REPORT

FORENSIC INVESTIGATION AND ROOT CAUSE ANALYSIS DECEMBER 14, 2005 INCIDENT UPPER RESERVOIR DIKE TAUM SAUK PLANT FERC PROJECT NO. 2277

1.0 INTRODUCTION

This Report documents the results of a forensic investigation into the root cause of the breach of the Upper Reservoir Dike at the Taum Sauk Plant, near Lesterville, Missouri, on December 14, 2005. The investigation was conducted by Paul C. Rizzo Associates, Inc. (RIZZO) between January 2 and February 28, 2006, at the request of Union Electric Company doing business as AmerenUE (AmerenUE) as required under 18 CFR 12.10 (a)(2)(i) and in response to a specific request of the Federal Energy Regulatory Commission (FERC).

RIZZO utilized several subcontractors and has included into this report the investigative work associated with project instrumentation, performed by Siemens Power Generation, Inc. (Siemens). Siemens focused on the instrumentation and control aspects of the investigation. While the Siemens work has been integrated into this Report, their actual report to AmerenUE and RIZZO is included in ***Appendix A***.

2.0 SUMMARY DESCRIPTION OF THE TAUM SAUK PLANT

The Taum Sauk Plant is located in Reynolds County, Missouri, on the East Fork of the Black River, approximately 90 miles southwest of St. Louis, Missouri. It is a reversible pumped storage project used to supplement the generation and transmission facilities of AmerenUE, and consists basically of a ridge top Upper Reservoir, a Shaft and Tunnel conduit, a 450-MW, two-unit pump-turbine, motor-generator plant, and a Lower Reservoir as illustrated on ***Figure 2-1***.

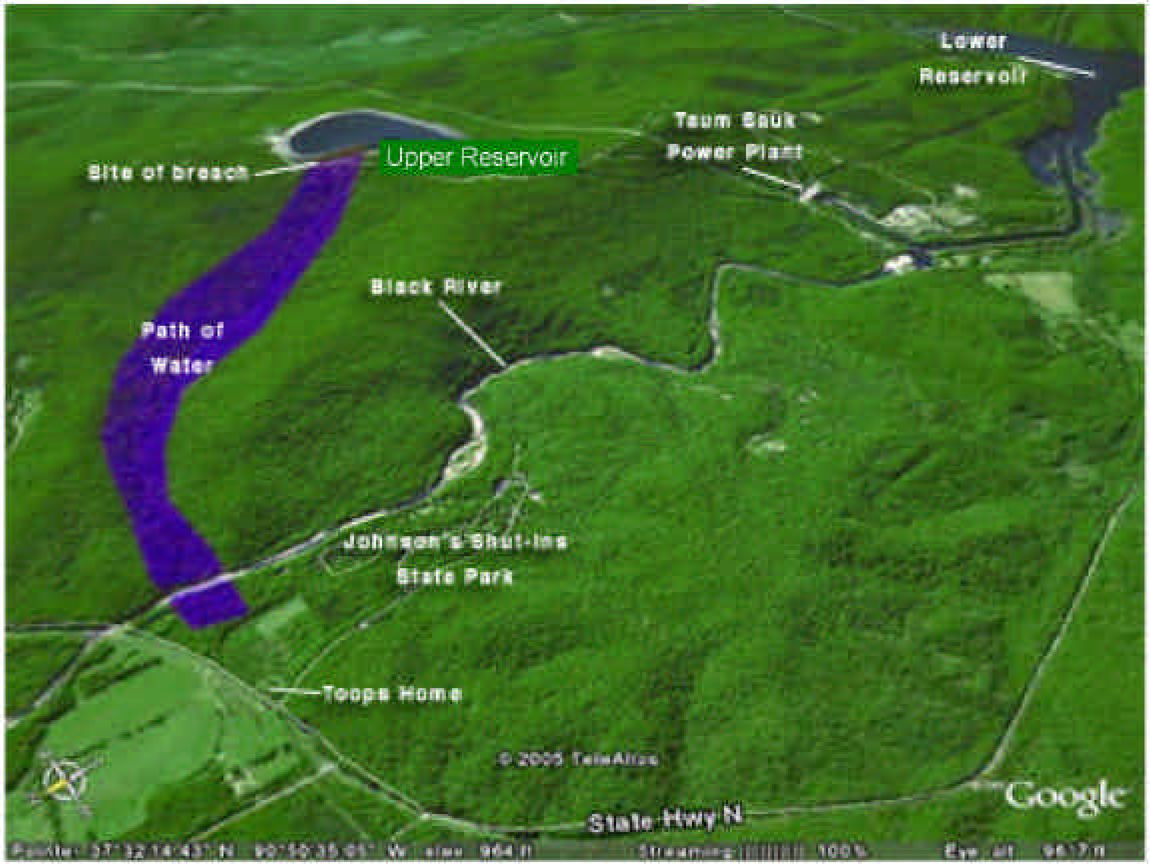

FIGURE 2-1

OVERALL VIEW OF TAUM SAUK PLANT LAYOUT

2.1 DAMS AND DIKES

The Taum Sauk Plant has an Upper Reservoir that is impounded by a Dike and a Lower Reservoir that is impounded by a Dam across the East Fork of the Black River. The Upper Reservoir Dike is the subject of this Report.

The Upper Reservoir Dike is 6,562-feet long and forms a kidney-shaped reservoir as illustrated on ***Figure 2-2***. The Dike is a concrete-faced dumped rockfill dam (CFRD) with a maximum height in the range of 84 feet above the reservoir floor. The floor is generally at El. 1505 and the 12-foot wide crest of the Dike is at El. 1589. A 10-foot- high, 1-foot-thick reinforced concrete Parapet Wall on the crest of the Dike fill extends the maximum pool level to El. 1599. However, as the Dike has settled over time, the true top of the Parapet Wall is as much as two feet lower than the design level at El. 1599.

FIGURE 2-2

VIEW OF UPPER RESERVOIR

The pneumatically placed upstream concrete face slab has a design thickness of 10 inches, and is reinforced with No. 7 bars at 12 inches, both ways. In actual placement, the slab thickness averaged nearly 18 inches due to the unevenness of the rockfill. There are no horizontal joints except at the junctures with the Parapet Wall and the foundation cutoff-slab. The face slab was placed in panels, 60 feet wide at their widest dimension. Expansion joints between the slabs, to accommodate movement caused by settlement of the rockfill, used asphaltic expansion joint material and U-shaped copper water stops.

As depicted on the design drawings, a reinforced concrete plinth was provided at the toe of the concrete face. Where the natural rock surface was substantially higher than the reservoir floor, the rock was excavated on a near vertical slope and the plinth was placed at the top of the excavated rock. In these areas, the rock cut between the reservoir floor and the plinth was sealed with a 4-inch layer of wire mesh-reinforced shotcrete. The entire reservoir bottom was sealed with two 2-inch layers of hot-mix asphaltic concrete placed over leveled and compacted quarry muck. Around the edge of the asphaltic concrete, a single line grout curtain was constructed to limit seepage under the Dike.

An Access Tunnel through the northern side of the Dike provides access to the Reservoir floor. The Access Tunnel is concrete lined, 19 feet in diameter, and horseshoe shaped. The upstream face is fitted with a hinged steel bulkhead gate that opens into the Upper Reservoir. The gate is 10.4-foot wide by 12.4-foot high and is hinged at the bottom. The gate is vertical when closed and horizontal when open.

The Upper Reservoir was constructed without a spillway. RIZZO presumes that this is because it has no drainage area and the only incoming flow is by pumping and direct rainfall. A system of redundant water level instruments was designed to prevent overtopping of the Dike by pumping. These instruments are addressed later in this Report.

2.2 LOWER RESERVOIR DAM

As shown on ***Figure 2-3***, the Lower Reservoir Dam is located in a narrow steep-sided gorge just downstream of the junction of Taum Sauk Creek and the East Fork of the Black River. It forms the Lower Reservoir with a surface area of 395 acres and a water level at the spillway crest. The canyon at this location is in exposed hard blocky rhyolite rock of good quality. The Lower Reservoir design volume at the spillway crest is 6,350 acre-feet.

FIGURE 2-3

VIEW OF LOWER RESERVOIR DAM

The Lower Reservoir Dam is a concrete gravity dam founded on rock with a maximum height of 60 feet above bedrock. The entire 390-foot long Lower Reservoir Dam is an ungated overflow spillway except for two piers that support the operating deck. The spillway crest is at El. 750 and the operating deck is at El. 765. The Dam section has a base width at the maximum section equal to 1.25 times the height and a downstream slope equal to 0.83 Horizontal to 1 Vertical. The spillway discharges to a reinforced concrete flip bucket with a 28-foot radius. The elevations of the flip-buckets for the abutment blocks are higher than those for the center blocks as may be seen on ***Figure 2-3***.

A single-line grout curtain is located along the upstream side of the gallery. The grout holes are spaced 6 feet apart and extend 20 feet below the base of the Dam. Foundation drainage consists of a longitudinal "box" drain formed with one-half of a 12-inch pipe. A longitudinal foundation drain in the bedrock, below the downstream side of the gallery, connects to transverse formed "box" drains at each block joint that discharge to the downstream face of the Dam. In addition, at each block joint, a formed drain extends from the foundation drain to the gallery floor.

Piezometers, installed in eight blocks, consist of copper tubing extending vertically down from the middle of the gallery, then horizontally within the bottom lift of concrete to a point 10 feet downstream of the downstream gallery wall. The tubing is terminated in an excavated depression in the foundation rock that is filled with gravel.

2.3 POWERHOUSE

The Taum Sauk Plant Powerhouse is located at the upstream end of the Lower Reservoir about two-miles from the Upper Reservoir as illustrated on ***Figure 2-4***. It is situated in a deep, narrow canyon through which a tailrace channel was excavated to connect to the East Fork of the Black River as shown on ***Figure 2-5***. The Powerhouse is connected to the Upper Reservoir via a concrete and steel-lined Shaft and tunnel (not to be confused with the Access Tunnel mentioned previously). The initial reversible pump-turbine rating for each unit was 175 MW, but these have been upgraded such that the total plant capacity is now in the range of 450 MW. The tailrace that leads to the Lower Reservoir is about 65-feet wide and 2,000-feet long.

FIGURE 2-4

VIEW OF POWERHOUSE IN RELATION TO UPPER RESERVOIR

FIGURE 2-5

VIEW OF POWERHOUSE

2.4 UPPER RESERVOIR OUTLET

The Upper Reservoir Outlet is the power conduit that consists of a 451-foot deep, 27.2-foot diameter Vertical Shaft shaped at the top as a typical “morning glory.” The top 110 feet of the Shaft is concrete-lined. It connects to a 4,765-foot long, 25-foot diameter, unlined horseshoe tunnel sloping at 5.7 percent which ties to a horizontal 1,807-foot long, 18.5-foot diameter steel-lined tunnel and a short penstock that bifurcates to the pump-generating plant. The morning glory intake is located in the southwestern portion of the Reservoir in a localized area of the floor that is 20 feet lower than the rest of the Reservoir floor to suppress vortex development. Two 9-foot ID spherical valves in the Powerhouse control flow from the Upper Reservoir.

2.5 LOWER RESERVOIR OUTLET

The outlet works through the Lower Reservoir Dam include a small and large sluice. The small sluice is a 16-inch diameter spiral welded pipe with an upstream invert at El. 710 and downstream invert El. 707. A 20-inch cast iron slide gate on the upstream face of the Dam controls flow through the small sluice. The slide gate motor operator is located on the top of the

4-foot wide pier on the crest of the Dam. An intake structure extends 7 feet upstream of the Dam and provides a single set of slots for either a trash rack or stop logs.

The large sluice is an 8-foot wide by 10-foot high steel-lined conduit with an invert at El 705. An 8-foot by 10-foot cast iron slide gate located on the upstream face of the Dam controls flow through the sluice. The slide gate motor operator is located atop the 13-foot wide pier on the spillway crest. An intake structure upstream of the sluice provides slots for stop logs and a trash rack.

2.5.1 Standard Operational Procedures[1]

The Taum Sauk Plant is a peaking and emergency reserve facility. A typical daily cycle in the summer is to generate from about 2 PM until 7 PM by releasing water from the Upper Reservoir through the turbines to the Lower Reservoir and pump from the Lower Reservoir to the Upper Reservoir from 11 PM until about 6 or 7 AM. Generation and pump start as well as the respective durations are determined by system needs and controlled from AmerenUE's Osage Plant. In the winter the number of cycles is typically less, with no cycles on some days. Operation in the fall and spring typically follows ambient temperature and system load requirements.

The normal maximum level for the Upper Reservoir is El. 1596. The Upper Reservoir can be drawn down to El. 1525 feet and possibly to El. 1515 if only one turbine/generator unit is operating without causing problems with the hydro machinery.

The normal minimum level in the Lower Reservoir is El. 736. Although this is above the bottom of the Lower Reservoir, operation below this level draws debris up the Powerhouse tailrace channel. The debris interferes with the pumping operations and sets the practical minimum water level elevation. The normal maximum water level is El. 749.5 feet or 6 inches below the spillway crest. AmerenUE operates the gates manually such that outflow over the spillway and through the sluice gates is equal to Lower Reservoir inflow to satisfy FERC license requirements.

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[1] The summary of Standard Operational Procedures is based on discussions with AmerenUE personnel.

The project is controlled through a microwave / fiber link from Taum Sauk to St. Louis to Osage. The Osage operators operate the Taum Sauk units under the direction of the load dispatcher in St. Louis.

As originally designed and constructed, the useable volume in the Lower Reservoir was greater than the volume of the Upper Reservoir. The design volume of the Lower Reservoir was reduced by the need to raise the minimum operating water level from El. 734 feet to El. 736 feet due to the debris being pulled up the tailrace channel. Although trash racks prevent the debris from being pulled into the pumps, the debris interferes with pumping operations.

2.6 ABRIDGED HISTORY OF ROCKFILL DAMS (AND DIKES)

To fully appreciate the design and construction bases employed in the late 1950s and early 1960s when the Rockfill Dike for the Upper Reservoir was built, we have looked at the state of the practice on a generic basis. We provide below an abridged history of the development of rockfill dams (and dikes) up to the mid 1960s. The following text is paraphrased and or directly quoted from ***Section 6*** in the text entitled “Development of Engineering for Dams in the United States” published by the International Committee on Large Dams (ICOLD), now named the United States Society for Dams (USSD), in 1988 as edited by Kollgaard and Chadwicke. We specifically utilize here Chapter 6 entitled “Rockfill Dams” authored by J. Barry Cooke and Arthur G. Strassburger. Incidentally, Mr. Cooke (deceased) was the primary consultant for the Upper Reservoir working for Sverdrup & Parcel, the designer.

> “The rockfill dam is defined as an embankment dam that relies on rockfill as the major structural element. Included in this definition are dams with an impervious face membrane or an interior core. Although gravel has properties similar to rockfill, the earth core-gravel shell dam is considered to be in the earthfill rather than in the rockfill category.
>
> The principal types of rockfill dams are the concrete face rockfill and the earth core rockfill, although other types and variations of rockfill dams may be the appropriate selection at times. Thus, most of the dams discussed in this section are of these two types…
>
> Although the use of rock in dams dates back to antiquity, the rockfill dam as it is now known is generally considered to be an outgrowth of the California gold rush. During the 1860s and 1870s, gold miners needed dams for reservoirs to store snow-melt in inaccessible locations, in the glaciated granite of the Sierra

Quote continued from preceding page.

> Nevada Mountains. Water was required at high pressure for hydraulic sluicing in placer mining. Solid rock, talus rock and trees were available. These resources, combined with the miners' know-how in drilling and blasting rock, resulted in rock crib and timber face rockfill dams. Irrigation and power companies later took over these older dams and supplemented them with higher dams, with dumped rockfill, and with face membranes constructed of concrete rather than of timber.
>
> As late as 1940, rockfill dams were generally defined as concrete face dumped rockfill dams. At about that time, as dumped rockfills became higher; leakage was becoming troublesome, resulting in development of the earth core rockfill dam. That type has now become one of the most frequently used dam types. In the 1960s, with the advent of compacted rockfill, the concrete face rockfill gradually resumed its place among rockfill dams and, with a fine performance record; this type is currently being increasingly selected for high dams.
>
> As rockfill designs have changed, so have construction practices changed markedly worldwide, particularly during recent decades. Such progress is a direct result of ICOLD activities. That development is discussed in this section principally in relation to United States dams.
>
> It is recognized that developments in other countries followed and often paralleled those in the United States. The trend in selection of the type of rockfill dam and of heights (in meters) is shown on ***Figure 2-6*** below (reproduced from Figure 6-1 in the reference document) for both United States and many foreign dams. As is evident, the development of the concrete face rockfill dam was primarily in the United States, followed by other countries in the late 1920s. By the late 1930s the earth core rockfill dam became popular and for about 20 years the concrete face rockfill reached a complete state of hiatus in the United States. By the 1950s, when dam building of all types increased dramatically throughout the world, both concrete face and earth core types were adopted worldwide. It is perhaps ironic that, in spite of the leadership of the United States in the development of both types of rockfill dams, the preponderance of construction of high dams of both types has, since the mid-1960s, shifted to other countries, the reason being that sites for high or major dams in the United States have been developed, as is the case for Europe and Japan.
>
> In the following text, discussions of the design trends of each type of rockfill dam are treated chronologically. Three periods are apparent from Figure 6-1 ***(Figure 2-6)***. These periods are approximately: Early Period (1900-1940), Transition Period (1940-1970), and Modern Period (1970-1988). Current practice in the use of the various features of each of the two major rockfill dam types is given…

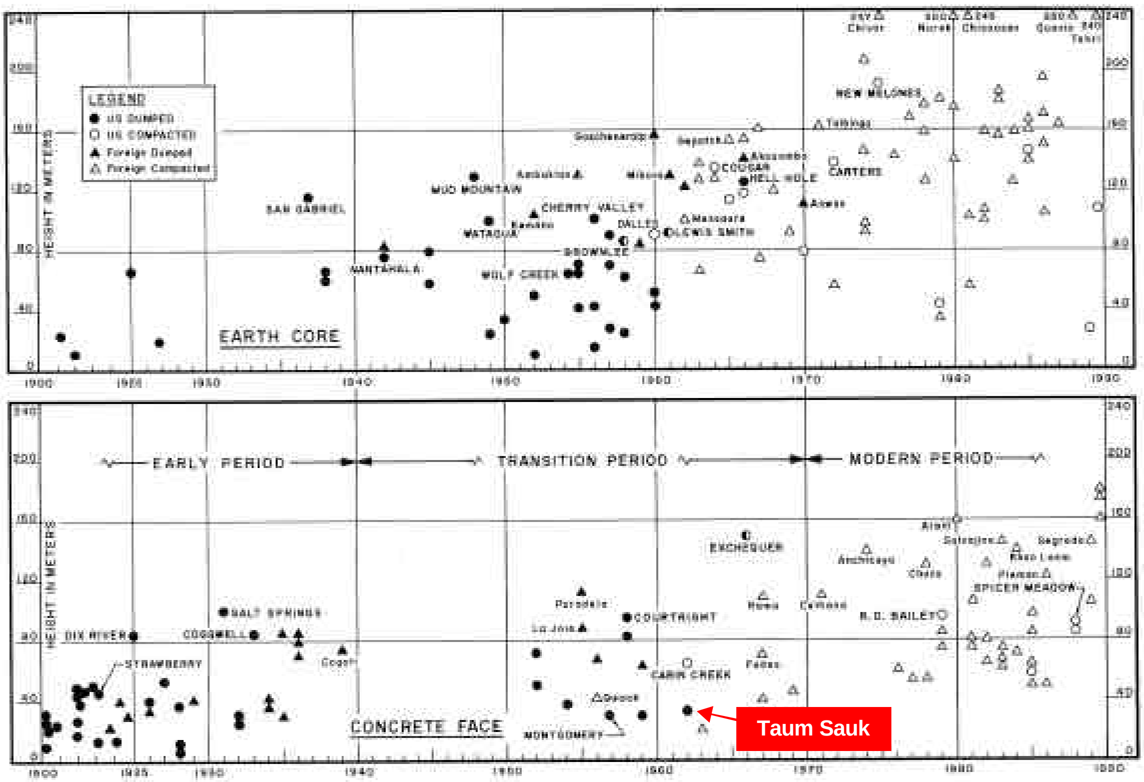

FIGURE 2-6

TRENDS IN TYPE AND HEIGHT OF ROCKFILL DAMS

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> **THE CONCRETE FACE ROCKFILL DAM**
> The concrete face rockfill dams built of dumped rockfill have all served well except for the higher ones which experienced excessive leakage initially. Such leakage, however, in no case affected safety; in some cases it represented a monetary loss and damage to the face was such that unwatering was required to permit face repair. The dumped rockfill, with segregated rock in the lower portion of the dam, had a modulus of compressibility of about one seventh that of compacted rockfill in the regions where water pressure was the highest. However, the interlocked large rocks were effective energy dissipaters, and leakage emerged safely.
>
> "Because all of the rockfill was downstream from the reservoir, safety was an inherent feature of the concrete face rockfill dams built of dumped rockfill. However, unwatering and repair could become necessary to reduce leakage. The history of the concrete face rockfill dam of dumped rockfill led to the earth core

Quote continued from preceding page.

> rockfill, where the dumped rockfill, earth core and filters were compatible. This transition to the earth core dumped rockfill is seen in Figure 6-1 (our ***Figure 2-6)***…
>
> **EARLY PERIOD (1900-1940)**
>
> As stated earlier, prior to 1900, timber face rockfill dams were used for reservoirs serving placer mining, and later for irrigation and power. Edward Wegman of New York Water Supply recognized this development in "Western States of the Union" in his book. In 1899 he wrote: "Within recent years a new style of dam has come into use in the Western States of the Union. We refer to what is known as a rockfill dam, an embankment consisting of rock dumped loosely except at the faces, where it is laid carefully as by masonry…
>
> A breakthrough in height of rockfill was made in 1925 by construction of the 275-feet high Dix River Dam. The Dix River design was similar to that of other rockfill dams built after 1910: that is, it used dumped rockfill, derrick placed rock, 1H:1V to 1.2H:IV upstream slope with a reinforced concrete face, and 1.4H:1V downstream slope. The early success of Dix River Dam led to the adoption of similar design for the 328-feet high Salt Springs Dam …
>
> Completion of this dam in 1931 and of the 280-feet high Cogswell Dam in 1935 closed the 1910-1940 Period. That period also saw the adoption of the concrete face rockfill dam in other countries. In 1940 only about one-third of the world's concrete face rockfill dams were outside the United States.
>
> As a consequence of excessive leakage, measured in tens of cfs, through the high Dix River and Salt Springs Dams, the popularity of the high concrete faced dumped rockfill declined.
>
> In 1940, at the end of this early period, rockfill dams were of nearly identical design, with the following dominant features:”
>
> 1. Dumped rockfill-placed in 20- to 200-feet lifts.
> 2. A cutoff trench in hard rock backfilled with concrete.
> 3. A face zone of large derrick (crane) placed rock.
> 4. The face slab panels were separated by compressible filler.
> 5. There was a single perimeter-joint waterstop.
>
> All of these features were to be changed during the 1940-1970 transition period. The changes improved performance and reduced cost.
>
> The principal reason for the changes was experience with cracks in the concrete face, spalling at joints and other joint problems, each causing leakage. However, these dams were safe, except when overtopped.

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> Nearly all are in service today, most with enlarged spillways. The most recent overtopped concrete face rockfill was Swift Dam in Montana. This dam was completed in 1915. It failed in 1964. The vital importance of an adequate spillway capacity for embankment dams was recognized as early as 1900, but the science for determining the design flood was in its infancy.
>
> **DEVELOPMENT OF DAM ENGINEERING IN THE UNITED STATES TRANSITION PERIOD (1940-1970)**
>
> During the 1940-1950 period, there were few dam completions because of World War II (***Figure 6-1 our Figure 2-6***). There were no concrete face rockfill dams and those embankment dams which were constructed were earth core rockfill, indicating a trend away from the concrete face dumped rockfill. The trend was logical because of the leakage experience previously mentioned. It was beginning to be evident to designers of high dams that the deformation characteristics of dumped rock and of concrete had not proven compatible. On the contrary, the flexibility of earth cores with filters rendered them capable of accommodating the large settlement of dumped rockfill.
>
> In the mid-1950s, there were sites that needed concrete face rockfill. Hence, the conventional design with dumped rockfill was continued for United States and foreign dams. The two highest, Paradela and Courtright, experienced excessive leakage. The leakage at both dams has since been permanently reduced to a nominal amount, but the sealing repair required unwatering…
>
> The transition from dumped to compacted rockfill for the concrete face rockfill dams and for the earth core rockfill began in 1955. Since 1967, all rockfill dams have been built with compacted rock."

Given the above abridged history and reflecting on the Upper Reservoir Rockfill Dike (URRD), we raise the following comments.

Although the URRD was completed in 1963, it did not follow the best construction practices available at the time of construction. It is RIZZO's opinion that it followed construction practices of the late 1940's. Specifically, the URRD was placed as a dumped rockfill dam and only the upstream (water side) concrete face was provided to reduce leakage. Given the state-of-the-practice at the time of construction, leakage through the URRD should have been expected and care should have been exercised during construction to limit the amount of fines placed within the URRD.

Poor behavior of dumped rockfill versus compacted rockfill was known at the time. It would appear, in hindsight, that the design was flawed and not consistent with the evolving state of the practice in the early 1960s. It is noted that the URRD was the last dumped rockfill dike built in the United States and possibly in the world (refer to ***Figure 2-6*** shown above).

2.7 UPPER RESERVOIR DIKE DESIGN – 1963 VERSUS 2006 CONSTRUCTION PRACTICES

Considering the development of concrete-faced rockfill dams over the last century plus, it is appropriate to understand the differences between modern day (2006) design and construction practices and those followed in the late 1950s and early 1960s when the Taum Sauk Plant was being designed and constructed. This comparison bears, to some degree, on the practices to be followed in the event that the Upper Reservoir is rebuilt. The following ***Table 2-1*** summarizes the differences as they apply to the Upper Reservoir Dike design and construction.

TABLE 2-1

DESIGN AND CONSTRUCTION PRACTICES
TAUM SAUK VERSUS 2006

TAUM SAUK DESIGN	2006 DESIGN AND CONSTRUCTION PRACTICES
Rock was dumped and re-positioned by sluicing with water (jets) from monitors.	Rock is dumped and compacted with heavy compactors and/or heavy tracked dozers.
Fines were removed by sluicing after rock was dumped into position.	Fines are removed by screening at the borrow area.
Foundation was prepared by removal of most deleterious material by dozers. A note on the Drawings that applies to the 70 feet nearest the upstream toe reads as follows: "Strip to sound rock with not more than 2 inches (average) of dirt. This dirt to be thoroughly saturated before placing rockfill." Another similar note that applies to the center portion of the Dike reads as follows: "Remove topsoil and loose, unstable, altered material as far as possible with bulldozer."	Foundation is prepared by hand labor, water jets, air jets and small excavators. A great deal of detail work, including dental concrete, is often required for concrete or RCC sections. Bulldozers do not allow for enough detail work and leave too much deleterious material behind.
Parapet walls were used to retain water on an "everyday" basis.	Parapet walls are used only if necessary to act as a short-term barrier against flood levels or wave action. They are not used on an "everyday" basis.
Grout curtain was installed to a depth of about 20 feet. There is no evidence of the design basis.	Grout curtains are designed to a depth where rock is essentially impermeable and generally not less than about 30 percent to 40 percent of the sustained head.

In comparing Taum Sauk Design with current (2006) design and construction practices, we note the several deficiencies with respect to the URRD that would be very costly, and perhaps impossible, to repair through an upgrade or remediation. These include excessive fines within the rockfill, inadequate foundation preparation, lack of compactive effort during rockfill placement, and the use of the parapet wall to store water on an everyday basis.

We conclude from this comparison that while the design was in all likelihood consistent with the general practice of the late 1950s and early 1960s, it was not consistent with the best practices of those times and, in any case it is not adequate by today's design and construction practices. Further to this point, we conclude that restoration of the Upper Reservoir to an operating condition following current practices can not be achieved by simply repairing the Breach Area. Restoration of the Upper Reservoir, if undertaken by AmerenUE, will necessarily involve a complete rebuild of the entire Rockfill Dike with a completely different design concept, one that is substantially more robust and capable of withstanding currently accepted earthquake loading criteria.

2.8 UPPER RESERVOIR DIKE CONSTRUCTION VERSUS DESIGN

As part of our comprehensive site reconnaissance effort with this forensic investigation, we have compared the intent of the original designer as reflected in the construction specifications with our observations. Two major observations evolved from this effort, specifically the fines content (particles of soil size as opposed to sand or gravel) of the rockfill and the preparation of the foundation.

The fines content issue stands out on the slopes of the Breach Area as illustrated below on ***Figure 2-7,*** which is a photo of the north side of the Breach Area. This is supposed to be a rockfill, but it is apparent than fines were left in place and comprise a significant percentage of the overall embankment. We submit that this was not the original designer's intent and that the shear strength and drainage properties of this finer material acts negatively on the performance of this type of dam and dike construction.

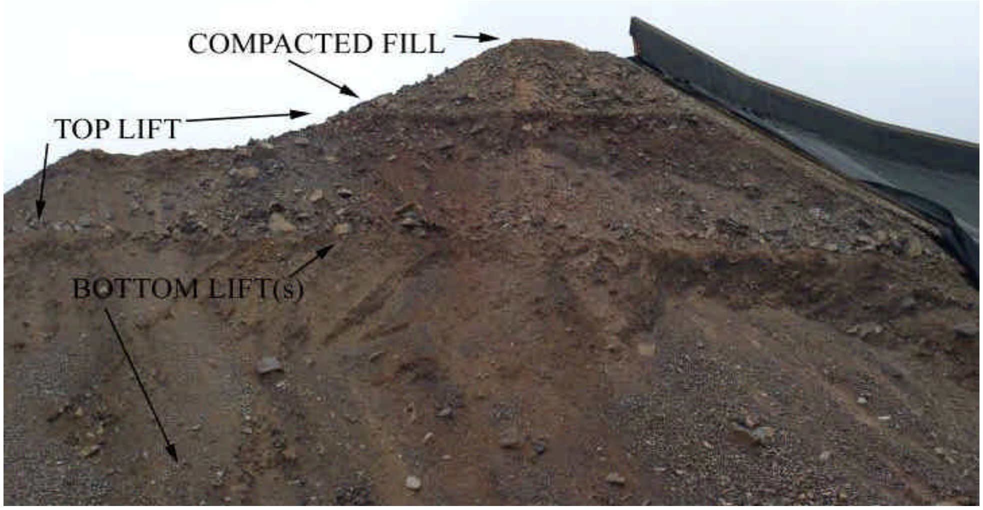


FIGURE 2-7

VIEW OF NORTH SIDE OF BREACH AREA

We have reviewed the original construction specifications for the Upper Reservoir as well as the notes on the Design Drawings and compared the language of these specifications and notes with observations made during this forensic investigation. We summarize this comparison in ***Table 2-2.***

TABLE 2-2

TAUM SAUK DESIGN VERSUS OBSERVED COMPLETED CONSTRUCTION

REFERENCE	SPECIFICATION OR LANGUAGE	POST EVENT OBSERVATION
Spec. EC-311 IV-b-7, Sec. D Rev. Mar. 1, 1961.	"All rock within this area shall be thoroughly sluiced to prevent the accumulation of fines in the upper portions of the face fills."	Specification not satisfied. See ***Figure 2-7***.
Spec. EC-311 IV-b-7, Sec. D Rev. Mar. 1, 1961.	"The criterion for determination of adequate sluicing by visual inspection shall be that the entire height of the progressing face and side slopes shall have the appearance of clean rock, and that no areas of concentrated fines, dirt or mud are in evidence."	Specification not satisfied. See ***Figure 2-7 and Figure 4-3*** (presented later).

TABLE 2-2
(CONTINUED)

TAUM SAUK DESIGN VERSUS OBSERVED COMPLETED CONSTRUCTION

REFERENCE	SPECIFICATION OR LANGUAGE	POST EVENT OBSERVATION
Spec. EC-311 IV-b-5, Sec. C Rev. Mar. 1, 1961.	"The contractor shall, by control of drilling operations and strength of blasting charge, make every effort to have the rock break into as large pieces as practical for the best construction of the Rockfill Dike."	Specification not satisfied. See ***Figure 2-7, and Figures 4-2*** and ***Figure 8-5,*** (presented later).
Spec. EC-311 IV-b-8, Sec. E Rev. Mar. 1, 1961.	"The jetting shall accomplish, principally, the following: a) Wash surface zones of fines away. b) Excavate pockets of spalls and distribute the spalls into voids between larger rocks in contact."	Specification not satisfied. See ***Figure 2-7 and Figure 4-3*** (presented later).
Drawings, <u>Typical Dike Section on Sound Rock</u>	"Remove topsoil and loose, unstable, altered material as far as possible with bulldozer."	Specification not satisfied in all locations. RIZZO forensic investigation borings encountered 18 inches of soil in some locations. (Refer to ***Appendix D***).

We conclude from this comparison that the actual construction deviated significantly and in a negative manner from the intent of the original design. It is our contention that this deviation contributed to the instability of the Rockfill Dike in the Breach Area and, as later discussed in context, contributed to the root cause of the Event of December 14, 2005.

2.9 HISTORICAL PERFORMANCE OF THE UPPER RESERVOIR

During the course of our records review, we observed that the Rockfill Dike at the Upper Reservoir has had a history of incidents stemming from the original design and construction. Leakage was a major problem immediately after first filling and slope movements have occurred over its history. These incidents have been repaired and maintained by AmerenUE on a timely basis following good practice where dam safety and/or project economics were impacted The remediation of the 1963 event is described in a short report dated May 15, 1964 prepared by P.A. Pickel, often referred to as the "Pickel Report" included in ***Appendix B.***

2.10 THE BREACHING OF GOUHOU DAM IN QINGHAI PROVINCE, CHINA

Dr. Gabriel Fernandez, a member of the AmerenUE Board of Consultants and Dr. A. J. Hendron, consultant to the FERC, brought to our attention the failure of the Gouhou Dam in China on August 27, 1993. A description of this event is available in a paper published by Mr. Zuyu Chen of the Institute of Water Conservancy and Hydroelectric Power Research. We quote several key paragraphs from his paper below and we provide the complete paper in ***Appendix C***:

> On August 27, 1993, a catastrophic dam failure happened at the Gouhou Reservoir, located near the town of Qiapogia, capital of the Gongho County, Qinghai Province. Breaching of this concrete face sand and gravel dam (CFGD) created an estimated 1,500 m^3/s peak discharge of water, sweeping away half of the embankment material and bringing about great losses in human lives and properties.
>
> The Gouhou dam started water impoundment on September 28, 1989. On October of the same year, corresponding to a reservoir water level of 3258 m, a concentrated flow appeared at the downstream slope somewhere 1.5 m higher than the toe (El. 3223m). Local remedial work included replacement of the scoured fill material, after which the flow seemed to disappear.
>
> October, 1990 saw the first high reservoir water level of 3274 m. The concentrated water flow re-appeared at the same location seen in 1989. The inflow measured at the weir near the toe of the dam was l81/m^3. No concentrated seepage was visualized during 1991-1992, a period whose reservoir water level was relatively low, not exceeding 3262 m (Yu. 1993).
>
> As a small project, limited instrumentation was available. It was measured that the settlement at the dam crest was 7cm. The water levels of the four open stand type piezometers of the abutment indicated that ground water level of the bed rock was lower than 3225 m, which is reasonably low. An earthquake of the magnitude 6.9 on the Richter scale hit the area on April 26, 1990 with its epicenter 40 km from the dam. The dam was found to be intact.
>
> **Failure Process**
>
> Starting from July 14, the water level of the reservoir kept rising from 3261m. On August 26 the reservoir level reached 3277 m which meant that it had been close to or sometimes higher than the horizontal slab of the crest wall ***(same as Parapet Wall at URRD)*** for about 24 hours before the dam failure. It must be emphasized that this statement, which is significant in explaining the causes of the dam failure as will be seen later.

> **Destructions of the Dam**
> The breaching of the dam created a triangle weir on the concrete face slab, which is 137 meter wide at the dam crest. The elevation of the lower point was 3250 m. Part of the slot went along the horizontal joint of the face slab. The flood cut through the dam body and created a 61 m wide chute with almost vertical side walls. Total amount of water released was estimated to be 2.61 million m^3. The remaining part of the dam body lower than 3250 m kept retaining water which overtopped *the crest* and created a water fall…
>
> **Discussions and Concluding Remarks**
> It is clear that the failure of the Gouhou dam was caused by the unexpected high phreatic line of the dam. Water came into the dam through damaged concrete slabs and their joints especially when it exceeds the slab of the crest wall. The fill material seemed to be not permeable enough to allow free draining…"

We find the failure of Gouhou Dam as described in this paper to strongly parallel the behavior of the Rockfill Dike at the Breach Area of the Upper Reservoir. As seen below in context, we treat a high phreatic surface caused by leakage through the face as Condition A in our stability analysis. As seen later in context, the cause of the failure of Gouhou Dam supports our interpretation of the root cause of the failure of the Upper Reservoir Dike at Taum Sauk.

3.0 SUMMARY DESCRIPTION OF THE SITE GEOLOGY

3.1 REGIONAL GEOLOGY

3.1.1 Geomorphology

The Taum Sauk Plant is located in the Saint Francois Mountains, part of the Ozark Plateau geomorphic province and part of the Ozark Mountains. The Ozark Plateau province is located chiefly in southern Missouri and northern Arkansas, between the Arkansas and Missouri rivers. It is bordered on the south by the Ouachita Physiographic province, on the south and east by the Coastal Plain province, on the east by the Interior Low Plateau province, and on the north and west by the Central Lowlands province. The province is small, with a total area of about 129,500 km^2. The Saint Francois Mountains are characteristically well-rounded, heavily eroded ridges or rolling upland with thin soils.

3.1.2 Geologic History

The Saint Francois Mountains are an approximately 1.5 billion years old Precambrian terrane of anorogenic granites and rhyolites. The granites intruded the volcanic units that overlay and surround them. These mountains are part of the continental shield. This type of lithologic succession of volcanic rock overlying related intrusive rock has been found in other shield areas. The area has been deeply eroded leaving rhyolitec knobs as high points and exposed granitic plutons. In Early Paleozoic times this area was central to the Ozark dome uplift and probably sub-aerially exposed as islands in the Cambrian seas that covered the area. During this time the Cambrian Lamotte Sandstone and overlying Bonne Terre Dolomite were deposited around the edges of the granitic and rhyolitec highs. It is important to note that the younger Paleozoic units that now surround the Saint Francois Mountains are flat lying with minimal deformation. Presumably these sediments overlaid the volcanic-igneous suite and protected it from erosion.

From youngest to oldest the regional formations include:

- **Eminence Dolomite:** Dolomite with some druse-coated chert;

- **Potosi Dolomite:** Dolomite with an abundance of druse-coated chert;

- **Elvins Group:**
  - Derby-Doerun Dolomite: alternating thin dolomite, siltstone, and shale; and
  - Davis Formation: glauconitic shale with fine-grained sandstone, limestone, and dolomite;

- **Bonnaterre Dolomite:** Dolomite, dolomitic limestone, and limestone; glauconitic in lower part;

- **Lamotte Sandstone:** Sandstone with some dolomitic and shaly lenses, coarse-grained to conglomeritic and arkosic at base;

- **Diabase Dikes and Sills;**

- **St. Francois Mountains Intrusive Suite:** Subvolcanic alkali granite ring complexes; and

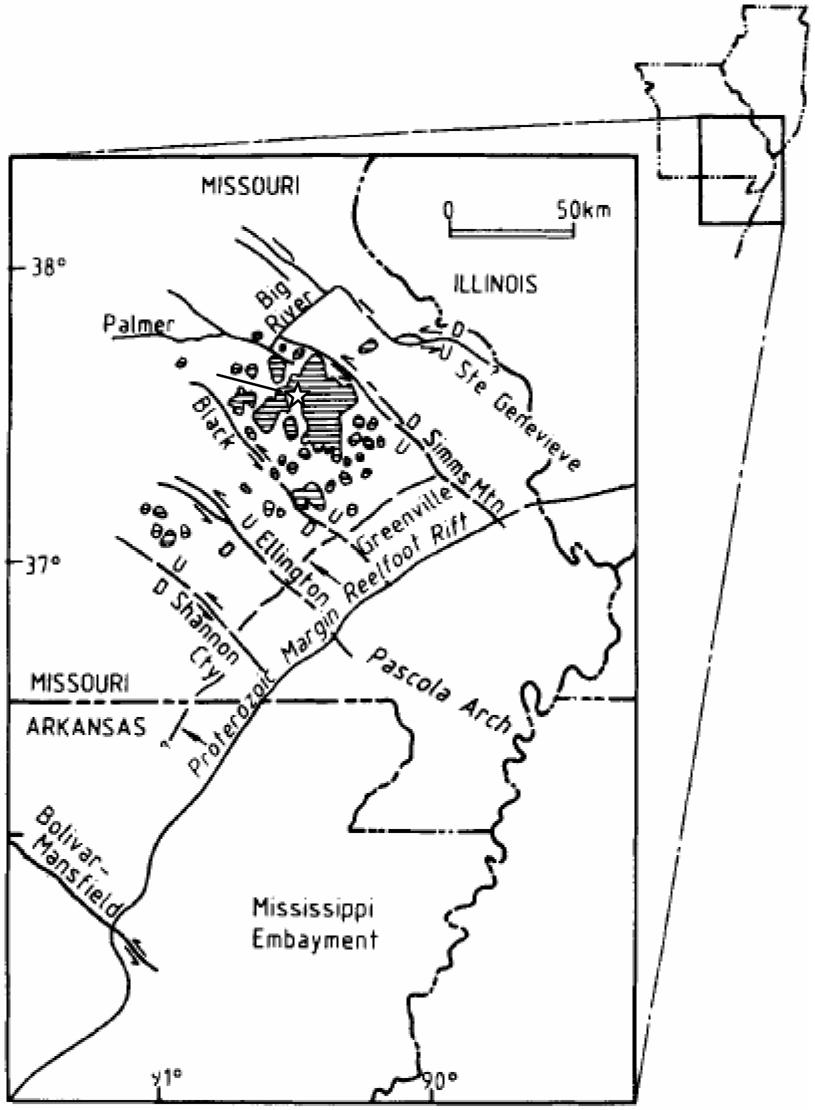
- **St. Francois Mountains Volcanic Supergroup:** Chiefly alkali rhyolite ash-flow tuffs with minor trachyte.

Several geologic features distinguish the Ozark Plateau province as a region. The faulting in the Ozarks is generally normal with most faults displaying a downward displacement on the southern side. Gentle folds are present, but these are generally of low amplitude. Surface rocks are older than those exposed in surrounding areas. This Province is distinguished from the Ouachita province by a less disturbed rock strata and a profusion of limestone and dolomite that when weathered from the parent rock accumulates at the surface. Streambeds contain abundant chert gravel washed from the hillsides.

This area of Missouri contains a wealth of lead and iron mineral resources. The rhyolites of the Saint Francois Mountains host several high-grade magmatic and hydrothermal hematite and magnetite iron deposits. The Cambrian Bonne Terre Formation is host to the Mississippi Valley-type lead deposits that have made Missouri's Lead Belt and Viburnam Trend the most prolific lead mining districts in the United States for over 100 years. Significant occurrences of barite, silver, cobalt, and copper have also been mined in the area.

The structural position of this Precambrian (1.48 Ga) volcanic-plutonic complex relative to the rest of the surrounding basement is due to its position at the crest of the Ozark Dome. The Ozark Dome is a structural high in the continental basement bounded by normal faults and strike-slip faults. Late Precambrian to Early Cambrian (Braile, et al., 1986) continental breakup gave genesis to the Reelfoot Rift, an aulocogen or failed rift arm of a continental pull-apart basin to the southeast of the Ozark Dome. Late Pennsylvanian-Early Permian Alleghenian compressive stress uplifted the Ozark Dome and Saint Francois Mountains (Clendinen, et al., 1989). Basement subsidence southeast of the Ozark Dome due to crustal thinning and sediment loading ensued as the Reelfoot and associated basement faults were reactivated during Late Paleozoic continental rifting. This process has contributed to the position of Ozark Dome as a structural and topographic high. In addition, isostatic rebound of the Dome due to denudation has contributed to the structural offset of the Ozark Dome from the surrounding areas. The Mississippi Embayment currently flanks the Ozark Dome to the southeast. The Mississippi Embayment contains a thick sequence of Phanerozoic sediments of marine, fluvial, and aeolian affinity which overlie the faulted basement associated with the Reelfoot Rift and New Madrid Rift Complex.

As shown on ***Figure 3-1*** there are a number of northwest trending faults associated with the Reelfoot Rift.



(Regional map showing relations of major faults in southeast Missouri and northeast Arkansas to Proterozoic margin of Reelfoot rift, from Clendinen, et al., 1989)

FIGURE 3-1

NORTHWEST TRENDING FAULTS ASSOCIATED WITH THE REELFOOT RIFT

The Black Fault is the closest of these named faults to the site.

3.2 SITE GEOLOGY

Pre-Cambrian rhyolite porphyry and granite porphyry characterize the geology of the site of the Taum Sauk Plant. The intrusive rock of the knob and ridge (i.e., Proffit Mountain), which accommodates the Upper Reservoir, is rhyolite porphyry, which is fresh high-compressive strength rock moderately to abundantly jointed. The 8th FERC Part 12 Independent Consultant

Safety Inspection Report, 2003, classifies the rock surrounding the Tunnel as granite porphyry, massive hard rock with infrequent and tight joints, and the bedrock at the Lower Reservoir Dam as hard, dense rhyolite porphyry cut by two closely-spaced sets of near-vertical joints, with only shallow weathering.

3.2.1 Lithology

The rock of the knob and ridge, which accommodates the Upper Reservoir, is rhyolite porphyry, which is described as fresh, high-compressive strength rock moderately to intensely jointed. This unit is mapped by Pratt, et al. (1992) Rolla 1° x 2° Quadrangle, as:

> **Alkali rhyolite:** Mostly dark red, purple, or gray aphanitic porphyry containing phenocrysts of pink or flesh-colored potassium feldspar, and with or without quartz phenocrysts, in a cryptocrystalline felsic groundmass. Taum Sauk Mountain and Bell Mountain are divisible into individual map units.

The map unit for the alkali rhyolite at the Upper Reservoir is:

> **Tuff:** Brick red, very well bedded, with sparse phenocrysts, equivalent to **Taum Sauk Rhyolite.**

Kisvarsanyi, et al., (1981) note prominent columnar jointing in the rhyolite adjacent to the Taum Sauk Plant. The tunnel is in granite porphyry, massive hard rock with infrequent and tight joints, mapped by Pratt, et al., (1992) as:

> **Amphibole-orthoclase granite, Slabtown-type:** Medium to fine-grained gray granite characterized by sodic amphibole and (or) biotite, orthoclase microperthite, and minor plagioclase. Medium silica content (70-73 percent). The **fine-grained (hypabyssal) equivalent** was mapped at the site.

The bedrock at the Lower Reservoir Dam is mostly hard, dense rhyolite porphyry cut by two closely spaced sets of near vertical joints, with only shallow weathering. Pratt, et al., (1992) mapped four lithologies adjacent to the lower reservoir as follows:

> **Stromatolite/Mud Facies:** Light gray to light brownish gray, finely crystalline limestone or dolomite. Plane laminated stromatolitic units averaging 0.3m thick grade upward into burrowed, largely pelletized and variably coquinoidal units averaging 0.8m thick; burrowed units may contain arkosic debris in upper parts. Also includes coarsely

recrystallized white vuggy dolomite ("white rock" of local usage). Includes stratigraphic equivalents ranging from Potosi Dolomite to Bonaterre Formation in age.

Ash-flow tuff: Red to dark maroon; contains a few percent phenocrysts of white feldspar with or without quartz; at top is about 25m of maroon air-fall tuff. Equivalent to Bell Mountain, Wildcat Mountain, and Russell Mountain rhyolites of Berry (1976). (subset of **Alkali rhyolite** unit)

Lava flow: Red to maroon; contains five percent phenocrysts of quartz and alkali feldspar; vividly banded red and white in many places. Equivalent to Royal Gorge Rhyolite of Berry (1976). (subset of **Alkali rhyolite** unit)

Tuff: Brick red, very well bedded; contains sparse phenocrysts. Equivalent to **Taum Sauk Rhyolite** of Berry (1976). (subset of **Alkali rhyolite** unit)

3.2.2 Geologic Structural Features

The geologic structure of the Saint Francois Terrane is marked by brittle deformation. Very little ductile deformation or metamorphism is documented. Contact metamorphism exists along the contact volcanic and intrusive units, but foliation and folding are not a significant part of the regional geology. Bedding due to debris, ash, and lava flow exists in the volcanic units and bedding structures are apparent in the Cambrian and Ordovician rocks.

The most significant geologic structural feature is an unconformity that separates the Upper Cambrian rocks and the Middle Proterozoic intrusive and volcanic rocks. This unconformity is marked by a basal boulder conglomerate described by Kisvarsanyi, et al., (1982) who also maps the unconformity at the Taum Saul Plant as a contact of Taum Sauk Rhyolite and Davis-Doerun Dolomite (not mapped as such by Pratt, et al.). The unconformity is tilted, implying structural displacement of blocks of the Saint Francois Terrane. Lowell (2000) discusses subsidence structures related to caldera collapse and shift, and this process having an important role in existing structure. At the site, two narrow faults, or significant shear zones, were reportedly exposed during the excavation for the Upper Reservoir. No faults are reported near the Lower Reservoir Dam. Pratt, et al. (1992) did not map any faults on the site, however numerous faults are mapped five kilometers to the east in the same or comparable geologic units as encountered at the site. In addition, a northeast striking fault is mapped two kilometers to the north. The lack of mapped structures at the site may be due to immature mapping. Many of the faults in the Saint Francois Terrane terminate at the boundary of Cenozoic sediments, while others' continuation is inferred. It is not apparent whether any attempt to map faults across unconsolidated sediment has been completed. The Black Fault exists seven to eight kilometers to the southwest. The Black Fault is a northwest striking feature exhibiting normal offset to the southwest. Strike slip motion along this fault is not recorded but is proposed by Clendenin, et al. (1989) based on orientation of slickensides. The Ellington Fault, 30 to 35 kilometers to the southwest, and the Sims Mountain Fault System, 40 to 45 kilometers to the northeast, exhibit similar strike to the Black Fault.

3.2.3 Upper Reservoir Dike and Upper Reservoir Construction

The foundation rock at the Upper Reservoir Dike, being the flattened top of Proffit Mountain, is generally fresh to slightly weathered, hard, moderately to abundantly jointed. Joints are generally steeply dipping, open, and some were filled with clayey products of weathering such that seepage would occur without proper measures to seal the reservoir floor. During construction, the overburden was observed to vary from a few feet to as much as 65 feet thick (MWH, 2003). Several significant clay seams, gently dipping, and up to four inches in thickness were encountered. Under the dike, the seams were treated either by excavating and backfilling with concrete or covering with smaller-sized compacted rockfill. The upstream (or inside) 70 feet of the base of the dike was specified to be prepared such that not more than two-inches (average) of soil were left in place. A filter zone and several layers of compacted rock were placed over questionable areas where piping of the foundation might be possible. Outside the 70-foot zone, the weathered rock was left in place where its competence was judged equivalent to the rockfill. Low areas or depressions in the natural topography were filled with compacted rock. Drainage to the outer slopes was reportedly provided for all foundation areas.

Jointed rhyolite porphyry was encountered in the upper 125 feet of the vertical shaft. Open joints, weathered rock, and infiltration of ground water were observed in the upper 20 to 25 feet of the shaft. Consequently, the shaft was lined with shotcrete and wire mesh where it passed through the rhyolite porphyry to the underlying massive granite porphyry. The shaft and tunnel are unlined through the granite porphyry. The horseshoe tunnel has been unwatered several times and the in the unlined portion, return water was been negligible and no rockfalls were reported (MWH, 2003) (Cooke and Strassburger, 1968).

Construction of the Upper Reservoir was accomplished by practically “shaving off” or flattening the top of Proffit Mountain, using the broken rhyolite and excavated residual soil to construct the Upper Reservoir Dike. Our findings based on forensic observations indicate that little or no effort was used to segregate the soil fines from the rock. The construction resulted in a Dike that was not typical of concrete-faced rockfill dams. Soil materials are prolifically mixed with the rock and the rock itself appears to have a wide range of particle sizes, ranging from gravel sizes to as large as four to five feet in diameter. For the most part, the rock is not slabby and is characterized as generally three-dimensional. Limited filters and special drainage features were reportedly included in the design to deal with questionable rock conditions on the upstream 70 feet of the dike foundation.

3.2.4 Lower Reservoir Dam

The bedrock at the Lower Reservoir Dam is hard, dense rhyolite porphyry with only shallow weathering. The foundation rock is fresh, dense, moderately but tightly jointed. Although the abutments have been subjected to high flows during spillway discharge, the rock shows little susceptibility to erosion due to high water flows.

Logs of three pre-construction borings are available for locations along the axis of the Dam. DH-15, on the left abutment, encountered 13 feet of "broken rhyolite" overlying 37 feet of "rhyolite." DH-14 on the right edge of the river encountered 10 feet of "sand and gravel" overlying "rhyolite." DH-16 on the right abutment encountered 49 feet of "rhyolite." The same drawing shows the depth of excavation along the upstream face to vary from 5 feet to about 30 feet. The broken rhyolite and sand and gravel encountered in the borings were reportedly removed, resulting in an irregular rock surface, typically varying one to three or more feet across the base of a block. The bedrock was reported as hard, dense rhyolite cut by two closely-spaced sets of vertical joints, the main set striking true North and the secondary set striking North 70° East. After cleaning, the exposed rock reportedly showed no evidence of alteration in either the joints or the exposed surface.

3.3 GEOLOGIC MAPPING OF THE BREACH AREA

As part of the overall field investigation associated with this forensic investigation, geologic mapping of the Breach Area was conducted on January 20 and 21, 2006. Lithology, fractures, orientation of rock fabric (banding), and any linear features such as shear zones and faults were mapped on a 1:600 scale. In addition, zones having soil cover were mapped. Field mapping included use of Global Positioning (GPS) equipment to accurately locate features.

The rock in the breach area is rhyolite as described in the legend of the Upper Reservoir Breach Area Geologic Map (***Plate 3-1***). Numerous fracture sets were mapped and are described in

Table 3-1. The dominant fracture sets are FS-1, FS-2, FS-12, and FS-14. Stereonet analysis of these data lead to the conclusion that fracture sets FS-2, FS-12, and FS-14 are likely the same set that strikes N40-60E and dips 85-90 NW and SE. These fractures are very continuous (greater than 100 feet in length) and are the dominant structural feature in the rock mass. Most of the fracture sets are too steeply dipping to present planar failure potential given the geometry of the slope of Proffit Mountain. However, less dominant, shallow dipping sets such as FS-7 may present the potential for localized planar failure.

TABLE 3-1

TAUM SAUK PLANT UPPER RESERVOIR BREACH GEOLOGIC DATA

FEATURE	DIP DIR.	DIP	DESCRIPTION
FS-1	310	76	Fracture set, closely to moderately spaced, very continuous(>100 ft.), moderately to slightly open, smooth to slightly rough, planar, partially to mostly healed with 1mm thick firm greenish gray coating, fractures occur throughout the entire rock mass.
FS-2	155	88	Fracture set, widely spaced(1 -3 ft.), very continuous, slightly to moderately open, mostly healed with firm to hard greenish gray coating, significant iron staining, fracture are prevalent across rock mass.
	145	90	
FS-3	240	78	Fracture set, widely spaced, very continuous, slightly open, moderately rough (R3), mostly healed with hard to firm greenish gray coating, moderate iron staining.
	243	73	
FS-4	105	72	Fracture set, very closely to closely spaced (<0.1-.03 ft.), slightly continuous (3-10 ft.), slightly open (<1mm), moderately healed with very thin (<1mm) hard to firm greenish gray coating, moderate iron staining.
FS-5	140	65	Fracture set, moderately continuous, planar, slightly to moderately rough, moderately open, partially healed with very thin (< 1 mm) firm greenish gray coating.
FS-6	87	28	Fracture set, widely spaced (1 -3 ft.), moderately continuous (10-30 ft.), slightly open, planar, slightly rough (R4), mostly healed with hard, very thin (<1mm) coating.
FS-7	262	38	Fracture set, widely spaced (2-3 ft.), moderately continuous, slightly open, moderately rough (R3), slightly undulatory.
FS-8	270	8	Fracture, slightly continuous, rough (R2), undulatory, partially healed, widely spaced.
FS-9	58	18	Fracture, slightly continuous, rough (R2), partially healed.
FS-10	346	28	Fracture set, moderately continuous, moderately spaced (0.3-1 ft.), moderately open to open (1-10mm), slightly to moderately rough (R4-R3), completely healed with very thin (<1mm) hard pale green coating.
	345	25	
FS-11	225	83	Fracture set, moderately continuous, widely to very widely spaced (2.5-4.5 ft.), planar, slightly rough (R4), moderately open.
FS-12	138	89	Fracture set, very continuous, closely to moderately spaced (0.2-1 ft.), slightly to moderately open, slightly to moderately rough, slightly undulatory. Fracture set occurs throughout rock mass.
	131	83	
	311	88	
FS-13	197	83	Fracture set, slightly continuous.
	202	87	
FS-14	318	85	
FS-15	160	88	Fracture set, highly continuous, moderately spaced (0.3-1 ft.), moderately open, moderately rough (R3), planar.
	135	90	

TABLE 3-1
(CONTINUED)

FEATURE	DIP DIR.	DIP	DESCRIPTION
FS-16	270	88	Fracture set, moderately continuous, moderately spaced.
	273	88	
	270	86	
FS-17	155	89	Likely same set as FS-2.
	154	88	
FS-18	57	87	Fracture set, moderately continuous, moderately to widely spaced (0.4-1.5 ft.), moderately open (1-2mm).
	54	87	
FS-19	135	90	Fracture set, moderately continuous, slightly to moderately open, planar, slightly rough (R4).
	135	84	
FS-20	143	88	Likely same set as FS-2.
	148	86	
	155	90	
FS-21	120	85	Fracture set, moderately continuous, closely to very closely spaced, slightly undulatory, slightly to moderately open.
	127	87	
	121	82	
	312	84	
FS-22	239	76	Fracture set, slightly to moderately continuous, closely to very closely spaced.
	244	76	
FS-23	220	15	Fracture set, moderately continuous, closely to very closely spaced.
	225	18	
FS-24	20	10	Fracture set, slightly continuous, closely to moderately spaced (0.1-0.4 ft.), slightly open.
	25	12	
FS-25	63	15	Fracture set, moderately continuous, closely spaced (0.1-0.3 ft.), slightly rough (R4).

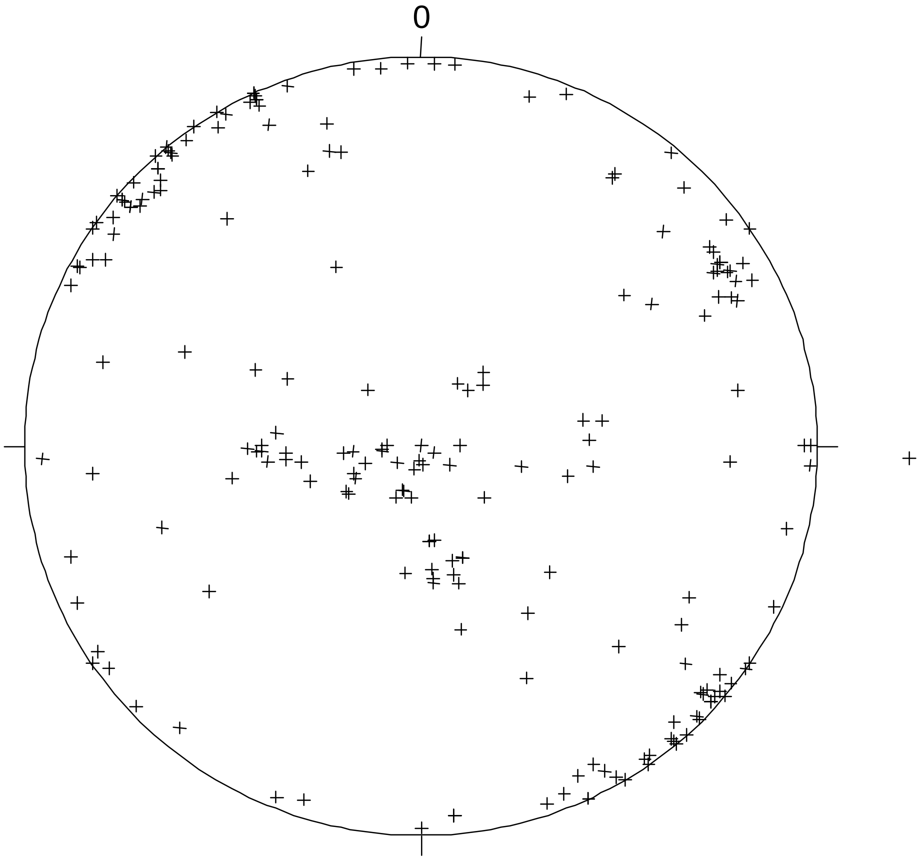


FIGURE 3-2

STEREONET OF FRACTURES: LOWER HEMISPHERE, POLE TO PLANE, N=193

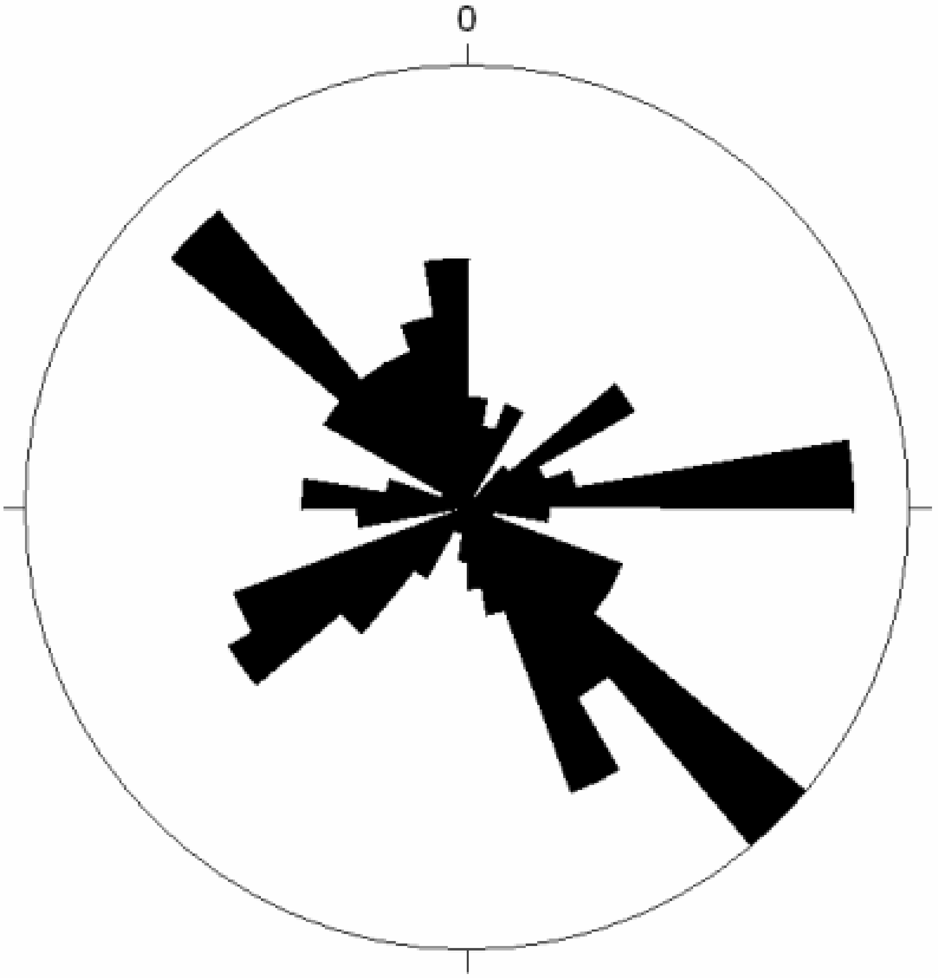


FIGURE 3-3

ROSE DIAGRAM OF FRACTURES, N=193

In locations where other fracture sets are prevalent, these sets are presented on the geologic map with a fracture symbol oriented by dip direction with dip of the fracture plane presented at the edge of the symbol. ***Plate 3-1,*** Breach Area Foundation Geology, presents significant geologic features of the rock mass at the breach. Several sets of shallow dipping fractures are present that dip both upstream and downstream. A description of these sets is included in ***Table 3-1.***

Figures 3-4 through ***3-7*** show some of the prevalent fracture sets in the breach area foundation.

FIGURE 3-4

FRACTURE SETS FS-1, FS-2, AND FS-6

FIGURE 3-5

FRACTURE SETS FS-9 AND FS-25

FIGURE 3-6

FRACTURE SET FS-10

In addition to fractures, shear zones and faults exist with the breach area. Five roughly east-west striking, steeply dipping shear zones are noted and presented on ***Plate 3-1***. These shear zones are linear, very continuous, and cut all other features. Rock within these shear zones is very broken. ***Figure 3-7*** shows shear zone SZ-2 from ***Plate 3-1***. A sense of offset on this feature could not be determined.

FIGURE 3-7

SHEAR ZONE SZ-2

Two fault zones with slickensides were mapped in the breach zone area. These faults strike N80-85E, exhibit shallow dip (20-30 degrees) to the NNW, and have slickensides that rake north to N10E and dip 15-20 degrees ***(see Figure 3-8)***.

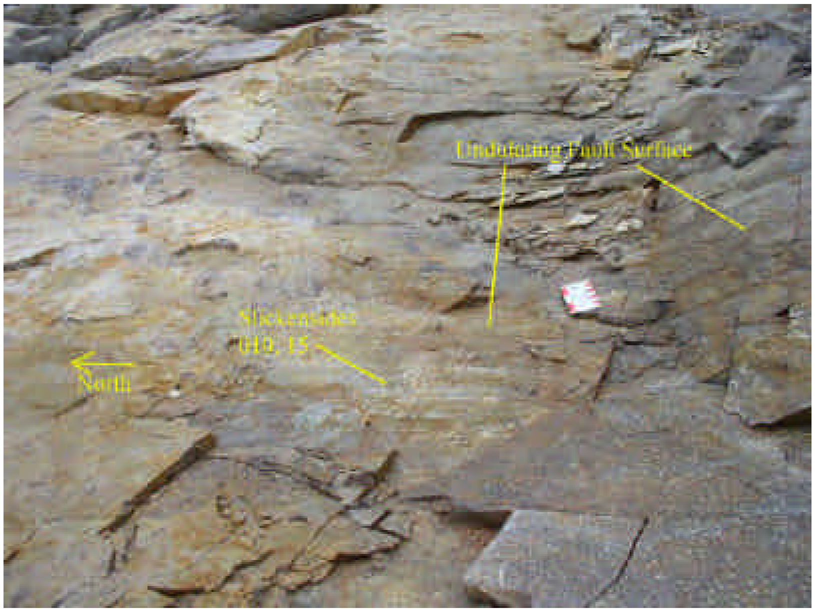


FIGURE 3-8

LOW ANGLE FAULT WITH SLICKENSIDES

In the vicinity of the toe of the Dike in the Breach Area, a contact of rhyolite and granite was observed. The granite body is shown on the ***Plate 3-1***. Fracture patterns do not appear to change across the contact zone, implying that the mechanical behavior of the granite is similar to the rhyolite that it intrudes. A narrow zone of contact metamorphism exists at the contact of the two rock types exhibiting fine grained equivalents of the rhyolite and granite. The contact zone does not exhibit differences in fracture patterns.

Rock mass classification of the breach area is presented on the ***Plate 3-2***, Breach Area Foundation Rock Mass Rating. The majority of the rock mass is classified as “fair” with sections of “poor” rock and “good” rock. Zones of soil cover are also depicted on ***Plate 3-2***.

3.4 FAULTING

Two narrow faults, or significant shear zones, were reportedly exposed during the excavation for the Upper Reservoir. Mapping of the breach area revealed shear zones and fault features as discussed in ***Section 3.3***. No faults are reported near the Lower Reservoir Dam. The nearest major fault zone is in the New Madrid Fault Zone, about 160 kilometers Southeast. Associated with the New Madrid Fault are a number of northwest trending faults. The closest of these faults is the Black Fault. As shown on ***Figure 3-9,*** the Black Fault is at least 25 miles long and at its closest point approximately 8 kilometers from the Upper Reservoir. This fault has both strike slip and normal offset. It is mapped as Cretaceous and possibly younger sediments in one location and is mapped as bounding the relatively young sediments in other area. The Quaternary-age sediments are colored yellow on ***Figure 3-9***. The shears mapped within the Breach Area are oriented such that they may be Riedel Shears associated with the Black Fault.

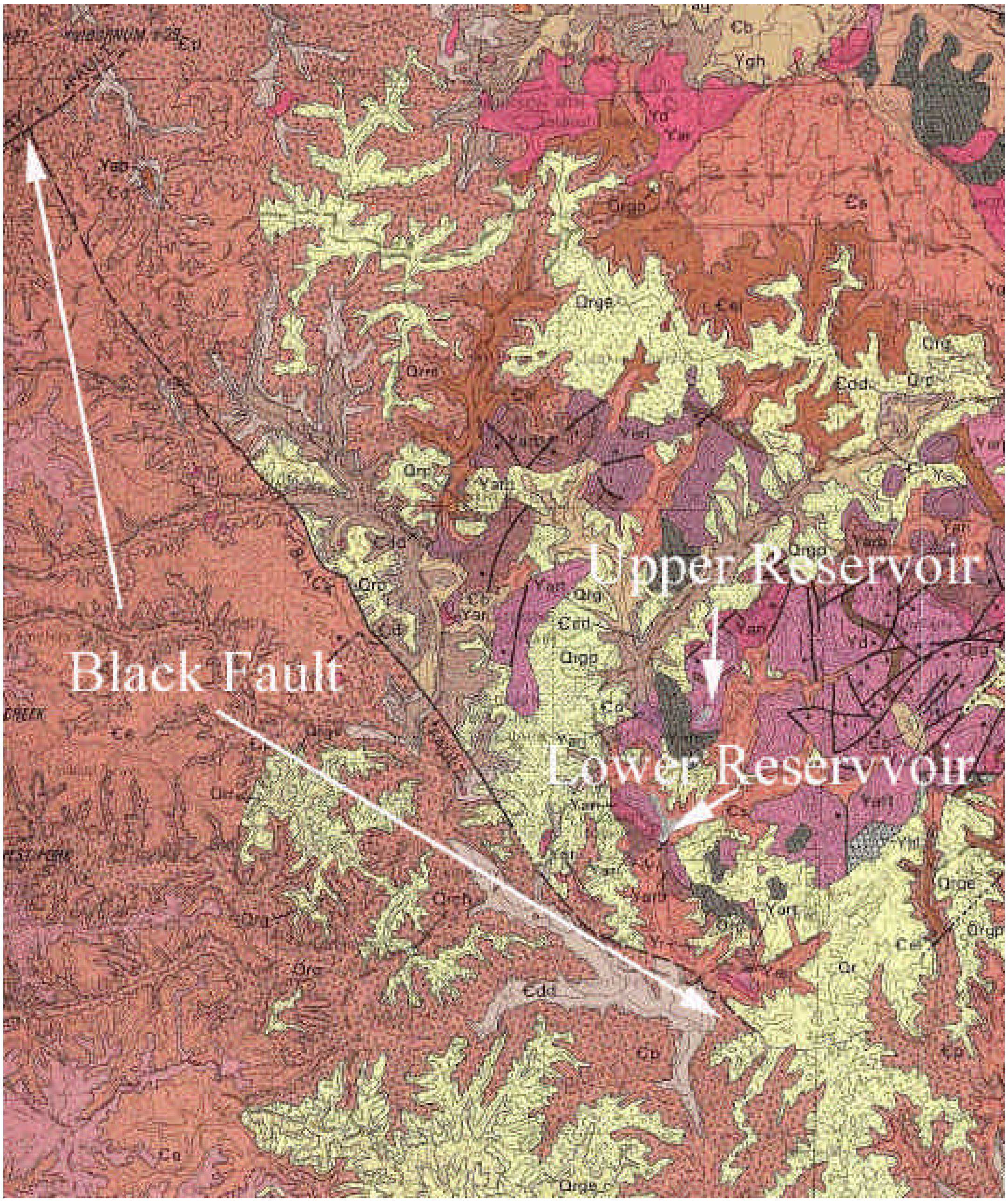


FIGURE 3-9

PORTION OF ROLLA 1° X 2° GEOLOGIC MAP

3.5 SEISMICITY

The Taum Sauk Plant is situated northwest of the Mississippi Embayment. The Mississippi Embayment is a south-southwest plunging synform associated with continental rifting which contains several active seismic zones. The most studied is the New Madrid Seismic Zone. The

New Madrid Seismic Zone extends from northeast Arkansas, through southeast Missouri, western Tennessee, western Kentucky, and to southern Illinois on the northwest limb of the Mississippi Embayment. Historically, the New Madrid Seismic Zone has been the site of some of the largest earthquakes in North America. Four earthquakes, with magnitudes greater than 7.0 occurred in December, 1811 through February, 1812. Hundreds of aftershocks followed over a period of several years. The largest earthquakes to have occurred since then were on January 4, 1843 and October 31, 1895 with magnitude estimated to be in the range of 6.0. Additional earthquakes with magnitudes greater than or equal to 5.0 have occurred in the area. Braile, et al., (1986), attribute seismicity to the New Madrid Rift Complex, a series of northeast and west-northwest striking fault zones related to reactivation of the Reelfoot Rift.

In addition to the New Madrid Seismic Zone, Langenheim and Hildenbrand (1997) identify the Commerce Geophysical Lineament and Commerce Fault, a zone in strike with and northwest of the New Madrid seismic zone as potential sources of seismicity. Anderson (1997) relates the Commerce Geophysical Lineament to Quaternary faulting. ***Figure 3-10*** shows the location of the Commerce Geophysical Lineament relative to the Taum Sauk Plant site and the New Madrid Seismic Zone.

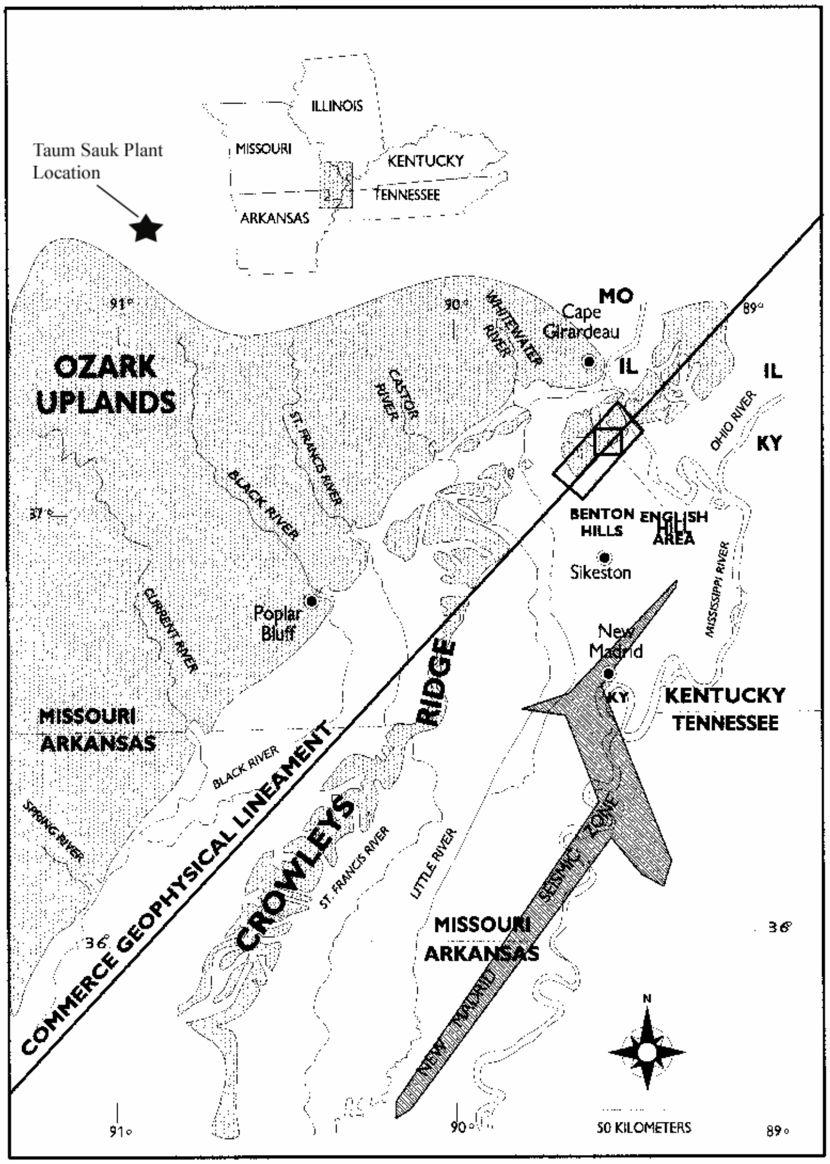


FIGURE 3-10

COMMERCE GEOPHYSICAL LINEAMENT AND NEW MADRID SEISMIC ZONE (FROM ANDERSON, 1998)

In addition, Clendenin, et al., (1989) identify northwest striking faults, such as the Black Fault, Simms Mountain Fault, and Ellington Fault as having left lateral and dip slip components as part of a transfer system oblique to and structurally related to the northeast striking New Madrid and Reelfoot structures, and as zones of potential seismic activity based on present day east-west compressive stress fields. The northwest striking Simms Mountain and Saint Genevieve Faults are recognized by Lowell (2000) as the mechanisms for a subsidence structure within the Saint

Francois Terrane. Although faulting within the Saint Francois Terrane has been established, the relationship to current seismicity within the New Madrid Seismic Zone is not clear. Pratt, et al., (1992) map numerous faults within the Cambrian and Late Proterozoic rocks of the Saint Francois Terrane, including the northwest striking faults previously discussed. Many of these faults terminate in map view as they intersect Quaternary through Cretaceous sediments while others are mapped as inferred across the younger sediments.

Occurrence of earthquakes with epicenters in the Saint Francois Mountains is sparse. USGS Quaternary Fault and Fold Database has the nearest features 30 miles to the northeast as the St. Louis-Cape Girardeau liquefaction features, which includes portions of Washington and St. Francois Counties. The largest earthquake with the epicenter roughly in the St. Francois Terrane, according to a search of the USGS earthquake catalog is a magnitude 4.4. The nearest epicenter found is within ten miles of the site with a magnitude of 4.0 in 1965.

3.6 SEDIMENT MAPPING OF THE BREACH CHANNEL

3.6.1 Generic Definition

For this forensic investigation, we use the term “debris torrent” to describe the transport of the material down the Breach Channel, differing from debris flows that generally stop or stay close to the foothills where flow originated. From a generic perspective, debris torrents are characterized by long stretches of bare soil and unstable channel banks that are scarred by the extremely rapid movement of debris, a type of mass movement that involves water-charged, predominantly coarse-grained inorganic and organic material flowing rapidly down a steep confined, pre-existing channel. It moves as a fluid, and the material is being continually deformed. Depending on the amount of water involved and the steepness of the slope, the rate of movement can be slow to very rapid.

A debris torrent might begin as a debris slide or as a debris flow, to later become a debris torrent when channelized in streams and moving rapidly downstream. The terms channelized debris flow as well as debris avalanche have been used when referring to similar processes.

3.6.2 Debris Torrent Process

Three consecutive steps are used to describe this debris torrent occurrence, specifically, initiation, transport and deposition.

Initiation is where the mass movement is triggered at the source area headwaters. At Taum Sauk, this is the failure of the Rockfill Dike at the Upper Reservoir.

Transport of the debris occurs down the initial zone, scouring and widening, as the debris flow grows in size. A straight and uniformly steep gradient channel, like Taum Sauk, represents the most favorable transport condition. Initiation and initial transportation and erosion of the channel occurred on an average slope of 13 degrees.

The zone of depletion of the debris (the zone where the displaced material was below the original ground surface) is the area from the downstream toe of the Rockfill Dike to the break in slope. This area is characterized as having a few remnant patches of residual soil, no vegetation and no material derived from the Rockfill Dike (or facing concrete). Only a small concrete block is observed close to the top. ***Figure 3-11*** shows this area as it is seen from the slope break to the initiation area.

FIGURE 3-11

ZONE OF DEPLETION FROM THE INITIATION AREA TO THE SLOPE BREAK

3.6.3 Deposition

Deposition occurs where either the channel gradient flattens to the point that there is insufficient energy for continued movement, or when the channel becomes laterally unconfined. At Taum Sauk, partial deposition and remobilization occurred when the slope flattened to about 4 degrees. The deposited material is highly variable, covering a wide range of particle sizes from very fine sand to boulders. We also observed old construction material and drilling pipes/bits derived from drilling operations associated with the blasting operations.

The primary factors affecting the deposition patterns are:

- Loss of confinement of the debris, especially in those areas where creeks drained into the main channel.
- Impediments to flow including trees, large boulders, and previously deposited natural debris; these impediments were removed from the zone of depletion during the debris torrent.
- The flow rate versus time as the Dike failed; and
- The changing channel gradient.

The zone of deposition extends downhill to Johnson Shut-Ins Park and into the Lower Reservoir, with some suspended sediments going over the Dam and further downstream. The degree of confinement for this flow ranged from confined to partly confined when traveling downhill, and unconfined when reached the foothill in Johnson Shut-Ins Park.

Once the availability of the source of material ended, i.e., when the Dike was fully breached, there was some local remobilization based on the fact that plugs of debris and banks were cut as much as 6 inches and boulders were remobilized from their original position. The height of the mix flow is shown to be at least 10 feet high, from overbank flows, based on marks left by rocks on trees left standing on the hillsides, where almost all minor vegetation was partially removed (***Figure 3-12***).

FIGURE 3-12

FACIES S1/S3 DEPOSITS OVER SLOPE IN SW OF SECTION 1, WITH MARKS ON TREES CAUSED BY ROCK PARTICLES

When referring to the deposition process, it should be noted that all of the original deposits along the Breach Channel were scoured, removed and displaced by sediments derived from the Breach Area as well as the reworked original deposits. When the coarse-grained debris from a “channellized” debris flow stops, it can take many forms, depending on the character of the debris and the debris fan, and on the presence of natural or artificial impediments. These forms, as shown in ***Figure 3-13***, include sheets or lobes of debris on the debris fan, plugs of debris deposited in the stream channel, and debris levees along the stream channel.

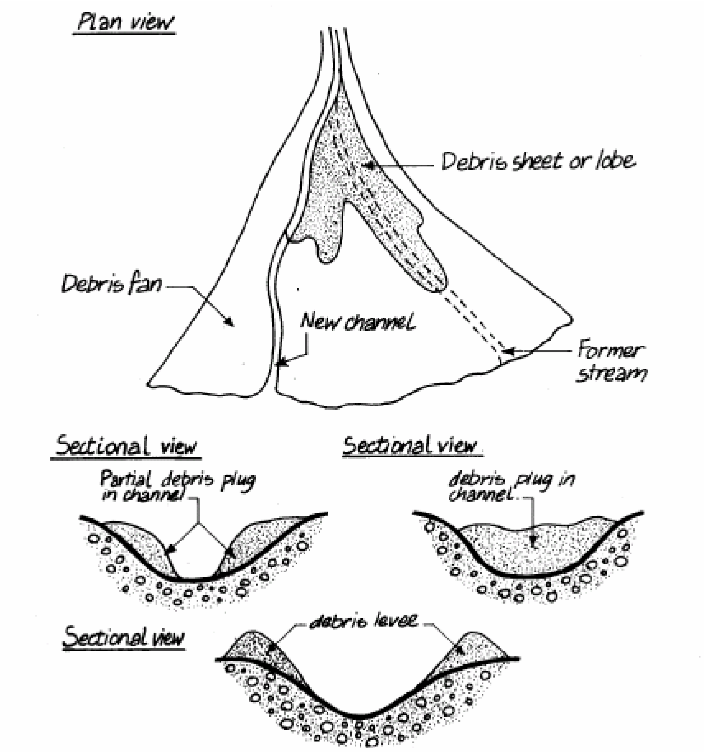


FIGURE 3-13

FORMS OF CHANNELLIZED DEBRIS FLOW DEPOSITION
(D.F. VANDINE, 1996)

Debris sheets or lobes are usually deposited over an extended portion of the debris fan. They are often characterized by a number of arms. The thicknesses of the deposited debris sheets along the Breach Channel area were estimated using the elevations shown in the topographic map for this same region and the actual elevations for the top of the debris. Based on this information it is estimated that the as much as 25 feet may have been deposited in the deepest part of the original creek channel that ran through the valley. At the break in slope near the Breach Area shown on ***Figure 3-11***, the thickness is estimated to be in the range of 15 feet.

The thickness decreases towards the borders of the channel with only minor variations due to the presence of levees. (Debris levees are steep-sided ridges that were found to be up to several feet in height. They lie outside and above the sides of a pre-existing stream channel, and can extend for many tens of feet along a channel.) Debris plugs were locally observed, as they tend to usually partially or completely fill the stream channel, which often results in an abrupt change in flow direction

Figure 3-14 shows the location of the sections developed as part of the overall mapping effort.

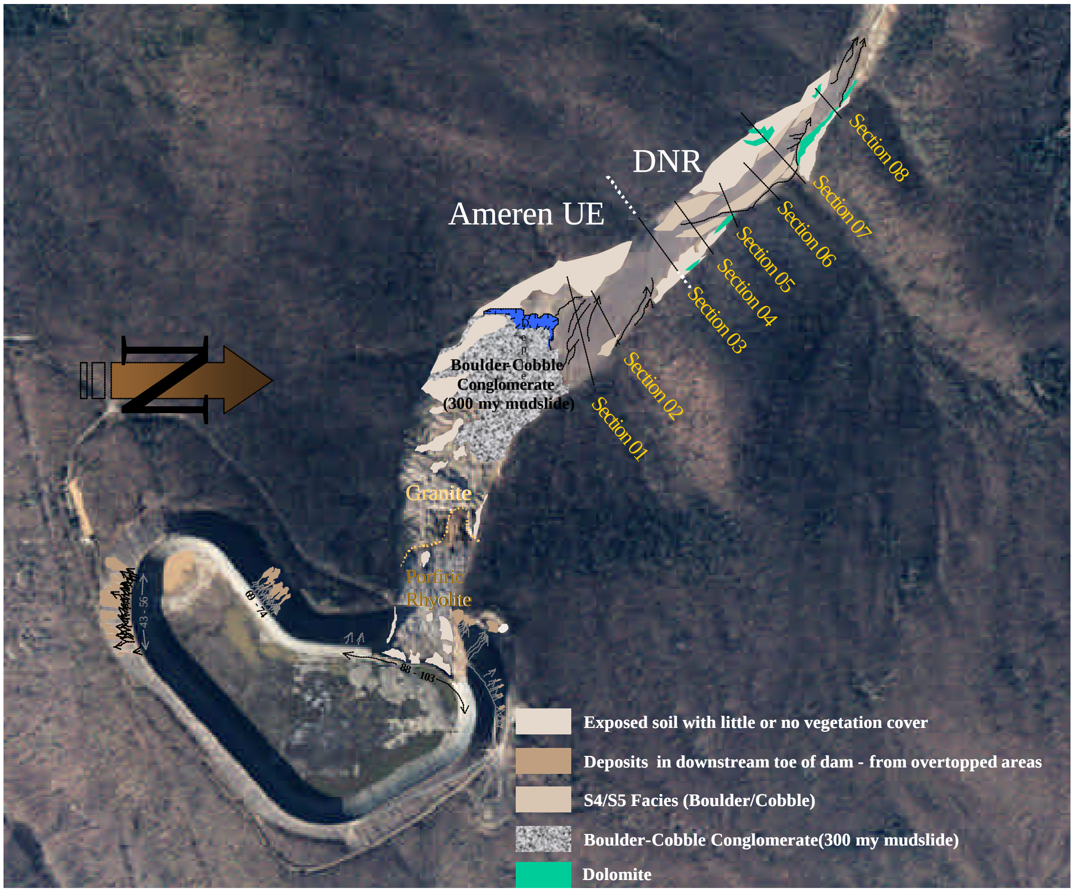


FIGURE 3-14

GENERALIZED DISTRIBUTION OF DEPOSITS DERIVED FROM BREACH AREA AND SUBSEQUENT DEBRIS TORRENT

Somewhat in contrast to expectation, the debris is more stratified and well sorted/poorly graded deposits, possibly as a result of the very high water content of the mix. These effects are shown in ***Figures 3-15 and 3-16*** where a cut into a debris plug is shown. The stratification and gradation is evident and extensions of the debris sheet are well sorted accumulations of facies S4/S5 sediments. This is in accordance with a more fluid type of mass movement, enhanced by the availability of a large rapid water source.

South end on section 3
S4/S5 facies levee

North end on section 6

North end on section 4

FIGURE 3-15

DIFFERENT LEVEES IN SIZE AND COMPOSITION
ALONG THE DEBRIS DEPOSITS

FIGURE 3-16

STRUCTURED DEPOSITS IN A DEBRIS PLUG CUT

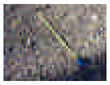
FIGURE 3-17

WELL-SORTED FACIES S4/S5 SHEET DEPOSIT, SECTION 6

3.6.4 Sediment Mapping

The sediment mapping conducted as part of the field investigation consisted of an assessment of the surface deposits, their characteristics and the evident processes associated with the actual location and distribution of such deposits. The volumes of these deposits was not estimated, only their character.

Referring back to ***Figure 3-14***, the deposits shown in Breach Area are those distinctive facies S4/S5, with larger particle sizes as shown on ***Figure 3-18***. The facies at the other sections indicated on ***Figure 3-14*** are shown on ***Figures 3-18 and 3-19***.

Facies	Description	Size	Image
S1	Medium to very coarse Sand with granules and pebble.	< 1”	
S2	Pebble with granules and coarse sand	1” – 3”	
S3	Cobble with pebble, granules and very coarse sand	3” – 6”	
S4	Cobble	6” – 1’	
S5	Boulders	> 1’	

Most particles are angular to subangular, derived from the rhyolite, porfiric rhyolite and granite; with traces of particles smaller than a very fine sand

Measuring tape used as scale is always indicating 3 feet

FIGURE 3-18

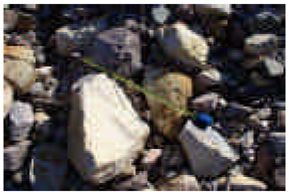
CHARACTERISTICS OF FACIES TYPES USED IN DESCRIBING SUPERFICIAL SEDIMENTS

S 1

S 2

S 3

S 4



S 5

FIGURE 3-19

FACIES TYPES USED IN DESCRIBING SECTIONS NORMAL TO FLOW

The Sections located on ***Figure 3-18*** are shown below on ***Figure 3-20*** and the fraction of the various facies at each section is indicated on ***Figure 3-21***.

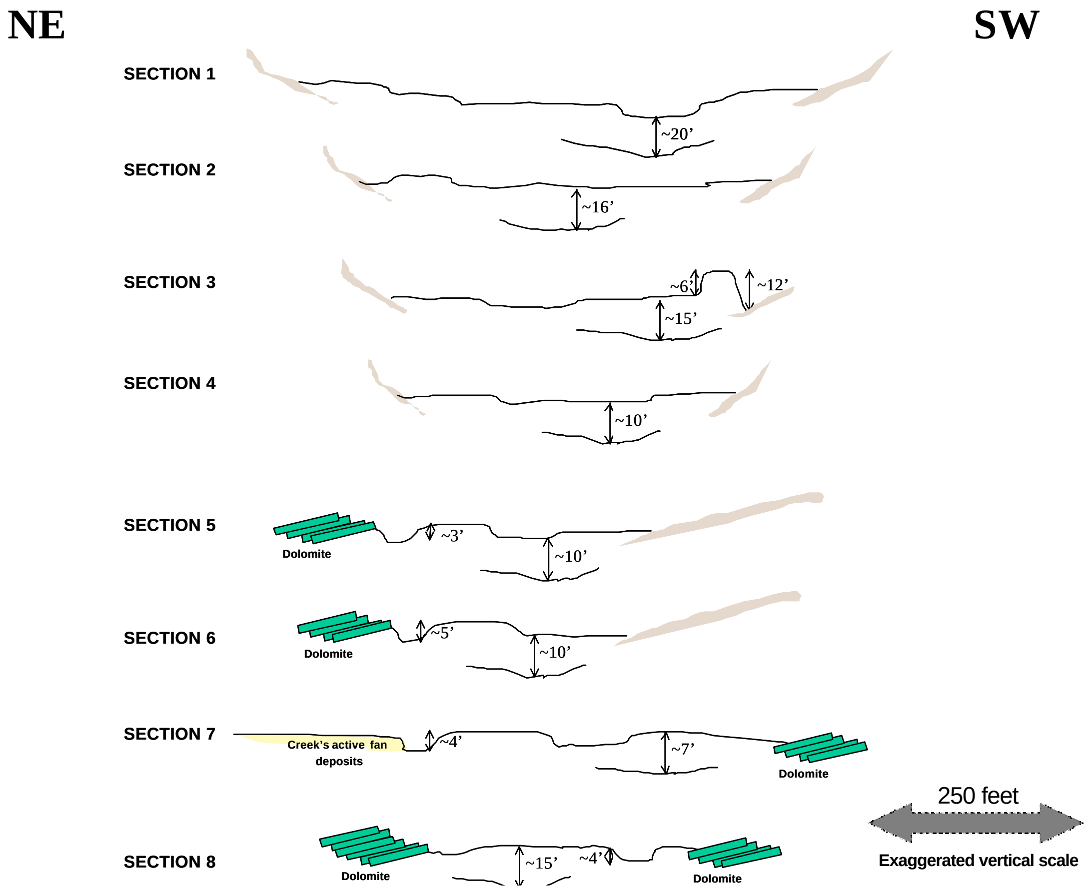


FIGURE 3-20

CROSS SECTIONS OF BREACHED CHANNEL

Facies (%)	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8
S 1 (%)	15	10	5	5	5	10	15	5
S 2 (%)	25	30	35	15	15	20	15	15
S 3 (%)	30	35	40	15	30	20	20	25
S 4 (%)	20	20	15	40	20	30	35	40
S 5 (%)	10	5	5	25	30	20	15	15
Max Size (feet)	10	3	5	2	5	5	2	3

FIGURE 3-21

FACIES FRACTION AT EACH MAPPED SECTION

4.0 DESCRIPTION OF THE DECEMBER 14, 2005 INCIDENT

During the early morning hours, around 5:00 AM, the northwest corner of the Dike around the Upper Reservoir breached over a width of about 700 feet, causing an uncontrolled, rapid release of water down the west slope of Profitt Mountain and into the East Fork of the Black River. An overall aerial view of the flow path is shown on ***Figure 2-1***. The following series Figures (***Figures 4-1 to 4-6***) provide a photographic description of the incident.

FIGURE 4-1

OVERALL VIEW OF THE BREACHED DIKE

FIGURE 4-2

CLOSE UP VIEW OF WEST SIDE OF BREACH AREA

FIGURE 4-3

CLOSE UP VIEW OF EAST SIDE OF BREACH AREA

FIGURE 4-4

VIEW FROM INSIDE UPPER RESERVOIR TOWARDS FLOW CHANNEL

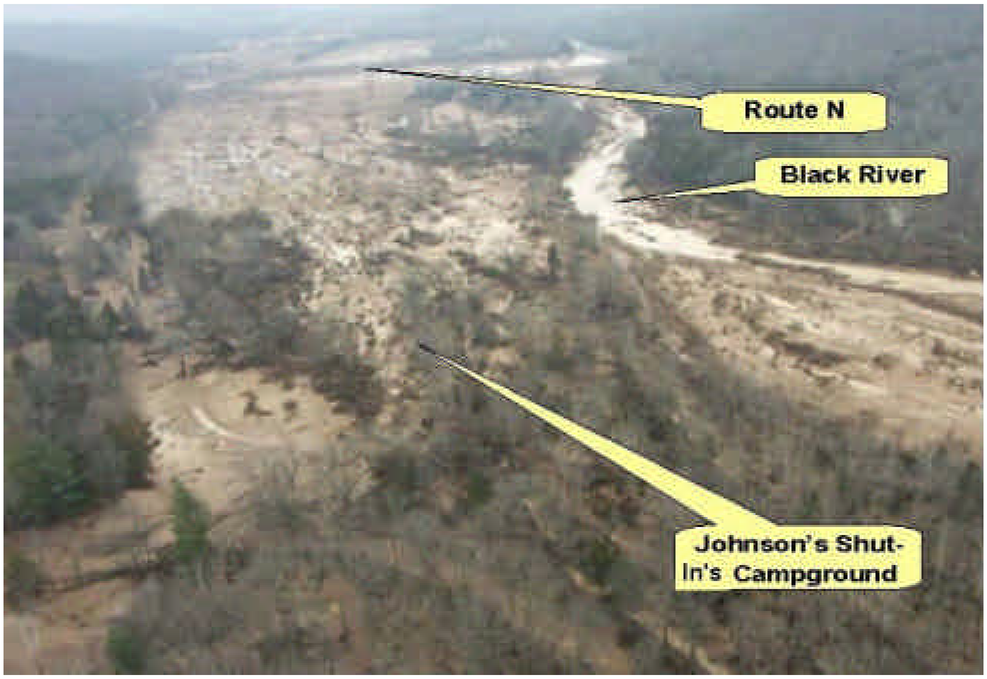


FIGURE 4-5

VIEW LOOKING NORTH AT FLOW CHANNEL

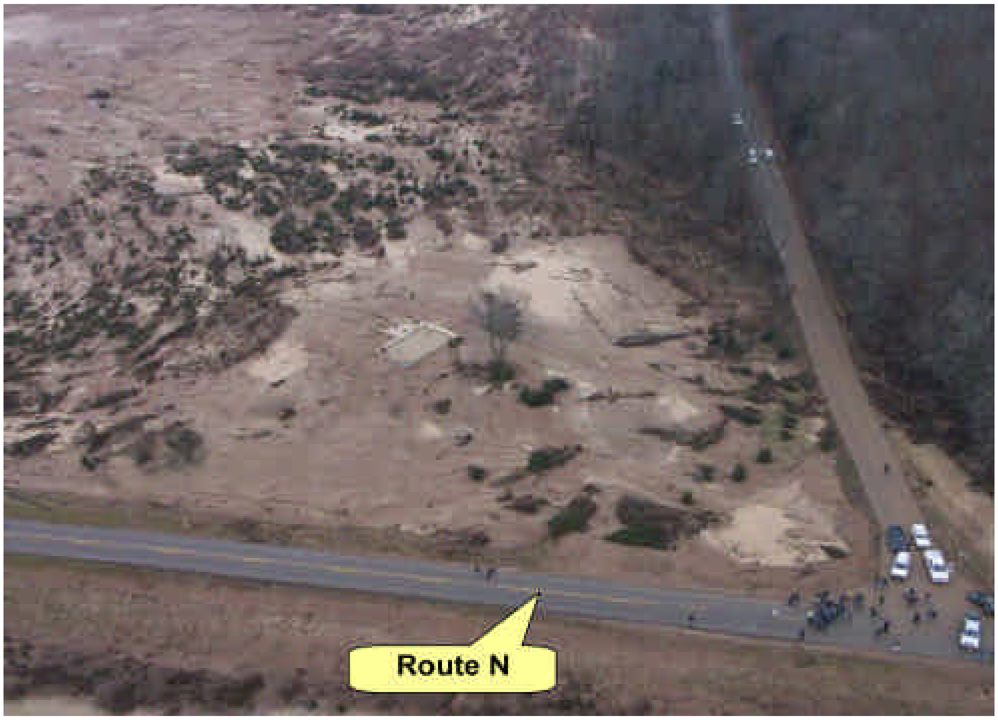


FIGURE 4-6

VIEW OF FLOW CHANNEL AND ROUTE N

The release of water destroyed a private residence, flooded Route N, and caused property and environmental damage to Johnson's Shut-Ins Campground. There were no fatalities. It is the purpose of this Report to document the results of a forensic investigation into the root cause of the event. For purposes of this Report, the Event is defined as the ***"uncontrolled, rapid release of water from the Upper Reservoir."*** It is the objective of the investigation reported herein to establish the root cause of this Event.

5.0 OVERALL APPROACH TO ROOT CAUSE ANALYSIS

5.1 OVERALL APPROACH

In order to conduct this forensic investigation and root cause analysis in a systematic manner consistent with the state of practice of root cause analysis, we have adopted the terminology and a modified version of the methodology utilized by the US Department of Energy as stated in their Root Cause Analysis Guidance Document (DOE, 1992).

The basic reason for investigating and reporting the causes of negative events is to enable the identification of corrective actions adequate to prevent recurrence, and thereby, protect the health and safety of the public, the workers, and the environment. In the case of the breach of the Upper Reservoir Dike, a primary purpose of this root cause analysis is to develop design parameters for a possible rebuild of the Upper Reservoir Dike if a decision is reached to do so. The rebuild would likely be an entire rebuild, rather than remediating the remnant Dike. DOE's suggested Phase III (Corrective Actions), Phase IV (Inform) other than this Report and Phase V (Follow-up) are not addressed in this report. Consequently, the root cause investigation reported here consists of two Phases defined by DOE as follows:

Phase I - Data Collection: It is important to begin the data collection phase of root cause analysis immediately following the occurrence identification to ensure that data are not lost. (Without compromising safety or recovery, data should be collected even during an occurrence.) The information that should be collected consists of conditions before, during, and after the occurrence; personnel involvement (including actions taken); environmental factors; and other information having relevance to the occurrence.

Phase II - Assessment: Any root cause analysis method may be used that includes the following steps:

1. Identify the problem.

2. Determine the significance of the problem.

3. Identify the causes (conditions or actions) immediately preceding and surrounding the problem.

4. Identify the reasons why the causes in the preceding step existed, working back to the root cause (the fundamental reason which, if corrected, will prevent recurrence of these and similar occurrences throughout the facility).

DOE guidance describes six common methodologies for conducting root cause analysis. We have adopted the Barrier Analysis Methodology, which is a systematic process that can be used to identify physical, administrative, and procedural barriers or controls that should have prevented the occurrence.

5.2 DEFINITIONS AS APPLIED TO THIS ROOT CAUSE ANALYSIS

The DOE Guidance utilizes certain definitions in the root cause analysis, some of which are adopted and utilized here:

Facility: Any equipment, structure, system, process, or activity that fulfills a specific purpose. In our case, the Facility is the Upper Reservoir.

Event: A real-time occurrence (e.g., pipe break, valve failure, loss of power). In our case, the Event is defined as follows:

"The uncontrolled, rapid release of water from the Upper Reservoir"

Cause (Causal Factor): A condition or an event that results in or contributes to an Event. In DOE Facilities, this could be anything from noise in an instrument channel, a pipe break, an operator error, or a weakness or deficiency in management or administration. In our case, Causal factors range from instrument failure to structural failures, all as discussed in context later in this Report.

Root Cause as used in this Report: The cause that directly resulted in the Event. In the parlance of this Report, this is the Root Cause of the ***"the uncontrolled, rapid release of water from the Upper Reservoir."***

Contributing Cause: A cause that contributed to an event but, by itself, would not have caused the event. For example, in the case of a leak, a contributing cause could be lack of adequate operator training in leak detection and response, resulting in a more severe event than would have otherwise occurred. We also use the terms Primary, Secondary, and Tertiary Contributing Causes to reflect our view of the degree that the Contributing Cause had on the Event, with a Tertiary Contributing Cause being the weakest contributor.

5.3 GENERIC OVERVIEW OF THE EVENT INVESTIGATION

The objective of investigating and reporting the cause of events is to enable the identification of corrective actions adequate to prevent recurrence, and thereby, protect the health and safety of the public, the workers, and the environment. Programs and facilities can then be improved and managed more efficiently and safely.

The investigation process is used to gain an understanding of the event, its causes, and what corrective actions are necessary to prevent recurrence. The line of reasoning in the investigation process is:

1. **Outline what happened step by step**.

2. **Begin with the event occurrence and define the problem**. In our case we have defined the event as ***"The uncontrolled, rapid release of water from the Upper Reservoir."***

3. **Determine what program element was supposed to have prevented this event?** Was it lacking or did it fail?

4. **Investigate the reasons why this situation was permitted to exist**.

This line of reasoning will explain why the event was not prevented and what corrective actions will be most effective. This reasoning should be kept in mind during the entire root cause process.

5.4 GENERIC COMMENTS ON DATA COLLECTION

It is important to begin the data collection phase of the root cause process immediately following event identification to ensure that data are not lost. The information that should be collected consists of conditions before, during, and after the event; personnel involvement; environmental factors; and other information having relevance to the condition or problem. For serious cases, photographing the area of the occurrence from several views may be useful in analyzing information developed during the investigation.

Every effort should be made to preserve physical evidence such as failed components, ruptured gaskets, burned leads, blown fuses, spilled fluids, partially completed work orders and procedures. Event participants and other knowledgeable individuals should be identified.

Once all the data associated with this event have been collected, the data should be verified to ensure accuracy. The investigation may be enhanced if some physical evidence is retained. Establishing a quarantine area, or the tagging and segregation of pieces and material, should be performed for failed equipment or components.

The basic need is to determine the direct, contributing and root causes so that effective corrective actions can be taken that will prevent recurrence. Some areas to be considered when determining what information is needed include:

- Activities related to the event.
- Hardware (equipment) or software (programmatic-type issues) associated with the occurrence.
- Recent administrative program or equipment changes.
- Physical environment or circumstances.

Some methods of gathering information include:

- Conducting interviews/collecting statements - Interviews must be fact finding and not fault finding. Preparing questions before the interview is essential to ensure that all necessary information is obtained.

- Interviews should be conducted, preferably in person, with those people who are most familiar with the problem. Although preparing for the interview is important, it should not delay prompt contact with participants and witnesses. The first interview may consist solely of hearing their narrative. A second, more-detailed interview can be arranged, if needed. The interviewer should always consider the interviewee's objectivity and frame of reference.

- Reviewing records: Review of relevant documents or portions of documents and reference their use in support of the root cause analysis.

- Acquiring related information: Some additional information that an evaluator should consider when analyzing the causes include:

    - Evaluating the need for laboratory tests, such as destructive/nondestructive failure analysis.

    - Viewing physical layout of system, component, or work area; developing layout sketches of the area; and taking photographs to better understand the condition.

    - Determining if operating experience information exists for similar events at other facilities.

    - Reviewing equipment supplier and manufacturer records to determine if correspondence has been received addressing this problem.

5.5 GENERIC COMMENTS ON DATA ASSESSMENT

The assessment phase includes analyzing the data to identify the causal factors, possibly summarizing the findings, and categorizing the findings by the cause categories. For example, cause categories might include some or all of the following:

- Equipment/Material Problem/Procedure Problem,
- Personnel Error,
- Design Problem,
- Training Deficiency,

- Management Problem, and
- External Phenomena.

These categories address the problems that could arise during operations prior to the event. Those elements necessary to perform any task are equipment/material, procedures (instructions), and personnel. Design and training determine the quality and effectiveness of equipment and personnel. These five elements must be managed, and therefore, management is also a necessary element. Whenever there is an event, one of these five elements was inadequate to prevent the occurrence. External phenomena beyond operational control serve as a sixth cause category. Note that a direct (root) cause or contributing cause can occur any place in the causal factor chain; that is, a root cause can be an operator error while a management problem can be a contributing cause, depending on the nature of the event.

5.6 BARRIER ANALYSIS

DOE provides a list of various methods for performing root cause analysis. Many of these methods are specialized and apply to specific situations or objectives. We have chosen to use the Barrier Analysis Method at Taum Sauk because, the Barriers are easily identified and fit well with the way in which Dikes and Dams are designed and constructed.

Generally speaking, Barrier Analysis is a systematic process that can be used to identify physical, administrative, and procedural barriers or controls that should have prevented the event. This technique should be used to determine why these barriers or controls failed and what is needed to prevent recurrence.

We use the term barrier as something, be it a physical component, an instrument, a management policy, an operations manual, etc., that otherwise prevents an event. At Taum Sauk, we include all of those barriers that existed prior to the event that were established to prevent an ***"uncontrolled, rapid release of water from the Upper Reservoir."*** Therefore, the following eight (8) questions were addressed for each Barrier.

1. Did the Barrier perform its intended function under normal operating conditions?

2. Did the Barrier perform its intended function under the upset or faulted condition?

3. Did the Barrier mitigate the Event severity?

4. Was the Barrier design adequate?

5. Did the Barrier design contemplate the occurrence of the Event?
6. Was the Barrier construction adequate?
7. Was the Barrier adequately maintained?
8. Was the Barrier inspected prior to Event?

6.0 DEFINITION OF THE UPPER RESERVOIR BARRIERS

In this Section we define the barriers available at the Taum Sauk Plant to prevent "***the uncontrolled, rapid release of water from the Upper Reservoir*.**" Reference is made to ***Figure 6-1*** and ***Table 6-1*** prepared for this purpose. It is noted that ***Table 6-1*** also includes postulated failure modes of each of the barriers, which, in turn, form the basis of the data assessment and investigations addressed in ***Section 7.0***.

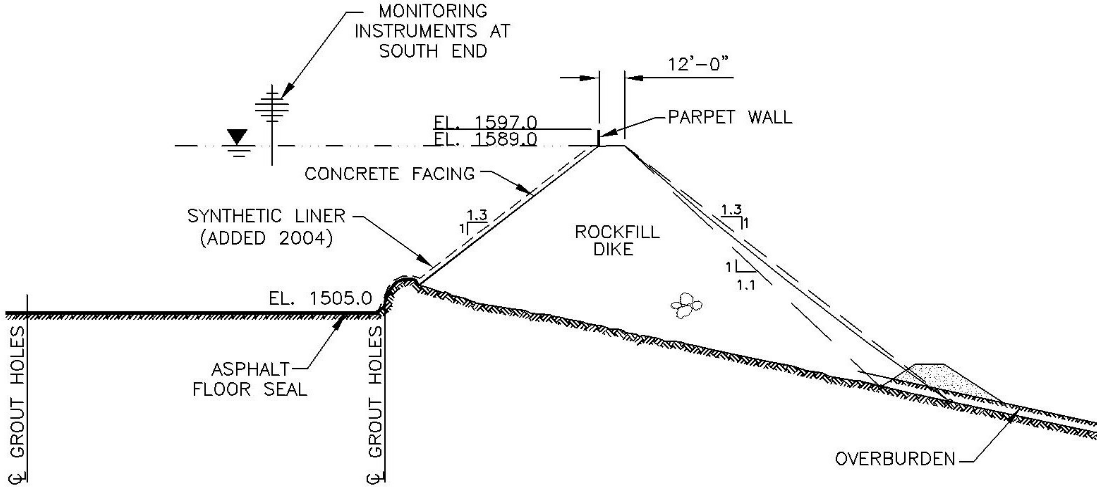


FIGURE 6-1

BARRIERS TO RAPID RELEASE

TABLE 6-1

UPPER RESERVOIR BARRIERS AND POTENTIAL FAILURE MODES

BARRIER NO.	DESCRIPTION	POTENTIAL FAILURE MODE	INVESTIGATION METHODOLOGY
1	Rockfill Dike	Wedge or Sliding Failure	Test Borings, Test Pits, Laboratory Tests, Design Review, Field Inspection and Analysis
		Circular Stability Failure	
		Piping Failure	
2	Concrete Face	Undermining of the Concrete with Consequential Structural Failure of the Concrete	Design Review, Field Inspection and Analysis
		Structural Failure of the Concrete with no undermining	
		Failure of the Waterstops	
3	Synthetic Liner	Loss of Support and Consequential Puncture or Tear Failure of the geosynthetic material	Design Review, Field Inspection and Analysis
4	Parapet Wall	Undermining of Foundation	Design Review, Field Inspection and Analysis
		Structural Failure of Concrete	
		Sliding Failure	
		Overturning Failure	
		Failure of the Joint Material between Wall Segments	
5	Asphalt Pavement of Reservoir Bottom	Excessive Leakage	Design Review and Field Inspection
6	Grout Curtain	Excessive Leakage	Design Review and Analysis
7	Foundation Filters	Clogging	Design Review and Analysis

TABLE 6-1
(CONTINUED)

BARRIER NO.	DESCRIPTION	POSTULATED FAILURE MODE	INVESTIGATION METHODOLOGY
8	Instrumentation	Support Failure	
		Power Failure	Design Review, Records Review and Interviews
		Loss of Redundant Devices	
		Failure of Measurement Device	
		Failure of Transmission System	
		Failure of Readout Device	
9	Operator Action	Failure to Read Instruments	Records Review and Interviews
		Failure to Take Action after Reading Instrument	
		Failure to Take Adequate Training	
		Failure to Follow Operational Procedures	
		Failure to Follow Inspection Procedures	
10	Management Oversight	Failure to Provide Adequate Training	Records Review and Interviews
		Failure to Provide Adequate Maintenance Procedures	
		Failure to Provide Adequate Redundant Systems	
		Failure to Provide Adequate Inspection Procedures	
		Failure to Respond to Project Inadequacies Found during Inspection Procedures	

7.0 SITE INVESTIGATION OF UPPER RESERVOIR BARRIERS

7.1 INTRODUCTION

The Upper Reservoir Barriers were investigated by several methods:

- Review of documents, FERC interview transcripts, construction records, and operation and maintenance history.
- Discussions with AmerenUE personnel.
- Geologic and engineering property mapping of the exposed foundation within the Breach Area as discussed in ***Section 3.0.***
- Mapping and description of the debris torrent in the Breach Channel below the Breach Area as discussed in ***Section 3.0***.
- Subsurface drilling.
- Laboratory testing of Breach Area soils and Dike material.

7.2 GEOLOGIC MAPPING

Geologic mapping was performed on January 19 and 20, 2006. RIZZO geologists mapped both geology and engineering properties following the guidelines and terminology given in the US Bureau of Reclamation Field Geology manual (http://www.usbr.gov/pmts/geology/). The mapping is mostly based on discontinuity survey combined with other parameters such as weathering, hardness, lithology, etc. These maps are described in ***Section 3.0*** **and** presented as ***Plates 3.1 and 3.2.***

In addition to the geologic mapping of the Breach Area, RIZZO geologists mapped and described the sediments deposition patterns on the property owned by AmerenUE in the Breach Channel below the Breach Area. This information is also presented above in ***Section 3.0.***

7.3 TEST BORING PROGRAM

A Test Boring Program has been undertaken with two primary objectives:

- Sampling and characterization of the material comprising the Rockfill Dike, including the interface zone near the bedrock.
- Sampling and characterization of the bedrock from rock core samples and in-hole testing.

The subsurface conditions of the Upper Reservoir Dike were explored by drilling seven (7) borings designated as TS-1 through TS-7. All borings were advanced to the top of the bedrock using a sonic drill rig. Please refer to ***Section 7.1.3*** for additional information regarding the sonic drilling technique. The locations of all seven borings are shown on the boring location plan presented on ***Plate 7.1***. For specific details associated with the subsurface materials encountered at each boring, please refer to the boring logs provided in ***Appendix D.*** All of the borings have been drilled either from the crest or from access roads on the north and east sides of the Dike. Also shown on ***Plate 7.1*** are the areas where soil samples were obtained by hand at or below the ground surface. These samples were obtained in the Breach Area at locations designated by RIZZO field people.

7.4 DRILLING AND SAMPLING OF THE ROCKFILL DIKE

Miller Drilling Inc. of Lawrenceburg, Tennessee, was subcontracted to perform the drilling and sampling of the Rockfill Dike, basically above the bedrock interface. Miller was chosen for this work as they operate several Versa Sonic® Drill rigs. This type of rig advances a borehole with sound waves focused on the shoe of the drill bit. The sound waves destroy material that contacts the bit. Most importantly these rigs can advance a bore hole through rip rap and rock fill.

Additionally, sonic drills have the capability of obtaining a continuous sample over a ten foot run. This is accomplished by employing a hollow drill bit the same size as the drill rods being used. Sonic rigs can sample 4 inch, or 6 inch diameter samples. When collecting 4 inch samples, the 4 inch drill stem is first advanced 10 feet; subsequently, an outer 6 inch drill stem is advanced over top of the 4 inch drill stem to keep the hole open; the 4 inch drill stem is withdrawn from the hole and the material inside the drill pipe is extruded out of the drill stem into a plastic bag or a bucket. Additional information about sonic drilling provided by Miller drilling is included below:

> A sonic drill is a machine that uses high frequency mechanical oscillations developed in the special drill head to transmit resonant vibrations and rotary power through the drill tooling to the drill bit. These oscillations allow it to achieve exceptional drilling penetration rates without the need for drilling fluids or air to effectively take overburden core samples. This is accomplished by the oscillator's conversion of centrifugal force generated by counter rotating, chambered rollers to sinusoidal or longitudinal force. Frequencies in excess of 180 Hz (as previously mentioned) are generated. These frequencies match the natural frequency of the drill tooling, resulting in little or no dampening of the vibratory wavelength to the bit. Therefore, this sonic vibratory action fluidizes the soil particles, destroying the shear strength and pushing the particles away from the tip of the drill bit and along the sides of the drill string. This liquefaction process allows for clean, rapid and smooth penetration of overburden formations. This unique methodology allows the machine to perform overburden and even bedrock core sample drilling with speed, precision, and an absolute minimal amount of disturbance and compaction that cannot be accomplished by any other equipment.
>
> One of the main advantages of the sonic technology is its superior ability to produce continuous core samples of both unconsolidated and consolidated formations with significant detail and accuracy. The core samples can be analyzed to provide a precise and detailed stratigraphic profile of any overburden condition including dry or wet/saturated sands and gravels, cobbles and boulders, clays, silts and hard tills. Recovery of a sample is consistently close to 100 percent.
>
> The sonic method uses a dual line of drill pipe. The inner string of drill rods has the core barrel(s) attached. All overburden core sampling is done ahead of the outer string of drill casing with no fluid or air added to insure accurate, representative, undiluted samples. After the core barrel has been advanced, the outer drill casing is advanced to the same depth. This can best be

> accomplished with water; however, dry casing advancement methods can also be employed and are done so often by Miller Drilling. With the outer casing left in place to hold the hole open, the core barrel is then removed from the borehole. The core sample can then be extracted into plastic sleeves, stainless steel sample trays, wooden core boxes or virtually any container. The outer drill casing ensures there is no sample contamination from uphole material by sealing it off prior to each sample run. When water use is permitted for casing advancement, it is by far the quickest and most effective means of combating heaving sands without the use of drilling mud or bentonite.
>
> The outer casing also serves to hold the borehole open for installation of monitoring wells, piezometers, vents, observation wells, instrumentation or other downhole equipment. The outer drill casing has nominal diameters of 6 inches and 8 inches, allowing ample space to install 2 and 4 inch wells with a 1 inch or 1 ¼ inch tremie pipe to place sand packs, seals, slurries and grouts into the annular space between the well screen/riser and the outer casing and borehole annulus. The drill bits used on the outer drill casing are open and are 5 7/8 inch through 8 ½ inch diameter depending on borehole size requirements.

Drilling started on January 17, 2006, and is complete as far as the forensic investigation is concerned. Drilling and sampling is continuing to obtain information to evaluate the possibility of a re-build of the Upper Reservoir, including rock coring using conventional drilling.

In the first boring undertaken with the sonic drill, both 4 inch and 6 inch diameter samples were collected. The smaller 4 inch sample had poor recovery and it appears that the drill rods pushed the material aside rather than sampling it. Thereafter, it was decided to continue only with 6 inch sampling. This resulted in the collection of at least 20 percent of the theoretical maximum amount of material during the sampling of a 10 foot run. Very commonly, 40 percent of the material was collected. In the upper 20 feet of the Dike, where the material was compacted fill, often 60 to 80 percent of the material was collected.

Because of space limitation on the crest of the Dike as shown on ***Figure 7-1***, the material was placed directly into buckets. ***Figures 7-2 and 7-3*** show the sample collection procedures utilized in the field. These samples were shipped to Geotechnics Laboratory in East Pittsburgh, PA for classification and additional testing as addressed below in ***Section 7.1.6***

FIGURE 7-1

SPACE LIMITATION ON THE CREST OF ROCK FILL DIKE

FIGURE 7- 2

SAMPLING ROCKFILL

FIGURE 7-3

TYPICAL ROCKFILL SAMPLE

The rockfill material obtained from the borings generally consists of boulders, gravel, and sand with a small percentage of fine material (i.e., less than 10 percent).

7.5 LABORATORY TESTING OF BREACH AREA SOILS AND DIKE MATERIAL

Laboratory testing was performed on the soil samples that make up the Taum Sauk Dike and its foundation soils. The laboratory testing program is summarized in ***Table 7-1***. Samples of the Dike material obtained during sonic drilling were placed in five gallon plastic buckets for shipment to the soils laboratory. Block samples of cohesive soil obtained by hand from the breach area were wrapped in cellophane and also placed in five gallon plastic buckets. Upon arrival at the laboratory, the samples were placed in large pans and photographed. These samples are designated as TS-Soil-01 to 04. In addition, two Shelby Tubes of foundation soil from the Breach Area were also obtained. These Shelby tubes were pushed by hand. Shelby tube samples are designated as TS-ST-01 and TS-ST-02.

TABLE 7-1

LABORATORY TESTING SUMMARY

TEST NAME	ASTM DESIGNATION	NUMBER OF SAMPLES
Sieve Analysis	D-422	74
Atterberg Limits	D-4318	33
Consolidated Undrained Triaxial Test with Pore Pressure Measurements (CU)	D-4767	3
Rock Density	-	1
Direct Shear Testing	D-3080	2
Water Content	D-2216	5
Flex-Wall Permeability (cohesive samples)	D-5084	2
Rigid Wall Permeability (gravel samples)	D-2434	3

The results from the sieve analyses and Atterberg Limits were used for classifying the samples in accordance with the Unified Soil Classification System (USCS). Classification information is used to identify material properties. Permeability test data has been used to confirm parameters used in seepage analyses in the forensic investigation. Triaxial and Direct Shear tests have been used to confirm estimates of shear strength parameters used for stability analyses. A density test result was used to confirm the estimated density value used in the forensic investigation. The results from the laboratory testing program are provided in ***Appendix E.***

7.5.1 Sieve Analysis Results

The results from all of the grain size analyses completed at the publication of this report are provided in graphical form on ***Figure 7-4***. These grain size curves are representative of rockfill samples that have been scalped of the material retained on a six inch sieve considering that the diameter of the borehole was six inches.

We have estimated the actual range of grain size curves of the rockfill by adjusting the upper and lower limits of the grain size curves shown in ***Figure 7-4*** by assuming that 10 to 30 percent of the rockfill would be retained on the 6 inch sieve. This assumption is consistent with typical rockfill gradations. These results are provided on ***Figure 7-5*** along with gradation limits for typical 2006 rockfill specifications taken from the Saluda Dam Remediation project.

Our review of our best estimate rockfill grain size for the Taum Sauk Dam relative to typical modern rockfill gradation specifications shown on ***Figure 7-5*** is summarized below:

1. The material has a wider variation in gradation than a typical 2006 rockfill specification;
2. The material has a larger percentage of fines (up to 25% passing No. 200 sieve) than a typical 2006 rockfill specification (i.e., maximum 5%); and
3. The material is poorly graded with respect to a typical 2006 rockfill specification.

We also conclude that the fines content is not high everywhere in the Upper Reservoir Dike but it is definitely high (i.e., up to 25 percent) in some locations, due to the way the Dike was built. Current (2006) construction practices would include a grain size distribution specification and test methods to verify compliance. In the 1960's, only limited means were typically utilized to control actual grain size of the placed rockfill.

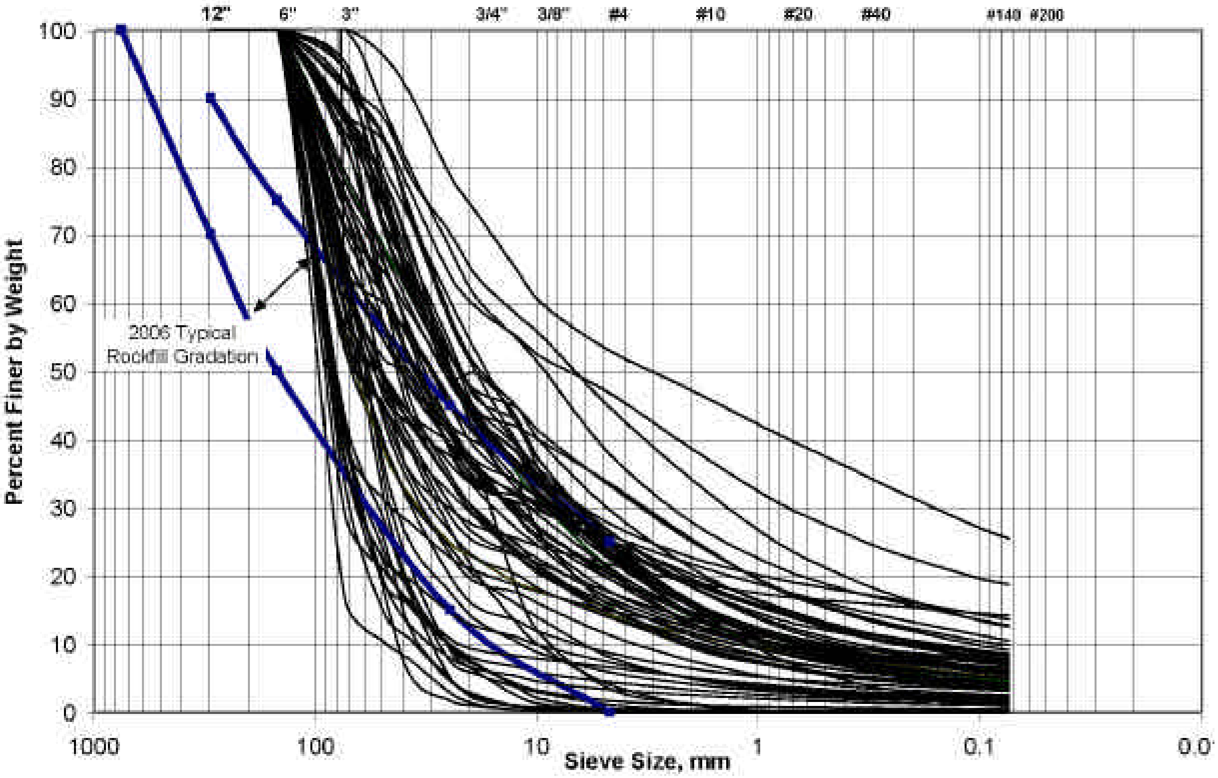


FIGURE 7-4

ROCKFILL GRADATION
(6” SCALPED)

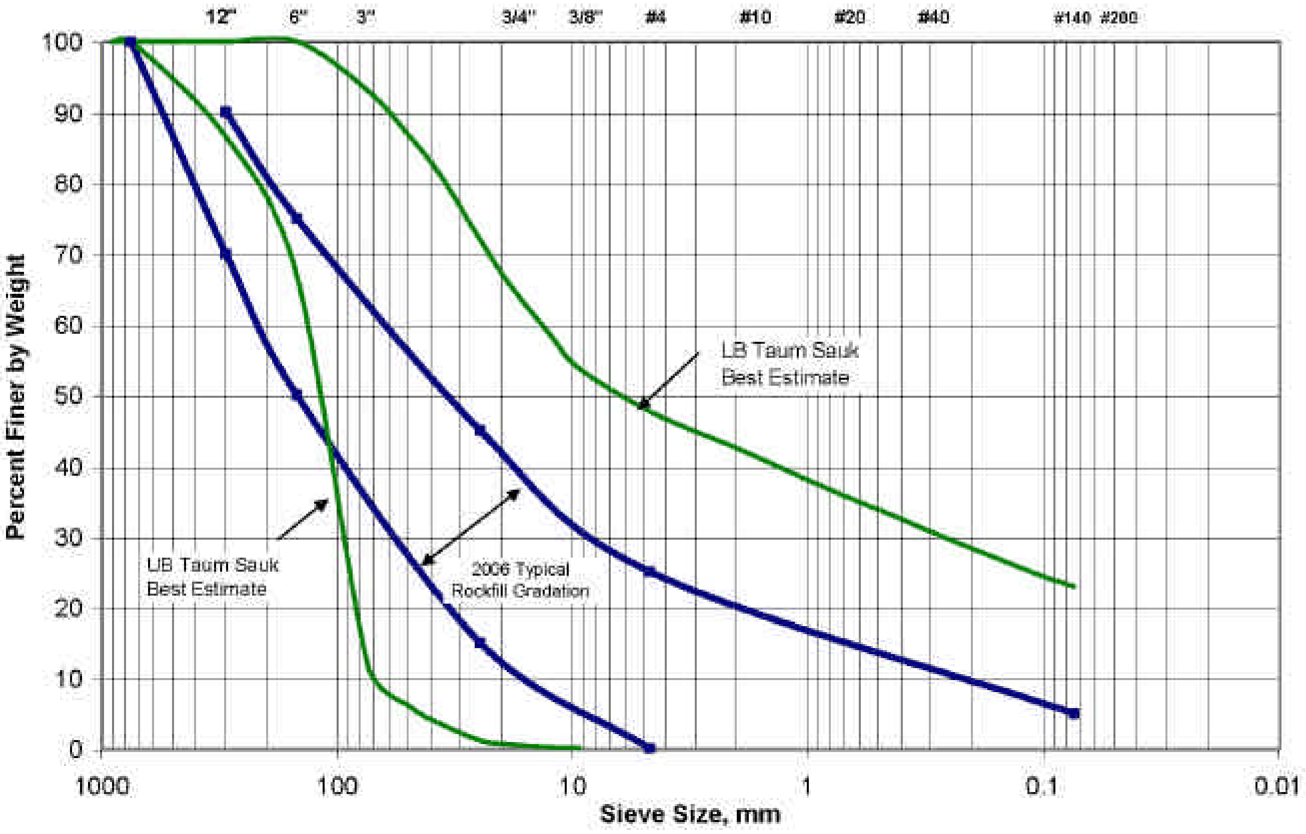


FIGURE 7-5

BEST ESTIMATE OF ROCKFILL GRADATION

7.5.2 Atterberg Limits Results

Atterberg limits have been performed on the fine (minus No. 40 sieve) portion of the dike material and foundation soils. The results are provided in ***Appendix E***. The fine portion of the rockfill is classified as CL-ML; silty clay to clayey silt of low plasticity.

7.5.3 Permeability Test Results

As shown in ***Table 7-2***, it appears that the measured permeability differs greatly from the permeability assumed in the SEEP2D (Boss International and Brigham Young University, 1999) Model (refer to Section 8.3). Recall that values assumed in the SEEP2D Model were back-calculated to match existing conditions. This can be explained by reviewing the original design drawings. In the original design, french drains are provided in the foundation soil layer at the downstream toe of the Rockfill Dike to convey seepage. Also, in some sections of the Dike, filter beds are provided under the rockfill. Most of the seepage quantity flows in the in the french drains and drainage blankets. Therefore, the permeability of the foundation soil layer does not significantly influence the calibration of the seepage quantity in the SEEP2D program. The permeability of french drains and filter beds control the quantity of seepage exiting from the downstream toe.

A much closer correlation exists with respect to the measured and assumed permeability of the rockfill. The permeability value utilized in the SEEP2D model is based on the calibration of the model from measured seepage quantity. In the case of the HDPE (synthetic) lined rockfill, the permeability of the rockfill has a negligible influence on the overall flow net pattern of the rockfill dike.

TABLE 7-2

SUMMARY OF PERMEABILITY TEST RESULTS

BORING NO.	SAMPLE NO.	DEPTH (FT)	MATERIAL TYPE	PERMEABILITY (CM/SEC)	ASSUMED PERMEABILITY (CM/SEC)
TS-ST-01	NA	0-2	Silty Clay	$1.30x10^{-6}$	$1.60x10^{-1}$
TS-ST-02	NA	0-2	Silty Clay	$3.80x10^{-7}$	
TS-4	S1+S2A,B,C	0-20	Rockfill	$5.47x10^{-1}$	$1.00x10^{-2}$
TS-4	S3+S4A,B	20-40	Rockfill	$2.50x10^{-1}$	
TS-4	S6+S7	50-70	Rockfill	$4.33x10^{-1}$	

7.5.4 Shear Strength Test Results

Three consolidated undrained triaxial tests with pore pressure measurements (CU) were performed on undisturbed foundation soil samples. In addition, two drained direct shear (DS) tests were also performed. In the drained test on normally consolidated clay samples, the strength envelop passes through the origin (i.e. no cohesion). The Best Fit Data as reported by the laboratory is shown in ***Table 7-3.*** This data contains both cohesion (c) and angle of internal friction (ø). These test results have been corrected for normally consolidated conditions by recalculating the failure envelope without cohesion.

TABLE 7-3

SUMMARY OF SHEAR STRENGTH TEST RESULTS

Boring No.	Sample No.	Depth (ft)	Test Type	Shear Strength Parameters				Assumed For Analysis
				Best Fit Data		Passing Through Origin		
				c (psi)	ø (degrees)	c’ (psi)	ø’ (degrees)	
TS-ST-01	NA	0-2	CU	2.78	34.0	0	37	Lower Bound C’ = 0 ø’ = 30° Best Estimate C’ = 0 ø’ = 33° Upper Bound C’ = 0 ø’ = 35°
TS-Soil-02	S-3	12-19		6.58	29.6	0	38	
TS-Soil-03	S-2	7-15		4.2	30.2	0	33	
TS-Soil-02	S-2	7-12	DS	7.58	21.3	0	28	
TS-Soil-04	S-2	5-11		4.95	28.6	0	36	

The modified (effective friction) angles with cohesion equal to zero are shown in ***Table 7-3***. These values vary from 28 to 38 degrees with an average value of 34 degrees. In the slope stability analyses, RIZZO assumed effective friction angles of 30 to 35 degrees with a best estimated value of 33 degrees. The best estimated value is based on the back calculation of incipient failure angle of an old slide at Taum Sauk site and found to be in a very close agreement with the laboratory measured value.

8.0 ANALYSIS OF UPPER RESERVOIR BARRIERS

Each of the physical Barriers cited on ***Table 6-1*** have been analyzed from the perspective of the postulated failure modes indicated thereon. As it was not practical to measure each of the parameters necessary for precise analysis, we performed a series of parametric analyses over the range of parameters deemed appropriate based on judgment, values cited in the professional literature and actual observations and measurements obtained from the field.

Following the discussion of the analyses completed, we summarize each of the physical Barriers and cite the impact of each in terms of Root Cause or Contributing Cause. As defined herein, a root cause is a cause that directly caused the Event and a primary, secondary or tertiary contributing cause is a cause that may have contributed to, but would not, either singularly or in combination with other primary, secondary or tertiary causes, have caused the Event. The descriptor primary, secondary or tertiary reflects our assessment of the degree that the cause contributed to the Event, with a tertiary cause having little or no effect on the Event

8.1 OVERTOPPING ANALYSIS

The initial task in our overall analysis effort was to develop an understanding of the portions of the Dike where overtopping occurred on December 14, 2005 and the magnitude of flow at these overtopping zones. This task was undertaken with a study of the most recent elevation survey of the top of the Parapet Wall as provided by AmerenUE. For Wall Segments 70 through 100 where AmerenUE has no recent survey data exists, the elevation of the top of each wall segment was estimated using the average Parapet Wall height, the maximum settlement between 2003 and 2005, and the elevation of monuments on the crest of the Dike in 2003. Using these elevations, flow was estimated by approximating each wall segment as a broad-crested weir. The highest level of water in the Upper Reservoir on December 14, 2005 was estimated at 1597.63 based on the Siemens report provided in ***Appendix A***. At this elevation, overtopping of the parapet wall will occur at the locations shown on ***Figure 8-1*** with the corresponding flows for each area. Details of flow characteristics at the lowest wall segment in each overtopping area are shown on ***Figures 8-2*** through ***8-4***. Overtopping flow is a function of time at each of the four overtopping zones. Flow also continues to go into storage, thereby continuing to raise the level in the Upper Reservoir until inflow equals outflow. The time at which the upper reservoir is at 1597.00 is taken as t = 0. Results shown on ***Figures 8-1*** through ***8-4*** are for a water level of 1597.63, which occurs after approximately 10 minutes, 20 seconds at a pump rate of 2600 cfs.

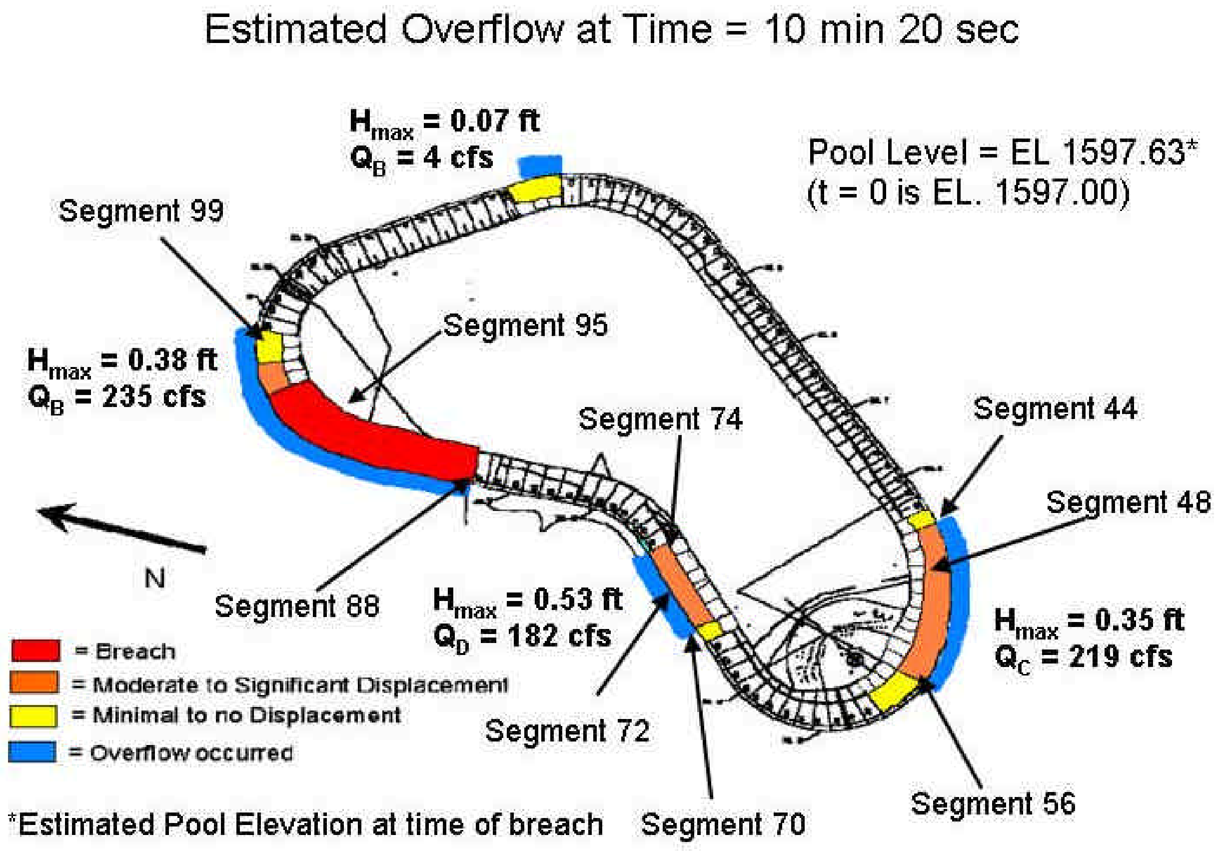


FIGURE 8-1

OVERTOPPING ZONES

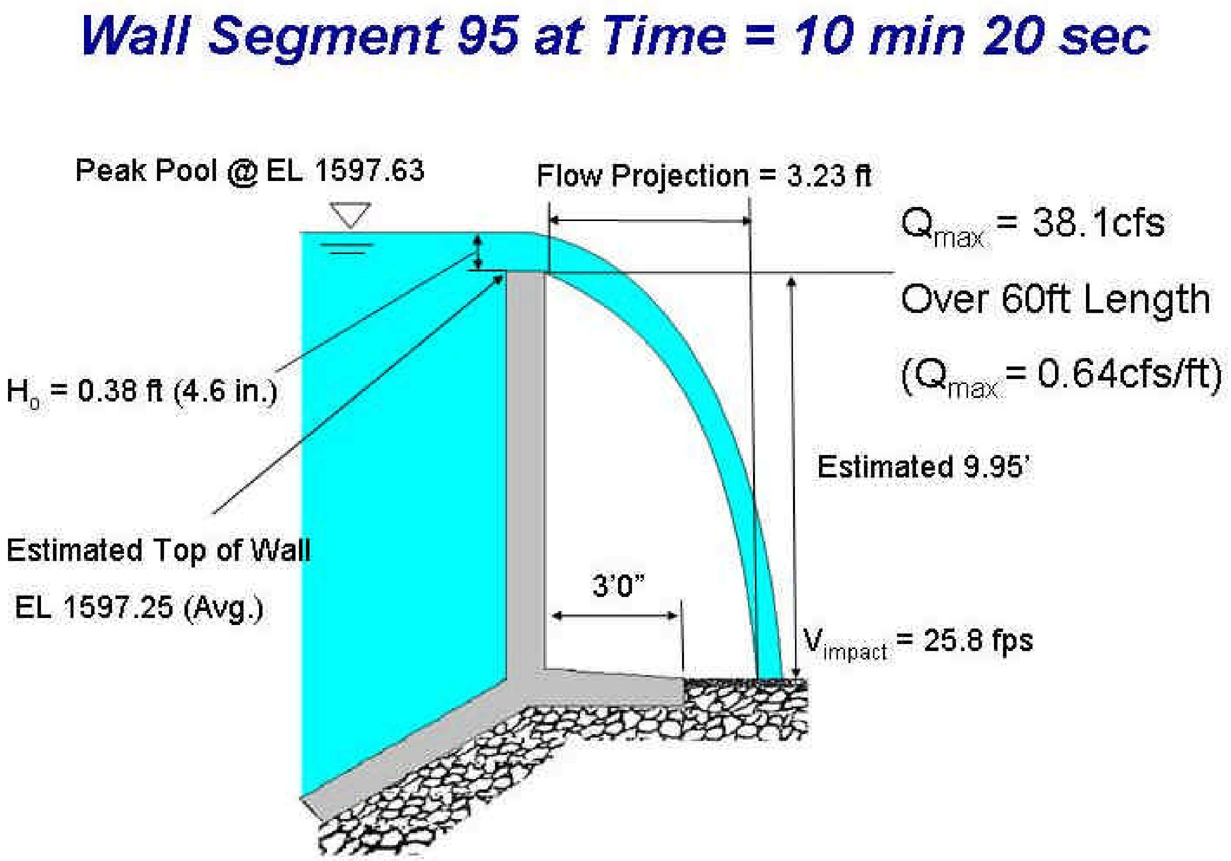


FIGURE 8-2

WEIR FLOW PROJECTION – WALL SEGMENT 95

The results of the overtopping analysis shown on ***Figures 8-1* and *Figure 8-2*** indicate that the total flow near Parapet Wall Segment 95, where the Breach occurred, is estimated to be 235 cfs at t = ~10 minutes, 20 seconds. The total flow over Wall Segment 95 (60 feet long) having an average top Elevation of 1597.25 is 38.1 cfs, or 0.64 cfs/ft. The overtopping flow rapidly infiltrated into the Rockfill Dike, resulting in a rapid rise in the phreatic surface and the pore pressure on the critical Dike/foundation interface.

The total flow over Wall Segment 72 (78 feet long) having an average top Elevation of 1597.10 is 80.1 cfs, or 1.03 cfs/ft. This is slightly greater than at the Breach Area but over a more concentrated zone. In the southwest corner as shown on ***Figure 8-4*** for Parapet Wall Segment 48, the flow is estimated to be 33.1 cfs over a length of 60 feet or about 0.55 cfs per foot. These flows caused Parapet Wall Segment Nos. 72 and 48 to be undermined as illustrated below on ***Figure 8-5*** and ***Figure 8-6*** respectively.

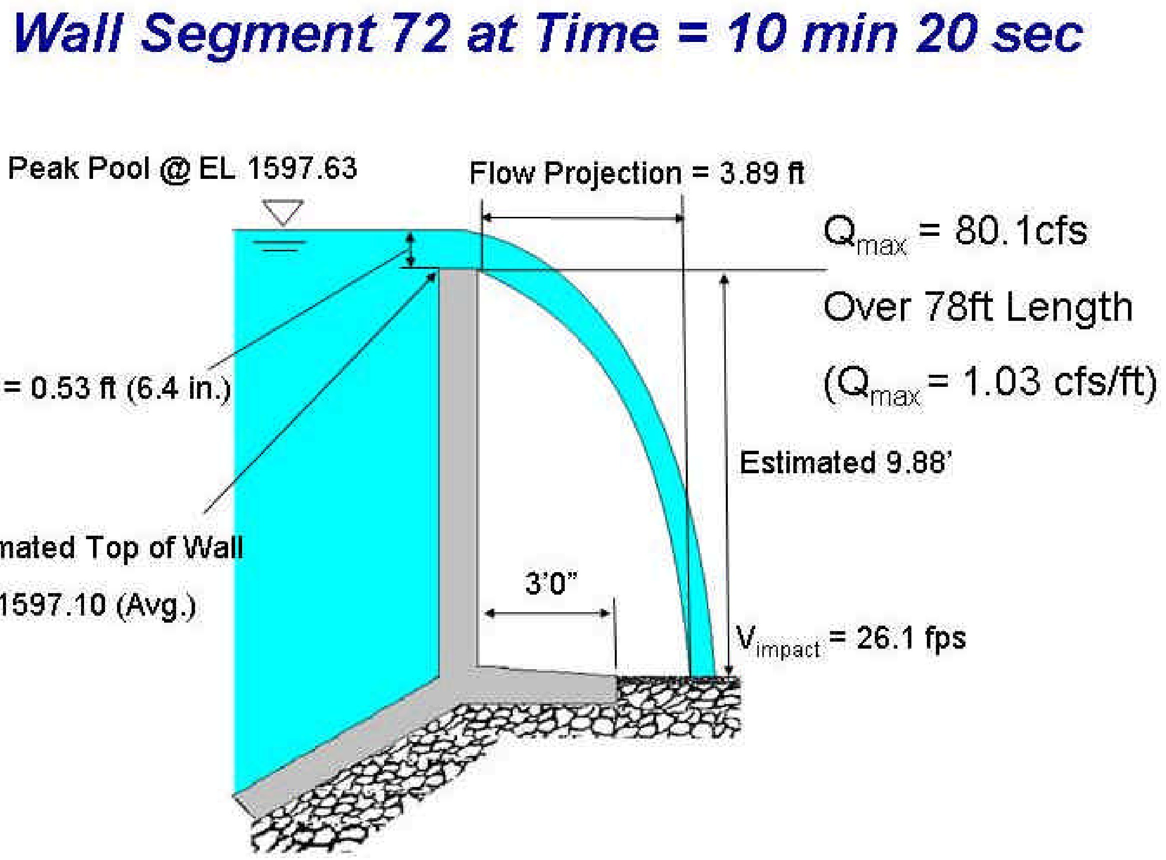


FIGURE 8-3

WEIR FLOW PROJECTION – WALL SEGMENT 72

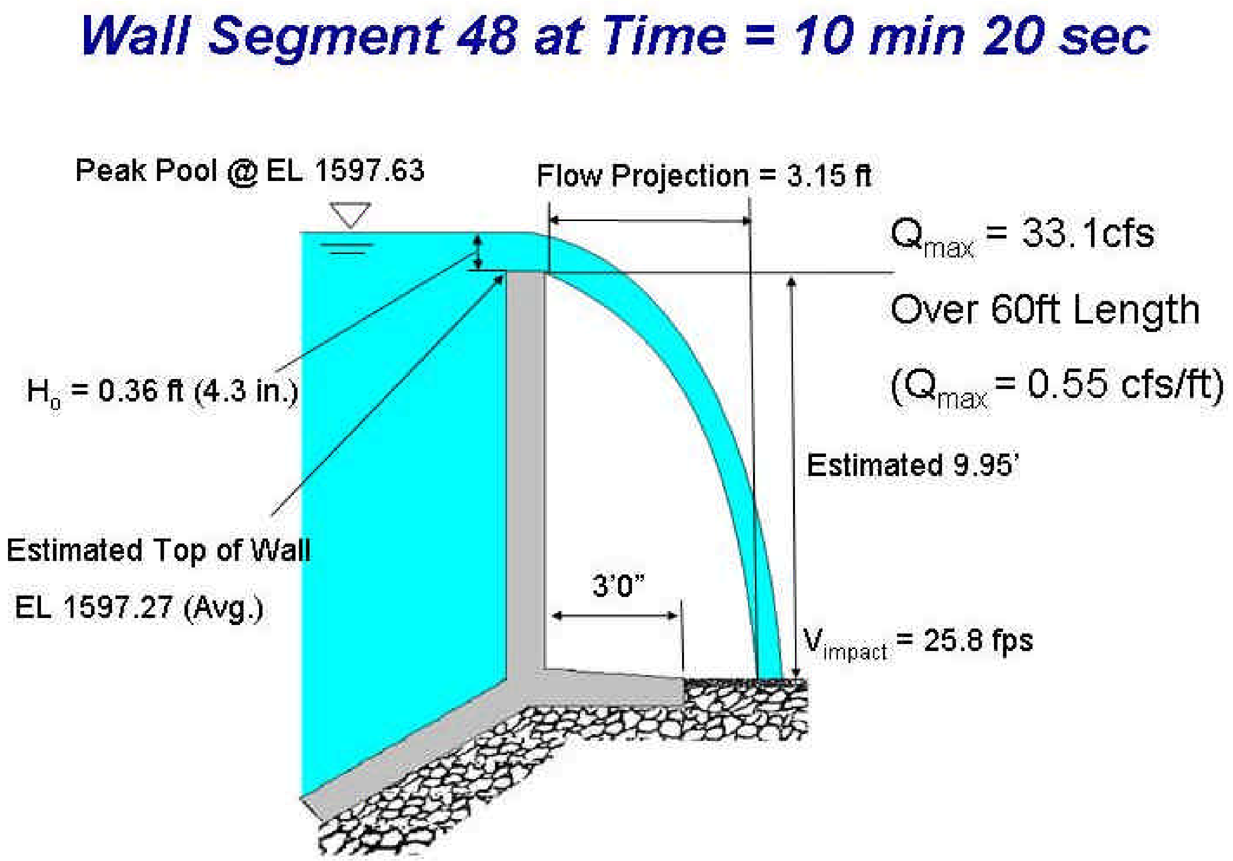


FIGURE 8-4

WEIR FLOW PROJECTION – WALL SEGMENT 48

FIGURE 8-5

PARAPET WALL SEGMENT 72 UNDERMINING

FIGURE 8-6

PARAPET WALL SEGMENTS 44 TO 56 UNDERMINING

8.2 PARAPET WALL STABILITY AND STRUCTURAL ANALYSIS

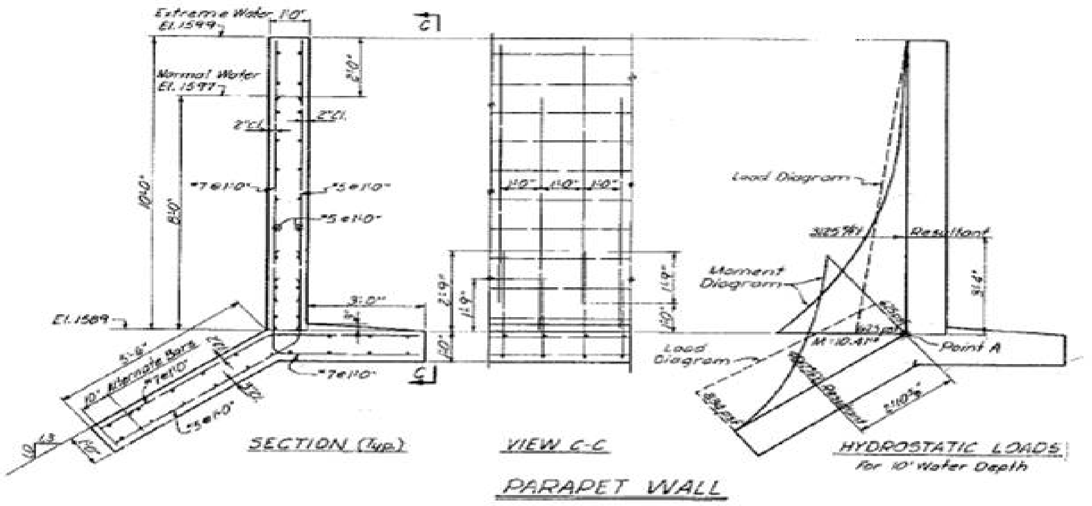
An analysis of the stability and structural integrity of the Parapet Wall was performed to assess the possibility that the Wall failed due to the water pressure associated with the Upper Reservoir level being in the range of El. 1598. Our analysis sets aside the question raised above as to whether it was good design practice in the 1960s to consider parapet walls on the crest of a dam in general as a means of retaining water on an “everyday” basis as opposed to storm conditions or wave conditions.

Our analysis considered six situations as follows:

- The original analysis of the Wall as presented on the construction drawing for the project.
- New overturning analysis of the Wall with the water level as high as El. 1599 with no undermining.
- New sliding analysis of the Wall with the water level as high as El. 1599 with no undermining.
- New overturning analysis of the Wall with the water level as high as El. 1599 with undermining.
- New sliding analysis of the Wall with the water level as high as El. 1599 with undermining.
- Structural analysis check of the concrete thickness and steel reinforcing.

8.2.1 Original Analysis of the Wall

Figure 8-7 below is a re-print of the original analysis taken from the original construction drawings.



Reinforcing steel bars are of billet steel, A.S.T.M. A15 Specification, intermediate grade, with deformations to A.S.T.M. A 305 specification.

Physical Properties:

Ultimate —— 70 - 90,000 p.s.i.

Yield —— 40,000 p.s.i. Minimum

Concrete is of 3000 pound strength at 28 days.

Loads on wall at base (Elev. 1589) per foot of wall:	Extreme High Water	Normal Water
Moment	10.41ᵏ	5.33ᵏ
Axial Load	1.50ᵏ	1.50ᵏ
Shear	3.125ᵏ	2.00ᵏ
Maximum Unit Stresses		
Reinforcing Steel	22,600 p.s.i.	10,900 p.s.i.
Concrete Fibre Stress	910 p.s.i.	465 p.s.i.
Concrete Shear Stress	30 p.s.i.	20 p.s.i.
Bond	131 p.s.i.	85 p.s.i.
Bond in Lap of 2'-3"	183 p.s.i.	88 p.s.i.

Stability under hydrostatic pressure for 10 ft. head of water

Moments about Point A.

Overturning 3125# x 3.33' = 10,406'#

Stabilizing 4012# x 2.88' = 11,555'#

1,149'#

Therefore, stabilizing moment on toe is greater than overturning moment on wall. Additional factor in favor of stability is pressure under downstream footing of wall, not included in this analysis.

FIGURE 8-7

ORIGINAL WALL ANALYSIS

We have a few comments on this analysis. Firstly, the designer summed moments about Point A at the downstream bottom corner of the vertical stem of some of the acting forces - not all. Theoretically, one can sum moments about any point so long as all forces and moments are considered. Practioners normally sum moments about the downstream toe, i.e., about the lower right hand corner of the base and all of the forces and moments would be considered.

Secondly, the originating analyst ignored the weight of the concrete and the soil pressure, and thirdly, the analyst ignored any uplift pressure that might develop under the foundation when the water level is in the range of El. 1598.

Our conclusion on this matter is that the original analysis would not be acceptable in a modern regulatory environment.

8.2.2 New Overturning Analysis with No Undermining

The forces considered for this analysis are illustrated below on ***Figure 8-8*** with the results shown on ***Figure 8-9.*** The results indicate that the Wall was stable against overturning for all practical purposes under the given water level and so long as no undermining had developed.

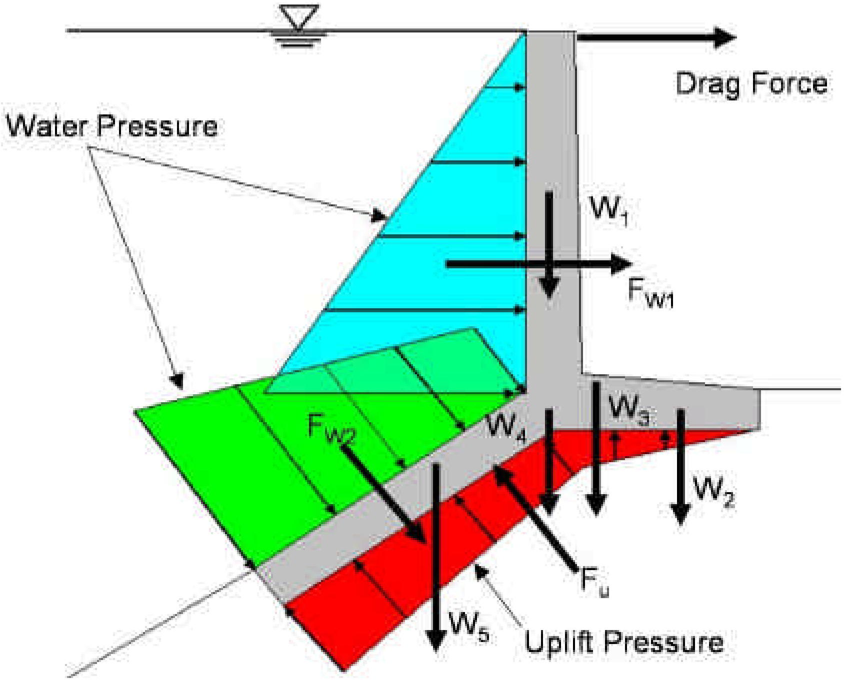


FIGURE 8-8

OVERTURNING ANALYSIS WITH NO UNDERMINING

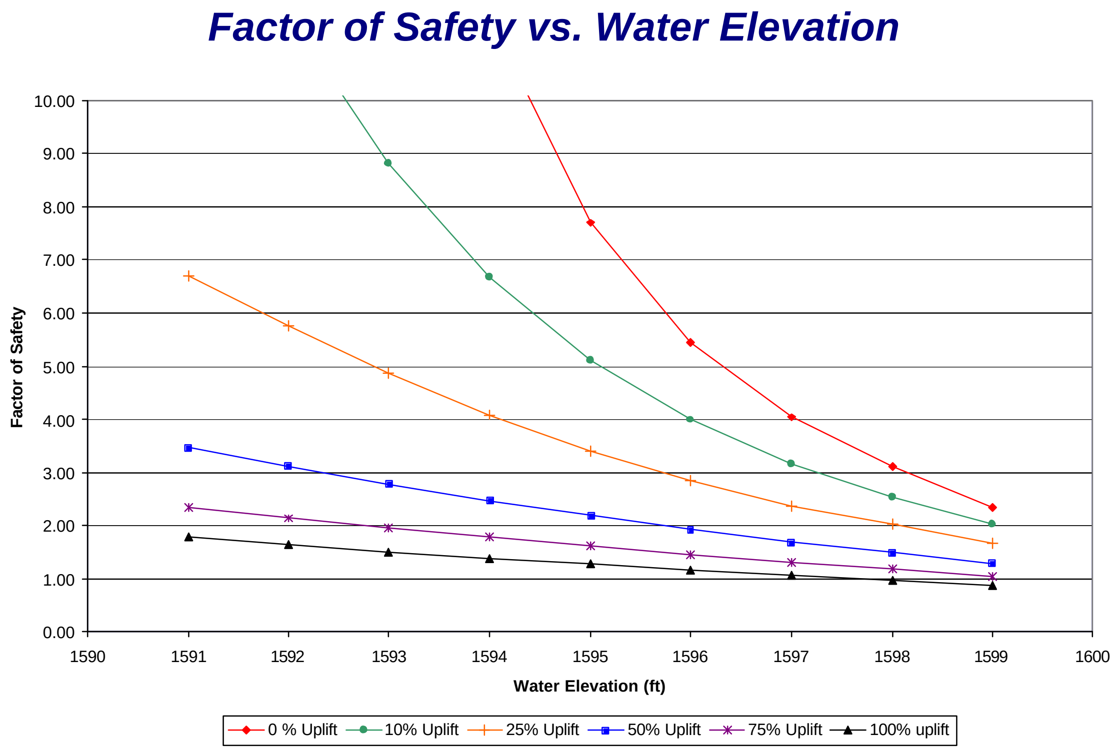


FIGURE 8-9

OVERTURNING STABILITY ANALYSIS RESULTS

8.2.3 New Sliding Analysis with No Undermining

The forces considered for the sliding analysis are illustrated below on ***Figure 8-10*** with the results shown on ***Figure 8-11.*** The results indicate that the Wall was stable against sliding for all practical purposes under the given water level and so long as no undermining had developed.

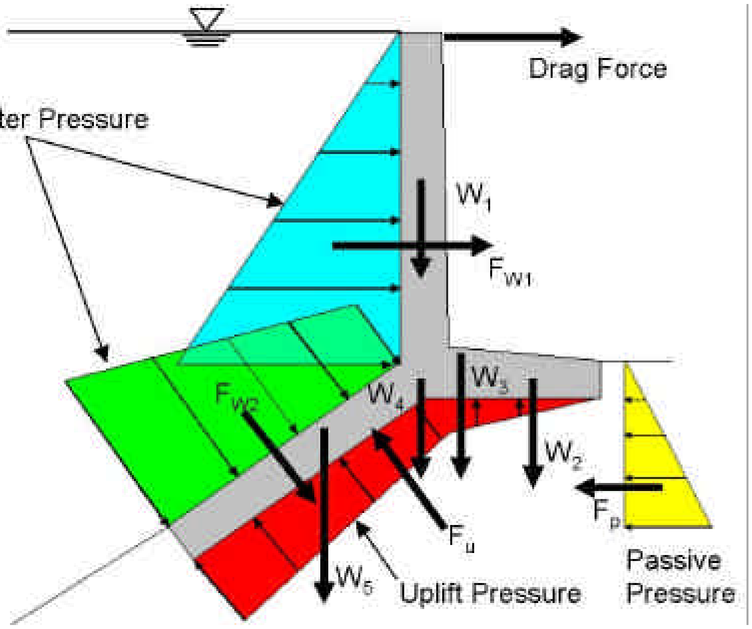


FIGURE 8-10

SLIDING ANALYSIS WITH NO UNDERMINING

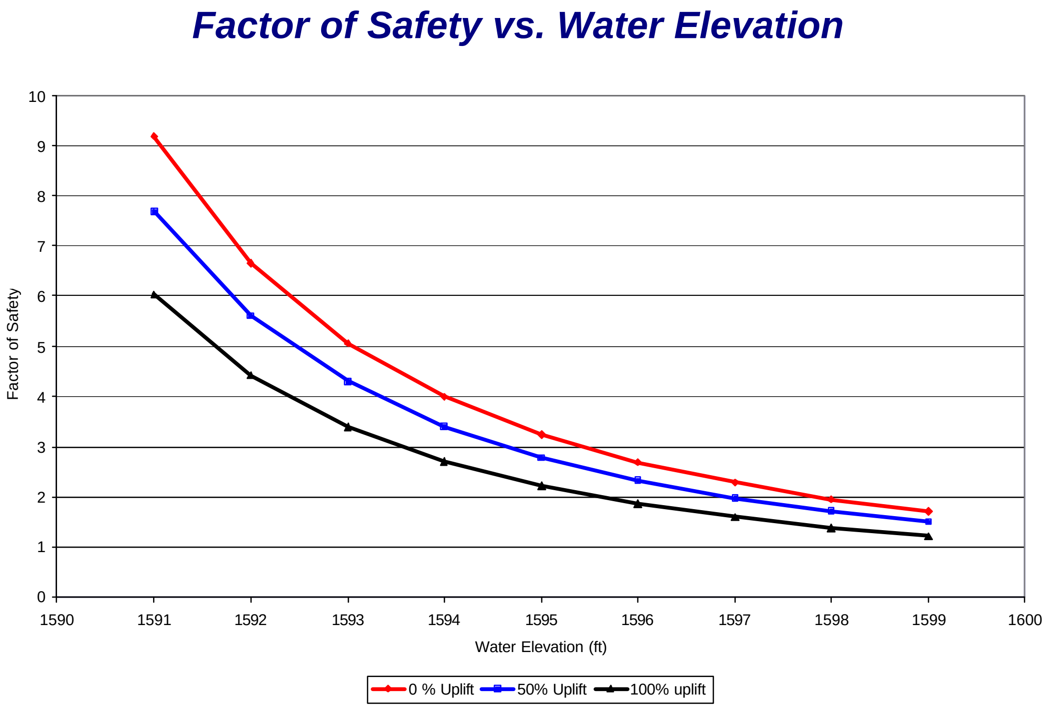


FIGURE 8-11

SLIDING ANALYSIS RESULTS

8.2.4 New Overturning Analysis with Undermining

The forces considered for this analysis are illustrated below on ***Figure 8-12*** with the results shown on ***Figure 8-13***. The results indicate that the Wall becomes unstable when undercutting penetrates about three feet under the wall. This analysis is two dimensional, and therefore for the Wall segment to actually fail, the entire 60 feet long Wall Segment would have to be undermined to this degree. We observe that Wall Segment 72 shown on ***Figure 8-5*** was probably "saved" by three dimensional action and the Wall Segments 44 to 56 shown on ***Figure 8-6*** were not undermined enough to result in an unstable situation.

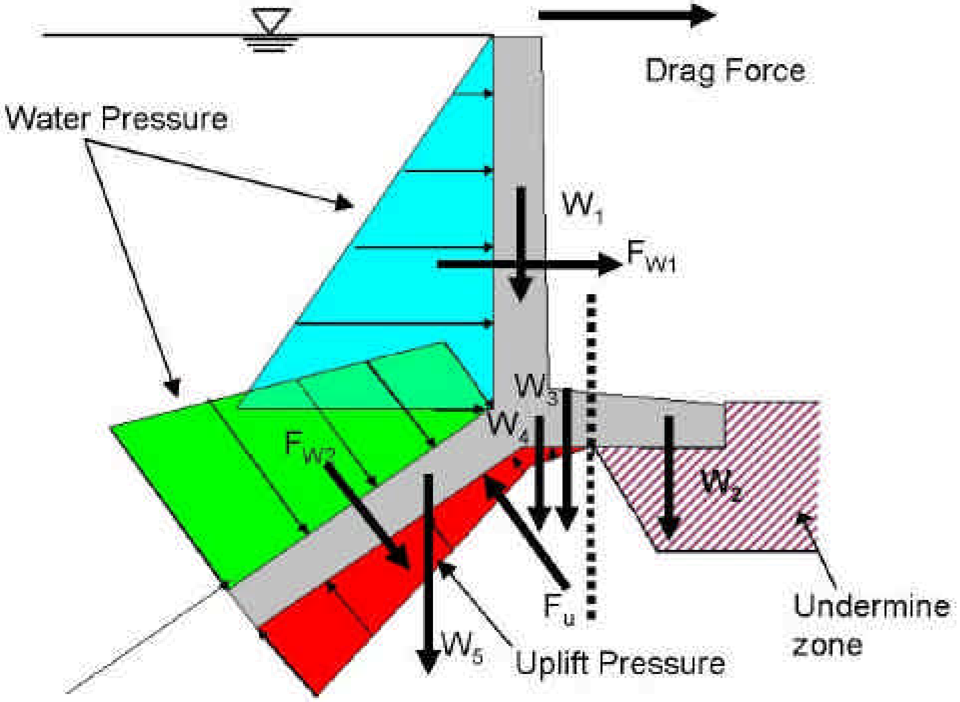


FIGURE 8-12

NEW OVERTURNING ANALYSIS WITH UNDERMINING

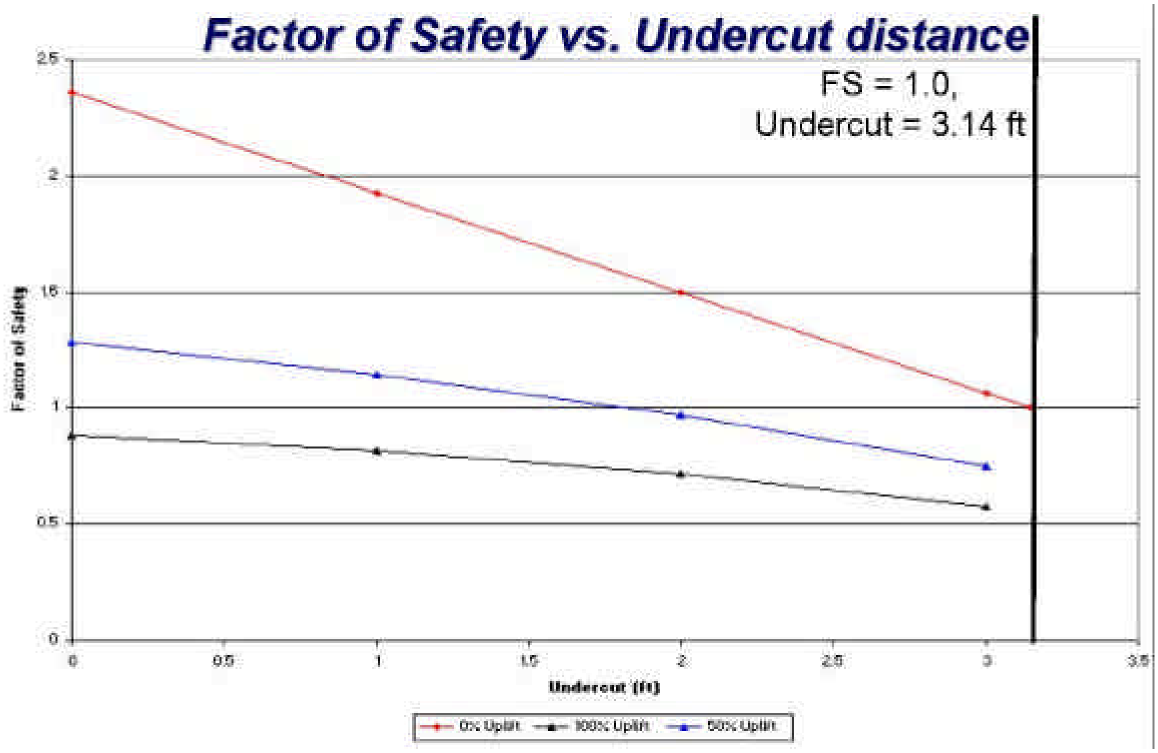
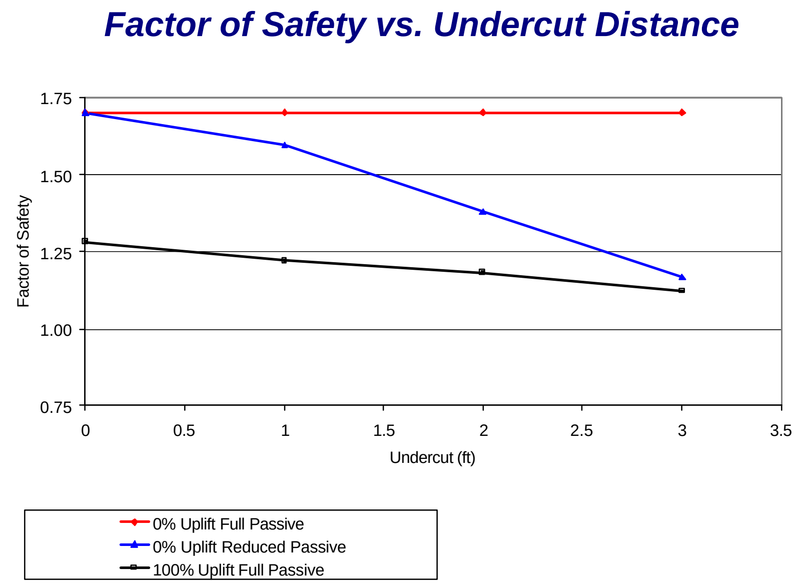


FIGURE 8-13

OVERTURNING RESULTS WITH UNDERMINING

8.2.5 New Sliding Analysis with Undermining

The forces considered for this analysis are illustrated are the same as shown on ***Figure 8-10*** for the overturning analysis and the results shown below on ***Figure 8-14***. The results indicate that the Wall will probably fail first due to overturning (before sliding) when undermining occurs, primarily because of the upstream sloping base.



*Passive Pressure is reduced as undercut distance increases. reduction for each undercut distance is shown in the table to the right.

undercut (ft)	% of Passive Pressure
3	50
2	70
1	90
0	100

FIGURE 8-14

SLIDING RESULTS WITH UNDERMINING

8.2.6 Structural Analysis Check of Concrete and Reinforcing Steel

Our check of the concrete stresses and reinforcing steel indicate that the Wall was adequately reinforced and that the thickness of the concrete compressing the stem and two bases is adequate.

8.2.7 Summary of Analysis Results for the Parapet Wall

Based on our analysis, we conclude the following:

- The Parapet Wall is stable for all practical purposes at water levels in the Upper Reservoir as high as El. 1599 so long as no undermining occurs.

- The Parapet Wall is marginally stable to unstable at water levels in the Upper Reservoir at El. 1599 when undercutting penetrates about three feet. Three dimensional effects, i.e., support from non-undermined portions of a Wall Segment, tend to stabilize individual Wall Segments as is the case with Wall Segment 72.

- The Wall is adequately designed with respect concrete thickness and reinforcing steel.

In terms of the Root Cause Analysis, as defined in ***Section 5.0,*** the failure of the Parapet Wall may have been a secondary contributing cause to the Event. RIZZO is unable to determine if the Parapet Wall failed before the Rockfill Dike or during the failure of the Rockfill Dike. There is inadequate evidence to assess the timing of Parapet Wall Failure. If the Parapet Wall failed before the Rockfill Dike, it could have (1) led to a much more rapid rise in the phreatic surface and associated pore pressures at the Dike/foundation interface and (2) led to the surface transport of rockfill on the downstream face, thereby diminishing the effective stress at the Dike/foundation interface. If the Parapet Wall failed during the failure of the Rockfill Dike, then it was not a contributing cause.

8.3 SEEPAGE ANALYSIS

The second step in our overall analysis effort was to develop an understanding of the seepage behavior and pore pressure distribution in the Rockfill Dike, especially at the critical Dike/foundation interface. This effort was undertaken with a computerized seepage analysis using the two dimensional program, SEEP2D (Boss International and Brigham Young University, 1999). We first established a “best estimate” set of properties for the Dike in the area of the Breach and the postulated a range of variability for these parameters. The range of properties was based on measurement and observation of properties in the field, judgment and values appearing in the literature.

We also used a model appropriate for the Breach Area; specifically we accounted for the increased depth to rock and the initial grout curtain, as well as the second grout curtain at this section. We also adjusted the boundary conditions of the model to account for the drainage ditch at the downstream toe of the Dike.

8.3.1 Property Calibration Runs

To check the validity and compatibility of our estimate of the basic relative permeability values, we performed a set of calibration runs. We estimated the seepage from the Upper Reservoir without the HDPE Liner (installed in 2004) and compared our results with estimated seepage reported by AmerenUE. We then adjusted slightly our estimates to affect a reasonable match between our estimate of seepage and AmerenUE's values. The model used for this calibration model is shown on ***Figure 8-15*** and the phreatic surface and flow net is shown on ***Figure 8-16***. Calculations are provided in ***Appendix F***.

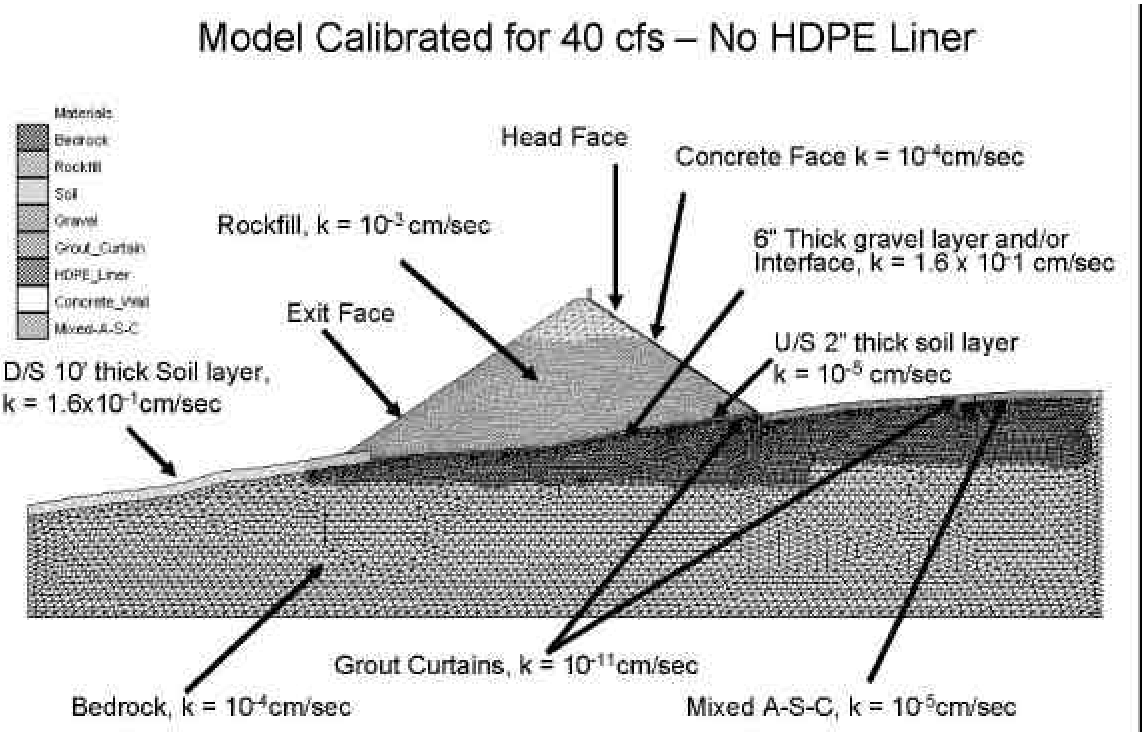


FIGURE 8-15

CALIBRATION MODEL

A comment pertaining to the calibration runs is that the overall calibration check is somewhat crude as the accuracy of the leakage rate available is limited. Specifically, the available leakage rates are such that one cannot distinguish water lost through the Dike from that lost through the bottom of the Upper Reservoir bottom or that lost through evaporation. Also, the configuration of the Dike varies significantly around the perimeter of the Upper Reservoir, whereas we considered only the geometry at the Breach Area as being reasonably indicative of all cross sections. Therefore, we are able to conclude only that our chosen parameters are in the proper range, but parametric runs as described below are necessary to fully understand the range of possible behavior of the Dike.

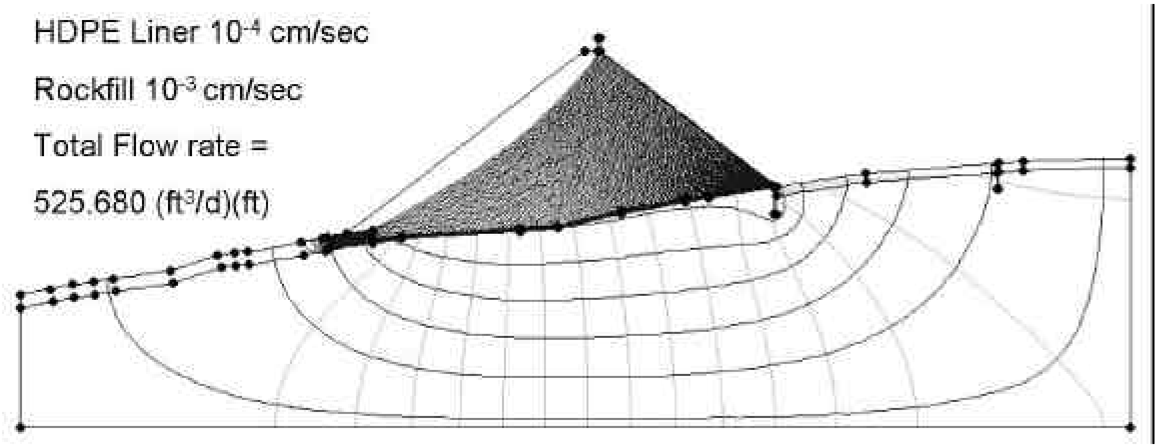


FIGURE 8-16

FLOW NET FOR CALIBRATION MODEL

A secondary observation with this model is that there are certain zones in the Dike, such as at the upstream toe, where the gradient may have been relatively high. This would suggest the possibility of fines transport within the Dike itself, i.e., movement of fines from the toe area toward the center of the Dike. Except for the small zone at the extreme downstream toe, the gradients were too low to move the fines through the Dike entirely. This observation is consistent with reports by AmerenUE that major quantities of fines were not observed in the Pump-Back Pond at the southeast corner of the Upper Reservoir, the sink for the toe drainage ditch. RIZZO personnel observed only minor quantities of fines buildup in portions of the drainage ditch, e.g., in the reach below Parapet Wall Segment 72.

Therefore, while some fines transport and subsequent clogging of the filters near to the upstream toe of the embankment would have theoretically been possible, clogging of the filters in this area would have not had a substantial impact on the phreatic surface at the downstream toe. Additionally, the gradients shown in ***Figure 8-16*** and field observations suggest that clogging of the filters under the downstream slope of the Dam did not occur.

8.3.2 Best Estimate and Parametric Runs

After calibrating the model shown on ***Figure 8-15*** and adding the HDPE Liner on the upstream face of the Dike, we performed a series of seepage analysis runs on the "Best Estimate" Model developed on ***Figure 8-15*** and modified to include the HDPE/LDPE Liner as shown in ***Figure 8-17***. The resulting flow net shown on ***Figure 8-18*** indicates that the Liner significantly changed the flow regime, dropping the phreatic surface to the level of the interface. This change increases the factor of safety for wedge failures along the interface significantly.

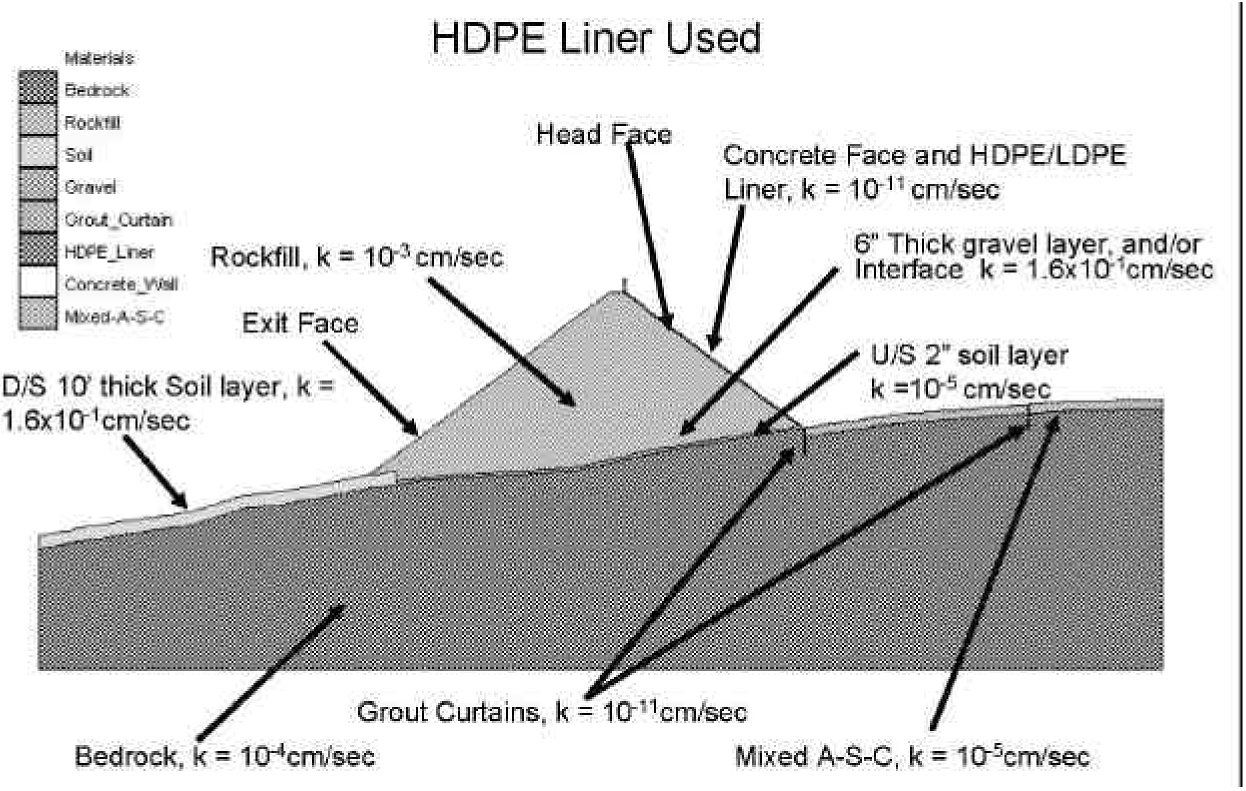


FIGURE 8-17

BEST ESTIMATE SEEPAGE MODEL WITH LINER

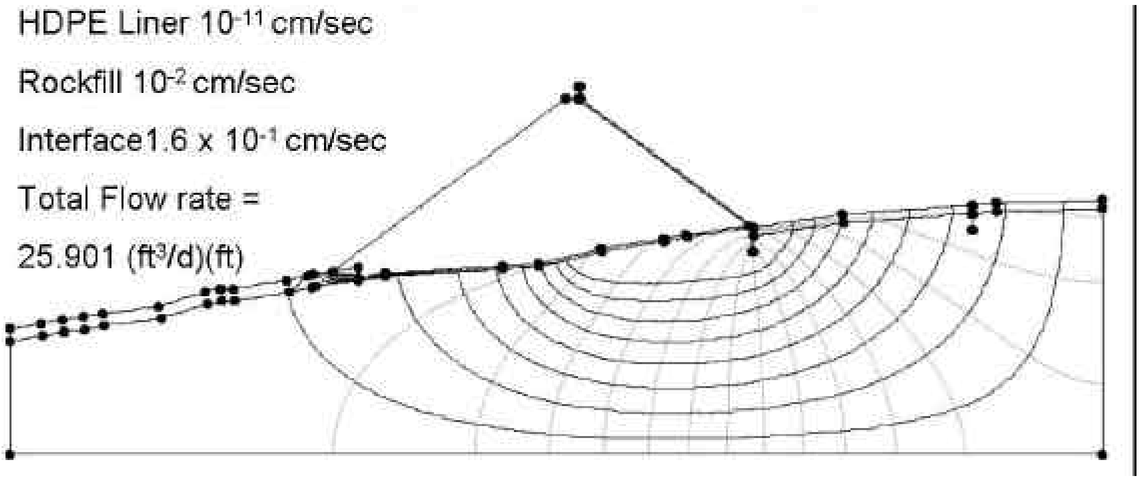


FIGURE 8-18

FLOW NET FOR BEST ESTIMATE SEEPAGE MODEL WITH LINER

The range of properties used in the parametric analysis of the seepage is summarized in ***Table 8-1***. It is noted that we ran variations of the Best Estimate Model for those parameters determined to be significant with respect to overall seepage and overall flow net configuration.

TABLE 8-1

RANGE OF SEEPAGE ANALYSIS PARAMETRIC RUNS

CASE NO.	**ROCKFILL k (cm/sec)**	**SOIL k (cm/sec)**	**FILTER k (cm/sec)**	**OBSERVATIONS**
1- BEST ESTIMATE	**1 X 10-3**	**1.6X10-1**	**1.6X10-1**	**NO PORE PRESSURE AT INTERFACE**
2	**$1 \text{ X } 10^{-2}$**	**$1.6\text{X}10^{-1}$**	**$1.6\text{X}10^{-1}$**	No pore pressure at interface
3	**$1 \text{ X } 10^{-4}$**	**$1.6\text{X}10^{-1}$**	**$1.6\text{X}10^{-1}$**	No pore pressure at interface
4	**$1 \text{ X } 10^{-3}$**	**$1.6\text{X}10^{-2}$**	**$1.6\text{X}10^{-2}$**	No pore pressure at interface
5	**$1 \text{ X } 10^{-3}$**	**$1.6\text{X}10^{-4}$**	**$1.6\text{X}10^{-4}$**	Pore pressure at interface
6	**$1 \text{ X } 10^{-3}$**	**$1.0\text{X}10^{-5}$**	**$1.6\text{X}10^{-5}$**	Pore pressure at interface

Note: 1. See ***Appendix F*** for related Calculations.

Not all parameters comprising the model are shown on the table as several were assessed interactively on the computer screen as not being significant. For example, we varied the permeability of the Two Grout Curtains and the Asphalt Pavement, but no significant change in the results was observed. Although our modeling shows that the assumed permeabilities of both the Grout Curtain and the Asphalt Pavement have a neglible effect on the phreatic surface, slight changes in pore pressures at the Dike/foundation interface can be expected, depending on the effectivness of the Grout Curtains and the Asphalt Pavement..

Additionally, RIZZO observed that the initial grout curtain installed during the original construction had to be reinforced along its original alignment and then supplemented with an additional curtain further upstream. RIZZO also observed that the initial curtain, as well as the supplemental curtain, may have been inadequately designed, particularly with respect to depth. Similarly, RIZZO observed that the asphalt pavement in the vicinity of the Breach Area had to be repaired at least once after the original construction.

The results of these parametric runs presented in ***Table 8-1*** indicate that the permeability of the soil at the Dike/foundation interface and the Filters has a significant effect on the pore flow net and the pore pressure on the interface. To illustrate this point, we show below on ***Figure 8-19*** the flow net for Case 6 where the permeability of these two zones is postulated to be in the range of 1 x 10^{-4} cm/sec. The results also indicate that with the HDPE Liner in place, the permeability of the rock fill comprising the Dike is less important for the range of parameters that we considered.

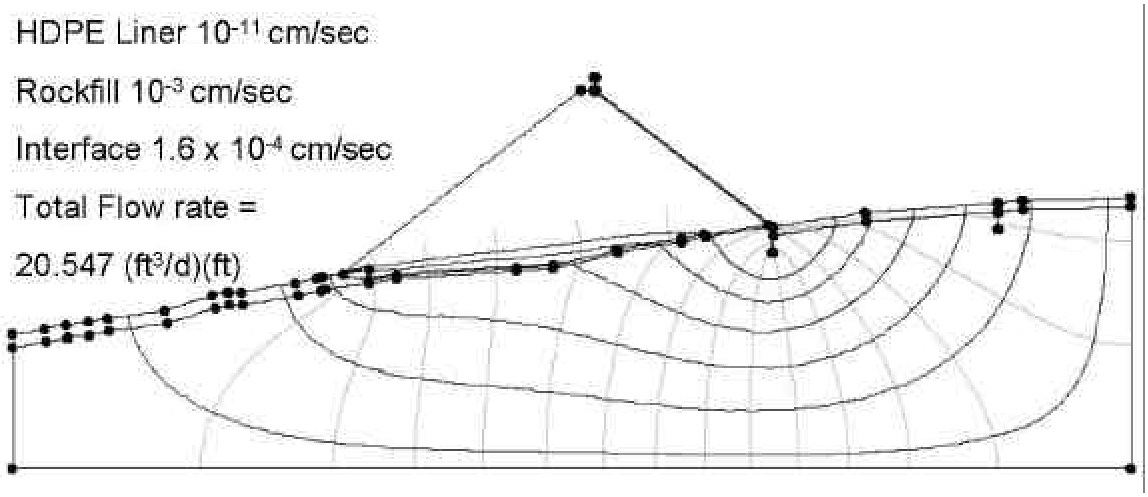


FIGURE 8-19

FLOW NET FOR PARAMETRIC CASE 5

($K_{INTERFACE} < K_{ROCKFILL}$)

8.4 FORENSIC STABILITY ANALYSIS

We have assessed the stability of the Rockfill Dike focusing on the geometry of the Breach Area and considering three Conditions:

Condition A	Best Estimate Seepage conditions with Best Estimate soil and rock properties prior to installation of the geosynthetic liner as described in ***Section 8.3.1*** where our calibration efforts are described. Stability Analyses worksheets are provided in ***Appendix F*** for all Conditions.
Condition B	Best Estimate Seepage with Best Estimate soil and rock properties plus a large number of parametric runs to gage sensitivity (after the installation of the geosynthetic liner). Seepage runs are described in ***Section 8.3.2***.

This **Condition B** is indicative of conditions just prior to the December 14, 2005 Event.

Condition C Best Estimate Seepage with Best Estimate soil and rock properties plus a number of parametric runs to gage sensitivity (after the installation of the geosynthetic liner) and during the overtopping event of December 14, 2006.

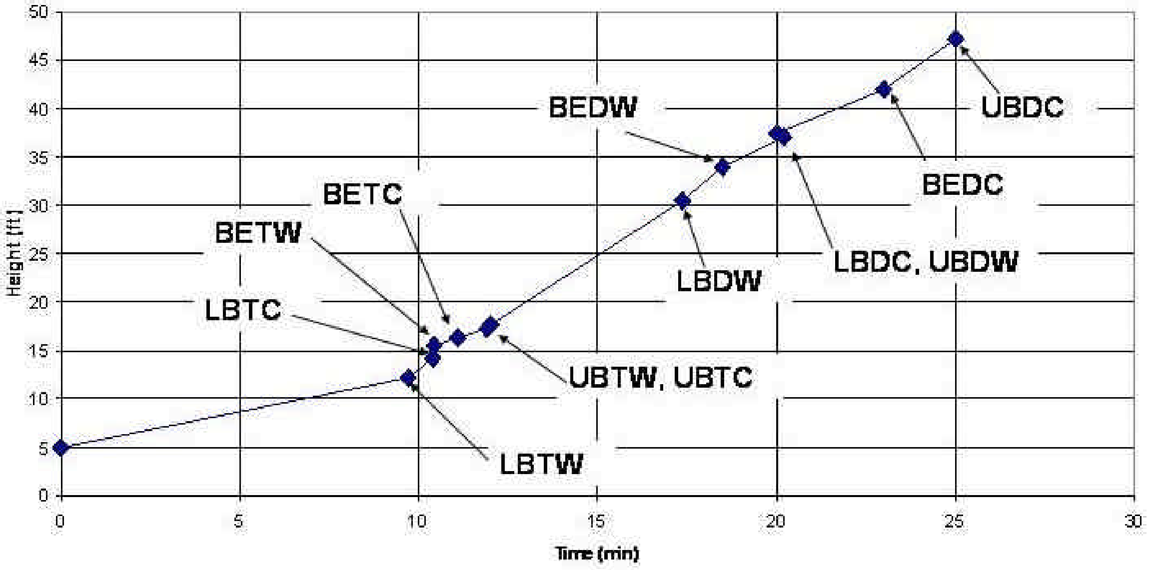
The computer program GSTABL7 was used to perform all Stability analysis (Gregory, 2003).

8.4.1 Phreatic Surface & Pore Pressure Conditions for Stability Analysis

For **Condition A** as defined above, we used the phreatic surface shown on ***Figure 8-16*** whereby most of the Dike is saturated.

For **Condition B** as defined above, we used a variety of phreatic surfaces in a parametric manner to capture the range of possible seepage postulated conditions as listed on ***Table 8-1.***

For **Condition C**, we interactively varied the phreatic surface with a series of runs starting with the **Condition B** case until the routine located a phreatic surface where the factor of safety against failure approached unity. As a check on the validity of the postulated failure surface from a timing perspective, we developed an infiltration model for the overtopping flow rates estimated for the Breach Area. This model with the results shown below on ***Figure 8-20*** shows our estimate of how the phreatic surface rose versus time during overtopping on December 14, 2005, and the estimated time when instability occurred - initially at the downstream toe and progressing up the downstream slope.



LEGEND

LB = Lower Bound	DW = Deep Wedge	DC = Deep Circular
BE = Best Estimate	TW = Toe Wedge	TC = Toe Circular

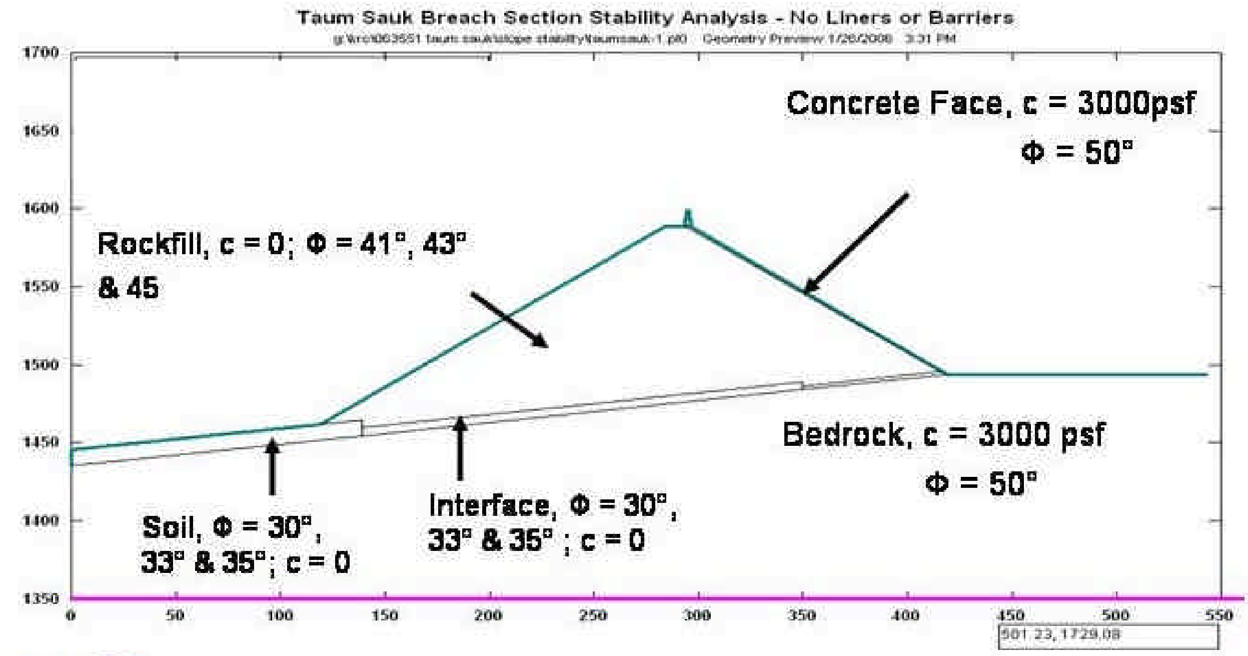
Note: The saturation height is measured above the toe.

FIGURE 8-20

HEIGHT OF SATURATION ABOVE BEDROCK VERSUS TIME

8.4.2 Soil and Rock Properties

Figure 8-21 below indicates the properties selected for the Best Estimate Cases and the parametric runs and ***Table 8-2*** describes the basis for selection



STABL7

FIGURE 8-21

SLOPE STABILITY ANALYSIS – MATERIAL PROPERTIES

TABLE 8-2

SUMMARY OF SOIL AND ROCK PROPERTIES

MATERIAL	LOWER BOUND	BEST ESTIMATE	UPPER BOUND	BASIS
Foundation Soil at toe	c = 0 $\phi = 30^{o}$	c = 0 $\phi = 33^{o}$	c = 0 $\phi = 35^{o}$	Field Observations, Lab Tests & Calibration with Condition A
Filter Material	c = 0 $\phi = 30^{o}$	c = 0 $\phi = 33^{o}$	c = 0 $\phi = 35^{o}$	Field Observations & Calibration with Condition A
Bedrock	c = 3000 psf $\phi = 50^{o}$	c = 3000 psf $\phi = 50^{o}$	c = 3000 psf $\phi = 50^{o}$	Judgment No parametrics
Concrete Face	c = 3000 psf $\phi = 50^{o}$	c = 3000 psf $\phi = 50^{o}$	c = 3000 psf $\phi = 50^{o}$	Judgment No parametrics
Rockfill	c = 0 psf $\phi = 41^{o}$	c = 0 $\phi = 43^{o}$	c = 0 $\phi = 45^{o}$	LB – suggested by BOC BE – Back calculated from surface slides UB – Back calculated from Breach Area

8.4.3 Results of Stability Analysis

A summary of the stability analysis for the three above Conditions is provided below in three corresponding Tables. Details of each of the computer runs for the Best Estimate Properties are shown on ***Figures 8-22 to 8-33***. Details for all of the computer runs are available in ***Appendix F***.

TABLE 8-3

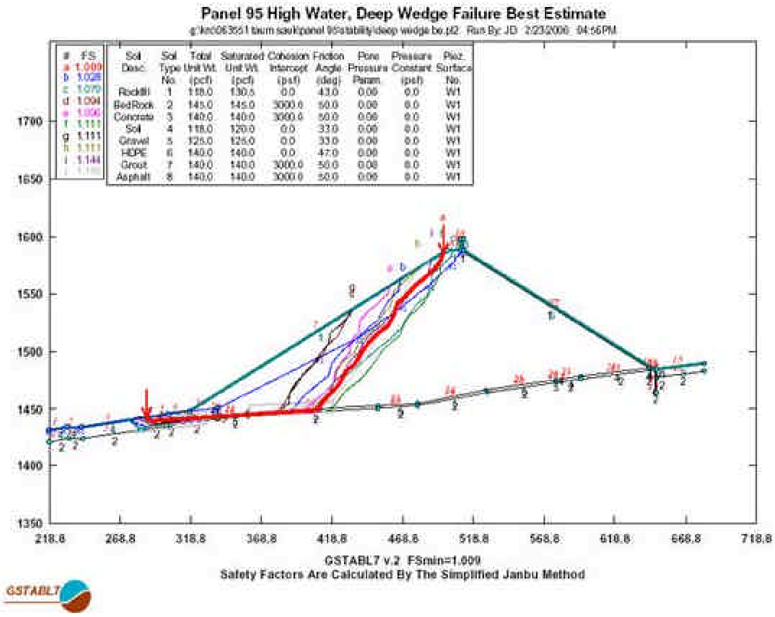
SUMMARY OF STABILITY ANALYSIS
FACTORS OF SAFETY
CONDITION A

PHREATIC SURFACE	LOWER BOUND PROPERTIES	BEST ESTIMATE PROPERTIES	UPPER BOUND PROPERTIES	FAILURE TYPE
Condition A	0.92	1.01	1.09	Deep Wedge - Fig. 8-22
Condition A	0.98	1.05	1.12	Deep Circle – Fig. 8-23
Condition A	1.06	1.15	1.13	Toe Wedge – Fig. 8-24
Condition A	1.11	1.13	1.21	Toe Circle – Fig. 8-25

It is noted that significant pore pressure probably existed at the Dike/foundation interface before the HDPE liner was installed. The results presented in ***Table 8-3*** indicate that the Rockfill Dike prior to installation of the geosynthetic liner in the Breach Area was marginally stable where the material properties were in the range of selected Lower Bounds.

We note that the elevated phreatic surface analyzed in Condition A represents estimated seepage conditions for the Rockfill Dike prior to installation of the synthetic liner. The assumed phreatic surface was estimated based on available information and data pertaining to the permeability of the various zones and was back-calculated to match the pre-liner recorded seepage quantities. Although an increase in pore pressure resulting from leaks through cracks in the concrete face would serve to diminish the factor of safety against stability failure of the Rockfill Dike (as shown in ***Table 8-3***), the placement of the synthetic liner in the fall of 2004 diminished, and probably eliminated, the leaks through the concrete face. Thus, any pore pressure attributed to leakage through the concrete face prior to the installation of the synthetic liner would likely have been dissipating at the time of the Event in December 2005. It is our opinion that the actual phreatic surface just prior to the Event was somewhere between that shown on ***Figure 8-16*** (pre-liner) and ***Figure 8-18*** (post-liner).

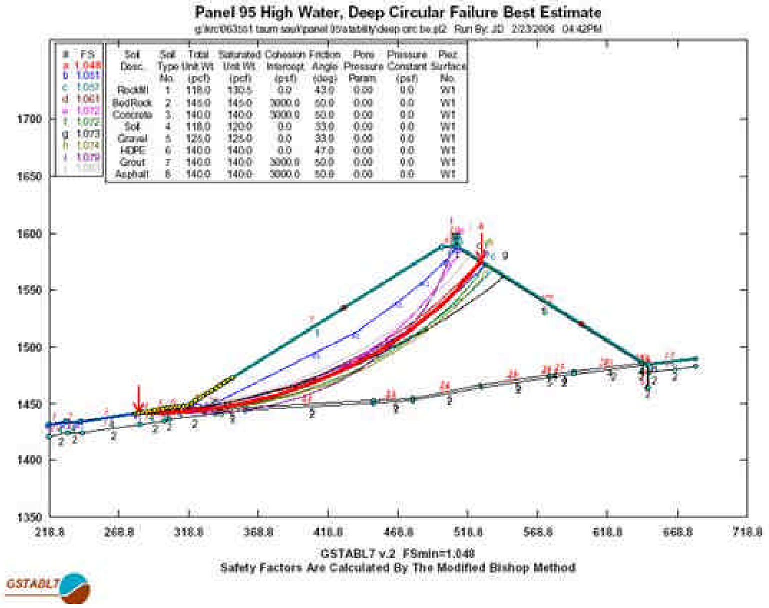
If any residual pore pressures remained, then leaks through cracks or expansion joints in the concrete on the upstream face of the Rockfill Dike may have been a secondary contributing cause of the Event from the perspective that leaks through cracks or expansion joints could have caused increased pore pressures at the Dike/foundation interface. However, we are unable to determine if these pore pressures had fully drained prior to the event.



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	43.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	33.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	33.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

FIGURE 8-22

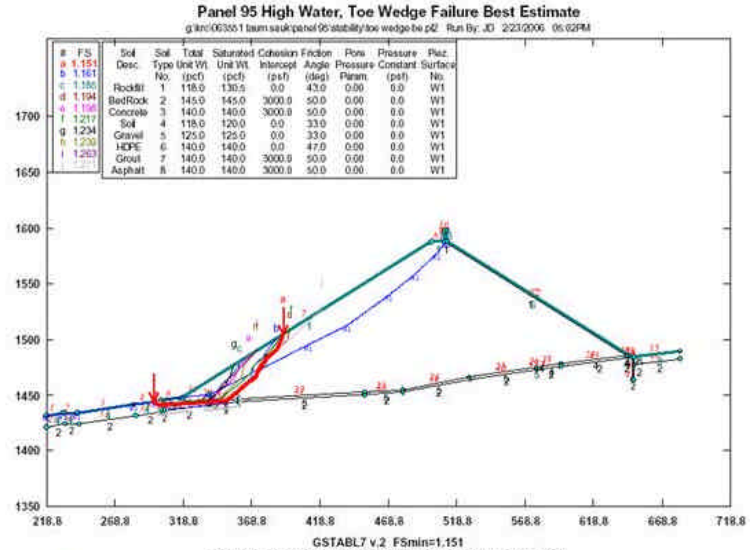
DEEP WEDGE FAILURE – CONDITION A (BEST ESTIMATE PROPERTIES)



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	43.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	33.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	33.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

FIGURE 8-23

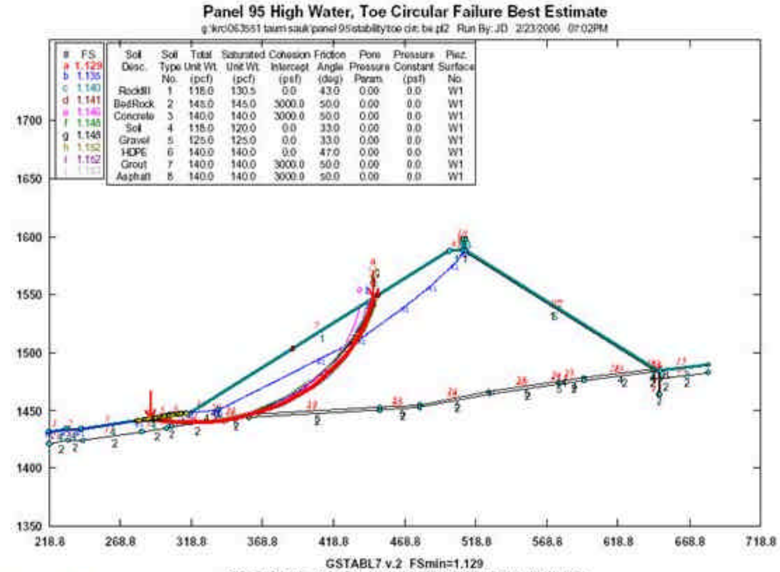
DEEP CIRCLE FAILURE – CONDITION A (BEST ESTIMATE PROPERTIES)



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	43.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	33.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	33.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

FIGURE 8-24

TOE WEDGE FAILURE – CONDITION A
(BEST ESTIMATE PROPERTIES)



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	43.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	33.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	33.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

FIGURE 8-25

TOE CIRCLE FAILURE – CONDITION A
(BEST ESTIMATE PROPERTIES)

TABLE 8-4

SUMMARY OF STABILITY ANALYSIS FACTORS OF SAFETY CONDITION B

PHREATIC SURFACE	LOWER BOUND PROPERTIES	BEST ESTIMATE PROPERTIES	UPPER BOUND PROPERTIES	FAILURE TYPE
Condition B	1.24	1.35	1.45	Deep Wedge – Fig. 8-26
Condition B	1.23	1.33	1.42	Deep Circle – Fig. 8-27
Condition B	1.10	1.21	1.30	Toe Wedge – Fig. 8-28
Condition B	1.11	1.23	1.32	Toe Circle – Fig. 8-29

The results presented in ***Table 8-4*** indicate that the Rockfill Dike after installation of the geosynthetic liner in the Breach Area resulted in a slightly higher factor of safety. However, the results indicated that the section would still not meet FERC criteria for stability under static conditions for maximum storage pool (i.e., FS=1.5) (FERC, 1991). Although dynamic analyses have not been run, past experience suggests a high probability of failure under significant earthquake loading. The addition of a pseudo-static earthquake coefficient would result in a lower factor of safety approaching one. A pseudo static factor less than about 1.3 results in some amount of permanent deformation which increases exponentially with successively lower factors of safety.

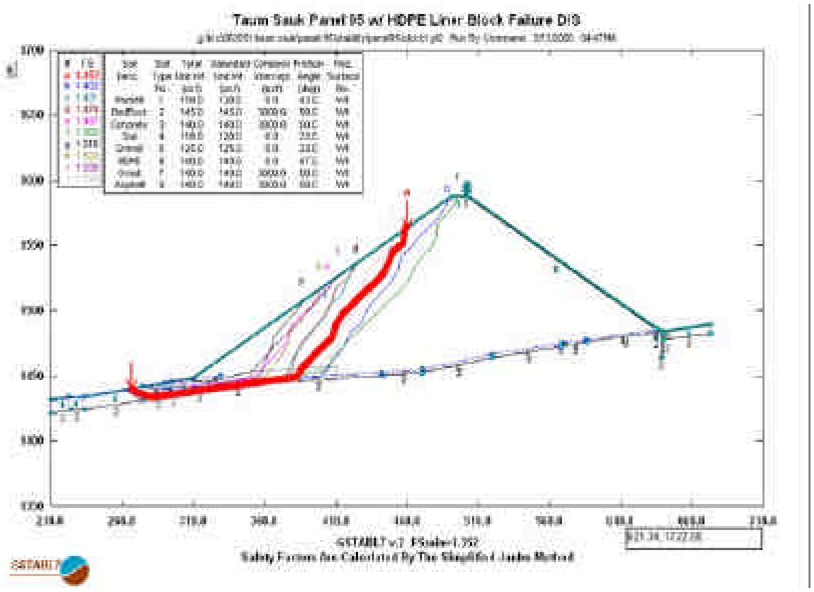
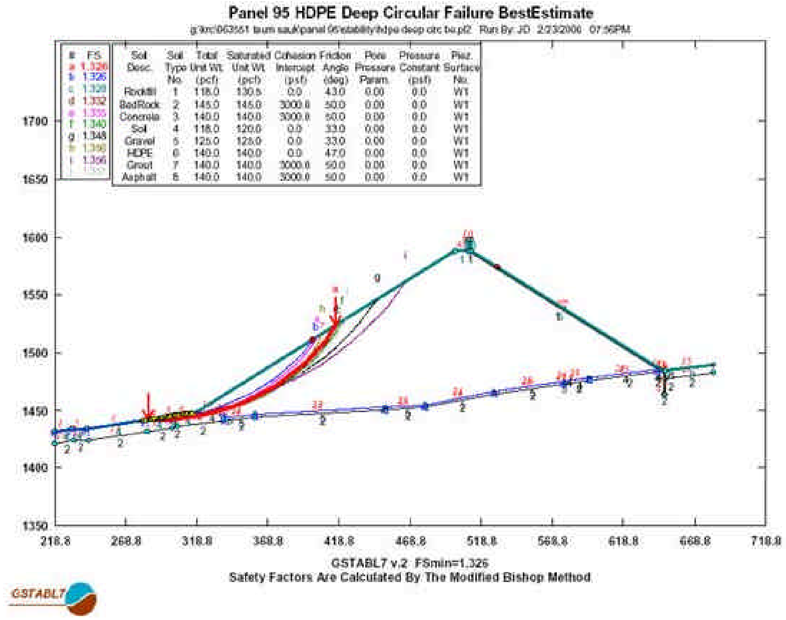


FIGURE 8-26

DEEP WEDGE FAILURE – CONDITION B
(BEST ESTIMATE PROPERTIES)



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	43.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	33.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	33.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

FIGURE 8-27

DEEP CIRCLE FAILURE – CONDITION B (BEST ESTIMATE PROPERTIES)

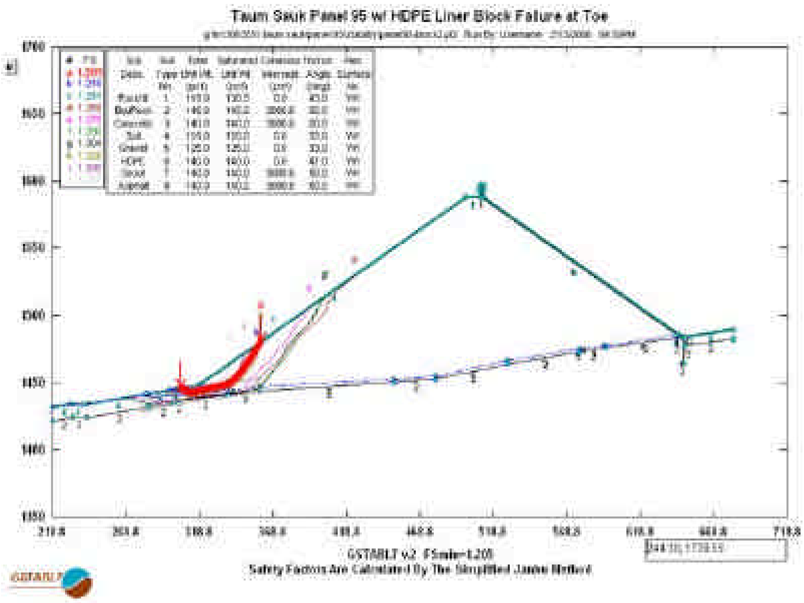


FIGURE 8-28

TOE WEDGE FAILURE – CONDITION B (BEST ESTIMATE PROPERTIES)

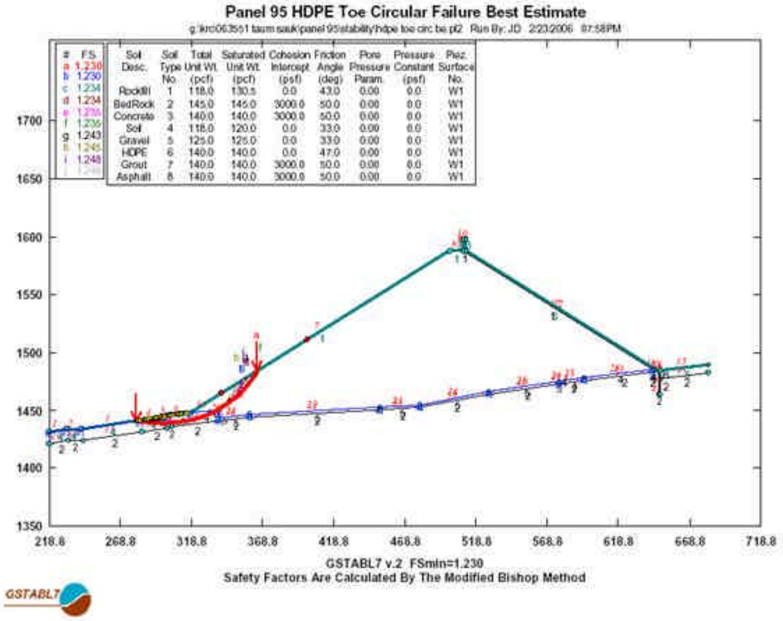


FIGURE 8-29

TOE CIRCLE FAILURE – CONDITION B
(BEST ESTIMATE PROPERTIES)

TABLE 8-5

SUMMARY OF STABILITY ANALYSIS HEIGHT OF PHREATIC SURFACE ABOVE BEDROCK TO PRODUCE FACTOR OF SAFETY OF 1.0 CONDITION C

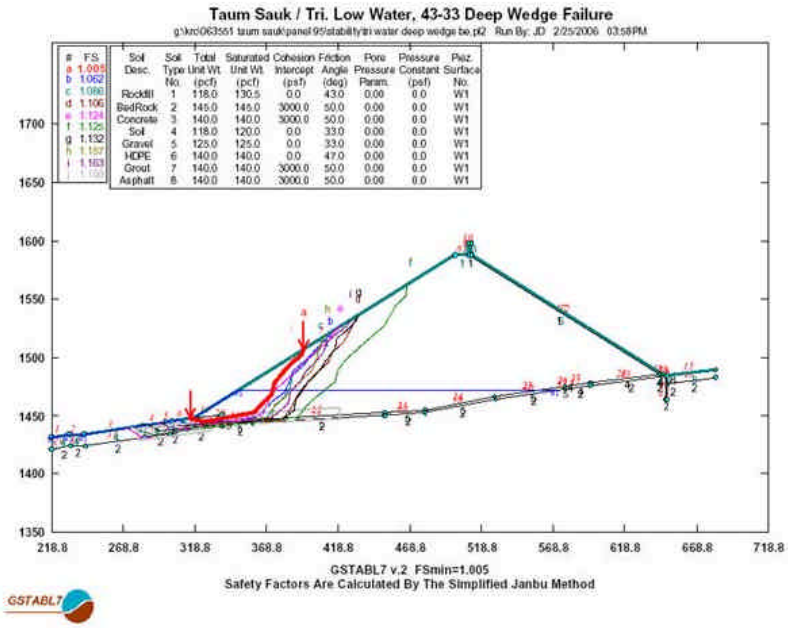
ESTIMATED TIME OF FAILURE (BE PROPERTIES)	LOWER BOUND PROPERTIES	BEST ESTIMATE PROPERTIES	UPPER BOUND PROPERTIES	FAILURE TYPE
18 min	31 ft	34 ft	37 ft	Intermediate to Deep Wedge - Fig. 8-30
23 min	37 ft	42 ft	47 ft	Deep Circle (Infinite Slope) – Fig. 8-31
11 min	12 ft	16 ft	17 ft	Toe Wedge – Fig. 8-32
12 min	14 ft	16 ft	17 ft	Toe Circle – Fig. 8-33

Notes:

1. The height of the phreatic surface is measured above the bedrock directly at the downstream toe.
2. The Estimated Time of Failure is our estimate when the Failure Type occurred. See ***Figure 8-20.***

The first line of Table 8-5 indicates that RIZZO estimates that it would take about 18 minutes for the phreatic surface to increase to 34 feet above the bedrock. With the phreatic surface at this level, an intermediate to deep wedge type failure would have a factor of safety of one. Based on the analyses presented, it is RIZZO's opinion that the failure began at the toe (with either a wedge or circular failure). ***Table 8-5*** indicates that the toe failure condition reached a factor of safety of one when the phreatic surface was in the range of 12 feet to 17 feet above the bedrock. This occurred in the range of 10 to 13 minutes after the Upper Reservoir level reached El. 1597. The results also indicate that while failure began at the toe, probably exacerbated by run off down the slope, it rapidly progressed up slope within minutes.

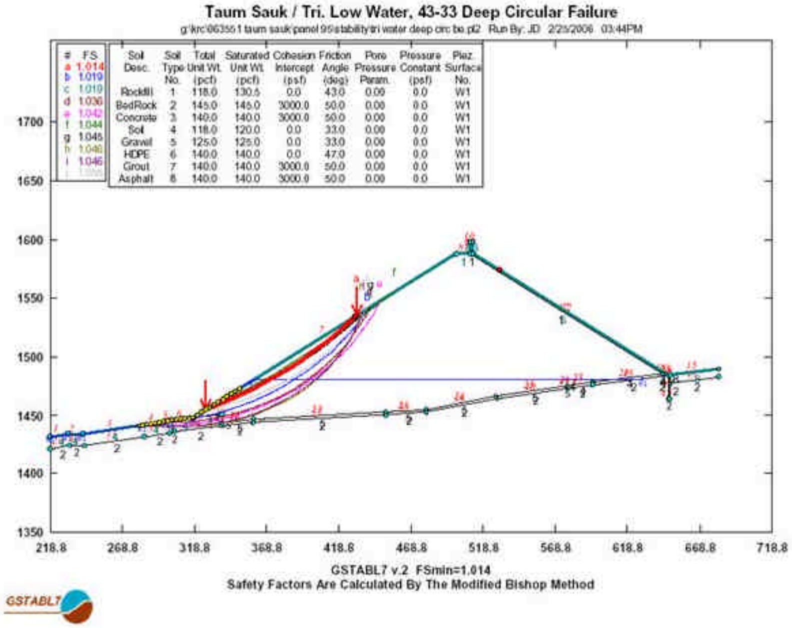
The increase in phreatic surface within the Dike on the day of the Event is directly attributed to the overtopping flow. RIZZO is unable to measure or calculate with precision the level and shape of the phreatic surface just prior to the overtopping. The analyses summarized in ***Table 8-5*** assumed that the initial (pre-overtopping) phreatic surface was about five feet above bedrock. In terms of the Barriers presented in ***Section 5.0***, this assumed initial phreatic surface might have been elevated by an ineffective Grout Curtain, Asphalt Pavement, or the Foundation Filters. Performance of the Foundation Filters was discussed and dismissed in ***Section 8.3.1*** as non-causal. If, on the other hand, the Grout Curtains and/or Asphaltic Pavement were ineffective and causing leakage through or seepage under, either could have impacted the level or the shape of the pore pressure distribution at the Dike/foundation interface. An increase in pore pressure would have diminished the (pre-overtopping) factor of safety against stability failure of the Rockfill Dike and possibly result in a faster time to failure as compared to the times presented in ***Table 8-5***. However, it is RIZZO's opinion that neither the Grout Curtains nor the Asphalt Pavement played a substantial role in the Event and that, at best, an ineffective Grout Curtain or an ineffective Asphalt Pavement may have been a secondary contributing cause.



