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Sampling and Hydrogeology of the Vadose Zone Beneath the 300 Area Process Ponds

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Introduction

Four open pits were excavated with the aid of a backhoe (Figure 1) beneath the 300 Area Process Ponds in April, 2003.

Figure 1. Excavation at South Process Pond Pit #1.

A map showing the locations of the four pits is presented in Figure 2. These excavations provided an excellent opportunity to evaluate the hydrogeology and geochemistry of the vadose zone beneath the recently remediated waste-disposal ponds.

Figure 2. Location of four excavated pits within the 300 Area Process Ponds.

Pits were excavated to the water table between 10-22 ft bgs (Figure 3). Since the water table is essentially flat in this area, the differences in water table depth beneath the excavations must be a result of variable surface elevation.

Figure 3. View looking into South Process Pond Pit #2 from cab of backhoe. Pool of water at the bottom is the top of the water table, which was 18 feet below ground surface at this location.

Figure 4. Hard working support crew.

Methods

As pits were excavated, representative sediment samples were collected with the backhoe at two-foot increments and laid into piles on the ground next to the pit. The sediment piles were immediately surveyed for radiological contamination (Figure 5). With one exception, no radiation above background levels was detected with hand-held instruments. The single exception occurred at the North Process Pond, Pit #2, which registered some near-surface contamination.

Figure 5. Excavated sediment piles being surveyed at South Process Pond, Pit #1.

After each pit was excavated, sediment samples were collected about every four feet from the sediment piles (Figure 6, left), and a water sample collected by the backhoe from the bottom of the pit (Figure 6, right). Samples removed from below the water table generally lacked particles smaller than fine sand; this is because fines were washed out these unconsolidated materials and went into suspension in the pool of water at bottom of the pit during excavation. The material in each of the piles was examined and logged for the following characteristics:

- Folk-Wentworth sediment classification
- Munsell color
- sorting
- largest clast size
- relative basalt content
- unusual features

Figure 6. Sampling at the South Process Pond. Left: Sediment samples were laid out in separate piles every two feet as pits were deepened. Each pile was labeled according the depth onto a pin flag. Right: muddy groundwater samples, removed from the bottom of the pits, were collected from the bucket of the backhoe.

Only sediment passing through a coarse, wire-mesh screen was included in samples that went into the plastic buckets (Figure 7). This included particles less than or equal to the size of small pebbles.

Figure 7. Four sediment samples, one about every four feet, were collected from the vadose zone in each pit. The coarser gravel fraction was removed by passing through a coarse wire-mesh screen. Right: coarser fraction sieved out.

Stratigraphy and Lithology

The vadose-zone sediments within the 300 Area consist entirely of coarse-grained Hanford formation, which was deposited during one or more Pleistocene cataclysmic floods. Generally loose, clast-supported, muddy sandy gravel was the predominant sediment type; lenses of matrix-supported gravelly sand occurred sporadically. The terms "mud" and "muddy" are used to describe undifferentiated silt- to clay-sized particles. Gravel clasts ranged from pebble to boulders up to several feet in diameter; most are subangular to subrounded and covered with a thin coating of mud. Material filling the matrices between gravel clasts was highly variable and consisted of a poorly to moderately sorted mixture of mud and/or fine to coarse sand. The mineralogy of the sand-sized particles consisted of 70-90% dark gray to black basalt (Figure 8), typical for the Hanford formation in this area.

Figure 8. Coarser sediment grains consist of predominantly basaltic rock fragments. Penny for scale.

Gravel-sized clasts are also composed predominantly of basalt with lesser amounts of other volcanic as well as qranitic and metamorphic clasts. Another clast type, unique to the flood deposits, are rounded rip-up clasts of semi-consolidated, fine-grained Ringold Formation. These include clasts of calcium-carbonate-cemented caliche, as well as clasts of compacted mud, originally deposited during Ringold time in either floodplain or lake environments (Figure 9). These same types of sediment are exposed in the Ringold Formation within the White Bluffs immediately across the river, as well as upstream of the 300 Area. Generally, Ringold rip-up clasts are larger than adjacent clasts (Figure 10), reflecting their short transport distance and lower bulk density, in contrast to lithified clasts. The fact that the rip-up clasts are rounded indicates they were transported as detrital material, along with other materials, during flooding.

Figure 9. Two types of rounded Ringold Formation rip-up clasts. Left: compact, finely laminated, lacustrine mud (i.e., undifferentiated silt and clay). Right: massive, pedogenically altered and weathered mud. Note abundant root traces filled with reddish iron oxide and white calcium carbonate, which developed in a floodplain-paleosol-type of environment during Ringold time around 3-5 million years ago. Identical sediment types are exposed in the White Bluffs across and upstream of the 300 Area. These semi-consolidated, detrital clasts were eroded off the White Bluffs and transported to the 300 Area during one or more cataclysmic, Ice-Age floods.

Figure 10. Concentration of Ringold rip-up clasts (circled), which rolled off the top of sediment pile. From 10 ft depth in South Process Pond, Pit #2. About half the volume from the backhoe bucket at this depth was composed of Ringold rip-up clasts. Notice most rip-up clasts are significantly larger than other clasts. Some of the less-consolidated rip-up clasts broke apart during excavation.

