PERMAFROST
TECHNOLOGY
FOUNDATION

FINAL REPORT
ON
FOUNDATION STABILIZATION
USING A
HEAT PUMP COOLING SYSTEM
AT
728 CONSTITUTION ROAD
FAIRBANKS, ALASKA

SEPTEMBER, 2000

Final Research Report

on

Foundation Stabilization
using a
Heat Pump Cooling System
at
728 Constitution Road
Fairbanks, Alaska

Acknowledgement

The Permafrost Technology Foundation would like to gratefully acknowledge the funding support from the Alaska Housing Finance Corporation. AHFC made possible this important research in the stabilization of building foundations that had been constructed on permafrost. AHFC's support on this and the other homes on which the Permafrost Technology Foundation has reported has been indispensable. In addition to donating the houses, AHFC provided a grant to fund the startup costs of the research on the houses. This grant has now been repaid in accordance with the conditions of the grant. Without AHFC's help the research and the technology that has been developed would not have been possible.

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Introduction

When a structure is built on thaw-unstable permafrost, the structure and associated site work introduce additional heat into the soil, and a new thermal balance begins to be established. This always involves thawing some of the permafrost, and if the thawed permafrost is unstable, support for the foundation is lost. One procedure for protecting the foundation is to keep the permafrost from thawing. To do this requires the design of a cooling system that will remove the heat that enters the soil before it gets to the permafrost.

In most designs for this purpose, the heat energy that is removed from the soil is discharged to the environment to be dispersed into the air above the site. However, heat energy is expensive to produce, so if the heat energy removed from the soil could be concentrated to a higher, more usable temperature to make it suitable for heating the structure, then a portion of the cost of the foundation stabilization could be recovered. The problem of course is the grade of the heat energy that is recovered from the soil. To be useful for heating purposes, the heat energy must be at a temperature that is higher than the structure that it is to heat. The heat energy removed from soil at a site in the interior of Alaska is usually at a temperature in the vicinity of 5 to 10°C (41 to 50°F). This is considered very low-grade heat energy and has very little practical value. To be useful it must be concentrated until its temperature is much higher. The practical way to concentrate heat is to use a compression/expansion procedure much the same as is used for a common refrigerator. In this case, however, instead of cooling the inside of a box as the refrigerator does, the device is set up to cool the soil beneath the house, and the heat removed from the soil is discharged back into the house to supplement the house's heating system.

The machine that is used for this type of operation is called a heat pump. The compressor in the heat pump compresses the working gas (called a refrigerant) until it is a hot, high-pressure fluid. When a gas is compressed, its temperature rises and much of the heat that it contains can be removed from the hot fluid by circulating it through a heat exchanger where fan-forced air removes the excess heat, cooling the hot, compressed fluid to near room temperature. The cooled high-pressure fluid is then allowed to expand as it flows through an expansion valve into another heat exchanger called the "expansion coil." When the high-pressure refrigerant (which has been cooled to room temperature) expands, it becomes very cold. As the cold gas circulates through the expansion coil, it absorbs heat from, and cools, a heat transfer liquid[1] until the liquid is well below the soil temperature beneath the building. The heat transfer liquid is then pumped into a grid of tubes that is embedded in the soil under the basement floor. The cold fluid flowing through the tube grid in the soil absorbs heat from the soil, cooling the soil and warming the fluid. The heat transfer fluid captures heat that has leaked through the floor of the house or has entered the soil from outside during warm weather and carries the heat back to the expansion coil of the heat pump. Meanwhile the refrigerant in the heat pump flows from the expansion coil back to the compressor where the cycle begins again. In this manner heat is absorbed from the soil, transferred to the refrigerant in the expansion coil, concentrated to a much higher temperature in the compressor and then discharged into the house to supplement the heating system.

The heat pump system requires a compressor, two heat exchangers, an expansion valve, and a grid of pipes or tubes where heat can be absorbed, in this case, from the soil beneath the house. Heat pumps are commonly used to heat homes in many localities in the lower 48 states where a source of low grade heat such as warm ground water is available or where soils are warmer than normally found here in Alaska. Most of these units operate at a coefficient of performance (COP) from about three to five. The COP is a measure of how much heat is captured by operating the heat pump. For a COP of three, every Watt of electricity that is used to run the heat pump results in three Watts of heat energy being discharged into the house. Obviously to offset the high cost of electricity, a high coefficient of performance is desirable. As the temperature of the heat source drops, so does the COP. When temperatures are as cold as the average soil temperatures in Alaska, the COP is usually well below 3. This coupled with the high cost of electricity discourages their use unless an abundant source of inexpensive heat, such as a hot spring, is available. The soil temperatures below a house, however, are considerably warmer than typical outdoor soils in Alaska. These warmer soils would allow a somewhat higher COP.

Commercial heat pump units are designed to heat an entire house, and the smallest of these units is usually larger than is needed for the purpose of cooling the soil beneath a house. However, a few manufacturers specialize in small, high-performance units that lend themselves to this application.

Protecting the permafrost under a house with a heated basement is difficult. There are only a few options available that are practical. One option is to abandon the basement, to insulate the floor above it, and to cool it as much as possible using winter air. A heated

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[1] (The fluid must be a liquid that will not freeze at the operating temperatures involved. A commercial heat transfer fluid which is a mixture of potassium acetate and water was chosen, see the appendix under Engineering Reports for the manufacturer's data on this product.)

basement, however, usually represents a substantial investment to the owner and one that he is reluctant to give up. (If the basement can be sacrificed, then the problem can be nicely solved using the forced-air cooled crawl space solution that is described in the Permafrost Technology Foundation book *Design Manual for Stabilizing Foundations on Permafrost*). Thermosyphons are still another approach that can be used, but the installation is difficult and they do not operate during the summer. (See Permafrost Technology Foundation report on a thermosyphon-stabilized foundation at Madcap Lane). The possibility of protecting the permafrost and thus stabilizing the foundation while at the same time using the heat recovered from the soil to help heat the house was an experiment that needed to be performed to assess the practicality of this enticing prospect for heated basements and to learn what problems awaited.