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	43.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	33.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	33.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

FIGURE 8-30

INTERMEDIATE TO DEEP WEDGE FAILURE – CONDIITON C (BEST ESTIMATE PROPERTIES)



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	43.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	33.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	33.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

FIGURE 8-31

DEEP CIRCLE (INFINITE SLOPE) FAILURE – CONDITION C (BEST ESTIMATE PROPERTIES)

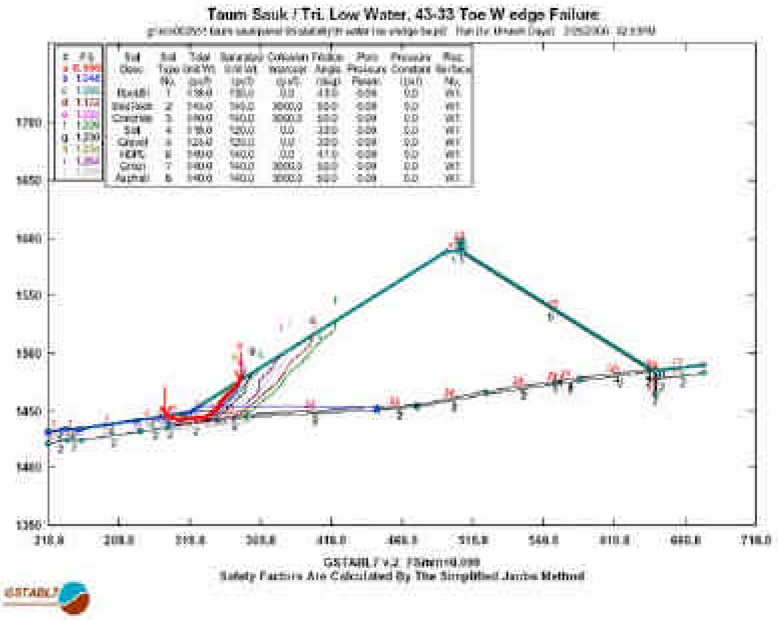


FIGURE 8-32

TOE WEDGE FAILURE – CONDITION C
(BEST ESTIMATE PROPERTIES)

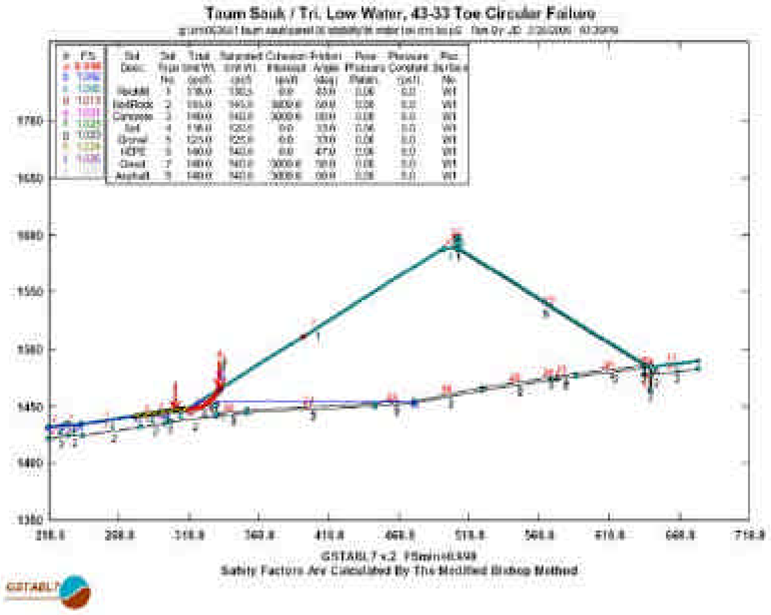


FIGURE 8-33

TOE CIRCLE FAILURE – CONDITION C
(BEST ESTIMATE PROPERTIES)

8.5 PREVIOUS SLOPE STABILITY ANALYSIS

Slope stability of the Upper Reservoir Dike was previously evaluated (by others) as part of the normal dam safety and inspection process. These analyses were included in the latest Part 12 Report (MWH, 2003) and the results showed that the Dike apparently met current dam safety requirements as per the FERC guidelines. In this section, we compare and contrast the existing analysis as compared to the post-incident analysis summarized in ***Section 8.4***.

Based on our review of these analyses, RIZZO has the following comments:

Phreatic Surface: In the previous analysis, it was assumed that no pore pressure exists in the rockfill (assumed a dry slope condition). While this is often consistent with a concrete faced rockfill dam, it is not appropriate for the Dike at Taum Sauk. The high percentage of fines within a rockfill has the effect of increasing pore pressures within a dam or dike. Substantial seepage was flowing through the Taum Sauk Dike with estimates of seepage ranging from 10 to 40 cfs with an average of about 20 cfs. When this seepage flow encountered fines, increased pore pressure resulted.

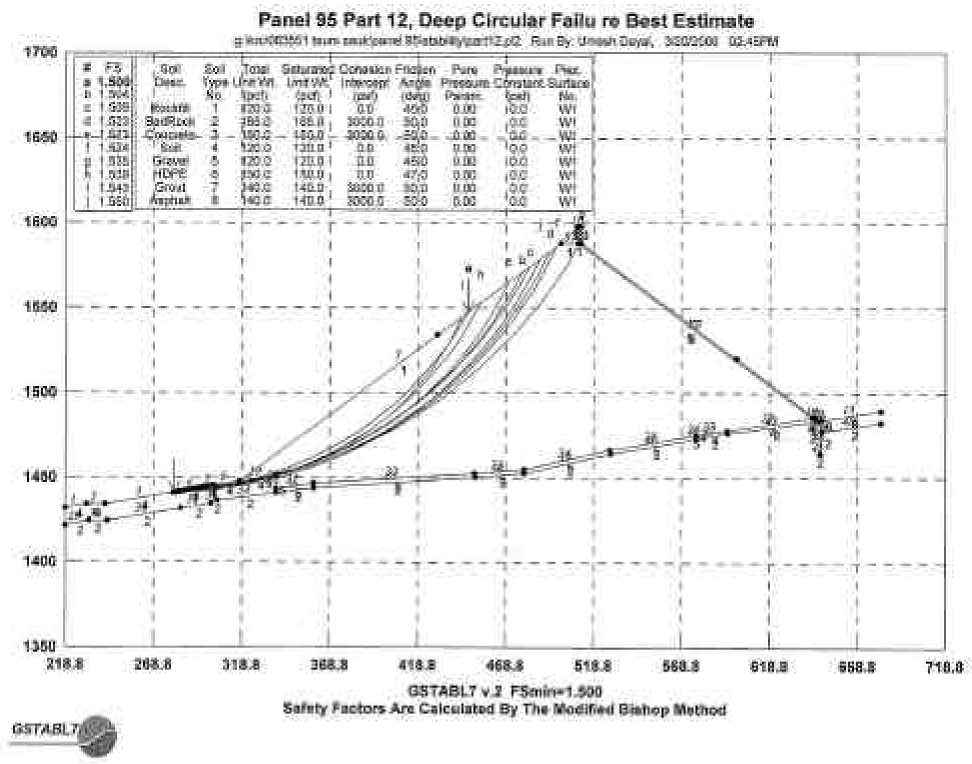
Utilizing the finite element-based SEEP2D modeling program and measured seepage quantities, RIZZO developed phreatic surfaces consistent with the concrete-lined and the HDPE-lined upstream face. These phreatic surfaces were used to calculate slope stability factors of safety. It is noted that the phreatic surface has an impact on the factor of safety (as the phreatic surface increases, the FS decreases).

Soil Properties: In the previous analysis, one type of material is assumed for the entire Rockfill Dike having shear strength properties of friction angle (ϕ) equal to 45 degrees with no cohesion. However, the original design drawings show three distinct soil layers within the downstream slope of the embankment; namely, rockfill, a filter layer, and unexcavated soil. RIZZO has performed a parametric investigation of the slope stability analyses assuming lower bound, best estimate, and upper bound material properties for each of these layers. Those material properties are listed in ***Table 8-2***. The estimated material property values were back-calculated from the failed slopes and confirmed with laboratory test results. The soil and filter layers located atop the weathered rock have much lower strength values in comparison to rockfill material. This foundation layer critically governs the factor of safety for slope stability. Lower shear strength values for the foundation material yields lower factors of safety.

Wedge versus Circular Failures: The original analyses assumed uniform strength properties for the embankment and the foundation. In this case, circular failure surfaces control. However, in the case analyzed herein, the foundation layer is significantly weaker than the overlying embankment. In this case, a wedge failure (with a resulting lower factor of safety) governs the slope stability analysis.

Actual Site Conditions: Inclusion of actual site conditions, as stated above, will result in a lower factor of safety as compared to the original analyses.

Independent Check: As a check, RIZZO has independently performed the slope stability analyses using the same geometry and strength properties as used in the original stability calculations—not the properties that RIZZO interprets to be appropriate. The results are presented on ***Figure 8-34***. These results show a factor of safety of 1.5 as reported in the original calculations prepared by the original designer.



Panel 95 Part 12, Deep Circular Failu re Best Estimate

g:\lrc\063551 tsum saul\panel 95stability\part12.pl2 Run By: Umesh Dayal, 3/30/2006 02:45PM

#	FS
a	1.500
b	1.504
c	1.509
d	1.523
e	1.523
f	1.524
g	1.535
h	1.538
i	1.543
j	1.550

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	120.0	120.0	0.0	45.0	0.00	0.0	W1
BedRock	2	165.0	165.0	3000.0	30.0	0.00	0.0	W1
Concrete	3	150.0	150.0	3000.0	30.0	0.00	0.0	W1
Soil	4	120.0	120.0	0.0	45.0	0.00	0.0	W1
Gravel	5	120.0	120.0	0.0	45.0	0.00	0.0	W1
HDPE	6	150.0	150.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	30.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.500
Safety Factors Are Calculated By The Modified Bishop Method

FIGURE 8-34

CHECK – ORIGINAL STABILITY ANALYSIS
FACTOR OF SAFETY EQUAL 1.5

9.0 OPERATION AND CONTROL AT TAUM SAUK

At the time of the event, the systems and controls were in-place to allow for the operation and control of the Taum Sauk Plant and to maintain the safety of the Upper Reservoir. We have conducted an analysis of the operation and control systems utilized at the Taum Sauk Plant as they apply to the Upper Reservoir by reviewing records, interview transcripts, the Siemens Report (***Attachment A***), and discussions with AmerenUE management.

The initial sub-sections presented below discuss the instrumentation and control systems. Following this we provide an overview of the AmerenUE organization as it relates to the operation of the Taum Sauk Plant. Based on this information, we evaluate the last three Upper Reservoir Barriers as listed on ***Table 6-1;*** namely, Instrumentation, Operator Action, and Management Oversight.

9.1 INSTRUMENTATION

The Taum Sauk Plant is operated remotely from the Osage Power Plant. Instrumentation at the site was designed to provide the Osage Operator with sufficient information to be able to control the pump and generation cycles for the Taum Sauk Plant. With regard to the instrumentation, two modes of failure were investigated. The first, failure of the instrumentation and controls system, was investigated by Siemens and a summary of their investigation is included herein. The second, investigated by RIZZO, contemplates a structural and/or mechanical failure of the instrument supports. Either could potentially lead to a loss of water level control of the Upper Reservoir.

9.1.1 Instrumentation and Controls System

Siemens was retained to perform an analysis of the Event with a focus on the instrumentation and controls system at the Taum Sauk Plant. A copy of the Report prepared by Siemens is included in ***Appendix A***. The Siemens investigation reviewed the instrumentation in the as-found condition following the incident. The instrumentation and controls system had been recently upgraded by AmerenUE during the Fall 2004 outage. The instrumentation upgrades were performed concurrently with the liner installation to take full advantage of the outage. A summary of the main points and conclusions from the Siemens Report is presented below.

9.1.1.1 Upper Reservoir Level Controls

Two independent monitoring devices were in place to monitor the water level of the Upper Reservoir at the time of the Event. The first, referred to as level control, was the primary means utilized to control the pump and generation cycles on a daily basis. The second, referred to as level protection, provides an additional means to stop the pump cycle when a certain water elevation is reached.

The level control of the Upper Reservoir was achieved through three level control transmitters. An average of the three level control transmitters is recorded at the Osage Hydro Plant on a continuous basis. Control of the pumps is set by the operator or when the auto stop elevation is reached. On the day of the Event, the first pump was set to auto stop at El. 1592 and the second at El. 1594. Either pump can be set as the first pump to auto stop. On the day of the Event, Pump No. 2 was set to auto stop first and Pump No. 1 was set to auto stop second.

The overflow protection system utilized two probes designed to activate when the water reached the level of either probe. On December 14, 2005 the observed elevations of these probes were El.1597.4 (HI Probe) and El. 1597.7 (HI-HI Probe), as opposed to the designed elevations of El. 1596.0 and El. 1596.2. Also, these probes were designed to operate independently, but the programming was altered such that both level probes would have to be in contact with water for 60 seconds to turn off the pumps. Incidentally, due to a programming error, the HI-HI Probe would only shut off Pump No. 1. This was not an issue on the day of the incident because Pump No. 2 had also stopped. Had the HI-HI Probe activated, Pump No. 1 would have been shut down.

The overflow protection probes were designed to trigger a rapid shutdown of both pumps. As such, significant stresses would be generated in the water conveyance system, as opposed to the gradual shutdown that occurred through the use of the level control system. The probes were designed to act in the case of an emergency such that the additional stresses in the system would be justified. However, continual trips by the protection probes could significantly reduce the life of the plant equipment.

It is important to note that no distinction was made between "*operational instrumentation*" and "*dam safety instrumentation*." Operational controls for the reservoir (i.e., level control transmitters) were set based on the operational procedures desired by plant management personnel. For example, operational procedures were set to assure a gradual shutdown of the units by avoiding the activation of the protection probes. Therefore, the auto stop elevations of the level control transmitters (operational instrumentation) should be adjusted to prevent this occurrence. On this basis, a failure of the operational instruments might result in operation problems, but would not have a significant effect on dam safety if the overflow protection instrumentation is fully functional.

The level protection probes, used synonymously herein with the term dam safety instrumentation, should have been designed and specified to prevent overtopping of the reservoir. The elevation of these probes should have been set to prevent the reservoir from exceeding the normal maximum elevation. As per the original drawings, the Upper Reservoir was designed to allow two feet of freeboard. At the time the new instrumentation was installed, the low point on the Parapet Wall was El. 1597.0. Therefore, the level protection probes should have been set to stop the pumps whenever the freeboard was reduced to less than two feet.

Based on RIZZO's understanding, the as-designed levels of the protection probes of El. 1596 and El. 1596.2 do not satisfy this design intent. The probes, in the as-designed configuration, would allow the freeboard to be reduced to less than one foot before stopping the pumps. Shortly after installation, the actual elevation of the protection probes was modified such that they were set at El. 1594.0 and El. 1597.7 or above the low point of the Parapet Wall. RIZZO speculates that this change was made to improve plant operation. In hindsight, rather than adjusting the elevation at the protection probes, the level control transmitters should have been adjusted to safely alter the operation of the plant. Moreover, the dam safety instrumentation should not have been altered without significant input from people familiar with dam safety requirements. Changes made to the instrumentation were not well documented and adequate quality checks were not performed prior to making changes. Where dam safety issues are concerned, additional quality control checks are appropriate.

9.1.1.2 Effects of Dike Settlement

Some additional comments are necessary to fully characterize the normal operating water level in the Upper Reservoir. Most earth and rock fill dams settle with time. As part of routine inspections, this settlement is monitored and documented over time. When the crest settles to below the design elevation, remedial measures are required to reinstate the crest elevation or to revise the operational procedures. At Taum Sauk, the designed crest elevation was El. 1599 and measured and recorded the initial operating level was El. 1597. The operating level (prior to the

Fall 2004 outage) was via a staff gage attached to the parapet wall. Operating level was reduced to El. 1596 as measured by the staff gage, presumably due to settlement following the initial construction. However, settlement of the parapet wall and staff gage reduced the actual operating level by an additional foot to El. 1595. Operating levels continued to be read from the staff gage and were recorded as El. 1596.0. As a result, Taum Sauk was operated with two feet of freeboard (as per the design) until the upgrade of the instrumentation and controls system during the Fall 2004 outage.

Following installation of the synthetic liner and the upgraded instrumentation and control systems, plant operation resumed at El. 1596.0. However, the elevations now recorded were actual elevations rather than the through the old staff gage which had settled one foot. This resulted in a one foot increase in the normal operating level and the loss of one-half of the design freeboard. This inadvertent reduction in the freeboard substantially increased the likelihood of overtopping in the event of instrumentation (or other) problems.

In summary, the exact purpose of each instrument installed is a critical component necessary to assure the correct function of the instrument. In the case of Taum Sauk, the level protection probes should have been documented in terms of their purpose, i.e., assure safety of the Upper Reservoir Dike by providing a fail-safe mechanism to prevent overtopping. Any changes to these instruments should then consider the documented intent and purpose of the instrument. Adjustment of the level protection probes should be based on dam safety considerations.

9.1.1.3 Programmable Logic Controller

Both sets of instruments are controlled by the same Programmable Logic Controller (PLC) and there is no fail-safe path to shut down the pumps in the event of the failure of the PLC. Based on Siemens investigatory work, there is no evidence of a hardware failure in either the PLC network system or in the wide-area network. Nevertheless, it is our view that a fail-safe should be considered if the project is rebuilt.

9.1.2 Instrumentation Support Systems

RIZZO has reviewed both the design and as-built system for securing the level controls. Refer to ***Appendix H*** for copies of the drawings showing the as-designed and as-built configuration of the instrumentation supports.

The instrumentation support system was designed by Shaw-Emcon in conjunction with the installation of the geosynthetic liner in 2004. The purpose of the liner was to reduce seepage through the Upper Reservoir Dike. The liner project was expanded to include the installation of four HDPE Pipes to house the new reservoir control instruments. The reservoir instrumentation and controls system was also upgraded during the Fall 2004 outage.

The level control transmitters were installed inside perforated HDPE Pipes. Four pipes were provided, two were to be for the level control transmitters and one was filled with concrete for ballast and one was to be used as a spare. All four were to be secured together to increase rigidity. The initial design of the upgraded instrumentation and controls system (see ***Appendix G*** – rev. 1 through 4) called for anchoring the four pipes to the liner with an HDPE strap welded to the HDPE liner. The liner installation contractor raised a concern that the weld would create a stress point and reduce the expected life of the liner.

At the request of AmerenUE, Shaw-Emcon redesigned the anchor supports. The redesign (see ***Appendix G*** – rev. 5) included two steel guide cables running parallel to the HDPE pipes. The cables were to be anchored at the base of the Parapet Wall and at the toe berm concrete at the base of the slope. The pipes were to be connected to the cable via eye bolts. With the addition of the guide cables, the concrete filled pipe was eliminated and only three HDPE pipes are shown on the redesigned (Revision 5) drawing. However, as the parts were already on-site, all four pipes were installed with two remaining empty.

In the field (during construction) it was noted that the Revision 5 design included a slack cable that ran along the existing slope of the Reservoir. The slack cable would not have provided the necessary support to secure the instrumentation. Again, AmerenUE contacted the designer who recommended that the cable be tensioned. A revised drawing was not issued reflecting this change.

The tensioned cable resulted in a variable distance between the cable and the pipes. This made the use of the specified eye-bolts impractical. Discussions between AmerenUE and the designer resulted in a change from eye-bolts to turnbuckles. The turnbuckles could be easily adjusted to account for this variable distance.

In summary, during the installation of the liner, several modifications were made to the instrumentation support systems. These changes were required to minimize the potential for damage to the liner and to better suit field conditions. All changes made were discussed with and received the approval of the designer, Shaw-Emcon.

The liner and new instrumentation system was put into service on November 15, 2004. A Final Construction Report (dated February 12, 2005) was issued to the FERC to document the completed liner installation project. However, the details of the instrumentation support (as contained in the Final Construction Report) are not reflective of the actual as-built conditions. The as-built condition of the instrumentation supports was resubmitted in February of 2006 reflecting correct information.

9.1.2.1 Field Change to Design

As outlined above, field changes were required because initial design was inadequate. The original design (Appendix H - Drawing # 8304-X-155099 Rev. 4) called for eye-bolts to attach the clamp baseboard/spacer to the guide cables. In the field, it was noted that once the guide cables are tensioned, the distance from the baseboard to the cable was quite variable. See ***Figure 9-1*** for an understanding of the turnbuckle locations.

FIGURE 9-1

TURNBUCKLE-GUIDE CABLE-INSTRUMENT CONDUIT SYSTEM

Since it would have been difficult and time-consuming to set the length of each eye-bolt to match the curvature of the embankment, the design was changed to accommodate turnbuckles in most clamp locations so that they could be field-adjusted as needed. The bottom anchor for the guide cable was changed to a turnbuckle also. We consider both changes to be a significant deviation from the original design. RIZZO's findings indicate that these field changes were poorly documented.

Overall, the substitution of a turnbuckle in a location where a bolt was originally specified was not adequate. From a generic perspective, the mechanism of bolted connections is such that the nut is held in place by the friction of the nut on the part being connected. The friction acting on the threads is not credited as there is an inherent gap between the threads of the bolt and of the nut that allows the nut to turn. This gap allows a slight vibration to release the friction in the thread-to-thread interface. In other words, to rely only on thread-to-thread friction to maintain the integrity of a bolted connection is not adequate and not consistent with function of the bolted connection.

At Taum Sauk, the turnbuckles were tightened, but no locking device, such as a locking nut or spot weld, was used to secure the fixity of the connection against vibratory effects. Thus, over time, the turnbuckle loosened and eventually was unscrewed completely. As can be seen in several photos available in the AmerenUE records, several turnbuckles were installed using less than one inch of thread.

9.1.2.2 Unistrut Failure

As may be seen in ***Figure 9-1***, the bottom portion of the turnbuckle is connected to a horizontal steel member, called a Unistrut. A Unistrut is a U-shaped member with flanges that allow for a clamp to grasp the member. We observe on ***Figure 9-2*** that the Unistrut assembly failed to function as intended. The nut-Unistrut assembly became disengaged when the lateral displacement of the Unistrut became more pronounced (over one or two feet) as may be seen on ***Figure 9-2***. It is RIZZO's opinion that the side to side movement of the instrumentation conduit allowed momentum to build up enough to create impact forces on the Unistrut-clamp connection. These impacts caused the clamps to slide off the Unistrut, leaving the instrumentation conduits to act as four individual elements instead of the much stiffer arrangement provided by the intended configuration.

FIGURE 9-2

LAYOUT OF INSTRUMENTATION CONDUITS AND UNISTRUTS

It has been postulated that movement of the instrumentation conduits in a back and forth swaying motion contributed to the failure of the turnbuckle-Unistrut-guide cable support system. This postulated behavior is difficult to quantify as it is not practical to ascertain the exact speed of the water flow in the vortex that forms around the “morning glory” inlet shaft. Indeed, the bottom surface of the Upper Reservoir around the “morning glory” was depressed to counter the possibility of vortex action during the generation cycle. In discussion with AmerenUE management, we understand anecdotally that vortex action occurs, possibly in the pumping mode as well. This is a difficult analytical problem to assess as regards the impact on the instrumentation conduits; therefore, we can only comment that no records or calculations were found that would document that this effort was undertaken.

If vortex action is postulated to cause circular flows around the “morning glory” resulting in tangential flows along the concrete facing on the Dike, the flow would have two negative effects on the support system.

Firstly, as the water flows around the turnbuckles, turbulence initiates a vibration in the turnbuckles. This, combined with the tension in the threads, can loosen the turnbuckles. ***Figure 9-1***, taken immediately after the installation of the HDPE pipes and supports, shows that many of the turnbuckles were installed with little or no male thread protruding from the female thread. This means that as a few as a dozen revolutions of the turnbuckle could have failed the connection.

Secondly, the water flow produces a lateral thrust on the conduit, causing lateral displacement. Since the conduit spacers/clamps allow upward movement along the guide cables, this lateral displacement is not converted to an axial force as it would if the conduit had been anchored at both ends. Only the guide cables can offer any resistance to this lateral movement of the conduit. But once the turnbuckles fail, the conduit is free to swing.

Figure 9-2 shows the lateral displacement noticed in the conduits about two months before the overtopping failure of the Reservoir. Plant operators were aware that this lateral displacement would have the effect of raising the gage instruments and lowered the pump auto stop elevation by two feet after this observation. It is RIZZO's opinion that that this was not sufficiently conservative considering the level of uncertainty involved.

9.1.3 AmerenUE Response

As discussed above and prior to the Event during October 2005, AmerenUE discovered that a portion of the HDPE pipe supports (housing the level controls) had failed. A plan and schedule was developed by AmerenUE to correct the observed problems. The repairs were not implemented prior to the December 14, 2005 Event. Our review of the records suggests that the partial failure of the instrumentation support systems for the level transmitters was not viewed as an immediate dam safety concern by AmerenUE. We surmise that AmerenUE observed that the protection probes (HI and HI HI) were un-affected and AmerenUE believed that these protection probes would serve as a backup should there be a complete failure of the level control system due to continued failure of the instrumentation support system.

As an added conservatism, and based on the observed problems with the level controls, the operating level of the Upper Reservoir was reduced by two feet such that the last pump would auto stop at El. 1594. In hindsight, the two foot reduction was not sufficiently conservative.

9.1.4 December 14, 2005 Event

Due to a failure of the system securing the HDPE pipes, the HDPE pipes containing the level control transmitters shifted and caused a change in the instrument elevation. This led to actual water levels being about four feet higher than the elevation recorded by the level control transmitters. During the morning of December 14, 2005 the auto stop elevation for the second pump (El. 1594) was not reached until overtopping had occurred and the Upper Reservoir Dike was very near to or at a failed condition. The maximum level recorded by the level transmitter was El. 1593.7 whereas actual peak reservoir level (based on post-incident physical observations) was approximately El. 1597.6.

The level protection system was designed as a backup to the level control system. However, the probes were set above the low point in the Parapet Wall (El. 1597). The probes (at the time of the Event) were installed too high (1597.4 and 1597.7) to be effective. Had the protection probes been maintained at their as-design levels at El.1596 and El. 1596.2, the uncontrolled release would likely have been avoided.

9.1.5 AmerenUE Organizational Structure

The following text was prepared to summarize the AmerenUE organizational structure as it relates to the operation and control of the Taum Sauk Project. Key management positions responsible for the Taum Sauk Plant are listed below. The first list contains positions which are directly responsible for the operation where as the second list shows positions responsible for providing engineering and technical support to operations.

Operational Personnel

- Vice President, Power Operations. This position oversees non-nuclear power operations and each of the four fossil plants report directly to him. The hydro-operations manager also reports to the VP of Power Operations.

- Manager, Hydro Operations. This position oversees and manages the operation of all of AmerenUE’s hydro plants. Plant Superintendent’s at each of AmerenUE’s three hydro plants report to the Manager of Hydro Operations.

- Plant Superintendent, Taum Sauk. This position oversees the operation of the Taum Sauk Plant. He is responsible for both operation and dam safety at the project. The Plant Superintendent oversees a Supervisor of Power Production and Engineering, as well as a number of hydro plant technicians.

Technical Services

- Vice President, Generation Technical Services. This position oversees the technical service group which provides engineering support for AmerenUE's coal, hydro, and gas (non-nuclear) generating stations including Taum Sauk. A number of managers report to the VP of Generation Technical Services covering a range of services.

- Manager, Generation Project Management. This position oversees and manages the engineering functions provided by the Technical Services Group. Managers covering mechanical, electrical, and civil/structural all report to the Manager of Generation Project Management.

- Managing Supervisor, Electrical and Controls Group. This position provides electrical and controls support services to all of AmerenUE's non-nuclear generating facilities including Taum Sauk.

- Managing Supervisor, Civil Structural Group. This position provides civil engineering support to AmerenUE's non-nuclear generating facilities including Taum Sauk.

According to discussions with AmerenUE personnel, the employee with primary responsibility for operation of Taum Sauk, including dam safety issues, is the Plant Superintendent. The Taum Sauk Plant Superintendent receives significant support from the Civil Structural Group and the Electrical and Controls Group (e.g., five-year Part 12 Inspections and design of plant modifications). Additionally, consultants are retained, as needed, to support AmerenUE's internal engineering function.

Daily and weekly inspections of the project, including the Upper Reservoir Dike, were completed under the direction of the Plant Superintendent. The checks were for the purposes of operation and maintenance as well as dam safety. However, it is RIZZO's opinion that the personnel completing these inspections were not adequately advised to dam safety issues. For instance, the design freeboard was two feet. Had this information been provided to the technicians performing the inspections, they would have been in a position to confirm that adequate freeboard existed during each inspection. Two instances where this information would have proved critical are highlighted below.

In one instance, during an inspection on September 27, 2005, AmerenUE personnel observed that the water surface of the Upper Reservoir was only about four-inches below the top of the Parapet Wall. As a result, the auto-stop position was lowered by two feet to El. 1594. Had dam safety considerations been thoroughly addressed, a more comprehensive review of the reservoir control systems would have been conducted. For instance, a review of why the level protection probes were not activated would have been appropriate.

During an inspection on September 30, 2005, AmerenUE personnel inspected the HI and HI-HI overflow protection probes and found the probes seven inches and four inches from the top of the Parapet Wall, respectively. The primary purpose of the protection probes should have been dam safety. Specifically, they should have been installed to ensure a minimum of two feet of freeboard. Accordingly, the probes should have been located about two feet below the crest of the parapet wall. Note that this change could have been affected without any knowledge of the variation in settlement along the Parapet Wall and without the need for any survey checks.

9.2 SUMMARY

The design and specification of the instrumentation and control systems were inadequate from a dam safety perspective. Furthermore, an inadequate initial design for the instrumentation supports led to field changes which led to the failure of the supports and errant readings of the water level in the Upper Reservoir. Additionally, the misplacement of HI and HI-HI Probes, as a result of human error, effectively disabled the as-designed level protection. These three items combined to allow the overtopping of the reservoir during the pump back cycle on the morning of December 14, 2005. Specific conclusions with respect to the Barrier Analysis are listed below.

- Design and specification of the instrumentation system was not sufficiently conservative. Had the protection probes been maintained at the design elevations, the overtopping event may not have occurred.

- Even given the loss of the level protection, overtopping still could have been prevented had the level control instrumentation supports not failed.

- Based on our judgment, plant operators and technicians were following operational and inspection procedures as provided by AmerenUE. However, we note that operator training in terms of dam safety was inadequate.

- Operation of the Upper Reservoir in terms of dam safety including maintaining the necessary freeboard was not adequately understood within the AmerenUE Organization.

- Responsibilities for plant operation and dam safety were combined under a single individual. Anyone with this job description may have to potentially balance dam safety and operational constraints.

- Adequate design quality assurance was not followed by AmerenUE and their consultants. Consultants and engineers, including software suppliers, should have followed an ANSI qualified program. This would include documentation of the intent of a design and would also require checks and verifications before making any changes to final design.

It is our overall conclusion that instrumentation failure and human error constitute primary and secondary contributing causes respectively to the Event. If AmerenUE elects to rebuild the Upper Reservoir, operational procedures and training in dam safety should be implemented. Also, consideration should be given to separating dam safety responsibility and operational responsibility.

10.0 SUMMARY RESULTS OF BARRIER ANALYSIS

The Barrier Analysis described in ***Section 5.0*** developed eight (8) questions to be addressed to the ten (10) Barriers described on ***Table 6-1*** and investigated and analyzed in ***Sections 7.0 through 9.0***. This Section summarizes the results in the formalized DOE Barrier Methodology as adopted for this forensic investigation.

The eight (8) questions developed in ***Section 5.0*** are repeated as follows for the convenience of the reader.

1. Did the Barrier perform its intended function under normal operating conditions?
2. Did the Barrier perform its intended function under the upset or faulted condition?
3. Did the Barrier mitigate the event severity?
4. Was the Barrier design adequate?
5. Did the Barrier design contemplate the occurrence of the Event?
6. Was the Barrier construction adequate?
7. Was the Barrier adequately maintained?
8. Was the Barrier inspected prior to Event?

These questions are addressed and answered in ***Table 10-1***. Those marked in "red" are direct, root causal in nature or are primary contributing causes, those marked in "yellow" are contributing secondary or tertiary causes and those "uncolored" are considered non-contributing causes to the Event. A "Y" is a yes or affirmative answer, an "N" is a no or negative answer and an NA implies that the question is Not Applicable to the Barrier.

TABLE 10-1

BARRIER ANALYSIS SUMMARY

	DIKE	FACE	LINER	PARAPET	ASPHALT	GROUT	FILTERS	INST.	OPERATOR	MGMT
Perform under normal operating conditions?	Y	Y(1)	Y	Y(1)	Y(1)	Y(2)	Y(2)	N	Y	Y
Perform under the upset or faulted condition?	N	NA	Y	N	Y(1)	Y(2)	Y(2)	N	Y(1)	Y(1)
Mitigate the event severity?	Y	Y	Y	Not Clear	Y	Y	Y	Y	N	N
Barrier design adequate? (3)	N	Y	Y	N	Y	N	N	N	NA	N
Design contemplate the Event?	N	N	N	N	N	N	N	Y	Y	Y
Barrier construction adequate? (4)	N	Y	Y	Y(1)	Y	N	N	N	NA	Y
Barrier adequately maintained?	Y	Y	Y	Y(1)	Y	NA	NA	N	Y(1)	Y(1)
Barrier inspected prior to Event?	Y	Y	Y	Y	Y(5)	Y(5)	Y(5)	Y	Y	Y

NOTES:

1. Yes, but possibly not as fully as the designer intended.
2. Yes, but possibly not as fully as intended by the designer, but there is no strong evidence in the affirmative or negative.
3. Compared against standards and practice in 2006 as opposed to the practice in the late 1950s and early 1960s.
4. Compared against the designer’s original intent and construction specifications.
5. Yes, to the extent practical or with indirect measurements or observations. FERC mandated inspections conducted as required.

11.0 CONCLUSIONS

The **root cause** of the Event of December 14, 2005, specifically ***"the uncontrolled, rapid release of water from the Upper Reservoir,"*** was the breach of the Rockfill Dike. Our forensic investigation indicates that the breach was a stability failure of the Rockfill Dike at the northwest corner of the Reservoir brought on by a rapid increase in the pore pressure at the Dike/foundation interface, stemming from the original design and construction which was flawed.

The Breach of the Rockfill Dike, the primary Barrier to the Event, is the root cause of the ***"rapid release of water from the Upper Reservoir."*** The stability failure of the Dike was caused by:

(1) A rapid rise in the phreatic surface and the associated pore pressure at the Dike/foundation interface caused by the flow overtopping the Parapet Wall.

(2) Weak foundation conditions attributed to the original design and construction specifications.

(3) Inadequate shear strength of the material comprising the rockfill attributed to the original design and construction practices.

(4) Poor construction practices and failure to meet the intended design criteria.

While the original design is considered to be consistent with the general design practice of the late 1950s and early 1960s, it is not consistent with the practice in 2006. Specifically, the rock at the Upper Reservoir was dumped and then sluiced with water to remove fine material and move the rock into a more dense state. Today, rockfill is compacted with compacters and carefully monitored to prevent the inclusion of fines with the rock. Water sluicing with monitors is an abandoned practice. In addition, the modern day designer places a great deal of emphasis on the preparation of the foundation rock, including hand cleaning and removal of soil, weathered rock and other relatively low strength material – none of which were adequately specified in the original design.

It is also RIZZO's opinion that the construction practice followed in the field during original construction was not consistent with the intent of the design as shown on the drawings and in the specifications. Sluicing was specified by the designer for the removal of fines from the dumped rock fill. Observation of the breach slopes clearly indicates that this was not uniformly achieved during construction. The designer also called for the foundation rock to be cleaned with a bulldozer such that not more than two inches of material was left in place. Yet, our field investigation has determined that as much as 18 inches of virgin, low strength material was left in place in certain areas.

The failure of the Reservoir level monitoring instrumentation to function as intended is a primary contributing cause. As defined herein, a primary, secondary or tertiary contributing cause is a cause that may have contributed to, but would not, either singularly or in combination with other primary, secondary or tertiary causes, have caused the stability failure of the Rockfill Dike. The failure of the level control instrumentation to function as intended is due to a failure of the instrumentation support system. The failure of the level protection instrumentation to function as intended is due to a misplacement of the HI and HI-HI level protection instrumentation as a result of human error.

It is RIZZO's opinion that inadequate attention was paid to dam safety considerations as regards the design, operation, and management of the facility and that this may have been a secondary contributing cause of the Event.

The failure of the Parapet Wall, the concrete upstream face of the Rockfill Dike, the performance of several grout curtains, and the asphalt liner may have been Secondary or Tertiary Contributing Causes of the Event, as discussed in ***Section 8.0.***

The performance of foundation filters was not a cause of the Event.

The synthetic liner placed on the upstream face of the Rockfill Dike was not a cause of the Event. It is Rizzo's view that the liner increased the factor of safety against stability failure.

It is our conclusion that the **root cause** of "***the uncontrolled, rapid release of water from the Upper Reservoir"*** was the breach of the Rockfill Dike—a stability failure at the northwest corner of the Reservoir brought on by a rapid increase in the pore pressure at the Dike/foundation interface, stemming from the original design and construction which was flawed.

Respectfully submitted,
Paul C. Rizzo Associates, Inc.

Paul Rizzo

Paul C. Rizzo, Ph.D., P.E.
President and Principal Investigator
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PCR/JMB/JPO/djs

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The Principal Investigator was supported in this investigation by key members of Paul C. Rizzo Associates, Inc., specifically, Mr. Jeffrey Bair, Mr. John Osterle, Mr. Howard Gault, Mr. John Charlton, Mr. Rolando Benetiz, Dr. Umesh Dayal, and Mr. Carl Rizzo plus the support of Siemens Power Generation, Inc.

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Finally, the Principal Investigator acknowledges the timely and cooperative support of the officers, managers and staff of AmerenUE, including Mr. Alan Kelley, Mr. Robert Powers, Mr. Mark Birk and Mr. Tom Hollenkamp.

REFERENCES

REFERENCES

Akinci, A., R.B. Herrmann, and C.J. Ammon, 1999. "Shallow Crustal Structure in the Central Conterminous United States from Teleseismic Receiver Functions." Saint Louis University, Department of Earth and Atmosperic Sciences.

Anderson, Neil L. 1998, "Subsurface Structure of the Commerce, English Hill and Related Faults in the Benton Hills of Southeastern Missouri: Collaborative Research, University of Missouri-Rolla, Department of Geology and Geophysics and Missouri Department of Natural Resources, Division of Geology and Land Survey." Retrieved January 23, 2006 from http://erp-web.er.usgs.gov/reports/annsum/vol140/cu/g3038.htm.

Anderson, J.E., JR., M.E. Bickford, A.L. Odom, and A.W. Berry, 1969. "Some Age Relations and Structural Features of the Precambrian Volcanic Terrane, St. Francois Mountains, Southeastern Missouri." Geological Society of America Bulletin, v. 80, pp. 1815-1818.

Berry, AW., Jr., 1976, Proposed stratigraphic column for Precambria volcanic rocks, western St. Francois Mountains, Missouri; in Klisvarsanyi, E.B., ed., Studies in Precambrian geology; Missouri Geological Survey Report of Investigations 61, p. 81-90.

Boss International and Bringham Young University, 1999, "SEEP2D" GMS Groundwater Modeling System.

Braile, L. W., W.J. Hinze, G.R. Keller, E.G. Lidiak, and J.L. Sexton, 1986. "Tectonic Development of the New Madrid Rift Complex, Mississippi Embayment, North America." Tectonics, Vol. 131, pp. 1-21.

Brunsden, D (1993) Mass movement: The research frontier and beyond: a geomorphological approach. Geomorphology, 7, pp 85-128.

Clendenin, C.W., C.A. Niewendorp, and G.R. Lowell, 1989. "Reinterpretation of Faulting in Southeast Missouri." Geology, Vol.17, pp. 217-220.

Delano, H. L., and Wilshusen, J. P., 2001, Landslides in Pennsylvania: Pennsylvania Geological Survey, 4th ser., Educational Series 9, 34 p.

D.F. VanDine (1996) Debris Flow Control Structures for Forest Engineering, British Columbia, Ministry of Forests, Research Program.

Gregory, 2003, "GSTABL7 with Stedwin, Slope Stability Analysis," Program Manual Version 2004, Geotechnical Engineering Software.

Kisvarsanyi, Eva B., 1981, “Granitic Ring Complexes and Precambrian hot-spot activity in the Saint Francois terrane, Midcontinent Region, United States.” Geology, Vol. 8, pp. 43-47.

Kisvarsanyi, E.B. and A.W. Hebrank, 1982, “Field Trip Guidebook to the St. Francois Mountains and the Historic Bonne Terre Mine.” Open File Report Series OFR-82-16-MR. Missouri Department of Natural Resources, Geological Survey and Resource Assessment Division, Rolla, MO, 39 pp.

IAEG Commission on Landslides (1990) Bulletin of the International Association of Engineering Geologists, 41

Langenheim, V.E. and T.G. Hildenbrand, 1997, “Commerce geophysical lineament-Its source, geometry, and relation to the Reelfoot rift and New Madrid seismic zone.” GSA Bulletin, Vol. 109, no. 5, pp. 580-595.

Lowell, Gary R. 2000, “Eruptive style of mesoproterozoic A-type calderas in Southeastern Missouri, USA.” Revista Brasileira de Geociencias, Vol. 30, pp. 745-751.

MWH, 2003 “Eighth FERC Part 12 Independent Consultant Safety Inspection Report”. prepared for AmerenUE.

Meert, J.G. and W. Stuckey, 2002, “Revisiting the paleomagnetism of the 1.476 Ga St. Francois Mountains igneous province, Missouri.” Tectonics, Vol. 21, No. 2, pp. 1-19.

Pierson, T.C. and J.E. Costa. 1987. A rheologic classification of subaerial sediment-water flows. In Debris flows/avalanches: process, recognition and mitigation. Reviews in Engineering Geology. J.E. Costa and G.F. Wieczorek (editors). Geol. Soc. Am., Vol. VII, pp. 1–12.

Pratt, W.P., M.A. Middendorf, I.R. Satterfield, and P.E. Gerdemann, 1992. “Geologic Map of the Rolla 1°x 2° Quadrangle, Missouri.” Missouri Department of Natural Resources, Division of Geology and Land Survey, Publication I-1998.

U.S. Department of Energy, 1992, “DOE Guideline, Root Cause Analysis Guidance Document,” DOE-NE-STD-1004-92, Washington, DC.

Van Dine, D.F., 1996, Debris Flow Control Structures for Forest Engineering: Res. Br., B.C. Min. For., Victoria B.C. Work Pap. p8/1996.

PLATES

PLOT 1:1

DRAWN BY B.F.R. 02/24/06

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APPROVED BY JPO 2-24-06

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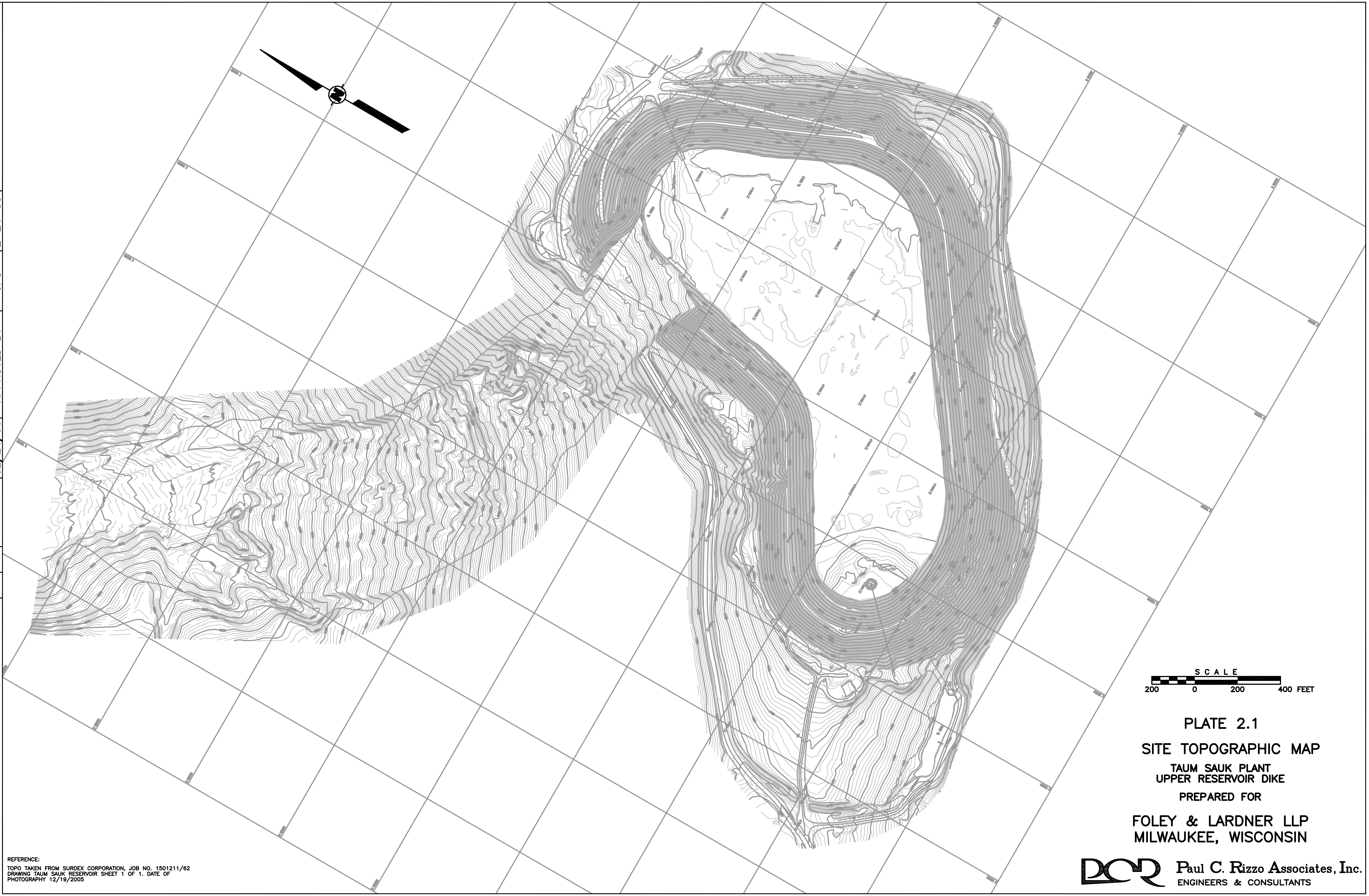

PLATE 2.1

SITE TOPOGRAPHIC MAP

TAUM SAUK PLANT
UPPER RESERVOIR DIKE

PREPARED FOR

FOLEY & LARDNER LLP
MILWAUKEE, WISCONSIN

Paul C. Rizzo Associates, Inc.
ENGINEERS & CONSULTANTS

REFERENCE:

TOPO TAKEN FROM SURDEX CORPORATION, JOB NO. 1501211/62 DRAWING TAUM SAUK RESERVOIR SHEET 1 OF 1. DATE OF PHOTOGRAPHY 12/19/2005

CAD FILE NUMBER 06-3551-E300

CHECKED BY

APPROVED BY

JEC 1-27-06

DRAWN BY

PLOT 1:1

LEGEND:

🟥 RHY1 – PORPHYRITIC RHYOLITE, very dark red to very dusky purple, aphanitic groundmass with 0.5–5mm feldspar phenocrysts, 0.5–2mm quartz phenocrysts, hard to very hard when fresh or slightly weathered, moderately to intensely fractured, 60% of mapped area is exposure of fresh to slightly weathered rock, 20% highly weathered rock, and 20% residual soil.

🟥 RHY2 – RHYOLITE, aphanitic, light red to moderate pink, fresh to slightly weathered, hard to very hard.

🟫 SOIL – residual and/or detrital soil. Residual soil contains abundant roots and is silt with clay (plasticity not noted). Detritus includes 1–6 inch rocks pressed into silt with clay. Soil is 0.1 to 1.6 feet thick. Some zones grade into weathered rock, approximately 20% of foundation area is covered with soil.

▨ BR – Breccia/damage zone.

⬚ BZ – "Baked" zone recrystallized by contact metamorphism.

FEATURE TYPE (F=Fracture, SZ=shear zone, sense of offset not determined)
^
F–22 – GEOLOGIC FEATURE NUMBERS (NOTE: Descriptions included in tables)
V
FEATURE NUMBER

00 ▲ – Dip and dip direction of banding.

23 – Dip and dip direction of fracture.

32 – Dip and dip direction of inclined fault.

⇐ 0.0 – Left lateral apparent offset.

⇒ 0.0 – Right lateral apparent offset.

30 – Plunge and plunge direction of slickensides.

PLATE 3.1

BREACH AREA FOUNDATION GEOLOGIC MAP

TAUM SAUK PLANT
UPPER RESERVOIR DIKE

PREPARED FOR

FOLEY & LARDNER LLP
MILWAUKEE, WISCONSIN

Paul C. Rizzo Associates, Inc.
ENGINEERS & CONSULTANTS

CAD FILE NUMBER 06-3551-301

CHECKED BY

APPROVED BY

JEC

1-27-06

DRAWN BY

PLOT 1:1

LEGEND:

🟧 – GOOD ROCK, Rock Mass Rating RMR 80–61.

🟨 – FAIR ROCK, rock mass rating 60–41.

🟥 – POOR ROCK, rock mass rating 40–21.

🟫 – Soil; residual and/or detrital soil. Residual soil contains abundant roots and is silt with clay (plasticity not noted). Detritus includes 1–6 inch rocks pressed into silt with clay. Soil is 0.1 to 1.6 feet thick. Some zones grade into weathered rock, approximately 20% of foundation area is covered with soil.

▨ BR – Breccia/damage zone.

☐ BZ –"Baked"zone recrystallized by contact metamorphism.

FEATURE TYPE (F=Fracture, SZ=shear zone, sense of offset not determined)

F–22 – GEOLOGIC FEATURE NUMBERS (NOTE: Descriptions included in tables)

FEATURE NUMBER

▲ 00 – Dip and dip direction of banding.

▬ 23 – Dip and dip direction of fracture.

32 – Dip and dip direction of inclined fault.

⇐ 0.0 – Left lateral apparent offset.

⇒ 0.0 – Right lateral apparent offset.

30 – Plunge and plunge direction of slickensides.

PLATE 3.2

BREACH AREA FOUNDATION ENGINEERING PROPERTIES MAP

TAUM SAUK PLANT
UPPER RESERVOIR DIKE

PREPARED FOR

FOLEY & LARDNER LLP
MILWAUKEE, WISCONSIN

Paul C. Rizzo Associates, Inc.
ENGINEERS & CONSULTANTS

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JFB 02/20/06
CHECKED BY JPO 2-24-06
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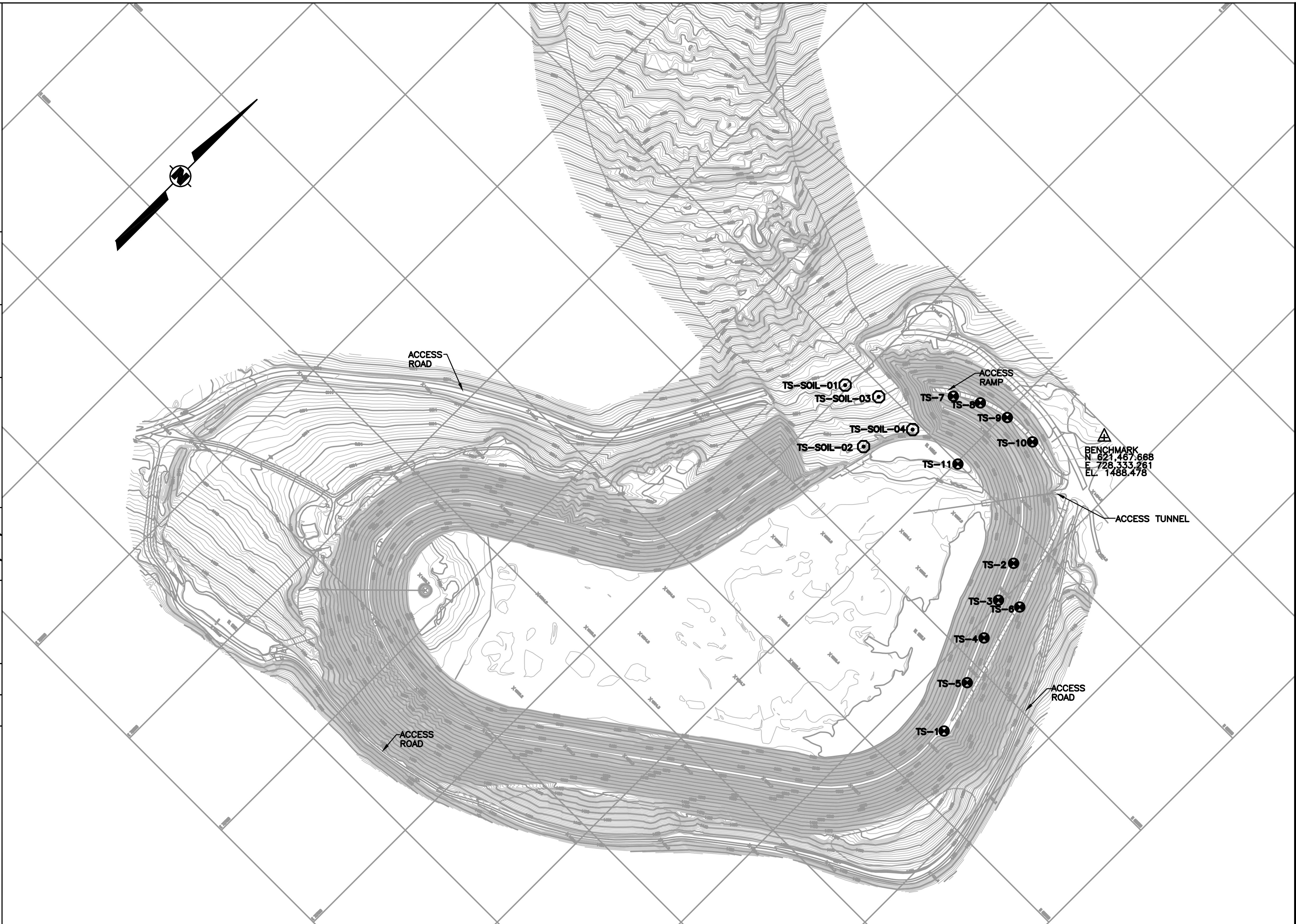
PLOT 1:1



LEGEND

TS-SOIL-01 ⊙ PCRA SOIL SAMPLE LOCATION AND DESIGNATION
TS-1 ● PCRA BORING LOCATION AND DESIGNATION

SCALE
200 0 200 400 FEET

REFERENCE:

TOPO TAKEN FROM SURDEX CORPORATION, JOB NO. 1501211/62 DRAWING TAUM SAUK RESERVOIR SHEET 1 OF 1. DATE OF PHOTOGRAPHY 12/19/2005.

PLATE 7.1

BORING LOCATION PLAN
TAUM SAUK PLANT
UPPER RESERVOIR DIKE

PREPARED FOR

FOLEY & LARDNER
MILWAUKEE, WISCONSIN

Paul C. Rizzo Associates, Inc.
ENGINEERS & CONSULTANTS

APPENDIX A

SIEMENS' REPORT
MARCH 24, 2006
AmerenUE

SIEMENS

L286001 Rev. 1

AmerenUE Taum Sauk Incident Instrumentation and Controls Root Cause Investigation Report

March 24, 2006

Document Status: Preliminary: ☐ Final: ☒

This report contains Critical Energy Infrastructure Information.

For Release outside of Siemens

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0. Revisions

Revision	Date	Section	Description Of Change
1	2006-03-24	All	Original Issue

1. About this Report

In the early morning of 14-Dec-05, at around 5:15am, according to information provided by Ameren, the retaining dam of the upper reservoir of Ameren's Taum Sauk pump storage plant breached and released approx. 1 billion gallons of water.

Ameren employees from the Taum Sauk plant and the engineering department in St. Louis reviewed and inspected the instrumentation and control system after the incident and provided information to the review team.

The Federal Energy Regulatory Commission (FERC) started an incident investigation immediately after the event (FERC P-2277).

During the ongoing investigations of the incident, Ameren has been represented by Foley and Lardner LLP. Foley and Lardner LLP retained the instrumentation and controls division of Siemens Power Generation, Inc. ("Siemens") as a consulting expert to Foley and Lardner to perform a root cause analysis of the incident with a focus on the instrumentation and controls system at the Taum Sauk site. Foley and Lardner LLP also retained Paul C. Rizzo Associates, Inc. as a consulting expert to perform a root cause analysis of the dam structure. This report is provided under and in accordance with the letter agreement between Siemens Power Generation Inc. and Foley and Lardner dated 30-Jan-06

This report represents the result of the root cause analysis performed by Siemens. The analysis was started on 9-Jan-06 with a kickoff meeting with Ameren employees at Ameren's headquarters in St. Louis. The information on which this report was based consisted of: raw data, drawings, reports and interviews, provided by Ameren employees; interviews with the instrument suppliers; retrieved data sheets from the supplier's web sites; and performed calculations based on the data provided by Ameren. In addition Siemens visited the Taum Sauk site on 12-Jan-06 and 26-Jan-06. Siemens did also perform interviews with the operators of the site located at the Osage plant on 17-Jan-06.

As requested by Foley and Lardner LLP, the report was completed by 10-Feb-06 and later revised to include level transmitters testing and analysis performed between 27-Feb and 24-Mar-06. This report is focused on technical aspects.

2. Abbreviations, Definitions, Symbols

2.1. Abbreviations

Abbreviation	Explanation
AB	Allen Bradley, a supplier of PLC systems
GE	General Electric Company
ESO	Energy Supply Operation: An Ameren department dispatching the generation assets of Ameren
FERC	Federal Energy Regulatory Commission (see www.ferc.gov)
HDPE	High density polyethylene, the material used for the instrument pipes. HDPE is lighter than water.
LAN	Local Area Network
LDS	Load Dispatch System: A computer system supplied by Areva which can be also used for remote monitoring and operation of the Taum Sauk plant.
LR	Lower Reservoir of the pump storage plant
MISO	Midwest Independent System Operator: An entity independent from Ameren which operates the Midwest power grid. Ameren is part of this organization.
PLC	Programmable Logic Controller
TR	Tail Race, water level at the entry to the power house, in relatively close proximity to the pumps
UR	Upper Reservoir of the pump storage plant
WAN	Wide Area Network

2.2. Definitions

Term	Definition
Generation cycle	Taum Sauk plant operation mode which releases the water stored in the upper reservoir into the lower reservoir to generate electricity.
Pump cycle	Taum Sauk plant operation mode which pumps water stored in the lower reservoir into the upper reservoir to be used for future Generation cycles.

2.3. Persons Interviewed

Name	Function
Robert Powers	VP Generation Technical Services
Mark Birk	VP Operations
James Witges	Manager Generation Project Engineering
Robert Ferguson	Managing Supervisor Generation Engineering
Chris Hawkins	Project Engineer
Tom Pierie	Project Engineer
Rick Cooper	Taum Sauk Plant Superintendent
Phil Thomson	Osage Plant Superintendent
Ed Dobson	Osage Hydro Plant Technician and Operator Trainer
Steve Bluemner	Project Engineer

3. The Taum Sauk Plant

3.1. Overview

3.1.1. About the Plant

The Taum Sauk plant is a pump storage plant located near Lesterville, MO. It consists of four main elements:

- the upper reservoir atop 1590 foot Proffit Mountain,
- a 7,000 foot-long shaft and tunnel inside the mountain;
- a power house containing two reversible pump-turbine generators;
- a lower reservoir formed by a dam across the East Fork of the Black River.

Taum Sauk stores water by pumping it to its upper reservoir when demand (and cost) for electricity is low (pump cycle) and then releases the water to generate electricity when the power is needed (generation cycle).

3.1.2. Plant Operation

Taum Sauk is operated remotely by the Osage hydro plant. All network communication is routed through the Ameren headquarters in St. Louis. The Energy Supply Operations (ESO) department located in St. Louis can also monitor the plant; however the operational responsibility is with the Osage plant.

The following map shows the approximate location of Taum Sauk, Osage and the Ameren headquarters:

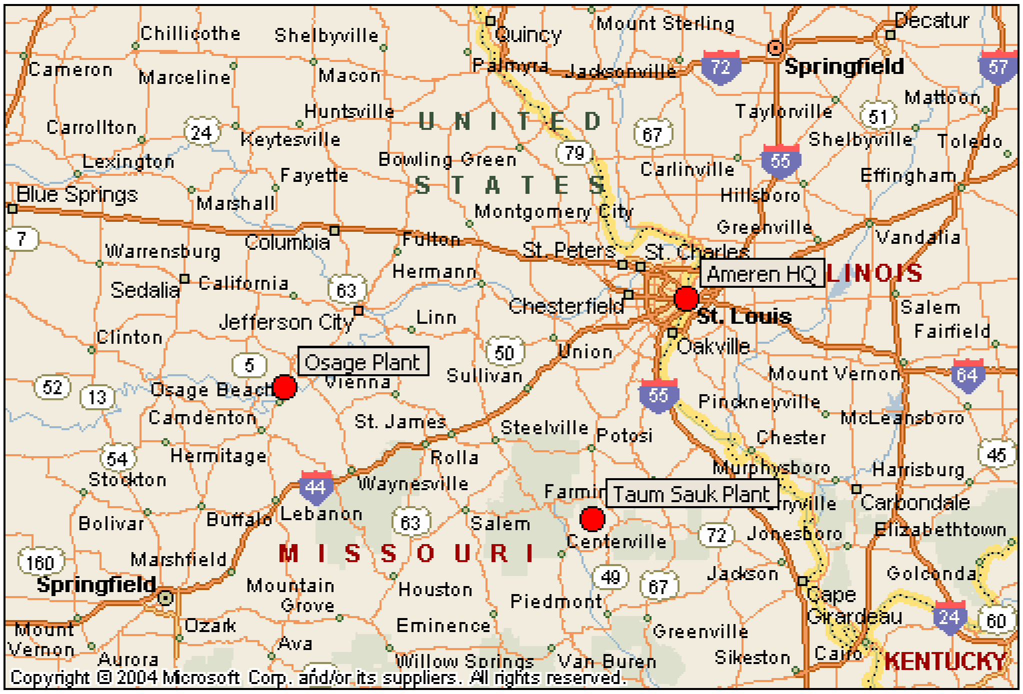

Figure 1: Overview Map

The following diagram shows the approximate driving distances between the Ameren facilities directly involved with the incident.

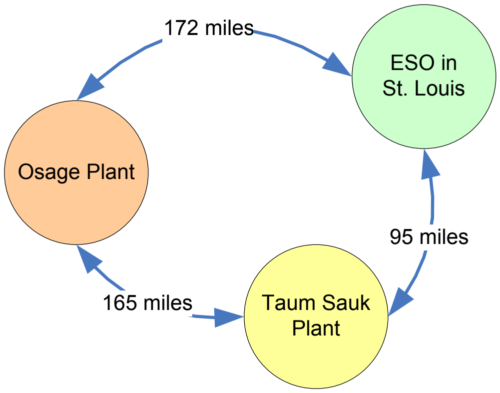

Figure 2: Approximate Driving Distances

There are no video cameras installed at Taum Sauk which could be used by the operators located at the Osage plant to visually monitor the reservoir levels.

The following sketch provides an overview of the Taum Sauk plant.

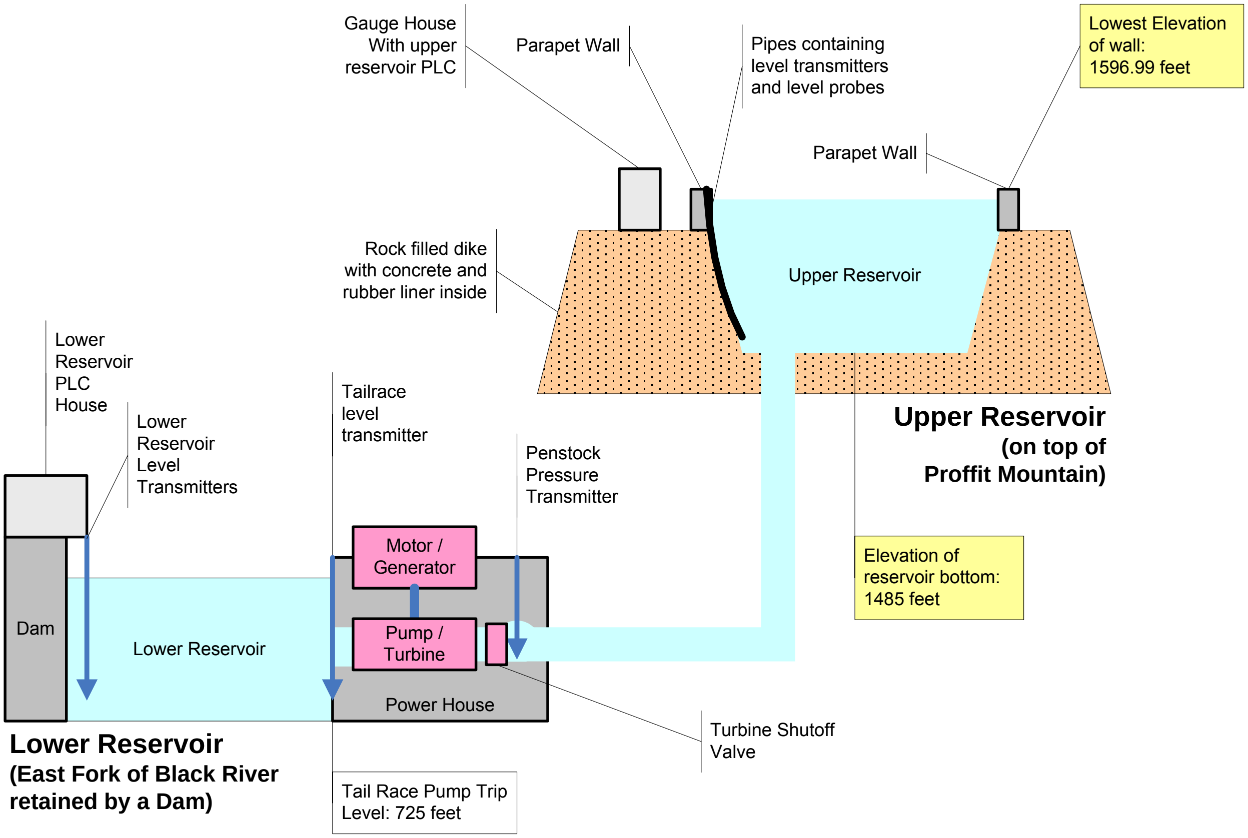

Figure 3: Taum Sauk Overview Sketch

The transmitters used for the upper reservoir level control and protection are installed at the following locations:

- Three level transmitters in one of the instrument pipes attached to the upper reservoir wall. These transmitters are intended to measure the water level in the Upper Reservoir. The control system is intended to use these measured values to control the filling of the Upper Reservoir while the Units are operating in “pump mode”.
- Four level probes (LO-LO, LO, HI and HI-HI) in a separate instrument pipe for level protection.
- One tailrace level transmitter located at the water entry at the power house. This transmitter is intended to measure the water level at the pump intake. The control system is intended to use the measured value to make sure the water level in the tail race exceeds the minimum level allowed for pump operation.
- Two lower reservoir level transmitters located at the lower reservoir dam. These transmitters are intended to measure the water level in the lower reservoir. The control system is intended to use these measured values to control the elevation of the lower reservoir.

The approximate distance between the upper reservoir gauge house and the power house is 7800 feet. The approximate distance between the lower reservoir and the power house is 11300 feet. The main PLC units, the local HMI and the engineering system are located inside the power house. The plant superintendent and the production supervisor have access to the PLC network from their laptops in the supervisor’s office. The plant superintendent has also access to the PLC network from his residence which is located on the plant property.

3.2. Upper Reservoir Level Monitoring, Control and Protection Overview

The following narrative overview was included in the report to provide a better understanding of the event sequence and the system overview. It is focused on the pump cycle because the incident to be investigated is related to this cycle. A more detailed description can be found in the subsequent chapters of this report.

3.2.1. Monitoring and Control

The upper reservoir water level is measured by three GE Druck PTX 1230 submersible transmitters. The transmitters are connected to analog inputs of an Allen Bradley (AB) PLC system, which consists of several individual PLCs communicating with each other via a local area network (LAN). The as-designed logic in those PLC systems allows the operators to view the average value generated by the three transmitters. However, the individual values generated by the three transmitters were not displayed through the control system to the operators. Neither were the operators able to remove a failed transducer from the average calculation without a programming change. The control system used the average Upper Reservoir data for all control functions[1]. In closed loop control, the PLC system provides logic to stop the pumps automatically if the average reading of the level transmitters reaches the operator selectable shut off setpoints. These setpoints include the upper reservoir water level, the lower reservoir water level and the tail race water level. The operator can also stop the pumps manually. This manual shutdown is usually requested by the energy supply operation based on grid load and financial considerations. All control is performed via the PLC system. The pumps are started by the operators on request by the energy supply operation.

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[1] Analysis of the as-found logic revealed that only two transmitters were used for the calculation of the average value on the day of the event.

There is no hardwired control for the operators at the Osage plant. The pump cycles are usually performed at night. The Taum Sauk plant is not staffed at night.

The operators can also monitor and operate through the LDS system which is installed in parallel to the Allen Bradley system. However, the LDS system uses the Allen Bradley PLC systems as a data source to read the level transmitter values. The close loop control logic for automatic pump shutoff is implemented in the Allen Bradley PLCs exclusively.

3.2.2. Protection

The overflow protection system utilizes two Warrick Series 1 probes (HI and HI-HI). Additional two probes are used to indicate Low and Low-Low level. These two level probes trigger input channels of the AB PLC system when the water level reaches a setpoint which is determined by the elevation of the probes. This setpoint is determined by the physical elevations of the two probes. In the as found logic, the AB PLC system is to trip pump #1 if both level probes are in contact with water simultaneously for longer than one minute. The program logic as reviewed by Siemens indicated that Pump #2 would not trip on protection. The PLC system is to generate an operator alarm if the water level reaches the HI-HI probe. It is not to generate an alarm or record an event, if it reaches the HI probe.

In addition, the PLC system also stops both pumps if the tail race level falls below a setpoint configured in the PLC program.

There is no hardwired protection.

3.2.3. Upper Reservoir Pump Shutoff Levels and Elevations on 14-Dec-05

The following table summarizes the pump shut off levels and elevations for the upper reservoir. All values are given in elevation above sea level. The first pump to be shut off in automatic control can be selected by the operator. This pump can be either pump #1 or pump #2.

Data Point	**Action**	**Setpoint Value at incident**	**Source**
UR Level Average	First Pump Auto Stop	1592.0	Process data archive[2]
Lower Reservoir Level Average[3]		736.5	Process data archive
Tail Race Level		730.0	Process data archive
UR Level Average	Second Pump Auto Stop	1594.0	Process data archive
Lower Reservoir Level Average		736.0	Process data archive
Tail Race Level		729.0	Process data archive
UR Level Average	Both Pumps Auto Stop	1594.2	Process data archive
Lower Reservoir Level Average		736.0	Process data archive
Tail Race Level		728.0	Process data archive
Elevation of HI Probe in UR	None	1597.4 (as found) 1597.3	Ameren's report to FERC submitted on 27-Jan-06 (as designed: 1595.9) Siemens calculation based on on-site measurements and survey data
Elevation HI-HI Probe in UR	Both Pumps Trip and Alarm	1597.7 (as found) 1597.7	Ameren's report to FERC submitted on 27-Jan-06 (as designed: 1596.2) Siemens calculation based on on-site measurements and survey data

The lowest point of the dam and wall structure as surveyed by Ameren on 6-Nov-04: 1596.99 (Source: IMG059025).

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[2] The process data archive values at the day of the incident were presented to Siemens by Ameren engineers on 19-Jan-06.

[3] Average of two transmitter readings installed in the lower reservoir. However, only one transmitter was used at the day of the event.

Based on the information above, the HI and the HI-HI probes were located in a position too high to be effective at the day of the incident. This observation is supported by the fact that no HI-HI alarm was recorded at the day of the incident.

3.3. Key Events

Date	Event	Source
June 1960	Construction of the plant begins	Ameren web site
20-Dec-63	Plant fully operational, begin of commercial operation, mostly used as a peaking unit	Ameren web site
1998	Updated runners with increased efficiency installed, begin of almost daily use of the plant	Ameren web site, Interviews
September 2004	Begin of installation of a liner to reduce water leakage from the upper reservoir. In parallel the instrumentations and control system is significantly upgraded.	Ameren documents
November 2004	The plant resumes operation	Ameren documents
September 2005	Taum Sauk employees report overtopping of the upper reservoir caused by high winds. Plant changes PLC logic to lower pump shut off level.	Ameren emails
4-Oct-05	Ameren discovers bow in instrumentation pipe and the pump shutoff level for the last pump is lowered from 1596ft to 1594ft above sea level. Similarly, the setpoint for stopping both pumps is lowered from 1596.2ft to 1594.2ft.	Ameren's report to FERC submitted on 27-Jan-06
13-Dec-05 22:33	Pump #1 is started	Process data archive
13-Dec-05 23:13	Pump #2 is started	Process data archive
14-Dec-05 04:42	Pump #2 stops automatically	Process data archive and Operator log
14-Dec-05 05:15	Pump #1 is stopped by operator upon power dispatcher request	Process data archive and Operator log
14-Dec-05 05:15	Upper Reservoir level begins to fall rapidly	Process data archive

4. Control System Overview

4.1. WAN Overview

The following sketch summarizes the wide area network structure based on information provided by Ameren engineers.

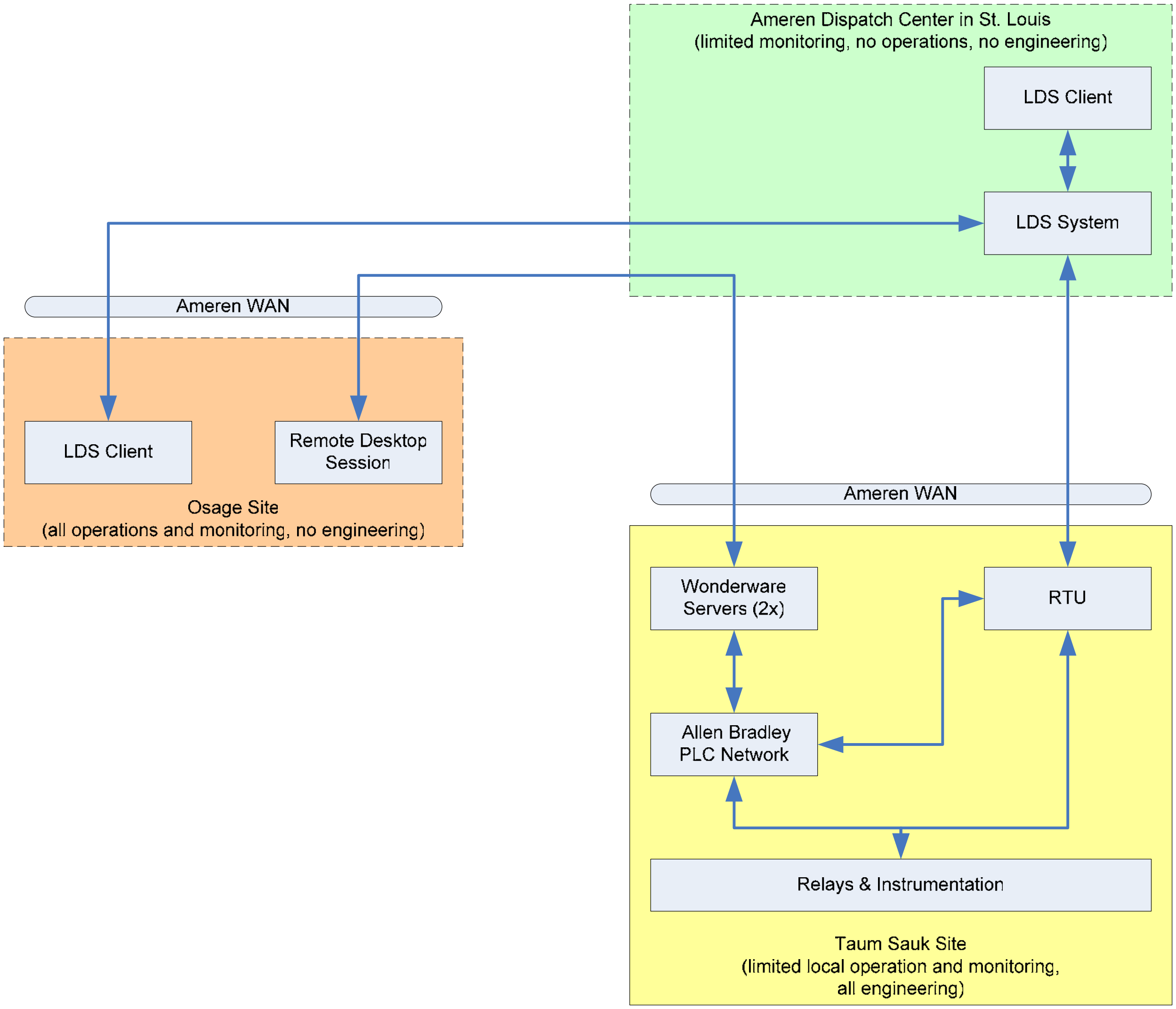

Figure 4: Taum Sauk WAN Overview

All engineering systems were located at the Taum Sauk plant. According to Ameren, remote access to those engineering systems was not permitted. According to operator accounts, the WAN was functional during the incident.

4.2. LAN Overview

The following sketch provides an overview of the local area network installed at the Taum Sauk plant based on sketches provided by Ameren engineers. The remote upper reservoir gauge house and the lower reservoir were connected through a Fiber Optic link and a DSL backup line. The Cisco switch 2 did automatically transfer to the DSL line if the fiber optic connection failed. The historical process data submitted to Siemens indicated that the communication between the PLCs was operational during the incident.

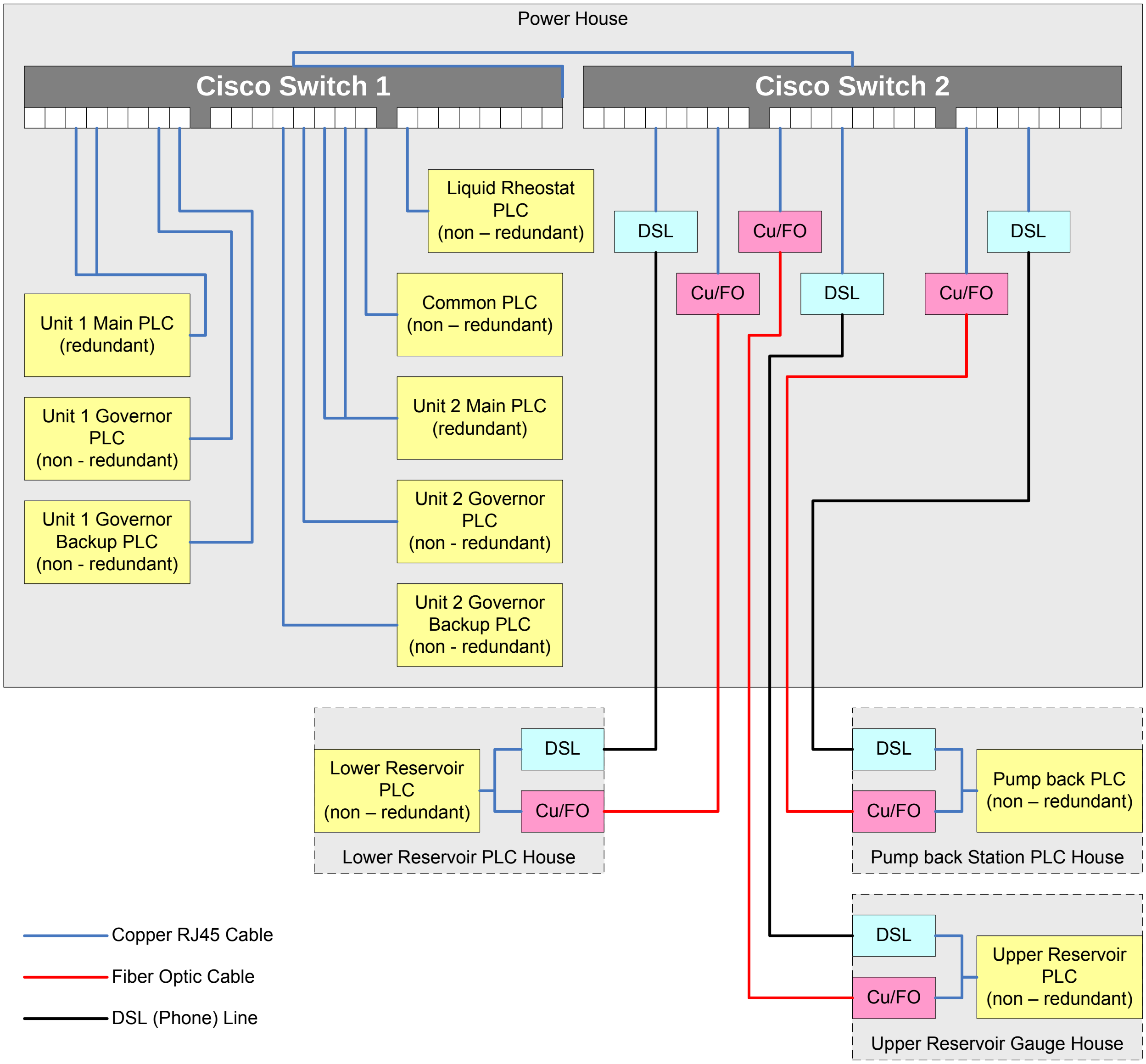

Figure 5: Taum Sauk LAN Overview

4.3. Power Distribution

4.3.1. General

Refer to IMG082735 - Schematic Diagram Upper Reservoir level drawing 8303-P-26648 r15 and IMG059220- Interconnection Diagram Level Controls Upper Reservoir & Lower Dam drawing 8303-X-26348 r8. Ameren engineers stated that no fuses were replaced nor circuit breakers reset after the incident.

4.3.2. Power Sources

4.3.2.1. Uninterruptible Power Supply

Per schematic and interconnection diagram referenced above: One 2-phase power feed provides power to Distribution Cab 4 located in the Upper Reservoir control house. Breaker 1 in distribution Cab 4 provides 120VAC to a receptacle. The 120VAC Uninterruptible Power Supply (UPS) under the table in the Upper Reservoir control house is plugged into this receptacle.

Loss of power to the UPS for more than 8 hours would disable the upper reservoir (UR) PLC, the analog level transmitters, all 4 Warrick level controllers (for the level probes), the Ethernet switch and communications to the Common PLC . This loss would immediately generate an “Upper Reservoir Loss of UPS Power - Com” alarm for operator indication. UR level control and protection would be disabled; Siemens turned off the UPS and observed the generation of the “Upper Reservoir Loss of UPS Power - Com” alarm. Although the alarm appeared at the proper time and was the proper color, name and comment the wording of the value of the alarm was backwards. – i.e. When the alarm was active the Wonderware screen showed NORMAL and when UPS power was turned back on the screen showed ALARM. The “Upper Reservoir Loss of UPS Power – Com” alarm does not appear in the Wonderware alarm log during the time of the event indicating that UPS power was on.

Upper Reservoir 24VDC Power Supply
Fuse FU-2 provides UPS power to this power supply. If this fuse was open or the power supply failed the 3 analog level transmitters would be inoperative (0 mA output) and the Ethernet switch would be inoperative. The level transmitters continued to track the falling water level for at least thirty minutes after the incident which suggests that this fuse and power supply was likely functioning. Output of the power supply was measured to be 24.0VDC on 2-2-06. The status of this fuse is not monitored.

Redundant 125VDC Power Supplies - Primary
If only the primary 125VDC power supply fails or loses its 120VAC input power the secondary 125VDC power supply is switched in by via relay 83X-1. The loss of the primary power supply alone does not affect the system’s ability to perform a Hi/Hi-Hi shutdown. The operators at the Osage plant will receive a common alarm when the primary power supply fails.

Redundant 125VDC Power Supplies - Secondary
If only the secondary 125VDC power supply fails or loses its 120VAC input power the primary 125VDC power supply continues to supply its loads unaffected. The loss of the secondary power supply alone does not affect the system’s ability to perform a Hi/Hi-Hi shutdown or generate a Hi-Hi alarm. The operators at the Osage plant will receive a common alarm when the secondary power supply fails

Redundant 125VDC Power Supplies - Both
If both 125VDC power supplies failed or lost their 120VAC input power the system would lose its ability to shutdown the pump on Hi/Hi-Hi and the ability to generate a Hi-Hi alarm. This event would generate a Lo-Lo alarm and an “Upper Reservoir Loss of UPS Power – Com” alarm. Neither of these alarms appear in the Wonderware alarm log during the time of the event which suggests that at least one of these power supplies was likely functioning.

4.3.2.2. Circuit Protection Devices

Analog Level Transmitters
Each of the three analog level transmitters has an individual unmonitored 1A fuse providing 24VDC power to its loop. Wonderware data logs show individual analog signals though the incident suggesting that all transmitters were powered through the incident. The level transmitters continued to track the level falling for at least 30 minutes after the incident, which suggests that these fuses were functioning.

Hi Warrick Level Controller
Fuse FU-4 provides uninterruptible 120VAC power to both the HI controller, LO controller and their associated Upper Reservoir PLC inputs. If this fuse blows it would prevent a pump trip on HI/HI-HI however it should not prevent the HI-HI alarm.

Hi Hi Warrick Level Controller
Fuse FU-3 provides uninterruptible 120VAC power to both the HI-HI controller and LO-LO controller. If this fuse blows it would prevent a HI/HI-HI trip and HI-HI alarm but should cause a LO-LO alarm to be generated. The LO-LO alarm was not present in the Wonderware alarm log during the time of the event which suggests that this fuse was active.

The contact output of the HI-HI controller utilizes redundant 125VDC power to drive an input of the Common PLC. The power for this input passes through the FU-8 fuse pair and four 0.5A fuses. If any of these 6 fuses were lost the input would be prevented from turning on preventing a HI/HI-HI trip and preventing a HI-HI alarm. Loss of either of the FU-8 pair of fuses should also cause a “Loss of Upper Reservoir Loss of UPS Power” alarm because they also power the normally energized input associated with that alarm. The “Loss of Upper Reservoir Loss of UPS Power” alarm was not present in the Wonderware alarm log during the time of the event which suggests that the FU-8 pair of fuses were active. The Common PLC input was operational upon examination by Ameren and Siemens engineers on 1/12/06 which suggests that all six of these fuses were active.

Upper Reservoir PLC
Fuse FU-1 provides UPS power to the UR PLC. Loss of power to the UR PLC would have prevented the HI signal from reaching the Common PLC and caused an “UR to Common PLC communication” alarm. The “UR to Common PLC communication lost” alarm was not present in the Wonderware alarm log during the time of the event which suggests that the fuse FU-8 pair of fuses was active.

4.4. Operator configurable Setpoints for Pump Stops

The operators can change setpoints for the pump stops. These setpoints are used in level control. The operators can also select which pump will stop automatically when the setpoints for the first pump to stop are reached. Level protection is not affected by these setpoints.

Variable	**Explanation**	**Reported Value at Event**[4]
URSP1 TSM01WmgUrsLvlPmp1SDStPt TSM02WmgUrsLvlPmp1SDStPt	Upper reservoir level setpoint for first pump to stop	1592.0
LRSP1 TSM01WmgLrsLvlPmp1SDStPt TSM02WmgLrsLvlPmp1SDStPt	Lower reservoir level setpoint for the first pump stop	736.5
TRSP1 TSM01WmgLrsTrcPmp1SDStPt TSM02WmgLrsTrcPmp1SDStPt	Tail race level setpoint for the first pump to stop	730.0
URSP2 TSM01WmgUrsLvlPmp2SDStPt TSM02WmgLrsTrcPmp1SDStPt	Upper reservoir level setpoint for second pump to stop	1594.0
LRSP2 TSM01WmgLrsLvlPmp2SDStPt TSM02WmgUrsLvlPmp2SDStPt	Lower reservoir level setpoint for the second pump to stop	736.0
TRSP2 TSM01WmgLrsTrcPmp2SDStPt TSM02WmgLrsTrcPmp2SDStPt	Tail race level setpoint for the second pump to stop	729.0
URSPT TSM01WmgUrsLvlPmpAllSDStPt TSM02WmgLrsTrcPmp2SDStPt	Upper reservoir level setpoint for both pumps to stop	1594.2
LRSPT TSM01WmgLrsLvlPmpAllSDStPt TSM02WmgUrsLvlPmpAllSDStPt	Lower reservoir level setpoint for both pumps to stop	736.0
TRSPT TSM01WmgLrsTrcPmpAllSDStPt TSM02WmgLrsLvlPmpAllSDStPt	Tail race level setpoint for both pumps to stop	728.0
U1STOPFIRST TSM01WmgUrs1stUnitShtdwnCmd TSM02WmgUrs1stUnitShtdwnCmd	Unit 1 Pump to be stopped first automatically on high or low levels	FALSE (means: stop Pump 2 first)

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[4] The values were provided by Ameren engineers.

4.5. PLC Logic Diagrams

The following PLC logic diagrams generated from PLC logic listings provided by Ameren provide an overview of the logic implemented inside the PLCs for pump trip and pump stop. The PLCs have other tasks besides these two functions which are not discussed here.

4.5.1. Upper Reservoir PLC Logic for Pump Trip and Stop

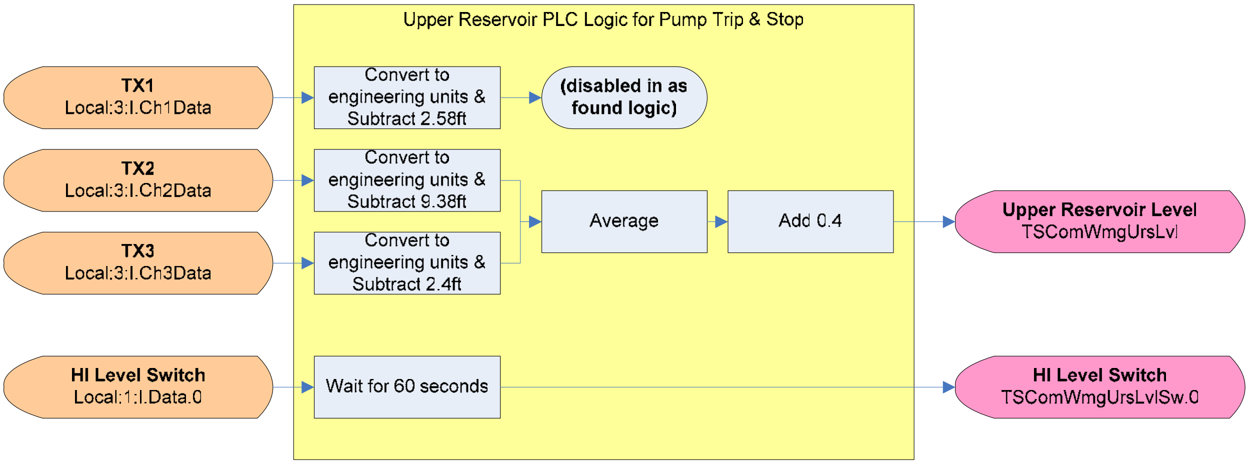

Figure 6: Upper Reservoir PLC Logic Diagram

The upper reservoir PLC is to read the three level transmitter signals through channel 1, 2 and 3 of the analog input card in slot 3. In the as found logic, the level transmitter signals are converted from 0.10000 integer range into actual engineering units. After this conversion, constants are subtracted. These constants were determined during the initial installation of the system in November 2004. The as found logic forms the average value of the two transmitters TX2 and TX3 and adds a constant of 0.4 to the average value. Transmitter TX1 is not used. The PLC also reads the HI level switch through channel 0 of the digital input card in slot 1. If the value becomes a 1 (e.g. the contact is closed), the PLC is to wait for 60 seconds before it makes this value available to other PLCs.

4.5.2. Common PLC Logic for Pump Trip and Stop

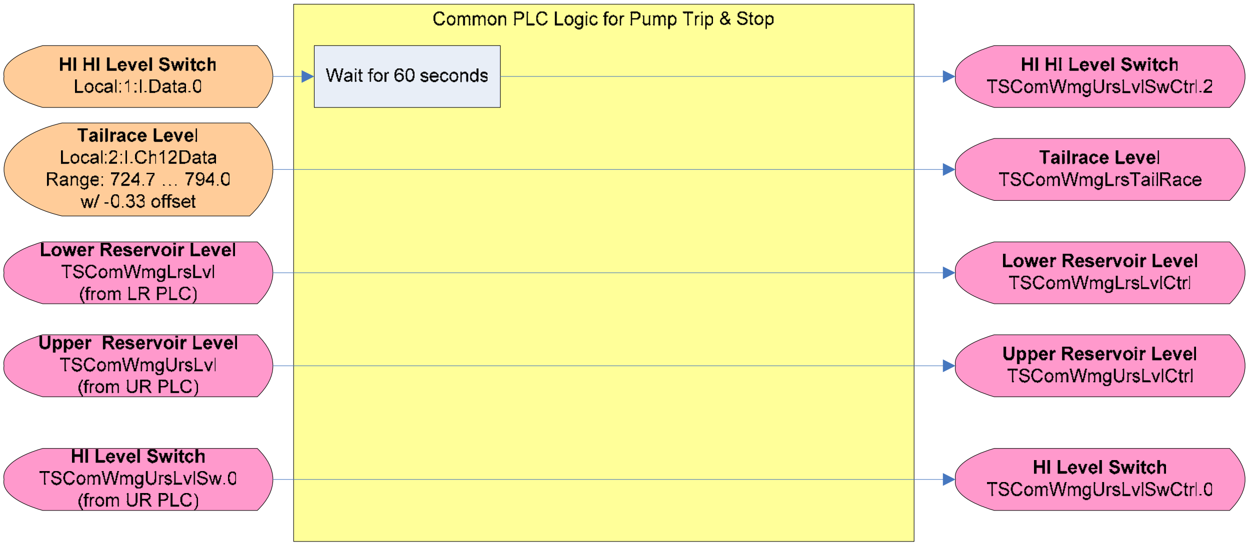

Figure 7: Common PLC Logic Diagram

The common PLC reads the HI HI level switch through channel 0 of the binary input card 1. The cable for the HI-HI signal is wired through the phone system from the UR PLC cabinet in the UR gauge house to the common PLC. The HI HI level signal needs to be active for 60 seconds before it is made available to other PLCs. The tailrace level transmitter is connected to the common PLC. The conversion to engineering units is performed in the input card.
The common PLC is also to receive the UR level average, the LR average from the LR PLC and the HI signal from the UR PLC. It does not perform any logic or conversions with these values; it passes them to other PLCs.

4.5.3. Lower Reservoir PLC Logic for Pump Trip and Stop

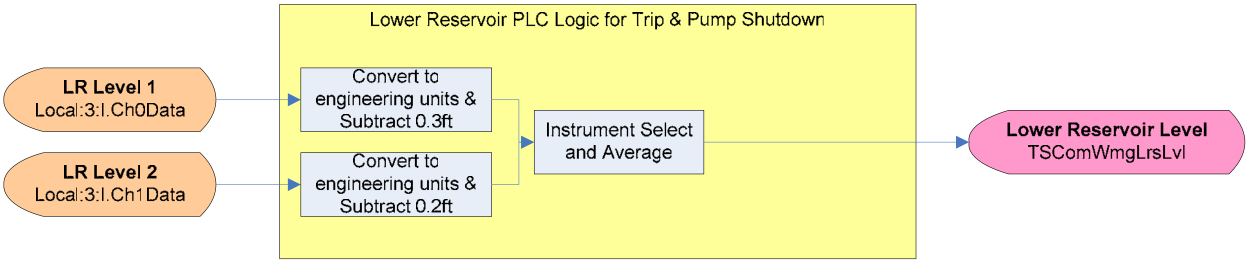

Figure 8: Lower Reservoir PLC Logic Diagram

The lower reservoir PLC is to read the LR level transmitters and converts the values into engineering units. Then it performs an average calculation of these two values. The operators can also choose to use either one of the two values instead of the average. According to the operator logs, transmitter #2 was not operational on 12-Dec-05, so transmitter #1 was selected as the sole source.

4.5.4. Unit 1 Main PLC Logic for Pump Trip

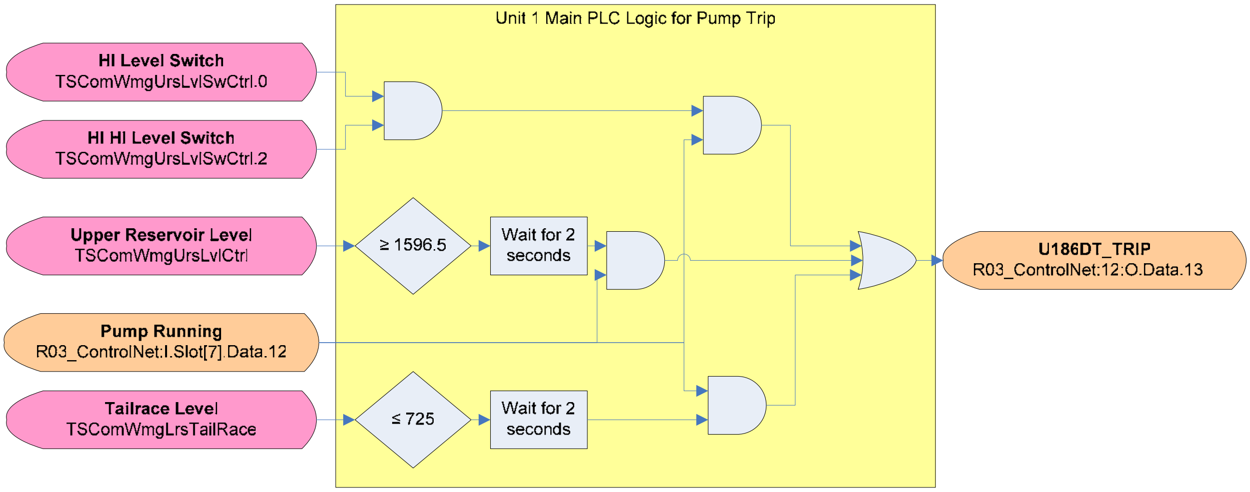

Figure 9: Unit 1 Main PLC Logic for Pump Trip

The Unit 1 main PLC performs the trip logic as outlined in the above sketch. Either a combination of the HI and HI-HI level switch, an indicated upper reservoir level of greater or equal than 1596.5 feet or a tailrace level of less or equal than 725 feet for more than 2 seconds is to trip the pump. The trip levels for the tailrace level (725 feet) and for the upper reservoir level (1596.5 feet) are coded into the PLC program and therefore not changeable by the operator.

The trip is performed by energizing the coil of relay 186DT which triggers an input signal of the governor PLC. This is to cause the governor PLC to trip the pump and to close the wicket gates. Since the historical process data indicates that the inputs for the trip signals were never satisfied (e.g. HI-HI alarm was never present, the maximum indicated upper reservoir level was 1593.72 which is below 1596.5 feet and the lowest tailrace level logged in the process data archive was 730.0 which is above 725.0 feet) during the incident, it is likely that relay 186DT was never energized and the trip circuit was therefore not further analyzed.

On the day of the incident, the Unit 2 pump was automatically stopped 33 minutes before the Unit 1 pump was stopped by the operator.

4.5.5. Unit 1 Main PLC Logic for Pump Stop

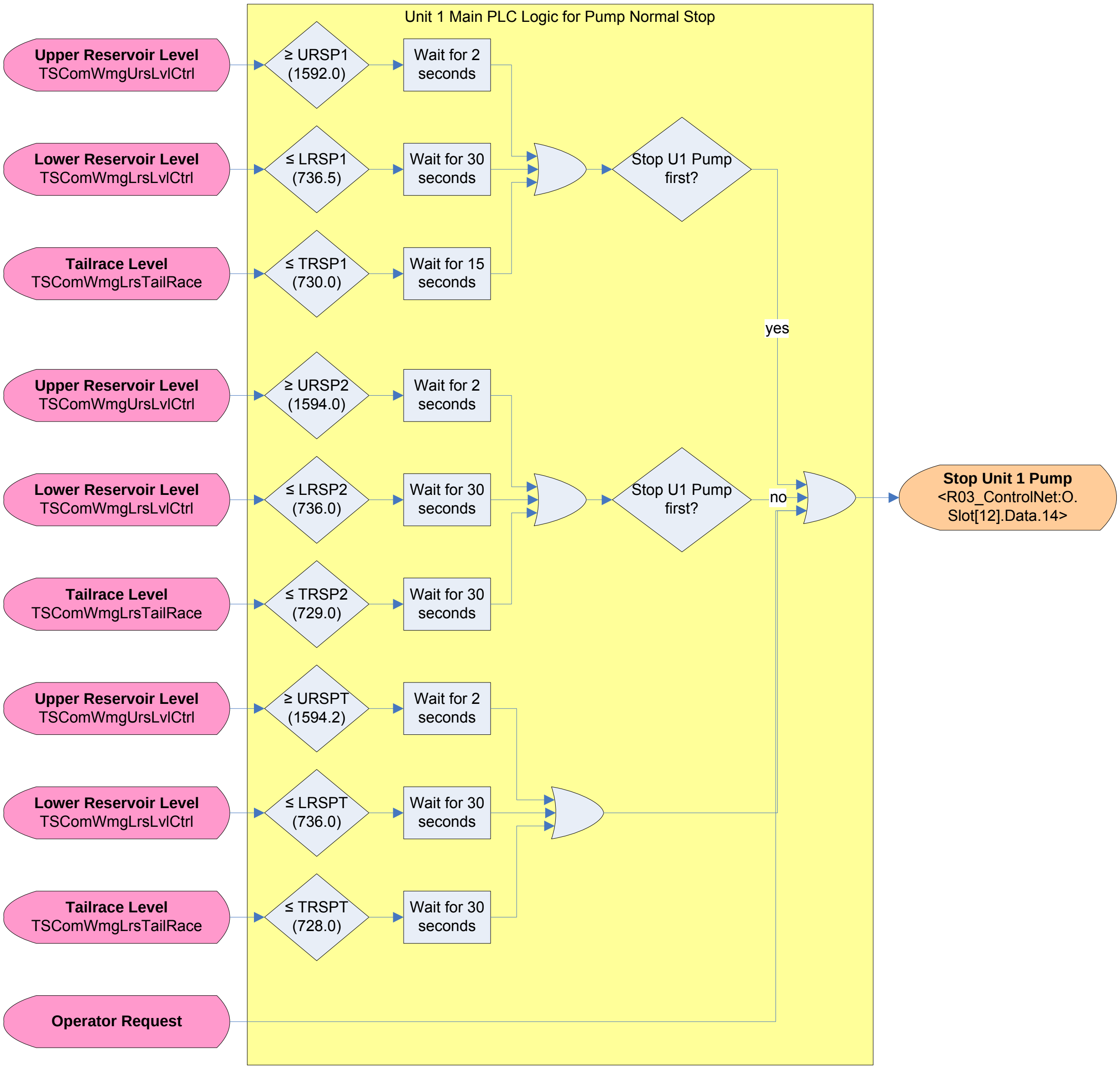

Figure 10: Unit 1 Main PLC Logic for Pump Stop

The logic for normal pump stop implemented in unit 1 main PLC is intended to stop pump #1 if the operator selectable set points for pump stop are exceeded. The effective set of setpoints is determined based on whether unit 1 is the first or the second unit to be shut down. The third set of setpoint is to shut down unit 1 regardless whether it has been selected to be shut down first or second. In any case, the signals need to exceed those setpoints for a pre-programmed period of time.

4.5.6. Unit 2 PLC Logic for Pump Trip

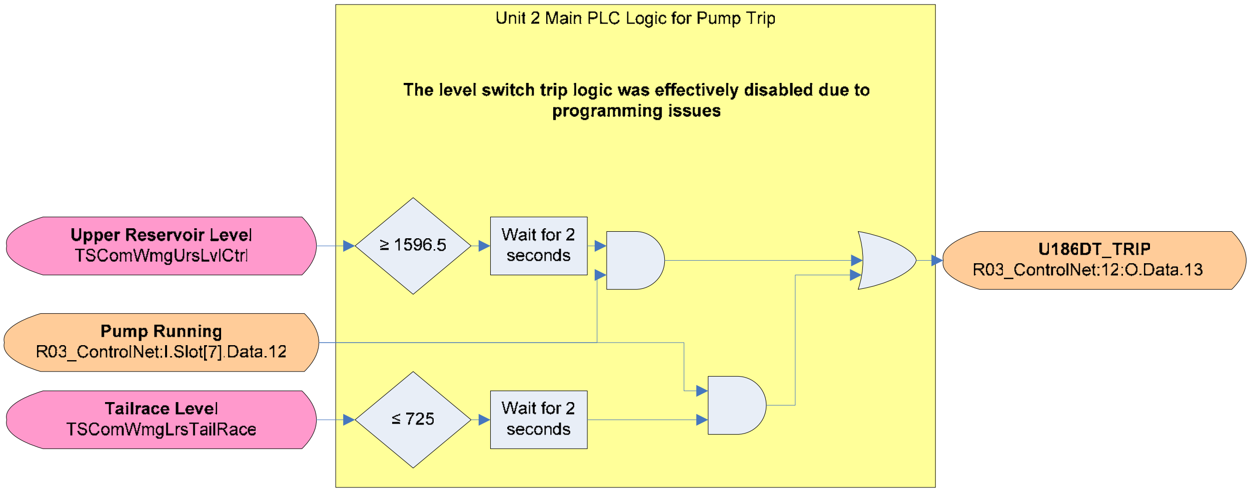

Figure 11: Unit 2 Main PLC Logic for Pump Trip

The trip logic implemented in the unit 2 PLC considers only the tailrace level and the upper reservoir level. The signals for the HI and HI-HI probes are not transmitted into the PLC. The logic for receiving the probe signal addresses the level transmitters; this appears to be in error. A review of the unit 2 main PLC program indicated a possible spelling error which led to this situation.

4.5.7. Unit 2 PLC Logic for Pump Stop

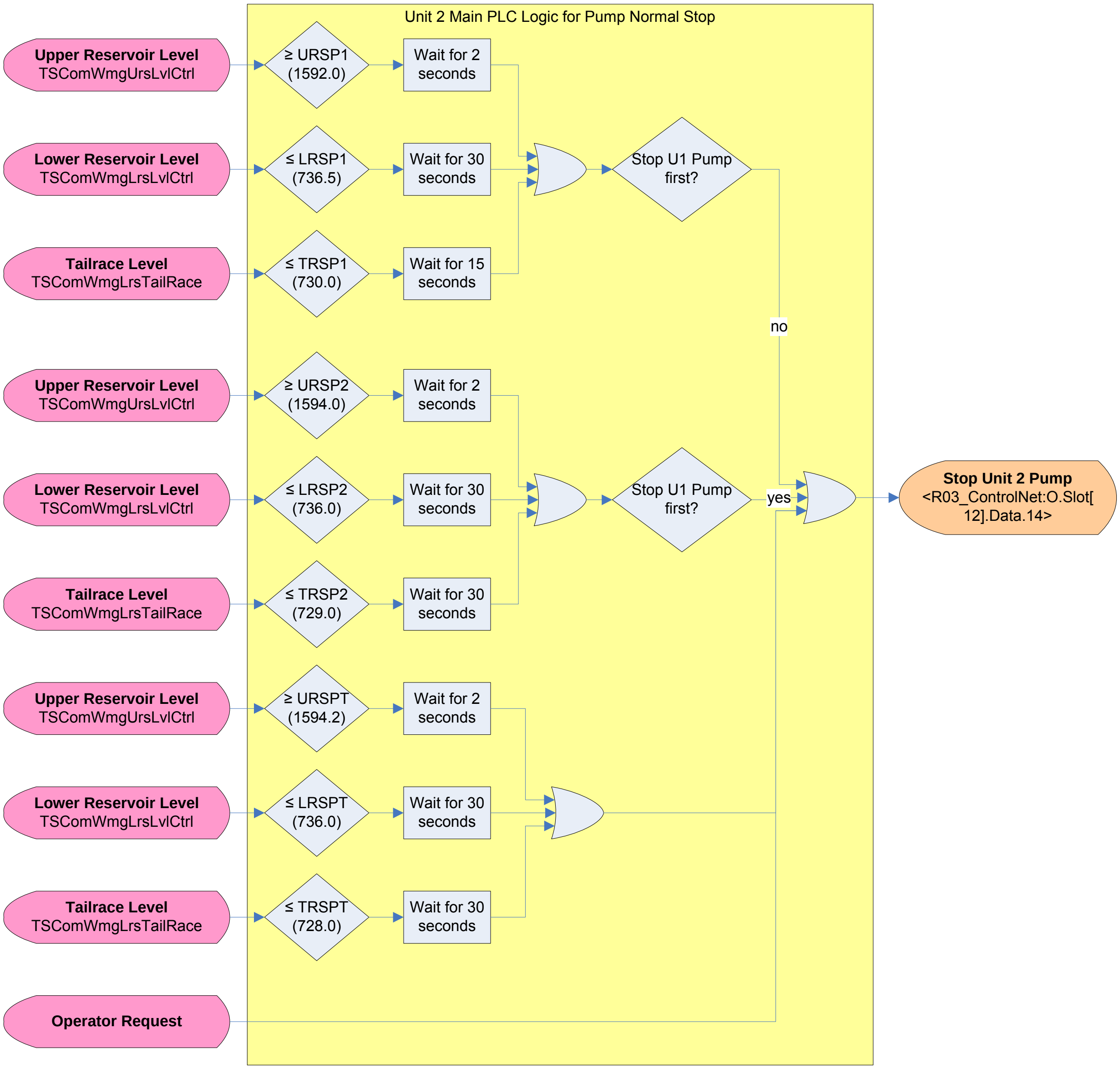

Figure 12: Unit 2 Main PLC Logic for Pump Stop

The logic for normal pump stop implemented in unit 2 main PLC is intended to stop pump #2 if the operator selectable set points for pump stop are exceeded. The effective set of setpoints is determined based on whether unit 2 is the first or the second unit to be shut down. The third set of setpoint is to shut down unit 2 regardless whether it has been selected to be shut down first or second. In any case, the signals need to exceed those setpoints for a pre-programmed period of time.

4.6. Instrumentation

4.6.1. Overview

The upper reservoir level instrumentation consists of 3 analog level transmitters and 4 discrete level probes, Low-Low, Low, Hi, and Hi-Hi. Only the Hi and Hi-Hi discrete sensors are utilized in the scheme to shut down the pumps on Hi reservoir level. In normal operation the PLC is to shut pumps off one at a time when the average of 2 of the analog level signals (one signal was disabled before the event) reach operator set setpoints. As a backup to the analog signals, the pumps are to be tripped if both the Hi and Hi-Hi probes sense water simultaneously for 60 seconds. A Hi-Hi level alarm is to be generated when the Hi-Hi probe senses water.

The 3 level transmitters and the Hi and Hi-Hi level probes were removed prior to the arrival of Siemens so information on this matter is based solely on interviews with Ameren personnel and documentation provided by Ameren.

4.6.1.1. Level Instrumentation Pipe Installation

Two HDPE pipes are utilized to hold in place and protect all of these instruments. Four pipes are installed (two are spares) into the upper reservoir and held against the liner per IMG121866 - Sketch SB1306-3 “Gage Pipe Supports As Constructed“. Also see the sidewall riser pipe cross-section detail on IMG013196 - Side Slope Relining Details III drawing 8304-X-155099 r5 for specifications of where holes were drilled into pipes. Also see the 15-Nov-04 photo of the pipe installation.

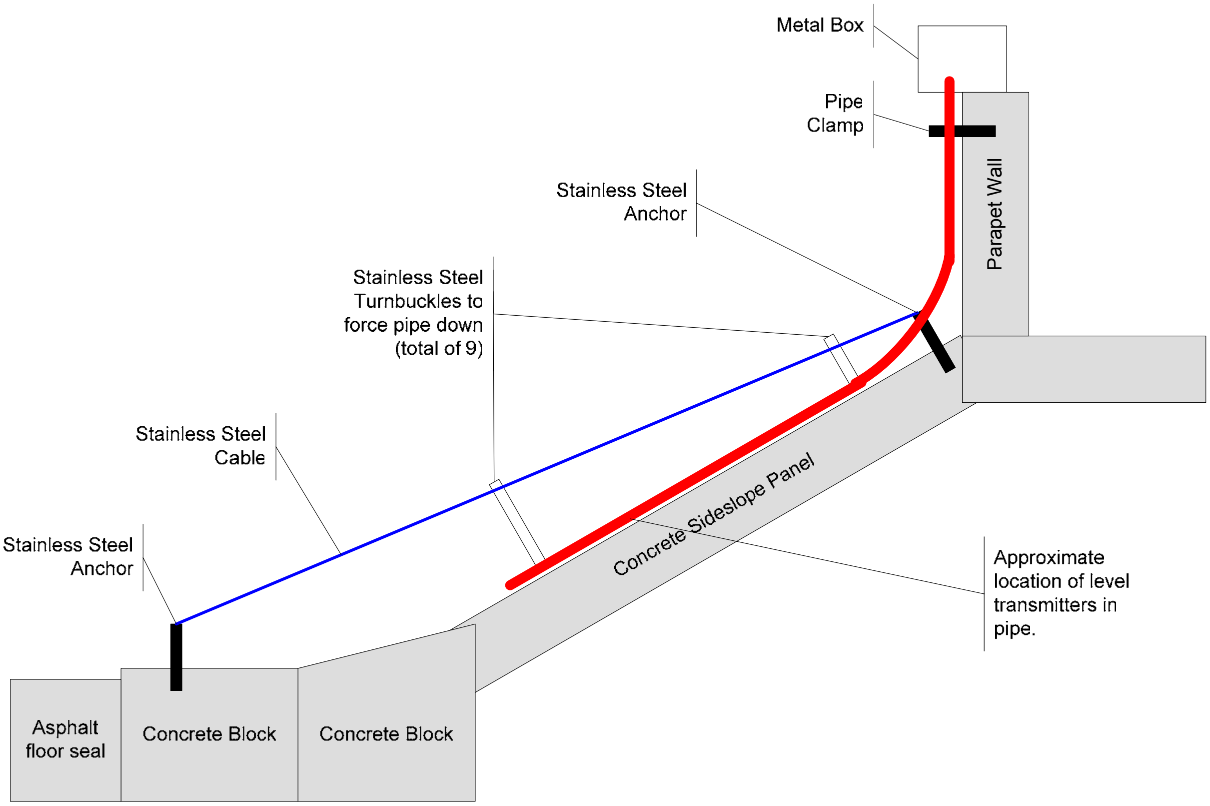

Figure 13: Instrumentation Pipe Installation Sketch

4.6.2. Analog Level Transmitters

4.6.2.1. Instruments Utilized

All 3 transmitters are GE Druck model PTX 1230 per IMG089629.01. This document also specifies their serial numbers and the PLC tag names associated with each. These transmitters are 4-20mA loop powered gauge pressure transmitters which are suspended in the water by their integral cable. These transmitters were supplied with 200 foot long cables and were calibrated at the factory to 0-100 psig. They measure the level of the water by measuring the pressure generated by the water above them referenced to atmospheric pressure. Maintaining these transmitters at a consistent vertical location is critical to proper operation of these devices. See product cutsheets IMG089630-089631 & other cut sheets. Each transmitter's 200 foot cable contains an air tube to provide the atmospheric pressure reference and 2 signal wires.

4.6.2.2. Installation

General
Refer to pipe installation drawings and photos referenced above. Also see the 16-Dec-2005 photo of cable hanging technique in upper reservoir instrument box and the 15-Dec-05 photo of transmitter cable air tube ends.

The three transmitter cables were tied together and all lowered to the same elevation, 1500 feet, about 15 feet above the bottom of the reservoir, where they hang by their cables in the northernmost of the 4 pipes. The uncut 200 foot long cables ran from the transmitters up through the transmitter box where they are supported using wire mesh cable grips. From there the cables ran though a pull box located below the upper reservoir instrument box where excess cable length was coiled. The cables were then routed to interface terminal blocks in the upper reservoir PLC panel. The ends of the vent tubes are located near these terminals in the upper reservoir PLC panel.

Protection of Pressure Transmitter Vent Tubes/Compensation for Barometric Pressure
Water or dirt in the vent tubes could cause significant errors in ambient pressure compensation. The ends of the vent tubes were located in the Upper Reservoir PLC control panel (see 15-Dec-05 photo). The Upper reservoir gauge house is heated in the winter and air conditioned in the summer. This helps to prevent condensation from forming and getting into the vent tubes. The heater in the gauge house was reported by Ameren personnel to have been working after the incident, and appeared to be working at Siemens' inpection. The pressure transmitter's manufacturer also recommends in the product literature that a dessicant be located in the panel with the vent tube ends. Dessicant was present upon Siemens inspection of the panel on 12-Jan-06. The upper reservoir PLC control panel is a gasketed and rated Nema 12 which is intended to provide protection against the ingress of dust and dripping liquids. It could also provide protection against bug nests, but it is not completely air tight. A photograph dated 15-Dec-05 (represented to Siemens to be the "as found" condition after the event), shows that the vent tubes were angled up which could invite entry of any dust and/or condensation present, however, the ends of the tubes appeared to be clean and dry. Also, the interior of the upper reservoir PLC cabinet appeared relatively clean and dry on Siemens's 12-Jan-06 visit. Given that, Siemens does not expect condensation or dirt build up on or in the vent tubes to have been an issue.

Bending Radius of Cable/Compensation for Barometric Pressure
Ameren engineers stated that no kinks or serious abrasions were found in the cables after the event. Photos of cables dated 16-Dec-05 provided to Siemens by Ameren showed a bending

radius of approximately 2”, i.e. about the same as the 4” diameter pipes (note these cables had been moved around after found). Although the instrument literature provided by Ameren and reviewed by Siemens did not indicate, Siemens contacted the manufacturer’s phone support (Rich Espisito 203-746-0400 on 1/19/06), which recommended a bending radius 6” or greater. Wire mesh cable grips were utilized to hang the cables to prevent kinking at the point of attachment. No as-found photos were given to Siemens for review of the bending radius where excess cable was coiled in a pull box, however Ameren engineers stated it to be approximately 1 foot (a 2’ diameter coil). A partial blockage could add some delay to the sensors ability to compensate for sudden atmospheric changes. A complete blockage could cause atmospheric pressure changes to be reflected as level changes by the transmitter. The weather data and the Wonderware data logs suggested no impact on level measurement due to change in barometric pressure. On 12/9/05 at 11:35 AM the instrumentation reading for Barometric pressure was 30.48 inches of mercury. The instrumentation indicated that barometric pressure fell steeply to 29.87 inches of mercury on 12/10/05 at 9 PM. During a portion of this time the UR fill level should have remained level since there was no generation or pumping activity. The Wonderware data for that time period did indeed (other than noise attributed to wave action) reflect no level change. Siemens therefore believes that the barometric pressure compensation of the transmitter was likely to be working properly.

Transmitter Cable Elongation effects

The cables are constructed with kevlar to prevent the cable from stretching due to the weight of the hanging transmitter. Siemens questioned the manufacturer’s technical phone support (see reference above), who did not indicate that there were any additional inaccuracy issues due to expansion and contraction of the cable length with temperature.

Installation in Pipe

According to installation drawings and pictures presented by Ameren, the transmitters were installed into a pipe with the holes per the installation drawings. If clogged, these pipes could impact the ability of the transmitters to accurately measure the reservoir level. Ameren engineers reported that they found no significant clogging throughout the length of the as-found level transmitter pipe. They reported that they checked for clogging with a borescope and by cutting a few large holes into the pipe (see photo marked 15-Dec-05). Ameren engineers also reported that the as-found 0.5” water passage holes drilled in the pipes showed no significant signs of clogging. Based on these reports, Siemens does not believe that this pipe served as a stilling well.

Holes in Nose Cone of Transmitter

The transmitter is provided with a nose cone that has small holes in it to allow water pressure to reach the sensor. Ameren engineers reported that these holes were observed to be significantly clogged after post-event removal of the transmitters from the pipe. They reported that these holes became clogged during the removal process. Siemens would expect that a total blockage of these holes could prevent the transmitters from registering level changes. This would appear to be contradicted by the data logs which suggest that the levels were changing. A partial blockage may have resulted in delayed pressure sensing. If the clogging was significant it is possible that the amount of clogging of each of the transmitters could vary and thus the amount of delay could vary as well. Since the data logs show all 3 transmitters’ outputs to be tracking well with one another it does not appear likely that the holes were clogged.

Expansion and Contraction of Pipes

The HDPE pipe experiences a broad range of temperatures throughout the year, from exposure to bright sunlight in the summer to cold winter air temperatures. At the 1500’ elevation, where the transmitters are located, several holes are drilled into the top of the pipe that allow for visual placement of the transmitters. There is a set of ½" holes around the pipe 1 foot (along the pipe) above and 7 foot below (along the pipe) the 1500 foot elevation. The 3 transmitters are each 0.69" in diameter and the pipe's inside diameter is 4.0" so they were not a tight fit. The pipe has a smooth interior and as reported to Siemens by Ameren engineers the transmitters slid easily up and down during installation and removal. Since the transmitters are suspended from the top and basically hanging in the pipe it is seems reasonable to assume that the transmitters would slide along the interior of the pipe without effect on their location even if the pipe's length changed considerably unless the expansion and contraction was enough to get them to hang up on the ½" holes located 1 foot above their normal height.

Loop Power Voltage
Proper operation of the transmitters is based on a proper loop power supply voltage. It was measured to be 24.0VDC on 2/2/06, and this is within the 10-30VDC range specified by the analog transmitter manufacturer's information provided by Ameren. Transmitter testing verified repeatable operation of the transmitter throughout the entirety of the supply voltage range.

Current Loop Load Impedance
The impedance of each current loop is the sum of the input impedance of the Allen Bradley 1796-IF4 analog input card (250 ohms) and the round trip resistance of the 200 foot cable. The cable was a 24AWG copper cable per GE Druck phone support (Rich Espisito 203-746-0400 on 2/3/06). The round trip resistance of the cable would be approximately 51 ohms. A total of 301 ohms falls within the operating area specified by the GE Druck instructions.

UR Analog Input Card Accuracy/Repeatability/Temperature Effects
The analog input card utilized is an Allen Bradley 1769-IF4 per the electrical schematic and Interconnection diagrams. The specifications of this module are given on page A-3 of the Compact I/O Analog Module User Manual, Allen Bradley Publication 1769-UM002B-EN-P - July 2005. Separate specifications are given for the accuracy, temperature drift and repeatability of this module. Siemens assumed that any inaccuracy was compensated for during the commissioning of the equipment and Siemens therefore does not include it in its analysis. The manufacturer's repeatability specification provided to Siemens stated plus or minus .03% of full scale. The accuracy drift with temperature was plus or minus 0.0045% per degree C. No actual data was provided to Siemens regarding the temperature of UR building. Since the UR building is climate controlled (heated and air conditioned with a thermostat) and since Ameren engineers reported that the heater was working immediately after the incident, Siemens assumed an internal building temperature of 25 degrees C plus or minus 5 degrees. The UR PLC panel is equipped with a cooling fan that exchanges building air with internal panel air intended to minimize the temperature rise above ambient in the panel, however even with the fan the internal temperature of the control panel would be somewhat higher than the room. Siemens assumed a temperature rise of 10 degrees C which would result in a maximum assumed variation of plus 15 degrees C. Therefore, with the climate control working properly one could reasonably expect to see a variation in the level measurement of around plus or minus 1-3 inches of water due to the inaccuracies of the analog input card. If the heater, air conditioner or PLC panel cooling fan ever failed the affects would be much greater. As this variance is plus or minus, this could also have provided a small favorable margin. In summary, assuming that the HVAC and PLC cooling systems were functional and operating as intended at the time of the event, Siemens believes the effect of potential accuracy variation to be negligible.

Breakage of Instrumentation Pipe Supports
IMG069851 – photos marked 15-Dec-05 of the instrumentation pipes show breakage of pipe supports and significant bending of the pipes which would have raised the position of the

transmitter above its original elevation of 1500 feet and made it read a lower than actual level. Pipes in the photo marked as 16-Dec-05 were substantially straighter than those in the photos marked 15-Dec-05 and as observed by Siemens on 12-Jan-06, the pipes appeared to be further straightened. As reported to Siemens by Ameren engineers, these pipes straightened on their own. Ameren provided Siemens what they represented to be a rough calculation based on the 15-Dec-05 pipe position showing a rise in transmitter elevation of at least 2.54 feet at the time of the event (see sketch below). This rise would result in an analog reading of at least 2.54 feet low. Based on the straightening observations and the fact that the pipes were buoyant it is reasonable to assume that the pipes were even more curved at the time of the event causing an even larger corresponding error. Ameren engineers performed further analysis which considered the number of failed clamp/unistrut assemblies. Based on this analysis, the maximum lift could have been significantly higher. However based on the historical data analysis, a lift of more than 4 feet seems to be unlikely (see chapter 5.2.3).

The analog transmitter calibration was checked during the initial filling of the upper reservoir and an adjustment factors were put into the PLC code to compensate for the error in elevation placement or signal output of the transmitters. Another adjustment factor of 0.4 ft was added to the PLC's level calculation to recalibrate the transmitters on 9/27/05. This 0.4 feet may take into account some of this bend since just 1 week later on 10/03/05 the breakage of supports and bowing of the pipes was reported by Ameren to have been noticed.

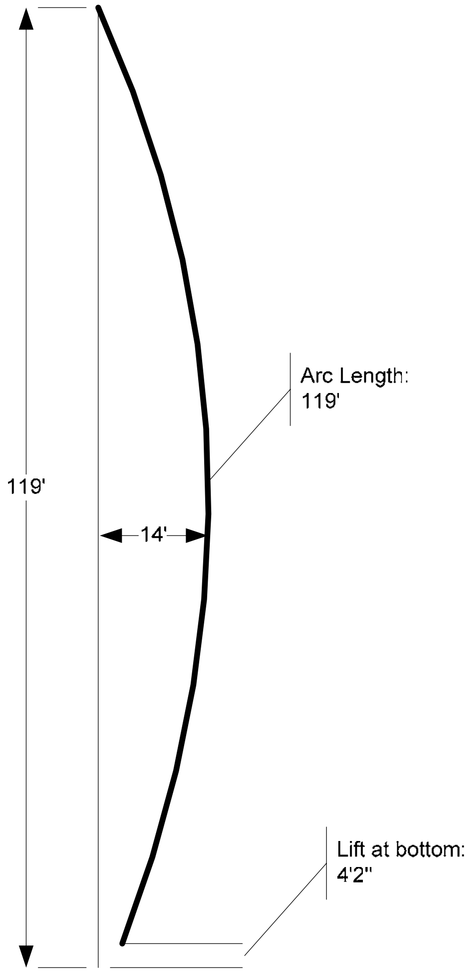

Figure 14: Instrument Pipe Bow Sketch

4.6.2.3. Level Transmitter Testing

Ameren and Siemens jointly designed and supervised testing of the level transmitters at the manufacturer's facility to determine the potential affects of transmitter repeatability, accuracy and sensitivity to temperature variations. The results of those tests are summarized in this section.
The analysis is focused on the transmitters TX2 and TX3 which were used for level control during the event.

Accuracy of test equipment

- The applied pressure had a variability of +/- 0.0075 psig
- The measurement device used to measure the signal output had a variability of +/- 0.0012mA which equals 0.0075 psig
- Total uncertainty (sum of the above): +/- .015 psig= 0.035 ft water

Transmitter Repeatability Tests:

In order to validate the repeatability of the transmitters, the mA output of the transmitters was measured three times at pressures between 0 and 100 psi. The measurements were made at a temperature of 5 degrees Celsius, the water temperature at the event.

As the following two charts demonstrate that the transmitter outputs were very repeatable:

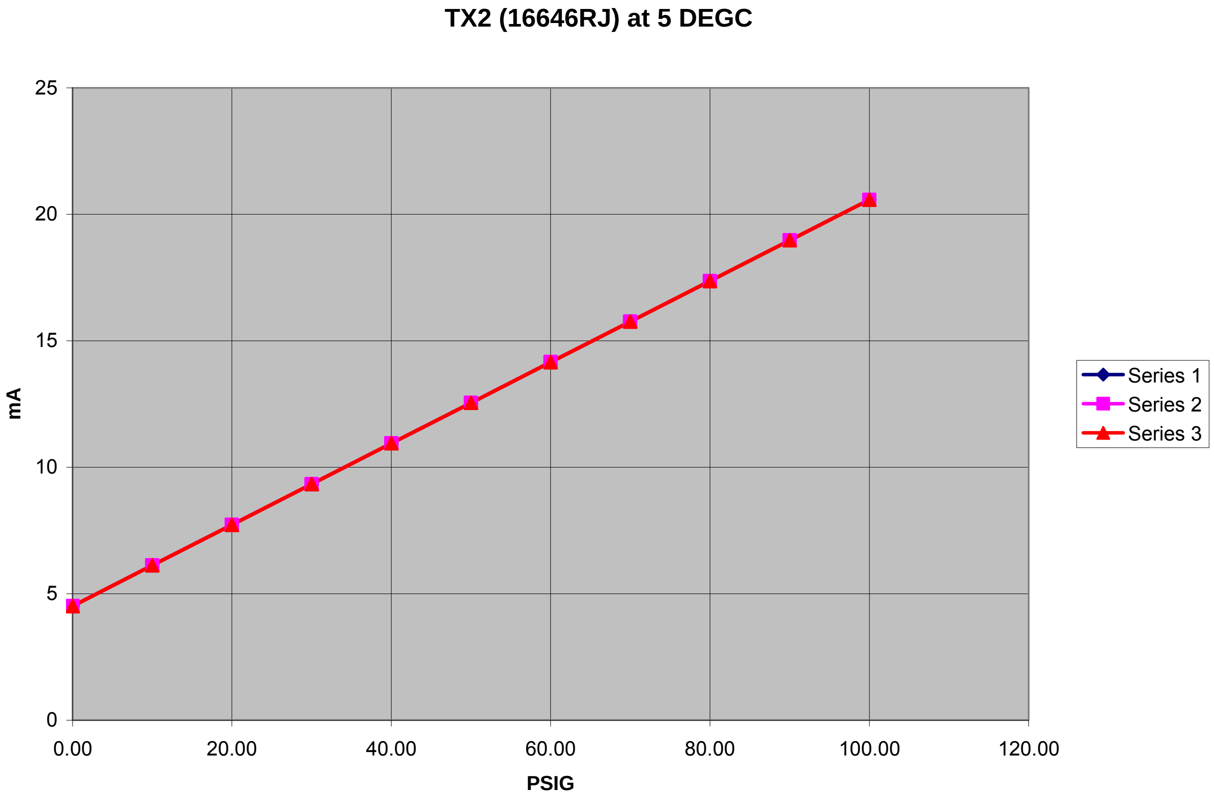

Figure 15: TX2 (16646RJ) Repeatability Test

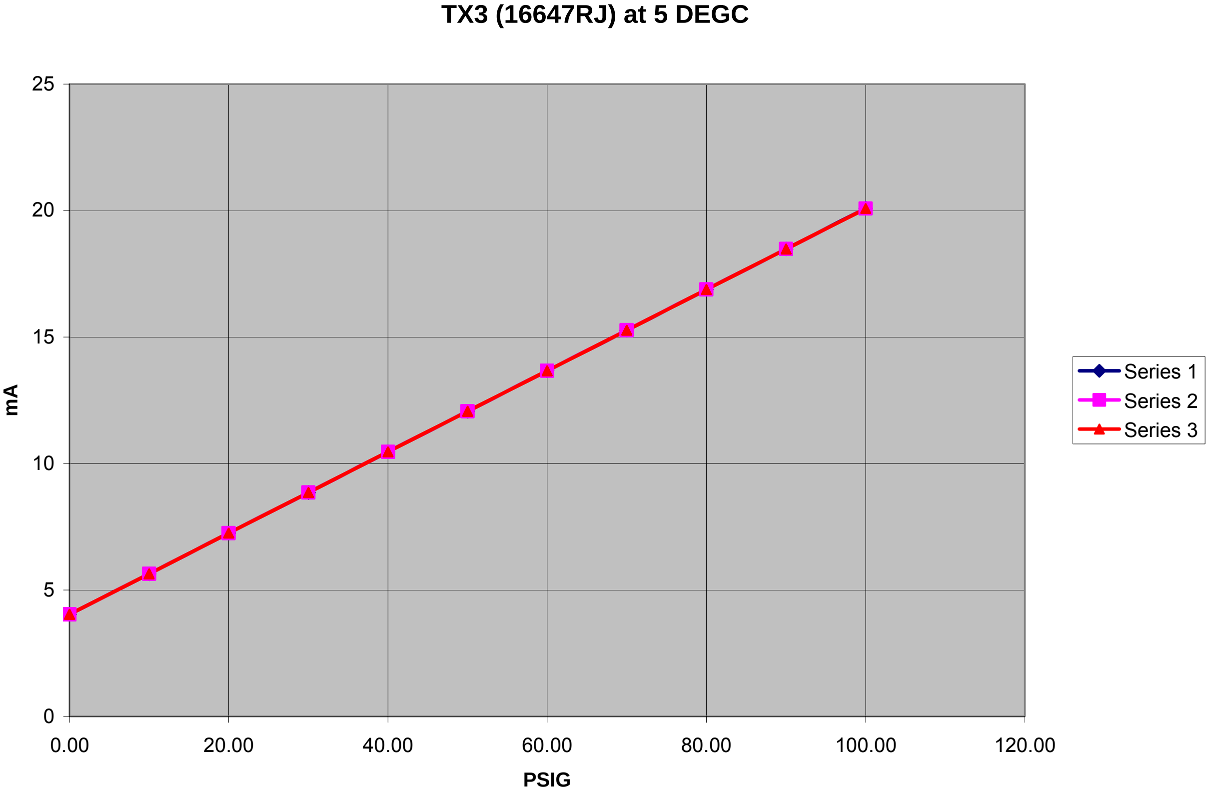

Figure 16: TX3 (16647RJ) Repeatability Test

Transmitter Linearity and Accuracy:

Since the transmitter range was 0 to 100 psig, an optimal transmitter would generate an output of 4 mA at 0 psig and 20 mA at 100 psig. The following two figures compare the measurement series 1 of the charts above for TX2 and TX3 with an optimal transmitter:

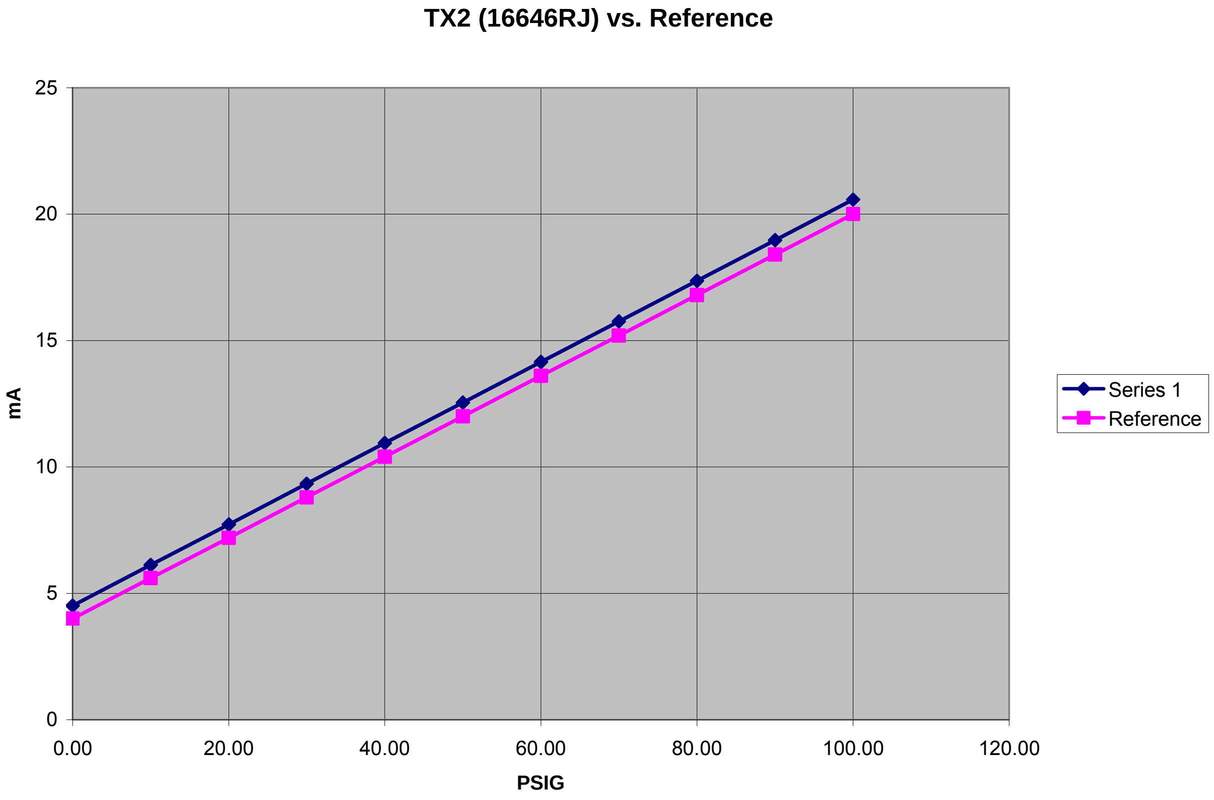

Figure 17: TX2 (16646RJ) vs. Reference

TX2 relates to the reference transmitter with a correlation coefficient of 0.99999994. This means that it is very linear. The average difference between TX2 and the reference transmitter is 0.545338 mA which equates to approx. 7.86 feet of water level at 5 degree Celsius.

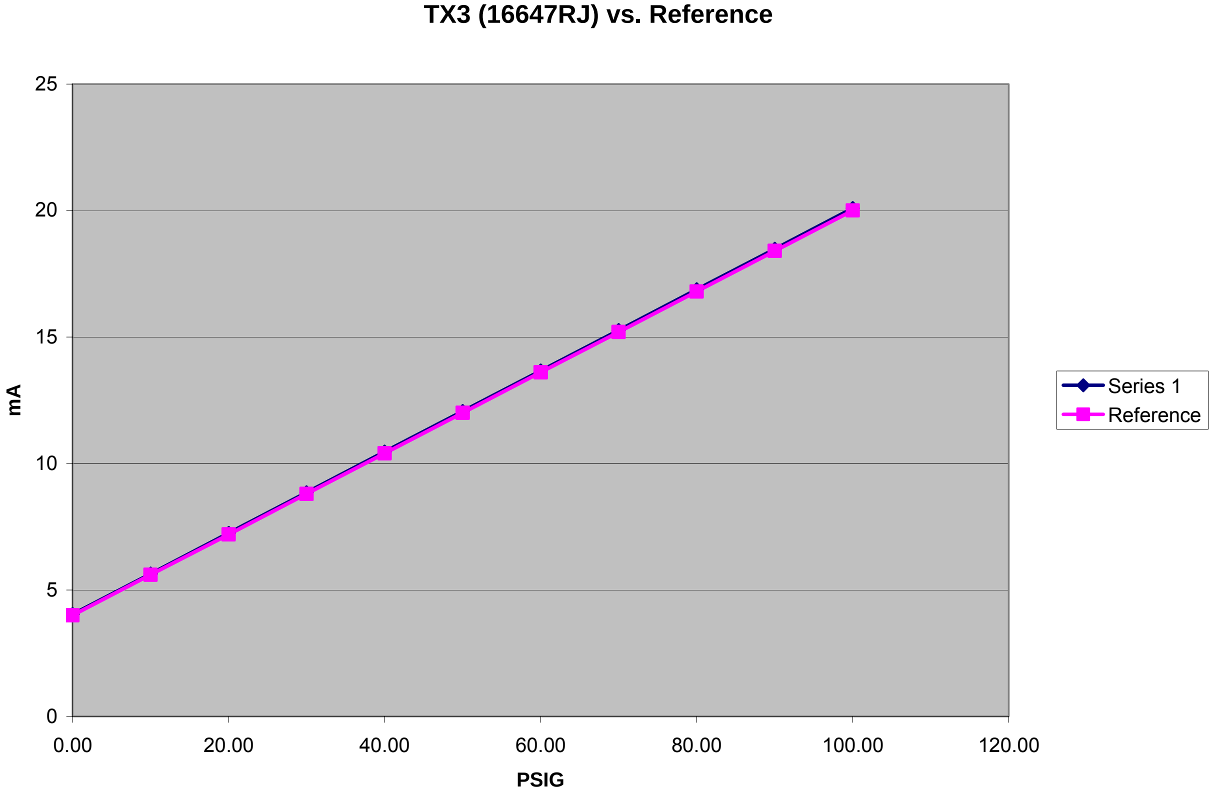

Figure 18: TX3 (16647RJ) vs. Reference

TX3 relates to the reference transmitter with a correlation coefficient of 0.99999996. This means that it is very linear as well. The average difference between TX3 and the reference transmitter is 0.059567 mA which equates to approx. 0.85 feet of water level at 5 degree Celsius.

Temperature Effects:

The following charts show the output of the transmitters TX2 and TX3 at 40 psig at different temperatures (two measurements for each temperature).

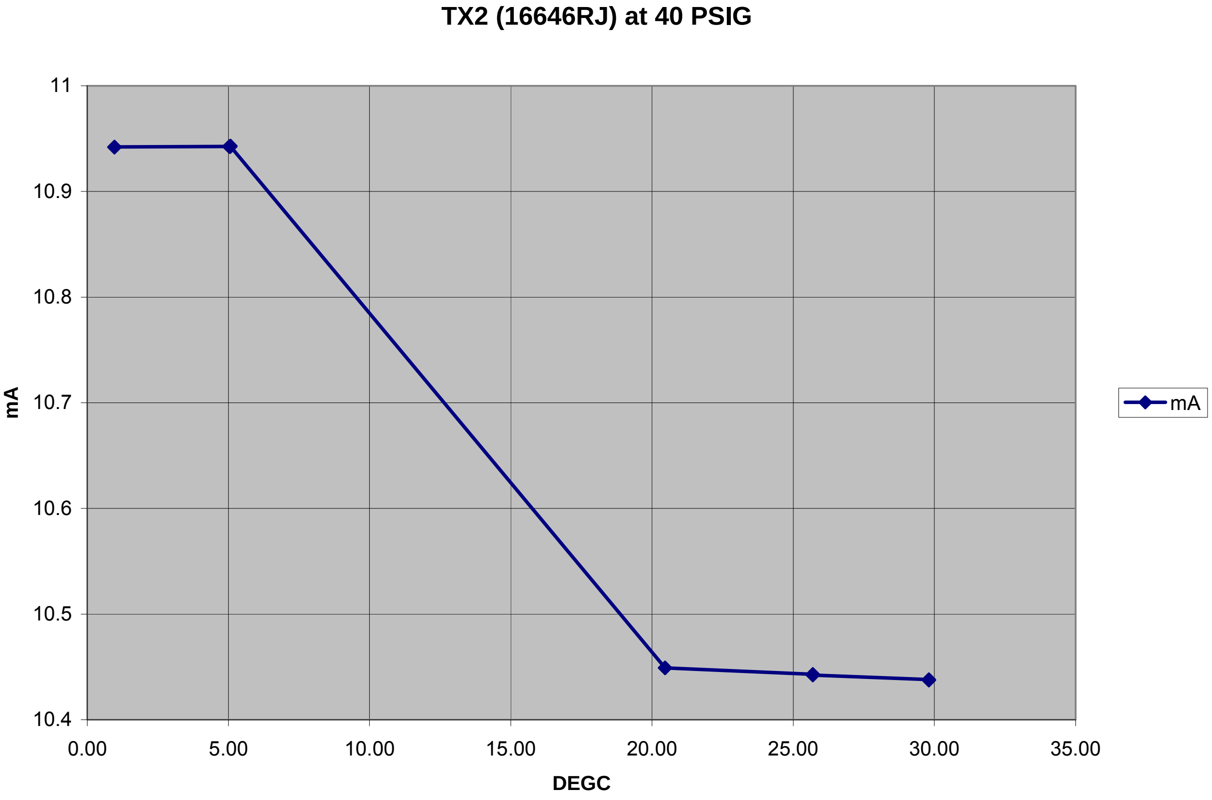

Figure 19: Temperature Sensitivity of TX2

One can see that there is a 0.5 mA step change between 5 degrees Celsius and 20 degrees Celsius. This 0.5 mA change equates to approx. 7.11 feet of water level (at 5 degrees Celsius).

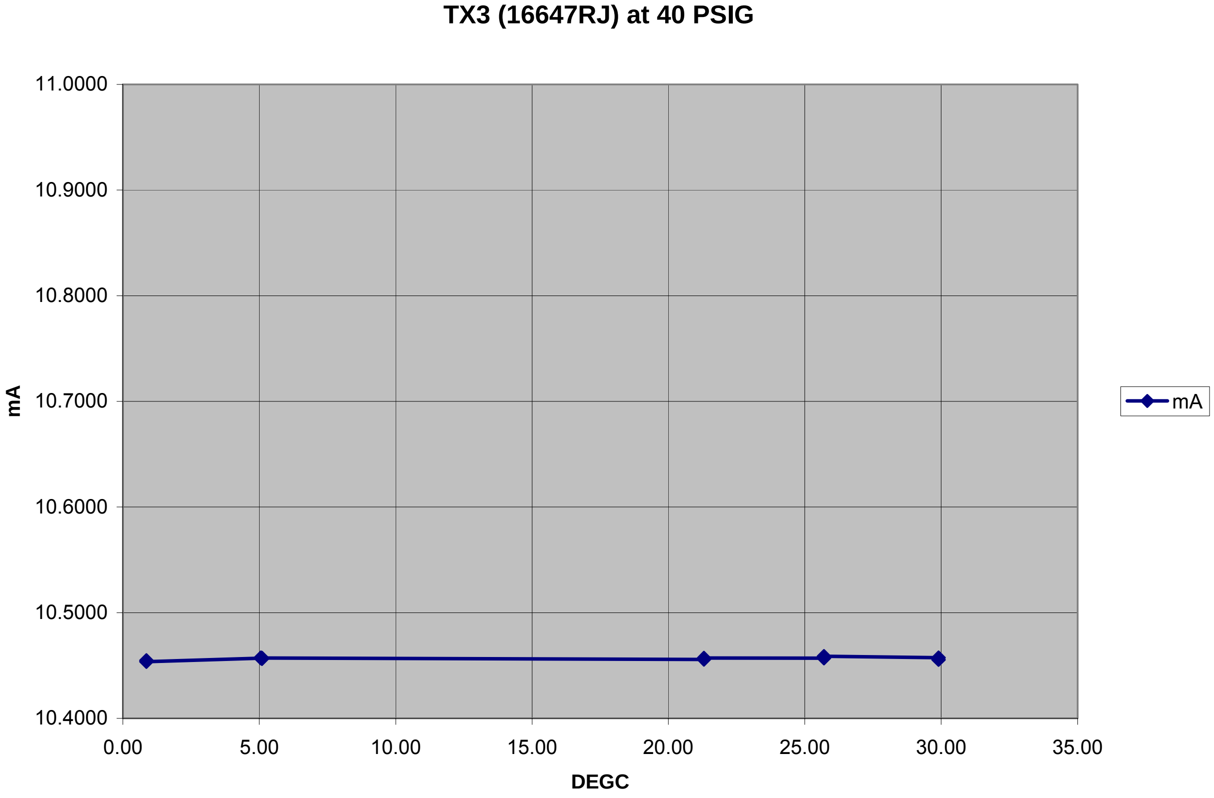

Figure 20: Temperature Sensitivity of TX3

TX3 is less sensitive to temperature changes.

Test Results Analysis:

As discussed in chapter 4.5.1, the as-found PLC logic in the upper reservoir PLC, computed the upper reservoir level as (((TX2 – 9.38) + (TX3 – 2.4)) / 2) + 0.4.
Since TX2 was reading an average of 7.86 feet too high and TX3 was reading an average of 0.85 feet too high, the PLC logic was subtracting more than necessary from the measured values. This would potentially cause the calculated average upper reservoir level reading too low. However, Ameren staff visually inspected the reservoir level on 27-Sep-05 and adjusted the PLC logic to match the upper reservoir level. This adjustment was performed at an approximate water temperature of 25 degrees Celsius. The temperature sensitivity of TX2 causes TX2 to indicate a lower water level at 20 degrees Celsius compared to a water temperature of 5 degrees Celsius (the approximate water temperature at the time of the incident). Therefore, the water level indicated by TX2 at the time of the event would be higher, which is favorable in this context.
Based on the test recordings and the other observations referenced above, it can be determined that the level transmitter repeatability, accuracy and temperature sensitivity did not adversely contribute to the incident.

4.6.3. Hi and HI-Hi Discrete Level Probes

4.6.3.1. Instruments Utilized

The electrical schematic and interconnection diagram state that the four conductivity based point level probes (Hi, Hi-Hi, Low and Low-Low) share a common reference probe and are each associated with their own individual controller. The cut sheet provided, IMG089629.01, states that all 4 level probes and the reference probe are GEMS Warrick Model 3W2 and that the controllers are GEMS Warrick Series 1 electromechanical type model 1H1DO. As reported to Siemens by Ameren engineers the insulated cable used was GEMS Warrick 3Z1A. IMG089629.01 also specifies the PLC tag names associated with each probe.

Each probe consists essentially of a piece of stainless steel rod suspended by an insulated wire. Each controller develops 300VAC between its unique probe and the common reference probe. This voltage is used to sense continuity between the probes. The sensitivity of the controllers selected is matched to the conductivity of natural lake water so that when water is present between the probes they energize their output relay to close a normally open dry contact which provides a signal to the associated PLC input. When no water is between the probes there is not enough conductivity and the controller's output relay de-energizes and returns its contacts to open state.

4.6.3.2. Installation

Refer to pipe installation drawings and photos provided by Ameren and referenced in the level instrumentation pipe installation section above. Also see the photo marked 16-Dec-2005 of cable hanging technique in upper reservoir instrument box. According to these drawings and photos, all five probes were installed into second northernmost pipe. According to the as-found black tape markers, the bottom of the probes were measured and calculated by Siemens to be installed at the following elevations: Hi probe 1597.3 feet and Hi-Hi probe 1597.7 feet (see sketch below). Ameren engineers stated that the as-found reference probe was located at 1515 feet, and that cables suspending the probes ran up the instrument pipe to the instrument box where they were supported with wire mesh cable grips. From there the drawings and photos indicate that the cables run through conduit to the Upper Reservoir PLC cabinet where they are terminated directly onto the terminals of their respective Warrick controllers. The ladder located a few feet from the Hi and Hi-Hi probes was reported to be grounded so it acted as an additional reference probe since the reference terminal of the Warricks was also tied to ground according to information provided by Ameren.

Probe Elevation with Respect to Top of Parapet Wall

The elevation reported of the top of the parapet wall at the instrument box is 1598.0 feet, however the elevation of the lowest part of the wall was only 1597.0 feet (according to drawings provided by Ameren), 0.3 and 0.7 feet below where the Hi and Hi-Hi sensors were located respectively. If this is the case, water would have passed over the lower portions of the parapet wall before these probes would have sensed water. No reference markings showing wall elevation and low point wall elevation were found near the location where the sensors would be adjusted.

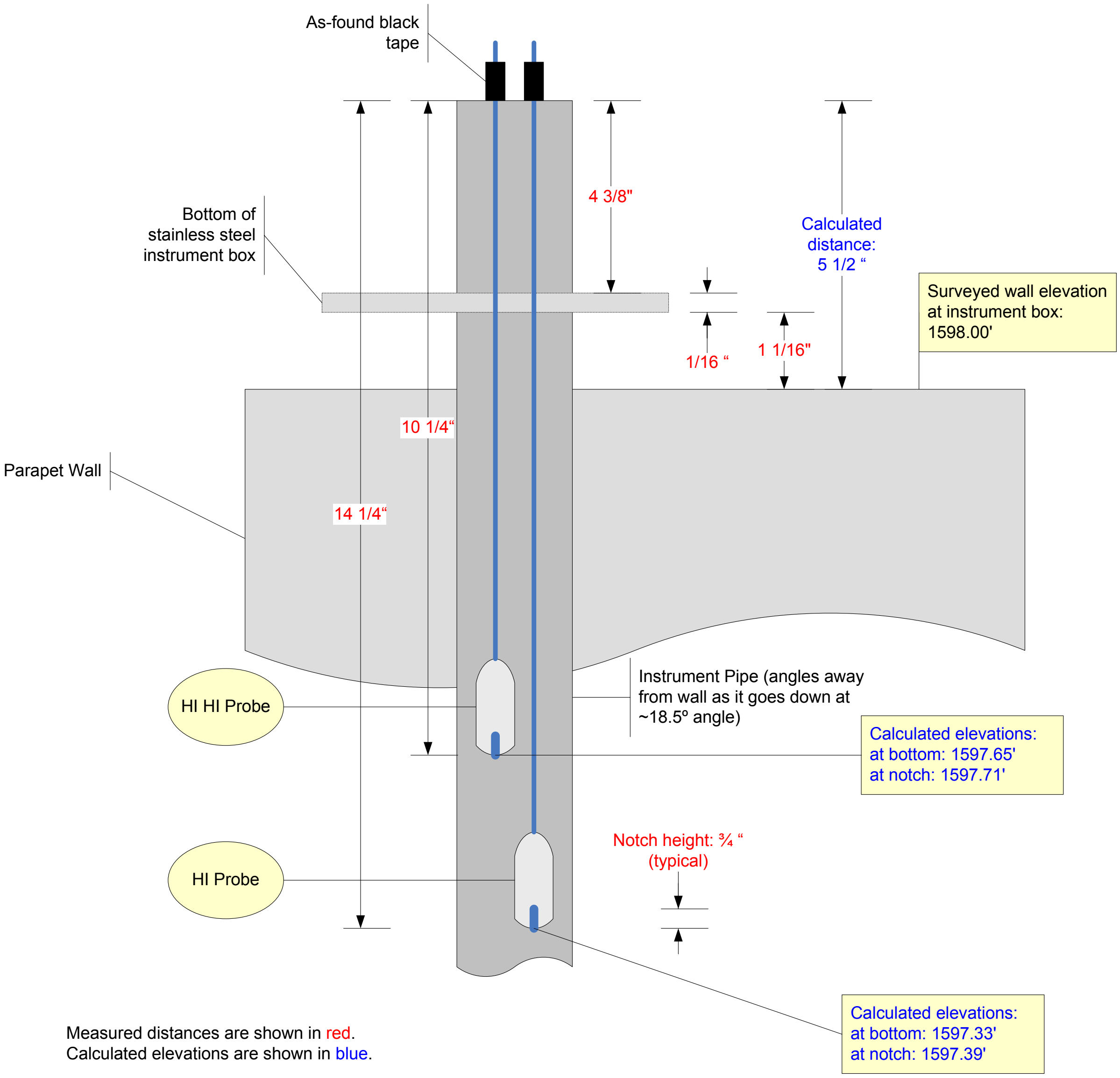

Figure 21: Level Probe Elevation Calculation

Distance between reference and sensing probe

Per the Warrick instruction manual page D3, Note 2 the total resistance must not exceed the sensitivity of the control. The letter D in the part number 1H1DO specifies the sensitivity of the control to be 7.0K ohms. The manufacturer's technical phone support person (Tom James 860-793-4545 1/27/06) said that the probes could be spaced up to four feet apart. The Hi-Hi probe was located worst case approximately 113 feet from the reference probe. The Hi probe was slightly closer to the reference probe. Ameren engineers stated that they successfully tested the operation of these probes by lowering them into the water when it was at a level of 1593.5 foot elevation (This tested an approximate worst case actual distance of 107 feet). Ameren engineers also stated that on 1/6/06 a spare controller operated properly at 125 feet in the lower reservoir using lengths of #10AWG wire stripped 1" from the end as the probes. Further post as-found testing conducted on 2/2/06 by Ameren and Siemens of the actual Hi and Hi-Hi probes and controllers showed that they were operational at a distance of approximately 200 feet.

Based on this test, Siemens believes that the probes would have operated correctly as intended if they had detected water.

Cable Length Limitations

The manufacturer recommends limiting the cable length of probes to a maximum of 500 feet with the 1H1DO controllers. Per 2/2/06 measurements perfomed by Ameren and Siemens the as-found cable lengths were: Hi - 37 feet 7 inches long, HI-Hi - 38 feet 3 inches and reference 196 feet long. The total length of cable is the sum of the reference probe and the signal probe. If these measurements are correct, these are within the manufacturer's stated maximum limit.

Potential Problems Due to Freezing

According to data provided by Ameren, temperatures were below freezing the evening of 12/12/05 starting at around 9 PM through noon on the 12/13/05 as well as the morning of the incident starting around 3 AM through the time of the incident. However, the plant was either generating or pumping during the entire time freezing temperatures existed. Water movement during these time periods would most likely have kept water from freezing in the instrumentation pipes. In the unlikely event that ice had formed on the probes, testing conducted by Ameren and Siemens on 2/2/06 suggested that the probes could have still worked regardless of the ice in the pipes.

5. Upper Reservoir Level Transmitter Data Analysis

All analysis is based on one minute archived data received from Ameren.

5.1. Upper Reservoir Transmitter Noise

The following chart shows the average transmitter reading (calculated in the PLC as the average of TX2 and TX3) on 11-Dec-05 between 09:20 and 09:46. The maximum variation is 0.1 feet. The last pump stopped at 07:50am on this morning. The data sample started 90 minutes after the last stop. It should be expected that there was no movement of the reservoir level.

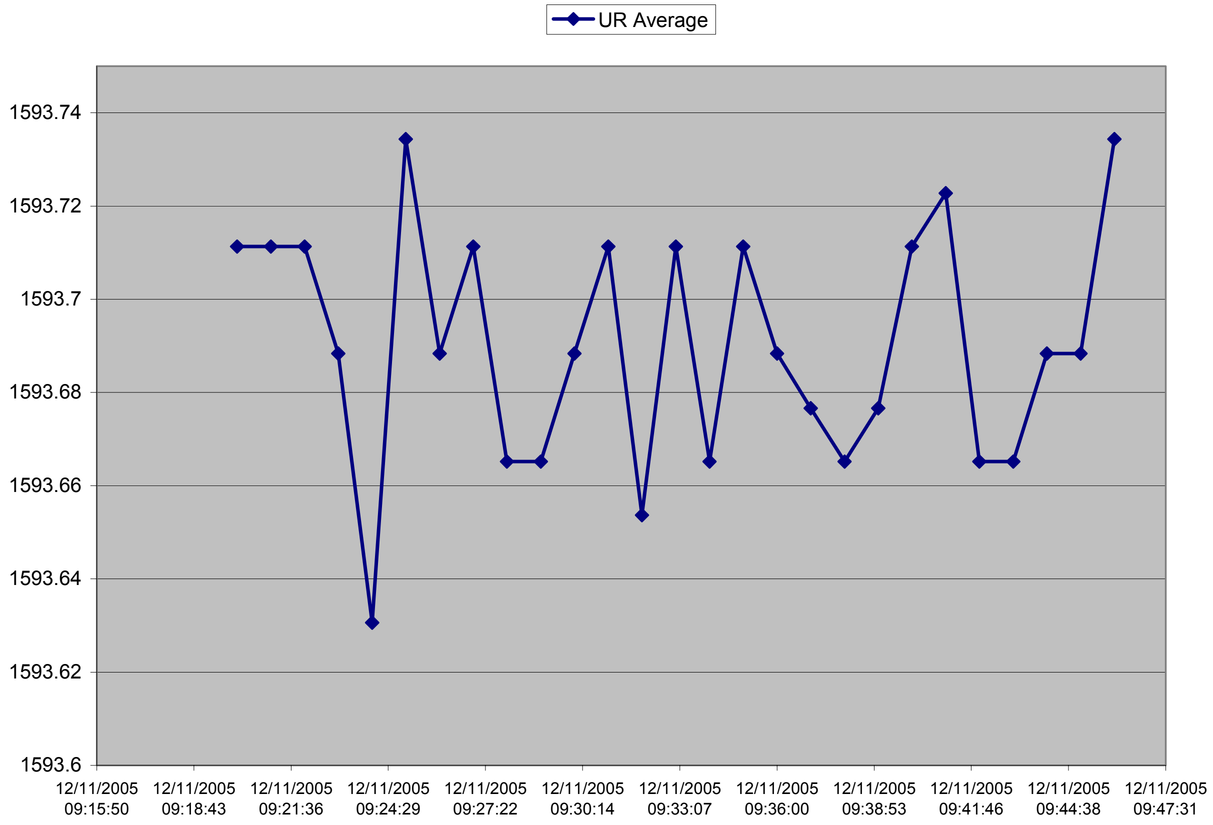

Figure 22: Average UR Transmitter Reading on 11-Dec-05 between 09:20 and 09:46

The following chart shows the individual transmitter readings for the same time period (note that TX1 was not used for the calculation of the average value):

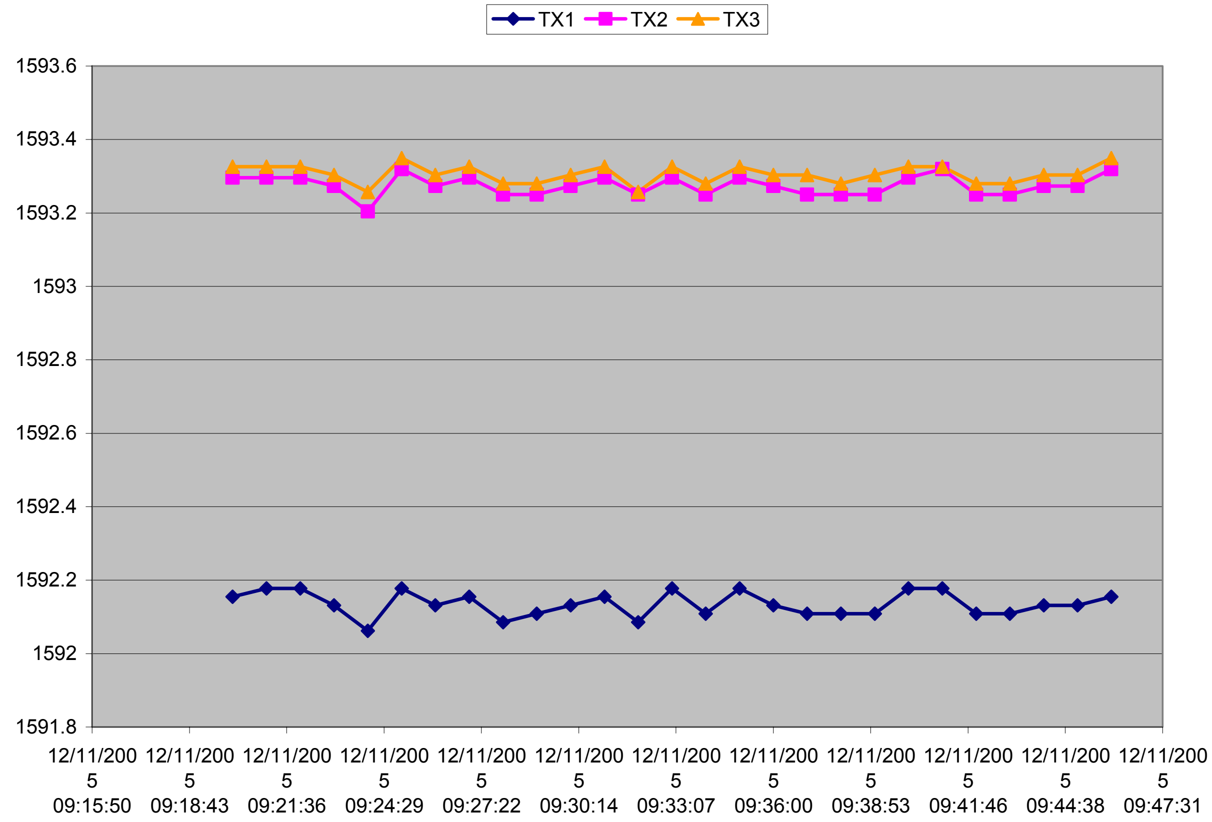

Figure 23: Individual UR Transmitter Reading on 11-Dec-05 between 09:20 and 09:46

This data indicates that all three transmitter readings are moving in parallel. This becomes more evident if the one minute value changes are plotted (here for TX2 and TX3 which were actually used for level control):

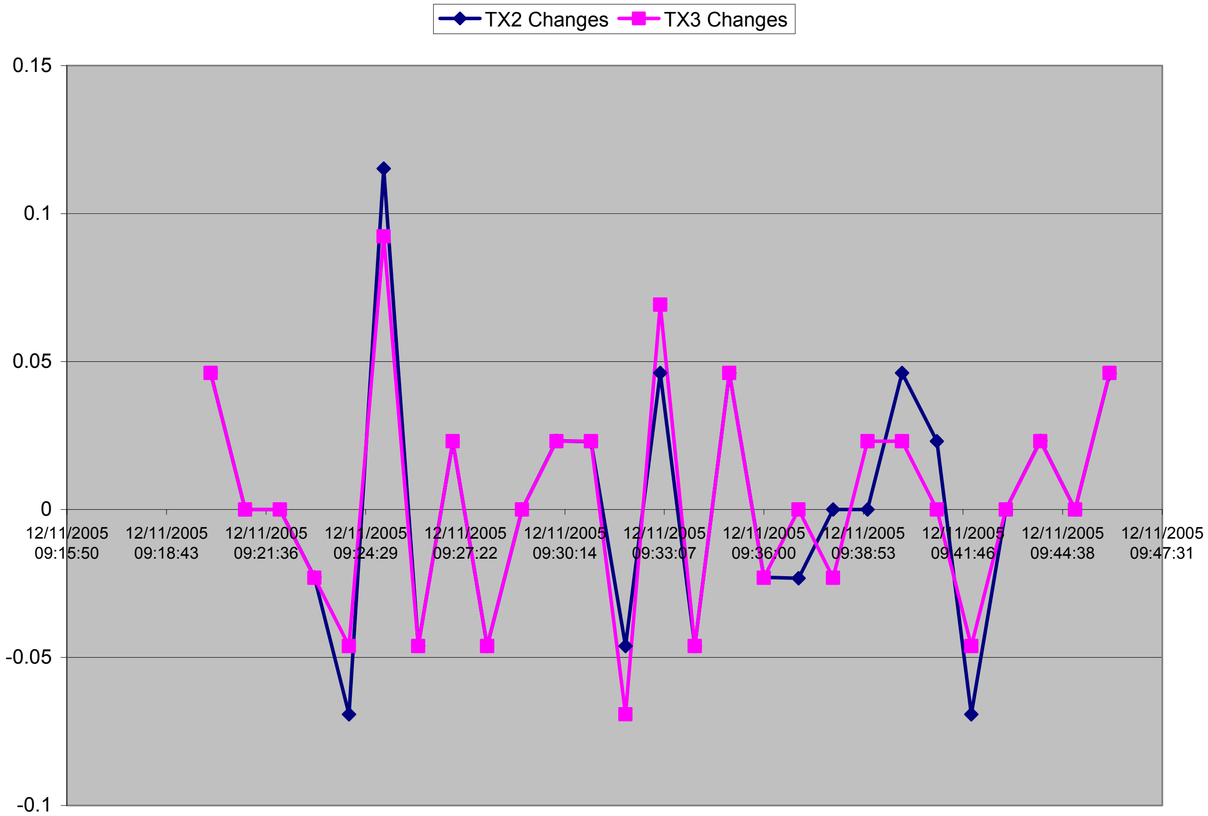

Figure 24: Individual UR Transmitter Reading Changes on 11-Dec-05

Several time intervals with different reservoir levels were reviewed. In all cases, a signal variation of ± 0.1 - 0.15 feet was observed.

Since all three transmitters are moving in parallel, these observations can not be explained with random noise. Siemens assumes that the value changes may have been caused by wave action which either caused actual depth changes sensed by the transmitters or which caused movement of the transmitters generating false noise.

5.2. Comparison between the Upper Reservoir Level and the Penstock Level

The following chart shows the UR level compared to the Penstock head during calm plant conditions (no generation or pumping) for the month of September 2005. The chart indicates that the head measured by the Penstock transmitter is closely correlated to upper reservoir level:

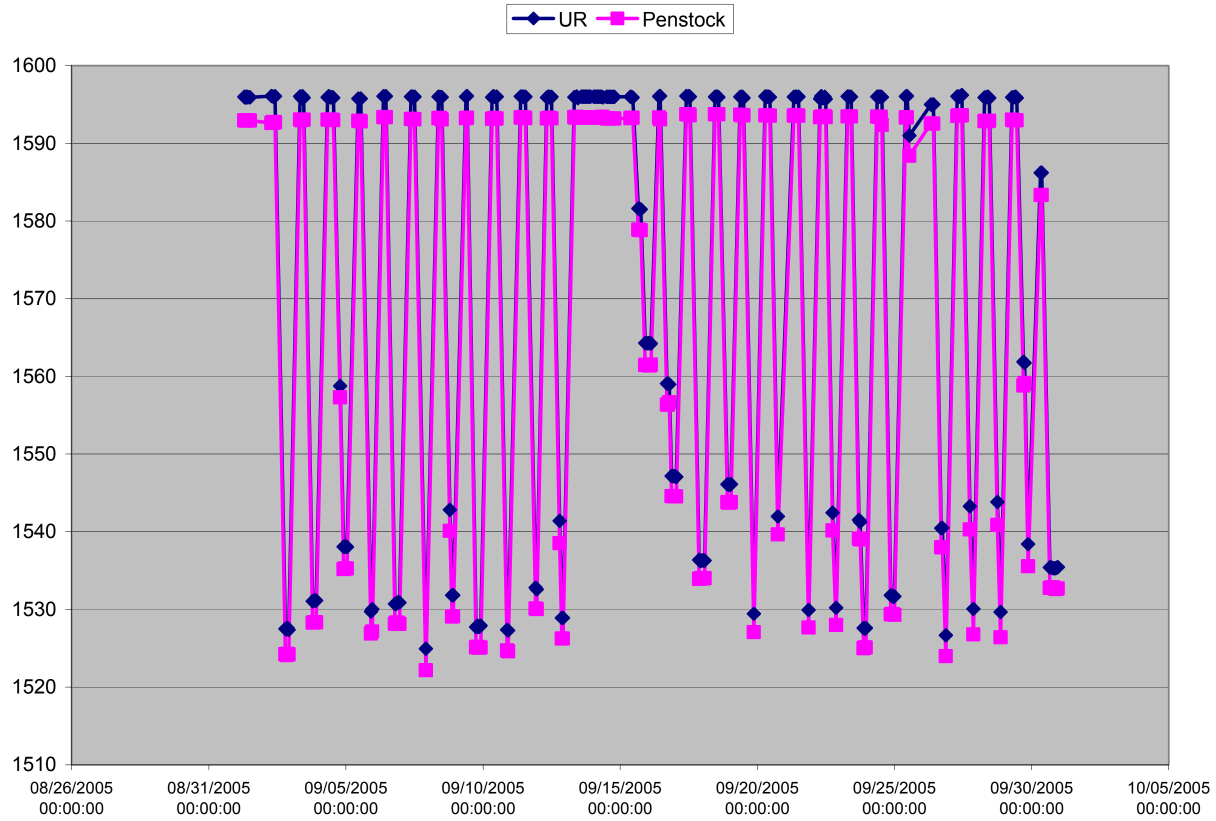

Figure 25: Comparison between UR Average and PS Level Transmitter Readings

The head measured by the penstock transmitter is not suitable for use as a level measurement while the Unit is operating as the measured pressure includes water flow and penstock loss affects that make an upper reservoir level correlation difficult.

5.2.1. Penstock Transmitter Quality

The following chart shows the readings of the UR level transmitter average vs. the PS head transmitter on 11-Dec-05 between 09:20 and 09:46 (the same time range was used as an example for the UR level transmitter noise discussion above):

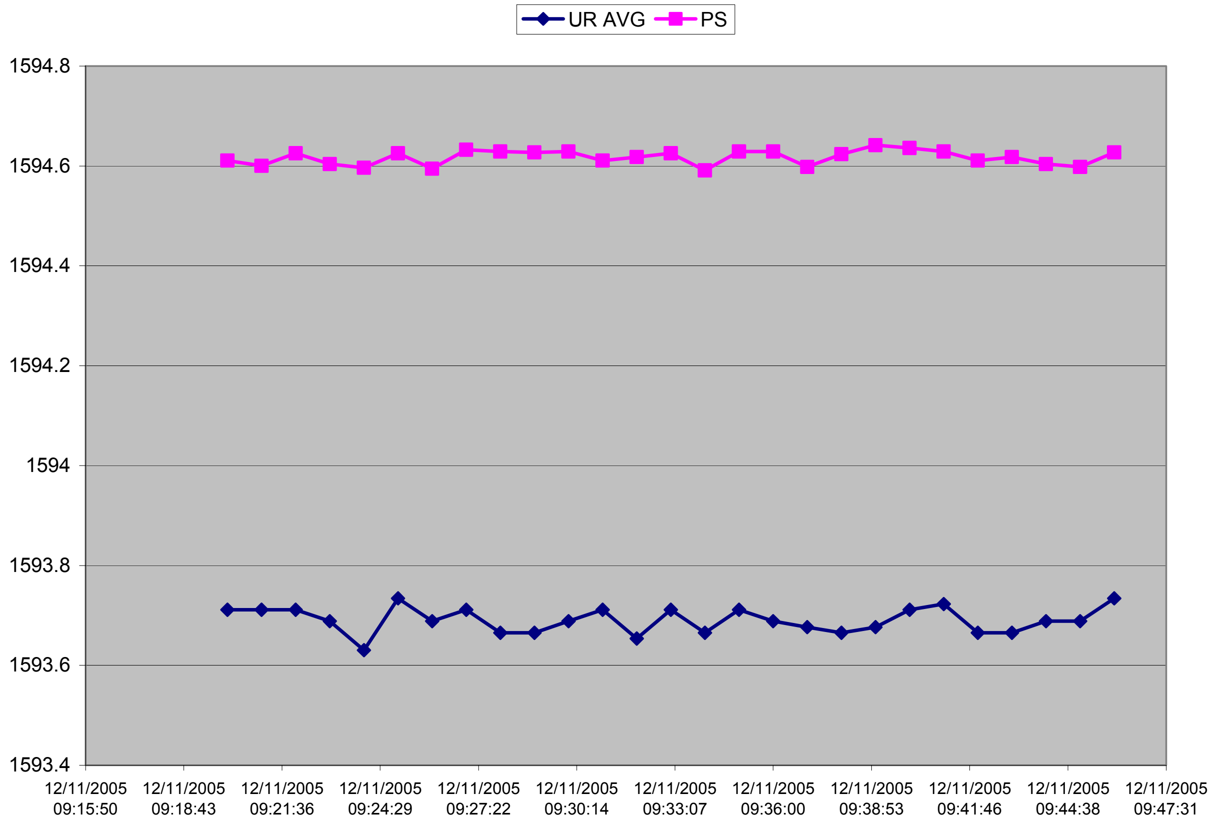

Figure 26: UR Average Transmitter Readings vs. PS Transmitter Readings

This chart indicates again that the levels measured by the UR average transmitters and the levels measured by the PS transmitters correlate and that the PS level transmitter shows less signal noise. Siemens concludes that the installation of the penstock transmitter filters out most wave action affects on level measurement.

The following chart shows the one minute value changes during the same time period for the average UR level average and the PS level:

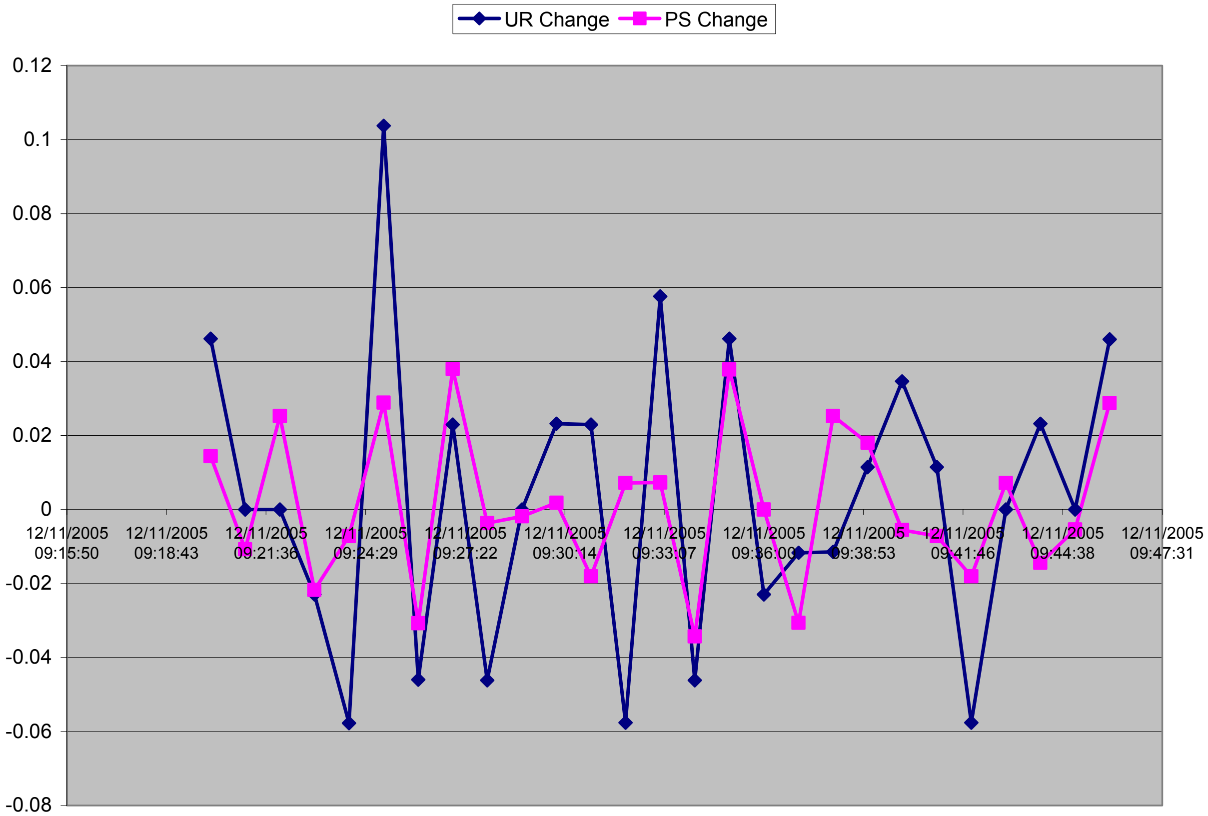

Figure 27: UR vs. PS Transmitter Reading Changes

Again, this chart indicates that the PS level transmitter shows less signal noise than the UR level transmitter average. The standard deviation for the UR series is 0.00399, the standard deviation of the PS series is 0.00204.

Since the PS transmitter shows a smaller standard deviation and its location in a controlled environment makes it less sensitive to mechanical and temperature related changes, it can be used as a reference to gauge the Upper Reservoir level transmitters under static (no flow) conditions.

5.2.2. Differences between the UR Level Transmitters and the PS Level Transmitters

The following chart shows the difference between the measured UR level and the measured penstock level during calm plant conditions from 1-Sep-05 until 14-Dec-05:

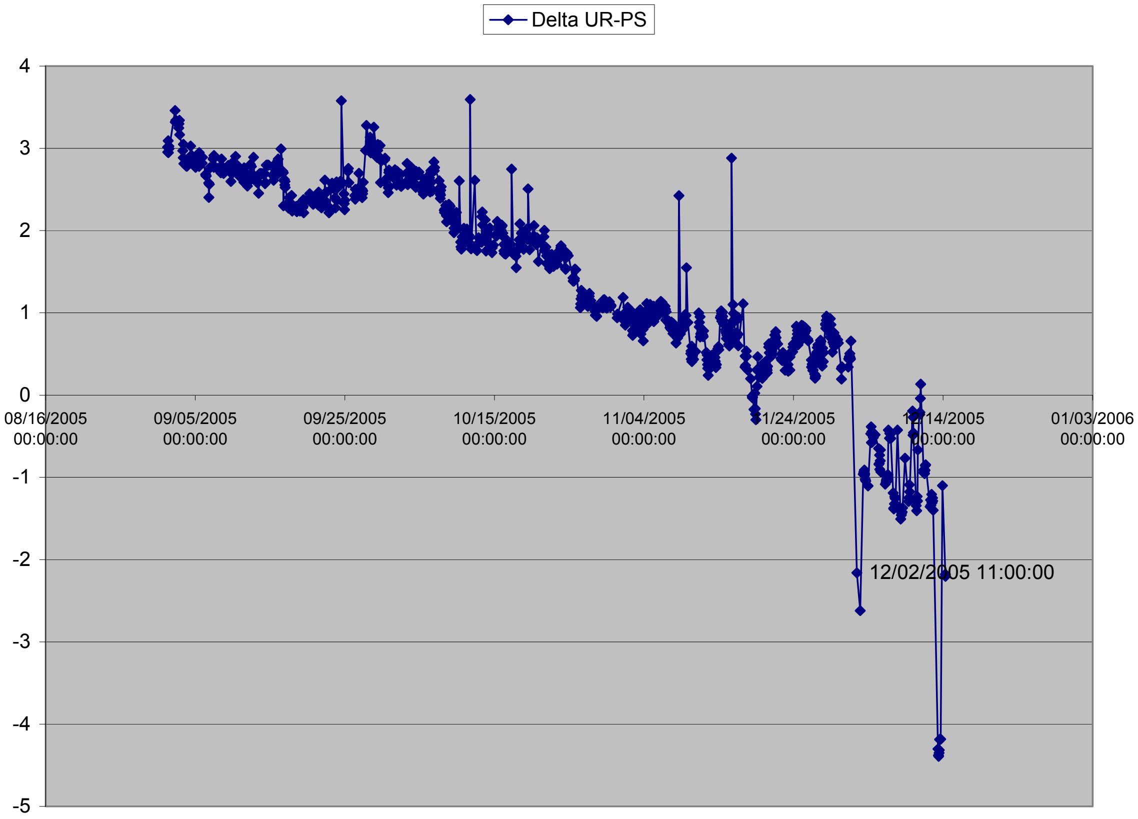

Figure 28: Difference between UR Transmitter Average and PS Transmitter

The gradual decrease of the difference may be explained with a gradual movement of the upper reservoir level transmitter locations. The step changes at the beginning and in the middle of December are discussed below.

The same data between 1-Dec-05 10:00am and 3-Dec-05 10:00am:

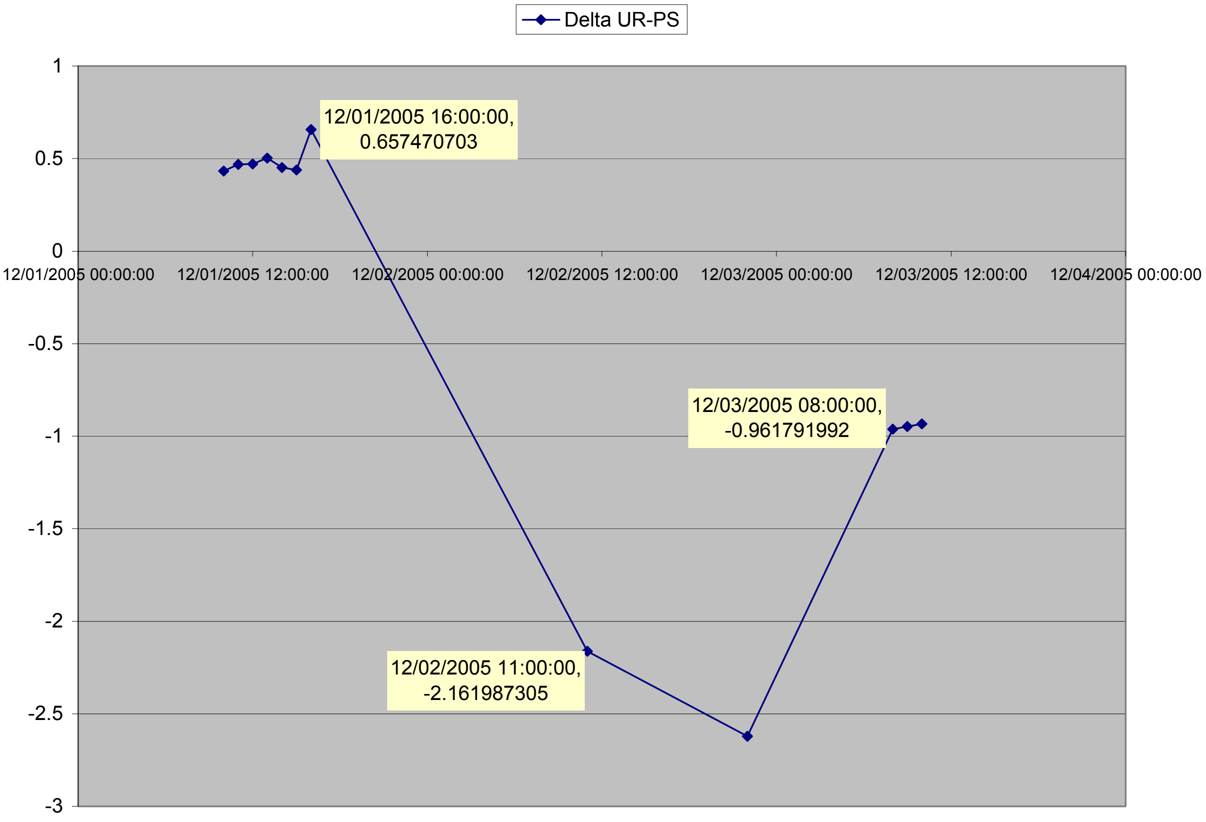

Figure 29: Difference between UR Transmitter Average and PS Transmitter between 1-Dec-05 and 3-Dec-05

Note the change in between 1-Dec-05 16:00, 2-Dec-05 11:00 and 3-Dec-05 08:00. This sudden change can not be explained by a change of environmental conditions. One assumption could be that the location of the UR level transmitters may have shifted during that time period.

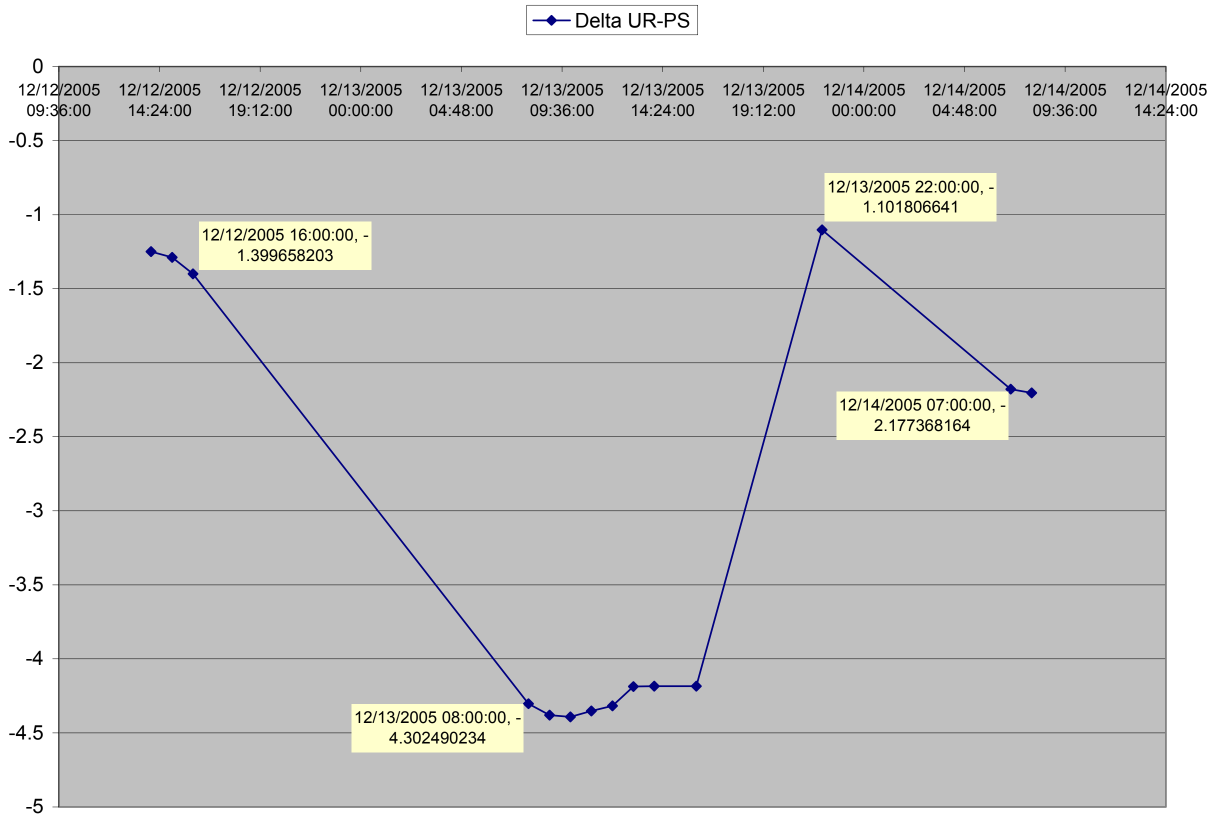

Figure 32: Difference between UR Transmitter Average and PS Transmitter between 12-Dec-05 and 13-Dec-05

A similar sudden change of the transmitter readings can be observed between 12-Dec-05 and 13-Dec-05. This change is also likely to be caused by a shift of the instrument elevation.

5.2.3. Upper Reservoir Level Transmitter Variance at the Time of the Incident

The maximum UR Level transmitter reading was 1593.72 at 5:15:00 AM. Since the lowest point elevation of the parapet wall was surveyed as 1597 feet, the actual water level must have been above that level.

In addition, the parapet wall was also overtopped at panels 44 – 53.

Here are the elevations of the panels 44 through 53 (each panel has two measurements – see IMG059025):

Panel	**Elevation**
44.1	1597.54
44.9	1597.46
45.1	1597.42
45.9	1597.33
46.1	1597.37
46.9	1597.26
47.1	1597.28
47.9	1597.34
48.1	1597.18
48.9	1597.35
49.1	1597.20
49.9	1597.35
50.1	1597.40
50.9	1597.33
51.1	1597.30
51.9	1597.55
52.1	1597.52
52.9	1597.46
53.1	1597.36
53.9	1597.43

The average elevation in this area is 1597.37 feet.

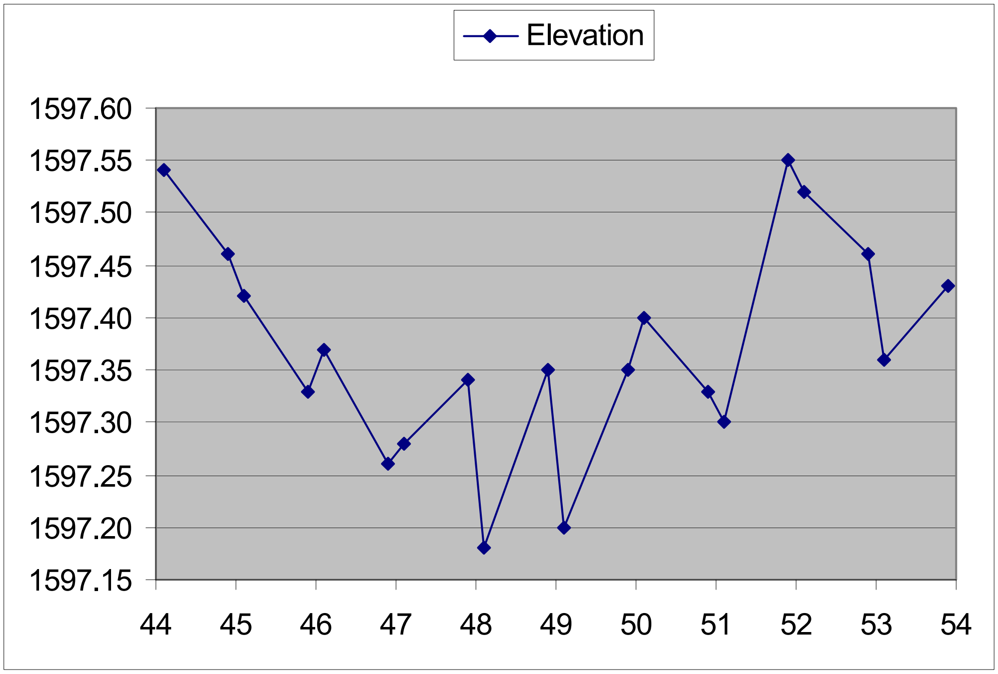

Figure 33: Surveyed Wall Elevations between Panel 44 and 53

Based on this information, it can be assumed that the upper reservoir level measurement which was used to control the automatic stop of the last pump was reading at least 3.65 feet (1597.37 – 1593.72) too low.

If one applies this constant to all UR transmitter readings as shown in the table below, then overtopping at the lowest point of the wall may have occurred between 05:05 and 05:16.

Date	UR Level	UR Level +3.65
12/14/2005 5:02	1593.077	1596.727
12/14/2005 5:03	1593.008	1596.658
12/14/2005 5:04	1593.181	1596.831
12/14/2005 5:05	1593.388	1597.038
12/14/2005 5:06	1593.204	1596.854
12/14/2005 5:07	1593.342	1596.992
12/14/2005 5:08	1593.434	1597.084
12/14/2005 5:09	1593.319	1596.969
12/14/2005 5:10	1593.619	1597.269
12/14/2005 5:11	1593.538	1597.188
12/14/2005 5:12	1593.573	1597.223
12/14/2005 5:13	1593.688	1597.338
12/14/2005 5:14	1593.619	1597.269
12/14/2005 5:15	1593.723	1597.373
12/14/2005 5:16	1593.388	1597.038
12/14/2005 5:17	1592.743	1596.393
12/14/2005 5:18	1590.355	1594.005
12/14/2005 5:19	1585.961	1589.611
12/14/2005 5:20	1581.590	1585.240

5.2.4. Upper Reservoir Level Transmitter Accuracy Discussion

As discussed in chapter 5.2.3, the average upper reservoir level reading was off by at least 3.65 feet low. The estimated minimum instrument lift was at least 2.54 feet. The difference of 1.11 feet (3.65 – 2.54) is most likely attributable to additional lift. As indicated in chapter 4.6.2.3 temperature affects are unlikely.

The following chart shows the difference between the UR and PS transmitter readings in calm conditions (after an auto pump stop), the ambient air temperature and the water temperature between 3-Sep-05 and 12-Dec-05:

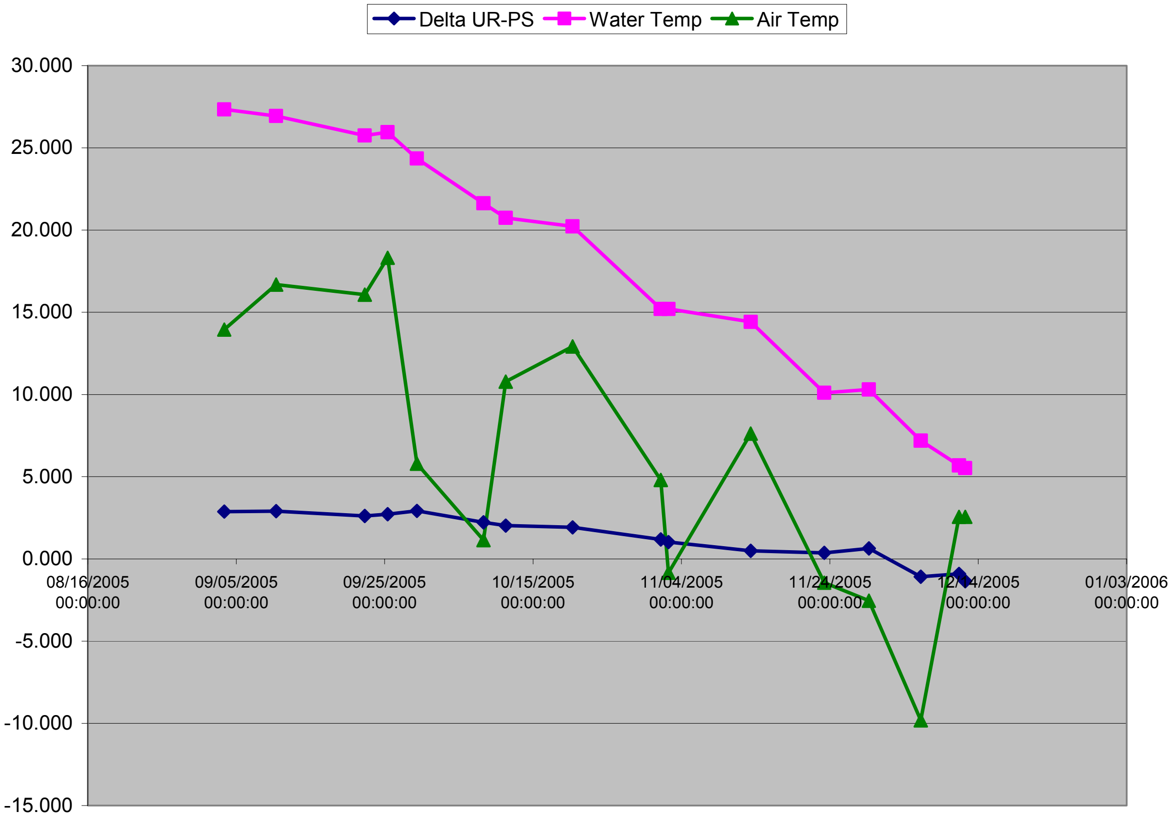

Figure 30: Transmitter Difference and Temperatures

6. Upper Reservoir Level Probe Alarm Analysis

The two level probes installed for overtopping protection generate binary signals. If both signals are active at the same time for more than 60 seconds, the Unit 1 Main PLC logic is to trip pump 1.

The following table summarizes the as-designed and as-found probe elevations as presented by Ameren on 13-Jan-06:

Probe	**As-designed Elevation**	**As-found Elevation[5]**
HI Probe	1595.9	1597.3
HI-HI Probe	1596.2	1597.7

Events generated by the HI-HI probe are displayed as an alarm on the operator screen and logged in the process data archive.

Ameren presented the following HI-HI alarm history between 1-Sep-05 and the incident date:

Number	**Date**	**Source**	**Duration**	**UR Level**
1	27-Sep-05 10:11	Osage Operator Log	Unknown	1596.062866
2	28-Sep-05 18:18:19	Process Data Archive	1 second	1543.345459
3	2-Nov-05 12:49:14	Process Data Archive	9 seconds	1578.452759

First HI-HI Alarm (on 27-Sep-05)

HI-HI Alarm number 1 could have been caused by a high level in the upper reservoir. According to the operator log, the last pumping cycle before this alarm ended on 27-Sep-05 at 05:57 with a pump auto stop[6].

The operator logs states that "*the HPT's (hydro plant technicians) are working on something @ Sauk*". In addition, the process data archive did not record values at 10:04 and 10:05. This is an indication that there could have been maintenance activities at the PLC which may have caused the alarm.

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[5] Siemens calculation.

[6] The process data archive entry supports the operator log entry. During one interview, Ameren voiced the concern that all process archive data may be off by 2 hours due to a set-up problem with the historian. However the operator log entries times correlate closely with the process data archive time stamps, which suggests that the process data archive time may have been correct at least since 1-Sep-05. Another Ameren document stated that the process archive time stamping was corrected in June 2005.

Second HI-HI Alarm (on 28-Sep-05)

The reservoir level was reported as too low to support that this alarm was caused by a high water level. The operator states that Jeff Scott (Production Supervisor at the Taum Sauk plant) called the Osage control room on 17:55. It is possible that he or other people were still at work when the alarm was recorded. Ameren's report to FERC states that this alarm may haven been caused by a lightning storm which moved through the area at that time. The short duration of the alarm is consistent with this assumption. If someone would have worked on the level probes, more alarms and longer alarm durations could be expected. This HI-HI alarm is not mentioned in the operator log.

Third 3 HI-HI Alarm (on 2-Nov-05)

Again, the reservoir level was reported to be too low to support that this alarm was caused by a high water level. The operator log states that the units were taken offline to support a diver. According to Ameren personnel the diver was working on the lower reservoir, not the upper reservoir. As of this writing, Siemens has no explanation for this alarm.

This HI-HI alarm is not mentioned in the operator log.

7. Fault Tree Analysis

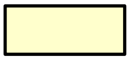
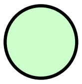
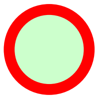
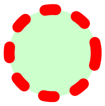
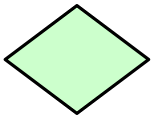
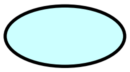
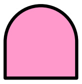
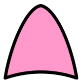
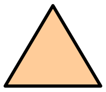
The fault tree analysis tool was used to perform the potential cause investigation. This tool allows a top down approach to find possible root causes for the incident. The root event is the fact that the dam was breached. As a first refinement step, a possible weakness of the dam structure and the possibility of an overspill are considered. Then possible causes for a weakness of the structure and the overspill are considered.

This process of finding possible causes for events stops when one of the following criteria is met:

- The possible cause analysis is covered in a different report (e.g. the dam structure analysis is covered in a report submitted by Paul C. Rizzo Associates)
- The possible cause would not contribute to the event analyzed (e.g. a transmitter malfunction of the tailrace level transmitter would not cause the pumps to stop)
- There is insufficient information to determine whether the possible cause was contributing to the event or not (e.g. events generated by the HI level probe were not stored in the process data archive)
- It is known that the possible cause did not contribute to the event (e.g. it is known that all three upper reservoir transmitters were powered and communicating since they continued to transmit data throughout the event)
- The search for possible causes becomes trivial (e.g. was water in the reservoir when the dam breached).

7.1. Fault Tree Symbols

The following symbols were used in the fault trees:

Fault Tree Analysis Symbol	Explanation
	Intermediate Event: Used to specify a failure event that occurs due to one or more causes acting through logic gates below it in the fault tree.
	Basic Initiating Event: Used to specify a failure event that does not require any further development i.e. it is a “leaf” of the fault tree and has no gates or events below it in the tree.
	Basic initiating Event which may have contributed to the failure with a high likelihood > 50%.
	Basic initiating Event which may have contributed to the failure with a lower likelihood ≤ 50%.
	Undeveloped Event: Used to specify a failure event that is not developed as far as it could be, either because the event is of no importance in this fault tree, or because there is not enough information available.
	Conditioning Event: Used to specify certain conditions upon any logic gate.
	And Gate: Used to show that the output fault will only happen if all of the inputs occur.
	Or Gate: Used to show that the output fault will only occur if one or more of the input faults take place.
	Not Gate: The output is true if the input is false and vice versa.
	Transfer symbol: Link to another fault tree diagram.

7.2. Fault Trees

7.2.1. Fault tree 1: Potential Causes for the Dam Breach

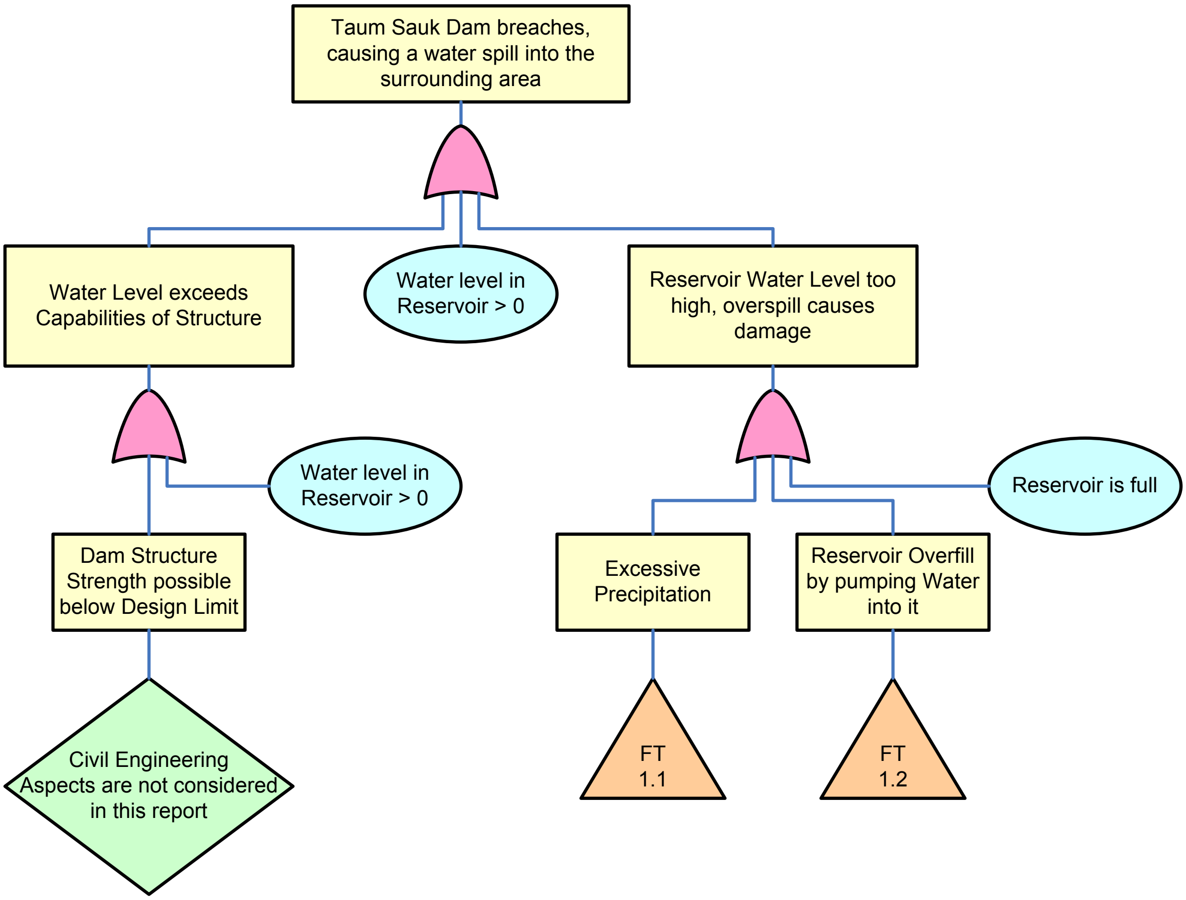


Figure 31: Fault Tree 1: Possible Causes for Dam Breach

The dam breach could have been caused either by a normal water level and a weakened dam structure or by water overspill which subsequently caused damage to the dam structure. The overspill could have been caused by precipitation or by pumping water into the reservoir. Since the dam structure analysis is covered by a separate report, this possibility is not explored further.

7.2.2. Fault Tree 1.1: Excessive Precipitation

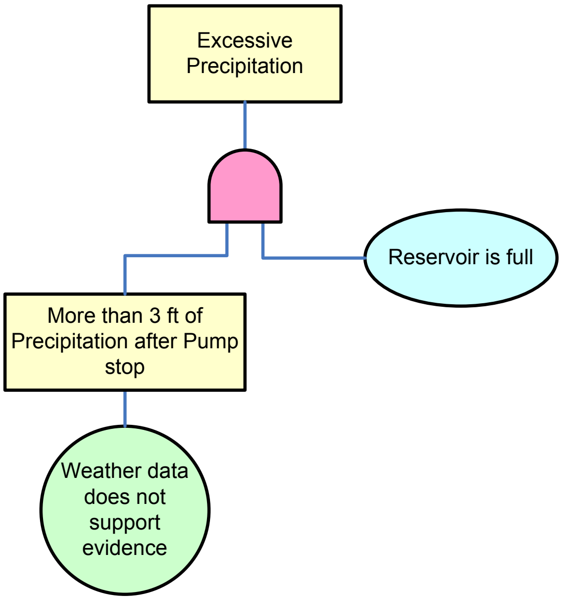


Figure 32: Fault Tree 1.1: Excessive Precipitation

Excessive precipitation may cause an overspill if it amounts to 3 feet after the auto-stop of the last pump which occurs at 1594[7] feet (the lowest wall elevation is 1597 feet). However, the weather data reviewed by Siemens does not support this possible cause.

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[7] This was the auto-stop setpoint at 14-Dec-05.

7.2.3. Fault Tree 1.2: Reservoir Overfill by Pumping Water

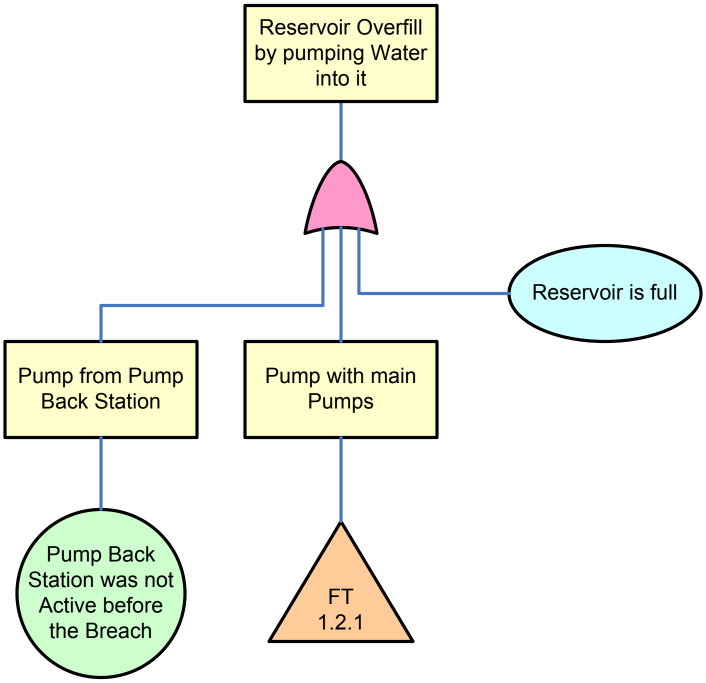

Figure 33: Fault Tree 1.2: Reservoir Overfill by Pumping Water

The reservoir can be filled by two independent pumping systems: The main pumps and a small pump-back pump. The main pumps are used to pump the water from the lower reservoir into the upper reservoir.

Since the upper reservoir was reported by Ameren to be leaking water at a small rate, the leakage water was collected in a small pond close to the UR. If the water level in that pond rises to a predefined level, it is to trigger a limit switch which causes the pump-back pump to start. The small size of the pump and the fact that it does not appear to have been running during the incident suggests that it did not contribute to the overfilling.

7.2.4. Fault Tree 1.2.1: Pump with main Pumps

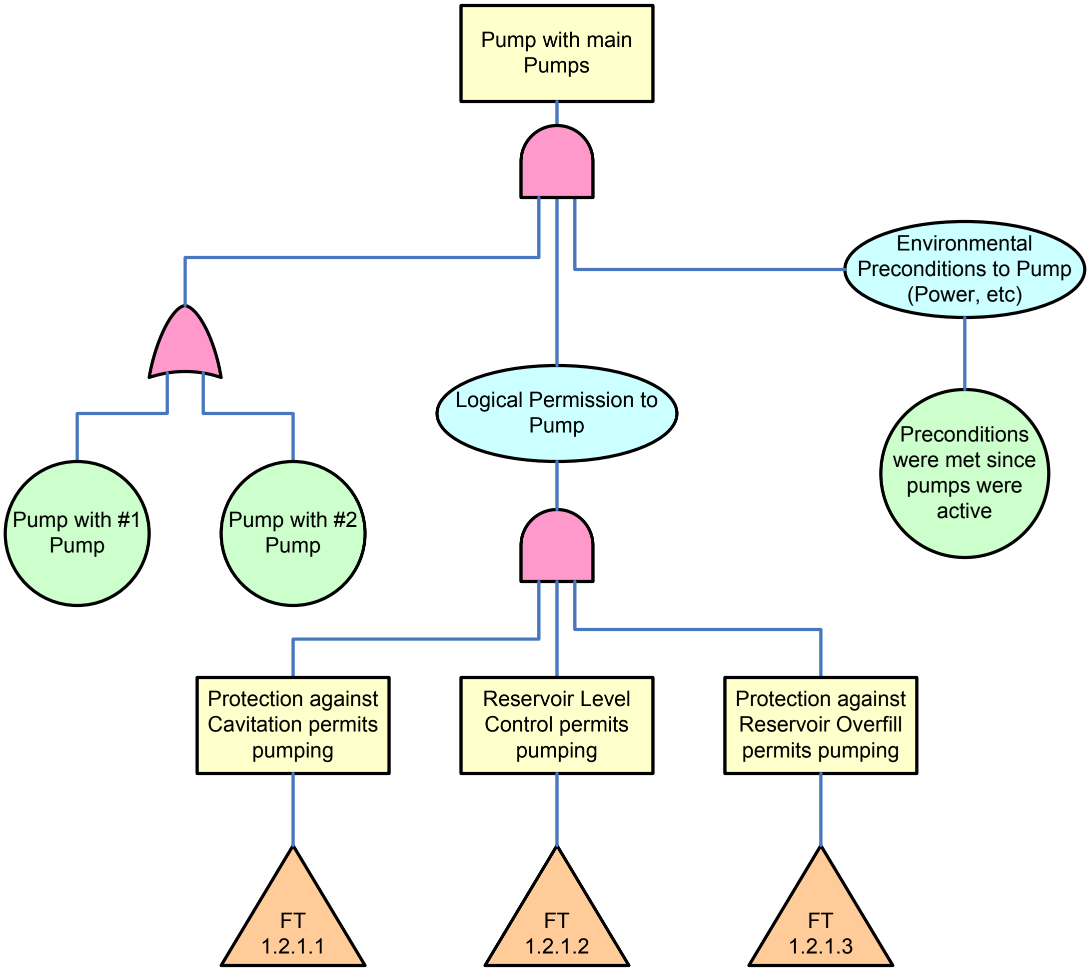

Figure 34: Fault Tree 1.2.1: Pump with Main Pumps

Certain environmental preconditions and permissions need to be met to enable the pumps to continue to operate. Start permissions for the pumps are not considered further since the data reviewed by Siemens suggests that the pumps were running throughout the incident.

To enhance readability, the permissions for the two pumps are analyzed in parallel. It has been discussed in this report that the pump trip logic for pump 2 may have been disabled due a programming issue. However, Siemens believes that this programming issue did not contribute adversely to the incident since pump 2 was to be stopped automatically by level control.

7.2.5. Fault Tree 1.2.1.1: Protection against Cavitation

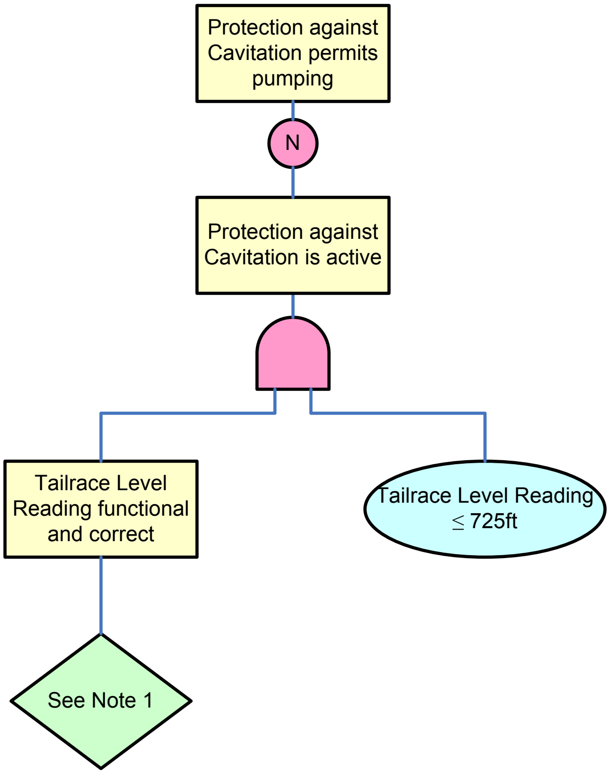

Figure 35: Fault Tree 1.2.1.1: Protection against Cavitation

Notes:

1	An incorrect tailrace reading by itself should not *cause* an overspill. An incorrect tailrace reading should only prevent an overspill if it fails low (≤ 725). The process data archive suggests a functional transmitter during the incident. A correct tailrace reading should not prevent an overspill if there is sufficient water in the tailrace.

Since Siemens believes that a wrong tail race reading would not be the root cause for an overspill, it is not considered any further.

7.2.6. Fault Tree 1.2.1.2: Level Control

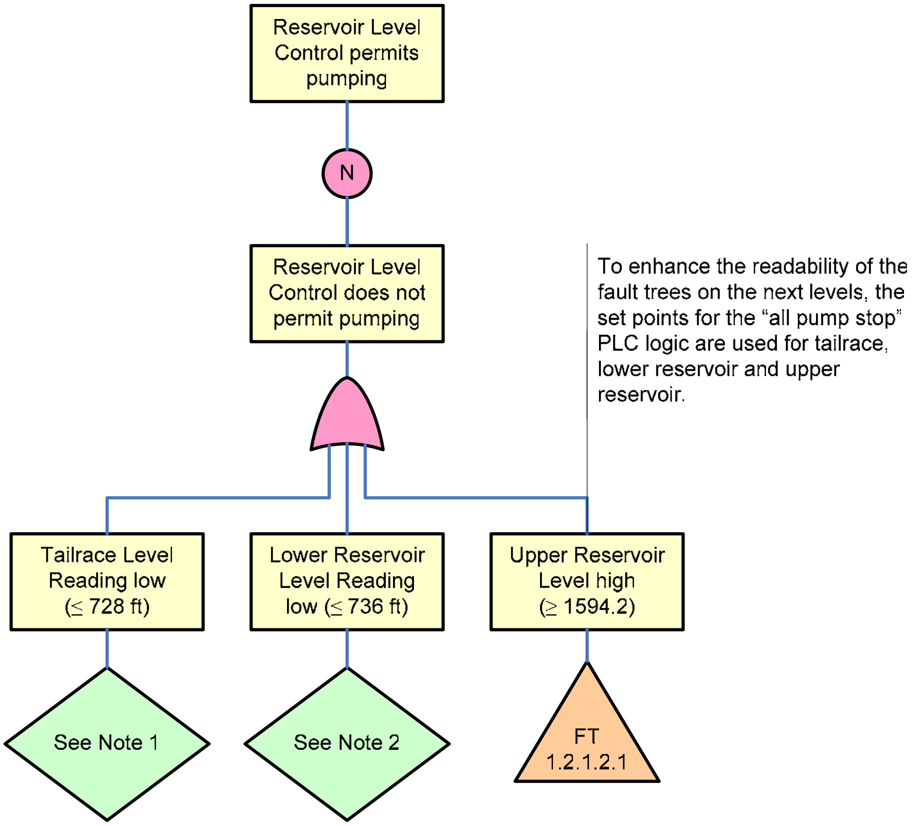

Figure 36: Fault Tree 1.2.1.2: Level Control

Notes

1	An incorrect tailrace reading by itself should not *cause* an overspill. An incorrect tailrace reading should only prevent an overspill if it fails low (≤ 725). The process data archive suggests a functional transmitter during the incident. A correct tailrace reading should not prevent an overspill if there is sufficient water in the tailrace
2	See tailrace transmitter discussion above. The same applies to the lower reservoir transmitters

Since Siemens believes that a wrong tail race or lower reservoir level reading would not be the root cause for an overspill, it is not considered any further.

7.2.7. Fault Tree 1.2.1.2.1: Upper Reservoir Level Control

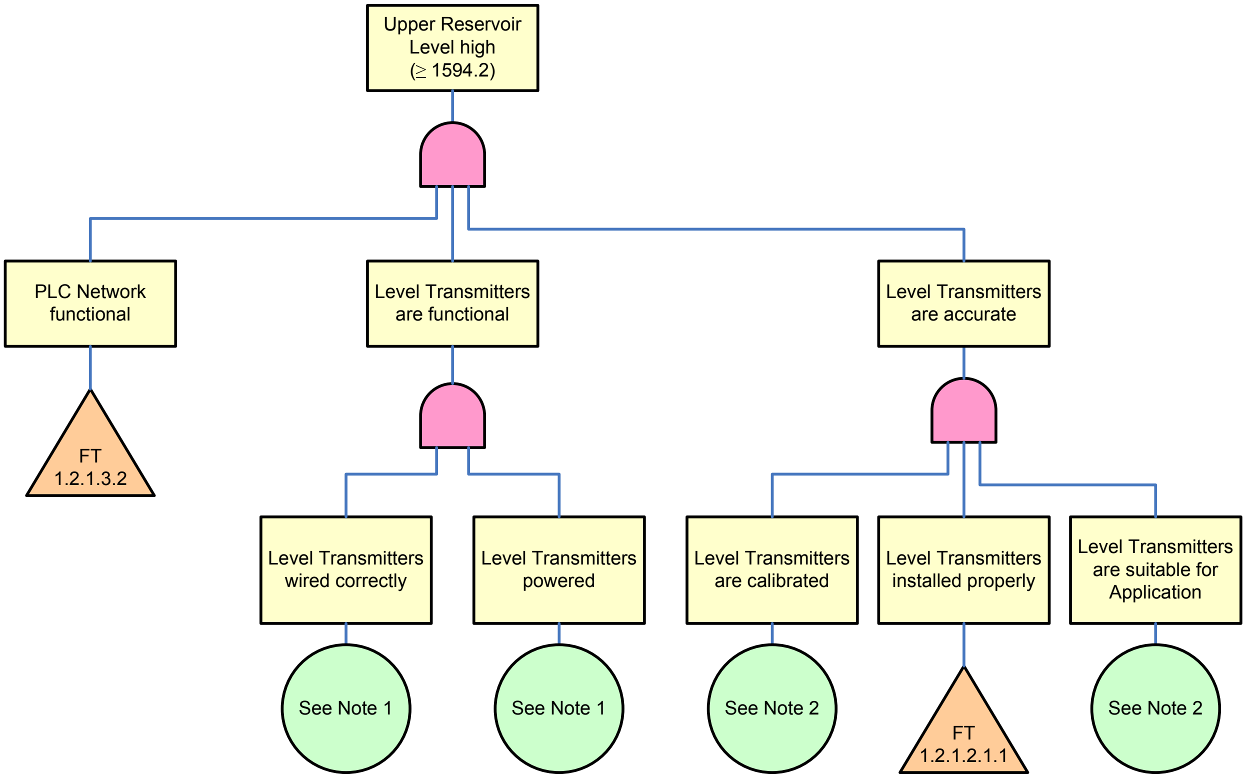

Figure 37: Fault Tree 1.2.1.2.1: Upper Reservoir Level Control

Notes

1	The transmitters were apparently accessible from the PLC system throughout the incident and the readings correlate with the physical events observed.
2	Testing of the transmitters at the manufacturer's facility demonstrated that the transmitters were sufficiently calibrated and suitable for this application (see chapter 4.6.2.3). The temperature sensitivity of TX2 did not contribute adversely to the event.

