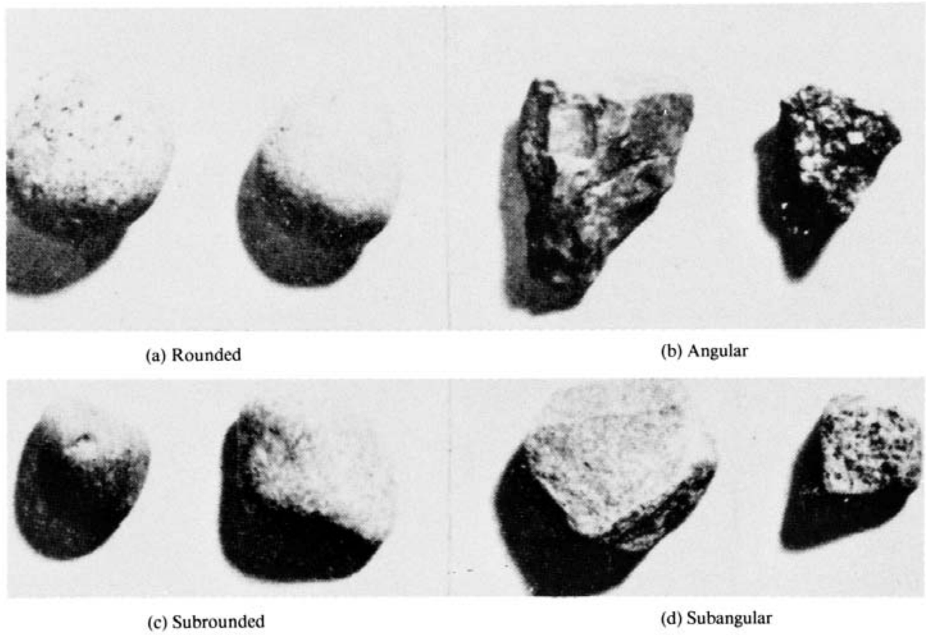


FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maxi-

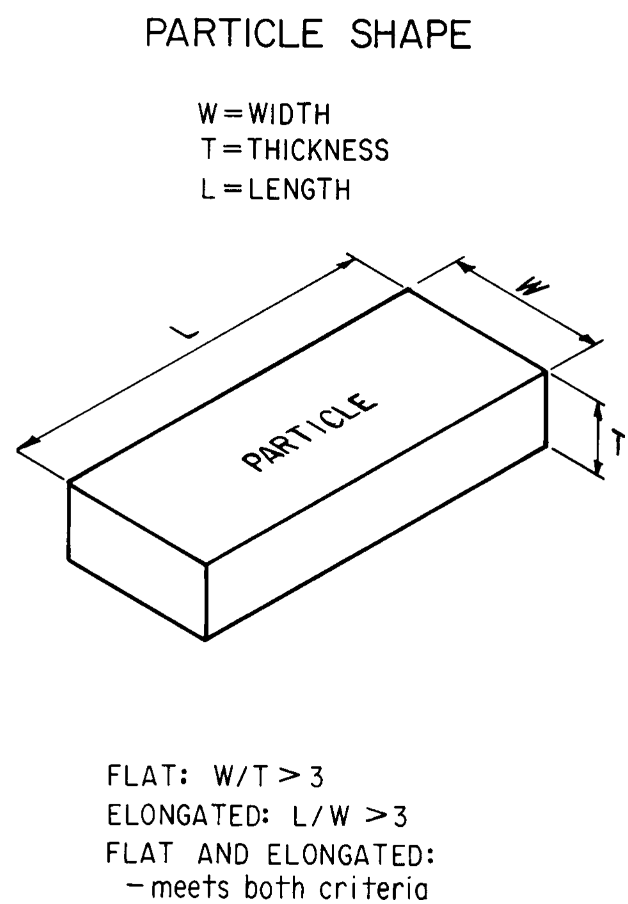


FIG. 4 Criteria for Particle Shape

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

mum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. “Hard” means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength*:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy*:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness*:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils*:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils*:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness and Plasticity
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown.

X2.4.3 *Broken Shells*—About 60 % uniformly graded gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % nonplastic fines; "Poorly Graded Gravel with Silt and Sand (GP-GM)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:	Suffix:
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D2488 – 09) that may impact the use of this standard. (Approved June 15, 2009.)

(*1*) Revised Section 1.2.3.

STANDARD OPERATING PROCEDURE
FIELD CLASSIFICATION OF SOIL
SOP 2

This standard operating procedure (SOP) presents the field classification of soils to be used by PNG field staff. In general, PNG has adopted ASTM D-2488-84 (attached), *Standard Practice for Description and Identification of Soils* (Visual-Manual Procedures). ASTM D-2488-84 uses the Universal Soil Classification (USC) system for naming soils. Field personnel are encouraged to study these procedures.

Soil descriptions should be precise and comprehensive without being verbose. The overall impression of the soil should not be distorted by excessive emphasis on minor constituents. In general, the similarities of consecutive soil samples should be emphasized and minor differences de-emphasized. These descriptions will be used to interpret aquifer properties and other potential contaminant transport properties, rather than interpret the exact mineralogy or tectonic environment. We are primarily interested in engineering and geochemical properties of the soil.

Soil descriptions should be provided in the Soil Description column of the soil boring log (see SAP-48) for each sample collected. If there is no difference between consecutive soil samples, subsequent descriptions can be noted as “same as above” or minor changes such as “increasing sand” or “becomes dark brown” can be added.

The format and order of soil descriptions should be as follows:

1. Group symbol—The group symbol should be placed in the Unified Symbol column
2. USC group name—The USC name should be identical to the ASTM D-2488-84 Group Name with the appropriate modifiers
3. Minor components
4. Color
5. Moisture
6. Additional descriptions.

The minimum elements of the soil descriptions are discussed below.