Because contaminants may have an affinity for mud-sized particles, the character and distribution of concentrated fine-grained material in the subsurface is important. While clast-supported, pebble to boulder gravel is the dominant sediment size in the 300 Area, the matrix between gravel clasts varies significantly between relatively permeable, gray to black basaltic sand to relatively impermeable brownish mud (Figure 11). Color is an indication of the type of matrix present. The color most often associated with coarse-grained facies of the Hanford formation is dark gray to black, due to a composition of mostly unweathered basaltic rock fragments eroded off the Channeled Scabland during Pleistocene flooding. Normally, flood deposits do not contain appreciable amounts of fine-grained mud, especially in the coarse facies. This is probably because fine-grained particles tend to go into suspension and are quickly flushed out of the basin with the floodwaters during flooding.

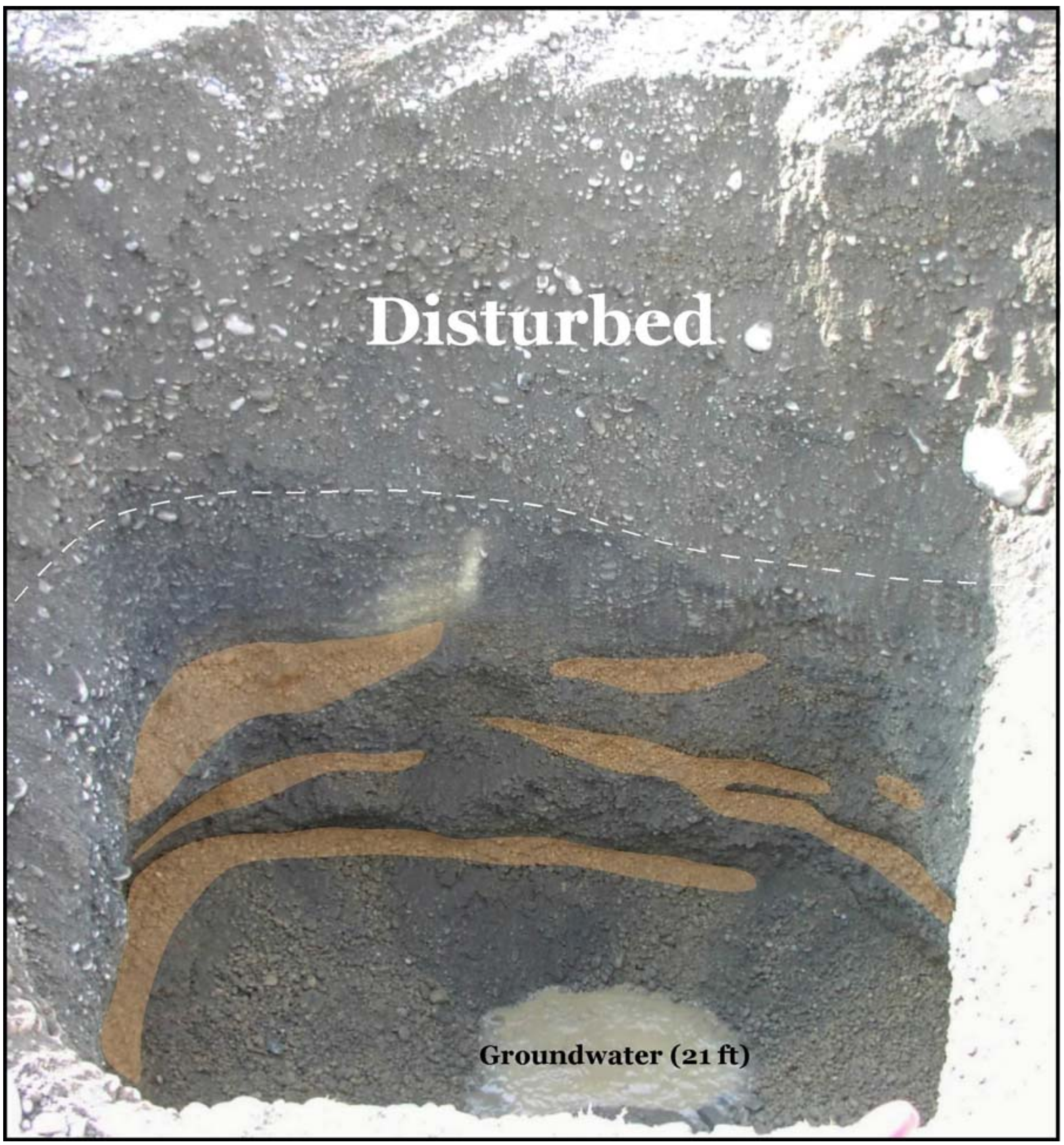

Figure 11. Example of the two different types of matrix fill that occurs within the gravelly facies of the Hanford formation in South Process Pond, Pit #1. In the brown intervals, matrices are filled with reworked Ringold mud, while gray intervals are filled with more permeable basaltic sand.