7.2.8. Fault Tree 1.2.1.2.1.1 Level Transmitters Installation

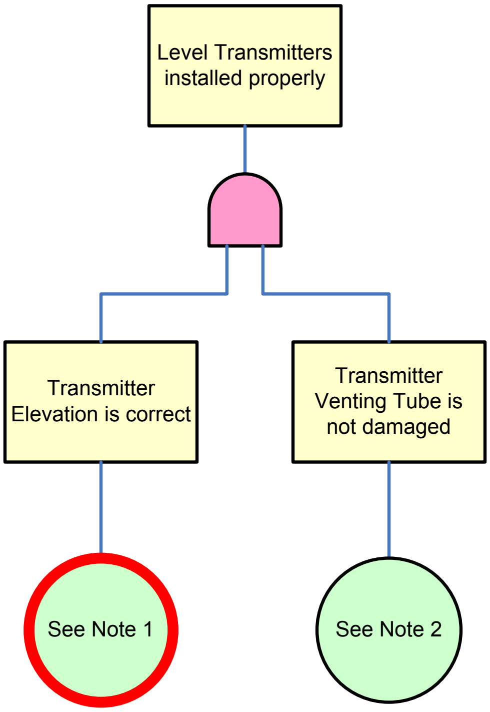

Figure 38: Fault Tree 1.2.1.2.1.1: Level Transmitter Installation

Notes:

1	The bow in the instrument pipe caused a shift in the elevation of the level transmitters. The transmitters were moved up, causing a reduction of the water level above them. Therefore the measured water level was likely too low. See also the pipe bow discussion in chapter 4.6.2.2.
2	The barometric air pressure was compared with level transmitter measurements. At stable plant conditions changes of the barometric pressure did not affect the level measurement of the upper reservoir. Therefore, Siemens assumes that the venting tube was not damaged.

7.2.9. Fault Tree 1.2.1.3: Level Protection

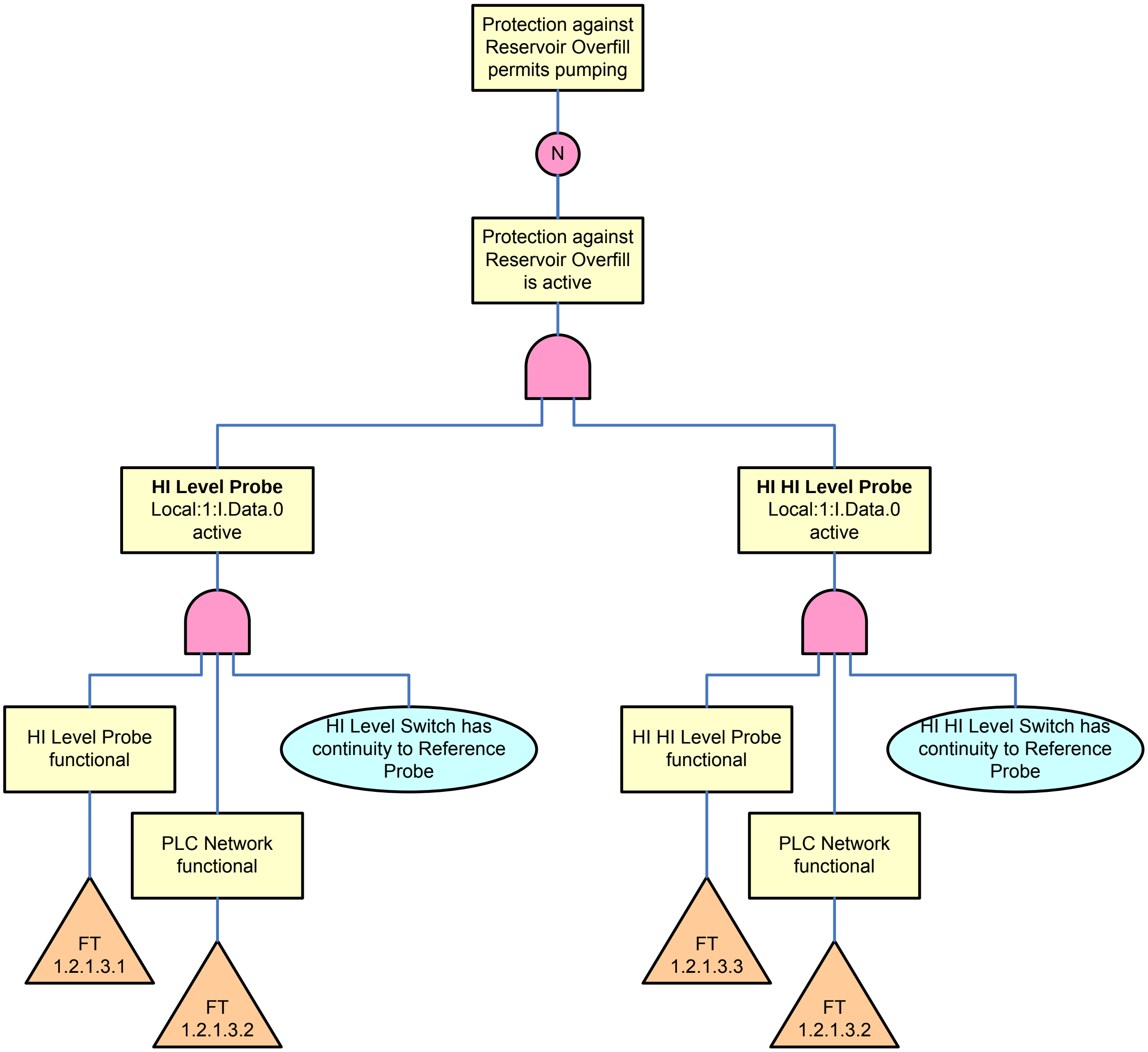

Figure 39: Fault Tree 1.2.1.3: Level Protection

In the as-found logic, the protection against overfill requires the HI and the HI-HI probe to become active. The probes can only become active if they are functional. In addition, the probe signals are processed properly only if the PLCs and the network are operational.

7.2.10. Fault Tree 1.2.1.3.1-3 Level Probe functional

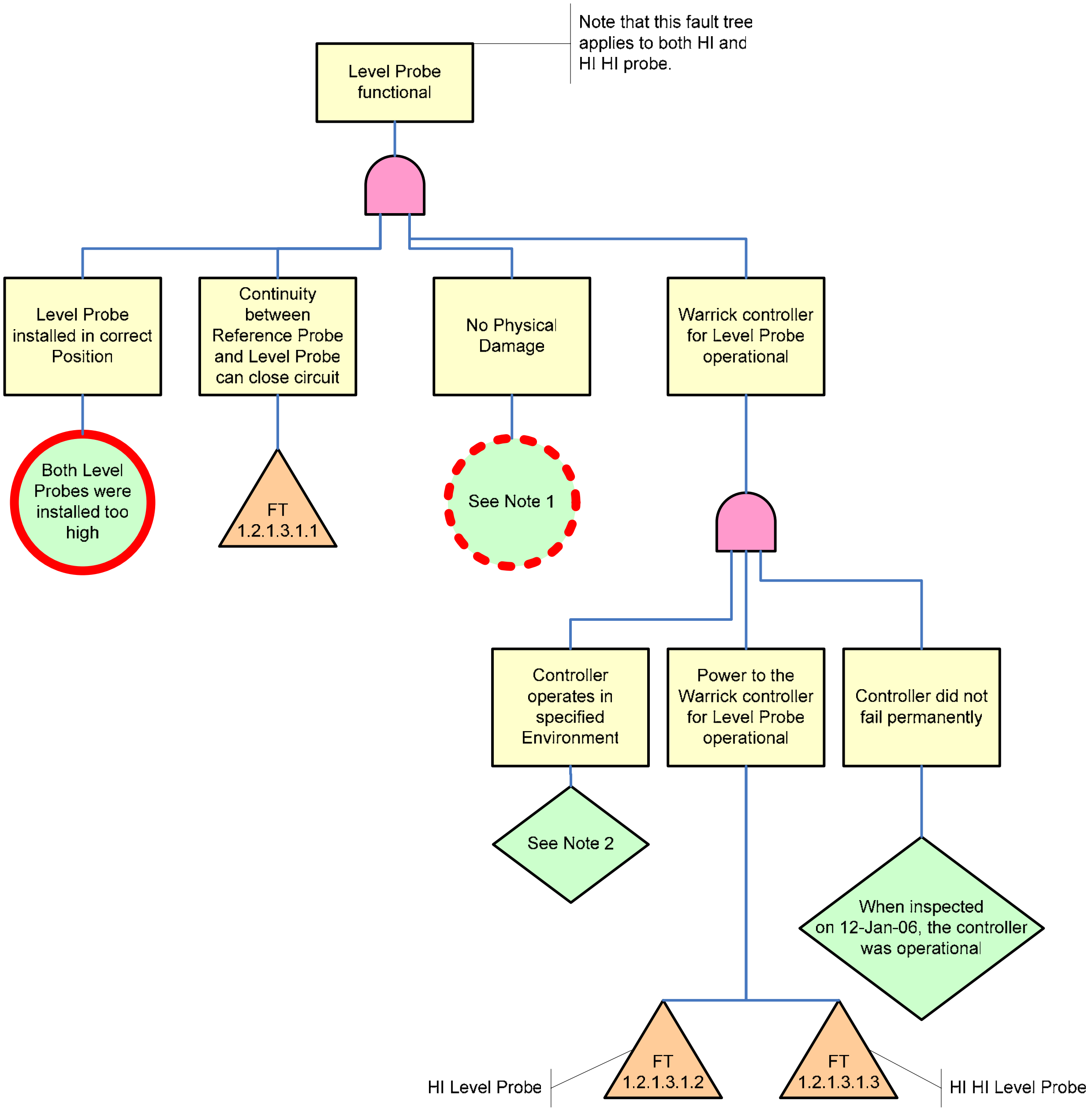

Figure 40: Fault Tree 1.2.1.3.1-3 Level Probe functional

Notes

1	Although the probes did not show substantial physical damage when inspected on 12-Jan-06, minor rust observed on the reference probe may have affected continuity. However, when tested on 2-Feb-06, the probes were operational.
2	Controller was installed in a controlled but unmonitored environment. No PLC components were believed by Siemens to have failed in the UR gauge house during the event

This fault tree applies to both the HI and the HI-HI level probes since they are of the same design. It is known that the level probes were installed too high which effectively disabled them.

7.2.11. Fault Tree 1.2.1.3.1.1: Continuity between the Signal Probe and the Reference Probe

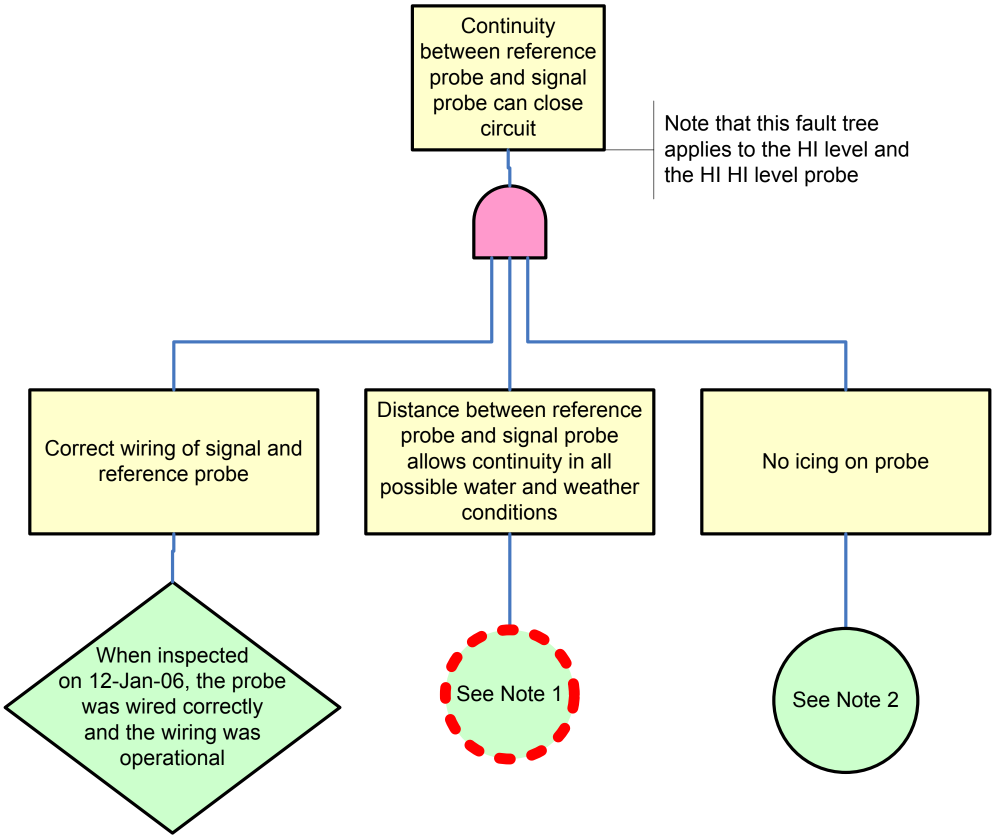

Figure 41: Fault Tree 1.2.1.3.1.1: Continuity between the Signal Probe and the Reference Probe

Notes:

1	The manufacturer (Tom James on 1/27/06) stated that the recommended maximum distance between the reference and the signal probe is 4 feet. However, when tested by Siemens and Ameren on 2-Feb-06, probes had continuity of up to 200 feet As installed, the probes were not only depending on the continuity of the water. The stainless steel cable and the ladder provided additional continuity.
2	The weather data suggests that icing may have occurred with a very small likelihood.

This fault tree applies to the HI and HI-HI level probes since they are of the same design. There is a very small likelihood of icing due to weather conditions[8] before the event. However, it is unlikely that the icing may have built up due to pumping activity and contributed adversely to the continuity.

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[8] Reported arial temperatures below the freezing point at the power house between 03:00am and 05:00am at the day of the incident.

7.2.12. Fault Tree 1.2.1.3.1.2: Power to HI Level Probe operational

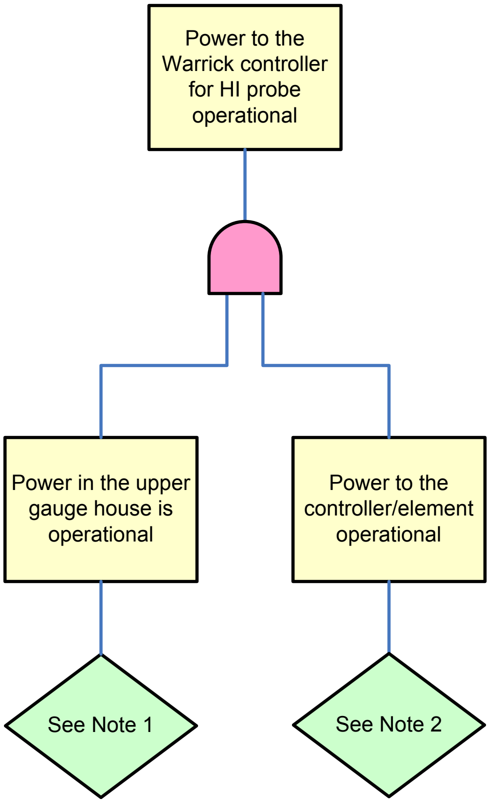

Figure 42: Fault Tree 1.2.1.3.1.2: Power to HI Level Probe operational

Notes

1	There was no UPS alarm and the PLC appears to have been operational during the event. Therefore Siemens assumes that the power in the upper gauge house was operational.
2	A failure of power would not be detected by the system or the operators. However, Ameren checked the circuit after the event and determined that the circuit was operational.

7.2.13. Fault Tree 1.2.1.3.1.3: Power to HI-HI Level Probe operational

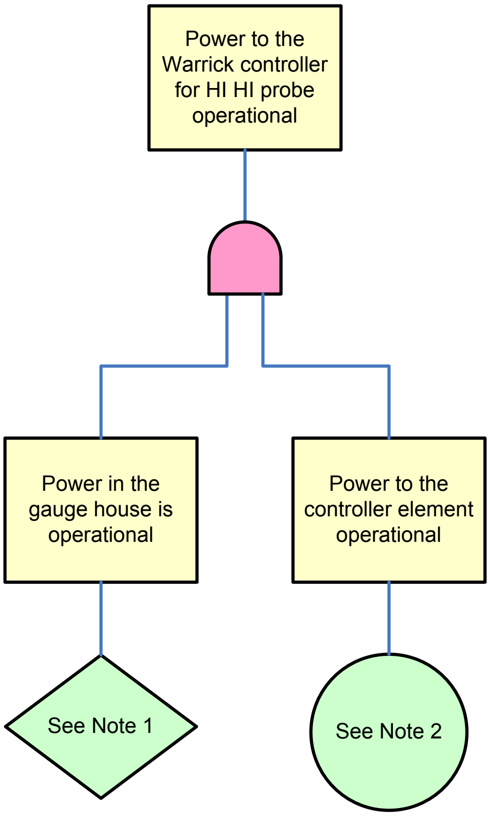

Figure 43: Fault Tree 1.2.1.3.1.3: Power to HI-HI Level Probe operational

Notes:

1	There was no UPS alarm and the PLC was operational during the event. Therefore, Siemens assumes that the power in the upper gauge house was operational.
2	A failure of power should cause a LO-LO alarm since both contacts are supplied by the same power source. That LO-LO alarm was not observed.

7.2.14. Fault Tree 1.2.1.3.2: PLC Network Functional

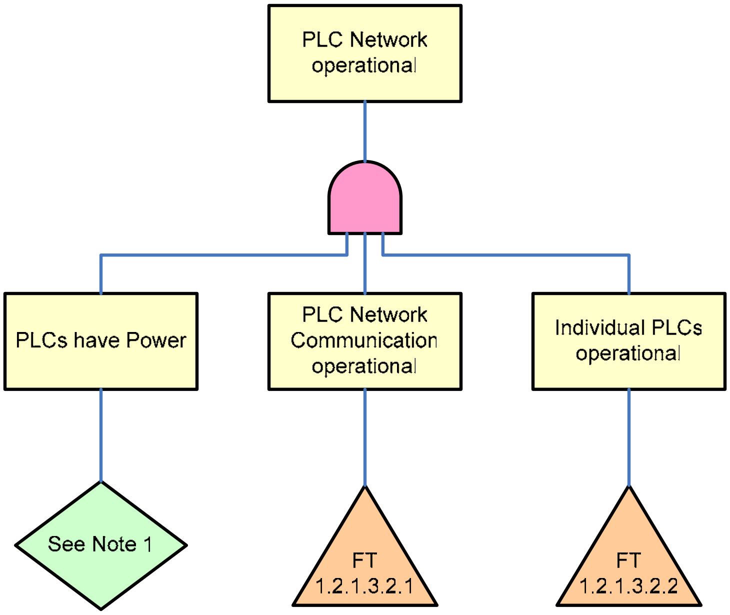

Figure 44: Fault Tree: 1.2.1.3.2 PLC Network Functional

Notes

1	Since all PLCs appear to have been communicating with WonderWare throughout the incident, it can be assumed that they had power.

The availability of power, network communication and the operational status of the individual PLCs are preconditions for the PLC network operation.

7.2.15. Fault Tree 1.2.1.3.2.1: PLC Network Communication

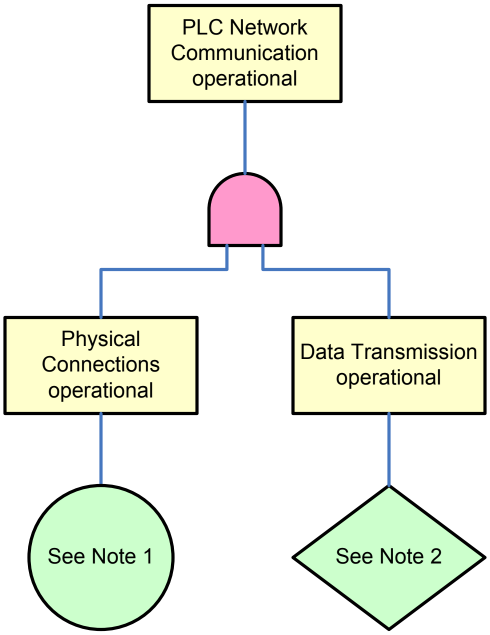

Figure 45: Fault Tree 1.2.1.3.2.1: PLC Network Communication

Notes

1	Physical Network errors are to be detected and generate an alarm. No such alarms were reviewed by Siemens as recorded at the day of the incident.
2	According to Ameren, the last PLC program change before the incident was performed on 7-Dec-05. Since that date, several auto pump stops were performed by the system. This suggests that the PLCs were transmitting data between each other. Since there were no active physical network alarms reported on the data historian at the day of the incident, Siemens assumes that the PLCs were transmitting data throughout the incident. The communication with the Wonderware data process archive also appears to have been operational throughout the day of the incident.

7.2.16. Fault tree 1.2.1.3.2.2: Individual PLC Status

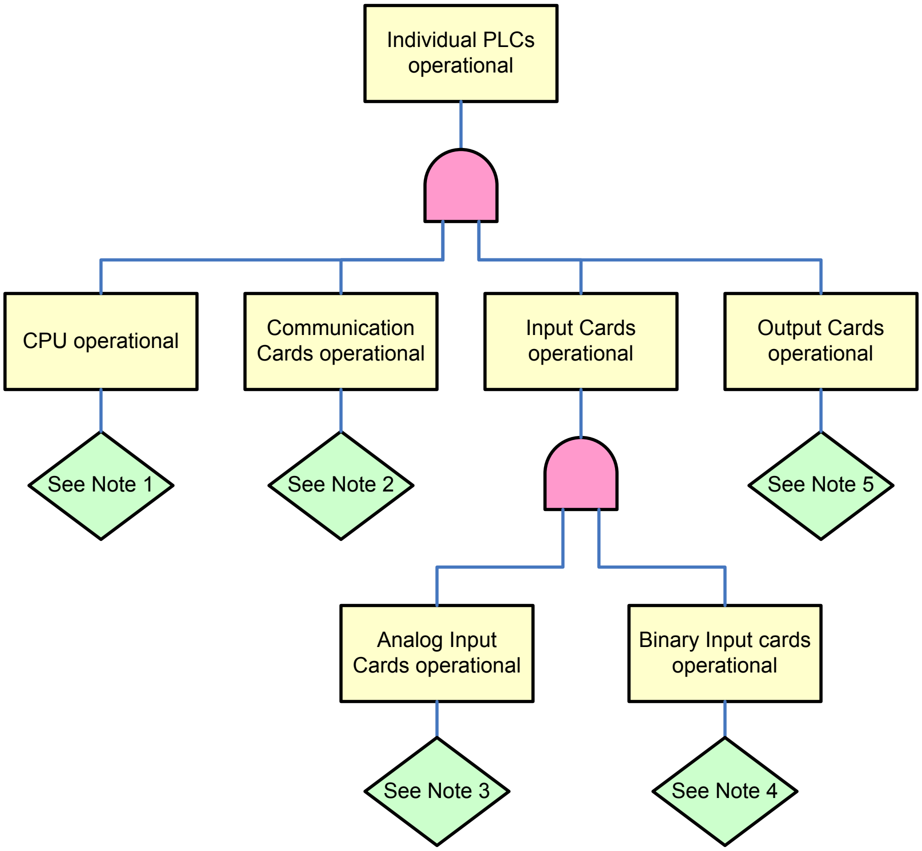

Figure 46: Fault tree 1.2.1.3.2.2: Individual PLC Status

Notes

1	The PLCs appear to have been in communication with the Wonderware process data archive throughout the event. Therefore, Siemens assumes that the CPUs were functional.
2	The PLCs appear to have been in communication with the Wonderware process data archive throughout the event. Therefore Siemens assumes that the communication cards were functional.
3	There is small likelihood that the analog input cards may have contributed to the level transmitter inaccuracy. However, according to the manufacturer's documentation and the fact that the building was thermostatically heated, and calculations performed by Siemens based upon the information reviewed, analog input inaccuracy may cause a variation of 1"-3" of water level.
4	Results of the testing of the level probes after the incident suggest that the binary input cards were operational.
5	It can not be determined whether the output cards on all PLCs were operational at the time of the incident. When tested on 2-Feb-06, the output cards appeared to be operational.

The active communication link to the Wonderware process data archive is consistent with the main PLC components (CPU & communication cards) being operational.

The analog input cards appeared to be transmitting data at the time of the event, which suggests those were operational.

The binary input cards were tested after the incident and the testing suggests that these were operational.

Analyzing the output cards would not contribute to this root cause analysis since the PLC logic would not have attempted to activate the necessary outputs to stop the pumps. Testing performed after the event suggests that the cards were operational on 2-Feb-06.

8. High Level Failure Mode Effects Analysis

The following table shows a high level failure mode effects analysis for the level control and level protection system for the upper reservoir.

Failure	**Operator Alarm**	**Operator Indication**	**Loss of UR Level Protection**	**Loss of UR Level Control**
PLC Network				
UR PLC Failure	Yes	Yes	Yes	Yes
Common PLC Failure	Yes	Yes	Yes	Yes
Unit 1 PLC Failure[9]	Yes	Yes	Yes	Yes
Unit 2 PLC Failure	Yes	Yes	Yes	Yes
Network Failure between PLCs	Yes	Yes	Yes	Yes
Network Failure to HMI	Yes	Yes	No	No
Power				
Power Failure in UR Gauge House for more than 8 hours.	Yes	Yes	Yes	Yes
Power failure in LR PLC House	Yes	Yes	No	No
Instrumentation				
Complete Loss of one Level Transmitter	No	No	No	No
Complete Loss of two Level Transmitters	No	Yes[10]	No	Yes[11]
Complete Loss of all three Level Transmitters	No	Yes	No	Yes
Complete loss of one Level Probe (HI or HI-HI)	No	No	Yes	No
Complete loss of both Level Probes	No	No	Yes	No
Loss of accuracy and repeatability of level transmitters	No	No	No	Yes
Elevation of Level Probes too high	No	No	Yes	No

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[9] The Unit 1 and Unit 2 Main PLCs are redundant.

[10] If the two transmitters used in level control failed.

[11] Only two of the three installed level transmitters were used, the signal of the third transmitter was disabled in the PLC logic.

9. Conclusion

The evidence reviewed by Siemens between 9-Jan-06 and 24-Mar-06 is consistent with a conclusion that the reservoir overspill was caused by failure of the upper reservoir level protection system and inaccurate readings within the level control system.

The level protection system was effectively disabled because the level probes were located in a position too high to sense water during the event (see chapter 4.6.3.2).

The level control system lost accuracy because of the shift of the instrumentation pipes causing a change of the instrument elevation.

No evidence of a hardware failure in the PLC network system or in the wide area network was observed.

There was also no evidence of an operator error observed. The pumping cycles vary greatly depending on the initial reservoir water level, equipment availability and energy demand. The operators had no visual contact with the upper reservoir and had to rely on the information presented by the control system and its control and protection features.

10. References

No	Title
1	Process data archive
2	Ameren's report to FERC submitted on 27-Jan-06
3	IMG013196 - Side Slope Relining Details III drawing 8304-X-155099 r5
4	IMG059025 – Taum Sauk Upper Reservoir Crest Survey Data
5	IMG059220- Interconnection Diagram Level Controls Upper Reservoir & Lower Dam drawing 8303-X-26348 r8
6	IMG069851 - 15-Dec-05 photos of the instrumentation pipes
7	IMG069852 - 16-Dec-05 photos of the instrumentation pipes
8	IMG082735 - Schematic Diagram Upper Reservoir level drawing 8303-P-26648 r15
9	IMG089629.01 – Level Instrument information
10	IMG089630-089631 & other GE Druck cutsheets
11	IMG121866 - Sketch SB1306-3 Gage Pipe Supports As Constructed
12	photo 15-Nov-04 of the as-installed pipe installation
13	photo 16-Dec-2005 of cable hanging technique in upper reservoir instrument box
14	photo 15-Dec-05 of transmitter cable air tube ends
15	Compact I/O Analog Module User Manual, Allen Bradley Publication 1769-UM002B-EN-P - July 2005

APPENDIX B

“PICKEL REPORT”

May 15, 1964

TAUM SAUK PROJECT
UPPER RESERVOIR
CORRECTIVE WORK - MARCH 14 TO APRIL 17, 1964

General

An outage of five weeks, beginning March 15, was scheduled to permit remedial work in the upper reservoir. During February and early March, a detailed program of contemplated work was developed, which included evaluation and testing of several types of sealing materials.

Dr. F. A. Nickell, consulting geologist, visited the project on February 21. He reviewed and concurred with the proposed plans, and recommended several additional features which were adopted.

The actual work closely followed the proposed plans, except where specific conditions indicated that modifications were in order. In general, these modifications increased the scope of work, and resulted in a more thorough job of sealing.

Various phases of the work are described in detail below.

Reservoir Draining and Inspection

The pool elevation had been lowered to about 1510 by normal plant operation. On March 14 it was lowered to 1503 by low-load generation, to allow time for any water trapped behind the face apron to bleed off. No water was observed to flow from cracks in the face apron, although this condition was common during previous drawdowns.

Extreme caution was observed in lowering level in the vortex basin below 1503, in order to avoid additional ruptures in the asphalt floor seal. The access tunnel gate was lowered on March 15, and pumping out of the depressed area commenced.

Significant observations during and after emptying the reservoir include the following:

1. A large number of cracks in the face apron - particularly at Panels 72 to 77 - were filled with leaves tightly packed. Even hair-line cracks had leaves sucked in.

2. Very few vertical expansion joints showed evidence of leaves being sucked in.

3. Igas caulking in the horizontal toe block joint had been depressed or failed in a number of places.

4. As level in the vortex basin was drawn down below 1500, air was sucked in through the asphalt floor at several places on both sides of the rain dike.

5. A rather rapid drawdown from 1496 to 1492 on March 17 caused a concrete patch in the vortex floor (about 75 feet from the shaft) to blow out.

6. The old crack in the depressed area floor had re-appeared in front of Panels 91 to 93. It was about 150 feet long, 3/4" wide at the maximum and tapering to nothing at the ends.

7. The general condition of the asphalt floor was excellent, except in the vortex basin where it was covered with 8 to 12 inches of sawdust, cinders, Bentonite clay, and leaves, and immediate inspection could not be made.

All toe blocks and face apron berms were covered with cinders, mud, gunite rebound, etc. These were thoroughly washed with fire hoses to permit detailed inspection and sealing of cracks.

Horizontal Expansion Joint and Toe Block

The horizontal joint above the toe block for the entire periphery of the reservoir had been caulked with Igas during the December, 1963 overhaul. In addition, Igas stoppers had been placed in the vertical joints above the toe block to prevent water from following the copper seal and getting behind the Igas of the horizontal joint.

All previous Igas work was carefully inspected and repaired where necessary. Most of the repairs were in areas where the caulking material had not bonded to the concrete properly. In such cases, the old material was removed, the surfaces cleaned and re-primed, and new material applied. The largest areas of this nature were at Panels 43 to 45, 69-70, and 90, where the entire length had not bonded.

At Panels 65 to 68, the test section of Silicone sealant in the toe block joint was removed and replaced with Igas.

After repairs were made, all joints were gone over with hot irons to smooth out the surface and to check bond to the concrete.

Several sections of toe block showed cracks. In chipping out three cracks for repair, large sections of concrete above the copper expansion joint - about four feet in length - broke out. These areas were primed with concrete adhesive and dry-packed with sand-cement mortar before the Igas repair was made.

Three hundred and five gallons of Igas were used in making joint repairs, and for stoppers in vertical joints.

At the toe of Panel 43 there was evidence of leakage between the toe block and the asphalt floor. This had been repaired previously with Igas, but the patch did not hold. The repair made under this program consisted of a concrete block about two feet high poured against the toe block. This construction extended beyond the end of the Panel 43 toe block and along the face apron of Panel 42, for a total length of 80 feet. The block was dowelled to the floor and also horizontally to the toe block or face apron. Twenty cubic yards of concrete were used.

Vertical Expansion Joints to Elevation 1565

The vertical expansion joints between face panels have long been suspected as a big contributor to the leakage, either through ruptures in the copper seal, or porous concrete at the edges of the copper. Evidence to support this supposition was obtained in February, 1964, when dye was injected through plastic tubes into twenty joints selected in areas of leakage. Eleven of these tests showed dye in leakage at the outer toe.

Physical inspection of the copper seal was attempted by removing short sections of the asphalt impregnated board. A few small holes were observed, but at least some of them were made by chisels during removal of the board. Because of possible additional damage to the copper, further inspection was discontinued.

It was decided to seal these joints at the face slab surface. The material chosen for this work was Silicone Sealant, furnished by General Electric Company. When properly installed and cured, this material develops the required strength and elasticity, and also bonds to the concrete.

The initial phase of this work was carried only to Elevation 1565, so that there would be a reasonable chance of completing and curing all joints within the time allowed.

Procedures for applying this sealant were as follows:

1. Chip out asphalt board in joint to a depth of about 1-1/2 inch. Where board had been cut too deep, it was built up with redwood strips. Some joints had opened up to such an extent that redwood board had to be inserted along the side of the asphalt board.

2. Exposed concrete edges in the joint were cleaned to remove asphalt, and then ground. Grinding was extended about one inch on the face slab surface on either side of the joint to remove loose concrete and rebound.

3. The ground concrete surfaces were painted with Silicone masonry primer.

4. Immediately after priming, the joint was partially filled with "Ethafoam" rope 3/4" or 1" diameter, or with 1/2" thick "Ethafoam" sheet, depending on width of the joint. The purpose of this was to provide a backing under the sealant, and also to prevent a bond between the sealant and the asphalt board.

5. The unfilled portion of the joint was now about 3/8" deep. Silicone sealant material was extruded into this space and worked with paddles to remove air bubbles. During this finishing process material was carried beyond the joint to provide a one inch lap about 1/8" thick on the panel faces.

At the bottom of each Silicone joint, a relief device was installed to reduce hydrostatic pressure behind the Silicone during reservoir drawdown. This consisted of a 3/8" check valve and 1/2" OD copper tube. The tube was worked through the asphalt board to the copper expansion joint, and sealed in place with Igas.

At the top of each Silicone joint (Elevation 1565), a stopper was installed to prevent water from entering along the copper expansion joint from above. A small section of asphalt board was removed and the space was then filled with Igas.

A total of 114 joints were sealed by this method, requiring 480 gallons of Silicone sealant.

Four joints were reserved for a test installation using Carboline caulking compound. These joints are at Panels 35-36, 36-37, 60-61, and 61-62. Preparation and application was essentially the same as for Silicone, except that the materials used were Carboline No. 190 primer, and Carboline No. 704 caulking.

Vertical Expansion Joints Above Elevation 1565

The second phase of joint sealing was to complete all vertical expansion joints from Elevation 1565 up to the horizontal joint below the parapet. Work was planned so that this could be accomplished with water in the reservoir to Elevation 1562.

Procedure was the same as for the initial phase. The stopper at 1565 was removed to a depth of about 1-1/2 inch, and replaced with "Ethafoam", so that any leakage in the upper section would have a connection to the vent valve at the bottom of the joint.

An additional Igas stopper was located at the horizontal joint below the parapet.

Four vertical parapet joints were also sealed with Silicone. These are located at Panels 11-12, 16-17, 30-31, and 32-33, which were observed to be leaking on previous occasions.

A total of 225 gallons of Silicone were used in the second phase, which was completed on April 30, 1964.

Face Apron Repairs

The face apron refers to those areas where original rock extended above the reservoir floor and formed a part of the dike after excavation. The excavated face was sealed by a four inch layer of "Gun-all" concrete and wire mesh as part of the original construction.

In practically all of these face apron areas there is at least one major crack, generally horizontal, in some cases as much as 1/2" wide. In addition, there are numerous smaller cracks varying from hair-line to 1/16" wide. These appear in a random horizontal and vertical pattern.

The major cracks had been repaired several times in the past, either by guniting, grouting, or caulking with Igas and other materials. This old material was chipped out and the cracks were thoroughly cleaned. The exposed surfaces were then painted with Carboline No. 192 Adhesive, after which the crack was dry-packed with sand-cement grout. In the larger cracks, a parting-strip of tar paper was inserted in the grout joint above the original fracture to localize any future movement or shrinkage.

The above preparatory work was to provide a back-up for the final sealing membrane which was applied in the following steps:

1. Face apron surface along the grouted joint and several inches on either side was sand blasted to remove dirt and loose concrete.

2. The cleaned surface was sprayed with Carboline No. 190 primer and allowed to dry for 24 hours.

3. A thin layer of Carboline No. 706 caulking was applied to the grouted portion of the joint, the purpose being to permit the final membrane to adjust to movement without developing high localized stresses.

4. The sealing membrane, Carboline No. 1304, was sprayed over the entire joint to a thickness of about 40 mils. This membrane was bonded to the original gunall surface on either side of the crack.

Minor cracks (1/16 inch and less) were sealed with Carboline membrane in the same manner as the major cracks, except that the chipping and grouting operations were omitted. A layer of Carboline No. 706 caulking placed over the crack serves as backing for the final membrane.

Hair-line cracks were not to be sealed under the scope of work originally planned. However, these cracks were so numerous and extensive that the work was extended to include as many as time and materials permitted. The general procedure involved sandblasting, priming with Carboline No. 190 primer, and spraying with Carboline No. 1304 membrane. In the final stages of the work (Panels 50 to 68) Carboline No. 704 caulking or General Electric Silicone sealant was substituted for the Carboline membrane in some areas.

Face apron sealing required the use of 37 gallons of primer, 72 gallons of Carboline No. 704 and 706 caulking, and 50 gallons of Carboline No. 1304 membrane.

Dr. F. A. Nickell had expressed the opinion that these face apron cracks were caused by hydrostatic pressure behind the gunall during reservoir drawdown. In accordance with his recommendations, a total of 104 relief devices were installed. These consist of 3/4" ball check valves on pipe nipples grouted into the face apron after 2-1/4" holes had been drilled two to three feet into rock. Holes were located by inspection in areas where water was seeping through the gunall, or in cracks. They are three to six feet above the floor, and average about three per panel.

Depressed Area Floor

In accordance with plans, the long crack in the asphalt floor of the depressed area was repaired by covering it with a reinforced concrete slab. Conveyor belting was placed over the actual crack after first placing a 2" layer of concrete. Another layer of concrete was then placed on top of the belt to seat it and hold it in place. After this concrete had set up, the 10" slab reinforced with 4 x 4 No. 6 mesh was poured. This slab extends from the toe block at Panel 90 to the middle of Panel 94, and is a minimum of ten feet wide. One hundred and ten cubic yards of concrete were used.

Edges of this slab where it rests on the asphalt floor were caulked with Igas.

This crack and slab are located in a low trough which receives the entire initial rush of water when this part of the reservoir is filled. To dissipate the energy and reduce the velocity at the lower end, several one-ton boulders were placed along the edge of the slab.

Prior to pouring the slab, a considerable amount of pressure grouting was done in that general area. A detailed description is given in a subsequent section.

Vortex Basin

Original plans did not contemplate any extensive repairs in this area other than a small amount of pressure grouting.

The blow-out at a previously repaired rupture was cleaned out and patched with concrete. Two 1-1/2" pipes with check valves were installed prior to placing the concrete.

A similar concrete patch in the floor near Panel 49 showed evidence of leakage and having raised up. This was completely removed and replaced with new concrete and a 1-1/2" check valve vent.

Construction equipment working in the area broke off or damaged 15 of the 3/4" check valves installed in November. The nipples were removed and the holes filled with grout.

Two holes showed running water all during this outage. In order to grout these holes it was necessary to install relief pipes, which were then closed with 1-1/2" check valves.

Green, red, and blue dye was inserted in several vent pipes for the purpose of tracing and identifying future leakage. Location of dye and other features described above is shown by Sketch No. 1.

Pressure grouting in the vortex basin area is described in the following section.

Pressure Grouting

Panels 72 to 77 As the major horizontal crack in the face apron in this area was being cleaned out and old patching material removed, some voids and hollow spots were visible below the gunall face. It was then decided to consolidate the rock by pressure grouting, with a line of grout holes below the crack and another line above it.

Two and one-half inch drill holes ten feet deep were drilled on ten foot centers. All holes were diagonal or sloping. The bottom row of holes encountered some discontinuity as compared to solid hard rock at various depths to about eight feet, after which the rock was hard. The upper row was generally more sound. A number of vertical holes were drilled at the top of the berm, but since these had to be hand drilled, and the rock was hard, this row was not completed.

A total of 100 holes were drilled in this area and required 1,108 cubic feet of cement grout to fill. Grout requirement varied from a minimum of one to a maximum of 155 cubic feet per hole. In most cases the holes held a pressure of 50 to 60 psi after filling, although in one case the gunall face was cracked with a pressure of 30 psi.

Location of holes and distribution of grout is shown by Sketch No. 2.

Depressed Area Additional grout holes were drilled in the depressed area in front of Panels 90 to 95. These were on a line parallel to and about four feet from the original grout curtain placed in November, and were spotted between the original holes. Additional holes along the toe block and across the depression were also drilled, as shown on Sketch No. 3.

Holes were drilled 10 and 20 feet deep. Generally the drill encountered several feet of clay and soft or broken rock, with hard rock consistently below seven feet.

A total of 97 holes were drilled, and required 2,739 cubic feet of grout. In some cases the grout pressure held at 40 to 60 psi, but as a general rule grouting had to be stopped when the asphalt floor started to raise. In several cases grout appeared in adjacent holes. Maximum take for one hole was 278 cubic feet.

See attached Sketch No. 3 for grout distribution.

Vortex Basin In this area, grout holes were drilled in three separate locations.

Along the rain dike a row of ten foot holes on ten foot centers was drilled, and also several random holes where air had been sucked in during emptying of the reservoir. Rock in this area is shattered for several feet, with some voids, then generally hard. After the initial holes had been grouted, six additional holes were drilled near one which had taken 37 cubic feet. These were drilled diagonally to a depth of 30 feet. When grouted, the average requirement was five cubic feet. The total requirement was 185 cubic feet for 29 holes.

At the toe in front of Panels 53 to 56, sixteen holes 20 feet deep were drilled between old grout holes. As in the previous grouting program, considerable trouble with water was encountered. The total requirement for these holes was 169 cubic feet.

Along the slope between the shaft and the rain dike, a series of ten foot holes on 10 foot centers was drilled. After grouting, intermediate holes 20 feet and 30 feet deep were drilled. The drilling process was very difficult because of broken rock up to six feet below the surface. Below six feet the rock was generally sound and hard, but many cavities were encountered. Three of the ten foot holes were redrilled to a depth of 20 feet after initial grouting. Although one of these holes had taken 123 cubic feet initially, none took more than four cubic feet when redrilled. A total of 77 holes required 2,828 cubic feet of grout.

Location of grout holes and distribution of grout in the vortex area is shown by Sketch No. 4.

Vertical Shaft Inspection

On April 11, a Union Electric engineer inspected the vertical shaft to a depth of about 200 feet suspended from a crane cable. Portable radio sets were used for communication.

The gunite lining to a depth of 130 feet was generally in good condition. A 2" hole about 100 feet down had been observed before the plant went into operation, and was in essentially the same condition at this time. Four small holes about 1/2" in diameter were noted, with evidence of previous leakage, but were not leaking at this time.

Two areas about 18 inches in diameter have a top layer of gunite spalled off, about 1/2" deep.

Just below the gunite collar at the clay seam 130 feet down there was a small hole from which water was pouring - about the equivalent of a garden hose.

Granite surfaces below the gunite collar were generally in original condition, with most surfaces showing a build-up of calcium deposits.

No holes or channels which could contribute appreciably to reservoir leakage were observed.

Inspection below the 200 foot level was not possible because of water in the shaft.

Summary of Results

The door of the access tunnel was closed on April 17, 1964. Refilling commenced on April 19, at which time the vortex basin and depressed area were filled to approximately Elevation 1505. During vortex basin filling, air was observed being forced through the asphalt floor.

Within four hours, leakage was observed at Panel 54, generally in the vicinity of the vortex basin. Green dye flowed from this leak for about two days. (After pool was raised to Elevation 1515, green dye showed up in leaks at Panels 42 and 49.)

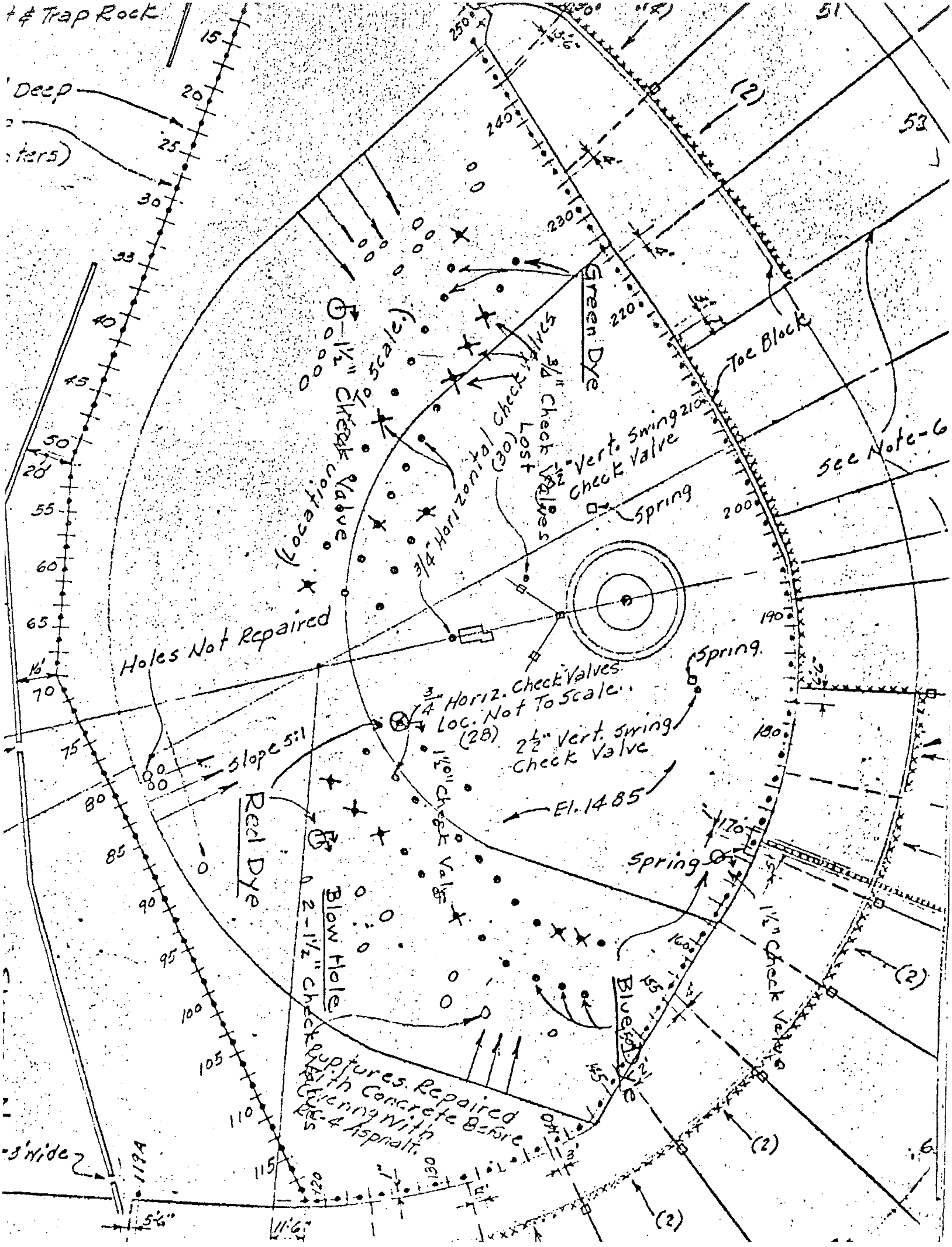
Reservoir filling above this level was carried out on a controlled basis so that leakage could be observed. In general, the level was increased 10 feet each day, and leakage was determined by change in reservoir level. The following tabulation represents the results of these observations.

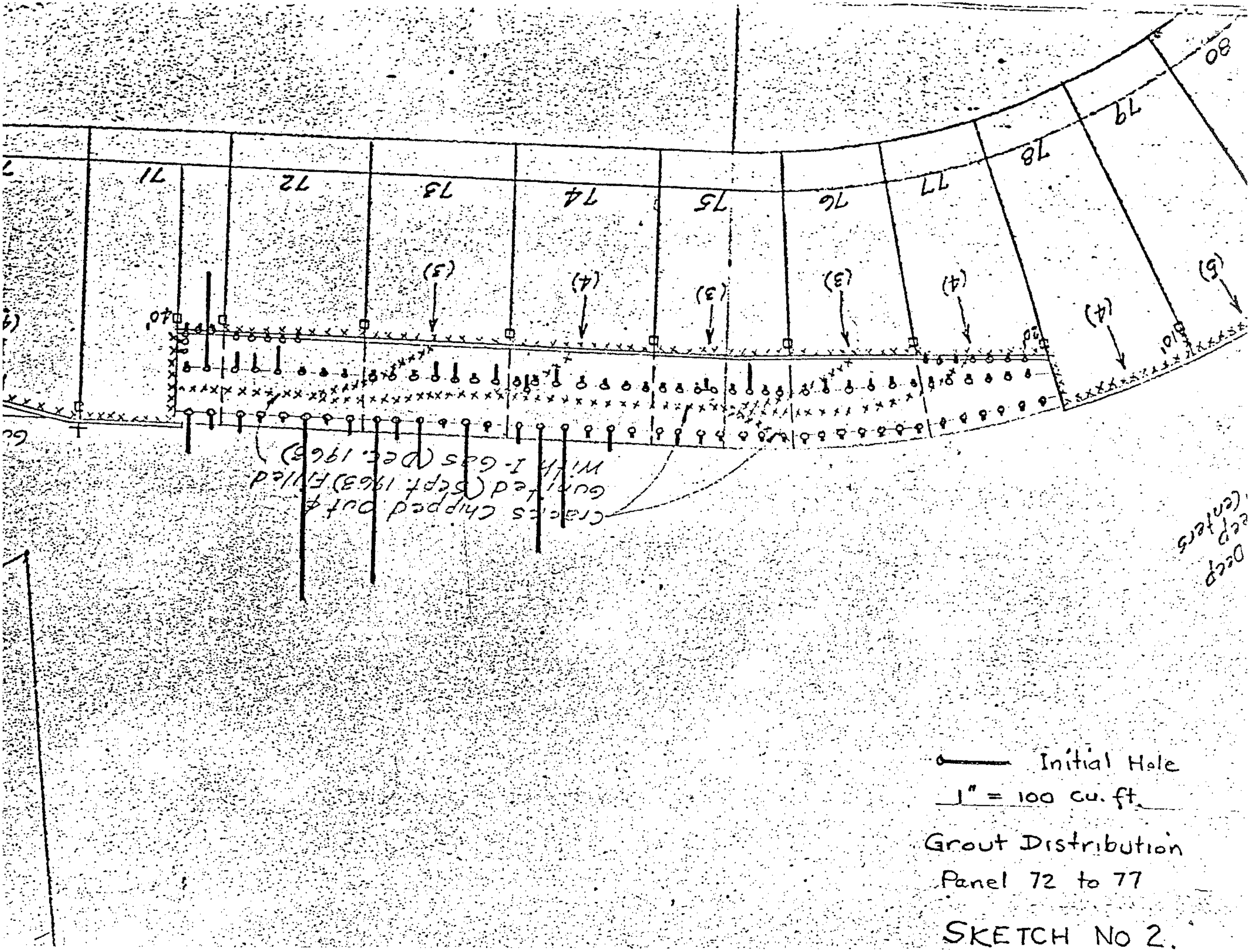
Date	Reservoir Level	Duration	Calculated Leakage
4-19-64	1505.7	10 hours	2 cfs (est.)
4-20-64	1515.95	19 hours	2.02 cfs
4-21-64	1529.85	55 hours	4.75 cfs
4-23-64	1539.85	16 hours	7.25 cfs
4-24-64	1550.48	16 hours	9.20 cfs
4-25-64	1549.83	10 hours	8.53 cfs
4-26-64	1560.64	23 hours	11.10 cfs

Location of leaks is generally the same as observed prior to this work, but are considerably reduced in volume. One of the larger leaks had been at Panels 71 and 79. This area was dry for two days, but leakage showed up on April 22. On April 23, red dye was observed in the flor from Panel 71, but not from 79.

PAPickel

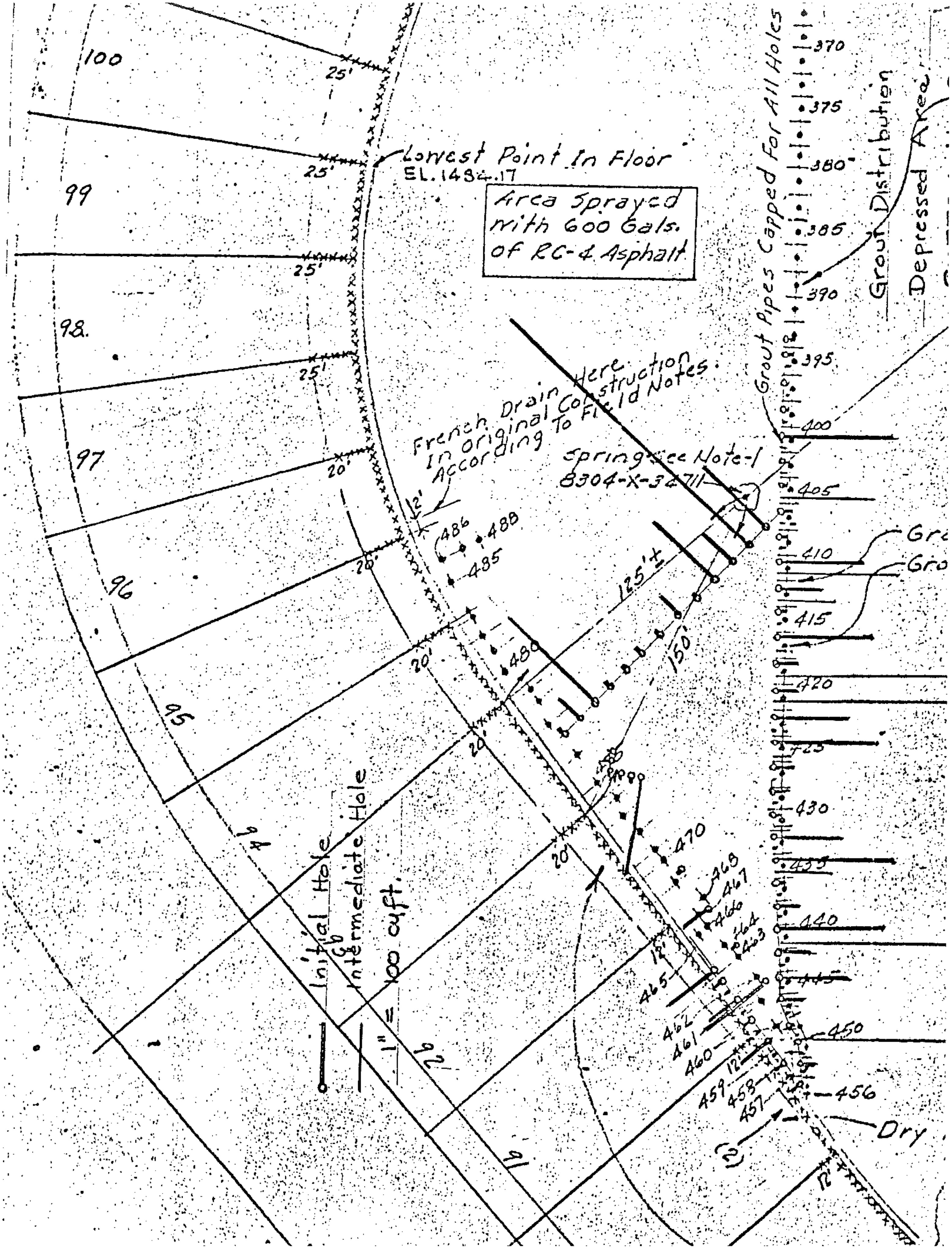
Prepared by: P. A. Pickel

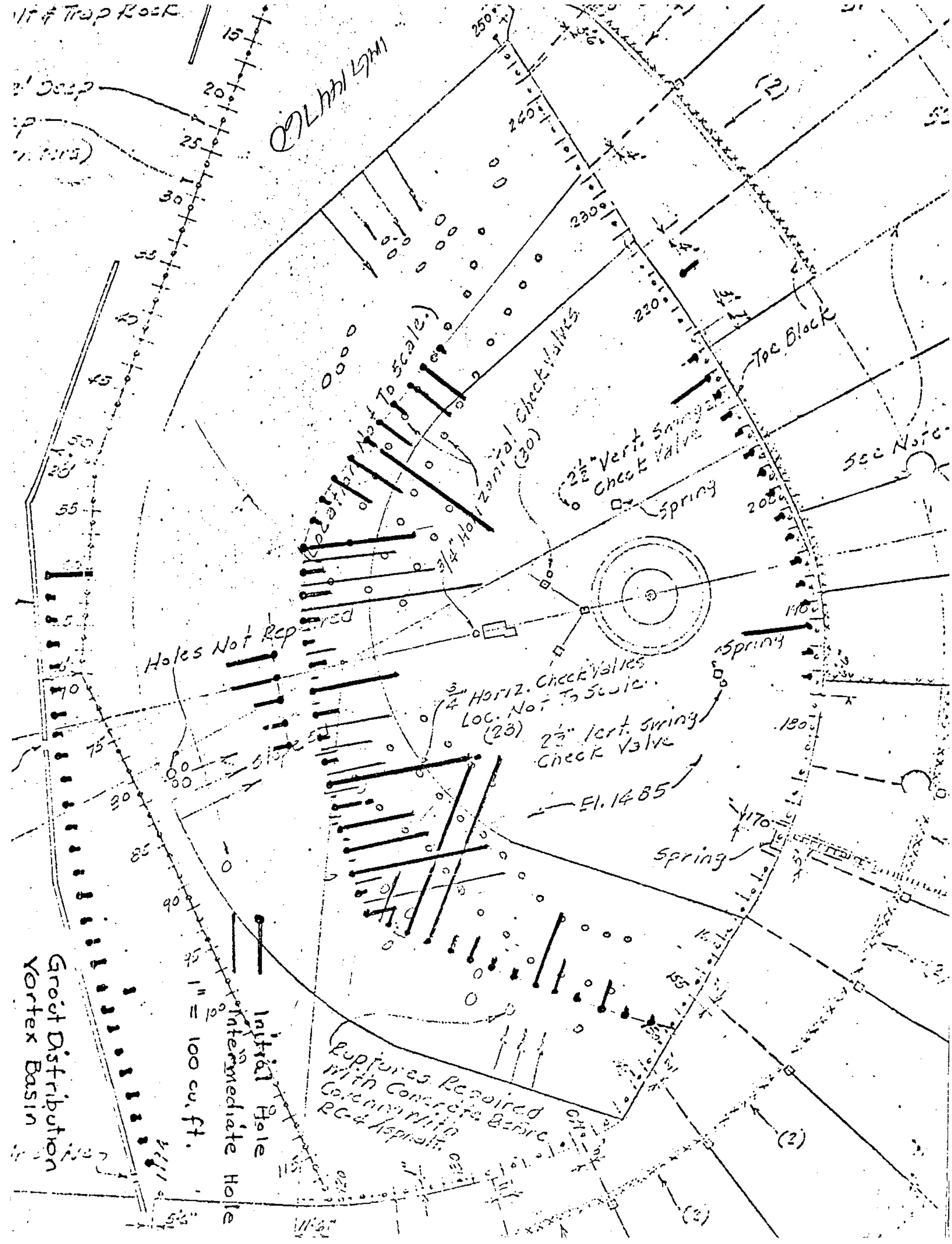

+ & Trap Rock
' Deep
ters)
15
20
25
30
35
40
45
50
20'
55
60
65
70
16'
75
80
85
90
95
100
105
110
115
119A
3' Wide
5'6"
11'6"
120
130
140
160
170
180
190
200
210
220
230
240
250°
230°
(2)
51
53
4'
4'
3½'
Green Dye
0-1½" Check Valve
(Location To Scale)
¾" Horizontal Check Valves
(30)
Lost
¾" Check Valves
2½" Vert. Swing 210 Check Valve
Spring
Toe Block
See Note-6
Holes Not Repaired
¾" Horiz. Check Valves
Loc. Not To Scale
(28)
2½" Vert. Swing Check Valve
Slope 5:1
Red Dye
1½" Check Valve
El. 1485
Spring
Spring
1½" Check Valve
Blow Hole
2-1½" Check Valves
Blue Dye
Ruptures Repaired With Concrete Before Covering With RC-4 Asphalt.
2'
3'
5'
(2)
(2)
(2)
(2)
6



Grout Distribution
Panel 72 to 77

SKETCH No 2.


100
25'
99
25'
Lowest Point In Floor
EL.1484.17
Area Sprayed
with 600 Gals.
of RC-4 Asphalt
98.
25'
25'
97
20'
96
20'
95
20'
20'
94
20'
92
91
French Drain Here
In Original Construction
According To Field Notes.
Spring-See Note-1
8304-X-32711
12'
486
488
485
480
125'±
150'
470
468
467
466
464
463
465
462
461
460
459
12'
458
457
456
Dry
(2)
12'
Initial Hole
Intermediate Hole
100 cu.ft.
1"
1"
Grout Pipes Capped For All Holes
370
375
380
385
390
395
400
405
410
415
420
425
430
435
440
445
450
Grout Distribution
Depressed Area
Gro
Gro


Grout Distribution
Vortex Basin
Initial Hole
Intermediate Hole
1" = 100 cu. ft.
Ruptures Repaired with Concrete Bars Contaminated with RC-4 Asphalt
Holes Not Repaired
3/4" Horizontal Check Valves (30)
Located Not To Scale.
2½" Vert. Swing Check Valve
Spring
3/4" Horiz. Check Valves Loc. Not To Scale. (23)
2½" Vert. Swing Check Valve
El. 1485
Spring
Spring
Toe Block
See Note
(2)
(2)
(2)
IMG14470
Trap Rock
15
20
25
30
35
40
45
50
55
65
70
75
80
85
90
95
100
110
115
120
155
160
170
180
190
200
220
230
240
250

APPENDIX C

GOUHOU DAM PAPER

BREACHING OF THE GOUHOU CONCRETE FACE SAND AND GRAVEL DAM

BY

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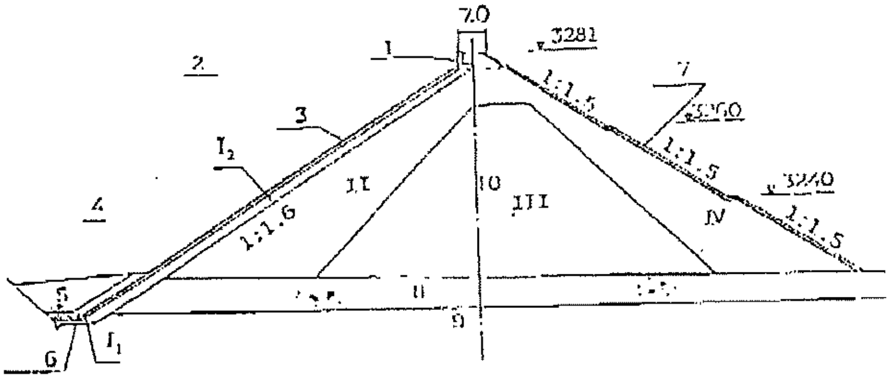
ABSTRACT

This paper gives a briefing of the failure of the Gouhou dam which happened on August 27, 1993 in Gongho County, Qinghai Province, China. Main aspects of design and construction are outlined, followed by a description of the failure process. Investigations both on the fill material and concrete structures were given after failure. Comments are given regarding the causes of the failure.

1.INTRODUCTION

On August 27, 1993, a catastrophic dam failure happened at the Guohou Reservoir, located near the town of Qiapoqia, capital of the Gongho County, Qinghai Province. Breaching of this concrete face sand and gravel dam (CFGD) created an estimated 1,500 m^3/s peak discharge of water, sweeping away half of the embankment material and bringing about great losses in human lives and properties.



1. Crest wall; 2. Normal water level; 3. Face slab; 4. Dead water level; 5. Random fill; 6. Clay.
7.Dry packed rock; 8.Alluvium; 9.Bed rock; 10.Dam axis

Fig. 1 Cross section of the dam

2. MAIN FEATURES OF THE DAM

2.1 General

The dam was 71 meter high measured from the alluvium river bed or 84 meter, from the bed rock where the plinths were placed. Normal and maximum water levels are both at the elevation 3278m, which is 3 meter lower than the crest of the dam. It was 265m long and 7 m wide at the crest. The upstream and downstream slopes were 1.6 on 1 and 1.5 on 1 respectively. Total water storage at normal water level was 3.3 million m^3 (Fig.1).

Average runoff of the Qiapoqia River is $0.4m^3/s$. The only discharge facility of the project was a 390 meter long tunnel located at the left abutment (Chu., et. al., 1992).

2.2 Foundation of the Dam

The Gouhou dam was founded on a 13 meter thick sand and gravel alluvium, underlain by highly fractured granite bedrock. The river alluvium, having a unit weight of 2.40 KN/m^3, coefficient of permeability of 20.9-94.5 m/d and coefficient of uniformity of 391, was believed to be dense, permeable and well graded. Consequently, It was decided that the alluvium would not be removed except where the plinth was to be placed. Excavation of the alluvium was undertaken there until the lightly weathered granite was exposed for placing the plinth. Grouting under the plinth was required until the value of ϖ, water intake per water head per unit length, went below 0.03 l/s-m-m.

2.3 The Fill Material and Zoning

The embankment sand and gravel material was taken from two borrow pits 3 kilometres downstream of the dam site. The gravels are hard, un-weathered, fairly granular and made of granite and sandstone. The report of the field geotechnical tests indicated that the content of fines (particle size less than 5mm) was 33%, that of silt (particle size less 0.1mm) was 4% and the coefficient of uniformity was 78 in average. It also gave an evaluation of coefficient of permeability being 1.48×10^{-1} cm/s.

The dam was divided into fours zones as shown in Fig. 1. Main features of the four parts are indicated in Table 1 from which one may find that no serious restrictions to the gradings of difference zones were given. Since large pebbles were rare, the dam was essentially a uniform sand and gravel one (Hong, 1990).

2.4 The Concrete Face Slabs

Concrete slabs were placed with vertical joints spaced at 14m in the middle part and 7m near abutments of the dam. A horizontal joint was provided at the elevation 3255m for early water storage during construction. The thickness of the slab is 30cm at the top and 60cm at the bottom of the dam. Reinforcement was provided for the face slabs. For the vertical joints in the middle part of the dam, where compressive stresses were believed to prevail, the joints were connected with copper W-type water stop and filled with mastic. For those near the abutments, where tensile stresses dominated, an additional rubber water stop was provided.

2.5 The Crest Wall

Following the common practice of CFRDs, an L-type crest wall was provided to save the volume of rockfill and facilitate concrete placement of slabs by the slip form.

The horizontal slabs of the crest wall were 35 cm thick reinforced by single layer of steel bars and

Table 1 Specifications for the fills of the various zones

Zone Number	Fills	Layer Thickness cm	Maximum Size 4mm	Relative Density	Dry Density KN/m^3
I1	Transition	20	20	0.8	2.30
I2	Transition	30	100	0.8	2.30
II	Old Borrow Pit	60	400	0.75	2.30
III	New Borrow Pit	90	600	0.70	2.26
IV	New Borrow Pit and Tunnel Rock Fragments	130	800	0.70	2.26

were connected with the face slab by rubber water stop. The elevation of the horizontal slab was 3277.35m. To accommodate possible settlement of the dam, transverse joints are provided at 6m spacing.

3. PERFORMANCE OF THE DAM

3.1 Behaviour of the dam before 1993

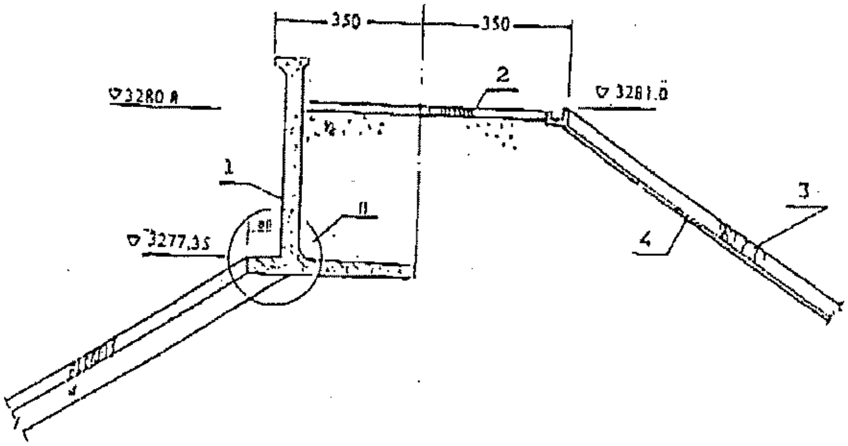
The Gouhou dam started water impoundment on September 28, 1989. On October of the same year, corresponding to a reservoir water level of 3258m, a concentrated flow appeared at the downstream slope somewhere 1.5m higher than the toe(ele. 3223m). Local remedial work included replacement of the scoured fill material, after which the flow seemed to disappear.

October, 1990 saw the first high reservoir water level of 3274m. The concentrated water flow re-appeared at the same location seen in 1989. The inflow measured at the weir near the toe of the dam was 18 l/m^3. No concentrated seepage was visualized during 1991-1992, a period whose reservoir water level was relatively low, not exceeding 3262m (Yu. 1993).

As a small project, limited instrumentation was available. It was measured that the settlement at the dam crest was 7cm. The water levels of the four open stand type piezometers of the abutment indicated that ground water level of the bed rock was lower than 3225m, which is reasonably low. An earthquake of the magnitude 6.9 on the Richter scale hit the area on April 26, 1990 with its epicentre 40 km from the dam. The dam was found to be intact.

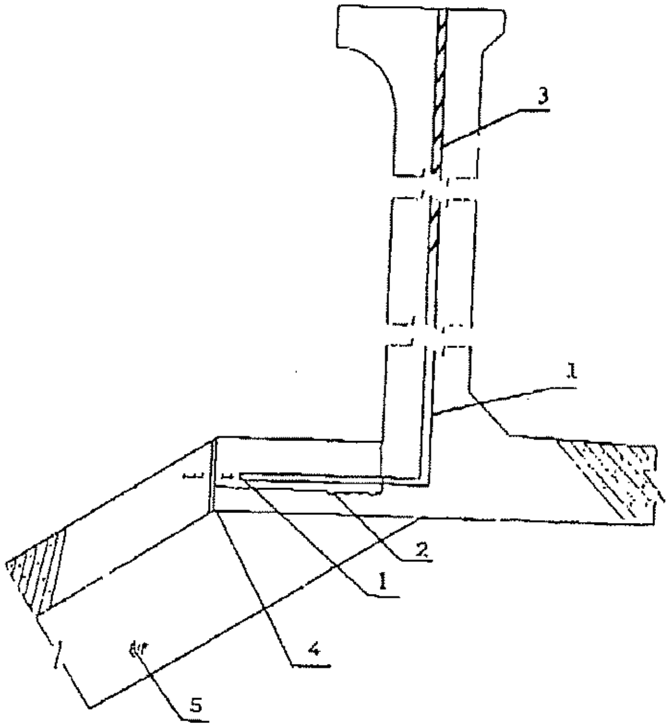
3.2 Failure Process.

Starting from July 14, the water level of the reservoir kept rising from 3261m. On August 26 the reservoir level reached 3277m which meant that it had been close to or sometimes higher than the horizontal slab of the crest wall for about 24 hours before the dam failure. It must be emphasized that this statement, which is significant in explaining the causes of the dam failure as will be seen later,



1. Reinforced concrete; 2. Pavement; 3. Masonry; 4. Transition.

a. Layout



b. Details

1. Rubber water stop; 2. Top of the intact concrete; 3. Timber soaked by oil; 4. Timber Fill; 5. Transition.

Fig. 2 The crest wall

图 3.失事后的大坝全景
Fig. 3. The breached dam

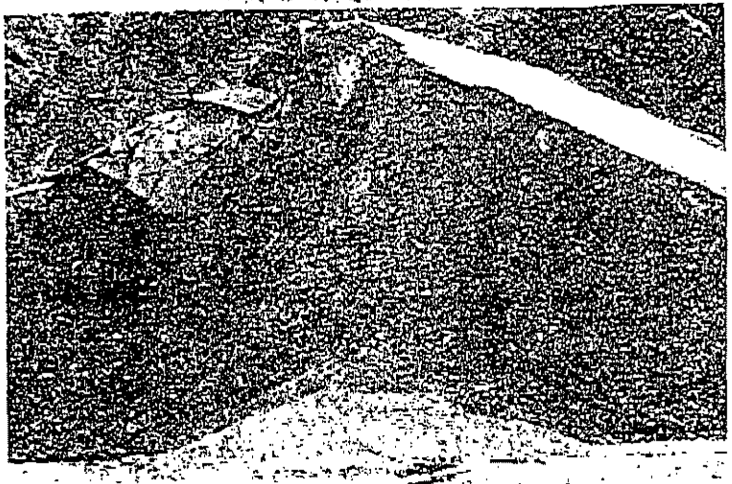


图 4.大坝缺口左侧面上涌水形成的冲沟
Fig. 4 The gullies cut by the flowing water

图 5.防浪墙底板碎裂情况
Fig. 5 The horizontal slab of the crest wall

was based on the memory of the administrative staff since the written records of water levels were destroyed by the flood during the dam failure. However, field survey of the water prints on the remaining parts of the wall gave a universally admitted water level at failure which was around 3277.3m.

At about 8:30 pm of August 27, Ms Sun Guilian, a villager, climbed on the dam slope with her sister She found water gushing out at the second berm (elevation 3260m) like 'tap water'. Since it started raining, they went back.

Hang Guo, the maintenance worker of the reservoir was probably the first one who witnessed the failure. He narrated:

'I heard a thunder-like noise. I went out of my office immediately and saw water splash and stones rolling on the dam slope. I also saw some fire flash probably created by the bumping stones. Then I managed a motorcycle, rushed to the town and reported to the leaders'

People were urged to leave their home immediately. However it was too late to evacuate all the residents when the flood reached the town of Qiapoqia, which is 13km downstream of the dam, at about 11:50 pm, a time which was confirmed by most survivors. The exact time when Mr. Hang discovered the incident was not clear. Tracing his activities, it was estimated to be around 9:15 am. The breaching of the dam developed very rapidly.

3.3 Destructions of the Dam

The breaching of the dam created a triangle weir on the concrete face slab, which is 137 meter wide at the dam crest. The elevation of the lower point was 3250m. Part of the slot went along the horizontal joint of the face slab. The flood cut through the dam body and created a 61m wide chute with almost vertical side walls. Total amount of water released was estimated to be 2.61 million m^3. The remaining part of the dam body lower than 3250m kept retaining water which overtopped the crest and created a water fall as shown in Fig. 3.

4. INVESTIGATIONS

4.1 Geotechnical Investigations

4.1.1 Visual Inspections

It has been found that the remaining part of the dam body was fully saturated from the top to the bottom of the dam. Apart from the all wet side walls that dipped for at least two days, evidence also includes:

- A number of concentrated flow which appeared on the side walls, creating more than ten gullies on both sides. The water flow lasted for at least two days (Fig. 4).
- Two concentrated flows identified on the downstream slope masonry of the remaining right part of the dam at elevation 2765m.
- Three typical piping holes seen on the left vertical wall, at the elevation 3226m.

The stability of the surviving left and right parts of the dam seemed to have been affected. Some longitudinal cracks and slightly bulging were seen on the right embankment. Cracks of the crest walls developed on both parts.

4.1.2 Grading of the Gravel Material

The lack of adequate drainage of the dam has aroused common concern about the grading of the fill material. All available field gradation test results have been collected. They include the 55 gradings obtained from the borrow pit and the dam body. The tests were carried out by the contractor for quality inspection purpose. The smallest, average and greatest contents of fines (particles less than 5mm) are 23.5%, 41.7%, 66.8%; and those of silt (particles less than 0.1mm) are 0.3%, 4.3%, 8.3% respectively. Fig. 6 gives three curves that represent the finest, coarsest and average gradations of the samples.

Very limited permeability tests were carried out during dam construction. Two shallow well permeameter tests were carried out in the surviving dam bodies by the case inspectors after failure, which gave the coefficients of permeability of 1.0×10^{-2} cm/s and 1.83×10^{-2} cm/s respectively.

4.2 Investigations of the Concrete Structures

4.2.1 The Face Slabs and Joints

There are eleven concrete debris on the river channel, which enabled us to check the quality of the joints and water stops. It has been found that some of the contacts between copper water stops and the concrete slab have not been fully filled. A two meter long clean un-scratched rubber stop found in one of the debris indicated that this rubber stop, having no contact with the surrounding concrete, had not suffered from shearing during dam failure. Some concrete exhibits 'honey holes', indicating poor quality during construction.

4.2.2 The Crest Wall

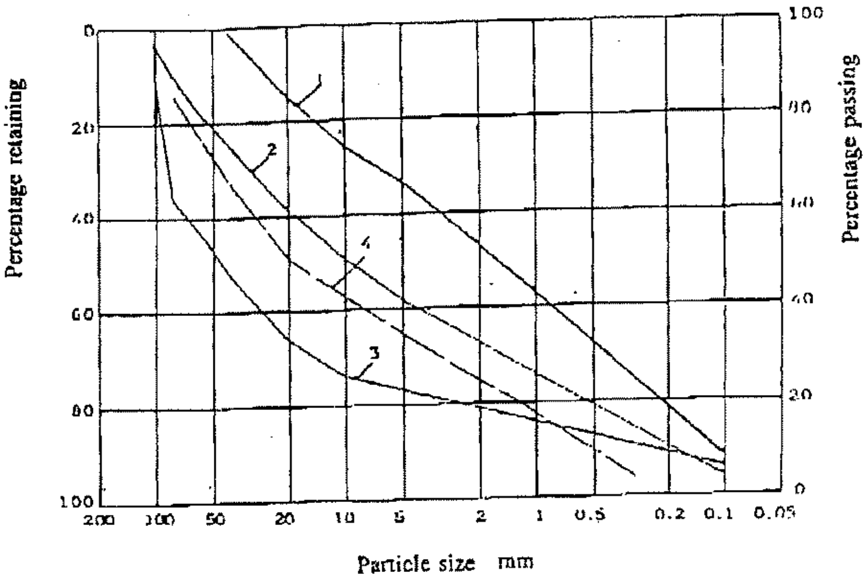
It was surprising to find that all the remaining horizontal slabs of the crest wall were highly fractured. The investigators were told that not long after the placement of the concrete, cracks developed on the slabs. They were then corrected by pasting cement mortar which again cracked. As a result of the concrete crumbling on top of the horizontal slabs, the existing intact slabs were invariably lower than the rubber water stop (Fig.2). There is no doubt that water would come into the dam through the unsealed gaps between the face slab and crest wall as soon as it exceeds the horizonal slab The investigators did find a number of holes and digged out some weed powder, indicating the path of seeping water (Fig. 5). As discussed above, the water level had been close or higher than the horizontal slab for about 24 hours before the failure.

5. DISCUSSIONS AND CONCLUDING REMARKS

It is clear that the failure of the Gouhou dam was caused by the unexpected high phreatic line of the dam. Water came into the dam through damaged concrete slabs and their joints especially when it exceeds the slab of the crest wall. The fill material seemed to be not permeable enough to allow free draining. Detailed study on the deficiencies both on design and construction phases are much demanded. The author hopes the following points might be of help in clarifying some issues.

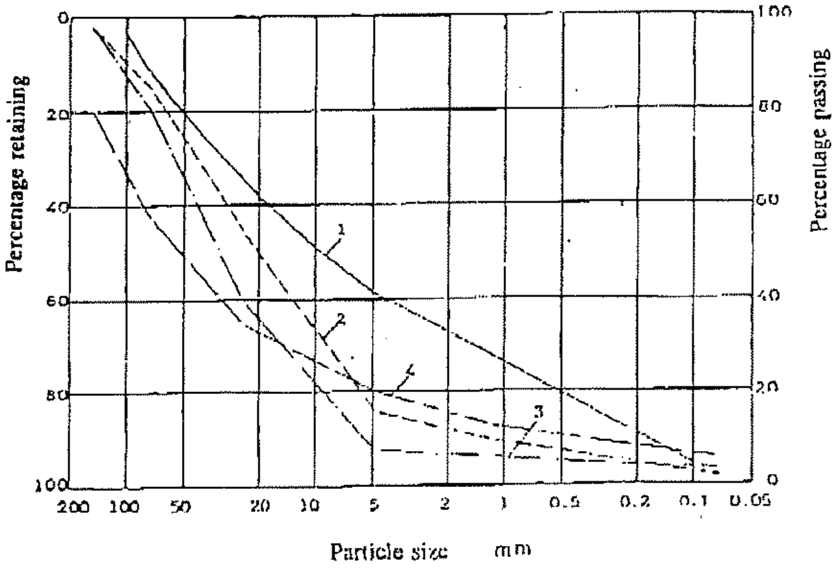
(1) All witnesses confirmed that failure started from the upper part of the dam. The remaining dam body still works satisfactorily in retaining water with an overflow through its crest (Fig.1). No seepage through foundation has been visualised. It is therefore confirmed that the foundation of the dam works perfectly and does not contribute to the failure.

(2) The Qiapoqia River is a small creek with a natural runoff not more than 0.8 m^3/s at the time of failure and it was found that the reservoir water level kept rising instead of lowering before failure. This means the maximum seepage into the dam body would not exceed 0.8 m^3/s, an order of magnitude several CFRDs have also experienced without failure. Compared with the gradings of the then existing three CFGDs in the world (Fell, R. et. al., 1992, Fig.7), the Gouhou fill material was



1,2,3: Selected gradings of 55 samples. 1, finest; 2. average; 3. coarsest. 4. Average of 8 samples taken from exploratory pit of borrow area.

Fig. 6 Gradations of the fills



1. Gouhou (based on 55 gradings; 2. Crotty; 3. Salvagina; 4. Golillas

Fig. 7. Comparisons of gradings.

relatively fine. However, unlike the three dams, special free drainage zone was absent. The designers have given similar discussions (Chu, 1992).

(3) The permeability of the fill material is a problem of common concern. The design of the dam was based on the test data taken from the borrow pit, which gave a value of 1.48×10^{-1} cm/s. The available 56 gradings of the fill material exhibit big variance as can be seen in Fig. 6. The average of the 55 samples taken from the dam was finer than that of the 8 samples taken from the borrow pit during design stage. Some risk analysis might be desirable in assessing the reliability of the field test data if the number of tests is not large enough and the locations of the samples are not reasonably representative.

(4) This dam has an important feature that the normal water level is above the horizontal slab of the crest wall. The reason of the cracking of the crest wall slab is still a question of much needed study. However, correcting the cracking by cement mortar is by all means wrong. As an important part of the dam structure, the crest wall is subjected to very complicated working conditions including settling of the foundation, rotating due to earth pressure, etc. Details of the crest wall must be carefully studied to assure safe performance of the wall.

The failure of the dam is unfortunate, but the lessons learned from this case are enlightening: *a leaking embankment with inadequate drainage can be dangerous.*

ACKNOWLEDGEMENTS

Part of the information of this paper is adopted from the design and construction documents prepared by the Water Resources Design Institute of Shanxi Province and the No. 20 Railway Construction Bureau to which the author is indebted.

REFERENCE

Chu, L. and Yang, Z., 1992. Some prebless in the design of the Gouhou concrete face sand and gravel dam. *Water Power*, pp.29-31, in Chinese.

Hong, C., 1990. Main features of the Gouhou concrete face rockfill dam. *Proceedings of CFRDs*. pp 167-173. Hohai University Press, in Chinese.

Yu, Y., 1993. Investigations on the seepage of the Gouhou concrete face sand and gravel dams. *Water Resources of Qinghai*, pp. 23-24, in Chinese.

Fell, R., MacCregor, P. and Stapledon, D., 1992. Geotechnical Engineering of Embankment Dams ,A A. Balkema, pp. 526-628.

APPENDIX D

BORING LOGS

Taum Sauk Plant, Upper Reservoir Dike. Foley & Lardner LLP **PROJECT NO. 06-3551**

LOG OF BORING NO. TS-1

COORDINATES
N 620241.78 E 728685.22

SURFACE EL: 1586.9

ELEVATION (FEET MSL)	DEPTH (FEET)	SAMPLE NO. OR RUN NO.	BLOW/6" & (N) OR % REC. & (RQD)	RECOVERY (ft.)	DESCRIPTION	USCS SYMBOL	REMARKS
	0				Gravel and SAND orangeish gray. Road base.		Not sampled
1583.9		S-1		100%	3' COBBLES with SAND, Rock fragments are Porphyritic rhyolite, angular to subangular, dark brown, The fragment shapes and colors are similar in all intervals except where stated	GP-GM	6" sampler Not cored boulders
1576.9	10	S-2		84%'	10' COBBLES and GRAVEL with sand/fines, Rock fragments are Dark Reddish Brown and sand/fines are moderate yellowish brown.	GP-GM	
1566.9	20				20' COBBLES and GRAVEL some sand, dark reddish brown	GW	Drilled with 4" core barrel . Poor recovery
	30	S-3		30%			
1546.9	40	S-4		30%	40'	GP	6" sampler. Rapid drilling rate, poor recovery, no water 800 lbs pressure, 800 PSI pressure.
1536.9	50	S-5		10%	50'	GP	Rapid drilling rate
1526.9	60	S-6		40%	60'	GP	Rapid drilling rate
	70						

DATE STARTED: 1/16/2006
DATE COMPLETED: 1/16/2006
FIELD GEOLOGIST: HWG
CHECKED BY: EGZ

GWL: DEPTH: N/A DATE/TIME:
GWL: DEPTH: DATE/TIME:
DRILLING METHOD: Sonic drilling with 6" diameter core. Sample typically taken every 10'

NOTES: All samples sent to Geotechnics laboratory for additional analysis

DRILLING CO.: Miller Co
DRILLER: Tracy
HELPER: Chris, Christian and Jeremy
RIG: VERSASONIC Rig

Taum Sauk Plant, Upper Reservoir Dike. Foley & Lardner LLP **PROJECT NO. 06-3551**

LOG OF BORING NO. TS-1

COORDINATES
N 620241.78 E 728685.22

SURFACE EL: 1586.9

ELEVATION (FEET MSL)	DEPTH (FEET)	SAMPLE NO. OR RUN NO.	BLOW/6" & (N) OR % REC. & (RQD)	RECOVERY (ft.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS
1516.9						70' COBBLES and GRAVEL with trace fines	GP	Rapid drilling rate
		S-7		60%				
1506.9	80					80' COBBLES and GRAVEL, trace fines	GP	Rapid drilling rate
		S-8		60%				
1496.9	90					90' COBBLES and GRAVEL some sand/fines	GP	
		S-10		82%				
1486.9	100	S-11		100%		100' COBBLES and GRAVEL trace fines; also present is soil with roots. Soil is Silty, bluish gray and moderate yellowish brown.	GP	
1483.9		S-12		50%		103' Rhyolite porphyry, Reddish brown, fractured	GP-GM	
1481.2						BOTTOM OF BORING 105.7'		See TS-1R for rock coring log
	110							
	120							
	130							
	140							

DATE STARTED: 1/16/2006
DATE COMPLETED: 1/16/2006
FIELD GEOLOGIST: HWG
CHECKED BY: EGZ

GWL: DEPTH: N/A DATE/TIME:
GWL: DEPTH: DATE/TIME:
DRILLING METHOD: Sonic drilling with 6" diameter core. Sample typically taken every 10'

NOTES: All samples sent to Geotechnics laboratory for additional analysis

DRILLING CO.: Miller Co

DRILLER: Tracy HELPER: Chris, Christian and Jeremy

RIG: VERSASONIC Rig

Taum Sauk Plant, Upper Reservoir Dike. Foley & Lardner LLP **PROJECT NO. 06-3551**

LOG OF BORING NO. TS-2

COORDINATES
N 620883.19 E 728417.47

SURFACE EL: 1587.45

ELEVATION (FEET MSL)	DEPTH (FEET)	SAMPLE NO. OR RUN NO.	BLOW/6" & (N) OR % REC. & (RQD)	RECOVERY (ft.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS
	0					Poorly graded GRAVEL; parking lot - road aggregate	GP	Not sampled
1584.5						3' COBBLES with GRAVEL, some sand, some clay, Rock fragments are angular to subangular, brownish gray. Sand is moderate yellowish brown. The fragment shapes and colors are similar in all intervals except where stated	GP-GC	6" sampler. Not cored boulders
		S-1		70%				
1577.5	10					10' COBBLES and GRAVEL some sand. Brownish gray	GP	Rapid drilling rate
		S-2		45%				
1569.5						18' COBBLES and GRAVEL some sand; trace fines. Rock fragments are reddish gray	GP	Moist from drilling
1568.0						18.5'	GP	
1567.5	20					20'	GW	Rapid drilling rate
		S-3		45%				
1557.5	30					30' COBBLES and GRAVEL some sand, trace fines. Rock fragments are reddish gray	GP	Rapid drilling rate
1553.5		S-4		50%		34' Boulder @ 34'-37.5'	GP	Slow drilling rate
1547.5	40					40'	GP	Fast drilling rate.
		S-5		50%				
1537.5	50					50' GRAVEL with sand, some silt	GP-GM	Rapid drilling rate except for 54-56' where moderate
		S-6		50%				
1527.5	60					60'	GP-GM	Slow drilling rate; drilled 10'/0.5 hr
		S-7		50%				
	70							

DATE STARTED: 1-19-06
DATE COMPLETED: 1-20-06
FIELD GEOLOGIST: HWG
CHECKED BY: EGZ

GWL: DEPTH: dry DATE/TIME: 3-13-06/ 08:00
GWL: DEPTH: DATE/TIME:
DRILLING METHOD: Sonic drilling with 6" diameter core. Sample typically taken every 10'

NOTES: All samples sent to Geotechnics laboratory for additional analysis

DRILLING CO.: Miller Co

DRILLER: Tracy HELPER: Chris, Christian and Jeremy

RIG: VERSASONIC Rig

Taum Sauk Plant, Upper Reservoir Dike. Foley & Lardner LLP **PROJECT NO. 06-3551**

LOG OF BORING NO. TS-2

COORDINATES
N 620883.19 E 728417.47

SURFACE EL: 1587.45

ELEVATION (FEET MSL)	DEPTH (FEET)	SAMPLE NO. OR RUN NO.	BLOW/6" & (N) OR % REC. & (RQD)	RECOVERY (ft.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS
1517.5						70' COBBLES and GRAVEL; trace fines - mostly derived from coring	GP	Rapid drilling rate 10'/1 min Moisture from drilling
		S-8		28%				
1507.5	80					80'	GC	Very rapid drilling rate; Moderate from 95' to 100'. Boulder 98'-100'. Changed to 4" sampler
	90	S-9		5%				
1487.5	100	S-10				100' Silty SAND, light yellowish gray Rhyolite (boulder and cobble)	GC	Changed back to 6" sampler
1482.0						BOTTOM OF BORING 104.5'		See TS2-R for rock coring log
	110							
	120							
	130							
	140							

DATE STARTED: 1-19-06
DATE COMPLETED: 1-20-06
FIELD GEOLOGIST: HWG
CHECKED BY: EGZ

GWL: DEPTH: dry DATE/TIME: 3-13-06/ 08:00
GWL: DEPTH: DATE/TIME:
DRILLING METHOD: Sonic drilling with 6" diameter core. Sample typically taken every 10'

NOTES: All samples sent to Geotechnics laboratory for additional analysis

DRILLING CO.: Miller Co

DRILLER: Tracy HELPER: Chris, Christian and Jeremy

RIG: VERSASONIC Rig

Taum Sauk Plant, Upper Reservoir Dike. Foley & Lardner LLP **PROJECT NO. 06-3551**

LOG OF BORING NO. TS-3

COORDINATES
N 620744.30 E 728478.45

SURFACE EL: 1587.4

ELEVATION (FEET MSL)	DEPTH (FEET)	SAMPLE NO. OR RUN NO.	BLOW/6" & (N) OR % REC. & (RQD)	RECOVERY (ft.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS
	0					SILT, SAND and GRAVEL, Grayish orange; road access cover 2'		Not sampled
1585.4		S-1		70%		Sandy GRAVEL with silt and cobble; grayish brown. Moist	GW-GM	
1577.4	10	S-2		50%		10' Rhyolitic GRAVEL fragments with sandy silt	GP-GC	Rapid drilling rate
1567.4	20	S-3		45%		COBBLES, GRAVEL, with sand; little fines. Rock fragments are reddish gray 20'	GP-GC	Moist from drilling Rapid drilling rate
1557.4	30	S-4		37%		30' COBBLES, GRAVEL, with sand; little fines. Rock fragments are reddish gray	GW	Rapid drilling rate
1547.4	40	S-5		25%		40'	GP	Fast drilling rate.
1537.4	50	S-6		50%		50' Rhyolitic COBBLES, GRAVEL some sand and silt.	GP-GM	Slow drilling rate
1527.4	60	S-7		50%		60' Boulders of Porphyritic Rhyolite	GP-GM	Slow drilling rate Boulders
	70							

DATE STARTED: 1-19-06
DATE COMPLETED: 1-20-06
FIELD GEOLOGIST: HWG
CHECKED BY: EGZ

GWL: DEPTH: 97.15 DATE/TIME: 3/13/06 08:00
GWL: DEPTH: DATE/TIME:
DRILLING METHOD: Sonic drilling with 6" diameter core. Sample typically taken every 10'

NOTES: All samples sent to Geotechnics laboratory for additional analysis

DRILLING CO.: Miller Co

DRILLER: Tracy

HELPER: Chris, Christian and Jeremy

RIG: VERSASONIC Rig

Taum Sauk Plant, Upper Reservoir Dike. Foley & Lardner LLP **PROJECT NO. 06-3551**

LOG OF BORING NO. TS-3

COORDINATES
N 620744.30 E 728478.45

SURFACE EL: 1587.4

ELEVATION (FEET MSL)	DEPTH (FEET)	SAMPLE NO. OR RUN NO.	BLOW/6" & (N) OR % REC. & (RQD)	RECOVERY (ft.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS
1517.4		S-8		28%		70' Several boulders of Porphyritic Rhyolite	GP	Slow drilling rate Boulders
1507.4	80	S-9		25%		80'	GP	Moderate drilling rate 80'-87'; rapid from 87' to 90'
1497.4	90	S-10		50		90' Silty SAND, olive gray (soil). Wet	GC	PP = 1.5 TSF
1491.5						BOTTOM OF BORING 95.9'		See TS-3R for rock coring log
	100							
	110							
	120							
	130							
	140							

DATE STARTED: 1-19-06
DATE COMPLETED: 1-20-06
FIELD GEOLOGIST: HWG
CHECKED BY: EGZ

GWL: DEPTH: 97.15 DATE/TIME: 3/13/06 08:00
GWL: DEPTH: DATE/TIME:
DRILLING METHOD: Sonic drilling with 6" diameter core. Sample typically taken every 10'

NOTES: All samples sent to Geotechnics laboratory for additional analysis

DRILLING CO.: Miller Co

DRILLER: Tracy HELPER: Chris, Christian and Jeremy

RIG: VERSASONIC Rig

Taum Sauk Plant, Upper Reservoir Dike. Foley & Lardner LLP **PROJECT NO. 06-3551**

LOG OF BORING NO. TS-4

COORDINATES
N 620602.03 E 728540.85

SURFACE EL: 1587.03'

ELEVATION (FEET MSL)	DEPTH (FEET)	SAMPLE NO. OR RUN NO.	BLOW/6" & (N) OR % REC. & (RQD)	RECOVERY (ft.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS
	0	S-1		40%		GRAVEL and Sand, with fines (silt) from drilling and upper road access. Rock fragments are angular to subangular, dark reddish brown. Sand/fines are moderate yellowish brown. The fragment shapes and colors are similar in all intervals except where stated	GP-GM	Boulders at 2-3' and 7-9'.
1577.0	10	S-2		80%		10' GRAVEL some sand, some fines (silt) - fines are existing and due to drilling.	GP-GM	Boulder at 15-16' Rapid drilling rate 19-20' Moderate drilling rate 10-18'
1567.0	20	S-3		50%		20' GRAVEL some sand and fines (silt). Rock fragments are Dark Reddish Brown and sand and fines are moderate yellowish brown.	GP-GM	Rapid drilling rate Moist from drilling and rain
1557.0	30	S-4		35%		30' GRAVEL, some sand	GP	Boulder at 34-36' Rapid drilling rate 30-34', 39-40'. Moderate drilling rate 36-39'
1551.0		S-4		50%		36' GRAVEL, Washed sample with no sand/fines preserved. Rapid drilling rate 30-34'	GP	Boulder at 15-16'
1547.0	40	S-5		20%		40' COBBLES and GRAVEL trace sand/fines	GP	Rapid drilling rate 45-50'
1537.0	50	S-6		20%		50' GRAVEL, some sand and fines (silt)	GP-GM	Rapid drilling rate except for 55-57' where it was moderate
1527.0	60	S-7		20%		60' GRAVEL trace sand/fines	GP	Rapid drilling rate 60-65', and moderate 65 70'
	70							

DATE STARTED: 1-20-2006
DATE COMPLETED: 1-21-2006
FIELD GEOLOGIST: RJB
CHECKED BY: EGZ

GWL: DEPTH: 96.8 DATE/TIME: 3-13-06/ 08:30
GWL: DEPTH: DATE/TIME:
DRILLING METHOD: Sonic drilling with 6" diameter core. Sample typically taken every 10'

NOTES: All samples sent to Geotechnics laboratory for additional analysis

DRILLING CO.: Miller Co
DRILLER: Tracy
HELPER: Chris, Christian and Jeremy
RIG: VERSASONIC Rig

Taum Sauk Plant, Upper Reservoir Dike. Foley & Lardner LLP **PROJECT NO. 06-3551**

LOG OF BORING NO. TS-4

COORDINATES
N 620602.03 E 728540.85

SURFACE EL: 1587.03'

ELEVATION (FEET MSL)	DEPTH (FEET)	SAMPLE NO. OR RUN NO.	BLOW/6" & (N) OR % REC. & (RQD)	RECOVERY (ft.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS
1517.0		S-8		20%		70' GRAVEL some cobbles, trace sand/fines	GP	Rapid drilling rate except for boulder 72-74'
1507.0	80	S-9		20%		80' GRAVEL some cobbles trace sand/fines	GP	Rapid drilling rate except for 84-88' where moderate. Boulder at 88-90'
1497.0	90	S-10		40%		90' COBBLES some and fines (silt) from soil layer and rock dust from drilling. The soil layer (about 4" thick) is light greenish gray with the presence of roots. Top of bedrock at 97.25'.	GP-GM	Moderate to slow drilling rate Boulder at 92-93'
1488.8						BOTTOM OF BORING 98.25'		See TS-4R for rock coring log
	100							
	110							
	120							
	130							
	140							

DATE STARTED: 1-20-2006
DATE COMPLETED: 1-21-2006
FIELD GEOLOGIST: RJB
CHECKED BY: EGZ

GWL: DEPTH: 96.8 DATE/TIME: 3-13-06/ 08:30
GWL: DEPTH: DATE/TIME:
DRILLING METHOD: Sonic drilling with 6" diameter core. Sample typically taken every 10'

NOTES: All samples sent to Geotechnics laboratory for additional analysis

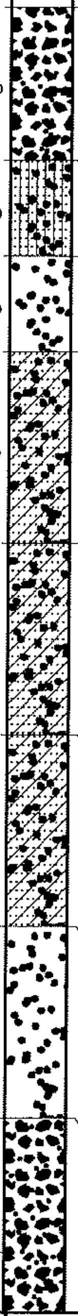
DRILLING CO.: Miller Co
DRILLER: Tracy
HELPER: Chris, Christian and Jeremy
RIG: VERSASONIC Rig

Taum Sauk Plant, Upper Reservoir Dike. Foley & Lardner LLP **PROJECT NO. 06-3551**

LOG OF BORING NO. TS-5

COORDINATES
N 620433.73 E 728614.27

SURFACE EL: 1587.13



ELEVATION (FEET MSL)	DEPTH (FEET)	SAMPLE NO. OR RUN NO.	BLOW/6" & (N) OR % REC. & (RQD)	RECOVERY (ft.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS
	0					Not Sampled 0 to 2 feet		
1585.1		S-1		60%		2' GRAVEL and COBBLES with Sand and Silt, dark to moderate reddish brown.	GW	
1577.1	10	S-2		40%		10'	GP-GM	
1572.1		S-3		80%		15' COBBLES, GRAVEL and trace Sand	GP	Slow drilling
1567.1	20	S-4		40%		20' COBBLES, CORED BOULDERS (>12") and trace Sand	GP-GC	Fast drilling 24 to 30'
1557.1	30	S-5		40%		30' GRAVEL, COBBLES AND Trace Sand And Silt, moist	GP-GC	Fast drilling 30 to 50'
1547.1	40	S-6		20%		40'	GP-GC	
1537.1	50	S-7		20%		50' COBBLES and GRAVEL some Sand, moist Boulder 50'-56'	GP	50 to 60" Slow drilling 56 to 60' fast drilling
1527.1	60	S-8		20%		60' COBBLES and GRAVEL some Sand, trace Silt Boulder	GW	Easy drillng 60 to 65' Exttremly Slow 65-67 (boulder) Not Sampled - switched to solid bit.
	70							

DATE STARTED: 1-21-06
DATE COMPLETED: 1-22-06
FIELD GEOLOGIST: RJB
CHECKED BY: EGZ

GWL: DEPTH: DATE/TIME:
GWL: DEPTH: DATE/TIME:
DRILLING METHOD: Sonic drilling with 6" diameter core. Sample typically taken every 10'

NOTES: All samples sent to Geotechnics laboratory for additional analysis

DRILLING CO.: Miller Drillng
DRILLER: Tracy
HELPER: Chris, Chris, and Jeremy
RIG: Versa Sonic

Taum Sauk Plant, Upper Reservoir Dike. Foley & Lardner LLP

PROJECT NO. 06-3551

LOG OF BORING NO. TS-5

COORDINATES
N 620433.73 E 728614.27

SURFACE EL: 1587.13

ELEVATION (FEET MSL)	DEPTH (FEET)	SAMPLE NO. OR RUN NO.	BLOW/6" & (N) OR % REC. & (RQD)	RECOVERY (ft.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS
					▨	Solid bit broke in hole (borehole abandoned.		71.5 to 80" very fast drilling
1507.1	80					BOTTOM OF BORING 80' Borehole backfilled with bentonite.		See TS-5R for rock coring log
	90							
	100							
	110							
	120							
	130							
	140							

DATE STARTED: 1-21-06
DATE COMPLETED: 1-22-06
FIELD GEOLOGIST: RJB
CHECKED BY: EGZ

GWL: DEPTH: DATE/TIME:
GWL: DEPTH: DATE/TIME:
DRILLING METHOD: Sonic drilling with 6" diameter core. Sample typically taken every 10'

NOTES: All samples sent to Geotechnics laboratory for additional analysis

DRILLING CO.: Miller Drillng
DRILLER: Tracy
HELPER: Chris, Chris, and Jeremy
RIG: Versa Sonic

Taum Sauk Plant, Upper Reservoir Dike. Foley & Lardner LLP

PROJECT NO. 06-3551

LOG OF BORING NO. TS-6

COORDINATES
N 620778.58 E 728552.28

SURFACE EL: 1537.29

ELEVATION (FEET MSL)	DEPTH (FEET)	SAMPLE NO. OR RUN NO.	BLOW/6" & (N) OR % REC. & (RQD)	RECOVERY (ft.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS
	0					Asphalt and gravel - no sample		
1535.3		S-1		50%		2' COBBLES, GRAVEL, and rock dust, dry, dark reddish brown, fines and sand are moderate yellowish brown	gp	easy drilling 4' to 5.5' boulders 5.5' to 7.5'
1532.3		S-2		75%		5'	GP	9' easy drilling
1527.3	10	S-3		50%		10' COBBLES, GRAVEL, with sand, moist, some dry clay	GM	
1517.3	20	S-4		40%		20' Similar to 10' to 20' but gravel is more abundant, more moist	GP-GC	17' easy drilling
1507.3	30	S-5		25%		30' GRAVEL, SAND, and some fines, moist, moderate yellowish brown	GM-GC	easy drilling
1497.3	40	S-6		25%		40' COBBLES, GRAVEL, trace fines	gp	easy drilling 49.5'
1487.3	50	S-7		5%		50' Similar to 40'-50', dry	GP-GM	most of sample lost in fishing broken 4" drilling pipe
1483.3						BOTTOM OF BORING 54'		See TS-6R for coring log
	60							
	70							

DATE STARTED: 1-24-06 DATE COMPLETED: 1-24-06 FIELD GEOLOGIST: RJB CHECKED BY: EGZ	GWL: DEPTH: dry DATE/TIME: 3-11-06 GWL: DEPTH: DATE/TIME: DRILLING METHOD: Sonic drilling with 6" diameter core. Sample typically taken every 10'	NOTES: All samples sent to Geotechnics laboratory for additional analysis
DRILLING CO.: Miller Drillng	DRILLER: Tracy HELPER: Chris, Chris, and Jeremy	RIG: Versa Sonic

Taum Sauk Plant, Upper Reservoir Dike. Foley & Lardner LLP **PROJECT NO. 06-3551**

LOG OF BORING NO. TS-7

COORDINATES
N 621176.86 E 727799.66

SURFACE EL: 1551.04

ELEVATION (FEET MSL)	DEPTH (FEET)	SAMPLE NO. OR RUN NO.	BLOW/6" & (N) OR % REC. & (RQD)	RECOVERY (ft.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS
	0	S-1		20%		GRAVEL and COBBLES with very little fines/sand. Rock fragments are angular to subangular, dark redish brown. Sand/fines are moderate yellowish brown. The fragment shapes and colors are similar in all intervals except where stated	gm	Not representative for gradation. Drilled first with 4" displacement bit to overcome boulder. Rapid drilling 6'-11'
1541.0	10	S-2		40%		10' COBBLES, fine GRAVEL, and sand/fines. Rock fragments are Dark Reddish Brown and sand/fines are moderate yellowish brown.	gw-gm	Boulder at 15-16' Rapid drilling rate 15-20' Moderate drilling rate 10-18'
1531.0	20	S-3		40%		20' COBBLES, GRAVEL, and sand/fines	gw-gm	Rapid drilling rate except 20-23' and 28-29' where moderate
1521.0	30	S-4		20%		30' COBBLES, GRAVEL with trace sand/fines.	GP	Rapid drilling rate
1511.0	40	S-5		30%		40' GRAVEL, some SAND	GW	Rapid drilling rate except for 43-45' where moderate
1501.0	50	S-6		30%		50' GRAVEL, some sand	GW	Rapid drilling rate except for 54-56' where moderate
1491.0	60	S-7		20%		60' COBBLES and GRAVEL with trace fines	GW	Rapid drilling rate
	70							

DATE STARTED: 1-24-2006
DATE COMPLETED: 1-24-2006
FIELD GEOLOGIST: RJB
CHECKED BY: EGZ

GWL: DEPTH: 106.5 DATE/TIME: 3-13-06/07:00
GWL: DEPTH: DATE/TIME:
DRILLING METHOD: Sonic drilling with 6" diameter core. Sample typically taken every 10'

NOTES: All samples sent to Geotechnics laboratory for additional analysis

DRILLING CO.: Miller Co
DRILLER: Tracy
HELPER: Chris, Christian and Jeremy
RIG: VERSASONIC Rig

Taum Sauk Plant, Upper Reservoir Dike. Foley & Lardner LLP **PROJECT NO. 06-3551**

LOG OF BORING NO. TS-7

COORDINATES
N 621176.86 E 727799.66

SURFACE EL: 1551.04

ELEVATION (FEET MSL)	DEPTH (FEET)	SAMPLE NO. OR RUN NO.	BLOW/6" & (N) OR % REC. & (RQD)	RECOVERY (ft.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS
1481.0		S-8		22%		70' COBBLES and GRAVEL some sand	GP	Rapid drilling rate except fo 75-77' where moderate
1471.0	80	S-9		30%		80' Mostly GRAVEL and COBBLES and trace sand/fines Top of bedrock at 86'.	GP	Rapid drilling rate except fo 84-87' where slow. Boulder at 88-90'
1464.0						BOTTOM OF BORING 87'		See TS-7R for rock coring log
	90							
	100							
	110							
	120							
	130							
	140							

DATE STARTED: 1-24-2006
DATE COMPLETED: 1-24-2006
FIELD GEOLOGIST: RJB
CHECKED BY: EGZ

GWL: DEPTH: 106.5 DATE/TIME: 3-13-06/07:00
GWL: DEPTH: DATE/TIME:
DRILLING METHOD: Sonic drilling with 6" diameter core. Sample typically taken every 10'

NOTES: All samples sent to Geotechnics laboratory for additional analysis

DRILLING CO.: Miller Co
DRILLER: Tracy HELPER: Chris, Christian and Jeremy
RIG: VERSASONIC Rig

APPENDIX E

LABORATORY TEST DATA

APPENDIX E1

LABORATORY DATA SUMMARY TABLE

Table E-1
Taum Sauk Forensic Geotecnical Investigation
Summary of Laboratory Testing

Boring *	Sample	Depth	% Fines (-200sieve)	Atterberg Limits		USCS Class (fines)	USCS Class (Sample)	Permeability (cm/sec)	Friction ø degrees	Cohesion c psi	Natural Moisture Content, %
				LL %	PL %						
TS-1	S-1	0-10	6.05				gp-gm				
TS-1	S-2	10-20	7.01				gp-gm				
TS-1	S-3	20-40	4.65				GW				
TS-1	S-4	40-50	0.82				GP				
TS-1	S-5	50-60	0.02				GP				
TS-1	S-6	60-70	0.05				GP				
TS-1	S-7	70-80	0.02				GP				
TS-1	S-8	80-90	0.42				GP				
TS-1	S-9	90-100	0.03				GP				
TS-1	S-10	90-100	0.00				GP				
TS-1	S-11	100-103	0.15				GP				
TS-1	S-12	103-105	8.55	NP**	NP		GP-GM				
TS-2	S-1	0-10	6.30	27	17	CL	GP-GC				
TS-2	S-2	10-20	3.99				GP				
TS-2	S-3	20-30	3.99				GW				
TS-2	S-4	30-40	2.44	NP	NP		GP				
TS-2	S-5	40-50	3.25				GP				
TS-2	S-6	50-60	7.88	19	16	ML	gp-gm				
TS-2	S-7	60-70	5.03	NP	NP		GP-GM	Rock Core Density = 163.9 pcf			
TS-2	S-8	70-80	4.09	22	18	CL-ML	GP				
TS-2	S-9	80-100	18.71	25	17	CL	GC				
TS-2	S-10	100-104.5	25.42	25	16	CL	GC				
TS-3	S-1	0-10	5.81				gw-gm				
TS-3	S-2	10-20	9.84	24	15	CL	GP-GC				
TS-3	S-3	20-30	6.81	23	15	CL	GP-GC				
TS-3	S-4	30-40	3.38	27	21	CL-ML	GW				
TS-3	S-5	40-50	1.00	24	19	CL-ML	GP				
TS-3	S-6	50-60	5.39	NP	NP		GP-GM				
TS-3	S-7	60-70	5.53	NP	NP		GP-GM				
TS-3	S-8	70-80	2.17	24	17	CL-ML	GP				
TS-3	S-9	80-90	3.10				GP				

Table E-1 (cont.)
Taum Sauk Forensic Geotecnical Investigation
Summary of Laboratory Testing

Boring *	Sample	Depth	% Fines (-200sieve)	Atterberg Limits		USCS Class (fines)	USCS Class (Sample)	Permeability (cm/sec)	Friction ø degrees	Cohesion c psi	Natural Moisture Content, %
				LL %	PL %						
TS-3	S-10	90-95.7	14.15	31	18	CL	GC				
TS-4	S-1**	0-10	6.42				gp-gm	5.47E-01			
TS-4	S-2**	10-13	6.09				gp-gm				
TS-4	S-2	13-16	7.28				gp-gm				
TS-4	S-2	16-20	1.51				GP				
TS-4	S-3**	20-30	8.30				gp-gm	2.50E-01			
TS-4	S-4**	30-36	1.88				GP				
TS-4	S-4	36-40	0.02				GP				
TS-4	S-5	40-50	3.63				GP				
TS-4	S-6**	50-60	7.30				gp-gm	4.33E-01			
TS-4	S-7**	60-70	4.44				GP				
TS-4	S-8	70-80	1.34				GP				
TS-4	S-9	80-90	0.08				GP				
TS-4	S-10	90-98.25	7.55				gp-gm				
TS-5	S-1	0-10	4.95	22	17	CL-ML	GW				
TS-5	S-2	10-15	7.56				GP-GM				
TS-5	S-3	15-20	4.91	19	15	CL-ML	GP				
TS-5	S-4	20-30	5.62	20	16	CL-ML	GP-GC				
TS-5	S-5	30-40	6.28	21	16	CL-ML	GP-GC				
TS-5	S-6	40-50	5.82	NP	NP		gp-gc				
TS-5	S-7	50-60	3.41	NP	NP		GP				
TS-5	S-8	60-67	3.94				GW				

Table E-1 (cont.)
Taum Sauk Forensic Geotecnical Investigation
Summary of Laboratory Testing

Boring *	Sample	Depth	% Fines (-200sieve)	Atterberg Limits LL %	PL %	USCS Class (fines)	USCS Class (Sample)	Permeability (cm/sec)	Friction ø degrees	Cohesion c psi	Natural Moisture Content, %
TS-6	S-2	5-10	4.92				GP				
TS-6	S-3	10-20	12.51	NP	NP		GM				
TS-6	S-4	20-30	8.22				GP-GC				
TS-6	S-5	30-40	12.68	28	7	CL-ML	GC-GM				
TS-6	S-7	50-54	10.48	NP	NP		GP-GM				
TS-7	S-1	0-10	13.59				gm				
TS-7	S-2	10-20	5.64				gw-gm				
TS-7	S-3	20-30	9.12				gw-gm				
TS-7	S-4	30-40	0.37				GP				
TS-7	S-5	40-50	4.60				GW				
TS-7	S-6	50-60	4.92				GW				
TS-7	S-7	60-70	1.41				GW				
TS-7	S-8	70-80	4.13				GP				
TS-7	S-9	80-90	0.06				GP				
TS-ST-01	N/A	0-2	48.30	31	20	CL	GC	1.30E-06	33.96	2.78	
TS-ST-02	N/A	0-2	77.62	64	25	CH	CH	3.80E-07			
TS-Soil-01	S-2	9-14	38.91	35	20	CL	GC				14.6
TS-Soil-02	S-2	7-12	70.92	59	23	CH	CH		21.3	7.58	26.7
TS-Soil-02	S-3	12-19	79.72	57	27	CH	CH		29.35	6.85	30.2
TS-Soil-03	S-2	7-15	59.54	37	19	CL	CL		30.22	4.2	19.2
TS-Soil-04	S-2	5-11	78.89	51	28	CH	CH		28.6	4.95	31.9

* See Plate 7.1 for Sample Locations

** Samples Combined for Permeability Testing

APPENDIX E2

SOIL PHOTOGRAPHS

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-1
Client Project	TAUM SAUK 06-3551	Depth (ft.)	0'-10'
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-01		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-1
Client Project	TAUM SAUK 06-3551	Depth (ft.)	10'-20'
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-02		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-1
Client Project	TAUM SAUK 06-3551	Depth (ft.)	20'-40'
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-03		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-1
Client Project	TAUM SAUK 06-3551	Depth (ft.)	40'-50'
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-04		

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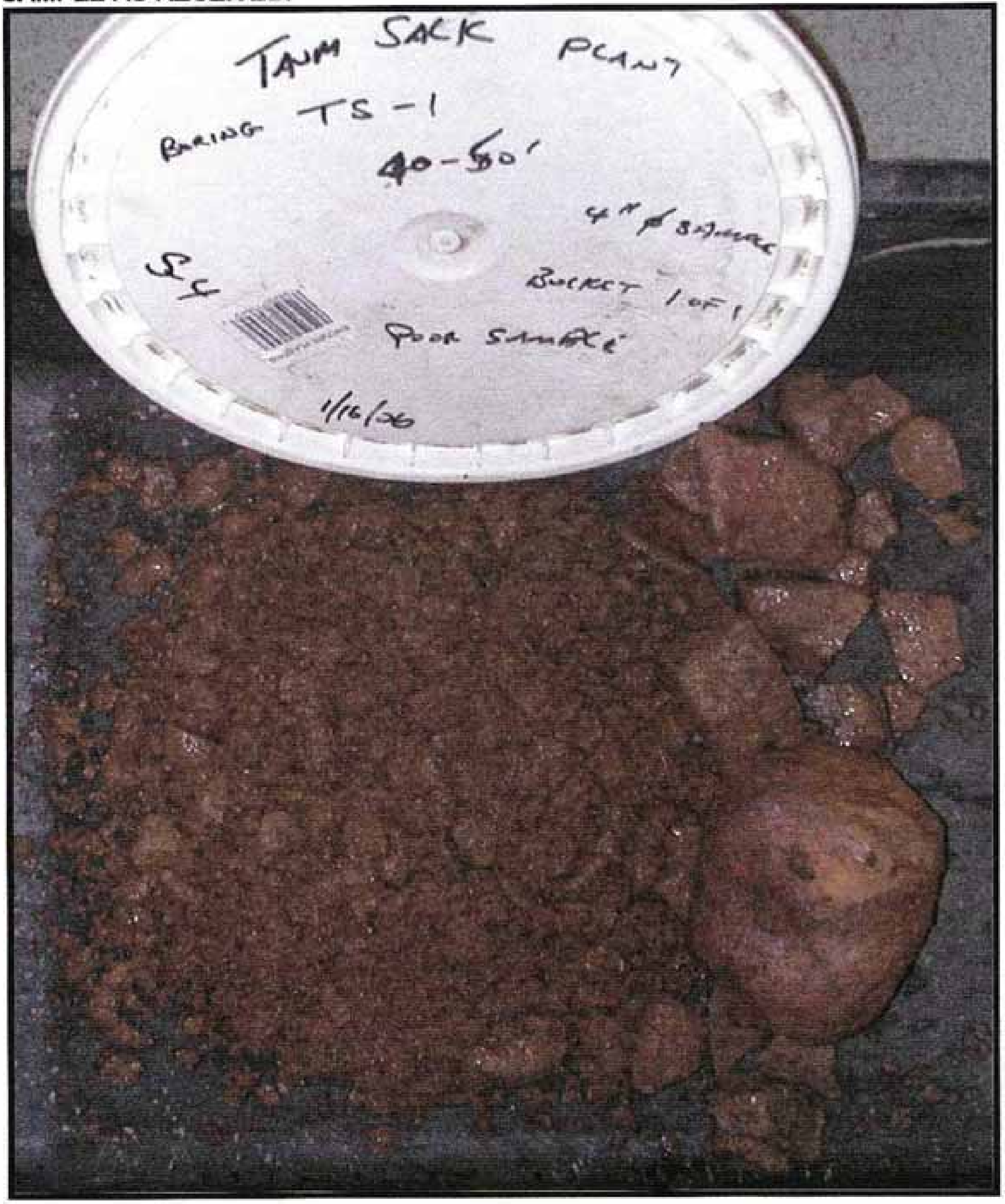

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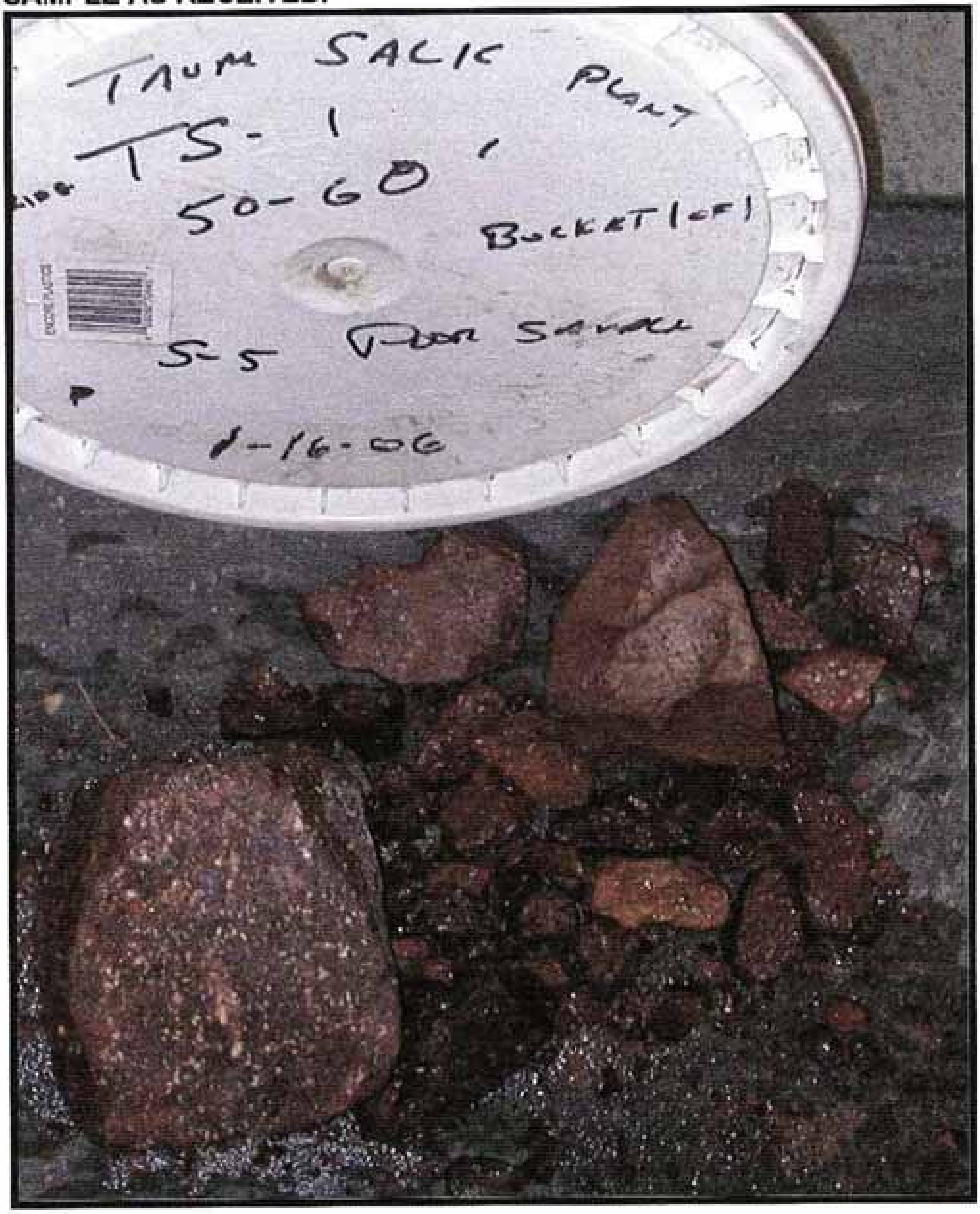
SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-1
Client Project	TAUM SAUK 06-3551	Depth (ft.)	50'-60'
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-05		

SAMPLE AS RECEIVED:



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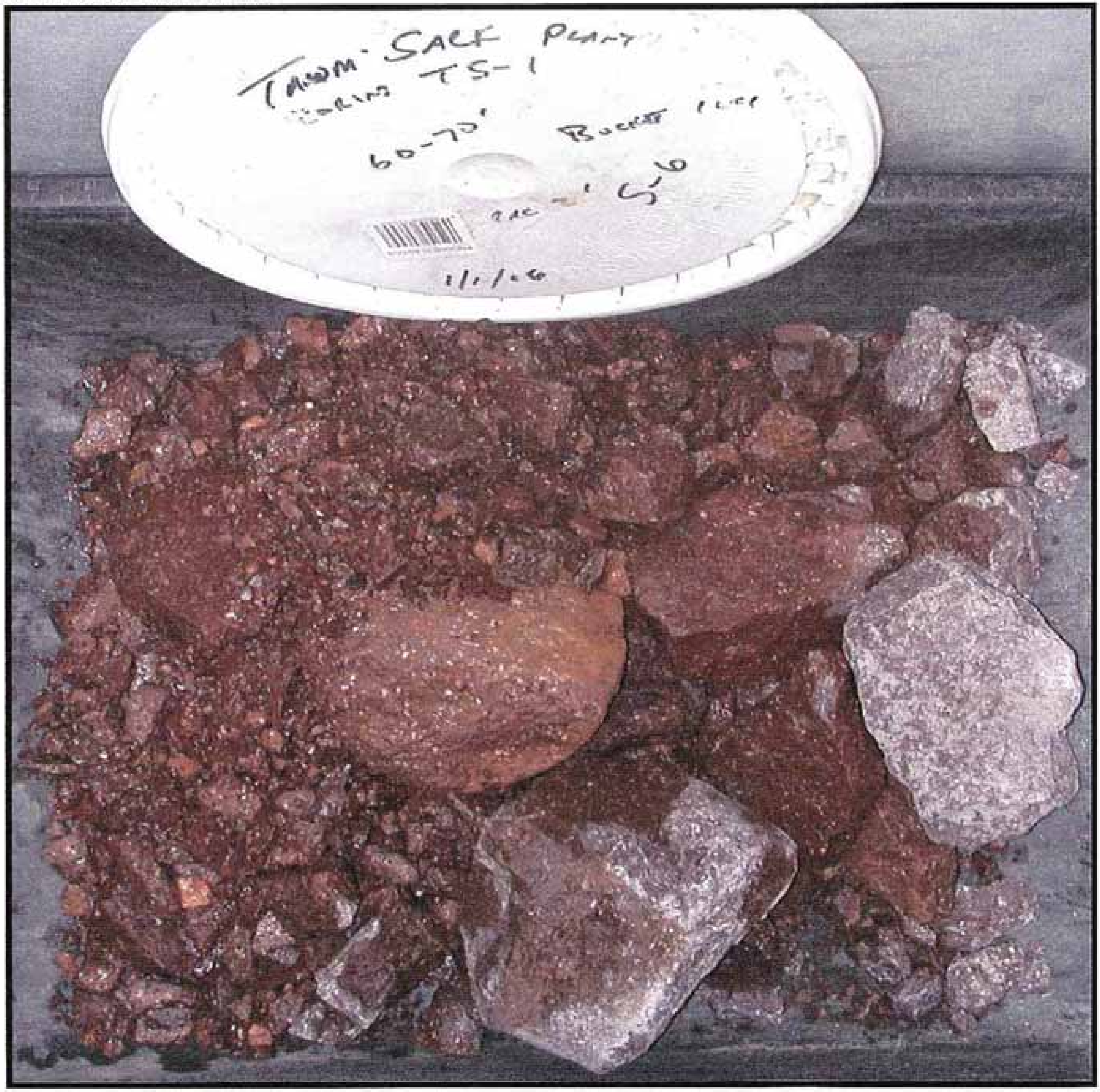
SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-1
Client Project	TAUM SAUK 06-3551	Depth (ft.)	60'-70'
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-06		

SAMPLE AS RECEIVED:



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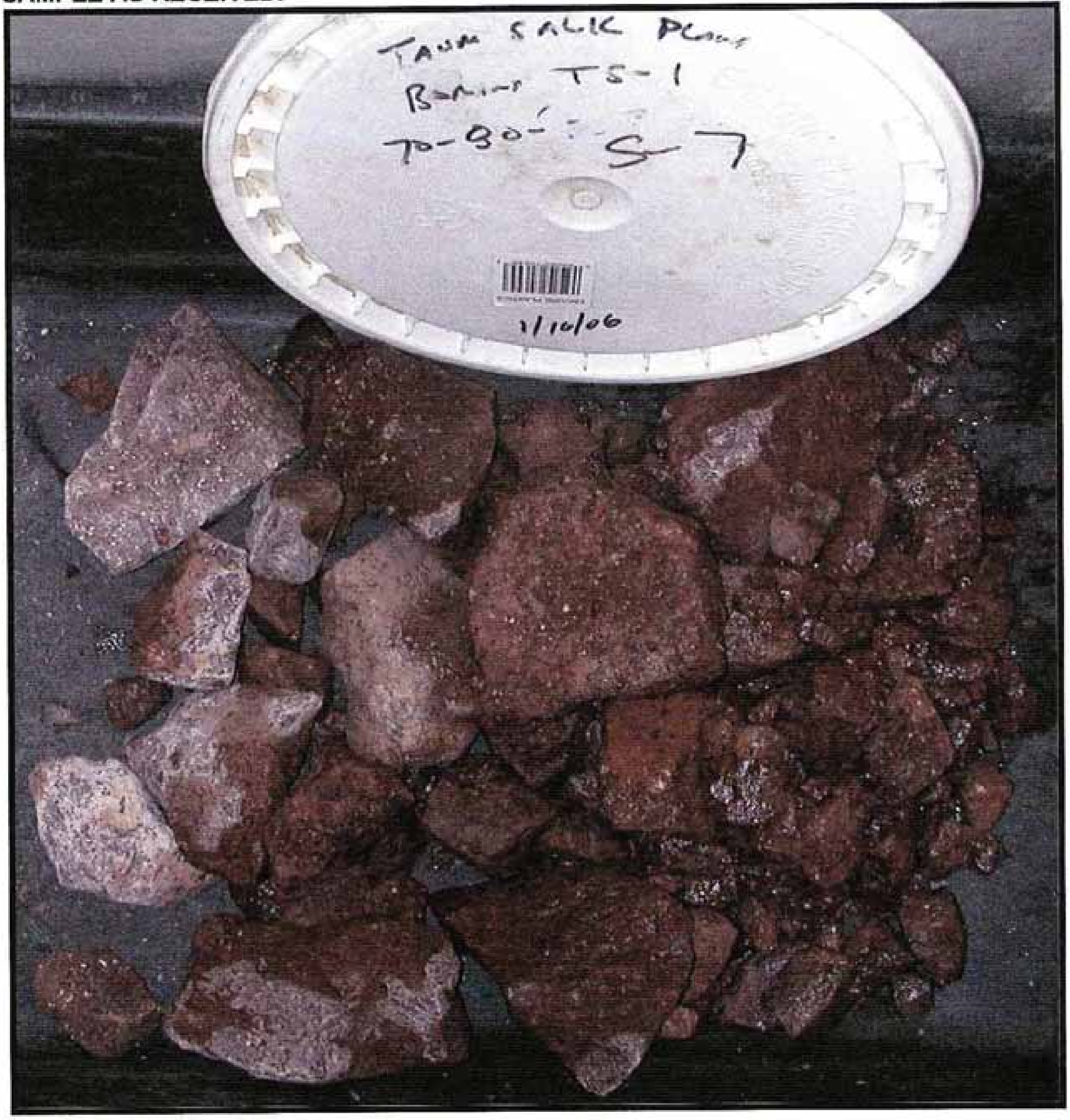
SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-1
Client Project	TAUM SAUK 06-3551	Depth (ft.)	70'-80'
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-07		

SAMPLE AS RECEIVED:



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SIEVE SAMPLE

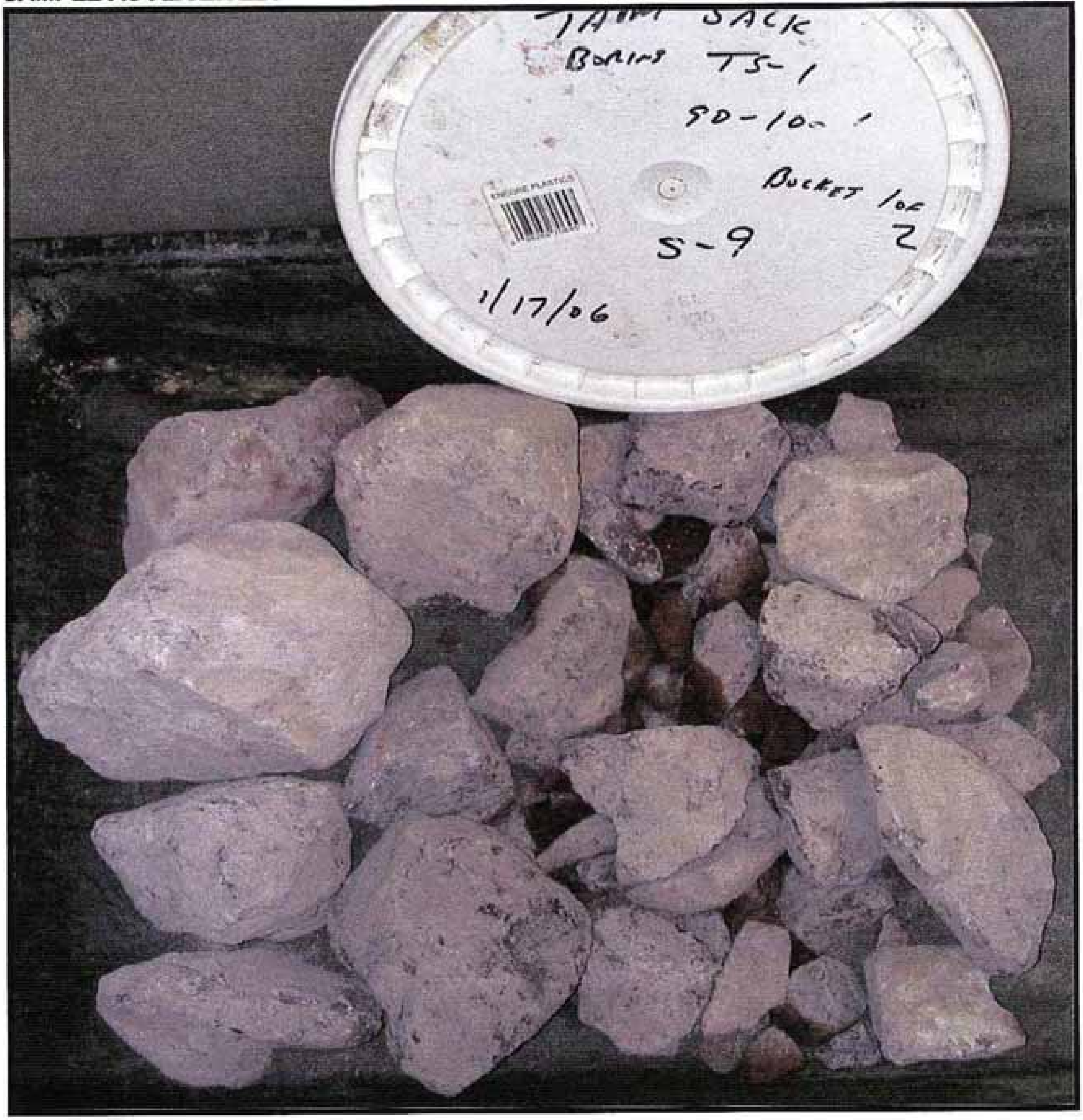
Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-1
Client Project	TAUM SAUK 06-3551	Depth (ft.)	80'-90'
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-08		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-1
Client Project	TAUM SAUK 06-3551	Depth (ft.)	90'-100'
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-09		

SAMPLE AS RECEIVED:



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SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-1
Client Project	TAUM SAUK 06-3551	Depth (ft.)	90'-100'
Project No.	2006-060-01	Sample No.	S-10
Lab ID	2006-060-01-10		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-1
Client Project	TAUM SAUK 06-3551	Depth (ft.)	100'-103'
Project No.	2006-060-01	Sample No.	S-11
Lab ID	2006-060-01-11		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-1
Client Project	TAUM SAUK 06-3551	Depth (ft.)	103'-105.7'
Project No.	2006-060-01	Sample No.	S-12
Lab ID	2006-060-01-12		

SAMPLE AS RECEIVED:

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SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-2
Client Project	TAUM SAUK 06-3551	Depth (ft.)	0'-10'
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-13		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

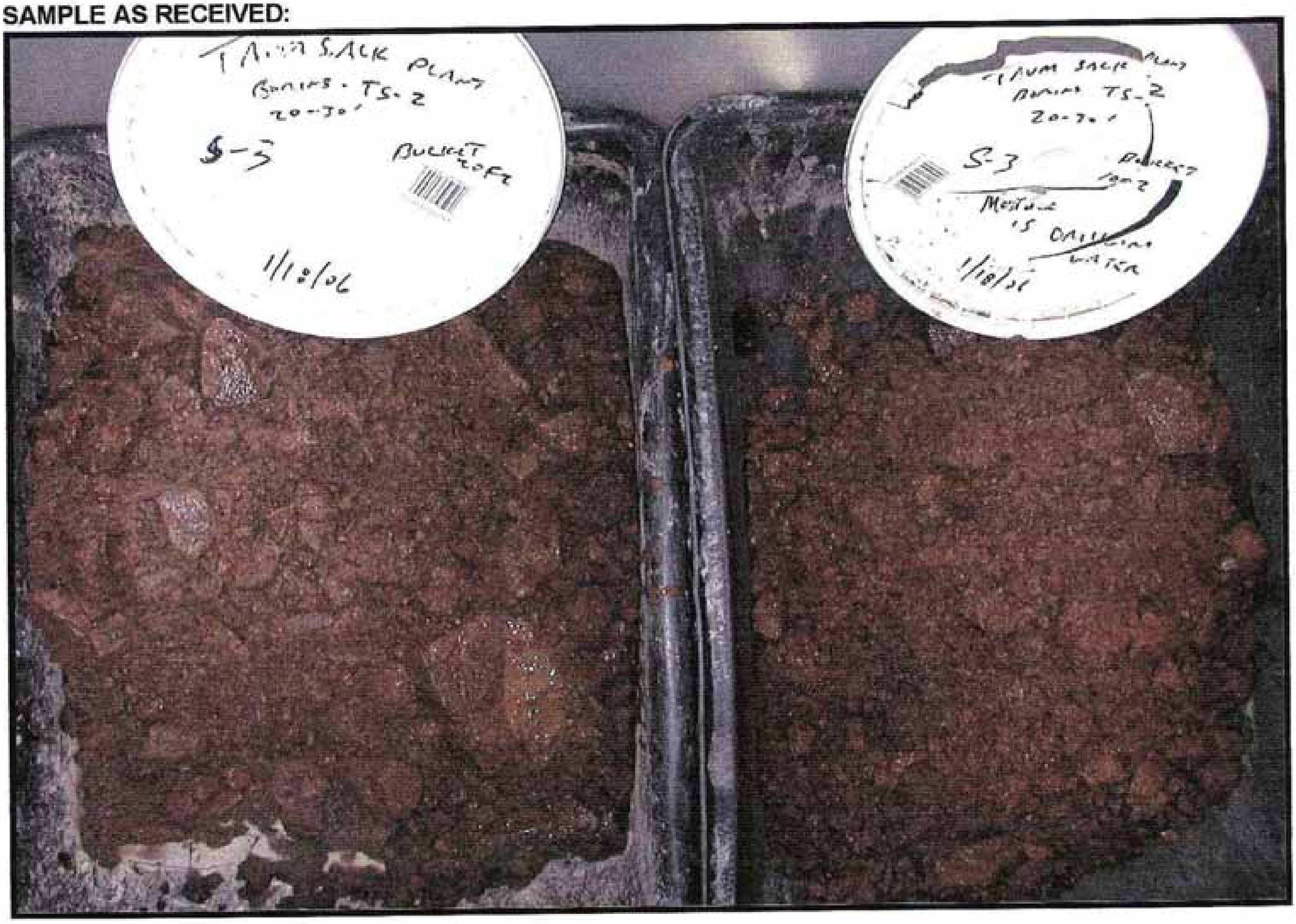
Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-2
Client Project	TAUM SAUK 06-3551	Depth (ft.)	10'-20'
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-14		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-2
Client Project	TAUM SAUK 06-3551	Depth (ft.)	20'-30'
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-15		

SAMPLE AS RECEIVED:



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SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-2
Client Project	TAUM SAUK 06-3551	Depth (ft.)	30'-40'
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-16		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-2
Client Project	TAUM SAUK 06-3551	Depth (ft.)	40'-50'
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-17		

SAMPLE AS RECEIVED:

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SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-2
Client Project	TAUM SAUK 06-3551	Depth (ft.)	50'-60'
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-18		

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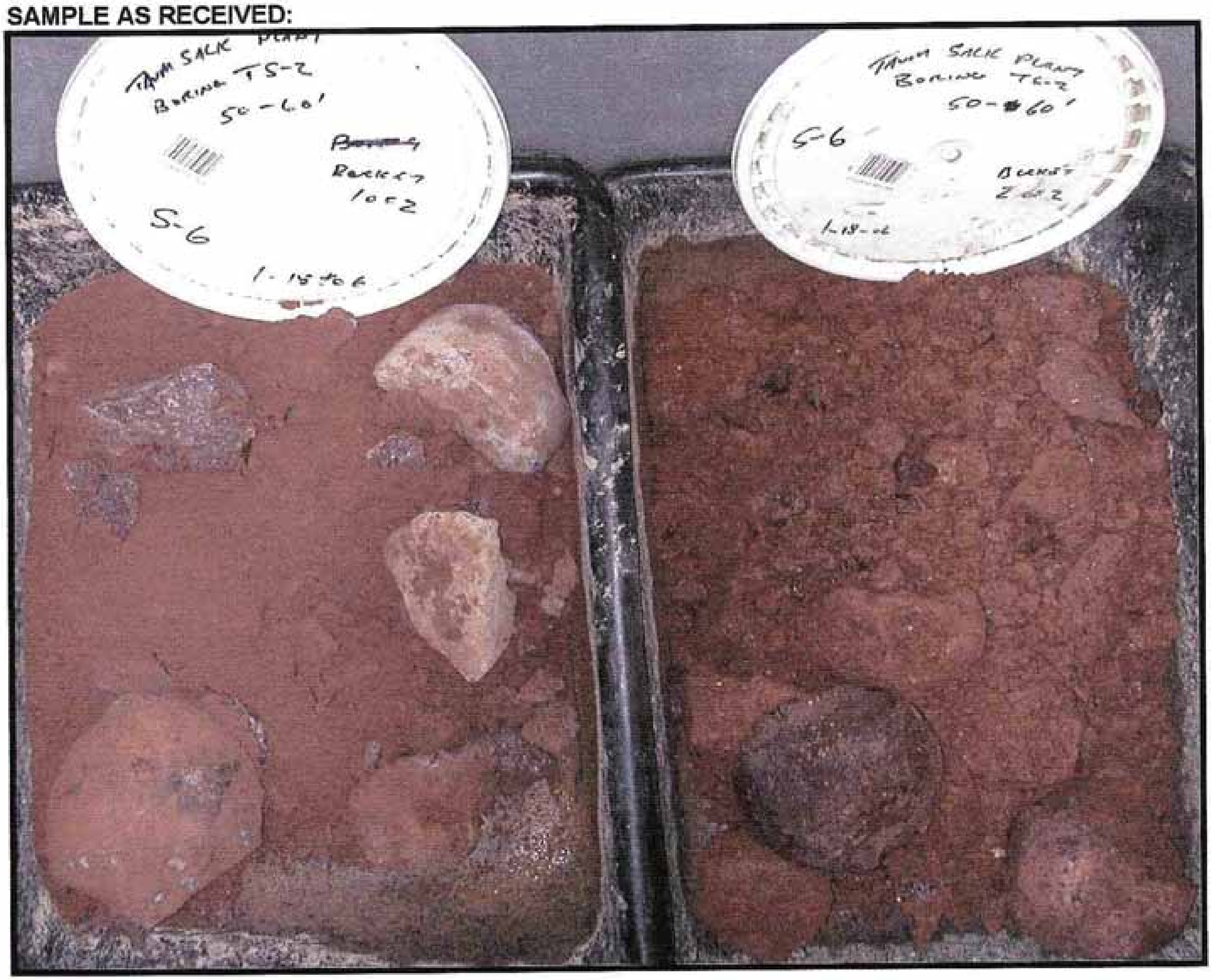
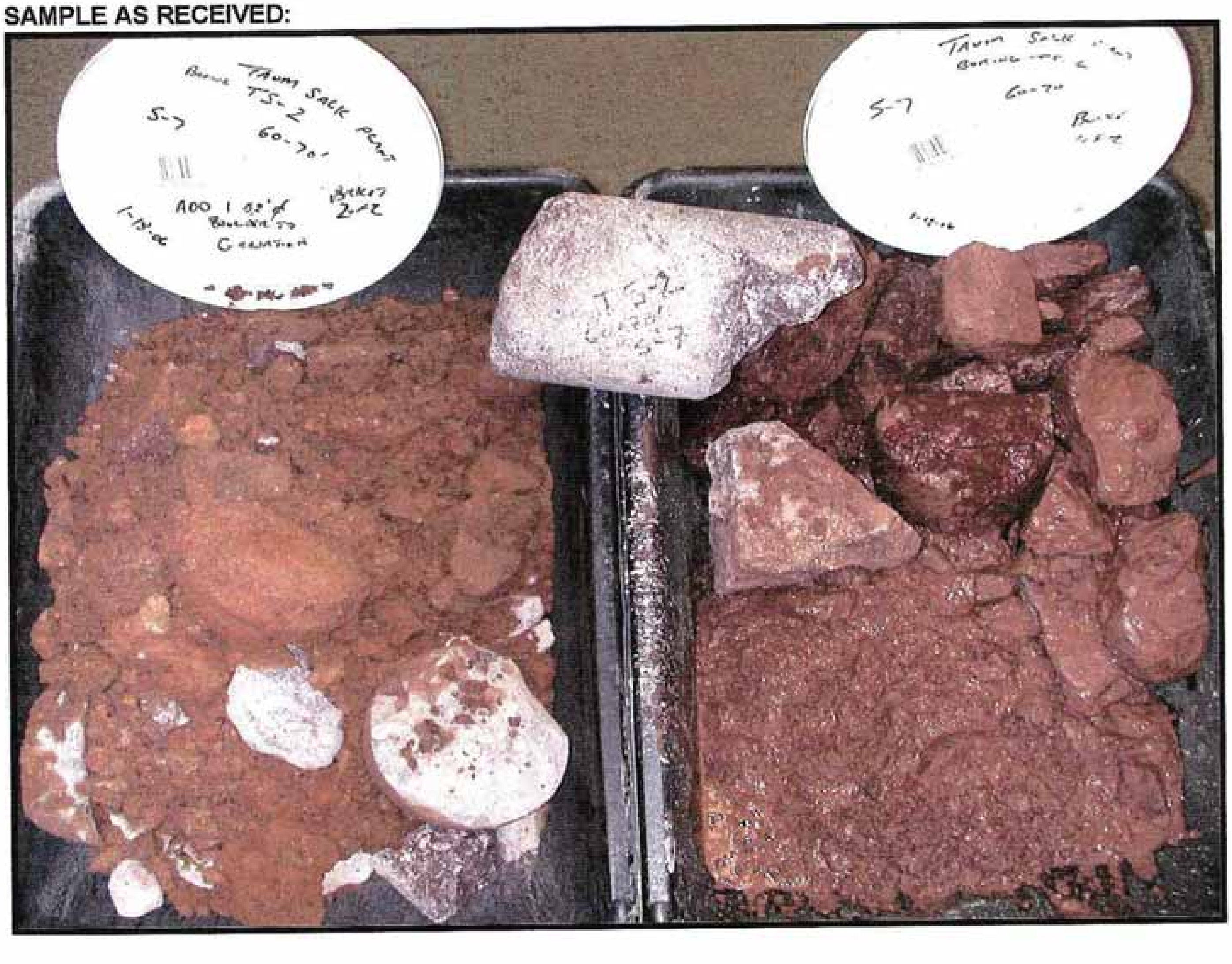


SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-2
Client Project	TAUM SAUK 06-3551	Depth (ft.)	60'-70'
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-19		

SAMPLE AS RECEIVED:



SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-2
Client Project	TAUM SAUK 06-3551	Depth (ft.)	70'-80'
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-20		

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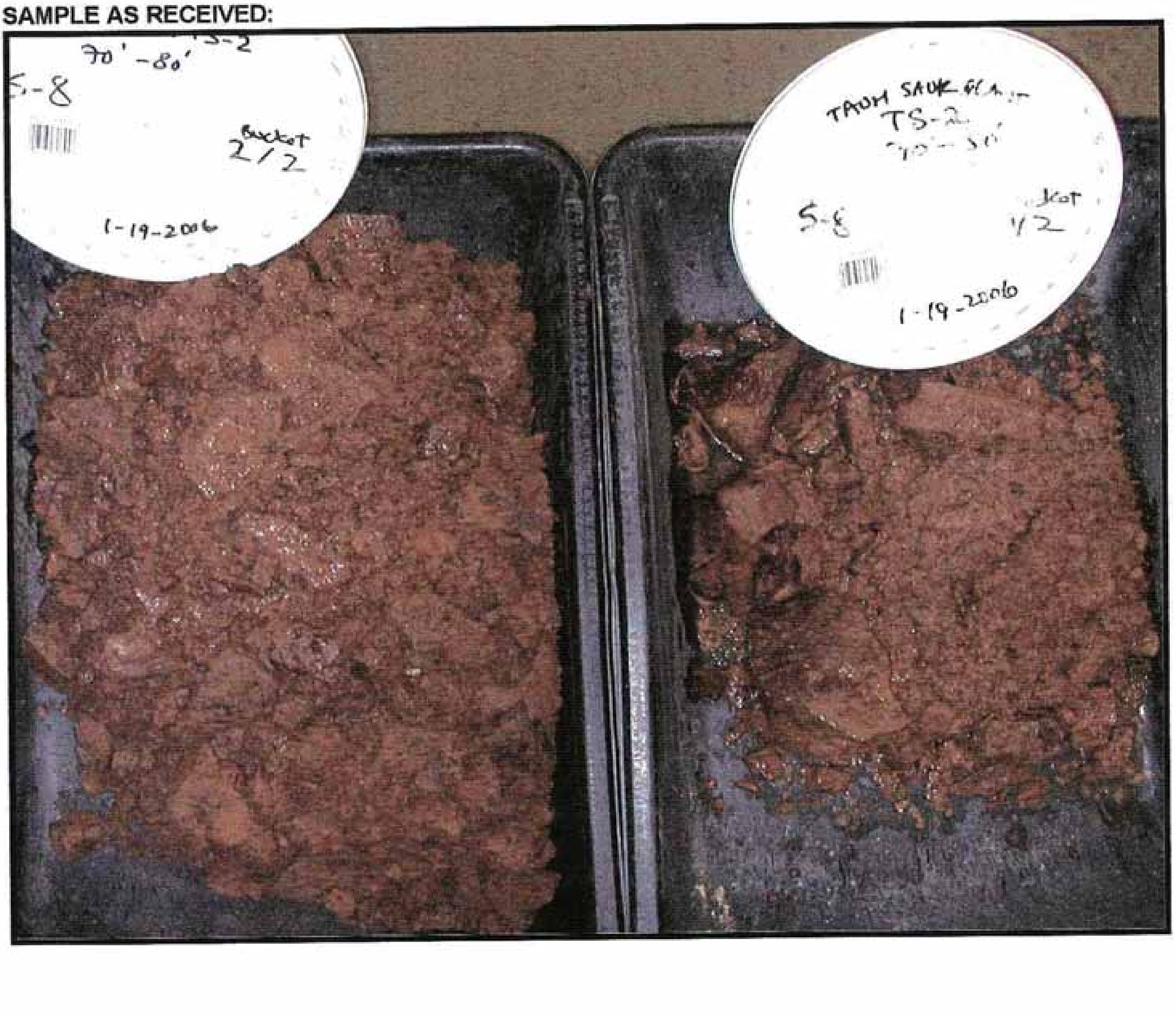
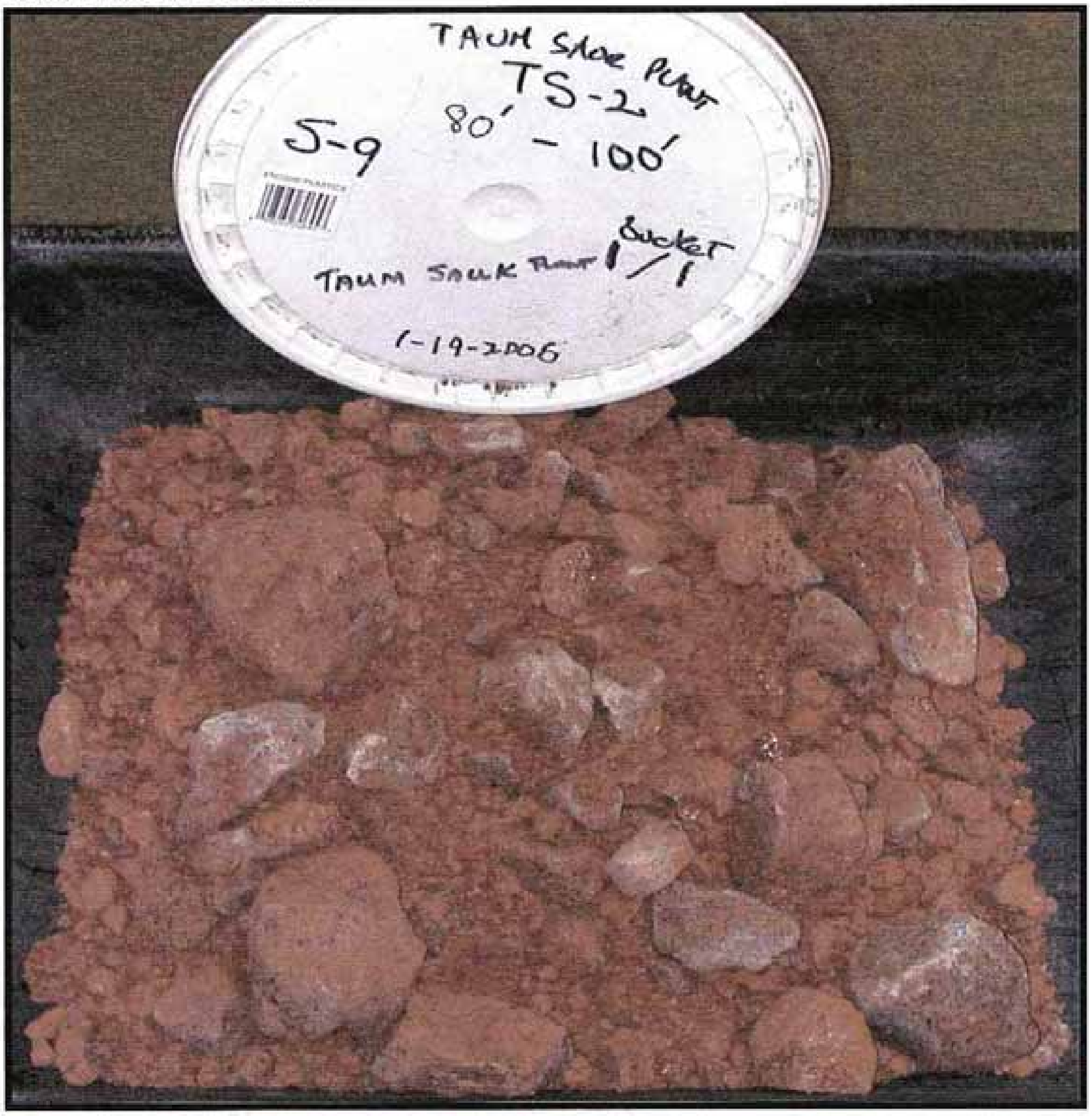


SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-2
Client Project	TAUM SAUK 06-3551	Depth (ft.)	80'-100'
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-21		

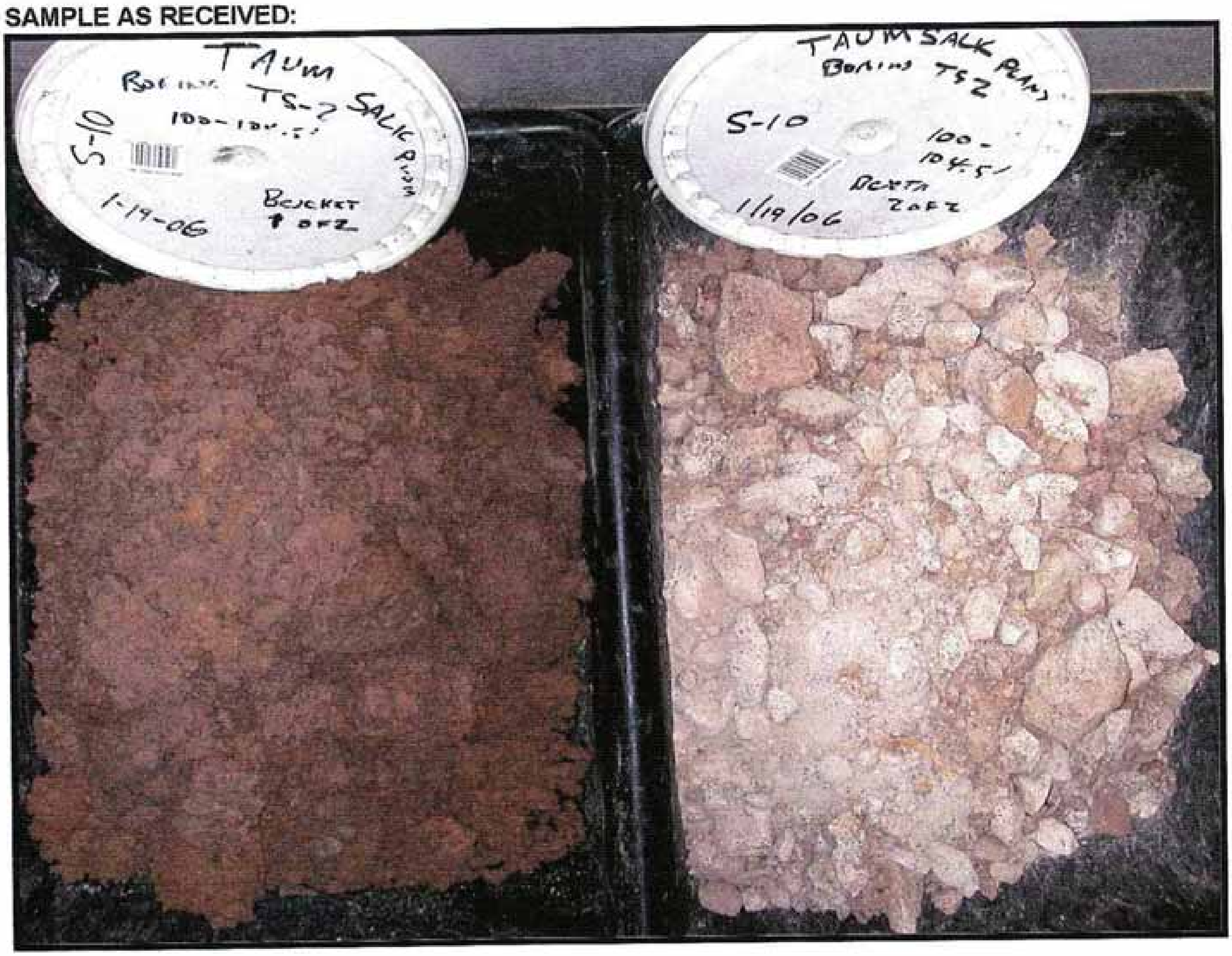
SAMPLE AS RECEIVED:



SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-2
Client Project	TAUM SAUK 06-3551	Depth (ft.)	100'-104.5'
Project No.	2006-060-01	Sample No.	S-10
Lab ID	2006-060-01-22		

SAMPLE AS RECEIVED:



SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-3
Client Project	TAUM SAUK 06-3551	Depth (ft.)	0'-10'
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-23		

SAMPLE AS RECEIVED:

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SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-3
Client Project	TAUM SAUK 06-3551	Depth (ft.)	10'-20'
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-24		

SAMPLE AS RECEIVED:

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INTEGRITY IN TESTING

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-3
Client Project	TAUM SAUK 06-3551	Depth (ft.)	20'-30'
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-25		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-3
Client Project	TAUM SAUK 06-3551	Depth (ft.)	30'-40'
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-26		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-3
Client Project	TAUM SAUK 06-3551	Depth (ft.)	40'-50'
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-27		

SAMPLE AS RECEIVED:

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INTEGRITY IN TESTING

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-3
Client Project	TAUM SAUK 06-3551	Depth (ft.)	50'-60'
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-28		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-3
Client Project	TAUM SAUK 06-3551	Depth (ft.)	60'-70'
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-29		

SAMPLE AS RECEIVED:

geotechnics
INTEGRITY IN TESTING

SIEVE SAMPLE

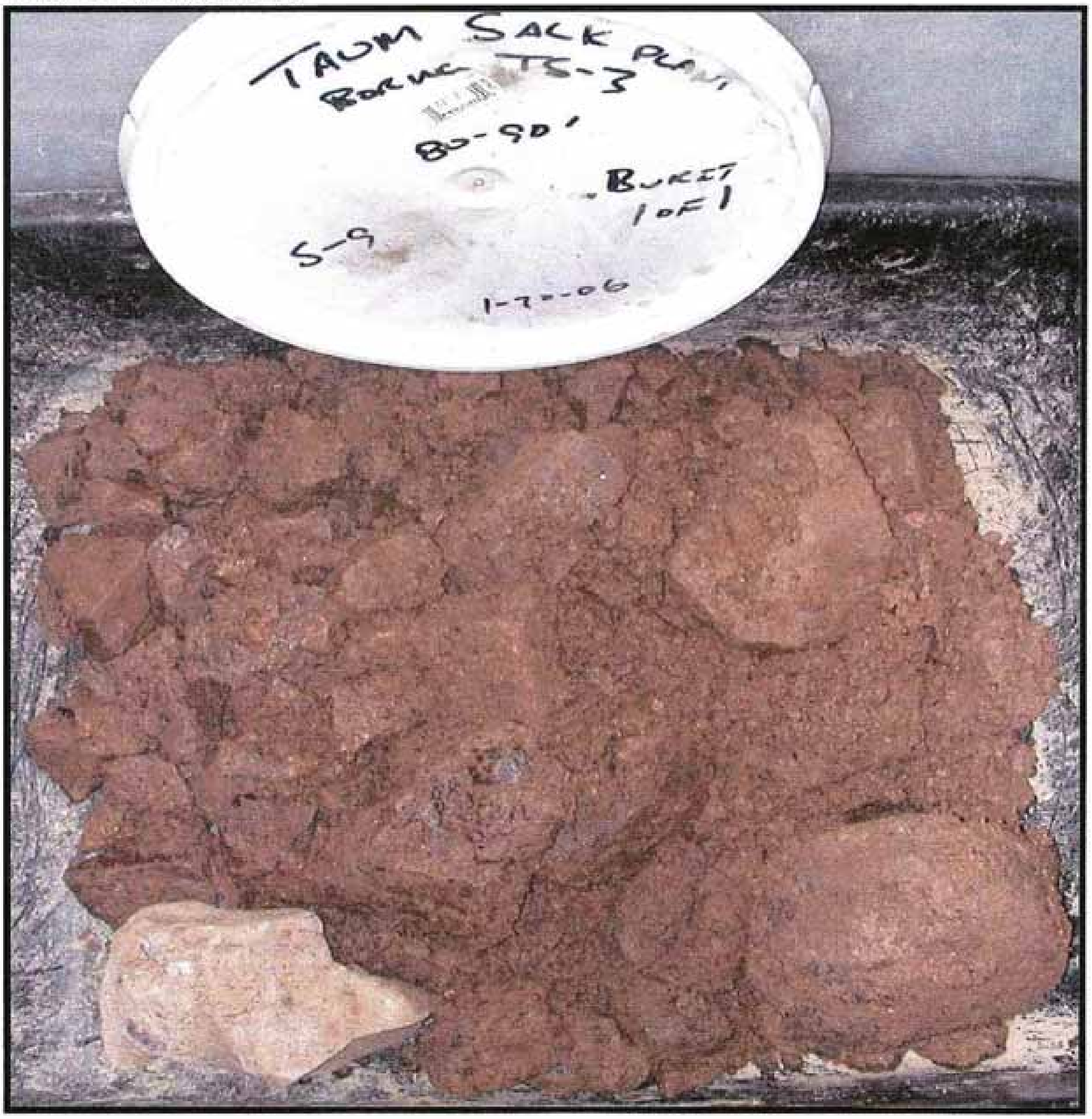
Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-3
Client Project	TAUM SAUK 06-3551	Depth (ft.)	70'-80'
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-30		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-3
Client Project	TAUM SAUK 06-3551	Depth (ft.)	80'-90'
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-31		

SAMPLE AS RECEIVED:



SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-3
Client Project	TAUM SAUK 06-3551	Depth (ft.)	90'-95.7'
Project No.	2006-060-01	Sample No.	S-10
Lab ID	2006-060-01-32		

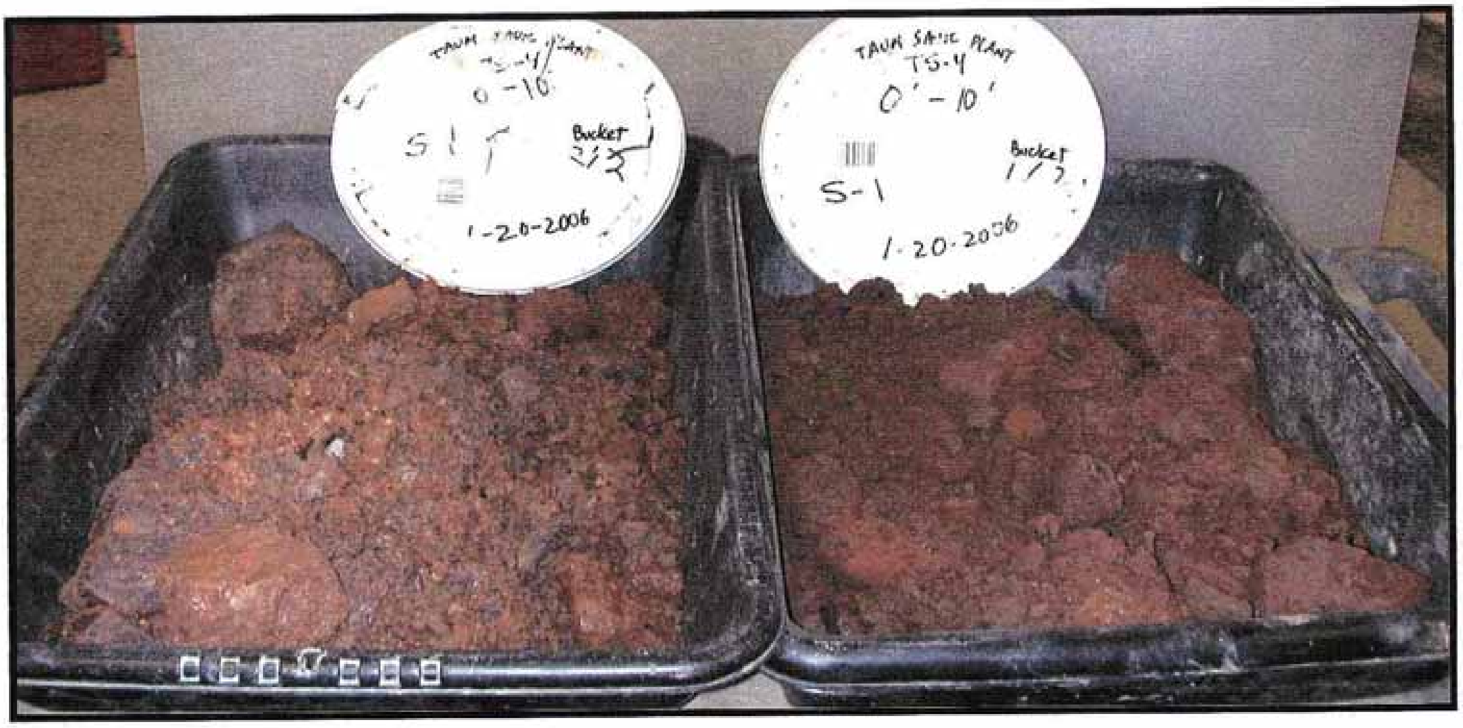
SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client PAUL C. RIZZO & ASSOCIATES, INC.
Client Project TAUM SAUK 06-3551
Project No. 2006-060-01
Lab ID 2006-060-01-33

Boring No.. TS-4
Depth (ft.) 0'-10'
Sample No. S-1

SAMPLE AS RECEIVED:



geotechnics
INTEGRITY IN TESTING

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-4
Client Project	TAUM SAUK 06-3551	Depth (ft.)	10'-13'
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-34		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-4
Client Project	TAUM SAUK 06-3551	Depth (ft.)	13'-16'
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-34		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-4
Client Project	TAUM SAUK 06-3551	Depth (ft.)	16'-20'
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-34		

SAMPLE AS RECEIVED:

geotechnics
INTEGRITY IN TESTING

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-4
Client Project	TAUM SAUK 06-3551	Depth (ft.)	20'-30'
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-35		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-4
Client Project	TAUM SAUK 06-3551	Depth (ft.)	30'-36'
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-36		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-4
Client Project	TAUM SAUK 06-3551	Depth (ft.)	36'-40'
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-36		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-4
Client Project	TAUM SAUK 06-3551	Depth (ft.)	40'-50'
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-37		

SAMPLE AS RECEIVED:

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INTEGRITY IN TESTING

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-4
Client Project	TAUM SAUK 06-3551	Depth (ft.)	50'-60'
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-38		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-4
Client Project	TAUM SAUK 06-3551	Depth (ft.)	60'-70'
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-39		

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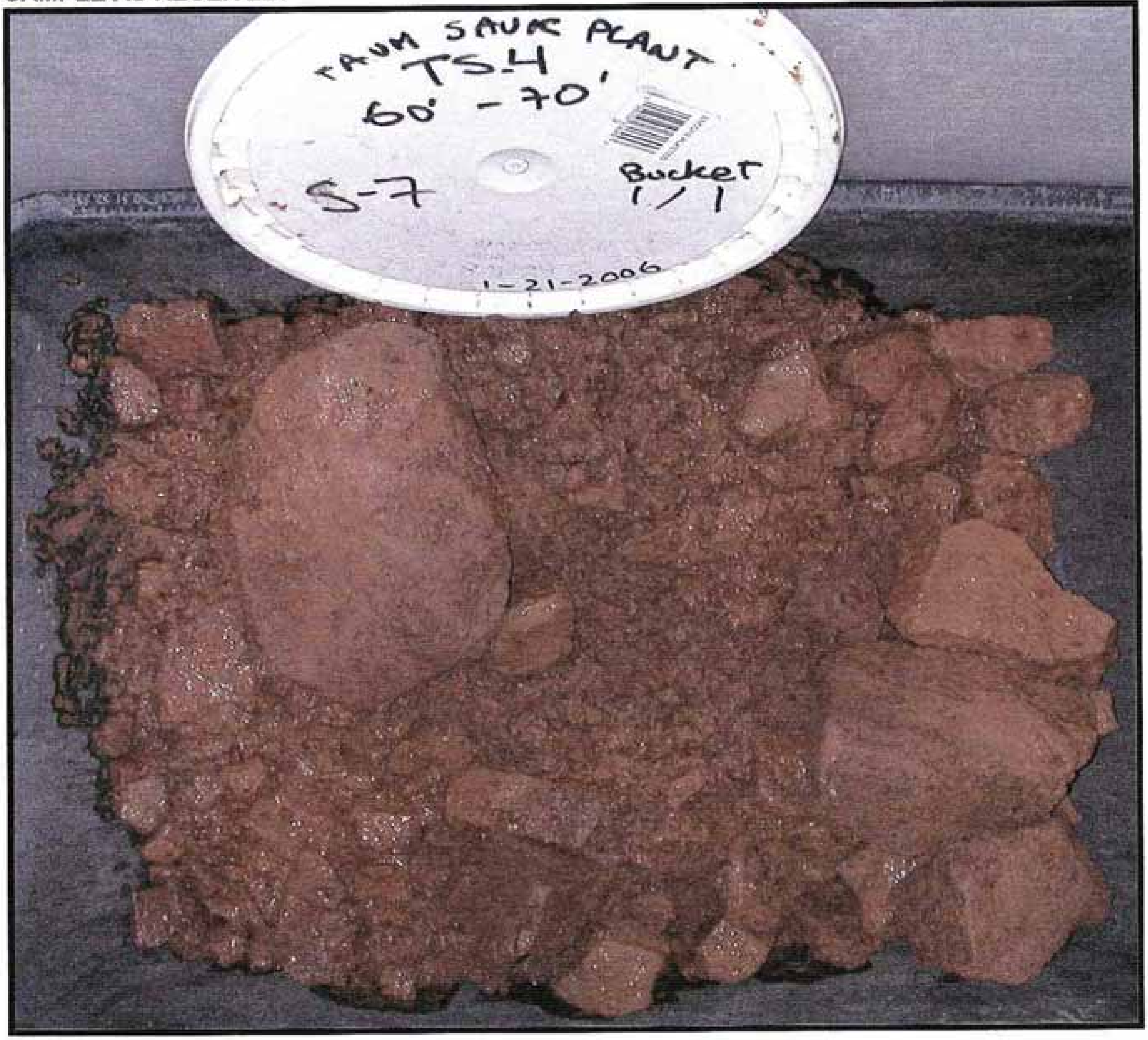


SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-4
Client Project	TAUM SAUK 06-3551	Depth (ft.)	70'-80'
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-40		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-4
Client Project	TAUM SAUK 06-3551	Depth (ft.)	80'-90'
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-41		

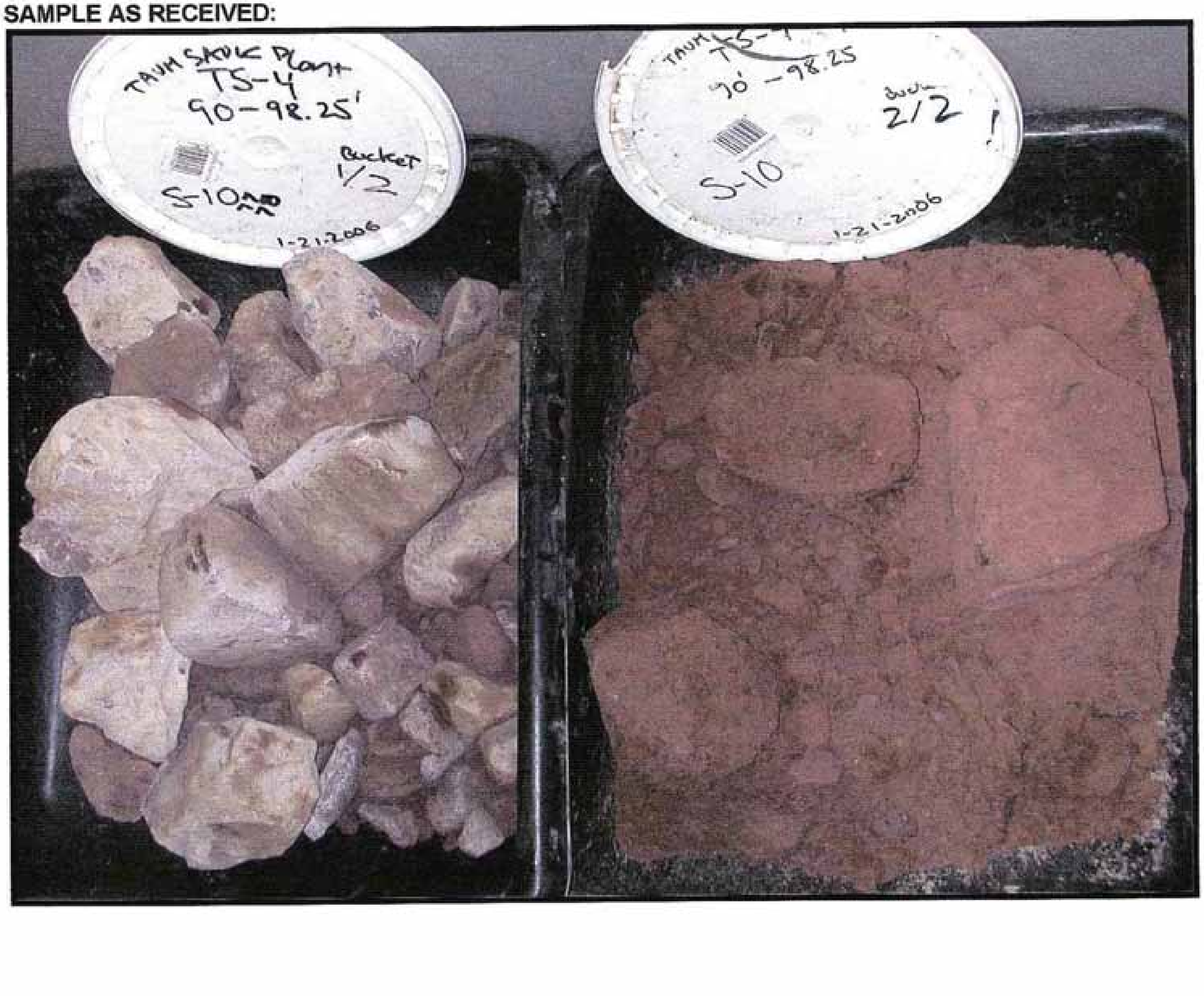
SAMPLE AS RECEIVED:

geotechnics
INTEGRITY IN TESTING

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-4
Client Project	TAUM SAUK 06-3551	Depth (ft.)	90'-98.25'
Project No.	2006-060-01	Sample No.	S-10
Lab ID	2006-060-01-42		

SAMPLE AS RECEIVED:



SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-5
Client Project	TAUM SAUK 06-3551	Depth (ft.)	0'-10'
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-43		

SAMPLE AS RECEIVED:

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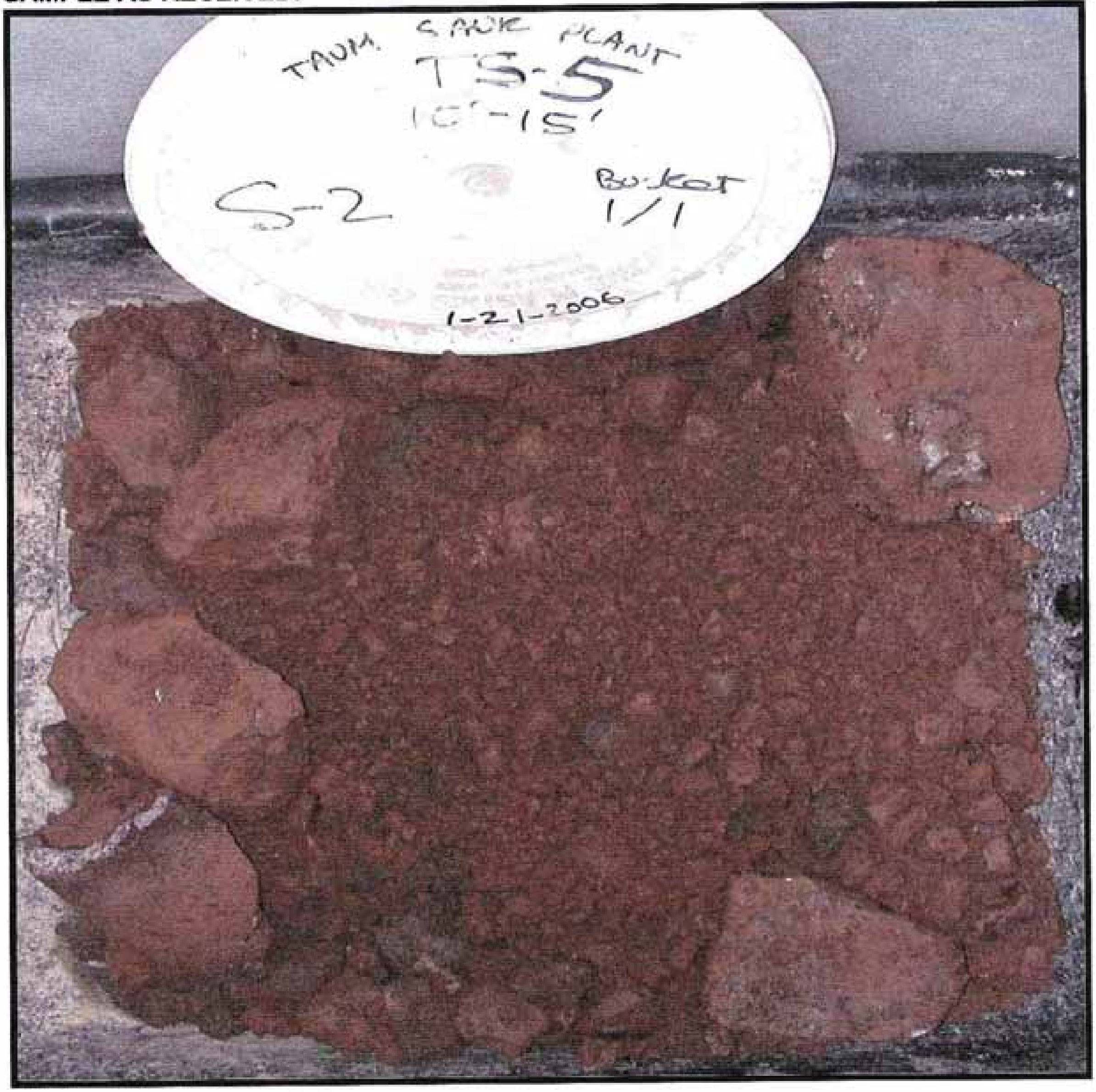
INTEGRITY IN TESTING

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-5
Client Project	TAUM SAUK 06-3551	Depth (ft.)	10'-15'
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-44		

SAMPLE AS RECEIVED:



SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-5
Client Project	TAUM SAUK 06-3551	Depth (ft.)	15'-20'
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-45		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

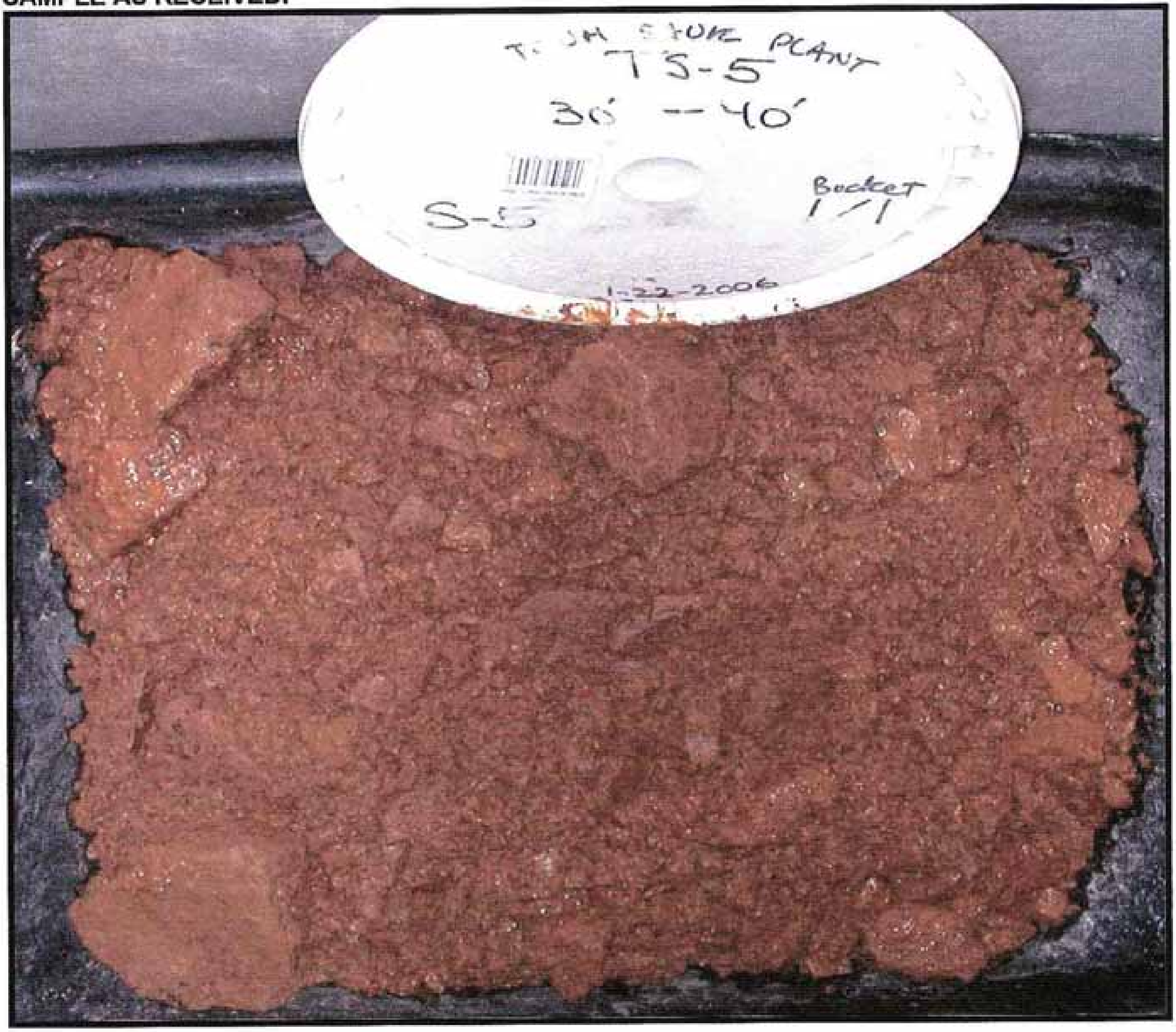
Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-5
Client Project	TAUM SAUK 06-3551	Depth (ft.)	20'-30'
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-46		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-5
Client Project	TAUM SAUK 06-3551	Depth (ft.)	30'-40'
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-47		

SAMPLE AS RECEIVED:



SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-5
Client Project	TAUM SAUK 06-3551	Depth (ft.)	40'-50'
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-48		

SAMPLE AS RECEIVED:

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INTEGRITY IN TESTING

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-5
Client Project	TAUM SAUK 06-3551	Depth (ft.)	50'-60'
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-49		

SAMPLE AS RECEIVED:

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INTEGRITY IN TESTING

SIEVE SAMPLE

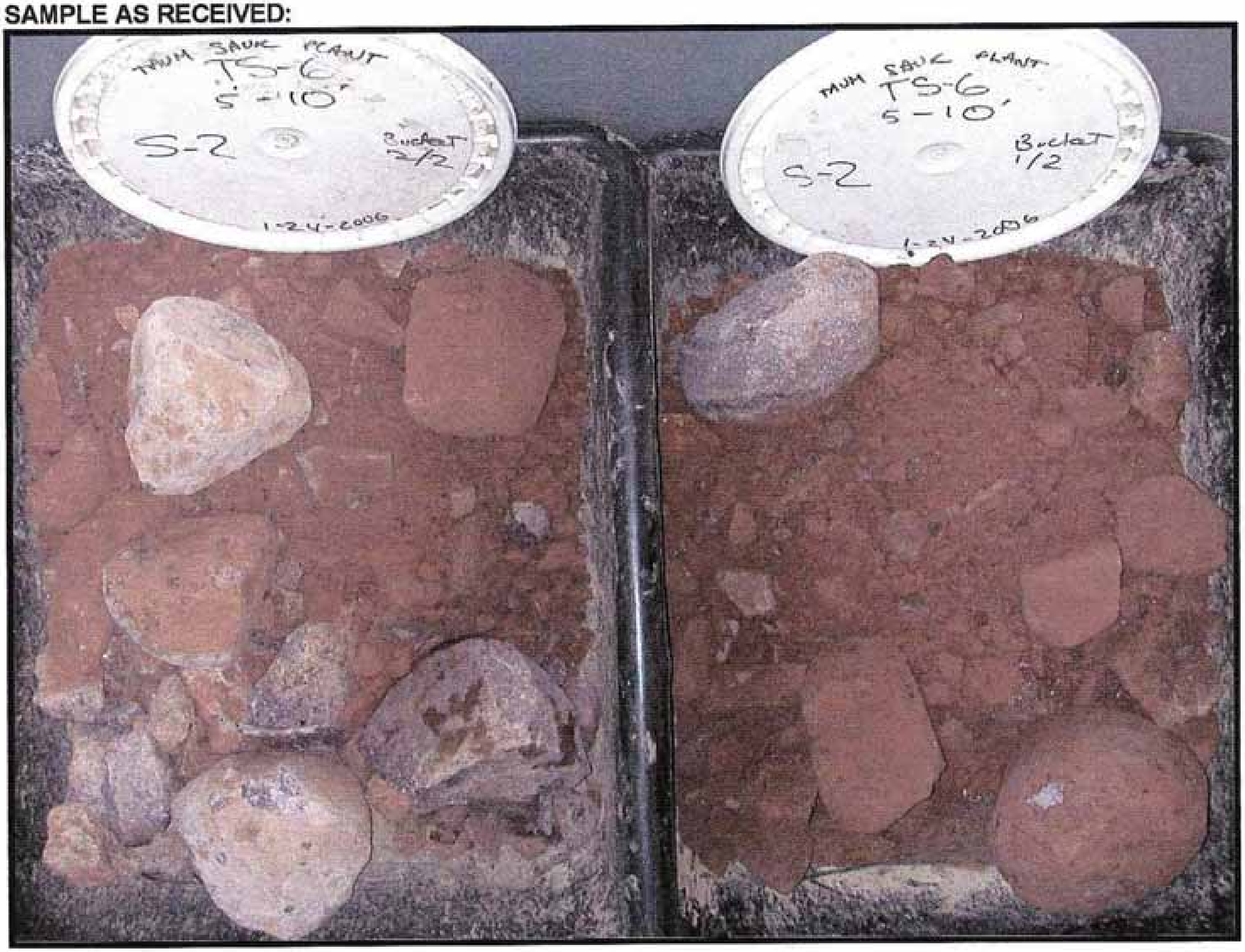
Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-5
Client Project	TAUM SAUK 06-3551	Depth (ft.)	60'-67'
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-50		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-6
Client Project	TAUM SAUK 06-3551	Depth (ft.)	5'-10'
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-52		

SAMPLE AS RECEIVED:



geotechnics
INTEGRITY IN TESTING

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-6
Client Project	TAUM SAUK 06-3551	Depth (ft.)	10'-20'
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-53		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

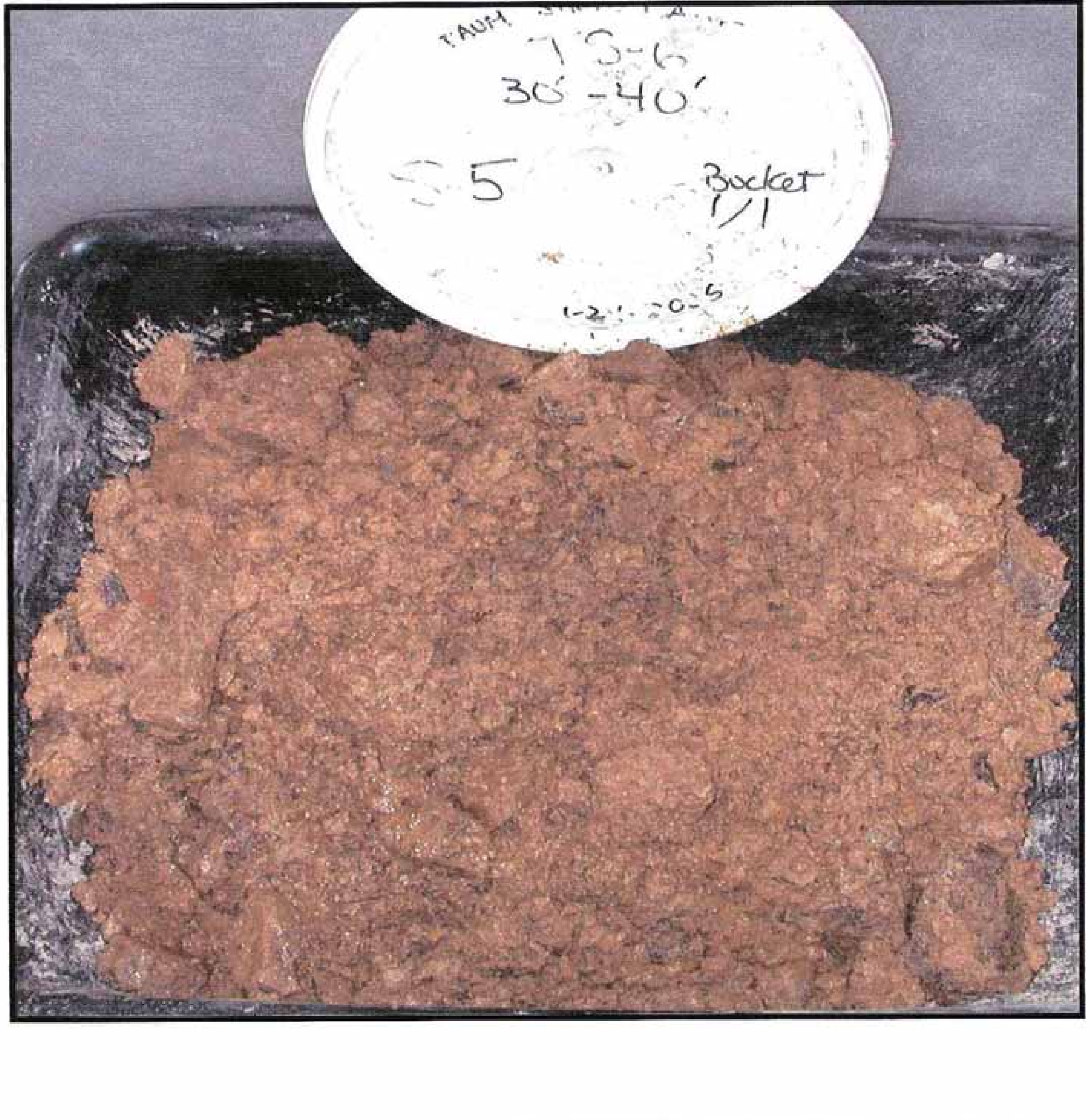
Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-6
Client Project	TAUM SAUK 06-3551	Depth (ft.)	20'-30'
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-54		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-6
Client Project	TAUM SAUK 06-3551	Depth (ft.)	30'-40'
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-55		

SAMPLE AS RECEIVED:



geotechnics
INTEGRITY IN TESTING

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-7
Client Project	TAUM SAUK 06-3551	Depth (ft.)	0'-10'
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-57		

SAMPLE AS RECEIVED:

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INTEGRITY IN TESTING

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-7
Client Project	TAUM SAUK 06-3551	Depth (ft.)	10'-20'
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-58		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-7
Client Project	TAUM SAUK 06-3551	Depth (ft.)	20'-30'
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-59		

SAMPLE AS RECEIVED:

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INTEGRITY IN TESTING

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-7
Client Project	TAUM SAUK 06-3551	Depth (ft.)	30'-40'
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-60		

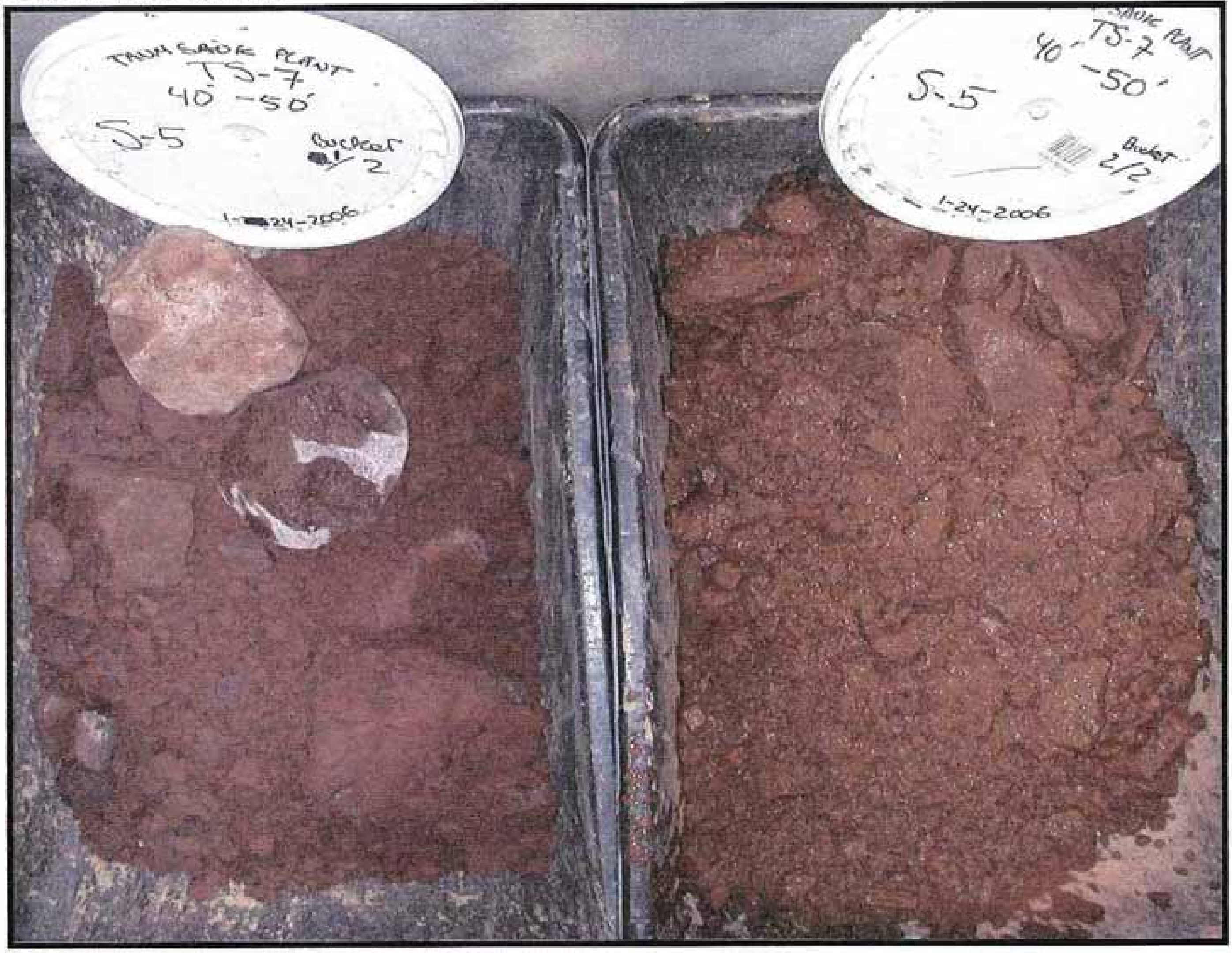
SAMPLE AS RECEIVED:

geotechnics
INTEGRITY IN TESTING

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-7
Client Project	TAUM SAUK 06-3551	Depth (ft.)	40'-50'
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-61		

SAMPLE AS RECEIVED:



SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-7
Client Project	TAUM SAUK 06-3551	Depth (ft.)	50'-60'
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-62		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-7
Client Project	TAUM SAUK 06-3551	Depth (ft.)	60'-70'
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-63		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-7
Client Project	TAUM SAUK 06-3551	Depth (ft.)	70'-80'
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-64		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-7
Client Project	TAUM SAUK 06-3551	Depth (ft.)	80'-87'
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-65		

SAMPLE AS RECEIVED:

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-SOIL-01
Client Project	TAUM SAUK 06-3551	Depth (in.)	9"-14"
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-67		

SAMPLE AS RECEIVED:

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SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-SOIL-02
Client Project	TAUM SAUK 06-3551	Depth (in.)	7"-12"
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-69		

SAMPLE AS RECEIVED:

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SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-6
Client Project	TAUM SAUK 06-3551	Depth (ft.)	50'-54'
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-02-01		

SAMPLE AS RECEIVED:

APPENDIX E3

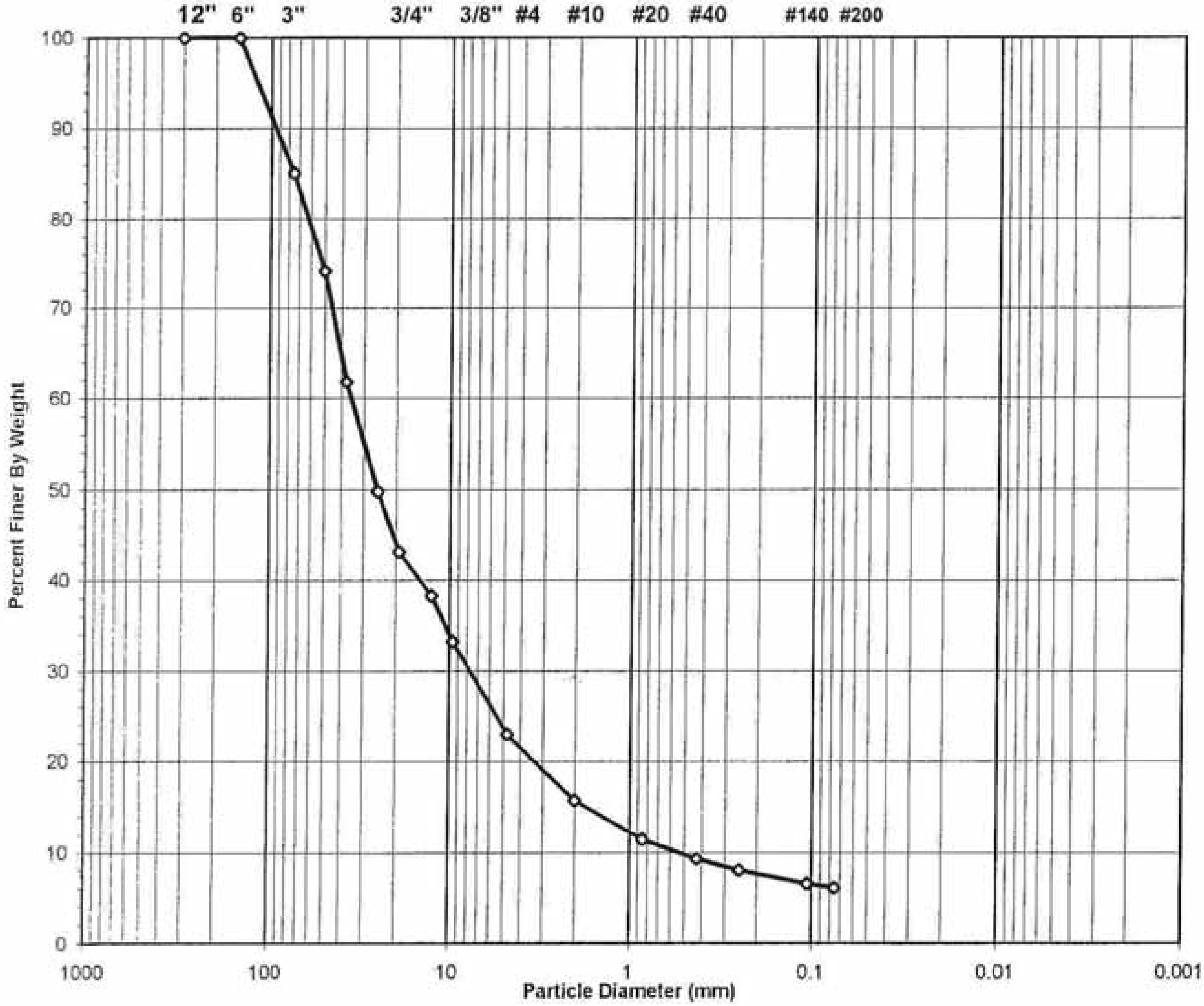
LABORATORY DATA SHEETS

BORING TS-1

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-01	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol	*gp-gm, ASSUMED*	**D60 =**	**35.3**	**CC =**	**3.1**
USCS Classification	*POORLY GRADED GRAVEL WITH SILT AND SAND*	**D30 =**	**7.7**	**CU =**	**66.4**
		D10 =	**0.5**		

Tested By PC Date 2/22/06 Checked By KB Date 2-23-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-01	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	656	Tare No.	1744
Wgt.Tare + Wet Specimen (gm)	1541.90	Wgt.Tare + Wet Specimen (gm)	1199.80
Wgt.Tare + Dry Specimen (gm)	1345.10	Wgt.Tare + Dry Specimen (gm)	1174.20
Weight of Tare (gm)	96.25	Weight of Tare (gm)	83.52
Weight of Water (gm)	196.80	Weight of Water (gm)	25.60
Weight of Dry Soil (gm)	1248.85	Weight of Dry Soil (gm)	1090.68
Moisture Content (%)	**15.8**	**Moisture Content (%)**	**2.3**

Wet Weight -3/4" Sample (gm)	12175	Weight of the Dry Specimen (gm)	1248.85
Dry Weight - 3/4" Sample (gm)	10517.6	Weight of minus #200 material (gm)	175.08
Wet Weight +3/4" Sample (gm)	14185.00	Weight of plus #200 material (gm)	1073.77
Dry Weight + 3/4" Sample (gm)	13859.69		
Total Dry Weight Sample (gm)	24377.3	**J - Factor (Percent Finer than 3/4")**	**0.4315**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	3722.00		14.92	14.92	85.08	**85.08**
2"	50	2740.00	(*)	10.98	25.90	74.10	**74.10**
1 1/2"	37.5	3073.00		12.32	38.22	61.78	**61.78**
1"	25	2990.00		11.98	50.20	49.80	**49.80**
3/4"	19	1660.00		6.65	56.85	43.15	**43.15**
1/2"	12.5	141.29		11.31	11.31	88.69	**38.26**
3/8"	9.5	147.11		11.78	23.09	76.91	**33.18**
#4	4.75	295.67		23.68	46.77	53.23	**22.97**
#10	2	209.70		16.79	63.56	36.44	**15.72**
#20	0.85	122.91	(**)	9.84	73.40	26.60	**11.48**
#40	0.425	63.08		5.05	78.45	21.55	**9.30**
#60	0.25	36.73		2.94	81.39	18.61	**8.03**
#140	0.106	44.50		3.56	84.96	15.04	**6.49**
#200	0.075	12.78		1.02	85.98	14.02	**6.05**
Pan	-	175.08		14.02	100.00	-	**-**

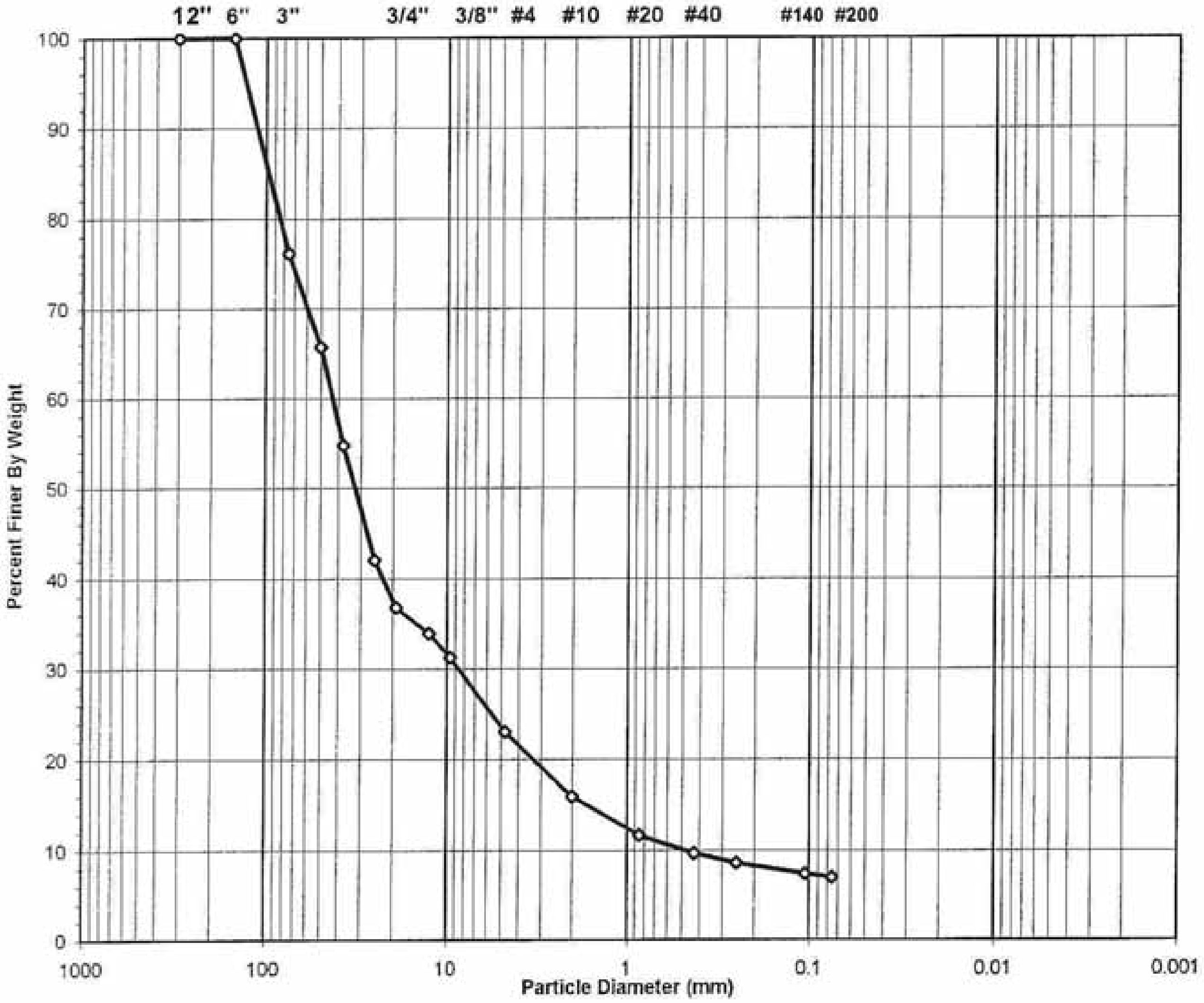
Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By AB. Date 2-23-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-02	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol	***gp-gm, ASSUMED***	**D60 =**	**43.0**	**CC =**	**3.5**
USCS Classification	***POORLY GRADED GRAVEL WITH SILT AND SAND***	**D30 =**	**8.5**	**CU =**	**90.0**
		D10 =	**0.5**		

Tested By PC Date 2/22/06 Checked By Date 2-23-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-02	Soil Color	REDDISH BROWN

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	2485	Tare No.	591
Wgt.Tare + Wet Specimen (gm)	1337.20	Wgt.Tare + Wet Specimen (gm)	633.90
Wgt.Tare + Dry Specimen (gm)	1147.30	Wgt.Tare + Dry Specimen (gm)	615.90
Weight of Tare (gm)	99.92	Weight of Tare (gm)	87.50
Weight of Water (gm)	189.90	Weight of Water (gm)	18.00
Weight of Dry Soil (gm)	1047.38	Weight of Dry Soil (gm)	528.40
Moisture Content (%)	**18.1**	**Moisture Content (%)**	**3.4**

Wet Weight -3/4" Sample (gm)	20860	Weight of the Dry Specimen (gm)	1047.38
Dry Weight - 3/4" Sample (gm)	17658.4	Weight of minus #200 material (gm)	199.39
Wet Weight +3/4" Sample (gm)	31350.00	Weight of plus #200 material (gm)	847.99
Dry Weight + 3/4" Sample (gm)	30317.24		
Total Dry Weight Sample (gm)	47975.6	**J - Factor (Percent Finer than 3/4")**	**0.3681**

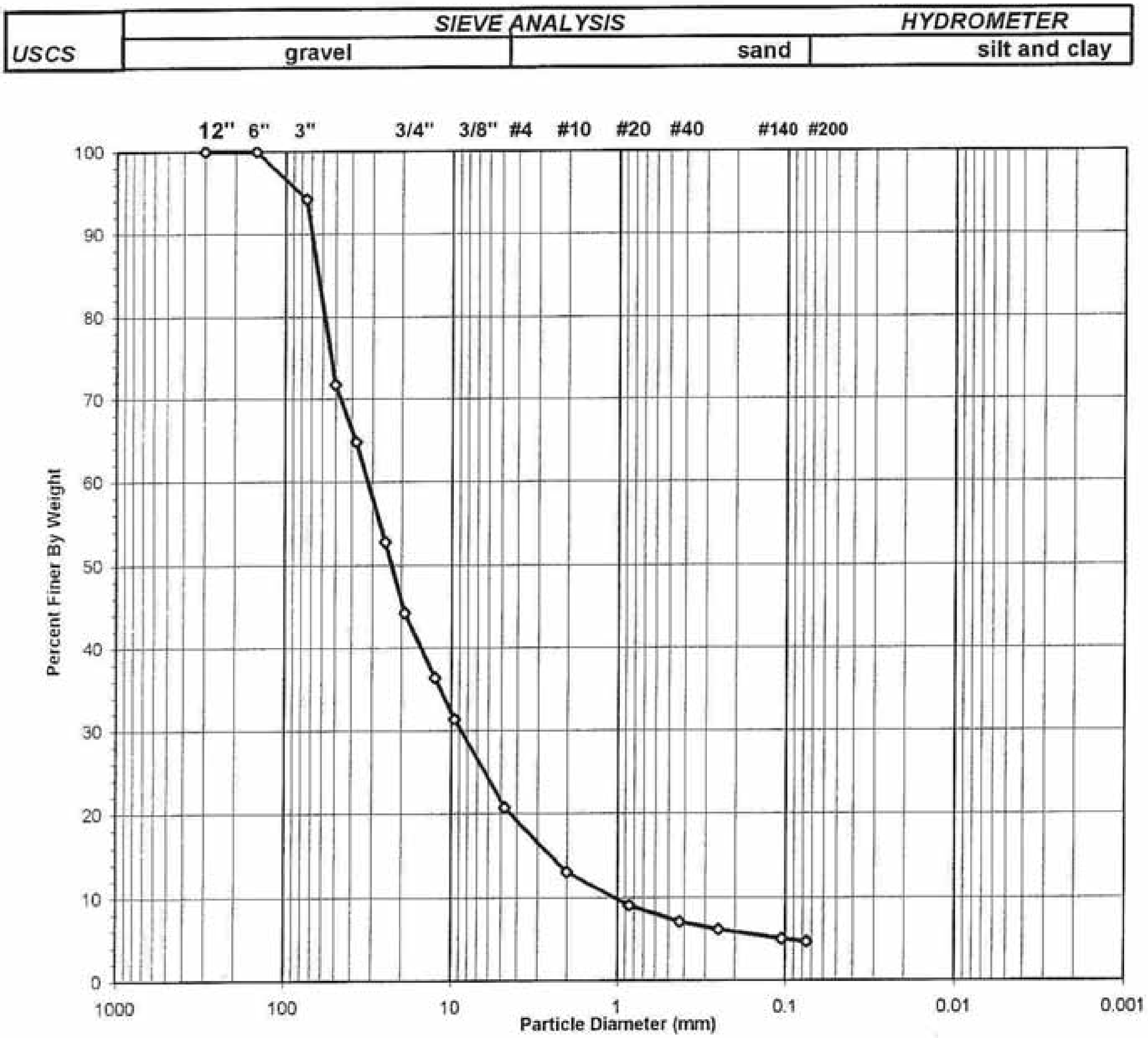
Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	11848.00		23.88	23.88	76.12	**76.12**
2"	50	5184.00	(*)	10.45	34.33	65.67	**65.67**
1 1/2"	37.5	5397.00		10.88	45.21	54.79	**54.79**
1"	25	6309.00		12.72	57.93	42.07	**42.07**
3/4"	19	2612.00		5.27	63.19	36.81	**36.81**
1/2"	12.5	81.12		7.75	7.75	92.25	**33.96**
3/8"	9.5	76.63		7.32	15.06	84.94	**31.26**
#4	4.75	232.35		22.18	37.25	62.75	**23.10**
#10	2	205.08		19.58	56.83	43.17	**15.89**
#20	0.85	120.90	(**)	11.54	68.37	31.63	**11.64**
#40	0.425	56.35		5.38	73.75	26.25	**9.66**
#60	0.25	30.14		2.88	76.63	23.37	**8.60**
#140	0.106	35.10		3.35	79.98	20.02	**7.37**
#200	0.075	10.32		0.99	80.96	19.04	**7.01**
Pan	-	199.39		19.04	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By Date 2-23-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-40
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-03	Soil Color	**REDDISH BROWN**



USCS Symbol	***gw, ASSUMED***	**D60 =**	**31.9**	**CC =**	**2.3**
USCS Classification	***WELL-GRADED GRAVEL WITH SAND***	**D30 =**	**8.7**	**CU =**	**30.6**
		D10 =	**1.0**		

Tested By PC Date 2/22/06 Checked By KB Date 2-23-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-40
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-03	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	708	Tare No.	579
Wgt.Tare + Wet Specimen (gm)	1260.40	Wgt.Tare + Wet Specimen (gm)	545.06
Wgt.Tare + Dry Specimen (gm)	1121.60	Wgt.Tare + Dry Specimen (gm)	533.49
Weight of Tare (gm)	98.76	Weight of Tare (gm)	83.85
Weight of Water (gm)	138.80	Weight of Water (gm)	11.57
Weight of Dry Soil (gm)	1022.84	Weight of Dry Soil (gm)	449.64
Moisture Content (%)	**13.6**	**Moisture Content (%)**	**2.6**

Wet Weight -3/4" Sample (gm)	6457	Weight of the Dry Specimen (gm)	1022.84
Dry Weight - 3/4" Sample (gm)	5685.5	Weight of minus #200 material (gm)	107.53
Wet Weight +3/4" Sample (gm)	7356.00	Weight of plus #200 material (gm)	915.31
Dry Weight + 3/4" Sample (gm)	7171.47		
Total Dry Weight Sample (gm)	12856.9	**J - Factor (Percent Finer than 3/4")**	**0.4422**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	767.00		5.82	5.82	94.18	**94.18**
2"	50	2962.00	(*)	22.46	28.28	71.72	**71.72**
1 1/2"	37.5	909.00		6.89	35.17	64.83	**64.83**
1"	25	1590.00		12.06	47.23	52.77	**52.77**
3/4"	19	1128.00		8.55	55.78	44.22	**44.22**
1/2"	12.5	181.09		17.70	17.70	82.30	**36.39**
3/8"	9.5	115.22		11.26	28.97	71.03	**31.41**
#4	4.75	245.70		24.02	52.99	47.01	**20.79**
#10	2	179.40		17.54	70.53	29.47	**13.03**
#20	0.85	92.05	(**)	9.00	79.53	20.47	**9.05**
#40	0.425	45.61		4.46	83.99	16.01	**7.08**
#60	0.25	21.97		2.15	86.14	13.86	**6.13**
#140	0.106	25.73		2.52	88.65	11.35	**5.02**
#200	0.075	8.54		0.83	89.49	10.51	**4.65**
Pan	-	107.53		10.51	100.00	-	-

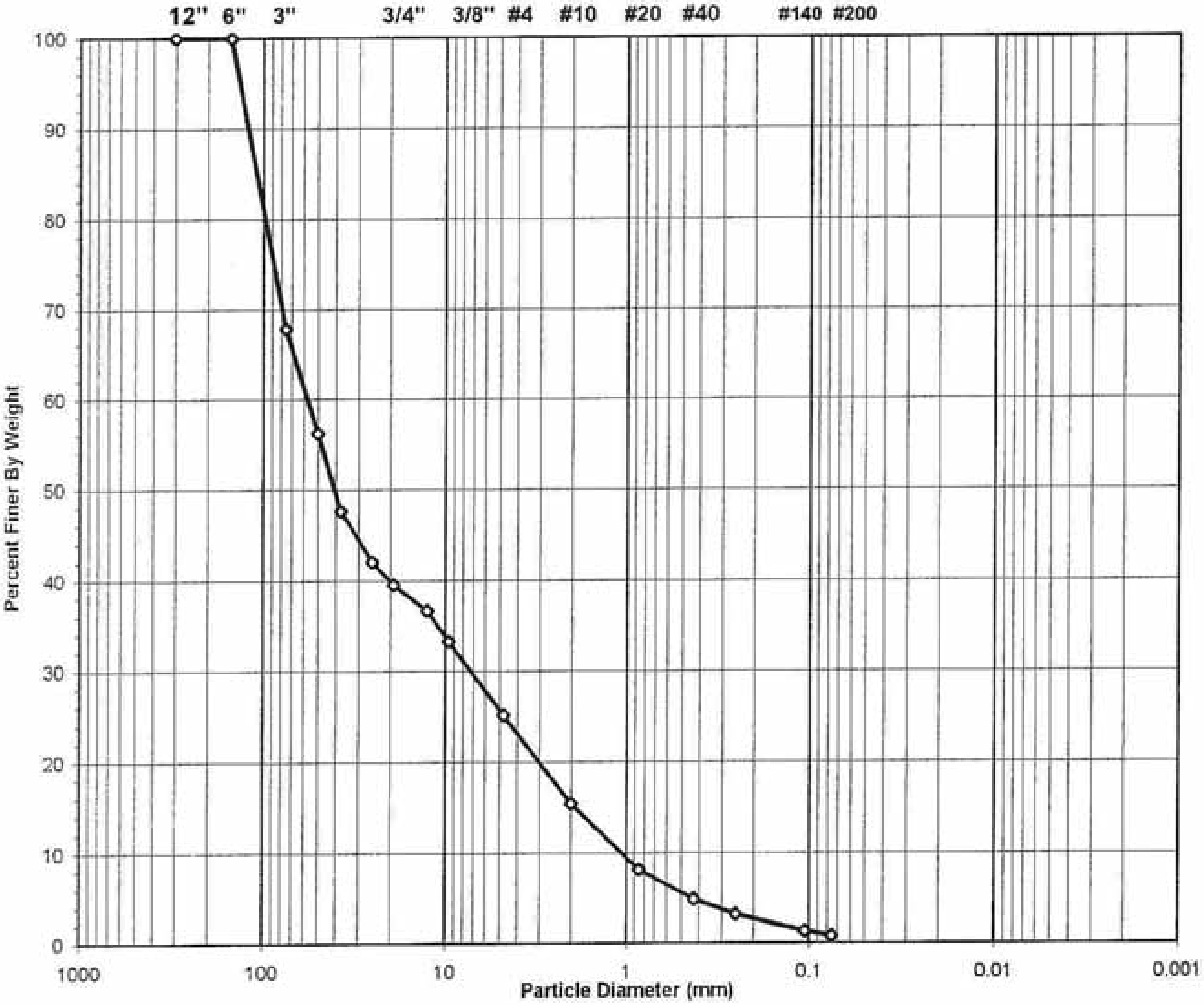
Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By Date 2-23-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-04	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol	*gp, ASSUMED*	D60 =	57.1	CC =	0.9
USCS Classification	*POORLY GRADED GRAVEL WITH SAND*	D30 =	7.2	CU =	53.7
		D10 =	1.1		