DEFINITIONS OF SOIL TYPES

The USC is an engineering properties system that uses grain size to classify soils. The first major distinction is between fine-grained soils (more than 50 percent passing the No. 200 sieve (75 μm/0.029 in.]) and coarse-grained soils (more than 50 percent retained by the No. 200 sieve). PNG has small No. 200 sieves available for the field geologists. These are necessary to classify soils that are near the cutoff size.

Fine-grained soils are classified as either silts or clays. Field determinations of silts and clays are based on observations of dry strength, dilatancy, toughness, and plasticity. Field procedures for these tests are included in ASTM D-2488-84 (Exhibit 1). If these tests are used, the results should be included in the soil description. At least one complete round of field tests should be performed for a site if these materials are encountered, preferably at the beginning of the field investigation. The modifiers “fat” and “lean” are used by ASTM to describe soils of high and low plasticity. The soil group symbols (i.e., CL, MH) already indicate plasticity characteristics, and these modifiers are not necessary in the description. Soils with high plasticity can be emphasized by describing them as “silty CLAY with high plasticity.” Plasticity is an important descriptor because it is often used to interpret whether an ML soil is acting as either a leaky or a competent aquitard. For example, an ML soil can be dilatent/nonplastic and serve as a transport pathway, or it can be highly plastic and very impervious.

Coarse-grained soils are classified as either predominantly gravel or sand, with the No. 4 sieve (4.75 mm/0.19 in.) being the division. Modifiers are used to describe the relative amounts of fine-grained soil, as noted below:

Description	Percent Fines	Group Symbol
Gravel (sand)	<5 percent	GW, GP (SW, SP)
Gravel (sand) with silt (clay)	5–15 percent	Hyphenated names
Silty (clayey) gravel (sand)	>15 percent	GM, GC (SM, SC)

The gradation of a coarse-grained soil is included in the specific soil name (i.e., fine to medium SAND with silt). Estimating the percent of size ranges following the group name is encouraged for mixtures of silt sand and gravel. Use of the modifiers “poorly graded” or “well graded” is not necessary as they are indicated by the group symbol.

A borderline symbol is shown with a slash (GM/SM). This symbol should be used when the soil cannot be distinctly placed in either soil group. A borderline symbol should also be used when describing interbedded soils of two or more soil group names when the thickness of the beds are approximately equal, such as “interbedded lenses and layers of fine sand and silt.” The use of a borderline symbol should not be used indiscriminately. Every effort should be made to place the soil into a single group.

One very helpful addition to the soil log form description is the percentage of silt/sand/gravel. Even if the geologist did not have sufficient time to properly define the soil, this percentage breakdown allows classification at a later date.

MINOR COMPONENTS

Minor components, such as cobbles, roots, construction debris, and kitchen sinks, should be preceded by the appropriate adjective reflecting relative percentages: Trace (0–5 percent), few (5–10 percent), little (15–25 percent), and some (30–45 percent). The word “occasional” can be applied to random particles of a larger size than the general soil matrix (i.e., occasional cobbles, occasional brick fragments). The term “with” indicates definite characteristics regarding the percentage of secondary particle size in the soil name. It will not be used to describe minor components. If a non-soil component exceeds 50 percent of an interval, it should be stated in place of the group name.

COLOR

The basic color of a soil, such as brown, gray, or red, must be given. The color term can be modified by adjectives such as light, dark, or mottled. Especially note staining or mottling. This information may be useful to establish water table fluctuations or contamination. The Munsell soil color chart designation is the PNG color standard. These charts are readily available and offer a high degree of consistency in descriptions between geologists.

MOISTURE CONTENT

The degree of moisture present in the soil should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed in Table 3 of ASTM D-2488-84.

ADDITIONAL DESCRIPTION

Features such as discontinuities, inclusions, joints, fissures, slickensides, bedding, laminations, root holes, and major mineralogical components should be noted if they are observed. Anything unusual should be noted. Additional soil descriptions may be made at the discretion of the project manager or as the field conditions warrant. The Soil Boring Log Form lists some optional descriptions, as does Table 13 of the ASTM standard. The reader is referred to the ASTM standard for procedures of these descriptions.

CONTACTS BETWEEN SOIL TYPES

The contact between two soil types must be clearly marked on the soil boring log. The field geologist or engineer, who has the advantage of watching the drilling rate and cuttings removal and can converse with the driller in real-time has the best perspective for interpreting the interval. If the contact is obvious and sharp, draw it in with a straight line. If it is gradational, a slanted line over the interval is appropriate. In the case where it is unclear, a dashed line over the most likely interval is used. In the preparation of cross-sections, it is impossible to interpret boring logs where soil sample descriptions change over a five or ten foot sample interval and there is no indication where this change would likely occurred.

Designation: D2488 – 09a

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (either intact or disturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids
D1452 Practice for Soil Exploration and Sampling by Auger Borings
D1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils
D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
D2113 Practice for Rock Core Drilling and Sampling of Rock for Site Investigation
D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve.

fine—passes a No. 40 (425-μm) sieve and is retained on a No. 200 (75-μm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols.*

