Effects of saline-sodic water on EC, SAR, and water retention
by Kimberly Marie Robinson

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Land Resources and Environmental Science
Montana State University
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Abstract:
There is significant concern regarding the potential impact of discharges of saline-sodic water from coal bed methane development sites within the Powder River Basin onto irrigated acreages of the area.

The specific objective of this study was to assess soil chemical and physical responses upon wetting with saline-sodic water. This was accomplished by exposing soil material collected from sites within the Powder River Basin to various combinations of two water qualities and three wetting/irrigation regimes. Water quality treatments consisted of either synthesized Powder River water or synthesized CBM product water. Wetting and irrigation regimes consisted of:1) a single wetting event, 2) a five-time wet/dry cycle and 3) a five-time wet/dry cycle followed by a single flood (flushing) event with distilled water.

Repeated irrigation with saline-sodic water or water with a chemical signature comparable to the CBM product water used in this study will result in a general increase in the soil salinity and sodicity. It is likely that elevated soil salinity levels will be substantially higher than published thresholds for some irrigated crops. The impact of rainfall on reducing EC and SAR is more predominant when salt concentrations are high, and in coarser-textured soils. Distilled water applications simulating rainfall resulted in a much greater lowering of EC than for SAR.

To assess the effects of saline-sodic water on the physical properties of the soil, water content was measured after the soils were exposed to the various water qualities and treatment scenarios at five different pressure potentials. It was found that water content associated with matric potential differed significantly due to predominant soil textures. Although statistically significant differences were detected among water quality treatments, differences were not considered large enough to have a significant ecological impact. It was determined that'CBM product water applied at these levels did not have a consistent significant impact on soil physical properties.

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APPROVAL

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Kimberly Marie Robinson

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

There is significant concern regarding the potential impact of discharges of saline-sodic water from coal bed methane development sites within the Powder River Basin onto irrigated acreages of the area.

The specific objective of this study was to assess soil chemical and physical responses upon wetting with saline-sodic water. This was accomplished by exposing soil material collected from sites within the Powder River Basin to various combinations of two water qualities and three wetting/irrigation regimes. Water quality treatments consisted of either synthesized Powder River water or synthesized CBM product water. Wetting and irrigation regimes consisted of: 1) a single wetting event, 2) a five-time wet/dry cycle and 3) a five-time wet/dry cycle followed by a single flood (flushing) event with distilled water.

Repeated irrigation with saline-sodic water or water with a chemical signature comparable to the CBM product water used in this study will result in a general increase in the soil salinity and sodicity. It is likely that elevated soil salinity levels will be substantially higher than published thresholds for some irrigated crops. The impact of rainfall on reducing EC and SAR is more predominant when salt concentrations are high, and in coarser-textured soils. Distilled water applications simulating rainfall resulted in a much greater lowering of EC than for SAR.

To assess the effects of saline-sodic water on the physical properties of the soil, water content was measured after the soils were exposed to the various water qualities and treatment scenarios at five different pressure potentials. It was found that water content associated with matric potential differed significantly due to predominant soil textures. Although statistically significant differences were detected among water quality treatments, differences were not considered large enough to have a significant ecological impact. It was determined that CBM product water applied at these levels did not have a consistent significant impact on soil physical properties.

CHAPTER 1

Introduction

The growing need for new sources of energy has spurred development of the coal bed methane (CBM) industry in the western United States. CBM has a wide variety of energy-related uses and is generally considered a cleaner form of energy than traditional coal and oil. Conservative estimates suggest that there are approximately 141 trillion cubic feet (TCF) of economically recoverable CBM within the continental United States (Nelson, 1999). CBM is an attractive energy source, as exploration costs are low and wells used to extract CBM are cost effective to drill.

Environmental concerns have arisen with the increased emphasis on the extraction of the CBM resource. The extraction of CBM involves pumping large volumes of water from the saturated, coal-bearing aquifers in order to release water pressure that is trapping the gas in the coal. The quality of this pumped water coproduced with methane is a source of concern. This coproduced water (called CBM product water in this paper) has a modestly high salinity hazard and often a very high sodium hazard based on standards used for irrigation suitability. CBM product water also contains a significant bicarbonate (HCO_3) component, which enhances the precipitation of relatively insoluble carbonate minerals (Rice, 2000).

Much of the current CBM development is occurring in the Powder River Basin of Montana and Wyoming (Figure 1). The Powder River Basin encompasses both the

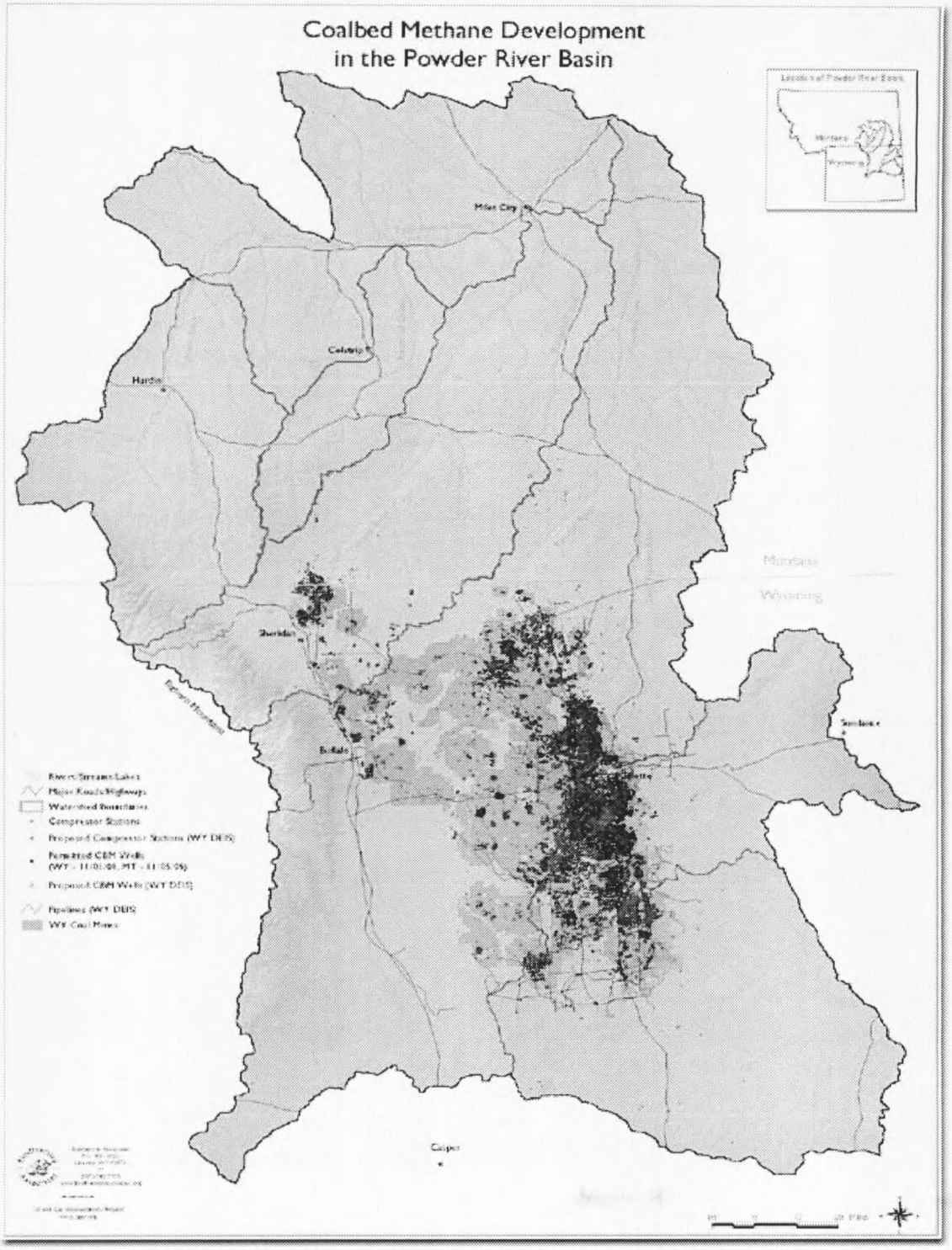


Figure 1. The Powder River Basin. Black dots represent permitted CBM wells. (Source: www.biodiversityassociates.org)

Powder River and the Tongue River watersheds. The Powder River originates in north-central Wyoming, flowing northward, where it joins the Yellowstone River near Terry, Montana. The soil survey for Powder River County, Montana (USDA, 1971) indicates that soils along the river within the basin consist primarily of silt loams, silty clay loams, and silty clays. These soils have historically been irrigated with Powder River water, roughly 4500 hectares in Montana (Brock, 1991). The Powder River Basin receives minimal precipitation, less than 35 cm annually. The basin's structural geology consists mostly of tertiary sandstones and shales (Thompson, 1991). The combination of these factors creates a flow within the Powder River that has an inherently high salt content, especially during periods of low flows. Suitability of Powder River water for irrigation varies seasonably. Figures 2-5 represent thirty years of water quality data collected by the United States Geological Society (USGS) on the Powder River at Moorhead, Montana. These figures show that water within the river is of marginal quality with respect to salinity and sodicity standards generally considered acceptable for irrigation.

Objectives

The present study assessed the effects of waters having a range of EC x SAR on chemical and physical properties of selected soil materials. A laboratory experiment was conducted that subjected soils of varying clay content to diverse wetting/drying regimes using two water qualities. It was hypothesized that saline-sodic water at the treatment levels used would have deleterious effects on chemical and physical

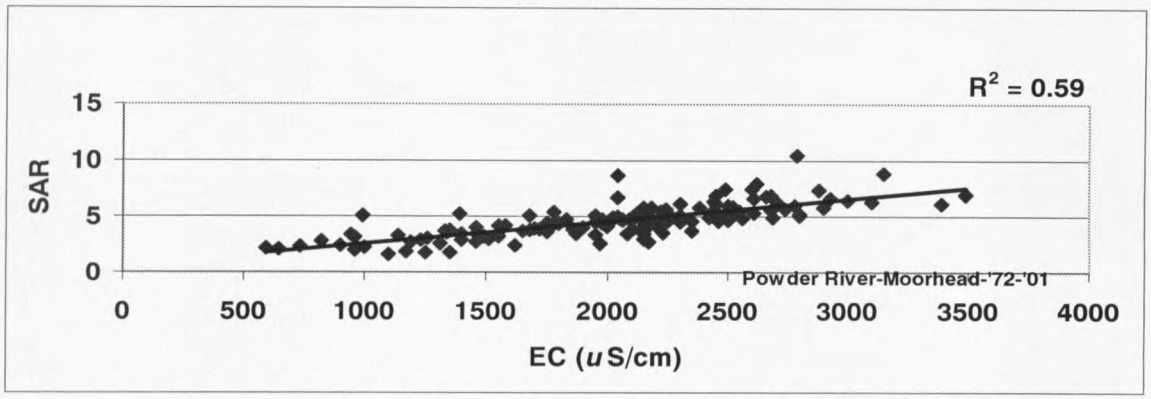


Figure 2. EC (electrical conductivity, u*S*/cm) vs. SAR (sodium adsorption ratio) for the Powder River. (Source: USGS-Station #06324500)

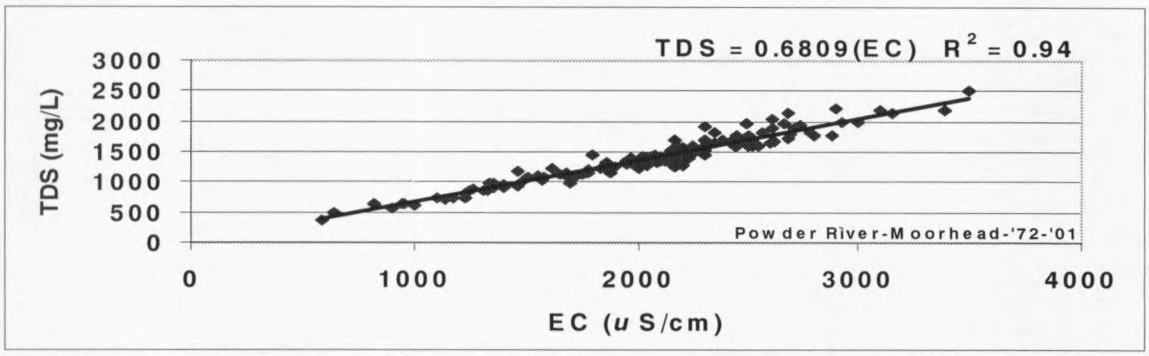


Figure 3. EC (uS/cm) vs. TDS (total dissolved solids, mg/L) for the Powder River. (Source: USGS-Station #06324500)

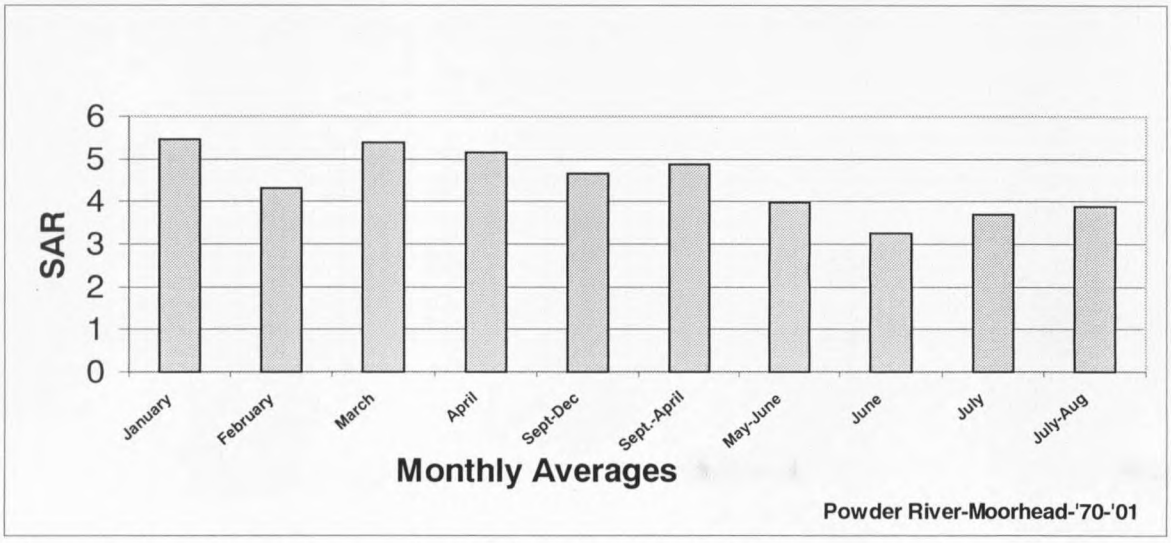


Figure 4. Monthly and seasonal numeric average SAR for the Powder River, non-flow weighted. (Source: USGS-Station #06324500)

properties of the soil. The overall goal was to determine the suitability of irrigating with marginally saline-sodic waters, while still maintaining the sustainability of the soil.

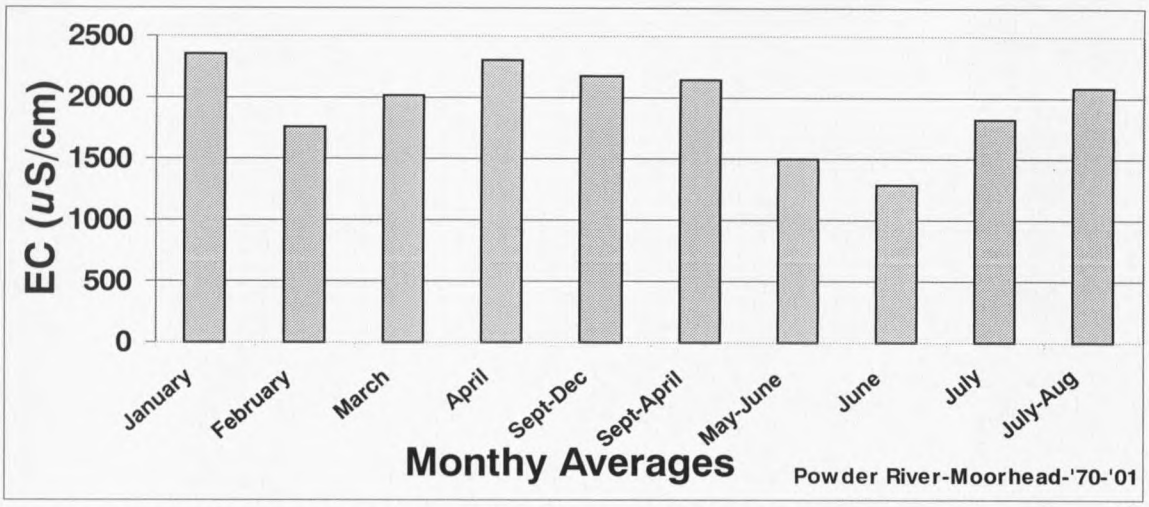


Figure 5. Monthly and seasonal numeric average EC (*u*S/cm) for the Powder River, non-flow weighted. (Source: USGS-Station #0634500)

Literature Review

Irrigation Water Quality

Land managers across the globe are increasingly being forced to use water of poor quality for irrigation. Two of the most critical criteria for accessing irrigation water quality are salinity and sodicity (Rhoades, 1972). Irrigation water containing excessive salts can have deleterious effects on soil physical and chemical properties.

Salinity Impacts

Ghassemi et al. (1995) argues that salinity is the most important criterion for evaluating irrigation water quality because it represents a total concentration of ions,

which most crops respond to rather than individual concentrations of specific salts. Electrical conductivity (EC) is used to estimate water and soil solution salinity. The EC of the soil saturation extract is approximately equal to 1.5 to 3 times the salt concentration of the irrigation water with a 15% leaching factor (Western Fertilizer Handbook, 1995). The amount of extra water added to leach the soil is referred to as the leaching requirement or leaching fraction. Saline soil water reduces crop growth if the average root zone salinity exceeds the threshold level of the crop. The suitability of water for irrigation, in terms of salinity thresholds, depends primarily on the kind and amounts of salts present, the soil type in question, specific plant species and growth stage, and the leaching fraction (Ayers and Westcot, 1976; Hanson et al., 1999; Rhoades, 1977; USDA, Natural Resources Conservation Service, 2002; Western Fertilizer Handbook, 1995).

Salinity becomes a problem when an excess amount of soluble salts restrict the ability of a plant to withdraw water effectively from the surrounding soil (Bauder and Brock, 2001; Hanson et al., 1999; USDA, Natural Resources Conservation Service, 2002; Western Fertilizer Handbook, 1995). Osmotic forces, resulting from the salt concentration, will hold water tighter, and make it less available for plant uptake. Elevated salinity levels also decrease evapotranspiration (Chhabra, 1996).

Salinity largely influences soil physical properties by its ability to keep a soil flocculated. High salinity promotes a structurally stable soil (Buckland et al., 2002). Elevated electrolyte concentrations cause fine particles to aggregate, resulting in a pore size distribution that contains larger void spaces than a non-flocculated soil. A well-

flocculated soil will exhibit good permeability and enhance the hydraulic conductivity (HC) of a soil. Soils with good aggregation will also shrink less than structureless soils, and will be less susceptible to cracks under field conditions (Mitchell and van Genuchten, 1992).

Sodicity Impacts

Sodicity is another important issue when assessing irrigation water suitability. It is not uncharacteristic of soils in arid and semi-arid regions to contain high amounts of exchangeable sodium (Quirk and Schofield, 1955). Exchangeable sodium, if found in amounts excessive to calcium and magnesium, can have deleterious effects on the soil. High amounts of exchangeable sodium can also lead to aggregate slaking and crust formation.

The sodium adsorption ratio (SAR) is used as an assessment of the sodicity hazard of the soil solution or applied water, while the exchangeable sodium percentage (ESP) reflects the degree to which the soil exchange complex is saturated with sodium. The ESP of the soil can be related to the SAR of the applied solution or soil solution, varying according to the soil/solution ratio of soil extracts examined (Halliwell et al., 2001). Therefore, the SAR of the irrigation water may be used as an index of the sodicity hazard of the water, providing it is relatable to the resultant SAR of the equilibrated soil water (Rhoades, 1972). Soil dispersion is the primary physical process associated with elevated sodium (Na) concentrations (Ayers and Westcot, 1976; Bauder and Brock, 2001; Buckman and Brady, 1967; Chen and Banin, 1975; Frenkel et al, 1978; Hanson et al., 1999; Miller and Gardiner, 2001).

Soil Swelling/Dispersion. The primary processes responsible for the physical disintegration of soil structure and reductions in infiltration or hydraulic conductivity (HC) of soils affected by exchangeable sodium are swelling and dispersion (Halliwell et al., 2001; Levy et al., 1999; Miller and Gardiner, 2001; So and Aylmore, 1993). Characteristics of the sodium ion (large size, single charge, and hydrated radius) tend to cause physical separation of soil particles. Quirk states, "The swelling of clay domains and their consequent destruction, resulting from the interaction of diffuse double layers in micropores, is quite clearly the primary cause of decreased permeability" (2001). Soil swelling and/or dispersion change the geometry of soil pores (Bresler et al., 1982), reducing pore size, causing bond weakening and particle separation (Curtin et al., 1994). This in turn reduces soil permeability (Mace and Amrhein, 2001). McNeal et al. (1968) quantified the relationship between soil swelling factors and hydraulic conductivity with the following function:

$$1 - y = cx^n / (1 + cx^n) \qquad \text{[Equation 1]}$$

where y = relative soil HC; x = swelling factor (the calculated interlayer swelling of soil montmorillonite); and c and n = constants for a given soil within a range of ESP values (n = 1 for ESP < 25, 2 for 25 < ESP <50, and 3 for 50 < ESP). McNeal provides the following nomogram that predicts interlayer swelling on the basis of ESP and soil solution salt concentration combinations.

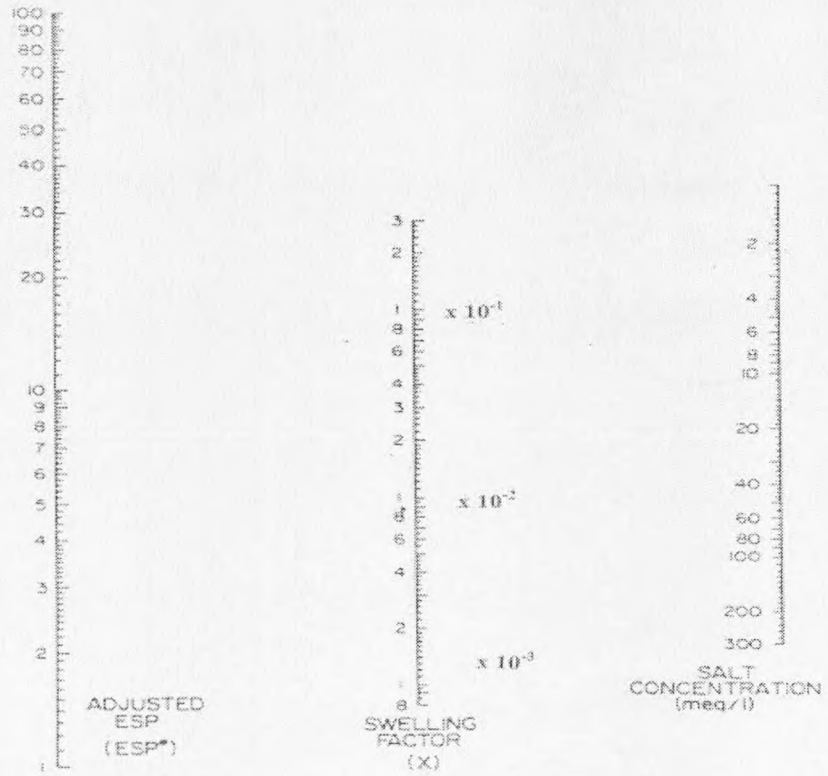


Figure 6. Swelling factor as a function of adjusted ESP and salt concentrations of the soil solution. (Source: McNeal, 1968).

This predictive relationship defines the relative degree to which the hydraulic conductivity (HC) will vary with the salt concentration of the solution and the soil ESP. Increasing the adjusted ESP or decreasing the salt concentration caused an increase in the swelling factor.

Mace and Amrhein (2001) leached synthetic drainage waters of varying SAR and EC concentrations through machine-packed soil columns to evaluate the effects of clay dispersion and swelling on HC. They reported that internal soil swelling decreases the number of macropores in a soil, thereby increasing the water holding capacity at low tension. Shainberg et al. (2001) conducted a similar study. Soils with varying levels of

initial ESP were leached with saline water. When the salt concentration of the leaching water was 3 meq/l, reductions in HC and clay dispersion decreased only when ESP values were greater than 12, whereas when distilled water was used to leach the soil, reductions in HC and dispersion where observed at ESPs of 1 and 2. Accordingly, Curtin et al. (1994) reported extensive swelling of soil clays when the ESP exceeded 10. Results from the study suggest that initial decreases in HC are attributable to swelling occurring at high salt concentrations, while dispersion becomes more important as electrolyte concentration decreases. In another study, researchers investigated whether the addition of sodium to water in an early irrigation would decrease infiltration during subsequent irrigation. Results showed that the infiltration rate decreased, with the reduction attributed to chemically induced dispersion of the soil (Hopmans et al., 1990).

Aggregate Slaking. Aggregate slaking is also another physical process associated with sodicity (Coughlan et al., 1991). The slaking of macroaggregates into microaggregates reduces the number of macropores, which in turn limits soil permeability (Oster and Shainberg, 2001). When a soil is structurally stable, the volume of transmitting pores, macropores, is high and the HC is high (Shainberg et al., 2001). Increasing sodium either in the soil solution or on soil exchange complex causes soil aggregates to disperse or slake into domains, which are reduced in size to the extent that they are transported with the water, thereby blocking the larger pores, and reducing the hydraulic conductivity (So and Aylmore, 1993). Crescimanno et al. (1995) saw this trend in their research, as they found reductions of 25% in HC when aggregate stability decreased, thereby increasing the susceptibility of the soil to cracks.

Bauder and Brock (1992) reported that irrigation with relatively high Na concentration water reduced surface soil macroporosity more than irrigation with relatively low Na concentration water. As clay swells into water conducting pores, and clay deposits within the pores, permeability decreases (Oster and Shainberg, 2001). Accordingly, Buckland et al. (2002) found that irrigation waters characterized by increased salinity/sodicity generally decreased aggregate stability.

Crust Formation. Crust formation is yet another characteristic of sodium-affected soils that may detrimentally affect the hydraulic properties of soils. The primary causes of surface crusting are physical dispersion due to impact of irrigation water/rainfall and chemical dispersion dependent on soil ESP and irrigation water EC (Agassi et al., 1981). Crust structure consists of two parts: 1) an upper skin seal caused by raindrop impact; and 2) a washed in zone formed by the accumulation of dispersed particles (McIntyre, 1958). Agassi et al. (1981) found that crust formation due to rainfall is greatly enhanced by clay dispersion and movement in the soil. Accordingly, Gal et al. (1984) studied the effect of soil sodicity and electrolyte concentration on the formation of structural crusts. Their study consisted of exposing sandy loam soil with an ESP of 1.0 or 11.6 to distilled water. At an ESP of 1.0, only a thin layer of compacted aggregates sealing the soil surface was observed. Yet, at an ESP of 11.6, the clay dispersed, and downward movement of the clay particles caused accumulation in the washed-in layer, causing crust formation and decreasing infiltration rates.

Another type of crust affected by salt concentration is depositional crusts, which refer to crusts formed by the movement of fine particles and their deposition a particular distance from their original location (Chen et al, 1980; Shainberg and Singer, 1985). Agassi et al. (1985) suggest that the high susceptibility of depositional crusts to salt concentrations of the irrigation water is similar to that of a structural crust. Shainberg and Singer (1985) studied the effects of salt concentration on the HC of depositional crusts. They measured the hydraulic conductivity of two soils as a function of the volume of suspension infiltrated and salt concentration of the applied water, in a range $\leq$ .005M. When the EC of the applied water was below 0.3 dS/m, the HC of the depositional crust was 2 to 3 orders of magnitude lower than that of bulk soils. When the EC exceeded 0.3 dS/m, the permeability increased markedly. Shainberg and Singer (1985) also reported that saturated HC of depositional crusts made of flocculated particles was much higher than saturated HC of crusts made of dispersed clay and silt particles.

Texture implications. A soil's texture will govern how it responds; texture largely reflects the clay content of a soil. Clay has a large specific surface area, which makes it more active in physiochemical processes than sand or silt (Keren and Shainberg, 1981). In semi-arid and arid regions, especially where marine deposition has been a predominant source of parent material, montmorillonite clay is often the dominant clay type. Because of its high specific surface area (~800 m^2g^{-1}), it is the most active clay in clay-solution interactions (Keren and Shainberg, 1981). Therefore, the physical and chemical effects of saline-sodic percolating waters on soil properties may be exacerbated when the clay mineralogy of an area is predominantly montmorillonite.

Understanding the colloidal properties of clays is essential to understanding the effect of exchangeable Na and electrolyte concentration on the physical properties of soils. The diffuse double layer formed at clay surfaces by adsorbed sodium ions creates high swelling pressures, and forms single clay platelets which tend to persist in dilute solutions (Keren and Shainberg, 1981). The repulsion forces between clay particles increases with increasing sodicity or decreasing salinity (Oster and Shainberg, 2001). In the Curtin et al. (1994) study, each soil type studied exhibited the same general response to different SAR and EC concentrations, i.e., soils that were predominantly clay textured were very sensitive to the composition of the applied solution. Data collected from this study suggest that fine textured soils would not be suitable for irrigation with sodic water because of poor sodium stability.

EC/SAR Relationship

The interactive relationship between the salt concentration of the irrigation water, SAR of the irrigation water, and physical properties of the soil is well defined in the literature. The permeability of a soil to water depends both on the ESP of the soil and on the salt concentration of the percolating solution (EC or salinity), tending to decrease with increasing ESP and decreasing salt concentration (McNeal et al., 1968; Quirk and Schofield, 1955). The greater the SAR, the greater the potential reduction of HC, yet the effects of a high SAR are greatly decreased as the total salt concentration increases (Curtin et al., 1994; McNeal, 1968; Shainberg et al., 1981; Mace and Amrhein, 2001). Many factors influence the permeability of a soil in accordance to the EC by SAR

interaction. These factors include organic matter, inorganic agents stabilizing soil aggregates and mechanical disturbance (Quirk and Schofield, 1955).

Quirk and Shofield (1955) were the first to qualify this relationship with respect to permeability. Hanson et al. (1999) also quantified this interactive effect of EC and SAR based on data initially reported by Ayers and Westcot (1976). Ayers and Westcot (1976) initially reported that even at a very high solution SAR, reductions to infiltration/permeability will be less severe if the EC of the irrigation water is maintained sufficiently high enough, irrespective of the constituency of the salinity component.

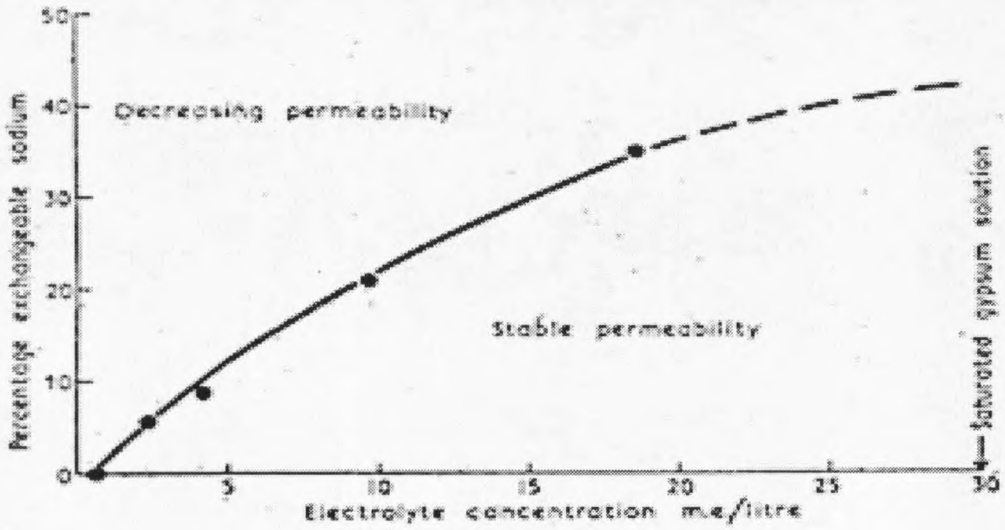


Figure 7. Permeability of soils as defined by the interaction between electrolyte concentration and the exchangeable sodium percentage. (Source: Quirk and Schofield, 1955)

Curtin et al. (1994) assessed the effects of SAR on a wide variety of soils. They reported that disproportionately high salt concentrations were needed to ensure satisfactory soil structure at high SAR values. VanOlphen (1977) reported that the soil

water salinity necessary to maintain flocculation of a Na-montmorillonite soil is 12 to 16 meq/l (276-368 mg/l). Oster et al. (1980) reports flocculation values for Ca and Na saturated montmorillonite with ESPs of 10 and 20 are 3 and 6 meq/l, respectively. These flocculation values correspond to salinities of approximately 300 and 600 uS/cm.

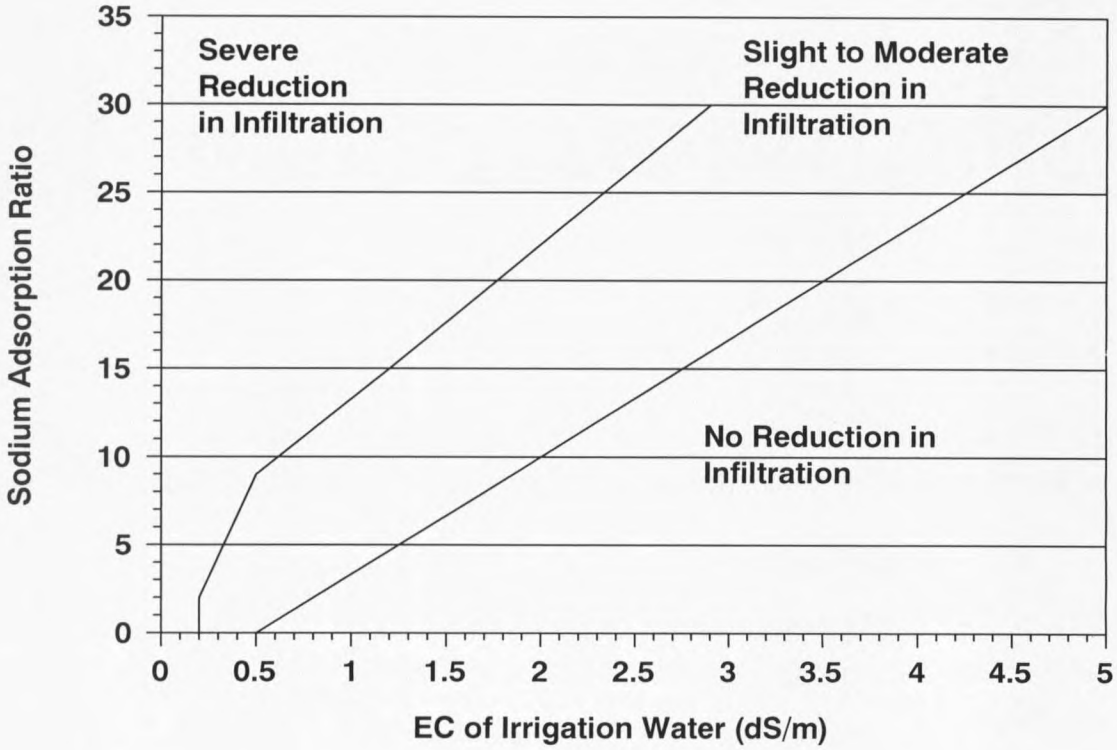


Figure 8. Reductions in infiltration as defined by the interaction between the EC and the SAR of the irrigation water. (Source: Hanson et al., 1999)

Rainfall Effects

The effects of rainfall on soil dispersion have significant implications in saline/sodic conditions. Leaching and rainfall affect soil solution chemistry and consequently relate to soil physical properties (Oster, 1994). In many cases, rainfall may

cause more alteration both chemically and physically to a soil than irrigation waters. Rainfall essentially has an electrical conductivity of zero, which does not promote or enhance the flocculation of soil with high amounts of exchangeable sodium. Irrigation with a non–saline water or rainfall will reduce the EC of the soil water near the surface of a soil, but will not reduce the ESP the same magnitude as the EC reduction (Oster, 1994). The ESP will be reduced to a much lesser extent. This disproportionate reduction in EC relative to the reduction in SAR relates to the number of exchangeable ions on the exchange sites of the soil, which is as much as 500 times greater than the number of ions in soil water. This means that the number of calcium and magnesium ions in the soil solution originating from precipitation or non-saline water is insufficient to replace the amount of exchangeable sodium within the soil.

Most irrigation water has a salt concentration much greater than that of rainwater. During the irrigation season, salt concentrations within the soil solution and in the irrigation water are usually elevated to an extent, thus reducing the potential for physical degradation due to dispersion. Yet, when the water source changes to rainwater, soil water within the upper soil layer is displaced by rain water, causing dilution, and increasing the possibility of degradation to the physical properties of the soil (Shainberg et al., 1981). Disproportionate lowering of the EC to the SAR or ESP will likely upset the balance between flocculation promoted by the electrolyte concentration and dispersion promoted by sodicity. The Shainberg et al. (1981) study demonstrates this effect. While the impacts of sodicity on surface soils are almost immediate with rainfall, subsurface soils will eventually be impacted if sufficient amounts of rainfall infiltrate

(Oster and Shainberg, 2001). Thus, the effects of exchangeable sodium are much more evident during the rainy season than during irrigation periods (Levy et al., 1994).

Shainberg et al. (1981) report that some soils are more susceptible to clay dispersion than others when leached with distilled water or rainfall. Rainfall produced structural deterioration in Na-soils, and thus rainfall effects need to be accounted for when evaluating the sodicity hazard of irrigation water. Buckland et al. (2002) likewise found that infiltration properties were significantly greater with irrigation water than with distilled water.

Raindrop Impact. The impact action of raindrops can also alter the physical properties of soil. Agassi et al. (1985) studied the effects of raindrop impact and applied water salinity on infiltration of sodic soils. They reported that soils experiencing high-energy rain were more sensitive to lower levels of ESP, compared to soils receiving low-energy rain. This could be explained by the beating action of the rain, which broke down aggregates at the soil surface. Accordingly, Shainberg et al. (2001) reported that aggregates are more stable and much less susceptible to the impacts of sodicity when exposed to wetting rates less than 10 mm/h. Agassi et al. (1985) suggests that during rainstorms, reductions in the infiltration rate result from crust formation.

Salinity/Sodicity Thresholds

Historically, the critical values used to define sodic conditions were an SAR of 12 and an ESP of 15 (U.S. Salinity Laboratory, 1954). This threshold was based on the assumption that deterioration of the soil would occur when the ESP exceeds the value of

15, which corresponds to the SAR of 12. Accepted ESP thresholds vary around the world, in large part due to the different mineralogy of soils (Halliwell et al., 2001). In Australia, sodic soils are defined as soils with ESP values greater than 5, according to McIntyre (1979) or soils exhibiting an ESP greater than 6, according to Northcote and Skene (1972).

More recent literature suggests that these numbers need to be redefined. Researchers have found that soil degradation often takes place at ESP/SAR values much lower than historically accepted thresholds. Cresimanno et al. (1995) suggests that an effective hazard of soil degradation can be shown in soils with ESP values of 2 to 5. Accordingly, Shainberg et al. (1981) suggest even an ESP of 5 can be detrimental to soil properties when high-quality water displaces the soil solution. Curtin et al. (1994) proposed that the acceptable SAR increases as the clay content of a soil decreases.

It is also substantiated in the literature that SAR/ESP thresholds depend on the corresponding salt concentration. Quirk and Schofield (1955) introduced the idea of a threshold electrolyte concentration (TEC), which is defined as a critical value that the electrolyte concentration of the soil solution must exceed to ensure that soil permeability can be maintained. Rhoades (1972) noted that one of the major difficulties in establishing permissible limits with which to evaluate the sodicity hazard of irrigation water is a lack of quantitative information on the interplay of exchangeable sodium, electrolyte concentration, and soil properties on soil permeability. He also notes that it is presently impractical and non-justifiable to set precise standards of wide applicability for irrigation water quality.

Crescimanno et al. (1995) investigated the effects of SAR on the physical properties of soils (aggregate stability, rate of selling-shrinkage, and saturated and unsaturated hydraulic conductivity) irrigated with water having a range of solution salt concentrations. The objective of their study was to gain a better understanding of the relationship between these soil properties and ESP, and to verify if a critical ESP threshold existed. They reported that structural stability of the soil decreased, the water content corresponding to specific matric suctions decreased, and aggregate slaking occurred across a continuum of ESP values, indicating that a critical ESP threshold was not representative of soil structural response to ESP.

Quirk and Schofield (1955) indicate that since the permeability of a soil is related to both the exchangeable sodium percentage and the electrolyte concentration, there is no basis for dividing soils into sodic or non-sodic categories at an ESP of 15. Sumner (1993) reports that sodicity effects may be observed at any ESP. So and Aylmore (1993) state that in pure clay water systems a critical ESP threshold can be shown, but in real soils too many factors influence the relationship between ESP and other soil physical parameters, making it difficult to establish the critical ESP value.

Salinity thresholds, unlike sodicity thresholds, are questioned to a lesser extent. The scientific literature reports no instances where salinity alone is related to soil properties; thresholds for salinity are generally set in the context of crop performance. Frenkel (1984) suggests that salinity classifications are rigid and don't take into account other factors that are necessary in determining the potential use of a water. Ghassemi et al. (1995) suggest that an assessment must be made in relation to crop tolerance to

salinity, leaching fraction, and equilibrated soil water salinity after irrigation water is applied.

Soil-Water Retention

One way to examine the effects of saline-sodic water on the physical properties of a soil is by assessing the effect of salinity and sodicity on the soil-water retention curve. Soil-water retention curves, also known as the soil water characteristic (SWC) or water release characteristic curves, define the relationship between soil water content and matric potential under equilibrium conditions (Bresler et al., 1982). The SWC is an important property in understanding the hydraulic characteristics of a soil, from the distribution of pore space, both size and interconnectedness, to many other characteristics (Or et al., 2002). The SWC is a highly nonlinear relationship influenced by texture and structure of the nonporous medium.

Texture i.e., the particle size distribution, largely shapes a soil water retention curve. Finer-textured soils have a higher water holding capacity than coarser textured soils. Accordingly, Rawls et al. (1982), using multiple linear regression analysis of soil water content at 12 soil water potentials, documented that clay content is the most important texture factor affecting SWC. Clay percentage within a soil will determine the amount of small micropores in a soil. As a soil begins to dry out, water will drain first from the larger pores. Smaller pores, like the micropores in the clay, will hold water longer and tighter. This explains why at the wet end of a water retention curve, the relationship is primarily influenced by structure and pore size distribution, as opposed the

dryer end, which is influenced more by specific surface area and texture of the particular soil.

In addition to texture, soil structural properties are influential on SWC relationships. A soil that is well aggregated will have more total pore space, a proportionally greater percentage of large pores, and greater overall water-holding capacity than a poorly aggregated soil. Likewise, a compacted soil will hold less total water, but will have a greater proportion of small and medium sized pores, which hold water tighter than do larger pores (Brady and Weil, 1999).

There are several ways to measure the required parameters for a SWC curve. One method often used within the laboratory is a pressure plate apparatus. Lima et al. (1990) estimated hydraulic conductivity using pressure chambers. Samples were treated with solutions of various SAR, and then water retention was measured during the drainage process over varying capillary pressure heads (matric potentials). Salinity effects on soil-water retention curves were then measured. Results indicated that increasing the amount of sodium or decreasing the electrolyte solution increased the water holding capacity of a soil for a specific pressure. Figure 9 shows the effects of concentration and composition of the soil solution on the water content of soils containing smectite clays. Soil water content increases as the salt concentration of the soil solution decreases or as the sodium concentration relative to calcium ratio (R) of the soil solution increases. This figure also illustrates that at a given water content, the amount of energy required to remove water increases as R increases. This energy requirement can be related to pore radius size.

Figure 9 shows that the pore size required to hold a particular amount of water decreases as R increases.

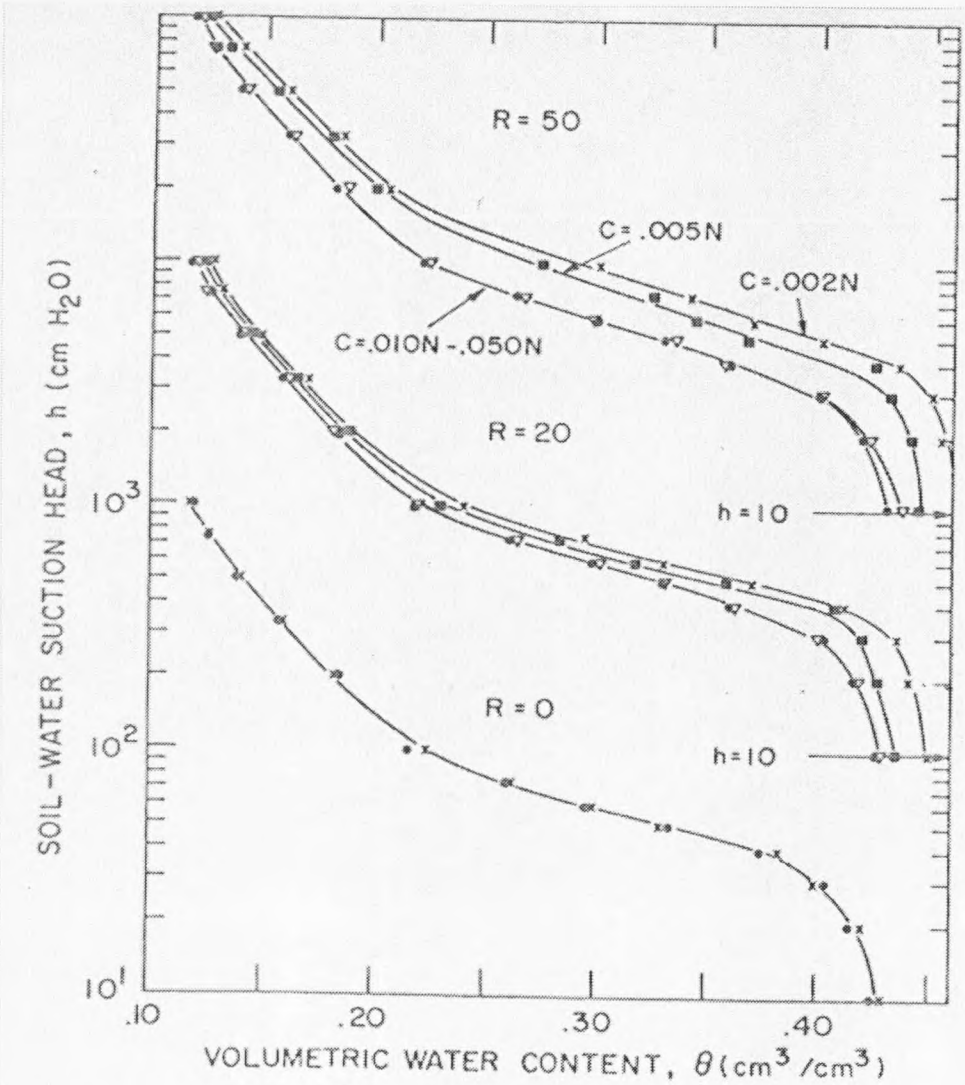


Figure 9. Soil-water suction head (h) as a function of the volumetric water content (theta) and equilibrium-solution concentration for three cationic (sodium to calcium) ratios (R). (Source: Bresler et al., 1982)

CHAPTER 2

STUDY OF SOIL CHEMICAL RESPONSES

Materials and Methods

Soil Sampling

A detailed assessment of soil series being irrigated with, or with the potential for irrigation along the Powder River and within the boundaries of the Buffalo Rapids Irrigation District (Prairie, Custer, Dawson, and Powder River counties) was completed (Table 1). Soil series data and irrigable acreages were obtained from the Buffalo Rapids Irrigation District in collaboration with Natural Resource Conservation Service (NRCS) soil scientists (VanFossen, personal communication[1]).

Table 1. Soil series with largest amounts of irrigable acres within the Buffalo Rapids Irrigation District.

Soil Series	*Taxonomy*	*Texture*	*Acres*
Cherry	Fine-silty, mixed, frigid Typic Ustochrepts	sicl	6052.4
Marias	Fine, smectitic, frigid Chromic Haphsturts	sic	3527.1
Spinekop	Fine-loamy, mixed, superactive, frigid Aridic Haplustepts	sicl	3045.3
Trembles	Coarse-loamy, mixed, calcareous, frigid Typic Ustifluvents	fsl/l	2640.8
Havre	Fine-loamy, mixed (calcareous) frigid Ustic Torifluvents	sil/sicl	2157.8
Busby	Coarse-loamy, mixed Borollic Camborthids	fsl	2002.1

[1] Steve VanFossen, Resource Soil Scientist, Lower Yellowstone Natural Resource Area, 3120 Valley Drive East, Miles City, MT, 59301-5500, (406)232-7905.

Resulting from the assessment, four predominant soil textures were identified for sampling and inclusion within the study (fine sandy loam - fsl, silt loam – sil, silty clay loam - sicl, and silty clay – sic). Using published and unpublished soil survey data and assistance from NRCS soil specialists, sixteen representative sites were selected for sampling, representing four of each dominant textural category (Figure 10). A sampling site representing each dominant soil textural category was located in each of the four previously identified counties. A soil pit was excavated at each site to a depth of 30 inches (75 cm) (Figure 11). Approximately 60 pounds (25 kg) of bulk soil material was collected from each of the top four soil horizons of each sampling site.

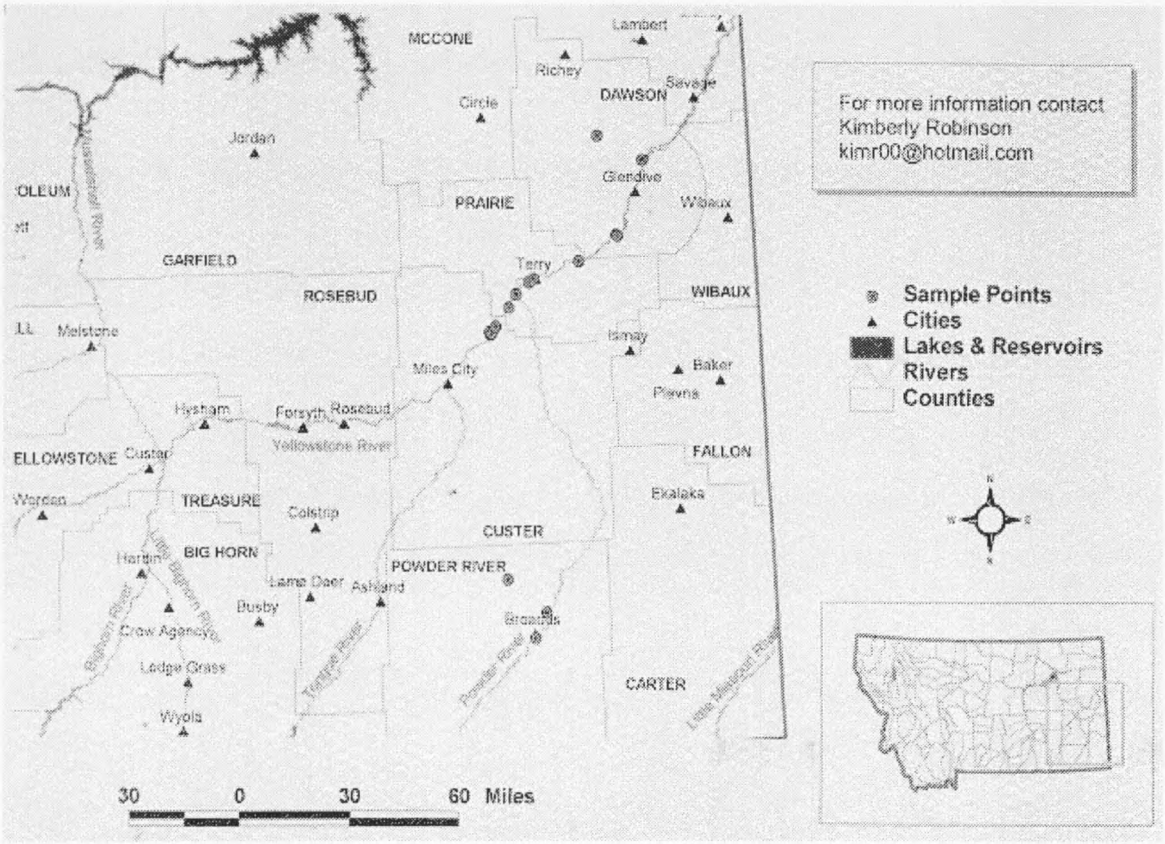


Figure 10. Sampling locations within the Powder River watershed, Prairie County Conservation District, and Buffalo Rapids Irrigation District.

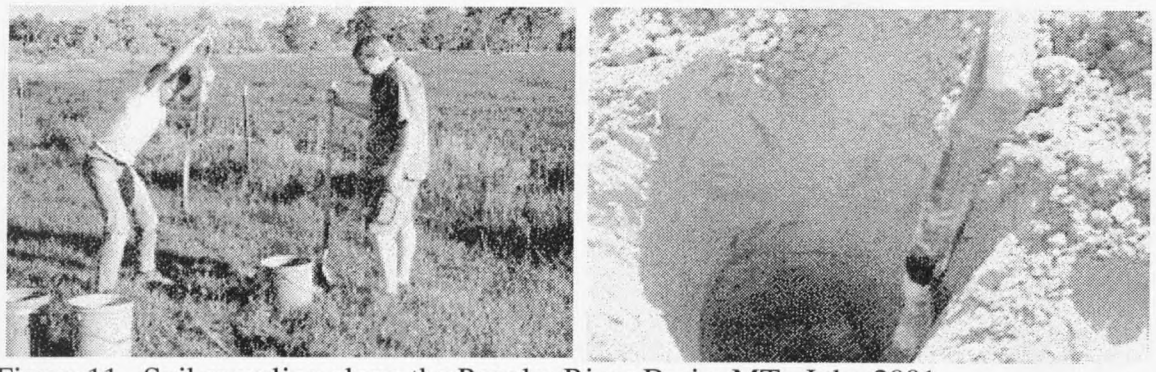


Figure 11. Soil sampling along the Powder River Basin, MT. July, 2001

A total of 54 horizons were sampled. These bulk samples, identified as baseline, were appropriately identified, labeled, and returned to the lab where they were air-dried and subsequently stored.

Laboratory Analysis

All chemical analyses of samples reported herein were completed on a contract basis by MDS Farmer Services (Harris Laboratories), Lincoln, NE. In an effort to achieve consistency in test procedures, this same laboratory completed all subsequent chemical analyses. Sub-samples of all baseline samples were oven dried (105 °C) and sieved (2 mm). Approximately 50 grams of each sub-sample were sent to Harris Laboratories for analyses of soluble saturated paste extracts and exchangeable base cations. The laboratory reported results as mg/L, meq/100g, and % CEC.

Quality Assurance/Quality Control-Soils

Quality control measures consisted of sending two check samples of a known soil each time batch soils were sent to the lab (Appendix A). Harris Laboratories also had their own quality control program. It consisted of daily check samples, daily duplicate

samples, weekly rerun trays, and blind check samples. The lab also works with the North American Proficiency Testing (NAPT) program. The daily check samples are run approximately every 30-40 samples. All laboratory QA/QC parameters were within control limits and there were no associated limits (data flags) to the use of the resulting data.

Baseline Characterizations

Baseline (pre-existing) chemical characterization for all soil materials is illustrated in Figure 12. Baseline conditions were assessed to provide a foundation to determine changes that occurred in soil chemistry when soil materials were exposed to treatment combinations.

