Appendix B

Geotech Data

CONTENTS

FIGURES

TABLES

B-1. GEOLOGIC DATA

B-1.1 Summary of Results of the ICDF Site Visits to Examine the Sediments in the ICDF Pit

B-1.1.1 Objective and Activity Performed

At the request of the ICDF project manager, visits to the ICDF excavation were made between August 29 and October 25, 2001, to conduct and record geologic observations during ICDF pit excavation activity. The project requested that a qualified geologist examine the sediments regularly throughout the excavation to confirm previous geotechnical work. The work was also to visually correlate geologic and depositional environments to previous geotechnical borings and establish the geologic framework of the excavated sediments prior to the installation of the landfill liners.

In addition to the field observations, the sediments observed in the excavation were compared to the boring logs of the two original soil borings that were drilled during the initial geotechnical work for placement of the ICDF excavation (see Figures B-1 and B-2). Comparisons between the observed sediments in the excavation and the original soil boring logs are discussed in Section B-1.1.4, Conclusions.

Based on the results of comments and suggestions submitted during internal INEEL Operations Review Board (ORB) document review during January and February 2001, clarifications and revisions to the original draft of this report and the daily site visit reports were made to the original field notes. During the site visit to the ICDF excavation by the agencies on October 16, 2001, copies of the field notes to date were provided to the agency representatives for their information.

The ICDF excavation was visited on nine separate occasions to observe sediments exposed during the ongoing excavation work. Reports of the field observation completed from the visit were prepared and forwarded to ICDF project personnel for their review.

The final site visit associated with the excavation took place on October 25 when the excavation was approximately at the final grade of the pit, and additional excavation was only taking place on the edges of the excavation to remove former access ramps from the pit.

B-1.1.2 Field Evaluation Process

During each of the field visits to examine the exposed sediments in the ICDF pit excavation, approximately ½ hour was spent in the excavation. The limited period of time available to conduct the field observations was due to safety concerns expressed by the project. The ½-hour lunch breaks by the heavy equipment operators was the only available time to safely enter the excavation without interfering with the work in progress. Entrance at this time allowed free access to the excavation without potential conflicts with operating heavy equipment and also lessened potential hazards dealing with heavy equipment operating in the pit while doing the field observations.

While in the pit bottom during each site visit, quick field observations were made of the sediments exposed in the excavation and changes in these sediments since the previous field visit. Field notes on observations and visually observed and measured dips of sedimentary beds were taken. During the last three site visits, digital photographs were also taken of important sedimentary relationships and bedding. Representative copies of these digital photographs are included with this report. The rest of the photographs are on file with the ICDF project.

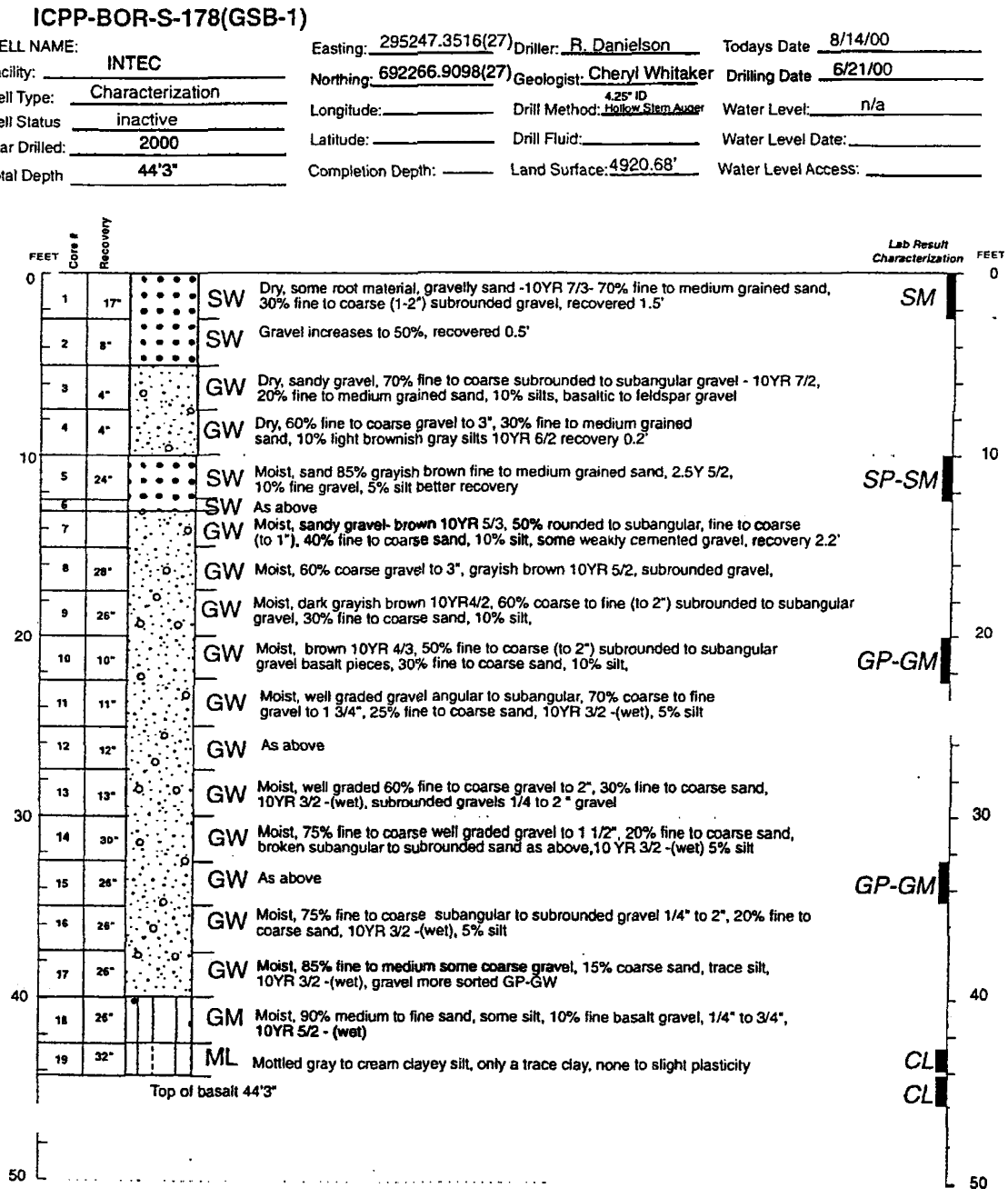


Figure B-1. Soil boring ICPP-BOR-S-178 (GSB-1).

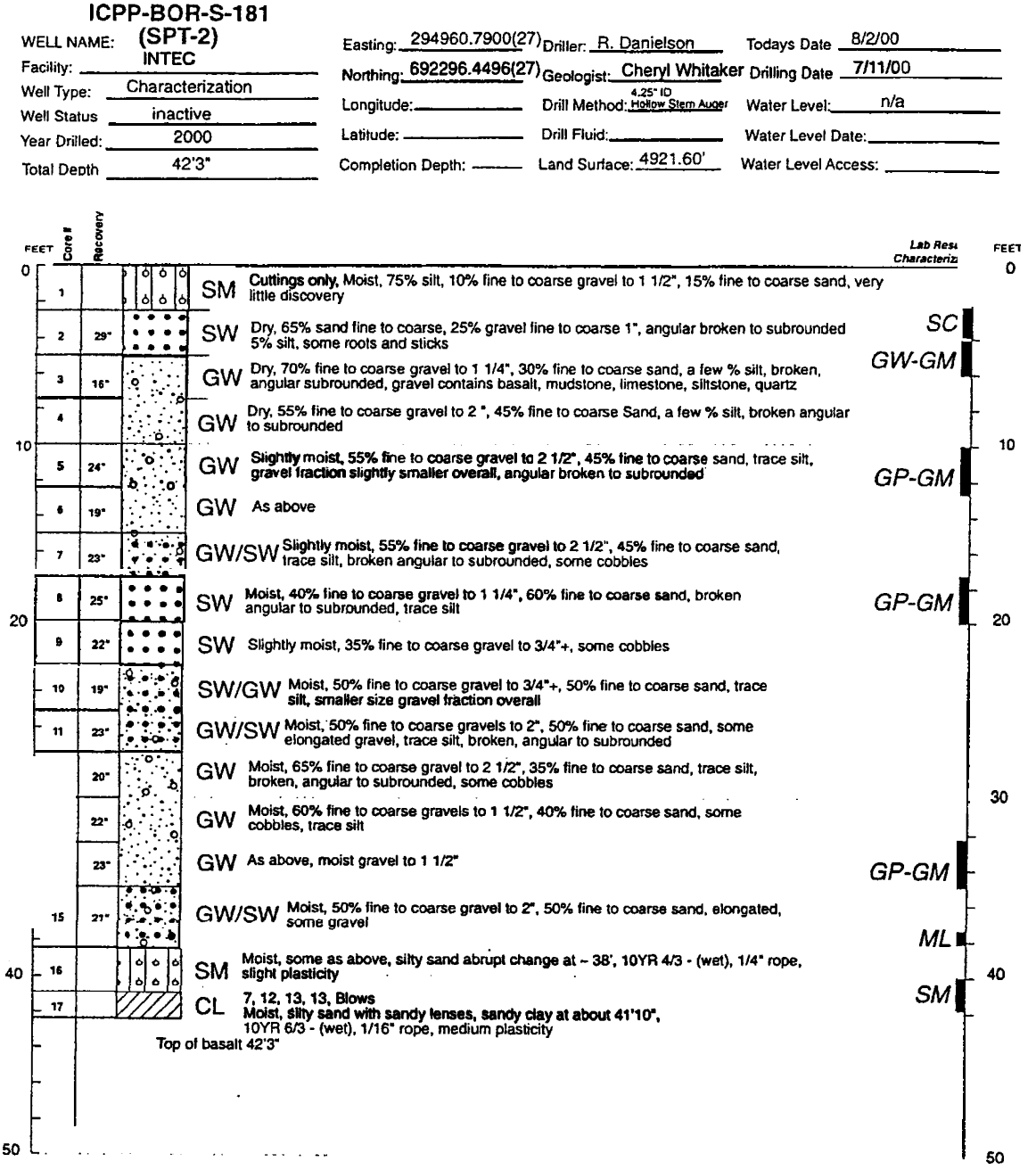


Figure B-2. Soil boring ICPP-BOR-S-181 (SPT-2).

It should be noted that by the time the field observation were requested and begun the upper 3 to 6 ft of sediments had already been removed from the area of the excavation. Therefore, no discussion or observations of these sediments was possible and are not included in this report.

B-1.1.3 Results of Field Visits

The field visits to the ICDF pit observed the excavation of the unconsolidated sediments from depths of approximately 6 ft below the ground surface (bgs) to the final grade of approximately 38 ft bgs. The results of the observations are summarized below by outlining the general composition of the unconsolidated sediments based on the depth of the sediments below the original ground surface.

Approximately 6 to 8 ft bgs

The upper 6 to 8 ft of sediments exposed in the excavation consisted of mixed fine to coarse gravels and fine to coarse-grained sand with little or no observed bedding or layering. Small sections of weakly cemented sand lenses approximately 1 ft thick with occasional voids (6 in. to 1 ft in diameter) were observed at erratic, discontinuous intervals within the gravels in the northwest quarter of the excavation.

Approximately 8 to 30 ft bgs:

Most of the western side of the excavation was sand and gravels similar to those observed in the upper 0- to 8-ft section discussed above with only occasional sandy interbeds.

The central portion of the excavation and extending nearly to the eastern edge consisted of interbedded sands and gravels. The sands and gravels occur in alternating 2- to 3-ft layers or beds with crosscutting and imbricated relationships. The beds consist of fine to coarse-grained sands with silt, and fine to coarse gravels with sand layers. The beds are generally more steeply dipping on the eastern side with observed and visually measured dips of 8 to 15 degrees to the west. The beds gradually become flatter or with variable shallow dips in both the easterly and westerly directions extending towards the center of the excavation. Towards the western side, the beds often dip gently to the east at observed and visually measured dips of 3 to 5 degrees to the east. Examples of these beds are shown in the photographs in Figure B-3.

Approximately 30 to 33 ft bgs:

Throughout most of the excavation at this depth thin alternating layers of fine to coarse gravels and fine to coarse-grained sand with minor silts and clays were observed. The sand layers are often moist, especially towards the center of the excavation.

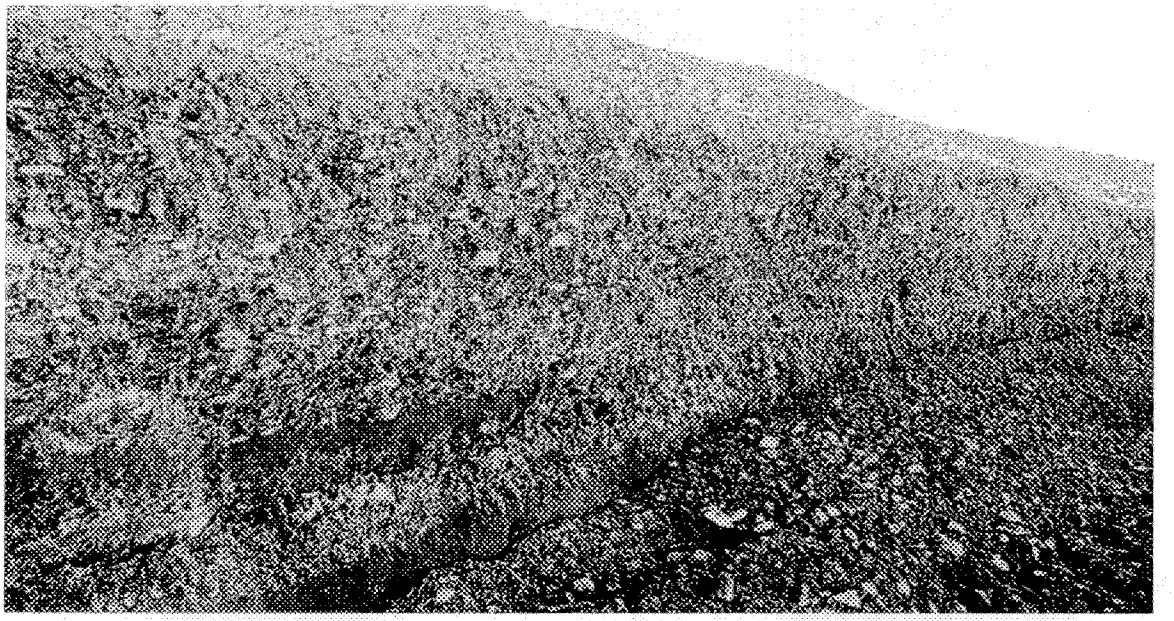
Approximately 33 to 36 ft bgs:

Throughout most of the excavation at this depth, thin, alternating layers of medium to coarse-grained sand with silt and minor (<10%) gravel, and pebble-sized pieces of quartz and shale in the sands were observed. The sands are often moist, especially towards the center of the excavation. Examples of this section are shown in the photographs in Figure B-4.

Approximately 36 to 38 ft bgs:

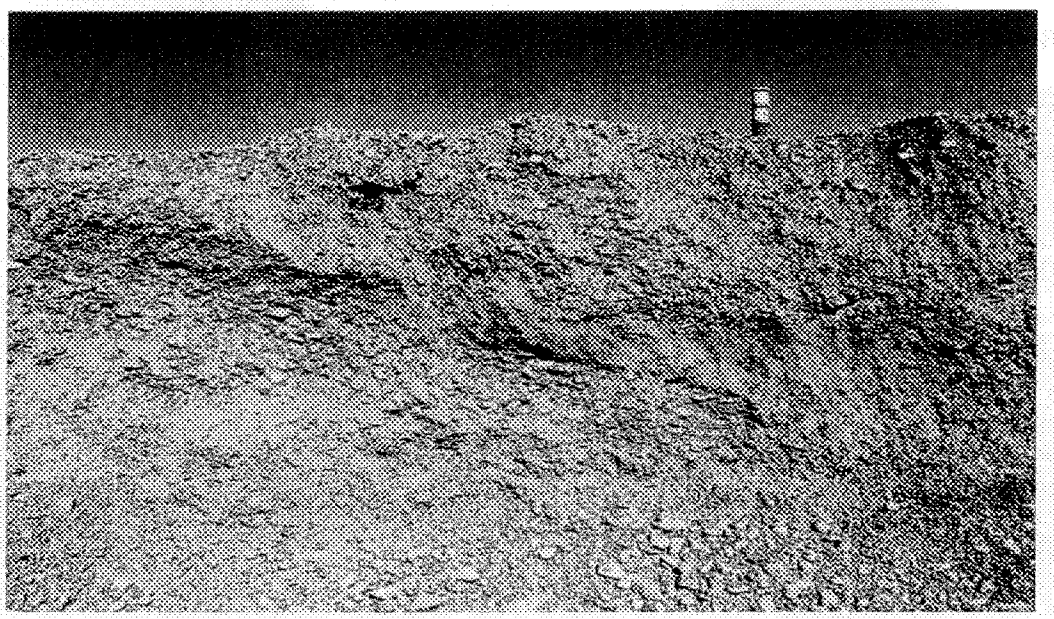
The lowermost unit exposed in the excavation is a reddish-brown silty clay with <10% fine-grained sand. This unit was observed in the bottom of the excavation throughout the north-central portion of the excavation extending nearly to the northwest and northeast corners of the pit. This unit is locally known as the "older alluvium" and the reddish-brown silt clay observed in the excavation probably represents the uppermost party of the "older alluvium". Examples of this section are shown in the photographs in Figure B-5.

Figure B-3. Four photographs of the sediments observed in the ICDF excavation at depth of 8 to 30 ft bgs.



Photograph looking south of excavation cut showing interbedded sands and gravel beds. Dark brown unit is sand bed. Photograph darkened to enhance features. Location of photograph is in the north central portion of the excavation. The larger dark bands of sand beds are approximately 1 ft thick. The entire cut is approximately 5 ft high.

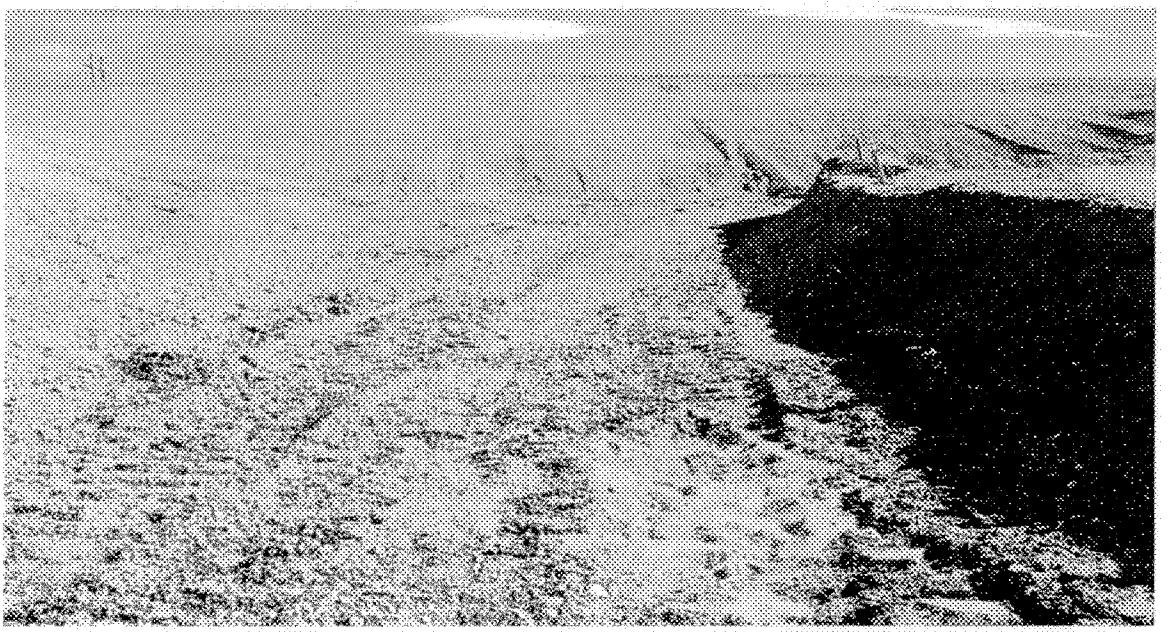
Additional photograph looking south of excavation cut showing interbedded relationship between sand and gravel beds. Photograph darkened to enhance features. Location of photograph is in the north central portion of the excavation. The largest dark band of the sand bed is approximately 1–2 ft thick. The entire cut is approximately 5 ft high.