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

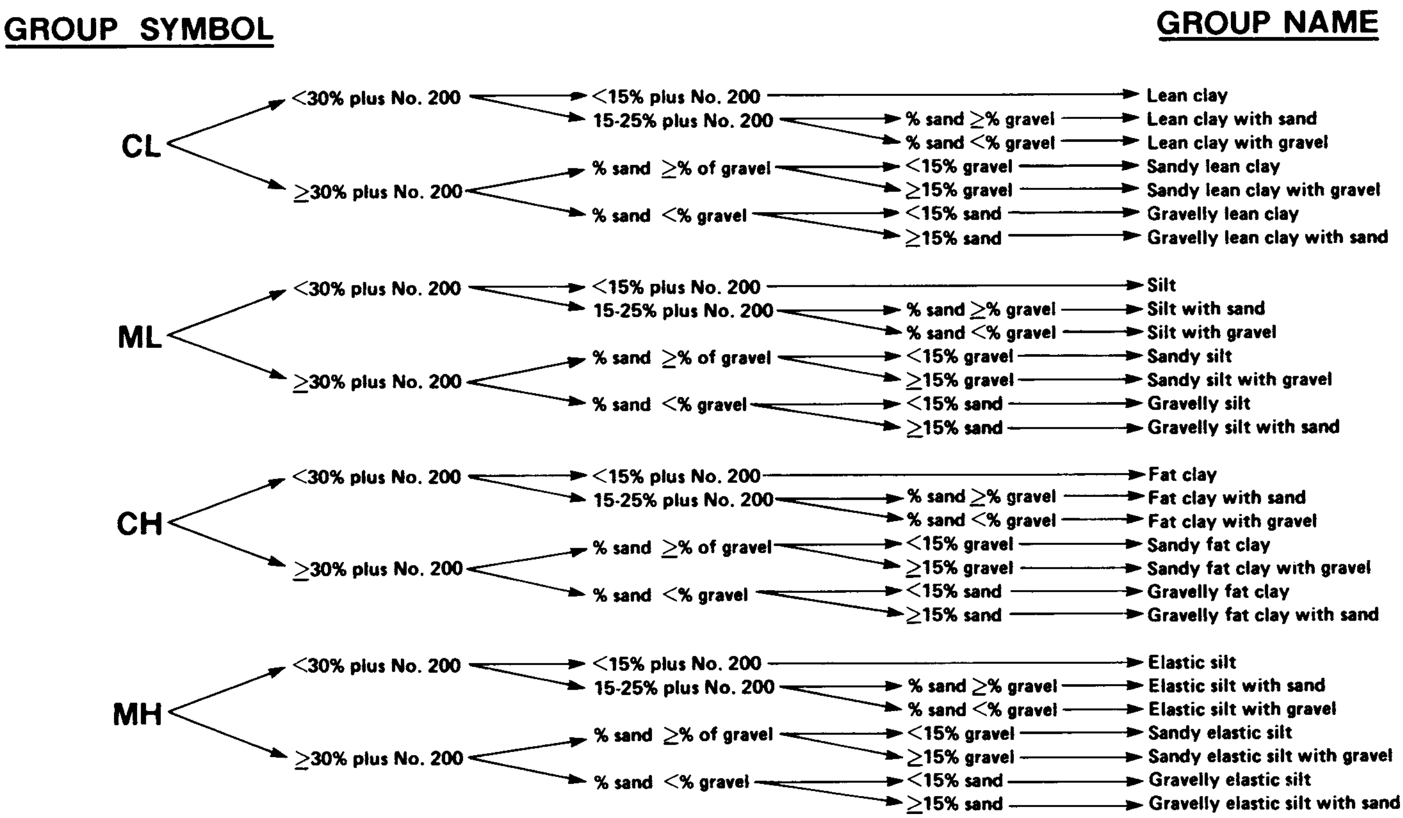
5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

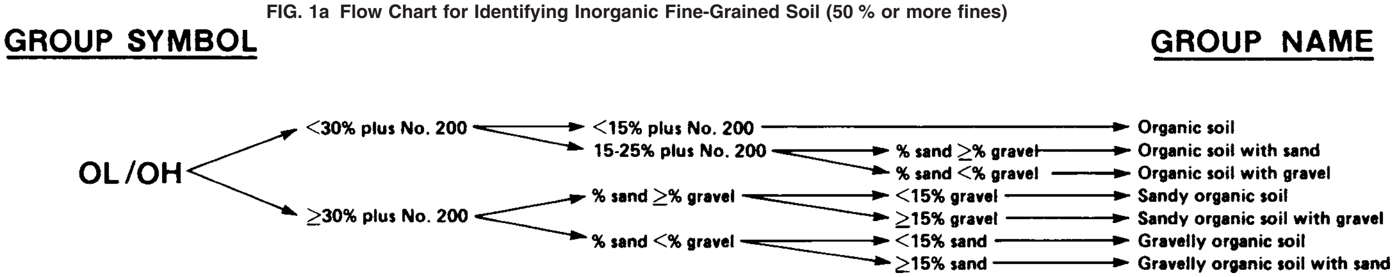
5.7 This practice may be used in combination with Practice D4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D3740 provides a means for evaluating some of those factors.



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

6. Apparatus

6.1 *Required Apparatus*:

6.1.1 *Pocket Knife or Small Spatula*.

6.2 *Useful Auxiliary Apparatus*:

6.2.1 *Test Tube and Stopper* (or jar with a lid).

6.2.2 *Hand Lens*.