Particle size analyses were also completed on each sample using the hydrometer method as described by Gee and Bauder (1986). Results were summarized as sand, silt, and clay fractions in g/100g of soil. Samples were then defined on the textural triangle (Figure 13). From this analysis soil samples were separated into four classes or categories. They were identified as: Textural Class 1- clay content-0-11%, loamy sand, sandy loam, loam; Textural Class 2- clay content-12-22%, sandy loam, loam, silt loam; Textural Class 3- clay content-23-33%-loam, silty clay loam; Textural Class 4- clay content-greater than 33%-silty clay loam, silty clay, clay.

The primary clay mineral present in a soil governs the response of a soil both chemically and physically. It was therefore important to determine the predominate clay mineralogy of soil samples. Six sub-samples, ranging in clay content from 34% to 67%, were sent to the North Dakota State University Minerals Characterization Laboratory for

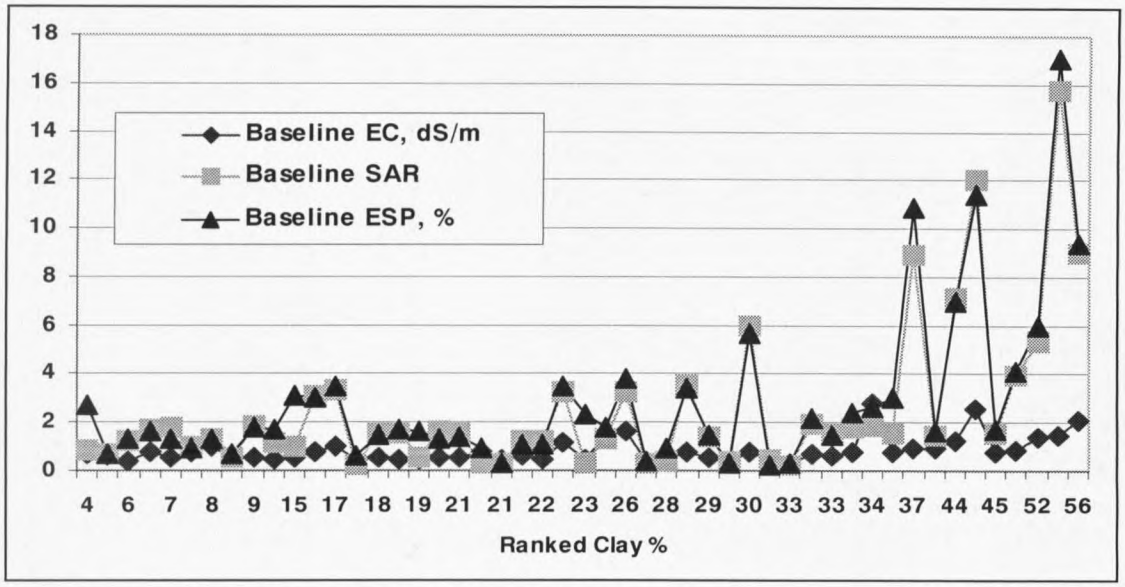


Figure 12. Pre-existing salinity (EC_{sat}) and sodicity (SAR) of soil solution saturated paste extract and exchangeable sodium percentage (ESP) of soil solid phase exchange complex versus clay (g clay/100g bulk soil) of individual soil materials.

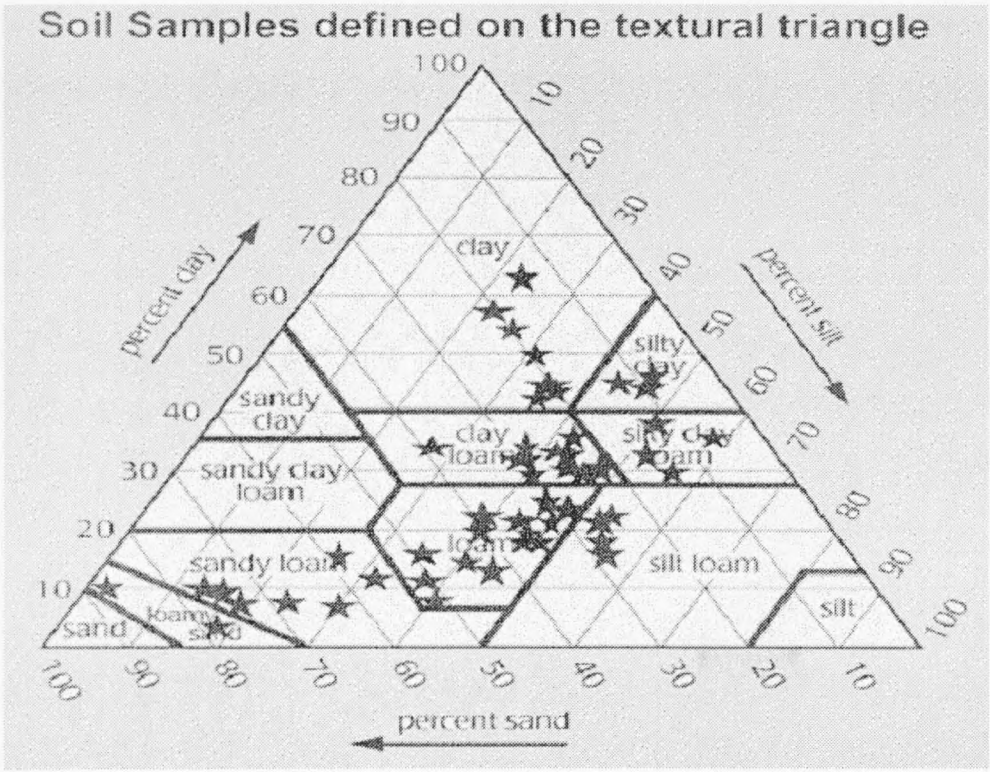


Figure 13. Soil textural triangle, illustrating representation of individual soil materials of study. Percent values reported were determined on a dry mass basis, (g/100g) x 100.

X-ray diffractometry (XRD) analysis. These samples were representative of the clay mineral fraction of soils within the ephemeral and perennial stream channels and adjacent up gradient terraces and benches where irrigation is currently practiced. XRD can determine the abundance of the differing clay mineral phases. Results showed that smectite was the dominant clay mineral in all samples (Appendix B).

Treatments

Treatments consisted of six different water quality x wetting regime combinations (Table 2). Soils from each horizon were treated with each of these combinations. Water quality treatments consisted of either synthesized Powder River water or synthesized CBM product water.

Table 2. Water quality x wetting regime treatment combinations.

Synthesized Water Quality	Wetting Regime
PR (Powder River)	
EC = 1.56 dS/m	1 X wet/dry with P.R.
SAR = 4.54	1 X wet/dry with CBM
pH = 8.03	5 X wet/dry with P.R.
	5 X wet/dry with CBM
CBM (Product Water)	5 X wet/dry with P.R. followed by leaching with 1 pore volume distilled water
EC = 3.12 dS/m	
SAR = 13.09	
pH = 8.22	5X wet/dry with CBM followed by leaching with 1 pore volume distilled water

Selection of target signatures for Powder River and CBM water was based on an extensive analysis of the chemistry of Powder River surface water and permitted CBM

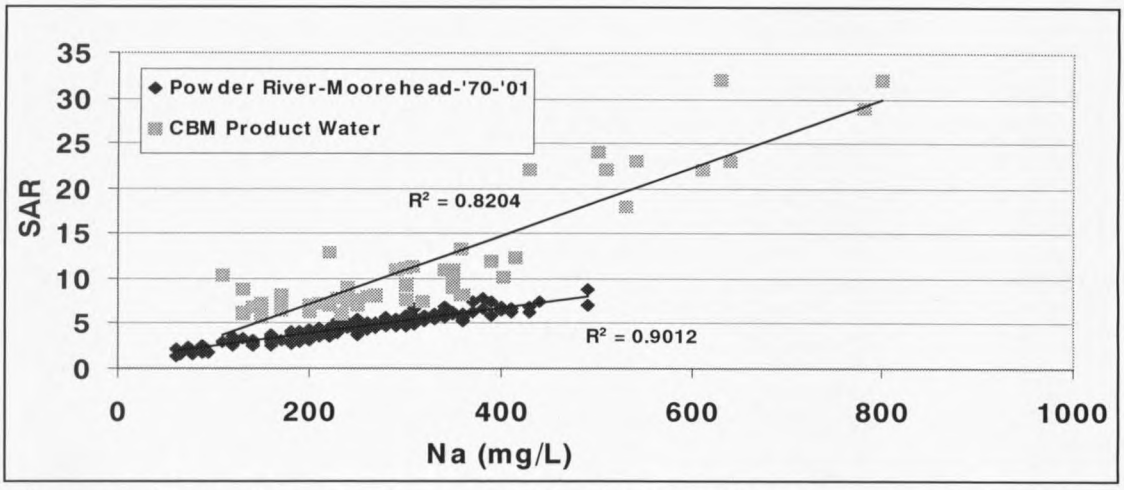


Figure 14. Na (sodium, mg/L) versus SAR of Powder River discharges of record in Montana and of permitted CBM discharges of record within the Powder River Basin, as of October, 2001. (Source: USGS-Station #06324500, USGS-Central Region Energy Resource Team, 2001).

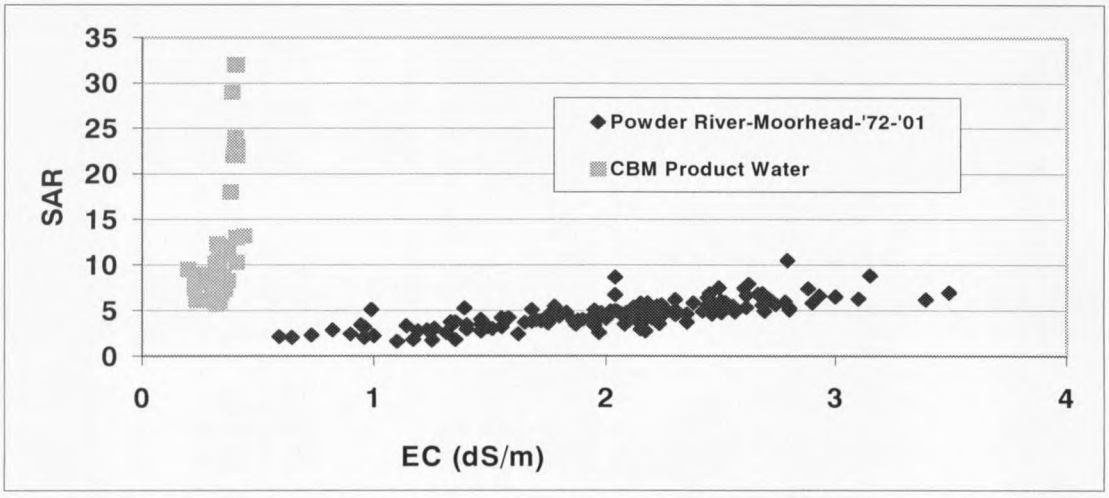


Figure 15. EC (dS/m) versus SAR of Powder River discharges of record in Montana and of permitted CBM discharges of record within the Powder River Basin, as of October, 2001. (Source: USGS-Station #06324500, USGS-Central Energy Team, 2001).

outfalls (discharges) within the Powder River watershed, as of October 2001 (Figures 14 - 15). Target water qualities were selected based on 10-90 percentile values or ranges, i.e., the thresholds were derived by deleting the values falling in the < 10 percentile groups and the values falling in the > 90 percentile group. Using the chemistry synthesis model MINTEQ2 (USEPA, 1991), a recipe was determined to create synthetic CBM product water and Powder River water. Chemical reagent combinations were combined with 60 liters of distilled water in approximately 200 liter barrels to create this water (Figure 16). A small submersible pump (1 gpm) was placed within each barrel to facilitate continuous mixing of the water. A new supply of water was synthesized weekly.

Figure 16. Barrel holding synthesized CBM water.

Water quality analyses were completed by Agvise Laboratories, Northwood, ND. Two 100 mL samples from the bulk supply (i.e., one of synthesized Powder River water and one of CBM product water) were submitted weekly to ensure that the bulk supply of water was within the water quality parameters set forth in the treatment standards (Appendix A). Water samples were analyzed for Mg, Ca, Na, EC, and pH.

Quality Assurance/Quality Control-Water

Agvise Laboratories quality controls consist of the following measures. 1) The ICP that tested the cations rechecks the standards after every forty samples tested in order to check the calibration of the instrument. The standards must be +/- 10%, or the run data are discarded and the batch samples are retested. 2) A laboratory check program totals the sum of the cations and compares it with the EC readings of each batch. All data is put into an Excel spreadsheet, and then the check program is overlaid to the data spreadsheet to ensure the cation data matches the EC readings. If any data points do not match, then they are retested. All QA/QC parameters were within control limits and there were no associated limits (data flags) to the use of the resulting data.

Experiment Construction

Drain holes were drilled in the bottom of plastic drinking cups (266 mL). Cheesecloth was cut and placed in the bottom of each cup. Each cup was then filled to the top with one of the 54 soil materials. Cups with the sample soil were then placed in large plastic containers, so that the appropriate treatment water could be poured into the container. This allowed for the soil to soak the treatment water from the bottom up, and

also provided for wetting nearly to saturation. Soils were allowed to imbibe water for a 24-hour period.

Soil samples receiving the 1X treatment (both P.R. and CBM), were then transferred to aluminum plates and were oven dried (105° C). These samples were ground, sieved (2 mm), and sent to Harris Laboratories for the same chemical analyses as baseline samples.

Samples receiving one of the 5X treatments were placed in the oven and dried at 35° C for 24 hours following the first wetting (Figure 17). This wetting/drying cycle was then repeated until completion of the fifth wetting event. Final drying for the 5X treatments (P.R. and CBM) was completed the same as the 1X treatments (oven dried at 105° C). These samples were likewise ground, sieved, and sent to Harris Laboratories.

Figure 17. Soil samples were dried to 35°C between wetting regimes.

The final treatment cycle consisted of a 5X treatment (as described previously), followed by a distilled water leaching application. For this treatment, racks were constructed to allow water to drain from the bottom of the soil filled cups. Following the fifth wet/dry cycle, empty cups were placed underneath each sample cup (Figure 18). Approximately one pore volume of distilled water was then poured on the surface of each sample. Leachate water was allowed to drain for 24 hours. After this 24-hour period, soil samples were oven dried in the same way as was done in the final drying period for the other treatments and likewise sent to Harris Laboratories for analyses.

Statistical Analyses

Analysis of variance (ANOVA) and mean separation tests were used to ascertain whether significant differences were present at the 95% level of confidence ($P = 0.05$). Data that exhibited non-normal characteristics were either log or square root transformed. Statistical analyses were first made by running a two-factor ANOVA with no interactions. Factors were textural category and water quality treatment x wetting regime with unequal replications. Data were then partitioned by textual category and one-way ANOVAs were run on each texture with the factor being water quality x wetting regime treatment. Significant differences at $P \leq 0.05$ were separated using the Student-Newman-Keuls method of pairwise multiple comparison for equal size data sets. Least-squares regression was used to evaluate associations between independent and dependent variables. These analyses were conducted using SigmaStat version 2.0 software (Jandel, 1995).

Figure 18. Samples were placed on mesh racks, so that distilled water would leach through the soil. This was the 5X + d treatment.

Results and Discussion

Soil Chemistry

Treatment effect on soil solution chemistry was evaluated by monitoring the resultant saturated paste extract EC and SAR and comparing the results with baseline conditions. Initial inspection indicated that the complete data set exhibited a bimodal distribution. This bimodal distribution was determined to be a consequence of diversity in response to treatment due to textural class differences and non-uniform treatment spacing. Subsequent comparisons were made by analyzing data based on textural class grouping.

Salinity

In almost all cases, the lowest baseline salinity (EC) values were measured in the coarser-textured soils (Figure 19, solid diamond symbols). Results indicate that differences in EC among textural classes 1, 2, and 3 following treatment were not significantly different (Table 3). Only textural class 4 had a significantly higher mean EC over all water quality treatments of 3.78 dS/m. This trend was expected as well-drained, coarser-textured soils naturally have greater leaching fractions and inherently lower salinity levels than fine-textured soils.

Salinity levels were significantly different between the water quality treatments and the baseline. Highest mean EC among all water quality treatments was 6.93 dS/m and was exhibited after soils received the 5X CBM treatment (Table 3).

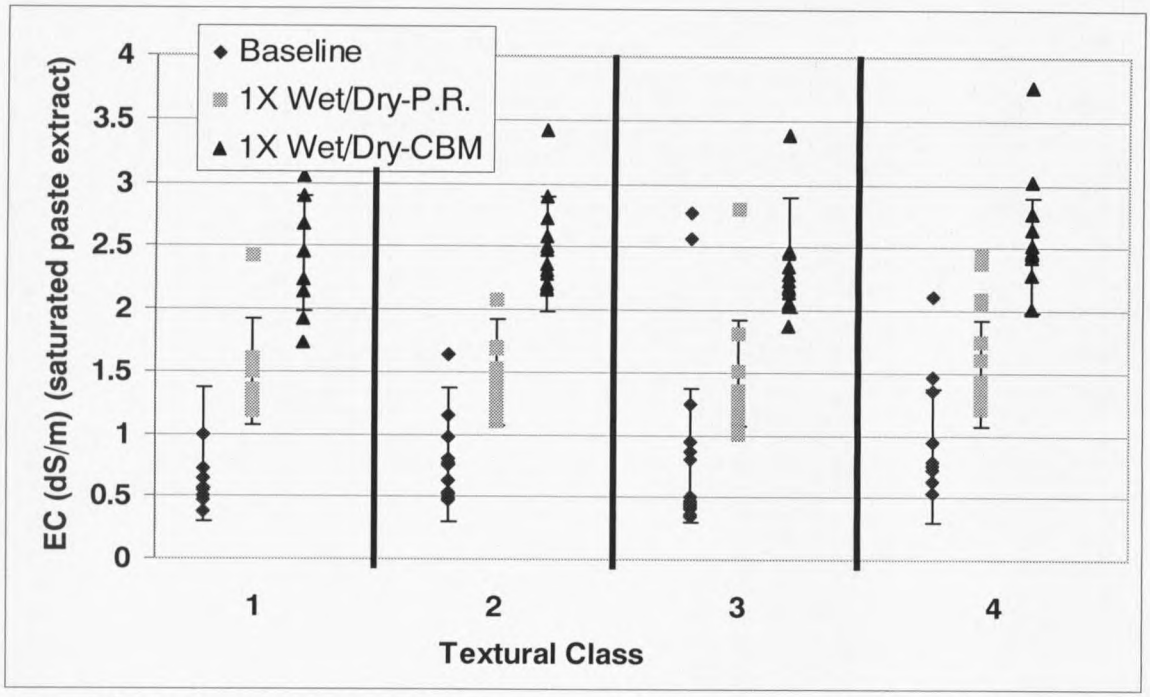


Figure 19. Soil solution saturated paste extract (EC_{sat}) versus textural class prior to treatment (baseline) and following a one-time wet/dry cycle with synthesized P.R. and CBM water qualities. Error bars represent +/- one standard deviation from the mean of each water quality treatment across all textural categories. The standard deviation within each textural class and water quality treatment is tabulated in Appendix C. Graphed data show the increase in EC from baseline levels (diamonds) after treatments (squares, 1X Wet/Dry-P.R.; triangles, 1X Wet/Dry-CBM) were imposed.

Water Quality Effects on EC. After a one-time wet/dry regime with synthesized CBM product water (EC = 3.12), the salinity of the solution extract of soils with the least baseline EC increased approximately 1.5 dS/m, to a value slightly greater than 2 dS/m (Figure 19, Table 4). The resultant increase in EC upon wetting with both Powder River and CBM product water was least for soils with the greatest initial EC. In general, EC of the saturated paste extract increased approximately 2 dS/m when the soil initially had an EC < 1.0 dS/m and was wet only once with CBM product water. The increase in EC was only approximately 1 dS/m when the baseline EC was > 1.0 dS/m.

Table 3. Mean EC and SAR by texture and mean EC and SAR by water quality treatment.

		n	Mean EC (dS/m)[+]	Mean SAR[+]
Textural Class				
	1	9	3.08 a	6.06 a
	2	13	3.39 a	6.04 a
	3	16	3.28 a	5.34 a
	4	11	3.78 b	7.91 b
Water Quality Treatment				
	Base	49	0.82 a	2.56 a
	1X P.R.	49	1.51 b	5.94 b
	1X CBM	49	2.46 c	3.92 b
	5X P.R.	49	3.21 d	4.94 b
	5X P+d	49	3.02 e	4.86 b
	5X CBM	49	6.93 f	11.31 c
	5X C+d	49	5.73 g	10.85 c

[+] Within treatment means followed by the same letter in the same column are not significantly different at $P \leq 0.05$.

As would be expected, a wetting-drying regime of 5 treatment cycles resulted in a significant increase in EC of the saturated paste extract (Figure 20). Results indicate that EC increased in all textural categories when irrigated with a 5X treatment. EC increased 4-6 dS/m above the baseline when repeatedly wetted with CBM product water. This represents more than a two-fold increase over the EC of the synthesized CBM product water. After the 5X CBM and 5X C+d treatments, mean saturated paste extract EC greatly exceeded the acceptable EC threshold (3 dS/m), thereby classifying these soils as saline. After the 5X P.R. and 5X P+d treatments, mean EC was significantly higher than baseline (3.21, 3.02 dS/m, respectively), and equilibrated just above this salinity threshold (Table 3, Figure 20).

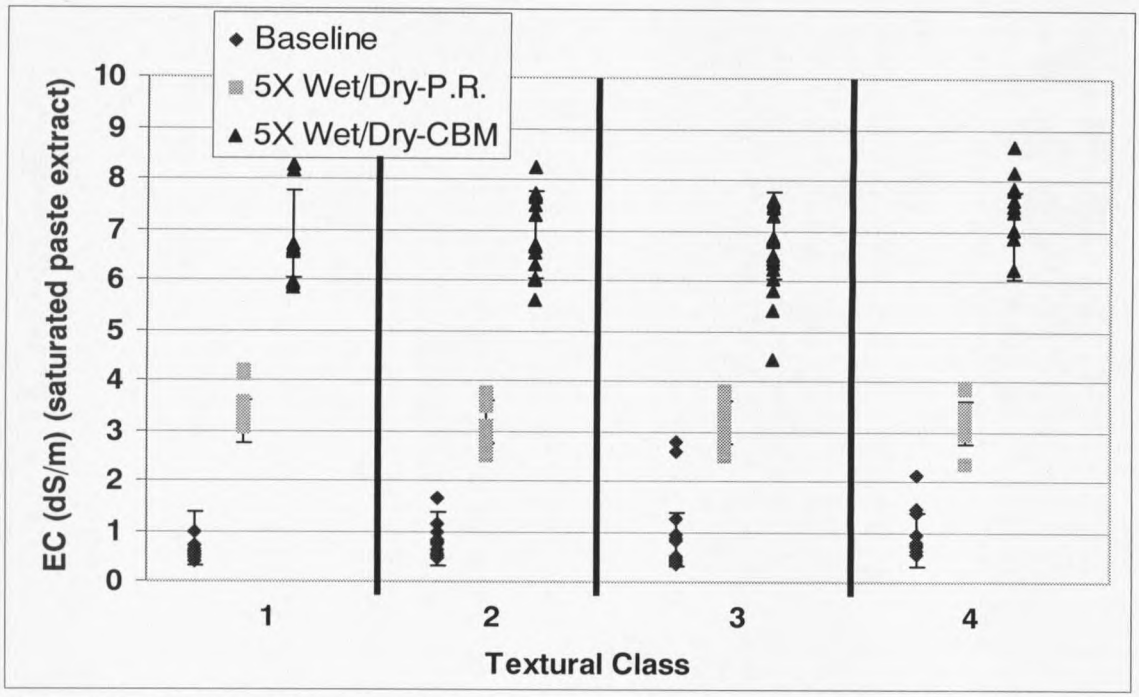


Figure 20. Soil solution saturated paste extract (EC_{sat}) versus textural class prior to treatment (baseline) and following a five-time wet/dry cycle with synthesized P.R. and CBM water qualities. Error bars represent +/- one standard deviation from the mean of each water quality treatment across all textural categories. The standard deviation within each textural class and water quality treatment is tabulated in Appendix C. Graphed data show the increase in EC from baseline levels (diamonds) after treatments (squares, 5X Wet/Dry-P.R.; triangles, 5X Wet/Dry-CBM) were imposed. Note: Scale change from Figure 19.

Subsequent wetting (following the 5X treatment) with a single time distilled water application resulted in a decrease in the EC of 41 of 49 samples (Figure 21). This decrease, averaging approximately 2 dS/m, represents a significant change when considering the flocculating effect of salinity in countering sodium-induced dispersion. Figure 21 shows that after a distilled water application to soils previously treated with CBM product water, the EC was still greater than acceptable standards. This would suggest that sporadic rainfall alone cannot reduce soil salinity to acceptable levels, yet is important when addressing EC x SAR interactions in soils.

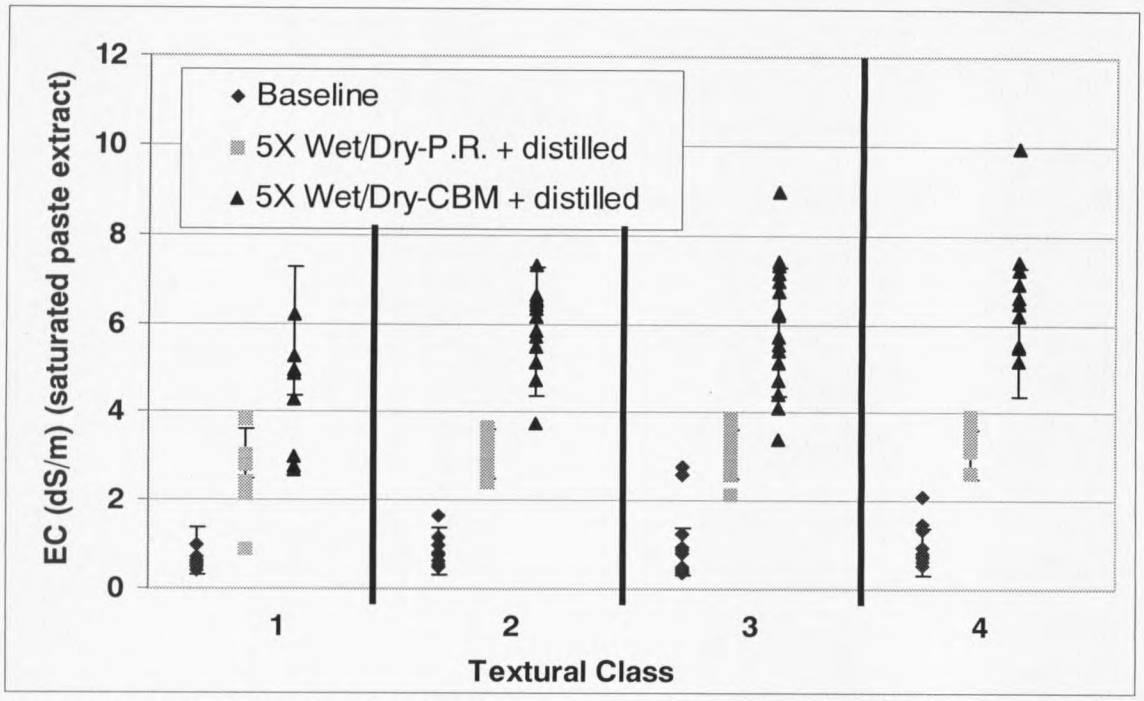


Figure 21. Soil solution saturated paste extract (EC_{sat}) versus textual class prior to treatment (baseline) and following a five-time wet/dry cycle with synthesized P.R. and CBM water qualities followed by distilled water. Error bars represent +/- one standard deviation from the mean of each water quality treatment across all textural categories. The standard deviation within each textural class and water quality treatment is tabulated in Appendix C. Graphed data show the increase in EC from baseline levels (diamonds) after treatments (squares, 5X Wet/Dry-P.R. + distilled; triangles, 5X Wet/Dry-CBM + distilled) were imposed. Note: Scale change from Figure 20.

Textural Effects on EC. Significant differences in EC were detected between all treatments within textural class 1, except in the 1X CBM treatment and the 5X P+d treatment (Table 4). This suggests that on coarse-textured soils, a one time wetting with CBM will result in an average EC that is not significantly different from wetting the soil five times with Powder River water and then leaching with distilled water. Greatest mean EC (6.74 dS/m) within the textural class 1 was detected in the 5X CBM treatment. Distilled water applications to this textural group resulted in significant reductions in EC regardless of previous water qualities.

In textural class 2, mean EC was significantly different among all treatments except the 5X P.R. and the 5X P+d. Results indicate a distilled water application on this soil textural group did reduce EC levels in soils treated with the 5X CBM treatment but not when these soils received the same treatment with PR water. This indicates that distilled water, i.e. rainfall, has a greater ability to reduce EC when salt concentrations are higher, as found in soils treated with CBM product water. Highest mean EC (6.92 dS/m) occurred after soils underwent the 5X CBM treatment cycle (Table 4). This represents a 6-fold increase from baseline, which also occurred in textural class 1.

Significant differences of EC within the textural class 3 mimicked results found within textural class 2. EC associated with all treatments was significantly different except the 5X P.R. and the 5X P+d, which were the same. As in textural class 2, this would suggest that distilled water decreases EC most when salt concentrations are high. Mean EC was highest in the 5X wet/dry cycles and was nearly equal to mean EC values in textural groups 1 and 2 receiving this same treatment.

Within the textural class 4, the EC did not differ significantly between the 1X CBM, 5X P.R. and 5X P+d treatments. This suggests that irrigation once with CBM product water will result in salinity values similar to soils that received 5X P.R. and 5X P+d treatments. EC of treatments of 5X CBM and 5X C+d were significantly greater than all other treatment mean ECs but did not differ significantly from each other. This effect was only observed with textural class 4. This suggests that the greater clay content within the textural class 4, as compared with the other textural classes, reduces the effectiveness of distilled water applications at lowering EC. Higher exchange capacities

Table 4. Treatment mean saturated paste extract EC and SAR for textural classes by water quality treatment.

SOIL TEXTURE	n	Water Quality Treatment	Mean EC (dS/m)[+]	Mean SAR[+]
Textural Class #1	9	Base	0.60 a	1.16 a*
		1X P.R.	1.45 b	3.08 b
Mean EC = 3.08a		1X CBM	2.38 c	5.90c
Mean SAR = 6.06a		5X P.R.	3.53 d	4.50 d
		5X P+d	2.57 c	3.90 e
		5X CBM	6.74 e	12.44 f
		5X C+d	4.32 f	11.36 g
Textural Class #2	13	Base	0.77 a	2.15 a
		1X P.R.	1.43 b	3.40 b
Mean EC = 3.39a		1X CBM	2.48 c	5.63 c
Mean SAR = 6.04a		5X P.R.	3.16 d	4.47 d
		5X P+d	3.08 d	4.50 d
		5X CBM	6.92 e	11.53 e
		5X C+d	5.90 f	10.65 f
Textural Class #3	16	Base	0.87 a*	1.97 a
		1X P.R.	1.36 b	3.10 b
Mean EC = 3.28a		1X CBM	2.23 c	5.02 c
Mean SAR = 5.34a		5X P.R.	2.93 d	4.10 d
		5X P+d	3.05 d	4.07 d
		5X CBM	6.57 e	9.57 e
		5X C+d	5.96 f	9.51 e
Textural Class #4	11	Base	1.05 a**	4.96 a**
		1X P.R.	1.82 b	6.11 b
Mean EC = 3.78b		1X CBM	2.74 c	7.20 b
Mean SAR = 7.91b		5X P.R.	3.23 c	6.68 b
		5X P+d	3.39 c	6.88 b
		5X CBM	7.49 d	11.69 c
		5X C+d	6.72 d	11.87 c

[+] Within treatment means followed by the same letter in the same column are not significantly different.

* Data analyzed using square root transformed data. Means reported in this table are actual means, derived from saturated paste extracts.

**Data analyzed using log transformed data. Means reported in this table are actual means, derived from saturated paste extracts.

of finer textured soils and greater percentages of non-readily draining interstitial spaces result in the ability of the soil to absorb and retain higher concentrations of salts.

Sodicity

Baseline sodicity (SAR) values were lowest in the coarser textured soils, consistent with EC measurements (Figure 22). Results indicate that differences in SAR associated with texture were only significantly greater in textural group 4(Table 3). Lowest mean SAR across all textural classes was 5.34, while the highest mean SAR was 7.91 in textural class 4. The baseline data clearly suggest that only three of the sampled soils were at the risk of substantial dispersion (SAR = 12) at the time of initial sampling (Figure 12).

Soil SAR responded differently to water quality treatment than did EC (Table 3). All water quality treatments resulted in significantly higher SAR levels than the baseline. However, mean SAR values for 1X P.R., 1X CBM, 5X P.R., and 5X P+d treatments were not significantly different from each other. This response was important with respect to the behavior of EC as opposed to the resultant SAR as a consequence of distilled water applications. Significant reduction in mean EC occurred after distilled water applications while there were no significant decreases in SAR when distilled water was applied. This is important when addressing the interaction between EC and SAR.

The 5X CBM and the 5X C+d treatments also were not significantly different from each other. As was the case in EC, the greatest mean SAR across all soil textural categories (11.31) was found in the 5X CBM water quality treatment (Table 3). Within

soil textural categories, the greatest mean SAR (11.87) occurred within textural class 4 after soils were treated with 5X C+d (Table 4).

Water Quality Effects on SAR. Similar to EC, SAR values increased in association with the SAR of the treatment water (Table 4). Soils with the lowest baseline SAR showed the greatest increase in SAR upon wetting with CBM water. A single wetting with Powder River water increased SAR approximately two units in soils with lowest initial solution SAR (Figure 22). For soils with baseline SAR values greater than about 3, a single wetting with either Powder River water or CBM water had little effect on solution SAR. In general, resultant SAR after a single wet/dry cycle of P.R. and CBM water qualities did not exceed 8, and therefore soils such as these studied here do not appear to be at risk of dispersion when exposed to single applications of CBM product water such as that used in this study.

Treatment involving a regime of five wetting-drying cycles with either Powder River water or CBM product water resulted in solution SAR values nearly equal to the SAR of the treatment water, i.e., SAR approaching values of 4-5 and 10-12 , respectively (Figure 23). Hence, it is reasonable to conclude that if the soil solution equilibrates with the applied water EC, soil solution SAR will equilibrate at a value equal to or greater than the SAR of the applied water over time. Upon repeated addition of CBM water approximately only 15% of SAR values exceed 12. These data indicate that on average, a five-time application of either Powder River or CBM product water under the conditions of forced leaching used in this study does not elevate the soil SAR to a greater than acceptable standard (SAR of 12), regardless of soil textural class (Table 4). Most of

the samples with elevated SARs were in the coarser textural categories, i.e. soils less inclined to disperse.

Treatment involving a five-time wet/dry cycle plus the application of distilled water exhibited the same trends in SAR as the 5X treatment across all soil textures and water quality treatments (Figure 24). Mean values show that the SAR of the soil solution changed little when the 5X cycle was followed by distilled water (Table 3). Only in the case of textural class 1 and 2 did the addition of distilled water cause a significant difference in SAR (Table 4). This was different from the significant reductions in EC

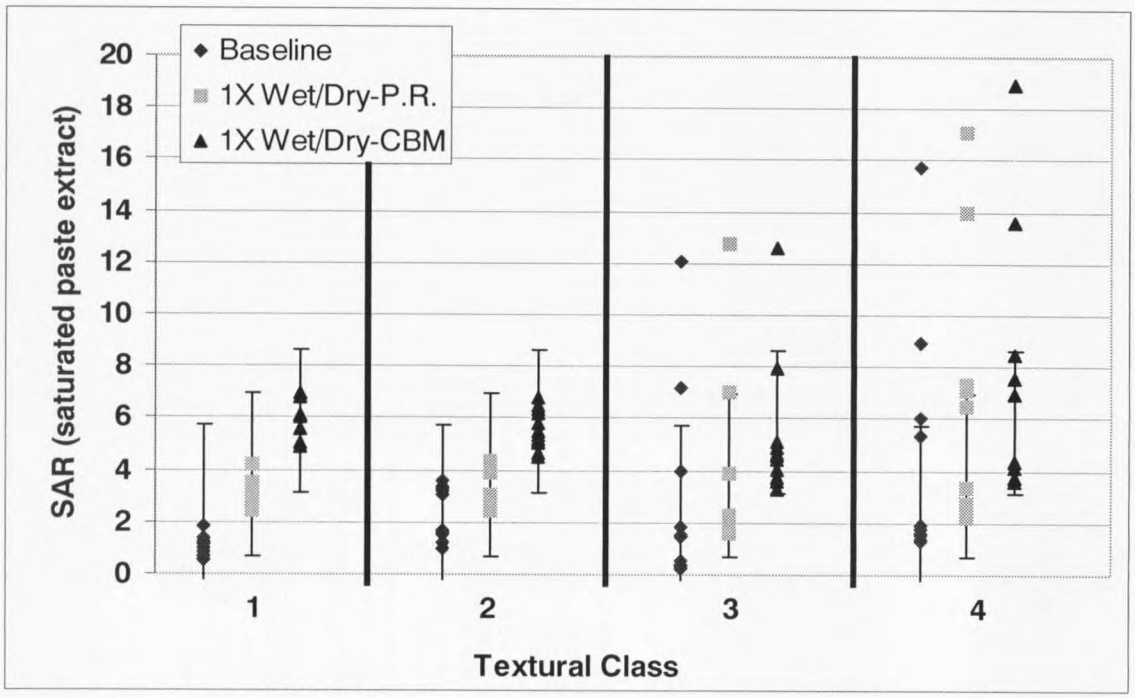


Figure 22. Soil solution saturated paste extract SAR versus textural class prior to treatment (baseline) and following a one-time wet/dry cycle with synthesized P.R. and CBM water qualities. Error bars represent +/- one standard deviation from the mean of each water quality treatment across all textural categories. The standard deviation within each textural class and water quality treatment is tabulated in Appendix C. Graphed data show the increase in SAR from baseline levels (diagonals) after treatments (squares, 1X Wet/Dry-P.R.; triangles, 1X Wet/Dry-CBM) were imposed.

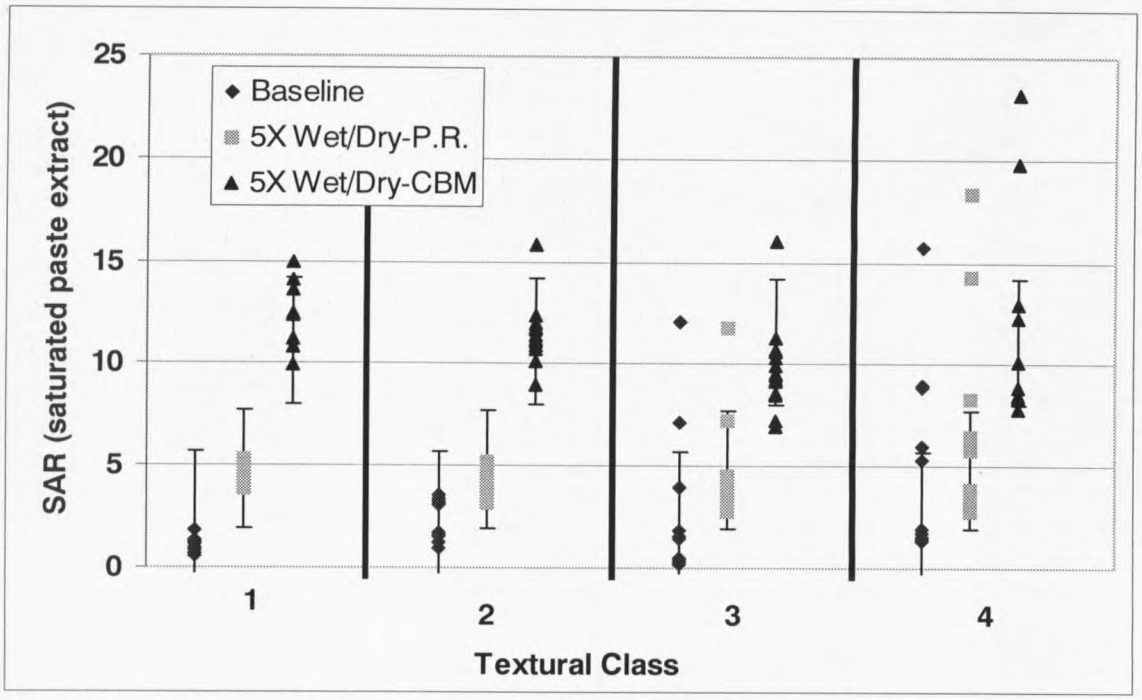


Figure 23. Soil solution saturated paste extract SAR versus textural class prior to treatment (baseline) and following a five-time wet/dry cycle with synthesized P.R. water and CBM water qualities. Error bars represent +/- one standard deviation from the mean of each water quality treatment across all textural categories. The standard deviation within each textural class and water quality treatment is tabulated in Appendix C. Graphed data show the increase in SAR from baseline levels (diamonds) after treatments (squares, 5X Wet/Dry-P.R.; triangles, 5X Wet/Dry-CBM) were imposed. Note: Scale change from Figure 22.

that occurred as a result of a distilled water application meant to simulate a rainfall event. This disproportionate lowering of EC in relation to the SAR is important when assessing the impact of irrigation waters on soil solution chemical properties. The implication of this is that the flocculating effect of salinity or EC may be reduced during rainfall events, thereby exacerbating the dispersive effects of sodium.

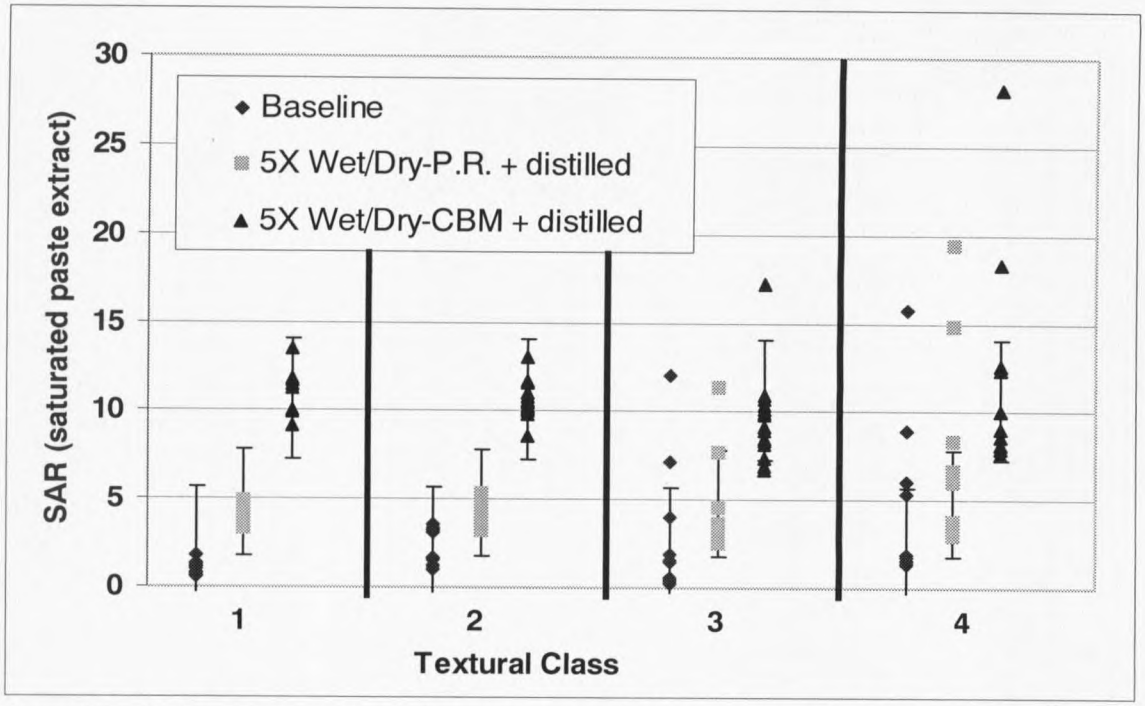


Figure 24. Soil solution saturated paste extract SAR versus textural class prior to treatment (baseline) and following a five-time wet/dry cycle with synthesized P.R. and CBM water qualities plus distilled water application. Error bars represent +/- one standard deviation from the mean of each water quality treatment across all textural categories. The standard deviation within each textural class and water quality treatment is tabulated in Appendix C. Graphed data show the increase in SAR from baseline levels (diamonds) after treatments (squares, 5X Wet/Dry-P.R. + distilled; triangles, 5X Wet/Dry-CBM + distilled) were imposed. Note: Scale change from figure 23.

Textural Effects on Sodicity. In textural class 1, significant differences in SAR were detected between all treatments (Table 4). Within this class, distilled water applications resulted in significant reductions of SAR. Greatest mean SAR (12.44) resulted from the 5X CBM treatment, a more than ten-fold increase from the baseline SAR of 1.16. This was the largest increase in all textures from mean baseline values. Within the textural class 1, the 5X CBM treatment elevated the SAR to an unacceptable level.

Within textural class 2, all treatments caused significant differences in SAR except the 5X P.R. and the 5X P+d (Table 4). In this textural class, results show that rainfall following irrigation with CBM water lowered SAR but did not when irrigating with Powder River water. This was the same trend that occurred in the EC data. This likewise would suggest that distilled water has a greater flushing effect when salt concentrations are higher.

Significant differences in SAR within textural class 3 were similar to the differences in textural group 2 (Table 4). The exception was that SAR values resulting from the 5X CBM and 5X C+d treatments were not significantly different from each other. This was different from the EC measurements, in that a significant reduction was determined with these two treatments. Within this textural class there is a disproportioniate lowering of EC relative to SAR.

In textural group 4, the SAR did not differ significantly between the 1X P.R., 1X CBM, 5X P.R. and 5X P+d treatments. These results indicate on soil textures included within this class, effects on SAR are likely to be the same whether irrigated one time with Powder River water, once with CBM water, 5 times with Powder River water or 5 times with Powder River and then followed by rainfall. Essentially, water quality treatments have less of an impact on increasing or lowering SAR levels in textual class 4.

Implications using previously published data

Data collected in this experiment have meaningful implications relative to previously published soil salinity x sodicity relationships (Figures 25-26). Based on these diagrams predictions can be made in respect to accepted irrigation water quality standards and dispersion risk thresholds.

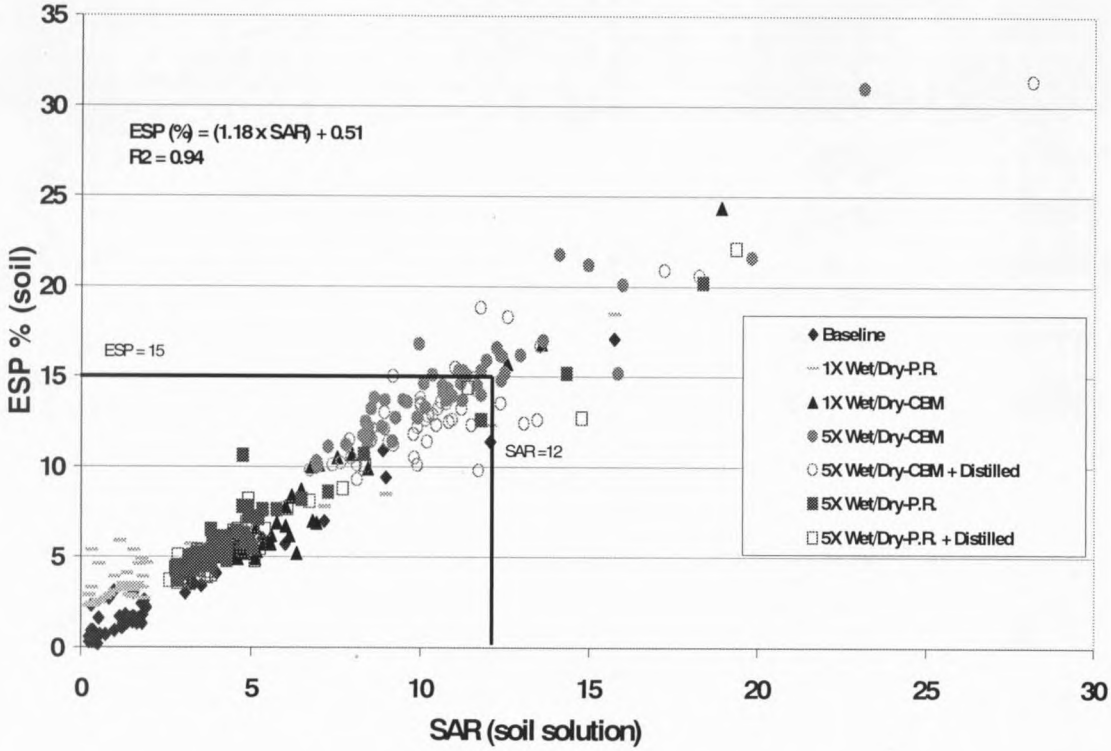


Figure 25. Soil solution SAR versus exchangeable sodium percentage (ESP) of soil solid phase exchange complex prior to treatment (baseline) and following treatment with various water quality x wetting regimes. Solid lines represent previously reported dispersion risk thresholds for ESP (15%) and SAR (12).

Previously published research reports a relationship between SAR of applied water and ESP of the soil as ESP of 15% = SAR of 12, i.e., SAR = 0.8 x ESP with respect to assumed risk of dispersion of fine material (U.S. Salinity Laboratory, 1954).

Data presented in Figure 25, derived from these studies, follow this same relationship, suggesting that the soil solution SAR is generally representative of the applied water SAR and the SAR can be used to approximate or estimate the resultant ESP. Using such criteria when referring to Figure 25, it becomes apparent that either repeated wetting/drying or wetting/drying followed by a single application of distilled water (simulating rainfall) elevates the ESP and SAR closer to previously published thresholds of SAR = 12, ESP = 15 (U.S. Salinity Laboratory, 1954).

Figure 26 illustrates the soil saturated paste extract EC and SAR following each of the treatment combinations. Imposed on this figure are two different sets of previously published threshold values. The two diagonal lines correspond to the thresholds reported by Hansen et al. (1999) with respect to EC x SAR combinations distinguishing no risk, moderate risk and severe risk of dispersion. These values were derived from earlier studies reported by Ayers and Westcot (1976). The 90-degree vertical x horizontal lines represent the EC threshold for salinity (i.e., EC = 3.0 dS/m) and the SAR value normally considered the diagnostic for sodic soils (i.e., SAR > 12), respectively. Similarly, these values were reported by Hanson et al. (1999) and were initially reported by Richards (1954). As can be seen, the data points cluster, relative to the EC x SAR combination of the respective treatment, with one exception. A single wetting with distilled water following a regime of five wet-dry cycles with CBM product water results in a shift of most data points left, closer to the threshold criteria (solid circles shift to open circles).

On initial inspection of Figure 26, a logical conclusion is that all data points falling to the right of the right-most diagonal line represent EC x SAR combinations that

pose little or no risk with respect to dispersion. This would suggest that dispersion is generally not at a high risk under conditions of the study reported herein. However, with respect to salinity, data presented in this figure depict a higher risk situation. Relying solely on the published plant tolerances to salinity (threshold of EC = 3 dS/m), three

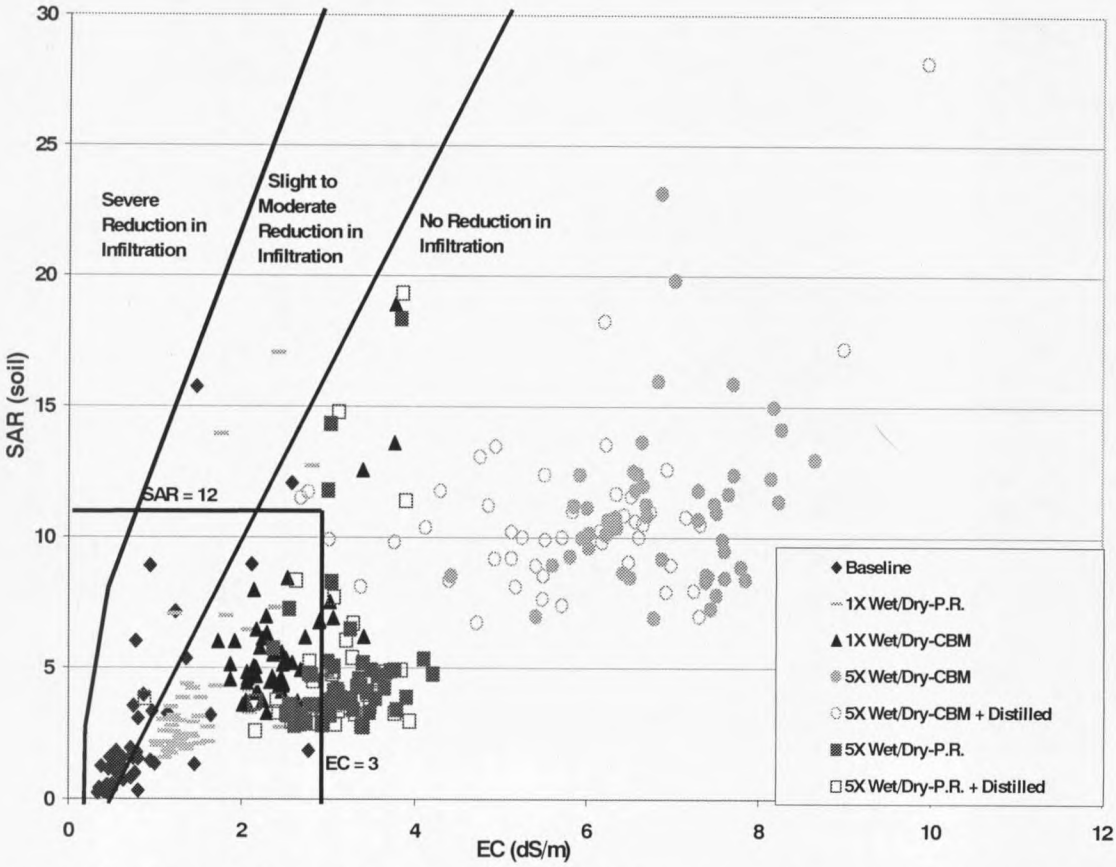


Figure 26. Soil solution saturated paste extract (EC_{sat}) versus soil solution SAR of soil material prior to treatment (baseline) and following treatment with various water quality x wetting regimes. Solid lines represent salinity and dispersion risk thresholds previously reported by Ayers and Westcot (1976), Hanson et al. (1999), Miller and Donahue (1995) and others. These lines are modified from published data lines resulting from personal communication with Blaine Hanson (2002).

significant points become evident from this figure: 1) essentially all of the EC data points associated with repeated wetting and drying with simulated CBM product water exceed

the 3 dS/m threshold; 2) subsequent wetting with simulated rainfall does not result in sufficient reduction in salinity to lower than 3 dS/m following repeated wetting with CBM product water; and 3) with repeated wetting and drying with simulated Powder River water, many soils demonstrate EC values greater than the 3 dS/m threshold. These latter soils are thus approaching the categorization of saline.

Resultant soil solution chemical data as depicted in Figures 25-26 would suggest that in many cases repeated irrigation with water of EC x SAR combinations used here to simulate CBM product water or in-stream mixed water may not pose an immediate risk of dispersion on most of the irrigable soils used in this study. Yet, the resultant salinity levels are likely to have significant adverse effect on plant production when salt intolerant plants are grown. Furthermore, in the event of significant rainfall during the irrigation season, availability of water of lower EC for irrigation, or repeated rainfall events during the non-irrigation season, it is likely that soil salinity values will be sufficiently lowered. Yet, this lower EC will reduce the offsetting effect of electrolyte-induced flocculation to the point where dispersion becomes more probable.

