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ASSESSMENT OF THE POTENTIAL FOR SLOPE FAILURE ON THE
BASIS OF NUMERICAL SIMULATION OF GROUND WATER CONDITIONS

by

Charles Neish Duncan Hotzel

A thesis submitted to the Faculty of
Graduate Studies in partial fulfill-
ment of the requirements for the Degree
of Master of Arts

Department of Geography
Carleton University

Ottawa, Canada

1978

The undersigned recommend to the Faculty of

Graduate Studies acceptance of the thesis

"ASSESSMENT OF THE POTENTIAL FOR SLOPE

FAILURE ON THE BASIS OF NUMERICAL SIMU-

LATION OF GROUND WATER CONDITIONS"

submitted by Charles N.D. Hotzel, B.A. in
partial fulfilment of the degree of Master
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August 30, 1978

ABSTRACT

Traditionally, stability has been treated as a static problem, a margin of error is built into most engineering solutions by designing using a factor of safety somewhat greater than unity. Most soil properties change slowly through time but may realistically be considered constants. The most important transient cause of stability change is changes in the groundwater conditions. Failure caused by transient groundwater conditions which result from extreme hydrological events are widespread and have important economic consequences. No satisfactory means of predicting the probability of failure on the basis of hydrological response has yet been demonstrated, although this is by implication the best means of assessing future stability.

A medium sized slope segment was constructed in the laboratory and used to simulate the effects of rainfall on stability. It was hoped that it would be possible to replicate the recorded results numerically. Ultimately, the slope geometry used in the physical simulation proved incompatible with the computer model. Transient groundwater change and consequent stability change were simulated both physically and numerically. Although the two types of simulation were not comparable, both demonstrate that large declines in stability occur in response to high magnitude rainfall events.

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INTRODUCTION

Hillslope morphology and the study of hill-forming processes have long occupied an important place in geomorphological literature. Much of the early work, however, consisted largely of inductive reasoning leading to generalizations concerning the nature of conditions which could be considered normal. Much of the geomorphological literature was devoted to theories of slope formation and valley retreat based on remarkably little observational evidence (see for example, Schumm and Mosley, (1973) who have collected a large number of these studies together in a single volume). It is evident that very few of the papers written during this period added much to the understanding of slope formation or the mechanics of stability and it was left to the civil engineers to provide a quantification of slope behaviour. Because of the nature of the problems involved in slope engineering, primarily problems requiring instantaneous solutions, the techniques developed were based on statics, tending to ignore the longer term dynamics of process, for which information is not readily available.

In a recent re-examination of the role of geomorphology in the study of landslides, Cook and Doornkamp, (1974) have identified three problem areas which they suggest may best be solved by the application of geomorphological techniques:

- a) Prediction of the occurrence of landslides;
- b) Stabilization of active landslides;
- c) Assessment of general landslide potential on an area basis.

They suggest that each of these problems is best approached through a good understanding of process and familiarity with the characteristics of landslide prone environments. Whilst Cook and Doornkamp go on to identify a large number of factors which may be indicators of potential instability, it is evident from their own review and from many previous studies that in a large proportion of landslide occurrences, groundwater is the critical factor.

The present study was stimulated by a re-examination of one of the first detailed long-term studies of hillslope behaviour (Rapp, 1960). The observations contained in the study were collected over a period of eight years and involved detailed measurement of the numerous active processes observed. These ranged from movements so slow as to be indiscernable, to those which occurred rapidly with catastrophic impact. As a result of the observations, Rapp listed the observed mechanisms in order of denudational importance. It is evident however, that the conclusions only apply to the period of observation.

When a longer, a shorter or just a different temporal period is considered, the order is likely to change. This conclusion is suggested by the fact that some of the most important denudation mechanisms occurred only once in approximately eight years of observations. Moreover, Rapp indicates that the cause of the catastrophic events involved, heavy rainfall, had a recurrence interval much greater than eight years. Clearly, therefore, had the study been conducted at a different point in time, it is probable that the order of importance would have been different. The importance of this observation lies in the fact that it draws attention to the infrequency of major landslides through time. In the case of the major landsliding observed by Rapp, it is probable that similar events recur with a frequency which is the same as that of rainfall events which give rise to critical ground-water conditions.

1.1 Objective

In the context of the present study, it is suggested that the most important factor in the majority of landslides is the occurrence of high groundwater levels (see for example, Skempton and De Lory, 1957; Carson, 1969b, 1971). The factors causing slope failure may be divided into two groups, those which relate to soil properties and slope geometry, and those which are dictated by ground water conditions. The former group is frequently essentially constant over long periods of time, it is therefore possible to measure soil properties and use them

in the static balance equations, traditionally used to assess stability. The latter group depends on the uncertainties of ground water hydrology at the location. It is evident, that at many slope locations, the possibility of critical ground water conditions which will lead to slope failure exists.

It is suggested that prediction of the frequency of the critical groundwater condition is the same as predicting the probability of failure, at any location for which it can be assumed that the other factors remain constant. Viewed from this perspective, stability becomes a function of time and the assessment of relative stability at different locations a function of the probable frequency of failure. The objective of the present study is to demonstrate the response of stability to changes in slope hydrology and to suggest and test one method by which the critical event size at different locations may be assessed. It is suggested that this will allow prediction of the frequency of failure to be made for any location for which basic rainfall information is available.

1.2 Terminology

The literature pertaining to slope stability provides a multiplicity of often inconsistent terminology, such that it is necessary to define the various terms used in the text. Standard references for landslide terminology are Sharpe (1938), Varnes (1958) and Skempton and Hutchinson (1969). The present discussion relates primarily to landslides in unconsolidated

soil material on steep hillsides. The following nomenclature is adopted to describe the range of phenomena discussed:

Landslide - is used in the widest sense to describe any rapid downslope movement of soil or rock material

Slide - describes the downslope displacement of blocks of soil or debris along a clearly defined shear plane

Flow - describes the downslope movement of a viscous soil mass in which no single plane of shear is visible, the motion in such cases is the result of glacierlike plastic deformation of the flow mass as a whole.

Flow-slide - describes transitional forms of failure which characteristically begin as slides, but because of high water content and soil characteristics are transformed into a viscous mass as the original soil structure is broken down by the motion of the sliding mass.

1.3 The Mechanics of Landsliding

The overall stability of any slope is governed by the relationship between forces tending to promote downslope movement (shear stress), and those forces tending to resist such movement (shear resistance). The ratio of the two which is the common measure of relative stability is termed the 'factor of safety'. Equation (1) indicates that when stress (s) exceeds resistance (t) the slope is unstable and the factor of safety is less than unity.

$$F_s = \frac{\sum s}{\sum t} = \frac{S}{T}$$

Equation 1

The equation has been used in engineering to assess the potential for failure on the basis of computation of the shear stress and the shear resistance² given the worst possible conditions. It is evident however, that to the degree that the worst possible ground water conditions may be unknown the computed factor of safety is likely to be incorrect.

1.4 Factors Affecting Stability

A number of reviews of the landslide process provide comprehensive lists of factors which may be implicated in landslide behaviour (Varnes, 1958; Jackson, 1966; Cook and Doornkamp, 1974). These factors fall logically into two groups:

(i) Those factors which over time act to reduce shear resistance on potential planes of shear; and

(ii) Those factors which over a period of time act to increase the shear stress.

Ultimately failure only occurs when at some point in time, the forces acting in a downslope direction exceed those mobilized to resist movement in this direction. Clearly therefore, landsliding is a product of dynamic change in one or more of the factors which contribute to shear resistance and shear strength. Consequently an understanding of the processes involved in promoting change, the probable rate of change, the direction of change, and the possible maximum change may be critical to stability estimates.

FIGURE 1

Slope top accumulation from a free fall bedrock face.

FIGURE 2

Slope toe erosion resulting from river erosion.

1.5 Long-term Changes in Stability

Many of the factors identified in Table 1 as implicated in failures can be considered subject to change only when considered in a geological time frame. Such factors have justifiably been treated as constants in the static engineering stability assessment. Factors in this category include soil strength characteristics, slope geometry, lithological geometry, changes in ground water conditions resulting from climatic change, and a number of other factors. Each of these factors is either measured directly or ignored in traditional stability assessments.

1.5.1 Long-term Changes in Stress

If, as a result of erosion or deposition, the overall slope angle at a location is increased, other factors remaining constant, the effective shearing stress increases. If for example, debris from a weathering rock face accumulates at the head of a slope as is depicted in Figure 1, the shear stress along potential failure surfaces such as that shown, is increased, whilst the shear resistance remains the same. Consequently the factor of safety declines.

Similarly, when the foot of a slope is eroded more rapidly than the slope can regrade, as is shown in Figure 2, the overall slope angle is increased and the factor of safety declines. Other factors believed to be implicated in long-term changes in shear stress include the unloading of glacial ice

TABLE 1
FACTORS LEADING TO REDUCED STABILITY

Factors leading to an increase in shear stress:

1. Removal of lateral or underlying support
 - undercutting by water (e.g. river, waves), or glacier ice
 - weathering of weaker strata at the toe of the slope
 - washing out of granular material by seepage erosion
 - man-made cuts and excavations, draining of lakes and reservoirs
2. Increased disturbing forces
 - natural accumulations of water, snow, talus
 - man-made pressures (e.g. stock-piles of ore, tip-heaps, rubbish dumps, or buildings)
3. Transitory earth stresses
 - earthquakes
 - continual passing of heavy traffic
4. Increased internal pressure
 - build up of pore-water pressures (e.g. in joints and cracks, especially in the tension crack zone at the rear of the slide)

Factors leading to a decrease in shearing resistance:

1. Materials
 - beds which decrease in shear strength if water content increases (clays, shale, mica, schist, talc, serpentine) (e.g. when local water table is artificially increased in height by reservoir construction, or as a result of stress release (vertical and/or horizontal) following slope formation)
 - low internal cohesion (e.g. consolidated clays, sands, porous organic matter)
 - in bedrock: faults, bedding planes, joints, foliation in schists, cleavage, brecciated zones, and pre-existing shears
2. Weathering changes
 - weathering reduces effective cohesion (c'), and to a lesser extent the angle of shearing resistance (ϕ')
 - absorption of water leading to changes in the fabric of clays (e.g. loss of bonds between particles or the formation of fissures)
3. Pore-water pressure increase
 - higher groundwater table as a result of increased precipitation or as a result of human interference (e.g. dam construction) (see 1 above)

and tectonic activity.

1.5.2 Long-term Changes in Shear Strength

Over extended periods of time, rocks and soil undergo chemical and physical changes which affect the ability of the material to resist shear. Hydration, drying, freeze-thaw, thermal expansion, chemical degradation, crystal growth, solution and biological activity may all be involved. Most commonly the overall effect of these mechanisms is to gradually reduce the mean size of the mineral grains which compose the soil. Kirkby (1972) suggests this degradation affects the shear resistance in three ways:

- (i) changes the cohesive strength;
- (ii) changes the coefficient of friction;
- (iii) changes the hydro-geological characteristics of the soil.

Each of these factors may ultimately increase the probability of failure.

(i) The forces resulting from cohesion may range from a few grams cm^{-2} in soils with low clay content to more than 10^6 gram cm^{-2} in some types of bedrock (Carson and Kirkby, 1972).

Cohesion is the result of molecular forces acting between clay micelles. As weathering takes place, some or all the cohesive strength may be lost as the number of bonds is reduced overall, and strong bonds are replaced by weaker ones. Thus Skempton (1964) suggests that cohesion is a function of parent material,

hydrological regime and the age of the soil, he concludes that over long periods of geological time, cohesion tends to approach zero. ~~In the case~~ of many hillslope soils, characteristically high hydraulic gradients tending to leach clay minerals may be a significant factor in the formation of granular soils with low cohesion.

(ii) The presence of granular soils of low cohesion in many locations, means that it is a characteristic of hillslope soils that much of the resistance to shear mobilized, is the result of friction. Frictional strength results from forces determined by grain to grain contact, the strength which it provides increases in direct proportion to the stress acting normal to the contact surfaces. The factor of proportionality between normal stress and the resultant frictional resistance is termed the coefficient of friction (ϕ). In granular soils Koerner (1970a) has shown that the coefficient of friction is a function of the shape, size, uniformity, density and mineral composition of the soil. He estimates that the coefficient may theoretically range between 0.29 and 1.0 for granular soils. Ringheim (1964) found that in soils containing smectitic minerals, coefficients of friction as low as 0.14 could be measured.

(iii) The effect of changes in the hydro-geological characteristics of a soil is less obvious than the changes in cohesive strength and frictional resistance. It results from the tendency of individual grains to decrease in size as the soil

weathers, this in turn reduces mean void size. Under these circumstances even though the porosity of the soil may increase, the tendency of the soil to saturate increases. This suggests that given the same flux of water moving into the soil the resultant groundwater levels will be higher, and consequently, mean shear resistance will be lower.

It should be noted that although it has been suggested that weathering is an extremely slow process, this assumption is not universally applicable and a number of examples of failure which resulted because of loss of cohesive strength over periods of a few tens of years may be found in engineering literature. It is suggested however that in the majority of cases loss of strength due to weathering is so slow as to justify the assumption that it is a constant.

Bailey (1971) has suggested that long-term climatic change resulting in changes in subsurface hydrology may also have the effect of changing the mean shear resistance. The example he gives is higher ground water levels during pluvial episodes believed characteristic of mid-latitudinal climates during glacial periods. Clearly thermal maxima periods also evidenced in the geological record, would tend to have lower mean groundwater levels and a higher mean shear resistance level. In a similar way long-term changes in temperature resulting in the formation of permanent ground ice or melting ground ice result in changes in shear resistance.

FIGURE 3

Changes in soil strength through time resulting from the effect of progressive weathering of the soil.

1.6 Short-term Changes in Stability

The slow changes in stability described above are seldom if ever directly responsible for failure, but merely provide a background stability which is regarded as constant and measured directly. Usually instability is triggered by much shorter-term effects which are superimposed on the basic long-term stability. Figure 3 is a diagrammatic representation of the relationship involved.

1.6.1 Short-term Changes in Stress

Failure may occur as the result of the imposition of sudden transitory shearing stress on a previously stable slope. For example seismic shocks are often accompanied by landslide activity in hilly or mountainous areas. The effects of the dynamic forces involved have been successfully predicted by considering the uphill acceleration in relation to the equilibrium shear strength. Effectively, downhill relative displacement occurs each time a shock wave applies an uphill acceleration which exceeds the acceleration equivalent of maximum shear strength (Lambe and Whitman, 1969). Earthquake activity may be extremely important locally in zones of seismic activity, such zones are relatively limited and well defined. This being the case, earthquake induced stress need only be included in stability analyses in those areas.

Changes in slope angle resulting from the supply of colluvial material or from erosion have been discussed in the

context of slow stability change. Occasionally however, these factors may cause sudden changes in stress resulting in transient effects which may result in failure. The sudden supply of large volumes of rock or debris at the head of a slide may result in one or more of the following effects:

(i) Sudden loading of the slope may result in the generation of high pore pressures.

(ii) The shock waves caused by a large volume of debris falling onto a slope may have a similar effect to those resulting from earthquake activity leading to failure.

In some cases erosion may be extremely rapid leading to oversteepening and failure.

(i) River and stream erosion frequently leads to undercutting and localized failures along river or stream banks.

(ii) Erosion of slope foot areas resulting in localized failure may also result in a sequence of retrogressive failures upslope, the effect of each small failure being to reduce the shear resistance of the segment immediately above.

(iii) Intense rainfall on unvegetated slopes may result in the formation of gullies, failure of the banks of these rapidly evolving features frequently results in the formation of mud flows.

1.6.2 Rapid Changes in Shear Resistance

The most common cause of transient changes in shear resistance is fluctuation in groundwater conditions. Abundant

evidence suggests that almost all slope failures are triggered by loss of shear resistance associated with high ground-water table conditions. This frequently results from the infiltration of rainfall or snowmelt. Initial losses of strength are frequently associated with a loss of capillary suction as the unsaturated water content of the soil increases. If infiltration continues long enough, however, a zone of saturation develops with the result that normal stress is reduced because the soil within the saturated zone is, in effect, displacing a volume of water.

1.7 Conclusion

It is suggested that short-term transient changes in stability are involved in almost all slope failures. These short-term effects are superimposed, in most cases, on a stability regime which has traditionally been considered static, but which probably changes slowly through time. It is suggested that although it is justifiable to treat the factors which comprise the underlying stability as constants because they change so slowly, a truly accurate stability analysis cannot be performed unless a good estimate of the effect of transient factors can be made. Recently progress has been made in predicting the effect of seismic shocks, one such transient effect. It is suggested that by far the most widespread and important effect leading to instability is the occurrence of high groundwater levels. Traditional stability analysis uses a static estimate

of groundwater which is likely to be either overly conservative or dangerously low. It is probable that a better basis for predicting groundwater levels, and the probability of failure, would be on the basis of the largest probable rainfall translated in terms of its effect on groundwater levels.

CHAPTER 2

The Occurrence of Hillslope Failures Induced by Rainfall

Shallow hillslope failures are regularly reported from different parts of the world: slides, flows and intermediate types of failure commonly accompany exceptionally heavy rainfall. Failures of this type do not appear to be restricted to any particular climatic zone. Examples cited below provide an insight into the importance of the shallow slide phenomenon on a global scale.

2.1 The Incidence and Economic Importance of Shallow Failures

Da Costa Nunes (1969) reports that heavy rainfall in 1966, in the region between Rio de Janeiro and Sao Paulo, Brazil, resulted in numerous landslides and mudflows which engulfed cars, trucks, buses and a large construction site. Deaths directly attributable to the failures exceeded 1000 people. In addition, the disaster seriously damaged several hydro plants reducing the power supply to Rio de Janeiro to 50%. Damage along the main road between the two largest cities in Brazil was so severe that reconstruction took nine months. During that time it is estimated that vehicles travelling

between the two cities covered an extra 400 million miles as the result of a two hour detour which the road repairs necessitated.

Temple and Rapp (1972) examined the results of moderately severe rainfall in the Mgeta region of Tanzania, and recorded over one thousand slope failures. The failures which resulted in six deaths, destroyed an estimated 500 hectares of agricultural crops in the predominantly agricultural area. In addition, the failures damaged irrigation works and cut all roads into the area for six weeks, during which time all produce had to be carried out of the area by hand.

Lumb (1975) and So (1971) both describe the occurrence of frequent catastrophic landslide episodes in Hong Kong. Landslides, they report, occur almost every year in the monsoon season, but the severity of slide activity varies with the duration and intensity of rainfall events. In 1966, an exceptionally bad year, flooding and landslides resulted in 64 deaths and left 2500 homeless. In 1972 when the rainfall was again exceptionally heavy, 182 failures were recorded of which the two most severe caused 138 deaths.

According to Campbell, "Debris flows generated during rainstorms present a greater risk of death and injury to Southern California residents than all other kinds of landslides.

combined" (Campbell, 1974, p.340). During the period 1962-71 failures of this type caused 23 deaths in the Los Angeles area alone.

Murota and Hashino (1971) believe that nearly all landslide phenomena in Japan result directly as a result of the effects of heavy rainfall. They report the occurrence of over 2600 landslides and flows in the 26 km long watershed of the Arita River, as a result of a single, extreme rainfall event in 1953.

Kidson (1952) and Gifford (1952) examined the rainfall distribution and the accompanying slope failures, of an extreme rainfall event which occurred in Southern England in 1952. Numerous other reports of rain-induced landslide activity from various parts of the world may be found in the literature; for example, Azami and Desvoraus (1974) in the French Alps; Wentworth (1943) and White (1949) in Hawaii; Prior and Graham (1975) and Hutchinson et al. (1974) in Northern Ireland; Zaruba and Mencl (1969) in Czechoslovakia; Lefroy (1889) and Mackay and Matthews (1973) in the Mackenzie Valley, Canada; Bailey (1971) in Oregon; Bishop and Stevens (1964) in Alaska; and Jackson (1966) in New Zealand. It is evident that these occurrences are widespread and that there is no obvious pattern to the occurrences recorded. Failures of this type occur from the Arctic to the Tropics, in both coastal and continental locations.

2.2 The Effects of Human Activity in Promoting Landsliding

Many landslide events are at least in part attributable to human activity. This is more obviously the case when the activity results in the creation of unnaturally steep slope gradients during engineering operations. Lumb (1975) points out that most of the recorded slides in Hong Kong occur on the sides of cuts in weathered igneous or volcanic soils. A major factor in the observed occurrences is the demand for construction sites, resulting in construction at sites which would not otherwise be considered suitable. Leighton (1972) believes that construction practices are responsible for many of the slope failures reported in Southern California. Elsewhere, in less populous areas, observers have stressed the role played by vegetation in slope stability, and have recorded the detrimental effects induced by removal of the natural vegetation (see for example Gray, 1969; Temple and Rapp, 1972; Tricart, 1972). Evidence appears to suggest that one of the important consequences of removal of the natural vegetation is the fact that it induces detrimental changes in the groundwater regime.

Bailey (1971) points out that studies carried out in various parts of the United States indicate that runoff from grassland appears to be considerably greater than runoff from forested land in the same area. He believes this means substantially higher groundwater levels after deforestation and consequently lower stability levels. Bailey suggests that the result of deforestation in the Teton would be the equivalent of a substantial increase in rainfall* which would automatically

* In terms of higher groundwater levels.

result in decreased stability levels. Gray (1969), in reviewing a number of studies of the effect of clear cutting on slope stability, found that in almost every case, they pointed to decreased stability following logging. He outlined four ways in which vegetation might affect stability:

- (i) increased strength resulting from root binding;
- (ii) shear stress resulting from load imposed by the growing trees;
- (iii) shear stress induced by wind action on growing trees;
- (iv) modification of soil moisture regime resulting from evapo-transpirative regime.

He concluded that the most important of these factors were strength resulting from root binding and modification of the soil moisture regime. Clear cutting he found generally resulted in loss of root-induced strength and higher groundwater tables because of loss of transpirative capacity of the trees. He found however, that although many studies had discussed these effects, there was little quantitative data available by which to assess the magnitude of the stability changes which could result from deforestation.

Rice and Foggin (1971) found that in areas in Southern California where natural vegetation succession had been replaced by grassland, significantly more failures occurred. In addition, it was also observed that the failures in the grassland areas were larger in area and deeper than those under natural vegetation. O'Laughlin (1973) examined landslide

activity and the effects of logging on slopes outside Vancouver. He found that in many cases, if the effects of tree root cohesion were not considered in computing safety factors, the result was safety factors of less than unity. Consequently, if the slopes were logged, failures followed. Both Bishop and Stevens (1964) and O'Laughlin (1973) found that on clear cut slopes, peak landslide activity occurred several years after the slopes had been logged. This was attributed to progressive decay of the root systems and higher groundwater tables. Ultimately, as new growth became established, the frequency of failures decreased. O'Laughlin (1973) observed that several failures on natural slopes in British Columbia were situated in hillside seep areas which had perennially high water levels and were prone to total saturation during rainfall events. Both Swanston (1974) and O'Laughlin (1973) found that both cut and fill zones on forestry roads that cut across slopes were prone to failure. This appeared to be attributable to the effects of the unnatural breaks in slope in intercepting slope runoff inducing locally high groundwater conditions.

Brown and Shen (1975) concluded that clear cutting might induce a short-term increase in stability because of the unloading of the weight of vegetation. The improvement they felt would, however, be small and short-lived. In the long term, they concluded that major losses in stability would result.

Gray (1969) suggests that the provision of methods to

predict stability levels induced by clear cutting is a major priority in the forestry industry. The effect of loss of root strength can be predicted on the basis of shear tests conducted on soil samples without roots. The problem is therefore, once again, the inability to predict groundwater levels.

A number of studies have looked at the effects of individual rainfall events on stability (see for example Gray, 1969; Swanston, 1974; O'Laughlin, 1973). These studies were intended to explore the relationship between rainfall magnitude and groundwater change. It is evident however, that relationships derived from direct correlations of this type are site specific and do not provide a viable means of assessing the response of different slopes.

The foregoing examination of literature relating to various aspects of the landsliding problem suggest:

- (i) that the problem is both costly and widespread;
- (ii) that human modification of sites where stability is marginal, frequently results in failure;
- (iii) that the problem lies primarily in predicting the groundwater conditions which will occur.

It is suggested that with the expansion of population into areas previously unsettled, and the decline in the availability of suitable construction sites in all areas, stability problems will become more common. At the present time there is clearly an inadequacy in existing predictive techniques.

As more and more marginal sites are developed, this will probably become more apparent. It is suggested that the only satisfactory means of solving this dilemma is through more accurate prediction of groundwater conditions.

2.3 The Relationship Between Rainfall and Stability

Although there is abundant evidence of a link between slope instability and rainfall, no satisfactory method of linking the two to provide a predictive analysis has thus far been demonstrated. Traditional engineering practice suggests that the factor of safety must be calculated on the basis of the worst possible groundwater conditions. Clearly however, in many cases, this represents an unknown which can only be estimated on the basis of previous experience. In situations where stability analysis computed on the basis of saturation to the ground surface yields a factor of safety greater than unity, the site is completely stable irrespective of future changes in groundwater conditions.* Frequently, however, in slope situations, this will not be the case. In such cases the analysis requires a realistic estimate of the worst possible groundwater conditions. This in turn is dependant on the characteristics of the worst probable rainfall or snow-melt conditions. Various approaches have been explored in an attempt to overcome this problem.

* Assuming artesian pressures do not occur.

2.3.1 The Probability of Similar Events Method

On a local scale in some areas where landsliding has occurred, an attempt to overcome the inherent uncertainty of unknown groundwater conditions by linking failure and rainfall event size directly. Da Costa Nunes (1969) calculated that catastrophic landslides which occurred in the Serra das Arras and Caraguatatuba regions of Brazil were associated with rainfall events likely to occur with a frequency between 700 and 2000 years. He concluded that landslide events of a similar magnitude could probably be expected to recur with a similar frequency. In the Mgeta, Tanzania, Temple and Rapp (1972) found widespread landsliding accompanied rainfall events with predicted return frequencies of between 2.5 and 11 years. On this basis they concluded that much more severe landslide events than those which had been observed were quite probable. The problem with the conclusions in both studies lies in the fact that it is assumed that event as a whole, or the 24 hour total is the relevant rainfall unit. The shortcomings of this type of reasoning are illustrated by a study conducted by Jackson (1966). This study utilized depth-duration tables for the Taikā region of New Zealand in an attempt to determine the size of the rainfall events which had actually caused the failures. Table 2 indicates that on the basis of the 24 hour total rainfall, the event had a probable recurrence frequency of less than 10 years. By contrast, however, the six hour intensity appears to have a probable recurrence interval which

TABLE 2
RAINFALL DEPTH-DURATION DATA

Duration	Maximum Depth (Inches) Recorded at Taita, 25-26 April, 1966	Depth Expected* for Return Period Stated		
		2yrs	10yrs	50yrs
20 min	0.64	0.40	0.63	0.84
30 min	0.80	0.49	0.68	0.86
1 hour	1.13	0.68	1.03	1.34
2 hours	1.70	0.94	1.39	1.79
6 hours	3.26	1.69	2.21	2.68
12 hours	3.79	2.23	3.03	3.73
24 hours	4.35	2.89	4.51	5.93
48 hours	5.20	3.67	5.95	7.95

(* These figures are for Lower Hutt, taken from Robertson (1963)).

Source: Jackson, R.J., 1966. Slips in Relation to Rainfall and Soil Characteristics, Journal of Hydrology, New Zealand, Vol. 5, p. 48.

FIGURE 4

Relation between rate of horizontal movement and 10-day accumulated rainfall, Waiomao Slide, Honolulu. (Source: Peck, 1967, p 414)

exceeds 200 years. The evidence provided by the study is inconclusive, but it seems probable that failures were strongly influenced by the six hour maximum. In addition to determining the duration of rainfall responsible for recorded slope failures, the information at best only provides an indication of the effects of rainfall of that particular duration and intensity. It provides no guide to the effects of shorter, more intense events or longer, less intense events which could induce similar groundwater conditions. From these examples, it must be concluded that the long-term predictive capability of this technique is extremely limited.

2.3.2 Rainfall-Groundwater Correlations

A number of studies have examined correlations between the magnitude of slide activity and rainfall, using as an index of slide activity either the volume of material moved or the distance moved. Peck (1967) found a high degree of correlation between 10-day rainfall totals and the distance moved by a perennially active landslide in Waiomao, Honolulu (see Figure 4). Bailey (1967) cited in Rice and Foggin (1971) found that locally in an area of Southern California, slide activity was more highly correlated with 10-day total rainfall than with other rainfall variables tested. Hutchinson et al. (1974) concluded that several days rainfall, which included a gradual increase in intensity towards the end of the period examined, was invariably associated with landsliding in an

unstable area of Northwestern Ireland. Lambe (1975) found a similar pattern to be responsible for landsliding in Hong Kong. Using multiple correlation, he determined that of the combinations of rainfall variables tested, 15-day total rainfall associated with intensity during the final 24 hours of the event provided the best explanation of the landslide events observed.

Although direct correlations between rainfall and slope failure emphasize the fact that the two are closely linked, they provide no clear elucidation of the relationship, and provide a relatively poor basis for predicting the future probability of failure.

Both Swanston (1967a) and O'Laughlin (1973), instead of correlating rainfall and slope failure directly, correlated changes in groundwater levels to rainfall. This technique, it was hoped, would yield data which could be used in conjunction with stability analysis of the conventional type to predict the size of events liable to cause failure. Once again however, the technique provides little room for extrapolation of the results to other situations, and to provide enough data even for site specific prediction would probably demand field measurement at the location over long periods of time.

2.3.3 Prediction from Water Balance Correlation

Murota and Hashino (1971) correlated the occurrence of

failure and the basin water balance in the Arita River watershed in Japan. Using water balance and landslide records collected over a number of years, they determined a threshold balance level beyond which failure began to occur. In this case the method appeared to provide an excellent means of predicting the approach of hazardous conditions in the valley as a whole. It does not, however, provide a means of assessing the probability of failure on individual slopes, the type of data most frequently required to fulfil design and site selection requirements.

CHAPTER 3

Deterministic Prediction of Slope Failure

In the present context, deterministic prediction means the use of models based on physical laws. The traditional types of stability analysis already used to estimate factor of safety are models of this type. Models of this type have a number of advantages over the alternative 'black box' correlative models which seem to be the only alternative means of predicting stability levels, but they also suffer from a number of drawbacks. The primary advantages are:

- (i) If good input data is available, the solutions provided by physics based models are extremely accurate.
- (ii) Physics based models provide an infinite amount of information on the cause-effect relationship of the variables involved.
- (iii) Once thoroughly tested, physical models are general and allow diverse situations to be replicated numerically.

Disadvantages include the following problems:

- (i) Physics based models frequently require large quantities of data. This must either be measured directly or based on laboratory tests. When the latter is the case, the results

of tests on relatively small samples amenable to laboratory tests are a source of error not readily estimated.

(ii) Often physics based models require large numbers of time consuming calculations, or can only be solved by techniques utilizing successive approximations. This means the techniques virtually demand the use of computers. Often, as is the case in the present context, even with the use of computers the size of the problem amenable to solution is limited by computer core space.

(iii) The generalizations included in almost all data collection are compounded in the final solution to a degree which is difficult to assess. As a consequence, physics based models require exhaustive testing against real world data.

3.1 Stability Prediction Using a Coupled Groundwater-Stability Model

The coupling of groundwater and stability prediction in a single test probably provides the only accurate method of predicting stability levels which are liable to occur during any stipulated design period. The model essentially consists of three parts:

1. Assessment of the probable rainfall, snowmelt or combination of the two liable to occur during the design period.
2. Computation of the effects of that event on groundwater levels.
3. Conventional static analysis of the resultant stress-resistance relationship.

3.1.1 Prediction of the Worst Probable Event

Many natural phenomena exhibit an inverse relationship between frequency and event size. Such relationships exist when the dependent phenomenon is the result of the coincident occurrence of a number of independent or semi-dependent variables. Under these circumstances the occurrence of a high magnitude event is the product of a degree of maximization of all, or most of the controlling variables. The mechanisms controlling many atmospheric phenomena are extremely complex and relatively poorly understood; consequently, physically based models allowing long-term prediction of hydrological events have not been developed. Under these circumstances, the approach to the prediction of events of different sizes usually adopted by hydrologists, is probabilistic, based on the record of previous events. Various functional relationships between event size and frequency have been identified by hydrologists, (see for example, Gumbel (1958); Reiche (1972); Chow (1964)). These relationships allow the recorded event series to be extended to events of sizes not experienced during the period of record collection, on the assumption that the same magnitude frequency relationship exists. An evaluation of the validity of the various functional relationships suggested by hydrologists, or the assumptions made in the extension of records is beyond the scope of the present study. Suffice to say that hazard prediction on this basis is well established and widely used in hydrology.

3.1.2 Prediction of Groundwater Conditions

The first successful prediction of groundwater flow was developed by Darcy during the nineteenth century. The model, however, was applicable only under saturated conditions. The explanation of the redistribution of groundwater under unsaturated conditions was much slower. The earliest unsaturated model, (see for example Green and Ampt, 1911 and Horton, 1940), merely predicted the rate of movement of a wetting front into an unsaturated soil. Philip (1957) developed analytical models to predict the redistribution of water infiltrating into homogeneous unsaturated soil with uniformly distributed soil moisture. Simultaneously numerical solutions were developed by Day and Luthin (1956) which ultimately extended the model capability to allow the treatment of more complex situations. Rubin (1968) pioneered a numerical solution which allowed treatment of saturated-unsaturated zones such as those which commonly occur close to the surface in humid regions.

Developments in numerical modelling were paralleled by increasing interest in subsurface hydrology in both geomorphology and forestry. In geomorphology interest was primarily stimulated by the desire to explain the nature of soil saturation leading to overland flow and erosion. In forestry interest was the result of a desire to understand the effects of forest cover on basin storage. Hewlett and Hibbert (1963) constructed an artificial slope segment using soil packed to its normal field

density in an inclined cement trough. The soil was saturated and then allowed to drain free from losses of moisture resulting from evaporation. During the course of drainage which took several months, measurements indicated that unsaturated flow from the upper slope fed a saturated zone near the outflow at the slope foot. Hewlett and Hibbert concluded that the soil layer was the primary source of perennial stream flow in many small stream basins, and that locally in the vicinity of perennial streams a zone of saturation was maintained which expanded and contracted according to rainfall conditions. On the basis of field observations, Betson (1964) developed the theory of 'partial area contribution', which suggested that certain areas of watersheds saturated easily giving rise to overland flow. Areas along stream margins are perhaps particularly prone to saturation in this way, because they are natural zones of flow convergence. In addition, when the streams are perennial, a zone of saturation already exists at some depth. Kirkby and Chorley (1967) suggest that flow convergence zones typically occur on stream margins, in hillside hollows and in areas of thinner, more permeable soil. In these areas they conclude, saturation is probable in response to rainfall of lower intensity and shorter duration than elsewhere. These suggestions appear to be supported by field investigations conducted by Betson and Marius (1969) and Dunne and Black (1970).

Observations of the growth of zones of saturation are of particular significance in the prediction of instability. It is evident

however that areas which are particularly prone to saturation under normal conditions are unlikely to be unstable. In adjacent areas however, the growth of zones of saturation under extreme rainfall conditions may be an important cause of observed failures. Swanston (1967b,c) and O'Laughlin (1973) both examined the role of expanding zones of saturation in inducing slope failure using piezometers. Both studies concluded that failures in the areas studied were triggered by expanding zones of saturation. The results obtained however do not provide a basis for a more generalized prediction of failure.

Freeze and Harlan (1969) outlined the basis of a model coupling saturated and unsaturated flow which they suggested might be utilized to simulate transient flow patterns on a basin wide scale. The model developed, (Freeze, 1972c), is highly generalized, and designed to predict flow patterns in two or three dimensions in non-homogeneous geological conditions. Freeze (1971) provides output demonstrating that theoretically, the model could be utilized to predict transient saturated-unsaturated flow conditions in a variety of possible real world situations. Stephenson and Freeze (1974) tested the model against a real world situation involving a small drainage basin in Idaho. It was found that because of difficulties measuring the geohydraulic properties of some of the formations, the model had to be calibrated to the basin. This was done by arbitrarily changing the geohydraulic properties of the soil

layers in the basin in successive simulations until a good fit for the field measurements was obtained. A brief outline of the physical basis of the 'Freeze Model' after Freeze (1974) is provided in Appendix I. The development of an understanding of the physical processes involved in the growth of transient zones of saturation and the relationship of such zones to high-magnitude, low-frequency rainfall events suggests the possibility of a coupled stability analysis utilizing groundwater models such as that developed by Freeze (1972c) to provide piezometric input.

3.1.3 Prediction of Stability

In the case of hillslopes on which a relatively shallow layer of soil overlies a more strongly consolidated parent material, it is frequently suggested that the 'infinite slope model' (Taylor, 1948) is applicable. Under these circumstances stability is considered to be a one dimensional problem, the depth to a potential plane of shearing and the depth to the water table being treated as being uniform throughout the slope. The application of this type of model can only be justified in situations in which the length of the slope is so great in relation to the thickness of unconsolidated slope sediment, that the influence of external factors such as shear resistance at the slope foot can be ignored. The balance of forces considered in the infinite slope model is given in Appendix II.

Frequently, however, slope boundary conditions are complex and stability problems are not amenable to the infinite slope model. Skempton and Hutchinson (1969) outline a number of types of failure which have been observed in nature. Frequently these involve circular or non-uniform failure surfaces suggesting a more complex type of analysis is required. A number of types of stability analysis have been developed for treatment of circular failure surfaces. Lambe and Whitman (1967) suggest that of these, the Bishop method (Bishop, 1955), is probably the most accurate (see Appendix III for an explanation of the balance of forces considered).

The model considers that failure will be along a circular slip surface, and that the most probable failure surface is that with the lowest safety factor. In general, field observation suggests that circular failure surfaces most commonly occur in homogeneous sediments. Clearly it is difficult to identify the lowest bound safety factor; consequently, the method adopted involves the analysis of a large number of failure surfaces in the vicinity of the most probable locations. By testing a large number of surfaces, a high degree of accuracy may be obtained. This however, commonly demands the use of computers.

In non-homogeneous soils, potential planes of failure will probably not be circular because of the tendency of failure surfaces to follow the inhomogeneities.

Morgenstern and Price (1965) provide a method of analysis which is non-circular and allows the assessment of factors of safety in situations where the geological conditions are non-homogeneous (see Appendix IV). According to Bailey and Whitman (1967) the Morgenstern and Price technique provides the most accurate assessment of stability available at the present time. It does however have two disadvantages:

- i) the finite element method used requires the use of computers - computation time far exceeding that of the Bishop method;
- ii) the method puts much greater demands on the experience of the person doing the analysis, requiring that the location and shape of possible failures be determined as inputs.

In general, each of the techniques provides a good assessment of stability provided the limitations of each technique are considered. In each case however, one of the required inputs is the groundwater table. In some cases, for example dams, piezometric conditions may be estimated fairly accurately as the zero potential line at both the head and the foot of the dam are liable to remain relatively stable. In the case of slopes however, where saturation zones are likely to develop in response to rainfall events, the relevant groundwater conditions are much more difficult to estimate. With the demand for development land and the development of new communications corridors, it is probable that sites on hillslopes where groundwater conditions of the type described prevail will increasingly be developed.

FIGURE 5

Slope design using design life criteria to determine safe design

FIGURE 6

Assessment of probability of failure

Terzaghi and Peck (1967) advocate extremely conservative design in areas where uncertainty exists:

... Design on the basis of the most unfavourable conditions is inevitably uneconomical, but no other procedure provides the designer in advance of construction with assurance that a soil supported structure will not develop defects (Terzaghi and Peck, 1967, p. 294).

Hough (1957) applying this philosophy to situations where the uncertainty involves groundwater level, suggests:

Porewater plays a major role in slope stability. If there is any possibility that a given slope may become wholly or partially saturated, stability analysis should be made for the slope in that condition (Hough, 1957, p. 213).

Clearly this philosophy is liable to lead to extremely uneconomical design for in hardly any case would it be possible to state unequivocally that there is no possibility of failure. It is suggested that one way, perhaps the only way of overcoming this problem, is through the utilization of a coupled, hydrologic-stability analysis, using as input the worst probable rainfall conditions likely to occur within the design period as determined by existing rainfall records. Figure 5 and Figure 6 are schematic solutions to two types of design problems using the coupled model approach.

3.2 Conclusions

Although it is generally accepted that heavy rainfall is the cause of most slope failures, there have been few attempts

to predict stability on the basis of the probable occurrence of rainfall conditions which will induce instability. Those attempts which have been made have been site specific and the results cannot be extrapolated to slope problems in general. It is suggested that the coupled hydrologic-stability model proposed offers the only solution available to solve this problem at the present time. The present investigation is an attempt to demonstrate the feasibility of this technique with examples of the application of the coupled model.

CHAPTER 4

Experimental Design

Experimental work was undertaken with two major objectives:

- i) to demonstrate by careful measurement and repetitive stability analysis that decline in the "real" factor of safety which accompanies prolonged rainfall events; and
- ii) to provide data from a closely monitored slope system which could be compared to the results generated by the combined hydrological and stability models.

Initially it appears that the only means of collecting the required data is through field investigation involving the instrumentation of suitable slopes and data collection over an extended time period. It quickly became apparent, however, that this approach involves numerous logistical problems associated with site selection, site access, instrument cost, data acquisition and uncertainty concerning the frequency of rainfall events which would provide suitable data. Although these problems are not insurmountable, it was decided that many of them could be eliminated by constructing a large-scale slope segment in the laboratory. In this way, a high degree

FIGURE 7
THE MODEL SLOPE SEGMENT

of control could be maintained over the test situation, minimizing the possibility that lack of agreement between measured and simulated results could arise from unknown factors within the slope system itself (i.e. unmeasured inhomogeneity).

4.1 The Experimental Slope

The objective in constructing the slope model was to closely replicate conditions found in natural slope situations whilst eliminating inhomogeneity and uncertainty. In this respect it is important to pack the soil to a constant bulk density, to ensure homogeneous rainfall distribution on the slope, to prevent leakage of water from the slope other than at the designated slope foot outlet area and to reduce shear resistance in the lateral dimension. Precautions taken to overcome these and other problems are described below.

4.1.1 The Slope Characteristics

The laboratory slope consisted of two segments joined at a hinge point. The upper adjustable segment, 3 metres long by 1 metre wide, was suspended from an A-frame by two 5 ton winches and could be adjusted to angles from 0° to 55° . The procedure adopted to change slope angle involved raising the slope slightly higher than the desired angle and then lowering it onto a preset adjustable jacking post so that the strain could be taken off the winches once the slope was in the desired

FIGURE 8

Textural composition of 72 samples of weathered granite from Hong Kong compared to the texture of the experimental soil (Source: Lumb, 1962, p 212)

position. The base of each segment was lined with cement such that the interface between the base and the slope soil resembled a soil-bedrock interface. The inside walls of the slope box were lined with polyethylene; this served two purposes, acting both to prevent water leakage, and to prevent frictional shear resistance between the box and soil not accounted for in stability analyses.

4.1.2 The Soil

The soil used in the experiments posed a problem. Clearly the fact that the soil had to be transported into the laboratory, packed in the slope segment box and periodically repacked after runs*, dictated the use of a totally noncohesive soil which could be repacked to essentially the same density. Use of the noncohesive soil also had several other advantages:

- a) It dried out relatively rapidly (i.e. about 4 weeks).
- b) It had relatively high permeability which reduced the duration of the individual experiments.
- c) It was possible to obtain diffusivity measurements for the soil using the Bruce and Klute (1956) method.
- d) The coefficient of friction could be obtained using simple shear box tests, avoiding the necessity of triaxial testing.

The soil selected was a mixture of two glacio-lacustrine sands obtained locally and mixed in the proportion of one part of the fine silty sand to two parts of the medium-grained sand. The resultant mixture provided permeability and grain size

* The soil was packed loosely by hand in a dry state prior to each experiment.

FIGURE 9

Rainfall System

characteristics similar to noncohesive soils found in Hong Kong (Lumb, 1962), which are highly susceptible to failure.* (See Figure 8).

4.1.3 Rainfall Simulation

It was important that the supply of water to the slope was relatively even and that the drops themselves were small. Large inhomogeneities in the water supply not only induce anomalous piezometric conditions which are difficult to simulate numerically, but also make it necessary to reduce the possible overall rainfall to avoid localized saturation which leads to surface soil flowage and gullyng. Large raindrops quickly cause drastic reductions in surface infiltration capacity by packing the surface soil layer. In order to overcome both these potential problems the rainfall simulation was accomplished by constructing a continuous network of 1/8-inch tygon tube mounted at 30 cm intervals on a board; at the four sides of the board, the tygon tubes were attached to 1/2-inch perspex feeder tubes which help to maintain equal pressure throughout the system (see Figure 9). The perspex tubes were fitted with valves which allowed air to be bled from the system prior to experimental runs. The tygon tubes, once mounted on the backing board, were perforated at intervals on the exposed surfaces using a coarse darning needle in order to obtain an extremely fine spray. Tests indicated that finer punctures resulted in the formation of drops instead of a fine spray, whilst coarser

* Grain size curve contained in Appendix XI.

implements resulted in water jets. The board itself was suspended above the slope and adjusted to the same angle as the slope.