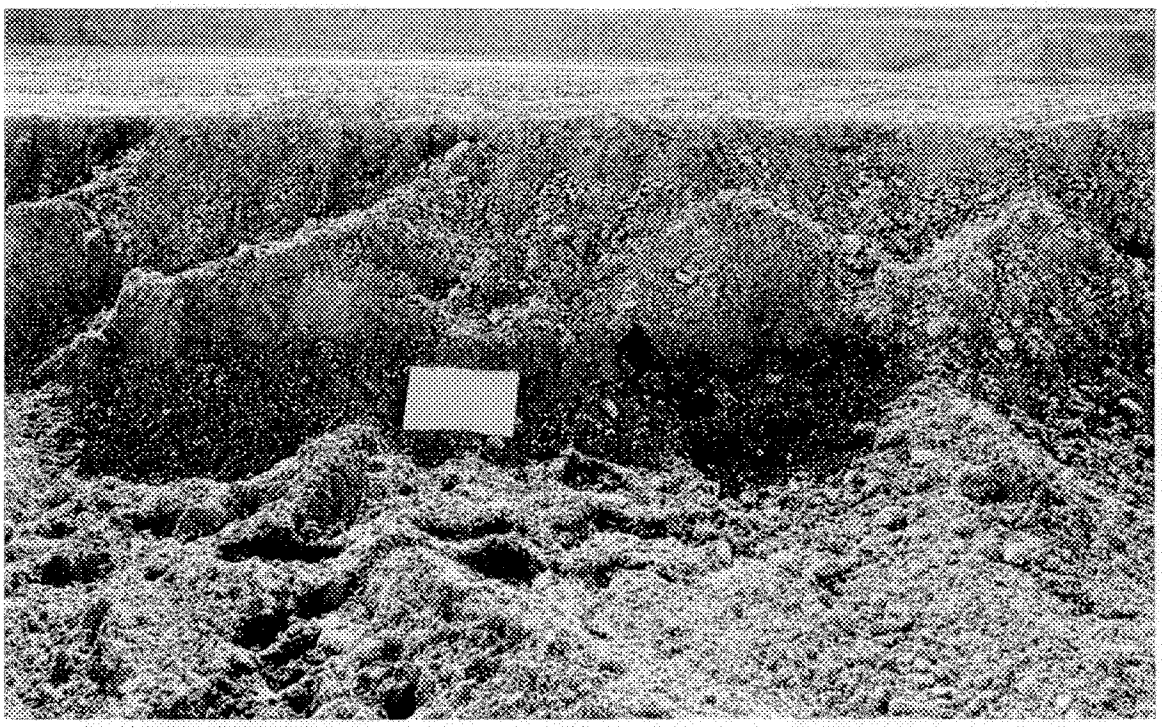
Photograph looking north of excavation cut showing cross-bedded, imbrecciated dark sand bed with gravel beds. Probable channel feature in middle of photograph. Photograph darkened to enhance features. Location of photograph is near the northeast central edge of the excavation. The larger dark band of sand beds is approximately ½ ft thick to the left increasing to approximately 2 ft thick to the right edge of the photograph. The entire cut is approximately 6 ft high.

Photograph looking north of excavation cut showing imbrecciated dark sand bed with gravel beds. Note dark brown sand bed in middle with gravel beds below and dipping gravel beds top right of the photograph. Probable channel feature in middle of photograph. Photograph darkened to enhance features. Location of photograph is near the northeast central edge of the excavation. The larger dark band of sand bed in the upper left is approximately 1 ft thick. The entire cut is approximately 6 ft high.

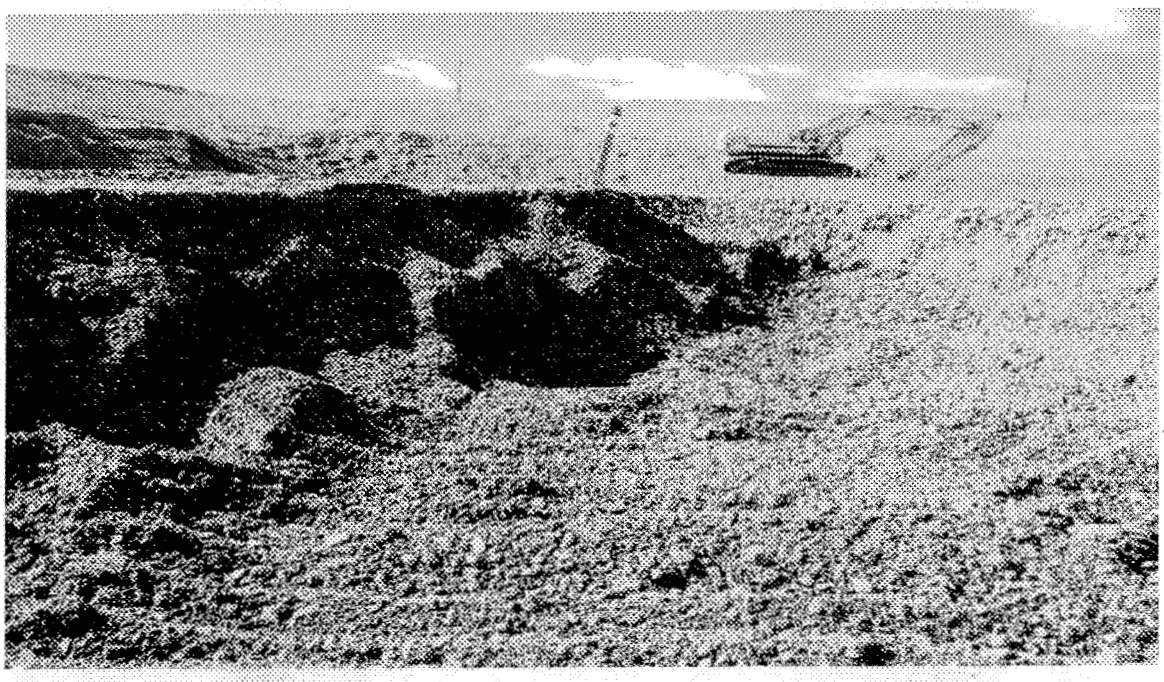
Figure B-4. Four photographs of the sediments observed in the ICDF excavation at depth of 33 to 36 ft bgs.



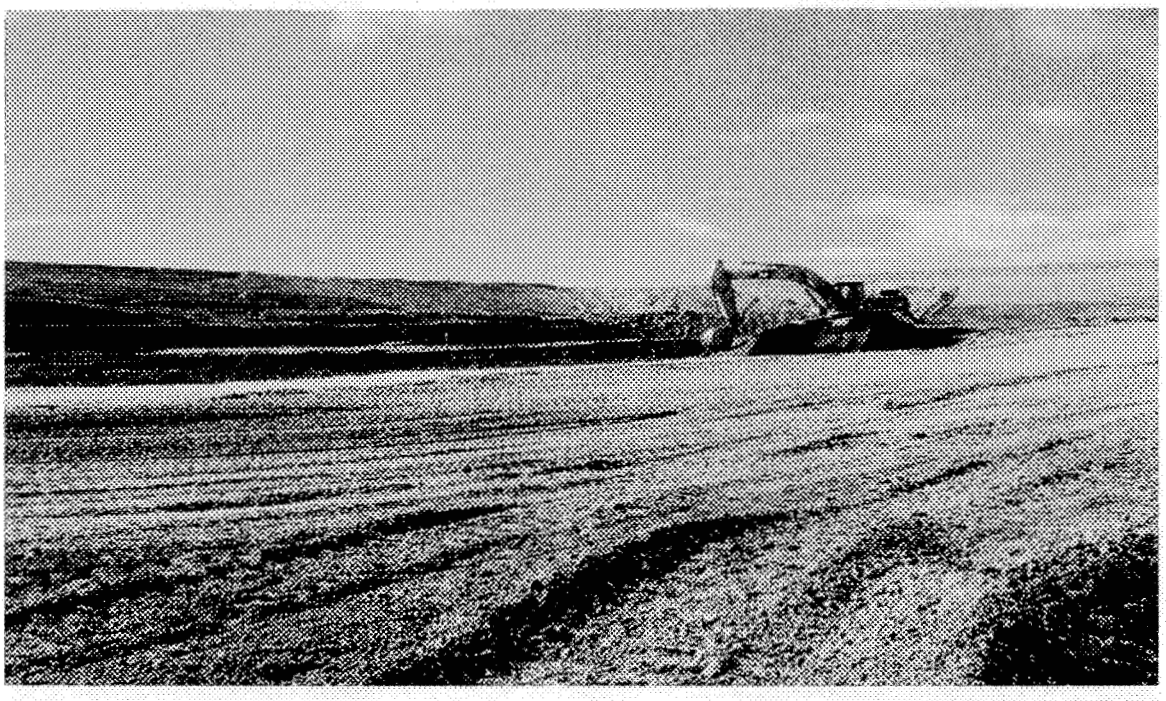
Photograph looking east of sand with silt and gravel in patch in foreground surrounded by coarser gravels. Location of photograph is near the northeast corner of the excavation. The delineators on the upper part of the cut for scale are approximately 4 ft high.



Photograph looking south from south central portion of excavation of fine to coarse-grained sand with silt and minor gravel with fine to coarse gravel above. Note dark brown moist sand bed in middle of photo. Clip board for scale. The entire cut is approximately 3 to 4 ft high.

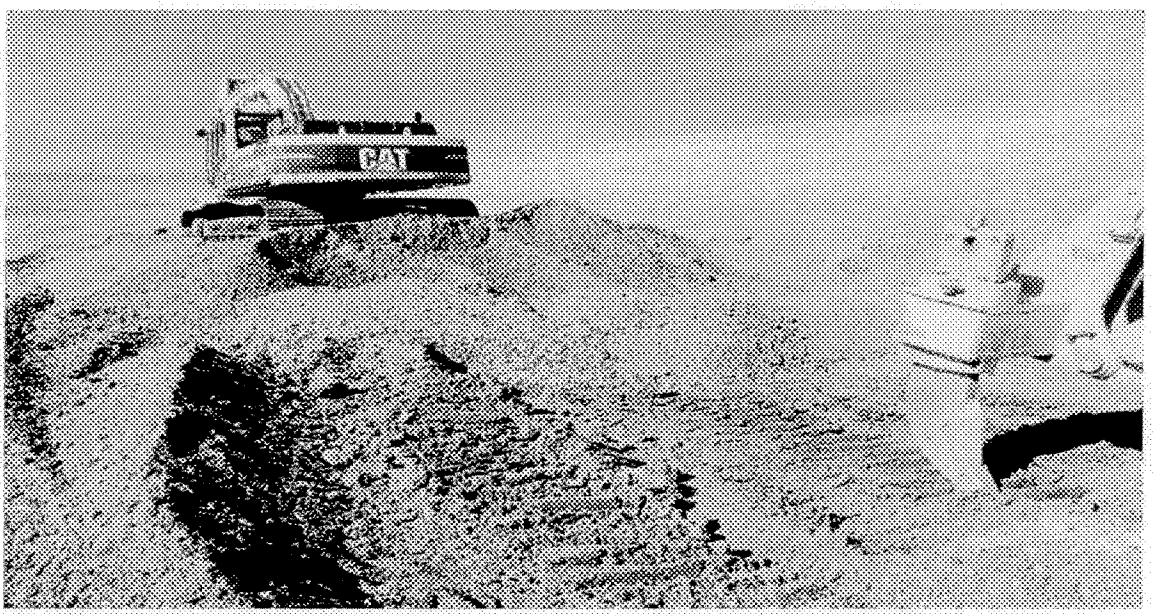


Photograph looking west in the south central potion of the excavation of fine to coarse-grained sand with minor silt and gravel at bottom of excavation with coarse gravel beds above. Note contact between units on the cut wall in the middle distance and the dark brown color of the moist sand layer below orange delineator cone. Delineator cone for scale is approximately 4 ft high. The entire cut is approximately 3 to 4 ft high.

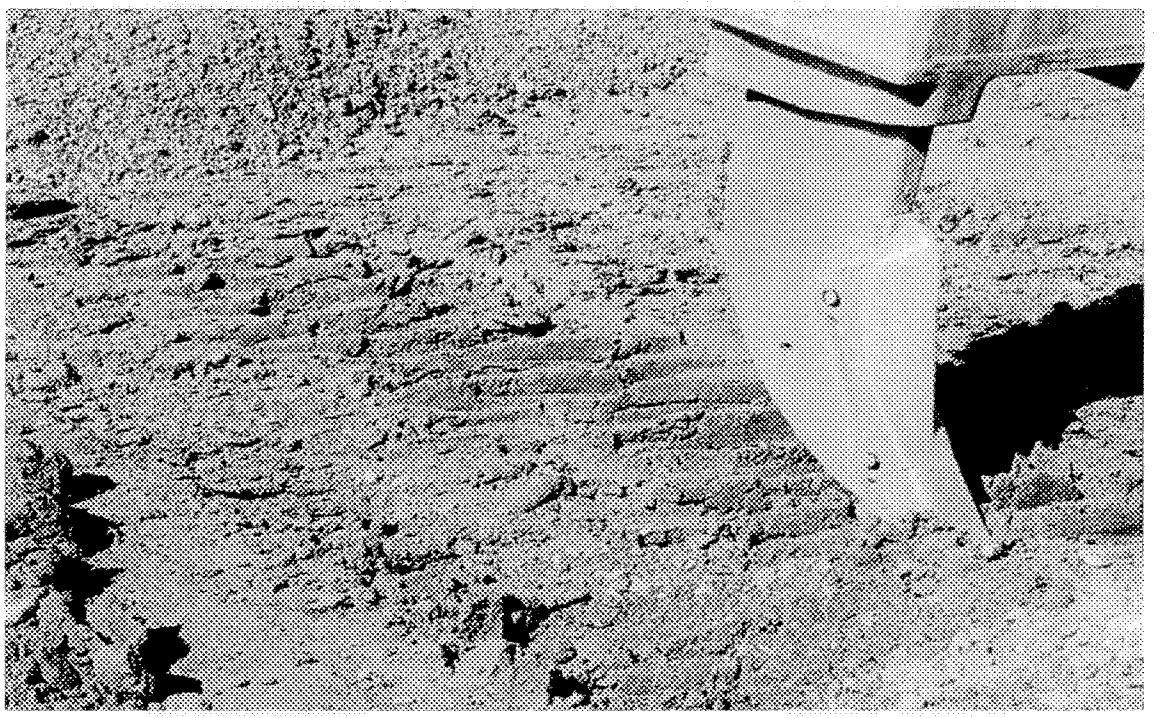


Photograph looking southwest from the north central portion of the excavation toward the southwest corner across floor of excavation to cut shown in photograph above. The majority of the floor of the excavation from the foreground to the cut consists of the sand layer with minor silt and gravel.

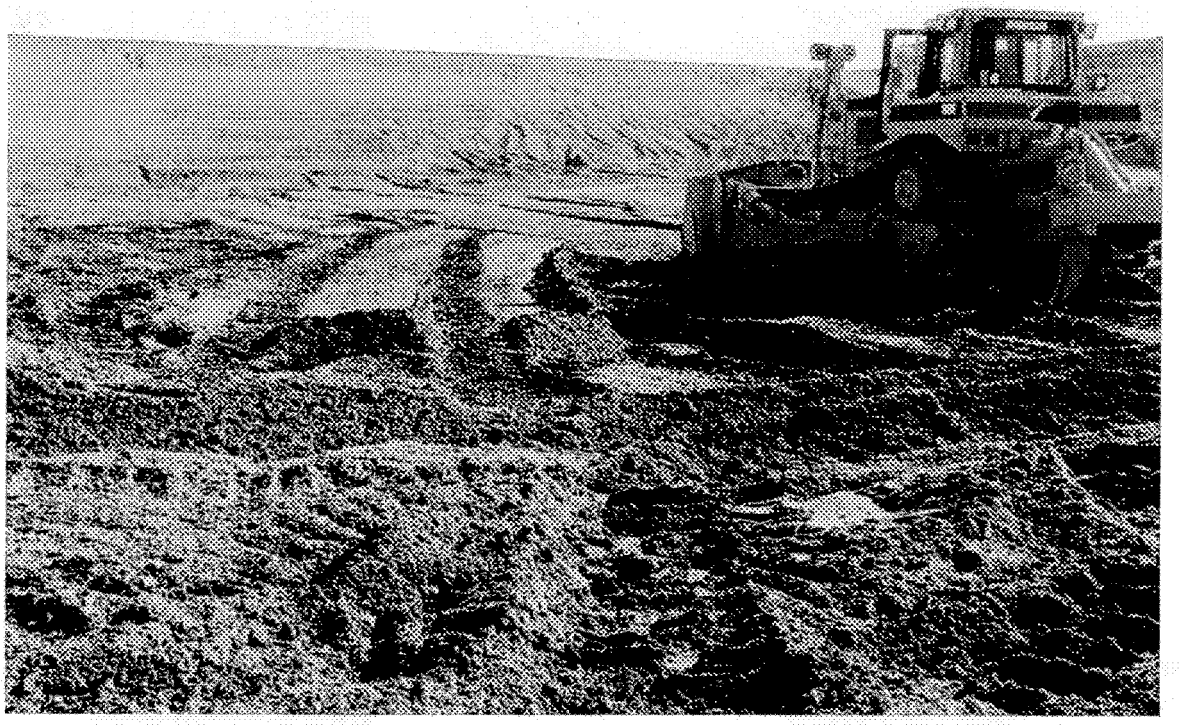
Figure B-5. Three photographs of the sediments observed in the ICDF excavation at depth of 36 to 38 ft bgs.



Photograph looking west of reddish brown silty clay unit exposed in the bottom of the excavation near back ripper of bulldozer. The reddish brown silty clay is the upper contact with the "older alluvium" which underlies much of the ICDF pit. Location of photograph is near the north central portion of the excavation. Bulldozer ripper blade for scale.



Close-up view of the silty clay shown in the photograph above. Location of photograph is near the north central portion of the excavation. Bulldozer ripper blade for scale.



Photograph looking east of reddish brown silty clay unit of upper "older alluvium" extending across the floor of the ICDF pit nearly to the east wall of the pit. Location of photograph is near the north central portion of the excavation. Bulldozer for scale.

B-1.1.4 Conclusions

The depositional environments described in the field observations site visit reports are older or "paleo" environments that represent deposition that may be related to much older deposition episodes. These depositional episodes may be related to earlier glaciation-related events in the surrounding mountain ranges. For details of these older glacial periods of depositions, refer to Rathburn (1991) and Barraclough et al. (1976). Barraclough et al. (1976) describes Pleistocene-aged (10,000 to 2 million years before present [mybp]) glacial deposition in the area of the INEEL from large quantities of coarse sands and gravels being released and deposited in a cataclysmic flood from the breakage of a glacial ice dam which had stored water and sediments behind the dam. It is reported this ice dam broke and a large quantity of water carrying coarse sand and gravel was washed out onto and was deposited on the plain below, part of which is now occupied by the INEEL. Such a cataclysmic event could provide the depositional source for the poorly sorted sands and gravels observed in portions of the ICDF excavation. Large quantities of coarse sand and gravels are often washed out from glacial environments and are deposited in the valleys below. This is a plausible explanation of the deposition of much of these sediments. The paleo-stream channels observed and described below could also occur in these environments during later stream erosion and depositional activities.

As stated in the introductory section of this report, part of the overall objective of the site visits during the ICDF excavation activity was to compare the sediments observed in the excavation to sediments logged in original geotechnical soil borings drilled in the area of the ICDF excavation. Two previous soil borings, ICPP-BOR-S-178 (GSB-1) and ICPP-BOR-S-181 (STP-2), were located in the area that was excavated for the ICDF pit (Figure B-6). The boring logs of these two soil borings are included with this report as Figures B-1 and B-2. The boring logs of these two soil borings were compared to the sediments observed in the ICDF excavation in approximately the same locations.

Overall, there is good general correlation between the logged sediments in the bore holes and the sediments observed in the excavation. The overall makeup of the sediments as poorly sorted fine to coarse gravels and fine to coarse sands correlates well between the boring logs and the field observations made of the excavation. The soil boring logs did note more moist sediments in the boreholes than was observed in the excavation. However, the ICDF excavation observations had the advantage of looking at the more lateral extent of the sediments from which the paleo-braided stream channel sediments were observed. This type of observation and correlation would be difficult to make in a single bore hole. In Borehole ICPP-BOR-S-181 (SPT-2), the depth of the uppermost contact with the "older alluvium" of approximately 35 ft bgs was closely matched with the occurrence of the "older alluvium" in the excavation. In Borehole ICPP-BOR-S-178 (GSB-1), the depth of the uppermost contact with the "older alluvium" was logged at 40 ft when the actual contact in the excavation was observed at approximately 36 ft bgs based on the control survey of the bottom of the excavation.

Based on the observations during the site visits during the excavation of the ICDF pit, the following conclusions are submitted.

1. The upper 8 ft of sediments exposed in the excavation show little to no evident bedding or layering of the coarse sands and gravels.