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

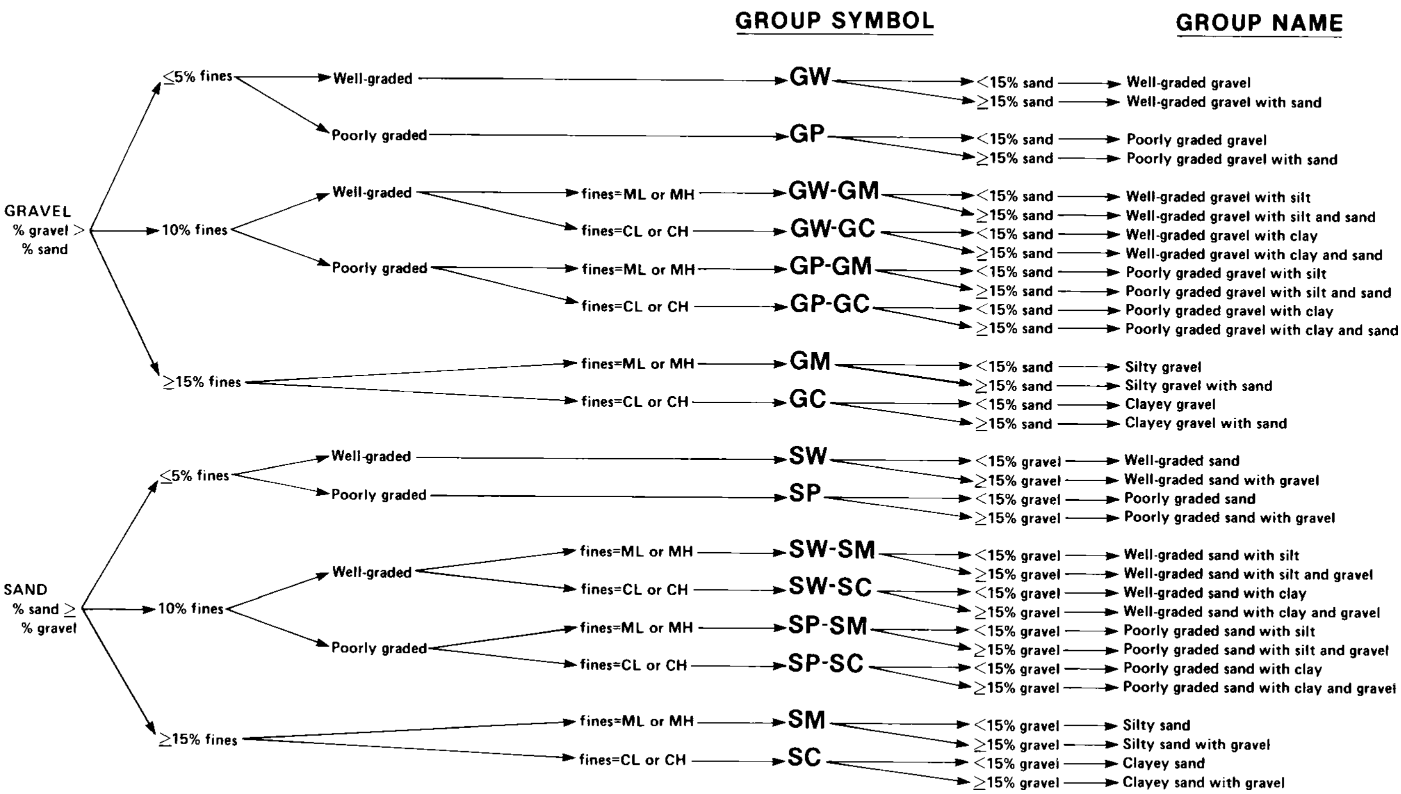
9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D1452, D1587, or D2113, or Test Method D1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (3⁄8 in.)	200 g (0.5 lb)
19.0 mm (3⁄4 in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table

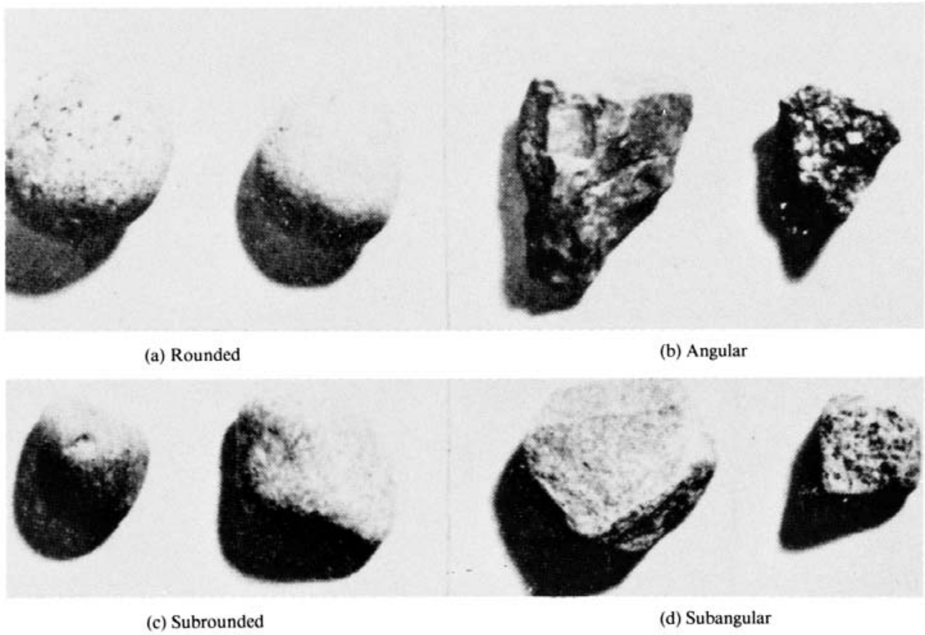


FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maxi-

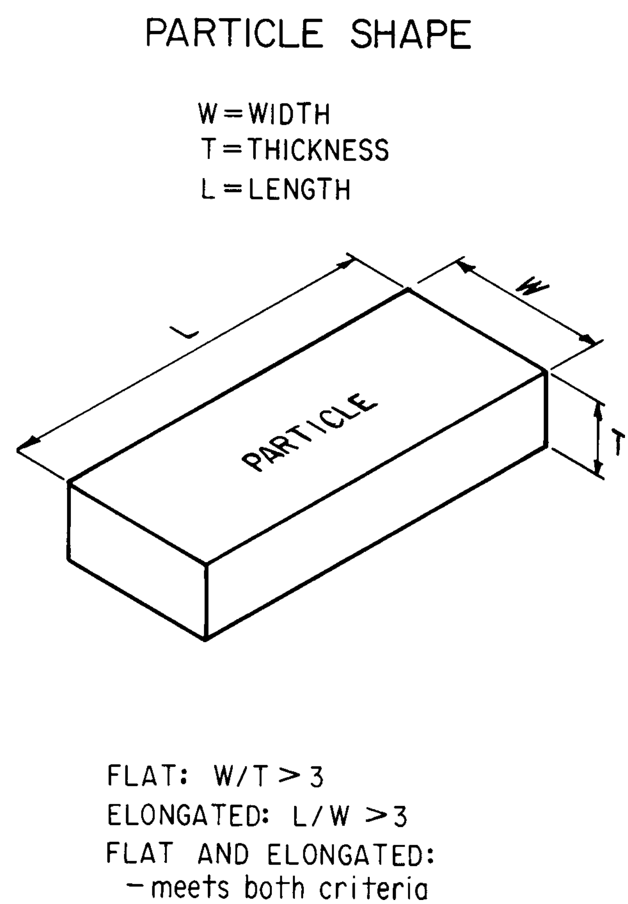


FIG. 4 Criteria for Particle Shape

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

mum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength*:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy*:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness*:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils*:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils*:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness and Plasticity
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown.