The water supply to the rainfall system was measured by an in-line GAP meter. Using the inlet valve, "rainfall" fluxes on the slope varying between 0.25 cm hr^{-1} to 6.5 cm hr^{-1} could be obtained. Although the system functioned well during runs, between experiments it was found that some perforations in the tygon tube became sealed, causing an uneven flux in subsequent runs. This problem was only overcome by testing the system for unevenness shortly before experiments, and making additional perforations in areas which required them.

4.1.4 Soil Water Measurement

Most systems designed for in situ soil water measurement involve the use of the relationship between pressure (ψ) and water content (θ) in unsaturated soil, "the characteristic curve". In unsaturated soil, the pressure is increasingly negative as the soil dries. In the present experiment, however, only the location of the saturated zone (indicated by the zero pressure isoline) was required. The system utilized employed between 40 and 50 tensiometers, referenced so that they could be used to measure both positive and negative pressures. The tensiometers themselves were made of 1/8-inch nylon tube, to the end of which a 1-inch by 1/4-inch porous top (Soil Moisture Corp.) was attached using epoxy. Prior to each experiment the

FIGURE 10

Tensiometer System ----- steps used to fill the system

tips were boiled in distilled water to remove air , and the whole system of tubes linking the porous tip in the soil with the reference mercury bath was carefully filled with distilled water. This routine demanded a sequential system described in Figure 10. Experience with the system indicated that all epoxy joints were liable to deterioration if allowed to remain wet for extended periods of time and some types of epoxy deteriorated extremely rapidly. To circumvent these problems, a number of different types of epoxy were tested and eventually the most satisfactory (Lepages, slow drying type) was selected. In spite of the fact that the epoxy proved quite reliable, periodic replacement of elbow joints and tensiometer tips had to be made. Consequently, although initially an attempt had been made to fabricate the system linking the porous tip to the reference bath as a single unit minimising the number of joints, it was later found that if all sections were replaceable, joints could quickly be replaced with spares, reducing the time required to put the system together and prepare for runs.

Pressure within the system was measured by balancing the suction of the unsaturated soil against a column of mercury. Several methods of monitoring the 40 to 50 columns were investigated and ultimately it was found that in terms of cost and the desired accuracy of readings, glass columns mounted on a board covered with metric graph paper (see Figure 11) could be photographed using high contrast film to yield a resolution of 1 mm

FIGURE 11

Tensiometer board and mercury reservoir.

of mercury. Although this method involved the possibility of loss of data resulting from faulty photographic technique, and required considerable expenditure of time in reading and recording data from the film negatives, the most obvious alternative, use of pressure transducers involved costs of between \$1500 and \$2000 for the transducers. Ultimately, although some data was lost, the photographic technique proved quite adequate.

Because of the variations in elevation of the tensiometers in the slope, in order to provide a reference level which could be used for both positive and negative pressure heads, the tensiometers were divided into two groups, each referenced to its own common mercury reservoir. The use of large common reservoirs minimized the change in reference mercury level resulting from the flow of mercury back into the reservoir as the soil became wet. In addition the use of two common reference levels simplified data processing which utilized a simple program to convert mercury column heights into pressure head in cm of water at the tensiometer tip location (Appendix V).

The data reduced to pressure head values is presented as Appendix VI, each data set is accompanied by a diagrammatic representation of the slope configuration used, the co-ordinates of the tensiometers and a log of the flux intensity for the run.

4.2 Limitations

The model was designed to provide a realistic parallel

PLATE I

2
Mudflow resulting from inhomogeneous rainfall

to natural slope conditions whilst maintaining a relatively simple experimental design. This had many advantages but also a few limitations.

Perhaps the most significant problem related to the fact that the slope surface was composed of bare non-cohesive soil. Although the problem of raindrop splash was largely overcome as described above, the fact that any simulation of rainfall has locally variable flux intensities meant that it was impractical to simulate rainfall fluxes close to the measured saturated infiltration capacity. It was found that generally any rainfall flux larger than 1.3 cm hr^{-1} generated local zones of saturation which resulted in overland flow and generated small mudflows on the surface (see Plate 1). As a consequence, although the infiltration capacity of the soil was approximately 2.2 cm hr^{-1} , fluxes of more than 1.3 cm hr^{-1} were seldom used.

A second problem which became apparent during early experiments was the tendency of the granular soil to pack down during rainfall events. This led to additional soil tests (i.e. suction moisture and diffusivity tests) to determine the range of values applicable to loosely and more densely packed soil. Ultimately it was concluded that the granular soil used had only one set of applicable characteristics. Although the soil packed down during experimental simulations, it also packed to approximately the same density during determination of the hydrogeological characteristics. Problems relating to density

of packing may also affect the friction angle. This problem has been examined by Kirkpatrick (1965) and Koerner (1970a). As a result of their experiments, it must be concluded that the effective angle of friction applicable to the soil packed down by wetting may be 2-3° higher than that determined experimentally. However, dilation was also measured in saturated areas during simulations (see Appendix VII) which reduced packing densities to values almost identical to those used in the friction angle determinations.

The third potential problem related to the use of tensiometers and glass columns. Under normal conditions the use of tensiometers is limited to relatively moist soil conditions, generally negative pressures less than 800-900 cm of water. In the present experiments the length of the glass columns which linked the tensiometer tubes and the mercury bath, approximately 30 cm, provided a further limitation and the slope moisture had to be maintained at the level which limited negative pressures to less than approximately -300 cm of water pressure.

4.3 Soil Testing Procedures

Soil tests were required to provide input data for the numerical models. Primarily these were hydrogeological tests involving determination of the "characteristic" relationship between suction (ψ) and moisture (θ), diffusivity determinations, conductivity measurements, and shear box testing to determine the coefficient of friction.

FIGURE 12
Suction-Moisture Curve for the Experimental Soil

4.3.1 Determination of the Characteristic Curve

In fact no single characteristic curve exists which describes the behaviour of a particular soil either wetting up or drying. Rather, outer bound curves exist which are linked by an infinite number of "scanning curves". Scanning curves describe the relationship of the soil wetting or drying as it crosses between the two outer bound curves. The path followed depends on the moisture content at which the process is reversed (i.e. from drying to wetting, or vice versa). A number of techniques are used to determine moisture content at different pressures; the technique employed varies according to the pressure range involved. The standard methods are described by Croney, Coleman and Black (1958). Of these, the present study utilized:

- 1) suction plate pF 1 - 2.48
- 2) pressure plate pF 2.48 - 3.40
- 3) pressure membrane pF 3.40 - 3.94
- 4) vacuum dessicator pF > 3.94

The characteristic curves and scanning curves obtained are shown in Figure 12. Moisture content for each of the imposed pressures was obtained by careful oven drying.

Because the soil used in the present experiment was largely composed of sand- and silt-sized particles, most of the testing, including all the scanning curves, fell within the range determined utilizing the suction plate.

FIGURE 13

Diffusivity curve for the experimental soil, used with the following relationship to compute diffusivity.

$$D(\theta_x) = -\frac{1}{2} \frac{1}{t} \left(\frac{dx}{d\theta} \right)_{\theta_x} \int_{\theta_n}^{\theta_x} x d\theta$$

4.3.2 Diffusivity and Conductivity

Diffusivity (D) and conductivity (K) for a unsaturated soil are related by:

$$K_e = D_e \frac{d\theta}{d\psi}$$

Consequently either property may be determined from the other if the characteristic curve for the soil is also available. Although methods of obtaining $K(\theta)$ directly, Black (1965), are available, experience indicated that these pose problems which are liable to result in error. As a consequence in the present investigation, $K(\theta)$ was determined from the curve of $D(\theta)$ obtained by the method of Bruce and Klute (1956). This method is applicable to noncohesive soils such as that used in the slope model. Figure 13 is a plot of the curve obtained with some of the tangents $\frac{dx}{d\theta}$ drawn in.

From $K(\theta)$, $k(\theta)$ permeability is obtained from the expression:

$$k(\theta) = K(\theta)\eta/\rho g$$

where η - viscosity (poises)

ρ - density of water

g - acceleration due to gravity

The results of the test for the soil used are presented as Appendix VII.

4.3.3 Grain Size Analysis

The soil used in the experiments was artificially prepared by mixing a fine, silty sand and a medium sand together. This procedure was adopted as a result of grain size analyses conducted on several different sands and soils with the aim of finding a soil with similar grain size characteristics to a slide prone soil described by Lumb (1975). The analyses were conducted according to methods prescribed in ASTM (1964). The fine fraction was first removed by wet sieving, the remaining coarse material was oven dried and sieved using a mechanical shaker. The silt-clay size fraction was subjected to pipette analysis, the resultant grain size distribution is comparable to distributions typical of failure prone soils from Hong Kong (Lumb, 1975). The use of non-cohesive soil simplified test procedures since sample preparation required little effort to disaggregate and disperse the soil.

4.3.4 Determination of the Coefficient of Friction

The coefficient of friction describes the magnitude of the frictional resistance mobilized by different types of soil. The origin of such resistance, closely investigated by Koerner (1970a,b), lies in a complex relationship between grain uniformity, mineralogy, particle shape, soil density and grain size. The coefficient of friction $\tan \phi$ is one of the basic requirements in stability analyses and is obtained by one of several methods dictated by the soil itself and its in situ

FIGURE 14

Stress-strain curves for the experimental soil under increasing load

structural characteristics. In the case of granular soils, the method most easily applied utilizes a direct shear test employing a shear box apparatus.

The coefficient of friction for the present soil was obtained using a strain controlled shear box in which the two halves of the box are moved apart at a predetermined rate, whilst the resistance mobilized is measured using a proving ring. The procedure followed in the tests is that prescribed in Lambe (1951). The results of these tests are summarized in Figure 14.*

4.4 Data Manipulation

The original aim of the project was to provide an integrated model consisting of the coupled hydrological and stability models outlined in Figure 5, the output from the former model transferred to the latter avoiding intermediate data handling stages. The constraints of time and computer resources prevented this degree of refinement and data from the first stage had to be recoded to provide input for the second stage. Data collected during the slope experiments also required considerable processing which could easily be avoided in future experimental projects.

4.4.1 Data Collection and Processing

The tensiometer tubes were photographed at intervals throughout each experiment using Kodak High Contrast Film in

* Data contained in Appendix XI.

a Leicaflex SLR camera, the work area being lit with tungsten spotlights. The films were developed and a filmstrip projector used to enlarge the image to a size which allowed the columns to be read to an accuracy of 1 mm of mercury. The levels themselves were read and recorded and the change in level of the mercury reservoir for each time interval was also recorded. The data were subsequently punched on cards and converted to absolute pressures with reference to the elevation of the tensiometer in the slope relative to the free mercury surface, using the computer program in Appendix V. The program created a file of pressures on disc which were used as input for SYMAP contour plots, the SYMAP option providing an interpolation between data points. The plots generated by this routine were replotted on graph paper, and the co-ordinate data for points on the piezometric surface for each designated time interval put on disc file.

The stability analysis used allowed nine peizometric surfaces to be entered simultaneously. This, in fact, meant that the factor of safety for nine time intervals could be investigated rapidly working from a computer terminal, requiring only minor editing after each analysis.

CHAPTER 5

5.1 Experimental Rationale

A number of physical simulations were conducted using the laboratory slope model. Two levels of rationale existed for the experiments conducted. In the narrower sense, variations in the boundary conditions from test to test were designed to mirror variations which occur in nature. The wider rationale however, involves three aspects:

- a) the desire to monitor the growth of saturated zones during prolonged rainfall events and to determine the degree to which the groundwater conditions required to support the use of the infinite slope model occur in nature;
- b) more generally, to characterize the manner in which stability declines through time in response to extreme rainfall;
- c) to provide data from a controlled and closely monitored physical environment against which the numerical simulation could be tested as proof of the applicability of this approach to stability problems.

Ultimately, it proved impossible to provide a comparison between laboratory measurements and simulated data using the

Freeze model because of a basic incompatibility between the data and the model. The data collected and the stability analysis conducted are however presented in Appendix IX in the belief that they may be useful to other workers attempting to develop and test numerical models predicting saturated-unsaturated infiltration in the future. The problems encountered in attempting numerical simulation of the laboratory measurements as they relate to the Freeze model are explained in Chapter 6. The present chapter, therefore, is primarily a descriptive examination of the data provided by the laboratory simulations, with some attempt to explain problems and anomalies which the collection and interpretation of the data provide.

5.2 Physical Simulation #1

The physical model was originally intended to represent a simple infinite slope system in which groundwater changes could be monitored through time. The attempt to recreate the infinite slope environment resulted from the belief that this was characteristic of many hillslopes where high magnitude rainfall events could result in slope failure. In addition, the relative simplicity of the infinite slope analysis is attractive.

It soon became apparent, however, that the infinite slope situation was difficult or impossible to re-create in the laboratory. This resulted from the fact that in order to collect groundwater data, the soil itself had to be relatively

thick. Under these circumstances, the requirement for the infinite slope situation, namely, infinitely shallow soil relative to slope length, could not be met in the laboratory. As a consequence of this discovery, a concave shape was adopted, utilizing an upper slope segment of relatively uniform thickness and a lower angle footslope wedge which acted to retain the upper slope. In the initial experiment the upper slope stood at 21.2° whilst the footslope formed a horizontal-based wedge. As the original intent had been to create an infinite slope segment, no provision had been made for rainfall on the lower slope.

5.2.1 Growth of the Zone of Saturation

At the outset of the experiment negative pressures were measured throughout the slope.* Consequently, the rainfall flux was initially set at 3.5 cm hr^{-1} , considerably greater than the saturated infiltration capacity of the soil. Subsequently the rainfall flux had to be reduced twice, first to 2.75 cm hr^{-1} and later to 1.6 cm hr^{-1} , when the infiltration capacity was exceeded. The movement of a wetting front induced by the surface moisture flux was evident from the rapid decline in suction at successive depths in the soil. As would be expected however, total saturation resulting in positive pressures did not develop during the infiltration phase. Positive pressures were first recorded between 2.5 and 3 hours after rainfall commenced (see

* The magnitude of negative porewater pressure is included as the initial pressure reading (see Appendix VI). Initial porewater pressures may be estimated by reference to Figure 12.

Appendix IX). Positive pressures first occurred at the interface between the sand and the underlying cement base as was expected.

Expansion of the saturated zone upslope along the soil-cement interface and upwards through the soil towards the surface ultimately resulted in total saturation in the zone at the foot of the headslope. During the latter part of the experiment, surface flowage began to occur in this region. The fact that the tensiometers in this area, numbers 26 to 30, all recorded positive pressures greater than hydrostatic, suggests that the flowage may have been caused by seepage towards the surface. Ultimately as the flowage became worse the experiment had to be discontinued (see Plate I). Because of the absence of rainfall flux on the footslope, after 5.5 hours when the experiment was discontinued, a considerable portion of the footslope remained unwetted.

5.2.2 Stability Change

The slope angle was set at 21.2° . Based on suggestions of Skempton and De Lory (1957), the soil density at saturation, 2.02 gm cm^{-3} , appeared to be particularly suitable for an approximation based on $1/2 \tan \phi$.

In these circumstances Skempton and De Lory show that under infinite slope conditions, a saturated slope will be unstable if saturated at any angle greater than $1/2 \tan \phi$. Thus in the present case as a simple approximation:

$$\begin{array}{rcl}
 \tan b & > & 1/2 \tan \phi \\
 \tan 21.2^\circ & > & 1/2 \tan 35.85^\circ \\
 .3878 & > & .3612
 \end{array}$$

suggests that the slope should fail if the infinite slope model was applicable. At this point however, it was quite apparent that the addition of the footslope had provided a retaining force which made the infinite slope presumption quite invalid. Consequently the final groundwater condition was analysed utilizing Bishops method. The analysis (see Appendix IX) indicates that the lowest bound failure circle had a computed factor of safety of 1.53.

5.3 Physical Simulation #2

The experiment was conducted primarily with a view to collecting accurate physical measurements against which the combined numerical model could be tested. The rainfall simulation began on a relatively dry slope and was maintained at a constant intensity throughout the experiment. Although it was originally intended that rainfall would be continued until slope failure occurred, ultimately after 12 hours when groundwater levels no longer appeared to be changing, the experiment was concluded.

5.3.1 Growth of the Zone of Saturation

Initially all soil water within the slope was held under capillary tension. Negative pressures continued to be recorded

at all tensiometers throughout the first two hours of infiltration as the wetting front moved downwards through the soil. Infiltration was maintained at 1.4 cm hr^{-1} , a rate well below saturated infiltration capacity because of the problems encountered with localized surface saturation resulting from inhomogeneity in the rainfall distribution. After 2.5 hours, the lowest slope-foot tensiometer #45, (see Appendix IX), indicated that the toe of the slope was saturated. Expansion of the saturation zone within the footslope continued until the whole footslope had saturated after approximately 6.5 hours. Saturation of the upper slope segment was not apparent until 7.5 hours after the rainfall had commenced. When an upper zone of saturation did begin to develop, it was characterized by an unexpected inhomogeneity at the break in slope, where an unsaturated zone continued to exist long after surrounding areas had saturated. The cause of the anomaly is probably attributable to the fact that the rainfall network which was constructed in two parts, had an area where the parts were connected in which there was a rainshadow resulting from complete overlap of the networks. In terms of the experimental surface as a whole, this is probably insignificant in terms of its effect.

The final three hours of rainfall were marked by the growth of a relatively uniform zone of saturation in the lower part of the headslope. This suggests that in a real infinite slope situation, groundwater conditions similar to those

required to make the application of infinite slope analysis valid, may prevail. The zone of saturation developed in the headslope probably results from the integration of surface flux and upslope seepage. As time progressed the anomalous unsaturated zone gradually disappeared. The experiment was eventually concluded when it appeared that the saturation zone was no longer expanding. Ultimately, closer examination of the data indicated that slow expansion was still taking place when the event ended.

5.3.2 Stability Change

Stability was assessed utilizing the Bishop method on the basis that the soil in which the failure was occurring was homogeneous and that the path of a failure would probably be an arc. At each time step several hundred potential failure surfaces were analysed. Appendix IX provides details of the lowest bound failure surface for the time steps which were examined.

In the early part of the experiment, the slope was totally unsaturated; under these circumstances the lower bound failure surface lay largely in the headslope, the factor of safety 1.84 is relatively high. The growth of the saturation zone did not affect stability levels until 4.5 hours after the rainfall had commenced. By this time the saturated zone extended almost to the break in slope. Development of the zone

of saturation results in the lower bound failure circle being displaced into the partly saturated footslope which now provides an area of lower shear resistance resulting in an overall decline in the computed factor of safety to 1.64. Continued expansion of the saturated zone in the footslope ultimately resulted in a decline in the factor of safety to 1.47. Clearly however, the footslope itself is below the angle at which failure can take place even when totally saturated.

The final phase of groundwater expansion was characterized after 7.5 hours by the establishment of a zone of saturation in the steep headslope. Growth of a zone of saturation in the headslope which stood approximately 6° above the angle of ultimate stability resulted in a decline in the factor of safety for the lower bound slip circle to 1.07 after 11.5 hours.

The experiment was concluded after 11.5 hours because it appeared that a stable groundwater level had been established (i.e. inflow and outflow balanced) so that the saturated zone had ceased expanding. It was not until later, following processing of the data, that it was discovered that groundwater levels were still rising and computed F_s values still declining at the conclusion of the experiment. It seems possible on the basis of the evidence presented that failure would probably have occurred had the experiment continued 1 to 2 hours longer.

Nevertheless the data collected appears to indicate the applicability of conceptual models suggesting the expansion of saturated zones in areas of flow convergence. In addition, the repetitive stability analysis demonstrates the effect of the development of these zones in inducing instability directly related to the duration and magnitude of the rainfall event involved. Where slope angles exceed the angle of ultimate stability, failure will occur if rainfall of sufficient magnitude is maintained over an extended period of time.

5.4 Physical Simulation #3

The experiment described is part of a longer sequence of shower activity, which continued intermittently for more than 36 hours. The sequence includes periods when the rainfall flux was discontinued and moisture allowed to redistribute. The period described commenced after the rainfall flux had been halted for six hours and steady state conditions had developed, the footslope remaining largely saturated.

5.4.1 Growth of the Zone of Saturation

The rainfall flux at the outset of the new rainfall sequence was set at 1.25 cm hr^{-1} . Because the footslope was already saturated and the slope just above the saturated zone in the steady state situation was close to saturation, extension of saturated conditions into the headslope began to occur within the first 30 minutes of the new rainfall period.

As in physical simulation #2, saturation in the upper slope took the form of a relatively thin zone adjacent to the cement base. The zone continued to develop during the first two hours of the new phase, but subsequently appeared to have stopped developing. At this point, small surface soil flows began to develop at some points on the slope surface because of inhomogeneity in the rainfall flux. Consequently the rainfall flux had to be reduced to 0.9 cm hr^{-1} . Tensiometer readings indicated that groundwater levels continued to rise for approximately 45 minutes after the reduction in flux, but then began to decline, indicating that seepage exceeded infiltration. Ultimately, the groundwater level stabilized and during the final three hours of the experiment did not change.

5.4.2. Stability Changes

Changes in stability were again monitored using Bishop's analysis and examining a large number of possible failure surfaces in the footslope and the lower part of the headslope. Computed factors of safety and slice data are presented in Appendix IX. Stability analysis at the beginning of the experiment indicated that the lower bound failure surface was situated in the footslope, unlike the previous simulation when the slope contained no saturated zone at the onset of the experiment. The rapid development of a saturated zone in the headslope resulted in rapidly declining factors of safety, 1.46 after 45 minutes,

1.37 after 1.75 hours. The lowest computed factor of safety 1.19 occurred 2.75 hours after the rainfall commenced, soon after the rainfall flux had been reduced to 0.9 cm hr^{-1} . Subsequently both the lower flux rate groundwater levels declined and computed factors of safety increased stabilizing between 1.29 and 1.35 for the final three hours of the experiment.

As in the previous experiment, failure to induce deep-seated instability was clearly attributable to the fact that the rainfall flux had to be maintained at a relatively low value because the surface of the slope was prone to develop soil flows. This highlights two of the major problems met in attempting to simulate slope failure in the laboratory. First the unconsolidated surface lent itself to soil flows and it was difficult to envisage any means by which the surface could be consolidated without seriously affecting shear resistance and hydraulic conductivity and also allow the soil to be repacked after each experiment. Secondly in spite of all attempts to induce relatively homogeneous rainfall, repeated surface flows at low rainfall fluxes indicated a low degree of success. Ultimately the results of the third physical simulation suggest that failure could be induced if it were possible to induce surface infiltration at a value slightly closer to saturated infiltration for the soil. Notably however, the results probably do reflect nature in that in unvegetated Alpine areas and arid areas where vegetation cover is low and infiltration capacity

low, the most common failure mode is probably flowage (see for example, Rapp, 1960; and Curry, 1966) as illustrative of this point. Shallow slides probably require higher infiltration capacities which result from the development of soil structure and a degree of surface consolidation resulting from vegetation cover.

In the one experiment in which failure was induced, it resulted when a high degree of homogeneity was achieved in the rainfall flux which was maintained at 1.7 cm hr^{-1} for 6.5 hours without flowage. Unfortunately soil moisture data for the experiment was not recorded.

5.5 Physical Simulation #4

In real world situation, the impermeable bedrock interface used in the first three physical simulations, and hypothesized in the infinite slope model to produce parallel flow, is probably not widely applicable. On steep mountain slopes underlain by well lithified bedrock it is more probable that the surface soil is commonly underlain by fractured and weathered bedrock resulting from unloading and physio-chemical soil forming processes. Layers of this type which exhibit high conductivities, compared to overlying soil, may exert a critical influence to groundwater redistribution and stability.

Stephenson and Freeze (1974) found that the conductivity of fractured and weathered bedrock layers in a drainage basin in Idaho exercised an important influence on the development of

the groundwater table during snowmelt. Hotzel (1976a,b) suggested that the presence of highly fractured bedrock underlying landslides on Vancouver Island could have been responsible for the development of high groundwater pressures which ultimately led to failure.

As a consequence of these observations it was decided to examine the effect of a 'fracture zone' beneath the experimental soil, in terms of its effects on groundwater redistribution and consequent stability changes.

A high permeability zone was constructed by randomly cementing bricks to the existing slope base, the proportion of solid brick being determined by measuring the proportion of solid rock exposed in the side of a landslide visited on northern Vancouver Island (Hotzel, 1976b). The spaces between the bricks were filled with crushed stone and the slope soil repacked to the density used in previous experiments. Experiment #4 was conducted using conditions similar to those employed in Experiment #2 with the addition of the permeable layer, so that the two experiments are directly comparable.

5.5.1 Growth of the Zone of Saturation

During the early phases of the experiment, the footslope gradually saturated as had occurred in Experiment #2. The shape of the developing zone of saturation at the end of four hours of rainfall was intermediate between that measured for

hour 3.5 and 4.5 in Experiment #2. During the succeeding hour, however, rapid growth of the saturated zone in the area of the break in slope occurred, the zone of saturation expanding in a wedge along the interface between the fracture zone and the overlying soil. The difference in the observed patterns is clearly attributable to the rapid transmission of water through the 'fractured layer'. At the foot of the head slope, the fracture layer ends and the further flow of water is impeded by the already saturated footslope. Further development of the zone of saturation was significantly different to that observed in previous experiments, a fact which is obviously attributable to the high permeability fracture zone.

Although the rainfall continued for 16 hours, the changes in the zone of saturation in the upper slope were relatively minor after hour 7. Significantly, the presence of the fracture layer prevented development of a thickening saturated layer on the upper slope such as had characterized the previous experiments. Small saturated zones did develop on the upper slope at two points, but these did not expand perceptibly after the 7th hour. These were presumably caused by discontinuities in the fracture layer causing localized saturation where water was forced to flow into the soil. Downslope seepage back into the fracture layer prevented their expansion. The fact that even the very slow expansion of the saturated zone which occurred after hour 7, ceased after hour 12, suggests that equilibrium between inflow and outflow fluxes had been reached and that further rise in groundwater levels could only have been achieved

by increasing rainfall fluxes. Ultimately the experiment was discontinued after 16 hours when it was quite apparent that groundwater levels were stable and that the rainfall flux could not be increased because of the danger of promoting superficial soil flows which usually occurred when rainfall flux exceeded 1.4 cm hr^{-1} .

The problems associated with determining soil water properties for fractured bedrock layers have been discussed by Stephenson and Freeze (1974). They conclude that measurements are both difficult to make and liable to inaccuracy because of natural inhomogeneity of the materials concerned. This may prove to be a major problem in attempts to utilize this approach to stability problems which can only be overcome by correlating the computer model and actual measured groundwater conditions prior to simulation for predictive purposes.

5.5.2 Stability Changes

The pattern of stability change during the first four hours of Experiment #4 was essentially similar to that observed in Experiment #2. Between hours 4 and 7 however, computed factor of safety values for the 'fractured bedrock' experiment declined rapidly in response to expansion of the saturated zone. Consequently by hour 7 the lowest bound factor of safety value for Experiment #4 was 1.37, much lower than that recorded with the impermeable bedrock layer ($F_s = 1.51$). Ultimately because a saturated layer above the fracture zone failed to

develop in the headslope, further declines in stability during the remaining nine hours of rainfall were minimal. This compares with the case for the impermeable bedrock which exhibited a continuous decline in stability to the end of the experiment.

5.6 Conclusions

In all, approximately eight physical simulations were conducted, four of these are discussed in the hope that the insights into problems associated with modelling slope failure will be of use to workers attempting to utilize this approach in the future. Only one deep-seated failure was induced; because of technical problems, the data relating to soil moisture change was not recovered. Experiment #2 was a deliberate attempt to replicate the conditions which prevailed on the occasion on which the slope failed. Unfortunately deterioration of the rainfall system discussed in the previous section had occurred during the interval between the two experiments and it proved impossible to induce a completely homogeneous rainfall distribution. As a result the maximum rainfall flux which was possible in the later experiment was only 1.48 cm hr^{-1} compared to approximately 1.70 cm hr^{-1} in the earlier physical simulation. The difference appeared to be critical for whereas a massive failure occurred after 6.5 hours in the original experiment, after 12 hours in the later experiment no failure had occurred. Later, when the factors of safety were computed for Experiment #2, it was discovered that the factor of safety had in fact dropped

PLATE II

Failure in the slope segment after 6.5 hours

to 1.07 and failure might have occurred had the experiment been allowed to continue. The results are however, in the absence of a failure for which all data is available, inconclusive.

The inability to induce a failure for which the soil moisture data were recovered made it even more desirable that the numerical simulation of the other experiments be accomplished. This would have allowed groundwater conditions for the experiment during which failure occurred to be simulated and tested against the observed 6.5 hour failure.

In each of the experiments for which data was recovered, the growth of a saturated zone was observed and the data utilized as input for the stability analysis. It is suggested that the declining factors of safety observed are characteristic of the real world situation. Ultimately it seems certain that had it been possible to infiltrate slightly higher moisture fluxes, failures would have occurred on each occasion. The limitations of the system used were not foreseen, and proved difficult to overcome. Data included in the Appendices may provide a basis for further numerical simulations and the experience provided may save many hours of frustration for future workers attempting to develop and test an integrated groundwater-stability model such as that discussed.

CHAPTER 6

Numerical Simulation using the L.S.O.R. Program

The numerical solution used, (Freeze, 1971), involves a number of assumptions and limitations. Some of these are explained in the various papers which explored the capabilities of the program (Freeze, 1971, 1972a, 1972b, 1974; Stephenson and Freeze, 1974), others only become evident when attempts are made to solve specific problems.

6.1 Simulation Problems and Limitations

The program assumes that all flow is laminar and Darcian, that inertial forces, velocity heads, osmotic forces, temperature gradients and chemical concentration gradients are insignificant when viewed in the context of the bulk flow which is a function of hydraulic head. In addition in the present case, the soil was assumed to be inelastic and isotropic. In the real world these assumptions may be questioned in the context of some special environments, it is however, important that in a majority of cases the assumptions made are probably quite justifiable. The numerical solution utilized to solve the non-linear parabolic partial differential equation of flow,

2

(see Appendix I), line successive over relaxation technique is fully described in Freeze (1971).

The decision to utilize the Freeze program was motivated by a number of factors. Firstly, the primary thrust of the study was an attempt to demonstrate the importance of transient groundwater conditions on stability, not an attempt to develop an extremely sophisticated groundwater model such as that which was ultimately used. It was felt in addition, that the complexity of the program involved and the problems involved in testing the program developed, were such that they might ultimately prove impossible to solve. Secondly, the description of the program (Freeze, 1971, 1972a) suggested that it was ideally suited for simulation of transient groundwater conditions resulting from individual high magnitude events such as those believed responsible for many hillslope failures. A third factor considered important was the fact that the program had already undergone extensive testing using both possible hypothetical situations and field data.

It was evident prior to the attempt to utilize the program that utilization was likely to involve numerous problems. Freeze (1972c) suggests in a disclaimer that the difficulties involved are likely to be so great as to make it worthwhile to develop programs to meet individual requirements rather than attempt to use that which he had developed. This advice was reiterated (Freeze, 1976, personal communication) when he

suggested that differences in computer systems and the sheer size of the program were likely to pose almost insurmountable problems for users.

The problems soon became apparent. Initially it was found that the size of the main program was such that it exceeded the maximum allowable for a single programming unit. Modifications made to the program involved breaking the main program into two parts so that one could be called as a subroutine. This was successfully accomplished and test runs indicated that the new version produced identical results to the unmodified version. Usage, however, continued to be problematic.

In the laboratory experiments the rainfall was infiltrated into the whole slope, in the model, however, it was necessary to designate nodes which could ultimately become seepage points prior to simulation, and a seepage node could not simultaneously be designated an infiltration node. This clearly posed a severe problem in terms of the slope shape which had been used in the physical experiments because the whole of the footslope ultimately saturated and seeped. In order to simulate the seepage conditions, therefore, it would have been necessary to designate the whole of the footslope, which composed approximately one-third of the whole infiltration surface as seepage. Under these circumstances the lower third of the slope could not receive infiltration and the whole simulation would become totally unrealistic.

Ultimately, even if the whole of the lower slope could have been designated as potential seepage without affecting the program, the wedge shape of the footslope provided conditions which the program could not handle. The problems resulted from the fact that it was a requirement of the program that surface nodes be maintained increasingly negative upslope. Clearly the long wedge shape provided conditions under which the upslope areas would become saturated before the foot providing instability in the solution.

It might be assumed that some of these problems could be overcome by commencing the simulation at a point when the slope foot area had already become saturated (i.e. after approximately five hours in most experiments). Under these circumstances further development of the zone of seepage was according to the physical measurements small and might have been ignored without substantial error. Unfortunately, the program demands that initially, steady state conditions prevail. Clearly conditions after five hours of infiltration were totally transient.

It was concluded, therefore, that the data collected in the laboratory experiments could not be replicated using the Freeze program. It was also clear that the shape of the slope used in the laboratory was somewhat unrealistic in terms of the real world and that the program would simulate other types of slope configuration. Under these circumstances it was

decided that a number of hypothetical situations could be examined utilizing the soil parameters measured in the laboratory but utilizing slope shapes which the program could accept. In this way it was hoped to show that the growth of groundwater tables and commensurate decline in factor of safety observed in the laboratory also occurred in the simulated situation even though the two could not be directly compared.

In the real world, embankment slopes such as those used in the numerical simulation might have relatively steep slopes. In such cases the fact that no infiltration occurs on the slope surface itself is a relatively minor source of error. Where the slope angle is lower, this error increases. In two of the numerical simulations undertaken, slope angles are relatively low. This was necessary to establish conditions of stability at the beginning of the simulation. Under these circumstances, the shape of the expanding zone of saturation is at least partly a function of the lack of infiltration on the slope escarpment. In the third test a steeper slope was used and the mechanical characteristics of the soil used were altered so that the slope was stable at the outset of the experiment. In each case, as infiltration progresses, growth of a zone of saturation results in declining stability. Ultimately events of sufficient magnitude and intensity may result in slope failure.

6.2 Conclusions

It is suggested that both the laboratory measurements and the results of numerical simulation using the saturated-unsaturated groundwater model underline the fact that instantaneous stability is a function of transient conditions which are changing constantly in response to external factors. Much evidence suggests that on a worldwide scale, factors which induce changes in groundwater are responsible for the majority of failures. Where rainfall and snowmelt events are responsible for groundwater changes, the frequency and size of such events may be predicted and used to predict the frequency of slope failure.

Far less was accomplished in both the laboratory and numerical simulation than had been hoped for. The basic incompatibility between the laboratory data and the available simulation technique was not foreseen and ultimately made it impossible to test the accuracy of the laboratory stability assessment. Much experience was gained which may be useful to those who may attempt to develop this technique in the future. The data collected in the physical simulations are provided in Appendix IX in the hope that in the future more flexible saturated-unsaturated groundwater simulation techniques may be developed with which the data may be compared.

Attempts to use the Freeze program provided a number of problems:

- a) It appeared that the model was very sensitive to slope geometry. The extent of the problem was not explored. It was however evident that on many of the occasions when an initial steady state could not be determined, the problem lay in the shape of the slope used.
- b) Apart from the fact that no infiltration is allowed on the seepage face, great difficulty was encountered establishing an initial steady state which would allow infiltration on any sloping surface. Notably most of the published results refer to slopes which are of the embankment type (see for example Freeze 1971, 1972c).
- c) Computer facilities limit the size of the problem which can be simulated. Even for small problems the required core space is large and run times long.

At the present time, the Freeze program appears both expensive and difficult to use. There can, however, be little doubt that a truly accurate assessment of stability can only be obtained through detailed knowledge of probable groundwater conditions. Short of measurement over extended periods of time, physics-based simulation is the only means by which such data can be obtained.

APPENDIX I

The hydrological model used in the present study was developed by R.A. Freeze. Various aspects of the model, its application and verification are reported in several papers; most important in the present context are Freeze (1971, 1972a, b,c), Freeze and Harlan (1969) and Stephenson and Freeze (1974). Much of the material contained in these papers is summarized in Freeze (1974) on which this appendix is based.

The model itself computes the redistribution of groundwater under partially saturated conditions in two or three dimensions, the analysis being based on successful coupling of flow and infiltration in the two different environments.

INFILTRATION

Derivation of hydraulic head

$$\text{Using } \phi = g z + (p - p_o) / \rho \quad (1)$$

(Hubbert, 1940)

where ϕ = hydraulic potential ϕ/g at the point

p = fluid pressure at the point = $\rho g \psi$

ρ = fluid density

p_o = atmospheric pressure taken as zero

Freeze shows that hydraulic head is numerically equal to the elevation head z plus the pressure head

$$\text{then } \phi g = g z + (\rho g \psi) / \rho$$

$$\text{therefore } \phi = z + \psi \quad (2)$$

Derivation of the saturated-unsaturated flow relationship

The flow velocity in a homogeneous saturated soil in the z direction is, according to Darcy's Law, described by:

$$v_z = -K_o \frac{\partial \phi}{\partial z} \quad (3)$$

where K_o is the constant, determined by soil properties, which determines the magnitude of v_z , and is termed saturated hydraulic conductivity.

Under non-homogeneous conditions K becomes a function of the particular soil type at depth z and consequently can be stated as:

$$K = -K_o (F) = K_z \quad (4)$$

where F represents the soil formation at z .

Under saturated conditions fluid pressure $\psi > 0$. When the soil is unsaturated however $\psi < 0$ and the water held within the soil pores is held by capillarity which results from surface tension which within a single homogeneous soil increases inversely relative to water content. Clearly under similar unsaturated conditions K is determined by the thickness of

water films within the pores themselves and is thus a function of moisture content, and therefore also of negative fluid pressure ψ . Thus:

$$\theta = \theta(\psi); K = K(\psi) \quad (5)$$

The functional relationships are commonly measured by standardized laboratory techniques (see Chapter 4).

It follows therefore that the equation for vertical flow in a saturated-unsaturated inhomogeneous system is:

$$v_z = K(F, \psi) \frac{\partial \phi}{\partial z} \quad (6)$$

where F indicates the soil formation.

Because in layered soil systems $F(z)$, the pressure head ψ changes with time as a function of changing moisture content, equation (6) may be restated as:

$$v_z = K(z, t) \frac{\partial \phi}{\partial z} \quad (6a)$$

Flow

The continuity equation of fluid flow relates changing stored volume of fluid to the net flow into a unit volume of the soil during one unit of time and takes the form:

$$\frac{\partial}{\partial z} (\theta n \rho v_z) = \frac{\partial}{\partial t} (\theta n \rho) \quad (7)$$

where θ = moisture content of the soil
 n = porosity
 ρ = density of water
 v_z = velocity of water
 t = time

Expanding on right hand side of (7):

$$\frac{\partial}{\partial t} (\theta n \rho) = n \rho \frac{\partial \theta}{\partial t} + \theta \rho \frac{\partial n}{\partial t} + \theta n \frac{\partial \rho}{\partial t} \quad (8)$$

The three terms define the three components of storage. It is clear that in cases when the soil is incompressible, such as is the situation in many natural hillslope environments, the first term, change in moisture content, is by far the most important factor. The other factors, changes in storage due to soil compressibility and to changes in fluid density are by comparison unimportant. Consequently (8) may realistically be simplified to yield:

$$\frac{\partial V_z}{\partial z} = \frac{\partial \theta}{\partial t} \quad (9)$$

introducing (6) into (9):

$$\frac{\partial}{\partial z} [K(F, \psi) \frac{\partial \phi}{\partial z}] = \frac{\partial \theta}{\partial t} \quad (10)$$

Within any soil F , the moisture content θ is a function of the pressure head (5). The slope of the curve defining the functional relationship is also a function of ψ and is known as the specific moisture capacity C . Where:

$$C(\psi) = \frac{\partial \theta(\psi)}{\partial \psi} \quad (11)$$

and for inhomogeneous soil layer conditions:

$$C(F, \psi) = \frac{\partial \theta(F, \psi)}{\partial \psi} \quad (11a)$$

Consequently when (2) is substituted into (10) and (11a) is related to the right hand side of (10), a final form of the flow equation applicable to saturated-unsaturated conditions in heterogeneous layered soil is obtained:

$$\frac{\partial}{\partial z} \left[K(F, \psi) \frac{\partial \psi}{\partial z} + 1 \right] = C(F, \psi) \frac{\partial \psi}{\partial t} \quad (12)$$

which can be solved to yield transient pressure head conditions $\psi(z, t)$. From these, hydraulic head and moisture content may be assessed through the individual characteristic $\theta(\psi)$ curves.

APPENDIX II

The Infinite Slope Model

The infinite slope model is applicable to situations in which the thickness of the failure mass is extremely small relative to its length. In those circumstances each unit segment of the slope is identical to every other unit segment and consequently internal forces $X_i = X_{i+1}$ and $E_i = E_{i+1}$ and may therefore be omitted from calculation of the factor of safety.

Depth of the Unconsolidated soil and the Water Table on an Infinite Slope

Under these circumstances the factor of safety as a whole is the same as that for each unit segment within the slope, and

$$F = \frac{S}{T} = \frac{\sum s}{\sum t} \quad (1)$$

Vertical stress = $W/l = z \delta \cos b$ where $l = 1/\cos b$

$\therefore$ Normal stress = $N = z \delta \cos^2 b$

Consequently the strength s for a unit segment of soil may be defined as:

$$s = c' + (z \delta \cos^2 b - z \delta w \cos^2 b) \tan \phi \quad (2)$$

or

$$s = c' + z \cos^2 b (\delta - \delta w) \tan \phi \quad (2a)$$

and the shear stress t as:

$$t = z \delta \sin b \cos b \quad (3)$$

Substituting (2a) and (3) in (1)

$$F = \frac{c' + z \cos^2 b (\delta - \delta w) \tan \phi}{z \delta \sin b \cos b} \quad (4)$$

Skempton and Delory (1957) in investigations of the variation of slope angle in slide prone areas in England extended this analysis to show the critical control exercised by characteristic or critical groundwater conditions.

If groundwater flow parallels the surface and the potential plane of shear, then for limiting equilibrium:

$$z \delta \sin b \cos b = c' + (\delta - \delta w) z \cos^2 b \tan \phi \quad (5)$$

where m is stated as a fraction of the total soil depth saturated by groundwater.

In hillslope problems frequently $C \approx 0$ and equation (5) reduces to:

$$\tan b = \frac{\delta - m \delta w}{\delta} \tan \phi \quad (6)$$

When δ and $\tan \phi$ are assumed to be constant through time, it is clear that the slope angle itself is entirely dependent on some critical value of m . By assuring that infrequent events occurred which resulted in a rise in the groundwater levels to the surface (i.e. $m = 1$) and assuming δ to be approximately 2 gm cm^{-3} good agreement was found between computed and observed stable slope angles.

APPENDIX III

Circular Analysis

Solutions using circular analysis assume that the failure body is cut from the slope and free to rotate on a circular failure surface. The mass itself is divided into segments and the equilibrium of each computed. Figure A shows the forces which act on each segment.

Figure A

Forces Acting on a Segment of the Friction Surface of a Potential Plane of Failure

The Ordinary Method of Slices

The solution assumes that the resultant forces acting on the sides of the segments are equal to zero.

$$F_s = \frac{\text{moment of shear along the failure arc}}{\text{moment of weight of the free body}}$$

$$F_s = \frac{R \sum_{i=1}^n S}{R \sum_{i=1}^n T} \quad (1)$$

where R = radius of the failure arc

n = the number of slices

$$S = c \cdot l + N' \tan \phi' \quad (2)$$

where N' = the effective normal force at the base Ni-Ui

$$N' = W \cos b - u \cdot l \quad (3)$$

Substituting (3) in (2)

$$S = c \cdot l + (W \cos b_i - u \cdot l) \tan \phi \quad (4)$$

T is the shear force resultant from forces acting parallel to the base;

$$T = W \sin b \quad (5)$$

Cancelling and combining (4) and (5) in (1):

$$F_s = \frac{\sum_{i=1}^{i=n} [c_i l_i + W_i (\cos b_i - u_i l_i) \tan \phi]}{\sum_{i=1}^{i=n} W_i \sin b_i} \quad (6)$$

Bishops Method of Slices

The ordinary method of slices is known to provide a conservative estimate, the error being between 5 and 15 percent for different cases (O'Laughlin, 1973). Bishop (1955) provides a solution which includes forces acting on the sides of slices which assumes zero resultant force in the vertical direction.

Bishop shows that when this approach is adopted N' in equation (2) is equal to:

$$N' = \frac{W_i - u_i l_i \cos b_i - \frac{c_i \sin b_i}{F_s}}{\cos b_i + \frac{(\tan \phi \sin b_i)}{F_s}} \quad (7)$$

Consequently, substituting equation (6) in (2) and combining equation (2) and (4) in (1):

$$F_s = \frac{\sum_{i=1}^{i=n} [c_i \cos b_i + (W_i - u_i l_i \cos b_i) \tan \phi] \frac{1}{\cos b_i (\tan \phi \sin b_i)}}{\sum_{i=1}^{i=n} W_i \sin b_i} \quad (8)$$

APPENDIX IV

Morgenstern and Price Stability Analysis

In some situations the most probable planes of shear are determined by natural lithological inhomogeneity and shear surfaces may consist of numerous segments. Frequently when such conditions exist, neither the infinite slope or circular friction models of analysis can provide an adequate estimate of stability. In order to overcome this problem, Morgenstern and Price (1965) constructed a general model which allows the analysis of irregular failure surfaces. The model again considers the failure mass to consist of segments each subject to stress and resistance. The most important difference between this type of model and the friction circle models is in the treatment of stress and resistance between segments. These forces, discussed in the previous appendix, are usually considered relatively unimportant and dismissed completely as in the infinite slope model and the ordinary method of slices, or simplified by an assumption applicable in special cases (failure on a circular arc) in Bishops model. Clearly when shear takes place along irregular surfaces, the resistance between individual slide segments is an important component of the total mobilized strength and cannot be dismissed in this manner. Consequently, the importance of the Morgenstern-Price solution is its treatment of the horizontal shear force E and the vertical

shear force X acting between and across slices (see Figure 16).

