APPENDIX I:

GEOARCHEOLOGICAL INVESTIGATIONS

GEOARCHEOLOGICAL INVESTIGATIONS AT THE FREDERICK LODGE SITE COMPLEX (7NC-J-97, 7NC-J-98, AND 7NC-J-99), SR 1 SMYRNA TO PINE TREE CORNERS, NEW CASTLE COUNTY, DELAWARE

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Introduction and Objectives

This report summarizes the results of geoarcheological investigations at the Frederick Lodge Site Complex (7NC-J-97, 7NC-J-98 and 7NC-J-99). These investigations were performed under contract to Parsons Engineering Science, Inc. as part of the DelDOT SR-1 project. Phase II studies were completed in the fall of 1999 and identified key environmental and site formation problems at the site complex (Schuldenrein 1999a). A formal research design was then prepared for the Phase III investigations (Schuldenrein 1999b), with the following general objectives:

- Development of a comprehensive stratigraphic framework for the site complex;
- Reconstruction of environmental trends preserved in the depositional sequences;
- Modeling site formation histories for the loci investigated;
- Presentation of a comprehensive perspective on human/environmental interactions at the site complex

This study utilizes contemporary landform relationships and subsurface chronologies and stratigraphies to formulate an overarching model of landscape history through time. To facilitate the presentation, standard earth science terminologies are utilized for characterizing landform segments and especially slopes (Summerfield 1991 and references). Subsurface sequences are described in terms of soil development (after Birkeland 1999; Buol et al 1997) and lithostratigraphy (after ISG 1994), depending on degree of subsurface weathering of deposits.

Archaeological sites 7NC-J-97, 7NC-J-98 and 7NC-J-99 span adjacent crest to midslope interfluves overlooking two bay/basins at the base of the landform (see Figure 1). Prehistoric cultural material and activity areas are dispersed with variable degrees of integrity within deposits of the interfluves and several slope contexts. Origins of the sediments are mixed, the product of colluvial, aeolian and alluvial sedimentation. Accordingly, the archeological sequence was arranged laterally as well as vertically within the relatively shallow sandy to fine sandy loam deposits. Pits and areas of staining were the result of geogenic or biogenic as well as anthropogenic site formation processes. Preservation of humic and eluvial horizons as well as weak Cambic (Bw) horizons signify long term podsolization, but multiple, albeit weakly developed soils point to disruption of pedogenesis and intervals of active sedimentation at the site. Deposition is related to primary occupations as well as to site abandonment sequences. Charcoal was poorly preserved, often in secondary contexts, and did not always correspond to ages of the occupations. Examination of the archeological assemblages in conjunction with the site stratigraphies has nevertheless provided results which can be used to test hypotheses about Holocene landscape history and regional environmental change as well as the taphonomy and site formation chronologies of the various site loci.

Figure 1. Project location as shown on USGS 7.5' Clayton Quadrangle.

Research Design and Field Methods

The Research Design for the present investigations was based on a provisional stratigraphic model developed over the course of Phase II testing (Schuldenrein 1999a, 1999b). The model was tested and refined in two stages during a field season that extended between December, 1999 and February, 2000. Stage 1 focused on refinement of stratigraphic relations by running three (3) stratigraphic transects across environmentally diagnostic and culturally sensitive locations across the site landscape. Stage 2 addressed locus specific

concerns, identifying those settings most appropriate for environmental reconstruction (in the case of landscape segments) and those furnishing information on anthropogenic activity and sedimentation.

The transects followed for Stage 1 are shown in Figure 2. They consisted of a series of strategically emplaced borings and (archeologically) excavated field units. As inspection of the excavation units and cores proceeded and archeological contexts became apparent the orientations of the three (3) transects were modified to accommodate key landform or stratigraphic breaks and/or loci of archeological significance. The transects ran as follows:

- NW-SE transect between N380 E420 and N210 E845;
- SW-NE transect between N220 E420 and N360 E600;
- N-S transect between N350 E715 and N140 E715;

The NW-SE geoarcheological transect (Transect 1) was modified to subsume the highest portions of the landscape trailing into the eastern margin of the primary bay/basin. The SW-NE transect (Transect 2) cross-cut the secondary bay/basin to document edaphic and soil-sedimentary changes across the most abrupt terrain in the project area. Both transects cut across the high landform that featured significant distributions of Woodland prehistoric materials. The third (N-S) transect incorporated several excavation units on the ridge crest which yielded the highest concentration of earlier (Archaic) materials and also intersected with Transect 1 at these archeologically rich loci; it extends south across a complex of buried features to an artificial pond excavated in the southeastern bay/basin and well into that landform.

In all, over sixty (60) excavation units were investigated by the field geoarcheologists. Additionally, fifteen (15) excavation units aligned with the key transects were examined in considerable stratigraphic detail. Finally, a total of nine (9) core borings were excavated to depths of up to 3 m and two backhoe trenches aligned with the western portion of Transect 1 were viewed and described in varying detail (for safety reasons). Figure 2 shows the locations of all excavation units, specifically diagnostic excavation units along initial and modified transects (red); augur borings (green), and backhoe trenches (blue).

At the conclusion of Stage 1, the transect coverage facilitated separation of broad landform/sediment units for the Frederick Lodge site complex. These units are of archeological significance insofar as they present the matrix contexts for primary archeological sediments in either buried or near surface context. The following units were recognized:

- Columbia Gravels
- Active or infilled bay/basin (silts and clays)
- Colluviated bay/basin margins (juncture of footslope and basin edge)
- Aeolian mantle (up to 1 m thick; culturally sterile) (early Holocene?)
- Colluvium (footslope locations)
- Cultural loci
    - Archaic
    - Woodland

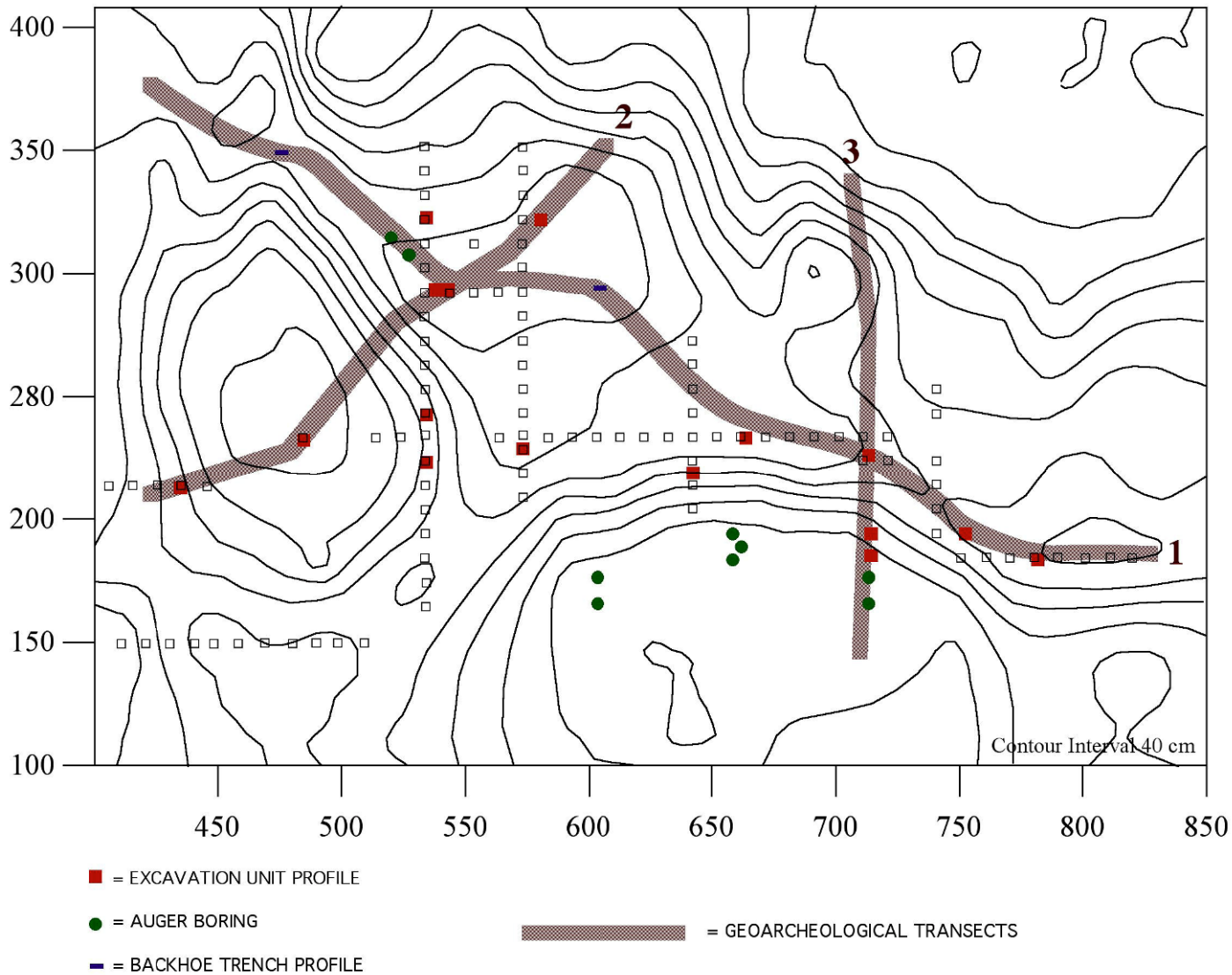

Figure 2. Configuration of Transects & Distribution of Excavation Units, Cores, & Backhoe Trenches at the Frederick Lodge Site (Stage 1).

The Stage 2 effort involved micro-stratigraphic mapping and soil-sediment sampling at key loci, principally the excavation blocks (Figure 3: Blocks A-G, I, and K). The specific field and laboratory tasks performed included:

- Description of stratigraphic exposures at ten (10) block locations and select settings along interfluve margins and bay/basins. The blocks and geomorphic settings provide a landscape and chronological context for the site complex;
- Radiometric sampling for absolute dates;
- Sediment and soil sampling and laboratory analysis to identify primary depositional (alluvial, colluvial, aeolian, etc.) and soil environments as well as post-depositional perturbation mechanisms by living organisms and soil processes.
- Chemical analysis to identify cultural features and to frame the archeological interpretation of the prehistoric activities that may have produced them.

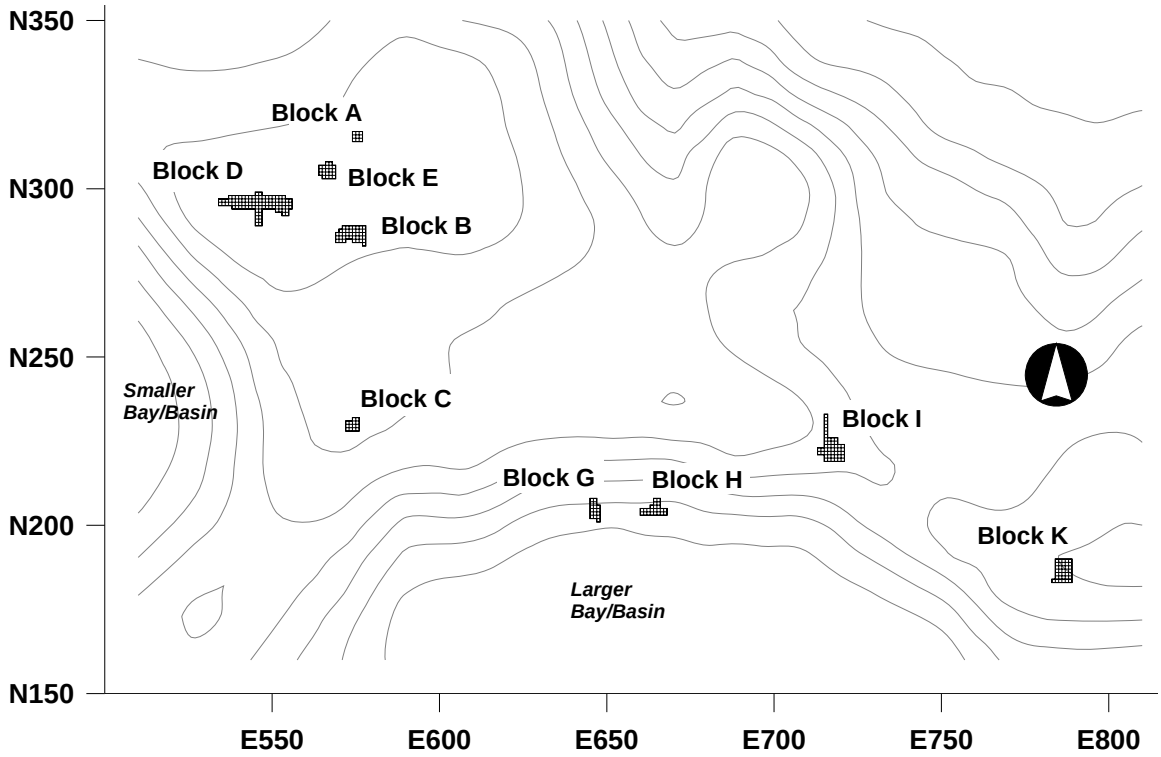

Figure 3. Block Map, Frederick Lodge Site Complex.

In the field, soil-stratigraphies were utilized, following the criteria in Soil Survey Staff (1993, 1994). Soil stratigraphies were followed for field recording purposes only, as depositional variability, facies variation, landform complexity, and subtle archeological horizonation suggested that an allostratigraphic scheme was more comprehensive (see subsequent discussion).

The sediment texture of each horizon was recorded in classes such as silt loam, fine sandy loam, silty clay loam, etc. (Birkeland 1999:10-11; Soil Survey Staff 1993). Color was recorded moist using the Munsell chart. The structure of each soil horizon was characterized in terms of the shape and size of peds (Birkeland 1999:12). Where structure was poorly

developed or not present, more attention was paid to sedimentological attributes such as bedforms and depositional sorting within a horizon (Reineck and Singh 1986). Boundaries between horizons were characterized in terms of both distinctness and topography (Birkeland 1999:356), with particular attention focused on boundaries that defined the tops of buried soils in each profile.

The profiles sampled for sedimentological and geochemical analyses were in all landscape positions, ranging from interfluve crests (ie. Block A; Figure 3) to mid-slopes (Block C) and bay/basin margins (Block F). For the interfluves—midslope to crest positions--profiles were sampled from the Columbia Formation sand and gravel beds upward through all of the natural soil horizons on the sites. At the bay/basin margins, sampling was more restricted, since deep sampling was precluded and the sequences were clearly of recent to later Holocene age. The maximum interval between samples was 30 cm, such that horizons thicker than that were split (e.g. 2AB1, 2AB2).

Physiographic and Geological Setting

Physiographically, the Frederick Lodge Site Complex is at the margins of the Mid-Drainage and Drainage Divide zones. This portion of the Delaware Coastal Plain is underlain by the Columbia Formation, which is dominated by unconsolidated and heavily reworked sands and gravels of Pleistocene age (Groot and Jordan 1999). Surface soils along the higher portion of the site area have been mapped as the Sassafras Series sandy loam. The lower lying bay/basin soils are classified as Fallingston Series Sandy Loam (Mathews and Lavoie 1970).

The bay/basins are numerous and distinctive landscape features that are thought to have emerged at the close of the Pleistocene and have been extensively investigated for human ecological purposes in Delaware (Kellogg and Custer 1994). The key localities studied for such purposes, Nowakowski Pond and Walter's Puddle, are north of Blackbird Creek, ca. 3.8 km north of Frederick Lodge. A critical paleoecological finding in these local bay/basin investigations is that their pollen and lithostratigraphies suggest a turn to moist conditions after 6000 B.P. (Kellogg and Custer 1994:97) following a protracted interval of Early Holocene erosion. These interpretations are based on evidence for the emergence of high water tables in the bay/basin depressions during the Middle Holocene.

Currently, the bay/basins flanking the project area to the south are small to extensive surface depressions that retain surface water. The extent of historic disturbance and reuse of these features is unclear, as no subsurface probing was undertaken in the basins themselves. Their distributions across the site landscape are southwest of 7NC-J-98 and immediately south of 7NC-J-97 (Figure 3). The basin depressions are 2 to 3 meters deep.

Across the greater landscape, site landforms include crest locations at 7NC-J-98, mid-slope to footslope settings at 7NC-J-97, and an eastern spur to mid-slope locus at 7NC-J-99. This latter area is an arcuate bend straddling the 50-foot contour line. Local topography is hummocky, possibly reflecting Late Holocene to historic swales and drainage impoundments. Standing water was observed in these low areas. The unique topo-stratigraphic relations are significant because surficial deposits are the coarsest in the project area. The soil forming environment at 7NC-J-99 promoted lamellar weathering instead of the more typical Spodosol sequence favored by the finer-grained, loamy sand sediments

capping the western portions of the site complex. To the north is the site of Black Diamond (7NC-J-224), a crescentic dune landform geomorphically linked to the Frederick Lodge site complex.

Hydrographically, Frederick Lodge occupies a drainage divide between two Delaware Bay watersheds. The catchments to the south and east empty into the headwaters of Sawmill Branch, which empties into Smyrna Creek. Sandom Branch is a first order tributary of Blackbird Creek and drains to the north. Blackbird Creek, in turn, feeds into Delaware Bay approximately eight kilometers east of the confluence with Sandom Branch. The mouths of both trunk streams are embayments, consistent with the coastal drainageways dominant across central and lower Delaware. Site elevations at the Frederick Lodge complexes are on the order of 50 to 55 feet above mean sea level. Thus topo-stratigraphic relations for all landscape segments north of the bay/basins themselves reflect local dispositions of the Columbia Formation.

The lithostratigraphy of the Columbia Formation has been described in detail by Jordan (1964) and its identification was critical to indexing the depth of archeological sensitivity across the project area. Accordingly, field profiles were examined to see to what degree sedimentary structures, composition, texture and stratification conformed to criteria widely recognized for the Columbia Formation, specifically in the central portion of the state. Facies were recognized as being "..... essentially unconsolidated although locally there may be considerable differences in the degree of induration due to interstitial clay and/or iron oxides. Heavy bands of limonite-cemented conglomerate are common, especially towards the north. Colors range from white through yellow, tan and brown to reddish brown" (Jordan 1964:2). While only broad and generic descriptions have been invoked to isolate fluvial from shoreline estuarine facies, mapping and sedimentology verify that the interfluve crests (7NC-J-98) are underlain by a fluvial facies of the Columbia Formation (see Jordan 1964).

The present work verified that the upper segment of the interfluve was modified by aeolian activity and weathering during the Holocene. As discussed subsequently, the weathered aeolian deposits along mid-slopes preserved archeological features. The criteria invoked to isolate these from the older Columbia Formation are presented in a subsequent section. This is critical in establishing the context for depositional processes and weathering patterns for the critical 1-2 m of soils and sediments that preserve the archeological succession in slope and crest settings. As noted, finer soils weather into Cambic profiles, while coarser, bedded deposits sustain lamellar bedding whose origins are arguably pedogenic or sedimentary. The abundance of colluvial sediment renders locus-specific identification of the Columbia facies doubly significant for tracking weathering and archeological preservation patterns in the Holocene matrices.

Stratigraphy

General Considerations

The depth of Quaternary sediments at the site is shallow, typically on the order of 1.0-1.5 m, beneath which gravelly sands of the Pleistocene Columbia Formation are encountered. The only exception to this context is the bay/basins, which preserved soft sediment accumulations to depths of ±3m.

With localized exceptions, the lateral zonation of Holocene sediment complexes across the artifact-rich interfluve segments conforms to the contours of the general landform, a gradually sloping pediment that was an agricultural field at the time of the investigation. The dominant soil profiles are Spodosols that feature sandy to sandy loam parent materials under boreal forest covers with vegetation that supplies mobile and sesquioxide-mobilizing organic compounds (Buol et al 1997). Classic profiles feature O-A-E-Bs-Cox succession (Birkeland 1999), but Bs horizons (containing amorphous organic concentrations) can be replaced by Cambic profiles (Bw horizons) representing a more extensive weathering regime, as in the Frederick Lodge columns. The most overriding aspect of the Frederick Lodge soil profiles is the dominance of the E horizon, which in many cases preserved archeological materials. Accordingly, the long-term weathering of the column is the dominant pedogenic process over the course of Holocene time.

The prevalence of the E horizon obscured more subtle soil stratification in lower horizons, and offers the possibility that two sequums, in a vertical sequence, are preserved. This is a common feature of eluviated soil columns (see Buol et al 1997:66) which underscores breaks in the soil development history of a landscape in which more than a single cycle of podsol evolution are recorded in the column.

At Frederick Lodge, one to two Holocene sola were in evidence at specific excavation blocks, depending on slope location and depth of post-Pleistocene accretion. The recognition of Bw horizons and/or lamellae reflect weathering suites that dominate sandy substrate; the degree of clay translocation was more subdued than on finer parent materials and rates of organic decomposition were similarly reduced.

Initial observations were that aeolian deposition was most evident at crest locations (7NC-J-98; blocks A, B, D, and E) while colluviation was more prominent along mid-slopes to the south and southeast (7NC-J-99; blocks I, and K). Midslopes (7NC-J-97) also featured sediments derived from both aeolian and sloped erosional contexts. The aeolian sands included a silt component such that deeper and clay enriched profiles formed at 7NC-J-98. At 7NC-J-99 coarser, but better sorted fine sands promoted lamellar weathering.

Since archeological assemblages across the project area produced artifact types ranging from bifurcate (Middle Archaic) points to Late Woodland assemblages, it was clear that over 8000 years of occupation were preserved at the site. Any stratification would clearly be compressed within 1-1.5 meters of sediment such that sedimentation rates were minimal and separation of components would be difficult to discern stratigraphically. Much of the separation was spatially based, although archeological stratigraphy was present in several locations. The lateral and vertical dispositions of sediment complexes, soil horizons, and archeological assemblages serve as the basis for the stratigraphic framework.

Allostratigraphy

To accommodate the subtleties in the cultural and natural horizonation, it was decided that the most appropriate stratigraphic framework would be an allostratigraphic system. The system is based on tracing individual strata on the basis of bounding discontinuities. It is appropriate for linking sets of grouped archeological, soil, and depositional units across space and time. Since units are defined by boundaries rather than by contents, they allow for

explaining the mechanisms that forced changes in stratigraphic ordering (see Ferring 2001). The system is especially flexible for situations in which breaks in deposition are inconsistent across a site and across segments of landforms (ie. slopes). Operationally, the allostratigraphic framework allowed for the expansion of soil-stratigraphies across the Blocks to accommodate the broader stratigraphic variability of the general site environment.

For the Frederick Lodge site complex, the transect most representative of the key stratigraphic breaks across the landform was the NW-SE sampling unit (Figure 2). Archeological information was provided for the key excavation blocks. Sedimentological profiles were integrated within the sequence to highlight co-eval occupation and landscape successions.

Based on field relations and stratigraphy, the following Allostratigraphic Units were identified (oldest to youngest):

- **AU-1:** Unweathered gravels and sands (with lag deposits) of the Columbia Formation [2C horizon];
- **AU-2:** Dominantly aeolian and colluvial sediments of Holocene age; they are bracketed by Early Holocene (base) and Late Holocene (top) Cambic (Bw) soil horizons; the composite Unit is preserved on the highest portion of the landform exclusively. Archeological materials of Middle Archaic through Late Woodland are present. On most slope locations two sub-units are recognized:
    - **AU-2a:** Thin, Early Holocene soil formed directly over Columbia Formation gravels; it may contain Early to Middle Archaic artifacts, either in situ or deflated [2AB];
    - **AU-2b:** Late Holocene soil and/or sediment developed over and/or underlain by aeolian silts, sands or colluvium; it preserves deflated and reworked Archaic artifacts and Woodland materials [A-Bw or AB-BC sola];
- **AU-3:** Historic soil chiefly represented by plowzone but irregularly underlain by thin aeolian or colluvial sediment, sometimes weakly weathered [Ap/AB sola]

In general, these subdivisions articulated with the following archaeological field horizons: Stratum "A" conformed to AU-3; Stratum "B" was equivalent to AU-2; and Stratum "C" represented the "sterile gravels and sands", or AU-1. Since field excavation considered "Stratum A" as plow zone ("Ap"), it also incorporates the uppermost weathered [AB} or unaltered aeolian sands and silts which post-date the Late Holocene soil (AU-2).

Figure 4 illustrates the composite stratigraphy spanning the site along Transect 1. Principal excavation blocks are illustrated. The section shows that the most discontinuous horizonation is that of AU-2, which splits into two sub-units along the mid-slope. AU-2a is typically a moderately weathered and rubefied (7.5 YR5/6) soil with subangular blocky structures and houses the Early to Middle Archaic assemblages, generally above the depths of peak soil formation. AU-2b is recognizable as a much looser, heterogeneous sediment matrix that is poorly structured and often friable. As shown, the upper sub-unit (AU-2b) is preserved in all locations from the mid-slope eastward with the exception of Block I. On the crest, AU-2 is

demonstrably a single, deeply weathered Holocene soil, not only because its Middle Archaic and Woodland components are separable, but because clay enrichment is pronounced (by 8%) within the unit, attesting to relatively long term soil development. Grading down to the mid-slope, AU-2a is recognized as an intact Early Holocene soil that preserves Early and Middle Archaic assemblages. Examples of such contexts are in blocks I and K; both contain high concentrations of illuviated clays at depths of 0.6 m, typically up to 0.2 m below the peak artifact levels but within the same soil horizon (2AB). Currently these settings comprise a topographic spur (Block I) and low knoll (Block K) that attest to meta-stable landform conditions earlier in the Holocene. Accordingly, the early components were sealed within a stable surface that weathered into a Cambic soil. Above the Early and Middle Archaic horizons are unstructured silts and fine sands that are clearly associated with later Holocene colluviation and deflation; this complex is assigned to AU-2b.

AU-3 represents the historic plow zone (Ap) and extends 0.2-0.4 m in depth into weakly weathered historic sediments. The horizon conformably overlies the uppermost prehistoric deposits everywhere, irrespective of the landform segment, and it can therefore be difficult to isolate. Often the boundary is represented by the passage from 10 YR4/2 fine sands to 7.5 YR5/6 sandy loams with structures moving from granular to weak-subangular blocky. Archeologically the transition is marked by the uppermost Woodland features in the profile at the crest of the landform (7NC-J-98; blocks A, B, D, and E). Along the midslope and toeslope (at the margins of the bay/basin) color transitions can grade somewhat sharper (5YR hues).

AU-1 is readily identifiable as the unweathered Columbia gravels (10 YR5/6) that are typically capped by well rounded pebbly sands and feature pockets of gravel lag. However, the Early Holocene soil formed on these gravels, rendering the contact (ie.Pleistocene/ Holocene interface) unconformable in nearly all locations.

The crest locations (7NC-J-98; Blocks A, B, D, and E) all display similar profiles and indicate paleosol evolution and slope stability for the duration of the Holocene. Block D was examined most extensively. Here, beneath a 0.2-0.4 m thickness of Ap or AC, there is a shallow accumulation of moderately well sorted sands and silts. Texturally, moderately well sorted sands and silts account for 75% are 20% of the sediment population respectively. The distributions indicate that the deposition is of aeolian origin (AU-3). This allostratum is underlain by a 0.5 m thick paleosol (AU-2) that is characterized by an appreciable increase in the clay-silt ratio (from 1:4 in AU-1 to 1:1 in AU-2). Such changes are mirrored in the geochemical record as well. Within the weathering horizon concentrations of Mg, K, and Fe increase appreciably, verifying the intense translocation of minerals attendant to long term soil formation. At the base of the profile, within the unweathered component of the Columbia Gravels (AU-1), sands increase to 87% of the sediment population and there are no indicators for clay or mineral translocation.

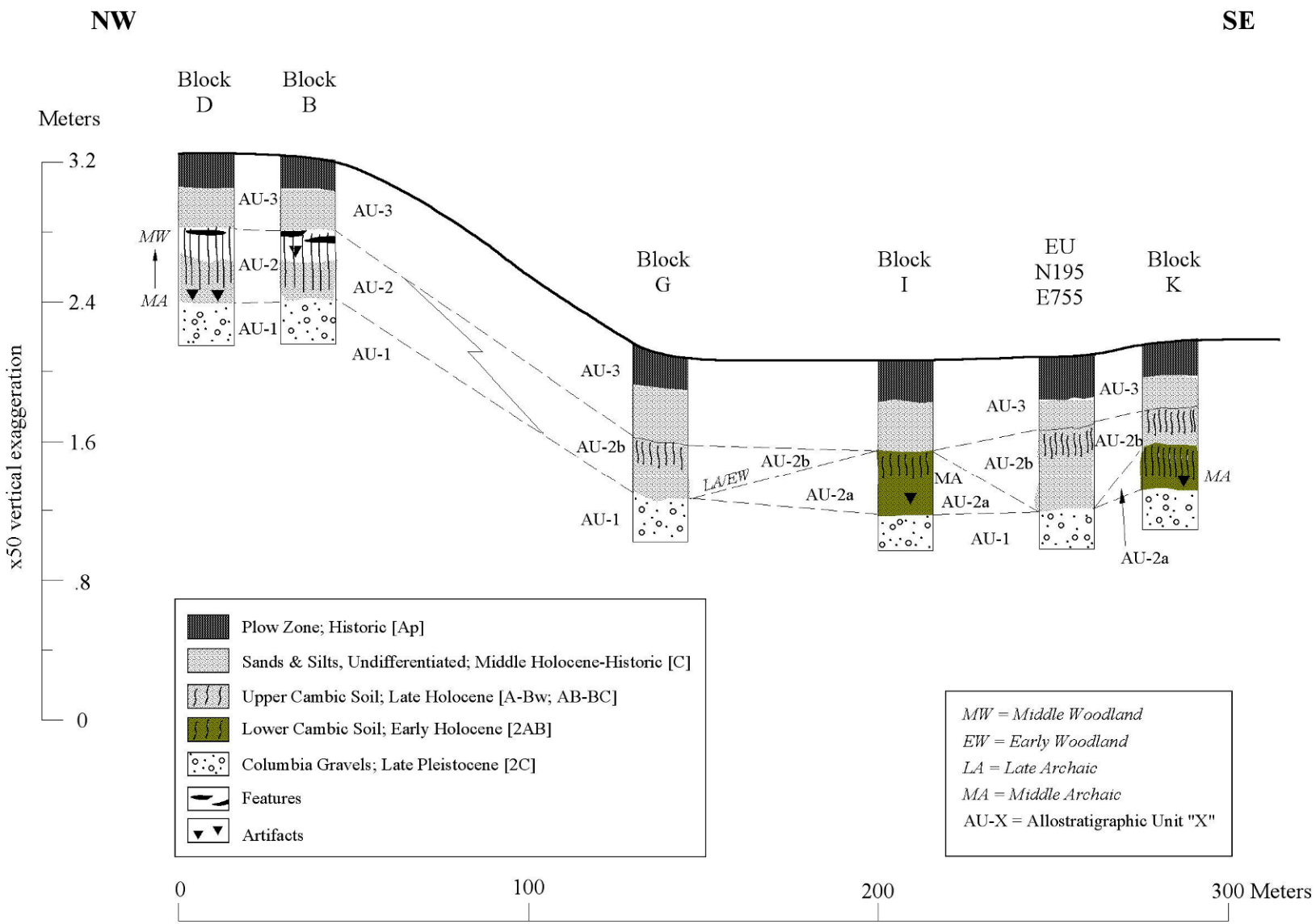

Figure 4. Generalized Transect Across Frederick Lodge.