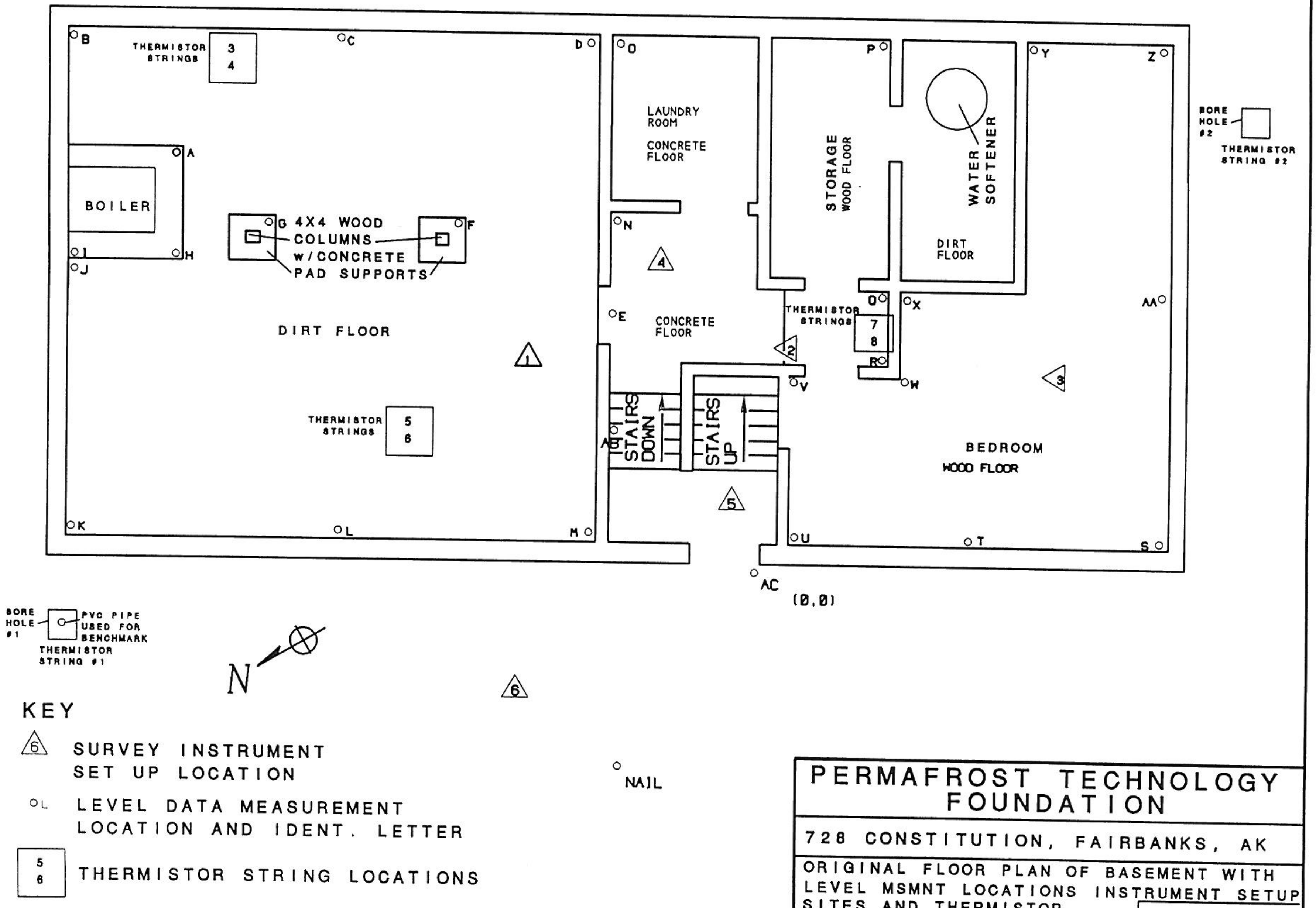
Structure Description

The house located at 728 Constitution St. is a three-bedroom 1-bath home with a heated, semi-finished daylight basement that contains an unfinished second bath, a bedroom, large workroom, laundry room, a storage room, and a small room containing the water treatment system.

The site is fine silt that is underlain by thaw-unstable permafrost. At the beginning of the project the building was undergoing settlement and had some distress in the form of sticking windows and doors and hairline cracks in the wallboard. It was also out of level by as much as 250 mm (10 inches) from the east corner to the west corner. (See figures 1 and 2 and the discussion of level measurements below.) The site is on a valley floor surrounded by tall trees making it a poor location for the use of thermosyphons since they would be sheltered from performance-enhancing winds. This appeared to be an ideal location to test the practicality of the heat pump solution.

Heat Pump Installation

Before the installation could be started, it was necessary to relevel the foundation of the house. To do this, the foundation wall was excavated to the bottom of the footing around the outside perimeter of the house. The existing wood floor in the bedroom (figure 1) was then removed. Since the large room on the north end of the basement had only a dirt floor, removing the wood floor on the south half gave access to the soil beneath the house over the entire basement except under a strip of concrete floor that lies across the middle of the basement (see fig. 3). Pneumatic pillow jacks were placed under the footing at regular intervals around the house. The pillow jacks were connected by hydraulic lines to a central control board where they could be connected to a central pressure pump as needed to provide jacking pressure to raise the footing until the house was level. Level information was supplied by a system of water levels with stations at each pillow jack (see fig. 4). A low-volume, high-pressure (500 psi) pump (the type normally used for car washing) supplied the pressure. This inexpensive pump provides the perfect combination



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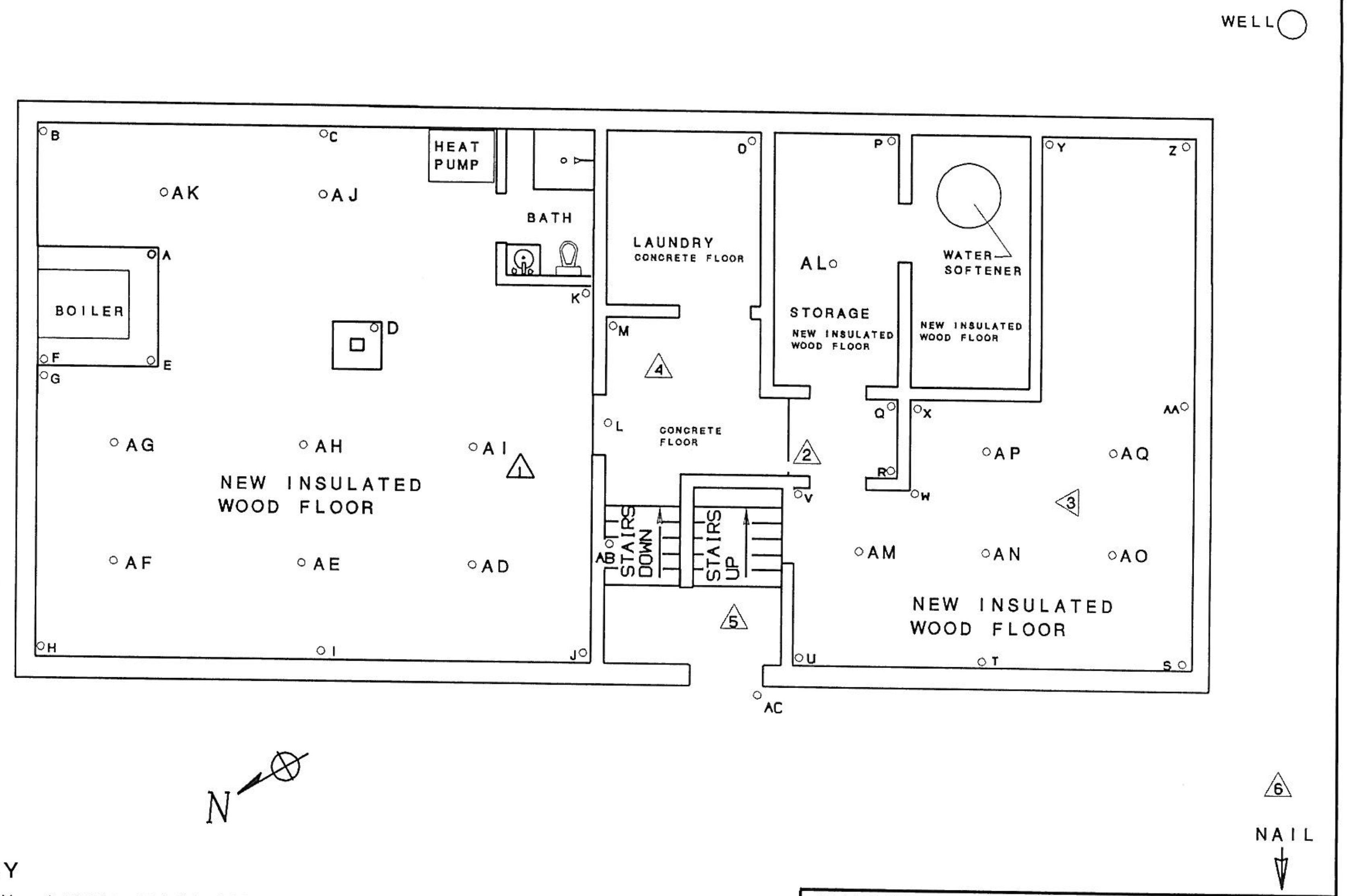
ORIGINAL FLOOR PLAN OF BASEMENT WITH LEVEL MSMNT LOCATIONS INSTRUMENT SETUP SITES AND THERMISTOR STRING LOCATIONS