2. The middle 8 to 30 ft exposed in the excavation may represent a paleo-braided stream channel system that deposited sediments throughout area of the center of the excavation. Based on the dips of the sediments, one edge of the braided stream channel was located near the eastern edge of the excavation as shown by the steeper westerly dip near the eastern edge. The eastern edge of this paleo-braided stream channel is located approximately 50 to 80 ft west of the eastern edge of the

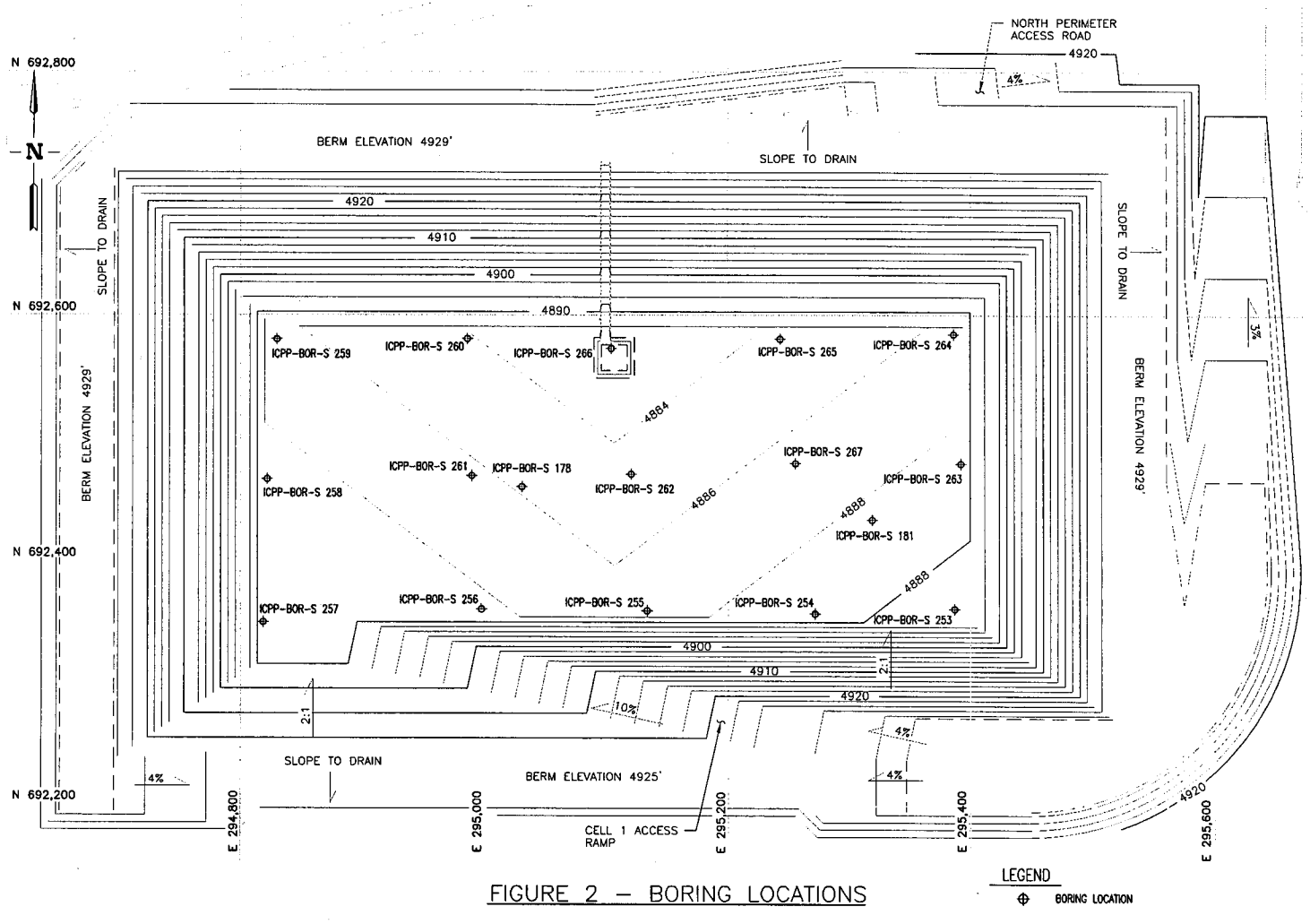


FIGURE 2 – BORING LOCATIONS

Figure B-6. Boring locations.

bottom of the excavation. This steep dip grades gradually westerly to flatter dips or sediments with variable shallow dips in both the easterly and westerly directions that may represent the braided channels in the stream system. The western edge of this paleo-braided stream system is located approximately 90 to 110 ft east of the western edge of the bottom of the excavation.

3. The section from 30 to 36 ft may represent a moderate energy paleo-depositional system with less coarse gravels and more sand. This section does not show the paleo-braided stream nature of the section above.

4. The final section in the bottom of the excavation from 36 to 38 ft is much finer-grained sand, silt and clay that are locally named the "older alluvium". The reddish-brown silty clay exposed in the bottom of the pit grades down to the fine silts and clays detected in the boreholes in the bottom of the pit.

B-1.1.5 Follow-up Soil Borings in the Bottom of the ICDF Pit

Following the completion of the excavation of the ICDF pit, the project manager requested that 15 shallow soil borings be drilled in the bottom of the pit. The objective of these borings was to identify and verify the depth of the sediments below the bottom of the pit to the basalt bedrock interface.

During the drilling of these boreholes, Lexan sample tubes of the sediments being drilled were collected for the entire drilled depth of each soil boring. A registered geologist was on site during the drilling of each soil boring and all of the sediments collected in the Lexan tubes was logged by the geologist using the Unified Soil Classification System and a Munsell color chart.

The results of the soil boring and logging activity are reported in the separate drilling summary section of this appendix.

B-1.2 Results of Initial Visits to Examine the ICDF Excavation Sediments

B-1.2.1 Visit on August 29, 2001

Objective

The objective of this work is for a qualified geologist to regularly examine sediments exposed during excavation of the ICDF Cell #1 to confirm previous geotechnical work. The work was also to visually correlate geologic and depositional environments to previous geotechnical borings and establish the geologic framework of the excavated sediments prior to the installation of the landfill liners.

Detail of Site Visit

The initial visit to the ICDF #1 Cell excavation took place on Wednesday, August 29, 2001. Approximately 2 hours were spent at the ICDF site with approximately 1 hour of that time spent in the excavation looking at the subsurface sediments currently exposed in the walls of the excavation.

Results

The following observations were made during this initial visit to the ICDF excavation:

1. The current excavation at the time of the visit ranged in depth from approximately 3 ft deep in the southwest corner to approximately 6 ft deep in the current northeast portion of the excavation. The deepest part being the area below worked on by the excavators during the site visit.

2. Along the north wall of the excavation, in the northwest corner observed during this visit, the upper most sediments consist of an approximately 2-ft-thick section of surface sediments made up of thinly bedded to graded silt, sand and fine gravel.

3. Below the surface sediments are approximately 3 to 4 ft of fine to coarse gravel (pebble to cobble size) mixed with fine to coarse-grained sand.

4. The gravel is composed is from 80% to 90% basalt fragments with the other 10+% being mostly quartz material.

5. There is little to no obvious bedding within most of the lower gravel unit.

6. In a small exposure in the north wall of the excavation, and also to the south of the north wall near the current excavation activity, a 1-ft-thick bedded, moderately cemented, moderately sorted sand with fine gravel bed is visible approximately 3 to 4 ft below the surface. This cemented, bedded sand unit has an observed and visually measured dip to the south at 8 to 10 degrees.

7. Below the cemented sand with gravel bed, there appears to be a void in the gravel and sand. The void is less than 1 ft below the bed.

8. Below the areas where the cemented sand with gravel bed was observed, there is approximately 2 ft of poorly sorted mixed fine to coarse gravel and sand.

9. The general impression when walking throughout the current excavation was that the gravels were becoming finer (smaller in overall size of individual gravel) toward the southern portion of the current excavation.

Summary of Field Observation

Based on the results of this initial visit, other than the single isolated void or hole observed below the cemented sand with gravel bed, there were no areas of unusual or anomalous geologic and sedimentary features observed in the excavation.

Submitted
August 31, 2001

B-1.2.2 Visit on September 13, 2001

Objective

The objective of this work is for a qualified geologist to regularly examine sediments exposed during excavation of the ICDF Cell #1 to confirm previous geotechnical work. The work was also to

visually correlate geologic and depositional environments to previous geotechnical borings and establish the geologic framework of the excavated sediments prior to the installation of the landfill liners.

Detail of Site Visit

The second visit to the ICDF #1 Cell excavation took place on Thursday, September 13, 2001. Approximately 2 hours were spent at the ICDF site with approximately 45 minutes of that time spent down in the excavation looking at the subsurface sediments currently exposed in the walls of the excavation. Since the level of equipment activity in the excavation has increased significantly since the previous visit, the only time spent in the excavation was during the lunch break by the crew.

Results

The following observations were made during this visit to the ICDF excavation:

1. The current excavation at the time of the visit ranged in depth from an estimated 8 to 9 ft deep in the southwest corner to estimated 12 ft deep in the current northeast portion of the excavation. Three excavators were working in various parts of the excavation at the time of the visit.

2. In the northwest corner of the excavation, 1- to 2-ft thick isolated sections of a weakly to moderately cemented, moderately sorted sand with fine gravel bed are still visible. This cemented layer was originally observed during the site visit on August 29, 2001.

3. Moving from the northwest to the southwest corner of the excavation the gravel become finer (smaller) and the gravel is roughly bedded with a 2 to 3 degree southerly observed and visually measured dip.

4. Along the south wall of the excavation at a depth of approximately 5 to 6 ft bgs is a fairly continuous 2- to 3-ft thick interbedded, weakly cemented fine to coarse-grained sand with silt and fine gravel.

5. In the central (middle) portion of the excavation at an estimated depth of 10 to 12 ft bgs a nearly continuous sandy/silty layer with less gravel (20 to 30%?) is exposed with rough bedding at 8 to 12 degrees observed and visually measured dip to the west.

6. Based on the observations made during this visit, the sand/silt bed exposed in the middle of the excavation dips to the west and then becomes flatter near the western edge of the excavation. There is also less gravel observed in the sandy/silty beds and the gravel that is present is well rounded and fine to coarse.

Summary of Field Observation

Based on the results of this second site visit, other than the cemented sand with gravel bed that was noted during the August 29, 2001, visit and observed again during this visit in the northwest corner of the excavation, there were no areas of unusual or anomalous geologic and sedimentary features observed in the excavation.

Submitted September 18, 2001

B-1.2.3 Visit on September 20, 2001

Objective

The objective of this work is for a qualified geologist to regularly examine sediments exposed during excavation of the ICDF Cell #1 to confirm previous geotechnical work. The work was also to visually correlate geologic and depositional environments to previous geotechnical borings and establish the geologic framework of the excavated sediments prior to the installation of the landfill liners.

Detail of Site Visit

The third visit to the ICDF #1 Cell excavation took place on Thursday, September 20, 2001. Approximately 2 hours were spent at the ICDF site with approximately 30 minutes of that time spent down in the excavation looking at the subsurface sediments currently exposed in the walls of the excavation. Since the level of equipment activity in the excavation remains high, the only time spent in the excavation was during the lunch break by the excavation crew.

Results

The following observations were made during this visit to the ICDF excavation:

1. The current excavation at the time of the visit ranged in depth from an estimated 12 ft deep in the north-central portion of the excavation to estimated 15 ft deep in the northwest and central portions of the excavation. Three excavators were working in various parts of the excavation at the time of the visit.

2. In the northwest corner of the excavation, several 1- to 2-ft thick isolated sections of weakly cemented, moderately sorted sand with fine gravel bed are still visible. The upper beds and pockets consist of coarse to medium-grained sand with 30% to 40% fine to coarse, well rounded to sub-angular gravel to 6-in. size with observed and visually measured dip of 2 degrees to the west. Beds below are 60% to 70% fine to coarse gravel with fine top medium-grained sand. The cemented layer was originally observed during the site visit on August 29, 2001.

3. In the north-central portion of the excavation at 12 to 13 ft bgs, the excavation is also starting to get into a sandy, coarse gravel similar seen in the lower beds noted in #2 above and also gravel was observed in the central portion of the excavation during the September 13th visit. Some larger cobble-sized gravel observed here but not in location #2 above. There was an observed and visually measured dip to the upper gravels of 3 degrees to the west.

4. In the central portion of the excavation at an approximate depth of 15 ft bgs the excavation exposes a fine angular to sub-angular gravel with interbedded fine sand with silt layers. This unit would be located below the gravelly sand unit observed throughout much of the south and central part of the excavation during the September 13th visit to the excavation. Observed and visually measured dip in these gravel with sand/silt interbeds is approximately 3 degrees to the east in the western part to 6 to 8 degrees to the west in the eastern part but the beds appear to have variable dips with some cross bedding of gravels overlying sand units.

5. It appears that the beds exposed in the excavation are gravels and sands of a possible paleo-braided stream channel origin with variable amounts of gravel and sand content with variable size gravels with variable degrees of rounding.

6. During this visit it appeared that the gravel/sand beds exposed in the middle of the excavation dip to the west and then become flatter to slightly eastward dipping near the western edge of the excavation. The beds appear to dip more steeply in the eastern portion of the excavation than in the western portion.

Summary of Field Observation

Based on the results of this visit, other than the cemented sand with gravel bed that was noted during the August 29, 2001, visit and observed again during this visit in the northwest corner of the excavation, there were no areas of unusual or anomalous geologic and sedimentary features observed in the excavation.

Submitted September 27, 2001

B-1.2.4 Visit on September 27, 2001

Objective

The objective of this work is for a qualified geologist to regularly examine sediments exposed during excavation of the ICDF Cell #1 to confirm previous geotechnical work. The work was also to visually correlate geologic and depositional environments to previous geotechnical borings and establish the geologic framework of the excavated sediments prior to the installation of the landfill liners.

Detail of Site Visit

The fourth visit to the ICDF #1 Cell excavation took place on Thursday, September 27, 2001. Approximately 2 hours were spent at the ICDF site with approximately 30 minutes of that time spent down in the excavation looking at the subsurface sediments currently exposed in the walls of the excavation. Since the level of equipment activity in the excavation continues to be high, the only time spent in the excavation was during the lunch break by the excavation crew.

Results

The following observations were made during this visit to the ICDF excavation:

1. The current excavation at the time of this visit ranged in depth from an estimated 15 ft deep in the north-central portion of the excavation to an estimated 18 ft deep in the northwest portions of the excavation. Three excavators were working in various parts of the excavation at the time of this visit.

2. The south wall of the excavation now exhibits sandy gravel beds with minor clay in the sand unit. This unit extends to the southwest corner of the excavation where it becomes a 3-ft-thick sandy lense with gravel with rough bedding at an observed and visually measured dip of 6 degrees to the north.

3. In the eastern portion of the south wall of the excavation, there is a sandy gravel exposed with more rounded gravel (to cobble size) with fine to coarse-grained sand. There is more gravel and less sand then observed during previous visits to this portion of the excavation. The current observed unit would be below the gravelly sand unit described in the September 13th visit report.

4. In the east central portion of the excavation at an approximate depth of 15 to 16 ft bgs, the excavation exposes sandy gravel beds with an observed and visually measured dip to the west of 5 to 15 degrees.

5. In the west central portion of the excavation at a depth of approximately 18 ft bgs, alternating layers of fine gravel with fine to coarse sand were observed. The alternating layers are from 6 in. to 1 ft thick and have an observed and visually measured dip to the west of 3 degrees.

6. In a newly exposed area of the excavation in the northwest corner near the north wall, the exposure appears sandier with fine to coarse, well-rounded gravels. This unit appears different from the sandy gravel units above since there is more fine gravel and a higher degree of rounding to the gravel. This may be the first exposure of a different, lower, more finely grained section. This area will be examined further and this unit will be looked for in other parts of the excavation during the next visit to the excavation next week.

Summary of Field Observation

Based on the results of this visit there were no areas of unusual or anomalous geologic and sedimentary features observed in the excavation.

Submitted September 27, 2001

B-1.2.5 Visit on October 5, 2001

Objective

The objective of this work is for a qualified geologist to regularly examine sediments exposed during excavation of the ICDF Cell #1 to confirm previous geotechnical work. The work was also to visually correlate geologic and depositional environments to previous geotechnical borings and establish the geologic framework of the excavated sediments prior to the installation of the landfill liners.

Detail of Site Visit

The fifth visit to the ICDF #1 Cell excavation took place on Thursday, October 4, 2001. Approximately 2 hours were spent at the ICDF site with approximately 30 minutes of that time spent down in the excavation looking at the subsurface sediments currently exposed in the walls of the excavation. Since the level of equipment activity in the excavation continues to be high, the only time spent in the excavation was during the lunch break by the excavation crew.

Results

The following observations were made during this visit to the ICDF excavation:

1. According to discussions with the on-site staff, the current excavation at the time of this visit ranged in depth from an estimated 20 ft deep in the northeast portion of the excavation to an estimated 25 ft deep in the southern half of the excavation. Three excavators were working in various parts of the excavation at the time of this visit.

2. The crew is also currently using material removed from the excavation to build up the berms around the excavation. At the time of this visit, the berm is approximately 3 ft above the normal ground surface

3. The excavation is currently working on removing material in the south central portion of the excavation. The majority of the gravels and sands exposed for examination during this visit are exposed around this south central portion of the excavation.

4. The overall material exposed in this south central cut is coarse gravels with 1-ft-thick beds of medium to coarse sand alternating with thinner (6 in. thick) beds of fine gravel with sand to sand.

5. In the southwest corner of the south central cut is exposed are several 1-ft-thick beds of fine to coarse-grained sand in cross-cutting relationships with general overall observed and visually measured dip of 5 degrees to the east.

6. On the north side of the central cut is exposed a series of beds dipping at various angles across the face of the cut in an east to west direction for approximately 300 ft, the following sequence was observed:

    a. At the eastern end of the cut are sandy gravel beds dipping westward at an observed and visually measured dips of 4 to 5 degrees and then increases to 6 degrees.

    b. Further east, the observed and visually measured dip of the sandy gravel beds increases to approximately 10 degrees to the east and then gradually flattens.

    c. In the middle portion of the cut are thin (6 in. thick) flat-laying beds of fine, well-rounded gravel with coarse-grained sand.

    d. In the eastern end of the cut are 6 in.-to-1-ft thick beds of coarse gravels with medium to coarse-grained sand.

7. The above-described section appears to be a cross-section across a shallow paleo-channel or series of paleo-channels from previous older stream/river deposition that may be similar to a braided stream channel sequence.

Summary of Field Observation

Based on the results of this visit, other than noted in the descriptions above, there were no areas of unusual or anomalous geologic and sedimentary features observed in the excavation.

Submitted October 11, 2001

B-1.2.6 Visit on October 10, 2001

Objective

The objective of this work is for a qualified geologist to regularly examine sediments exposed during excavation of the ICDF Cell #1 to confirm previous geotechnical work. The work was also to visually correlate geologic and depositional environments to previous geotechnical borings and establish the geologic framework of the excavated sediments prior to the installation of the landfill liners.

Detail of Site Visit

The sixth visit to the ICDF #1 Cell excavation took place on Wednesday, October 10, 2001. Approximately 2 hours were spent at the ICDF site with approximately 30 minutes of that time spent down in the excavation looking at the subsurface sediments currently exposed in the walls of the excavation. Since the level of equipment activity in the excavation continues to be high, the only time spent in the excavation was during the lunch break by the excavation crew.

Results

The following observations were made during this visit to the ICDF excavation:

1. The current excavation at the time of this visit was estimated to range in depth below the normal ground surface from an estimated 25 ft deep in the northwest portion of the excavation to an estimated 28 ft deep in the southeastern and northeastern portions of the excavation where the active excavation was currently taking place. Two excavators and one bulldozer plus associated trucks were working in various parts of the excavation at the time of this visit.

2. The crew continues to remove material from the excavation to build up the berms around the excavation. At the time of this visit, the berm on the north side is approximately 2 to 3 ft above the normal ground surface while the berm on the southwest side is approximately 4 ft above the normal ground surface.

3. The excavation is currently working on removing material in the northeast, east central, and southeast portions of the excavation. The majority of the gravels and sands exposed for examination during this visit are exposed in the cuts in this material.

4. The overall material exposed in the cuts are alternating sequences of coarse gravels with 1- to 3-ft-thick beds of medium to coarse sand alternating with thinner (6 in. thick) beds of fine gravel with sand to sand with gravel beds.

5. In the southeast excavation cuts are exposed a series of alternating beds that may represent a filled, cross cutting paleo-channel with interbedded sands and gravels. The sequence along the cut going from east to west over a distance of approximately 300 to 400 ft is as follows:

    a. At the eastern end of the cut are coarse-grained unconsolidated sand beds that appear to be filling a paleo-channel. The sand bed is overlain and underlain by cross cutting interbedded units of fine to coarse gravel and fine to coarse-grained sand lenses. The eastern limb of this channel has an observed and visually measured dip to the west of 15 degrees.

    b. Further to the east by approximately 100 ft are thin (6 in.) to thick (3 ft) beds of coarse to fine gravels with interbedded sand lenses 6 in. to 2 ft thick. Observed and visually measured dips vary across this 20-ft-long cut from 10 degrees to the west on the eastern end to 16 degrees to the east on the western end.

    c. Approximately 50 to 100 ft to the west, the observed and visually measured dip decreases to 4 degrees to the east.

    d. At the western end of the cut are exposed thin (6 in. to 1 ft) beds of fine gravel mixed with alternating 1- to 2-ft-thick beds of beds of coarse gravel with sand. Beds are level to gently westward dipping at an observed and visually measured angle of 4 degrees.

6. At the very bottom of the current cuts at depths of approximately 28 ft below the normal ground surface, there appear to be an increased amount of sand with some clay being excavated. This will be checked during the next site visit next week.

Summary of Field Observation

Based on the results of this visit, other than the geologic observations noted in the discussions above, there were no areas of unusual or anomalous geologic and sedimentary features observed in the excavation.

Submitted October 11, 2001

B-1.2.7 Visit on October 18, 2001

Objective

The objective of this work is for a qualified geologist to regularly examine sediments exposed during excavation of the ICDF Cell #1 to confirm previous geotechnical work. The work was also to visually correlate geologic and depositional environments to previous geotechnical borings and establish the geologic framework of the excavated sediments prior to the installation of the landfill liners.

Detail of Site Visit

The seventh visit to the ICDF #1 Cell excavation took place on Thursday, October 18, 2001. Approximately 2 hours were spent at the ICDF site with approximately 30 minutes of that time spent down in the excavation looking at the subsurface sediments currently exposed in the walls of the excavation. Since the level of equipment activity in the excavation continues to be high, the only time spent in the excavation was during the lunch break by the excavation crew. Digital photographs were taken during this site visit.

Results

The following observations were made during this visit to the ICDF excavation:

1. The current excavation at the time of this visit was estimated to range in depth below the normal ground surface from an estimated 28–30 ft deep. Three excavators and one bulldozer plus associated trucks were working in various parts of the excavation at the time of this visit.

2. The crew continues to remove material from the excavation to build up the berms around the excavation. At the time of this visit, the berm on the northeast corner is approximately 5-6 ft above the normal ground surface while the berm on the northwest corner is approximately 4-5 ft above the normal ground surface.

3. The active excavation was currently taking place in the northeast corner, the north central and western sections of the excavation. The majority of the gravels and sands exposed for examination during this visit are exposed in the cuts in these areas.

4. In the north central part of the excavation cuts are exposed a series of thin (6-in.-thick) alternating beds of fine to coarse gravels with fine to coarse-grained sand with minor silts and clays. The beds have an observed and visually measured dip of 6 degrees to the north.