Summary and Conclusions

The following observations were made during this study:

1. Repeated irrigation with saline-sodic water or water with a chemical signature comparable to the CBM product water used in this study will result in a general increase in the soil salinity and sodicity.

2. Repeated irrigation or dispersal of CBM product water to irrigable land is likely to result in elevated soil salinity levels substantially higher than published thresholds for some irrigated crops.
3. It appears that soil solution salinity will equilibrate at an EC value approximately 2-3 times the EC of the applied water; in contrast, soil solution SAR appears to equilibrate at a level comparable to the SAR of the applied water as long as leaching occurs. These results are consistent with previously reported findings.
4. Application of salt-free water following elevation of soil solution salinity and SAR through repeated wetting effectively reduced soil solution salinity while having little or no effect on sodicity. The implication of this is that the flocculating effect of salinity may be reduced, thereby exacerbating the dispersive effects of sodium, as a consequence of uncontrollable rainfall or dispersals of relatively salt-free spring runoff to soils previously irrigation with saline-sodic water.
5. The lowering impact of rainfall on EC and SAR is more predominant when salt concentrations are high, and in coarser textured soils.
6. The greatest increases in EC and SAR upon wetting with either CBM or P.R. water were in coarser-textured soils.
7. Based on previously published EC x SAR combination thresholds for protection against particle dispersion, in few instances of this study were soil solution salinity x sodicity combinations measured which exceed these thresholds following single wetting events. In essentially all instances where saline-sodic water was repeatably

applied, the resulting soil solution salinity and sodicity were significantly elevated to levels in close proximity to the previously published EC x SAR standards.

8. Results of this study appear to be consistent with previously published reports of the relationship between exchangeable sodium percentage (ESP) and solution SAR, i.e., SAR = 0.8 x ESP (approximately). Utilizing an ESP threshold of 15, the majority of treated soil samples exceeding this value resulted from alternate wetting regimes with CBM product water followed by simulated rainfall.

CHAPTER 3

STUDY OF SOIL PHYSICAL RESPONSES

Materials and Methods

Experiment Construction

A system of four pressure plate apparati to measure soil water retention was assembled in the laboratory at Montana State University. Pressure was supplied to the pressure plate apparati via PVC tubing connected to an air compressor (Figure 27). A pressure regulator and gage was installed at the inflow line at each apparatus to regulate and monitor the applied pressure. Each apparatus was equipped with outflow ports to drain water off the plates.

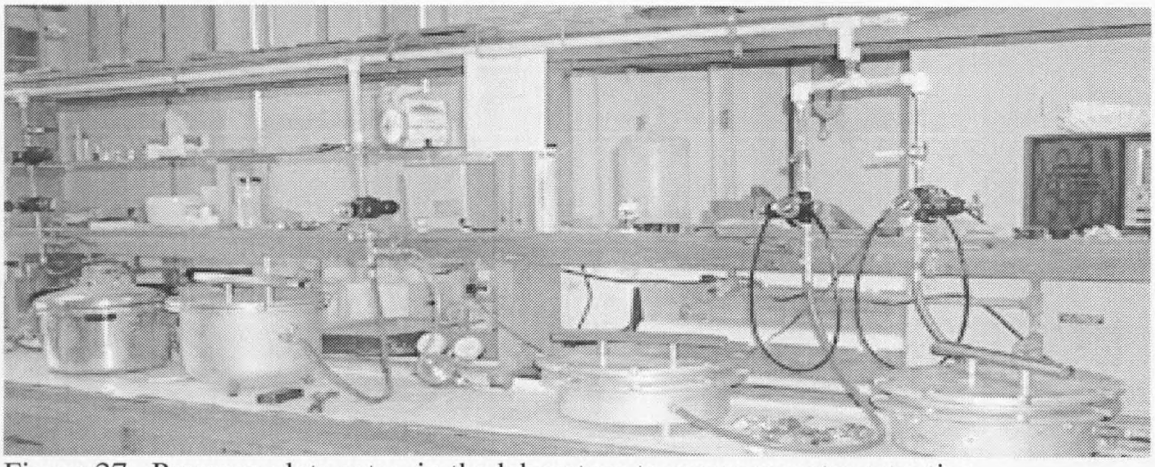


Figure 27. Pressure plate setup in the laboratory to measure water retention.

Treatments

Treatments consisted of six different water qualities x wetting regime combinations (Table 2), following the same treatment combination scenario described in Chapter 2. As described in the previous chapter, water qualities consisted of either synthesized Powder River water or synthesized CBM product water. After treatment combinations were imposed on sample soils using procedures described for the chemistry portion of this study, water retention of these soils was then measured at -1/10, -1/3, -1, -5, -15 bars of applied pressure. Equilibrium pressure was equated with matric potential, but with a sign change. Each treatment combination was replicated three times at each matric potential. The 1X P.R. treatment was categorized as the "control" treatment in all subsequent statistical analyses.

Soils

Soil used in this phase of the investigation was from the same collection of soil materials used in the study of soil chemical responses (Chapter 2). Soil used in this experiment was air dried, ground, and passed through a 4 mm sieve before exposure to the respective water quality x wetting regimes.

Experimental Design and Treatments

Ceramic pressure plate dimensions allowed for 14 rings (14 samples) to be placed on each plate. One sample of check soil was placed on each plate. One bar ceramic plates were used to measure water retention at -1/10 bar and -1/3 bar pressures; 5 bar ceramic plates were used to measure retention at -1 and -5 bars; and 15 bar ceramic plates

were used to measure retention at -15 bars of pressure. Plates were left in the pressure apparati under applied pressure for varying time according to the pressure prescribed for the particular treatment: -1/10 bar-2 days; -1/3 bar-3 days; -1, -5, -15 bars-5 days. This was done to allow soils to reach equilibrium with the applied pressures. Time constraints and a pre-study assessment justified that 15 bar plates should be left on for five days. Numerous references recommend up to 2 weeks equilibration time for -15 bar moisture content determinations. To justify the shortened time period used here, a mini-experiment was conducted prior to the study where -15 bars of pressure was applied to a subset of "control" samples for 3 days, 5 days, 7 days, 10 days, and 14 days. All data were compared to 14-day data. The best linear correlation was found with samples left on for 5 days (Appendix A). Based on the correlation and linear regression of known 5-day and 15-day equilibration water contents, the following adjustments were made to subsequent data: $Pw < 0.13$ – no change, $Pw > 0.13 \leq 0.18$ subtract 0.03, $Pw > .18$ subtract 0.05, where Pw was the gravimetric water content determined following a 5-day equilibration period at -15 bars applied pressure.

Another modification of the procedure which was instituted to minimize non-treatment induced variability was as follows: metal weights were placed on top of samples that received -1, -5, or -15 bars of pressure to ensure that samples were kept in contact with plates at all times.

For the 1X treatment, retaining rings were placed directly on the ceramic plates and soil was placed within the ring. Treatment water was administered by continual application of the designated synthetic water quality around the rings on the plate until

the soils were completely saturated. Samples were allowed to sit overnight so that complete saturation was assured. The following day synthesized treatment water was again applied to the plates. Saturated soil samples were then placed inside the pressure chamber (Figure 28). Pressure was increased to the designated level and moisture was forced from the soil sample. Excess water in each soil sample moved through the porous membrane and was deposited outside the chamber. At the end of the run, the soil samples were removed from the chamber and transferred to aluminum weighing tins. Samples were then weighed, dried (105°C), and re-weighed (Figure 29). Thus, for known pressure (equilibrated with matric potential), the moisture content of the soil on a gravimetric basis was accurately determined.

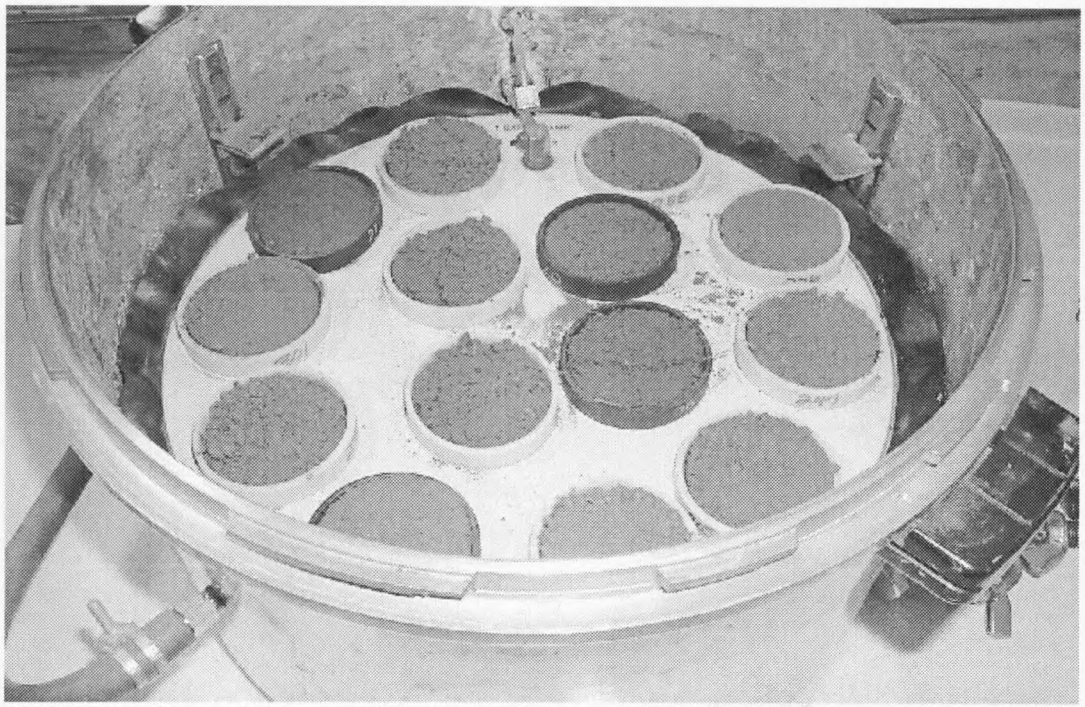


Figure 28. Ceramic plates with rubber rings containing soil were placed within the pressure chamber. This particular pressure plate holds four plates (52 samples, 4 checks).

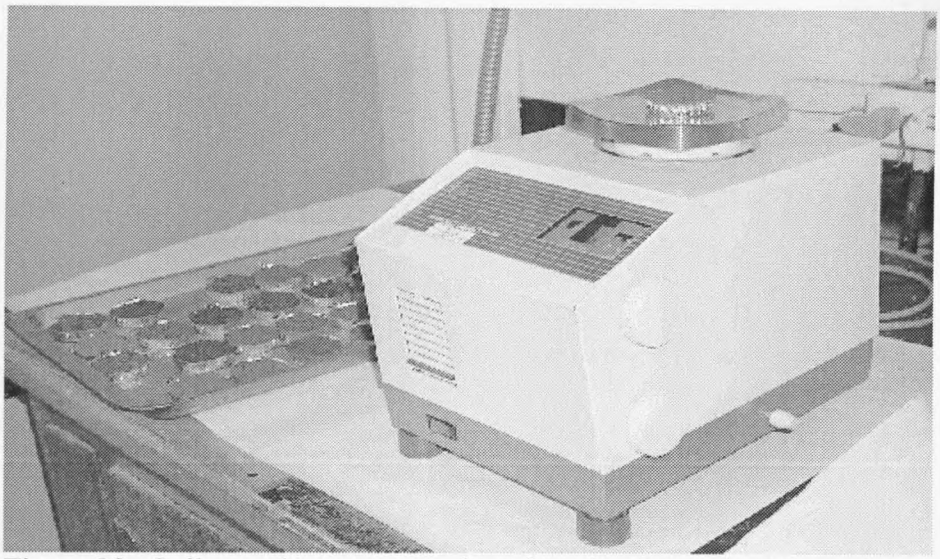


Figure 29. Soil samples were transferred to aluminum tins where they could be weighed.

The procedure of the 5X treatments was somewhat different from the 1X treatments. Rings of sample soil were placed on wire mesh racks (the same as described in the soil chemistry phase of this project). These racks were then placed in plastic containers. The synthetic water quality was poured around the racks up to the point where soils soaked up the water, allowing for complete saturation (Figure 30 - 31).

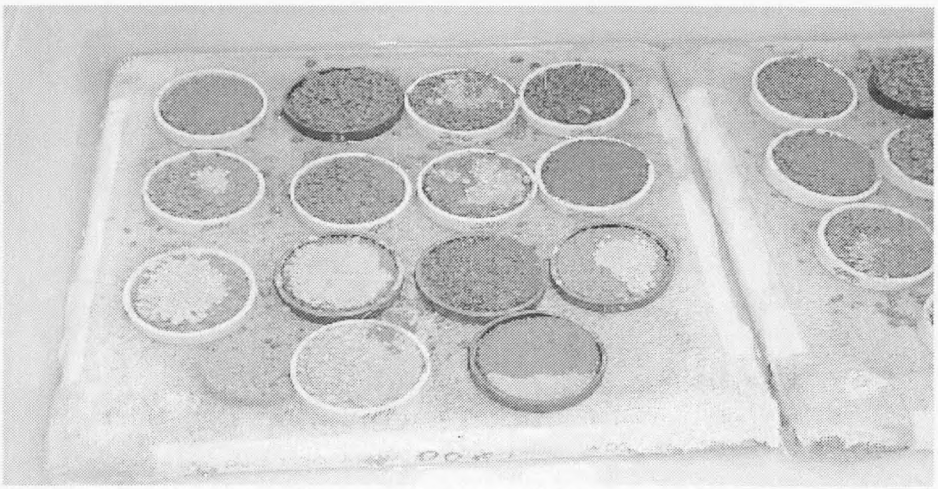


Figure 30. Sample soils on racks are soaking up synthetic water poured around the racks.

Figure 31. Racks inside plastic containers that hold soils saturated with synthetic waters.

After saturation, racks holding these soils were transported to the dryer, and were dried to 35°C for 24 hours (Figure 32). At the end of this period, racks were transported back to the plastic containers and the process was repeated. For the final wetting, samples were transported from the racks to the ceramic plates. As with the 1X treatment, samples were allowed to saturate overnight, rewet the following morning, and were then placed in the pressure chamber.

The same procedure was followed for the 5X + d treatments. Final wetting on the plates consisted of a distilled water application. After samples were saturated with distilled water, the plates were placed in the pressure chambers. The chamber was then closed and an hour was allowed to pass before the pressure was applied.

Figure 32. Racks holding soil samples were dried to 35°C between wetting regimes.

Quality Assurance/Quality Control

Two 100 mL water samples from the bulk supply (i.e., one of synthesized Powder River water and one of CBM product water) were submitted weekly to Agvise Laboratory, Northwood, N.D to ensure that the bulk supply of water was within the water quality parameters set forth in the treatment standards. Quality control procedures of this laboratory are identified in Chapter 2.

To ascertain accuracy within pressure plates a ring of check soil was placed on each ceramic plate within pressure apparati for each run. The check soil was subjected to the same treatment as the other soils on the plate. Thus, this check detected differences

between plates within the particular chamber. Check samples indicated that there were no associated limits (data flags) to the use of the resulting data (Appendix B).

Statistical Analysis

Analysis of variance techniques and mean separation tests were used to ascertain whether significant differences due to textural category of water quality x wetting regime were present at the 95% level of confidence (P = 0.05). Statistical analysis was first completed by running a two-factor ANOVA with no interactions. Factors were texture and water quality treatment with unequal replications. One-way ANOVAs were then run on each texture with the factor being water quality treatment. Because of the non-equality of spacing of the matric potential steps and the prior assumptions that: 1) there would be significant differences due to matric potential treatment, and 2) comparisons among matric potentials was not an interest of this study, matric potential was not analyzed as a source of variation in outcomes.

In some instances the resultant data sets failed normality tests. Where possible, the data were log transformed to overcome this inadequacy. Some data were not transformable. The lack of positive tests of normality does not necessarily always subject the data to question or negate the use of traditional ANOVA in data analysis. Data sets can fail the normality test for several reasons. In numerous instances, Monte Carlo simulation has been used to document the lack of validity of the assumptions associated with tests of normality. Normality means that data are normally distributed and therefore are dependent on a treatment method that is consistently and repeatedly applied or treated with the same conditions. Normality is also an assumption of equally or uniformly

spaced treatment. It is also dependent of a large sampling population and variation among replications. The necessary minimum sample size to show significance increases as the magnitude of the effect to be demonstrated decreases. Typical minimum data sets for normality include n values in excess of 50 and often approaching n = 100. Under these conditions many data sets do not pass normality tests, as was the case in the data that will be presented. There are several reasons that would explain the non-normal behavior of this data. For one, the data set size was small (only 3 replications per treatment). There were not enough observations to develop a curve that would depict normality. Limitations of data set size were necessitated by time constraints, lab equipment, expense, and labor. Secondly, the variance among reps was minimal (Table 4). Differences between reps were sufficiently small that there was no significant test of variation or distribution. Therefore, a normally distributed population was not expected.

Non-normal data that was unable to be transformed into a normal distribution was analyzed using Kruskal-Wallis one-way analysis of variance on ranks. This is a nonparametric test that does not have a normal distribution and equal variance assumptions. All pairwise multiple comparisons of non-normal data were made using the Tukey test. Pairwise comparisons on normally distributed data were made using the Student-Neuman-Keuls test. These analyses were made using Sigma Stat version 2.0 software (Jandel, 1995).

Table 5. Examples of variation between replications of four different soil materials.

Texture				- 1/10 bar	-1/3 bar	-1 bar	-5 bar	-15 bar
	Sample	Treatment	Rep					
FSL	1	1X PR	1	0.30	0.14	0.10	0.08	0.05
	1	1X PR	2	0.32	0.18	0.09	0.07	0.06
	1	1X PR	3	0.34	0.16	0.09	0.06	0.05
	Variance			0.0004	0.0004	2E-05	0	2E-06
SiL	20	5X PR	1	0.36	0.23	0.14	0.10	0.09
	20	5X PR	2	0.34	0.24	0.13	0.10	0.09
	20	5X PR	3	0.34	0.24	0.14	0.11	0.10
	Variance			0.0001	3E-05	2E-05	0	5E-05
SiCL	42	5X CBM	1	0.40	0.30	0.15	0.11	0.09
	42	5X CBM	2	0.41	0.27	0.17	0.11	0.08
	42	5X CBM	3	0.42	0.28	0.17	0.10	0.08
	Variance			1E-04	0.0002	2E-04	0	1E-05
SiC	50	5X CBM + distilled	1	0.38	0.27	0.21	0.17	0.11
	50	5X CBM + distilled	2	0.39	0.27	0.20	0.16	0.13
	50	5X CBM + distilled	3	0.39	0.29	0.20	0.16	0.13
	Variance			3E-05	0.0001	3E-05	0	2E-04

Results and Discussion

Soil Physical Properties

Treatment effects on soil physical properties were evaluated by monitoring resultant water content of soils after coming into equilibrium with various pressure potentials.

Texture implications. Equilibrium water retention (on mass basis) was significantly different among all textural categories at each equilibrium matric potential (Table 6). Greatest mean water content across all water quality x wetting regimes and among all matric potentials occurred textural group 4. This was expected inasmuch as finer-textured soils typically have more total pore space and lesser bulk densities than coarser-textured soils. While there were significant differences in water retention within all matric potentials as a function of texture, the largest ranges in water retention between textural classes were found at -1/10 and -1/3 bar potentials (Table 6). The response seen at this potential is directly associated with the texture of those soils.

The effects of water quality treatment on mean water content were substantially less apparent than textural effects on water content (Table 6). Although there were reportable significant differences due to water quality, water content was generally similar among all matric potentials and water quality treatments within a given matric potential treatment (Table 6).

Table 6. Mean gravimetric water content at -1/10, -1/3, -1, -5 and -15 bars as a function of textural category and water quality treatment.

		Matric Potential				
		-1/10 bar	-1/3 bar	-1 bar	-5 bar	-15 bar
Texture		Mean gravimetric water content (g H_2O/ g dry soil)[+]				
	1	0.25 a	0.11 a	0.06 a	0.05 a	0.04 a
	2	0.33 b	0.21 b	0.13 b	0.10 b	0.08 b
	3	0.39 c	0.28 c	0.20 c	0.15 c	0.11 c
	4	0.45 d	0.32 d	0.23 d	0.18 d	0.14 d
Water Quality Treatment						
	1X P.R.	0.37 a	0.23 a	0.16 a	0.12 a	0.09 a
	1X CBM	0.37 a	0.22 a	0.16 a	0.12 a	0.09 a
	5X P.R.	0.35 b	0.23 a	0.14 b	0.12 a	0.09 a
	5X P+d	0.35 b	0.23 a	0.16 a	0.12 a	0.09 a
	5X CBM	0.35 b	0.23 a	0.15 c	0.12 a	0.09 a
	5X C+d	0.35 b	0.23 a	0.16 a	0.12 a	0.09 a

[+] Within treatment means followed by the same letter in the same column are not significantly different.

At -1/10 bar, the gravimetric water contents associated with the 1X treatments with P.R. water and CBM product water were not significantly different from each other. Yet, these treatments resulted in significantly greater water contents than the 5X treatments with P.R. and CBM water and the subsequent distilled water treatments. Ghezzehei and Or (2000) reported that successive wetting and drying cycles can cause aggregate coalescence and the reduction of interaggregate porosity. Coalescence would happen more effectively at the 5X treatment than at the 1X treatment, because at the 5X treatment level there would be a greater opportunity for particle migration. This explains the reduction in water retention observed after the 5X treatment. This process is also more evident in coarser-textured soils that exhibit a larger range in particle size as

opposed to the finer textured soils. There were no significant differences in gravimetric water content at -1/3 bar as a consequence of water quality treatment. Water content at -1/3 bar matric potential ranged from 0.22 - 0.23 g H_20/g dry soil.

At -1 bar, significant differences in water content occurred between the 5X P.R. and the 1X P.R. or 1X CBM treatments (Table 6). Water contents of the 5X P.R. and 5X CBM treatments at -1 bar matric potential were significantly different from each other and from resultant water contents of the distilled water application treatments, which were not significantly different from each other.

There were no significant differences in water content among water quality treatments at -5 and -15 bars. Water content at -5 bars of pressure was 0.12 g H_20/g dry soil across all water quality treatments. Water content at -15 bars of pressure was 0.09 g H_20/g dry soil across all water quality treatments. This suggests in the drier range of moisture release curves water quality treatments have less of an effect on the physical properties of a soil.

Water Quality Treatment Effects. Within textural class 1, significant differences among water quality treatments were only found to occur at -1/10 bar of pressure (Table 7). This was expected as differences in coarser-textured soils are more likely to occur at higher matric potentials because of the dominance of large pore spaces. The water contents associated with 1X P.R. and 1X CBM treatments were not significantly different from each other, but were significantly greater than the water content resulting from 5X treatments with either P.R. water and CBM product water and the subsequent

Table 7.. Mean water content at -1/10, -1/3, -1, -5 and -15 bars for each textural class by water quality treatment.

Texture			-1/10 bar	-1/3 bar	-1 bar	-5 bar	-15 bar
Textural Class #1	WQ Trt	N	Median	Mean	Mean	Median	Median
	1X P.R.	27	0.29 a	0.11 a	0.06 a	0.04 a	0.04 a
	1X CBM	27	0.28 a	0.10 a	0.06 a	0.05 a	0.04 a
	5X P.R.	27	0.24 b	0.11 a	0.06 a	0.05 a	0.04 a
	5X P+d	27	0.25 b	0.11 a	0.06 a	0.04 a	0.04 a
	5X CBM	27	0.24 b	0.12 a	0.06 a	0.05 a	0.04 a
	5X C+d	27	0.25 b	0.12 a	0.06 a	0.05 a	0.04 a
Textural Class #2	WQ Trt	N	Median	Median	Median	Median	Median
	1X P.R.	39	0.36 a	0.22 a	0.15 a	0.10 a	0.08 a
	1X CBM	39	0.35 a	0.22 a	0.14 a	0.11 a	0.08 a
	5X P.R.	39	0.31 b	0.21 a	0.13 a	0.10 a	0.08 a
	5X P+d	39	0.32 b	0.20 a	0.13 a	0.10 a	0.08 a
	5X CBM	39	0.32 b	0.21 a	0.13 a	0.10 a	0.08 a
	5X C+d	39	0.32 b	0.22 a	0.14 a	0.10 a	0.08 a
Textural Class #3	WQ Trt	N	Median	Median	Median	Median	Median
	1X P.R.	51	0.39 a	0.26 a	0.19 a	0.14 a	0.11 a
	1X CBM	51	0.39 a	0.26 a	0.19 a	0.14 a	0.11 a
	5X P.R.	51	0.41 a	0.27 b	0.17 a	0.14 a	0.11 a
	5X P+d	51	0.38 a	0.26 b	0.19 a	0.14 a	0.11 a
	5X CBM	51	0.41 a	0.28 b	0.18 a	0.14 a	0.11 a
	5X C+d	51	0.38 a	0.27 b	0.20 a	0.15 a	0.11 a
Textural Class #4	WQ Trt	N	Median	Median	Median	Median	Median
	1X P.R.	39	0.43 a	0.30 a	0.22 a	0.17 a	0.13 a
	1X CBM	39	0.42 a	0.29 a	0.22 a	0.17 a	0.13 a
	5X P.R.	39	0.41 a	0.31 a	0.20 b	0.16 a	0.13 a
	5X P+d	39	0.40 a	0.29 a	0.21 a	0.16 a	0.13 a
	5X CBM	39	0.42 a	0.29 a	0.20 b	0.16 a	0.13 a
	5X C+d	39	0.41 a	0.29 a	0.21 a	0.16 a	0.13 a

+ Within treatment means, i.e., textural category or matric potential, followed by the same letter in the same column are not significantly different.

treatments with distilled water. Addition of saline sodic water, whose effects are best demonstrated at the 5X and 5X + d treatment levels, resulted in reductions to water

retention when the soil was near saturation. These significant reductions detected at -1/10 bar matric potential are a consequence of a loss of porosity.

As was the case in textural class 1, significant differences within textural class 2 due to water quality treatment were only found to occur at -1/10 bar of pressure (Table 7). Again the water contents at -1/10 bar resulting from the 1X cycles with P.R. and CBM were not significantly different from each other, but were significantly greater than the -1/10 bar water contents resulting from all other water quality treatments. As was the case in textural group 1, the significant reductions that occurred within this textural class are attributed to the loss of large pores and the loss of the interstitial spaces between these pores. As previously reported (Bresler et al., 1982; Curtin et al., 1994; So and Aylmore, 1993), possible mechanisms include: 1) pore loss through swelling, 2) pore loss through structural collapse, and 3) pore loss through plugging subsequent to slaking.

A different trend appeared in textural class 3. Within this texture, significant differences due to water quality treatment were only found at -1/3 bar. As was the case in the previous two textural groups, the water contents resultant from the 1X treatments with P.R. or CBM water were not significantly different from each other, but were significantly greater than the water contents associated with all subsequent water quality treatments.

In finer-textured soils, differences in water retention are more likely to occur at lower potentials (greater applied pressure). Within textural class 4, significant differences among water quality treatments occurred at -1 bar of pressure. The water content associated with the 5X treatments with either P.R. or CBM water were not

significantly different from each other, but were significantly lower than the rest of the water contents resulting from the other water quality treatments. Typically, soils within this textual group will have few large pore spaces that can be lost due to saline-sodic water when the soil is saturated. Therefore, in this textural category there is a loss of finer spaces, which likely would only have significance at greater applied pressure, i.e., lesser matric potential and when the soil is drier.

Results indicate that saline-sodic water of the qualities applied at these levels did not have a preponderance of significant impacts on soil physical structure, i.e., water retention. While statistically significant differences were detected among water quality treatments, the differences do not appear to be large enough to have a significant impact on the long-term soil physical properties of the soils studied.

Changes from Baseline. For purposes of comparison the baseline condition was the 1X P.R. treatment. This treatment represented an irrigation scenario that would likely occur under present management conditions. Differences in water content from the baseline due to water quality treatment within a single textural category are illustrated in Figures 33-37. Treatments applied to the textural groups 1 and 2 at -1/10 bar behaved similarly with respect to the differences observed in water retention from baseline (Figure 33). For the most part, treatments within these textural groups resulted in very small reductions in retained water. At -1/10 bar (Figure 23) the reductions observed were likely due to the loss of large pore spaces and the lack of formation of small pore spaces resulting from repeated wetting and drying cycles. Results within textural class 3 show an entirely different trend (Figure 33). While there were reductions in water retention

from baseline to the same extent as found in the previous textural classes, a large portion of the treated soils were found to have greater water contents than the baseline (up to 0.15g H_20/g dry soil). The largest increase from baseline across all textural categories and all matric potentials was measured at -1/10 bar matric potential. The increases are likely due to texture and matric potential, as the greater clay content would provide more small pores to hold water when large pores are lost and a soil close to saturation would not yet exhibit any of the effects related to elevated sodium levels. Within the textural group 4, there was some increase in water retention from the baseline although the majority of soils exhibited small reductions.

Differences in water retention from the baseline at -1/3 bar were similar across all textures (Figure 34). The large majority of data show that water content ranged from 0.05g H_20/g dry soil greater than the baseline to 0.05g H_20/g dry soil less than the baseline.

At -1 bar, there were minimal changes in water retention from the baseline (Figure 35). The largest differences were found in the finer-textured soils; the observed reductions were minimal (-0.05 g). Differences at -5 and -15 bars of applied pressure from the baseline were minimal as well (Figures 36-37). With the exception of a couple of outliers, water retention remained between 0.05g H_20/g dry soil and -0.05g H_20/g dry soil greater and smaller than baseline levels. These data reiterate some of the observations made previously. That is, the largest differences and variability in the water retention of the soils studied are found at matric potentials closer to saturation. This occurs because at the wet end of the spectrum, a majority of retained water is held in the

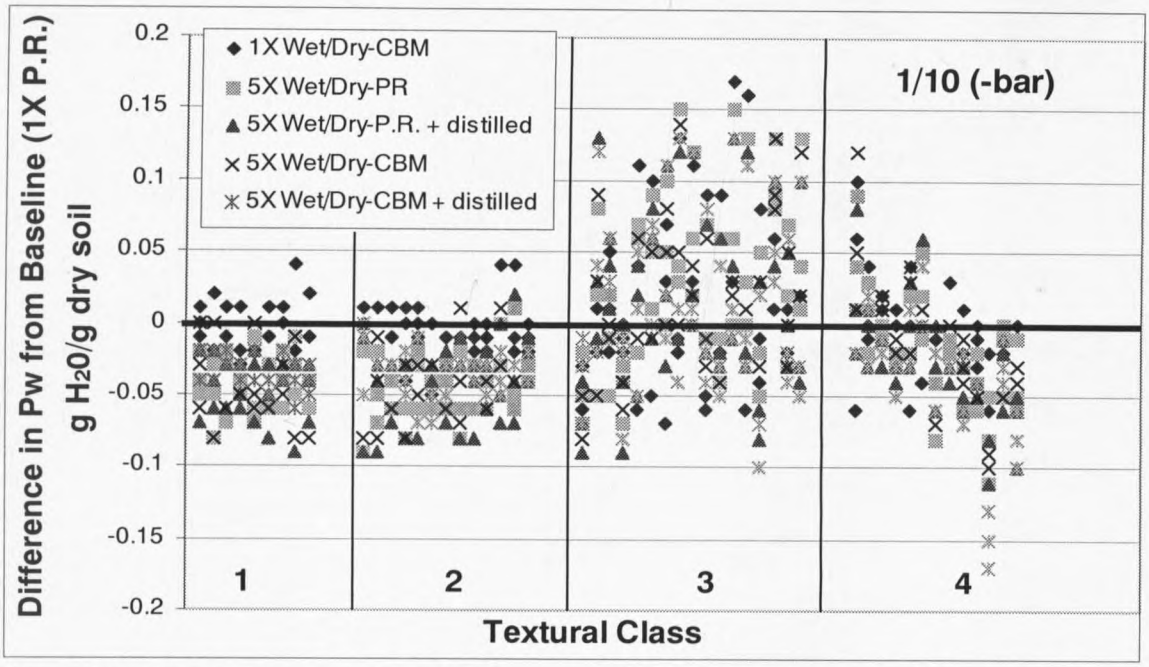


Figure 33. Differences in water retention from the baseline (Pw) at -1/10 bar applied pressure after undergoing water quality treatments for each textural class.

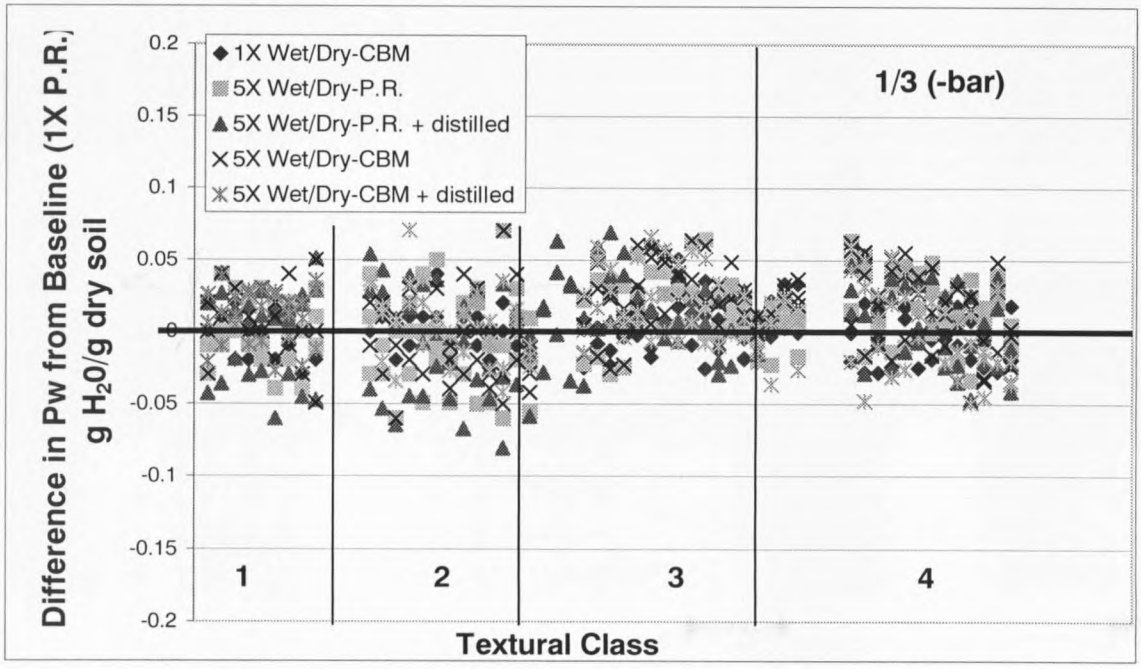


Figure 34. Differences in water retention from the baseline (Pw) at -1/3 bar applied pressure after undergoing water quality treatments for each textural class.

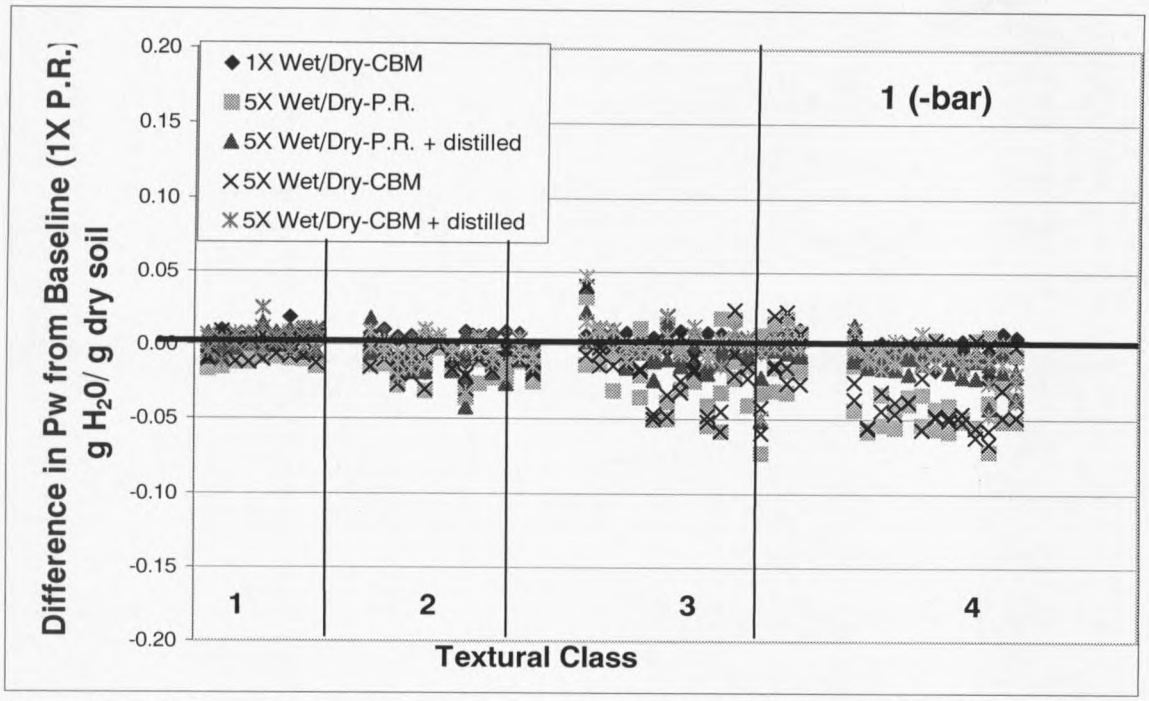


Figure 35. Differences in water retention from the baseline (Pw) at -1 bar applied pressure after undergoing water quality treatments for each textural class.

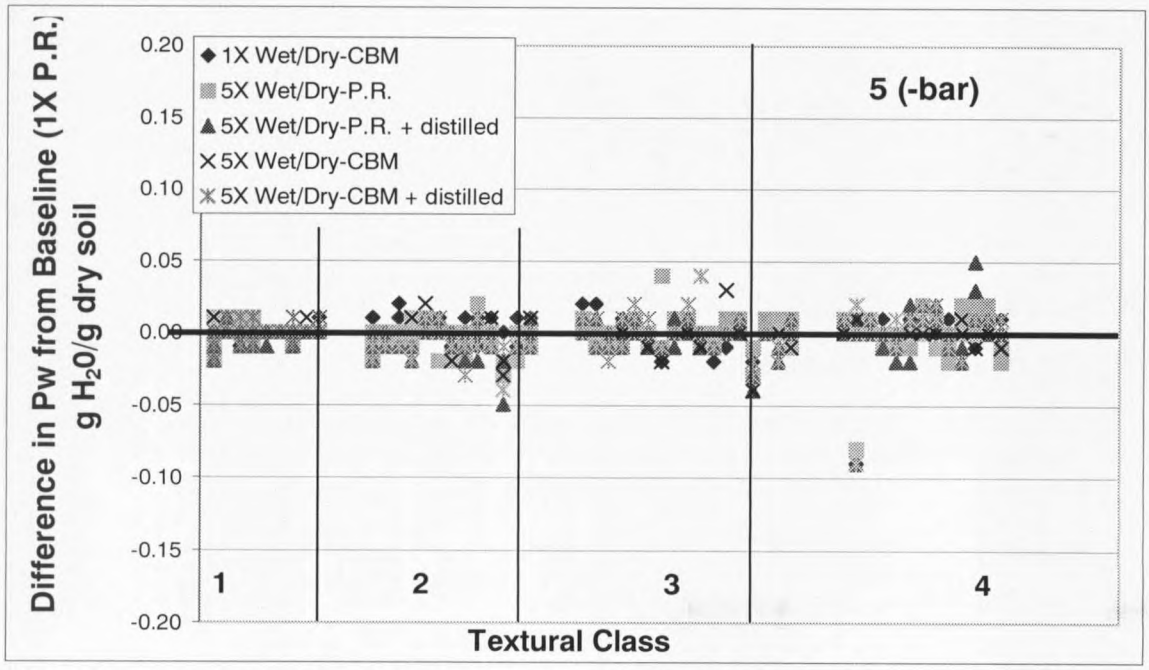


Figure 36. Differences in water retention from the baseline (Pw) at -5 bar applied pressure after undergoing water quality treatments for each textural class.

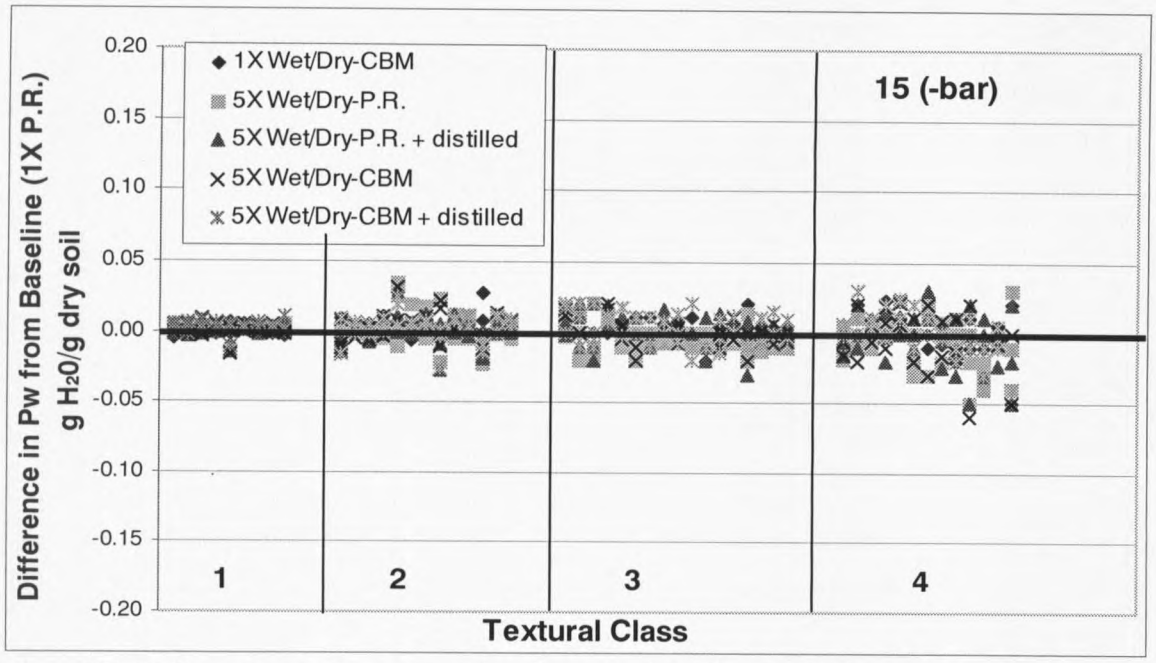


Figure 37. Differences in water retention from the baseline (Pw) at -15 bar applied pressure after undergoing water quality treatments for each textural class.

large diameter pores. The loss of these large diameter pores would likely result in a loss of total pore space at the wet end, but not at the drier end.

Water Characteristic Determinations. The analysis of variance provides a means for identifying the sources of variation in the water content measurements that can be attributed to water quality x wetting regime (Table 7). However, it does not provide a means for comparing the complete moisture release curves for each textural class by wetting regime combination (Figures 38-41). For purposes of comparison, moisture release curves were derived using linear regression of transformed data. A log-log transformation was applied to the data. All transformations were made on absolute data values. The slope of the linear regression of log transformed matric potential versus log transformed water content (Table 8) is the rate at which log water content decreases as

log matric potential decreases. This rate represents the change in water retention as the soil goes to a lesser potential. For all water quality treatments, as the clay content increased the slope decreased, indicating that clayey soils retain more water at lesser potentials. The regression slope coefficients (Table 8) and the moisture release curves indicate that the changes in water content at the matric potentials studied were the same regardless of water quality treatment applied.

Table 8. Regression of matric potential on water content by treatment for each textural class.

W.Q. Treatment	Textural Class	Equation	r^2	Regression Slope
1X P.R.	Fine Sandy Loam	log10(Water Content) = -1.090 - (0.373 * log10(Matric Potential)	0.782	0.373
1X P.R.	Silt Loam	log10(Water Content) = -0.814 - (0.302 * log10(Matric Potential)	0.765	0.302
1X P.R.	Silty Clay Loam	log10(Water Content) = -0.684 - (0.234 * log10(Matric Potential)	0.817	0.234
1X P.R.	Silty Clay	log10(Water Content) = -0.601 - (0.227 * log10(Matric Potential)	0.794	0.227
1X CBM	Fine Sandy Loam	log10(Water Content) = -1.099 - (0.356 * log10(Matric Potential)	0.750	0.356
1X CBM	Silt Loam	log10(Water Content) = -0.812 - (0.291 * log10(Matric Potential)	0.741	0.291
1X CBM	Silty Clay Loam	log10(Water Content) = -0.675 - (0.244 * log10(Matric Potential)	0.855	0.244
1X CBM	Silty Clay	log10(Water Content) = -0.607 - (0.227 * log10(Matric Potential)	0.812	0.227
5X P.R.	Fine Sandy Loam	log10(Water Content) = -1.108 - (0.346 * log10(Matric Potential)	0.788	0.346
5X P.R.	Silt Loam	log10(Water Content) = -0.844 - (0.284 * log10(Matric Potential)	0.740	0.284
5X P.R.	Silty Clay Loam	log10(Water Content) = -0.682 - (0.256 * log10(Matric Potential)	0.793	0.256
5X P.R.	Silty Clay	log10(Water Content) = -0.615 - (0.232 * log10(Matric Potential)	0.809	0.232

Table 8. continued.

W.Q. Treatment	Textural Class	Equation	r^2	Regression Slope
5X CBM	Fine Sandy Loam	log10(Water Content) = -1.097 - (0.347 * log10(Matric Potential)	0.791	0.347
5X CBM	Silt Loam	log10(Water Content) = -0.832 - (0.280 * log10(Matric Potential)	0.751	0.280
5X CBM	Silty Clay Loam	log10(Water Content) = -0.673 - (0.250 * log10(Matric Potential)	0.872	0.250
5X CBM	Silty Clay	log10(Water Content) = -0.615 - (0.228 * log10(Matric Potential)	0.803	0.228
5P + d	Fine Sandy Loam	log10(Water Content) = -1.166 - (0.263 * log10(Matric Potential)	0.660	0.263
5P + d	Silt Loam	log10(Water Content) = -0.865 - (0.251 * log10(Matric Potential)	0.622	0.251
5P + d	Silty Clay Loam	log10(Water Content) = -0.686 - (0.224 * log10(Matric Potential)	0.770	0.224
5P + d	Silty Clay	log10(Water Content) = -0.623 - (0.201 * log10(Matric Potential)	0.696	0.201
5C + d	Fine Sandy Loam	log10(Water Content) = -1.080 - (0.344 * log10(Matric Potential)	0.797	0.344
5C + d	Silt Loam	log10(Water Content) = -0.828 - (0.285 * log10(Matric Potential)	0.761	0.285
5C+d	Silty Clay Loam	log10(Water Content) = -0.671 - (0.242 * log10(Matric Potential)	0.859	0.242
5C+d	Silty Clay	log10(Water Content) = -0.608 - (0.215 * log10(Matric Potential)	0.822	0.215

+ Median values followed by the same letter in the same column are not significantly different. Ln (x) = -log of matric potential; y = predicted gravimetric water content g H_20/g dry soil.

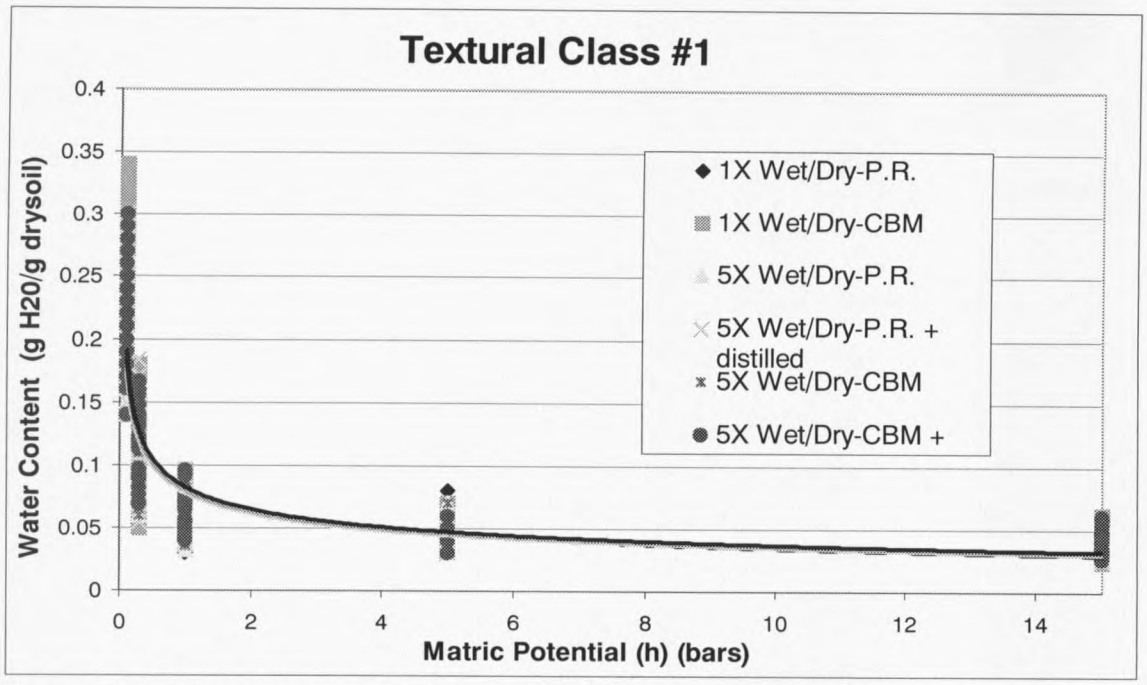


Figure 38. Water content as a function of matric potential within textural class 1. Fitted lines between data points represent logarithmic trend lines.

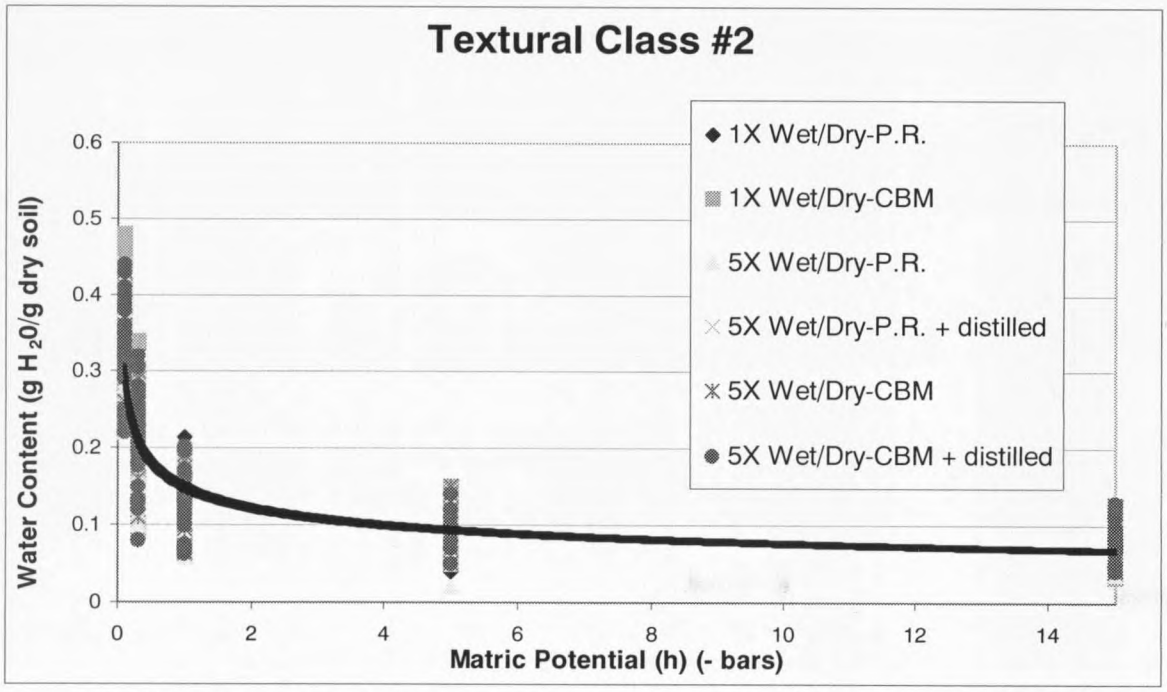


Figure 39. Water content as a function of matric potential within textural class 2. Fitted lines between data points represent logarithmic trend lines.

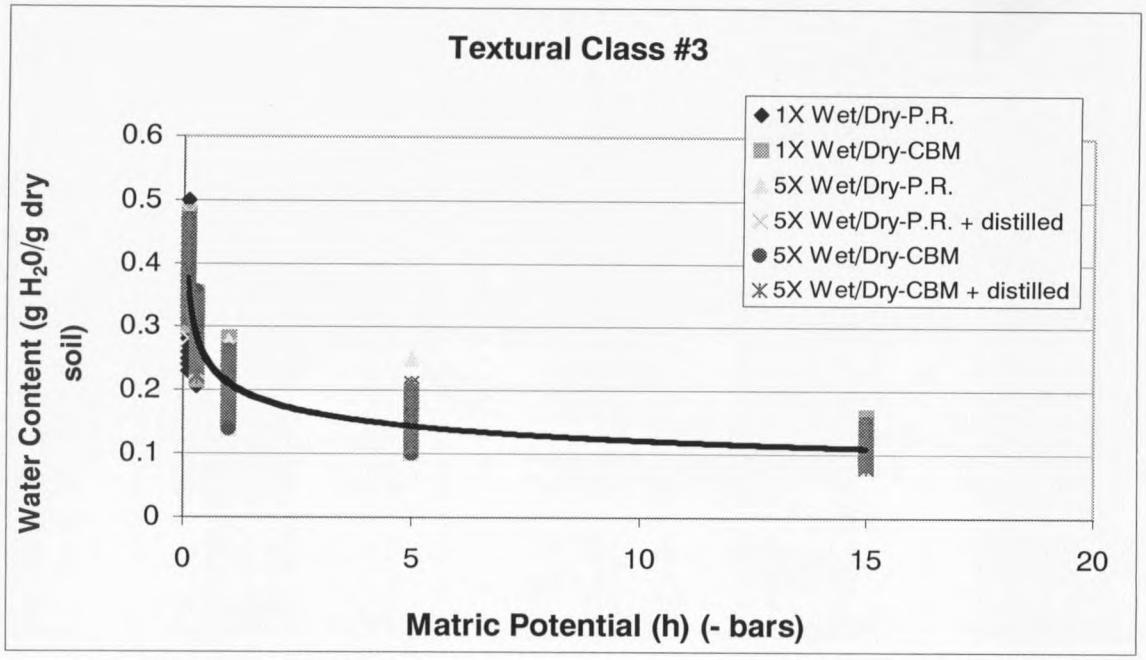


Figure 40. Water content as a function of matric potential within textural class 3. Fitted lines between data points represent logarithmic trend lines.