Radiocarbon dates of 3700±40 B.P. (Beta-149971) and 9890±50 B.P. (Beta-149972) within AU-2 bolster arguments for the longevity of the weathering profile at crest locations. Specimens were extracted from free carbon in the cultural horizons (field stratum "B"). While there is a critical disparity in the temporal range of these dates—sources of potential contamination are numerous—their antiquity is certainly within the range of the weathering profile from which they were procured. This suggests that while localized radiocarbon reworking and adsorption of organic matter may account for erroneous dates, the general time frame represented is fully consistent with the duration of AU-2.

Archeological assemblages at 7NC-J-98 are separable (in Block D especially) within the profile and range from Early and Middle Archaic to Woodland in correct stratigraphic order. It must be kept in mind, however, that the weathering profile is thin and developed on a sandy substrate. Thus, sources of bioturbation and vertical displacement are numerous and the possibility of mixing in many situations is strong, even though the weathering profile is intact.

The assessment of graded mid-slope (7NC-J-99) and more poorly preserved toe-slope assemblages is more problematic. The deep AU-2 soil is not preserved in these locations, as slope processes have typically remobilized sediment either by colluviation or deflation. Figure 4 shows that AU-2a is contained in Blocks I and K. In the case of Block I, the evidence is in the form of the paleosol [2AB} that shows a gradual, but clear increase in clays at 0.8 m as well as concomitant peaks in Fe, Mg, OM, and Ca at that level. As elsewhere, artifact concentrations are highest 0.1-0.2 m above the most weathered portion of the profile. Since the Ap and underlying AB/BC horizons are clearly associated with the same parent material, it is clear that the weathering profile was formed on the eroded Columbia gravels. This coupled with the earlier Holocene archeological diagnostics—bifurcate-base points—suggests that only the older paleosol is preserved and the stratigraphic succession proceeds from AU-1 to AU-2a to AU-3.

The mid-slope context at 7NC-J-99 (Block K) warrants additional commentary. Here a pronounced 2AB soil horizon was recognizable that featured peak clay concentrations paralleled by a rise in OM (other geochemical tests were not performed). These data support the pervasiveness of the Early Holocene soil across the site and in all topographic settings. However, in contrast with a higher, mid-slope location (7NC-J-97; Block I), there is an abrupt transition from the cover sediments to the paleosol. Since poorly sorted upper sediments with isolated (and possibly displaced) Woodland artifacts capped the sequence, it appears that AU-2a is capped by AU-2b at this location. More significantly, a radiocarbon date of 1200±40 B.P. (Beta-150338) was obtained within the 2AB. Since this determination was from a bulk sample it may be too young, but consistent with mobilization of later Holocene sediments in the vicinity. Both the date and sediment composition suggest that lower mid-slope settings (7NC-J-99; Block K) were depositional loci for AU-2, effectively registering a compressed version of the composite Holocene paleosol preserved on the crest of the landform (7NC-J-98). The depths and seriation of the archeological assemblages—documenting the Woodland to Archaic transition—are discussed subsequently to clarify the allostratigraphy at this location.

As noted, the site's environments began to stabilize during the Early Holocene when, hydrographic balances began to adjust to post-glacial moisture and circulation regimes. A

major threshold for stable environments is 6000 B.P. when the stream networks for the Middle Atlantic assumed their contemporary morphologies (Schuldenrein 1998). However, for Delaware in general, and for Frederick Lodge in particular, the local environmental chronologies are best registered in the two primary bay/basins on the western and southern edges of the project area respectively.

Site Formation Sequences

Analysis Methods

Cultural materials at most loci at the Frederick Lodge site complex were diffuse and, with the exception of several features, there were limited clear associations between artifact clusters and soil horizons or well stratified deposits. As discussed, in many cases long term podsolization (or A-E horizonation), the dominant pedogenic process, masked whatever cultural horizonation may have existed. Podsolization also obscured evidence of geological stratification. In slope settings, evidence for colluviation was not unequivocal; there were no apparent textural, bedding or structural properties distinctive to the sediment matrix. Accordingly, the strategy utilized for reconstructing artifact bearing sediments with soil horizons and allostrata involved the examination of co-varying sets of sedimentological, geochemical and artifact density data. The data were plotted vertically in representative stratigraphic profiles for individual blocks. Major efforts focused on artifact rich loci to explore the connections between anthropogenic and geological sedimentation. This would form the basis for a site formation history at individual loci and ultimately across the Frederick Lodge site complex.

Sedimentological assessments involved composite granulometry to determine changes in depositional environment, and particularly to establish aeolian, colluvial and alluvial sediment origins (following Folk 1974). Particle size distribution (granulometry) characterized relative percentages (by weight) for three fractions: sands (<4Ø), silts (<8Ø), and clays (>8Ø). Dry and/or wet sieving segregated size grades within the sand fraction, while the hydrometer method separated the silt and clay fractions. To isolate variability within the size frequency distributions, a series of statistical parameters were also examined. Parameters of sorting (So), skewness (Sk), and kurtosis (Kg) were calculated using the method of moments (after Friedman and Sanders, 1978).

A battery of quantitative geochemical tests was applied to soil horizons to obtain signatures of limited weathering on the interfluves and their slope segments and to isolate evidence for human occupation in the form of disaggregated cultural residues. Varying contributions of organic and chemical elements are often associated with formerly stable surfaces that may have sustained prehistoric occupations. The elements, or ions, tested to identify weathering and anthropogenic additions to the profile included calcium (Ca), magnesium (Mg) potassium (K) and phosphorous (P). The most common cultural residues isolated by these ion tests are bone, wood ash, excreta, and animal meat and tubers (Cook and Heizer 1965; Anderson and Schuldenrein 1985; Kolb et al. 1990; Schuldenrein 1989). To examine the degree of weathering and oxidation/reduction in the sola (i.e., “AB”, “Bw”), relative concentrations of mobile iron (Fe) was measured, along with organic matter (OM) and pH. Covarying trends can help to determine if vertical or lateral changes in a profile are

attributable to soil forming processes, human inputs into the sediments, or combinations of pedogenic and anthropogenic transformations to the matrix.

To examine the degree of anthropogenic sedimentation in greater detail, geochemical analyses of feature phosphates were undertaken. The strategy has proven effective in sorting out human activity patterns. The extent and performance of specific activities at the site was determined by measuring concentrations of inorganic phosphates and assessing fractionation patterns. The method facilitates reconstructions of the types of activities, duration, and even the relative antiquity of particular feature types. Techniques in this study followed the methodology initially outlined by Eidt (1984) for phosphate fractionation and subsequently refined by Schuldenrein (1995) for North American hunter-gatherer sites.

Next, a broad measure of cultural activity by locus was obtained by plotting artifact densities by depth. Provenience designations were provided by archeologists in the form of artifact counts by 10 cm levels. For each block, densities were calculated by 10 cm level and plotted vertically on graphs to depict changing concentrations vertically. These data were superposed on the pedo-stratigraphies registered in the field and ultimately the site allostratigraphy. In this way it was possible to assess changing trends in artifact distributions by position in the soil column. Systematic plots of densities would reveal patterning in the soil formation record and/or the depositional sequence. It would then be possible to isolate occupation, abandonment, and post-abandonment processes that have resulted in the preservation of the unique archeological records at Frederick Lodge.

Finally, an experimental strategy was followed to determine the origin of sand grains on particular landscape segments. By examining the transformations to the surfaces of sand grains (frosting vs. polishing) in quantitative fashion it is possible to recognize mechanisms of sand transport and then infer the dominant origins of particular sedimentary settings. Results of this analysis are presented in Attachment 1.

Sediment Stratigraphy at the Frederick Lodge Site Complex

It is convenient to begin discussion with sequences at the crest (7NC-J-98) and proceed to mid-slope (7NC-J-97, 7NC-J-99) locations. Block G at 7NC-J-97 is the best example of a toe-slope location. Slope-based landform and stratigraphic relations assume that the most stable soils and oldest depositional sequences are preserved at the upper landform segments and that progressive erosion and generally younger capping deposits accumulated downslope. At each locus detailed sediment sampling was performed at the most representative Block profiles, as indicated.

7NC-J-98 (Block D[crest]; Figure 5)

The resolution of AU-1, AU-2, and AU-3 is clearest at this location (Figure 5). Beginning with the sedimentology, it is noted that the textural variability is most prominent at this crest locus. The coarsest sediments belong to the Columbia Formation sandy gravel complex (AU-1). A pronounced increase in clays is characteristic of unequivocal weathering in the Holocene soil (AU-2), which for a sandy parent material, is quite thick (>0.4 m). It houses artifacts ranging from Middle Archaic to Woodland, in generally consistent stratigraphic order. The extent of weathering is underscored initially by the Fe concentrations that peak between 0.6-0.7 m, and more significantly by parallel vertical trends in K and Mg, both

indicators of clay mineral alteration (illite to montmorillonite) (Birekeland 1999:101) and typical of forest soils (Buol et al 1997). More than anything else, these broad weathering trends for the depth of the examined profile point to the long-term duration of the Spodosol. However, fluctuations in organic matter and the clear identification of a 2AB horizon immediately beneath the C suggest that less developed, prehistoric-aged soils are masked by the weathered portion of the solum. Further, the presence of substantial artifact concentrations may be associated with human activity, which certainly could have imparted Ca, K, and Mg to the upper sediment (AU-3) that leached out deeper in the profile (AU-2), thus imparting high concentrations of these ions. It is not possible to sort out the weathering vs. anthropogenic source of the elemental contributions definitively. The soil sequence may be bi-sequal (soil formed within an older soil) on these grounds.

Additional information is furnished by the archeological distributions. The densest concentrations of artifacts are confined to AU-3 (archaeo-stratum "A"). Typology suggests that these artifacts are Early/Middle Woodland. Their frequencies are variable. Profile horizonation is consistent with an upper solum (A or AB horizons) that is in a state of dynamic equilibrium, such that episodic contributions to the top of the sequence are also being eroded and weathered. Unquestionably late Holocene weathering affected only the lower profile (beneath the 2AB and Woodland horizons); however, during the limited Woodland occupation aeolian sedimentation was ongoing, even as portions of the crest were in the process of attrition. Accordingly there is a relatively deep accumulation of Woodland materials within the AC horizons (AU-3; upper 0.4 m). The sealed deposits are beneath these depths in AU-2, which constitutes the 2AB/Bw horizons. The artifact density plots show that a weakly bimodal distribution, with a small but significant peak at the AU-1/AU-2 interface, occurs at the contact between the uppermost Columbia Formation and earlier Holocene deposition. This context represents the intact Middle Archaic occupation level.

7NC-J-97 (Block I [midslope]; Figure 6)

The stratigraphy of mid-slope location (Block I) typically differs from that of the crest, as illustrated in Figure 5. In general slope gradations result in more friable cover sediments because of susceptibility to erosion (preservation of AU-2a; Figure 6). The geochemistry shows less pronounced peaks in diagnostic weathering indicators (compare Figures 5 and 6). The solum of AU-2 (Block D) shows more abrupt weathering breaks than in AU-2a (Block I). Higher concentrations of sands attests to the greater mobility of successive cover sediments along the mid-slope—because of deflation and colluviation--than at the crest locus. The present slope position at location I appears to have obtained in the prehistoric past as well, given the sedimentology of the deeper portions of the profile. It therefore constituted an erodible portion of the landscape for much of the late Holocene. Nevertheless, there is evidence of intact archeological occupation such that some surface reworking must have occurred during prehistoric times.

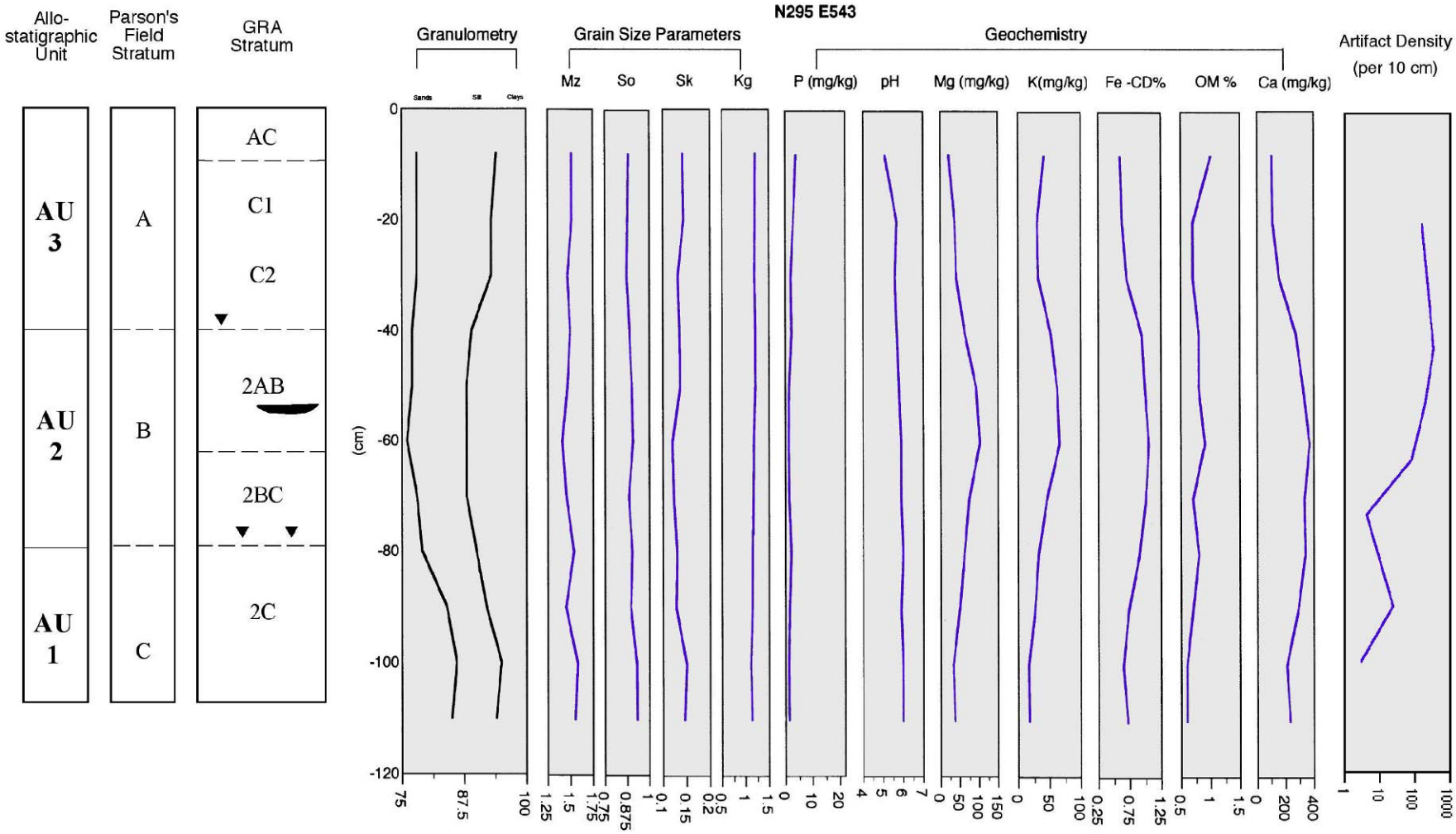

Figure 5. Block D.

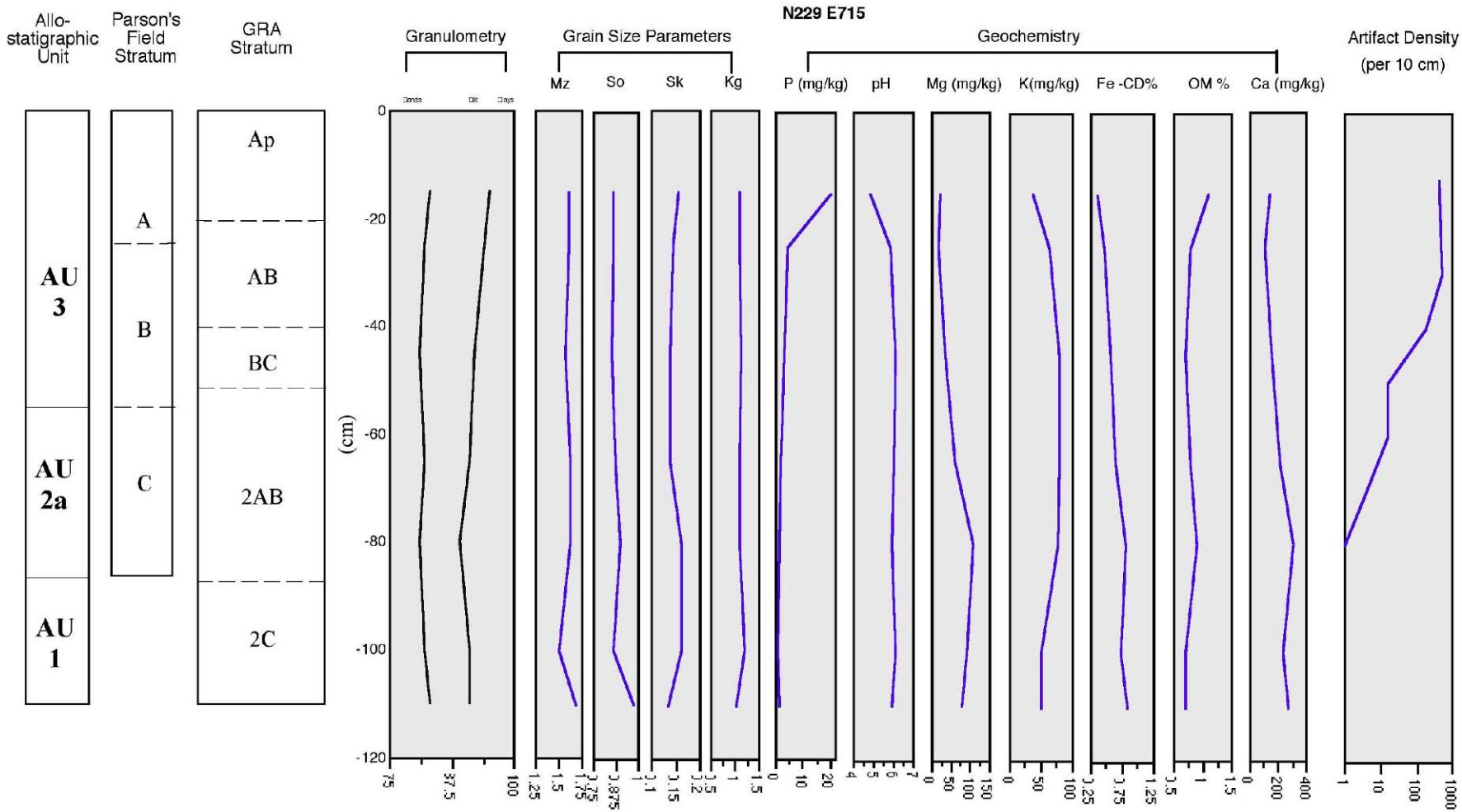

Figure 6. Block I.

The composite sequence for Block I (Figure 6) shows that its mid-slope location accounts for the allostratigraphy. The sequence here (top to bottom) is AU-3/AU-2a/AU-1. AU-2a and represents the basal Early Holocene Cambic paleosol formed on the Columbia Formation. Extensive surface stripping along the gradient accounts for soil truncation and no pronounced pedogenesis during the Late Holocene; historic deposits have accumulated directly on the unconformity. The sedimentology of the sequence is more uniform than that of the crest, with grain size distributions featuring sand-silt-clay proportions of 80-13-7-with some coarsening in the upper 0.5 m. Skewness variability in AU-2a reflects fining in the tails because of soil formation (horizon 2AB). Geochemical trends also reflect translocation of minerals in the same horizon, most notably Mg and Fe. The 2AB designation is confirmed by a minor bulge in organic matter and Ca.

The diagnostic artifacts in this Block are all within the Middle Archaic time frame and, based on the stratigraphy, it would appear that these are most likely associated with the interface of AU-2a and AU-3. Highest artifact densities occurred within AU-3 and this is probably a result of sediment reworking. Above the BC horizon (within AU-3) is a weak AB horizon between 0.2 and 0.4 m. This provenience featured the highest artifact counts; however the soil is relatively recent and incorporated artifact clusters of probable Archaic age. The soil horizon developed from older, mixed and eroded Holocene sediments. The weathering interval, and therefore the soil, probably dates to the Late Holocene.

7NC-J-97 (Block G [toeslope]; Figure 7)

Block G features a slightly different stratigraphic sequence, with AU-2b capping AU-1 (Figure 7). AU-2b here is a relatively unweathered sandy sediment of presumed colluvial origin. Sedimentological trends show that the coarsest sands in the column are, expectedly, associated with the heterogeneous cover sediments of historic age (AU-1). Woodland artifacts are dispersed within AU-2b and are clearly part of a better sorted deposition that is also very weakly weathered (AC horizon). Organic matter results show progressive decreases in concentrations, suggesting that in many locations the Columbia sands and gravels were capped by veneers that neither stabilized nor sustained soil formation.

7NC-J-99 (Block K [midlsope]; Figure 8)

As noted, this portion of the site featured coarser sediments in the substrate. The dominance of sands is apparent in the sedimentological signature of Columbia Formation; this has resulted in the preservation of sub-horizontal lamellae. Allostratigraphic units AU-2a and AU-2b are preserved in the column and this is the most representative section for all of the primary ASU's. The landform itself is the easternmost spur of the site. The presence of the Early Holocene paleosol—horizon 2AB (AU-2a)—is signaled sedimentologically by the spike in clays as well as an increase in organic matter. The 2AB also contains a Middle Archaic assemblage.

Preliminary indications are that the Woodland artifacts are associated with the Cambic solum (Bw) beneath the Ap horizon and that the C horizon, which marks an increase in coarser sediment from underlying units, represents a renewed phase of sedimentation by colluviation and/or aeolian activity.

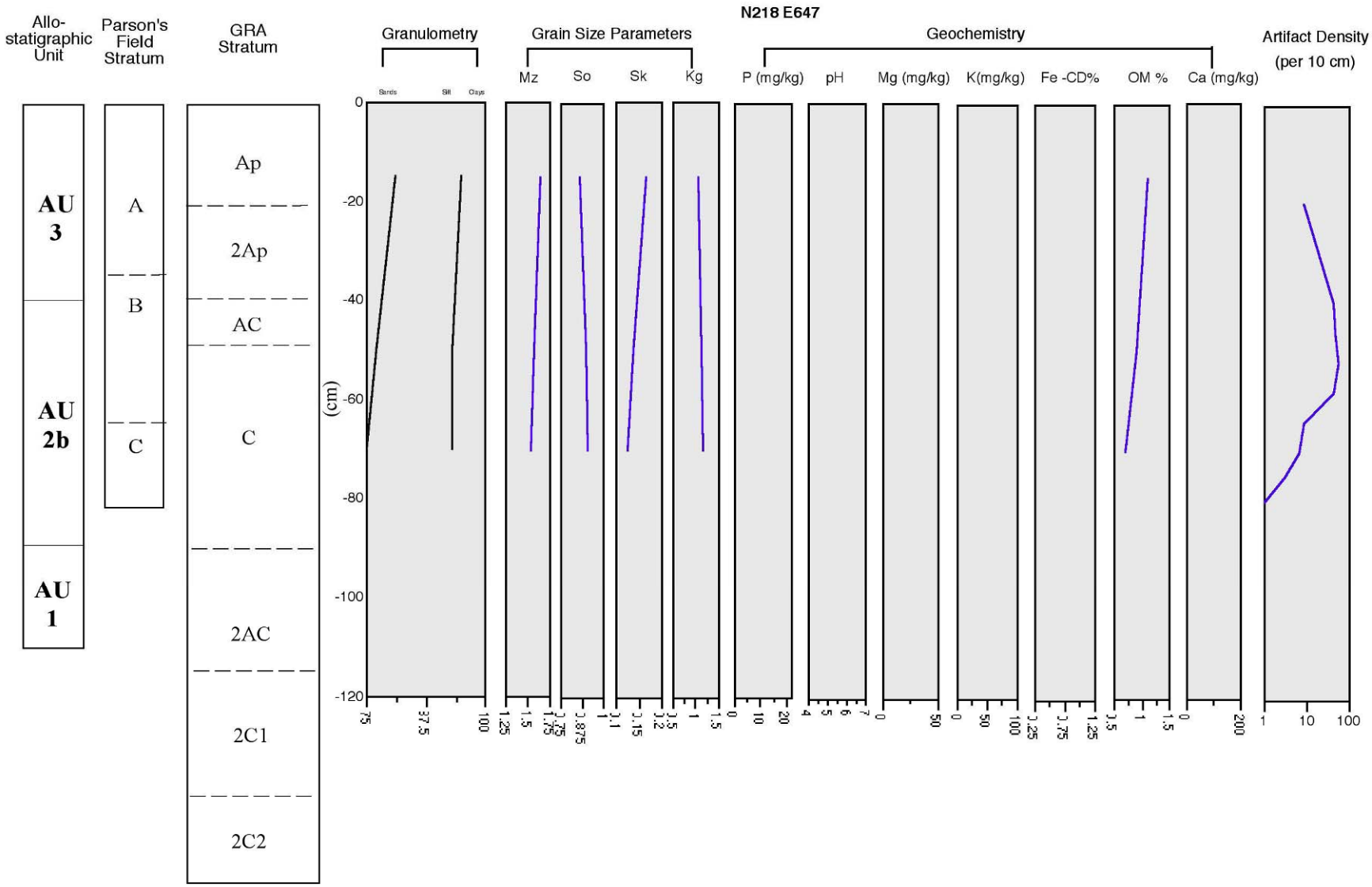

Figure 7. Block G.

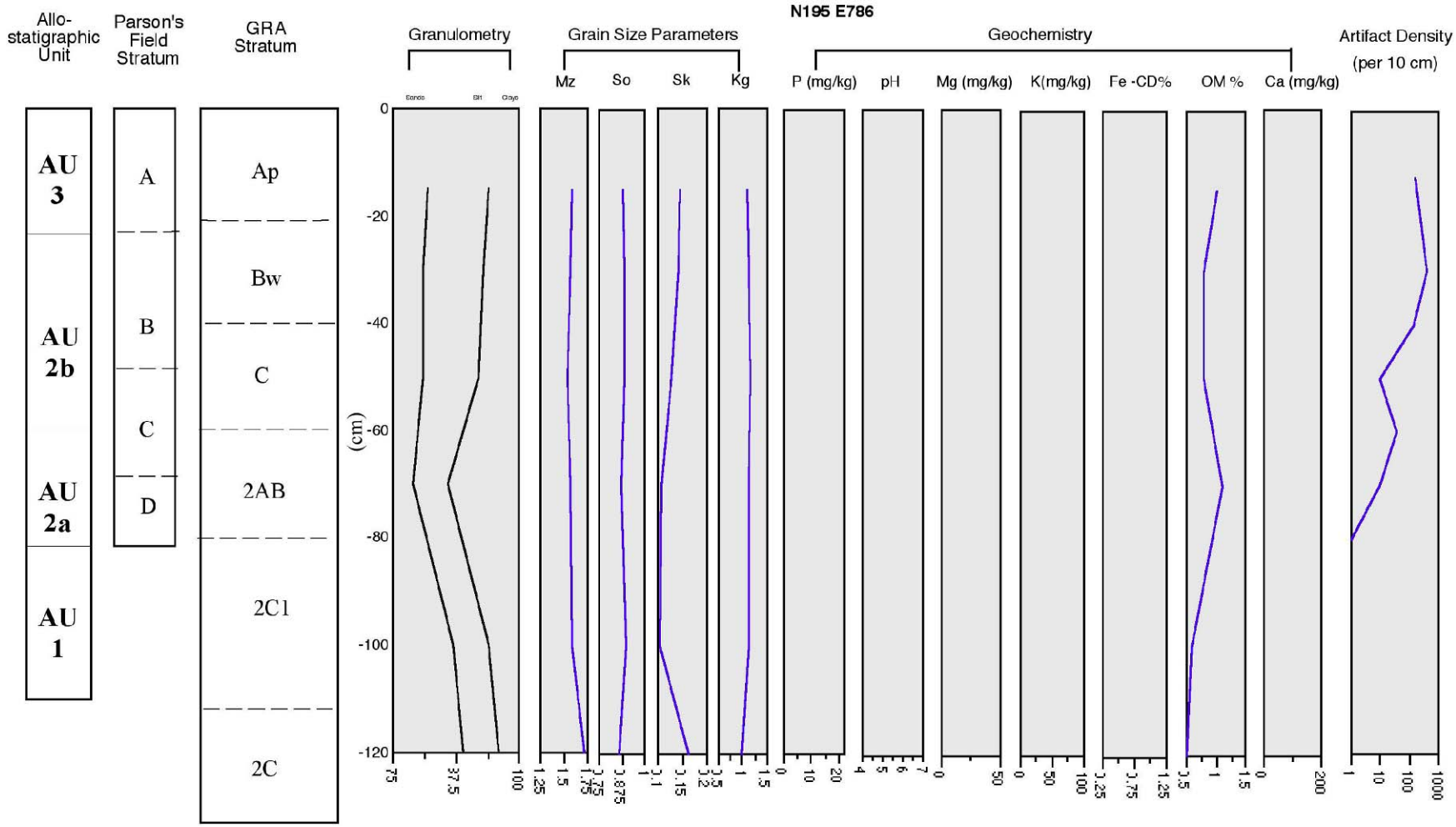

Figure 8. Block K.

Feature Studies

Geochemical studies were performed on Features 6 (Block C) and 10 (Block E). For the SR 1 project generally, the feature analyses were concentrated on the Sandom Branch sites. Table 1 summarizes the preliminary results for the cultural features sampled for the project.