FIG. 1



KEY

○AH LEVEL DATA MEASUREMENT LOCATION AND IDENT. LETTER LOCATIONS ADDED AFTER HEAT PUMP INSTALL. ARE AD THRU AQ AND LOCATION D

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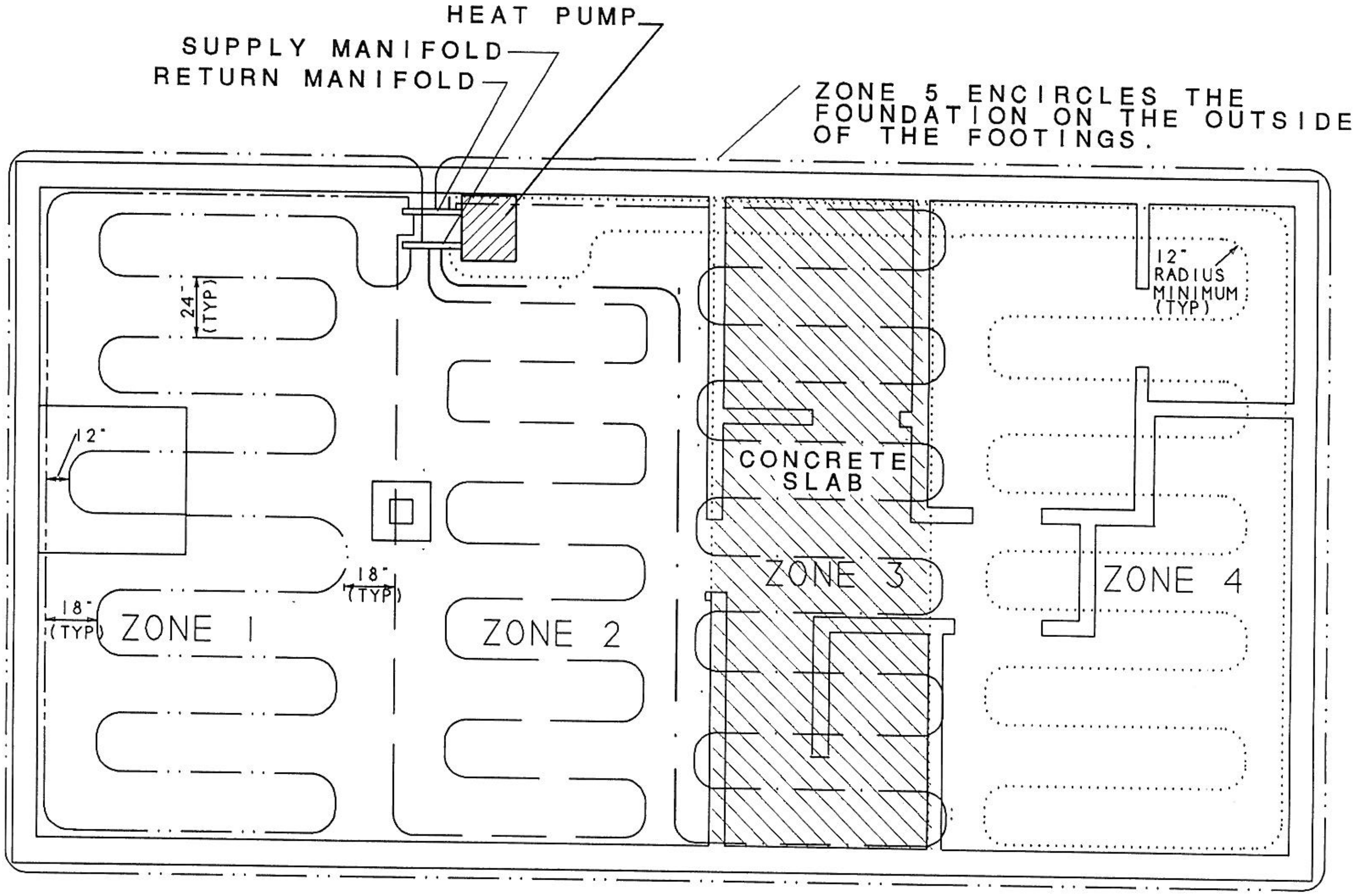
LOCATION OF ADDED LEVEL MEASUREMENT POINTS AFTER INSTALLATION OF HEAT PUMP SYSTEM.

FIG. 2



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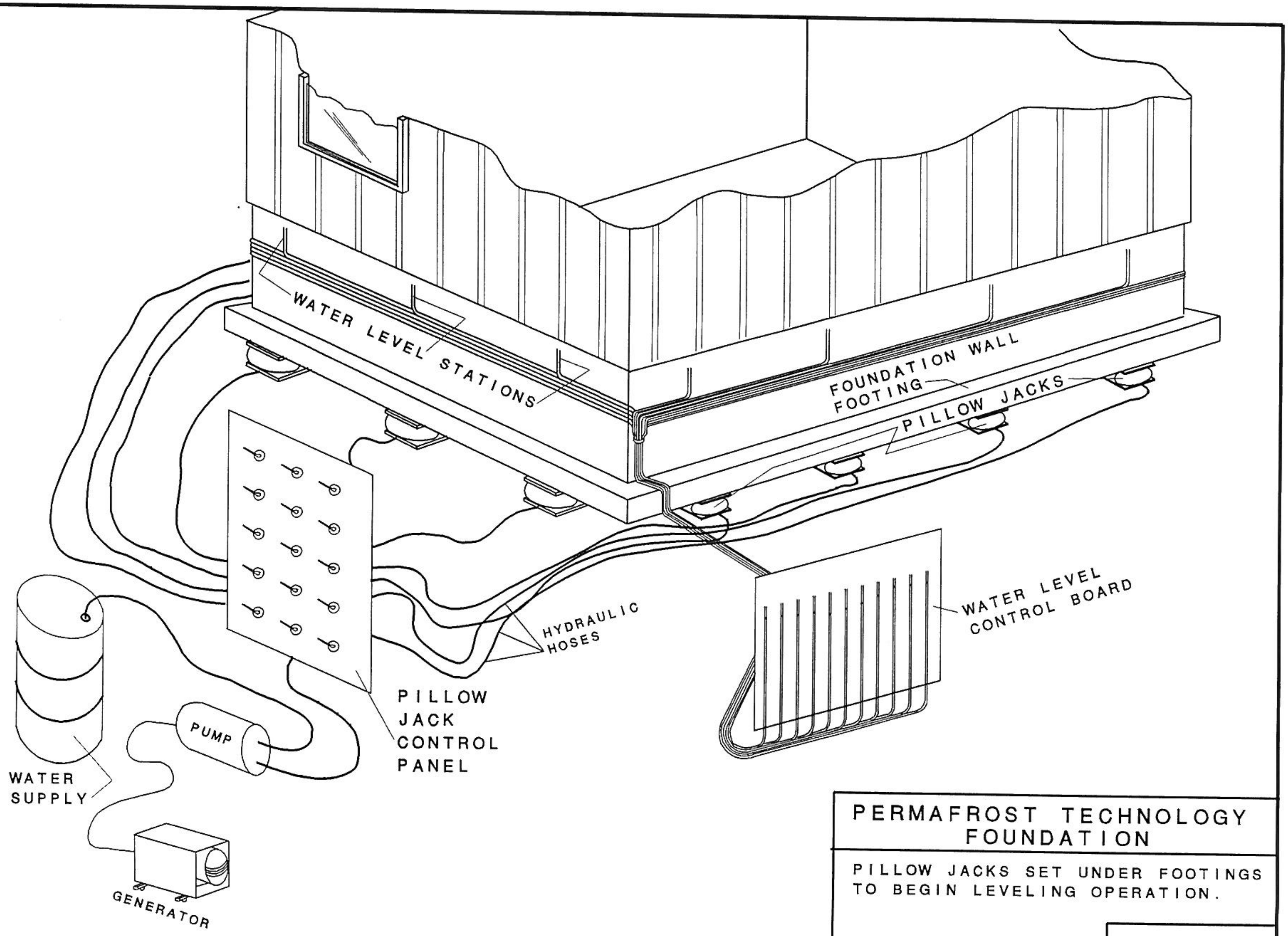
HEAT PUMP COOLING PIPE GRID LAYOUT