Whitman and Bailey (1967) show that unless assumptions can be made, generalized solutions are statically indeterminate.

Morgenstern and Price (1965) overcome this problem by assuming that $\tan \alpha_i$, the tangent of the interslice angle, can be described as a function of X and E such that:

$$\tan \alpha_i = \frac{X_i}{E_i} = \lambda f(i)$$

where α_i is the angle of the line of thrust in segment i .

The unknown λ determines the magnitude of the function and although it is unknown, it is automatically determined as part of the solution.

The introduction of this assumption, which describes the way in which α_i varies within each failure segment, requires that judgement be exercised in selecting suitable functions on the basis of field conditions and experience, and that the computed values of X and E are realistic (for a more complete discussion of this problem see Whitman and Bailey, 1967).

Skempton and Hutchinson (1969) indicate that values of F obtained using different but reasonable assumptions concerning $f(i)$ are extremely similar and that analyses of circular shear surfaces using the Morgenstern and Price model produce close agreement with the results of analysis using the Bishop model.

APPENDIX V

COMPUTER PROGRAM FOR CONVERSION OF TENSIOMETER READINGS
TO PRESSURE HEADS

```

1.    DIMENSION TENS(50),BASE1(200),BASE2(200),COLM(200),SATP(200)
2.    DIMENSION TIMES(200),PINH20(200)
3.    C READ THE TIMES OF THE INDIVIDUAL READINGS
4.    READ(2,1) MHSUM1,MHSUM2,NLM,NUMT,HL1,HL2,N
5.    READ(3,10) (TIMES(J),J=1,NUMT)
6.    C READ IN THE ELEVATIONS OF THE INDIVIDUAL TENSIOEIEHS
7.    READ(5,2) (TENS(I),I=1,NUM)
8.    C READ IN THE TABLE OF SURFACE LEVEL CHANGE THROUGH TIME
9.    READ(5,3) (BASE1(I),I=1,NUMT)
10.   READ(5,3) (BASE2(I),I=1,NUMT)
11.   C LEVEL OF THE HG ON THE CHART
12.   C READ THE HEIGHT OF HG SURFACE, # OF TENSIOEIEHS, # UNIT INTERVALS THE INITIAL
13.   C FOR EACH TENSIOEIEH (I) CALCULATE THE PRESSURE FOR EACH TIME INTERVAL(J)
14.   C STEP 1 CALCULATE LENGTH OF COLUMN IN EACH TENSIOEIEH AT ZERO PRESSURE
15.   C FREE SURFACE LEVEL = ORIGINAL SURFACE LEVEL + THE CUMULATIVE INCREASE IN LEVEL
16.   C L TO THIS TIME
17.   C READ ALL THE COLUMN HEIGHTS FOR N TENSIOEIEHS
18.   DO 41 N=1,NUM
19.     WRITE(6,9) I
20.     WRITE(6,7)
21.     IF (I.GT.N) MHSUM = MHSUM2; ELSE BL2; GO TO 50
22.     MHSUM = MHSUM1; HL=BL1
23.     50 READ(3,6) (COLM(J),J=1,NUMT)
24.     49 DO JJ = 1,NUMT
25.       C CALCULATE THE FREE SURFACE HEIGHT FOR TIME (JJ)
26.       IF (I.GT.N) BASE = BASE2(JJ); GO TO 51
27.       BASE = BASE1(JJ)
28.       51 TSUR = MHSUM + BASE/10
29.       C CALCULATE ZERO PRESSURE FOR THIS TENSIOEIEH AT THIS TIME (JJ) IN CM ABOVE BASE
30.       SATP(JJ) = TSUR - TENS(I)
31.       C CONVERT THE HEIGHT OF THE DIFFERENCE BETWEEN SURFACE OF HG HEIGHT AND TENSIOEIEH
32.       CTER ELEVATION TO CM OF MERCURY
33.       SATP(JJ) = SATP(JJ)/1.3566
34.       C SATP NOW HOLDS THE HEIGHT OF THE COLUMN OF HG ABOVE THE FREE HG SURFACE
35.       C WHICH IS EQUAL TO ZERO PRESSURE
36.       C CALCULATE THE LENGTH OF HG COLS CRE ZERO PRESSURE
37.       C CALCULATE WHAT THIS MEANS IN TERMS OF A READING ON THE CHART BY ADDING
38.       C PRESENT FREE SURFACE READING ON THE CHART TO THE HEIGHT OF THE COLUMN ABOVE
39.       C THE FREE SURFACE AT ZERO PRESSURE
40.       THLEN = HL + BASE
41.       C CALCULATE THE LENGTH OF THE COL ABOVE THE FREE SURFACE FOR THE PRESENT READING
42.       THCOL = COLM(JJ) - TRUEB
43.       C SUBTRACT THE HG COL LENGTH FROM BASE HT AT ZERO PRESSURE TO GAVE LENGTH OF
44.       C COL ATTRIBUTABLE TO PRESSURE DIFFERENTIAL
45.       C IF COL LENGTH IS GREATER THAN BASE AT ZERO LENGTH PRESSURE IS NEGATIVE
46.       PINHG = SATP(JJ) - THCOL
47.       PINH20(JJ) = PINHG*1.3546
48.       5 CONTINUE
49.       C WRITE DATA FOR THIS TENSIOEIEH TO TAPE
50.       WRITE(3,11) (PINH20(J),J=1,NUMT)
51.       WRITE(6,8) (TIMES(J),PINH20(J),J=1,NUMT)
52.       6 CONTINUE
53.       1 FORMAT(2F5.1,12,13,2F3.1,12)
54.       2 FORMAT(20F4.0)
55.       3 FORMAT(80F1.0)
56.       4 FORMAT(4X,19F4.0)
57.       7 FORMAT(5X,'TIME',4X,'PRESSURE',4X,'TIME',4X,'PRESSURE',4X,'TIME',
58.       10X,'PRESSURE',4X,'TIME',4X,'PRESSURE',4X,'TIME',4X,'PRESSURE',4X,
59.       11TIME',4X,'PRESSURE')
60.       8 FORMAT(6(5X,F5.2,5X,F5.0))
61.       9 FORMAT(1H0,'PITZOMEIEH #',12)
62.       10 FORMAT(16F5.2)
63.       11 FORMAT(5X,19F5.0)
64.       END FILE 3
65.       REWIND 3
66.       STOP
67.       END

```


APPENDIX VI

Information Relating to Four Physical Simulations

PHYSICAL SIMULATION #1
Tensiometer Co-ordinates

Tensiometer #	X Co-ordinate	Y Co-ordinate	Tensiometer #	X Co-ordinate	Y Co-ordinate
1	420	17	26	256	49
2	420	13	27	256	42
3	410	22	28	256	36
4	410	17	29	256	31
5	410	13	30	256	26
6	370	22	31	218	60
7	370	17	32	218	55
8	370	13	33	218	50
9	353	22	34	218	45
10	353	17	35	218	40
11	353	13	36	200	67
12	328	25	37	200	62
13	328	22	38	200	57
14	328	17	39	200	52
15	328	13	40	200	47
16	308	33	41	200	80
17	308	28	42	163	75
18	308	22	43	163	70
19	308	17	44	163	65
20	308	13	45	163	60
21	288	35	46	116	97
22	288	30	47	116	92
23	288	25	48	116	87
24	288	20	49	116	82
25	288	15	50	116	77

RAINFALL FLUX - EXPERIMENT #1

Recorded flow US gal/min	Time (min)	Δt	Rainfall cm/hr	Corrected Rainfall cm/hr	Rainfall flux cm/sec
0.67	65	2.20-3.25	6.2076	5.5868	0.001552
0.5	40	3.25-4.05	4.6333	4.1700	0.00116
0.3	105	4.05-6.10	2.7800	2.5020	0.000695
0.1	20	6.10-6.30	0.9267	0.8340	0.000232
0.2	60	6.30-7.30	1.8534	1.6680	0.000463

EXPERIMENT 1

RUN #1

PIEZOMETER # 1

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-219.	.05	-217.	.10	-219.	.15	-219.	.20	-219.	.25	-219.
.30	-219.	.35	-219.	.40	-217.	.45	-215.	.50	-215.	.55	-209.
1.00	-205.	1.05	-202.	1.10	-197.	1.15	-193.	1.20	-189.	1.25	-185.
1.30	-182.	1.35	-178.	1.40	-174.	1.45	-168.	1.50	-164.	1.55	-160.
2.00	-156.	2.10	-155.	2.15	-153.	2.20	-151.	2.25	-149.	2.30	-148.
2.35	-145.	2.40	-143.	2.45	-140.	2.50	-140.	2.55	-140.	3.00	-140.
3.05	-140.	3.10	-137.	3.15	-136.	3.20	-132.	3.25	-129.	3.30	-126.
3.35	-124.	3.40	-122.	3.45	-121.	3.50	-118.	3.55	-115.	4.00	-114.
4.05	-113.	4.10	-110.	4.15	-109.	4.20	-107.	4.25	-106.	4.30	-103.
4.35	-102.	4.40	-101.	4.45	-99.	4.50	-96.	4.55	-95.	5.00	-94.
5.05	-90.	5.10	-90.	5.15	-87.	5.20	-86.	5.25	-84.	5.30	-80.
5.35	-79.	5.40	-75.	5.45	-72.	5.50	-69.				

PIEZOMETER # 2

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-243.	.05	-243.	.10	-243.	.15	-243.	.20	-243.	.25	-243.
.30	-243.	.35	-243.	.40	-242.	.45	-244.	.50	-243.	.55	-242.
1.00	-242.	1.05	-240.	1.10	-238.	1.15	-230.	1.20	-236.	1.25	-235.
1.30	-233.	1.35	-231.	1.40	-228.	1.45	-223.	1.50	-221.	1.55	-218.
2.00	-217.	2.10	-216.	2.15	-216.	2.20	-216.	2.25	-216.	2.30	-214.
2.35	-214.	2.40	-213.	2.45	-213.	2.50	-213.	2.55	-214.	3.00	-214.
3.05	-214.	3.10	-214.	3.15	-214.	3.20	-212.	3.25	-212.	3.30	-209.
3.35	-208.	3.40	-208.	3.45	-208.	3.50	-200.	3.55	-205.	4.00	-205.
4.05	-204.	4.10	-201.	4.15	-201.	4.20	-201.	4.25	-198.	4.30	-198.
4.35	-198.	4.40	-198.	4.45	-197.	4.50	-194.	4.55	-193.	5.00	-191.
5.05	-189.	5.10	-187.	5.15	-183.	5.20	-182.	5.25	-178.	5.30	-172.
5.35	-168.	5.40	-162.	5.45	-158.	5.50	-155.				

PIEZOMETER # 3

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-260.	.05	-260.	.10	-260.	.15	-262.	.20	-262.	.25	-262.
.30	-262.	.35	-263.	.40	-263.	.45	-262.	.50	-262.	.55	-262.
1.00	-262.	1.05	-263.	1.10	-261.	1.15	-261.	1.20	-261.	1.25	-261.
1.30	-260.	1.35	-258.	1.40	-257.	1.45	-252.	1.50	-243.	1.55	-214.
2.00	-204.	2.10	-195.	2.15	-187.	2.20	-179.	2.25	-171.	2.30	-149.
2.35	-150.	2.40	-145.	2.45	-142.	2.50	-138.	2.55	-134.	3.00	-131.
3.05	-129.	3.10	-123.	3.15	-120.	3.20	-115.	3.25	-112.	3.30	-107.
3.35	-104.	3.40	-101.	3.45	-99.	3.50	-93.	3.55	-88.	4.00	-85.
4.05	-81.	4.10	-77.	4.15	-74.	4.20	-72.	4.25	-68.	4.30	-65.
4.35	-61.	4.40	-57.	4.45	-54.	4.50	-51.	4.55	-48.	5.00	-47.
5.05	-35.	5.10	-34.	5.15	-30.	5.20	-28.	5.25	-26.	5.30	-23.
5.35	-22.	5.40	-19.	5.45	-19.	5.50	-17.				

PIEZOMETER # 4

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-255.	.05	-255.	.10	-255.	.15	-257.	.20	-257.	.25	-257.
.30	-257.	.35	-258.	.40	-257.	.45	-257.	.50	-257.	.55	-257.
1.00	-257.	1.05	-258.	1.10	-256.	1.15	-256.	1.20	-256.	1.25	-250.
1.30	-246.	1.35	-240.	1.40	-237.	1.45	-237.	1.50	-217.	1.55	-208.
2.00	-199.	2.10	-191.	2.15	-182.	2.20	-168.	2.25	-156.	2.30	-144.
2.35	-125.	2.40	-115.	2.45	-111.	2.50	-106.	2.55	-101.	3.00	-92.
3.05	-83.	3.10	-79.	3.15	-75.	3.20	-69.	3.25	-67.	3.30	-61.
3.35	-59.	3.40	-57.	3.45	-54.	3.50	-53.	3.55	-49.	4.00	-44.
4.05	-46.	4.10	-46.	4.15	-45.	4.20	-45.	4.25	-44.	4.30	-42.
4.35	-41.	4.40	-40.	4.45	-38.	4.50	-36.	4.55	-38.	5.00	-34.
5.05	-29.	5.10	-27.	5.15	-25.	5.20	-23.	5.25	-21.	5.30	-18.
5.35	-18.	5.40	-17.	5.45	-15.	5.50	-14.				

PIEZOMETER # 5

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-243.	.05	-243.	.10	-243.	.15	-244.	.20	-244.	.25	-244.
.30	-244.	.35	-246.	.40	-244.	.45	-244.	.50	-244.	.55	-243.
1.00	-244.	1.05	-246.	1.10	-244.	1.15	-244.	1.20	-244.	1.25	-244.
1.30	-244.	1.35	-244.	1.40	-240.	1.45	-241.	1.50	-216.	1.55	-218.
2.00	-204.	2.10	-194.	2.15	-187.	2.20	-181.	2.25	-176.	2.30	-171.
2.35	-160.	2.40	-156.	2.45	-149.	2.50	-143.	2.55	-134.	3.00	-126.
3.05	-116.	3.10	-109.	3.15	-105.	3.20	-99.	3.25	-94.	3.30	-88.
3.35	-84.	3.40	-82.	3.45	-78.	3.50	-74.	3.55	-68.	4.00	-67.
4.05	-64.	4.10	-61.	4.15	-59.	4.20	-56.	4.25	-55.	4.30	-52.
4.35	-50.	4.40	-49.	4.45	-48.	4.50	-44.	4.55	-41.	5.00	-37.
5.05	-32.	5.10	-29.	5.15	-25.	5.20	-21.	5.25	-19.	5.30	-15.
5.35	-14.	5.40	-13.	5.45	-11.	5.50	-10.				

PIEZOMETER # 6

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-232.	.05	-239.	.10	-232.	.15	-232.	.20	-233.	.25	-233.
.30	-233.	.35	-233.	.40	-232.	.45	-233.	.50	-233.	.55	-232.
1.00	-232.	1.05	-232.	1.10	-230.	1.15	-230.	1.20	-230.	1.25	-230.
1.30	-230.	1.35	-230.	1.40	-232.	1.45	-229.	1.50	-229.	1.55	-229.
2.00	-229.	2.10	-230.	2.15	-230.	2.20	-230.	2.25	-230.	2.30	-230.
2.35	-230.	2.40	-230.	2.45	-230.	2.50	-230.	2.55	-230.	3.00	-230.
3.05	-230.	3.10	-230.	3.15	-230.	3.20	-229.	3.25	-229.	3.30	-229.
3.35	-229.	3.40	-229.	3.45	-229.	3.50	-229.	3.55	-227.	4.00	-227.
4.05	-227.	4.10	-227.	4.15	-227.	4.20	-227.	4.25	-227.	4.30	-227.
4.35	-227.	4.40	-227.	4.45	-227.	4.50	-227.	4.55	-225.	5.00	-223.
5.05	-219.	5.10	-217.	5.15	-213.	5.20	-207.	5.25	-202.	5.30	-192.
5.35	-184.	5.40	-172.	5.45	-161.	5.50	-144.				

PIEZOMETEN # 7

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-234.	.05	-234.	.10	-234.	.15	-234.	.20	-234.	.25	-234.
.30	-234.	.35	-235.	.40	-235.	.45	-235.	.50	-235.	.55	-235.
1.00	-232.	1.05	-232.	1.10	-231.	1.15	-231.	1.20	-231.	1.25	-231.
1.30	-231.	1.35	-231.	1.40	-231.	1.45	-231.	1.50	-229.	1.55	-229.
2.00	-229.	2.10	-229.	2.15	-229.	2.20	-231.	2.25	-231.	2.30	-231.
2.35	-231.	2.40	-231.	2.45	-231.	2.50	-232.	2.55	-232.	3.00	-232.
3.05	-232.	3.10	-232.	3.15	-232.	3.20	-231.	3.25	-231.	3.30	-229.
3.35	-229.	3.40	-229.	3.45	-229.	3.50	-227.	3.55	-225.	4.00	-225.
4.05	-224.	4.10	-222.	4.15	-222.	4.20	-221.	4.25	-221.	4.30	-220.
4.35	-218.	4.40	-216.	4.45	-212.	4.50	-209.	4.55	-205.	5.00	-199.
5.05	-191.	5.10	-186.	5.15	-179.	5.20	-168.	5.25	-159.	5.30	-143.
5.35	-138.	5.40	-117.	5.45	-102.	5.50	-88.				

PIEZOMETEN # 8

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-232.	.05	-232.	.10	-232.	.15	-232.	.20	-232.	.25	-232.
.30	-234.	.35	-234.	.40	-234.	.45	-234.	.50	-234.	.55	-232.
1.00	-232.	1.05	-232.	1.10	-231.	1.15	-231.	1.20	-231.	1.25	-231.
1.30	-231.	1.35	-231.	1.40	-231.	1.45	-229.	1.50	-229.	1.55	-229.
2.00	-229.	2.10	-229.	2.15	-229.	2.20	-229.	2.25	-229.	2.30	-229.
2.35	-229.	2.40	-229.	2.45	-229.	2.50	-229.	2.55	-229.	3.00	-229.
3.05	-229.	3.10	-229.	3.15	-229.	3.20	-216.	3.25	-214.	3.30	-209.
3.35	-204.	3.40	-199.	3.45	-193.	3.50	-188.	3.55	-174.	4.00	-167.
4.05	-157.	4.10	-143.	4.15	-117.	4.20	-214.	4.25	-32.	4.30	-38.
4.35	-25.	4.40	-17.	4.45	-15.	4.50	-11.	4.55	-11.	5.00	-8.
5.05	-7.	5.10	-6.	5.15	-3.	5.20	-137.	5.25	-2.	5.30	-0.
5.35	-0.	5.40	1.	5.45	1.	5.50	1.				

PIEZOMETEN # 9

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-212.	.05	-212.	.10	-212.	.15	-212.	.20	-212.	.25	-213.
.30	-213.	.35	-213.	.40	-213.	.45	-213.	.50	-213.	.55	-211.
1.00	-211.	1.05	-211.	1.10	-210.	1.15	-210.	1.20	-210.	1.25	-210.
1.30	-211.	1.35	-211.	1.40	-211.	1.45	-208.	1.50	-208.	1.55	-210.
2.00	-210.	2.10	-210.	2.15	-210.	2.20	-210.	2.25	-210.	2.30	-211.
2.35	-210.	2.40	-210.	2.45	-210.	2.50	-210.	2.55	-210.	3.00	-210.
3.05	-210.	3.10	-210.	3.15	-210.	3.20	-208.	3.25	-208.	3.30	-208.
3.35	-208.	3.40	-208.	3.45	-208.	3.50	-208.	3.55	-207.	4.00	-207.
4.05	-206.	4.10	-204.	4.15	-203.	4.20	-202.	4.25	-200.	4.30	-196.
4.35	-192.	4.40	-181.	4.45	-176.	4.50	-168.	4.55	-160.	5.00	-145.
5.05	-125.	5.10	-114.	5.15	-103.	5.20	-88.	5.25	-74.	5.30	-59.
5.35	-46.	5.40	-32.	5.45	-22.	5.50	-12.				

PIEZOMETEN #10

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-224.	.05	-224.	.10	-224.	.15	-225.	.20	-225.	.25	-225.
.30	-225.	.35	-225.	.40	-224.	.45	-224.	.50	-224.	.55	-223.
1.00	-221.	1.05	-220.	1.10	-217.	1.15	-210.	1.20	-213.	1.25	-210.
1.30	-206.	1.35	-204.	1.40	-201.	1.45	-195.	1.50	-191.	1.55	-182.
2.00	-176.	2.10	-171.	2.15	-164.	2.20	-157.	2.25	-151.	2.30	-143.
2.35	-132.	2.40	-120.	2.45	-110.	2.50	-115.	2.55	-110.	3.00	-106.
3.05	-103.	3.10	-99.	3.15	-96.	3.20	-92.	3.25	-88.	3.30	-84.
3.35	-80.	3.40	-78.	3.45	-71.	3.50	-64.	3.55	-58.	4.00	-49.
4.05	-48.	4.10	-38.	4.15	-33.	4.20	-27.	4.25	-22.	4.30	-18.
4.35	-12.	4.40	-10.	4.45	-10.	4.50	-8.	4.55	-8.	5.00	-7.
5.05	-6.	5.10	-4.	5.15	-2.	5.20	-2.	5.25	-0.	5.30	-0.
5.35	-0.	5.40	-0.	5.45	-1.	5.50	1.				

PIEZOMETEN #11

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-213.	.05	-213.	.10	-213.	.15	-213.	.20	-213.	.25	-215.
.30	-215.	.35	-216.	.40	-215.	.45	-215.	.50	-216.	.55	-215.
1.00	-215.	1.05	-216.	1.10	-214.	1.15	-214.	1.20	-214.	1.25	-214.
1.30	-214.	1.35	-214.	1.40	-214.	1.45	-212.	1.50	-209.	1.55	-208.
2.00	-205.	2.10	-202.	2.15	-199.	2.20	-198.	2.25	-195.	2.30	-194.
2.35	-190.	2.40	-186.	2.45	-183.	2.50	-181.	2.55	-179.	3.00	-177.
3.05	-176.	3.10	-172.	3.15	-170.	3.20	-167.	3.25	-163.	3.30	-159.
3.35	-155.	3.40	-152.	3.45	-149.	3.50	-145.	3.55	-139.	4.00	-133.
4.05	-129.	4.10	-124.	4.15	-116.	4.20	-102.	4.25	-92.	4.30	-82.
4.35	-19.	4.40	-3.	4.45	-2.	4.50	-0.	4.55	1.	5.00	2.
5.05	2.	5.10	4.	5.15	5.	5.20	6.	5.25	6.	5.30	6.
5.35	6.	5.40	8.	5.45	8.	5.50	8.				

PIEZOMETEN #12

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-216.	.05	-216.	.10	-216.	.15	-216.	.20	-216.	.25	-216.
.30	-217.	.35	-216.	.40	-213.	.45	-208.	.50	-198.	.55	-187.
1.00	-167.	1.05	-152.	1.10	-149.	1.15	-118.	1.20	-98.	1.25	-98.
1.30	-86.	1.35	-80.	1.40	-72.	1.45	-64.	1.50	-60.	1.55	-56.
2.00	-56.	2.10	-54.	2.15	-52.	2.20	-50.	2.25	-50.	2.30	-50.
2.35	-44.	2.40	-49.	2.45	-49.	2.50	-49.	2.55	-49.	3.00	-49.
3.05	-49.	3.10	-46.	3.15	-46.	3.20	-44.	3.25	-43.	3.30	-33.
3.35	-27.	3.40	-22.	3.45	-20.	3.50	-16.	3.55	-12.	4.00	-10.
4.05	-8.	4.10	-7.	4.15	-3.	4.20	-3.	4.25	-0.	4.30	3.
4.35	4.	4.40	4.	4.45	4.	4.50	4.	4.55	4.	5.00	4.
5.05	4.	5.10	4.	5.15	5.	5.20	5.	5.25	5.	5.30	5.
5.35	5.	5.40	5.	5.45	5.	5.50	5.				

PIEZOMETER #13

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-203.	.05	-203.	.10	-203.	.15	-203.	.20	-203.	.25	-203.
.30	-205.	.35	-205.	.40	-203.	.45	-203.	.50	-198.	.55	-194.
1.00	-187.	1.05	-182.	1.10	-174.	1.15	-167.	1.20	-158.	1.25	-148.
1.30	-144.	1.35	-137.	1.40	-134.	1.45	-125.	1.50	-119.	1.55	-114.
2.00	-110.	2.10	-100.	2.15	-100.	2.20	-96.	2.25	-93.	2.30	-91.
2.35	-87.	2.40	-83.	2.45	-80.	2.50	-77.	2.55	-74.	3.00	-73.
3.05	-72.	3.10	-70.	3.15	-68.	3.20	-62.	3.25	-60.	3.30	-55.
3.35	-38.	3.40	-31.	3.45	-24.	3.50	-19.	3.55	-13.	4.00	-11.
4.05	-8.	4.10	-5.	4.15	-3.	4.20	0.	4.25	1.	4.30	3.
4.35	3.	4.40	3.	4.45	4.	4.50	4.	4.55	4.	5.00	4.
5.05	4.	5.10	4.	5.15	6.	5.20	6.	5.25	6.	5.30	6.
5.35	7.	5.40	7.	5.45	7.	5.50	8.				

PIEZOMETER #14

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-183.	.05	-183.	.10	-183.	.15	-183.	.20	-183.	.25	-183.
.30	-185.	.35	-185.	.40	-185.	.45	-185.	.50	-185.	.55	-183.
1.00	-183.	1.05	-183.	1.10	-182.	1.15	-182.	1.20	-182.	1.25	-182.
1.30	-178.	1.35	-174.	1.40	-170.	1.45	-165.	1.50	-159.	1.55	-156.
2.00	-151.	2.10	-147.	2.15	-144.	2.20	-138.	2.25	-134.	2.30	-130.
2.35	-126.	2.40	-121.	2.45	-117.	2.50	-114.	2.55	-110.	3.00	-103.
3.05	-102.	3.10	-95.	3.15	-88.	3.20	-79.	3.25	-69.	3.30	-59.
3.35	-48.	3.40	-41.	3.45	-36.	3.50	-30.	3.55	-23.	4.00	-19.
4.05	-15.	4.10	-12.	4.15	-8.	4.20	-6.	4.25	-3.	4.30	0.
4.35	1.	4.40	4.	4.45	5.	4.50	6.	4.55	6.	5.00	8.
5.05	9.	5.10	9.	5.15	11.	5.20	11.	5.25	11.	5.30	11.
5.35	12.	5.40	12.	5.45	12.	5.50	13.				

PIEZOMETER #15

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-162.	.05	-162.	.10	-163.	.15	-165.	.20	-165.	.25	-165.
.30	-165.	.35	-165.	.40	-163.	.45	-163.	.50	-163.	.55	-162.
1.00	-162.	1.05	-162.	1.10	-160.	1.15	-160.	1.20	-160.	1.25	-160.
1.30	-158.	1.35	-158.	1.40	-156.	1.45	-151.	1.50	-148.	1.55	-141.
2.00	-132.	2.10	-124.	2.15	-113.	2.20	-103.	2.25	-91.	2.30	-80.
2.35	-72.	2.40	-65.	2.45	-57.	2.50	-53.	2.55	-52.	3.00	-45.
3.05	-36.	3.10	-36.	3.15	-30.	3.20	-23.	3.25	-18.	3.30	-13.
3.35	-10.	3.40	-7.	3.45	-4.	3.50	-3.	3.55	1.	4.00	2.
4.05	4.	4.10	5.	4.15	6.	4.20	8.	4.25	9.	4.30	10.
4.35	12.	4.40	12.	4.45	12.	4.50	12.	4.55	12.	5.00	12.
5.05	12.	5.10	12.	5.15	15.	5.20	13.	5.25	13.	5.30	13.
5.35	13.	5.40	13.	5.45	13.	5.50	15.				

PIEZOMETER #16

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-208.	.05	-208.	.10	-209.	.15	-208.	.20	-208.	.25	-208.
.30	-209.	.35	-209.	.40	-209.	.45	-209.	.50	-209.	.55	-208.
1.00	-205.	1.05	-196.	1.10	-190.	1.15	-184.	1.20	-179.	1.25	-174.
1.30	-165.	1.35	-154.	1.40	-153.	1.45	-144.	1.50	-138.	1.55	-134.
2.00	-127.	2.10	-121.	2.15	-115.	2.20	-108.	2.25	-104.	2.30	-99.
2.35	-95.	2.40	-91.	2.45	-84.	2.50	-79.	2.55	-75.	3.00	-70.
3.05	-68.	3.10	-61.	3.15	-54.	3.20	-45.	3.25	-35.	3.30	-27.
3.35	-23.	3.40	-20.	3.45	-19.	3.50	-10.	3.55	-12.	4.00	-11.
4.05	-10.	4.10	-8.	4.15	-5.	4.20	-4.	4.25	-3.	4.30	1.
4.35	0.	4.40	0.	4.45	0.	4.50	0.	4.55	0.	5.00	0.
5.05	0.	5.10	0.	5.15	1.	5.20	1.	5.25	1.	5.30	1.
5.35	1.	5.40	1.	5.45	1.	5.50	1.				

PIEZOMETER #17

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-189.	.05	-188.	.10	-189.	.15	-189.	.20	-189.	.25	-189.
.30	-190.	.35	-190.	.40	-189.	.45	-189.	.50	-189.	.55	-188.
1.00	-188.	1.05	-188.	1.10	-186.	1.15	-186.	1.20	-185.	1.25	-185.
1.30	-185.	1.35	-183.	1.40	-183.	1.45	-181.	1.50	-181.	1.55	-181.
2.00	-181.	2.10	-177.	2.15	-174.	2.20	-172.	2.25	-172.	2.30	-170.
2.35	-168.	2.40	-167.	2.45	-164.	2.50	-162.	2.55	-160.	3.00	-155.
3.05	-148.	3.10	-136.	3.15	-120.	3.20	-101.	3.25	-90.	3.30	-82.
3.35	-21.	3.40	-15.	3.45	-11.	3.50	-10.	3.55	-6.	4.00	-6.
4.05	-5.	4.10	-3.	4.15	0.	4.20	1.	4.25	1.	4.30	2.
4.35	4.	4.40	4.	4.45	4.	4.50	4.	4.55	4.	5.00	4.
5.05	4.	5.10	4.	5.15	5.	5.20	5.	5.25	5.	5.30	5.
5.35	5.	5.40	5.	5.45	5.	5.50	5.				

PIEZOMETER #18

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-170.	.05	-170.	.10	-171.	.15	-170.	.20	-170.	.25	-171.
.30	-171.	.35	-171.	.40	-169.	.45	-169.	.50	-169.	.55	-168.
1.00	-168.	1.05	-168.	1.10	-167.	1.15	-167.	1.20	-163.	1.25	-160.
1.30	-154.	1.35	-145.	1.40	-131.	1.45	-120.	1.50	-103.	1.55	-91.
2.00	-88.	2.10	-69.	2.15	-61.	2.20	-58.	2.25	-54.	2.30	-50.
2.35	-45.	2.40	-42.	2.45	-41.	2.50	-38.	2.55	-36.	3.00	-28.
3.05	-26.	3.10	-22.	3.15	-16.	3.20	-12.	3.25	-9.	3.30	-5.
3.35	-5.	3.40	-3.	3.45	1.	3.50	3.	3.55	4.	4.00	6.
4.05	7.	4.10	7.	4.15	10.	4.20	10.	4.25	11.	4.30	11.
4.35	11.	4.40	11.	4.45	11.	4.50	11.	4.55	11.	5.00	11.
5.05	11.	5.10	11.	5.15	12.	5.20	14.	5.25	14.	5.30	14.
5.35	14.	5.40	14.	5.45	14.	5.50	14.				

PIEZOMETR #19

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-148.	.05	-148.	.10	-148.	.15	-150.	.20	-150.	.25	-150.
.30	-150.	.35	-150.	.40	-150.	.45	-150.	.50	-150.	.55	-148.
1.00	-148.	1.05	-148.	1.10	-147.	1.15	-147.	1.20	-147.	1.25	-147.
1.30	-144.	1.35	-141.	1.40	-141.	1.45	-134.	1.50	-129.	1.55	-141.
2.00	-91.	2.10	-56.	2.15	-50.	2.20	-45.	2.25	-41.	2.30	-33.
2.35	-29.	2.40	-26.	2.45	-25.	2.50	-23.	2.55	-21.	3.00	-18.
3.05	-15.	3.10	-11.	3.15	-7.	3.20	-2.	3.25	-0.	3.30	4.
3.35	5.	3.40	6.	3.45	6.	3.50	9.	3.55	12.	4.00	12.
4.05	13.	4.10	15.	4.15	15.	4.20	17.	4.25	17.	4.30	17.
4.35	19.	4.40	19.	4.45	19.	4.50	19.	4.55	19.	5.00	19.
5.05	19.	5.10	19.	5.15	20.	5.20	20.	5.25	20.	5.30	20.
5.35	20.	5.40	20.	5.45	20.	5.50	20.				

PIEZOMETR #20

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-148.	.05	-144.	.10	-144.	.15	-140.	.20	-140.	.25	-140.
.30	-146.	.35	-147.	.40	-147.	.45	-147.	.50	-147.	.55	-146.
1.00	-146.	1.05	-146.	1.10	-144.	1.15	-144.	1.20	-144.	1.25	-144.
1.30	-144.	1.35	-144.	1.40	-144.	1.45	-141.	1.50	-141.	1.55	-141.
2.00	-137.	2.10	-130.	2.15	-122.	2.20	-106.	2.25	-82.	2.30	-60.
2.35	-46.	2.40	-34.	2.45	-26.	2.50	-22.	2.55	-17.	3.00	-11.
3.05	-7.	3.10	-4.	3.15	1.	3.20	4.	3.25	5.	3.30	10.
3.35	12.	3.40	12.	3.45	15.	3.50	10.	3.55	17.	4.00	14.
4.05	19.	4.10	20.	4.15	20.	4.20	23.	4.25	23.	4.30	24.
4.35	25.	4.40	25.	4.45	25.	4.50	25.	4.55	25.	5.00	25.
5.05	25.	5.10	25.	5.15	27.	5.20	25.	5.25	25.	5.30	25.
5.35	25.	5.40	25.	5.45	25.	5.50	25.				

PIEZOMETR #21

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-204.	.05	-204.	.10	-204.	.15	-203.	.20	-191.	.25	-184.
.30	-122.	.35	-77.	.40	-46.	.45	-32.	.50	-28.	.55	-25.
1.00	-25.	1.05	-24.	1.10	-22.	1.15	-22.	1.20	-21.	1.25	-21.
1.30	-21.	1.35	-21.	1.40	-20.	1.45	-17.	1.50	-17.	1.55	-17.
2.00	-16.	2.10	-16.	2.15	-16.	2.20	-17.	2.25	-17.	2.30	-17.
2.35	-17.	2.40	-17.	2.45	-17.	2.50	-17.	2.55	-16.	3.00	-16.
3.05	-14.	3.10	-13.	3.15	-10.	3.20	-7.	3.25	-6.	3.30	-5.
3.35	-3.	3.40	-2.	3.45	-1.	3.50	2.	3.55	3.	4.00	3.
4.05	5.	4.10	6.	4.15	6.	4.20	6.	4.25	8.	4.30	7.
4.35	7.	4.40	7.	4.45	7.	4.50	6.	4.55	5.	5.00	5.
5.05	6.	5.10	6.	5.15	7.	5.20	7.	5.25	7.	5.30	7.
5.35	7.	5.40	7.	5.45	7.	5.50	7.				

PIEZOMETR #22

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-157.	.05	-157.	.10	-159.	.15	-154.	.20	-159.	.25	-154.
.30	-159.	.35	-159.	.40	-157.	.45	-157.	.50	-153.	.55	-148.
1.00	-111.	1.05	-88.	1.10	-64.	1.15	-55.	1.20	-49.	1.25	-43.
1.30	-39.	1.35	-38.	1.40	-36.	1.45	-32.	1.50	-30.	1.55	-30.
2.00	-28.	2.10	-27.	2.15	-25.	2.20	-25.	2.25	-24.	2.30	-23.
2.35	-20.	2.40	-19.	2.45	-16.	2.50	-16.	2.55	-15.	3.00	-12.
3.05	-9.	3.10	-7.	3.15	-4.	3.20	-1.	3.25	0.	3.30	2.
3.35	2.	3.40	3.	3.45	4.	3.50	6.	3.55	7.	4.00	8.
4.05	8.	4.10	8.	4.15	10.	4.20	10.	4.25	10.	4.30	10.
4.35	10.	4.40	10.	4.45	10.	4.50	10.	4.55	10.	5.00	10.
5.05	10.	5.10	10.	5.15	11.	5.20	11.	5.25	11.	5.30	11.
5.35	11.	5.40	11.	5.45	11.	5.50	11.				

PIEZOMETR #23

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-156.	.05	-156.	.10	-158.	.15	-158.	.20	-158.	.25	-158.
.30	-156.	.35	-159.	.40	-158.	.45	-158.	.50	-158.	.55	-158.
1.00	-156.	1.05	-151.	1.10	-141.	1.15	-120.	1.20	-107.	1.25	-96.
1.30	-72.	1.35	-64.	1.40	-54.	1.45	-44.	1.50	-46.	1.55	-45.
2.00	-42.	2.10	-37.	2.15	-35.	2.20	-33.	2.25	-31.	2.30	-31.
2.35	-27.	2.40	-25.	2.45	-22.	2.50	-19.	2.55	-15.	3.00	-11.
3.05	-7.	3.10	-4.	3.15	-2.	3.20	1.	3.25	1.	3.30	4.
3.35	4.	3.40	5.	3.45	7.	3.50	9.	3.55	11.	4.00	12.
4.05	12.	4.10	13.	4.15	15.	4.20	15.	4.25	15.	4.30	15.
4.35	15.	4.40	15.	4.45	15.	4.50	15.	4.55	15.	5.00	15.
5.05	15.	5.10	15.	5.15	16.	5.20	16.	5.25	16.	5.30	16.
5.35	16.	5.40	16.	5.45	16.	5.50	16.				

PIEZOMETR #24

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-149.	.05	-149.	.10	-149.	.15	-149.	.20	-150.	.25	-150.
.30	-150.	.35	-150.	.40	-148.	.45	-148.	.50	-148.	.55	-147.
1.00	-147.	1.05	-147.	1.10	-146.	1.15	-146.	1.20	-146.	1.25	-143.
1.30	-106.	1.35	-79.	1.40	-63.	1.45	-47.	1.50	-43.	1.55	-40.
2.00	-37.	2.10	-34.	2.15	-32.	2.20	-29.	2.25	-26.	2.30	-24.
2.35	-20.	2.40	-17.	2.45	-13.	2.50	-9.	2.55	-5.	3.00	1.
3.05	3.	3.10	9.	3.15	10.	3.20	12.	3.25	12.	3.30	14.
3.35	14.	3.40	14.	3.45	16.	3.50	17.	3.55	19.	4.00	20.
4.05	20.	4.10	21.	4.15	21.	4.20	21.	4.25	22.	4.30	22.
4.35	22.	4.40	22.	4.45	22.	4.50	22.	4.55	22.	5.00	22.
5.05	22.	5.10	22.	5.15	24.	5.20	24.	5.25	24.	5.30	24.
5.35	24.	5.40	24.	5.45	24.	5.50	24.				

PIEZOMETER #25

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-135.	.05	-137.	.10	-135.	.15	-135.	.20	-135.	.25	-135.
.30	-135.	.35	-137.	.40	-135.	.45	-135.	.50	-135.	.55	-134.
1.00	-135.	1.05	-135.	1.10	-134.	1.15	-134.	1.20	-134.	1.25	-134.
1.30	-130.	1.35	-130.	1.40	-130.	1.45	-127.	1.50	-124.	1.55	-123.
2.00	-115.	2.10	-99.	2.15	-81.	2.20	-67.	2.25	-47.	2.30	-35.
2.35	-8.	2.40	-15.	2.45	-10.	2.50	-6.	2.55	-1.	3.00	3.
3.05	7.	3.10	11.	3.15	13.	3.20	15.	3.25	17.	3.30	17.
3.35	10.	3.40	18.	3.45	21.	3.50	21.	3.55	23.	4.00	23.
4.05	25.	4.10	25.	4.15	25.	4.20	25.	4.25	26.	4.30	26.
4.35	26.	4.40	26.	4.45	26.	4.50	26.	4.55	26.	5.00	27.
5.05	27.	5.10	27.	5.15	29.	5.20	27.	5.25	27.	5.30	27.
5.35	27.	5.40	27.	5.45	27.	5.50	27.				

PIEZOMETER #26

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-173.	.05	-107.	.10	-107.	.15	-173.	.20	-105.	.25	-100.
.30	-152.	.35	-142.	.40	-129.	.45	-116.	.50	-104.	.55	-93.
1.00	-81.	1.05	-73.	1.10	-54.	1.15	-51.	1.20	-49.	1.25	-45.
1.30	-39.	1.35	-38.	1.40	-35.	1.45	-27.	1.50	-24.	1.55	-24.
2.00	-21.	2.10	-20.	2.15	-19.	2.20	-19.	2.25	-17.	2.30	-16.
2.35	-15.	2.40	-16.	2.45	-13.	2.50	-13.	2.55	-12.	3.00	-8.
3.05	-7.	3.10	-1.	3.15	2.	3.20	4.	3.25	6.	3.30	7.
3.35	8.	3.40	8.	3.45	10.	3.50	10.	3.55	11.	4.00	11.
4.05	12.	4.10	14.	4.15	14.	4.20	14.	4.25	14.	4.30	14.
4.35	14.	4.40	14.	4.45	11.	4.50	10.	4.55	11.	5.00	10.
5.05	10.	5.10	10.	5.15	11.	5.20	11.	5.25	11.	5.30	11.
5.35	11.	5.40	11.	5.45	11.	5.50	11.				

PIEZOMETER #27

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-149.	.05	-149.	.10	-149.	.15	-149.	.20	-149.	.25	-149.
.30	-149.	.35	-149.	.40	-146.	.45	-139.	.50	-127.	.55	-116.
1.00	-103.	1.05	-93.	1.10	-74.	1.15	-74.	1.20	-66.	1.25	-61.
1.30	-52.	1.35	-50.	1.40	-40.	1.45	-39.	1.50	-33.	1.55	-32.
2.00	-28.	2.10	-25.	2.15	-23.	2.20	-20.	2.25	-20.	2.30	-17.
2.35	-16.	2.40	-12.	2.45	-12.	2.50	-12.	2.55	-9.	3.00	-4.
3.05	-1.	3.10	4.	3.15	9.	3.20	10.	3.25	13.	3.30	14.
3.35	14.	3.40	14.	3.45	15.	3.50	15.	3.55	18.	4.00	18.
4.05	19.	4.10	19.	4.15	21.	4.20	21.	4.25	21.	4.30	21.
4.35	21.	4.40	21.	4.45	19.	4.50	18.	4.55	19.	5.00	18.
5.05	17.	5.10	18.	5.15	19.	5.20	18.	5.25	18.	5.30	18.
5.35	18.	5.40	18.	5.45	18.	5.50	18.				

PIEZOMETER #28

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-129.	.05	-129.	.10	-129.	.15	-129.	.20	-129.	.25	-129.
.30	-129.	.35	-129.	.40	-128.	.45	-128.	.50	-128.	.55	-127.
1.00	-127.	1.05	-127.	1.10	-125.	1.15	-125.	1.20	-124.	1.25	-120.
1.30	-110.	1.35	-99.	1.40	-80.	1.45	-65.	1.50	-53.	1.55	-44.
2.00	-36.	2.10	-30.	2.15	-26.	2.20	-22.	2.25	-19.	2.30	-18.
2.35	-15.	2.40	-13.	2.45	-6.	2.50	-2.	2.55	4.	3.00	8.
3.05	10.	3.10	15.	3.15	15.	3.20	19.	3.25	20.	3.30	20.
3.35	21.	3.40	21.	3.45	23.	3.50	23.	3.55	25.	4.00	25.
4.05	27.	4.10	27.	4.15	27.	4.20	28.	4.25	28.	4.30	28.
4.35	28.	4.40	27.	4.45	27.	4.50	25.	4.55	25.	5.00	25.
5.05	27.	5.10	25.	5.15	27.	5.20	27.	5.25	27.	5.30	27.
5.35	27.	5.40	28.	5.45	27.	5.50	27.				

PIEZOMETER #29

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-128.	.05	-128.	.10	-130.	.15	-128.	.20	-124.	.25	-124.
.30	-124.	.35	-122.	.40	-123.	.45	-123.	.50	-123.	.55	-122.
1.00	-122.	1.05	-122.	1.10	-120.	1.15	-120.	1.20	-123.	1.25	-121.
1.30	-121.	1.35	-121.	1.40	-121.	1.45	-119.	1.50	-115.	1.55	-110.
2.00	-102.	2.10	-93.	2.15	-78.	2.20	-60.	2.25	-48.	2.30	-40.
2.35	-31.	2.40	-22.	2.45	-6.	2.50	5.	2.55	11.	3.00	15.
3.05	17.	3.10	21.	3.15	21.	3.20	24.	3.25	25.	3.30	25.
3.35	25.	3.40	26.	3.45	26.	3.50	26.	3.55	29.	4.00	29.
4.05	30.	4.10	30.	4.15	32.	4.20	32.	4.25	32.	4.30	32.
4.35	32.	4.40	32.	4.45	30.	4.50	30.	4.55	30.	5.00	29.
5.05	30.	5.10	30.	5.15	32.	5.20	32.	5.25	32.	5.30	32.
5.35	32.	5.40	32.	5.45	32.	5.50	32.				