Figure 9 shows the results of phosphate fractionation results for the Frederick Lodge sites. Samples were obtained from the two features identified, at scaled depths. These samples are compared to a North American data bank of known feature and land use types as well as the Sandom Branch sites. These results suggest that despite the broad range of time represented by the Frederick Lodge occupations, a limited series of activity patterns are represented. By contrast, the Sandom Branch sites, which sustained a much more limited series of temporal occupations, contained a more diverse set of features. The Sandom sites had later (Woodland) occupations, perhaps representing more complex patterns of site utilization. It is possible that by that time, seasonal subsistence rounds may account for different adaptive strategies and land use patterns, as represented by feature types.

Bay/Basins

Two bay/basins were identified across the landscape, one larger depression to the south, and a second smaller basin to the west. A total of seven (7) augers and one excavation unit were excavated into the larger depression. A single excavation unit was emplaced into the western basin. Figure 10 illustrates the landscape relations and upper stratigraphy of the terrain grading into the western bay/basin.

Bay/basins are widespread pond features, thought to have formed at the end of the Pleistocene. They extend from the Middle Atlantic to the Southeastern Coastal Plains. In Delaware their evolution has been linked to a “basin to bay” formation sequence, attributable to combined effects of free ground water and wind processes (Rasmussen 1958).

A number of bay/basin localities were cored for pollen studies in earlier phases of the SR 1 project. The most relevant to the project area was Walter’s Puddle, 2 km north of the Blackbird site complex (Newby et al 1994). A 4 meter deep core documented the terminal Pleistocene pine, oak, sedge vegetation followed by a 6000 year depositional hiatus (ca. 12,000-6000 B.P.) during the Early Holocene. After that time the oak-dominant forests began to take hold. Earlier interpretations held that climatic conditions deteriorated during the hiatus, when water levels were somewhat depressed, although the onset of drying conditions represented by the hiatus could not be established. Water began to refill the basins after 6000 B.P (see Kellogg and Custer 1994).

The bay/basin study at Frederick Lodge can potentially provide additional clues to the timing of climatic cycles. This might help explain if the clustering of Middle Archaic loci on the landform are related to proximity to the bay/basins that held at least seasonal waters during the dry phases of the earlier Holocene. None of the gleyed deposits encountered by the cores penetrating into the basins have yet been dated. The cores can clearly be linked with analogous (and dated) sequences in central Delaware to extrapolate depositional sequences and to infer climatic chronologies.

Table I-1. Archaeological Features - Summary of Chemical Analyses.

Site	Feature	Stratum	Age	Fill Chemistry (Relative)	Type of Feature
Frederick Lodge					
7NC-J-97/98/99	6	70-140 cmbs		Low OM. High Ca, Mg, K, P	cultural - large basin
7NC-J-97/98/99	10	40-110 cmbs		Low OM. High Ca, Mg, K, P	cultural - large basin (domicile?)
Sandom Branch					
7NC-J-227	19	I-1	1220"40 B.P.	not analyzed	cultural - hearth?
7NC-J-227	5	I-2	1850"40 B.P.	not analyzed	cultural - hearth?
7NC-J-227	36	I-1	2780"40 B.P.	not analyzed	cultural - hearth?
7NC-J-227	40	I-1		High OM. Mod Ca. Low Mg. Mod K. High P. Low P2O5.	cultural - FCR cluster
7NC-J-228	7	I-5	3770"40 B.P.	Low OM. Mod Ca, Mg. High K. Low P. High P2O5.	cultural - small basin
7NC-J-228	34	40 cmbs	3860"40 B.P.	High OM. High Ca. Mod Mg, K, P. High P2O5.	cultural - small basin
7NC-J-228	3	80 cmbs		Mod OM, Ca, Mg, K. High P. Mod P2O5.	cultural - large basin
7NC-J-228	3	110 cmbs		Low OM. Mod Ca, Mg. High K. Low P. High P2O5.	cultural - large basin
7NC-J-228	38	I-5		Low OM. High Ca, Mg, K. Low P. High P2O5.	cultural - small basin
7NC-J-228	43	I-4		Low OM. High Ca, Mg, K. Mod P. High P2O5.	cultural - small basin
7NC-J-228	39	60 cmbs		High OM. Mod Ca, Mg. High K, P. High P2O5.	cultural - small basin
7NC-J-228	8	40-55 cmbs		Mod OM. High Ca, Mg, K. Mod P, P2O5.	noncultural - burrow?
7NC-J-228	13			Low OM. Low Ca, Mg, K, P, P2O5.	noncultural - tree hollow?

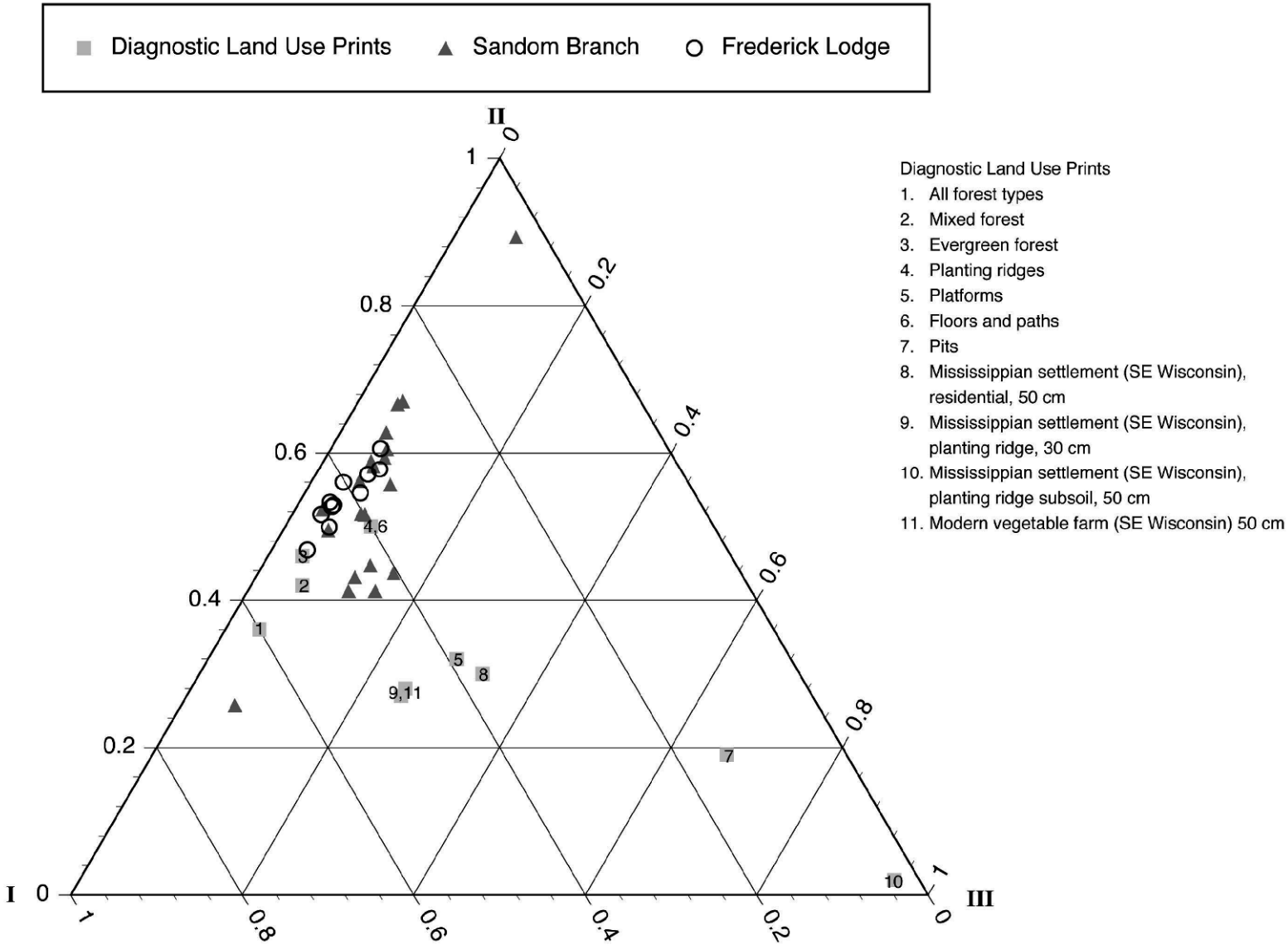

Figure 9. Phosphate fractionation for Smyrna-Pine.

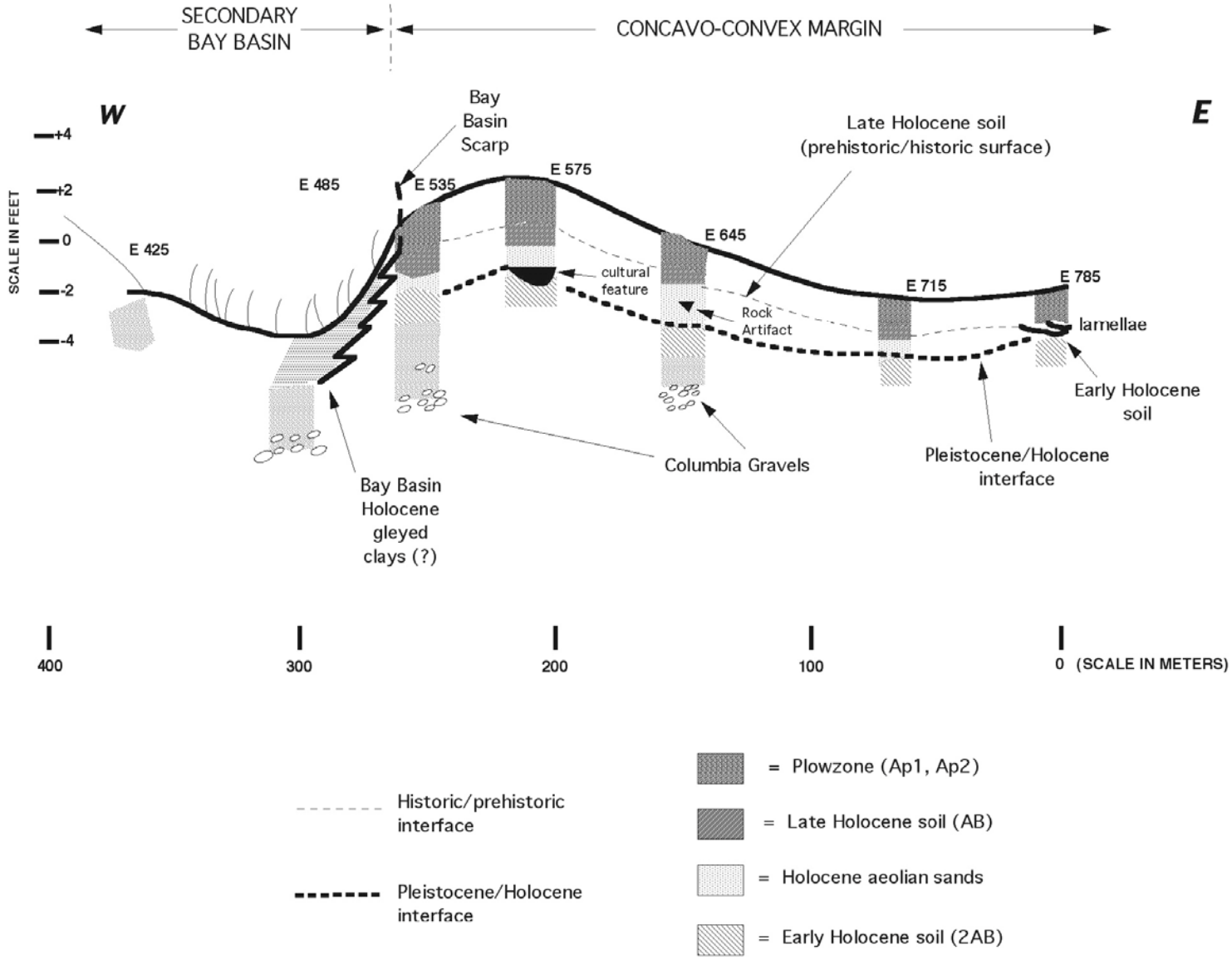

Figure 10. Landscape relations and subsurface stratigraphy, Frederick Lodge Site Complex, margins of western Bay Basin.

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Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 1

Sample ID N195 E786 Ap

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.4	0.4
0	1.1	1.5
0.5	5.2	6.7
1	15.5	22.2
1.5	27.3	49.5
2	23.0	72.5
2.5	12.7	85.2
3	8.8	94.0
3.5	4.6	98.6
4	1.4	100.0

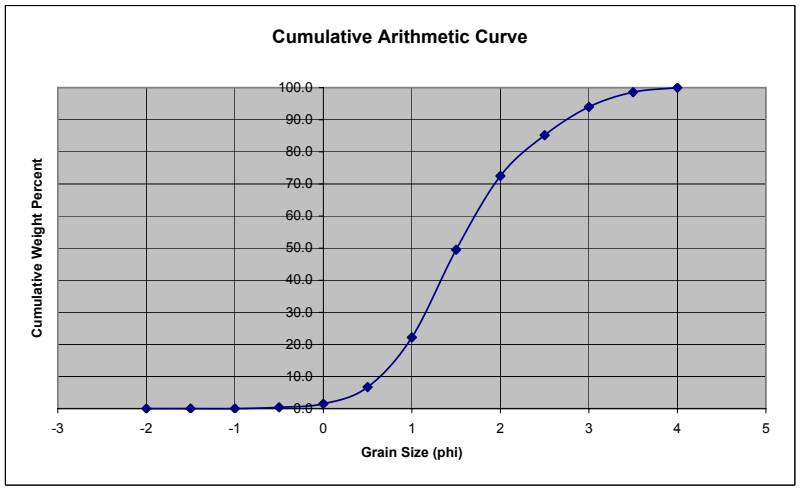
Grain Size Statistics		
Median (Md)	1.511	
Geometric Mean (Mz)	1.588	
Sorting (So)	0.875	moderately sorted
Standard Deviation	0.826	moderately sorted
Skewness (SkG)	0.140	positively skewed
(SkI)	0.146	positively skewed
Kurtosis (Kg)	1.085	mesokurtic

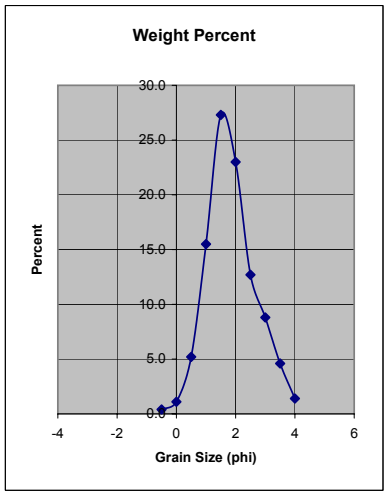
Phi5	0.800
Phi16	1.051
Phi25	1.511
Phi50	2.098
Phi75	2.453
Phi84	3.109
Phi95	0.000

Chemical Tests		
Test		Units
pH	4	
Available P		mg/kg
Organic Matter (OM)	1.0	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	82
Silt	12
Clay	6

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 2

Sample ID N195 E786 Bw

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
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-1.5		0.0
-1		0.0
-0.5	0.4	0.4
0	1.4	1.8
0.5	5.7	7.5
1	16.0	23.5
1.5	27.2	50.7
2	22.7	73.4
2.5	12.3	85.7
3	8.3	94.0
3.5	4.4	98.4
4	1.6	100.0

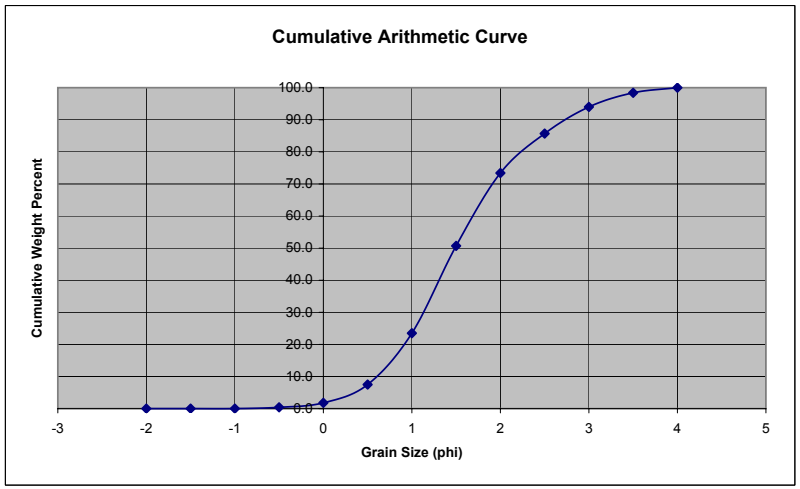
Grain Size Statistics		
Median (Md)	1.487	
Geometric Mean (Mz)	1.561	
Sorting (So)	0.888	moderately sorted
Standard Deviation	0.833	moderately sorted
Skewness (SkG)	0.133	positively skewed
(SkI)	0.141	positively skewed
Kurtosis (Kg)	1.119	leptokurtic

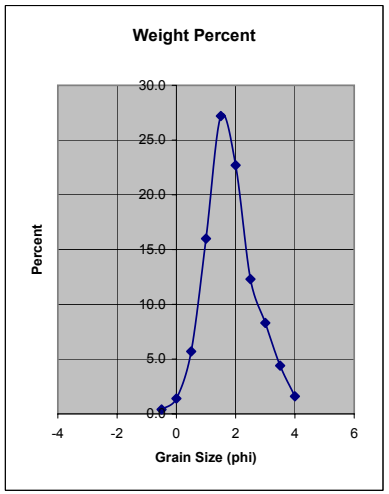
Phi5	0.766
Phi16	1.028
Phi25	1.487
Phi50	2.065
Phi75	2.431
Phi84	3.114
Phi95	0.000

Chemical Tests		
Test		Units
pH	4.5	
Available P		mg/kg
Organic Matter (OM)	0.8	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	81
Silt	12
Clay	7

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 3

Sample ID N195 E786 C

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.5	0.5
0	1.6	2.1
0.5	6.3	8.4
1	15.9	24.3
1.5	27.3	51.6
2	22.6	74.2
2.5	12.1	86.3
3	8.0	94.3
3.5	4.2	98.5
4	1.5	100.0

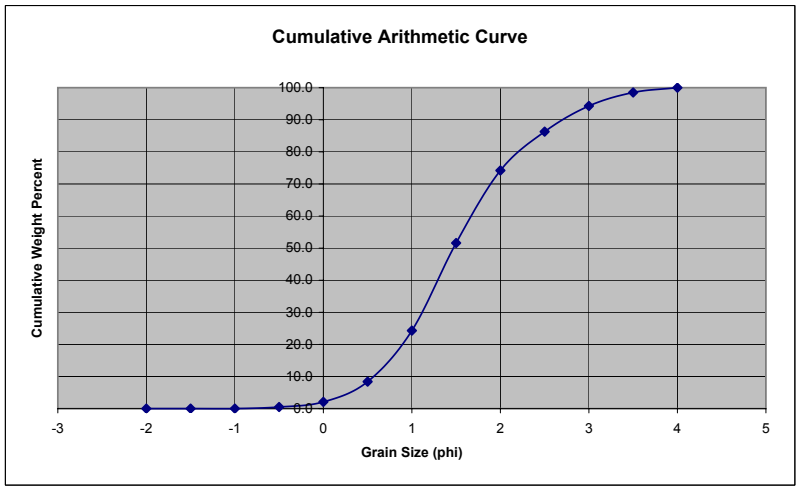
Grain Size Statistics		
Median (Md)	1.471	
Geometric Mean (Mz)	1.538	
Sorting (So)	0.892	moderately sorted
Standard Deviation	0.833	moderately sorted
Skewness (SkG)	0.122	positively skewed
(SkI)	0.126	positively skewed
Kurtosis (Kg)	1.146	leptokurtic

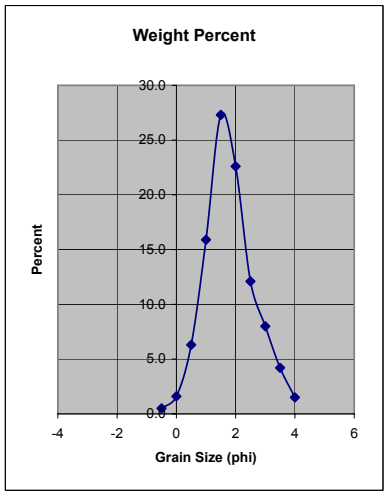
Phi5	0.739
Phi16	1.013
Phi25	1.471
Phi50	2.033
Phi75	2.405
Phi84	3.083
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.1	
Available P		mg/kg
Organic Matter (OM)	0.8	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	81
Silt	11
Clay	8

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 4

Sample ID N195 E786 2AB

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.00
-1.5		0.00
-1		0.00
-0.5	0.50	0.50
0	2.00	2.50
0.5	5.30	7.80
1	14.80	22.60
1.5	27.40	50.00
2	23.50	73.50
2.5	13.00	86.50
3	8.20	94.70
3.5	3.90	98.60
4	1.40	100.00

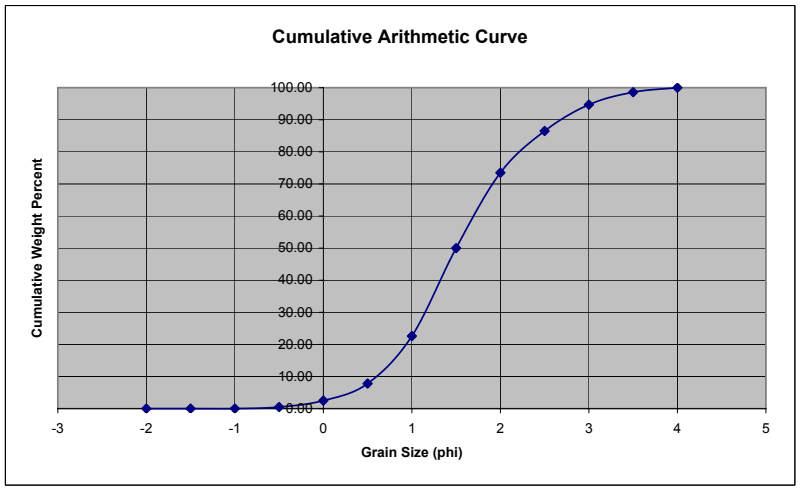
Grain Size Statistics		
Median (Md)	1.500	
Geometric Mean (Mz)	1.560	
Sorting (So)	0.874	moderately sorted
Standard Deviation	0.813	moderately sorted
Skewness (SkG)	0.111	positively skewed
(SkI)	0.105	positively skewed
Kurtosis (Kg)	1.133	leptokurtic

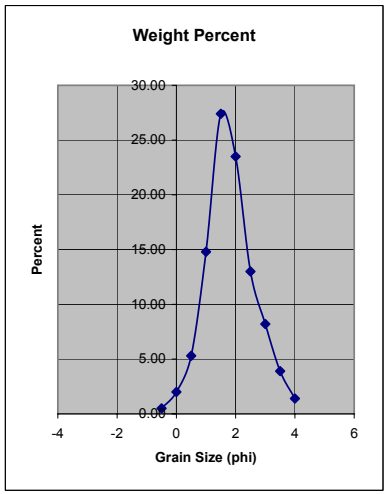
Phi5	0.777
Phi16	1.044
Phi25	1.500
Phi50	2.058
Phi75	2.404
Phi84	3.038
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.2	
Available P		mg/kg
Organic Matter (OM)	1.1	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	79
Silt	7
Clay	14

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 5

Sample ID N195 E786 2C1

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.00
-1.5		0.00
-1		0.00
-0.5	1.00	1.00
0	1.50	2.50
0.5	5.10	7.60
1	14.10	21.70
1.5	26.50	48.20
2	23.90	72.10
2.5	13.20	85.30
3	8.60	93.90
3.5	4.40	98.30
4	1.70	100.00

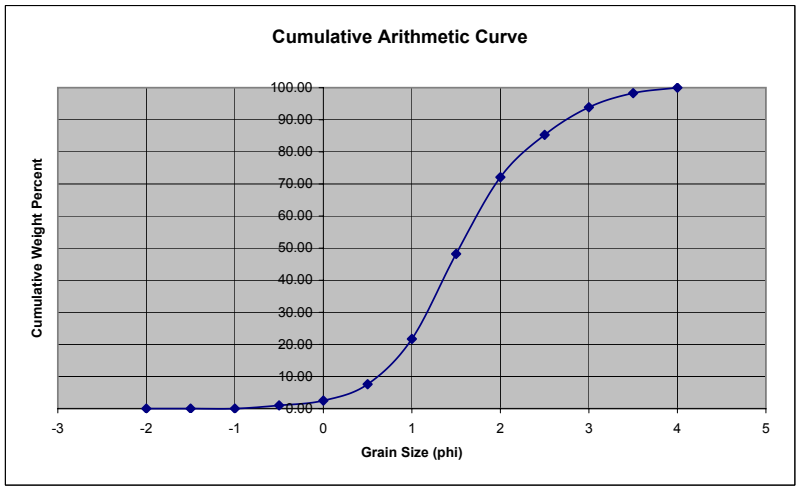
Grain Size Statistics		
Median (Md)	1.538	
Geometric Mean (Mz)	1.595	
Sorting (So)	0.893	moderately sorted
Standard Deviation	0.826	moderately sorted
Skewness (SkG)	0.105	positively skewed
(SkI)	0.104	positively skewed
Kurtosis (Kg)	1.127	leptokurtic

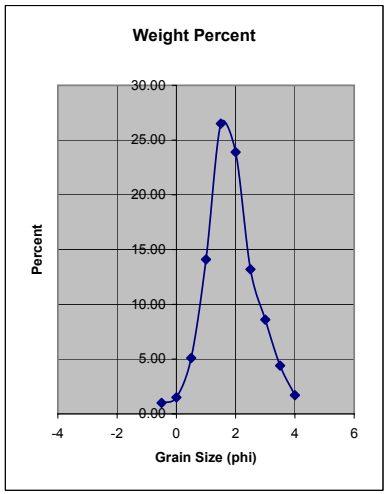
Phi5	0.798
Phi16	1.062
Phi25	1.538
Phi50	2.110
Phi75	2.451
Phi84	3.125
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.5	
Available P		mg/kg
Organic Matter (OM)	0.6	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	87
Silt	7
Clay	6

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 6

Sample ID N195 E786 2C2

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.1	0.1
0	1.0	1.1
0.5	3.7	4.8
1	13.4	18.2
1.5	26.1	44.3
2	23.5	67.8
2.5	14.5	82.3
3	10.7	93.0
3.5	5.4	98.4
4	1.6	100.0

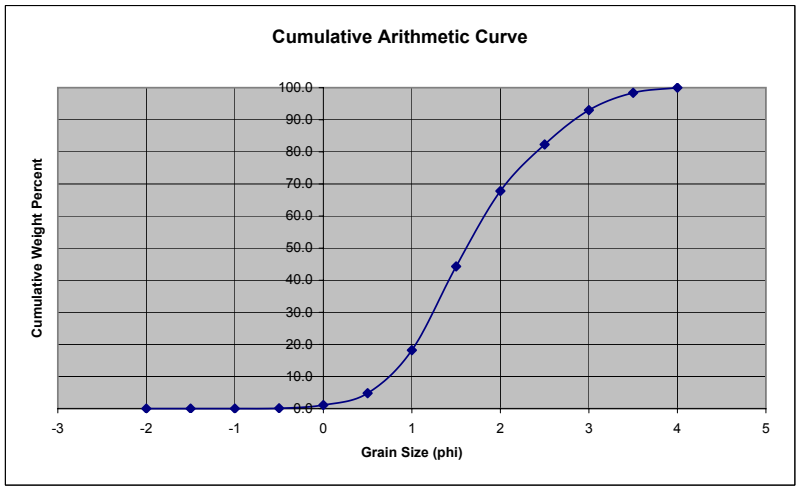
Grain Size Statistics		
Median (Md)	1.621	
Geometric Mean (Mz)	1.706	
Sorting (So)	0.862	moderately sorted
Standard Deviation	0.831	moderately sorted
Skewness (SkG)	0.153	positively skewed
(SkI)	0.161	positively skewed
Kurtosis (Kg)	0.982	mesokurtic

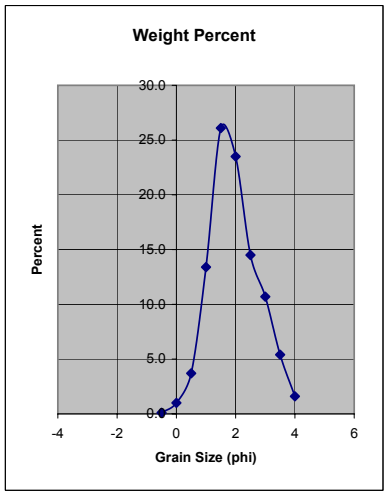
Phi5	0.918
Phi16	1.130
Phi25	1.621
Phi50	2.248
Phi75	2.579
Phi84	3.185
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.6	
Available P		mg/kg
Organic Matter (OM)	0.5	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	89
Silt	7
Clay	4

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 7

Sample ID N229 E715 Ap

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.2	0.2
0	1.1	1.3
0.5	4.8	6.1
1	15.1	21.2
1.5	27.6	48.8
2	23.5	72.3
2.5	12.9	85.2
3	8.7	93.9
3.5	4.5	98.4
4	1.6	100.0

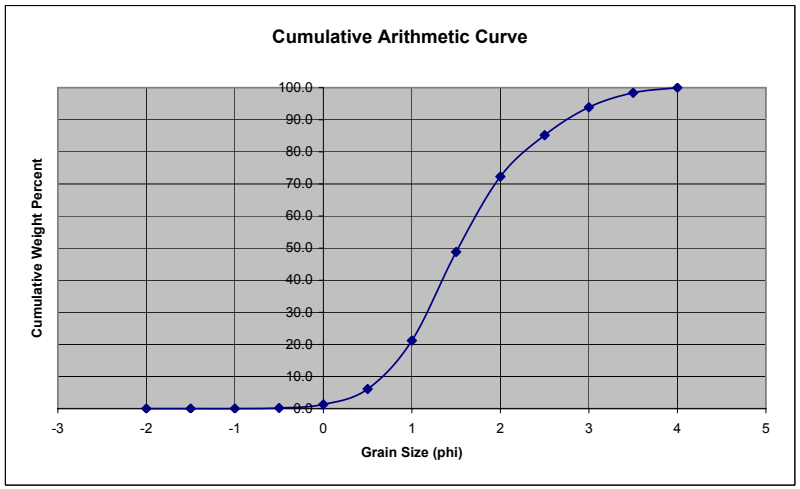
Grain Size Statistics		
Median (Md)	1.526	
Geometric Mean (Mz)	1.602	
Sorting (So)	0.863	moderately sorted
Standard Deviation	0.813	moderately sorted
Skewness (SkG)	0.142	positively skewed
(SkI)	0.154	positively skewed
Kurtosis (Kg)	1.083	mesokurtic