5. In the northwest corner of the excavation are a series of mixed, crudely bedded fine to coarse gravels with sand that are moist near the bottom of the cut. In the southern portion of this cut are exposed two 1- to 2-ft-thick beds of medium to coarse-grained sand with minor fine gravels (<10% gravel) that are moist. The sand beds appear to be cutoff to the north by the gravels beds but only a small section of the sand is exposed and the beds cannot be followed anywhere.

6. In the northeast corner of the excavation are cuts that expose thin-bedded fine to coarse gravels with fine to coarse sands. The overall section has an observed and visually measured dip to the west of 5 degrees. At the bottom of this cut there is increased clay content in the sand/gravel mix and the sediments are moist.

Summary of Field Observation

Based on the results of this visit, other than the geologic observations noted in the discussions above, there were no areas of unusual or anomalous geologic and sedimentary features observed in the excavation.

Submitted October 25, 2001

B-1.2.8 Visit on October 22, 2001

Objective

The objective of this work is for a qualified geologist to regularly examine sediments exposed during excavation of the ICDF Cell #1 to confirm previous geotechnical work. The work was also to visually correlate geologic and depositional environments to previous geotechnical borings and establish the geologic framework of the excavated sediments prior to the installation of the landfill liners.

Detail of Site Visit

The eighth visit to the ICDF #1 Cell excavation took place on Monday, October 22, 2001. This was an unscheduled visit that resulted from a call from the ICDF site crew about possible clay beds being encountered in the bottom of the excavation. A trip out to the site took place on short notice and approximately 2 hours were spent at the ICDF site with approximately 30 minutes of that time spent down in the excavation looking at the subsurface sediments currently exposed in the walls of the excavation. Since the level of equipment activity in the excavation continues to be high, the only time spent in the excavation was during the lunch break by the excavation crew. Also present in the bottom of the excavation to look at the clay beds were Larry McManamon and Chris Duncan, both from BBWI. Digital photographs were taken during this site visit.

Results

The following observations were made during this visit to the ICDF excavation:

1. The current excavation at the time of this visit was estimated to range in depth below the normal ground surface from an estimated 33–35 ft deep. It appears that the southern portion of the excavation is at or close to final grade. Three excavators and one bulldozer plus associated trucks were working in various parts of the excavation at the time of this visit.

2. The crew continues to remove material from the excavation to build up the berms around the excavation or the excavated material is being hauled to the soil storage pile south of the ICDF excavation.

3. The active excavation was currently taking place in the northeast corner, the north central and western sections of the excavation. The majority of the gravels, sands, silt and clays exposed for examination during this visit are exposed in the cuts in these areas.

4. In the north central part of the excavation exposed in the bottom of the cut are exposures of reddish-brown silty clay. The silty clay has minor (<10%) fine-grained sand and the material exposed is dry to moist.

5. In the northeast corner of the excavation addition exposures of the silty clay observed in #4 above were also observed. In this area, the silty clays appear to be overlain by a medium to coarse-grained sand that contains approximately 10-15% small pebble-sized pieces of quartz and shale. This sequence of silty clay and overlying sand beds were observed in three locations in this northeast corner.

6. In the northcentral portion of the excavation is a 2-ft-high cut that exposes medium to coarse-grained sands that are well-sorted with very little (<5%) fine gravel. This appears to be a very clean sand and is moist at the bottom of the cut.

Summary of Field Observation

The well sorted sand beds and the silty clay beds observed during this site visit may represent the uppermost part of what is called the "older alluvium". This "older alluvium" is commonly located immediately above the bedrock basalts in the area of the ICDF.

Based on the results of this visit, other than noted in the discussions above. there were no areas of unusual or anomalous geologic and sedimentary features observed in the excavation.

Submitted October 25, 2001

B-1.2.9 Visit on October 25, 2001

Objective

The objective of this work is for a qualified geologist to regularly examine sediments exposed during excavation of the ICDF Cell #1 to confirm previous geotechnical work. The work was also to visually correlate geologic and depositional environments to previous geotechnical borings and establish the geologic framework of the excavated sediments prior to the installation of the landfill liners.

Detail of Site Visit

The ninth visit to the ICDF #1 Cell excavation took place on Thursday, October 25, 2001. Approximately 2 hours was spent at the ICDF site with approximately 30 minutes of that time spent down in the excavation looking at the subsurface sediments currently exposed in the walls of the excavation. The level of equipment activity in the excavation continues to be high, the only time spent in the excavation was during the lunch break by the excavation crew. Digital photographs were taken during this site visit.

Results

The following observations were made during this visit to the ICDF excavation:

1. According to Site personnel, the bottom ICDF excavation is at final grade. Only the corners below previous temporary excavation access roads are now being removed from the pit. Two excavators and one bulldozer plus associated trucks were working in the excavation at the time of this visit.

2. The crew continues to remove material from the excavation to build up the berms around the excavation or the excavated material is being hauled to the soil storage pile south of the ICDF excavation.

3. The active excavation was currently taking place in the north central, southwest and southeast corner portions of the excavation. The majority of the gravels, sands, silt and clays exposed for examination during this visit are exposed in the cuts in these areas.

4. In the north central part of the excavation is a cut approximately 3 ft high that exposes a series of (from top to bottom of the cut) thin to poorly bedded fine to coarse gravel with sand and minor silts and clay; grades downward to medium to coarse-grained sand with sub-angular, well-rounded gravel; grades downward to moist reddish-brown silty clay. The silty clay is visible throughout the floor of the excavation in this area, and exposed in the floor throughout the northeast quarter of the excavation.

5. In the southeast corner of the excavation, the area beneath the former temporary access road is being excavated. This excavation exposes thick bedded, fine to coarse gravels with moist interbedded and cross-bedded sandy gravel beds that are level to gently dipping to the west with an observed and visually measured dip of 2 to 3 degrees.

6. Along the south central wall of the excavation is exposed an approximately 1-ft-thick prominent moist gravelly sand bed that is visible about 2 ft above the bottom of the excavation. This bed appears to be fairly continuous along this wall for at least several hundred feet and may be the same sand being exposed in the current excavation below the temporary access road being removed in the southwest corner of the excavation.

7. Also exposed in the southwest corner of the excavation beneath the temporary access road are sands and gravel that appear to be similar to the gravel with sands exposed above the silty clay beds noted in #4 above.

Summary of Field Observation

The well sorted sand beds and the silty clay beds observed during this site visit may represent the uppermost part of what is called the "older alluvium". This "older alluvium" is commonly the unit located immediately above the bedrock basalts in the area of the ICDF.

Based on the results of this visit, other than noted in the discussions above, there were no areas of unusual or anomalous geologic and sedimentary features observed in the excavation.

Submitted October 30, 2001

B-2. GEOTECHNICAL DATA

B-2.1 Summary of the ICDF Pit Grade to Bedrock Interface Boreholes

By Gregory W. Studley, PG
INEEL Environmental Restoration
November 26, 2001

B-2.1.1 Introduction

This supplemental report summarizes the auger-boring activities started and completed between November 12 to 15, 2001, at the INEEL CERCLA Disposal Facility (ICDF) project. For additional definition of the bedrock interface, sub-pit floor lithology, and correlation with previously applied geotechnical and geophysical investigations, 15 auger borings were completed to the bedrock interface. The borings were more or less evenly distributed across the pit floor (Figure B-6).

B-2.1.2 Work Performed

Fifteen auger-bore holes were completed the week of November 12, 2001, with 126.26 ft total footage drilled. Data were acquired with an Acker auger-rig equipped with 6.5 in. OD, 4.25 in. ID auger flights, utilizing 2.5-ft sample runs with sample integrity maintained by being collected in 2.5-ft Lexan™ tubes. The sample tubes were capped, tapped, logged, and documented by an on-site registered geologist throughout the drilling program. The resulting sample tubes are stored in a cargo storage facility at INTEC until disposition is determined. Upon refusal at the bedrock interface, all boreholes were completed by back-filling with bentonite hole plug. The bentonite hole plug was hydrated as back-filling took place, producing a nonreactive impermeable natural product borehole seal.

Samples of the subsurface lithology were described and documented in logbook number ER-35-00 Environmental Restoration Sample & Core Description Logbook. Below is a summary of the recorded field logs advancing major divisions of the Unified Soil Classification System and Munsell® Color chart. Copies of the actual filed boring logs are attached. A copy of the Unified Soil Classification System designations utilized is also attached as part of Section B-2.3. Figures B-6, B-7, B-8, and B-9 and Table B-1 present boring locations, geotechnical results, bedrock contours, "old alluvium" contours, and thickness of "old alluvium" remaining in the pit after excavation..

ICPP-BOR-S-253 (ID#1766) **DRILLED: 11-13-01**

Southeast corner and first auger bore hole in series along south wall of the ICDF pit.

0-2.5 ft	GM-predominantly silty gravels, gravel-sand mix, dry-slightly moist, probably disturbed/construction material. Fining near bottom and/or increase in fine sand/silt content
2.5-5.0	SM-silty sand, slightly moist, gravel near bottom
5.0-7.5	SM with gravel- sand and silt with gravel up to 20mm, slightly moist; moderate pale brown color- consistent throughout sample run (10 yr 5/4)
7.5-10	Poor recovery; fine sand, silt, clay mix with gravel of diverse sizes, moist to very moist
10-12.5	SM/SC-very fine sand, silt, clay; moist- forms nice ribbon- very pale orange (10 yr 8/2); ashy appearance? Caliche?
12.5-13	SC-refusal at bedrock. interface - basalt chips, wet; clay, silt, sand mix with basalt gravel/rubble. Fines are very light color(10 yr 8/2); T.D. 13.0 ft
13.0 ft	Total Depth

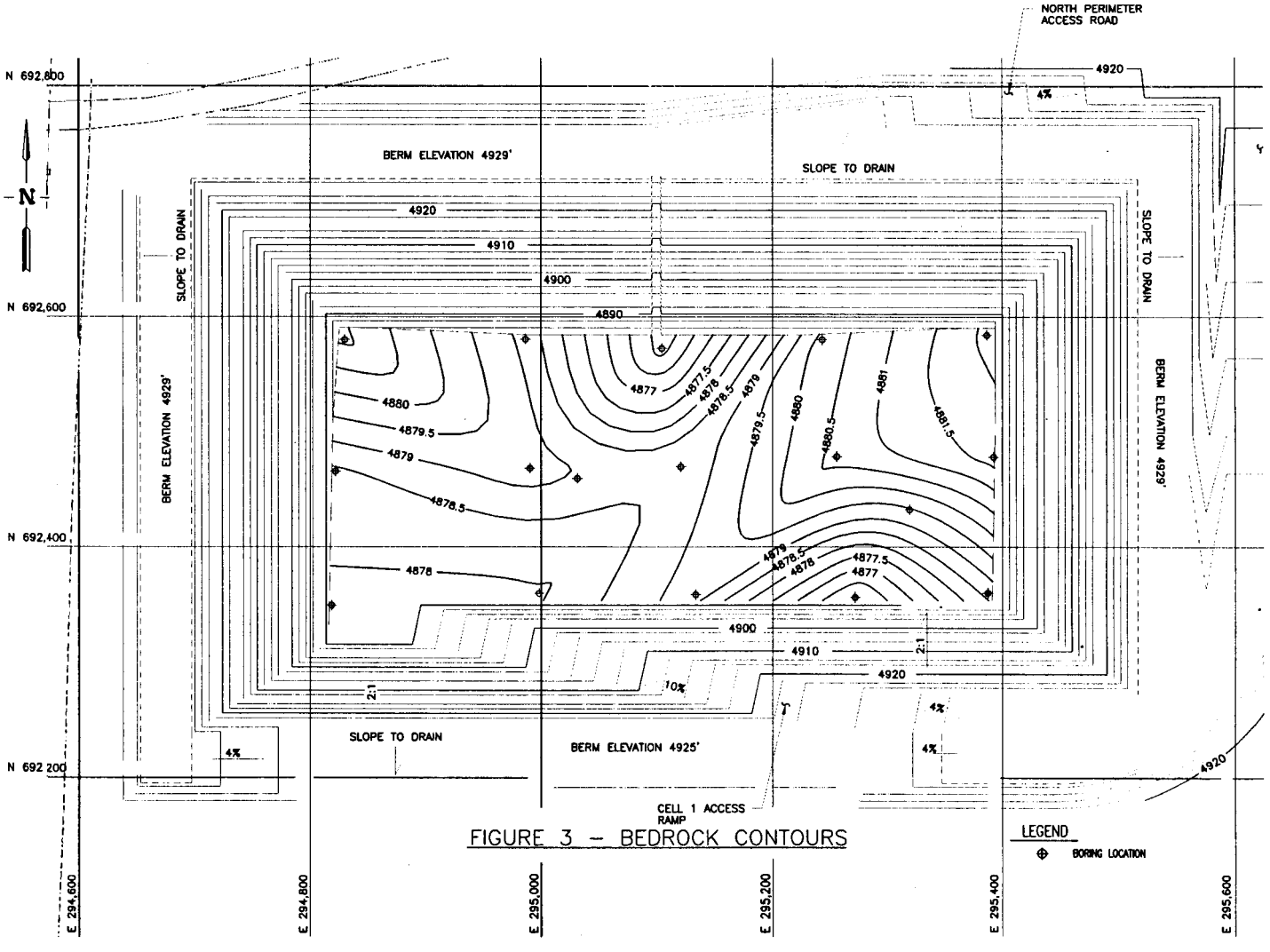


FIGURE 3 – BEDROCK CONTOURS

Figure B-7. Top of bedrock contours.

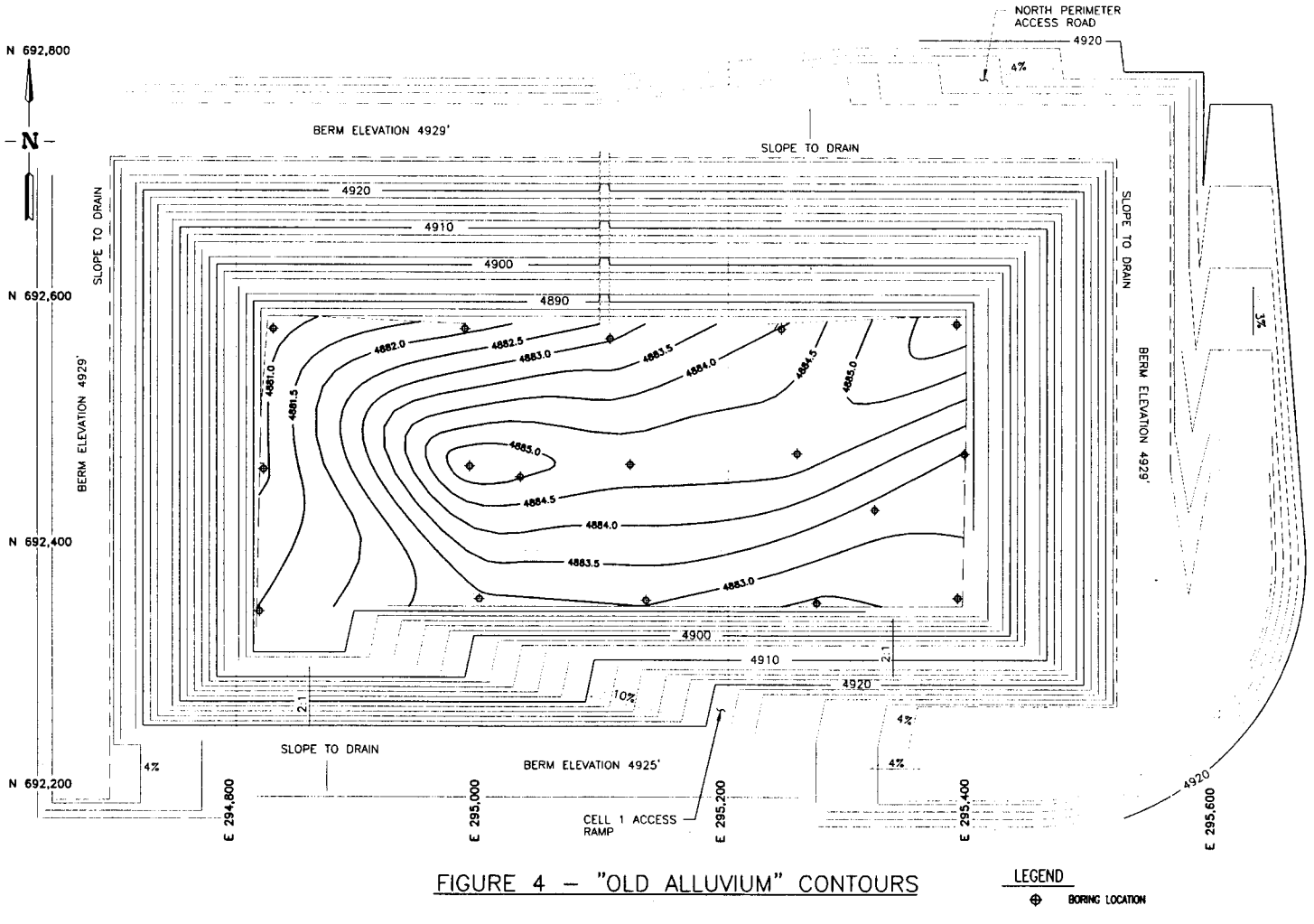


FIGURE 4 – "OLD ALLUVIUM" CONTOURS

LEGEND

⊕ BORING LOCATION

Figure B-8. Top of "Old Alluvium" remaining after pit excavation.

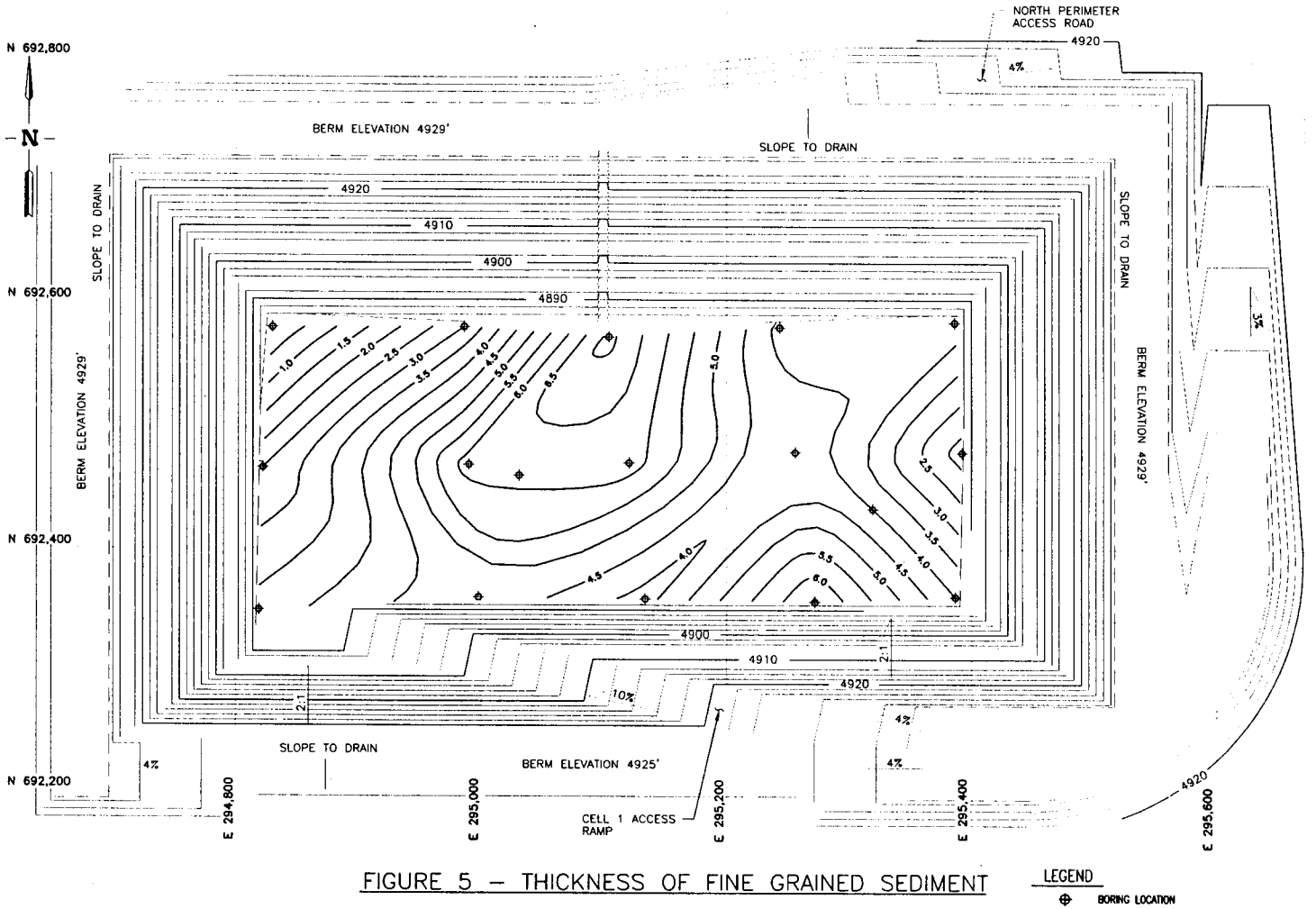


FIGURE 5 – THICKNESS OF FINE GRAINED SEDIMENT

LEGEND

⊕ BORING LOCATION

Figure B-9. Thickness of fine-grained sediment.

Table B-1. ICDF landfill Cell 1 floor geotechnical investigation results.