PIEZOMETER #30

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-122.	.05	-122.	.10	-122.	.15	-123.	.20	-117.	.25	-117.
.30	-117.	.35	-117.	.40	-115.	.45	-115.	.50	-115.	.55	-114.
1.00	-114.	1.05	-114.	1.10	-112.	1.15	-112.	1.20	-115.	1.25	-115.
1.30	-114.	1.35	-114.	1.40	-114.	1.45	-111.	1.50	-111.	1.55	-111.
2.00	-111.	2.10	-108.	2.15	-103.	2.20	-98.	2.25	-78.	2.30	-62.
2.35	-43.	2.40	-28.	2.45	-7.	2.50	4.	2.55	14.	3.00	18.
3.05	20.	3.10	25.	3.15	26.	3.20	29.	3.25	30.	3.30	31.
3.35	31.	3.40	31.	3.45	31.	3.50	33.	3.55	35.	4.00	37.
4.05	37.	4.10	38.	4.15	38.	4.20	38.	4.25	38.	4.30	38.
4.35	38.	4.40	37.	4.45	37.	4.50	35.	4.55	35.	5.00	34.
5.05	35.	5.10	35.	5.15	37.	5.20	37.	5.25	37.	5.30	37.
5.35	37.	5.40	37.	5.45	37.	5.50	37.				

PIEZOMETEN #31

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-101.	.05	-101.	.10	-101.	.15	-101.	.20	-101.	.25	-101.
.30	-101.	.35	-101.	.40	-101.	.45	-101.	.50	-101.	.55	-101.
1.00	-152.	1.05	-150.	1.10	-143.	1.15	-141.	1.20	-136.	1.25	-131.
1.30	-131.	1.35	-124.	1.40	-120.	1.45	-113.	1.50	-109.	1.55	-102.
2.00	-97.	2.10	-93.	2.15	-87.	2.20	-84.	2.25	-79.	2.30	-72.
2.35	-67.	2.40	-60.	2.45	-53.	2.50	-46.	2.55	-38.	3.00	-32.
3.05	-28.	3.10	-22.	3.15	-18.	3.20	-15.	3.25	-14.	3.30	-13.
3.35	-11.	3.40	-11.	3.45	-10.	3.50	-9.	3.55	-7.	4.00	-7.
4.05	-7.	4.10	-7.	4.15	-7.	4.20	-7.	4.25	-7.	4.30	-7.
4.35	-6.	4.40	-6.	4.45	-6.	4.50	-6.	4.55	-7.	5.00	-7.
5.05	-7.	5.10	-7.	5.15	-7.	5.20	-7.	5.25	-7.	5.30	-7.
5.35	-7.	5.40	-7.	5.45	-7.	5.50	-7.				

PIEZOMETEN #32

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-158.	.05	-158.	.10	-157.	.15	-157.	.20	-157.	.25	-157.
.30	-157.	.35	-155.	.40	-154.	.45	-150.	.50	-143.	.55	-144.
1.00	-124.	1.05	-113.	1.10	-98.	1.15	-90.	1.20	-77.	1.25	-68.
1.30	-63.	1.35	-58.	1.40	-52.	1.45	-48.	1.50	-47.	1.55	-41.
2.00	-41.	2.10	-41.	2.15	-41.	2.20	-41.	2.25	-41.	2.30	-40.
2.35	-37.	2.40	-33.	2.45	-28.	2.50	-25.	2.55	-23.	3.00	-20.
3.05	-17.	3.10	-17.	3.15	-16.	3.20	-13.	3.25	-13.	3.30	-12.
3.35	-10.	3.40	-10.	3.45	-10.	3.50	-9.	3.55	-8.	4.00	-6.
4.05	-6.	4.10	-6.	4.15	-5.	4.20	-5.	4.25	-5.	4.30	-5.
4.35	-5.	4.40	-5.	4.45	-5.	4.50	-5.	4.55	-5.	5.00	-5.
5.05	-5.	5.10	-5.	5.15	-5.	5.20	-5.	5.25	-5.	5.30	-5.
5.35	-5.	5.40	-5.	5.45	-5.	5.50	-5.				

PIEZOMETEN #33

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-153.	.05	-153.	.10	-152.	.15	-152.	.20	-152.	.25	-152.
.30	-152.	.35	-150.	.40	-149.	.45	-148.	.50	-142.	.55	-136.
1.00	-126.	1.05	-115.	1.10	-102.	1.15	-93.	1.20	-76.	1.25	-68.
1.30	-61.	1.35	-56.	1.40	-51.	1.45	-46.	1.50	-45.	1.55	-42.
2.00	-41.	2.10	-41.	2.15	-41.	2.20	-41.	2.25	-41.	2.30	-38.
2.35	-31.	2.40	-24.	2.45	-18.	2.50	-15.	2.55	-12.	3.00	-11.
3.05	-9.	3.10	-7.	3.15	-5.	3.20	-4.	3.25	-3.	3.30	-1.
3.35	-1.	3.40	1.	3.45	1.	3.50	1.	3.55	3.	4.00	3.
4.05	3.	4.10	3.	4.15	4.	4.20	4.	4.25	4.	4.30	4.
4.35	4.	4.40	4.	4.45	4.	4.50	4.	4.55	4.	5.00	4.
5.05	4.	5.10	3.	5.15	3.	5.20	3.	5.25	3.	5.30	3.
5.35	3.	5.40	3.	5.45	3.	5.50	3.				

PIEZOMETEN #34

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-147.	.05	-147.	.10	-146.	.15	-146.	.20	-146.	.25	-143.
.30	-142.	.35	-136.	.40	-136.	.45	-133.	.50	-128.	.55	-117.
1.00	-79.	1.05	-61.	1.10	-53.	1.15	-51.	1.20	-45.	1.25	-41.
1.30	-60.	1.35	-58.	1.40	-56.	1.45	-53.	1.50	-49.	1.55	-42.
2.00	-25.	2.10	-23.	2.15	-23.	2.20	-23.	2.25	-23.	2.30	-22.
2.35	-17.	2.40	-10.	2.45	-6.	2.50	-3.	2.55	-0.	3.00	1.
3.05	2.	3.10	4.	3.15	5.	3.20	6.	3.25	8.	3.30	8.
3.35	8.	3.40	8.	3.45	9.	3.50	9.	3.55	11.	4.00	12.
4.05	12.	4.10	12.	4.15	12.	4.20	12.	4.25	12.	4.30	12.
4.35	9.	4.40	12.	4.45	12.	4.50	11.	4.55	11.	5.00	11.
5.05	12.	5.10	12.	5.15	12.	5.20	12.	5.25	12.	5.30	12.
5.35	12.	5.40	12.	5.45	12.	5.50	12.				

PIEZOMETEN #35

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-138.	.05	-138.	.10	-137.	.15	-138.	.20	-137.	.25	-138.
.30	-138.	.35	-136.	.40	-136.	.45	-136.	.50	-138.	.55	-136.
1.00	-138.	1.05	-138.	1.10	-136.	1.15	-136.	1.20	-136.	1.25	-136.
1.30	-136.	1.35	-136.	1.40	-135.	1.45	-135.	1.50	-133.	1.55	-124.
2.00	-100.	2.10	-102.	2.15	-83.	2.20	-81.	2.25	-66.	2.30	-40.
2.35	-22.	2.40	-10.	2.45	-10.	2.50	-8.	2.55	-1.	3.00	2.
3.05	5.	3.10	6.	3.15	7.	3.20	9.	3.25	9.	3.30	10.
3.35	11.	3.40	11.	3.45	11.	3.50	11.	3.55	13.	4.00	14.
4.05	14.	4.10	14.	4.15	16.	4.20	16.	4.25	16.	4.30	16.
4.35	17.	4.40	16.	4.45	16.	4.50	16.	4.55	16.	5.00	16.
5.05	16.	5.10	16.	5.15	16.	5.20	16.	5.25	16.	5.30	16.
5.35	16.	5.40	16.	5.45	16.	5.50	16.				

PIEZOMETEN #36

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-180.	.05	-180.	.10	-177.	.15	-174.	.20	-159.	.25	-142.
.30	-111.	.35	-97.	.40	-83.	.45	-71.	.50	-60.	.55	-54.
1.00	-50.	1.05	-46.	1.10	-41.	1.15	-41.	1.20	-41.	1.25	-40.
1.30	-41.	1.35	-41.	1.40	-40.	1.45	-40.	1.50	-37.	1.55	-37.
2.00	-36.	2.10	-36.	2.15	-37.	2.20	-36.	2.25	-29.	2.30	-26.
2.35	-25.	2.40	-25.	2.45	-25.	2.50	-24.	2.55	-22.	3.00	-18.
3.05	-18.	3.10	-17.	3.15	-16.	3.20	-14.	3.25	-14.	3.30	-13.
3.35	-11.	3.40	-11.	3.45	-10.	3.50	-10.	3.55	-9.	4.00	-9.
4.05	-7.	4.10	-7.	4.15	-7.	4.20	-7.	4.25	-7.	4.30	-7.
4.35	-11.	4.40	-7.	4.45	-7.	4.50	-7.	4.55	-7.	5.00	-7.
5.05	-7.	5.10	-7.	5.15	-7.	5.20	-7.	5.25	-7.	5.30	-7.
5.35	-7.	5.40	-7.	5.45	-7.	5.50	-7.				

PIEZOMETEN #37

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-169.	.05	-169.	.10	-168.	.15	-168.	.20	-168.	.25	-168.
.30	-168.	.35	-167.	.40	-167.	.45	-167.	.50	-167.	.55	-167.
1.00	-161.	1.05	-158.	1.10	-145.	1.15	-141.	1.20	-131.	1.25	-124.
1.30	-120.	1.35	-114.	1.40	-108.	1.45	-100.	1.50	-96.	1.55	-89.
2.00	-85.	2.10	-81.	2.15	-77.	2.20	-72.	2.25	-62.	2.30	-48.
2.35	-30.	2.40	-30.	2.45	-23.	2.50	-19.	2.55	-16.	3.00	-12.
3.05	-12.	3.10	-11.	3.15	-9.	3.20	-9.	3.25	-8.	3.30	-6.
3.35	-8.	3.40	-8.	3.45	-8.	3.50	-5.	3.55	-2.	4.00	-2.
4.05	-1.	4.10	-1.	4.15	-1.	4.20	0.	4.25	0.	4.30	0.
4.35	0.	4.40	0.	4.45	0.	4.50	0.	4.55	-1.	5.00	-1.
5.05	-1.	5.10	-1.	5.15	-1.	5.20	-1.	5.25	-1.	5.30	-1.
5.35	-1.	5.40	0.	5.45	0.	5.50	0.				

PIEZOMETEN #38

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-160.	.05	-160.	.10	-159.	.15	-159.	.20	-159.	.25	-159.
.30	-159.	.35	-157.	.40	-157.	.45	-157.	.50	-157.	.55	-152.
1.00	-145.	1.05	-137.	1.10	-119.	1.15	-109.	1.20	-88.	1.25	-75.
1.30	-69.	1.35	-61.	1.40	-54.	1.45	-48.	1.50	-45.	1.55	-42.
2.00	-42.	2.10	-39.	2.15	-39.	2.20	-38.	2.25	-34.	2.30	-27.
2.35	-22.	2.40	-18.	2.45	-12.	2.50	-11.	2.55	-10.	3.00	-7.
3.05	-7.	3.10	-4.	3.15	-4.	3.20	-3.	3.25	-3.	3.30	-1.
3.35	-1.	3.40	-1.	3.45	-1.	3.50	-0.	3.55	1.	4.00	1.
4.05	3.	4.10	3.	4.15	3.	4.20	3.	4.25	3.	4.30	3.
4.35	3.	4.40	3.	4.45	3.	4.50	3.	4.55	3.	5.00	3.
5.05	3.	5.10	3.	5.15	3.	5.20	3.	5.25	3.	5.30	3.
5.35	3.	5.40	3.	5.45	3.	5.50	3.				

PIEZOMETEN #39

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-157.	.05	-157.	.10	-157.	.15	-157.	.20	-158.	.25	-158.
.30	-158.	.35	-157.	.40	-157.	.45	-157.	.50	-157.	.55	-157.
1.00	-157.	1.05	-157.	1.10	-155.	1.15	-155.	1.20	-152.	1.25	-144.
1.30	-90.	1.35	-52.	1.40	-40.	1.45	-36.	1.50	-33.	1.55	-32.
2.00	-33.	2.10	-32.	2.15	-32.	2.20	-28.	2.25	-20.	2.30	-11.
2.35	-9.	2.40	-6.	2.45	-2.	2.50	1.	2.55	1.	3.00	2.
3.05	2.	3.10	4.	3.15	5.	3.20	6.	3.25	6.	3.30	6.
3.35	6.	3.40	8.	3.45	8.	3.50	9.	3.55	10.	4.00	10.
4.05	12.	4.10	12.	4.15	12.	4.20	12.	4.25	12.	4.30	12.
4.35	12.	4.40	12.	4.45	12.	4.50	10.	4.55	10.	5.00	9.
5.05	10.	5.10	12.	5.15	12.	5.20	12.	5.25	12.	5.30	12.
5.35	12.	5.40	12.	5.45	12.	5.50	12.				

PIEZOMETEN #40

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-141.	.05	-141.	.10	-139.	.15	-139.	.20	-141.	.25	-141.
.30	-141.	.35	-139.	.40	-139.	.45	-141.	.50	-141.	.55	-141.
1.00	-141.	1.05	-41.	1.10	-139.	1.15	-141.	1.20	-141.	1.25	-139.
1.30	-141.	1.35	-138.	1.40	-135.	1.45	-122.	1.50	-99.	1.55	-70.
2.00	-57.	2.10	-50.	2.15	-43.	2.20	-35.	2.25	-16.	2.30	-9.
2.35	-6.	2.40	-4.	2.45	-1.	2.50	2.	2.55	3.	3.00	6.
3.05	6.	3.10	6.	3.15	7.	3.20	9.	3.25	9.	3.30	10.
3.35	10.	3.40	10.	3.45	10.	3.50	11.	3.55	13.	4.00	13.
4.05	13.	4.10	13.	4.15	13.	4.20	13.	4.25	13.	4.30	13.
4.35	13.	4.40	13.	4.45	13.	4.50	13.	4.55	13.	5.00	13.
5.05	13.	5.10	13.	5.15	14.	5.20	14.	5.25	14.	5.30	13.
5.35	13.	5.40	13.	5.45	13.	5.50	13.				

PIEZOMETEN #41

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-167.	.05	-167.	.10	-166.	.15	-167.	.20	-166.	.25	-166.
.30	-177.	.35	-164.	.40	-163.	.45	-136.	.50	-92.	.55	-78.
1.00	-58.	1.05	-34.	1.10	-25.	1.15	-26.	1.20	-25.	1.25	-23.
1.30	-25.	1.35	-35.	1.40	-23.	1.45	-22.	1.50	-20.	1.55	-20.
2.00	-16.	2.10	-15.	2.15	-15.	2.20	-11.	2.25	-10.	2.30	-8.
2.35	-8.	2.40	-8.	2.45	-7.	2.50	-7.	2.55	-7.	3.00	-7.
3.05	-6.	3.10	-6.	3.15	-4.	3.20	-4.	3.25	-4.	3.30	-4.
3.35	-8.	3.40	-3.	3.45	-3.	3.50	-3.	3.55	-1.	4.00	-1.
4.05	-1.	4.10	-0.	4.15	-7.	4.20	-0.	4.25	-0.	4.30	-0.
4.35	-0.	4.40	-0.	4.45	-0.	4.50	-0.	4.55	-0.	5.00	-1.
5.05	-0.	5.10	-0.	5.15	-0.	5.20	-0.	5.25	-0.	5.30	-0.
5.35	-0.	5.40	-0.	5.45	-0.	5.50	-0.				

PIEZOMETEN #42

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-180.	.05	-180.	.10	-180.	.15	-180.	.20	-181.	.25	-181.
.30	-182.	.35	-180.	.40	-180.	.45	-177.	.50	-182.	.55	-139.
1.00	-108.	1.05	-77.	1.10	-55.	1.15	-47.	1.20	-39.	1.25	-38.
1.30	-33.	1.35	-30.	1.40	-29.	1.45	-28.	1.50	-28.	1.55	-25.
2.00	-24.	2.10	-24.	2.15	-22.	2.20	-21.	2.25	-17.	2.30	-14.
2.35	-14.	2.40	-11.	2.45	-10.	2.50	-10.	2.55	-10.	3.00	-9.
3.05	-7.	3.10	-7.	3.15	-6.	3.20	-6.	3.25	-6.	3.30	-6.
3.35	-5.	3.40	-5.	3.45	-5.	3.50	-5.	3.55	-3.	4.00	-2.
4.05	-2.	4.10	-2.	4.15	-2.	4.20	-2.	4.25	-2.	4.30	-2.
4.35	-2.	4.40	-2.	4.45	-2.	4.50	-2.	4.55	-2.	5.00	-2.
5.05	-2.	5.10	-2.	5.15	-2.	5.20	-2.	5.25	-2.	5.30	-2.
5.35	-2.	5.40	-2.	5.45	-2.	5.50	-2.				

PIEZOMETEN #43											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-100.	.05	-100.	.10	-103.	.15	-101.	.20	-101.	.25	-102.
.30	-100.	.35	-97.	.40	-98.	.45	-97.	.50	-97.	.55	-100.
1.00	-70.	1.05	-69.	1.10	-67.	1.15	-64.	1.20	-58.	1.25	-47.
1.30	-47.	1.35	-44.	1.40	-40.	1.45	-39.	1.50	-38.	1.55	-38.
2.00	-38.	2.10	-38.	2.15	-35.	2.20	-29.	2.25	-25.	2.30	-19.
2.35	-17.	2.40	-16.	2.45	-13.	2.50	-12.	2.55	-12.	3.00	-12.
3.05	-10.	3.10	-10.	3.15	-9.	3.20	-8.	3.25	-8.	3.30	-8.
3.35	-8.	3.40	-8.	3.45	-8.	3.50	-8.	3.55	-5.	4.00	-5.
4.05	-4.	4.10	-4.	4.15	-4.	4.20	-4.	4.25	-4.	4.30	-4.
4.35	-4.	4.40	-4.	4.45	-4.	4.50	-4.	4.55	-4.	5.00	-4.
5.05	-4.	5.10	-4.	5.15	-4.	5.20	-4.	5.25	-4.	5.30	-4.
5.35	-4.	5.40	-4.	5.45	-4.	5.50	-4.				

PIEZOMETEN #44											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-170.	.05	-170.	.10	-170.	.15	-170.	.20	-171.	.25	-171.
.30	-171.	.35	-170.	.40	-170.	.45	-172.	.50	-172.	.55	-172.
1.00	-172.	1.05	-172.	1.10	-171.	1.15	-171.	1.20	-171.	1.25	-168.
1.30	-153.	1.35	-123.	1.40	-100.	1.45	-75.	1.50	-64.	1.55	-33.
2.00	-46.	2.10	-42.	2.15	-37.	2.20	-30.	2.25	-22.	2.30	-16.
2.35	-12.	2.40	-9.	2.45	-7.	2.50	-4.	2.55	-4.	3.00	-3.
3.05	-3.	3.10	-3.	3.15	-1.	3.20	-0.	3.25	-0.	3.30	1.
3.35	1.	3.40	1.	3.45	1.	3.50	1.	3.55	4.	4.00	4.
4.05	4.	4.10	5.	4.15	5.	4.20	5.	4.25	5.	4.30	4.
4.35	5.	4.40	5.	4.45	5.	4.50	4.	4.55	3.	5.00	4.
5.05	5.	5.10	5.	5.15	5.	5.20	5.	5.25	5.	5.30	5.
5.35	5.	5.40	5.	5.45	5.	5.50	5.				

PIEZOMETEN #45											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-154.	.05	-154.	.10	-154.	.15	-154.	.20	-155.	.25	-155.
.30	-155.	.35	-154.	.40	-154.	.45	-156.	.50	-156.	.55	-156.
1.00	-156.	1.05	-156.	1.10	-155.	1.15	-155.	1.20	-155.	1.25	-156.
1.30	-156.	1.35	-156.	1.40	-155.	1.45	-144.	1.50	-123.	1.55	-113.
2.00	-90.	2.10	-72.	2.15	-52.	2.20	-36.	2.25	-25.	2.30	-15.
2.35	-10.	2.40	-7.	2.45	-4.	2.50	-2.	2.55	-2.	3.00	1.
3.05	2.	3.10	2.	3.15	2.	3.20	2.	3.25	2.	3.30	5.
3.35	5.	3.40	5.	3.45	5.	3.50	5.	3.55	8.	4.00	8.
4.05	6.	4.10	8.	4.15	8.	4.20	8.	4.25	8.	4.30	8.
4.35	8.	4.40	8.	4.45	8.	4.50	8.	4.55	8.	5.00	8.
5.05	8.	5.10	8.	5.15	8.	5.20	8.	5.25	8.	5.30	8.
5.35	8.	5.40	8.	5.45	8.	5.50	8.				

PIEZOMETEN #46											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-206.	.05	-206.	.10	-204.	.15	-204.	.20	-199.	.25	-198.
.30	-138.	.35	-107.	.40	-88.	.45	-68.	.50	-57.	.55	-50.
1.00	-44.	1.05	-39.	1.10	-36.	1.15	-35.	1.20	-25.	1.25	-24.
1.30	-33.	1.35	-32.	1.40	-29.	1.45	-27.	1.50	-25.	1.55	-25.
2.00	-23.	2.10	-23.	2.15	-23.	2.20	-20.	2.25	-18.	2.30	-18.
2.35	-18.	2.40	-17.	2.45	-16.	2.50	-15.	2.55	-13.	3.00	-12.
3.05	-12.	3.10	-12.	3.15	-12.	3.20	-10.	3.25	-10.	3.30	-10.
3.35	-10.	3.40	-10.	3.45	-10.	3.50	-10.	3.55	-9.	4.00	-8.
4.05	-8.	4.10	-8.	4.15	-8.	4.20	-8.	4.25	-8.	4.30	-8.
4.35	-8.	4.40	-8.	4.45	-8.	4.50	-10.	4.55	-10.	5.00	-10.
5.05	-8.	5.10	-8.	5.15	-8.	5.20	-8.	5.25	-8.	5.30	-8.
5.35	-8.	5.40	-8.	5.45	-8.	5.50	-8.				

PIEZOMETEN #47											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-198.	.05	-198.	.10	-194.	.15	-190.	.20	-198.	.25	-198.
.30	-198.	.35	-197.	.40	-197.	.45	-197.	.50	-197.	.55	-192.
1.00	-103.	1.05	-109.	1.10	-133.	1.15	-108.	1.20	-69.	1.25	-107.
1.30	-47.	1.35	-42.	1.40	-41.	1.45	-35.	1.50	-35.	1.55	-34.
2.00	-32.	2.10	-32.	2.15	-31.	2.20	-26.	2.25	-24.	2.30	-22.
2.35	-22.	2.40	-19.	2.45	-16.	2.50	-13.	2.55	-12.	3.00	-12.
3.05	-11.	3.10	-9.	3.15	-9.	3.20	-9.	3.25	-9.	3.30	-9.
3.35	-9.	3.40	-9.	3.45	-9.	3.50	-9.	3.55	-8.	4.00	-7.
4.05	-7.	4.10	-7.	4.15	-7.	4.20	-7.	4.25	-7.	4.30	-7.
4.35	-7.	4.40	-7.	4.45	-7.	4.50	-7.	4.55	-7.	5.00	-7.
5.05	-7.	5.10	-7.	5.15	-7.	5.20	-7.	5.25	-7.	5.30	-7.
5.35	-7.	5.40	-7.	5.45	-7.	5.50	-7.				

PIEZOMETEN #48											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-188.	.05	-185.	.10	-188.	.15	-185.	.20	-174.	.25	-176.
.30	-159.	.35	-148.	.40	-144.	.45	-143.	.50	-143.	.55	-136.
1.00	-136.	1.05	-135.	1.10	-129.	1.15	-125.	1.20	-116.	1.25	-112.
1.30	-105.	1.35	-84.	1.40	-75.	1.45	-67.	1.50	-61.	1.55	-56.
2.00	-53.	2.10	-50.	2.15	-48.	2.20	-42.	2.25	-36.	2.30	-29.
2.35	-26.	2.40	-22.	2.45	-19.	2.50	-15.	2.55	-15.	3.00	-15.
3.05	-14.	3.10	-14.	3.15	-13.	3.20	-11.	3.25	-13.	3.30	-11.
3.35	-11.	3.40	-11.	3.45	-11.	3.50	-10.	3.55	-8.	4.00	-8.
4.05	-8.	4.10	-8.	4.15	-2.	4.20	-7.	4.25	-7.	4.30	-7.
4.35	-7.	4.40	-7.	4.45	-7.	4.50	-7.	4.55	-7.	5.00	-7.
5.05	-7.	5.10	-7.	5.15	-7.	5.20	-7.	5.25	-7.	5.30	-7.
5.35	-7.	5.40	-7.	5.45	-7.	5.50	-7.				

PIEZOMETEN #49

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-200.	.05	-200.	.10	-199.	.15	-200.	.20	-200.	.25	-200.
.30	-200.	.35	-199.	.40	-200.	.45	-200.	.50	-200.	.55	-200.
1.00	-204.	1.05	-204.	1.10	-203.	1.15	-203.	1.20	-205.	1.25	-204.
1.30	-205.	1.35	-204.	1.40	-200.	1.45	-190.	1.50	-190.	1.55	-104.
2.00	-180.	2.10	-173.	2.15	-101.	2.20	-142.	2.25	-98.	2.30	-44.
2.35	-21.	2.40	-14.	2.45	-12.	2.50	-10.	2.55	-9.	3.00	-8.
3.05	-6.	3.10	-6.	3.15	-5.	3.20	-5.	3.25	-5.	3.30	-5.
3.35	-5.	3.40	-5.	3.45	-5.	3.50	-5.	3.55	-2.	4.00	-1.
4.05	-1.	4.10	-1.	4.15	-1.	4.20	-1.	4.25	-1.	4.30	-1.
4.35	-1.	4.40	-1.	4.45	1.	4.50	1.	4.55	1.	5.00	1.
5.05	1.	5.10	1.	5.15	1.	5.20	1.	5.25	1.	5.30	1.
5.35	1.	5.40	1.	5.45	1.	5.50	1.				

PIEZOMETEN #50

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-171.	.05	-178.	.10	-169.	.15	-171.	.20	-171.	.25	-171.
.30	-171.	.35	-172.	.40	-172.	.45	-173.	.50	-173.	.55	-173.
1.00	-175.	1.05	-175.	1.10	-173.	1.15	-173.	1.20	-173.	1.25	-173.
1.30	-173.	1.35	-173.	1.40	-172.	1.45	-172.	1.50	-108.	1.55	-157.
2.00	-134.	2.10	-105.	2.15	-70.	2.20	-50.	2.25	-38.	2.30	-27.
2.35	-19.	2.40	-11.	2.45	-5.	2.50	-1.	2.55	-1.	3.00	0.
3.05	2.	3.10	2.	3.15	2.	3.20	3.	3.25	3.	3.30	4.
3.35	4.	3.40	4.	3.45	6.	3.50	6.	3.55	7.	4.00	8.
4.05	8.	4.10	8.	4.15	8.	4.20	8.	4.25	8.	4.30	8.
4.35	8.	4.40	8.	4.45	7.	4.50	7.	4.55	7.	5.00	7.
5.05	8.	5.10	8.	5.15	8.	5.20	8.	5.25	8.	5.30	8.
5.35	8.	5.40	8.	5.45	10.	5.50	10.				

*SIOP# 0

RAINFALL FLUX - EXPERIMENT #2

Recorded flow US gal/min	Time (hrs)	Δt	Rainfall cm/hr	Corrected Rainfall cm/hr	Rainfall flux cm/sec
0.375	12		2.3164	2.0848	0.00058

PHYSICAL SIMULATION #2
Tensiometer Co-ordinates

Tensiometer #	X Co-ordinate	Y Co-ordinate	Tensiometer #	X Co-ordinate	Y Co-ordinate
1	17.5	150	21	180	92.5
2	17.5	160	22	205	57.5
3	17.5	170	23	205	67.5
4	45	137	24	205	77.5
5	45	147	25	232	42.5
6	45	157	26	232	52.5
7	72.5	124	27	232	62.5
8	72.5	134	28	257	27
9	72.5	144	29	257	37
10	100	113	30	257	47
11	100	123	31	285	12
12	100	133	32	285	22
13	126	100	33	285	32
14	126	110	34	315	12
15	126	120	35	315	22
16	153.5	83.5	36	345	12
17	153.5	93.5	37	345	22
18	153.5	103.5	38	345	27
19	180	72.5	39	376	17
20	180	82.5			

EXPERIMENT 2

RUN #2

PIEZOMETER # 1

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-130.	1.45	-129.	2.00	-130.	2.15	-130.	2.30	-130.	2.45	-130.
3.00	-112.	3.15	-50.	3.30	-2.	3.45	-18.	4.00	-16.	4.15	-15.
4.30	-45.	4.45	-15.	5.00	-13.	5.15	-13.	5.30	-13.	5.45	-13.
6.00	-13.	6.15	-13.	6.30	-13.	6.45	-13.	7.00	-12.	7.15	-12.
7.30	-12.	7.45	-12.	8.00	-12.	8.15	-12.	8.30	-12.	8.45	-11.
9.00	-11.	9.15	-11.	9.30	-9.	9.45	-9.	10.00	-9.	10.15	-8.
10.30	-8.	10.45	-8.	11.00	-8.	11.15	-8.	11.30	-8.	11.45	-8.

PIEZOMETER # 2

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-125.	1.45	-113.	2.00	-84.	2.15	-21.	2.30	-14.	2.45	-9.
3.00	-7.	3.15	-7.	3.30	-7.	3.45	-7.	4.00	-7.	4.15	-7.
4.30	-7.	4.45	-7.	5.00	-7.	5.15	-7.	5.30	-7.	5.45	-7.
6.00	-7.	6.15	-7.	6.30	-9.	6.45	-10.	7.00	-9.	7.15	-9.
7.30	-9.	7.45	-9.	8.00	-9.	8.15	-9.	8.30	-9.	8.45	-9.
9.00	-9.	9.15	-9.	9.30	-9.	9.45	-9.	10.00	-9.	10.15	-9.
10.30	-9.	10.45	-9.	11.00	-9.	11.15	-9.	11.30	-9.	11.45	-9.

PIEZOMETER # 3

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-165.	1.45	-4.	2.00	-1.	2.15	-1.	2.30	-1.	2.45	0.
3.00	0.	3.15	-1.	3.30	-1.	3.45	-2.	4.00	-2.	4.15	-2.
4.30	-5.	4.45	-5.	5.00	-5.	5.15	-5.	5.30	-5.	5.45	-5.
6.00	-5.	6.15	-6.	6.30	-6.	6.45	-8.	7.00	-8.	7.15	-8.
7.30	-8.	7.45	-8.	8.00	-8.	8.15	-8.	8.30	-8.	8.45	-8.
9.00	-8.	9.15	-8.	9.30	-8.	9.45	-8.	10.00	-9.	10.15	-9.
10.30	-9.	10.45	-9.	11.00	-10.	11.15	-10.	11.30	-10.	11.45	-13.

PIEZOMETER # 4

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-89.	1.45	-72.	2.00	-42.	2.15	-24.	2.30	-15.	2.45	-17.
3.00	-15.	3.15	-15.	3.30	-15.	3.45	-14.	4.00	-13.	4.15	-13.
4.30	-13.	4.45	-13.	5.00	-11.	5.15	-11.	5.30	-11.	5.45	-11.
6.00	-11.	6.15	-11.	6.30	-11.	6.45	-10.	7.00	-10.	7.15	-9.
7.30	-7.	7.45	-7.	8.00	-6.	8.15	-6.	8.30	-6.	8.45	-6.
9.00	-5.	9.15	-5.	9.30	-3.	9.45	-2.	10.00	-2.	10.15	-2.
10.30	-0.	10.45	-0.	11.00	-0.	11.15	1.	11.30	1.	11.45	-21.

PIEZOMETER # 5

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-112.	1.45	-8.	2.00	-4.	2.15	-2.	2.30	-2.	2.45	-2.
3.00	-2.	3.15	-2.	3.30	-9.	3.45	-2.	4.00	-2.	4.15	-2.
4.30	-2.	4.45	-2.	5.00	-2.	5.15	-2.	5.30	-4.	5.45	-4.
6.00	-2.	6.15	0.	6.30	2.	6.45	2.	7.00	-1.	7.15	-1.
7.30	-2.	7.45	-1.	8.00	-1.	8.15	-2.	8.30	-2.	8.45	-2.
9.00	-2.	9.15	-2.	9.30	0.	9.45	2.	10.00	2.	10.15	2.
10.30	2.	10.45	2.	11.00	2.	11.15	2.	11.30	2.	11.45	-6.

PIEZOMETER # 6

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-125.	1.45	-4.	2.00	-4.	2.15	-4.	2.30	-4.	2.45	-4.
3.00	-4.	3.15	-4.	3.30	-4.	3.45	-4.	4.00	-4.	4.15	-4.
4.30	-4.	4.45	-4.	5.00	-4.	5.15	-3.	5.30	-3.	5.45	-4.
6.00	-4.	6.15	-2.	6.30	1.	6.45	1.	7.00	-3.	7.15	1.
7.30	-3.	7.45	-3.	8.00	-3.	8.15	-3.	8.30	-3.	8.45	-4.
9.00	-3.	9.15	-3.	9.30	-3.	9.45	-3.	10.00	-3.	10.15	-4.
10.30	-3.	10.45	-3.	11.00	-4.	11.15	-3.	11.30	-4.	11.45	-12.

PIEZOMETER # 7

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-80.	1.45	-77.	2.00	-76.	2.15	-73.	2.30	-58.	2.45	-38.
3.00	-25.	3.15	-19.	3.30	-17.	3.45	-16.	4.00	-16.	4.15	-15.
4.30	-15.	4.45	-15.	5.00	-13.	5.15	-13.	5.30	-13.	5.45	-13.
6.00	-13.	6.15	-11.	6.30	-9.	6.45	-8.	7.00	-6.	7.15	-5.
7.30	-5.	7.45	-9.	8.00	-2.	8.15	-1.	8.30	-1.	8.45	0.
9.00	0.	9.15	2.	9.30	2.	9.45	2.	10.00	2.	10.15	3.
10.30	3.	10.45	3.	11.00	3.	11.15	4.	11.30	4.	11.45	-8.

PIEZOMETER # 8

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-91.	1.45	-71.	2.00	-46.	2.15	-22.	2.30	-15.	2.45	-14.
3.00	-14.	3.15	-12.	3.30	-12.	3.45	-12.	4.00	-12.	4.15	-12.
4.30	-12.	4.45	-12.	5.00	-12.	5.15	-12.	5.30	-12.	5.45	-12.
6.00	-12.	6.15	-12.	6.30	-12.	6.45	-12.	7.00	-12.	7.15	-12.
7.30	-12.	7.45	-11.	8.00	-10.	8.15	-10.	8.30	-10.	8.45	-10.
9.00	-10.	9.15	-8.	9.30	-8.	9.45	-7.	10.00	-7.	10.15	-7.
10.30	-7.	10.45	-6.	11.00	-6.	11.15	-6.	11.30	-6.	11.45	-12.

PIEZOMETER #9

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-151.	1:45	-127.	2:00	-116.	2:15	-97.	2:30	-82.	2:45	-73.
3:00	-68.	3:15	-64.	3:30	-62.	3:45	-59.	4:00	-56.	4:15	-54.
4:30	-52.	4:45	-49.	5:00	-47.	5:15	-45.	5:30	-44.	5:45	-36.
6:00	-40.	6:15	-36.	6:30	-32.	6:45	-29.	7:00	-26.	7:15	-25.
7:30	-22.	7:45	-22.	8:00	-20.	8:15	-20.	8:30	-20.	8:45	-18.
9:00	-18.	9:15	-18.	9:30	-17.	9:45	-17.	10:00	-16.	10:15	-16.
10:30	-16.	10:45	-14.	11:00	-14.	11:15	-14.	11:30	-14.	11:45	-14.

PIEZOMETER #10

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-84.	1:45	-81.	2:00	-78.	2:15	-75.	2:30	-71.	2:45	-64.
3:00	-59.	3:15	-54.	3:30	-48.	3:45	-44.	4:00	-39.	4:15	-35.
4:30	-32.	4:45	-29.	5:00	-25.	5:15	-23.	5:30	-21.	5:45	-18.
6:00	-16.	6:15	-13.	6:30	-10.	6:45	-8.	7:00	-6.	7:15	-5.
7:30	-4.	7:45	-2.	8:00	-2.	8:15	-1.	8:30	0.	8:45	2.
9:00	2.	9:15	3.	9:30	5.	9:45	5.	10:00	5.	10:15	5.
10:30	5.	10:45	6.	11:00	6.	11:15	6.	11:30	6.	11:45	-2.

PIEZOMETER #11

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-91.	1:45	-20.	2:00	-18.	2:15	-15.	2:30	-14.	2:45	-15.
3:00	-14.	3:15	-14.	3:30	-14.	3:45	-15.	4:00	-14.	4:15	-14.
4:30	-14.	4:45	-14.	5:00	-14.	5:15	-14.	5:30	-14.	5:45	-14.
6:00	-14.	6:15	-14.	6:30	-14.	6:45	-14.	7:00	-14.	7:15	-12.
7:30	-12.	7:45	-12.	8:00	-11.	8:15	-11.	8:30	-11.	8:45	-10.
9:00	-8.	9:15	-8.	9:30	-7.	9:45	-5.	10:00	-5.	10:15	-5.
10:30	-5.	10:45	-5.	11:00	-4.	11:15	-4.	11:30	-4.	11:45	-12.

PIEZOMETER #12

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-105.	1:45	-21.	2:00	-17.	2:15	-15.	2:30	-13.	2:45	-13.
3:00	-13.	3:15	-13.	3:30	-13.	3:45	-13.	4:00	-13.	4:15	-13.
4:30	-13.	4:45	-13.	5:00	-13.	5:15	-13.	5:30	-13.	5:45	-13.
6:00	-14.	6:15	-14.	6:30	-14.	6:45	-14.	7:00	-14.	7:15	-14.
7:30	-14.	7:45	-14.	8:00	-14.	8:15	-14.	8:30	-14.	8:45	-14.
9:00	-14.	9:15	-14.	9:30	-14.	9:45	-14.	10:00	-13.	10:15	-13.
10:30	-13.	10:45	-13.	11:00	-13.	11:15	-13.	11:30	-13.	11:45	-17.

PIEZOMETER #13

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-84.	1:45	-75.	2:00	-62.	2:15	-46.	2:30	-30.	2:45	-20.
3:00	-14.	3:15	-8.	3:30	-7.	3:45	-5.	4:00	-5.	4:15	-4.
4:30	-4.	4:45	-4.	5:00	-4.	5:15	-4.	5:30	-4.	5:45	-4.
6:00	-4.	6:15	-4.	6:30	-3.	6:45	-1.	7:00	-1.	7:15	-0.
7:30	1.	7:45	3.	8:00	4.	8:15	5.	8:30	5.	8:45	7.
9:00	7.	9:15	8.	9:30	9.	9:45	11.	10:00	11.	10:15	11.
10:30	11.	10:45	11.	11:00	11.	11:15	11.	11:30	12.	11:45	9.

PIEZOMETER #14

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-12.	1:45	-30.	2:00	-82.	2:15	-63.	2:30	-44.	2:45	-37.
3:00	-30.	3:15	-29.	3:30	-28.	3:45	-28.	4:00	-26.	4:15	-26.
4:30	-26.	4:45	-26.	5:00	-26.	5:15	-26.	5:30	-25.	5:45	-25.
6:00	-24.	6:15	-21.	6:30	-18.	6:45	-18.	7:00	-15.	7:15	-14.
7:30	-13.	7:45	-11.	8:00	-10.	8:15	-9.	8:30	-7.	8:45	-7.
9:00	-6.	9:15	-6.	9:30	-5.	9:45	-5.	10:00	-5.	10:15	-3.
10:30	-3.	10:45	-2.	11:00	-2.	11:15	-2.	11:30	-2.	11:45	-14.

PIEZOMETER #15

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-106.	1:45	-40.	2:00	-30.	2:15	-21.	2:30	-17.	2:45	-15.
3:00	-13.	3:15	-12.	3:30	-12.	3:45	-12.	4:00	-12.	4:15	-12.
4:30	-12.	4:45	-12.	5:00	-12.	5:15	-12.	5:30	-12.	5:45	-12.
6:00	-12.	6:15	-12.	6:30	-12.	6:45	-12.	7:00	-12.	7:15	-12.
7:30	-12.	7:45	-12.	8:00	-12.	8:15	-12.	8:30	-11.	8:45	-11.
9:00	-8.	9:15	-5.	9:30	-5.	9:45	-5.	10:00	-5.	10:15	-5.
10:30	-5.	10:45	-5.	11:00	-5.	11:15	-5.	11:30	-5.	11:45	-11.

PIEZOMETER #16

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-65.	1:45	-62.	2:00	-63.	2:15	-62.	2:30	-62.	2:45	-57.
3:00	-43.	3:15	-28.	3:30	-17.	3:45	-13.	4:00	-10.	4:15	-9.
4:30	-8.	4:45	-2.	5:00	-8.	5:15	-8.	5:30	-6.	5:45	-6.
6:00	-6.	6:15	-5.	6:30	-4.	6:45	-2.	7:00	0.	7:15	2.
7:30	4.	7:45	6.	8:00	9.	8:15	10.	8:30	11.	8:45	13.
9:00	14.	9:15	15.	9:30	17.	9:45	17.	10:00	17.	10:15	18.
10:30	18.	10:45	19.	11:00	19.	11:15	19.	11:30	19.	11:45	14.

PIEZOMETER #17

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-93.	1:45	-90.	2:00	-88.	2:15	-84.	2:30	-80.	2:45	-71.
3:00	-64.	3:15	-53.	3:30	-43.	3:45	-38.	4:00	-33.	4:15	-30.
4:30	-29.	4:45	-27.	5:00	-26.	5:15	-26.	5:30	-26.	5:45	-26.
6:00	-26.	6:15	-26.	6:30	-25.	6:45	-25.	7:00	-23.	7:15	-20.
7:30	-18.	7:45	-16.	8:00	-14.	8:15	-12.	8:30	-11.	8:45	-10.
9:00	-8.	9:15	-7.	9:30	-6.	9:45	-6.	10:00	-4.	10:15	-4.
10:30	-3.	10:45	-4.	11:00	-3.	11:15	-3.	11:30	-3.	11:45	-4.

PIEZOMETER #18

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-105.	1:45	-30.	2:00	-26.	2:15	-24.	2:30	-22.	2:45	-21.
3:00	-21.	3:15	-21.	3:30	-20.	3:45	-20.	4:00	-20.	4:15	-20.
4:30	-20.	4:45	-20.	5:00	-20.	5:15	-20.	5:30	-20.	5:45	-20.
6:00	-20.	6:15	-20.	6:30	-21.	6:45	-21.	7:00	-21.	7:15	-20.
7:30	-20.	7:45	-20.	8:00	-18.	8:15	-17.	8:30	-16.	8:45	-14.
9:00	-14.	9:15	-13.	9:30	-11.	9:45	-11.	10:00	-10.	10:15	-10.
10:30	-10.	10:45	-10.	11:00	-10.	11:15	-9.	11:30	-10.	11:45	-14.

PIEZOMETER #19

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-83.	1:45	-83.	2:00	-85.	2:15	-83.	2:30	-83.	2:45	-85.
3:00	-83.	3:15	-79.	3:30	-74.	3:45	-66.	4:00	-53.	4:15	-45.
4:30	-40.	4:45	-34.	5:00	-32.	5:15	-30.	5:30	-29.	5:45	-28.
6:00	-25.	6:15	-24.	6:30	-22.	6:45	-19.	7:00	-15.	7:15	-13.
7:30	-9.	7:45	-6.	8:00	-2.	8:15	-1.	8:30	2.	8:45	4.
9:00	5.	9:15	6.	9:30	8.	9:45	9.	10:00	9.	10:15	9.
10:30	10.	10:45	10.	11:00	10.	11:15	10.	11:30	10.	11:45	9.

PIEZOMETER #20

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-101.	1:45	-78.	2:00	-75.	2:15	-62.	2:30	-55.	2:45	-48.
3:00	-41.	3:15	-37.	3:30	-37.	3:45	-35.	4:00	-35.	4:15	-35.
4:30	-35.	4:45	-33.	5:00	-33.	5:15	-32.	5:30	-32.	5:45	-32.
6:00	-32.	6:15	-32.	6:30	-32.	6:45	-29.	7:00	-26.	7:15	-24.
7:30	-21.	7:45	-18.	8:00	-16.	8:15	-12.	8:30	-10.	8:45	-5.
9:00	-9.	9:15	-7.	9:30	-7.	9:45	-7.	10:00	-7.	10:15	-6.
10:30	-7.	10:45	-7.	11:00	-3.	11:15	-3.	11:30	-3.	11:45	-7.