Tested By PC Date 2/22/06 Checked By KVB Date 2-23-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-04	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	2487	Tare No.	629
Wgt.Tare + Wet Specimen (gm)	1223.00	Wgt.Tare + Wet Specimen (gm)	487.62
Wgt.Tare + Dry Specimen (gm)	1015.20	Wgt.Tare + Dry Specimen (gm)	478.97
Weight of Tare (gm)	95.29	Weight of Tare (gm)	86.53
Weight of Water (gm)	207.80	Weight of Water (gm)	8.65
Weight of Dry Soil (gm)	919.91	Weight of Dry Soil (gm)	392.44
Moisture Content (%)	**22.6**	**Moisture Content (%)**	**2.2**

Wet Weight -3/4" Sample (gm)	2318	Weight of the Dry Specimen (gm)	919.91
Dry Weight - 3/4" Sample (gm)	1890.9	Weight of minus #200 material (gm)	19.15
Wet Weight +3/4" Sample (gm)	2955.00	Weight of plus #200 material (gm)	900.76
Dry Weight + 3/4" Sample (gm)	2891.27		
Total Dry Weight Sample (gm)	4782.1	**J - Factor (Percent Finer than 3/4")**	**0.3954**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	1575.00		32.22	32.22	67.78	**67.78**
2"	50	566.00	(*)	11.58	43.81	56.19	**56.19**
1 1/2"	37.5	423.00		8.65	52.46	47.54	**47.54**
1"	25	267.00		5.46	57.92	42.08	**42.08**
3/4"	19	124.00		2.54	60.46	39.54	**39.54**
1/2"	12.5	67.43		7.33	7.33	92.67	**36.64**
3/8"	9.5	78.56		8.54	15.87	84.13	**33.27**
#4	4.75	188.53		20.49	36.36	63.64	**25.16**
#10	2	227.52		24.73	61.10	38.90	**15.38**
#20	0.85	169.55	(**)	18.43	79.53	20.47	**8.09**
#40	0.425	75.71		8.23	87.76	12.24	**4.84**
#60	0.25	38.29		4.16	91.92	8.08	**3.19**
#140	0.106	43.52		4.73	96.65	3.35	**1.32**
#200	0.075	11.65		1.27	97.92	2.08	**0.82**
Pan	-	19.15		2.08	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By Date 2-23-06

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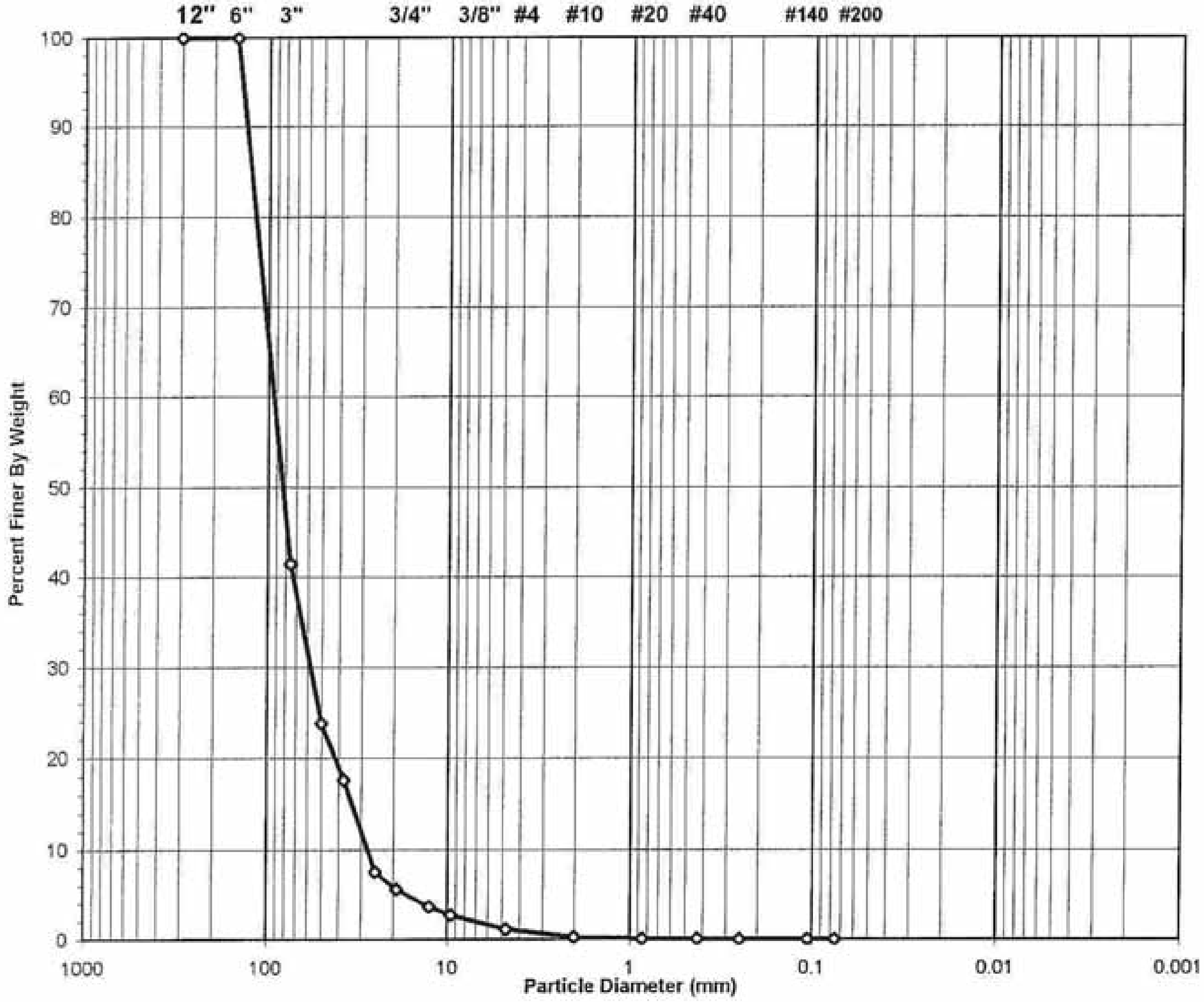
SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-05	Soil Color	**REDDISH BROWN**

USCS	*SIEVE ANALYSIS*		*HYDROMETER*
	gravel	sand	silt and clay



USCS Symbol *gp, ASSUMED*

USCS Classification *POORLY GRADED GRAVEL*

Tested By PC Date 2/22/06 Checked By KYB Date 2-23-06

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INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-05	Soil Color	REDDISH BROWN

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	707	Tare No.	543
Wgt.Tare + Wet Specimen (gm)	339.80	Wgt.Tare + Wet Specimen (gm)	462.40
Wgt.Tare + Dry Specimen (gm)	332.80	Wgt.Tare + Dry Specimen (gm)	453.01
Weight of Tare (gm)	99.53	Weight of Tare (gm)	82.28
Weight of Water (gm)	7.00	Weight of Water (gm)	9.39
Weight of Dry Soil (gm)	233.27	Weight of Dry Soil (gm)	370.73
Moisture Content (%)	**3.0**	**Moisture Content (%)**	**2.5**

Wet Weight -3/4" Sample (gm)	251	Weight of the Dry Specimen (gm)	233.27
Dry Weight - 3/4" Sample (gm)	243.7	Weight of minus #200 material (gm)	0.94
Wet Weight +3/4" Sample (gm)	4226.00	Weight of plus #200 material (gm)	232.33
Dry Weight + 3/4" Sample (gm)	4121.61		
Total Dry Weight Sample (gm)	4365.3	**J - Factor (Percent Finer than 3/4")**	**0.0558**

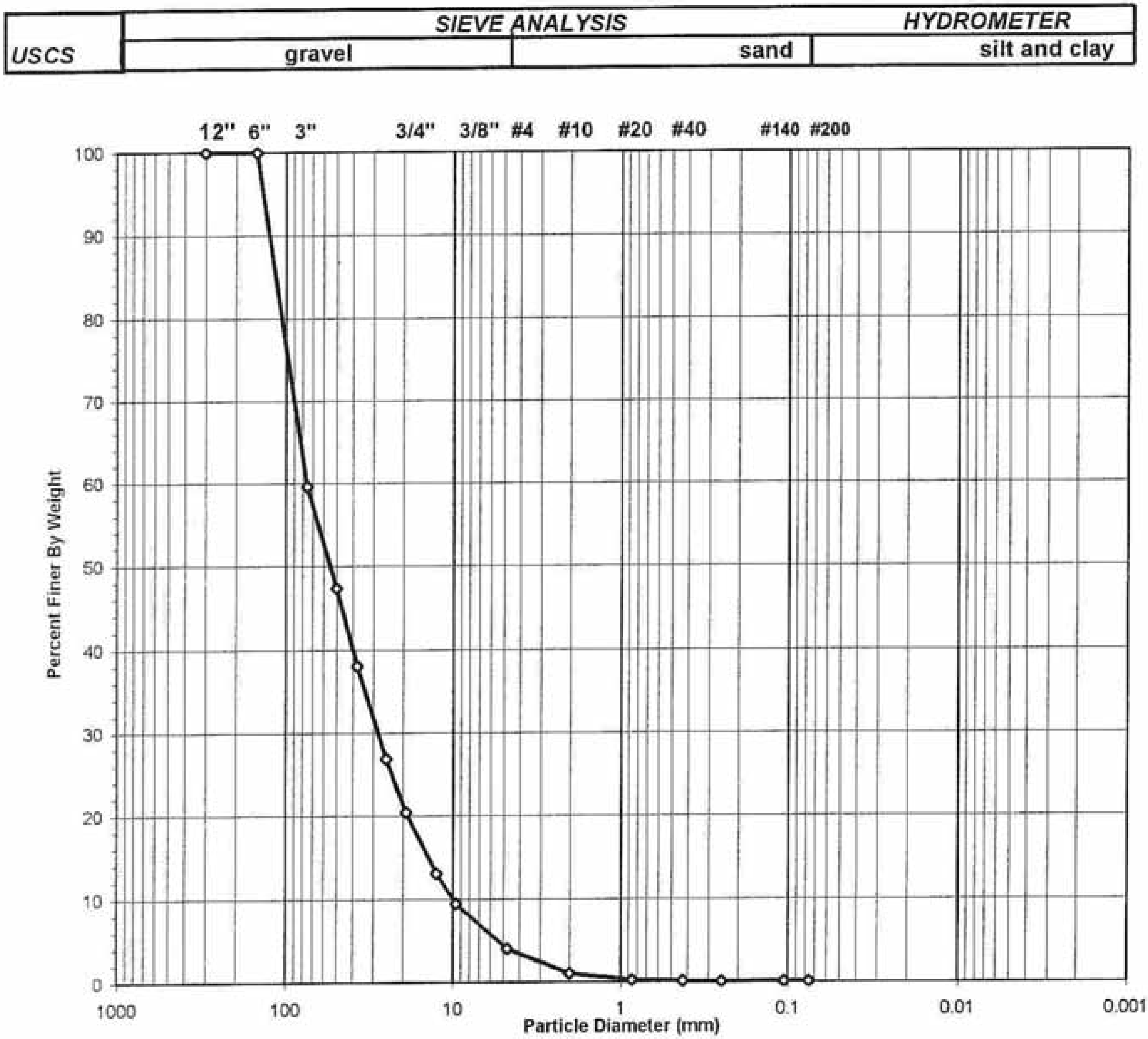
Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	2620.00		58.54	58.54	41.46	**41.46**
2"	50	790.00	(*)	17.65	76.19	23.81	**23.81**
1 1/2"	37.5	277.00		6.19	82.38	17.62	**17.62**
1"	25	453.00		10.12	92.50	7.50	**7.50**
3/4"	19	86.00		1.92	94.42	5.58	**5.58**
1/2"	12.5	80.80		34.64	34.64	65.36	**3.65**
3/8"	9.5	37.49		16.07	50.71	49.29	**2.75**
#4	4.75	69.06		29.61	80.31	19.69	**1.10**
#10	2	35.08		15.04	95.35	4.65	**0.26**
#20	0.85	7.74	(**)	3.32	98.67	1.33	**0.07**
#40	0.425	1.46		0.63	99.30	0.70	**0.04**
#60	0.25	0.34		0.15	99.44	0.56	**0.03**
#140	0.106	0.20		0.09	99.53	0.47	**0.03**
#200	0.075	0.16		0.07	99.60	0.40	**0.02**
Pan	-	0.94		0.40	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By KYB Date 2-23-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	60-70
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-06	Soil Color	**REDDISH BROWN**



USCS Symbol ***gp, ASSUMED***

USCS Classification ***POORLY GRADED GRAVEL***

Tested By PC Date 2/22/06 Checked By YKB Date 2-23-06

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	60-70
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-06	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	970	Tare No.	565
Wgt.Tare + Wet Specimen (gm)	1216.30	Wgt.Tare + Wet Specimen (gm)	882.00
Wgt.Tare + Dry Specimen (gm)	1175.30	Wgt.Tare + Dry Specimen (gm)	873.80
Weight of Tare (gm)	102.84	Weight of Tare (gm)	82.93
Weight of Water (gm)	41.00	Weight of Water (gm)	8.20
Weight of Dry Soil (gm)	1072.46	Weight of Dry Soil (gm)	790.87
Moisture Content (%)	**3.8**	**Moisture Content (%)**	**1.0**

Wet Weight -3/4" Sample (gm)	4626	Weight of the Dry Specimen (gm)	1072.46
Dry Weight - 3/4" Sample (gm)	4455.7	Weight of minus #200 material (gm)	2.83
Wet Weight +3/4" Sample (gm)	17547.00	Weight of plus #200 material (gm)	1069.63
Dry Weight + 3/4" Sample (gm)	17366.93		
Total Dry Weight Sample (gm)	21822.6	**J - Factor (Percent Finer than 3/4")**	**0.2042**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	8911.00		40.41	40.41	59.59	**59.59**
2"	50	2708.00	(*)	12.28	52.70	47.30	**47.30**
1 1/2"	37.5	2035.00		9.23	61.93	38.07	**38.07**
1"	25	2461.00		11.16	73.09	26.91	**26.91**
3/4"	19	1432.00		6.49	79.58	20.42	**20.42**
1/2"	12.5	385.91		35.98	35.98	64.02	**13.07**
3/8"	9.5	190.72		17.78	53.77	46.23	**9.44**
#4	4.75	283.16		26.40	80.17	19.83	**4.05**
#10	2	157.09		14.65	94.82	5.18	**1.06**
#20	0.85	42.59	(**)	3.97	98.79	1.21	**0.25**
#40	0.425	7.38		0.69	99.48	0.52	**0.11**
#60	0.25	1.47		0.14	99.61	0.39	**0.08**
#140	0.106	1.01		0.09	99.71	0.29	**0.06**
#200	0.075	0.30		0.03	99.74	0.26	**0.05**
Pan	-	2.83		0.26	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By YKB Date 2-23-06

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Dry Density

Client	PC RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	60-70
Project No.	2006-060-02	Sample No.	S-7
Lab ID	2006-060-01	Test Type	CORE

Visual Description	Reddish Gray Rock

Weight of Wet Soil + Tare (gm)	8389.00
Weight of Tare (gm)	0.00
Volume (cm^3)	3192.00

MOISTURE / DENSITY

Tare Number	X
Wt. of Tare & WS (gm)	8389.00
Wt. of Tare & DS (gm)	8382.00
Wt. of Tare (gm)	0.00
Wt. of Water (gm)	7.00
Wt. of DS (gm)	8382.00
Wet Density (gm/cc)	2.63
Wet Density (pcf)	164.1
Moisture Content (%)	**0.1**
Dry Density (pcf)	**163.9**

Tested By DB *Date* 3/23/06 *Checked By* KyB *Date* 3-23-06

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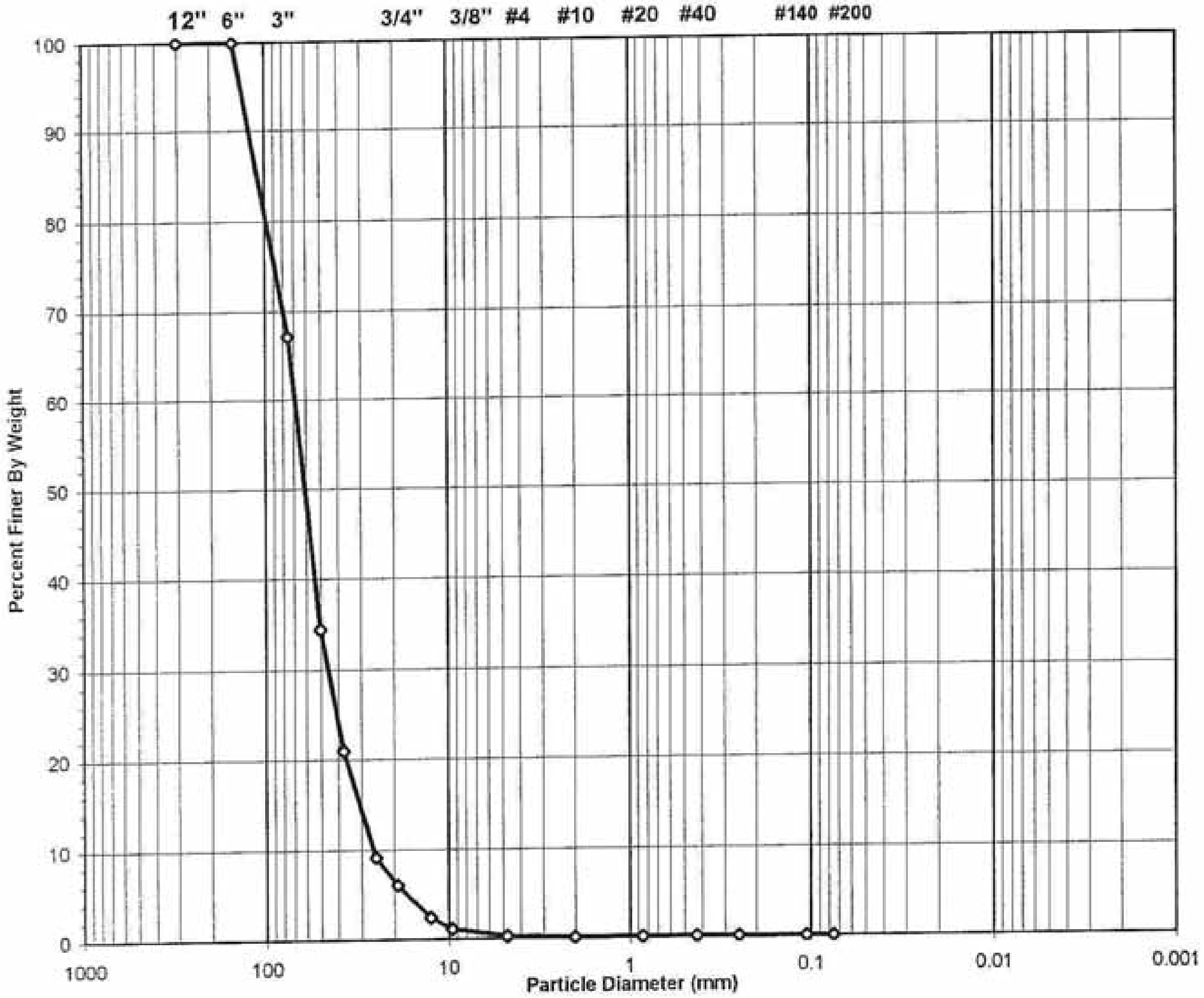
SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-07	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		***HYDROMETER***
USCS	**gravel**	**sand**	**silt and clay**



USCS Symbol	***gp, ASSUMED***	**D60 =**	**68.7**	**CC =**	**1.2**
USCS Classification	***POORLY GRADED GRAVEL***	**D30 =**	**45.5**	**CU =**	**2.7**
		D10 =	**25.8**		

Tested By PC Date 2/22/06 Checked By KB Date 2-23-06

page 1 of 2 **DCN: CT-S3A DATE 6-25-98 REVISION 2** *C:\MSOFFICE\Excel\PrintQ\[U251.xls]Sheet1*

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INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-07	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	2327	Tare No.	628
Wgt.Tare + Wet Specimen (gm)	825.80	Wgt.Tare + Wet Specimen (gm)	397.57
Wgt.Tare + Dry Specimen (gm)	813.20	Wgt.Tare + Dry Specimen (gm)	392.85
Weight of Tare (gm)	98.51	Weight of Tare (gm)	85.22
Weight of Water (gm)	12.60	Weight of Water (gm)	4.72
Weight of Dry Soil (gm)	714.69	Weight of Dry Soil (gm)	307.63
Moisture Content (%)	1.8	**Moisture Content (%)**	**1.5**

Wet Weight -3/4" Sample (gm)	748	Weight of the Dry Specimen (gm)	714.69
Dry Weight - 3/4" Sample (gm)	735.0	Weight of minus #200 material (gm)	2.72
Wet Weight +3/4" Sample (gm)	11690.00	Weight of plus #200 material (gm)	711.97
Dry Weight + 3/4" Sample (gm)	11513.35		
Total Dry Weight Sample (gm)	12248.4	**J - Factor (Percent Finer than 3/4")**	**0.0600**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	4090.00		32.89	32.89	67.11	**67.11**
2"	50	4060.00	(*)	32.65	65.53	34.47	**34.47**
1 1/2"	37.5	1680.00		13.51	79.04	20.96	**20.96**
1"	25	1471.00		11.83	90.87	9.13	**9.13**
3/4"	19	389.00		3.13	94.00	6.00	**6.00**
1/2"	12.5	425.86		59.59	59.59	40.41	**2.43**
3/8"	9.5	151.91		21.26	80.84	19.16	**1.15**
#4	4.75	107.80		15.08	95.93	4.07	**0.24**
#10	2	19.85		2.78	98.70	1.30	**0.08**
#20	0.85	3.35	(**)	0.47	99.17	0.83	**0.05**
#40	0.425	1.20		0.17	99.34	0.66	**0.04**
#60	0.25	0.64		0.09	99.43	0.57	**0.03**
#140	0.106	1.00		0.14	99.57	0.43	**0.03**
#200	0.075	0.36		0.05	99.62	0.38	**0.02**
Pan	-	2.72		0.38	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By KiB Date 2-23-06

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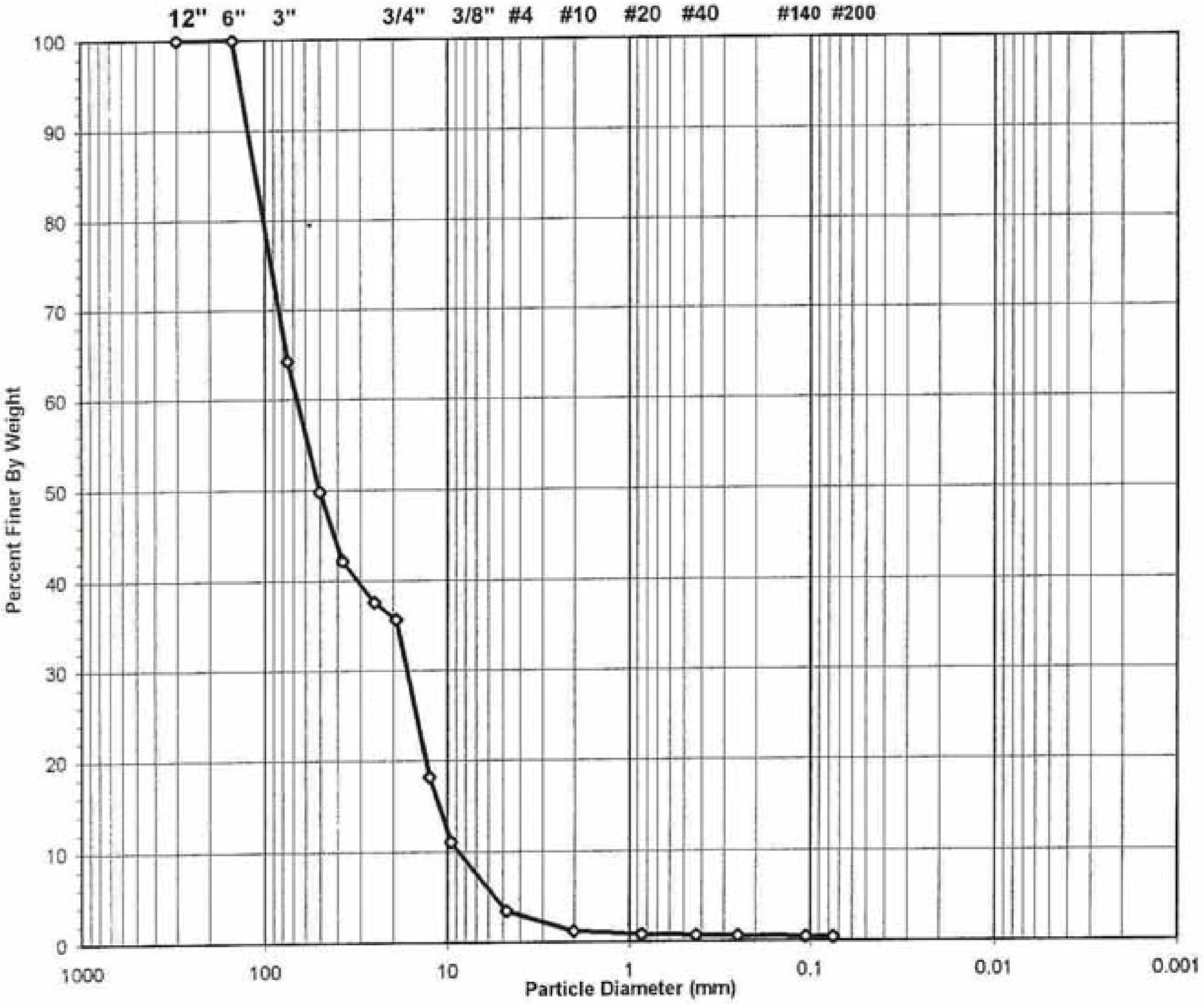
SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	80-90
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-08	Soil Color	**REDDISH BROWN**

USCS	*SIEVE ANALYSIS*		*HYDROMETER*
	gravel	sand	silt and clay



USCS Symbol	***gp, ASSUMED***	D60 =	66.5	CC =	0.5
USCS Classification	***POORLY GRADED GRAVEL***	D30 =	16.6	CU =	7.7
		D10 =	8.6		

Tested By PC Date 2/22/06 Checked By KYB Date 2-23-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	80-90
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-08	Soil Color	REDDISH BROWN

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	637	Tare No.	673
Wgt.Tare + Wet Specimen (gm)	1338.70	Wgt.Tare + Wet Specimen (gm)	547.31
Wgt.Tare + Dry Specimen (gm)	1291.50	Wgt.Tare + Dry Specimen (gm)	538.89
Weight of Tare (gm)	101.40	Weight of Tare (gm)	72.66
Weight of Water (gm)	47.20	Weight of Water (gm)	8.42
Weight of Dry Soil (gm)	1190.10	Weight of Dry Soil (gm)	466.23
Moisture Content (%)	**4.0**	**Moisture Content (%)**	**1.8**

Wet Weight -3/4" Sample (gm)	13864	Weight of the Dry Specimen (gm)	1190.10
Dry Weight - 3/4" Sample (gm)	13335.1	Weight of minus #200 material (gm)	14.00
Wet Weight +3/4" Sample (gm)	24495.00	Weight of plus #200 material (gm)	1176.10
Dry Weight + 3/4" Sample (gm)	24060.47		
Total Dry Weight Sample (gm)	37395.6	**J - Factor (Percent Finer than 3/4")**	**0.3566**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	13593.00		35.70	35.70	64.30	**64.30**
2"	50	5532.00	(*)	14.53	50.24	49.76	**49.76**
1 1/2"	37.5	2881.00		7.57	57.80	42.20	**42.20**
1"	25	1760.00		4.62	62.43	37.57	**37.57**
3/4"	19	729.00		1.91	64.34	35.66	**35.66**
1/2"	12.5	583.50		49.03	49.03	50.97	**18.18**
3/8"	9.5	237.61		19.97	69.00	31.00	**11.06**
#4	4.75	253.79		21.33	90.32	9.68	**3.45**
#10	2	75.37		6.33	96.65	3.35	**1.19**
#20	0.85	13.38	(**)	1.12	97.78	2.22	**0.79**
#40	0.425	4.24		0.36	98.13	1.87	**0.67**
#60	0.25	2.69		0.23	98.36	1.64	**0.58**
#140	0.106	4.14		0.35	98.71	1.29	**0.46**
#200	0.075	1.38		0.12	98.82	1.18	**0.42**
Pan	-	14.00		1.18	100.00	-	-

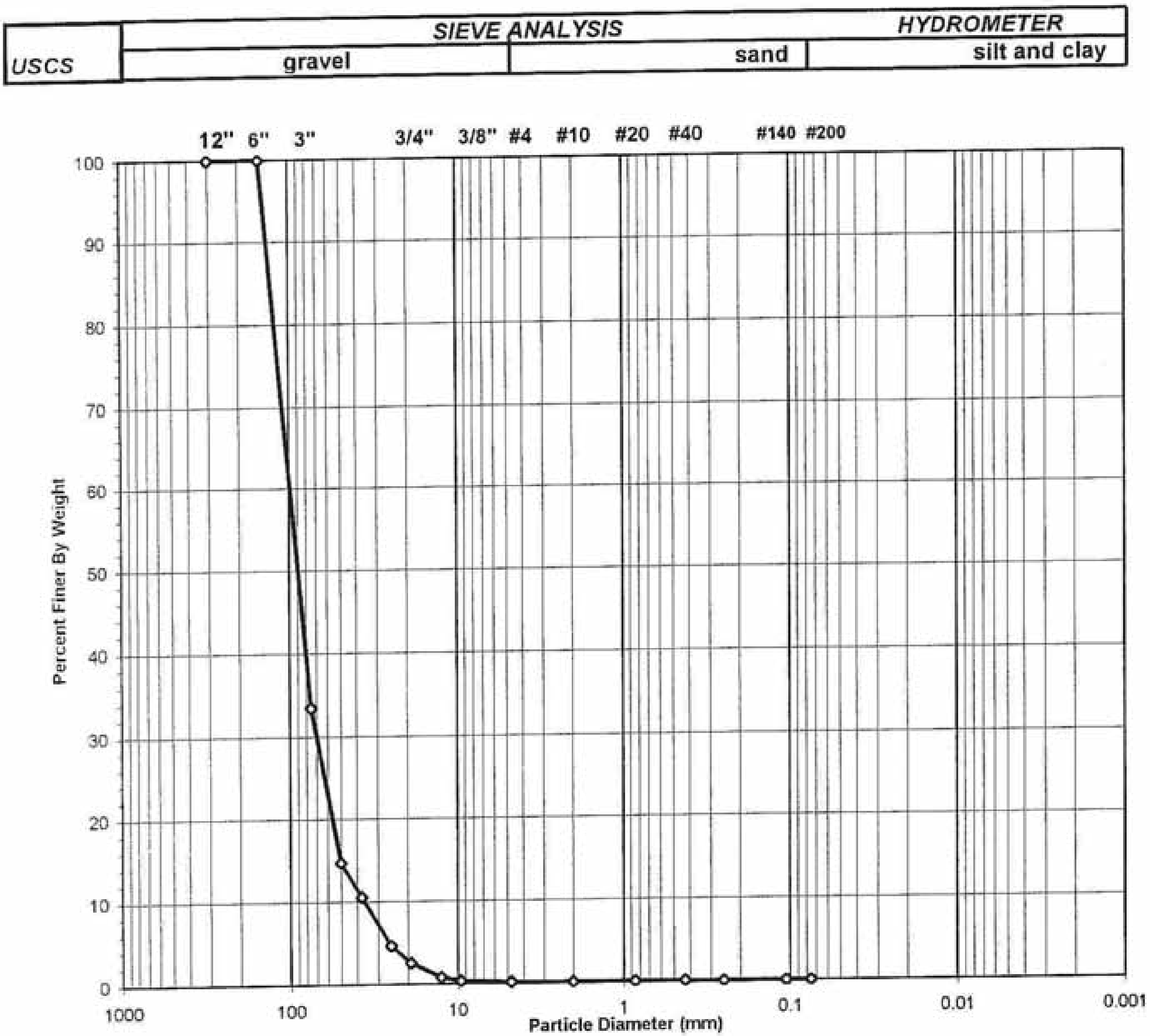
Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By Date 2-23-06

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	90-100
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-09	Soil Color	**REDDISH BROWN**



USCS Symbol *gp, ASSUMED*

USCS Classification ***POORLY GRADED GRAVEL***

Tested By	PC	Date	2/22/06	Checked By	KB	Date	2-23-06

page 1 of 2 DCN: CT-S3A DATE 6-25-98 REVISION 2 C:\MSOFFICE\Excel\PrintQ\[U253.xls]Sheet1

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	90-100
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-09	Soil Color	**REDDISH BROWN AND GRAY**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	1619	Tare No.	604
Wgt.Tare + Wet Specimen (gm)	482.50	Wgt.Tare + Wet Specimen (gm)	891.30
Wgt.Tare + Dry Specimen (gm)	479.15	Wgt.Tare + Dry Specimen (gm)	888.20
Weight of Tare (gm)	95.51	Weight of Tare (gm)	87.13
Weight of Water (gm)	3.35	Weight of Water (gm)	3.10
Weight of Dry Soil (gm)	383.64	Weight of Dry Soil (gm)	801.07
Moisture Content (%)	**0.9**	**Moisture Content (%)**	**0.4**

Wet Weight -3/4" Sample (gm)	493	Weight of the Dry Specimen (gm)	383.64
Dry Weight - 3/4" Sample (gm)	488.7	Weight of minus #200 material (gm)	3.87
Wet Weight +3/4" Sample (gm)	18976.00	Weight of plus #200 material (gm)	379.77
Dry Weight + 3/4" Sample (gm)	18902.85		
Total Dry Weight Sample (gm)	19391.6	**J - Factor (Percent Finer than 3/4")**	**0.0252**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	12942.00		66.48	66.48	33.52	**33.52**
2"	50	3660.00	(*)	18.80	85.28	14.72	**14.72**
1 1/2"	37.5	812.00		4.17	89.46	10.54	**10.54**
1"	25	1162.00		5.97	95.42	4.58	**4.58**
3/4"	19	400.00		2.05	97.48	2.52	**2.52**
1/2"	12.5	259.58		67.66	67.66	32.34	**0.82**
3/8"	9.5	69.50		18.12	85.78	14.22	**0.36**
#4	4.75	38.90		10.14	95.92	4.08	**0.10**
#10	2	6.96		1.81	97.73	2.27	**0.06**
#20	0.85	2.33	(**)	0.61	98.34	1.66	**0.04**
#40	0.425	0.89		0.23	98.57	1.43	**0.04**
#60	0.25	0.52		0.14	98.71	1.29	**0.03**
#140	0.106	0.77		0.20	98.91	1.09	**0.03**
#200	0.075	0.32		0.08	98.99	1.01	**0.03**
Pan	-	3.87		1.01	100.00	-	**-**

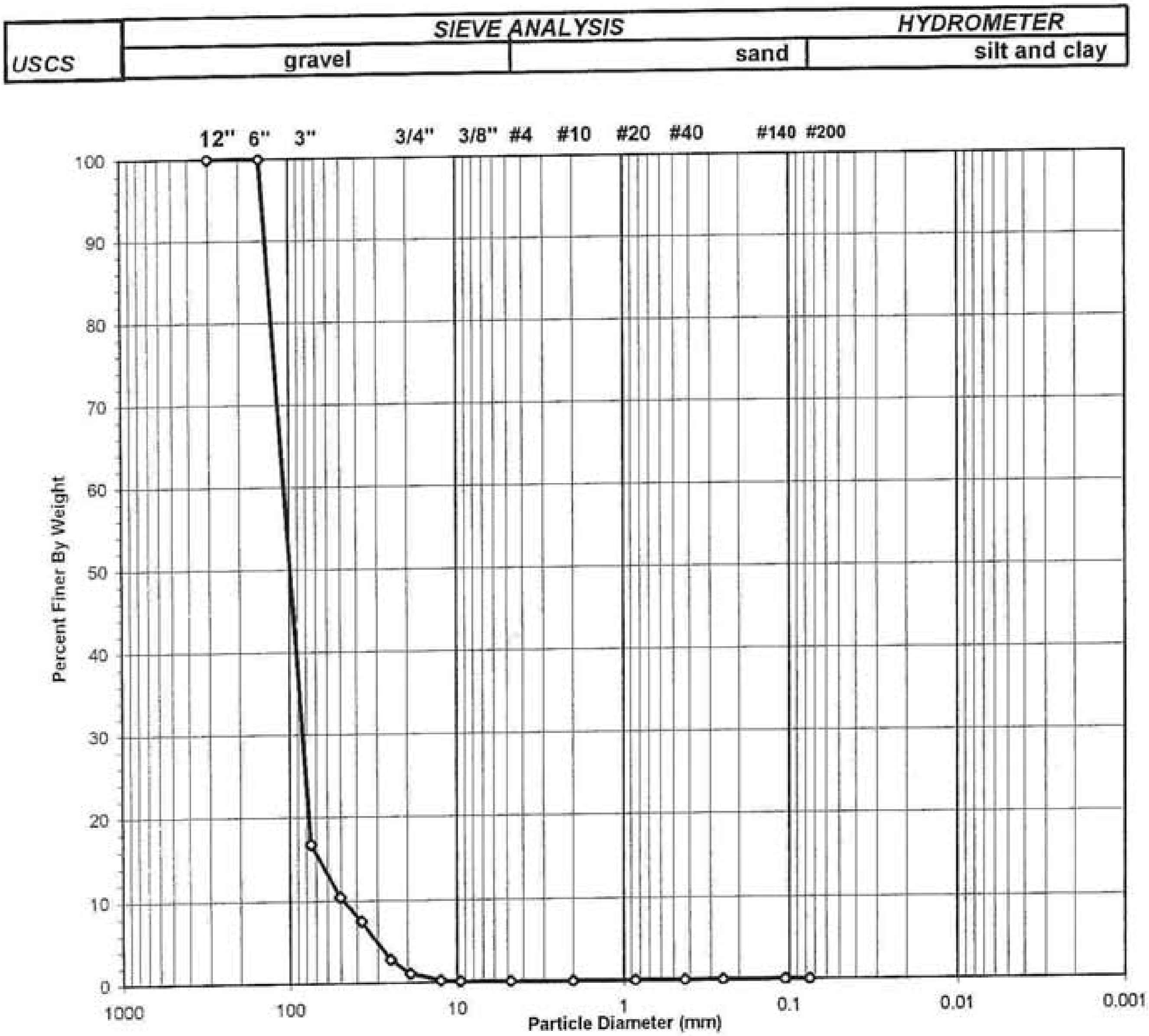
Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By KB Date 2-23-06

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-10
Lab ID	2006-060-01-10	Soil Color	REDDISH BROWN



USCS Symbol ***gp, ASSUMED***

USCS Classification ***POORLY GRADED GRAVEL***

Tested By PC Date 2/22/06 Checked By KB Date 2-23-06

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INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-10
Lab ID	2006-060-01-10	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	669	Tare No.	607
Wgt.Tare + Wet Specimen (gm)	323.19	Wgt.Tare + Wet Specimen (gm)	422.02
Wgt.Tare + Dry Specimen (gm)	320.14	Wgt.Tare + Dry Specimen (gm)	419.52
Weight of Tare (gm)	96.83	Weight of Tare (gm)	83.05
Weight of Water (gm)	3.05	Weight of Water (gm)	2.50
Weight of Dry Soil (gm)	223.31	Weight of Dry Soil (gm)	336.47
Moisture Content (%)	**1.4**	**Moisture Content (%)**	**0.7**

Wet Weight -3/4" Sample (gm)	230	Weight of the Dry Specimen (gm)	223.31
Dry Weight - 3/4" Sample (gm)	226.9	Weight of minus #200 material (gm)	0.67
Wet Weight +3/4" Sample (gm)	19751.00	Weight of plus #200 material (gm)	222.64
Dry Weight + 3/4" Sample (gm)	19605.33		
Total Dry Weight Sample (gm)	19832.2	**J - Factor (Percent Finer than 3/4")**	**0.0114**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	16632.00		83.24	83.24	16.76	**16.76**
2"	50	1265.00	(*)	6.33	89.58	10.42	**10.42**
1 1/2"	37.5	574.00		2.87	92.45	7.55	**7.55**
1"	25	937.00		4.69	97.14	2.86	**2.86**
3/4"	19	343.00		1.72	98.86	1.14	**1.14**
1/2"	12.5	167.57		75.04	75.04	24.96	**0.29**
3/8"	9.5	28.75		12.87	87.91	12.09	**0.14**
#4	4.75	19.43		8.70	96.61	3.39	**0.04**
#10	2	5.35		2.40	99.01	0.99	**0.01**
#20	0.85	0.72	(**)	0.32	99.33	0.67	**0.01**
#40	0.425	0.31		0.14	99.47	0.53	**0.01**
#60	0.25	0.17		0.08	99.55	0.45	**0.01**
#140	0.106	0.22		0.10	99.65	0.35	**0.00**
#200	0.075	0.12		0.05	99.70	0.30	**0.00**
Pan	-	0.67		0.30	100.00	-	-

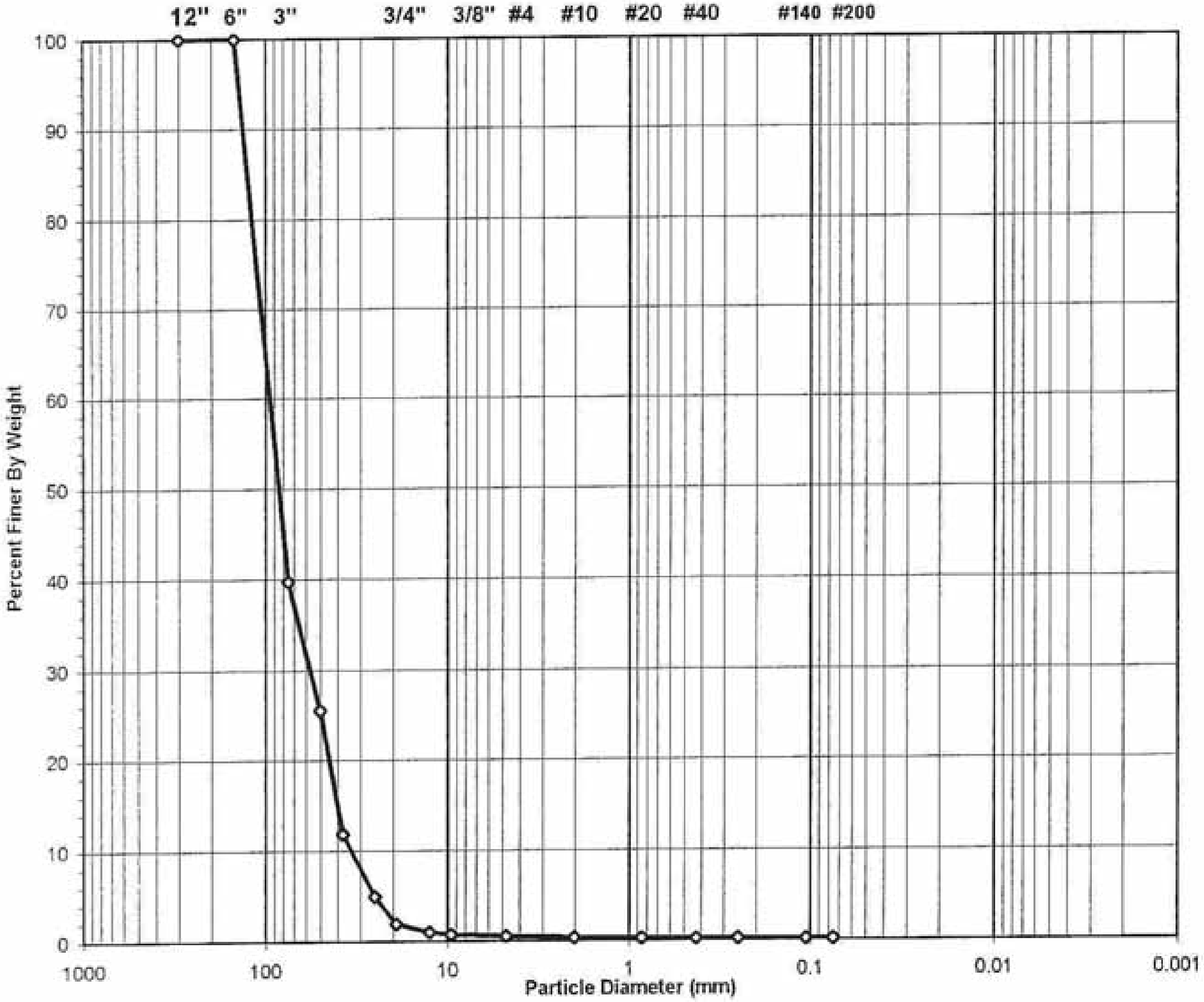
Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By YKB Date 2-23-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	100-103
Project No.	2006-060-01	Sample No.	S-11
Lab ID	2006-060-01-11	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		***HYDROMETER***
USCS	**gravel**	**sand**	**silt and clay**



USCS Symbol ***gp, ASSUMED***

USCS Classification ***POORLY GRADED GRAVEL***

Tested By PC Date 2/22/06 Checked By KYB Date 2-23-06

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	100-103
Project No.	2006-060-01	Sample No.	S-11
Lab ID	2006-060-01-11	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	950	Tare No.	872
Wgt.Tare + Wet Specimen (gm)	372.60	Wgt.Tare + Wet Specimen (gm)	983.40
Wgt.Tare + Dry Specimen (gm)	361.77	Wgt.Tare + Dry Specimen (gm)	974.10
Weight of Tare (gm)	102.82	Weight of Tare (gm)	110.55
Weight of Water (gm)	10.83	Weight of Water (gm)	9.30
Weight of Dry Soil (gm)	258.95	Weight of Dry Soil (gm)	863.55
Moisture Content (%)	**4.2**	**Moisture Content (%)**	**1.1**

Wet Weight -3/4" Sample (gm)	303	Weight of the Dry Specimen (gm)	258.95
Dry Weight - 3/4" Sample (gm)	290.8	Weight of minus #200 material (gm)	20.96
Wet Weight +3/4" Sample (gm)	15087.00	Weight of plus #200 material (gm)	237.99
Dry Weight + 3/4" Sample (gm)	14926.25		
Total Dry Weight Sample (gm)	15217.1	**J - Factor (Percent Finer than 3/4")**	**0.0191**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	9275.00		60.30	60.30	39.70	**39.70**
2"	50	2175.00	(*)	14.14	74.44	25.56	**25.56**
1 1/2"	37.5	2105.00		13.69	88.13	11.87	**11.87**
1"	25	1068.00		6.94	95.07	4.93	**4.93**
3/4"	19	464.00		3.02	98.09	1.91	**1.91**
1/2"	12.5	123.84		47.82	47.82	52.18	**1.00**
3/8"	9.5	37.88		14.63	62.45	37.55	**0.72**
#4	4.75	29.15		11.26	73.71	26.29	**0.50**
#10	2	21.22		8.19	81.90	18.10	**0.35**
#20	0.85	11.48	(**)	4.43	86.34	13.66	**0.26**
#40	0.425	6.01		2.32	88.66	11.34	**0.22**
#60	0.25	2.89		1.12	89.77	10.23	**0.20**
#140	0.106	4.10		1.58	91.36	8.64	**0.17**
#200	0.075	1.42		0.55	91.91	8.09	**0.15**
Pan	-	20.96		8.09	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By KB Date 2-23-06

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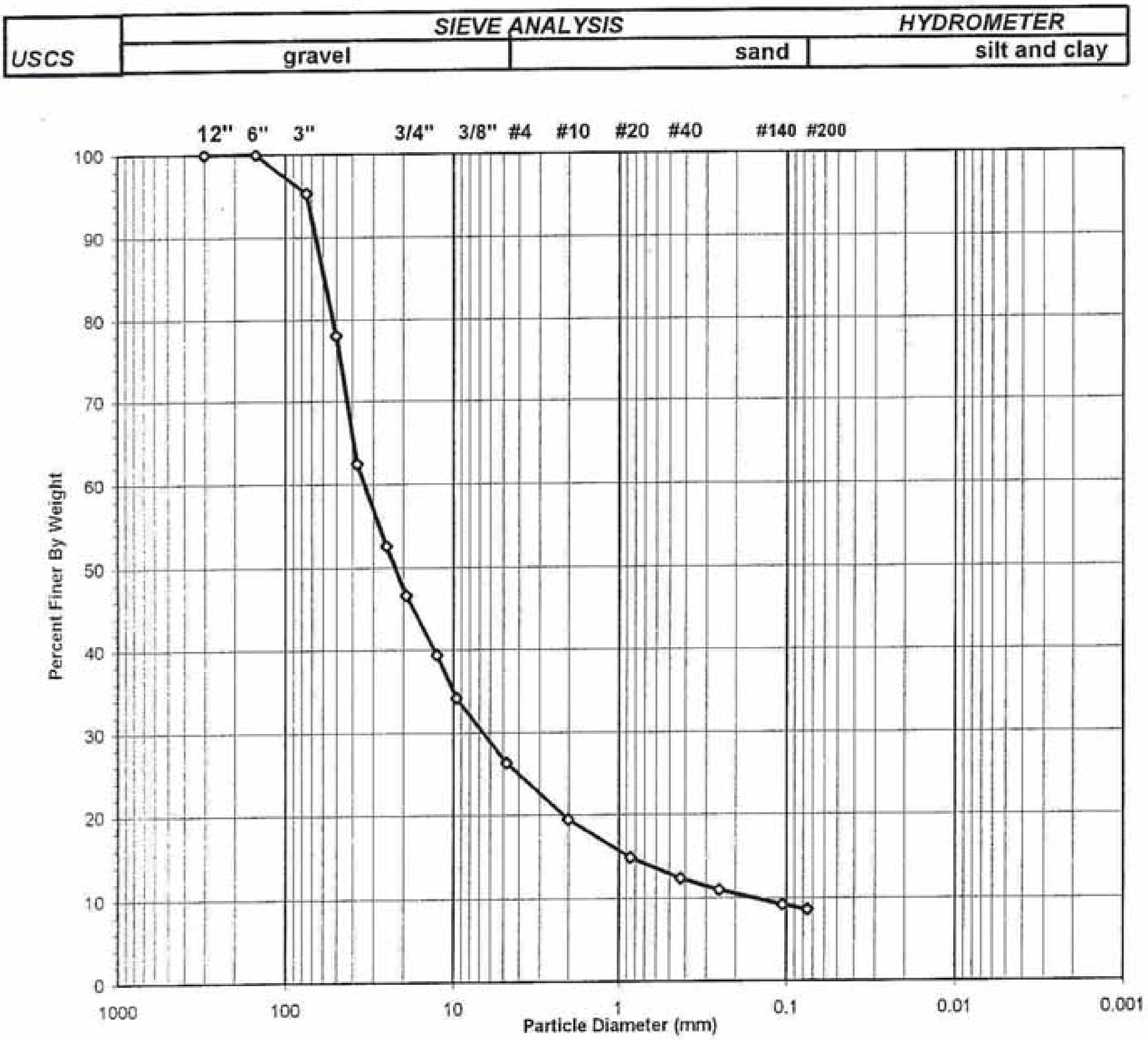
SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	103-105
Project No.	2006-060-01	Sample No.	S-12
Lab ID	2006-060-01-12	Soil Color	**REDDISH BROWN**



USCS Symbol ***GP-GM, TESTED***

USCS Classification ***POORLY GRADED GRAVEL WITH SILT AND SAND (NON-PLASTIC FINES)***

D60 =	33.9	CC =	8.1
D30 =	6.5	CU =	216.3
D10 =	0.2		

Tested By PC Date 2/22/06 Checked By KB Date 2-28-06

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	103-105
Project No.	2006-060-01	Sample No.	S-12
Lab ID	2006-060-01-12	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	658	Tare No.	615
Wgt.Tare + Wet Specimen (gm)	1333.80	Wgt.Tare + Wet Specimen (gm)	591.33
Wgt.Tare + Dry Specimen (gm)	1273.90	Wgt.Tare + Dry Specimen (gm)	581.89
Weight of Tare (gm)	97.61	Weight of Tare (gm)	84.25
Weight of Water (gm)	59.90	Weight of Water (gm)	9.44
Weight of Dry Soil (gm)	1176.29	Weight of Dry Soil (gm)	497.64
Moisture Content (%)	**5.1**	**Moisture Content (%)**	**1.9**

Wet Weight -3/4" Sample (gm)	15756	Weight of the Dry Specimen (gm)	1176.29
Dry Weight - 3/4" Sample (gm)	14992.5	Weight of minus #200 material (gm)	215.70
Wet Weight +3/4" Sample (gm)	17482.00	Weight of plus #200 material (gm)	960.59
Dry Weight + 3/4" Sample (gm)	17156.55		
Total Dry Weight Sample (gm)	32149.1	**J - Factor (Percent Finer than 3/4")**	**0.4663**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	1534.00		4.68	4.68	95.32	**95.32**
2"	50	5663.00	(*)	17.29	21.97	78.03	**78.03**
1 1/2"	37.5	5088.00		15.53	37.50	62.50	**62.50**
1"	25	3257.00		9.94	47.44	52.56	**52.56**
3/4"	19	1940.00		5.92	53.37	46.63	**46.63**
1/2"	12.5	183.50		15.60	15.60	84.40	**39.36**
3/8"	9.5	129.55		11.01	26.61	73.39	**34.22**
#4	4.75	197.94		16.83	43.44	56.56	**26.38**
#10	2	173.93		14.79	58.23	41.77	**19.48**
#20	0.85	114.81	(**)	9.76	67.99	32.01	**14.93**
#40	0.425	64.90		5.52	73.50	26.50	**12.36**
#60	0.25	34.90		2.97	76.47	23.53	**10.97**
#140	0.106	44.95		3.82	80.29	19.71	**9.19**
#200	0.075	16.11		1.37	81.66	18.34	**8.55**
Pan	-	215.70		18.34	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By KB Date 2-28-06

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ASTM D 4318-00 (SOP - S4)

Client	PAUL C. RIZZO	Boring No.	TS-1
Client Reference	TAUM SAUK 06-3551	Depth (ft)	103-105
Project No.	2006-060-01	Sample No.	S-12
Lab ID	2006-060-01-12	Visual Description	**BROWN SILT** (Minus No. 40 sieve material, Airdried)

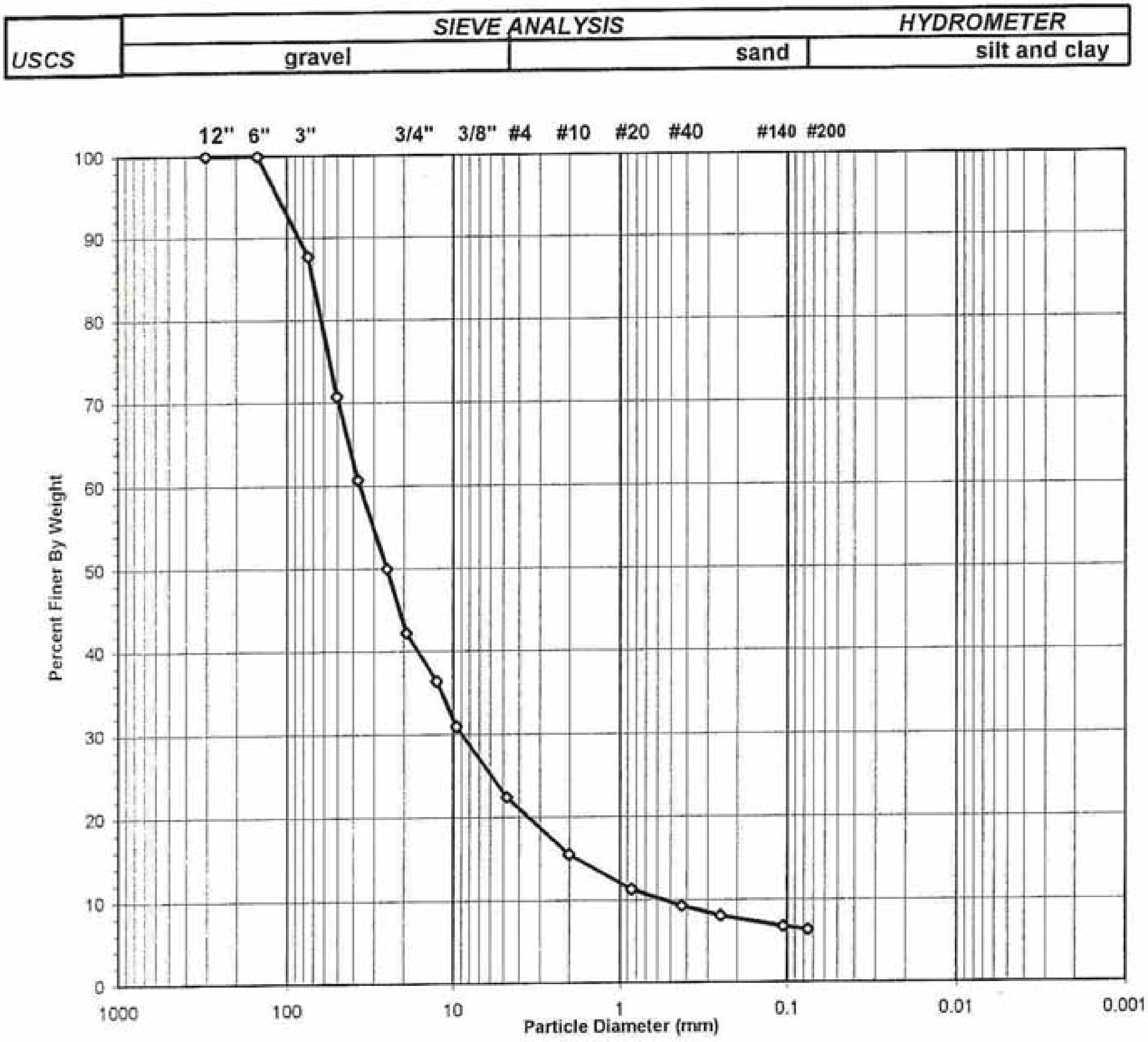
NON - PLASTIC MATERIAL

Tested By DB *Date* 2/24/06 *Checked By* YKB *Date* 2-27-06

BORING TS-2

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	0-10
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-13	Soil Color	**REDDISH BROWN**



USCS Symbol	*GP-GM, TESTED*	D60 =	36.5	CC =	3.9
USCS Classification	*POORLY GRADED GRAVEL WITH SILT AND SAND (NON-PLASTIC FINES)*	D30 =	8.8	CU =	67.3
		D10 =	0.5		

Tested By PC Date 2/24/06 Checked By KB Date 2-28-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	0-10
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-13	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	951	Tare No.	548
Wgt.Tare + Wet Specimen (gm)	1191.70	Wgt.Tare + Wet Specimen (gm)	923.30
Wgt.Tare + Dry Specimen (gm)	1105.30	Wgt.Tare + Dry Specimen (gm)	899.20
Weight of Tare (gm)	102.74	Weight of Tare (gm)	80.68
Weight of Water (gm)	86.40	Weight of Water (gm)	24.10
Weight of Dry Soil (gm)	1002.56	Weight of Dry Soil (gm)	818.52
Moisture Content (%)	8.6	**Moisture Content (%)**	2.9

Wet Weight -3/4" Sample (gm)	21120	Weight of the Dry Specimen (gm)	1002.56
Dry Weight - 3/4" Sample (gm)	19444.3	Weight of minus #200 material (gm)	149.71
Wet Weight +3/4" Sample (gm)	27400.00	Weight of plus #200 material (gm)	852.85
Dry Weight + 3/4" Sample (gm)	26616.33		
Total Dry Weight Sample (gm)	46060.6	**J - Factor (Percent Finer than 3/4")**	**0.4221**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	5832.00		12.30	12.30	87.70	**87.70**
2"	50	8044.00	(*)	16.96	29.26	70.74	**70.74**
1 1/2"	37.5	4741.00		10.00	39.26	60.74	**60.74**
1"	25	5098.00		10.75	50.01	49.99	**49.99**
3/4"	19	3685.00		7.77	57.79	42.21	**42.21**
1/2"	12.5	140.58		14.02	14.02	85.98	**36.30**
3/8"	9.5	127.43		12.71	26.73	73.27	**30.93**
#4	4.75	201.40		20.09	46.82	53.18	**22.45**
#10	2	165.66		16.52	63.34	36.66	**15.47**
#20	0.85	98.28	(**)	9.80	73.15	26.85	**11.34**
#40	0.425	48.90		4.88	78.03	21.97	**9.28**
#60	0.25	28.55		2.85	80.87	19.13	**8.07**
#140	0.106	32.75		3.27	84.14	15.86	**6.70**
#200	0.075	9.30		0.93	85.07	14.93	**6.30**
Pan	-	149.71		14.93	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/24/06 Checked By KB Date 2-28-06

geotechnics
INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	0-10
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-13	Soil Description	**REDDISH BROWN LEAN CLAY**

Note: ***The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.*** (Minus No. 40 sieve material, Airdried)

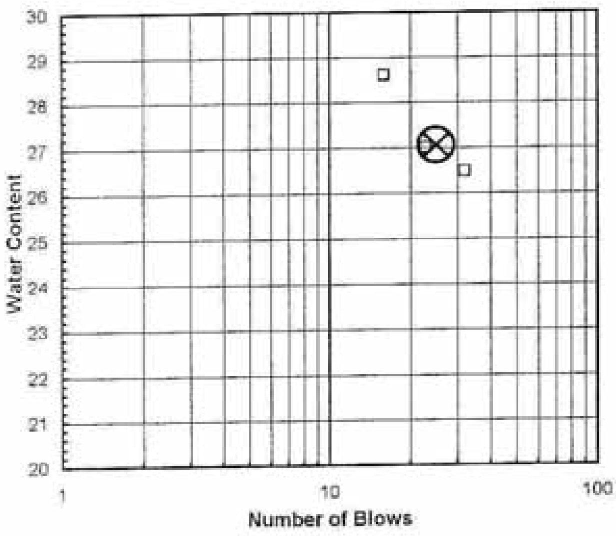
Liquid Limit Test	1	2	3	
				M
Tare Number	183	225	238	U
Wt. of Tare & WS (gm)	41.41	39.80	41.64	L
Wt. of Tare & DS (gm)	37.11	35.50	37.01	T
Wt. of Tare (gm)	20.87	19.57	20.83	I
Wt. of Water (gm)	4.3	4.3	4.6	P
Wt. of DS (gm)	16.2	15.9	16.2	O
				I
Moisture Content (%)	**26.5**	**27.0**	**28.6**	N
Number of Blows	**32**	**23**	**16**	T

Plastic Limit Test	1	2	Range
Tare Number	248	249	
Wt. of Tare & WS (gm)	25.64	26.39	
Wt. of Tare & DS (gm)	24.69	25.60	
Wt. of Tare (gm)	19.21	20.97	
Wt. of Water (gm)	0.9	0.8	
Wt. of DS (gm)	5.5	4.6	
Moisture Content (%)	**17.3**	**17.1**	**0.3**

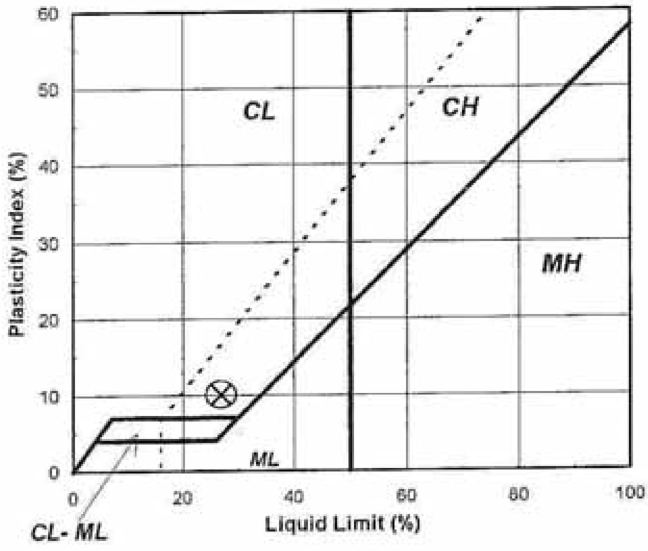
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**27**
Plastic Limit (%)	**17**
Plasticity Index (%)	**10**
USCS Symbol	**CL**

Flow Curve



Plasticity Chart



Tested By *TO* *Date* *2/24/06* *Checked By* YKB *Date* 2-27-06

page 1 of 1 **DCN:** CT-S4B **DATE:** 10/8/01 **REVISION:** 2

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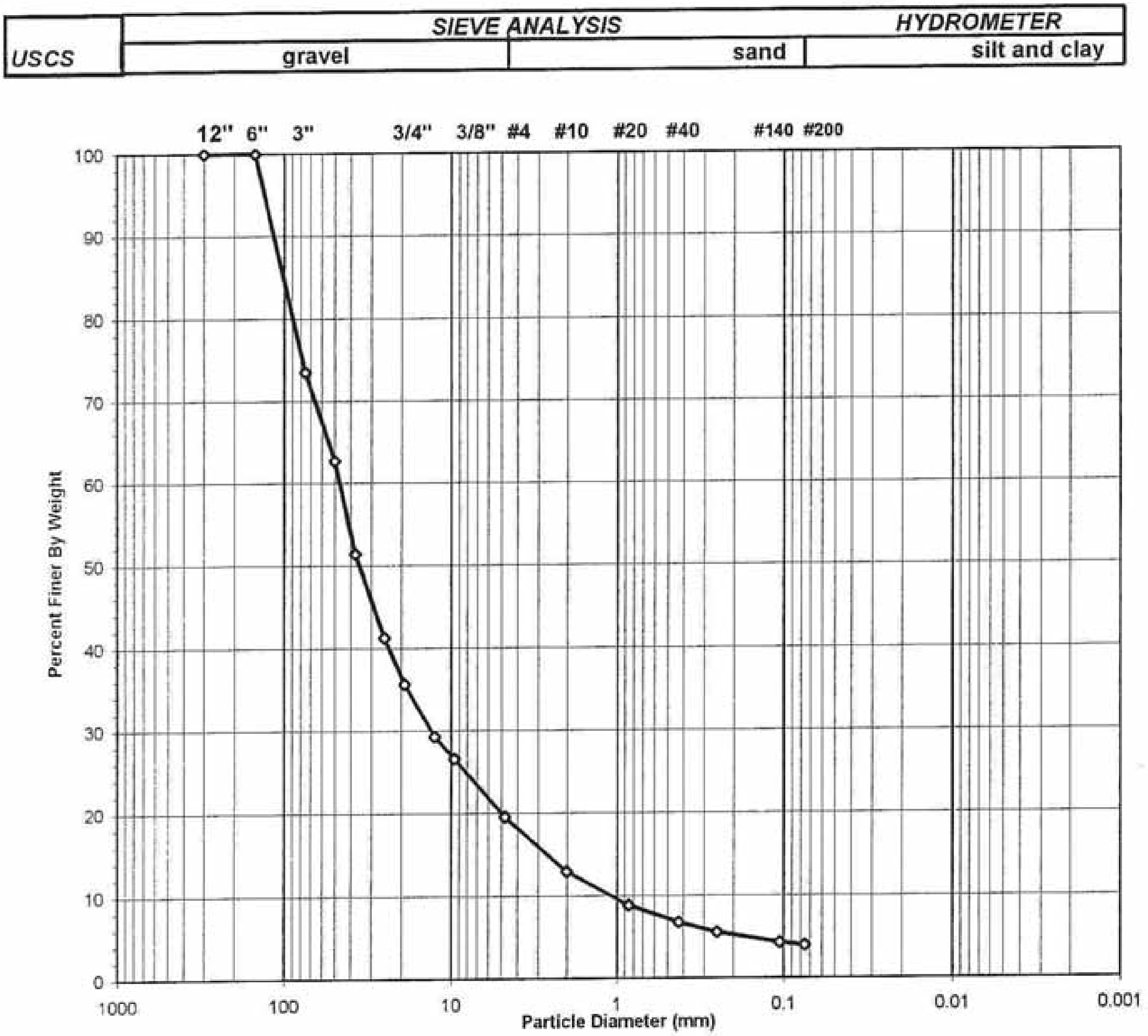
SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	10-20
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-14	Soil Color	**REDDISH BROWN**



USCS Symbol	***gp, ASSUMED***	**D60 =**	**46.7**	**CC =**	**3.4**
USCS Classification	***POORLY GRADED GRAVEL WITH SAND***	**D30 =**	**13.1**	**CU =**	**43.0**
		D10 =	**1.1**		

Tested By PC Date 2/24/06 Checked By KYB Date 2-24-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	10-20
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-14	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	964	Tare No.	617
Wgt.Tare + Wet Specimen (gm)	1406.30	Wgt.Tare + Wet Specimen (gm)	986.70
Wgt.Tare + Dry Specimen (gm)	1314.00	Wgt.Tare + Dry Specimen (gm)	973.70
Weight of Tare (gm)	102.92	Weight of Tare (gm)	83.94
Weight of Water (gm)	92.30	Weight of Water (gm)	13.00
Weight of Dry Soil (gm)	1211.08	Weight of Dry Soil (gm)	889.76
Moisture Content (%)	**7.6**	**Moisture Content (%)**	**1.5**

Wet Weight -3/4" Sample (gm)	18684	Weight of the Dry Specimen (gm)	1211.08
Dry Weight - 3/4" Sample (gm)	17360.9	Weight of minus #200 material (gm)	135.30
Wet Weight +3/4" Sample (gm)	31737.00	Weight of plus #200 material (gm)	1075.78
Dry Weight + 3/4" Sample (gm)	31279.98		
Total Dry Weight Sample (gm)	48640.9	**J - Factor (Percent Finer than 3/4")**	**0.3569**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	13079.00		26.50	26.50	73.50	**73.50**
2"	50	5342.00	(*)	10.82	37.33	62.67	**62.67**
1 1/2"	37.5	5571.00		11.29	48.61	51.39	**51.39**
1"	25	4989.00		10.11	58.72	41.28	**41.28**
3/4"	19	2756.00		5.58	64.31	35.69	**35.69**
1/2"	12.5	217.72		17.98	17.98	82.02	**29.28**
3/8"	9.5	90.49		7.47	25.45	74.55	**26.61**
#4	4.75	239.71		19.79	45.24	54.76	**19.54**
#10	2	225.80		18.64	63.89	36.11	**12.89**
#20	0.85	137.62	(**)	11.36	75.25	24.75	**8.83**
#40	0.425	69.87		5.77	81.02	18.98	**6.77**
#60	0.25	39.13		3.23	84.25	15.75	**5.62**
#140	0.106	44.08		3.64	87.89	12.11	**4.32**
#200	0.075	11.36		0.94	88.83	11.17	**3.99**
Pan	-	135.30		11.17	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

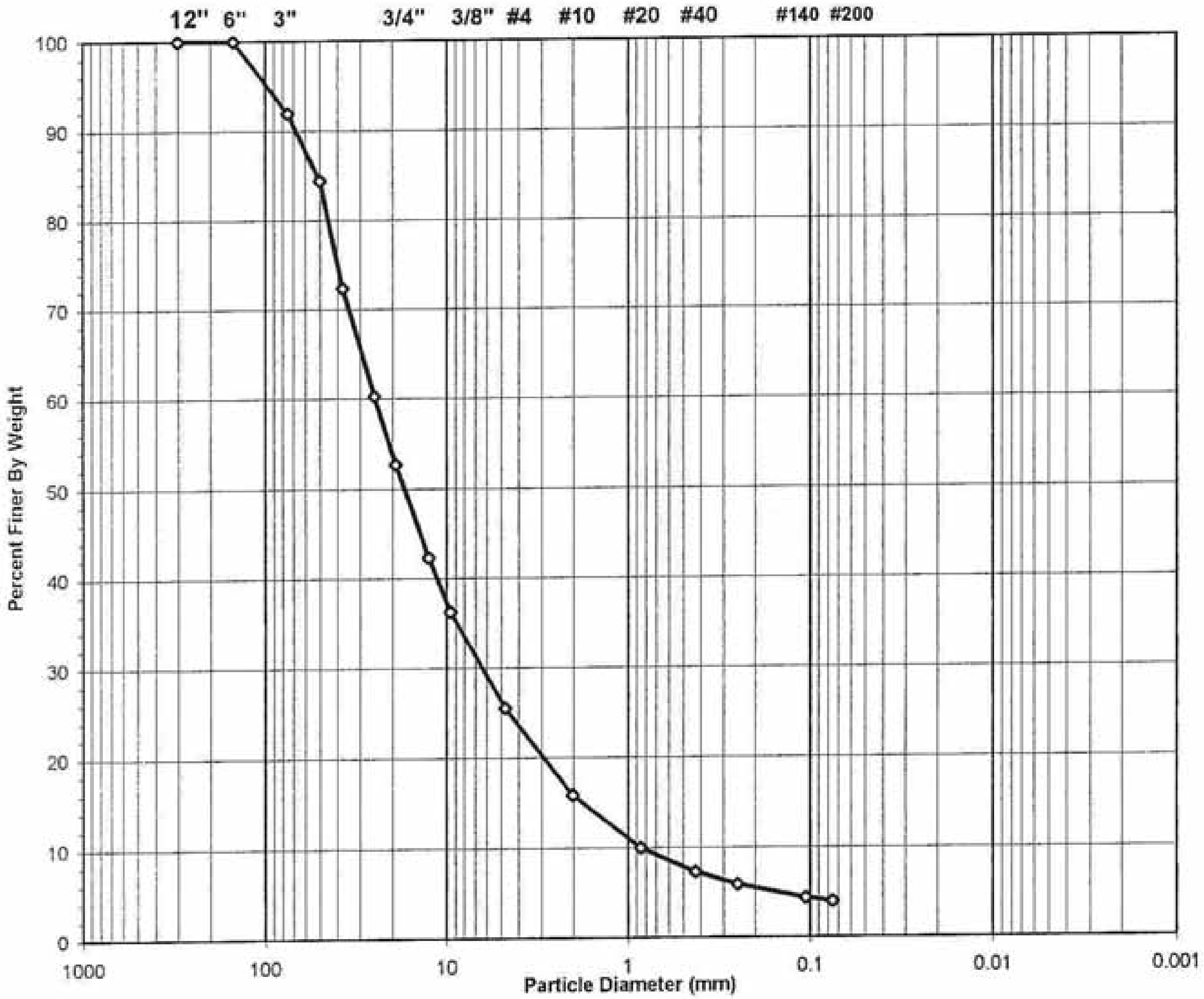
Tested By PC Date 2/24/06 Checked By KR Date 2-24-06

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-15	Soil Color	**REDDISH BROWN**

USCS	***SIEVE ANALYSIS***		***HYDROMETER***
	gravel	**sand**	**silt and clay**



USCS Symbol	***gw, ASSUMED***	**D60 =**	**24.7**	**CC =**	**1.9**
USCS Classification	***WELL-GRADED GRAVEL WITH SAND***	**D30 =**	**6.3**	**CU =**	**28.9**
		D10 =	**0.9**		

Tested By PC Date 2/24/06 Checked By KB Date 2-24-06

page 1 of 2 **DCN: CT-S3A DATE 6-25-98 REVISION 2** *C:\MSOFFICE\Excel\PrintQ\[U312.xls]Sheet1*

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-15	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	665	Tare No.	883
Wgt.Tare + Wet Specimen (gm)	1578.10	Wgt.Tare + Wet Specimen (gm)	1223.90
Wgt.Tare + Dry Specimen (gm)	1462.80	Wgt.Tare + Dry Specimen (gm)	1201.10
Weight of Tare (gm)	95.86	Weight of Tare (gm)	110.38
Weight of Water (gm)	115.30	Weight of Water (gm)	22.80
Weight of Dry Soil (gm)	1366.94	Weight of Dry Soil (gm)	1090.72
Moisture Content (%)	**8.4**	**Moisture Content (%)**	**2.1**

Wet Weight -3/4" Sample (gm)	26121	Weight of the Dry Specimen (gm)	1366.94
Dry Weight - 3/4" Sample (gm)	24089.1	Weight of minus #200 material (gm)	103.46
Wet Weight +3/4" Sample (gm)	22093.00	Weight of plus #200 material (gm)	1263.48
Dry Weight + 3/4" Sample (gm)	21640.63		
Total Dry Weight Sample (gm)	45729.7	**J - Factor (Percent Finer than 3/4")**	**0.5268**

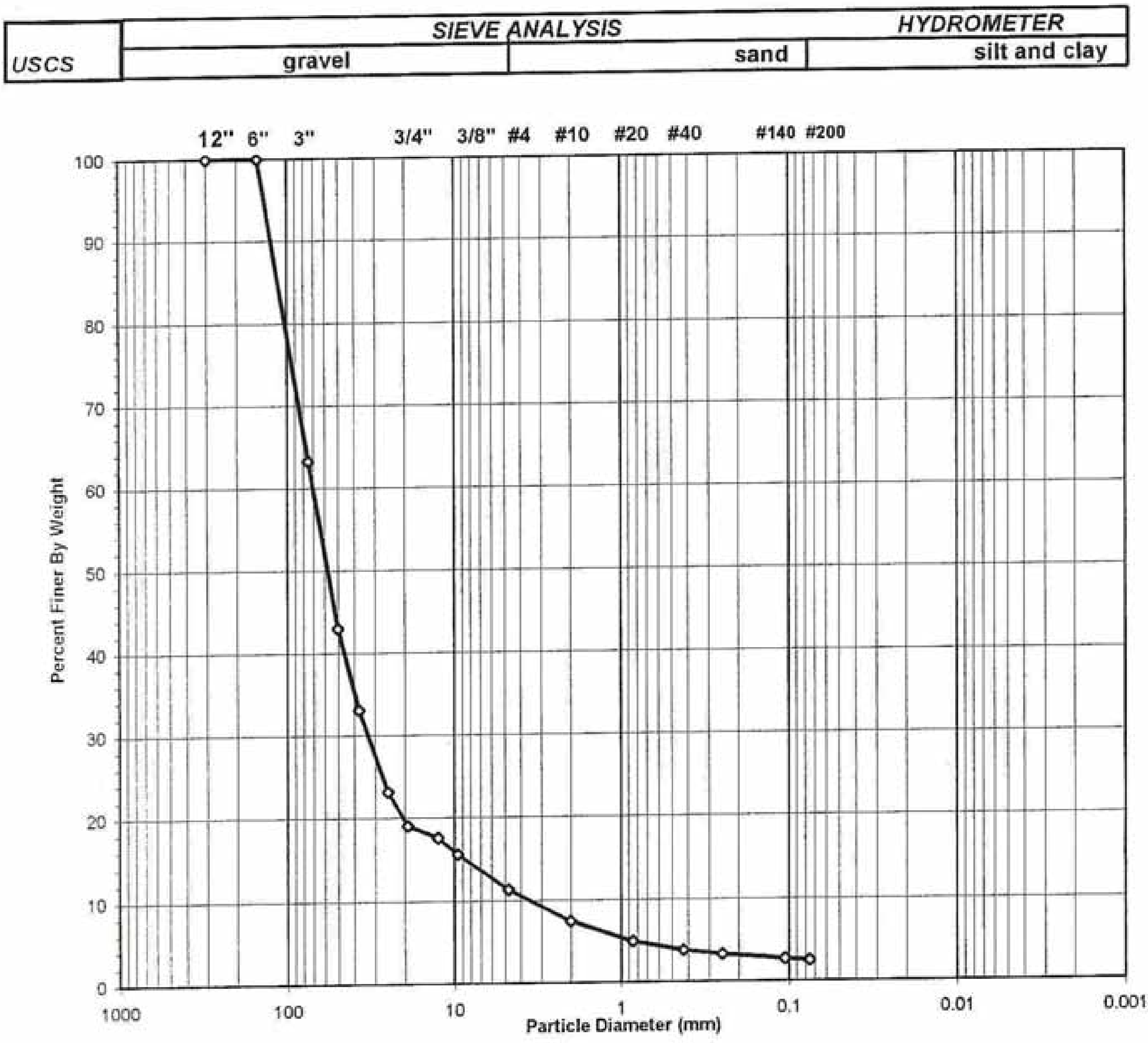
Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	3759.00		8.05	8.05	91.95	**91.95**
2"	50	3528.00	(*)	7.56	15.61	84.39	**84.39**
1 1/2"	37.5	5620.00		12.04	27.65	72.35	**72.35**
1"	25	5626.00		12.05	39.70	60.30	**60.30**
3/4"	19	3560.00		7.63	47.32	52.68	**52.68**
1/2"	12.5	269.14		19.69	19.69	80.31	**42.31**
3/8"	9.5	157.30		11.51	31.20	68.80	**36.24**
#4	4.75	278.31		20.36	51.56	48.44	**25.52**
#10	2	251.36		18.39	69.95	30.05	**15.83**
#20	0.85	152.42	(**)	11.15	81.10	18.90	**9.96**
#40	0.425	68.58		5.02	86.11	13.89	**7.32**
#60	0.25	35.79		2.62	88.73	11.27	**5.94**
#140	0.106	39.71		2.91	91.64	8.36	**4.41**
#200	0.075	10.87		0.80	92.43	7.57	**3.99**
Pan	-	103.46		7.57	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/24/06 Checked By YAB Date 2-24-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	30-40
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-16	Soil Color	REDDISH BROWN



USCS Symbol	*gp, ASSUMED*	D60 =	70.2	CC =	4.4
USCS Classification	*POORLY GRADED GRAVEL*	D30 =	33.1	CU =	19.8
		D10 =	3.5		

Tested By PC Date 2/24/06 Checked By KB Date 2-27-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	30-40
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-16	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	700	Tare No.	553
Wgt.Tare + Wet Specimen (gm)	1242.80	Wgt.Tare + Wet Specimen (gm)	440.70
Wgt.Tare + Dry Specimen (gm)	1195.20	Wgt.Tare + Dry Specimen (gm)	436.45
Weight of Tare (gm)	98.36	Weight of Tare (gm)	84.33
Weight of Water (gm)	47.60	Weight of Water (gm)	4.25
Weight of Dry Soil (gm)	1096.84	Weight of Dry Soil (gm)	352.12
Moisture Content (%)	**4.3**	**Moisture Content (%)**	**1.2**

Wet Weight -3/4" Sample (gm)	8814	Weight of the Dry Specimen (gm)	1096.84
Dry Weight - 3/4" Sample (gm)	8447.4	Weight of minus #200 material (gm)	141.02
Wet Weight +3/4" Sample (gm)	36416.00	Weight of plus #200 material (gm)	955.82
Dry Weight + 3/4" Sample (gm)	35981.71		
Total Dry Weight Sample (gm)	44429.1	**J - Factor (Percent Finer than 3/4")**	**0.1901**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	16503.00		36.70	36.70	63.30	**63.30**
2"	50	9144.00	(*)	20.34	57.04	42.96	**42.96**
1 1/2"	37.5	4448.00		9.89	66.93	33.07	**33.07**
1"	25	4451.00		9.90	76.83	23.17	**23.17**
3/4"	19	1870.00		4.16	80.99	19.01	**19.01**
1/2"	12.5	82.16		7.49	7.49	92.51	**17.59**
3/8"	9.5	115.18		10.50	17.99	82.01	**15.59**
#4	4.75	247.87		22.60	40.59	59.41	**11.30**
#10	2	220.73		20.12	60.71	39.29	**7.47**
#20	0.85	145.28	(**)	13.25	73.96	26.04	**4.95**
#40	0.425	66.35		6.05	80.01	19.99	**3.80**
#60	0.25	29.77		2.71	82.72	17.28	**3.28**
#140	0.106	35.90		3.27	86.00	14.00	**2.66**
#200	0.075	12.58		1.15	87.14	12.86	**2.44**
Pan	-	141.02		12.86	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/24/06 Checked By KYB Date 2-27-06

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INTEGRITY IN TESTING

ATTERBERG LIMIT

ASTM D 4318-00 (SOP - S4)

Client PAUL C. RIZZO
Client Reference TAUM SAUK 06-3551
Project No. 2006-060-01
Lab ID 2006-060-01-16

Boring No. TS-2
Depth (ft) 30-40
Sample No. S-4
Visual Description **BROWN SILT**
(Minus No. 40 sieve material, Airdried)

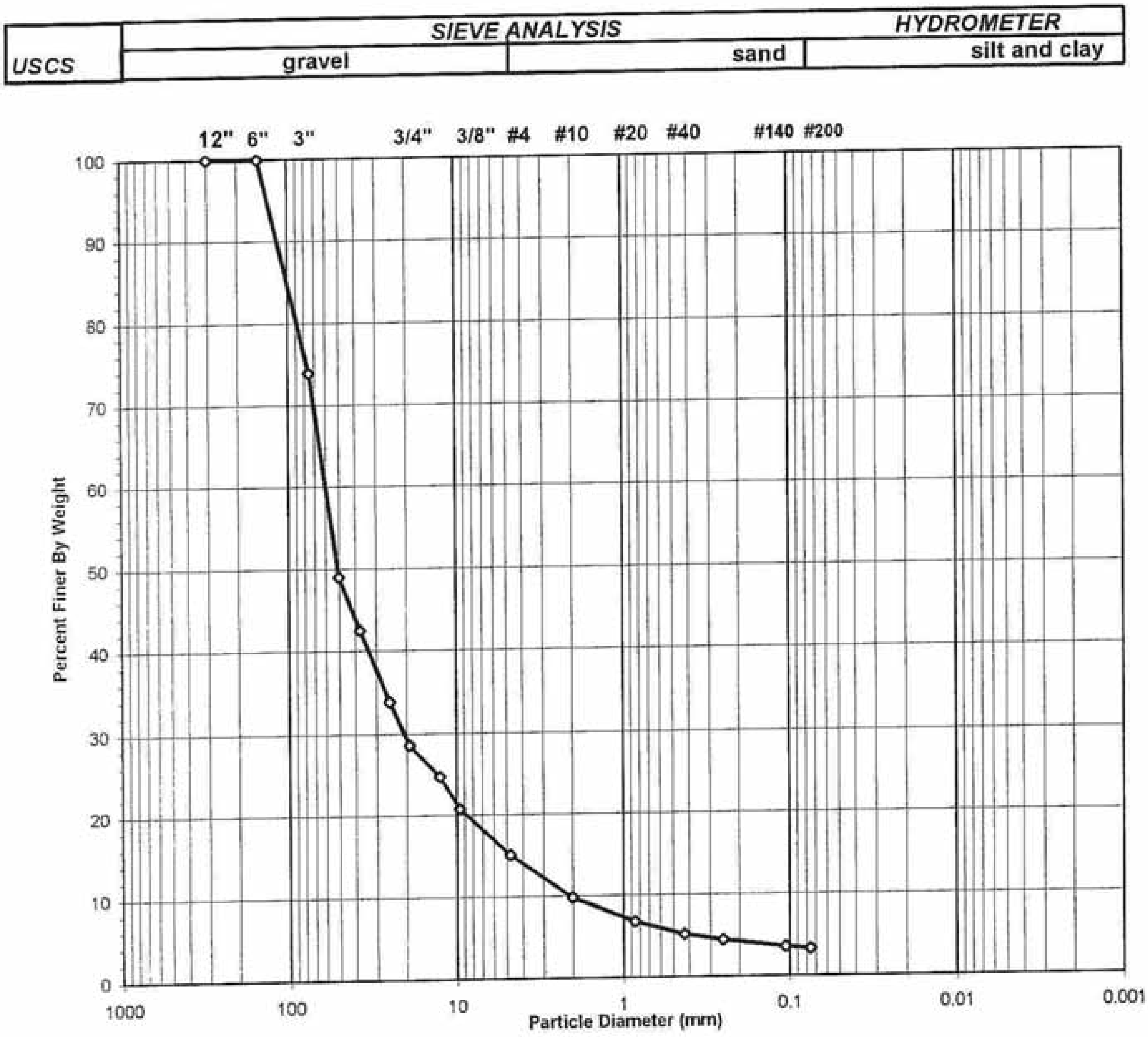
NON - PLASTIC MATERIAL

Tested By TO *Date* 3/5/06 *Checked By* KB *Date* 3-6-06

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	40-50
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-17	Soil Color	REDDISH BROWN



USCS Symbol	*gp, ASSUMED*	D60 =	59.9	CC =	3.4
USCS Classification	*POORLY GRADED GRAVEL*	D30 =	20.4	CU =	28.8
		D10 =	2.1		

Tested By PC Date 2/24/06 Checked By KYB Date 2-24-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	40-50
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-17	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	846	Tare No.	599
Wgt.Tare + Wet Specimen (gm)	1219.50	Wgt.Tare + Wet Specimen (gm)	756.80
Wgt.Tare + Dry Specimen (gm)	1137.40	Wgt.Tare + Dry Specimen (gm)	727.70
Weight of Tare (gm)	100.49	Weight of Tare (gm)	84.15
Weight of Water (gm)	82.10	Weight of Water (gm)	29.10
Weight of Dry Soil (gm)	1036.91	Weight of Dry Soil (gm)	643.55
Moisture Content (%)	**7.9**	**Moisture Content (%)**	**4.5**

Wet Weight -3/4" Sample (gm)	11848	Weight of the Dry Specimen (gm)	1036.91
Dry Weight - 3/4" Sample (gm)	10978.7	Weight of minus #200 material (gm)	117.57
Wet Weight +3/4" Sample (gm)	28615.00	Weight of plus #200 material (gm)	919.34
Dry Weight + 3/4" Sample (gm)	27377.07		
Total Dry Weight Sample (gm)	38355.8	**J - Factor (Percent Finer than 3/4")**	**0.2862**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	10490.00		26.17	26.17	73.83	**73.83**
2"	50	9974.00	(*)	24.88	51.04	48.96	**48.96**
1 1/2"	37.5	2613.00		6.52	57.56	42.44	**42.44**
1"	25	3441.00		8.58	66.15	33.85	**33.85**
3/4"	19	2097.00		5.23	71.38	28.62	**28.62**
1/2"	12.5	139.10		13.41	13.41	86.59	**24.78**
3/8"	9.5	145.50		14.03	27.45	72.55	**20.77**
#4	4.75	205.41		19.81	47.26	52.74	**15.10**
#10	2	193.08		18.62	65.88	34.12	**9.77**
#20	0.85	111.07	(**)	10.71	76.59	23.41	**6.70**
#40	0.425	55.96		5.40	81.99	18.01	**5.16**
#60	0.25	26.69		2.57	84.56	15.44	**4.42**
#140	0.106	31.79		3.07	87.63	12.37	**3.54**
#200	0.075	10.74		1.04	88.66	11.34	**3.25**
Pan	-	117.57		11.34	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

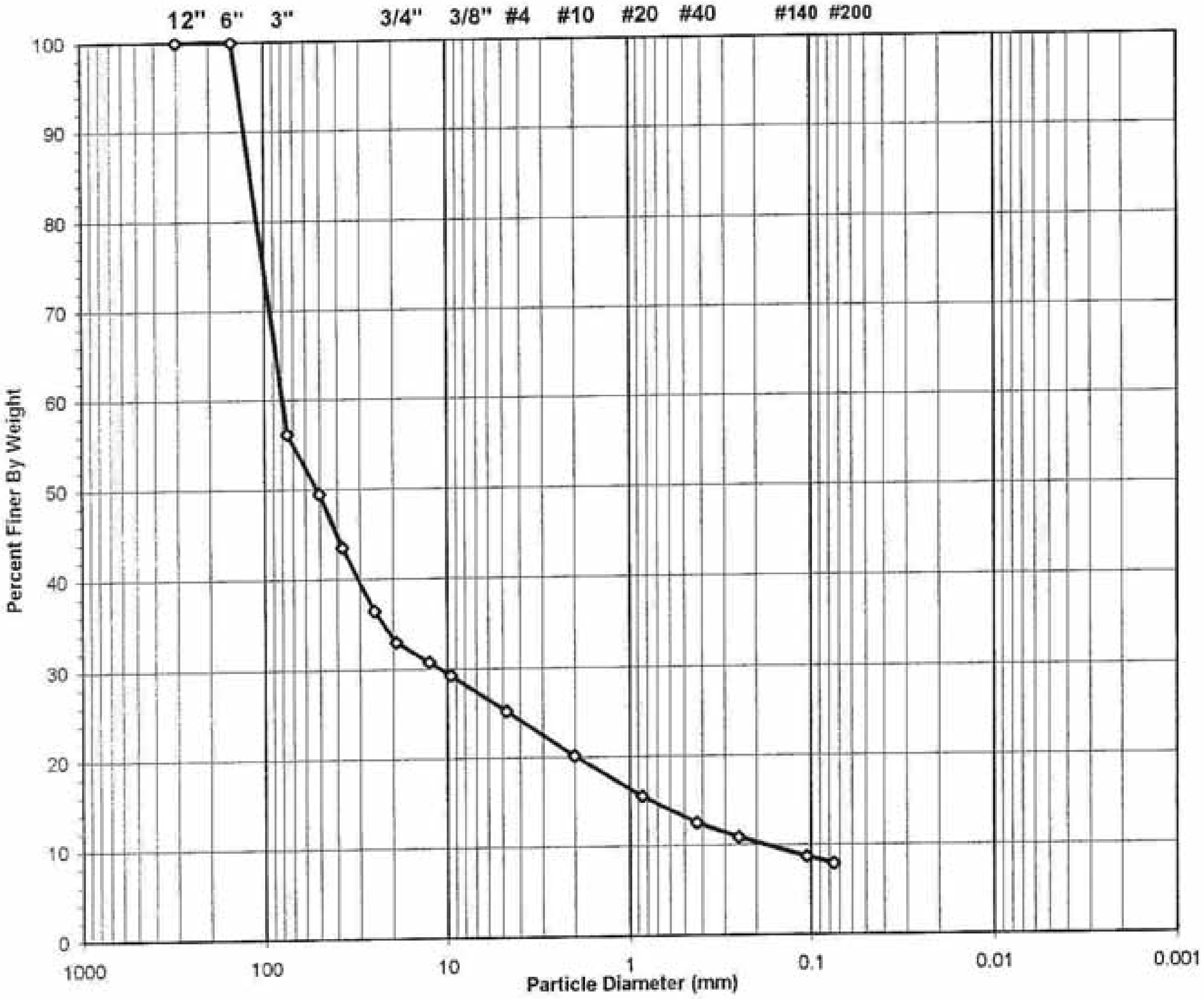
Tested By PC Date 2/24/06 Checked By YkB Date 2-24-06

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-60
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-18	Soil Color	**REDDISH BROWN**

USCS	*SIEVE ANALYSIS*		*HYDROMETER*
	gravel	sand	silt and clay



USCS Symbol *gp-gm, ASSUMED*

USCS Classification *POORLY GRADED GRAVEL WITH SILT AND SAND*

Tested By PC Date 2/24/06 Checked By Date 2-27-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-60
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-18	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	663	Tare No.	607
Wgt.Tare + Wet Specimen (gm)	1259.20	Wgt.Tare + Wet Specimen (gm)	543.41
Wgt.Tare + Dry Specimen (gm)	1184.00	Wgt.Tare + Dry Specimen (gm)	533.30
Weight of Tare (gm)	98.31	Weight of Tare (gm)	82.96
Weight of Water (gm)	75.20	Weight of Water (gm)	10.11
Weight of Dry Soil (gm)	1085.69	Weight of Dry Soil (gm)	450.34
Moisture Content (%)	**6.9**	**Moisture Content (%)**	**2.2**

Wet Weight -3/4" Sample (gm)	16549	Weight of the Dry Specimen (gm)	1085.69
Dry Weight - 3/4" Sample (gm)	15477.0	Weight of minus #200 material (gm)	259.10
Wet Weight +3/4" Sample (gm)	32110.00	Weight of plus #200 material (gm)	826.59
Dry Weight + 3/4" Sample (gm)	31404.97		
Total Dry Weight Sample (gm)	46882.0	**J - Factor (Percent Finer than 3/4")**	**0.3301**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	21017.00		43.85	43.85	56.15	**56.15**
2"	50	3210.00	(*)	6.70	50.54	49.46	**49.46**
1 1/2"	37.5	2880.00		6.01	56.55	43.45	**43.45**
1"	25	3363.00		7.02	63.57	36.43	**36.43**
3/4"	19	1640.00		3.42	66.99	33.01	**33.01**
1/2"	12.5	73.26		6.75	6.75	93.25	**30.79**
3/8"	9.5	50.66		4.67	11.41	88.59	**29.24**
#4	4.75	132.53		12.21	23.62	76.38	**25.21**
#10	2	166.05		15.29	38.92	61.08	**20.17**
#20	0.85	150.98	(**)	13.91	52.82	47.18	**15.57**
#40	0.425	99.91		9.20	62.02	37.98	**12.54**
#60	0.25	55.43		5.11	67.13	32.87	**10.85**
#140	0.106	72.66		6.69	73.82	26.18	**8.64**
#200	0.075	25.11		2.31	76.13	23.87	**7.88**
Pan	-	259.10		23.87	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/24/06 Checked By KVB Date 2-27-06

geotechnics
INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-60
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-18	Soil Description	**BROWN SILT**

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Airdried)

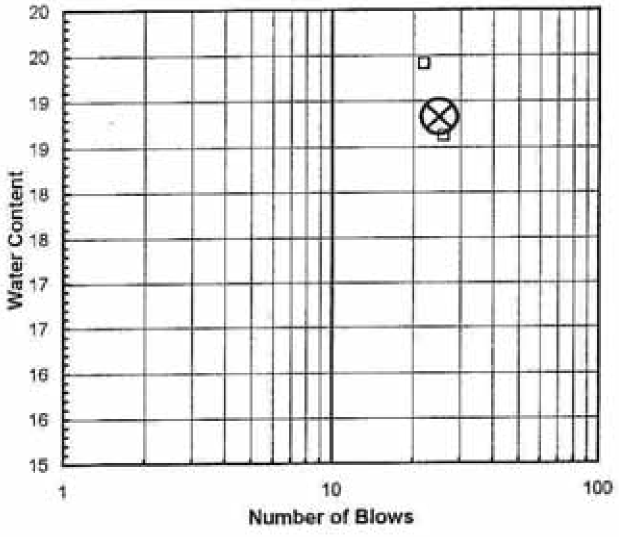
Liquid Limit Test	1	2	3	
				M
Tare Number	2289	2314	2305	U
Wt. of Tare & WS (gm)	44.70	43.23	42.60	L
Wt. of Tare & DS (gm)	40.89	39.17	38.89	T
Wt. of Tare (gm)	20.43	18.25	20.95	I
Wt. of Water (gm)	3.8	4.1	3.7	P
Wt. of DS (gm)	20.5	20.9	17.9	O
				I
Moisture Content (%)	**18.6**	**19.4**	**20.7**	N
Number of Blows	**26**	**22**	**15**	T

Plastic Limit Test	1	2	Range
Tare Number	119	2298	
Wt. of Tare & WS (gm)	23.72	24.50	
Wt. of Tare & DS (gm)	22.90	23.60	
Wt. of Tare (gm)	17.69	17.92	
Wt. of Water (gm)	0.8	0.9	
Wt. of DS (gm)	5.2	5.7	
Moisture Content (%)	**15.7**	**15.8**	**-0.1**

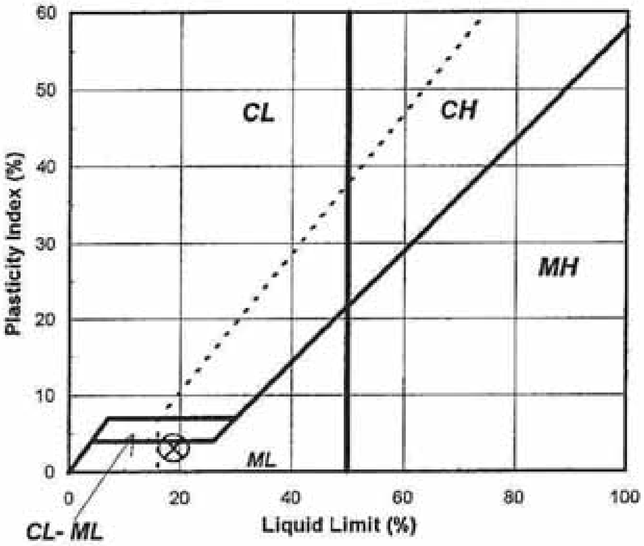
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**19**
Plastic Limit (%)	**16**
Plasticity Index (%)	**3**
USCS Symbol	**ML**

Flow Curve



Plasticity Chart



Tested By TO *Date* 3/5/06 *Checked By* KB *Date* 3-6-06

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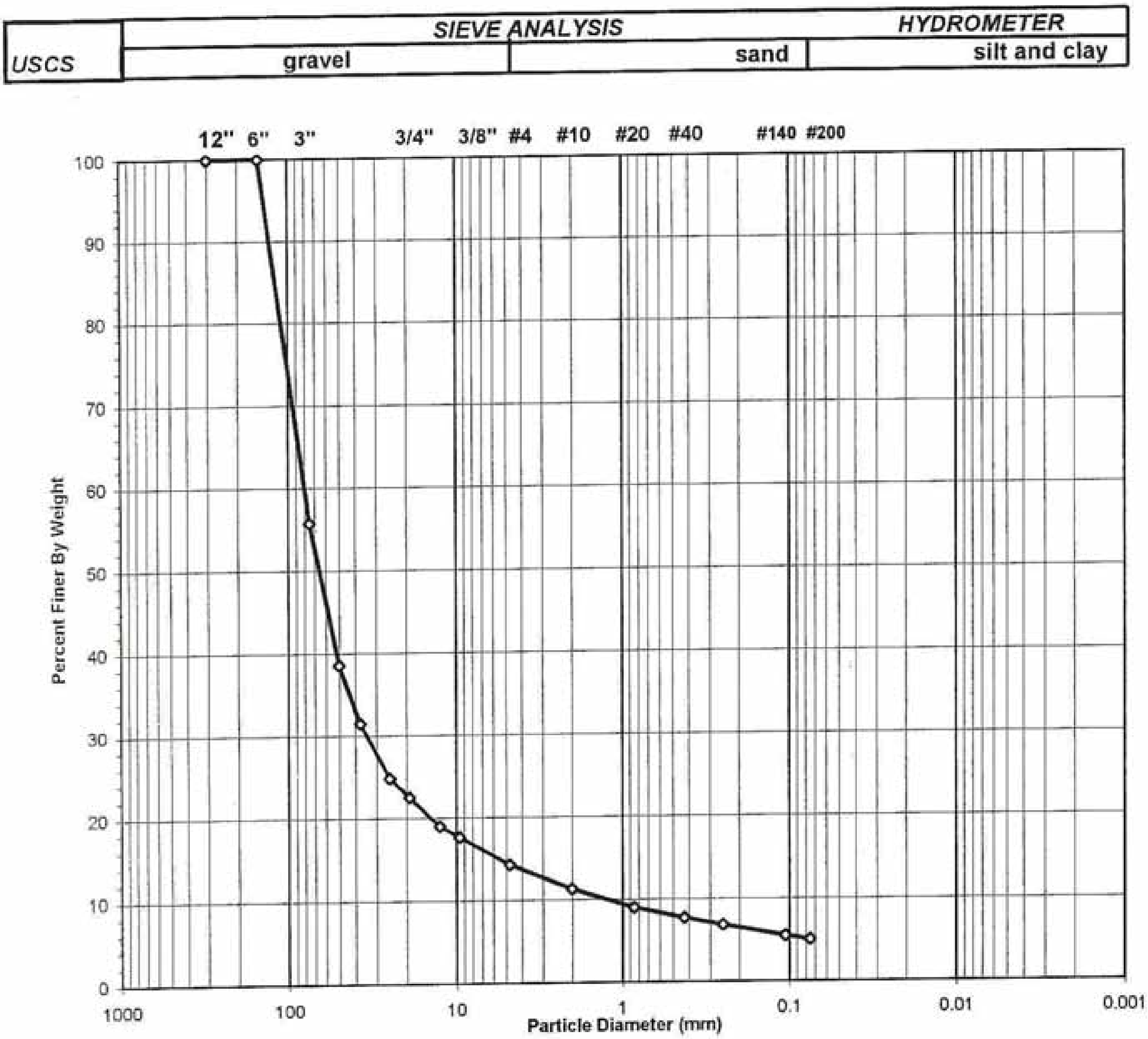
SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	60-70
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-19	Soil Color	**REDDISH BROWN**



USCS Symbol ***GP-GM, TESTED***

USCS Classification ***POORLY GRADED GRAVEL WITH SILT (NON-PLASTIC FINES)***

Tested By JP Date 2/27/06 Checked By YKB Date 3-1-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	60-70
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-19	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	952	Tare No.	578
Wgt.Tare + Wet Specimen (gm)	1378.00	Wgt.Tare + Wet Specimen (gm)	1294.40
Wgt.Tare + Dry Specimen (gm)	1287.00	Wgt.Tare + Dry Specimen (gm)	1283.60
Weight of Tare (gm)	103.51	Weight of Tare (gm)	84.45
Weight of Water (gm)	91.00	Weight of Water (gm)	10.80
Weight of Dry Soil (gm)	1183.49	Weight of Dry Soil (gm)	1199.15
Moisture Content (%)	**7.7**	**Moisture Content (%)**	**0.9**

Wet Weight -3/4" Sample (gm)	15973	Weight of the Dry Specimen (gm)	1183.49
Dry Weight - 3/4" Sample (gm)	14832.5	Weight of minus #200 material (gm)	264.62
Wet Weight +3/4" Sample (gm)	51579.00	Weight of plus #200 material (gm)	918.87
Dry Weight + 3/4" Sample (gm)	51118.61		
Total Dry Weight Sample (gm)	65951.1	**J - Factor (Percent Finer than 3/4")**	**0.2249**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	29424.00		44.22	44.22	55.78	**55.78**
2"	50	11476.00	(*)	17.25	61.46	38.54	**38.54**
1 1/2"	37.5	4688.00		7.04	68.51	31.49	**31.49**
1"	25	4437.00		6.67	75.17	24.83	**24.83**
3/4"	19	1554.00		2.34	77.51	22.49	**22.49**
1/2"	12.5	185.19		15.65	15.65	84.35	**18.97**
3/8"	9.5	71.00		6.00	21.65	78.35	**17.62**
#4	4.75	177.15		14.97	36.62	63.38	**14.26**
#10	2	158.12		13.36	49.98	50.02	**11.25**
#20	0.85	119.15	(**)	10.07	60.04	39.96	**8.99**
#40	0.425	67.41		5.70	65.74	34.26	**7.71**
#60	0.25	44.80		3.79	69.52	30.48	**6.85**
#140	0.106	70.83		5.98	75.51	24.49	**5.51**
#200	0.075	25.22		2.13	77.64	22.36	**5.03**
Pan	-	264.62		22.36	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/27/06 Checked By KB Date 3-1-06

geotechnics
INTEGRITY IN TESTING

ATTERBERG LIMIT

ASTM D 4318-00 (SOP - S4)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	60-70
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-19	Visual Description	**REDDISH BROWN SILT** (MInus No. 40 sieve material, Airdried)

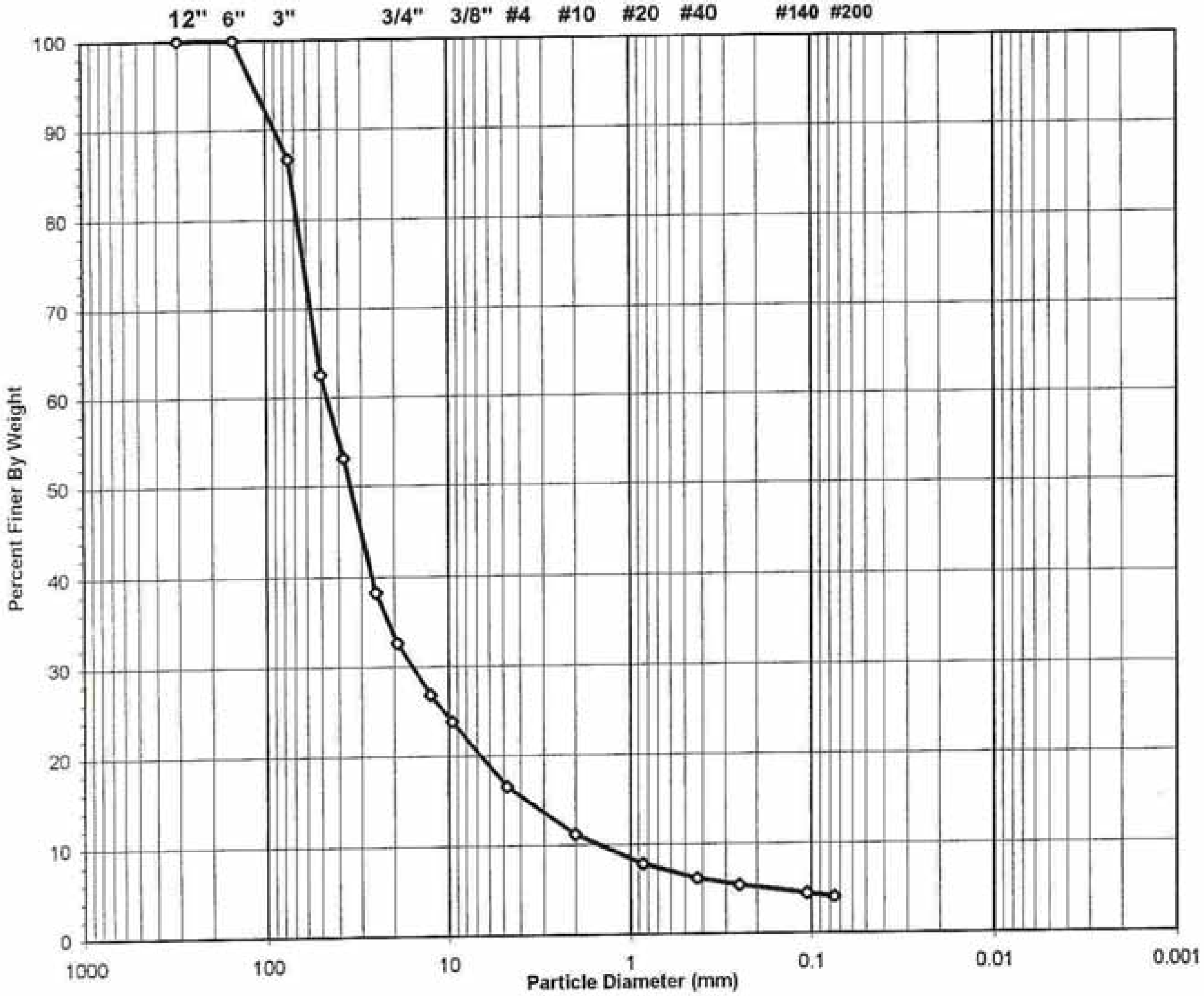
NON - PLASTIC MATERIAL

Tested By TO *Date* 2/28/06 *Checked By* KB *Date* 3-1-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	70-80
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-20	Soil Color	**REDDISH BROWN**

USCS	***SIEVE ANALYSIS***		***HYDROMETER***
	gravel	**sand**	**silt and clay**



USCS Symbol	*GP, TESTED*	D60 =	46.3	CC =	3.6
USCS Classification	*POORLY GRADED GRAVEL*	D30 =	15.7	CU =	31.2
		D10 =	1.5		

Tested By JP Date 2/27/06 Checked By KYB Date 3-1-06

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	70-80
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-20	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	703	Tare No.	564
Wgt.Tare + Wet Specimen (gm)	1395.40	Wgt.Tare + Wet Specimen (gm)	1165.00
Wgt.Tare + Dry Specimen (gm)	1303.20	Wgt.Tare + Dry Specimen (gm)	1142.30
Weight of Tare (gm)	100.66	Weight of Tare (gm)	82.56
Weight of Water (gm)	92.20	Weight of Water (gm)	22.70
Weight of Dry Soil (gm)	1202.54	Weight of Dry Soil (gm)	1059.74
Moisture Content (%)	**7.7**	**Moisture Content (%)**	**2.1**

Wet Weight -3/4" Sample (gm)	14665	Weight of the Dry Specimen (gm)	1202.54
Dry Weight - 3/4" Sample (gm)	13620.7	Weight of minus #200 material (gm)	150.51
Wet Weight +3/4" Sample (gm)	28702.00	Weight of plus #200 material (gm)	1052.03
Dry Weight + 3/4" Sample (gm)	28100.09		
Total Dry Weight Sample (gm)	41720.8	**J - Factor (Percent Finer than 3/4")**	**0.3265**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	5672.00		13.31	13.31	86.69	**86.69**
2"	50	10282.00	(*)	24.13	37.44	62.56	**62.56**
1 1/2"	37.5	4041.00		9.48	46.92	53.08	**53.08**
1"	25	6325.00		14.84	61.76	38.24	**38.24**
3/4"	19	2382.00		5.59	67.35	32.65	**32.65**
1/2"	12.5	211.89		17.62	17.62	82.38	**26.89**
3/8"	9.5	110.25		9.17	26.79	73.21	**23.90**
#4	4.75	273.79		22.77	49.56	50.44	**16.47**
#10	2	195.87		16.29	65.84	34.16	**11.15**
#20	0.85	121.11	(**)	10.07	75.92	24.08	**7.86**
#40	0.425	60.73		5.05	80.97	19.03	**6.21**
#60	0.25	29.71		2.47	83.44	16.56	**5.41**
#140	0.106	36.09		3.00	86.44	13.56	**4.43**
#200	0.075	12.59		1.05	87.48	12.52	**4.09**
Pan	-	150.51		12.52	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/27/06 Checked By Date 3-1-06

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client PAUL C. RIZZO
Client Reference TAUM SAUK 06-3551
Project No. 2006-060-01
Lab ID 2006-060-01-20

Boring No. TS-2
Depth (ft) 70-80
Sample No. S-8
Soil Description **REDDISH BROWN SILTY CLAY**
(Minus No. 40 sieve material, Airdried)

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

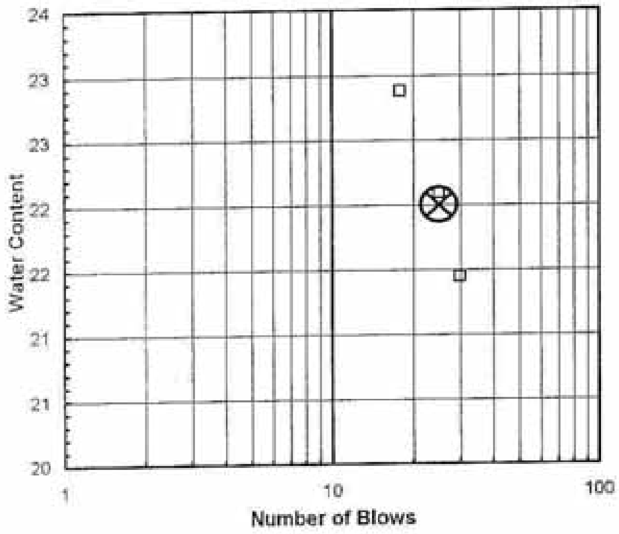
Liquid Limit Test	**1**	**2**	**3**	
Tare Number	2	58	137	**M U L T I P O I N T**
Wt. of Tare & WS (gm)	38.82	41.56	42.91	
Wt. of Tare & DS (gm)	34.55	37.19	38.37	
Wt. of Tare (gm)	14.64	17.41	18.53	
Wt. of Water (gm)	4.3	4.4	4.5	
Wt. of DS (gm)	19.9	19.8	19.8	
Moisture Content (%)	**21.4**	**22.1**	**22.9**	
Number of Blows	**30**	**25**	**18**	

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	217	240	
Wt. of Tare & WS (gm)	25.97	26.06	
Wt. of Tare & DS (gm)	25.05	25.12	
Wt. of Tare (gm)	19.94	19.87	
Wt. of Water (gm)	0.9	0.9	
Wt. of DS (gm)	5.1	5.3	
Moisture Content (%)	**18.0**	**17.9**	**0.1**

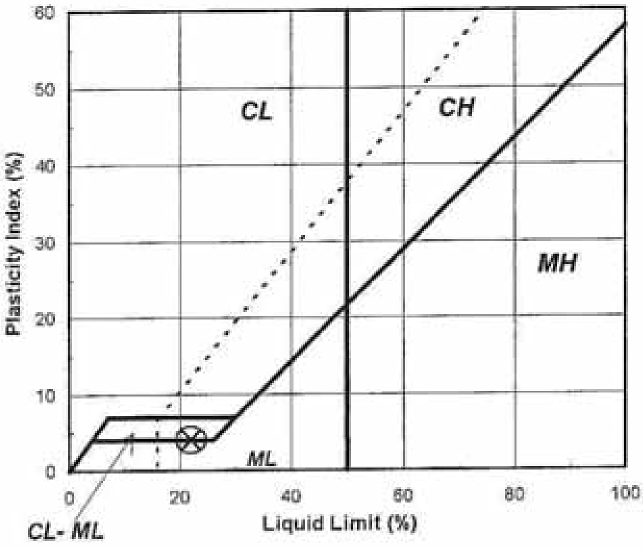
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**22**
Plastic Limit (%)	**18**
Plasticity Index (%)	**4**
USCS Symbol	**CL-ML**

Flow Curve



Plasticity Chart

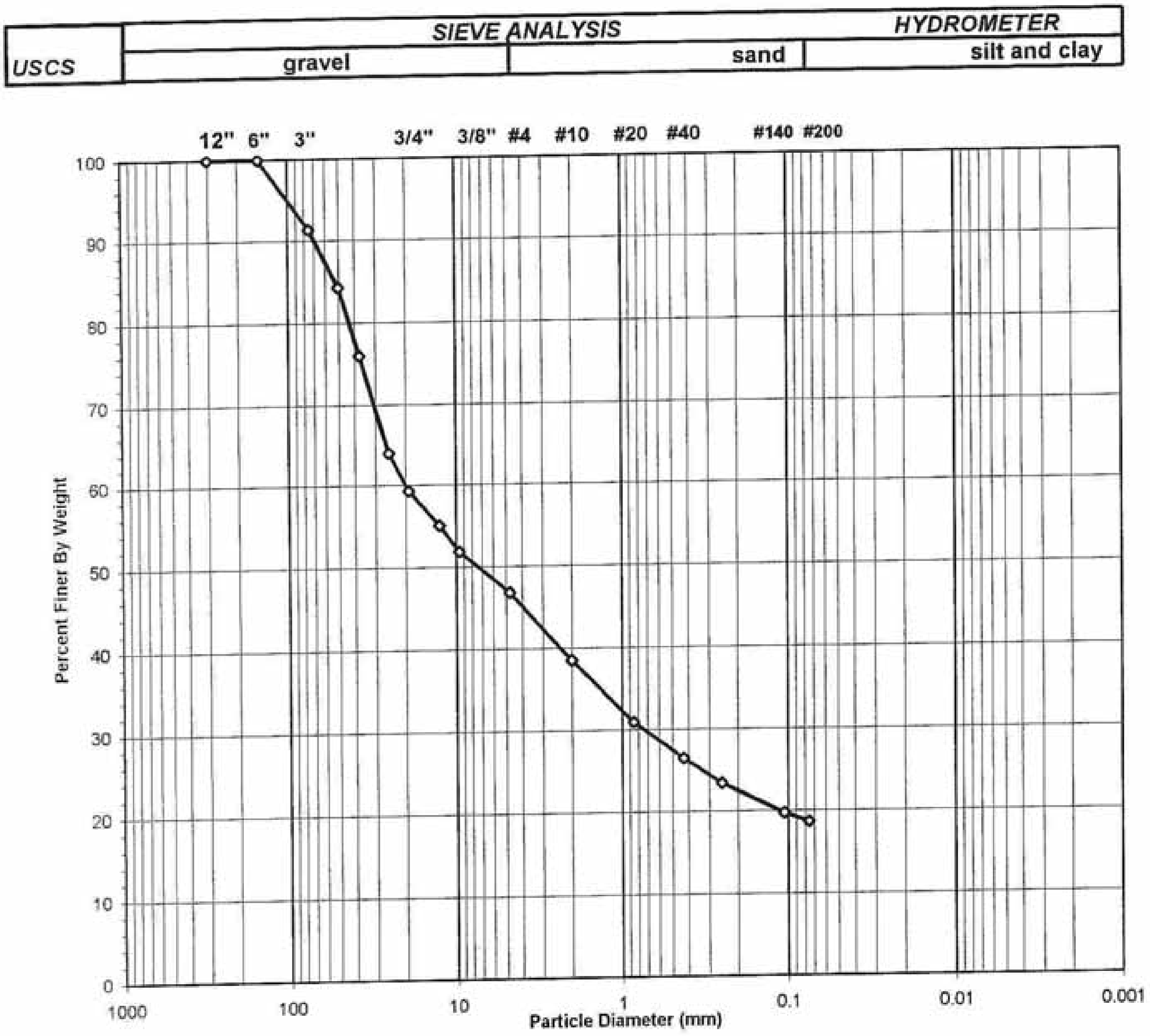


Tested By *BS* *Date* *2/28/06* *Checked By* KB *Date* 3-1-06

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	80-100
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-21	Soil Color	**REDDISH BROWN**



USCS Symbol *GC, TESTED*

USCS Classification *CLAYEY GRAVEL WITH SAND*

Tested By JP Date 2/27/06 Checked By KB Date 3-1-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	80-100
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-21	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	1644	Tare No.	1123
Wgt.Tare + Wet Specimen (gm)	1126.70	Wgt.Tare + Wet Specimen (gm)	1171.00
Wgt.Tare + Dry Specimen (gm)	1048.90	Wgt.Tare + Dry Specimen (gm)	1156.90
Weight of Tare (gm)	93.09	Weight of Tare (gm)	85.27
Weight of Water (gm)	77.80	Weight of Water (gm)	14.10
Weight of Dry Soil (gm)	955.81	Weight of Dry Soil (gm)	1071.63
Moisture Content (%)	**8.1**	**Moisture Content (%)**	**1.3**

Wet Weight -3/4" Sample (gm)	12388	Weight of the Dry Specimen (gm)	955.81
Dry Weight - 3/4" Sample (gm)	11455.6	Weight of minus #200 material (gm)	301.55
Wet Weight +3/4" Sample (gm)	7963.00	Weight of plus #200 material (gm)	654.26
Dry Weight + 3/4" Sample (gm)	7859.59		
Total Dry Weight Sample (gm)	19315.1	**J - Factor (Percent Finer than 3/4")**	**0.5931**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	1688.00		8.63	8.63	91.37	**91.37**
2"	50	1386.00	(*)	7.08	15.71	84.29	**84.29**
1 1/2"	37.5	1627.00		8.31	24.02	75.98	**75.98**
1"	25	2340.00		11.96	35.98	64.02	**64.02**
3/4"	19	922.00		4.71	40.69	59.31	**59.31**
1/2"	12.5	69.45		7.27	7.27	92.73	**55.00**
3/8"	9.5	50.85		5.32	12.59	87.41	**51.84**
#4	4.75	81.83		8.56	21.15	78.85	**46.77**
#10	2	132.74		13.89	35.04	64.96	**38.53**
#20	0.85	121.85	(**)	12.75	47.78	52.22	**30.97**
#40	0.425	72.71		7.61	55.39	44.61	**26.46**
#60	0.25	48.76		5.10	60.49	39.51	**23.43**
#140	0.106	59.03		6.18	66.67	33.33	**19.77**
#200	0.075	17.04		1.78	68.45	31.55	**18.71**
Pan	-	301.55		31.55	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/27/06 Checked By YKB Date 3-1-06

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	80-100
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-21	Soil Description	**REDDISH BROWN LEAN CLAY**

***Note:* The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.** (Minus No. 40 sieve material, Airdried)

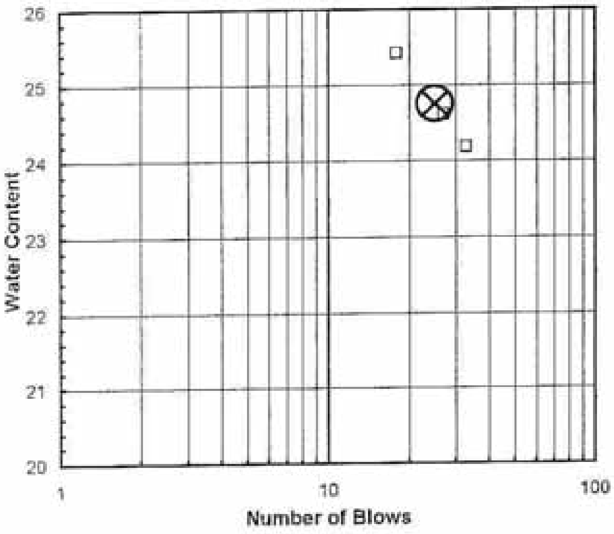
Liquid Limit Test	**1**	**2**	**3**	**MULTIPOINT**
Tare Number	29	O2	246	
Wt. of Tare & WS (gm)	38.42	37.34	38.76	
Wt. of Tare & DS (gm)	34.29	32.80	34.48	
Wt. of Tare (gm)	17.21	14.35	17.64	
Wt. of Water (gm)	4.1	4.5	4.3	
Wt. of DS (gm)	17.1	18.5	16.8	
Moisture Content (%)	**24.2**	**24.6**	**25.4**	
Number of Blows	**33**	**27**	**18**	

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	68	224	
Wt. of Tare & WS (gm)	22.41	26.26	
Wt. of Tare & DS (gm)	21.53	25.22	
Wt. of Tare (gm)	16.41	19.15	
Wt. of Water (gm)	0.9	1.0	
Wt. of DS (gm)	5.1	6.1	
Moisture Content (%)	**17.2**	**17.1**	**0.1**

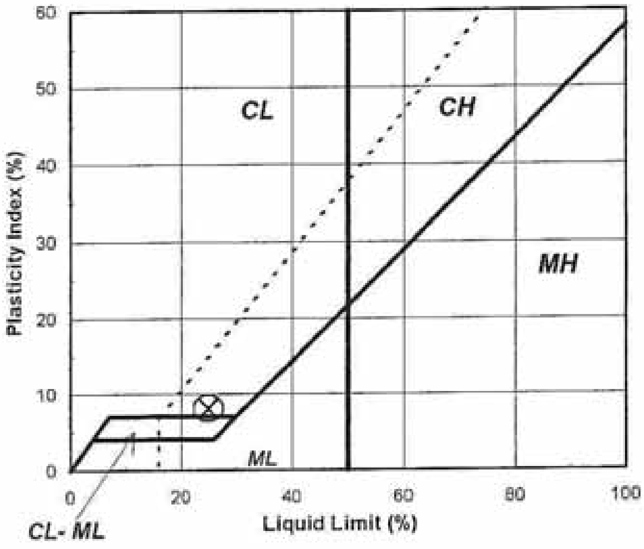
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**25**
Plastic Limit (%)	**17**
Plasticity Index (%)	**8**
USCS Symbol	**CL**

Flow Curve



Plasticity Chart



Tested By *TO* *Date* *2/28/06* *Checked By* VKB *Date* 3-1-06

page 1 of 1 DCN: CT-S4B DATE: 10/8/01 REVISION: 2

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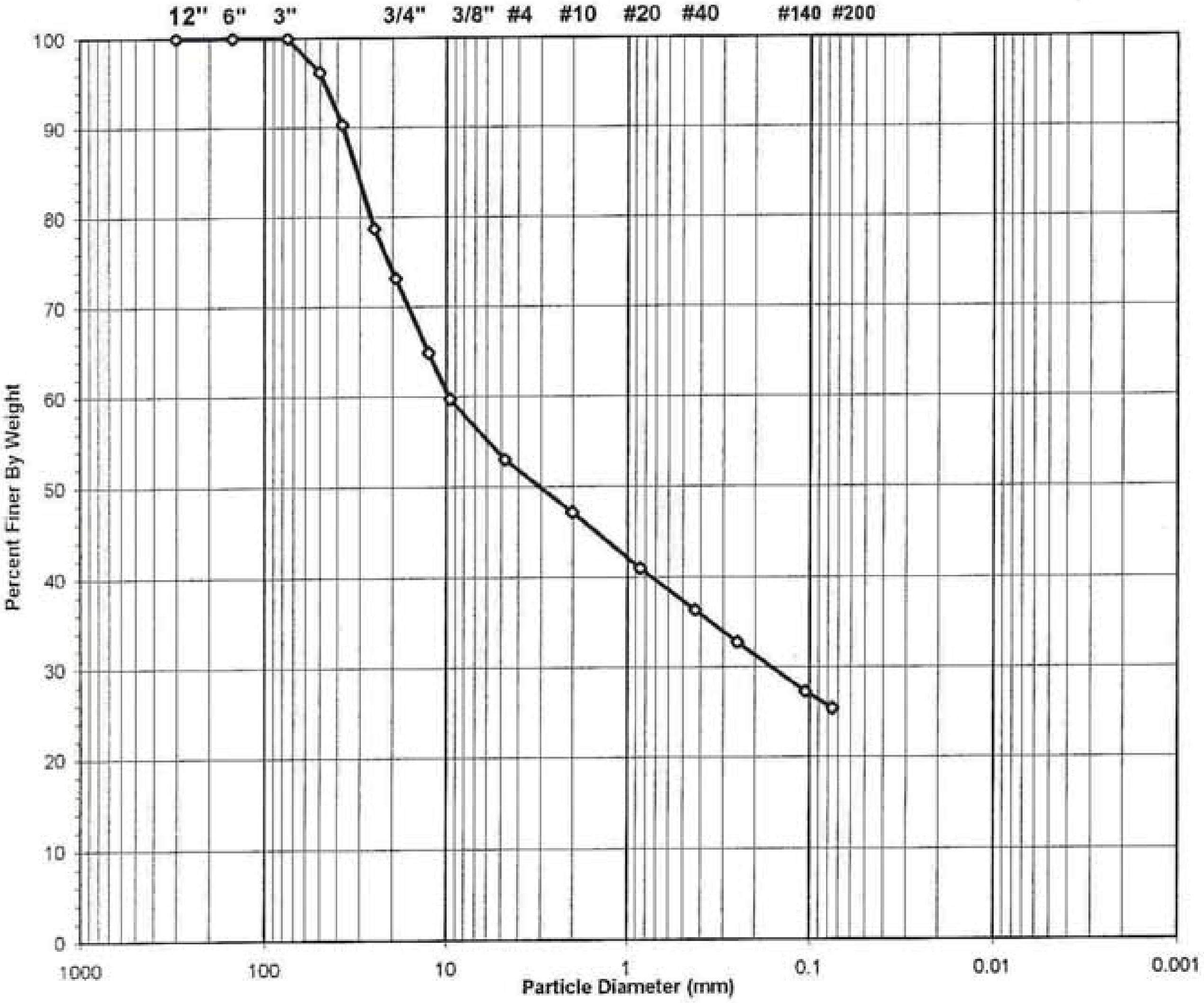
geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	100-104.5
Project No.	2006-060-01	Sample No.	S-10
Lab ID	2006-060-01-22	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol ***GC, TESTED***

USCS Classification ***CLAYEY GRAVEL WITH SAND***

Tested By JP Date 2/27/06 Checked By KYB Date 3-1-06

page 1 of 2 DCN: CT-S3A DATE 6-25-98 REVISION 2 *C:\MSOFFICE\Excel\PrintQ\[U418.xls]Sheet1*

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	100-104.5
Project No.	2006-060-01	Sample No.	S-10
Lab ID	2006-060-01-22	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	701	Tare No.	602
Wgt.Tare + Wet Specimen (gm)	1276.70	Wgt.Tare + Wet Specimen (gm)	1154.80
Wgt.Tare + Dry Specimen (gm)	1182.30	Wgt.Tare + Dry Specimen (gm)	1131.30
Weight of Tare (gm)	100.37	Weight of Tare (gm)	85.69
Weight of Water (gm)	94.40	Weight of Water (gm)	23.50
Weight of Dry Soil (gm)	1081.93	Weight of Dry Soil (gm)	1045.61
Moisture Content (%)	**8.7**	**Moisture Content (%)**	**2.2**

Wet Weight -3/4" Sample (gm)	35182	Weight of the Dry Specimen (gm)	1081.93
Dry Weight - 3/4" Sample (gm)	32358.7	Weight of minus #200 material (gm)	375.69
Wet Weight +3/4" Sample (gm)	12117.00	Weight of plus #200 material (gm)	706.24
Dry Weight + 3/4" Sample (gm)	11850.66		
Total Dry Weight Sample (gm)	44209.3	**J - Factor (Percent Finer than 3/4")**	**0.7319**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	0.00		0.00	0.00	100.00	**100.00**
2"	50	1722.00	(*)	3.81	3.81	96.19	**96.19**
1 1/2"	37.5	2646.00		5.85	9.66	90.34	**90.34**
1"	25	5258.00		11.63	21.30	78.70	**78.70**
3/4"	19	2491.00		5.51	26.81	73.19	**73.19**
1/2"	12.5	123.27		11.39	11.39	88.61	**64.85**
3/8"	9.5	75.86		7.01	18.41	81.59	**59.72**
#4	4.75	100.04		9.25	27.65	72.35	**52.95**
#10	2	86.62		8.01	35.66	64.34	**47.09**
#20	0.85	90.70	(**)	8.38	44.04	55.96	**40.96**
#40	0.425	68.17		6.30	50.34	49.66	**36.35**
#60	0.25	53.14		4.91	55.25	44.75	**32.75**
#140	0.106	80.86		7.47	62.73	37.27	**27.28**
#200	0.075	27.58		2.55	65.28	34.72	**25.42**
Pan	-	375.69		34.72	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/27/06 Checked By KB Date 3-1-06

geotechnics
INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-2
Client Reference	TAUM SAUK 06-3551	Depth (ft)	100-104.5
Project No.	2006-060-01	Sample No.	S-10
Lab ID	2006-060-01-22	Soil Description	**REDDISH BROWN LEAN CLAY**
			(Minus No. 40 sieve material, Airdried)

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

Liquid Limit Test	**1**	**2**	**3**
Tare Number	226	252	259
Wt. of Tare & WS (gm)	44.31	41.65	44.50
Wt. of Tare & DS (gm)	39.19	37.06	38.91
Wt. of Tare (gm)	18.02	18.69	17.35
Wt. of Water (gm)	5.1	4.6	5.6
Wt. of DS (gm)	21.2	18.4	21.6
Moisture Content (%)	**24.2**	**25.0**	**25.9**
Number of Blows	**34**	**27**	**19**

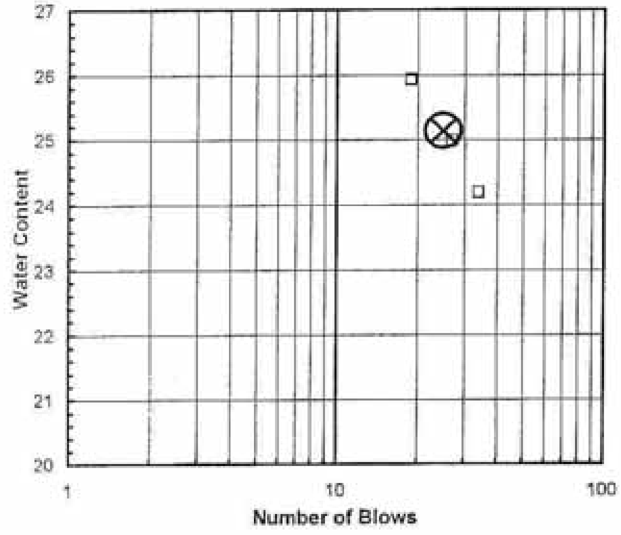
MULTIPOINT

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	2254	2301	
Wt. of Tare & WS (gm)	22.95	26.14	
Wt. of Tare & DS (gm)	22.13	25.28	
Wt. of Tare (gm)	16.82	19.78	
Wt. of Water (gm)	0.8	0.9	
Wt. of DS (gm)	5.3	5.5	
Moisture Content (%)	**15.4**	**15.6**	**-0.2**

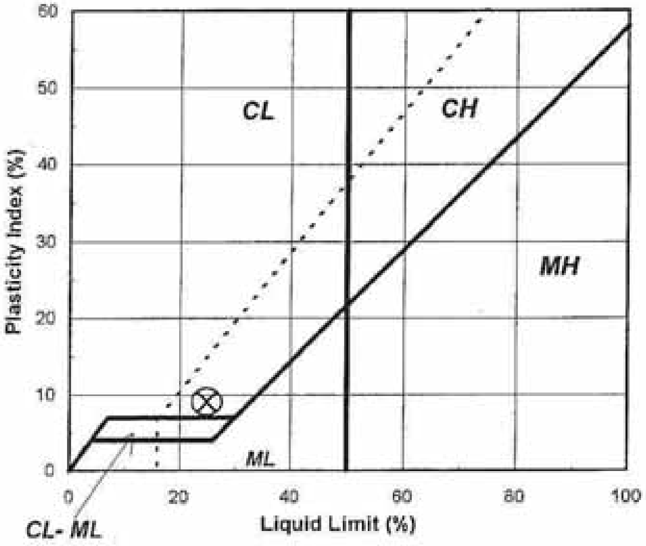
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**25**
Plastic Limit (%)	**16**
Plasticity Index (%)	**9**
USCS Symbol	**CL**

Flow Curve



Plasticity Chart



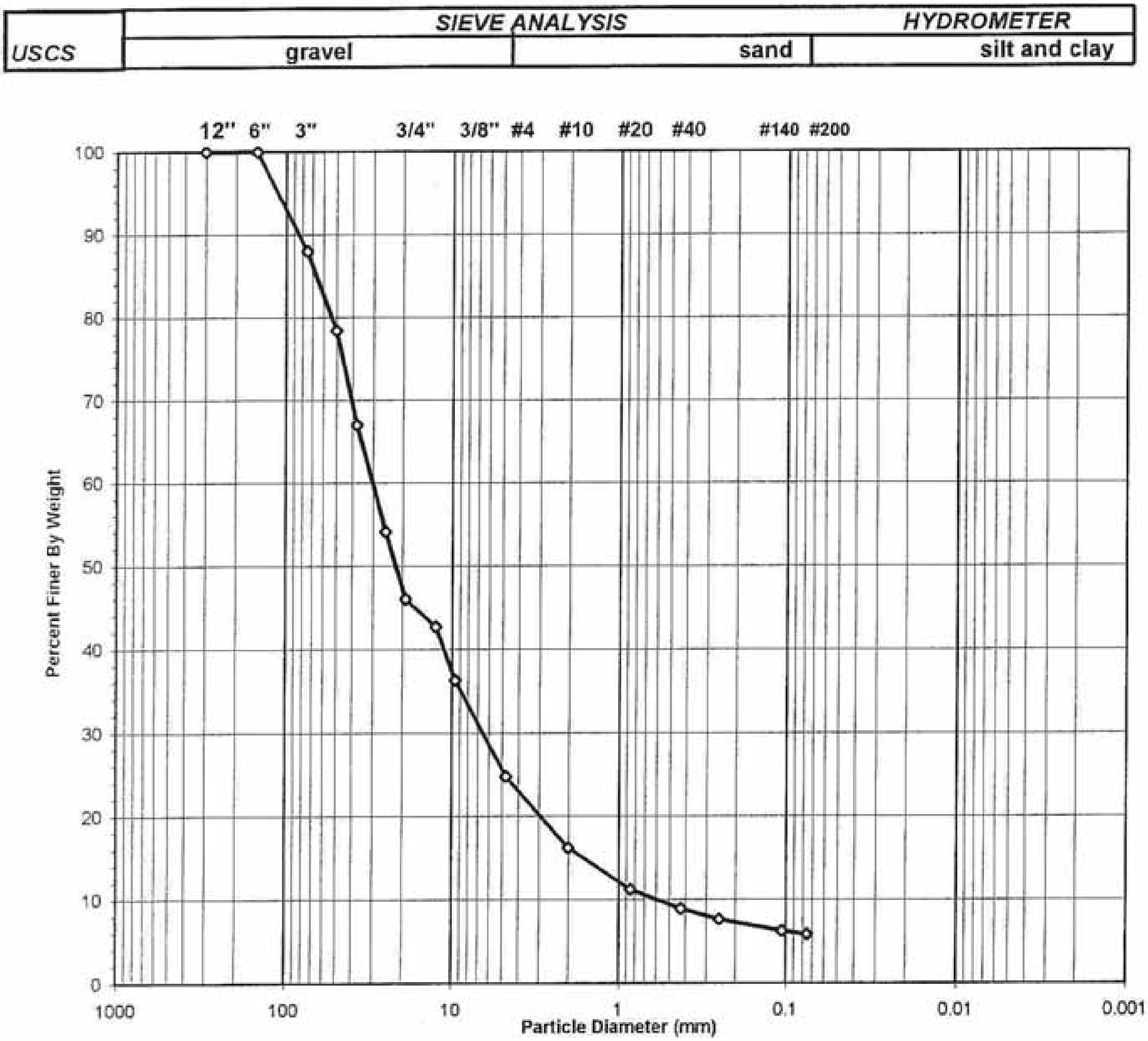
Tested By BS *Date* 2/28/06 *Checked By* YKB *Date* 3-1-06

BORING TS-3

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-23	Soil Color	**REDDISH BROWN**



USCS Symbol	***gw-gm, ASSUMED***	**D60 =**	**30.1**	**CC =**	**2.3**
USCS Classification	***WELL-GRADED GRAVEL WITH SILT AND SAND***	**D30 =**	**6.5**	**CU =**	**50.3**
		D10 =	**0.6**		

Tested By PC Date 2/22/06 Checked By KyB Date 2-23-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-23	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	2344	Tare No.	555
Wgt.Tare + Wet Specimen (gm)	1372.80	Wgt.Tare + Wet Specimen (gm)	544.93
Wgt.Tare + Dry Specimen (gm)	1282.80	Wgt.Tare + Dry Specimen (gm)	533.37
Weight of Tare (gm)	95.59	Weight of Tare (gm)	81.98
Weight of Water (gm)	90.00	Weight of Water (gm)	11.56
Weight of Dry Soil (gm)	1187.21	Weight of Dry Soil (gm)	451.39
Moisture Content (%)	**7.6**	**Moisture Content (%)**	**2.6**

Wet Weight -3/4" Sample (gm)	23345	Weight of the Dry Specimen (gm)	1187.21
Dry Weight - 3/4" Sample (gm)	21700.0	Weight of minus #200 material (gm)	149.97
Wet Weight +3/4" Sample (gm)	26166.00	Weight of plus #200 material (gm)	1037.24
Dry Weight + 3/4" Sample (gm)	25512.63		
Total Dry Weight Sample (gm)	47212.6	**J - Factor (Percent Finer than 3/4")**	**0.4596**

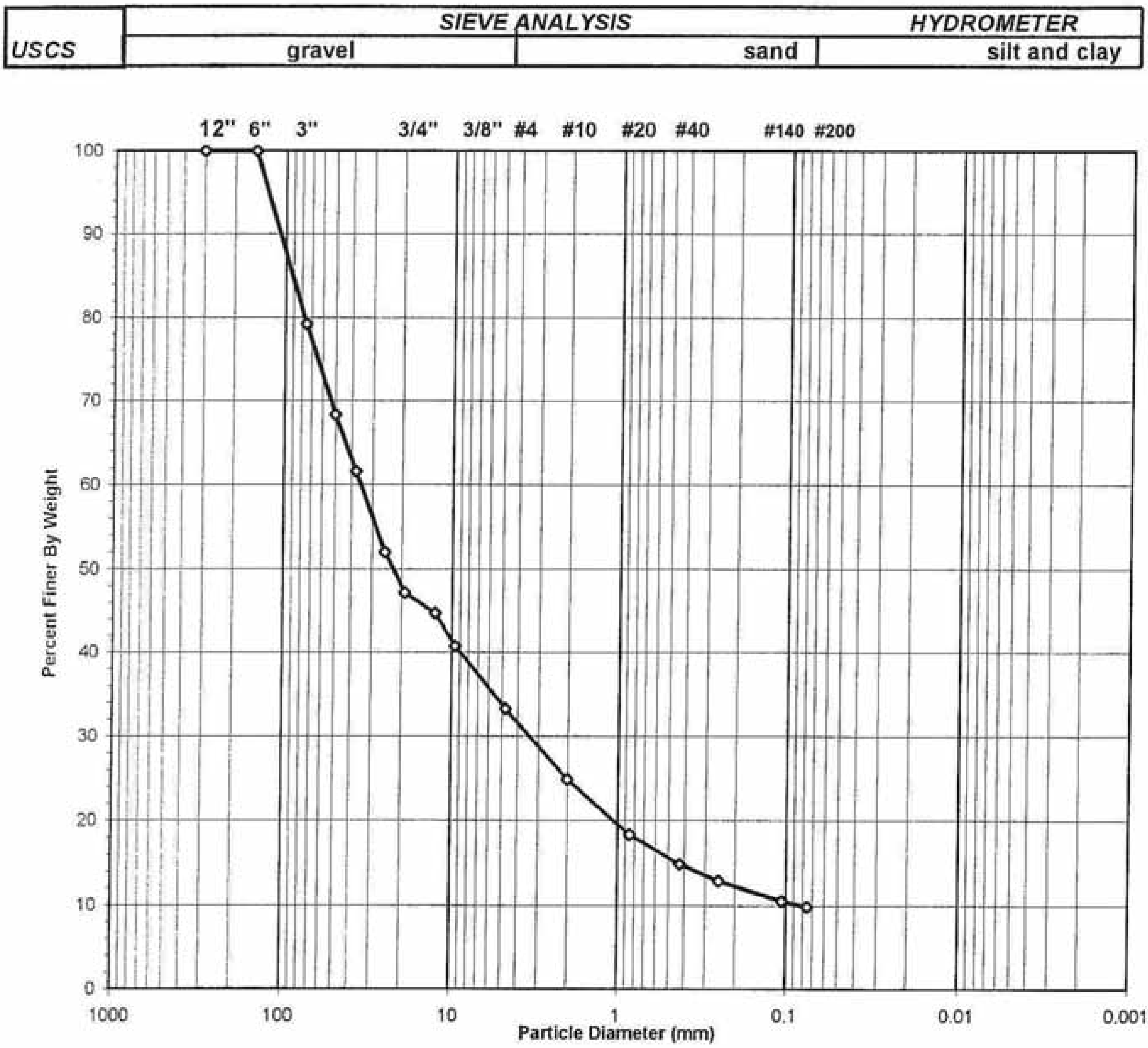
Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	5797.00		11.97	11.97	88.03	**88.03**
2"	50	4670.00	(*)	9.64	21.62	78.38	**78.38**
1 1/2"	37.5	5511.00		11.38	33.00	67.00	**67.00**
1"	25	6264.00		12.94	45.93	54.07	**54.07**
3/4"	19	3924.00		8.10	54.04	45.96	**45.96**
1/2"	12.5	85.60		7.21	7.21	92.79	**42.65**
3/8"	9.5	163.37		13.76	20.97	79.03	**36.32**
#4	4.75	298.86		25.17	46.14	53.86	**24.75**
#10	2	220.44		18.57	64.71	35.29	**16.22**
#20	0.85	130.05	(**)	10.95	75.67	24.33	**11.18**
#40	0.425	60.40		5.09	80.75	19.25	**8.85**
#60	0.25	31.95		2.69	83.45	16.55	**7.61**
#140	0.106	36.36		3.06	86.51	13.49	**6.20**
#200	0.075	10.21		0.86	87.37	12.63	**5.81**
Pan	-	149.97		12.63	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By Date 2-23-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	10-20
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-24	Soil Color	**REDDISH BROWN**



USCS Symbol ***GP-GC, TESTED***

USCS Classification ***POORLY GRADED GRAVEL WITH CLAY AND SAND***

D60 = **35.1** **CC =** **4.0**

D30 = **3.4** **CU =** **431.7**

D10 = **0.1**

Tested By PC Date 2/22/06 Checked By KB Date 2-28-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	10-20
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-24	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	686	Tare No.	585
Wgt.Tare + Wet Specimen (gm)	1227.90	Wgt.Tare + Wet Specimen (gm)	1185.20
Wgt.Tare + Dry Specimen (gm)	1158.50	Wgt.Tare + Dry Specimen (gm)	1169.10
Weight of Tare (gm)	97.42	Weight of Tare (gm)	85.61
Weight of Water (gm)	69.40	Weight of Water (gm)	16.10
Weight of Dry Soil (gm)	1061.08	Weight of Dry Soil (gm)	1083.49
Moisture Content (%)	**6.5**	**Moisture Content (%)**	**1.5**

Wet Weight -3/4" Sample (gm)	24936	Weight of the Dry Specimen (gm)	1061.08
Dry Weight - 3/4" Sample (gm)	23405.2	Weight of minus #200 material (gm)	221.55
Wet Weight +3/4" Sample (gm)	26632.00	Weight of plus #200 material (gm)	839.53
Dry Weight + 3/4" Sample (gm)	26242.06		
Total Dry Weight Sample (gm)	49647.2	**J - Factor (Percent Finer than 3/4")**	**0.4714**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	10481.00		20.80	20.80	79.20	**79.20**
2"	50	5489.00	(*)	10.89	31.70	68.30	**68.30**
1 1/2"	37.5	3386.00		6.72	38.42	61.58	**61.58**
1"	25	4858.00		9.64	48.06	51.94	**51.94**
3/4"	19	2418.00		4.80	52.86	47.14	**47.14**
1/2"	12.5	55.31		5.21	5.21	94.79	**44.69**
3/8"	9.5	89.90		8.47	13.69	86.31	**40.69**
#4	4.75	167.07		15.75	29.43	70.57	**33.27**
#10	2	188.00		17.72	47.15	52.85	**24.92**
#20	0.85	147.54	(**)	13.90	61.05	38.95	**18.36**
#40	0.425	78.42		7.39	68.44	31.56	**14.88**
#60	0.25	44.68		4.21	72.65	27.35	**12.89**
#140	0.106	53.39		5.03	77.69	22.31	**10.52**
#200	0.075	15.22		1.43	79.12	20.88	**9.84**
Pan	-	221.55		20.88	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By KB Date 2-28-06

geotechnics
INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	10-20
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-24	Soil Description	**REDDISH BROWN LEAN CLAY**

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Airdried)

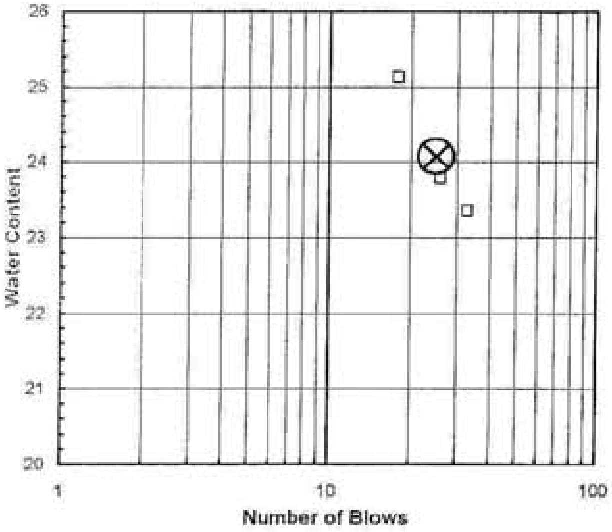
Liquid Limit Test	**1**	**2**	**3**	**MULTIPOINT**
Tare Number	174	250	252	
Wt. of Tare & WS (gm)	42.99	43.54	43.43	
Wt. of Tare & DS (gm)	37.81	38.54	38.46	
Wt. of Tare (gm)	15.63	17.52	18.68	
Wt. of Water (gm)	5.2	5.0	5.0	
Wt. of DS (gm)	22.2	21.0	19.8	
Moisture Content (%)	**23.4**	**23.8**	**25.1**	
Number of Blows	**33**	**26**	**18**	

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	253	254	
Wt. of Tare & WS (gm)	24.69	24.45	
Wt. of Tare & DS (gm)	23.79	23.65	
Wt. of Tare (gm)	17.82	18.38	
Wt. of Water (gm)	0.9	0.8	
Wt. of DS (gm)	6.0	5.3	
Moisture Content (%)	**15.1**	**15.2**	**-0.1**

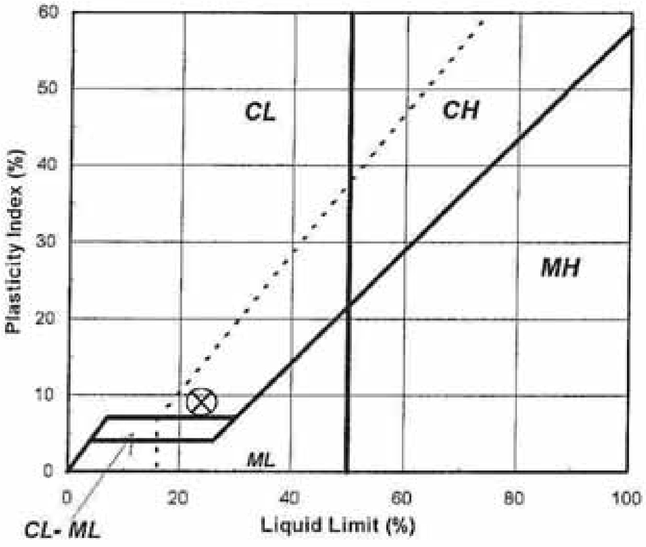
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**24**
Plastic Limit (%)	**15**
Plasticity Index (%)	**9**
USCS Symbol	**CL**

Flow Curve



Plasticity Chart

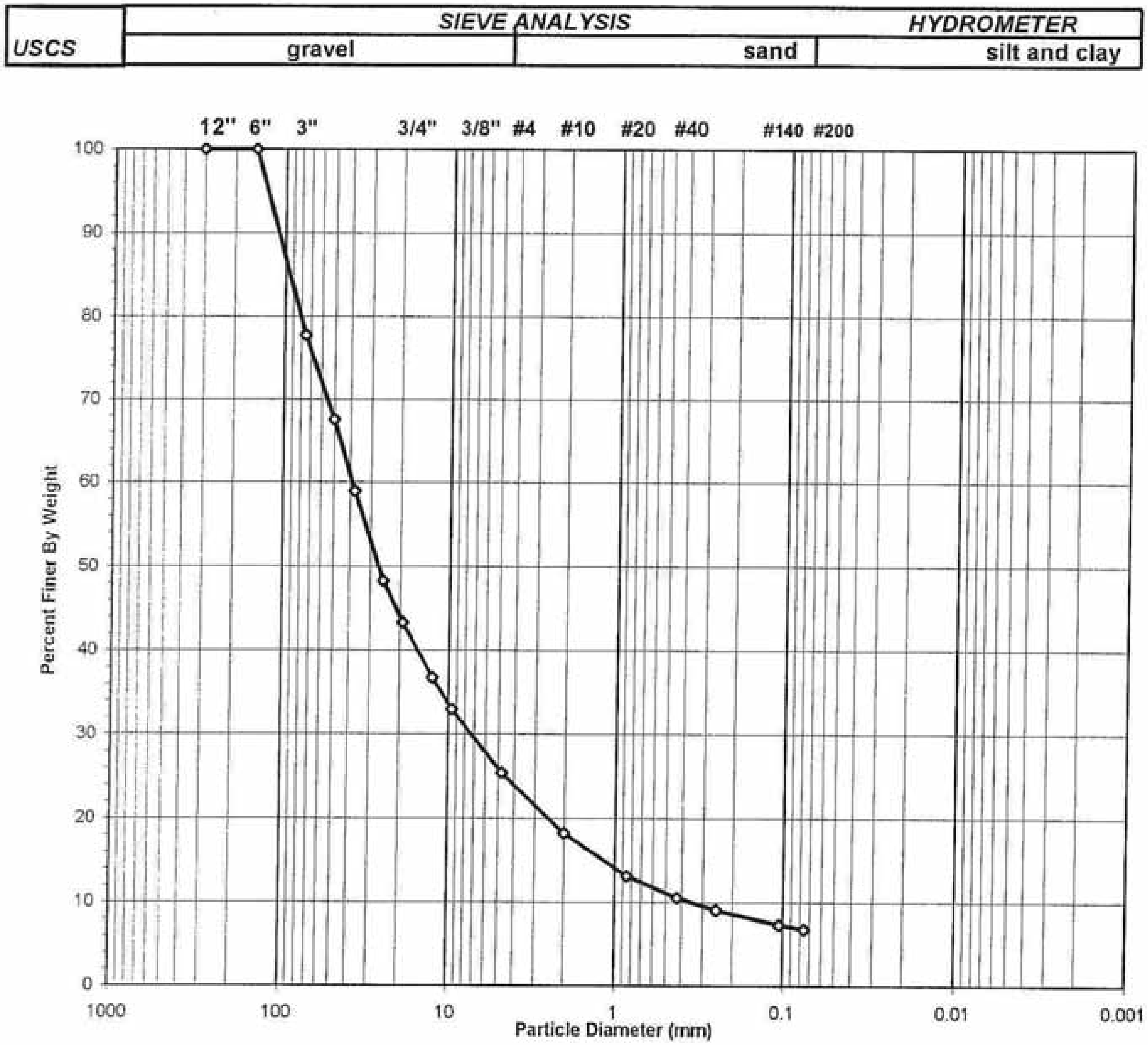


Tested By	*BS*	*Date*	*2/24/06*	*Checked By*	KVR	*Date*	2-27-06

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-25	Soil Color	REDDISH BROWN



USCS Symbol	*GP-GC, TESTED*	D60 =	38.9	CC =	3.8
USCS Classification	*POORLY GRADED GRAVEL WITH CLAY AND SAND*	D30 =	7.2	CU =	109.9
		D10 =	0.4		

Tested By PC Date 2/23/06 Checked By KLB Date 2-28-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-25	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	706	Tare No.	892
Wgt.Tare + Wet Specimen (gm)	1368.50	Wgt.Tare + Wet Specimen (gm)	1327.20
Wgt.Tare + Dry Specimen (gm)	1265.30	Wgt.Tare + Dry Specimen (gm)	1293.40
Weight of Tare (gm)	100.96	Weight of Tare (gm)	109.93
Weight of Water (gm)	103.20	Weight of Water (gm)	33.80
Weight of Dry Soil (gm)	1164.34	Weight of Dry Soil (gm)	1183.47
Moisture Content (%)	8.9	**Moisture Content (%)**	2.9

Wet Weight -3/4" Sample (gm)	22425	Weight of the Dry Specimen (gm)	1164.34
Dry Weight - 3/4" Sample (gm)	20599.2	Weight of minus #200 material (gm)	183.29
Wet Weight +3/4" Sample (gm)	27796.00	Weight of plus #200 material (gm)	981.05
Dry Weight + 3/4" Sample (gm)	27024.19		
Total Dry Weight Sample (gm)	47623.4	**J - Factor (Percent Finer than 3/4")**	**0.4325**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	10917.00		22.29	22.29	77.71	**77.71**
2"	50	5002.00	(*)	10.21	32.50	67.50	**67.50**
1 1/2"	37.5	4195.00		8.56	41.06	58.94	**58.94**
1"	25	5229.00		10.68	51.74	48.26	**48.26**
3/4"	19	2453.00		5.01	56.75	43.25	**43.25**
1/2"	12.5	176.46		15.16	15.16	84.84	**36.70**
3/8"	9.5	101.19		8.69	23.85	76.15	**32.94**
#4	4.75	202.52		17.39	41.24	58.76	**25.42**
#10	2	193.77		16.64	57.88	42.12	**18.22**
#20	0.85	137.56	(**)	11.81	69.70	30.30	**13.11**
#40	0.425	70.23		6.03	75.73	24.27	**10.50**
#60	0.25	38.82		3.33	79.06	20.94	**9.06**
#140	0.106	46.46		3.99	83.05	16.95	**7.33**
#200	0.075	14.04		1.21	84.26	15.74	**6.81**
Pan	-	183.29		15.74	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/23/06 Checked By KB Date 2-28-06

geotechnics
INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-25	Soil Description	**REDDISH BROWN LEAN CLAY**

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Airdried)

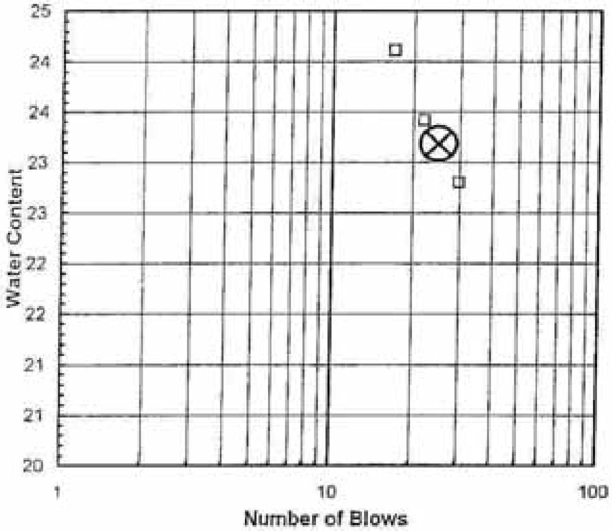
Liquid Limit Test	1	2	3	
				M
Tare Number	68	182	219	U
Wt. of Tare & WS (gm)	40.62	44.07	45.40	L
Wt. of Tare & DS (gm)	36.13	39.23	40.41	T
Wt. of Tare (gm)	16.42	18.56	19.72	I
Wt. of Water (gm)	4.5	4.8	5.0	P
Wt. of DS (gm)	19.7	20.7	20.7	O
				I
Moisture Content (%)	**22.8**	**23.4**	**24.1**	N
Number of Blows	**30**	**22**	**17**	T

Plastic Limit Test	1	2	Range
Tare Number	234	2294	
Wt. of Tare & WS (gm)	25.11	26.22	
Wt. of Tare & DS (gm)	24.29	25.34	
Wt. of Tare (gm)	18.98	19.68	
Wt. of Water (gm)	0.8	0.9	
Wt. of DS (gm)	5.3	5.7	
Moisture Content (%)	**15.4**	**15.5**	**-0.1**

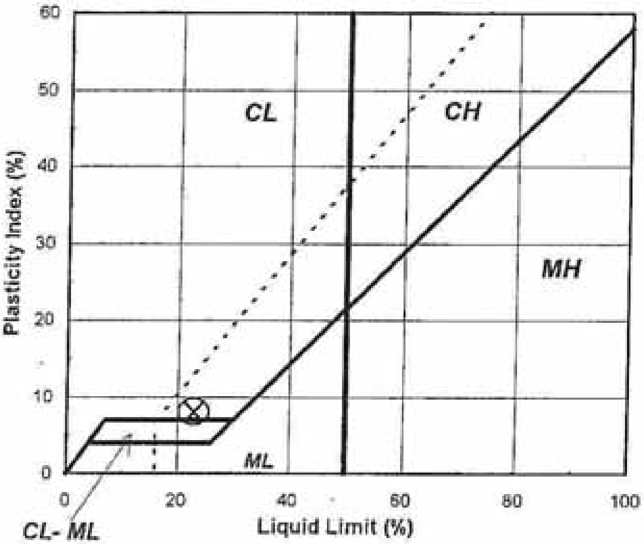
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**23**
Plastic Limit (%)	**15**
Plasticity Index (%)	**8**
USCS Symbol	**CL**

Flow Curve



Plasticity Chart



Tested By	*JP*	*Date*	*2/24/06*	*Checked By*	YKB	*Date*	2-27-06

page 1 of 1 DCN: CT-S4B DATE: 10/8/01 REVISION: 2

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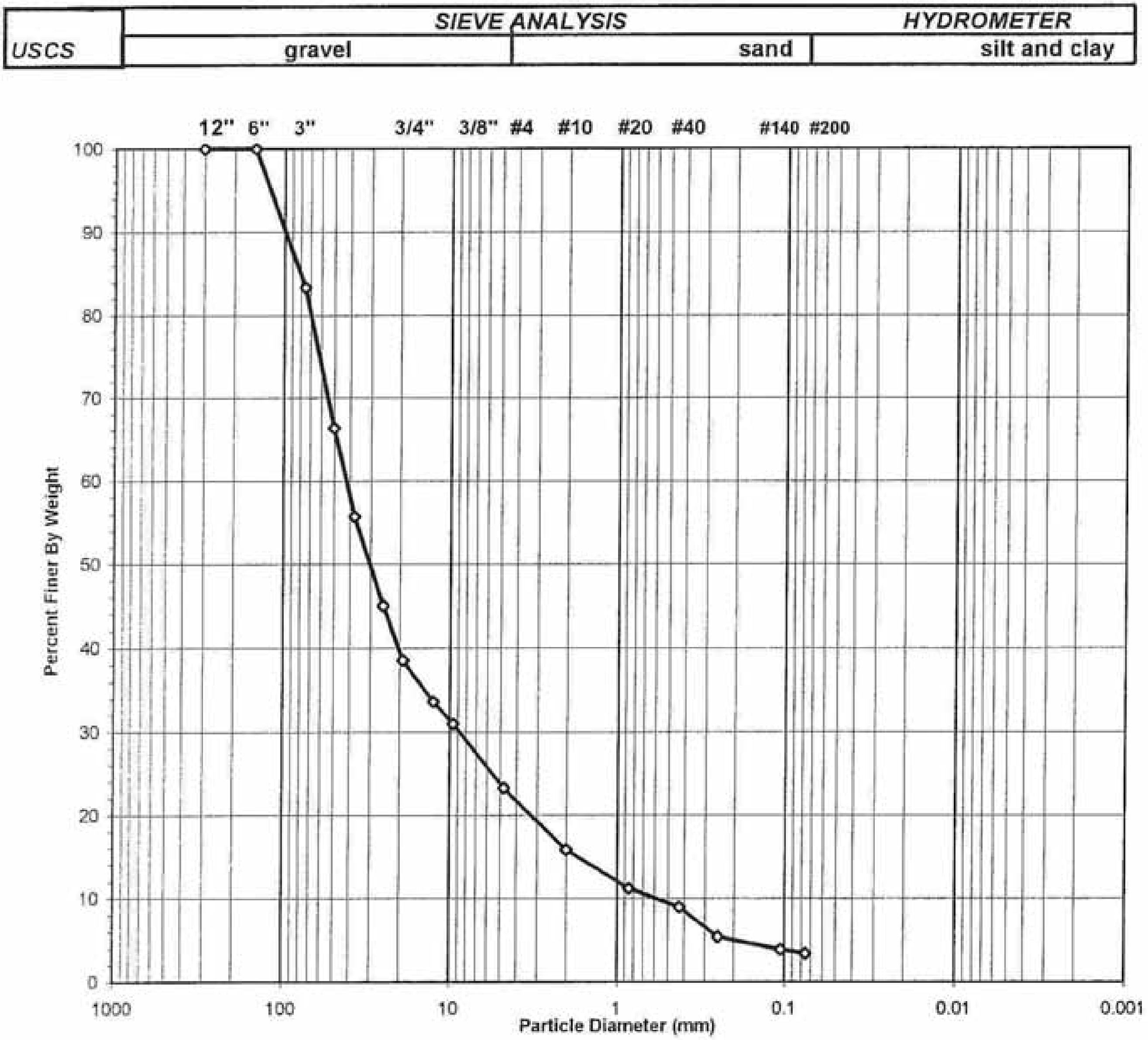
geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	30-40
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-26	Soil Color	BROWN



USCS Symbol ***GW, TESTED*** **D60 = 42.1** **CC = 3.0**

USCS Classification ***WELL-GRADED GRAVEL WITH SAND*** **D30 = 8.7** **CU = 70.4**

D10 = 0.6

Tested By PC Date 2/23/06 Checked By KB Date 2-28-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	30-40
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-26	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	2338	Tare No.	1694
Wgt.Tare + Wet Specimen (gm)	1262.30	Wgt.Tare + Wet Specimen (gm)	405.99
Wgt.Tare + Dry Specimen (gm)	1157.30	Wgt.Tare + Dry Specimen (gm)	390.36
Weight of Tare (gm)	97.56	Weight of Tare (gm)	83.80
Weight of Water (gm)	105.00	Weight of Water (gm)	15.63
Weight of Dry Soil (gm)	1059.74	Weight of Dry Soil (gm)	306.56
Moisture Content (%)	**9.9**	**Moisture Content (%)**	**5.1**

Wet Weight -3/4" Sample (gm)	15003	Weight of the Dry Specimen (gm)	1059.74
Dry Weight - 3/4" Sample (gm)	13650.5	Weight of minus #200 material (gm)	92.92
Wet Weight +3/4" Sample (gm)	22855.00	Weight of plus #200 material (gm)	966.82
Dry Weight + 3/4" Sample (gm)	21746.26		
Total Dry Weight Sample (gm)	35396.8	**J - Factor (Percent Finer than 3/4")**	**0.3856**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	6195.00		16.65	16.65	83.35	**83.35**
2"	50	6316.00	(*)	16.98	33.63	66.37	**66.37**
1 1/2"	37.5	3958.00		10.64	44.27	55.73	**55.73**
1"	25	3976.00		10.69	54.96	45.04	**45.04**
3/4"	19	2410.00		6.48	61.44	38.56	**38.56**
1/2"	12.5	134.98		12.74	12.74	87.26	**33.65**
3/8"	9.5	73.04		6.89	19.63	80.37	**30.99**
#4	4.75	211.36		19.94	39.57	60.43	**23.30**
#10	2	204.95		19.34	58.91	41.09	**15.84**
#20	0.85	129.30	(**)	12.20	71.11	28.89	**11.14**
#40	0.425	61.64		5.82	76.93	23.07	**8.90**
#60	0.25	95.99		9.06	85.99	14.01	**5.40**
#140	0.106	42.57		4.02	90.01	9.99	**3.85**
#200	0.075	12.99		1.23	91.23	8.77	**3.38**
Pan	-	92.92		8.77	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/23/06 Checked By KYR Date 2-28-06

geotechnics
INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	30-40
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-26	Soil Description	**BROWN SILTY CLAY**

***Note:* The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.** (Minus No. 40 sieve material, Airdried)

Liquid Limit Test	1	2	3
Tare Number	O2	95	189
Wt. of Tare & WS (gm)	27.96	28.78	36.29
Wt. of Tare & DS (gm)	25.19	26.16	32.71
Wt. of Tare (gm)	14.35	16.25	19.65
Wt. of Water (gm)	2.8	2.6	3.6
Wt. of DS (gm)	10.8	9.9	13.1
Moisture Content (%)	**25.6**	**26.4**	**27.4**
Number of Blows	**35**	**27**	**19**

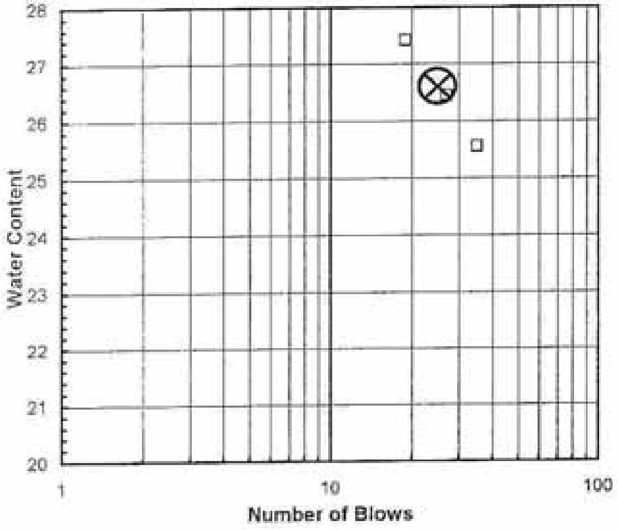
MULTIPOINT

Plastic Limit Test	1	2	Range
Tare Number	240	245	
Wt. of Tare & WS (gm)	25.52	26.09	
Wt. of Tare & DS (gm)	24.54	25.05	
Wt. of Tare (gm)	19.88	20.03	
Wt. of Water (gm)	1.0	1.0	
Wt. of DS (gm)	4.7	5.0	
Moisture Content (%)	**21.0**	**20.7**	**0.3**

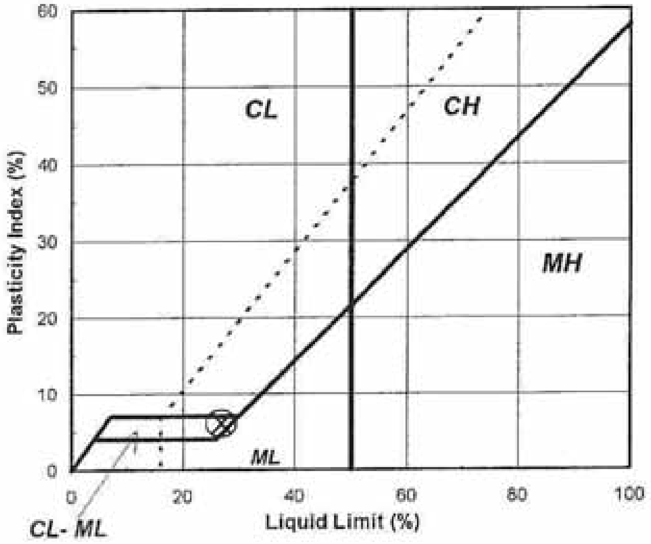
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**27**
Plastic Limit (%)	**21**
Plasticity Index (%)	**6**
USCS Symbol	**CL-ML**

Flow Curve



Plasticity Chart

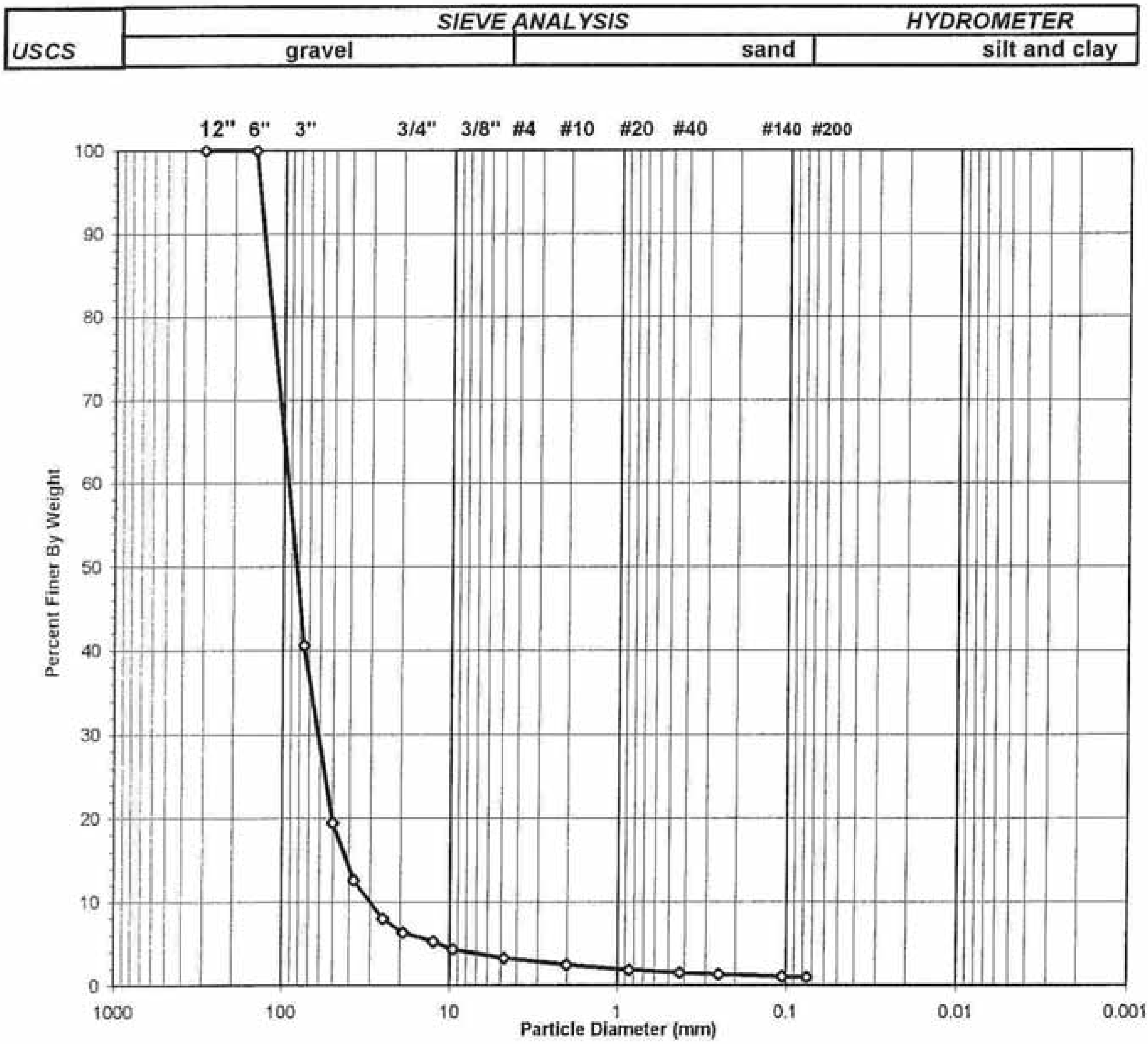


Tested By BS *Date* 2/24/06 *Checked By* KVB *Date* 2-27-06

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	40-50
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-27	Soil Color	**REDDISH BROWN**



USCS Symbol ***GP, TESTED***

USCS Classification ***POORLY GRADED GRAVEL***

Tested By PC Date 2/23/06 Checked By KYB Date 2-28-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	40-50
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-27	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	928	Tare No.	900
Wgt.Tare + Wet Specimen (gm)	925.10	Wgt.Tare + Wet Specimen (gm)	1116.30
Wgt.Tare + Dry Specimen (gm)	864.40	Wgt.Tare + Dry Specimen (gm)	1075.90
Weight of Tare (gm)	103.43	Weight of Tare (gm)	110.09
Weight of Water (gm)	60.70	Weight of Water (gm)	40.40
Weight of Dry Soil (gm)	760.97	Weight of Dry Soil (gm)	965.81
Moisture Content (%)	**8.0**	**Moisture Content (%)**	**4.2**

Wet Weight -3/4" Sample (gm)	1792	Weight of the Dry Specimen (gm)	760.97
Dry Weight - 3/4" Sample (gm)	1659.6	Weight of minus #200 material (gm)	120.12
Wet Weight +3/4" Sample (gm)	25584.00	Weight of plus #200 material (gm)	640.85
Dry Weight + 3/4" Sample (gm)	24556.79		
Total Dry Weight Sample (gm)	26216.4	**J - Factor (Percent Finer than 3/4")**	**0.0633**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	16226.00		59.41	59.41	40.59	**40.59**
2"	50	5765.00	(*)	21.11	80.51	19.49	**19.49**
1 1/2"	37.5	1891.00		6.92	87.44	12.56	**12.56**
1"	25	1250.00		4.58	92.01	7.99	**7.99**
3/4"	19	452.00		1.65	93.67	6.33	**6.33**
1/2"	12.5	127.44		16.75	16.75	83.25	**5.27**
3/8"	9.5	109.85		14.44	31.18	68.82	**4.36**
#4	4.75	127.88		16.80	47.99	52.01	**3.29**
#10	2	98.07		12.89	60.87	39.13	**2.48**
#20	0.85	74.36	(**)	9.77	70.65	29.35	**1.86**
#40	0.425	40.24		5.29	75.93	24.07	**1.52**
#60	0.25	23.25		3.06	78.99	21.01	**1.33**
#140	0.106	29.97		3.94	82.93	17.07	**1.08**
#200	0.075	9.79		1.29	84.21	15.79	**1.00**
Pan	-	120.12		15.79	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/23/06 Checked By KB Date 2-28-06

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	40-50
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-27	Soil Description	**REDDISH BROWN SILTY CLAY**

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Airdried)

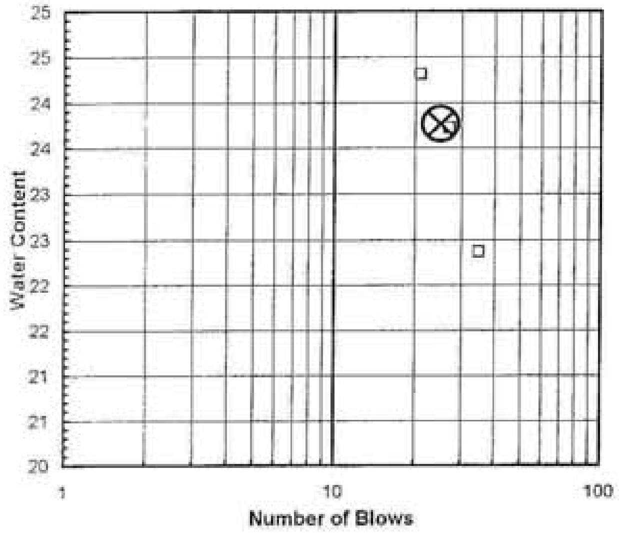
Liquid Limit Test	1	2	3	
				M
Tare Number	119	194	226	**U**
Wt. of Tare & WS (gm)	40.06	36.86	39.75	**L**
Wt. of Tare & DS (gm)	35.97	32.99	35.50	**T**
Wt. of Tare (gm)	17.68	16.67	18.02	**I**
Wt. of Water (gm)	4.1	3.9	4.3	**P**
Wt. of DS (gm)	18.3	16.3	17.5	**O**
				I
Moisture Content (%)	**22.4**	**23.7**	**24.3**	**N**
Number of Blows	**35**	**27**	**21**	**T**

Plastic Limit Test	1	2	Range
Tare Number	232	259	
Wt. of Tare & WS (gm)	24.02	25.50	
Wt. of Tare & DS (gm)	23.03	24.18	
Wt. of Tare (gm)	17.91	17.36	
Wt. of Water (gm)	1.0	1.3	
Wt. of DS (gm)	5.1	6.8	
Moisture Content (%)	**19.3**	**19.4**	**0.0**

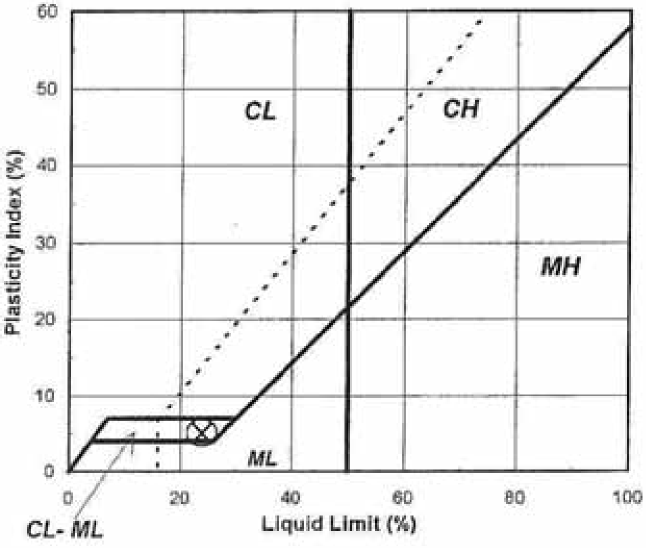
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**24**
Plastic Limit (%)	**19**
Plasticity Index (%)	**5**
USCS Symbol	**CL-ML**

Flow Curve



Plasticity Chart



Tested By BS *Date* 2/24/06 *Checked By* KyB *Date* 2-27-06

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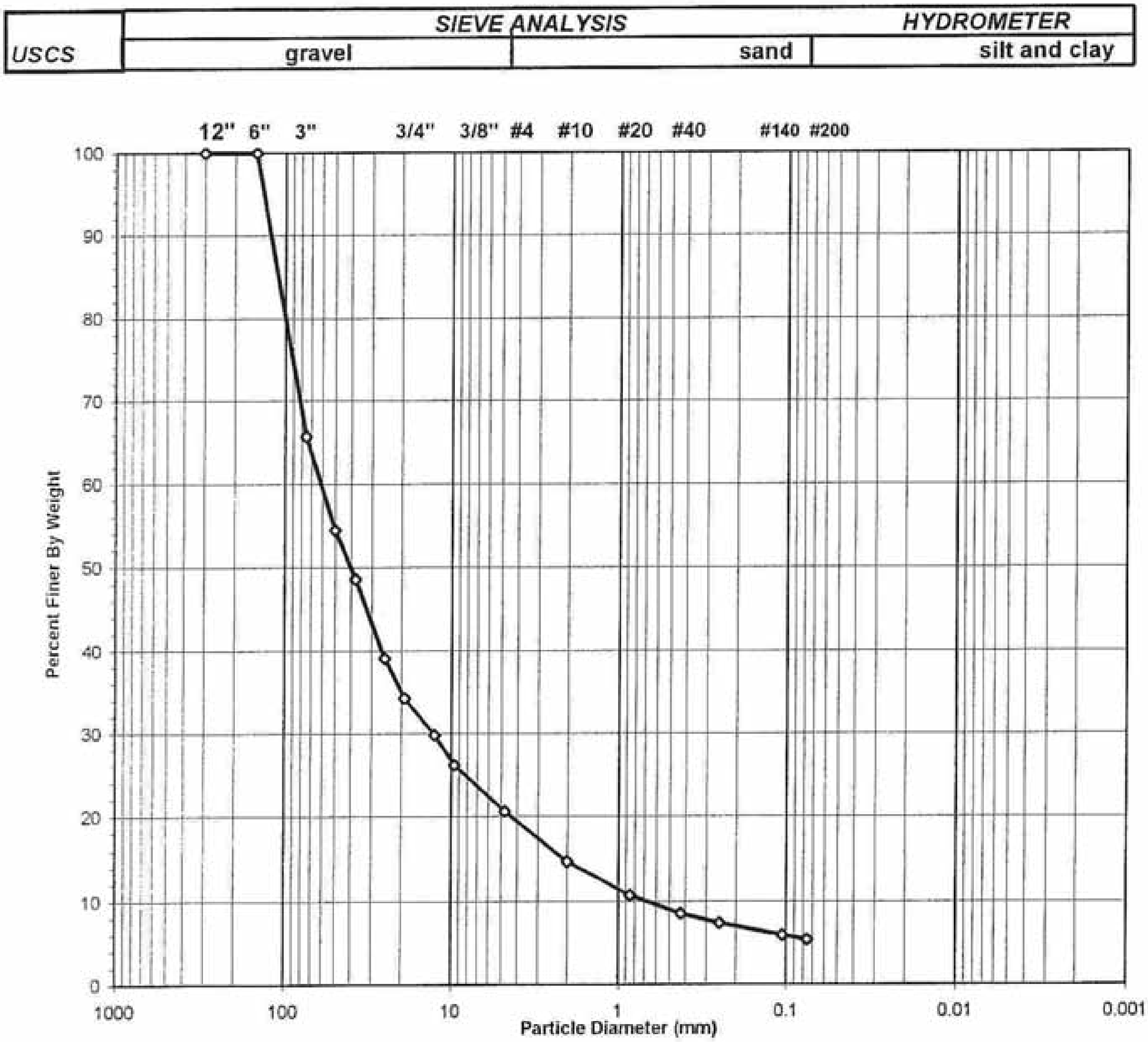
SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-60
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-28	Soil Color	**REDDISH BROWN**



USCS Symbol	*GP-GM, TESTED*	D60 =	61.0	CC =	3.9
USCS Classification	*POORLY GRADED GRAVEL WITH SILT AND SAND (NON-PLASTIC FINES)*	D30 =	12.7	CU =	90.7
		D10 =	0.7		

Tested By PC Date 2/23/06 Checked By KB Date 2-28-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-60
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-28	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	1005	Tare No.	901
Wgt.Tare + Wet Specimen (gm)	1337.20	Wgt.Tare + Wet Specimen (gm)	1064.40
Wgt.Tare + Dry Specimen (gm)	1266.90	Wgt.Tare + Dry Specimen (gm)	1054.70
Weight of Tare (gm)	100.15	Weight of Tare (gm)	110.39
Weight of Water (gm)	70.30	Weight of Water (gm)	9.70
Weight of Dry Soil (gm)	1166.75	Weight of Dry Soil (gm)	944.31
Moisture Content (%)	**6.0**	**Moisture Content (%)**	**1.0**

Wet Weight -3/4" Sample (gm)	20239	Weight of the Dry Specimen (gm)	1166.75
Dry Weight - 3/4" Sample (gm)	19088.8	Weight of minus #200 material (gm)	183.52
Wet Weight +3/4" Sample (gm)	36945.00	Weight of plus #200 material (gm)	983.23
Dry Weight + 3/4" Sample (gm)	36569.36		
Total Dry Weight Sample (gm)	55658.2	**J - Factor (Percent Finer than 3/4")**	**0.3430**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	19274.00		34.28	34.28	65.72	**65.72**
2"	50	6337.00	(*)	11.27	45.55	54.45	**54.45**
1 1/2"	37.5	3299.00		5.87	51.41	48.59	**48.59**
1"	25	5373.00		9.56	60.97	39.03	**39.03**
3/4"	19	2662.00		4.73	65.70	34.30	**34.30**
1/2"	12.5	152.98		13.11	13.11	86.89	**29.80**
3/8"	9.5	122.09		10.46	23.58	76.42	**26.21**
#4	4.75	190.74		16.35	39.92	60.08	**20.60**
#10	2	201.50		17.27	57.19	42.81	**14.68**
#20	0.85	134.16	(**)	11.50	68.69	31.31	**10.74**
#40	0.425	74.52		6.39	75.08	24.92	**8.55**
#60	0.25	39.08		3.35	78.43	21.57	**7.40**
#140	0.106	50.48		4.33	82.76	17.24	**5.91**
#200	0.075	17.68		1.52	84.27	15.73	**5.39**
Pan	-	183.52		15.73	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/23/06 Checked By KB Date 2-28-06

geotechnics
INTEGRITY IN TESTING

ATTERBERG LIMIT

ASTM D 4318-00 (SOP - S4)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-60
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-28	Visual Description	**REDDISH BROWN SILT** (Minus No. 40 sieve material, Airdried)

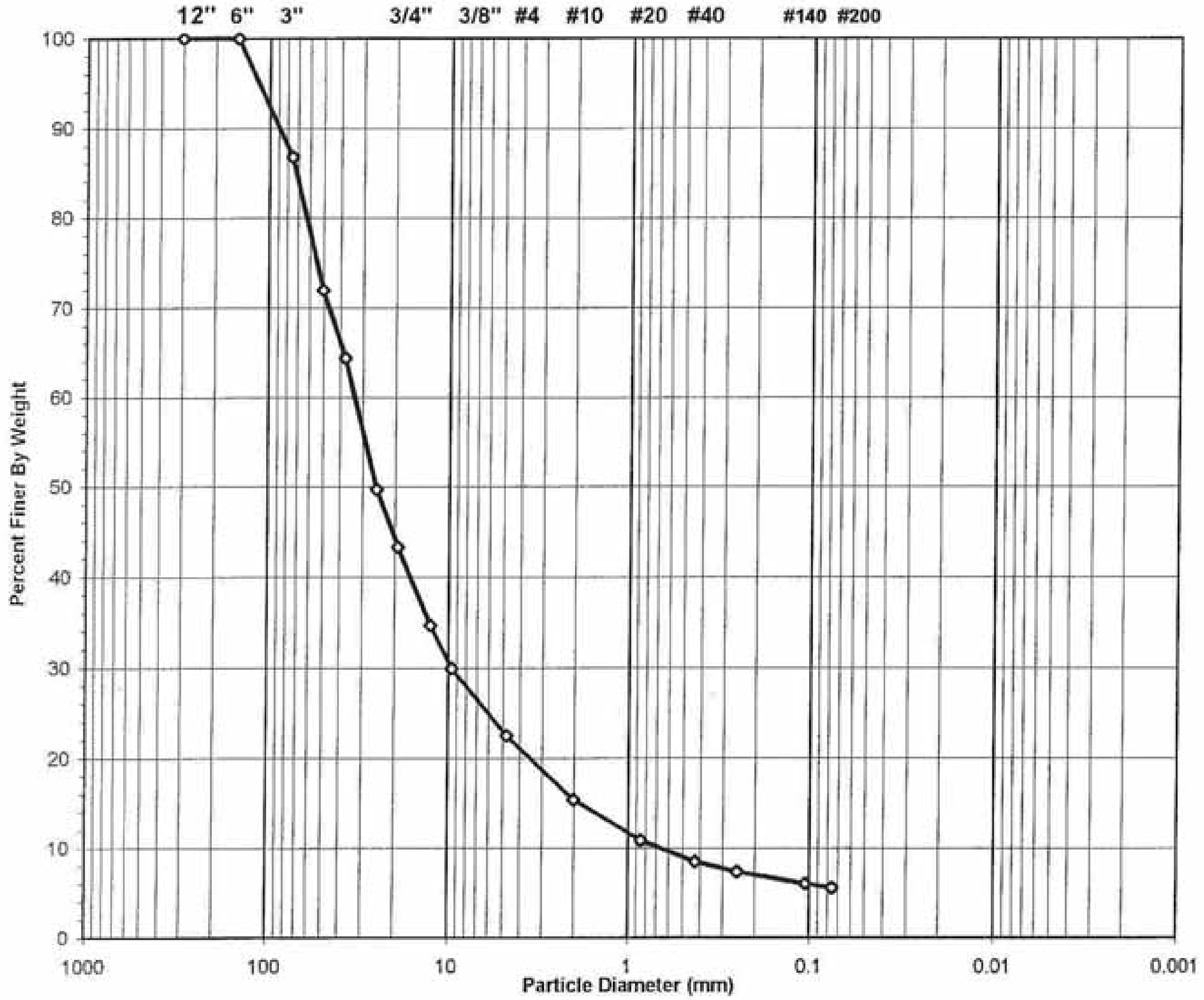
NON - PLASTIC MATERIAL

Tested By BS *Date* 2/24/06 *Checked By* YKB *Date* 2-27-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	60-70
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-29	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		HYDROMETER
USCS	gravel	sand	silt and clay



USCS Symbol ***GP-GM, TESTED***

USCS Classification ***POORLY GRADED GRAVEL WITH SILT AND SAND (NON-PLASTIC FINES)***

D60 = 33.2
CC = 4.1
D30 = 9.5
CU = 49.7
D10 = 0.7

Tested By PC Date 2/23/06 Checked By KB Date 3-8-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	60-70
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-29	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	705	Tare No.	898
Wgt.Tare + Wet Specimen (gm)	1420.10	Wgt.Tare + Wet Specimen (gm)	440.01
Wgt.Tare + Dry Specimen (gm)	1346.40	Wgt.Tare + Dry Specimen (gm)	432.66
Weight of Tare (gm)	101.30	Weight of Tare (gm)	110.00
Weight of Water (gm)	73.70	Weight of Water (gm)	7.35
Weight of Dry Soil (gm)	1245.10	Weight of Dry Soil (gm)	322.66
Moisture Content (%)	**5.9**	**Moisture Content (%)**	**2.3**

Wet Weight -3/4" Sample (gm)	19959	Weight of the Dry Specimen (gm)	1245.10
Dry Weight - 3/4" Sample (gm)	18843.6	Weight of minus #200 material (gm)	159.37
Wet Weight +3/4" Sample (gm)	25301.00	Weight of plus #200 material (gm)	1085.73
Dry Weight + 3/4" Sample (gm)	24737.49		
Total Dry Weight Sample (gm)	43581.1	**J - Factor (Percent Finer than 3/4")**	**0.4324**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	5871.00		13.17	13.17	86.83	**86.83**
2"	50	6609.00	(*)	14.83	28.00	72.00	**72.00**
1 1/2"	37.5	3379.00		7.58	35.58	64.42	**64.42**
1"	25	6596.00		14.80	50.38	49.62	**49.62**
3/4"	19	2846.00		6.38	56.76	43.24	**43.24**
1/2"	12.5	247.73		19.90	19.90	80.10	**34.64**
3/8"	9.5	134.58		10.81	30.71	69.29	**29.96**
#4	4.75	213.52		17.15	47.85	52.15	**22.55**
#10	2	206.62		16.59	64.45	35.55	**15.37**
#20	0.85	131.31	(**)	10.55	74.99	25.01	**10.81**
#40	0.425	67.27		5.40	80.40	19.60	**8.48**
#60	0.25	32.74		2.63	83.03	16.97	**7.34**
#140	0.106	39.17		3.15	86.17	13.83	**5.98**
#200	0.075	12.79		1.03	87.20	12.80	**5.53**
Pan	-	159.37		12.80	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/23/06 Checked By KB Date 3-8-06

geotechnics
INTEGRITY IN TESTING

ATTERBERG LIMIT

ASTM D 4318-00 (SOP - S4)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	60-70
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-29	Visual Description	**REDDISH BROWN SILT** (Minus No. 40 sieve material, Airdried)

NON - PLASTIC MATERIAL

Tested By	*BS*	*Date*	*3/1/06*	*Checked By*	KYB	*Date*	3-7-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	70-80
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-30	Soil Color	**BROWN**

USCS Symbol ***GP, TESTED***

USCS Classification ***POORLY GRADED GRAVEL***

Tested By PC Date 2/23/06 Checked By KB Date 2-28-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	70-80
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-30	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	2471	Tare No.	913
Wgt.Tare + Wet Specimen (gm)	1267.80	Wgt.Tare + Wet Specimen (gm)	551.71
Wgt.Tare + Dry Specimen (gm)	1192.40	Wgt.Tare + Dry Specimen (gm)	546.61
Weight of Tare (gm)	100.33	Weight of Tare (gm)	110.77
Weight of Water (gm)	75.40	Weight of Water (gm)	5.10
Weight of Dry Soil (gm)	1092.07	Weight of Dry Soil (gm)	435.84
Moisture Content (%)	**6.9**	**Moisture Content (%)**	**1.2**

Wet Weight -3/4" Sample (gm)	3360	Weight of the Dry Specimen (gm)	1092.07
Dry Weight - 3/4" Sample (gm)	3143.0	Weight of minus #200 material (gm)	260.17
Wet Weight +3/4" Sample (gm)	31781.00	Weight of plus #200 material (gm)	831.90
Dry Weight + 3/4" Sample (gm)	31413.41		
Total Dry Weight Sample (gm)	34556.4	**J - Factor (Percent Finer than 3/4")**	**0.0910**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	24758.00		70.82	70.82	29.18	**29.18**
2"	50	2908.00	(*)	8.32	79.13	20.87	**20.87**
1 1/2"	37.5	1696.00		4.85	83.99	16.01	**16.01**
1"	25	1833.00		5.24	89.23	10.77	**10.77**
3/4"	19	586.00		1.68	90.90	9.10	**9.10**
1/2"	12.5	101.71		9.31	9.31	90.69	**8.25**
3/8"	9.5	58.99		5.40	14.72	85.28	**7.76**
#4	4.75	143.89		13.18	27.89	72.11	**6.56**
#10	2	179.73		16.46	44.35	55.65	**5.06**
#20	0.85	144.15	(**)	13.20	57.55	42.45	**3.86**
#40	0.425	85.43		7.82	65.37	34.63	**3.15**
#60	0.25	43.60		3.99	69.36	30.64	**2.79**
#140	0.106	54.52		4.99	74.36	25.64	**2.33**
#200	0.075	19.88		1.82	76.18	23.82	**2.17**
Pan	-	260.17		23.82	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/23/06 Checked By YKB Date 2-28-06

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	70-80
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-30	Soil Description	**BROWN SILTY CLAY**

***Note:* The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.** (Minus No. 40 sieve material, Airdried)

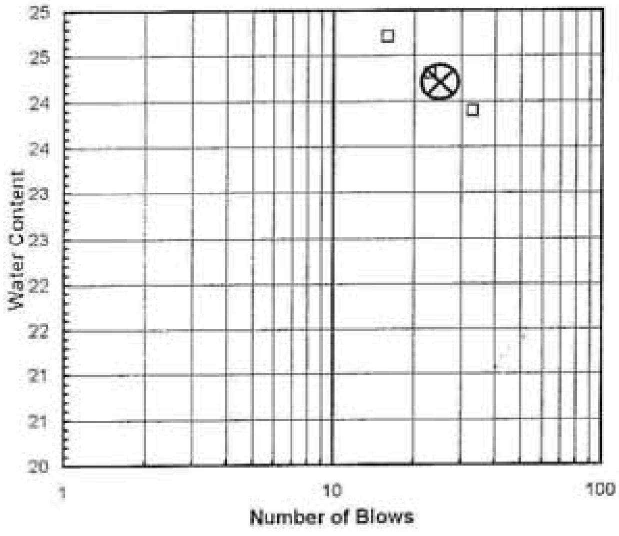
Liquid Limit Test	**1**	**2**	**3**	
				M
Tare Number	O	40A	142	**U**
Wt. of Tare & WS (gm)	42.80	45.04	48.47	**L**
Wt. of Tare & DS (gm)	38.43	39.64	42.94	**T**
Wt. of Tare (gm)	20.14	17.42	20.56	**I**
Wt. of Water (gm)	4.4	5.4	5.5	**P**
Wt. of DS (gm)	18.3	22.2	22.4	**O**
				I
Moisture Content (%)	**23.9**	**24.3**	**24.7**	**N**
Number of Blows	**33**	**23**	**16**	**T**

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	209	213	
Wt. of Tare & WS (gm)	23.71	24.93	
Wt. of Tare & DS (gm)	22.79	24.05	
Wt. of Tare (gm)	17.42	18.88	
Wt. of Water (gm)	0.9	0.9	
Wt. of DS (gm)	5.4	5.2	
Moisture Content (%)	**17.1**	**17.0**	**0.1**

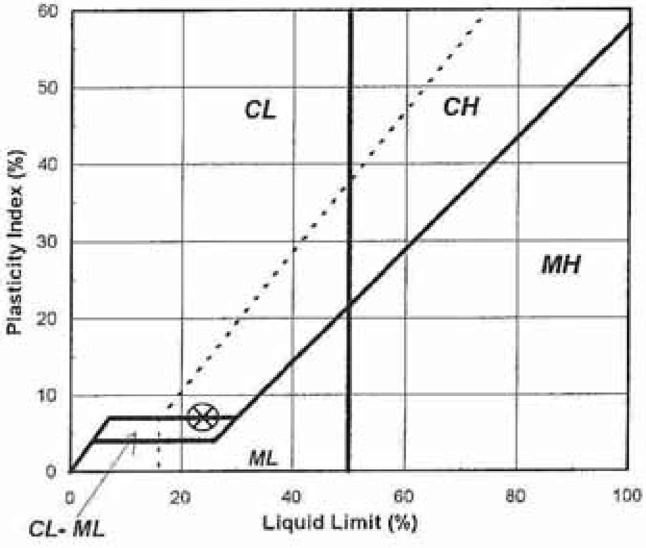
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**24**
Plastic Limit (%)	**17**
Plasticity Index (%)	**7**
USCS Symbol	**CL-ML**

Flow Curve



Plasticity Chart

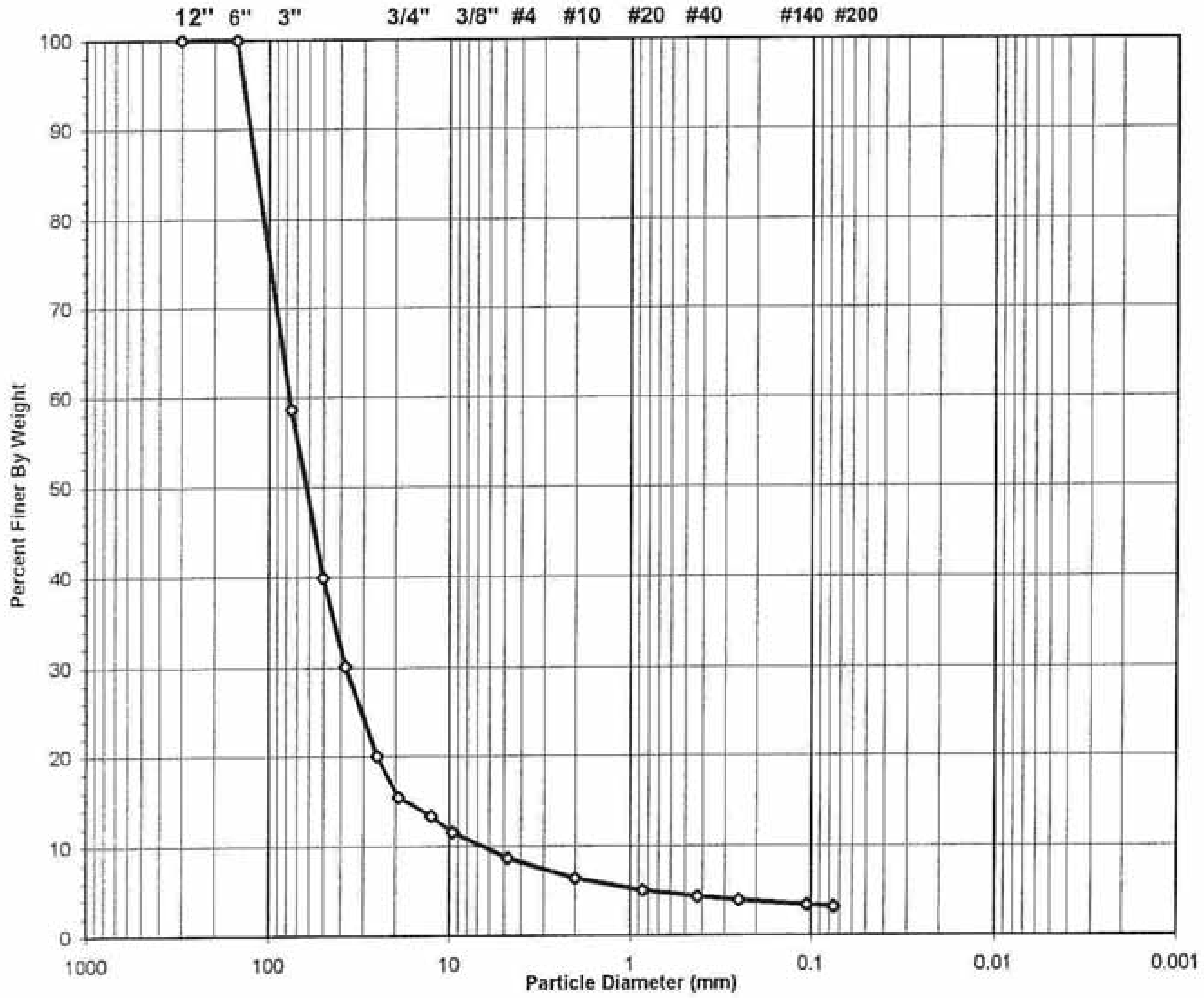


Tested By BS *Date* 2/24/06 *Checked By* YKB *Date* 2-27-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	80-90
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-31	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		***HYDROMETER***
USCS	**gravel**	**sand**	**silt and clay**



USCS Symbol ***gp, ASSUMED***

USCS Classification ***POORLY GRADED GRAVEL***

Tested By PC Date 2/23/06 Checked By KYB Date 2-24-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	80-90
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-31	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	635	Tare No.	888
Wgt.Tare + Wet Specimen (gm)	1300.70	Wgt.Tare + Wet Specimen (gm)	538.89
Wgt.Tare + Dry Specimen (gm)	1196.70	Wgt.Tare + Dry Specimen (gm)	521.60
Weight of Tare (gm)	100.06	Weight of Tare (gm)	110.50
Weight of Water (gm)	104.00	Weight of Water (gm)	17.29
Weight of Dry Soil (gm)	1096.64	Weight of Dry Soil (gm)	411.10
Moisture Content (%)	**9.5**	**Moisture Content (%)**	**4.2**

Wet Weight -3/4" Sample (gm)	3647	Weight of the Dry Specimen (gm)	1096.64
Dry Weight - 3/4" Sample (gm)	3331.1	Weight of minus #200 material (gm)	220.08
Wet Weight +3/4" Sample (gm)	19023.00	Weight of plus #200 material (gm)	876.56
Dry Weight + 3/4" Sample (gm)	18255.22		
Total Dry Weight Sample (gm)	21586.3	**J - Factor (Percent Finer than 3/4")**	**0.1543**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	9316.00		41.42	41.42	58.58	**58.58**
2"	50	4196.00	(*)	18.65	60.07	39.93	**39.93**
1 1/2"	37.5	2200.00		9.78	69.85	30.15	**30.15**
1"	25	2282.00		10.14	79.99	20.01	**20.01**
3/4"	19	1029.00		4.57	84.57	15.43	**15.43**
1/2"	12.5	144.02		13.13	13.13	86.87	**13.40**
3/8"	9.5	130.48		11.90	25.03	74.97	**11.57**
#4	4.75	205.87		18.77	43.80	56.20	**8.67**
#10	2	163.33		14.89	58.70	41.30	**6.37**
#20	0.85	100.28	(**)	9.14	67.84	32.16	**4.96**
#40	0.425	51.36		4.68	72.53	27.47	**4.24**
#60	0.25	26.55		2.42	74.95	25.05	**3.87**
#140	0.106	38.27		3.49	78.44	21.56	**3.33**
#200	0.075	16.40		1.50	79.93	20.07	**3.10**
Pan	-	220.08		20.07	100.00	-	-

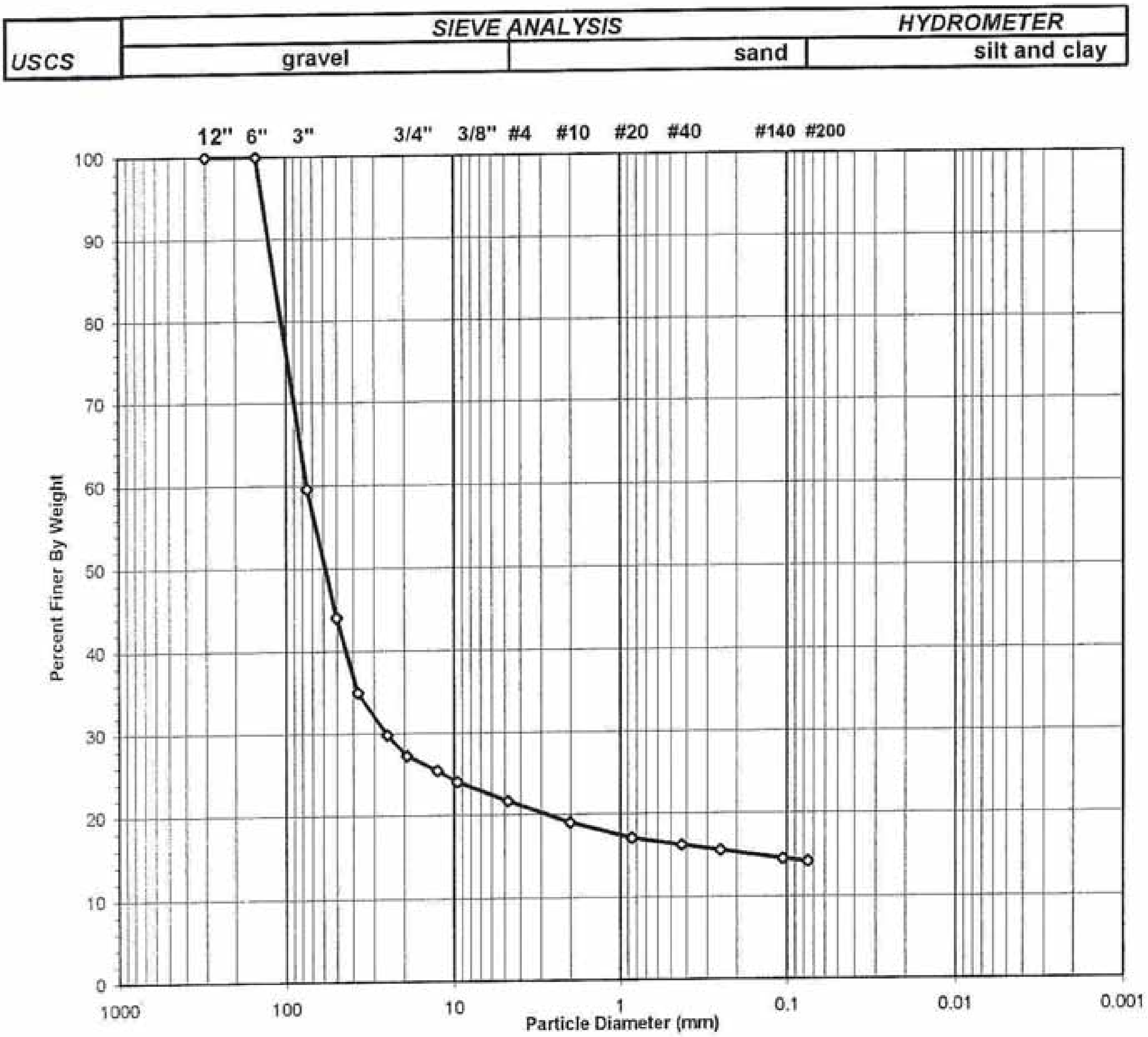
Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By	PC	Date	2/23/06	Checked By		Date	2-24-06

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	90-95.7
Project No.	2006-060-01	Sample No.	S-10
Lab ID	2006-060-01-32	Soil Color	**REDDISH BROWN**



USCS Symbol ***GC, TESTED***

USCS Classification ***CLAYEY GRAVEL***

Tested By PC Date 2/23/06 Checked By KB Date 2-28-06

page 1 of 2

DCN: CT-S3A DATE 6-25-98 REVISION 2

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INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	90-95.7
Project No.	2006-060-01	Sample No.	S-10
Lab ID	2006-060-01-32	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	1913	Tare No.	882
Wgt.Tare + Wet Specimen (gm)	1169.40	Wgt.Tare + Wet Specimen (gm)	1038.30
Wgt.Tare + Dry Specimen (gm)	1020.90	Wgt.Tare + Dry Specimen (gm)	1015.20
Weight of Tare (gm)	101.80	Weight of Tare (gm)	110.42
Weight of Water (gm)	148.50	Weight of Water (gm)	23.10
Weight of Dry Soil (gm)	919.10	Weight of Dry Soil (gm)	904.78
Moisture Content (%)	**16.2**	**Moisture Content (%)**	**2.6**

Wet Weight -3/4" Sample (gm)	9783	Weight of the Dry Specimen (gm)	919.10
Dry Weight - 3/4" Sample (gm)	8422.2	Weight of minus #200 material (gm)	476.71
Wet Weight +3/4" Sample (gm)	23029.00	Weight of plus #200 material (gm)	442.39
Dry Weight + 3/4" Sample (gm)	22455.68		
Total Dry Weight Sample (gm)	30877.9	**J - Factor (Percent Finer than 3/4")**	**0.2728**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	12787.00		40.38	40.38	59.62	**59.62**
2"	50	4926.00	(*)	15.56	55.94	44.06	**44.06**
1 1/2"	37.5	2892.00		9.13	65.07	34.93	**34.93**
1"	25	1621.00		5.12	70.19	29.81	**29.81**
3/4"	19	803.00		2.54	72.72	27.28	**27.28**
1/2"	12.5	60.60		6.59	6.59	93.41	**25.48**
3/8"	9.5	46.17		5.02	11.62	88.38	**24.11**
#4	4.75	80.87		8.80	20.42	79.58	**21.71**
#10	2	89.52		9.74	30.16	69.84	**19.05**
#20	0.85	65.11	(**)	7.08	37.24	62.76	**17.12**
#40	0.425	30.46		3.31	40.55	59.45	**16.21**
#60	0.25	21.74		2.37	42.92	57.08	**15.57**
#140	0.106	35.00		3.81	46.73	53.27	**14.53**
#200	0.075	12.92		1.41	48.13	51.87	**14.15**
Pan	-	476.71		51.87	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/23/06 Checked By KR Date 2-28-06

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-3
Client Reference	TAUM SAUK 06-3551	Depth (ft)	90-95.7
Project No.	2006-060-01	Sample No.	S-10
Lab ID	2006-060-01-32	Soil Description	**REDDISH BROWN LEAN CLAY**

(Minus No. 40 sieve material, Airdried)

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

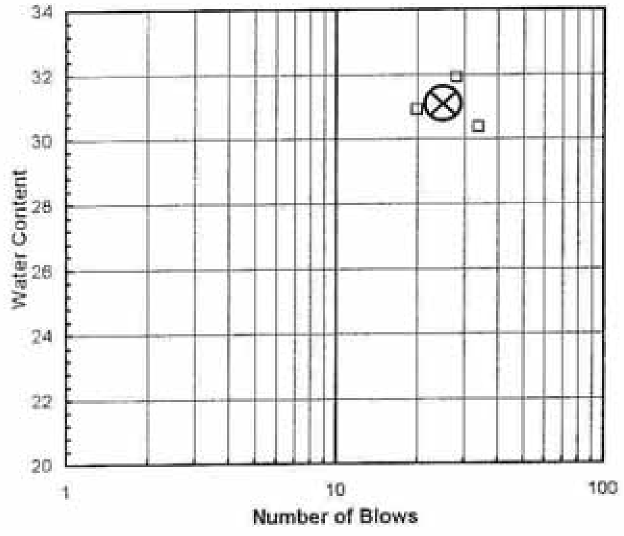
Liquid Limit Test	**1**	**2**	**3**	
				M
Tare Number	44	12	37	**U**
Wt. of Tare & WS (gm)	39.99	41.33	35.99	**L**
Wt. of Tare & DS (gm)	34.41	35.07	30.99	**T**
Wt. of Tare (gm)	16.02	15.44	14.81	**I**
Wt. of Water (gm)	5.6	6.3	5.0	**P**
Wt. of DS (gm)	18.4	19.6	16.2	**O**
				I
Moisture Content (%)	**30.3**	**31.9**	**30.9**	**N**
Number of Blows	**34**	**28**	**20**	**T**

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	2298	2305	
Wt. of Tare & WS (gm)	24.12	26.79	
Wt. of Tare & DS (gm)	23.18	25.91	
Wt. of Tare (gm)	17.92	20.94	
Wt. of Water (gm)	0.9	0.9	
Wt. of DS (gm)	5.3	5.0	
Moisture Content (%)	**17.9**	**17.7**	**0.2**

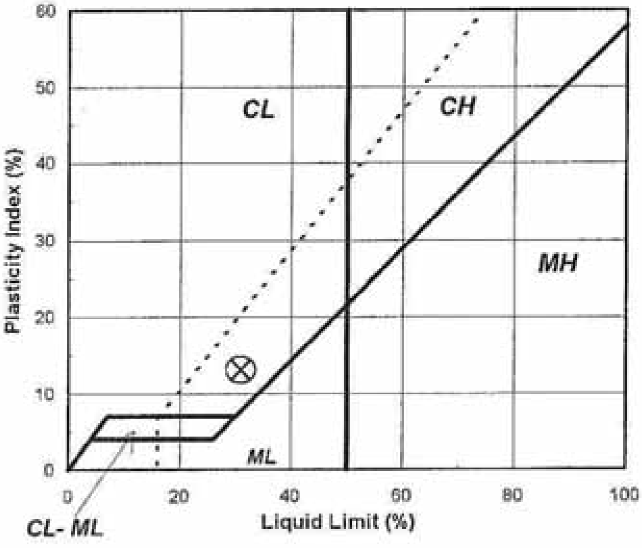
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**31**
Plastic Limit (%)	**18**
Plasticity Index (%)	**13**
USCS Symbol	**CL**

Flow Curve



Plasticity Chart



Tested By JP *Date* 2/24/06 *Checked By* KVB *Date* 2-27-06

BORING TS-4

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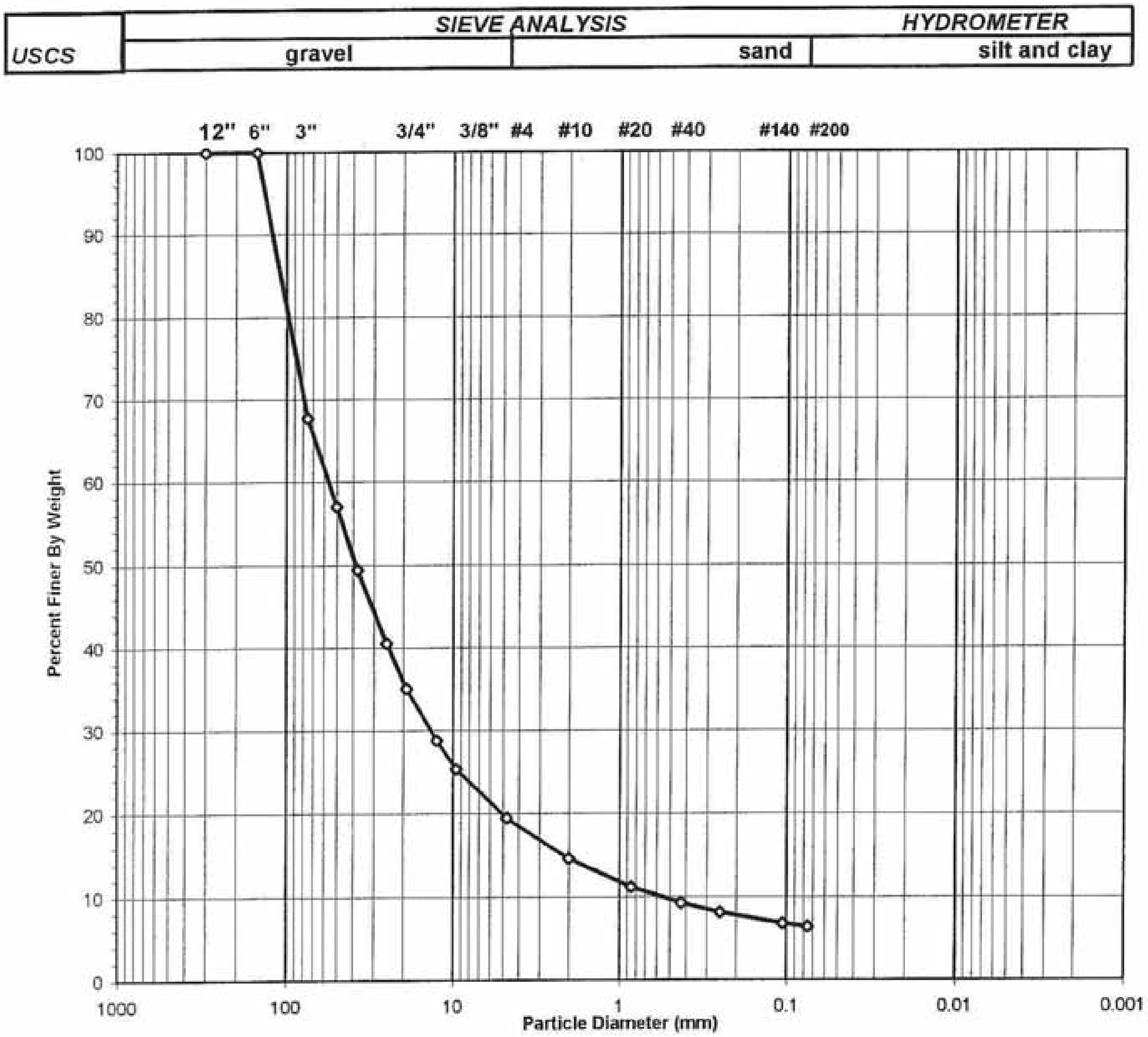
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-33	Soil Color	**REDDISH GRAY**