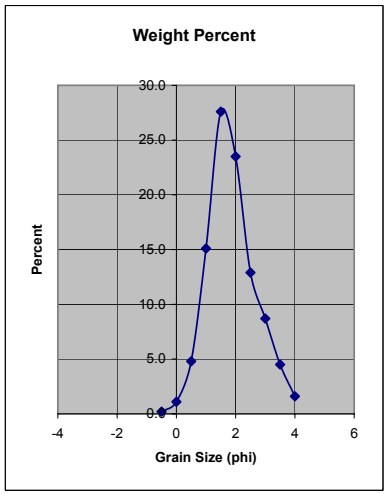
Phi5	0.828
Phi16	1.069
Phi25	1.526
Phi50	2.105
Phi75	2.453
Phi84	3.122
Phi95	0.000

Chemical Tests		
Test		Units
pH	4.8	
Available P		mg/kg
Organic Matter (OM)	1.1	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	83
Silt	12
Clay	5

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 8

Sample ID N229 E715 AB

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.4	0.4
0	1.1	1.5
0.5	4.9	6.4
1	14.6	21.0
1.5	28.0	49.0
2	23.8	72.8
2.5	12.8	85.6
3	8.6	94.2
3.5	4.4	98.6
4	1.4	100.0

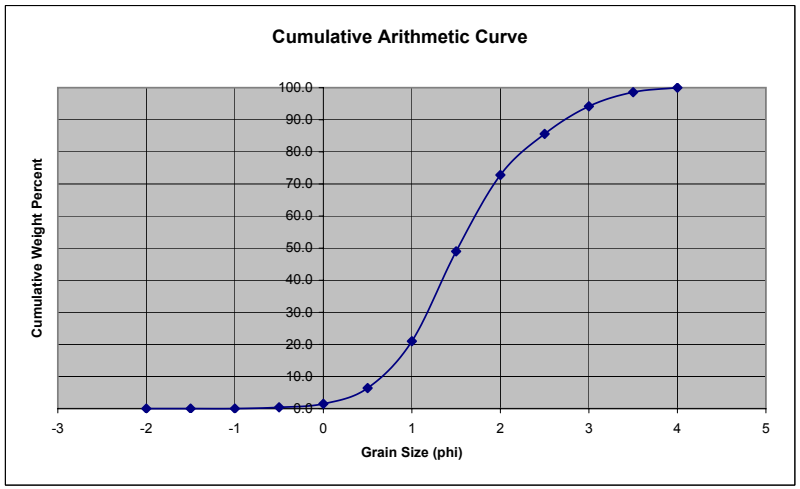
Grain Size Statistics		
Median (Md)	1.521	
Geometric Mean (Mz)	1.596	
Sorting (So)	0.858	moderately sorted
Standard Deviation	0.804	moderately sorted
Skewness (SkG)	0.139	positively skewed
(SkI)	0.144	positively skewed
Kurtosis (Kg)	1.104	mesokurtic

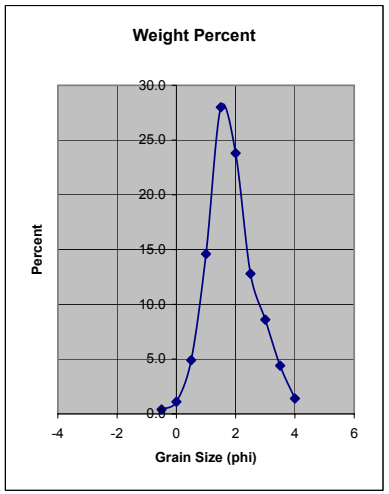
Phi5	0.829
Phi16	1.071
Phi25	1.521
Phi50	2.086
Phi75	2.438
Phi84	3.091
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.8	
Available P		mg/kg
Organic Matter (OM)	0.8	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	82
Silt	12
Clay	6

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 9

Sample ID N229 E715 BC

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.4	0.4
0	1.2	1.6
0.5	5.1	6.7
1	15.1	21.8
1.5	28.1	49.9
2	23.8	73.7
2.5	12.6	86.3
3	8.3	94.6
3.5	4.1	98.7
4	1.3	100.0

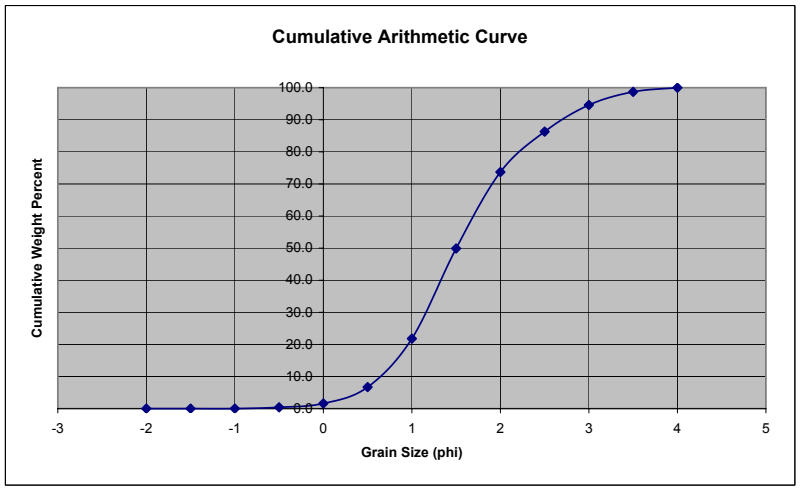
Grain Size Statistics		
Median (Md)	1.502	
Geometric Mean (Mz)	1.573	
Sorting (So)	0.853	moderately sorted
Standard Deviation	0.800	moderately sorted
Skewness (SkG)	0.133	positively skewed
(SkI)	0.136	positively skewed
Kurtosis (Kg)	1.119	leptokurtic

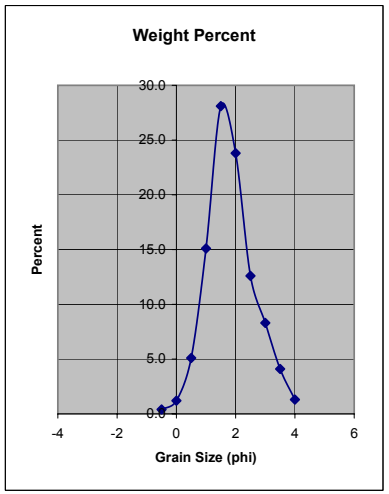
Phi5	0.808
Phi16	1.057
Phi25	1.502
Phi50	2.052
Phi75	2.409
Phi84	3.049
Phi95	0.000

Chemical Tests		
Test		Units
pH	6.1	
Available P		mg/kg
Organic Matter (OM)	0.7	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	81
Silt	11
Clay	8

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 10

Sample ID N229 E715 2AB1

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.4	0.4
0	1.3	1.7
0.5	4.8	6.5
1	14.1	20.6
1.5	27.4	48.0
2	23.8	71.8
2.5	13.1	84.9
3	8.9	93.8
3.5	4.7	98.5
4	1.5	100.0

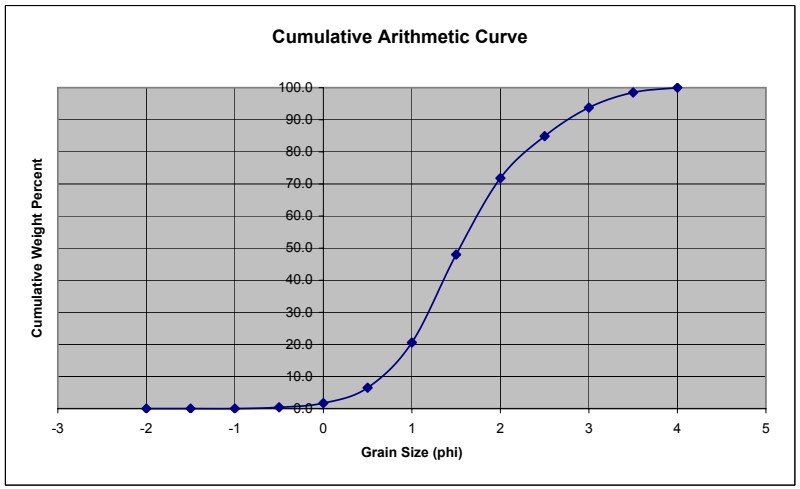
Grain Size Statistics		
Median (Md)	1.542	
Geometric Mean (Mz)	1.615	
Sorting (So)	0.871	moderately sorted
Standard Deviation	0.814	moderately sorted
Skewness (SkG)	0.134	positively skewed
(SkI)	0.137	positively skewed
Kurtosis (Kg)	1.095	mesokurtic

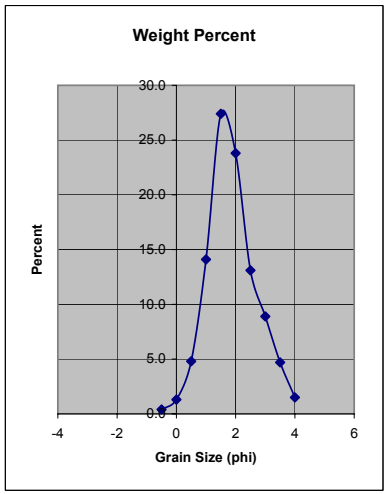
Phi5	0.837
Phi16	1.080
Phi25	1.542
Phi50	2.122
Phi75	2.466
Phi84	3.128
Phi95	0.000

Chemical Tests		
Test		Units
pH	6	
Available P		mg/kg
Organic Matter (OM)	0.8	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	82
Silt	9
Clay	9

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 11

Sample ID N229 E715 2AB2

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.3	0.3
0	1.3	1.6
0.5	5.1	6.7
1	14.5	21.2
1.5	27.6	48.8
2	22.9	71.7
2.5	12.3	84.0
3	8.9	92.9
3.5	5.3	98.2
4	1.8	100.0

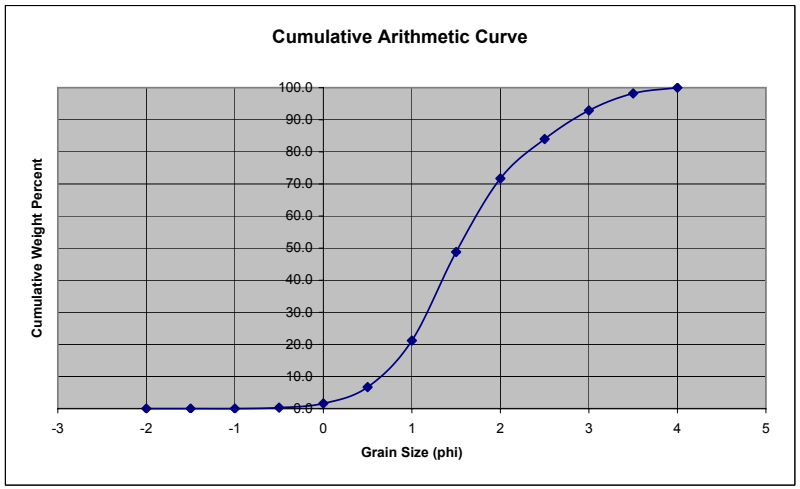
Grain Size Statistics		
Median (Md)	1.526	
Geometric Mean (Mz)	1.616	
Sorting (So)	0.897	moderately sorted
Standard Deviation	0.840	moderately sorted
Skewness (SkG)	0.160	positively skewed
(SkI)	0.163	positively skewed
Kurtosis (Kg)	1.102	mesokurtic

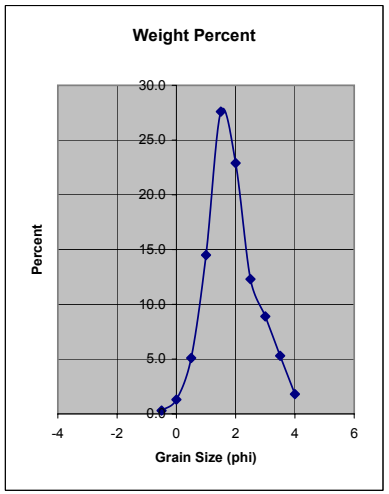
Phi5	0.821
Phi16	1.069
Phi25	1.526
Phi50	2.134
Phi75	2.500
Phi84	3.198
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.9	
Available P		mg/kg
Organic Matter (OM)	0.9	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	81
Silt	8
Clay	11

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 12

Sample ID N229 E715 2C1

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.4	0.4
0	1.4	1.8
0.5	5.7	7.5
1	17.2	24.7
1.5	29.7	54.4
2	22.4	76.8
2.5	10.8	87.6
3	6.8	94.4
3.5	3.9	98.3
4	1.7	100.0

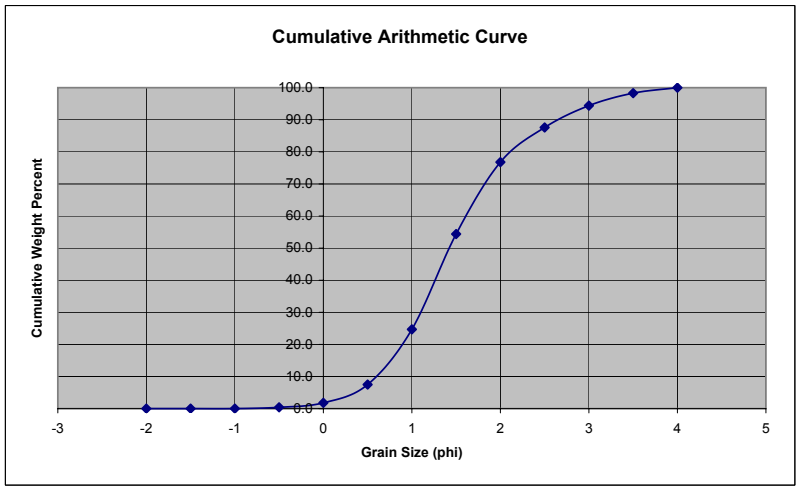
Grain Size Statistics		
Median (Md)	1.426	
Geometric Mean (Mz)	1.502	
Sorting (So)	0.863	moderately sorted
Standard Deviation	0.793	moderately sorted
Skewness (SkG)	0.144	positively skewed
(SkI)	0.162	positively skewed
Kurtosis (Kg)	1.200	leptokurtic

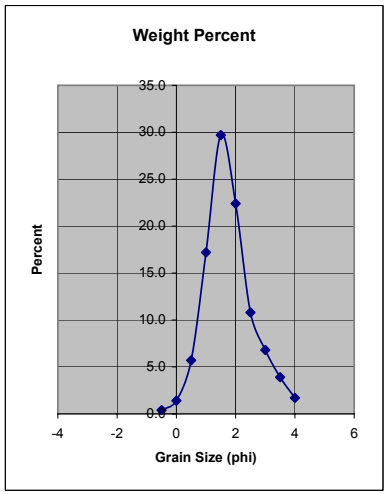
Phi5	0.747
Phi16	1.005
Phi25	1.426
Phi50	1.960
Phi75	2.333
Phi84	3.077
Phi95	0.000

Chemical Tests		
Test		Units
pH	6.1	
Available P		mg/kg
Organic Matter (OM)	0.7	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	82
Silt	9
Clay	9

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 13

Sample ID N229 E715 2C2

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.8	0.8
0	1.5	2.3
0.5	5.3	7.6
1	14.4	22.0
1.5	24.3	46.3
2	20.9	67.2
2.5	13.3	80.5
3	11.0	91.5
3.5	6.2	97.7
4	2.3	100.0

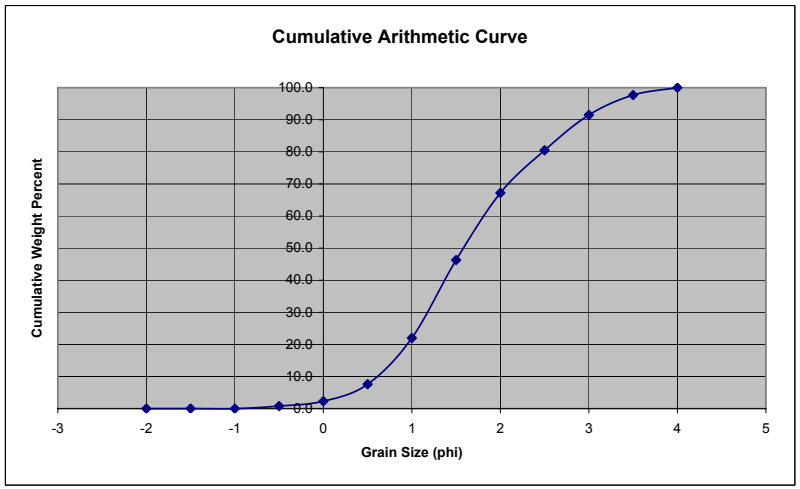
Grain Size Statistics		
Median (Md)	1.589	
Geometric Mean (Mz)	1.680	
Sorting (So)	0.971	moderately sorted
Standard Deviation	0.934	moderately sorted
Skewness (SkG)	0.147	positively skewed
(SkI)	0.133	positively skewed
Kurtosis (Kg)	1.008	mesokurtic

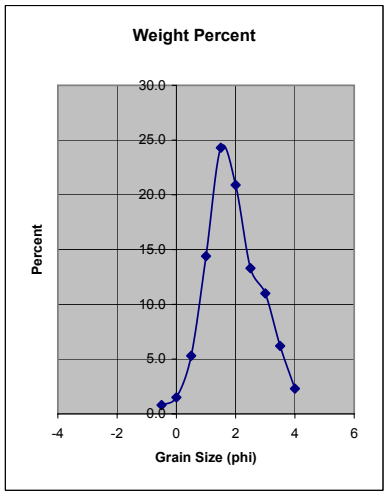
Phi5	0.792
Phi16	1.062
Phi25	1.589
Phi50	2.293
Phi75	2.659
Phi84	3.282
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.9	
Available P		mg/kg
Organic Matter (OM)	0.7	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	83
Silt	8
Clay	9

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 14

Sample ID N207 E666 colluvium

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.5	0.5
0	1.6	2.1
0.5	5.7	7.8
1	15.8	23.6
1.5	26.3	49.9
2	22.1	72.0
2.5	12.6	84.6
3	8.6	93.2
3.5	5.0	98.2
4	1.8	100.0

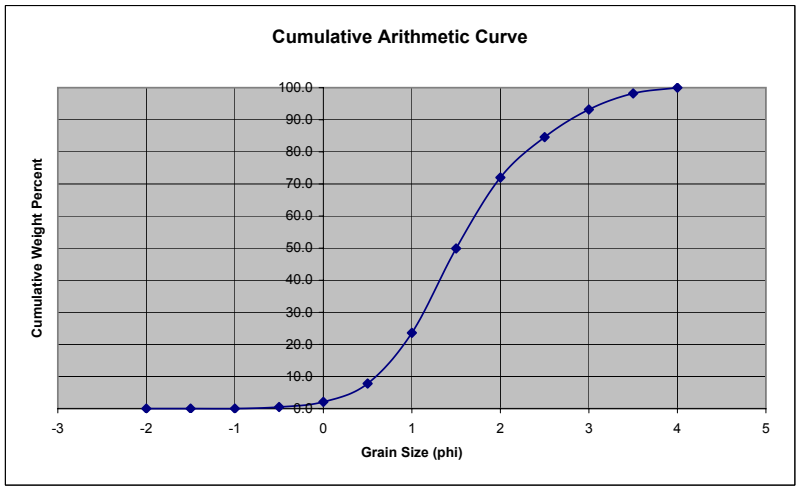
Grain Size Statistics		
Median (Md)	1.502	
Geometric Mean (Mz)	1.579	
Sorting (So)	0.917	moderately sorted
Standard Deviation	0.858	moderately sorted
Skewness (SkG)	0.135	positively skewed
(SkI)	0.141	positively skewed
Kurtosis (Kg)	1.098	mesokurtic

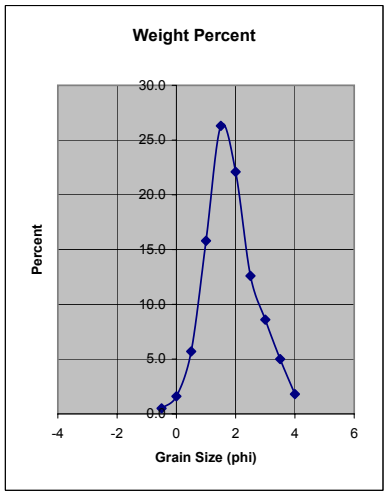
Phi5	0.759
Phi16	1.027
Phi25	1.502
Phi50	2.119
Phi75	2.476
Phi84	3.180
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.4	
Available P		mg/kg
Organic Matter (OM)	0.8	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	83
Silt	11
Clay	6

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 15

Sample ID N218 E647 Ap

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.3	0.3
0	1.0	1.3
0.5	4.2	5.5
1	13.8	19.3
1.5	27.8	47.1
2	23.6	70.7
2.5	13.4	84.1
3	9.3	93.4
3.5	5.0	98.4
4	1.6	100.0

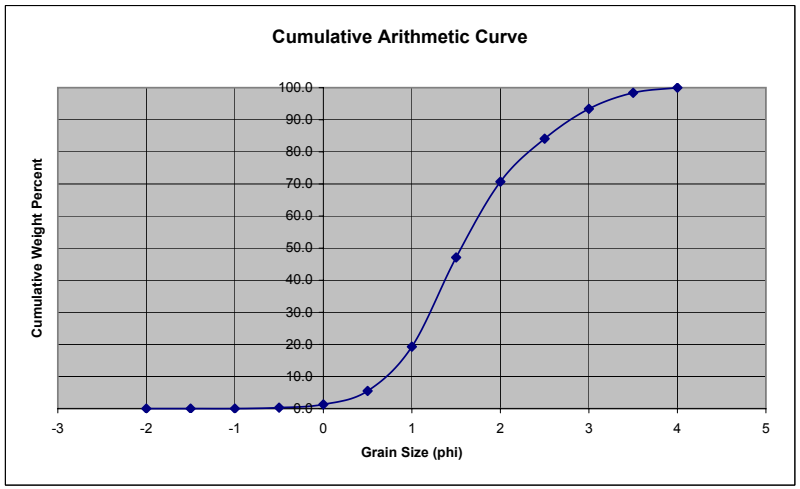
Grain Size Statistics		
Median (Md)	1.561	
Geometric Mean (Mz)	1.646	
Sorting (So)	0.857	moderately sorted
Standard Deviation	0.808	moderately sorted
Skewness (SkG)	0.157	positively skewed
(SkI)	0.166	positively skewed
Kurtosis (Kg)	1.054	mesokurtic

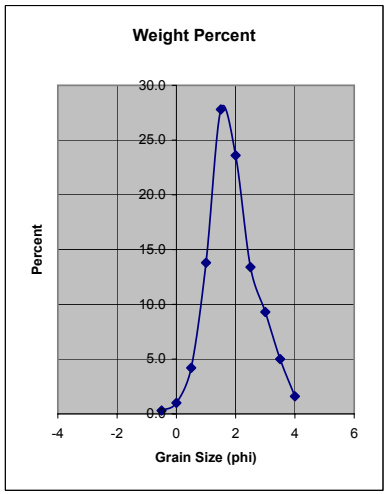
Phi5	0.880
Phi16	1.103
Phi25	1.561
Phi50	2.160
Phi75	2.496
Phi84	3.160
Phi95	0.000

Chemical Tests		
Test		Units
pH	4	
Available P		mg/kg
Organic Matter (OM)	1.1	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	81
Silt	14
Clay	5

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 16

Sample ID N218 E647 B/C

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.8	0.8
0	1.4	2.2
0.5	5.6	7.8
1	15.5	23.3
1.5	27.4	50.7
2	22.2	72.9
2.5	12.4	85.3
3	8.6	93.9
3.5	4.7	98.6
4	1.4	100.0

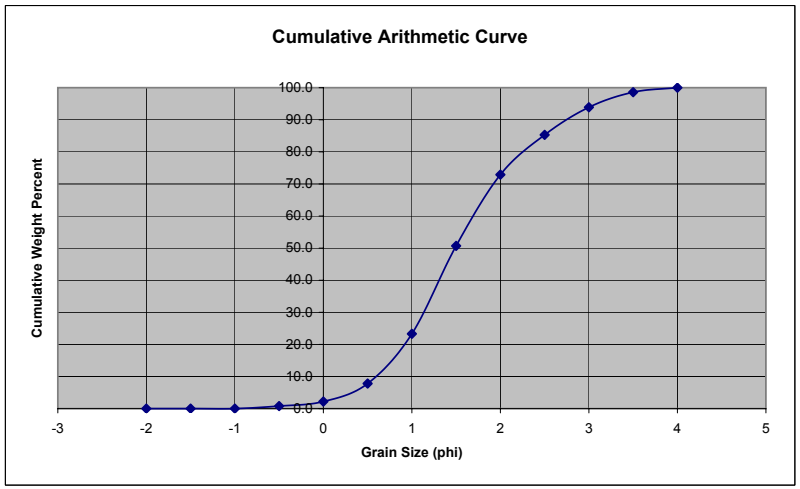
Grain Size Statistics		
Median (Md)	1.487	
Geometric Mean (Mz)	1.566	
Sorting (So)	0.899	moderately sorted
Standard Deviation	0.842	moderately sorted
Skewness (SkG)	0.141	positively skewed
(SkI)	0.139	positively skewed
Kurtosis (Kg)	1.115	leptokurtic

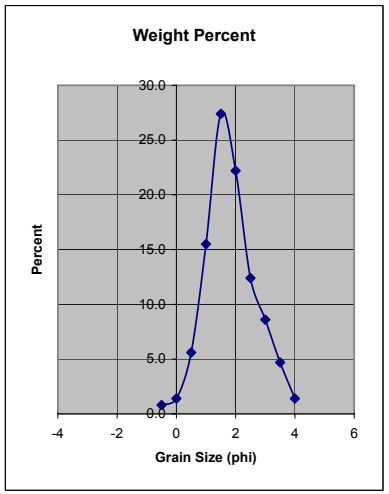
Phi5	0.765
Phi16	1.031
Phi25	1.487
Phi50	2.085
Phi75	2.448
Phi84	3.117
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.3	
Available P		mg/kg
Organic Matter (OM)	0.9	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	77
Silt	16
Clay	7

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 17

Sample ID N218 E647 C

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	1.0	1.0
0	2.0	3.0
0.5	5.8	8.8
1	16.0	24.8
1.5	27.4	52.2
2	22.2	74.4
2.5	11.9	86.3
3	8.0	94.3
3.5	4.2	98.5
4	1.5	100.0

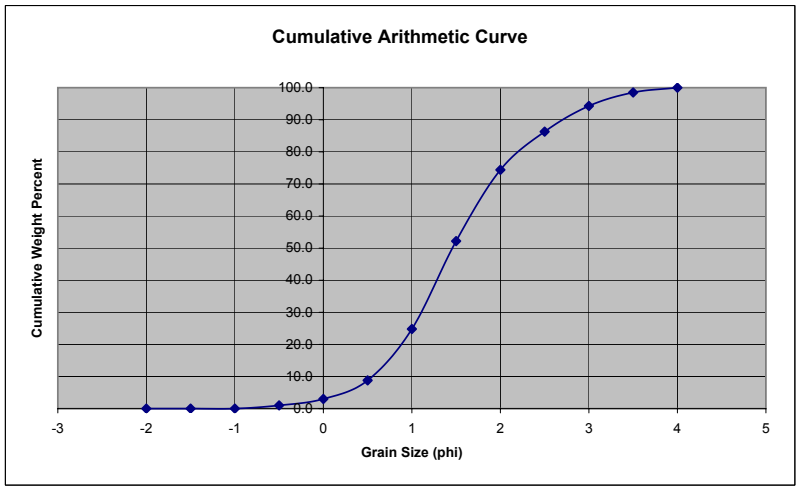
Grain Size Statistics		
Median (Md)	1.460	
Geometric Mean (Mz)	1.529	
Sorting (So)	0.905	moderately sorted
Standard Deviation	0.839	moderately sorted
Skewness (SkG)	0.124	positively skewed
(SkI)	0.120	positively skewed
Kurtosis (Kg)	1.168	leptokurtic

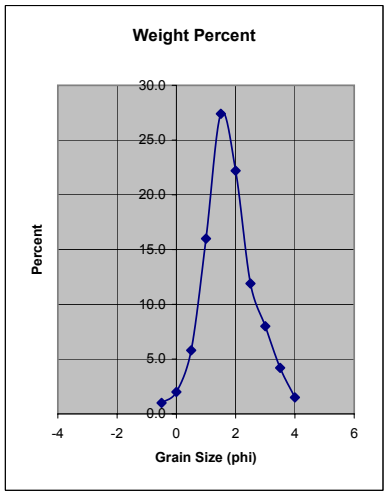
Phi5	0.725
Phi16	1.004
Phi25	1.460
Phi50	2.025
Phi75	2.403
Phi84	3.083
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.6	
Available P		mg/kg
Organic Matter (OM)	0.7	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD		%

Granulometry	
Class.	Percent
Sand	75
Silt	18
Clay	7

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 18

Sample ID N225 E575 Feat 6 crtl 70-80cm

Metrics

Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

Grain Size Statistics

Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests

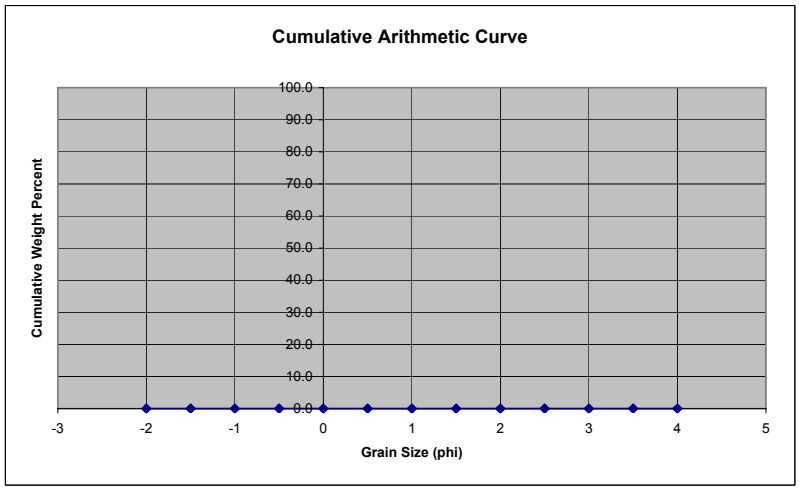
Test		Units
pH	5.3	
Available P	1.4	mg/kg
Organic Matter (OM)	0.9	%
Exch Ca	321.8	mg/kg
Exch Mg	136.5	mg/kg
Exch K	92.6	mg/kg
Fe - CD	1.14	%