PIEZOMETER #21

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-111.	1:45	-32.	2:00	-34.	2:15	-31.	2:30	-31.	2:45	-31.
3:00	-31.	3:15	-31.	3:30	-31.	3:45	-31.	4:00	-31.	4:15	-31.
4:30	-31.	4:45	-30.	5:00	-30.	5:15	-28.	5:30	-28.	5:45	-28.
6:00	-28.	6:15	-28.	6:30	-28.	6:45	-28.	7:00	-28.	7:15	-28.
7:30	-28.	7:45	-26.	8:00	-23.	8:15	-20.	8:30	-17.	8:45	-17.
9:00	-17.	9:15	-16.	9:30	-15.	9:45	-15.	10:00	-17.	10:15	-15.
10:30	-15.	10:45	-13.	11:00	-11.	11:15	-12.	11:30	-11.	11:45	-12.

PIEZOMETER #22

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-101.	1:45	-94.	2:00	-94.	2:15	-94.	2:30	-94.	2:45	-94.
3:00	-94.	3:15	-94.	3:30	-95.	3:45	-94.	4:00	-84.	4:15	-75.
4:30	-64.	4:45	-50.	5:00	-43.	5:15	-37.	5:30	-33.	5:45	-30.
6:00	-27.	6:15	-27.	6:30	-23.	6:45	-23.	7:00	-23.	7:15	-16.
7:30	-16.	7:45	-16.	8:00	1.	8:15	4.	8:30	4.	8:45	4.
9:00	4.	9:15	4.	9:30	3.	9:45	3.	10:00	3.	10:15	7.
10:30	4.	10:45	4.	11:00	4.	11:15	4.	11:30	4.	11:45	4.

PIEZOMETER #23

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-107.	1:45	-101.	2:00	-101.	2:15	-101.	2:30	-101.	2:45	-90.
3:00	-81.	3:15	-67.	3:30	-60.	3:45	-49.	4:00	-47.	4:15	-40.
4:30	-37.	4:45	-33.	5:00	-33.	5:15	-33.	5:30	-32.	5:45	-29.
6:00	-32.	6:15	-32.	6:30	-30.	6:45	-29.	7:00	-26.	7:15	-25.
7:30	-20.	7:45	-14.	8:00	-13.	8:15	-10.	8:30	-6.	8:45	-6.
9:00	-6.	9:15	-5.	9:30	-5.	9:45	-6.	10:00	-6.	10:15	-3.
10:30	-2.	10:45	-3.	11:00	1.	11:15	1.	11:30	-2.	11:45	1.

PIEZOMETER #24

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1:00	-144.	1:45	-146.	2:00	-143.	2:15	-143.	2:30	-138.	2:45	-133.
3:00	-124.	3:15	-118.	3:30	-105.	3:45	-97.	4:00	-91.	4:15	-84.
4:30	-77.	4:45	-76.	5:00	-70.	5:15	-70.	5:30	-67.	5:45	-63.
6:00	-63.	6:15	-63.	6:30	-62.	6:45	-62.	7:00	-62.	7:15	-62.
7:30	-62.	7:45	-61.	8:00	-61.	8:15	-62.	8:30	-62.	8:45	-62.
9:00	-62.	9:15	-62.	9:30	-62.	9:45	-62.	10:00	-62.	10:15	-62.
10:30	-62.	10:45	-62.	11:00	-62.	11:15	-62.	11:30	-62.	11:45	-62.

PIEZOMETER #24

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-97.	1.45	-96.	2.00	-96.	2.15	-96.	2.30	-96.	2.45	-96.
3.00	-95.	3.15	-96.	3.30	-96.	3.45	-96.	4.00	-93.	4.15	-83.
4.30	-72.	4.45	-57.	5.00	-50.	5.15	-45.	5.30	-39.	5.45	-35.
6.00	-28.	6.15	-26.	6.30	-22.	6.45	-19.	7.00	-15.	7.15	-11.
7.30	-8.	7.45	-1.	8.00	-1.	8.15	5.	8.30	5.	8.45	5.
9.00	5.	9.15	5.	9.30	4.	9.45	5.	10.00	5.	10.15	5.
10.30	5.	10.45	5.	11.00	8.	11.15	5.	11.30	5.	11.45	7.

PIEZOMETER #26

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-67.	1.45	-59.	2.00	-59.	2.15	-59.	2.30	-59.	2.45	-59.
3.00	-52.	3.15	-45.	3.30	-38.	3.45	-32.	4.00	-25.	4.15	-22.
4.30	-22.	4.45	-18.	5.00	-18.	5.15	-18.	5.30	-14.	5.45	-18.
6.00	-18.	6.15	-18.	6.30	-17.	6.45	-11.	7.00	-11.	7.15	-7.
7.30	-5.	7.45	-5.	8.00	2.	8.15	2.	8.30	2.	8.45	5.
9.00	5.	9.15	9.	9.30	9.	9.45	9.	10.00	9.	10.15	9.
10.30	9.	10.45	9.	11.00	9.	11.15	9.	11.30	13.	11.45	9.

PIEZOMETER #27

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-129.	1.45	-123.	2.00	-112.	2.15	-88.	2.30	-77.	2.45	-62.
3.00	-61.	3.15	-47.	3.30	-51.	3.45	-48.	4.00	-48.	4.15	-47.
4.30	-47.	4.45	-48.	5.00	-48.	5.15	-47.	5.30	-47.	5.45	-47.
6.00	-47.	6.15	-47.	6.30	-47.	6.45	-47.	7.00	-47.	7.15	-47.
7.30	-47.	7.45	-47.	8.00	-47.	8.15	-47.	8.30	-47.	8.45	-39.
9.00	-34.	9.15	-28.	9.30	-28.	9.45	-28.	10.00	-28.	10.15	-28.
10.30	-28.	10.45	-28.	11.00	-28.	11.15	-28.	11.30	-28.	11.45	-28.

PIEZOMETER #28

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-7.	1.45	-4.	2.00	-4.	2.15	-4.	2.30	-4.	2.45	-4.
3.00	-1.	3.15	0.	3.30	-4.	3.45	-3.	4.00	-4.	4.15	-4.
4.30	-4.	4.45	-4.	5.00	-4.	5.15	1.	5.30	6.	5.45	3.
6.00	3.	6.15	6.	6.30	10.	6.45	10.	7.00	16.	7.15	16.
7.30	16.	7.45	16.	8.00	23.	8.15	25.	8.30	26.	8.45	25.
9.00	26.	9.15	25.	9.30	27.	9.45	26.	10.00	23.	10.15	26.
10.30	23.	10.45	23.	11.00	26.	11.15	27.	11.30	27.	11.45	27.

PIEZOMETER #29

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-136.	1.45	-111.	2.00	-111.	2.15	-109.	2.30	-105.	2.45	-91.
3.00	-72.	3.15	-71.	3.30	-64.	3.45	-61.	4.00	-57.	4.15	-51.
4.30	-49.	4.45	-46.	5.00	-44.	5.15	-37.	5.30	-33.	5.45	-30.
6.00	-29.	6.15	-26.	6.30	-19.	6.45	-17.	7.00	-13.	7.15	-17.
7.30	-17.	7.45	-3.	8.00	-3.	8.15	-3.	8.30	-3.	8.45	-3.
9.00	-3.	9.15	-3.	9.30	-3.	9.45	-3.	10.00	-6.	10.15	-6.
10.30	-3.	10.45	-4.	11.00	-2.	11.15	-0.	11.30	2.	11.45	-3.

PIEZOMETER #30

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-160.	1.45	-54.	2.00	-40.	2.15	-37.	2.30	-33.	2.45	-33.
3.00	-13.	3.15	-33.	3.30	-33.	3.45	-33.	4.00	-32.	4.15	-29.
4.30	-28.	4.45	-27.	5.00	-27.	5.15	-27.	5.30	-27.	5.45	-27.
6.00	-25.	6.15	-20.	6.30	-20.	6.45	-20.	7.00	-13.	7.15	-17.
7.30	-12.	7.45	-13.	8.00	-9.	8.15	-6.	8.30	-6.	8.45	-6.
9.00	-6.	9.15	-6.	9.30	-5.	9.45	-6.	10.00	-6.	10.15	-6.
10.30	-5.	10.45	-2.	11.00	-2.	11.15	-4.	11.30	-4.	11.45	-2.

PIEZOMETER #31

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-129.	1.45	-126.	2.00	-123.	2.15	-120.	2.30	-97.	2.45	-94.
3.00	-12.	3.15	-5.	3.30	2.	3.45	2.	4.00	4.	4.15	7.
4.30	8.	4.45	8.	5.00	10.	5.15	11.	5.30	15.	5.45	15.
6.00	14.	6.15	15.	6.30	16.	6.45	15.	7.00	18.	7.15	18.
7.30	22.	7.45	22.	8.00	22.	8.15	22.	8.30	22.	8.45	22.
9.00	23.	9.15	22.	9.30	25.	9.45	22.	10.00	22.	10.15	22.
10.30	19.	10.45	25.	11.00	25.	11.15	26.	11.30	25.	11.45	22.

PIEZOMETER #32

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-177.	1.45	-15.	2.00	-15.	2.15	-12.	2.30	-10.	2.45	-10.
3.00	-10.	3.15	-7.	3.30	-7.	3.45	-6.	4.00	-2.	4.15	-2.
4.30	-2.	4.45	2.	5.00	5.	5.15	9.	5.30	11.	5.45	12.
6.00	12.	6.15	12.	6.30	12.	6.45	12.	7.00	13.	7.15	13.
7.30	12.	7.45	12.	8.00	12.	8.15	13.	8.30	13.	8.45	13.
9.00	13.	9.15	12.	9.30	13.	9.45	12.	10.00	12.	10.15	12.
10.30	13.	10.45	15.	11.00	15.	11.15	12.	11.30	12.	11.45	15.

PIEZOMETER #73

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-180.	1.45	-32.	2.00	-46.	2.15	-29.	2.30	-23.	2.45	-25.
3.00	-25.	3.15	-18.	3.30	-18.	3.45	-16.	4.00	-12.	4.15	-12.
4.30	-9.	4.45	-9.	5.00	-5.	5.15	-2.	5.30	-1.	5.45	1.
6.00	-1.	6.15	-2.	6.30	-2.	6.45	-1.	7.00	2.	7.15	2.
7.30	2.	7.45	2.	8.00	2.	8.15	2.	8.30	2.	8.45	3.
9.00	-3.	9.15	3.	9.30	2.	9.45	2.	10.00	2.	10.15	2.
10.30	2.	10.45	2.	11.00	2.	11.15	2.	11.30	2.	11.45	2.

PIEZOMETER #74

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-133.	1.45	-12.	2.00	-5.	2.15	-1.	2.30	2.	2.45	6.
3.00	6.	3.15	8.	3.30	10.	3.45	11.	4.00	15.	4.15	16.
4.30	18.	4.45	19.	5.00	22.	5.15	22.	5.30	23.	5.45	23.
6.00	19.	6.15	22.	6.30	22.	6.45	22.	7.00	22.	7.15	22.
7.30	22.	7.45	22.	8.00	22.	8.15	22.	8.30	22.	8.45	23.
9.00	23.	9.15	23.	9.30	22.	9.45	22.	10.00	22.	10.15	22.
10.30	22.	10.45	22.	11.00	22.	11.15	22.	11.30	22.	11.45	22.

PIEZOMETER #75

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-143.	1.45	-15.	2.00	-8.	2.15	-8.	2.30	-6.	2.45	-4.
3.00	-3.	3.15	-2.	3.30	-0.	3.45	1.	4.00	5.	4.15	5.
4.30	9.	4.45	8.	5.00	9.	5.15	11.	5.30	12.	5.45	12.
6.00	12.	6.15	11.	6.30	9.	6.45	9.	7.00	9.	7.15	9.
7.30	9.	7.45	9.	8.00	8.	8.15	8.	8.30	9.	8.45	12.
9.00	9.	9.15	9.	9.30	9.	9.45	9.	10.00	12.	10.15	8.
10.30	9.	10.45	9.	11.00	11.	11.15	8.	11.30	8.	11.45	8.

PIEZOMETER #76

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-153.	1.45	-153.	2.00	-149.	2.15	-114.	2.30	-58.	2.45	-19.
3.00	-5.	3.15	6.	3.30	8.	3.45	10.	4.00	15.	4.15	15.
4.30	19.	4.45	16.	5.00	18.	5.15	21.	5.30	19.	5.45	21.
6.00	15.	6.15	19.	6.30	18.	6.45	18.	7.00	19.	7.15	16.
7.30	18.	7.45	18.	8.00	15.	8.15	15.	8.30	15.	8.45	19.
9.00	18.	9.15	19.	9.30	18.	9.45	15.	10.00	15.	10.15	15.
10.30	15.	10.45	15.	11.00	19.	11.15	15.	11.30	15.	11.45	19.

PIEZOMETER #77

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-177.	1.45	-144.	2.00	-117.	2.15	-43.	2.30	-60.	2.45	-22.
3.00	-29.	3.15	-19.	3.30	-14.	3.45	-8.	4.00	-6.	4.15	-2.
4.30	2.	4.45	2.	5.00	1.	5.15	5.	5.30	5.	5.45	5.
6.00	2.	6.15	4.	6.30	2.	6.45	2.	7.00	2.	7.15	2.
7.30	2.	7.45	2.	8.00	2.	8.15	2.	8.30	2.	8.45	4.
9.00	2.	9.15	2.	9.30	-2.	9.45	-2.	10.00	-0.	10.15	-2.
10.30	-2.	10.45	-2.	11.00	-2.	11.15	-2.	11.30	-2.	11.45	-0.

PIEZOMETER #78

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-213.	1.45	-32.	2.00	-21.	2.15	-24.	2.30	-20.	2.45	-20.
3.00	-13.	3.15	-11.	3.30	-7.	3.45	-7.	4.00	-4.	4.15	-3.
4.30	0.	4.45	0.	5.00	0.	5.15	4.	5.30	3.	5.45	3.
6.00	3.	6.15	3.	6.30	0.	6.45	0.	7.00	0.	7.15	0.
7.30	0.	7.45	0.	8.00	0.	8.15	0.	8.30	0.	8.45	1.
9.00	1.	9.15	0.	9.30	-1.	9.45	-1.	10.00	-1.	10.15	-1.
10.30	1.	10.45	0.	11.00	3.	11.15	-3.	11.30	-3.	11.45	-3.

PIEZOMETER #79

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-142.	1.45	-98.	2.00	-24.	2.15	-3.	2.30	2.	2.45	6.
3.00	8.	3.15	10.	3.30	14.	3.45	17.	4.00	16.	4.15	17.
4.30	18.	4.45	20.	5.00	20.	5.15	18.	5.30	18.	5.45	20.
6.00	17.	6.15	21.	6.30	21.	6.45	18.	7.00	20.	7.15	18.
7.30	20.	7.45	20.	8.00	20.	8.15	20.	8.30	17.	8.45	21.
9.00	21.	9.15	20.	9.30	20.	9.45	18.	10.00	21.	10.15	17.
10.30	17.	10.45	17.	11.00	20.	11.15	17.	11.30	17.	11.45	20.

STOP

RAINFALL FLUX - EXPERIMENT #3

Recorded flow US gal/min	Time (hrs)	Δt	Rainfall cm/hr	Corrected Rainfall cm/hr	Rainfall flux cm/sec
0.3	5.25	8.30-1.45	1.8533	1.6680	0.000463
0.2	2.50	1.45-4.15	1.2353	1.1118	0.000309
0	4.25	4.15-8.30	-	-	-
0.3	1.75	8.30-10.15	1.8533	1.6680	0.000463
0.2	4.75	10.15-3.00	1.2353	1.1118	0.000309
0	6.25	3.00-9.15	-	-	-
0.3	2.50	9.15-11.45	1.8533	1.6680	0.000463
0.2	6.25	11.45-5.00	1.2353	1.1118	0.000309
0	2.0	5.00-7.00	-	-	-
0.3	1.75	7.00-8.45	1.8533	1.6680	0.00463

PHYSICAL SIMULATION #3
Tensiometer Co-ordinates

Tensiometer #	X Co-ordinate	Y Co-ordinate	Tensiometer #	X Co-ordinate	Y Co-ordinate
1	11	144	24	172	90.5
2	11	154	25	194	53
3	11	164	26	194	63
4	33	131	27	194	73
5	33	141	28	215	44
6	33	151	29	215	54
7	60	120	30	215	64
8	60	130	31	240	30
9	60	140	32	240	40
10	82	108	33	240	50
11	82	118	34	263	22.5
12	82	128	35	263	32.5
13	105	98	36	263	42.5
14	105	108	37	284	14
15	105	118	38	284	24
16	127.5	85	39	284	34
17	127.5	95	40	307.5	17
18	127.5	105	41	307.5	27
19	150	82	42	332.5	14
20	150	92	43	332.5	24
21	150	102	44	357.5	16
22	172	70.5	45	382.5	11
23	172	80.5			

EXPERIMENT 3

RUN #3

PIEZOMETER # 1

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-277.	1.50	-277.	1.00	-276.	1.25	-276.	1.50	-277.	1.75	-277.
2.00	-277.	2.25	-278.	2.50	-278.	2.75	-236.	3.00	-136.	3.25	-61.
3.50	-47.	3.75	-47.	4.00	-41.	4.25	-38.	4.50	-36.	4.75	-33.
13.75	-28.	14.00	-28.	14.50	-24.	14.75	-21.	15.00	-18.	15.25	-17.
15.50	-15.	16.00	-17.	16.25	-17.	16.50	-15.	24.75	-51.	25.00	-51.
25.25	-49.	25.50	-44.	25.75	-38.	26.00	-34.	26.25	-32.	26.50	-28.
27.00	-21.	27.50	-17.	27.75	-17.	28.00	-17.	28.25	-17.	28.50	-17.
29.00	-17.	29.25	-17.	29.50	-17.	29.75	-17.	30.00	-17.	30.50	-17.
32.50	-17.	34.50	-34.	36.75	-36.	35.00	-33.	35.25	-28.	35.50	-28.
35.75	-17.	36.00	-17.	36.25	-17.	36.50	-17.	37.00	-17.		

PIEZOMETER # 2

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-314.	1.50	-314.	1.00	-314.	1.25	-314.	1.50	-303.	1.75	-268.
2.00	-210.	2.25	-139.	2.50	-96.	2.75	-66.	3.00	-57.	3.25	-48.
3.50	-47.	3.75	-43.	4.00	-40.	4.25	-39.	4.50	-38.	4.75	-35.
13.75	-35.	14.00	-36.	14.50	-31.	14.75	-28.	15.00	-25.	15.25	-23.
15.50	-23.	16.00	-23.	16.25	-23.	16.50	-21.	24.75	-61.	25.00	-61.
25.25	-58.	25.50	-50.	25.75	-44.	26.00	-40.	26.25	-38.	26.50	-34.
27.00	-27.	27.50	-24.	27.75	-24.	28.00	-24.	28.25	-24.	28.50	-24.
29.00	-24.	29.25	-24.	29.50	-24.	29.75	-24.	30.00	-24.	30.50	-24.
32.50	-24.	34.50	-44.	36.75	-44.	35.00	-43.	35.25	-36.	35.50	-32.
35.75	-25.	36.00	-25.	36.25	-23.	36.50	-24.	37.00	-24.		

PIEZOMETER # 3

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-253.	1.50	-253.	1.00	-236.	1.25	-223.	1.50	-210.	1.75	-199.
2.00	-193.	2.25	-166.	2.50	-179.	2.75	-172.	3.00	-168.	3.25	-163.
3.50	-157.	3.75	-152.	4.00	-146.	4.25	-142.	4.50	-136.	4.75	-124.
13.75	-60.	14.00	-58.	14.50	-50.	14.75	-44.	15.00	-42.	15.25	-38.
15.50	-37.	16.00	-34.	16.25	-33.	16.50	-31.	24.75	-76.	25.00	-67.
25.25	-65.	25.50	-64.	25.75	-61.	26.00	-57.	26.25	-56.	26.50	-52.
27.00	-44.	27.50	-39.	27.75	-39.	28.00	-37.	28.25	-37.	28.50	-37.
29.00	-35.	29.25	-35.	29.50	-34.	29.75	-34.	30.00	-34.	30.50	-34.
32.50	-33.	34.50	-45.	36.75	-46.	35.00	-46.	35.25	-45.	35.50	-42.
35.75	-37.	36.00	-37.	36.25	-34.	36.50	-34.	37.00	-34.		

PIEZOMETER # 4

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-241.	1.50	-278.	1.00	-276.	1.25	-276.	1.50	-276.	1.75	-275.
2.00	-275.	2.25	-268.	2.50	-261.	2.75	-250.	3.00	-241.	3.25	-242.
3.50	-210.	3.75	-191.	4.00	-176.	4.25	-162.	4.50	-139.	4.75	-119.
13.75	-20.	14.00	-20.	14.50	-13.	14.75	-11.	15.00	-5.	15.25	-4.
15.50	-2.	16.00	-2.	16.25	-1.	16.50	-1.	24.75	-44.	25.00	-44.
25.25	-43.	25.50	-39.	25.75	-34.	26.00	-29.	26.25	-24.	26.50	-21.
27.00	-11.	27.50	-4.	27.75	-4.	28.00	-4.	28.25	-4.	28.50	-4.
29.00	-4.	29.25	-4.	29.50	-4.	29.75	-4.	30.00	-4.	30.50	-4.
32.50	-4.	34.50	-25.	36.75	-24.	35.00	-24.	35.25	-20.	35.50	-17.
35.75	-11.	36.00	-6.	36.25	-4.	36.50	-4.	37.00	-4.		

PIEZOMETER # 5

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-329.	1.50	-328.	1.00	-327.	1.25	-325.	1.50	-178.	1.75	-52.
2.00	-34.	2.25	-34.	2.50	-31.	2.75	-27.	3.00	-26.	3.25	-25.
3.50	-25.	3.75	-25.	4.00	-23.	4.25	-23.	4.50	-21.	4.75	-21.
13.75	-25.	14.00	-25.	14.50	-18.	14.75	-15.	15.00	-14.	15.25	-14.
15.50	-14.	16.00	-14.	16.25	-14.	16.50	-14.	24.75	-50.	25.00	-48.
25.25	-39.	25.50	-35.	25.75	-27.	26.00	-26.	26.25	-23.	26.50	-21.
27.00	-15.	27.50	-14.	27.75	-14.	28.00	-14.	28.25	-14.	28.50	-14.
29.00	-14.	29.25	-14.	29.50	-14.	29.75	-14.	30.00	-14.	30.50	-14.
32.50	-14.	34.50	-38.	36.75	-34.	35.00	-27.	35.25	-21.	35.50	-16.
35.75	-15.	36.00	-14.	36.25	-14.	36.50	-14.	37.00	-14.		

PIEZOMETER # 6

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-313.	1.50	-265.	1.00	-117.	1.25	-47.	1.50	-41.	1.75	-24.
2.00	-28.	2.25	-28.	2.50	-28.	2.75	-28.	3.00	-28.	3.25	-28.
3.50	-28.	3.75	-28.	4.00	-26.	4.25	-24.	4.50	-26.	4.75	-25.
13.75	-33.	14.00	-32.	14.50	-25.	14.75	-22.	15.00	-21.	15.25	-20.
15.50	-20.	16.00	-20.	16.25	-20.	16.50	-20.	24.75	-72.	25.00	-55.
25.25	-45.	25.50	-39.	25.75	-35.	26.00	-32.	26.25	-31.	26.50	-29.
27.00	-21.	27.50	-21.	27.75	-21.	28.00	-21.	28.25	-21.	28.50	-21.
29.00	-21.	29.25	-21.	29.50	-21.	29.75	-21.	30.00	-21.	30.50	-21.
32.50	-21.	34.50	-44.	36.75	-41.	35.00	-35.	35.25	-31.	35.50	-26.
35.75	-21.	36.00	-21.	36.25	-21.	36.50	-21.	37.00	-21.		

PIEZOMETER # 7

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-230.	1.50	-230.	1.00	-230.	1.25	-230.	1.50	-224.	1.75	-227.
2.00	-180.	2.25	-119.	2.50	-79.	2.75	-51.	3.00	-40.	3.25	-31.
3.50	-27.	3.75	-24.	4.00	-20.	4.25	-17.	4.50	-10.	4.75	-6.
13.75	-13.	14.00	-13.	14.50	-2.	14.75	0.	15.00	3.	15.25	3.
15.50	5.	16.00	5.	16.25	5.	16.50	5.	16.75	-40.	16.50	-40.
25.25	-30.	25.50	-31.	25.75	-21.	26.00	-10.	26.25	-10.	26.50	-5.
27.00	0.	27.50	3.	27.75	2.	28.00	2.	28.25	0.	28.50	0.
29.00	0.	29.25	0.	29.50	2.	29.75	0.	30.00	0.	30.50	0.
32.50	0.	34.50	-27.	34.75	-25.	35.00	-16.	35.25	-10.	35.50	-8.
35.75	0.	36.00	3.	36.25	3.	36.50	3.	37.00	3.		

PIEZOMETER # 8

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-250.	1.50	-203.	1.00	-246.	1.25	-119.	1.50	-54.	1.75	-38.
2.00	-30.	2.25	-27.	2.50	-27.	2.75	-27.	3.00	-26.	3.25	-26.
3.50	-24.	3.75	-23.	4.00	-23.	4.25	-20.	4.50	-16.	4.75	-12.
13.75	-23.	14.00	-10.	14.50	-10.	14.75	-8.	15.00	-8.	15.25	-7.
15.50	-7.	16.00	-5.	16.25	-5.	16.50	-7.	16.75	-40.	16.50	-45.
25.25	-37.	25.50	-30.	25.75	-23.	26.00	-18.	26.25	-14.	26.50	-11.
27.00	-8.	27.50	-7.	27.75	-8.	28.00	-7.	28.25	-8.	28.50	-8.
29.00	-8.	29.25	-8.	29.50	-7.	29.75	-8.	30.00	-8.	30.50	-8.
32.50	-8.	34.50	-34.	34.75	-28.	35.00	-22.	35.25	-15.	35.50	-10.
35.75	-8.	36.00	-7.	36.25	-7.	36.50	-7.	37.00	-7.		

PIEZOMETER # 9

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-334.	1.50	-318.	1.00	-211.	1.25	-106.	1.50	-48.	1.75	-32.
2.00	-34.	2.25	-28.	2.50	-26.	2.75	-24.	3.00	-24.	3.25	-24.
3.50	-24.	3.75	-22.	4.00	-22.	4.25	-21.	4.50	-20.	4.75	-17.
13.75	-29.	14.00	-24.	14.50	-15.	14.75	-13.	15.00	-13.	15.25	-13.
15.50	-13.	16.00	-13.	16.25	-13.	16.50	-13.	16.75	-67.	16.50	-45.
25.25	-37.	25.50	-30.	25.75	-26.	26.00	-22.	26.25	-20.	26.50	-18.
27.00	-13.	27.50	-13.	27.75	-13.	28.00	-13.	28.25	-13.	28.50	-13.
29.00	-13.	29.25	-13.	29.50	-13.	29.75	-13.	30.00	-13.	30.50	-13.
32.50	-13.	34.50	-40.	34.75	-33.	35.00	-26.	35.25	-20.	35.50	-17.
35.75	-13.	36.00	-13.	36.25	-13.	36.50	-13.	37.00	-13.		

PIEZOMETER # 10

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-201.	1.50	-203.	1.00	-202.	1.25	-202.	1.50	-202.	1.75	-115.
2.00	-40.	2.25	-32.	2.50	-29.	2.75	-27.	3.00	-25.	3.25	-25.
3.50	-21.	3.75	-16.	4.00	-11.	4.25	-5.	4.50	-1.	4.75	3.
13.75	-9.	14.00	-1.	14.50	6.	14.75	6.	15.00	6.	15.25	7.
15.50	7.	16.00	7.	16.25	7.	16.50	6.	16.75	-36.	16.50	-32.
25.25	-21.	25.50	-17.	25.75	-9.	26.00	-2.	26.25	2.	26.50	8.
27.00	6.	27.50	7.	27.75	6.	28.00	6.	28.25	6.	28.50	6.
29.00	6.	29.25	6.	29.50	6.	29.75	6.	30.00	6.	30.50	6.
32.50	6.	34.50	-20.	34.75	-15.	35.00	-4.	35.25	3.	35.50	6.
35.75	6.	36.00	8.	36.25	7.	36.50	7.	37.00	7.		

PIEZOMETER # 11

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-239.	1.50	-240.	1.00	-162.	1.25	-99.	1.50	-60.	1.75	-38.
2.00	-35.	2.25	-25.	2.50	-22.	2.75	-21.	3.00	-21.	3.25	-19.
3.50	-18.	3.75	-16.	4.00	-11.	4.25	-8.	4.50	-2.	4.75	1.
13.75	-16.	14.00	-6.	14.50	1.	14.75	2.	15.00	2.	15.25	2.
15.50	2.	16.00	2.	16.25	2.	16.50	2.	16.75	-46.	16.50	-39.
25.25	-26.	25.50	-23.	25.75	-16.	26.00	-8.	26.25	-4.	26.50	-0.
27.00	2.	27.50	2.	27.75	2.	28.00	1.	28.25	-0.	28.50	1.
29.00	1.	29.25	1.	29.50	2.	29.75	2.	30.00	2.	30.50	2.
32.50	2.	34.50	-29.	34.75	-25.	35.00	-14.	35.25	-8.	35.50	-0.
35.75	2.	36.00	2.	36.25	2.	36.50	2.	37.00	2.		

PIEZOMETER # 12

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-240.	1.50	-230.	1.00	-142.	1.25	-81.	1.50	-47.	1.75	-28.
2.00	-21.	2.25	-17.	2.50	-14.	2.75	-13.	3.00	-12.	3.25	-12.
3.50	-12.	3.75	-12.	4.00	-12.	4.25	-8.	4.50	-3.	4.75	-2.
13.75	-22.	14.00	-21.	14.50	-3.	14.75	-1.	15.00	1.	15.25	1.
15.50	-1.	16.00	-1.	16.25	-2.	16.50	-2.	16.75	-55.	16.50	-40.
25.25	-29.	25.50	-21.	25.75	-17.	26.00	-16.	26.25	-8.	26.50	-6.
27.00	-1.	27.50	-2.	27.75	-5.	28.00	-6.	28.25	-6.	28.50	-6.
29.00	-6.	29.25	-8.	29.50	-6.	29.75	-6.	30.00	-6.	30.50	-6.
32.50	-6.	34.50	-37.	34.75	-32.	35.00	-21.	35.25	-13.	35.50	-8.
35.75	-3.	36.00	-1.	36.25	-2.	36.50	-3.	37.00	-3.		

PIEZOMETER #13

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-191	1.50	-92	1.00	-73	1.25	-64	1.50	-45	1.75	-32
2.00	-29	2.25	-28	2.50	-25	2.75	-24	3.00	-22	3.25	-21
3.50	-17	3.75	-11	4.00	-5	4.25	-1	4.50	2	4.75	6
13.75	-6	14.00	1	14.50	6	14.75	6	15.00	8	15.25	8
15.50	8	16.00	8	16.25	8	16.50	10	24.75	-28	25.00	-28
25.25	-22	25.50	-15	25.75	-6	26.00	1	26.25	4	26.50	5
27.00	6	27.50	6	27.75	8	28.00	8	28.25	6	28.50	8
29.00	8	29.25	6	29.50	6	29.75	6	30.00	6	30.50	6
32.50	8	34.50	-18	34.75	-11	35.00	-2	35.25	4	35.50	6
35.75	6	36.00	8	36.25	8	36.50	8	37.00	8		

PIEZOMETER #14

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-207	1.50	-203	1.00	-53	1.25	-38	1.50	-34	1.75	-28
2.00	-28	2.25	-28	2.50	-28	2.75	-27	3.00	-25	3.25	-24
3.50	-19	3.75	-13	4.00	-8	4.25	-4	4.50	-1	4.75	0
13.75	-16	14.00	-4	14.50	2	14.75	2	15.00	2	15.25	2
15.50	2	16.00	2	16.25	2	16.50	2	24.75	-43	25.00	-32
25.25	-27	25.50	-19	25.75	-8	26.00	-1	26.25	-1	26.50	0
27.00	0	27.50	2	27.75	2	28.00	0	28.25	0	28.50	0
29.00	0	29.25	0	29.50	0	29.75	2	30.00	2	30.50	2
32.50	2	34.50	-28	34.75	-17	35.00	-8	35.25	-1	35.50	2
35.75	2	36.00	2	36.25	2	36.50	2	37.00	2		

PIEZOMETER #15

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-240	1.50	-231	1.00	-198	1.25	-171	1.50	-136	1.75	-96
2.00	-69	2.25	-48	2.50	-34	2.75	-21	3.00	-18	3.25	-14
3.50	-12	3.75	-11	4.00	-7	4.25	-4	4.50	-2	4.75	0
13.75	-34	14.00	-19	14.50	-15	14.75	-14	15.00	-18	15.25	-14
15.50	-14	16.00	-14	16.25	-15	16.50	-16	24.75	-80	25.00	-46
25.25	-41	25.50	-34	25.75	-23	26.00	-21	26.25	-19	26.50	-18
27.00	-8	27.50	-8	27.75	-8	28.00	-8	28.25	-10	28.50	-10
29.00	-10	29.25	-8	29.50	-10	29.75	-10	30.00	-10	30.50	-10
32.50	-8	34.50	-38	34.75	-26	35.00	-18	35.25	-12	35.50	-10
35.75	-8	36.00	-8	36.25	-8	36.50	-8	37.00	-8		

PIEZOMETER #16

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-181	1.50	-182	1.00	-180	1.25	-180	1.50	-179	1.75	-173
2.00	-160	2.25	-134	2.50	-110	2.75	-84	3.00	-64	3.25	-51
3.50	-41	3.75	-26	4.00	-15	4.25	-8	4.50	-3	4.75	7
13.75	-3	14.00	-1	14.50	3	14.75	3	15.00	3	15.25	3
15.50	4	16.00	4	16.25	4	16.50	3	24.75	-33	25.00	-28
25.25	-16	25.50	-15	25.75	-8	26.00	-1	26.25	1	26.50	3
27.00	3	27.50	3	27.75	3	28.00	3	28.25	3	28.50	3
29.00	3	29.25	3	29.50	3	29.75	3	30.00	3	30.50	3
32.50	3	34.50	-15	34.75	-12	35.00	-7	35.25	-0	35.50	4
35.75	4	36.00	4	36.25	4	36.50	3	37.00	3		

PIEZOMETER #17

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-194	1.50	-184	1.00	-91	1.25	-52	1.50	-37	1.75	-30
2.00	-29	2.25	-26	2.50	-26	2.75	-26	3.00	-23	3.25	-22
3.50	-18	3.75	-12	4.00	-6	4.25	-0	4.50	5	4.75	5
13.75	-10	14.00	-0	14.50	4	14.75	5	15.00	5	15.25	7
15.50	7	16.00	7	16.25	5	16.50	5	24.75	-35	25.00	-27
25.25	-21	25.50	-14	25.75	-8	26.00	-2	26.25	1	26.50	2
27.00	5	27.50	5	27.75	5	28.00	5	28.25	5	28.50	5
29.00	5	29.25	5	29.50	5	29.75	5	30.00	5	30.50	5
32.50	5	34.50	-22	34.75	-12	35.00	-10	35.25	1	35.50	2
35.75	4	36.00	5	36.25	4	36.50	5	37.00	5		

PIEZOMETER #18

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-207	1.50	-45	1.00	-34	1.25	-31	1.50	-28	1.75	-26
2.00	-26	2.25	-26	2.50	-26	2.75	-26	3.00	-25	3.25	-25
3.50	-22	3.75	-20	4.00	-13	4.25	-9	4.50	-8	4.75	-6
13.75	-24	14.00	-12	14.50	-8	14.75	-6	15.00	-6	15.25	-6
15.50	-6	16.00	-6	16.25	-8	16.50	-8	24.75	-50	25.00	-37
25.25	-32	25.50	-26	25.75	-16	26.00	-12	26.25	-9	26.50	-9
27.00	-8	27.50	-8	27.75	-8	28.00	-8	28.25	-8	28.50	-8
29.00	-8	29.25	-9	29.50	-8	29.75	-8	30.00	-8	30.50	-8
32.50	-8	34.50	-36	34.75	-25	35.00	-21	35.25	-12	35.50	-8
35.75	-9	36.00	-8	36.25	-8	36.50	-6	37.00	-8		

PIEZOMETER #19											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-170.	1.50	-170.	1.00	-170.	1.25	-168.	1.50	-154.	1.75	-131.
2.00	-101.	2.25	-72.	2.50	-55.	2.75	-43.	3.00	-38.	3.25	-33.
3.50	-29.	3.75	-18.	4.00	-7.	4.25	-2.	4.50	2.	4.75	5.
13.75	-3.	14.00	0.	14.50	0.	14.75	0.	15.00	0.	15.25	0.
15.50	0.	16.00	0.	16.25	0.	16.50	0.	16.75	-28.	16.50	-17.
25.25	-10.	25.50	-3.	25.75	4.	26.00	4.	26.25	8.	26.50	8.
27.00	0.	27.50	0.	27.75	0.	28.00	0.	28.25	0.	28.50	0.
29.00	0.	29.25	0.	29.50	0.	29.75	0.	30.00	0.	30.50	0.
32.50	0.	34.50	-13.	34.75	-3.	35.00	5.	35.25	0.	35.50	0.
35.75	0.	36.00	0.	36.25	0.	36.50	0.	37.00	0.		

PIEZOMETER #20											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-167.	1.50	-165.	1.00	-115.	1.25	-65.	1.50	-38.	1.75	-28.
2.00	-24.	2.25	-22.	2.50	-20.	2.75	-18.	3.00	-16.	3.25	-15.
3.50	-12.	3.75	-4.	4.00	0.	4.25	5.	4.50	10.	4.75	14.
13.75	-1.	14.00	10.	14.50	10.	14.75	10.	15.00	12.	15.25	12.
15.50	12.	16.00	12.	16.25	12.	16.50	12.	16.75	-24.	16.50	-15.
25.25	-7.	25.50	5.	25.75	14.	26.00	14.	26.25	14.	26.50	14.
27.00	14.	27.50	14.	27.75	14.	28.00	12.	28.25	12.	28.50	12.
29.00	11.	29.25	11.	29.50	11.	29.75	11.	30.00	11.	30.50	11.
32.50	11.	34.50	-12.	34.75	-1.	35.00	5.	35.25	11.	35.50	14.
35.75	14.	36.00	14.	36.25	14.	36.50	14.	37.00	14.		

PIEZOMETER #21											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-190.	1.50	-56.	1.00	-26.	1.25	-25.	1.50	-21.	1.75	-21.
2.00	-21.	2.25	-18.	2.50	-17.	2.75	-15.	3.00	-14.	3.25	-14.
3.50	-13.	3.75	-5.	4.00	-5.	4.25	-0.	4.50	4.	4.75	4.
13.75	-11.	14.00	-0.	14.50	-0.	14.75	-0.	15.00	2.	15.25	2.
15.50	2.	16.00	2.	16.25	2.	16.50	2.	16.75	-34.	16.50	-21.
25.25	-17.	25.50	-5.	25.75	4.	26.00	4.	26.25	4.	26.50	4.
27.00	4.	27.50	4.	27.75	4.	28.00	2.	28.25	2.	28.50	2.
29.00	1.	29.25	1.	29.50	1.	29.75	1.	30.00	1.	30.50	1.
32.50	1.	34.50	-22.	34.75	-11.	35.00	-5.	35.25	1.	35.50	4.
35.75	4.	36.00	4.	36.25	4.	36.50	4.	37.00	4.		

PIEZOMETER #22											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-141.	1.50	-144.	1.00	-143.	1.25	-138.	1.50	-133.	1.75	-121.
2.00	-103.	2.25	-76.	2.50	-53.	2.75	-37.	3.00	-31.	3.25	-27.
3.50	-25.	3.75	-12.	4.00	-4.	4.25	2.	4.50	4.	4.75	13.
13.75	8.	14.00	15.	14.50	19.	14.75	14.	15.00	25.	15.25	25.
15.50	25.	16.00	25.	16.25	25.	16.50	25.	16.75	10.	16.50	-4.
25.25	2.	25.50	6.	25.75	12.	26.00	17.	26.25	17.	26.50	20.
27.00	20.	27.50	20.	27.75	20.	28.00	19.	28.25	19.	28.50	19.
29.00	17.	29.25	17.	29.50	17.	29.75	17.	30.00	17.	30.50	17.
32.50	17.	34.50	-2.	34.75	5.	35.00	12.	35.25	20.	35.50	20.
35.75	20.	36.00	20.	36.25	20.	36.50	20.	37.00	20.		

PIEZOMETER #23											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-152.	1.50	-148.	1.00	-120.	1.25	-71.	1.50	-49.	1.75	-41.
2.00	-37.	2.25	-33.	2.50	-30.	2.75	-26.	3.00	-23.	3.25	-22.
3.50	-19.	3.75	-13.	4.00	-5.	4.25	1.	4.50	6.	4.75	9.
13.75	12.	14.00	6.	14.50	12.	14.75	12.	15.00	12.	15.25	12.
15.50	12.	16.00	12.	16.25	12.	16.50	12.	16.75	-21.	16.50	-17.
25.25	-11.	25.50	-6.	25.75	1.	26.00	1.	26.25	6.	26.50	9.
27.00	9.	27.50	9.	27.75	9.	28.00	8.	28.25	8.	28.50	8.
29.00	6.	29.25	6.	29.50	6.	29.75	6.	30.00	6.	30.50	6.
32.50	6.	34.50	-13.	34.75	-6.	35.00	3.	35.25	9.	35.50	9.
35.75	9.	36.00	9.	36.25	9.	36.50	9.	37.00	9.		

PIEZOMETER #24											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-172.	1.50	-154.	1.00	-111.	1.25	-70.	1.50	-47.	1.75	-40.
2.00	-39.	2.25	-36.	2.50	-32.	2.75	-31.	3.00	-29.	3.25	-27.
3.50	-24.	3.75	-20.	4.00	-12.	4.25	-4.	4.50	-2.	4.75	4.
13.75	-13.	14.00	-2.	14.50	4.	14.75	4.	15.00	-1.	15.25	-1.
15.50	-1.	16.00	-1.	16.25	-1.	16.50	-1.	16.75	-32.	16.50	-27.
25.25	-21.	25.50	-16.	25.75	-9.	26.00	-6.	26.25	-6.	26.50	-4.
27.00	-1.	27.50	-1.	27.75	-1.	28.00	-1.	28.25	-1.	28.50	-1.
29.00	-2.	29.25	-2.	29.50	-2.	29.75	-2.	30.00	-2.	30.50	-2.
32.50	-2.	34.50	-23.	34.75	-13.	35.00	-9.	35.25	-4.	35.50	-1.
35.75	-1.	36.00	-1.	36.25	-1.	36.50	-1.	37.00	-1.		