However, the character of the flood sediment is different in 300 Area and, unlike most other flood deposits, for it does have more concentrated fines in the form of rip-up clasts as well as beds with fine-grained, brown-colored, matrix filling Ringold materials (Figure 11). The brown color, derived from the Ringold Formation, is the result of much long period of weathering - over many millions of years compared to the Hanford formation, which is mostly only about 13-18,000 years old. As mentioned, the fine-grained Ringold matrix is unusual for the Hanford formation and probably the result of the 300 Area being directly across the river and just downstream of an abundant supply of Ringold detritus during Ice-Age flooding. It is possible that some of the brown-colored, fine-grained intervals may be associated with concentrations of Ringold rip-up clasts that disintegrated during or soon after deposition by the floods. Rip-up clasts are relatively unconsolidated and, not surprisingly, don't survive flood transport far from their source, which is why they are rarely observed inland of the 300 Area and the Columbia River.

Flood deposits of the Hanford formation in the 300 Area are relatively heterogeneous and anisotropic. Some weak bedding and stratification was apparent in excavated pit exposures. However, because of the complex hydrodynamics involved in cataclysmic flooding, individual beds do not appear to extend far laterally. For example, in Figure 11 individual beds are discontinuous across the width of the trench.

Two unusual features observed in materials extracted from the excavated pits include: 1) dark weathering rinds on cemented micaceous sandstone clasts of the Ringold Formation, and 2) clumps of dark organic(?)-rich material in the sediment matrix. The weathering rinds (Figure 12) appear to be composed of an iron and/or manganese oxide. This type of weathering rind was observed only on cemented Ringold sandstone clasts. The weathering rind must have developed *in situ* since the Pleistocene, because of the loose, powdery nature of this surface, which would have been destroyed during flood transport.

Figure 12. Unusual weathering rinds on cemented Ringold clasts. Left: 2-ft diameter, micaceous, cemented sandstone boulder from 17 ft depth in Pit #2. Boulder was split open with the blade of the backhoe showing an unusually thick, dark reddish brown weathering rind around the outside. Right: micaceous cemented conglomeratic sandstone boulder with a dark weathering rind, from 8 f t depth in North Process Pond, Pit #1.

The clumps of loose, dark brown, decomposed organic(?)-rich material in some of the sediment matrix are illustrated in Figure 13. These aggregates appeared in the sediment piles either in isolated clumps (Figure 13, right) or within Ringold rip-up clasts (Figure 13, left). It is possible that this material is not organic at all but a weathering product (i.e., iron and/or manganese oxide). I collected a sample of this material, which so far has not been chemically analyzed. This sample is still available for analysis to anyone interested in examining further.

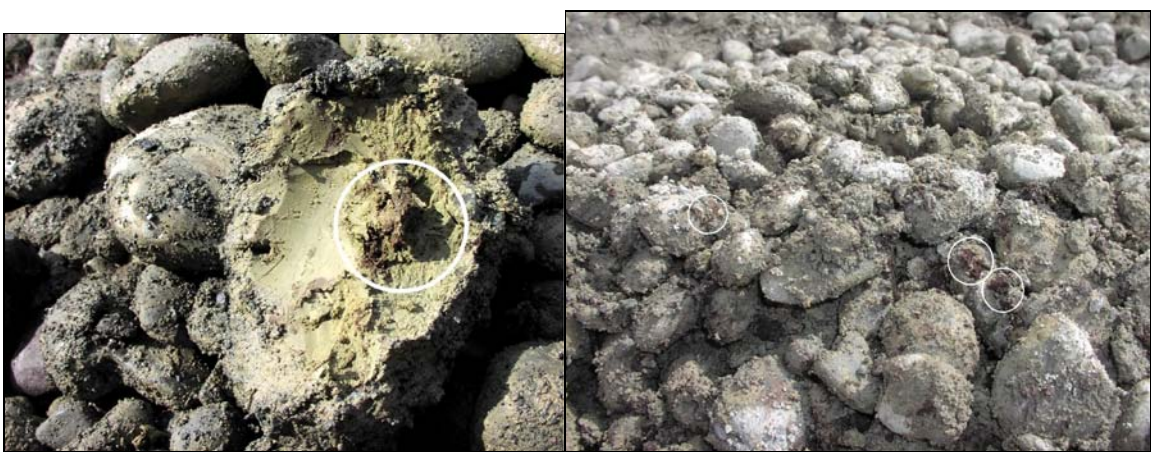

Figure 13. Decomposed organic matter(?).Left: clump of dark brown organic(?) matter(circled), embedded in a rip-up clast composed of olive-colored compact mud. Clast probably came from a Ringold paleosol, which was later worn away and transported during Ice-Age flooding Right: dark organic(?) clumps (circled) are dispersed throughout the sediment pile. Both examples from South Process Pond, Pit #1.

Sediments in both pits appeared to be uniformly moist all the way to the water table. Normally, coarse-grained facies of the Hanford formation in the vadose zone are dry to slightly moist at depths beyond several feet of ground surface. Apparently, increased moisture was present in these pits as a result of water applied at the surface, for dust control, in the days preceding pit excavation.

South Process Pond

A summary sampling and geologic log for the two pits within the South Process Pond is presented in Figure 14. Composite photographs of the excavations along with close-up photos of the material from discrete depths are shown in Figures 15 (Pit #1) and Figure 16 (Pit #2).