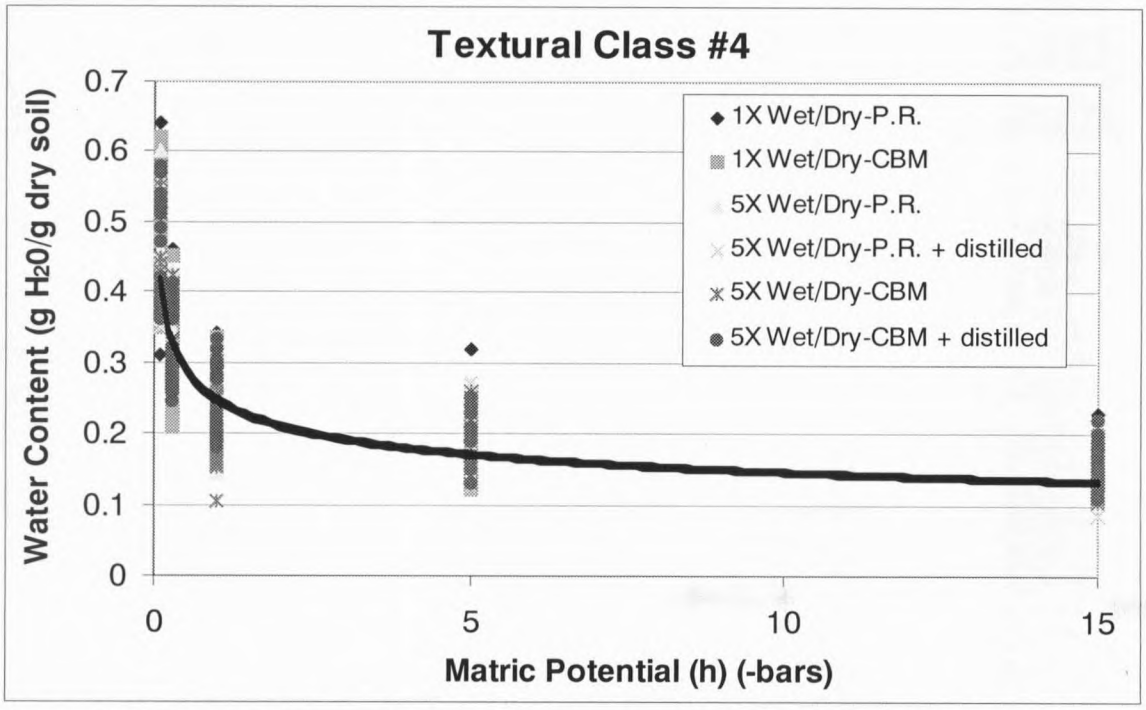


Figure 41. Water content as a function of matric potential within the textural class 4. Fitted lines between data points represent logarithmic trend lines.

Summary and Conclusions

The following observations were made during this study:

1. Water content associated with matric potential differed significantly due to predominant soil texture at all matric potentials investigated in this study.
2. Significant differences in water holding capacity of coarser-textured soils occur due to water quality treatment more often at greater matric potentials (wetter conditions). In finer-textured soils, differences in water holding capacity due to water quality treatment are more likely to occur at lower potentials (drier conditions).
3. Significant changes in water holding capacity due to water quality treatment are only on the order of 0.02-0.04 g H_2O/g dry soil. The change reflected a decrease in water holding capacity of textural classes 1 and 2 and an increase in water holding capacity of textural class 3.
4. Reductions in water retention in coarser-textured soils are attributable to the loss of large pore spaces.
5. The addition of saline-sodic water had the greatest effect on soil physical properties when the soil is near saturation. Changes in water holding capacity are likely to have non-discernible impact on irrigation suitability.
6. Successive wetting/drying cycles can cause aggregate coalescence and the loss of interaggregate porosity; this appeared to occur more often in the coarser-textured soils.

7. CBM product water applied at these levels did not have a consistent significant impact on soil physical properties, i.e., water-holding capacity.

CHAPTER 4

SUMMARY AND CONCLUSIONS

The specific objective of this study was to understand what possible effects modestly saline and sodic water, intended to simulate CBM product water, might have on irrigable acreages within the Powder River Basin of Montana and Wyoming. The study consisted of a two-part laboratory project. The first part assessed soil chemical responses to wetting with saline-sodic water, and the second assessed soil physical responses to wetting with saline-sodic water.

Repeated irrigation with modestly saline-sodic water or water with a chemical signature comparable to the CBM product water used in this study resulted in a general increase in the soil salinity and sodicity. Single wetting events with either Powder River water or CBM signature product water resulted in the elevation of both ESP and SAR. However, the resultant levels do not appear to pose a risk of dispersion or salt stress to commonly grown crops for the most part. Repeated wetting and drying with CBM signature water, such in the case of sprinkler irrigation or routine flooding, resulted in significant elevation of EC, SAR, and ESP with resultant values closer to, or in some cases greater than, previously published thresholds of SAR = 12, ESP = 15%. These results validate that the previously reported ESP-SAR relationship holds, even in the event of native soils and/or those soil materials irrigated with CBM signature water. Consistent with previously findings, soil solution salinity will equilibrate at an EC value

approximately 2-3 times that of the applied water. In contrast, soil solution SAR will equilibrate at a level comparable to the SAR of the applied water as long as leaching occurs. Repeated irrigation with CBM product water resulted in elevated soil salinity levels substantially higher than published thresholds for some irrigated crops. Subsequent leaching with simulated rainfall significantly reduced soil solution salinity, but had little or no effect on sodicity. This implies that the flocculating effect of salinity may be reduced, thereby exacerbating the dispersive effects of sodium, as a consequence of uncontrollable rainfall or dispersals of relatively salt-free spring runoff to soils previously irrigated with saline-sodic water. Yet, with the water quality values used in this study (Table 2), in few instances were resultant soil solution salinity x sodicity combinations found to be exceeding the threshold categories where reductions in infiltration occur according to thresholds published by Ayers and Westcot (1976), Hanson et al. (1999), and Miller and Donahue (1995).

The greatest increases in soil solution EC and SAR after treatment with either CBM or P.R. waters were found in the coarser-textured soils. Rainfall, i.e. single distilled water application, was found to have a greater impact on reducing EC and SAR when salt concentrations were high, and in coarser-textured soils. Across all water quality application treatments, textural group 4 had a significantly greater mean EC and SAR of 3.78 dS/m and 7.91, respectively. Higher exchange capacities of finer textured soils and greater percentages of non-readily draining interstitial spaces result in the ability of finer soils to absorb and retain higher concentrations of salts upon leaching. Across all

textural classes, greatest mean EC and SAR (6.93 dS/m and 11.31, respectively) occurred after soils received the 5X CBM water quality treatment.

Soil water retention was used as an indicator to determine the impacts of CBM signature water on the physical properties of a soil. As expected, the water content differed significantly among the textures of the soils investigated at all matric potentials. Differences in water retention due to water quality treatment of coarser-textured soils occurred more often at greater matric potentials, while significant difference in water retention in finer-textured soils were more likely to occur at lower potentials. Significant changes in water retention due to water quality treatment were only on the order of 0.02-0.04g H_20/g dry soil. The change reflected a decrease in water retention of textural classes 1 and 2 and an increase in water holding capacity of the textural class 3. These changes, although statistically significant, were not considered large enough to have a significant ecological impact. This was apparent in the moisture release curves that were constructed for each texture. The curves indicated that changes in water retention at the matric potentials studied were the same regardless of water quality treatment applied. It was concluded that modestly saline-sodic water applied at these levels did not have a consistently significant impact on soil water retention. Thus, the standards used in this project defining CBM product water (EC = 3.12; SAR = 13.09) can be considered to be protective of soil physical properties.

BIBLIOGRAPHY

BIBLIOGRAPHY

Agassi, M., J. Morin, and I. Shainberg. 1985. Effect of raindrop impact energy and water salinity on infiltration rates of sodic soils. Soil Sci. Soc. Am. J. 49:186-191.

Agassi, M., I. Shainberg and J. Morin. 1981. Effect of electrolyte concentration and soil sodicity on infiltration rate and crust formation. Soil Sci. Soc. Am J. 48:848-51.

Ayers, R.S. and D.W. Westcot. 1976. Water quality for agriculture. FAO Irrigation and Drainage Paper No. 29 (Rev 1). Food and Agriculture Organization of the United Nations.

Balks, M.R., W.J. Bond, and C.J. Smith. 1998. Effects of sodium accumulation on soil physical properties under an effluent-irrigated plantation. Aust. J. Soil Res. 36:821-830.

Bauder, J.W. and T.A. Brock. 1992. Crop species, amendment, and water quality effects on selected soil physical properties. Soil Sci. Soc. Am. J. 56:1292-1298.

Bauder, J.W. and T.A. Brock. 2001. Irrigation water quality, soil amendment, and crop effects on sodium leaching. Arid Land Res. and Mgt. 15:101-113.

Brady, N. C., and R. R. Weil. 1999. The Nature and Properties of Soils, 12th edition. Prentice Hall, Upper Saddle River, N.J. 881 p.

Bresler, E., B.L. McNeal, and D.L. Carter. 1982. Saline and Sodic Soils. Principles-Dynamics-Modeling. Springer-Verlag, Berlin, Heidelberg. 236 p.

Buckland, G.D., D.R. Bennett, D.E. Mikalson, E. de Jong, and C. Chang. 2002. Soil salinization and sodication from alternate irrigations with saline-sodic water and simulated rain. Can. J. Soil Sci. 82:297-309.

Buckman, H.O. and N.C. Brady. 1967. The Nature and Properties of Soils. The MacMillan Company, New York, NY.

Brock, T.A. 1991. Effect of irrigation water quality, amendment and crop on salt leaching and sodium displacement. M.S. Thesis. Montana State University, Bozeman, MT.

Chen, Y. and A. Banin. 1975. Scanning electron microscope (SEM) observations of soil structure changes induced by sodium calcium exchange in relation to hydraulic conductivity. Soil Sci. Soc. Am. J. 120:428-436.

Chen, J., J. Trachitzky, J. Brouwer, J. Morin and A. Banin. 1980. Scanning electron microscope observations on soil crusts and their formation. Soil Sci. 130:49-55.

Chhabra, R. 1996. Soil Salinity and Water Quality. A.A. Balkema Publishers, Broookfield, VT. 284 p.

Coughlan, K.J., D. McGarry, J.R. Loch, B. Brideg, and G.D. Slith. 1991. The measurement of soil structure: some practical initiatives. Aust. J. Soil Res. 29:869-889.

Crescimanno, G., M. Iovino, and G. Provenzano. 1995. Influence of salinity and sodicity on soil structural and hydraulic characteristics. Soil Sci. Soc. Am. J. 59:1701-1708.

Curtin, D., H. Steppuhn, and F. Selles. 1994. Structural stability of Chernozemic soils as affected by exchangeable sodium and electrolyte concentration. Can. J. Soil Sci. 74: 157-164.

Frenkel, H., J.O. Goertzen, and J.D. Rhoades. 1978. Effect of clay type and content, exchangeable sodium percentage, and electrolyte concentration on clay dispersion and soil hydraulic conductivity. Soil Sci. Soc. Am. J. 142:32-39.

Frenkel, H. 1984. Reassessment of water quality criteria for irrigation. In. Shainberg, I. and Shalhevet, J. eds. Soil Salinity Under Irrigation: processes and management. Berlin: Springer-Verlag. 143-172.

Gal, M., L. Arcan, I. Shainberg and R. Keren. 1984. The effect of exchangeable Na and phosphogypsum on the structure of soil crust-SEM observations. Soil Sci. Soc. Am. J. 48:872-878.

Gee, G.W. and J.W. Bauder. 1986. Particle-size analysis. Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods-Agronomy Monograph no. 9 (2nd Edition).

Ghassemi, F., A.J. Jakeman and H.A. Nix. 1995. Salinisation of Land and Water Resources: Human causes, extent, management and case studies. Univ. of New South Wales Press LTD, Sidney, Austrailia. 526 p.

Ghezzehei, T.A. and D. Or. 2000. Dynamics of soil aggregate coalescence governed by capillary and rheological processes. Water Resour. Res. 36:367-379.

Halliwell, D.J., K.Barlow, and D. Nash. 2001. A review of the effects of wastewater

sodium on soil physical properties and their implications for irrigation systems. Aust. J. Soil Res. 39:1259-1267.

Hanson, B., S.R.Grattan and A. Fulton. 1999. Agricultural salinity and drainage. Div. Agric. and Natural Resources Publ. 3375, University of California Irrigation Prog. Univ. of California, Davis. (Available from Univ. California, Comm. Services-Publications. 67-1 san Pablo Avenue, 2nd Floor, Oakland, CA 94608-1239; 510-642-2431.)

Hopmans, J.W., J. MacIntyre, and R.J. Southard. 1990. Water quality and subsurface soil variabilities affect infiltration. California Agriculture. 44:10-12.

Jandel Corporation. 1995. SigmaStat for Windows. Version 2.0.

Keren, R. and I. Shainberg. 1981. Effect of dissolution rate on the efficiency of industrial and mined gypsum in improving infiltration of a sodic soil. Soil Sci. Soc. Am. J. 45:103-107.

Lima, L.A., M.E. Grismer, and D.R. Nielsen. 1990. Salinity effects on yolo loam properties. Soil Science. 150:451-458.

Levy, G.J., A. Rosenthal, J. Rorchitzky, I. Shainberg, and Y. Cehn. 1999. Soil hydraulic conductivity changes caused by irrigation with reclaimed water waters. Journal of Environ. Qual. 28:1658-1664.

Levy, G.J., J. Levin, and I. Shainberg. 1994. Seal formation and interill soil erosion. Soil Sci. Soc. Am. J. 58:203-209.

Mace, J.E. and C. Amrhein. 2001. Leaching and reclamation of a soil irrigation with moderate SAR waters. Soil Sci. Am. J. 65:199-204.

McIntyre, D.S. 1958. Permeability measurements of soil crusts formed by raindrop impact. Soil Sci. 85:185-189.

McIntyre, D.S. 1979. Exchangeable sodium, subplasticity and hydraulic conductivity on some australian soils. Aust. J. Soil Res. 17:115-120.

McNeal, B.L., D.A. Layfield, W.A. Norvell, and J.S. Rhoades. 1968. Factors influencing hydraulic conductivity of soils in the presence of mixed salt solutions. Soil Sci. Soc. Am. Proc. 32:187-190.

Miller, R.W. and R.L. Donahue. 1995. Soils in Our Environment, Seventh Edition, Prentice Hall, Upper Saddle River, NJ.

Miller, R.W. and D.T. Gardiner. 2001. Soils in Our Environment, Ninth Edition. Prentice Hall, Upper Saddle River, NJ.

Mitchell, A.R. and M. Th. van Genuchten. 1992. Shrinkage of bare cultivated soil. Soil Sci. Soc. Am. J. 56:1036-1042.

Nelson, C.R., 1999. Changing perceptions regarding the size and production potential of coalbed methane resources, in Gas TIPS: Gas Research Institute, v. 5, no. 2, p 4-11.

Northcote, K.H., and J.K.M. Skene. 1972. Australian soils with saline and sodic properties. CSIRO Aust. Soil Publ. 27.

Or, D., J. M. Wraith, and M. Tuller. 2002. Agricultural and Environmental Soil Physics. Bozeman, MT.

Oster, J.D., I. Shainberg, and J.D. Wood. 1980. Flocculation value and gel structure of Na/Ca montmorillonite and illite suspensions. Soil Sci. Soc. Am. J. 44:955-959.

Oster, J. D. 1994. Irrigation with poor quality water. Agric. Water Manage. 25:271-297.

Oster, J.D. and I. Shainberg. 2001. Soil responses to sodicity and salinity: challenges and opportunities. Aust. J. Soil Res. 39:1219-1224.

Quirk, J.P. and R.K. Schofield. 1955. The effect of electrolyte concentration on soil permeability. J. of Soil Sci. 6:163-178.

Quirk, J.P., 2001. The significance of the threshold and turbidity concentrations in relation to sodicity and microstructure. Aust. J. Soil Res. 39:1185-1217.

Rawls, W.J., D.L Brakenseik, and K.E. Saxton. 1982. Estimation of soil water properties. Trans. ASAE 25:1316-1320.

Rengasamy, P. and K.A. Olsson. 1993. Irrigation and sodicity. Aust. J. Soil Res. 31:821-37.

Rhoades, J.D. 1972. Quality of water for irrigation. Soil Science. 113:277-284.

Rhoades. J.D. 1977. Potential for using saline agricultural drainage waters for irrigation. Proc. from Water Management for Irrigation and Drainage. Am. Soc. of Civ. Eng. Reno, Nevada. July 20-22, 1977.

Rice, D.D., 2001. Coalbed methane-an untapped energy resource and an environmental

concern: U.S. Geological Survey Fact Sheet FS-019-97. (Available only on the web at http://energy.usgs.gov/factsheets/Coalbed/coalmeth.html).

Richards, L.A. 1954. Diagnosis and improvement of saline and alkali soils. US Agriculture Handbook. No. 60. 159p.

Shainberg, I. and J. Letey. 1984. Response of soils to sodic and saline conditions. Hilgardia. 52:1-57.

Shainberg, I., J.D. Rhoades, and R.J. Prather. 1981. Effect of low electrolyte concentration on clay dispersion and hydraulic conductivity of a sodic soil. Soil Sci. Soc. Am. J. 45:273-277.

Shainberg, I. and J.M. Singer. 1985. Effect of electrolyte concentration on the hydraulic properties of depositional crust. Soil Sci. Soc. Am. J. 49:1260-1263.

Shainberg, I., G.J.Levy, D. Goldstein, A.I. Mamedov, and J. Letey. 2001. Prewetting rate and sodicity effects on the hydraulic conductivity of soils. Aust. J. Soil Res. 39:1279-1291.

So, H.B. and L.A.G. Aylmore. 1993. How do sodic soils behave? The effects of sodicity on soil physical behaviour. Aust. J. Soil Res. 31:761-777.

Sumner, M.E. 1993. Sodic soils: new perspectives. Aust. J. Soil Res. 31:683-750.

Taylor, S.A and G.L. Ashcroft. 1972. Physical Edaphology: The Physics of Irrigated and Nonirrigated Soils. W.H. Freeman and Company, San Francisco, CA.

Thompson, K.S. 1991. Irrigation water quality effects on soil salinity and crop production in the Powder River Basin, MT. M.S. Thesis. Montana State University, Bozeman, MT.

USDA. 1971. Soil survey of the Powder River area, Montana. SCS. Washington, D.C.

USDA, Natural Resources Conservation Service. 2002. Soil Conservationists. Salinity Management Guide – Salt Management. Available at: http://www.launionsweb.org/salintiy.htm. 2002.

USEPA. 1991. MINTEQ2A/PRODEFA2. A geochemical model for environmental systems. Version 3.0. Environmental Research Laboratory, Office of Research and Development, Athens, GA.

US Salinity Laboratory Staff. 1954. 'Diagnosis and improvement of saline alkali soils.' USDA Agricultural Handbook No. 60. (US Government Printing Office: Washington)

VanOlphen, H. 1977. An Introduction to Clay Colliod Chemistry. 2nd ed. Interscience Pub. New York, NY.

Western Fertilizer Handbook. 1995. Produced by the Soil Improvement Committee of the California Fertilizer Association. Interstate Publishers, Inc., Sacramento, California, 1995.

APPENDICES

APPENDIX A

QUALITY CHECKS

Table 9. Sub-samples of bulk water supply to monitor water chemistries.

ID	Mg (ppm)	Ca (ppm)	Na (ppm)	EC (mmhos/cm)	pH	Calculated SAR	Date
CBM	28	59	459	3.01	8.44	12.15	3/20/02
P.R.	24	66	173	1.47	8.40	4.57	
CBM	29	31	471	3.07	8.30	14.39	3/28/02
P.R.	27	41	177	1.46	8.28	5.19	
CBM	29	53	469	2.84	8.16	4.75	4/03/02
P.R.	23	53	469	2.84	8.16	12.68	
CBM	29	27	463	3.07	8.46	14.53	4/10/02
P.R.	22	32	171	1.35	8.35	5.61	
CBM	28	60	452	3.12	8.2	11.91	4/18/02
P.R.	23	64	172	1.54	8.12	4.63	
CBM	29	32	475	2.97	8.44	14.43	4/24/02
P.R.	23	33	179	1.39	8.26	5.77	
CBM	28	48	461	2.98	8.23	12.89	5/01/02
P.R.	21	55	162	1.36	8.21	4.64	
CBM	27	80	455	2.88	7.87	11.05	5/23/02
P.R.	23	103	182	1.67	7.76	4.16	
CBM	28	89	452	3.37	8.11	10.56	6/05/02
P.R.	23	101	170	1.80	7.94	3.92	
CBM	29	50	472	3.16	8.10	12.96	6/12/02
P.R.	24	58	180	1.61	8.57	4.95	
CBM	31	100	484	3.36	7.95	10.69	6/19/02
P.R.	25	87	175	1.66	8.06	4.20	
CBM	30	42	482	3.52	8.50	13.68	6/27/02
P.R.	25	54	183	1.74	8.09	5.09	
CBM	30	62	488	3.35	8.16	12.55	7/03/02
P.R.	23	51	171	1.48	8.14	4.92	
CBM	30	48	502	3.28	8.21	13.08	7/10/02
P.R.	22	32	170	1.41	7.98	5.58	
CBM	28	62	449	3.37	8.10	11.72	7/31/02
P.R.	23	70	175	1.72	7.99	4.57	
CBM	29	73	452	3.44	8.45	11.16	8/08/02
P.R.	23	60	170	1.54	7.99	4.66	
CBM	30	52	481	3.12	8.60	12.96	8/14/02
P.R.	25	56	176	1.34	8.36	4.85	
CBM	29	62	454	3.08	8.06	11.76	8/28/02
P.R.	24	60	180	1,63	8.12	4.89	
CBM	30	25	490	3.05	8.44	15.41	9/04/02
P.R.	24	40	187	1.42	8.31	5.69	
CBM	29	31	486	3.03	8.29	14.86	9/11/02
P.R.	24	58	177	1.49	8.06	4.86	

Table 9 cont.

ID	Mg (ppm)	Ca (ppm)	Na (ppm)	EC (mmhos/cm)	pH	Calculated SAR	Date
CBM	28	38	471	2.97	8.12	13.94	9/19/02
P.R.	24	24	185	1.39	8.16	6.29	
CBM	22	72	454	2.83	7.77	11.8	10/04/02
P.R.	24	96	177	1.43	7.85	4.13	
CBM	29	61	470	3.04	7.92	12.23	10/11/02
P.R.	23	99	172	1.48	7.95	3.99	
CBM	29	58	466	2.78	8.09	12.30	10/16/02
P.R.	24	63	185	1.36	8.24	4.96	
CBM	28	53	454	2.91	7.85	12.37	10/23/02
P.R.	24	63	181	1.50	7.87	4.85	
CBM	29	45	488	3.01	8.05	13.75	11/07/02
P.R.	25	50	187	1.44	7.98	5.31	
CBM	28	49	466	2.83	8.15	12.96	11/14/02
P.R.	23	44	176	1.30	8.17	5.27	
CBM	27	33	446	2.94	8.44	13.74	11/22/02
P.R.	23	39	169	1.41	8.10	5.23	
CBM	27	23	460	2.81	8.11	15.19	12/09/02
P.R.	23	37	181	1.33	8.12	5.68	

Table 10. Check sample chemistry analysis. Two reps of check soil were sent to Harris Laboratories with each batch of soil. Four batches of samples were analyzed.

Sample	pH	EC	Na	Ca	Mg	K	HCO3	Date
		mmhos/cm	Meq/L	Meq/L	Meq/L	Meq/L	Meq/L	
BATCH 1-1	7.7	0.44	0.8	2.5	1.0	0.1	2.1	11/8/01
BATCH 1-2	7.7	0.37	0.6	2.2	0.9	0.1	3	11/8/01
BATCH 2-1	7.9	0.4	0.7	2.5	1	0.2	2.8	3/19/02
BATCH 2-2	7.9	0.38	0.8	2.7	1	0.2	2.8	3/19/02
BATCH 3.1	7.7	0.36	0.6	2.6	1	0.2	3.5	5/20/02
BATCH 3-2	7.7	0.36	0.6	2.6	1	0.1	3.5	5/20/02
BATCH 4-1	7.8	0.47	1.1	3.1	1.1	0.1	2.5	6/21/02
BATCH 4-2	7.7	0.43	0.8	3	1	0.1	3.1	6/21/02

Table 11. Water content of check soil for P.R. and CBM water qualities for each pressure plate run.

POWDER RIVER					
MATRIC POTENTIAL	TREATMENT	SAMPLE ID	REP 1	REP 2	REP 3
-1/10 BAR	1X	56	0.46	0.47	0.47
		57	0.47	0.46	0.48
		58	0.45	0.46	0.44
		59	0.44	0.43	0.44
	5X	56	0.41	0.41	0.41
		57	0.41	0.42	0.41
		58	0.42	0.43	0.41
		59	0.41	0.43	0.41
	5X+d	56	0.40	0.42	0.40
		57	0.40	0.41	0.38
		58	0.41	0.40	0.40
		59	0.39	0.40	0.39
-1/3 BAR	1X	56	0.25	0.33	0.28
		57	0.29	0.34	0.29
		58	0.31	0.28	0.30
		59	0.33	0.29	0.30
	5X	56	0.28	0.24	0.26
		57	0.29	0.26	0.29
		58	0.31	0.28	0.28
		59	0.32	0.30	0.28
	5X + d	56	0.27	0.24	0.31
		57	0.27	0.26	0.30
		58	0.28	0.28	0.28
		59	0.29	0.29	0.29
-1 BAR	1X	56	0.18	0.18	0.18
		57	0.19	0.18	0.17
		58	0.20	0.18	0.18
		59	0.19	0.18	0.17
	5X	56	0.18	0.17	0.15
		57	0.18	0.18	0.17
		58	0.15	0.15	0.17
		59	0.15	0.16	0.17
	5X + d	56	0.17	0.18	0.19
		57	0.17	0.18	0.16
		58	0.17	0.17	0.16
		59	0.18	0.18	0.16
-5 BAR	1X	56	0.14	0.16	0.13
		57	0.12	0.13	0.13
		58	0.13	0.13	0.13
		59	0.12	0.13	0.12
	5X	56	0.12	0.13	0.13
		57	0.12	0.13	0.13
		58	0.14	0.12	0.13
		59	0.13	0.12	0.12
	5X + d	56	0.13	0.12	0.13
		57	0.13	0.13	0.13
		58	0.13	0.13	0.13
		59	0.13	0.13	0.12

Table 11 cont.

MATRIC POTENTIAL	TREATMENT	SAMPLE ID	REP 1	REP 2	REP 3
-15 BAR	1X	56	0.11	0.12	0.11
		57	0.11	0.12	0.09
		58	0.12	0.13	0.11
		59	0.12	0.12	0.12
	5X	56	0.10	0.11	0.11
		57	0.10	0.10	0.12
		58	0.10	0.11	0.12
		59	0.11	0.11	0.12
	5X + d	56	0.11	0.10	0.10
		57	0.11	0.10	0.11
		58	0.11	0.12	0.11
		59	0.11	0.11	0.12
CBM					
-1/10 BAR	1X	56	0.44	0.46	0.44
		57	0.45	0.47	0.46
		58	0.45	0.46	0.44
		59	0.44	0.44	0.44
	5X	56	0.40	0.42	0.40
		57	0.40	0.43	0.41
		58	0.41	0.42	0.43
		59	0.42	0.43	0.42
	5X + d	56	0.40	0.41	0.42
		57	0.41	0.40	0.42
		58	0.40	0.39	0.39
		59	0.37	0.40	0.40
-1/3 BAR	1X	56	0.26	0.30	0.27
		57	0.27	0.33	0.28
		58	0.32	0.27	0.30
		59	0.32	0.29	0.33
	5X	56	0.27	0.25	0.28
		57	0.28	0.30	0.28
		58	0.31	0.29	0.31
		59	0.31	0.27	0.34
	5X + d	56	0.27	0.30	0.30
		57	0.26	0.32	0.30
		58	0.29	0.29	0.27
		59	0.30	0.27	0.30

Table 11 cont.

MATRIC POTENTIAL	TREATMENT	SAMPLE ID	REP 1	REP 2	REP 3
-1 BAR	1X	56	0.18	0.18	0.19
		57	0.18	0.19	0.17
		58	0.20	0.18	0.18
		59	0.19	0.18	0.17
	5X	56	0.18	0.18	0.15
		57	0.18	0.17	0.16
		58	0.15	0.16	0.17
		59	0.16	0.16	0.17
	5X + d	56	0.17	0.18	0.16
		57	0.17	0.18	0.16
		58	0.18	0.18	0.17
		59	0.18	0.17	0.16
-5 BAR	1X	56	0.13	0.14	0.13
		57	0.13	0.14	0.13
		58	0.13	0.13	0.13
		59	0.13	0.14	0.13
	5X	56	0.13	0.13	0.14
		57	0.13	0.13	0.14
		58	0.13	0.13	0.13
		59	0.14	0.13	0.13
	5X + d	56	0.13	0.12	0.13
		57	0.13	0.12	0.13
		58	0.14	0.13	0.13
		59	0.15	0.13	0.14
-15 BAR	1X	56	0.11	0.12	0.11
		57	0.12	0.12	0.12
		58	0.14	0.12	0.14
		59	0.13	0.12	0.13
	5X	56	0.10	0.11	0.12
		57	0.11	0.12	0.12
		58	0.12	0.11	0.11
		59	0.11	0.11	0.12
	5X + d	56	0.11	0.11	0.12
		57	0.12	0.10	0.11
		58	0.08	0.11	0.12
		59	0.12	0.11	0.11

Table 12. Moisture retention at -15 bars for sample soils for periods of 3 and 14 days.

ID #	Days	Wet Weight	Dry Weight	Moisture Content	Days	Wet Weight	Dry Weight	Moisture Content
1	3	25.10	23.88	0.05	14	32.44	30.76	0.05
15	3	26.98	25.08	0.08	14	29.17	26.71	0.09
27	3	26.02	22.58	0.15	14	31.24	26.54	0.18
28	3	24.18	20.60	0.17	14	27.13	23.40	0.16
39	3	26.10	22.40	0.17	14	28.57	25.05	0.14
49	3	25.83	22.19	0.16	14	25.56	22.04	0.16
1	3	27.97	26.39	0.06	14	26.15	24.91	0.05
15	3	29.56	27.22	0.09	14	29.30	27.00	0.09
27	3	27.61	23.51	0.17	14	27.32	23.53	0.16
28	3	26.47	22.25	0.19	14	26.38	23.12	0.14
39	3	29.86	24.83	0.20	14	27.97	24.77	0.13
49	3	31.75	26.90	0.18	14	21.88	19.24	0.14

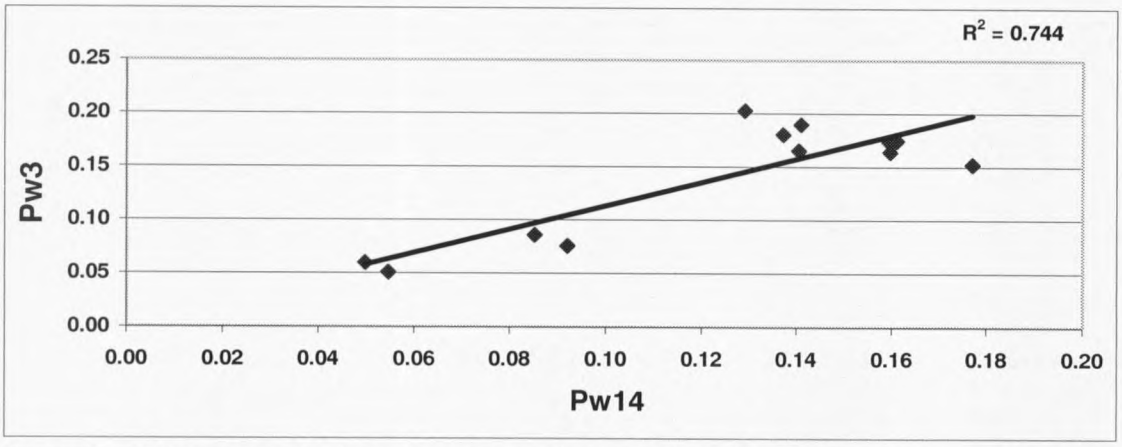


Figure 42. Moisture retention of sample soils at -15 bars left on the pressure plate for 3 days vs. samples left on for 14 days.

Table 13. Moisture retention at -15 bars for sample soils for periods of 5 and 14 days.

ID #	Days	Wet Weight	Dry Weight	Moisture Content	Days	Wet Weight	Dry Weight	Moisture Content
3	5	25.59	24.52	0.04	14	25.25	24.28	0.04
9	5	28.37	27.64	0.03	14	30.59	29.65	0.03
19	5	30.41	28.12	0.08	14	27.07	24.88	0.09
31	5	25.10	21.67	0.16	14	27.79	23.81	0.17
46	5	27.50	24.38	0.13	14	27.59	24.52	0.13
53	5	33.05	26.04	0.27	14	30.45	25.28	0.20
3	5	26.10	24.92	0.05	14	25.79	24.91	0.04
9	5	30.80	29.63	0.04	14	34.83	33.90	0.03
19	5	28.09	25.80	0.09	14	29.31	27.05	0.08
31	5	26.73	22.75	0.17	14	30.80	26.92	0.14
46	5	32.10	28.26	0.14	14	29.33	26.45	0.11
53	5	33.30	27.43	0.21	14	28.51	24.34	0.17

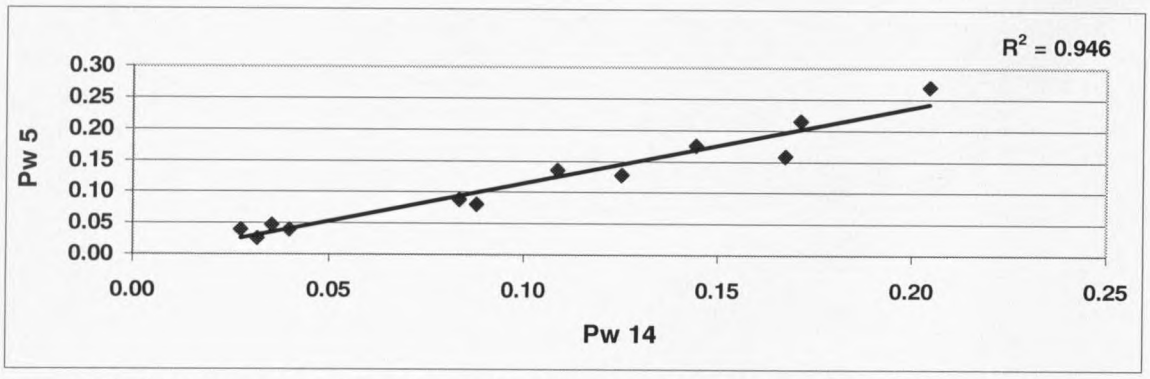


Figure 43. Moisture retention of sample soils at -15 bars left on the pressure plate for 5 days vs. samples left on for 14 days.

Table 14. Moisture retention at -15 bars for sample soils for periods of 7 and 14 days.

ID #	Days	Wet Weight	Dry Weight	Moisture Content	Days	Wet Weight	Dry Weight	Moisture Content
6	7	28.50	27.29	0.04	14	29.87	28.49	0.05
20	7	23.20	21.01	0.10	14	25.39	22.94	0.11
24	7	25.28	23.58	0.07	14	26.07	24.00	0.09
32	7	27.25	23.22	0.17	14	24.25	21.87	0.11
35	7	25.72	22.21	0.16	14	28.88	24.82	0.16
41	7	25.68	23.46	0.09	14	27.46	25.00	0.10
6	7	31.31	29.87	0.05	14	31.60	30.30	0.04
20	7	24.71	22.21	0.11	14	27.07	24.63	0.10
24	7	26	23.94	0.09	14	29.40	27.25	0.08
32	7	28.42	24.07	0.18	14	28.72	25.04	0.15
35	7	31.41	27.05	0.16	14	27.25	24.21	0.13
41	7	27.65	25.25	0.10	14	25.32	23.44	0.08

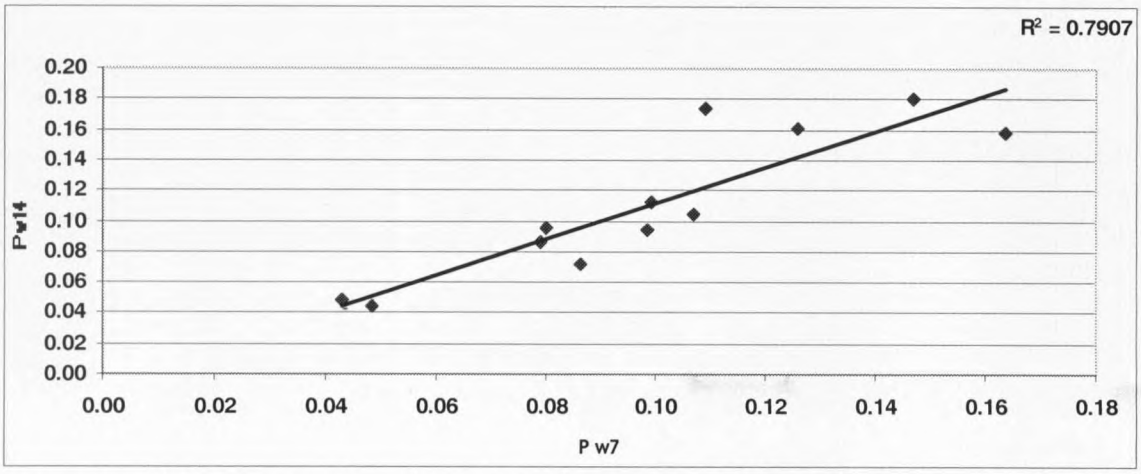


Figure 44. Moisture retention of sample soils at -15 bars left on the pressure plate for 7 days vs. samples left on for 14 days.

Table 15. Moisture retention at -15 bars for sample soils for periods of 10 and 14 days.

ID #	Days	Wet Weight	Dry Weight	Moisture Content	Days	Wet Weight	Dry Weight	Moisture Content
8	10	21.82	21.14	0.03	14	26.51	25.63	0.03
12	10	24.01	23.06	0.04	14	22.33	21.45	0.04
23	10	23.13	21.15	0.09	14	23.59	21.92	0.08
34	10	20.41	18.43	0.11	14	34.72	30.25	0.15
36	10	25.93	21.97	0.18	14	30.33	26.44	0.15
44	10	31.53	26.11	0.21	14	29.61	24.72	0.20
8	10	27.93	26.98	0.04	14	29.61	28.68	0.03
12	10	5.72	5.55	0.03	14	25.82	24.83	0.04
23	10	21.68	19.75	0.10	14	27.37	25.31	0.08
34	10	24.82	22.52	0.10	14	25.17	23.00	0.09
36	10	29.76	25.31	0.18	14	30.85	26.95	0.14
44	10	31.21	26.03	0.20	14	28.07	23.86	0.18

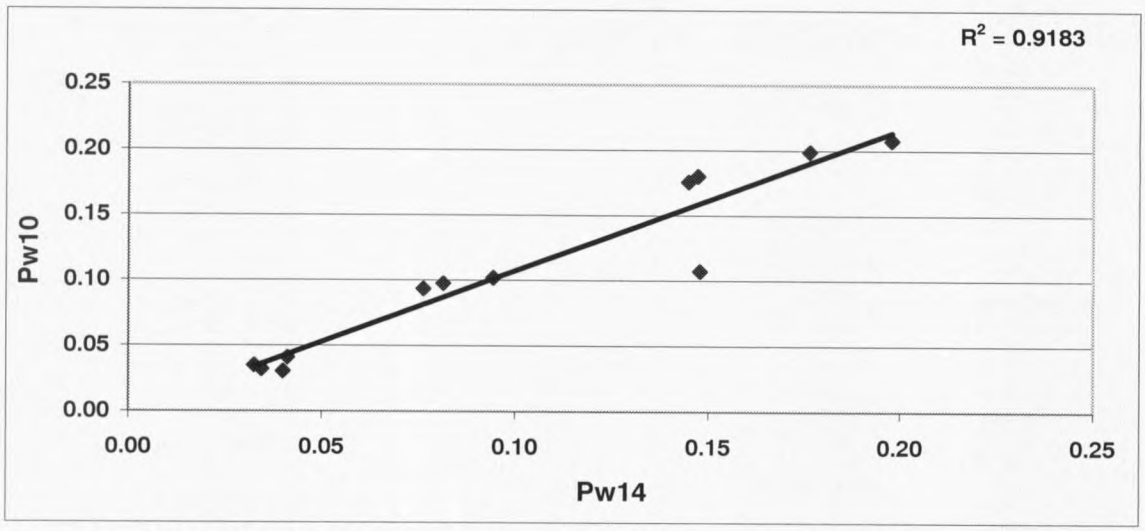


Figure 45. Moisture retention of sample soils at -15 bars left on the pressure plate for 10 days vs. samples left on for 14 days.

APPENDIX B

XRD FIGURES

Figure 46. XRD analysis for sample #1 (ID-SiCL 31) studied to determine the predominant clay type.

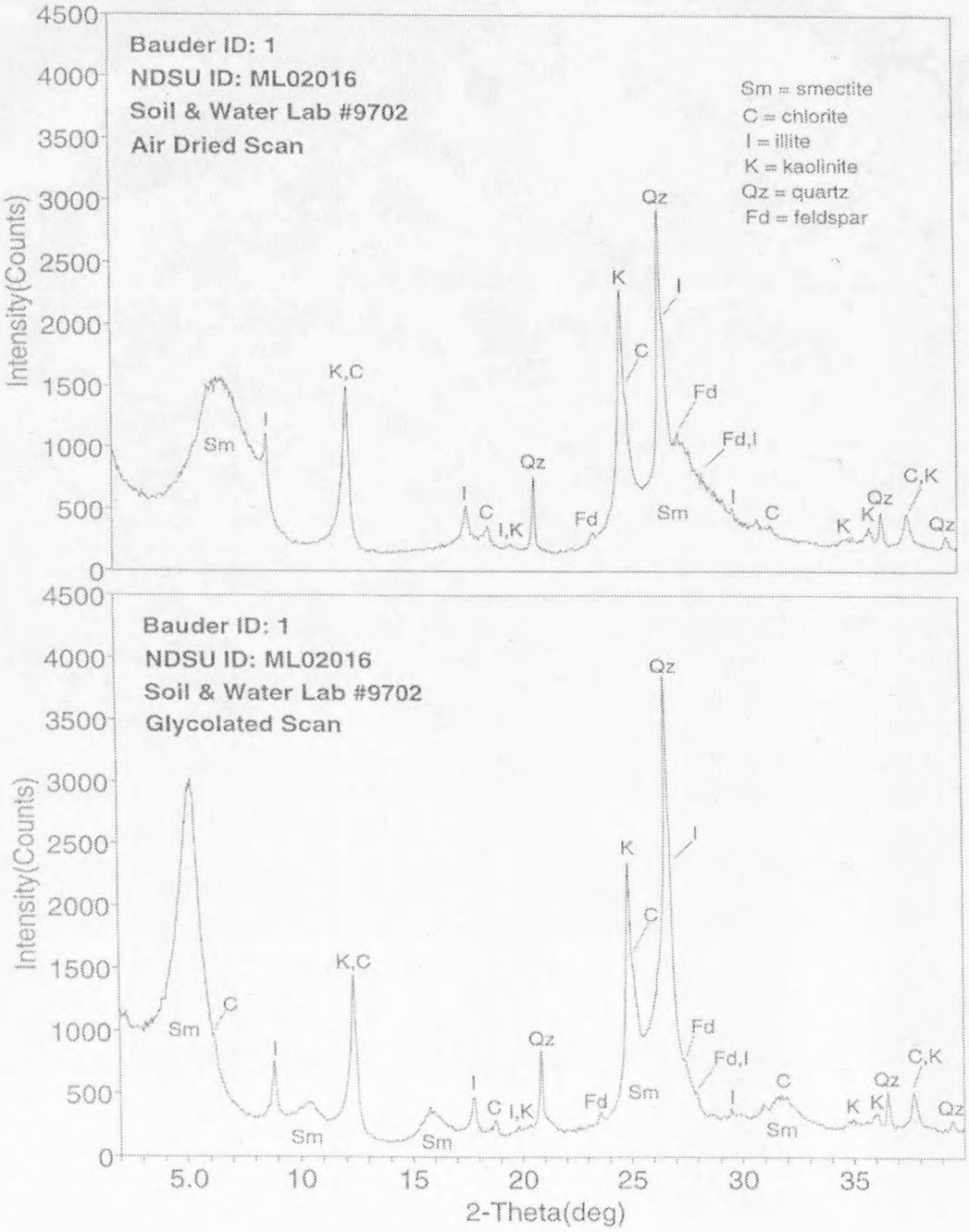


Figure 47. XRD analysis for sample #2 (ID-SiCL 28) studied to determine the predominant clay type.

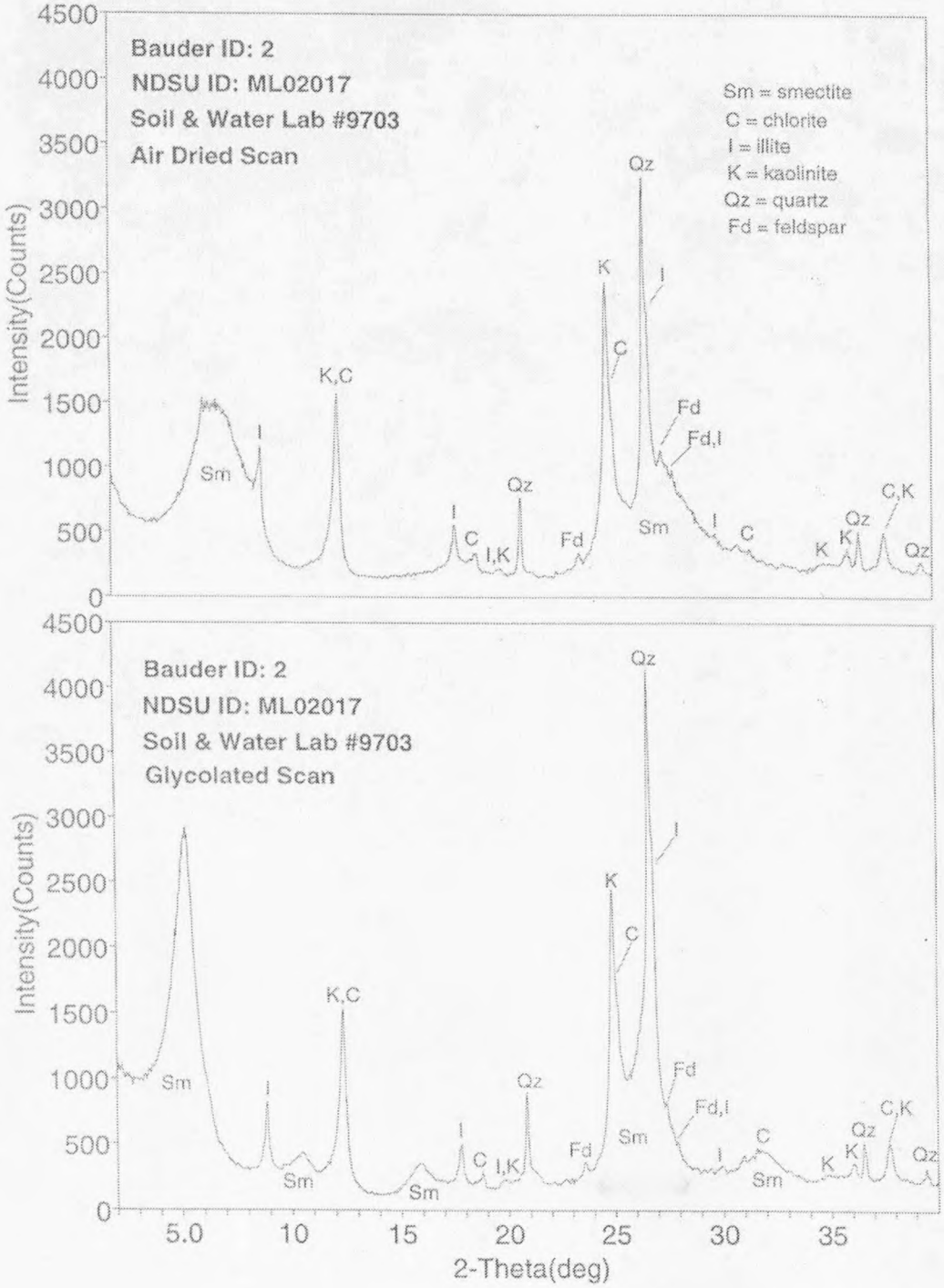


Figure 48. XRD analysis for sample #3 (ID-SiC 50) studied to determine the predominant clay type.

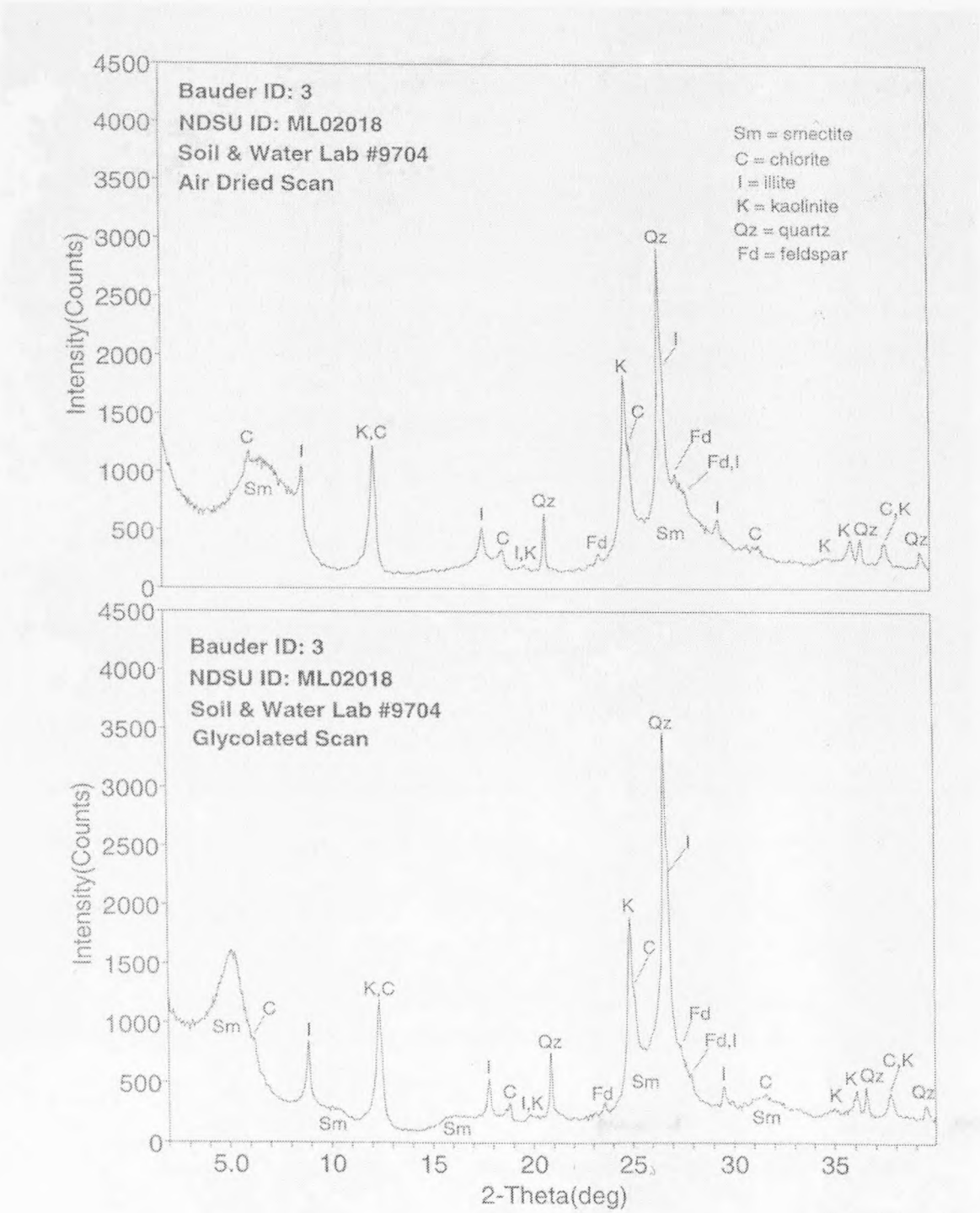


Figure 49. XRD analysis for sample #4 (ID-SiC 48) studied to determine the predominant clay type.

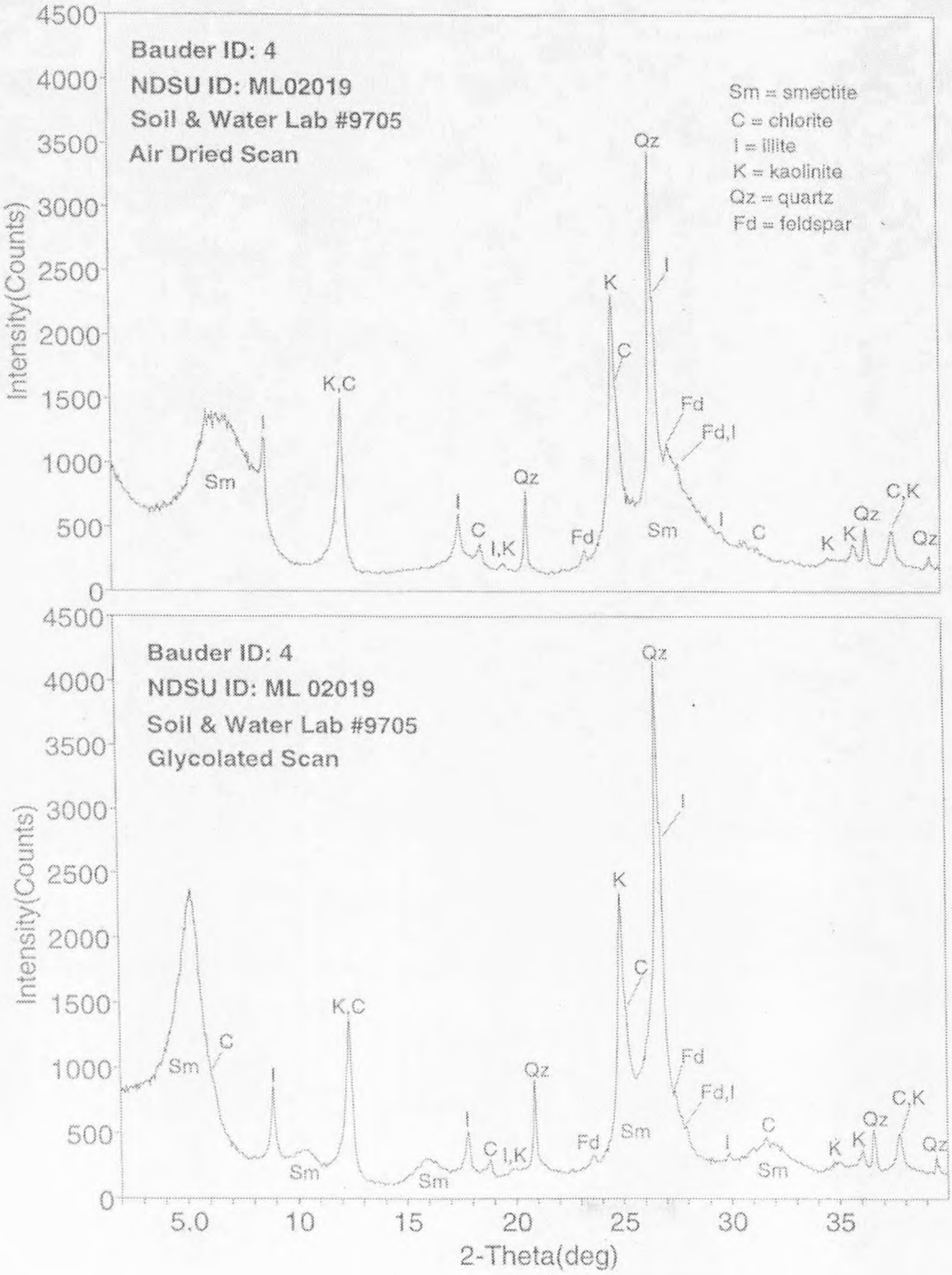


Figure 50. XRD analysis for sample #5 (ID-SiC 47) studied to determine the predominant clay type.