PIEZOMETER #25

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-127	1.50	-127	1.00	-126	1.25	-123	1.50	-120	1.75	-117
2.00	-112	2.25	-107	2.50	-101	2.75	-90	3.00	-82	3.25	-66
3.50	-55	3.75	-40	4.00	-21	4.25	-9	4.50	6	4.75	13
13.75	15	14.00	19	14.50	22	14.75	22	15.00	23	15.25	23
15.50	23	16.00	23	16.25	23	16.50	23	16.75	-1	16.50	6
25.25	11	25.50	14	25.75	18	26.00	21	26.25	22	26.50	22
27.00	22	27.50	23	27.75	23	28.00	23	28.25	23	28.50	23
29.00	23	29.25	23	29.50	22	29.75	22	30.00	22	30.50	22
32.50	22	34.50	5	34.75	10	35.00	17	35.25	21	35.50	22
35.75	22	36.00	23	36.25	23	36.50	23	37.00	22		

PIEZOMETER #26

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-139	1.50	-130	1.00	-114	1.25	-92	1.50	-76	1.75	-66
2.00	-61	2.25	-57	2.50	-53	2.75	-50	3.00	-46	3.25	-43
3.50	-42	3.75	-37	4.00	-27	4.25	-19	4.50	-7	4.75	-6
13.75	3	14.00	5	14.50	9	14.75	11	15.00	11	15.25	12
15.50	12	16.00	12	16.25	12	16.50	12	16.75	-14	16.50	-7
25.25	-6	25.50	3	25.75	5	26.00	8	26.25	11	26.50	9
27.00	11	27.50	11	27.75	11	28.00	11	28.25	11	28.50	11
29.00	11	29.25	11	29.50	9	29.75	9	30.00	9	30.50	9
32.50	9	34.50	-8	34.75	-1	35.00	5	35.25	7	35.50	9
35.75	11	36.00	11	36.25	11	36.50	12	37.00	11		

PIEZOMETER #27

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-151	1.50	-82	1.00	-51	1.25	-44	1.50	-44	1.75	-43
2.00	-81	2.25	-41	2.50	-41	2.75	-41	3.00	-41	3.25	-40
3.50	-39	3.75	-36	4.00	-30	4.25	-24	4.50	-13	4.75	-7
13.75	-10	14.00	-5	14.50	-2	14.75	-1	15.00	-1	15.25	-1
15.50	-1	16.00	-2	16.25	-2	16.50	-3	16.75	-20	16.50	-18
25.25	-13	25.50	-11	25.75	-7	26.00	-6	26.25	-5	26.50	-5
27.00	-3	27.50	3	27.75	3	28.00	2	28.25	2	28.50	2
29.00	2	29.25	2	29.50	1	29.75	1	30.00	1	30.50	1
32.50	1	34.50	-20	34.75	-10	35.00	-5	35.25	-2	35.50	2
35.75	2	36.00	3	36.25	2	36.50	2	37.00	2		

PIEZOMETER #28

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-122	1.50	-121	1.00	-121	1.25	-119	1.50	-117	1.75	-117
2.00	-117	2.25	-117	2.50	-110	2.75	-106	3.00	-104	3.25	-100
3.50	-94	3.75	-79	4.00	-77	4.25	-68	4.50	-52	4.75	1
13.75	9	14.00	15	14.50	16	14.75	16	15.00	16	15.25	16
15.50	16	16.00	16	16.25	16	16.50	16	16.75	-2	16.50	2
25.25	6	25.50	9	25.75	-13	26.00	13	26.25	14	26.50	14
27.00	16	27.50	16	27.75	16	28.00	16	28.25	16	28.50	16
29.00	16	29.25	16	29.50	16	29.75	16	30.00	16	30.50	16
32.50	16	34.50	2	34.75	9	35.00	10	35.25	13	35.50	13
35.75	14	36.00	14	36.25	16	36.50	14	37.00	16		

PIEZOMETER #29

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-132	1.50	-129	1.00	-125	1.25	-123	1.50	-110	1.75	-101
2.00	-95	2.25	-89	2.50	-82	2.75	-74	3.00	-73	3.25	-69
3.50	-63	3.75	-59	4.00	-53	4.25	-49	4.50	-28	4.75	-12
13.75	-1	14.00	3	14.50	6	14.75	6	15.00	4	15.25	6
15.50	6	16.00	6	16.25	6	16.50	6	16.75	-13	16.50	-8
25.25	-4	25.50	-1	25.75	0	26.00	2	26.25	3	26.50	3
27.00	4	27.50	6	27.75	4	28.00	4	28.25	4	28.50	4
29.00	4	29.25	4	29.50	3	29.75	3	30.00	3	30.50	3
32.50	3	34.50	-9	34.75	-3	35.00	-1	35.25	2	35.50	3
35.75	3	36.00	2	36.25	3	36.50	3	37.00	3		

PIEZOMETER #30

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-144	1.50	-143	1.00	-141	1.25	-140	1.50	-130	1.75	-124
2.00	-117	2.25	-111	2.50	-105	2.75	-94	3.00	-87	3.25	-78
3.50	-72	3.75	-65	4.00	-61	4.25	-59	4.50	-52	4.75	-29
13.75	-11	14.00	-7	14.50	-4	14.75	-4	15.00	-4	15.25	-4
15.50	-4	16.00	-4	16.25	-4	16.50	-7	16.75	-25	16.50	-18
25.25	-15	25.50	-11	25.75	-10	26.00	-10	26.25	-8	26.50	-7
27.00	-7	27.50	-2	27.75	-2	28.00	-2	28.25	-2	28.50	-3
29.00	-2	29.25	-3	29.50	-3	29.75	-2	30.00	-2	30.50	-2
32.50	-3	34.50	-18	34.75	-11	35.00	-7	35.25	-4	35.50	-4
35.75	-3	36.00	-3	36.25	-2	36.50	-3	37.00	-3		

PIEZOMETER #31

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-82.	1.50	-82.	1.00	-80.	1.25	-74.	1.50	-78.	1.75	-65.
2.00	-61.	2.25	-58.	2.50	-33.	2.75	-1.	3.00	7.	3.25	13.
3.50	14.	3.75	15.	4.00	18.	4.25	18.	4.50	21.	4.75	24.
13.75	40.	14.00	40.	14.50	41.	14.75	42.	15.00	42.	15.25	42.
15.50	42.	16.00	42.	16.25	44.	16.50	42.	24.75	34.	25.00	34.
25.25	38.	25.50	38.	25.75	38.	26.00	38.	26.25	38.	26.50	38.
27.00	38.	27.50	40.	27.75	40.	28.00	40.	28.25	40.	28.50	40.
29.00	40.	29.25	40.	29.50	40.	29.75	38.	30.00	38.	30.50	38.
32.50	38.	34.50	34.	34.75	34.	35.00	37.	35.25	36.	35.50	38.
35.75	38.	36.00	38.	36.25	38.	36.50	38.	37.00	38.		

PIEZOMETER #32

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-118.	1.50	-111.	1.00	-106.	1.25	-102.	1.50	-98.	1.75	-69.
2.00	-60.	2.25	-50.	2.50	-45.	2.75	-30.	3.00	-26.	3.25	-20.
3.50	-19.	3.75	-16.	4.00	-15.	4.25	-15.	4.50	-11.	4.75	-6.
13.75	4.	14.00	8.	14.50	9.	14.75	8.	15.00	8.	15.25	8.
15.50	8.	16.00	8.	16.25	8.	16.50	8.	24.75	-8.	25.00	-3.
25.25	5.	25.50	7.	25.75	8.	26.00	8.	26.25	8.	26.50	8.
27.00	8.	27.50	8.	27.75	9.	28.00	9.	28.25	8.	28.50	8.
29.00	8.	29.25	8.	29.50	8.	29.75	8.	30.00	8.	30.50	8.
32.50	8.	34.50	-1.	34.75	5.	35.00	7.	35.25	8.	35.50	8.
35.75	8.	36.00	8.	36.25	8.	36.50	8.	37.00	8.		

PIEZOMETER #33

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-130.	1.50	-111.	1.00	-86.	1.25	-56.	1.50	-43.	1.75	-33.
2.00	-30.	2.25	-30.	2.50	-32.	2.75	-32.	3.00	-32.	3.25	-29.
3.50	-26.	3.75	-24.	4.00	-22.	4.25	-21.	4.50	-20.	4.75	-16.
13.75	-3.	14.00	-1.	14.50	-1.	14.75	-1.	15.00	-1.	15.25	-1.
15.50	-1.	16.00	-1.	16.25	-1.	16.50	-1.	24.75	-16.	25.00	-6.
25.25	-3.	25.50	-2.	25.75	-2.	26.00	-2.	26.25	-2.	26.50	-2.
27.00	-2.	27.50	-1.	27.75	-1.	28.00	-2.	28.25	-1.	28.50	-1.
29.00	-1.	29.25	-2.	29.50	-2.	29.75	-2.	30.00	-2.	30.50	-2.
32.50	-2.	34.50	-11.	34.75	-3.	35.00	-2.	35.25	-2.	35.50	-2.
35.75	-2.	36.00	-2.	36.25	-2.	36.50	-2.	37.00	-2.		

PIEZOMETER #34

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-82.	1.50	-90.	1.00	-80.	1.25	-87.	1.50	-81.	1.75	-40.
2.00	-14.	2.25	-1.	2.50	6.	2.75	11.	3.00	13.	3.25	16.
3.50	16.	3.75	17.	4.00	18.	4.25	20.	4.50	20.	4.75	22.
13.75	26.	14.00	28.	14.50	29.	14.75	29.	15.00	29.	15.25	28.
15.50	28.	16.00	28.	16.25	28.	16.50	28.	24.75	20.	25.00	25.
25.25	26.	25.50	26.	25.75	26.	26.00	26.	26.25	26.	26.50	26.
27.00	26.	27.50	26.	27.75	26.	28.00	26.	28.25	26.	28.50	26.
29.00	26.	29.25	26.	29.50	26.	29.75	26.	30.00	26.	30.50	26.
32.50	26.	34.50	22.	34.75	25.	35.00	25.	35.25	25.	35.50	25.
35.75	25.	36.00	25.	36.25	25.	36.50	25.	37.00	26.		

PIEZOMETER #35

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-122.	1.50	-121.	1.00	-27.	1.25	-19.	1.50	-16.	1.75	-16.
2.00	-16.	2.25	-15.	2.50	-12.	2.75	-7.	3.00	-5.	3.25	-4.
3.50	-3.	3.75	-1.	4.00	-1.	4.25	-1.	4.50	0.	4.75	3.
13.75	4.	14.00	11.	14.50	11.	14.75	11.	15.00	11.	15.25	11.
15.50	11.	16.00	11.	16.25	11.	16.50	11.	24.75	0.	25.00	8.
25.25	10.	25.50	10.	25.75	10.	26.00	10.	26.25	10.	26.50	10.
27.00	10.	27.50	11.	27.75	11.	28.00	10.	28.25	10.	28.50	10.
29.00	10.	29.25	11.	29.50	10.	29.75	8.	30.00	8.	30.50	8.
32.50	10.	34.50	11.	34.75	8.	35.00	8.	35.25	10.	35.50	10.
35.75	8.	36.00	-10.	36.25	10.	36.50	8.	37.00	10.		

PIEZOMETER #36

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-152.	1.50	-46.	1.00	-10.	1.25	-9.	1.50	-9.	1.75	-9.
2.00	-10.	2.25	-11.	2.50	-13.	2.75	-11.	3.00	-10.	3.25	-9.
3.50	-9.	3.75	-7.	4.00	-6.	4.25	-6.	4.50	-4.	4.75	-2.
13.75	-4.	14.00	1.	14.50	2.	14.75	2.	15.00	2.	15.25	2.
15.50	2.	16.00	2.	16.25	2.	16.50	1.	24.75	-10.	25.00	-8.
25.25	1.	25.50	1.	25.75	-0.	26.00	1.	26.25	1.	26.50	1.
27.00	1.	27.50	1.	27.75	1.	28.00	1.	28.25	1.	28.50	1.
29.00	1.	29.25	2.	29.50	1.	29.75	1.	30.00	1.	30.50	1.
32.50	1.	34.50	-9.	34.75	-2.	35.00	-0.	35.25	-0.	35.50	1.
35.75	1.	36.00	1.	36.25	1.	36.50	-0.	37.00	1.		

PIEZOMETER #37											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-113.	1.50	-114.	1.00	-114.	1.25	-112.	1.50	-114.	1.75	-111.
2.00	-60.	2.25	-3.	2.50	8.	2.75	14.	3.00	14.	3.25	16.
3.50	16.	3.75	18.	4.00	18.	4.25	19.	4.50	19.	4.75	20.
13.75	25.	14.00	27.	14.50	27.	14.75	27.	15.00	27.	15.25	27.
15.50	27.	16.00	27.	16.25	27.	16.50	26.	16.75	19.	16.50	25.
25.25	25.	25.50	25.	25.75	25.	26.00	25.	26.25	25.	26.50	25.
27.00	25.	27.50	23.	27.75	23.	28.00	23.	28.25	23.	28.50	23.
29.00	23.	29.25	23.	29.50	23.	29.75	23.	30.00	23.	30.50	23.
32.50	22.	34.50	19.	34.75	22.	35.00	23.	35.25	23.	35.50	23.
35.75	23.	36.00	23.	36.25	23.	36.50	23.	37.00	23.		

PIEZOMETER #38											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-127.	1.50	-127.	1.00	-125.	1.25	-117.	1.50	-80.	1.75	-30.
2.00	-14.	2.25	-4.	2.50	1.	2.75	5.	3.00	6.	3.25	6.
3.50	9.	3.75	9.	4.00	9.	4.25	10.	4.50	10.	4.75	10.
13.75	10.	14.00	17.	14.50	17.	14.75	17.	15.00	17.	15.25	17.
15.50	17.	16.00	17.	16.25	17.	16.50	16.	16.75	6.	16.50	15.
25.25	15.	25.50	15.	25.75	15.	26.00	14.	26.25	15.	26.50	16.
27.00	16.	27.50	16.	27.75	16.	28.00	15.	28.25	15.	28.50	15.
29.00	15.	29.25	15.	29.50	15.	29.75	15.	30.00	15.	30.50	15.
32.50	15.	34.50	10.	34.75	15.	35.00	15.	35.25	15.	35.50	15.
35.75	15.	36.00	15.	36.25	15.	36.50	15.	37.00	15.		

PIEZOMETER #39											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-149.	1.50	-82.	1.00	-25.	1.25	-18.	1.50	-17.	1.75	-16.
2.00	-17.	2.25	-14.	2.50	-10.	2.75	-6.	3.00	-5.	3.25	-5.
3.50	-2.	3.75	-1.	4.00	-1.	4.25	0.	4.50	0.	4.75	2.
13.75	2.	14.00	7.	14.50	7.	14.75	7.	15.00	7.	15.25	7.
15.50	7.	16.00	7.	16.25	7.	16.50	6.	16.75	-2.	16.50	6.
25.25	6.	25.50	6.	25.75	6.	26.00	6.	26.25	6.	26.50	6.
27.00	6.	27.50	6.	27.75	6.	28.00	5.	28.25	5.	28.50	5.
29.00	5.	29.25	5.	29.50	5.	29.75	5.	30.00	5.	30.50	5.
32.50	5.	34.50	-4.	34.75	5.	35.00	5.	35.25	5.	35.50	5.
35.75	5.	36.00	5.	36.25	5.	36.50	5.	37.00	5.		

PIEZOMETER #40											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-129.	1.50	-128.	1.00	-126.	1.25	-123.	1.50	-77.	1.75	-20.
2.00	-1.	2.25	5.	2.50	8.	2.75	12.	3.00	13.	3.25	13.
3.50	13.	3.75	15.	4.00	16.	4.25	16.	4.50	16.	4.75	16.
13.75	16.	14.00	20.	14.50	20.	14.75	20.	15.00	20.	15.25	20.
15.50	20.	16.00	20.	16.25	19.	16.50	19.	16.75	11.	16.50	17.
25.25	19.	25.50	17.	25.75	19.	26.00	19.	26.25	19.	26.50	19.
27.00	19.	27.50	19.	27.75	17.	28.00	17.	28.25	17.	28.50	17.
29.00	17.	29.25	17.	29.50	17.	29.75	17.	30.00	17.	30.50	17.
32.50	17.	34.50	11.	34.75	17.	35.00	17.	35.25	17.	35.50	17.
35.75	17.	36.00	17.	36.25	17.	36.50	17.	37.00	17.		

PIEZOMETER #41											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-153.	1.50	-151.	1.00	-140.	1.25	-128.	1.50	-114.	1.75	-109.
2.00	-98.	2.25	-40.	2.50	-6.	2.75	-1.	3.00	3.	3.25	3.
3.50	3.	3.75	5.	4.00	6.	4.25	6.	4.50	6.	4.75	6.
13.75	6.	14.00	10.	14.50	10.	14.75	10.	15.00	10.	15.25	10.
15.50	10.	16.00	10.	16.25	9.	16.50	9.	16.75	1.	16.50	9.
25.25	9.	25.50	9.	25.75	9.	26.00	9.	26.25	9.	26.50	9.
27.00	9.	27.50	9.	27.75	7.	28.00	7.	28.25	7.	28.50	7.
29.00	7.	29.25	7.	29.50	7.	29.75	7.	30.00	7.	30.50	7.
32.50	7.	34.50	1.	34.75	7.	35.00	7.	35.25	7.	35.50	7.
35.75	7.	36.00	7.	36.25	7.	36.50	7.	37.00	7.		

PIEZOMETER #42											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-130.	1.50	-129.	1.00	-49.	1.25	-1.	1.50	7.	1.75	10.
2.00	10.	2.25	12.	2.50	14.	2.75	14.	3.00	14.	3.25	14.
3.50	15.	3.75	16.	4.00	16.	4.25	15.	4.50	16.	4.75	16.
13.75	16.	14.00	19.	14.50	19.	14.75	19.	15.00	19.	15.25	19.
15.50	19.	16.00	19.	16.25	19.	16.50	19.	16.75	12.	16.50	19.
25.25	18.	25.50	19.	25.75	19.	26.00	19.	26.25	19.	26.50	19.
27.00	19.	27.50	19.	27.75	19.	28.00	18.	28.25	18.	28.50	18.
29.00	18.	29.25	18.	29.50	18.	29.75	18.	30.00	18.	30.50	18.
32.50	18.	34.50	14.	34.75	18.	35.00	18.	35.25	18.	35.50	18.
35.75	18.	36.00	18.	36.25	18.	36.50	18.	37.00	18.		

PIEZOMETER #43											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-156	1.50	-56	1.00	-11	1.25	-6	1.50	-9	1.75	2
2.00	0	2.25	5	2.50	5	2.75	6	3.00	6	3.25	6
3.50	0	3.75	8	4.00	8	4.25	8	4.50	8	4.75	8
13.75	5	14.00	9	14.50	9	14.75	9	15.00	9	15.25	9
15.50	9	16.00	9	16.25	9	16.50	9	16.75	9	17.00	9
25.25	9	25.50	9	25.75	9	26.00	9	26.25	9	26.50	9
27.00	9	27.50	9	27.75	9	28.00	8	28.25	8	28.50	8
29.00	8	29.25	8	29.50	8	29.75	8	30.00	8	30.50	8
32.50	8	34.50	1	34.75	8	35.00	8	35.25	8	35.50	8
35.75	8	36.00	8	36.25	8	36.50	8	37.00	8		

PIEZOMETER #44											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-161	1.50	-151	1.00	-90	1.25	-17	1.50	6	1.75	9
2.00	10	2.25	10	2.50	9	2.75	9	3.00	10	3.25	10
3.50	10	3.75	10	4.00	10	4.25	10	4.50	10	4.75	10
13.75	14	14.00	13	14.50	13	14.75	12	15.00	13	15.25	12
15.50	12	16.00	12	16.25	12	16.50	12	16.75	9	17.00	10
25.25	10	25.50	10	25.75	10	26.00	10	26.25	12	26.50	12
27.00	12	27.50	12	27.75	12	28.00	12	28.25	12	28.50	10
29.00	10	29.25	10	29.50	10	29.75	10	30.00	10	30.50	10
32.50	10	34.50	9	34.75	10	35.00	10	35.25	10	35.50	10
35.75	10	36.00	10	36.25	10	36.50	10	37.00	10		

PIEZOMETER #45											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-229	1.50	-188	1.00	-12	1.25	11	1.50	11	1.75	11
2.00	13	2.25	13	2.50	13	2.75	11	3.00	11	3.25	11
3.50	11	3.75	11	4.00	13	4.25	13	4.50	11	4.75	13
13.75	23	14.00	25	14.50	25	14.75	25	15.00	25	15.25	25
15.50	25	16.00	25	16.25	25	16.50	23	16.75	23	17.00	23
25.25	23	25.50	23	25.75	23	26.00	23	26.25	23	26.50	23
27.00	23	27.50	23	27.75	23	28.00	23	28.25	23	28.50	23
29.00	23	29.25	23	29.50	23	29.75	23	30.00	23	30.50	23
32.50	23	34.50	23	34.75	23	35.00	23	35.25	23	35.50	23
35.75	23	36.00	23	36.25	23	36.50	23	37.00	23		

ASTOP A 0

RAINFALL FLUX - EXPERIMENT #4

Recorded flow US gal/min	Time (hrs)	Δt	Rainfall cm/hr	Corrected Rainfall cm/hr	Rainfall flux cm/sec
0.375	14.0	1pm-3am	2.3164	2.0848	0.00058
0.5	2.0	3am-5am	3.0889	2.7800	0.000772

PHYSICAL SIMULATION #4
Tensiometer Co-ordinates

Tensiometer #	X Co-ordinate	Y Co-ordinate	Tensiometer #	X Co-ordinate	Y Co-ordinate
1	26	148	22	215	53
2	26	158	23	215	63
3	26	168	24	Missing data	
4	53	134	25	240	38
5	53	144	26	240	48
6	53	154	27	240	58
7	80	121	28	267	25
8	80	131	29	267	35
9	80	141	30	267	45
10	107	108	31	292	12
11	107	118	32	292	17
12	Missing data		33	292	27
13	135	95	34	317	15
14	135	105	35	317	25
15	135	115	36	317	30
16	162	80	37	343	12
17	162	90	38	343	22
18	162	100	39	343	27
19	188	68	40	367	15
20	188	78	41	367	25
21	188	88			

EXPERIMENT 4

MUN44

PIEZOMETER # 1											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-123.	1.15	-123.	2.30	-123.	3.45	-123.	4.60	-123.	5.75	-123.
1.30	-123.	1.45	-123.	2.00	-123.	2.15	-123.	2.30	-123.	2.45	-123.
3.00	-113.	3.15	-102.	3.30	-53.	3.45	-30.	4.00	-19.	4.15	-13.
4.30	-10.	4.45	-9.	5.00	-7.	5.15	-6.	5.30	-6.	5.45	-6.
6.00	-6.	6.15	-6.	6.30	-6.	6.45	-6.	7.00	-5.	7.15	-5.
7.30	-5.	7.45	-5.	8.00	-6.	8.15	-6.	8.30	-6.	8.45	-6.
9.00	-4.	9.15	-6.	9.30	-6.	9.45	-5.	10.00	-5.	10.15	-5.
10.30	-5.	10.45	-5.	11.00	-5.	11.15	-5.	11.30	-5.	11.45	-5.
12.00	-5.	12.15	-5.	12.30	-5.	12.45	-5.	13.00	-5.	13.15	-3.
13.30	-3.	13.45	-3.	14.00	-3.	14.15	-3.	14.30	-3.	14.45	-3.
15.00	-3.	15.15	-3.	15.30	-3.	15.45	-3.	16.00	-3.	16.15	-3.
16.30	-2.	16.45	-2.								

PIEZOMETER # 2											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-110.	1.15	-111.	2.30	-110.	3.45	-110.	4.60	-110.	5.75	-108.
1.30	-107.	1.45	-104.	2.00	-99.	2.15	-85.	2.30	-50.	2.45	-29.
3.00	-19.	3.15	-17.	3.30	-10.	3.45	-17.	4.00	-10.	4.15	-10.
4.30	-10.	4.45	-15.	5.00	-13.	5.15	-13.	5.30	-13.	5.45	-13.
6.00	-13.	6.15	-13.	6.30	-12.	6.45	-12.	7.00	-12.	7.15	-12.
7.30	-12.	7.45	-12.	8.00	-12.	8.15	-12.	8.30	-12.	8.45	-12.
9.00	-12.	9.15	-12.	9.30	-12.	9.45	-12.	10.00	-12.	10.15	-11.
10.30	-12.	10.45	-11.	11.00	-11.	11.15	-11.	11.30	-11.	11.45	-11.
12.00	-11.	12.15	-11.	12.30	-11.	12.45	-11.	13.00	-11.	13.15	-11.
13.30	-11.	13.45	-11.	14.00	-11.	14.15	-11.	14.30	-11.	14.45	-11.
15.00	-11.	15.15	-11.	15.30	-9.	15.45	-9.	16.00	-9.	16.15	-9.
16.30	-9.	16.45	-9.								

PIEZOMETER # 3											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-122.	1.15	-122.	2.30	-121.	3.45	-121.	4.60	-120.	5.75	-118.
1.30	-107.	1.45	-99.	2.00	-80.	2.15	-70.	2.30	-50.	2.45	-40.
3.00	-30.	3.15	-25.	3.30	-22.	3.45	-21.	4.00	-19.	4.15	-19.
4.30	-21.	4.45	-19.	5.00	-19.	5.15	-19.	5.30	-19.	5.45	-19.
6.00	-19.	6.15	-19.	6.30	-19.	6.45	-19.	7.00	-19.	7.15	-19.
7.30	-19.	7.45	-19.	8.00	-19.	8.15	-19.	8.30	-19.	8.45	-19.
9.00	-19.	9.15	-19.	9.30	-19.	9.45	-19.	10.00	-19.	10.15	-19.
10.30	-19.	10.45	-19.	11.00	-19.	11.15	-19.	11.30	-19.	11.45	-18.
12.00	-18.	12.15	-18.	12.30	-18.	12.45	-18.	13.00	-18.	13.15	-18.
13.30	-18.	13.45	-18.	14.00	-18.	14.15	-18.	14.30	-18.	14.45	-18.
15.00	-16.	15.15	-16.	15.30	-15.	15.45	-15.	16.00	-15.	16.15	-15.
16.30	-15.	16.45	-15.								

PIEZOMETER # 4											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-27.	1.15	-21.	2.30	-15.	3.45	-15.	4.60	-14.	5.75	-11.
1.30	-10.	1.45	-10.	2.00	-10.	2.15	-10.	2.30	-8.	2.45	-8.
3.00	-8.	3.15	-8.	3.30	-7.	3.45	-5.	4.00	-5.	4.15	-4.
4.30	-4.	4.45	-3.	5.00	-3.	5.15	-1.	5.30	-3.	5.45	-1.
6.00	-1.	6.15	-1.	6.30	-1.	6.45	-1.	7.00	-0.	7.15	-1.
7.30	-1.	7.45	-1.	8.00	-1.	8.15	-1.	8.30	-1.	8.45	-1.
9.00	-1.	9.15	-1.	9.30	-1.	9.45	-1.	10.00	-1.	10.15	-1.
10.30	-1.	10.45	-1.	11.00	-1.	11.15	-1.	11.30	-1.	11.45	-1.
12.00	-0.	12.15	-0.	12.30	-1.	12.45	-1.	13.00	-1.	13.15	-1.
13.30	-0.	13.45	-0.	14.00	-0.	14.15	-0.	14.30	-0.	14.45	-0.
15.00	-0.	15.15	-0.	15.30	-0.	15.45	-0.	16.00	-0.	16.15	-0.
16.30	-1.	16.45	-1.								

PIEZOMETER # 5											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-70.	1.15	-59.	2.30	-37.	3.45	-22.	4.60	-13.	5.75	-10.
1.30	-9.	1.45	-7.	2.00	-7.	2.15	-7.	2.30	-6.	2.45	-7.
3.00	-6.	3.15	-6.	3.30	-7.	3.45	-7.	4.00	-7.	4.15	-7.
4.30	-6.	4.45	-7.	5.00	-8.	5.15	-7.	5.30	-7.	5.45	-8.
6.00	-7.	6.15	-7.	6.30	-7.	6.45	-7.	7.00	-6.	7.15	-6.
7.30	-6.	7.45	-6.	8.00	-6.	8.15	-6.	8.30	-6.	8.45	-6.
9.00	-6.	9.15	-6.	9.30	-6.	9.45	-7.	10.00	-7.	10.15	-7.
10.30	-7.	10.45	-7.	11.00	-7.	11.15	-7.	11.30	-7.	11.45	-7.
12.00	-7.	12.15	-7.	12.30	-6.	12.45	-6.	13.00	-6.	13.15	-7.
13.30	-7.	13.45	-7.	14.00	-7.	14.15	-7.	14.30	-7.	14.45	-7.
15.00	-6.	15.15	-5.	15.30	-5.	15.45	-5.	16.00	-5.	16.15	-5.
16.30	-3.	16.45	-3.								

PIEZOMETER # 6											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-20.	1.15	-12.	2.30	-5.	3.45	-4.	4.60	-4.	5.75	-3.
1.30	-3.	1.45	-3.	2.00	-3.	2.15	-4.	2.30	-2.	2.45	-4.
3.00	-5.	3.15	-5.	3.30	-5.	3.45	-7.	4.00	-8.	4.15	-8.
4.30	-8.	4.45	-7.	5.00	-8.	5.15	-7.	5.30	-8.	5.45	-8.
6.00	-8.	6.15	-8.	6.30	-8.	6.45	-8.	7.00	-8.	7.15	-8.
7.30	-8.	7.45	-8.	8.00	-7.	8.15	-7.	8.30	-7.	8.45	-7.
9.00	-7.	9.15	-7.	9.30	-7.	9.45	-7.	10.00	-7.	10.15	-7.
10.30	-7.	10.45	-7.	11.00	-7.	11.15	-7.	11.30	-7.	11.45	-7.
12.00	-7.	12.15	-7.	12.30	-7.	12.45	-7.	13.00	-5.	13.15	-5.
13.30	-7.	13.45	-7.	14.00	-7.	14.15	-7.	14.30	-7.	14.45	-5.
15.00	-5.	15.15	-5.	15.30	-5.	15.45	-5.	16.00	-5.	16.15	-5.
16.30	-4.	16.45	-4.								

PIEZOMETER # 7

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-85.	1.15	-81.	2.30	-35.	2.45	-22.	1.00	-13.	1.15	-12.
1.30	-12.	1.45	-13.	2.00	-13.	2.15	-13.	2.30	-10.	2.45	-10.
3.00	-10.	3.15	-9.	3.30	-9.	3.45	-7.	4.00	-8.	4.15	-8.
4.30	-5.	4.45	-5.	5.00	-3.	5.15	-2.	5.30	-3.	5.45	-3.
6.00	-3.	6.15	-3.	6.30	-5.	6.45	-3.	7.00	-2.	7.15	-2.
7.30	-2.	7.45	-2.	8.00	-2.	8.15	-2.	8.30	-2.	8.45	-2.
9.00	-2.	9.15	-2.	9.30	-2.	9.45	-2.	10.00	-2.	10.15	-2.
10.30	-2.	10.45	-2.	11.00	-2.	11.15	-2.	11.30	-2.	11.45	-2.
12.00	-2.	12.15	-2.	12.30	-2.	12.45	-1.	13.00	-2.	13.15	-2.
13.30	-2.	13.45	-1.	14.00	-1.	14.15	-1.	14.30	-1.	14.45	-1.
15.00	-1.	15.15	-1.	15.30	-1.	15.45	-1.	16.00	-1.	16.15	-1.
16.30	1.	16.45	-1.								

PIEZOMETER # 8

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-80.	1.15	-81.	2.30	-80.	2.45	-81.	1.00	-13.	1.15	-13.
1.30	-26.	1.45	-17.	2.00	-13.	2.15	-8.	2.30	-2.	2.45	2.
3.00	3.	3.15	4.	3.30	4.	3.45	4.	4.00	4.	4.15	4.
4.30	4.	4.45	6.	5.00	6.	5.15	6.	5.30	7.	5.45	7.
6.00	7.	6.15	7.	6.30	8.	6.45	8.	7.00	8.	7.15	8.
7.30	8.	7.45	8.	8.00	8.	8.15	8.	8.30	8.	8.45	8.
9.00	8.	9.15	6.	9.30	7.	9.45	7.	10.00	7.	10.15	7.
10.30	7.	10.45	7.	11.00	7.	11.15	7.	11.30	7.	11.45	7.
12.00	7.	12.15	7.	12.30	7.	12.45	7.	13.00	7.	13.15	7.
13.30	7.	13.45	7.	14.00	7.	14.15	7.	14.30	7.	14.45	7.
15.00	8.	15.15	8.	15.30	8.	15.45	8.	16.00	8.	16.15	8.
16.30	8.	16.45	8.								

PIEZOMETER # 9

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-75.	1.15	-53.	2.30	-15.	2.45	-9.	1.00	-4.	1.15	-8.
1.30	-4.	1.45	-4.	2.00	-4.	2.15	-8.	2.30	-4.	2.45	-4.
3.00	-6.	3.15	-6.	3.30	-6.	3.45	-7.	4.00	-6.	4.15	-6.
4.30	-10.	4.45	-10.	5.00	-10.	5.15	-10.	5.30	-10.	5.45	-10.
6.00	-10.	6.15	-10.	6.30	-10.	6.45	-10.	7.00	-10.	7.15	-10.
7.30	-10.	7.45	-10.	8.00	-10.	8.15	-10.	8.30	-11.	8.45	-11.
9.00	-11.	9.15	-11.	9.30	-11.	9.45	-11.	10.00	-11.	10.15	-11.
10.30	-11.	10.45	-11.	11.00	-11.	11.15	-11.	11.30	-11.	11.45	-11.
12.00	-12.	12.15	-12.	12.30	-11.	12.45	-11.	13.00	-11.	13.15	-12.
13.30	-11.	13.45	-11.	14.00	-11.	14.15	-11.	14.30	-11.	14.45	-11.
15.00	-11.	15.15	-11.	15.30	-11.	15.45	-11.	16.00	-11.	16.15	-11.
16.30	-10.	16.45	-10.								

PIEZOMETER #10

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-100.	1.15	-107.	2.30	-107.	2.45	-107.	1.00	-106.	1.15	-106.
1.30	-107.	1.45	-106.	2.00	-103.	2.15	-102.	2.30	-106.	2.45	-106.
3.00	-13.	3.15	-12.	3.30	-12.	3.45	-9.	4.00	-7.	4.15	-7.
4.30	-5.	4.45	-4.	5.00	-5.	5.15	-4.	5.30	-4.	5.45	-4.
6.00	-4.	6.15	-4.	6.30	-4.	6.45	-4.	7.00	-4.	7.15	-4.
7.30	-4.	7.45	-4.	8.00	-4.	8.15	-4.	8.30	-4.	8.45	-4.
9.00	-4.	9.15	-4.	9.30	-4.	9.45	-4.	10.00	-5.	10.15	-4.
10.30	-5.	10.45	-4.	11.00	-4.	11.15	-4.	11.30	-4.	11.45	-5.
12.00	-4.	12.15	-4.	12.30	-4.	12.45	-4.	13.00	-4.	13.15	-4.
13.30	-4.	13.45	-4.	14.00	-4.	14.15	-4.	14.30	-4.	14.45	-4.
15.00	-4.	15.15	-3.	15.30	-3.	15.45	-3.	16.00	-3.	16.15	-3.
16.30	-3.	16.45	-3.								

PIEZOMETER #11

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-217.	1.15	-220.	2.30	-219.	2.45	-219.	1.00	-214.	1.15	-167.
1.30	-90.	1.45	-60.	2.00	-48.	2.15	-36.	2.30	-22.	2.45	-16.
3.00	-17.	3.15	-17.	3.30	-17.	3.45	-17.	4.00	-17.	4.15	-17.
4.30	-15.	4.45	-14.	5.00	-14.	5.15	-14.	5.30	-14.	5.45	-14.
6.00	-14.	6.15	-14.	6.30	-14.	6.45	-14.	7.00	-13.	7.15	-13.
7.30	-13.	7.45	-13.	8.00	-13.	8.15	-13.	8.30	-13.	8.45	-13.
9.00	-13.	9.15	-13.	9.30	-13.	9.45	-13.	10.00	-13.	10.15	-13.
10.30	-14.	10.45	-13.	11.00	-13.	11.15	-13.	11.30	-13.	11.45	-13.
12.00	-13.	12.15	-11.	12.30	-11.	12.45	-11.	13.00	-11.	13.15	-11.
13.30	-11.	13.45	-11.	14.00	-11.	14.15	-11.	14.30	-11.	14.45	-11.
15.00	-11.	15.15	-10.	15.30	-10.	15.45	-10.	16.00	-10.	16.15	-10.
16.30	-10.	16.45	-10.								

PIEZOMETER #12

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-77.	1.15	-79.	2.30	-76.	2.45	-51.	1.00	-19.	1.15	-11.
1.30	-9.	1.45	-7.	2.00	-7.	2.15	-7.	2.30	-8.	2.45	-8.
3.00	-8.	3.15	-8.	3.30	-8.	3.45	-8.	4.00	-8.	4.15	-8.
4.30	-8.	4.45	-8.	5.00	-8.	5.15	-8.	5.30	-3.	5.45	-3.
6.00	-3.	6.15	-3.	6.30	-3.	6.45	-3.	7.00	-3.	7.15	-3.
7.30	-3.	7.45	-4.	8.00	-3.	8.15	-3.	8.30	-3.	8.45	-3.
9.00	-3.	9.15	-3.	9.30	-3.	9.45	-3.	10.00	-3.	10.15	-2.
10.30	-2.	10.45	-2.	11.00	-2.	11.15	-2.	11.30	-2.	11.45	-2.
12.00	-2.	12.15	-2.	12.30	-2.	12.45	-2.	13.00	-2.	13.15	-2.
13.30	-2.	13.45	-2.	14.00	-2.	14.15	-2.	14.30	-2.	14.45	-2.
15.00	-2.	15.15	-2.	15.30	-2.	15.45	-2.	16.00	-2.	16.15	-2.
16.30	-0.	16.45	-0.								

PIEZOMETER #13

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-107.	1.15	-108.	1.30	-108.	1.45	-108.	1.00	-107.	1.15	-107.
1.30	-81.	1.45	-44.	2.00	-35.	2.15	-29.	2.30	-29.	2.45	-29.
3.00	-24.	3.15	-24.	3.30	-23.	3.45	-21.	4.00	-20.	4.15	-17.
4.30	-17.	4.45	-17.	5.00	-16.	5.15	-14.	5.30	-16.	5.45	-16.
6.00	-14.	6.15	-14.	6.30	-14.	6.45	-14.	7.00	-14.	7.15	-14.
7.30	-14.	7.45	-14.	8.00	-14.	8.15	-14.	8.30	-14.	8.45	-14.
9.00	-14.	9.15	-14.	9.30	-14.	9.45	-14.	10.00	-14.	10.15	-14.
10.30	-14.	10.45	-14.	11.00	-14.	11.15	-14.	11.30	-14.	11.45	-14.
12.00	-14.	12.15	-13.	12.30	-13.	12.45	-13.	13.00	-13.	13.15	-13.
13.30	-13.	13.45	-13.	14.00	-13.	14.15	-13.	14.30	-13.	14.45	-13.
15.00	-13.	15.15	-13.	15.30	-13.	15.45	-13.	16.00	-13.	16.15	-13.
16.30	-13.	16.45	-13.								

PIEZOMETER #14

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-92.	1.15	-59.	1.30	-34.	1.45	-25.	1.00	-16.	1.15	-15.
1.30	-14.	1.45	-14.	2.00	-12.	2.15	-12.	2.30	-11.	2.45	-11.
3.00	-11.	3.15	-12.	3.30	-14.	3.45	-14.	4.00	-14.	4.15	-14.
4.30	-14.	4.45	-15.	5.00	-15.	5.15	-14.	5.30	-15.	5.45	-15.
6.00	-14.	6.15	-15.	6.30	-15.	6.45	-15.	7.00	-15.	7.15	-15.
7.30	-15.	7.45	-15.	8.00	-15.	8.15	-15.	8.30	-15.	8.45	-15.
9.00	-15.	9.15	-15.	9.30	-15.	9.45	-15.	10.00	-15.	10.15	-15.
10.30	-15.	10.45	-15.	11.00	-15.	11.15	-15.	11.30	-15.	11.45	-15.
12.00	-15.	12.15	-15.	12.30	-15.	12.45	-15.	13.00	-15.	13.15	-15.
13.30	-15.	13.45	-15.	14.00	-15.	14.15	-15.	14.30	-15.	14.45	-15.
15.00	-15.	15.15	-15.	15.30	-15.	15.45	-15.	16.00	-15.	16.15	-14.
16.30	-14.	16.45	-14.								

PIEZOMETER #15

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-107.	1.15	-109.	1.30	-107.	1.45	-107.	1.00	-104.	1.15	-107.
1.30	-107.	1.45	-107.	2.00	-107.	2.15	-107.	2.30	-84.	2.45	-47.
3.00	-19.	3.15	-12.	3.30	-9.	3.45	-8.	4.00	-7.	4.15	-5.
4.30	-3.	4.45	-3.	5.00	-3.	5.15	-3.	5.30	-1.	5.45	-1.
6.00	-1.	6.15	0.	6.30	0.	6.45	0.	7.00	0.	7.15	0.
7.30	0.	7.45	0.	8.00	0.	8.15	0.	8.30	0.	8.45	0.
9.00	0.	9.15	0.	9.30	0.	9.45	0.	10.00	0.	10.15	0.
10.30	0.	10.45	0.	11.00	0.	11.15	0.	11.30	0.	11.45	0.
12.00	0.	12.15	0.	12.30	0.	12.45	0.	13.00	0.	13.15	0.
13.30	0.	13.45	0.	14.00	0.	14.15	1.	14.30	1.	14.45	1.
15.00	1.	15.15	1.	15.30	4.	15.45	1.	16.00	1.	16.15	1.
16.30	-1.	16.45	-1.								

PIEZOMETER #16

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-120.	1.15	-79.	1.30	-53.	1.45	-36.	1.00	-62.	1.15	-19.
1.30	-25.	1.45	-30.	2.00	-30.	2.15	-26.	2.30	-22.	2.45	-22.
3.00	-21.	3.15	-21.	3.30	-21.	3.45	-21.	4.00	-19.	4.15	-19.
4.30	-19.	4.45	-19.	5.00	-18.	5.15	-18.	5.30	-18.	5.45	-17.
6.00	-17.	6.15	-17.	6.30	-17.	6.45	-17.	7.00	-17.	7.15	-17.
7.30	-17.	7.45	-15.	8.00	-15.	8.15	-15.	8.30	-17.	8.45	-17.
9.00	-17.	9.15	-17.	9.30	-15.	9.45	-15.	10.00	-15.	10.15	-15.
10.30	-15.	10.45	-15.	11.00	-15.	11.15	-15.	11.30	-14.	11.45	-15.
12.00	-14.	12.15	-14.	12.30	-14.	12.45	-14.	13.00	-14.	13.15	-14.
13.30	-14.	13.45	-14.	14.00	-14.	14.15	-14.	14.30	-14.	14.45	-14.
15.00	-14.	15.15	-14.	15.30	-14.	15.45	-14.	16.00	-14.	16.15	-14.
16.30	-14.	16.45	-14.								

PIEZOMETER #17

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-139.	1.15	-138.	1.30	-127.	1.45	-119.	1.00	-74.	1.15	-49.
1.30	-19.	1.45	-17.	2.00	-17.	2.15	-17.	2.30	-16.	2.45	-16.
3.00	-16.	3.15	-16.	3.30	-12.	3.45	-17.	4.00	-19.	4.15	-19.
4.30	-17.	4.45	-17.	5.00	-17.	5.15	-17.	5.30	-19.	5.45	-19.
6.00	-19.	6.15	-17.	6.30	-19.	6.45	-17.	7.00	-17.	7.15	-19.
7.30	-17.	7.45	-17.	8.00	-17.	8.15	-17.	8.30	-17.	8.45	-17.
9.00	-19.	9.15	-19.	9.30	-17.	9.45	-17.	10.00	-17.	10.15	-17.
10.30	-17.	10.45	-17.	11.00	-17.	11.15	-17.	11.30	-17.	11.45	-17.
12.00	-17.	12.15	-17.	12.30	-17.	12.45	-17.	13.00	-17.	13.15	-17.
13.30	-17.	13.45	-17.	14.00	-17.	14.15	-17.	14.30	-17.	14.45	-17.
15.00	-17.	15.15	-17.	15.30	-17.	15.45	-17.	16.00	-17.	16.15	-17.
16.30	-17.	16.45	-17.								

PIEZOMETER #18

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
1.00	-143.	1.15	-143.	1.30	-143.	1.45	-143.	1.00	-143.	1.15	-143.
1.30	-143.	1.45	-141.	2.00	-90.	2.15	-49.	2.30	-28.	2.45	-23.
3.00	-21.	3.15	-18.	3.30	-17.	3.45	-14.	4.00	-13.	4.15	-10.
4.30	-9.	4.45	-10.	5.00	-7.	5.15	-7.	5.30	-7.	5.45	-7.
6.00	-7.	6.15	-7.	6.30	-7.	6.45	-7.	7.00	-7.	7.15	-7.
7.30	-7.	7.45	-6.	8.00	-7.	8.15	-7.	8.30	-7.	8.45	-7.
9.00	-7.	9.15	-6.	9.30	-6.	9.45	-6.	10.00	-6.	10.15	-6.
10.30	-6.	10.45	-6.	11.00	-6.	11.15	-6.	11.30	-6.	11.45	-6.
12.00	-6.	12.15	-6.	12.30	-6.	12.45	-6.	13.00	-6.	13.15	-6.
13.30	-6.	13.45	-6.	14.00	-6.	14.15	-6.	14.30	-6.	14.45	-6.
15.00	-6.	15.15	-6.	15.30	-6.	15.45	-6.	16.00	-6.	16.15	-6.
16.30	-6.	16.45	-5.								

PIEZOMETER #19											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-138.	1.15	-137.	2.30	-119.	3.45	-105.	4.00	-92.	5.15	-85.
1.30	-21.	1.45	-13.	2.00	-12.	2.15	-12.	2.30	-10.	2.45	-10.
3.00	-10.	3.15	-10.	3.30	-10.	3.45	-10.	4.00	-10.	4.15	-10.
4.30	-10.	4.45	-10.	5.00	-10.	5.15	-10.	5.30	-10.	5.45	-10.
6.00	-10.	6.15	-9.	6.30	-9.	6.45	-9.	7.00	-9.	7.15	-9.
7.30	-9.	7.45	-8.	8.00	-8.	8.15	-9.	8.30	-9.	8.45	-9.
9.00	-9.	9.15	-8.	9.30	-8.	9.45	-8.	10.00	-8.	10.15	-8.
10.30	-8.	10.45	-8.	11.00	-8.	11.15	-8.	11.30	-8.	11.45	-8.
12.00	-8.	12.15	-8.	12.30	-8.	12.45	-8.	13.00	-8.	13.15	-8.
13.30	-8.	13.45	-8.	14.00	-8.	14.15	-8.	14.30	-8.	14.45	-8.
15.00	-8.	15.15	-8.	15.30	-8.	15.45	-8.	16.00	-8.	16.15	-8.
16.30	-8.	16.45	-8.								