BORING NAME	WELL ID	Boring Elevation	Boring Depth (ft)	Bedrock Elevation	Fine-grained thickness (ft)	Fine-grained Elevation	Northing	Easting
ICPP-BOR-S-253	1766	4891.65	13.00	4878.65	4.00	4882.65	692360.78	295386.91
ICPP-BOR-S-254	1767	4889.18	13.25	4875.93	6.50	4882.43	692356.94	295271.75
ICPP-BOR-S-255	1768	4887.84	8.56	4879.28	3.80	4883.08	692359.24	295133.51
ICPP-BOR-S-256	1769	4888.33	10.40	4877.93	5.00	4882.93	692360.41	294997.66
ICPP-BOR-S-257	1770	4889.18	11.35	4877.83	3.70	4881.53	692349.96	294818.56
ICPP-BOR-S-258	1771	4888.91	10.50	4878.41	2.50	4880.91	692466.18	294821.98
ICPP-BOR-S-259	1772	4888.25	7.15	4881.10	0.00	4881.10	692580.33	294829.84
ICPP-BOR-S-260	1773	4884.86	6.00	4878.86	3.00	4881.86	692580.78	294986.06
ICPP-BOR-S-261	1774	4886.04	6.75	4879.29	6.25	4885.54	692468.91	294989.82
ICPP-BOR-S-262	1775	4885.30	6.75	4878.55	6.25	4884.80	692470.24	295120.70
ICPP-BOR-S-263	1776	4889.87	8.15	4881.72	1.75	4883.47	692478.82	295392.19
ICPP-BOR-S-264	1777	4887.97	5.85	4882.12	3.85	4885.97	692584.57	295386.09
ICPP-BOR-S-265	1778	4885.28	5.10	4880.18	3.85	4884.03	692580.54	295243.19
ICPP-BOR-S-266	1779	4882.95	7.15	4875.80	7.15	4882.95	692572.77	295104.28
ICPP-BOR-S-267	1780	4887.02	6.35	4880.67	4.15	4884.82	692479.02	295255.82

ICPP-BOR-S-254 (ID#1767) **DRILLED: 11-13-01**

Second auger bore hole in series along south wall of the ICDF pit—116 ft west of #253.

0-2.5 ft GW-disturbed construction material, gravel > 40mm, rapidly fining downward (SM), pale brown (10yr 5/2), slightly moist,

2.5-5.0 SM-silt and sand mix, minor gravel lenses, > silt/clay(?) near bottom of sample run, slightly moist to moist

5.0-7.5 SM/ML-moderate reddish orange brown (10 yr 6/6), moist; forms long ribbon; very fine sand, silt, clay

7.5-10 SC/ML-very fine sand, silt, clay, moderate reddish brown (10 yr 6/6), moist

10-12.5 SC/ML-very fine sand, silt, clay, pale yellow brown (10 yr 6/2); @ 11.3 ft SC/ML grayish pale orange (10 yr 8/2)

12.5-13.25 SC/ML - as above, refusal T.D. @ 13.25 ft, very moist to wet, yellowish brown(10 yr 5/4), basalt in pick-up shoe

13.25 ft Total Depth

ICPP-BOR-S-255 (ID#1768) **DRILLED: 11-14-01**

Third auger bore hole in series along south wall of ICDF pit-139 ft west of #254

0-2.5 ft GW-disturbed construction gravel (?) grading rapidly to SM-silty sand mix, dry-slightly moist; well sorted sand lense beneath construction gravel

2.5-5.0 As above going to SM-mix, darker brown (10 yr 4/2), slight increase in moisture from above, with minor gravel lense(s) (some clasts greater 20mm. @ bottom of run; moist, very fine sand/silt, dark yellowish brown (10 yr 6/6)

5.0-7.5 SC/SM-dark yellowish brown (10 yr 6/6), moist, fining downward (?) to ML(?)-very fine sand, silt, clay

7.5-8.56 Gravel lense (0.5 ft) (?) then SC/SM-very fine sand/silt/clay (?), dark yellow orange (10 yr 6/6); then grading to SC/ML- very pale orange (10 yr 8/2); as above with increase in clay element, very moist, 0.3 ft thick; refusal -T.D.@ 8.56 ft; basalt rubble (N3) dark grey color, with above mix; very moist. Very fine sand, slit, clay mix, (10 yr 8/2), has an ash appearance (?) as well as; caliche aspects; if CaCO then likely caliche.

8.56 ft Total Depth

ICPP-BOR-S-256 (ID#1769) **DRILLED : 11-14-01**

Fourth auger bore hole in series along south wall of ICDF pit—137 ft west of #255

0-2.5 ft GW-GM-.5 ft disturbed/construction pit grade gravel then gravel/sand mix, some clasts greater 40mm, fining downward with increase in sand content, moderate brown/dark yellow brown color (5 yr 4/4-10 yr 4/4), dry to slightly moist

2.5-5.0 GM-as above, silt, sand, gravel mix, slight increase in moisture (?), dark yellowish brown (10 yr 4/2); @ 4 ft SC-silty sand with only minor gravel element (?)

5.0-7.5 SM (?)- moist, yellowish brown (10yr 6/6), fining into SC/SM/ML(?)-fine sand, silt, clay, moist, greater 50% fines; forms wet sticky ribbon, moist to wet at 7.5 ft

7.5-10.4 SC/SM/ML-as above, increase in sand content near bottom of sample run, color becoming lighter w/ N8 grey mix; T.D. @ 10.4 ft, basalt rubble, refusal with very thin whitish clay layer on dark basalt rubble/clay mix. Note: light colored (whitish) clay (?) layer on top of bedrock interface is very thin (<0.2 ft) appears same as previously mentioned ash/caliche looking unit. Could be playa/lacustrine unit (clay element) on undulating surface-erosion/deposition which causes variable thickness and leaching-bleaching aspect of caliche formation

10.4 ft Total Depth

ICPP-BOR-S-257 (ID#1770) **DRILLED: 11-14-01**

Southwest corner and fifth auger bore hole in series along south wall of ICDF pit and first in series along west wall—181 ft west of #256.

0-2.5 ft Construction fill/disturbed gravel (GW gravel greater 50mm) mix top 1 ft grades rapidly to a silty sandy gravel mix-GM/SM-dry-slightly moist, pale brown (5 yr 5/2), increase sand content @ bottom of run, sand lense?

2.5-5.0 GM-silt, sand, gravel mix, moderate brown (10 yr 5/4/10 yr 4/4/), dry to slightly moist; SM-sand lense at lower part of sample run, very fine sand /silt mix, moist, yellowish orange brown color (10 yr 6/6/);increase sand @ bottom of sample run

5.0-7.5 SM-silty sand, grayish in color (5 yr 3/2), dry to slightly moist, grading to a well-sorted sand lense, SW-light brownish grey (5 yr 6/1), dry, very fine to fine grained, approximately 2 ft thick

7.5-10 As above, top 0.4 ft grading to SC/SM-very fine sand, silt, clay mix rest of sample run SC/SM/ML (?) mix, moist, yellowish orange brown (10yr 6/6), increase clay element (?) increase sand @ bottom of sample run with clay, SC-silty sand with silt & clay stringers, slightly moist. Note: no lexan tube in barrel-had to dump sample after logging

10-11.35 SM-silty sand, fine-grained (sand lense?) slightly moist with clay stringers. Refusal-basalt rubble-T.D.@ 11.35 ft; bedrock interface.

11.35 ft Total Depth

ICPP-BOR-S-258 (ID#1771) **DRILLED: 11-14-01**

Second auger borehole in series along west wall of ICDF pit—117 ft north of #257

0-2.5 ft GW-construction gravel (?), greater 50mm; flattened gravel-indication of imbrication (?);GM-gravel sand, silt mix with sand stringers, dry- slightly moist, light brownish grey (5yr 6/1); fine to medium grained sand, overall 20% fines (?)

2.5-5.0 As above GM; 3.5-4.5 ft sand lense, SW- light brownish grey (5yr 6/1), well sorted fine-medium grained, dry-slightly moist, fining downward to very silty, very fine sand, SM-brown chroma (10 yr 5/4), slightly moist, with clay element (?) at bottom

5.0-7.5 As above but rapidly changes to sand/gravel mix (GM) lense then to SM (?) sand with little to no fines SW(?) then back into gravel, sand, silt mix; fine grained stringers at bottom of run

7.5-10.4 As above to 8.4 ft; SC/SM/ML (?)-slightly moist, very fine sand-silt-with clay(?) element, moderate brown (5 yr 4/4); sample run predominately silty sand with clay/silt as stringers; @10.5 ft/ refusal/T.D. pick up shoe-sandy basalt gravel on basalt rubble, dry to slightly moist

10.5 ft Total Depth

ICPP-BOR-S-259 (ID# 1772) **DRILLED: 11-14-01**

Northwest corner and third auger borehole in series along west wall of ICDF pit, first in series along north wall—115 ft north of #258

0-2.5 ft Construction gravel/disturbed alluvial material; GW-GM increasing sand content toward middle of sample run; sand lense at approximately 3 ft, well sorted, dry-slightly moist, moderate yellowish brown (10 yr 5/4), grading rapidly downward to GM then to SM mix; at bottom of sample run-silty sand

2.5-5.0 As above; at 3.5 ft, SC/SM-silty sand with clay (?), moist, grading into very fine to fine sand, SW-nicely sorted, at bottom of sample run, moderate yellow brown (10 yr 5/4)

5.0-7.15 As above, at 5 ft gravel lense, rapidly into SW-sand lense, well sorted, .8-1 ft thick, dry-slightly moist, pale yellowish brown (10 yr 6/2), fine-medium grained; grading into SM-very silty sand, only slightly moist, yellowish brown (10 yr 5/4); no clay layer (?). T.D./refusal @ 7.15 ft; pick up shoe, basalt rubble

7.15 ft Total Depth

ICPP-BOR-S-260 (ID#1773) **DRILLED: 11-14-01**

Second auger borehole in series along north wall of ICDF pit—157 ft east of #259

0-2.5 ft Disturbed/construction/GW-GW (?); at 1.3 ft SW/SM fining downward to SM-silty sand, slightly moist to moist, yellowish orange-brown (10 yr 6/6); possibly ML-clay stringer at bottom of run

2.5-5.0 GM-silty gravel/sand mix; at 3.8 ft SM-silty, very fine sand, moist, yellowish brown (10 yr 5/4); increasing fines (> 50%) SM/ML (?) if clay content near bottom of run, definite silt increase

5.0-6.0 SM-silty sand lense with increasing (noticeable) clay, moist; 5.4 ft -5.8 ft ML-clay, moist (10 yr 8/2) (clay-caliche-ash (?)) layer mixed with basalt gravel/rubble; at 6.0 ft refusal-T.D.-basalt rubble. Note: clay-ashy appearing-layer possible leached/bleached

caliche/CaCo3 hardened formational deposit of playB-lacustrine depositional environment

6.0 ft Total Depth

ICPP-BOR-S-261 (ID#1774) **DRILLED: 11-14-01**

Auger borehole/west-central part of ICDF pit—114 ft south of #260

0-2.5 ft GM-gravel, sand, silt mix, thin layer, approximately .5ft; SM-silt/fine grained sand mix grading to SC/SM/ML (?), moist; at bottom of sample run .5ft lense-silty/very fine sand with clay, (SC/ML)

2.5-5.0 As above: SC/ML-silty sand-clay

5.0-6.75 As above-same depositional unit; SC/ML-very moist, silt/clay/very fine sand mix; at 6.75 ft, T.D.-refusal-bedrock interface, basalt rubble mix with very moist, silt-clay-very fine sand mix, ML (?)-yellowish brown (10yr 5/4);no recognizable ashy-looking caliche (?) layer

6.75 ft Total Depth

ICPP-BOR-S-262 (ID# 1775) **DRILLED: 11-14-01**

Auger borehole in center of ICDF pit floor—133 ft east of #261

0-2.5 ft SM-silty very fine-fine sand, dry to slightly moist, moderate yellowish brown (10 yr 5/2); unit has minor gravel lenses (?); at 1.5 ft SC/SM/ML-moist, predominately greater than 50% fines, moderate yellowish brown (10 yr 5/4); forms well developed ribbon

2.5-5.0 As above; clay lense at 4.0 ft; increase in sand content/less silt (?) SC

5.0-6.75 SC/SM/ML-mix, moist, fine sand/silt/clay (?), moderate yellowish brown (10 yr 5/4); white-ashy appearing (?) chips in pick up shoe; very thin, caliche (?)-clay/very fine sand on basalt-bedrock-T.D./refusal at 6.75 ft. Caliche (?)zone-bleached, leached relict topography possibly playa environment—doubtful overbank- on undulating surface of basalt

6.75 ft Total Depth

ICPP-BOR-S-263 (ID#1776) **DRILLED: 11-15-01**

Auger borehole center of east wall of ICDF pit

0-2.5 ft GW-construction gravel at very top then GM-predominately sand/silt/ gravel mix-borderline GM/SM-dry-slightly moist, pale brown (5 yr 5/2), medium grained sand with silt mix, less than 25% fines; grains appear nicely sorted –all the same size –subrounded to -subangular grains

2.5-5.0 As above; darker in color/increase in moisture (?) (5 yr 4/4), 25-35% fines (?), well sorted

5.0-7.5 As above, slightly moist to moist; at 6.1ft SC/SM/ML (?)-very silty fine sand with clay element, slightly moist-moist, moderate yellowish brown (10 yr 5/4); sand is very fine to – fine grained, well sorted, greater than 50% fines-forms rough ribbon

7.5-8.15 As above; at 7.9 ft SC/ML-light color (10 yr 8/2), moist, very fine sand/clay; sand/clay unit rests on bedrock interface-basalt; at 8.15 ft—refusal-T.D

8.15 ft Total Depth

ICPP-BOR-S-264 (ID#1777) **DRILLED: 11-15-01**

Northeast corner and third auger borehole in series along north wall of ICDF pit—107 ft north of #263

0-2.5 ft GM-gravel, sand, silt, mix, slightly moist, moderate brown (10 yr 4/2); grading rapidly downward to SM-slightly moist, fine to –medium-grained sand, moderate yellowish brown (10 yr 5/4); section has gravel stringers

2.5-5.85 As above; at 4.3 ft SM- silty sand, slightly moist, yellowish orange-brown (10 yr 6/6), moderately well sorted with subrounded to subangular grains, 25% fines; forms short broken ribbon. Note: sample integrity for acquisition compromised-recovery 2.2 feet out of 2.5 foot run; however, refusal/bedrock at 5.85 ft. logged only bottom .85ft of sample run. At approximately 5.4 ft SM/ML-whitish caliche-ashy appearing color (10 yr 8/2), very fine sand/clay layer-caliche(?) formation environment (?) on bedrock interface-refusal-T.D. 5.85ft

5.85 ft Total Depth

ICPP-BOR-S-265 (ID#1778) **DRILLED: 11-15-01**

Fourth auger borehole in series along north wall of ICDF pit—145 ft west of #264

0-2.5 ft GM/SM-predominately very fine sand with gravel, 25% fines (?), dry, moderate yellowish brown (10 yr 5/4), nicely sorted, subrounded grains; at 1.5 ft SM-silty sand, slightly moist-moist, yellowish orange (10 yr 6/1), forms well developed-long ribbon (clay element)

2.5-5.1 Sandy gravel lense 2.5-3.0 ft; (possible slough from above?) at 3.0 ft SM-silty very fine sand, slightly moist-moist with silt/clay stringers, moderate yellowish brown (10 yr 5/4). At 4.1 ft SC/ML- yellowish grey color (5 yr 7/2 to 10 yr 8/2), slightly moist to moist, very fine grained sand/silt/clay-ash/caliche unit? Sample run is downward fining sequence. Refusal-T.D. at 5.1 ft—bedrock interface/basalt

5.1 ft Total Depth

ICPP-BOR-S-266 (ID#1779) **DRILLED: 11-15-01**

Auger borehole at center of north wall/sump of ICDF pit—140 ft west of #265

0-2.5 ft SW/SM- dry, fine-grained, well sorted, subrounded to subangular, pale brown (5 yr 5/2). At 2.1 ft increase in silt content with possible clay element (SM/SC/ML?), slight moist, lighter color (10 yr 6/2), very fine sand-silt unit

2.5-5.0 ML (?)-grayish orange brown (10 yr 7/2), greater than 50% fines, very fine sand-silt, slightly moist to moist, clay element (?) appearing as fines, sample run has lighter color(10 yr 6/2); streaks at bottom of sample run, forms rough ribbon

5.0-7.15 As above; at 6.4 ft ML-clay, very light color (10 yr 8/2), ashy appearing-caliche(?)/clay unit, leached/bleached (?) relict topography (?), darker streaks last 0.4 ft, basalt/clay mix (basalt element in fines); refusal-T.D. at 7.15 ft/no recovery in pick up shoe

7.15 ft Total Depth

ICPP-BOR-S-267 (ID#1780) **DRILLED: 11-15-01**

Final borehole in ICDF pit—103 ft south southeast of #265

0-2.5 ft GM/SM mix, grading/fining downward to SM mix with gravel stringers, slightly moist-moist, pale brown (5 yr 5/2), fine to –medium-grained sand, less than 25% fines? Increase in silt content near bottom of sample run,

2.5-5.0 As above; at 2.9 ft SC/ML-very fine grained sand/silt with clay element (?), greater than 50% fines, slightly moist, forms nice ribbon but can feel grains, well sorted sand-silt size, moderate yellowish brown (10 yr 5/4)

5.0-6.35 GM-basalt gravel lense (?) SC/SM/ML-slightly moist, streaky color (grain size?), predominately SM with whitish layer right on top of bedrock. Refusal-T.D. at 6.35 ft. Note: no real identification on caliche-ashy looking layer, could be absent? Definite grain size increase at bedrock interface; fine to medium grained sand in pick up shoe.

6.35 ft Total Depth

B-2.1.3 Summary

Cursory observation of the ICDF pit walls leads to an interpretation of an alluvial paleo-braided stream environment of deposition; however, external, as well as internal, criteria are subtle and would require a definitive investigation. Braiding commonly results where partially incompetent streams form longitudinal bars by depositing coarse elements of bed load which trap finer elements, which were exhibited in certain areas of the pit wall and as indicated by the poorly sorted-imbricated look. Also, transverse bars formed of better-sorted sediment are tabular and wedge-shaped. They may either be the only depositional form or may be deposited on downstream ends of longitudinal bars, thus, the better sorted "sand lenses" observed offset and/or juxtaposed to the poorly sorted appearing units traversing across the central north-south area of the ICDF pit walls.

The above observation is in contrast to the pit floor and predominantly represented in the lithology of the auger bore holes comprised of finer grained textures with appreciable amount of fines consisting of

fine grained sands, silts, and clay which indicate a different environment of deposition. Playa or inland lake environments of deposition exhibit similar lithology. This transition from alluvial systems to inland lake environments is readily observed in modern intramontane basins.

Inland playas are usually dried-up, vegetation-free, flat-floored areas composed of evenly stratified sheets of fine grained sand, silt, and clays; representing the bottom part of shallow, completely closed or undrained, desert lake basins in which water accumulates (as after a rain) and quickly evaporated, usually leaving deposits of soluble salts. It may be hard or soft, and smooth or rough. This environment is also prone to the development of caliche-which can be represented by gravel, rock, soil or alluvium cemented with soluble nitrate salts and calcium carbonate hardening.

The interpreted transition from braided stream to playa is represented in almost all of the auger bore holes-coarse, poorly sorted, gravel, sand, and silts to well sorted fined grained sand, silts and clays. This interpreted transition can be observed in the ICDF pit walls and pit floor-especially in the sump area.

The whitish very fine grained sand/clay layer observed in several of the auger bore holes at the basalt-bedrock interface may be representative of a bleached/leached relict regolith with the subsequent formation of caliche.

B-2.2 Drilling Core Logs

FORM EG&G-3026
(Rev. 05-88)

Page 1 of 2

DRILLING CORE LOG

Date: 11-13-01 Borehole: ICPP-BOR-5-253

Geologist: Hehn/Smolsky Sample No.:

Core Length: 2.5' (ft.) Cored Interval: Pitgrade 0' ICDF Top

Bottom

Depth Below Land Surface (ft.)	Core #	Core Diagram	Recovery (ft)	Description
PG 0 – 1025	1	GC-/GM	1.7	Gravel, sand, silt — construction fill; > fines 50%, 10YR 5/4, SL moist-dry; gravels sub rounded - sub angular; Note: Near bottom of run appear to be out of construction fill? GM/GC, 5YR 5/4 < gravel > sand/silt > 50 sand fn-med, 15% gravel
2.5 – 1027, 1035	2	SP-SM	2.1	SP-SM: silty sand, minor gravel < 20% fines; SL > moist. SL darker 10YR 5/4 - 10YR 4/3; sands sub round - sub angular; > gravel near bottom
5.0 – 1037, 1049, 1051	3		2.2	SP from SM; sand, silt (20%) gravel; gravel up 20 mm; sand/silt SL moist; < fine in middle of run; color is consist. mod. pale brown - m-dyel brown 5YR 5/2 10YR 5/4
7.0 – 1058, 1100, 10.0	4	SC-/CL	.8	Poor recovery - gravel zone @ or near top? At sand, silt, clay; predominant sand gravel from recovery moist - v. moist @ bottom; Poor recovery due to pickup shoe SL. plugged (clay/gravel lense?); basalt chips? @ bottom / clay moist, 10YR 5/4

Remarks: PG = Pitgrade : GPS/WGS 84 343342E 482521N (GDS 343328, GWS 217)

Note: Color changes due to cloud cover/sun/moisture content (> moist color darker)

107

FORM EG&G-3026 (Rev. 05-88)

DRILLING CORE LOG

Date: 11.13.01

Borehole: ICPP-BER-S-253

Geologist: Hehn / Shuley

Sample No.:

Core Length: 2.5' (Core) (Recovered) (ft.)