USCS Symbol	*gp-gm, ASSUMED*	**D60 =**	**55.9**	**CC =**	**5.8**
USCS Classification	*POORLY GRADED GRAVEL WITH SILT*	**D30 =**	**13.5**	**CU =**	**99.4**
		D10 =	**0.6**		

Tested By JP Date 2/20/06 Checked By KYB Date 2-20-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-33	Soil Color	**REDDISH GRAY**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	934	Tare No.	973
Wgt.Tare + Wet Specimen (gm)	1078.50	Wgt.Tare + Wet Specimen (gm)	1043.20
Wgt.Tare + Dry Specimen (gm)	1013.90	Wgt.Tare + Dry Specimen (gm)	1024.20
Weight of Tare (gm)	189.56	Weight of Tare (gm)	102.34
Weight of Water (gm)	64.60	Weight of Water (gm)	19.00
Weight of Dry Soil (gm)	824.34	Weight of Dry Soil (gm)	921.86
Moisture Content (%)	**7.8**	**Moisture Content (%)**	**2.1**

Wet Weight -3/4" Sample (gm)	18552	Weight of the Dry Specimen (gm)	824.34
Dry Weight - 3/4" Sample (gm)	17203.8	Weight of minus #200 material (gm)	150.90
Wet Weight +3/4" Sample (gm)	32506.00	Weight of plus #200 material (gm)	673.44
Dry Weight + 3/4" Sample (gm)	31849.56		
Total Dry Weight Sample (gm)	49053.4	**J - Factor (Percent Finer than 3/4")**	**0.3507**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	16145.00		32.25	32.25	67.75	**67.75**
2"	50	5368.00	(*)	10.72	42.97	57.03	**57.03**
1 1/2"	37.5	3803.00		7.60	50.57	49.43	**49.43**
1"	25	4450.00		8.89	59.46	40.54	**40.54**
3/4"	19	2740.00		5.47	64.93	35.07	**35.07**
1/2"	12.5	147.52		17.90	17.90	82.10	**28.80**
3/8"	9.5	80.88		9.81	27.71	72.29	**25.35**
#4	4.75	137.63		16.70	44.40	55.60	**19.50**
#10	2	114.15		13.85	58.25	41.75	**14.64**
#20	0.85	82.17	(**)	9.97	68.22	31.78	**11.15**
#40	0.425	45.25		5.49	73.71	26.29	**9.22**
#60	0.25	26.33		3.19	76.90	23.10	**8.10**
#140	0.106	30.73		3.73	80.63	19.37	**6.79**
#200	0.075	8.78		1.07	81.69	18.31	**6.42**
Pan	-	150.90		18.31	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/20/06 Checked By AB Date 2-20-06

RIGID WALL CONSTANT HEAD PERMEABILITY

ASTM D 2434-68 (SOP-S35) Modified

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 03-3551	Depth(ft.)	0-20
Project No.	2006-060-02	Sample No.	S1+S2A,B,C
Lab ID	2006-060-02-02	Visual Description	BROWN CLAYEY SAND AND ROCK FRAGMENTS

Unit Weight

Wt. of Wet Material (gm)	15558
Average Length (in)	11.6
Permeameter Diameter (in)	7.5
Sample Volume (cc)	8426.9
Unit Dry Weight (gm/cc)	1.75
Unit Dry Weight (pcf)	109.1

Water Content

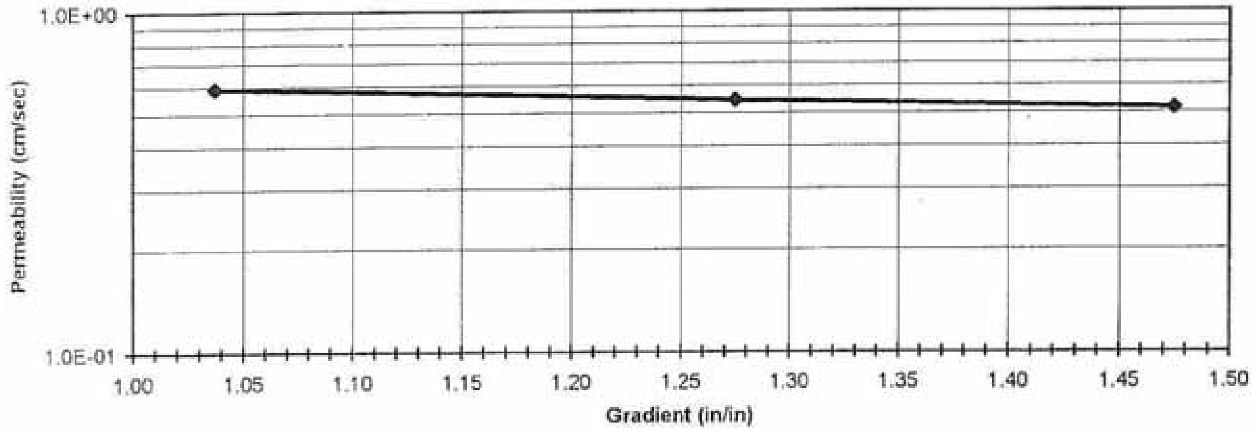
Tare Number	915
Wt. of Tare & Wet Mat.(gm)	674.20
Wt. of Tare & Dry Mat.(gm)	644.20
Wt. of Tare (gm)	110.17
Wt. Water (gm)	30.00
Wt. of Dry Material (gm)	534.03

	Test 1	Test 2	Test 3
Piezometer Spacing (in)	*8*	*8*	*8*
Temperature (° C)	*20.3*	*20.5*	*20.5*
Temp. Correction Factor	*0.9926*	*0.9879*	*0.9879*

Water Content (%) **5.6** *(Measured)*

Load (psf) **NA**

Test No.	Replicate No.	Head (in)	Gradient (in/in)	Elapsed Time (sec)	Collection Tube (divisions)	Collected Volume (cc)	Permeability 20° C (cm/s)	Average Permeability (cm/s)
1	1	8.30	1.04	40.9	5	7220.5	5.9E-01	
1	2	8.30	1.04	40.8	5	7220.5	5.9E-01	**5.9E-01**
1	3	8.30	1.04	41.1	5	7220.5	5.9E-01	
2	1	10.20	1.28	36.1	5	7220.5	5.4E-01	
2	2	10.20	1.28	36.2	5	7220.5	5.4E-01	**5.4E-01**
2	3	10.20	1.28	36.1	5	7220.5	5.4E-01	
3	1	11.80	1.48	32.8	5	7220.5	5.2E-01	
3	2	11.80	1.48	33.0	5	7220.5	5.1E-01	**5.1E-01**
3	3	11.80	1.48	33.1	5	7220.5	5.1E-01	



Tested By DDA Date 2/24/06 Checked By KB Date 3-2-06

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	10-13
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-34	Soil Color	**REDDISH GRAY**

<table>
<tr><td rowspan="2"><i>USCS</i></td><td colspan="2"><i>SIEVE ANALYSIS</i></td><td><i>HYDROMETER</i></td></tr>
<tr><td>gravel</td><td>sand</td><td>silt and clay</td></tr>
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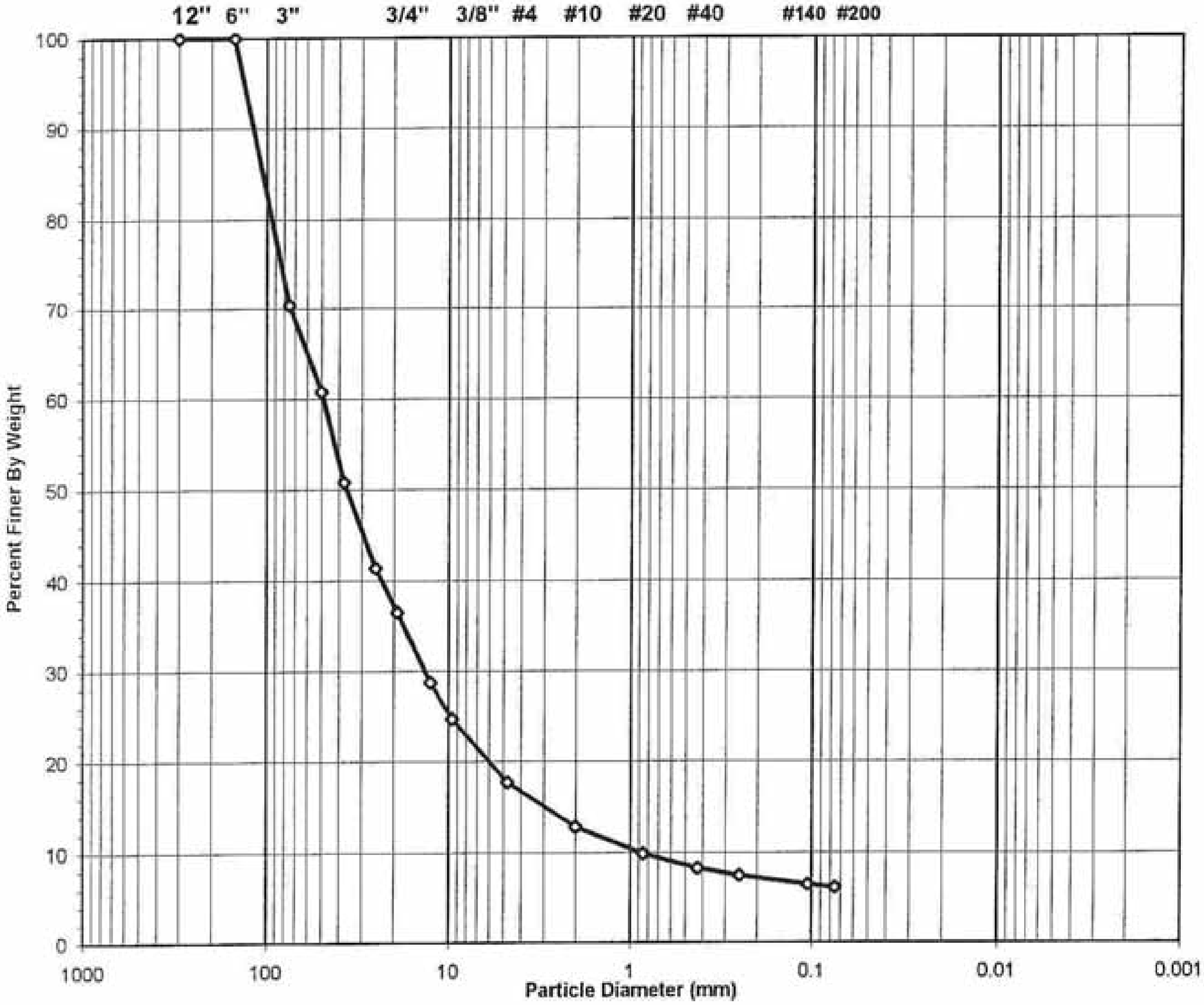

USCS Symbol	*gp-gm, ASSUMED*	D60 =	48.8	CC =	4.1
USCS Classification	*POORLY GRADED GRAVEL WITH SILT*	D30 =	13.4	CU =	55.1
		D10 =	0.9		

Tested By JP Date 2/20/06 Checked By KVB Date 2-20-06

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	10-13
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-34	Soil Color	**REDDISH GRAY**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	697	Tare No.	915
Wgt.Tare + Wet Specimen (gm)	1284.10	Wgt.Tare + Wet Specimen (gm)	716.20
Wgt.Tare + Dry Specimen (gm)	1205.00	Wgt.Tare + Dry Specimen (gm)	703.70
Weight of Tare (gm)	101.40	Weight of Tare (gm)	110.21
Weight of Water (gm)	79.10	Weight of Water (gm)	12.50
Weight of Dry Soil (gm)	1103.60	Weight of Dry Soil (gm)	593.49
Moisture Content (%)	**7.2**	**Moisture Content (%)**	**2.1**

Wet Weight -3/4" Sample (gm)	9039	Weight of the Dry Specimen (gm)	1103.60
Dry Weight - 3/4" Sample (gm)	8434.5	Weight of minus #200 material (gm)	184.46
Wet Weight +3/4" Sample (gm)	15012.00	Weight of plus #200 material (gm)	919.14
Dry Weight + 3/4" Sample (gm)	14702.34		
Total Dry Weight Sample (gm)	23136.8	**J - Factor (Percent Finer than 3/4")**	**0.3645**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	6997.00		29.62	29.62	70.38	**70.38**
2"	50	2254.00	(*)	9.54	39.16	60.84	**60.84**
1 1/2"	37.5	2382.00		10.08	49.24	50.76	**50.76**
1"	25	2215.00		9.38	58.62	41.38	**41.38**
3/4"	19	1164.00		4.93	63.55	36.45	**36.45**
1/2"	12.5	234.27		21.23	21.23	78.77	**28.72**
3/8"	9.5	119.39		10.82	32.05	67.95	**24.77**
#4	4.75	214.13		19.40	51.45	48.55	**17.70**
#10	2	149.40		13.54	64.99	35.01	**12.76**
#20	0.85	88.03	(**)	7.98	72.96	27.04	**9.86**
#40	0.425	48.84		4.43	77.39	22.61	**8.24**
#60	0.25	24.77		2.24	79.63	20.37	**7.42**
#140	0.106	30.12		2.73	82.36	17.64	**6.43**
#200	0.075	10.19		0.92	83.29	16.71	**6.09**
Pan	-	184.46		16.71	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/20/06 Checked By KRB Date 2-20-06

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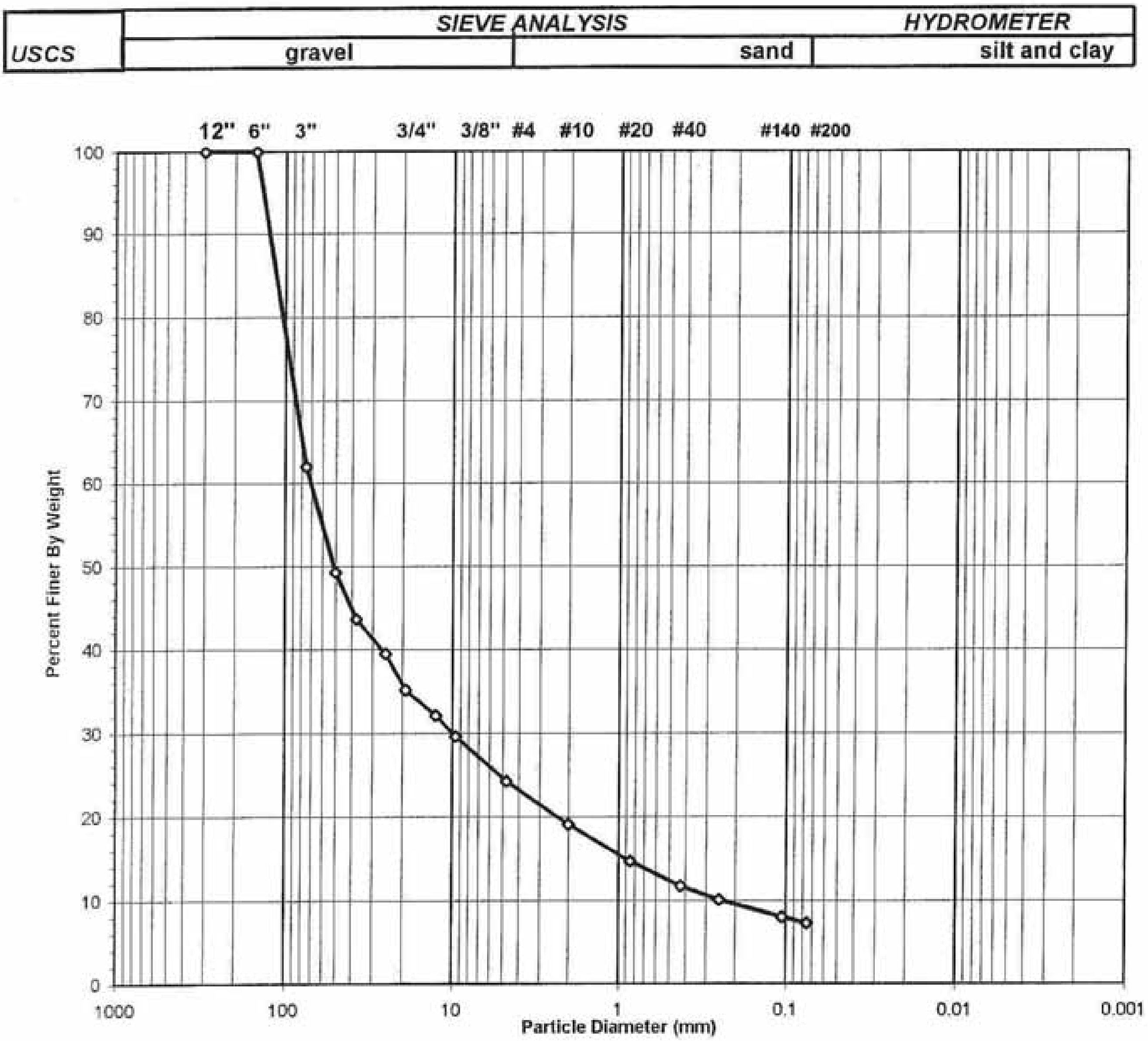
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	13-16
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-34	Soil Color	**REDDISH GRAY**



USCS Symbol	***gp-gm, ASSUMED***	**D60 =**	**70.4**	**CC =**	**5.7**
USCS Classification	***POORLY GRADED GRAVEL WITH SILT AND SAND***	**D30 =**	**9.9**	**CU =**	**289.2**
		D10 =	**0.2**		

Tested By JP Date 2/20/06 Checked By KB Date 2-20-06

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geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	13-16
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-34	Soil Color	**REDDISH GRAY**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	631	Tare No.	894
Wgt.Tare + Wet Specimen (gm)	1196.90	Wgt.Tare + Wet Specimen (gm)	701.50
Wgt.Tare + Dry Specimen (gm)	1149.30	Wgt.Tare + Dry Specimen (gm)	696.40
Weight of Tare (gm)	100.57	Weight of Tare (gm)	110.40
Weight of Water (gm)	47.60	Weight of Water (gm)	5.10
Weight of Dry Soil (gm)	1048.73	Weight of Dry Soil (gm)	586.00
Moisture Content (%)	**4.5**	**Moisture Content (%)**	**0.9**

Wet Weight -3/4" Sample (gm)	6425	Weight of the Dry Specimen (gm)	1048.73
Dry Weight - 3/4" Sample (gm)	6146.0	Weight of minus #200 material (gm)	216.95
Wet Weight +3/4" Sample (gm)	11410.00	Weight of plus #200 material (gm)	831.78
Dry Weight + 3/4" Sample (gm)	11311.55		
Total Dry Weight Sample (gm)	17457.6	**J - Factor (Percent Finer than 3/4")**	**0.3521**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	6689.00		37.99	37.99	62.01	**62.01**
2"	50	2254.00	(*)	12.80	50.78	49.22	**49.22**
1 1/2"	37.5	990.00		5.62	56.41	43.59	**43.59**
1"	25	732.00		4.16	60.56	39.44	**39.44**
3/4"	19	745.00		4.23	64.79	35.21	**35.21**
1/2"	12.5	91.08		8.68	8.68	91.32	**32.15**
3/8"	9.5	75.49		7.20	15.88	84.12	**29.61**
#4	4.75	161.42		15.39	31.27	68.73	**24.20**
#10	2	152.78		14.57	45.84	54.16	**19.07**
#20	0.85	129.64	(**)	12.36	58.20	41.80	**14.71**
#40	0.425	88.99		8.49	66.69	33.31	**11.73**
#60	0.25	49.47		4.72	71.41	28.59	**10.07**
#140	0.106	62.18		5.93	77.34	22.66	**7.98**
#200	0.075	20.73		1.98	79.31	20.69	**7.28**
Pan	-	216.95		20.69	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/20/06 Checked By Date 2-20-06

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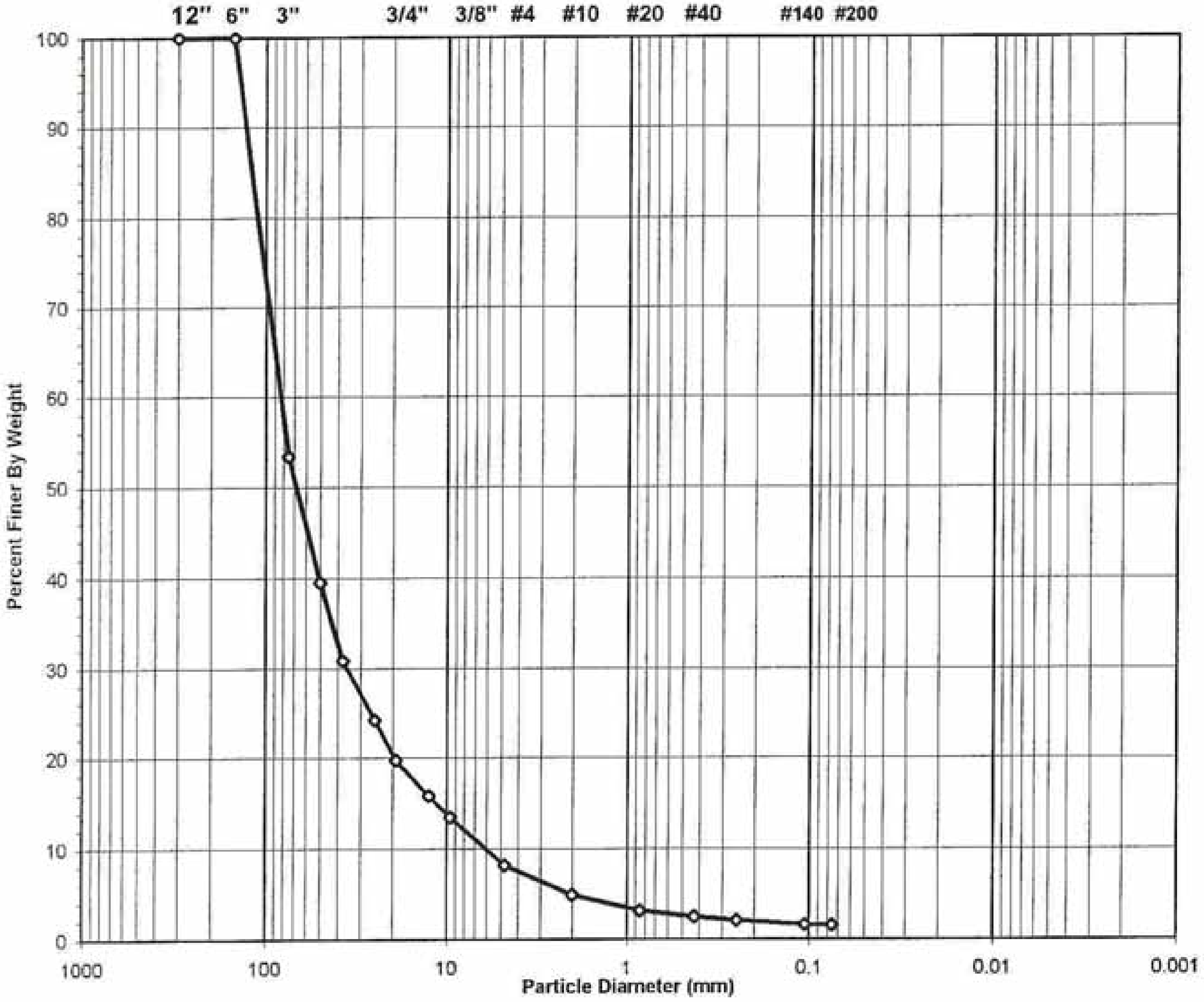
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	16-20
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-34	Soil Color	**REDDISH GRAY**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol ***gp, ASSUMED***

USCS Classification ***POORLY GRADED GRAVEL***

Tested By JP Date 2/20/06 Checked By Date 2-20-06

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INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	16-20
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-34	Soil Color	**REDDISH GRAY**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	1920	Tare No.	927
Wgt.Tare + Wet Specimen (gm)	1359.30	Wgt.Tare + Wet Specimen (gm)	1327.30
Wgt.Tare + Dry Specimen (gm)	1274.00	Wgt.Tare + Dry Specimen (gm)	1314.90
Weight of Tare (gm)	100.08	Weight of Tare (gm)	102.84
Weight of Water (gm)	85.30	Weight of Water (gm)	12.40
Weight of Dry Soil (gm)	1173.92	Weight of Dry Soil (gm)	1212.06
Moisture Content (%)	7.3	**Moisture Content (%)**	1.0

Wet Weight -3/4" Sample (gm)	11273	Weight of the Dry Specimen (gm)	1173.92
Dry Weight - 3/4" Sample (gm)	10509.4	Weight of minus #200 material (gm)	89.46
Wet Weight +3/4" Sample (gm)	43119.00	Weight of plus #200 material (gm)	1084.46
Dry Weight + 3/4" Sample (gm)	42682.34		
Total Dry Weight Sample (gm)	53191.7	**J - Factor (Percent Finer than 3/4")**	**0.1976**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	25053.00		46.62	46.62	53.38	**53.38**
2"	50	7441.00	(*)	13.85	60.47	39.53	**39.53**
1 1/2"	37.5	4638.00		8.63	69.10	30.90	**30.90**
1"	25	3605.00		6.71	75.81	24.19	**24.19**
3/4"	19	2382.00		4.43	80.24	19.76	**19.76**
1/2"	12.5	231.96		19.76	19.76	80.24	**15.85**
3/8"	9.5	141.99		12.10	31.85	68.15	**13.46**
#4	4.75	318.58		27.14	58.99	41.01	**8.10**
#10	2	194.61		16.58	75.57	24.43	**4.83**
#20	0.85	99.82	(**)	8.50	84.07	15.93	**3.15**
#40	0.425	41.52		3.54	87.61	12.39	**2.45**
#60	0.25	22.29		1.90	89.51	10.49	**2.07**
#140	0.106	26.32		2.24	91.75	8.25	**1.63**
#200	0.075	7.37		0.63	92.38	7.62	**1.51**
Pan	-	89.46		7.62	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/20/06 Checked By Date 2-20-06

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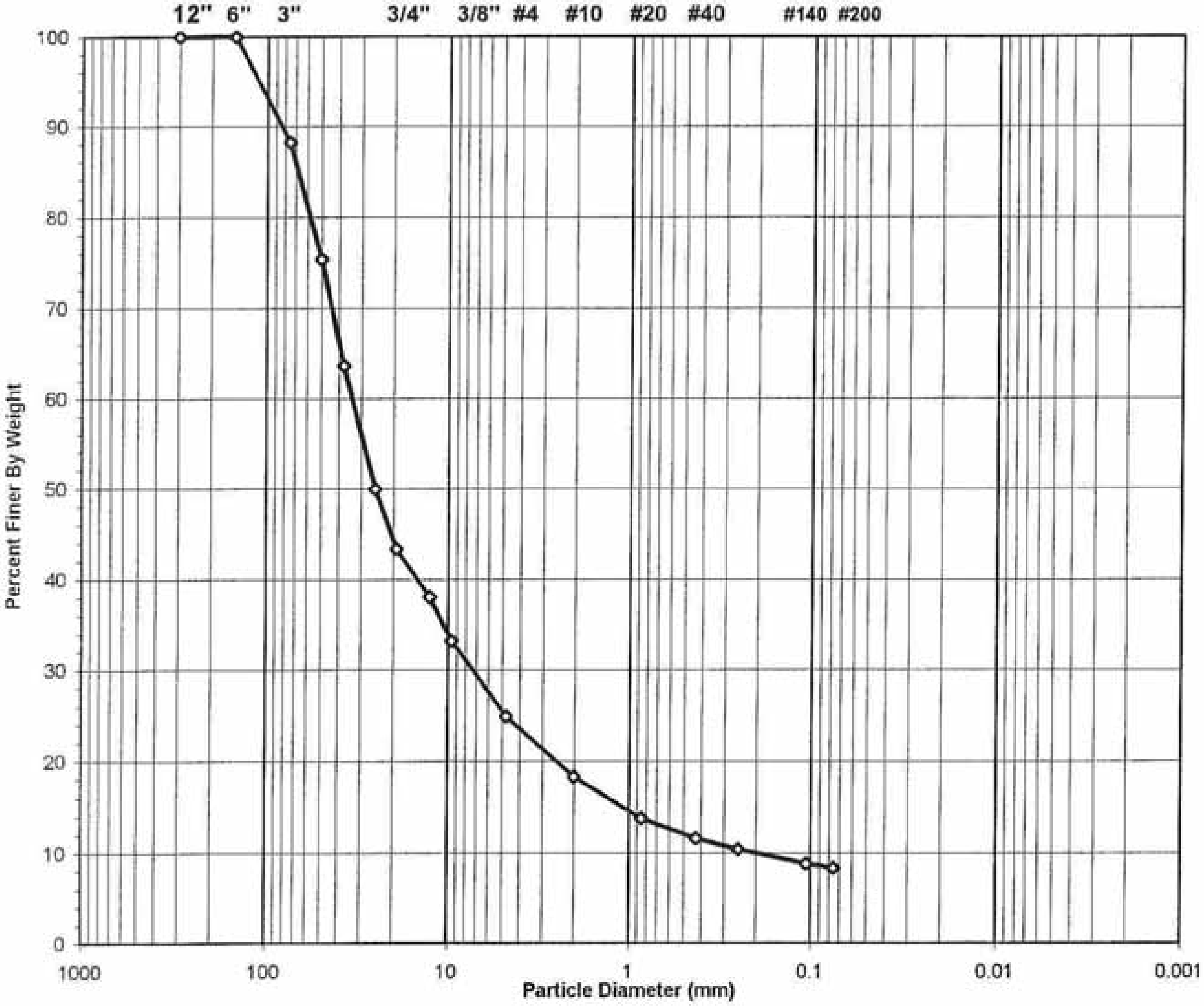
INTEGRITY IN TESTING

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-35	Soil Color	**REDDISH GRAY**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol ***gp-gm, ASSUMED***

USCS Classification ***POORLY GRADED GRAVEL WITH SILT AND SAND***

D60 = **33.7** **CC =** **7.7**

D30 = **7.3** **CU =** **164.9**

D10 = **0.2**

Tested By JP Date 2/20/06 Checked By KYB Date 2-20-06

page 1 of 2

DCN: CT-S3A DATE 6-26-98 REVISION 2

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-35	Soil Color	**REDDISH GRAY**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	2334	Tare No.	902
Wgt.Tare + Wet Specimen (gm)	1075.30	Wgt.Tare + Wet Specimen (gm)	1133.40
Wgt.Tare + Dry Specimen (gm)	967.10	Wgt.Tare + Dry Specimen (gm)	1090.90
Weight of Tare (gm)	100.97	Weight of Tare (gm)	110.75
Weight of Water (gm)	108.20	Weight of Water (gm)	42.50
Weight of Dry Soil (gm)	866.13	Weight of Dry Soil (gm)	980.15
Moisture Content (%)	**12.5**	**Moisture Content (%)**	**4.3**

Wet Weight -3/4" Sample (gm)	19184	Weight of the Dry Specimen (gm)	866.13
Dry Weight - 3/4" Sample (gm)	17053.6	Weight of minus #200 material (gm)	166.00
Wet Weight +3/4" Sample (gm)	23275.00	Weight of plus #200 material (gm)	700.13
Dry Weight + 3/4" Sample (gm)	22307.72		
Total Dry Weight Sample (gm)	39361.3	**J - Factor (Percent Finer than 3/4")**	**0.4333**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	4834.00		11.77	11.77	88.23	**88.23**
2"	50	5295.00	(*)	12.89	24.66	75.34	**75.34**
1 1/2"	37.5	4807.00		11.70	36.37	63.63	**63.63**
1"	25	5652.00		13.76	50.13	49.87	**49.87**
3/4"	19	2687.00		6.54	56.67	43.33	**43.33**
1/2"	12.5	105.35		12.16	12.16	87.84	**38.06**
3/8"	9.5	97.51		11.26	23.42	76.58	**33.18**
#4	4.75	164.69		19.01	42.44	57.56	**24.94**
#10	2	132.45		15.29	57.73	42.27	**18.31**
#20	0.85	91.40	(**)	10.55	68.28	31.72	**13.74**
#40	0.425	43.29		5.00	73.28	26.72	**11.58**
#60	0.25	24.19		2.79	76.07	23.93	**10.37**
#140	0.106	31.20		3.60	79.67	20.33	**8.81**
#200	0.075	10.05		1.16	80.83	19.17	**8.30**
Pan	-	166.00		19.17	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/20/06 Checked By Date 2-20-06

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INTEGRITY IN TESTING

RIGID WALL CONSTANT HEAD PERMEABILITY

ASTM D 2434-68 (SOP-S35) Modified

Client	Paul C. Rizzo & Associates, Inc.	Boring No.	TS-4
Client Reference	TRUM SAUK 06-3551	Depth(ft.)	20-40
Project No.	2006-060-02	Sample No.	S3+S4A,B
Lab ID	2006-060-02-03	Visual Description	BROWN CLAYEY SAND W/ ROCK

Unit Weight

Wt. of Wet Material (gm)	16448
Average Length (in)	11.7
Permeameter Diameter (in)	7.5
Sample Volume (cc)	8455.8
Unit Dry Weight (gm/cc)	1.76
Unit Dry Weight (pcf)	110.1

Water Content

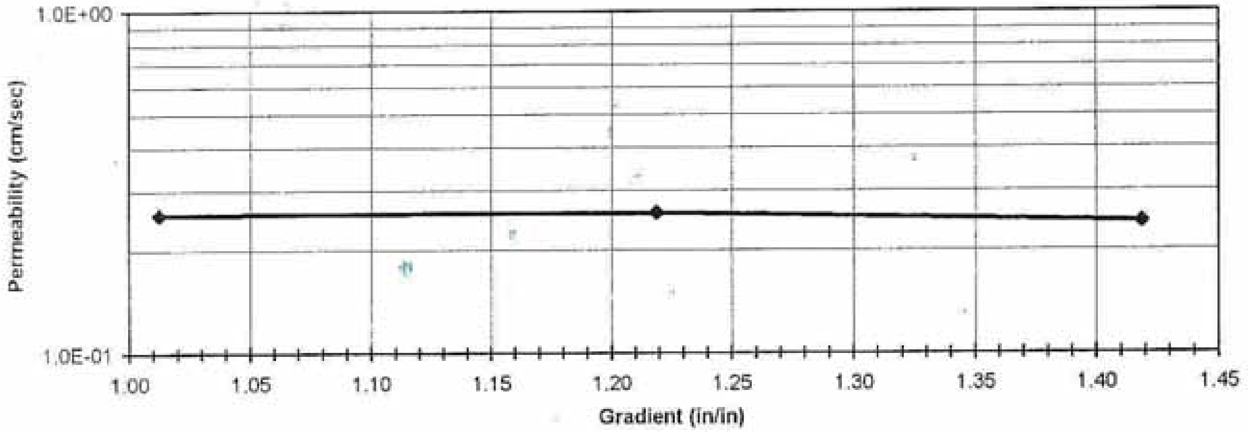
Tare Number	503
Wt. of Tare & Wet Mat.(gm)	1037.00
Wt. of Tare & Dry Mat.(gm)	949.40
Wt. of Tare (gm)	96.15
Wt. Water (gm)	87.60
Wt. of Dry Material (gm)	853.25

	Test 1	Test 2	Test 3
Piezometer Spacing (in)	*8*	*8*	*8*
Temperature (° C)	*23.5*	*23.6*	*23.7*
Temp. Correction Factor	*0.9203*	*0.9182*	*0.9160*

Water Content (%) ***10.3***
(Measured)

Load (psf) ***NA***

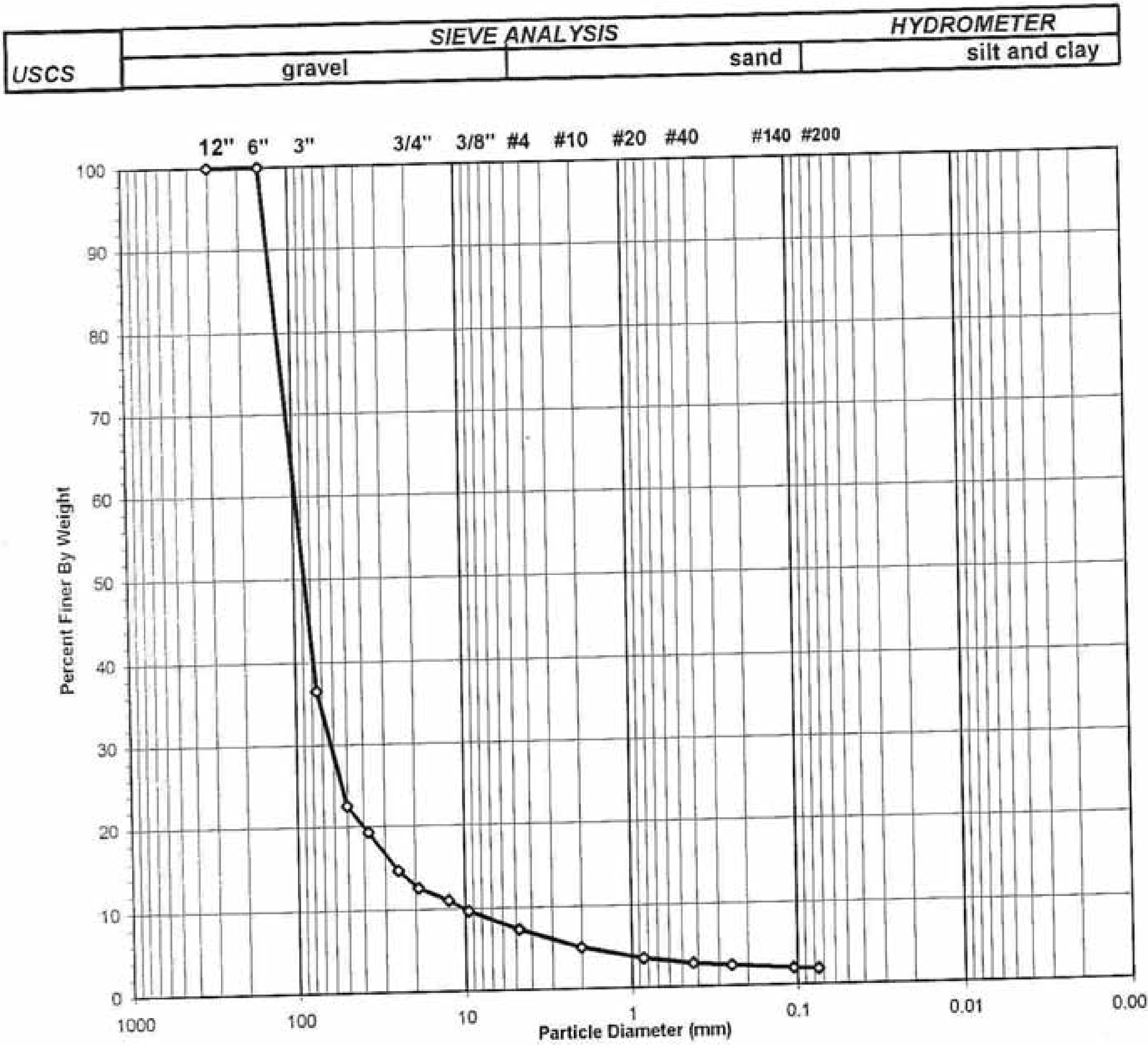
Test No.	Replicate No.	Head (in)	Gradient (in/in)	Elapsed Time (sec)	Collection Tube (divisions)	Collected Volume (cc)	Permeability 20° C (cm/s)	Average Permeability (cm/s)
1	1	8.10	1.01	54.3	3	4332.3	2.5E-01	
1	2	8.10	1.01	54.3	3	4332.3	2.5E-01	**2.5E-01**
1	3	8.10	1.01	54.5	3	4332.3	2.5E-01	
2	1	9.75	1.22	44.6	3	4332.3	2.6E-01	
2	2	9.75	1.22	44.2	3	4332.3	2.6E-01	**2.6E-01**
2	3	9.75	1.22	44.5	3	4332.3	2.6E-01	
3	1	11.35	1.42	40.5	3	4332.3	2.4E-01	
3	2	11.35	1.42	40.6	3	4332.3	2.4E-01	**2.4E-01**
3	3	11.35	1.42	40.4	3	4332.3	2.4E-01	



Tested By DDA Date 3/2/06 Checked By KB Date 3-3-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	30-36
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-36	Soil Color	**BROWN**



USCS Symbol ***gp, ASSUMED***

USCS Classification ***POORLY GRADED GRAVEL***

Tested By PC Date 2/18/06 Checked By YKB Date 2-20-06

DCN: CT-S3A DATE 6-25-98 REVISION 2

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geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	30-36
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-36	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	701	Tare No.	903
Wgt.Tare + Wet Specimen (gm)	1471.50	Wgt.Tare + Wet Specimen (gm)	705.40
Wgt.Tare + Dry Specimen (gm)	1297.10	Wgt.Tare + Dry Specimen (gm)	687.60
Weight of Tare (gm)	100.33	Weight of Tare (gm)	109.67
Weight of Water (gm)	174.40	Weight of Water (gm)	17.80
Weight of Dry Soil (gm)	1196.77	Weight of Dry Soil (gm)	577.93
Moisture Content (%)	**14.6**	**Moisture Content (%)**	**3.1**

Wet Weight -3/4" Sample (gm)	4066	Weight of the Dry Specimen (gm)	1196.77
Dry Weight - 3/4" Sample (gm)	3548.8	Weight of minus #200 material (gm)	179.33
Wet Weight +3/4" Sample (gm)	25535.00	Weight of plus #200 material (gm)	1017.44
Dry Weight + 3/4" Sample (gm)	24772.03		
Total Dry Weight Sample (gm)	28320.9	**J - Factor (Percent Finer than 3/4")**	**0.1253**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	18529.00		63.47	63.47	36.53	**36.53**
2"	50	4087.00	(*)	14.00	77.47	22.53	**22.53**
1 1/2"	37.5	936.00		3.21	80.68	19.32	**19.32**
1"	25	1359.00		4.66	85.33	14.67	**14.67**
3/4"	19	624.00		2.14	87.47	12.53	**12.53**
1/2"	12.5	146.63		12.25	12.25	87.75	**11.00**
3/8"	9.5	126.45		10.57	22.82	77.18	**9.67**
#4	4.75	225.80		18.87	41.69	58.31	**7.31**
#10	2	220.46		18.42	60.11	39.89	**5.00**
#20	0.85	140.30	(**)	11.72	71.83	28.17	**3.53**
#40	0.425	69.59		5.81	77.64	22.36	**2.80**
#60	0.25	33.66		2.81	80.46	19.54	**2.45**
#140	0.106	40.54		3.39	83.84	16.16	**2.02**
#200	0.075	14.01		1.17	85.02	14.98	**1.88**
Pan	-	179.33		14.98	100.00	-	**-**

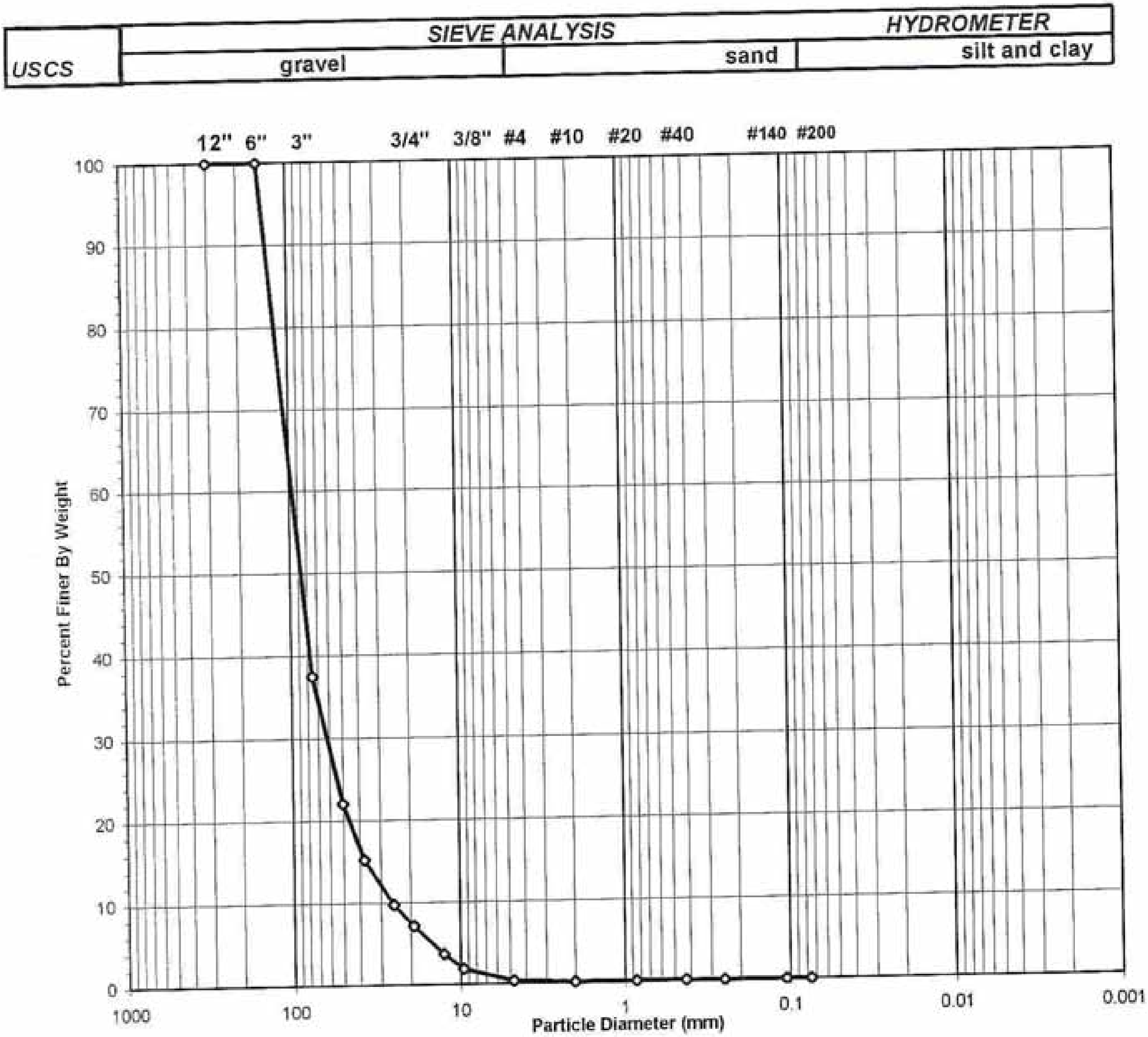
Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/18/06 Checked By Date 2-20-06

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	36-40
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-36	Soil Color	**BROWN**



USCS Symbol *gp, ASSUMED*

USCS Classification **POORLY GRADED GRAVEL**

Tested By PC Date 2/18/06 Checked By YKB Date 2-20-06

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geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	36-40
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-36	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	967	Tare No.	883
Wgt.Tare + Wet Specimen (gm)	1256.70	Wgt.Tare + Wet Specimen (gm)	1204.80
Wgt.Tare + Dry Specimen (gm)	1242.50	Wgt.Tare + Dry Specimen (gm)	1199.00
Weight of Tare (gm)	103.71	Weight of Tare (gm)	110.31
Weight of Water (gm)	14.20	Weight of Water (gm)	5.80
Weight of Dry Soil (gm)	1138.79	Weight of Dry Soil (gm)	1088.69
Moisture Content (%)	**1.2**	**Moisture Content (%)**	**0.5**

Wet Weight -3/4" Sample (gm)	2648	Weight of the Dry Specimen (gm)	1138.79
Dry Weight - 3/4" Sample (gm)	2615.4	Weight of minus #200 material (gm)	3.29
Wet Weight +3/4" Sample (gm)	34311.00	Weight of plus #200 material (gm)	1135.50
Dry Weight + 3/4" Sample (gm)	34129.18		
Total Dry Weight Sample (gm)	36744.6	**J - Factor (Percent Finer than 3/4")**	**0.0712**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	23098.00		62.53	62.53	37.47	**37.47**
2"	50	5701.00	(*)	15.43	77.96	22.04	**22.04**
1 1/2"	37.5	2519.00		6.82	84.78	15.22	**15.22**
1"	25	2039.00		5.52	90.30	9.70	**9.70**
3/4"	19	954.00		2.58	92.88	7.12	**7.12**
1/2"	12.5	553.20		48.58	48.58	51.42	**3.66**
3/8"	9.5	291.33		25.58	74.16	25.84	**1.84**
#4	4.75	236.09		20.73	94.89	5.11	**0.36**
#10	2	46.48		4.08	98.97	1.03	**0.07**
#20	0.85	4.18	(**)	0.37	99.34	0.66	**0.05**
#40	0.425	1.50		0.13	99.47	0.53	**0.04**
#60	0.25	0.94		0.08	99.55	0.45	**0.03**
#140	0.106	1.35		0.12	99.67	0.33	**0.02**
#200	0.075	0.43		0.04	99.71	0.29	**0.02**
Pan	-	3.29		0.29	100.00	-	**-**

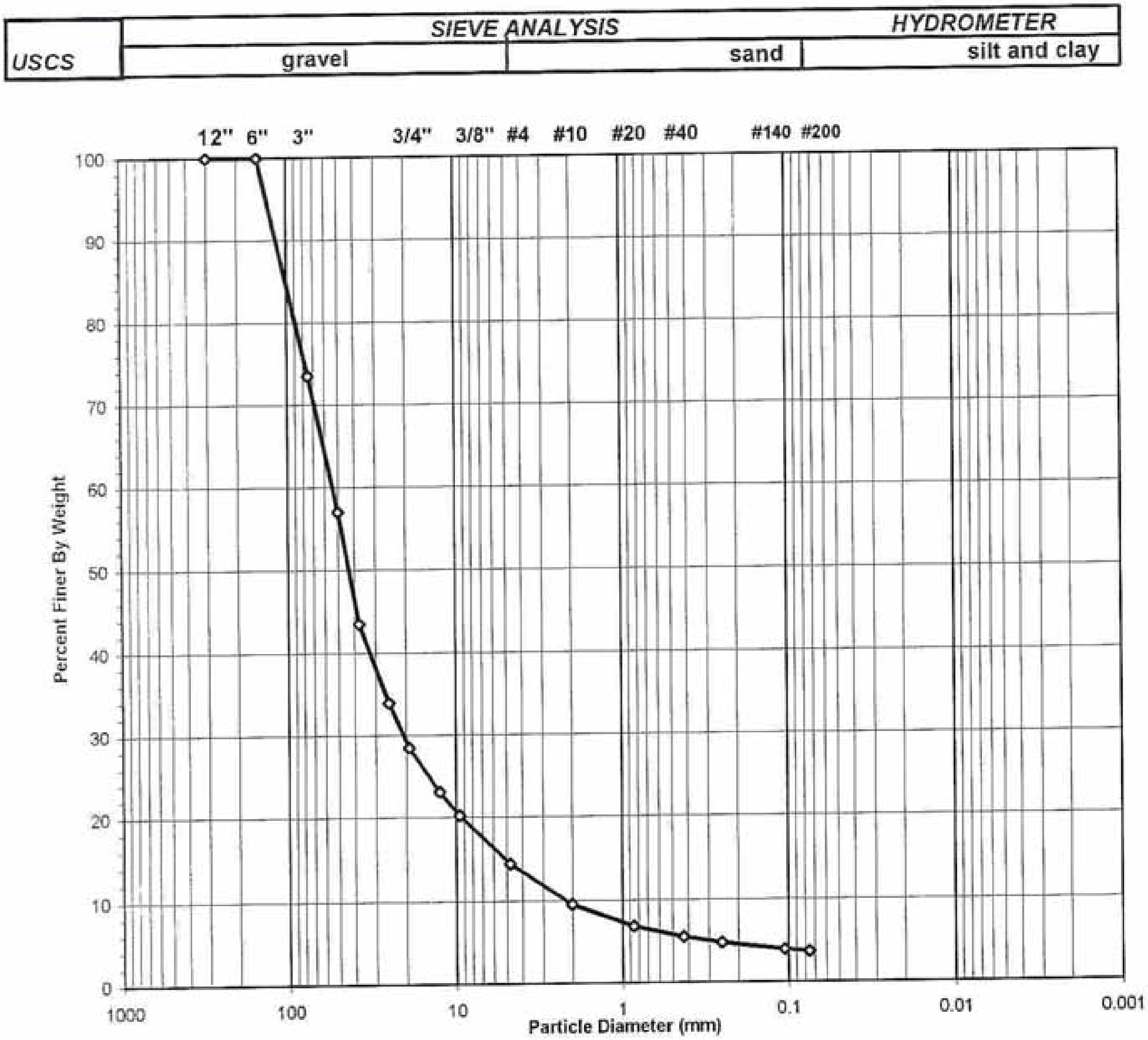
Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/18/06 Checked By YKB Date 2-20-06

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	40-50
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-37	Soil Color	**BROWN**



USCS Symbol	*gp, ASSUMED*	D60 =	53.8	CC =	3.6
USCS Classification	*POORLY GRADED GRAVEL*	D30 =	20.5	CU =	24.7
		D10 =	2.2		

Tested By PC Date 2/18/06 Checked By MMB Date 2-20-06

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	40-50
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-37	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	677	Tare No.	875
Wgt.Tare + Wet Specimen (gm)	1260.40	Wgt.Tare + Wet Specimen (gm)	1228.80
Wgt.Tare + Dry Specimen (gm)	1165.40	Wgt.Tare + Dry Specimen (gm)	1215.10
Weight of Tare (gm)	98.85	Weight of Tare (gm)	110.50
Weight of Water (gm)	95.00	Weight of Water (gm)	13.70
Weight of Dry Soil (gm)	1066.55	Weight of Dry Soil (gm)	1104.60
Moisture Content (%)	**8.9**	**Moisture Content (%)**	**1.2**

Wet Weight -3/4" Sample (gm)	9824	Weight of the Dry Specimen (gm)	1066.55
Dry Weight - 3/4" Sample (gm)	9020.5	Weight of minus #200 material (gm)	135.93
Wet Weight +3/4" Sample (gm)	22909.00	Weight of plus #200 material (gm)	930.62
Dry Weight + 3/4" Sample (gm)	22628.35		
Total Dry Weight Sample (gm)	31648.9	**J - Factor (Percent Finer than 3/4")**	**0.2850**

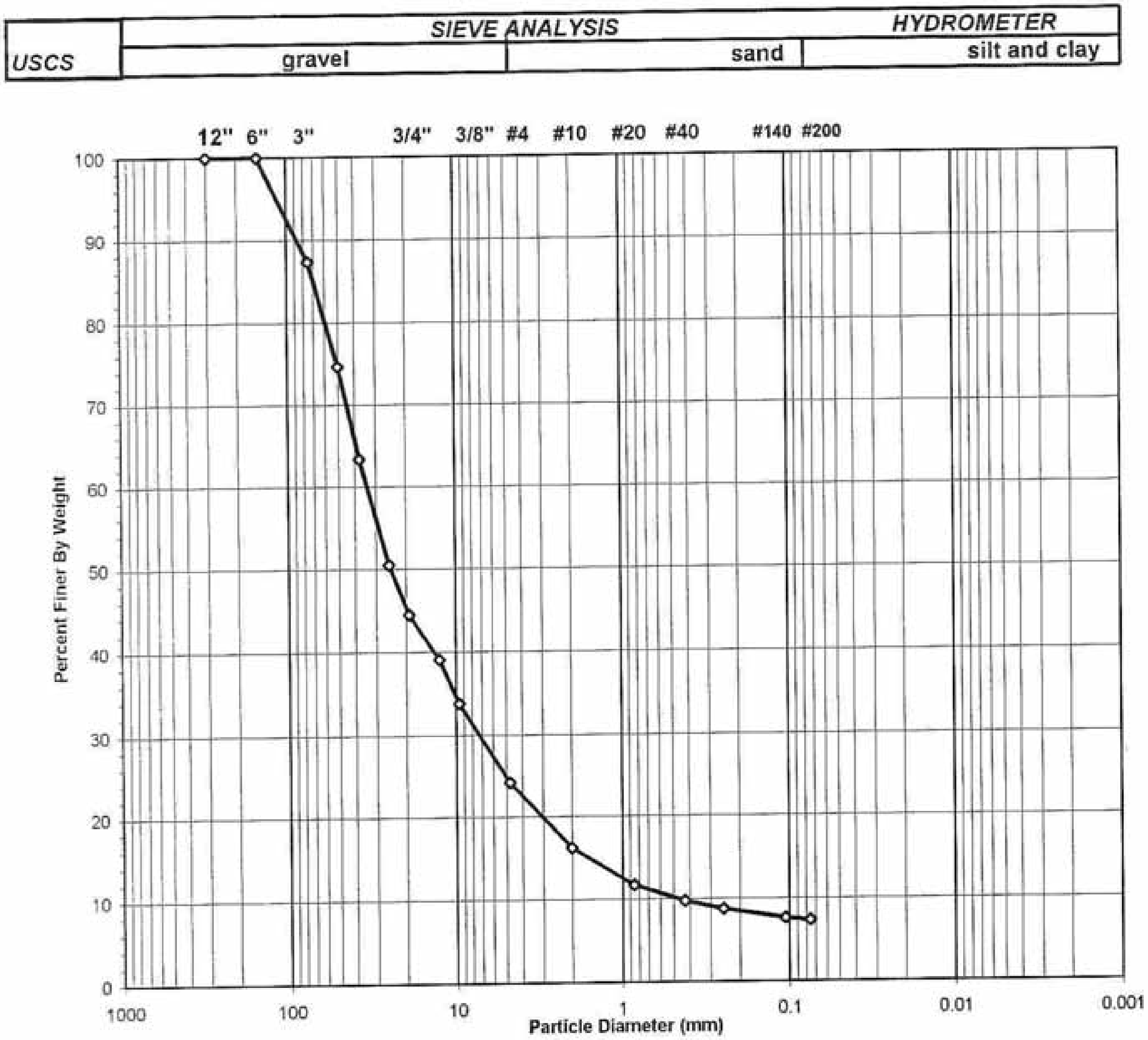
Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	8490.00		26.50	26.50	73.50	**73.50**
2"	50	5283.00	(*)	16.49	42.99	57.01	**57.01**
1 1/2"	37.5	4332.00		13.52	56.51	43.49	**43.49**
1"	25	3068.00		9.58	66.08	33.92	**33.92**
3/4"	19	1736.00		5.42	71.50	28.50	**28.50**
1/2"	12.5	202.11		18.95	18.95	81.05	**23.10**
3/8"	9.5	106.86		10.02	28.97	71.03	**20.25**
#4	4.75	219.99		20.63	49.60	50.40	**14.37**
#10	2	180.94		16.96	66.56	33.44	**9.53**
#20	0.85	99.77	(**)	9.35	75.91	24.09	**6.86**
#40	0.425	50.82		4.76	80.68	19.32	**5.51**
#60	0.25	25.86		2.42	83.10	16.90	**4.82**
#140	0.106	32.41		3.04	86.14	13.86	**3.95**
#200	0.075	11.86		1.11	87.26	12.74	**3.63**
Pan	-	135.93		12.74	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/18/06 Checked By YhR Date 2-20-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-60
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-38	Soil Color	**BROWN**



USCS Symbol	*gp-gm, ASSUMED*	**D60 =**	**33.8**	**CC =**	**3.3**
USCS Classification	*POORLY GRADED GRAVEL WITH SILT AND SAND*	**D30 =**	**7.2**	**CU =**	**72.2**
		D10 =	**0.5**		

Tested By PC Date 2/18/06 Checked By Date 2-20-06

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INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-60
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-38	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	946	Tare No.	873
Wgt.Tare + Wet Specimen (gm)	1621.70	Wgt.Tare + Wet Specimen (gm)	860.80
Wgt.Tare + Dry Specimen (gm)	1475.00	Wgt.Tare + Dry Specimen (gm)	847.30
Weight of Tare (gm)	188.34	Weight of Tare (gm)	109.56
Weight of Water (gm)	146.70	Weight of Water (gm)	13.50
Weight of Dry Soil (gm)	1286.66	Weight of Dry Soil (gm)	737.74
Moisture Content (%)	**11.4**	**Moisture Content (%)**	**1.8**

Wet Weight -3/4" Sample (gm)	15633	Weight of the Dry Specimen (gm)	1286.66
Dry Weight - 3/4" Sample (gm)	14033.0	Weight of minus #200 material (gm)	211.28
Wet Weight +3/4" Sample (gm)	17868.00	Weight of plus #200 material (gm)	1075.38
Dry Weight + 3/4" Sample (gm)	17546.91		
Total Dry Weight Sample (gm)	31579.9	**J - Factor (Percent Finer than 3/4")**	**0.4444**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	4070.00		12.66	12.66	87.34	**87.34**
2"	50	4089.00	(*)	12.72	25.37	74.63	**74.63**
1 1/2"	37.5	3626.00		11.28	36.65	63.35	**63.35**
1"	25	4164.00		12.95	49.60	50.40	**50.40**
3/4"	19	1919.00		5.97	55.56	44.44	**44.44**
1/2"	12.5	156.20		12.14	12.14	87.86	**39.04**
3/8"	9.5	151.81		11.80	23.94	76.06	**33.80**
#4	4.75	277.85		21.59	45.53	54.47	**24.20**
#10	2	232.92		18.10	63.64	36.36	**16.16**
#20	0.85	129.94	(**)	10.10	73.74	26.26	**11.67**
#40	0.425	56.16		4.36	78.10	21.90	**9.73**
#60	0.25	29.15		2.27	80.37	19.63	**8.72**
#140	0.106	32.10		2.49	82.86	17.14	**7.62**
#200	0.075	9.25		0.72	83.58	16.42	**7.30**
Pan	-	211.28		16.42	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/18/06 Checked By Date 2-20-06

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geotechnics
INTEGRITY IN TESTING

RIGID WALL CONSTANT HEAD PERMEABILITY

ASTM D 2434-68 (SOP-S35) Modified

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth(ft.)	50-70
Project No.	2006-060-02	Sample No.	S6+S7
Lab ID	2006-060-02-04	Visual Description	BROWN CLAYEY SAND WITH ROCK FRAGMENTS

Unit Weight

Wt. of Wet Material (gm)	17626
Average Length (in)	11.6
Permeameter Diameter (in)	7.5
Sample Volume (cc)	8426.9
Unit Dry Weight (gm/cc)	1.93
Unit Dry Weight (pcf)	120.2

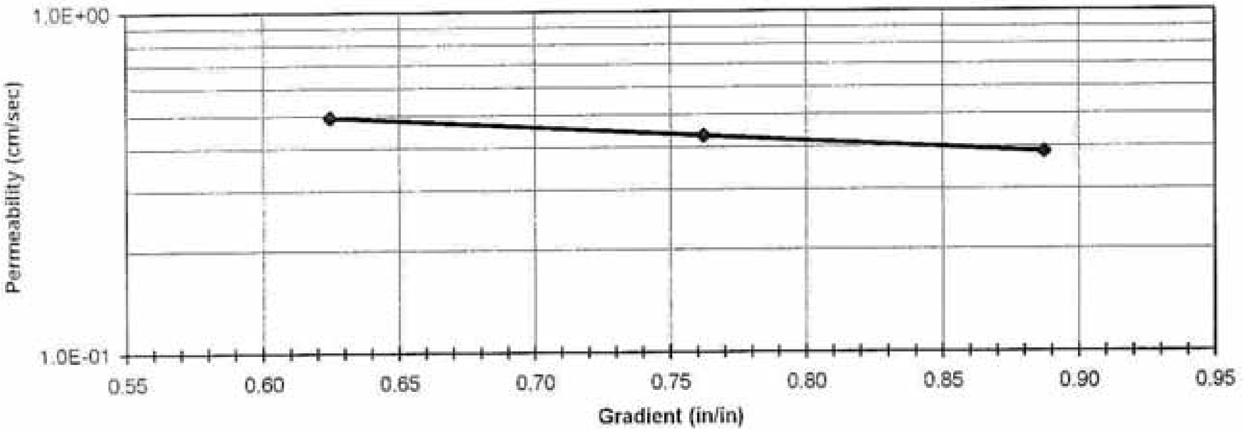
Water Content

Tare Number	892
Wt. of Tare & Wet Mat.(gm)	779.40
Wt. of Tare & Dry Mat.(gm)	726.40
Wt. of Tare (gm)	110.00
Wt. Water (gm)	53.00
Wt. of Dry Material (gm)	616.40

	Test 1	Test 2	Test 3
Piezometer Spacing (in)	*8*	*8*	*8*
Temperature (° C)	*22.5*	*22.9*	*23.5*
Temp. Correction Factor	*0.9421*	*0.9333*	*0.9203*

Water Content (%)	***8.6***
	(Measured)
Load (psf)	***NA***

Test No.	Replicate No.	Head (in)	Gradient (in/in)	Elapsed Time (sec)	Collection Tube (divisions)	Collected Volume (cc)	Permeability 20° C (cm/s)	Average Permeability (cm/s)
1	1	5.00	0.63	46.6	3	4332.3	4.9E-01	**4.9E-01**
1	2	5.00	0.63	46.4	3	4332.3	4.9E-01	
1	3	5.00	0.63	46.3	3	4332.3	4.9E-01	
2	1	6.10	0.76	43.1	3	4332.3	4.3E-01	**4.3E-01**
2	2	6.10	0.76	43.0	3	4332.3	4.3E-01	
2	3	6.10	0.76	43.0	3	4332.3	4.3E-01	
3	1	7.10	0.89	41.0	3	4332.3	3.8E-01	**3.8E-01**
3	2	7.10	0.89	41.0	3	4332.3	3.8E-01	
3	3	7.10	0.89	41.1	3	4332.3	3.8E-01	



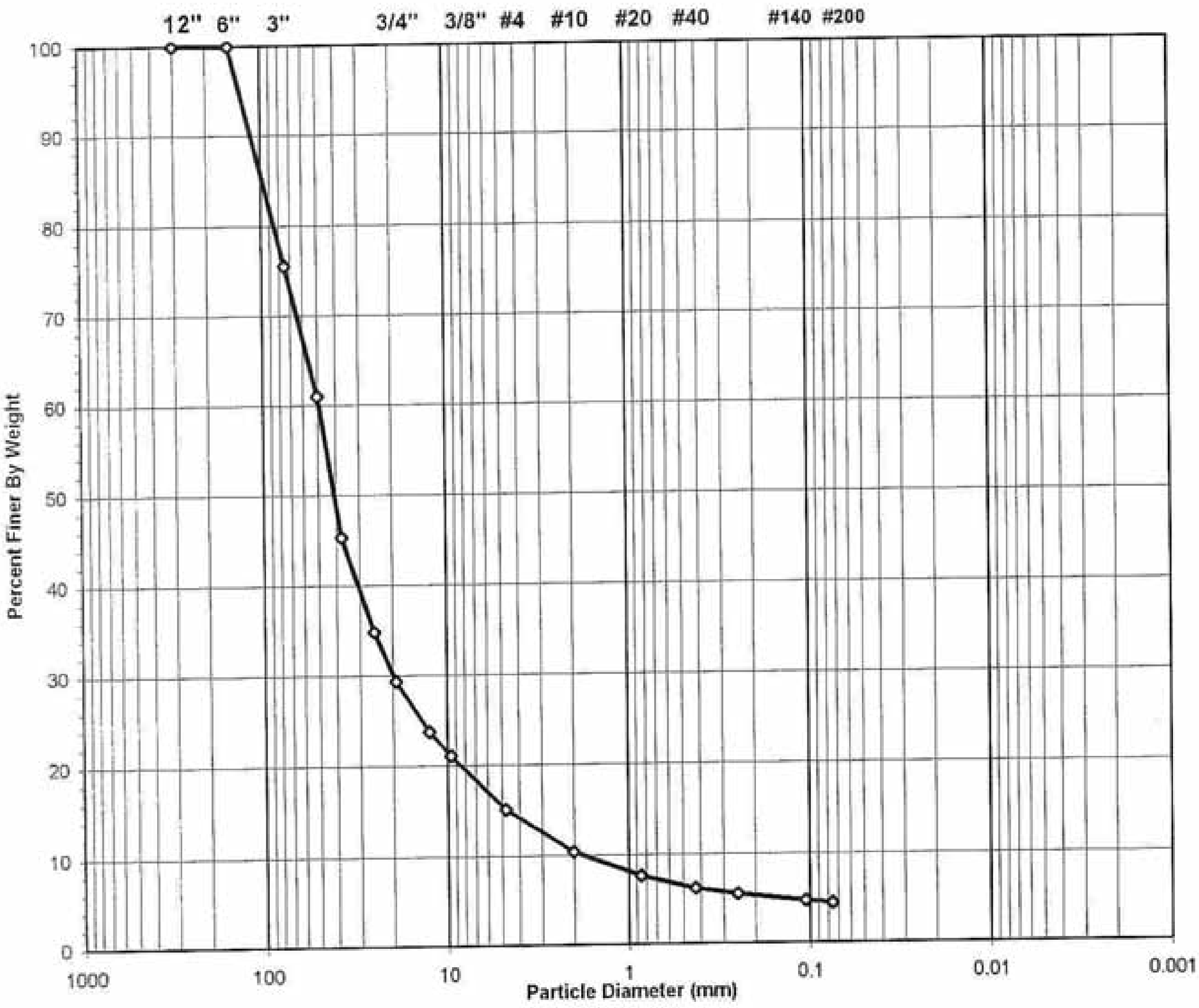
Tested By DDA Date 2/27/06 Checked By Date 3-2-06

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	60-70
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-39	Soil Color	**BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol	*gp, ASSUMED*	D60 =	49.1	CC =	4.4
USCS Classification	*POORLY GRADED GRAVEL*	D30 =	19.7	CU =	27.4
		D10 =	1.8		

Tested By JP Date 2/21/06 Checked By KB Date 2-22-06

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	60-70
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-39	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	927	Tare No.	542
Wgt.Tare + Wet Specimen (gm)	1273.70	Wgt.Tare + Wet Specimen (gm)	486.30
Wgt.Tare + Dry Specimen (gm)	1176.90	Wgt.Tare + Dry Specimen (gm)	474.14
Weight of Tare (gm)	102.88	Weight of Tare (gm)	82.36
Weight of Water (gm)	96.80	Weight of Water (gm)	12.16
Weight of Dry Soil (gm)	1074.02	Weight of Dry Soil (gm)	391.78
Moisture Content (%)	**9.0**	**Moisture Content (%)**	**3.1**

Wet Weight -3/4" Sample (gm)	10360	Weight of the Dry Specimen (gm)	1074.02
Dry Weight - 3/4" Sample (gm)	9503.5	Weight of minus #200 material (gm)	162.76
Wet Weight +3/4" Sample (gm)	23629.00	Weight of plus #200 material (gm)	911.26
Dry Weight + 3/4" Sample (gm)	22917.68		
Total Dry Weight Sample (gm)	32421.2	**J - Factor (Percent Finer than 3/4")**	**0.2931**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	8176.00		24.46	24.46	75.54	**75.54**
2"	50	4847.00	(*)	14.50	38.96	61.04	**61.04**
1 1/2"	37.5	5258.00		15.73	54.69	45.31	**45.31**
1"	25	3512.00		10.51	65.19	34.81	**34.81**
3/4"	19	1836.00		5.49	70.69	29.31	**29.31**
1/2"	12.5	203.24		18.92	18.92	81.08	**23.77**
3/8"	9.5	99.03		9.22	28.14	71.86	**21.06**
#4	4.75	219.33		20.42	48.57	51.43	**15.08**
#10	2	173.11		16.12	64.68	35.32	**10.35**
#20	0.85	99.06	(**)	9.22	73.91	26.09	**7.65**
#40	0.425	52.65		4.90	78.81	21.19	**6.21**
#60	0.25	25.64		2.39	81.20	18.80	**5.51**
#140	0.106	29.49		2.75	83.94	16.06	**4.71**
#200	0.075	9.71		0.90	84.85	15.15	**4.44**
Pan	-	162.76		15.15	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/21/06 Checked By KB Date 2-22-06

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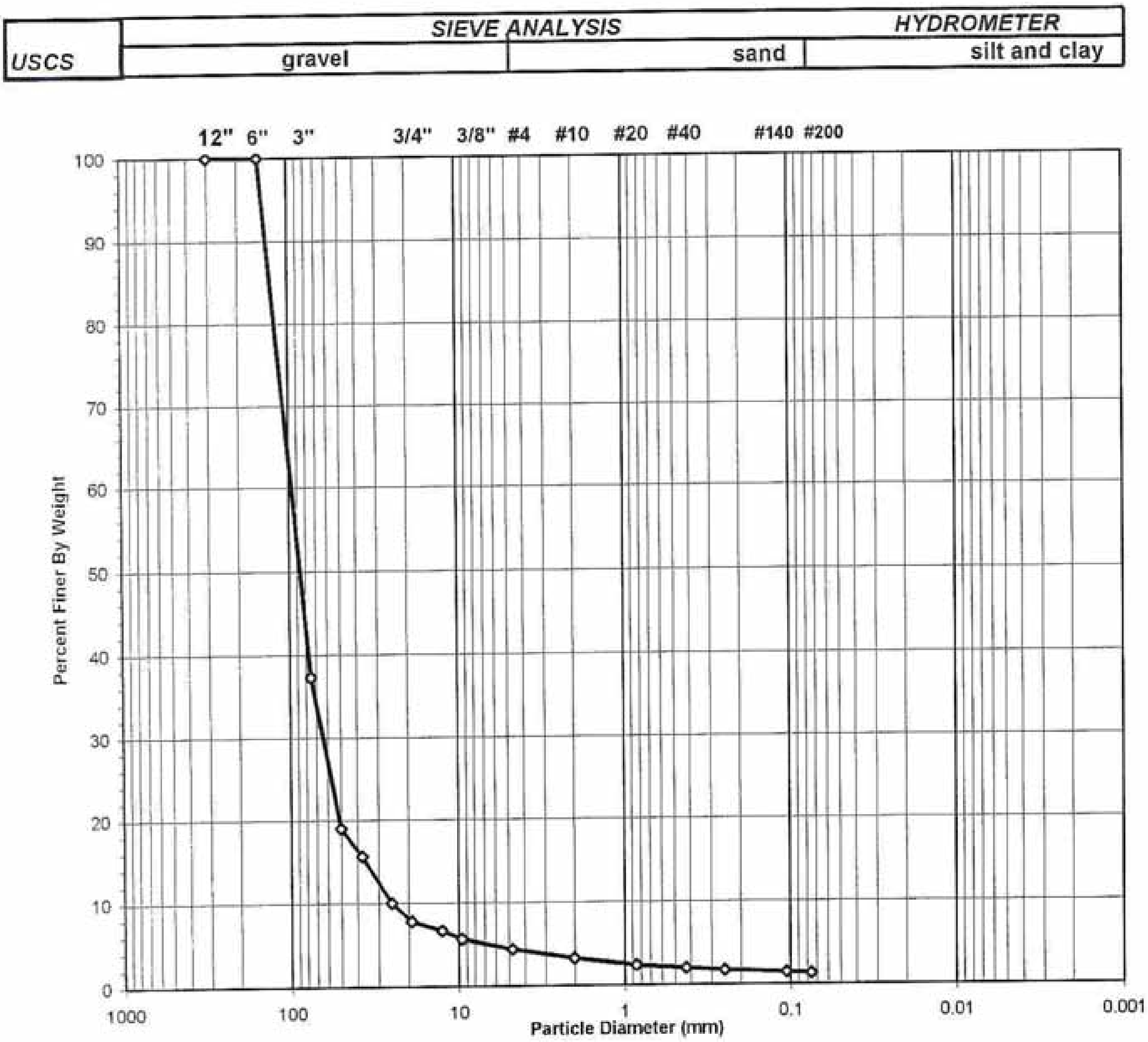
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-40	Soil Color	**BROWN**



USCS Symbol ***gp, ASSUMED***

USCS Classification ***POORLY GRADED GRAVEL***

Tested By JP Date 2/21/06 Checked By KHB Date 2-22-06

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-40	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	973	Tare No.	899
Wgt.Tare + Wet Specimen (gm)	1239.30	Wgt.Tare + Wet Specimen (gm)	971.60
Wgt.Tare + Dry Specimen (gm)	1165.20	Wgt.Tare + Dry Specimen (gm)	964.70
Weight of Tare (gm)	102.42	Weight of Tare (gm)	110.10
Weight of Water (gm)	74.10	Weight of Water (gm)	6.90
Weight of Dry Soil (gm)	1062.78	Weight of Dry Soil (gm)	854.60
Moisture Content (%)	**7.0**	**Moisture Content (%)**	**0.8**

Wet Weight -3/4" Sample (gm)	2186	Weight of the Dry Specimen (gm)	1062.78
Dry Weight - 3/4" Sample (gm)	2043.5	Weight of minus #200 material (gm)	182.74
Wet Weight +3/4" Sample (gm)	24387.00	Weight of plus #200 material (gm)	880.04
Dry Weight + 3/4" Sample (gm)	24191.68		
Total Dry Weight Sample (gm)	26235.2	**J - Factor (Percent Finer than 3/4")**	**0.0779**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	16581.00		62.70	62.70	37.30	**37.30**
2"	50	4831.00	(*)	18.27	80.96	19.04	**19.04**
1 1/2"	37.5	908.00		3.43	84.40	15.60	**15.60**
1"	25	1485.00		5.61	90.01	9.99	**9.99**
3/4"	19	582.00		2.20	92.21	7.79	**7.79**
1/2"	12.5	158.29		14.89	14.89	85.11	**6.63**
3/8"	9.5	128.91		12.13	27.02	72.98	**5.68**
#4	4.75	173.07		16.28	43.31	56.69	**4.42**
#10	2	162.01		15.24	58.55	41.45	**3.23**
#20	0.85	110.32	(**)	10.38	68.93	31.07	**2.42**
#40	0.425	56.43		5.31	74.24	25.76	**2.01**
#60	0.25	33.75		3.18	77.42	22.58	**1.76**
#140	0.106	43.97		4.14	81.55	18.45	**1.44**
#200	0.075	13.29		1.25	82.81	17.19	**1.34**
Pan	-	182.74		17.19	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

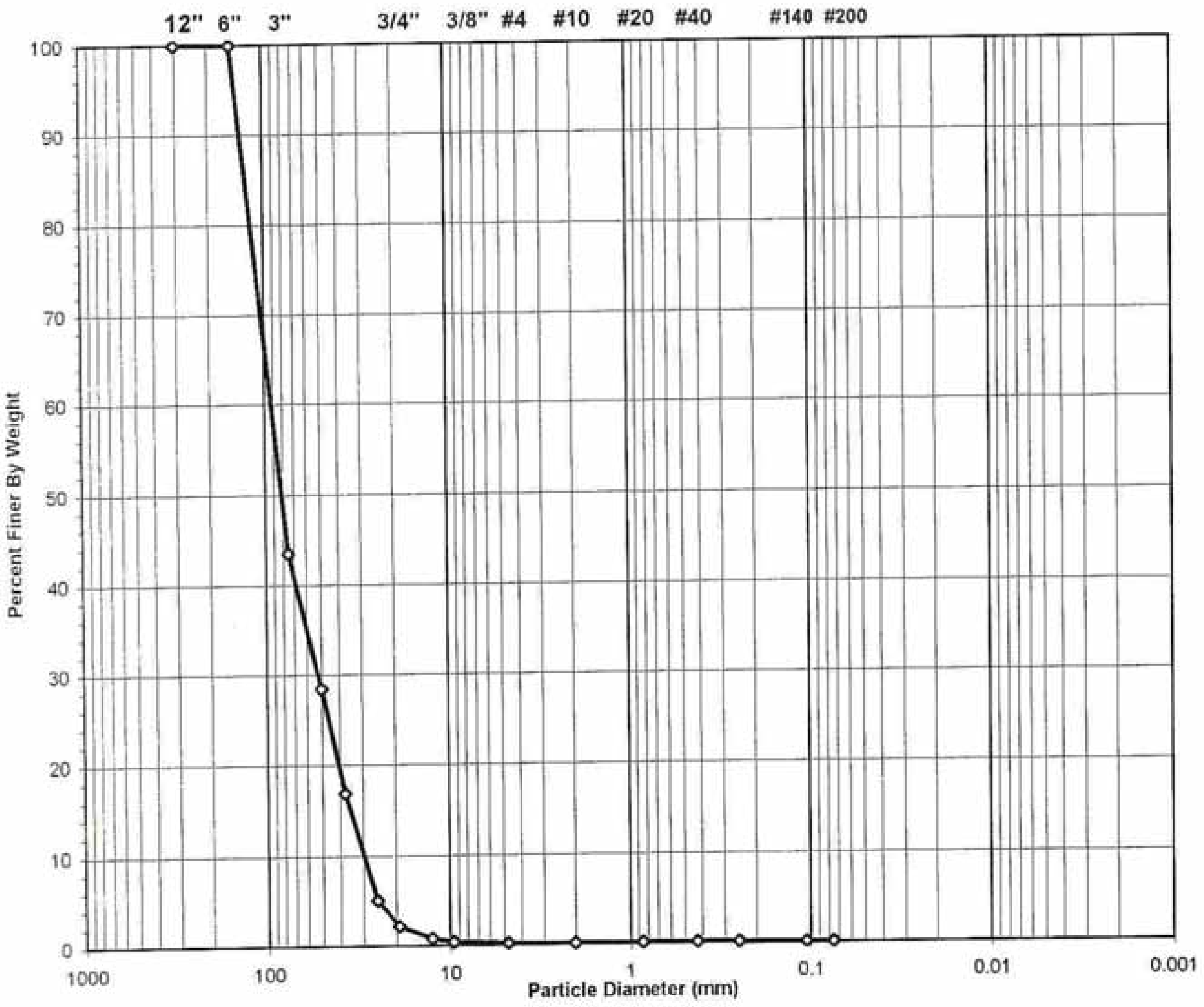
Tested By JP Date 2/21/06 Checked By Date 2-22-06

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	80-90
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-41	Soil Color	BROWN

USCS	*SIEVE ANALYSIS*		*HYDROMETER*
	gravel	sand	silt and clay



USCS Symbol ***gp, ASSUMED***

USCS Classification ***POORLY GRADED GRAVEL***

Tested By JP Date 2/21/06 Checked By KB Date 2-22-06

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	80-90
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-41	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	674	Tare No.	897
Wgt.Tare + Wet Specimen (gm)	739.00	Wgt.Tare + Wet Specimen (gm)	814.20
Wgt.Tare + Dry Specimen (gm)	731.00	Wgt.Tare + Dry Specimen (gm)	809.50
Weight of Tare (gm)	99.64	Weight of Tare (gm)	109.86
Weight of Water (gm)	8.00	Weight of Water (gm)	4.70
Weight of Dry Soil (gm)	631.36	Weight of Dry Soil (gm)	699.64
Moisture Content (%)	**1.3**	**Moisture Content (%)**	**0.7**

Wet Weight -3/4" Sample (gm)	641	Weight of the Dry Specimen (gm)	631.36
Dry Weight - 3/4" Sample (gm)	633.0	Weight of minus #200 material (gm)	22.46
Wet Weight +3/4" Sample (gm)	28728.40	Weight of plus #200 material (gm)	608.90
Dry Weight + 3/4" Sample (gm)	28536.70		
Total Dry Weight Sample (gm)	29169.7	**J - Factor (Percent Finer than 3/4")**	**0.0217**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	16599.00		56.53	56.53	43.47	**43.47**
2"	50	4424.00	(*)	15.07	71.59	28.41	**28.41**
1 1/2"	37.5	3385.00		11.53	83.12	16.88	**16.88**
1"	25	3468.40		11.81	94.93	5.07	**5.07**
3/4"	19	852.00		2.90	97.83	2.17	**2.17**
1/2"	12.5	405.41		64.21	64.21	35.79	**0.78**
3/8"	9.5	118.74		18.81	83.02	16.98	**0.37**
#4	4.75	51.71		8.19	91.21	8.79	**0.19**
#10	2	11.20		1.77	92.98	7.02	**0.15**
#20	0.85	7.37	(**)	1.17	94.15	5.85	**0.13**
#40	0.425	4.46		0.71	94.86	5.14	**0.11**
#60	0.25	3.30		0.52	95.38	4.62	**0.10**
#140	0.106	5.09		0.81	96.19	3.81	**0.08**
#200	0.075	1.62		0.26	96.44	3.56	**0.08**
Pan	-	22.46		3.56	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/21/06 Checked By Date 2-22-06

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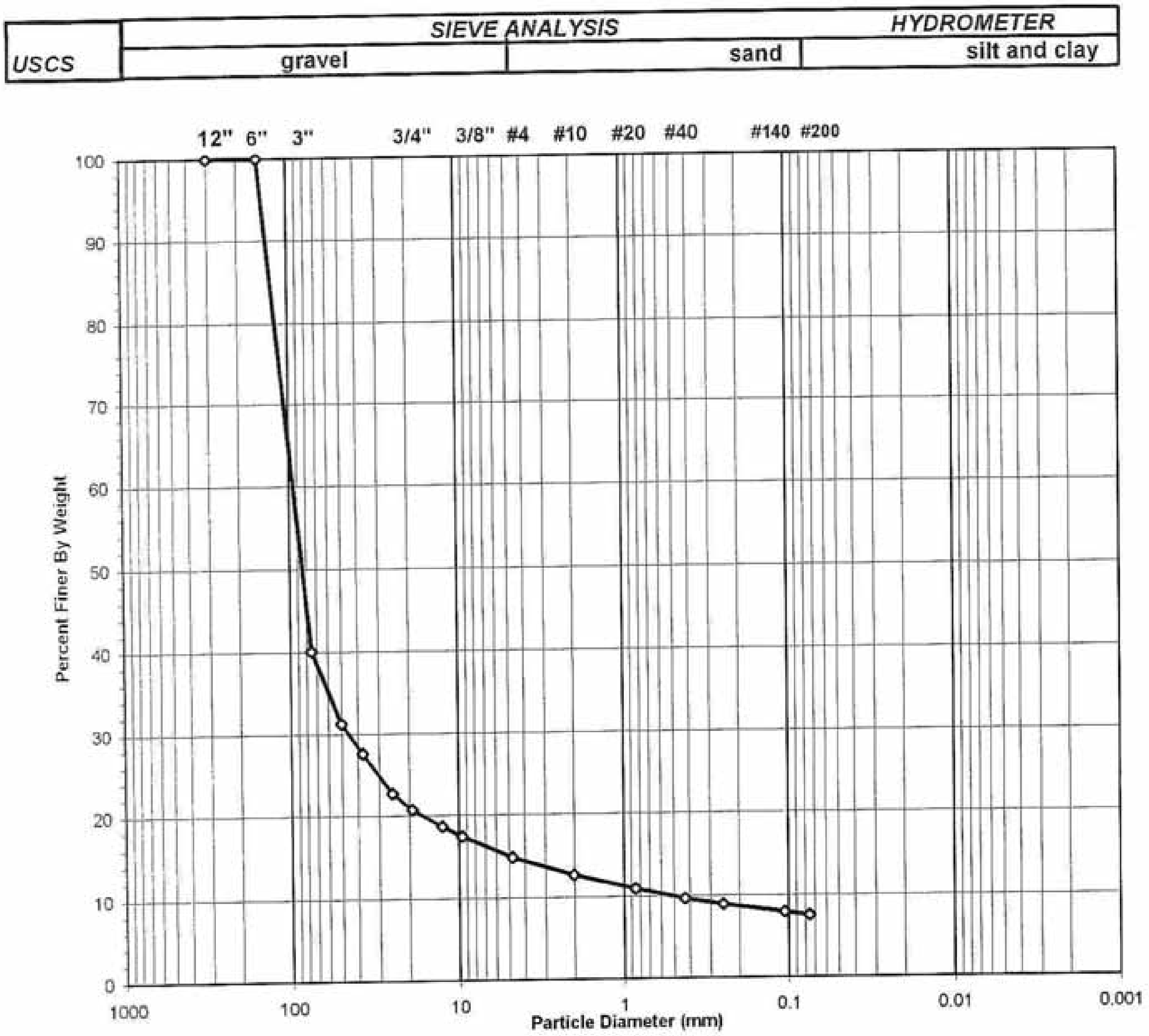
SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	90-98.25
Project No.	2006-060-01	Sample No.	S-10
Lab ID	2006-060-01-42	Soil Color	**BROWN**



USCS Symbol ***gp-gm, ASSUMED***

USCS Classification ***POORLY GRADED GRAVEL WITH SILT***

Tested By JP Date 2/21/06 Checked By KYB Date 2-22-06

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-4
Client Reference	TAUM SAUK 06-3551	Depth (ft)	90-98.25
Project No.	2006-060-01	Sample No.	S-10
Lab ID	2006-060-01-42	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	683	Tare No.	879
Wgt.Tare + Wet Specimen (gm)	1305.80	Wgt.Tare + Wet Specimen (gm)	504.57
Wgt.Tare + Dry Specimen (gm)	1217.60	Wgt.Tare + Dry Specimen (gm)	499.80
Weight of Tare (gm)	99.83	Weight of Tare (gm)	110.15
Weight of Water (gm)	88.20	Weight of Water (gm)	4.77
Weight of Dry Soil (gm)	1117.77	Weight of Dry Soil (gm)	389.65
Moisture Content (%)	**7.9**	**Moisture Content (%)**	**1.2**

Wet Weight -3/4" Sample (gm)	12073	Weight of the Dry Specimen (gm)	1117.77
Dry Weight - 3/4" Sample (gm)	11190.0	Weight of minus #200 material (gm)	408.45
Wet Weight +3/4" Sample (gm)	43487.00	Weight of plus #200 material (gm)	709.32
Dry Weight + 3/4" Sample (gm)	42961.08		
Total Dry Weight Sample (gm)	54151.1	**J - Factor (Percent Finer than 3/4")**	**0.2066**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	32862.00		59.95	59.95	40.05	**40.05**
2"	50	4825.00	(*)	8.80	68.75	31.25	**31.25**
1 1/2"	37.5	1991.00		3.63	72.39	27.61	**27.61**
1"	25	2710.00		4.94	77.33	22.67	**22.67**
3/4"	19	1099.00		2.00	79.34	20.66	**20.66**
1/2"	12.5	111.70		9.99	9.99	90.01	**18.60**
3/8"	9.5	62.74		5.61	15.61	84.39	**17.44**
#4	4.75	139.44		12.47	28.08	71.92	**14.86**
#10	2	118.87		10.63	38.72	61.28	**12.66**
#20	0.85	95.58	(**)	8.55	47.27	52.73	**10.90**
#40	0.425	66.43		5.94	53.21	46.79	**9.67**
#60	0.25	39.90		3.57	56.78	43.22	**8.93**
#140	0.106	54.24		4.85	61.63	38.37	**7.93**
#200	0.075	20.42		1.83	63.46	36.54	**7.55**
Pan	-	408.45		36.54	100.00	-	-

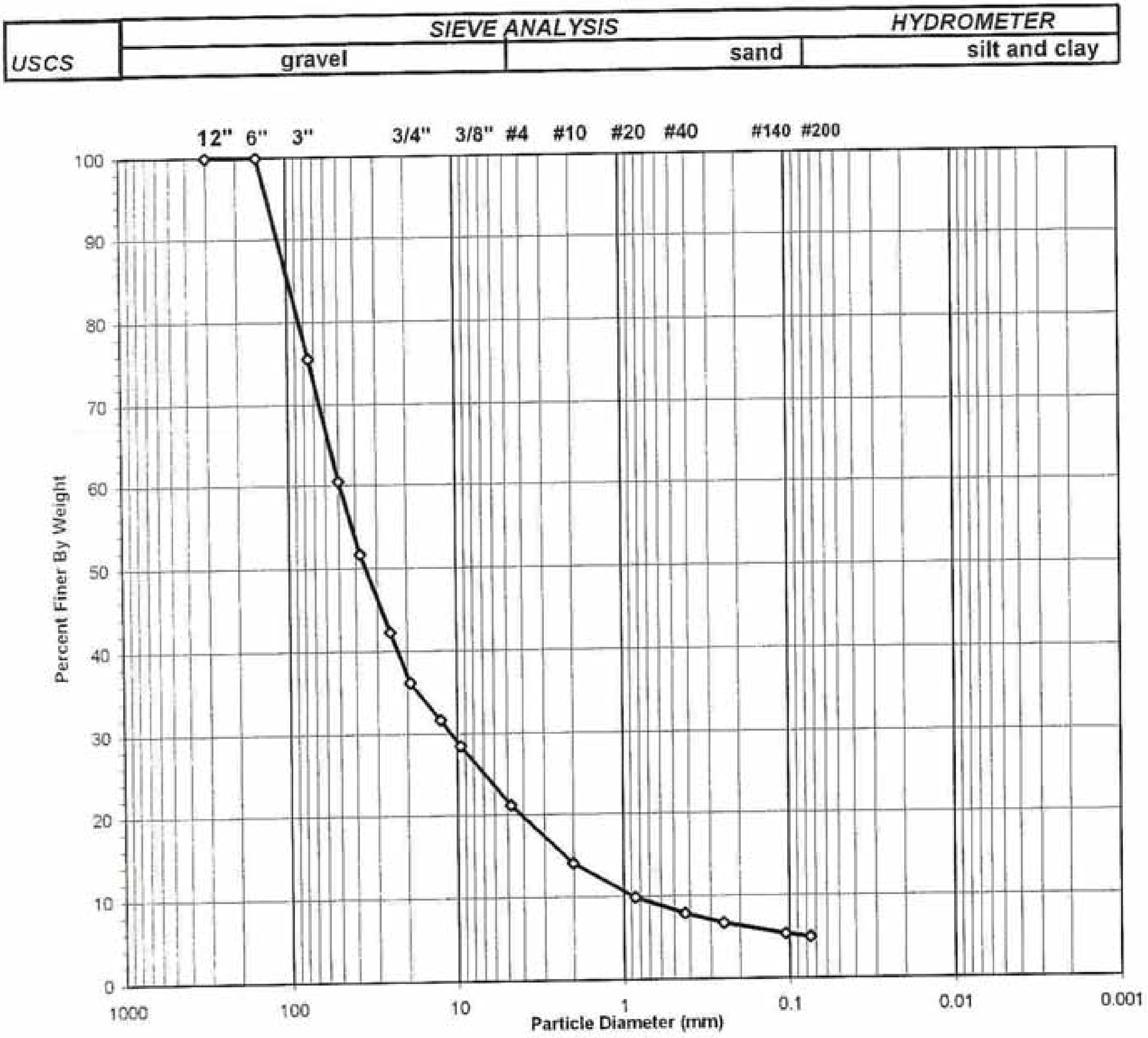
Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/21/06 Checked By VHB Date 2-22-06

BORING TS-5

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	0-10
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-43	Soil Color	**REDDISH BROWN**



USCS Symbol	*GW, TESTED*	D60 =	49.2	CC =	2.7
USCS Classification	*WELL-GRADED GRAVEL WITH SAND*	D30 =	10.9	CU =	56.4
		D10 =	0.9		

Tested By JP Date 2/27/06 Checked By KB Date 3-1-06

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	0-10
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-43	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	932	Tare No.	537
Wgt.Tare + Wet Specimen (gm)	1335.50	Wgt.Tare + Wet Specimen (gm)	532.37
Wgt.Tare + Dry Specimen (gm)	1261.20	Wgt.Tare + Dry Specimen (gm)	522.83
Weight of Tare (gm)	103.11	Weight of Tare (gm)	82.48
Weight of Water (gm)	74.30	Weight of Water (gm)	9.54
Weight of Dry Soil (gm)	1158.09	Weight of Dry Soil (gm)	440.35
Moisture Content (%)	**6.4**	**Moisture Content (%)**	**2.2**

Wet Weight -3/4" Sample (gm)	23953	Weight of the Dry Specimen (gm)	1158.09
Dry Weight - 3/4" Sample (gm)	22508.9	Weight of minus #200 material (gm)	158.29
Wet Weight +3/4" Sample (gm)	40558.00	Weight of plus #200 material (gm)	999.80
Dry Weight + 3/4" Sample (gm)	39697.96		
Total Dry Weight Sample (gm)	62206.8	**J - Factor (Percent Finer than 3/4")**	**0.3618**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	15571.00		24.50	24.50	75.50	**75.50**
2"	50	9545.00	(*)	15.02	39.52	60.48	**60.48**
1 1/2"	37.5	5629.00		8.86	48.38	51.62	**51.62**
1"	25	5974.00		9.40	57.78	42.22	**42.22**
3/4"	19	3839.00		6.04	63.82	36.18	**36.18**
1/2"	12.5	145.17		12.54	12.54	87.46	**31.65**
3/8"	9.5	102.54		8.85	21.39	78.61	**28.44**
#4	4.75	233.55		20.17	41.56	58.44	**21.15**
#10	2	227.87		19.68	61.23	38.77	**14.03**
#20	0.85	133.02	(**)	11.49	72.72	27.28	**9.87**
#40	0.425	65.26		5.64	78.35	21.65	**7.83**
#60	0.25	37.89		3.27	81.63	18.37	**6.65**
#140	0.106	42.89		3.70	85.33	14.67	**5.31**
#200	0.075	11.61		1.00	86.33	13.67	**4.95**
Pan	-	158.29		13.67	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/27/06 Checked By Date 3-1-06

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INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	0-10
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-43	Soil Description	**BROWN SILTY CLAY**
			(Minus No. 40 sieve material, Airdried)

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

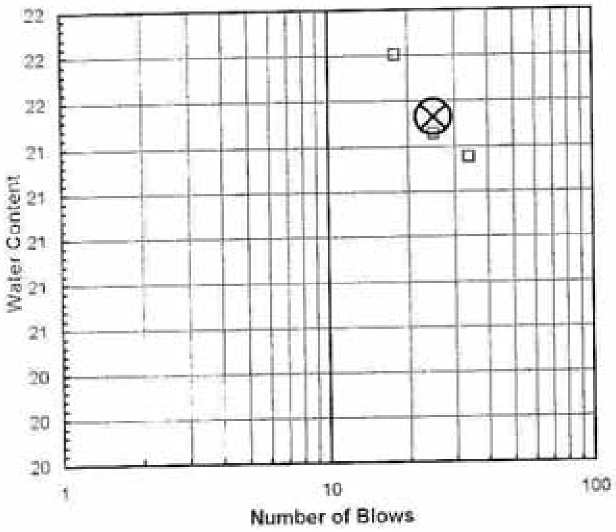
Liquid Limit Test	**1**	**2**	**3**	
Tare Number	OO1	2045	2223	M U L T I P O I N T
Wt. of Tare & WS (gm)	35.29	41.72	40.04	
Wt. of Tare & DS (gm)	31.50	37.71	36.31	
Wt. of Tare (gm)	13.75	19.02	19.20	
Wt. of Water (gm)	3.8	4.0	3.7	
Wt. of DS (gm)	17.8	18.7	17.1	
Moisture Content (%)	**21.4**	**21.5**	**21.8**	
Number of Blows	**34**	**25**	**18**	

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	2294	2303	
Wt. of Tare & WS (gm)	25.71	24.66	
Wt. of Tare & DS (gm)	24.83	23.74	
Wt. of Tare (gm)	19.68	18.38	
Wt. of Water (gm)	0.9	0.9	
Wt. of DS (gm)	5.2	5.4	
Moisture Content (%)	**17.1**	**17.2**	**-0.1**

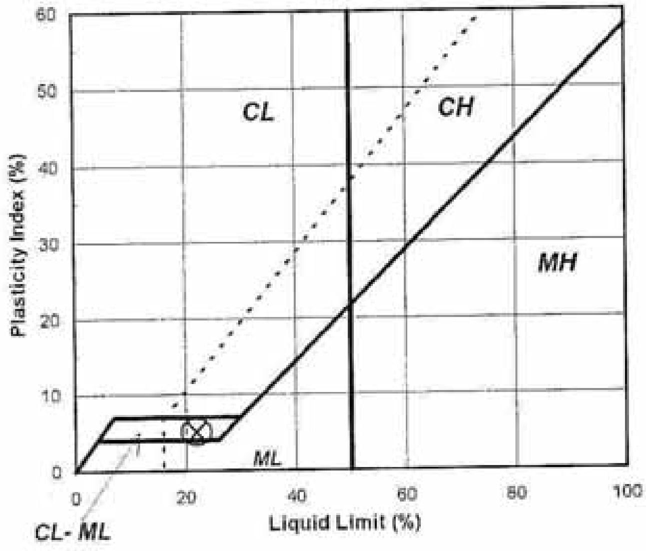
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**22**
Plastic Limit (%)	**17**
Plasticity Index (%)	**5**
USCS Symbol	**CL-ML**

Flow Curve



Plasticity Chart



Tested By BS *Date* 2/27/06 *Checked By* KR *Date* 2-28-06

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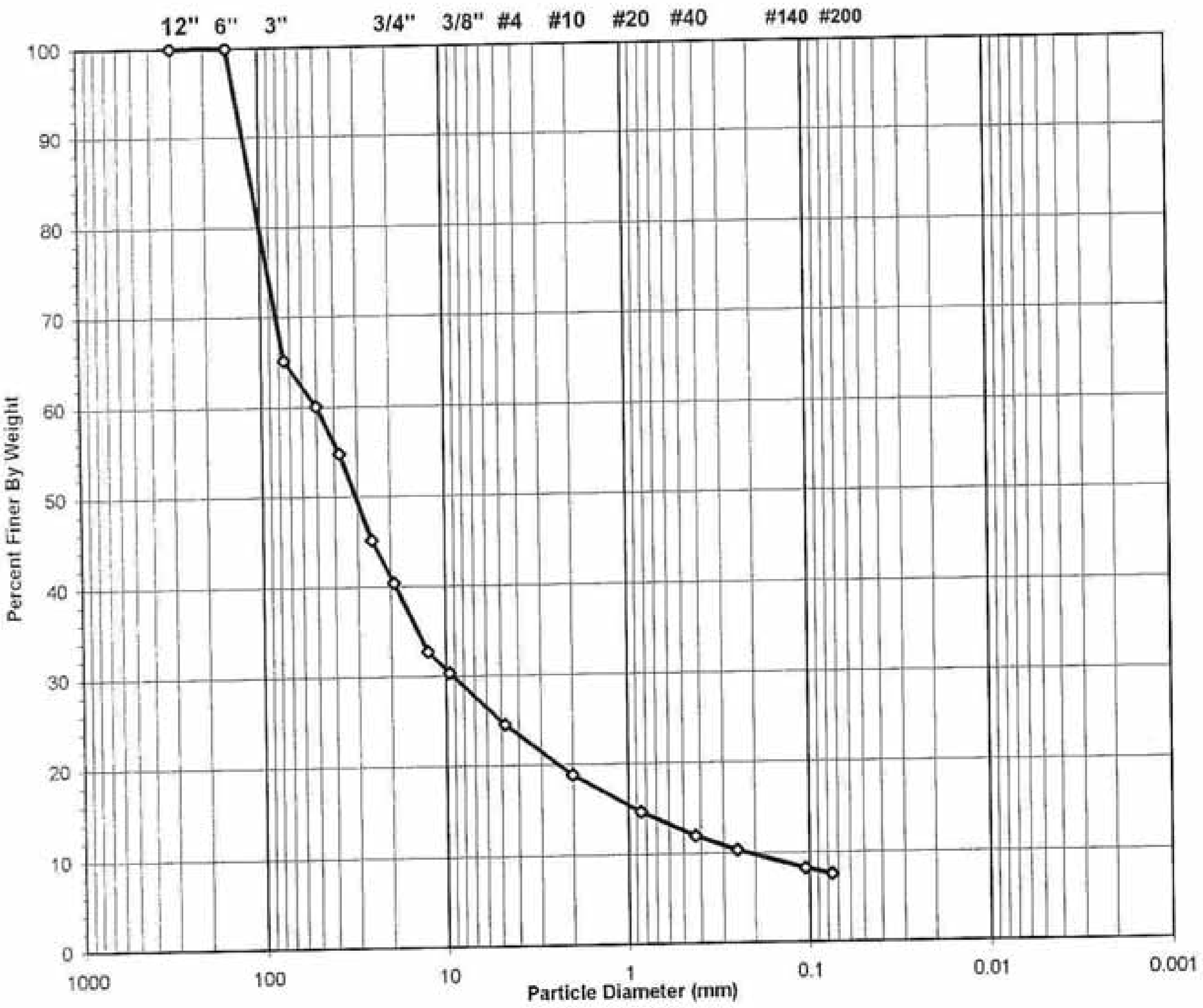
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	10-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-44	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol	*GP-GM, TESTED*	D60 =	49.9	CC =	7.6
USCS Classification	*POORLY GRADED GRAVEL WITH SILT AND SAND (NON-PLASTIC FINES)*	D30 =	9.1	CU =	227.0
		D10 =	0.2		

Tested By JP Date 2/28/06 Checked By KB Date 3-1-06

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DCN: CT-S3A DATE 6-25-98 REVISION 2

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	10-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-44	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	2337	Tare No.	883
Wgt.Tare + Wet Specimen (gm)	1356.60	Wgt.Tare + Wet Specimen (gm)	472.93
Wgt.Tare + Dry Specimen (gm)	1293.70	Wgt.Tare + Dry Specimen (gm)	466.42
Weight of Tare (gm)	98.48	Weight of Tare (gm)	110.52
Weight of Water (gm)	62.90	Weight of Water (gm)	6.51
Weight of Dry Soil (gm)	1195.22	Weight of Dry Soil (gm)	355.90
Moisture Content (%)	**5.3**	**Moisture Content (%)**	**1.8**

Wet Weight -3/4" Sample (gm)	11279	Weight of the Dry Specimen (gm)	1195.22
Dry Weight - 3/4" Sample (gm)	10715.1	Weight of minus #200 material (gm)	223.48
Wet Weight +3/4" Sample (gm)	16091.00	Weight of plus #200 material (gm)	971.74
Dry Weight + 3/4" Sample (gm)	15801.96		
Total Dry Weight Sample (gm)	26517.1	**J - Factor (Percent Finer than 3/4")**	**0.4041**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	9414.00		34.86	34.86	65.14	**65.14**
2"	50	1374.00	(*)	5.09	39.95	60.05	**60.05**
1 1/2"	37.5	1436.00		5.32	45.27	54.73	**54.73**
1"	25	2591.00		9.60	54.87	45.13	**45.13**
3/4"	19	1276.00		4.73	59.59	40.41	**40.41**
1/2"	12.5	226.19		18.92	18.92	81.08	**32.76**
3/8"	9.5	71.64		5.99	24.92	75.08	**30.34**
#4	4.75	171.68		14.36	39.28	60.72	**24.54**
#10	2	169.64		14.19	53.48	46.52	**18.80**
#20	0.85	123.12	(**)	10.30	63.78	36.22	**14.64**
#40	0.425	80.70		6.75	70.53	29.47	**11.91**
#60	0.25	47.26		3.95	74.48	25.52	**10.31**
#140	0.106	61.14		5.12	79.60	20.40	**8.24**
#200	0.075	20.37		1.70	81.30	18.70	**7.56**
Pan	-	223.48		18.70	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/28/06 Checked By KB Date 3-1-06

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INTEGRITY IN TESTING

ATTERBERG LIMIT

ASTM D 4318-00 (SOP - S4)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	10-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-44	Visual Description	**BROWN SILT** (Minus No. 40 sieve material, Airdried)

NON - PLASTIC MATERIAL

Tested By BS Date 2/28/06 Checked By KB Date 2-28-06

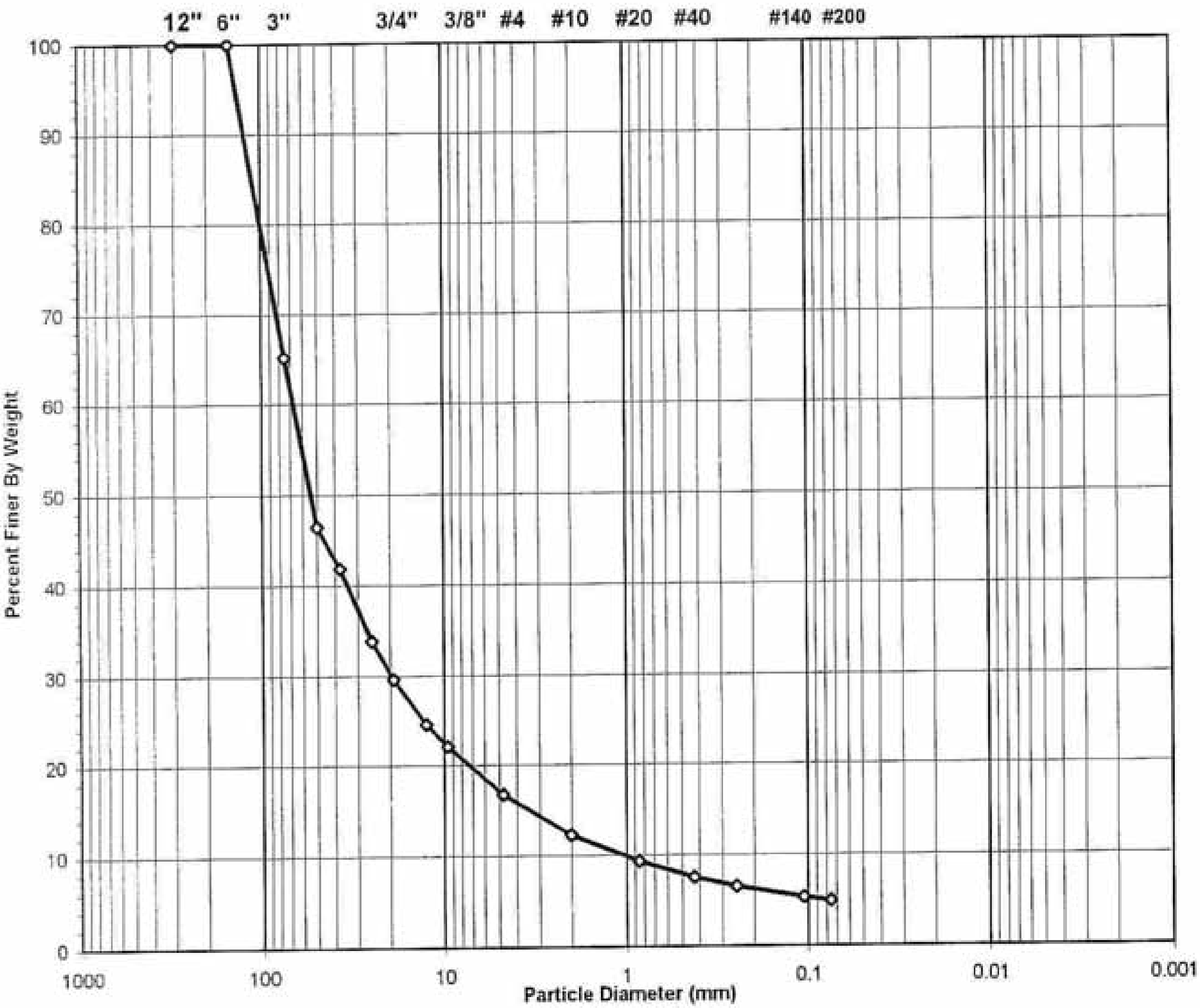
geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	15-20
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-45	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol	*GP, TESTED*	D60 =	67.1	CC =	5.4
USCS Classification	*POORLY GRADED GRAVEL*	D30 =	19.5	CU =	64.2
		D10 =	1.0		

Tested By JP Date 2/28/06 Checked By KB Date 3-1-06

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INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	15-20
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-45	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	1343	Tare No.	612
Wgt.Tare + Wet Specimen (gm)	1351.60	Wgt.Tare + Wet Specimen (gm)	494.86
Wgt.Tare + Dry Specimen (gm)	1300.90	Wgt.Tare + Dry Specimen (gm)	490.77
Weight of Tare (gm)	96.83	Weight of Tare (gm)	83.00
Weight of Water (gm)	50.70	Weight of Water (gm)	4.09
Weight of Dry Soil (gm)	1204.07	Weight of Dry Soil (gm)	407.77
Moisture Content (%)	**4.2**	**Moisture Content (%)**	**1.0**

Wet Weight -3/4" Sample (gm)	18096	Weight of the Dry Specimen (gm)	1204.07
Dry Weight - 3/4" Sample (gm)	17364.8	Weight of minus #200 material (gm)	199.45
Wet Weight +3/4" Sample (gm)	41639.00	Weight of plus #200 material (gm)	1004.62
Dry Weight + 3/4" Sample (gm)	41225.50		
Total Dry Weight Sample (gm)	58590.3	**J - Factor (Percent Finer than 3/4")**	**0.2964**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	20601.00		34.81	34.81	65.19	**65.19**
2"	50	11121.00	(*)	18.79	53.60	46.40	**46.40**
1 1/2"	37.5	2691.00		4.55	58.15	41.85	**41.85**
1"	25	4725.00		7.98	66.14	33.86	**33.86**
3/4"	19	2501.00		4.23	70.36	29.64	**29.64**
1/2"	12.5	206.55		17.15	17.15	82.85	**24.55**
3/8"	9.5	100.23		8.32	25.48	74.52	**22.09**
#4	4.75	216.64		17.99	43.47	56.53	**16.75**
#10	2	183.60		15.25	58.72	41.28	**12.23**
#20	0.85	119.58	(**)	9.93	68.65	31.35	**9.29**
#40	0.425	73.30		6.09	74.74	25.26	**7.49**
#60	0.25	39.69		3.30	78.03	21.97	**6.51**
#140	0.106	48.89		4.06	82.09	17.91	**5.31**
#200	0.075	16.14		1.34	83.44	16.56	**4.91**
Pan	-	199.45		16.56	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/28/06 Checked By YKB Date 3-1-06

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INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	15-20
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-45	Soil Description	**REDDISH BROWN SILTY CLAY**

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

(Minus No. 40 sieve material, Airdried)

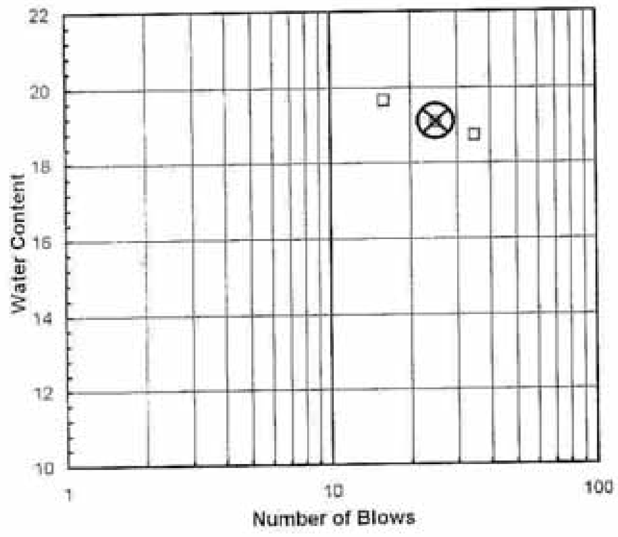
Liquid Limit Test	**1**	**2**	**3**	**MULTIPOINT**
Tare Number	2305	2298	2289	
Wt. of Tare & WS (gm)	43.09	40.59	44.62	
Wt. of Tare & DS (gm)	39.60	36.96	40.65	
Wt. of Tare (gm)	20.95	17.93	20.43	
Wt. of Water (gm)	3.5	3.6	4.0	
Wt. of DS (gm)	18.7	19.0	20.2	
Moisture Content (%)	**18.7**	**19.1**	**19.6**	
Number of Blows	**35**	**25**	**16**	

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	43	53	
Wt. of Tare & WS (gm)	25.16	25.20	
Wt. of Tare & DS (gm)	24.35	24.36	
Wt. of Tare (gm)	19.03	18.80	
Wt. of Water (gm)	0.8	0.8	
Wt. of DS (gm)	5.3	5.6	
Moisture Content (%)	**15.2**	**15.1**	0.1

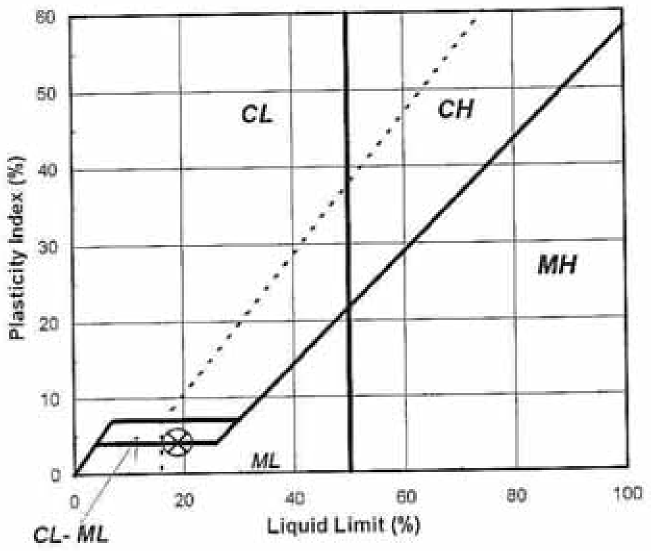
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**19**
Plastic Limit (%)	**15**
Plasticity Index (%)	**4**
USCS Symbol	**CL-ML**

Flow Curve



Plasticity Chart

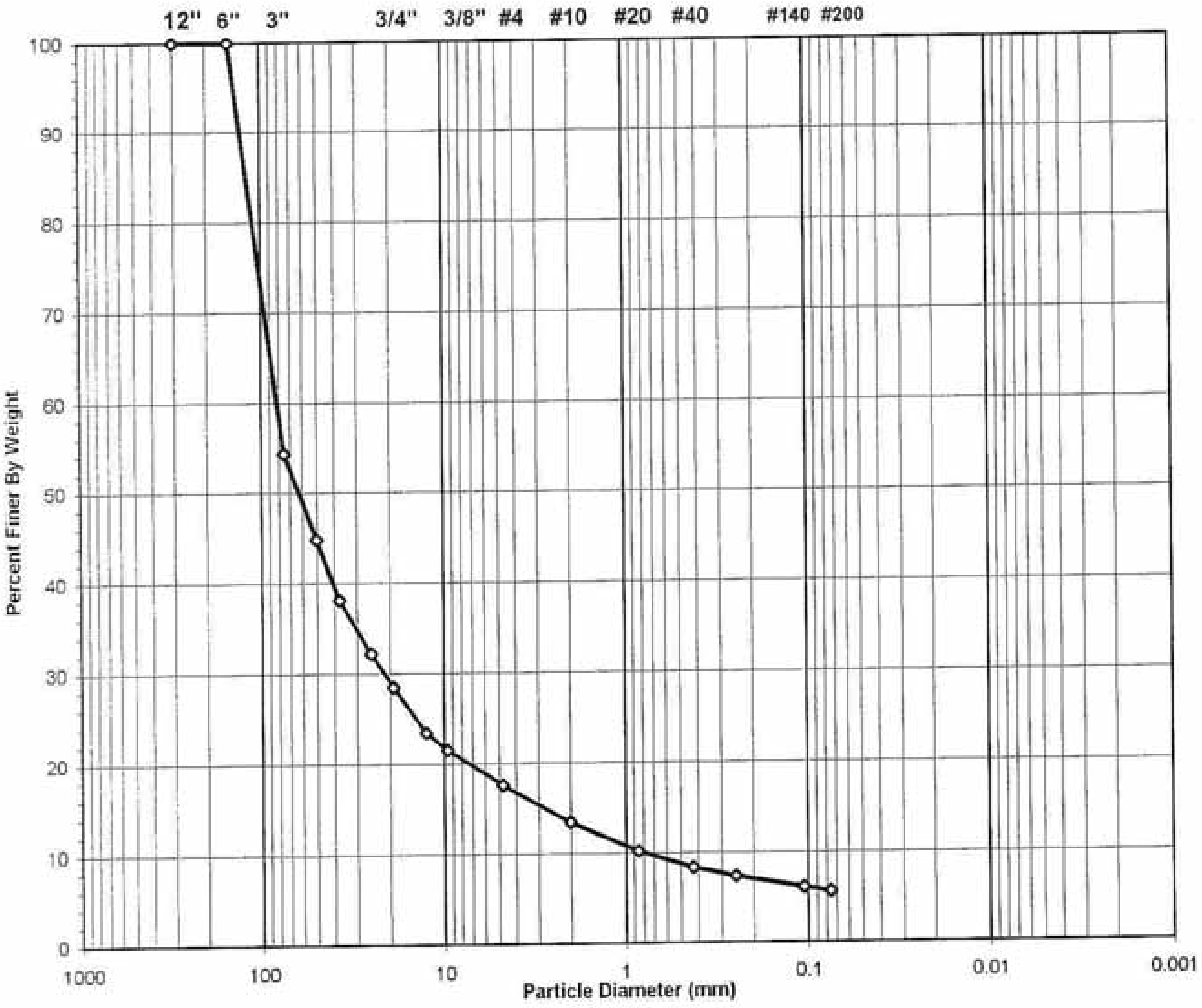


Tested By TO *Date* 2/28/06 *Checked By* YKB *Date* 3-1-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-46	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol *GP-GC, TESTED*

USCS Classification *POORLY GRADED GRAVEL WITH SILTY CLAY*

Tested By JP Date 2/28/06 Checked By KLB Date 3-1-06

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INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-46	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	1653	Tare No.	599
Wgt.Tare + Wet Specimen (gm)	1269.70	Wgt.Tare + Wet Specimen (gm)	1036.90
Wgt.Tare + Dry Specimen (gm)	1197.80	Wgt.Tare + Dry Specimen (gm)	1029.50
Weight of Tare (gm)	94.11	Weight of Tare (gm)	84.33
Weight of Water (gm)	71.90	Weight of Water (gm)	7.40
Weight of Dry Soil (gm)	1103.69	Weight of Dry Soil (gm)	945.17
Moisture Content (%)	**6.5**	**Moisture Content (%)**	**0.8**

Wet Weight -3/4" Sample (gm)	18606	Weight of the Dry Specimen (gm)	1103.69
Dry Weight - 3/4" Sample (gm)	17468.0	Weight of minus #200 material (gm)	217.77
Wet Weight +3/4" Sample (gm)	44251.00	Weight of plus #200 material (gm)	885.92
Dry Weight + 3/4" Sample (gm)	43907.24		
Total Dry Weight Sample (gm)	61375.3	**J - Factor (Percent Finer than 3/4")**	**0.2846**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	28251.00		45.67	45.67	54.33	**54.33**
2"	50	5921.00	(*)	9.57	55.24	44.76	**44.76**
1 1/2"	37.5	4146.00		6.70	61.95	38.05	**38.05**
1"	25	3618.00		5.85	67.80	32.20	**32.20**
3/4"	19	2315.00		3.74	71.54	28.46	**28.46**
1/2"	12.5	192.58		17.45	17.45	82.55	**23.49**
3/8"	9.5	74.34		6.74	24.18	75.82	**21.58**
#4	4.75	155.05		14.05	38.23	61.77	**17.58**
#10	2	159.41		14.44	52.68	47.32	**13.47**
#20	0.85	126.50	(**)	11.46	64.14	35.86	**10.21**
#40	0.425	73.16		6.63	70.77	29.23	**8.32**
#60	0.25	38.56		3.49	74.26	25.74	**7.33**
#140	0.106	48.74		4.42	78.68	21.32	**6.07**
#200	0.075	17.58		1.59	80.27	19.73	**5.62**
Pan	-	217.77		19.73	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/28/06 Checked By Date 3-1-06

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INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-46	Soil Description	**REDDISH BROWN SILTY CLAY**

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

(Minus No. 40 sieve material, Airdried)

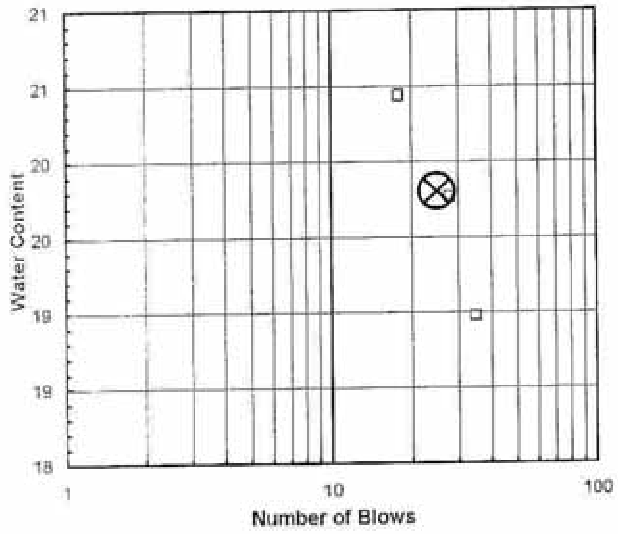
Liquid Limit Test	**1**	**2**	**3**	
Tare Number	261	2232	2253	**MULTIPOINT**
Wt. of Tare & WS (gm)	40.76	38.70	47.78	
Wt. of Tare & DS (gm)	36.96	35.19	42.92	
Wt. of Tare (gm)	16.93	17.43	19.14	
Wt. of Water (gm)	3.8	3.5	4.9	
Wt. of DS (gm)	20.0	17.8	23.8	
Moisture Content (%)	**19.0**	**19.8**	**20.4**	
Number of Blows	**35**	**28**	**18**	

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	2303	2314	
Wt. of Tare & WS (gm)	24.41	25.22	
Wt. of Tare & DS (gm)	23.58	24.25	
Wt. of Tare (gm)	18.37	18.26	
Wt. of Water (gm)	0.8	1.0	
Wt. of DS (gm)	5.2	6.0	
Moisture Content (%)	**15.9**	**16.2**	**-0.3**

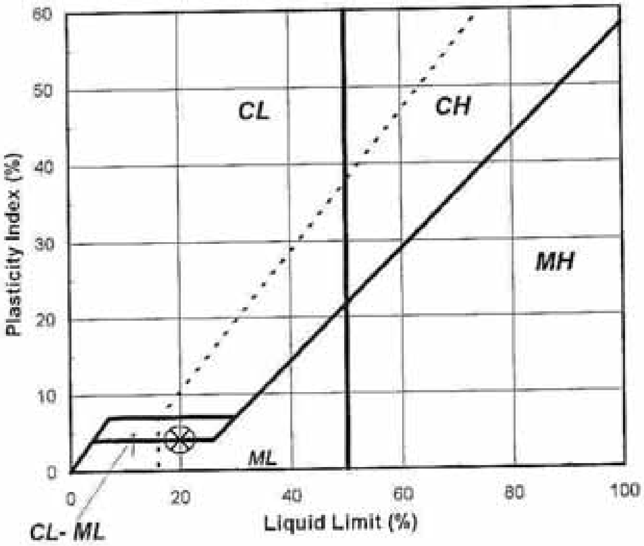
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**20**
Plastic Limit (%)	**16**
Plasticity Index (%)	**4**
USCS Symbol	**CL-ML**

Flow Curve



Plasticity Chart



Tested By	BS	*Date*	2/28/06	*Checked By* YKB	*Date* 3-1-06

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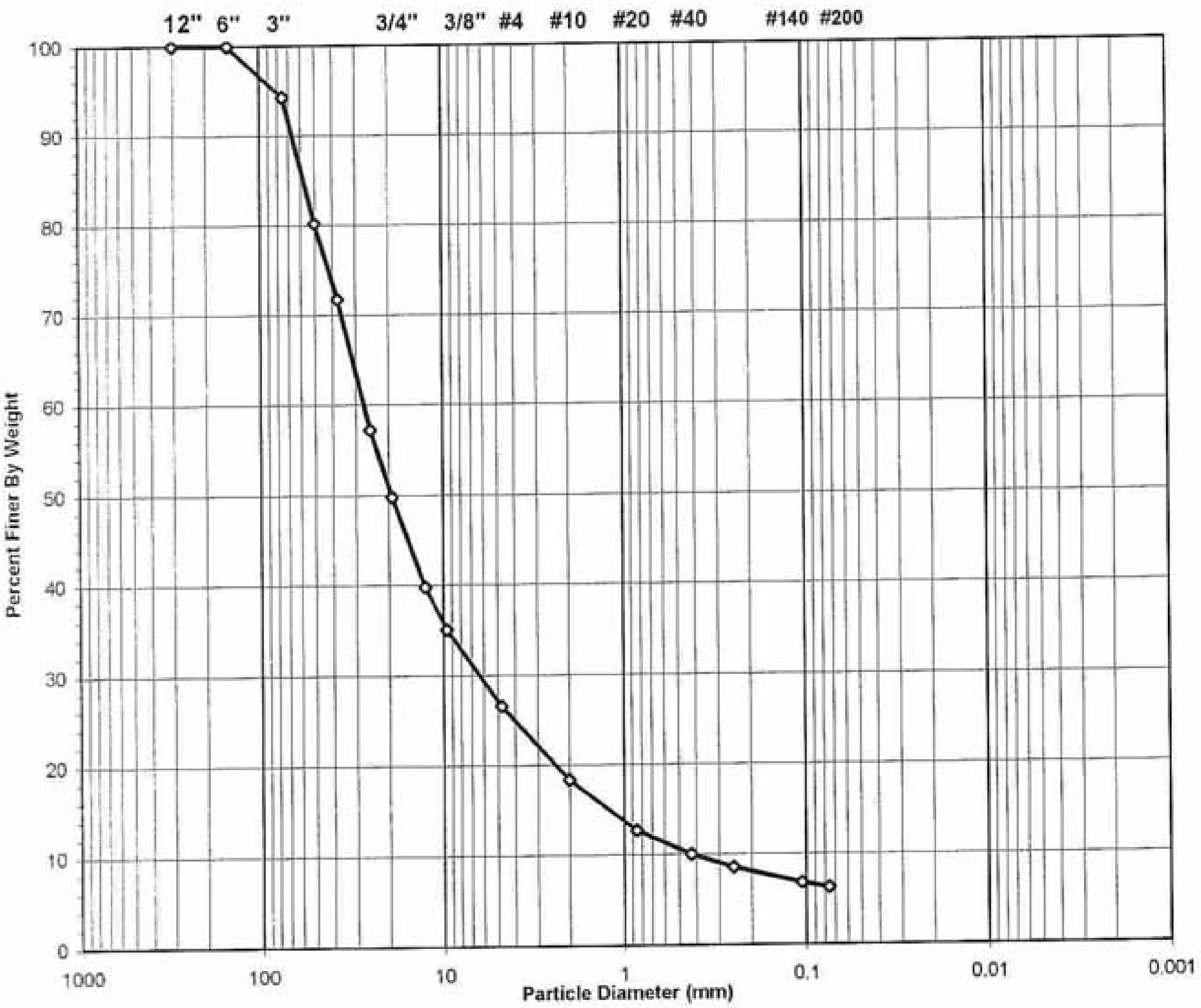
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	30-40
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-47	Soil Color	**REDDISH BROWN**

USCS	*SIEVE ANALYSIS*		*HYDROMETER*
	gravel	sand	silt and clay



USCS Symbol	*GP-GC, TESTED*	D60 =	27.0	CC =	3.4
USCS Classification	*POORLY GRADED GRAVEL WITH SILTY CLAY AND SAND*	D30 =	6.3	CU =	63.1
		D10 =	0.4		

Tested By JP Date 2/28/06 Checked By Date 3-1-06

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INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	30-40
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-47	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	517	Tare No.	910
Wgt.Tare + Wet Specimen (gm)	1187.40	Wgt.Tare + Wet Specimen (gm)	707.90
Wgt.Tare + Dry Specimen (gm)	1101.00	Wgt.Tare + Dry Specimen (gm)	687.40
Weight of Tare (gm)	98.58	Weight of Tare (gm)	110.34
Weight of Water (gm)	86.40	Weight of Water (gm)	20.50
Weight of Dry Soil (gm)	1002.42	Weight of Dry Soil (gm)	577.06
Moisture Content (%)	**8.6**	**Moisture Content (%)**	**3.6**

Wet Weight -3/4" Sample (gm)	18861	Weight of the Dry Specimen (gm)	1002.42
Dry Weight - 3/4" Sample (gm)	17364.3	Weight of minus #200 material (gm)	126.57
Wet Weight +3/4" Sample (gm)	18157.00	Weight of plus #200 material (gm)	875.85
Dry Weight + 3/4" Sample (gm)	17534.10		
Total Dry Weight Sample (gm)	34898.4	**J - Factor (Percent Finer than 3/4")**	**0.4976**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	2062.00		5.71	5.71	94.29	**94.29**
2"	50	5094.00	(*)	14.10	19.80	80.20	**80.20**
1 1/2"	37.5	3059.00		8.46	28.27	71.73	**71.73**
1"	25	5250.00		14.53	42.79	57.21	**57.21**
3/4"	19	2692.00		7.45	50.24	49.76	**49.76**
1/2"	12.5	202.08		20.16	20.16	79.84	**39.73**
3/8"	9.5	93.70		9.35	29.51	70.49	**35.08**
#4	4.75	171.67		17.13	46.63	53.37	**26.55**
#10	2	164.35		16.40	63.03	36.97	**18.40**
#20	0.85	114.81	(**)	11.45	74.48	25.52	**12.70**
#40	0.425	55.01		5.49	79.97	20.03	**9.97**
#60	0.25	29.52		2.94	82.91	17.09	**8.50**
#140	0.106	34.61		3.45	86.37	13.63	**6.78**
#200	0.075	10.10		1.01	87.37	12.63	**6.28**
Pan	-	126.57		12.63	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/28/06 Checked By KB Date 3-1-06

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	30-40
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-47	Soil Description	**REDDISH BROWN SILTY CLAY**

(Minus No. 40 sieve material, Airdried)

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

Liquid Limit Test	1	2	3
Tare Number	242	2184	40A
Wt. of Tare & WS (gm)	42.65	41.05	37.71
Wt. of Tare & DS (gm)	38.81	37.40	33.97
Wt. of Tare (gm)	20.09	20.21	17.43
Wt. of Water (gm)	3.8	3.7	3.7
Wt. of DS (gm)	18.7	17.2	16.5
Moisture Content (%)	**20.5**	**21.2**	**22.6**
Number of Blows	**27**	**24**	**15**

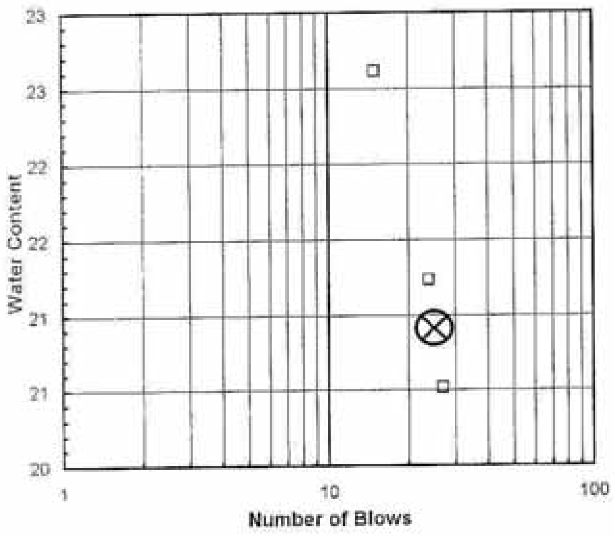
MULTIPOINT

Plastic Limit Test	1	2	**Range**
Tare Number	225	142	
Wt. of Tare & WS (gm)	26.08	26.81	
Wt. of Tare & DS (gm)	25.19	25.94	
Wt. of Tare (gm)	19.58	20.57	
Wt. of Water (gm)	0.9	0.9	
Wt. of DS (gm)	5.6	5.4	
Moisture Content (%)	**15.9**	**16.2**	**-0.3**

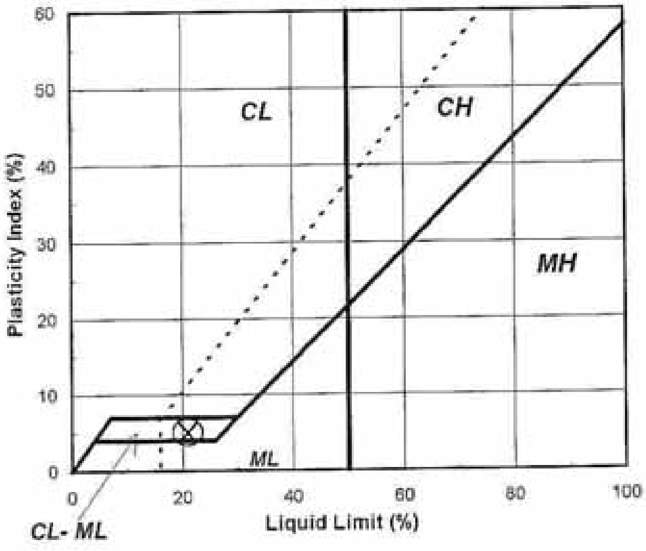
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**21**
Plastic Limit (%)	**16**
Plasticity Index (%)	**5**
USCS Symbol	**CL-ML**

Flow Curve



Plasticity Chart

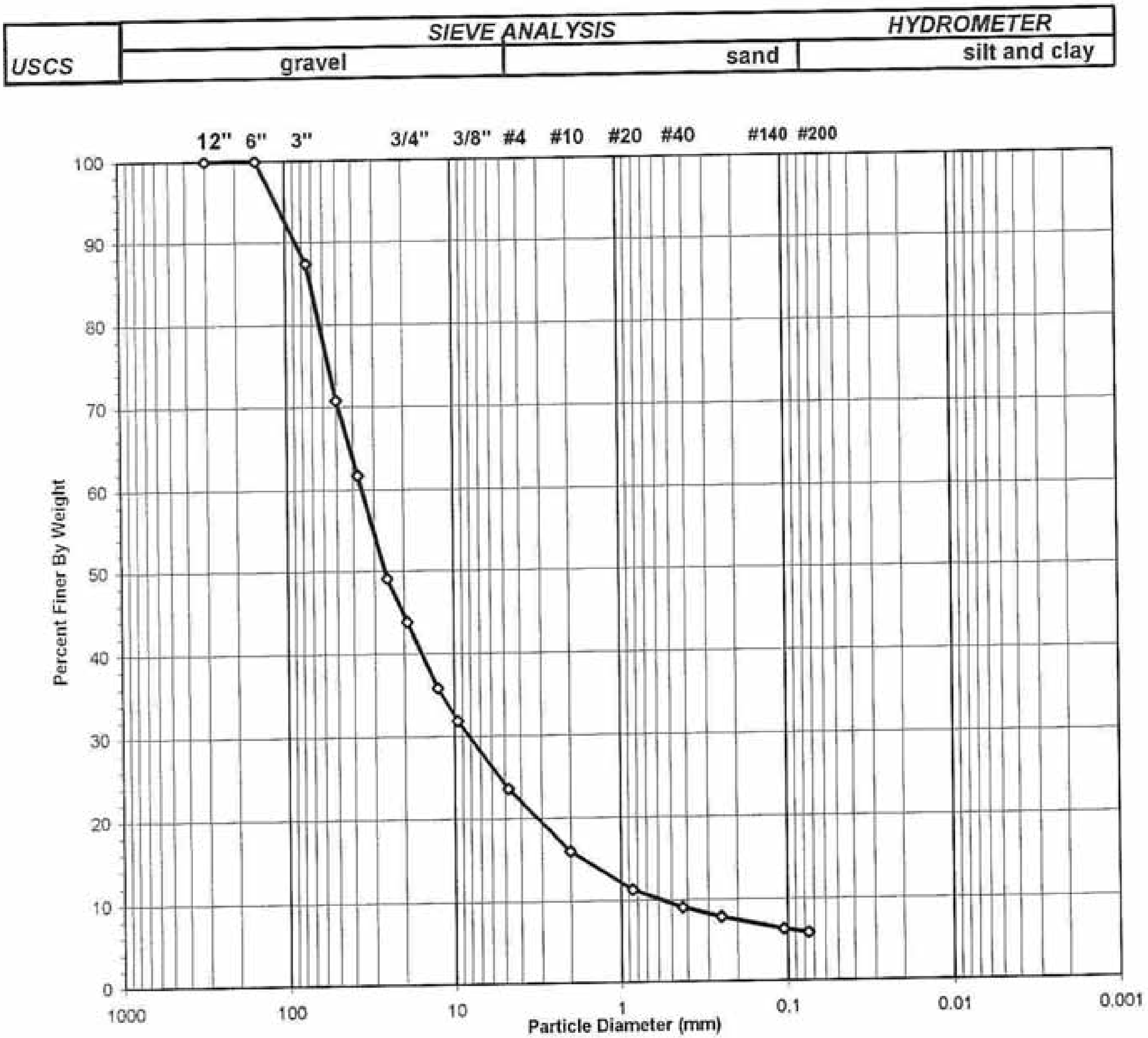


Tested By	*TO*	*Date*	*2/28/06*	*Checked By*	YKB	*Date*	3-1-06

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	40-50
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-48	Soil Color	**REDDISH BROWN**



USCS Symbol	*gp-gc, ASSUMED*	D60 =	35.5	CC =	3.3
USCS Classification	*POORLY GRADED GRAVEL WITH SILTY CLAY AND SAND*	D30 =	8.1	CU =	61.9
		D10 =	0.6		

Tested By JP Date 2/28/06 Checked By Date 3-8-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	40-50
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-48	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	514	Tare No.	552
Wgt.Tare + Wet Specimen (gm)	1196.70	Wgt.Tare + Wet Specimen (gm)	698.30
Wgt.Tare + Dry Specimen (gm)	1055.70	Wgt.Tare + Dry Specimen (gm)	683.50
Weight of Tare (gm)	96.71	Weight of Tare (gm)	81.59
Weight of Water (gm)	141.00	Weight of Water (gm)	14.80
Weight of Dry Soil (gm)	958.99	Weight of Dry Soil (gm)	601.91
Moisture Content (%)	**14.7**	**Moisture Content (%)**	**2.5**

Wet Weight -3/4" Sample (gm)	17195	Weight of the Dry Specimen (gm)	958.99
Dry Weight - 3/4" Sample (gm)	14990.9	Weight of minus #200 material (gm)	127.37
Wet Weight +3/4" Sample (gm)	19695.00	Weight of plus #200 material (gm)	831.62
Dry Weight + 3/4" Sample (gm)	19222.35		
Total Dry Weight Sample (gm)	34213.2	**J - Factor (Percent Finer than 3/4")**	**0.4382**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	4440.00		12.67	12.67	87.33	**87.33**
2"	50	5786.00	(*)	16.51	29.17	70.83	**70.83**
1 1/2"	37.5	3189.00		9.10	38.27	61.73	**61.73**
1"	25	4442.00		12.67	50.94	49.06	**49.06**
3/4"	19	1838.00		5.24	56.18	43.82	**43.82**
1/2"	12.5	174.27		18.17	18.17	81.83	**35.85**
3/8"	9.5	88.10		9.19	27.36	72.64	**31.83**
#4	4.75	179.94		18.76	46.12	53.88	**23.61**
#10	2	167.00		17.41	63.54	36.46	**15.98**
#20	0.85	103.29	(**)	10.77	74.31	25.69	**11.26**
#40	0.425	48.42		5.05	79.36	20.64	**9.05**
#60	0.25	26.92		2.81	82.16	17.84	**7.82**
#140	0.106	33.51		3.49	85.66	14.34	**6.28**
#200	0.075	10.17		1.06	86.72	13.28	**5.82**
Pan	-	127.37		13.28	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

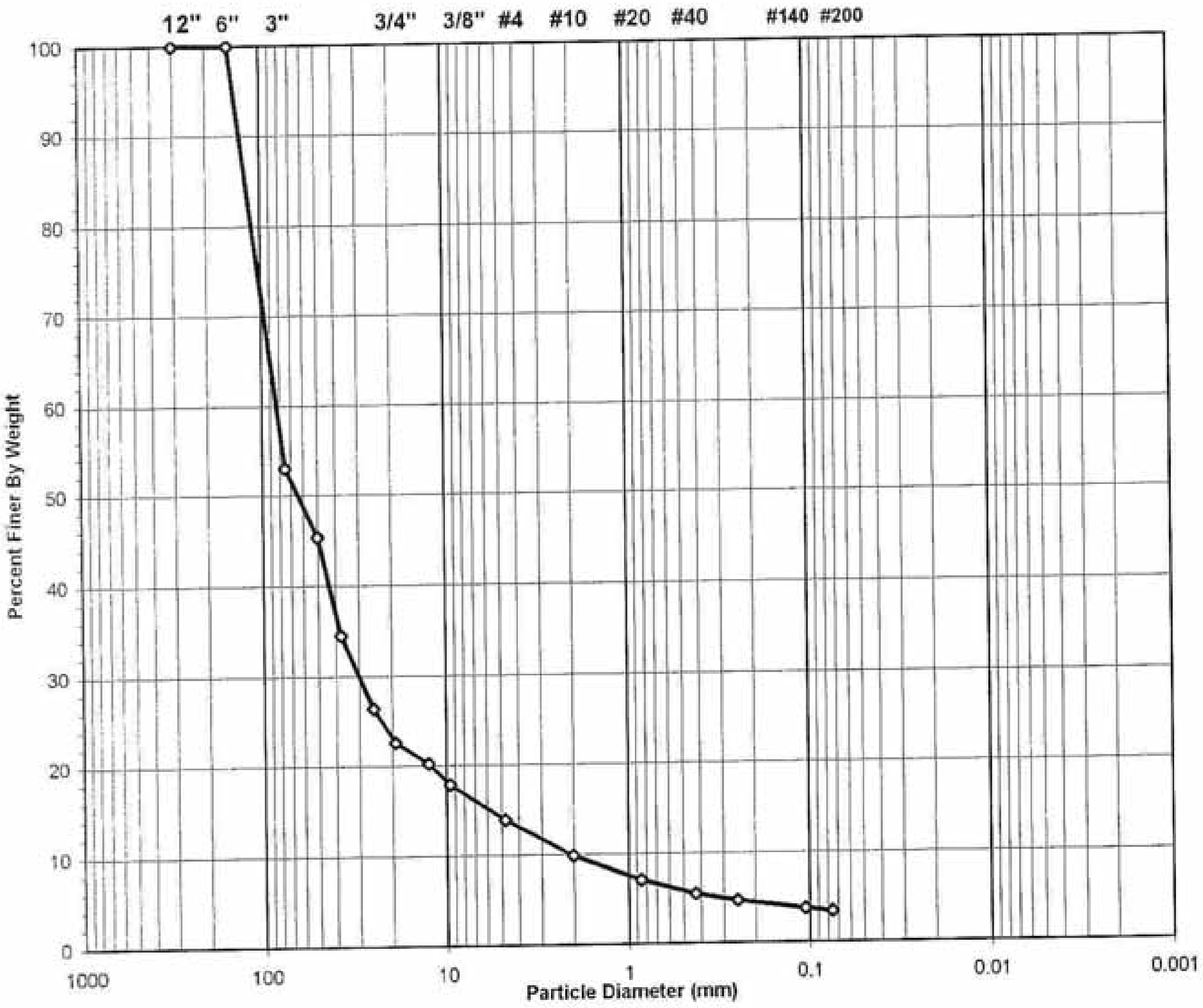
Tested By JP Date 2/28/06 Checked By KB Date 3-8-06

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-60
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-49	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol ***GP, TESTED***

USCS Classification ***POORLY GRADED GRAVEL***
(NON-PLASTIC FINES)

Tested By JP Date 2/28/06 Checked By KCB Date 3-1-06

page 1 of 2 DCN: CT-S3A DATE 6-25-98 REVISION 2 *C:\MSOFFICE\Excel\PrintQ\[U424.xls]Sheet1*

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-60
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-49	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	1923	Tare No.	615
Wgt.Tare + Wet Specimen (gm)	1196.00	Wgt.Tare + Wet Specimen (gm)	600.20
Wgt.Tare + Dry Specimen (gm)	1143.10	Wgt.Tare + Dry Specimen (gm)	593.10
Weight of Tare (gm)	100.21	Weight of Tare (gm)	84.38
Weight of Water (gm)	52.90	Weight of Water (gm)	7.10
Weight of Dry Soil (gm)	1042.89	Weight of Dry Soil (gm)	508.72
Moisture Content (%)	**5.1**	**Moisture Content (%)**	**1.4**

Wet Weight -3/4" Sample (gm)	9529	Weight of the Dry Specimen (gm)	1042.89
Dry Weight - 3/4" Sample (gm)	9069.0	Weight of minus #200 material (gm)	157.45
Wet Weight +3/4" Sample (gm)	31510.00	Weight of plus #200 material (gm)	885.44
Dry Weight + 3/4" Sample (gm)	31076.28		
Total Dry Weight Sample (gm)	40145.3	**J - Factor (Percent Finer than 3/4")**	**0.2259**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	19144.00		47.03	47.03	52.97	**52.97**
2"	50	3124.00	(*)	7.67	54.71	45.29	**45.29**
1 1/2"	37.5	4422.00		10.86	65.57	34.43	**34.43**
1"	25	3258.00		8.00	73.57	26.43	**26.43**
3/4"	19	1562.00		3.84	77.41	22.59	**22.59**
1/2"	12.5	110.14		10.56	10.56	89.44	**20.20**
3/8"	9.5	109.92		10.54	21.10	78.90	**17.82**
#4	4.75	183.12		17.56	38.66	61.34	**13.86**
#10	2	184.13		17.66	56.32	43.68	**9.87**
#20	0.85	131.10	(**)	12.57	68.89	31.11	**7.03**
#40	0.425	71.69		6.87	75.76	24.24	**5.48**
#60	0.25	36.26		3.48	79.24	20.76	**4.69**
#140	0.106	43.94		4.21	83.45	16.55	**3.74**
#200	0.075	15.14		1.45	84.90	15.10	**3.41**
Pan	-	157.45		15.10	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/28/06 Checked By KB Date 3-1-06

geotechnics
INTEGRITY IN TESTING

ATTERBERG LIMIT

ASTM D 4318-00 (SOP - S4)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-60
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-49	Visual Description	**REDDISH BROWN SILT** (Minus No. 40 sieve material, Airdried)

NON - PLASTIC MATERIAL

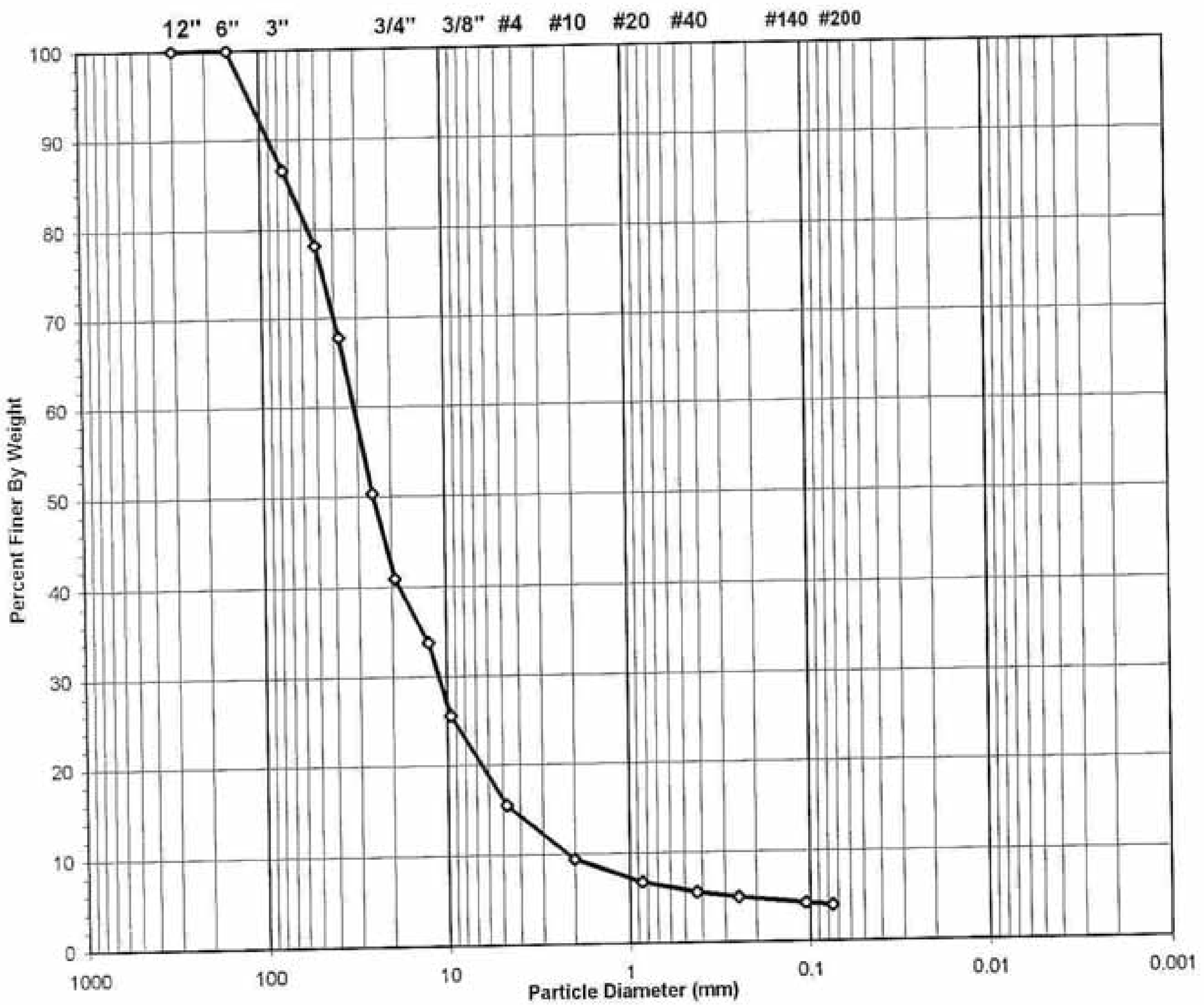
Tested By BS *Date* 2/28/06 *Checked By* KJB *Date* 3-1-06

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	60-67
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-50	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol	*gw, ASSUMED*	D60 =	31.3	CC =	1.8
USCS Classification	*WELL-GRADED GRAVEL*	D30 =	11.0	CU =	14.3
		D10 =	2.2		

Tested By PC Date 2/23/06 Checked By Date 3-8-06

page 1 of 2 DCN: CT-S3A DATE 6-25-98 REVISION 2 *C:\MSOFFICE\Excel\PrintQ\[U588.xls]Sheet1*

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-5
Client Reference	TAUM SAUK 06-3551	Depth (ft)	60-67
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-50	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	959	Tare No.	728
Wgt.Tare + Wet Specimen (gm)	1212.70	Wgt.Tare + Wet Specimen (gm)	691.50
Wgt.Tare + Dry Specimen (gm)	1161.90	Wgt.Tare + Dry Specimen (gm)	677.30
Weight of Tare (gm)	103.11	Weight of Tare (gm)	86.47
Weight of Water (gm)	50.80	Weight of Water (gm)	14.20
Weight of Dry Soil (gm)	1058.79	Weight of Dry Soil (gm)	590.83
Moisture Content (%)	**4.8**	**Moisture Content (%)**	**2.4**

Wet Weight -3/4" Sample (gm)	14209	Weight of the Dry Specimen (gm)	1058.79
Dry Weight - 3/4" Sample (gm)	13558.5	Weight of minus #200 material (gm)	101.93
Wet Weight +3/4" Sample (gm)	20027.00	Weight of plus #200 material (gm)	956.86
Dry Weight + 3/4" Sample (gm)	19556.97		
Total Dry Weight Sample (gm)	33115.4	**J - Factor (Percent Finer than 3/4")**	**0.4094**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	4552.00		13.42	13.42	86.58	**86.58**
2"	50	2881.00	(*)	8.50	21.92	78.08	**78.08**
1 1/2"	37.5	3482.00		10.27	32.19	67.81	**67.81**
1"	25	5940.00		17.52	49.70	50.30	**50.30**
3/4"	19	3172.00		9.35	59.06	40.94	**40.94**
1/2"	12.5	183.94		17.37	17.37	82.63	**33.83**
3/8"	9.5	214.71		20.28	37.65	62.35	**25.53**
#4	4.75	258.70		24.43	62.09	37.91	**15.52**
#10	2	159.13		15.03	77.11	22.89	**9.37**
#20	0.85	68.55	(**)	6.47	83.59	16.41	**6.72**
#40	0.425	30.17		2.85	86.44	13.56	**5.55**
#60	0.25	16.37		1.55	87.98	12.02	**4.92**
#140	0.106	19.29		1.82	89.81	10.19	**4.17**
#200	0.075	6.00		0.57	90.37	9.63	**3.94**
Pan	-	101.93		9.63	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/23/06 Checked By KB Date 3-8-06

BORING TS-6

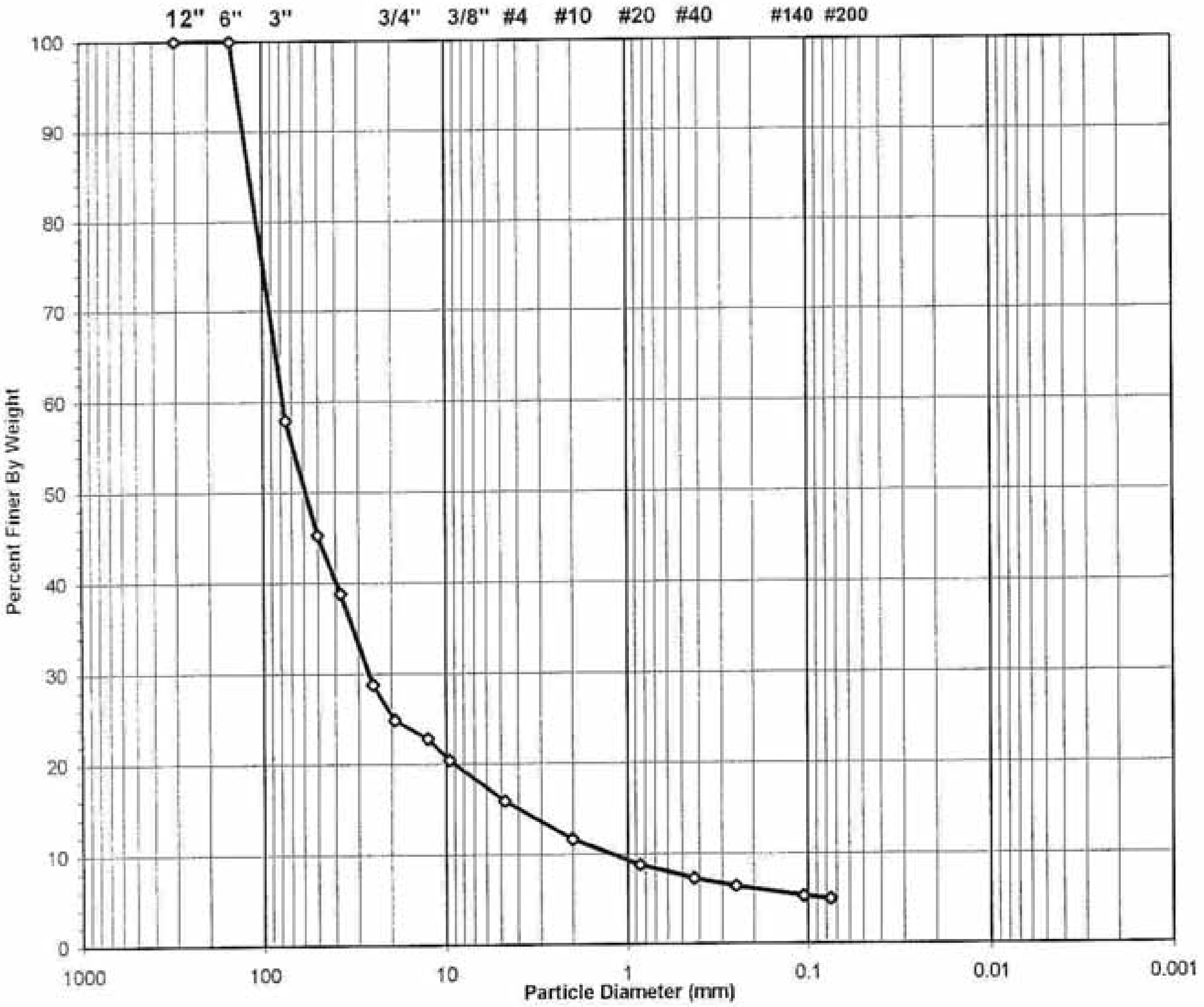
geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-6
Client Reference	TAUM SAUK 06-3551	Depth (ft)	5-10
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-52	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol ***gp, ASSUMED***

USCS Classification ***POORLY GRADED GRAVEL***

Tested By PC Date 2/23/06 Checked By VKB Date 2-24-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-6
Client Reference	TAUM SAUK 06-3551	Depth (ft)	5-10
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-52	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	2492	Tare No.	729
Wgt.Tare + Wet Specimen (gm)	1425.50	Wgt.Tare + Wet Specimen (gm)	636.40
Wgt.Tare + Dry Specimen (gm)	1368.60	Wgt.Tare + Dry Specimen (gm)	629.70
Weight of Tare (gm)	97.16	Weight of Tare (gm)	86.39
Weight of Water (gm)	56.90	Weight of Water (gm)	6.70
Weight of Dry Soil (gm)	1271.44	Weight of Dry Soil (gm)	543.31
Moisture Content (%)	**4.5**	**Moisture Content (%)**	**1.2**

Wet Weight -3/4" Sample (gm)	14720	Weight of the Dry Specimen (gm)	1271.44
Dry Weight - 3/4" Sample (gm)	14089.5	Weight of minus #200 material (gm)	251.78
Wet Weight +3/4" Sample (gm)	43118.00	Weight of plus #200 material (gm)	1019.66
Dry Weight + 3/4" Sample (gm)	42592.75		
Total Dry Weight Sample (gm)	56682.2	**J - Factor (Percent Finer than 3/4")**	**0.2486**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	24132.00		42.06	42.06	57.94	**57.94**
2"	50	7284.00	(*)	12.69	54.75	45.25	**45.25**
1 1/2"	37.5	3702.00		6.45	61.20	38.80	**38.80**
1"	25	5734.00		9.99	71.19	28.81	**28.81**
3/4"	19	2266.00		3.95	75.14	24.86	**24.86**
1/2"	12.5	102.81		8.09	8.09	91.91	**22.85**
3/8"	9.5	123.93		9.75	17.83	82.17	**20.42**
#4	4.75	231.34		18.20	36.03	63.97	**15.90**
#10	2	217.00		17.07	53.10	46.90	**11.66**
#20	0.85	148.23	(**)	11.66	64.75	35.25	**8.76**
#40	0.425	76.80		6.04	70.79	29.21	**7.26**
#60	0.25	44.92		3.53	74.33	25.67	**6.38**
#140	0.106	56.70		4.46	78.79	21.21	**5.27**
#200	0.075	17.93		1.41	80.20	19.80	**4.92**
Pan	-	251.78		19.80	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/23/06 Checked By KLB Date 2-24-06

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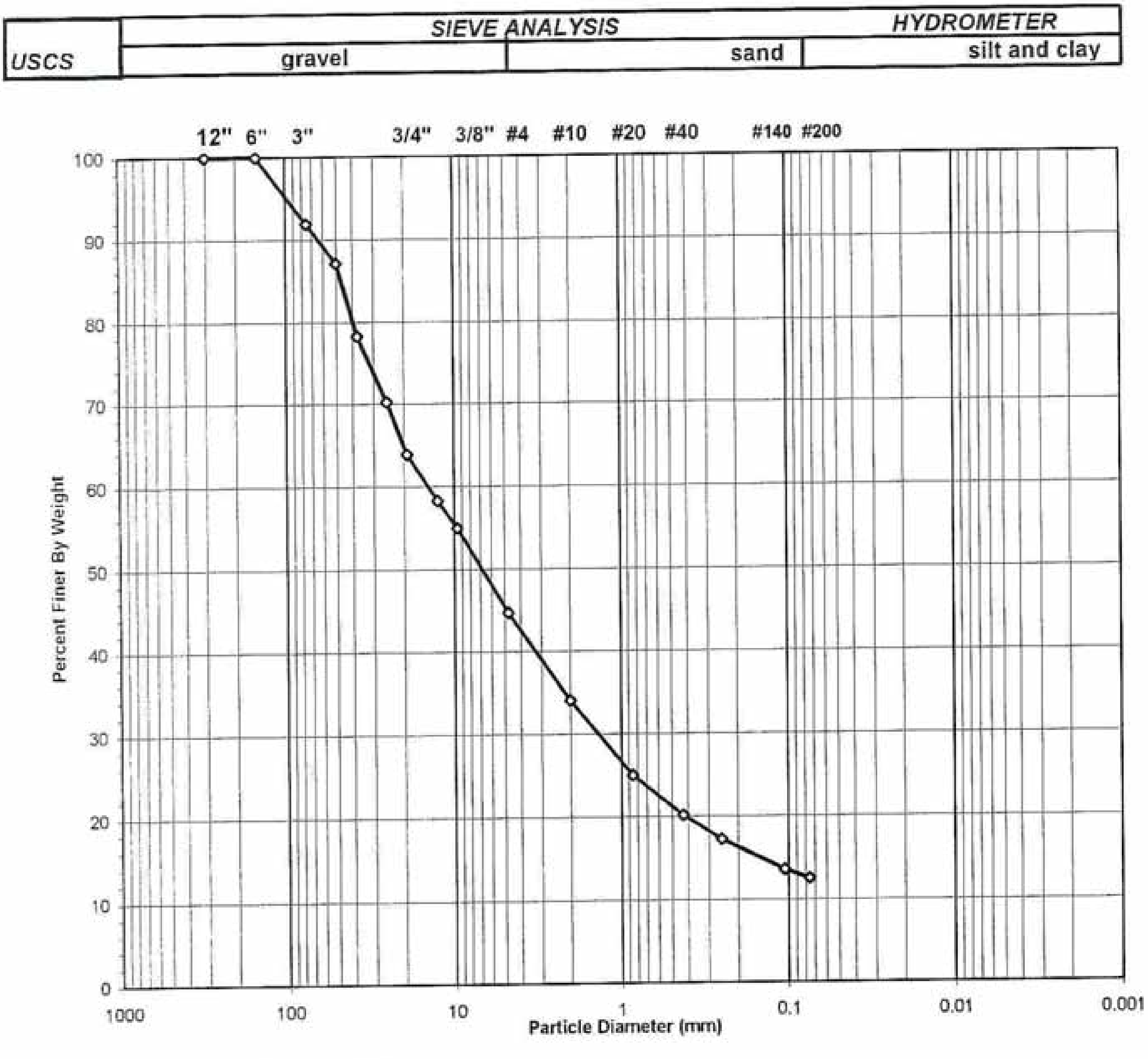
page 2 of 2

DCN: CT-S3A DATE 5-17-00 REVISION 3

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-6
Client Reference	TAUM SAUK 06-3551	Depth (ft)	10-20
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-53	Soil Color	**REDDISH BROWN**



USCS Symbol ***GM, TESTED***

USCS Classification ***SILTY GRAVEL WITH SAND***
(NON-PLASTIC FINES)

Tested By JP Date 2/28/06 Checked By YKB Date 3-1-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-6
Client Reference	TAUM SAUK 06-3551	Depth (ft)	10-20
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-53	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	674	Tare No.	584
Wgt.Tare + Wet Specimen (gm)	1244.30	Wgt.Tare + Wet Specimen (gm)	517.24
Wgt.Tare + Dry Specimen (gm)	1196.20	Wgt.Tare + Dry Specimen (gm)	510.66
Weight of Tare (gm)	99.76	Weight of Tare (gm)	82.30
Weight of Water (gm)	48.10	Weight of Water (gm)	6.58
Weight of Dry Soil (gm)	1096.44	Weight of Dry Soil (gm)	428.36
Moisture Content (%)	**4.4**	**Moisture Content (%)**	**1.5**

Wet Weight -3/4" Sample (gm)	15231	Weight of the Dry Specimen (gm)	1096.44
Dry Weight - 3/4" Sample (gm)	14590.9	Weight of minus #200 material (gm)	214.65
Wet Weight +3/4" Sample (gm)	8371.00	Weight of plus #200 material (gm)	881.79
Dry Weight + 3/4" Sample (gm)	8244.36		
Total Dry Weight Sample (gm)	22835.3	**J - Factor (Percent Finer than 3/4")**	**0.6390**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	1863.00		8.04	8.04	91.96	**91.96**
2"	50	1124.00	(*)	4.85	12.88	87.12	**87.12**
1 1/2"	37.5	2058.00		8.88	21.76	78.24	**78.24**
1"	25	1863.00		8.04	29.79	70.21	**70.21**
3/4"	19	1463.00		6.31	36.10	63.90	**63.90**
1/2"	12.5	96.40		8.79	8.79	91.21	**58.28**
3/8"	9.5	57.57		5.25	14.04	85.96	**54.92**
#4	4.75	175.03		15.96	30.01	69.99	**44.72**
#10	2	183.88		16.77	46.78	53.22	**34.01**
#20	0.85	153.78	(**)	14.03	60.80	39.20	**25.05**
#40	0.425	84.39		7.70	68.50	31.50	**20.13**
#60	0.25	50.08		4.57	73.07	26.93	**17.21**
#140	0.106	62.44		5.69	78.76	21.24	**13.57**
#200	0.075	18.22		1.66	80.42	19.58	**12.51**
Pan	-	214.65		19.58	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/28/06 Checked By KB Date 3-1-06

geotechnics
INTEGRITY IN TESTING

ATTERBERG LIMIT

ASTM D 4318-00 (SOP - S4)

Client	PAUL C. RIZZO	Boring No.	TS-6
Client Reference	TAUM SAUK 06-3551	Depth (ft)	10-20
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-53	Visual Description	**REDDISH BROWN SILT** (Minus No. 40 sieve material, Airdried)

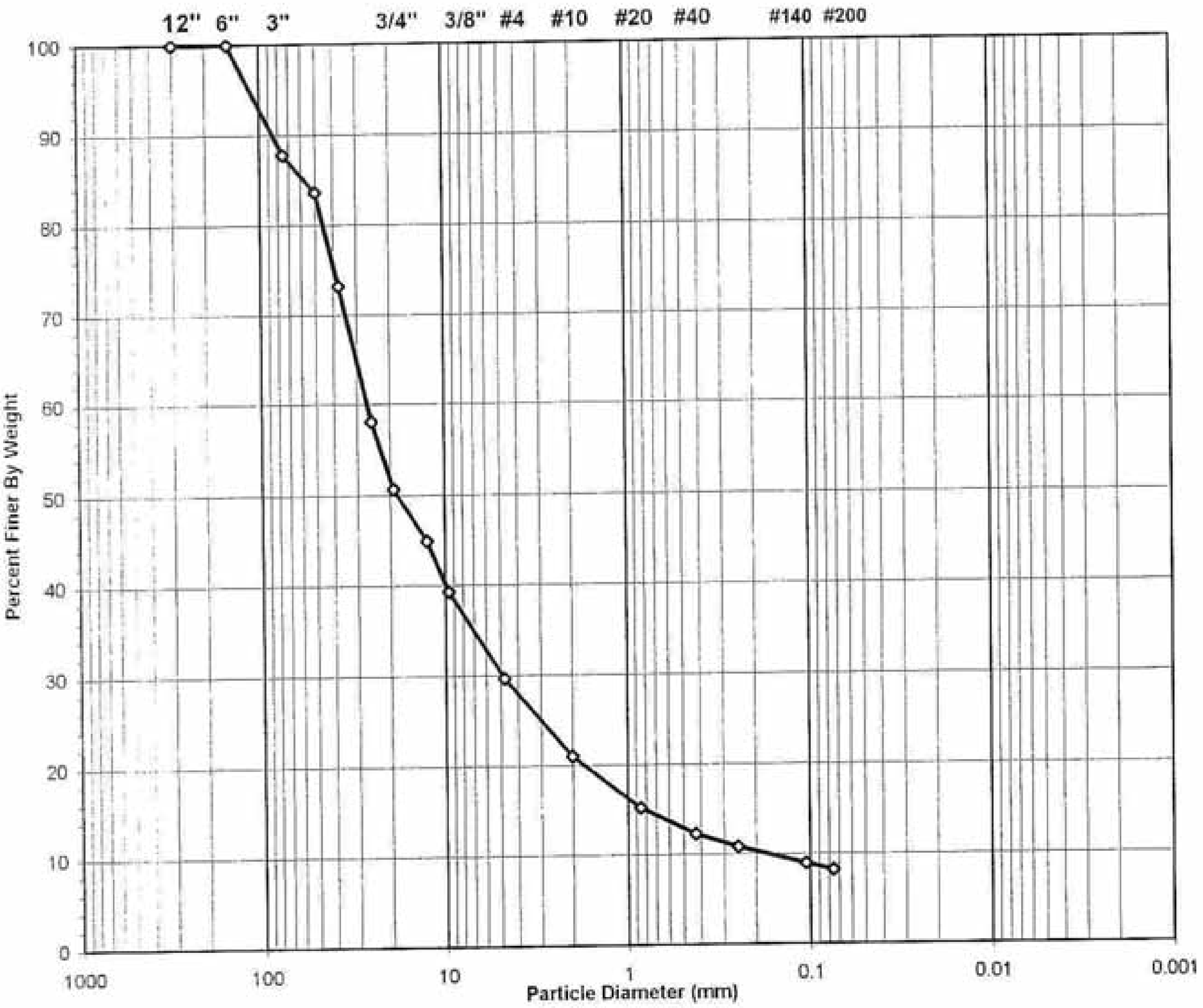
NON - PLASTIC MATERIAL

Tested By TO *Date* 2/28/06 *Checked By* KLB *Date* 3-1-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-6
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-54	Soil Color	**REDDISH BROWN**

USCS	*SIEVE ANALYSIS*		*HYDROMETER*
	gravel	sand	silt and clay



USCS Symbol	*GP-GC, TESTED*	**D60 =**	**26.3**	**CC =**	**5.1**
USCS Classification	*POORLY GRADED GRAVEL WITH SILTY CLAY AND SAND*	**D30 =**	**4.9**	**CU =**	**150.3**
		D10 =	**0.2**		

Tested By PC Date 2/22/06 Checked By Date 2-28-06

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INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-6
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-54	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	2445	Tare No.	604
Wgt.Tare + Wet Specimen (gm)	1230.30	Wgt.Tare + Wet Specimen (gm)	1037.90
Wgt.Tare + Dry Specimen (gm)	1143.10	Wgt.Tare + Dry Specimen (gm)	1014.80
Weight of Tare (gm)	93.29	Weight of Tare (gm)	87.11
Weight of Water (gm)	87.20	Weight of Water (gm)	23.10
Weight of Dry Soil (gm)	1049.81	Weight of Dry Soil (gm)	927.69
Moisture Content (%)	**8.3**	**Moisture Content (%)**	**2.5**

Wet Weight -3/4" Sample (gm)	22977	Weight of the Dry Specimen (gm)	1049.81
Dry Weight - 3/4" Sample (gm)	21214.8	Weight of minus #200 material (gm)	170.29
Wet Weight +3/4" Sample (gm)	21189.00	Weight of plus #200 material (gm)	879.52
Dry Weight + 3/4" Sample (gm)	20674.20		
Total Dry Weight Sample (gm)	41889.0	**J - Factor (Percent Finer than 3/4")**	**0.5065**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	5228.00		12.18	12.18	87.82	**87.82**
2"	50	1792.00	(*)	4.17	16.35	83.65	**83.65**
1 1/2"	37.5	4496.00		10.47	26.82	73.18	**73.18**
1"	25	6482.00		15.10	41.92	58.08	**58.08**
3/4"	19	3191.00		7.43	49.35	50.65	**50.65**
1/2"	12.5	120.79		11.51	11.51	88.49	**44.82**
3/8"	9.5	114.79		10.93	22.44	77.56	**39.28**
#4	4.75	198.88		18.94	41.38	58.62	**29.69**
#10	2	180.15		17.16	58.54	41.46	**21.00**
#20	0.85	119.80	(**)	11.41	69.96	30.04	**15.22**
#40	0.425	61.13		5.82	75.78	24.22	**12.27**
#60	0.25	30.73		2.93	78.71	21.29	**10.78**
#140	0.106	39.20		3.73	82.44	17.56	**8.89**
#200	0.075	14.05		1.34	83.78	16.22	**8.22**
Pan	-	170.29		16.22	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By JKB Date 2-28-06

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INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-6
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-54	Soil Description	**REDDISH BROWN SILTY CLAY** (Minus No. 40 sieve material, Airdried)

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

Liquid Limit Test	**1**	**2**	**3**
Tare Number	224	4000	84
Wt. of Tare & WS (gm)	42.24	45.98	41.44
Wt. of Tare & DS (gm)	37.94	41.15	36.90
Wt. of Tare (gm)	19.14	20.42	18.02
Wt. of Water (gm)	4.3	4.8	4.5
Wt. of DS (gm)	18.8	20.7	18.9
Moisture Content (%)	**22.9**	**23.3**	**24.0**
Number of Blows	**32**	**24**	**16**

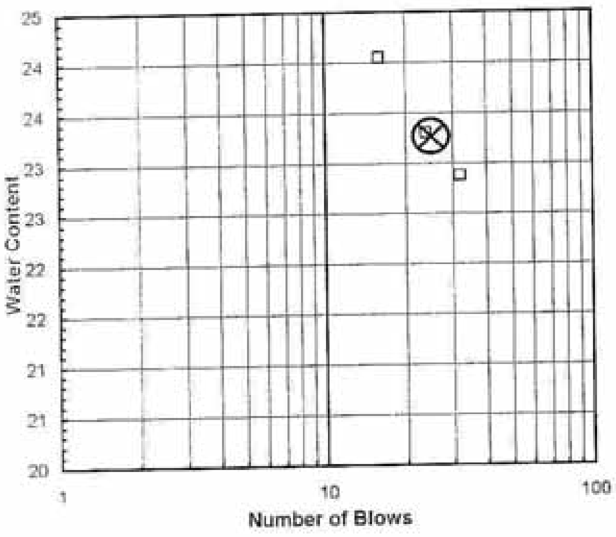
MULTIPOINT

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	OO1	2223	
Wt. of Tare & WS (gm)	19.80	25.60	
Wt. of Tare & DS (gm)	18.98	24.74	
Wt. of Tare (gm)	13.76	19.21	
Wt. of Water (gm)	0.8	0.9	
Wt. of DS (gm)	5.2	5.5	
Moisture Content (%)	**15.7**	**15.6**	**0.2**

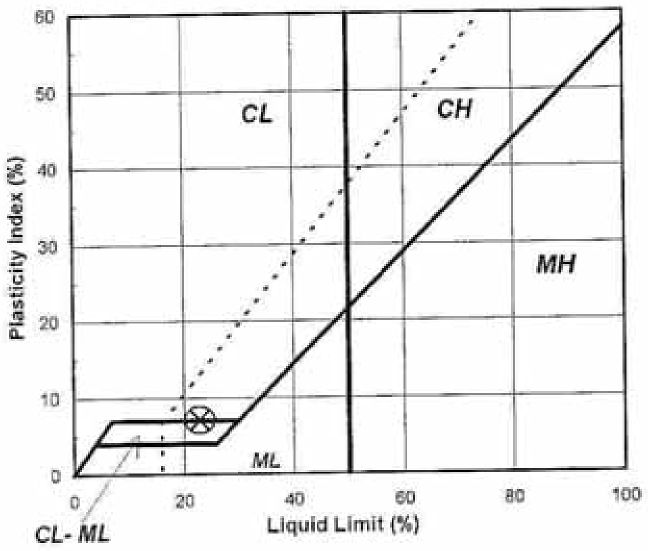
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**23**
Plastic Limit (%)	**16**
Plasticity Index (%)	**7**
USCS Symbol	**CL-ML**

Flow Curve



Plasticity Chart



Tested By JP *Date* 2/24/06 *Checked By* YKB *Date* 2-27-06

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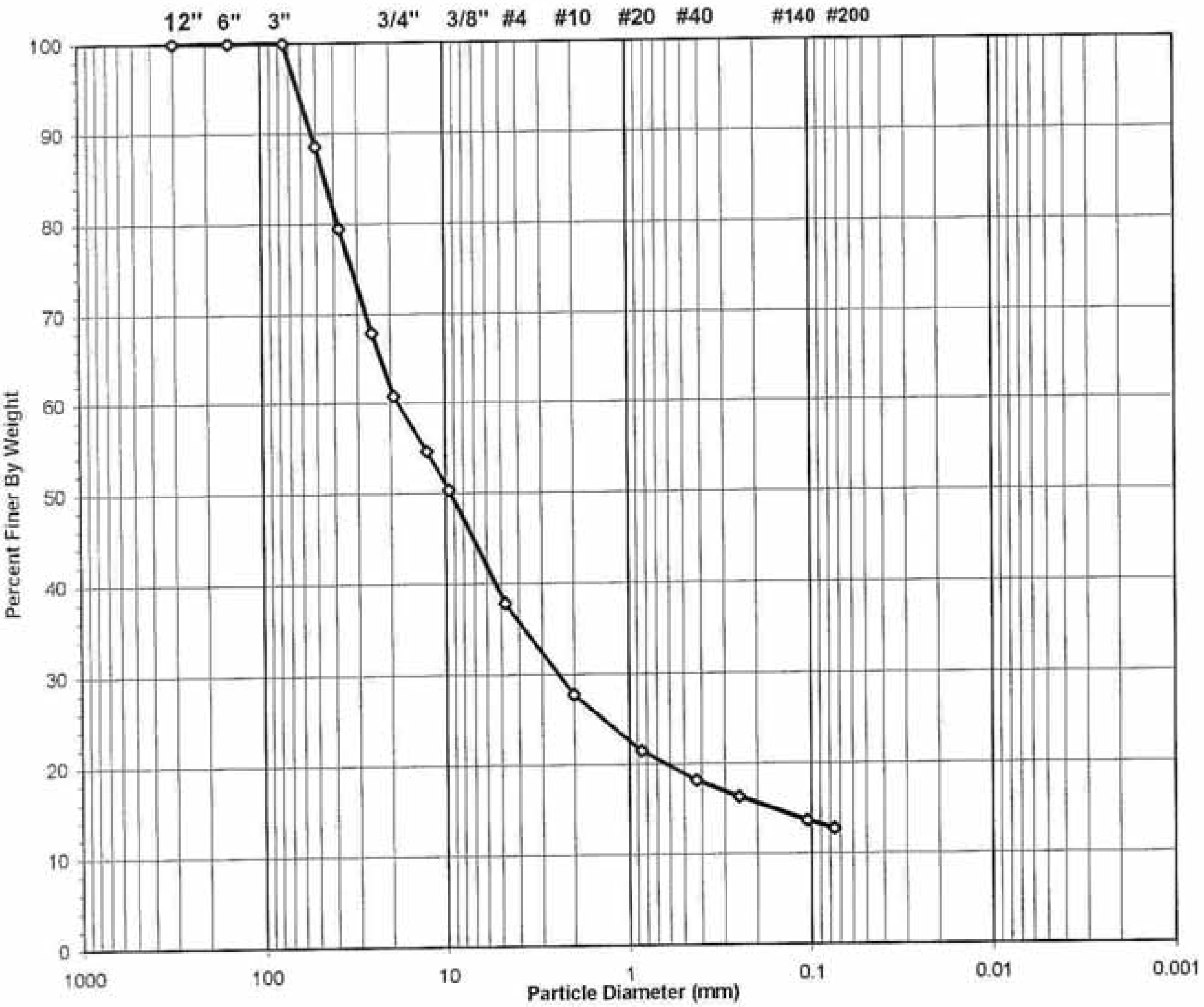
SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-6
Client Reference	TAUM SAUK 06-3551	Depth (ft)	30-40
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-55	Soil Color	BROWN

USCS	SIEVE ANALYSIS		HYDROMETER
	gravel	sand	silt and clay



USCS Symbol *GC-GM, TESTED*

USCS Classification *SILTY, CLAYEY GRAVEL WITH SAND*

Tested By PC Date 2/23/06 Checked By KKB Date 3-8-06

DCN: CT-S3A DATE 6-25-98 REVISION 2 *C:\MSOFFICE\Excel\PrintQ\[U288.xls]Sheet1*

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-6
Client Reference	TAUM SAUK 06-3551	Depth (ft)	30-40
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-55	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	660	Tare No.	577
Wgt.Tare + Wet Specimen (gm)	1200.50	Wgt.Tare + Wet Specimen (gm)	502.76
Wgt.Tare + Dry Specimen (gm)	1068.20	Wgt.Tare + Dry Specimen (gm)	481.43
Weight of Tare (gm)	98.66	Weight of Tare (gm)	84.51
Weight of Water (gm)	132.30	Weight of Water (gm)	21.33
Weight of Dry Soil (gm)	969.54	Weight of Dry Soil (gm)	396.92
Moisture Content (%)	**13.6**	**Moisture Content (%)**	**5.4**

Wet Weight -3/4" Sample (gm)	20485	Weight of the Dry Specimen (gm)	969.54
Dry Weight - 3/4" Sample (gm)	18025.3	Weight of minus #200 material (gm)	202.36
Wet Weight +3/4" Sample (gm)	12276.00	Weight of plus #200 material (gm)	767.18
Dry Weight + 3/4" Sample (gm)	11649.95		
Total Dry Weight Sample (gm)	29675.3	**J - Factor (Percent Finer than 3/4")**	**0.6074**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	0.00		0.00	0.00	100.00	**100.00**
2"	50	3584.00	(*)	11.46	11.46	88.54	**88.54**
1 1/2"	37.5	2854.00		9.13	20.59	79.41	**79.41**
1"	25	3602.00		11.52	32.11	67.89	**67.89**
3/4"	19	2236.00		7.15	39.26	60.74	**60.74**
1/2"	12.5	97.15		10.02	10.02	89.98	**54.66**
3/8"	9.5	69.39		7.16	17.18	82.82	**50.31**
#4	4.75	198.38		20.46	37.64	62.36	**37.88**
#10	2	161.51		16.66	54.30	45.70	**27.76**
#20	0.85	100.48	(**)	10.36	64.66	35.34	**21.47**
#40	0.425	53.19		5.49	70.15	29.85	**18.13**
#60	0.25	29.45		3.04	73.18	26.82	**16.29**
#140	0.106	41.87		4.32	77.50	22.50	**13.67**
#200	0.075	15.76		1.63	79.13	20.87	**12.68**
Pan	-	202.36		20.87	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/23/06 Checked By Date 3-8-06

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ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-6
Client Reference	TAUM SAUK 06-3551	Depth (ft)	30-40
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-55	Soil Description	**BROWN SILTY CLAY**
			(Minus No. 40 sieve material, Airdried)

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

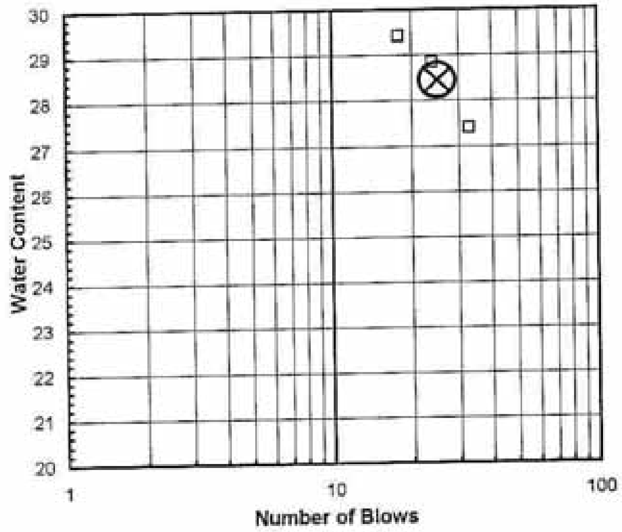
Liquid Limit Test	**1**	**2**	**3**	**MULTIPOINT**
Tare Number	162	253	254	
Wt. of Tare & WS (gm)	44.58	40.73	40.61	
Wt. of Tare & DS (gm)	38.89	35.61	35.56	
Wt. of Tare (gm)	18.13	17.85	18.39	
Wt. of Water (gm)	5.7	5.1	5.1	
Wt. of DS (gm)	20.8	17.8	17.2	
Moisture Content (%)	**27.4**	**28.8**	**29.4**	
Number of Blows	**33**	**24**	**18**	

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	2228	2288	
Wt. of Tare & WS (gm)	23.11	25.53	
Wt. of Tare & DS (gm)	22.06	24.46	
Wt. of Tare (gm)	17.05	19.35	
Wt. of Water (gm)	1.1	1.1	
Wt. of DS (gm)	5.0	5.1	
Moisture Content (%)	**21.0**	**20.9**	**0.0**

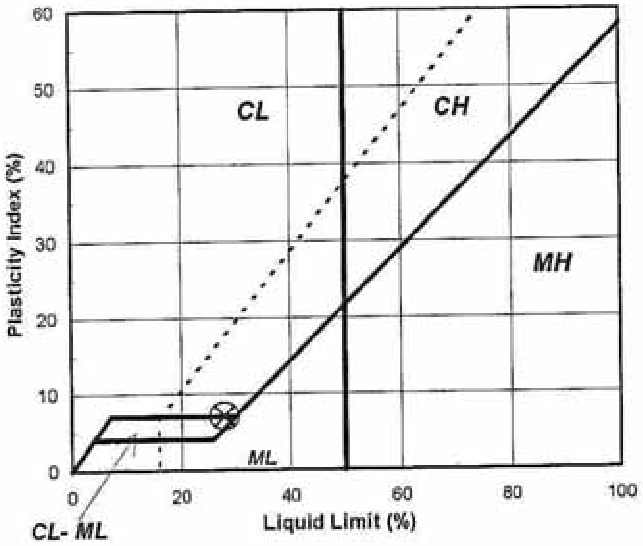
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**28**
Plastic Limit (%)	**21**
Plasticity Index (%)	**7**
USCS Symbol	**CL-ML**

Flow Curve



Plasticity Chart



Tested By BS *Date* 3/3/06 *Checked By* *Date* 3-6-06

page 1 of 1 **DCN:** CT-S4B **DATE:** 10/8/01 **REVISION:** 2

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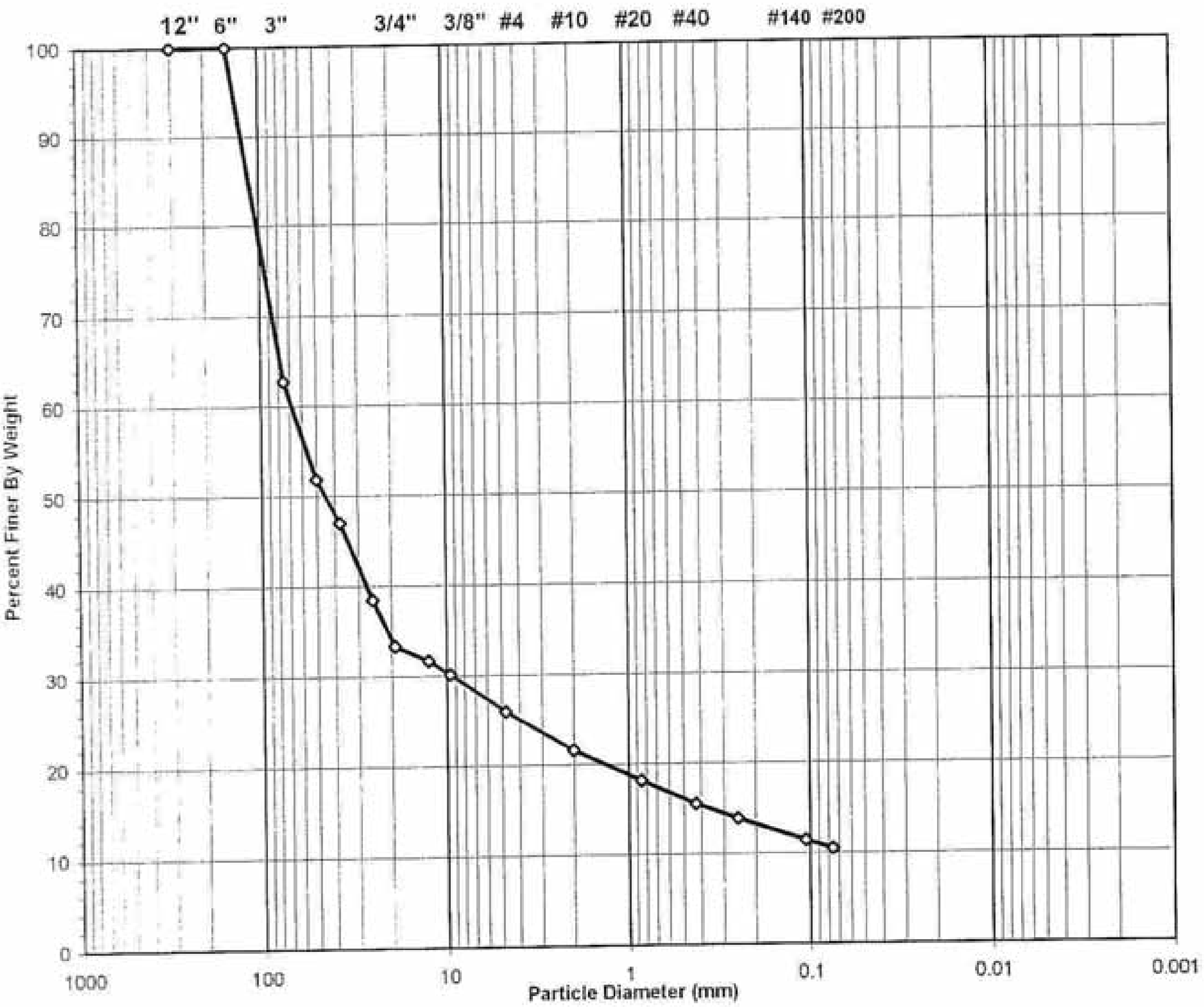
SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-6
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-54
Project No.	2006-060-02	Sample No.	S-7
Lab ID	2006-060-02-01	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol *GP-GM, TESTED*

USCS Classification *POORLY GRADED GRAVEL WITH SILT AND SAND (NON-PLASTIC FINES)*

Tested By PC Date 2/24/06 Checked By KB Date 3-2-06

page 1 of 2 DCN: CT-S2A DATE 6-25-98 REVISION 2 *C:\MSOFFICE\Excel\PrintQ\[U313.xls]Sheet1*

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-6
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-54
Project No.	2006-060-02	Sample No.	S-7
Lab ID	2006-060-02-01	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	502	Tare No.	906
Wgt.Tare + Wet Specimen (gm)	1090.10	Wgt.Tare + Wet Specimen (gm)	1015.00
Wgt.Tare + Dry Specimen (gm)	998.00	Wgt.Tare + Dry Specimen (gm)	996.90
Weight of Tare (gm)	102.31	Weight of Tare (gm)	110.78
Weight of Water (gm)	92.10	Weight of Water (gm)	18.10
Weight of Dry Soil (gm)	895.69	Weight of Dry Soil (gm)	886.12
Moisture Content (%)	**10.3**	**Moisture Content (%)**	**2.0**

Wet Weight -3/4" Sample (gm)	5524	Weight of the Dry Specimen (gm)	895.69
Dry Weight - 3/4" Sample (gm)	5009.0	Weight of minus #200 material (gm)	281.61
Wet Weight +3/4" Sample (gm)	10229.00	Weight of plus #200 material (gm)	614.08
Dry Weight + 3/4" Sample (gm)	10024.24		
Total Dry Weight Sample (gm)	15033.2	**J - Factor (Percent Finer than 3/4")**	**0.3332**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	5713.00		37.24	37.24	62.76	**62.76**
2"	50	1680.00	(*)	10.95	48.19	51.81	**51.81**
1 1/2"	37.5	751.00		4.90	53.09	46.91	**46.91**
1"	25	1293.00		8.43	61.52	38.48	**38.48**
3/4"	19	792.00		5.16	66.68	33.32	**33.32**
1/2"	12.5	43.50		4.86	4.86	95.14	**31.70**
3/8"	9.5	41.76		4.66	9.52	90.48	**30.15**
#4	4.75	113.18		12.64	22.15	77.85	**25.94**
#10	2	115.91		12.94	35.10	64.90	**21.63**
#20	0.85	93.70	(**)	10.46	45.56	54.44	**18.14**
#40	0.425	71.55		7.99	53.55	46.45	**15.48**
#60	0.25	44.94		5.02	58.56	41.44	**13.81**
#140	0.106	65.35		7.30	65.86	34.14	**11.38**
#200	0.075	24.19		2.70	68.56	31.44	**10.48**
Pan	-	281.61		31.44	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/24/06 Checked By KB Date 3-2-06

ATTERBERG LIMIT

ASTM D 4318-00 (SOP - S4)

Client	PAUL C. RIZZO	Boring No.	TS-6
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-54
Project No.	2006-060-02	Sample No.	S-7
Lab ID	2006-060-02-01	Visual Description	**REDDISH BROWN SILT** (Minus No. 40 sieve material, Airdried)

NON - PLASTIC MATERIAL

Tested By BS *Date* 2/24/06 *Checked By* YHR *Date* 2-27-06

BORING TS-7

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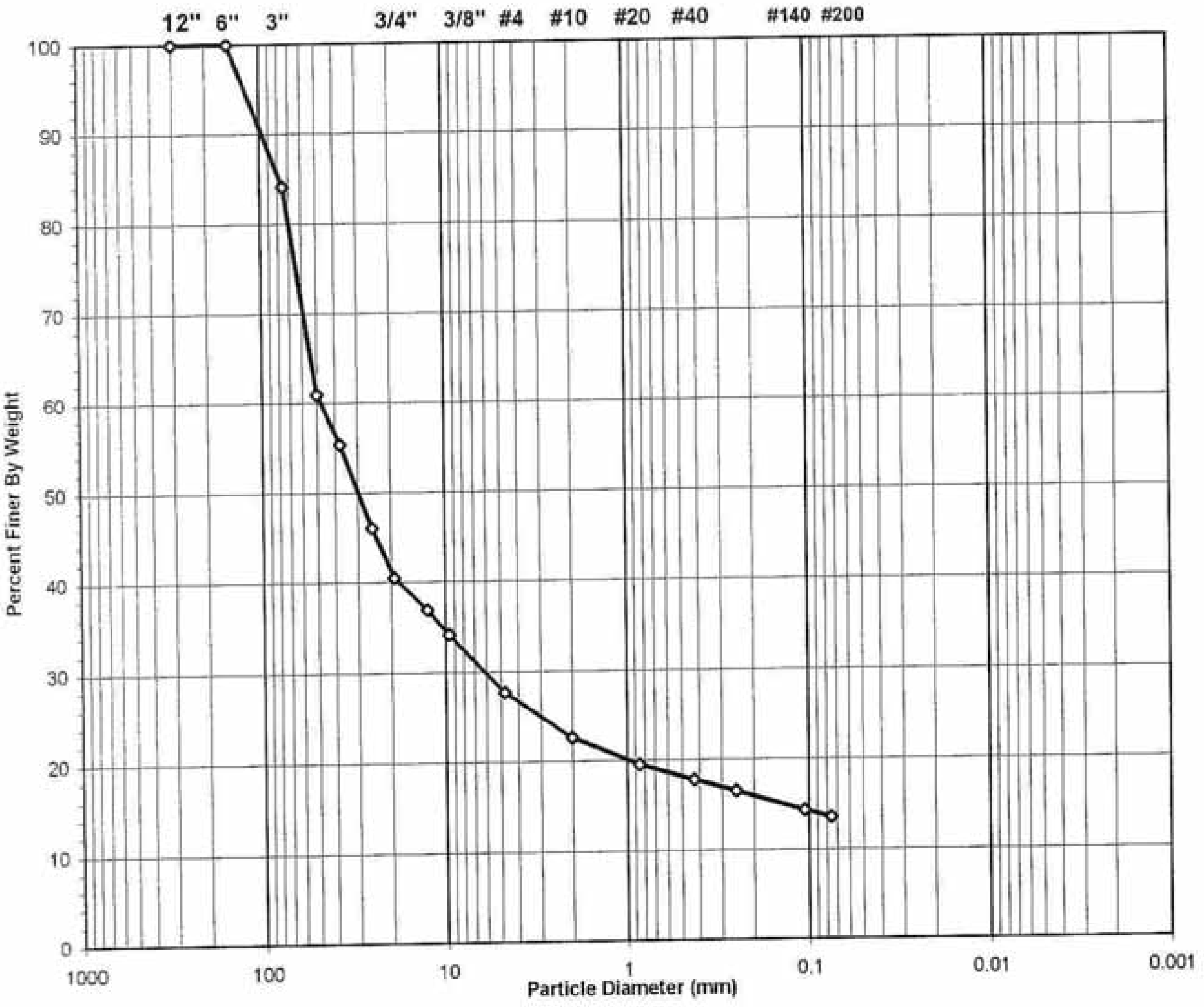
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-57	Soil Color	**BROWN**

USCS	*SIEVE ANALYSIS*		*HYDROMETER*
	gravel	sand	silt and clay



USCS Symbol *gm, ASSUMED*

USCS Classification *SILTY GRAVEL*

Tested By JP Date 2/21/06 Checked By Date 2-22-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-1
Lab ID	2006-060-01-57	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	931	Tare No.	885
Wgt.Tare + Wet Specimen (gm)	1347.50	Wgt.Tare + Wet Specimen (gm)	462.74
Wgt.Tare + Dry Specimen (gm)	1237.70	Wgt.Tare + Dry Specimen (gm)	449.67
Weight of Tare (gm)	103.37	Weight of Tare (gm)	110.13
Weight of Water (gm)	109.80	Weight of Water (gm)	13.07
Weight of Dry Soil (gm)	1134.33	Weight of Dry Soil (gm)	339.54
Moisture Content (%)	**9.7**	**Moisture Content (%)**	**3.8**

Wet Weight -3/4" Sample (gm)	9630	Weight of the Dry Specimen (gm)	1134.33
Dry Weight - 3/4" Sample (gm)	8780.1	Weight of minus #200 material (gm)	381.09
Wet Weight +3/4" Sample (gm)	13420.00	Weight of plus #200 material (gm)	753.24
Dry Weight + 3/4" Sample (gm)	12922.57		
Total Dry Weight Sample (gm)	21702.7	**J - Factor (Percent Finer than 3/4")**	**0.4046**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	3583.00		15.90	15.90	84.10	**84.10**
2"	50	5221.00	(*)	23.17	39.06	60.94	**60.94**
1 1/2"	37.5	1263.00		5.60	44.67	55.33	**55.33**
1"	25	2105.00		9.34	54.01	45.99	**45.99**
3/4"	19	1248.00		5.54	59.54	40.46	**40.46**
1/2"	12.5	100.39		8.85	8.85	91.15	**36.88**
3/8"	9.5	77.05		6.79	15.64	84.36	**34.13**
#4	4.75	181.39		15.99	31.63	68.37	**27.66**
#10	2	141.36		12.46	44.10	55.90	**22.62**
#20	0.85	85.18	(**)	7.51	51.60	48.40	**19.58**
#40	0.425	49.59		4.37	55.98	44.02	**17.81**
#60	0.25	34.39		3.03	59.01	40.99	**16.58**
#140	0.106	61.30		5.40	64.41	35.59	**14.40**
#200	0.075	22.59		1.99	66.40	33.60	**13.59**
Pan	-	381.09		33.60	100.00	-	-

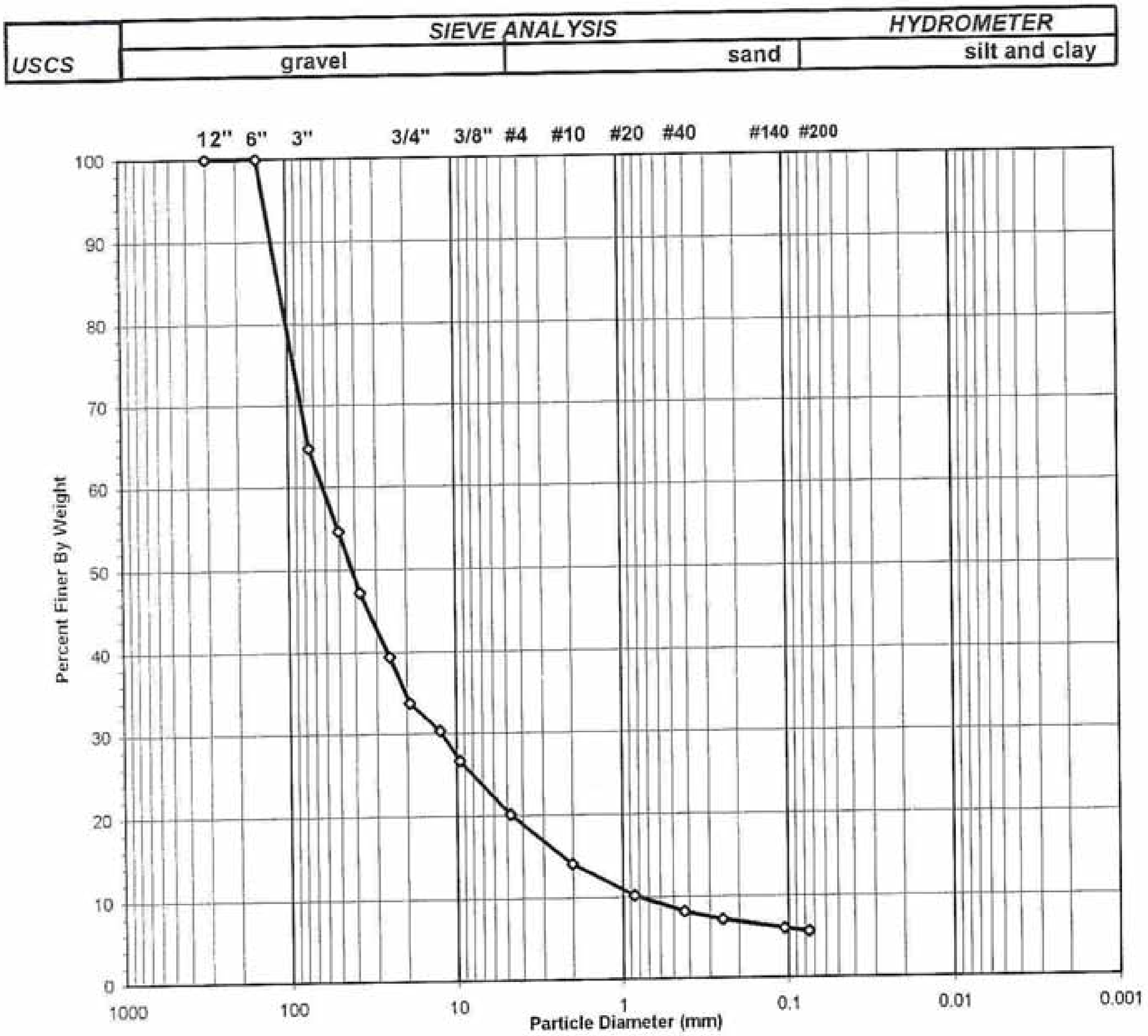
Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/21/06 Checked By YKB Date 2-22-06

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-58	Soil Color	**BROWN**



USCS Symbol	*gw-gm, ASSUMED*	D60 =	62.1	CC =	3.0
USCS Classification	*WELL-GRADED GRAVEL WITH SILT*	D30 =	12.2	CU =	76.9
		D10 =	0.8		

Tested By JP Date 2/21/06 Checked By KB Date 2-22-06

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geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-58	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	2349	Tare No.	891
Wgt.Tare + Wet Specimen (gm)	1357.70	Wgt.Tare + Wet Specimen (gm)	735.20
Wgt.Tare + Dry Specimen (gm)	1277.70	Wgt.Tare + Dry Specimen (gm)	723.70
Weight of Tare (gm)	97.76	Weight of Tare (gm)	110.45
Weight of Water (gm)	80.00	Weight of Water (gm)	11.50
Weight of Dry Soil (gm)	1179.94	Weight of Dry Soil (gm)	613.25
Moisture Content (%)	**6.8**	**Moisture Content (%)**	**1.9**

Wet Weight -3/4" Sample (gm)	21937	Weight of the Dry Specimen (gm)	1179.94
Dry Weight - 3/4" Sample (gm)	20544.1	Weight of minus #200 material (gm)	197.16
Wet Weight +3/4" Sample (gm)	41120.00	Weight of plus #200 material (gm)	982.78
Dry Weight + 3/4" Sample (gm)	40363.09		
Total Dry Weight Sample (gm)	60907.2	**J - Factor (Percent Finer than 3/4")**	**0.3373**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	21922.00		35.33	35.33	64.67	**64.67**
2"	50	6229.00	(*)	10.04	45.37	54.63	**54.63**
1 1/2"	37.5	4639.00		7.48	52.85	47.15	**47.15**
1"	25	4823.00		7.77	60.62	39.38	**39.38**
3/4"	19	3507.00		5.65	66.27	33.73	**33.73**
1/2"	12.5	117.75		9.98	9.98	90.02	**30.36**
3/8"	9.5	129.48		10.97	20.95	79.05	**26.66**
#4	4.75	227.46		19.28	40.23	59.77	**20.16**
#10	2	213.47		18.09	58.32	41.68	**14.06**
#20	0.85	136.81	(**)	11.59	69.92	30.08	**10.15**
#40	0.425	69.28		5.87	75.79	24.21	**8.17**
#60	0.25	33.42		2.83	78.62	21.38	**7.21**
#140	0.106	40.52		3.43	82.05	17.95	**6.05**
#200	0.075	14.59		1.24	83.29	16.71	**5.64**
Pan	-	197.16		16.71	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/21/06 Checked By YKB Date 2-22-06

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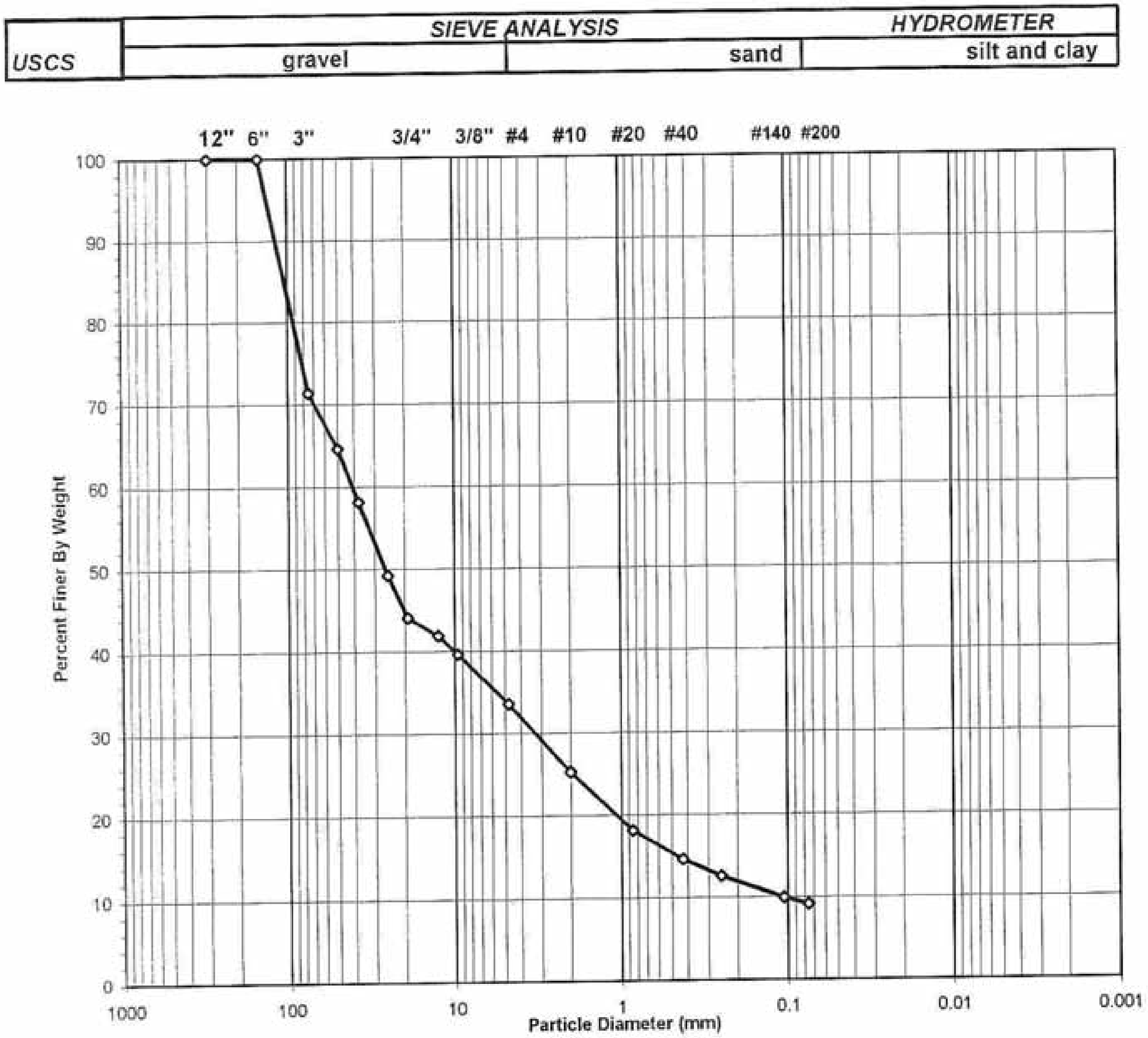
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-59	Soil Color	**BROWN**



USCS Symbol	***gw-gm, ASSUMED***	**D60 =**	**40.7**	**CC =**	**2.4**
USCS Classification	***WELL-GRADED GRAVEL WITH SILT AND SAND***	**D30 =**	**3.3**	**CU =**	**374.3**
		D10 =	**0.1**		

Tested By JP Date 2/21/06 Checked By KB Date 2-22-06

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-59	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	633	Tare No.	614
Wgt.Tare + Wet Specimen (gm)	1350.40	Wgt.Tare + Wet Specimen (gm)	602.70
Wgt.Tare + Dry Specimen (gm)	1271.50	Wgt.Tare + Dry Specimen (gm)	595.01
Weight of Tare (gm)	100.49	Weight of Tare (gm)	84.64
Weight of Water (gm)	78.90	Weight of Water (gm)	7.69
Weight of Dry Soil (gm)	1171.01	Weight of Dry Soil (gm)	510.37
Moisture Content (%)	**6.7**	**Moisture Content (%)**	**1.5**

Wet Weight -3/4" Sample (gm)	18125	Weight of the Dry Specimen (gm)	1171.01
Dry Weight - 3/4" Sample (gm)	16980.9	Weight of minus #200 material (gm)	242.35
Wet Weight +3/4" Sample (gm)	21892.00	Weight of plus #200 material (gm)	928.66
Dry Weight + 3/4" Sample (gm)	21567.04		
Total Dry Weight Sample (gm)	38547.9	**J - Factor (Percent Finer than 3/4")**	**0.4405**

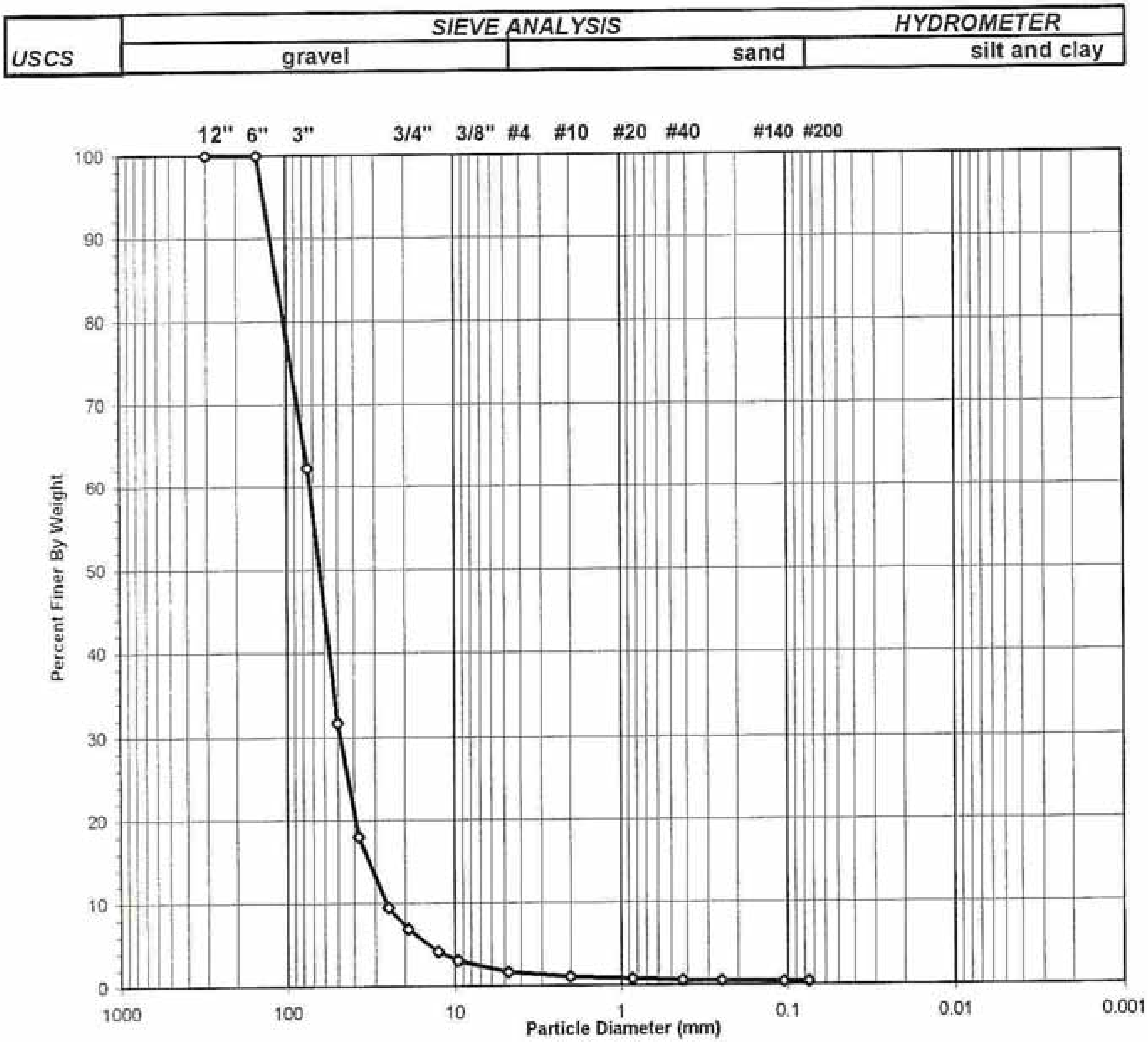
Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	11200.00		28.62	28.62	71.38	**71.38**
2"	50	2655.00	(*)	6.79	35.41	64.59	**64.59**
1 1/2"	37.5	2516.00		6.43	41.84	58.16	**58.16**
1"	25	3523.00		9.00	50.84	49.16	**49.16**
3/4"	19	1998.00		5.11	55.95	44.05	**44.05**
1/2"	12.5	59.07		5.04	5.04	94.96	**41.83**
3/8"	9.5	60.28		5.15	10.19	89.81	**39.56**
#4	4.75	159.43		13.61	23.81	76.19	**33.56**
#10	2	219.61		18.75	42.56	57.44	**25.30**
#20	0.85	191.13	(**)	16.32	58.88	41.12	**18.11**
#40	0.425	94.10		8.04	66.92	33.08	**14.57**
#60	0.25	54.63		4.67	71.58	28.42	**12.52**
#140	0.106	69.02		5.89	77.48	22.52	**9.92**
#200	0.075	21.39		1.83	79.30	20.70	**9.12**
Pan	-	242.35		20.70	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/21/06 Checked By Date 2-22-06

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-60	Soil Color	BROWN



USCS Symbol ***gp, ASSUMED***

USCS Classification ***POORLY GRADED GRAVEL***

D60 = **72.7** **CC =** **1.2**

D30 = **48.2** **CU =** **2.8**

D10 = **25.6**

Tested By JP Date 2/21/06 Checked By KB Date 2-22-06

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INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	20-30
Project No.	2006-060-01	Sample No.	S-4
Lab ID	2006-060-01-60	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	955	Tare No.	876
Wgt.Tare + Wet Specimen (gm)	1197.00	Wgt.Tare + Wet Specimen (gm)	840.50
Wgt.Tare + Dry Specimen (gm)	1179.50	Wgt.Tare + Dry Specimen (gm)	837.90
Weight of Tare (gm)	102.34	Weight of Tare (gm)	110.07
Weight of Water (gm)	17.50	Weight of Water (gm)	2.60
Weight of Dry Soil (gm)	1077.16	Weight of Dry Soil (gm)	727.83
Moisture Content (%)	**1.6**	**Moisture Content (%)**	**0.4**

Wet Weight -3/4" Sample (gm)	1946	Weight of the Dry Specimen (gm)	1077.16
Dry Weight - 3/4" Sample (gm)	1914.9	Weight of minus #200 material (gm)	58.72
Wet Weight +3/4" Sample (gm)	26128.00	Weight of plus #200 material (gm)	1018.44
Dry Weight + 3/4" Sample (gm)	26035.00		
Total Dry Weight Sample (gm)	27949.9	**J - Factor (Percent Finer than 3/4")**	**0.0685**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	10573.00		37.69	37.69	62.31	**62.31**
2"	50	8579.00	(*)	30.58	68.28	31.72	**31.72**
1 1/2"	37.5	3836.00		13.68	81.95	18.05	**18.05**
1"	25	2407.00		8.58	90.54	9.46	**9.46**
3/4"	19	733.00		2.61	93.15	6.85	**6.85**
1/2"	12.5	426.92		39.63	39.63	60.37	**4.14**
3/8"	9.5	172.11		15.98	55.61	44.39	**3.04**
#4	4.75	213.66		19.84	75.45	24.55	**1.68**
#10	2	96.00		8.91	84.36	15.64	**1.07**
#20	0.85	44.26	(**)	4.11	88.47	11.53	**0.79**
#40	0.425	25.76		2.39	90.86	9.14	**0.63**
#60	0.25	14.59		1.35	92.21	7.79	**0.53**
#140	0.106	18.78		1.74	93.96	6.04	**0.41**
#200	0.075	6.36		0.59	94.55	5.45	**0.37**
Pan	-	58.72		5.45	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