JULY 25, 1993

FIG. 3



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PILLOW JACKS SET UNDER FOOTINGS TO BEGIN LEVELING OPERATION.

FIG. 4

of pressure and sufficient flow. The advantage of this type of pump is that it supplies more than enough pressure and sufficient volume to very slowly and carefully lift the house. An additional plus for the pump was that it is readily available at local hardware stores at a very economical price (~$400). With this arrangement, one person acting as lift master can coordinate the raising of the entire house without over stressing any portion of the foundation wall or footing. When the lifting limit of one of the hydraulic pillow jacks was reached (approximately 14 inches), the two jacks on either side of it would support the load while the fully extended jack was deflated and the gravel pad below the jack was raised by about 10 inches and compacted. Then the jack was replaced and reinflated giving it another 14 inches of lifting range. Once the footing had been jacked to a position where the floor of the house was as near level as materials allowed, pea gravel was placed and compacted under the footing to support the house in the new level position. The pillow jacks were removed and the trench around the outside of the house was backfilled. Then the heat pump system was installed.

A grid of cooling tubes buried in the soil under the basement floor was required to intercept heat flowing from the house into the soil. The dirt floor was leveled, and Wirsbo™ plastic tubing was laid in a grid on the soil as shown in figure 3. This was easily done in the south half where the plywood floor had been removed and in the large north room which only had a dirt floor. The concrete floor strip crossing the middle of the basement, however, presented some complications. The concrete strip is approximately 12 feet wide and serves as the floor to the utility room, storage room, and the hall at the bottom of the stairs. To install the cooling tubes under the concrete slab, tunnels were excavated from each side until they met. This labor intensive operation allowed the plastic tubing to be pushed back and forth under the slab until the grid was established (fig. 3). The basement area was divided into four cooling zones so that cooling could be controlled to provide each zone the amount of cooling necessary. Some zones (e.g. beneath the boiler and under the concrete slab) were expected to need more cooling than others. The tubes from all zones were connected to a central header where control valves allowed the amount of cooling fluid to each zone to be regulated.

The tunnels under the concrete slab also provided a means of getting the plastic cooling tubes from the heat pump location in the large north room to zone 4 on the south side of the concrete slab. (In retrospect it would probably have been easier and less expensive to have removed the concrete slab rather than try to work under it) .

A fifth zone was added to provide cooling around the outside of the footing. This was designed to capture summer heat that penetrated the ground. Since the heat pump operates all year (unlike passive devices such as thermosyphons and crawl space cooling systems which only cool in the winter), the influx of heat during the summer could also be captured and diverted before it reached the permafrost.

The heat pump unit was placed in the large north room as shown in figure 3. Heat extracted from the soil by the cold fluid in the cooling tubes is pumped back to the heat pump unit where it is transferred to the heat pump working fluid (refrigerant) in a heat exchanger (called the expansion coil). The heat pump compressor then concentrates the heat to a much higher temperature by compressing the refrigerant. The refrigerant leaves the compressor and flows to a second heat exchanger called the condenser coil where the heat in the hot compressed fluid is transferred to air flowing through the coil and then circulating through a duct that runs along the south east wall of the basement along the ceiling and discharges into the various rooms in the basement to supplement the normal hot water baseboard heating system of the house. The heat can be vented to the outside during the summer when it is not wanted in the house. This is done by switching the damper in the duct on top of the heat pump and opening the exit door on the outside of the house.

Four inches of extruded-expanded urethane foam insulation were installed over the cooling tube grid, and a wooden plywood floor was installed over the insulation. This greatly reduced the heat flux through the floor into the soil beneath the house thus reducing the load on the cooling grid. The sewer pipe was place in its own insulated utilidor to protect it from freezing since it is located in the soil below the floor and below the cooling grid. Once the installation was complete, the heat pump was activated and the zones were balanced with the control valves at the header to provide the proper amount of cooling to each so that a uniform temperature existed throughout the soil beneath the house.

The liquid that is pumped through the cooling tube grid must be capable of operating at below-freezing temperatures without freezing or becoming too viscous to pump. It must also be non-corrosive and a good heat transfer fluid. If a leak should occur, it is also desirable that:

1. the fluid that might leak into the frozen ground not cause any ice to melt, and
2. it is not toxic.

Three fluids were considered as candidates for the working fluid in the cooling grid. A mixture of ethylene glycol (automobile antifreeze) and water, a mixture of methyl alcohol and water, and a commercial heat transfer fluid trade named Cryotech™ GS4 heat transfer fluid. The latter is a 50% mixture of potassium acetate in water (with the addition of 1% corrosion inhibitors). After considering all of the factors involved, the Cryotech™ fluid was chosen as the best selection for this application. Data sheets on this fluid are contained in the appendix of this report.

Level Measurements

Level measurements were taken to determine the relative elevation of the basement floor. The level measurements were made using a small precise telescopic level mounted on a tripod (sometime referred to as a "contractor's level") and a surveyor's rod calibrated in millimeters. The millimeter rod was used instead of a standard surveyor's rod to give more precision to the measurements. Since the distance from the level to the rod was rarely over 15 feet, the rod could easily be read to the nearest millimeter (0.04 in.).

It should be noted, however, that when level measurement are this precise, that perturbations can and do occur. These small changes are due to the placement of the rod from one measurement set to the next. Often the rod had to be placed behind furniture, and it was impossible to determine if it was sitting on the same spot as the previous measurement or if an electrical cord or a magazine etc. happened to be under the rod (even the thickness of several sheets of paper will show up at this precision). There was also the possibility for a gross error in reading the rod, since the level had the standard three cross hairs (center, upper and lower) used for measuring distances in surveying. If the operator was inexperienced (student labor was used for these measurements), a reading could be made using either the upper or lower cross hair instead of the center one. This error would yield an elevation that was in error by several tens of millimeters to as much as a few inches. These errors, however, are readily discernible when the data is plotted as a function of time (see the level measurement charts in the appendix).

Level data on the floor in the basement was collected several times a year and accumulated for a period of seven and one half years. The level data plotted as a function of time are shown in figure 2 and in the appendix of this report. Each measurement location is designated on the floor plan by a letter. Different groups of letters were plotted together on the charts to show relevant comparisons such as the south wall or the diagonal across the structure. In each chart, all levels are referenced to a single reference point "A". This allows the elevation of each point to be compared as a relative elevation on the floor plan with respect to point A. From this data, differential elevations between different parts of the floor can be seen easily and tracked with time.