Cored Interval: Rt Grnd ICPP Top
B.R. @ 13 ft Bottom

Depth Below Land Surface (ft.)	Core Diagram	Description
10		V fn sand, slt, cly, moist, formerly ribbon; 10YR 8/2 v pale orange(?) color
11.13		? 50% fines? Ash/caliche??
	5	@ .5' basalt gravel 10YR 8/2 ↓
		10YR 8/2 V. fn sand - slt - cly
11.14		P.U. shoe 10YR/8/2 v. fn sn slt cly
12.5		moist. 75% fines? caliche?
11.22	13 ft	T.D. Refusal @ ~13.0 Rt [1124]
	6	V. moist (basalt chips) to wet (out of P.U. shoe) B.R basalt clay, sand w/ basalt gravel - 10YR 8/2 -
15		
	7	T.D 13 ft @ 1124
17.5		
	8	
20		

Remarks: will pull auger flights back filling w/ bentonite ? hydrating w/ ~ 1-2 gal every 5 ft.

Photo # 4 of core @ location of Bore hole 253

FORM EG&G-3026
(Rev 05-88)

DRILLING CORE LOG

Date: 11-13-01

Borehole: ICPP-BOR-S-254

Geologist: Kehn / Studley

Sample No.:

Core Length: 2.5' (ft.)

Cored Interval: Pit grade ICDF Top

— Bottom

— time / core ft / Recovered (ft)

Depth Below Land Surface (ft.)			Core Diagram		Description
PG. 0 – 2.5	1445 – 1418	1	GW/GP, GP	1.5	Silty sand/gravel mix – consistent [illegible] upper gravels 2" ; < 50% fines .5–1' pale BROWN 5YR 5/2 ; subrounded elements sl moist ; fining ↓ ; predom. GP? near bottom but maybe SP/SM – color / pale BROWN throughout. Also indicating moisture (sl moist)
2.5 – 5.0	1428 – 1434	2	SM	1.9	SP/SM silty sands / silty mix w/ some gravel near top ; 10 YR 5/4 predom. silty sands, sl moist. gravel comes/goes rapidly – stringers/[illegible] > silt / sl clayey ?? near bottom w/ gravel ? sl moist – moist
5.0 – 7.5	1452 – 1500	3	SM/ML	2.5	Top 1.3 silt sand w/ some clay/minor gravel GM/SM → SC/ML bottom 1.2 ft – silt/clayey vfn sand 10YR 6/6, moist, forms long ribbon
7.5 – 10	1509 – 1514	4		2.5	P.U. shovel clayey 10YR 5/4 sl eyed elements. SC/ML silty-clay/sl sandy (v.v. fn) 10YR 5/4 – 10YR 6/6 ; moist

Remarks: PG = Pit Grade GPS/WGS84 343309E 4825213N

Note: GPS doesn't appear to be working correctly?

* Moisture inside Lexan obscures sample w/in short time

111

FORM
(Rev. 05-88)

DRILLING CORE LOG

Date: 11-13-01 | Borehole: ICPP-BOR-S-254

Geologist: Hehn/Studley | Sample No.:

Core Length: 2.5' (ft.) | Cored Interval: Pt grade ICDF Top

corer ... recovery (ft) | 13.25 ft Bottom

A/A As above

Depth Below Land Surface (ft.)			Core Diagram		Description
10	1518				top 1.2 ft SM/ML, sl moist - moist
					10YR 6/2 - pale yel brown. silty -
					clay/sand (v. fn)
		5	sl/SM/ML	2.5	@ 1.3 ft down → 10YR 8/2
					sl/SM/ML v. Lt color
12.5	1529				Large basalt chunk in P.U. shoe & moist T-wet
	1536		sl/SM/ML	.9	A/A color → 10YR 5/4 Yel-brown
			13.25 ft		Refusal @ 13.25 ft 1537 T.D
		6			
15					
		7			
17.5					

Remarks: Large basalt chunk when broke open revealed cavities filled w silt/clay & v. moist - wet

113

FORM EG&G-3026 (Rev. 05-88)

DRILLING CORE LOG

Date: 11.14.01

Borehole: ICPP-BOR-5-255

Geologist: STUDLEY

Sample No.:

Core Length: 2.5' (ft.)

Cored Interval: P.t grade ICDF Top; 8.56' Bottom

Depth Below Land Surface (ft.)	Core #	Core Diagram	Recovery (ft)	Description
PG-0 833	1		1.0	V. top construction disturbed gravel gravel → silty sand mix. DRK yel brown 10YR 5/4 GW/SM mix predom. sub round - sub angular. DRY - v. sl. moist @ top, SW lens beneath gravel
2.5 836	2		1.3	— moisture condition obscure sample A/A → SM mix DRK yel brown 10YR 4/2 sl. ↑ moisture from above — GM/SM mix more silty sandy mix than gravel (some > 1") → v. fn SN/SLT 10YR 5/4 - 6/6 ↑ moist
5.0 ~~847~~ 838	3	SC	2.5	SM/SC @ top 10YR 6/6 appears moist v. slty/clay? sn. → ML (?) v. slty/clay / v. fn snd 10YR 6/6 moist
7.5			0.5	Gravel lense → SM/ML + v. fn snd/slt/cly 10YR 6/6 → 10YR 8/2 v. fn snd/slt/cly (?) on top basalt rubble (v. moist) N3 dk gray
853	4		1.3	Refusal @ 8.56 ft (driller) @ 0853 - T.D. Note: light colored slt/cly(?)/v. fn snd has ash aspects/element ? or caliche
10				TD 8.56 ft

Remarks: Note - D.T. Borschel ok'd leaving borehole only partially back filled w/ bent. : Top 64" left open. 2) 10YR 8/2 unit could be an ash layer (H2O laid (?)) breaking down → clay ??

115

FORM EG&G-... (Rev. 05-88)

DRILLING CORE LOG

Date: 11-14-01

Borehole: ICPP-BOR-5-256

Geologist: Studley

Sample No.:

Core Length: 2.5' (ft.)

Cored Interval: P.t grade (PG) Top; 10.4' Bottom

A/A As above

Depth Below Land Surface (ft.)	Core Run	Core Diagram	Recovery	Description
PG @ 924	1		1.8	top several in to .5 ft construction fill/disturbed pit grade gravels/snd m caliche element @ just below surface m GW-GM construction? > SND ↓ Mix of SLT/SND Gravel-up 2" Mod Brwn - Drk yel Brw 5YR 4/4 - 10YR 4/2 Dry - sl moist
2.5 925	2		1.3	A/A Slt/Snd/Gravel mix GM Sl > moisture? 10YR 4/2 - Drk yel Brown Cly @ N 4' (driller) more of a silty snd → gravel mix SC
5.0 932	3		2.5	sm moist (?) yel Brown 10YR 5/4 - 6/6 SM/ML/SCU. Fn snd - slt - cly (?) > 50% fines forms wet sticky ribbon > moist. to wet (?)
7.5 936	4		2.5	A/A > Snd near bottom @ also color becoming lt (N8) dry mix w/above → basalt rubble
10 947 / 956	BR.	basalt Rubble		10.4' (?) Refusal (driller) v. thin white cly lyr clay (N8) basalt Rubble mix - Refusal only sl moist to moist B.R. TD 10.4 ft

Remarks: Note: lt colored (white cly (?) layer) on top of B.R. is v. thin - < .2' - is same as interpret. as caliche unit - could be lacustrine/playa or undulating surface - ∴ coming & going in thickness

FORM EG&G-3026 (Rev. 05-88)

DRILLING CORE LOG

Date: 11·14·01

Borehole: ICPP·BOR·S·257

Geologist: SHADLEY

Sample No.:

Core Length: 25' (ft.)

Cored Interval: Pitgrade (P.G.) Top; 11.35 Bottom

Depth Below Land Surface (ft.)			Core Diagram	Core Recovery	Description
PG	0 1015		GM		construction fill - disturbed gravel (>2") mix @ top 1.0 ft (+) → predom GM/SM mix; dry-sl moist pale brown 5YR 5/2 gravel/snd subround - <
		1		1.2	> snd @ bottom snd lense ? w/slt
2.5	1018		GM		SM/GM slt snd/gravel mix mod brwn 10YR 5/4 / 5YR 4/4 dry - sl moist
		2		1.5	
			SM/ML	Lense	Lense vfn slt/sn (moist ?) yel-org-brn 10YR 6/6 > snd ?
5.0	1027		GM		SM (slt snds) more gray in color 5YR 3/2 dry - sl moist → sndy
		3	SM / SW	1.8	snd lense (SW) dry lt brwgray 5YR 6/1 vfn-fn ~2 ft thick
7.5			SW		A/A sl moist (Top .4') → slt/cly/v.fn snd mix SM/ML/SC
Missing sample		4	SM/ML/SC	2.2	Predom sltymoist SM/ML yel orge brn 10YR 6/6 slty snds w/ > cly element > snd @ bottom & cly element (1-3' thick)
10					SM slty snd, fn, sl moist, slt cly stringr
		5	SM	1.35	
11.35			Basalt Rubble / B.Q.		TD. Refusal @ 11.35' (driller) 1042

Remarks: Note: 7.5 - 10 No lexan tube in barrel - had to dump after logging in split barrel

119

FORM EG&G-3026
(Rev 05-88)

DRILLING CORE LOG

Date: 11·14·01

Borehole: ICPP - BDR - S - 258

Geologist: SHUDLEY

Sample No.:

Core Length: 2.5 (ft.)

Cored Interval: At GRADE (P.G.) Top; 10.5' Bottom

Depth Below Land Surface (ft.)	time	core #	Core Diagram	Recovery (ft)	Description
P.G. 0	1241	1	GM	1.7	construction/disturbed fill – GW-W/ gravel > 3" (flatten imbricated ??) gravel SND/minor SLT mix GM gravel/W/SN stringers, Lt brw gry 5YR 6/1 SND – fn-med 10-20% fines? Dry – SL MOIST(?)
2.5	1243 / 1246	2	GM, SW	2.2	2.5-3.5 A/A GM 3.5-4.5 SND lense SW Lt Brn gry 5YR 6/1 wellsorted fn-med, Dry – SL moist fining ↓ ? to V SLT V.FNS (SM) 10YR 5/4 SL moist moist cly element ?
5.0	1247 / 1252	3	SM	1.6	Very top V.SLTY SND (A/A) → SND/gravel mix (GM) lense → SND W/ fines (SM ?) maybe < fines (SW ??) → gravel/SND/SLT stringer → @ 5.40m
7.5	1255 / 1300	4	SM/ML/SC	2.2	A/A (8.4') @ 9' SLT SND/clay (?) SM/ML SL MOIST Vfn SN – SLT – Clay element moderate BROWN 5YR 4/4 But predom. SLT SND W/ fines (clay SLT) as thin stringers
10	1304 / Refusal @ 10.5 @ 1314	5		.5	sndy gravel/basalt gravel (?) 5YR 4/1 B.R. basalt Rubble – DRY only SL MOIST Refusal 10.5' (Driller 1314) T.D.

Remarks: overcast – sct [illegible] > WIND ↓ temp (pm)

FORM EG&G-3026
(Rev. 05-88)

DRILLING CORE LOG

Date: 11-14-01

Borehole: ICPP-BOR-5-259

Geologist: STUDLEY

Sample No.:

Core Length: 2.5 (ft.)

Cored Interval: Pitgrade (PG) Top; 7.15' Bottom

Depth Below Land Surface (ft.)		Core #	Core Diagram	Core Recovery (ft)	Description
P.G. 0	1334	1		1.7	disturbe Alluvium / const. gravel GW → GM > SND cont. mod. yel BRWN 10YR 5/4 DRY - SL moist fn - med SND lense w m. pole? → GM mix
2.5	1338				SM @ bottom?
		2		2.5	@ 2.5 → slty snd w/ cly element? moist v fn - fn SM/ML?
5.0	1337		SW/SM		Nicely sorted SAND/SILT @ bottom 10YR 5/4 w/ gravel stringy → SND lense SW? ~.8'-1' thick / Dry - SL moist? pale yel. BRWN 10YR 6/2 FN - med grnd SAND
		3	SW, SM	1.7	→ SM v. Slty? SND yel BRWN 10YR 5/4 ONLY SL MOIST — NO cly LAYER (?)
7.5	1348				TD. B.R./Basalt Rubble - Refusal @ 7.15'
		4	B.R. Basalt Rubble		
10					

Remarks:

FORM EG&G-3026
(Rev 05-88)

DRILLING CORE LOG

Date: 11-14-01

Borehole: ICPP-SCR-5-260

Geologist: Studley

Sample No.:

Core Length: 2.5 (ft.)

Cored Interval: Pit graded P.G. Top; 6.0 Bottom

Depth Below Land Surface (ft.)	Core #	Core Diagram	Recovery	Description
Pg 0 1409	1		2.2	disturb. construction / GW/GM @ 1.3' → SW/GM w/ large silt element fine ↓ ? into SM sl moist - moist ? yel orange brown 10YR 6/6 ? FN - VFN ↓ > slt content ?
				Possibly slt/cly strong @ bottom ?
2.5 1411	2		2.5	GM lense @ top @ 3.8' slt / v. fn snd, moist, yel brown 10YR 5/4 > fines > 50% SM-ML ? lt cly element; finer sand near bottom > slt ?
5.0	3	SM	(?) 1.3	SM lense → slt cly element moist (?) bottom, 6-.8' (?) ML / basalt rubble mix (N4) ML 10YR 8/2 (cly-ash layer) (??) - excel seal - TD. Refusal @ 6.0 (driller) 1424 Note cly-ash layer could easily be a caliche/cly layer from playa - lacustrine depositional environment
6.0 Refusal 1424				
7.5	4			
10				

Remarks:

125

FORM EG&G-3026
(Rev. 05-88)

DRILLING CORE LOG

Date: 11.14.01

Geologist: STUDLEY

Core Length: 2.5 * (Lost) (Recovery) (ft.)

Borehole: LCPP-BOR.5-261

Sample No.:

Cored Interval: P.G. GRADE (P.G.) Top
6.75' Bottom

Depth Below Land Surface (ft.)		Core Diagram		Description
P.G.	0 1450	1	2.2	GW/GM Gravel-snd-slt mix construction of P.t floor V. thin layers → SM slt/FN snd mix → SM/ML mix, moist
2.5	1452	2	2.5	@ bottom 6" moist v silty/V FN SN mix SM-ML-SC N/A
5.0	1457	3	1.7	P.U. Shale @ bottom V. moist slt/cly/V. FN snd ML? → SM, SL moist-moist, yel brown 10YR5/4 BR. biscuit pebble / silty FN snd mix (SM) SL moist? — No Recognz. Ash Layer (?) caliche ?? T.D. B.R. Refusal @ 6.75 ft (Driller) time 1501
7.5		4		
10.0				

Remarks:

FORM EG&G-3026
(Rev. 05-88)

DRILLING CORE LOG

Date: 11-14-01
Borehole: ICPP BDR S 262

Geologist: SHUDLEY
Sample No.:

Core Length: 2.5 (ft.)
Cored Interval: Pt Grade (P.C.) Top
6.75' Bottom

Depth Below Land Surface (ft.)		Core #	Core Diagram	Recovery	Description
P.G. 0	1518	1		2.5	Gray SM v. minor gravel - slty fn-v.fn sd mod yel brwn 10YR 5/2 dry - sl mast(?) @ 1.5' SM/ML mod yel brwn 10YR 5/4 moist medium > 50% fines form well develop R. spoon
2.5	1521	2		2.5	A/A cly lense @ 4.0 ft → SM/ML > SND content < SLT white ashy chips in Bit. shoe (??) → SC
5.0	1523	3	SC	1.5	ML/SM, moist(?), fn snd/slt / cly element? mod yel brwn 10YR 5/4 caliche - playa - lacustrine / doubtful loess v. thin ash/cly/v.fn snd on basalt 10YR 8/1 Refusal @ 6.75' (driller) 1543 T.D. basalt chips / rubble
	1543 6.76'				
7.5		4			
10					

Remarks: note: the ashy appearing element @ or near bottom
maybe interpreted to be a caliche

FORM EG&G-3026
(Rev. 05-88)

DRILLING CORE LOG

Date: 11-15-01 Borehole: ICPP-BOR-S-263

Geologist: STUDLEY Sample No.:

Core Length: 2.5 (ft.) Cored Interval: P.t grade Top

8.15 ft Bottom

– time

Depth Below Land Surface (ft.)	time	Core #	Core Diagram	Recovery	Description
P.G 0	913	1	GM	1.7	Constr gravel @ very top → GM predom SND/silty mix borderline GM/SM/(SW) – construct element? Dry – v.sl moist, pale brown 5YR 5/? predom med gr SND w/ slt element mix ≤ 25% fines – appears nicely sorted // sub round – sub angular All SND same size
2.5	914 / 917	2	SM-GM	1.8	A/A GM, darker? 5YR 4/4 Dry – sl moist, SND – fn-med gr > moist?? > slt element? ≤ 50% – but still appreciable fines 25-35? SND All same size – Nicely sorted
5.0	918 / 926	3	GM	1.8	A/A > moist sl moist – moist @ ~6.1 ft v.slt SND/w/ cly element sl moist – moist, mod yel brown 10YR 5/? SM-ML: SN vfn – fn ≥ 50% fines? form rough ribbon, SNDS well sorted
6.1 >					
			SM-ML/SC		
7.5	928	4	BR	1.0	A/A @ ~7.9' ML(?)/SM-ML w. light color, moist, vfn SN-cly(?)-slt 10YR 8/2 on top of B.R (Ash layer?) @ 8.15 ft Refusal B.R. Basalt
	936				
10					

Remarks: back filled w/ hole plug hydrated w/ ~5 gal total 4 bgs 3/4 (holeplug) 50#

FORM EG&G-3026
(Rev. 05-88)

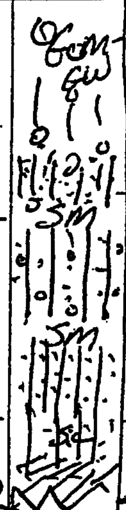
DRILLING CORE LOG

Date: 11-15-01 Borehole: ICPP-BOR-S-264

Geologist: SHUDLEY Sample No.:

Core Length: 2.5 (ft.) Cored Interval: Pit grade Top

~time 5.85' Bottom

Depth Below Land Surface (ft.)	(time)	Run	Core Diagram	Recovery	Description
P.G. 0	954	1		1.8	GM Silt gravel-snd mix sl moist 10YR 4/2 : disturb. construct. @ v. top : -> SM silty sand fn-med gr, mottled brwn 10YR 5/4 sl moist - moist. > silt content from above some gravel stringers or contamin. ??
2.5	955 / 958	2		2.0	A/A @ 4.3' > slt element v. silty snd snd fn gr yel org brwn 10YR 6/6 ? sl moist, fairly sorted, sub round sub angular 25% fines ? form only a short broken ribbon
5.0	1000 / 1010	BR 3		2.2	?? sluff - contamination !!?? logging bottom .85" only @ ~5.4 ft SM/ML ash?! 10YR 8/2 v fn silt/cly layer caliche environment ?? @ 5.85 ft refusal B.R. (driller)
7.5	1014			1014	
		4			
10					

Remarks: 952 set-up : refusal @ 1014
2 bgs bent. / 4 gal H2O
1036 @ next site (265) 3 set up
263-264 107 ft (N)

131

FORM EG&G-3026
(Rev. 05-88)

DRILLING CORE LOG

Date: 11·15·01 Borehole: ICPP·BOR·5·265

Geologist: STUDLEY Sample No.:

Core Length: 2·5 (ft.) Cored Interval: Regolith (PG) Top
5.1 ft Bottom

Depth Below Land Surface (ft.)	Core #	Core Diagram	Recovery	Description
P.G. 0	1	GM	2.2	GM/SM predom SAND, 25% fines ORG - only SL MOIST MOD yel BRWN 10YR 5/4 ?? - NICE Interbed SM / SILT Rock @ 1.5' SM >> SILT element SC Moist – Moist (?) yel orge 10YR 6 Forms NICE Ribbon (Cly element ??) Sandy gravel lense @ top 3.8' (cuttings?)
2.5 – 1043	2	SM	2.5	SM – SLTY V FN SND, SL moist – moist SILT – CLY Lense/Stringer ? V. FN – FN SND MOD yel BRWN 10YR 5/4
5.0 – 1051	3	ML	.1	@ 4.1 ft yel GRAY 5Y 7/2 → 10YR/8 SC/ML SL Moist – Moist V FN GR SND/SLT/CLY (?) ASH unit? push shoe ↓ FINING sequence – caliche?
7.5	4	B.R		@ 5.1 ft (push shoe) Refusal B.R. basalt T.D 5.1 ft 1051
10.0				

Remarks:

backfilled w 2 bags bent / ~3 gal H2O

264 – 265 145 ft W

FORM EG&G-3026
(Rev. 05-88)

DRILLING CORE LOG

Date: 11.15.01 Borehole: ICPP-BOR-S-266

Geologist: STUDLEY Sample No.:

Core Length: 2.5 (ft.) Cored Interval: Pit grade Top

—time A/A AS Above 7.15' Bottom

Depth Below Land Surface (ft.)	Core #	Core Diagram	Recovery	Description
PGD 1253	1	SM	1.9	SW/SM FN gr, DRY, well sorted sub round - sub angular pale brown 5YR 5/2 @ 2.1 ft > slt content/element → SM/ML? 10YR 6/2 > moist v fine gr snd/slt unit
2.5 1254	2	ML	1.9	ML? gry-orange-brwn 5YR 7/2 > 50% fines, v-fn sn-slt sl moist - moist (?) cly element appearing w/ fines – color streaks – color chg @ bottom – lenses - streaking pale yel BRWN 10YR 6/2 # form rough ribbon som fel grains
5.0 1258	3	SM ML	2.4	SM/ML A/A @ 6.4' 10YR 8/2 Ashy appearing vv. fn snd/clay unit - leaching/bleaching - caliche scenario Darker streaks last .4' streaks/lenses in unit (basalt element in fines ?)
7.5 1310 1315	4			A/A NO SAMPLE Refusal @ 7.15' (DRILLER) No Recovery from shoe but whitish clay smear on outside
10				

Remarks:

backfilled 4.5 bgs benton. ~5 gal H_2O

265 - 266 140 AW

131

FORM EG&G-3026
(Rev. 05-88)

DRILLING CORE LOG

Date: 11-15-01

Borehole: ICPP-BOR-5-267

Geologist: STUDLEY

Sample No.:

Core Length: 2.5 (ft.)