X2.4.3 *Broken Shells*—About 60 % uniformly graded gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % nonplastic fines; "Poorly Graded Gravel with Silt and Sand (GP-GM)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:	Suffix:
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D2488 – 09) that may impact the use of this standard. (Approved June 15, 2009.)

(*1*) Revised Section 1.2.3.

STANDARD OPERATING PROCEDURE
HYDROCARBON FIELD SCREENING FOR SOIL
SOP 3

This standard operating procedure (SOP) presents the qualitative field screening methods for hydrocarbons in soil. Field screening results are site-specific. The results may vary with soil type, soil moisture and organic content, ambient air temperature, and type of contaminant.

Field screening will be conducted on soil samples obtained from exploratory boreholes or excavations. Field screening results are used as a general guideline to delineate areas with potential residual hydrocarbons in soils. In addition, field screening results are used as a basis for selecting soil samples for chemical analysis. The field screening methods employed include 1) visual examination, 2) sheen testing, and 3) headspace vapor testing using an OVM 580B photoionization detector (PID) (or equivalent) calibrated to isobutylene. Sheen testing and headspace vapor testing are more sensitive screening methods that have been effective in detecting hydrocarbon concentrations below typical underground storage tank (UST) regulatory cleanup guidelines. The results of headspace and sheen screening should be included on the borehole logs or field notes.

VISUAL SCREENING

Visual screening consists of inspecting the soil for the presence of stains indicative of residual petroleum hydrocarbons. Visual screening is generally more effective in detecting the presence of heavier petroleum hydrocarbons, such as motor oil, or when hydrocarbon concentrations are high. Indications of the presence of hydrocarbons typically include a mottled appearance or dark discoloration of the soil.

SHEEN TESTING

Sheen testing involves immersion of the soil sample in water and observing the water surface for signs of sheen. A representative soil sample is placed into a clean stainless steel or plastic pan filled with clean water with as little disturbance as possible. Visual evidence of sheen forming on the surface of the water is classified as follows:

- No sheen (NS): No visible sheen on the water surface
- Colorless Sheen (CS) : Light, nearly colorless sheen; spread is irregular, not rapid; film dissipates rapidly (Note: light colorless sheens can be confused with sheens produced by organic content). Note that this sheen may or may not indicate the presence hydrocarbons.
- Heavy Sheen (HS): Light to heavy colorful film with iridescence; stringy, spread is rapid; sheen flows off the sample; most or all of water surface is covered with sheen

Following the sheen test, the pan must be decontaminated with methanol and distilled water prior to the next sampling event.

HEADSPACE VAPOR TESTING

Headspace vapor testing involves placing a small representative soil sample in a plastic sample bag. The sealed sample bag should be allowed to sit at ambient temperature for approximately ten minutes. The sample bag is then shaken slightly to promote volatilization to the air trapped in the bag. The probe of a PID equipped with a 10.6 eV bulb or equivalent, calibrated to isobutylene, is inserted into the bag to withdraw air from the bag. The instrument measures the concentration of organic vapors within the sample bag headspace in parts per million (ppm).

STANDARD OPERATING PROCEDURE
EQUIPMENT DECONTAMINATION FOR SOIL AND WATER SAMPLING
SOP 4

This standard operating procedure (SOP) describes procedures for decontamination of sampling equipment, drilling equipment and other tools that could come in to contact with contaminated media. Procedures were adopted from guidance documents and reports prepared by USEPA and include:

- Technical Enforcement Guidance Document (USEPA, November 1992).
- Compendium of Superfund Field Operations Methods (EPA, December 1987).
- Protocol for Ground-Water Evaluations (USEPA, September 1986).
- Technical Guidance Manual for Hydrogeologic Investigations and Ground Water Monitoring Programs (Ohio EPA, June, 1993).
- Field Sampling Procedures Manual (New Jersey DEP, July 1986).
- ASTM 5088-90 Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites (1992).

Personnel performing the decontamination procedures will wear protective clothing as specified in the site-specific Health and Safety Plan.

Benefits of an appropriately developed, executed, and documented equipment decontamination program are three-fold:

- Minimize the spread of contaminants within a study area or from site to site,
- Reduce the potential for worker exposure, and
- Improve data quality and reliability by eliminating the opportunity for cross-contamination

DECONTAMINATION REAGENTS

- Detergents shall be nonphosphate
- Acid rinses (inorganic constituents) shall be reagent grade nitric or hydrochloric acid
- Solvent rinses (organic constituents) shall be pesticide grade methanol, hexane, isopropopanol or acetone
- Deionized water rinse shall be organic free, reagent grade (generally provided by laboratory)
- Tap water rinse shall be either local tap water or distilled water available from retail stores. Note that this distilled water generally contains low levels of organic contaminants and can not be used for Deionized rinse or blanks.

INORGANIC CONTAMINATED SAMPLING EQUIPMENT

- Wash equipment with nonphosphate detergent, scrubbing off any residues
- Rinse generously with tap water
- Rinse equipment with Acid Rinse (0.1 N nitric or hydrochloric)
- Rinse with Reagent Water
- Allow to air dry

After decontaminating all sampling equipment, the gloves and other disposables will be placed in garbage bags. The wash and rinse will be containerized for proper disposal.

ORGANICALLY CONTAMINATED SAMPLING EQUIPMENT

- Wash equipment with nonphosphate detergent, scrubbing off any residues
- Rinse generously with tap water
- Rinse equipment with Solvent Rinse
- Rinse with Reagent Water
- Allow to air dry

After decontaminating all sampling equipment, the gloves and other disposables will be placed in garbage bags. The wash and rinse will be containerized for proper disposal.