This system, however does not give information as to the absolute elevation of the house with respect to the ground outside, and therefore any elevation variation of point A is also reflected in all other points. Determining absolute elevations requires a stable surveyor's benchmark or other stable reference outside the structure. No stable surveyor's benchmark was available at this location, so a nail was driven into a large tree to attempt to provide a quasi-stable reference. Elevation reference to the nail was collected from late 1993 until mid 1999. The movement of reference point A with respect to the nail gives an indication of the overall movement of the foundation, and whether it is settling or heaving. The relative elevations of all other points with respect to Point A allow differential movement within the house to be tracked, and that is the most important information for these studies since differential movement of the foundation would produce wracking of the structure which could eventually cause problems and require repairs.

For perspective, a differential floor elevation of one to two inches (25 mm to 50 mm) across the length of an average room is not noticeable to the casual observer. Up to four inches (100 mm) over the distance across a normal room, although noticeable, is not an overly unpleasant condition with which to live.

Loose soils also raise the concern of settlement during a dynamic event such as an earthquake. During the period over which the level measurements were made on this house, there were 15 earthquakes in the Fairbanks vicinity (approximately a 30 mile radius) over Richter 4.0. Of those 15, one was ranked at 5.0 on Nov 1, 1992 and one was 6.2 on October 6, 1995. This last one was the most significant event, since it was not only the largest but also the shallowest at only 9 km below the surface. It was felt very strongly by residents of Fairbanks. However, reviewing the data on level measurements shows that no significant measurable settlement can be identified in our data during any of these events. This suggests that either settlement into the loose soils beneath the structure was not triggered by a dynamic event of this magnitude or that settlement into the loose soils was already complete before the Permafrost Technology Foundation started monitoring the structure. These circumstances and observations do not preclude the possibility of settlement during a more severe earthquake or other type of dynamic event, but they are an indication of the relative stability of the structure.

Temperature Measurement

When the permafrost test borings were drilled, a thermistor string with 12 thermistors was placed in each hole. In addition thermistor strings were installed in six other locations in the basement. The thermistor strings were positioned to measure temperatures at the surface of the ground and at various depths. These temperatures were monitored periodically; usually at the same time the level measurements were taken (and sometimes more often) resulting in a database of seven years of soil temperatures beneath and around the house. The temperature data were plotted on charts to give a graphic indication of the soil temperature trends with respect to time over the duration of the study. Some of these charts are included in the appendix of this report.

Thermistors are capable of measuring temperature to the nearest one thousandth of a °C. Thermistors were used because they provide greater precision and are easier to read than thermocouples; however, they have the disadvantage of being more fragile, and they can drift a few thousands of a degree over time. To obtain the maximum accuracy the strings must be calibrated in a reference bath both before and after their use. These thermistor strings were calibrated before placing them in the hole, but since once installed they are buried, it is impractical to remove them without destroying them, therefore the secondary calibration cannot be made. The temperatures, therefore, are reliable to about a tenth of a degree Celsius. However, for the purposes required for these studies, an accuracy of one tenth of a degree Celsius is adequate.

Thermistors located at various depths allow us to track the temperatures at those depths to determine if the permafrost is getting deeper, remaining stable, or actually rising. The data also alerts us to any anomalies in temperature that may occur due to outside influences such as new construction nearby, landscaping modifications, or damage or deterioration of protective insulation.

Geotechnical Exploration

In order to determine the condition of the soils below the structure, two boreholes were drilled and samples of the soil were taken at regular intervals of depth (see appendix for borehole logs). A split-spoon core barrel driven through the hollow drill stem using a 300-pound hammer and a 30-inch drop was used to collect core samples. The number of hammer blows required to drive the core barrel gives information on the competency of the soil at each sample depth. These samples are considered "disturbed samples." However, since they are retrieved essentially intact in their natural state, they provide very useful information about the soil. This method of sampling was continued until frozen ground was encountered. Below this, the soils were sampled with a dry core barrel. This sampling process brings to the surface a five-foot-long, three-inch-diameter, intact soil sample. Representative soil samples were then sent to the laboratory for analysis of grain size and water content. With this data, a model of the soil conditions and types was constructed for the hole. This model does not necessarily apply to the soils under the structure since soil conditions can, and often do, change radically over short distances, but if boreholes on both sides of the structure are similar in nature, then the conditions of the soils beneath the house can be inferred at least.