The uppermost 5 ft in each of the trenches consisted of massive muddy sandy gravel. The lack of any internal structure in this interval suggested it is backfill material and/or material that was disturbed during clean-up operations that took place at the bottom of the former process pond. Below 5 ft are crudely stratified beds of clast-supported muddy sandy gravel to muddy gravel with minor lenses of gravelly sand. In Pit #1 there is an upper and lower interval, while in Pit #2 there is a single thick interval with Ringold rip-up clasts. Many giant rip ups occurred at about 10 ft depth in Pit #2 (Figure 16). A mud-dominated matrix occasionally, but not always, occurs near zones with concentrations of rip ups. Intervals with a mud-dominated matrix are brown to grayish brown in color (Figure 14).

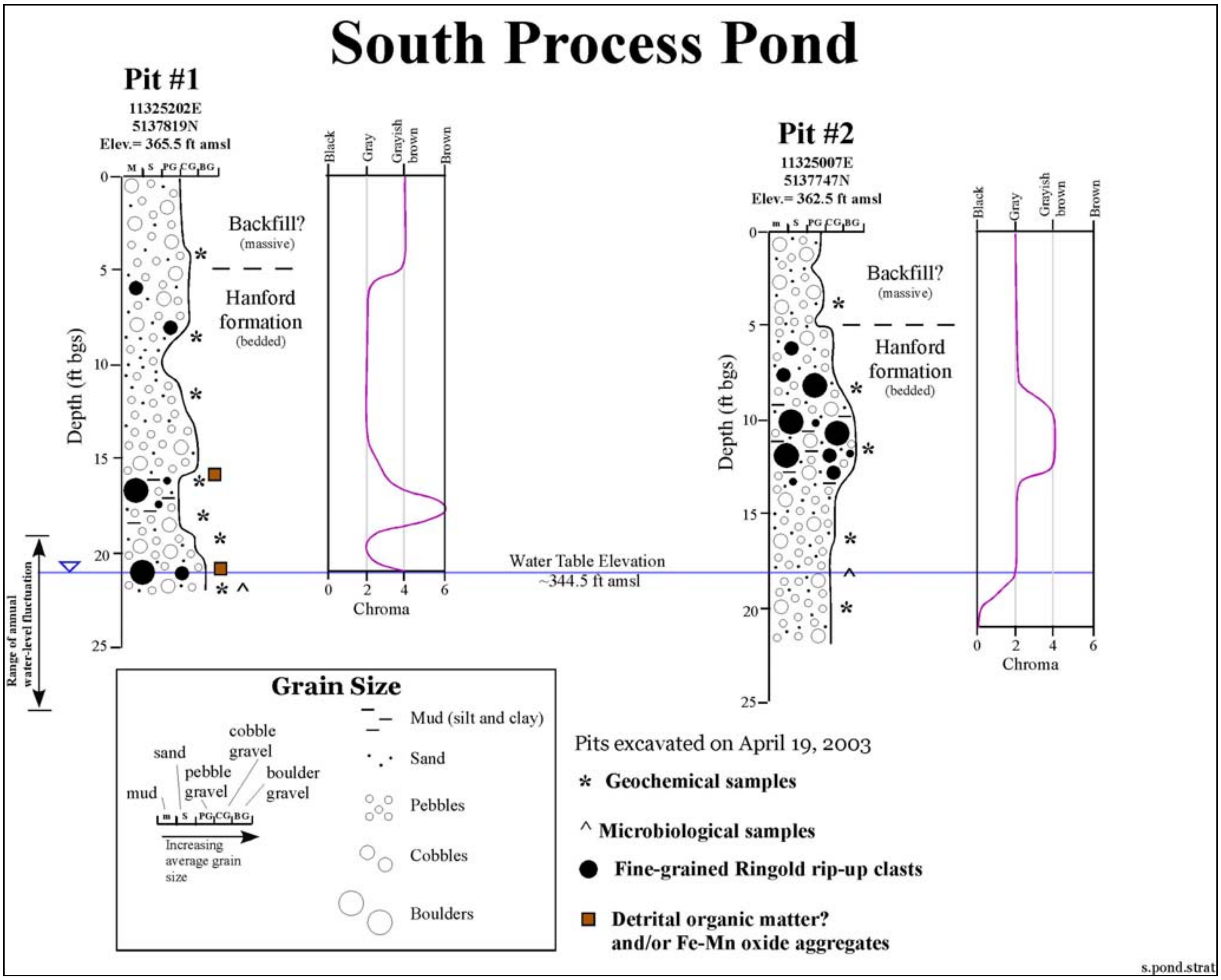

Figure 14. Summary logs for the two South Process Pond pit excavations.