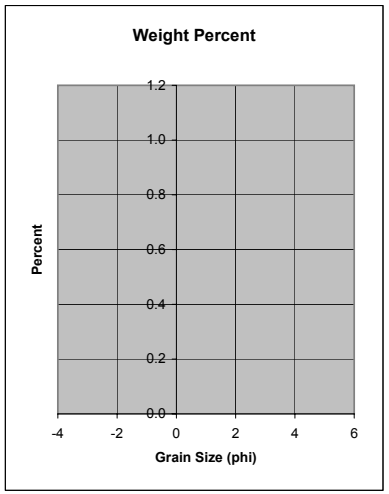
Granulometry

Class.	Percent
Sand	75
Silt	12
Clay	13

P fractionation

Fraction	mg/kg	Perc
1a	55.3	3
1b	3.6	2
1 (All)	58.9	36
2	94.7	58
3	9.3	5
Sum	162.9	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 19

Sample ID N225 E575 Feat 6 crtl 140-150cm

Metrics

Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

Grain Size Statistics

Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests

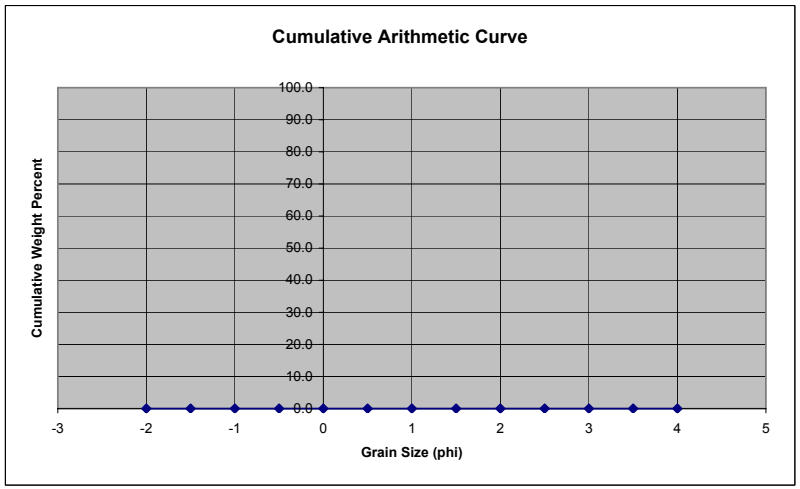
Test		Units
pH	5.3	
Available P	1.5	mg/kg
Organic Matter (OM)	0.6	%
Exch Ca	156.7	mg/kg
Exch Mg	67.1	mg/kg
Exch K	58.1	mg/kg
Fe - CD	0.86	%

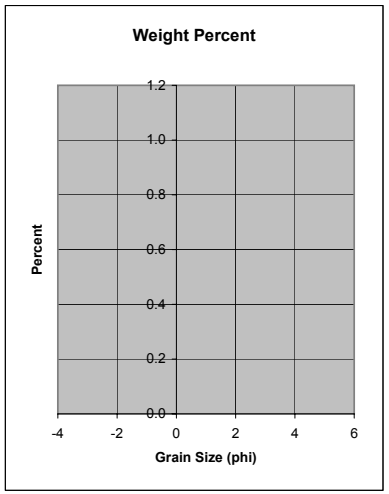
Granulometry

Class.	Percent
Sand	79
Silt	14
Clay	7

P fractionation

Fraction	mg/kg	Perc
1a	41.9	35
1b	3.3	2
1 (All)	45.2	37
2	68.4	57
3	5.8	4
Sum	119.4	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 20

Sample ID N225 E575 Feat 6 Str 1 70-80cm

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

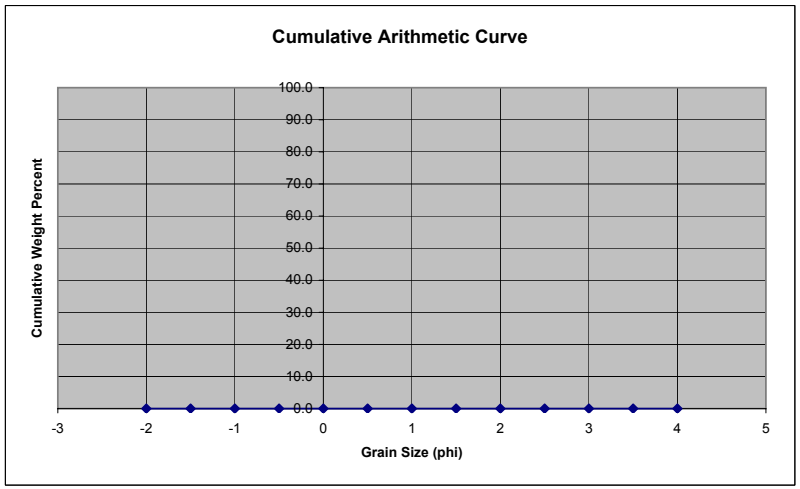
Grain Size Statistics		
Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

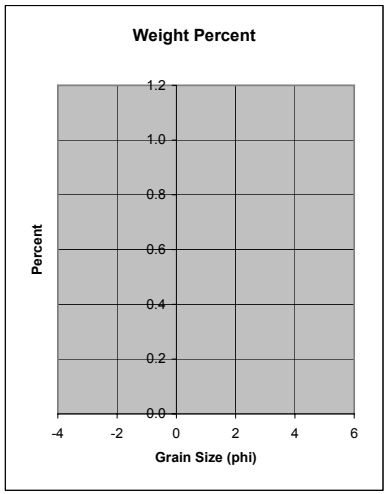
Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.6	
Available P	6.4	mg/kg
Organic Matter (OM)	0.7	%
Exch Ca	173.8	mg/kg
Exch Mg	47.4	mg/kg
Exch K	54.0	mg/kg
Fe - CD	0.73	%

Granulometry	
Class.	Percent
Sand	71
Silt	20
Clay	9

P fractionation		
Fraction	mg/kg	Perc
1a	53.4	38
1b	6.1	4
1 (All)	59.5	42
2	73.3	52
3	5.9	4
Sum	138.7	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 21

Sample ID N225 E575 Feat 6 Str 1 80-90cm

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

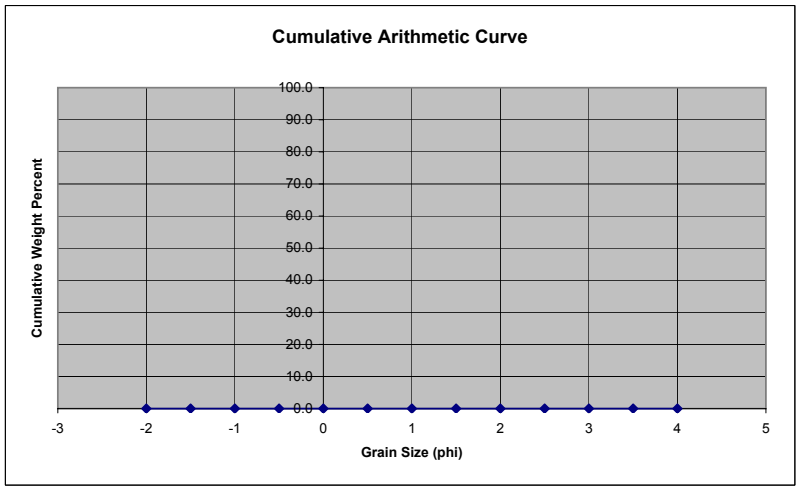
Grain Size Statistics		
Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

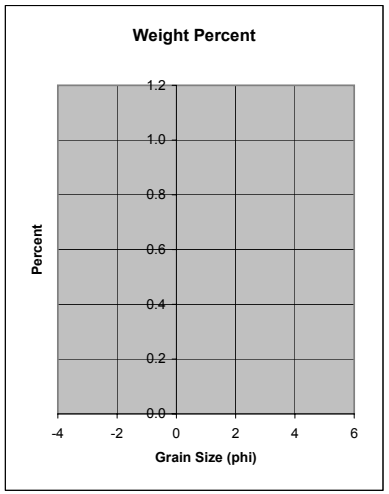
Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.6	
Available P	5.1	mg/kg
Organic Matter (OM)	0.7	%
Exch Ca	203.1	mg/kg
Exch Mg	50.8	mg/kg
Exch K	58.2	mg/kg
Fe - CD	0.76	%

Granulometry	
Class.	Percent
Sand	71
Silt	20
Clay	9

P fractionation		
Fraction	mg/kg	Perc
1a	54.9	39
1b	4.6	3
1 (All)	59.5	43
2	73.6	53
3	5.0	3
Sum	138.1	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 22

Sample ID N225 E575 Feat 6 Str 1 90-100cm

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

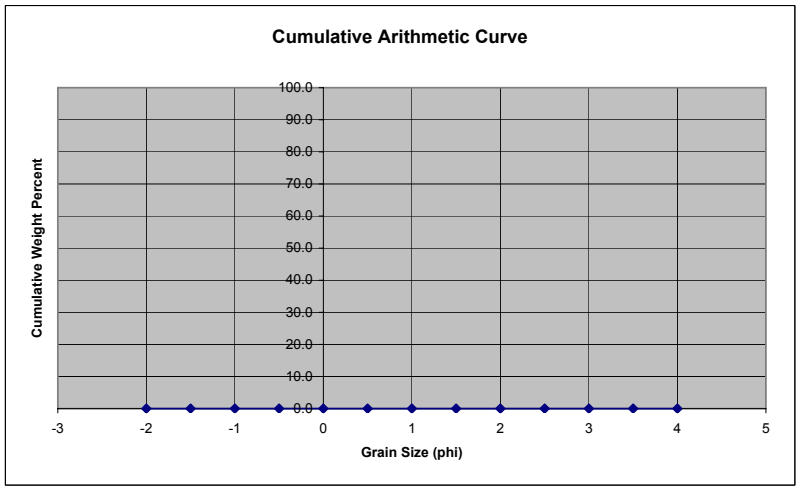
Grain Size Statistics		
Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

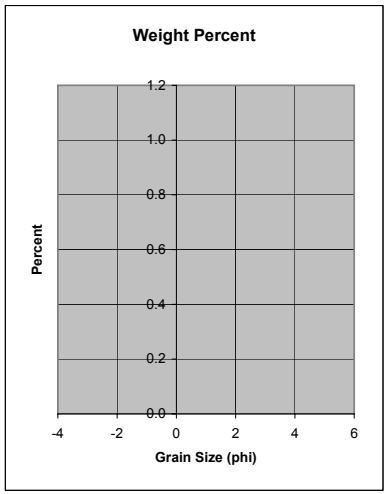
Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.4	
Available P	5.5	mg/kg
Organic Matter (OM)	0.7	%
Exch Ca	160.2	mg/kg
Exch Mg	39.4	mg/kg
Exch K	54.4	mg/kg
Fe - CD	0.68	%

Granulometry	
Class.	Percent
Sand	70
Silt	22
Clay	8

P fractionation		
Fraction	mg/kg	Perc
1a	51.7	39
1b	4.9	3
1 (All)	56.6	43
2	69.1	52
3	5.4	4
Sum	131.1	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 23

Sample ID N225 E575 Feat 6 Str 1 100-110cm

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

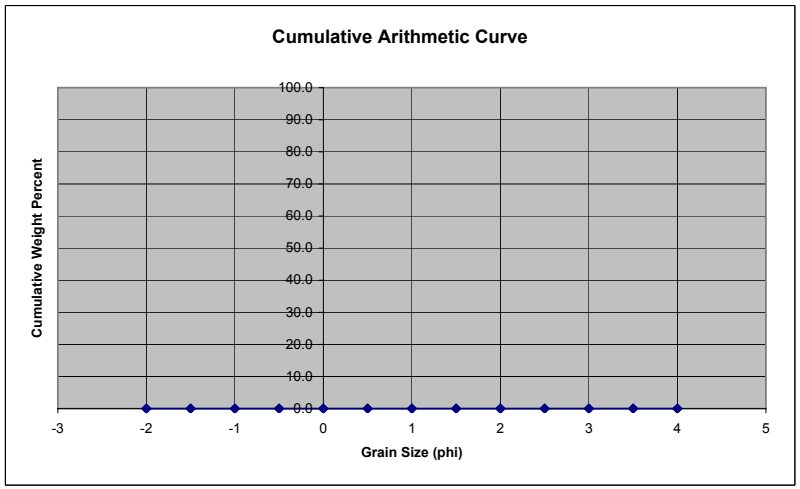
Grain Size Statistics		
Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

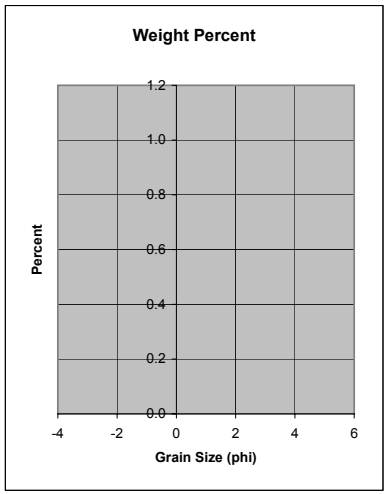
Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.5	
Available P	6.7	mg/kg
Organic Matter (OM)	0.7	%
Exch Ca	153.4	mg/kg
Exch Mg	40.4	mg/kg
Exch K	57.0	mg/kg
Fe - CD	0.65	%

Granulometry	
Class.	Percent
Sand	71
Silt	22
Clay	7

P fractionation		
Fraction	mg/kg	Perc
1a	56.4	42
1b	3.3	2
1 (All)	59.7	44
2	68.6	51
3	4.6	3
Sum	132.9	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 24

Sample ID N225 E575 Feat 6 Str 1 110-120cm

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

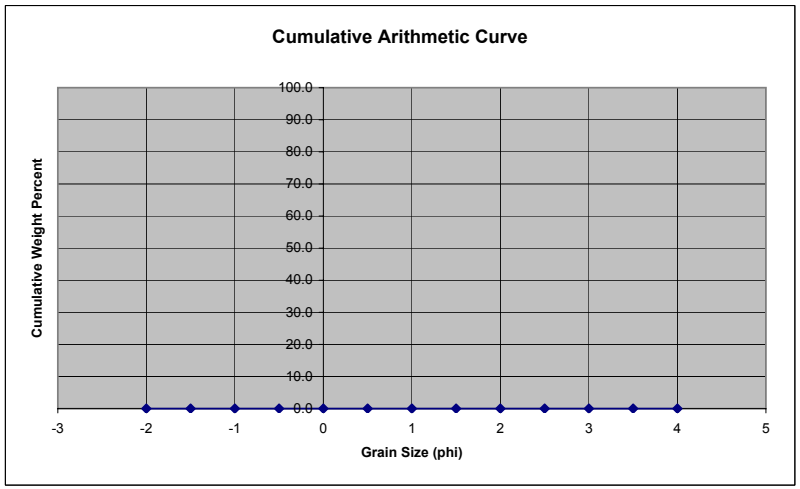
Grain Size Statistics		
Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

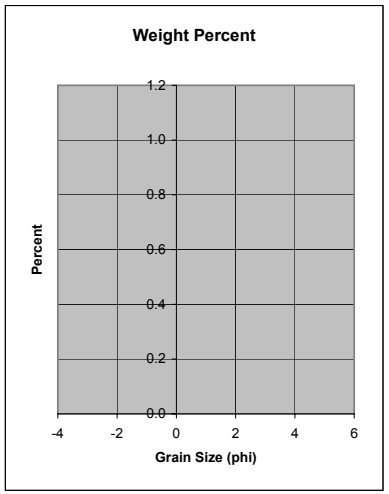
Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.7	
Available P	10.5	mg/kg
Organic Matter (OM)	0.7	%
Exch Ca	110.9	mg/kg
Exch Mg	35.2	mg/kg
Exch K	53.0	mg/kg
Fe - CD	0.60	%

Granulometry	
Class.	Percent
Sand	72
Silt	22
Clay	6

P fractionation		
Fraction	mg/kg	Perc
1a	63.1	45
1b	5.2	3
1 (All)	68.3	49
2	65.2	46
3	5.9	4
Sum	139.4	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 25

Sample ID N225 E575 Feat 6 Str 1 120-130cm

Metrics

Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

Grain Size Statistics

Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests

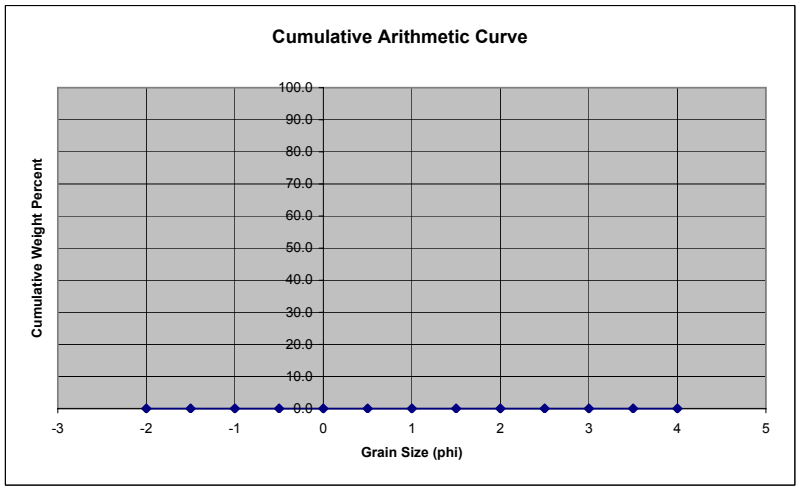
Test		Units
pH	5.8	
Available P	4.1	mg/kg
Organic Matter (OM)	0.6	%
Exch Ca	124.8	mg/kg
Exch Mg	42.1	mg/kg
Exch K	63.5	mg/kg
Fe - CD	0.63	%

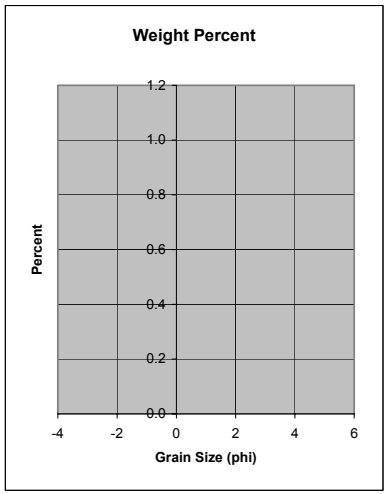
Granulometry

Class.	Percent
Sand	71
Silt	22
Clay	7

P fractionation

Fraction	mg/kg	Perc
1a	39.0	37
1b	2.7	2
1 (All)	41.7	40
2	58.0	55
3	3.9	3
Sum	103.6	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 26

Sample ID N225 E575 Feat 6 Str 1 130-140cm

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

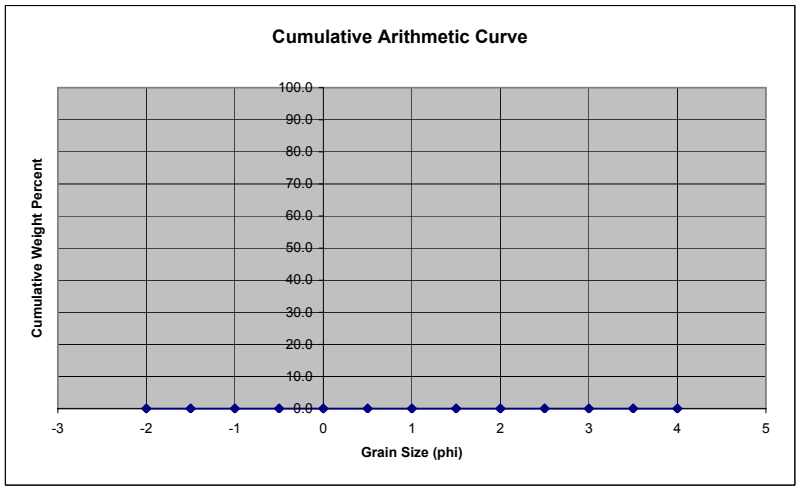
Grain Size Statistics		
Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

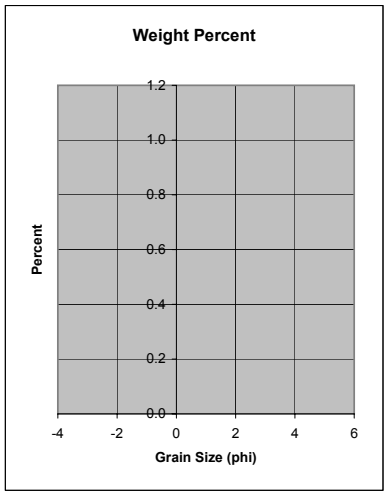
Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.7	
Available P	0.9	mg/kg
Organic Matter (OM)	0.7	%
Exch Ca	220.4	mg/kg
Exch Mg	104.3	mg/kg
Exch K	86.9	mg/kg
Fe - CD	0.95	%

Granulometry	
Class.	Percent
Sand	73
Silt	17
Clay	10

P fractionation		
Fraction	mg/kg	Perc
1a	37.2	29
1b	4.6	3
1 (All)	41.8	33
2	75.5	60
3	7.2	5
Sum	124.5	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 27

Sample ID N295 E543 AC

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.7	0.7
0	1.8	2.5
0.5	5.8	8.3
1	16.0	24.3
1.5	29.3	53.6
2	22.2	75.8
2.5	11.1	86.9
3	7.5	94.4
3.5	4.2	98.6
4	1.4	100.0

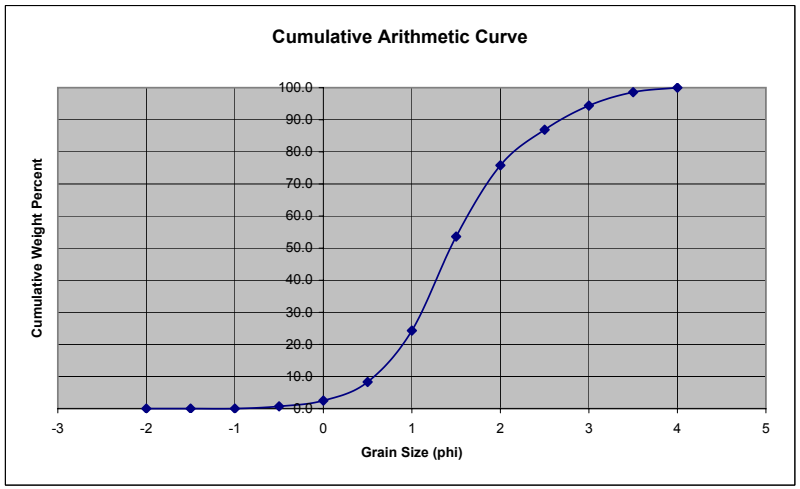
Grain Size Statistics		
Median (Md)	1.439	
Geometric Mean (Mz)	1.516	
Sorting (So)	0.883	moderately sorted
Standard Deviation	0.814	moderately sorted
Skewness (SkG)	0.143	positively skewed
(SkI)	0.143	positively skewed
Kurtosis (Kg)	1.207	leptokurtic

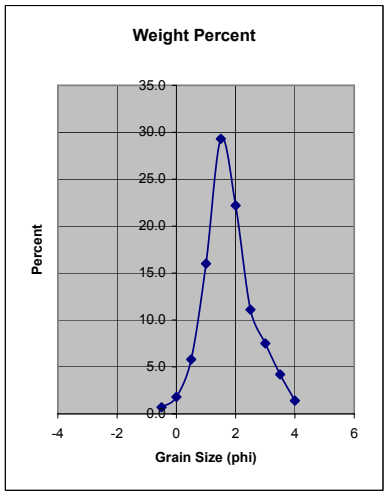
Phi5	0.741
Phi16	1.012
Phi25	1.439
Phi50	1.982
Phi75	2.369
Phi84	3.071
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.1	
Available P		mg/kg
Organic Matter (OM)	1.0	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD	0.60	%

Granulometry	
Class.	Percent
Sand	79
Silt	16
Clay	6

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 28

Sample ID N295 E543 C1

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.7	0.7
0	1.6	2.3
0.5	5.9	8.2
1	16.2	24.4
1.5	29.3	53.7
2	22.3	76.0
2.5	11.1	87.1
3	7.4	94.5
3.5	4.0	98.5
4	1.5	100.0

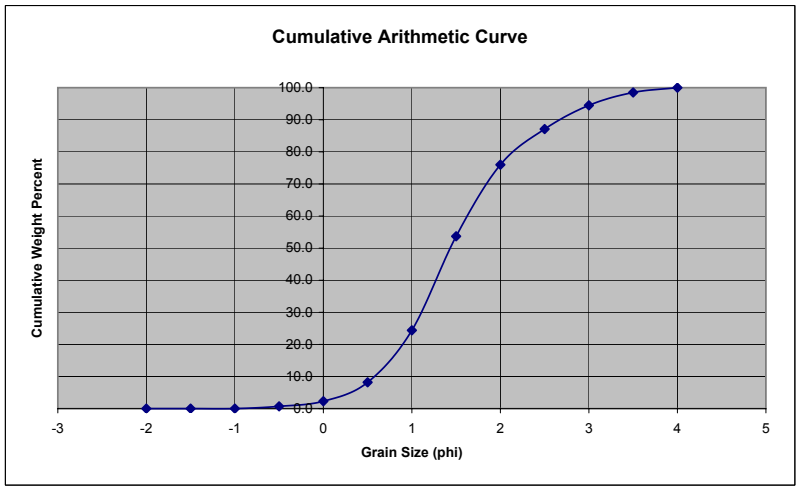
Grain Size Statistics		
Median (Md)	1.437	
Geometric Mean (Mz)	1.513	
Sorting (So)	0.877	moderately sorted
Standard Deviation	0.810	moderately sorted
Skewness (SkG)	0.140	positively skewed
(SkI)	0.144	positively skewed
Kurtosis (Kg)	1.201	leptokurtic

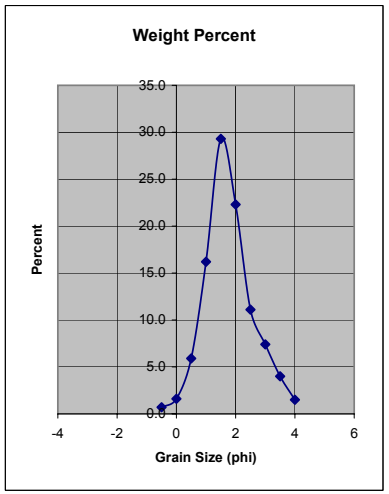
Phi5	0.741
Phi16	1.010
Phi25	1.437
Phi50	1.978
Phi75	2.360
Phi84	3.063
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.7	
Available P		mg/kg
Organic Matter (OM)	0.7	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD	0.63	%

Granulometry	
Class.	Percent
Sand	78
Silt	15
Clay	7

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 29

Sample ID N295 E543 C2

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.7	0.7
0	2.1	2.8
0.5	6.3	9.1
1	17.2	26.3
1.5	29.7	56.0
2	21.8	77.8
2.5	10.3	88.1
3	6.8	94.9
3.5	3.7	98.6
4	1.4	100.0

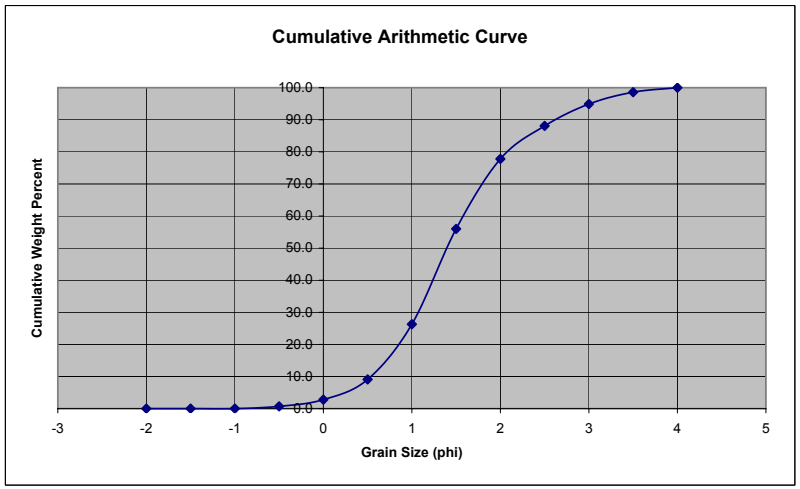
Grain Size Statistics		
Median (Md)	1.399	
Geometric Mean (Mz)	1.467	
Sorting (So)	0.873	moderately sorted
Standard Deviation	0.800	moderately sorted
Skewness (SkG)	0.127	positively skewed
(SkI)	0.132	positively skewed
Kurtosis (Kg)	1.195	leptokurtic

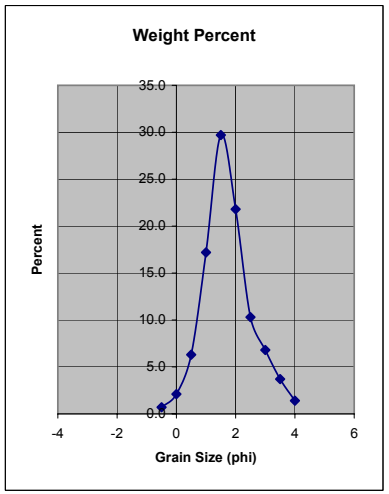
Phi5	0.701
Phi16	0.962
Phi25	1.399
Phi50	1.936
Phi75	2.301
Phi84	3.014
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.6	
Available P		mg/kg
Organic Matter (OM)	0.7	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD	0.70	%

Granulometry	
Class.	Percent
Sand	78
Silt	15
Clay	7

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 30

Sample ID N295 E543 2AB1

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.8	0.8
0	2.0	2.8
0.5	6.3	9.1
1	16.2	25.3
1.5	29.3	54.6
2	21.9	76.5
2.5	10.7	87.2
3	7.3	94.5
3.5	4.1	98.6
4	1.4	100.0