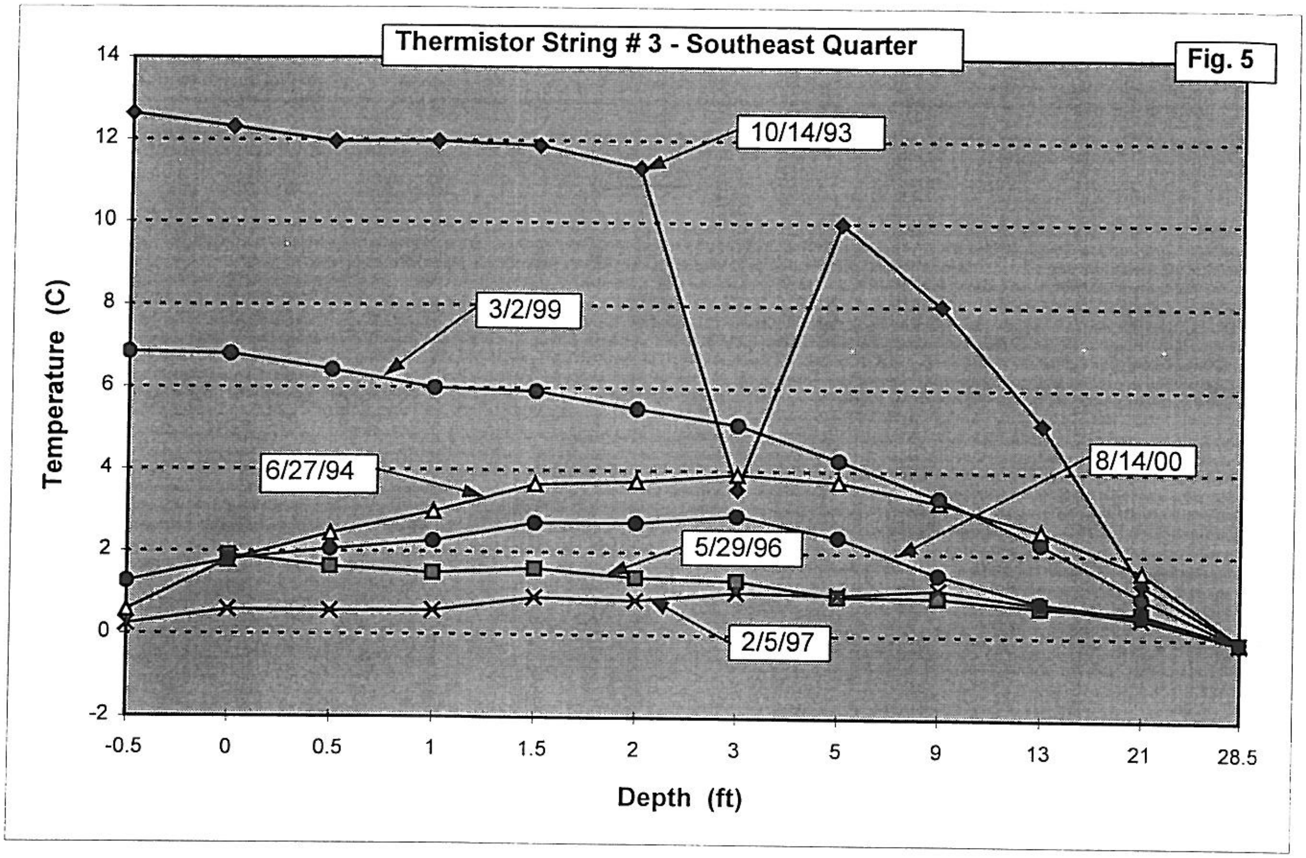
Results

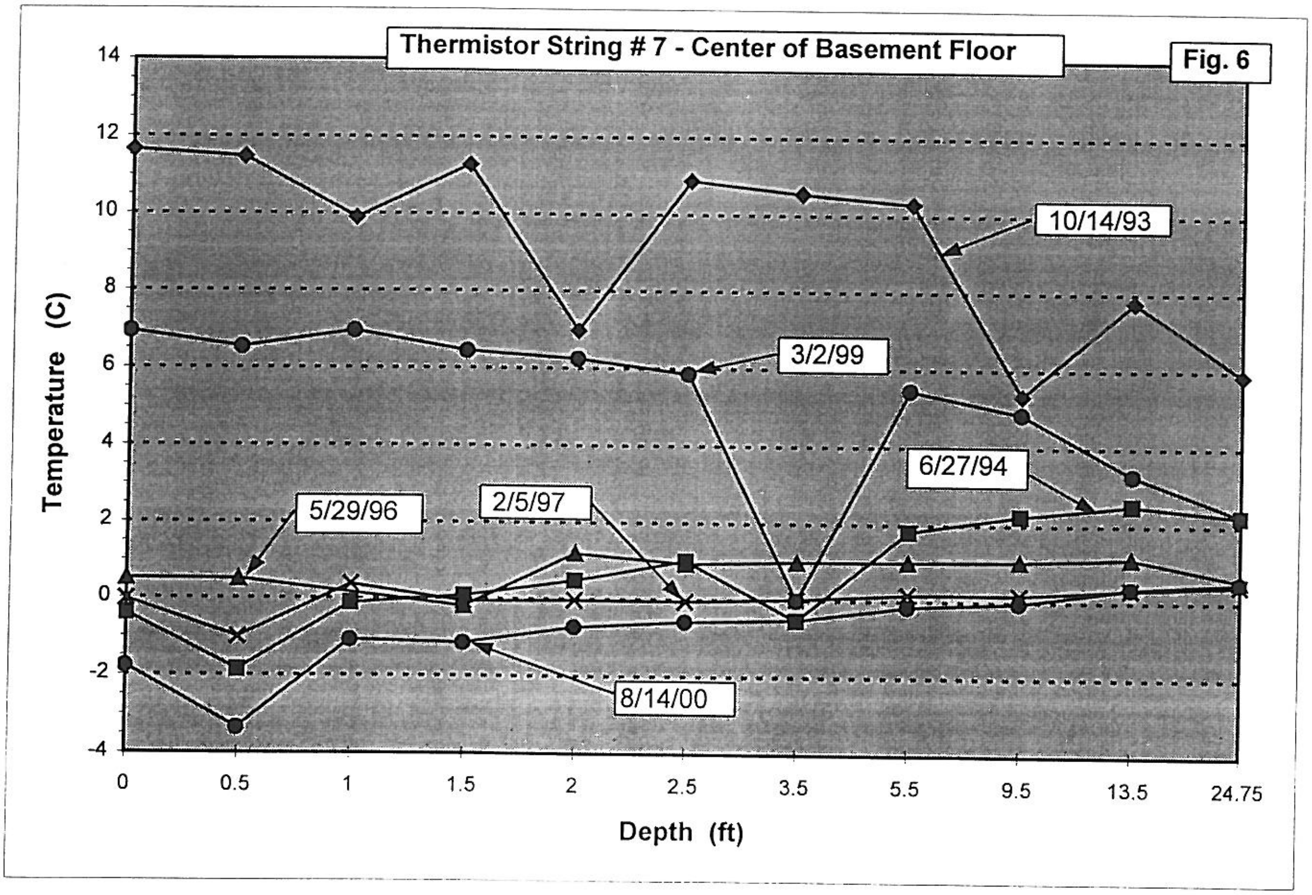
Soil Temperatures

Soil temperature measurements were collected, as stated above, for eight years (1992 - 2000) during which time the house was the property of the Permafrost Technology Foundation. The heat pump cooling system was installed in the fall of 1993. The data collection programs for both the level data and temperature data were upgraded to provide more complete coverage of the structure after the releveling and heat pump installation in 1993. Seven new thermistor strings were installed during the releveling work and 15 new level measurement points were established after the installation of the heat pump cooling grid. Temperature and level data were collected more frequently after the installation of this system. The additional data allowed more precise tracking of the performance of the system. Thus a database of nearly seven years has been established on the performance of the heat pump system.

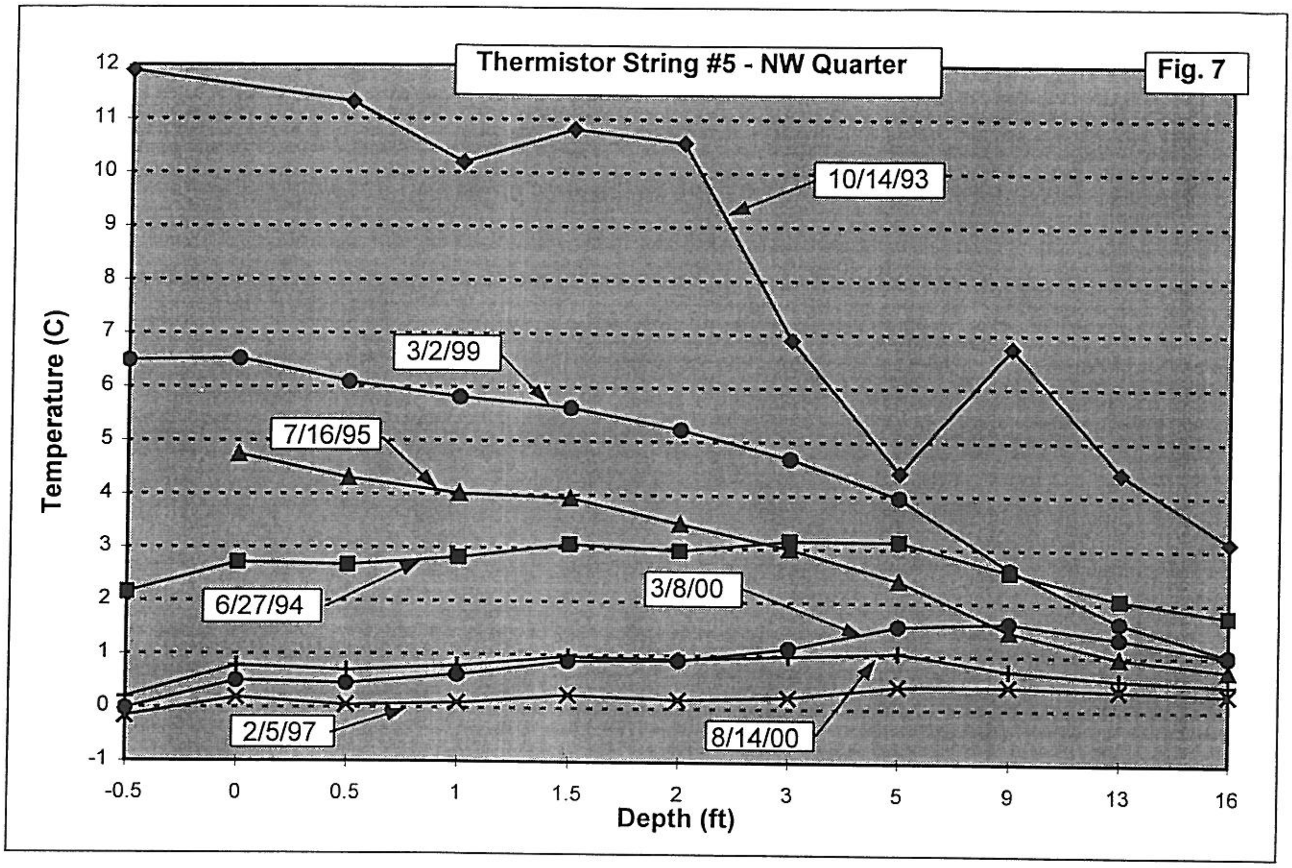
The temperature data shows that the heat pump system effectively removes heat from the soil beneath the house. Figures 5, 6, 7 & 8 show that the soil temperatures near the surface dropped by as much as 12°C (22°F) in the first eight months after the heat pump was activated in October of 1993 and continued to decline until the temperature at all levels was near 0°C (32°F) in February of 1997. With temperature trends clearly indicated, data collection was changed to a less frequent schedule in 1997 to reduce cost.