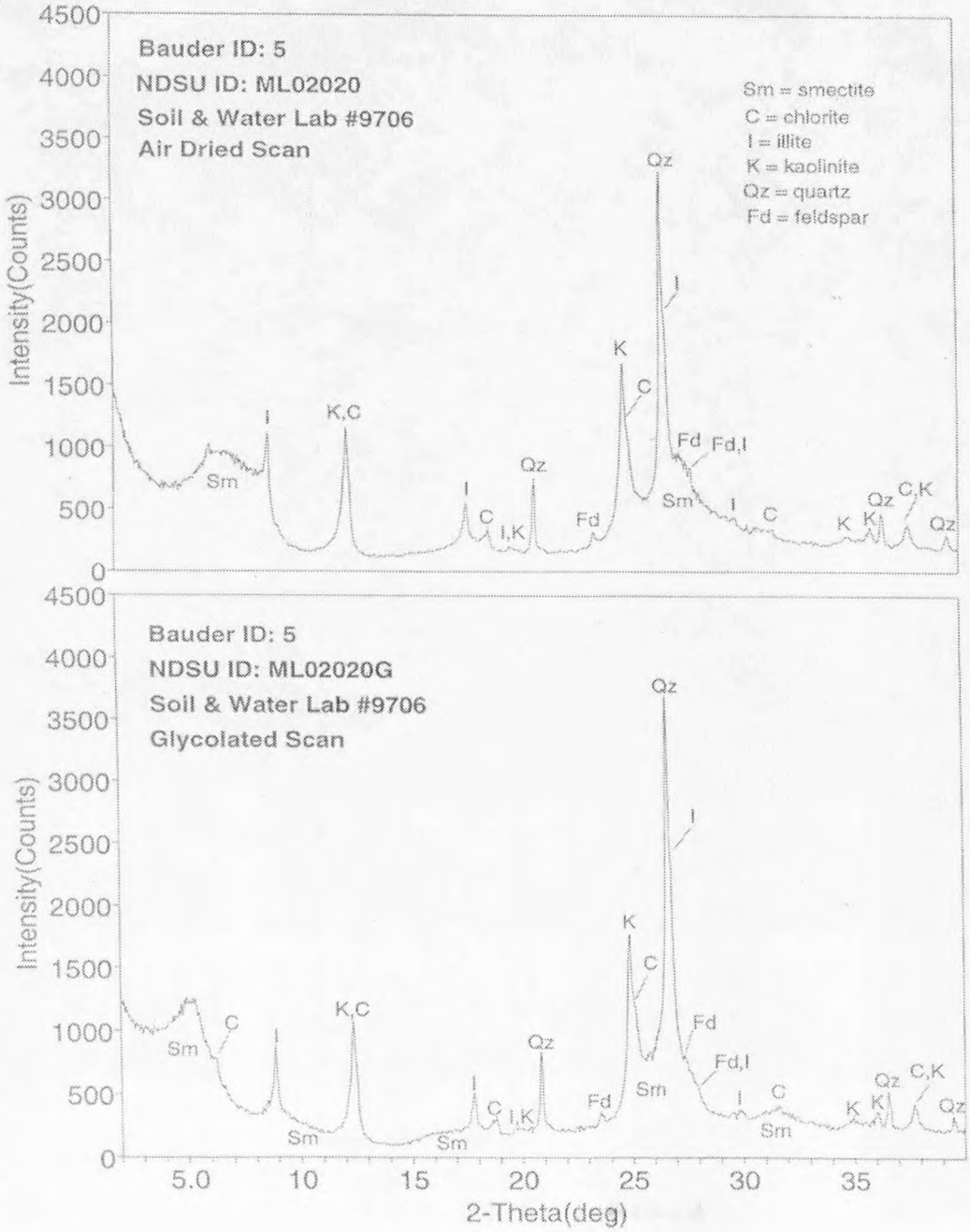
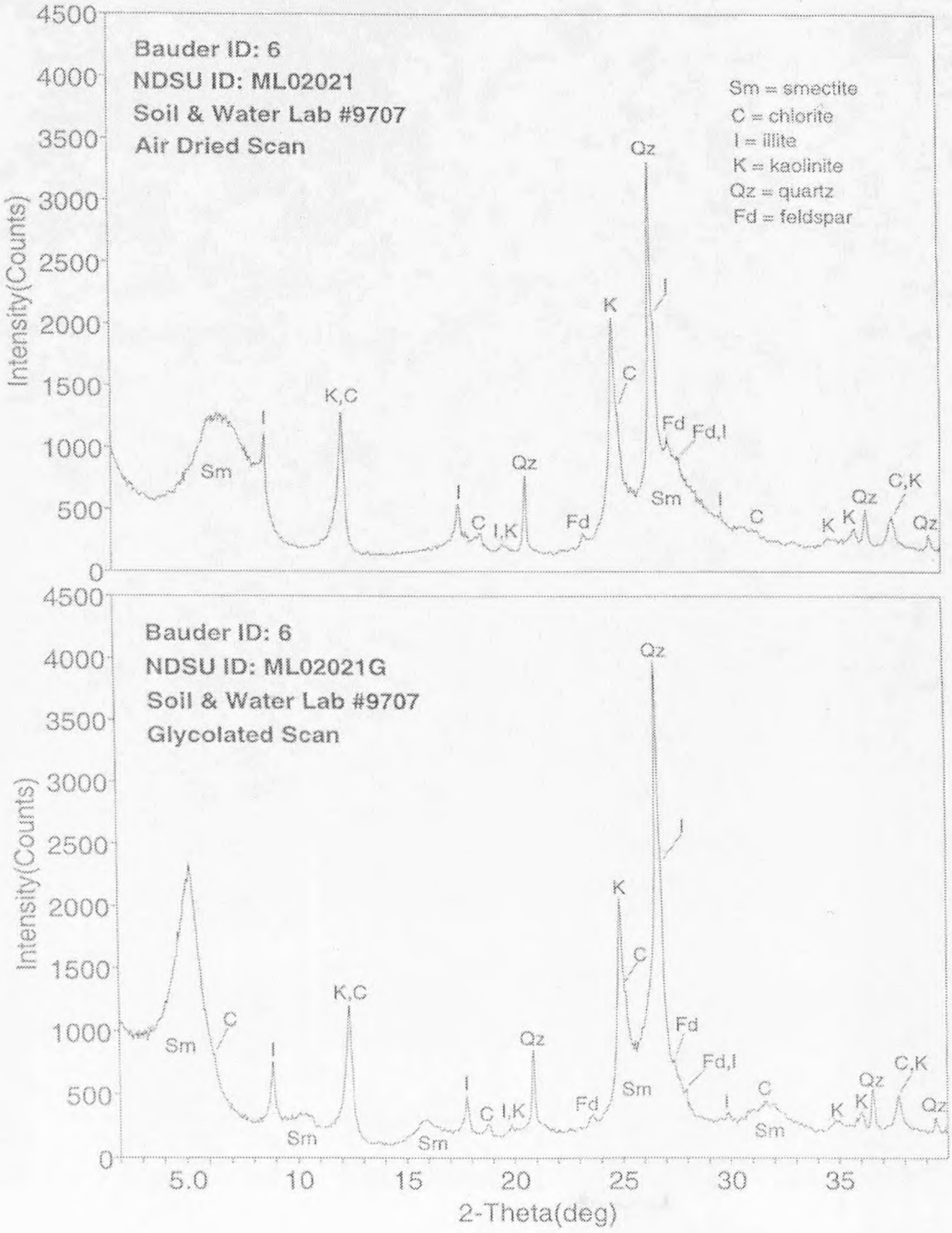


Figure 51. XRD analysis for sample #6 (ID-SiC 44) studied to determine the predominant clay type.



APPENDIX C

STATISTICAL TABLES

Table 16. Standard deviations within each textural class and water quality treatment for EC measurements.

TEXTURAL CLASS	WATER QUALITY TREATMENT	STANDARD DEVIATION
1	Baseline	0.18
2	Baseline	0.33
3	Baseline	0.75
4	Baseline	0.48
1	1X Wet/Dry-P.R.	0.39
2	1X Wet/Dry-P.R.	0.27
3	1X Wet/Dry-P.R.	0.43
4	1X Wet/Dry-P.R.	0.48
1	1X Wet/Dry-CBM	0.44
2	1X Wet/Dry-CBM	0.36
3	1X Wet/Dry-CBM	0.36
4	1X Wet/Dry-CBM	0.57
1	5X Wet/Dry-P.R.	0.38
2	5X Wet/Dry-P.R.	0.39
3	5X Wet/Dry-P.R.	0.40
4	5X Wet/Dry-P.R.	0.43
1	5X Wet/Dry-P.R. + distilled	0.82
2	5X Wet/Dry-P.R. + distilled	0.39
3	5X Wet/Dry-P.R. + distilled	0.39
4	5X Wet/Dry-P.R. + distilled	0.38
1	5X Wet/Dry-CBM	0.90
2	5X Wet/Dry-CBM	0.81
3	5X Wet/Dry-CBM	0.87
4	5X Wet/Dry-CBM	0.65
1	5X Wet/Dry-CBM + distilled	1.24
2	5X Wet/Dry-CBM + distilled	0.94
3	5X Wet/Dry-CBM + distilled	1.45
4	5X Wet/Dry-CBM + distilled	1.30

Table 17. Standard deviations within each textural class and water quality treatment for SAR measurements.

TEXTURAL CLASS	WATER QUALITY TREATMENT	STANDARD DEVIATION
1	Baseline	0.44
2	Baseline	0.97
3	Baseline	3.26
4	Baseline	4.66
1	1X Wet/Dry-P.R.	0.56
2	1X Wet/Dry-P.R.	0.81
3	1X Wet/Dry-P.R.	2.88
4	1X Wet/Dry-P.R.	5.11
1	1X Wet/Dry-CBM	0.68
2	1X Wet/Dry-CBM	0.73
3	1X Wet/Dry-CBM	2.27
4	1X Wet/Dry-CBM	4.94
1	5X Wet/Dry-P.R.	0.52
2	5X Wet/Dry-P.R.	0.60
3	5X Wet/Dry-P.R.	2.33
4	5X Wet/Dry-P.R.	5.15
1	5X Wet/Dry-P.R. + distilled	0.60
2	5X Wet/Dry-P.R. + distilled	0.72
3	5X Wet/Dry-P.R. + distilled	2.29
4	5X Wet/Dry-P.R. + distilled	5.42
1	5X Wet/Dry-CBM	1.62
2	5X Wet/Dry-CBM	1.57
3	5X Wet/Dry-CBM	2.15
4	5X Wet/Dry-CBM	5.18
1	5X Wet/Dry-CBM + distilled	1.51
2	5X Wet/Dry-CBM + distilled	1.08
3	5X Wet/Dry-CBM + distilled	2.43
4	5X Wet/Dry-CBM + distilled	6.27

Table 18. Two-way analysis of variance of electrical conductivity for textural class #1.

Two Way Analysis of Variance
Data source: Textural Class #1
General Linear Model (No Interactions)
Dependent Variable: ec(dS/m)

Normality Test:	Passed	(P > 0.200)
Equal Variance Test:	Passed	(P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
trt	6	221.646	36.941	92.961	<0.001
rep	8	9.387	1.173	2.953	0.009
Residual	48	19.074	0.397		
Total	62	250.107	4.034		

The difference in the mean values among the different levels of trt is greater than would be expected by chance after allowing for effects of differences in rep. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of rep is greater than would be expected by chance after allowing for effects of differences in trt. There is a statistically significant difference (P = 0.009). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for trt : 1.000
Power of performed test with alpha = 0.0500: for rep : 0.742

Least square means for trt :

Group	**Mean**
1CBM	2.397
1PR	1.454
5C+d	4.324
5CBM	6.736
5P+d	2.573
5PR	3.527
Base	0.600

Std Err of LS Mean = 0.210

Least square means for rep :

Group	**Mean**
1.000	3.083
2.000	2.921
3.000	3.713
4.000	3.340
5.000	2.783
6.000	3.543
7.000	2.369
8.000	2.891
9.000	3.143

Std Err of LS Mean = 0.238

Table 18. Two-way analysis of variance of electrical conductivity for textural class #1 continued.

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :
Comparisons for factor: **trt**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
5CBM vs. Base	6.136	7	29.199	<0.001	Yes
5CBM vs. 1PR	5.281	6	25.133	<0.001	Yes
5CBM vs. 1CBM	4.339	5	20.649	<0.001	Yes
5CBM vs. 5P+d	4.162	4	19.808	<0.001	Yes
5CBM vs. 5PR	3.209	3	15.271	<0.001	Yes
5CBM vs. 5C+d	2.411	2	11.474	<0.001	Yes
5C+d vs. Base	3.724	6	17.725	<0.001	Yes
5C+d vs. 1PR	2.870	5	13.658	<0.001	Yes
5C+d vs. 1CBM	1.928	4	9.174	<0.001	Yes
5C+d vs. 5P+d	1.751	3	8.334	<0.001	Yes
5P+d vs. 5PR	0.798	2	3.797	0.010	Yes
5PR vs. Base	2.927	5	13.928	<0.001	Yes
5PR vs. 1PR	2.072	4	9.862	<0.001	Yes
5PR vs. 1CBM	1.130	3	5.378	0.001	Yes
5PR vs. 5P+d	0.953	2	4.537	0.003	Yes
5P+d vs. Base	1.973	4	9.391	<0.001	Yes
5P+d vs. 1PR	1.119	3	5.325	0.001	Yes
5P+d vs. 1CBM	0.177	2	0.841	0.555	No
1CBM vs. Base	1.797	3	8.550	<0.001	Yes
1CBM vs. 1PR	0.942	2	4.484	0.003	Yes
1PR vs. Base	0.854	2	4.066	0.006	Yes

Comparisons for factor: **rep**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
3.000 vs. 7.000	1.344	9	5.642	0.006	Yes
3.000 vs. 5.000	0.930	8	3.903	0.130	No
3.000 vs. 8.000	0.821	7	3.448	0.206	Do Not Test
3.000 vs. 2.000	0.791	6	3.322	0.195	Do Not Test
3.000 vs. 1.000	0.630	5	2.644	0.347	Do Not Test
3.000 vs. 9.000	0.570	4	2.392	0.339	Do Not Test
3.000 vs. 4.000	0.373	3	1.565	0.515	Do Not Test
3.000 vs. 6.000	0.170	2	0.713	0.616	Do Not Test
6.000 vs. 7.000	1.174	8	4.929	0.022	Yes
6.000 vs. 5.000	0.760	7	3.190	0.287	Do Not Test
6.000 vs. 8.000	0.651	6	2.734	0.395	Do Not Test
6.000 vs. 2.000	0.621	5	2.608	0.361	Do Not Test
6.000 vs. 1.000	0.460	4	1.931	0.527	Do Not Test
6.000 vs. 9.000	0.400	3	1.679	0.467	Do Not Test
6.000 vs. 4.000	0.203	2	0.851	0.550	Do Not Test
4.000 vs. 7.000	0.971	7	4.077	0.080	No
4.000 vs. 5.000	0.557	6	2.338	0.568	Do Not Test
4.000 vs. 8.000	0.449	5	1.883	0.673	Do Not Test

Table 18. Two-way analysis of variance of electrical conductivity for textural class #1 continued.

4.000 vs. 2.000	0.419	4	1.757	0.604	Do Not Test
4.000 vs. 1.000	0.257	3	1.079	0.727	Do Not Test
4.000 vs. 9.000	0.197	2	0.827	0.561	Do Not Test
9.000 vs. 7.000	0.774	6	3.250	0.215	Do Not Test
9.000 vs. 5.000	0.360	5	1.511	0.822	Do Not Test
9.000 vs. 8.000	0.251	4	1.055	0.878	Do Not Test
9.000 vs. 2.000	0.221	3	0.929	0.789	Do Not Test
9.000 vs. 1.000	0.0600	2	0.252	0.860	Do Not Test
1.000 vs. 7.000	0.714	5	2.998	0.229	Do Not Test
1.000 vs. 5.000	0.300	4	1.259	0.810	Do Not Test
1.000 vs. 8.000	0.191	3	0.803	0.838	Do Not Test
1.000 vs. 2.000	0.161	2	0.678	0.634	Do Not Test
2.000 vs. 7.000	0.553	4	2.320	0.366	Do Not Test
2.000 vs. 5.000	0.139	3	0.582	0.911	Do Not Test
2.000 vs. 8.000	0.0300	2	0.126	0.930	Do Not Test
8.000 vs. 7.000	0.523	3	2.194	0.276	Do Not Test
8.000 vs. 5.000	0.109	2	0.456	0.749	Do Not Test
5.000 vs. 7.000	0.414	2	1.739	0.225	Do Not Test

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Table 19. Two-way analysis of variance of electrical conductivity for textural class #2.

Two Way Analysis of Variance
Data source: Textural Class #2
General Linear Model (No Interactions)
Dependent Variable: EC(dS/m)
Normality Test: Passed (P = 0.091)
Equal Variance Test: Passed (P = 1.000)

Source of Variation	DF	SS	MS	F	P
wqtrt	6	395.283	65.880	258.002	<0.001
rep	12	7.472	0.623	2.439	0.010
Residual	72	18.385	0.255		
Total	90	421.140	4.679		

The difference in the mean values among the different levels of wqtrt is greater than would be expected by chance after allowing for effects of differences in rep. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of rep is greater than would be expected by chance after allowing for effects of differences in wqtrt. There is a statistically significant difference (P = 0.010). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for wqtrt : 1.000
Power of performed test with alpha = 0.0500: for rep : 0.725

Least square means for wqtrt :

Group	Mean
1CBM	2.483
1PR	1.428
5C+d	5.897
5CBM	6.918
5P+d	3.080
5PR	3.163
Base	0.772

Std Err of LS Mean = 0.140

Least square means for rep :

Group	Mean
1.000	2.871
2.000	2.930
3.000	3.354
4.000	3.163
5.000	3.290
6.000	3.374
7.000	3.517
8.000	3.699
9.000	3.466
10.000	3.307
11.000	3.949
12.000	3.506
13.000	3.663

Std Err of LS Mean = 0.191

Table 19. Two-way analysis of variance of electrical conductivity for textural class #2 continued.

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :
Comparisons for factor: **wqtrt**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
5CBM vs. Base	6.146	7	43.854	<0.001	Yes
5CBM vs. 1PR	5.490	6	39.172	<0.001	Yes
5CBM vs. 1CBM	4.435	5	31.642	<0.001	Yes
5CBM vs. 5P+d	3.838	4	27.383	<0.001	Yes
5CBM vs. 5PR	3.755	3	26.790	<0.001	Yes
5CBM vs. 5C+d	1.021	2	7.283	<0.001	Yes
5C+d vs. Base	5.125	6	36.571	<0.001	Yes
5C+d vs. 1PR	4.469	5	31.889	<0.001	Yes
5C+d vs. 1CBM	3.414	4	24.358	<0.001	Yes
5C+d vs. 5P+d	2.817	3	20.099	<0.001	Yes
5C+d vs. 5PR	2.734	2	19.507	<0.001	Yes
5PR vs. Base	2.392	5	17.064	<0.001	Yes
5PR vs. 1PR	1.735	4	12.382	<0.001	Yes
5PR vs. 1CBM	0.680	3	4.852	0.003	Yes
5PR vs. 5P+d	0.0831	2	0.593	0.676	No
5P+d vs. Base	2.308	4	16.471	<0.001	Yes
5P+d vs. 1PR	1.652	3	11.790	<0.001	Yes
5P+d vs. 1CBM	0.597	2	4.259	0.004	Yes
1CBM vs. Base	1.712	3	12.212	<0.001	Yes
1CBM vs. 1PR	1.055	2	7.530	<0.001	Yes
1PR vs. Base	0.656	2	4.682	0.002	Yes

Comparisons for factor: **rep**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
11.000 vs. 1.000	1.077	13	5.640	0.009	Yes
11.000 vs. 2.000	1.019	12	5.333	0.016	Yes
11.000 vs. 4.000	0.786	11	4.114	0.141	No
11.000 vs. 5.000	0.659	10	3.448	0.320	Do Not Test
11.000 vs. 10.000	0.641	9	3.358	0.314	Do Not Test
11.000 vs. 3.000	0.594	8	3.112	0.364	Do Not Test
11.000 vs. 6.000	0.574	7	3.007	0.349	Do Not Test
11.000 vs. 9.000	0.483	6	2.528	0.480	Do Not Test
11.000 vs. 12.000	0.443	5	2.319	0.478	Do Not Test
11.000 vs. 7.000	0.431	4	2.259	0.387	Do Not Test
11.000 vs. 13.000	0.286	3	1.496	0.543	Do Not Test
11.000 vs. 8.000	0.250	2	1.309	0.358	Do Not Test
8.000 vs. 1.000	0.827	12	4.331	0.112	No
8.000 vs. 2.000	0.769	11	4.024	0.162	Do Not Test
8.000 vs. 4.000	0.536	10	2.805	0.613	Do Not Test
8.000 vs. 5.000	0.409	9	2.139	0.846	Do Not Test
8.000 vs. 10.000	0.391	8	2.049	0.831	Do Not Test
8.000 vs. 3.000	0.344	7	1.803	0.861	Do Not Test
8.000 vs. 6.000	0.324	6	1.698	0.835	Do Not Test

Table 19. Two-way analysis of variance of electrical conductivity for textural class #2 continued.

8.000 vs. 9.000	0.233	5	1.219	0.910	Do Not Test
8.000 vs. 12.000	0.193	4	1.010	0.891	Do Not Test
8.000 vs. 7.000	0.181	3	0.950	0.781	Do Not Test
8.000 vs. 13.000	0.0357	2	0.187	0.895	Do Not Test
13.000 vs. 1.000	0.791	11	4.144	0.134	Do Not Test
13.000 vs. 2.000	0.733	10	3.837	0.188	Do Not Test
13.000 vs. 4.000	0.500	9	2.618	0.649	Do Not Test
13.000 vs. 5.000	0.373	8	1.952	0.863	Do Not Test
13.000 vs. 10.000	0.356	7	1.862	0.842	Do Not Test
13.000 vs. 3.000	0.309	6	1.616	0.862	Do Not Test
13.000 vs. 6.000	0.289	5	1.511	0.822	Do Not Test
13.000 vs. 9.000	0.197	4	1.032	0.885	Do Not Test
13.000 vs. 12.000	0.157	3	0.823	0.830	Do Not Test
13.000 vs. 7.000	0.146	2	0.763	0.591	Do Not Test
7.000 vs. 1.000	0.646	10	3.381	0.347	Do Not Test
7.000 vs. 2.000	0.587	9	3.074	0.434	Do Not Test
7.000 vs. 4.000	0.354	8	1.855	0.892	Do Not Test
7.000 vs. 5.000	0.227	7	1.189	0.980	Do Not Test
7.000 vs. 10.000	0.210	6	1.100	0.971	Do Not Test
7.000 vs. 3.000	0.163	5	0.853	0.974	Do Not Test
7.000 vs. 6.000	0.143	4	0.748	0.952	Do Not Test
7.000 vs. 9.000	0.0514	3	0.269	0.980	Do Not Test
7.000 vs. 12.000	0.0114	2	0.0598	0.966	Do Not Test
12.000 vs. 1.000	0.634	9	3.321	0.328	Do Not Test
12.000 vs. 2.000	0.576	8	3.014	0.405	Do Not Test
12.000 vs. 4.000	0.343	7	1.795	0.864	Do Not Test
12.000 vs. 5.000	0.216	6	1.129	0.967	Do Not Test
12.000 vs. 10.000	0.199	5	1.040	0.948	Do Not Test
12.000 vs. 3.000	0.151	4	0.793	0.943	Do Not Test
12.000 vs. 6.000	0.131	3	0.688	0.878	Do Not Test
12.000 vs. 9.000	0.0400	2	0.209	0.883	Do Not Test
9.000 vs. 1.000	0.594	8	3.112	0.364	Do Not Test
9.000 vs. 2.000	0.536	7	2.805	0.434	Do Not Test
9.000 vs. 4.000	0.303	6	1.586	0.871	Do Not Test
9.000 vs. 5.000	0.176	5	0.920	0.966	Do Not Test
9.000 vs. 10.000	0.159	4	0.830	0.936	Do Not Test
9.000 vs. 3.000	0.111	3	0.583	0.911	Do Not Test
9.000 vs. 6.000	0.0914	2	0.479	0.736	Do Not Test
6.000 vs. 1.000	0.503	7	2.633	0.512	Do Not Test
6.000 vs. 2.000	0.444	6	2.326	0.572	Do Not Test
6.000 vs. 4.000	0.211	5	1.107	0.935	Do Not Test
6.000 vs. 5.000	0.0843	4	0.441	0.989	Do Not Test
6.000 vs. 10.000	0.0671	3	0.352	0.967	Do Not Test
6.000 vs. 3.000	0.0200	2	0.105	0.941	Do Not Test
3.000 vs. 1.000	0.483	6	2.528	0.480	Do Not Test
3.000 vs. 2.000	0.424	5	2.221	0.521	Do Not Test

Table 19. Two-way analysis of variance of electrical conductivity for textural class #2 continued.

3.000 vs. 4.000	0.191	4	1.002	0.893	Do Not Test
3.000 vs. 5.000	0.0643	3	0.337	0.969	Do Not Test
3.000 vs. 10.000	0.0471	2	0.247	0.862	Do Not Test
10.000 vs. 1.000	0.436	5	2.281	0.494	Do Not Test
10.000 vs. 2.000	0.377	4	1.975	0.506	Do Not Test
10.000 vs. 4.000	0.144	3	0.755	0.855	Do Not Test
10.000 vs. 5.000	0.0171	2	0.0898	0.950	Do Not Test
5.000 vs. 1.000	0.419	4	2.192	0.414	Do Not Test
5.000 vs. 2.000	0.360	3	1.885	0.382	Do Not Test
5.000 vs. 4.000	0.127	2	0.666	0.639	Do Not Test
4.000 vs. 1.000	0.291	3	1.526	0.530	Do Not Test
4.000 vs. 2.000	0.233	2	1.219	0.392	Do Not Test
2.000 vs. 1.000	0.0586	2	0.307	0.829	Do Not Test

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Table 20. Two-way analysis of variance of electrical conductivity for textural class #3.

Two Way Analysis of Variance
Data source: Textural Class #3
General Linear Model (No Interactions)
Dependent Variable: sqrt(-EC(dS/m)-

Normality Test:	Passed	(P = 0.014)
Equal Variance Test:	Passed	(P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
rep	15	1.412	0.0942	2.777	0.001
wqtrt	6	36.558	6.093	179.666	<0.001
Residual	90	3.052	0.0339		
Total	111	41.022	0.370		

The difference in the mean values among the different levels of rep is greater than would be expected by chance after allowing for effects of differences in wqtrt. There is a statistically significant difference (P = 0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of wqtrt is greater than would be expected by chance after allowing for effects of differences in rep. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for rep : 0.899
Power of performed test with alpha = 0.0500: for wqtrt : 1.000

Least square means for rep :

Group	**Mean**
1.000	1.724
2.000	1.779
3.000	1.777
4.000	1.734
5.000	1.651
6.000	1.683
7.000	1.688
8.000	1.663
9.000	1.563
10.000	1.757
11.000	2.061
12.000	1.725
13.000	1.628
14.000	1.659
15.000	1.544
16.000	1.680

Std Err of LS Mean = 0.0696

Table 20. Two-way analysis of variance of electrical conductivity for textural class #3 continued.

Least square means for wqtrt :

Group	Mean		
1CBM	1.491		
1PR	1.154		
5C+d	2.424		
5CBM	2.557		
5P+d	1.744		
5PR	1.709	Base	0.873

Std Err of LS Mean = 0.0460

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **rep**

Comparison	Diff of Means	p	q	P	P<0.050
11.000 vs. 15.000	0.517	16	7.429	<0.001	Yes
11.000 vs. 9.000	0.498	15	7.149	<0.001	Yes
11.000 vs. 13.000	0.433	14	6.217	0.002	Yes
11.000 vs. 5.000	0.410	13	5.897	0.005	Yes
11.000 vs. 14.000	0.402	12	5.771	0.005	Yes
11.000 vs. 8.000	0.398	11	5.720	0.005	Yes
11.000 vs. 16.000	0.381	10	5.480	0.007	Yes
11.000 vs. 6.000	0.378	9	5.425	0.007	Yes
11.000 vs. 7.000	0.373	8	5.363	0.006	Yes
11.000 vs. 1.000	0.337	7	4.845	0.016	Yes
11.000 vs. 12.000	0.336	6	4.833	0.012	Yes
11.000 vs. 4.000	0.327	5	4.702	0.011	Yes
11.000 vs. 10.000	0.304	4	4.373	0.014	Yes
11.000 vs. 3.000	0.284	3	4.078	0.014	Yes
11.000 vs. 2.000	0.282	2	4.045	0.005	Yes
2.000 vs. 15.000	0.236	15	3.384	0.527	No
2.000 vs. 9.000	0.216	14	3.104	0.634	Do Not Test
2.000 vs. 13.000	0.151	13	2.172	0.944	Do Not Test
2.000 vs. 5.000	0.129	12	1.852	0.976	Do Not Test
2.000 vs. 14.000	0.120	11	1.726	0.979	Do Not Test
2.000 vs. 8.000	0.117	10	1.675	0.973	Do Not Test
2.000 vs. 16.000	0.0999	9	1.435	0.984	Do Not Test
2.000 vs. 6.000	0.0960	8	1.380	0.977	Do Not Test
2.000 vs. 7.000	0.0917	7	1.318	0.966	Do Not Test
2.000 vs. 1.000	0.0557	6	0.800	0.993	Do Not Test
2.000 vs. 12.000	0.0548	5	0.788	0.981	Do Not Test
2.000 vs. 4.000	0.0457	4	0.657	0.967	Do Not Test
2.000 vs. 10.000	0.0228	3	0.328	0.971	Do Not Test
2.000 vs. 3.000	0.00228	2	0.0327	0.982	Do Not Test
3.000 vs. 15.000	0.233	14	3.351	0.510	Do Not Test
3.000 vs. 9.000	0.214	13	3.071	0.614	Do Not Test

Table 20. Two-way analysis of variance of electrical conductivity for textural class #3 continued.

3.000 vs. 13.000	0.149	12	2.139	0.933	Do Not Test
3.000 vs. 5.000	0.127	11	1.820	0.969	Do Not Test
3.000 vs. 14.000	0.118	10	1.693	0.971	Do Not Test
3.000 vs. 8.000	0.114	9	1.642	0.962	Do Not Test
3.000 vs. 16.000	0.0976	8	1.403	0.975	Do Not Test
3.000 vs. 6.000	0.0938	7	1.347	0.963	Do Not Test
3.000 vs. 7.000	0.0894	6	1.285	0.943	Do Not Test
3.000 vs. 1.000	0.0534	5	0.767	0.983	Do Not Test
3.000 vs. 12.000	0.0526	4	0.755	0.951	Do Not Test
3.000 vs. 4.000	0.0434	3	0.624	0.898	Do Not Test
3.000 vs. 10.000	0.0205	2	0.295	0.835	Do Not Test
10.000 vs. 15.000	0.213	13	3.056	0.621	Do Not Test
10.000 vs. 9.000	0.193	12	2.776	0.716	Do Not Test
10.000 vs. 13.000	0.128	11	1.844	0.966	Do Not Test
10.000 vs. 5.000	0.106	10	1.524	0.986	Do Not Test
10.000 vs. 14.000	0.0973	9	1.398	0.986	Do Not Test
10.000 vs. 8.000	0.0938	8	1.347	0.980	Do Not Test
10.000 vs. 16.000	0.0771	7	1.107	0.986	Do Not Test
10.000 vs. 6.000	0.0732	6	1.052	0.976	Do Not Test
10.000 vs. 7.000	0.0689	5	0.990	0.956	Do Not Test
10.000 vs. 1.000	0.0329	4	0.472	0.987	Do Not Test
10.000 vs. 12.000	0.0320	3	0.460	0.944	Do Not Test
10.000 vs. 4.000	0.0229	2	0.329	0.817	Do Not Test
4.000 vs. 15.000	0.190	12	2.727	0.738	Do Not Test
4.000 vs. 9.000	0.170	11	2.447	0.816	Do Not Test
4.000 vs. 13.000	0.105	10	1.516	0.986	Do Not Test
4.000 vs. 5.000	0.0832	9	1.196	0.995	Do Not Test
4.000 vs. 14.000	0.0744	8	1.069	0.995	Do Not Test
4.000 vs. 8.000	0.0709	7	1.018	0.991	Do Not Test
4.000 vs. 16.000	0.0542	6	0.779	0.994	Do Not Test
4.000 vs. 6.000	0.0503	5	0.723	0.986	Do Not Test
4.000 vs. 7.000	0.0460	4	0.661	0.966	Do Not Test
4.000 vs. 1.000	0.00997	3	0.143	0.994	Do Not Test
4.000 vs. 12.000	0.00913	2	0.131	0.926	Do Not Test
12.000 vs. 15.000	0.181	11	2.596	0.756	Do Not Test
12.000 vs. 9.000	0.161	10	2.316	0.826	Do Not Test
12.000 vs. 13.000	0.0964	9	1.384	0.987	Do Not Test
12.000 vs. 5.000	0.0741	8	1.064	0.995	Do Not Test
12.000 vs. 14.000	0.0653	7	0.938	0.994	Do Not Test
12.000 vs. 8.000	0.0618	6	0.887	0.989	Do Not Test
12.000 vs. 16.000	0.0451	5	0.647	0.991	Do Not Test
12.000 vs. 6.000	0.0412	4	0.592	0.975	Do Not Test
12.000 vs. 7.000	0.0369	3	0.530	0.926	Do Not Test
12.000 vs. 1.000	0.000847	2	0.0122	0.993	Do Not Test

Table 20. Two-way analysis of variance of electrical conductivity for textural class #3 continued.

1.000 vs. 15.000	0.180	10	2.584	0.716	Do Not Test
1.000 vs. 9.000	0.160	9	2.304	0.786	Do Not Test
1.000 vs. 13.000	0.0955	8	1.372	0.978	Do Not Test
1.000 vs. 5.000	0.0732	7	1.052	0.989	Do Not Test
1.000 vs. 14.000	0.0645	6	0.926	0.986	Do Not Test
1.000 vs. 8.000	0.0609	5	0.875	0.972	Do Not Test
1.000 vs. 16.000	0.0442	4	0.635	0.970	Do Not Test
1.000 vs. 6.000	0.0404	3	0.580	0.912	Do Not Test
1.000 vs. 7.000	0.0360	2	0.518	0.715	Do Not Test
7.000 vs. 15.000	0.144	9	2.067	0.870	Do Not Test
7.000 vs. 9.000	0.124	8	1.786	0.910	Do Not Test
7.000 vs. 13.000	0.0595	7	0.855	0.997	Do Not Test
7.000 vs. 5.000	0.0372	6	0.535	0.999	Do Not Test
7.000 vs. 14.000	0.0284	5	0.409	0.999	Do Not Test
7.000 vs. 8.000	0.0249	4	0.358	0.994	Do Not Test
7.000 vs. 16.000	0.00819	3	0.118	0.996	Do Not Test
7.000 vs. 6.000	0.00434	2	0.0623	0.965	Do Not Test
6.000 vs. 15.000	0.140	8	2.004	0.847	Do Not Test
6.000 vs. 9.000	0.120	7	1.724	0.885	Do Not Test
6.000 vs. 13.000	0.0551	6	0.792	0.993	Do Not Test
6.000 vs. 5.000	0.0329	5	0.472	0.997	Do Not Test
6.000 vs. 14.000	0.0241	4	0.346	0.995	Do Not Test
6.000 vs. 8.000	0.0206	3	0.295	0.976	Do Not Test
6.000 vs. 16.000	0.00386	2	0.0554	0.969	Do Not Test
16.000 vs. 15.000	0.136	7	1.949	0.812	Do Not Test
16.000 vs. 9.000	0.116	6	1.669	0.845	Do Not Test
16.000 vs. 13.000	0.0513	5	0.737	0.985	Do Not Test
16.000 vs. 5.000	0.0290	4	0.417	0.991	Do Not Test
16.000 vs. 14.000	0.0202	3	0.291	0.977	Do Not Test
16.000 vs. 8.000	0.0167	2	0.240	0.866	Do Not Test
8.000 vs. 15.000	0.119	6	1.709	0.832	Do Not Test
8.000 vs. 9.000	0.0995	5	1.429	0.850	Do Not Test
8.000 vs. 13.000	0.0346	4	0.497	0.985	Do Not Test
8.000 vs. 5.000	0.0123	3	0.177	0.991	Do Not Test
8.000 vs. 14.000	0.00355	2	0.0510	0.971	Do Not Test
14.000 vs. 15.000	0.115	5	1.658	0.767	Do Not Test
14.000 vs. 9.000	0.0959	4	1.378	0.764	Do Not Test
14.000 vs. 13.000	0.0310	3	0.446	0.947	Do Not Test
14.000 vs. 5.000	0.00878	2	0.126	0.929	Do Not Test
5.000 vs. 15.000	0.107	4	1.532	0.701	Do Not Test
5.000 vs. 9.000	0.0871	3	1.252	0.651	Do Not Test
5.000 vs. 13.000	0.0223	2	0.320	0.822	Do Not Test
13.000 vs. 15.000	0.0844	3	1.212	0.669	Do Not Test
13.000 vs. 9.000	0.0649	2	0.932	0.512	Do Not Test
9.000 vs. 15.000	0.0195	2	0.280	0.844	Do Not Test

Table 20. Two-way analysis of variance of electrical conductivity for textural class #3 continued.

Comparisons for factor: **wqtrt**

Comparison	Diff of Means	p	q	P	P<0.050
5CBM vs. Base	1.683	7	36.562	<0.001	Yes
5CBM vs. 1PR	1.403	6	30.465	<0.001	Yes
5CBM vs. 1CBM	1.066	5	23.151	<0.001	Yes
5CBM vs. 5PR	0.848	4	18.416	<0.001	Yes
5CBM vs. 5P+d	0.813	3	17.659	<0.001	Yes
5CBM vs. 5C+d	0.133	2	2.879	0.045	Yes
5C+d vs. Base	1.551	6	33.683	<0.001	Yes
5C+d vs. 1PR	1.270	5	27.586	<0.001	Yes
5C+d vs. 1CBM	0.933	4	20.272	<0.001	Yes
5C+d vs. 5PR	0.715	3	15.538	<0.001	Yes
5C+d vs. 5P+d	0.680	2	14.780	<0.001	Yes
5P+d vs. Base	0.870	5	18.903	<0.001	Yes
5P+d vs. 1PR	0.590	4	12.806	<0.001	Yes
5P+d vs. 1CBM	0.253	3	5.492	<0.001	Yes
5P+d vs. 5PR	0.0349	2	0.758	0.594	No
5PR vs. Base	0.835	4	18.146	<0.001	Yes
5PR vs. 1PR	0.555	3	12.048	<0.001	Yes
5PR vs. 1CBM	0.218	2	4.735	0.001	Yes
1CBM vs. Base	0.617	3	13.411	<0.001	Yes
1CBM vs. 1PR	0.337	2	7.314	<0.001	Yes
1PR vs. Base	0.281	2	6.097	<0.001	Yes

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Table 21. Two-way analysis of variance of electrical conductivity for textural class #4.

Two Way Analysis of Variance
Data source: Textural Class #4
General Linear Model (No Interactions)
Dependent Variable: log10(-EC(dS/m)

Normality Test:	Passed	(P > 0.200)
Equal Variance Test:	Passed	(P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
wqtrt	6	6.350	1.058	127.580	<0.001
rep	10	0.193	0.0193	2.331	0.021
Residual	60	0.498	0.00830		
Total	76	7.041	0.0926		

The difference in the mean values among the different levels of wqtrt is greater than would be expected by chance after allowing for effects of differences in rep. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of rep is greater than would be expected by chance after allowing for effects of differences in wqtrt. There is a statistically significant difference (P = 0.021). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for wqtrt : 1.000
Power of performed test with alpha = 0.0500: for rep : 0.615

Least square means for wqtrt :

Group	**Mean**
1CBM	0.430
1PR	0.246
5C+d	0.820
5CBM	0.873
5P+d	0.528
5PR	0.505
Base	-0.0167

Std Err of LS Mean = 0.0275

Least square means for rep :

Group	**Mean**
1.000	0.525
2.000	0.471
3.000	0.441
4.000	0.456
5.000	0.429
6.000	0.547
7.000	0.486
8.000	0.502
9.000	0.435
10.000	0.590
11.000	0.437

Std Err of LS Mean = 0.0344

Table 21. Two-way analysis of variance of electrical conductivity for textural class #4 continued.

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **wqtrt**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
5CBM vs. Base	0.890	7	32.395	<0.001	Yes
5CBM vs. 1PR	0.627	6	22.844	<0.001	Yes
5CBM vs. 1CBM	0.443	5	16.137	<0.001	Yes
5CBM vs. 5PR	0.368	4	13.401	<0.001	Yes
5CBM vs. 5P+d	0.345	3	12.568	<0.001	Yes
5CBM vs. 5C+d	0.0525	2	1.911	0.182	No
5C+d vs. Base	0.837	6	30.484	<0.001	Yes
5C+d vs. 1PR	0.575	5	20.933	<0.001	Yes
5C+d vs. 1CBM	0.391	4	14.226	<0.001	Yes
5C+d vs. 5PR	0.316	3	11.491	<0.001	Yes
5C+d vs. 5P+d	0.293	2	10.657	<0.001	Yes
5P+d vs. Base	0.544	5	19.827	<0.001	Yes
5P+d vs. 1PR	0.282	4	10.276	<0.001	Yes
5P+d vs. 1CBM	0.0980	3	3.569	0.038	Yes
5P+d vs. 5PR	0.0229	2	0.833	0.558	No
5PR vs. Base	0.522	4	18.993	<0.001	Yes
5PR vs. 1PR	0.259	3	9.443	<0.001	Yes
5PR vs. 1CBM	0.0751	2	2.736	0.058	No
1CBM vs. Base	0.446	3	16.258	<0.001	Yes
1CBM vs. 1PR	0.184	2	6.707	<0.001	Yes
1PR vs. Base	0.262	2	9.551	<0.001	Yes

Comparisons for factor: **rep**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
10.000 vs. 5.000	0.161	11	4.681	0.055	No
10.000 vs. 9.000	0.154	10	4.483	0.067	Do Not Test
10.000 vs. 11.000	0.153	9	4.445	0.061	Do Not Test
10.000 vs. 3.000	0.149	8	4.322	0.062	Do Not Test
10.000 vs. 4.000	0.134	7	3.887	0.104	Do Not Test
10.000 vs. 2.000	0.119	6	3.443	0.161	Do Not Test
10.000 vs. 7.000	0.104	5	3.014	0.221	Do Not Test
10.000 vs. 8.000	0.0881	4	2.560	0.279	Do Not Test
10.000 vs. 1.000	0.0651	3	1.891	0.381	Do Not Test
10.000 vs. 6.000	0.0424	2	1.231	0.388	Do Not Test
6.000 vs. 5.000	0.119	10	3.450	0.322	Do Not Test
6.000 vs. 9.000	0.112	9	3.252	0.359	Do Not Test
6.000 vs. 11.000	0.111	8	3.214	0.325	Do Not Test
6.000 vs. 3.000	0.106	7	3.091	0.319	Do Not Test
6.000 vs. 4.000	0.0914	6	2.656	0.425	Do Not Test
6.000 vs. 2.000	0.0762	5	2.212	0.526	Do Not Test

Table 21. Two-way analysis of variance of electrical conductivity for textural class #4 continued.

6.000 vs. 7.000	0.0614	4	1.783	0.591	Do Not Test
6.000 vs. 8.000	0.0458	3	1.329	0.618	Do Not Test
6.000 vs. 1.000	0.0227	2	0.660	0.642	Do Not Test
1.000 vs. 5.000	0.0961	9	2.790	0.568	Do Not Test
1.000 vs. 9.000	0.0892	8	2.592	0.601	Do Not Test
1.000 vs. 11.000	0.0879	7	2.554	0.549	Do Not Test
1.000 vs. 3.000	0.0837	6	2.431	0.525	Do Not Test
1.000 vs. 4.000	0.0687	5	1.996	0.623	Do Not Test
1.000 vs. 2.000	0.0534	4	1.552	0.692	Do Not Test
1.000 vs. 7.000	0.0387	3	1.123	0.708	Do Not Test
1.000 vs. 8.000	0.0230	2	0.669	0.638	Do Not Test
8.000 vs. 5.000	0.0730	8	2.121	0.804	Do Not Test
8.000 vs. 9.000	0.0662	7	1.923	0.820	Do Not Test
8.000 vs. 11.000	0.0649	6	1.885	0.766	Do Not Test
8.000 vs. 3.000	0.0607	5	1.762	0.725	Do Not Test
8.000 vs. 4.000	0.0457	4	1.327	0.784	Do Not Test
8.000 vs. 2.000	0.0304	3	0.883	0.807	Do Not Test
8.000 vs. 7.000	0.0156	2	0.454	0.749	Do Not Test
7.000 vs. 5.000	0.0574	7	1.667	0.899	Do Not Test
7.000 vs. 9.000	0.0506	6	1.469	0.903	Do Not Test
7.000 vs. 11.000	0.0493	5	1.431	0.849	Do Not Test
7.000 vs. 3.000	0.0450	4	1.308	0.792	Do Not Test
7.000 vs. 4.000	0.0300	3	0.873	0.811	Do Not Test
7.000 vs. 2.000	0.0148	2	0.429	0.763	Do Not Test
2.000 vs. 5.000	0.0426	6	1.238	0.951	Do Not Test
2.000 vs. 9.000	0.0358	5	1.040	0.947	Do Not Test
2.000 vs. 11.000	0.0345	4	1.002	0.893	Do Not Test
2.000 vs. 3.000	0.0302	3	0.879	0.809	Do Not Test
2.000 vs. 4.000	0.0153	2	0.444	0.755	Do Not Test
4.000 vs. 5.000	0.0273	5	0.794	0.980	Do Not Test
4.000 vs. 9.000	0.0205	4	0.596	0.975	Do Not Test
4.000 vs. 11.000	0.0192	3	0.558	0.918	Do Not Test
4.000 vs. 3.000	0.0150	2	0.435	0.760	Do Not Test
3.000 vs. 5.000	0.0124	4	0.359	0.994	Do Not Test
3.000 vs. 9.000	0.00554	3	0.161	0.993	Do Not Test
3.000 vs. 11.000	0.00424	2	0.123	0.931	Do Not Test
11.000 vs. 5.000	0.00813	3	0.236	0.985	Do Not Test
11.000 vs. 9.000	0.00131	2	0.0380	0.979	Do Not Test
9.000 vs. 5.000	0.00683	2	0.198	0.889	Do Not Test

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Table 22. Two-way analysis of variance of sodium adsorption ratio for textural class #1.

Two Way Analysis of Variance

Data source: Textural Class #1 SAR
General Linear Model (No Interactions)
Dependent Variable: sqrt(-SAR-)

Normality Test:	Passed	(P > 0.200)
Equal Variance Test:	Passed	(P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
Treat	6	41.425	6.904	476.543	<0.001
reps	8	1.116	0.139	9.626	<0.001
Residual	48	0.695	0.0145		
Total	62	43.236	0.697		

The difference in the mean values among the different levels of Treat is greater than would be expected by chance after allowing for effects of differences in reps. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of reps is greater than would be expected by chance after allowing for effects of differences in Treat. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for Treat : 1.000
Power of performed test with alpha = 0.0500: for reps : 1.000

Least square means for Treat :

Group	**Mean**
Base	1.060
1PR	1.749
1CBM	2.424
5PR	2.124
5P+d	1.988
5CBM	3.520
5C+d	3.364

Std Err of LS Mean = 0.0401

Least square means for reps :

Group	**Mean**
1.000	2.134
2.000	2.175
3.000	2.447
4.000	2.249
5.000	2.208
6.000	2.510
7.000	2.335
8.000	2.304
9.000	2.502

Std Err of LS Mean = 0.0455

Table 22. Two-way analysis of variance of sodium adsorption ratio for textural class #1 continued.

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor:

TreatComparison	Diff of Means	p	q	P	P<0.050
5CBM vs. Base	2.460	7	61.307	<0.001	Yes
5CBM vs. 1PR	1.771	6	44.143	<0.001	Yes
5CBM vs. 5P+d	1.532	5	38.187	<0.001	Yes
5CBM vs. 5PR	1.396	4	34.806	<0.001	Yes
5CBM vs. 1CBM	1.096	3	27.317	<0.001	Yes
5CBM vs. 5C+d	0.156	2	3.889	0.009	Yes
5C+d vs. Base	2.304	6	57.418	<0.001	Yes
5C+d vs. 1PR	1.615	5	40.254	<0.001	Yes
5C+d vs. 5P+d	1.376	4	34.298	<0.001	Yes
5C+d vs. 5PR	1.240	3	30.917	<0.001	Yes
5C+d vs. 1CBM	0.940	2	23.427	<0.001	Yes
1CBM vs. Base	1.364	5	33.991	<0.001	Yes
1CBM vs. 1PR	0.675	4	16.827	<0.001	Yes
1CBM vs. 5P+d	0.436	3	10.870	<0.001	Yes
1CBM vs. 5PR	0.300	2	7.489	<0.001	Yes
5PR vs. Base	1.063	4	26.502	<0.001	Yes
5PR vs. 1PR	0.375	3	9.337	<0.001	Yes
5PR vs. 5P+d	0.136	2	3.381	0.021	Yes
5P+d vs. Base	0.928	3	23.121	<0.001	Yes
5P+d vs. 1PR	0.239	2	5.957	<0.001	Yes
1PR vs. Base	0.689	2	17.164	<0.001	Yes

Comparisons for factor: **reps**

Comparison	Diff of Means	p	q	P	P<0.050
6.000 vs. 1.000	0.376	9	8.272	<0.001	Yes
6.000 vs. 2.000	0.335	8	7.366	<0.001	Yes
6.000 vs. 5.000	0.302	7	6.630	<0.001	Yes
6.000 vs. 4.000	0.261	6	5.747	0.002	Yes
6.000 vs. 8.000	0.206	5	4.523	0.020	Yes
6.000 vs. 7.000	0.175	4	3.838	0.044	Yes
6.000 vs. 3.000	0.0626	3	1.375	0.598	No
6.000 vs. 9.000	0.00769	2	0.169	0.906	Do Not Test
9.000 vs. 1.000	0.369	8	8.103	<0.001	Yes
9.000 vs. 2.000	0.327	7	7.197	<0.001	Yes
9.000 vs. 5.000	0.294	6	6.461	<0.001	Yes
9.000 vs. 4.000	0.254	5	5.578	0.002	Yes
9.000 vs. 8.000	0.198	4	4.355	0.018	Yes
9.000 vs. 7.000	0.167	3	3.670	0.033	Yes
9.000 vs. 3.000	0.0549	2	1.206	0.398	Do Not Test
3.000 vs. 1.000	0.314	7	6.897	<0.001	Yes

Table 22. Two-way analysis of variance of sodium adsorption ratio for textural class #1 continued.

3.000 vs. 2.000	0.273	6	5.991	0.001	Yes
3.000 vs. 5.000	0.239	5	5.255	0.005	Yes
3.000 vs. 4.000	0.199	4	4.372	0.017	Yes
3.000 vs. 8.000	0.143	3	3.148	0.077	No
3.000 vs. 7.000	0.112	2	2.463	0.088	Do Not Test
7.000 vs. 1.000	0.202	6	4.434	0.033	Yes
7.000 vs. 2.000	0.160	5	3.527	0.109	No
7.000 vs. 5.000	0.127	4	2.792	0.212	Do Not Test
7.000 vs. 4.000	0.0868	3	1.908	0.375	Do Not Test
7.000 vs. 8.000	0.0312	2	0.685	0.630	Do Not Test
8.000 vs. 1.000	0.171	5	3.749	0.077	No
8.000 vs. 2.000	0.129	4	2.842	0.199	Do Not Test
8.000 vs. 5.000	0.0958	3	2.107	0.305	Do Not Test
8.000 vs. 4.000	0.0557	2	1.223	0.392	Do Not Test
4.000 vs. 1.000	0.115	4	2.525	0.293	Do Not Test
4.000 vs. 2.000	0.0736	3	1.619	0.492	Do Not Test
4.000 vs. 5.000	0.0402	2	0.883	0.535	Do Not Test
5.000 vs. 1.000	0.0747	3	1.642	0.482	Do Not Test
5.000 vs. 2.000	0.0335	2	0.735	0.606	Do Not Test
2.000 vs. 1.000	0.0412	2	0.907	0.525	Do Not Test

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Table 23. Two-way analysis of variance of sodium adsorption ratio for textural class #2.

Two Way Analysis of Variance
Data source: Textural Class #2 SAR data in Notebook
General Linear Model (No Interactions)
Dependent Variable: SAR

Normality Test:	Passed	(P = 0.016)
Equal Variance Test:	Passed	(P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
Treat	6	1021.748	170.291	356.767	<0.001
REP	12	45.501	3.792	7.944	<0.001
Residual	72	34.367	0.477		
Total	90	1101.616	12.240		

The difference in the mean values among the different levels of Treat is greater than would be expected by chance after allowing for effects of differences in REP. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of REP is greater than would be expected by chance after allowing for effects of differences in Treat. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for Treat : 1.000
Power of performed test with alpha = 0.0500: for REP : 1.000

Least square means for Treat :

Group	**Mean**
Base	2.147
1PR	3.398
1CBM	5.631
5PR	4.465
5P+d	4.495
5CBM	11.534
5C+d	10.649

Std Err of LS Mean = 0.192

Table 23. Two-way analysis of variance of sodium adsorption ratio for textural class #2 continued.

Least square means for REP :

Group	Mean
1.000	4.684
2.000	5.483
3.000	5.281
4.000	6.589
5.000	6.383
6.000	7.353
7.000	5.343
8.000	6.523
9.000	6.786
10.000	5.617
11.000	6.391
12.000	5.916
13.000	6.244

Std Err of LS Mean = 0.261

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **Treat**

Comparison	Diff of Means	p	q	P	P<0.050
5CBM vs. Base	9.387	7	48.988	<0.001	Yes
5CBM vs. 1PR	8.135	6	42.457	<0.001	Yes
5CBM vs. 5PR	7.068	5	36.889	<0.001	Yes
5CBM vs. 5P+d	7.039	4	36.736	<0.001	Yes
5CBM vs. 1CBM	5.903	3	30.807	<0.001	Yes
5CBM vs. 5C+d	0.885	2	4.617	0.002	Yes
5C+d vs. Base	8.502	6	44.372	<0.001	Yes
5C+d vs. 1PR	7.251	5	37.840	<0.001	Yes
5C+d vs. 5PR	6.184	4	32.272	<0.001	Yes
5C+d vs. 5P+d	6.155	3	32.119	<0.001	Yes
5C+d vs. 1CBM	5.018	2	26.190	<0.001	Yes
1CBM vs. Base	3.484	5	18.181	<0.001	Yes
1CBM vs. 1PR	2.232	4	11.650	<0.001	Yes
1CBM vs. 5PR	1.165	3	6.082	<0.001	Yes
1CBM vs. 5P+d	1.136	2	5.929	<0.001	Yes
5P+d vs. Base	2.348	4	12.252	<0.001	Yes
5P+d vs. 1PR	1.096	3	5.721	<0.001	Yes
5P+d vs. 5PR	0.0292	2	0.153	0.914	No
5PR vs. Base	2.318	3	12.099	<0.001	Yes
5PR vs. 1PR	1.067	2	5.568	<0.001	Yes
1PR vs. Base	1.252	2	6.531	<0.001	Yes

Comparisons for factor: **REP**

Comparison	Diff of Means	p	q	P	P<0.050
6.000 vs. 1.000	2.669	13	10.219	<0.001	Yes
6.000 vs. 3.000	2.071	12	7.933	<0.001	Yes

Table 23. Two-way analysis of variance of sodium adsorption ratio for textural class #2 continued.