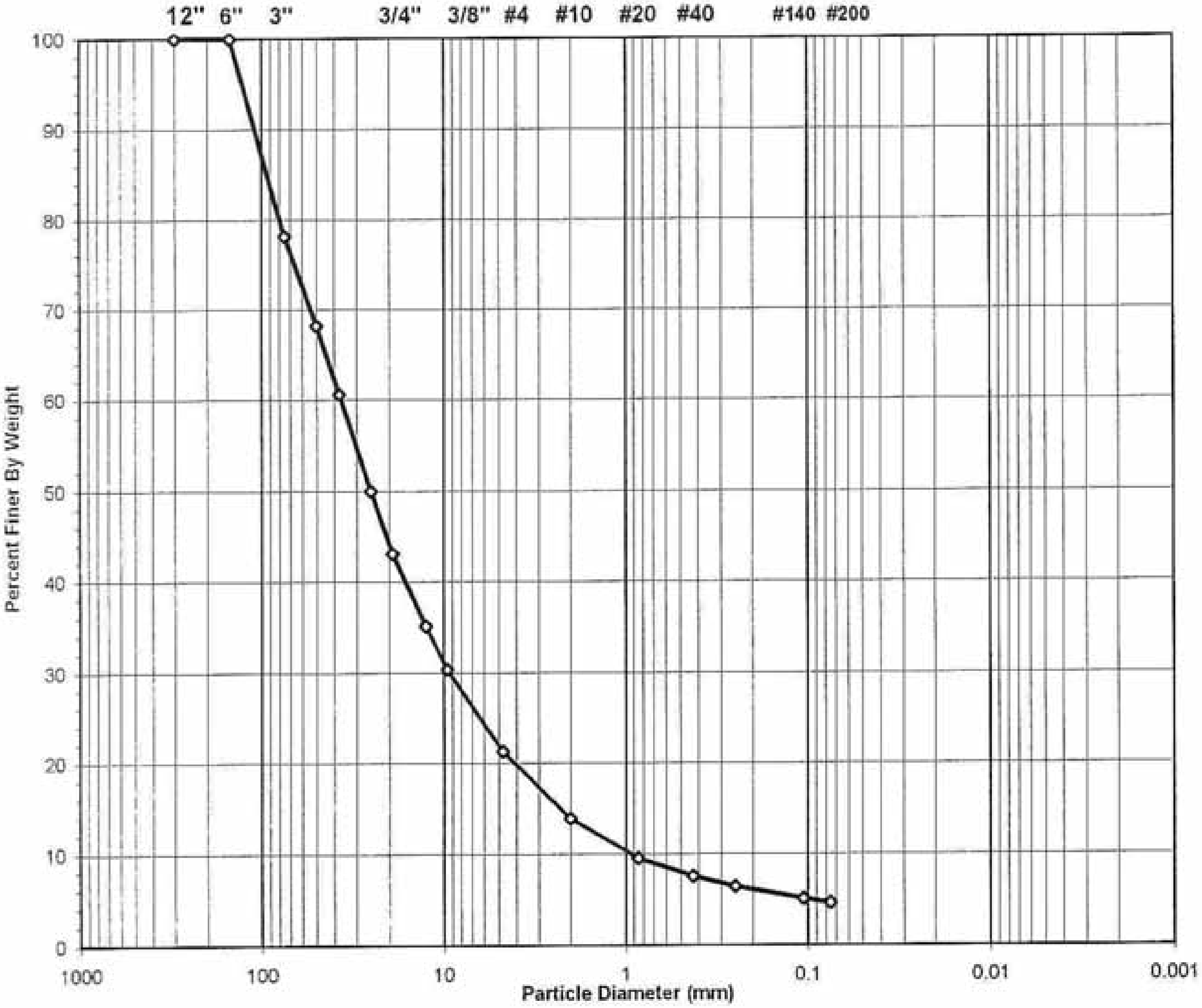
Tested By JP Date 2/21/06 Checked By Date 2-22-06

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-61	Soil Color	**REDDISH BROWN**

USCS	*SIEVE ANALYSIS*		*HYDROMETER*
	gravel	sand	silt and clay



USCS Symbol	*gw, ASSUMED*	D60 =	36.7	CC =	2.5
USCS Classification	*WELL-GRADED GRAVEL WITH SAND*	D30 =	9.2	CU =	39.4
		D10 =	0.9		

Tested By JP Date 2/21/06 Checked By KYB Date 2-22-06

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-5
Lab ID	2006-060-01-61	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	662	Tare No.	729
Wgt.Tare + Wet Specimen (gm)	1199.20	Wgt.Tare + Wet Specimen (gm)	665.70
Wgt.Tare + Dry Specimen (gm)	1199.20	Wgt.Tare + Dry Specimen (gm)	647.40
Weight of Tare (gm)	95.10	Weight of Tare (gm)	86.38
Weight of Water (gm)	0.00	Weight of Water (gm)	18.30
Weight of Dry Soil (gm)	1104.10	Weight of Dry Soil (gm)	561.02
Moisture Content (%)	**0.0**	**Moisture Content (%)**	**3.3**

Wet Weight -3/4" Sample (gm)	20481	Weight of the Dry Specimen (gm)	1104.10
Dry Weight - 3/4" Sample (gm)	20481.0	Weight of minus #200 material (gm)	118.08
Wet Weight +3/4" Sample (gm)	27988.00	Weight of plus #200 material (gm)	986.02
Dry Weight + 3/4" Sample (gm)	27103.89		
Total Dry Weight Sample (gm)	47584.9	**J - Factor (Percent Finer than 3/4")**	**0.4304**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	10757.00		21.89	21.89	78.11	**78.11**
2"	50	4873.00	(*)	9.92	31.81	68.19	**68.19**
1 1/2"	37.5	3740.00		7.61	39.42	60.58	**60.58**
1"	25	5219.00		10.62	50.04	49.96	**49.96**
3/4"	19	3399.00		6.92	56.96	43.04	**43.04**
1/2"	12.5	203.12		18.40	18.40	81.60	**35.12**
3/8"	9.5	120.60		10.92	29.32	70.68	**30.42**
#4	4.75	234.97		21.28	50.60	49.40	**21.26**
#10	2	189.21		17.14	67.74	32.26	**13.89**
#20	0.85	111.51	(**)	10.10	77.84	22.16	**9.54**
#40	0.425	51.19		4.64	82.47	17.53	**7.54**
#60	0.25	29.06		2.63	85.11	14.89	**6.41**
#140	0.106	35.36		3.20	88.31	11.69	**5.03**
#200	0.075	11.00		1.00	89.31	10.69	**4.60**
Pan	-	118.08		10.69	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/21/06 Checked By VKB Date 2-22-06

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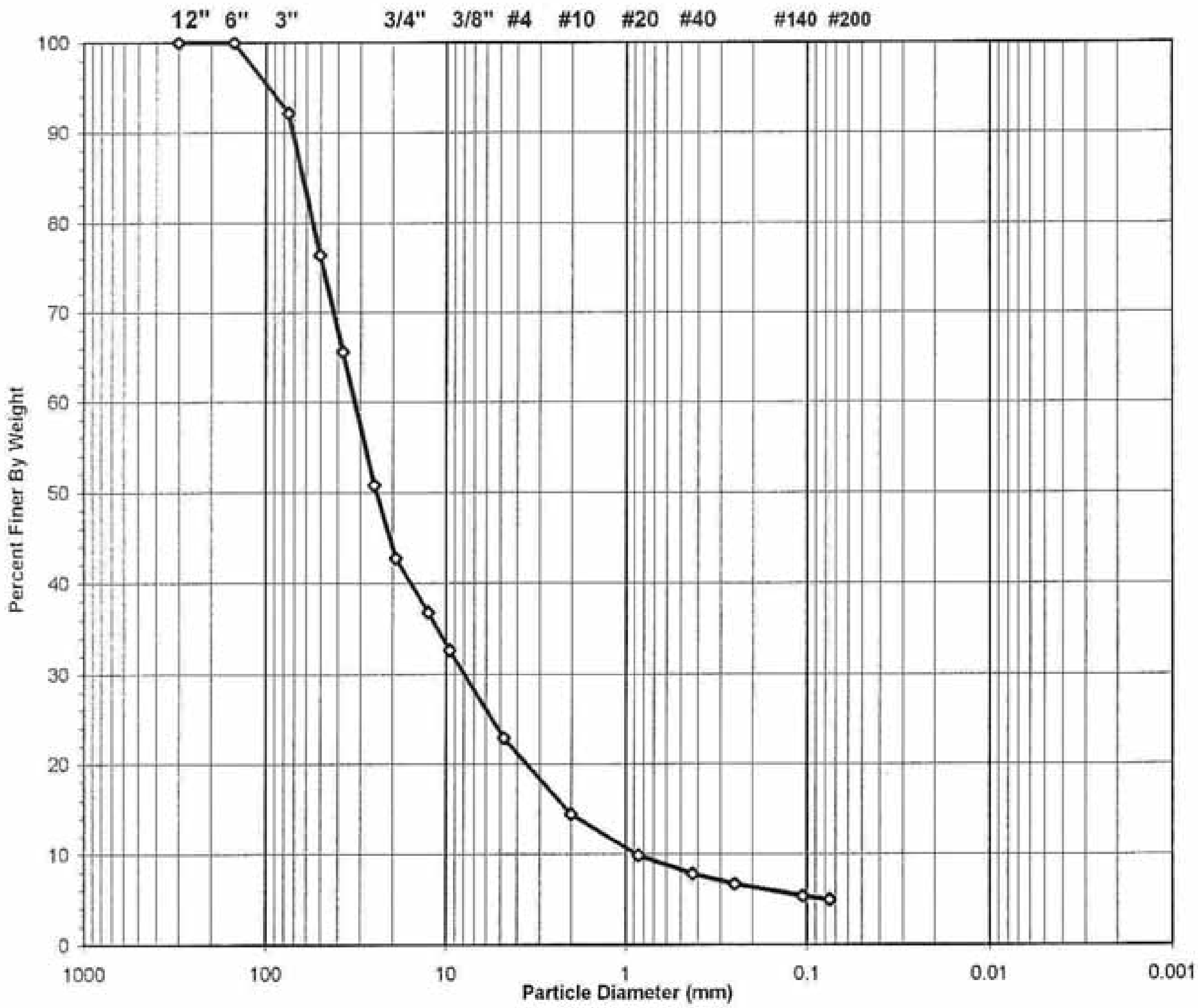
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-60
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-62	Soil Color	**BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol	*gw, ASSUMED*	D60 =	32.2	CC =	2.2
USCS Classification	*WELL-GRADED GRAVEL WITH SAND*	D30 =	7.9	CU =	36.7
		D10 =	0.9		

Tested By JP Date 2/21/06 Checked By Date 2-22-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	50-60
Project No.	2006-060-01	Sample No.	S-6
Lab ID	2006-060-01-62	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	861	Tare No.	603
Wgt.Tare + Wet Specimen (gm)	1445.80	Wgt.Tare + Wet Specimen (gm)	705.40
Wgt.Tare + Dry Specimen (gm)	1351.90	Wgt.Tare + Dry Specimen (gm)	683.80
Weight of Tare (gm)	100.80	Weight of Tare (gm)	84.40
Weight of Water (gm)	93.90	Weight of Water (gm)	21.60
Weight of Dry Soil (gm)	1251.10	Weight of Dry Soil (gm)	599.40
Moisture Content (%)	**7.5**	**Moisture Content (%)**	**3.6**

Wet Weight -3/4" Sample (gm)	20450	Weight of the Dry Specimen (gm)	1251.10
Dry Weight - 3/4" Sample (gm)	19022.3	Weight of minus #200 material (gm)	144.05
Wet Weight +3/4" Sample (gm)	26457.00	Weight of plus #200 material (gm)	1107.05
Dry Weight + 3/4" Sample (gm)	25536.76		
Total Dry Weight Sample (gm)	44559.1	**J - Factor (Percent Finer than 3/4")**	**0.4269**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	3630.00		7.86	7.86	92.14	**92.14**
2"	50	7265.00	(*)	15.74	23.60	76.40	**76.40**
1 1/2"	37.5	4985.00		10.80	34.40	65.60	**65.60**
1"	25	6860.00		14.86	49.26	50.74	**50.74**
3/4"	19	3717.00		8.05	57.31	42.69	**42.69**
1/2"	12.5	172.91		13.82	13.82	86.18	**36.79**
3/8"	9.5	120.96		9.67	23.49	76.51	**32.66**
#4	4.75	287.06		22.94	46.43	53.57	**22.87**
#10	2	247.47		19.78	66.21	33.79	**14.42**
#20	0.85	134.62	(**)	10.76	76.97	23.03	**9.83**
#40	0.425	59.60		4.76	81.74	18.26	**7.80**
#60	0.25	32.87		2.63	84.36	15.64	**6.67**
#140	0.106	39.26		3.14	87.50	12.50	**5.33**
#200	0.075	12.30		0.98	88.49	11.51	**4.92**
Pan	-	144.05		11.51	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

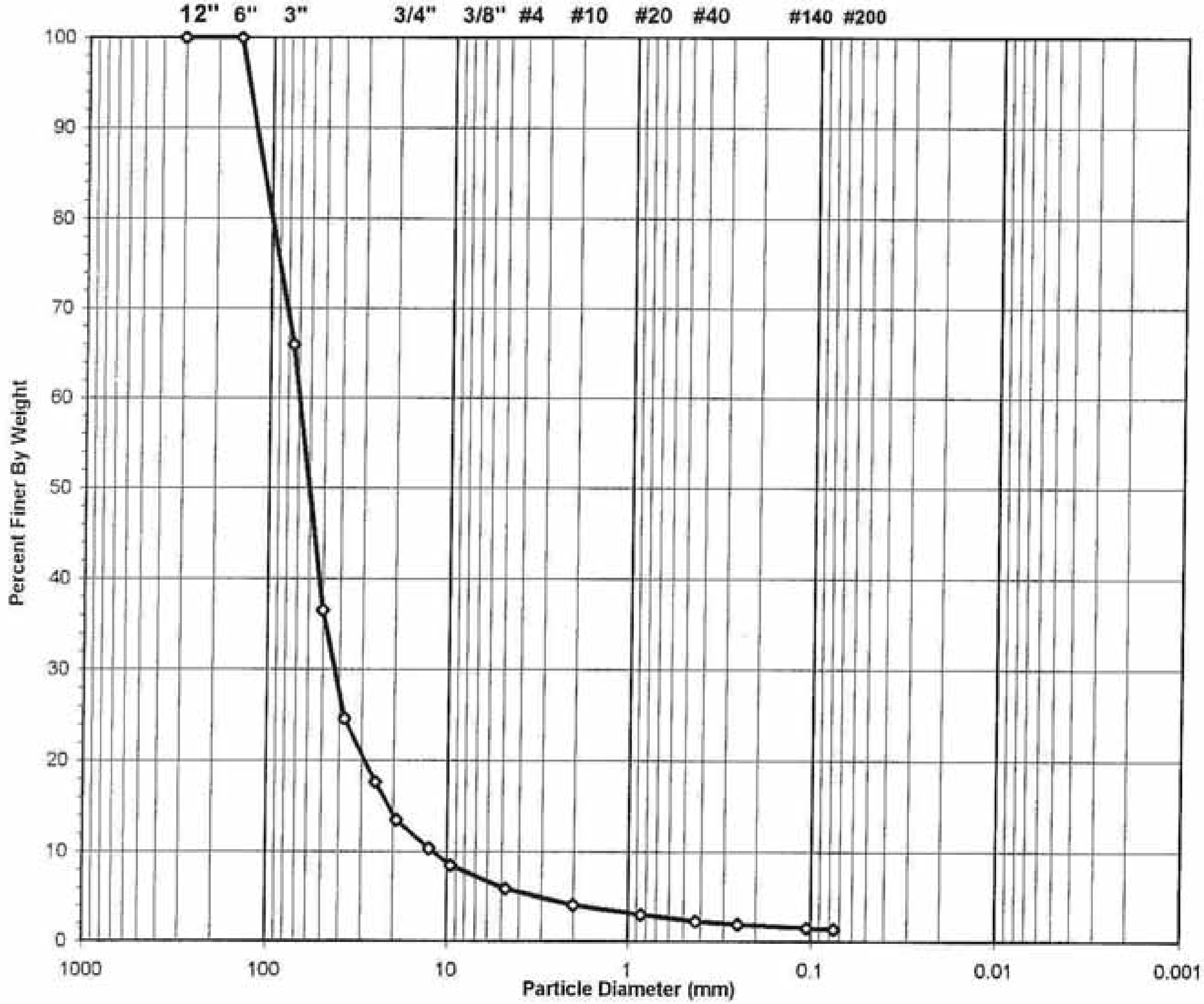
Tested By JP Date 2/21/06 Checked By YKB Date 2-22-06

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-63	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol	*gw, ASSUMED*	D60 =	69.1	CC =	2.2
USCS Classification	*WELL-GRADED GRAVEL*	D30 =	42.7	CU =	5.8
		D10 =	11.9		

Tested By JP Date 2/21/06 Checked By KYB Date 2-22-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-7
Lab ID	2006-060-01-63	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	1221	Tare No.	548
Wgt.Tare + Wet Specimen (gm)	1235.40	Wgt.Tare + Wet Specimen (gm)	919.40
Wgt.Tare + Dry Specimen (gm)	1164.40	Wgt.Tare + Dry Specimen (gm)	897.50
Weight of Tare (gm)	97.91	Weight of Tare (gm)	80.54
Weight of Water (gm)	71.00	Weight of Water (gm)	21.90
Weight of Dry Soil (gm)	1066.49	Weight of Dry Soil (gm)	816.96
Moisture Content (%)	**6.7**	**Moisture Content (%)**	**2.7**

Wet Weight -3/4" Sample (gm)	2820	Weight of the Dry Specimen (gm)	1066.49
Dry Weight - 3/4" Sample (gm)	2644.0	Weight of minus #200 material (gm)	111.81
Wet Weight +3/4" Sample (gm)	17477.00	Weight of plus #200 material (gm)	954.68
Dry Weight + 3/4" Sample (gm)	17020.73		
Total Dry Weight Sample (gm)	19664.7	**J - Factor (Percent Finer than 3/4")**	**0.1345**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	6883.00		34.09	34.09	65.91	**65.91**
2"	50	5928.00	(*)	29.36	63.45	36.55	**36.55**
1 1/2"	37.5	2412.00		11.95	75.39	24.61	**24.61**
1"	25	1410.00		6.98	82.37	17.63	**17.63**
3/4"	19	844.00		4.18	86.55	13.45	**13.45**
1/2"	12.5	247.57		23.21	23.21	76.79	**10.32**
3/8"	9.5	147.67		13.85	37.06	62.94	**8.46**
#4	4.75	207.41		19.45	56.51	43.49	**5.85**
#10	2	139.46		13.08	69.58	30.42	**4.09**
#20	0.85	88.93	(**)	8.34	77.92	22.08	**2.97**
#40	0.425	53.38		5.01	82.93	17.07	**2.30**
#60	0.25	27.07		2.54	85.47	14.53	**1.95**
#140	0.106	32.02		3.00	88.47	11.53	**1.55**
#200	0.075	11.17		1.05	89.52	10.48	**1.41**
Pan	-	111.81		10.48	100.00	-	**-**

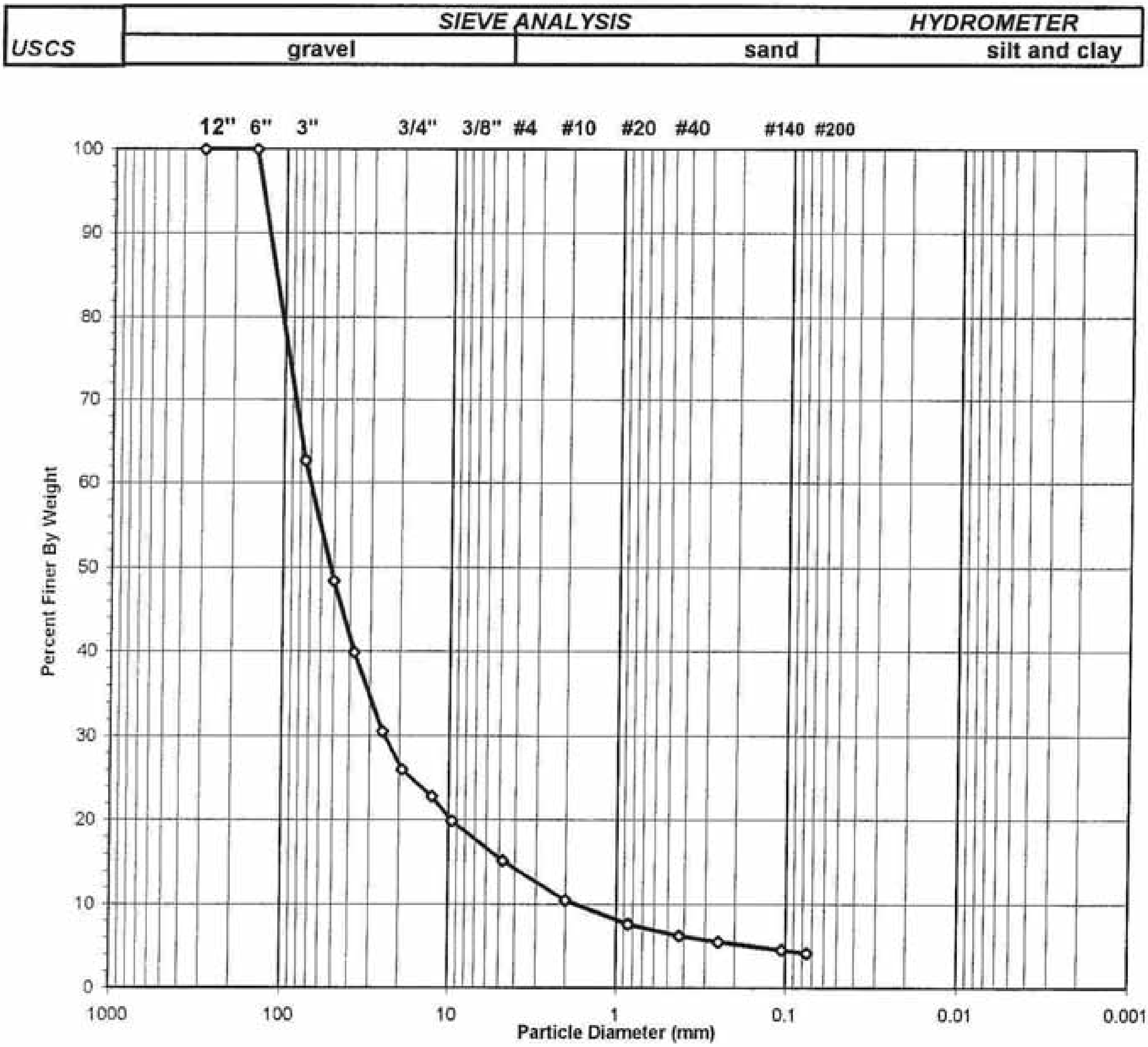
Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/21/06 Checked By Date 2-22-06

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-64	Soil Color	**BROWN**



USCS Symbol	***gp, ASSUMED***	**D60 =**	**69.5**	**CC =**	**4.8**
USCS Classification	***POORLY GRADED GRAVEL***	**D30 =**	**24.2**	**CU =**	**39.8**
		D10 =	**1.7**		

Tested By JP Date 2/21/06 Checked By KB Date 2-22-06

page 1 of 2 DCN: CT-S3A DATE 6-25-98 REVISION 2 C:\MSOFFICE\Excel\PrintQ\[U209.xls]Sheet1

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-8
Lab ID	2006-060-01-64	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	650	Tare No.	9
Wgt.Tare + Wet Specimen (gm)	1176.30	Wgt.Tare + Wet Specimen (gm)	735.60
Wgt.Tare + Dry Specimen (gm)	1107.50	Wgt.Tare + Dry Specimen (gm)	719.70
Weight of Tare (gm)	98.60	Weight of Tare (gm)	74.29
Weight of Water (gm)	68.80	Weight of Water (gm)	15.90
Weight of Dry Soil (gm)	1008.90	Weight of Dry Soil (gm)	645.41
Moisture Content (%)	**6.8**	**Moisture Content (%)**	**2.5**

Wet Weight -3/4" Sample (gm)	9677	Weight of the Dry Specimen (gm)	1008.90
Dry Weight - 3/4" Sample (gm)	9059.2	Weight of minus #200 material (gm)	160.18
Wet Weight +3/4" Sample (gm)	26433.00	Weight of plus #200 material (gm)	848.72
Dry Weight + 3/4" Sample (gm)	25797.47		
Total Dry Weight Sample (gm)	34856.7	**J - Factor (Percent Finer than 3/4")**	**0.2599**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	13331.00		37.33	37.33	62.67	**62.67**
2"	50	5098.00	(*)	14.27	51.60	48.40	**48.40**
1 1/2"	37.5	3048.00		8.53	60.13	39.87	**39.87**
1"	25	3343.00		9.36	69.49	30.51	**30.51**
3/4"	19	1613.00		4.52	74.01	25.99	**25.99**
1/2"	12.5	122.87		12.18	12.18	87.82	**22.82**
3/8"	9.5	112.62		11.16	23.34	76.66	**19.92**
#4	4.75	185.81		18.42	41.76	58.24	**15.14**
#10	2	181.86		18.03	59.78	40.22	**10.45**
#20	0.85	110.05	(**)	10.91	70.69	29.31	**7.62**
#40	0.425	54.88		5.44	76.13	23.87	**6.20**
#60	0.25	28.72		2.85	78.98	21.02	**5.46**
#140	0.106	37.51		3.72	82.70	17.30	**4.50**
#200	0.075	14.40		1.43	84.12	15.88	**4.13**
Pan	-	160.18		15.88	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/21/06 Checked By Date 2-22-06

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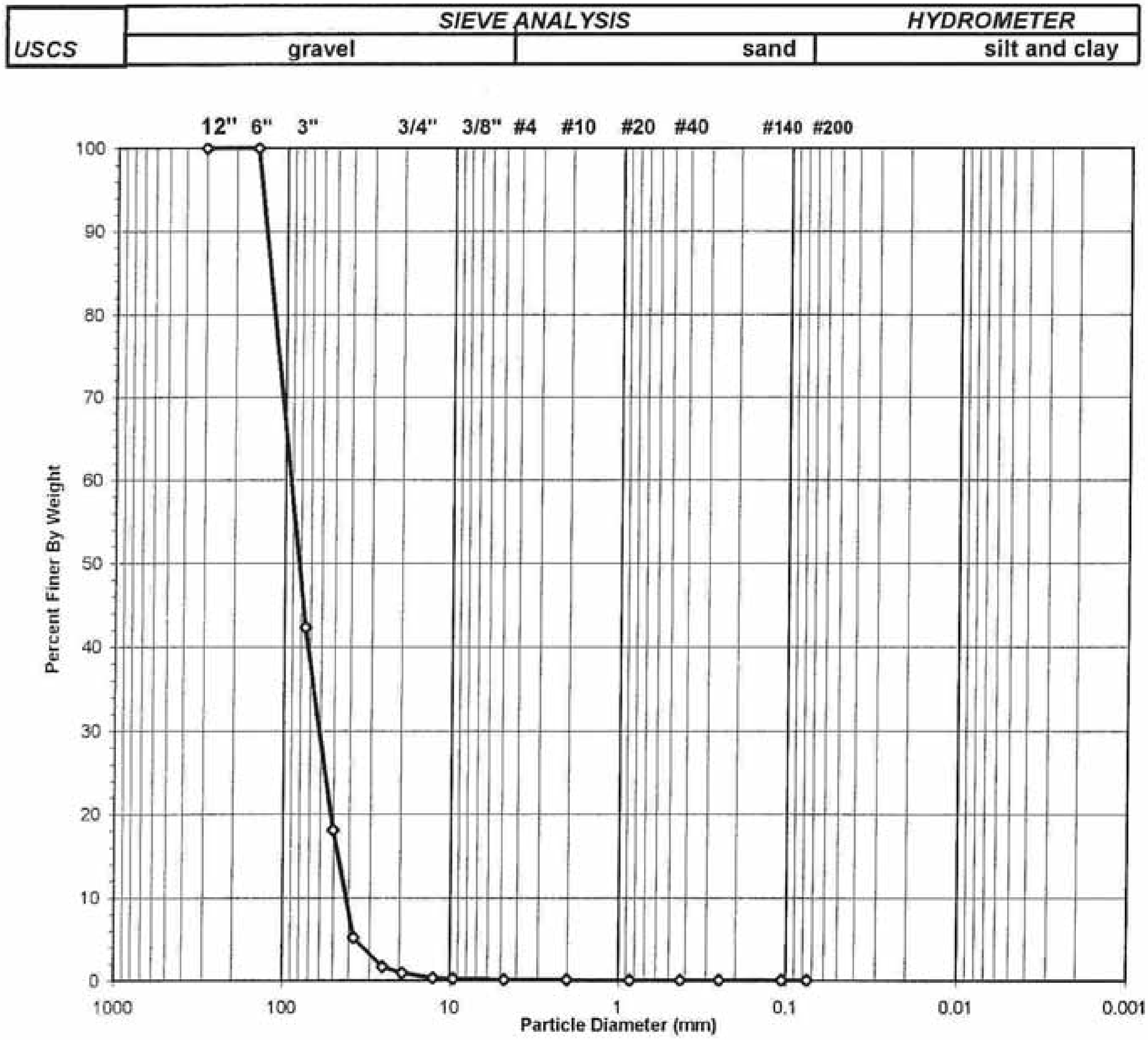
INTEGRITY IN TESTING

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-65	Soil Color	**REDDISH GRAY**



USCS Symbol ***gp, ASSUMED***

USCS Classification ***POORLY GRADED GRAVEL***

Tested By PC Date 2/22/06 Checked By KYB Date 2-23-06

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INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-7
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	S-9
Lab ID	2006-060-01-65	Soil Color	**REDDISH GRAY**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	667	Tare No.	641
Wgt.Tare + Wet Specimen (gm)	322.03	Wgt.Tare + Wet Specimen (gm)	1301.80
Wgt.Tare + Dry Specimen (gm)	321.79	Wgt.Tare + Dry Specimen (gm)	1299.40
Weight of Tare (gm)	95.80	Weight of Tare (gm)	98.50
Weight of Water (gm)	0.24	Weight of Water (gm)	2.40
Weight of Dry Soil (gm)	225.99	Weight of Dry Soil (gm)	1200.90
Moisture Content (%)	**0.1**	**Moisture Content (%)**	**0.2**

Wet Weight -3/4" Sample (gm)	228	Weight of the Dry Specimen (gm)	225.99
Dry Weight - 3/4" Sample (gm)	227.8	Weight of minus #200 material (gm)	15.28
Wet Weight +3/4" Sample (gm)	24310.90	Weight of plus #200 material (gm)	210.71
Dry Weight + 3/4" Sample (gm)	24262.41		
Total Dry Weight Sample (gm)	24490.2	**J - Factor (Percent Finer than 3/4")**	**0.0093**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	14148.00		57.65	57.65	42.35	**42.35**
2"	50	5956.00	(*)	24.27	81.93	18.07	**18.07**
1 1/2"	37.5	3163.00		12.89	94.82	5.18	**5.18**
1"	25	858.00		3.50	98.31	1.69	**1.69**
3/4"	19	185.90		0.76	99.07	0.93	**0.93**
1/2"	12.5	150.09		66.41	66.41	33.59	**0.31**
3/8"	9.5	15.62		6.91	73.33	26.67	**0.25**
#4	4.75	26.96		11.93	85.26	14.74	**0.14**
#10	2	7.62		3.37	88.63	11.37	**0.11**
#20	0.85	3.30	(**)	1.46	90.09	9.91	**0.09**
#40	0.425	2.09		0.92	91.01	8.99	**0.08**
#60	0.25	1.28		0.57	91.58	8.42	**0.08**
#140	0.106	2.61		1.15	92.73	7.27	**0.07**
#200	0.075	1.14		0.50	93.24	6.76	**0.06**
Pan	-	15.28		6.76	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By PC Date 2/22/06 Checked By Date 2-23-06

SHELBY TUBE SAMPLE

TS-ST01

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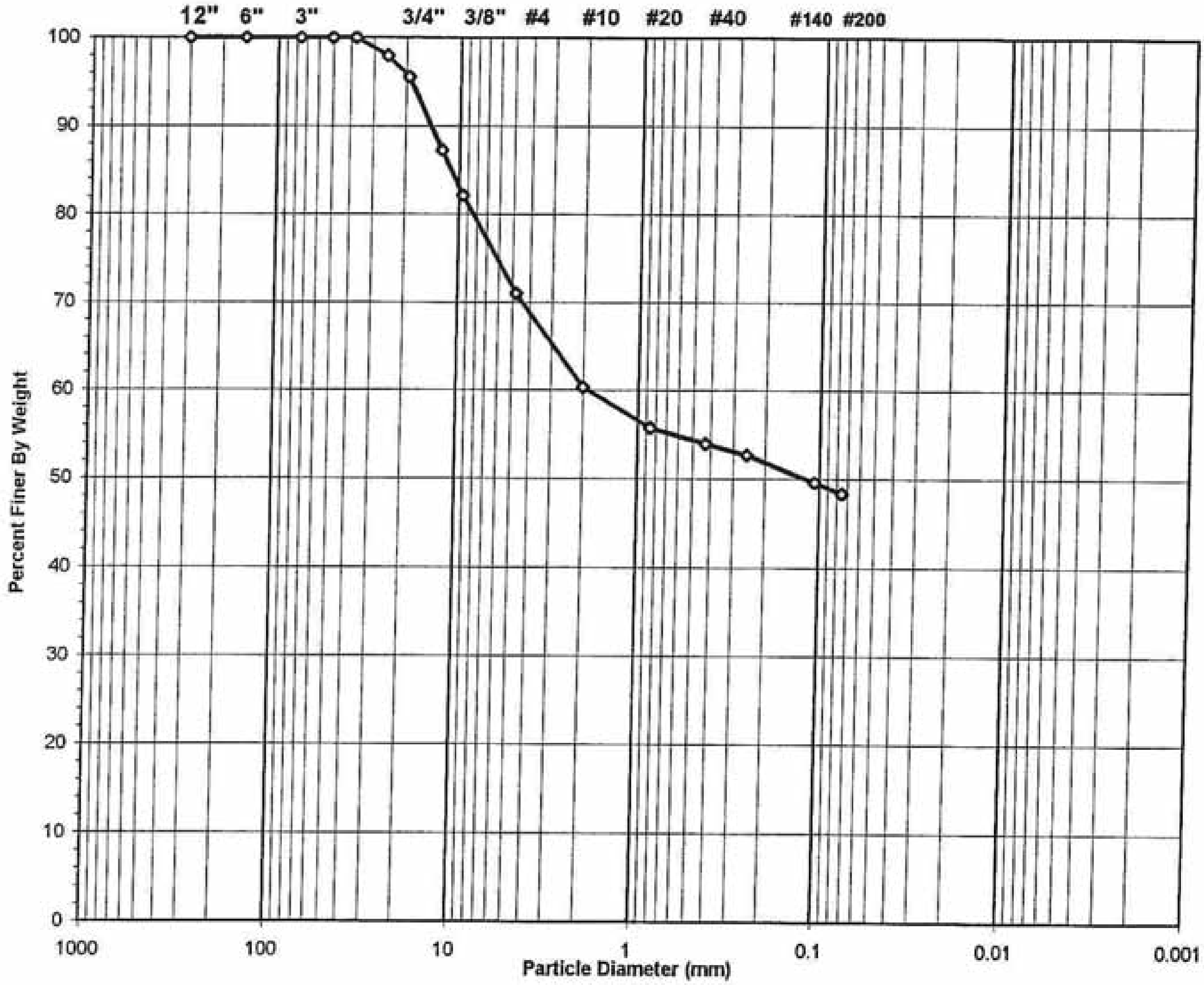
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-ST-01
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-75	Soil Color	BROWN AND GRAY

USCS	*SIEVE ANALYSIS*		*HYDROMETER*
	gravel	sand	silt and clay



USCS Symbol ***GC, TESTED***

USCS Classification ***CLAYEY GRAVEL WITH SAND***

Tested By JP Date 3/1/06 Checked By KYB Date 3-6-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-ST-01
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-75	Soil Color	BROWN AND GRAY

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	920	Tare No.	NA
Wgt.Tare + Wet Specimen (gm)	856.04	Wgt.Tare + Wet Specimen (gm)	NA
Wgt.Tare + Dry Specimen (gm)	738.50	Wgt.Tare + Dry Specimen (gm)	NA
Weight of Tare (gm)	103.00	Weight of Tare (gm)	NA
Weight of Water (gm)	117.54	Weight of Water (gm)	NA
Weight of Dry Soil (gm)	635.50	Weight of Dry Soil (gm)	NA
Moisture Content (%)	**18.5**	**Moisture Content (%)**	NA

Wet Weight -3/4" Sample (gm)	NA	Weight of the Dry Specimen (gm)	635.50
Dry Weight - 3/4" Sample (gm)	300.3	Weight of minus #200 material (gm)	306.92
Wet Weight +3/4" Sample (gm)	NA	Weight of plus #200 material (gm)	328.58
Dry Weight + 3/4" Sample (gm)	28.28		
Total Dry Weight Sample (gm)	NA		

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00	0.00	0.00	100.00	**100.00**
6"	150	0.00	0.00	0.00	100.00	**100.00**
3"	75	0.00	0.00	0.00	100.00	**100.00**
2"	50	0.00	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00	100.00	**100.00**
1"	25.0	12.96	2.04	2.04	97.96	**97.96**
3/4"	19.0	15.32	2.41	4.45	95.55	**95.55**
1/2"	12.50	52.44	8.25	12.70	87.30	**87.30**
3/8"	9.50	33.21	5.23	17.93	82.07	**82.07**
#4	4.75	70.63	11.11	29.04	70.96	**70.96**
#10	2.00	67.37	10.60	39.64	60.36	**60.36**
#20	0.850	29.39	4.62	44.27	55.73	**55.73**
#40	0.425	11.32	1.78	46.05	53.95	**53.95**
#60	0.250	8.10	1.27	47.32	52.68	**52.68**
#140	0.106	19.69	3.10	50.42	49.58	**49.58**
#200	0.075	8.15	1.28	51.70	48.30	**48.30**
Pan	-	306.92	48.30	100.00	-	-

Tested By JP Date 3/1/06 Checked By KB Date 3-6-06

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-ST-01
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-75	Soil Description	BROWN AND GRAY LEAN CLAY

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Airdried)

Liquid Limit Test	1	2	3
Tare Number	45	O	9
Wt. of Tare & WS (gm)	40.08	40.31	36.55
Wt. of Tare & DS (gm)	34.71	35.56	31.45
Wt. of Tare (gm)	17.60	20.13	15.77
Wt. of Water (gm)	5.4	4.8	5.1
Wt. of DS (gm)	17.1	15.4	15.7
Moisture Content (%)	**31.4**	**30.8**	**32.5**
Number of Blows	**30**	**24**	**15**

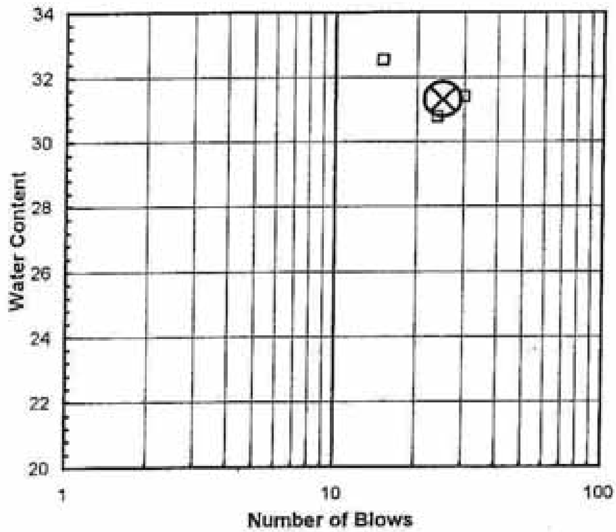
MULTIPOINT

Plastic Limit Test	1	2	Range
Tare Number	58	4000	
Wt. of Tare & WS (gm)	23.65	26.75	
Wt. of Tare & DS (gm)	22.61	25.68	
Wt. of Tare (gm)	17.41	20.43	
Wt. of Water (gm)	1.0	1.1	
Wt. of DS (gm)	5.2	5.3	
Moisture Content (%)	**20.0**	**20.4**	**-0.4**

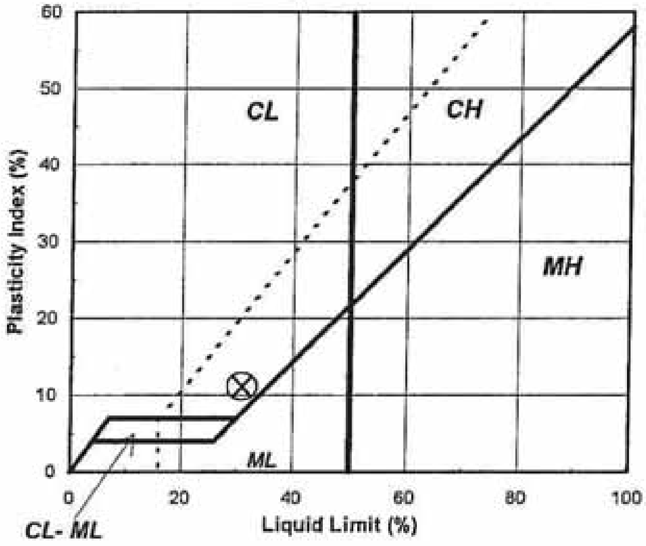
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**31**
Plastic Limit (%)	**20**
Plasticity Index (%)	**11**
USCS Symbol	**CL**

Flow Curve



Plasticity Chart



Tested By TO *Date* 3/5/06 *Checked By* KLB *Date* 3-6-06

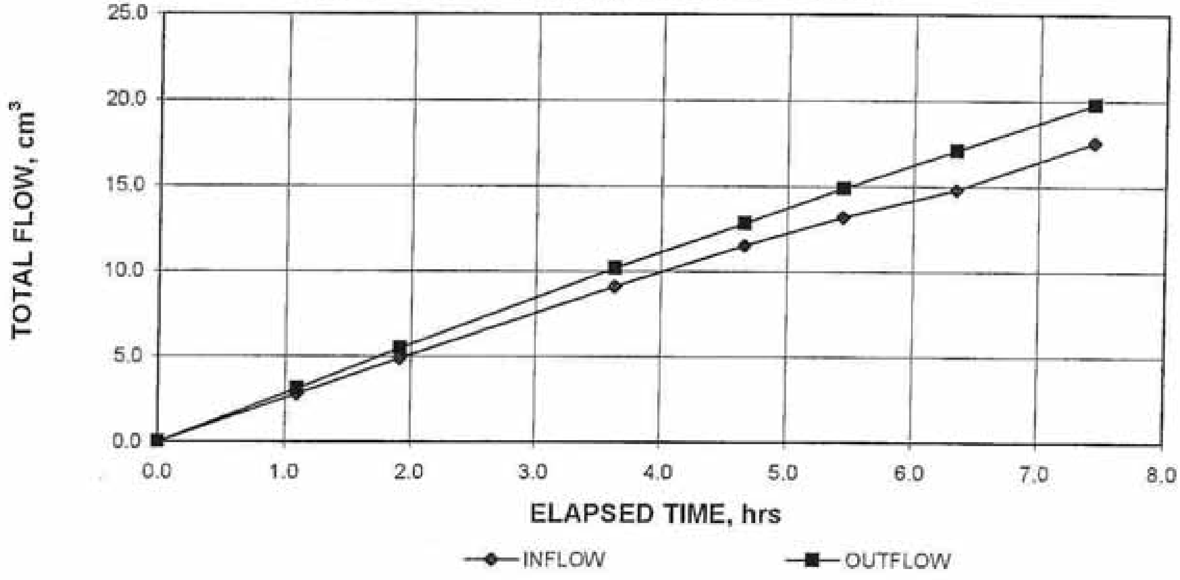
PERMEABILITY TEST

ASTM D 5084-90(Reapproved 1997)
(SOP-S22A & S22B)

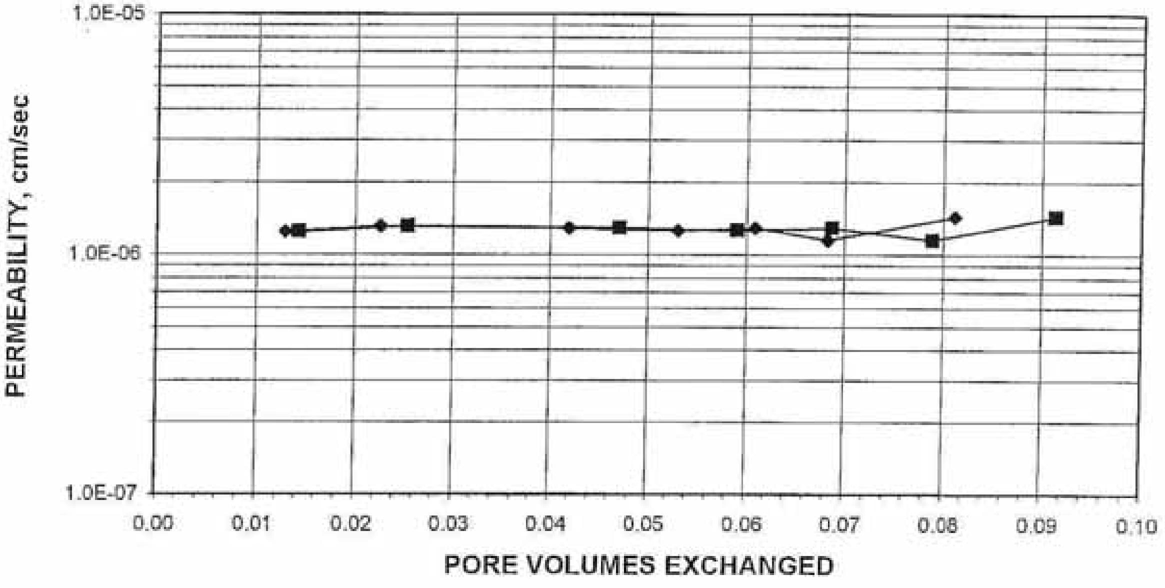
Client	PAUL C. RIZZO	Boring No.	TS-ST-01
Client Project	TAUM SAUK 06-3551	Depth (ft.)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID No.	2006-060-01-75		

AVERAGE PERMEABILITY = 1.3E-06 cm/sec @ 20°C
AVERAGE PERMEABILITY = 1.3E-08 m/sec @ 20°C

TOTAL FLOW vs. ELAPSED TIME



PORE VOLUMES EXCHANGED vs. PERMEABILITY



Tested By: JCM Date: 02/17/06 Checked By: KB Date: 2-24-06

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INTEGRITY IN TESTING

PERMEABILITY TEST

ASTM D 5084-03
(SOP-S22A & S22B)

Client	PAUL C. RIZZO	Boring No.	TS-ST-01
Client Project	TAUM SAUK 06-3551	Depth (ft.)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID No.	2006-060-01-75		
		Specific Gravity	2.70 Assumed
		Sample Condition	Undisturbed

Visual Description: BROWN AND GRAY MOTTLED CLAY AND SAND

MOISTURE CONTENT:	BEFORE TEST	AFTER TEST
Tare Number	621	NO AFTER TEST WATER CONTENT, SAMPLE USED FOR CU
Wt. of Tare & WS (gm.)	164.59	
Wt. of Tare & DS (gm.)	152.43	
Wt. of Tare (gm.)	86.94	
Wt. of Water (gm.)	12.16	
Wt. of DS (gm.)	65.49	
Moisture Content (%)	**18.6**	

SPECIMEN:	BEFORE TEST	AFTER TEST
Wt. of Tube & WS (gm.)	1219.13	NA
Wt. of Tube (gm.)	0.00	NA
Wt. of WS (calc)(gm.)	1219.13	1219.13
Length 1 (in.)	5.775	5.659
Length 2 (in.)	5.764	5.703
Length 3 (in.)	5.801	5.707
Top Diameter (in.)	2.876	2.850
Middle Diameter (in.)	2.853	2.850
Bottom Diameter (in.)	2.876	2.869
Average Length (in.)	5.78	5.69
Average Area (in.^{2})	6.46	6.41
Sample Volume (cm^3)	612.04	597.44
Unit Wet Wt. (gm./ cm^3)	1.99	2.04
Unit Wet Wt. (pcf)	124.3	127.4
Unit Dry Wt. (pcf)	104.9	
Unit Dry Wt. (gm./ cm^3)	1.68	
Void Ratio, e	0.61	
Porosity, n	0.38	
Pore Volume (cm^3)	231.2	
Total Wgt. Of Sample After Test		1230.9

Tested By: JCM Date: 02/17/06 Checked By: KVB Date: 2-24-06

PERMEABILITY TEST

ASTM D 5084-90(Reapproved 1997)
(SOP-S22A & S22B)

Client	PAUL C. RIZZO	Boring No.	TS-ST-01
Client Project	TAUM SAUK 06-3551	Depth (ft.)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID No.	2006-060-01-75		

Pressure Heads (Constant)	
Top Cap (psi)	67.5
Bottom Cap (psi)	70.0
Cell (psi)	75.0
Total Pressure Head (cm)	175.8
Hydraulic Gradient	12.16

Final Sample Dimensions	
Sample Length (cm), L	14.45
Sample Diameter (cm)	7.26
Sample Area (cm^2), A	41.34
Inflow Burette Area (cm^2), a-in	0.877
Outflow Burette Area (cm^2), a-out	0.904
B Parameter (%)	97

AVERAGE PERMEABILITY = 1.3E-06 cm/sec @ 20°C
AVERAGE PERMEABILITY = 1.3E-08 m/sec @ 20°C

DATE (mm/dd/yy)	TIME (hr)	(min)	ELAPSED TIME t (hr)	TOTAL INFLOW (cm^3)	TOTAL OUTFLOW (cm^3)	TOTAL HEAD h (cm)	FLOW (0 flow) (1 stop)	TEMP. (°C)	INCREMENTAL PERMEABILITY @ 20°C (cm/sec)
02/20/06	8	57	0.0	0.0	0.0	200.9	0	22.6	NA
02/20/06	10	3	1.1	2.8	3.1	194.4	0	22.0	1.2E-06
02/20/06	10	52	1.9	4.9	5.5	189.4	0	22.0	1.3E-06
02/20/06	12	35	3.6	9.1	10.2	179.5	0	22.0	1.3E-06
02/20/06	13	37	4.7	11.5	12.8	173.9	0	22.0	1.3E-06
02/20/06	14	24	5.5	13.2	14.9	169.7	0	22.0	1.3E-06
02/20/06	15	18	6.4	14.8	17.1	165.4	0	22.0	1.2E-06
02/20/06	16	23	7.4	17.6	19.8	159.3	1	22.0	1.4E-06

Tested By: JCM Date: 02/17/06 Checked By: KYB Date: 2-21-06

SHELBY TUBE SAMPLE

TS-ST02

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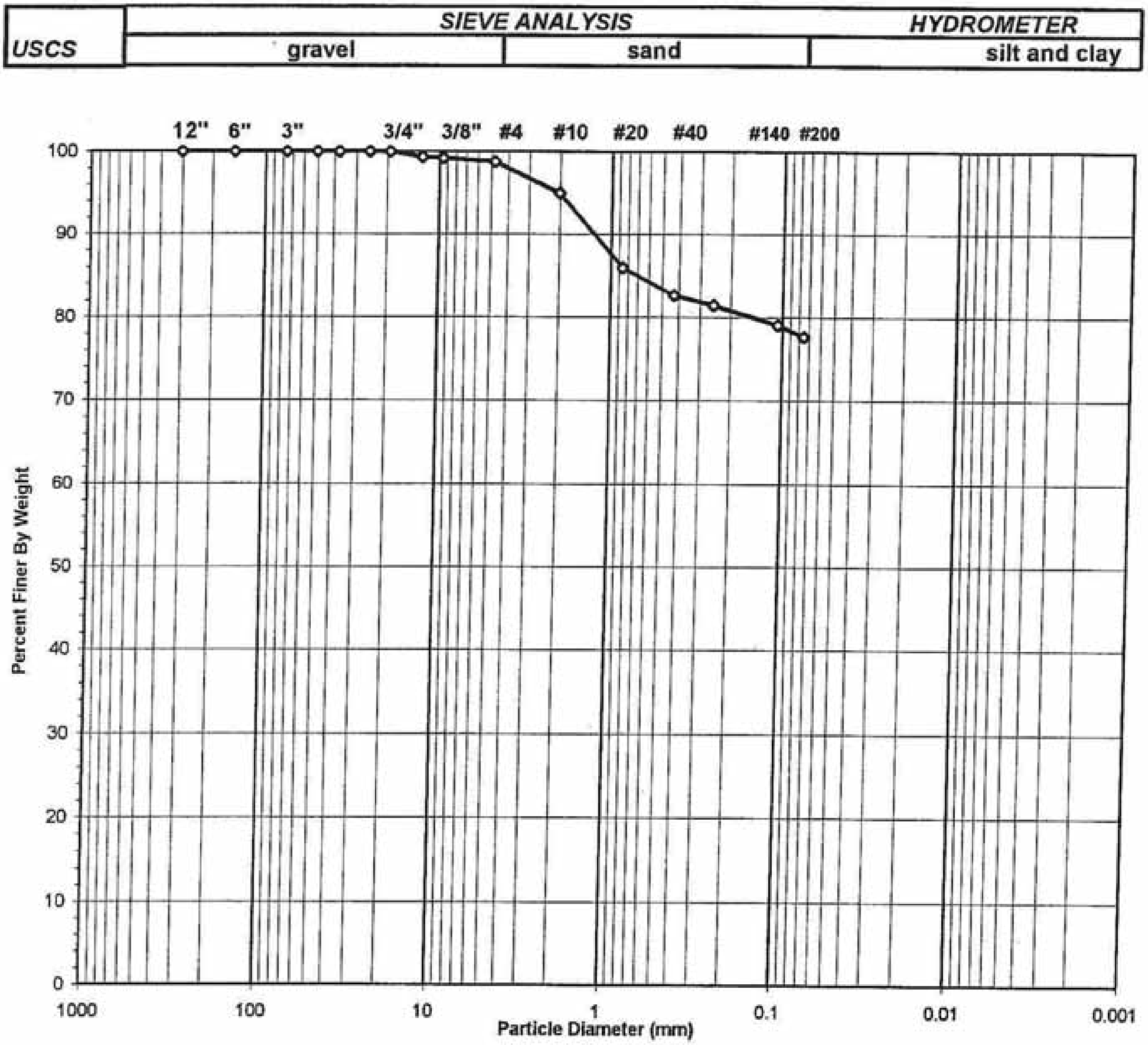
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-ST-02
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-76	Soil Color	BROWN AND GRAY



USCS Symbol ***CH, TESTED***

USCS Classification ***FAT CLAY WITH SAND***

Tested By JP Date 3/1/06 Checked By KYB Date 3-6-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-ST-02
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-76	Soil Color	BROWN AND GRAY

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	966	Tare No.	NA
Wgt.Tare + Wet Specimen (gm)	683.25	Wgt.Tare + Wet Specimen (gm)	NA
Wgt.Tare + Dry Specimen (gm)	553.90	Wgt.Tare + Dry Specimen (gm)	NA
Weight of Tare (gm)	103.11	Weight of Tare (gm)	NA
Weight of Water (gm)	129.35	Weight of Water (gm)	NA
Weight of Dry Soil (gm)	450.79	Weight of Dry Soil (gm)	NA
Moisture Content (%)	**28.7**	**Moisture Content (%)**	**NA**

Wet Weight -3/4" Sample (gm)	NA	Weight of the Dry Specimen (gm)	450.79
Dry Weight - 3/4" Sample (gm)	100.9	Weight of minus #200 material (gm)	349.91
Wet Weight +3/4" Sample (gm)	NA	Weight of plus #200 material (gm)	100.88
Dry Weight + 3/4" Sample (gm)	0.00		
Total Dry Weight Sample (gm)	NA		

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00	0.00	0.00	100.00	**100.00**
6"	150	0.00	0.00	0.00	100.00	**100.00**
3"	75	0.00	0.00	0.00	100.00	**100.00**
2"	50	0.00	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00	100.00	**100.00**
1"	25.0	0.00	0.00	0.00	100.00	**100.00**
3/4"	19.0	0.00	0.00	0.00	100.00	**100.00**
1/2"	12.50	2.93	0.65	0.65	99.35	**99.35**
3/8"	9.50	0.80	0.18	0.83	99.17	**99.17**
#4	4.75	1.55	0.34	1.17	98.83	**98.83**
#10	2.00	17.10	3.79	4.96	95.04	**95.04**
#20	0.850	40.93	9.08	14.04	85.96	**85.96**
#40	0.425	15.10	3.35	17.39	82.61	**82.61**
#60	0.250	5.36	1.19	18.58	81.42	**81.42**
#140	0.106	10.57	2.34	20.93	79.07	**79.07**
#200	0.075	6.54	1.45	22.38	77.62	**77.62**
Pan	-	349.91	77.62	100.00	-	-

Tested By JP Date 3/1/06 Checked By YKB Date 3-6-06

geotechnics
INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-ST-02
Client Reference	TAUM SAUK 06-3551	Depth (ft)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-76	Soil Description	**BROWN AND GRAY FAT CLAY**

***Note:* The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.** (Minus No. 40 sieve material, Airdried)

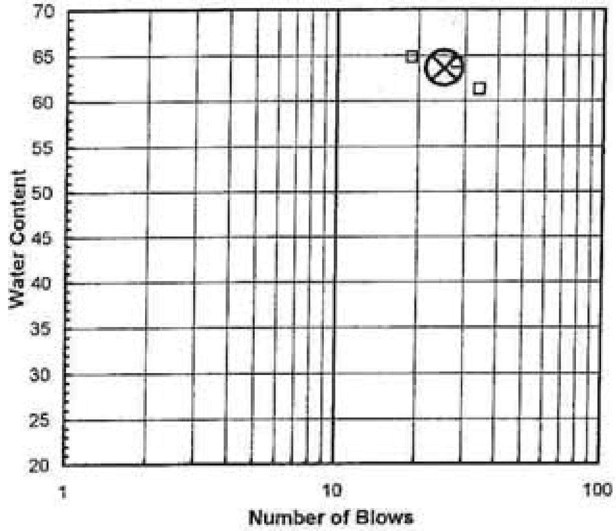
Liquid Limit Test	**1**	**2**	**3**	
				M
Tare Number	4	1158	222	**U**
Wt. of Tare & WS (gm)	28.79	38.27	39.48	**L**
Wt. of Tare & DS (gm)	23.34	30.86	31.97	**T**
Wt. of Tare (gm)	14.45	19.32	20.38	**I**
Wt. of Water (gm)	5.5	7.4	7.5	**P**
Wt. of DS (gm)	8.9	11.5	11.6	**O**
				I
Moisture Content (%)	**61.3**	**64.2**	**64.8**	**N**
Number of Blows	**34**	**28**	**19**	**T**

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	246	242	
Wt. of Tare & WS (gm)	23.70	26.53	
Wt. of Tare & DS (gm)	22.52	25.26	
Wt. of Tare (gm)	17.65	20.14	
Wt. of Water (gm)	1.2	1.3	
Wt. of DS (gm)	4.9	5.1	
Moisture Content (%)	**24.2**	**24.8**	**-0.6**

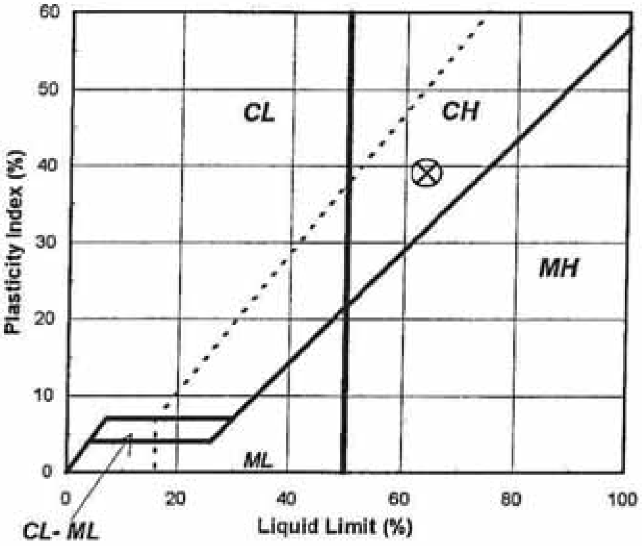
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**64**
Plastic Limit (%)	**25**
Plasticity Index (%)	**39**
USCS Symbol	**CH**

Flow Curve



Plasticity Chart



Tested By JAC *Date* 3/3/06 *Checked By* KB *Date* 3-6-06

PERMEABILITY TEST

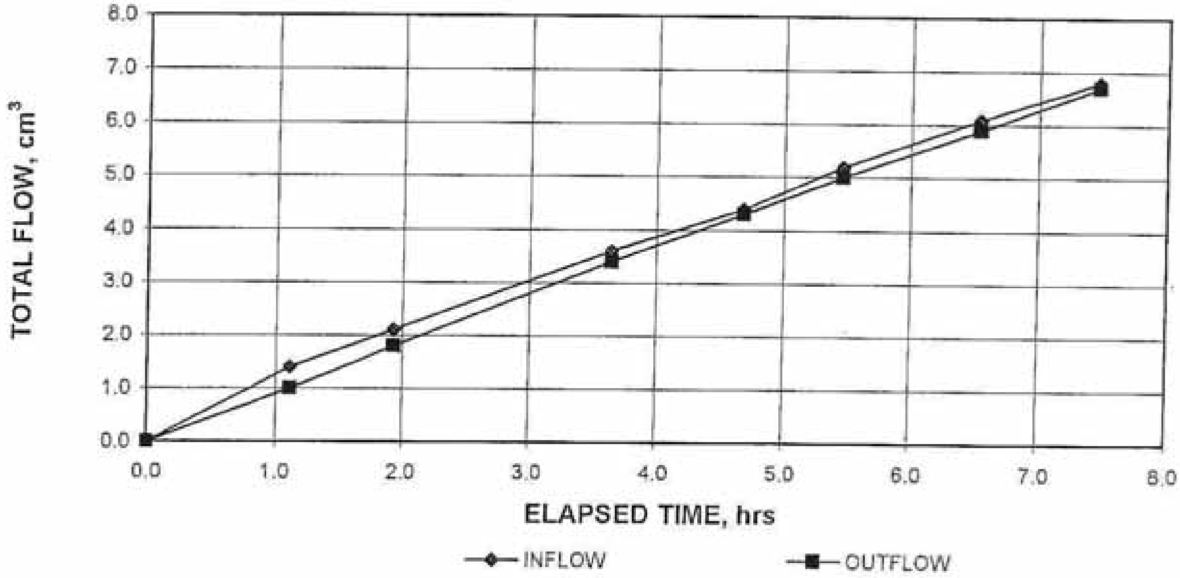
ASTM D 5084-90(Reapproved 1997)
(SOP-S22A & S22B)

geotechnics
INTEGRITY IN TESTING

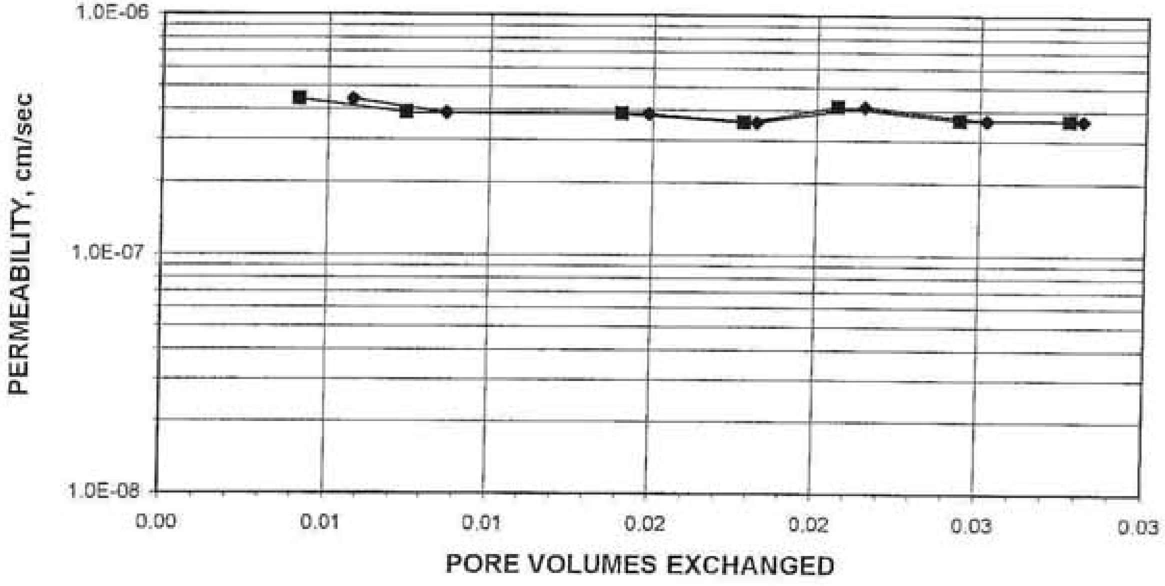
Client	PAUL C. RIZZO	Boring No.	TS-ST-02
Client Project	TAUM SAUK 06-3551	Depth (ft.)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID No.	2006-060-01-76		

AVERAGE PERMEABILITY = 3.8E-07 cm/sec @ 20°C
AVERAGE PERMEABILITY = 3.8E-09 m/sec @ 20°C

TOTAL FLOW vs. ELAPSED TIME



PORE VOLUMES EXCHANGED vs. PERMEABILITY



Tested By: JCM Date: 02/16/06 Checked By: KB Date: 2-24-06

geotechnics
INTEGRITY IN TESTING

PERMEABILITY TEST

ASTM D 5084-03
(SOP-S22A & S22B)

Client	PAUL C. RIZZO	Boring No.	TS-ST-02
Client Project	TAUM SAUK 06-3551	Depth (ft.)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID No.	2006-060-01-76		
		Specific Gravity	2.70 Assumed
		Sample Condition	Undisturbed

Visual Description: BROWN SANDY CLAY

MOISTURE CONTENT:	BEFORE TEST		AFTER TEST
Tare Number	1710	NO AFTER TEST WATER CONTENT, SAMPLE USED FOR CU	
Wt. of Tare & WS (gm.)	96.73		
Wt. of Tare & DS (gm.)	93.53		
Wt. of Tare (gm.)	82.33		
Wt. of Water (gm.)	3.20		
Wt. of DS (gm.)	11.20		
Moisture Content (%)	**28.6**		

SPECIMEN:	BEFORE TEST	AFTER TEST
Wt. of Tube & WS (gm.)	1006.30	NA
Wt. of Tube (gm.)	0.00	NA
Wt. of WS (calc.)(gm.)	1006.30	1006.30
Length 1 (in.)	5.083	5.064
Length 2 (in.)	5.070	5.072
Length 3 (in.)	5.060	5.065
Top Diameter (in.)	2.852	2.857
Middle Diameter (in.)	2.852	2.853
Bottom Diameter (in.)	2.856	2.857
Average Length (in.)	5.07	5.07
Average Area ($in.^2$)	6.39	6.40
Sample Volume (cm^3)	531.36	531.81
Unit Wet Wt. (gm./ cm^3)	1.89	1.89
Unit Wet Wt. (pcf)	118.2	118.1
Unit Dry Wt. (pcf)	91.9	
Unit Dry Wt. (gm./ cm^3)	1.47	
Void Ratio, e	0.83	
Porosity, n	0.45	
Pore Volume (cm^3)	241.5	
Total Wgt. Of Sample After Test		1014.1

Tested By: JCM Date: 02/16/06 Checked By: KB Date: 2-24-06

PERMEABILITY TEST

ASTM D 5084-90(Reapproved 1997)
(SOP-S22A & S22B)

Client	PAUL C. RIZZO
Client Project	TAUM SAUK 06-3551
Project No.	2006-060-01
Lab ID No.	2006-060-01-76

Boring No.	TS-ST-02
Depth (ft.)	NA
Sample No.	NA

Pressure Heads (Constant)

Top Cap (psi)	67.5
Bottom Cap (psi)	70.0
Cell (psi)	75.0
Total Pressure Head (cm)	175.8
Hydraulic Gradient	13.66

Final Sample Dimensions

Sample Length (cm), L	12.87
Sample Diameter (cm)	7.25
Sample Area (cm^2), A	41.32
Inflow Burette Area (cm^2), a-in	0.984
Outflow Burette Area (cm^2), a-out	0.842
B Parameter (%)	98

AVERAGE PERMEABILITY = 3.8E-07 cm/sec @ 20°C
AVERAGE PERMEABILITY = 3.8E-09 m/sec @ 20°C

DATE (mm/dd/yy)	TIME (hr)	TIME (min)	ELAPSED TIME t (hr)	TOTAL INFLOW (cm^3)	TOTAL OUTFLOW (cm^3)	TOTAL HEAD h (cm)	FLOW (0 flow) (1 stop)	TEMP. (°C)	INCREMENTAL PERMEABILITY @ 20°C (cm/sec)
02/20/06	8	57	0.0	0.0	0.0	199.7	0	22.6	NA
02/20/06	10	4	1.1	1.4	1.0	197.1	0	22.0	4.4E-07
02/20/06	10	53	1.9	2.1	1.8	195.5	0	22.0	3.9E-07
02/20/06	12	36	3.7	3.6	3.4	192.0	0	22.0	3.9E-07
02/20/06	13	38	4.7	4.4	4.3	190.2	0	22.0	3.6E-07
02/20/06	14	25	5.5	5.2	5.0	188.5	0	22.0	4.2E-07
02/20/06	15	30	6.6	6.1	5.9	186.5	0	22.0	3.7E-07
02/20/06	16	25	7.5	6.8	6.7	184.9	1	22.0	3.7E-07

Tested By: JCM Date: 02/16/06 Checked By: Date: 2-24-06

SHELBY TUBE SAMPLE

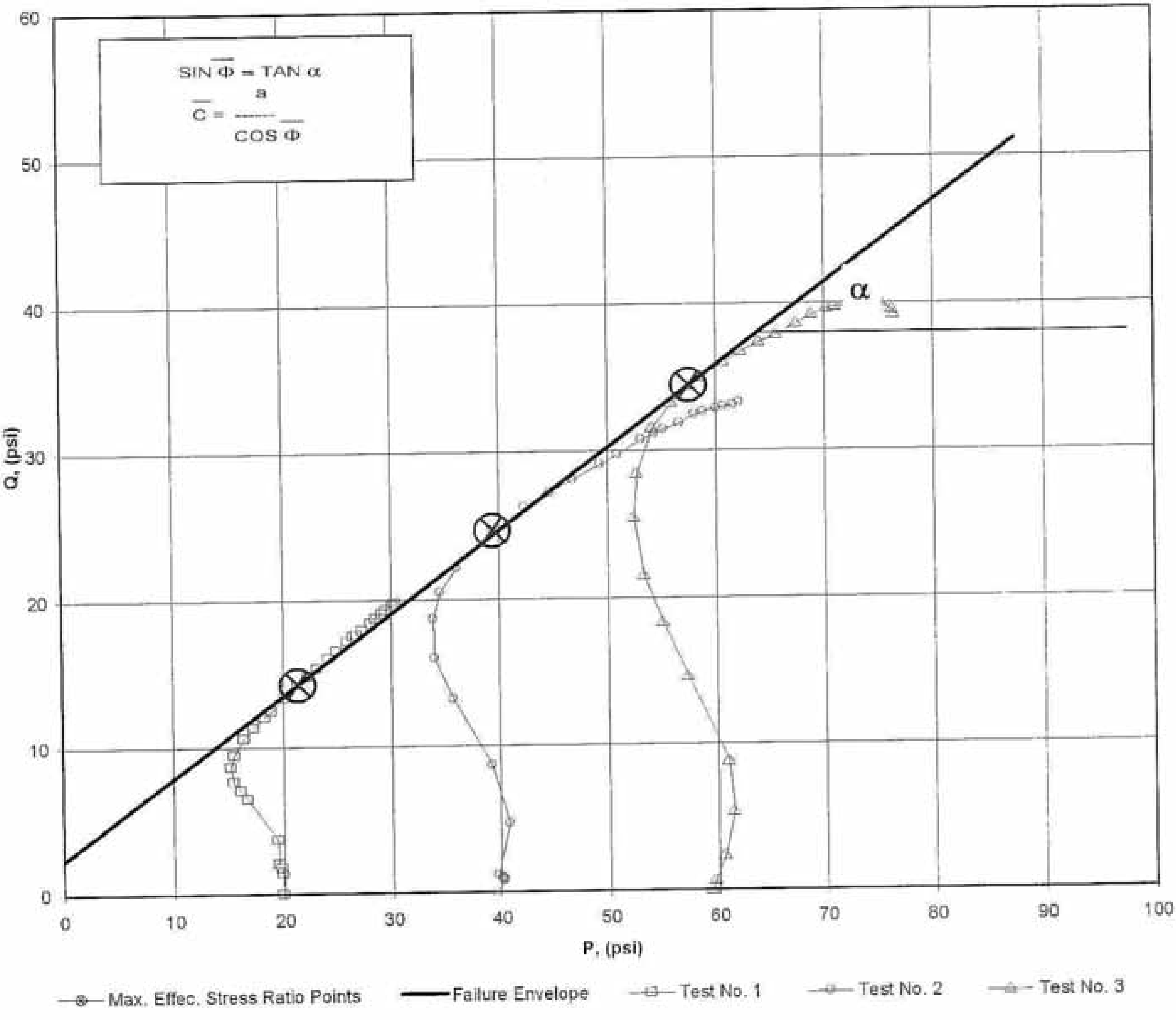
TS-ST01 & 02

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-ST-01 & 02
Client Reference	TAUM SAUK 06-3551	Depth(ft.)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-75& 76		

Consolidated Undrained Triaxial Test with Pore Pressure



a	=	2.30	$\overline{C}$	=	2.78
α	=	29.2	$\overline{\Phi}$	=	33.96

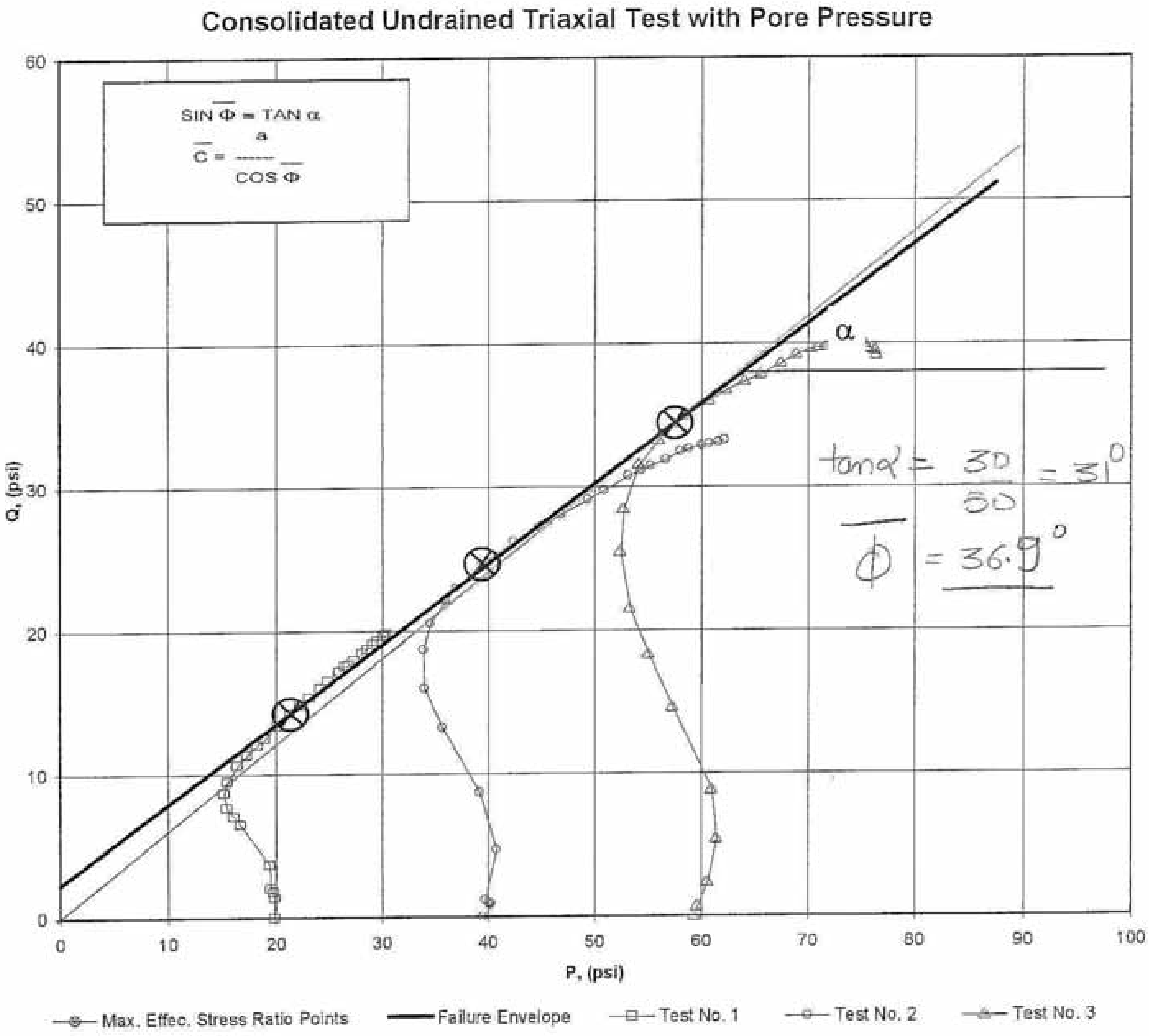
Tested By JCM Date 02/22/06 Approved By DB Date 2/27/06

geotechnics
INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-ST-01 & 02
Client Reference	TAUM SAUK 06-3551	Depth(ft.)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-75& 76		



tanα = 30/50 = 31°

$\overline{\phi}$ = 36.9°

a	=	2.30	$\overline{C}$	=	2.78
α	=	29.2	$\overline{\Phi}$	=	33.96

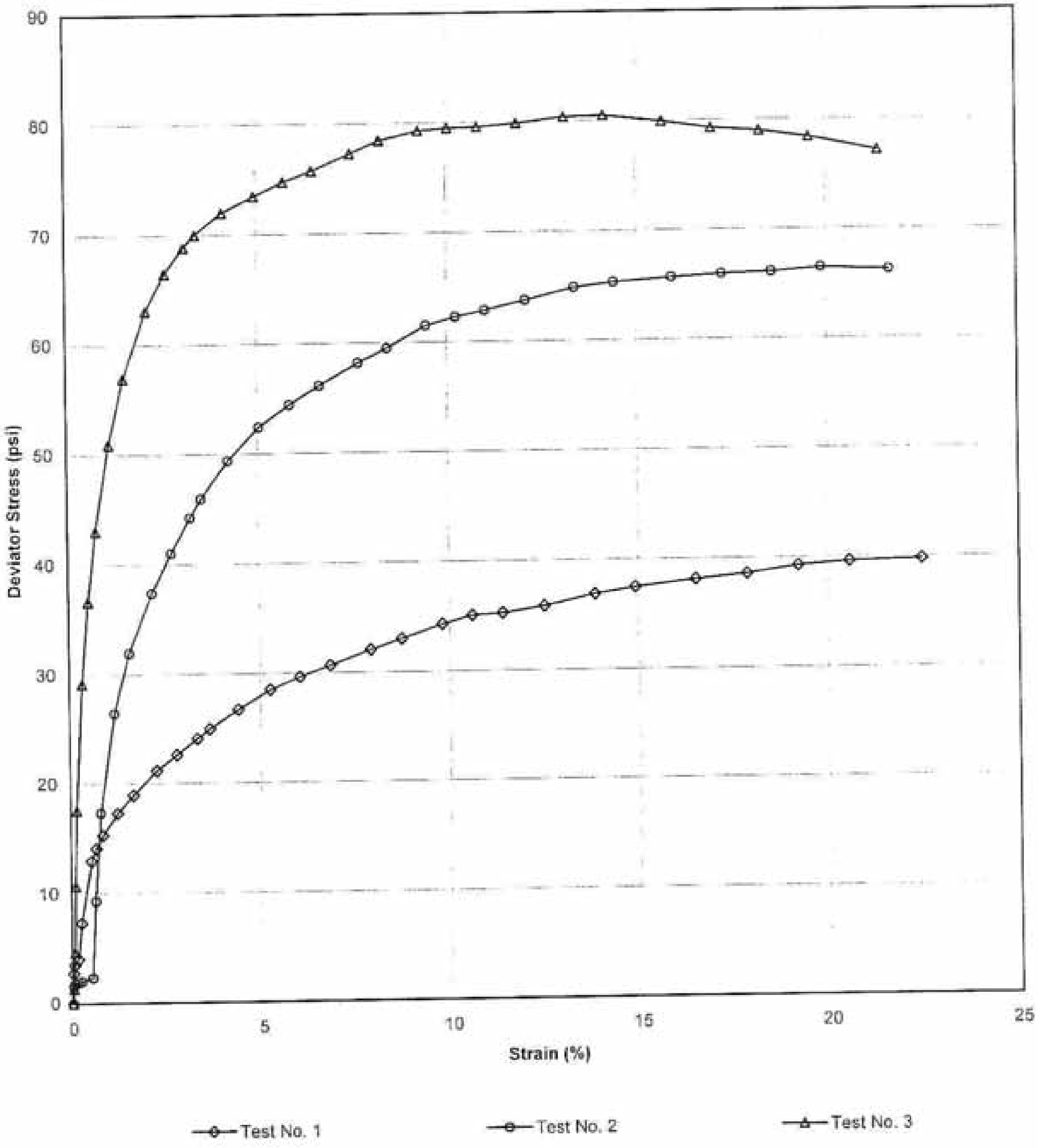
Tested By JCM Date 02/22/06 Approved By DB Date 2/27/06

geotechnics
INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-ST-01& 02
Client Reference	TAUM SAUK 06-3551	Depth(ft.)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-75&76		
Visual Description:	BROWN & GRAY MOTTLED CLAY & SAND (UNDISTURBED & AFTER PERMEABILITY)		



Tested By JCM Date 02/22/06 Approved By DB Date 2/27/06

CONSOLIDATED UNDRAINED TRIAXIAL TEST WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-ST-01
Client Reference	TAUM SAUK 06-3551	Depth(ft.)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-75		

Visual Description: BROWN & GRAY MOTTLED CLAY & SAND (AFTER PERMEABILITY)

Stage No.	1
Test No	1

INITIAL SAMPLE DIMENSIONS (in)

Length 1	5.659	Diameter 1	2.850
Length 2	5.703	Diameter 2	2.850
Length 3	5.707	Diameter 3	2.869
Avg Leng.=	5.690	Avg. Diam.=	2.856

PRESSURES (psi)

Cell Pressure(psi)	60.0
Back Pressure(psi)	40.1
Eff. Cons. Pressure(psi)	19.9
Pore Pressure Response (%)	98

VOLUME CHANGE

Initial Burette Reading (ml)	72.0
Final Burette Reading (ml)	48.7
Final Change (ml)	23.3

MAXIMUM OBLIQUITY POINTS

$\overline{P}$ = 21.37
Q = 14.24

Initial Dial Reading (D.R.), mils	45
D.R. After Saturation, mils	101
D.R. After Consolidation, mils	139

LOAD (LBS)	DEFORMATION (INCHES)	PORE PRESSURE (PSI)
14.1	0.000	40.1
31.0	0.001	41.5
35.6	0.003	41.9
38.8	0.009	42.5
58.8	0.014	44.2
93.2	0.030	49.7
100.3	0.037	50.9
107.9	0.047	52.2
120.5	0.069	53.5
131.1	0.092	54.0
145.7	0.127	54.2
155.3	0.156	54.0
165.3	0.187	53.7
171.3	0.205	53.5
183.7	0.248	53.2
196.5	0.295	52.9
205.5	0.339	52.5
213.9	0.384	52.2
225.4	0.444	51.8
233.7	0.490	51.6
244.9	0.550	51.2
252.2	0.594	51.0
255.7	0.639	50.8
262.8	0.700	50.6
273.8	0.775	50.3
281.2	0.835	50.1
291.1	0.925	49.9
299.1	1.001	49.8
309.0	1.076	49.5
316.7	1.151	49.5
325.7	1.257	49.3

Tested By JCM Date 02/22/06 Input Checked By YKB Date 2-27-06

geotechnics
INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-ST-01
Client Reference	TAUM SAUK 06-3551	Depth(ft.)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-75		

Visual Description: BROWN & GRAY MOTTLED CLAY & SAND (AFTER PERMEABILITY)

Effective Confining Pressure (psi)	19.9	*Stage No.*	1
		Test No	1

INITIAL DIMENSIONS

Initial Sample Length (in.)	5.69
Initial Sample Diameter (in.)	2.86
Initial Sample Area (in^2)	6.41
Initial Sample Volume (in^3)	36.46

VOLUME CHANGE

Volume After Consolidation (in^3)	33.96
Length After Consolidation (in)	5.60
Area After Consolidation (in^2)	6.069

Strain (%)	Deviation Stress	ΔU	$\overline{\sigma}_1$	$\overline{\sigma}_3$	Effective Principle Stress Ratio	$\overline{A}$	$\overline{P}$	Q
0.02	2.78	1.38	21.29	18.5	1.150	0.51	19.90	1.39
0.05	3.54	1.85	21.59	18.1	1.196	0.53	19.82	1.77
0.15	4.07	2.36	21.61	17.5	1.232	0.59	19.58	2.03
0.25	7.34	4.10	23.14	15.8	1.464	0.57	19.47	3.67
0.53	12.97	9.64	23.22	10.3	2.264	0.76	16.74	6.48
0.66	14.12	10.85	23.17	9.1	2.560	0.78	16.11	7.06
0.84	15.32	12.07	23.15	7.8	2.958	0.80	15.49	7.66
1.23	17.32	13.36	23.86	6.5	3.647	0.79	15.20	8.66
1.65	18.96	13.87	24.99	6.0	4.142	0.75	15.51	9.48
2.26	21.19	14.07	27.02	5.8	4.633	0.68	16.43	10.59
2.79	22.62	13.86	28.66	6.0	4.744	0.63	17.35	11.31
3.34	24.09	13.65	30.34	6.3	4.854	0.58	18.30	12.05
3.67	24.95	13.44	31.42	6.5	4.861	0.55	18.94	12.48
4.42	26.72	13.06	33.55	6.8	4.907	0.50	20.20	13.36
5.27	28.48	12.77	35.60	7.1	4.995	0.46	21.37	14.24
6.06	29.63	12.43	37.10	7.5	4.965	0.43	22.29	14.81
6.86	30.66	12.06	38.49	7.8	4.913	0.40	23.16	15.33
7.94	32.05	11.72	40.23	8.2	4.920	0.37	24.20	16.03
8.75	33.02	11.47	41.45	8.4	4.918	0.35	24.94	16.51
9.82	34.29	11.10	43.09	8.8	4.898	0.33	25.94	17.15
10.62	35.06	10.94	44.02	9.0	4.914	0.32	26.49	17.53
11.42	35.26	10.71	44.45	9.2	4.836	0.31	26.82	17.63
12.51	35.85	10.51	45.24	9.4	4.818	0.30	27.32	17.93
13.86	36.87	10.21	46.55	9.7	4.805	0.28	28.12	18.43
14.92	37.45	10.05	47.30	9.9	4.801	0.27	28.58	18.73
16.53	38.10	9.82	48.18	10.1	4.778	0.26	29.13	19.05
17.88	38.56	9.72	48.74	10.2	4.789	0.26	29.46	19.28
19.22	39.25	9.42	49.73	10.5	4.745	0.24	30.11	19.63
20.57	39.60	9.36	50.15	10.5	4.757	0.24	30.34	19.80
22.47	39.80	9.16	50.54	10.7	4.708	0.23	30.64	19.90

Tested By JCM Date 02/22/06 Input Checked By KVB Date 2-27-06

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

geotechnics
INTEGRITY IN TESTING

Client	PAUL C. RIZZO	Boring No.	TS-ST-02
Client Reference	TAUM SAUK 06-3551	Depth(ft.)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-76		

Visual Description: BROWN & GRAY MOTTLED CLAY & SAND (UNDISTURBED)

Stage No.	1
Test No	2

PRESSURES (psi)

Cell Pressure(psi)	89.9
Back Pressure(psi)	50.3
Eff. Cons. Pressure(ps	39.6
Pore Pressure Response (%)	96

MAXIMUM OBLIQUITY POINTS

$\overline{P}$ = 39.45

Q = 24.68

INITIAL SAMPLE DIMENSIONS (in)

Length 1	4.682	Diameter 1	2.864
Length 2	4.759	Diameter 2	2.862
Length 3	4.730	Diameter 3	2.897
Avg Leng.=	4.724	Avg. Diam.=	2.874

VOLUME CHANGE

Initial Burette Reading (ml)	72.0
Final Burette Reading (ml)	49.2
Final Change (ml)	22.8
Initial Dial Reading (D.R.), mils	74
D.R. After Saturation, mils	127
D.R. After Consolidation, mils	232

LOAD (LBS)	DEFORMATION (INCHES)	PORE PRESSURE (PSI)
17.2	0.000	50.3
26.8	0.001	50.4
28.4	0.003	50.5
29.0	0.006	50.7
29.7	0.011	50.8
31.6	0.024	51.3
75.1	0.028	53.7
125.3	0.036	59.3
182.5	0.053	67.4
217.9	0.072	71.9
253.4	0.100	74.7
277.7	0.123	75.9
299.6	0.146	76.0
311.5	0.160	75.9
335.8	0.192	75.1
358.5	0.230	73.7
374.5	0.267	72.4
389.0	0.303	71.1
406.9	0.350	69.7
418.9	0.385	68.7
437.4	0.432	67.5
446.2	0.467	66.7
454.0	0.503	66.1
465.4	0.551	65.1
479.9	0.611	64.3
488.6	0.658	63.7
500.2	0.729	62.7
510.0	0.789	62.2
519.2	0.849	61.3
530.1	0.908	60.9
539.9	0.990	60.2

Tested By JCM Date 02/22/06 Input Checked By YKB Date 2-27-06

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-ST-02
Client Reference	TAUM SAUK 06-3551	Depth(ft.)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-76		

Visual Description: BROWN & GRAY MOTTLED CLAY & SAND (UNDISTURBED)

Effective Confining Pressure (psi)	39.6	*Stage No.*	1
		Test No	2

INITIAL DIMENSIONS

Initial Sample Length (in.)	4.72
Initial Sample Diameter (in.)	2.87
Initial Sample Area (in^2)	6.49
Initial Sample Volume (in^3)	30.65

VOLUME CHANGE

Volume After Consolidation (in^3)	28.23
Length After Consolidation (in)	4.57
Area After Consolidation (in^2)	6.183

Strain (%)	Deviation Stress	ΔU	$\overline{\sigma}_1$	$\overline{\sigma}_3$	Effective Principle Stress Ratio	$\overline{A}$	$\overline{P}$	Q
0.01	1.56	0.13	41.02	39.5	1.039	0.09	40.24	0.78
0.06	1.82	0.16	41.26	39.4	1.046	0.09	40.35	0.91
0.14	1.90	0.38	41.12	39.2	1.048	0.21	40.17	0.95
0.24	2.02	0.54	41.08	39.1	1.052	0.28	40.07	1.01
0.52	2.32	1.02	40.90	38.6	1.060	0.46	39.74	1.16
0.62	9.31	3.44	45.47	36.2	1.257	0.38	40.82	4.66
0.79	17.35	9.05	47.90	30.6	1.568	0.54	39.22	8.67
1.17	26.43	17.10	48.92	22.5	2.175	0.67	35.71	13.21
1.58	31.95	21.59	49.96	18.0	2.774	0.70	33.98	15.97
2.19	37.37	24.40	52.57	15.2	3.459	0.68	33.88	18.69
2.70	41.00	25.59	55.01	14.0	3.926	0.65	34.51	20.50
3.20	44.22	25.65	58.16	13.9	4.171	0.60	36.06	22.11
3.50	45.93	25.59	59.94	14.0	4.277	0.58	36.98	22.97
4.21	49.35	24.83	64.13	14.8	4.341	0.52	39.45	24.68
5.04	52.42	23.43	68.59	16.2	4.242	0.47	42.38	26.21
5.84	54.41	22.09	71.92	17.5	4.107	0.42	44.72	27.21
6.64	56.14	20.81	74.93	18.8	3.988	0.39	46.86	28.07
7.67	58.20	19.36	78.44	20.2	3.875	0.35	49.34	29.10
8.43	59.50	18.43	80.67	21.2	3.811	0.32	50.92	29.75
9.46	61.53	17.25	83.89	22.4	3.752	0.29	53.12	30.77
10.24	62.29	16.41	85.48	23.2	3.686	0.27	54.34	31.15
11.02	62.87	15.80	86.66	23.8	3.642	0.26	55.23	31.43
12.08	63.73	14.80	88.53	24.8	3.570	0.24	56.66	31.87
13.37	64.83	13.99	90.45	25.6	3.531	0.22	58.03	32.42
14.41	65.26	13.37	91.48	26.2	3.488	0.21	58.86	32.63
15.96	65.65	12.38	92.87	27.2	3.412	0.20	60.05	32.83
17.28	65.93	11.87	93.66	27.7	3.378	0.19	60.70	32.97
18.59	66.10	11.04	94.66	28.6	3.315	0.17	61.61	33.05
19.89	66.46	10.65	95.41	29.0	3.295	0.17	62.18	33.23
21.68	66.22	9.92	95.89	29.7	3.231	0.16	62.79	33.11

Tested By JCM Date 02/22/06 Input Checked By KB Date 2-27-06

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-ST-02
Client Reference	TAUM SAUK 06-3551	Depth(ft.)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-76		

Visual Description: BROWN & GRAY MOTTLED CLAY & SAND (AFTER PERMEABILITY)

Stage No.	1
Test No	3

PRESSURES (psi)

Cell Pressure(psi)	99.7
Back Pressure(psi)	40.3
Eff. Cons. Pressure(ps	59.4
Pore Pressure Response (%)	98

MAXIMUM OBLIQUITY POINTS

$\overline{P}$ = 57.51
Q = 34.43

INITIAL SAMPLE DIMENSIONS (in)

Length 1	5.064	Diameter 1	2.857
Length 2	5.072	Diameter 2	2.853
Length 3	5.060	Diameter 3	2.857
Avg Leng.=	5.065	Avg. Diam.=	2.856

VOLUME CHANGE

Initial Burette Reading (ml)	48.0
Final Burette Reading (ml)	28.2
Final Change (ml)	19.8

Initial Dial Reading (D.R.), mils	49
D.R. After Saturation, mils	59
D.R. After Consolidation, mils	160

LOAD (LBS)	DEFORMATION (INCHES)	PORE PRESSURE (PSI)
18.8	0.000	40.3
27.3	0.001	40.7
48.1	0.003	41.4
85.8	0.005	43.6
129.1	0.008	47.5
202.1	0.016	56.9
249.4	0.025	63.0
290.5	0.036	67.9
341.2	0.054	72.7
380.8	0.074	75.4
422.5	0.104	77.1
446.4	0.129	76.9
464.0	0.153	76.6
472.9	0.168	76.0
489.2	0.204	74.9
503.0	0.245	74.0
515.4	0.284	72.9
526.2	0.322	71.9
541.9	0.372	70.8
554.4	0.410	69.9
566.2	0.461	69.0
572.6	0.499	68.4
577.9	0.537	67.7
586.7	0.589	67.0
598.8	0.651	65.9
606.3	0.702	65.3
612.9	0.779	64.3
617.3	0.844	63.7
624.4	0.906	62.9
629.2	0.970	62.4
633.5	1.060	61.8

Tested By JCM Date 02/22/06 Input Checked By KYR Date 2-27-06

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-ST-02
Client Reference	TAUM SAUK 06-3551	Depth(ft.)	NA
Project No.	2006-060-01	Sample No.	NA
Lab ID	2006-060-01-76		

Visual Description: BROWN & GRAY MOTTLED CLAY & SAND (AFTER PERMEABILITY)

Effective Confining Pressure (psi)	59.4	*Stage No.*	1
		Test No	3

INITIAL DIMENSIONS

Initial Sample Length (in.)	5.07
Initial Sample Diameter (in.)	2.86
Initial Sample Area (in^2)	6.40
Initial Sample Volume (in^3)	32.44

VOLUME CHANGE

Volume After Consolidation (in^3)	31.04
Length After Consolidation (in)	4.95
Area After Consolidation (in^2)	6.266

Strain (%)	Deviation Stress	Δ U	$\overline{\sigma}_1$	$\overline{\sigma}_3$	Effective Principle Stress Ratio	$\overline{A}$	$\overline{P}$	Q
0.02	1.36	0.39	60.37	59.0	1.023	0.29	59.69	0.68
0.06	4.67	1.11	62.96	58.3	1.080	0.24	60.63	2.33
0.10	10.69	3.28	66.81	56.1	1.190	0.31	61.47	5.34
0.16	17.57	7.15	69.82	52.2	1.336	0.42	61.03	8.78
0.33	29.16	16.63	71.93	42.8	1.682	0.58	57.35	14.58
0.51	36.62	22.67	73.35	36.7	1.997	0.63	55.04	18.31
0.73	43.04	27.59	74.86	31.8	2.353	0.65	53.33	21.52
1.10	50.90	32.44	77.86	27.0	2.888	0.65	52.41	25.45
1.50	56.92	35.13	81.18	24.3	3.345	0.63	52.72	28.46
2.10	63.07	36.76	85.71	22.6	3.786	0.59	54.18	31.54
2.60	66.47	36.62	89.25	22.8	3.917	0.56	56.02	33.23
3.10	68.86	36.32	91.94	23.1	3.983	0.54	57.51	34.43
3.40	70.01	35.69	93.72	23.7	3.953	0.52	58.71	35.01
4.11	71.99	34.62	96.77	24.8	3.905	0.49	60.78	36.00
4.95	73.45	33.72	99.13	25.7	3.860	0.47	62.40	36.72
5.73	74.71	32.64	101.47	26.8	3.792	0.45	64.11	37.35
6.49	75.72	31.60	103.52	27.8	3.724	0.43	65.66	37.86
7.50	77.22	30.49	106.13	28.9	3.671	0.40	67.52	38.61
8.27	78.41	29.64	108.18	29.8	3.635	0.39	68.97	39.21
9.30	79.25	28.66	109.99	30.7	3.578	0.37	70.36	39.62
10.07	79.49	28.05	110.84	31.3	3.536	0.36	71.09	39.74
10.85	79.55	27.37	111.59	32.0	3.483	0.35	71.81	39.78
11.89	79.86	26.70	112.56	32.7	3.442	0.34	72.63	39.93
13.14	80.41	25.59	114.22	33.8	3.378	0.32	74.02	40.20
14.18	80.47	24.98	114.89	34.4	3.338	0.32	74.66	40.24
15.73	79.90	23.97	115.33	35.4	3.255	0.31	75.38	39.95
17.03	79.26	23.41	115.25	36.0	3.203	0.30	75.62	39.63
18.29	78.98	22.56	115.82	36.8	3.144	0.29	76.33	39.49
19.58	78.34	22.15	115.59	37.3	3.103	0.29	76.42	39.17
21.39	77.12	21.52	115.00	37.9	3.036	0.28	76.44	38.56

Tested By JCM Date 02/22/06 Input Checked By KVB Date 2-27-06

CONSOLIDATED UNDRAINED TRIAXIAL TEST WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO		
Client Reference	TAUM SAUK 06-3551		
Project No.	2006-060-01		
Lab ID	2006-060-01-75 & 76	Specific Gravity (assumed)	2.7

Visual Description: BROWN AND GRAY MOTTLED CLAY AND SAND (UNDISTURBED)

SAMPLE CONDITION SUMMARY

Boring No.	TS-ST-01	TS-ST-02	TS-ST-02
Depth (ft)	NA	NA	NA
Sample No.	NA	NA	NA
Test No.	T1	T2	T3
Deformation Rate (in/min)	0.002	0.002	0.002
Back Pressure (psi)	40.1	50.3	40.3
Consolidation Time (days)	1	1	1
Initial State (w%)	18.6	26.5	28.6
Total Unit Weight (pcf)	124.4	114.9	118.2
Dry Unit Weight (pcf)	104.9	90.8	92.0
Final State (w%)	18.5	27.2	28.7
Initial State Void Ratio,e	0.607	0.856	0.833

Tested By JCM Date 02/22/06 Input Checked By YHB Date 2-28-06

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DCN: CT-S28 DATE 6-25-98 REVISION: 1

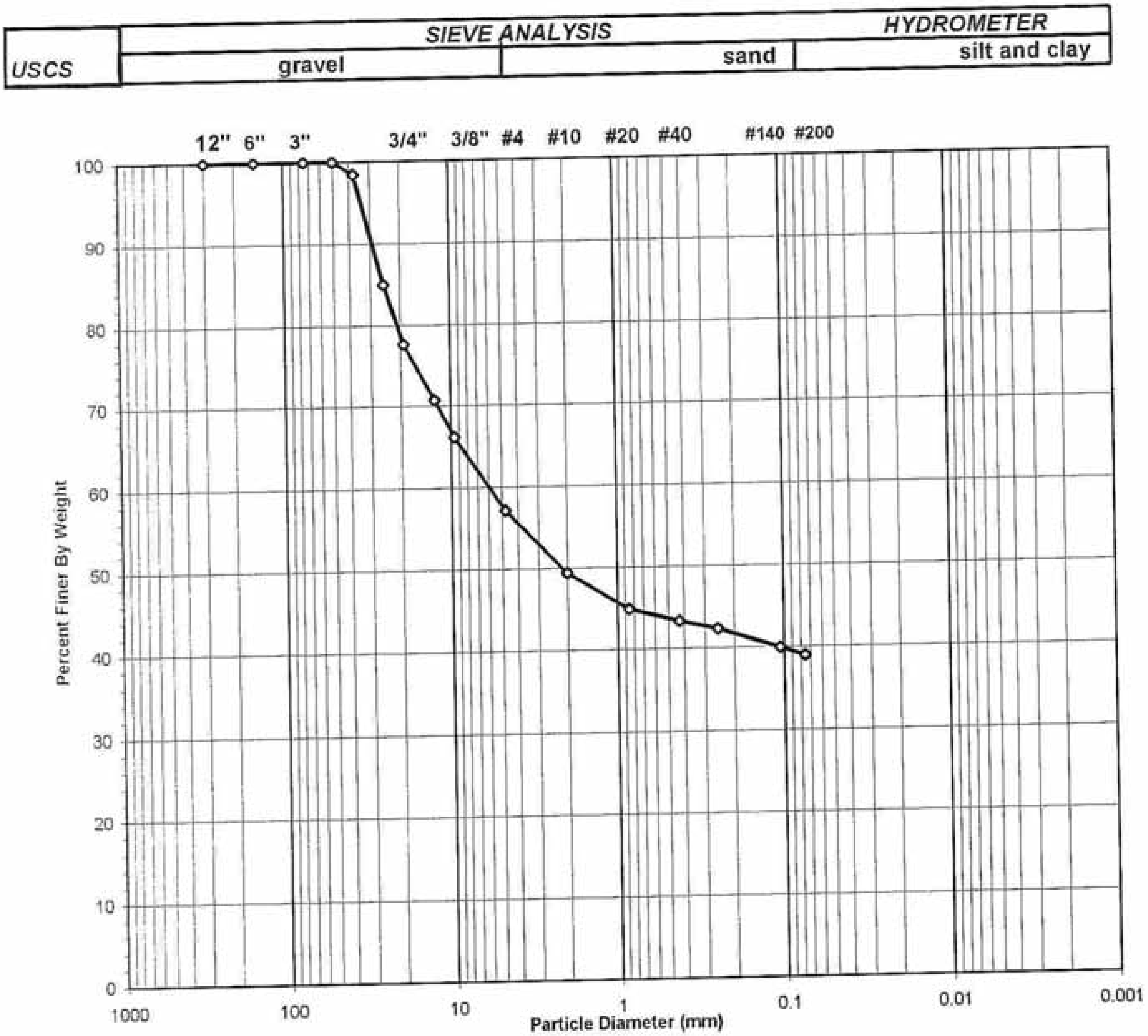
SOIL SAMPLE TS-SOIL 01

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-01
Client Reference	TAUM SAUK 06-3551	Depth (in)	9-14
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-67	Soil Color	BROWN



USCS Symbol ***GC, TESTED***

USCS Classification ***CLAYEY GRAVEL WITH SAND***

Tested By JP Date 2/28/06 Checked By KB Date 3-1-06

page 1 of 2 DCN: CT-S3A DATE 6-25-98 REVISION 2 *C:\MSOFFICE\Excel\PrintQ\[U426.xls]Sheet1*

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-01
Client Reference	TAUM SAUK 06-3551	Depth (in)	9-14
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-67	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	967	Tare No.	1126
Wgt.Tare + Wet Specimen (gm)	1111.50	Wgt.Tare + Wet Specimen (gm)	383.04
Wgt.Tare + Dry Specimen (gm)	975.60	Wgt.Tare + Dry Specimen (gm)	358.34
Weight of Tare (gm)	103.44	Weight of Tare (gm)	84.82
Weight of Water (gm)	135.90	Weight of Water (gm)	24.70
Weight of Dry Soil (gm)	872.16	Weight of Dry Soil (gm)	273.52
Moisture Content (%)	**15.6**	**Moisture Content (%)**	**9.0**

Wet Weight -3/4" Sample (gm)	3141	Weight of the Dry Specimen (gm)	872.16
Dry Weight - 3/4" Sample (gm)	2717.6	Weight of minus #200 material (gm)	437.28
Wet Weight +3/4" Sample (gm)	854.72	Weight of plus #200 material (gm)	434.88
Dry Weight + 3/4" Sample (gm)	783.93		
Total Dry Weight Sample (gm)	3501.5	**J - Factor (Percent Finer than 3/4")**	**0.7761**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	0.00		0.00	0.00	100.00	**100.00**
2"	50	0.00	(*)	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	59.19		1.55	1.55	98.45	**98.45**
1"	25	514.80		13.48	15.04	84.96	**84.96**
3/4"	19	280.73		7.35	22.39	77.61	**77.61**
1/2"	12.5	77.24		8.86	8.86	91.14	**70.74**
3/8"	9.5	51.02		5.85	14.71	85.29	**66.20**
#4	4.75	101.30		11.61	26.32	73.68	**57.18**
#10	2	87.62		10.05	36.37	63.63	**49.39**
#20	0.85	51.28	(**)	5.88	42.25	57.75	**44.82**
#40	0.425	16.62		1.91	44.15	55.85	**43.34**
#60	0.25	11.19		1.28	45.44	54.56	**42.35**
#140	0.106	27.36		3.14	48.57	51.43	**39.91**
#200	0.075	11.25		1.29	49.86	50.14	**38.91**
Pan	-	437.28		50.14	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/28/06 Checked By Date 3-1-06

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-01
Client Reference	TAUM SAUK 06-3551	Depth (in)	9-14
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-67	Soil Description	**BROWN LEAN CLAY**

(Minus No. 40 sieve material, Airdried)

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

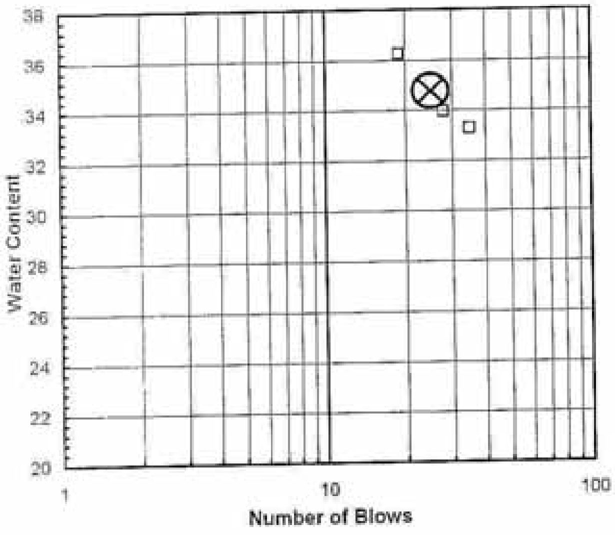
Liquid Limit Test	**1**	**2**	**3**	**MULTIPOINT**
Tare Number	119	230	250	
Wt. of Tare & WS (gm)	42.20	41.68	37.78	
Wt. of Tare & DS (gm)	36.08	35.75	32.39	
Wt. of Tare (gm)	17.69	18.28	17.52	
Wt. of Water (gm)	6.1	5.9	5.4	
Wt. of DS (gm)	18.4	17.5	14.9	
Moisture Content (%)	**33.3**	**33.9**	**36.2**	
Number of Blows	**35**	**28**	**19**	

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	2294	2365	
Wt. of Tare & WS (gm)	25.73	23.92	
Wt. of Tare & DS (gm)	24.72	22.87	
Wt. of Tare (gm)	19.68	17.61	
Wt. of Water (gm)	1.0	1.1	
Wt. of DS (gm)	5.0	5.3	
Moisture Content (%)	**20.0**	**20.0**	**0.1**

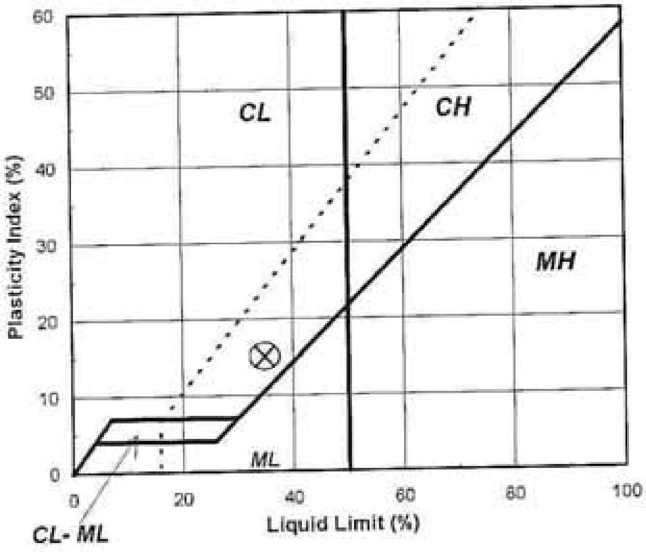
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**35**
Plastic Limit (%)	**20**
Plasticity Index (%)	**15**
USCS Symbol	**CL**

Flow Curve



Plasticity Chart



Tested By BS *Date* 2/28/06 *Checked By* YKY *Date* 3-1-06

page 1 of 1 DCN: CT-S4B DATE: 10/8/01 REVISION: 2

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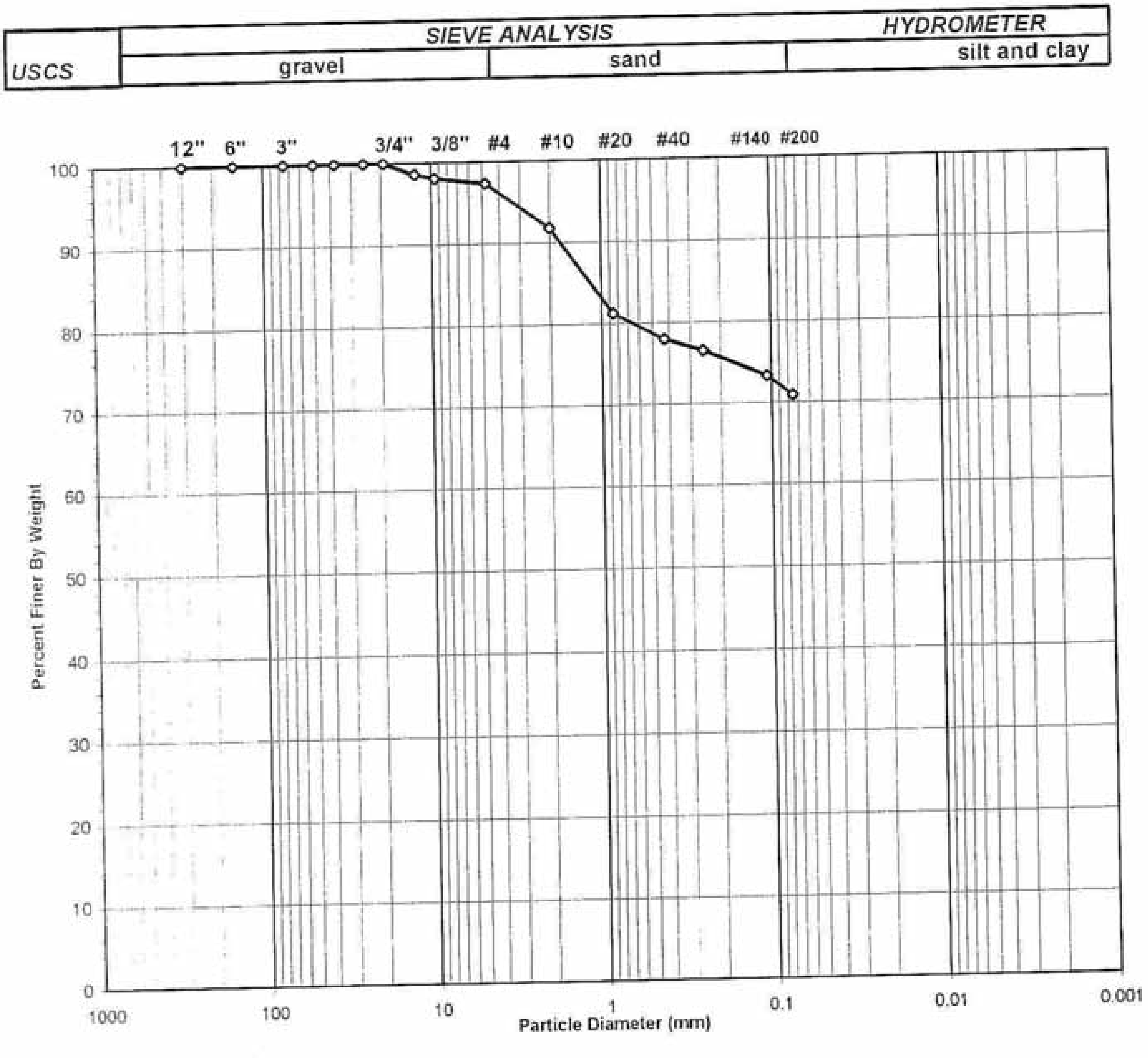
SOIL SAMPLE TS-SOIL 02

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth (in)	7-12
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-69	Soil Color	REDDISH BROWN



USCS Symbol *CH, TESTED*

USCS Classification *FAT CLAY WITH SAND*

Tested By JP Date 2/28/06 Checked By KR Date 3-2-06

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WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth (in)	7-12
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-69	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	690	Tare No.	NA
Wgt.Tare + Wet Specimen (gm)	715.89	Wgt.Tare + Wet Specimen (gm)	NA
Wgt.Tare + Dry Specimen (gm)	580.28	Wgt.Tare + Dry Specimen (gm)	NA
Weight of Tare (gm)	99.39	Weight of Tare (gm)	NA
Weight of Water (gm)	135.61	Weight of Water (gm)	NA
Weight of Dry Soil (gm)	480.89	Weight of Dry Soil (gm)	NA
Moisture Content (%)	**28.2**	**Moisture Content (%)**	**NA**

Wet Weight -3/4" Sample (gm)	NA	Weight of the Dry Specimen (gm)	480.89
Dry Weight - 3/4" Sample (gm)	139.8	Weight of minus #200 material (gm)	341.05
Wet Weight +3/4" Sample (gm)	NA	Weight of plus #200 material (gm)	139.84
Dry Weight + 3/4" Sample (gm)	0.00		
Total Dry Weight Sample (gm)	NA		

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00	0.00	0.00	100.00	**100.00**
6"	150	0.00	0.00	0.00	100.00	**100.00**
3"	75	0.00	0.00	0.00	100.00	**100.00**
2"	50	0.00	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00	100.00	**100.00**
1"	25.0	0.00	0.00	0.00	100.00	**100.00**
3/4"	19.0	0.00	0.00	0.00	100.00	**100.00**
1/2"	12.50	6.61	1.37	1.37	98.63	**98.63**
3/8"	9.50	2.67	0.56	1.93	98.07	**98.07**
#4	4.75	3.52	0.73	2.66	97.34	**97.34**
#10	2.00	26.41	5.49	8.15	91.85	**91.85**
#20	0.850	50.94	10.59	18.75	81.25	**81.25**
#40	0.425	15.84	3.29	22.04	77.96	**77.96**
#60	0.250	6.89	1.43	23.47	76.53	**76.53**
#140	0.106	15.34	3.19	26.66	73.34	**73.34**
#200	0.075	11.62	2.42	29.08	70.92	**70.92**
Pan	-	341.05	70.92	100.00	-	-

Tested By JP Date 2/28/06 Checked By Date 3-2-06

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth (in)	7-12
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-69	Soil Description	**REDDISH BROWN FAT CLAY**
			(Minus No. 40 sieve material, Airdried)

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

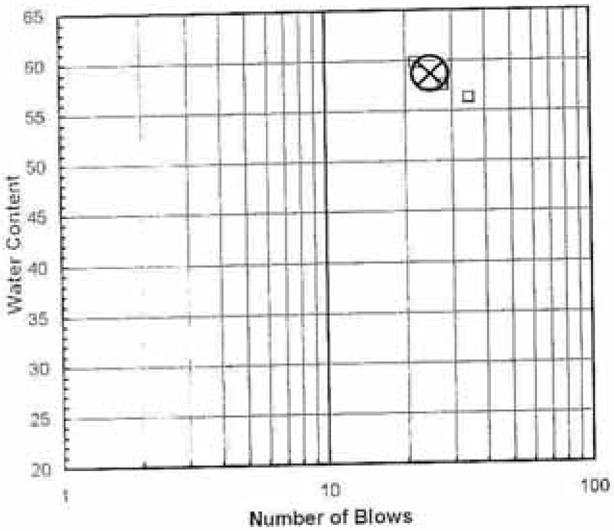
Liquid Limit Test	**1**	**2**	**3**	
Tare Number	16	26	27	
Wt. of Tare & WS (gm)	39.30	42.18	42.97	
Wt. of Tare & DS (gm)	32.01	33.31	34.55	**MULTIPOINT**
Wt. of Tare (gm)	19.06	17.90	20.48	
Wt. of Water (gm)	7.3	8.9	8.4	
Wt. of DS (gm)	13.0	15.4	14.1	
Moisture Content (%)	**56.3**	**57.6**	**59.8**	
Number of Blows	**35**	**28**	**22**	

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	48	53	
Wt. of Tare & WS (gm)	24.27	25.48	
Wt. of Tare & DS (gm)	23.11	24.21	
Wt. of Tare (gm)	18.15	18.82	
Wt. of Water (gm)	1.2	1.3	
Wt. of DS (gm)	5.0	5.4	
Moisture Content (%)	**23.4**	**23.6**	**-0.2**

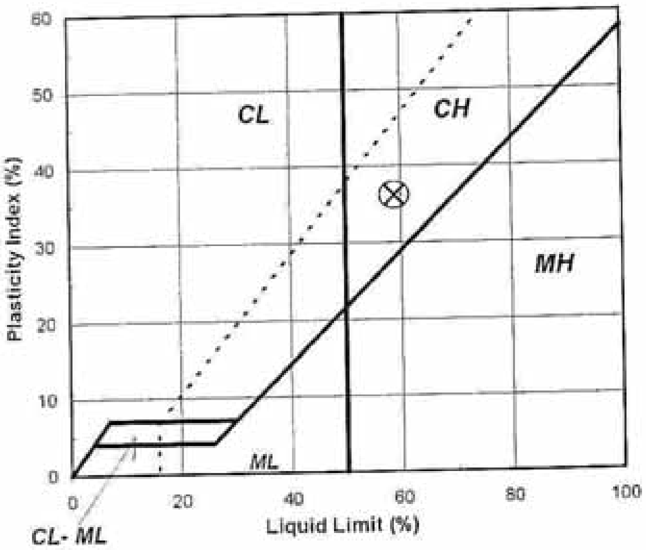
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**59**
Plastic Limit (%)	**23**
Plasticity Index (%)	**36**
USCS Symbol	**CH**

Flow Curve



Plasticity Chart



Tested By BS *Date* 3/1/06 *Checked By* KB *Date* 3-2-06

page 1 of 1	DCN: CT-S4B	DATE: 10/8/01	REVISION: 2	

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geotechnics
INTEGRITY IN TESTING

DIRECT SHEAR

ASTM D 3080-04 (SOP-S21)

Client	PAUL C. RIZZO & ASSOC.	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth (in)	7-12
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-69	Visual Description	BROWN AND REDDISH GRAY MOTTLED CLAY

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED

Maximum Shear Stress (psi)		Normal Stress (psi)
15.37	(1)	20
25.87	(2)	40
30.97	(3)	60

Overall Regression Analysis

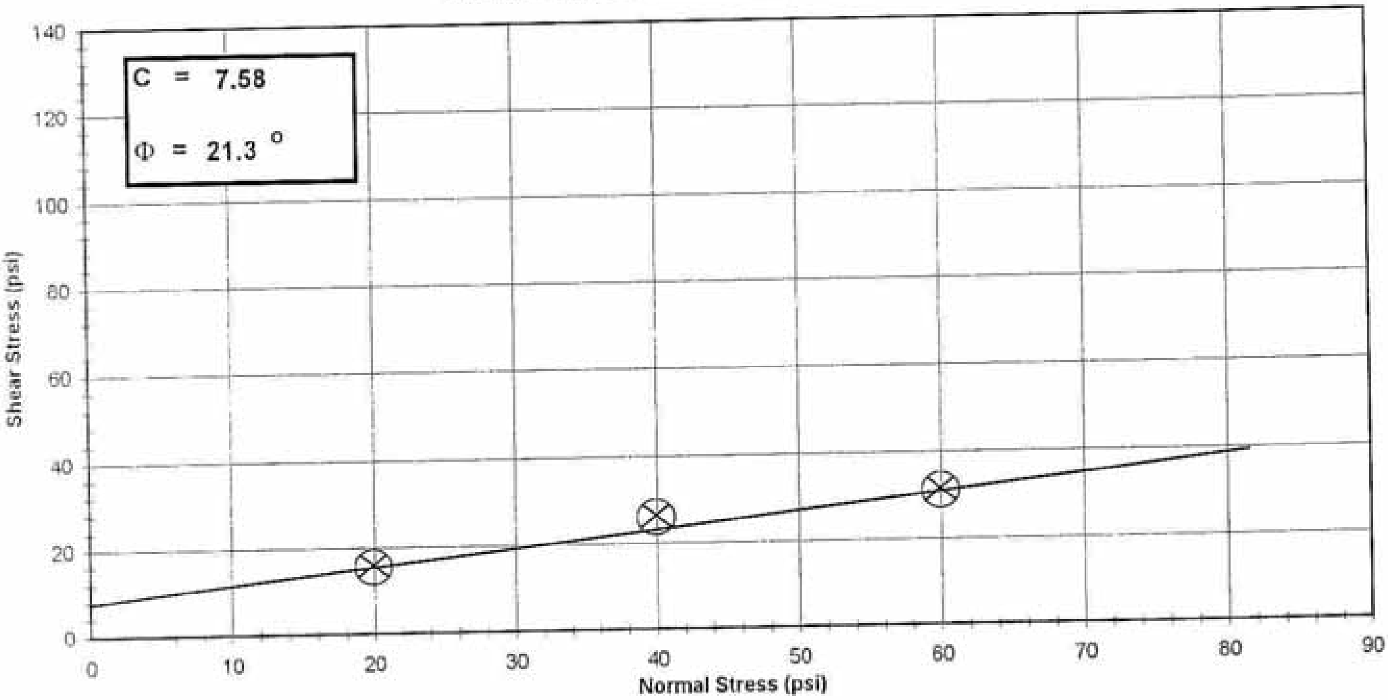
Slope = 0.39
C = 8.48
Φ = 21.3 degrees

Selected Points	Shear Stress (psi)	Normal Stress (psi)
1	15.37	20
3	30.97	60

Selected Points Regression

Slope = 0.39
C = 7.58
Φ = 21.3 degrees

SHEAR STRESS vs. NORMAL STRESS



Note: Graph not to scale

Tested By *TM* *Date* *2/28/06* *Approved By* DB *Date* 2/28/06

geotechnics
INTEGRITY IN TESTING

DIRECT SHEAR

ASTM D 3080-04 (SOP-S21)

Client	PAUL C. RIZZO & ASSOC.	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth (in)	7-12
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-69	Visual Description	BROWN AND REDDISH GRAY MOTTLED CLAY

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED

Maximum Shear Stress (psi)		Normal Stress (psi)
15.37	(1)	**20**
25.87	(2)	**40**
30.97	(3)	**60**

Overall Regression Analysis

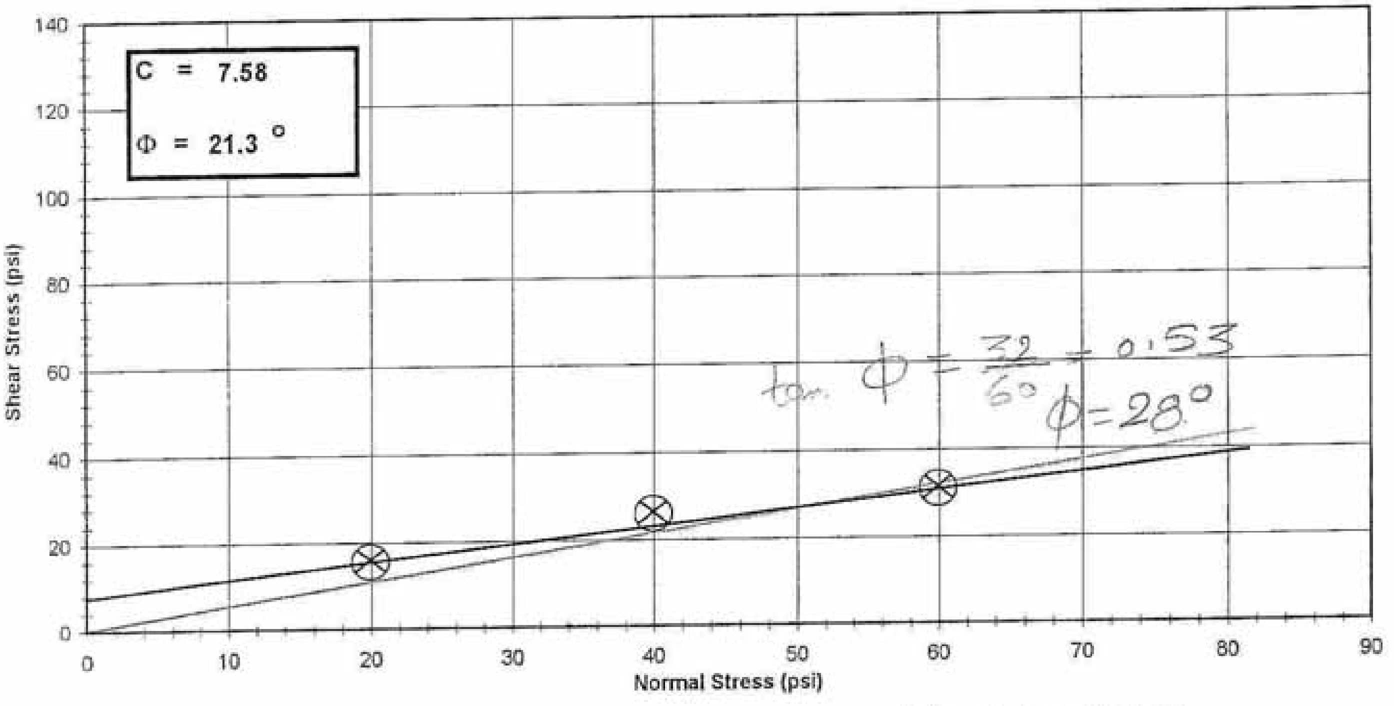
Slope = 0.39
C = **8.48**
Φ = **21.3** **degrees**

Selected Points	Shear Stress (psi)	Normal Stress (psi)
1	15.37	20
3	30.97	60

Selected Points Regression

Slope = 0.39
C = **7.58**
Φ = **21.3** **degrees**

SHEAR STRESS vs. NORMAL STRESS



tan Φ = 32/60 = 0.53
Φ = 28°

Note: Graph not to scale

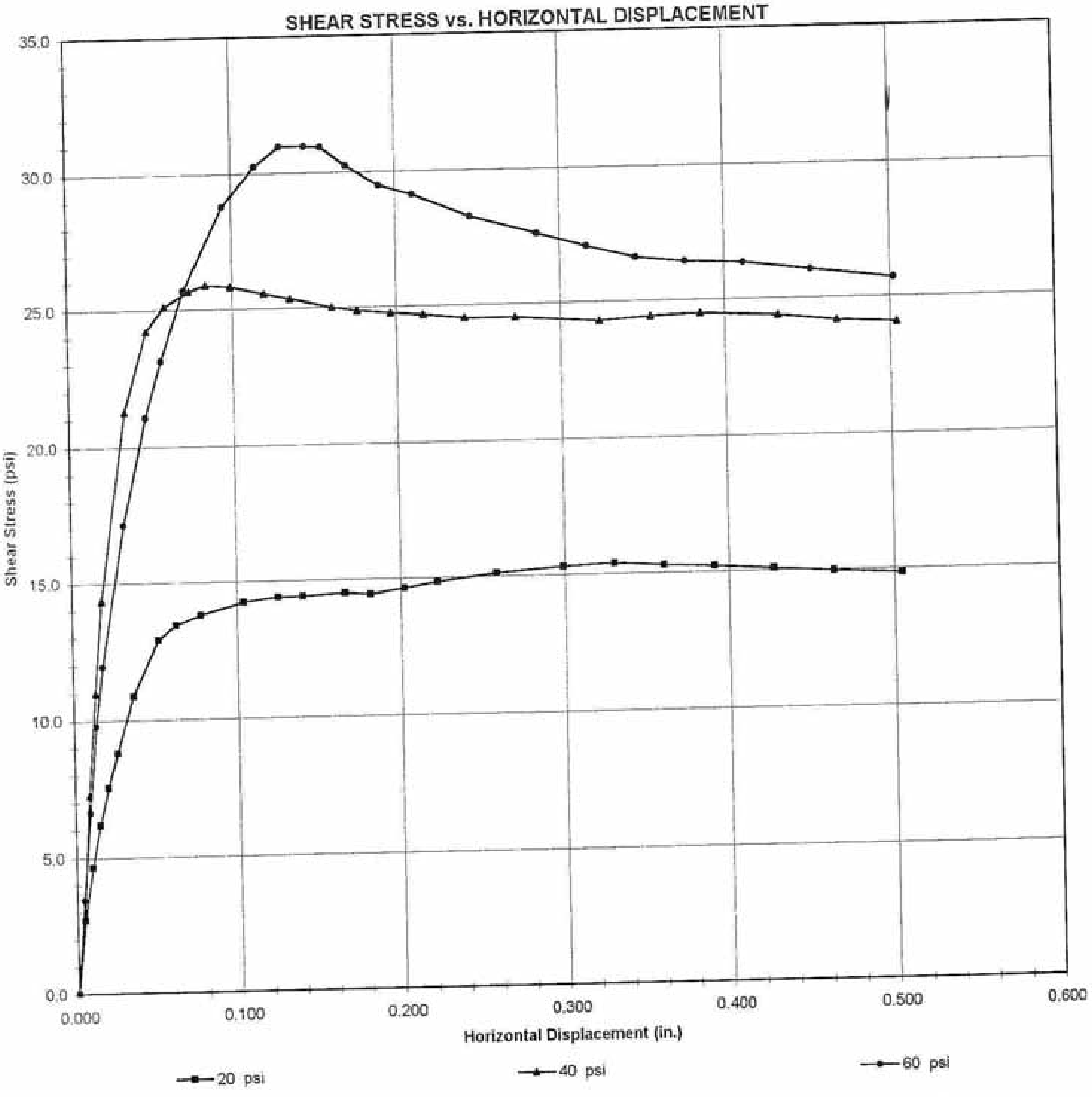
Tested By TM *Date* 2/28/06 *Approved By* DB *Date* 2/28/06

DIRECT SHEAR

ASTM D 3080-04 (SOP-S21)

Client	PAUL C. RIZZO & ASSOC.	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth (in)	7-12
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-69	Visual Description	BROWN AND REDDISH GRAY MOTTLED CLAY

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED



Tested By TM *Date* 2/28/06 *Approved By* DS *Date* 2/28/06

DIRECT SHEAR

ASTM D 3080-04 (SOP-S21)

Client	PAUL C. RIZZO & ASSOC.	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth (in)	7-12
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-69	Visual Description	BROWN AND REDDISH GRAY MOTTLED CLAY

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED

Machine ID # G 783

SHEAR BOX DATA

Wt.of Wet Specimen & Ring(gm)	605.83	Specific Gravity (Assumed)	2.70
Weight of Ring (gm)	457.26	Volume of Solids(cc)	43.2
Weight of Wet Specimen (gm)	148.57	Initial Consolidation Dial Reading (in.)	0.0
Initial Specimen Height (in)	1	Final Consolidation Dial Reading (in.)	0.0266
Specimen Diameter (in)	2.5	Corrected Final Cons. Reading (in.)	0.0208
Wet Density (pcf)	115.3	Void Ratio Before Consolidation	0.86
Dry Density (pcf)	**90.5**	**Void Ratio After Consolidation**	0.82

Moisture Content	*Before Test*	*After Test*
Tare ID	1399	D-1
Wt. Wet Soil & Tare (gm)	165.81	183.64
Wt. Dry Soil & Tare (gm)	138.38	148.06
Wt. Tare (gm)	38.19	34.68
Wt. of Water (gm)	27.43	35.58
Wt. of Dry Soil (gm)	100.19	113.38
Moisture Content (%)	**27.4**	**31.4**

Testing Parameters	
Normal Stress(psi)	**20**
Strain Rate(in/min)	0.00144
Machine Deflection (in.)	0.0058

Horizontal Displacement (in)	Shear Force (lbs)	Shear Stress (psi)	Vertical Dial Reading (in)	Vertical Displacement (+)incr,(-)decr (in)	Shear To Normal Ratio
0.000	0.0	**0.00**	0.0000	0.0000	0.00
0.005	13.3	**2.72**	-0.0002	0.0002	0.14
0.010	22.7	**4.63**	-0.0002	0.0002	0.23
0.015	30.3	**6.18**	0.0003	-0.0003	0.31
0.020	37.0	**7.53**	0.0005	-0.0005	0.38
0.026	43.2	**8.80**	0.0008	-0.0008	0.44
0.036	53.4	**10.89**	0.0012	-0.0012	0.54
0.052	63.3	**12.89**	0.0016	-0.0016	0.64
0.063	65.9	**13.42**	0.0019	-0.0019	0.67
0.078	67.6	**13.78**	0.0021	-0.0021	0.69
0.104	69.8	**14.22**	0.0023	-0.0023	0.71
0.125	70.7	**14.40**	0.0026	-0.0026	0.72
0.140	70.7	**14.41**	0.0031	-0.0031	0.72
0.166	71.1	**14.49**	0.0034	-0.0034	0.72
0.182	70.8	**14.42**	0.0034	-0.0034	0.72
0.202	71.8	**14.62**	0.0033	-0.0033	0.73
0.223	72.8	**14.83**	0.0034	-0.0034	0.74
0.259	74.2	**15.12**	0.0034	-0.0034	0.76
0.299	75.0	**15.29**	0.0034	-0.0034	0.76
0.331	75.5	**15.37**	0.0033	-0.0033	0.77
0.361	75.0	**15.27**	0.0035	-0.0035	0.76
0.391	74.6	**15.20**	0.0034	-0.0034	0.76
0.427	74.0	**15.07**	0.0033	-0.0033	0.75
0.463	73.4	**14.95**	0.0032	-0.0032	0.75
0.505	72.9	**14.85**	0.0031	-0.0031	0.74

Tested By TM *Date* 2/24/06 *Input Checked By* GU *Date* 2-28-06

DIRECT SHEAR

ASTM D 3080-04 (SOP-S21)

Client	PAUL C. RIZZO & ASSOC.	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth (in)	7-12
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-69	Visual Description	BROWN AND REDDISH GRAY MOTTLED CLAY

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED

Machine ID # G 783

SHEAR BOX DATA

Wt.of Wet Specimen & Ring(gm)	348.4	Specific Gravity (Assumed)	2.70
Weight of Ring (gm)	203.55	Volume of Solids(cc)	42.0
Weight of Wet Specimen (gm)	144.85	Initial Consolidation Dial Reading (in.)	0.0
Initial Specimen Height (in)	1	Final Consolidation Dial Reading (in.)	0.0334
Specimen Diameter (in)	2.5	Corrected Final Cons. Reading (in.)	0.0260
Wet Density (pcf)	112.4	Void Ratio Before Consolidation	0.92
Dry Density (pcf)	**87.9**	**Void Ratio After Consolidation**	0.87

Moisture Content	*Before Test*	*After Test*
Tare ID	D-3	T-16
Wt. Wet Soil & Tare (gm)	215.14	236.48
Wt. Dry Soil & Tare (gm)	176.12	201.92
Wt. Tare (gm)	36.06	92.68
Wt. of Water (gm)	39.02	34.56
Wt. of Dry Soil (gm)	140.06	109.24
Moisture Content (%)	**27.9**	**31.6**

Testing Parameters	
Normal Stress(psi)	**40**
Strain Rate(in/min)	0.00144
Machine Deflection (in.)	0.0074

Horizontal Displacement (in)	Shear Force (lbs)	Shear Stress (psi)	Vertical Dial Reading (in)	Vertical Displacement (+)incr,(-)decr (in)	Shear To Normal Ratio
0.000	0.0	**0.00**	0.0000	0.0000	0.00
0.004	13.6	**2.78**	0.0003	-0.0003	0.07
0.008	35.7	**7.27**	0.0003	-0.0003	0.18
0.013	53.9	**10.98**	0.0001	-0.0001	0.27
0.018	70.4	**14.33**	0.0001	-0.0001	0.36
0.033	104.3	**21.26**	-0.0001	0.0001	0.53
0.048	119.0	**24.23**	0.0000	0.0000	0.61
0.059	123.3	**25.11**	-0.0002	0.0002	0.63
0.074	126.0	**25.67**	0.0007	-0.0007	0.64
0.084	127.0	**25.87**	0.0012	-0.0012	0.65
0.099	126.7	**25.80**	0.0018	-0.0018	0.65
0.119	125.3	**25.53**	0.0023	-0.0023	0.64
0.135	124.4	**25.34**	0.0026	-0.0026	0.63
0.161	122.7	**25.00**	0.0030	-0.0030	0.63
0.176	122.0	**24.85**	0.0032	-0.0032	0.62
0.197	121.5	**24.75**	0.0034	-0.0034	0.62
0.216	121.0	**24.66**	0.0038	-0.0038	0.62
0.242	120.3	**24.52**	0.0042	-0.0042	0.61
0.273	120.3	**24.50**	0.0042	-0.0042	0.61
0.324	119.3	**24.30**	0.0045	-0.0045	0.61
0.355	119.9	**24.43**	0.0046	-0.0046	0.61
0.386	120.2	**24.49**	0.0044	-0.0044	0.61
0.432	119.7	**24.38**	0.0059	-0.0059	0.61
0.468	118.6	**24.16**	0.0062	-0.0062	0.60
0.504	118.0	**24.05**	0.0062	-0.0062	0.60

Tested By TM *Date* 2/27/06 *Input Checked By* GU *Date* 2-28-06

geotechnics
INTEGRITY IN TESTING

DIRECT SHEAR

ASTM D 3080-04 (SOP-S21)

Client	PAUL C. RIZZO & ASSOC.	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth (in)	7-12
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-69	Visual Description	BROWN AND REDDISH GRAY MOTTLED CLAY

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED

Machine ID # G 783

SHEAR BOX DATA

Wt.of Wet Specimen & Ring(gm)	601.13	Specific Gravity (Assumed)	2.70
Weight of Ring (gm)	457.26	Volume of Solids(cc)	41.6
Weight of Wet Specimen (gm)	143.87	Initial Consolidation Dial Reading (in.)	0.0
Initial Specimen Height (in)	1	Final Consolidation Dial Reading (in.)	0.0391
Specimen Diameter (in)	2.5	Corrected Final Cons. Reading (in.)	0.0303
Wet Density (pcf)	111.7	Void Ratio Before Consolidation	0.93
Dry Density (pcf)	**87.1**	**Void Ratio After Consolidation**	0.88

Moisture Content	*Before Test*	*After Test*
Tare ID	1399	D-7
Wt. Wet Soil & Tare (gm)	140.74	185.75
Wt. Dry Soil & Tare (gm)	118.20	152.19
Wt. Tare (gm)	38.18	42.24
Wt. of Water (gm)	22.54	33.56
Wt. of Dry Soil (gm)	80.02	109.95
Moisture Content (%)	**28.2**	**30.5**

Testing Parameters	
Normal Stress(psi)	**60**
Strain Rate(in/min)	0.00144
Machine Deflection (in.)	0.0088

Horizontal Displacement (in)	Shear Force (lbs)	Shear Stress (psi)	Vertical Dial Reading (in)	Vertical Displacement (+)incr,(-)decr (in)	Shear To Normal Ratio
0.000	0.0	**0.00**	0.0000	0.0000	0.00
0.004	17.0	**3.46**	0.0001	-0.0001	0.06
0.009	32.6	**6.63**	0.0001	-0.0001	0.11
0.013	48.0	**9.78**	0.0001	-0.0001	0.16
0.018	58.7	**11.95**	0.0001	-0.0001	0.20
0.032	84.0	**17.12**	0.0001	-0.0030	0.29
0.046	103.4	**21.06**	0.0030	-0.0062	0.35
0.056	113.6	**23.14**	0.0062	-0.0081	0.39
0.070	126.1	**25.69**	0.0081	-0.0105	0.43
0.095	141.4	**28.80**	0.0105	-0.0149	0.48
0.115	148.5	**30.25**	0.0149	-0.0170	0.50
0.130	152.0	**30.97**	0.0170	-0.0184	0.52
0.145	152.0	**30.97**	0.0184	-0.0195	0.52
0.155	151.8	**30.93**	0.0195	-0.0199	0.52
0.170	148.4	**30.23**	0.0199	-0.0203	0.50
0.190	144.8	**29.50**	0.0203	-0.0208	0.49
0.211	143.0	**29.13**	0.0208	-0.0212	0.49
0.246	138.8	**28.28**	0.0212	-0.0217	0.47
0.286	135.4	**27.58**	0.0217	-0.0222	0.46
0.317	132.9	**27.07**	0.0222	-0.0223	0.45
0.347	130.6	**26.60**	0.0223	-0.0225	0.44
0.377	129.7	**26.42**	0.0225	-0.0226	0.44
0.412	129.3	**26.33**	0.0226	-0.0227	0.44
0.452	127.8	**26.03**	0.0227	-0.0228	0.43
0.503	126.1	**25.69**	0.0228	-0.0229	0.43

Tested By *TM* *Date* *2/23/06* *Input Checked By* GU *Date* 2-28-06

PHOTOGRAPH

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-SOIL-02
Client Project	TAUM SAUK 06-3551	Depth (ft.)	12-19
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-70		

SAMPLE: AFTER CU

geotechnics
INTEGRITY IN TESTING

PHOTOGRAPH

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-SOIL-02
Client Project	TAUM SAUK 06-3551	Depth (ft.)	12-19
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-70		

SAMPLE: AFTER CU

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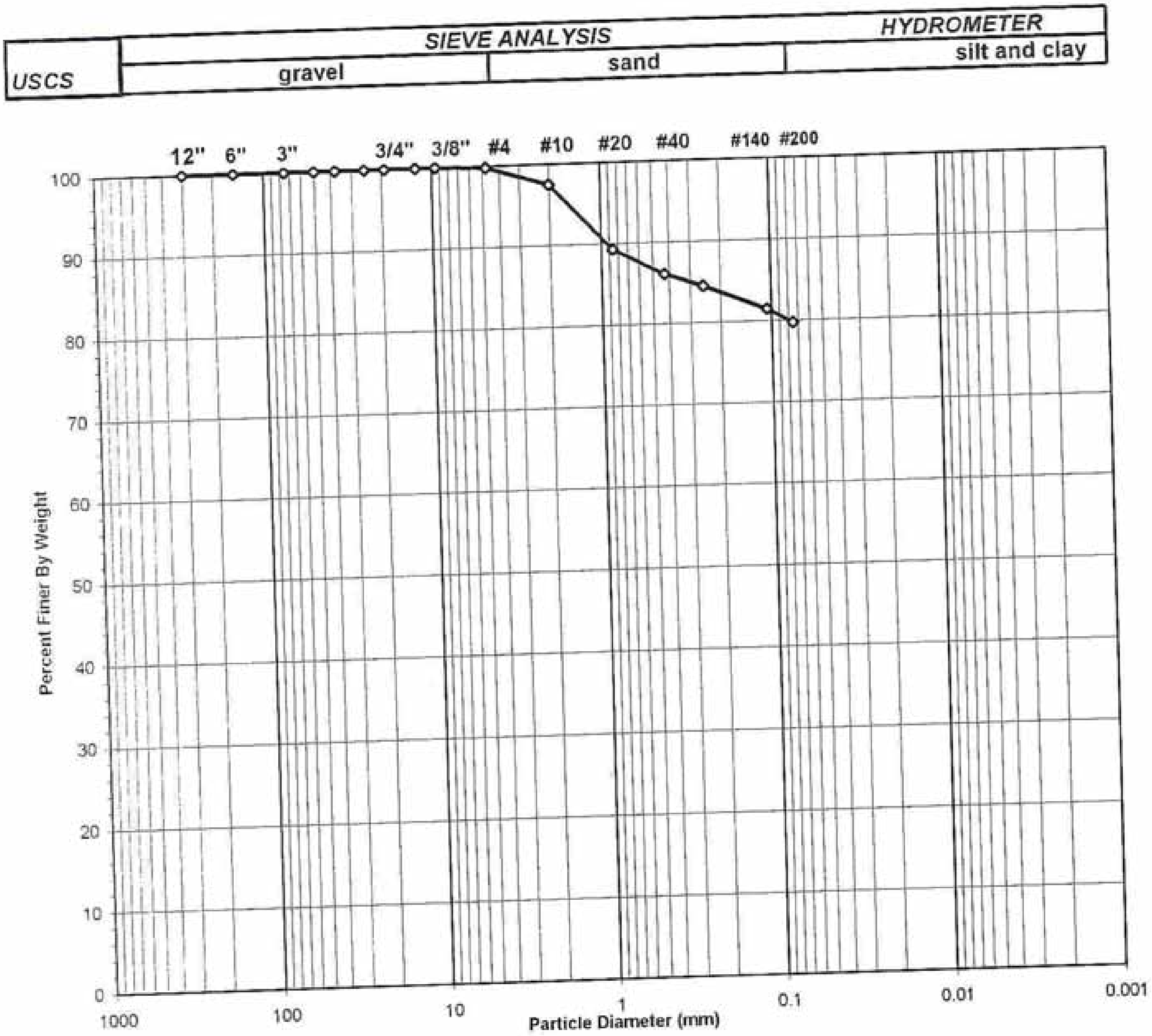
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth (in)	12-19
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-70	Soil Color	**REDDISH BROWN**



USCS Symbol **CH, TESTED**

USCS Classification **FAT CLAY WITH SAND**

Tested By JP Date 2/27/06 Checked By KB Date 3-1-06

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page 1 of 2 DCN: CT-S3C DATE 6-25-98 REVISION: 2

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth (in)	12-19
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-70	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	685	Tare No.	NA
Wgt.Tare + Wet Specimen (gm)	790.40	Wgt.Tare + Wet Specimen (gm)	NA
Wgt.Tare + Dry Specimen (gm)	669.10	Wgt.Tare + Dry Specimen (gm)	NA
Weight of Tare (gm)	98.37	Weight of Tare (gm)	NA
Weight of Water (gm)	121.30	Weight of Water (gm)	NA
Weight of Dry Soil (gm)	570.73	Weight of Dry Soil (gm)	NA
Moisture Content (%)	**21.3**	**Moisture Content (%)**	**NA**

Wet Weight -3/4" Sample (gm)	NA	Weight of the Dry Specimen (gm)	570.73
Dry Weight - 3/4" Sample (gm)	115.7	Weight of minus #200 material (gm)	454.99
Wet Weight +3/4" Sample (gm)	NA	Weight of plus #200 material (gm)	115.74
Dry Weight + 3/4" Sample (gm)	0.00		
Total Dry Weight Sample (gm)	NA		

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00	0.00	0.00	100.00	**100.00**
6"	150	0.00	0.00	0.00	100.00	**100.00**
3"	75	0.00	0.00	0.00	100.00	**100.00**
2"	50	0.00	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00	100.00	**100.00**
1"	25.0	0.00	0.00	0.00	100.00	**100.00**
3/4"	19.0	0.00	0.00	0.00	100.00	**100.00**
1/2"	12.50	0.00	0.00	0.00	100.00	**100.00**
3/8"	9.50	0.00	0.00	0.00	100.00	**100.00**
#4	4.75	1.12	0.20	0.20	99.80	**99.80**
#10	2.00	13.41	2.35	2.55	97.45	**97.45**
#20	0.850	46.54	8.15	10.70	89.30	**89.30**
#40	0.425	18.27	3.20	13.90	86.10	**86.10**
#60	0.250	8.95	1.57	15.47	84.53	**84.53**
#140	0.106	17.54	3.07	18.54	81.46	**81.46**
#200	0.075	9.91	1.74	20.28	79.72	**79.72**
Pan	-	454.99	79.72	100.00	-	**-**

Tested By JP Date 2/27/06 Checked By KKB Date 3-1-06

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DCN: CT-S3C DATE 6-26-98 REVISION: 2

geotechnics
INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth (in)	12-19
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-70	Soil Description	**REDDISH BROWN FAT CLAY**
			(Minus No. 40 sieve material, Airdried)

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

Liquid Limit Test	**1**	**2**	**3**
Tare Number	19	21	22
Wt. of Tare & WS (gm)	40.14	40.95	40.97
Wt. of Tare & DS (gm)	32.86	32.41	32.31
Wt. of Tare (gm)	19.50	17.21	17.44
Wt. of Water (gm)	7.3	8.5	8.7
Wt. of DS (gm)	13.4	15.2	14.9
Moisture Content (%)	**54.5**	**56.2**	**58.2**
Number of Blows	**35**	**26**	**20**

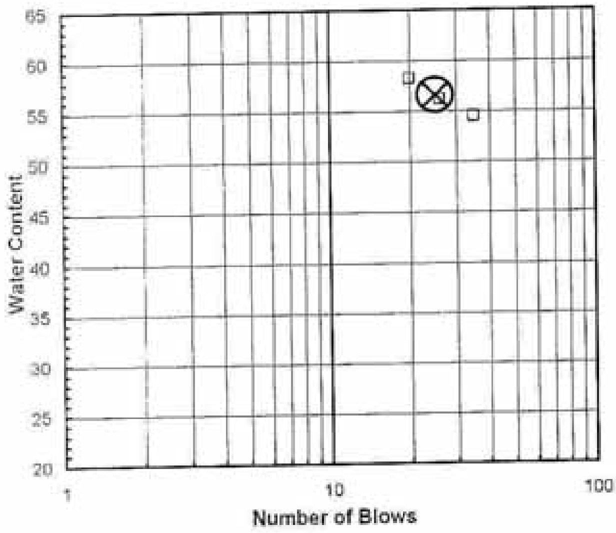
MULTIPOINT

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	27	38	
Wt. of Tare & WS (gm)	26.55	24.38	
Wt. of Tare & DS (gm)	25.28	23.11	
Wt. of Tare (gm)	20.49	18.34	
Wt. of Water (gm)	1.3	1.3	
Wt. of DS (gm)	4.8	4.8	
Moisture Content (%)	**26.5**	**26.6**	**-0.1**

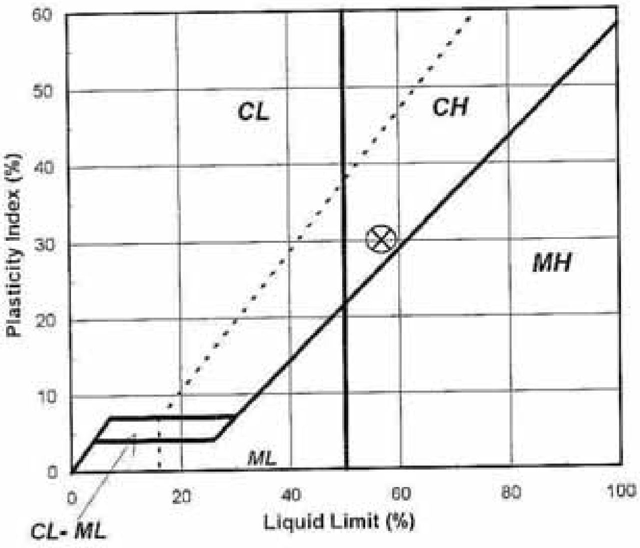
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**57**
Plastic Limit (%)	**27**
Plasticity Index (%)	**30**
USCS Symbol	**CH**

Flow Curve



Plasticity Chart



Tested By BS *Date* 2/28/06 *Checked By* *Date* 3-1-06

page 1 of 1 DCN: CT-S4B DATE: 10/8/01 REVISION: 2

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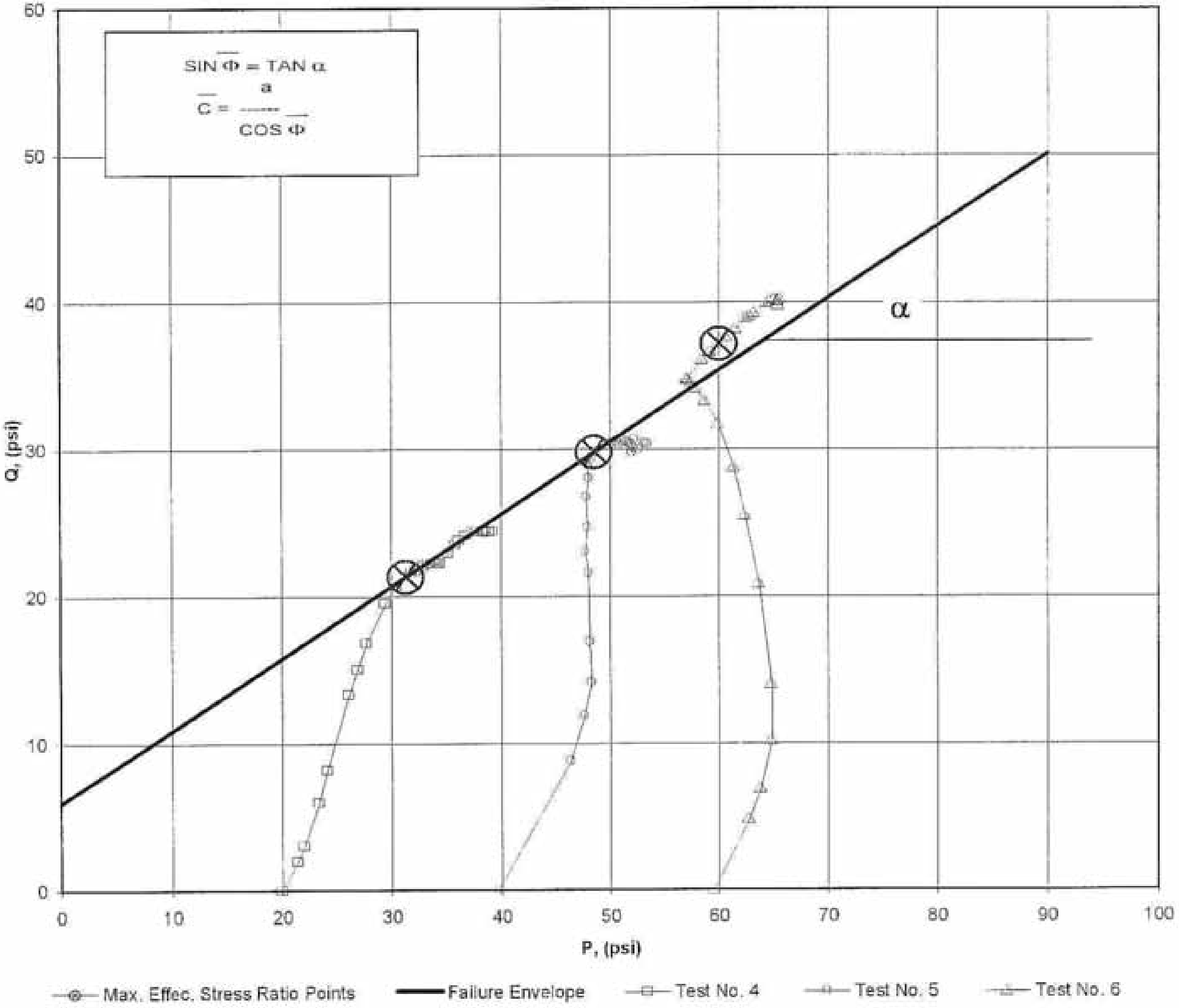
CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth(in.)	12-19
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-70		

Consolidated Undrained Triaxial Test with Pore Pressure



a	=	5.97	$\overline{C}$	=	6.85
α	=	26.1	$\overline{\Phi}$	=	29.35

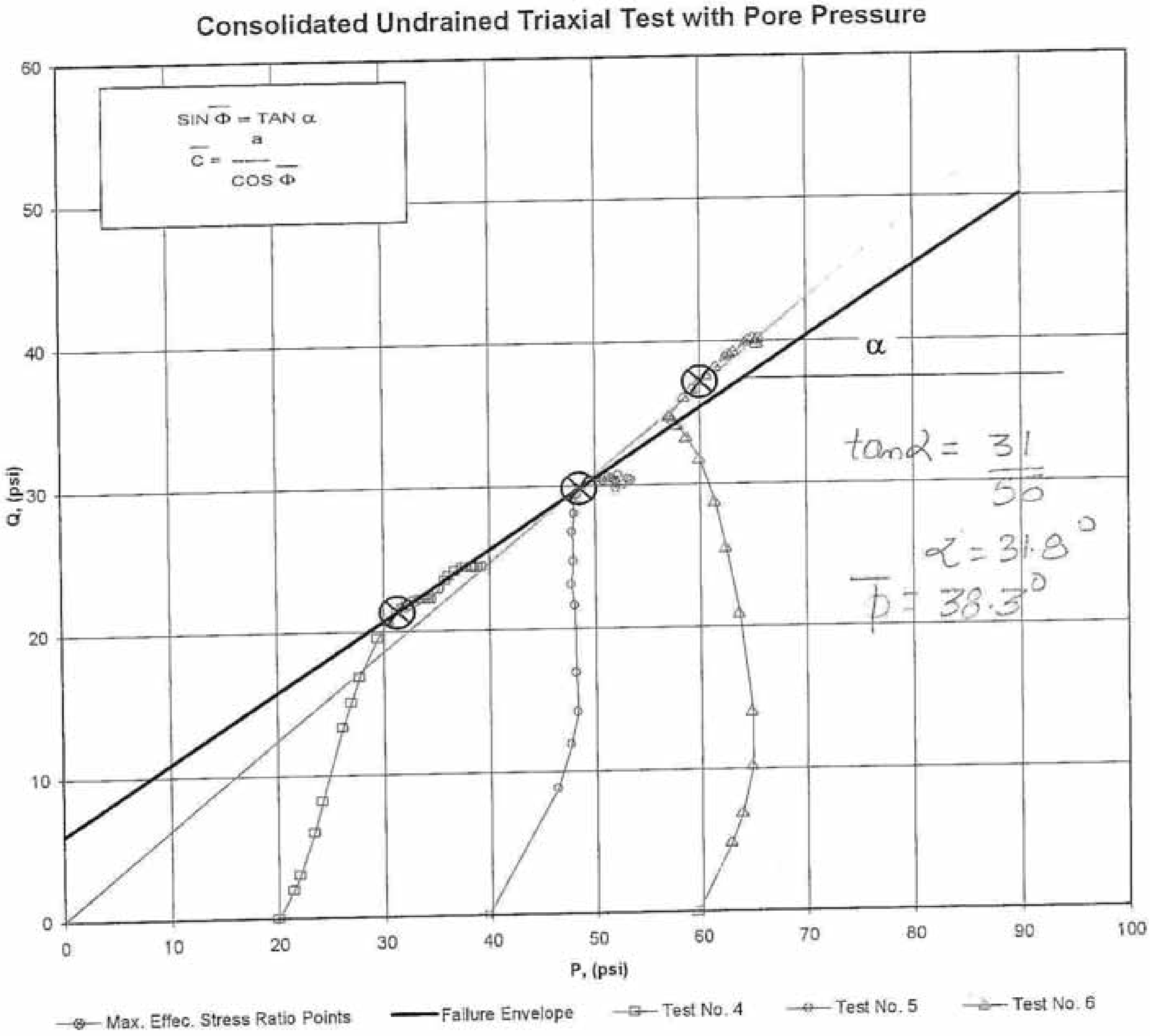
Tested By JCM Date 02/23/06 Approved By DB Date 3/2/06

geotechnics
INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth(in.)	12-19
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-70		



a	=	5.97	$\overline{C}$	=	6.85
α	=	26.1	$\overline{\Phi}$	=	29.35

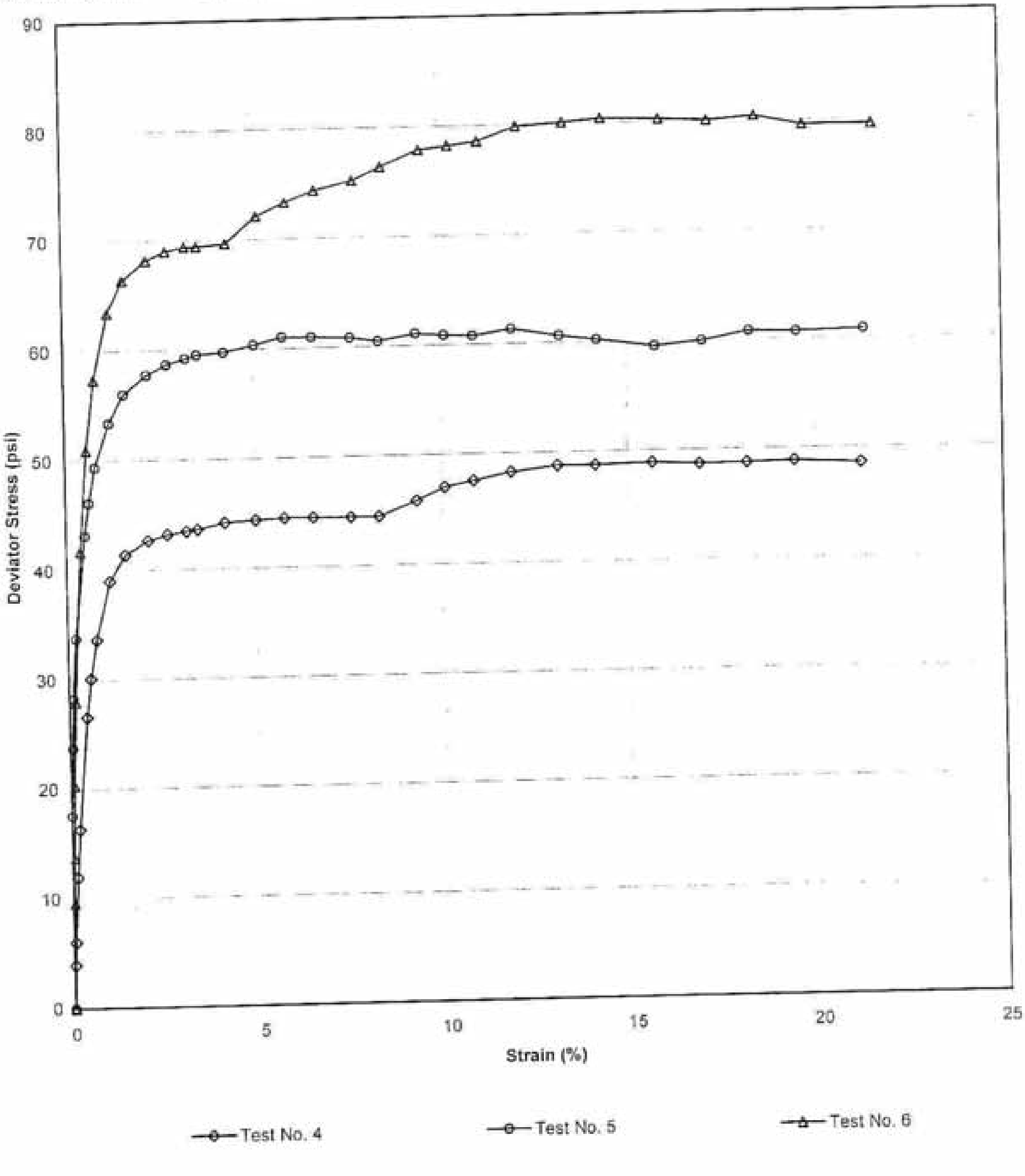
Tested By JCM Date 02/23/06 Approved By DB Date 3/2/06

DCN: CT-S28 DATE 6-25-98 REVISION 1

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth(in.)	12-19
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-70		
Visual Description:	BROWN & GRAY MOTTLED CLAY (UNDISTURBED)		



Tested By JCM Date 02/23/06 Approved By DB Date 3/2/06

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth(in.)	12-19
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-70		

Visual Description: BROWN & GRAY MOTTLED CLAY (UNDISTURBED)

Stage No.	1
Test No	4

PRESSURES (psi)

Cell Pressure(psi)	55.4
Back Pressure(psi)	35.4
Eff. Cons. Pressure(psi)	20.0
Pore Pressure Response (%)	99

MAXIMUM OBLIQUITY POINTS

$\overline{P}$ = 31.35
Q = 21.34

INITIAL SAMPLE DIMENSIONS (in)

Length 1	2.988	Diameter 1	1.461
Length 2	2.991	Diameter 2	1.402
Length 3	2.966	Diameter 3	1.403
Avg Leng.=	2.982	Avg. Diam.=	1.422

VOLUME CHANGE

Initial Burette Reading (ml)	24.0
Final Burette Reading (ml)	22.4
Final Change (ml)	1.6
Initial Dial Reading (D.R.), mils	83
D.R. After Saturation, mils	94
D.R. After Consolidation, mils	108

LOAD (LBS)	DEFORMATION (INCHES)	PORE PRESSURE (PSI)
12.1	0.000	35.4
18.2	0.001	35.9
21.5	0.001	36.4
30.7	0.004	38.0
37.5	0.006	39.4
53.6	0.014	42.6
59.1	0.017	43.5
64.7	0.023	44.5
73.3	0.034	45.5
77.3	0.046	45.6
79.7	0.064	45.4
80.9	0.079	45.2
81.7	0.094	44.9
82.2	0.103	44.8
83.6	0.124	44.5
84.5	0.148	44.2
85.3	0.171	43.9
85.9	0.194	43.7
86.7	0.223	43.4
87.3	0.246	43.2
90.4	0.276	43.1
93.2	0.298	43.1
94.8	0.321	43.0
97.0	0.351	42.8
99.2	0.388	42.3
100.1	0.418	41.9
102.0	0.463	41.4
103.0	0.500	41.1
104.5	0.538	40.8
106.1	0.575	40.6
107.7	0.628	40.2

Tested By JCM Date 02/23/06 Input Checked By KB Date 3-2-06

geotechnics
INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth(in.)	12-19
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-70		

Visual Description: BROWN & GRAY MOTTLED CLAY (UNDISTURBED)

Effective Confining Pressure (psi)	20.0	*Stage No.*	1
		Test No	4

INITIAL DIMENSIONS

Initial Sample Length (in.)	2.98
Initial Sample Diameter (in.)	1.42
Initial Sample Area (in^2)	1.59
Initial Sample Volume (in^3)	4.74

VOLUME CHANGE

Volume After Consolidation (in^3)	4.59
Length After Consolidation (in)	2.96
Area After Consolidation (in^2)	1.551

Strain (%)	Deviation Stress	ΔU	$\overline{\sigma}_1$	$\overline{\sigma}_3$	Effective Principle Stress Ratio	$\overline{A}$	$\overline{P}$	Q
0.02	3.94	0.55	23.40	19.5	1.203	0.14	21.42	1.97
0.04	6.04	0.97	25.07	19.0	1.317	0.16	22.05	3.02
0.13	11.96	2.58	29.38	17.4	1.687	0.22	23.40	5.98
0.22	16.34	4.03	32.31	16.0	2.023	0.25	24.14	8.17
0.46	26.62	7.16	39.46	12.8	3.073	0.27	26.15	13.31
0.59	30.12	8.13	41.99	11.9	3.538	0.27	26.93	15.06
0.76	33.65	9.11	44.54	10.9	4.090	0.27	27.72	16.83
1.14	39.00	10.05	48.95	9.9	4.921	0.26	29.45	19.50
1.55	41.38	10.21	51.18	9.8	5.225	0.25	30.49	20.69
2.16	42.67	9.99	52.68	10.0	5.264	0.24	31.35	21.34
2.67	43.17	9.75	53.42	10.2	5.212	0.23	31.84	21.59
3.18	43.45	9.52	53.93	10.5	5.148	0.22	32.20	21.73
3.48	43.62	9.38	54.24	10.6	5.109	0.22	32.43	21.81
4.20	44.19	9.09	55.10	10.9	5.050	0.21	33.01	22.09
5.02	44.36	8.80	55.57	11.2	4.960	0.20	33.38	22.18
5.79	44.48	8.54	55.93	11.5	4.883	0.19	33.69	22.24
6.55	44.48	8.31	56.18	11.7	4.804	0.19	33.94	22.24
7.56	44.45	8.00	56.44	12.0	4.705	0.18	34.22	22.22
8.32	44.47	7.80	56.67	12.2	4.644	0.18	34.44	22.24
9.33	45.81	7.68	58.13	12.3	4.718	0.17	35.23	22.90
10.09	47.00	7.65	59.35	12.3	4.807	0.16	35.85	23.50
10.86	47.54	7.57	59.97	12.4	4.824	0.16	36.20	23.77
11.86	48.25	7.35	60.90	12.6	4.816	0.15	36.77	24.13
13.12	48.78	6.90	61.88	13.1	4.723	0.14	37.49	24.39
14.13	48.75	6.53	62.22	13.5	4.619	0.14	37.85	24.38
15.65	48.89	6.04	62.85	14.0	4.502	0.12	38.40	24.44
16.92	48.68	5.74	62.94	14.3	4.415	0.12	38.60	24.34
18.18	48.75	5.45	63.30	14.6	4.350	0.11	38.93	24.38
19.46	48.84	5.17	63.68	14.8	4.292	0.11	39.26	24.42
21.22	48.57	4.79	63.77	15.2	4.194	0.10	39.49	24.28

Tested By JCM Date 02/23/06 Input Checked By KB Date 3-2-06

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

geotechnics
INTEGRITY IN TESTING

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth(in.)	12-19
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-70		

Visual Description: BROWN & GRAY MOTTLED CLAY (UNDISTURBED)

Stage No.	1
Test No	5

PRESSURES (psi)

Cell Pressure(psi)	75.6
Back Pressure(psi)	35.9
Eff. Cons. Pressure(ps	39.7
Pore Pressure Response (%)	100

MAXIMUM OBLIQUITY POINTS

$\overline{P}$ = 48.57

Q = 29.78

INITIAL SAMPLE DIMENSIONS (in)

Length 1	3.048	Diameter 1	1.380
Length 2	3.052	Diameter 2	1.407
Length 3	3.057	Diameter 3	1.385
Avg Leng.=	3.052	Avg. Diam.=	1.391

VOLUME CHANGE

Initial Burette Reading (ml)	24.0
Final Burette Reading (ml)	21.0
Final Change (ml)	3.0
Initial Dial Reading (D.R.), mils	54
D.R. After Saturation, mils	65
D.R. After Consolidation, mils	94

LOAD (LBS)	DEFORMATION (INCHES)	PORE PRESSURE (PSI)
13.8	0.000	35.9
39.5	0.001	38.0
48.5	0.002	39.8
55.2	0.003	41.5
63.3	0.006	44.3
77.2	0.015	49.1
81.7	0.019	50.9
86.6	0.024	52.3
92.8	0.035	54.4
97.0	0.048	55.6
100.2	0.066	56.5
102.0	0.082	56.6
103.3	0.097	56.8
104.0	0.106	56.8
105.0	0.128	56.6
106.7	0.152	56.1
108.5	0.175	55.8
109.2	0.198	55.5
110.0	0.229	55.2
110.3	0.252	54.9
112.3	0.282	54.7
112.8	0.305	54.5
113.5	0.328	54.2
115.6	0.359	54.0
115.9	0.398	53.9
116.4	0.428	53.5
117.1	0.475	53.3
119.4	0.513	52.8
122.5	0.551	52.8
124.0	0.589	52.5
126.8	0.643	52.0

Tested By JCM Date 02/23/06 Input Checked By KB Date 3-2-06

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INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth(in.)	12-19
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-70		

Visual Description: BROWN & GRAY MOTTLED CLAY (UNDISTURBED)

Effective Confining Pressure (psi)	39.7	*Stage No.*	1
		Test No	5

INITIAL DIMENSIONS		VOLUME CHANGE	
Initial Sample Length (in.)	3.05	Volume After Consolidation (in^3)	4.40
Initial Sample Diameter (in.)	1.39	Length After Consolidation (in)	3.01
Initial Sample Area (in^2)	1.52	Area After Consolidation (in^2)	1.462
Initial Sample Volume (in^3)	4.64		

Strain (%)	Deviation Stress	ΔU	$\overline{\sigma}_1$	$\overline{\sigma}_3$	Effective Principle Stress Ratio	$\overline{A}$	$\overline{P}$	Q
0.02	17.57	2.12	55.15	37.6	1.468	0.12	46.36	8.79
0.07	23.76	3.93	59.53	35.8	1.664	0.17	47.65	11.88
0.11	28.29	5.57	62.43	34.1	1.829	0.20	48.28	14.15
0.21	33.79	8.44	65.05	31.3	2.081	0.25	48.15	16.89
0.49	43.16	13.25	69.62	26.5	2.632	0.31	48.03	21.58
0.62	46.15	15.01	70.85	24.7	2.869	0.33	47.77	23.08
0.79	49.38	16.42	72.66	23.3	3.122	0.33	47.97	24.69
1.17	53.42	18.54	74.59	21.2	3.524	0.35	47.88	26.71
1.58	56.05	19.68	76.07	20.0	3.800	0.35	48.04	28.03
2.19	57.81	20.59	76.92	19.1	4.025	0.36	48.02	28.90
2.71	58.72	20.69	77.73	19.0	4.089	0.35	48.37	29.36
3.22	59.25	20.88	78.07	18.8	4.147	0.35	48.45	29.62
3.52	59.56	20.91	78.35	18.8	4.170	0.35	48.57	29.78
4.23	59.75	20.68	78.76	19.0	4.141	0.35	48.89	29.87
5.04	60.35	20.25	79.81	19.5	4.102	0.34	49.63	30.18
5.81	61.02	19.88	80.84	19.8	4.079	0.33	50.33	30.51
6.58	60.95	19.58	81.08	20.1	4.029	0.32	50.60	30.48
7.60	60.82	19.31	81.21	20.4	3.983	0.32	50.80	30.41
8.36	60.48	19.05	81.14	20.7	3.928	0.31	50.89	30.24
9.37	61.09	18.82	81.98	20.9	3.926	0.31	51.43	30.55
10.13	60.88	18.57	82.01	21.1	3.881	0.31	51.57	30.44
10.89	60.78	18.31	82.17	21.4	3.842	0.30	51.78	30.39
11.92	61.35	18.11	82.94	21.6	3.841	0.30	52.27	30.67
13.21	60.61	18.02	82.29	21.7	3.796	0.30	51.99	30.31
14.22	60.22	17.64	82.28	22.1	3.730	0.29	52.17	30.11
15.76	59.53	17.41	81.82	22.3	3.670	0.29	52.06	29.77
17.02	59.93	16.94	82.69	22.8	3.633	0.28	52.73	29.97
18.28	60.76	16.88	83.59	22.8	3.662	0.28	53.21	30.38
19.54	60.65	16.57	83.78	23.1	3.622	0.27	53.46	30.32
21.33	60.80	16.09	84.42	23.6	3.575	0.26	54.02	30.40

Tested By JCM Date 02/23/06 Input Checked By YHB Date 3-2-06

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INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth(in.)	12-19
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-70		

Visual Description: BROWN & GRAY MOTTLED CLAY (UNDISTURBED)

Stage No.	1
Test No	6

PRESSURES (psi)

Cell Pressure(psi)	95.4
Back Pressure(psi)	35.8
Eff. Cons. Pressure(ps	59.6
Pore Pressure Response (%)	100

MAXIMUM OBLIQUITY POINTS

$\overline{P}$ = 60.01
Q = 37.17

INITIAL SAMPLE DIMENSIONS (in)

Length 1	3.088	Diameter 1	1.407
Length 2	3.078	Diameter 2	1.385
Length 3	3.075	Diameter 3	1.418
Avg Leng.=	3.080	Avg. Diam.=	1.403

VOLUME CHANGE

Initial Burette Reading (ml)	24.0
Final Burette Reading (ml)	20.3
Final Change (ml)	3.7
Initial Dial Reading (D.R.), mils	57
D.R. After Saturation, mils	70
D.R. After Consolidation, mils	112

LOAD (LBS)	DEFORMATION (INCHES)	PORE PRESSURE (PSI)
16.0	0.000	35.8
30.2	0.001	37.4
36.3	0.002	38.5
46.1	0.003	40.7
57.5	0.005	44.6
78.0	0.011	52.6
91.9	0.017	58.5
101.7	0.024	62.7
111.0	0.036	67.2
115.9	0.048	69.8
119.3	0.067	71.6
121.1	0.083	72.4
122.2	0.098	72.8
122.6	0.108	73.0
123.7	0.131	73.1
128.5	0.156	72.9
131.3	0.179	72.8
134.0	0.203	72.6
136.6	0.234	72.3
139.6	0.257	72.1
143.4	0.288	71.8
145.0	0.312	71.6
146.7	0.336	71.4
150.5	0.367	70.9
152.9	0.405	70.7
155.0	0.436	70.5
157.3	0.483	70.1
159.2	0.522	70.0
162.0	0.560	69.9
162.8	0.599	69.7
166.2	0.654	69.4

Tested By JCM Date 02/23/06 Input Checked By KB Date 3-2-06

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INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-02
Client Reference	TAUM SAUK 06-3551	Depth(in.)	12-19
Project No.	2006-060-01	Sample No.	S-3
Lab ID	2006-060-01-70		

Visual Description: BROWN & GRAY MOTTLED CLAY (UNDISTURBED)

Effective Confining Pressure (psi)	59.6	*Stage No.*	1
		Test No	6

INITIAL DIMENSIONS

Initial Sample Length (in.)	3.08
Initial Sample Diameter (in.)	1.40
Initial Sample Area (in^2)	1.55
Initial Sample Volume (in^3)	4.76

VOLUME CHANGE

Volume After Consolidation (in^3)	4.48
Length After Consolidation (in)	3.03
Area After Consolidation (in^2)	1.480

Strain (%)	Deviation Stress	Δ U	$\overline{\sigma}_1$	$\overline{\sigma}_3$	Effective Principle Stress Ratio	$\overline{A}$	$\overline{P}$	Q
0.03	9.59	1.65	67.55	58.0	1.166	0.17	62.75	4.80
0.06	13.74	2.67	70.66	56.9	1.241	0.19	63.80	6.87
0.10	20.31	4.92	74.99	54.7	1.372	0.24	64.84	10.16
0.17	27.99	8.78	78.81	50.8	1.551	0.31	64.81	14.00
0.37	41.73	16.82	84.51	42.8	1.975	0.40	63.65	20.86
0.57	50.96	22.67	87.89	36.9	2.380	0.44	62.41	25.48
0.80	57.42	26.92	90.10	32.7	2.757	0.47	61.39	28.71
1.19	63.45	31.35	91.70	28.2	3.246	0.49	59.97	31.72
1.60	66.43	34.03	91.99	25.6	3.598	0.51	58.78	33.21
2.22	68.22	35.83	91.99	23.8	3.870	0.53	57.88	34.11
2.73	69.04	36.62	92.01	23.0	4.005	0.53	57.49	34.52
3.25	69.39	37.03	91.95	22.6	4.075	0.53	57.26	34.69
3.57	69.43	37.22	91.81	22.4	4.102	0.54	57.10	34.71
4.33	69.64	37.34	91.90	22.3	4.128	0.54	57.08	34.82
5.16	72.10	37.14	94.56	22.5	4.210	0.52	58.51	36.05
5.93	73.29	36.99	95.90	22.6	4.242	0.50	59.25	36.64
6.71	74.34	36.76	97.18	22.8	4.255	0.49	60.01	37.17
7.73	75.17	36.51	98.26	23.1	4.255	0.49	60.68	37.58
8.50	76.39	36.26	99.73	23.3	4.273	0.47	61.53	38.19
9.52	77.86	36.00	101.46	23.6	4.299	0.46	62.53	38.93
10.30	78.17	35.80	101.97	23.8	4.285	0.46	62.88	39.09
11.09	78.52	35.60	102.51	24.0	4.272	0.45	63.26	39.26
12.13	79.85	35.09	104.36	24.5	4.259	0.44	64.43	39.93
13.38	80.12	34.93	104.79	24.7	4.247	0.44	64.73	40.06
14.41	80.39	34.71	105.28	24.9	4.230	0.43	65.09	40.20
15.96	80.25	34.30	105.54	25.3	4.172	0.43	65.42	40.12
17.24	80.07	34.21	105.46	25.4	4.153	0.43	65.43	40.03
18.50	80.40	34.14	105.86	25.5	4.157	0.42	65.66	40.20
19.79	79.55	33.87	105.28	25.7	4.091	0.43	65.50	39.77
21.62	79.56	33.64	105.53	26.0	4.064	0.42	65.74	39.78

Tested By JCM Date 02/23/06 Input Checked By KB Date 3-2-06

geotechnics
INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO		
Client Reference	TAUM SAUK 06-3551		
Project No.	2006-060-01		
Lab ID	2006-060-01-70	Specific Gravity (assumed)	2.7

Visual Description: BROWN AND GRAY MOTTLED CLAY (UNDISTURBED)

SAMPLE CONDITION SUMMARY

Boring No.	TS-SOIL-02	TS-SOIL-02	TS-SOIL-02
Depth (in)	12-19	12-19	12-19
Sample No.	S-3	S-3	S-3
Test No.	T4	T5	T6
Deformation Rate (in/min)	0.001	0.001	0.001
Back Pressure (psi)	35.4	35.9	35.8
Consolidation Time (days)	1	1	1
Initial State (w%)	30.2	30.2	30.2
Total Unit Weight (pcf)	115.7	113.4	111.8
Dry Unit Weight (pcf)	88.9	87.1	85.9
Final State (w%)	34.7	30.6	30.1
Initial State Void Ratio,e	0.897	0.934	0.963

Tested By JCM Date 02/23/06 Input Checked By KB Date 3-2-06

SOIL SAMPLE TS-SOIL 03

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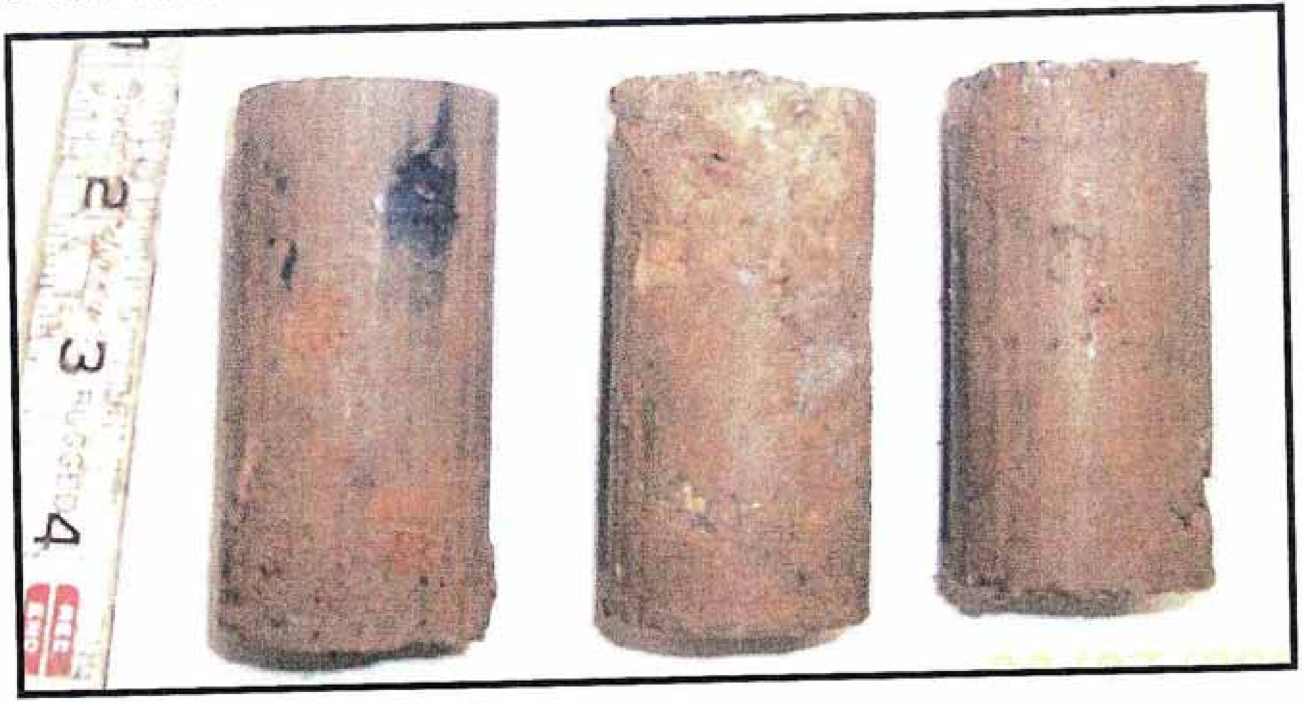
PHOTOGRAPH

Client	PAUL C. RIZZO & ASSOCIATES, INC.
Client Project	TAUM SAUK 06-3551
Project No.	2006-060-01
Lab ID	2006-060-01-72

Boring No..	TS-SOIL-03
Depth (in.)	7-15
Sample No.	S-2

SAMPLE: BEFORE CU



PHOTOGRAPH

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-SOIL-03
Client Project	TAUM SAUK 06-3551	Depth (in.)	7-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-72		

SAMPLE: AFTER CU TEST #7

PHOTOGRAPH

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-SOIL-03
Client Project	TAUM SAUK 06-3551	Depth (in.)	7-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-72		

SAMPLE: AFTER CU TEST #8

PHOTOGRAPH

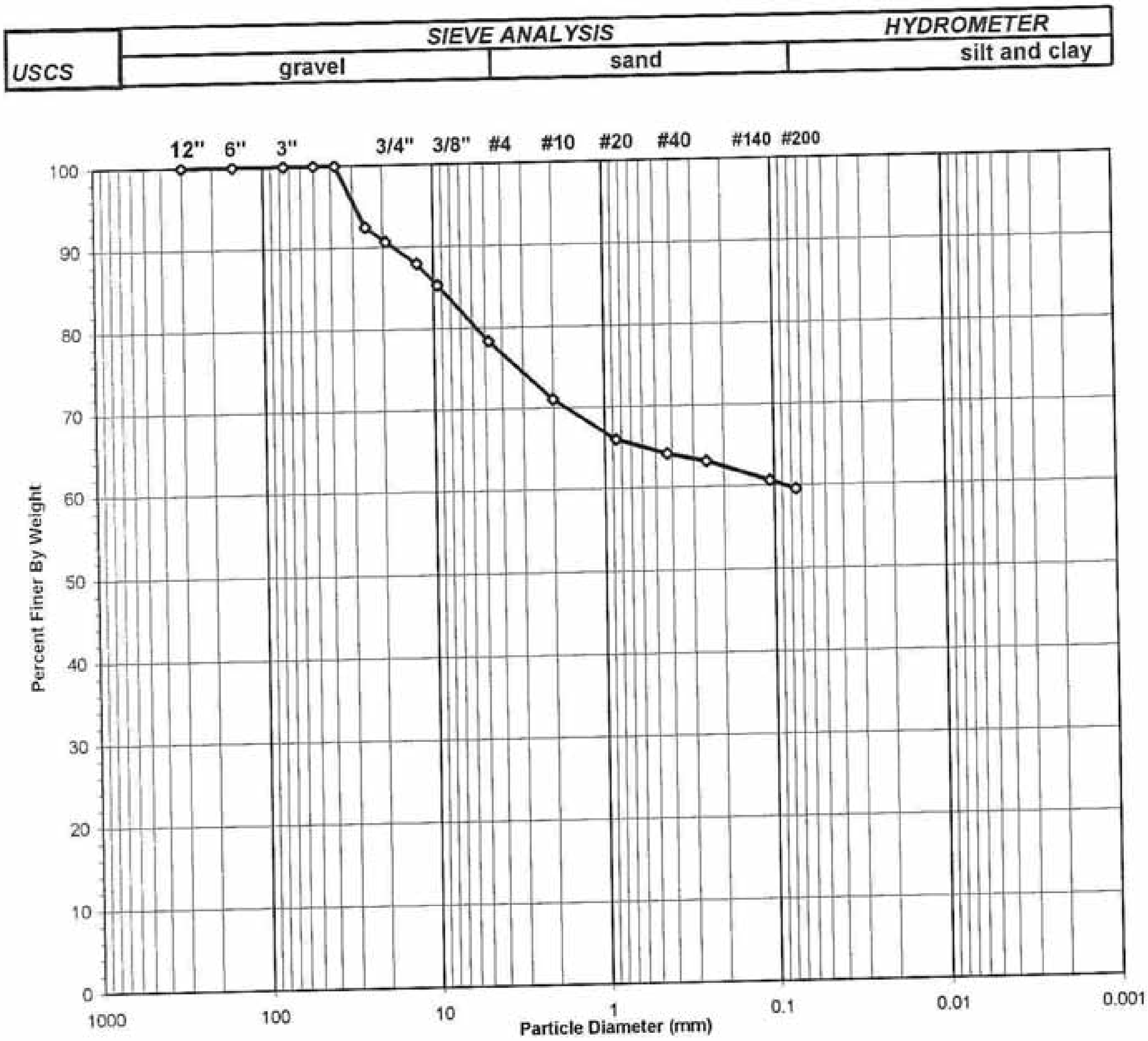
Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No..	TS-SOIL-03
Client Project	TAUM SAUK 06-3551	Depth (in.)	7-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-72		

SAMPLE: AFTER CU TEST #9

SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-03
Client Reference	TAUM SAUK 06-3551	Depth (in)	7-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-72	Soil Color	BROWN



USCS Symbol CL, TESTED

USCS Classification GRAVELLY LEAN CLAY WITH SAND

Tested By PC Date 3/10/06 Checked By KKB Date 3-13-06

geotechnics
INTEGRITY IN TESTING

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-03
Client Reference	TAUM SAUK 06-3551	Depth (in)	7-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-72	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	653	Tare No.	NA
Wgt.Tare + Wet Specimen (gm)	879.37	Wgt.Tare + Wet Specimen (gm)	NA
Wgt.Tare + Dry Specimen (gm)	763.40	Wgt.Tare + Dry Specimen (gm)	NA
Weight of Tare (gm)	96.56	Weight of Tare (gm)	NA
Weight of Water (gm)	115.97	Weight of Water (gm)	NA
Weight of Dry Soil (gm)	666.84	Weight of Dry Soil (gm)	NA
Moisture Content (%)	17.4	**Moisture Content (%)**	NA

Wet Weight -3/4" Sample (gm)	NA	Weight of the Dry Specimen (gm)	666.84
Dry Weight - 3/4" Sample (gm)	207.6	Weight of minus #200 material (gm)	397.05
Wet Weight +3/4" Sample (gm)	NA	Weight of plus #200 material (gm)	269.79
Dry Weight + 3/4" Sample (gm)	62.16		
Total Dry Weight Sample (gm)	NA		

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00	0.00	0.00	100.00	**100.00**
6"	150	0.00	0.00	0.00	100.00	**100.00**
3"	75	0.00	0.00	0.00	100.00	**100.00**
2"	50	0.00	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00	100.00	**100.00**
1"	25.0	49.97	7.49	7.49	92.51	**92.51**
3/4"	19.0	12.19	1.83	9.32	90.68	**90.68**
1/2"	12.50	18.29	2.74	12.06	87.94	**87.94**
3/8"	9.50	17.80	2.67	14.73	85.27	**85.27**
#4	4.75	46.54	6.98	21.71	78.29	**78.29**
#10	2.00	48.37	7.25	28.97	71.03	**71.03**
#20	0.850	33.92	5.09	34.05	65.95	**65.95**
#40	0.425	12.41	1.86	35.91	64.09	**64.09**
#60	0.250	6.94	1.04	36.95	63.05	**63.05**
#140	0.106	16.09	2.41	39.37	60.63	**60.63**
#200	0.075	7.27	1.09	40.46	59.54	**59.54**
Pan	-	397.05	59.54	100.00	-	-

Tested By PC Date 3/10/06 Checked By Date 3-13-06

DCN: CT-S3C DATE 6-25-98 REVISION: 2

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INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-03
Client Reference	TAUM SAUK 06-3551	Depth (in)	7-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-72	Soil Description	**BROWN LEAN CLAY**
			(Minus No. 40 sieve material, Airdried)

***Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description*.**

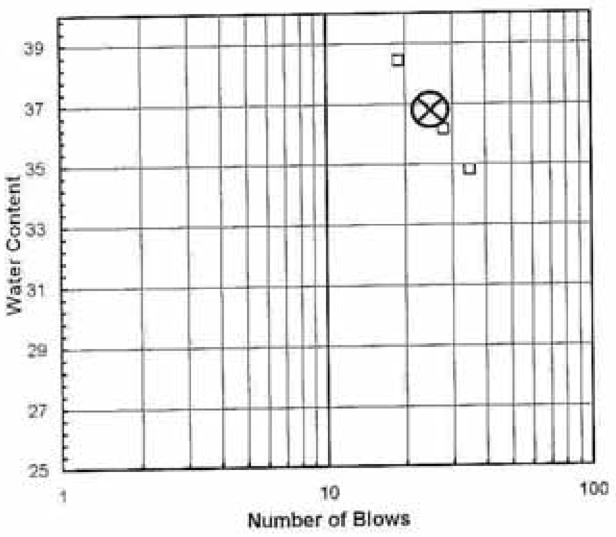
Liquid Limit Test	**1**	**2**	**3**	**MULTIPOINT**
Tare Number	3	5	8	
Wt. of Tare & WS (gm)	39.83	36.95	41.61	
Wt. of Tare & DS (gm)	33.68	30.85	34.22	
Wt. of Tare (gm)	16.01	13.98	15.00	
Wt. of Water (gm)	6.2	6.1	7.4	
Wt. of DS (gm)	17.7	16.9	19.2	
Moisture Content (%)	**34.8**	**36.2**	**38.4**	
Number of Blows	**35**	**28**	**19**	

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	9	40	
Wt. of Tare & WS (gm)	21.91	22.11	
Wt. of Tare & DS (gm)	20.93	21.04	
Wt. of Tare (gm)	15.78	15.54	
Wt. of Water (gm)	1.0	1.1	
Wt. of DS (gm)	5.2	5.5	
Moisture Content (%)	**19.0**	**19.5**	**-0.4**

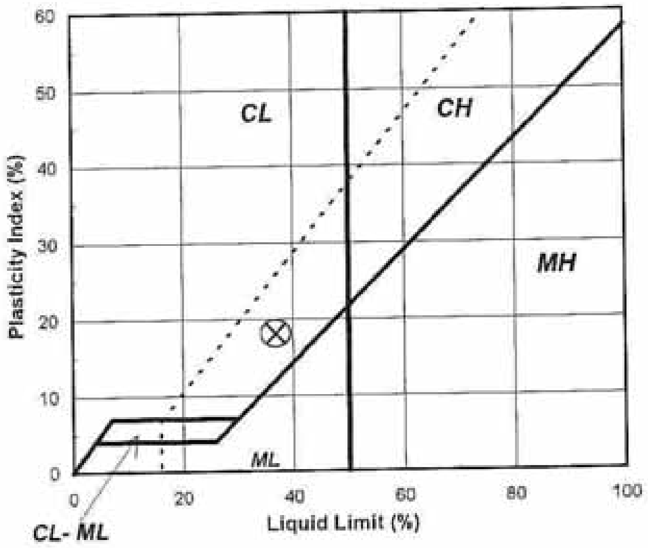
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**37**
Plastic Limit (%)	**19**
Plasticity Index (%)	**18**
USCS Symbol	**CL**

Flow Curve



Plasticity Chart



Tested By BS *Date* 3/9/06 *Checked By* KR *Date* 3-13-06

page 1 of 1 **DCN:** CT-S4B **DATE:** 10/8/01 **REVISION:** 2

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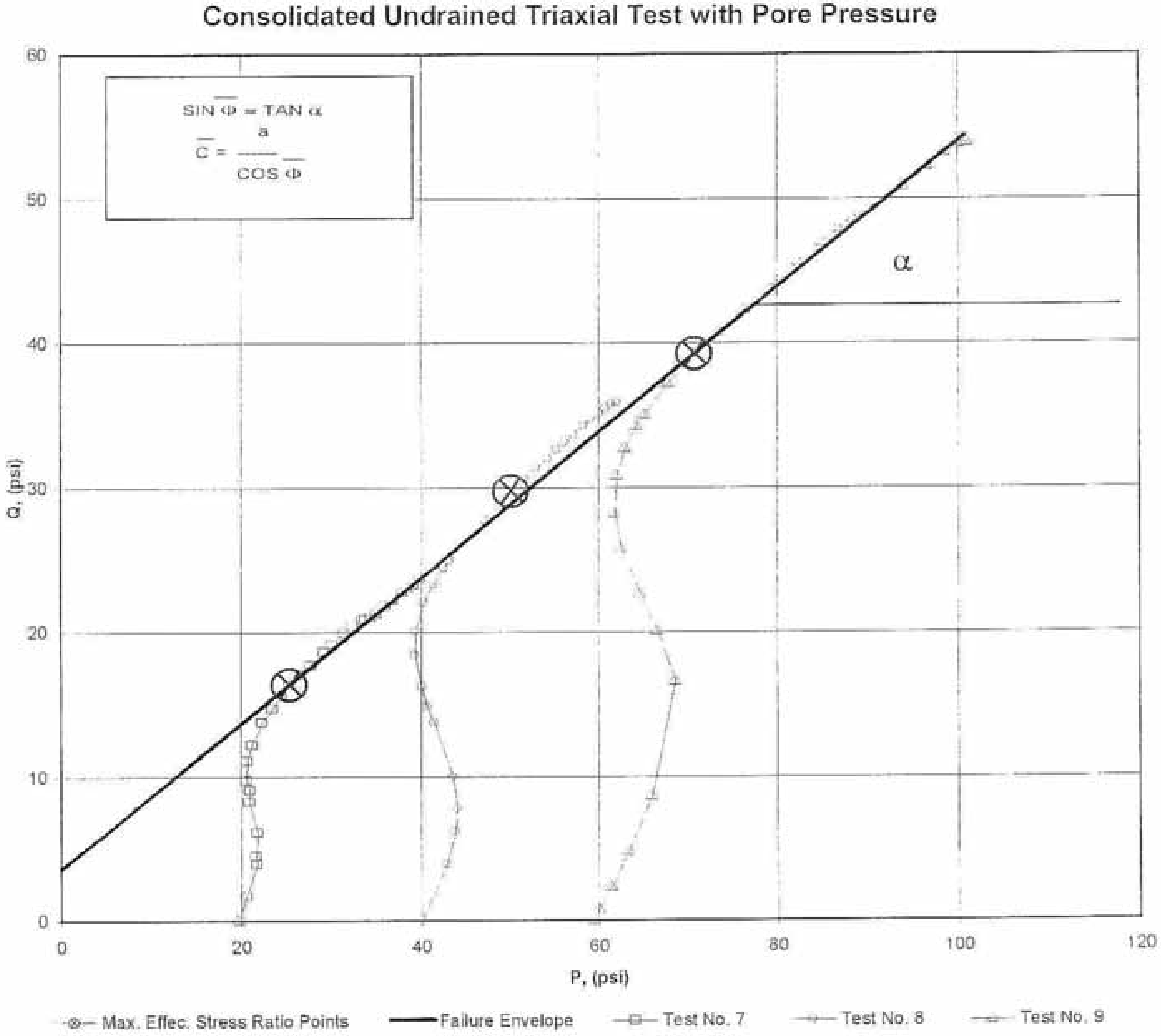
INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS
ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-03
Client Reference	TAUM SAUK 06-3551	Depth(in.)	7-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-72		



a	=	3.63	$\overline{C}$	=	4.20
α	=	26.7	$\overline{\Phi}$	=	30.22

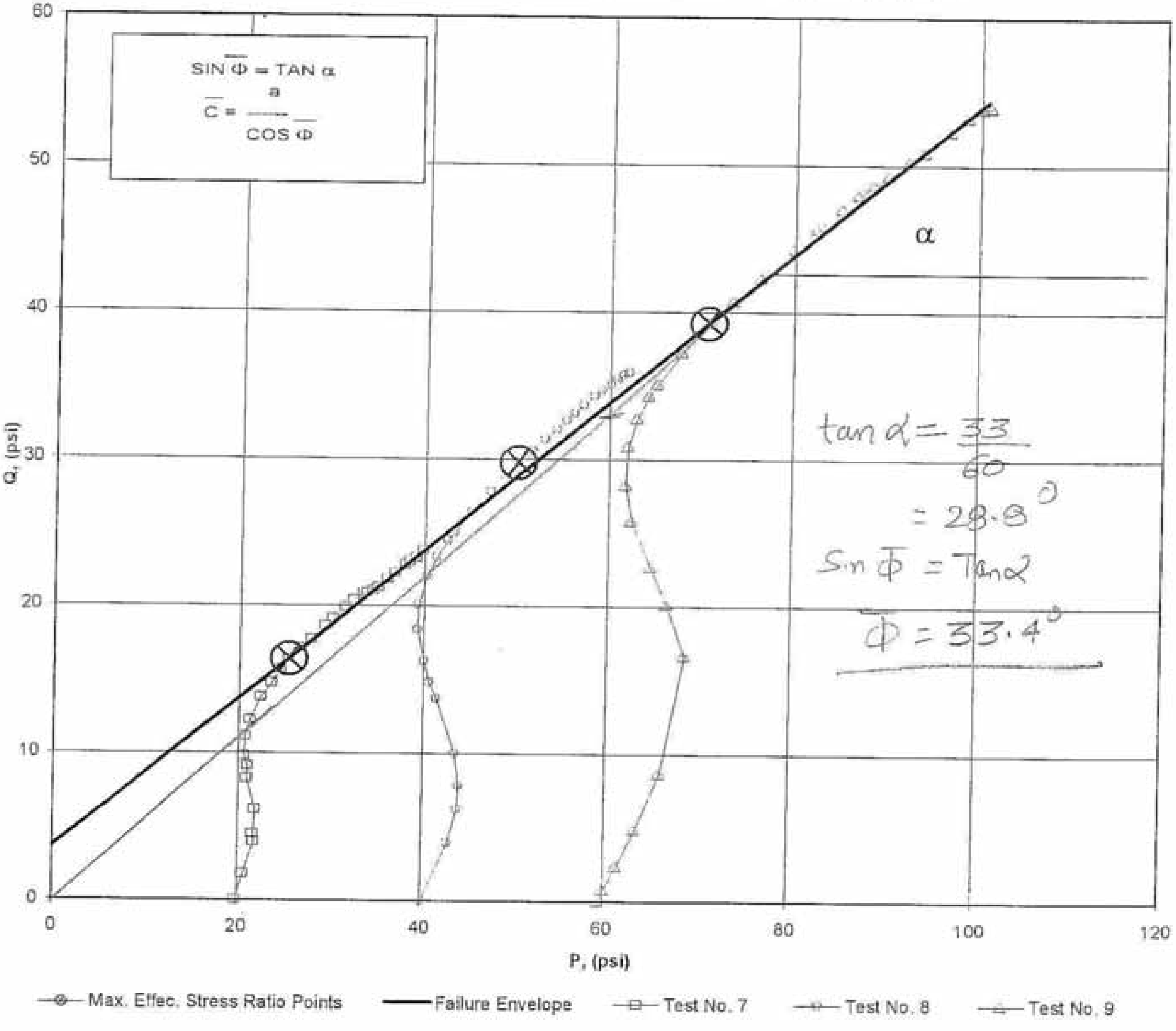
Tested By JCM Date 03/07/06 Approved By DB Date 3/13/06

geotechnics
INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS
ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-03
Client Reference	TAUM SAUK 06-3551	Depth(in.)	7-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-72		

Consolidated Undrained Triaxial Test with Pore Pressure



$\tan \alpha = \frac{33}{60}$
$= 28.8^{\circ}$
$\sin \overline{\Phi} = \tan \alpha$
$\overline{\Phi} = 33.4^{\circ}$

a	=	3.63	$\overline{C}$	=	4.20
α	=	26.7	$\overline{\Phi}$	=	30.22

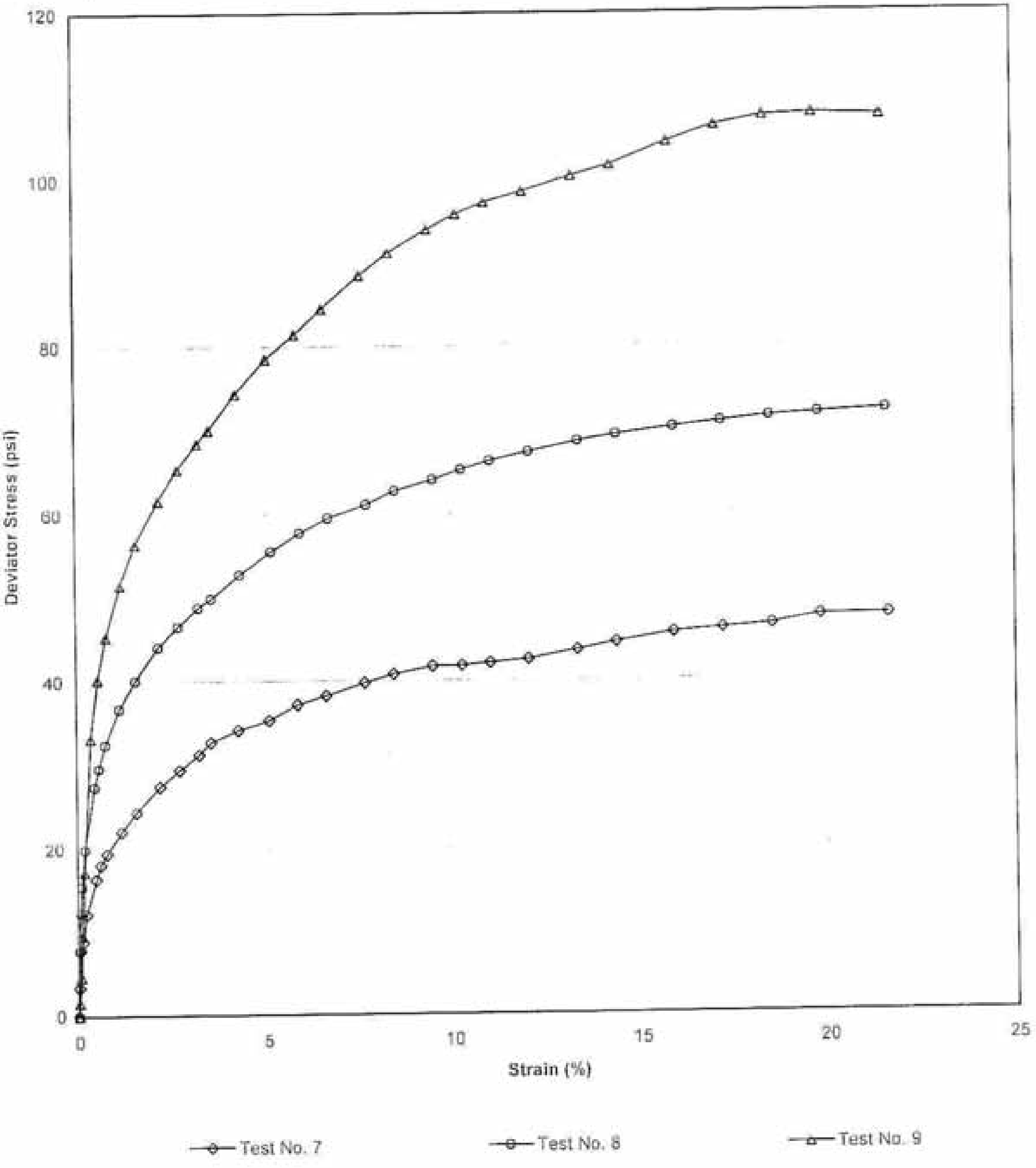
Tested By JCM Date 03/07/06 Approved By DB Date 3/13/06

geotechnics
INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-03
Client Reference	TAUM SAUK 06-3551	Depth(in.)	7-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-72		
Visual Description:	BROWN SANDY CLAY, SOME ORGANIC MATERIAL (UNDISTURBED)		



Tested By JCM Date 03/07/06 Approved By DB Date 3/13/06

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

geotechnics
INTEGRITY IN TESTING

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-03
Client Reference	TAUM SAUK 06-3551	Depth(in.)	7-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-72		

Visual Description: BROWN SANDY CLAY, SOME ORGANIC MATERIAL (UNDISTURBED)

Stage No.	1
Test No	7

PRESSURES (psi)

Cell Pressure(psi)	60.1
Back Pressure(psi)	40.3
Eff. Cons. Pressure(psi)	19.8
Pore Pressure Response (%)	97

MAXIMUM OBLIQUITY POINTS

$\overline{P}$ = 25.33
Q = 16.38

INITIAL SAMPLE DIMENSIONS (in)

Length 1	3.113	Diameter 1	1.421
Length 2	3.147	Diameter 2	1.423
Length 3	3.152	Diameter 3	1.420
Avg Leng.=	3.137	Avg. Diam.=	1.421

VOLUME CHANGE

Initial Burette Reading (ml)	24.0
Final Burette Reading (ml)	22.0
Final Change (ml)	2.0

Initial Dial Reading (D.R.), mils	50
D.R. After Saturation, mils	109
D.R. After Consolidation, mils	126

LOAD (LBS)	DEFORMATION (INCHES)	PORE PRESSURE (PSI)
12.4	0.000	40.3
17.6	0.001	41.2
24.2	0.002	42.3
25.8	0.004	43.0
30.7	0.007	44.4
37.1	0.015	47.4
39.7	0.019	48.2
41.8	0.024	49.3
45.9	0.036	50.5
49.5	0.048	51.1
54.4	0.067	51.5
57.6	0.083	51.4
60.7	0.099	51.3
63.1	0.108	51.2
65.8	0.131	50.7
68.1	0.156	50.0
71.4	0.179	49.4
73.6	0.203	49.1
76.7	0.234	48.5
78.9	0.259	48.1
81.3	0.291	47.6
82.0	0.315	47.1
83.1	0.339	46.7
84.6	0.370	46.3
87.6	0.410	45.9
90.1	0.441	45.6
93.5	0.488	45.0
95.6	0.528	44.7
97.8	0.568	44.3
101.1	0.608	43.9
103.2	0.663	43.6

Tested By JCM Date 03/07/06 Input Checked By KYB Date 3-13-06

geotechnics
INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS
ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-03
Client Reference	TAUM SAUK 06-3551	Depth(in.)	7-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-72		

Visual Description: BROWN SANDY CLAY, SOME ORGANIC MATERIAL (UNDISTURBED)

Effective Confining Pressure (psi)	19.8	*Stage No.*	1
		Test No	7

INITIAL DIMENSIONS

Initial Sample Length (in.)	3.14
Initial Sample Diameter (in.)	1.42
Initial Sample Area (in^2)	1.59
Initial Sample Volume (in^3)	4.98

VOLUME CHANGE

Volume After Consolidation (in^3)	4.57
Length After Consolidation (in)	3.06
Area After Consolidation (in^2)	1.494

Strain (%)	Deviation Stress	ΔU	$\overline{\sigma_1}$	$\overline{\sigma_3}$	Effective Principle Stress Ratio	$\overline{A}$	$\overline{P}$	Q
0.02	3.47	0.94	22.33	18.9	1.184	0.28	20.60	1.74
0.06	7.90	1.97	25.72	17.8	1.443	0.26	21.78	3.95
0.13	8.94	2.65	26.09	17.1	1.521	0.31	21.62	4.47
0.23	12.23	4.10	27.93	15.7	1.779	0.35	21.82	6.12
0.49	16.46	7.10	29.16	12.7	2.296	0.44	20.93	8.23
0.61	18.17	7.89	30.08	11.9	2.525	0.45	21.00	9.08
0.79	19.50	8.95	30.35	10.8	2.798	0.47	20.60	9.75
1.17	22.13	10.18	31.76	9.6	3.300	0.47	20.69	11.07
1.57	24.42	10.80	33.42	9.0	3.713	0.46	21.21	12.21
2.19	27.51	11.23	36.08	8.6	4.211	0.42	22.33	13.76
2.71	29.45	11.06	38.19	8.7	4.371	0.39	23.46	14.73
3.23	31.30	10.99	40.11	8.8	4.555	0.36	24.46	15.65
3.54	32.76	10.85	41.70	8.9	4.661	0.34	25.33	16.38
4.27	34.20	10.37	43.64	9.4	4.626	0.31	26.53	17.10
5.10	35.35	9.70	45.45	10.1	4.500	0.28	27.78	17.68
5.86	37.18	9.14	47.84	10.7	4.486	0.25	29.25	18.59
6.63	38.24	8.84	49.20	11.0	4.491	0.24	30.08	19.12
7.66	39.75	8.18	51.37	11.6	4.420	0.21	31.50	19.87
8.45	40.76	7.79	52.77	12.0	4.395	0.20	32.39	20.38
9.50	41.71	7.27	54.24	12.5	4.329	0.18	33.38	20.85
10.29	41.78	6.83	54.75	13.0	4.221	0.17	33.86	20.89
11.06	42.06	6.42	55.44	13.4	4.143	0.16	34.41	21.03
12.08	42.48	6.00	56.27	13.8	4.079	0.15	35.04	21.24
13.38	43.60	5.60	57.79	14.2	4.071	0.13	35.99	21.80
14.41	44.50	5.26	59.04	14.5	4.060	0.12	36.79	22.25
15.94	45.60	4.67	60.73	15.1	4.014	0.11	37.93	22.80
17.25	46.07	4.40	61.47	15.4	3.991	0.10	38.44	23.03
18.57	46.52	3.97	62.35	15.8	3.939	0.09	39.09	23.26
19.86	47.55	3.65	63.70	16.2	3.944	0.08	39.92	23.77
21.66	47.60	3.27	64.13	16.5	3.880	0.07	40.33	23.80

Tested By JCM Date 03/07/06 Input Checked By KB Date 3-13-06

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INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS
ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-03
Client Reference	TAUM SAUK 06-3551	Depth(in.)	7-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-72		

Visual Description: BROWN SANDY CLAY (UNDISTURBED)

Stage No.	1
Test No	8

PRESSURES (psi)

Cell Pressure(psi)	80.2
Back Pressure(psi)	40.1
Eff. Cons. Pressure(ps	40.1
Pore Pressure Response (%)	100

MAXIMUM OBLIQUITY POINTS

$\overline{P}$ = 50.18
Q = 29.75

INITIAL SAMPLE DIMENSIONS (in)

Length 1	3.033	Diameter 1	1.432
Length 2	3.026	Diameter 2	1.430
Length 3	3.023	Diameter 3	1.422
Avg Leng.=	3.027	Avg. Diam.=	1.428

VOLUME CHANGE

Initial Burette Reading (ml)	24.0
Final Burette Reading (ml)	20.6
Final Change (ml)	3.4
Initial Dial Reading (D.R.), mils	57
D.R. After Saturation, mils	68
D.R. After Consolidation, mils	117

LOAD (LBS)	DEFORMATION (INCHES)	PORE PRESSURE (PSI)
17.6	0.000	40.1
29.8	0.001	41.2
36.7	0.002	42.5
41.7	0.003	43.9
48.6	0.006	46.6
60.3	0.014	52.4
63.7	0.017	54.3
68.2	0.022	56.4
75.1	0.034	59.2
80.6	0.046	60.8
87.3	0.064	61.9
91.6	0.080	62.1
95.7	0.096	62.1
97.6	0.106	61.9
102.9	0.129	61.5
108.2	0.153	60.9
112.5	0.176	60.3
116.2	0.199	59.8
120.0	0.229	59.0
123.5	0.252	58.6
127.0	0.283	57.9
130.0	0.305	57.5
132.7	0.328	57.1
136.0	0.359	56.6
140.0	0.398	56.2
142.9	0.428	55.8
146.7	0.473	55.2
149.9	0.511	54.8
153.1	0.550	54.4
156.0	0.588	54.0
160.0	0.642	53.5

Tested By JCM Date 03/07/06 Input Checked By KB Date 3-13-06

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS
ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

geotechnics
INTEGRITY IN TESTING

Client: PAUL C. RIZZO
Client Reference: TAUM SAUK 06-3551
Project No.: 2006-060-01
Lab ID: 2006-060-01-72

Boring No.: TS-SOIL-03
Depth(in.): 7-15
Sample No.: S-2

Visual Description: BROWN SANDY CLAY (UNDISTURBED)

Effective Confining Pressure (psi) 40.1
Stage No. 1
Test No 8

INITIAL DIMENSIONS

Initial Sample Length (in.)	3.03
Initial Sample Diameter (in.)	1.43
Initial Sample Area (in^2)	1.60
Initial Sample Volume (in^3)	4.85

VOLUME CHANGE

Volume After Consolidation (in^3)	4.59
Length After Consolidation (in)	2.97
Area After Consolidation (in^2)	1.546

Strain (%)	Deviation Stress	ΔU	$\overline{\sigma}_1$	$\overline{\sigma}_3$	Effective Principle Stress Ratio	$\overline{A}$	$\overline{P}$	Q
0.02	7.87	1.08	46.89	39.0	1.202	0.14	42.96	3.93
0.06	12.37	2.40	50.07	37.7	1.328	0.19	43.89	6.18
0.10	15.57	3.81	51.86	36.3	1.429	0.24	44.08	7.79
0.20	19.98	6.52	53.56	33.6	1.595	0.33	43.57	9.99
0.46	27.48	12.35	55.23	27.8	1.990	0.45	41.49	13.74
0.58	29.64	14.21	55.54	25.9	2.145	0.48	40.71	14.82
0.75	32.50	16.29	56.30	23.8	2.365	0.50	40.06	16.25
1.14	36.78	19.11	57.77	21.0	2.753	0.52	39.38	18.39
1.55	40.08	20.74	59.44	19.4	3.071	0.52	39.40	20.04
2.17	44.12	21.82	62.40	18.3	3.414	0.49	40.34	22.06
2.69	46.57	22.03	64.64	18.1	3.578	0.47	41.35	23.29
3.23	48.85	21.96	66.99	18.1	3.693	0.45	42.57	24.43
3.57	49.89	21.82	68.18	18.3	3.729	0.44	43.23	24.95
4.34	52.78	21.38	71.50	18.7	3.819	0.41	45.11	26.39
5.17	55.55	20.76	74.89	19.3	3.872	0.37	47.12	27.77
5.94	57.75	20.22	77.63	19.9	3.905	0.35	48.75	28.88
6.70	59.50	19.67	79.93	20.4	3.913	0.33	50.18	29.75
7.73	61.08	18.95	82.24	21.2	3.888	0.31	51.69	30.54
8.49	62.70	18.45	84.34	21.6	3.897	0.29	52.99	31.35
9.52	63.99	17.85	86.25	22.3	3.876	0.28	54.25	32.00
10.29	65.19	17.42	87.86	22.7	3.874	0.27	55.27	32.59
11.07	66.22	17.01	89.31	23.1	3.868	0.26	56.20	33.11
12.10	67.28	16.55	90.84	23.6	3.857	0.25	57.20	33.64
13.40	68.53	16.05	92.58	24.0	3.850	0.23	58.31	34.27
14.43	69.33	15.66	93.77	24.4	3.837	0.23	59.10	34.66
15.96	70.19	15.07	95.22	25.0	3.804	0.21	60.12	35.10
17.23	70.84	14.67	96.27	25.4	3.786	0.21	60.85	35.42
18.52	71.42	14.29	97.22	25.8	3.768	0.20	61.51	35.71
19.82	71.77	13.88	98.00	26.2	3.737	0.19	62.11	35.89
21.62	72.19	13.40	98.89	26.7	3.704	0.19	62.79	36.09

Tested By JCM Date 03/07/06 Input Checked By KB Date 3-13-06

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-03
Client Reference	TAUM SAUK 06-3551	Depth(in.)	7-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-72		

Visual Description: BROWN SANDY CLAY (UNDISTURBED)

Stage No.	1
Test No	9

PRESSURES (psi)

Cell Pressure(psi)	100.4
Back Pressure(psi)	40.8
Eff. Cons. Pressure(ps	59.6
Pore Pressure Response (%)	99

MAXIMUM OBLIQUITY POINTS

$\overline{P}$ = 70.77

Q = 39.25

INITIAL SAMPLE DIMENSIONS (in)

Length 1	3.117	Diameter 1	1.442
Length 2	3.107	Diameter 2	1.437
Length 3	3.078	Diameter 3	1.441
Avg Leng.=	3.101	Avg. Diam.=	1.440

VOLUME CHANGE

Initial Burette Reading (ml)	24.0
Final Burette Reading (ml)	19.5
Final Change (ml)	4.5
Initial Dial Reading (D.R.), mils	65
D.R. After Saturation, mils	75
D.R. After Consolidation, mils	127

LOAD (LBS)	DEFORMATION (INCHES)	PORE PRESSURE (PSI)
17.1	0.000	40.8
19.6	0.001	41.1
24.4	0.002	41.3
32.2	0.003	41.8
44.1	0.006	43.0
69.0	0.011	48.4
80.1	0.017	54.0
88.2	0.024	58.4
98.3	0.036	63.6
106.3	0.048	66.8
115.2	0.067	69.2
121.6	0.082	70.1
127.2	0.098	70.4
130.1	0.107	70.3
138.0	0.129	69.8
145.7	0.154	68.9
151.6	0.177	67.7
157.8	0.200	66.4
166.2	0.231	64.8
172.0	0.254	63.7
178.5	0.286	62.3
183.2	0.310	61.5
187.0	0.333	60.6
191.3	0.364	59.5
197.2	0.404	58.3
201.7	0.435	57.3
210.2	0.482	55.9
216.8	0.520	55.0
222.1	0.560	54.1
225.9	0.600	53.2
230.2	0.655	52.1

Tested By JCM Date 03/07/06 Input Checked By Date 3-13-06

DCN: CT-S28 DATE 6-25-98 REVISION 1

geotechnics
INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST
WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-03
Client Reference	TAUM SAUK 06-3551	Depth(in.)	7-15
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-72		