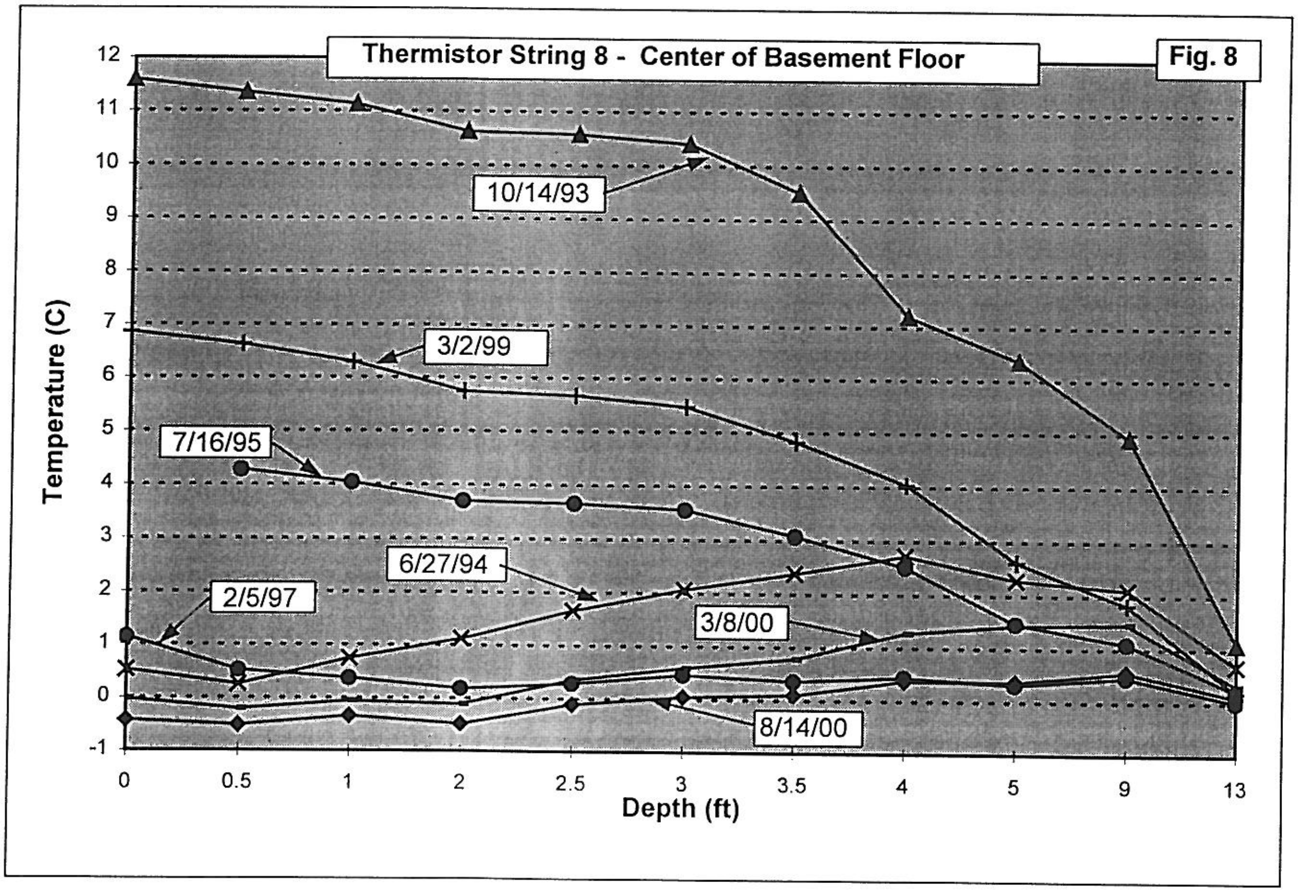
In early 1999 the pump that circulates the cooling fluid from the heat pump to the cooling-tube grid failed, and by the next data collection on March 2, 1999 the soil