6.000 vs. 7.000	2.010	11	7.697	<0.001	Yes
6.000 vs. 2.000	1.870	10	7.161	<0.001	Yes
6.000 vs. 10.000	1.736	9	6.647	<0.001	Yes
6.000 vs. 12.000	1.437	8	5.504	0.005	Yes
6.000 vs. 13.000	1.109	7	4.245	0.054	No
6.000 vs. 5.000	0.970	6	3.715	0.104	Do Not Test
6.000 vs. 11.000	0.961	5	3.682	0.080	Do Not Test
6.000 vs. 8.000	0.830	4	3.179	0.120	Do Not Test
6.000 vs. 4.000	0.764	3	2.927	0.104	Do Not Test
6.000 vs. 9.000	0.567	2	2.172	0.129	Do Not Test
9.000 vs. 1.000	2.101	12	8.047	<0.001	Yes
9.000 vs. 3.000	1.504	11	5.761	0.005	Yes
9.000 vs. 7.000	1.443	10	5.525	0.008	Yes
9.000 vs. 2.000	1.303	9	4.989	0.020	Yes
9.000 vs. 10.000	1.169	8	4.475	0.045	Yes
9.000 vs. 12.000	0.870	7	3.332	0.233	No
9.000 vs. 13.000	0.541	6	2.073	0.687	Do Not Test
9.000 vs. 5.000	0.403	5	1.543	0.811	Do Not Test
9.000 vs. 11.000	0.394	4	1.510	0.710	Do Not Test
9.000 vs. 8.000	0.263	3	1.007	0.757	Do Not Test
9.000 vs. 4.000	0.197	2	0.755	0.595	Do Not Test
4.000 vs. 1.000	1.904	11	7.293	<0.001	Yes
4.000 vs. 3.000	1.307	10	5.006	0.023	Yes
4.000 vs. 7.000	1.246	9	4.770	0.031	Yes
4.000 vs. 2.000	1.106	8	4.234	0.070	No
4.000 vs. 10.000	0.971	7	3.720	0.132	Do Not Test
4.000 vs. 12.000	0.673	6	2.577	0.459	Do Not Test
4.000 vs. 13.000	0.344	5	1.318	0.883	Do Not Test
4.000 vs. 5.000	0.206	4	0.788	0.944	Do Not Test
4.000 vs. 11.000	0.197	3	0.755	0.855	Do Not Test
4.000 vs. 8.000	0.0657	2	0.252	0.859	Do Not Test
8.000 vs. 1.000	1.839	10	7.041	<0.001	Yes
8.000 vs. 3.000	1.241	9	4.754	0.032	Yes
8.000 vs. 7.000	1.180	8	4.519	0.041	Yes
8.000 vs. 2.000	1.040	7	3.983	0.086	Do Not Test
8.000 vs. 10.000	0.906	6	3.468	0.153	Do Not Test
8.000 vs. 12.000	0.607	5	2.325	0.475	Do Not Test
8.000 vs. 13.000	0.279	4	1.067	0.875	Do Not Test
8.000 vs. 5.000	0.140	3	0.536	0.924	Do Not Test
8.000 vs. 11.000	0.131	2	0.503	0.723	Do Not Test
11.000 vs. 1.000	1.707	9	6.538	<0.001	Yes
11.000 vs. 3.000	1.110	8	4.251	0.068	No
11.000 vs. 7.000	1.049	7	4.016	0.082	Do Not Test
11.000 vs. 2.000	0.909	6	3.479	0.150	Do Not Test
11.000 vs. 10.000	0.774	5	2.965	0.233	Do Not Test

Table 23. Two-way analysis of variance of sodium adsorption ratio for textural class #2 continued.

11.000 vs. 12.000	0.476	4	1.822	0.573	Do Not Test
11.000 vs. 13.000	0.147	3	0.563	0.916	Do Not Test
11.000 vs. 5.000	0.00857	2	0.0328	0.982	Do Not Test
5.000 vs. 1.000	1.699	8	6.505	<0.001	Yes
5.000 vs. 3.000	1.101	7	4.218	0.057	Do Not Test
5.000 vs. 7.000	1.040	6	3.983	0.066	Do Not Test
5.000 vs. 2.000	0.900	5	3.447	0.117	Do Not Test
5.000 vs. 10.000	0.766	4	2.932	0.172	Do Not Test
5.000 vs. 12.000	0.467	3	1.789	0.420	Do Not Test
5.000 vs. 13.000	0.139	2	0.531	0.709	Do Not Test
13.000 vs. 1.000	1.560	7	5.974	0.001	Yes
13.000 vs. 3.000	0.963	6	3.687	0.109	Do Not Test
13.000 vs. 7.000	0.901	5	3.452	0.116	Do Not Test
13.000 vs. 2.000	0.761	4	2.916	0.176	Do Not Test
13.000 vs. 10.000	0.627	3	2.402	0.213	Do Not Test
13.000 vs. 12.000	0.329	2	1.258	0.377	Do Not Test
12.000 vs. 1.000	1.231	6	4.716	0.016	Yes
12.000 vs. 3.000	0.634	5	2.429	0.430	Do Not Test
12.000 vs. 7.000	0.573	4	2.194	0.413	Do Not Test
12.000 vs. 2.000	0.433	3	1.658	0.474	Do Not Test
12.000 vs. 10.000	0.299	2	1.143	0.422	Do Not Test
10.000 vs. 1.000	0.933	5	3.572	0.096	No
10.000 vs. 3.000	0.336	4	1.286	0.800	Do Not Test
10.000 vs. 7.000	0.274	3	1.050	0.739	Do Not Test
10.000 vs. 2.000	0.134	2	0.514	0.717	Do Not Test
2.000 vs. 1.000	0.799	4	3.058	0.144	Do Not Test
2.000 vs. 3.000	0.201	3	0.771	0.849	Do Not Test
2.000 vs. 7.000	0.140	2	0.536	0.706	Do Not Test
7.000 vs. 1.000	0.659	3	2.522	0.183	Do Not Test
7.000 vs. 3.000	0.0614	2	0.235	0.868	Do Not Test
3.000 vs. 1.000	0.597	2	2.287	0.110	Do Not Test

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Table 24. Two-way analysis of variance of sodium adsorption ratio for textural class #3.

Two Way Analysis of Variance
Data source: Textural Class #3 SAR data in Notebook
General Linear Model (No Interactions)
Dependent Variable: SAR

Normality Test:	Passed	(P = 0.022)
Equal Variance Test:	Passed	(P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
Treat	6	878.375	146.396	166.852	<0.001
REP	15	600.293	40.020	45.612	<0.001
Residual	90	78.966	0.877		
Total	111	1557.634	14.033		

The difference in the mean values among the different levels of Treat is greater than would be expected by chance after allowing for effects of differences in REP. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of REP is greater than would be expected by chance after allowing for effects of differences in Treat. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for Treat : 1.000
Power of performed test with alpha = 0.0500: for REP : 1.000

Least square means for Treat :

Group	**Mean**
Base	1.974
1PR	3.100
1CBM	5.024
5PR	4.099
5P+d	4.069
5CBM	9.567
5C+d	9.514

Std Err of LS Mean = 0.234

Least square means for REP :

Group	**Mean**
1.000	4.261
2.000	3.779
3.000	5.596
4.000	5.136
5.000	4.313
6.000	3.784
7.000	8.256
8.000	4.850
9.000	4.276
10.000	4.007

Table 24. Two-way analysis of variance of sodium adsorption ratio for textural class #3 continued.

11.000	13.394
12.000	5.130
13.000	4.576
14.000	4.724
15.000	4.454
16.000	4.831

Std Err of LS Mean = 0.354

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :
Comparisons for factor: **Treat**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
5CBM vs. Base	7.593	7	32.425	<0.001	Yes
5CBM vs. 1PR	6.468	6	27.618	<0.001	Yes
5CBM vs. 5P+d	5.499	5	23.482	<0.001	Yes
5CBM vs. 5PR	5.469	4	23.353	<0.001	Yes
5CBM vs. 1CBM	4.543	3	19.401	<0.001	Yes
5CBM vs. 5C+d	0.0531	2	0.227	0.873	No
5C+d vs. Base	7.540	6	32.198	<0.001	Yes
5C+d vs. 1PR	6.414	5	27.392	<0.001	Yes
5C+d vs. 5P+d	5.446	4	23.255	<0.001	Yes
5C+d vs. 5PR	5.416	3	23.127	<0.001	Yes
5C+d vs. 1CBM	4.490	2	19.174	<0.001	Yes
1CBM vs. Base	3.050	5	13.025	<0.001	Yes
1CBM vs. 1PR	1.924	4	8.218	<0.001	Yes
1CBM vs. 5P+d	0.956	3	4.081	0.014	Yes
1CBM vs. 5PR	0.926	2	3.953	0.006	Yes
5PR vs. Base	2.124	4	9.072	<0.001	Yes
5PR vs. 1PR	0.999	3	4.265	0.009	Yes
5PR vs. 5P+d	0.0300	2	0.128	0.928	No
5P+d vs. Base	2.094	3	8.944	<0.001	Yes
5P+d vs. 1PR	0.969	2	4.137	0.004	Yes
1PR vs. Base	1.126	2	4.807	0.001	Yes

Comparisons for factor: **REP**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
11.000 vs. 2.000	9.616	16	27.160	<0.001	Yes
11.000 vs. 6.000	9.610	15	27.144	<0.001	Yes
11.000 vs. 10.000	9.387	14	26.515	<0.001	Yes
11.000 vs. 1.000	9.133	13	25.796	<0.001	Yes
11.000 vs. 9.000	9.119	12	25.756	<0.001	Yes
11.000 vs. 5.000	9.081	11	25.651	<0.001	Yes
11.000 vs. 15.000	8.940	10	25.252	<0.001	Yes
11.000 vs. 13.000	8.819	9	24.909	<0.001	Yes
11.000 vs. 14.000	8.670	8	24.489	<0.001	Yes

Table 24. Two-way analysis of variance of sodium adsorption ratio for textural class #3 continued.

11.000 vs. 16.000	8.563	7	24.186	<0.001	Yes
11.000 vs. 8.000	8.544	6	24.134	<0.001	Yes
11.000 vs. 12.000	8.264	5	23.343	<0.001	Yes
11.000 vs. 4.000	8.259	4	23.327	<0.001	Yes
11.000 vs. 3.000	7.799	3	22.028	<0.001	Yes
11.000 vs. 7.000	5.139	2	14.514	<0.001	Yes
7.000 vs. 2.000	4.477	15	12.646	<0.001	Yes
7.000 vs. 6.000	4.471	14	12.630	<0.001	Yes
7.000 vs. 10.000	4.249	13	12.000	<0.001	Yes
7.000 vs. 1.000	3.994	12	11.282	<0.001	Yes
7.000 vs. 9.000	3.980	11	11.242	<0.001	Yes
7.000 vs. 5.000	3.943	10	11.137	<0.001	Yes
7.000 vs. 15.000	3.801	9	10.737	<0.001	Yes
7.000 vs. 13.000	3.680	8	10.394	<0.001	Yes
7.000 vs. 14.000	3.531	7	9.975	<0.001	Yes
7.000 vs. 16.000	3.424	6	9.672	<0.001	Yes
7.000 vs. 8.000	3.406	5	9.620	<0.001	Yes
7.000 vs. 12.000	3.126	4	8.829	<0.001	Yes
7.000 vs. 4.000	3.120	3	8.813	<0.001	Yes
7.000 vs. 3.000	2.660	2	7.513	<0.001	Yes
3.000 vs. 2.000	1.817	14	5.133	0.029	Yes
3.000 vs. 6.000	1.811	13	5.116	0.027	Yes
3.000 vs. 10.000	1.589	12	4.487	0.082	No
3.000 vs. 1.000	1.334	11	3.769	0.233	Do Not Test
3.000 vs. 9.000	1.320	10	3.728	0.217	Do Not Test
3.000 vs. 5.000	1.283	9	3.624	0.218	Do Not Test
3.000 vs. 15.000	1.141	8	3.224	0.316	Do Not Test
3.000 vs. 13.000	1.020	7	2.881	0.399	Do Not Test
3.000 vs. 14.000	0.871	6	2.461	0.509	Do Not Test
3.000 vs. 16.000	0.764	5	2.159	0.548	Do Not Test
3.000 vs. 8.000	0.746	4	2.106	0.448	Do Not Test
3.000 vs. 12.000	0.466	3	1.315	0.623	Do Not Test
3.000 vs. 4.000	0.460	2	1.299	0.361	Do Not Test
4.000 vs. 2.000	1.357	13	3.833	0.265	No
4.000 vs. 6.000	1.351	12	3.817	0.244	Do Not Test
4.000 vs. 10.000	1.129	11	3.188	0.474	Do Not Test
4.000 vs. 1.000	0.874	10	2.469	0.766	Do Not Test
4.000 vs. 9.000	0.860	9	2.429	0.734	Do Not Test
4.000 vs. 5.000	0.823	8	2.324	0.723	Do Not Test
4.000 vs. 15.000	0.681	7	1.925	0.821	Do Not Test
4.000 vs. 13.000	0.560	6	1.582	0.873	Do Not Test
4.000 vs. 14.000	0.411	5	1.162	0.923	Do Not Test
4.000 vs. 16.000	0.304	4	0.859	0.929	Do Not Test
4.000 vs. 8.000	0.286	3	0.807	0.836	Do Not Test
4.000 vs. 12.000	0.00571	2	0.0161	0.991	Do Not Test

Table 24. Two-way analysis of variance of sodium adsorption ratio for textural class #3 continued.

12.000 vs. 2.000	1.351	12	3.817	0.244	Do Not Test
12.000 vs. 6.000	1.346	11	3.801	0.222	Do Not Test
12.000 vs. 10.000	1.123	10	3.172	0.436	Do Not Test
12.000 vs. 1.000	0.869	9	2.453	0.724	Do Not Test
12.000 vs. 9.000	0.854	8	2.413	0.683	Do Not Test
12.000 vs. 5.000	0.817	7	2.308	0.662	Do Not Test
12.000 vs. 15.000	0.676	6	1.909	0.757	Do Not Test
12.000 vs. 13.000	0.554	5	1.566	0.802	Do Not Test
12.000 vs. 14.000	0.406	4	1.146	0.850	Do Not Test
12.000 vs. 16.000	0.299	3	0.843	0.823	Do Not Test
12.000 vs. 8.000	0.280	2	0.791	0.578	Do Not Test
8.000 vs. 2.000	1.071	11	3.026	0.553	Do Not Test
8.000 vs. 6.000	1.066	10	3.010	0.513	Do Not Test
8.000 vs. 10.000	0.843	9	2.381	0.755	Do Not Test
8.000 vs. 1.000	0.589	8	1.662	0.937	Do Not Test
8.000 vs. 9.000	0.574	7	1.622	0.912	Do Not Test
8.000 vs. 5.000	0.537	6	1.517	0.891	Do Not Test
8.000 vs. 15.000	0.396	5	1.118	0.933	Do Not Test
8.000 vs. 13.000	0.274	4	0.775	0.947	Do Not Test
8.000 vs. 14.000	0.126	3	0.355	0.966	Do Not Test
8.000 vs. 16.000	0.0186	2	0.0525	0.971	Do Not Test
16.000 vs. 2.000	1.053	10	2.974	0.531	Do Not Test
16.000 vs. 6.000	1.047	9	2.958	0.486	Do Not Test
16.000 vs. 10.000	0.824	8	2.328	0.721	Do Not Test
16.000 vs. 1.000	0.570	7	1.610	0.914	Do Not Test
16.000 vs. 9.000	0.556	6	1.570	0.876	Do Not Test
16.000 vs. 5.000	0.519	5	1.465	0.838	Do Not Test
16.000 vs. 15.000	0.377	4	1.065	0.875	Do Not Test
16.000 vs. 13.000	0.256	3	0.722	0.866	Do Not Test
16.000 vs. 14.000	0.107	2	0.303	0.831	Do Not Test
14.000 vs. 2.000	0.946	9	2.671	0.623	Do Not Test
14.000 vs. 6.000	0.940	8	2.655	0.570	Do Not Test
14.000 vs. 10.000	0.717	7	2.026	0.783	Do Not Test
14.000 vs. 1.000	0.463	6	1.307	0.939	Do Not Test
14.000 vs. 9.000	0.449	5	1.267	0.898	Do Not Test
14.000 vs. 5.000	0.411	4	1.162	0.844	Do Not Test
14.000 vs. 15.000	0.270	3	0.763	0.852	Do Not Test
14.000 vs. 13.000	0.149	2	0.420	0.767	Do Not Test
13.000 vs. 2.000	0.797	8	2.252	0.754	Do Not Test
13.000 vs. 6.000	0.791	7	2.235	0.695	Do Not Test
13.000 vs. 10.000	0.569	6	1.606	0.865	Do Not Test
13.000 vs. 1.000	0.314	5	0.888	0.970	Do Not Test
13.000 vs. 9.000	0.300	4	0.847	0.932	Do Not Test
13.000 vs. 5.000	0.263	3	0.742	0.859	Do Not Test

Table 24. Two-way analysis of variance of sodium adsorption ratio for textural class #3 continued.

13.000 vs. 15.000	0.121	2	0.343	0.809	Do Not Test
15.000 vs. 2.000	0.676	7	1.909	0.827	Do Not Test
15.000 vs. 6.000	0.670	6	1.892	0.763	Do Not Test
15.000 vs. 10.000	0.447	5	1.263	0.899	Do Not Test
15.000 vs. 1.000	0.193	4	0.545	0.981	Do Not Test
15.000 vs. 9.000	0.179	3	0.504	0.932	Do Not Test
15.000 vs. 5.000	0.141	2	0.399	0.778	Do Not Test
5.000 vs. 2.000	0.534	6	1.509	0.893	Do Not Test
5.000 vs. 6.000	0.529	5	1.493	0.829	Do Not Test
5.000 vs. 10.000	0.306	4	0.864	0.929	Do Not Test
5.000 vs. 1.000	0.0514	3	0.145	0.994	Do Not Test
5.000 vs. 9.000	0.0371	2	0.105	0.941	Do Not Test
9.000 vs. 2.000	0.497	5	1.404	0.858	Do Not Test
9.000 vs. 6.000	0.491	4	1.388	0.760	Do Not Test
9.000 vs. 10.000	0.269	3	0.759	0.854	Do Not Test
9.000 vs. 1.000	0.0143	2	0.0404	0.977	Do Not Test
1.000 vs. 2.000	0.483	4	1.364	0.770	Do Not Test
1.000 vs. 6.000	0.477	3	1.348	0.608	Do Not Test
1.000 vs. 10.000	0.254	2	0.718	0.613	Do Not Test
10.000 vs. 2.000	0.229	3	0.646	0.892	Do Not Test
10.000 vs. 6.000	0.223	2	0.629	0.657	Do Not Test
6.000 vs. 2.000	0.00571	2	0.0161	0.991	Do Not Test

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Table 25. Two-way analysis of variance of sodium adsorption ratio for textural class #4.

Two Way Analysis of Variance
Data source: Textural Class #4 SAR data in Notebook
General Linear Model (No Interactions)
Dependent Variable: log10(-SAR-)

Normality Test:	Passed	(P > 0.200)
Equal Variance Test:	Passed	(P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
Treat	6	2.321	0.387	43.417	<0.001
REP	10	4.905	0.491	55.059	<0.001
Residual	60	0.535	0.00891		
Total	76	7.760	0.102		

The difference in the mean values among the different levels of Treat is greater than would be expected by chance after allowing for effects of differences in REP. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of REP is greater than would be expected by chance after allowing for effects of differences in Treat. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for Treat : 1.000
Power of performed test with alpha = 0.0500: for REP : 1.000

Least square means for Treat :

Group	**Mean**
Base	0.527
1PR	0.665
1CBM	0.785
5PR	0.733
5P+d	0.743
5CBM	1.037
5C+d	1.035

Std Err of LS Mean = 0.0285

Least square means for REP :

Group	**Mean**
1.000	0.534
2.000	0.847
3.000	0.914
4.000	0.627
5.000	0.565
6.000	0.960
7.000	1.159
8.000	0.621
9.000	0.571

Table 25. Two-way analysis of variance of sodium absorption ratio for textural class #4 continued.

10.000 1.296
11.000 0.587
Std Err of LS Mean = 0.0357

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **Treat**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
5CBM vs. Base	0.510	7	17.906	<0.001	Yes
5CBM vs. 1PR	0.372	6	13.066	<0.001	Yes
5CBM vs. 5PR	0.304	5	10.685	<0.001	Yes
5CBM vs. 5P+d	0.293	4	10.310	<0.001	Yes
5CBM vs. 1CBM	0.252	3	8.841	<0.001	Yes
5CBM vs. 5C+d	0.00206	2	0.0723	0.959	No
5C+d vs. Base	0.508	6	17.834	<0.001	Yes
5C+d vs. 1PR	0.370	5	12.994	<0.001	Yes
5C+d vs. 5PR	0.302	4	10.613	<0.001	Yes
5C+d vs. 5P+d	0.291	3	10.237	<0.001	Yes
5C+d vs. 1CBM	0.250	2	8.769	<0.001	Yes
1CBM vs. Base	0.258	5	9.065	<0.001	Yes
1CBM vs. 1PR	0.120	4	4.225	0.021	Yes
1CBM vs. 5PR	0.0525	3	1.844	0.399	No
1CBM vs. 5P+d	0.0418	2	1.469	0.303	Do Not Test
5P+d vs. Base	0.216	4	7.597	<0.001	Yes
5P+d vs. 1PR	0.0784	3	2.757	0.134	No
5P+d vs. 5PR	0.0107	2	0.375	0.792	Do Not Test
5PR vs. Base	0.206	3	7.222	<0.001	Yes
5PR vs. 1PR	0.0678	2	2.382	0.097	Do Not Test
1PR vs. Base	0.138	2	4.840	0.001	Yes

Comparisons for factor: **REP**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
10.000 vs. 1.000	0.762	11	21.370	<0.001	Yes
10.000 vs. 5.000	0.731	10	20.498	<0.001	Yes
10.000 vs. 9.000	0.725	9	20.335	<0.001	Yes
10.000 vs. 11.000	0.709	8	19.886	<0.001	Yes
10.000 vs. 8.000	0.675	7	18.908	<0.001	Yes
10.000 vs. 4.000	0.669	6	18.752	<0.001	Yes
10.000 vs. 2.000	0.449	5	12.590	<0.001	Yes
10.000 vs. 3.000	0.382	4	10.702	<0.001	Yes
10.000 vs. 6.000	0.336	3	9.405	<0.001	Yes
10.000 vs. 7.000	0.137	2	3.846	0.009	Yes
7.000 vs. 1.000	0.625	10	17.524	<0.001	Yes
7.000 vs. 5.000	0.594	9	16.651	<0.001	Yes

Table 25. Two-way analysis of variance of sodium adsorption ratio for textural class #4 continued.

7.000 vs. 9.000	0.588	8	16.489	<0.001	Yes
7.000 vs. 11.000	0.572	7	16.040	<0.001	Yes
7.000 vs. 8.000	0.537	6	15.062	<0.001	Yes
7.000 vs. 4.000	0.532	5	14.906	<0.001	Yes
7.000 vs. 2.000	0.312	4	8.743	<0.001	Yes
7.000 vs. 3.000	0.245	3	6.855	<0.001	Yes
7.000 vs. 6.000	0.198	2	5.559	<0.001	Yes
6.000 vs. 1.000	0.427	9	11.965	<0.001	Yes
6.000 vs. 5.000	0.396	8	11.092	<0.001	Yes
6.000 vs. 9.000	0.390	7	10.929	<0.001	Yes
6.000 vs. 11.000	0.374	6	10.481	<0.001	Yes
6.000 vs. 8.000	0.339	5	9.503	<0.001	Yes
6.000 vs. 4.000	0.333	4	9.347	<0.001	Yes
6.000 vs. 2.000	0.114	3	3.184	0.071	No
6.000 vs. 3.000	0.0462	2	1.296	0.363	Do Not Test
3.000 vs. 1.000	0.381	8	10.669	<0.001	Yes
3.000 vs. 5.000	0.349	7	9.796	<0.001	Yes
3.000 vs. 9.000	0.344	6	9.633	<0.001	Yes
3.000 vs. 11.000	0.328	5	9.184	<0.001	Yes
3.000 vs. 8.000	0.293	4	8.207	<0.001	Yes
3.000 vs. 4.000	0.287	3	8.051	<0.001	Yes
3.000 vs. 2.000	0.0674	2	1.888	0.187	Do Not Test
2.000 vs. 1.000	0.313	7	8.781	<0.001	Yes
2.000 vs. 5.000	0.282	6	7.908	<0.001	Yes
2.000 vs. 9.000	0.276	5	7.745	<0.001	Yes
2.000 vs. 11.000	0.260	4	7.296	<0.001	Yes
2.000 vs. 8.000	0.225	3	6.318	<0.001	Yes
2.000 vs. 4.000	0.220	2	6.163	<0.001	Yes
4.000 vs. 1.000	0.0934	6	2.618	0.442	No
4.000 vs. 5.000	0.0623	5	1.746	0.732	Do Not Test
4.000 vs. 9.000	0.0565	4	1.583	0.679	Do Not Test
4.000 vs. 11.000	0.0404	3	1.134	0.703	Do Not Test
4.000 vs. 8.000	0.00556	2	0.156	0.913	Do Not Test
8.000 vs. 1.000	0.0878	5	2.462	0.417	Do Not Test
8.000 vs. 5.000	0.0567	4	1.590	0.676	Do Not Test
8.000 vs. 9.000	0.0509	3	1.427	0.574	Do Not Test
8.000 vs. 11.000	0.0349	2	0.978	0.492	Do Not Test
11.000 vs. 1.000	0.0530	4	1.484	0.721	Do Not Test
11.000 vs. 5.000	0.0218	3	0.612	0.902	Do Not Test
11.000 vs. 9.000	0.0160	2	0.449	0.752	Do Not Test
9.000 vs. 1.000	0.0369	3	1.036	0.745	Do Not Test
9.000 vs. 5.000	0.00581	2	0.163	0.909	Do Not Test
5.000 vs. 1.000	0.0311	2	0.873	0.540	Do Not Test

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Table 26. One-way analysis of variance (water quality treatment) of mean water content at -1/10 bar for textural class #1.

One Way Analysis of Variance

Data source: -1/10 BAR – Textural Class #1 DATA in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: FSL DATA in Notebook

Group	N	Missing	Median	25%	75%
1XPR	27	0	0.290	0.240	0.310
1XCBM	27	0	0.280	0.223	0.310
5XPR	27	0	0.240	0.195	0.270
5XCBM	27	0	0.240	0.193	0.270
5XPR+d	27	0	0.250	0.200	0.270
5XCBM+d	27	0	0.250	0.200	0.280

H = 20.513 with 5 degrees of freedom. (P = 0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparison	Diff of Ranks	q	P<0.05
1XPR vs 5XPR	1130.000	4.636	Yes
1XPR vs 5XPR+d	1119.500	4.593	Yes
1XPR vs 5XCBM	1096.000	4.496	Yes
1XPR vs 5XCBM+d	886.000	3.635	No
1XPR vs 1XCBM	268.500	1.102	Do Not Test
1XCBM vs 5XPR	861.500	3.534	No
1XCBM vs 5XPR+d	851.000	3.491	Do Not Test
1XCBM vs 5XCBM	827.500	3.395	Do Not Test
1XCBM vs 5XCBM+d	617.500	2.533	Do Not Test
5XCBM+d vs 5XPR	244.000	1.001	Do Not Test
5XCBM+d vs 5XPR+d	233.500	0.958	Do Not Test
5XCBM+d vs 5XCBM	210.000	0.862	Do Not Test
5XCBM vs 5XPR	34.000	0.139	Do Not Test
5XCBM vs 5XPR+d	23.500	0.0964	Do Not Test
5XPR+d vs 5XPR	10.500	0.0431	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Table 27. One-way analysis of variance (water quality treatment) of mean water content at -1/3 bar for textural class #1.

One Way Analysis of Variance

Data source: -1/3 BAR – Textural Class #1 DATA in Notebook

Normality Test: Passed (P = 0.089)
Equal Variance Test: Passed (P = 0.827)

Group Name	N	Missing	Mean	Std Dev	SEM
1XPR	27	0	0.109	0.0337	0.00649
1XCBM	27	0	0.102	0.0362	0.00697
5XPR	27	0	0.110	0.0304	0.00585
5XCBM	27	0	0.115	0.0282	0.00543
5XPR+d	27	0	0.109	0.0334	0.00642
5XCBM+d	27	0	0.120	0.0307	0.00591

Source of Variation	DF	SS	MS	F	P
Between Groups	5	0.00491	0.000981	0.947	0.453
Residual	156	0.162	0.00104		
Total	161	0.167			

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.453).

Power of performed test with alpha = 0.050: 0.050
The power of the performed test (0.050) is below the desired power of 0.800.
You should interpret the negative findings cautiously.

Table 28. One-way analysis of variance (water quality treatment) of mean water content at -1 bar for textural class #1.

One Way Analysis of Variance

Data source: -1 BAR – Textural Class #1 DATA in Notebook

Normality Test: Passed (P = 0.043)
Equal Variance Test: Passed (P = 0.845)

Group Name	N	Missing	Mean	Std Dev	SEM
1XPR	27	0	0.0607	0.0177	0.00341
1XCBM	27	0	0.0604	0.0170	0.00327
5XPR	27	0	0.0570	0.0138	0.00266
5XCBM	27	0	0.0589	0.0158	0.00304
5XPR+d	27	0	0.0630	0.0166	0.00319
5XCBM+d	27	0	0.0637	0.0167	0.00321

Source of Variation	DF	SS	MS	F	P
Between Groups	5	0.000835	0.000167	0.627	0.679
Residual	156	0.0415	0.000266		
Total	161	0.0423			

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.679).

Power of performed test with alpha = 0.050: 0.050
The power of the performed test (0.050) is below the desired power of 0.800.
You should interpret the negative findings cautiously.

Table 29. One-way analysis of variance (water quality treatment) of mean water content at -5 bar for textural class #1.

One Way Analysis of Variance

Data source: -5 BAR Textural Class #1 DATA in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: 5 BARR – Textural Class #1 DATA in Notebook

Group	N	Missing	Median	25%	75%
1XPR	27	0	0.0400	0.0400	0.0500
1XCBM	27	0	0.0500	0.0400	0.0500
5XPR	27	0	0.0500	0.0400	0.0500
5XCBM	27	0	0.0500	0.0400	0.0500
5XPR+d	27	0	0.0400	0.0300	0.0500
5XCBM+d	27	0	0.0500	0.0400	0.0500

H = 1.613 with 5 degrees of freedom. (P = 0.900)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.900)

Table 30. One-way analysis of variance (water quality treatment) of mean water content at -15 bar for textural class #1.

One Way Analysis of Variance

Data source: -15 BAR FSL DATA in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: Textural Class #1 DATA in Notebook

Group	N	Missing	Median	25%	75%
1XPR	27	0	0.0400	0.0300	0.0400
1XCBM	27	0	0.0400	0.0300	0.0400
5XPR	27	0	0.0400	0.0300	0.0400
5XCBM	27	0	0.0400	0.0300	0.0400
5XPR+d	27	0	0.0400	0.0300	0.0400
5XCBM+d	27	0	0.0400	0.0325	0.0500

H = 5.075 with 5 degrees of freedom. (P = 0.407)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that The difference is due to random sampling variability; there is not a statistically significant difference (P = 0.407)

Table 31. One-way analysis of variance (water quality treatment) of mean water content at -1/10 bar for textural class #2.

One Way Analysis of Variance

Data source: -1/10 BAR – Textural Class #2 DATA in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: Textural Class #2 DATA in Notebook

Group	N	Missing	Median	25%	75%
1XPR	39	0	0.360	0.330	0.380
1XCBM	39	0	0.350	0.320	0.378
5XPR	39	0	0.310	0.290	0.340
5XCBM	39	0	0.320	0.290	0.350
5XPR+d	39	0	0.320	0.292	0.340
5XCBM+d	39	0	0.320	0.300	0.348

H = 25.617 with 5 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparison	Diff of Ranks	q	P<0.05
1XPR vs 5XPR	2206.500	5.219	Yes
1XPR vs 5XPR+d	2005.500	4.744	Yes
1XPR vs 5XCBM	1906.500	4.510	Yes
1XPR vs 5XCBM+d	1905.500	4.507	Yes
1XPR vs 1XCBM	367.000	0.868	No
1XCBM vs 5XPR	1839.500	4.351	Yes
1XCBM vs 5XPR+d	1638.500	3.876	No
1XCBM vs 5XCBM	1539.500	3.642	Do Not Test
1XCBM vs 5XCBM+d	1538.500	3.639	Do Not Test
5XCBM+d vs 5XPR	301.000	0.712	No
5XCBM+d vs 5XPR+d	100.000	0.237	Do Not Test
5XCBM+d vs 5XCBM	1.000	0.00237	Do Not Test
5XCBM vs 5XPR	300.000	0.710	Do Not Test
5XCBM vs 5XPR+d	99.000	0.234	Do Not Test
5XPR+d vs 5XPR	201.000	0.475	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Table 32. One-way analysis of variance (water quality treatment) of mean water content at -1/3 bar for textural class #2.

One Way Analysis of Variance

Data source: -1/3 BAR – Textural Class #2 DATA in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: SiL DATA in Notebook

Group	N	Missing	Median	25%	75%
1XPR	39	0	0.220	0.185	0.248
1XCBM	39	0	0.220	0.178	0.240
5XPR	39	0	0.210	0.193	0.230
5XCBM	39	0	0.210	0.200	0.238
5XPR+d	39	0	0.200	0.180	0.230
5XCBM+d	39	0	0.220	0.193	0.248

H = 4.252 with 5 degrees of freedom. (P = 0.514)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.514)

Table 33. One-way analysis of variance (water quality treatment) of mean water content at -1 bar for textural class #2.

One Way Analysis of Variance

Data source: -1 BAR – Textural Class #2 DATA in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: SiL DATA in Notebook

Group	N	Missing	Median	25%	75%
1XPR	39	0	0.150	0.130	0.160
1XCBM	39	0	0.140	0.130	0.160
5XPR	39	0	0.130	0.113	0.140
5XCBM	39	0	0.130	0.113	0.140
5XPR+d	39	0	0.130	0.123	0.148
5XCBM+d	39	0	0.140	0.113	0.150

H = 12.161 with 5 degrees of freedom. (P = 0.033)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.033)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparison	Diff of Ranks	q	P<0.05
1XPR vs 5XPR	1655.500	3.916	No
1XPR vs 5XCBM	1243.500	2.941	Do Not Test
1XPR vs 5XPR+d	928.500	2.196	Do Not Test
1XPR vs 5XCBM+d	759.000	1.795	Do Not Test
1XPR vs 1XCBM	57.500	0.136	Do Not Test
1XCBM vs 5XPR	1598.000	3.780	Do Not Test
1XCBM vs 5XCBM	1186.000	2.805	Do Not Test
1XCBM vs 5XPR+d	871.000	2.060	Do Not Test
1XCBM vs 5XCBM+d	701.500	1.659	Do Not Test
5XCBM+d vs 5XPR	896.500	2.121	Do Not Test
5XCBM+d vs 5XCBM	484.500	1.146	Do Not Test
5XCBM+d vs 5XPR+d	169.500	0.401	Do Not Test
5XPR+d vs 5XPR	727.000	1.720	Do Not Test
5XPR+d vs 5XCBM	315.000	0.745	Do Not Test
5XCBM vs 5XPR	412.000	0.975	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Table 34. One-way analysis of variance (water quality treatment) of mean water content at -5 bar for textural class #2.

One Way Analysis of Variance

Data source: -5 BAR – Textural Class #2 DATA in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: SiL DATA in Notebook

Group	N	Missing	Median	25%	75%
1XPR	39	0	0.1000	0.0900	0.110
1XCBM	39	0	0.110	0.0925	0.120
5XPR	39	0	0.1000	0.0900	0.1000
5XCBM	39	0	0.1000	0.0825	0.110
5XPR+d	39	0	0.1000	0.0725	0.1000
5XCBM+d	39	0	0.1000	0.0800	0.1000

H = 9.866 with 5 degrees of freedom. (P = 0.079)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.079)

Table 35. One-way analysis of variance (water quality treatment) of mean water content at -15 bar for textural class #2.

One Way Analysis of Variance

Data source: -15 BAR - Textural Class #2 DATA in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: Textural Class #2 DATA in Notebook

Group	N	Missing	Median	25%	75%
1XPR	39	0	0.0800	0.0700	0.0900
1XCBM	39	0	0.0800	0.0700	0.0900
5XPR	39	0	0.0800	0.0700	0.0875
5XCBM	39	0	0.0800	0.0725	0.0900
5XPR+d	39	0	0.0800	0.0700	0.0800
5XCBM+d	39	0	0.0800	0.0700	0.0900

H = 2.997 with 5 degrees of freedom. (P = 0.701)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.701)

Table 36. One-way analysis of variance (water quality treatment) of mean water content at -1/10 bar for textural class #3.

One Way Analysis of Variance

Data source: -1/10 BAR – Textural Class #3

Normality Test: Passed (P = 0.057)

Equal Variance Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: Data 4 in Notebook

Group	N	Missing	Median	25%	75%
1XPR	51	0	0.390	0.335	0.428
1XCBM	51	0	0.390	0.360	0.438
5XPR	51	0	0.410	0.380	0.430
5XCBM	51	0	0.410	0.370	0.430
5XPR+d	51	0	0.380	0.350	0.430
5XCBM+d	51	0	0.380	0.350	0.430

H = 7.626 with 5 degrees of freedom. (P = 0.178)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.178)

Table 37. One-way analysis of variance (water quality treatment) of mean water content at -1/3 bar for textural class #3.

One Way Analysis of Variance

Data source: -1/3 BAR – Textural Class #3 in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: SiCL in Notebook

Group	N	Missing	Median	25%	75%
1XPR	51	0	0.260	0.230	0.300
1XCBM	51	0	0.260	0.240	0.300
5XPR	51	0	0.270	0.250	0.328
5XCBM	51	0	0.280	0.260	0.328
5XPR+d	51	0	0.260	0.250	0.330
5XCBM+d	51	0	0.270	0.250	0.320

H = 14.045 with 5 degrees of freedom. (P = 0.015)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.015)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparison	Diff of Ranks	q	P<0.05
5XCBM vs 1XPR	2799.000	4.430	Yes
5XCBM vs 1XCBM	2550.000	4.036	Yes
5XCBM vs 5XPR+d	1374.500	2.175	No
5XCBM vs 5XCBM+d	1296.500	2.052	Do Not Test
5XCBM vs 5XPR	815.000	1.290	Do Not Test
5XPR vs 1XPR	1984.000	3.140	No
5XPR vs 1XCBM	1735.000	2.746	Do Not Test
5XPR vs 5XPR+d	559.500	0.885	Do Not Test
5XPR vs 5XCBM+d	481.500	0.762	Do Not Test
5XCBM+d vs 1XPR	1502.500	2.378	Do Not Test
5XCBM+d vs 1XCBM	1253.500	1.984	Do Not Test
5XCBM+d vs 5XPR+d	78.000	0.123	Do Not Test
5XPR+d vs 1XPR	1424.500	2.254	Do Not Test
5XPR+d vs 1XCBM	1175.500	1.860	Do Not Test
1XCBM vs 1XPR	249.000	0.394	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Table 38. One-way analysis of variance (water quality treatment) of mean water content at -1 bar for textural class #3.

One Way Analysis of Variance

Data source: -1 BAR – Textural Class #3 in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: SiCL in Notebook

Group	N	Missing	Median	25%	75%
1XPR	51	0	0.190	0.170	0.240
1XCBM	51	0	0.190	0.170	0.240
5XPR	51	0	0.170	0.160	0.218
5XCBM	51	0	0.180	0.170	0.218
5XPR+d	51	0	0.190	0.170	0.240
5XCBM+d	51	0	0.200	0.170	0.248

H = 13.339 with 5 degrees of freedom. (P = 0.020)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.020)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparison	Diff of Ranks	q	P<0.05
5XCBM+d vs 5XPR	2516.000	3.982	No
5XCBM+d vs 5XCBM	1814.000	2.871	Do Not Test
5XCBM+d vs 5XPR+d	707.500	1.120	Do Not Test
5XCBM+d vs 1XPR	375.500	0.594	Do Not Test
5XCBM+d vs 1XCBM	65.000	0.103	Do Not Test
1XCBM vs 5XPR	2451.000	3.879	Do Not Test
1XCBM vs 5XCBM	1749.000	2.768	Do Not Test
1XCBM vs 5XPR+d	642.500	1.017	Do Not Test
1XCBM vs 1XPR	310.500	0.491	Do Not Test
1XPR vs 5XPR	2140.500	3.388	Do Not Test
1XPR vs 5XCBM	1438.500	2.277	Do Not Test
1XPR vs 5XPR+d	332.000	0.525	Do Not Test
5XPR+d vs 5XPR	1808.500	2.862	Do Not Test
5XPR+d vs 5XCBM	1106.500	1.751	Do Not Test
5XCBM vs 5XPR	702.000	1.111	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Table 39. One-way analysis of variance (water quality treatment) of mean water content at -5 bar for textural class #3.

One Way Analysis of Variance

Data source: -5 BAR – Textural Class #3 in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: SiCL in Notebook

Group	N	Missing	Median	25%	75%
1XPR	51	0	0.140	0.110	0.190
1XCBM	51	0	0.140	0.113	0.190
5XPR	51	0	0.140	0.120	0.180
5XCBM	51	0	0.140	0.120	0.180
5XPR+d	51	0	0.140	0.110	0.180
5XCBM+d	51	0	0.150	0.113	0.188

H = 0.630 with 5 degrees of freedom. (P = 0.987)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.987)

Table 40. One-way analysis of variance (water quality treatment) of mean water content at -15 bar for textural class #3.

One Way Analysis of Variance

Data source: -15 BAR – Textural Class #3 in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: Textural Class #3 in Notebook

Group	N	Missing	Median	25%	75%
1XPR	51	0	0.110	0.0900	0.138
1XCBM	51	0	0.110	0.0900	0.140
5XPR	51	0	0.110	0.0900	0.130
5XCBM	51	0	0.110	0.1000	0.130
5XPR+d	51	0	0.110	0.1000	0.130
5XCBM+d	51	0	0.110	0.1000	0.130

H = 3.475 with 5 degrees of freedom. (P = 0.627)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.627)

Table 41. One-way analysis of variance (water quality treatment) of mean water content at -1/10 bar for textural class #4.

One Way Analysis of Variance

Data source: -1/10 BAR – Textural Class #4 DATA in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: Textural Class #4 DATA in Notebook

Group	N	Missing	Median	25%	75%
1XPR	39	0	0.430	0.400	0.518
1XCBM	39	0	0.420	0.400	0.508
5XPR	39	0	0.410	0.390	0.530
5XCBM	39	0	0.420	0.400	0.518
5XPR+d	39	0	0.400	0.383	0.520
5XCBM+d	39	0	0.410	0.390	0.490

H = 8.670 with 5 degrees of freedom. (P = 0.123)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.123)

Table 42. One-way analysis of variance (water quality treatment) of mean water content at -1/3 bar for textural class #4.

One Way Analysis of Variance

Data source: -1/3 BAR – Textural Class #4 DATA in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: Textural Class #4 DATA in Notebook

Group	N	Missing	Median	25%	75%
1XPR	39	0	0.300	0.250	0.360
1XCBM	39	0	0.290	0.260	0.357
5XPR	39	0	0.310	0.290	0.398
5XCBM	39	0	0.290	0.280	0.378
5XPR+d	39	0	0.290	0.270	0.380
5XCBM+d	39	0	0.290	0.270	0.360

H = 8.113 with 5 degrees of freedom. (P = 0.150)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.150)

Table 43. One-way analysis of variance (water quality treatment) of mean water content at -1 bar for textural class #4.

One Way Analysis of Variance

Data source: -1 BAR – Textural Class #4 DATA in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: Textural Class #4 DATA in Notebook

Group	N	Missing	Median	25%	75%
1XPR	39	0	0.220	0.200	0.297
1XCBM	39	0	0.220	0.200	0.290
5XPR	39	0	0.200	0.170	0.250
5XCBM	39	0	0.200	0.170	0.250
5XPR+d	39	0	0.210	0.190	0.290
5XCBM+d	39	0	0.210	0.200	0.280

H = 19.035 with 5 degrees of freedom. (P = 0.002)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.002)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparison	Diff of Ranks	q	P<0.05
1XPR vs 5XPR	1855.000	4.388	Yes
1XPR vs 5XCBM	1800.000	4.258	Yes
1XPR vs 5XPR+d	736.500	1.742	No
1XPR vs 5XCBM+d	409.000	0.967	Do Not Test
1XPR vs 1XCBM	116.500	0.276	Do Not Test
1XCBM vs 5XPR	1738.500	4.112	Yes
1XCBM vs 5XCBM	1683.500	3.982	No
1XCBM vs 5XPR+d	620.000	1.467	Do Not Test
1XCBM vs 5XCBM+d	292.500	0.692	Do Not Test
5XCBM+d vs 5XPR	1446.000	3.420	No
5XCBM+d vs 5XCBM	1391.000	3.290	Do Not Test
5XCBM+d vs 5XPR+d	327.500	0.775	Do Not Test
5XPR+d vs 5XPR	1118.500	2.646	Do Not Test
5XPR+d vs 5XCBM	1063.500	2.516	Do Not Test
5XCBM vs 5XPR	55.000	0.130	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Table 44. One-way analysis of variance (water quality treatment) of mean water content at -5 bar for textural class #4.

One Way Analysis of Variance

Data source: -5 BAR – Textural Class #4 DATA in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: SiC DATA in Notebook

Group	N	Missing	Median	25%	75%
1XPR	39	0	0.170	0.143	0.220
1XCBM	39	0	0.170	0.150	0.230
5XPR	39	0	0.160	0.150	0.230
5XCBM	39	0	0.160	0.150	0.228
5XPR+d	39	0	0.160	0.150	0.230
5XCBM+d	39	0	0.160	0.150	0.230

H = 0.839 with 5 degrees of freedom. (P = 0.974)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.974)

Table 45. One-way analysis of variance (water quality treatment) of mean water content at -15 bar for textural class #4.

One Way Analysis of Variance

Data source: -15 BAR - Textural Class #4 DATA in Notebook

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: Textural Class #4 DATA in Notebook

Group	N	Missing	Median	25%	75%
1XPR	39	0	0.130	0.120	0.170
1XCBM	39	0	0.130	0.120	0.158
5XPR	39	0	0.130	0.120	0.150
5XCBM	39	0	0.130	0.120	0.150
5XPR+d	39	0	0.130	0.113	0.168
5XCBM+d	39	0	0.130	0.130	0.158

H = 1.166 with 5 degrees of freedom. (P = 0.948)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.948)

Table 46. Linear regressions of matric potential on water content (all textures and treatments).

Linear Regression

Data source: Textural Class #1 - 1XCBM

log10(-Water Co = -1.099 - (0.356 * log10(-6-))

N = 135.000

R = 0.866 Rsqr = 0.750 Adj Rsqr = 0.748

Standard Error of Estimate = 0.163

	Coefficient	Std. Error	t	P
Constant	-1.099	0.0141	-77.909	<0.001
log10(-6-)	-0.356	0.0178	-19.990	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	10.648	10.648	399.593	<0.001
Residual	133	3.544	0.0266		
Total	134	14.193	0.106		

Normality Test: Passed (P = 0.130)
Constant Variance Test: Failed (P = 0.002)
Power of performed test with alpha = 0.050: 1.000

Linear Regression

Data source: Textural Class #4 - 1XCBM

log10(-Water Co = -0.607 - (0.227 * log10(-6-))

N = 195.000

R = 0.901 Rsqr = 0.812 Adj Rsqr = 0.811

Standard Error of Estimate = 0.087

	Coefficient	Std. Error	t	P
Constant	-0.607	0.00624	-97.315	<0.001
log10(-6-)	-0.227	0.00786	-28.908	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	6.291	6.291	835.671	<0.001
Residual	193	1.453	0.00753		
Total	194	7.743	0.0399		

Normality Test: Passed (P = 0.038)
Constant Variance Test: Passed (P = 0.341)
Power of performed test with alpha = 0.050: 1.000

Table 46. Linear regressions of matric potential on water content (all textures and treatments) continued.

Linear Regression

Data source: Textural Class #3 - 1XCBM

log10(-Water Co = -0.675 - (0.244 * log10(-6-))

N = 255.000

R = 0.925 Rsqr = 0.855 Adj Rsqr = 0.855

Standard Error of Estimate = 0.080

	Coefficient	Std. Error	t	P
Constant -	0.675	0.00501	-134.644	<0.001
log10(-6-)	-0.244	0.00632	-38.638	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	9.492	9.492	1492.883	<0.001
Residual	253	1.609	0.00636		
Total	254	11.100	0.0437		

Normality Test: Failed (P = 0.008)
Constant Variance Test: Failed (P = <0.001)
Power of performed test with alpha = 0.050: 1.000

Linear Regression

Data source: Textural Class #2 - 1XCBM

log10(-Water Co = -0.812 - (0.291 * log10(-6-))

N = 195.000
R = 0.861 Rsqr = 0.741 Adj Rsqr = 0.740

Standard Error of Estimate = 0.136

	Coefficient	Std. Error	t	P
Constant	-0.812	0.00980	-82.865	<0.001
log10(-6-)	-0.291	0.0124	-23.518	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	10.280	10.280	553.089	<0.001
Residual	193	3.587	0.0186		
Total	194	13.867	0.0715		

Normality Test: Failed (P = <0.001)
Constant Variance Test: Passed (P = 0.027)
Power of performed test with alpha = 0.050: 1.000

Table 46. Linear regressions of matric potential on water content (all textures and treatments) continued.

Linear Regression

Data source: Textural Class #1 - 1XPR

log10(-Water Co = -1.090 - (0.373 * log10(-6-))

N = 135.000

R = 0.884 Rsqr = 0.782 Adj Rsqr = 0.781
Standard Error of Estimate = 0.157

	Coefficient	Std. Error	t	P
Constant	-1.090	0.0135	-80.491	<0.001
log10(-6-)	-0.373	0.0171	-21.853	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	11.738	11.738	477.541	<0.001
Residual	133	3.269	0.0246		
Total	134	15.007	0.112		

Normality Test: Passed (P = 0.060)
Constant Variance Test: Failed (P = 0.004)
Power of performed test with alpha = 0.050: 1.000

Linear Regression

Data source: Textural Class #4 - 1XPR

log10(-Water Co = -0.601 - (0.227 * log10(-6-))

N = 195.000

R = 0.891 Rsqr = 0.794 Adj Rsqr = 0.793

Standard Error of Estimate = 0.092

	Coefficient	Std. Error	t	P
Constant	-0.601	0.00661	-90.995	<0.001
log10(-6-)	-0.227	0.00833	-27.243	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	6.274	6.274	742.197	<0.001
Residual	193	1.631	0.00845		
Total	194	7.905	0.0407		

Normality Test: Passed (P = 0.083)
Constant Variance Test: Passed (P = 0.111)
Power of performed test with alpha = 0.050: 1.000

Table 46. Linear regressions of matric potential on water content (all textures and treatments) continued.

Linear Regression

Data source: Textural Class #3 - 1XPR

log10(-Water Co = -0.684 - (0.234 * log10(-6-))

N = 255.000

R = 0.904 Rsqr = 0.817 Adj Rsqr = 0.817

Standard Error of Estimate = 0.088

	Coefficient	Std. Error	t	P
Constant	-0.684	0.00551	-124.057	<0.001
log10(-6-)	-0.234	0.00695	-33.645	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	8.694	8.694	1131.988	<0.001
Residual	253	1.943	0.00768		
Total	254	10.637	0.0419		

Normality Test: Passed (P = 0.044)
Constant Variance Test: Failed (P = <0.001)
Power of performed test with alpha = 0.050: 1.000

Linear Regression

Data source: Textural Class #2 - 1XPR

log10(-Water Co = -0.814 - (0.302 * log10(-6-))

N = 195.000

R = 0.875 Rsqr = 0.765 Adj Rsqr = 0.764

Standard Error of Estimate = 0.133

	Coefficient	Std. Error	t	P
Constant	-0.814	0.00955	-85.235	<0.001
log10(-6-)	-0.302	0.0120	-25.061	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	11.076	11.076	628.039	<0.001
Residual	193	3.404	0.0176		
Total	194	14.479	0.0746		

Normality Test: Failed (P = <0.001)
Constant Variance Test: Passed (P = 0.014)
Power of performed test with alpha = 0.050: 1.000

Table 46. Linear regressions of matric potential on water content (all textures and treatments) continued.

Linear Regression

Data source: Textural Class #1 - 5xCBM + d

log10(-Water Co = -1.080 - (0.344 * log10(-6-))

N = 135.000

R = 0.893 Rsqr = 0.797 Adj Rsqr = 0.795

Standard Error of Estimate = 0.138

	Coefficient	Std. Error	t	P
Constant	-1.080	0.0120	-90.350	<0.001
log10(-6-)	-0.344	0.0151	-22.828	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	9.972	9.972	521.096	<0.001
Residual	133	2.545	0.0191		
Total	134	12.517	0.0934		

Normality Test: Passed (P = 0.056)
Constant Variance Test: Passed (P = 0.913)
Power of performed test with alpha = 0.050: 1.000

Linear Regression

Data source: Textural Class #4 - 5XCBM+D

log10(-Water Co = -0.608 - (0.215 * log10(-6-))

N = 195.000

R = 0.907 Rsqr = 0.822 Adj Rsqr = 0.821

Standard Error of Estimate = 0.080

	Coefficient	Std. Error	t	P
Constant	-0.608	0.00572	-106.279	<0.001
log10(-6-)	-0.215	0.00721	-29.850	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	5.638	5.638	891.020	<0.001
Residual	193	1.221	0.00633		
Total	194	6.859	0.0354		

Normality Test: Failed (P = <0.001)
Constant Variance Test: Passed (P = 0.065)
Power of performed test with alpha = 0.050: 1.000

Table 46. Linear regressions of matric potential on water content (all textures and treatments) continued.

Linear Regression

Data source: Textural Class #3 - 5XCBM+D

log10(-Water Co = -0.671 - (0.242 * log10(-6-))

N = 255.000

R = 0.927 Rsqr = 0.859 Adj Rsqr = 0.858

Standard Error of Estimate = 0.078

	Coefficient	Std. Error	t	P
Constant	-0.671	0.00489	-137.279	<0.001
log10(-6-)	-0.242	0.00616	-39.208	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	9.285	9.285	1537.260	<0.001
Residual	253	1.528	0.00604		
Total	254	10.813	0.0426		

Normality Test: Passed (P = 0.024)
Constant Variance Test: Failed (P = <0.001)
Power of performed test with alpha = 0.050: 1.000

Linear Regression

Data source: Textural Class #2 - 5XCBM+D in Notebook

log10(-Water Co = -0.828 - (0.285 * log10(-6-))

N = 195.000

R = 0.872 Rsqr = 0.761 Adj Rsqr = 0.760

Standard Error of Estimate = 0.127

	Coefficient	Std. Error	t	P
Constant	-0.828	0.00911	-90.884	<0.001
log10(-6-)	-0.285	0.0115	-24.805	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	9.878	9.878	615.268	<0.001
Residual	193	3.098	0.0161		
Total	194	12.976	0.0669		

Normality Test: Failed (P = <0.001)
Constant Variance Test: Passed (P = 0.022)
Power of performed test with alpha = 0.050: 1.000

Table 46. Linear regressions of matric potential on water content (all textures and treatments) continued.