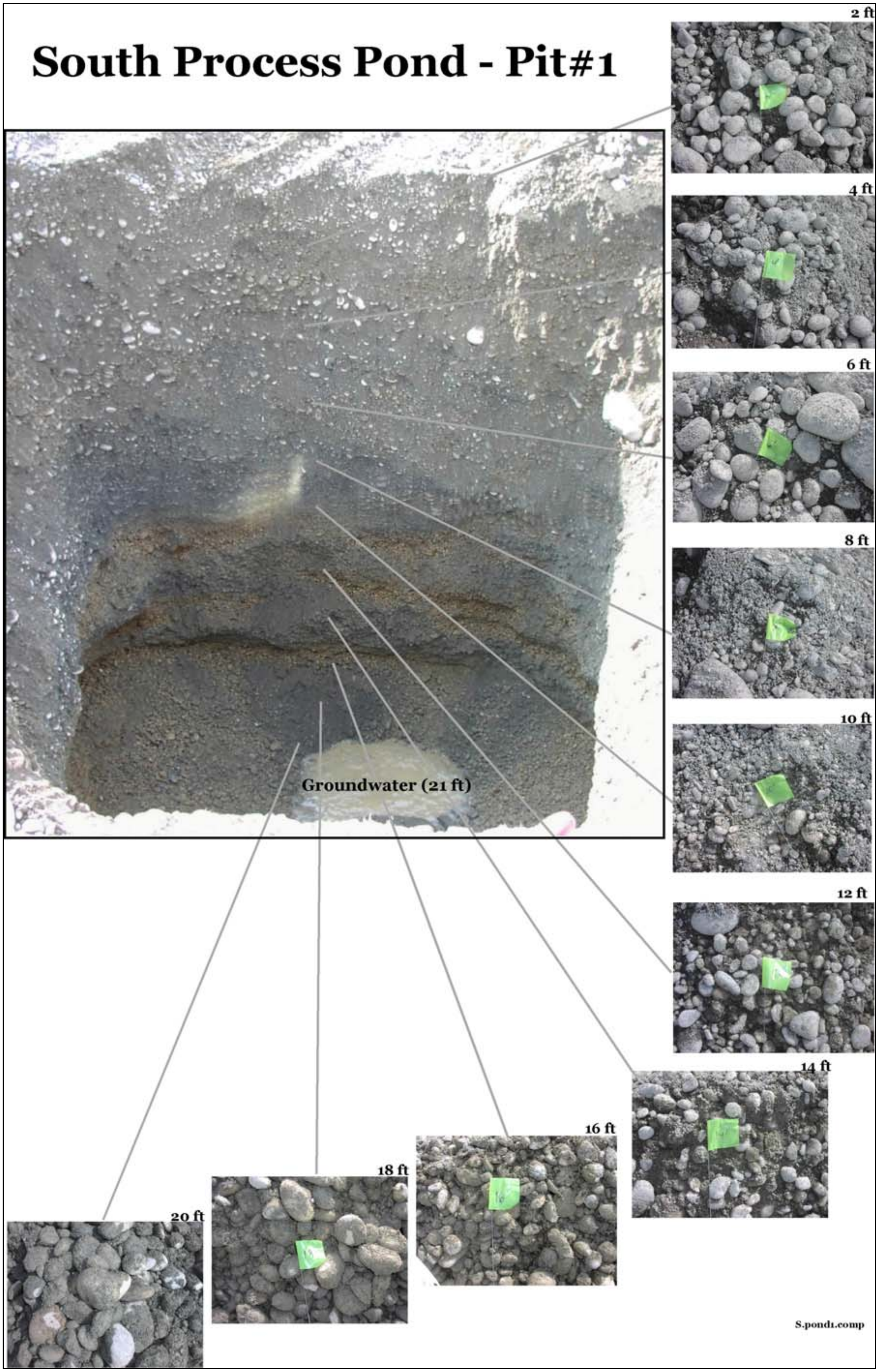

Figure 15. South Process Pond Pit, #1.