DECONTAMINATION OF SAMPLING PUMPS

When pumps (e.g., submersible or bladder) are submerged below the water surface to collect water samples, they shall be thoroughly cleaned and flushed between uses. This cleaning process consists of an external detergent wash and high-pressure tap water rinse, or steam cleaning of pump casing, tubing, and cables, followed by a flush of potable water through the pump. This flushing can be accomplished by placing the pump in a newly purchased plastic garbage can filled with tap water and pumping multiple volumes through the pump. The procedure should be repeated first with detergent water and then with tap water. Blanks can be performed by pouring Reagent Water through the pump into the appropriate sample container.

STANDARD OPERATING PROCEDURE
GEOPROBE SOIL SAMPLING
SOP 6

Continuous or discrete soil samples can be collected using direct-push "GeoProbe"[R] equipment and techniques. The GeoProbe equipment is mounted on a one-ton van or similar small truck. Borings are advanced by hydraulically pushing or hammering small-diameter steel rods into the subsurface. Sampling rods vary in outside diameter between two inches and 0.75 inches. Specialized tools are added to the base of the rod string in order to collect soil, groundwater, and/or vapor samples.

All soil samples are collected in new, dedicated clear acrylic liners placed inside the steel drive rods. Continuous soil sample cores can be collected as the rods are advanced. To collect discrete soil samples, the drive rods are advanced to the desired sampling depth with a disposable steel drive point blocking the sampler. A threaded pin locking the drive point can then be removed and soil then enters the sample rod/tube assembly as the rod string is advanced. Sample rods/tubes are typically four feet in length, and must be removed from the open hole to collect the sample. Sampling equipment is then decontaminated, a new drive point is locked into place, and the rod assembly is driven back into the open hole to the new desired sampling interval.

The following standard procedures are followed during sample collection:

- The recovered sample tube is opened on a clean surface using a decontaminated knife or specialized cutter. Representative soils are quickly transferred to appropriate sample containers and sample disturbance is minimized. Each sample container is immediately labeled and sealed.
- Representative portions of each soil sample are transferred from the sample tube to new zip-lock type plastic bags or polyethylene bags and sealed. Volatile head-space vapor readings are then measured as described in the SAP or SOP 3 (Hydrocarbon Field Screening for Soil). After head-space measurements have been recorded, a small volume of clean water is added to the soil. After agitation, the soil-water mixture is observed for visible sheen.
- Soil observed through the sample interval is then logged according to PNG's format described in the SOP.
- Following sample collection and logging, the sample rods and equipment are decontaminated in an isolated and dedicated area as follows.
  - All re-usable sampling equipment and down-hole equipment will be decontaminated using a hot pressure washer or in a solution of water and non-phosphatic detergent.
  - The sampling equipment will be rinsed with distilled or de-ionized water following washing.

STANDARD OPERATING PROCEDURE
FIELD MEASUREMENT OF TEMPERATURE, PH AND ELECTRICAL CONDUCTIVITY FOR GROUNDWATER
SOP 11

This standard operating procedure (SOP) describes general methods for collecting field measurements of temperature, pH, and electrical conductivity (EC) (field parameters) during groundwater sampling. These measurements are collected during well purging prior to sampling to evaluate the representativeness of the water being tested. The procedures outlined in this SOP are suitable for most commercially available instruments.

PROCEDURE

Purge the well until three continuous readings of the field parameters differ within the range shown below or a minimum of three well casing volumes. The well casing volume is calculated using the *Groundwater Sampling Form.* Field parameters should be collected continuously during purging of the third or last well casing volume.

- Rinse a 250- or 500-ml plastic beaker with small portions of sample water three times.
- Rinse electrodes with sample water.
- Fill beaker and measure sample temperature to nearest 1°C using NBS-calibrated mercury thermometer or similar.
- Adjust pH meter temperature compensator to sample temperature.
- Immerse electrodes in sample while swirling the sample, if needed, to provide thorough mixing. Turn on temperature meter, allow temperature to stabilize and record value on sampling form. Turn on pH meter, allow the meter to stabilize and record on sampling form. Turn on Conductance meter, allow the meter to stabilize and record on sampling form. Note any problems such as unusual drift of meter.
- Following temperature, pH, and conductance measurements, measure oxidation-reduction potential (ORP) using the pre-calibrated ORP meter. Lastly measure dissolved oxygen (DO) using pre-calibrated DO meter.
- Repeat procedure for a total of at least three measurements with three to five minutes between each measurement.
- The groundwater is considered stabilized if the following criteria are met with three consecutive measurements:

Temperature	± 3 percent of reading (minimum of ± 0.2 C)
pH	± 0.1 units, minimum
Conductance	± 3 percent of reading
Dissolved Oxygen	± 10 percent of reading
Redox (ORP)	± 10 mV
Turbidity	± 10 percent NTU or < 10 NTU (Turbidity is not a water chemistry indicator parameter but is useful as an indicator of pumping stress on the formation)

INSTRUMENT CALIBRATION

Calibrate pH meter in the field laboratory at the beginning of any day of fieldwork or field laboratory work when field parameters will be measured, then recalibrate each time and at a minimum of every ten samples analyzed. Meters will be calibrated according to manufactures instructions.

MAINTENANCE

- Store meters in the field laboratory, with pH electrodes immersed in a Paraffin-covered beaker of tap water.
- Inspect electrodes weekly.
- Check batteries each time meter is used. Carry a spare battery pack and a screwdriver into the field.