Cored Interval: Pit gravels (P.G.) Top
6.35 ft Bottom

Depth Below Land Surface (ft.)	Time	Core Diagram	Recovery	Description
PG 1334		GM	1.5	GM/SM MIX GRADING (FINING ↓) more to SM mix w/ gravel stringers SL moist - moist (?) Pale BRWN 5YR 5/2 MIN - mod gr SND < 25% fines? >SCt near bottom of RUN
2.5 1335 1329		ML-SC	2.4	SND Nicely sorted (same size) A/A @ 2.9' SC/ML? U. FN gr SND/SCt w/ Cly? element > 50% fines SL moist; foam Nice Ribbon - can feel grains. w/well sorted SND/SCt size MOD YEL BRWN 10YR 5/4
5.0 1341		GM. BASALT	???	GM. BASALT gravel dense ?? → SM/ML/SC SL moist; streaky (color) good size) predom SM (?) w/ whitish layer right on top B Refusal @ 6.35 TP 1346 (DRILLER)
7.5		BR		Note: No real IDENT. on Ashy Layer Absent? but definite SC > grain size @ BR interface FN-med SAND ??
10				

Remarks:

backfilled 3.5 bgs bent. 3/4 hole plug 5gal H2O
265 to 267 103 ft SSE

B-2.3 ASTM Standard D 2487, United Soil Classification System

The following pages describe the ASTM Unified Soil Classification System.

Designation: D 2487 – 00

Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)[1]

This standard is issued under the fixed designation D 2487; 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 describes a system for classifying mineral and organo-mineral soils for engineering purposes based on laboratory determination of particle-size characteristics, liquid limit, and plasticity index and shall be used when precise classification is required.

NOTE 1—Use of this standard will result in a single classification group symbol and group name except when a soil contains 5 to 12 % fines or when the plot of the liquid limit and plasticity index values falls into the crosshatched area of the plasticity chart. In these two cases, a dual symbol is used, for example, GP-GM, CL-ML. When the laboratory test results indicate that the soil is close to another soil classification group, the borderline condition can be indicated with two symbols separated by a slash. The first symbol should be the one based on this standard, for example, CL/CH, GM/SM, SC/CL. Borderline symbols are particularly useful when the liquid limit value of clayey soils is close to 50. These soils can have expansive characteristics and the use of a borderline symbol (CL/CH, CH/CL) will alert the user of the assigned classifications of expansive potential.

1.2 The group symbol portion of this system is based on laboratory tests performed on the portion of a soil sample passing the 3-in. (75-mm) sieve (see Specification E 11).

1.3 As a classification system, this standard is limited to naturally occurring soils.

NOTE 2—The group names and symbols used in this test method may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. See Appendix X2.

1.4 This standard is for qualitative application only.

NOTE 3—When quantitative information is required for detailed designs of important structures, this test method must be supplemented by laboratory tests or other quantitative data to determine performance characteristics under expected field conditions.

1.5 This standard is the ASTM version of the Unified Soil Classification System. The basis for the classification scheme is the Airfield Classification System developed by A. Casagrande in the early 1940's.[2] It became known as the Unified Soil Classification System when several U.S. Government Agencies adopted a modified version of the Airfield System in 1952.

1.6 *This standard does not purport to address all of the safety concerns, 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.*

1.7 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should not 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:*

C 117 Test Method for Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing[3]

C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregates[3]

C 702 Practice for Reducing Field Samples of Aggregate to Testing Size[3]

D 420 Guide to Site Characterization for Engineering, Design and Construction Purposes

D 421 Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[4]

D 422 Test Method for Particle-Size Analysis of Soils[4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[4]

D 1140 Test Method for Amount of Material in Soils Finer than the No. 200 (75-μm) Sieve[4]

D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock[4]

[1] This standard is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved March 10, 2000. Published May 2000. Originally published as D 2487 – 66 T. Last previous edition D 2487 – 98.

[2] Casagrande, A., "Classification and Identification of Soils," *Transactions*, ASCE, 1948, p. 901.

[3] *Annual Book of ASTM Standards*, Vol 04.02.

[4] *Annual Book of ASTM Standards*, Vol 04.08.

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

D 2217 Practice for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[4]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[4]

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction[5]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[4]

D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[4]

D 4427 Classification of Peat Samples by Laboratory Testing[4]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[6]

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 4—For particles retained on a 3-in. (75-mm) U.S. 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) U.S. standard sieve, and

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) U.S. standard 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.

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) U.S. standard sieve with the following subdivisions:

Coarse—passes 3-in. (75-mm) sieve and retained on ¾-in. (19-mm) sieve, and

Fine—passes ¾-in. (19-mm) sieve and retained on 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 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) U.S. standard sieve with the following subdivisions:

Coarse—passes No. 4 (4.75-mm) sieve and retained on No. 10 (2.00-mm) sieve,

Medium—passes No. 10 (2.00-mm) sieve and retained on No. 40 (425-μm) sieve, and

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

3.1.7 *silt*—soil passing a No. 200 (75-μm) U.S. standard 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 if the plot of plasticity index versus liquid limit falls below the "A" line.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *coefficient of curvature, Cc*—the ratio $(D_{30})^2/(D_{10} \times D_{60})$, where D_{60}, D_{30}, and D_{10} are the particle sizes corresponding to 60, 30, and 10 % finer on the cumulative particle-size distribution curve, respectively.

3.2.2 *coefficient of uniformity, Cu*—the ratio D_{60}/D_{10}, where D_{60} and D_{10} are the particle diameters corresponding to 60 and 10 % finer on the cumulative particle-size distribution curve, respectively.

4. Summary

4.1 As illustrated in Table 1, this classification system identifies three major soil divisions: coarse-grained soils, fine-grained soils, and highly organic soils. These three divisions are further subdivided into a total of 15 basic soil groups.

[4] *Annual Book of ASTM Standards*, Vol 04.09.
[5] *Annual Book of ASTM Standards*, Vol 14.02.

TABLE 1 Soil Classification Chart

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
COARSE-GRAINED SOILS	Gravels	Clean Gravels	Cu ≥ 4 and 1 ≤ Cc ≤ 3[C]	GW	Well-graded gravel[D]
More than 50 % retained on No. 200 sieve	More than 50 % of coarse fraction retained on No. 4 sieve	Less than 5 % fines[E]	Cu < 4 and/or 1 > Cc > 3[C]	GP	Poorly graded gravel[D]
		Gravels with Fines	Fines classify as ML or MH	GM	Silty gravel[D,F,G]
		More than 12 % fines[E]	Fines classify as CL or CH	,urule;1>GC	Clayey gravel[D,F,G]
	Sands	Clean Sands	Cu ≥ 6 and 1 ≤ Cc ≤ 3[C]	SW	Well-graded sand[H]

TABLE 1 *Continued*

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
	50 % or more of coarse	Less than 5 % fines[I]	Cu < 6 and/or 1 > Cc > 3[C]	SP	Poorly graded sand[H]
	fraction passes No. 4 sieve	Sands with Fines	Fines classify as ML or MH	SM	Silty sand[F,G,H]
		More than 12 % fines[I]	Fines classify as CL or CH	SC	Clayey sand[F,G,H]
FINE-GRAINED SOILS	Silts and Clays	inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
50 % or more passes the No.	Liquid limit less than 50		PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
200 seive		organic	Liquid limit – oven dried < 0.75	OL	Organic clay[K,L,M,N]
			Liquid limit – not dried	OL	Organic silt[K,L,M,O]
	Silts and Clays	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
	Liquid limit 50 or more		PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	Liquid limit – oven dried < 0.75	OH	Organic clay[K,L,M,P]
			Liquid limit – not dried		Organic silt[K,L,M,Q]
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] $Cu = D_{60}/D_{10}$ $Cc = (D_{30})^2 / D_{10} \times D_{60}$
[D] If soil contains ≥15 % sand, add "with sand" to group name.
[E] Gravels with 5 to 12 % fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay
[F] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[G] If fines are organic, add "with organic fines" to group name.
[H] If soil contains ≥15 % gravel, add "with gravel" to group name.
[I] Sands with 5 to 12 % fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay
[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29 % plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥30 % plus No. 200, predominantly sand, add "sand " to group name.
[M] If soil contains ≥30 % plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below" A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.

4.2 Based on the results of visual observations and prescribed laboratory tests, a soil is catalogued according to the basic soil groups, assigned a group symbol(s) and name, and thereby classified. The flow charts, Fig. 1 for fine-grained soils, and Fig. 3 for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name.

5. Significance and Use

5.1 This standard classifies soils from any geographic location into categories representing the results of prescribed laboratory tests to determine the particle-size characteristics, the liquid limit, and the plasticity index.

5.2 The assigning of a group name and symbol(s) along with the descriptive information required in Practice D 2488 can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.3 The various groupings of this classification system have been devised to correlate in a general way with the engineering behavior of soils. This standard provides a useful first step in any field or laboratory investigation for geotechnical engineering purposes.

5.4 This standard may also be used as an aid in training personnel in the use of Practice D 2488.

5.5 This standard may be used in combination with Practice D 4083 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 D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 In addition to the apparatus that may be required for obtaining and preparing the samples and conducting the prescribed laboratory tests, a plasticity chart, similar to Fig. 4,

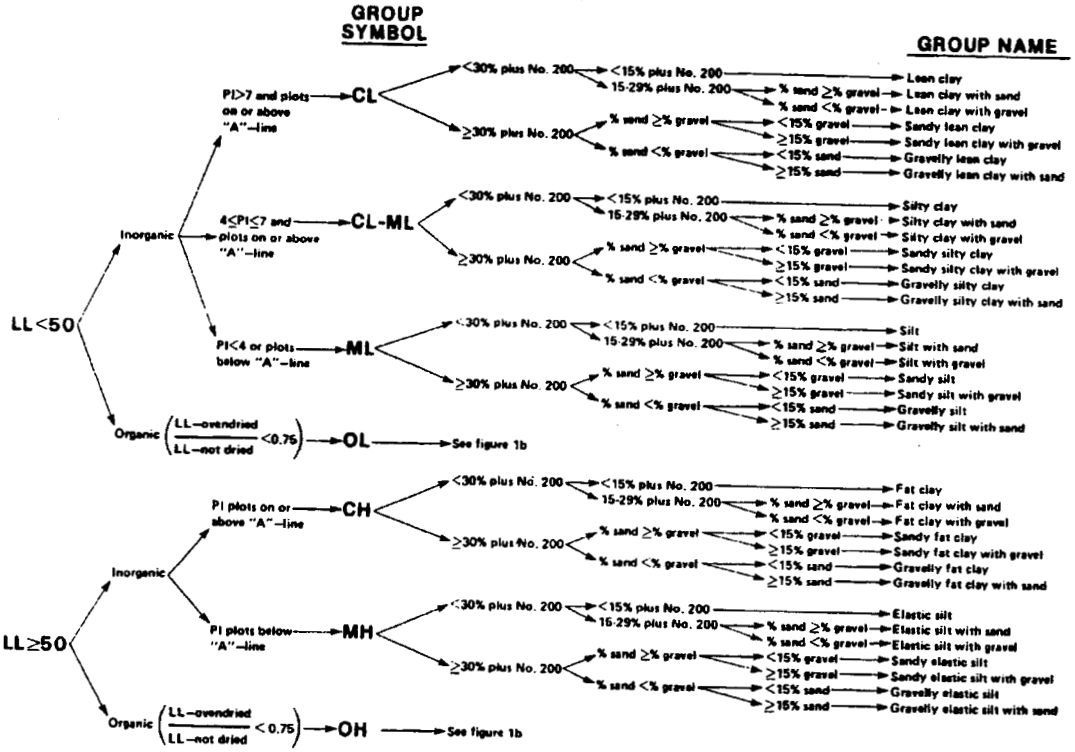


FIG. 1 Flow Chart for Classifying Fine-Grained Soil (50 % or More Passes No. 200 Sieve)

and a cumulative particle-size distribution curve, similar to Fig. 5, are required.

NOTE 6—The "U" line shown on Fig. 4 has been empirically determined to be the approximate "upper limit" for natural soils. It is a good check against erroneous data, and any test results that plot above or to the left of it should be verified.

7. Sampling

7.1 Samples shall be obtained and identified in accordance with a method or methods, recommended in Guide D 420 or by other accepted procedures.

7.2 For accurate identification, the minimum amount of test sample required for this test method will depend on which of the laboratory tests need to be performed. Where only the particle-size analysis of the sample is required, specimens having the following minimum dry weights are required:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ 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)

Whenever possible, the field samples should have weights two to four times larger than shown.

7.3 When the liquid and plastic limit tests must also be performed, additional material will be required sufficient to provide 150 g to 200 g of soil finer than the No. 40 (425-μm) sieve.

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

8. Classification of Peat

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

8.2 If desired, classification of type of peat can be performed in accordance with Classification D 4427.

9. Preparation for Classification

9.1 Before a soil can be classified according to this standard, generally the particle-size distribution of the minus 3-in. (75-mm) material and the plasticity characteristics of the minus No. 40 (425-μm) sieve material must be determined. See 9.8 for the specific required tests.

9.2 The preparation of the soil specimen(s) and the testing for particle-size distribution and liquid limit and plasticity index shall be in accordance with accepted standard procedures. Two procedures for preparation of the soil specimens for

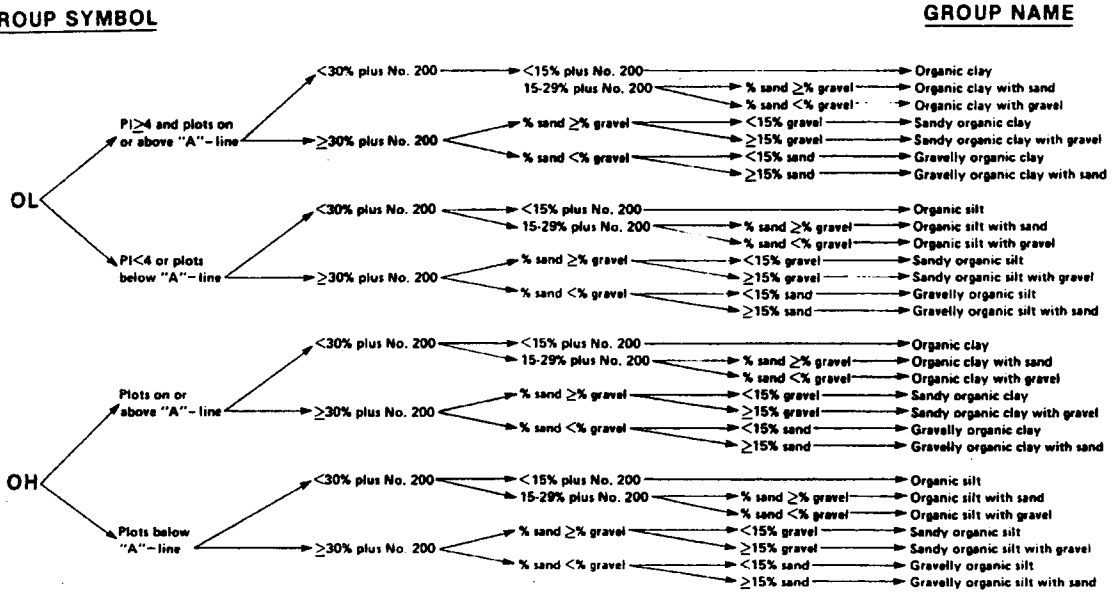


FIG. 2 Flow Chart for Classifying Organic Fine-Grained Soil (50 % or More Passes No. 200 Sieve)

testing for soil classification purposes are given in Appendixes X3 and X4. Appendix X3 describes the wet preparation method and is the preferred method for cohesive soils that have never dried out and for organic soils.

9.3 When reporting soil classifications determined by this standard, the preparation and test procedures used shall be reported or referenced.

9.4 Although the test procedure used in determining the particle-size distribution or other considerations may require a hydrometer analysis of the material, a hydrometer analysis is not necessary for soil classification.

9.5 The percentage (by dry weight) of any plus 3-in. (75-mm) material must be determined and reported as auxiliary information.

9.6 The maximum particle size shall be determined (measured or estimated) and reported as auxiliary information.

9.7 When the cumulative particle-size distribution is required, a set of sieves shall be used which include the following sizes (with the largest size commensurate with the maximum particle size) with other sieve sizes as needed or required to define the particle-size distribution:

3-in. (75-mm)
¾-in. (19.0-mm)
No. 4 (4.75-mm)
No. 10 (2.00-mm)
No. 40 (425-μm)
No. 200 (75-μm)

9.8 The tests required to be performed in preparation for classification are as follows:

9.8.1 For soils estimated to contain less than 5 % fines, a plot of the cumulative particle-size distribution curve of the fraction coarser than the No. 200 (75-μm) sieve is required. A semi-log plot of percent passing versus partical-size or sieve size/sieve number is plotted as shown in Fig. 5.

9.8.2 For soils estimated to contain 5 to 15 % fines, a cumulative particle-size distribution curve, as described in 9.8.1, is required, and the liquid limit and plasticity index are required.

9.8.2.1 If sufficient material is not available to determine the liquid limit and plasticity index, the fines should be estimated to be either silty or clayey using the procedures described in Practice D 2488 and so noted in the report.

9.8.3 For soils estimated to contain 15 % or more fines, a determination of the percent fines, percent sand, and percent gravel is required, and the liquid limit and plasticity index are required. For soils estimated to contain 90 % fines or more, the percent fines, percent sand, and percent gravel may be estimated using the procedures described in Practice D 2488 and so noted in the report.

10. Preliminary Classification Procedure

10.1 Class the soil as fine-grained if 50 % or more by dry weight of the test specimen passes the No. 200 (75-μm) sieve and follow Section 3.1.2.

10.2 Class the soil as coarse-grained if more than 50 % by dry weight of the test specimen is retained on the No. 200 (75-μm) sieve and follow Section 12.

11. Procedure for Classification of Fine-Grained Soils (50 % or more by dry weight passing the No. 200 (75-μm) sieve)

11.1 The soil is an inorganic clay if the position of the plasticity index versus liquid limit plot, Fig. 4, falls on or above the "A" line, the plasticity index is greater than 4, and the presence of organic matter does not influence the liquid limit as determined in 11.3.2.

NOTE 7—The plasticity index and liquid limit are determined on the

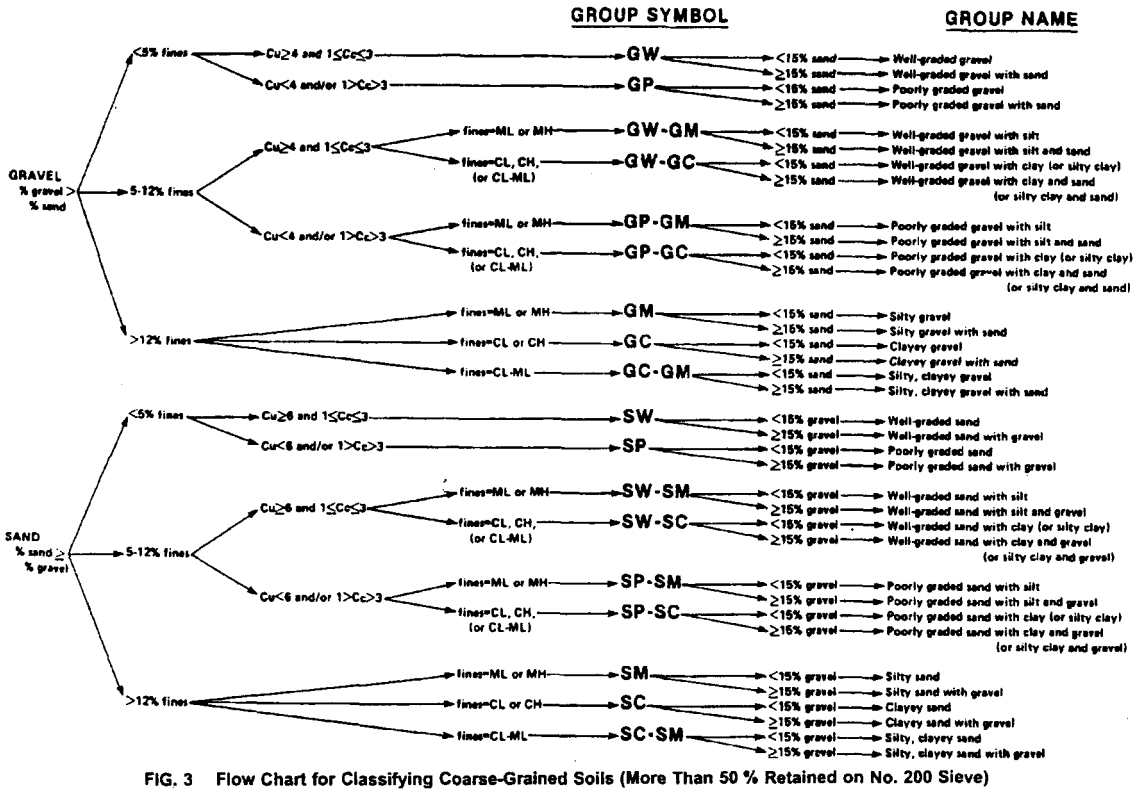


FIG. 3 Flow Chart for Classifying Coarse-Grained Soils (More Than 50 % Retained on No. 200 Sieve)

minus No. 40 (425 μm) sieve material.