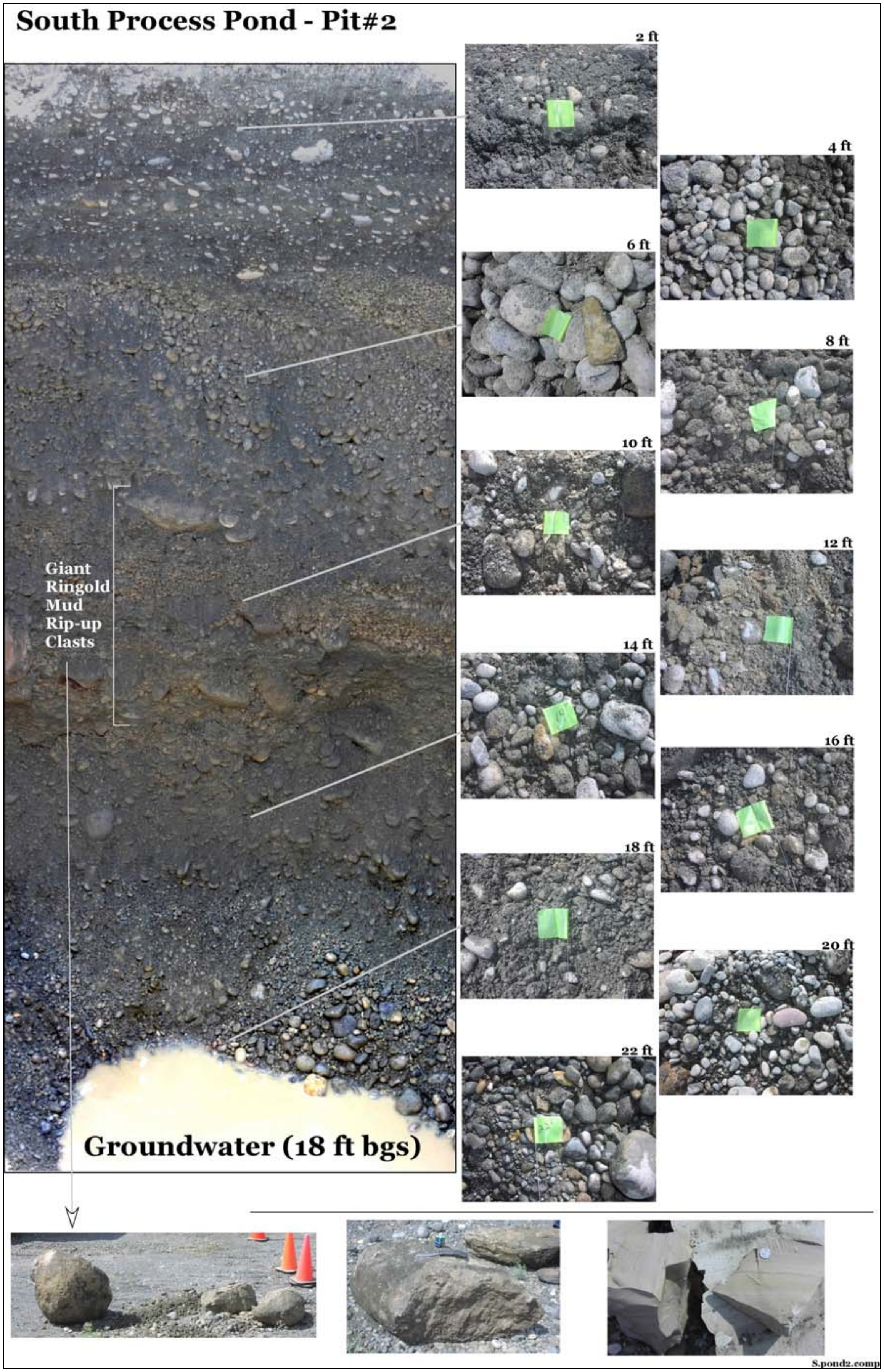
South Process Pond - Pit#2
2 ft
4 ft
6 ft
8 ft
10 ft
12 ft
14 ft
16 ft
18 ft
20 ft
22 ft
Giant
Ringold
Mud
Rip-up
Clasts
Groundwater (18 ft bgs)
S.pond2.comp

Figure 16. South Process Pond Pit, #2.

North Process Pond

A summary sampling and geologic log for the two pits within the North Process Pond is presented in Figure 17. Composite photographs of the excavations along with close-up photos of the material from discrete depths are shown in Figures 18 (Pit #1) and Figure 19 (Pit #2).

The uppermost 5 ft in Pit #1 consisted of massive muddy sandy gravel. The lack of any internal structure in this interval suggested it is backfill material and/or material that was disturbed during clean-up operations that took place at the bottom of the former process pond. In Pit #2, on the other hand, bedded Hanford formation appears to extend all the way to the surface suggesting little or no disturbance occurred at the surface here. Below the zone of disturbance lie crudely stratified beds of clast-supported muddy sandy gravel to muddy gravel with minor lenses of gravelly sand. In Pit #1 some large Ringold rip-up clasts occur between 4-8 ft bgs, and a well-defined, relatively thick (6 ft), muddy, yellowish-brown matrix-filled zone occurs between 11-17 ft bgs (Figure 18).