Linear Regression

Data source: Textural Class #1 - 5XPR+D

log10(-Water Co = -1.166 - (0.263 * log10(-6-))

N = 108.000

R = 0.812 Rsqr = 0.660 Adj Rsqr = 0.657

Standard Error of Estimate = 0.124

	Coefficient	Std. Error	t	P
Constant	-1.166	0.0134	-86.773	<0.001
log10(-6-)	-0.263	0.0183	-14.342	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	3.156	3.156	205.707	<0.001
Residual	106	1.626	0.0153		
Total	107	4.782	0.0447		

Normality Test: Failed (P = 0.003)
Constant Variance Test: Passed (P = 0.456)
Power of performed test with alpha = 0.050: 1.000

Linear Regression

Data source: Textural Class #4 - 5XPR+D

log10(-Water Co = -0.623 - (0.201 * log10(-6-))

N = 156.000

R = 0.834 Rsqr = 0.696 Adj Rsqr = 0.694

Standard Error of Estimate = 0.087

	Coefficient	Std. Error	t	P
Constant	-0.623	0.00785	-79.304	<0.001
log10(-6-)	-0.201	0.0107	-18.773	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	2.667	2.667	352.440	<0.001
Residual	154	1.165	0.00757		
Total	155	3.832	0.0247		

Normality Test: Failed (P = <0.001)
Constant Variance Test: Passed (P = 0.077)
Power of performed test with alpha = 0.050: 1.000

Table 46. Linear regressions of matric potential on water content (all textures and treatments) continued.

Linear Regression

Data source: Textural Class #3 - 5XPR+D

log10(-Water Co = -0.686 - (0.224 * log10(-6-))

N = 204.000

R = 0.877 Rsqr = 0.770 Adj Rsqr = 0.769

Standard Error of Estimate = 0.080

	Coefficient	Std. Error	t	P
Constant	-0.686	0.00632	-108.512	<0.001
log10(-6-)	-0.224	0.00863	-26.001	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	4.337	4.337	676.028	<0.001
Residual	202	1.296	0.00642		
Total	203	5.633	0.0277		

Normality Test: Failed (P = 0.001)
Constant Variance Test: Passed (P = 0.133)
Power of performed test with alpha = 0.050: 1.000

Linear Regression

Data source: Textural Class #2 - 5XPR+D

log10(-Water Co = -0.865 - (0.251 * log10(-6-))

N = 156.000

R = 0.789 Rsqr = 0.622 Adj Rsqr = 0.619

Standard Error of Estimate = 0.128

	Coefficient	Std. Error	t	P
Constant	-0.865	0.0116	-74.757	<0.001
log10(-6-)	-0.251	0.0158	-15.911	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	4.160	4.160	253.160	<0.001
Residual	154	2.530	0.0164		
Total	155	6.690	0.0432		

Normality Test: Failed (P = <0.001)
Constant Variance Test: Passed (P = 0.166)
Power of performed test with alpha = 0.050: 1.000

Table 46. Linear regressions of matric potential on water content (all textures and treatments) continued.

Linear Regression

Data source: Textural Class #1 - 5XCBM

log10(-Water Co = -1.097 - (0.347 * log10(-6-))

N = 135.000

R = 0.889 Rsqr = 0.791 Adj Rsqr = 0.789
Standard Error of Estimate = 0.142

	Coefficient	td. Error	t	P
Constant	-1.097	0.0123	-89.452	<0.001
log10(-6-)	-0.347	0.0155	-22.438	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	10.134	10.134	503.484	<0.001
Residual	133	2.677	0.0201		
Total	134	12.811	0.0956		

Normality Test: Passed (P = 0.012)
Constant Variance Test: Passed (P = 0.812)
Power of performed test with alpha = 0.050: 1.000

Linear Regression

Data source: Textural Class #4 - 5XCBM

log10(-Water Co = -0.615 - (0.228 * log10(-6-))

N = 195.000

R = 0.896 Rsqr = 0.803 Adj Rsqr = 0.802

Standard Error of Estimate = 0.090

	Coefficient	Std. Error	t	P
Constant	-0.615	0.00645	-95.469	<0.001
log10(-6-)	-0.228	0.00813	-28.050	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	6.324	6.324	786.811	<0.001
Residual	193	1.551	0.00804		
Total	194	7.875	0.0406		

Normality Test: Passed (P = 0.193)
Constant Variance Test: Passed (P = 0.093)
Power of performed test with alpha = 0.050: 1.000

Table 46. Linear regressions of matric potential on water content (all textures and treatments) continued.

Linear Regression

Data source: Textural Class #3 - 5XCBM

log10(-Water Co = -0.673 - (0.250 * log10(-6-))

N = 255.000

R = 0.934 Rsqr = 0.872 Adj Rsqr = 0.872

Standard Error of Estimate = 0.076

	Coefficient	Std. Error	t	P
Constant	-0.673	0.00477	-141.093	<0.001
log10(-6-)	-0.250	0.00601	-41.576	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	9.952	9.952	1728.552	<0.001
Residual	253	1.457	0.00576		
Total	254	11.408	0.0449		

Normality Test: Passed (P = 0.095)
Constant Variance Test: Failed (P = <0.001)
Power of performed test with alpha = 0.050: 1.000

Linear Regression

Data source: Textural Class #2 - 5XCBM

log10(-Water Co = -0.832 - (0.280 * log10(-6-))

N = 195.000

R = 0.866 Rsqr = 0.751 Adj Rsqr = 0.749

Standard Error of Estimate = 0.128

	Coefficient	Std. Error	t	P
Constant	-0.832	0.00921	-90.346	<0.001
log10(-6-)	-0.280	0.0116	-24.096	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	9.528	9.528	580.626	<0.001
Residual	193	3.167	0.0164		
Total	194	12.695	0.0654		

Normality Test: Failed (P = <0.001)
Constant Variance Test: Failed (P = 0.001)
Power of performed test with alpha = 0.050: 1.000

Table 46. Linear regressions of matric potential on water content (all textures and treatments) continued.

Linear Regression

Data source: Textural Class #1 - 5XPR

log10(-Water Co = -1.108 - (0.346 * log10(-6-))

N = 135.000

R = 0.888Rsqr = 0.788 Adj Rsqr = 0.787

Standard Error of Estimate = 0.143

	Coefficient	Std. Error	t	P
Constant	-1.108	0.0123	-89.991	<0.001
log10(-6-)	-0.346	0.0155	-22.260	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	10.062	10.062	495.503	<0.001
Residual	133	2.701	0.0203		
Total	134	12.763	0.0952		

Normality Test: Passed (P = 0.066)
Constant Variance Test: Passed (P = 0.253)
Power of performed test with alpha = 0.050: 1.000

Linear Regression

Data source: Textural Class #4 - 5XPR

log10(-Water Co = -0.615 - (0.232 * log10(-6-))

N = 195.000
R = 0.899 Rsqr = 0.809 Adj Rsqr = 0.808

Standard Error of Estimate = 0.090

	Coefficient	Std. Error	t	P
Constant	-0.615	0.00644	-95.427	<0.001
log10(-6-)	-0.232	0.00812	-28.595	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	6.569	6.569	817.662	<0.001
Residual	193	1.550	0.00803		
Total	194	8.119	0.0419		

Normality Test: Passed (P = 0.070)
Constant Variance Test: Passed (P = 0.131)
Power of performed test with alpha = 0.050: 1.000

Table 46. Linear regressions of matric potential on water content (all textures and treatments) continued.

Linear Regression

Data source: Textural Class #3 - 5XPR

log10(-Water Co = -0.682 - (0.256 * log10(-6-))

N = 255.000

R = 0.891 Rsqr = 0.793 Adj Rsqr = 0.792

Standard Error of Estimate = 0.104

	Coefficient	Std. Error	t	P
Constant	-0.682	0.00652	-104.673	<0.001
log10(-6-)	-0.256	0.00822	-31.142	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	10.424	10.424	969.840	<0.001
Residual	253	2.719	0.0107		
Total	254	13.143	0.0517		

Normality Test: Passed (P = 0.047)
Constant Variance Test: Failed (P = <0.001)
Power of performed test with alpha = 0.050: 1.000

Linear Regression

Data source: Textural Class #2 - 5XPR

log10(-Water Co = -0.844 - (0.284 * log10(-6-))

N = 195.000
R = 0.860 Rsqr = 0.740 Adj Rsqr = 0.739

Standard Error of Estimate = 0.134

	Coefficient	Std. Error	t	P
Constant	-0.844	0.00961	-87.790	<0.001
log10(-6-)	-0.284	0.0121	-23.431	<0.001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	9.818	9.818	548.996	<0.001
Residual	193	3.452	0.0179		
Total	194	13.270	0.0684		

Normality Test: Failed (P = <0.001)
Constant Variance Test: Passed (P = 0.032)
Power of performed test with alpha = 0.050: 1.000

APPENDIX D

DATA FILES

Table 54. Chemistry data (pH, EC (dS/m)) before and after treatment with various water qualities and wetting regimes.

	pH	Base EC	1PR EC	1CBM EC	5PR EC	5P+d EC	5CBM EC	5C+d EC
FSL1	8.2	0.57	1.28	2.68	3.26	2.91	5.95	4.93
FSL3	8.4	0.51	1.3	2.46	3.06	2.42	5.85	4.85
FSL4	8.4	1.0	1.5	2.89	4.21	3.84	8.26	4.29
FSL6	8.2	0.47	2.43	2.14	3.44	2.95	6.7	5.25
FSL7	8.2	0.64	1.35	2.46	3.33	2.16	6.54	3.00
FSL8	8.6	0.55	1.21	1.73	4.1	2.82	8.17	6.22
FSL9	8.5	0.38	1.23	1.92	3.57	0.88	5.92	2.68
FSL11	8.1	0.72	1.61	3.05	3.37	2.14	6.59	2.76
FSL12	8.3	0.56	1.18	2.24	3.4	3.04	6.64	4.94
SiL13	7.8	0.48	1.22	2.17	2.52	2.61	5.6	5.50
SiL14	8.2	0.77	1.44	2.47	3.11	2.4	6.56	3.76
SiL15	8.1	0.63	1.3	2.32	3.1	3.45	6.03	6.65
SiL16	8.2	0.97	1.37	2.17	2.8	2.98	6.01	5.84
SiL17	8.1	0.75	1.43	2.21	2.77	2.98	6.33	6.56
SiL18	8.3	0.75	1.69	2.29	3.06	3.39	7.69	4.75
SiL19	8.2	0.49	1.41	2.16	3.02	2.73	7.5	7.31
SiL20	8.2	1.15	1.52	2.73	3.77	3.27	7.29	6.16
SiL21	8.6	0.81	1.7	2.9	2.99	2.78	6.65	6.43
SiL22	8.2	0.52	1.11	2.51	3.11	3.14	7.64	5.12
SiL23	8.1	1.64	2.08	3.41	3.5	3.06	8.23	5.72
SiL24	8.2	0.54	1.19	2.36	3.65	3.59	6.69	6.52
SiL25	8.3	0.53	1.1	2.58	3.72	3.66	7.71	6.34
SiCL26	8.0	0.43	1.11	2.19	3.79	3.08	6.42	6.98
SiCL27	7.8	0.95	1.51	2.29	3.4	2.15	7.44	7.3
SiCL28	7.9	0.87	1.32	1.87	3.35	3.57	6.5	7.41
SiCL29	8.2	0.45	1.36	2.48	2.78	2.98	7.48	6.74
SiCL30	8.2	0.44	1.15	2.05	2.61	2.85	7.6	5.41
SiCL31	7.9	0.81	1.26	2.06	2.92	3.39	6.78	4.72
SiCL32	8.4	1.24	1.81	2.14	2.54	3.06	6.35	4.12
SiCL33	8.5	0.81	1.18	2.06	2.69	2.99	6.25	5.52
SiCL34	8.3	0.34	1.02	2.17	2.74	2.94	5.81	4.40
SiCL35	8.3	2.77	1.15	2.24	2.67	2.93	5.41	5.72
SiCL36	8.6	2.57	2.8	3.39	2.99	3.89	6.82	8.98
SiCL37	8.5	0.45	1.28	2.35	2.56	3.11	7.29	7.15
SiCL38	7.9	0.41	1.16	2.07	2.64	2.57	7.57	5.12
SiCL40	8.4	0.48	1.36	2.45	3.18	3.26	4.42	6.25
SiCL41	8.5	0.36	1.01	2.06	2.51	2.98	6.87	3.37
SiCL42	8.3	0.5	1.22	1.87	3.54	3.08	6.03	6.18
SiC43	8.3	1.46	1.61	2.77	3.38	3.94	7.5	7.24
SiC44	8.4	1.36	2.07	2.28	2.36	3.2	6.22	6.6
SiC45	8.4	0.78	1.22	2.52	3.25	3.29	8.65	5.51
SiC46	8.3	0.72	2.09	2.43	2.93	3.48	7.6	5.49
SiC47	8.3	0.63	1.28	2.01	3.02	3.77	7.84	6.92
SiC48	8.0	2.11	2.38	3.02	3.03	2.62	8.14	6.93
SiC49	9.0	0.94	1.75	3.76	3.02	3.11	7.01	6.2
SiC50	8.4	0.79	2.44	2.46	3.9	3.48	7.79	6.48
SiC51	8.3	0.54	1.32	2.64	3.29	3.31	7.38	7.39
SiC53	9.1	1.47	2.41	3.77	3.83	3.85	6.86	9.95
SiC54	8.2	0.75	1.43	2.47	3.47	3.25	7.39	5.17

Table 55. Chemistry data (Na (mg/L), Ca (mg/L)) before and after treatment with various water qualities and wetting regimes.

	Base Na	1PR Na	1CBM Na	5PR Na	5P+d Na	5CBM Na	5C+d Na	Base Ca	1PR Ca	1CBM Ca	5PR Ca	5P+d Ca	5CBM Ca	5C+d Ca
FSL1	1.3	5.5	12	11.6	9.6	33.1	27.9	2.4	4.8	8.4	13.6	11.5	16	13.3
FSL3	0.8	4.9	12.8	11.8	8.4	35.2	30.9	3	6.2	7.8	12.6	10	15	11.6
FSL4	2.2	5.7	14.1	16.2	14.3	49.7	25.8	2.9	3.7	4.8	14.2	10.1	14.2	5.5
FSL6	1.3	11.7	10.4	12.7	10.1	39.1	30.7	1.9	11.3	5.7	14.7	12.1	19.6	14.1
FSL7	1.1	5.2	12.4	13.2	8.6	40.5	19.8	3.5	6.5	7.2	14.6	8.1	15.8	6
FSL8	2.2	5.5	9.8	17.3	11.5	52.3	39.6	1.5	3.3	2.8	12.1	7.6	13	9
FSL9	1.3	5.5	10.7	14.4	4.7	36.7	18.9	1.6	4.9	4.6	14.3	2.3	13.1	4
FSL11	1.3	6.2	16.3	13	8.2	40.4	20.1	3.7	7.7	8.1	14	7.8	15.7	4.5
FSL12	2.2	6	11.8	14.6	12.4	41.9	33.1	1.9	3.6	4.4	10	8.5	11.2	7.4
SiL13	1.8	4.8	10.1	8.4	8.5	30.1	28.6	1.3	3.6	4.7	7.3	7	11.7	11.5
SiL14	1.6	6	11.5	11.4	9.1	38.9	23.6	3.4	5.4	6.5	11.2	7.9	14.2	7.1
SiL15	1.8	5.1	10.4	12.3	12.2	34.6	38	3	5.9	7.3	12.1	12.9	15.9	17.4
SiL16	4.9	7.6	12.2	12	12.7	34.9	34.9	3	4.2	5	9.3	9.2	14	14.2
SiL17	4.7	8	12.1	12.4	13.2	37.2	37.9	1.5	3	3.5	5.6	5.9	9.4	10.2
SiL18	2.5	8.8	12.2	14.4	14.3	51.9	32.4	2.7	4.9	4.5	10.3	9.7	12.4	7.4
SiL19	1.6	5.4	10.9	11.1	9.6	43.9	41	2.2	6.4	6.2	11.7	10.3	21.4	20.6
SiL20	5.4	8.1	14.3	15.8	15.1	43	35.7	3.9	6.2	7.6	14.9	11.3	18.5	17.5
SiL21	4.3	8.9	16.2	14	13.2	40.6	37.2	1	2.4	2.9	4.2	3.8	5.8	6.3
SiL22	2.0	4.7	12.1	11.1	11.2	44.6	31.5	2	4.1	6.2	9.6	10.8	17.9	11.6
SiL23	7.2	10	17	15.1	13.5	47.7	32.9	7	8.2	10.6	13.7	11.1	25	15.1
SiL24	2.0	5.2	11.9	13.8	13.6	39.4	42.5	2	4.1	5.4	13.1	11.1	14.4	16.2
SiL25	2.1	5.1	11	14.9	14.5	46.1	38.8	1.7	2.9	4.7	9.9	9.4	14.1	11.3
SiCL26	0.5	3.2	9.2	11.8	8.9	32.2	35.8	2.2	4.9	6.2	15.1	12.3	17	20
SiCL27	2.5	4.9	8.3	9.2	6.4	33	31.3	3.9	7.5	8.7	15.5	8.5	28.5	27.9
SiCL28	5.2	6.9	9.9	11.8	13.7	32.7	36.1	2.2	4.3	4.9	9	11.8	19.9	23.8
SiCL29	0.3	4	10.2	9.5	9.8	41.2	38.5	2.4	6.6	7.8	10.5	10.9	20.1	18.8
SiCL30	0.7	3.7	8.5	7.8	8.4	39.1	29.3	2.3	5.1	6.2	9.8	10.7	21.1	13.4
SiCL31	2.4	4.2	8.2	8.4	9.2	29.4	22.6	3.3	6	7.1	12.5	14.6	24.9	15.6
SiCL32	8.9	12.3	13.1	14.8	16.7	37.1	26	2	4.1	3.5	5.5	6.2	16.8	8.2
SiCL33	0.4	3.6	9.1	8.4	10.1	35.4	32.1	2.5	6.4	6.2	10.6	11.7	16.7	15.6
SiCL34	0.3	3.8	9	8.3	8.5	31.6	24.1	1.8	4.1	5.8	10.2	9.3	13.8	10
SiCL35	6.7	4.2	8.8	8.3	9	25.1	27.9	16.5	5.2	7.5	11.8	12.2	17.9	19.6
SiCL36	20	23.3	24	21.1	25.6	49.4	64	3.3	4.3	4.4	4.1	6.4	11.8	16.9
SiCL37	0.7	4.7	10.4	9.2	9.7	39.7	40.9	2.6	6.2	7.3	10	12.8	20.8	21.6
SiCL38	0.4	4	9.8	8.4	8	41.3	29.2	2	4.6	4.8	8.5	8.4	19.2	11.5
SiCL40	0.4	4.6	10.9	11.2	11.1	24.2	35.3	2.5	6.9	7.4	13.4	12.9	11.3	17
SiCL41	0.5	3.9	9.9	8.4	9.4	35.9	19.8	1.4	3.1	3.8	6.8	8.8	15	5.8
SiCL42	0.5	4.4	9	12.2	10.4	35.3	33.8	2.7	5.6	4.7	12.9	10.4	16.8	14.8
SiC43	3.0	5.2	9.9	9.3	10.7	34.6	33.9	6.8	7.6	10.1	15.3	17.6	26.8	24.6
SiC44	8.2	13	13.7	12	16.1	35.6	36.3	3.1	5.6	5.3	6.1	9.8	17	18.2
SiC45	5.7	9.1	15.9	16.6	16.3	51.7	35.3	1.1	2	4.1	8.2	7.3	19	9.9
SiC46	2.7	9.1	10.4	10.8	12.5	36.5	27.6	2.6	10.4	7.7	12.9	14.6	25.6	17.9
SiC47	2.2	4.8	8.2	10	11.6	37.6	33	2.5	6.2	6.9	13.3	17	27.3	23.4
SiC48	15	15.6	17.6	19.3	16.5	49.4	43.4	3.6	6.2	7.3	7.3	5.2	21.7	15.6
SiC49	8.2	15.9	27	22.2	22.9	51.5	39.6	1	1.4	3.2	2.1	2	5.3	3.7
SiC50	2.7	9	10.2	13.9	11.8	40.5	33.6	3	14.5	8.1	17.5	14.9	27.9	18.3
SiC51	1.8	5.1	10	10.9	10.5	35.8	36.5	2.1	6.2	9.2	13.6	13.6	24.2	23.7
SiC53	12.2	18.3	31.1	29.9	30.3	54.8	82.6	0.5	0.9	1.5	1.8	1.6	3.2	4.2
SiC54	2.3	5.4	10.8	10.7	10.9	35.9	27.1	2.6	6.3	7.4	13.2	12.1	21.7	13.5

Table 56. Chemistry data (Mg (mg/L), HCO3 (mg/L)) before and after treatment with various water qualities and wetting regimes.

	Base Mg	1PR Mg	1CBM Mg	5PR Mg	5P+d Mg	5CBM Mg	5C+d Mg	Base HCO_3	1PR HCO_3	1CBM HCO_3	5PR HCO_3	5P+d HCO_3	5CBM HCO_3	5C+d HCO_3
FSL1	1.1	1.9	3.5	4.7	4.1	6.1	5.2	1.8	3.2	4	3.8	2.3	3	3
FSL3	1	2	2.7	3.6	2.9	4.8	3.6	2.5	3.8	3.8	2.7	2.6	3.2	3.5
FSL4	2.4	2.8	3.9	8.9	6.7	10.6	4.1	3.2	3.5	4	2.9	2.6	3	3
FSL6	0.7	4.1	2.7	4.5	3.7	6.6	4.8	1.7	3	2.6	2.7	2.5	4.3	2
FSL7	1.2	2.6	2.6	4.3	2.6	5.2	2	2	2.8	3	3	2.6	4	3
FSL8	1.4	2.7	2.5	8.8	5.5	11.4	8.1	2.1	3	4	3.2	2.7	3.5	4
FSL9	0.6	1.7	1.7	4.4	0.7	4.5	1.4	2.6	2.6	2.3	2.6	3.2	4	3.5
FSL11	1.2	2.5	3	4.2	2.3	5.5	1.4	1.8	3.6	4.5	3	2.6	3.4	4.2
FSL12	1.1	2.2	3	5.8	5	7.7	4.7	2.3	3	3.8	3.2	2.6	3.2	3.8
SiL13	1.3	3.4	4.6	6.5	6.4	11	10.9	3.3	3.5	2.8	3.1	3.6	2.8	3
SiL14	1.8	2.9	3.5	5.4	3.8	7.6	4.5	2.5	4	3	2.6	3.2	2.5	3.2
SiL15	1.4	2.8	3.5	5.2	5.6	7.4	8.8	3	4.6	2.5	3	3	3	3
SiL16	1.3	1.8	2.1	3.5	3.5	5.7	5.9	3.1	4	3	3.2	3.2	3.1	3.2
SiL17	2	4.1	5.3	7.7	8.3	14.5	15.4	4.2	4.2	3	3	2.9	3.6	3.3
SiL18	1.6	3.4	2.9	5.9	5.9	9	4.9	3.1	3.2	3	2.9	2.5	3	3.2
SiL19	1.2	3.2	3.2	5.5	4.8	10.8	10.1	4	3.8	4.5	2.7	3	2.9	3.5
SiL20	1.6	2.6	3.1	5.6	4.3	8.1	6.9	3.2	2.5	3	2.8	2.5	2.8	3.3
SiL21	2.9	6.1	8.4	10.1	8.8	17.3	17.3	3.6	3	4	3.1	3	3	3.1
SiL22	1.3	2.4	4	5.4	5.9	11.3	7.5	3	3.2	4.1	2.6	2.5	2.5	3.6
SiL23	3	3.4	4.4	5.1	4.3	10.2	6.6	2.2	3	3	2	2.8	2.3	2.6
SiL24	1.4	2.8	3.9	8	7.1	10.2	10.8	3	4.5	4	2.1	2.6	2	3
SiL25	1.5	2.7	4.3	8.6	8.5	13.6	10.8	2.5	4.9	3.5	3	2.3	2.3	2.6
SiCL26	1.5	3.2	4.1	8.9	7.2	10.8	12.2	4.1	3.8	3	3.1	3.1	2.5	3
SiCL27	2	3.2	4.1	6.6	3.6	12.8	12.5	2.6	3.8	3	2.6	3	4	3.4
SiCL28	1.2	2.1	2.5	4.3	5.8	10	12.2	4	4.5	3.5	3.1	3.1	4	3.5
SiCL29	0.8	2.2	2.8	3.3	4.2	6.7	6	3.3	4.3	3.8	3.2	2.8	12.3	4
SiCL30	1.6	3.2	4	5.5	6.2	12.9	8.2	4.5	3	3.2	3.4	3.4	3.5	3
SiCL31	1.6	2.6	3.2	5.2	6.2	11.1	7	2.9	3.6	2.5	3.5	2.3	3	3.5
SiCL32	1.1	2.1	1.9	2.8	3.2	8.9	4.4	3.7	3	3.8	3.2	3.8	3.1	3
SiCL33	0.9	2.1	2.2	3.1	3.4	5.4	5.4	4	3.2	5.3	3	3.1	2.5	3
SiCL34	1.3	2.8	4.1	6.1	5.9	9.5	6.7	4	5	3	2.6	3.2	1.8	3.5
SiCL35	9.4	2.2	3.5	4.9	5.3	8.1	8.9	2.5	3	3	2.2	3	2.8	3.2
SiCL36	2.2	2.4	2.9	2.3	3.7	7.3	10.7	4	2.6	4	12.3	3.2	3	3.4
SiCL37	0.9	2.1	2.6	3	3.9	6.9	7.3	3.5	4.5	5	3.1	2.5	3.5	4
SiCL38	1.7	3.7	4.2	6.1	6.2	15.6	8.7	3.3	4.6	4.2	2.2	2.4	2	3.2
SiCL40	1.1	3	3.7	5.2	5.1	4.8	7.1	3.5	3.9	3.1	2.5	3.5	4.5	3
SiCL41	1.5	3.4	4.5	6.5	8.5	15.7	6.1	3	3.2	2.9	2.2	2.5	2.7	3.4
SiCL42	1.7	3.4	3.1	7.2	6.2	10.3	9	3.6	3.2	3.2	2.3	3	2.8	3.2
SiC43	3.6	3.5	5.1	6.9	7.9	12.6	11.8	2.1	3.2	3.5	2.3	2.6	3.5	3.6
SiC44	1.6	2.5	2.4	2.6	4.3	7.9	8.2	3	2.9	4.5	2.2	3	3.2	3.2
SiC45	0.7	1.3	3	4.9	4.5	12.8	6.4	4	3.1	3.8	2.5	2.9	3.5	3
SiC46	1.3	4.6	3.7	5.6	6.6	11.9	8.3	3.5	4.5	4	2.3	2.7	3.3	2.8
SiC47	1.4	2.9	3.4	6	7.8	13.1	11.6	4.1	3	3	2.8	2.3	3.1	3.2
SiC48	2	2.9	3.6	3.5	2.6	10.8	8.2	3.8	3.5	4	3.2	3.1	3	4
SiC49	0.7	1.2	4.7	2.7	2.8	8.2	5.7	5	5	4	2.8	3	4	3.3
SiC50	1.6	6.8	4.2	8.1	7.1	13.9	9.3	3.3	3	3.5	2.8	3.1	3	4
SiC51	1.2	3.1	5.1	6.7	7	13	12.7	2.5	3.5	3.2	3.2	3.4	2.8	3.5
SiC53	0.7	1.4	3.9	3.5	3.3	8	13	3	3.6	3.2	2.3	3.3	3	3
SiC54	1.8	3.9	4.9	7.8	7.4	14.1	8.9	2.2	2.8	2.5	1.6	3.3	2.8	2.5

Table 57. Chemistry data (CEC, ESP) before and after treatment with various water qualities and wetting regimes.

	CEC	Base ESP	1PR ESP	1CBM ESP	5PR ESP	5P+d ESP	5CBM ESP	5C+d ESP
FSL1	16.3	3.1	3.9	6.2	6.5	5.4	16.8	15
FSL3	16.2	0.7	2.5	5.7	5.5	4.5	14.6	13.2
FSL4	14.3	1.3	4.1	10	10.6	8.2	21.8	18.8
FSL6	18.9	1.7	5.9	5.9	5.7	4.9	14.3	13.8
FSL7	16.0	0.7	2.7	6.2	4.8	3.9	15.2	10.1
FSL8	12.8	1.8	3.9	7.8	7.6	6.4	21.2	16.7
FSL9	13.5	1.3	3.5	6.7	6.3	4	16.2	12.3
FSL11	14.8	2.7	2.9	6.9	5.5	4	16.1	9.8
FSL12	18.5	1.3	3.3	6.2	7.2	5.4	17	12.6
SiL13	24.0	1.7	3.2	6.2	5	5.1	13.7	12.1
SiL14	19.5	0.9	3.1	4.9	5.1	4.2	14	10.5
SiL15	23.1	1.1	3.3	5.5	6.1	5.1	13.3	13.2
SiL16	20.8	3.5	5.3	8.7	7.8	6.6	15.3	15.5
SiL17	30.3	3.4	5	6.9	6.3	6	13.7	13.6
SiL18	19.6	1.6	4.6	5.2	5.5	4.8	15.2	12.4
SiL19	23.5	1.1	3.2	5.5	4.8	4.9	13.9	12.3
SiL20	27.2	3.5	5.3	8.3	7.8	6.5	15.3	12.8
SiL21	25.0	3	4.9	7	7.1	5.5	15.9	12.5
SiL22	23.8	1.5	3.4	5.7	5.8	5.4	14.5	11.4
SiL23	23.3	3.8	5.7	8.4	7.2	6.9	15.1	13.4
SiL24	23.6	1.4	3.5	5.7	6	5.9	13.7	14.9
SiL25	22.6	1.3	3.5	5.3	5.8	5.6	14.8	14.2
SiCL26	23.4	0.9	2.3	5.2	5.2	5.1	13.8	13
SiCL27	35.1	1.6	2.9	4.5	4.4	3.7	11.1	10.1
SiCL28	37.2	4.1	5	6.6	6.4	6.5	12.2	11.4
SiCL29	22.7	0.6	2.9	5.1	5.2	4.7	15.3	12.6
SiCL30	26.1	0.2	2.6	4.8	4.5	4	13.7	12.1
SiCL31	37.6	1.7	2.8	4.5	3.8	3.6	10.3	9.8
SiCL32	39.3	7	7.8	10.7	8.6	8.8	15.1	12.9
SiCL33	23.2	0.9	3.3	5.1	4.7	4.5	14.5	12.2
SiCL34	24.2	0.3	2.3	5	4.3	3.7	12.7	10.7
SiCL35	34.3	2.6	2.7	4.8	3.7	3.8	10	10.1
SiCL36	38.9	11.4	12.3	15.7	12.6	14.4	20.1	20.9
SiCL37	22.0	1.6	4.6	5.4	4.5	4.5	14.1	13.5
SiCL38	24.8	0.4	2.3	4.9	4.3	4.1	12.7	11.2
SiCL40	24.4	2.3	5.4	5.2	4.7	4.6	13.2	12.6
SiCL41	24.5	0.3	2.4	5.2	4.6	4.4	11.4	9.3
SiCL42	24.1	0.3	2.4	5.4	4.7	4.6	13.6	11.8
SiC43	30.6	1.8	3.2	5	4.3	4.4	11.2	10.5
SiC44	41.8	6	7.4	10.1	7.6	7.7	14.6	13.5
SiC45	29.1	5.7	7.4	9.9	8.2	8.1	16.2	13.5
SiC46	33.4	2.2	4.7	5.6	4.9	5.4	11.3	10.2
SiC47	31.6	1.5	3.4	4.9	5	5	12.5	11.5
SiC48	42.5	9.4	8.5	10.5	10.7	10.1	16.6	18.3
SiC49	33.4	10.9	12	16.8	15.2	12.7	21.6	20.6
SiC50	32.1	2.4	4.9	5.8	5.9	5.3	12.2	11.4
SiC51	36.7	1.5	2.9	5.2	5	4.7	11.7	11.5
SiC53	40.0	17.1	18.5	24.4	20.2	22.1	31	31.4
SiC54	33.1	3	5.4	6.3	4.3	4.3	11.7	10.1

Table 58. Soil water content for each soil material (3 reps) at each water quality treatment and at each matric potential.

ID	Texture	Treatment	Rep	-1/10 Bar	-1/3 Bar	-1 Bar	-5 Bar	-15 Bar
1	FSL	1XPR	1	0.30	0.14	0.10	0.08	0.05
1	FSL	1XPR	2	0.32	0.18	0.09	0.07	0.06
1	FSL	1XPR	3	0.34	0.16	0.09	0.06	0.05
3	FSL	1XPR	1	0.24	0.08	0.07	0.04	0.04
3	FSL	1XPR	2	0.27	0.13	0.07	0.05	0.04
3	FSL	1XPR	3	0.29	0.11	0.08	0.05	0.04
4	FSL	1XPR	1	0.29	0.1	0.06	0.05	0.04
4	FSL	1XPR	2	0.3	0.12	0.06	0.05	0.04
4	FSL	1XPR	3	0.32	0.11	0.07	0.04	0.03
6	FSL	1XPR	1	0.31	0.13	0.07	0.05	0.04
6	FSL	1XPR	2	0.31	0.15	0.07	0.06	0.04
6	FSL	1XPR	3	0.31	0.13	0.08	0.05	0.04
7	FSL	1XPR	1	0.19	0.06	0.05	0.04	0.04
7	FSL	1XPR	2	0.23	0.1	0.04	0.04	0.03
7	FSL	1XPR	3	0.24	0.08	0.05	0.04	0.03
8	FSL	1XPR	1	0.28	0.09	0.05	0.04	0.03
8	FSL	1XPR	2	0.3	0.14	0.05	0.04	0.03
8	FSL	1XPR	3	0.3	0.09	0.06	0.04	0.03
9	FSL	1XPR	1	0.23	0.07	0.04	0.04	0.03
9	FSL	1XPR	2	0.24	0.1	0.04	0.03	0.03
9	FSL	1XPR	3	0.23	0.07	0.05	0.03	0.03
11	FSL	1XPR	1	0.17	0.05	0.03	0.03	0.03
11	FSL	1XPR	2	0.2	0.1	0.04	0.03	0.03
11	FSL	1XPR	3	0.24	0.06	0.04	0.03	0.03
12	FSL	1XPR	1	0.32	0.1	0.06	0.05	0.04
12	FSL	1XPR	2	0.32	0.16	0.06	0.05	0.04
12	FSL	1XPR	3	0.34	0.12	0.07	0.05	0.04
13	SiL	1XPR	1	0.38	0.23	0.17	0.14	0.11
13	SiL	1XPR	2	0.4	0.27	0.16	0.13	0.11
13	SiL	1XPR	3	0.45	0.24	0.17	0.12	0.10
14	SiL	1XPR	1	0.27	0.11	0.07	0.05	0.04
14	SiL	1XPR	2	0.29	0.17	0.07	0.06	0.05
14	SiL	1XPR	3	0.32	0.12	0.08	0.05	0.04
15	SiL	1XPR	1	0.35	0.21	0.15	0.10	0.08
15	SiL	1XPR	2	0.36	0.26	0.16	0.11	0.09
15	SiL	1XPR	3	0.38	0.22	0.16	0.11	0.09
16	SiL	1XPR	1	0.36	0.21	0.15	0.10	0.08
16	SiL	1XPR	2	0.39	0.24	0.13	0.10	0.08
16	SiL	1XPR	3	0.41	0.21	0.14	0.09	0.08
17	SiL	1XPR	1	0.45	0.27	0.21	0.13	0.11
17	SiL	1XPR	2	0.45	0.33	0.19	0.14	0.12
17	SiL	1XPR	3	0.48	0.3	0.19	0.13	0.10
18	SiL	1XPR	1	0.28	0.08	0.07	0.05	0.04
18	SiL	1XPR	2	0.28	0.13	0.06	0.05	0.04
18	SiL	1XPR	3	0.3	0.11	0.06	0.04	0.04
19	SiL	1XPR	1	0.34	0.22	0.15	0.11	0.08
19	SiL	1XPR	2	0.36	0.25	0.15	0.11	0.08
19	SiL	1XPR	3	0.37	0.23	0.15	0.10	0.07
20	SiL	1XPR	1	0.38	0.21	0.17	0.11	0.11
20	SiL	1XPR	2	0.4	0.27	0.16	0.12	0.09
20	SiL	1XPR	3	0.42	0.24	0.17	0.11	0.08
21	SiL	1XPR	1	0.35	0.15	0.10	0.07	0.06
21	SiL	1XPR	2	0.36	0.2	0.09	0.08	0.06

Table 58 cont.

21	SiL	1XPR	3	0.37	0.16	0.11	0.06	0.06
22	SiL	1XPR	1	0.33	0.21	0.16	0.11	0.08
22	SiL	1XPR	2	0.33	0.25	0.15	0.11	0.08
22	SiL	1XPR	3	0.35	0.23	0.16	0.10	0.07
23	SiL	1XPR	1	0.38	0.16	0.15	0.12	0.09
23	SiL	1XPR	2	0.34	0.26	0.14	0.12	0.09
23	SiL	1XPR	3	0.37	0.24	0.13	0.11	0.08
24	SiL	1XPR	1	0.34	0.18	0.14	0.11	0.07
24	SiL	1XPR	2	0.29	0.22	0.13	0.10	0.08
24	SiL	1XPR	3	0.36	0.2	0.14	0.10	0.07
25	SiL	1XPR	1	0.31	0.21	0.15	0.10	0.07
25	SiL	1XPR	2	0.32	0.25	0.14	0.10	0.08
25	SiL	1XPR	3	0.33	0.23	0.14	0.09	0.07
26	SiCL	1XPR	1	0.4	0.23	0.15	0.13	0.10
26	SiCL	1XPR	2	0.37	0.27	0.17	0.13	0.11
26	SiCL	1XPR	3	0.42	0.23	0.18	0.13	0.09
27	SiCL	1XPR	1	0.47	0.26	0.24	0.18	0.12
27	SiCL	1XPR	2	0.35	0.31	0.24	0.19	0.14
27	SiCL	1XPR	3	0.41	0.29	0.23	0.19	0.12
28	SiCL	1XPR	1	0.4	0.29	0.24	0.19	0.14
28	SiCL	1XPR	2	0.44	0.33	0.24	0.19	0.15
28	SiCL	1XPR	3	0.43	0.30	0.25	0.20	0.12
29	SiCL	1XPR	1	0.42	0.24	0.18	0.11	0.08
29	SiCL	1XPR	2	0.43	0.27	0.16	0.12	0.09
29	SiCL	1XPR	3	0.45	0.24	0.17	0.11	0.08
30	SiCL	1XPR	1	0.29	0.26	0.19	0.13	0.11
30	SiCL	1XPR	2	0.33	0.21	0.19	0.14	0.12
30	SiCL	1XPR	3	0.4	0.24	0.18	0.13	0.10
31	SiCL	1XPR	1	0.36	0.33	0.25	0.19	0.14
31	SiCL	1XPR	2	0.36	0.27	0.25	0.19	0.14
31	SiCL	1XPR	3	0.44	0.29	0.25	0.19	0.14
32	SiCL	1XPR	1	0.35	0.33	0.25	0.21	0.15
32	SiCL	1XPR	2	0.41	0.28	0.26	0.21	0.14
32	SiCL	1XPR	3	0.47	0.30	0.24	0.21	0.15
33	SiCL	1XPR	1	0.25	0.22	0.17	0.11	0.09
33	SiCL	1XPR	2	0.39	0.22	0.17	0.11	0.09
33	SiCL	1XPR	3	0.37	0.23	0.17	0.11	0.08
34	SiCL	1XPR	1	0.24	0.25	0.19	0.14	0.11
34	SiCL	1XPR	2	0.33	0.21	0.19	0.14	0.12
34	SiCL	1XPR	3	0.35	0.24	0.20	0.13	0.10
35	SiCL	1XPR	1	0.35	0.31	0.25	0.18	0.13
35	SiCL	1XPR	2	0.44	0.26	0.24	0.18	0.13
35	SiCL	1XPR	3	0.44	0.31	0.24	0.17	0.11
36	SiCL	1XPR	1	0.39	0.35	0.27	0.21	0.14
36	SiCL	1XPR	2	0.48	0.31	0.26	0.20	0.15
36	SiCL	1XPR	3	0.5	0.33	0.26	0.20	0.15
37	SiCL	1XPR	1	0.24	0.22	0.16	0.11	0.09
37	SiCL	1XPR	2	0.36	0.22	0.15	0.11	0.09
37	SiCL	1XPR	3	0.39	0.22	0.15	0.11	0.08
38	SiCL	1XPR	1	0.23	0.25	0.20	0.14	0.10
38	SiCL	1XPR	2	0.35	0.23	0.19	0.14	0.11
38	SiCL	1XPR	3	0.36	0.25	0.19	0.13	0.10
39	SiCL	1XPR	1	0.4	0.34	0.27	0.20	0.13
39	SiCL	1XPR	2	0.48	0.32	0.24	0.19	0.14
39	SiCL	1XPR	3	0.5	0.34	0.22	0.20	0.12
40	SiCL	1XPR	1	0.27	0.27	0.17	0.11	0.09

Table 58 cont.

40	SiCL	1XPR	2	0.33	0.25	0.17	0.11	0.10
40	SiCL	1XPR	3	0.33	0.28	0.16	0.11	0.09
41	SiCL	1XPR	1	0.26	0.23	0.18	0.13	0.10
41	SiCL	1XPR	2	0.33	0.22	0.17	0.13	0.10
41	SiCL	1XPR	3	0.36	0.22	0.16	0.12	0.10
42	SiCL	1XPR	1	0.28	0.27	0.17	0.10	0.09
42	SiCL	1XPR	2	0.39	0.25	0.16	0.11	0.09
42	SiCL	1XPR	3	0.4	0.27	0.16	0.11	0.08
43	SiC	1XPR	1	0.31	0.28	0.20	0.14	0.13
43	SiC	1XPR	2	0.41	0.21	0.18	0.14	0.13
43	SiC	1XPR	3	0.38	0.24	0.19	0.14	0.13
44	SiC	1XPR	1	0.49	0.41	0.31	0.23	0.17
44	SiC	1XPR	2	0.52	0.33	0.30	0.22	0.17
44	SiC	1XPR	3	0.55	0.36	0.30	0.32	0.15
45	SiC	1XPR	1	0.38	0.27	0.20	0.13	0.11
45	SiC	1XPR	2	0.38	0.24	0.19	0.13	0.11
45	SiC	1XPR	3	0.37	0.25	0.18	0.12	0.11
46	SiC	1XPR	1	0.41	0.30	0.21	0.15	0.11
46	SiC	1XPR	2	0.42	0.25	0.20	0.15	0.11
46	SiC	1XPR	3	0.42	0.24	0.20	0.15	0.13
47	SiC	1XPR	1	0.38	0.30	0.21	0.16	0.12
47	SiC	1XPR	2	0.43	0.25	0.20	0.16	0.11
47	SiC	1XPR	3	0.4	0.25	0.20	0.15	0.11
48	SiC	1XPR	1	0.48	0.38	0.29	0.24	0.17
48	SiC	1XPR	2	0.54	0.35	0.31	0.23	0.18
48	SiC	1XPR	3	0.54	0.37	0.30	0.25	0.17
49	SiC	1XPR	1	0.43	0.31	0.25	0.17	0.14
49	SiC	1XPR	2	0.45	0.27	0.24	0.18	0.12
49	SiC	1XPR	3	0.46	0.30	0.23	0.17	0.13
50	SiC	1XPR	1	0.4	0.29	0.22	0.15	0.11
50	SiC	1XPR	2	0.42	0.25	0.20	0.15	0.13
50	SiC	1XPR	3	0.4	0.27	0.20	0.14	0.13
51	SiC	1XPR	1	0.43	0.33	0.23	0.17	0.14
51	SiC	1XPR	2	0.45	0.26	0.22	0.16	0.12
51	SiC	1XPR	3	0.46	0.30	0.22	0.17	0.11
52	SiC	1XPR	1	0.61	0.46	0.34	0.25	0.23
52	SiC	1XPR	2	0.62	0.39	0.33	0.25	0.19
52	SiC	1XPR	3	0.62	0.41	0.32	0.25	0.17
53	SiC	1XPR	1	0.64	0.41	0.33	0.22	0.18
53	SiC	1XPR	2	0.62	0.38	0.31	0.22	0.18
53	SiC	1XPR	3	0.64	0.40	0.29	0.23	0.17
54	SiC	1XPR	1	0.4	0.29	0.21	0.14	0.13
54	SiC	1XPR	2	0.4	0.24	0.19	0.14	0.13
54	SiC	1XPR	3	0.43	0.25	0.20	0.14	0.13
55	SiC	1XPR	1	0.49	0.36	0.28	0.20	0.19
55	SiC	1XPR	2	0.47	0.33	0.26	0.20	0.15
55	SiC	1XPR	3	0.51	0.33	0.26	0.20	0.12
1	FSL	1XCBM	1	0.30	0.13	0.10	0.06	0.05
1	FSL	1XCBM	2	0.33	0.18	0.09	0.07	0.06
1	FSL	1XCBM	3	0.33	0.15	0.09	0.07	0.05
3	FSL	1XCBM	1	0.22	0.09	0.08	0.05	0.04
3	FSL	1XCBM	2	0.29	0.12	0.06	0.05	0.05
3	FSL	1XCBM	3	0.27	0.1	0.07	0.05	0.04
4	FSL	1XCBM	1	0.28	0.08	0.06	0.04	0.04
4	FSL	1XCBM	2	0.31	0.14	0.06	0.05	0.04
4	FSL	1XCBM	3	0.25	0.11	0.06	0.05	0.04

Table 58 cont.

6	FSL	1XCBM	1	0.28	0.11	0.08	0.05	0.04
6	FSL	1XCBM	2	0.32	0.15	0.07	0.05	0.05
6	FSL	1XCBM	3	0.29	0.12	0.07	0.05	0.04
7	FSL	1XCBM	1	0.17	0.06	0.05	0.04	0.03
7	FSL	1XCBM	2	0.21	0.1	0.04	0.04	0.04
7	FSL	1XCBM	3	0.23	0.07	0.05	0.04	0.03
8	FSL	1XCBM	1	0.22	0.07	0.05	0.04	0.03
8	FSL	1XCBM	2	0.29	0.1	0.05	0.04	0.04
8	FSL	1XCBM	3	0.31	0.1	0.06	0.04	0.03
9	FSL	1XCBM	1	0.19	0.05	0.05	0.04	0.03
9	FSL	1XCBM	2	0.24	0.11	0.04	0.03	0.03
9	FSL	1XCBM	3	0.24	0.06	0.04	0.03	0.03
11	FSL	1XCBM	1	0.14	0.05	0.04	0.03	0.02
11	FSL	1XCBM	2	0.24	0.07	0.04	0.03	0.03
11	FSL	1XCBM	3	0.22	0.06	0.04	0.03	0.03
12	FSL	1XCBM	1	0.31	0.08	0.06	0.06	0.04
12	FSL	1XCBM	2	0.34	0.17	0.06	0.05	0.05
12	FSL	1XCBM	3	0.33	0.13	0.07	0.05	0.04
13	SiL	1XCBM	1	0.36	0.23	0.18	0.14	0.12
13	SiL	1XCBM	2	0.4	0.27	0.17	0.13	0.12
13	SiL	1XCBM	3	0.46	0.25	0.18	0.13	0.10
14	SiL	1XCBM	1	0.25	0.1	0.08	0.05	0.04
14	SiL	1XCBM	2	0.3	0.16	0.07	0.06	0.05
14	SiL	1XCBM	3	0.3	0.13	0.09	0.05	0.04
15	SiL	1XCBM	1	0.34	0.21	0.16	0.11	0.08
15	SiL	1XCBM	2	0.37	0.24	0.15	0.11	0.09
15	SiL	1XCBM	3	0.37	0.22	0.16	0.13	0.08
16	SiL	1XCBM	1	0.32	0.2	0.15	0.10	0.08
16	SiL	1XCBM	2	0.4	0.24	0.13	0.09	0.09
16	SiL	1XCBM	3	0.41	0.22	0.14	0.10	0.08
17	SiL	1XCBM	1	0.44	0.28	0.20	0.14	0.11
17	SiL	1XCBM	2	0.46	0.34	0.20	0.15	0.13
17	SiL	1XCBM	3	0.48	0.3	0.19	0.13	0.09
18	SiL	1XCBM	1	0.23	0.09	0.06	0.05	0.03
18	SiL	1XCBM	2	0.28	0.17	0.06	0.05	0.04
18	SiL	1XCBM	3	0.26	0.09	0.06	0.05	0.04
19	SiL	1XCBM	1	0.33	0.2	0.15	0.10	0.08
19	SiL	1XCBM	2	0.35	0.24	0.15	0.11	0.09
19	SiL	1XCBM	3	0.36	0.22	0.14	0.10	0.07
20	SiL	1XCBM	1	0.37	0.22	0.16	0.12	0.10
20	SiL	1XCBM	2	0.39	0.27	0.17	0.12	0.11
20	SiL	1XCBM	3	0.41	0.23	0.17	0.12	0.08
21	SiL	1XCBM	1	0.34	0.16	0.10	0.07	0.07
21	SiL	1XCBM	2	0.36	0.22	0.10	0.07	0.07
21	SiL	1XCBM	3	0.35	0.15	0.10	0.07	0.06
22	SiL	1XCBM	1	0.32	0.21	0.15	0.11	0.08
22	SiL	1XCBM	2	0.33	0.23	0.16	0.12	0.09
22	SiL	1XCBM	3	0.33	0.21	0.15	0.11	0.07
23	SiL	1XCBM	1	0.35	0.16	0.14	0.12	0.12
23	SiL	1XCBM	2	0.38	0.28	0.14	0.12	0.10
23	SiL	1XCBM	3	0.37	0,24	0.13	0.11	0.08
24	SiL	1XCBM	1	0.32	0.17	0.14	0.10	0.08
24	SiL	1XCBM	2	0.33	0.23	0.14	0.11	0.08
24	SiL	1XCBM	3	0.35	0.2	0.14	0.10	0.07
25	SiL	1XCBM	1	0.29	0.20	0.14	0.10	0.07
25	SiL	1XCBM	2	0.31	0.24	0.14	0.11	0.08

Table 58 cont.

25	SiL	1XCBM	3	0.33	0.20	0.14	0.10	0.07
26	SiCL	1XCBM	1	0.34	0.24	0.18	0.13	0.10
26	SiCL	1XCBM	2	0.34	0.24	0.18	0.15	0.11
26	SiCL	1XCBM	3	0.4	0.24	0.18	0.14	0.09
27	SiCL	1XCBM	1	0.42	0.27	0.24	0.20	0.13
27	SiCL	1XCBM	2	0.36	0.30	0.25	0.19	0.14
27	SiCL	1XCBM	3	0.39	0.28	0.22	0.18	0.12
28	SiCL	1XCBM	1	0.38	0.30	0.23	0.19	0.14
28	SiCL	1XCBM	2	0.45	0.32	0.24	0.19	0.15
28	SiCL	1XCBM	3	0.48	0.27	0.24	0.20	0.12
29	SiCL	1XCBM	1	0.4	0.23	0.17	0.12	0.09
29	SiCL	1XCBM	2	0.43	0.27	0.17	0.12	0.10
29	SiCL	1XCBM	3	0.44	0.24	0.17	0.11	0.08
30	SiCL	1XCBM	1	0.4	0.26	0.20	0.14	0.11
30	SiCL	1XCBM	2	0.37	0.24	0.19	0.14	0.11
30	SiCL	1XCBM	3	0.34	0.24	0.18	0.13	0.10
31	SiCL	1XCBM	1	0.46	0.32	0.26	0.19	0.15
31	SiCL	1XCBM	2	0.46	0.25	0.25	0.19	0.14
31	SiCL	1XCBM	3	0.39	0.30	0.24	0.19	0.14
32	SiCL	1XCBM	1	0.42	0.34	0.26	0.19	0.14
32	SiCL	1XCBM	2	0.44	0.29	0.26	0.20	0.14
32	SiCL	1XCBM	3	0.4	0.31	0.25	0.19	0.16
33	SiCL	1XCBM	1	0.38	0.27	0.18	0.11	0.09
33	SiCL	1XCBM	2	0.38	0.22	0.17	0.11	0.09
33	SiCL	1XCBM	3	0.35	0.25	0.16	0.11	0.09
34	SiCL	1XCBM	1	0.35	0.24	0.19	0.14	0.11
34	SiCL	1XCBM	2	0.36	0.22	0.19	0.14	0.11
34	SiCL	1XCBM	3	0.35	0.24	0.19	0.13	0.10
35	SiCL	1XCBM	1	0.44	0.34	0.25	0.18	0.13
35	SiCL	1XCBM	2	0.38	0.27	0.24	0.18	0.14
35	SiCL	1XCBM	3	0.39	0.28	0.24	0.16	0.12
36	SiCL	1XCBM	1	0.48	0.35	0.28	0.20	0.14
36	SiCL	1XCBM	2	0.46	0.30	0.26	0.19	0.15
36	SiCL	1XCBM	3	0.48	0.33	0.25	0.18	0.13
37	SiCL	1XCBM	1	0.41	0.23	0.17	0.11	0.09
37	SiCL	1XCBM	2	0.39	0.23	0.16	0.11	0.10
37	SiCL	1XCBM	3	0.39	0.24	0.15	0.10	0.09
38	SiCL	1XCBM	1	0.39	0.25	0.20	0.14	0.11
38	SiCL	1XCBM	2	0.38	0.22	0.19	0.14	0.10
38	SiCL	1XCBM	3	0.3	0.23	0.18	0.13	0.10
39	SiCL	1XCBM	1	0.48	0.35	0.26	0.19	0.13
39	SiCL	1XCBM	2	0.47	0.31	0.24	0.18	0.15
39	SiCL	1XCBM	3	0.46	0.32	0.23	0.18	0.14
40	SiCL	1XCBM	1	0.36	0.26	0.18	0.11	0.09
40	SiCL	1XCBM	2	0.34	0.25	0.17	0.11	0.09
40	SiCL	1XCBM	3	0.39	0.30	0.16	0.11	0.08
41	SiCL	1XCBM	1	0.33	0.26	0.18	0.13	0.10
41	SiCL	1XCBM	2	0.34	0.22	0.17	0.13	0.10
41	SiCL	1XCBM	3	0.34	0.24	0.17	0.12	0.09
42	SiCL	1XCBM	1	0.41	0.30	0.17	0.11	0.09
42	SiCL	1XCBM	2	0.4	0.25	0.17	0.11	0.09
42	SiCL	1XCBM	3	0.42	0.27	0.16	0.10	0.08
43	SiC	1XCBM	1	0.41	0.26	0.20	0.15	0.13
43	SiC	1XCBM	2	0.35	0.21	0.19	0.14	0.12
43	SiC	1XCBM	3	0.44	0.24	0.19	0.14	0.12
44	SiC	1XCBM	1	0.53	0.38	0.30	0.23	0.17

Table 58 cont.