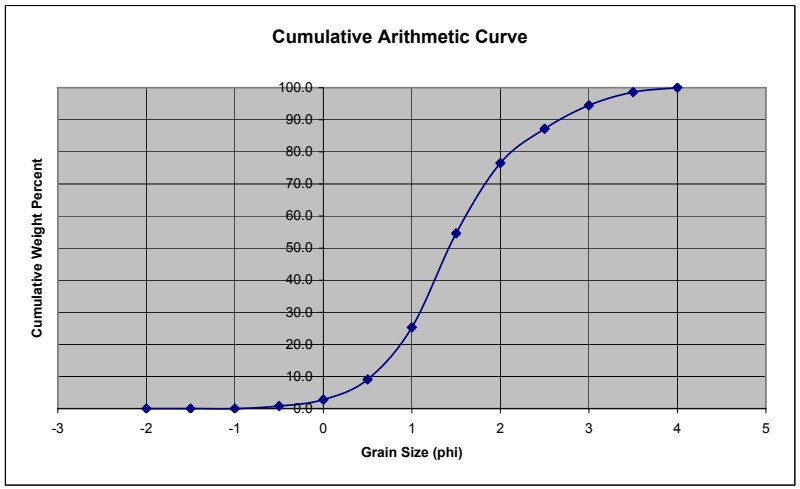
Grain Size Statistics		
Median (Md)	1.422	
Geometric Mean (Mz)	1.495	
Sorting (So)	0.890	moderately sorted
Standard Deviation	0.819	moderately sorted
Skewness (SkG)	0.135	positively skewed
(SkI)	0.135	positively skewed
Kurtosis (Kg)	1.213	leptokurtic

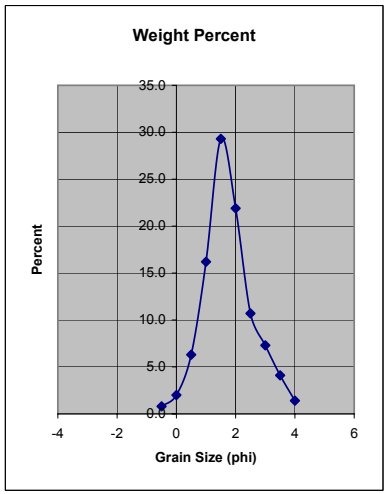
Phi5	0.713
Phi16	0.991
Phi25	1.422
Phi50	1.966
Phi75	2.350
Phi84	3.061
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.7	
Available P		mg/kg
Organic Matter (OM)	0.8	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD	0.94	%

Granulometry	
Class.	Percent
Sand	77
Silt	12
Clay	11

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 31

Sample ID N295 E543 2AB2

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.9	0.9
0	2.3	3.2
0.5	6.8	10.0
1	16.7	26.7
1.5	29.5	56.2
2	21.2	77.4
2.5	10.1	87.5
3	6.9	94.4
3.5	4.0	98.4
4	1.6	100.0

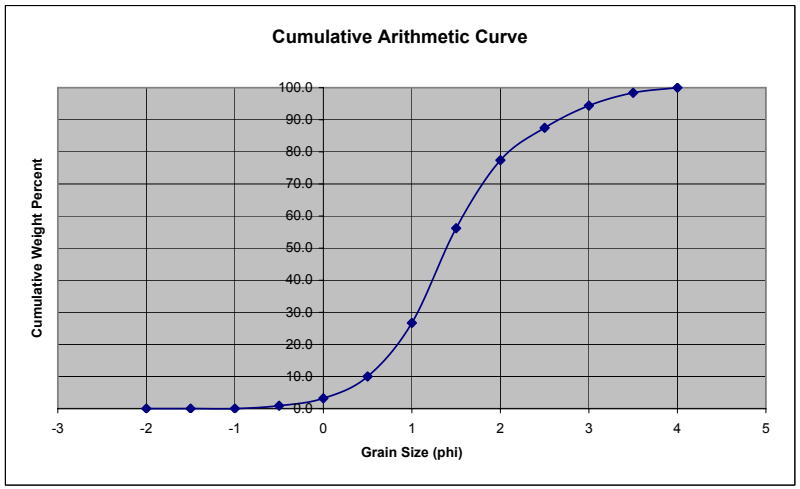
Grain Size Statistics		
Median (Md)	1.395	
Geometric Mean (Mz)	1.467	
Sorting (So)	0.902	moderately sorted
Standard Deviation	0.824	moderately sorted
Skewness (SkG)	0.131	positively skewed
(SkI)	0.137	positively skewed
Kurtosis (Kg)	1.213	leptokurtic

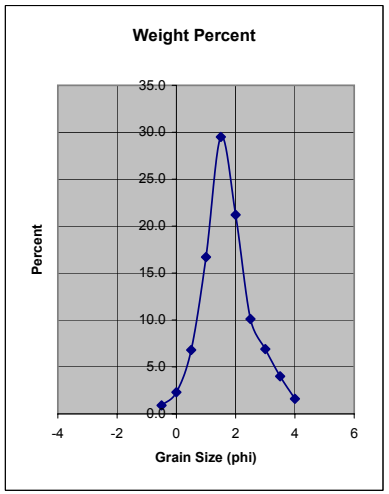
Phi5	0.680
Phi16	0.949
Phi25	1.395
Phi50	1.943
Phi75	2.327
Phi84	3.075
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.8	
Available P		mg/kg
Organic Matter (OM)	0.8	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD	0.99	%

Granulometry	
Class.	Percent
Sand	77
Silt	11
Clay	12

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 32

Sample ID N295 E543 2AB3

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	1.6	1.6
0	2.7	4.3
0.5	7.5	11.8
1	18.2	30.0
1.5	28.9	58.9
2	20.1	79.0
2.5	9.5	88.5
3	6.3	94.8
3.5	3.7	98.5
4	1.5	100.0

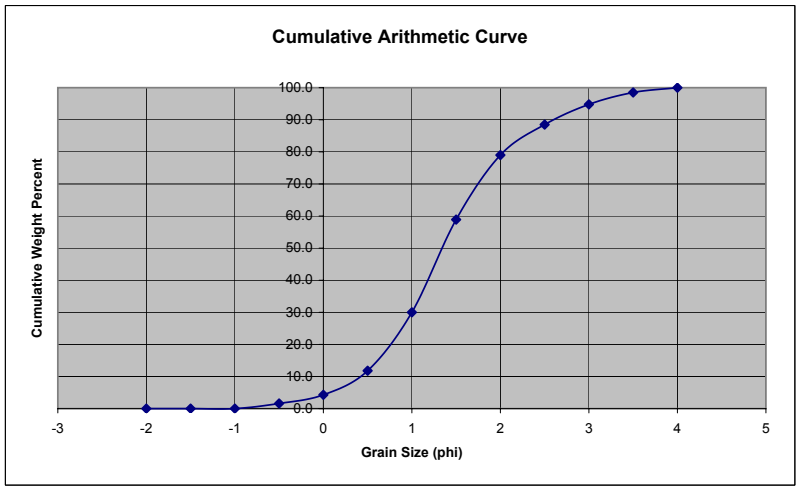
Grain Size Statistics		
Median (Md)	1.346	
Geometric Mean (Mz)	1.408	
Sorting (So)	0.909	moderately sorted
Standard Deviation	0.824	moderately sorted
Skewness (SkG)	0.113	positively skewed
(SkI)	0.121	positively skewed
Kurtosis (Kg)	1.177	leptokurtic

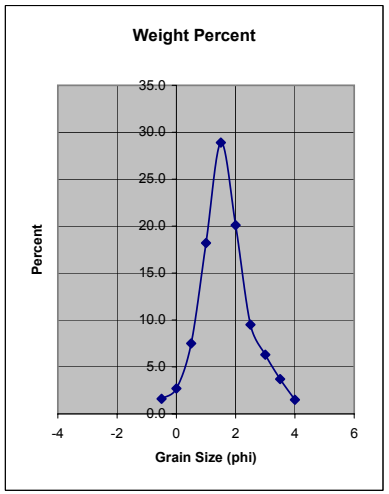
Phi5	0.615
Phi16	0.863
Phi25	1.346
Phi50	1.900
Phi75	2.263
Phi84	3.027
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.9	
Available P		mg/kg
Organic Matter (OM)	0.9	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD	1.05	%

Granulometry	
Class.	Percent
Sand	76
Silt	12
Clay	12

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 33

Sample ID N295 E543 2BC1

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	1.2	1.2
0	2.2	3.4
0.5	6.4	9.8
1	17.7	27.5
1.5	29.2	56.7
2	21.1	77.8
2.5	10.4	88.2
3	6.9	95.1
3.5	3.7	98.8
4	1.2	100.0

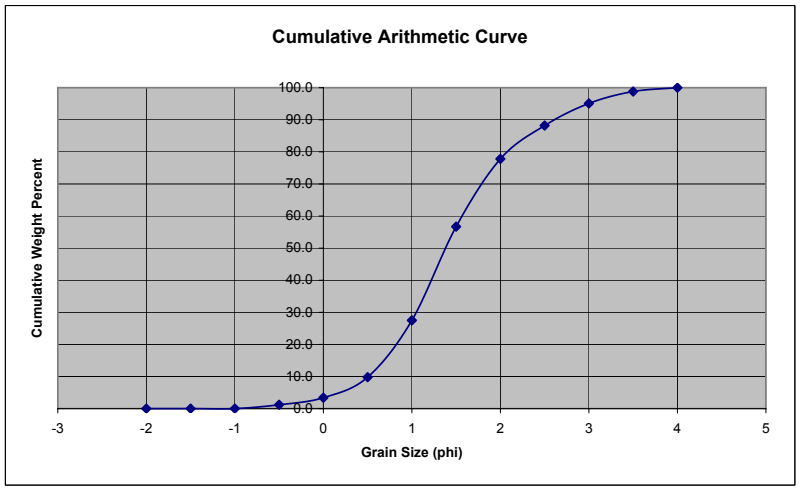
Grain Size Statistics		
Median (Md)	1.385	
Geometric Mean (Mz)	1.453	
Sorting (So)	0.884	moderately sorted
Standard Deviation	0.811	moderately sorted
Skewness (SkG)	0.125	positively skewed
(SkI)	0.123	positively skewed
Kurtosis (Kg)	1.170	leptokurtic

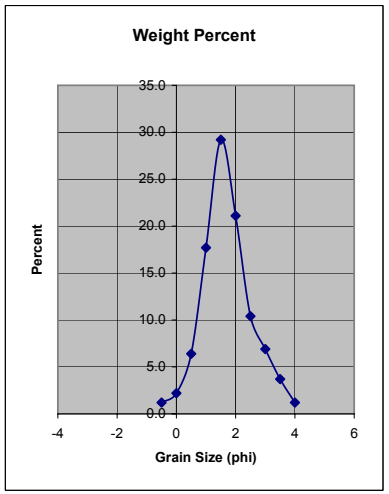
Phi5	0.675
Phi16	0.929
Phi25	1.385
Phi50	1.934
Phi75	2.298
Phi84	2.993
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.9	
Available P		mg/kg
Organic Matter (OM)	0.7	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD	1.00	%

Granulometry	
Class.	Percent
Sand	78
Silt	10
Clay	12

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 34

Sample ID N295 E543 2BC2

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	1.2	1.2
0	1.7	2.9
0.5	5.7	8.6
1	15.9	24.5
1.5	27.9	52.4
2	21.7	74.1
2.5	11.9	86.0
3	8.3	94.3
3.5	4.3	98.6
4	1.4	100.0

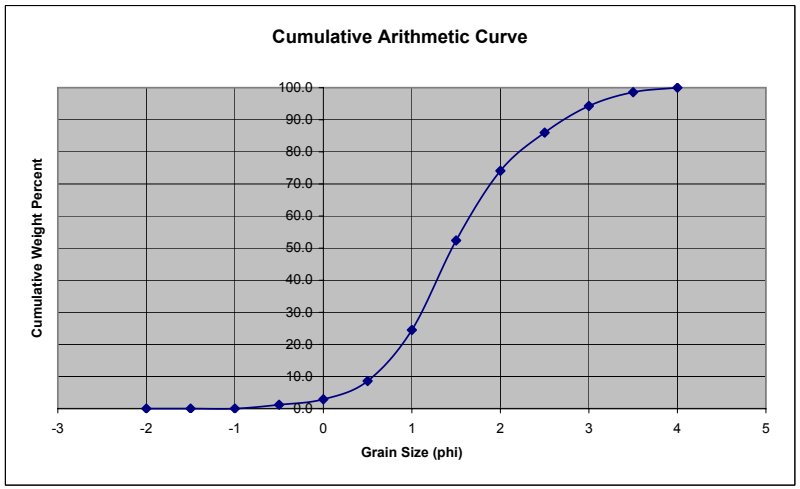
Grain Size Statistics		
Median (Md)	1.457	
Geometric Mean (Mz)	1.535	
Sorting (So)	0.904	moderately sorted
Standard Deviation	0.842	moderately sorted
Skewness (SkG)	0.139	positively skewed
(SkI)	0.130	positively skewed
Kurtosis (Kg)	1.154	leptokurtic

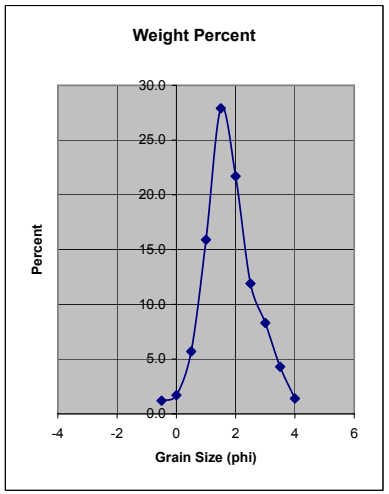
Phi5	0.733
Phi16	1.009
Phi25	1.457
Phi50	2.038
Phi75	2.416
Phi84	3.081
Phi95	0.000

Chemical Tests		
Test		Units
pH	6	
Available P		mg/kg
Organic Matter (OM)	0.8	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD	0.90	%

Granulometry	
Class.	Percent
Sand	79
Silt	11
Clay	10

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 35

Sample ID N295 E543 2C1

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	1.2	1.2
0	2.4	3.6
0.5	6.6	10.2
1	18.3	28.5
1.5	28.6	57.1
2	20.3	77.4
2.5	10.5	87.9
3	7.1	95.0
3.5	3.7	98.7
4	1.3	100.0

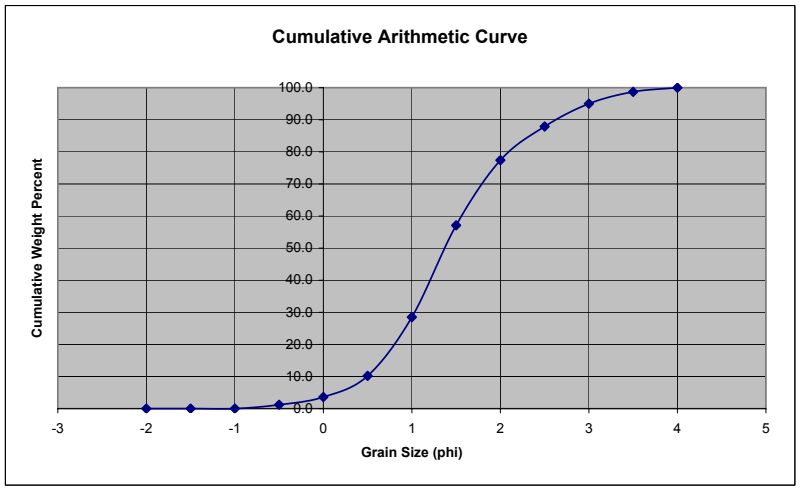
Grain Size Statistics		
Median (Md)	1.376	
Geometric Mean (Mz)	1.450	
Sorting (So)	0.896	moderately sorted
Standard Deviation	0.828	moderately sorted
Skewness (SkG)	0.133	positively skewed
(SkI)	0.128	positively skewed
Kurtosis (Kg)	1.144	leptokurtic

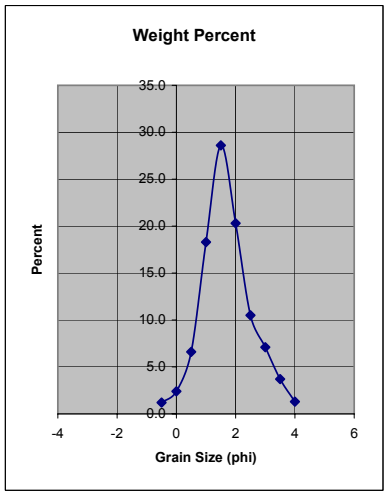
Phi5	0.658
Phi16	0.904
Phi25	1.376
Phi50	1.941
Phi75	2.314
Phi84	3.000
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.9	
Available P		mg/kg
Organic Matter (OM)	0.7	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD	0.93	%

Granulometry	
Class.	Percent
Sand	84
Silt	8
Clay	8

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 36

Sample ID N295 E543 2C2

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.7	0.7
0	1.9	2.6
0.5	5.6	8.2
1	15.6	23.8
1.5	27.1	50.9
2	21.2	72.1
2.5	12.1	84.2
3	9.1	93.3
3.5	5.0	98.3
4	1.7	100.0

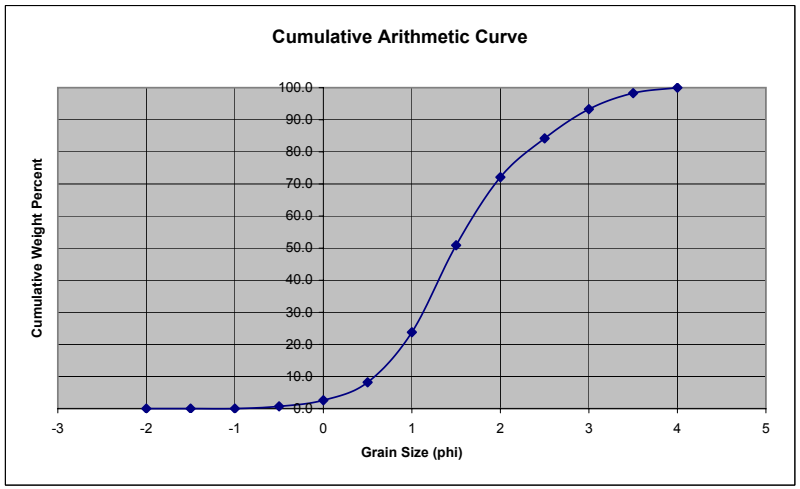
Grain Size Statistics		
Median (Md)	1.483	
Geometric Mean (Mz)	1.575	
Sorting (So)	0.928	moderately sorted
Standard Deviation	0.871	moderately sorted
Skewness (SkG)	0.158	positively skewed
(SkI)	0.150	positively skewed
Kurtosis (Kg)	1.104	mesokurtic

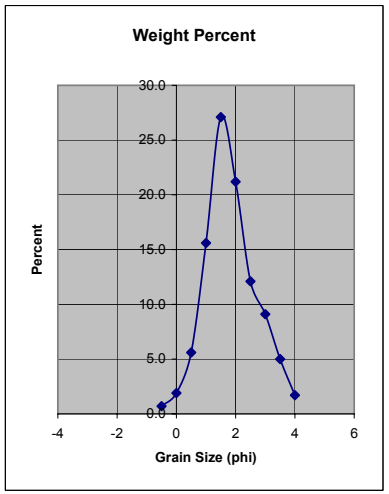
Phi5	0.750
Phi16	1.022
Phi25	1.483
Phi50	2.120
Phi75	2.492
Phi84	3.170
Phi95	0.000

Chemical Tests		
Test		Units
pH	6	
Available P		mg/kg
Organic Matter (OM)	0.6	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD	0.64	%

Granulometry	
Class.	Percent
Sand	86
Silt	9
Clay	5

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 37

Sample ID N295 E543 2C3

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5	0.9	0.9
0	1.9	2.8
0.5	6.0	8.8
1	16.1	24.9
1.5	27.1	52.0
2	21.1	73.1
2.5	11.7	84.8
3	8.6	93.4
3.5	4.9	98.3
4	1.7	100.0

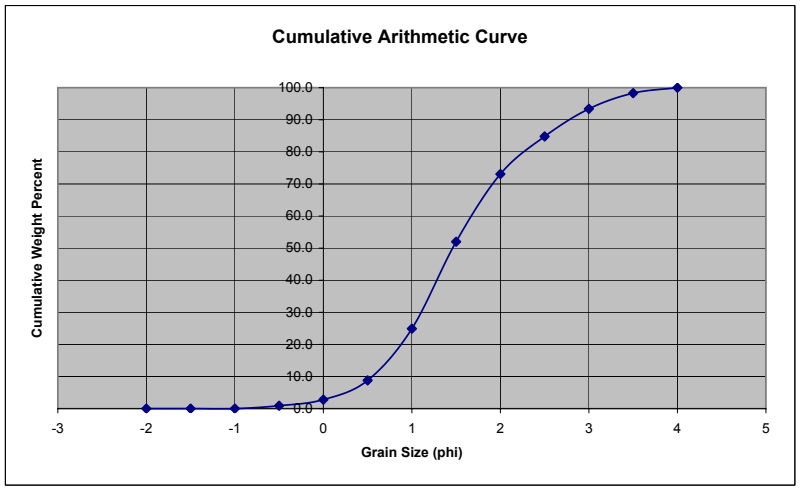
Grain Size Statistics		
Median (Md)	1.463	
Geometric Mean (Mz)	1.551	
Sorting (So)	0.932	moderately sorted
Standard Deviation	0.871	moderately sorted
Skewness (SkG)	0.151	positively skewed
(SkI)	0.146	positively skewed
Kurtosis (Kg)	1.131	leptokurtic

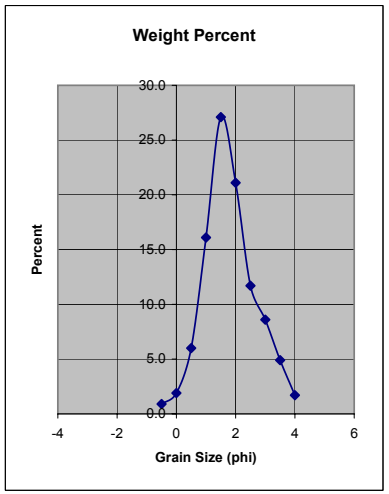
Phi5	0.724
Phi16	1.002
Phi25	1.463
Phi50	2.081
Phi75	2.466
Phi84	3.163
Phi95	0.000

Chemical Tests		
Test		Units
pH	6	
Available P		mg/kg
Organic Matter (OM)	0.6	%
Exch Ca		mg/kg
Exch Mg		mg/kg
Exch K		mg/kg
Fe - CD	0.72	%

Granulometry	
Class.	Percent
Sand	85
Silt	9
Clay	6

P fractionation		
Fraction	mg/kg	Perc
1a		#DIV
1b		#DIV
1 (All)	0.00	#DIV
2		#DIV
3		#DIV
Sum	0.00	#DIV





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 38

Sample ID N305 E566 Feat 10 ctr 60-70cm

Metrics

Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

Grain Size Statistics

Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests

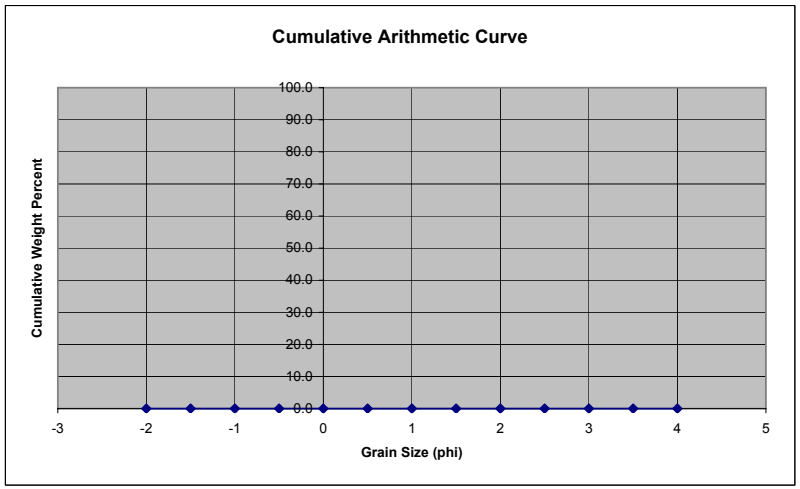
Test		Units
pH	5.9	
Available P	2.1	mg/kg
Organic Matter (OM)	0.9	%
Exch Ca	318.6	mg/kg
Exch Mg	116.9	mg/kg
Exch K	83.7	mg/kg
Fe - CD	1.15	%

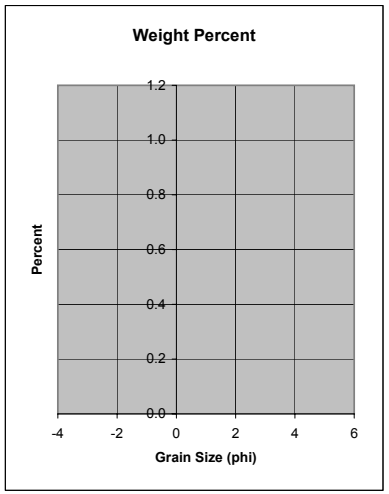
Granulometry

Class.	Percent
Sand	73
Silt	14
Clay	13

P fractionation

Fraction	mg/kg	Perc
1a	64.9	33
1b	4.9	2
1 (All)	69.8	36
2	108.7	56
3	13.6	7
Sum	192.1	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 39

Sample ID N305 E566 Feat 10 ctr below feat.

Metrics

Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

Grain Size Statistics

Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests

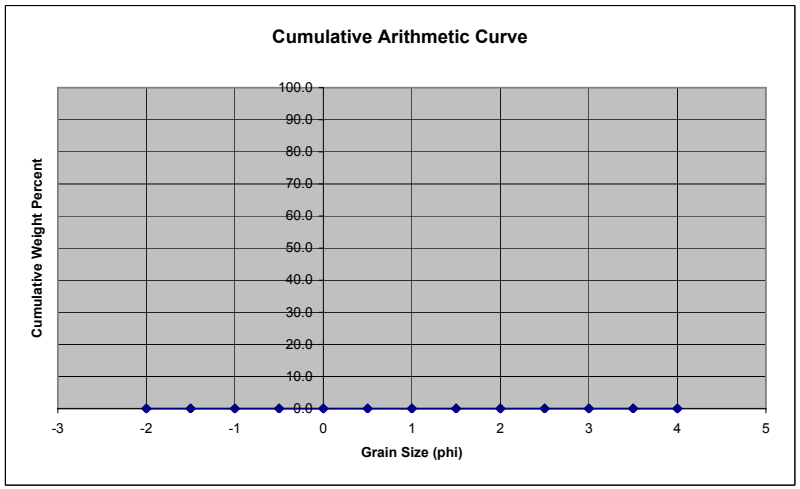
Test		Units
pH	5.9	
Available P	3.6	mg/kg
Organic Matter (OM)	0.7	%
Exch Ca	276.0	mg/kg
Exch Mg	96.3	mg/kg
Exch K	42.8	mg/kg
Fe - CD	0.92	%

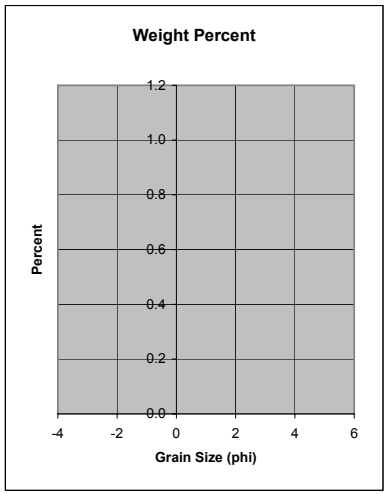
Granulometry

Class.	Percent
Sand	80
Silt	10
Clay	10

P fractionation

Fraction	mg/kg	Perc
1a	60.2	33
1b	5.2	2
1 (All)	65.4	35
2	106.7	58
3	9.8	5
Sum	181.9	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 40

Sample ID N305 E566 Feat 10 ctr 130cm

Metrics

Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

Grain Size Statistics

Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests

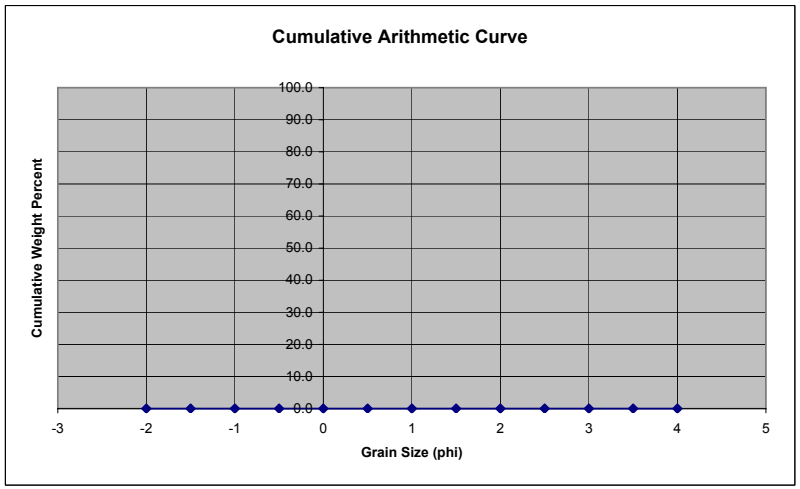
Test		Units
pH	5.8	
Available P	2.9	mg/kg
Organic Matter (OM)	0.7	%
Exch Ca	287.1	mg/kg
Exch Mg	64.8	mg/kg
Exch K	25.2	mg/kg
Fe - CD	0.95	%

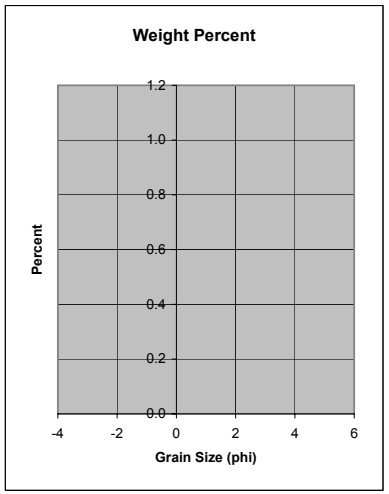
Granulometry

Class.	Percent
Sand	80
Silt	12
Clay	8

P fractionation

Fraction	mg/kg	Perc
1a	57.3	31
1b	4.9	2
1 (All)	62.2	34
2	108.1	60
3	9.4	5
Sum	179.7	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 41

Sample ID N305 E566 Feat 10 Str. 1 40-50cm

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

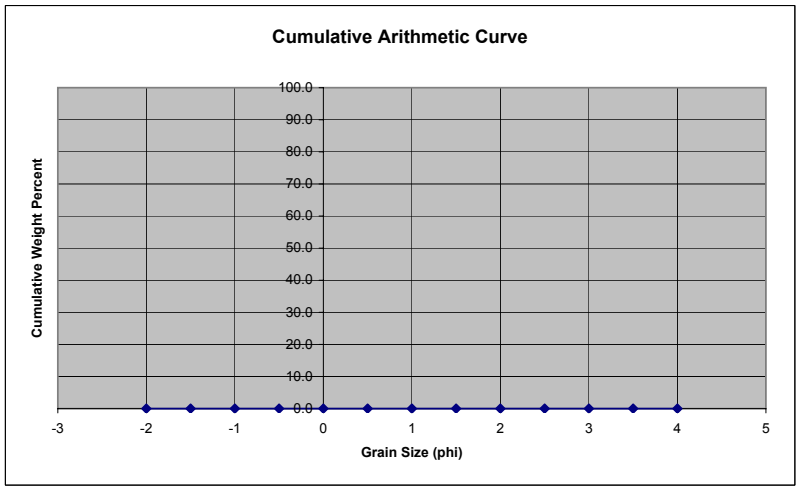
Grain Size Statistics		
Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