PIEZOMETER #20											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-70.	1.15	-67.	2.30	-61.	3.45	-50.	4.00	-42.	5.15	-40.
1.30	-29.	1.45	-12.	2.00	-8.	2.15	-8.	2.30	-7.	2.45	-7.
3.00	-7.	3.15	-7.	3.30	-7.	3.45	-7.	4.00	-7.	4.15	-7.
4.30	-7.	4.45	-6.	5.00	-3.	5.15	-3.	5.30	-3.	5.45	-3.
6.00	-3.	6.15	-3.	6.30	-3.	6.45	-1.	7.00	-1.	7.15	-3.
7.30	-3.	7.45	-1.	8.00	-1.	8.15	-1.	8.30	-3.	8.45	-3.
9.00	-3.	9.15	-1.	9.30	-1.	9.45	-1.	10.00	-1.	10.15	-1.
10.30	-1.	10.45	-1.	11.00	-1.	11.15	-1.	11.30	-1.	11.45	-1.
12.00	-1.	12.15	-1.	12.30	-1.	12.45	-1.	13.00	-1.	13.15	-1.
13.30	-1.	13.45	-1.	14.00	-1.	14.15	-1.	14.30	-1.	14.45	-1.
15.00	-1.	15.15	-3.	15.30	-1.	15.45	-1.	16.00	-1.	16.15	-1.
16.30	-1.	16.45	-1.								

PIEZOMETER #21											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-141.	1.15	-141.	2.30	-140.	3.45	-140.	4.00	-140.	5.15	-140.
1.30	-140.	1.45	-140.	2.00	-140.	2.15	-136.	2.30	-61.	2.45	-41.
3.00	-13.	3.15	-5.	3.30	-2.	3.45	-1.	4.00	1.	4.15	3.
4.30	5.	4.45	5.	5.00	6.	5.15	6.	5.30	6.	5.45	6.
6.00	6.	6.15	6.	6.30	6.	6.45	6.	7.00	6.	7.15	6.
7.30	6.	7.45	6.	8.00	6.	8.15	6.	8.30	6.	8.45	6.
9.00	8.	9.15	8.	9.30	8.	9.45	8.	10.00	8.	10.15	8.
10.30	8.	10.45	8.	11.00	8.	11.15	8.	11.30	6.	11.45	6.
12.00	8.	12.15	8.	12.30	8.	12.45	8.	13.00	8.	13.15	8.
13.30	6.	13.45	5.	14.00	5.	14.15	5.	14.30	6.	14.45	5.
15.00	6.	15.15	6.	15.30	6.	15.45	6.	16.00	6.	16.15	6.
16.30	6.	16.45	6.								

PIEZOMETER #22											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-187.	1.15	-186.	2.30	-186.	3.45	-186.	4.00	-173.	5.15	-181.
1.30	-149.	1.45	-139.	2.00	-116.	2.15	-62.	2.30	-42.	2.45	-25.
3.00	-32.	3.15	-21.	3.30	-28.	3.45	-24.	4.00	-23.	4.15	-21.
4.30	-21.	4.45	-21.	5.00	-20.	5.15	-20.	5.30	-20.	5.45	-19.
6.00	-19.	6.15	-19.	6.30	-19.	6.45	-19.	7.00	-19.	7.15	-19.
7.30	-19.	7.45	-19.	8.00	-19.	8.15	-19.	8.30	-19.	8.45	-19.
9.00	-19.	9.15	-17.	9.30	-17.	9.45	-17.	10.00	-17.	10.15	-17.
10.30	-17.	10.45	-17.	11.00	-17.	11.15	-16.	11.30	-16.	11.45	-16.
12.00	-16.	12.15	-16.	12.30	-16.	12.45	-16.	13.00	-16.	13.15	-15.
13.30	-15.	13.45	-15.	14.00	-15.	14.15	-15.	14.30	-15.	14.45	-15.
15.00	-13.	15.15	-12.	15.30	-12.	15.45	-12.	16.00	-12.	16.15	-12.
16.30	-17.	16.45	-17.								

PIEZOMETER #23											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-162.	1.15	-161.	2.30	-161.	3.45	-161.	4.00	-148.	5.15	-136.
1.30	-128.	1.45	-122.	2.00	-114.	2.15	-91.	2.30	-37.	2.45	-17.
3.00	-10.	3.15	-7.	3.30	-6.	3.45	-3.	4.00	1.	4.15	2.
4.30	4.	4.45	4.	5.00	2.	5.15	5.	5.30	5.	5.45	6.
6.00	6.	6.15	6.	6.30	6.	6.45	6.	7.00	6.	7.15	6.
7.30	6.	7.45	6.	8.00	6.	8.15	6.	8.30	8.	8.45	6.
9.00	6.	9.15	6.	9.30	8.	9.45	8.	10.00	8.	10.15	8.
10.30	8.	10.45	8.	11.00	8.	11.15	9.	11.30	9.	11.45	9.
12.00	9.	12.15	9.	12.30	9.	12.45	9.	13.00	9.	13.15	10.
13.30	10.	13.45	10.	14.00	10.	14.15	10.	14.30	10.	14.45	10.
15.00	12.	15.15	12.	15.30	13.	15.45	13.	16.00	13.	16.15	13.
16.30	8.	16.45	8.								

PIEZOMETER #24											
TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-180.	1.15	-180.	2.30	-180.	3.45	-180.	4.00	-179.	5.15	-177.
1.30	-179.	1.45	-177.	2.00	-170.	2.15	-150.	2.30	-87.	2.45	-48.
3.00	-38.	3.15	-27.	3.30	-21.	3.45	-19.	4.00	-15.	4.15	-12.
4.30	-9.	4.45	-9.	5.00	-6.	5.15	-6.	5.30	-6.	5.45	-6.
6.00	-6.	6.15	-6.	6.30	-5.	6.45	-5.	7.00	-5.	7.15	-5.
7.30	-5.	7.45	-5.	8.00	-5.	8.15	-5.	8.30	-5.	8.45	-5.
9.00	-5.	9.15	-4.	9.30	-4.	9.45	-4.	10.00	-4.	10.15	-4.
10.30	-4.	10.45	-4.	11.00	-4.	11.15	-2.	11.30	-2.	11.45	-2.
12.00	-2.	12.15	-2.	12.30	-2.	12.45	-2.	13.00	-1.	13.15	-1.
13.30	-1.	13.45	-1.	14.00	-1.	14.15	0.	14.30	0.	14.45	0.
15.00	0.	15.15	0.	15.30	0.	15.45	0.	16.00	0.	16.15	0.
16.30	0.	16.45	-1.								

PIEZOMETER #25

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-197.	1.15	-197.	2.30	-197.	3.45	-197.	4.60	-197.	5.75	-197.
1.30	-142.	1.45	-53.	2.00	-19.	3.15	-15.	4.30	-14.	5.45	-14.
3.00	-14.	3.15	-14.	3.30	-14.	3.45	-14.	4.00	-14.	4.15	-14.
4.30	-12.	4.45	-11.	5.00	-10.	5.15	-10.	5.30	-10.	5.45	-10.
6.00	-10.	6.15	-8.	6.30	-8.	6.45	-8.	7.00	-10.	7.15	-10.
7.30	-8.	7.45	-7.	8.00	-7.	8.15	-7.	8.30	-7.	8.45	-7.
9.00	-7.	9.15	-7.	9.30	-7.	9.45	-7.	10.00	-7.	10.15	-7.
10.30	-7.	10.45	-7.	11.00	-7.	11.15	-7.	11.30	-8.	11.45	-8.
12.00	-6.	12.15	-6.	12.30	-6.	12.45	-6.	13.00	-6.	13.15	-6.
13.30	-6.	13.45	-6.	14.00	-6.	14.15	-6.	14.30	-4.	14.45	-4.
15.00	-4.	15.15	-3.	15.30	-3.	15.45	-3.	16.00	-3.	16.15	-3.

PIEZOMETER #26

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-175.	1.15	-174.	2.30	-174.	3.45	-174.	4.60	-174.	5.75	-174.
1.30	-172.	1.45	-171.	2.00	-171.	2.15	-172.	2.30	-172.	2.45	-172.
3.00	-172.	3.15	-159.	3.30	-91.	3.45	-20.	4.00	-5.	4.15	-1.
4.30	4.	4.45	8.	5.00	12.	5.15	15.	5.30	18.	5.45	18.
6.00	10.	6.15	10.	6.30	19.	6.45	19.	7.00	19.	7.15	19.
7.30	20.	7.45	20.	8.00	20.	8.15	22.	8.30	20.	8.45	22.
9.00	20.	9.15	20.	9.30	22.	9.45	22.	10.00	23.	10.15	22.
10.30	22.	10.45	22.	11.00	22.	11.15	22.	11.30	22.	11.45	23.
12.00	23.	12.15	23.	12.30	23.	12.45	23.	13.00	23.	13.15	23.
13.30	23.	13.45	24.	14.00	24.	14.15	24.	14.30	24.	14.45	24.
15.00	24.	15.15	24.	15.30	24.	15.45	24.	16.00	24.	16.15	24.

PIEZOMETER #27

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-220.	1.15	-219.	2.30	-220.	3.45	-220.	4.60	-220.	5.75	-217.
1.30	-217.	1.45	-216.	2.00	-216.	2.15	-217.	2.30	-201.	2.45	-171.
3.00	-105.	3.15	-50.	3.30	-37.	3.45	-20.	4.00	-22.	4.15	-18.
4.30	-14.	4.45	-11.	5.00	-7.	5.15	-6.	5.30	-3.	5.45	-2.
6.00	1.	6.15	1.	6.30	1.	6.45	1.	7.00	2.	7.15	2.
7.30	4.	7.45	4.	8.00	4.	8.15	5.	8.30	5.	8.45	4.
9.00	4.	9.15	4.	9.30	5.	9.45	5.	10.00	6.	10.15	5.
10.30	5.	10.45	5.	11.00	5.	11.15	6.	11.30	6.	11.45	6.
12.00	6.	12.15	6.	12.30	6.	12.45	6.	13.00	6.	13.15	6.
13.30	6.	13.45	6.	14.00	6.	14.15	6.	14.30	5.	14.45	6.
15.00	8.	15.15	8.	15.30	8.	15.45	8.	16.00	8.	16.15	8.

PIEZOMETER #28

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-240.	1.15	-240.	2.30	-236.	3.45	-237.	4.60	-237.	5.75	-23.
1.30	-72.	1.45	-43.	2.00	-28.	2.15	-23.	2.30	-20.	2.45	-19.
3.00	-19.	3.15	-17.	3.30	-17.	3.45	-17.	4.00	-17.	4.15	-17.
4.30	-17.	4.45	-16.	5.00	-13.	5.15	-9.	5.30	-9.	5.45	-6.
6.00	-5.	6.15	-4.	6.30	-4.	6.45	-4.	7.00	-4.	7.15	-8.
7.30	-4.	7.45	-2.	8.00	-2.	8.15	-2.	8.30	-2.	8.45	-2.
9.00	-2.	9.15	-2.	9.30	-2.	9.45	-2.	10.00	-2.	10.15	-1.
10.30	-1.	10.45	-1.	11.00	-1.	11.15	-1.	11.30	-1.	11.45	0.
12.00	0.	12.15	0.	12.30	0.	12.45	0.	13.00	0.	13.15	0.
13.30	0.	13.45	0.	14.00	0.	14.15	0.	14.30	0.	14.45	0.
15.00	0.	15.15	0.	15.30	2.	15.45	2.	16.00	2.	16.15	2.

PIEZOMETER #29

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-130.	1.15	-135.	2.30	-133.	3.45	-135.	4.60	-126.	5.75	-122.
1.30	-91.	1.45	-50.	2.00	-26.	2.15	-14.	2.30	1.	2.45	4.
3.00	7.	3.15	8.	3.30	9.	3.45	9.	4.00	12.	4.15	13.
4.30	10.	4.45	19.	5.00	21.	5.15	23.	5.30	27.	5.45	28.
6.00	30.	6.15	30.	6.30	30.	6.45	30.	7.00	30.	7.15	30.
7.30	31.	7.45	31.	8.00	31.	8.15	31.	8.30	31.	8.45	31.
9.00	31.	9.15	31.	9.30	31.	9.45	31.	10.00	31.	10.15	32.
10.30	31.	10.45	32.	11.00	32.	11.15	32.	11.30	32.	11.45	32.
12.00	32.	12.15	34.	12.30	34.	12.45	34.	13.00	34.	13.15	34.
13.30	34.	13.45	34.	14.00	34.	14.15	34.	14.30	34.	14.45	34.
15.00	34.	15.15	34.	15.30	35.	15.45	35.	16.00	35.	16.15	35.

PIEZOMETER #30

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-122.	1.15	-122.	2.30	-113.	3.45	-85.	4.60	-53.	5.75	-35.
1.30	-20.	1.45	-13.	2.00	-9.	2.15	-8.	2.30	-8.	2.45	-4.
3.00	-3.	3.15	-3.	3.30	-3.	3.45	-3.	4.00	0.	4.15	2.
4.30	3.	4.45	6.	5.00	10.	5.15	11.	5.30	14.	5.45	15.
6.00	10.	6.15	18.	6.30	18.	6.45	18.	7.00	18.	7.15	19.
7.30	21.	7.45	21.	8.00	21.	8.15	22.	8.30	22.	8.45	21.
9.00	21.	9.15	21.	9.30	22.	9.45	21.	10.00	22.	10.15	22.
10.30	21.	10.45	22.	11.00	22.	11.15	22.	11.30	22.	11.45	22.
12.00	21.	12.15	23.	12.30	23.	12.45	23.	13.00	23.	13.15	23.
13.30	25.	13.45	25.	14.00	25.	14.15	25.	14.30	25.	14.45	25.
15.00	25.	15.15	25.	15.30	25.	15.45	25.	16.00	25.	16.15	25.

PIEZOMETER #31

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-144.	1.15	-144.	2.30	-143.	3.45	-143.	4.60	-141.	5.75	-140.
1.30	-120.	1.45	-142.	2.00	-130.	2.15	-27.	2.30	-15.	2.45	-15.
3.00	-10.	3.15	-10.	3.30	-8.	3.45	-8.	4.00	-6.	4.15	-4.
4.30	-0.	4.45	1.	5.00	0.	5.15	8.	5.30	11.	5.45	13.
6.00	13.	6.15	13.	6.30	15.	6.45	15.	7.00	15.	7.15	15.
7.30	15.	7.45	15.	8.00	15.	8.15	15.	8.30	15.	8.45	15.
9.00	15.	9.15	15.	9.30	15.	9.45	15.	10.00	15.	10.15	15.
10.30	15.	10.45	16.	11.00	16.	11.15	16.	11.30	16.	11.45	16.
12.00	16.	12.15	16.	12.30	16.	12.45	16.	13.00	16.	13.15	16.
13.30	17.	13.45	17.	14.00	17.	14.15	17.	14.30	17.	14.45	17.
15.00	17.	15.15	17.	15.30	17.	15.45	19.	16.00	19.	16.15	19.
16.30	19.	16.45	17.								

PIEZOMETER #32

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-122.	1.15	-118.	2.30	-107.	3.45	-87.	4.60	-46.	5.75	-28.
1.30	-15.	1.45	-9.	2.00	-5.	2.15	-2.	2.30	0.	2.45	3.
3.00	3.	3.15	5.	3.30	5.	3.45	6.	4.00	9.	4.15	10.
4.30	13.	4.45	14.	5.00	18.	5.15	21.	5.30	25.	5.45	25.
6.00	26.	6.15	26.	6.30	28.	6.45	28.	7.00	28.	7.15	28.
7.30	28.	7.45	28.	8.00	28.	8.15	28.	8.30	28.	8.45	28.
9.00	28.	9.15	28.	9.30	28.	9.45	28.	10.00	28.	10.15	28.
10.30	28.	10.45	28.	11.00	28.	11.15	28.	11.30	29.	11.45	29.
12.00	29.	12.15	29.	12.30	29.	12.45	29.	13.00	29.	13.15	29.
13.30	29.	13.45	29.	14.00	29.	14.15	29.	14.30	29.	14.45	30.
15.00	30.	15.15	30.	15.30	30.	15.45	30.	16.00	30.	16.15	30.
16.30	30.	16.45	30.								

PIEZOMETER #33

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-144.	1.15	-144.	2.30	-143.	3.45	-126.	4.60	-84.	5.75	-33.
1.30	-18.	1.45	-12.	2.00	-11.	2.15	-10.	2.30	-10.	2.45	-8.
3.00	-8.	3.15	-8.	3.30	-8.	3.45	-4.	4.00	-1.	4.15	-0.
4.30	3.	4.45	4.	5.00	7.	5.15	9.	5.30	11.	5.45	12.
6.00	14.	6.15	14.	6.30	14.	6.45	14.	7.00	15.	7.15	15.
7.30	15.	7.45	15.	8.00	15.	8.15	15.	8.30	15.	8.45	15.
9.00	15.	9.15	15.	9.30	15.	9.45	15.	10.00	16.	10.15	15.
10.30	15.	10.45	15.	11.00	15.	11.15	15.	11.30	15.	11.45	15.
12.00	15.	12.15	16.	12.30	16.	12.45	16.	13.00	16.	13.15	16.
13.30	16.	13.45	16.	14.00	16.	14.15	16.	14.30	16.	14.45	16.
15.00	16.	15.15	16.	15.30	16.	15.45	16.	16.00	16.	16.15	16.
16.30	16.	16.45	16.								

PIEZOMETER #34

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-71.	1.15	-50.	2.30	-34.	3.45	-24.	4.60	-16.	5.75	-13.
1.30	-12.	1.45	-10.	2.00	-12.	2.15	-10.	2.30	-10.	2.45	-10.
3.00	-10.	3.15	-10.	3.30	-10.	3.45	-10.	4.00	-9.	4.15	-5.
4.30	-8.	4.45	-2.	5.00	0.	5.15	3.	5.30	6.	5.45	6.
6.00	6.	6.15	6.	6.30	7.	6.45	7.	7.00	7.	7.15	7.
7.30	7.	7.45	7.	8.00	9.	8.15	9.	8.30	9.	8.45	9.
9.00	10.	9.15	10.	9.30	10.	9.45	10.	10.00	10.	10.15	10.
10.30	10.	10.45	11.	11.00	11.	11.15	11.	11.30	11.	11.45	11.
12.00	11.	12.15	11.	12.30	11.	12.45	11.	13.00	13.	13.15	13.
13.30	13.	13.45	13.	14.00	13.	14.15	13.	14.30	13.	14.45	13.
15.00	13.	15.15	13.	15.30	14.	15.45	14.	16.00	14.	16.15	14.
16.30	14.	16.45	14.								

PIEZOMETER #35

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-127.	1.15	-125.	2.30	-125.	3.45	-127.	4.60	-125.	5.75	-144.
1.30	-124.	1.45	-121.	2.00	-119.	2.15	-118.	2.30	-113.	2.45	-109.
3.00	-84.	3.15	-52.	3.30	-31.	3.45	-15.	4.00	-6.	4.15	2.
4.30	7.	4.45	11.	5.00	15.	5.15	16.	5.30	19.	5.45	20.
6.00	20.	6.15	21.	6.30	21.	6.45	23.	7.00	23.	7.15	23.
7.30	23.	7.45	23.	8.00	24.	8.15	24.	8.30	24.	8.45	24.
9.00	26.	9.15	24.	9.30	26.	9.45	26.	10.00	26.	10.15	26.
10.30	26.	10.45	26.	11.00	26.	11.15	26.	11.30	26.	11.45	26.
12.00	26.	12.15	26.	12.30	26.	12.45	26.	13.00	26.	13.15	26.
13.30	27.	13.45	26.	14.00	27.	14.15	27.	14.30	27.	14.45	27.
15.00	27.	15.15	27.	15.30	27.	15.45	27.	16.00	28.	16.15	28.
16.30	28.	16.45	28.								

PIEZOMETER #36

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
0.00	-174.	1.15	-173.	2.30	-173.	3.45	-173.	4.60	-173.	5.75	-171.
1.30	-173.	1.45	-171.	2.00	-171.	2.15	-164.	2.30	-110.	2.45	-72.
3.00	-36.	3.15	-18.	3.30	-7.	3.45	-2.	4.00	8.	4.15	8.
4.30	9.	4.45	10.	5.00	13.	5.15	14.	5.30	16.	5.45	17.
6.00	17.	6.15	19.	6.30	19.	6.45	19.	7.00	19.	7.15	19.
7.30	19.	7.45	19.	8.00	19.	8.15	19.	8.30	19.	8.45	19.
9.00	20.	9.15	20.	9.30	20.	9.45	20.	10.00	20.	10.15	20.
10.30	20.	10.45	20.	11.00	20.	11.15	20.	11.30	20.	11.45	20.
12.00	20.	12.15	20.	12.30	20.	12.45	20.	13.00	20.	13.15	20.
13.30	20.	13.45	20.	14.00	20.	14.15	20.	14.30	21.	14.45	21.
15.00	21.	15.15	21.	15.30	24.	15.45	21.	16.00	23.	16.15	23.
16.30	23.	16.45	23.								

PIEZOMETEN #37

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-143.	.15	-134.	.30	-105.	.45	-90.	1.00	-85.	1.15	-48.
1.30	-35.	1.45	-28.	2.00	-24.	2.15	-20.	2.30	-17.	2.45	-16.
3.00	-13.	3.15	-10.	3.30	-9.	3.45	-5.	4.00	-2.	4.15	1.
4.30	2.	4.45	2.	5.00	3.	5.15	6.	5.30	7.	5.45	7.
6.00	7.	6.15	9.	6.30	7.	6.45	9.	7.00	9.	7.15	9.
7.30	9.	7.45	9.	8.00	9.	8.15	9.	8.30	9.	8.45	9.
9.00	9.	9.15	9.	9.30	10.	9.45	10.	10.00	10.	10.15	10.
10.30	10.	10.45	10.	11.00	10.	11.15	10.	11.30	10.	11.45	10.
12.00	10.	12.15	10.	12.30	10.	12.45	10.	13.00	10.	13.15	12.
13.30	12.	13.45	12.	14.00	12.	14.15	12.	14.30	12.	14.45	12.
15.00	12.	15.15	12.	15.30	12.	15.45	13.	16.00	12.	16.15	12.
16.30	12.	16.45	12.								

PIEZOMETEN #38

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-104.	.15	-104.	.30	-104.	.45	-105.	1.00	-102.	1.15	-100.
1.30	-129.	1.45	-110.	2.00	-91.	2.15	-76.	2.30	-61.	2.45	-55.
3.00	-41.	3.15	-34.	3.30	-28.	3.45	-22.	4.00	-17.	4.15	-13.
4.30	-9.	4.45	6.	5.00	-2.	5.15	-1.	5.30	2.	5.45	4.
6.00	5.	6.15	4.	6.30	8.	6.45	8.	7.00	9.	7.15	10.
7.30	10.	7.45	10.	8.00	12.	8.15	12.	8.30	12.	8.45	12.
9.00	12.	9.15	13.	9.30	13.	9.45	13.	10.00	13.	10.15	13.
10.30	13.	10.45	13.	11.00	13.	11.15	14.	11.30	14.	11.45	14.
12.00	16.	12.15	16.	12.30	16.	12.45	16.	13.00	16.	13.15	16.
13.30	16.	13.45	16.	14.00	16.	14.15	16.	14.30	16.	14.45	16.
15.00	16.	15.15	16.	15.30	17.	15.45	17.	16.00	16.	16.15	17.
16.30	17.	16.45	17.								

PIEZOMETEN #39

TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE	TIME	PRESSURE
.00	-163.	.15	-134.	.30	-81.	.45	-56.	1.00	-41.	1.15	-31.
1.30	-26.	1.45	-21.	2.00	-17.	2.15	-13.	2.30	-9.	2.45	-9.
3.00	-5.	3.15	-4.	3.30	-4.	3.45	-4.	4.00	-1.	4.15	2.
4.30	2.	4.45	3.	5.00	3.	5.15	3.	5.30	4.	5.45	4.
6.00	4.	6.15	4.	6.30	4.	6.45	4.	7.00	4.	7.15	4.
7.30	4.	7.45	4.	8.00	4.	8.15	4.	8.30	4.	8.45	4.
9.00	4.	9.15	6.	9.30	6.	9.45	6.	10.00	6.	10.15	6.
10.30	6.	10.45	6.	11.00	6.	11.15	6.	11.30	6.	11.45	6.
12.00	7.	12.15	6.	12.30	7.	12.45	7.	13.00	7.	13.15	7.
13.30	7.	13.45	7.	14.00	7.	14.15	7.	14.30	7.	14.45	8.
15.00	8.	15.15	8.	15.30	8.	15.45	8.	16.00	8.	16.15	8.
16.30	8.	16.45	8.								

PIEZOMETER #

EXPERIMENT 1
Slope Shape and Tensiometer Locations

EXPERIMENT 2
Slope Shape and Tensiometer Locations

EXPERIMENT 3
Slope Shape and Tensiometer Locations

EXPERIMENT 4

Slope Shape and Tensiometer Locations

APPENDIX VII

BULK DENSITY DETERMINATIONS

	Bulk Density gm cm ⁻³	Mean ₋₁ gm cm
Determinations made after 6 hrs of rainfall	1.7923 1.7458	1.7691
Determinations made after 7.5 hours, soil appears to be close to flowage	1.6892 1.7142	1.7017
Determination made after 8.5 hours, soil taken from a flowage area	1.6490 1.6588	1.6539
Soil taken from flowed material stabilized on the footslope	1.8846 1.8185	1.8516
Soil taken from the area above the flowage area at the end of experiment	1.5960 1.6279	1.6129

APPENDIX VIII

WETTING CURVE

θV	Log P	P cm	Diffusivity $D(\theta)$ cm/sec	Conductivity $k(\theta)$ cm/sec	Permeability $k(\theta)$ cm ²
1	3.580	3802	8.209×10^{-5}	9.512×10^{-11}	9.700×10^{-16}
2	2.950	891.2	2.940×10^{-4}	5.642×10^{-9}	5.753×10^{-14}
3	2.480	302.0	5.386×10^{-4}	2.329×10^{-8}	2.376×10^{-13}
4	2.300	199.5	7.900×10^{-4}	6.769×10^{-8}	6.903×10^{-13}
5	2.170	147.9	9.530×10^{-4}	1.099×10^{-7}	1.120×10^{-12}
6	2.060	114.8	1.572×10^{-3}	2.798×10^{-7}	2.853×10^{-12}
7	1.960	91.2	2.193×10^{-3}	6.051×10^{-7}	6.171×10^{-12}
8	1.900	77.6	2.238×10^{-3}	9.947×10^{-7}	1.014×10^{-11}
9	1.840	69.2	2.630×10^{-3}	1.553×10^{-6}	1.585×10^{-11}
10	1.800	63.1	2.861×10^{-3}	1.957×10^{-6}	1.996×10^{-11}
11	1.760	57.5	3.844×10^{-3}	3.258×10^{-6}	3.322×10^{-11}
12	1.725	53.1	8.002×10^{-3}	8.580×10^{-6}	8.750×10^{-11}
13	1.700	50.1	1.107×10^{-2}	5.447×10^{-5}	5.555×10^{-10}
14	1.680	47.9	1.291×10^{-2}	6.227×10^{-5}	6.350×10^{-10}
15	1.650	44.7	1.520×10^{-2}	9.515×10^{-5}	9.704×10^{-10}
16	1.630	42.7	1.697×10^{-2}	1.312×10^{-4}	1.338×10^{-9}
17	1.610	40.7	2.161×10^{-2}	2.149×10^{-4}	2.192×10^{-9}
18	1.590	38.9	2.681×10^{-2}	2.199×10^{-4}	2.243×10^{-9}
19	1.580	38.0	3.131×10^{-2}	2.209×10^{-4}	2.253×10^{-9}
20	1.560	36.3	3.627×10^{-2}	2.273×10^{-4}	2.318×10^{-9}
21	1.550	35.5	4.193×10^{-2}	2.394×10^{-4}	2.441×10^{-9}
22	1.530	33.9	6.360×10^{-2}	3.802×10^{-4}	3.877×10^{-9}
23	1.510	32.4	7.146×10^{-2}	4.474×10^{-4}	4.562×10^{-9}
24	1.480	30.2	7.920×10^{-2}	4.958×10^{-4}	5.056×10^{-9}
25	1.440	27.5	8.894×10^{-2}	5.224×10^{-4}	5.327×10^{-9}
26	1.400	25.1	1.490×10^{-1}	5.601×10^{-4}	5.712×10^{-9}
27	1.340	21.9	2.653×10^{-1}	8.945×10^{-4}	9.122×10^{-9}
28	1.260	18.2			

DRYING CURVE

Vθ	Log P	P cm	D(θ)	k(θ)	k(θ)
1	3.580	3801.89	8.209×10^{-5}		
2	3.140	1380.38	2.940×10^{-4}	1.911×10^{-9}	1.947×10^{-14}
3	2.860	724.44	5.386×10^{-4}	1.154×10^{-8}	1.1791×10^{-13}
4	2.650	446.68	7.900×10^{-4}	3.871×10^{-8}	3.943×10^{-13}
5	2.500	316.228	9.530×10^{-4}	1.188×10^{-7}	1.210×10^{-12}
6	2.400	251.189	1.572×10^{-3}	6.919×10^{-7}	7.048×10^{-12}
7	2.320	208.930	2.193×10^{-3}	1.162×10^{-6}	1.184×10^{-11}
8	2.268	185.353	2.238×10^{-3}	1.546×10^{-6}	1.576×10^{-11}
9	2.212	166.725	2.630×10^{-3}	2.478×10^{-6}	2.527×10^{-11}
10	2.180	151.356	2.861×10^{-3}	3.829×10^{-6}	3.905×10^{-11}
11	2.145	139.637	3.844×10^{-3}	5.400×10^{-6}	5.507×10^{-11}
12	2.110	128.825	8.002×10^{-3}	8.968×10^{-6}	9.145×10^{-11}
13	2.080	120.226	1.107×10^{-2}	1.299×10^{-5}	1.325×10^{-10}
14	2.050	112.202	1.291×10^{-2}	1.661×10^{-5}	1.694×10^{-10}
15	2.020	104.471	1.520×10^{-2}	2.475×10^{-5}	2.524×10^{-10}
16	2.000	100.000	1.697×10^{-2}	2.827×10^{-5}	2.883×10^{-10}
17	1.965	92.257	2.161×10^{-2}	3.600×10^{-5}	3.671×10^{-10}
18	1.940	87.096	2.681×10^{-2}	4.504×10^{-5}	4.593×10^{-10}
19	1.905	80.353	3.131×10^{-2}	5.571×10^{-5}	5.681×10^{-10}
20	1.880	75.856	3.627×10^{-2}	7.589×10^{-5}	7.739×10^{-10}
21	1.850	70.795	4.193×10^{-2}	7.952×10^{-5}	8.101×10^{-9}
22	1.815	65.313	6.360×10^{-2}	1.068×10^{-4}	1.088×10^{-9}
23	1.770	58.884	7.146×10^{-2}	1.315×10^{-4}	1.340×10^{-9}
24	1.730	52.703	7.920×10^{-2}	1.437×10^{-4}	1.464×10^{-9}
25	1.680	47.863	8.894×10^{-2}	1.453×10^{-4}	1.481×10^{-9}
26	1.620	41.687	1.490×10^{-1}	2.407×10^{-4}	2.455×10^{-9}
27	1.550	35.481	2.653×10^{-1}	4.619×10^{-4}	4.705×10^{-9}

APPENDIX IX

GROUNDWATER CONDITIONS AND STABILITY ANALYSIS
FOR THE PHYSICAL SIMULATIONS

CENTRELINE	ROTTOM	WIDTH	WIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	WZFR0
12.280	.593	.713	14.768	.000	-.288	1.044	-.300	.000
11.567	.424	.713	38.153	.000	-.173	1.015	-.174	.000
10.854	.341	.713	53.798	13.979	-.058	1.002	-.059	.000
10.141	.340	.713	65.999	35.746	.056	1.002	.054	.000
9.428	.421	.713	74.758	44.500	.171	1.015	.173	.000
8.715	.589	.713	81.342	49.728	.285	1.043	.298	.000
8.002	.849	.713	80.571	49.348	.400	1.091	.437	.000
7.289	1.217	.713	71.989	30.164	.515	1.166	.600	.000
6.576	1.716	.713	53.817	11.217	.629	1.287	.810	.000
5.863	2.394	.713	22.622	.000	.744	1.496	1.113	.000
1.53	6.22	10.49	6.55	.33	558.	146.	7.97	3

EXPERIMENT 1

5.5 HOURS

F=1.53

CENTRELINE	ROTTOM	WIDTH	WEIGHT	POREPRESS	SIN	ALPHA	SEC	ALPHA	TAN	ALPHA	U7FRO
11.575	1.890	.779	11.219	.000	.198	1.020	.1202	.000			
10.796	.778	.779	28.269	.060	.088	1.004	.088	.000			
10.016	.752	.779	38.392	.000	.022	1.000	.022	.000			
9.237	.812	.779	47.398	.000	.131	1.009	.131	.000			
8.458	.960	.779	68.068	.000	.241	1.030	.241	.000			
7.679	1.201	.779	81.239	.000	.351	1.068	.375	.000			
6.899	1.548	.779	86.046	.000	.461	1.127	.519	.000			
6.120	2.018	.779	81.007	.000	.570	1.218	.694	.000			
5.341	2.645	.779	63.455	.000	.680	1.364	.924	.000			
4.561	3.496	.779	28.027	.000	.790	1.631	1.288	.000			
1.844	7.10	10.17	7.85	.75	533.	198.	8.96	2

CENTRELINE	ROTOR	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UTERO
11.575	.890	.779	11.219	.000	.198	1.020	-.202	.000
10.796	.778	.779	28.269	.000	-.088	1.004	-.088	.000
10.016	.752	.779	38.392	.000	.022	1.000	.022	.000
9.237	.812	.779	47.398	.000	.131	1.009	.132	.000
8.458	.960	.779	68.068	.000	.241	1.030	.242	.000
7.679	1.201	.775	81.239	.000	.351	1.068	.375	.000
6.899	1.548	.779	86.048	.000	.461	1.127	.518	.000
6.120	2.018	.779	81.007	.000	.570	1.214	.694	.000
5.341	2.645	.779	63.455	.000	.680	1.364	.928	.000
4.561	3.496	.779	28.027	.000	.790	1.631	1.288	.000
1.84	7.10	10.17	7.85	.75	533.	188.	8.96	?

CENTRELINE	MOISTURE	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	U7FRO
11.800	.872	.751	9.987	6.634	-.185	1.017	-.188	.000
11.049	.772	.751	25.165	16.050	-.079	1.003	-.079	.000
10.298	.753	.751	34.147	18.720	.027	1.000	.027	.000
9.546	.813	.751	36.985	.000	.133	1.009	.134	.000
8.795	.955	.751	52.419	.000	.239	1.030	.244	.000
8.043	1.185	.751	64.956	.000	.345	1.065	.367	.000
7.292	1.511	.751	70.056	.000	.450	1.120	.505	.000
6.540	1.950	.751	66.486	.000	.556	1.203	.669	.000
5.789	2.529	.751	52.107	.000	.662	1.334	.884	.000
5.037	3.302	.751	22.813	.000	.768	1.561	1.199	.000
1.68	7.10	10.49	7.85	.75	435	157	8.54	2

CENTRELINE	ROOT	WIDTH	HEIGHT	POREPRESS	SIN	ALPHA	SEC	ALPHA	TAN	ALPHA	UZERO
11.800	.872	.751	9.987	6.090	-.185	1.017	-.188	.000			.000
11.049	.772	.751	25.165	15.352	-.079	1.003	-.079	.000			.000
10.298	.753	.751	34.147	20.833	.027	1.000	.027	.000			.000
9.546	.813	.751	36.985	18.750	.133	1.009	.134	.000			.000
8.795	.955	.751	52.419	.000	.239	1.030	.244	.000			.000
8.043	1.185	.751	64.956	.000	.345	1.045	.347	.000			.000
7.292	1.511	.751	70.056	.000	.450	1.120	.508	.000			.000
6.540	1.950	.751	66.486	.000	.556	1.203	.669	.000			.000
5.789	2.529	.751	52.107	.000	.662	1.334	.884	.000			.000
5.037	3.302	.751	22.813	.000	.768	1.561	1.199	.000			.000
1.58	7.10	10.49	7.85	.75	.435	157.	8.54	2

CENTRELINE	PORTION	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UTFRQ
11.800	.872	.751	9.987	6.063	-.185	1.017	-.188	.000
11.049	1.772	.751	25.165	15.334	-.079	1.003	-.079	.000
10.298	.753	.751	34.147	20.824	.027	1.000	.027	.000
9.546	.813	.751	36.985	20.150	.133	1.009	.134	.000
8.795	.955	.751	52.419	3.664	.239	1.030	.244	.000
8.043	1.185	.751	64.956	.000	.345	1.065	.367	.000
7.292	1.511	.751	70.056	.000	.450	1.120	.505	.000
6.540	1.950	.751	66.486	.000	.556	1.203	.669	.000
5.789	2.529	.751	52.107	.000	.662	1.334	.784	.000
5.037	3.302	.751	22.813	.000	.768	1.561	1.199	.000
1.55	7.10	10.49	7.85	.75	.435	157.	8.54	2

CENTRELINE	BOUYOM	WIDTH	WEIGHT	POKEPRESS	SIN ALPHA	SIC ALPHA	TAN ALPHA	LZERC
12.018	.856	.706	8.542	4.970	-.174	1.016	-.177	.000
11.312	.768	.706	21.437	12.829	-.072	1.003	-.073	.000
10.666	.753	.706	29.165	17.486	.029	1.000	.029	.000
9.900	.810	.706	31.660	18.961	.131	1.009	.132	.000
9.194	.941	.706	35.223	21.880	.233	1.028	.239	.000
8.488	1.150	.706	46.758	.000	.335	1.061	.355	.000
7.782	1.445	.706	52.058	.000	.436	1.111	.485	.000
7.076	1.840	.706	50.182	.000	.538	1.186	.632	.000
6.370	2.356	.706	39.538	.000	.640	1.301	.832	.000
5.664	3.033	.706	17.226	.000	.741	1.490	1.105	.000
1.47	6.04	10.81	7.69	.75	332.	114.	7.92	3

CENTRELINE	EDITION	WIDTH	WEIGHT	ROCKPRESS	SIN	ALPHA	SEC	ALPHA	TAN	ALPHA	LZENC
11.575		.890	11.219	6.572	-4198	1.020	-.202	.000			.000
10.796		.778	28.269	16.920	-.088	1.004	-.088	.000			.000
10.016		.752	38.392	23.041	.022	1.000	.022	.000			.000
9.227		.812	47.398	28.745	.131	1.009	.133	.000			.000
8.358		.960	68.068	17.028	.241	1.030	.248	.000			.000
7.679		1.201	81.239	17.948	.351	1.068	.375	.000			.000
6.899		1.548	86.048	11.614	.461	1.127	.515	.000			.000
6.120		2.018	81.007	4.739	.570	1.218	.694	.000			.000
5.341		2.645	63.455	.000	.680	1.364	.928	.000			.000
4.561		3.496	28.027	.000	.790	1.631	1.288	.000			.000
1.72	7.10	10.17	7.85	.75	533.	198.	R.96	3

CENTRELINE	ROTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	WFFRO
11.575	.890	.779	11.219	6.056	-.198	1.020	-.202	.000
10.796	.778	.779	28.269	16.247	-.088	1.004	-.088	.000
10.016	.752	.779	38.392	22.211	.022	1.000	.022	.000
9.237	.812	.779	47.398	23.992	.131	1.009	.132	.000
8.458	.960	.779	68.068	5.523	.241	1.030	.248	.000
7.679	1.201	.779	81.239	20.680	.351	1.068	.375	.000
6.899	1.548	.779	86.048	14.913	.461	1.127	.519	.000
6.120	2.018	.779	81.007	9.036	.570	1.218	.694	.000
5.341	2.645	.779	63.455	12.978	.680	1.364	.928	.000
4.561	3.496	.779	28.027	.000	.790	1.631	1.288	.000
1.30	7.10	10.17	7.85	.75	533.	198.	8.96	2

CENTRELINE	ROTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZERO
11.575	.890	.779	11.219	6.848	-.198	1.020	-.202	.000
10.796	.778	.779	28.269	17.254	-.088	1.004	-.088	.000
10.016	.752	.779	38.392	23.433	.022	1.000	.022	.000
9.237	.812	.779	47.398	28.102	.131	1.009	.132	.000
8.458	.960	.779	68.068	.908	.241	1.030	.248	.000
7.679	1.201	.779	81.239	22.099	.351	1.048	.375	.000
6.899	1.548	.779	86.048	22.105	.461	1.127	.519	.000
6.120	2.018	.779	81.007	18.031	.570	1.218	.694	.000
5.341	2.645	.779	63.455	15.998	.680	1.364	.928	.000
4.561	3.496	.779	28.027	.000	.790	1.631	1.288	.000
1.19	7.10	10.17	7.85	.75	533.	198.	8.96	2

CENTRIFUGAL POSITION	WIDTH	WEIGHT	PURPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZEFC	
11.568	.892	765	10.925	6.608	-.201	1.021	-.206	.000
10.804	.779	765	27.554	16.818	-.091	1.004	-.092	.000
10.079	.751	765	37.481	22.876	-.019	1.000	.019	.000
9.274	.808	765	45.272	27.931	.129	1.008	.130	.000
8.509	.952	765	65.309	21.557	.239	1.030	.246	.000
7.745	1.148	765	78.106	23.665	.349	1.067	.373	.000
6.980	1.527	765	82.834	21.411	.460	1.126	.518	.000
6.215	1.987	765	78.054	23.743	.570	1.217	.693	.000
5.450	2.602	765	61.194	18.761	.680	1.364	.928	.000
4.686	3.437	765	27.056	.000	.790	1.632	1.290	.000
1.07	6.94	10.17	7.69	.75	514.	190.	8.79	3

CENTRFLINE	BOTTOM	WIDTH	WEIGHT	POKEPRESS	SIN	ALPHA	SEC	ALPHA	TAN	ALPHA	UZEFC
12,429	.642	.798	15.398	9.343	-.296	1.047		.0310			.000
11,631	.449	.798	39.430	24.016	-.174	1.015		.0176			.000
10,834	.359	.798	53.619	20.845	-.051	1.001		.0051			.000
10,036	.367	.798	61.489	20.062	.071	1.003		.071			.000
9,239	.473	.798	69.813	20.899	.194	1.019		.198			.000
8,441	.684	.798	74.957	14.883	.316	1.054		.333			.000
7,643	1.010	.798	83.419	7.226	.439	1.113		.488			.000
6,846	1.472	.798	82.820	.000	.561	1.208		.678			.000
6,042	2.110	.798	67.872	.000	.684	1.371		.937			.000
5,250	3.010	.798	31.523	.000	.806	1.691		1.364			.000
1.74	6.51	10.50	6.86	.35	580.	182.	9.22	.3			.000

F=1.74

EXPERIMENT 3

24.5 HOURS

CENTRELINE	BOTTOM	WIDTH	HEIGHT	POREPRESS	9IN ALPHA	SEC ALPHA	TAN ALPHA	UZERO
12.429	.642	.798	15.398	9.419	-.296	1.047	-.310	.000
11.631	.449	.798	39.430	24.100	-.174	1.015	-.176	.000
10.834	.359	.798	53.619	31.590	-.051	1.001	-.051	.000
10.036	.367	.798	61.489	36.633	.071	1.003	.071	.000
9.239	.473	.798	69.813	38.844	.194	1.019	.198	.000
8.441	.684	.798	74.957	25.072	.316	1.054	.353	.000
7.643	1.010	.798	83.419	15.084	.439	1.113	.488	.000
6.846	1.472	.798	82.820	2.207	.561	1.208	.678	.000
6.048	2.110	.798	67.872	.000	.684	1.371	.937	.000
5.250	3.010	.798	31.523	.000	.806	1.691	1.364	.000
1.46	6.51	10.50	6.86	.35	580.	182.	.22	3

CENTRELINE	BOTTOM	WIDTH	HEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZEFC
12.429	.642	.798	15.398	8.926	-.296	1.047	0.310	.000
11.631	.449	.798	39.430	23.316	-.174	1.015	0.126	.000
10.834	.359	.798	53.619	30.515	-.051	1.001	0.051	.000
10.036	.367	.798	61.489	35.267	.071	1.003	.071	.000
9.239	.475	.798	69.813	34.834	.194	1.019	.198	.000
8.441	.684	.798	74.957	28.569	.316	1.054	.333	.000
7.643	1.010	.798	83.419	20.095	.439	1.113	.488	.000
6.846	1.472	.798	82.820	16.937	.561	1.208	.676	.000
6.048	2.110	.798	67.872	5.245	.684	1.371	.937	.000
5.250	3.010	.798	31.523	.000	.806	1.691	1.364	.000
1.37	6.51	10.50	6.86	.35	580.	182.	9.22	3

F=1.37

EXPERIMENT 3

26.5 HOURS

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZEFO
12.429	.642	.798	15.398	9.388	-.296	1.047	-.310	.000
11.631	.449	.798	39.430	24.051	-.174	1.015	-.176	.000
10.834	.359	.798	53.619	31.523	-.051	1.001	-.051	.000
10.036	.367	.798	61.489	37.296	.071	1.003	.071	.000
9.239	.473	.798	69.813	44.407	.194	1.019	.198	.000
8.441	.684	.798	74.957	37.253	.316	1.054	.333	.000
7.643	1.010	.798	83.419	25.433	.439	1.113	.488	.000
6.846	1.472	.798	82.820	23.487	.561	1.208	.678	.000
6.048	2.110	.798	67.872	12.782	.684	1.371	.937	.000
5.250	3.010	.798	31.523	.000	.806	1.691	1.364	.000
1.19	6.51	10.50	6.86	.35	580.	182.	9.22	3