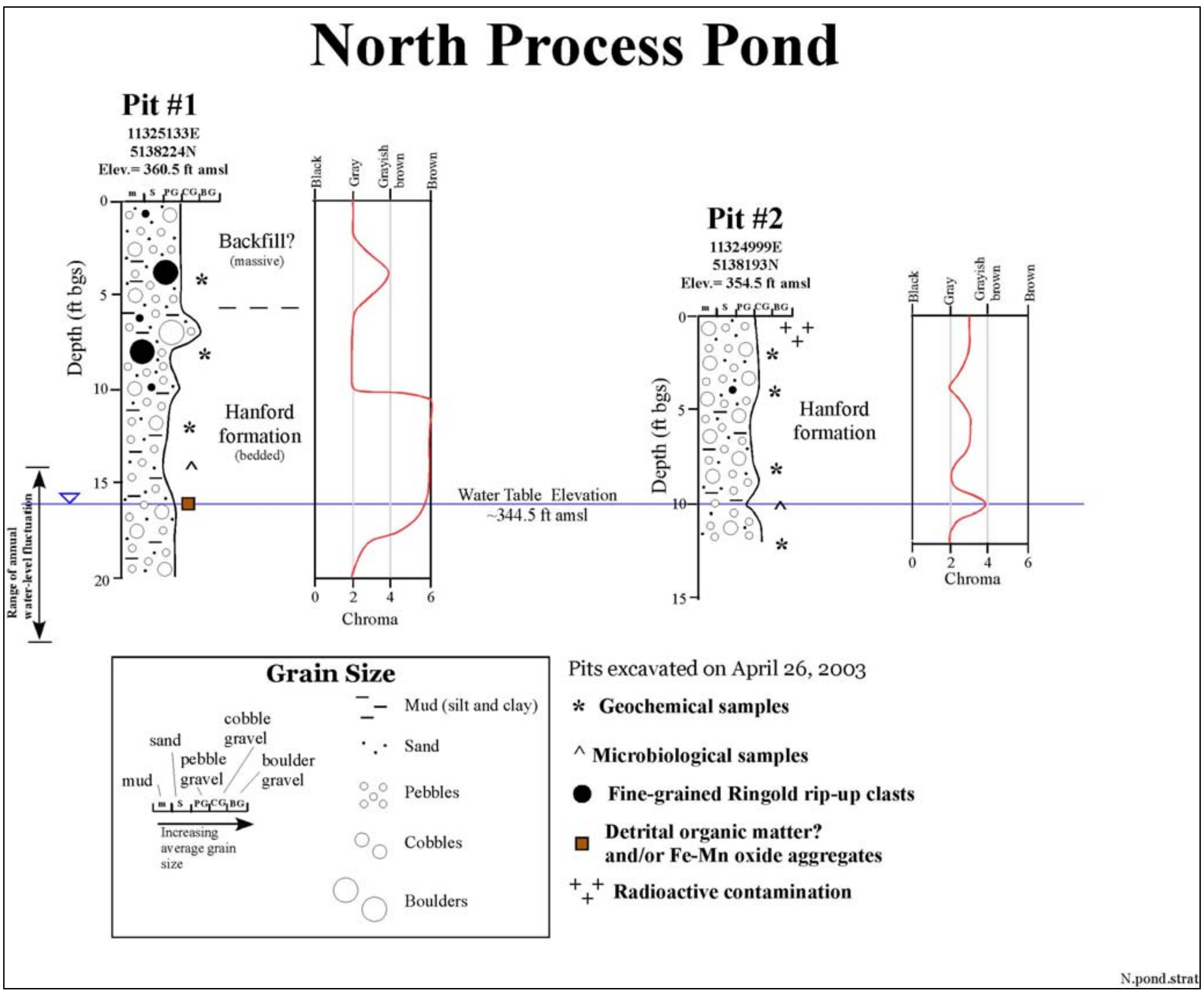

Figure 17. Summary logs for the two North Process Pond pit excavations.

North Process Pond - Pit #1

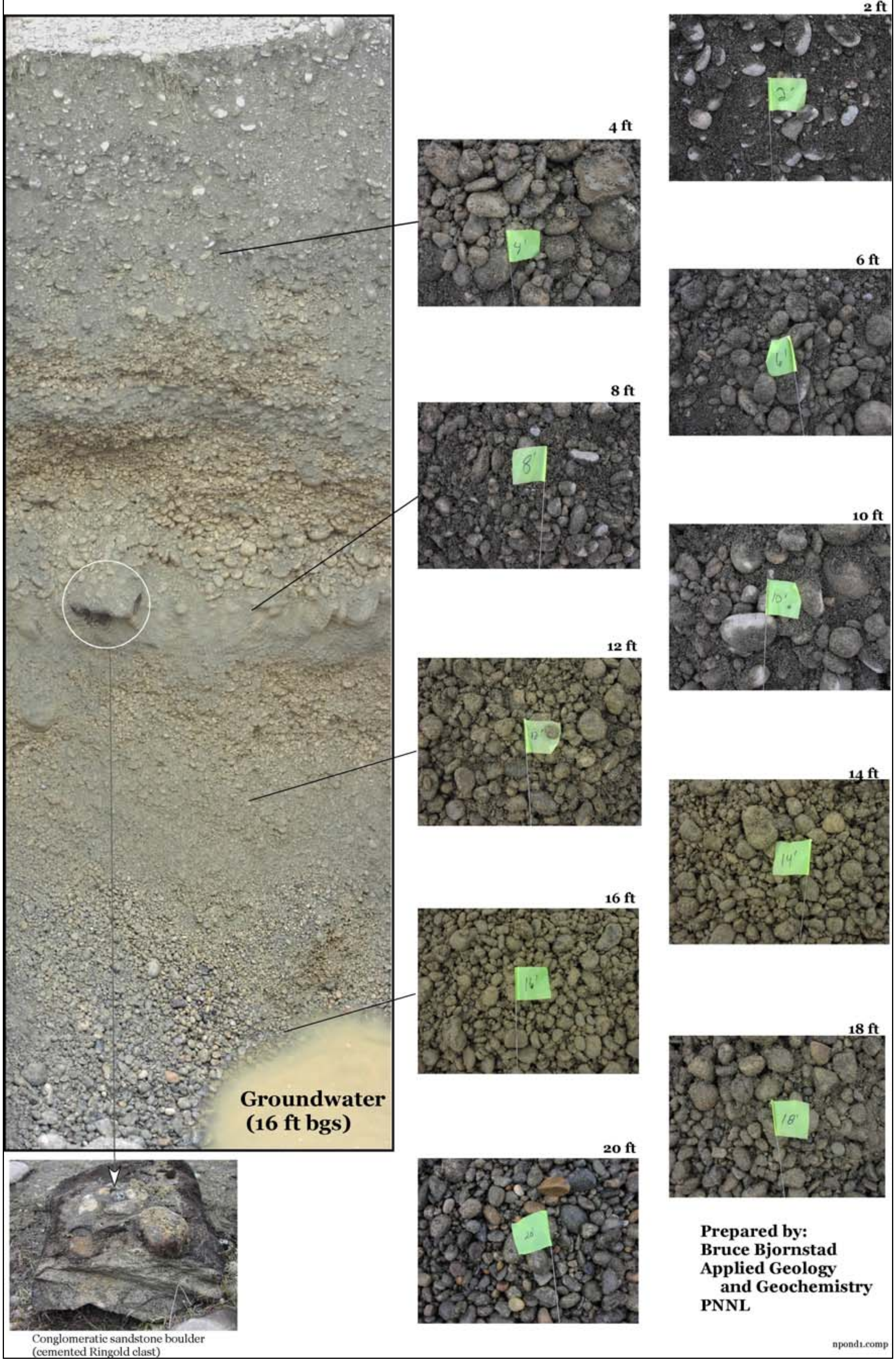

Figure 18. North Process Pond Pit, #1.