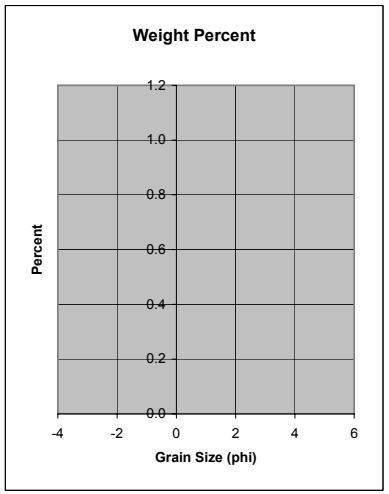
Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests		
Test		Units
pH	6.1	
Available P	3.7	mg/kg
Organic Matter (OM)	0.9	%
Exch Ca	91.2	mg/kg
Exch Mg	62.8	mg/kg
Exch K	68.4	mg/kg
Fe - CD	0.57	%

Granulometry	
Class.	Percent
Sand	80
Silt	14
Clay	6

P fractionation		
Fraction	mg/kg	Perc
1a	32.5	32
1b	4.0	4
1 (All)	36.5	36
2	56.7	57
3	6.1	6
Sum	99.3	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 42

Sample ID N305 E566 Feat 10 Str. 1 60-70cm

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

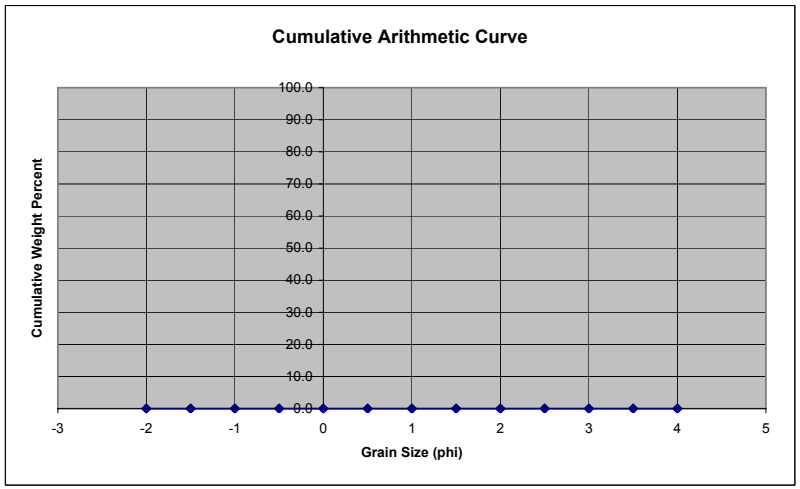
Grain Size Statistics		
Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

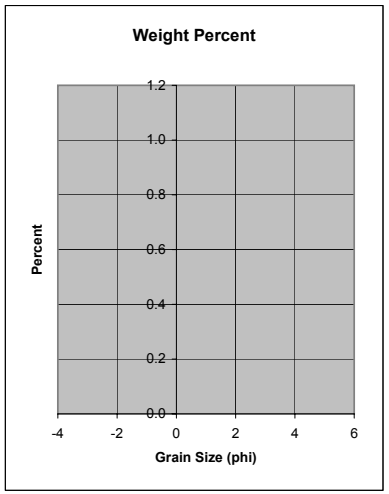
Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests		
Test		Units
pH	6	
Available P	4.1	mg/kg
Organic Matter (OM)	0.7	%
Exch Ca	194.7	mg/kg
Exch Mg	60.6	mg/kg
Exch K	60.0	mg/kg
Fe - CD	0.91	%

Granulometry	
Class.	Percent
Sand	77
Silt	13
Clay	10

P fractionation		
Fraction	mg/kg	Perc
1a	61.3	35
1b	5.8	3
1 (All)	67.1	38
2	94.0	54
3	11.1	6
Sum	172.2	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 43

Sample ID N305 E566 Feat 10 Str. 1 80-90cm

Metrics

Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

Grain Size Statistics

Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests

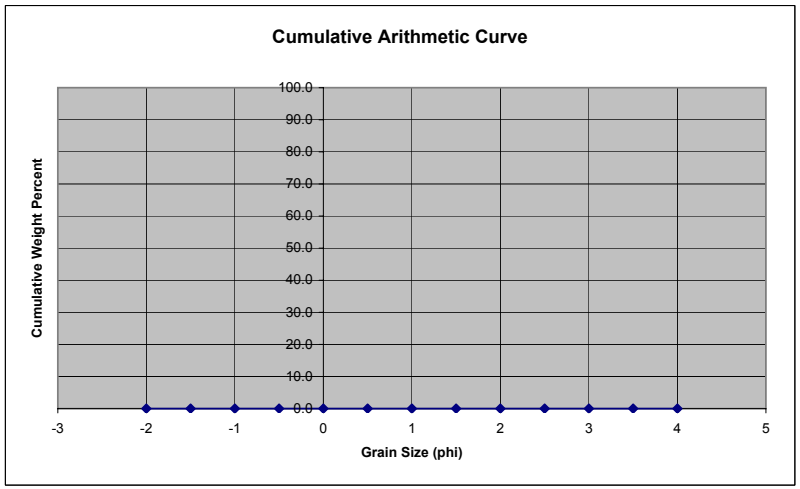
Test		Units
pH	5.9	
Available P	2.2	mg/kg
Organic Matter (OM)	0.8	%
Exch Ca	246.0	mg/kg
Exch Mg	143.3	mg/kg
Exch K	77.8	mg/kg
Fe - CD	1.09	%

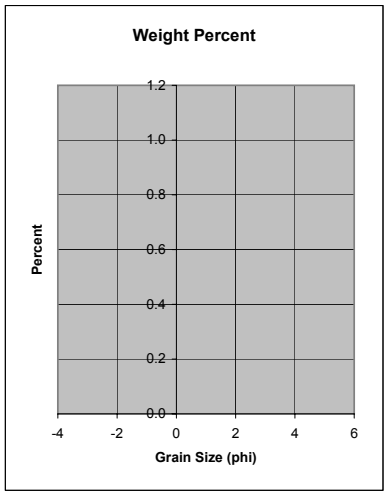
Granulometry

Class.	Percent
Sand	77
Silt	10
Clay	13

P fractionation

Fraction	mg/kg	Perc
1a	63.7	32
1b	6.1	3
1 (All)	69.8	35
2	115.0	57
3	14.0	7
Sum	198.8	100





Site: Frederick Lodge (9NC-J-97/98/99)

Date: April-03

Lab ID: 44

Sample ID N305 E566 Feat 10 Str. 1 100-110cm

Metrics		
Grain Size (phi)	Weight Percent	Cumulative Weight
-2		0.0
-1.5		0.0
-1		0.0
-0.5		0.0
0		0.0
0.5		0.0
1		0.0
1.5		0.0
2		0.0
2.5		0.0
3		0.0
3.5		0.0
4		0.0

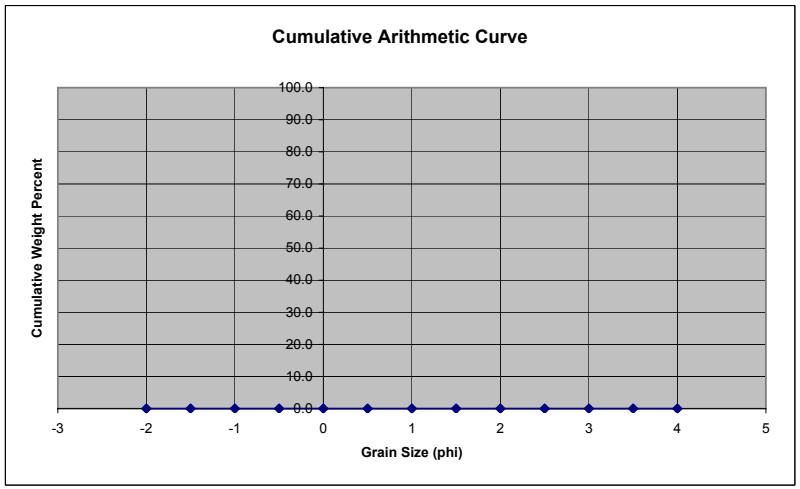
Grain Size Statistics		
Median (Md)	0.000	
Geometric Mean (Mz)	0.000	
Sorting (So)	0.000	very well sorted
Standard Deviation	0.000	very well sorted
Skewness (SkG)	#DIV/0!	#DIV/0!
(SkI)	#DIV/0!	#DIV/0!
Kurtosis (Kg)	#DIV/0!	#DIV/0!

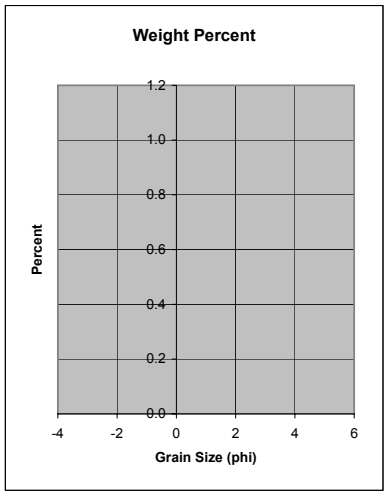
Phi5	0.000
Phi16	0.000
Phi25	0.000
Phi50	0.000
Phi75	0.000
Phi84	0.000
Phi95	0.000

Chemical Tests		
Test		Units
pH	5.7	
Available P	8.5	mg/kg
Organic Matter (OM)	0.8	%
Exch Ca	250.0	mg/kg
Exch Mg	140.5	mg/kg
Exch K	55.0	mg/kg
Fe - CD	1.15	%

Granulometry	
Class.	Percent
Sand	78
Silt	10
Clay	12

P fractionation		
Fraction	mg/kg	Perc
1a	124.4	42
1b	8.0	2
1 (All)	132.4	44
2	147.3	49
3	15.4	5
Sum	295.1	100





Attachment 1:

Sand Grain Transformation Study

ATTACHMENT 1

An Examination of Sand Grain Morphology and Surface Texture in the Identification of Aeolian and Fluvial Sedimentation Processes Frederick Lodge Site Complex, New Castle County, Delaware

Suanna C. Selby, October 2003

Introduction

The following report summarizes the results of a quantitative analysis of quartz-grain micromorphology to the identification of sedimentation processes. Key physical characteristics of sand grain samples from the Frederick Lodge Site Complex in New Castle County, Delaware, were examined. Close observation of these samples, made in comparison with analysis of control samples from known environmental contexts, permits limited correlation with past environments of deposition. Reconstruction of these environments provides a more complete picture of past landscapes of human habitation.

Central to this study is the question of the differential influence of fluvial or aeolian transport processes in the development of the landform on which archaeological sites rest. Presently, the sites of the Frederick Lodge complex are situated within moderately undulating crest and interfluve landforms adjacent to modern Bay Basins. Geoarcheological investigations suggest the combined influence of aeolian and colluvial processes on the deposits; alluvial processes are less visible within the local site setting. While the broad outline of Holocene landscape development is known for the sites (Schuldenrein 2003), the micromorphological examination of constituent sediments and their characteristics, specifically grain morphology and surface texture, contribute a semi-quantitative measure of that history.

Typically, the sediments which underlie the Frederick Lodge sites are quartz-rich, fine to coarse sands which vary from moderate to poorly sorted deposits, as derived from the Columbia Formation. The homogeneous composition and identifiable texture of these deposits permit sedimentological analysis of individual grains as described by Butzer and Gladfelter (1968), Holliday (1992), and Waters (1992). Analysis of the depositional history of these sediments focuses on characteristics of the sediment grains themselves, grain shape and surface features

Literature review

There is no consensus among researchers concerning the effects of aeolian vs. fluvial process on individual sand grains. However, sedimentologists recognize at least three elements of sedimentation that impact grain shape and surface texture: entrainment, transport and abrasion (Cooke, Warren and Goudie 1993:314; Lancaster 1995:85-88; Livingstone and Warren 1996:29, 113; Pye and Tsoar 1990). Entrainment is the lifting of grains into the flow medium (water or air); this is expressed mathematically as the relationship between the energy required to move a grain of sand and the gravitational, cohesive or other forces which resist that movement. Transport is the mechanism of movement once grains are entrained; transport may take many forms including saltation (leaping), creep, suspension or other

means. Importantly, the impact between saltating grains suspended in air has many times more force than the abrasion between grains suspended in water or creeping under the force of gravity. Such forceful collisions alter grains transported by wind, and therefore provide one avenue for evaluating depositional environments. Abrasion is the impact grains have on each other while in transport; grains may abrade or collide with each other, affecting the shape and texture of individual sands.

In unimodal sedimentary environments (fluvial or aeolian) the reconstructed sedimentation process culminates in sand deposition. The model does not accommodate the influence of disturbance and, by extension, the effects of multiple sedimentation perhaps by different agency. As a result, the one-to-one correspondence of certain morphologies or surface textures to a particular sedimentary process may be a difficult correlation to establish. While some researchers posit a genetic link between the micromorphological features of sand grains and the environmental conditions in which they developed (Pettijohn 1949), others emphasize the limitations of such correlations, given multiple episodes of entrainment, transport and abrasion (Folk and Ward 1957; Wentworth 1922).

Although this research does not provide conclusive measures for distinguishing aeolian from fluvial processes (Roper 1985), studies suggest that the micromorphology of sand grains may provide indications of the genetic origins of a sedimentary deposit. Specifically, measurement of several shape and surface texture features may provide enough evidence to grossly separate depositional histories. Butzer and Gladfelter, in their analysis of Nilotic deposits in Nubia, suggest that rounding (morphology) and frosting or polish (surface texture) may indicate the "inherited traits…[of] a complex past history" for Nile River sand deposits (1968:475). Ahlbrant (1979) agrees, noting that texture, grain size, and sorting may be other diagnostic factors in determining depositional history.

Several factors relating to grain size, shape, and surface texture are significant in the analysis of sedimentary history. Livingstone and Warren (1996:113-114) (after Barrett 1980) and Waters (1992:20-29) define the morphological characteristics abstracted for this study:

Size refers to the diameter of clastic particles. Ranging from less than a millimeter to over 2mm, particles are classified as clays, silts, sands or gravels. Sand-sized particles vary from very fine (0.125 mm) to very coarse (2mm) sands. Larger particles are designated pebbles or gravels; smaller particles make up the silt and clay size classes. These designations describe the overall texture of the sand in a deposit.

Sorting measures the similarity in size between particles in a sedimentary unit, ranging from very poorly (heterogeneous sizing) to very well (homogeneous sizing) sorted materials. Samples that exhibit fewer size classes, are said to be well sorted. Samples which contain a variety of grain sizes, gravelly sand for instance, are said to be poorly sorted. Sorting is also a general proxy for environment of deposition. Aeolian deposits tend to be winnowed of the largest and smallest particles, becoming very well sorted during transport. Colluvial sediments may contain clays, silts, sands, and larger materials, exhibiting poor sorting.

Sphericity is the "overall shape" of a single grain and measures the approximation of a grain as compared to a sphere (Livingstone and Warren 1996:113). Grains may vary between oblate (disk-shaped), prolate (roller-shaped) or bladed (thinned) as they approach an equant or spherical morphology. As a grain comes close to approximating a sphere, it is said to have undergone extensive modification through either repeated or long distance transport. Abrasion is a significant influence on the sphericity of grains.

Roundness is a description of the smoothness of the edges and corners on an individual grain (Waters 1992:23-27). Grains are classified as very angular, angular, subangular, subrounded, rounded and well rounded. Repeated episodes of grain-to-grain contact tend to modify, or round, the edges of the particles.

Surface texture, or microrelief, refers to the pitting, scratching, frosting, or polish of a grain surface. Frosting appears as a translucent surface on the grain and may be cause by either physical abrasion during transport or chemical etching after deposition. Surface frosting is most frequently associated with particles transported by wind action. Polishing appears as a transparent surface with a glassy or vitreous luster, and is attributed to contact with other grains during transport in moving water (Roper 1985:24-24; Livingstone and Warren 1996:115).

Ideally, grains from an aeolian sedimentary context would be similarly sized, well sorted, well rounded sands exhibiting a high degree of sphericity and composed primarily of frosted surfaces. In contrast, alluvial or colluvial settings will feature sediments that are moderate to poorly sorted, with subangular to angular grains, low sphericity and a low percentage of surface frosting.

Given these assumptions, the present study assesses characteristics in several sand samples that distinguish between the two ends of the transport spectrum: aeolian vs. fluvial origins. Colluvial contexts are mixed by definition and would be difficult to differentiate microscopically. Three features were isolated for quantitative analysis: grain sphericity, grain morphology and surface texture. This analysis measures indices of sphericity, roundness and ratios of frosting to polish on small samples of sand from the sites. It is hypothesized that grains influenced by an aeolian environment will tend to higher sphericity, a higher rounding index and a higher percentage of frosted sands, while grains originating in a fluvial environment will tend to be less spherical or rounded and have a higher percentage of polished particles.

Methodology

Sediments were taken from 16 samples of fine to coarse sands at 10 localities across the site (Table 1). Two sets of additional samples from modern alluvial (3 samples) and aeolian settings (7 samples) were taken as control samples. These controls were acquired from the vicinity of the Frederick Lodge sites as well as another study location in North Carolina. Table 1 lists the samples and provenience information. Summaries of the morphological and surface texture observations for both study and control samples are listed as well. Only sands from the C horizons in any of the stratigraphic exposures were analyzed in this study.

Feature samples and sands from the A, B or E horizons were eliminated in order to limit the physical or chemical influence of human or pedogenic factors on the micromorphology of the sands.

Tables 2 and 3 summarize the statistical analyses completed for the physical parameters of roundness, frosting and polish. Study and control samples were included. Major statistical indicators of mean, mode, medium, maximum and minimum values were calculated. These calculations provide the variables for comparison.

Texture, Sorting and Sphericity

Approximately 10 grams of sand were taken from sample bags and allowed to dry overnight in small plastic cups. Once dry, the sands were loose and easy to observe. First, sand texture was determined without magnification using comparison to a Wentworth sand gauge. Next, an estimate of the relative sorting of grains was determined using a very poorly to very well sorted scale (Waters 1992:24 after Compton 1962) both with and without magnification (Table 1). Third, sphericity was determined on a scale from high to low as follows (Table 1 and Figure 1).

Sphericity	Sphericity Value
High	1
Moderate to high	2
Moderate	3
Moderate to low	4
Low	5

Roundness

Random samples of fifty (50) grains from all sand fractions were extracted from the cups and placed in a glass dish. These grains were inspected at 1x and 4x magnification under a binocular microscope. Only quartz grains were observed. Each of the fifty grains was examined for grain morphology (roundness) and predominant surface texture (frosting versus polish). Grain morphology, specifically roundness of grains, was described according to the four-category system used by Butzer and Gladfelter (1968:474).

- *Angular*: Irregular grain surfaces dominated by edges and corners which are sharp.
- *Subangular*: Irregular grain surfaces; edges and corners visible, but less sharp and possibly curved or rounded.
- *Subrounded*: Irregular grain outline, but edges and corners more curved and smoothed.
- *Rounded*: Grain outline smoothed, tending toward an oval or circular shape; edges and corners absent.

Following the model established by Butzer and Gladfelter (1968:475), arbitrary values were assigned to grains of each of these four categories:

Rounding Class	Value (per grain)	Rounding Index (100 grains)
Angular	0	0-250
Subangular	5	250-500
Subrounded	10	500-750
Rounded	15	750-1,250

The rounding index was calculated as a simple total for the 50-grain samples (RI); the rounding index was then doubled and reported as 2RI to obtain a comparable index for the 100-grain samples examined by Butzer and Gladfelter (Tables 1, 2, and 3; Figures 2 and 3).

Surface Texture

Surface texture, specifically frosting and polish, was also examined. Each of the grains in the 50-grain sample was inspected for evidence of either a transparent, buffed luster (frosting) or a vitreous, brilliant luster (polish). Counts for each category were recorded and a ratio (percentage) of the predominant surface texture to the entire sample was reported. The counts were then qualified with a descriptor.

Surface Texture Percentage	Descriptor
Under 10%	Infrequent
10-29%	Slight and occasional
29-49%	Visible and frequent
50-75%	Dominant and very frequent
Above 76%	Predominant

Basic statistical calculations for the resulting raw data on morphology and surface texture were computed, and are reported in both table and chart formats (Tables 1, 2, and 3; Figures 4 and 5).

Observations from Frederick Lodge

Sixteen samples were collected and examined. Ten additional samples from modern alluvial and aeolian depositional contexts were used as controls for comparison of morphological and surface features. Ten sampling localities were represented in the sample universe, including the following proveniences:

Provenience	Total Number of Samples	Sample Numbers
7NC-J-97 Block G N218 E647	1	FL15
7NC-J-97 N225 E670	2	FL2, FL3
7NC-J-98 Block B N288 E578	1	FL5
7NC-J-98 Block B N305 E585	1	FL4
7NC-J-98 Block D N305 E545	3	FL6, FL7, FL8
7NC-J-98 NE Edge N296 E620	1	FL17
7NC-J-98 NW Edge N350 E475	1	FL11
7NC-J-99 N185 E715	3	FL12, FL13, FL14

7NC-J-99 Block L N190 E820	2	FL9, FL10
7NC-J-99 N195 E755	1	FL16
Control - Aeolian	7	FB5, FB6, FB7, FB 8, FB9, FB10, FB11
Control - Alluvial	3	FL1, FB15, FB28

Observations for each locality are as follows.

7NC-J-97 Block G N218 E647

One sample from provenience 7NC-J-97 Block G N218 E647 was observed. Sample FL15 was a poorly sorted, very coarse to medium sand with low sphericity. This sample was collected from the 2C horizon of Block G at 90 cm below surface. Roundness was observed as subangular with an RI value of 295 (2RI value of 590), with frosted grains characterized as slight and occasional or 24% of the sample.

7NC-J-97 N225 E670

Provenience 7NC-J-97 N225 E670 contained two samples for investigation. Samples FL2 and FL3 were collected from horizons 2C1 at 80 cm below surface and 2C2 at 110 cm below surface respectively. Sample FL2 was a poorly sorted, very coarse to medium sand with moderate to low sphericity. A rounding index value of 480 (2RI of 920) denotes subangular morphology. FL 3 was another poorly sorted sample, containing very coarse to coarse sands. Sphericity was moderate to low, and the RI value of 335 (2RI of 670) indicated subangularity. In both samples, the frosting to polish ratio was 28% to 74%, with slightly frosted grains appearing occasionally.

7NC-J-98 Block B N288 E578

Sample FL5 from provenience 7NC-J-98 Block B N288 E578 was a coarse to medium sand collected from the 2C horizon at an unknown (or unrecorded) depth below surface. Sorting was moderate to low, and the roundness class was subangular (RI value of 380; 2RI value of 760). Frosted grains appeared infrequently within the sample, and the degree of frosting was slight (24%).

7NC-J-98 Block B N305 E585

Provenience 7NC-J-98 Block B N305 E585 contained only one sample, sample FL4. The sands were collected from horizon 2C at 120 cm below surface. Grains were medium sands, moderately to well sorted, with moderate to low sphericity. Roundness values of 360 and 720 (2RI) indicated a subangular physical appearance. Unlike previously described samples, FL4 exhibited a higher degree of frosting. Forty percent of the sample was visibly frosted, a significant difference from the 7NC-J-97 samples.

7NC-J-98 Block D N305 E545

Three samples were removed from Block D N305 E545, including FL6, FL7, and FL8. These samples contained medium to fine sands in horizons C, 2C1 and 2C2, at depths of 60 to 120 cm below surface. Overall grain size similarities suggested a moderately to well

sorted sample, while grain morphology appeared to retain a subangular character (RI value of 360; 2RI value of 720). Sample FL6 reflected only slight and occasional frosting (28%), while the percentage of frosted grains from FL7 and FL8 exceeded 44%. In the case of the lowest horizons in Block D, the frosted sand particles were both clearly visible and frequently observed among the grains.

7NC-J-98 NE Edge N296 E620

One sample from the NE edge of unit N296 E620 was observed under the microscope. Sample FL17 was removed from the 2C horizon at 120 cm below surface and contained coarse to medium sands. Both sorting and sphericity were characterized as moderate. The grains were again subangular in their morphology (RI value of 335; 2RI value of 670). Frosted to polished surface textures appeared in a roughly 1 to 3 ratio (28% to 72%).

7NC-J-98 NW Edge N350 E475

A single sample from the NW edge of unit N350 E475 was collected from the 2C horizon at a depth of 100 cm. Moderately to well sorted coarse to medium sands made up the sample. Sphericity was moderate, also. The rounding index suggested a subangular character with a RI value of 360 (2RI value of 720). Visible indication of frosting appeared frequently on the sand grains (36%).

7NC-J-99 N185 E715

The first of two sets of samples from 7NC-J-99 was populated by C horizon sediments from unit N185 E715. Samples FL12, FL13, and FL14 ranged from fine, moderately well sorted sands at 45 cm below surface to coarse, poorly sorted sands at 85 cm depth. Sphericity varied from moderate to low, while roundness values indicated a consistently subangular morphology between all three horizons (RI values of 335 to 440; 2RI values of 670-880). Surprisingly, samples FL12 and FL14 at the top and bottom of the C-horizon package (C1 and 2C respectively) had high frosting values. Both FL12 and FL14 contained visible and frequent numbers of frosted sand grains (42% and 38% respectively), while FL13 contained only occasional sand grains with a slightly frosted surface texture (28%).

7NC-J-99 Block L N190 E820

The second set of samples from 7NC-J-99 was removed from depths of 100-120 cm below surface in Block L. Samples FL9 (horizon 2C1) and FL10 (horizon 2C2) were both poorly sorted coarse sands exhibiting moderate to low sphericity. Roundness values tended toward the subangular values (RI of 365 and 440; 2RI of 730 and 880 respectively). Sand grains of sample FL9 reflected slight and occasional frosting (26%), while sample FL10 showed more intense visible and frequent frosting (36%).

7NC-J-99 N195 E755

One sample from provenience 7NC-J-97 N195 E755 was examined. Sample FL 16 was a coarse to medium sand collected from horizon 2C at 120 cm below surface. Sorting was poor and overall sphericity was moderate. Roundness was observed as subangular, with an

RI value of 335 (2RI value of 670) on the Butzer and Gladfelter (1968) scale. Slightly frosted grains were observed occasionally through the sample, comprising 28% of the total.

Control – Aeolian

Seven samples from a modern dune complex near Fort Bragg, North Carolina provided adequate comparative control (FB5, FB6, FB7, FB 8, FB9, FB10, FB11). These moderately to well sorted sands were collected from surface contexts and ranged from coarse to fine textures. Further, these samples tended to have moderate to high sphericity values, and ranged from angular to subangular roundness index values (RI of 220 to 480; 2RI of 440 to 960), with a mean value of 296 (2RI of 592) (Table 2). Most notably, the ratio of frosted to polished grains indicated a dominant to predominant frequency of frosted surface textures, with percentages exceeding 75%, or greater than 3 to 1 in some samples.

Control – Alluvial

Three samples were used as comparative references for a modern alluvial context. One sample from a Bay Basin at Frederick Lodge (FL1) was used in addition to two alluvial samples from extant streams near Fort Bragg, North Carolina (FB15 and FB28). Textures ranged from very coarse to fine. Sorting varied considerably between well to poor, while sphericity remained moderate. Roundness values were low, with a mean value of 275 or 2R1 of 550 (Table 2). Frosted grains from the North Carolina samples were the lowest values observed (14-20%), while the Frederick Lodge reference indicated more visible and frequent frosting (30%).

Interpretations

Tables 1, 2, and 3 report the results of key statistical evaluations of the Frederick Lodge and control samples. Figures 1 through 5 illustrate the key differences between sphericity, roundness and surface texture. Summaries of the physical features are reported below.

Texture and Sorting

Although not evaluated quantitatively, several general observations can be made regarding Wentworth texture and overall sorting patterns with respect to the three localities within the Frederick Lodge site complex. First, 7NC-J-98 was composed of predominantly medium sands, with one instance of medium to fine sands (sample FL12 at 45 cm below surface). Further, the grain size homogeneity at this location appeared to be moderate to well sorted sand grains. This observation is consistent with upslope landscape positions, and supports the geoarchaeological interpretation of a high elevation point or crest at this site.

In contrast, 7NC-J-97 and 7NC-J-99 exhibit very coarse to coarse sand grain sizes with moderate to poor sorting. Such a variety in grain sizes is indicative of downslope landscape positions where gravity promotes the accumulation of various grains, especially larger clasts. The reconstruction of a mid- or toe-slope location for these two proveniences is reinforced by the texture and sorting patterns.

Sphericity

Quantitative evaluations of sphericity ranged from moderate to low values (3 to 5) (Table 1). Such a limited range of variation in overall patterns of sphericity, for both the Frederick Lodge and control samples, does not provide an adequate marker for environment of deposition. Ideally, aeolian environments would produce sand grains with moderate to high (3 to 1) values of sphericity. However, some degree of aeolian mobilization is possible, given this signature.

Samples from 7NC-J-98 (samples FL7, FL8, FL1, FL17) and 7NC-J-99 (samples FL10, FL12, FL13, FL16) had a sphericity index of 3 (moderate), a value comparable to the majority of aeolian reference samples (FB5, FB6, FB7, FB9, FB10) and one alluvial control (FB15) (Figure 1). While no values of high sphericity were noted, the trend is toward sphericity measures typical of modern aeolian contexts. The 7NC-J-98 and 7NC-J-99 locations at Frederick Lodge were interpreted as mid-slope to crest positions on the landform. These areas are microenvironments where wind-transported grains are likely to accumulate. Small numbers of grains are mobilized by wind, saltating (bouncing) and abrading as they settled upslope, and becoming slightly more spherical in the process.

Of the Frederick Lodge samples, specimen FL15 from 7NC-J-97 Block G N218 E647 exhibited a value of 5, the lowest overall sphericity. This signifies a depositional environment where sands are either not mobile, or where a mix of sediments with varying sphericity would accumulate. Geoarchaeological observation of Block G at a toe-slope location would suggest a high probability of colluvial processes influencing this part of the landform. Gravity and erosion would permit the deposition of grains with varying sphericity to collect at the base of a higher elevation point. The short distance of transport combined with a low incidence of abrasion would maintain the oblate, prolate or bladed shapes of the individual grains.