44	SiC	1XCBM	2	0.51	0.31	0.30	0.23	0.19
44	SiC	1XCBM	3	0.55	0.38	0.29	0.23	0.16
45	SiC	1XCBM	1	0.39	0.27	0.20	0.13	0.11
45	SiC	1XCBM	2	0.38	0.23	0.18	0.13	0.11
45	SiC	1XCBM	3	0.39	0.22	0.18	0.12	0.11
46	SiC	1XCBM	1	0.42	0.29	0.22	0.16	0.11
46	SiC	1XCBM	2	0.4	0.22	0.20	0.15	0.13
46	SiC	1XCBM	3	0.42	0.28	0.20	0.15	0.13
47	SiC	1XCBM	1	0.42	0.29	0.21	0.16	0.12
47	SiC	1XCBM	2	0.37	0.26	0.20	0.16	0.11
47	SiC	1XCBM	3	0.4	0.26	0.20	0.15	0.11
48	SiC	1XCBM	1	0.48	0.40	0.29	0.24	0.17
48	SiC	1XCBM	2	0.5	0.32	0.30	0.24	0.15
48	SiC	1XCBM	3	0.54	0.37	0.30	0.24	0.15
49	SiC	1XCBM	1	0.42	0.31	0.23	0.17	0.13
49	SiC	1XCBM	2	0.41	0.27	0.24	0.18	0.12
49	SiC	1XCBM	3	0.42	0.28	0.23	0.17	0.13
50	SiC	1XCBM	1	0.39	0.29	0.21	0.15	0.11
50	SiC	1XCBM	2	0.4	0.25	0.20	0.15	0.13
50	SiC	1XCBM	3	0.43	0.28	0.20	0.14	0.13
51	SiC	1XCBM	1	0.44	0.32	0.22	0.17	0.12
51	SiC	1XCBM	2	0.42	0.27	0.22	0.17	0.12
51	SiC	1XCBM	3	0.44	0.30	0.22	0.16	0.11
52	SiC	1XCBM	1	0.6	0.45	0.33	0.26	0.18
52	SiC	1XCBM	2	0.59	0.37	0.33	0.26	0.20
52	SiC	1XCBM	3	0.62	0.41	0.33	0.25	0.16
53	SiC	1XCBM	1	0.58	0.40	0.31	0.23	0.16
53	SiC	1XCBM	2	0.6	0.36	0.30	0.23	0.17
53	SiC	1XCBM	3	0.59	0.41	0.26	0.22	0.16
54	SiC	1XCBM	1	0.38	0.26	0.21	0.15	0.13
54	SiC	1XCBM	2	0.38	0.21	0.20	0.15	0.13
54	SiC	1XCBM	3	0.42	0.27	0.19	0.14	0.13
55	SiC	1XCBM	1	0.49	0.34	0.27	0.21	0.14
55	SiC	1XCBM	2	0.47	0.31	0.26	0.21	0.14
55	SiC	1XCBM	3	0.5	0.35	0.26	0.20	0.14
1	FSL	5XPR	1	0.28	0.16	0.09	0.06	0.06
1	FSL	5XPR	2	0.28	0.15	0.08	0.06	0.05
1	FSL	5XPR	3	0.29	0.15	0.07	0.07	0.05
3	FSL	5XPR	1	0.21	0.12	0.07	0.05	0.04
3	FSL	5XPR	2	0.22	0.12	0.07	0.06	0.04
3	FSL	5XPR	3	0.21	0.11	0.06	0.05	0.04
4	FSL	5XPR	1	0.27	0.13	0.06	0.05	0.04
4	FSL	5XPR	2	0.27	0.12	0.06	0.05	0.04
4	FSL	5XPR	3	0.25	0.11	0.06	0.05	0.04
6	FSL	5XPR	1	0.27	0.15	0.07	0.05	0.04
6	FSL	5XPR	2	0.26	0.14	0.07	0.05	0.04
6	FSL	5XPR	3	0.26	0.12	0.06	0.06	0.05
7	FSL	5XPR	1	0.18	0.09	0.05	0.04	0.03
7	FSL	5XPR	2	0.17	0.08	0.05	0.04	0.03
7	FSL	5XPR	3	0.17	0.07	0.04	0.04	0.03
8	FSL	5XPR	1	0.25	0.11	0.05	0.04	0.03
8	FSL	5XPR	2	0.24	0.1	0.06	0.04	0.04
8	FSL	5XPR	3	0.24	0.1	0.05	0.04	0.03
9	FSL	5XPR	1	0.21	0.09	0.04	0.03	0.03
9	FSL	5XPR	2	0.18	0.08	0.05	0.03	0.03
9	FSL	5XPR	3	0.19	0.07	0.04	0.03	0.03

Table 58 cont.

11	FSL	5XPR	1	0.16	0.07	0.04	0.03	0.03
11	FSL	5XPR	2	0.15	0.06	0.04	0.03	0.03
11	FSL	5XPR	3	0.21	0.06	0.03	0.03	0.03
12	FSL	5XPR	1	0.28	0.13	0.06	0.05	0.04
12	FSL	5XPR	2	0.28	0.15	0.06	0.05	0.04
12	FSL	5XPR	3	0.28	0.13	0.06	0.05	0.04
13	SiL	5XPR	1	0.36	0.27	0.16	0.12	0.10
13	SiL	5XPR	2	0.38	0.24	0.16	0.12	0.11
13	SiL	5XPR	3	0.36	0.25	0.16	0.12	0.10
14	SiL	5XPR	1	0.25	0.13	0.07	0.05	0.04
14	SiL	5XPR	2	0.24	0.14	0.07	0.05	0.05
14	SiL	5XPR	3	0.25	0.11	0.06	0.05	0.04
15	SiL	5XPR	1	0.31	0.21	0.14	0.10	0.08
15	SiL	5XPR	2	0.32	0.2	0.13	0.10	0.08
15	SiL	5XPR	3	0.32	0.22	0.13	0.10	0.08
16	SiL	5XPR	1	0.33	0.23	0.14	0.09	0.08
16	SiL	5XPR	2	0.33	0.21	0.12	0.10	0.07
16	SiL	5XPR	3	0.33	0.21	0.12	0.10	0.08
17	SiL	5XPR	1	0.43	0.31	0.18	0.14	0.11
17	SiL	5XPR	2	0.42	0.28	0.18	0.14	0.11
17	SiL	5XPR	3	0.42	0.3	0.18	0.14	0.13
18	SiL	5XPR	1	0.24	0.13	0.06	0.05	0.04
18	SiL	5XPR	2	0.22	0.11	0.06	0.05	0.04
18	SiL	5XPR	3	0.24	0.1	0.06	0.02	0.06
19	SiL	5XPR	1	0.31	0.2	0.14	0.09	0.08
19	SiL	5XPR	2	0.32	0.2	0.14	0.11	0.08
19	SiL	5XPR	3	0.31	0.22	0.13	0.10	0.09
20	SiL	5XPR	1	0.36	0.23	0.14	0.10	0.09
20	SiL	5XPR	2	0.34	0.24	0.13	0.10	0.09
20	SiL	5XPR	3	0.34	0.24	0.14	0.11	0.10
21	SiL	5XPR	1	0.32	0.18	0.09	0.07	0.06
21	SiL	5XPR	2	0.3	0.15	0.09	0.08	0.06
21	SiL	5XPR	3	0.31	0.18	0.08	0.08	0.07
22	SiL	5XPR	1	0.29	0.21	0.13	0.10	0.08
22	SiL	5XPR	2	0.29	0.2	0.14	0.10	0.08
22	SiL	5XPR	3	0.29	0.22	0.14	0.10	0.08
23	SiL	5XPR	1	0.35	0.23	0.12	0.09	0.07
23	SiL	5XPR	2	0.34	0.2	0.12	0.10	0.07
23	SiL	5XPR	3	0.34	0.23	0.11	0.09	0.07
24	SiL	5XPR	1	0.29	0.21	0.13	0.09	0.08
24	SiL	5XPR	2	0.3	0.2	0.13	0.10	0.08
24	SiL	5XPR	3	0.3	0.2	0.13	0.10	0.08
25	SiL	5XPR	1	0.28	0.22	0.13	0.09	0.07
25	SiL	5XPR	2	0.29	0.19	0.12	0.09	0.07
25	SiL	5XPR	3	0.29	0.20	0.12	0.09	0.07
26	SiCL	5XPR	1	0.35	0.26	0.18	0.13	0.10
26	SiCL	5XPR	2	0.35	0.24	0.17	0.14	0.10
26	SiCL	5XPR	3	0.35	0.25	0.17	0.13	0.11
27	SiCL	5XPR	1	0.42	0.32	0.23	0.18	0.12
27	SiCL	5XPR	2	0.43	0.30	0.23	0.19	0.12
27	SiCL	5XPR	3	0.43	0.32	0.22	0.18	0.13
28	SiCL	5XPR	1	0.42	0.33	0.23	0.18	0.13
28	SiCL	5XPR	2	0.39	0.30	0.24	0.19	0.13
28	SiCL	5XPR	3	0.42	0.32	0.22	0.19	0.14
29	SiCL	5XPR	1	0.39	0.27	0.17	0.11	0.09
29	SiCL	5XPR	2	0.39	0.25	0.16	0.11	0.09

Table 58 cont.

29	SiCL	5XPR	3	0.38	0.25	0.16	0.11	0.09
30	SiCL	5XPR	1	0.36	0.28	0.16	0.14	0.10
30	SiCL	5XPR	2	0.39	0.26	0.17	0.14	0.11
30	SiCL	5XPR	3	0.38	0.25	0.20	0.13	0.10
31	SiCL	5XPR	1	0.41	0.34	0.20	0.19	0.12
31	SiCL	5XPR	2	0.45	0.32	0.20	0.19	0.14
31	SiCL	5XPR	3	0.45	0.33	0.24	0.18	0.13
32	SiCL	5XPR	1	0.45	0.36	0.21	0.20	0.14
32	SiCL	5XPR	2	0.46	0.33	0.21	0.20	0.14
32	SiCL	5XPR	3	0.47	0.34	0.25	0.25	0.14
33	SiCL	5XPR	1	0.4	0.26	0.14	0.12	0.08
33	SiCL	5XPR	2	0.42	0.24	0.14	0.12	0.09
33	SiCL	5XPR	3	0.41	0.23	0.17	0.11	0.08
34	SiCL	5XPR	1	0.36	0.28	0.17	0.15	0.10
34	SiCL	5XPR	2	0.39	0.27	0.17	0.15	0.11
34	SiCL	5XPR	3	0.37	0.26	0.20	0.14	0.11
35	SiCL	5XPR	1	0.42	0.33	0.19	0.17	0.13
35	SiCL	5XPR	2	0.43	0.33	0.02	0.17	0.12
35	SiCL	5XPR	3	0.43	0.31	0.24	0.17	0.11
36	SiCL	5XPR	1	0.45	0.35	0.22	0.21	0.14
36	SiCL	5XPR	2	0.47	0.34	0.23	0.19	0.15
36	SiCL	5XPR	3	0.46	0.36	0.28	0.19	0.14
37	SiCL	5XPR	1	0.39	0.25	0.14	0.12	0.08
37	SiCL	5XPR	2	0.42	0.23	0.14	0.12	0.09
37	SiCL	5XPR	3	0.39	0.23	0.16	0.11	0.08
38	SiCL	5XPR	1	0.36	0.27	0.16	0.15	0.10
38	SiCL	5XPR	2	0.38	0.26	0.17	0.14	0.11
38	SiCL	5XPR	3	0.36	0.25	0.19	0.14	0.10
39	SiCL	5XPR	1	0.45	0.34	0.19	0.17	0.12
39	SiCL	5XPR	2	0.46	0.33	0.20	0.18	0.12
39	SiCL	5XPR	3	0.45	0.32	0.23	0.17	0.13
40	SiCL	5XPR	1	0.4	0.28	0.14	0.12	0.08
40	SiCL	5XPR	2	0.42	0.25	0.15	0.12	0.09
40	SiCL	5XPR	3	0.41	0.25	0.17	0.11	0.08
41	SiCL	5XPR	1	0.33	0.25	0.15	0.14	0.09
41	SiCL	5XPR	2	0.35	0.24	0.15	0.13	0.10
41	SiCL	5XPR	3	0.33	0.23	0.18	0.12	0.09
42	SiCL	5XPR	1	0.41	0.28	0.15	0.11	0.08
42	SiCL	5XPR	2	0.43	0.26	0.14	0.11	0.08
42	SiCL	5XPR	3	0.41	0.25	0.17	0.10	0.08
43	SiC	5XPR	1	0.4	0.30	0.16	0.14	0.11
43	SiC	5XPR	2	0.42	0.28	0.17	0.15	0.11
43	SiC	5XPR	3	0.42	0.29	0.19	0.15	0.13
44	SiC	5XPR	1	0.52	0.40	0.25	0.23	0.16
44	SiC	5XPR	2	0.53	0.38	0.25	0.23	0.16
44	SiC	5XPR	3	0.53	0.40	0.29	0.24	0.16
45	SiC	5XPR	1	0.37	0.28	0.14	0.13	0.10
45	SiC	5XPR	2	0.38	0.26	0.15	0.13	0.11
45	SiC	5XPR	3	0.36	0.26	0.18	0.13	0.12
46	SiC	5XPR	1	0.39	0.29	0.16	0.15	0.12
46	SiC	5XPR	2	0.39	0.29	0.16	0.15	0.12
46	SiC	5XPR	3	0.4	0.27	0.19	0.14	0.13
47	SiC	5XPR	1	0.4	0.29	0.17	0.15	0.12
47	SiC	5XPR	2	0.41	0.29	0.17	0.15	0.12
47	SiC	5XPR	3	0.42	0.29	0.20	0.15	0.13
48	SiC	5XPR	1	0.53	0.40	0.26	0.23	0.15

Table 58 cont.

48	SiC	5XPR	2	0.56	0.39	0.25	0.23	0.15
48	SiC	5XPR	3	0.53	0.41	0.30	0.24	0.17
49	SiC	5XPR	1	0.39	0.31	0.19	0.19	0.11
49	SiC	5XPR	2	0.41	0.32	0.20	0.18	0.14
49	SiC	5XPR	3	0.38	0.33	0.24	0.17	0.14
50	SiC	5XPR	1	0.39	0.31	0.16	0.14	0.12
50	SiC	5XPR	2	0.4	0.28	0.16	0.14	0.11
50	SiC	5XPR	3	0.39	0.28	0.19	0.15	0.13
51	SiC	5XPR	1	0.4	0.31	0.18	0.15	0.13
51	SiC	5XPR	2	0.42	0.29	0.17	0.16	0.13
51	SiC	5XPR	3	0.4	0.31	0.20	0.16	0.11
52	SiC	5XPR	1	0.57	0.43	0.29	0.25	0.18
52	SiC	5XPR	2	0.6	0.42	0.27	0.26	0.17
52	SiC	5XPR	3	0.56	0.43	0.33	0.27	0.17
53	SiC	5XPR	1	0.56	0.42	0.26	0.22	0.16
53	SiC	5XPR	2	0.57	0.40	0.27	0.23	0.14
53	SiC	5XPR	3	0.53	0.40	0.29	0.25	0.14
54	SiC	5XPR	1	0.39	0.31	0.16	0.14	0.12
54	SiC	5XPR	2	0.4	0.28	0.16	0.15	0.12
54	SiC	5XPR	3	0.38	0.28	0.20	0.16	0.13
55	SiC	5XPR	1	0.44	0.35	0.23	0.19	0.15
55	SiC	5XPR	2	0.46	0.32	0.22	0.19	0.14
55	SiC	5XPR	3	0.45	0.33	0.25	0.18	0.15
51	SiC	5XPR	3	0.4	0.31	0.20	0.16	0.11
52	SiC	5XPR	1	0.57	0.43	0.29	0.25	0.18
52	SiC	5XPR	2	0.6	0.42	0.27	0.26	0.17
52	SiC	5XPR	3	0.56	0.43	0.33	0.27	0.17
53	SiC	5XPR	1	0.56	0.42	0.26	0.22	0.16
53	SiC	5XPR	2	0.57	0.40	0.27	0.23	0.14
53	SiC	5XPR	3	0.53	0.40	0.29	0.25	0.14
54	SiC	5XPR	1	0.39	0.31	0.16	0.14	0.12
54	SiC	5XPR	2	0.4	0.28	0.16	0.15	0.12
54	SiC	5XPR	3	0.38	0.28	0.20	0.16	0.13
55	SiC	5XPR	1	0.44	0.35	0.23	0.19	0.15
55	SiC	5XPR	2	0.46	0.32	0.22	0.19	0.14
55	SiC	5XPR	3	0.45	0.33	0.25	0.18	0.15
1	FSL	5XPR+d	1	0.28	0.16	0.09	0.06	0.05
1	FSL	5XPR+d	2	0.3	0.14	0.10	0.06	0.06
1	FSL	5XPR+d	3	0.27	0.18	0.09	0.06	0.06
3	FSL	5XPR+d	1	0.22	0.12	0.07	0.05	0.04
3	FSL	5XPR+d	2	0.23	0.09	0.07	0.05	0.04
3	FSL	5XPR+d	3	0.23	0.14	0.07	0.05	0.04
4	FSL	5XPR+d	1	0.26	0.11	0.06	0.04	0.04
4	FSL	5XPR+d	2	0.27	0.10	0.06	0.04	0.04
4	FSL	5XPR+d	3	0.26	0.12	0.07	0.04	0.04
6	FSL	5XPR+d	1	0.26	0.13	0.08	0.05	0.05
6	FSL	5XPR+d	2	0.28	0.12	0.08	0.05	0.05
6	FSL	5XPR+d	3	0.25	0.15	0.08	0.05	0.04
7	FSL	5XPR+d	1	0.17	0.09	0.05	0.04	0.03
7	FSL	5XPR+d	2	0.2	0.07	0.06	0.03	0.03
7	FSL	5XPR+d	3	0.17	0.09	0.05	0.03	0.03
8	FSL	5XPR+d	1	0.25	0.10	0.05	0.04	0.03
8	FSL	5XPR+d	2	0.25	0.08	0.06	0.04	0.03
8	FSL	5XPR+d	3	0.22	0.10	0.05	0.04	0.03
9	FSL	5XPR+d	1	0.20	0.08	0.04	0.03	0.03
9	FSL	5XPR+d	2	0.21	0.07	0.05	0.03	0.03

Table 58 cont.

9	FSL	5XPR+d	3	0.19	0.08	0.05	0.03	0.03
11	FSL	5XPR+d	1	0.14	0.07	0.04	0.03	0.02
11	FSL	5XPR+d	2	0.17	0.05	0.04	0.03	0.03
11	FSL	5XPR+d	3	0.15	0.08	0.04	0.03	0.03
12	FSL	5XPR+d	1	0.28	0.13	0.06	0.05	0.04
12	FSL	5XPR+d	2	0.29	0.11	0.07	0.05	0.04
12	FSL	5XPR+d	3	0.27	0.17	0.07	0.05	0.04
13	SiL	5XPR+d	1	0.38	0.26	0.17	0.12	0.10
13	SiL	5XPR+d	2	0.39	0.23	0.18	0.12	0.10
13	SiL	5XPR+d	3	0.36	0.29	0.17	0.12	0.10
14	SiL	5XPR+d	1	0.24	0.14	0.07	0.05	0.04
14	SiL	5XPR+d	2	0.25	0.12	0.07	0.05	0.04
14	SiL	5XPR+d	3	0.23	0.16	0.07	0.05	0.04
15	SiL	5XPR+d	1	0.32	0.22	0.14	0.09	0.08
15	SiL	5XPR+d	2	0.33	0.20	0.15	0.10	0.08
15	SiL	5XPR+d	3	0.31	0.23	0.14	0.10	0.08
16	SiL	5XPR+d	1	0.33	0.23	0.13	0.09	0.07
16	SiL	5XPR+d	2	0.36	0.20	0.13	0.08	0.08
16	SiL	5XPR+d	3	0.33	0.25	0.13	0.08	0.08
17	SiL	5XPR+d	1	0.44	0.30	0.20	0.14	0.12
17	SiL	5XPR+d	2	0.44	0.28	0.20	0.14	0.12
17	SiL	5XPR+d	3	0.4	0.29	0.19	0.14	0.12
18	SiL	5XPR+d	1	0.24	0.12	0.07	0.05	0.04
18	SiL	5XPR+d	2	0.24	0.11	0.07	0.05	0.04
18	SiL	5XPR+d	3	0.27	0.11	0.06	0.05	0.04
19	SiL	5XPR+d	1	0.32	0.22	0.14	0.10	0.08
19	SiL	5XPR+d	2	0.33	0.20	0.14	0.10	0.08
19	SiL	5XPR+d	3	0.3	0.21	0.13	0.10	0.08
20	SiL	5XPR+d	1	0.35	0.23	0.13	0.11	0.08
20	SiL	5XPR+d	2	0.39	0.20	0.16	0.10	0.08
20	SiL	5XPR+d	3	0.34	0.23	0.15	0.10	0.08
21	SiL	5XPR+d	1	0.32	0.18	0.10	0.07	0.06
21	SiL	5XPR+d	2	0.32	0.17	0.10	0.06	0.06
21	SiL	5XPR+d	3	0.29	0.16	0.11	0.07	0.07
22	SiL	5XPR+d	1	0.30	0.21	0.15	0.10	0.08
22	SiL	5XPR+d	2	0.31	0.20	0.14	0.10	0.08
22	SiL	5XPR+d	3	0.29	0.20	0.14	0.10	0.08
23	SiL	5XPR+d	1	0.33	0.19	0.14	0.07	0.07
23	SiL	5XPR+d	2	0.34	0.18	0.12	0.10	0.07
23	SiL	5XPR+d	3	0.3	0.21	0.13	0.09	0.08
24	SiL	5XPR+d	1	0.30	0.19	0.14	0.10	0.08
24	SiL	5XPR+d	2	0.31	0.18	0.14	0.09	0.08
24	SiL	5XPR+d	3	0.29	0.21	0.13	0.09	0.08
25	SiL	5XPR+d	1	0.30	0.21	0.13	0.11	0.07
25	SiL	5XPR+d	2	0.3	0.19	0.13	0.09	0.08
25	SiL	5XPR+d	3	0.29	0.21	0.13	0.09	0.07
26	SiCL	5XPR+d	1	0.36	0.25	0.19	0.14	0.10
26	SiCL	5XPR+d	2	0.28	0.24	0.19	0.13	0.10
26	SiCL	5XPR+d	3	0.35	0.25	0.18	0.13	0.11
27	SiCL	5XPR+d	1	0.46	0.33	0.25	0.19	0.13
27	SiCL	5XPR+d	2	0.48	0.31	0.25	0.18	0.13
27	SiCL	5XPR+d	3	0.44	0.33	0.24	0.18	0.14
28	SiCL	5XPR+d	1	0.46	0.33	0.25	0.19	0.13
28	SiCL	5XPR+d	2	0.48	0.30	0.25	0.18	0.13
28	SiCL	5XPR+d	3	0.44	0.33	0.25	0.19	0.14
29	SiCL	5XPR+d	1	0.38	0.24	0.17	0.12	0.09

Table 58 cont.

29	SiCL	5XPR+d	2	0.43	0.23	0.16	0.11	0.09
29	SiCL	5XPR+d	3	0.36	0.25	0.17	0.11	0.10
30	SiCL	5XPR+d	1	0.33	0.26	0.19	0.14	0.11
30	SiCL	5XPR+d	2	0.35	0.26	0.18	0.14	0.12
30	SiCL	5XPR+d	3	0.35	0.24	0.18	0.14	0.11
31	SiCL	5XPR+d	1	0.42	0.34	0.24	0.19	0.15
31	SiCL	5XPR+d	2	0.44	0.34	0.23	0.19	0.14
31	SiCL	5XPR+d	3	0.43	0.33	0.24	0.18	0.14
32	SiCL	5XPR+d	1	0.46	0.34	0.26	0.20	0.15
32	SiCL	5XPR+d	2	0.43	0.34	0.25	0.20	0.14
32	SiCL	5XPR+d	3	0.44	0.34	0.25	0.20	0.14
33	SiCL	5XPR+d	1	0.37	0.24	0.16	0.12	0.11
33	SiCL	5XPR+d	2	0.38	0.24	0.16	0.10	0.10
33	SiCL	5XPR+d	3	0.36	0.24	0.16	0.11	0.09
34	SiCL	5XPR+d	1	0.36	0.27	0.20	0.14	0.11
34	SiCL	5XPR+d	2	0.35	0.27	0.19	0.14	0.12
34	SiCL	5XPR+d	3	0.35	0.25	0.19	0.14	0.11
35	SiCL	5XPR+d	1	0.42	0.31	0.23	0.17	0.13
35	SiCL	5XPR+d	2	0.42	0.32	0.22	0.17	0.13
35	SiCL	5XPR+d	3	0.42	0.30	0.22	0.17	0.11
36	SiCL	5XPR+d	1	0.45	0.34	0.27	0.20	0.15
36	SiCL	5XPR+d	2	0.46	0.35	0.25	0.19	0.14
36	SiCL	5XPR+d	3	0.47	0.34	0.25	0.19	0.13
37	SiCL	5XPR+d	1	0.37	0.23	0.16	0.11	0.09
37	SiCL	5XPR+d	2	0.4	0.24	0.15	0.11	0.11
37	SiCL	5XPR+d	3	0.38	0.23	0.15	0.11	0.09
38	SiCL	5XPR+d	1	0.35	0.26	0.19	0.15	0.11
38	SiCL	5XPR+d	2	0.33	0.26	0.19	0.14	0.12
38	SiCL	5XPR+d	3	0.33	0.25	0.18	0.14	0.10
39	SiCL	5XPR+d	1	0.43	0.31	0.22	0.16	0.13
39	SiCL	5XPR+d	2	0.42	0.34	0.21	0.16	0.11
39	SiCL	5XPR+d	3	0.42	0.31	0.22	0.17	0.13
40	SiCL	5XPR+d	1	0.37	0.27	0.17	0.11	0.10
40	SiCL	5XPR+d	2	0.37	0.27	0.16	0.11	0.10
40	SiCL	5XPR+d	3	0.37	0.25	0.16	0.11	0.09
41	SiCL	5XPR+d	1	0.31	0.23	0.18	0.11	0.10
41	SiCL	5XPR+d	2	0.33	0.25	0.17	0.11	0.11
41	SiCL	5XPR+d	3	0.33	0.23	0.17	0.11	0.10
42	SiCL	5XPR+d	1	0.38	0.25	0.17	0.11	0.09
42	SiCL	5XPR+d	2	0.35	0.26	0.15	0.11	0.10
42	SiCL	5XPR+d	3	0.37	0.25	0.16	0.11	0.08
43	SiC	5XPR+d	1	0.39	0.29	0.19	0.14	0.13
43	SiC	5XPR+d	2	0.39	0.26	0.19	0.14	0.13
43	SiC	5XPR+d	3	0.39	0.27	0.18	0.15	0.11
44	SiC	5XPR+d	1	0.50	0.38	0.30	0.23	0.17
44	SiC	5XPR+d	2	0.52	0.38	0.29	0.23	0.16
44	SiC	5XPR+d	3	0.52	0.37	0.29	0.23	0.17
45	SiC	5XPR+d	1	0.35	0.26	0.18	0.13	0.11
45	SiC	5XPR+d	2	0.37	0.25	0.17	0.13	0.11
45	SiC	5XPR+d	3	0.36	0.27	0.17	0.13	0.12
46	SiC	5XPR+d	1	0.37	0.28	0.20	0.15	0.13
46	SiC	5XPR+d	2	0.39	0.27	0.20	0.15	0.11
46	SiC	5XPR+d	3	0.38	0.28	0.19	0.14	0.11
47	SiC	5XPR+d	1	0.41	0.29	0.19	0.15	0.13
47	SiC	5XPR+d	2	0.4	0.28	0.20	0.14	0.13
47	SiC	5XPR+d	3	0.4	0.28	0.19	0.15	0.11

Table 58 cont.

48	SiC	5XPR+d	1	0.54	0.38	0.30	0.25	0.18
48	SiC	5XPR+d	2	0.54	0.38	0.29	0.25	0.17
48	SiC	5XPR+d	3	0.54	0.38	0.29	0.23	0.17
49	SiC	5XPR+d	1	0.43	0.32	0.24	0.19	0.15
49	SiC	5XPR+d	2	0.42	0.31	0.24	0.19	0.15
49	SiC	5XPR+d	3	0.4	0.31	0.23	0.19	0.14
50	SiC	5XPR+d	1	0.37	0.27	0.20	0.16	0.09
50	SiC	5XPR+d	2	0.38	0.28	0.20	0.16	0.13
50	SiC	5XPR+d	3	0.37	0.26	0.19	0.16	0.13
51	SiC	5XPR+d	1	0.40	0.29	0.21	0.16	0.11
51	SiC	5XPR+d	2	0.39	0.29	0.21	0.16	0.11
51	SiC	5XPR+d	3	0.41	0.27	0.21	0.16	0.12
52	SiC	5XPR+d	1	0.57	0.41	0.32	0.24	0.18
52	SiC	5XPR+d	2	0.58	0.41	0.32	0.24	0.19
52	SiC	5XPR+d	3	0.57	0.40	0.32	0.23	0.19
53	SiC	5XPR+d	1	0.53	0.38	0.29	0.27	0.19
53	SiC	5XPR+d	2	0.54	0.39	0.29	0.25	0.15
53	SiC	5XPR+d	3	0.53	0.39	0.28	0.24	0.17
54	SiC	5XPR+d	1	0.38	0.27	0.19	0.15	0.13
54	SiC	5XPR+d	2	0.39	0.27	0.19	0.14	0.13
54	SiC	5XPR+d	3	0.37	0.27	0.19	0.15	0.11
55	SiC	5XPR+d	1	0.43	0.32	0.25	0.20	0.14
55	SiC	5XPR+d	2	0.42	0.31	0.24	0.20	0.13
55	SiC	5XPR+d	3	0.41	0.31	0.23	0.20	0.14
1	FSL	5XCBM	1	0.30	0.16	0.09	0.07	0.05
1	FSL	5XCBM	2	0.29	0.15	0.09	0.07	0.06
1	FSL	5XCBM	3	0.28	0.16	0.08	0.07	0.06
3	FSL	5XCBM	1	0.24	0.12	0.07	0.05	0.04
3	FSL	5XCBM	2	0.23	0.12	0.07	0.05	0.04
3	FSL	5XCBM	3	0.21	0.12	0.07	0.05	0.04
4	FSL	5XCBM	1	0.27	0.13	0.06	0.05	0.04
4	FSL	5XCBM	2	0.27	0.13	0.06	0.05	0.04
4	FSL	5XCBM	3	0.26	0.12	0.06	0.05	0.04
6	FSL	5XCBM	1	0.27	0.13	0.07	0.05	0.05
6	FSL	5XCBM	2	0.27	0.16	0.08	0.06	0.04
6	FSL	5XCBM	3	0.26	0.14	0.07	0.06	0.05
7	FSL	5XCBM	1	0.19	0.09	0.05	0.04	0.03
7	FSL	5XCBM	2	0.18	0.1	0.05	0.04	0.03
7	FSL	5XCBM	3	0.18	0.08	0.04	0.04	0.04
8	FSL	5XCBM	1	0.24	0.11	0.05	0.04	0.03
8	FSL	5XCBM	2	0.24	0.12	0.05	0.04	0.03
8	FSL	5XCBM	3	0.24	0.1	0.05	0.04	0.04
9	FSL	5XCBM	1	0.2	0.11	0.04	0.03	0.03
9	FSL	5XCBM	2	0.2	0.09	0.04	0.03	0.03
9	FSL	5XCBM	3	0.18	0.09	0.04	0.03	0.03
11	FSL	5XCBM	1	0.16	0.07	0.04	0.03	0.02
11	FSL	5XCBM	2	0.17	0.07	0.04	0.04	0.03
11	FSL	5XCBM	3	0.16	0.06	0.04	0.03	0.03
12	FSL	5XCBM	1	0.28	0.15	0.06	0.05	0.04
12	FSL	5XCBM	2	0.28	0.11	0.07	0.05	0.04
12	FSL	5XCBM	3	0.26	0.12	0.06	0.05	0.05
13	SiL	5XCBM	1	0.37	0.25	0.17	0.13	0.10
13	SiL	5XCBM	2	0.39	0.26	0.16	0.12	0.10
13	SiL	5XCBM	3	0.37	0.26	0.15	0.12	0.11
14	SiL	5XCBM	1	0.26	0.13	0.07	0.05	0.04
14	SiL	5XCBM	2	0.25	0.14	0.07	0.05	0.04

Table 58 cont.

14	SiL	5XCBM	3	0.24	0.13	0.07	0.05	0.05
15	SiL	5XCBM	1	0.32	0.22	0.14	0.10	0.08
15	SiL	5XCBM	2	0.33	0.2	0.14	0.10	0.08
15	SiL	5XCBM	3	0.32	0.21	0.13	0.11	0.09
16	SiL	5XCBM	1	0.33	0.24	0.13	0.09	0.08
16	SiL	5XCBM	2	0.34	0.22	0.12	0.09	0.08
16	SiL	5XCBM	3	0.33	0.23	0.12	0.10	0.09
17	SiL	5XCBM	1	0.42	0.29	0.18	0.14	0.12
17	SiL	5XCBM	2	0.43	0.3	0.18	0.14	0.13
17	SiL	5XCBM	3	0.43	0.32	0.19	0.15	0.13
18	SiL	5XCBM	1	0.25	0.11	0.06	0.05	0.04
18	SiL	5XCBM	2	0.25	0.13	0.06	0.05	0.05
18	SiL	5XCBM	3	0.25	0.11	0.06	0.05	0.04
19	SiL	5XCBM	1	0.31	0.21	0.14	0.09	0.08
19	SiL	5XCBM	2	0.32	0.21	0.13	0.10	0.09
19	SiL	5XCBM	3	0.31	0.21	0.14	0.10	0.08
20	SiL	5XCBM	1	0.39	0.25	0.15	0.11	0.10
20	SiL	5XCBM	2	0.36	0.24	0.14	0.11	0.11
20	SiL	5XCBM	3	0.35	0.24	0.14	0.11	0.09
21	SiL	5XCBM	1	0.32	0.18	0.10	0.07	0.06
21	SiL	5XCBM	2	0.32	0.18	0.10	0.08	0.07
21	SiL	5XCBM	3	0.31	0.16	0.09	0.07	0.06
22	SiL	5XCBM	1	0.29	0.21	0.14	0.10	0.09
22	SiL	5XCBM	2	0.29	0.21	0.14	0.10	0.09
22	SiL	5XCBM	3	0.29	0.2	0.15	0.11	0.08
23	SiL	5XCBM	1	0.35	0.23	0.14	0.08	0.07
23	SiL	5XCBM	2	0.35	0.21	0.14	0.09	0.08
23	SiL	5XCBM	3	0.34	0.21	0.11	0.09	0.08
24	SiL	5XCBM	1	0.3	0.22	0.14	0.10	0.08
24	SiL	5XCBM	2	0.3	0.2	0.13	0.10	0.09
24	SiL	5XCBM	3	0.3	0.2	0.13	0.10	0.08
25	SiL	5XCBM	1	0.29	0.20	0.13	0.09	0.08
25	SiL	5XCBM	2	0.29	0.21	0.12	0.09	0.08
25	SiL	5XCBM	3	0.29	0.20	0.13	0.10	0.08
26	SiCL	5XCBM	1	0.35	0.24	0.19	0.13	0.11
26	SiCL	5XCBM	2	0.36	0.25	0.17	0.14	0.12
26	SiCL	5XCBM	3	0.34	0.26	0.17	0.14	0.11
27	SiCL	5XCBM	1	0.42	0.31	0.24	0.18	0.14
27	SiCL	5XCBM	2	0.44	0.30	0.24	0.19	0.14
27	SiCL	5XCBM	3	0.44	0.32	0.22	0.19	0.13
28	SiCL	5XCBM	1	0.42	0.32	0.24	0.19	0.14
28	SiCL	5XCBM	2	0.43	0.30	0.24	0.19	0.15
28	SiCL	5XCBM	3	0.43	0.32	0.24	0.19	0.14
29	SiCL	5XCBM	1	0.4	0.25	0.17	0.11	0.10
29	SiCL	5XCBM	2	0.39	0.25	0.16	0.12	0.11
29	SiCL	5XCBM	3	0.39	0.26	0.17	0.12	0.10
30	SiCL	5XCBM	1	0.35	0.27	0.18	0.14	0.11
30	SiCL	5XCBM	2	0.38	0.27	0.17	0.14	0.11
30	SiCL	5XCBM	3	0.39	0.27	0.19	0.14	0.11
31	SiCL	5XCBM	1	0.41	0.34	0.21	0.18	0.13
31	SiCL	5XCBM	2	0.43	0.32	0.20	0.19	0.13
31	SiCL	5XCBM	3	0.43	0.35	0.25	0.18	0.12
32	SiCL	5XCBM	1	0.43	0.34	0.22	0.19	0.14
32	SiCL	5XCBM	2	0.46	0.33	0.21	0.20	0.14
32	SiCL	5XCBM	3	0.47	0.35	0.26	0.19	0.14
33	SiCL	5XCBM	1	0.39	0.26	0.14	0.11	0.10

Table 58 cont.

33	SiCL	5XCBM	2	0.39	0.24	0.14	0.11	0.09
33	SiCL	5XCBM	3	0.42	0.27	0.17	0.11	0.09
34	SiCL	5XCBM	1	0.36	0.28	0.17	0.15	0.11
34	SiCL	5XCBM	2	0.37	0.27	0.17	0.14	0.11
34	SiCL	5XCBM	3	0.37	0.27	0.19	0.14	0.11
35	SiCL	5XCBM	1	0.41	0.33	0.19	0.17	0.11
35	SiCL	5XCBM	2	0.41	0.32	0.19	0.17	0.12
35	SiCL	5XCBM	3	0.43	0.33	0.24	0.16	0.13
36	SiCL	5XCBM	1	0.43	0.35	0.22	0.20	0.14
36	SiCL	5XCBM	2	0.44	0.34	0.21	0.20	0.15
36	SiCL	5XCBM	3	0.46	0.35	0.26	0.19	0.14
37	SiCL	5XCBM	1	0.37	0.27	0.14	0.11	0.09
37	SiCL	5XCBM	2	0.39	0.24	0.15	0.11	0.08
37	SiCL	5XCBM	3	0.41	0.25	0.17	0.14	0.08
38	SiCL	5XCBM	1	0.34	0.28	0.17	0.15	0.12
38	SiCL	5XCBM	2	0.36	0.26	0.17	0.14	0.11
38	SiCL	5XCBM	3	0.37	0.26	0.19	0.14	0.10
39	SiCL	5XCBM	1	0.43	0.34	0.21	0.18	0.13
39	SiCL	5XCBM	2	0.45	0.33	0.19	0.16	0.12
39	SiCL	5XCBM	3	0.47	0.33	0.23	0.16	0.11
40	SiCL	5XCBM	1	0.4	0.28	0.16	0.12	0.09
40	SiCL	5XCBM	2	0.42	0.26	0.15	0.12	0.09
40	SiCL	5XCBM	3	0.41	0.28	0.18	0.11	0.09
41	SiCL	5XCBM	1	0.31	0.26	0.15	0.13	0.10
41	SiCL	5XCBM	2	0.33	0.24	0.16	0.13	0.10
41	SiCL	5XCBM	3	0.33	0.25	0.18	0.12	0.09
42	SiCL	5XCBM	1	0.4	0.30	0.15	0.11	0.09
42	SiCL	5XCBM	2	0.41	0.27	0.17	0.11	0.08
42	SiCL	5XCBM	3	0.42	0.28	0.17	0.10	0.08
43	SiC	5XCBM	1	0.43	0.28	0.17	0.15	0.12
43	SiC	5XCBM	2	0.42	0.28	0.16	0.15	0.13
43	SiC	5XCBM	3	0.43	0.29	0.20	0.14	0.11
44	SiC	5XCBM	1	0.51	0.40	0.25	0.23	0.15
44	SiC	5XCBM	2	0.53	0.38	0.25	0.23	0.17
44	SiC	5XCBM	3	0.52	0.40	0.29	0.23	0.17
45	SiC	5XCBM	1	0.37	0.26	0.15	0.14	0.11
45	SiC	5XCBM	2	0.4	0.25	0.15	0.14	0.11
45	SiC	5XCBM	3	0.38	0.28	0.18	0.13	0.11
46	SiC	5XCBM	1	0.4	0.28	0.17	0.15	0.12
46	SiC	5XCBM	2	0.41	0.29	0.17	0.15	0.13
46	SiC	5XCBM	3	0.4	0.29	0.20	0.15	0.12
47	SiC	5XCBM	1	0.41	0.29	0.17	0.16	0.13
47	SiC	5XCBM	2	0.41	0.29	0.17	0.15	0.13
47	SiC	5XCBM	3	0.44	0.30	0.20	0.15	0.12
48	SiC	5XCBM	1	0.53	0.38	0.27	0.24	0.16
48	SiC	5XCBM	2	0.54	0.39	0.25	0.23	0.16
48	SiC	5XCBM	3	0.55	0.40	0.30	0.24	0.18
49	SiC	5XCBM	1	0.39	0.29	0.10	0.19	0.11
49	SiC	5XCBM	2	0.41	0.32	0.19	0.19	0.14
49	SiC	5XCBM	3	0.39	0.31	0.24	0.17	0.14
50	SiC	5XCBM	1	0.39	0.29	0.17	0.15	0.12
50	SiC	5XCBM	2	0.4	0.27	0.16	0.15	0.12
50	SiC	5XCBM	3	0.4	0.28	0.20	0.16	0.13
51	SiC	5XCBM	1	0.42	0.29	0.18	0.16	0.13
51	SiC	5XCBM	2	0.42	0.29	0.17	0.16	0.11
51	SiC	5XCBM	3	0.42	0.30	0.21	0.16	0.12

Table 58 cont.

52	SiC	5XCBM	1	0.56	0.41	0.28	0.26	0.17
52	SiC	5XCBM	2	0.58	0.41	0.27	0.26	0.18
52	SiC	5XCBM	3	0.57	0.42	0.33	0.25	0.19
53	SiC	5XCBM	1	0.51	0.37	0.26	0.21	0.15
53	SiC	5XCBM	2	0.53	0.38	0.25	0.22	0.14
53	SiC	5XCBM	3	0.54	0.36	0.29	0.23	0.14
54	SiC	5XCBM	1	0.39	0.28	0.16	0.15	0.12
54	SiC	5XCBM	2	0.39	0.28	0.16	0.14	0.13
54	SiC	5XCBM	3	0.38	0.28	0.20	0.15	0.13
55	SiC	5XCBM	1	0.45	0.33	0.23	0.20	0.14
55	SiC	5XCBM	2	0.44	0.33	0.22	0.19	0.15
55	SiC	5XCBM	3	0.45	0.33	0.25	0.19	0.15
1	FSL	5XCBM+d	1	0.28	0.17	0.09	0.06	0.05
1	FSL	5XCBM+d	2	0.3	0.16	0.10	0.06	0.06
1	FSL	5XCBM+d	3	0.3	0.17	0.09	0.06	0.06
3	FSL	5XCBM+d	1	0.22	0.12	0.07	0.05	0.04
3	FSL	5XCBM+d	2	0.23	0.12	0.07	0.05	0.05
3	FSL	5XCBM+d	3	0.25	0.12	0.07	0.05	0.05
4	FSL	5XCBM+d	1	0.27	0.12	0.06	0.04	0.04
4	FSL	5XCBM+d	2	0.27	0.13	0.07	0.05	0.04
4	FSL	5XCBM+d	3	0.29	0.11	0.07	0.05	0.04
6	FSL	5XCBM+d	1	0.27	0.16	0.07	0.05	0.05
6	FSL	5XCBM+d	2	0.27	0.14	0.08	0.05	0.05
6	FSL	5XCBM+d	3	0.28	0.16	0.08	0.06	0.05
7	FSL	5XCBM+d	1	0.17	0.09	0.07	0.04	0.03
7	FSL	5XCBM+d	2	0.19	0.09	0.05	0.04	0.04
7	FSL	5XCBM+d	3	0.2	0.10	0.05	0.04	0.04
8	FSL	5XCBM+d	1	0.24	0.11	0.05	0.04	0.03
8	FSL	5XCBM+d	2	0.25	0.11	0.06	0.04	0.04
8	FSL	5XCBM+d	3	0.26	0.12	0.06	0.04	0.04
9	FSL	5XCBM+d	1	0.19	0.09	0.04	0.03	0.03
9	FSL	5XCBM+d	2	0.2	0.10	0.05	0.03	0.03
9	FSL	5XCBM+d	3	0.21	0.08	0.04	0.04	0.04
11	FSL	5XCBM+d	1	0.14	0.07	0.04	0.03	0.03
11	FSL	5XCBM+d	2	0.16	0.08	0.04	0.03	0.03
11	FSL	5XCBM+d	3	0.18	0.07	0.04	0.03	0.03
12	FSL	5XCBM+d	1	0.28	0.14	0.07	0.05	0.04
12	FSL	5XCBM+d	2	0.29	0.15	0.07	0.05	0.05
12	FSL	5XCBM+d	3	0.29	0.15	0.07	0.06	0.05
13	SiL	5XCBM+d	1	0.38	0.27	0.17	0.12	0.10
13	SiL	5XCBM+d	2	0.39	0.27	0.17	0.12	0.11
13	SiL	5XCBM+d	3	0.4	0.27	0.17	0.12	0.11
14	SiL	5XCBM+d	1	0.24	0.13	0.07	0.05	0.04
14	SiL	5XCBM+d	2	0.24	0.15	0.07	0.05	0.05
14	SiL	5XCBM+d	3	0.25	0.13	0.07	0.05	0.05
15	SiL	5XCBM+d	1	0.32	0.22	0.14	0.10	0.08
15	SiL	5XCBM+d	2	0.32	0.23	0.15	0.10	0.09
15	SiL	5XCBM+d	3	0.34	0.22	0.13	0.10	0.09
16	SiL	5XCBM+d	1	0.34	0.28	0.13	0.09	0.08
16	SiL	5XCBM+d	2	0.35	0.26	0.13	0.08	0.09
16	SiL	5XCBM+d	3	0.36	0.24	0.13	0.09	0.08
17	SiL	5XCBM+d	1	0.44	0.31	0.20	0.14	0.13
17	SiL	5XCBM+d	2	0.43	0.32	0.20	0.14	0.13
17	SiL	5XCBM+d	3	0.41	0.32	0.20	0.14	0.12
18	SiL	5XCBM+d	1	0.23	0.08	0.07	0.05	0.05
18	SiL	5XCBM+d	2	0.22	0.13	0.06	0.05	0.04

Table 58 cont.

18	SiL	5XCBM+d	3	0.23	0.12	0.07	0.05	0.04
19	SiL	5XCBM+d	1	0.31	0.22	0.15	0.10	0.09
19	SiL	5XCBM+d	2	0.32	0.22	0.15	0.10	0.08
19	SiL	5XCBM+d	3	0.32	0.23	0.15	0.10	0.08
20	SiL	5XCBM+d	1	0.35	0.22	0.14	0.11	0.08
20	SiL	5XCBM+d	2	0.34	0.26	0.16	0.09	0.09
20	SiL	5XCBM+d	3	0.36	0.25	0.14	0.10	0.07
21	SiL	5XCBM+d	1	0.32	0.18	0.11	0.07	0.07
21	SiL	5XCBM+d	2	0.32	0.20	0.10	0.07	0.07
21	SiL	5XCBM+d	3	0.31	0.18	0.10	0.07	0.06
22	SiL	5XCBM+d	1	0.30	0.22	0.15	0.10	0.09
22	SiL	5XCBM+d	2	0.3	0.22	0.14	0.10	0.09
22	SiL	5XCBM+d	3	0.3	0.22	0.15	0.10	0.08
23	SiL	5XCBM+d	1	0.33	0.19	0.13	0.08	0.08
23	SiL	5XCBM+d	2	0.32	0.23	0.12	0.11	0.08
23	SiL	5XCBM+d	3	0.33	0.20	0.11	0.10	0.07
24	SiL	5XCBM+d	1	0.31	0.20	0.14	0.10	0.08
24	SiL	5XCBM+d	2	0.3	0.23	0.14	0.10	0.08
24	SiL	5XCBM+d	3	0.3	0.21	0.13	0.09	0.08
25	SiL	5XCBM+d	1	0.29	0.19	0.14	0.10	0.08
25	SiL	5XCBM+d	2	0.29	0.22	0.14	0.09	0.08
25	SiL	5XCBM+d	3	0.29	0.22	0.13	0.09	0.07
26	SiCL	5XCBM+d	1	0.37	0.23	0.20	0.13	0.12
26	SiCL	5XCBM+d	2	0.36	0.25	0.19	0.13	0.11
26	SiCL	5XCBM+d	3	0.35	0.26	0.18	0.14	0.11
27	SiCL	5XCBM+d	1	0.45	0.32	0.26	0.19	0.14
27	SiCL	5XCBM+d	2	0.47	0.33	0.25	0.18	0.13
27	SiCL	5XCBM+d	3	0.45	0.34	0.24	0.19	0.13
28	SiCL	5XCBM+d	1	0.46	0.32	0.25	0.19	0.14
28	SiCL	5XCBM+d	2	0.47	0.33	0.25	0.18	0.14
28	SiCL	5XCBM+d	3	0.45	0.34	0.25	0.18	0.14
29	SiCL	5XCBM+d	1	0.41	0.24	0.17	0.12	0.09
29	SiCL	5XCBM+d	2	0.41	0.27	0.16	0.11	0.10
29	SiCL	5XCBM+d	3	0.37	0.25	0.17	0.12	0.09
30	SiCL	5XCBM+d	1	0.34	0.27	0.19	0.15	0.11
30	SiCL	5XCBM+d	2	0.34	0.26	0.19	0.14	0.11
30	SiCL	5XCBM+d	3	0.35	0.24	0.19	0.14	0.12
31	SiCL	5XCBM+d	1	0.43	0.33	0.25	0.20	0.14
31	SiCL	5XCBM+d	2	0.42	0.33	0.25	0.19	0.14
31	SiCL	5XCBM+d	3	0.44	0.31	0.24	0.19	0.15
32	SiCL	5XCBM+d	1	0.46	0.33	0.26	0.20	0.15
32	SiCL	5XCBM+d	2	0.43	0.34	0.26	0.20	0.15
32	SiCL	5XCBM+d	3	0.46	0.33	0.26	0.20	0.14
33	SiCL	5XCBM+d	1	0.38	0.27	0.16	0.11	0.08
33	SiCL	5XCBM+d	2	0.35	0.24	0.16	0.11	0.09
33	SiCL	5XCBM+d	3	0.38	0.22	0.17	0.11	0.09
34	SiCL	5XCBM+d	1	0.36	0.28	0.20	0.15	0.10
34	SiCL	5XCBM+d	2	0.34	0.26	0.20	0.15	0.11
34	SiCL	5XCBM+d	3	0.35	0.24	0.20	0.15	0.12
35	SiCL	5XCBM+d	1	0.43	0.32	0.24	0.18	0.11
35	SiCL	5XCBM+d	2	0.4	0.31	0.23	0.18	0.12
35	SiCL	5XCBM+d	3	0.42	0.30	0.23	0.21	0.13
36	SiCL	5XCBM+d	1	0.43	0.34	0.26	0.20	0.13
36	SiCL	5XCBM+d	2	0.45	0.34	0.26	0.20	0.15
36	SiCL	5XCBM+d	3	0.45	0.32	0.26	0.19	0.15
37	SiCL	5XCBM+d	1	0.37	0.25	0.16	0.12	0.08

Table 58 cont.

37	SiCL	5XCBM+d	2	0.37	0.25	0.16	0.11	0.09
37	SiCL	5XCBM+d	3	0.38	0.22	0.16	0.11	0.09
38	SiCL	5XCBM+d	1	0.34	0.26	0.20	0.15	0.11
38	SiCL	5XCBM+d	2	0.34	0.26	0.19	0.15	0.11
38	SiCL	5XCBM+d	3	0.33	0.24	0.19	0.14	0.11
39	SiCL	5XCBM+d	1	0.42	0.33	0.22	0.18	0.12
39	SiCL	5XCBM+d	2	0.41	0.32	0.23	0.17	0.13
39	SiCL	5XCBM+d	3	0.4	0.31	0.23	0.17	0.11
40	SiCL	5XCBM+d	1	0.37	0.29	0.17	0.12	0.08
40	SiCL	5XCBM+d	2	0.36	0.25	0.17	0.11	0.09
40	SiCL	5XCBM+d	3	0.38	0.24	0.16	0.11	0.10
41	SiCL	5XCBM+d	1	0.32	0.25	0.18	0.12	0.10
41	SiCL	5XCBM+d	2	0.31	0.24	0.18	0.11	0.10
41	SiCL	5XCBM+d	3	0.32	0.22	0.18	0.11	0.11
42	SiCL	5XCBM+d	1	0.38	0.27	0.17	0.11	0.10
42	SiCL	5XCBM+d	2	0.34	0.26	0.16	0.11	0.09
42	SiCL	5XCBM+d	3	0.37	0.24	0.16	0.11	0.09
43	SiC	5XCBM+d	1	0.40	0.26	0.20	0.15	0.13
43	SiC	5XCBM+d	2	0.39	0.26	0.19	0.15	0.13
43	SiC	5XCBM+d	3	0.42	0.30	0.19	0.15	0.13
44	SiC	5XCBM+d	1	0.51	0.36	0.30	0.23	0.20
44	SiC	5XCBM+d	2	0.53	0.38	0.29	0.24	0.17
44	SiC	5XCBM+d	3	0.52	0.39	0.30	0.23	0.16
45	SiC	5XCBM+d	1	0.36	0.26	0.18	0.13	0.12
45	SiC	5XCBM+d	2	0.36	0.25	0.18	0.13	0.12
45	SiC	5XCBM+d	3	0.36	0.28	0.18	0.13	0.11
46	SiC	5XCBM+d	1	0.36	0.27	0.20	0.15	0.13
46	SiC	5XCBM+d	2	0.37	0.26	0.20	0.15	0.11
46	SiC	5XCBM+d	3	0.39	0.29	0.21	0.15	0.13
47	SiC	5XCBM+d	1	0.39	0.27	0.21	0.16	0.13
47	SiC	5XCBM+d	2	0.4	0.27	0.20	0.15	0.13
47	SiC	5XCBM+d	3	0.41	0.29	0.20	0.16	0.13
48	SiC	5XCBM+d	1	0.53	0.38	0.30	0.25	0.19
48	SiC	5XCBM+d	2	0.54	0.38	0.29	0.24	0.17
48	SiC	5XCBM+d	3	0.58	0.38	0.30	0.24	0.16
49	SiC	5XCBM+d	1	0.41	0.32	0.24	0.19	0.14
49	SiC	5XCBM+d	2	0.41	0.29	0.23	0.19	0.13
49	SiC	5XCBM+d	3	0.4	0.30	0.23	0.19	0.13
50	SiC	5XCBM+d	1	0.38	0.27	0.21	0.17	0.11
50	SiC	5XCBM+d	2	0.39	0.27	0.20	0.16	0.13
50	SiC	5XCBM+d	3	0.39	0.29	0.20	0.16	0.13
51	SiC	5XCBM+d	1	0.41	0.29	0.22	0.16	0.12
51	SiC	5XCBM+d	2	0.38	0.26	0.21	0.16	0.11
51	SiC	5XCBM+d	3	0.4	0.28	0.21	0.16	0.11
52	SiC	5XCBM+d	1	0.57	0.41	0.33	0.23	0.22
52	SiC	5XCBM+d	2	0.58	0.40	0.32	0.23	0.19
52	SiC	5XCBM+d	3	0.58	0.40	0.32	0.23	0.18
53	SiC	5XCBM+d	1	0.49	0.36	0.28	0.23	0.17
53	SiC	5XCBM+d	2	0.49	0.36	0.28	0.23	0.14
53	SiC	5XCBM+d	3	0.47	0.38	0.28	0.23	0.14
54	SiC	5XCBM+d	1	0.36	0.27	0.20	0.16	0.12
54	SiC	5XCBM+d	2	0.37	0.26	0.19	0.15	0.13
54	SiC	5XCBM+d	3	0.42	0.28	0.19	0.16	0.13
55	SiC	5XCBM+d	1	0.41	0.32	0.24	0.21	0.15
55	SiC	5XCBM+d	2	0.41	0.29	0.24	0.20	0.14
55	SiC	5XCBM+d	3	0.41	0.31	0.23	0.21	0.15

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