Visual Description: BROWN SANDY CLAY (UNDISTURBED)

Effective Confining Pressure (psi)	59.6	*Stage No.*	1
		Test No	9

INITIAL DIMENSIONS

Initial Sample Length (in.)	3.10
Initial Sample Diameter (in.)	1.44
Initial Sample Area (in^2)	1.63
Initial Sample Volume (in^3)	5.05

VOLUME CHANGE

Volume After Consolidation (in^3)	4.73
Length After Consolidation (in)	3.04
Area After Consolidation (in^2)	1.555

Strain (%)	Deviation Stress	ΔU	$\overline{\sigma}_1$	$\overline{\sigma}_3$	Effective Principle Stress Ratio	$\overline{A}$	$\overline{P}$	Q
0.02	1.59	0.31	60.88	59.3	1.027	0.20	60.08	0.79
0.06	4.67	0.47	63.80	59.1	1.079	0.10	61.46	2.34
0.11	9.68	1.00	68.27	58.6	1.165	0.10	63.44	4.84
0.18	17.30	2.23	74.67	57.4	1.302	0.13	66.02	8.65
0.37	33.28	7.60	85.28	52.0	1.640	0.23	68.64	16.64
0.57	40.26	13.16	86.70	46.4	1.867	0.33	66.57	20.13
0.79	45.37	17.58	87.40	42.0	2.080	0.39	64.71	22.69
1.18	51.57	22.78	88.39	36.8	2.401	0.45	62.60	25.79
1.58	56.47	25.99	90.07	33.6	2.680	0.46	61.84	28.23
2.20	61.69	28.36	92.93	31.2	2.975	0.46	62.08	30.85
2.70	65.40	29.27	95.73	30.3	3.156	0.45	63.03	32.70
3.22	68.48	29.58	98.50	30.0	3.281	0.44	64.26	34.24
3.54	70.10	29.48	100.22	30.1	3.327	0.42	65.17	35.05
4.25	74.40	28.96	105.03	30.6	3.428	0.39	67.83	37.20
5.07	78.50	28.08	110.02	31.5	3.491	0.36	70.77	39.25
5.83	81.44	26.86	114.17	32.7	3.488	0.33	73.45	40.72
6.58	84.52	25.55	118.57	34.0	3.482	0.31	76.31	42.26
7.59	88.56	23.99	124.17	35.6	3.487	0.27	79.89	44.28
8.36	91.26	22.91	127.95	36.7	3.487	0.25	82.32	45.63
9.42	94.02	21.54	132.08	38.1	3.470	0.23	85.07	47.01
10.20	95.88	20.74	134.74	38.9	3.467	0.22	86.80	47.94
10.97	97.27	19.78	137.10	39.8	3.443	0.21	88.46	48.64
11.99	98.57	18.69	139.48	40.9	3.410	0.19	90.19	49.28
13.29	100.40	17.47	142.52	42.1	3.383	0.18	92.33	50.20
14.32	101.68	16.49	144.80	43.1	3.358	0.16	93.96	50.84
15.85	104.47	15.12	148.94	44.5	3.349	0.15	96.71	52.23
17.13	106.41	14.24	151.77	45.4	3.346	0.14	98.56	53.21
18.43	107.51	13.26	153.85	46.3	3.320	0.12	100.10	53.76
19.74	107.76	12.38	154.98	47.2	3.282	0.12	101.10	53.88
21.54	107.47	11.26	155.81	48.3	3.223	0.11	102.07	53.74

Tested By JCM Date 03/07/06 Input Checked By KYB Date 3-13-06

geotechnics
INTEGRITY IN TESTING

CONSOLIDATED UNDRAINED TRIAXIAL TEST WITH PORE PRESSURE READINGS

ASTM D4767-95 / AASHTO T297-94 (SOP-S28)

Client	PAUL C. RIZZO		
Client Reference	TAUM SAUK 06-3551		
Project No.	2006-060-01		
Lab ID	2006-060-01-72	Specific Gravity (assumed)	2.7

Visual Description: BROWN SANDY CLAY, SOME ORGANIC MATERIAL (UNDISTURBED)

SAMPLE CONDITION SUMMARY

Boring No.	TS-SOIL-03	TS-SOIL-03	TS-SOIL-03
Depth (in)	7-15	7-15	7-15
Sample No.	S-2	S-2	S-2
Test No.	T7	T8	T9
Deformation Rate (in/min)	0.001	0.001	0.001
Back Pressure (psi)	40.3	40.1	40.8
Consolidation Time (days)	1	1	1
Initial State (w%)	17.8	19.2	19.6
Total Unit Weight (pcf)	127.8	126.9	123.2
Dry Unit Weight (pcf)	108.5	106.5	103.0
Final State (w%)	21.1	18.9	17.2
Initial State Void Ratio,e	0.554	0.582	0.636

Tested By JCM Date 03/07/06 Input Checked By YAB Date 3-13-06

DCN: CT-S28 DATE 6-25-98 REVISION: 1

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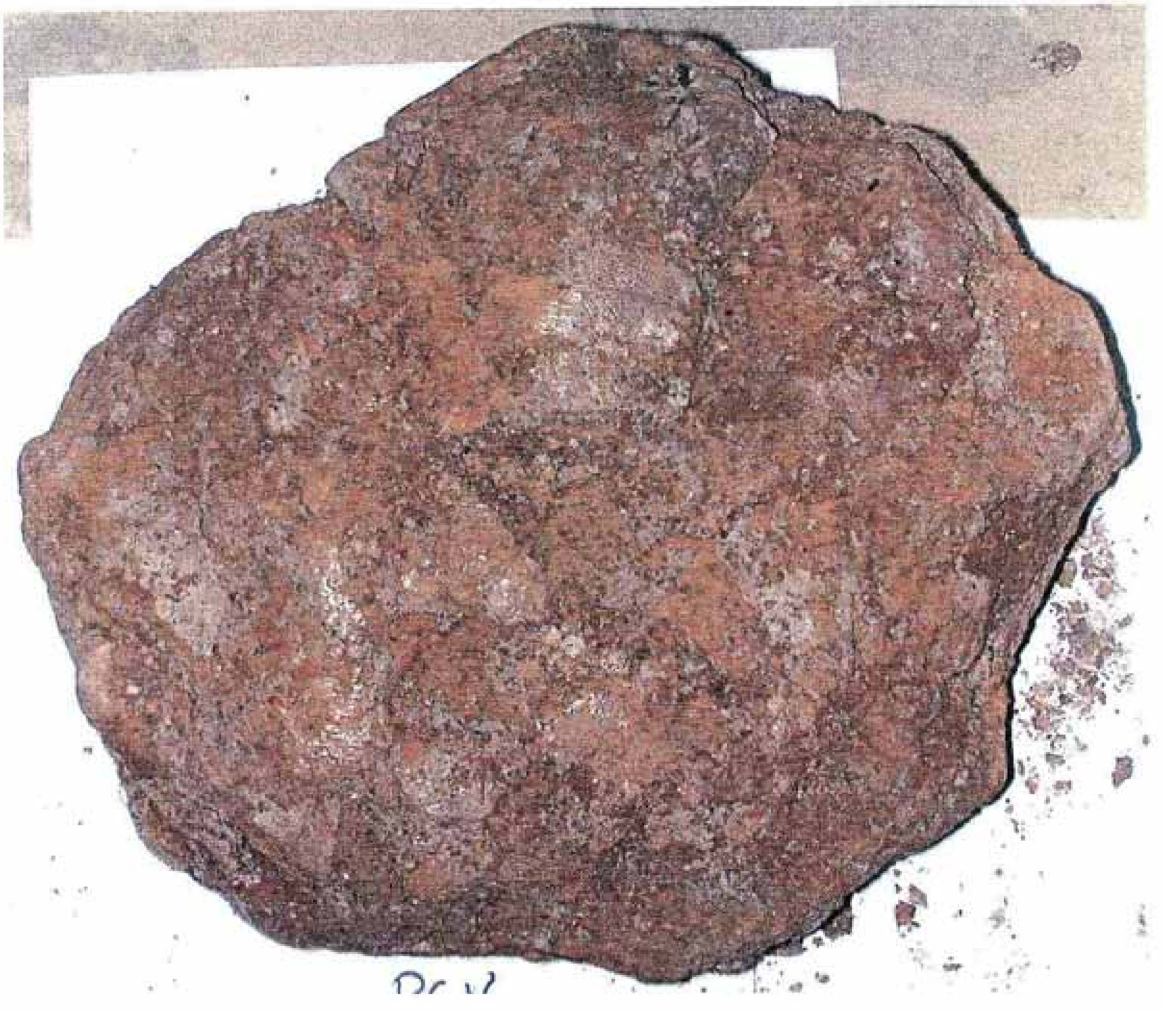
SOIL SAMPLE TS-SOIL 04

SIEVE SAMPLE

Client	PAUL C. RIZZO & ASSOCIATES, INC.	Boring No.	TS-SOIL-04
Client Project	TAUM SAUK 06-3551	Depth (in.)	5" - 11"
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-74		

SAMPLE AS RECEIVED:



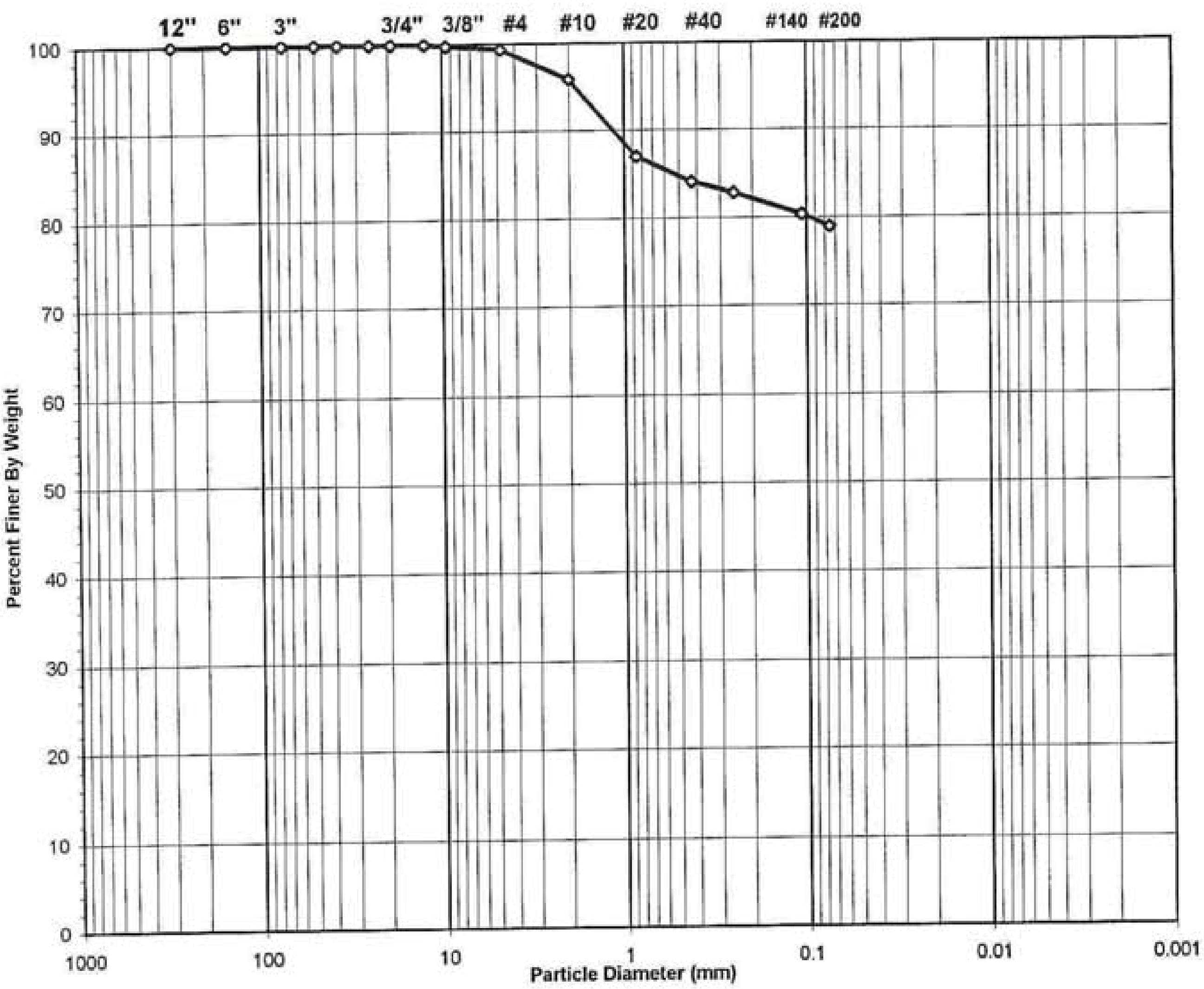
\\Dave\excel\PC RIZZO\06-060-01 pic pages\[2006-060-01-74.xls]

geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-04
Client Reference	TAUM SAUK 06-3551	Depth (in)	5-11
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-74	Soil Color	REDDISH BROWN

USCS	*SIEVE ANALYSIS*		*HYDROMETER*
	gravel	sand	silt and clay



USCS Symbol ***CH, TESTED***

USCS Classification ***FAT CLAY WITH SAND***

Tested By JP Date 3/1/06 Checked By KYB Date 3-6-06

WASH SIEVE ANALYSIS

ASTM D 422-63/AASHTO T88-00 (SOP-S3)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-04
Client Reference	TAUM SAUK 06-3551	Depth (in)	5-11
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-74	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	527	Tare No.	NA
Wgt.Tare + Wet Specimen (gm)	1195.60	Wgt.Tare + Wet Specimen (gm)	NA
Wgt.Tare + Dry Specimen (gm)	949.80	Wgt.Tare + Dry Specimen (gm)	NA
Weight of Tare (gm)	96.35	Weight of Tare (gm)	NA
Weight of Water (gm)	245.80	Weight of Water (gm)	NA
Weight of Dry Soil (gm)	853.45	Weight of Dry Soil (gm)	NA
Moisture Content (%)	**28.8**	**Moisture Content (%)**	NA

Wet Weight -3/4" Sample (gm)	NA	Weight of the Dry Specimen (gm)	853.45
Dry Weight - 3/4" Sample (gm)	180.2	Weight of minus #200 material (gm)	673.26
Wet Weight +3/4" Sample (gm)	NA	Weight of plus #200 material (gm)	180.19
Dry Weight + 3/4" Sample (gm)	0.00		
Total Dry Weight Sample (gm)	NA		

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00	0.00	0.00	100.00	**100.00**
6"	150	0.00	0.00	0.00	100.00	**100.00**
3"	75	0.00	0.00	0.00	100.00	**100.00**
2"	50	0.00	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00	100.00	**100.00**
1"	25.0	0.00	0.00	0.00	100.00	**100.00**
3/4"	19.0	0.00	0.00	0.00	100.00	**100.00**
1/2"	12.50	0.00	0.00	0.00	100.00	**100.00**
3/8"	9.50	1.96	0.23	0.23	99.77	**99.77**
#4	4.75	3.12	0.37	0.60	99.40	**99.40**
#10	2.00	29.38	3.44	4.04	95.96	**95.96**
#20	0.850	76.57	8.97	13.01	86.99	**86.99**
#40	0.425	25.06	2.94	15.95	84.05	**84.05**
#60	0.250	10.83	1.27	17.21	82.79	**82.79**
#140	0.106	21.29	2.49	19.71	80.29	**80.29**
#200	0.075	11.98	1.40	21.11	78.89	**78.89**
Pan	-	673.26	78.89	100.00	-	-

Tested By JP Date 3/1/06 Checked By Date 3-6-06

DCN: CT-S3C DATE 6-25-98 REVISION: 2

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INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	PAUL C. RIZZO	Boring No.	TS-SOIL-04
Client Reference	TAUM SAUK 06-3551	Depth (in)	5-11
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-74	Soil Description	REDDISH BROWN FAT CLAY

(Minus No. 40 sieve material, Airdried)

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

Liquid Limit Test	**1**	**2**	**3**
Tare Number	1158	2184	189
Wt. of Tare & WS (gm)	41.89	41.70	41.02
Wt. of Tare & DS (gm)	34.34	34.40	33.60
Wt. of Tare (gm)	19.32	20.21	19.67
Wt. of Water (gm)	7.6	7.3	7.4
Wt. of DS (gm)	15.0	14.2	13.9
Moisture Content (%)	**50.3**	**51.4**	**53.3**
Number of Blows	**29**	**23**	**19**

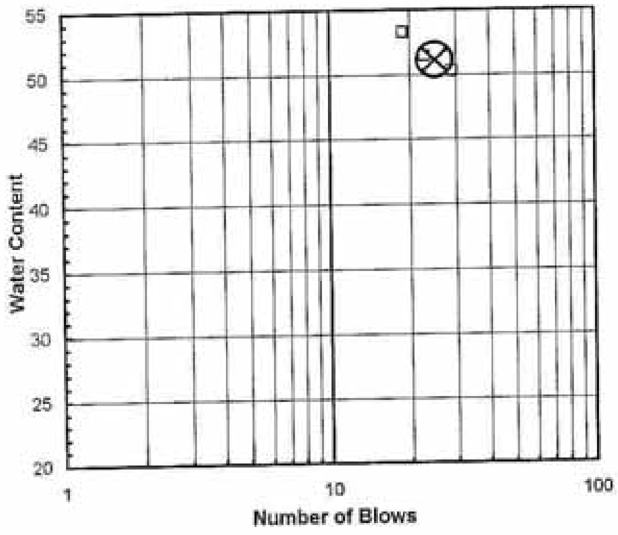
MULTIPOINT

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	31	3	
Wt. of Tare & WS (gm)	22.54	22.43	
Wt. of Tare & DS (gm)	21.12	21.05	
Wt. of Tare (gm)	16.00	16.00	
Wt. of Water (gm)	1.4	1.4	
Wt. of DS (gm)	5.1	5.1	
Moisture Content (%)	**27.7**	**27.3**	**0.4**

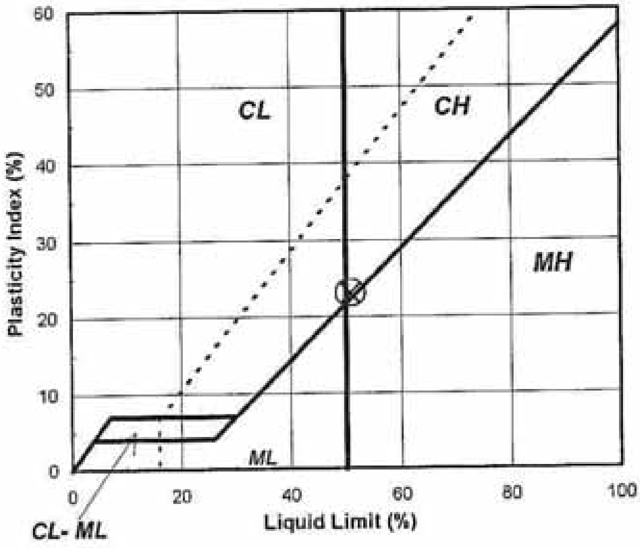
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**51**
Plastic Limit (%)	**28**
Plasticity Index (%)	**23**
USCS Symbol	**CH**

Flow Curve



Plasticity Chart



Tested By TO *Date* 3/5/06 *Checked By* KB *Date* 3-6-06

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INTEGRITY IN TESTING

DIRECT SHEAR

ASTM D 3080-04 (SOP-S21)

Client	PAUL C. RIZZO & ASSOC.	Boring No.	TS-SOIL-04
Client Reference	TAUM SAUK 06-3551	Depth (in)	5-11
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-74	Visual Description	BROWN, REDDISH BROWN AND GRAY MOTTLED CLAY

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED

Maximum Shear Stress (psi)		Normal Stress (psi)
15.84	(1)	**20**
26.74	(2)	**40**
42.24	(3)	**60**

Overall Regression Analysis

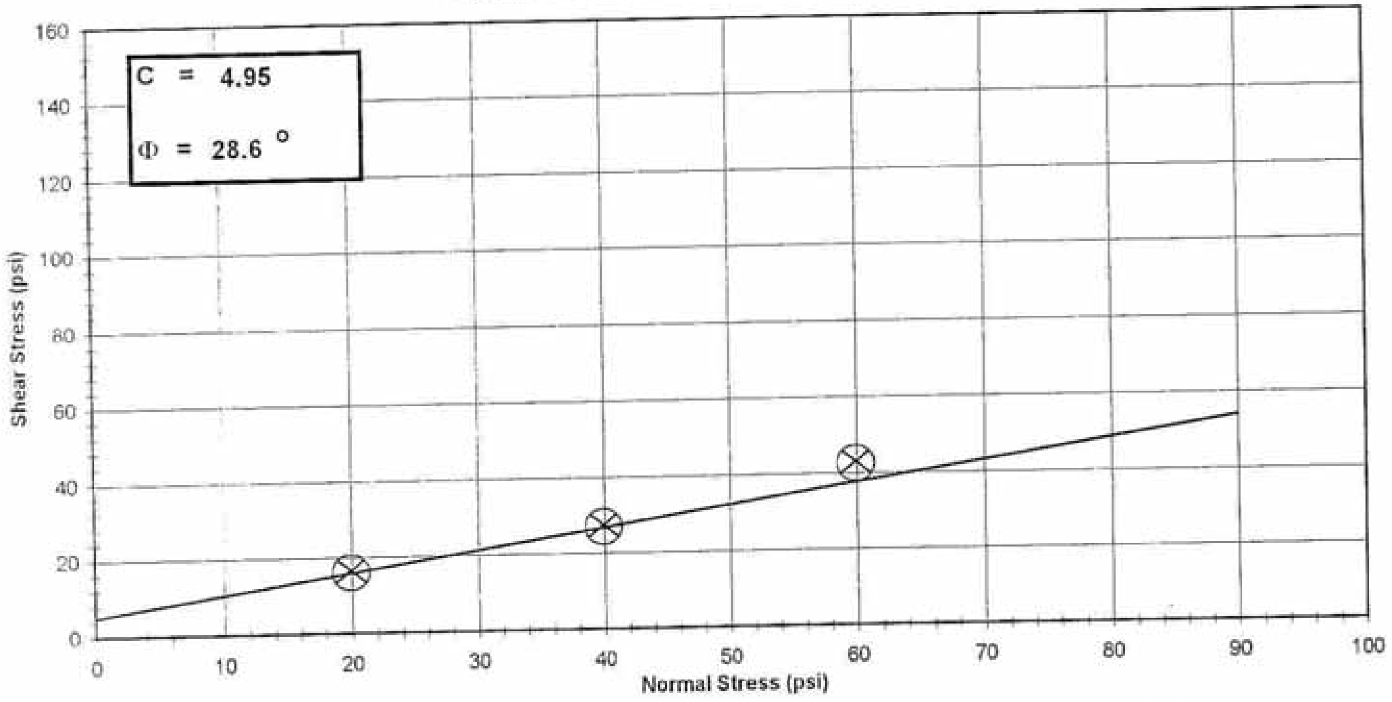
Slope = 0.66
C = **1.88**
Φ = **33.4** **degrees**

Selected Points	Shear Stress (psi)	Normal Stress (psi)
1	15.84	20
2	26.74	40

Selected Points Regression

Slope = 0.54
C = **4.95**
Φ = **28.6** **degrees**

SHEAR STRESS vs. NORMAL STRESS



Note: Graph not to scale

Tested By TM *Date* 3/3/06 *Approved By* DB *Date* 3/3/06

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INTEGRITY IN TESTING

DIRECT SHEAR

ASTM D 3080-04 (SOP-S21)

Client	PAUL C. RIZZO & ASSOC.	Boring No.	TS-SOIL-04
Client Reference	TAUM SAUK 06-3551	Depth (in)	5-11
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-74	Visual Description	BROWN, REDDISH BROWN AND GRAY MOTTLED CLAY

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED

Maximum Shear Stress (psi)		Normal Stress (psi)
15.84	(1)	**20**
26.74	(2)	**40**
42.24	(3)	**60**

Overall Regression Analysis

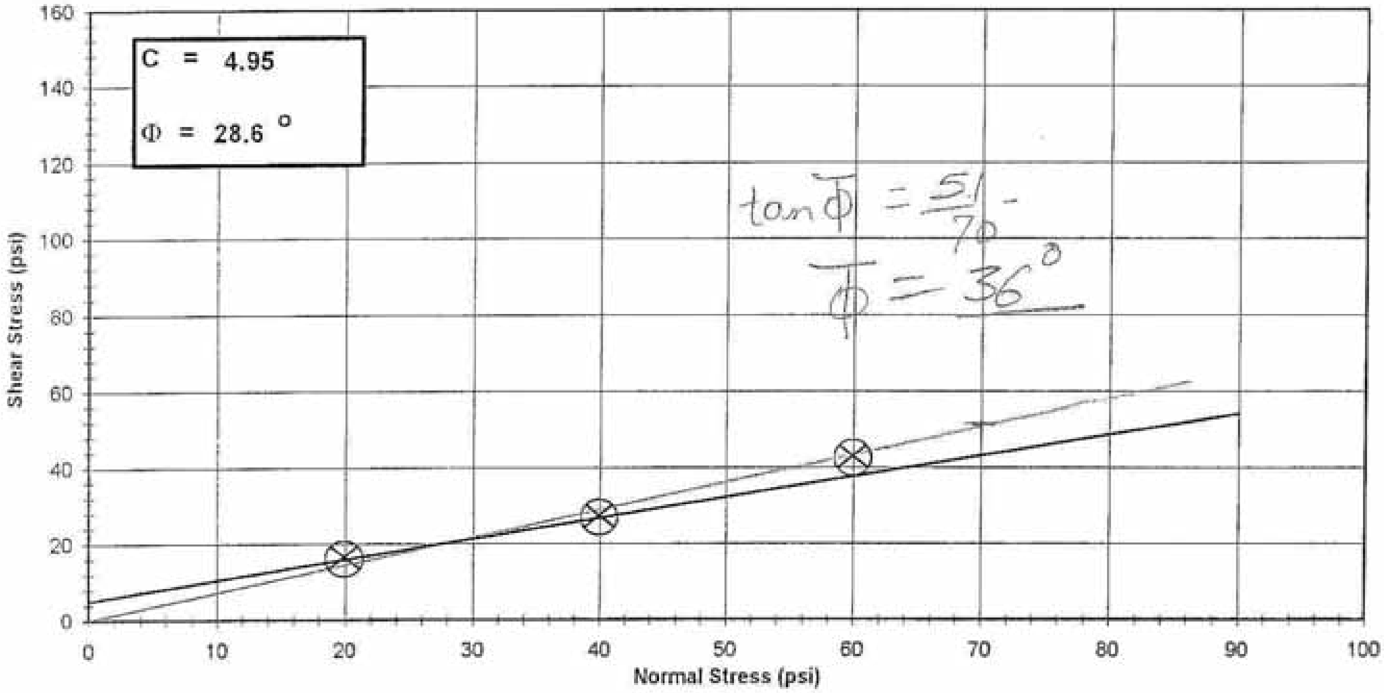
Slope = 0.66
C = 1.88
Φ = 33.4 degrees

Selected Points	Shear Stress (psi)	Normal Stress (psi)
1	15.84	20
2	26.74	40

Selected Points Regression

Slope = 0.54
C = 4.95
Φ = 28.6 degrees

SHEAR STRESS vs. NORMAL STRESS



tan Φ = 51/70 -
Φ = 36°

Note: Graph not to scale

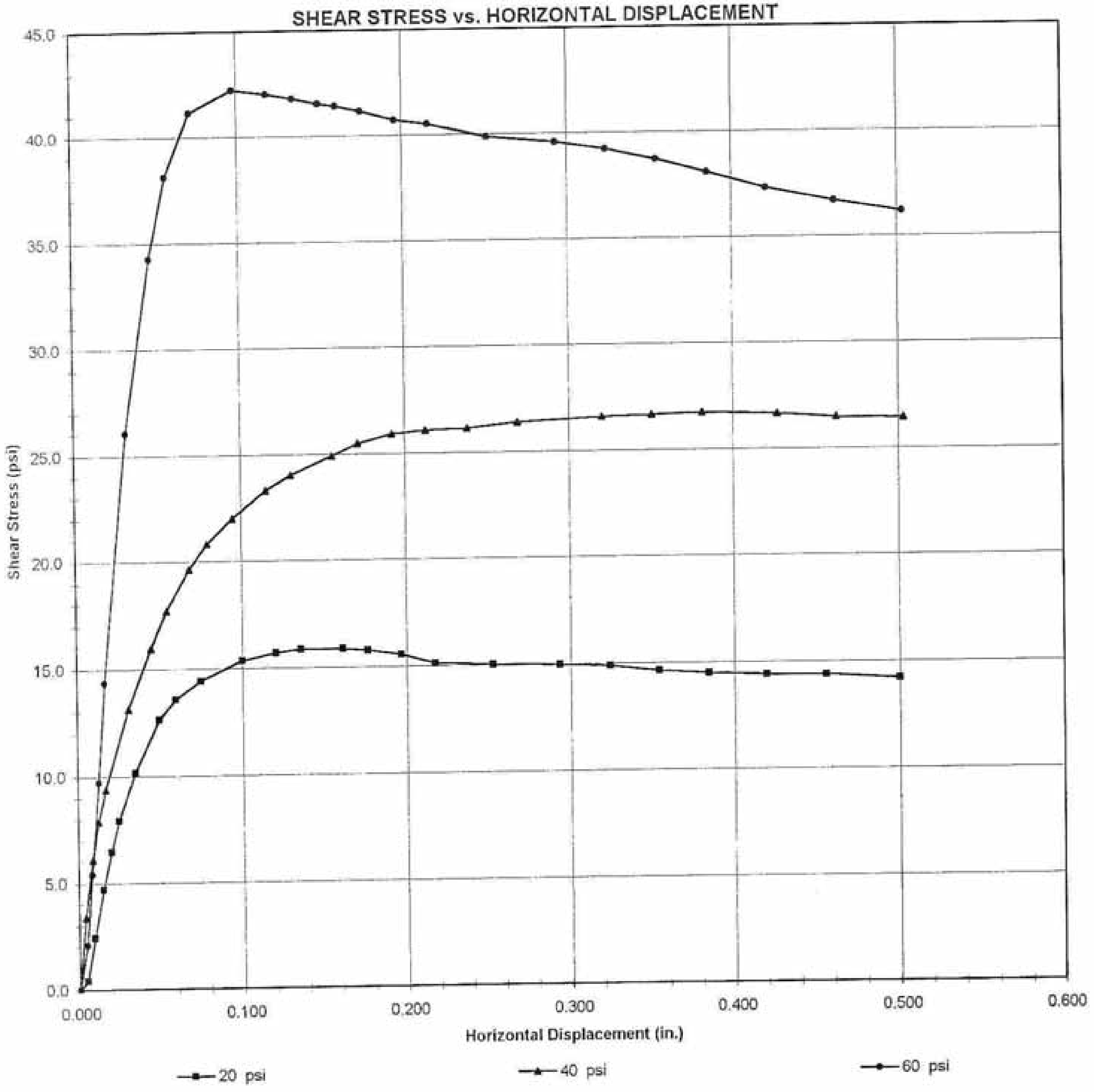
Tested By TM *Date* 3/3/06 *Approved By* DB *Date* 3/3/06

DIRECT SHEAR

ASTM D 3080-04 (SOP-S21)

Client	PAUL C. RIZZO & ASSOC.	Boring No.	TS-SOIL-04
Client Reference	TAUM SAUK 06-3551	Depth (in)	5-11
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-74	Visual Description	BROWN, REDDISH BROWN AND GRAY MOTTLED CLAY

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED



Tested By TM *Date* 3/3/06 *Approved By* DB *Date* 3/3/06

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INTEGRITY IN TESTING

DIRECT SHEAR

ASTM D 3080-04 (SOP-S21)

Client	PAUL C. RIZZO & ASSOC.	Boring No.	TS-SOIL-04
Client Reference	TAUM SAUK 06-3551	Depth (in)	5-11
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-74	Visual Description	BROWN, REDDISH BROWN AND GRAY MOTTLED CLAY

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED

Machine ID # G 783

SHEAR BOX DATA

Wt.of Wet Specimen & Ring(gm)	609.02	Specific Gravity (Assumed)	2.70
Weight of Ring (gm)	457.26	Volume of Solids(cc)	44.5
Weight of Wet Specimen (gm)	151.76	Initial Consolidation Dial Reading (in.)	0.0
Initial Specimen Height (in)	1	Final Consolidation Dial Reading (in.)	0.0127
Specimen Diameter (in)	2.5	Corrected Final Cons. Reading (in.)	0.0069
Wet Density (pcf)	117.8	Void Ratio Before Consolidation	0.81
Dry Density (pcf)	**93.3**	**Void Ratio After Consolidation**	0.79

Moisture Content	*Before Test*	*After Test*
Tare ID	T-16	D-3
Wt. Wet Soil & Tare (gm)	258.13	189.25
Wt. Dry Soil & Tare (gm)	223.69	156.08
Wt. Tare (gm)	92.70	36.04
Wt. of Water (gm)	34.44	33.17
Wt. of Dry Soil (gm)	130.99	120.04
Moisture Content (%)	**26.3**	**27.6**

Testing Parameters	
Normal Stress(psi)	**20**
Strain Rate(in/min)	0.00144
Machine Deflection (in.)	0.0058

Horizontal Displacement (in)	Shear Force (lbs)	Shear Stress (psi)	Vertical Dial Reading (in)	Vertical Displacement (+)incr,(-)decr (in)	Shear To Normal Ratio
0.000	0.0	**0.00**	0.0000	0.0000	0.00
0.005	2.0	**0.41**	-0.0008	0.0008	0.02
0.009	11.9	**2.42**	-0.0024	0.0024	0.12
0.015	23.1	**4.71**	-0.0029	0.0029	0.24
0.020	31.6	**6.44**	-0.0029	0.0029	0.32
0.025	38.9	**7.92**	-0.0029	0.0029	0.40
0.035	49.9	**10.16**	-0.0029	0.0029	0.51
0.050	62.1	**12.64**	-0.0028	0.0028	0.63
0.060	66.6	**13.56**	-0.0026	0.0026	0.68
0.075	70.8	**14.42**	-0.0023	0.0023	0.72
0.100	75.2	**15.33**	-0.0021	0.0021	0.77
0.121	77.0	**15.69**	-0.0021	0.0021	0.78
0.136	77.8	**15.84**	-0.0021	0.0021	0.79
0.161	77.7	**15.84**	-0.0021	0.0021	0.79
0.177	77.3	**15.75**	-0.0021	0.0021	0.79
0.197	76.3	**15.54**	-0.0021	0.0021	0.78
0.217	74.2	**15.12**	-0.0022	0.0022	0.76
0.253	73.7	**15.01**	-0.0025	0.0025	0.75
0.294	73.5	**14.97**	-0.0025	0.0025	0.75
0.324	73.0	**14.88**	-0.0027	0.0027	0.74
0.354	71.7	**14.61**	-0.0026	0.0026	0.73
0.384	71.1	**14.49**	-0.0026	0.0026	0.72
0.420	70.6	**14.39**	-0.0026	0.0026	0.72
0.455	70.5	**14.36**	-0.0029	0.0029	0.72
0.500	69.6	**14.18**	-0.0028	0.0028	0.71

Tested By TM *Date* 3/1/06 *Input Checked By* GU *Date* 3-3-06

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INTEGRITY IN TESTING

DIRECT SHEAR

ASTM D 3080-04 (SOP-S21)

Client	PAUL C. RIZZO & ASSOC.	Boring No.	TS-SOIL-04
Client Reference	TAUM SAUK 06-3551	Depth (in)	5-11
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-74	Visual Description	BROWN, REDDISH BROWN AND GRAY MOTTLED CLAY

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED

Machine ID # G 783

SHEAR BOX DATA

Wt.of Wet Specimen & Ring(gm)	349.48	Specific Gravity (Assumed)	2.70
Weight of Ring (gm)	203.58	Volume of Solids(cc)	42.0
Weight of Wet Specimen (gm)	145.9	Initial Consolidation Dial Reading (in.)	0.0
Initial Specimen Height (in)	1	Final Consolidation Dial Reading (in.)	0.0400
Specimen Diameter (in)	2.5	Corrected Final Cons. Reading (in.)	0.0326
Wet Density (pcf)	113.2	Void Ratio Before Consolidation	0.91
Dry Density (pcf)	**88.1**	**Void Ratio After Consolidation**	0.85

Moisture Content	*Before Test*	*After Test*
Tare ID	D-3	D-1
Wt. Wet Soil & Tare (gm)	235.13	181.63
Wt. Dry Soil & Tare (gm)	190.91	149.72
Wt. Tare (gm)	36.05	34.68
Wt. of Water (gm)	44.22	31.91
Wt. of Dry Soil (gm)	154.86	115.04
Moisture Content (%)	**28.6**	**27.7**

Testing Parameters	
Normal Stress(psi)	**40**
Strain Rate(in/min)	0.00144
Machine Deflection (in.)	0.0074

Horizontal Displacement (in)	Shear Force (lbs)	Shear Stress (psi)	Vertical Dial Reading (in)	Vertical Displacement (+)incr,(-)decr (in)	Shear To Normal Ratio
0.000	0.0	**0.00**	0.0000	0.0000	0.00
0.004	16.6	**3.38**	0.0002	-0.0002	0.08
0.008	29.8	**6.07**	0.0002	-0.0002	0.15
0.012	38.5	**7.84**	0.0002	-0.0002	0.20
0.017	46.0	**9.37**	0.0002	-0.0002	0.23
0.031	64.4	**13.12**	0.0000	0.0000	0.33
0.045	78.2	**15.94**	0.0025	-0.0025	0.40
0.055	86.9	**17.69**	0.0042	-0.0042	0.44
0.069	96.3	**19.61**	0.0067	-0.0067	0.49
0.080	102.2	**20.82**	0.0082	-0.0082	0.52
0.095	108.1	**22.02**	0.0093	-0.0093	0.55
0.115	114.4	**23.31**	0.0108	-0.0108	0.58
0.131	118.0	**24.03**	0.0114	-0.0114	0.60
0.156	122.3	**24.91**	0.0124	-0.0124	0.62
0.172	124.9	**25.45**	0.0126	-0.0126	0.64
0.192	127.1	**25.89**	0.0127	-0.0127	0.65
0.213	127.9	**26.06**	0.0127	-0.0127	0.65
0.238	128.3	**26.13**	0.0127	-0.0127	0.65
0.269	129.5	**26.39**	0.0126	-0.0126	0.66
0.320	130.6	**26.60**	0.0127	-0.0127	0.66
0.351	130.8	**26.65**	0.0126	-0.0126	0.67
0.381	131.3	**26.74**	0.0127	-0.0127	0.67
0.427	130.8	**26.65**	0.0127	-0.0127	0.67
0.463	129.9	**26.47**	0.0127	-0.0127	0.66
0.503	129.7	**26.43**	0.0127	-0.0127	0.66

Tested By *TM* *Date* *3/2/06* *Input Checked By* GU *Date* 3-3-06

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INTEGRITY IN TESTING

DIRECT SHEAR

ASTM D 3080-04 (SOP-S21)

Client	PAUL C. RIZZO & ASSOC.	Boring No.	TS-SOIL-04
Client Reference	TAUM SAUK 06-3551	Depth (in)	5-11
Project No.	2006-060-01	Sample No.	S-2
Lab ID	2006-060-01-74	Visual Description	BROWN, REDDISH BROWN AND GRAY MOTTLED CLAY

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED

Machine ID # G 783

SHEAR BOX DATA

Wt.of Wet Specimen & Ring(gm)	611.35	Specific Gravity (Assumed)	2.70
Weight of Ring (gm)	457.26	Volume of Solids(cc)	46.3
Weight of Wet Specimen (gm)	154.09	Initial Consolidation Dial Reading (in.)	0.0
Initial Specimen Height (in)	1	Final Consolidation Dial Reading (in.)	0.0516
Specimen Diameter (in)	2.5	Corrected Final Cons. Reading (in.)	0.0428
Wet Density (pcf)	119.6	Void Ratio Before Consolidation	0.74
Dry Density (pcf)	**96.9**	**Void Ratio After Consolidation**	0.66

Moisture Content	*Before Test*	*After Test*
Tare ID	01	1399
Wt. Wet Soil & Tare (gm)	154.55	190.84
Wt. Dry Soil & Tare (gm)	134.96	159.47
Wt. Tare (gm)	51.22	38.16
Wt. of Water (gm)	19.59	31.37
Wt. of Dry Soil (gm)	83.74	121.31
Moisture Content (%)	**23.4**	**25.9**

Testing Parameters	
Normal Stress(psi)	**60**
Strain Rate(in/min)	0.00144
Machine Deflection (in.)	0.0088

Horizontal Displacement (in)	Shear Force (lbs)	Shear Stress (psi)	Vertical Dial Reading (in)	Vertical Displacement (+)incr,(-)decr (in)	Shear To Normal Ratio
0.000	0.0	**0.00**	0.0000	0.0000	0.00
0.005	10.2	**2.07**	0.0000	0.0000	0.03
0.008	26.6	**5.41**	-0.0001	0.0001	0.09
0.013	47.8	**9.73**	0.0000	0.0000	0.16
0.017	70.4	**14.35**	-0.0001	0.0001	0.24
0.031	127.9	**26.06**	0.0000	0.0000	0.43
0.047	168.3	**34.29**	-0.0002	0.0002	0.57
0.057	187.1	**38.12**	-0.0002	0.0002	0.64
0.072	202.1	**41.16**	-0.0001	0.0001	0.69
0.098	207.3	**42.24**	-0.0001	0.0001	0.70
0.118	206.3	**42.02**	0.0002	-0.0002	0.70
0.134	205.2	**41.80**	0.0005	-0.0005	0.70
0.150	203.9	**41.54**	0.0011	-0.0011	0.69
0.160	203.3	**41.41**	0.0017	-0.0017	0.69
0.175	202.1	**41.16**	0.0023	-0.0023	0.69
0.196	200.0	**40.74**	0.0026	-0.0026	0.68
0.216	198.8	**40.51**	0.0034	-0.0034	0.68
0.252	195.8	**39.88**	0.0044	-0.0044	0.66
0.293	194.3	**39.57**	0.0055	-0.0055	0.66
0.324	192.4	**39.20**	0.0060	-0.0060	0.65
0.355	189.9	**38.69**	0.0063	-0.0063	0.64
0.385	186.7	**38.04**	0.0066	-0.0066	0.63
0.421	183.0	**37.28**	0.0072	-0.0072	0.62
0.462	180.0	**36.67**	0.0075	-0.0075	0.61
0.503	177.5	**36.16**	0.0081	-0.0081	0.60

Tested By TM *Date* 2/28/06 *Input Checked By* GU *Date* 3-3-06

MOISTURE CONTENT

ASTM D 2216 (SOP-S1)

Client	PAUL C. RIZZO
Client Reference	TAUM SAUK 06-3551
Project No.	2006-060-01

Lab ID	067	069	070	072	074
Boring No.	TS-SOIL-01	TS-SOIL-02	TS-SOIL-02	TS-SOIL-03	TS-SOIL-04
Depth (in)	9-14	7-12	12-19	7-15	5-11
Sample No.	S-2	S-2	S-3	S-2	S-2
Tare Number	1126	D-3	884	614	497
Wt. of Tare & WS (gm)	417.6	163.32	352.07	149.02	217.03
Wt. of Tare & DS (gm)	375.09	136.51	295.88	138.68	166.58
Wt. of Tare (gm)	84.89	36.05	109.76	84.69	8.24
Wt. of Water (gm)	42.51	26.81	56.19	10.34	50.45
Wt. of DS (gm)	290.2	100.46	186.12	53.99	158.34
Water Content (%)	**14.6**	**26.7**	**30.2**	**19.2**	**31.9**

Notes : *NA*

Tested By *TM* *Date* *2/21/06* *Checked By* KR *Date* 3-13-06

APPENDIX F

CALCULATIONS

APPENDIX F

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CALCULATION BRIEF

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PARAPET WALL OVERFLOW CALCULATION

Purpose:

Estimate overtopping flow at each segment of the parapet wall for the December 14, 2005 overtopping event. Calculate the impact velocity and distance from the wall for water overtopping the parapet wall of the Taum Sauk upper reservoir at wall segments 48, 72, and 95. Determine the relationship between overtopping flow and time for wall segment 95

References:

1. KdG. (December 27, 2005) "Taum Sauk Upper Reservoir Crest Survey Data," Revision 2.
2. Merritt, Frederick S. (1983) "Standard Handbook for Civil Engineers," Third Edition, McGraw Hill. (excerpts included as ***Attachment A***)
3. United States Department of the Interior, Bureau of Reclamation (USBR). (1987) "Design of Small Dams," Third Edition, Water Resources Technical Publication. (excerpts included as ***Attachment B***)
4. Siemens. (February 10, 2006) "AmerenUE Taum Sauk Incident Investigation Report."
5. US Army Corps of Engineers, Hydrologic Engineering Center. (May 2003) "Hydrologic Modeling System HEC-HMS" Version 2.2.2.

Background:

The upper reservoir dike of the Taum Sauk Pumped Storage Project failed on December 14, 2005 due to uncontrolled overtopping. This resulted in a dike failure and release of water from the upper reservoir. The reservoir wall was breached at wall segments 88 to 99 and overtopped in three other locations.

Assumptions:

1. Flow into the reservoir was approximately 2600 cfs and one pump was running at the time of the event.

2. Weir coefficient is based on values published by Merritt (1983). See table in ***Attachment A***.

3. Estimation of top of wall elevations for breached section

   For wall segments surveyed in 2005, the top of wall height is the average of the surveyed elevations at each end (Reference 1). Wall segments 69 through 99 were not surveyed in 2005. Top of wall elevation for these wall segments is estimated using survey data from 2003 for the monuments at the base of the wall, average wall height, and maximum settlement for all monuments on the dam from 2003 to 2005. Average wall height is the average difference between the elevation of the monument at the base of the wall and the surveyed top of the wall. Settlement is the maximum difference in surveyed elevation for monuments around the dam in 2003 and 2005. Using the maximum settlement is justified because the highest sections of rockfill have the largest settlements, and wall segments 69 through 99 are at the tallest section of rockfill dam.

Calculations:

1. Weir Equation

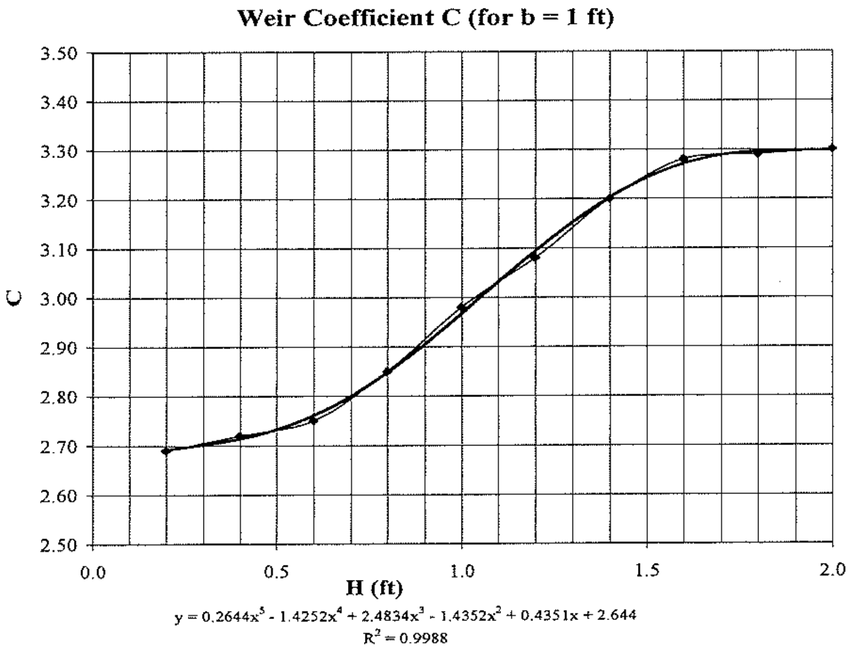
Each wall segment is modeled as a broad crested weir with the top at the elevation found previously. The flow over each segment is found for reservoir elevations ranging from 1597.00 to 1599.00 in 0.1 ft increments.

Flow over a broad crested weir is given by the equation

$Q = CLH^{3/2}$

where
Q = flow in cfs
C = discharge coefficient
L = effective length of crest (ft)
H = depth of flow above elevation of crest (ft)

The discharge coefficient C depends on the head H and the breadth of the weir. For overtopping of the parapet wall, the breadth of the weir is 1 ft. A curve was fit in excel to estimate C for different heads with the top of the parapet wall acting as a broad crested weir. H vs C values are as taken from Merritt (1983) for a one foot wide broad crested weir.(see ***Attachment A***) The graph of C vs. H and the corresponding equation fit in Excel are shown below.



For each wall segment the head H is found for water heights from elevation 1597.00 to 1599.00. At each elevation, a weir coefficient is estimated using the equation shown on the graph above. The flow over each wall segment is estimated for the range of water elevations. These flows are summed for all wall segments to find the flow overtopping the reservoir at each elevation. The calculations for wall segments 88 to 95 are given in ***Attachment E***.

2. Flow Projection

Wall segments 48, 72, and 95 have the lowest elevation of all wall segments. At these segments the horizontal distance the flow travels and the impact velocity of the flow will be calculated. The shape of the flow over the crest of the wall can be approximated using the equation below for flow over a sharp crested weir.

$$\frac{y}{H_o} = -K\left(\frac{x}{H_o}\right)^n$$

where
y = vertical distance (ft)
H_o = depth of flow above crest (ft)
x = horizontal projection of flow (ft)

K and n are constants from Merritt (1983) Figure 21 (***Attachment B***). To find K and n, h_a and h_o are required. Values for h_o and h_a are found using the equations below and an iterative process in Excel.

$h_o = H_o - h_a$ and

$$h_a = \frac{q^2}{2g(P+h_o)^2}$$

Now solving for x,

$$x = H_o\left(\frac{y}{H_oK}\right)^{1/n}$$

3. Impact Velocity

The impact velocity of the flow over the parapet wall can be approximated using conservation of energy

$$V^2 = 2gH$$

where
V = impact velocity (fps)
g = gravity (ft/sec^2)
H = wall height (ft) + H_o (ft)

4

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 4 of 39
Chkd. By: PM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

4. Overtopping flow vs. time

Based on the report by Siemens (Reference 4), the reservoir elevation at the time of failure was 1597.63 and one pump was on giving a flow into the reservoir of approximately 2600 cfs. For this inflow, the relationship between reservoir elevation and time was found using HEC-HMS (Reference 5). HEC-HMS results are given in ***Attachment D***. The flow overtopping the wall at specific times was then found by matching the flow over the wall calculated at each reservoir elevation with the time corresponding to that reservoir elevation from HEC-HMS. A reservoir elevation of 1597.00 is taken as time 0. Using this data, it will take the upper reservoir approximately 10 minutes 20 seconds to reach elevation 1597.63. Table 1 below shows the relationship between flow over wall segment 95 and time for 0 to 34 minutes.

Table 1

Flow Over Wall Segment 95

Time (min)	Reservoir Elevation	Flow Over Wall Segment 95 (cfs)	Cumulative Outflow Wall Segment 95 (cf)	Flow per Foot Wall Segment 95 (cfs)	Cumulative flow per foot Wall Segment 95 (cf/ft)	Water in dam for 80% infiltration
0	1597	0.00	0.00	0.00	0.00	0.00
1	1597.1	0.00	0.00	0.00	0.00	0.00
2	1597.1	0.00	0.00	0.00	0.00	0.00
3	1597.2	0.00	0.00	0.00	0.00	0.00
4	1597.3	1.80	108.00	0.03	1.80	1.44
5	1597.3	1.80	216.00	0.03	3.60	2.88
6	1597.4	9.30	774.00	0.16	12.90	10.32
7	1597.4	9.30	1332.00	0.16	22.20	17.76
8	1597.5	20.20	2544.00	0.34	42.40	33.92
9	1597.6	33.70	4566.00	0.56	76.10	60.88
10	1597.6	33.70	6588.00	0.56	109.80	87.84
11	1597.7	49.30	9546.00	0.82	159.10	127.28
12	1597.7	49.30	12504.00	0.82	208.40	166.72
13	1597.7	49.30	15462.00	0.82	257.70	206.16
14	1597.8	67.30	19500.00	1.12	325.00	260.00
15	1597.8	67.30	23538.00	1.12	392.30	313.84
16	1597.8	67.30	27576.00	1.12	459.60	367.68
17	1597.9	87.40	32820.00	1.46	547.00	437.60
18	1597.9	87.40	38064.00	1.46	634.40	507.52
19	1597.9	87.40	43308.00	1.46	721.80	577.44
20	1597.9	87.40	48552.00	1.46	809.20	647.36
21	1597.9	87.40	53796.00	1.46	896.60	717.28
22	1597.9	87.40	59040.00	1.46	984.00	787.20
23	1597.9	87.40	64284.00	1.46	1071.40	857.12
24	1597.9	87.40	69528.00	1.46	1158.80	927.04
25	1598	109.90	76122.00	1.83	1268.70	1014.96
26	1598	109.90	82716.00	1.83	1378.60	1102.88
27	1598	109.90	89310.00	1.83	1488.50	1190.80
28	1598	109.90	95904.00	1.83	1598.40	1278.72
29	1598	109.90	102498.00	1.83	1708.30	1366.64
30	1598	109.90	109092.00	1.83	1818.20	1454.56
31	1598	109.90	115686.00	1.83	1928.10	1542.48
32	1598	109.90	122280.00	1.83	2038.00	1630.40
33	1598	109.90	128874.00	1.83	2147.90	1718.32
34	1598	109.90	135468.00	1.83	2257.80	1806.24

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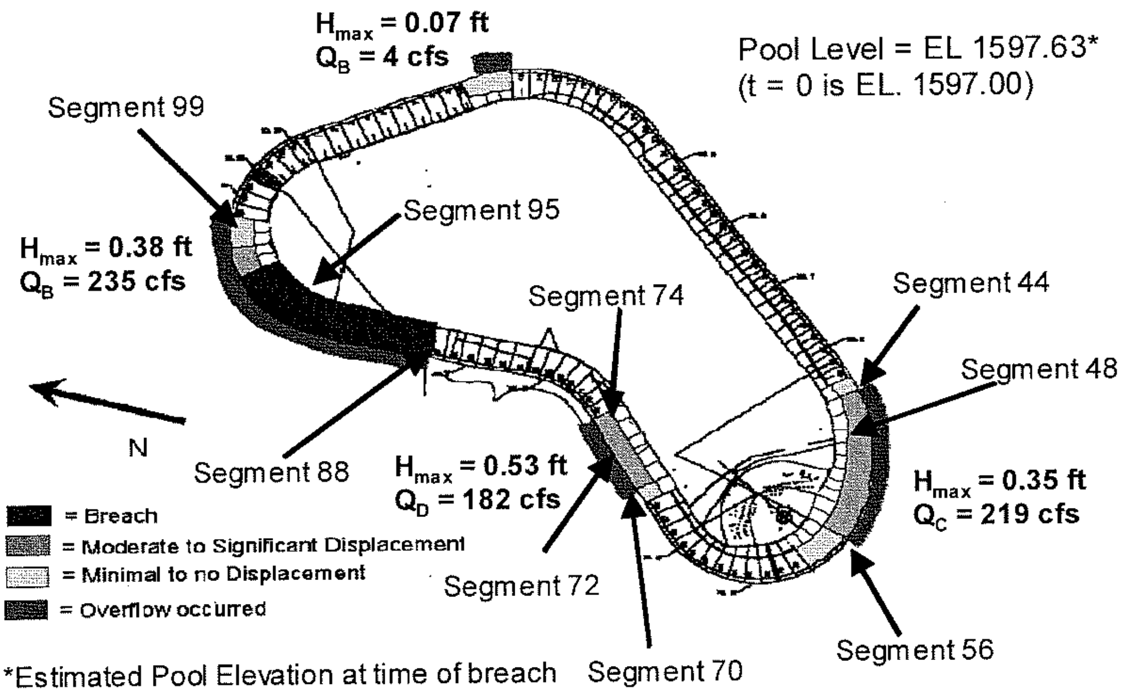
Summary of Results:

Based on the estimated top of wall elevations and the estimated reservoir elevation at the time of failure of 1597.63 overtopping will occur in four areas. Wall segments overtopped at reservoir elevation 1597.63 and the overtopping flow for each area at elevation 1597.00 to 1599.00 are listed in Table 2. The lowest wall segment in each overtopped section is also listed; wall segment 95 is the lowest in the breached area.

Figure 1

Estimated Overflow at Time = 10 min 20 sec



By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 6 of 39
Chkd. By: SM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

TABLE 2

TAUM SAUK UPPER RESERVOIR
ESTIMATED FLOW OVER WALL SEGMENTS

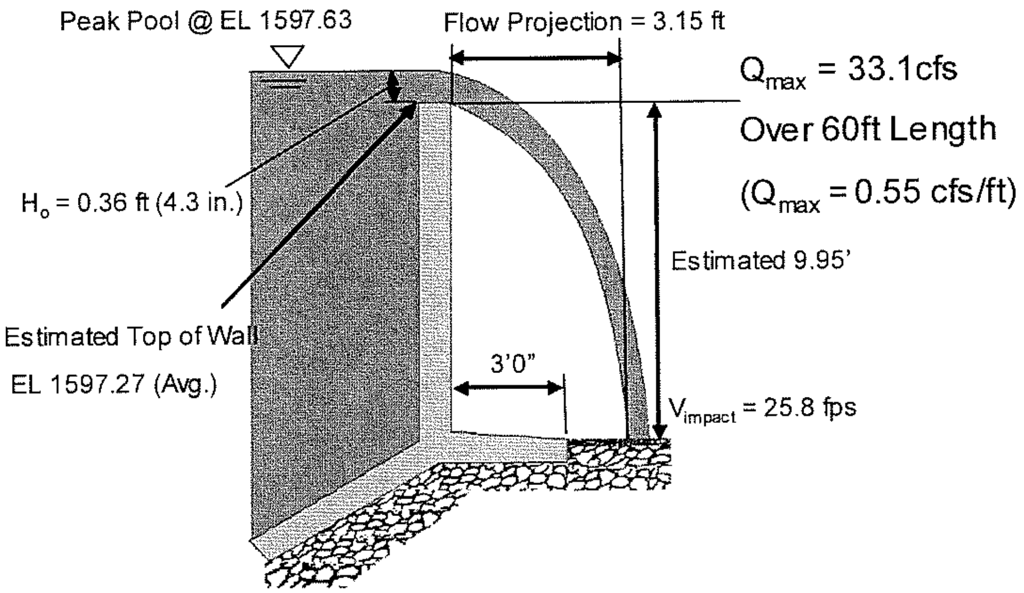
(segments grouped by pre-existing low sections)

GROUP	"A" (Breached)	"B"	"C"	"D"	ALL SEGMENTS	FLOW TO STORAGE
Lowest Wall Segment	Segment 95	Segment 12	Segment 49	Segment 72		
T.O.W.(EL)	1597.25	1597.56	1597.28	1597.1		
Overtopped @EL 1579.63	Segments 89 - 99	Segments 11 - 12	Segments 44 - 53	Segments 70 - 74		
Pool Level (EL)	Q_A (cfs)	Q_B (cfs)	Q_C (cfs)	Q_D (cfs)	$Q_{OVERFLOW}$ (cfs)	$Q_{STORAGE}$ (cfs)
1597.00	-	-	-	-	-	
1597.10	-	-	-	-	-	
1597.20	-	-	-	10.70	10.70	2,589.30
1597.30	2.7	-	1.2	31.80	35.70	2,564.30
1597.40	33.5	-	23.9	64.60	122.00	2,478.00
1597.50	99.7	-	84.7	107.00	291.40	2,308.60
1597.60	198.1	1.40	183.1	162.60	545.20	2,054.80
1597.63	234.5	4.10	218.6	181.70	638.90	1,961.10
1597.70	333.1	15.60	314.3	230.10	893.10	1,706.90
1597.80	509.8	59.10	482.5	308.10	1,359.50	1,240.50
1597.90	730.2	159.90	690.5	397.50	1,978.10	621.90
1597.98	939.3	293.40	883.4	483.90	2,600.00	-
1598.00	1,002.8	339.00	940.9	509.70	2,792.40	-
1598.10	1,333.1	614.00	1,241.9	649.70	3,838.70	-
1598.20	1,724.4	987.50	1,599.8	815.90	5,127.60	-
1598.30	2,178.7	1,459.70	2,007.0	1,005.90	6,651.30	-
1598.40	2,701.3	2,016.50	2,460.8	1,215.00	8,393.60	-
1598.50	3,297.3	2,654.90	2,962.2	1,443.30	10,357.70	-
1598.60	3,954.9	3,372.60	3,508.2	1,687.80	12,523.50	-
1598.70	4,671.8	4,175.20	4,093.5	1,950.40	14,890.90	-
1598.80	5,442.6	5,059.40	4,717.7	2,227.00	17,446.70	-
1598.90	6,259.9	6,029.80	5,375.1	2,517.40	20,182.20	-
1599.00	7,121.5	7,082.00	6,060.4	2,823.00	23,086.90	-

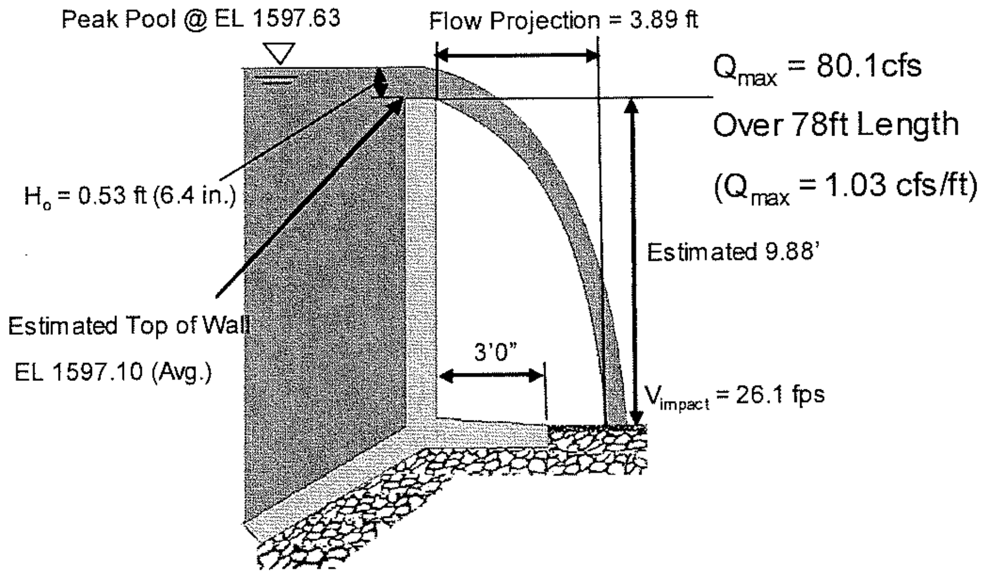
G:\paulm\06-3551 - Taum Sauk Dam\Taum Sauk - Reservoir Overflow 4 (REVISED jd 2-06).xls

The flow projection and impact velocity of overtopping flow for a reservoir elevation of 1597.63 at wall segments 48, 72 and 95 are shown in the figures below.

Wall Segment 48 at Time = 10 min 20 sec

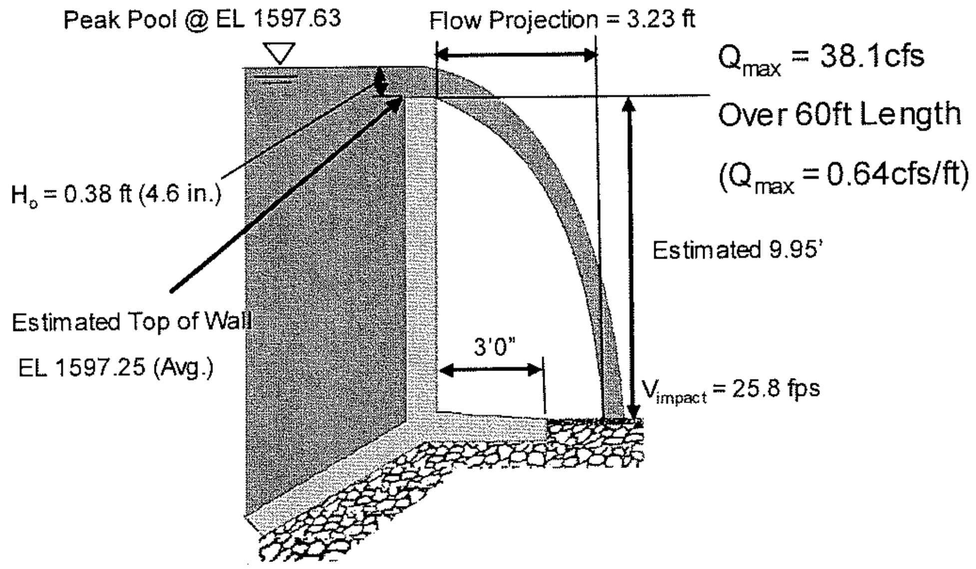


Wall Segment 72 at Time = 10 min 20 sec



By: TD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 8 of 39
Chkd. By: JM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

Wall Segment 95 at Time = 10 min 20 sec



Conclusions:

Overtopping would occur in four areas at a reservoir elevation of 1597.63. The greatest total flow would occur in the area of the breach. At the lower wall segments, flow overtopping the wall extends past the toe of the concrete parapet wall and strikes the crest of the rockfill berm which could cause undermining.

ATTACHMENTS

Attachment A

Weir Coefficients

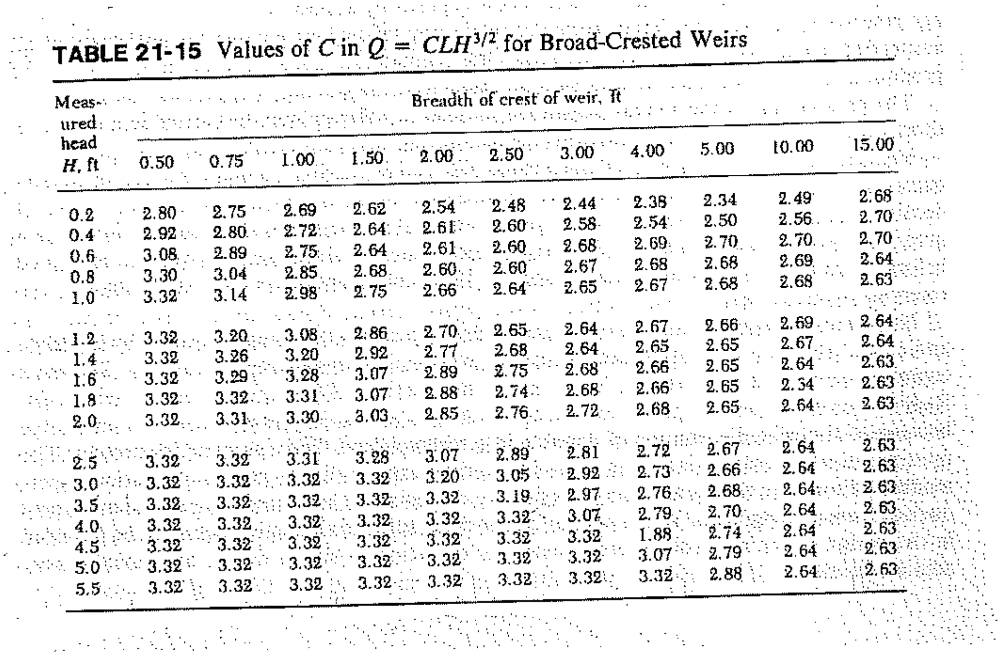


TABLE 21-15 Values of C in $Q = CLH^{3/2}$ for Broad-Crested Weirs

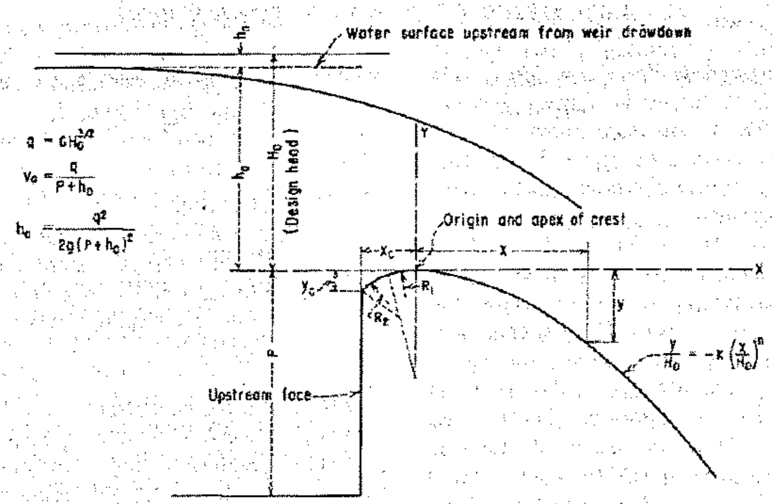
Measured head H, ft	Breadth of crest of weir, ft										
	0.50	0.75	1.00	1.50	2.00	2.50	3.00	4.00	5.00	10.00	15.00
0.2	2.80	2.75	2.69	2.62	2.54	2.48	2.44	2.38	2.34	2.49	2.68
0.4	2.92	2.80	2.72	2.64	2.61	2.60	2.58	2.54	2.50	2.56	2.70
0.6	3.08	2.89	2.75	2.64	2.61	2.60	2.68	2.69	2.70	2.70	2.70
0.8	3.30	3.04	2.85	2.68	2.60	2.60	2.67	2.68	2.68	2.69	2.64
1.0	3.32	3.14	2.98	2.75	2.66	2.64	2.65	2.67	2.68	2.68	2.63
1.2	3.32	3.20	3.08	2.86	2.70	2.65	2.64	2.67	2.66	2.69	2.64
1.4	3.32	3.26	3.20	2.92	2.77	2.68	2.64	2.65	2.65	2.67	2.64
1.6	3.32	3.29	3.28	3.07	2.89	2.75	2.68	2.66	2.65	2.64	2.63
1.8	3.32	3.32	3.31	3.07	2.88	2.74	2.68	2.66	2.65	2.34	2.63
2.0	3.32	3.31	3.30	3.03	2.85	2.76	2.72	2.68	2.65	2.64	2.63
2.5	3.32	3.32	3.31	3.28	3.07	2.89	2.81	2.72	2.67	2.64	2.63
3.0	3.32	3.32	3.32	3.32	3.20	3.05	2.92	2.73	2.66	2.64	2.63
3.5	3.32	3.32	3.32	3.32	3.32	3.19	2.97	2.76	2.68	2.64	2.63
4.0	3.32	3.32	3.32	3.32	3.32	3.32	3.07	2.79	2.70	2.64	2.63
4.5	3.32	3.32	3.32	3.32	3.32	3.32	3.32	1.88	2.74	2.64	2.63
5.0	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.07	2.79	2.64	2.63
5.5	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	2.88	2.64	2.63

Reference 2

Attachment B

Nappe Flow Projection from Parapet Wall

366 DESIGN OF SMALL DAMS



(A) ELEMENTS OF NAPPE-SHAPED CREST PROFILES

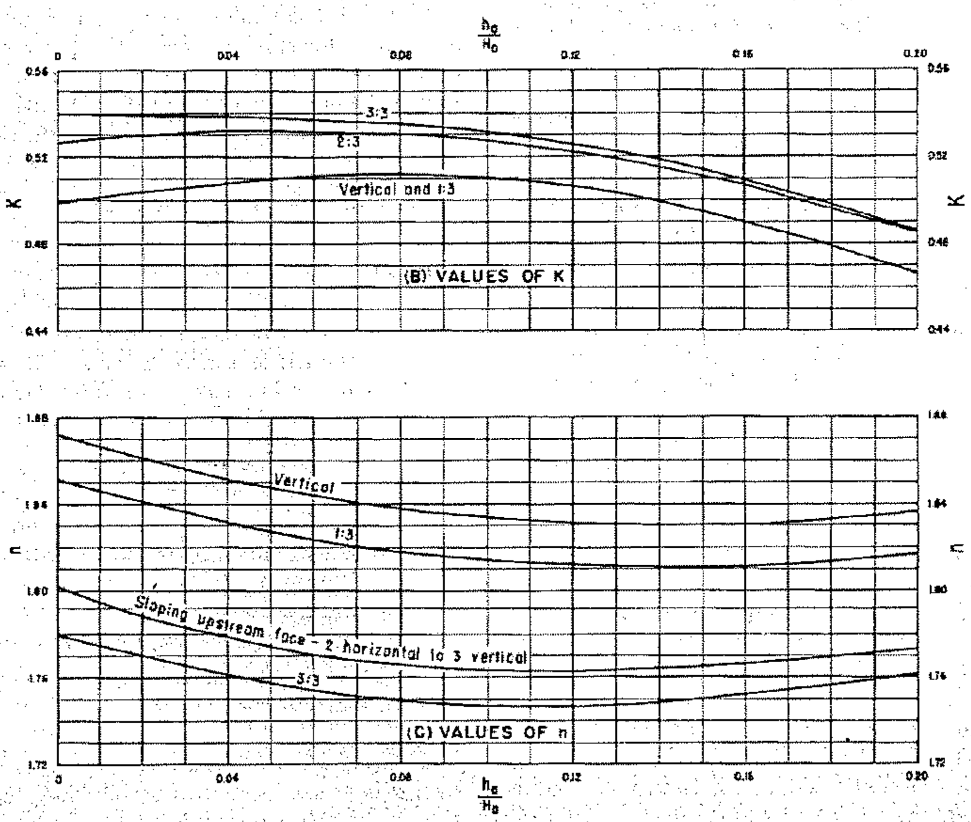


Figure 9-21.—Factors for definition of nappe-shaped crest profiles. 288-D-2406. (Sheet 1 of 2).

Reference 3

Attachment C

Estimation of Top of Wall Elevations in Breached Section

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 15 of 39
Chkd. By: PM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

Estimation of Top of Wall Elevations

Monument Number	11/19/2003 Elevation	12/20/2005 Elevation	Change in Elevation	Wall Panel Number	12/20/2005 EL. T/Wall	Wall Height	Estimated Wall Height	Estimated Settlement	Estimated EL. T/Wall
1	1588.010	1587.950	-0.060	5	1597.770	9.820			
2	1587.920	1587.840	-0.080	10	1597.650	9.810			
3	1587.980	1587.910	-0.070	15	1597.740	9.830			
4	1588.090	1588.040	-0.050	20	1597.890	9.850			
5	1588.250	1588.200	-0.050	25	1598.080	9.880			
6	1588.410	1588.370	-0.040	30	1598.250	9.880			
7	1588.650	1588.570	-0.080	35	1598.430	9.860			
8	1588.220	1588.150	-0.070	40	1598.200	10.050			
9	1587.500	1587.430	-0.070	45	1597.380	9.950			
9A	1587.380			49	1597.280				
10	1587.360	1587.300	-0.060	50	1597.370	10.070			
11	1587.790	1587.730	-0.060	55	1597.750	10.020			
12	1588.330	1588.250	-0.080	60	1598.230	9.980			
13	1588.120	1588.090	-0.030	65	1598.130	10.040			
14	1587.680	1587.620	-0.060	70	1597.500	9.880			
15	1588.110			75	1597.920		9.951	-0.090	1597.971
16	1588.550			80			9.951	-0.090	1598.411
17	1588.330			85			9.951	-0.090	1598.191
18	1587.490			90			9.951	-0.090	1597.351
19	1587.390			95			9.951	-0.090	1597.251
20	1587.700	1587.630	-0.070	100	1597.690	10.060			
21	1588.090	1588.030	-0.060	105	1598.200	10.170			
22	1588.310	1588.220	-0.090	107	1598.220	10.000			
23	1588.150	1588.070	-0.080	110	1598.030	9.960			

Attachment D

HEC-HMS Results

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Overflow Conditions Sheet No. 17 of 39
Chkd. By: FM Date: 3/7/06 Proj. No. 06-3551

HMS * Summary of Results for Reservoir-1

Project : Taum Sauk Run Name : Run 2

Start of Run : 14Dec05 0000 Basin Model : Upper Res-2
End of Run : 14Dec05 0500 Met. Model : Met 1
Execution Time : 25Feb06 1648 Control Specs : Control 1

Date	Time	Reservoir Storage (ac-ft)	Reservoir Elevation (ft)		Inflow (cfs)	Outflow (cfs)
13 Dec 05	2400	0.000	1597.0	0	2600.0	0.0
14 Dec 05	0001	3.581	1597.1	0	2600.0	0.0
14 Dec 05	0002	7.160	1597.1		2600.0	3.1
14 Dec 05	0003	10.733	1597.2	0	2600.0	10.0
14 Dec 05	0004	14.290	1597.3	1.8	2600.0	25.1
14 Dec 05	0005	17.817	1597.3	4.23	2600.0	53.9
14 Dec 05	0006	21.287	1597.4		2600.0	107.8
14 Dec 05	0007	24.658	1597.4	9.3	2600.0	197.0
14 Dec 05	0008	27.898	1597.5	20.2	2600.0	298.2
14 Dec 05	0009	30.972	1597.6		2600.0	438.8
14 Dec 05	0010	33.854	1597.6	33.7	2600.0	576.4
14 Dec 05	0011	36.528	1597.7	49.3	2600.0	741.2
14 Dec 05	0012	38.976	1597.7		2600.0	903.9
14 Dec 05	0013	41.185	1597.7		2600.0	1089.3
14 Dec 05	0014	43.152	1597.8		2600.0	1254.5
14 Dec 05	0015	44.895	1597.8	67.3	2600.0	1414.4
14 Dec 05	0016	46.412	1597.8		2600.0	1583.5
14 Dec 05	0017	47.712	1597.9		2600.0	1728.4
14 Dec 05	0018	48.827	1597.9		2600.0	1852.7
14 Dec 05	0019	49.783	1597.9		2600.0	1959.3
14 Dec 05	0020	50.551	1597.9		2600.0	2067.7
14 Dec 05	0021	51.259	1597.9		2600.0	2161.4
14 Dec 05	0022	51.810	1597.9		2600.0	2238.6
14 Dec 05	0023	52.264	1597.9	87.9	2600.0	2302.2
14 Dec 05	0024	52.638	1597.9		2600.0	2354.7
14 Dec 05	0025	52.946	1598.0		2600.0	2397.8
14 Dec 05	0026	53.200	1598.0		2600.0	2433.4
14 Dec 05	0027	53.410	1598.0	109.9	2600.0	2462.6
14 Dec 05	0028	53.582	1598.0		2600.0	2486.9
14 Dec 05	0029	53.724	1598.0		2600.0	2506.8
14 Dec 05	0030	53.841	1598.0		2600.0	2523.2
14 Dec 05	0031	53.938	1598.0		2600.0	2536.7
14 Dec 05	0032	54.017	1598.0		2600.0	2547.9
14 Dec 05	0033	54.082	1598.0		2600.0	2557.1
14 Dec 05	0034	54.136	1598.0		2600.0	2564.6
14 Dec 05	0035	54.181	1598.0		2600.0	2570.8
14 Dec 05	0036	54.218	1598.0		2600.0	2576.0
14 Dec 05	0037	54.248	1598.0		2600.0	2580.2
14 Dec 05	0038	54.273	1598.0		2600.0	2583.7
14 Dec 05	0039	54.293	1598.0		2600.0	2586.6
14 Dec 05	0040	54.310	1598.0		2600.0	2588.9

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 18 of 39
Chkd. By: PM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

Date	Time	Reservoir Storage (ac-ft)	Reservoir Elevation (ft)	Inflow (cfs)	Outflow (cfs)
14 Dec 05	0041	54.324	1598.0	2600.0	2590.9
14 Dec 05	0042	54.335	1598.0	2600.0	2592.5
14 Dec 05	0043	54.345	1598.0	2600.0	2593.8
14 Dec 05	0044	54.353	1598.0	2600.0	2594.9
14 Dec 05	0045	54.359	1598.0	2600.0	2595.8
14 Dec 05	0046	54.364	1598.0	2600.0	2596.5
14 Dec 05	0047	54.369	1598.0	2600.0	2597.1
14 Dec 05	0048	54.372	1598.0	2600.0	2597.6
14 Dec 05	0049	54.375	1598.0	2600.0	2598.1
14 Dec 05	0050	54.378	1598.0	2600.0	2598.4
14 Dec 05	0051	54.380	1598.0	2600.0	2598.7
14 Dec 05	0052	54.381	1598.0	2600.0	2598.9
14 Dec 05	0053	54.383	1598.0	2600.0	2599.1
14 Dec 05	0054	54.384	1598.0	2600.0	2599.3
14 Dec 05	0055	54.385	1598.0	2600.0	2599.4
14 Dec 05	0056	54.385	1598.0	2600.0	2599.5
14 Dec 05	0057	54.386	1598.0	2600.0	2599.6
14 Dec 05	0058	54.386	1598.0	2600.0	2599.7
14 Dec 05	0059	54.387	1598.0	2600.0	2599.7
14 Dec 05	0100	54.387	1598.0	2600.0	2599.8
14 Dec 05	0101	54.388	1598.0	2600.0	2599.8
14 Dec 05	0102	54.388	1598.0	2600.0	2599.8
14 Dec 05	0103	54.388	1598.0	2600.0	2599.9
14 Dec 05	0104	54.388	1598.0	2600.0	2599.9
14 Dec 05	0105	54.388	1598.0	2600.0	2599.9
14 Dec 05	0106	54.388	1598.0	2600.0	2599.9
14 Dec 05	0107	54.388	1598.0	2600.0	2599.9
14 Dec 05	0108	54.389	1598.0	2600.0	2600.0
14 Dec 05	0109	54.389	1598.0	2600.0	2600.0
14 Dec 05	0110	54.389	1598.0	2600.0	2600.0
14 Dec 05	0111	54.389	1598.0	2600.0	2600.0
14 Dec 05	0112	54.389	1598.0	2600.0	2600.0
14 Dec 05	0113	54.389	1598.0	2600.0	2600.0
14 Dec 05	0114	54.389	1598.0	2600.0	2600.0
14 Dec 05	0115	54.389	1598.0	2600.0	2600.0
14 Dec 05	0116	54.389	1598.0	2600.0	2600.0
14 Dec 05	0117	54.389	1598.0	2600.0	2600.0
14 Dec 05	0118	54.389	1598.0	2600.0	2600.0
14 Dec 05	0119	54.389	1598.0	2600.0	2600.0
14 Dec 05	0120	54.389	1598.0	2600.0	2600.0
14 Dec 05	0121	54.389	1598.0	2600.0	2600.0
14 Dec 05	0122	54.389	1598.0	2600.0	2600.0
14 Dec 05	0123	54.389	1598.0	2600.0	2600.0
14 Dec 05	0124	54.389	1598.0	2600.0	2600.0
14 Dec 05	0125	54.389	1598.0	2600.0	2600.0
14 Dec 05	0126	54.389	1598.0	2600.0	2600.0
14 Dec 05	0127	54.389	1598.0	2600.0	2600.0
14 Dec 05	0128	54.389	1598.0	2600.0	2600.0
14 Dec 05	0129	54.389	1598.0	2600.0	2600.0
14 Dec 05	0130	54.389	1598.0	2600.0	2600.0
14 Dec 05	0131	54.389	1598.0	2600.0	2600.0

Attachment E

Parapet Wall Overflow Calculations

(G:\paulm\06-3551 – Taum Sauk Dam\Taum Sauk Reservoir Overflow 4 (REVISED jd 2-06).xls)

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Overflow Conditions Sheet No. 20 of 39
Chkd. By: Date: 3/7/06 Proj. No. 06-3551

Panel	1			2			3			4			5			6		
Data	T.O.W.(EL) = 1598.00 L (ft) = 75			T.O.W.(EL) = 1597.98 L (ft) = 60			T.O.W.(EL) = 1597.90 L (ft) = 60			T.O.W.(EL) = 1597.83 L (ft) = 60			T.O.W.(EL) = 1597.77 L (ft) = 60			T.O.W.(EL) = 1597.79 L (ft) = 60		
Pool Level (EL)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
1597.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.80	-	-	-	-	-	-	-	-	-	-	-	-	0.03	2.66	**0.8**	0.01	2.65	**0.2**
1597.90	-	-	-	-	-	-	-	-	-	0.07	2.67	**3.0**	0.13	2.68	**7.5**	0.11	2.68	**5.9**
1597.98	-	-	-	-	-	-	0.08	2.67	**3.5**	0.15	2.68	**9.2**	0.21	2.69	**15.4**	0.19	2.69	**13.2**
1598.00	-	-	-	0.02	2.65	**0.4**	0.10	2.68	**5.1**	0.17	2.69	**11.3**	0.23	2.69	**17.8**	0.21	2.69	**15.5**
1598.10	0.10	2.68	**6.4**	0.12	2.68	**6.7**	0.20	2.69	**14.4**	0.27	2.70	**22.7**	0.33	2.70	**30.7**	0.31	2.70	**28.0**
1598.20	0.20	2.69	**18.0**	0.22	2.69	**16.7**	0.30	2.70	**26.6**	0.37	2.71	**36.6**	0.43	2.72	**46.0**	0.41	2.72	**42.8**
1598.30	0.30	2.70	**33.3**	0.32	2.70	**29.3**	0.40	2.71	**41.1**	0.47	2.73	**52.8**	0.53	2.74	**63.4**	0.51	2.73	**59.7**
1598.40	0.40	2.71	**51.4**	0.42	2.72	**44.4**	0.50	2.73	**57.9**	0.57	2.75	**71.0**	0.63	2.77	**83.1**	0.61	2.76	**78.9**
1598.50	0.50	2.73	**72.4**	0.52	2.74	**61.6**	0.60	2.76	**77.0**	0.67	2.79	**91.8**	0.73	2.81	**105.2**	0.71	2.80	**100.5**
1598.60	0.60	2.76	**96.2**	0.62	2.77	**81.1**	0.70	2.80	**98.4**	0.77	2.83	**114.7**	0.83	2.86	**129.8**	0.81	2.85	**124.7**
1598.70	0.70	2.80	**123.0**	0.72	2.81	**103.0**	0.80	2.85	**122.4**	0.87	2.89	**140.7**	0.93	2.92	**157.1**	0.91	2.91	**151.6**
1598.80	0.80	2.85	**152.9**	0.82	2.86	**127.4**	0.90	2.90	**148.6**	0.97	2.95	**169.1**	1.03	2.99	**187.5**	1.01	2.97	**180.9**
1598.90	0.90	2.90	**185.7**	0.92	2.92	**154.6**	1.00	2.97	**178.2**	1.07	3.01	**199.9**	1.13	3.05	**219.8**	1.11	3.04	**213.3**
1599.00	1.00	2.97	**222.7**	1.02	2.98	**184.2**	1.10	3.03	**209.7**	1.17	3.07	**233.1**	1.23	3.11	**254.5**	1.21	3.10	**247.6**

(21)

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 21 of 39
Chkd. By: Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

7			8			9			11A			10			11		
T.O.W.(EL) =		1597.91	T.O.W.(EL) =		1597.75	T.O.W.(EL) =		1597.73	T.O.W.(EL) =		1597.72	T.O.W.(EL) =		1597.65	T.O.W.(EL) =		1597.59
	L (ft) =	60		L (ft) =	60		L (ft) =	58		L (ft) =	29		L (ft) =	61		L (ft) =	58
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	2.65	**0.2**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	2.66	**1.2**
-	-	-	-	-	-	-	-	-	-	-	-	0.05	2.66	**1.8**	0.11	2.68	**5.7**
-	-	-	0.05	2.66	**1.8**	0.07	2.67	**2.9**	0.08	2.67	**1.8**	0.15	2.68	**9.5**	0.21	2.69	**15.0**
-	-	-	0.15	2.68	**9.3**	0.17	2.69	**10.9**	0.18	2.69	**6.0**	0.25	2.70	**20.6**	0.31	2.70	**27.0**
0.07	2.67	**2.9**	0.23	2.69	**17.6**	0.25	2.70	**19.4**	0.26	2.70	**10.3**	0.33	2.70	**31.0**	0.39	2.71	**38.1**
0.09	2.67	**4.3**	0.25	2.70	**20.2**	0.27	2.70	**22.0**	0.28	2.70	**11.6**	0.35	2.71	**34.2**	0.41	2.72	**41.4**
0.19	2.69	**13.4**	0.35	2.71	**33.7**	0.37	2.71	**35.4**	0.38	2.71	**18.4**	0.45	2.72	**50.1**	0.51	2.73	**57.7**
0.29	2.70	**25.3**	0.45	2.72	**49.3**	0.47	2.73	**51.0**	0.48	2.73	**26.3**	0.55	2.75	**68.4**	0.61	2.76	**76.3**
0.39	2.71	**39.6**	0.55	2.75	**67.3**	0.57	2.75	**68.6**	0.58	2.75	**35.2**	0.65	2.78	**88.9**	0.71	2.80	**97.2**
0.49	2.73	**56.2**	0.65	2.78	**87.4**	0.67	2.79	**88.7**	0.68	2.79	**45.4**	0.75	2.82	**111.7**	0.81	2.85	**120.5**
0.59	2.76	**75.0**	0.75	2.82	**109.9**	0.77	2.83	**110.9**	0.78	2.84	**56.7**	0.85	2.88	**137.7**	0.91	2.91	**146.5**
0.69	2.80	**96.3**	0.85	2.88	**135.4**	0.87	2.89	**136.0**	0.88	2.89	**69.2**	0.95	2.94	**166.1**	1.01	2.97	**174.9**
0.79	2.84	**119.6**	0.95	2.94	**163.3**	0.97	2.95	**163.5**	0.98	2.95	**83.0**	1.05	3.00	**196.9**	1.11	3.04	**206.2**
0.89	2.90	**146.1**	1.05	3.00	**193.7**	1.07	3.01	**193.2**	1.08	3.02	**98.3**	1.15	3.06	**230.2**	1.21	3.10	**239.3**
0.99	2.96	**174.9**	1.15	3.06	**226.4**	1.17	3.07	**225.3**	1.18	3.08	**114.5**	1.25	3.12	**266.0**	1.31	3.16	**274.8**
1.09	3.02	**206.2**	1.25	3.12	**261.6**	1.27	3.13	**259.8**	1.28	3.14	**131.9**	1.35	3.18	**304.3**	1.41	3.21	**311.7**

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By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Overflow Conditions Sheet No. 22 of 39
Chkd. By: PRM Date: 3/7/06 Proj. No. 06-3551

12			13			14			15			16			17		
T.O.W.(EL) =		1597.56	T.O.W.(EL) =		1597.73	T.O.W.(EL) =		1597.72	T.O.W.(EL) =		1597.74	T.O.W.(EL) =		1597.80	T.O.W.(EL) =		1597.90
L (ft) =		58	L (ft) =		65	L (ft) =		58	L (ft) =		50	L (ft) =		58	L (ft) =		54
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.04	2.66	**1.2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.07	2.67	**2.9**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.14	2.68	**8.1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.24	2.70	**18.4**	0.07	2.67	**3.2**	0.08	2.67	**3.5**	0.06	2.67	**2.0**	-	-	-	-	-	-
0.34	2.71	**31.2**	0.17	2.69	**12.3**	0.18	2.69	**11.9**	0.16	2.69	**8.6**	0.10	2.68	**4.9**	-	-	-
0.42	2.72	**42.7**	0.25	2.70	**21.8**	0.26	2.70	**20.6**	0.24	2.70	**15.7**	0.18	2.69	**11.8**	0.08	2.67	**3.2**
0.44	2.72	**46.0**	0.27	2.70	**24.6**	0.28	2.70	**23.2**	0.26	2.70	**17.9**	0.20	2.69	**14.0**	0.10	2.68	**4.6**
0.54	2.74	**63.1**	0.37	2.71	**39.6**	0.38	2.71	**36.8**	0.36	2.71	**29.3**	0.30	2.70	**25.7**	0.20	2.69	**13.0**
0.64	2.77	**82.3**	0.47	2.73	**57.2**	0.48	2.73	**52.7**	0.46	2.72	**42.4**	0.40	2.71	**39.8**	0.30	2.70	**24.0**
0.74	2.82	**104.1**	0.57	2.75	**76.9**	0.58	2.75	**70.5**	0.56	2.75	**57.6**	0.50	2.73	**56.0**	0.40	2.71	**37.0**
0.84	2.87	**128.2**	0.67	2.79	**99.5**	0.68	2.79	**90.7**	0.66	2.78	**74.5**	0.60	2.76	**74.4**	0.50	2.73	**52.1**
0.94	2.93	**154.9**	0.77	2.83	**124.3**	0.78	2.84	**113.5**	0.76	2.83	**93.8**	0.70	2.80	**95.1**	0.60	2.76	**69.3**
1.04	2.99	**183.9**	0.87	2.89	**152.4**	0.88	2.89	**138.4**	0.86	2.88	**114.8**	0.80	2.85	**118.3**	0.70	2.80	**88.6**
1.14	3.06	**216.0**	0.97	2.95	**183.2**	0.98	2.95	**166.0**	0.96	2.94	**138.3**	0.90	2.90	**143.6**	0.80	2.85	**110.1**
1.24	3.12	**249.9**	1.07	3.01	**216.5**	1.08	3.02	**196.6**	1.06	3.00	**163.7**	1.00	2.97	**172.3**	0.90	2.90	**133.7**
1.34	3.17	**285.2**	1.17	3.07	**252.5**	1.18	3.08	**229.0**	1.16	3.07	**191.8**	1.10	3.03	**202.7**	1.00	2.97	**160.4**
1.44	3.22	**322.7**	1.27	3.13	**291.2**	1.28	3.14	**263.7**	1.26	3.13	**221.3**	1.20	3.09	**235.6**	1.10	3.03	**188.8**

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall
Chkd. By: Date: 3/7/06 Overflow Conditions

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18			19			20			21			22			23		
T.O.W.(EL) =		1597.88	T.O.W.(EL) =		1597.90	T.O.W.(EL) =		1597.89	T.O.W.(EL) =		1597.89	T.O.W.(EL) =		1597.96	T.O.W.(EL) =		1597.96
	L (ft) =	56		L (ft) =	58		L (ft) =	58		L (ft) =	58		L (ft) =	58		L (ft) =	58
H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.02	2.65	**0.4**	-	-	-	0.01	2.65	**0.2**	0.01	2.65	**0.2**	-	-	-	-	-	-
0.10	2.68	**4.6**	0.08	2.67	**3.4**	0.09	2.67	**4.1**	0.09	2.67	**4.1**	0.02	2.65	**0.4**	0.02	2.65	**0.4**
0.12	2.68	**6.2**	0.10	2.68	**4.9**	0.11	2.68	**5.7**	0.11	2.68	**5.7**	0.04	2.66	**1.2**	0.04	2.66	**1.2**
0.22	2.69	**15.5**	0.20	2.69	**14.0**	0.21	2.69	**15.0**	0.21	2.69	**15.0**	0.14	2.68	**8.1**	0.14	2.68	**8.1**
0.32	2.70	**27.4**	0.30	2.70	**25.7**	0.31	2.70	**27.0**	0.31	2.70	**27.0**	0.24	2.70	**18.4**	0.24	2.70	**18.4**
0.42	2.72	**41.5**	0.40	2.71	**39.8**	0.41	2.72	**41.4**	0.41	2.72	**41.4**	0.34	2.71	**31.2**	0.34	2.71	**31.2**
0.52	2.74	**57.5**	0.50	2.73	**56.0**	0.51	2.73	**57.7**	0.51	2.73	**57.7**	0.44	2.72	**46.0**	0.44	2.72	**46.0**
0.62	2.77	**75.7**	0.60	2.76	**74.4**	0.61	2.76	**76.3**	0.61	2.76	**76.3**	0.54	2.74	**63.1**	0.54	2.74	**63.1**
0.72	2.81	**96.1**	0.70	2.80	**95.1**	0.71	2.80	**97.2**	0.71	2.80	**97.2**	0.64	2.77	**82.3**	0.64	2.77	**82.3**
0.82	2.86	**118.9**	0.80	2.85	**118.3**	0.81	2.85	**120.5**	0.81	2.85	**120.5**	0.74	2.82	**104.1**	0.74	2.82	**104.1**
0.92	2.92	**144.3**	0.90	2.90	**143.6**	0.91	2.91	**146.5**	0.91	2.91	**146.5**	0.84	2.87	**128.2**	0.84	2.87	**128.2**
1.02	2.98	**171.9**	1.00	2.97	**172.3**	1.01	2.97	**174.9**	1.01	2.97	**174.9**	0.94	2.93	**154.9**	0.94	2.93	**154.9**
1.12	3.04	**201.8**	1.10	3.03	**202.7**	1.11	3.04	**206.2**	1.11	3.04	**206.2**	1.04	2.99	**183.9**	1.04	2.99	**183.9**

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By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 24 of 39
Chkd. By: JM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

24			25			26			27			28			29		
T.O.W.(EL) =		1598.03	T.O.W.(EL) =		1598.08	T.O.W.(EL) =		1598.15	T.O.W.(EL) =		1598.14	T.O.W.(EL) =		1598.16	T.O.W.(EL) =		1598.18
L (ft) =		67	L (ft) =		66	L (ft) =		58	L (ft) =		59	L (ft) =		59	L (ft) =		58
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.07	2.67	**3.3**	0.02	2.65	**0.5**	-	-	-	-	-	-	-	-	-	-	-	-
0.17	2.69	**12.6**	0.12	2.68	**7.4**	0.05	2.66	**1.7**	0.06	2.67	**2.3**	0.04	2.66	**1.3**	0.02	2.65	**0.4**
0.27	2.70	**25.4**	0.22	2.69	**18.3**	0.15	2.68	**9.0**	0.16	2.69	**10.2**	0.14	2.68	**8.3**	0.12	2.68	**6.5**
0.37	2.71	**40.9**	0.32	2.70	**32.3**	0.25	2.70	**19.6**	0.26	2.70	**21.1**	0.24	2.70	**18.7**	0.22	2.69	**16.1**
0.47	2.73	**58.9**	0.42	2.72	**48.9**	0.35	2.71	**32.5**	0.36	2.71	**34.5**	0.34	2.71	**31.7**	0.32	2.70	**28.3**
0.57	2.75	**79.3**	0.52	2.74	**67.8**	0.45	2.72	**47.6**	0.46	2.72	**50.1**	0.44	2.72	**46.8**	0.42	2.72	**42.9**
0.67	2.79	**102.5**	0.62	2.77	**89.3**	0.55	2.75	**65.1**	0.56	2.75	**68.0**	0.54	2.74	**64.1**	0.52	2.74	**59.6**
0.77	2.83	**128.1**	0.72	2.81	**113.3**	0.65	2.78	**84.5**	0.66	2.78	**87.9**	0.64	2.77	**83.7**	0.62	2.77	**78.4**
0.87	2.89	**157.1**	0.82	2.86	**140.2**	0.75	2.82	**106.2**	0.76	2.83	**110.6**	0.74	2.82	**105.9**	0.72	2.81	**99.6**
0.97	2.95	**188.8**	0.92	2.92	**170.1**	0.85	2.88	**130.9**	0.86	2.88	**135.5**	0.84	2.87	**130.4**	0.82	2.86	**123.2**

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By: JD Date: 3-7-06 Subject Estimate of Parapet Wall
Chkd. By: PM Date: 3/7/06 Overflow Conditions

Sheet No. 25 of 39
Proj. No. 06-3551

30			31			32			33			34			35		
T.O.W.(EL) =		1598.25	T.O.W.(EL) =		1598.28	T.O.W.(EL) =		1598.35	T.O.W.(EL) =		1598.29	T.O.W.(EL) =		1598.28	T.O.W.(EL) =		1598.43
L (ft) =		60	L (ft) =		60	L (ft) =		68	L (ft) =		59	L (ft) =		58	L (ft) =		60
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	2.66	**1.8**	0.02	2.65	**0.4**	-	-	-	0.01	2.65	**0.2**	0.02	2.65	**0.4**	-	-	-
0.15	2.68	**9.3**	0.12	2.68	**6.7**	0.05	2.66	**2.0**	0.11	2.68	**5.8**	0.12	2.68	**6.5**	-	-	-
0.25	2.70	**20.2**	0.22	2.69	**16.7**	0.15	2.68	**10.6**	0.21	2.69	**15.3**	0.22	2.69	**16.1**	0.07	2.67	**3.0**
0.35	2.71	**33.7**	0.32	2.70	**29.3**	0.25	2.70	**22.9**	0.31	2.70	**27.5**	0.32	2.70	**28.3**	0.17	2.69	**11.3**
0.45	2.72	**49.3**	0.42	2.72	**44.4**	0.35	2.71	**38.2**	0.41	2.72	**42.1**	0.42	2.72	**42.9**	0.27	2.70	**22.7**
0.55	2.75	**67.3**	0.52	2.74	**61.6**	0.45	2.72	**55.8**	0.51	2.73	**58.7**	0.52	2.74	**59.6**	0.37	2.71	**36.6**
0.65	2.78	**87.4**	0.62	2.77	**81.1**	0.55	2.75	**76.3**	0.61	2.76	**77.6**	0.62	2.77	**78.4**	0.47	2.73	**52.8**
0.75	2.82	**109.9**	0.72	2.81	**103.0**	0.65	2.78	**99.1**	0.71	2.80	**98.8**	0.72	2.81	**99.6**	0.57	2.75	**71.0**

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By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 26 of 39
Chkd. By: Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

36			37			38			39			40			41		
T.O.W.(EL) =		1598.61	T.O.W.(EL) =		1598.51	T.O.W.(EL) =		1598.44	T.O.W.(EL) =		1598.36	T.O.W.(EL) =		1598.20	T.O.W.(EL) =		1598.03
	L (ft) =	59		L (ft) =	59		L (ft) =	58		L (ft) =	60		L (ft) =	60		L (ft) =	61
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	2.67	**3.0**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17	2.69	**11.5**
-	-	-	-	-	-	-	-	-	-	-	-	0.10	2.68	**5.1**	0.27	2.70	**23.1**
-	-	-	-	-	-	-	-	-	0.04	2.66	**1.3**	0.20	2.69	**14.4**	0.37	2.71	**37.2**
-	-	-	-	-	-	0.06	2.67	**2.3**	0.14	2.68	**8.4**	0.30	2.70	**26.6**	0.47	2.73	**53.7**
-	-	-	0.09	2.67	**4.3**	0.16	2.69	**10.0**	0.24	2.70	**19.0**	0.40	2.71	**41.1**	0.57	2.75	**72.2**
0.09	2.67	**4.3**	0.19	2.69	**13.1**	0.26	2.70	**20.8**	0.34	2.71	**32.2**	0.50	2.73	**57.9**	0.67	2.79	**93.3**
0.19	2.69	**13.1**	0.29	2.70	**24.9**	0.36	2.71	**34.0**	0.44	2.72	**47.6**	0.60	2.76	**77.0**	0.77	2.83	**116.6**
0.29	2.70	**24.9**	0.39	2.71	**38.9**	0.46	2.72	**49.2**	0.54	2.74	**65.2**	0.70	2.80	**98.4**	0.87	2.89	**143.1**
0.39	2.71	**38.9**	0.49	2.73	**55.2**	0.56	2.75	**66.8**	0.64	2.77	**85.1**	0.80	2.85	**122.4**	0.97	2.95	**171.9**

27

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 27 of 39
Chkd. By: Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

42			43			44			45			46			47		
T.O.W.(EL) =		1597.82	T.O.W.(EL) =		1597.65	T.O.W.(EL) =		1597.50	T.O.W.(EL) =		1597.38	T.O.W.(EL) =		1597.31	T.O.W.(EL) =		1597.31
L (ft) =		60	L (ft) =		60	L (ft) =		60	L (ft) =		59	L (ft) =		60	L (ft) =		60
H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	0.02	2.65	**0.4**	0.09	2.67	**4.3**	0.09	2.67	**4.3**
-	-	-	-	-	-	-	-	-	0.12	2.68	**6.6**	0.19	2.69	**13.4**	0.19	2.69	**13.4**
-	-	-	-	-	-	0.10	2.68	**5.1**	0.22	2.69	**16.4**	0.29	2.70	**25.3**	0.29	2.70	**25.3**
-	-	-	-	-	-	0.13	2.68	**7.5**	0.25	2.70	**19.9**	0.32	2.70	**29.3**	0.32	2.70	**29.3**
-	-	-	0.05	2.66	**1.8**	0.20	2.69	**14.4**	0.32	2.70	**28.8**	0.39	2.71	**39.6**	0.39	2.71	**39.6**
-	-	-	0.15	2.68	**9.3**	0.30	2.70	**26.6**	0.42	2.72	**43.7**	0.49	2.73	**56.2**	0.49	2.73	**56.2**
0.08	2.67	**3.6**	0.25	2.70	**20.2**	0.40	2.71	**41.1**	0.52	2.74	**60.6**	0.59	2.76	**75.0**	0.59	2.76	**75.0**
0.16	2.69	**10.2**	0.33	2.70	**30.5**	0.48	2.73	**54.2**	0.60	2.76	**75.4**	0.67	2.79	**91.5**	0.67	2.79	**91.5**
0.18	2.69	**12.3**	0.35	2.71	**33.7**	0.50	2.73	**57.9**	0.62	2.77	**79.8**	0.69	2.80	**96.3**	0.69	2.80	**96.3**
0.28	2.70	**24.0**	0.45	2.72	**49.3**	0.60	2.76	**77.0**	0.72	2.81	**101.3**	0.79	2.84	**119.6**	0.79	2.84	**119.6**
0.38	2.71	**38.1**	0.55	2.75	**67.3**	0.70	2.80	**98.4**	0.82	2.86	**125.3**	0.89	2.90	**146.1**	0.89	2.90	**146.1**
0.48	2.73	**54.5**	0.65	2.78	**87.4**	0.80	2.85	**122.4**	0.92	2.92	**152.0**	0.99	2.96	**174.9**	0.99	2.96	**174.9**
0.58	2.75	**72.9**	0.75	2.82	**109.9**	0.90	2.90	**148.6**	1.02	2.98	**181.1**	1.09	3.02	**206.2**	1.09	3.02	**206.2**
0.68	2.79	**93.9**	0.85	2.88	**135.4**	1.00	2.97	**178.2**	1.12	3.04	**212.6**	1.19	3.09	**240.7**	1.19	3.09	**240.7**
0.78	2.84	**117.4**	0.95	2.94	**163.3**	1.10	3.03	**209.7**	1.22	3.11	**247.3**	1.29	3.15	**276.9**	1.29	3.15	**276.9**
0.88	2.89	**143.1**	1.05	3.00	**193.7**	1.20	3.09	**243.7**	1.32	3.16	**282.7**	1.39	3.20	**314.6**	1.39	3.20	**314.6**
0.98	2.95	**171.7**	1.15	3.06	**226.4**	1.30	3.15	**280.1**	1.42	3.21	**320.5**	1.49	3.24	**353.6**	1.49	3.24	**353.6**
1.08	3.02	**203.4**	1.25	3.12	**261.6**	1.40	3.20	**318.0**	1.52	3.25	**359.3**	1.59	3.27	**393.4**	1.59	3.27	**393.4**
1.18	3.08	**236.9**	1.35	3.18	**299.3**	1.50	3.24	**357.1**	1.62	3.27	**397.8**	1.69	3.29	**433.7**	1.69	3.29	**433.7**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 28 of 39
Chkd. By: Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

48			49			50			51			52			53		
T.O.W.(EL) =		1597.27	T.O.W.(EL) =		1597.28	T.O.W.(EL) =		1597.37	T.O.W.(EL) =		1597.41	T.O.W.(EL) =		1597.49	T.O.W.(EL) =		1597.40
	L (ft) =	60		L (ft) =	59		L (ft) =	60		L (ft) =	60		L (ft) =	60		L (ft) =	60
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.03	2.66	**0.8**	0.02	2.65	**0.4**	-	-	-	-	-	-	-	-	-	-	-	-
0.13	2.68	**7.5**	0.12	2.68	**6.6**	0.03	2.66	**0.8**	-	-	-	-	-	-	-	-	-
0.23	2.69	**17.8**	0.22	2.69	**16.4**	0.13	2.68	**7.5**	0.09	2.67	**4.3**	0.01	2.65	**0.2**	0.10	2.68	**5.1**
0.33	2.70	**30.7**	0.32	2.70	**28.8**	0.23	2.69	**17.8**	0.19	2.69	**13.4**	0.11	2.68	**5.9**	0.20	2.69	**14.4**
0.36	2.71	**35.1**	0.35	2.71	**33.1**	0.26	2.70	**21.5**	0.22	2.69	**16.7**	0.14	2.68	**8.4**	0.23	2.69	**17.8**
0.43	2.72	**46.0**	0.42	2.72	**43.7**	0.33	2.70	**30.7**	0.29	2.70	**25.3**	0.21	2.69	**15.5**	0.30	2.70	**26.6**
0.53	2.74	**63.4**	0.52	2.74	**60.6**	0.43	2.72	**46.0**	0.39	2.71	**39.6**	0.31	2.70	**28.0**	0.40	2.71	**41.1**
0.63	2.77	**83.1**	0.62	2.77	**79.8**	0.53	2.74	**63.4**	0.49	2.73	**56.2**	0.41	2.72	**42.8**	0.50	2.73	**57.9**
0.71	2.80	**100.2**	0.70	2.80	**96.5**	0.61	2.76	**78.6**	0.57	2.75	**70.7**	0.49	2.73	**55.9**	0.58	2.75	**72.6**
0.73	2.81	**105.2**	0.72	2.81	**101.3**	0.63	2.77	**83.1**	0.59	2.76	**75.0**	0.51	2.73	**59.7**	0.60	2.76	**77.0**
0.83	2.86	**129.8**	0.82	2.86	**125.3**	0.73	2.81	**105.2**	0.69	2.80	**96.3**	0.61	2.76	**78.9**	0.70	2.80	**98.4**
0.93	2.92	**157.1**	0.92	2.92	**152.0**	0.83	2.86	**129.8**	0.79	2.84	**119.6**	0.71	2.80	**100.5**	0.80	2.85	**122.4**
1.03	2.99	**187.5**	1.02	2.98	**181.1**	0.93	2.92	**157.1**	0.89	2.90	**146.1**	0.81	2.85	**124.7**	0.90	2.90	**148.6**
1.13	3.05	**219.8**	1.12	3.04	**212.6**	1.03	2.99	**187.5**	0.99	2.96	**174.9**	0.91	2.91	**151.6**	1.00	2.97	**178.2**
1.23	3.11	**254.5**	1.22	3.11	**247.3**	1.13	3.05	**219.8**	1.09	3.02	**206.2**	1.01	2.97	**180.9**	1.10	3.03	**209.7**
1.33	3.17	**291.7**	1.32	3.16	**282.7**	1.23	3.11	**254.5**	1.19	3.09	**240.7**	1.11	3.04	**213.3**	1.20	3.09	**243.7**
1.43	3.21	**329.4**	1.42	3.21	**320.5**	1.33	3.17	**291.7**	1.29	3.15	**276.9**	1.21	3.10	**247.6**	1.30	3.15	**280.1**
1.53	3.25	**369.0**	1.52	3.25	**359.3**	1.43	3.21	**329.4**	1.39	3.20	**314.6**	1.31	3.16	**284.3**	1.40	3.20	**318.0**
1.63	3.28	**409.5**	1.62	3.27	**397.8**	1.53	3.25	**369.0**	1.49	3.24	**353.6**	1.41	3.21	**322.5**	1.50	3.24	**357.1**
1.73	3.29	**449.2**	1.72	3.29	**437.9**	1.63	3.28	**409.5**	1.59	3.27	**393.4**	1.51	3.25	**361.8**	1.60	3.27	**397.1**

(29)

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 29 of 39
Chkd. By: Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

54			55			56			57			58			59		
T.O.W.(EL) =		1597.64	**T.O.W.(EL) =**		1597.75	**T.O.W.(EL) =**		1597.85	**T.O.W.(EL) =**		1597.99	**T.O.W.(EL) =**		1598.00	**T.O.W.(EL) =**		1598.08
L (ft) =		58	**L (ft) =**		59	**L (ft) =**		59	**L (ft) =**		59	**L (ft) =**		68	**L (ft) =**		50
H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.06	2.67	**2.3**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.16	2.69	**10.0**	0.05	2.66	**1.8**	-	-	-	-	-	-	-	-	-	-	-	-
0.26	2.70	**20.8**	0.15	2.68	**9.2**	0.05	2.66	**1.8**	-	-	-	-	-	-	-	-	-
0.34	2.71	**31.0**	0.23	2.69	**17.3**	0.13	2.68	**7.3**	-	-	-	-	-	-	-	-	-
0.36	2.71	**34.0**	0.25	2.70	**19.9**	0.15	2.68	**9.2**	0.01	2.65	**0.2**	-	-	-	-	-	-
0.46	2.72	**49.2**	0.35	2.71	**33.1**	0.25	2.70	**19.9**	0.11	2.68	**5.8**	0.10	2.68	**5.8**	0.02	2.65	**0.4**
0.56	2.75	**66.8**	0.45	2.72	**48.4**	0.35	2.71	**33.1**	0.21	2.69	**15.3**	0.20	2.69	**16.4**	0.12	2.68	**5.6**
0.66	2.78	**86.5**	0.55	2.75	**66.2**	0.45	2.72	**48.4**	0.31	2.70	**27.5**	0.30	2.70	**30.2**	0.22	2.69	**13.9**
0.76	2.83	**108.8**	0.65	2.78	**86.0**	0.55	2.75	**66.2**	0.41	2.72	**42.1**	0.40	2.71	**46.6**	0.32	2.70	**24.4**
0.86	2.88	**133.2**	0.75	2.82	**108.1**	0.65	2.78	**86.0**	0.51	2.73	**58.7**	0.50	2.73	**65.6**	0.42	2.72	**37.0**
0.96	2.94	**160.4**	0.85	2.88	**133.2**	0.75	2.82	**108.1**	0.61	2.76	**77.6**	0.60	2.76	**87.2**	0.52	2.74	**51.4**
1.06	3.00	**189.9**	0.95	2.94	**160.6**	0.85	2.88	**133.2**	0.71	2.80	**98.8**	0.70	2.80	**111.5**	0.62	2.77	**67.6**
1.16	3.07	**222.5**	1.05	3.00	**190.4**	0.95	2.94	**160.6**	0.81	2.85	**122.6**	0.80	2.85	**138.7**	0.72	2.81	**85.8**
1.26	3.13	**256.8**	1.15	3.06	**222.6**	1.05	3.00	**190.4**	0.91	2.91	**149.0**	0.90	2.90	**168.4**	0.82	2.86	**106.2**
1.36	3.18	**292.5**	1.25	3.12	**257.3**	1.15	3.06	**222.6**	1.01	2.97	**177.9**	1.00	2.97	**202.0**	0.92	2.92	**128.8**

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 30 of 39
Chkd. By: RM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

60			61			62			63			64			65		
T.O.W.(EL) =		1598.23	T.O.W.(EL) =		1598.34	T.O.W.(EL) =		1598.35	T.O.W.(EL) =		1598.27	T.O.W.(EL) =		1598.16	T.O.W.(EL) =		1598.13
	L (ft) =	58		L (ft) =	60		L (ft) =	59		L (ft) =	59		L (ft) =	61		L (ft) =	60
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	0.04	2.66	**1.3**	0.07	2.67	**3.0**
0.07	2.67	**2.9**	-	-	-	-	-	-	0.03	2.66	**0.8**	0.14	2.68	**8.6**	0.17	2.69	**11.3**
0.17	2.69	**10.9**	0.06	2.67	**2.4**	0.05	2.66	**1.8**	0.13	2.68	**7.4**	0.24	2.70	**19.4**	0.27	2.70	**22.7**
0.27	2.70	**22.0**	0.16	2.69	**10.3**	0.15	2.68	**9.2**	0.23	2.69	**17.5**	0.34	2.71	**32.8**	0.37	2.71	**36.6**
0.37	2.71	**35.4**	0.26	2.70	**21.5**	0.25	2.70	**19.9**	0.33	2.70	**30.2**	0.44	2.72	**48.4**	0.47	2.73	**52.8**
0.47	2.73	**51.0**	0.36	2.71	**35.1**	0.35	2.71	**33.1**	0.43	2.72	**45.3**	0.54	2.74	**66.3**	0.57	2.75	**71.0**
0.57	2.75	**68.6**	0.46	2.72	**50.9**	0.45	2.72	**48.4**	0.53	2.74	**62.4**	0.64	2.77	**86.5**	0.67	2.79	**91.8**
0.67	2.79	**88.7**	0.56	2.75	**69.1**	0.55	2.75	**66.2**	0.63	2.77	**81.7**	0.74	2.82	**109.5**	0.77	2.83	**114.7**
0.77	2.83	**110.9**	0.66	2.78	**89.4**	0.65	2.78	**86.0**	0.73	2.81	**103.4**	0.84	2.87	**134.8**	0.87	2.89	**140.7**

31

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Overflow Conditions Sheet No. 31 of 39
Chkd. By: Date: 3/7/06 Proj. No. 06-3551

66			67			68			69			70			71		
T.O.W.(EL) =		1598.21	**T.O.W.(EL) =**		1598.25	**T.O.W.(EL) =**		1598.22	**T.O.W.(EL) =**		1598.03	**T.O.W.(EL) =**		1597.50	**T.O.W.(EL) =**		1597.10
L (ft) =		63	**L (ft) =**		58	**L (ft) =**		57	**L (ft) =**		60	**L (ft) =**		60	**L (ft) =**		60
H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.64	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10	2.68	**5.1**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.20	2.69	**14.4**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.30	2.70	**26.6**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.40	2.71	**41.1**
-	-	-	-	-	-	-	-	-	-	-	-	0.10	2.68	**5.1**	0.50	2.73	**57.9**
-	-	-	-	-	-	-	-	-	-	-	-	0.13	2.68	**7.5**	0.53	2.74	**63.4**
-	-	-	-	-	-	-	-	-	-	-	-	0.20	2.69	**14.4**	0.60	2.76	**77.0**
-	-	-	-	-	-	-	-	-	-	-	-	0.30	2.70	**26.6**	0.70	2.80	**98.4**
-	-	-	-	-	-	-	-	-	-	-	-	0.40	2.71	**41.1**	0.80	2.85	**122.4**
-	-	-	-	-	-	-	-	-	-	-	-	0.48	2.73	**54.2**	0.88	2.89	**142.8**
-	-	-	-	-	-	-	-	-	-	-	-	0.50	2.73	**57.9**	0.90	2.90	**148.6**
-	-	-	-	-	-	-	-	-	0.07	2.67	**3.0**	0.60	2.76	**77.0**	1.00	2.97	**178.2**
-	-	-	-	-	-	-	-	-	0.17	2.69	**11.3**	0.70	2.80	**98.4**	1.10	3.03	**209.7**
0.09	2.67	**4.5**	0.05	2.66	**1.7**	0.08	2.67	**3.4**	0.27	2.70	**22.7**	0.80	2.85	**122.4**	1.20	3.09	**243.7**
0.19	2.69	**14.0**	0.15	2.68	**9.0**	0.18	2.69	**11.7**	0.37	2.71	**36.6**	0.90	2.90	**148.6**	1.30	3.15	**280.1**
0.29	2.70	**26.6**	0.25	2.70	**19.6**	0.28	2.70	**22.8**	0.47	2.73	**52.8**	1.00	2.97	**178.2**	1.40	3.20	**318.0**
0.39	2.71	**41.6**	0.35	2.71	**32.5**	0.38	2.71	**36.2**	0.57	2.75	**71.0**	1.10	3.03	**209.7**	1.50	3.24	**357.1**
0.49	2.73	**59.0**	0.45	2.72	**47.6**	0.48	2.73	**51.7**	0.67	2.79	**91.8**	1.20	3.09	**243.7**	1.60	3.27	**397.1**
0.59	2.76	**78.8**	0.55	2.75	**65.1**	0.58	2.75	**69.2**	0.77	2.83	**114.7**	1.30	3.15	**280.1**	1.70	3.29	**437.5**
0.69	2.80	**101.1**	0.65	2.78	**84.5**	0.68	2.79	**89.2**	0.87	2.89	**140.7**	1.40	3.20	**318.0**	1.80	3.30	**478.2**
0.79	2.84	**125.6**	0.75	2.82	**106.2**	0.78	2.84	**111.5**	0.97	2.95	**169.1**	1.50	3.24	**357.1**	1.90	3.30	**518.6**

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By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 32 of 39
Chkd. By: BM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

72			73			74			75			76			77		
T.O.W.(EL) =		1597.11	T.O.W.(EL) =		1597.30	T.O.W.(EL) =		1597.90	T.O.W.(EL) =		1597.85	T.O.W.(EL) =		1597.94	T.O.W.(EL) =		1598.03
	L (ft) =	78		L (ft) =	60		L (ft) =	60		L (ft) =	52		L (ft) =	42		L (ft) =	45
H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.09	2.67	**5.6**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.19	2.69	**17.4**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.29	2.70	**32.9**	0.10	2.68	**5.1**	-	-	-	-	-	-	-	-	-	-	-	-
0.39	2.71	**51.5**	0.20	2.69	**14.4**	-	-	-	-	-	-	-	-	-	-	-	-
0.49	2.73	**73.0**	0.30	2.70	**26.6**	-	-	-	-	-	-	-	-	-	-	-	-
0.52	2.74	**80.1**	0.33	2.70	**30.7**	-	-	-	-	-	-	-	-	-	-	-	-
0.59	2.76	**97.6**	0.40	2.71	**41.1**	-	-	-	-	-	-	-	-	-	-	-	-
0.69	2.80	**125.2**	0.50	2.73	**57.9**	-	-	-	-	-	-	-	-	-	-	-	-
0.79	2.84	**155.5**	0.60	2.76	**77.0**	-	-	-	0.05	2.66	**1.5**	-	-	-	-	-	-
0.87	2.89	**182.5**	0.68	2.79	**93.6**	0.08	2.67	**3.5**	0.13	2.68	**6.4**	0.04	2.66	**0.9**	-	-	-
0.89	2.90	**189.9**	0.70	2.80	**98.4**	0.10	2.68	**5.1**	0.15	2.68	**8.1**	0.06	2.67	**1.7**	-	-	-
0.99	2.96	**227.4**	0.80	2.85	**122.4**	0.20	2.69	**14.4**	0.25	2.70	**17.5**	0.16	2.69	**7.4**	0.07	2.67	**2.4**
1.09	3.02	**268.1**	0.90	2.90	**148.6**	0.30	2.70	**26.6**	0.35	2.71	**29.2**	0.26	2.70	**15.2**	0.17	2.69	**8.8**
1.19	3.09	**312.9**	1.00	2.97	**178.2**	0.40	2.71	**41.1**	0.45	2.72	**42.7**	0.36	2.71	**24.8**	0.27	2.70	**17.4**
1.29	3.15	**360.0**	1.10	3.03	**209.7**	0.50	2.73	**57.9**	0.55	2.75	**58.3**	0.46	2.72	**35.9**	0.37	2.71	**27.9**
1.39	3.20	**409.0**	1.20	3.09	**243.7**	0.60	2.76	**77.0**	0.65	2.78	**75.8**	0.56	2.75	**48.7**	0.47	2.73	**40.1**
1.49	3.24	**459.6**	1.30	3.15	**280.1**	0.70	2.80	**98.4**	0.75	2.82	**95.2**	0.66	2.78	**62.9**	0.57	2.75	**53.8**
1.59	3.27	**511.4**	1.40	3.20	**318.0**	0.80	2.85	**122.4**	0.85	2.88	**117.4**	0.76	2.83	**79.1**	0.67	2.79	**69.5**
1.69	3.29	**563.8**	1.50	3.24	**357.1**	0.90	2.90	**148.6**	0.95	2.94	**141.6**	0.86	2.88	**96.8**	0.77	2.83	**86.8**
1.79	3.29	**614.6**	1.60	3.27	**397.1**	1.00	2.97	**178.2**	1.05	3.00	**167.8**	0.96	2.94	**116.5**	0.87	2.89	**106.3**
1.89	3.30	**668.8**	1.70	3.29	**437.5**	1.10	3.03	**209.7**	1.15	3.06	**196.2**	1.06	3.01	**138.4**	0.97	2.95	**127.6**

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 33 of 39
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78			79			80			81			82		
T.O.W.(EL) =		1598.11	T.O.W.(EL) =		1598.20	T.O.W.(EL) =		1598.29	T.O.W.(EL) =		1598.37	T.O.W.(EL) =		1598.33
	L (ft) =	44		L (ft) =	44		L (ft) =	44		L (ft) =	50		L (ft) =	59
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.09	2.67	**3.0**	-	-	-	-	-	-	-	-	-	-	-	-
0.19	2.69	**9.5**	0.10	2.68	**3.6**	0.01	2.65	**0.1**	-	-	-	-	-	-
0.29	2.70	**18.2**	0.20	2.69	**10.5**	0.11	2.68	**4.3**	0.03	2.66	**0.7**	0.07	2.67	**3.1**
0.39	2.71	**28.6**	0.30	2.70	**19.4**	0.21	2.69	**11.4**	0.13	2.68	**6.3**	0.17	2.69	**11.4**
0.49	2.73	**40.7**	0.40	2.71	**30.0**	0.31	2.70	**20.6**	0.23	2.69	**14.8**	0.27	2.70	**22.6**
0.59	2.76	**54.5**	0.50	2.73	**42.3**	0.41	2.72	**31.5**	0.33	2.70	**25.6**	0.37	2.71	**36.3**
0.69	2.79	**69.8**	0.60	2.76	**56.2**	0.51	2.73	**43.8**	0.43	2.72	**38.3**	0.47	2.73	**52.3**
0.79	2.84	**87.1**	0.70	2.80	**71.9**	0.61	2.76	**57.9**	0.53	2.74	**52.9**	0.57	2.75	**70.3**
0.89	2.90	**106.5**	0.80	2.85	**89.5**	0.71	2.80	**73.8**	0.63	2.77	**69.3**	0.67	2.79	**90.8**

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By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 34 of 39
Chkd. By: JAM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

83			84			85			86			87			88		
T.O.W.(EL) =		1598.29	T.O.W.(EL) =		1598.24	T.O.W.(EL) =		1598.19	T.O.W.(EL) =		1598.03	T.O.W.(EL) =		1597.87	T.O.W.(EL) =		1597.70
L (ft) =		59	L (ft) =		60	L (ft) =		59	L (ft) =		59	L (ft) =		59	L (ft) =		60
H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	2.64	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10	2.68	**5.2**
-	-	-	-	-	-	-	-	-	-	-	-	0.03	2.66	**1.0**	0.20	2.69	**14.6**
-	-	-	-	-	-	-	-	-	-	-	-	0.11	2.68	**6.0**	0.28	2.70	**24.0**
-	-	-	-	-	-	-	-	-	-	-	-	0.13	2.68	**7.8**	0.30	2.70	**26.8**
-	-	-	-	-	-	-	-	-	0.07	2.67	**2.8**	0.23	2.70	**18.1**	0.40	2.71	**41.3**
-	-	-	-	-	-	0.01	2.65	**0.2**	0.17	2.69	**11.0**	0.33	2.71	**31.0**	0.50	2.73	**58.1**
0.01	2.65	**0.3**	0.06	2.66	**2.2**	0.11	2.68	**5.8**	0.27	2.70	**22.2**	0.43	2.72	**46.0**	0.60	2.76	**77.2**
0.11	2.68	**6.1**	0.16	2.69	**10.0**	0.21	2.69	**15.3**	0.37	2.71	**35.8**	0.53	2.74	**63.2**	0.70	2.80	**98.6**
0.21	2.69	**15.8**	0.26	2.70	**21.1**	0.31	2.70	**27.5**	0.47	2.73	**51.6**	0.63	2.77	**82.7**	0.80	2.85	**122.6**
0.31	2.70	**28.1**	0.36	2.71	**34.7**	0.41	2.72	**42.1**	0.57	2.75	**69.5**	0.73	2.82	**104.8**	0.90	2.91	**149.4**
0.41	2.72	**42.9**	0.46	2.72	**50.4**	0.51	2.73	**58.7**	0.67	2.79	**90.0**	0.83	2.87	**129.2**	1.00	2.97	**178.5**
0.51	2.74	**59.7**	0.56	2.75	**68.6**	0.61	2.76	**77.6**	0.77	2.83	**112.5**	0.93	2.93	**156.2**	1.10	3.03	**210.1**
0.61	2.77	**78.8**	0.66	2.78	**88.8**	0.71	2.80	**98.8**	0.87	2.89	**138.0**	1.03	2.99	**185.7**	1.20	3.09	**244.1**
0.71	2.81	**100.2**	0.76	2.83	**111.8**	0.81	2.85	**122.6**	0.97	2.95	**165.9**	1.13	3.05	**217.5**	1.30	3.15	**280.5**

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Chkd. By: PM Date: 3/7/06 Proj. No. 06-3551

89			90			91			92			93		
T.O.W.(EL) =		1597.53	**T.O.W.(EL) =**		1597.35	**T.O.W.(EL) =**		1597.33	**T.O.W.(EL) =**		1597.31	**T.O.W.(EL) =**		1597.29
	L (ft) =	59		**L (ft) =**	59		**L (ft) =**	60		**L (ft) =**	60		**L (ft) =**	60
H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	0.01	2.65	**0.1**
-	-	-	0.05	2.66	**1.8**	0.07	2.67	**2.9**	0.09	2.67	**4.1**	0.11	2.68	**5.5**
-	-	-	0.15	2.68	**9.2**	0.17	2.69	**11.2**	0.19	2.69	**13.0**	0.21	2.69	**15.0**
0.07	2.67	**2.8**	0.25	2.70	**19.9**	0.27	2.70	**22.5**	0.29	2.70	**24.9**	0.31	2.70	**27.3**
0.10	2.67	**4.8**	0.28	2.70	**23.6**	0.30	2.70	**26.4**	0.32	2.70	**28.9**	0.34	2.71	**31.6**
0.17	2.69	**10.9**	0.35	2.71	**33.1**	0.37	2.71	**36.4**	0.39	2.71	**39.1**	0.41	2.71	**42.0**
0.27	2.70	**22.1**	0.45	2.72	**48.4**	0.47	2.73	**52.5**	0.49	2.73	**55.7**	0.51	2.73	**58.8**
0.37	2.71	**35.6**	0.55	2.75	**66.2**	0.57	2.75	**70.7**	0.59	2.76	**74.5**	0.61	2.76	**78.0**
0.45	2.72	**47.8**	0.63	2.77	**81.5**	0.65	2.78	**86.8**	0.67	2.78	**90.6**	0.68	2.79	**94.7**
0.47	2.73	**51.5**	0.65	2.78	**86.0**	0.67	2.79	**91.5**	0.69	2.79	**95.3**	0.71	2.80	**99.5**
0.57	2.75	**69.4**	0.75	2.82	**108.1**	0.77	2.83	**114.4**	0.79	2.84	**118.9**	0.81	2.85	**123.6**
0.67	2.79	**89.8**	0.85	2.88	**133.2**	0.87	2.89	**140.3**	0.89	2.90	**145.3**	0.91	2.91	**150.4**
0.77	2.83	**112.3**	0.95	2.94	**160.6**	0.97	2.95	**168.7**	0.99	2.96	**174.1**	1.01	2.97	**179.6**
0.87	2.89	**137.8**	1.05	3.00	**190.4**	1.07	3.01	**199.5**	1.09	3.02	**205.3**	1.11	3.03	**211.3**
0.97	2.95	**165.7**	1.15	3.06	**222.6**	1.17	3.07	**232.7**	1.19	3.09	**239.7**	1.21	3.10	**246.1**
1.07	3.01	**195.9**	1.25	3.12	**257.3**	1.27	3.13	**268.3**	1.29	3.14	**275.0**	1.31	3.15	**281.9**
1.17	3.07	**228.5**	1.35	3.18	**294.3**	1.37	3.19	**306.4**	1.39	3.20	**313.6**	1.41	3.20	**319.9**
1.27	3.13	**263.6**	1.45	3.22	**331.7**	1.47	3.23	**344.9**	1.49	3.24	**352.5**	1.51	3.24	**359.0**
1.37	3.19	**301.0**	1.55	3.26	**371.2**	1.57	3.26	**384.2**	1.59	3.27	**392.2**	1.61	3.27	**399.1**
1.47	3.23	**338.8**	1.65	3.28	**410.2**	1.67	3.28	**424.1**	1.69	3.29	**432.5**	1.71	3.29	**439.6**

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By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 36 of 39
Chkd. By: JRM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

94			95			96			97			98		
T.O.W.(EL) =		1597.27	T.O.W.(EL) =		1597.25	T.O.W.(EL) =		1597.34	T.O.W.(EL) =		1597.43	T.O.W.(EL) =		1597.52
L (ft) =		60	L (ft) =		60	L (ft) =		60	L (ft) =		60	L (ft) =		58
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.03	2.66	0.8	0.05	2.66	1.8	-	-	-	-	-	-	-	-	-
0.13	2.68	7.5	0.15	2.68	9.3	0.06	2.67	2.4	-	-	-	-	-	-
0.23	2.69	17.8	0.25	2.70	20.2	0.16	2.69	10.3	0.07	2.67	3.0	-	-	-
0.33	2.70	30.7	0.35	2.71	33.7	0.26	2.70	21.5	0.17	2.69	11.3	0.08	2.67	3.5
0.36	2.71	35.1	0.38	2.71	38.1	0.29	2.70	25.3	0.20	2.69	14.4	0.11	2.68	5.7
0.43	2.72	46.0	0.45	2.72	49.3	0.36	2.71	35.1	0.27	2.70	22.7	0.18	2.69	11.9
0.53	2.74	63.4	0.55	2.75	67.3	0.46	2.72	50.9	0.37	2.71	36.6	0.28	2.70	23.2
0.63	2.77	83.1	0.65	2.78	87.4	0.56	2.75	69.1	0.47	2.73	52.8	0.38	2.71	36.8
0.71	2.80	100.2	0.73	2.81	104.9	0.64	2.77	84.8	0.55	2.74	66.8	0.46	2.72	49.0
0.73	2.81	105.2	0.75	2.82	109.9	0.66	2.78	89.4	0.57	2.75	71.0	0.48	2.73	52.7
0.83	2.86	129.8	0.85	2.88	135.4	0.76	2.83	112.5	0.67	2.79	91.8	0.58	2.75	70.5
0.93	2.92	157.1	0.95	2.94	163.3	0.86	2.88	137.8	0.77	2.83	114.7	0.68	2.79	90.7
1.03	2.99	187.5	1.05	3.00	193.7	0.96	2.94	165.9	0.87	2.89	140.7	0.78	2.84	113.5
1.13	3.05	219.8	1.15	3.06	226.4	1.06	3.00	196.4	0.97	2.95	169.1	0.88	2.89	138.4
1.23	3.11	254.5	1.25	3.12	261.6	1.16	3.07	230.1	1.07	3.01	199.9	0.98	2.95	166.0
1.33	3.17	291.7	1.35	3.18	299.3	1.26	3.13	265.6	1.17	3.07	233.1	1.08	3.02	196.6
1.43	3.21	329.4	1.45	3.22	337.3	1.36	3.18	302.6	1.27	3.13	268.8	1.18	3.08	229.0
1.53	3.25	369.0	1.55	3.26	377.5	1.46	3.23	341.9	1.37	3.19	306.9	1.28	3.14	263.7
1.63	3.28	409.5	1.65	3.28	417.1	1.56	3.26	381.1	1.47	3.23	345.4	1.38	3.19	299.9
1.73	3.29	449.2	1.75	3.29	457.0	1.66	3.28	420.9	1.57	3.26	384.8	1.48	3.23	337.3

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Overflow Conditions Sheet No. 37 of 39
Chkd. By: JM Date: 3/7/06 Proj. No. 06-3551

99			100			101			102			103		
T.O.W.(EL) =		1597.61	**T.O.W.(EL) =**		1597.67	**T.O.W.(EL) =**		1597.78	**T.O.W.(EL) =**		1597.83	**T.O.W.(EL) =**		1597.92
	L (ft) =	80		**L (ft) =**	60		**L (ft) =**	57		**L (ft) =**	51		**L (ft) =**	62
H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.02	2.65	**0.6**	-	-	-	-	-	-	-	-	-	-	-	-
0.09	2.67	**5.8**	0.03	2.66	**0.8**	-	-	-	-	-	-	-	-	-
0.19	2.69	**17.8**	0.13	2.68	**7.5**	0.02	2.65	**0.4**	-	-	-	-	-	-
0.29	2.70	**33.7**	0.23	2.69	**17.8**	0.12	2.68	**6.4**	0.07	2.67	**2.5**	-	-	-
0.37	2.71	**48.5**	0.31	2.70	**27.8**	0.20	2.69	**13.6**	0.15	2.68	**7.8**	0.06	2.67	**2.3**
0.39	2.71	**52.8**	0.33	2.70	**30.7**	0.22	2.69	**15.8**	0.17	2.69	**9.6**	0.08	2.67	**3.7**
0.49	2.73	**74.9**	0.43	2.72	**46.0**	0.32	2.70	**27.9**	0.27	2.70	**19.3**	0.18	2.69	**12.7**
0.59	2.76	**100.1**	0.53	2.74	**63.4**	0.42	2.72	**42.2**	0.37	2.71	**31.1**	0.28	2.70	**24.8**
0.69	2.80	**128.4**	0.63	2.77	**83.1**	0.52	2.74	**58.6**	0.47	2.73	**44.9**	0.38	2.71	**39.4**
0.79	2.84	**159.5**	0.73	2.81	**105.2**	0.62	2.77	**77.1**	0.57	2.75	**60.4**	0.48	2.73	**56.3**
0.89	2.90	**194.8**	0.83	2.86	**129.8**	0.72	2.81	**97.9**	0.67	2.79	**78.0**	0.58	2.75	**75.3**
0.99	2.96	**233.3**	0.93	2.92	**157.1**	0.82	2.86	**121.0**	0.77	2.83	**97.5**	0.68	2.79	**97.0**
1.09	3.02	**274.9**	1.03	2.99	**187.5**	0.92	2.92	**146.9**	0.87	2.89	**119.6**	0.78	2.84	**121.3**
1.19	3.09	**320.9**	1.13	3.05	**219.8**	1.02	2.98	**175.0**	0.97	2.95	**143.7**	0.88	2.89	**147.9**
1.29	3.15	**369.2**	1.23	3.11	**254.5**	1.12	3.04	**205.4**	1.07	3.01	**169.9**	0.98	2.95	**177.4**
1.39	3.20	**419.5**	1.33	3.17	**291.7**	1.22	3.11	**238.9**	1.17	3.07	**198.1**	1.08	3.02	**210.2**

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By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Overflow Conditions Sheet No. 38 of 39
Chkd. By: Date: 3/7/06 Proj. No. 06-3551

104			105			106			107			108		
T.O.W.(EL) =		1597.92	**T.O.W.(EL) =**		1598.02	**T.O.W.(EL) =**		1598.11	**T.O.W.(EL) =**		1598.22	**T.O.W.(EL) =**		1598.03
	L (ft) =	59		**L (ft) =**	59		**L (ft) =**	58		**L (ft) =**	58		**L (ft) =**	68
H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.06	2.67	**2.2**	-	-	-	-	-	-	-	-	-	-	-	-
0.08	2.67	**3.6**	-	-	-	-	-	-	-	-	-	-	-	-
0.18	2.69	**12.1**	0.08	2.67	**3.6**	-	-	-	-	-	-	0.07	2.67	**3.4**
0.28	2.70	**23.6**	0.18	2.69	**12.1**	0.09	2.67	**4.2**	-	-	-	0.17	2.69	**12.8**
0.38	2.71	**37.5**	0.28	2.70	**23.6**	0.19	2.69	**12.9**	0.08	2.67	**3.5**	0.27	2.70	**25.8**
0.48	2.73	**53.6**	0.38	2.71	**37.5**	0.29	2.70	**24.5**	0.18	2.69	**11.9**	0.37	2.71	**41.5**
0.58	2.75	**71.7**	0.48	2.73	**53.6**	0.39	2.71	**38.3**	0.28	2.70	**23.2**	0.47	2.73	**59.8**
0.68	2.79	**92.3**	0.58	2.75	**71.7**	0.49	2.73	**54.3**	0.38	2.71	**36.8**	0.57	2.75	**80.5**
0.78	2.84	**115.4**	0.68	2.79	**92.3**	0.59	2.76	**72.5**	0.48	2.73	**52.7**	0.67	2.79	**104.0**
0.88	2.89	**140.8**	0.78	2.84	**115.4**	0.69	2.80	**93.1**	0.58	2.75	**70.5**	0.77	2.83	**130.0**
0.98	2.95	**168.9**	0.88	2.89	**140.8**	0.79	2.84	**115.7**	0.68	2.79	**90.7**	0.87	2.89	**159.5**
1.08	3.02	**200.0**	0.98	2.95	**168.9**	0.89	2.90	**141.2**	0.78	2.84	**113.5**	0.97	2.95	**191.6**

By: J D Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 39 of 39
Chkd. By: PM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

109			110			111		
T.O.W.(EL) =		1598.06	**T.O.W.(EL) =**		1598.03	**T.O.W.(EL) =**		1598.00
	L (ft) =	60		**L (ft) =**	36		**L (ft) =**	34
H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
0.04	2.66	**1.3**	0.07	2.67	**1.8**	0.10	2.68	**2.9**
0.14	2.68	**8.4**	0.17	2.69	**6.8**	0.20	2.69	**8.2**
0.24	2.70	**19.0**	0.27	2.70	**13.6**	0.30	2.70	**15.1**
0.34	2.71	**32.2**	0.37	2.71	**22.0**	0.40	2.71	**23.3**
0.44	2.72	**47.6**	0.47	2.73	**31.7**	0.50	2.73	**32.8**
0.54	2.74	**65.2**	0.57	2.75	**42.6**	0.60	2.76	**43.6**
0.64	2.77	**85.1**	0.67	2.79	**55.1**	0.70	2.80	**55.8**
0.74	2.82	**107.7**	0.77	2.83	**68.8**	0.80	2.85	**69.3**
0.84	2.87	**132.6**	0.87	2.89	**84.4**	0.90	2.90	**84.2**
0.94	2.93	**160.2**	0.97	2.95	**101.5**	1.00	2.97	**101.0**

STABILITY ANALYSIS OF PARAPET WALL CALCULATION

By JDD. Date 1-13-06. Subject Taum Sauk Dam. Sheet No. 1 of 12.
Chkd. by KZ. Date 3-23-06. Stability Analysis of Parapet Wall Proj. No. 06-3551.

Objective:

Determine the Factor of Safety for the reinforced concrete parapet wall of the Taum Sauk upper reservoir against overturning and sliding assuming seepage occurs under the wall.

Background:

The upper reservoir dike of the Taum Sauk Pumped Storage Project failed on December 14, 2005 due to flooding. This resulted in a dike failure and release of water from the upper reservoir. The parapet wall was shown to be stable in the original analysis if no seepage under the wall occurs.

References:

1) Lindeburg, Michael R. Civil Engineering Reference Manual, Fourth Edition. Belmont, CA: Professional Publications, Inc. 1986.
2) Reference Design Theory Manual for Armor Form, Erosion Protection Mats. Nicolon Corporation. 1989. p. 283
3) Das, Braja M. Principles of Geotechnical Engineering. Brooks/Cole. 2002. p. 411 – 413., p. 420 – 422.
4) PCRA Calculation. Taum Sauk Plant, Stability Analysis of Failed Zone. February 2006. p. 8-13.

Methodology:

This calculation checks the stability of the parapet wall of the upper reservoir. The factor of safety against overturning and sliding are calculated. To check overturning, all forces acting on the wall are calculated. Lever arms are calculated for each force, and the moment about the toe of the wall is calculated. To check sliding, the horizontal forces are compared to the resistance due to friction at the base from the vertical forces and passive soil force.

Assumptions:

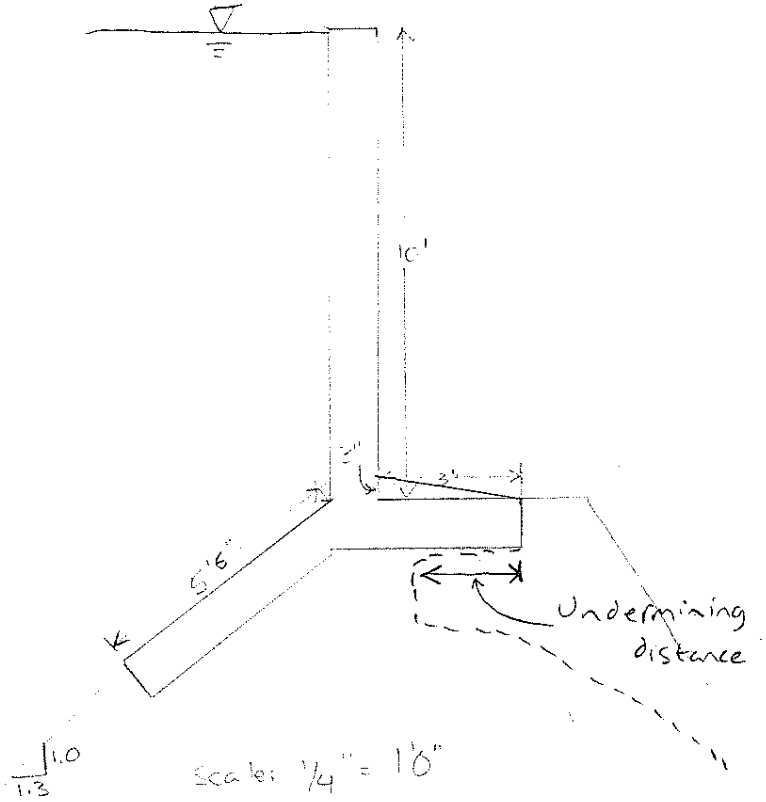
1) Water in the reservoir is at the top of the parapet wall, an elevation of 1599'.
2) Leakage occurs under the base of the wall causing an uplift pressure.
3) Unit weight of concrete is 150lb/ft^3.
4) The uplift pressure is assumed to be equal to the full depth of the water at the bottom of the footing at the upstream side and zero at the toe of the parapet wall.
5) In the sliding calculation; wall friction angle $\delta = 30$ degrees (Reference 3), Rockfill friction angle $\Phi = 41$ degrees (Reference 4) and $\gamma = 130.5$ lb/ft^3.

By JDD Date 1/13/06 Subject Taum Sauk Parapet Wall Sheet No. 2 of 12

Chkd. By EZ Date 3-3-06 Proj. No. 06-3551

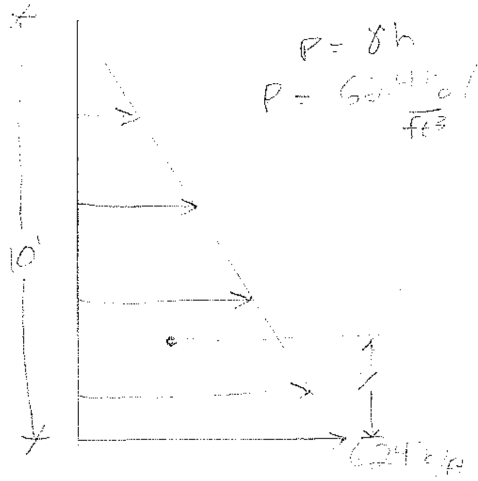
Taum Sauk Parapet Wall Cross section

(i) Overturning



Scale: 1/4" = 1'0"

Step 1: Water Pressure



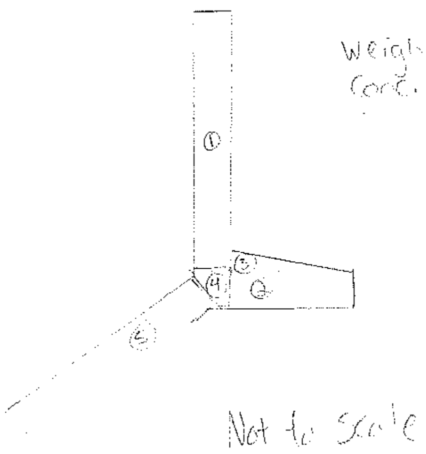
$P = \gamma h$

$P = 62.4\ \frac{lb}{ft^3}\,(10ft) = 624\ lb/ft$

$\frac{1}{2}(624\ lb/ft)(10ft) = 3120\ lb$

$X = \frac{1}{3}(10) = 3.33ft$

Step 2: Vertical Forces



Not to Scale

Weights of Conc. sections

1) 10ft (1ft)(1ft) = 10ft³ (150 lb/ft³) = 1500 lb

2) 3ft (1')(1')(150 lb/ft³) = 450 lb

3) 0.25ft (1/2)(3)(1')(150 lb/ft³) = 56.3 lb

4) 1/2 (1')(1')(1') = 0.5 ft³ (150 lb/ft³) = 75 lb

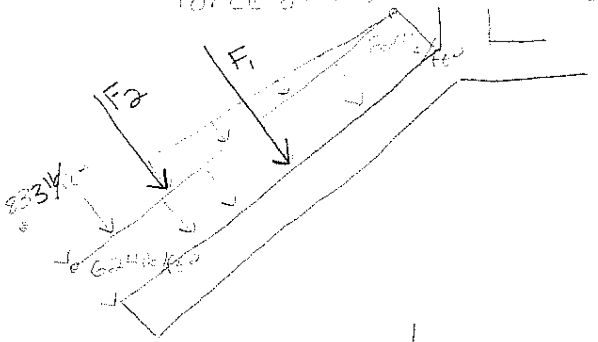
5) 5.5ft (1')(1')(150 lb/ft³) = 825 lb

Total - 2906 lb concrete

By JDD Date 1/13/06 Subject Taum Sauk Parapet Wall Sheet No. 3 of 12

Chkd. By EZ Date 3-3-06 Proj. No. 06-3551

Force of water on heel



Pressures -

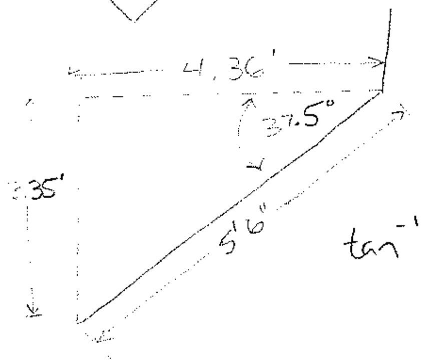
$p_1 = 62.4 \frac{lb}{ft^3} (10ft) = 624 lb/ft^2$

$p_2 = 62.4 lb/ft^3 (10 + 3.35 = 833 lb/ft^2$

Forces -

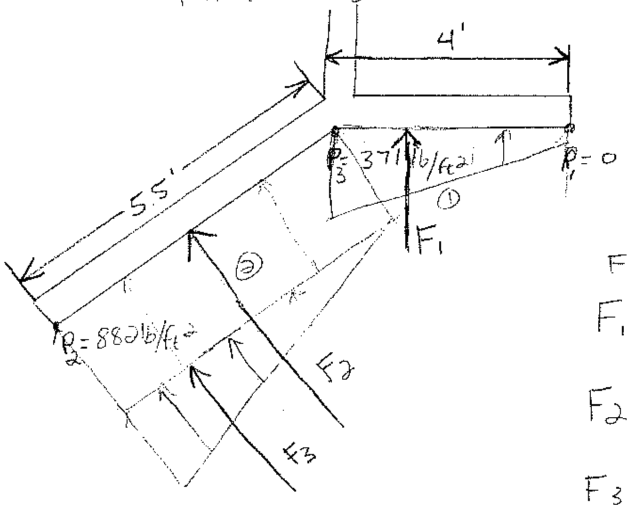
$F_1 = 624 lb/ft^2 (5.5ft) = 3432 lb$

$F_2 = \frac{1}{2} (833 - 624)(5.5) = 575 lb$



$\tan^{-1}\left(\frac{3.35}{4.36}\right) = 37.5°$

Uplift Pressure



Pressures

$p_1 = 0$

$p_2 : (10 + 3.35 + 1(\cos 37.5))62.4 = 883 lb/ft^2$

$p_3 = \frac{4}{9.5}(882) = 372 lb/ft^2$

Forces

$F_1 = 372(4)(\frac{1}{2}) = 744 lb$

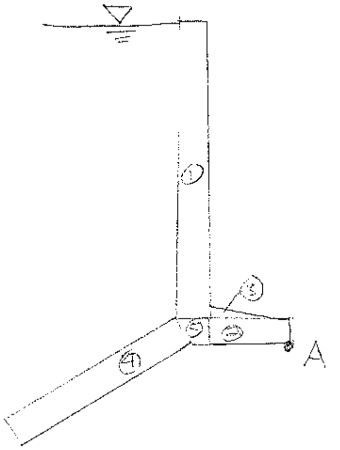
$F_2 = 372(5.5) = 2046 lb$

$F_3 = (883 - 372)(5.5)(\frac{1}{2}) = 1403 lb$

By JDD Date 1/13/06 Subject Taum Sauk Parapet Wall Sheet No. 4 of 12

Chkd. By EZ Date 3-3-06 Proj. No. 06-3551

Grp 3: Moments



$\Sigma M_A \overset{\curvearrowright}{+}$

(a) Stabilizing

concrete sections

1) 1500 lb (3 + 0.5) = 5250 ft·lb

2) 450 lb (1.5) = 675 ft·lb

3) 56.3 lb $(\frac{2}{3})$(3) = 112.6 ft·lb

4) 825 lb $(\frac{4.36}{2} + 1 + 3)$ = 5098.5 ft·lb

5) 75 lb (3 + 1/3(1)) = 250 ft·lb

water on heel

3430 lb (cos 37.5°)(6.18 ft) + 3430 (sin 37.5°)$(\frac{3.35}{2} - 1)$

16827 + 1410 = 18237 lb·ft

575 lb (cos 37.5°)$(4 + \frac{2}{3}(4.36))$ + 575 (sin 37.5°)(3.35$(\frac{2}{3})$ - 1)

3151 + 432 = 3583 ft·lb

(b) Overturning

Active load

3120 lb (3.33 + 1) = 13,510 ft·lb

Uplift on toe

744 lb (4)$(\frac{2}{3})$ = 1984 ft·lb

Uplift on heel

2046 (cos 37.5°)$(\frac{4.36}{2} + 4)$ + 2046 (sin 37.5°)$(\frac{3.35}{2})$

= 10031 + 2086 = 12117 ft·lb

By JDD Date 1/13/06 Subject Taum Sauk Parapet Wall Sheet No. 5 of 12

Chkd. By EZ Date 3-3-06 Proj. No. 06-3551

$1403\,(\cos 37.5°)(4+4.36(2/3)) + 1403\,(\sin 37.5°)(3.35(2/3))$

$7688 + 1907 = 9595$ ft.lb

Overtopping Force Assuming depth of water above wall of 0.8ft
Average tractive stress due to flowing water (Ref. Design Theory Manual for Armor Form, Erosion Protection Mats, Nicolon Corporation, 1989 p. 283)

$\tau = \gamma_w d S \quad \gamma_w = 62.4 \quad d = 0.8 \quad S = 1$

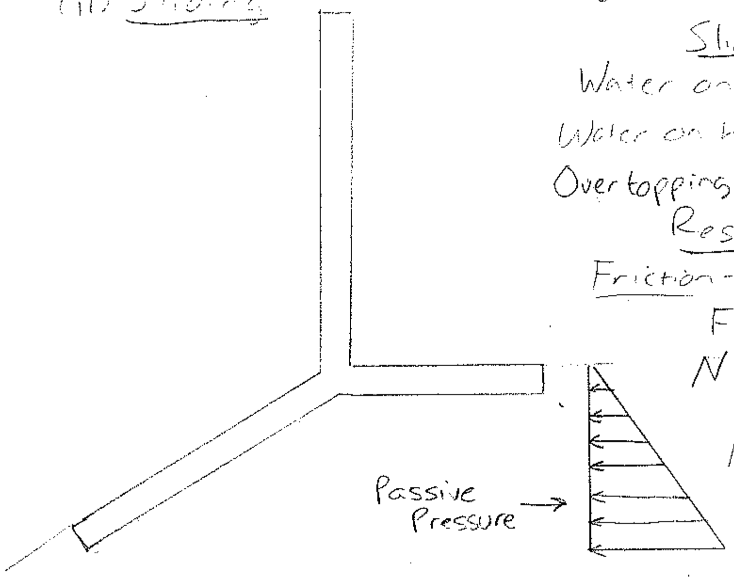
$\tau = 62.4\,(0.8) = 49.9$ lb/ft²

Total tractive force per unit length = 49.9(1) = 50 lb

50 lb (11 ft) = 550 ft.lb

$F.S. = \frac{\text{Stabilizing}}{\text{Overturning}} = \frac{33206}{37756} = 0.879$

(ii) Sliding



Sliding Forces

Water on Stem - 3120 lb

Water on heel - 4007 (sin 37.5°) = 2439 lb

Overtopping - 50 lb/ft (1 ft) = 50 lb

Resisting Forces

Friction -

$F = N \tan\phi$ (Reference 3)

$N = 2906 + (4007 \cos 37.5°) - 744 - 2046(\cos 37.5°) - 1403(\cos 37.5°)$

$F = 2605\text{ lb}\,(\tan 30°) = 1505\text{ lb}$

Passive Pressure

$\gamma' = (130.5 - 62.4) = 68.1$ lb/ft³

$K_p = \frac{1+\sin\phi}{1-\sin\phi} = 4.8$ (for Cohesionless soils, Ref. 3)

$P_p = \frac{1}{2} K_p \gamma H^2$

$= \frac{1}{2}(4.8)(68.1)(4.35)^2 = 3093$ lb/ft²

Uplift on heel -

$2046(\sin 37.5°) + 1403(\sin 37.5°) = 2100$ lb

$F.S. = \frac{\text{Resisting}}{\text{Sliding}} = \frac{6698}{5609} = 1.19$

Results:

Factors of safety against sliding and overturning were calculated using the excel spreadsheet shown on sheet 7. The values on sheet 7 are for a specific case with no undermining and a water elevation of 1599 feet. Graphs and data tables for the following cases are included in ***Attachment A***.

- Factor of Safety against overturning vs. water elevation for varying amounts of uplift
- Factor of Safety against sliding vs. water elevation for varying amounts of uplift
- Factor of Safety against overturning vs. undermining distance for varying amounts of uplift
- Factor of Safety against sliding vs. undermining distance for varying amounts of passive pressure

Conclusions:

The stability analysis shows that the factor of safety against overturning is inadequate. Overturning could occur when there is leakage under the parapet wall. The factor of safety against sliding is also inadequate when there is leakage under the parapet wall. Undermining further reduces the factor of safety against overturning and sliding. As undermine distance increases, the Factors of Safety for overturning and sliding are reduced.

Attachment A
Stability Analysis Data Tables and Graphs

By JDD . Date 1-13-06 . Subject Taum Sauk Dam . Sheet No. 8 of 12.
Chkd. by . Date 3-23-06 . Stability Analysis of Parapet Wall Proj. No. 06-3551 .

STABILITY CALCULATION OF PARAPET WALL ASSUMING LEAKAGE UNDER WALL

OVERTURNING

Density of Concrete (pcf)	150
Density of Water (pcf)	62.4

Top El. of Wall	1599
Bottom El. of Wall	1589
Bottom El. of Toe	1588
Stem height (ft)	10
Stem Thickness (ft)	1
Length of Toe (ft)	3
Toe Thickness(ft)	1
Length of Heel (ft)	5.5
Heel Thickness (ft)	1
U/S Slope	1.3
Horz. Proj. of Heel	4.36
Vertical Proj. Of Heel	3.35
Angle of Heel (rad)	0.66
Water Press on Stem	624
Water Press on Heel	833.25
Max Toe Thickness	1.25
Uplift Pressure at toe	0
Uplift Pressure under stem	371.7
Uplift Pressure at heel	882.7
Effective Drag	1.0

Item	Force (lb)	Lv. Arm (ft)	Moment (ft*lb)
Stem	1500	3.50	5250
Toe 1	450	1.50	675
Toe2	56	2.00	112.5
Triangle	75	3.33	250
Heel	825	6.18	5098.3
Water Pr. On Stem	3120	4.33	13520.0
Water Pr. 1 On Heel	3432	-	18226.61
Water Pr. 2 On Heel	575	-	3583.6
Uplift Pr. 1 On Heel	2044	-	12102.5
Uplift Pr. 2 On Heel	1405	-	9608.8
Uplift on Toe	743	2.67	1982.2
Overtopping Drag	50	11.00	550.0

OVERTURNING

Total Stabilizing	**33196**
Total Overturning	**37764**
F.S.	**0.879**

SLIDING

Horiz. force of water on stem	3120.0
Horiz. force of water on heel	2443.4
Horiz. force of uplift on heel	2103.2
wall friction Φ (degrees)	30.0
N	2605.1
friction	1504.1
Passive Pressure	
Rockfill friction angle (rad)	0.72
Kp	4.82
Gamma	130.5
Gamma effective	68.1
H (vert. dist. of heel)	4.35
Pp (at bottom of heel)	3107

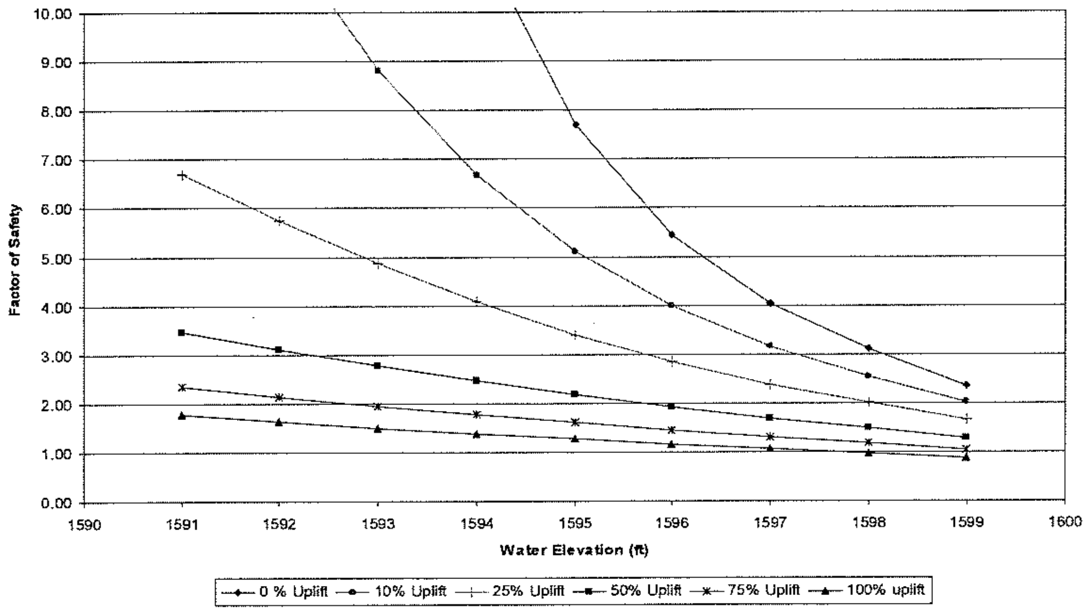
SLIDING

Total sliding	**5563.4**
Total resisting	**6714.6**
F.S.	**1.207**

By JDD . Date 1-13-06 . Subject Taum Sauk Dam . Sheet No. 9 of 12.
Chkd. by KZ . Date 3-23-06. Stability Analysis of Parapet Wall Proj. No. 06-3551 .

Overturning Analysis

Factor of Safety vs. Water Elevation



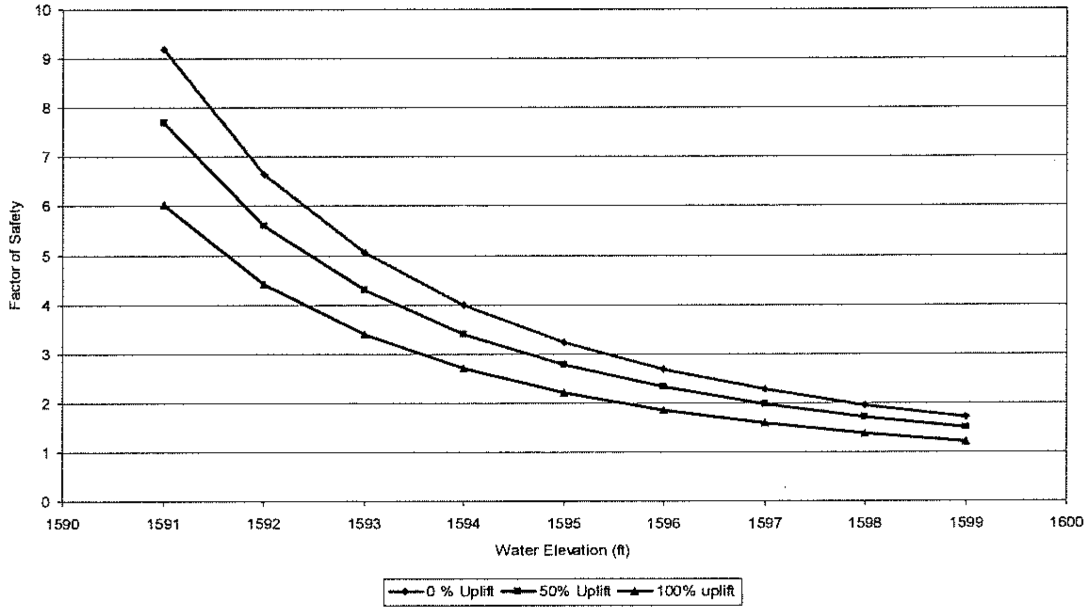
Factor of Safety Against Overturning

0 % Uplift	Water Depth	Overturning
	1599	2.36
	1598	3.10
	1597	4.04
	1596	5.44
	1595	7.69
	1594	11.58
	1593	19.11
	1592	36.39
	1591	89.49
10% Uplift	Water Depth	Factor of Safety
	1599	2.02
	1598	2.55
	1597	3.16
	1596	3.98
	1595	5.11
	1594	6.67
	1593	8.80
	1592	11.62
	1591	15.04
25% Uplift	Water Depth	Factor of Safety
	1599	1.66
	1598	2.01
	1597	2.38
	1596	2.84
	1595	3.40
	1594	4.08
	1593	4.86
	1592	5.75
	1591	6.69

50% Uplift	Water Depth	Factor of Safety
	1599	1.28
	1598	1.49
	1597	1.69
	1596	1.92
	1595	2.18
	1594	2.47
	1593	2.79
	1592	3.12
	1591	3.48
75% Uplift	Water Depth	Factor of Safety
	1599	1.04
	1598	1.18
	1597	1.31
	1596	1.45
	1595	1.61
	1594	1.77
	1593	1.95
	1592	2.14
	1591	2.35
100% uplift	Water Depth	Factor of Safety
	1599	0.88
	1598	0.98
	1597	1.07
	1596	1.17
	1595	1.27
	1594	1.38
	1593	1.50
	1592	1.63
	1591	1.77

By JDD . Date 1-13-06 . Subject Taum Sauk Dam . Sheet No. 10 of 12.
Chkd. by KE . Date 3-13-06. Stability Analysis of Parapet Wall Proj. No. 06-3551 .

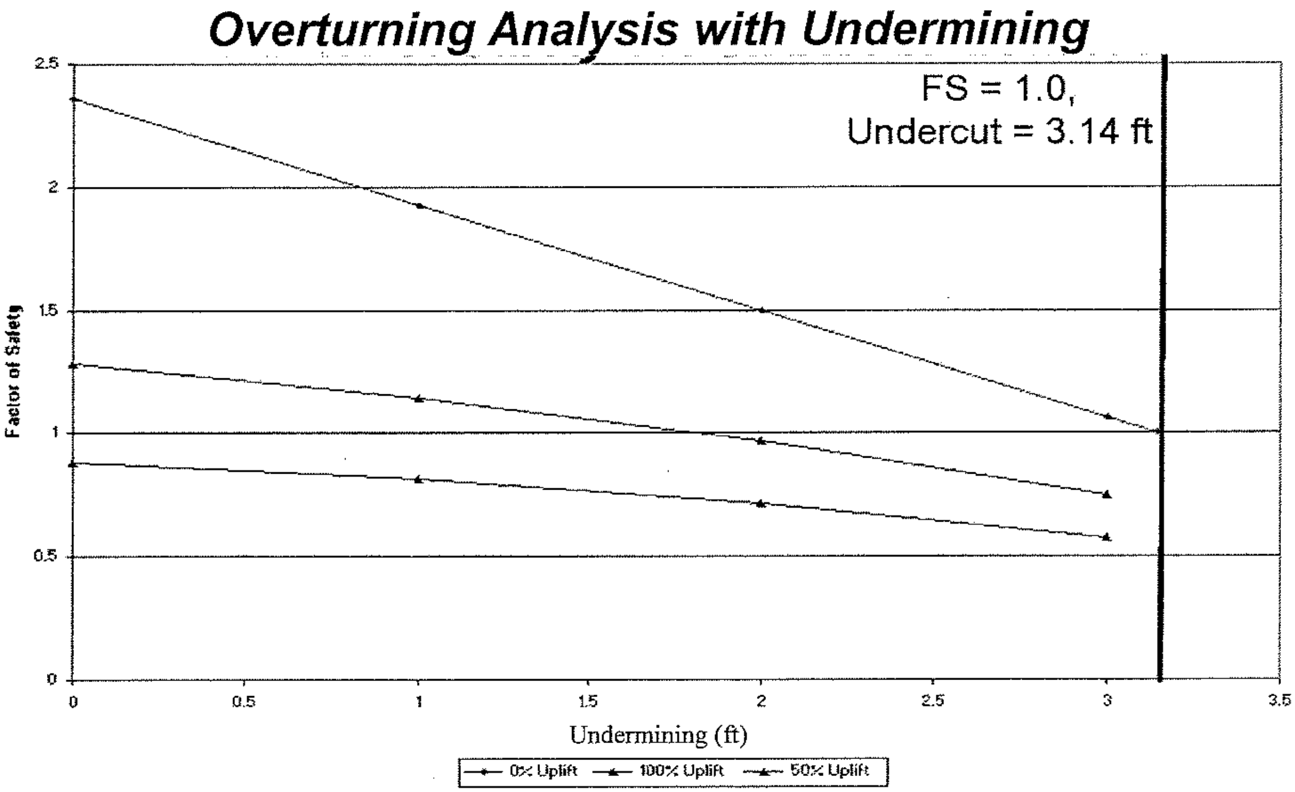
Sliding Analysis
Factor of Safety vs. Water Elevation



Factor of Safety against Sliding

0 % Uplift	Water Depth	Factor of Safety
	1599	1.70
	1598	1.96
	1597	2.28
	1596	2.69
	1595	3.24
	1594	3.99
	1593	5.05
	1592	6.64
	1591	9.18
50% Uplift	Water Depth	Factor of Safety
	1599	1.49
	1598	1.70
	1597	1.97
	1596	2.32
	1595	2.78
	1594	3.40
	1593	4.29
	1592	5.61
	1591	7.71
100% uplift	Water Depth	Factor of Safety
	1599	1.21
	1598	1.38
	1597	1.59
	1596	1.86
	1595	2.22
	1594	2.71
	1593	3.40
	1592	4.42
	1591	6.04

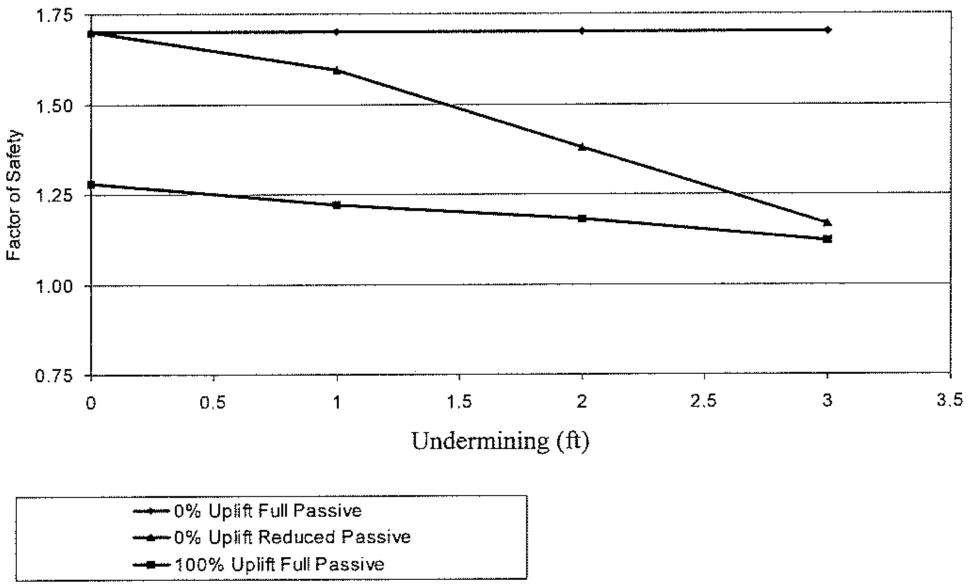
By JDD . Date 1-13-06 . Subject Taum Sauk Dam . Sheet No. 11 of 12.
Chkd. by KR . Date 3-23-06. Stability Analysis of Parapet Wall Proj. No. 06-3551 .



Factor of Safety Against Overturning with Undermining

	Undermining	Factor of Safety
0% Uplift	0	2.36
	1	1.93
	2	1.49
	3	1.06
100% Uplift	0	0.88
	1	0.81
	2	0.72
	3	0.58
100% Uplift Full Passive	0	1.28
	1	1.22
	2	1.18
	3	1.12

Sliding Analysis with Undermining



*Passive Pressure is reduced as undercut distance increases.
reduction for each undercut distance is shown in the table to the right.

Undermining (ft)	% of Passive Pressure
3	50
2	70
1	90
0	100

Factor of Safety Against Sliding with Undermining

Undermining	Full Passive Pressure	Reduced Passive Pressure	100% Uplift Full Passive
0	1.70	1.70	1.28
1	1.70	1.59	1.22
2	1.70	1.38	1.18
3	1.70	1.17	1.12

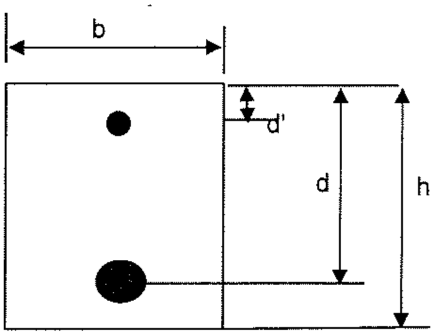
REINFORCED CONCRETE WALL CALCULATION

By DF Date 1/19/06 Subject Taum Sauk Sheet No. 1 of 4
Chkd. By Date 1/19/06 RC Pond Wall Check Proj. No. 06-3551

Purpose: Check the section design of water pond retaining wall

Reference: Reinforced Concrete, Fifth edition, Edward G. Nawy. Chapter 5 and Chapter 6

Assumption: Selfweight has little effect on structure and can be neglected.
Assume single-reinforced concrete beam behavior



water pressure

level(ft)	density(lb/f	water pressure(lb/ft^2)
0	62.41983	0
10	62.41983	624.2
13.35	62.41983	833.3

Moment and shear force

	Length(ft)	M_max @ pt. A (lb-ft)	shear_max(lb)
Upright	10	10403	3121
Slant	5.5	11549	4008
Back	3	10403	3633

material property

fc'=	3	ksi	beta1=	0.85	for fc'<4ksi
fy=	40	ksi			

refer to 5.9

A: Check Critical Section of Upright Wall

section property

b=	12	in	h=	12	in
d,dt=	9.5625	in			

	area(in^2)	diameter(in)
#7	0.6	0.875

ρ=A/bd 0.005229 > ρmin= 0.005 yes

Use single #7 reinforcement:

a=As*fy/(0.85*f'c*b= 0.784314 in

c=a/beta1= 0.922722 in refer to 5.3

c/dt= 0.096494 <0.375 Φ= 0.9 refer to Fig 5.5

Mn=As*fy*(d-a/2)= 220.0882 k-ft refer to 5.4b

ΦMn=0.9*Mn= 198.0794 k-ft >> M_A_max= 10.403 k-ft ok

Paul C. Rizzo Associates, Inc.
ENGINEERS & CONSULTANTS

By DF Date 1/19/06 Subject Taum Sauk Sheet No. 2 of 4

Chkd. By NG Date 1/19/06 RC Pond Wall Check Proj. No. 06-3551

Vn>Vc>1.9*b*d*sqrt(fc')= 11941.72 lb refer to 6.8, 6.11

ΦVn=0.75Vn> 8956.291 >> V_max= 3121 lb ok

B: Check Critical Section of Slant Wall

section property

b=	12	in	h=	12	in
d,dt=	9.5625	in			

	area(in^2)	diameter(in)	
#7	0.6	0.875	

ρ=A/bd 0.005229 > ρmin= 0.005 yes

Use single #7 reinforcement:

a=As*fy/(0.85*f'c*b= 0.784314 in

c=a/beta1= 0.922722 in refer to 5.3

c/dt= 0.096494 <0.375 Φ= 0.9 refer to Fig 5.5

Mn=As*fy*(d-a/2)= 220.0882 k-ft refer to 5.4b

ΦMn=0.9*Mn= 198.0794 k-ft >> M_A_max= 11.5 k-ft ok

Vn>Vc>1.9*b*d*sqrt(fc')= 11941.72 lb refer to 6.8, 6.11

ΦVn=0.75Vn> 8956.291 >> V_max= 4008.1 lb ok

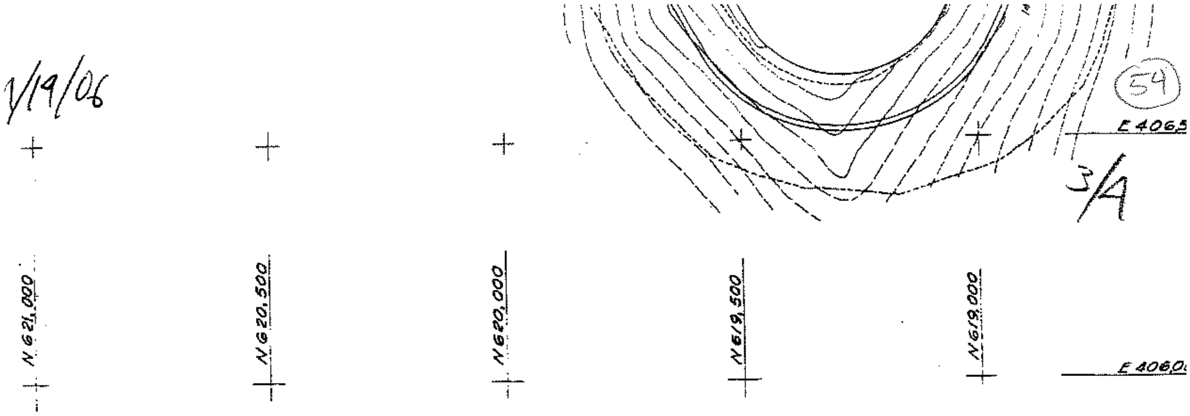
C: Check Critical Section of Back Wall

Same as A. ok

ckd NG 1/19/06

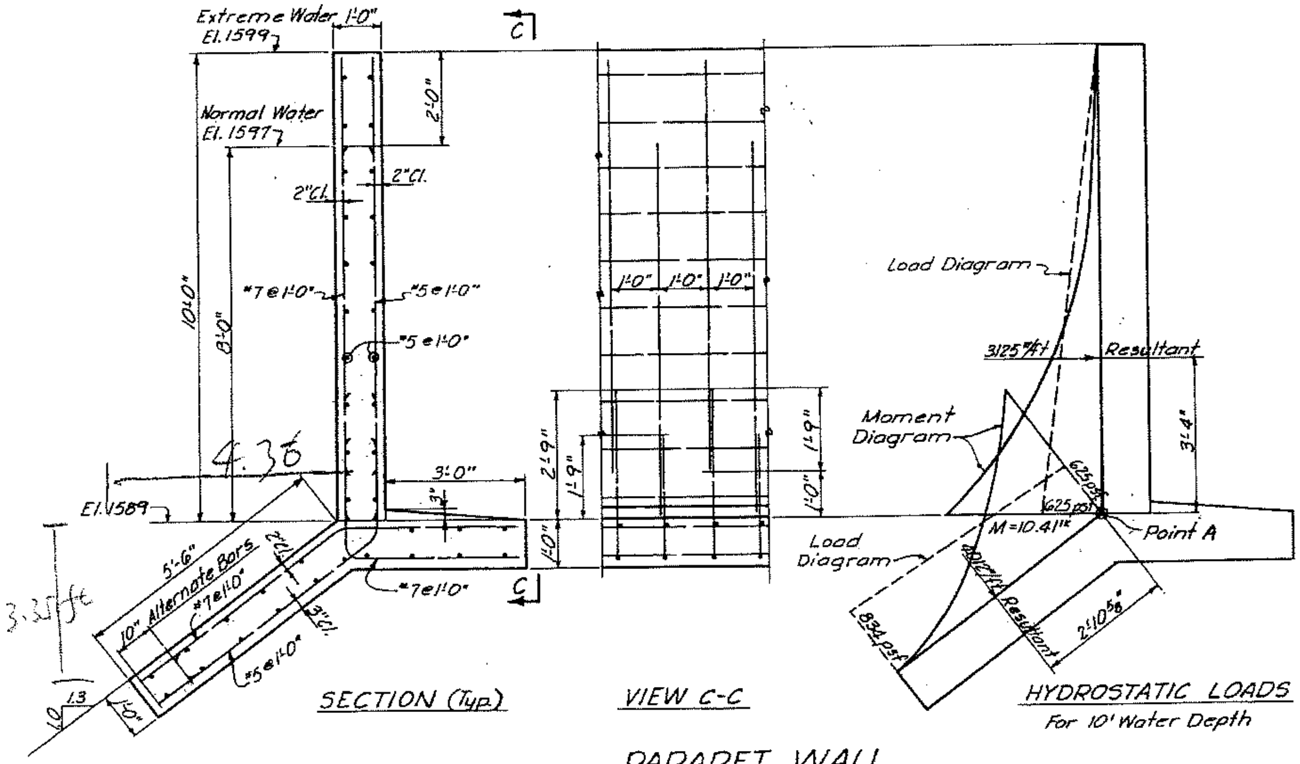
(54)

3/A



LOCATION PLAN

Upper Reservoir
Scale: 1"=200'-0"
Rock surface contours from dwg. 8304-X-26021



SECTION (Typ.)

VIEW C-C

HYDROSTATIC LOADS
For 10' Water Depth

PARAPET WALL

Reinforcing steel bars are of billet steel, A.S.T.M. A15 Specification, intermediate grade, with deformations to A.S.T.M. A 305 specification.

Physical Properties:
Ultimate —— 70-90,000 p.s.i. ✓
Yield —— 40,000 p.s.i. Minimum
Concrete is of 3000 pound strength at 28 days.

Loads on wall at base (Elev. 1589) per foot of wall:	Extreme High Water	Normal Water
Moment ————	10.41'k	5.33'k
Axial Load ————	1.50k	1.50k
Shear ————	3.125k	2.00k
Maximum Unit Stresses		
Reinforcing Steel ————	22,600 p.s.i.	10,900 p.s.i.
Concrete Fibre Stress ———	910 p.s.i.	465 p.s.i.
Concrete Shear Stress ——	30 p.s.i.	20 p.s.i.
Bond ————	131 p.s.i.	85 p.s.i.
Bond in Lap of 2'-3" ————	183 p.s.i.	88 p.s.i.

Stability under hydrostatic pressure for 10 ft. head of water.

Moments about Point A.

Overturning 3125# x 3.33' = 10,406'#
Stabilizing 4012# x 2.88' = 11,555'#
1,149'#

Therefore, stabilizing moment on toe is greater than overturning moment on wall. Additional factor in favor of stabilit is pressure under downstream footing o wall, not included in this analysis.

— From DWG # 8304-X-26157

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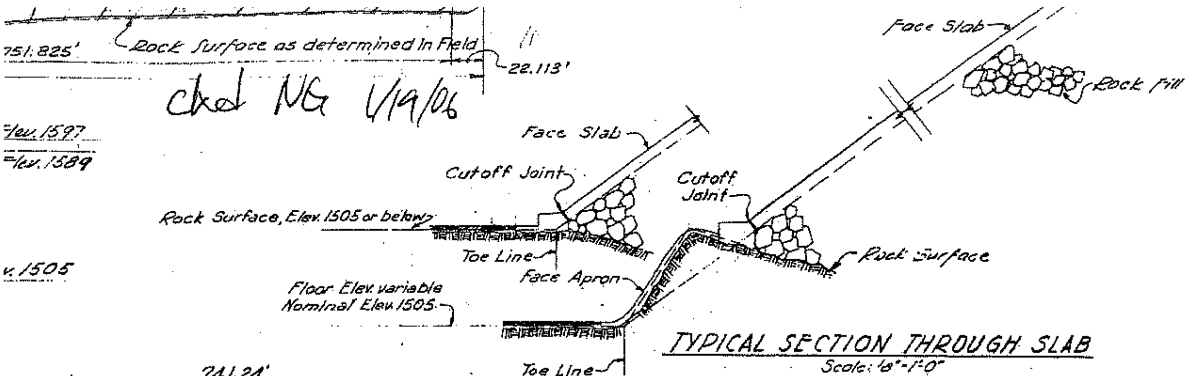
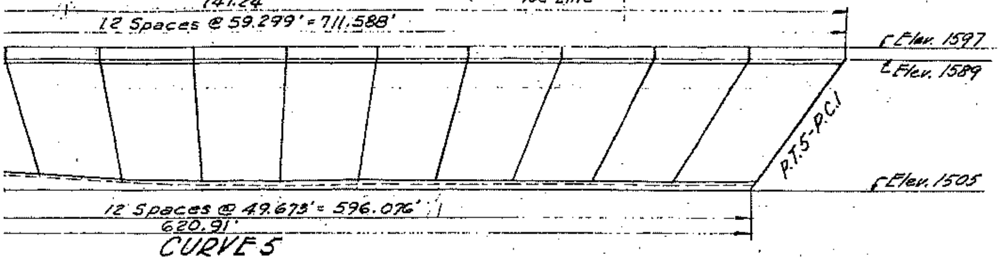
4/4

Chkd NG 1/19/06

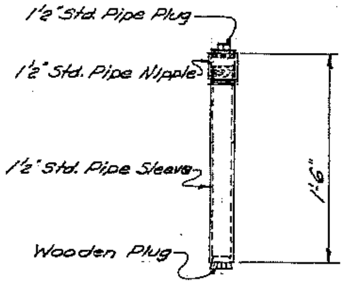


TYPICAL SECTION THROUGH SLAB

Scale: 1/8"=1'-0"

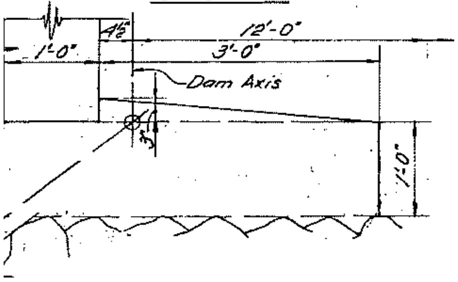


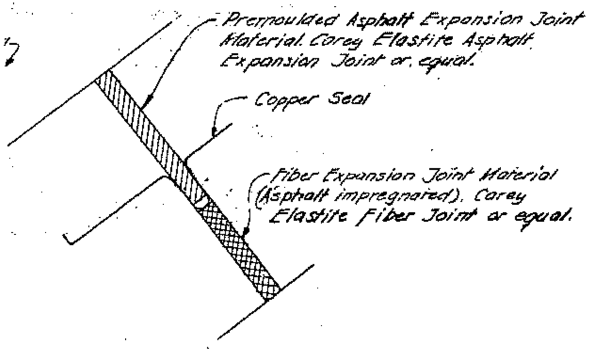
CURVE 5



PIPE SLEEVE

Scale: 1½"=1'-0"

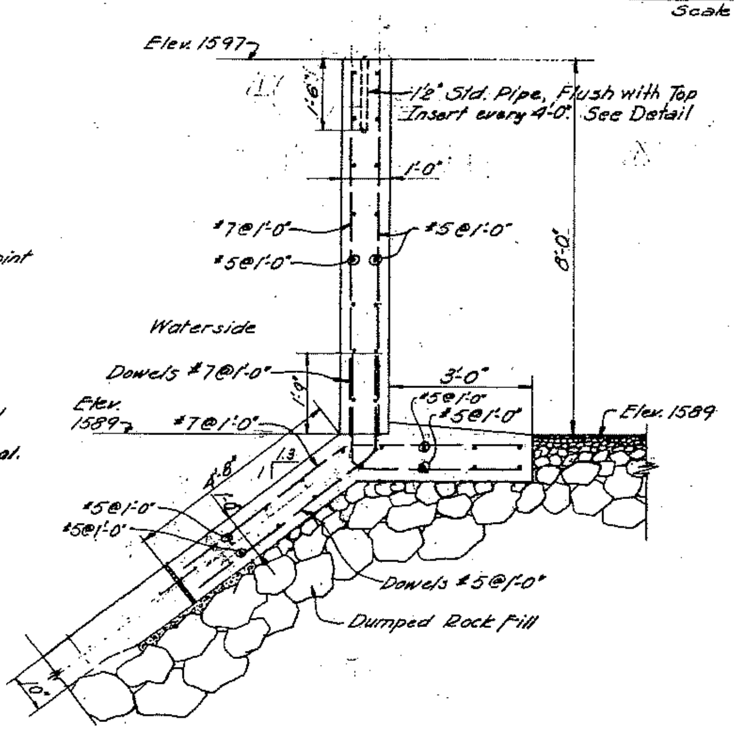




APET FOOTING JOINT

Scale: ¼"=1"

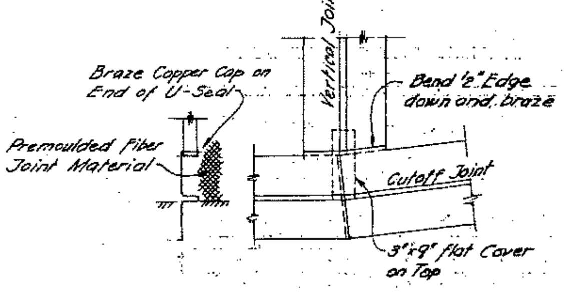
al Joint on the two central Joints only
al Joint (except for the two central Joints)
tical Joint



TYPICAL SECTION THROUGH PARAPET WALL

Scale: ½"=1'-0"

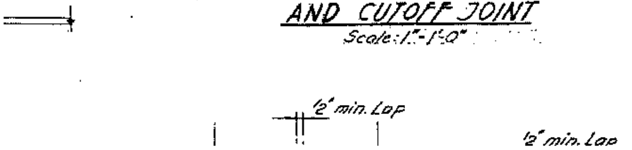
NOTE:
Work this Drawing with Drawings 8304-X-26055 & 26115



20

INTERSECTION VERTICAL JOINT AND CUTOFF JOINT

Scale: 1"=1'-0"



REFERENCE DRAWINGS:
Upper Reservoir

8304-X-026054

SEEP2D ANALYSIS OF FAILED ZONE CALCULATION

By UD . Date 2-20-06 . Subject Taum Sauk Plant . Sheet No. 1 of 16 .
Chkd. by JPG . Date 3/20/06 . SEEP2D Analysis of Failed Zone . Proj. No. 06-3551-01.

OBJECTIVE:

The forensic stability analysis of the failed embankment of the Upper Reservoir of Taum Sauk Plant requires the calibration of the Seepage Model and determination of phreatic surface and/or flownet through the failed section of the berm. For the stability analysis of the berm, a typical cross section has been selected as shown in ***Figure 1*** which is based on the details given in ***Reference 1***. The seepage analysis is carried out for different values of the permeability to investigate the sensitivity of various material properties and then to develop the best estimate phreatic surface which can be utilized in the slope stability analysis.

REFERENCES:

1. Sverdrup & Parcel Engineering Co., Upper Reservoir, Site Plan and General Design, Taum Sauk Project, Union Electric System, St. Louis, MD, 7-7-60.
2. Surdex Corporation, "Upper Reservoir, Rockfill Dike, Ameren Service Co., Job No. 1501211/62, Date of Photography 12/19/2005.
3. SEEP 2-D Analysis, "GMS, Ground Water Modeling System", Boss International, Inc and Brigham Young University, 1999.
4. FFC Safety Report Prepared by J. Barry Cooke, Consulting Engineer, Taum Sauk Project, Upper Dam, Union Electric Company, 7-26-1968.
5. 1998 Review of Safety Report (Seventh Five-Year Report), Inspection of Project Works, Taum Sauk Project, FERC, Licensed Project No. 2277, Union Electric Company, St. Louis, Missouri, Prepared by J. Barry Cooke and Arthur G. Strassburger, March 1998.
6. 8th FERC Part 12 Independent Report, Taum Sauk Project, FERC, Project No. 2277, Prepared for AmerenUE, Prepared by MWH, August 2003.

METHODOLOGY:

Calibration Modeling:
Parapet Wall Segment No. 95, located approximately in the middle of the failed section, was selected for developing the seepage model and calibration of permeability values of the various materials. The bedrock elevations and the general cross-sections are developed from ***References 1 and 2***. In ***Reference 6***, the average flow of seepage through the entire section of the dam is reported to be about 40 cfs prior to installation of HDPE and LDPE Liners on the Upstream Face of the Dike. Assuming total length of rockfill dike of 6562 feet (***Reference 5***), the seepage is calculated to be 527 cu ft/day/ft. ***Figure 1*** shows the Calibration Model which consists of following:

- 1' thick Upstream Face of Concrete/HDPE Liner
- Rockfill
- 1' thick Upstream Asphalt Layer
- Two rows of Grout Curtains (***Reference 4***)
- 6" Gravel Layer
- 10' Thick Downstream Soil Layer extending 20' in to the rockfill
- Bedrock

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The Flownets for the analyzed cross sections were calculated using the GMS3.0/SEEP2D program. SEEP2D is a two-dimensional finite element groundwater model developed by U.S. Army Corps of Engineers Waterways Experiment Station (WES). GMS3.0, a graphical representation of the program, is developed by Brigham Young University (***Reference 3***).

To check the validity and compatibility of our estimate of the basic relative permeability values, we performed a set of calibration runs. We estimated the seepage from the Upper Reservoir without the HDPE Liner (installed in 2004) and compared our results with estimated seepage reported in the ***Reference 5***. We then slightly adjusted our model to find a reasonable match between our estimate of seepage and measured values. The phreatic surface and flow net for the calibration model is shown on ***Figure 2***.
The permeability values for the various materials as determined from the Calibration Model are given in ***Table 1***. As shown on ***Figure 2***, the average seepage flow for this model is about 525 cu ft/day.

Table 1: Values of permeability used for seepage analysis

Type of soil	**Permeability, k (cm/s)**	**Soil #**
Bedrock	10^{-4}	1
Rockfill	10^{-3}	2
Concrete Face	10^{-4}	3
Concrete/Liner	10^{-11}	4
Grout Barrier	10^{-11}	5
Asphalt	10^{-5}	6
Soil	1.6×10^{-1}	7
Gravel	1.6×10^{-1}	8

The overall calibration check is somewhat crude as the accuracy of the leakage rate available is limited. Specifically, the available leakage rates are such that one cannot distinguish from that lost through the Dike, the bottom of the Upper Reservoir, or evaporation. Also, the configuration of the Dike varies significantly around the perimeter of the Upper Reservoir, whereas we considered only the geometry at the Breach Area as being reasonably indicative of all cross sections. Therefore, we are able to conclude only that our chosen parameters are in the proper range, but parametric runs as described below are necessary to fully understand the range of possible behavior of the Dike.

PARAMETRIC EVALUATIONS

After calibrating the model shown in ***Figure 1*** and adding the HDPE Liner on the upstream face of the Dike, a series of seepage analysis runs were performed on the "Best Estimate" Model shown on ***Figure 3***. Analyses were carried out on each geometry assuming:

a) Water pool elevation = 1598 ft, (Assuming a one foot of settlement)
b) The embankment with a 1 ft concrete/rubber liner with permeability of 10^{-11} cm/s,
c) Two rows of Grout Curtains each 20 feet deep,
d) Asphalt Liner at the bottom of the dam.

The results are summarized in ***Table 2*** and resulting flow net are shown on ***Figures 4 through 12***. The results indicate that the Liner significantly changed the flow regime, dropping the phreatic surface to the level of the interface. The range of properties used in the parametric analysis of the seepage is summarized on ***Figure 3*** and parametric variations in ***Table 2***. It is to be noted that variations of the Best Estimate Model for those parameters determined to be significant with respect to overall seepage and overall flow net configurations are presented in this analysis. Not all parameters comprising the model are shown on the table as several were assessed interactively on the computer screen as not being significant. For example, we varied the permeability of the two Grout Curtains, but no significant changes in the results were observed and therefore, we have not included these analyses in the present calculations.

Table 2: Summary of SEEP2D Analysis Results

Case	Description	Figure No.	Discharge (ft^3/d/ft)	Phreatic Surface	Remark	Filename
Calibration Model	Permeability Calibration	1	40cfs (for entire reservoir length)		Assuming concrete is leaking	
A-1	Liner 10-4	2	525.7	Very High in Rockfill	Other K's unchanged	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-i.sps
Liner Model	Liner 10-11	3	2 cfs (for entire reservoir length)		Other K's unchanged	
B-1	Rockfill 10-2	4	25.9	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-m.sps
B-2	Rockfill 10-3	5	25.9	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-l.sps
B-3	Rockfill 10-4	6	25.9	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-n.sps
B-4	Interface 1.6x10-2	7	24.7	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-q.sps
B-5 (A)	Interface 1.6x10-4	8	20.5	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-r.sps
B-5 (B)	Interface 1.0x10-5	9	19.6	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-s.sps
B-6 (A)	Soil 1.6x10-2 Filter 1.6x10-1	10	25.8	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-o.sps
B-6 (B)	Soil 1.6x10-3 Filter 1.6x10-1	11	25.7	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-p.sps

ASSUMPTIONS:

1. The general geometry of the section is taken from ***Reference 1***.
2. Boundary conditions for each trial are marked on ***Figure 3***.
3. Reservoir elevation has been set at 1598 feet for this analysis.
4. The geometry with no concrete/rubber liner has been simplified by setting the permeability of the liner equal to the permeability of the concrete.
5. To simplify the seepage analysis the permeability of concrete, the liner, and the grout barrier are assumed equal to $K=10^{-11}$ cm/sec. This conservative value has been selected to ensure that all the barriers are impermeable. Other permeability values have been assumed either based on the Calibration Model shown on ***Figure 3*** or from the parametric evaluation.
6. The exit face is assumed to be located along the downstream slope of the embankment and the rock-face.

INPUT:

The input parameters required for GMS3.0/SEEP2D program consist of the dam cross-sections, permeability of various soil/rock layers, Maximum upstream water head and exit face of the seepage. ***Figures 1 and 3*** present the cross sections, boundary conditions and other required input parameters.

COMPUTER OUTPUT & RESULTS:

The output flow nets are shown in ***Figures 2 and 4 through 11***. Each geometry is analyzed for upstream water elevation of 1598 ft.

CONCLUSIONS:

The results of these parametric evaluations indicate that the permeability of the soil at the Dike/foundation interface and the Filters has a significant effect on the flow net and the pore pressure on the interface. The seepage is within the soil/filter layer.

(60)

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FIGURES

(61)

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FIGURE 1

Model Calibrated for 40 cfs – No HDPE Liner

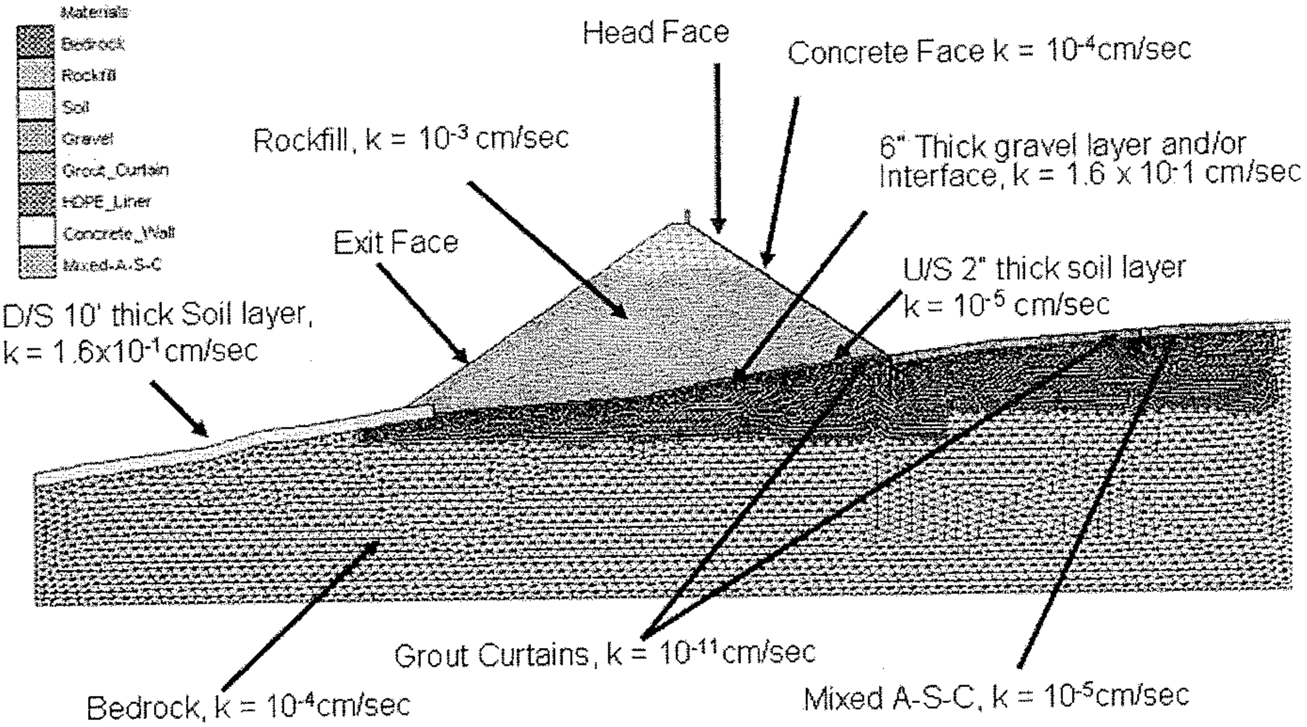

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FIGURE 2

HDPE Liner 10^{-4} cm/sec

Rockfill 10^{-3} cm/sec

Total Flow rate =

525.680 (ft^3/d)(ft)

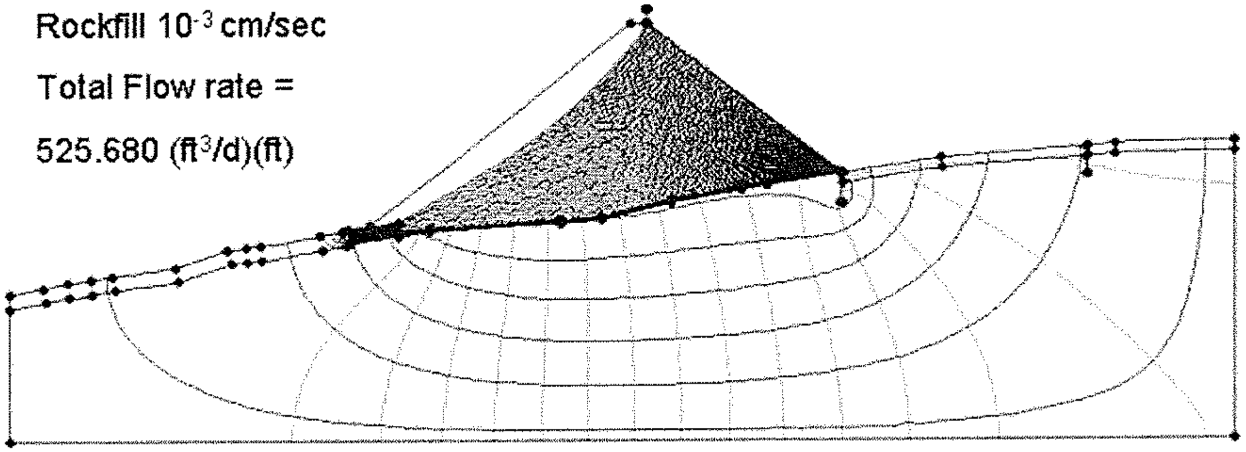

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FIGURE 3

HDPE Liner Used

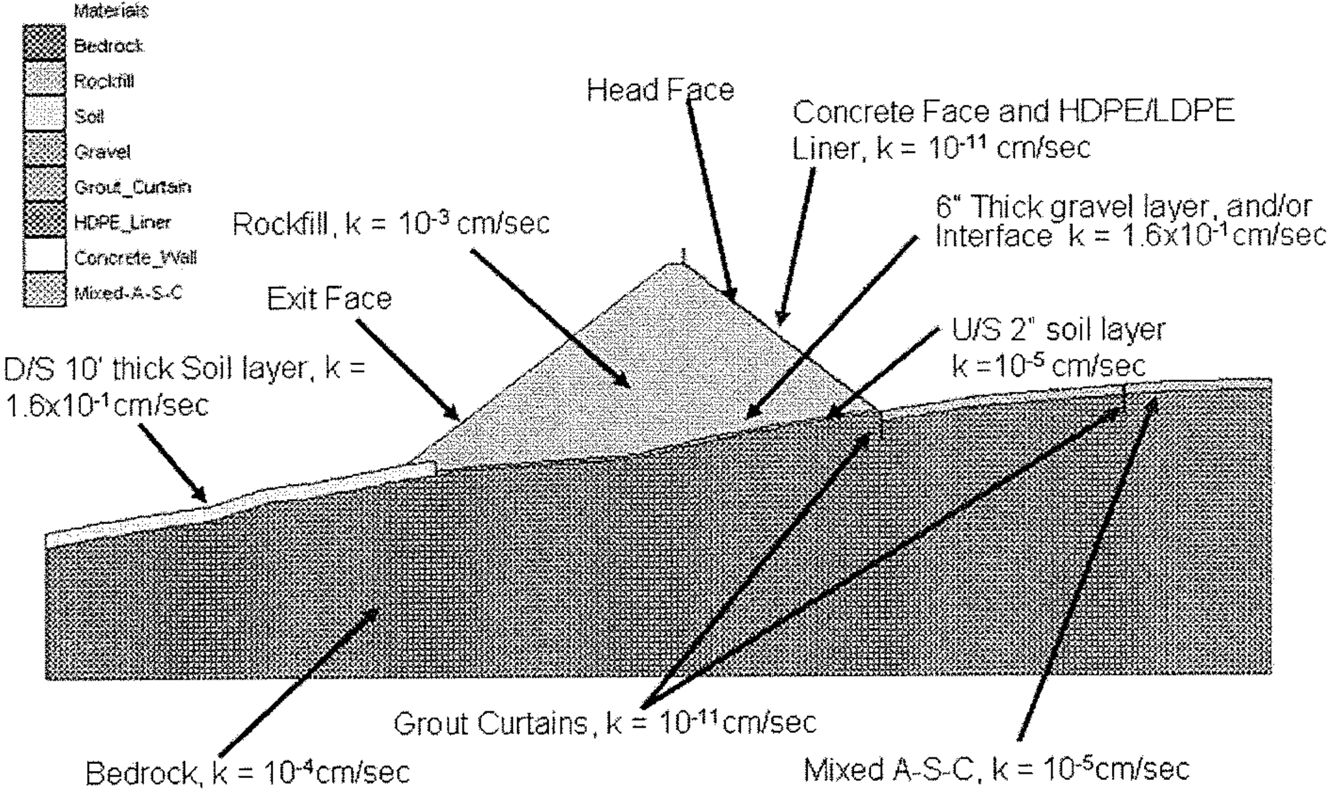
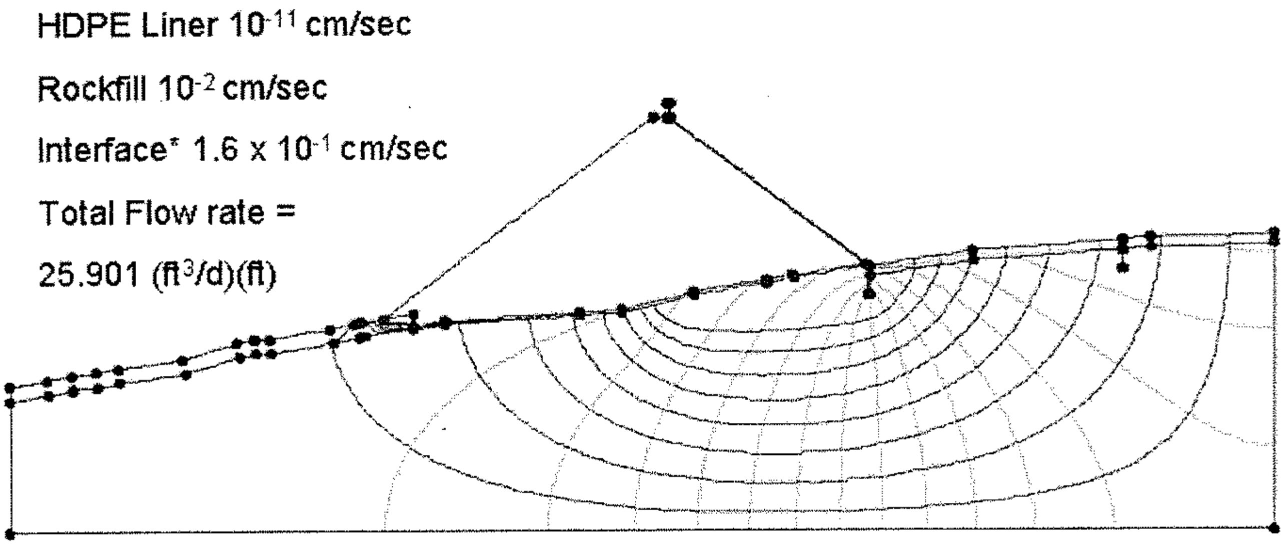


FIGURE 4



HDPE Liner 10^{-11} cm/sec

Rockfill 10^{-2} cm/sec

Interface* 1.6 x 10^{-1} cm/sec

Total Flow rate =

25.901 (ft^3/d)(ft)

*Interface is composed of soil and gravel layer

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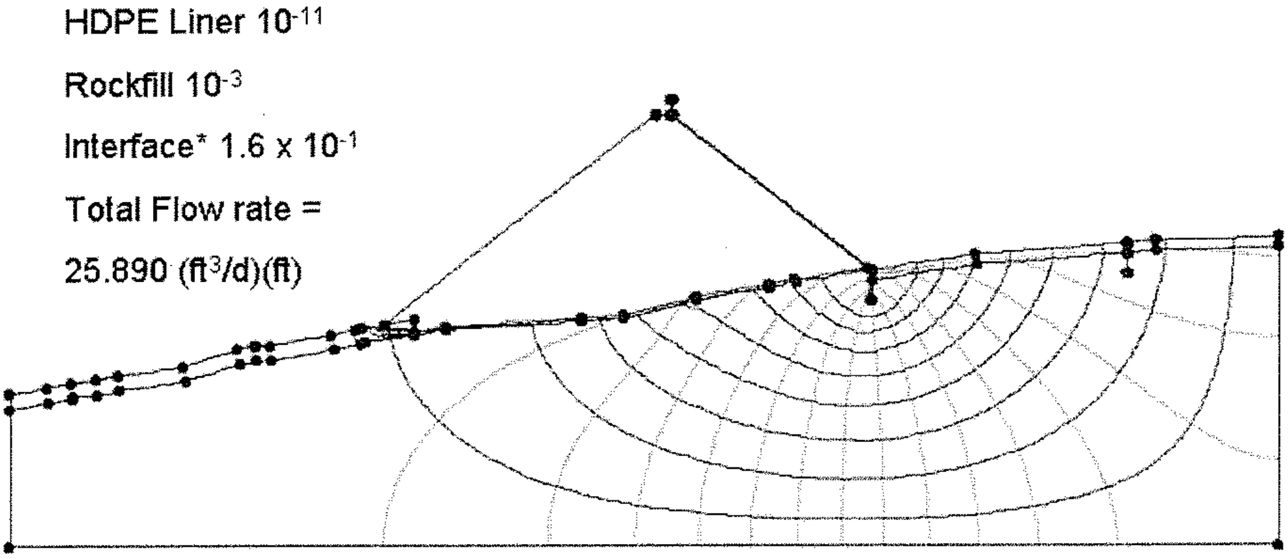
FIGURE 5



*Interface is composed of soil and gravel layer

G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-I.sps

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FIGURE 6

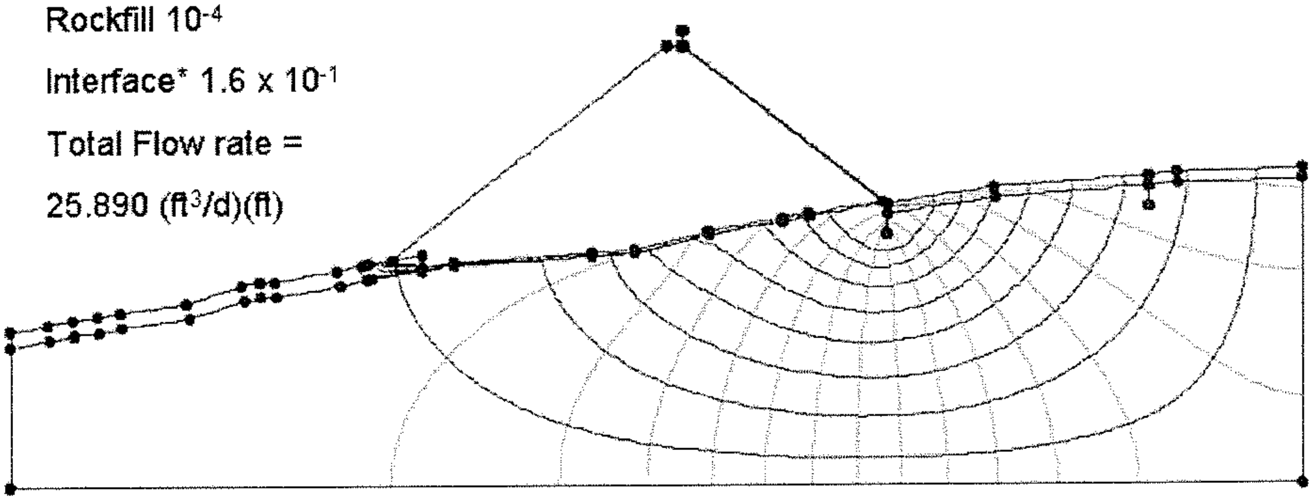
HDPE Liner 10^{-11}

Rockfill 10^{-4}

Interface* 1.6×10^{-1}

Total Flow rate =

25.890 (ft^3/d)(ft)



*Interface is composed of soil and gravel layer

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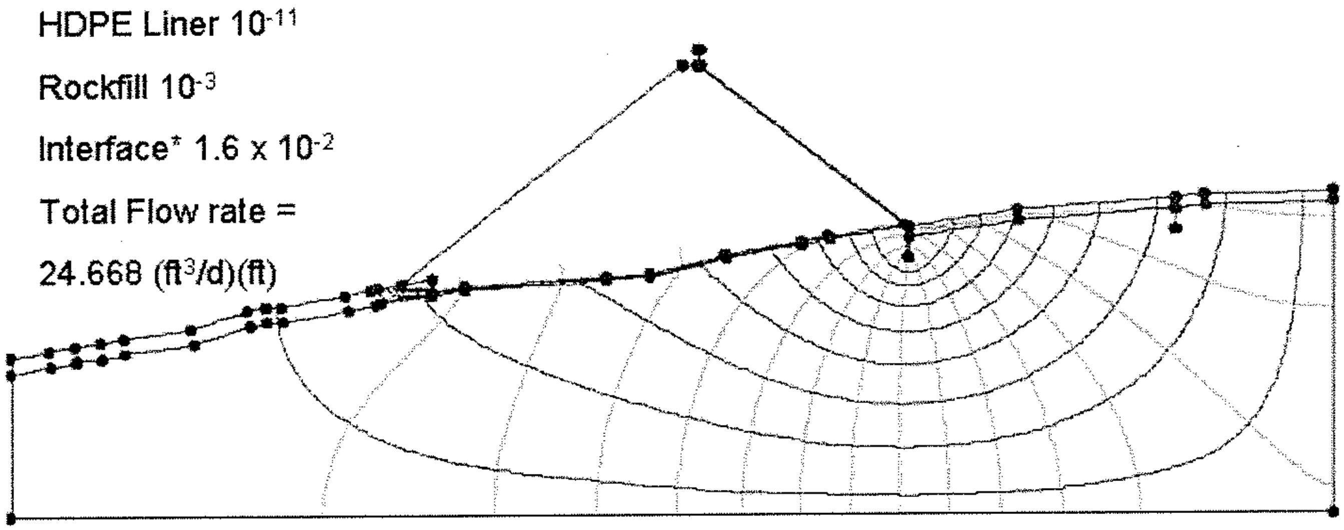
FIGURE 7



HDPE Liner 10^{-11}

Rockfill 10^{-3}

Interface* 1.6×10^{-2}

Total Flow rate =

24.668 $(ft^3/d)(ft)$

*Interface is composed of soil and gravel layer

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FIGURE 8

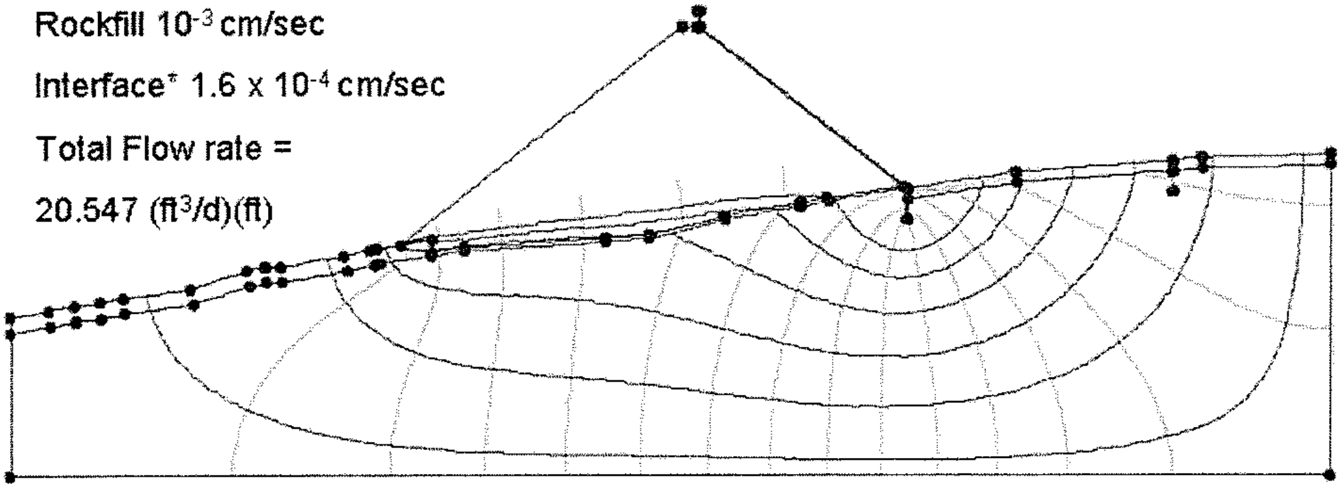
HDPE Liner 10^{-11} cm/sec

Rockfill 10^{-3} cm/sec

Interface* 1.6 x 10^{-4} cm/sec

Total Flow rate =

20.547 (ft^3/d)(ft)



*Interface is composed of soil and gravel layer

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FIGURE 9

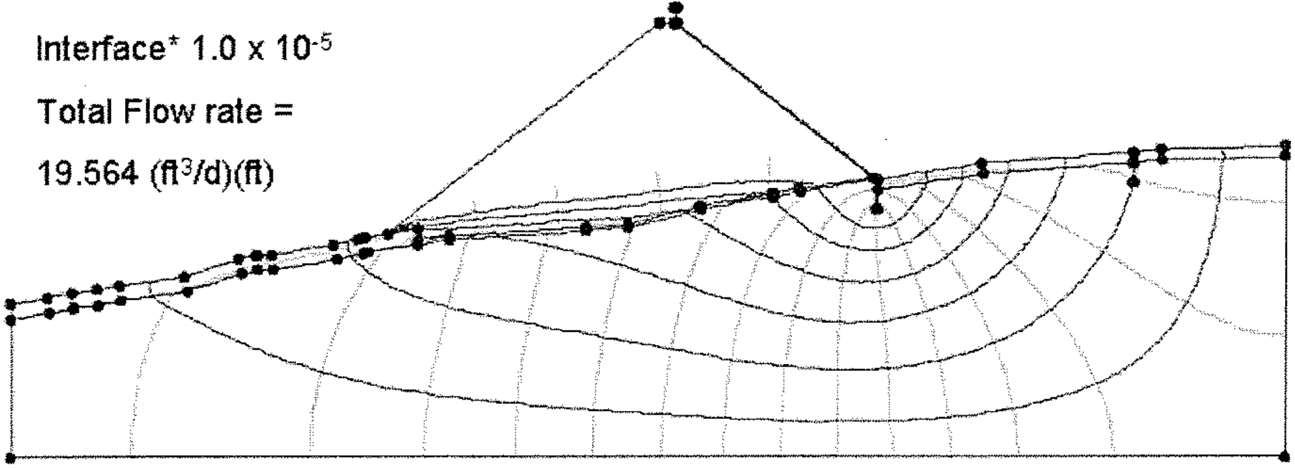
HDPE Liner 10^{-11}

Rockfill 10^{-3}

Interface* 1.0×10^{-5}

Total Flow rate =

19.564 (ft^3/d)(ft)



*Interface is composed of soil and gravel layer

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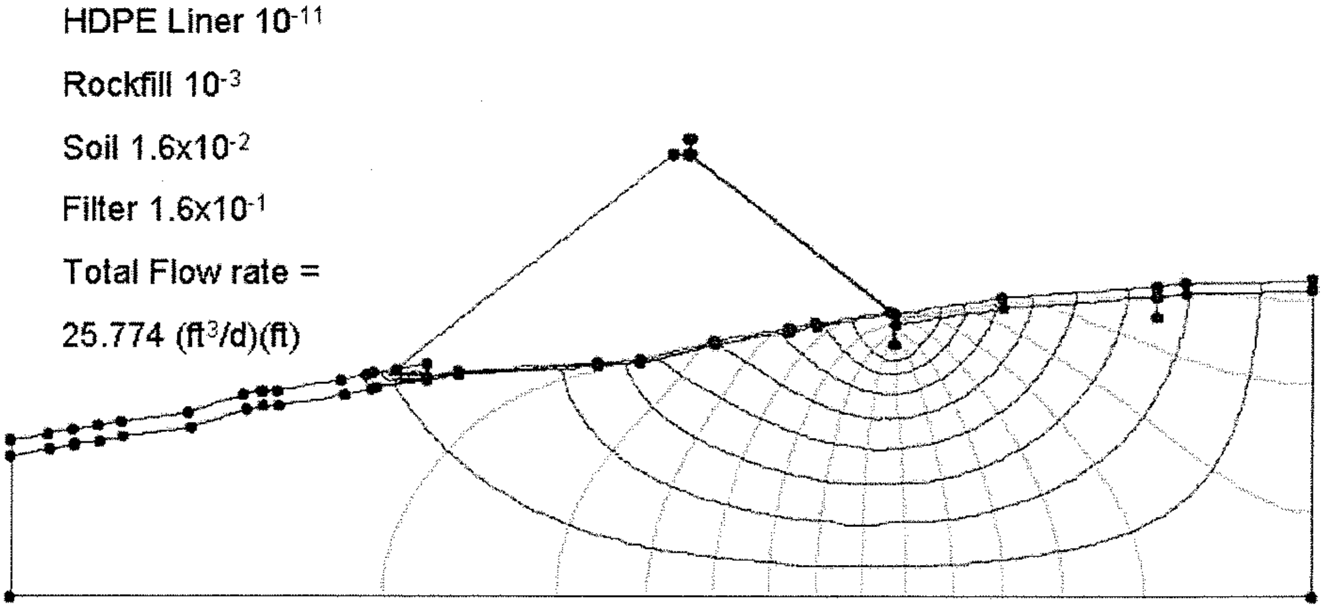
⑩

FIGURE 10



HDPE Liner 10^{-11}

Rockfill 10^{-3}

Soil 1.6×10^{-2}

Filter 1.6×10^{-1}

Total Flow rate =

25.774 (ft^3/d)(ft)

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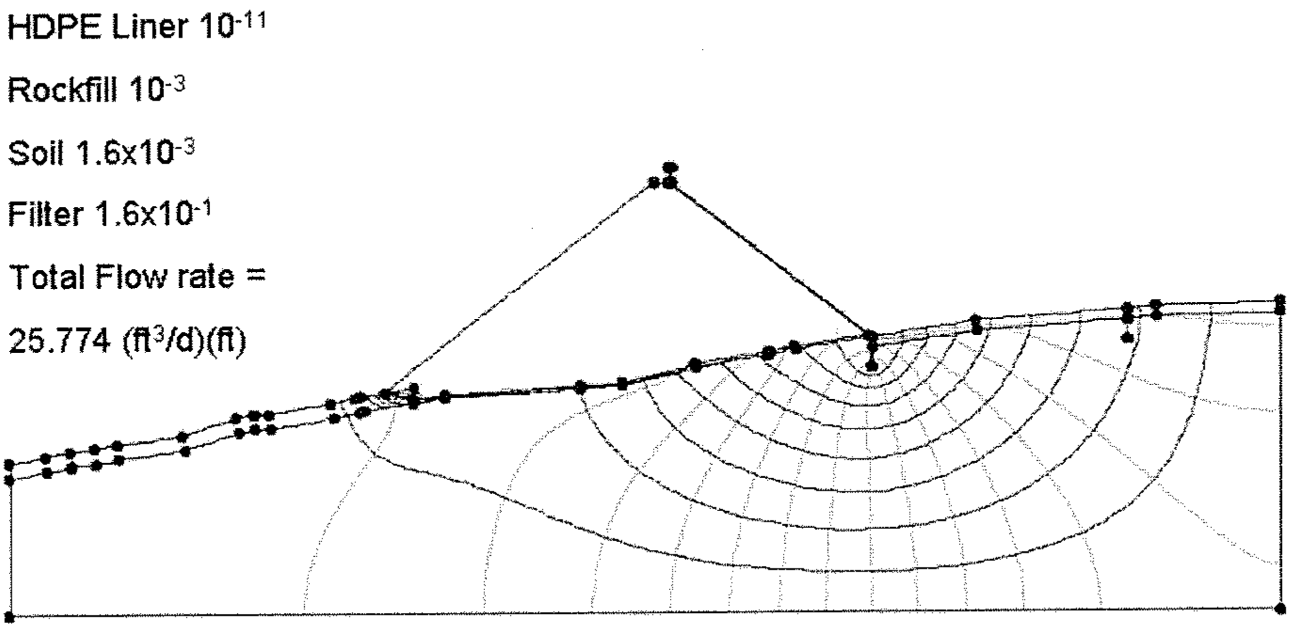
Chkd. by JPG . Date 3/20/06 . SEEP2D Analysis of Failed Zone . .