Roundness

Comparative roundness was determined using calculations for the mean, mode, median, maximum, and minimum values established during inspection of the 50-grain samples. Frederick Lodge rounding index (RI) values ranged from 295 to 460 (2RI from 590 to 920) on the Butzer and Gladfelter scale (1968). The average RI for the study samples was 369.4 (2RI: 738.8), with a mode of 335 (2RI: 670) and a median of 360 (720) (Tables 2 and 3). The high values of the Frederick Lodge samples were closer to the RIs calculated for the aeolian control samples (mean: 295.7; mean 2RI: 591.4) than for the alluvial control samples (mean 275; mean 2RI: 550). Other statistical measures (mode, median, maximum and minimum) were comparable between the two data sets (Figure 2).

The 2RI values were used to graphically compare the study samples to the reference group. Figure 3 grouped the Frederick Lodge samples according to their proveniences. All of the study samples exceeded a 2RI value of 500, and 94% of these samples exceeded 2RI values of 670, indicating a high degree of rounding. The aeolian reference group was similarly distributed above a 2RI of 500, with one sample (FB10) reaching 960. In contrast, the

alluvial samples remained comparatively low; one sample (FB11) reached only 440 for its 2RI estimate.

All site locations (7NC-J-97, 7NC-J-98, 7NC-J-99) showed peak rounding values above 750 (2RI) for one or more samples. The high value for sample FL2 (2RI: 920) from 7NC-J-97 N225 E670 may reflect a localized catchment point on the mid-slope for saltating grains. In contrast, sample FL15 from 7NC-J-97 Block G N218 E647 is the lowest 2RI value, merely 590, suggesting that colluvial mixing of angular and rounded grains were accumulating at the toe-slope or low elevation positions on the landform.

Frosting

The mean frosting percentage for the Frederick Lodge study samples is 32.4%, indicating that the frosted surface textures are distinct and common within a given sand population. The mean values for the aeolian control samples exceed 65%, while the average for the alluvial reference group is 20%. Thus frosting is more characteristic of the aeolian group than of the alluvial sample set.

Figure 4 demonstrates this trend more distinctly, showing the close statistical relationship between the Frederick Lodge and aeolian control groups. Samples within Cluster #1 are estimated between 36% and 55% on the scatter plot, indicating a high degree of similarity between the environments of deposition. A second cluster suggests an affinity with the alluvial control group with frosting measured under 30%. This clustering may reflect the influence of colluvial processes which have been hypothesized for sections of the site complex, particularly areas of 7NC-J-97 discussed above. Figure 5 bolsters this interpretation, highlighting the relatively low frosting percentages for 7NC-J-97 Block G as well as the unit at N225 E670. None of these frosting percentages exceed 30%.

Samples from 7NC-J-98 Blocks B and D, including the NW edge sample area, contained the highest percentage of frosted sand grains (see also Figure 5). Four of the seven samples from this area contained frosting percentages in excess of 36%; more than a third to nearly half of the sand grains observed showed visible and frequent surface frosting. This high percentage of frosted grains is consistent with the crest landscape setting.

Several of the 7NC-J-99 sample units also featured high frosting ratios. Three of the six samples were calculated above 32%, comparable to the aeolian control group. One of these samples, FL12 from 7NC-J-99 N185 E715, reached a frequent frosting level of 42%. The remaining three samples ranged from 26-28%. These mixed results indicate an environment under the influence of both aeolian and alluvial or even colluvial processes. A mid-slope landscape setting is area where such results would be possible. The reconstruction of a mid-slope environment for 7NC-J-99 by the geoarcheological investigation (Schuldenrein this report) is supported by this study's micromorphological observations.

Conclusions

Based on the evaluation of this study sample universe, the overall landscape picture at Frederick Lodge is that of a partly to mostly aeolian environment where the dominant

transport mechanism is wind action moving sand grains up and downslope. Samples from AU-2, including the various C horizons evaluated in this experimental study, indicate an environment being influenced by conditions favorable for aeolian transport of sediments.

General and specific observations of sand grain texture, morphology and surface features support the reconstruction of landscape settings including landform crest, mid-slope and toe-slope positions. High elevation settings, specifically 7NC-J-98, are dominated by finer and more homogeneous sand sizes, with greater sphericity, rounding and most importantly frosting ratios. Such locations are likely to be environments where aeolian transportation of sand grains occurs. Lower elevations are not dominated by any one key physical characteristic, but appear to be mixed accumulations of sand sizes, sorting patterns, morphologies and surface textures. In these locations, colluvial or alluvial process may overprint or dominate the aeolian system. The reconstruction of a crest in the vicinity of 7NC-J-98 with 7NC-J-97 and 7NC-J-99 at more mid-slope or toe-slope positions is reinforced by this experimental study.

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Table 1. Summary of Observations for Frederick Lodge and Control Samples

									Observations at 1x and 4x magnification								
Sample #	**SITE**	**BLOCK**	**North**	**East**	**Stratum**	**cm BS**	**Wentworth Texture**	**Sorting**	**Sphericity**	**S Value**	**Roundness**	**RI Value**	**2RI Value**	**Polish**	**P% Value**	**Frosting**	**F% Value**
FL15	7NC-J-97	BLOCK G	N218	E647	2C	90	very coarse to medium sand	poor	low	**5**	subangular	**295**	**590**	dominant	**76**	slight and occasional	**24**
FL2	7NC-J-97		N225	E670	2C1	80	very coarse to medium sand	poor	moderate to low	**4**	subangular	**460**	**920**	dominant	**72**	slight and occasional	**28**
FL3	7NC-J-97		N225	E670	2C2	110	very coarse to coarse sand	poor	moderate to low	**4**	subangular	**335**	**670**	dominant	**74**	slight and occasional	**26**
FL5	7NC-J-98	BLOCK B	N288	E578	2C	?	coarse to medium sand	moderate to poor	moderate to low	**4**	subangular	**380**	**760**	dominant	**76**	slight and occasional	**24**
FL4	7NC-J-98	BLOCK B	N305	E585	2C	120	medium sand	moderate to well	moderate to low	**4**	subangular	**360**	**720**	dominant	**60**	visible and frequent	**40**
FL6	7NC-J-98	BLOCK D	N305	E545	C	60	medium sand	moderate	moderate to low	**4**	subangular	**385**	**770**	dominant	**72**	slight and occasional	**28**
FL7	7NC-J-98	BLOCK D	N305	E545	2C1	100	medium sand	moderate to well	moderate	**3**	subangular	**360**	**720**	dominant	**54**	visible and frequent	**46**
FL8	7NC-J-98	BLOCK D	N305	E545	2C2	120	medium to fine sand	moderate to well	moderate	**3**	subangular	**360**	**720**	dominant	**56**	visible and frequent	**44**
FL17	7NC-J-98	NE EDGE	N296	E620	2C	120	coarse to medium sand	moderate	moderate	**3**	subangular	**335**	**670**	dominant	**72**	slight and occasional	**28**
FL11	7NC-J-98	NW EDGE	N350	E475	2C	100	coarse to medium sand	moderate to well	moderate	**3**	subangular	**360**	**720**	dominant	**64**	visible and frequent	**36**
FL12	7NC-J-99		N185	E715	C1	45	medium to fine sand	moderate	moderate	**3**	subangular	**440**	**880**	dominant	**58**	visible and frequent	**42**
FL13	7NC-J-99		N185	E715	C2	60	coarse to medium sand	poor	moderate	**3**	subangular	**335**	**670**	dominant	**72**	slight and occasional	**28**
FL14	7NC-J-99		N185	E715	2C	85	coarse sand	poor	moderate to low	**4**	subangular	**365**	**730**	dominant	**62**	visible and frequent	**38**
FL9	7NC-J-99	BLOCK L	N190	E820	2C1	100	coarse sand	poor	moderate to low	**4**	subangular	**365**	**730**	dominant	**74**	slight and occasional	**26**
FL10	7NC-J-99	BLOCK L	N190	E820	2C2	120	coarse sand	poor	moderate	**3**	subangular	**440**	**880**	dominant	**68**	visible and frequent	**32**

Table 1. Summary of Observations for Frederick Lodge and Control Samples

									Observations at 1x and 4x magnification								
Sample #	**SITE**	**BLOCK**	**North**	**East**	**Stratum**	**cm BS**	**Wentworth Texture**	**Sorting**	**Sphericity**	**S Value**	**Roundness**	**RI Value**	**2RI Value**	**Polish**	**P% Value**	**Frosting**	**F% Value**
FL16	7NC-J-99		N195	E755	2C	120	coarse to medium sand	poor	moderate	**3**	subangular	**335**	**670**	dominant	**72**	slight and occasional	**28**

Table 2. Statistical Analysis of Sand Study and Control Samples

Sand Study Samples					**Control Samples**									
					Alluvial					**Aeolian**				
Sample	**RI**	**2RI**	**P %**	**F %**	**Sample**	**RI**	**2RI**	**P %**	**F %**	**Sample**	**RI**	**2RI**	**P %**	**F %**
FL16	335	670	72	28	FL1	330	660	70	30	FB5	250	500	58	42
FL15	295	590	76	24	FB15	275	550	80	20	FB6	255	510	50	50
FL2	460	920	72	28	FB28	220	440	86	14	FB7	255	510	34	66
FL3	335	670	74	26						FB8	265	530	16	84
FL5	380	760	76	24						FB9	305	610	48	52
FL4	360	720	60	40						FB10	480	960	16	84
FL6	385	770	72	28						FB11	260	520	22	78
FL7	360	720	54	46										
FL8	360	720	56	44										
FL17	335	670	72	28										
FL11	360	720	64	36										
FL12	440	880	58	42										
FL13	335	670	72	28										
FL14	365	730	62	38										
FL9	365	730	74	26										
FL10	440	880	68	32										

Table 3. Summary of Statistical Analyses for Sand Study and Control Samples

Mean Values for Rounding Index (2RI), Frosting, Polish

Region	Number of Samples	2RI	Polish %	Frosting %
Frederick Lodge	16	738.8	67.6	32.4
Control - Alluvian	3	550.0	78.7	21.3
Control - Aeolian	7	591.4	34.9	65.1

Rounding Index (2RI)

Samples	Mean	Mode	Median	Maximum	Minimum
Frederick Lodge	738.8	670	720	920	590
Control - Alluvial	550.0	0	550	660	440
Control - Aeolian	591.4	510	520	960	500

Mode Values for Rounding Index (2RI), Frosting, Polish

Region	Number of Samples	2RI	Polish %	Frosting %
Frederick Lodge	16	670	72	28
Control - Alluvian	3	0	0	0
Control - Aeolian	7	510	16	84

Polish (%)

Samples	Mean	Mode	Median	Maximum	Minimum
Frederick Lodge	67.6	72	72	76	54
Control - Alluvial	78.7	0	80	86	70
Control - Aeolian	34.9	16	34	58	16

Median Values for Rounding Index (2RI), Frosting, Polish

Region	Number of Samples	2RI	Polish %	Frosting %
Frederick Lodge	16	720	72	28
Control - Alluvian	3	550	80	20
Control - Aeolian	7	520	34	66

Frosting (%)

Samples	Mean	Mode	Median	Maximum	Minimum
Frederick Lodge	32.4	28	28	46	24
Control - Alluvial	21.3	0	20	30	14
Control - Aeolian	65.1	84	66	84	42

Maximum Values for Rounding Index (2RI), Frosting, Polish

Region	Number of Samples	2RI	Polish %	Frosting %
Frederick Lodge	16	920	76	46
Control - Alluvian	3	660	86	30
Control - Aeolian	7	960	58	84

Minimum Values for Rounding Index (2RI), Frosting, Polish

Region	Number of Samples	2RI	Polish %	Frosting %
Frederick Lodge	16	590	54	24
Control - Alluvian	3	440	70	14
Control - Aeolian	7	500	16	42

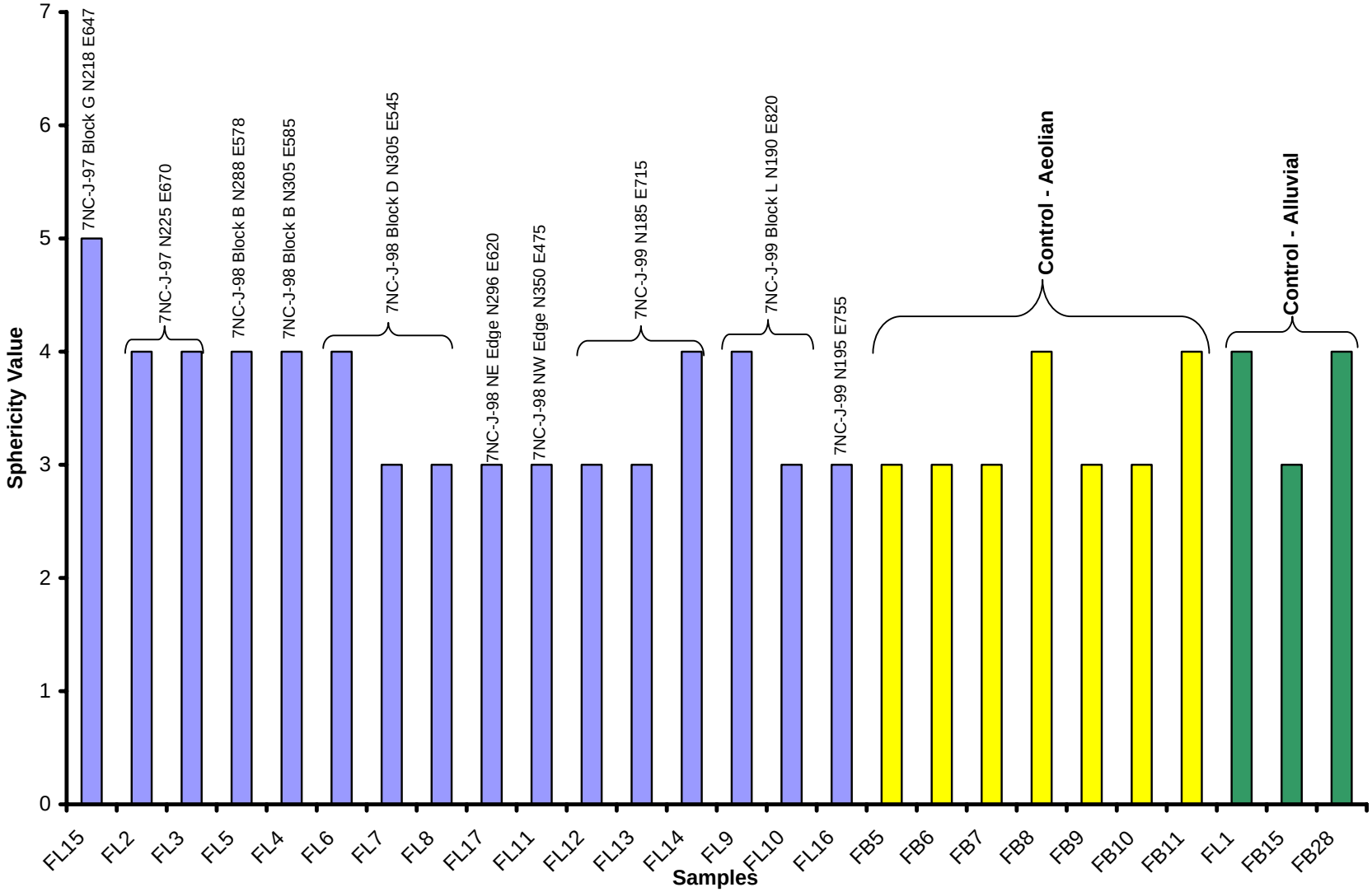

Figure 1. Sphericity.

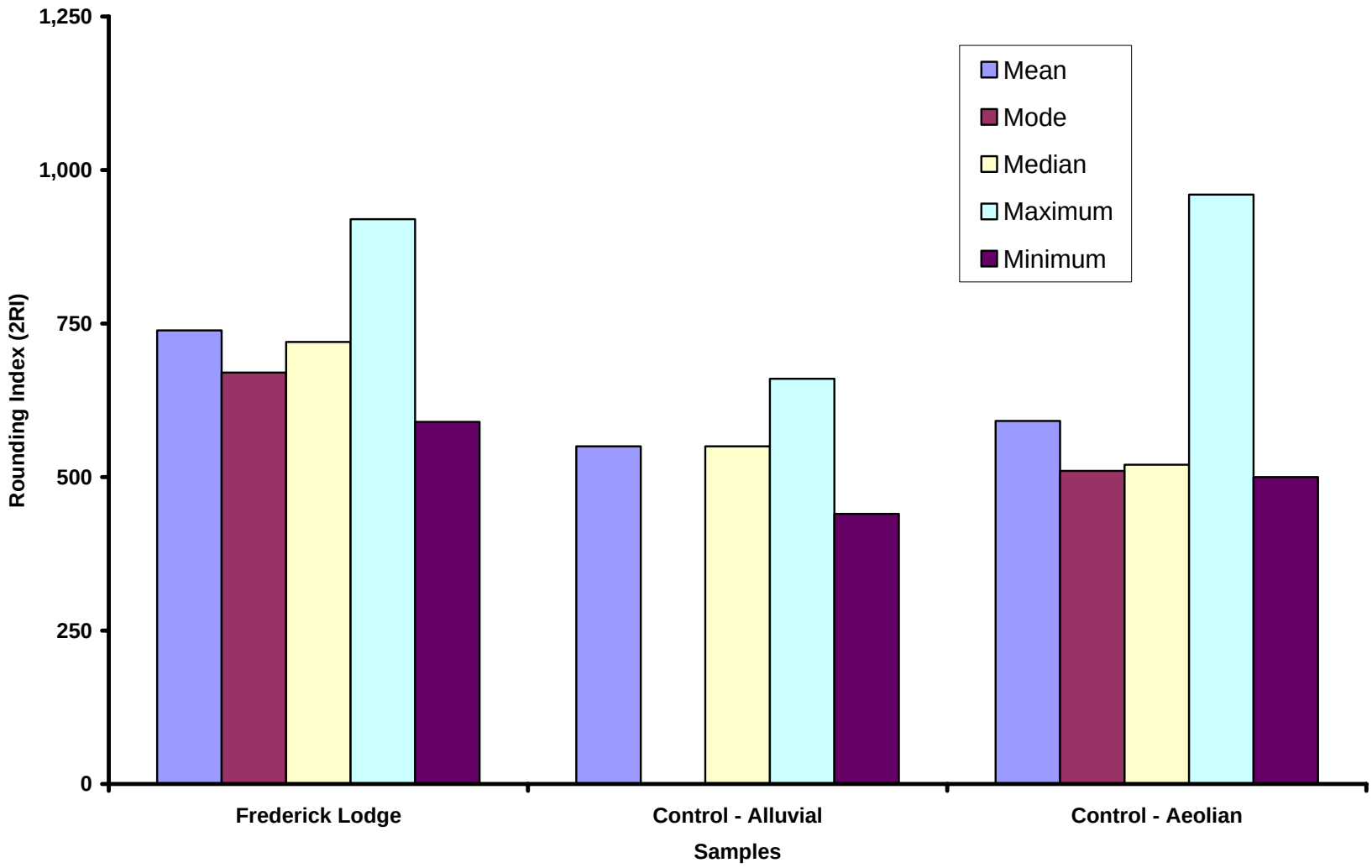

Figure 2. Grain Morphology.

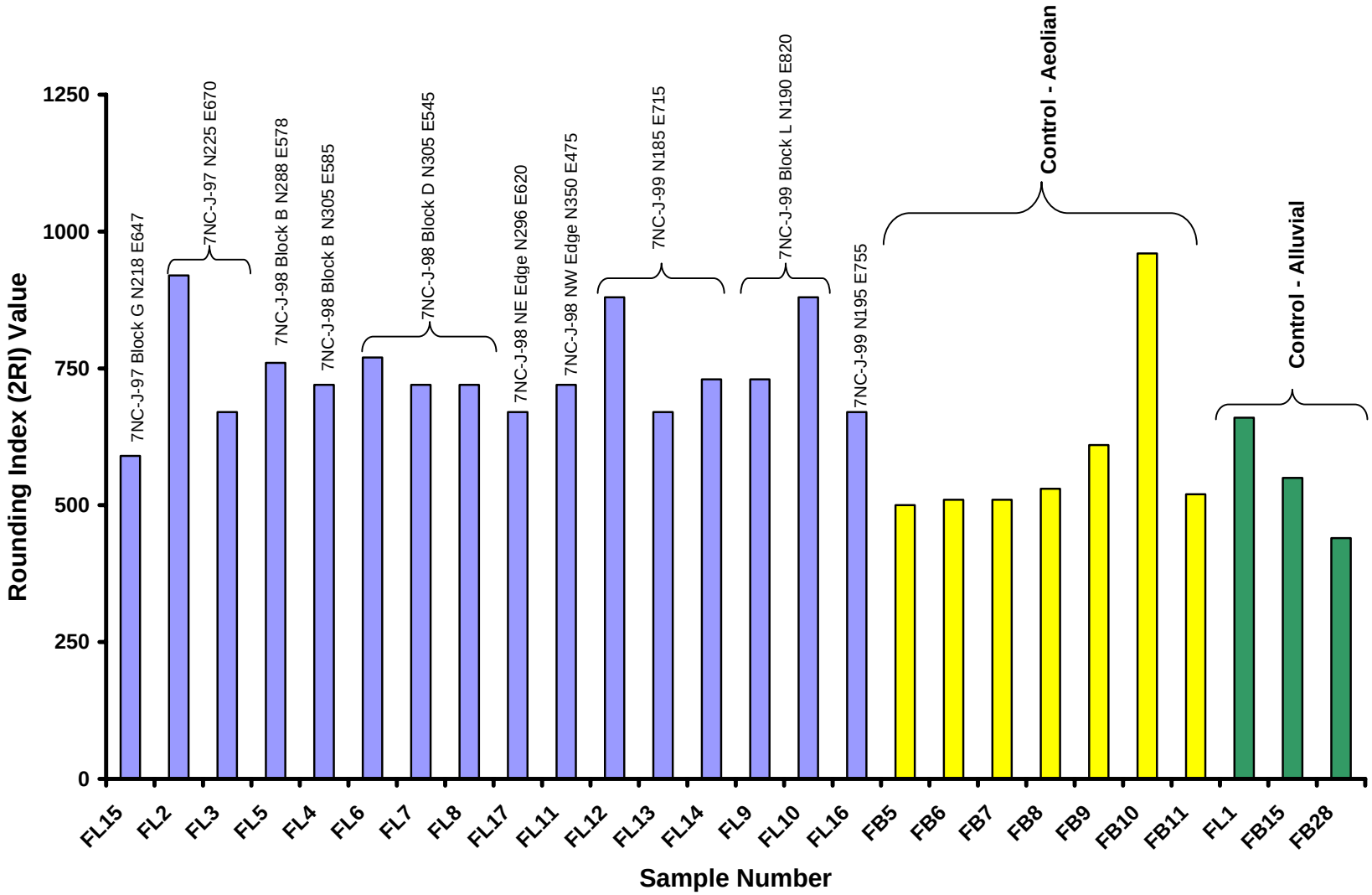

Figure 3. Roundness.

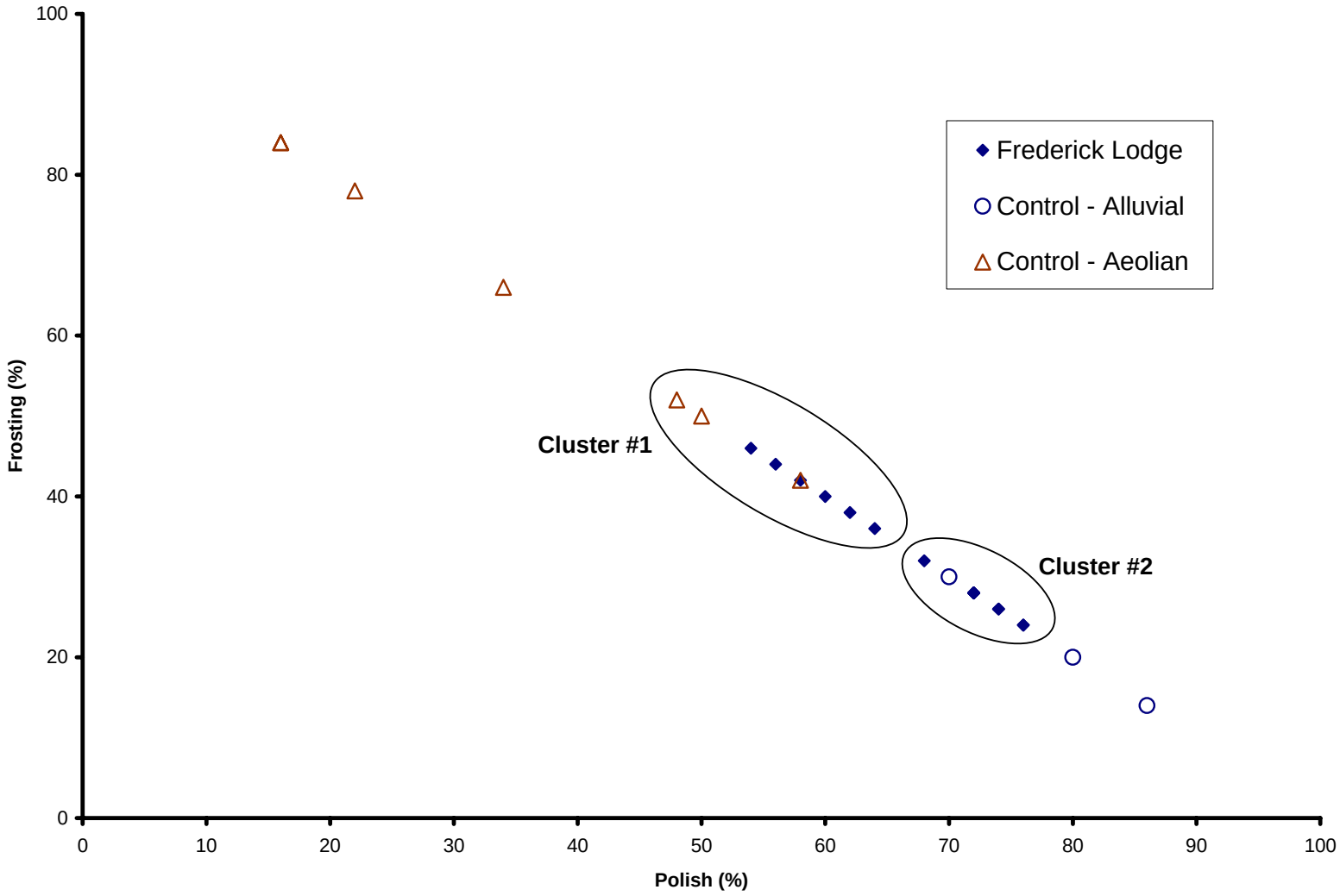

Figure 4. Surface Texture.

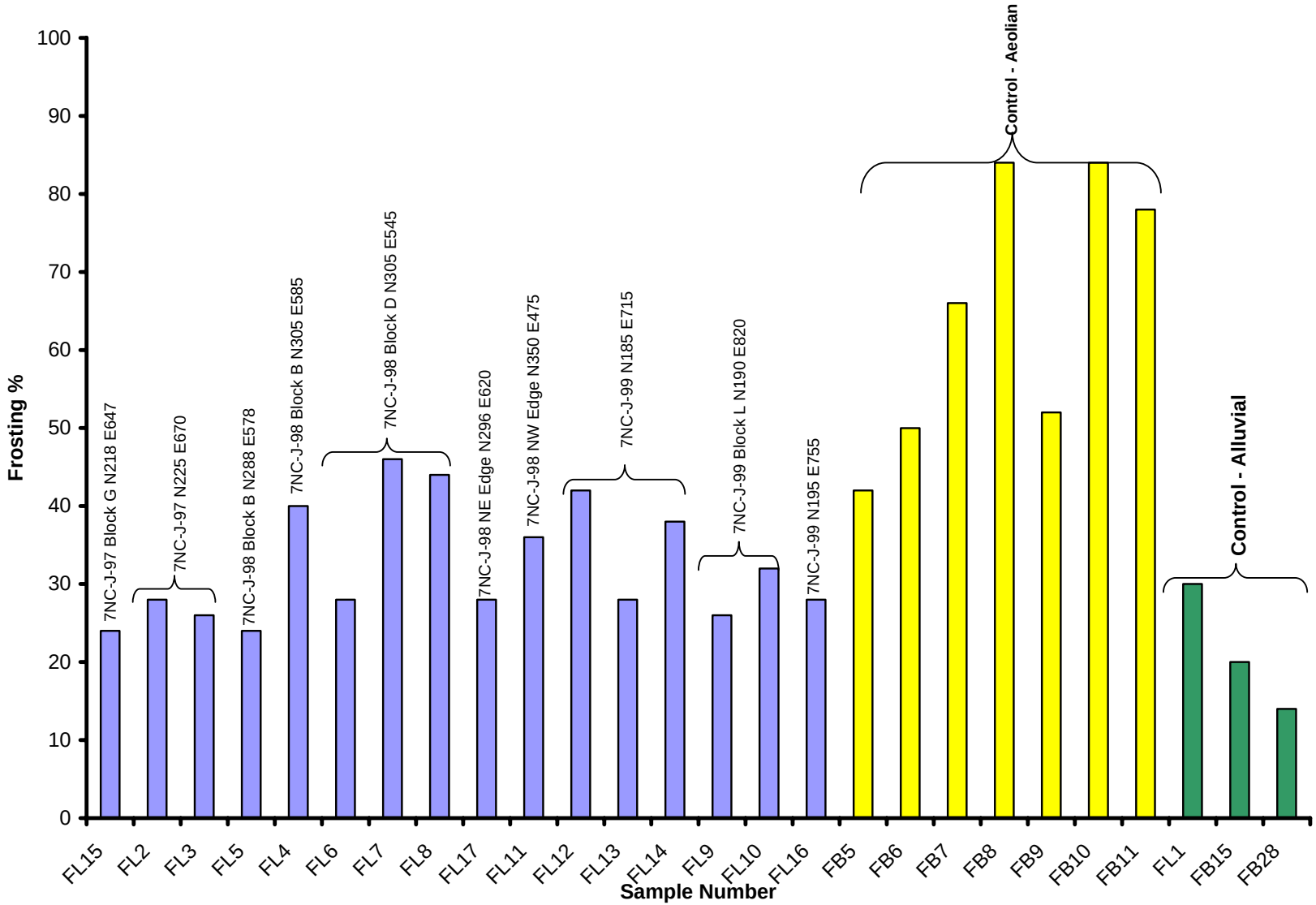

Figure 5. Frosting.

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