11.1.1 Classify the soil as a *lean clay,* CL, if the liquid limit is less than 50. See area identified as CL on Fig. 4.

11.1.2 Classify the soil as a *fat clay,* CH, if the liquid limit is 50 or greater. See area identified as CH on Fig. 4.

NOTE 8—*In cases where the liquid limit exceeds 110 or the plasticity index exceeds 60, the plasticity chart may be expanded by maintaining the same scale on both axes and extending the "A" line at the indicated slope.*

11.1.3 Classify the soil as a *silty clay,* CL-ML, if the position of the plasticity index versus liquid limit plot falls on or above the "A" line and the plasticity index is in the range of 4 to 7. See area identified as CL-ML on Fig. 4.

11.2 The soil is an inorganic silt if the position of the plasticity index versus liquid limit plot, Fig. 4, falls below the "A" line or the plasticity index is less than 4, and presence of organic matter does not influence the liquid limit as determined in 11.3.2.

11.2.1 Classify the soil as a *silt,* ML, if the liquid limit is less than 50. See area identified as ML on Fig. 4.

11.2.2 Classify the soil as an *elastic silt,* MH, if the liquid limit is 50 or greater. See area identified as MH on Fig. 4.

11.3 The soil is an organic silt or clay if organic matter is present in sufficient amounts to influence the liquid limit as determined in 11.3.2.

11.3.1 If the soil has a dark color and an organic odor when moist and warm, a second liquid limit test shall be performed on a test specimen which has been oven dried at 110 ± 5°C to a constant weight, typically over night.

11.3.2 The soil is an organic silt or organic clay if the liquid limit after oven drying is less than 75 % of the liquid limit of the original specimen determined before oven drying (see Procedure B of Practice D 2217).

11.3.3 Classify the soil as an *organic silt* or *organic clay,* OL, if the liquid limit (not oven dried) is less than 50 %. Classify the soil as an *organic silt,* OL, if the plasticity index is less than 4, or the position of the plasticity index versus liquid limit plot falls below the "A" line. Classify the soil as an *organic clay,* OL, if the plasticity index is 4 or greater and the position of the plasticity index versus liquid limit plot falls on or above the "A" line. See area identified as OL (or CL-ML) on Fig. 4.

11.3.4 Classify the soil as an *organic clay* or *organic silt,* OH, if the liquid limit (not oven dried) is 50 or greater. Classify the soil as an *organic silt,* OH, if the position of the plasticity index versus liquid limit plot falls below the "A" line. Classify the soil as an *organic clay,* OH, if the position of the plasticity index versus liquid-limit plot falls on or above the "A" line. See area identified as OH on Fig. 4.

11.4 If less than 30 % but 15 % or more of the test specimen is retained on the No. 200 (75-μm) sieve, the words" with sand" or "with gravel" (whichever is predominant) shall be added to the group name. For example, lean clay with sand,

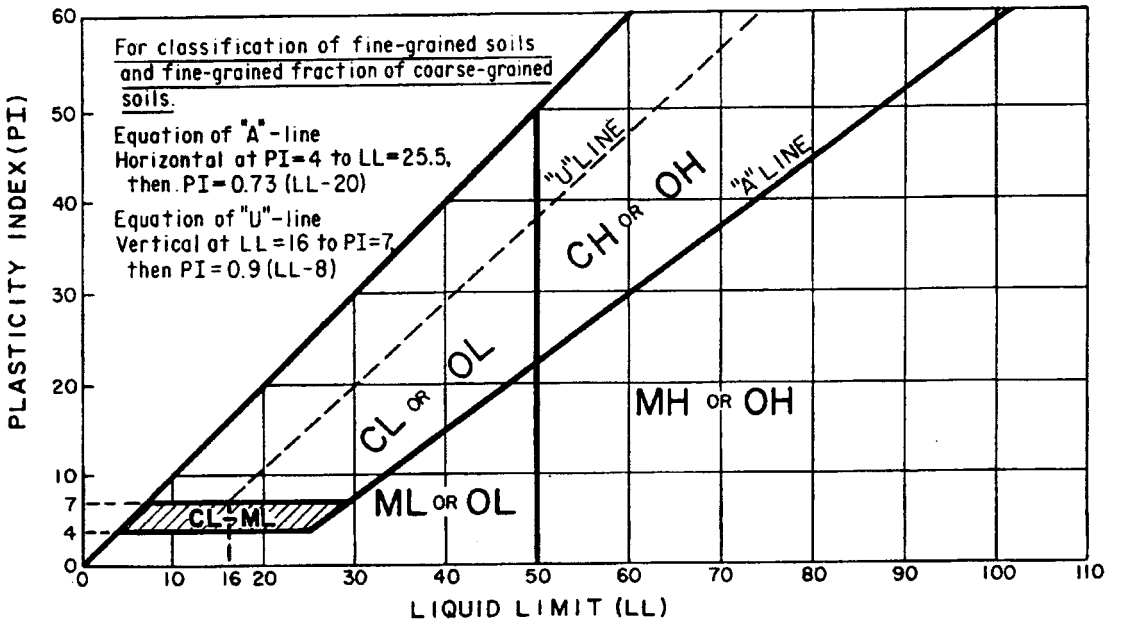
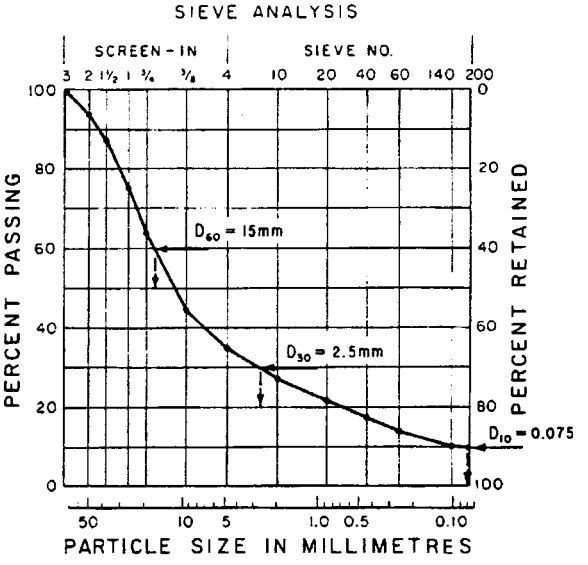


FIG. 4 Plasticity Chart



$$Cu = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200 \qquad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$$

FIG. 5 Cumulative Particle-Size Plot

CL; silt with gravel, ML. If the percent of sand is equal to the percent of gravel, use "with sand."

11.5 If 30 % or more of the test specimen is retained on the No. 200 (75-μm) sieve, the words "sandy" or" gravelly" shall be added to the group name. Add the word "sandy" if 30 % or more of the test specimen is retained on the No. 200 (75-μm) sieve and the coarse-grained portion is predominantly sand. Add the word "gravelly" if 30 % or more of the test specimen

is retained on the No. 200 (75-μm) sieve and the coarse-grained portion is predominantly gravel. For example, sandy lean clay, CL; gravelly fat clay, CH; sandy silt, ML. If the percent of sand is equal to the percent of gravel, use "sandy."

12. Procedure for Classification of Coarse-Grained Soils (more than 50 % retained on the No. 200 (75-μm) sieve)

12.1 Class the soil as gravel if more than 50 % of the coarse fraction [plus No. 200 (75-μm) sieve] is retained on the No. 4 (4.75-mm) sieve.

12.2 Class the soil as sand if 50 % or more of the coarse fraction [plus No. 200 (75-μm) sieve] passes the No. 4 (4.75-mm) sieve.

12.3 If 12 % or less of the test specimen passes the No. 200 (75-μm) sieve, plot the cumulative particle-size distribution, Fig. 5, and compute the coefficient of uniformity, *Cu*, and coefficient of curvature, *Cc*, as given in Eqs 1 and 2.

$$Cu = D_{60}/D_{10} \quad (1)$$

$$Cc = (D_{30})^2/(D_{10} \times D_{60}) \quad (2)$$

where:

D_{10}, D_{30}, and D_{60} = the particle-size diameters corresponding to 10, 30, and 60 %, respectively, passing on the cumulative particle-size distribution curve, Fig. 5.

NOTE 9—It may be necessary to extrapolate the curve to obtain the D_{10} diameter.

12.3.1 If less than 5 % of the test specimen passes the No. 200 (75-μm) sieve, classify the soil as a *well-graded gravel*, GW, or *well-graded sand*, SW, if Cu is greater than or equal to 4.0 for gravel or greater than 6.0 for sand, and Cc is at least 1.0 but not more than 3.0.

12.3.2 If less than 5 % of the test specimen passes the No. 200 (75-μm) sieve, classify the soil as *poorly graded gravel*, GP, or *poorly graded sand*, SP, if either the *Cu* or the *Cc* criteria for well-graded soils are not satisfied.

12.4 If more than 12 % of the test specimen passes the No. 200 (75-μm) sieve, the soil shall be considered a coarse-grained soil with fines. The fines are determined to be either clayey or silty based on the plasticity index versus liquid limit plot on Fig. 4. (See 9.8.2.1 if insufficient material available for testing) (see Note 7).

12.4.1 Classify the soil as a *clayey gravel*, GC, or *clayey sand*, SC, if the fines are clayey, that is, the position of the plasticity index versus liquid limit plot, Fig. 4, falls on or above the "A" line and the plasticity index is greater than 7.

12.4.2 Classify the soil as a *silty gravel*, GM, or *silty sand*, SM, if the fines are silty, that is, the position of the plasticity index versus liquid limit plot, Fig. 4, falls below the "A" line or the plasticity index is less than 4.

12.4.3 If the fines plot as a silty clay, CL-ML, classify the soil as a *silty, clayey gravel*, GC-GM, if it is a gravel or a *silty, clayey sand*, SC-SM, if it is a sand.

12.5 If 5 to 12 % of the test specimen passes the No. 200 (75-μm) sieve, give the soil a dual classification using two group symbols.

12.5.1 The first group symbol shall correspond to that for a gravel or sand having less than 5 % fines (GW, GP, SW, SP), and the second symbol shall correspond to a gravel or sand having more than 12 % fines (GC, GM, SC, SM).

12.5.2 The group name shall correspond to the first group symbol plus "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example, well-graded gravel with clay, GW-GC; poorly graded sand with silt, SP-SM (See 9.8.2.1 if insufficient material available for testing).

NOTE 10—If the fines plot as a *silty clay*, CL-ML, the second group symbol should be either GC or SC. For example, a poorly graded sand with 10 % fines, a liquid limit of 20, and a plasticity index of 6 would be classified as a poorly graded sand with silty clay, SP-SC.

12.6 If the specimen is predominantly sand or gravel but contains 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, clayey sand with gravel.

12.7 If the field sample contained 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.

13. Report

13.1 The report should include the group name, group symbol, and the results of the laboratory tests. The particle-size distribution shall be given in terms of percent of gravel, sand, and fines. The plot of the cumulative particle-size distribution curve shall be reported if used in classifying the soil. Report appropriate descriptive information according to the procedures in Practice D 2488. A local or commercial name or geologic interpretation for the material may be added at the end of the descriptive information if identified as such. The test procedures used shall be referenced.

NOTE 11—*Example: Clayey Gravel with Sand and Cobbles* (GC)—46 % fine to coarse, hard, subrounded gravel; 30 % fine to coarse, hard, subrounded sand; 24 % clayey fines, LL = 38, PI = 19; weak reaction with HCl; original field sample had 4 % hard, subrounded cobbles; maximum dimension 150 mm.

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

Geologic Interpretation—alluvial fan.

NOTE 12—Other examples of soil descriptions are given in Appendix X1.

14. Precision and Bias

14.1 Criteria for acceptability depends on the precision and bias of Test Methods D 422, D 1140 and D 4318.

15. Keywords

15.1 Atterberg limits; classification; clay; gradation; gravel; laboratory classification; organic soils; sand; silt; soil classification; soil tests

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF DESCRIPTIONS USING SOIL CLASSIFICATION

X1.1 The following examples show how the information required in 13.1 can be reported. The appropriate descriptive information from Practice D 2488 is included for illustrative purposes. The additional descriptive terms that would accompany the soil classification should be based on the intended use of the classification and the individual circumstances.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—73 % fine to coarse, hard, subangular gravel; 23 % fine to coarse, hard, subangular sand; 4 % fines; Cc = 2.7, Cu = 12.4.

X1.1.2 *Silty Sand with Gravel (SM)*—61 % predominantly fine sand; 23 % silty fines, LL = 33, PI = 6; 16 % fine, hard, subrounded gravel; no reaction with HCl; (field sample smaller than recommended). *In-Place Conditions*—Firm, stratified and contains lenses of silt 1 to 2 in. thick, moist, brown to gray; in-place density = 106 lb/ft^3 and in-place moisture = 9 %.

X1.1.3 *Organic Clay (OL)*—100 % fines, LL (not dried) = 32, LL (oven dried) = 21, PI (not dried) = 10; wet, dark brown, organic odor, weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—74 % fine to coarse, hard, subangular reddish sand; 26 % organic and silty dark-brown fines, LL (not dried) = 37, LL (oven dried) = 26, PI (not dried) = 6, wet, weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—78 % fine to coarse, hard, subrounded to subangular gravel; 16 % fine to coarse, hard, subrounded to subangular sand; 6 % silty (estimated) fines; moist, brown; no reaction with HCl; original field sample had 7 % hard, subrounded cobbles and 2 % hard, subrounded boulders with a maximum dimension of 18 in.

X2. USING SOIL CLASSIFICATION AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, ETC.

X2.1 The group names and symbols used in this standard 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, etc.).

X2.2 Materials such as shells, crushed rock, slag, etc., should be identified as such. However, the procedures used in this standard for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, a classification in accordance with this standard may be assigned to aid in describing the material.

X2.3 If a classification is used, 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 soil classifications could be incorporated into a description system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2- to 4-in. pieces of shale from power auger hole, dry, brown, no reaction with HCl. After laboratory processing by slaking in water for 24 h, material classified as "Sandy Lean Clay (CL)"—61 % clayey fines, LL = 37, PI = 16; 33 % fine to medium sand; 6 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"—91 % fine to medium sand; 9 % silty (estimated) fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—62 % gravel-size broken shells; 31 % sand and sand-size shell pieces; 7 % fines; would be classified as "Poorly Graded Gravel with Sand (GP)".

X2.4.4 *Crushed Rock*—Processed gravel and cobbles from Pit No. 7; "Poorly Graded Gravel (GP)"—89 % fine, hard, angular gravel-size particles; 11 % coarse, hard, angular sand-size particles, dry, tan; no reaction with HCl; Cc = 2.4, Cu = 0.9.

X3. PREPARATION AND TESTING FOR CLASSIFICATION PURPOSES BY THE WET METHOD

X3.1 This appendix describes the steps in preparing a soil sample for testing for purposes of soil classification using a wet-preparation procedure.

X3.2 Samples prepared in accordance with this procedure should contain as much of their natural water content as possible and every effort should be made during obtaining, preparing, and transportating the samples to maintain the natural moisture.

X3.3 The procedures to be followed in this standard assume that the field sample contains fines, sand, gravel, and plus 3-in. (75-mm) particles and the cumulative particle-size distribution plus the liquid limit and plasticity index values are required

(see 9.8). Some of the following steps may be omitted when they are not applicable to the soil being tested.

X3.4 If the soil contains plus No. 200 (75-μm) particles that would degrade during dry sieving, use a test procedure for determining the particle-size characteristics that prevents this degradation.

X3.5 Since this classification system is limited to the portion of a sample passing the 3-in. (75-mm) sieve, the plus 3-in. (75-mm) material shall be removed prior to the determination of the particle-size characteristics and the liquid limit and plasticity index.

X3.6 The portion of the field sample finer than the 3-in. (75-mm) sieve shall be obtained as follows:

X3.6.1 Separate the field sample into two fractions on a 3-in. (75-mm) sieve, being careful to maintain the natural water content in the minus 3-in. (75-mm) fraction. Any particles adhering to the plus 3-in. (75-mm) particles shall be brushed or wiped off and placed in the fraction passing the 3-in. (75-mm) sieve.

X3.6.2 Determine the air-dry or oven-dry weight of the fraction retained on the 3-in. (75-mm) sieve. Determine the total (wet) weight of the fraction passing the 3-in. (75-mm) sieve.

X3.6.3 Thoroughly mix the fraction passing the 3-in. (75-mm) sieve. Determine the water content, in accordance with Test Method D 2216, of a representative specimen with a minimum dry weight as required in 7.2. Save the water-content specimen for determination of the particle-size analysis in accordance with X3.8.

X3.6.4 Compute the dry weight of the fraction passing the 3-in. (75-mm) sieve based on the water content and total (wet) weight. Compute the total dry weight of the sample and calculate the percentage of material retained on the 3-in. (75-mm) sieve.

X3.7 Determine the liquid limit and plasticity index as follows:

X3.7.1 If the soil disaggregates readily, mix on a clean, hard surface and select a representative sample by quartering in accordance with Practice C 702.

X3.7.1.1 If the soil contains coarse-grained particles coated with and bound together by tough clayey material, take extreme care in obtaining a representative portion of the No. 40 (425-μm) fraction. Typically, a larger portion than normal has to be selected, such as the minimum weights required in 7.2.

X3.7.1.2 To obtain a representative specimen of a basically cohesive soil, it may be advantageous to pass the soil through a ¾-in. (19-mm) sieve or other convenient size so the material can be more easily mixed and then quartered or split to obtain the representative specimen.

X3.7.2 Process the representative specimen in accordance with Procedure B of Practice D 2217.

X3.7.3 Perform the liquid-limit test in accordance with Test Method D 4318, except the soil shall not be air dried prior to the test.

X3.7.4 Perform the plastic-limit test in accordance with Test Method D 4318, except the soil shall not be air dried prior to the test, and calculate the plasticity index.

X3.8 Determine the particle-size distribution as follows:

X3.8.1 If the water content of the fraction passing the 3-in. (75-mm) sieve was required (X3.6.3), use the water-content specimen for determining the particle-size distribution. Otherwise, select a representative specimen in accordance with Practice C 702 with a minimum dry weight as required in 7.2.

X3.8.2 If the cumulative particle-size distribution including a hydrometer analysis is required, determine the particle-size distribution in accordance with Test Method D 422. See 9.7 for the set of required sieves.

X3.8.3 If the cumulative particle-size distribution without a hydrometer analysis is required, determine the particle-size distribution in accordance with Method C 136. See 9.7 for the set of required sieves. The specimen should be soaked until all clayey aggregations have softened and then washed in accordance with Test Method C 117 prior to performing the particle-size distribution.

X3.8.4 If the cumulative particle-size distribution is not required, determine the percent fines, percent sand, and percent gravel in the specimen in accordance with Test Method C 117, being sure to soak the specimen long enough to soften all clayey aggregations, followed by Test Method C 136 using a nest of sieves which shall include a No. 4 (4.75-mm) sieve and a No. 200 (75-μm) sieve.

X3.8.5 Calculate the percent fines, percent sand, and percent gravel in the minus 3-in. (75-mm) fraction for classification purposes.

X4. AIR-DRIED METHOD OF PREPARATION OF SOILS FOR TESTING FOR CLASSIFICATION PURPOSES

X4.1 This appendix describes the steps in preparing a soil sample for testing for purposes of soil classification when air-drying the soil before testing is specified or desired or when the natural moisture content is near that of an air-dried state.

X4.2 If the soil contains organic matter or mineral colloids that are irreversibly affected by air drying, the wet-preparation method as described in Appendix X3 should be used.

X4.3 Since this classification system is limited to the portion of a sample passing the 3-in. (75-mm) sieve, the plus 3-in. (75-mm) material shall be removed prior to the determination of the particle-size characteristics and the liquid limit and plasticity index.

X4.4 The portion of the field sample finer than the 3-in. (75-mm) sieve shall be obtained as follows:

X4.4.1 Air dry and weigh the field sample.

X4.4.2 Separate the field sample into two fractions on a 3-in. (75-mm) sieve.

X4.4.3 Weigh the two fractions and compute the percentage

of the plus 3-in. (75-mm) material in the field sample.

X4.5 Determine the particle-size distribution and liquid limit and plasticity index as follows (see 9.8 for when these tests are required):

X4.5.1 Thoroughly mix the fraction passing the 3-in. (75-mm) sieve.

X4.5.2 If the cumulative particle-size distribution including a hydrometer analysis is required, determine the particle-size distribution in accordance with Test Method D 422. See 9.7 for the set of sieves that is required.

X4.5.3 If the cumulative particle-size distribution without a hydrometer analysis is required, determine the particle-size distribution in accordance with Test Method D 1140 followed by Method C 136. See 9.7 for the set of sieves that is required.

X4.5.4 If the cumulative particle-size distribution is not required, determine the percent fines, percent sand, and percent gravel in the specimen in accordance with Test Method D 1140 followed by Method C 136 using a nest of sieves which shall include a No. 4 (4.75-mm) sieve and a No. 200 (75-μm) sieve.

X4.5.5 If required, determine the liquid limit and the plasticity index of the test specimen in accordance with Test Method D 4318.

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 = cobbles
	b = boulders

X5.4 The soil classification symbol is to be enclosed in parentheses. 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

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1998) that may impact the use of this standard.

(1) Added Practice D 3740 to Section 2.

(2) Added Note 5 under 5.5 and renumbered subsequent notes.

B-3. REFERENCES

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