North Process Pond - Pit #2

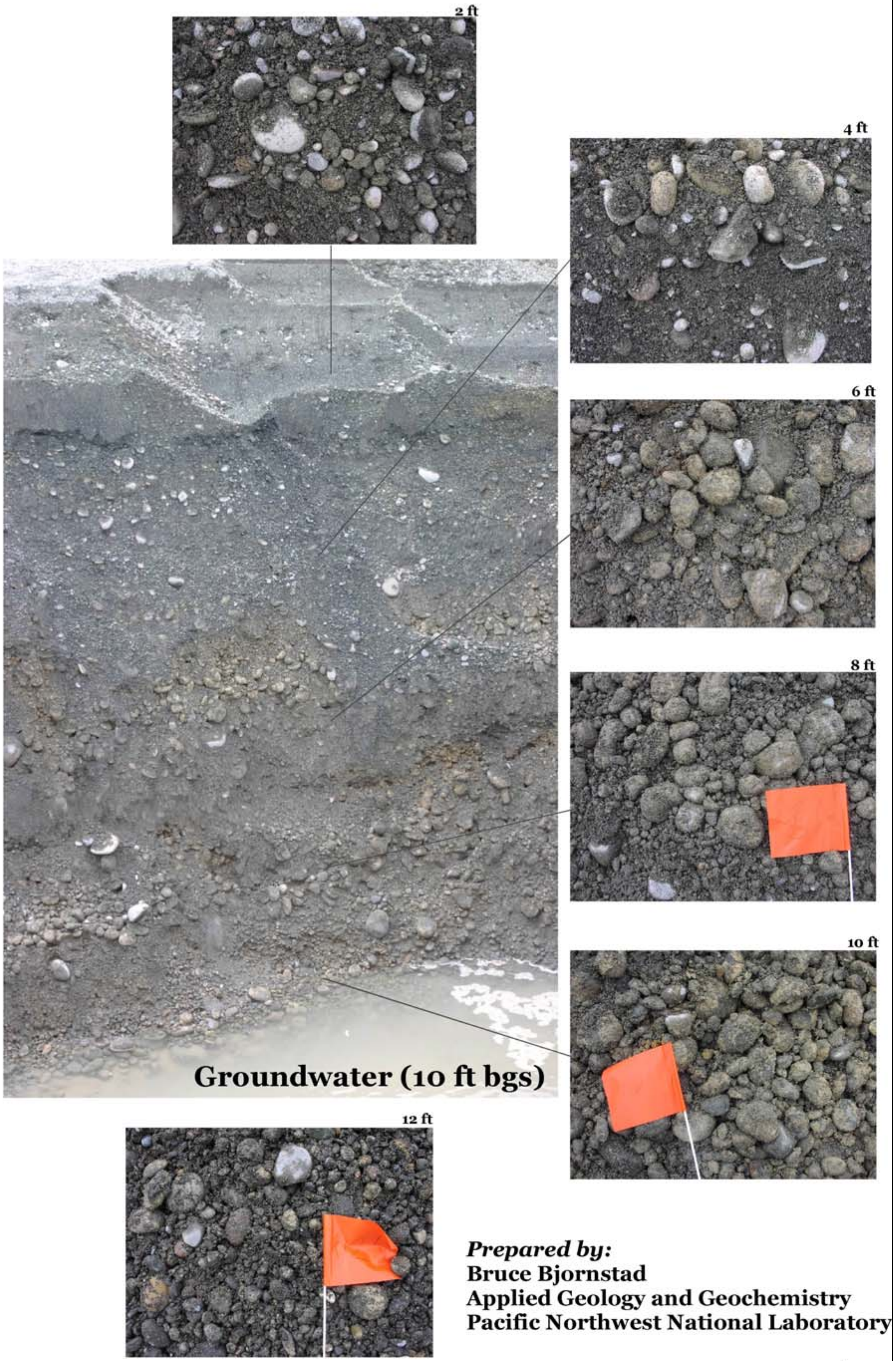

Figure 19. North Process Pond Pit, #2.

In Pit #2 radioactive contamination was found, associated with a greenish-colored mineral observed at and just below the surface (Figure 20). The mineralization was described by one on-site worker, with many years of clean-up experience in the 300 Area Process Ponds, as copper uranyl phosphate. The contamination was not found below a few feet of the surface.

Figure 20. Near-surface contamination encountered at north pond, pit #2. Radioactive contamination appears to be associated with green-colored mineralization only observed in the upper few feet in this excavation.