GROUNDWATER
SAMPLE COLLECTION FORM

Well ID no____________________________ Project name__________________________
Sample no.___________________________ Project no.____________________________
Date______/___/______________________ Collector______________________________

Well Information

Monument condition ☐ Good ☐ Needs repair______________________________
Well cap condition ☐ Good ☐ Locked ☐ Replaced ☐ Needs replacement
Headspace reading ☐ Not measured _______ ppm ☐ Odor_____________
Elevation mark ☐ Yes ☐ Added ☐ Other _________________________
Well diameter ☐ 2-inch ☐ 4-inch ☐ 6-inch ☐ Other ____________

Purge Data

Total well depth______________ft ☐ Clean bottom ☐ Muddy bottom ☐ Not measured
Depth to product_____________ft
Depth to water_______________ft
Casing volume ______________ft (H_2O) X ___________gpf = ________ X 3 = _____________
Casing volumes 3/4"=0.02 gpf 1"=0.04 gpf 2"=0.16 gpf 4"=0.65 gpf 6"= 1.47 gpf
Bladder Pumps: ¼" Tubing purge: 5.3mL/ft + 100mL; 3/8" Tubing purge: 9.5 mL/ft + 500mL

Purge Method

Pump type ☐ Peristaltic ☐ Bladder ☐ Submersible ☐ Other_____________
Purge tubing ☐ New LDPE ☐ New HDPE ☐ New Teflon ☐ New Tygon ☐ Other ______
Bailer type ☐ Disposable ☐ Teflon ☐ Stainless ☐ PVC ☐ Other ______
Purge start time______________Purge stop time______________Purge rate__________________
Refill Timer Setting______ Discharge Timer Setting ______ Pressure Setting______ Flow Rate _______

Field Parameters

Meter used ☐ HYDAC Ξ QED Flow Cell ☐ Hanna ☐ Other____________

Gallons / mL	pH	Temp (F)	Conductivity	ORP	DO mg/L	Turbidity	Comments

Sampling Device

Bailer ☐ Disposable ☐ Stainless ☐ Teflon ☐ Other __________________
Filter Type_________ Size________ (micron) Bailer cord used ☐ Monofillament

Bottles Filled Time_________

Number	Type			Preservative					Filtration	
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No

Comments:

Sampler's Signature_____________________________________Date_________/___/_________

STANDARD OPERATING PROCEDURE
LOW-FLOW PERISTALTIC PUMP GROUNDWATER SAMPLING
SOP 17

This standard operating procedure (SOP) is designed to assist the user in taking representative groundwater samples groundwater samples will be collected using low-flow (minimal drawdown) purging and sampling methods as discussed in U.S. EPA, Ground Water Issue, Publication Number EPA/540/S-95/504, April 1996 by Puls, R.W. and M.J. Barcelona - "Low-Flow (Minimal Drawdown) Ground-water Sampling Procedures."

The field sampler's objective is to purge and sample the well so that the water that is discharged from the pump, and subsequently collected, is representative of the formation water from the aquifer's identified zone of interest.

This SOP is applied when the wells to be sampled are not equipped with dedicated down well equipment.

INITIAL PUMP FLOW TEST PROCEDURES

If possible, the optimum flow rate for each well will be established during well development/redevelopment or in advance of the actual sampling event. The monitoring well must be gauged for depth to water (SWL) prior to the installation of the disposable sampling tubing and before pumping of any water from the well. The measurement will be documented on a Field Data Sheet.

After tubing installation and confirmation that the SWL has returned to its original level (as determined prior to tubing installation), the peristaltic pump should be started at a discharge rate less than 0.5 liters per minute (0.13 gal/min) without any In-Line Flow Cell connected. The water level in the well casing must be monitored continuously for any change from the original measurement. If significant drawdown is observed, the pump's flow rate should be incrementally reduced until the SWL drawdown ceases and stabilizes. Total drawdown from the initial (static) water level should not exceed 25 percent of the distance between tubing inlet location and the top of the well screen (for example, if a well has a ten-foot screen zone and the tubing inlet is located mid-screen; the maximum drawdown should be 1.25 feet). In any case, the water level in the well should not be lowered below the top of the screen/intake zone of the well.

Once the specific well's optimum flow rate, without an In-Line Flow Cell connected, has been determined and documented, connect the In-Line Flow Cell system to be used to the well discharge and determine the control settings required to achieve the well's determined optimum flow rate with the In-Line Flow Cell connected (due to the system's back-pressure, the flow rate will be decreased by ten to 20 percent).

PURGE AND SAMPLING EVENTS

Prior to the initiation of purging a well, the Static Water Level will be measured and documented. The peristaltic pump will be started utilizing its documented control settings and its flow rate will be confirmed by volumetric discharge measurement with the In-Line Flow Cell connected. If necessary, any minor modifications to the control settings to achieve the well's optimum flow rate will be documented on the gauging sheet. When the optimum pump flow rate has been established, the SWL drawdown has stabilized within the required range, and at least one pump system volume (down well extraction tubing, pump head tubing, and discharge tubing volume) has been purged, begin taking field measurements for pH, temperature (T), conductivity (Ec), oxygen reduction potential (ORP), dissolved oxygen (DO), and turbidity (TU) using an in-line flow cell. All water chemistry field measurements will be documented on the gauging sheet. Measurements should be taken every three to five minutes until stabilization has been achieved. Stabilization is achieved after all parameters have stabilized for three consecutive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or dissolved oxygen. Three consecutive measurements indicating stability should be within:

Temperature	± 3 percent of reading (minimum of ± 0.2 C)
pH	± 0.1 units, minimum
Conductance	± 3 percent of reading
Dissolved Oxygen	± 10 percent of reading
Redox (ORP)	± 10 mV
Turbidity	± 10 percent NTU or < 10 NTU (Turbidity is not a water chemistry indicator parameter but is useful as an indicator of pumping stress on the formation)

When water quality parameters have stabilized, and there has been no change in the stabilized SWL (i.e., no continuous drawdown), sampling collection may begin.