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZEFO
12.429	.642	.798	15.398	8.388	-.296	1.047	.9.310	.000
11.671	.449	.798	39.430	24.051	-.174	1.015	.9.176	.000
10.834	.359	.798	53.619	31.523	-.051	1.001	.9.051	.000
10.056	.367	.798	61.489	36.183	.071	1.003	.9.071	.000
9.239	.473	.798	69.813	34.747	.194	1.019	.9.198	.000
8.441	.664	.798	74.957	27.229	.316	1.054	.9.333	.000
7.643	1.010	.798	83.419	20.080	.439	1.113	.9.488	.000
6.846	1.472	.798	82.620	20.535	.561	1.208	.9.678	.000
6.048	2.110	.798	67.872	10.468	.884	1.371	.9.937	.000
5.250	3.010	.798	31.523	.000	.806	1.691	1.364	.000
1.332	6.51	10.50	6.86	.35	580.	182.	9.22	3

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	DEC ALPHA	TAN ALPHA	UZERO
12.429	.642	.798	15.398	9.388	-.296	1.047	-.310	.000
11.631	.449	.798	19.430	24.051	-.174	1.015	-.176	.000
10.834	.359	.798	53.619	51.523	-.051	1.001	-.051	.000
10.036	.367	.798	61.489	36.511	.071	1.003	.071	.000
9.239	.473	.798	69.613	37.599	.194	1.019	.198	.000
8.441	.684	.798	74.957	51.833	.316	1.054	.353	.000
7.643	1.010	.798	83.419	21.828	.439	1.113	.488	.000
6.846	1.472	.798	82.820	21.510	.561	1.208	.672	.000
6.042	2.110	.798	67.872	8.203	.684	1.371	.937	.000
5.250	3.010	.798	31.523	.000	.806	1.691	1.364	.000
1.29	6.51	10.50	6.86	.35	580.	182.	9.22	.3

CENTRELINE	BOTTOM	WIDTH	HEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZERO
12.429	.642	.798	15.398	9.388	-.296	1.047	.310	.000
11.631	.449	.798	39.430	24.051	-.174	1.015	.176	.000
10.834	.359	.798	53.619	31.523	-.051	1.001	.051	.000
10.036	.367	.798	61.489	36.183	.071	1.003	.071	.000
9.239	.473	.798	69.813	34.747	.194	1.019	.198	.000
8.441	.684	.798	74.957	27.452	.316	1.054	.333	.000
7.643	1.010	.798	83.419	22.104	.439	1.113	.486	.000
6.846	1.472	.798	82.820	20.098	.561	1.208	.678	.000
6.048	2.110	.798	67.872	3.093	.684	1.371	.937	.000
5.250	3.010	.798	31.523	.000	.806	1.691	1.364	.000
1.35	6.51	10.50	6.86	.35	580.	182.	9.22	3

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POKEPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZEFO
12.046	.920	.790	10.611	.000	-.218	1.025	-.223	.000
11.256	.790	.790	26.144	.000	-.106	1.006	-.107	.000
10.465	.750	.790	34.409	.000	.005	1.000	.005	.000
9.675	.798	.790	35.530	.000	.116	1.007	.117	.000
8.885	.936	.790	53.937	.000	.228	1.027	.234	.000
8.094	1.170	.790	71.087	.000	.339	1.063	.360	.000
7.304	1.510	.790	79.636	.000	.450	1.120	.504	.000
6.514	1.975	.790	78.093	.000	.561	1.208	.679	.000
5.723	2.597	.790	63.142	.000	.673	1.352	.909	.000
4.973	3.444	.790	27.972	.000	.784	1.611	1.263	.000
1.84	7.10	10.50	7.85	.75	481.	180.	9.04	3

CERTIFICATE	ROTOR	WIDTH	WEIGHT	POKEPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	USEFC
12.044	.920	.790	10.611	.000	-.214	1.025	-.223	.000
11.256	.790	.790	26.144	9.760	-.106	1.006	-.107	.000
10.465	.750	.790	34.409	.000	.005	1.000	.005	.000
9.675	.798	.790	35.530	.000	.116	1.007	.117	.000
8.865	.936	.790	53.937	.000	.228	1.027	.234	.000
8.054	1.170	.790	71.087	.000	.339	1.063	.360	.000
7.304	1.510	.790	79.636	.000	.450	1.120	.504	.000
6.514	1.975	.790	78.093	.000	.561	1.208	.679	.000
5.723	2.597	.790	63.142	.000	.673	1.352	.909	.000
4.973	3.404	.790	27.912	.000	.784	1.611	1.263	.000
1.79	7.10	10.50	7.85	.75	481.	100.	9.04	3

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	BIN ALPHA	SEC ALPHA	TAN ALPHA	UZEHC
12.026	.922	.775	10.339	5.297	-.221	1.025	-.227	.000
11.261	.792	.775	25.507	14.866	-.140	1.006	-.110	.000
10.385	.750	.775	33.644	20.144	.002	1.000	.002	.000
9.710	.795	.775	34.879	21.208	.114	1.007	.115	.000
8.934	.929	.775	51.282	7.616	.226	1.026	.232	.000
8.159	1.157	.775	67.907	3.783	.337	1.062	.358	.000
7.383	1.429	.775	76.236	7.148	.449	1.119	.503	.000
6.608	1.944	.775	74.829	.000	.561	1.208	.677	.000
5.832	2.554	.775	60.844	.000	.673	1.351	.909	.000
5.057	3.385	.775	26.980	.000	.784	1.612	1.264	.000
1.47	6.94	10.50	7.69	.75	462.	172.	8.87	3

CENTRELINE	ROTTOM	WIDTH	WEIGHT	POKEPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	USEFC
12.036	.922	.775	10.339	5.297	-.221	1.025	-.227	.000
11.261	.792	.775	25.507	14.866	-.110	1.006	-.110	.000
10.485	.750	.775	33.644	20.144	.002	1.000	.002	.000
9.710	.795	.775	34.879	21.208	.114	1.007	.115	.000
8.934	.929	.775	51.282	20.524	.226	1.026	.232	.000
8.159	1.157	.775	67.907	10.328	.337	1.062	.358	.000
7.383	1.489	.775	76.236	7.148	.449	1.119	.503	.000
6.608	1.944	.775	74.829	.000	.561	1.208	.677	.000
5.872	2.554	.775	60.844	.000	.673	1.351	.909	.000
5.057	3.385	.775	26.980	.000	.784	1.612	1.264	.000
1.37	6.94	10.50	7.69	.75	462.	172.	8.87	3

CENTRELINE	BOTTOM	WIDTH	WEIGHT	PURPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZEFC
12.046	.920	.790	10.611	5.439	-.218	1.025	-.223	.000
11.256	.790	.790	26.144	15.243	-.106	1.006	-.107	.000
10.265	.750	.790	34.409	20.611	.005	1.000	.005	.000
9.675	.798	.790	35.530	21.619	.116	1.007	.117	.000
8.885	.936	.790	93.937	33.755	.228	1.027	.234	.000
8.054	1.170	.790	71.087	9.880	.339	1.063	.360	.000
7.304	1.510	.790	79.626	6.419	.450	1.120	.504	.000
6.514	1.975	.790	78.093	.000	.561	1.208	.679	.000
5.723	2.597	.790	63.142	.000	.673	1.352	.909	.000
4.933	3.444	.790	27.972	.000	.784	1.611	1.263	.000
1.32	7.10	10.50	7.85	.75	481.	180.	9.04	3

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POKEPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZEFO
12.026	.924	.761	10.068	5.155	-.225	1.026	-.231	.000
11.265	.793	.761	24.872	14.490	-.113	1.006	-.114	.000
10.504	.750	.761	32.879	19.677	-.001	1.000	-.001	.000
9.744	.792	.761	34.221	20.795	.112	1.006	.112	.000
8.983	.922	.761	48.690	30.394	.224	1.026	.230	.000
8.223	1.144	.761	64.796	21.866	.336	1.062	.397	.000
7.462	1.469	.761	72.905	8.146	.448	1.119	.501	.000
6.702	1.914	.761	71.630	.000	.560	1.207	.676	.000
5.941	2.512	.761	58.481	.000	.672	1.351	.908	.000
5.181	3.326	.761	26.005	.000	.785	1.613	1.265	.000
1.27	6.78	10.50	7.53	.75	.445.	164.	8.70	3

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZEFO
12.004	.927	.731	9.532	4.876	1.233	1.028	-.239	.000
11.273	.796	.731	23.611	13.745	1.120	1.007	-.121	.000
10.542	.750	.731	31.351	18.745	1.007	1.000	-.007	.000
9.812	.787	.731	32.889	19.960	1.107	1.006	.107	.000
9.081	.908	.731	43.695	27.198	.220	1.025	.225	.000
8.351	1.118	.731	58.781	23.834	.333	1.060	.353	.000
7.620	1.427	.731	66.452	9.704	.446	1.117	.498	.000
6.889	1.853	.731	65.426	.000	.559	1.206	.674	.000
6.159	2.426	.731	53.387	.000	.672	1.350	.907	.000
5.428	3.209	.731	24.103	.000	.785	1.615	1.268	.000
1.26	6.46	10.50	7.21	.75	409.	148.	8.36	3

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SLC ALPHA	TAN ALPHA	U2EFC
12.004	.927	.731	9.532	4.876	-.233	1.028	-.239	.000
11.273	.796	.731	23.611	13.745	-.120	1.007	-.121	.000
10.542	.750	.731	31.351	18.745	-.007	1.000	-.007	.000
9.812	.787	.731	32.889	19.960	.107	1.006	.107	.000
9.081	.908	.731	43.695	27.198	.220	1.025	.225	.000
8.351	1.118	.731	58.781	23.834	.333	1.060	.353	.000
7.620	1.427	.731	66.452	9.704	.446	1.117	.498	.000
6.889	1.853	.731	65.426	.000	.559	1.206	.674	.000
6.159	2.426	.731	53.387	.000	.672	1.350	.907	.000
5.428	3.209	.731	24.103	.000	.785	1.615	1.268	.000
1.26	6.46	10.50	7.21	.75	409.	148.	8.36	3

APPENDIX X

GROUNDWATER CONDITIONS AND STABILITY ANALYSIS
FOR THE NUMERICAL SIMULATIONS

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZERO
6.966	1.294	.453	2.196	.000	-.358	1.071	-.383	-.000
6.212	1.154	.453	16.322	.000	-.229	1.027	-.236	-.000
6.059	1.078	.453	28.341	.000	-.101	1.005	-.102	-.000
5.605	1.061	.453	38.785	.000	.027	1.000	.027	-.000
5.152	1.103	.453	47.678	.000	.155	1.012	.157	-.000
4.698	1.205	.453	54.962	.000	.283	1.043	.295	-.000
4.245	1.373	.453	60.485	.000	.411	1.097	.451	-.000
3.791	1.619	.453	54.396	.000	.539	1.187	.640	-.000
3.338	1.963	.453	38.389	.000	.667	1.343	.896	-.000
2.884	2.454	.453	15.591	.000	.795	1.650	1.312	-.000
2.33	3.54	5.70	4.60	1.06	357.	109.	5.20	3

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	JZERO
7.138	1.276	.481	.516	.000	-.396	1.089	-.431	-.000
6.652	1.107	.481	15.362	.417	-.263	1.036	-.273	-.000
6.171	1.011	.481	29.322	2.274	-.130	1.009	-.131	-.000
5.690	.980	.481	44.426	4.131	.003	1.000	.003	-.000
5.210	1.013	.481	51.722	5.988	.135	1.009	.137	-.000
4.729	1.113	.481	60.158	7.845	.268	1.038	.279	-.000
4.248	1.284	.481	66.568	9.803	.401	1.092	.438	-.000
3.767	1.539	.481	61.585	12.076	.534	1.183	.632	-.000
3.286	1.902	.481	43.715	5.222	.667	1.342	.895	-.000
2.805	2.426	.481	17.917	.000	.800	1.665	1.332	-.000
2.02	3.62	5.70	4.60	.98	388.	118.	5.53	2

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZERO
7.133	1.276	.481	.516	2.104	-.396	1.089	-.431	-.000
6.652	1.107	.481	15.362	2.456	-.263	1.036	-.273	-.000
6.171	1.011	.481	29.322	4.629	-.130	1.009	-.131	-.000
5.690	.980	.481	41.426	6.803	.003	1.000	.003	-.000
5.210	1.013	.481	51.722	8.976	.135	1.009	.137	-.000
4.729	1.113	.481	60.158	11.149	.268	1.038	.279	-.000
4.248	1.284	.481	66.568	13.387	.401	1.092	.438	-.000
3.767	1.539	.481	61.585	15.189	.534	1.183	.632	-.000
3.286	1.902	.481	43.715	7.862	.667	1.342	.895	-.000
2.805	2.426	.481	17.917	.000	.800	1.665	1.332	-.000
1.85	3.62	5.70	.98	388.	.118.	5.53	3

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CENTRELINE	BOTTOM	WIDTH	HEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZERO
7.133	1.276	.481	.516	4.808	-.396	1.089	-.431	-.000
6.652	1.107	.481	15.362	4.808	-.263	1.036	-.273	-.000
6.171	1.011	.481	29.322	4.808	-.130	1.009	-.131	-.000
5.690	.980	.481	41.426	7.438	.003	1.000	.003	-.000
5.210	1.013	.481	51.722	10.769	.135	1.009	.137	-.000
4.729	1.113	.481	60.158	14.100	.268	1.038	.279	-.000
4.248	1.284	.481	66.568	17.431	.401	1.092	.438	-.000
3.767	1.539	.481	61.585	18.981	.534	1.183	.632	-.000
3.286	1.902	.481	43.715	11.408	.667	1.342	.895	-.000
2.805	2.426	.481	17.917	.000	.800	1.666	1.332	-.000
1.70	3.62	5.70	4.60	.98	388.	118.	5.53	3

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	JZERO
7.133	1.276	.481	.516	9.617	-.396	1.089	-.431	-.000
6.452	1.107	.481	15.362	9.617	-.263	1.036	-.273	-.000
6.171	1.011	.481	29.322	9.617	-.130	1.009	-.131	-.000
5.690	.980	.481	41.426	12.018	.003	1.000	.003	-.000
5.210	1.013	.481	51.722	15.060	.135	1.009	.137	-.000
4.729	1.113	.481	60.158	18.103	.268	1.038	.279	-.000
4.248	1.284	.481	66.568	21.145	.401	1.092	.438	-.000
3.767	1.539	.481	61.585	22.407	.534	1.183	.632	-.000
3.286	1.902	.481	43.715	14.542	.667	1.342	.895	-.000
2.305	2.426	.481	17.917	1.838	.800	1.665	1.332	-.000
1.41	3.62	5.70	4.60	.98	388.	118.	5.53	3

CENTRELINE	BOTTOM	WIDTH	HEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZZERO
6.906	.643	.005	.688	-.022	.351	1.068	.375	-.00
6.901	.644	.005	.689	-.022	.352	1.068	.376	-.00
6.896	.646	.005	.689	-.022	.353	1.069	.377	-.00
6.891	.648	.005	.690	-.022	.354	1.069	.379	-.00
6.887	.650	.005	.691	-.021	.355	1.070	.380	-.00
6.882	.652	.005	.692	-.021	.356	1.070	.381	-.00
6.877	.654	.005	.693	-.021	.357	1.071	.382	-.00
6.872	.655	.005	.694	-.021	.358	1.071	.383	-.00
6.868	.657	.005	.694	-.021	.359	1.071	.385	-.00
6.863	.659	.005	.695	-.020	.360	1.072	.386	-.00
6.717	.718	.286	43.018	-.035	.390	1.085	.423	-.00
6.431	.850	.286	45.609	-.089	.448	1.118	.501	-.00
6.145	1.005	.286	47.808	.606	.506	1.159	.587	-.00
5.859	1.187	.286	45.569	1.401	.564	1.211	.684	-.00
5.572	1.398	.286	50.832	1.957	.623	1.278	.796	-.00
5.286	1.644	.286	51.450	2.226	.681	1.366	.930	-.00
5.000	1.934	.286	47.782	.000	.739	1.485	1.098	-.00
4.714	2.278	.286	35.030	.000	.798	1.658	1.322	-.00
4.428	2.700	.286	26.654	.000	.856	1.933	1.655	-.00
4.142	3.250	.286	10.063	.000	.914	2.467	2.255	-.00
1.42	4.91	8.63	5.24	.33	419.	257.	4.29	3

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZERO
6.906	.643	.005	.688	-.023	.351	1.068	.375	-.00
6.901	.644	.005	.689	-.023	.352	1.068	.376	-.00
6.896	.646	.005	.689	-.022	.353	1.069	.377	-.00
6.891	.648	.005	.690	-.022	.354	1.069	.379	-.00
6.887	.650	.005	.691	-.022	.355	1.070	.380	-.00
6.882	.652	.005	.692	-.022	.356	1.070	.381	-.00
6.877	.654	.005	.693	-.022	.357	1.071	.382	-.00
6.872	.655	.005	.694	-.021	.358	1.071	.383	-.00
6.868	.657	.005	.694	-.021	.359	1.071	.385	-.00
6.863	.659	.005	.695	-.021	.360	1.072	.386	-.00
6.717	.718	.286	43.018	-.874	.390	1.086	.423	-.00
6.431	.850	.286	45.609	-.133	.448	1.118	.501	-.00
6.145	1.005	.286	47.808	.608	.506	1.159	.587	-.00
5.859	1.187	.286	49.569	1.349	.564	1.211	.684	-.00
5.572	1.398	.286	50.832	2.090	.623	1.278	.796	-.00
5.286	1.644	.286	51.450	2.781	.681	1.366	.930	-.00
5.000	1.934	.286	47.782	.000	.739	1.485	1.098	-.00
4.714	2.278	.286	39.030	.000	.798	1.658	1.322	-.00
4.428	2.700	.286	26.604	.000	.856	1.933	1.655	-.00
4.142	3.250	.286	10.563	.000	.914	2.467	2.255	-.00
1.32	4.91	8.63	6.24	.39	419.	257.	4.29	3

CENTRELINE	BOTTOM	WIDTH	WEIGHT	PORPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	JZERO
6.906	.643	.005	.688	.037	.351	1.068	.375	-.000
6.901	.644	.005	.689	.037	.352	1.068	.375	-.000
6.896	.646	.005	.689	.038	.353	1.069	.377	-.000
6.891	.648	.005	.690	.038	.354	1.069	.379	-.000
6.887	.650	.005	.691	.038	.355	1.070	.380	-.000
6.882	.652	.005	.692	.039	.356	1.070	.381	-.000
6.877	.654	.005	.693	.039	.357	1.071	.382	-.000
6.872	.655	.005	.694	.039	.358	1.071	.383	-.000
6.868	.657	.005	.694	.040	.359	1.071	.385	-.000
6.863	.659	.005	.695	.040	.360	1.072	.386	-.000
6.717	.718	.286	43.018	2.383	.390	1.086	.423	-.000
6.431	.850	.286	45.609	4.143	.448	1.118	.501	-.000
5.145	1.005	.286	47.808	5.303	.506	1.159	.587	-.000
5.859	1.187	.286	49.569	6.464	.564	1.211	.684	-.000
5.572	1.398	.286	50.832	7.624	.623	1.278	.796	-.000
5.286	1.644	.286	51.450	8.704	.681	1.366	.930	-.000
5.000	1.934	.286	47.782	4.692	.739	1.485	1.098	-.000
4.714	2.278	.286	39.030	.000	.798	1.658	1.322	-.000
4.428	2.700	.286	26.654	.000	.856	1.933	1.655	-.000
4.142	3.250	.286	10.563	.000	.914	2.467	2.255	-.000
1.29	4.91	8.63	5.24	.33	419.	257.	4.29	3

[illegible]

5.906	.643	.005	.688	.105	.351	1.068	.375	-.000
6.901	.644	.005	.689	.105	.352	1.068	.376	-.000
6.896	.646	.005	.689	.106	.353	1.069	.377	-.000
6.891	.648	.005	.690	.106	.354	1.069	.379	-.000
6.887	.650	.005	.691	.106	.355	1.070	.380	-.000
6.882	.652	.005	.692	.107	.356	1.070	.381	-.000
6.877	.654	.005	.693	.107	.357	1.071	.382	-.000
6.872	.655	.005	.694	.108	.358	1.071	.383	-.000
6.868	.657	.005	.694	.108	.359	1.071	.385	-.000
6.863	.659	.005	.695	.108	.360	1.072	.386	-.000
6.717	.718	.286	43.018	7.146	.390	1.086	.423	-.000
6.431	.850	.286	45.609	8.471	.448	1.118	.501	-.000
5.145	1.005	.286	47.808	9.796	.506	1.159	.587	-.000
5.859	1.187	.286	49.569	11.120	.564	1.211	.684	-.000
5.572	1.398	.286	50.832	12.445	.623	1.278	.796	-.000
5.286	1.644	.286	51.450	13.589	.681	1.366	.930	-.000
5.000	1.934	.286	47.782	9.842	.739	1.485	1.098	-.000
4.714	2.278	.286	39.030	5.004	.798	1.658	1.322	-.000
4.428	2.700	.286	26.654	.000	.856	1.933	1.655	-.000
4.142	3.250	.286	10.563	.000	.914	2.467	2.255	-.000
1.15	4.91	8.63	5.24	.33	419.	257.	4.29	4

6.906	.643	.005	.688	.127	.351	1.068	.375	-.000
6.901	.644	.005	.689	.127	.352	1.068	.376	-.000
6.896	.646	.005	.689	.128	.353	1.069	.377	-.000
6.891	.648	.005	.690	.128	.354	1.069	.379	-.000
6.887	.650	.005	.691	.128	.355	1.070	.380	-.000
6.882	.652	.005	.692	.129	.356	1.070	.381	-.000
6.877	.654	.005	.693	.129	.357	1.071	.382	-.000
6.872	.655	.005	.694	.130	.358	1.071	.383	-.000
6.868	.657	.005	.694	.130	.359	1.071	.385	-.000
6.863	.659	.005	.695	.130	.360	1.072	.385	-.000
6.717	.718	.286	43.018	8.501	.390	1.086	.423	-.000
6.431	.850	.286	45.609	9.901	.448	1.118	.501	-.000
6.145	1.005	.286	47.808	11.301	.506	1.159	.587	-.000
5.859	1.187	.286	49.569	12.701	.564	1.211	.684	-.000
5.572	1.398	.286	50.832	14.102	.623	1.278	.795	-.000
5.286	1.644	.286	51.450	15.422	.681	1.366	.930	-.000
5.000	1.934	.286	47.782	11.649	.739	1.485	1.098	-.000
4.714	2.278	.286	39.030	6.887	.798	1.658	1.322	-.000
4.428	2.700	.286	26.654	.733	.856	1.933	1.655	-.000
4.142	3.250	.286	10.563	.000	.914	2.467	2.255	-.000
1.10	4.91	8.63	5.24	.33	419.	257.	4.29	4

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZERO
5.906	.643	.005	.688	.168	.351	1.068	.375	-.000
6.901	.644	.005	.689	.168	.352	1.068	.376	-.000
6.896	.646	.005	.689	.169	.353	1.069	.377	-.000
6.891	.648	.005	.690	.169	.354	1.069	.379	-.000
6.887	.650	.005	.691	.170	.355	1.070	.380	-.000
6.882	.652	.005	.692	.170	.356	1.070	.381	-.000
6.877	.654	.005	.693	.171	.357	1.071	.382	-.000
6.872	.655	.005	.694	.171	.358	1.071	.383	-.000
6.868	.657	.005	.694	.171	.359	1.071	.385	-.000
6.863	.659	.005	.695	.172	.360	1.072	.386	-.000
6.717	.718	.286	43.018	11.034	.390	1.086	.423	-.000
6.431	.850	.286	45.609	12.530	.448	1.118	.501	-.000
6.145	1.005	.286	47.808	14.026	.506	1.159	.587	-.000
5.859	1.187	.286	49.569	15.522	.564	1.211	.684	-.000
5.572	1.398	.286	50.832	16.805	.623	1.278	.795	-.000
5.286	1.644	.286	51.450	17.656	.681	1.366	.930	-.000
5.000	1.934	.286	47.782	13.415	.739	1.485	1.098	-.000
4.714	2.278	.286	39.030	8.183	.798	1.658	1.322	-.000
4.428	2.700	.286	26.654	2.444	.856	1.933	1.655	-.000
4.142	3.250	.286	10.563	.000	.914	2.467	2.255	-.000
1.03	4.91	8.63	5.24	.33	419.	257.	4.29	4

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	JZERO
7.376	.816	.881	32.554	-10.241	-.404	1.093	-.441	-.000
6.695	.566	.681	161.329	-2.135	-.285	1.043	-.297	-.000
5.014	.409	.681	191.170	5.013	-.165	1.014	-.168	-.000
5.334	.336	.681	194.064	10.096	-.046	1.001	-.045	-.000
4.653	.345	.681	193.699	14.223	.073	1.003	.073	-.000
3.973	.436	.681	190.062	16.868	.192	1.019	.195	-.000
3.292	.614	.681	182.986	19.513	.311	1.052	.328	-.000
2.612	.886	.681	172.118	21.136	.431	1.108	.477	-.000
1.931	1.270	.681	156.807	21.724	.550	1.197	.658	-.000
1.250	1.796	.681	126.443	8.886	.669	1.345	.900	-.000
1.10	5.71	5.07	6.04	.33	1601.	253.	7.91

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZERR
7.376	.816	.681	32.554	-5.522	-.404	1.093	-.441	-.000
6.695	.566	.681	161.329	13.932	-.285	1.043	-.297	-.000
5.014	.409	.681	191.170	31.214	-.165	1.014	-.168	-.000
5.334	.336	.681	194.064	43.810	-.046	1.001	-.046	-.000
4.653	.345	.681	193.699	54.637	.073	1.003	.073	-.000
3.973	.436	.681	190.062	62.719	.192	1.019	.196	-.000
3.292	.614	.681	182.986	70.801	.311	1.052	.328	-.000
2.612	.886	.681	172.118	76.035	.431	1.108	.477	-.000
1.931	1.270	.681	156.807	78.390	.550	1.197	.658	-.000
1.250	1.796	.681	126.443	67.318	.669	1.345	.900	-.000
1.09	5.71	5.07	6.04	.33	1601.	253.	7.91

CENTRELINE	BOTTOM	WIDTH	WEIGHT	POREPRESS	SIN ALPHA	SEC ALPHA	TAN ALPHA	UZERO
7.376	.816	.681	32.554	-.877	-.404	1.093	-.441	-.000
6.695	.566	.681	161.329	21.124	-.285	1.043	-.297	-.000
6.014	.409	.681	191.170	40.286	-.165	1.014	-.168	-.000
5.334	.336	.681	194.064	53.324	-.046	1.001	-.046	-.000
4.653	.345	.681	193.699	63.902	.073	1.003	.073	-.000
3.973	.436	.681	190.062	70.661	.192	1.019	.196	-.000
3.292	.614	.681	182.986	77.421	.311	1.052	.328	-.000
2.612	.886	.681	172.118	81.941	.431	1.108	.477	-.000
1.931	1.270	.681	156.807	84.198	.550	1.197	.658	-.000
1.250	1.796	.681	126.443	79.028	.669	1.345	.900	-.000
1.08	5.71	5.07	6.04	.33	1601.	253.	7.91

APPENDIX XI

MISCELLANEOUS SOIL DATA

SHEAR TEST DATA

Experimental Soil Test #1

Shear Box 6 cm x 6 cm

Inside Depth 3.8 cm

Soil thickness 1.95 cm

Normal Load = 6.997 kg

Normal stress = .1943 kg/cm

Shear Rate = .036 cm/min

Shear Dial (cm)	Shear Displacement (cm)	Proving Ring (cm)	Shear Force (kg)	$\tan^{-1} \left(\frac{s}{\sigma} \right)$ (degrees)
.3100		.12000	0	
.3110	.0010	.12010	.0278	8.14
.3125	.0025	.12015	.0416	12.08
.3140	.0040	.12017	.0472	13.65
.3150	.0050	.12019	.0527	15.18
.3155	.0050	.12021	.0583	16.70
.3160	.0060	.12022	.0611	17.46
.3170	.0070	.12023	.0639	18.20
.3195	.0095	.12024	.0694	19.66
.3225	.0125	.12025	.0778	21.82
.3228	.0128	.12028	.0888	24.56
.3231	.0131	.12032	.0944	25.91
.3234	.0134	.12034	.0972	26.58
.3237	.0137	.12035	.1027	27.86
.3239	.0139	.12037	.1056	28.52
.3242	.0142	.12038	.1083	29.13
.3245	.0145	.12039	.1111	29.76
.3248	.0148	.12040	.1167	30.99
.3251	.0151	.12041	.1194	31.57
.3254	.0154	.12042	.1222	32.17
.3257	.0157	.12044	.1250	32.75
.3260	.0160	.12045	.1277	33.31
.3263	.0163	.12046	.1306	33.90
.3266	.0166	.12048	.1333	33.45
.3269	.0169	.12049	.1361	35.01

Experimental Soil Test #1

Shear Box 6 cm x 6 cm
 Inside Depth 3.8 cm
 Soil thickness 1.95 cm

Normal Load = 6.997 kg
 Normal stress = .1943 kg/cm
 Shear Rate = .036 cm/min

Shear Dial (cm)	Shear Displacement (cm)	Proving Ring (cm)	Shear Force (kg)	$\tan^{-1} \left(\frac{s}{z\delta} \right)$ (degrees)
.32	.0172	.12049	.1361	35.01
.3275	.0175	.12049	.1361	35.01
.3278	.0178	.12049	.1361	35.01

$$\phi = 35.01 = \phi_m = \phi_n$$

Experimental Soil Test #2

Shear Box 6 x 6 cm

Inside Depth 3.8 cm

Soil thickness 2.0 cm

Normal Load = .10 kg

Normal stress = .4721 kg cm²

Shear Rate = .036 cm

Shear Dial (cm)	Shear Displ. (cm)	Proving Ring (cm)	Shear Force (kg)	$\tan^{-1} \frac{s}{z}$ (degrees)
.3250		.15015	0	
.3260	.0010	.15020	.0138	1.67
.3265	.0015	.15030	.0416	5.04
.3270	.0020	.15035	.0555	6.70
.3280	.0030	.15040	.0694	8.36
.3295	.0040	.15043	.0778	9.35
.3300	.0050	.15045	.0833	10.00
.3330	.0080	.15048	.0917	10.99
.3360	.0110	.15050	.0972	11.63
.3390	.0140	.15070	.1528	17.93
.3415	.0165	.15080	.1666	19.44
.3445	.0195	.15088	.2027	23.23
.3475	.0225	.15095	.2222	25.20
.3505	.0255	.15105	.2500	27.90
.3530	.0280	.15115	.2778	30.47
.3560	.0310	.15120	.2916	31.70
.3590	.0340	.15127	.3111	33.38
.3620	.0370	.15133	.3278	34.77
.3650	.040	.15135	.3333	35.22
.3653	.0430	.15135	.3333	35.22

$$\phi = 35.22 = \phi_m = \phi_n$$

Experimental Soil Test # 3

Shear Box 6 x 6 cm
 Inside Depth 3.8 cm
 Soil thickness 2.0 cm

Normal Load = 20 kg
 Normal stress = .7497 kg
 Shear Rate = .036 cm/min

Shear Dial (cm)	Shear Displace- ment (cm)	Proving Ring (cm)	Shear Force (kg)	$\tan^{-1}$ $(\frac{s}{z})$
.2500		.15013	0	-
.2510	.0010	.15040	.0750	5.71
.2515	.0015	.15062	.1361	10.29
.2520	.0020	.15080	.1861	13.94
.2525	.0025	.15090	.2139	15.92
.2530	.0030	.15100	.2417	17.86
.2537	.0037	.15105	.2555	18.82
.2543	.0043	.15112	.2750	20.14
.2544	.0044	.15116	.2861	20.88
.2580	.0080	.15129	.3222	23.26
.2600	.0100	.15152	.3861	27.25
.2630	.0130	.15171	.4389	30.35
.2660	.0160	.15190	.4917	33.26
.2690	.0190	.15200	.5194	34.71
.2720	.0220	.15203	.5277	35.14
.2750	.0250	.15207	.5388	35.70
.2780	.0280	.15207	.5388	35.70
.2810	.0310	.15207	.5388	35.70

Grain Size Distribution of the
Experimental Soil

BIBLIOGRAPHY

- American Society for Testing Materials, 1964. Procedures for testing soils. American Soc. for Testing Materials, Philadelphia, PA.
- Azimi, C. and P. Desvarreaux, 1974. A Study of One Special Type of Mudflow in the French Alps. Quarterly Journal of Engineering Geology, 7(4), pp. 329-338.
- Bailey, R.G., 1971. Landslide Hazards Related to Land Use Planning in the Teton National Forest, N.W. Wyoming. U.S. Dept. Agriculture, Forest Service, Washington, D.C.
- Bailey, R.G. and R.M. Rice, 1969. Soil Slippage: An Indicator of Slope Stability on Chapparral Watersheds of S. California. Professional Geographer, 21(3), pp. 172-177.
- Bailey, R.V. and A.B. Whitman, 1967. Use of Computers for Slope Stability Analysis. Proc. American Soc. of Civil Engineers, Foundations Division, pp. 475-497.
- Betson, B.P., 1964. What is Watershed Runoff. Journal of Geophysical Research, 69, pp. 1541-1551.
- Betson, R.P. and J.B. Marius, 1969. Source Areas of Storm Runoff. Water Resour. Research, 5, pp. 574-582.
- Bishop, A.W., 1955. The use of tree slip circle in the stability of slopes. Geotechnique, 5, pp. 7-17.
- Bishop, D.M. and M.E. Stevens, 1964. Landslides on logged areas in South East Alaska. U.S. Forest Service, NOR 1, pp. 1-18.
- Black, C.A. (Ed.), 1965. Methods of Soil Analysis, Part I. American Society of Agronomy.
- Bruce, R.R. and A. Klute, 1956. The Measurement of Soil Diffusivity. Soil Sci. Soc. Am. Proc., Vol. 20, pp. 458-462.
- Brown, C.B. and M.S. Shen, 1975. Effects of deforestation on slopes. A.S.C.E., Journal of Geotechnical Engineers, Foundation Division, Vol. 100, pp. 147-166.
- Campbell, R.H., 1974. Debris Flows originating from Soil Slips during Rainstorms in Southern California. Q. Journal Engineering Geology, 7(4), pp. 339-349.

- Carson, M.A., 1960b. Models of Hillslope Development under Mass Failure. Geographical Analysis, 1, pp. 76-100.
- Carson, M.A., 1971a. Application of the Concept of Threshold Slopes to the Laramie Mountains, Wyoming. Trans. IBG, Special publication 3.
- Carson, M.A. and M.J. Kirby, 1972. Hillslope Form and Process. Cambridge University Press, 175 pp.
- Chow, V.T. (Ed.), 1974. Handbook of Applied Hydrology. McGraw Hill, N.Y., 1418 pp.
- Cook, R.U. and J.C. Doornkamp, 1974. Geomorphology in Environment Management. Oxford University Press, 413 pp.
- Croney, D., J.D. Coleman and W.P.M. Black, 1958. Movement and Distribution of Water in Soil in Relation to Highway Design and Performance. Special Report, Highway Res. Board, Washington, 40, pp. 226-252.
- Da Coasta Nunes, A.J., 1969. Landslides in Soils of Decomposed Rock due to Intense Rainstorms. 7th Int. Proc. Found. Eng. Soil Mech., Mexico, pp. 547-555.
- Curry, R.C., 1966. Observations of Alpine Mudflows in the Ten Mile Range, Central Colorado. Bull. Geol. Soc. Am., Vol. 77, pp. 771-776.
- Day, P.R. and J.N. Luthin, 1956. A numerical solution of the differential equation for flow for a vertical drainage problem. Soil Sci. Am. Proc., 20, pp. 443-447.
- Dunne, T. and R.D. Black, 1970a. An experimental investigation of runoff production in permeable soils. Water Resources Research, 6, pp. 478-490.
- Dunne, T. and R.D. Black, 1970b. Partial area contributions to storm runoff in a small New England watershed. Water Resources Research, 6, pp. 1296-1311.
- Freeze, R.A., 1971. Three-dimensional, transient saturated-unsaturated flow in a groundwater basin. Water Resources Research, 7(2), pp. 347-366.
- Freeze, R.A., 1972a. Role of subsurface flow in generating surface runoff 1, Base Flow Contributions to Channel Flow. Water Resources Research, 8(3), pp. 609-623.

- Freeze, R.A., 1972b. Role of subsurface flow in generating surface runoff 2, Upstream Source Areas. Water Resources Research, 8(5), pp. 1272-1283.
- Freeze, R.A., 1972c. A physics based approach to hydrologic response modelling - Phase I Model Development. I.B.M. Watson Research Centre, Yorktown Heights, N.Y.. N.T.I.S. Publication W 73-03257.
- Freeze, R.A., 1974. Stream Flow Generation. Reviews of Geophysics and Space Physics, 12(4), pp. 627-647.
- Freeze, R.A. and R.L. Harlan, 1969. Blueprint for a physically-based digitally-simulated hydrologic response model. J. Hydrology, 9, pp. 237-258.
- Gifford, J., 1953. Landslides on Exmoor caused by the Storm of August 15, 1952. Geography, 38, pp. 9-17.
- Green, W.H. and G.A. Ampt, 1911. Studies in soil physics. J. Agricultural Science, 4, pp. 1-24.
- Gray, D.H., 1969. Effect of Forest Clear Cutting on the Stability of Natural Slopes. University of Michigan, Ann Arbor, 67 pp.
- Gumbel, E.J., 1958. The Theory of Extremes. Columbia University Press.
- Hewlett, J.D. and A.R. Hibbest, 1963. Moisture and energy conditions within a sloping soil mass during draining. J. Geophys. Research, 68(4), pp. 1081-1089.
- Horton, R.E., 1940. An approach towards physical interpretation of infiltration capacity. Soil Sci. Soc. Proc., 5, pp. 399-417.
- Hotzel, C., 1976a. Description of a landslide in the Uclulet area - Vancouver Island. Report prepared for McMillan Blodel. Unpublished.
- Hotzel, C., 1976b. Landsliding in the Holberg Inlet area. Report prepared for Rayonier Canada (B.C.) Ltd. Vancouver.
- Hough, B.K., 1957. Basic Soils Engineering. Ronald Press, N.Y. 513 pp.
- Hutchinson, J.N. et al., 1974. An Antrim Mudslide. Q. Jnl. Eng. Geol., 7(4), pp. 363-76.

Jackson, 1966. Slips in relation to rainfall and soil characteristics. Journal of Hydrology, N.Z., Vol. 5, pp. 45-53.

Kidson, C., 1952. The Exmoor Storm of 15 August 1952. Geography, 38, pp. 1-8.

Kirkby, M.J., 1972. Landslides and Weathering Rates. Working Paper No. 34, Department of Geography, University of Leeds, U.K.

Kirkby, M.J. and R.J. Chorley, 1967. Overland Flow, Through Flow, and Erosion. Int. Assoc. Sci. Hydrol. Bull. 12(3), pp. 5-21.

Kirkpatrick, W.M., 1965. Effects of grainsize and grading on the shearing behaviour of granular materials. 6th Int. Conf. Soil Mech. Found. Eng., Toronto, Vol. 1, pp. 273-277.

Koerner, R.M., 1970a. Effect of particle characteristics on soil strength. Journal of Soil Mech. and Foundations Division, Proc. Am. Soc. Eng., 4, p. 1221.

Lambe, T.W., 1951. Soil Testing for Engineers. Wiley, N.Y.

Lambe, T.W. and R.V. Whitman, 1965. Soil Mechanics. Wiley, New York. 553 pp.

Lefroy, J.H., 1889. Report upon the depth of permanently frozen soil in the polar regions, its geographical limits and relations to the present poles of greatest cold. Proc. Royal Geogr. Soc., Vol. 11, pp. 740-746.

Leighton, F.B., 1970. Landslides, in Geologic Hazards and Public Problems, R.A. Olson and M.M. Wallace (eds). United States Office Emergency Preparedness, Region 7, Proc. Conf. San Francisco, Calif., pp. 97-132.

Lumb, P., 1962. The properties of decomposed granite. Geotechnique, 12, pp. 226-243.

Lumb, P., 1975. Slope failures in Hong Kong. Q. Journal of Eng. Geol., Vol. 8, pp. 31-65.

MacKay, J.R. and B. Matthews, 1973. Geomorphology and Quarternary History of the Mackenzie River Valley near Fort Good Hope. Can. Jour. Earth Sci., p. 26.

- Morgenstern, N.R. and V.E. Price, 1965. The analysis of the stability of general slip surfaces. Geotechnique, 15, pp. 79-93.
- Murota, A. and M. Hashino, 1971. An application of simulated rainfall models to forecasting of the long term variation of river beds in Systems Approach to Hydrology, V. Yevjevich (ed.). Proc. of First Bilateral US-Japan Seminar in Hydrology, Water Resources Publication, Fort Collins, Colorado.
- O'Laughlin, C.L. An investigation of the stability of the steep-land forest soils in the vast mountains, south-west British Columbia. Unpublished Ph.D. Thesis, University of British Columbia, 147 pp.
- Peck, R.B., 1967. Stability of Natural Slopes. Jour. SM & FD, ASCE 93, SM4, pp. 403-417.
- Phillip, J.R., 1957. The Theory of Infiltration IV: Sorbtivity and Algebraic Infiltration Equations. Soil Science, 84, pp. 257-264.
- Prior, D.B. and J. Graham, 1974. Landslides in the Magho district of Fermanagh, N.I. Engineering Geology, 8(4), pp. 341-360.
- Rice, R.M. and G.T. Foggin, 1971. Effect of high intensity storms on soil slippage on mountainous watersheds in Southern California. Water Resources Research, 7, pp. 1485-1496.
- Reiche, 1972. Log Pearson III and Grumbel Analysis of Floods. Second Internat. Symposium of Hydrology, Fort Collins, Colorado, pp. 291-303.
- Ringheim, A.S., 1964. Experiences with Bearpaw Shales at the South Saskatchewan River dam. Proc. 8th International Congress on Large Dams, 1, pp. 529-550.
- Rubin, J., 1968. Numerical Analysis of Pondered Rainfall Infiltration. Water in the Unsaturated Zone. UNESCO Symposium, Vol. 1, pp. 440-450.
- Schumm, S.A. and M.P. Mosley (Eds.), 1973. Slope Morphology. Dowden Hutchinson and Ross Inc., Stroudsburg, P.A.
- Sharp, C.F.S., 1938. Landslides and Related Phenomena. Columbia University Press, New York. Reprinted 1960 by Paganet Books Inc., N.J., 137 pp.

- Skempton, A.W., 1964. Long-term stability of clay slopes. Rankine Lecture, Geotechnique, Vol. 14, pp. 75-102.
- Skempton, A.W. and F.A. De Lory, 1957. Stability of Natural Slopes in London Clay. Proc. 7th Int. Conf. on Soil Mech. and Foundation Engineering, 2, pp. 378-381.
- Skempton, A.W. and J.N. Hutchinson, 1969. Stability of Natural Slopes and Embankment sections. Proc. 7th International Conference on Soil Mechanics and Foundation Engineering, State of the Art Volume, pp. 291-340.
- So, C.L., 1971. Mass Movements Associated with the Rainstorms of June 1966 in Hong Kong. Trans. Institute of British Geographers, 53, pp. 55-65.
- Stephenson, G.R. and R.A. Freeze, 1974. Mathematical simulation of sub-surface flow: Contributions to snowmelt runoff, Reynolds Creek Watershed, Idaho. Water Resources Research, 10(2), pp. 284-294.
- Swanston, D.N., 1967b. Debris avalanching in the soils derived from bedrock. USDA Forest Section, Note PNW-64, 7 pp.
- Swanston, D.N., 1967c. Soil water piezometry in a southeast Alaska landslide area. USDA For. Serv. Res. Note PNW-68, 17 pp., illus.
- Swanston, D.N., 1969. Mass wasting on coastal Alaska. US Dept. Agric. and Forest Service. Res. Paper. PNW-83, 15 pp.
- Swanston, D.N., 1974. The forest Ecosystem of Southeast Alaska: #5. Soil Mass Movement. P.N.W. Forest and Range Exp. Sta. Forest Service. Technical Report PNW 17.
- Taylor, P.D., 1948. Fundamentals of Soil Mechanics. Wiley, N.Y.
- Temple, P.H. and A. Rapp, 1972. Landslides in the Mgeta Area Western Muguru Mountains, Tanzania. Geografiska Annaler, V. 54, pp. 157-193.
- Terzaghi, K. and R.B. Peck, 1967. Soil Mechanics in Engineering Practice. 2nd Edition. Wiley, New York. 729 pp.
- Tricart, J., 1972. Introduction to Climatic Geomorphology. Longmans Pub., London.

Vargas, M. and E. Pichler, 1957. Residual Soil and Rock Slides in Sautos, Brazil. Pro. 4th Intern. Conf. Soil Mech., Vol. 2, pp. 394-398.

Varnes, D.J., 1958. Landslide Types and Processes in Landslides and Engineering Practice, E.B. Eckel (Ed.). Highway Research Board, Washington, Special Report 29; NAS-NRC publ. 544, 232 pp.

Wentworth, C.K., 1943. Soil avalanches in Oahu, Hawaii. Bull. of the Geological Soc. Am., 54, pp. 53-64.

White, S.E., 1949. Processes of erosion on the steep slopes of Oahu, Hawaii. Am. Journal Sci., Vol. 247, pp. 168-186.

Zaruba, Q. and V. Mencl, 1969. Landslides and River Control. Elsevier Press, Amsterdam. 205 pp.

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