FIGURE 11



HDPE Liner 10^{-11}

Rockfill 10^{-3}

Soil $1.6x10^{-3}$

Filter $1.6x10^{-1}$

Total Flow rate =

25.774 (ft^3/d)(ft)

G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-p.sps

STABILITY ANALYSIS OF FAILED ZONE CALCULATION

OBJECTIVE:

To evaluation of the stability of slope of the failed dike of the Upper Reservoir of Taum Sauk Plant. A typical cross section of the failed dike has been selected from ***Ref. 1*** for analysis. The slope stability analyses are carried out for a range of soil strength properties and possible phreatic surfaces as obtained from the SEEP2D analysis.

REFERENCES:

1. Sverdrup & Parcel Engineering Co., Upper Reservoir, Site Plan and General Design, Taum Sauk Project, Union Electric System, St. Louis, MD, 7-7-60.
2. Surdex Corporation, "Upper Reservoir, Rockfill Dike, Ameran Service Co., Job No. 1501211/62, Date of Photography 12/19/2005.
3. PRCA Calc. "Taum Sauk Plant, Seep2d Analysis of Failed Zone Project", February 2006.
4. Gregory G. H., "GSTABL7 with STEDwin, Slope Stability Analysis", Program Manual Version 2.004, Geotechnical Engineering Software, 2003.
5. FFC Safety Report Prepared by J. Barry Cooke, Consulting Engineer, Taum Sauk Project, Upper Dam, Union Electric Company, 7-26-1968.
6. 1998 Review of Safety Report (Seventh Five-Year Report), Inspection of Project Works, Taum Sauk Project, FERC, Licensed Project No. 2277, Union Electric Company, St. Louis, Missouri, Prepared by J. Barry Cooke and Arthur G. Strassburger, March 1998.
7. 8th FERC Part 12 Independent Report, Taum Sauk Project, FERC, Project No. 2277, Prepared for AmerenUE, Prepared by MWH, August 2003.
8. PCRA Calc. "Estimate of Parapet Wall Overflow Conditions" , February 2006.

METHODOLOGY:

The slope stability analysis for the Dike was performed using the computer program GSTABL7 with STEDwin (Gregory 2003). This program was originally developed by Purdue University for the Indiana State Highway Commission in 1986 and later revised and marketed by Geotechnical Engineering Software Company. This program estimates the factor of safety against slope failure utilizing a two-dimensional limiting equilibrium method. The estimate of the factor of safety against slope instability is performed using the Simplified Bishop method of slices, which is applicable to circular shaped failure surfaces, the Simplified Janbu method of slices, which is applicable to failure surfaces of a general shape, or Spencer's method of slices which is applicable to surfaces having a circular and/or random failure surfaces. The analysis performed by RIZZO is based on the Modified Bishop Method. Information about the theory used in GSTALB7 can be found User's Manual (Ref. 4). This program has been verified in accordance with RIZZO's Quality Assurance Program.

ASSUMPTIONS:

(1) Typical Section:

The Parapet Wall Segment No. 95, located approximately in the middle of the failed section, is selected for this stability analysis. The bedrock elevations and the general cross-section are developed from ***References 1 and 2***. The crest of the dike is located at Elevation 1588 ft (assuming rockfill settlement of a foot). A ten feet high concrete wall has been constructed on the top of the crest to allow for additional storage. The dike was a rockfill berm on a bedrock foundation. A concrete lining covers the entire upstream slope. In 2004, HDPE/LDPE was installed on the top of the concrete lining to minimize the seepage. Two rows of 20 ft deep grout barriers are located at the heel of the upstream slope. A seepage analysis (***Ref. 3***) was performed to obtain the phreatic surface applicable for the pre-failure analyses. The typical cross-section used for stability analyses is given in ***Attachment B***.

(2) Phreatic Surface:

Following phreatic surfaces were assumed for the analysis:

Condition A – Flownet condition prior to installation of geosynthetic liner was established from SEEP2D, assuming a leaking concrete lining barrier. The Flownet of this model is shown in ***Figure No. 2 of Reference 3,*** and top phreatic surface is shown in the Slope Stability analysis results (***Attachment A***).As shown in these figures, more than 90% of the dike is found to be saturated for this condition of analysis.

Condition B – Flownet condition after installation of geosynthetic liner, assuming an impermeable barrier (***Figure No. 3 of Reference 3***). We have used a variety of phreatic surfaces in a parametric manner to capture the range of possible seepage conditions.

Condition C – Flownet condition during over topping event where the phreatic surface is interactively varied with a series of runs starting with the Condition B case until a phreatic surface is located where the factor of safety against failure is 1.0.

Condition D – Flownet condition after installation of geosynthetic liner, assuming permeability of the interface material (k = higher than the rockfill and impermeable barrier (***Figure No. 9 of Reference 3***)

(3) Material Properties:

Table 1 gives the strength properties selected for the lower bound estimate, best estimate and upper bound estimate. These properties are depicted in Attachment B.
Two slide zones were found on the D/S toe of the Upper Reservoir; one is located at the south side and the other one at south-east corner of the reservoir. Those slides were analysis, assuming fully saturated conditions (the slides are located below the U/S bottom elevation of the reservoir) and infinite slope. The calculation is given in Attachment A. Based on these calculations the best estimate soil properties were $\Phi = 33^0$ for soil fill / natural soil and $\Phi = 43^0$ for rockfill.

TABLE 1: SUMMARY OF SOIL AND ROCK PROPERTIES

Material	Lower Bound	Best Estimate	Upper Bound	Basis
D/S Foundation Soil at toe	c = 0 ϕ = 30°	c = 0 ϕ = 33°	c = 0 ϕ = 35°	Field Observations & Lab Tests
Filter Material/ Interface	c = 0 ϕ = 30°	c = 0 ϕ = 33°	c = 0 ϕ = 35°	Field Observations
Bedrock	c = 3000 psf ϕ = 50°	c = 3000 psf ϕ = 50°	c = 3000 psf ϕ = 50°	Judgment No parametrics
U/S Foundation Soil at toe	c = 0 ϕ = 30°	c = 0 ϕ = 33°	c = 0 ϕ = 35°	Field Observations & Lab Tests
Concrete Face	c = 3000 psf ϕ = 50°	c = 3000 psf ϕ = 50°	c = 3000 psf ϕ = 50°	Judgment No parametrics
Rockfill	c = 0 psf ϕ = 41°	c = 0 ϕ = 43°	c = 0 ϕ = 45°	LB – suggested by BOC BE – Back calculated from surface slides UB – Back calculated from Breach Area

(4) Estimated Time of Failure:
The time of failure is estimated by calculating the time it takes to saturate the rockfill up to the phreatic surface in the dike to a level where the factor of safety against sliding is 1.0 for Condition C. The height of the phreatic surface is estimated by trial and error from GSTABL for each of the 12 cases analyzed. The phreatic surface in the dike is assumed to be of the same level from U/S to D/S ends, and the bottom five feet of the rockfill above bedrock of the cross section at wall segment 95 is assumed to be saturated. A one foot wide cross section of the dam at wall segment 95 is considered. An effective porosity of 15% is used for the rockfill in the dam (assuming total porosity of 20% with 5% reduction due to natural moisture). The complete analysis of estimated time of failure is given in Attachment D.

STABILITY ANALYSIS:

Forty eight separate analyses have been run on the typical cross section. The analyses are carried out for four phreatic conditions listed above and variation of soil properties as listed in Table 1. Each condition is analyzed for deep circular failure, deep wedge failure, circular toe failure and circular toe wedge failure.

RESULTS:

The slope stability analysis results are summarized in Table 2, 3, 4 and 5 for various assumed phreatic conditions. Plots of the ten most critical failure surfaces plots are given in Attachment B and computer output results are in Attachment C.

TABLE 2: SUMMARY OF FACTORS OF SAFETY FOR CONDITION A

PHREATIC SURFACE	LB PROPERTIES	BE PROPERTIES	UB PROPERTIES	FAILURE TYPE
Condition A	0.92	1.01	1.09	Deep Wedge
Condition A	0.98	1.05	1.12	Deep Circle
Condition A	1.06	1.15	1.13	Toe Wedge
Condition A	1.11	1.13	1.21	Toe Circle

TABLE 3: SUMMARY OF FACTOR OF SAFETY FOR CONDITION B

PHREATIC SURFACE	LB PROPERTIES	BE PROPERTIES	UB PROPERTIES	FAILURE TYPE
Condition B	1.24	1.35	1.45	Deep Wedge
Condition B	1.23	1.33	1.42	Deep Circle
Condition B	1.10	1.21	1.30	Toe Wedge
Condition B	1.11	1.23	1.32	Toe Circle

TABLE 4: SUMMARY OF PHREATIC SURFACE HEIGHT FOR CONDITION C AND FACTOR OF SAFETY = 1.00

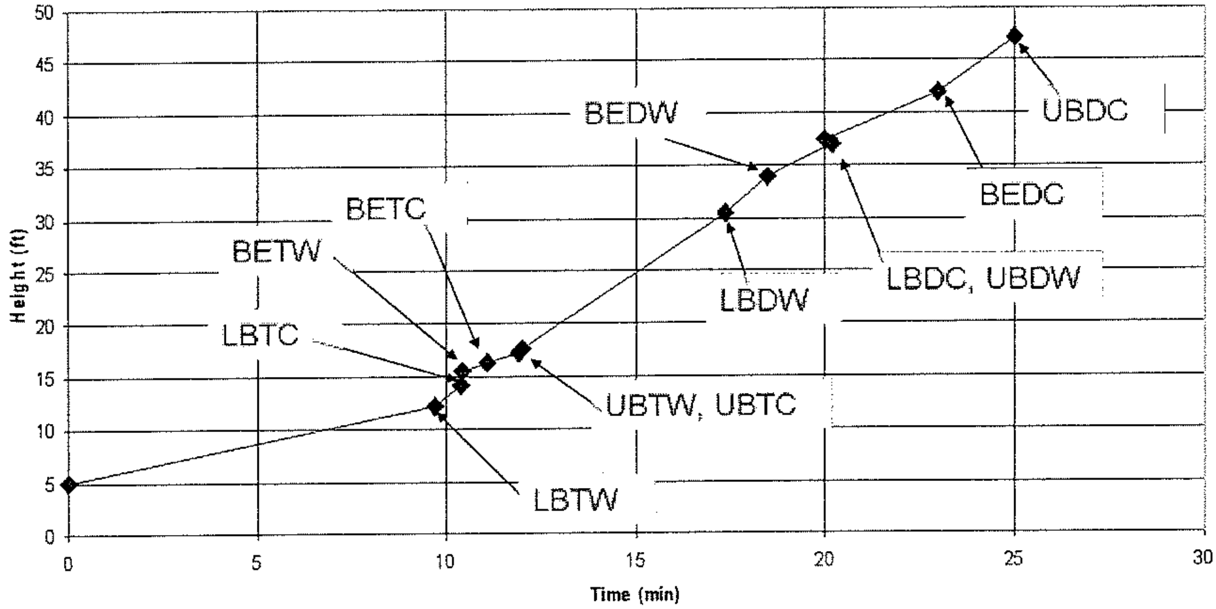
LB PROPERTIES (1) (FEET)	BE PROPERTIES(1) (FEET)	UB PROPERTIES(1) (FEET)	FAILURE TYPE	ESTIMATED TIME OF FAILURE (BE PROPERTIES) (2)
31	34	37	Intermediate to Deep Wedge	18 min
37	42	47	Deep Circle (Infinite Slope)	23 min
12	16	17	Toe Wedge	11 min
14	16	17	Toe Circle	12 min

Notes:
1.The height of the phreatic surface is measured above the bedrock directly at the downstream toe.
2. The estimated time of failure is our estimate of when the failure type occurred. See *Appendix D.*

TABLE 5: SUMMARY OF FACTORS OF SAFETY FOR CONDITION D

PHREATIC SURFACE	LB PROPERTIES	BE PROPERTIES	UB PROPERTIES	FAILURE TYPE
Condition D	1.16	1.26	1.36	Deep Wedge
Condition D	1.14	1.22	1.31	Deep Circle
Condition D	0.91	1.01	1.08	Toe Wedge
Condition D	0.98	1.09	1.17	Toe Circle

FIGURE 1: HEIGHT OF SATURATION VS. TIME FOR CONDITION C



CONCLUSIONS:

1. The results presented in ***Table 2*** indicate that the Rockfill Dike prior to installation of the geosynthetic liner in the Breach Area was marginally stable and possibly near a failure condition in some locations where the material properties were in the range of selected Lower Bounds.
2. The results presented in ***Table 3*** indicate that the Rockfill Dike after installation of the geosynthetic liner in the Breach Area was marginally stable and would not meet FERC criteria for stability under static conditions for maximum storage pool (i.e., FS=1.5)(FERC, 1991). Although dynamic analyses have not been run, past experience suggests a high probability of failure under significant earthquake.
3. The results presented in ***Table 4*** and ***Figure 1*** indicate that the Rockfill Dike failed when the phreatic surface was in the range of 12 feet to 17 feet above the bedrock at the toe. This

occurred in the range of 10 to 13 minutes after the Upper Reservoir level reached El. 1597.00. The results also indicate that while failure began at the toe, probably exacerbated by run off down the slope, it rapidly progressed up slope within minutes.

4. The results presented in ***Table 5*** indicate that with the HDPE Liner in place, the rockfill slope is marginally stable and the factor of safety values are lower than for Condition B.

ATTACHMENT – A

Back Calculations of Soil and Rockfill Material Parameters

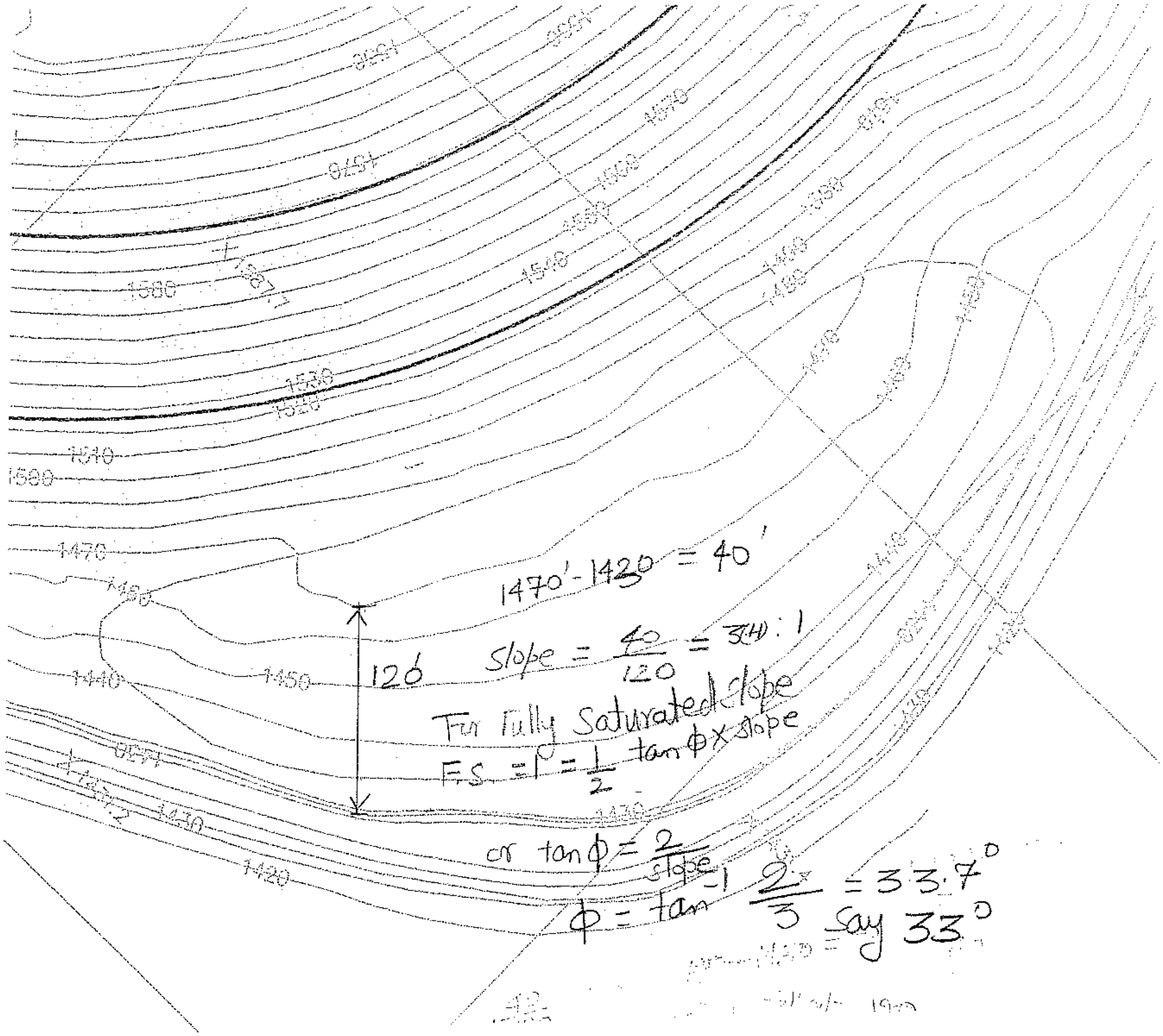
By UD Date 2/13/06 Subject Taum Sauk Upper Reservoir Sheet No. 8 of 43

Chkd. By JPG Date 3/20/06 Estimation of Fill Properties Proj. No. 06-3551

Objective: Estimate the Angle of Internal Friction (φ) of Rockfill & Soil Embankment / Natural Soil Fill from the past slides of soil/rockfill embankment at Taum Sauk

Soil Embankment

Location of Slide: The location of the slide and most critical failure plane is shown below for soil embankment



$1470' - 1430 = 40'$

Slope $= \frac{40}{120} = 3(H):1$

For fully saturated slope

$F.S. = 1 = \frac{1}{2} \tan\phi \times \text{slope}$

or $\tan\phi = \frac{2}{\text{slope}}$

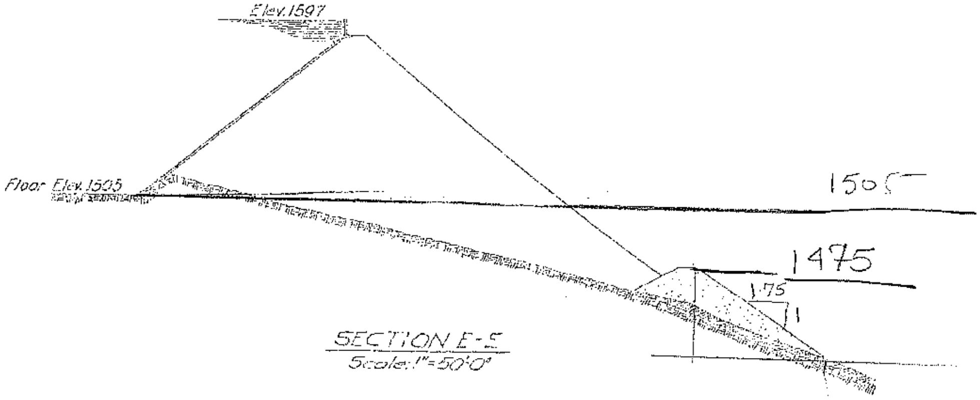
$\phi = \tan^{-1}\frac{2}{3} = 33.7^{\circ}$ say 33°

Soil Fill / Natural Soil Slide

By U.D Date 2/13/05 Subject Taum Sauk Upper Reservoir Sheet No. 9 of 43

Chkd. By JPG Date 3/20/06 Estimation of fill Properties Proj. No. 06-3551

The section E-E of the original Drawing is taken at close vicinity of the failure area.



SECTION E-E
Scale: 1"=50'0"

According to the section E-E the soil berm is constructed below El. 1475. The failure has occured below the El. 1470 and therefore, it is presumed that this slide failure has occured in soil berm. The reservoir bottom near the slide failure surface is 1505±. The critical failure slope is likely to be saturated.

Assuming infinite slope the F.S. (H.Y. Huang 1983)

$$= (1 - r_u) \frac{\tan \phi}{\tan \alpha}$$

By UD Date 2/13/06 Subject Taum Sauk Upper Reservoir Sheet No. 10 of 43

Chkd. By JPG Date 3/20/06 Estimation Of Fill Properties Proj. No. 06-3551

$$\tan\alpha = \frac{1470-1430}{120}$$

$$= 0.333$$

$r_u = 0.5$ for fully saturated condition

$$\tan\phi = \frac{\tan\alpha}{(1-1/2)} \quad \text{for F.S. } = 1$$

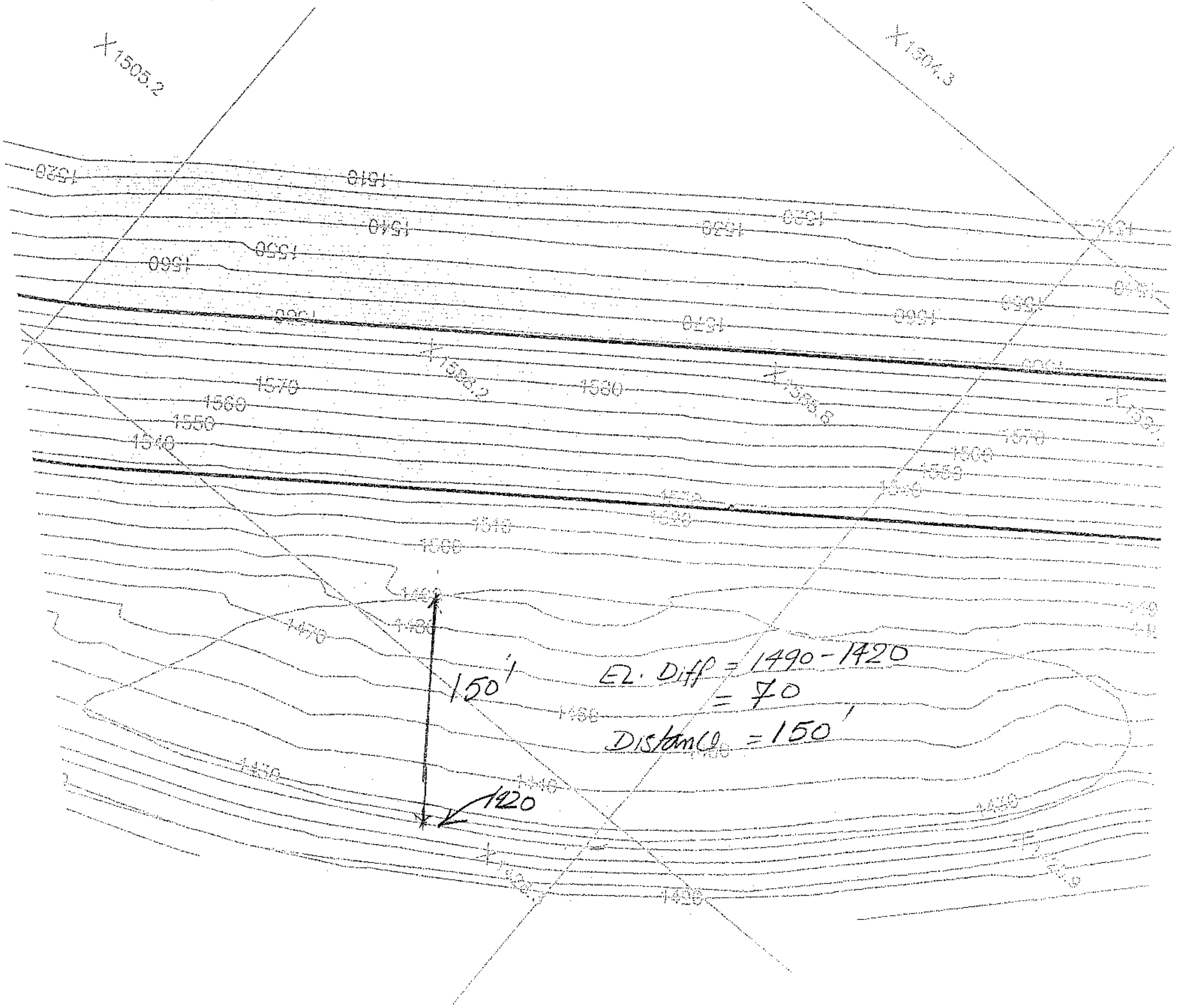
$$\phi = 33.7^\circ$$

say $\underline{33^\circ}$

By UD Date 2/13/06 Subject Taum Sauk Upper Reservoir Sheet No. 11 of 43

Chkd. By JPG Date 3/20/06 Estimation of Fill Properties Proj. No. 06-3551

Rockfill Embankment: The location of Critical failure plane of Rock Embankment is given below:



Rockfill Slide

$$\tan\alpha = \frac{70}{150}$$

Assuming Fully saturated conditions as the reservoir bottom is at El. 1505. and the slide failure is below El. 149

By UD Date 2/13/06 Subject Taum Sauk Upper Reservoir Sheet No. 12 of 43
Chkd. By JPG Date 3/20/06 Estimation of Fill Properties Proj. No. 06-3551

$$\tan \phi = \frac{\tan \alpha}{\left(1 - \frac{1}{2}\right)}$$

$$= \frac{70}{150 \times 0.5}$$

$$\phi = 43^\circ$$

Therefore Assume $\phi = 33^\circ$ for soil fill and natural soil and for rockfill 43°

Reference: Stability Analysis of Earth Slopes by Yang H. Huang, Van Nostrand Reinhold Company, New York, 1983, Page 72.

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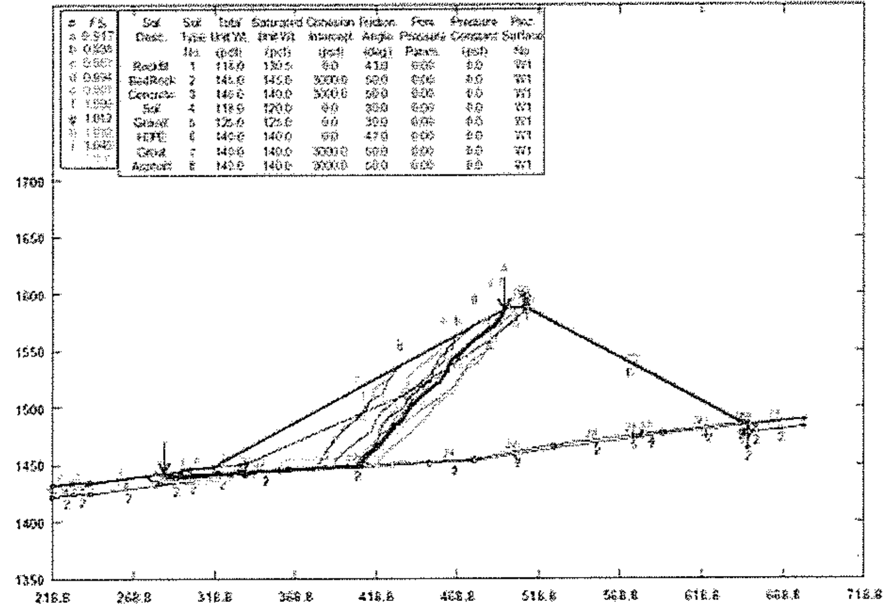
By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 13 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

ATTACHMENT – B
Slope Stability Analysis Results

Condition A Leaking Liner

Lower Bound

Panel 95 High Water, Deep Wedge Failure Lower Bound



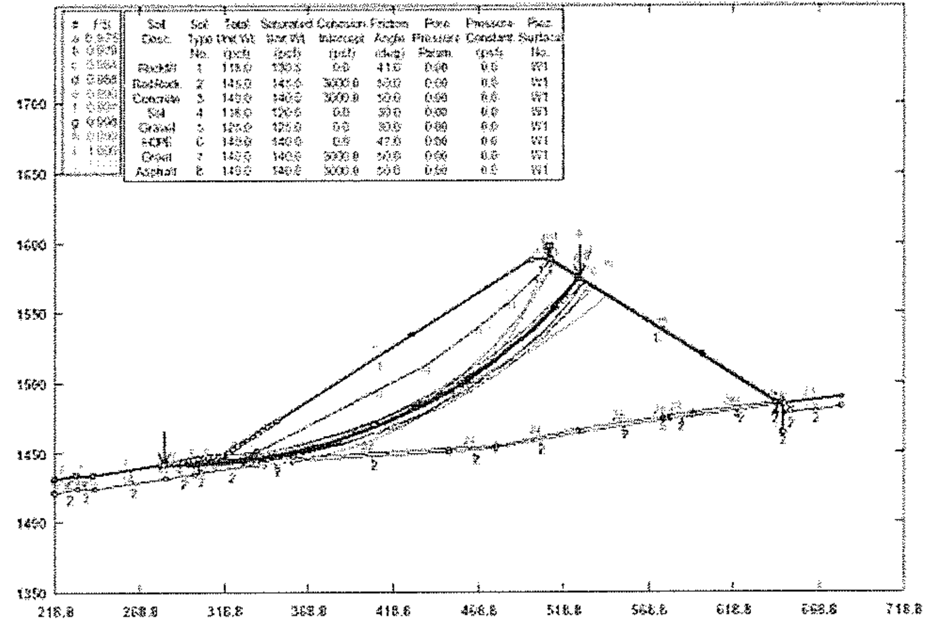
#	FS
a	0.917
b	0.936
c	0.967
d	0.994
e	0.997
f	1.004
g	1.012
h	1.030
i	1.040

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	41.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	30.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	30.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=0.917
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

Panel 95 High Water, Deep Circular Failure Lower Bound



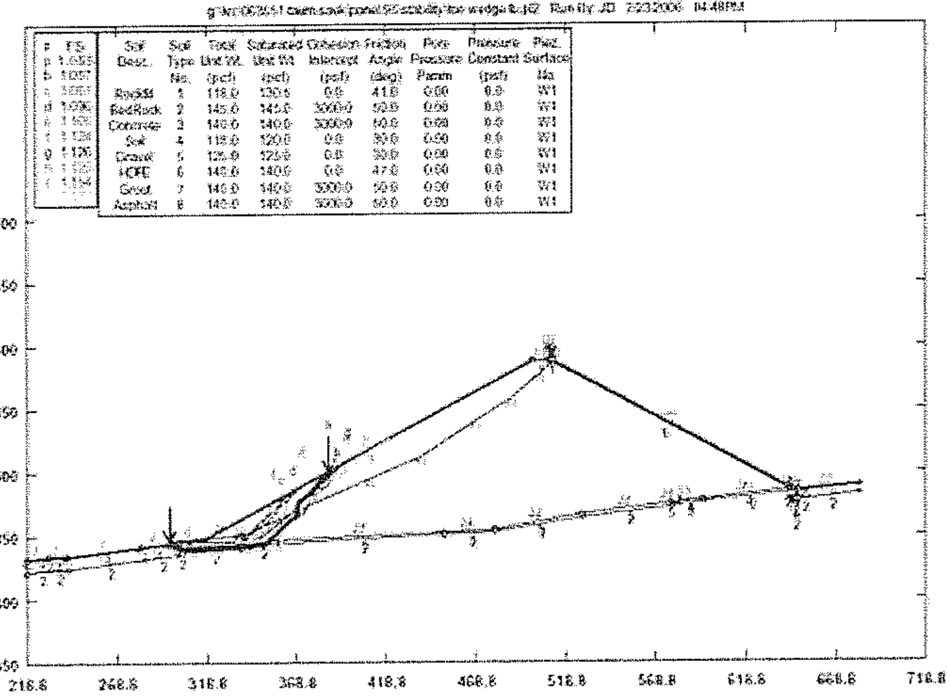
#	FS
a	0.975
b	0.979
c	0.984
d	0.988
e	0.990
f	0.994
g	0.996
h	1.002
i	1.006

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	41.0	0.00	0.0	W1
RedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	30.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	30.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=0.975
Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 15 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .



Panel 95 High Water, Toe Wedge Failure Lower Bound

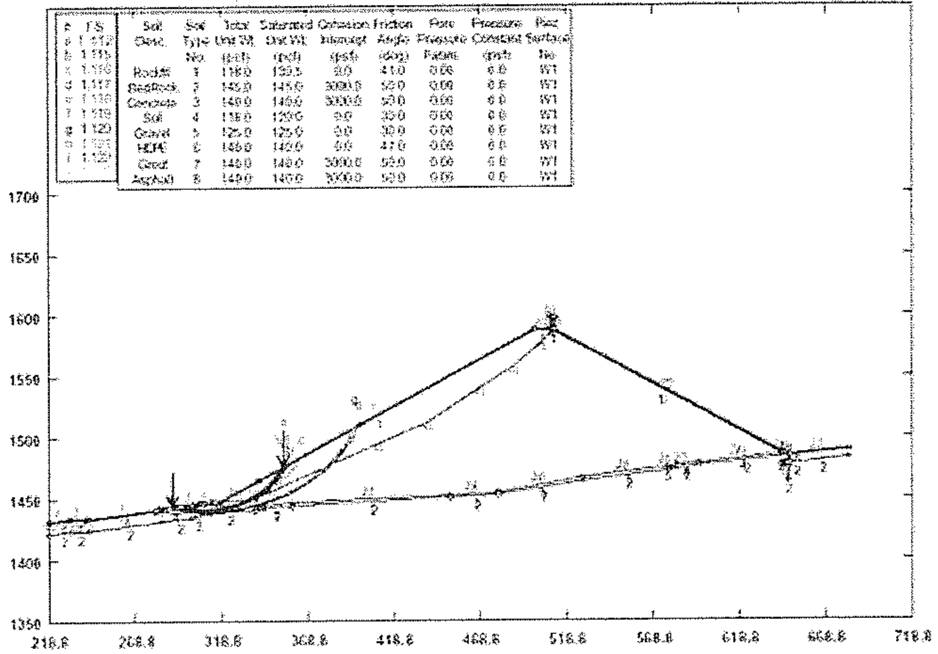
[illegible] Run By: JD 2/23/2006 04:48PM

#	FS
a	1.055
b	1.057
c	1.061
d	1.096
e	1.101
f	1.124
g	1.126
h	1.132
i	1.134

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
RockFill	1	118.0	130.0	0.0	41.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	30.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	30.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	60.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.055
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7



Panel 95 High Water, Toe Circular Failure Lower Bound

[illegible] Run By: JD 2/23/2006 04:30PM

#	FS
a	1.112
b	1.115
c	1.116
d	1.117
e	1.118
f	1.119
g	1.120
h	1.121
i	1.122

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
RockFill	1	118.0	130.5	0.0	41.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	30.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.112
Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

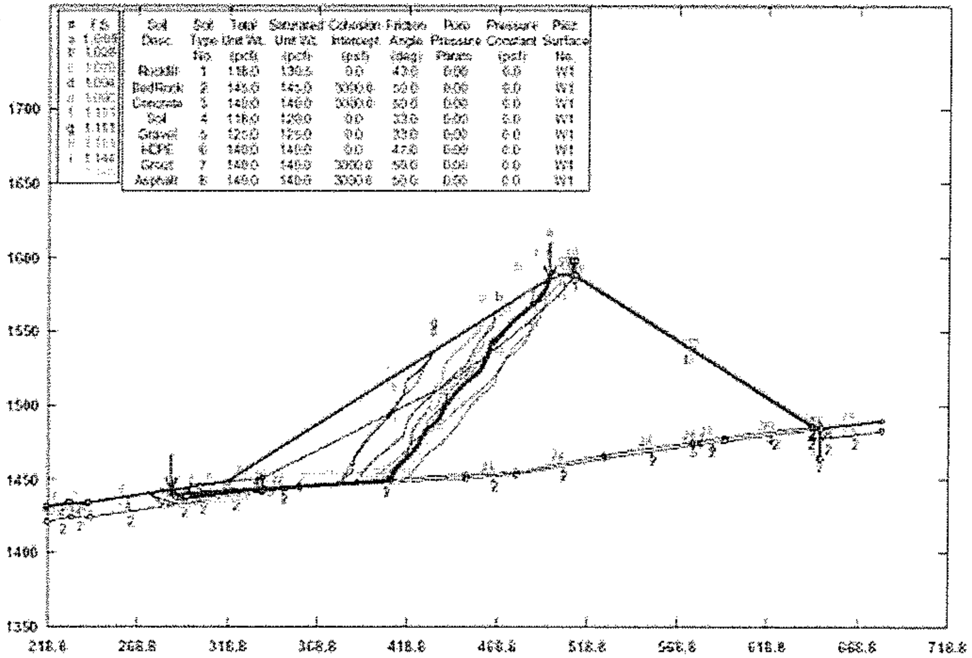
(87)

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 16 of 43 .
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

Condition A Leaking Liner

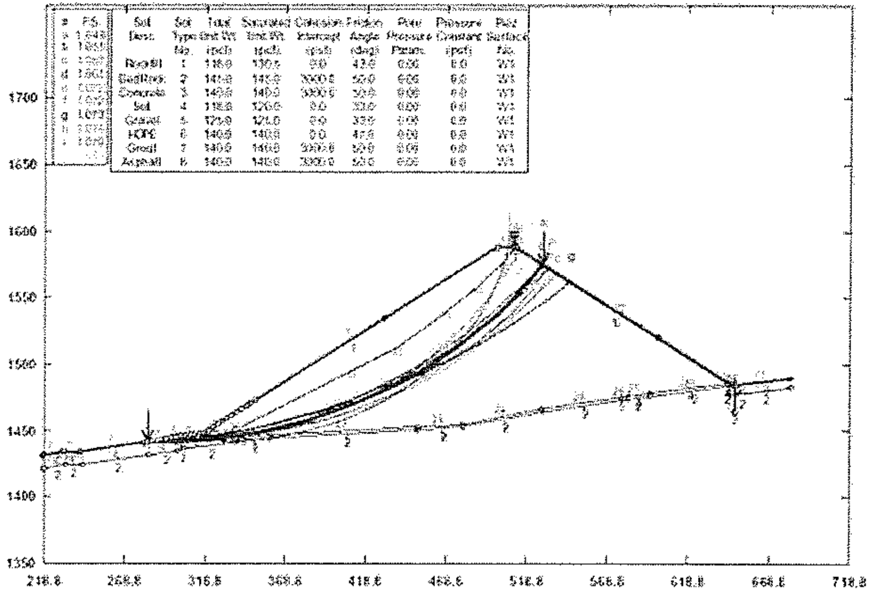
Best Estimate

Panel 95 High Water, Deep Wedge Failure Best Estimate



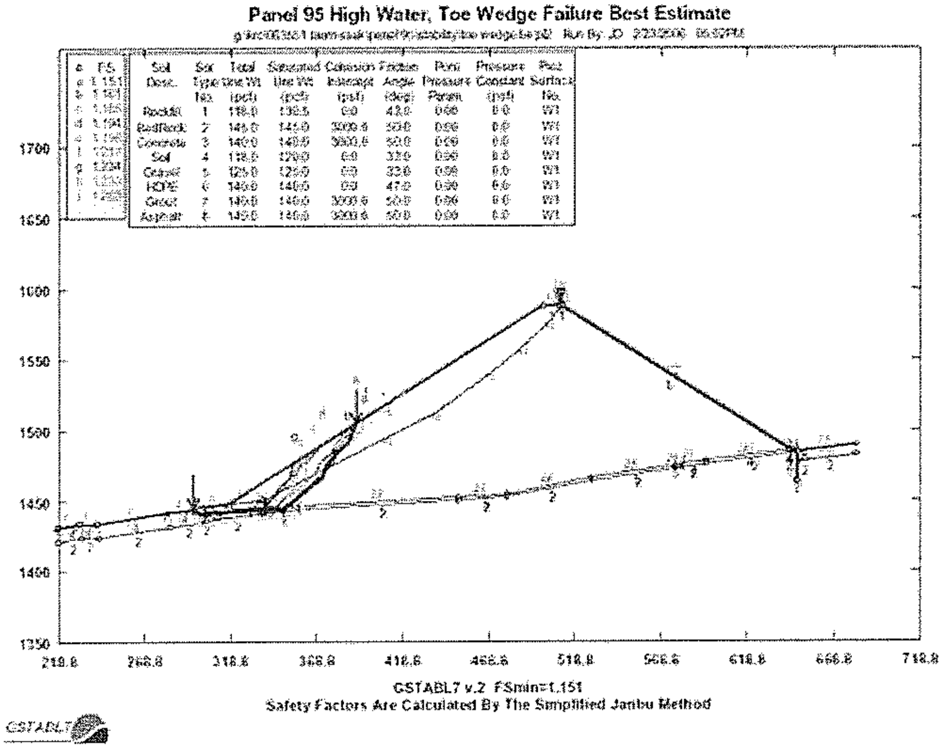
GSTABL7 v.2 FSmin=1.009
Safety Factors Are Calculated By The Simplified Janbu Method

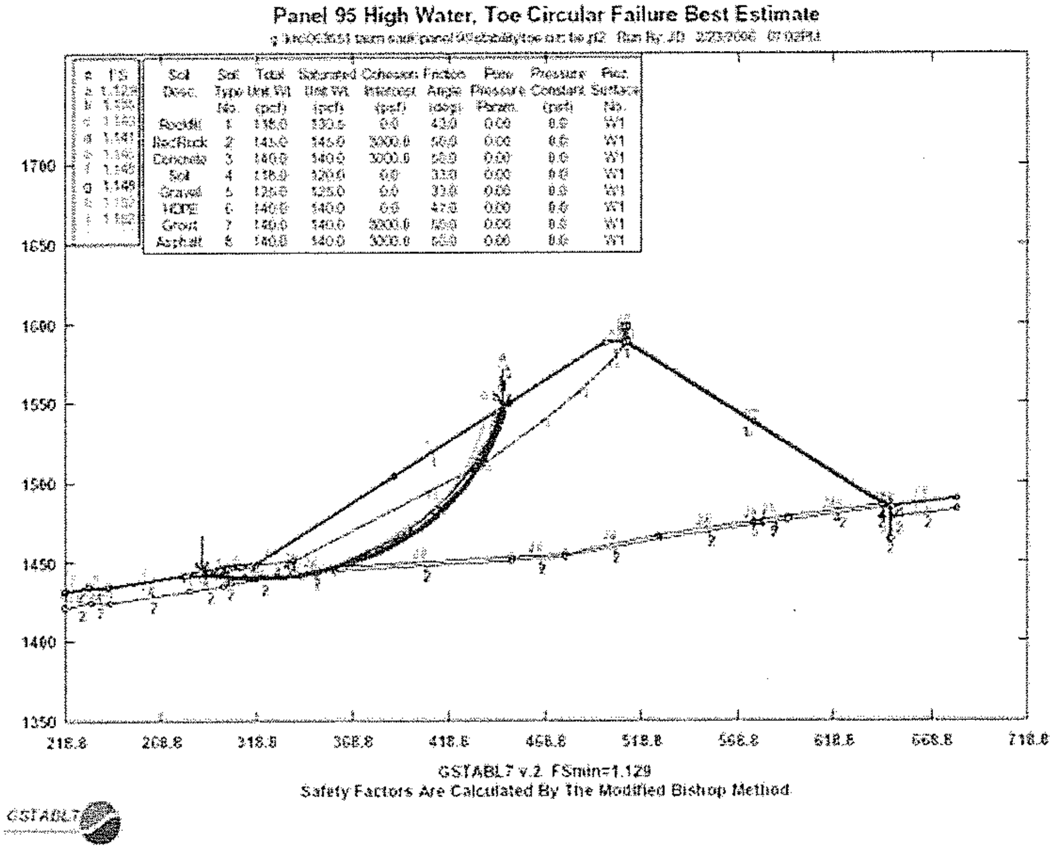
Panel 95 High Water, Deep Circular Failure Best Estimate



GSTABL7 v.2 FSmin=1.648
Safety Factors Are Calculated By The Modified Bishop Method

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 17 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .





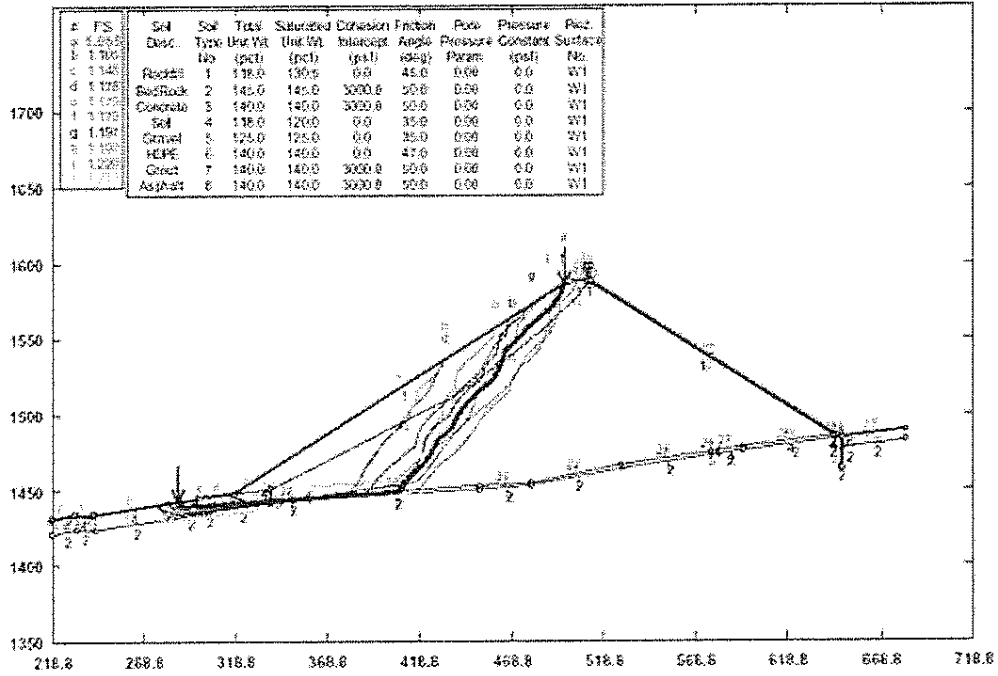
89

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 18 of 43
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

Condition A Leaking Liner

Upper Bound

Panel 95 High Water, Deep Wedge Failure Upper Bound

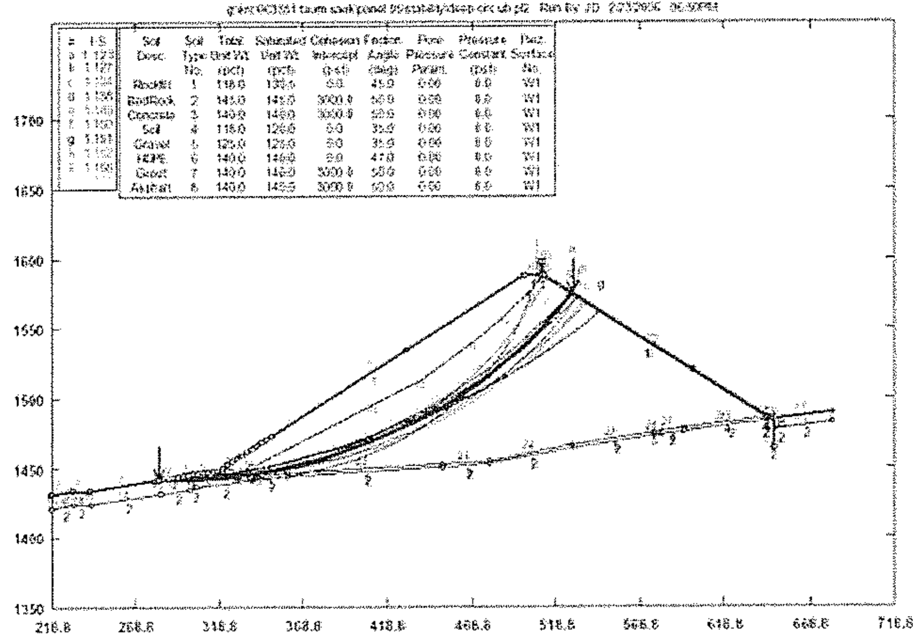


Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.0	0.0	45.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.085
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

Panel 95 High Water, Deep Circular Failure Upper Bound



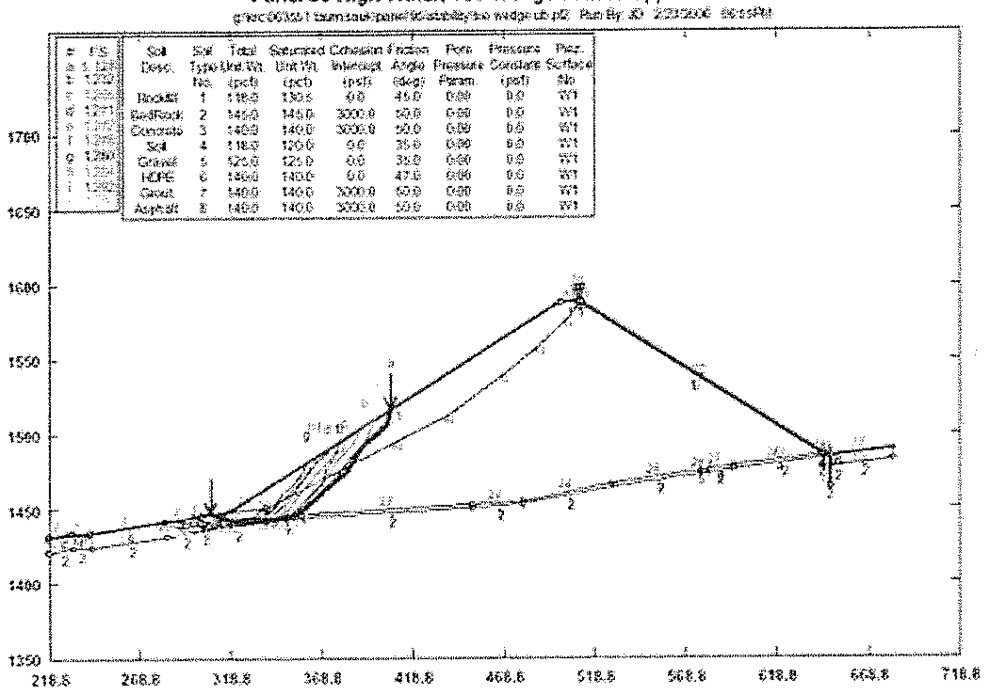
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.0	0.0	45.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.123
Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

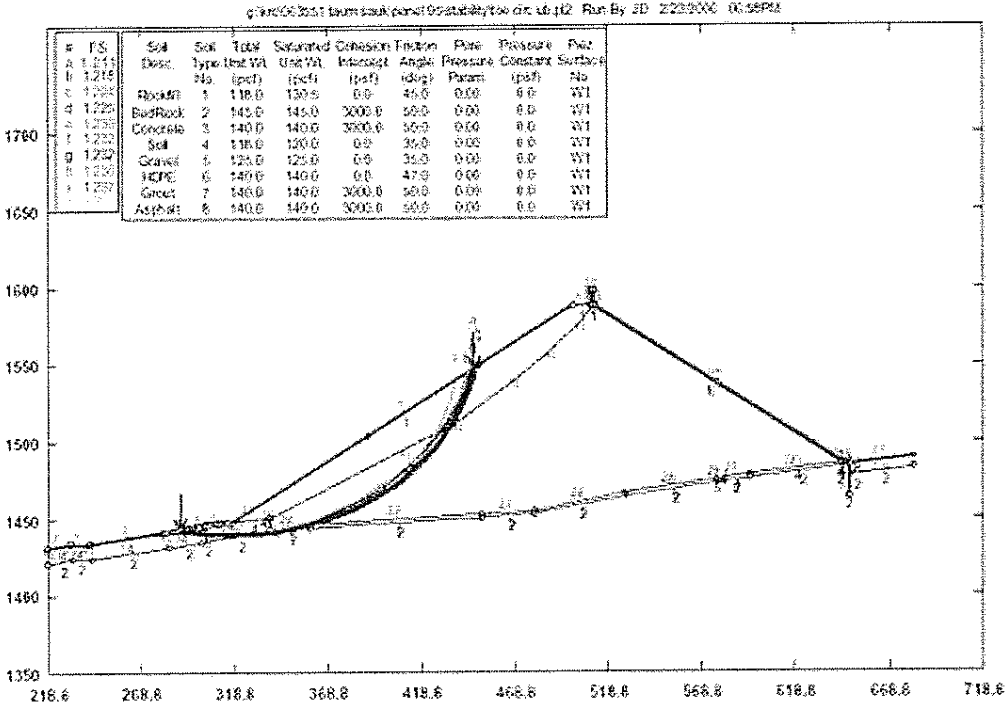
By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 19 of 43.
Chkd. by JPG. Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

Panel 95 High Water, Toe Wedge Failure Upper Bound



GSTABL7 v.2 FSmin=1.128
Safety Factors Are Calculated By The Simplified Janbu Method

Panel 95 High Water, Toe Circular Failure Upper Bound

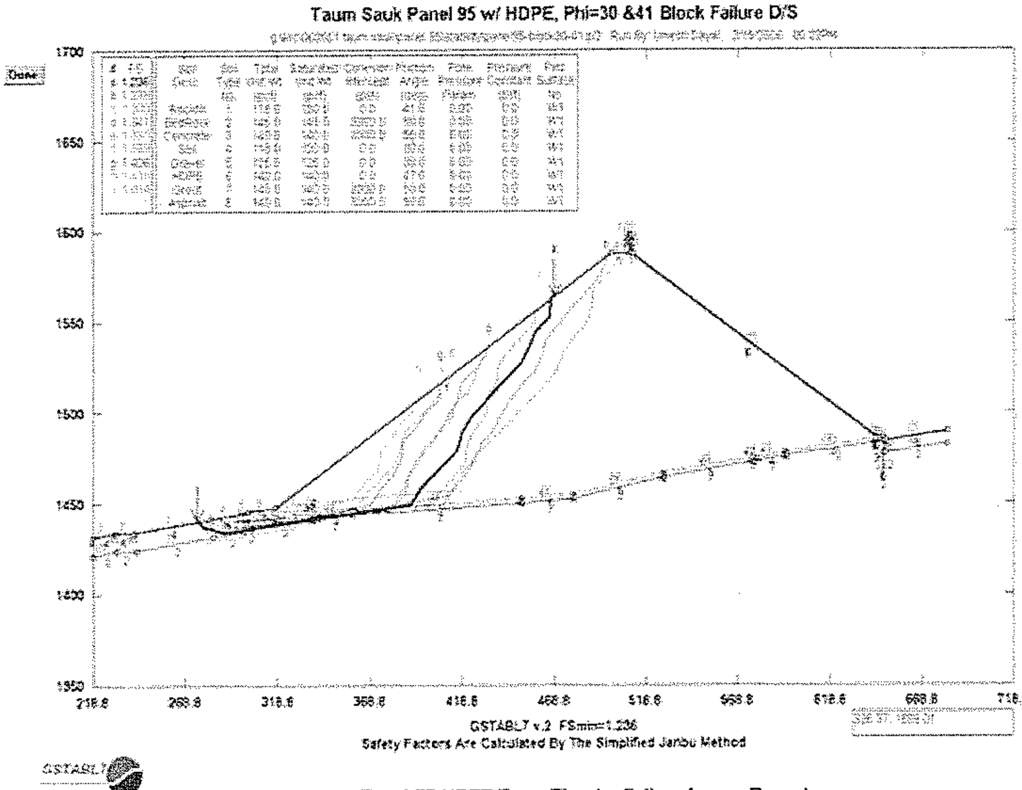


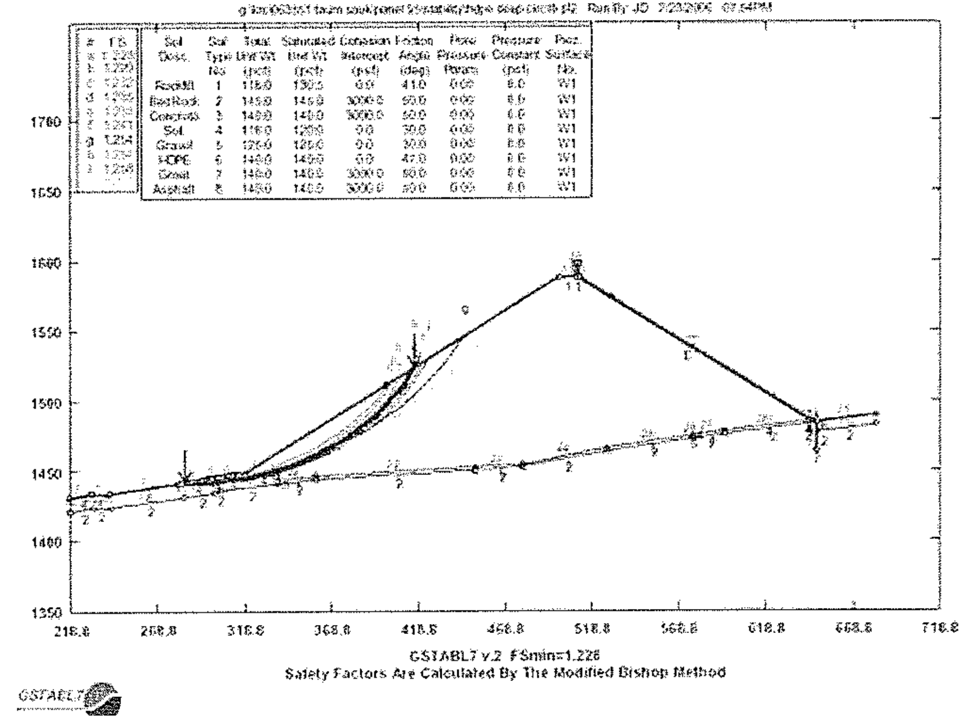
GSTABL7 v.2 FSmin=1.211
Safety Factors Are Calculated By The Modified Bishop Method

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 20 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

Condition B HDPE effective

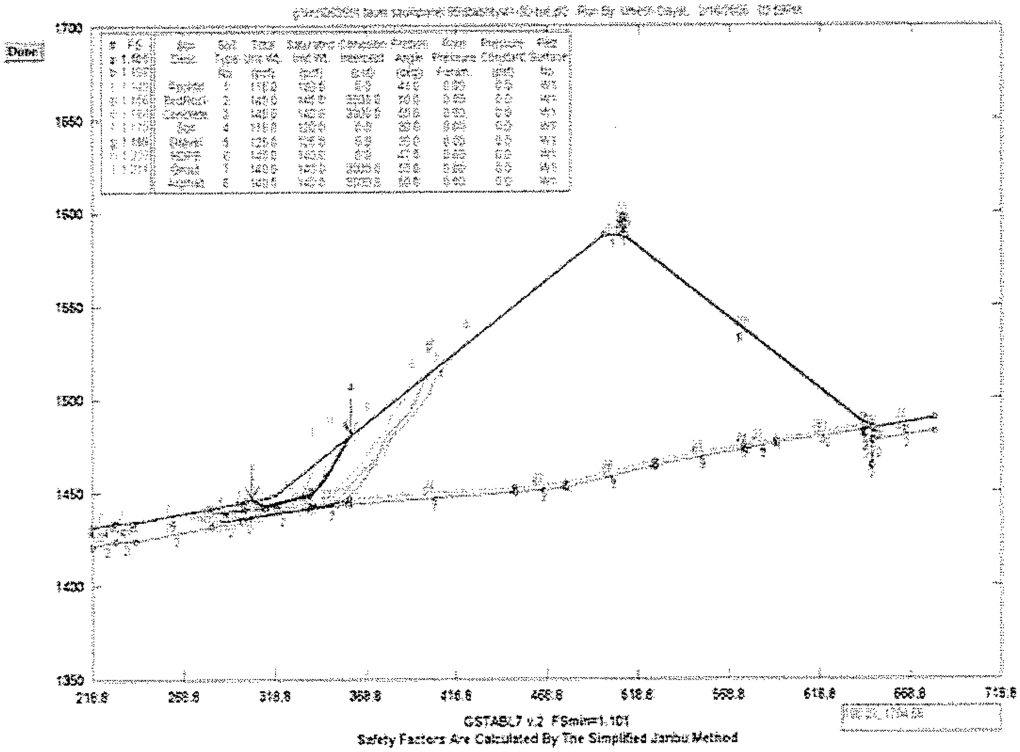
Lower Bound





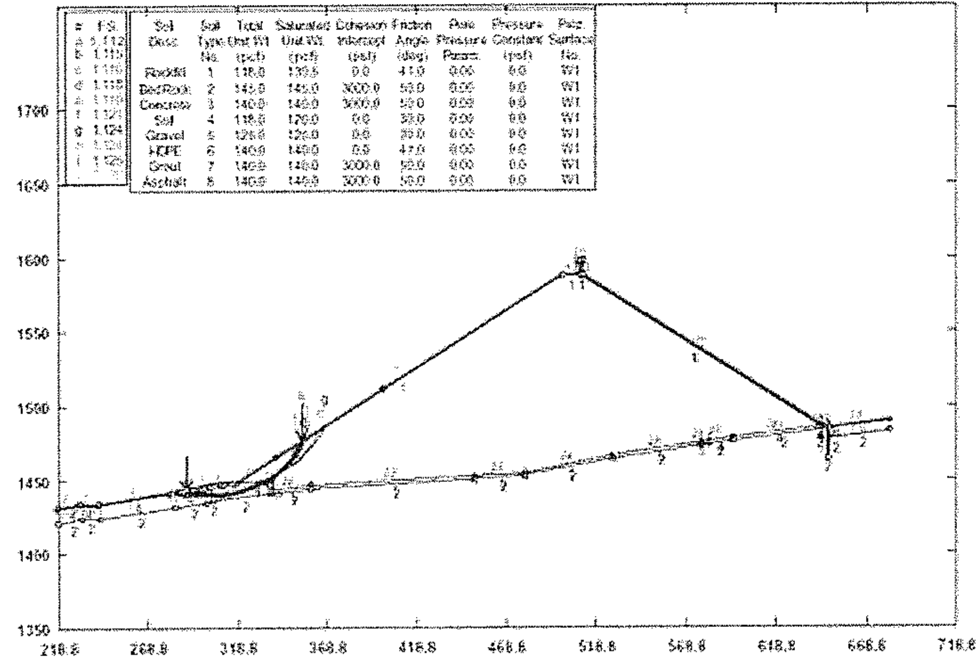
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	115.0	130.0	0.0	41.0	0.00	0.0	W1
Bed Rock	2	145.0	145.0	3000.0	60.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	60.0	0.00	0.0	W1
Soil	4	115.0	120.0	0.0	30.0	0.00	0.0	W1
Gravel	5	120.0	125.0	0.0	30.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	60.0	0.00	0.0	W1
Asphalt	8	145.0	140.0	3000.0	60.0	0.00	0.0	W1

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 21 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .



Taum Sauk Panel 95 Toe Failure 41-30 Block Failure at Toe

GSTABL7 v.2 FSmin=1.101
Safety Factors Are Calculated By The Simplified Janbu Method



Panel 95 HDPE Toe Circular Failure LowerBound

GSTABL7 v.2 FSmin=1.112
Safety Factors Are Calculated By The Modified Bishop Method

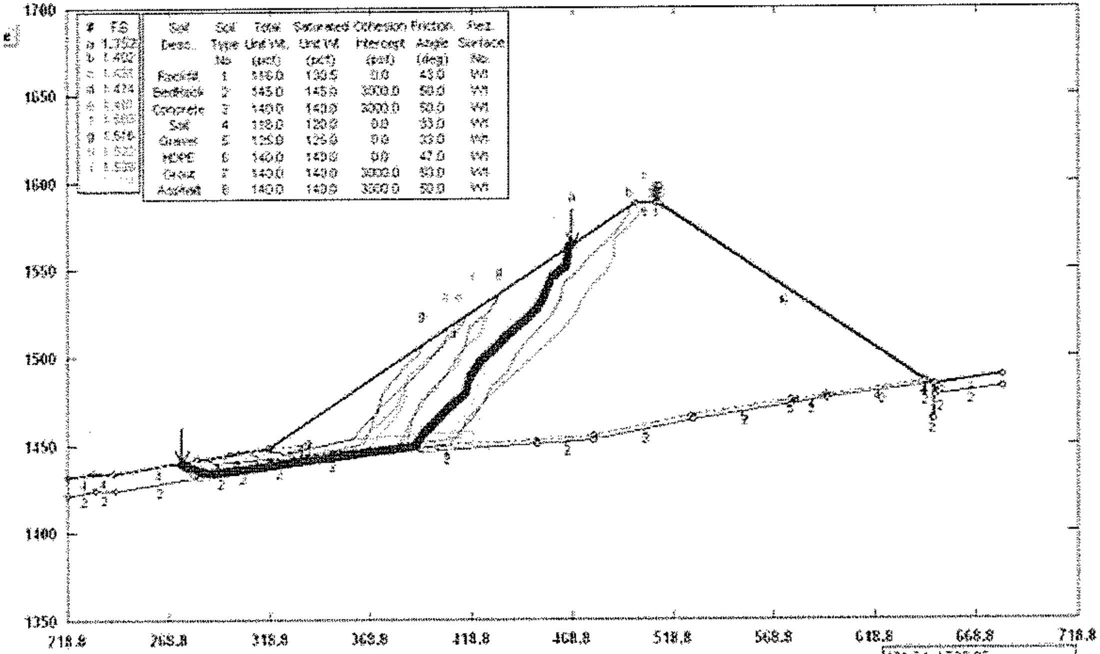
93

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 22 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

Condition B HDPE effective

Best Estimate

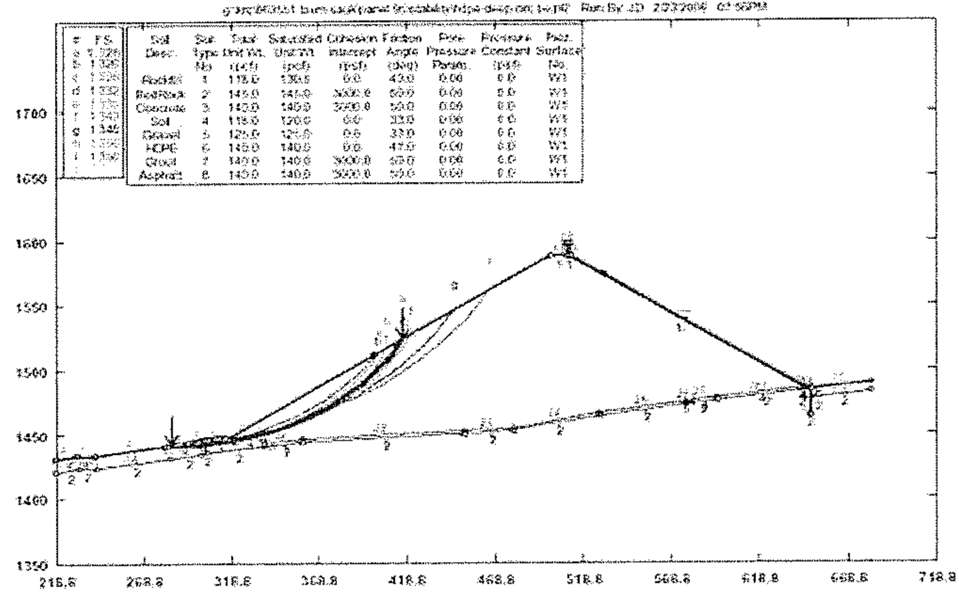
Taum Sauk Panel 95 w/ HDPE Liner Block Failure D/S



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Rockfill	1	115.0	130.5	0.0	43.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	W1
Soil	4	118.0	120.0	0.0	33.0	W1
Gravel	5	125.0	125.0	0.0	33.0	W1
HDPE	6	140.0	140.0	0.0	47.0	W1
Grout	7	140.0	140.0	3000.0	50.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	W1

GSTABL7 v.2 FSmin=1.352
Safety Factors Are Calculated By The Simplified Janbu Method

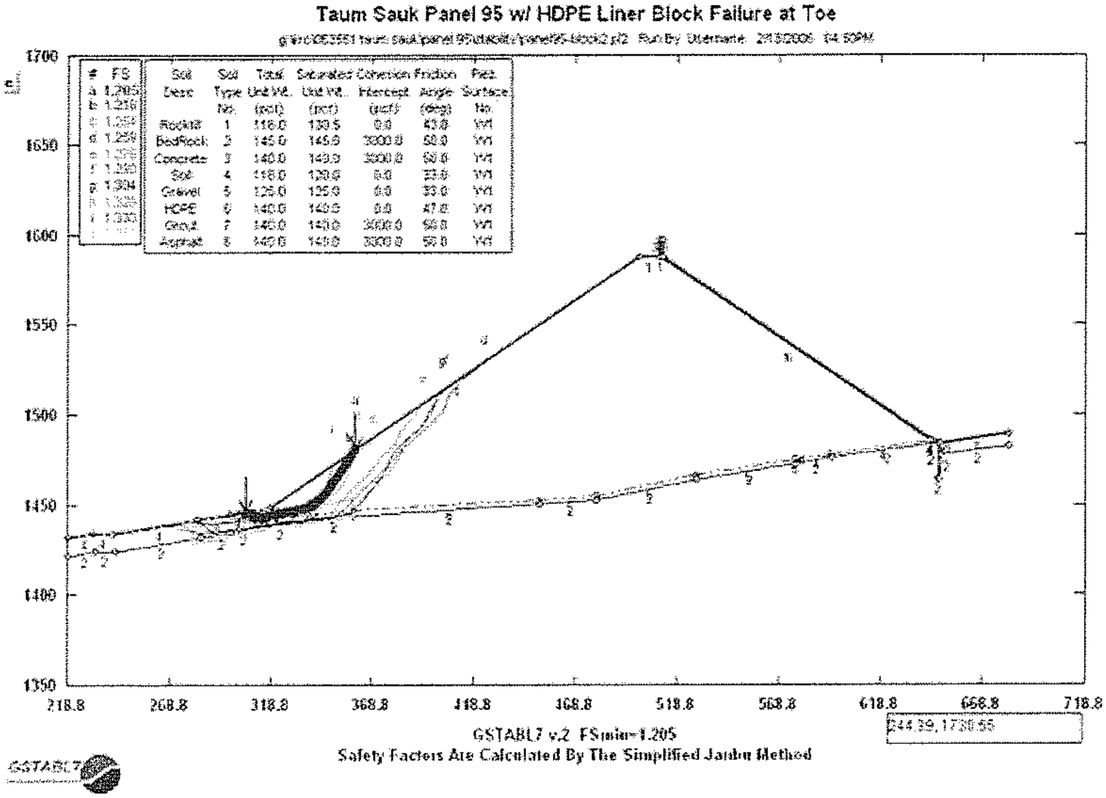
Panel 95 HDPE Deep Circular Failure BestEstimate

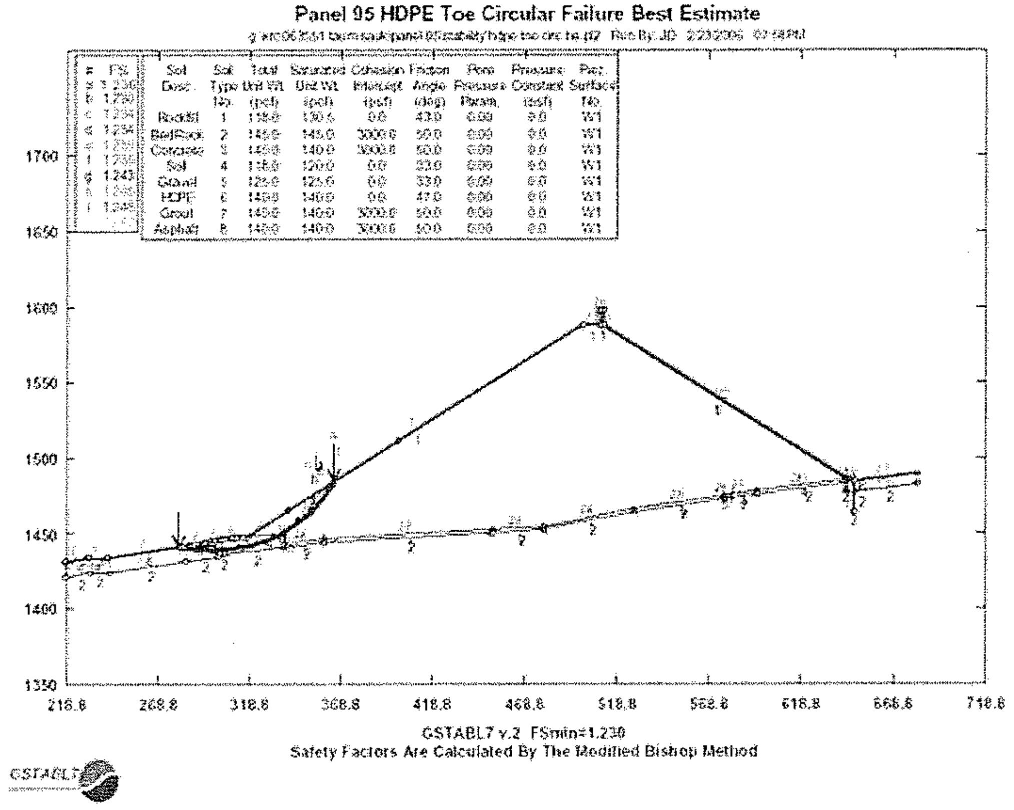


Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	115.0	130.5	0.0	43.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	115.0	120.0	0.0	33.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	33.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.326
Safety Factors Are Calculated By The Modified Bishop Method

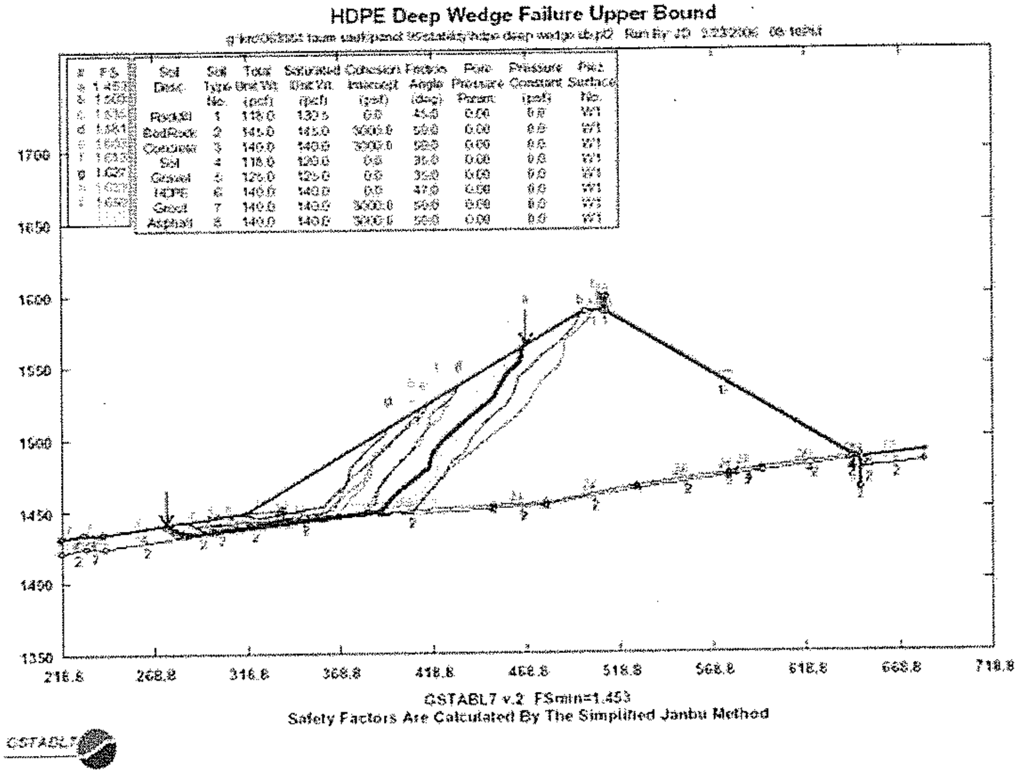
By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 23 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .



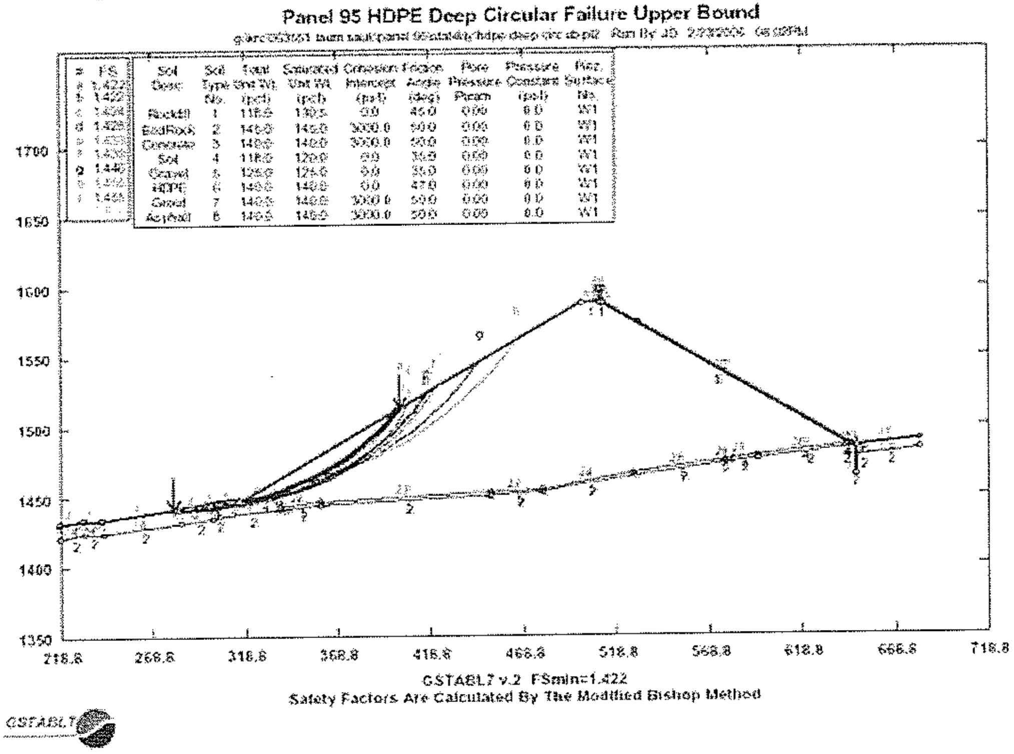


Condition B HDPE effective

Upper Bound

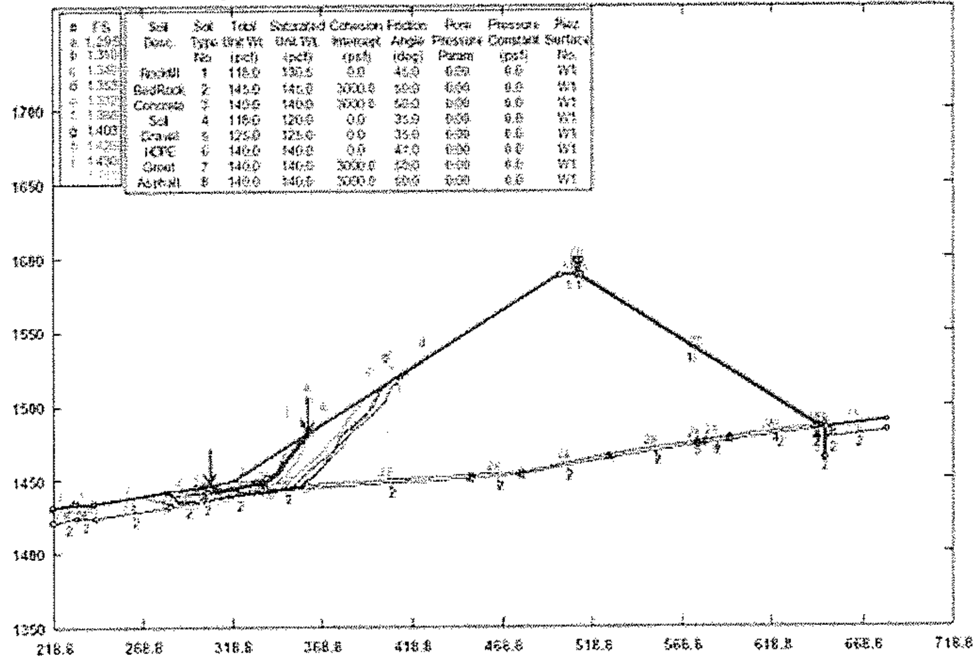


Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	45.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1



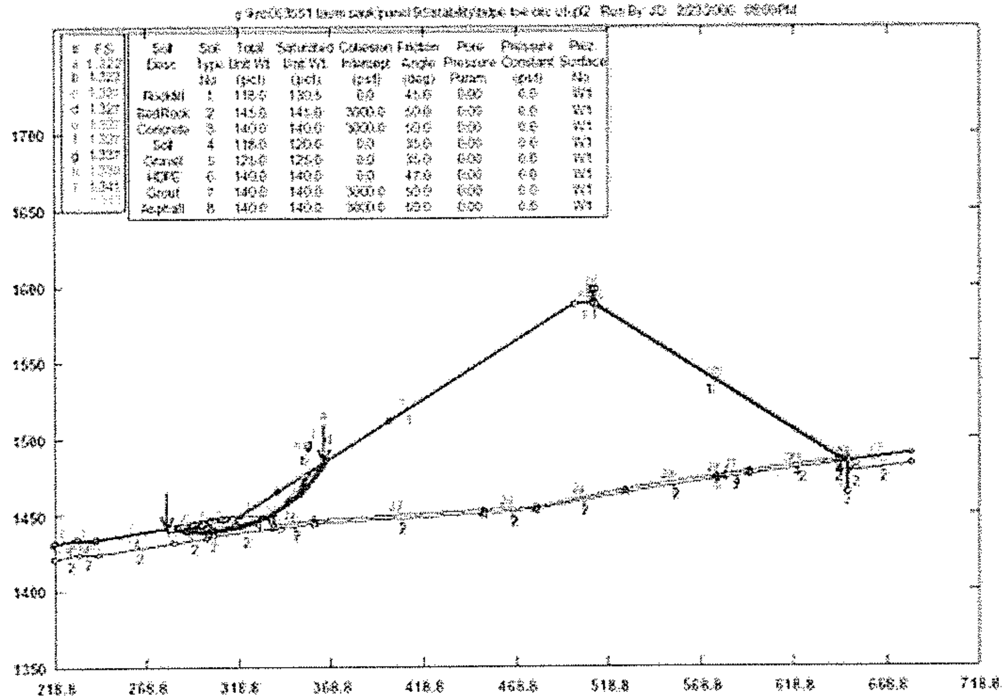
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	45.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

HDPE Toe Wedge Failure Upper Bound



GSTABL7 v.2 FSmin=1.295
Safety Factors Are Calculated By The Simplified Janbu Method

Panel 95 HDPE Toe Circular Failure UpperBound



GSTABL7 v.2 FSmin=1.322
Safety Factors Are Calculated By The Modified Bishop Method

Paul C. Rizzo Associates, Inc.
CONSULTANTS

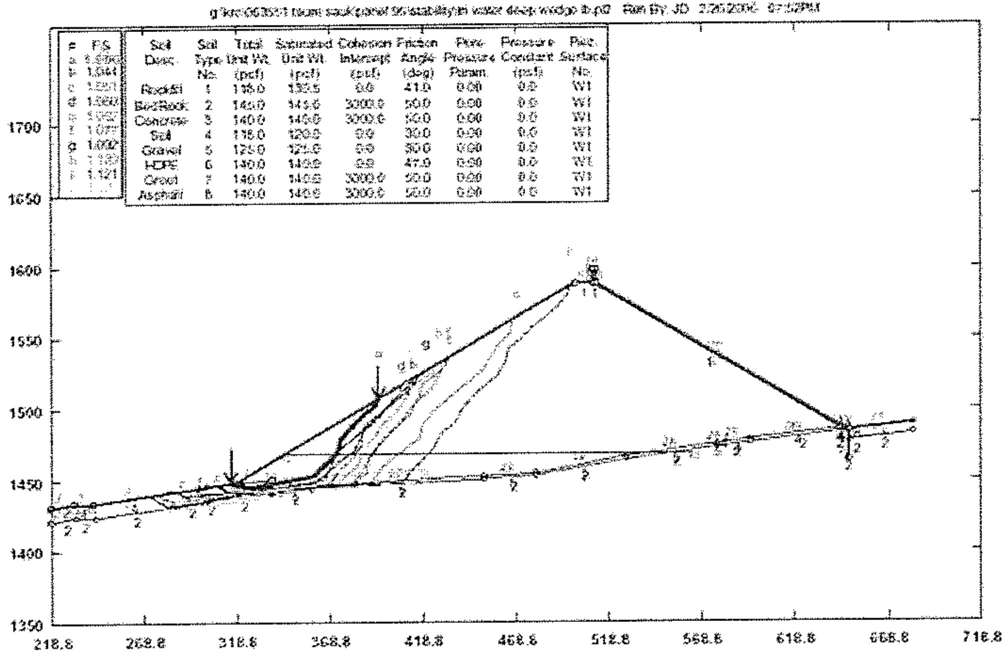
By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 26 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

Condition C F.S. = 1 with level water surface

Lower Bound

Taum Sauk / Tri. Low Water, 41-30 Deep Wedge Failure

g:\krc\063551 taum sauk\panel 96\stability\tri water deep wedge b.pl2 Run By: JD 2/26/2006 07:52PM



#	FS
a	1.006
b	1.044
c	[illegible]
d	1.060
e	[illegible]
f	1.071
g	1.092
h	[illegible]
i	1.121

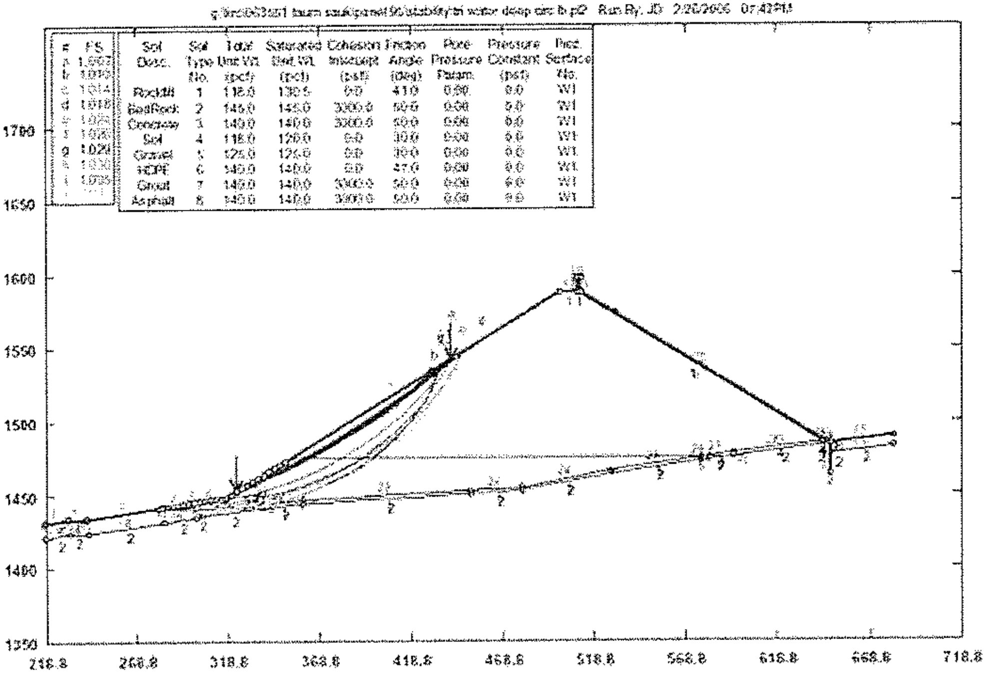
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	41.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	30.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	30.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.006
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

Taum Sauk / Tri. Low Water, 41-30 Deep Circular Failure

g:\krc\063551 taum sauk\panel 96\stability\tri water deep circ b.pl2 Run By: JD 2/26/2006 07:42PM



#	FS
a	1.007
b	1.010
c	1.014
d	1.018
e	1.026
f	1.026
g	1.029
h	1.030
i	1.035

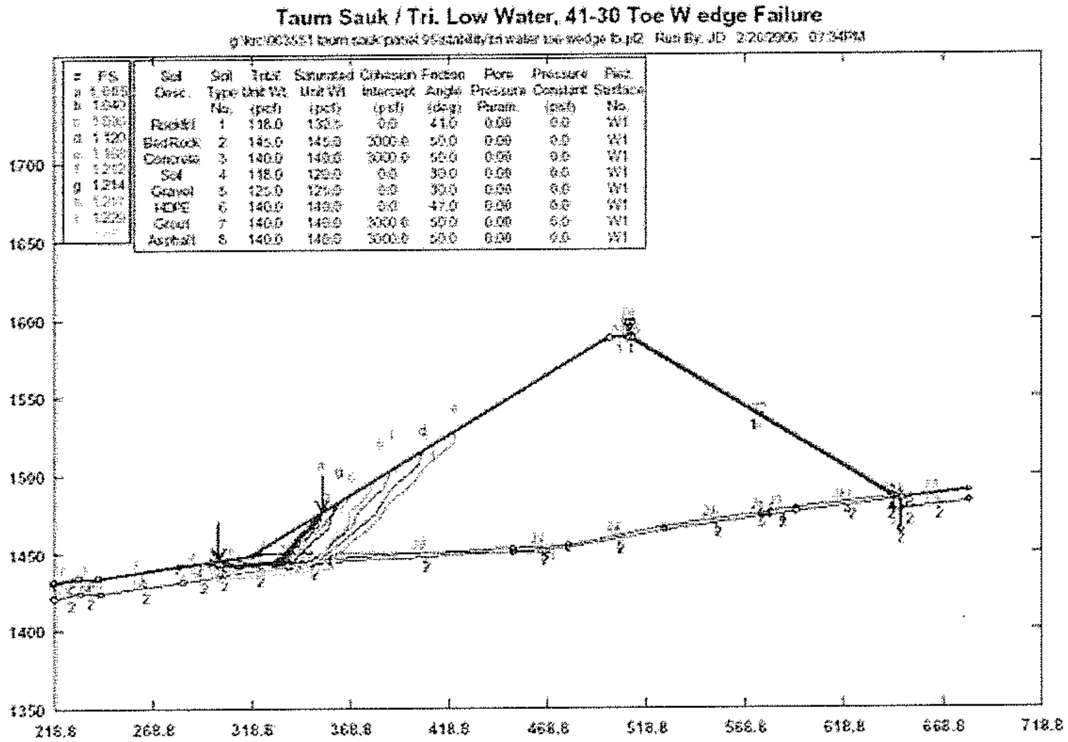
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	41.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	30.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	30.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.007
Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

(98)

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 27 of 43.
Chkd. by JPG . Date 3/20/06. Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .



Taum Sauk / Tri. Low Water, 41-30 Toe Wedge Failure

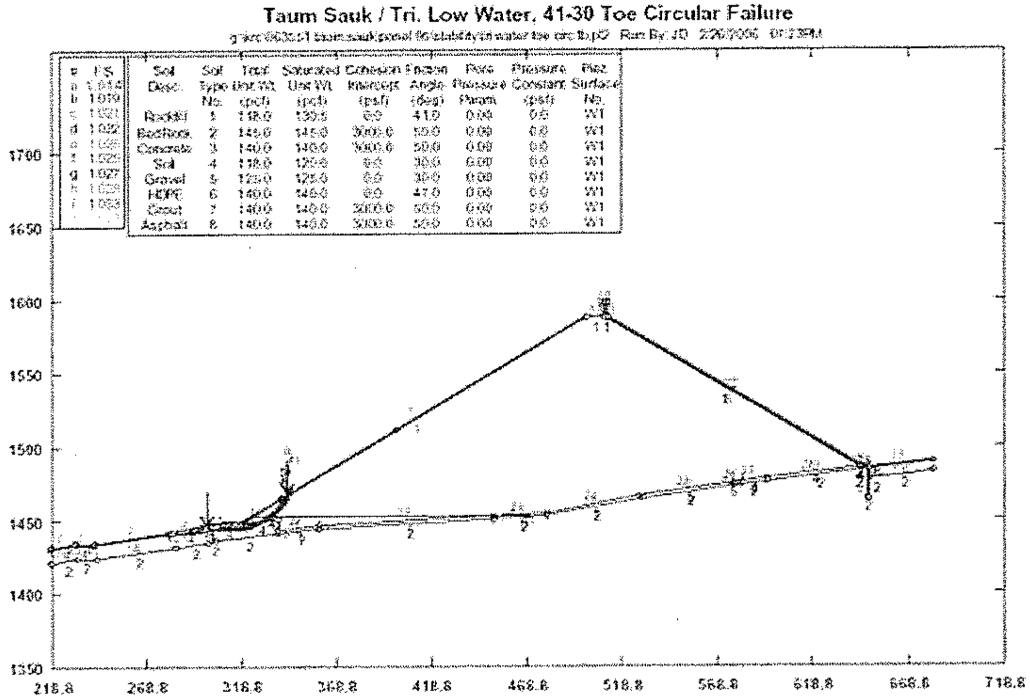
g:\trc\063551 taum sauk\panel 95\stability\tri water toe wedge fb.pl2 Run By: JD 2/26/2006 07:34PM

#	FS
a	1.005
b	1.040
c	1.090
d	1.120
e	1.180
f	1.202
g	1.214
h	1.217
i	1.229

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	41.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	30.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	30.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.005
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7



Taum Sauk / Tri. Low Water, 41-30 Toe Circular Failure

g:\trc\063551 taum sauk\panel 95\stability\tri water toe circ fb.pl2 Run By: JD 2/26/2006 07:23PM

#	FS
a	1.014
b	1.019
c	1.021
d	1.022
e	1.025
f	1.025
g	1.027
h	1.029
i	1.053

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	41.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	30.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	30.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.014
Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

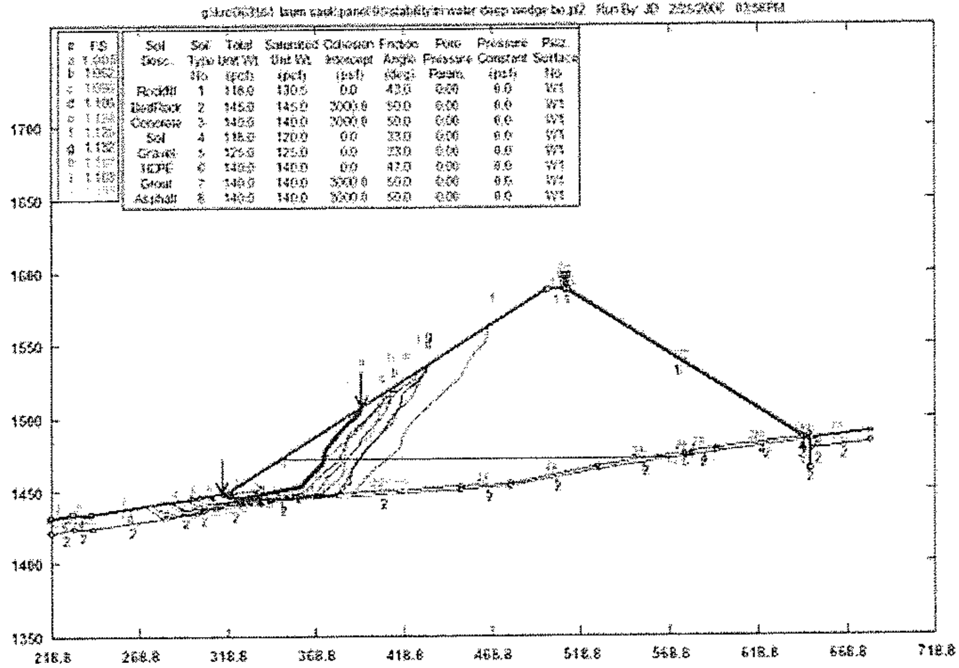
By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 28 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

Condition C F.S. = 1 with level water surface

Best Estimate

Taum Sauk / Tri. Low Water, 43-33 Deep Wedge Failure

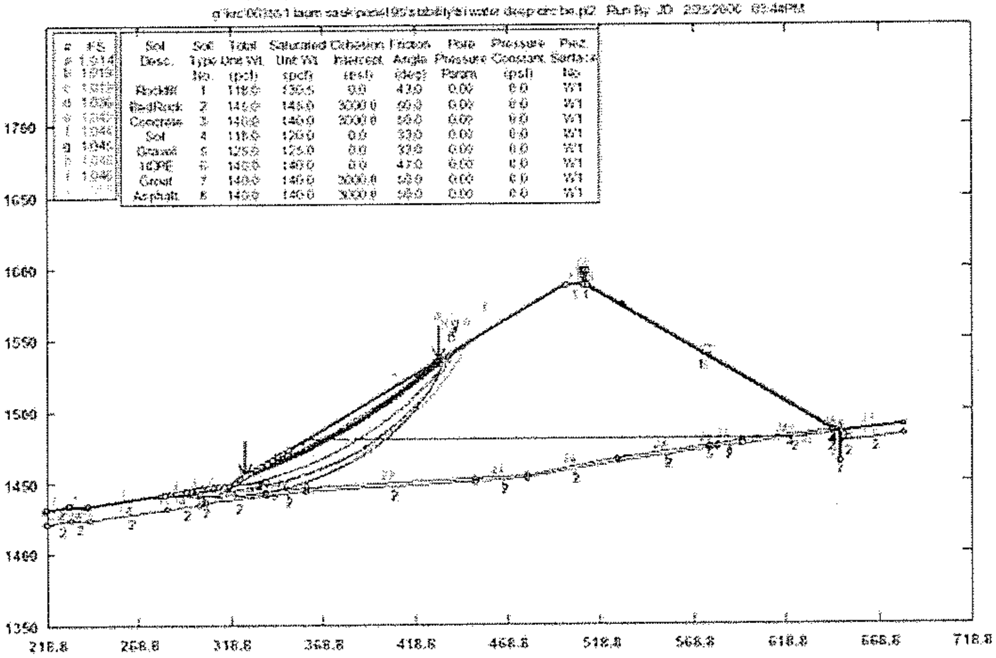
g:\ucl06351 taum sauk\panel\95\stability\tri water deep wedge be.pl2 Run By: JD 2/25/2006 03:58PM



GSTABL7 v.2 FSmin=1.005
Safety Factors Are Calculated By The Simplified Janbu Method

Taum Sauk / Tri. Low Water, 43-33 Deep Circular Failure

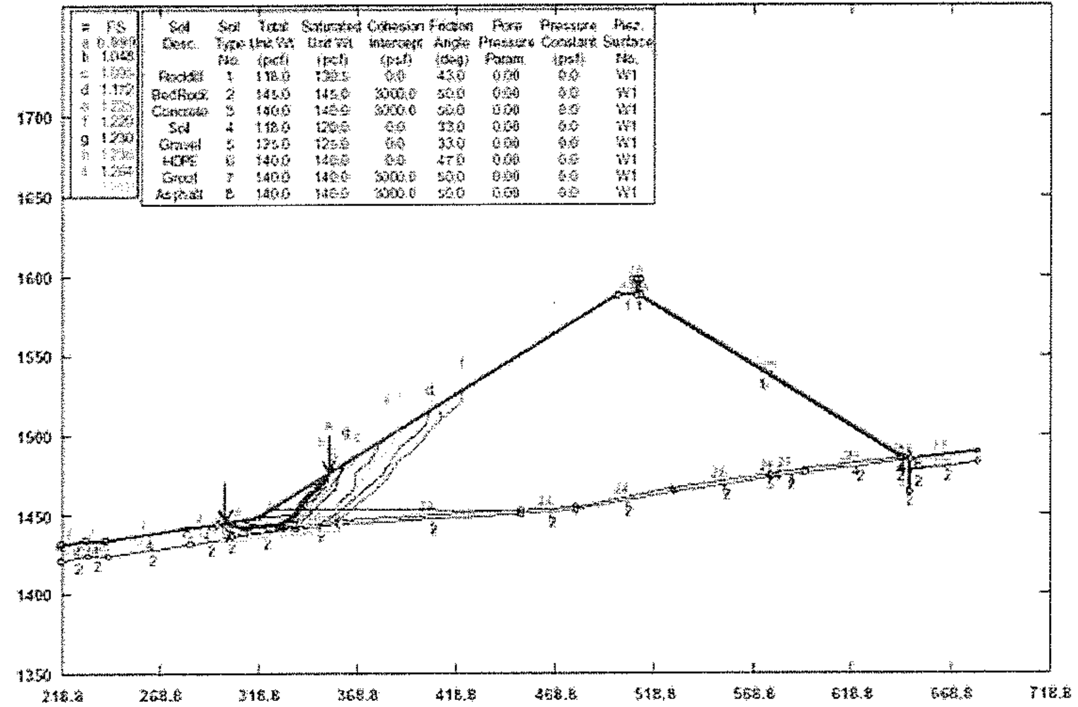
g:\ucl06351 taum sauk\panel\95\stability\tri water deep circ be.pl2 Run By: JD 2/25/2006 03:44PM



GSTABL7 v.2 FSmin=1.014
Safety Factors Are Calculated By The Modified Bishop Method

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 39 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

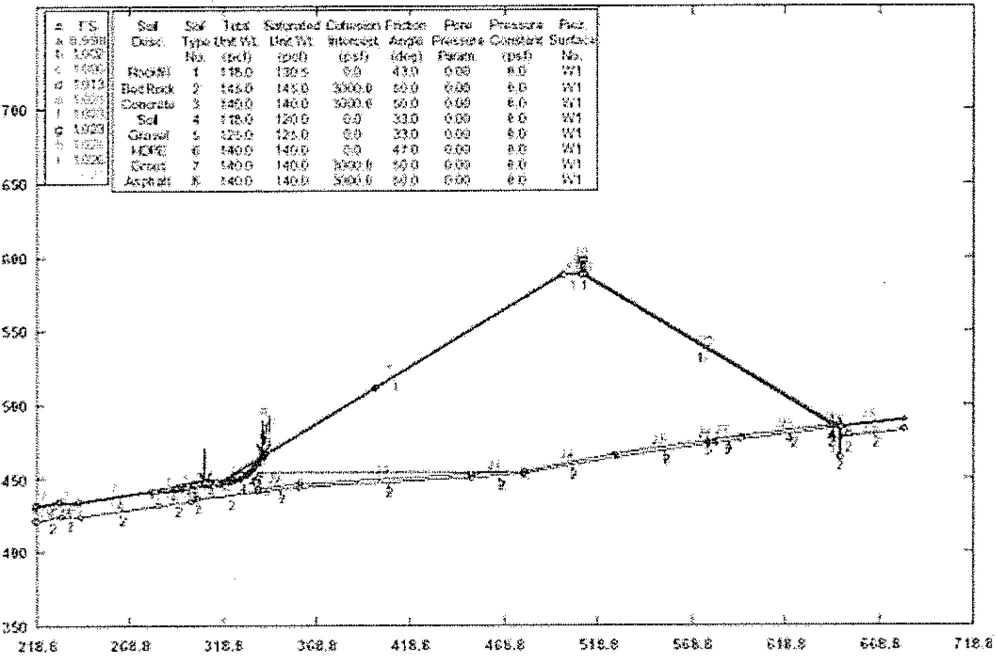
Taum Sauk / Tri. Low Water, 43-33 Toe Wedge Failure



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	43.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	33.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	33.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=0.999
Safety Factors Are Calculated By The Simplified Janbu Method

Taum Sauk / Tri. Low Water, 43-33 Toe Circular Failure



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	43.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	33.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	33.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

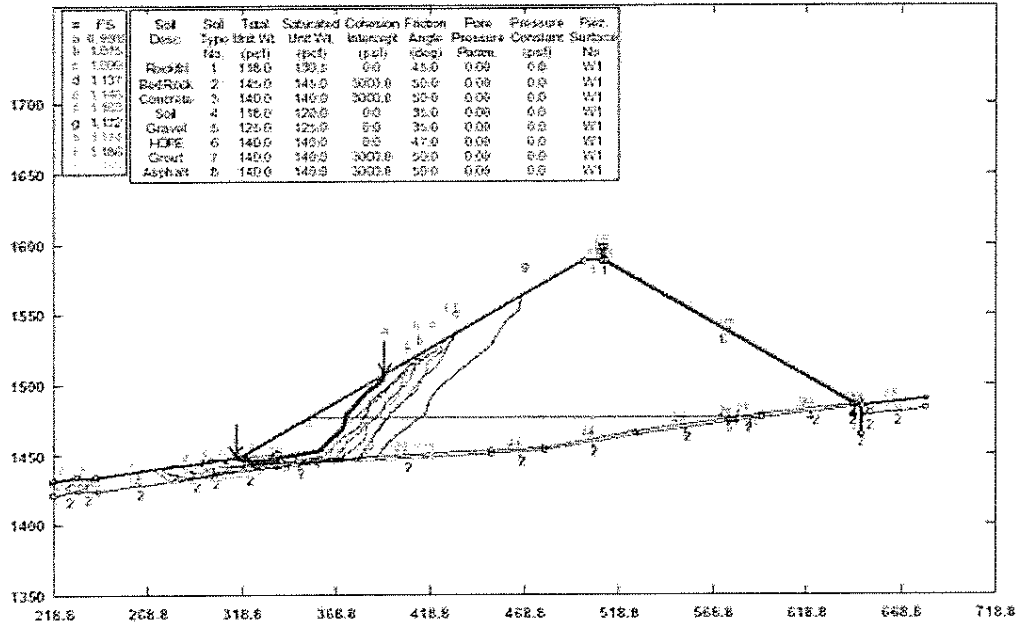
GSTABL7 v.2 FSmin=0.998
Safety Factors Are Calculated By The Modified Bishop Method

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 30 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

Condition C F.S. = 1 with level water surface

Upper Bound

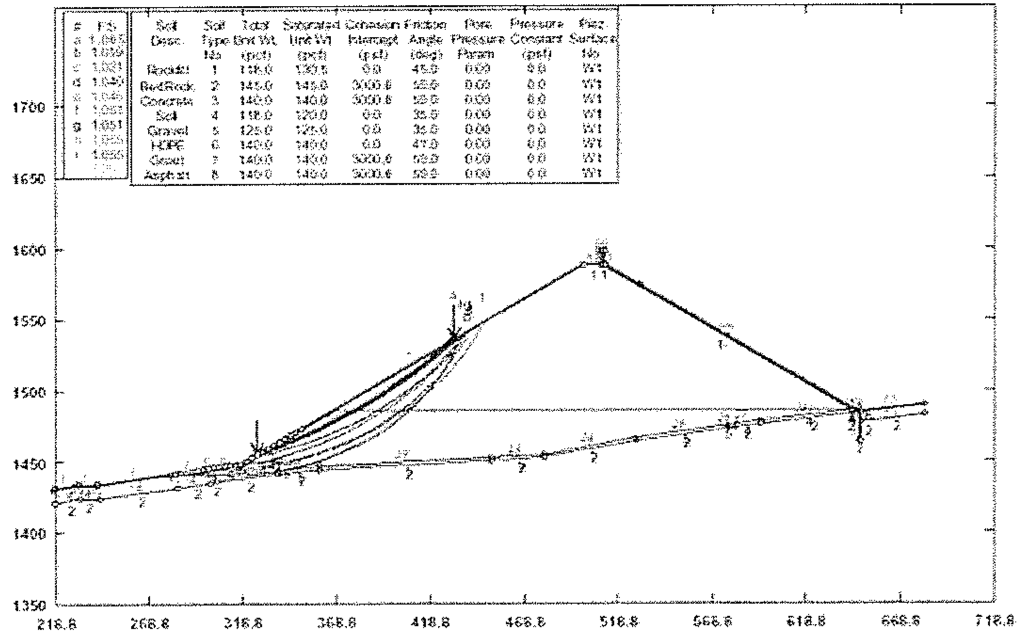
Taum Sauk / Tri. Low Water, 45-35 Deep Wedge Failure



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	45.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	116.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=0.998
Safety Factors Are Calculated By The Simplified Janbu Method

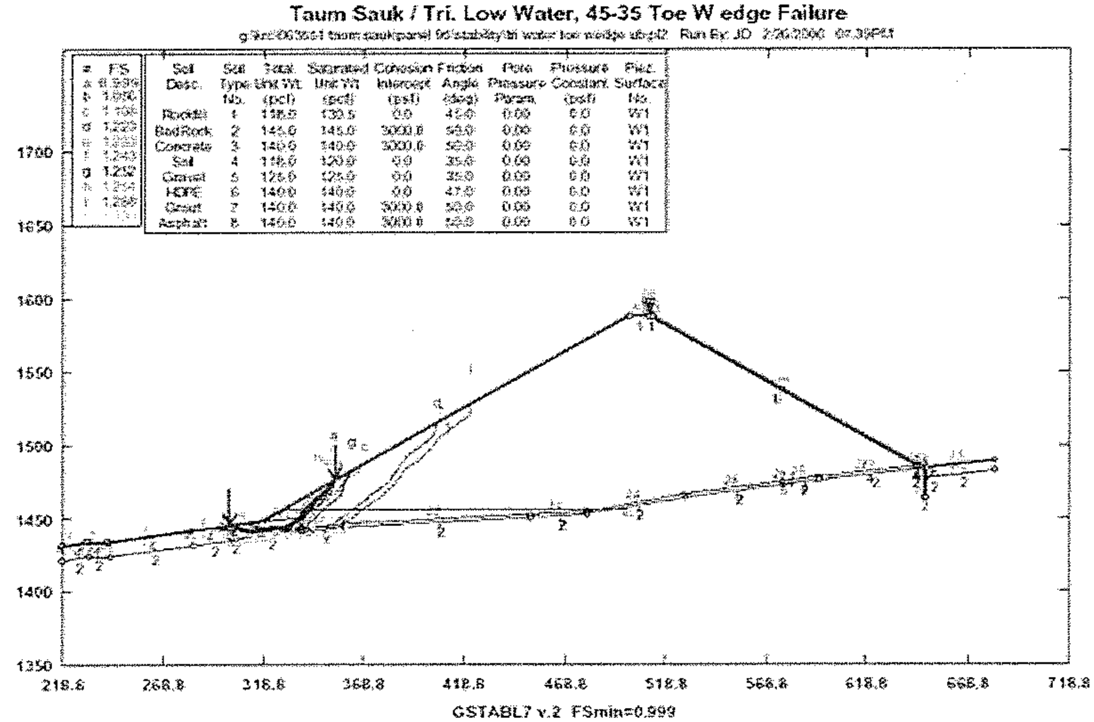
Taum Sauk / Tri. Low Water, 45-35 Deep Circular Failure



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	45.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.005
Safety Factors Are Calculated By The Modified Bishop Method

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 31 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .



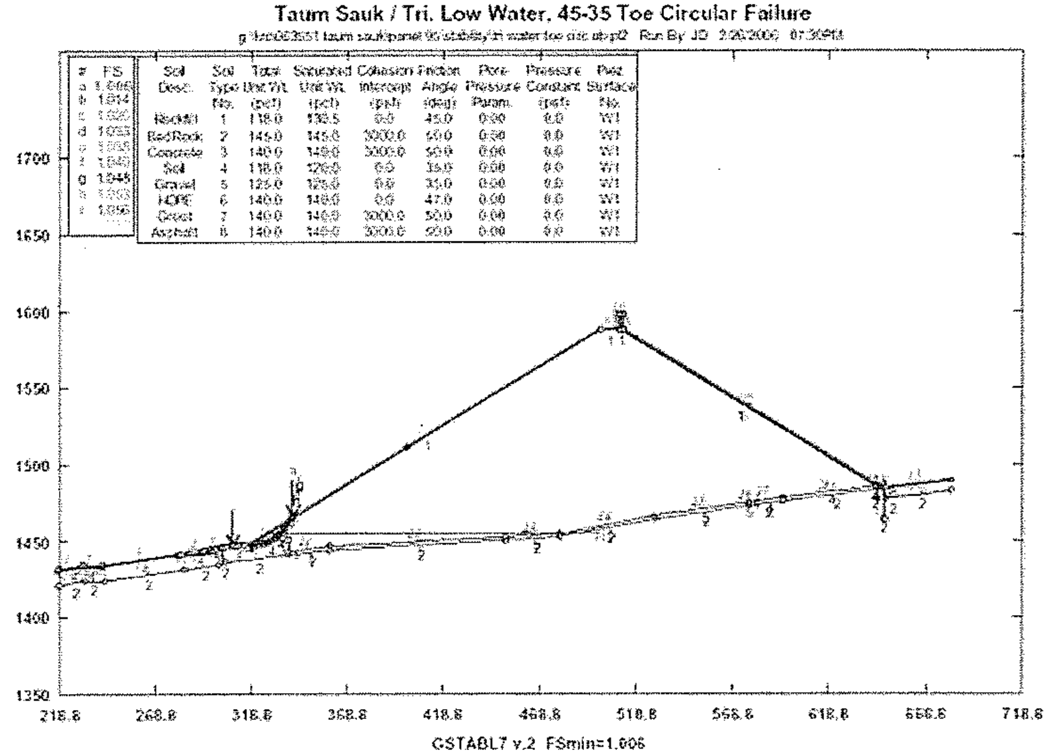
Taum Sauk / Tri. Low Water, 45-35 Toe Wedge Failure

g:\...\taum sauk\panel 9\stability\tri water toe wedge.stb.pl2 Run By: JD 2/26/2006 07:39PM

#	FS
a	0.999
b	1.050
c	1.106
d	1.229
e	1.232
f	1.243
g	1.252
h	1.254
i	1.288

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	45.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	60.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=0.999
Safety Factors Are Calculated By The Simplified Janbu Method



Taum Sauk / Tri. Low Water, 45-35 Toe Circular Failure

g:\...\taum sauk\panel 9\stability\tri water toe circ.stb.pl2 Run By: JD 2/26/2006 07:30PM

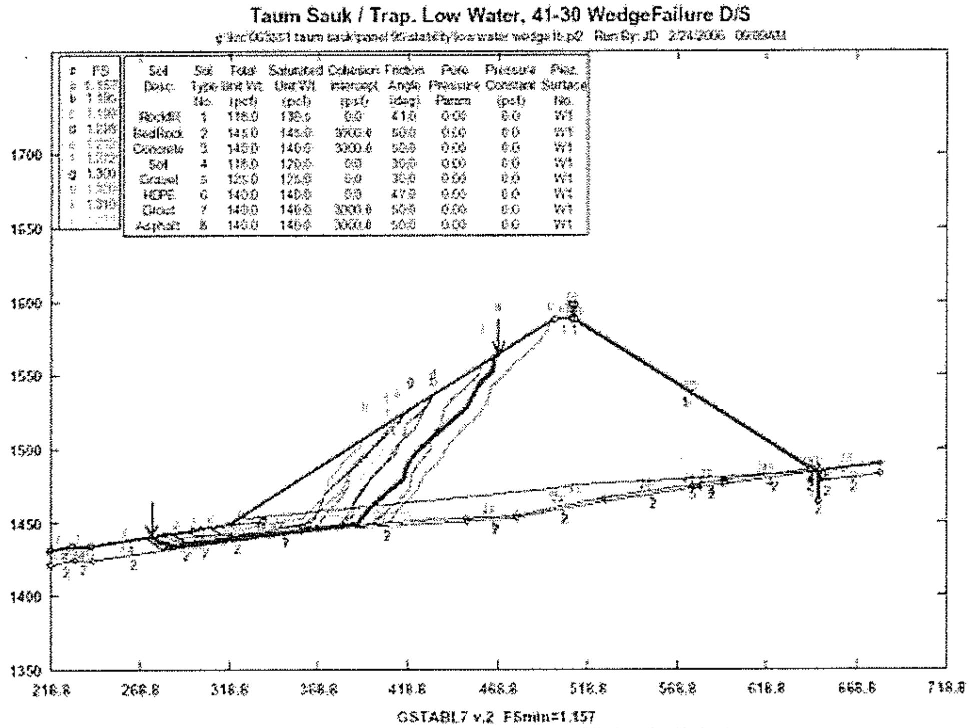
#	FS
a	1.006
b	1.014
c	1.026
d	1.033
e	1.035
f	1.040
g	1.045
h	1.053
i	1.056

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	45.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	60.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

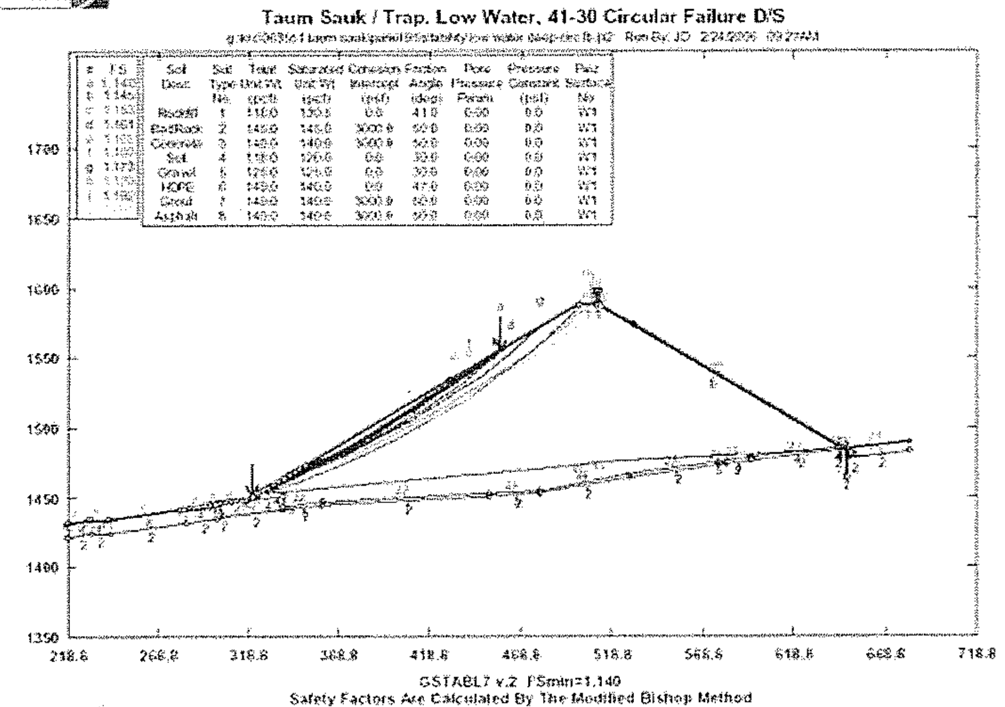
GSTABL7 v.2 FSmin=1.006
Safety Factors Are Calculated By The Modified Bishop Method

Condition D Low Water Level

Lower Bound



GSTABL7 v.2 FSmin=1.157
Safety Factors Are Calculated By The Simplified Janbu Method



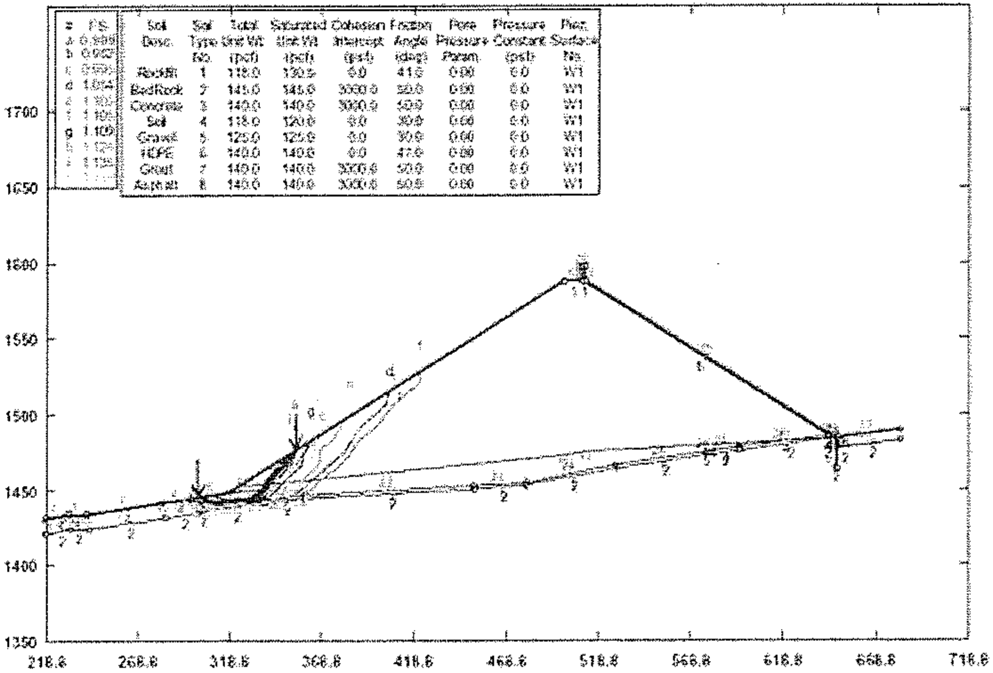
GSTABL7 v.2 FSmin=1.140
Safety Factors Are Calculated By The Modified Bishop Method

(104)

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 33 of 43 .
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

Taum Sauk / Trap. Low Water, 41-30 Toe Wedge Failure

g:\krc\063551 taum sauk\panel 9\stability\low water toe wedge b.pl2 Run By: JD 2/24/2006 09:43AM



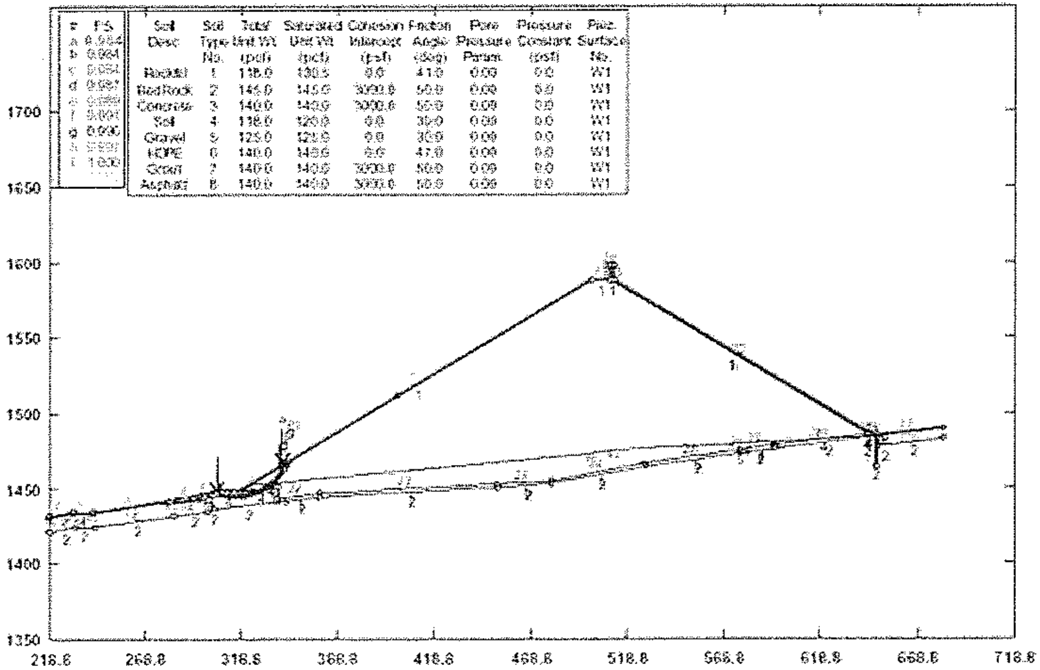
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	41.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	30.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	30.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=0.909
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

Taum Sauk / Trap. Low Water, 41-30 Toe Circular Failure

g:\krc\063551 taum sauk\panel 9\stability\low water toe circ b.pl2 Run By: JD 2/24/2006 05:26PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	41.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	30.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	30.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=0.984
Safety Factors Are Calculated By The Modified Bishop Method

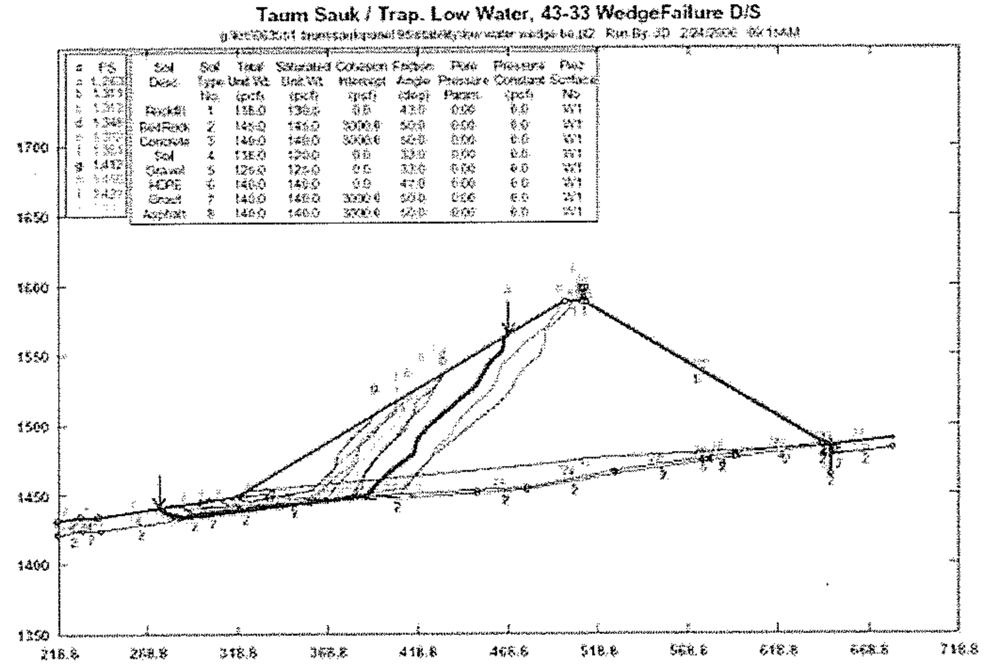
GSTABL7

105

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 34 of 43.
Chkd. by JRG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

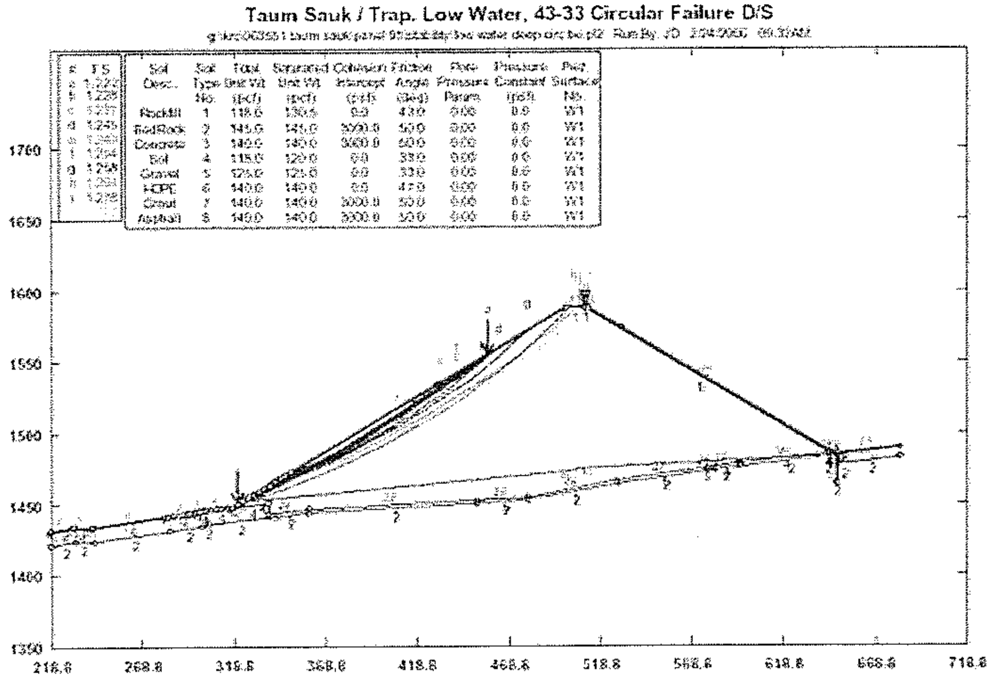
Condition D Low Water Level

Best Estimate



Taum Sauk / Trap. Low Water, 43-33 WedgeFailure D/S

GSTABL7 v.2 FSmin=1.263
Safety Factors Are Calculated By The Simplified Janbu Method



Taum Sauk / Trap. Low Water, 43-33 Circular Failure D/S

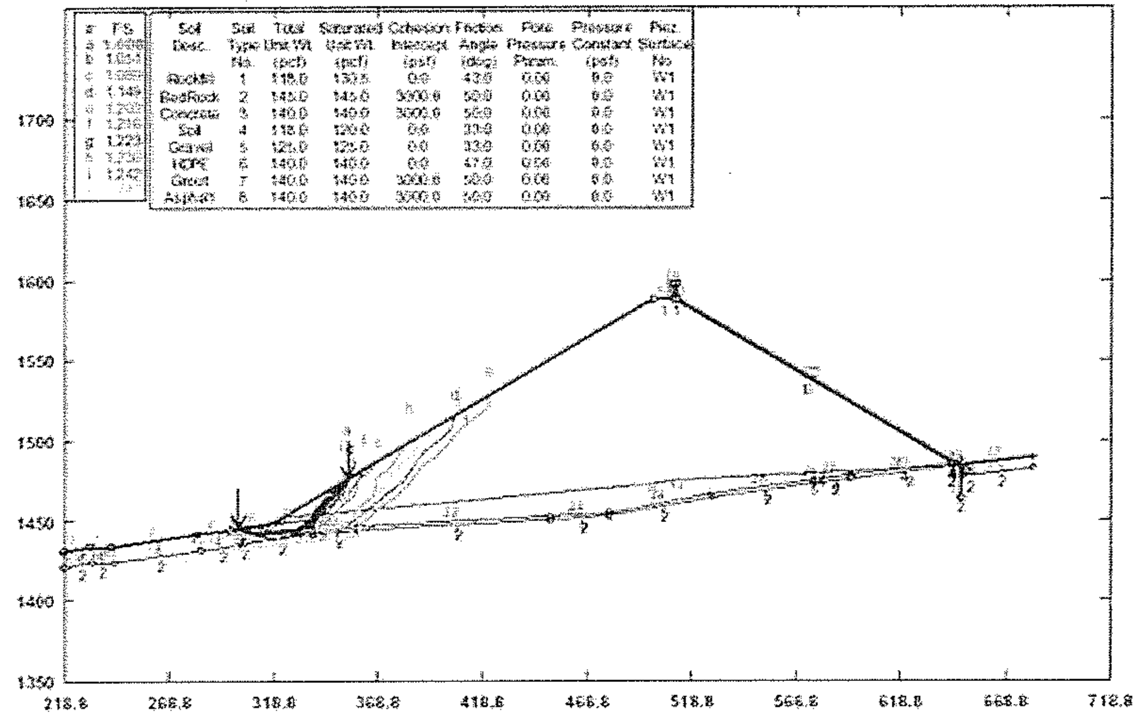
GSTABL7 v.2 FSmin=1.222
Safety Factors Are Calculated By The Modified Bishop Method

106

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 35 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

Taum Sauk / Trap. Low Water, 43-33 Toe Wedge Failure

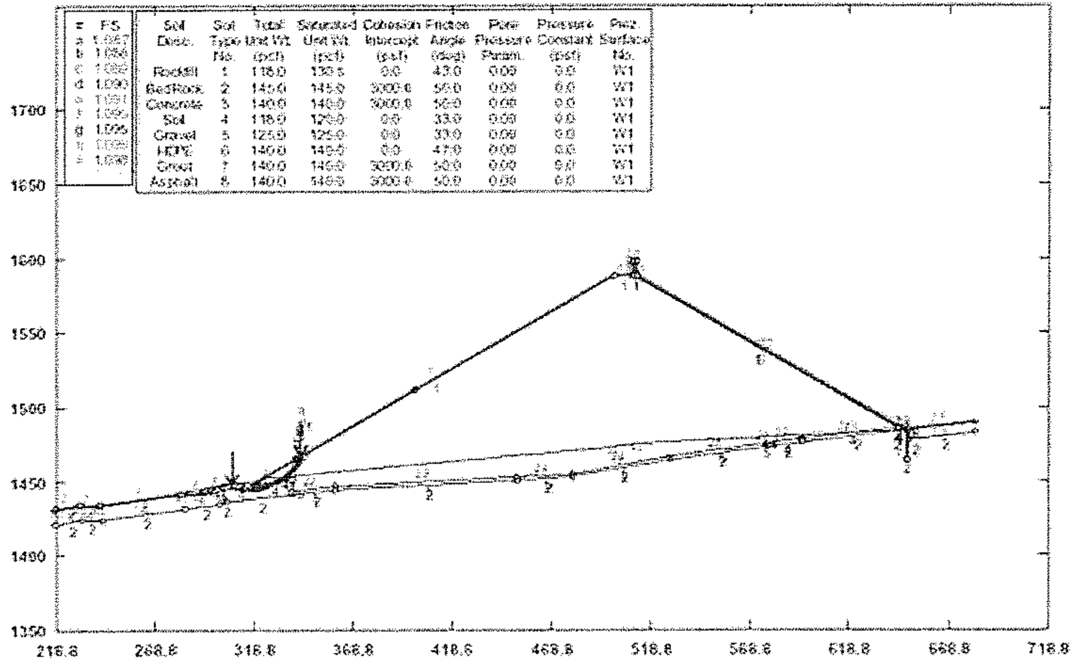
g:\[illegible]\taum sauk\panel 95\stability\low water toe wedge toe pl2 Run By: JD 2/24/2006 09:45AM



GSTABL7 v.2 FSmin=1.008
Safety Factors Are Calculated By The Simplified Janbu Method

Taum Sauk / Trap. Low Water, 43-33 Toe Circular Failure

g:\[illegible]\taum sauk\panel 95\stability\low water toe circ toe pl2 Run By: JD 2/24/2006 06:50PM

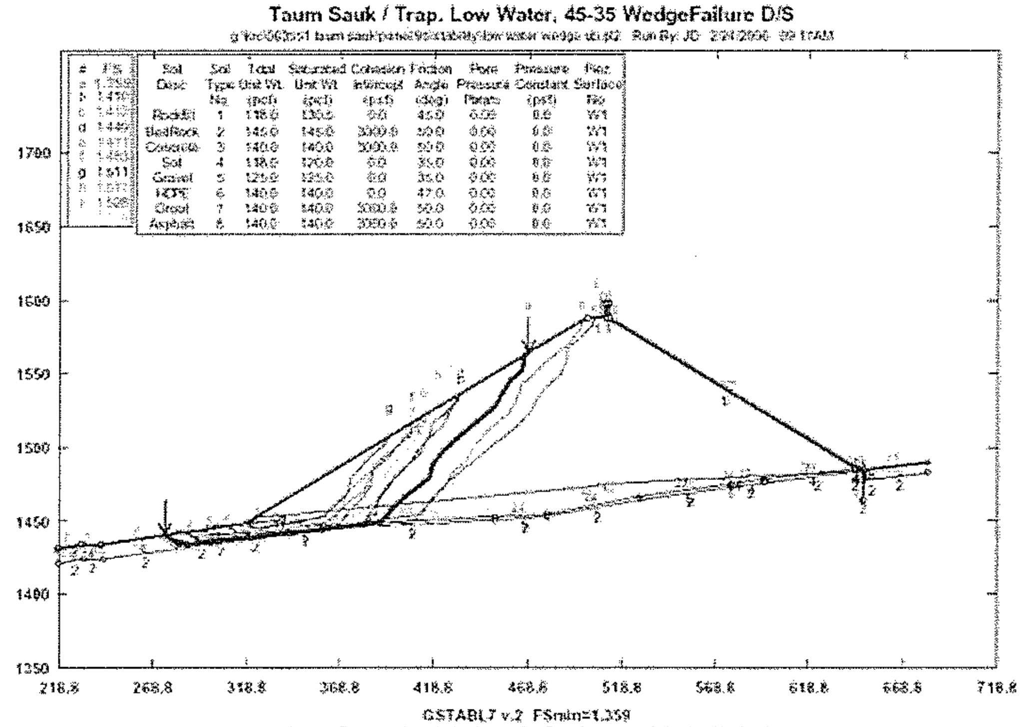


GSTABL7 v.2 FSmin=1.087
Safety Factors Are Calculated By The Modified Bishop Method

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 36 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

Condition D Low Water Level

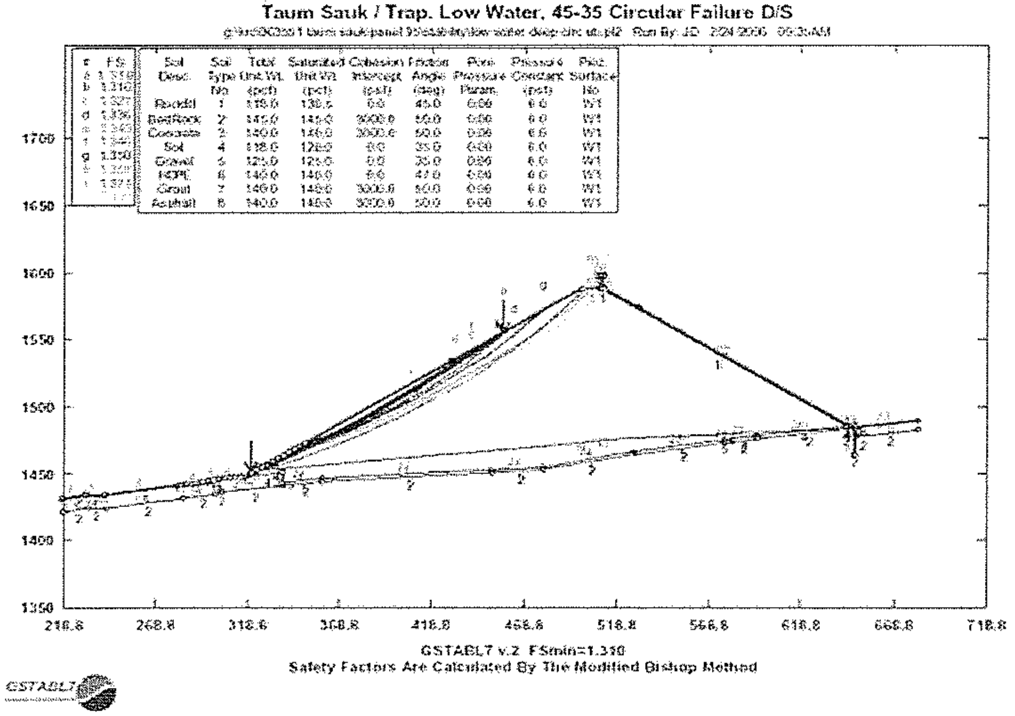
Upper Bound



Taum Sauk / Trap. Low Water, 45-35 WedgeFailure D/S

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.0	0.0	45.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.359
Safety Factors Are Calculated By The Simplified Janbu Method



Taum Sauk / Trap. Low Water, 45-35 Circular Failure D/S

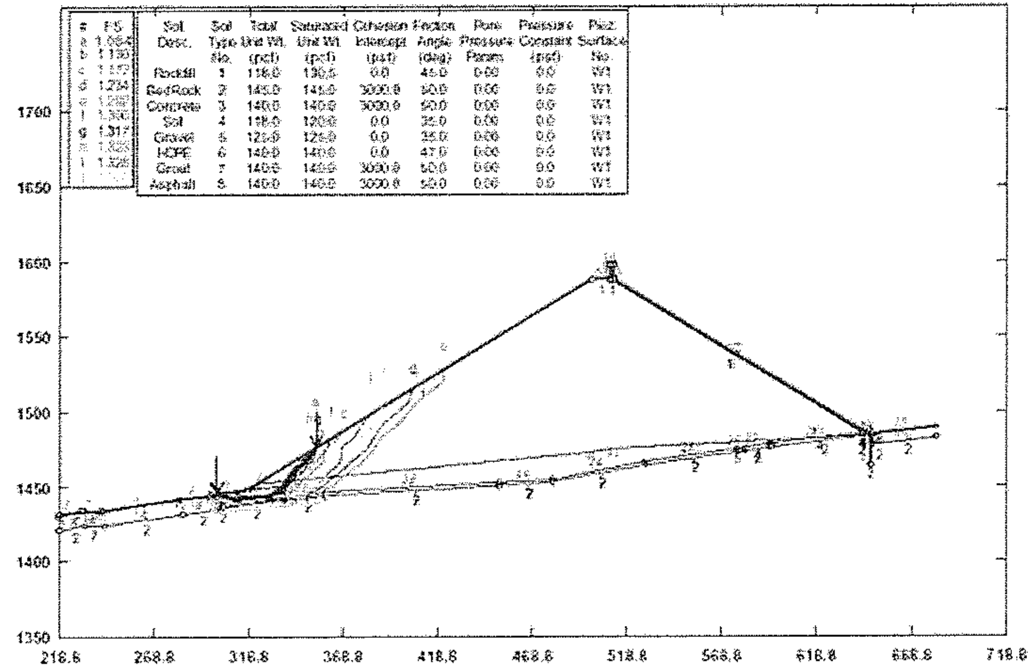
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.0	0.0	45.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.310
Safety Factors Are Calculated By The Modified Bishop Method

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 37 of 43.
Chkd. by JPG . Date 3/30/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

Taum Sauk / Trap. Low Water, 45-35 Toe Wedge Failure

g:\kc\063551 taum sauk\panel 06\stability\low water toe wedge ub.pl2 Run By: JD 2/24/2006 09:46AM

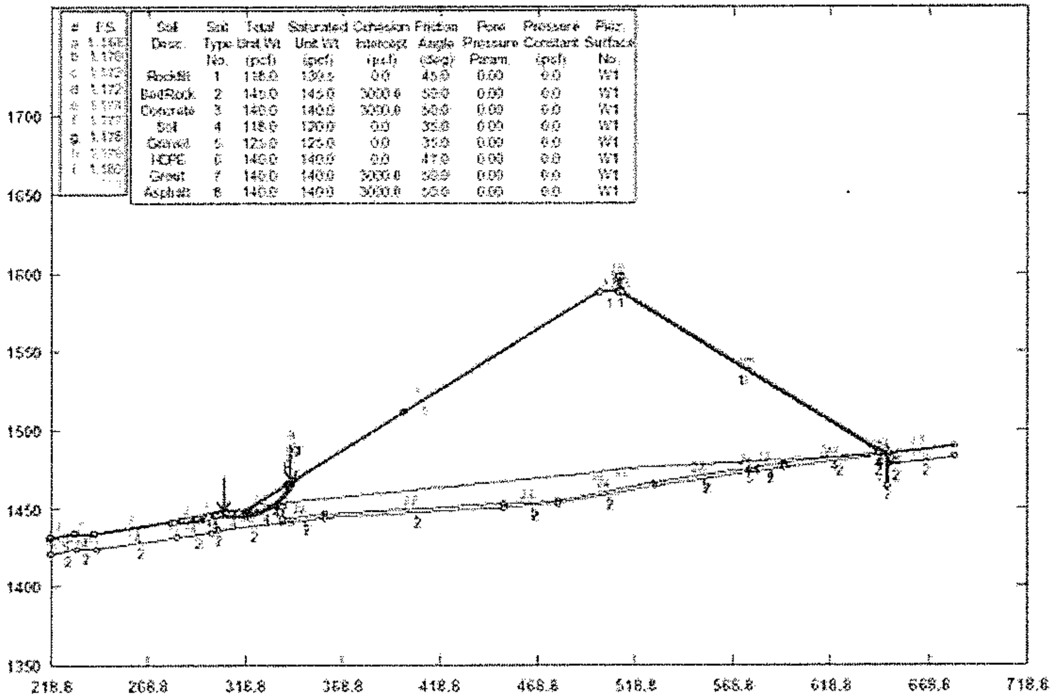


Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	45.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.084
Safety Factors Are Calculated By The Simplified Janbu Method

Taum Sauk / Trap. Low Water, 45-35 Toe Circular Failure

g:\kc\063551 taum sauk\panel 06\stability\low water toe circ ub.pl2 Run By: JD 2/24/2006 05:38PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	45.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.168
Safety Factors Are Calculated By The Modified Bishop Method

(109)

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 38 of 43.
Chkd. by JPG. Date 3/20/06. Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

ATTACHMENT – C
Computer Output of Slope Stability Analysis

List of GSTABL Files

Condition	Material Properties	Failure Type	Filename*
A	Lower Bound	Deep Wedge	deep wedge lb.pl2
		Deep Circular	deep circ lb.pl2
		Toe Wedge	toe wedge lb.pl2
		Toe Circular	toe circ lb.pl2
	Best Estimate	Deep Wedge	deep wedge be.pl2
		Deep Circular	deep circ be.pl2
		Toe Wedge	toe wedge be.pl2
		Toe Circular	toe circ be.pl2
	Upper Bound	Deep Wedge	deep wedge ub.pl2
		Deep Circular	deep circ ub.pl2
		Toe Wedge	toe wedge ub.pl2
		Toe Circular	toe circ ub.pl2
B	Lower Bound	Deep Wedge	panel95-block30-41.pl2
		Deep Circular	hdpe deep circ lb.pl2
		Toe Wedge	41-30 toe.pl2
		Toe Circular	hdpe toe circ lb.pl2
	Best Estimate	Deep Wedge	panel95-block1.pl2
		Deep Circular	hdpe deep circ be.pl2
		Toe Wedge	panel95-block2.pl2
		Toe Circular	hdpe toe circ be.pl2
	Upper Bound	Deep Wedge	hdpe deep wedge ub.pl2
		Deep Circular	hdpe deep circ ub.pl2
		Toe Wedge	hdpe toe wedge ub.pl2
		Toe Circular	hdpe toe circ ub.pl2
C	Lower Bound	Deep Wedge	tri water deep wedge lb.pl2
		Deep Circular	tri water deep circ lb.pl2
		Toe Wedge	tri water toe wedge lb.pl2
		Toe Circular	tri water toe circ lb.pl2
	Best Estimate	Deep Wedge	tri water deep wedge be.pl2
		Deep Circular	tri water deep circ be.pl2
		Toe Wedge	tri water toe wedge be.pl2
		Toe Circular	tri water toe circ be.pl2
	Upper Bound	Deep Wedge	tri water deep wedge ub.pl2
		Deep Circular	tri water deep circ ub.pl2
		Toe Wedge	tri water toe wedge ub.pl2
		Toe Circular	tri water toe circ ub.pl2
D	Lower Bound	Deep Wedge	low water wedge lb.pl2
		Deep Circular	low water deep circ lb.pl2
		Toe Wedge	low water toe wedge lb.pl2
		Toe Circular	low water toe circ lb.pl2
	Best Estimate	Deep Wedge	low water wedge be.pl2
		Deep Circular	low water deep circ be.pl2
		Toe Wedge	low water toe wedge be.pl2
		Toe Circular	low water toe circ be.pl2
	Upper Bound	Deep Wedge	low water wedge ub.pl2
		Deep Circular	low water deep circ ub.pl2
		Toe Wedge	low water toe wedge ub.pl2
		Toe Circular	low water toe circ ub.pl2

*All files are located in G:\KRC\063551 Taum Sauk\Panel 95\Stability and on the CD included with this calculation

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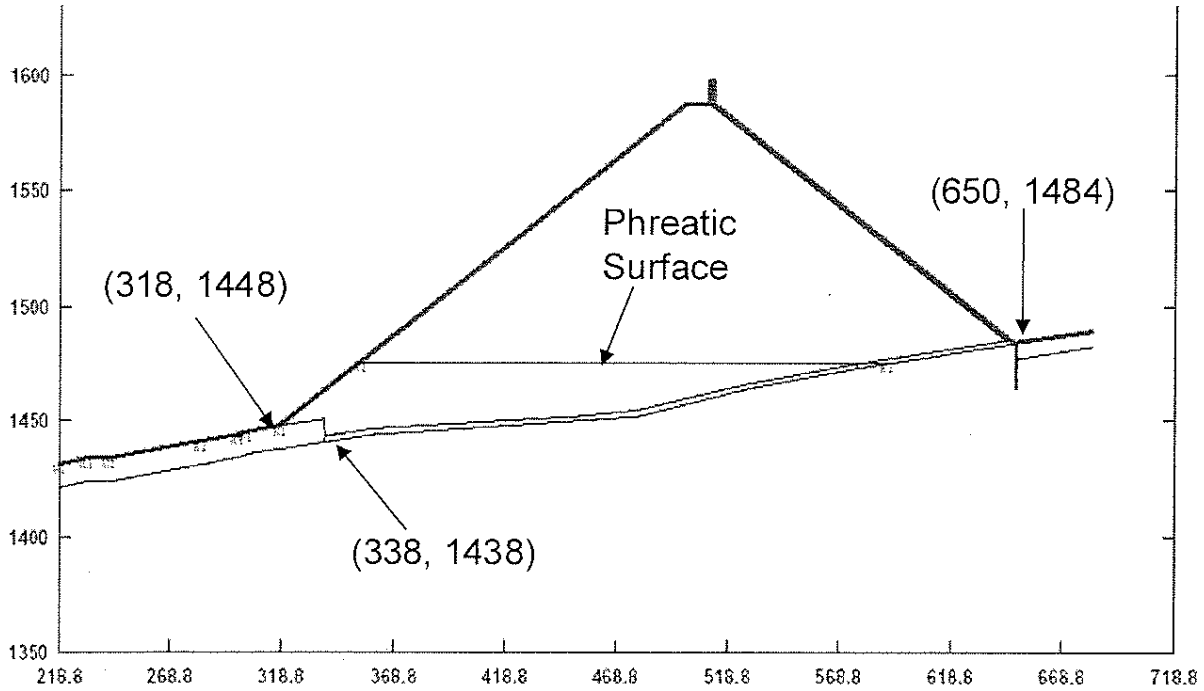
By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 40 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

ATTACHMENT – D
Estimation of Time of Failure

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 41 of 43.
Chkd. by JRG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

The time of failure is estimated by finding the time it takes water that is overtopping the parapet wall at segment 95 to raise the phreatic surface in the dam to a level where the factor of safety against sliding is 1. The height of the phreatic surface that will cause a failure is estimated in GSTABL (Reference 4) for each of the 12 cases analyzed. The phreatic surface in the dam is assumed to be at the same elevation at the upstream and downstream ends, and the bottom five feet of rockfill above bedrock of the cross section at wall segment 95 are assumed to be saturated. A one foot wide cross section of the dam at wall segment 95 is considered. An effective porosity of 15% is used for the rockfill in the dam (assuming total porosity of 20% with 5% reduction due to natural moisture. A figure showing the cross section considered with key coordinates and an example phreatic surface is shown below.



The area under the phreatic surface is approximated with two triangles. The bottom five feet of rockfill are assumed to be saturated, so this area is subtracted from the total. A table listing the area under the phreatic surface, accounting for 15% porosity and 5 feet of saturation, is shown below.

Areas (sf)			
Net Porosity = 15%			
Failure Type	Lower Bound	Best Estimate	Upper Bound
Deep Wedge	462	536	650
Deep Circular	664	850	1017
Toe Wedge	80	102	170
Toe Circular	103	134	163

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 42 of 43.
Chkd. by JRG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

Areas listed in the table above are considered for a one foot wide cross section, so volume is found by multiplying the areas by the one foot width. The flow over the parapet wall at segment 95 is considered for a one foot wide section from 0 to 34 minutes (Reference 8) and is shown below.

Flow Over Wall Segment 95

Time (min)	Reservoir Elevation	Flow Over Wall Segment 95	Cumulative Outflow Wall Segment 95 (cf)	Flow per Foot Wall Segment 95 (cfs)	Cumulative flow per foot Wall Segment 95 (cf/ft)	Water in dam for 80% infiltration
0	1597	0.00	0.00	0.00	0.00	0.00
1	1597.1	0.00	0.00	0.00	0.00	0.00
2	1597.1	0.00	0.00	0.00	0.00	0.00
3	1597.2	0.00	0.00	0.00	0.00	0.00
4	1597.3	1.80	108.00	0.03	1.80	1.44
5	1597.3	1.80	216.00	0.03	3.60	2.88
6	1597.4	9.30	774.00	0.16	12.90	10.32
7	1597.4	9.30	1332.00	0.16	22.20	17.76
8	1597.5	20.20	2544.00	0.34	42.40	33.92
9	1597.6	33.70	4566.00	0.56	76.10	60.88
10	1597.6	33.70	6588.00	0.56	109.80	87.84
11	1597.7	49.30	9546.00	0.82	159.10	127.28
12	1597.7	49.30	12504.00	0.82	208.40	166.72
13	1597.7	49.30	15462.00	0.82	257.70	206.16
14	1597.8	67.30	19500.00	1.12	325.00	260.00
15	1597.8	67.30	23538.00	1.12	392.30	313.84
16	1597.8	67.30	27576.00	1.12	459.60	367.68
17	1597.9	87.40	32820.00	1.46	547.00	437.60
18	1597.9	87.40	38064.00	1.46	634.40	507.52
19	1597.9	87.40	43308.00	1.46	721.80	577.44
20	1597.9	87.40	48552.00	1.46	809.20	647.36
21	1597.9	87.40	53796.00	1.46	896.60	717.28
22	1597.9	87.40	59040.00	1.46	984.00	787.20
23	1597.9	87.40	64284.00	1.46	1071.40	857.12
24	1597.9	87.40	69528.00	1.46	1158.80	927.04
25	1598	109.90	76122.00	1.83	1268.70	1014.96
26	1598	109.90	82716.00	1.83	1378.60	1102.88
27	1598	109.90	89310.00	1.83	1488.50	1190.80
28	1598	109.90	95904.00	1.83	1598.40	1278.72
29	1598	109.90	102498.00	1.83	1708.30	1366.64
30	1598	109.90	109092.00	1.83	1818.20	1454.56
31	1598	109.90	115686.00	1.83	1928.10	1542.48
32	1598	109.90	122280.00	1.83	2038.00	1630.40
33	1598	109.90	128874.00	1.83	2147.90	1718.32
34	1598	109.90	135468.00	1.83	2257.80	1806.24

By UD/JD . Date 2-27-06 . Subject Taum Sauk Plant . Sheet No. 43 of 43.
Chkd. by JPG . Date 3/20/06 . Stability Analysis of Failed Zone . Proj. No. 06-3551-02 .

An infiltration rate of 80% is assumed, meaning that 80% of the flow overtopping the parapet wall enters the dam and 20% runs off. Time to failure using the assumptions and values listed above is shown below for each of the 12 failure conditions.

Time to Failure (min)*			
	Lower Bound	Best Estimate	Upper Bound
Deep Wedge	17.4	18.5	20.0
Deep Circular	20.2	23.0	25.0
Toe Wedge	9.7	10.4	11.9
Toe Circular	10.4	11.1	12.0

*time 0 corresponds to reservoir elevation 1597.00

APPENDIX G

INSTRUMENTATION SUPPORT DRAWINGS

PRINT DIST.	
REVISIONS	
REV.	W.O.
0	ISSUED FOR REGULATORY APPROVAL

NOTES/SPECIFICATIONS

CONCRETE

1. REMOVE ALL DEBRIS AND DIRT FROM BENEATH SURFACES TO RECEIVE CONCRETE. POWERWASH ALL SURFACES PRIOR TO CONCRETE PLACEMENT.
2. AIR ENTRAINED, NORMAL WEIGHT STEEL FIBER REINFORCED CONCRETE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH (f'c) OF 3000 PSI. TYPE II CEMENT MEETING ASTM C150 SHALL BE USED. THE MIX SHALL HAVE A MAXIMUM ALLOWABLE WATER/CEMENT RATIO OF 0.45, AIR CONTENT BETWEEN 2 TO 3%, AND SLUMP BETWEEN 3–5 INCHES. AGGREGATES USED SHALL MEET ASTM C33 AND MAXIMUM SIZE SHALL BE 1". THE CONCRETE SHALL HAVE STEEL FIBERS A MINIMUM OF 33 POUNDS PER CUBIC YARD. THE STEEL FIBERS SHALL BE 'XOREX', AS MANUFACTURED BY NOVOCON OR APPROVED EQUAL. ONLY POTABLE WATER SHALL BE USED. CONTRACTOR SHALL SUBMIT CONCRETE MIX DESIGN FOR ENGINEER'S APPROVAL BEFORE CONCRETE PLACEMENT.
3. ANY ADMIXTURE TO BE USED IN CONCRETE SHALL HAVE APPROVAL OF THE ENGINEER IN CHARGE PRIOR TO USE. NO ADMIXTURE CONTAINING CALCIUM CHLORIDE WILL BE ACCEPTABLE.
4. ALL REINFORCING BARS TO BE NEW DEFORMED BILLET STEEL PER ASTM A–615 GRADE 60 BARS. ALL WELDED WIRE FABRIC (WWF) TO BE IN ACCORDANCE WITH ASTM A–185. FURNISH WWF IN FLAT SHEETS ONLY. PLACE 2 INCHES BENEATH TOP OF SLAB SURFACE, UNLESS OTHERWISE NOTED.
5. DETAILING OF CONCRETE REINFORCEMENT SHALL BE IN ACCORDANCE WITH ACI 315 "MANUAL OF STANDARD PRACTICE OF DETAILING REINFORCED CONCRETE STRUCTURES". CLEARANCES AS NOTED ON DETAILS ON THIS SHEET.
6. HYDROTITE WATERSTOPS SHALL BE INSTALLED AS SHOWN ON THE DRAWINGS AND SHALL BE CONTINUOUS. WATERSTOPS SHALL BE INSTALLED PER MANUFACTURER'S INSTRUCTIONS USING A SEALANT AS NECESSARY.
7. ALL CONCRETE WORK SHALL BE IN ACCORDANCE WITH THE LATEST EDITION OF ACI 318 "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE".
8. CONTRACTOR SHALL BE SOLELY RESPONSIBLE FOR THE DESIGN AND ENGINEERING OF FORMWORK AS WELL AS ITS CONSTRUCTION. USE SMOOTH FORMS ON ALL SURFACES CONFORMING THE SHAPE LINE AND DIMENSIONS SHOWN. FORM COATING AND REMOVAL SHALL CONFORM TO ACI 347.
9. CURING SHALL CONFORM TO ACI 308. PROTECT FRESHLY DEPOSITED CONCRETE IMMEDIATELY FROM PREMATURE DRYING, EXCESSIVE HOT OR COLD TEMPERATURES AND EXCESSIVE MOISTURE LOSS FOR A PERIOD NOT LESS THAN 7 DAYS. PROTECT CONCRETE AND FINISHED SURFACES FROM DAMAGING MECHANICAL DISTURBANCES.
10. PROVIDE A SMOOTH FORMED FINISH ON ALL FORMED SURFACES AND A BROOM FINISH ON ALL UNFORMED SLAB SURFACES. ALL SLAB TOLERANCES SHALL MEET ACI 117 REQUIREMENTS.
11. QUALITY CONTROL:

    A– THE CONTRACTOR SHALL EMPLOY THE SERVICES OF AN INDEPENDENT TESTING LABORATORY TO PERFORM THE FOLLOWING:

        1– SLUMP TEST SHALL BE MADE IN THE FIELD AT A RATE OF ONE PER TRUCK.

        2– FIELD TEST CYLINDERS SPECIMENS SHALL BE TAKEN AT A RATE OF ONE SET PER 25 CUBIC YARDS AND IN GENERAL NOT LESS THAN ONE SET OF SPECIMENS WILL BE TAKEN IN ANY ONE DAY. ADDITIONAL CYLINDERS SHALL BE TAKEN AT THE ENGINEER'S DISCRETION. CONDUCT STRENGTH TEST FOR CONCRETE ACCORDING TO THE FOLLOWING PROCEDURES:

            A– SECURE SAMPLES IN ACCORDANCE WITH ASTM C–172.

            B– MOLD FIVE SPECIMENS FROM EACH SAMPLE ACCORDING TO ASTM C31, CURE UNDER STANDARD MOISTURE AND TEMPERATURE CONDITIONS AS SPECIFIED IN ASTM C31.

            C– TEST ONE SPECIMEN AT 7 DAYS AND AT 14 DAYS, AND TWO AT 28 DAYS ACCORDING TO ASTM C39. IF ONE OR BOTH OF THE 28–DAY TESTS INDICATE A COMPRESSIVE STRENGTH BELOW THE STRENGTH REQUIRED, THE FIFTH SPECIMEN SHALL BE TESTED AT 56 DAYS. THE STRENGTH OF THE CONCRETE WILL BE CONSIDERED POTENTIALLY DEFICIENT IF THE AVERAGES OF 2 CONSECUTIVE SETS OF STRENGTH TEST RESULTS FAIL TO EQUAL OR EXCEED THE SPECIFIED STRENGTH. ADDITIONAL TESTING MAY BE REQUIRED AS DIRECTED BY THE ENGINEER.

        3– DETERMINE THE FOLLOWING WHEN TEST CYLINDERS ARE TAKEN:
            A– AIR CONTENT
            B– SLUMP
            C– CONCRETE TEMPERATURE (NOTE: TEMPERATURE SHOULD BE CHECKED MORE FREQUENTLY IF ADVERSE WEATHER CONDITIONS ARE EXPECTED)

    B– TEST RESULTS WILL BE REPORTED IN WRITING TO ENGINEER WITHIN 24 HOURS THAT TESTS ARE MADE. REPORTS OF COMPRESSIVE STRENGTH TESTS SHALL CONTAIN THE PROJECT IDENTIFICATION NAME AND NUMBER, DATE OF CONCRETE BATCH IN STRUCTURE, DESIGN COMPRESSIVE STRENGTH AT 28 DAYS, CONCRETE MIX PROPORTIONS AND MATERIALS.

    C– CONCRETE AND CONCRETE WORK WHICH IN THE OPINION OF THE ENGINEER, DOES NOT MEET WITH THE REQUIREMENTS OF THIS SPECIFICATIONS OR WHICH DOES NOT REPRESENT GOOD WORKMANSHIP, SHALL BE REMOVED FROM THE SITE AND REPLACED WITH CONCRETE CONFORMING TO THE SPECIFICATIONS AT THE SOLE EXPENSE OF THE CONTRACTOR. THE DECISION OF THE ENGINEER AS TO WHETHER SUBSTANDARD CONCRETE IS TO BE ACCEPTED OR REJECTED SHALL BE FINAL.

OTHER NOTES

1. SEE SCHEDULE OF MATERIALS FOR SPECIFICATIONS OF OTHER MATERIALS.
2. ALL PRODUCTS SHALL BE INSTALLED PER MANUFACTURER'S INSTALLATION INSTRUCTIONS.
3. STAINLESS STEEL BATTENS SHALL BE CONTINUOUS SUPPORT TO LINER. BATTENS SHALL BUTT AGAINST EACH OTHER WITHOUT A GAP. BATTEN CANTILEVER FROM ANCHOR BOLT SHALL NOT EXCEED 6 INCHES.
4. CONTRACTOR SHALL BE RESPONSIBLE FOR DESIGN AND INSTALLATION OF TEMPORARY PLATFORMS AND SUPPORTS REQUIRED FOR INSTALLATION OF LINER SYSTEM.
5. CONTRACTOR SHALL TAKE ALL PRECAUTIONS SO AS NOT TO DAMAGE THE EXISTING STRUCTURES DURING INSTALLATION OF LINER SYSTEM. ANY DAMAGE INCURRED SHALL BE REPAIRED AT CONTRACTOR'S EXPENSE.

SCHEDULE OF MATERIALS

ITEM	MANUFACTURER	PRODUCT
GEOMEMBRANE	GSE LINING TECHNOLOGY, INC.	80 MIL HD TEXTURED
NONWOVEN GEOTEXTILE	GSE LINING TECHNOLOGY, INC.	NONWOVEN POLYPROPYLENE GEOTEXTILE NW16
WOVEN GEOTEXTILE	SYNTHETIC INDUSTRIES	–
ANCHOR BOLT (TYPE A)	HILTI	KWIK BOLT II, ½" DIAMETER, AISI 304 STAINLESS STEEL (WITH STAINLESS STEEL WASHERS)
ANCHOR BOLT (TYPE B)	HILTI	KWIK BOLT II, ⅝" DIAMETER, AISI 304 STAINLESS STEEL (WITH STAINLESS STEEL WASHERS)
BATTEN (ANGLE)	–	3" X 2" X ¼" ANGLE, AISI 304 STAINLESS STEEL
BATTEN (FLAT)	–	2" X 3/16" FLAT STOCK, AISI 304 STAINLESS STEEL
POWDER ACTIVATED PIN	HILTI	X–CR, STAINLESS STEEL NAIL
GASKET	–	NEOPRENE
SILICONE SEAL (FOR WATERSTOP)	GREENSTREAK	LEAKMASTER
WATER STOP	GREENSTREAK	HYDROTITE CJ–0725–3K
POLYLOCK	GSE LINING TECHNOLOGY, INC.	POLYLOCK

NOTE: CONTRACTOR MAY REQUEST SUSTITUTION OF ANY PRODUCT PROVIDED CONTRACTOR CAN MAKE EQUIVALENCY DEMONSTRATION.

PREPARED BY

EMCON/OWT
Solid Waste Services

NOTICE OF LIMITED RESPONSIBILITY

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ADAM STEPHEN LARKY
10/26/01

DRAWN D. STEHLE
CHKD. A.E. MAXSON
SUPV. N/A
APPD. A. LARKY 12/26/01

SIDE SLOPE RELINING
SPECIFICATIONS & SCHEDULES

LOCATION 0011010
8304-X-155099
CLASS

Ameren
ST. LOUIS MISSOURI
TAUM SAUK UPPER RESERVOIR
TAUM SAUK, MISSOURI
REV NO. 0

PRINT
DIST.

REVISIONS

REV. 0	W.O.	

ISSUED FOR
REGULATORY
APPROVAL

REV. 1	W.O.	

REVISED PER
COMMENTS

		1"
		1"
		1"
		¾"

NOTE: CONTRACTOR MAY REQUEST SUSTITUTION OF ANY PRODUCT PROVIDED CONTRACTOR CAN MAKE EQUIVALENCY DEMONSTRATION.

NOTES/SPECIFICATIONS

CONCRETE

1. REMOVE ALL DEBRIS AND DIRT FROM BENEATH SURFACES TO RECEIVE CONCRETE. POWERWASH ALL SURFACES PRIOR TO CONCRETE PLACEMENT.
2. AIR ENTRAINED, NORMAL WEIGHT FIBER REINFORCED CONCRETE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH (f'c) OF 3000 PSI. TYPE II CEMENT MEETING ASTM C150 SHALL BE USED. THE MIX SHALL HAVE A MAXIMUM ALLOWABLE WATER/CEMENT RATIO OF 0.45, AIR CONTENT BETWEEN 2 TO 3%, AND SLUMP BETWEEN 3-5 INCHES. AGGREGATES USED SHALL MEET ASTM C33 AND MAXIMUM SIZE SHALL BE 1". THE CONCRETE SHALL HAVE POLYPROPYLENE FIBERS A MINIMUM OF 33 POUNDS PER CUBIC YARD. ONLY POTABLE WATER SHALL BE USED. CONTRACTOR SHALL SUBMIT CONCRETE MIX DESIGN FOR ENGINEER'S APPROVAL BEFORE CONCRETE PLACEMENT. 1
3. ANY ADMIXTURE TO BE USED IN CONCRETE SHALL HAVE APPROVAL OF THE ENGINEER IN CHARGE PRIOR TO USE. NO ADMIXTURE CONTAINING CALCIUM CHLORIDE WILL BE ACCEPTABLE.
4. ALL REINFORCING BARS TO BE NEW DEFORMED BILLET STEEL PER ASTM A-615 GRADE 60 BARS. ALL WELDED WIRE FABRIC (WWF) TO BE IN ACCORDANCE WITH ASTM A-185. FURNISH WWF IN FLAT SHEETS ONLY. PLACE 2 INCHES BENEATH TOP OF SLAB SURFACE, UNLESS OTHERWISE NOTED.
5. DETAILING OF CONCRETE REINFORCEMENT SHALL BE IN ACCORDANCE WITH ACI 315 "MANUAL OF STANDARD PRACTICE OF DETAILING REINFORCED CONCRETE STRUCTURES". CLEARANCES AS NOTED ON DETAILS ON THIS SHEET.
6. HYDROTITE WATERSTOPS SHALL BE INSTALLED AS SHOWN ON THE DRAWINGS AND SHALL BE CONTINUOUS. WATERSTOPS SHALL BE INSTALLED PER MANUFACTURER'S INSTRUCTIONS USING A SEALANT AS NECESSARY.
7. ALL CONCRETE WORK SHALL BE IN ACCORDANCE WITH THE LATEST EDITION OF ACI 318 "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE".
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9. CURING SHALL CONFORM TO ACI 308. PROTECT FRESHLY DEPOSITED CONCRETE IMMEDIATELY FROM PREMATURE DRYING, EXCESSIVE HOT OR COLD TEMPERATURES AND EXCESSIVE MOISTURE LOSS FOR A PERIOD NOT LESS THAN 7 DAYS. PROTECT CONCRETE AND FINISHED SURFACES FROM DAMAGING MECHANICAL DISTURBANCES.
10. PROVIDE A SMOOTH FORMED FINISH ON ALL FORMED SURFACES AND A BROOM FINISH ON ALL UNFORMED SLAB SURFACES. ALL SLAB TOLERANCES SHALL MEET ACI 117 REQUIREMENTS.

GEOSYNTHETICS

1. SEE "COA/COC PLAN - TAUM SAUK PUMPED STORAGE FACILITY UPPER RESEVOIR RELINING PROJECT" FOR GEOSYNTHETICS MATERIAL AND INSTALLATION REQUIREMENTS AND QUALITY CONTROL/ QUALITY ASSURANCE PROCEDURES. 1

OTHER NOTES

1. SEE SCHEDULE OF MATERIALS FOR SPECIFICATIONS OF OTHER MATERIALS.
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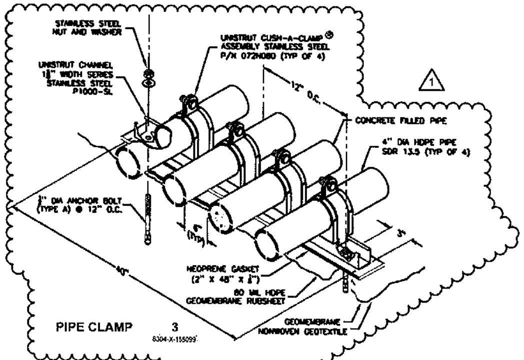
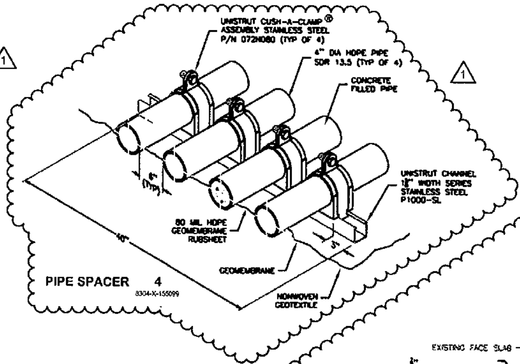
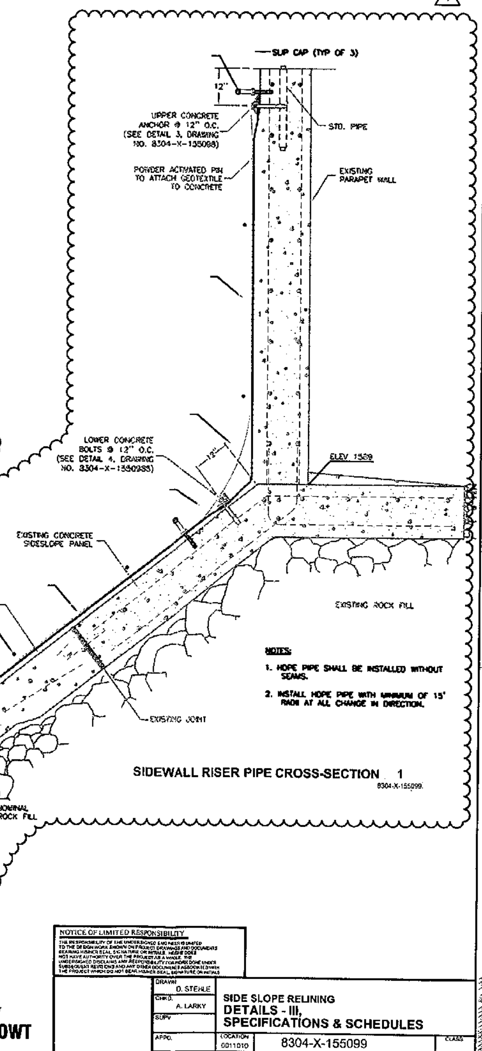
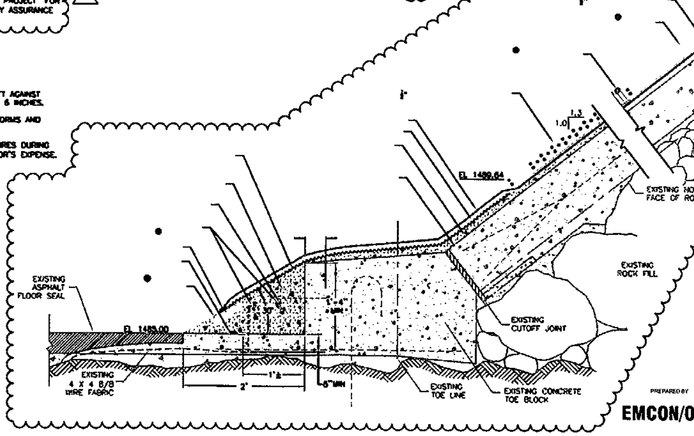


PIPE CLAMP 3
8304-X-155099



PIPE SPACER 4
8304-X-155099

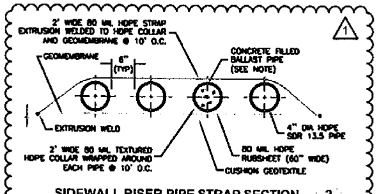




NOTES:

1. HDPE PIPE SHALL BE INSTALLED WITHOUT SEAMS.
2. INSTALL HDPE PIPE WITH MINIMUM OF 15' RADII AT ALL CHANGE IN DIRECTION.

SIDEWALL RISER PIPE CROSS-SECTION 1
8304-X-155099



SIDEWALL RISER PIPE STRAP SECTION 2
8304-X-155099

NOTE:

1. ALTERNATIVE PIPE BALLAST SYSTEMS SUCH AS AS CONCRETE COLLARS MAY BE USED PROVIDED A MINIMUM BALLAST WEIGHT OF 9 LBS/FT OF PIPE IS PROVIDED.

NOTICE OF LIMITED RESPONSIBILITY

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PREPARED BY
EMCON/OWT

DRAWN D. STEHLE
CHK'D. A. LARKY
SUPV
APPD.

SIDE SLOPE RELINING
DETAILS - III,
SPECIFICATIONS & SCHEDULES

LOCATION 0011010
8304-X-155099
CLASS

ST. LOUIS
MISSOURI

TAUM SAUK UPPER RESERVOIR
TAUM SAUK, MISSOURI

REV NO. 1

PRINT DIST.	
REVISIONS	
REV. 0	W.O. DATE 12/28/01
ISSUED FOR REGULATORY APPROVAL	
REV. 1	W.O. DATE 03/07/02
REVISED PER COMMENTS	
REV. 2	W.O. DATE 04/11/02
REVISED PER FIELD CHANGES	

NOTE: CONTRACTOR MAY REQUEST SUSTITUTION OF ANY PRODUCT PROVIDED CONTRACTOR CAN MAKE EQUIVALENCY DEMONSTRATION.

NOTES/SPECIFICATIONS

CONCRETE

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10. PROVIDE A SMOOTH FORMED FINISH ON ALL FORMED SURFACES AND A BROOM FINISH ON ALL UNFORMED SLAB SURFACES. ALL SLAB TOLERANCES SHALL MEET ACI 117 REQUIREMENTS.

GEOSYNTHETICS

1. SEE "CQA/CQC PLAN - TAUM SAUK PUMPED STORAGE FACILITY UPPER RESEVOIR RELINING PROJECT" FOR GEOSYNTHETICS MATERIAL AND INSTALLATION REQUIREMENTS AND QUALITY CONTROL/ QUALITY ASSURANCE PROCEDURES. △1

OTHER NOTES

1. SEE SCHEDULE OF MATERIALS FOR SPECIFICATIONS OF OTHER MATERIALS.
2. ALL PRODUCTS SHALL BE INSTALLED PER MANUFACTURER'S INSTALLATION INSTRUCTIONS.
3. STAINLESS STEEL BATTENS SHALL BE CONTINUOUS SUPPORT TO LINER. BATTENS SHALL BUTT AGAINST EACH OTHER WITHOUT A GAP. BATTEN CANTILEVER FROM ANCHOR BOLT SHALL NOT EXCEED 6 INCHES.
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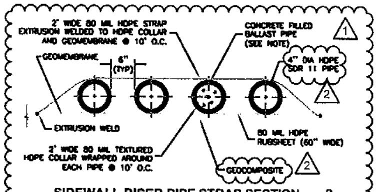
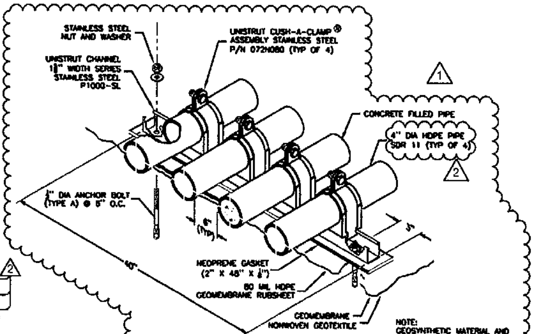


SIDEWALL RISER PIPE STRAP SECTION 2
8304-X-155099

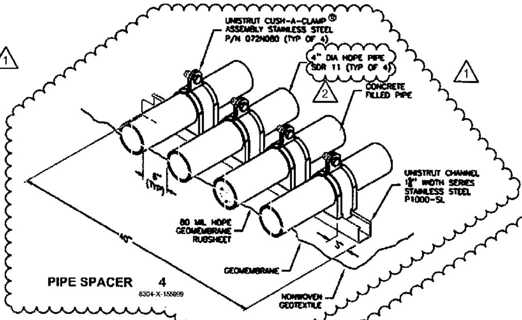
NOTE:

1. ALTERNATIVE PIPE BALLAST SYSTEMS SUCH AS AS CONCRETE COLLARS MAY BE USED PROVIDED A MINIMUM BALLAST WEIGHT OF 9 LBS/FT OF PIPE IS PROVIDED.

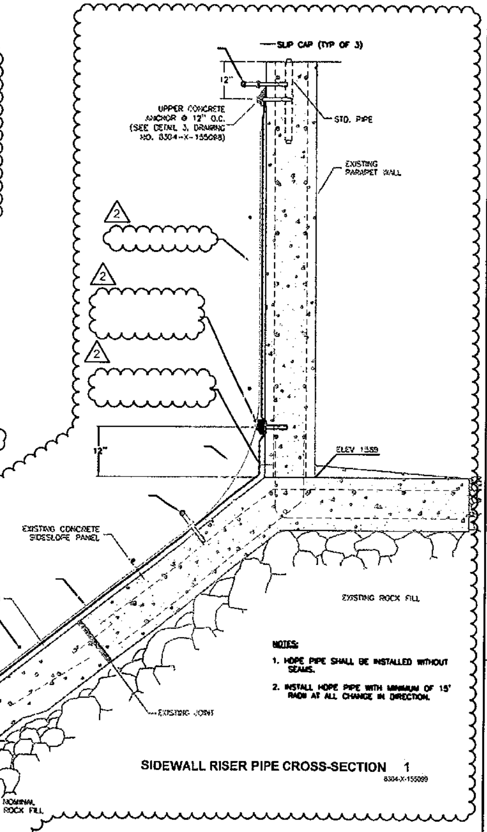


NOTE:
GEOSYNTHETIC MATERIAL AND NEOPRENE GASKET MAY NOT BE REQUIRED FOR UPPER PIPE CLAMP DEPENDING ON ACTUAL CONSTRUCTION.

PIPE CLAMP 3
8304-X-155099



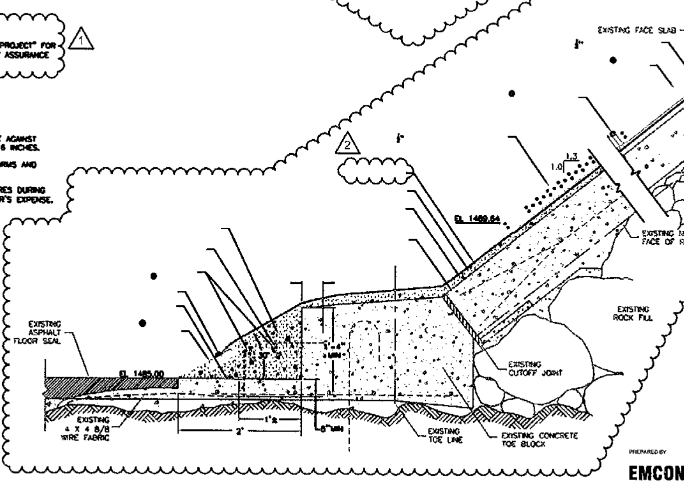
PIPE SPACER 4
8304-X-155099



NOTES:

1. HDPE PIPE SHALL BE INSTALLED WITHOUT SEAMS.
2. INSTALL HDPE PIPE WITH MINIMUM OF 15' RADII AT ALL CHANGE IN DIRECTION.

SIDEWALL RISER PIPE CROSS-SECTION 1
8304-X-155099



PREPARED BY
EMCON/OWT

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DRAWN D. STEHLE
CHKD. A. LARKY
SUPV. N/A
APPD. A. LARKY 12/28/01

SIDE SLOPE RELINING
DETAILS - III,
SPECIFICATIONS & SCHEDULES

LOCATION 0011010
8304-X-155099
CLASS

ST. LOUIS MISSOURI
TAUM SAUK UPPER RESERVOIR
TAUM SAUK, MISSOURI
REV NO. 2

PRINT DIST.

REVISIONS

REV.	W.O.	DATE	
0		12/26/01	ISSUED FOR REGULATORY APPROVAL
1		03/07/02	REVISED PER COMMENTS
2		04/11/02	REVISED PER FIELD CHANGES
3		09/18/03	REVISED PER FIELD ACTIVITIES

SCHEDULE OF MATERIALS

ITEM	MANUFACTURER	PRODUCT
GEOMEMBRANE	GSE LINING TECHNOLOGY, INC.	80 MIL HD TEXTURED GEOMEMBRANE
[illegible]	[illegible]	[illegible]
~~GEONET~~	~~GSE LINING TECHNOLOGY, INC.~~	~~HYPERNET HF~~
[illegible]	[illegible]	[illegible]
ANCHOR BOLT (TYPE A)	HILTI	KWIK BOLT II, ½" DIAMETER, AISI 304 STAINLESS STEEL (WITH STAINLESS STEEL WASHERS)
ANCHOR BOLT (TYPE B)	HILTI	KWIK BOLT II, ¾" DIAMETER, AISI 304 STAINLESS STEEL (WITH STAINLESS STEEL WASHERS)
BATTEN (ANGLE)	-	¼" X 1.5" X 3" ANGLE, AISI STAINLESS STEEL
BATTEN (FLAT)	-	¼" X 3" FLAT STOCK AISI STAINLESS STEEL
POWDER ACTUATED PIN	HILTI OR APPROVED EQUAL	X-DNI GALVANIZED STEEL PIN WITH INTEGRAL WASHER
GASKET	-	NEOPRENE
SILICONE SEAL (FOR WATERSTOP)	GREENSTREAK	LEAKMASTER
WATER STOP	GREENSTREAK	HYDROTITE CJ-0725-3K
POLYLOCK	GSE LINING TECHNOLOGY, INC.	POLYLOCK
HDPE PIPE	CHEVRON	PLEXCO PE 3408
VFPE GEOMEMBRANE	GSE LINING TECHNOLOGY, INC.	80 MIL TEXTURED ULTRA FLEXIBLE GEOMEMBRANE
GEOFOAM	CONTOUR (FOAM) PRODUCTS, INC.	ASTM TYPE IX GEOFOAM
GEOCOMPOSITE	GSE LINING TECHNOLOGY, INC.	DOUBLE-SIDED NONWOVEN POLYPROPYLENE GEOTEXTILE NW8 AND HYPERNET HF

NOTE: CONTRACTOR MAY REQUEST SUSTITUTION OF ANY PRODUCT PROVIDED CONTRACTOR CAN MAKE EQUIVALENCY DEMONSTRATION.

NOTES/SPECIFICATIONS

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GEOSYNTHETICS

1. SEE "COA/COC PLAN – TAUM SAUK PUMPED STORAGE FACILITY UPPER RESEVOIR RELINING PROJECT" FOR GEOSYNTHETICS MATERIAL AND INSTALLATION REQUIREMENTS AND QUALITY CONTROL/ QUALITY ASSURANCE PROCEDURES.

OTHER NOTES

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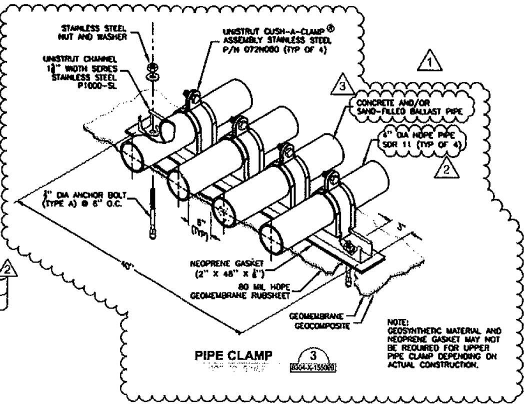
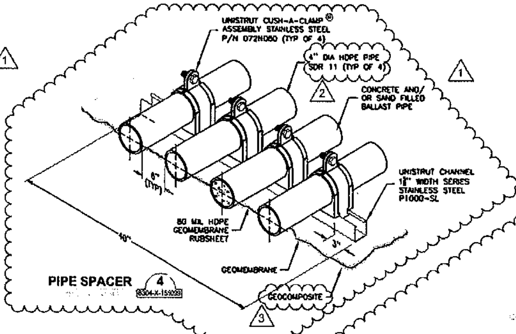


PIPE CLAMP 3

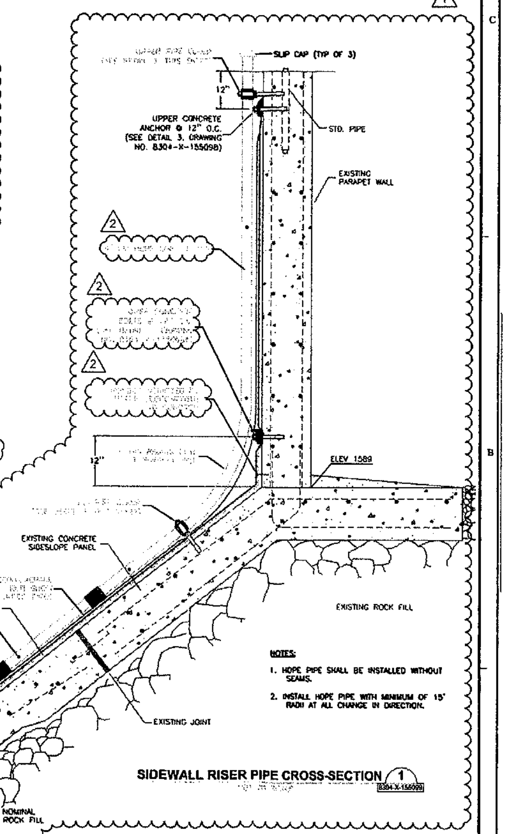
8304-X-155099

NOTE:
GEOSYNTHETIC MATERIAL AND NEOPRENE GASKET MAY NOT BE REQUIRED FOR UPPER PIPE CLAMP DEPENDING ON ACTUAL CONSTRUCTION.



PIPE SPACER 4

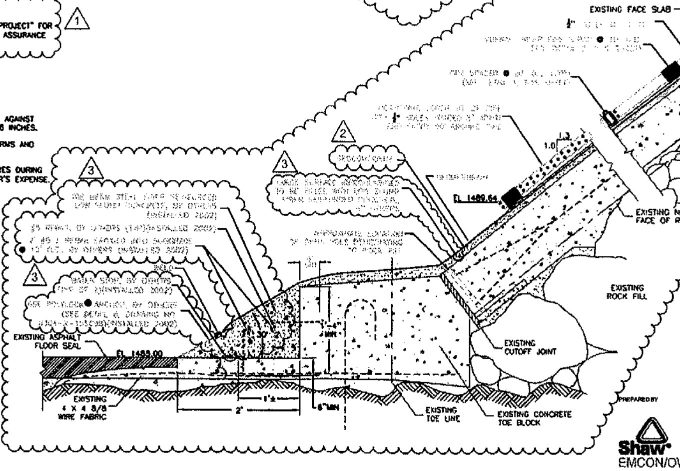
8304-X-155099

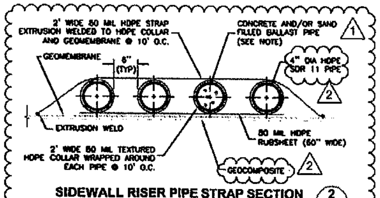


NOTES:
1. HDPE PIPE SHALL BE INSTALLED WITHOUT SEAMS.
2. INSTALL HDPE PIPE WITH MINIMUM OF 15' RADII AT ALL CHANGE IN DIRECTION.

SIDEWALL RISER PIPE CROSS-SECTION 1

8304-X-155099





SIDEWALL RISER PIPE STRAP SECTION 2

NOT TO SCALE

8304-X-155099

NOTE:
1. ALTERNATIVE PIPE BALLAST SYSTEMS SUCH AS AS CONCRETE COLLARS MAY BE USED PROVIDED A MINIMUM BALLAST WEIGHT OF 9 LBS/FT OF PIPE IS PROVIDED.

PREPARED BY
Shaw®
EMCON/OWT, Inc.

DRAWN D. STEHLE
CHKD. A. LARKY
SUPV. N/A
APPD. A. LARKY 12/26/01

SIDE SLOPE RELINING
DETAILS - III,
SPECIFICATIONS & SCHEDULES

LOCATION 001010
8304-X-155099
CLASS

ST. LOUIS MISSOURI
TAUM SAUK UPPER RESERVOIR
TAUM SAUK, MISSOURI
REV NO. 3

PRINT DIST.	
REVISIONS	
REV. 0	W.O. DATE 12/26/01
ISSUED FOR REGULATORY APPROVAL	
REV.	W.O. DATE 03/07/02
REVISED PER COMMENTS	
REV. 2	W.O. DATE 04/11/02
REVISED PER FIELD CHANGES	
REV. 3	W.O. DATE 09/18/03
REVISED PER FIELD ACTIVITIES	
REV. 4	W.O. DATE 09/01/04
ADDED WELD TO WALL, REVISED GEOMEMBRANE AND GECOMPOSITE AND LOWERED LOWER BATTEN	
REV. 5	W.O. DATE 10/05/04

SCHEDULE OF MATERIALS

ITEM	MANUFACTURER	PRODUCT
GEOMEMBRANE	GSE LINING TECHNOLOGY, INC.	80 MIL HD TEXTURED GEOMEMBRANE
~~NONWOVEN GEOTEXTILE~~	~~GSE LINING TECHNOLOGY, INC.~~	~~NONWOVEN POLYPROPYLENE GEOTEXTILE NW16~~
~~GEONET~~	~~GSE LINING TECHNOLOGY, INC.~~	~~HYPERNET HF~~
~~WOVEN GEOTEXTILE~~	~~HUESKER OR SYNTHETIC INDUSTRIES~~	~~COMTRAC 200 OR GEOTEX 10 X 6~~
ANCHOR BOLT (TYPE A)	HILTI	KWIK BOLT II, 1" DIAMETER, AISI 304 STAINLESS STEEL (WITH STAINLESS STEEL WASHERS)
ANCHOR BOLT (TYPE B)	HILTI	KWIK BOLT II, 1" DIAMETER, AISI 304 STAINLESS STEEL (WITH STAINLESS STEEL WASHERS)
BATTEN (ANGLE)	–	1" X 3" X 3" ANGLE, AISI STAINLESS STEEL
BATTEN (FLAT)	–	¼"X 2" FLAT STOCK, AISI STAINLESS STEEL
POWDER ACTIVATED PIN	HILTI OR APPROVED EQUAL	X-DNI GALVANIZED STEEL PIN WITH INTEGRAL WASHER
GASKET	–	NEOPRENE
SILICONE SEAL (FOR WATERSTOP)	GREENSTREAK	LEAKMASTER
WATER STOP	GREENSTREAK	HYDROTITE CJ-0725-3K
POLYLOCK	GSE LINING TECHNOLOGY, INC.	POLYLOCK
HDPE PIPE	CPCHEM	PLEXCO PE-3408
VFPE GEOMEMBRANE	GSE LINING TECHNOLOGY, INC.	80 MIL TEXTURED ULTRA FRICTIONFLEX GEOMEMBRANE
GEOFOAM	CONTOUR (FOAM) PRODUCTS, INC.	ASTI TYPE IX GEOFOAM
GEOCOMPOSITE	GSE LINING TECHNOLOGY, INC.	DOUBLE-SIDED NONWOVEN POLYPROPYLENE GEOTEXTILE NW8 AND HYPERNET ~~HF~~

NOTE: CONTRACTOR MAY REQUEST SUSTITUTION OF ANY PRODUCT PROVIDED CONTRACTOR CAN MAKE EQUIVALENCY DEMONSTRATION.

NOTES/SPECIFICATIONS

CONCRETE

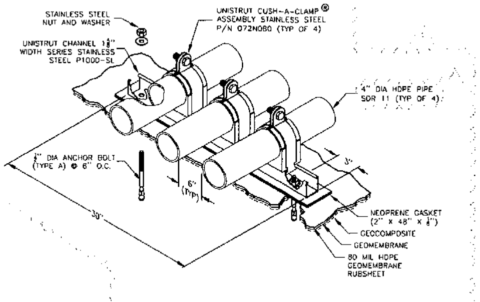
1. REMOVE ALL DEBRIS AND DIRT FROM BENEATH SURFACES TO RECEIVE CONCRETE. POWERWASH ALL SURFACES PRIOR TO CONCRETE PLACEMENT.
2. AIR ENTRAINED, NORMAL WEIGHT FIBER REINFORCED CONCRETE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH (f'c) OF 3000 PSI. TYPE II CEMENT MEETING ASTM C150 SHALL BE USED. THE MIX SHALL HAVE A MAXIMUM ALLOWABLE WATER/CEMENT RATIO OF 0.45, AIR CONTENT BETWEEN 2 TO 3%, AND SLUMP BETWEEN 3-5 INCHES. AGGREGATES USED SHALL MEET ASTM C33 AND MAXIMUM SIZE SHALL BE 1". THE CONCRETE SHALL HAVE POLYPROPYLENE FIBERS A MINIMUM OF 33 POUNDS PER CUBIC YARD. ONLY POTABLE WATER SHALL BE USED. CONTRACTOR SHALL SUBMIT CONCRETE MIX DESIGN FOR ENGINEER'S APPROVAL BEFORE CONCRETE PLACEMENT.
3. ANY ADMIXTURE TO BE USED IN CONCRETE SHALL HAVE APPROVAL OF THE ENGINEER IN CHARGE PRIOR TO USE. NO ADMIXTURE CONTAINING CALCIUM CHLORIDE WILL BE ACCEPTABLE.
4. ALL REINFORCING BARS TO BE NEW DEFORMED BILLET STEEL PER ASTM A-615 GRADE 60 BARS. ALL WELDED WIRE FABRIC (WWF) TO BE IN ACCORDANCE WITH ASTM A-185. FURNISH WWF IN FLAT SHEETS ONLY. PLACE 2 INCHES BENEATH TOP OF SLAB SURFACE, UNLESS OTHERWISE NOTED.
5. DETAILING OF CONCRETE REINFORCEMENT SHALL BE IN ACCORDANCE WITH ACI 315 "MANUAL OF STANDARD PRACTICE OF DETAILING REINFORCED CONCRETE STRUCTURES". CLEARANCES AS NOTED ON DETAILS ON THIS SHEET.
6. HYDROTITE WATERSTOPS SHALL BE INSTALLED AS SHOWN ON THE DRAWINGS AND SHALL BE CONTINUOUS. WATERSTOPS SHALL BE INSTALLED PER MANUFACTURER'S INSTRUCTIONS USING A SEALANT AS NECESSARY.
7. ALL CONCRETE WORK SHALL BE IN ACCORDANCE WITH THE LATEST EDITION OF ACI 318 "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE".
8. CONTRACTOR SHALL BE SOLELY RESPONSIBLE FOR THE DESIGN AND ENGINEERING OF FORMWORK AS WELL AS ITS CONSTRUCTION. USE SMOOTH FORMS ON ALL SURFACES CONFORMING THE SHAPE LINE AND DIMENSIONS SHOWN. FORM COATING AND REMOVAL SHALL CONFORM TO ACI 347.
9. CURING SHALL CONFORM TO ACI 308. PROTECT FRESHLY DEPOSITED CONCRETE IMMEDIATELY FROM PREMATURE DRYING, EXCESSIVE HOT OR COLD TEMPERATURES AND EXCESSIVE MOISTURE LOSS FOR A PERIOD NOT LESS THAN 7 DAYS. PROTECT CONCRETE AND FINISHED SURFACES FROM DAMAGING MECHANICAL DISTURBANCES.
10. PROVIDE A SMOOTH FORMED FINISH ON ALL FORMED SURFACES AND A BROOM FINISH ON ALL UNFORMED SLAB SURFACES. ALL SLAB TOLERANCES SHALL MEET ACI 117 REQUIREMENTS.

GEOSYNTHETICS

1. SEE "CQA/CQC PLAN – TAUM SAUK PUMPED STORAGE FACILITY UPPER RESEVOIR RELINING PROJECT" FOR GEOSYNTHETICS MATERIAL AND INSTALLATION REQUIREMENTS AND QUALITY CONTROL/ QUALITY ASSURANCE PROCEDURES.

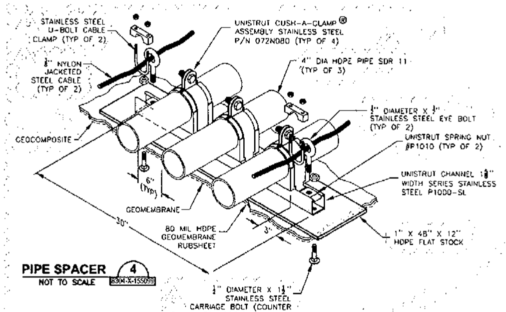
OTHER NOTES

1. SEE SCHEDULE OF MATERIALS FOR SPECIFICATIONS OF OTHER MATERIALS.
2. ALL PRODUCTS SHALL BE INSTALLED PER MANUFACTURER'S INSTALLATION INSTRUCTIONS.
3. STAINLESS STEEL BATTENS SHALL BE CONTINUOUS SUPPORT TO LINER. BATTENS SHALL BUTT AGAINST EACH OTHER WITHOUT A GAP. BATTEN CANTILEVER FROM ANCHOR BOLT SHALL NOT EXCEED 6 INCHES.
4. CONTRACTOR SHALL BE RESPONSIBLE FOR DESIGN AND INSTALLATION OF TEMPORARY PLATFORMS AND SUPPORTS REQUIRED FOR INSTALLATION OF LINER SYSTEM.
5. CONTRACTOR SHALL TAKE ALL PRECAUTIONS SO AS NOT TO DAMAGE THE EXISTING STRUCTURES DURING INSTALLATION OF LINER SYSTEM. ANY DAMAGE INCURRED SHALL BE REPAIRED AT CONTRACTOR'S EXPENSE.

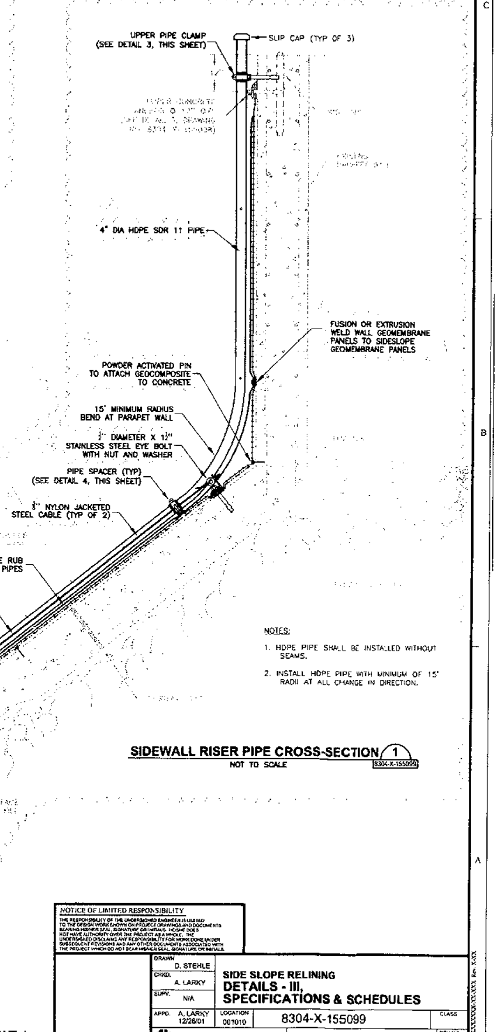


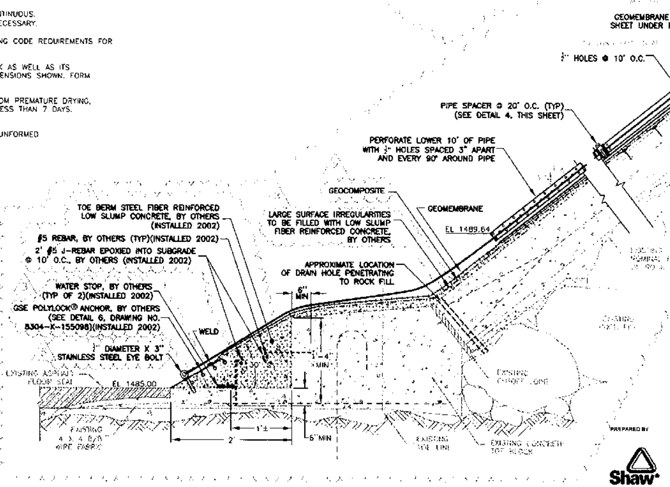
PIPE CLAMP (3)
NOT TO SCALE 8304-X-155099

NOTE:
GEOSYNTHETIC MATERIAL AND NEOPRENE GASKET MAY NOT BE REQUIRED FOR UPPER PIPE CLAMP DEPENDING ON ACTUAL CONSTRUCTION.



PIPE SPACER (4)
NOT TO SCALE 8304-X-155099





NOTES:

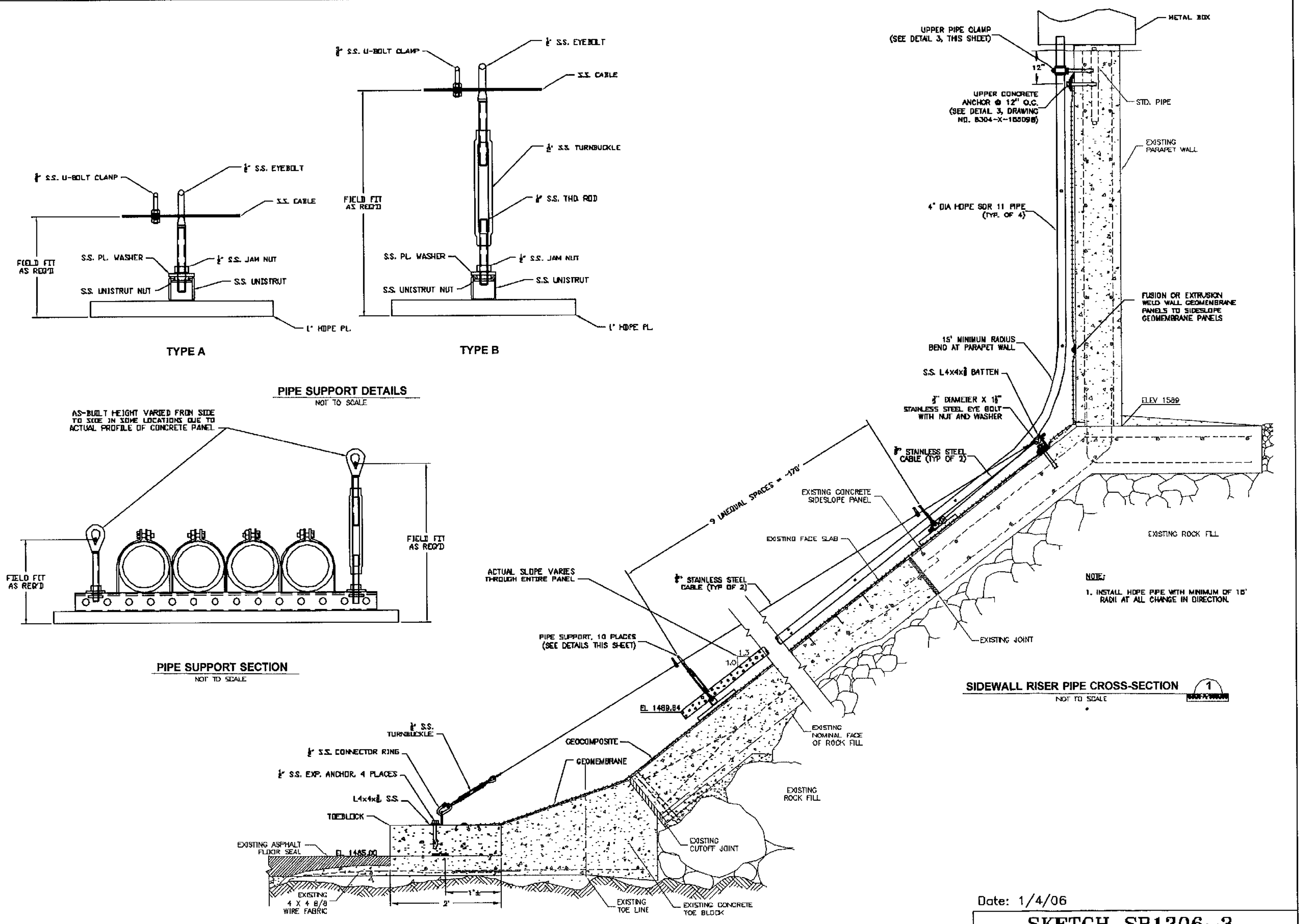
1. HDPE PIPE SHALL BE INSTALLED WITHOUT SEAMS.
2. INSTALL HDPE PIPE WITH MINIMUM OF 15' RADII AT ALL CHANGE IN DIRECTION.

SIDEWALL RISER PIPE CROSS-SECTION (1)
NOT TO SCALE 8304-X-155099

NOTICE OF LIMITED RESPONSIBILITY

PREPARED BY
Shaw
EMCON/OWT, Inc.

DRAWN D. STEHLE	SIDE SLOPE RELINING **DETAILS - III, SPECIFICATIONS & SCHEDULES**	
CHKD. A. LARKY		
SUPV. N/A		
APPD. A. LARKY 12/26/01	LOCATION 001010	8304-X-155099	CLASS
Ameren ST. LOUIS MISSOURI	TAUM SAUK UPPER RESERVOIR TAUM SAUK, MISSOURI	REV NO. 5



TYPE A

TYPE B

PIPE SUPPORT DETAILS
NOT TO SCALE

PIPE SUPPORT SECTION
NOT TO SCALE

SIDEWALL RISER PIPE CROSS-SECTION
NOT TO SCALE

NOTE:
1. INSTALL HDPE PIPE WITH MINIMUM OF 15' RADII AT ALL CHANGE IN DIRECTION.

Date: 1/4/06

SKETCH SB1306-3
GAGE PIPE SUPPORTS
AS CONSTRUCTED

PRINT DIST.

REVISIONS

REV. 0 W.O. DATE 12/26/01
ISSUED FOR REGULATORY APPROVAL

REV. 1 W.O. DATE 03/07/02
REVISED PER COMMENTS

REV. 2 W.O. DATE 04/11/02
REVISED PER FIELD CHANGES

REV. 3 W.O. DATE 09/18/03
REVISED PER FIELD ACTIVITIES

REV. 4 W.O. DATE 08/06/04
ADDED WELD TO WALL, REVISED GEOMEMBRANE AND GECOMPOSITE AND LOWERED LOWER BATTEN

SCHEDULE OF MATERIALS

ITEM	MANUFACTURER	PRODUCT
GEOMEMBRANE	GSE LINING TECHNOLOGY, INC.	80 MIL HD TEXTURED GEOMEMBRANE
~~NONWOVEN GEOTEXTILE~~	~~GSE LINING TECHNOLOGY, INC.~~	~~NONWOVEN POLYPROPYLENE GEOTEXTILE NW16~~
~~GEONET~~	~~GSE LINING TECHNOLOGY, INC.~~	~~HYPERNET HF~~
~~WOVEN GEOTEXTILE~~	~~HUESKER OR SYNTHETIC INDUSTRIES~~	~~COMTRAC 200 OR GEOTEX 16 X 6~~
ANCHOR BOLT (TYPE A)	HILTI	KWIK BOLT II, 1" DIAMETER, AISI 304 STAINLESS STEEL (WITH STAINLESS STEEL WASHERS)
ANCHOR BOLT (TYPE B)	HILTI	KWIK BOLT II, 1" DIAMETER, AISI 304 STAINLESS STEEL (WITH STAINLESS STEEL WASHERS)
BATTEN (ANGLE)	–	1" X 1.5" X 3" ANGLE, AISI STAINLESS STEEL
BATTEN (FLAT)	–	3/8"X 2" FLAT STOCK, AISI STAINLESS STEEL
POWDER ACTIVATED PIN	HILTI OR APPROVED EQUAL	X-DNI GALVANIZED STEEL PIN WITH INTEGRAL WASHER
GASKET	–	NEOPRENE
SILICONE SEAL (FOR WATERSTOP)	GREENSTREAK	LEAKMASTER
WATER STOP	GREENSTREAK	HYDROTITE CJ-0725-3K
POLYLOCK	GSE LINING TECHNOLOGY, INC.	POLYLOCK
HDPE PIPE	CPCHEM	PLEXCO PE-3408
VFPE GEOMEMBRANE	GSE LINING TECHNOLOGY, INC.	(80) MIL TEXTURED ULTRA FRICTIONFLEX GEOMEMBRANE
GEOFOAM	CONTOUR (FOAM) PRODUCTS, INC.	ASTI TYPE IX GEOFOAM
GEOCOMPOSITE	GSE LINING TECHNOLOGY, INC.	DOUBLE-SIDED NONWOVEN POLYPROPYLENE GEOTEXTILE NW8 AND HYPERNET ~~HF~~

NOTE: CONTRACTOR MAY REQUEST SUSTITUTION OF ANY PRODUCT PROVIDED CONTRACTOR CAN MAKE EQUIVALENCY DEMONSTRATION.

NOTES/SPECIFICATIONS

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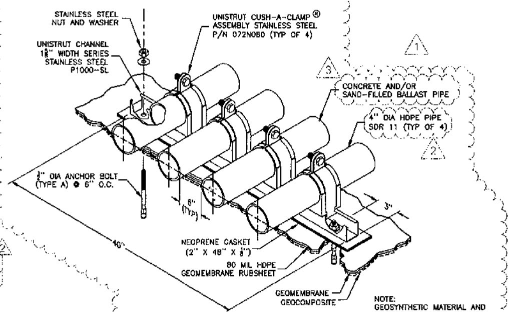
10. PROVIDE A SMOOTH FORMED FINISH ON ALL FORMED SURFACES AND A BROOM FINISH ON ALL UNFORMED SLAB SURFACES. ALL SLAB TOLERANCES SHALL MEET ACI 117 REQUIREMENTS.

GEOSYNTHETICS

1. SEE "COA/CQC PLAN – TAUM SAUK PUMPED STORAGE FACILITY UPPER RESEVOIR RELINING PROJECT" FOR GEOSYNTHETICS MATERIAL AND INSTALLATION REQUIREMENTS AND QUALITY CONTROL/ QUALITY ASSURANCE PROCEDURES.

OTHER NOTES

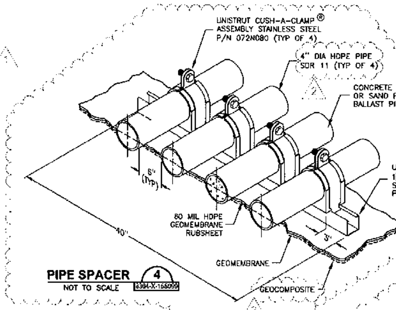
1. SEE SCHEDULE OF MATERIALS FOR SPECIFICATIONS OF OTHER MATERIALS.
2. ALL PRODUCTS SHALL BE INSTALLED PER MANUFACTURER'S INSTALLATION INSTRUCTIONS.
3. STAINLESS STEEL BATTENS SHALL BE CONTINUOUS SUPPORT TO LINER. BATTENS SHALL BUTT AGAINST EACH OTHER WITHOUT A GAP. BATTEN CANTILEVER FROM ANCHOR BOLT SHALL NOT EXCEED 6 INCHES.
4. CONTRACTOR SHALL BE RESPONSIBLE FOR DESIGN AND INSTALLATION OF TEMPORARY PLATFORMS AND SUPPORTS REQUIRED FOR INSTALLATION OF LINER SYSTEM.
5. CONTRACTOR SHALL TAKE ALL PRECAUTIONS SO AS NOT TO DAMAGE THE EXISTING STRUCTURES DURING INSTALLATION OF LINER SYSTEM. ANY DAMAGE INCURRED SHALL BE REPAIRED AT CONTRACTOR'S EXPENSE.



NOTE:
GEOSYNTHETIC MATERIAL AND NEOPRENE GASKET MAY NOT BE REQUIRED FOR UPPER PIPE CLAMP DEPENDING ON ACTUAL CONSTRUCTION.

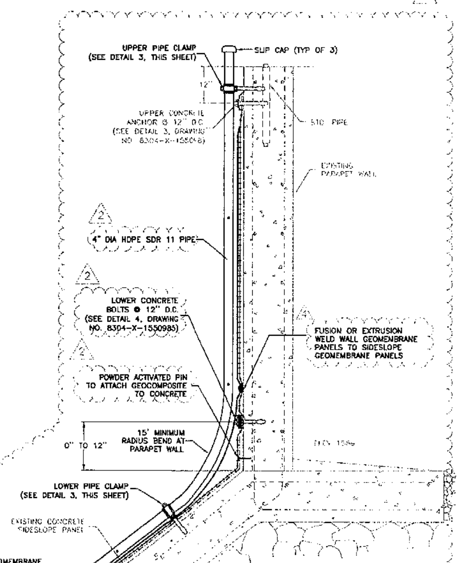
PIPE CLAMP (3)

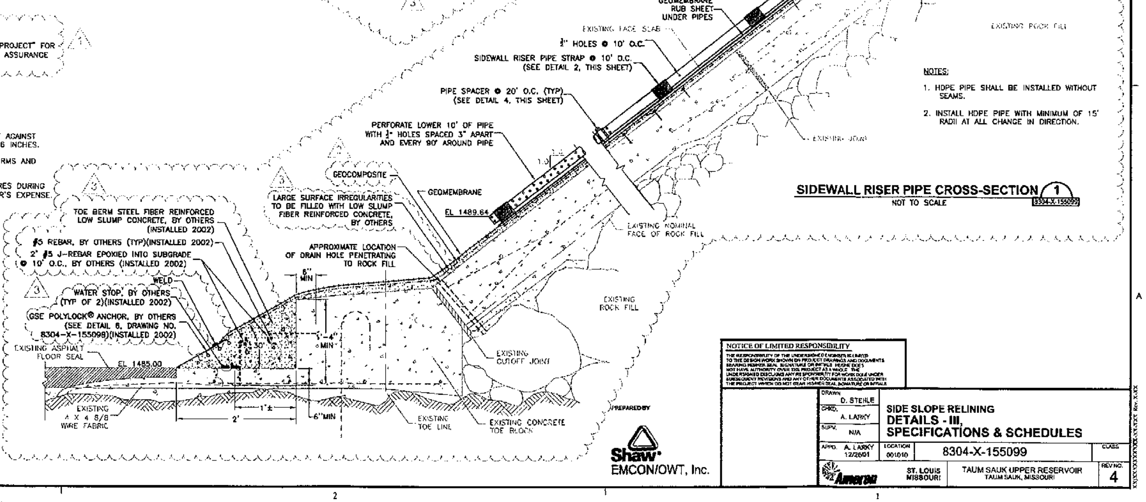
NOT TO SCALE 8304-X-155099



PIPE SPACER (4)

NOT TO SCALE 8304-X-155099



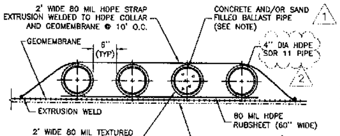


NOTES:

1. HDPE PIPE SHALL BE INSTALLED WITHOUT SEAMS.
2. INSTALL HDPE PIPE WITH MINIMUM OF 15' RADII AT ALL CHANGE IN DIRECTION.

SIDEWALL RISER PIPE CROSS-SECTION (1)

NOT TO SCALE 8304-X-155099



SIDEWALL RISER PIPE STRAP SECTION (2)

NOT TO SCALE 8304-X-155099

NOTE:

1. ALTERNATIVE PIPE BALLAST SYSTEMS SUCH AS AS CONCRETE COLLARS MAY BE USED PROVIDED A MINIMUM BALLAST WEIGHT OF 9 LBS/FT OF PIPE IS PROVIDED.

PREPARED BY

Shaw®
EMCON/OWT, Inc.

NOTICE OF LIMITED RESPONSIBILITY

THE RESPONSIBILITY OF THE UNDERSIGNED ENGINEER IS LIMITED TO THE DESIGN WORK SHOWN ON PROJECT DRAWINGS AND DOCUMENTS BEARING HIS/HER SEAL, SIGNATURE OR INITIALS. HE/SHE DOES NOT HAVE AUTHORITY OVER THE PROJECT AS A WHOLE. THE UNDERSIGNED DISCLAIMS ANY RESPONSIBILITY FOR WORK DONE UNDER SUBSEQUENT REVISIONS AND ANY OTHER DOCUMENTS ASSOCIATED WITH THE PROJECT WHICH DO NOT BEAR HIS/HER SEAL, SIGNATURE OR INITIALS.

DRAWN D. STEHLE
CHKD. A. LARKY
SUPV. N/A
APPD. A. LARKY 12/26/01

SIDE SLOPE RELINING
DETAILS - III,
SPECIFICATIONS & SCHEDULES

LOCATION 001010
8304-X-155099
CLASS

Ameren
ST. LOUIS MISSOURI
TAUM SAUK UPPER RESERVOIR
TAUM SAUK, MISSOURI
REV NO. 4