EQUIPMENT LIST

The following equipment is needed to conduct low flow purging and sampling:

- Portable peristaltic pump equipped with a flow controller set to operate at the specific well's documented optimum flow rate.
- Disposable down well sampling tubing of sufficient length to intake groundwater at the target sampling depth for each well.
- In-Line Flow Cell and meter(s) with connection fittings and tubing to measure water quality.
- Water Level Probe or installed dedicated water level measurement system.
- Photoionization detector (PID).
- Sample containers appropriate for the analytical requirements.
- Field measurement documentation forms.
- 300 to 500 milliliter graduated cylinder or measuring cup.
- Five gallon bucket(s) for containerizing purge water.
- Wristwatch with second hand or stopwatch.
- Sufficient cleaning and decontamination supplies if portable Water Level Probe is utilized.

PROCEDURE

- Calibrate all field instruments at the start of each day's deployment per the instrument manufacturer's instructions. Record calibration data.
- Drive to the first well scheduled to be sampled (typically the least contaminated). Make notes in the field log book describing the well condition and activity in the vicinity of the well. Decontaminate the portable water gauging probe by washing with phosphate-free detergent, rinsing with potable water, and rinsing with deionized water.
- Remove the wellhead cover and take a measurement of the well vapor space with a PID. Record the measurement on the gauging and sampling sheet.

- Measure the depth to water from the surveyed reference mark on the wellhead and record the measurement on the gauging and sampling sheet. Lock the water level meter in place so that the level can be monitored during purging and sampling. When placing the probe in the well, take precautions to not disturb or agitate the water.
- Insert a sufficient length of disposable sampling tubing into the well casing to insure that the tip of the tubing is located within the appropriate sampling depth within the well screen.
- Insert a new length of flexible silicone tubing into the peristaltic pump head fixture.
- Connect the down well sampling tubing to the silicone tubing in the peristaltic pump head fixture.
- Connect a new length of disposable pump discharge tubing to the silicone tubing in the peristaltic pump head fixture and secure to drain the flow-rate test purge water into the purge water collection container.
- Start the peristaltic pump. Set the pump controller settings to the documented settings for the specific well. Confirm the flow rate is equal to the well's established optimum flow rate. Modify as necessary (documenting any required modifications).
- Monitor the water level and confirm that the SWL drawdown has stabilized within the well's allowable limits.
- Remove the pump discharge tubing.
- Connect the pump discharge tubing to the In-Line flow cells "IN" fitting.
- Connect the Flow Cell's "OUT" line and secure to drain the purge water into the purge water collection container.
- After a single pump-system's volume (down well sampling tubing, pump head silicone tubing, and discharge tubing volume) has been adequately purged, read, and record water quality field measurements every three to five minutes until all parameters have stabilized within their allowable ranges for at least three consecutive measurements. When stabilization has been achieved, sample collection may begin.
- Disconnect the flow cell, and it's tubing, from the pump discharge line before collecting samples. Decrease the pump rate to 100 milliliters per minute or less by lowering the pump controller's setting prior to collecting samples for volatiles. Refer to the task instructions for the correct order and procedures for filling sample containers. Place the samples in a cooler with enough ice to keep them at 4 degrees Centigrade.
- Once samples for volatiles have been collected, re-establish pump flow rate to the original purge flow rate by inputting the documented controller settings for the well without the In-Line Flow Cell connected, and collect remaining samples.
- When all sample containers have been filled, make a final measurement of the well's Static Water Level and record the measurement on the gauging and sampling sheet. Measure the Total Depth of the well and record the measurement, as well.
- Measure and record total purge volume collected. Consolidate generated purge water.
- Remove and decontaminate the Portable Water Level Probe with phosphate-free detergent, rinsing with potable water and rinsing with deionized water.

- Disconnect and dispose of each length of down well sampling tubing, silicone pump head tubing, and pump discharge tubing.
- Secure the peristaltic pump in the portable pump carrying case.
- Secure the wellhead cover and secure with its lock. Move equipment to next well to be sampled.
- At the end of each day, post calibrate all field instruments and record the measurements.
- Clean and decontaminate the In-Line Flow Cell with phosphate-free detergent, rinsing with potable water, and rinsing with deionized water.
- Photocopies of all completed forms should be made each day. The copies should be retained on site. The original forms will be kept in the PNG Environmental project file.

GROUNDWATER SAMPLE COLLECTION FORM

Well ID no____________________________ Project name__________________________
Sample no.____________________________ Project no.____________________________
Date______/___/______________________ Collector______________________________

Well Information

Monument condition ☐ Good ☐ Needs repair_____________________________
Well cap condition ☐ Good ☐ Locked ☐ Replaced ☐ Needs replacement
Headspace reading ☐ Not measured _______ ppm ☐ Odor_____________
Elevation mark ☐ Yes ☐ Added ☐ Other _________________________
Well diameter ☐ 2-inch ☐ 4-inch ☐ 6-inch ☐ Other ____________

Purge Data

Total well depth______________ft ☐ Clean bottom ☐ Muddy bottom ☐ Not measured
Depth to product_____________ft
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Casing volume ______________ft (H_2O) X ___________gpf = ________ X 3 = ______________
Casing volumes 3/4”=0.02 gpf 1”=0.04 gpf 2”=0.16 gpf 4”=0.65 gpf 6”= 1.47 gpf
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Purge Method

Pump type ☐ Peristaltic ☐ Bladder ☐ Submersible ☐ Other_____________
Purge tubing ☐ New LDPE ☐ New HDPE ☐ New Teflon ☐ New Tygon ☐ Other ______
Bailer type ☐ Disposable ☐ Teflon ☐ Stainless ☐ PVC ☐ Other ______
Purge start time______________Purge stop time______________Purge rate__________________
Refill Timer Setting______ Discharge Timer Setting ______ Pressure Setting______ Flow Rate _______

Field Parameters

Meter used ☐ HYDAC Ξ QED Flow Cell ☐ Hanna ☐ Other____________

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Sampling Device

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Filter Type__________ Size________ (micron) Bailer cord used ☐ Monofillament

Bottles Filled Time_________

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___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No

Comments:

Sampler’s Signature____________________________________Date_________/___/_________