Figures 5 and 6 Temperatures vs Depth on Specific Dates

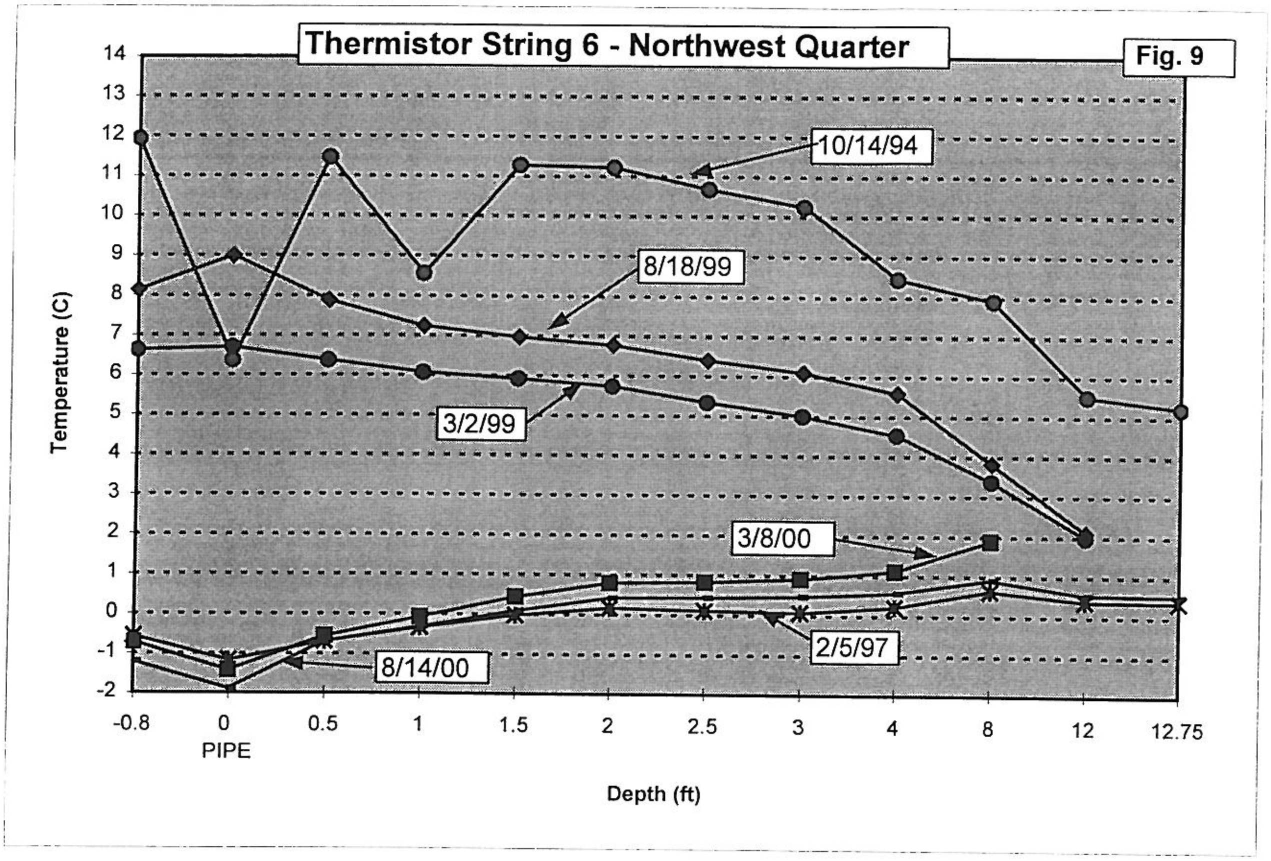


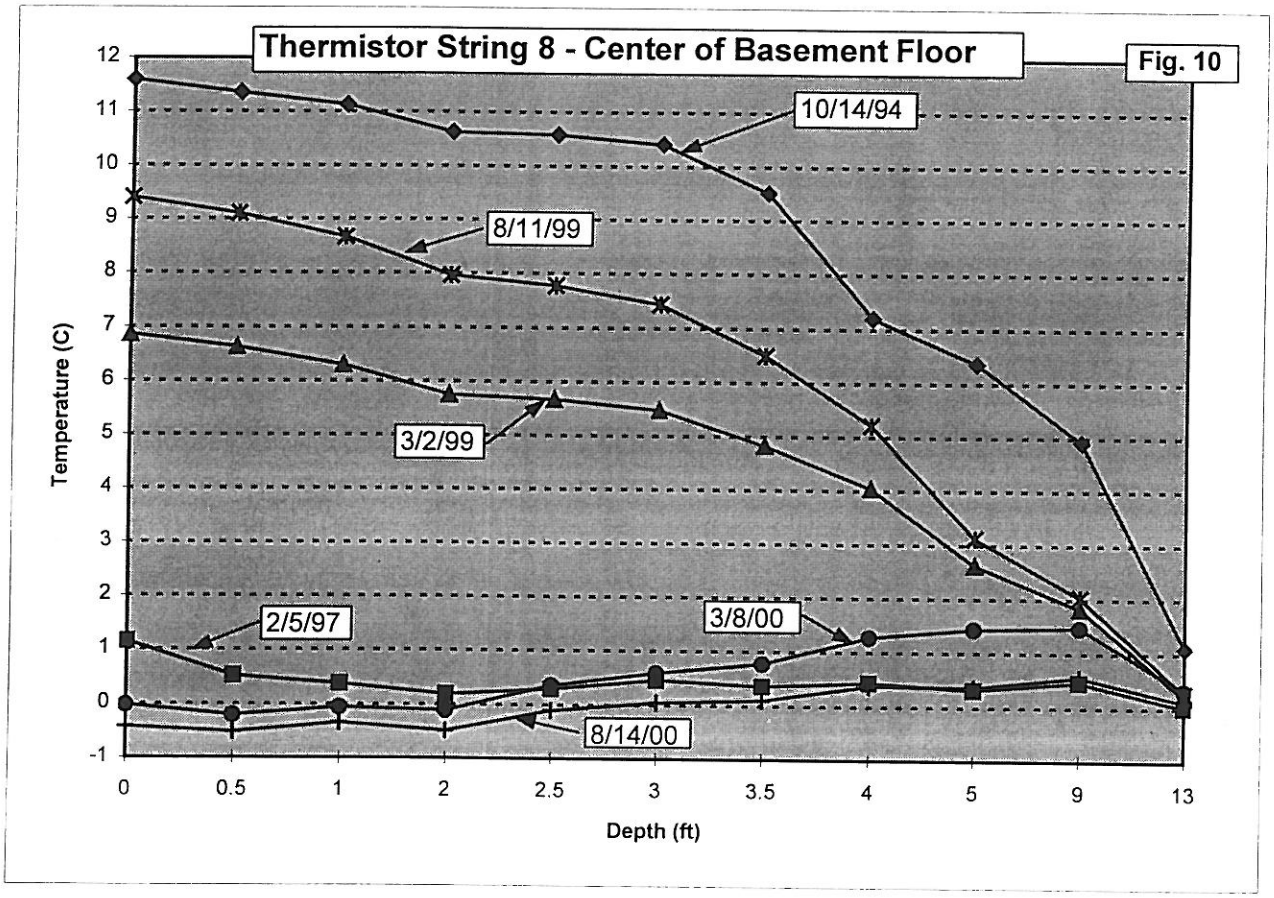


Figures 7 and 8 Soil Temperatures vs. Depth on Specific Dates temperatures near the surface had risen by slightly over 6°C (11°F). A pump failure of this kind is very unusual, since the type of circulating pump used has a reputation for reliability and long life. Pumps of this type normally operate in heating systems for decades without failure. However, inspection at the time of repair showed that the fluid level in the cooling tube circuit had dropped (probably due to evaporation) leaving the circulating pump to run "dry" thus causing the failure (this pump uses the circulated fluid for lubrication of its bearings). A new pump (a type which does not use the circulating fluid for lubrication) was installed and the system was placed back in operation. However the new pump also failed after only approximately 2 months operation so that the system did not get completely back into operation until late July 1999. The heat pump operated for 12 months (July 1999 to July 2000), before the circulation pump once again failed. This time it was discovered that the pump motor was not sealed and in the cold environment in which it operates, water was collecting in the motor coils, shorting the motor and causing it to fail. The pump was changed to the original type whose motor is sealed but whose bearings cannot be allowed to run dry. A reservoir will be installed on the intake of the pump to preclude the possibility of the pump running dry. This should eliminate this failure from ever happening again.

After the pump failure in early 1999, by March 1999, with no cold fluid circulating in the soil cooling grid, the soil temperatures rose by as much as 6°C (11°F) near the floor surface and by about 2°C (3.5°F) at and below the 24 ft depth. However, they were still substantially colder than the soil temperatures when the heat pump was first put into service in 1993 (figures 5 through 8). As the system removes heat from the soil, a cold soil mass is established that serves as a buffer to protect the permafrost for several weeks in cases of equipment failure such as this. Even with the second pump failure in, June 1999, allowing the system to be without cooling for over 5 months, soil temperatures on August 11, 1999 were still substantially below the 1994 temperatures as seen in figures 9 and 10. Once the circulation of the cold fluid was re-established the soil temperatures again dropped until by March 2000 they were approaching the pre-failure 1997 temperatures and by August 2000 they were even colder than 1997 under the center of the basement floor; as seen in thermistor string #8 (figures 7 through 10).

The thermal inertia of the soil mass beneath the house can also be seen in figures 9 and 10. As discussed above, the pump that circulated fluid through the cooling-tube grid failed sometime in early 1999. Unfortunately, the exact time of the pump failure is unknown, however, the progress of soil warming can be seen in figures 9 and 10. The circulation of cold fluid to the cooling grid was finally re-established in early August 1999 and by that time temperatures had risen by 8°C (15.2°F) at the surface and nearly 1.5°C (2.5°F) at the 12 ft depth. In the five months between March and early August 1999 the progress of the warming was 2.5°C (4.5°F) near the surface and 0.07°C (0.13°F) at the 13 ft depth. This shows that the thermal inertia of the soil gave several weeks of protection to the permafrost even after active cooling had stopped. This provided a comfortable margin during which repairs were made even though a full scale shut down of the cooling system had occurred. The ability of the heat pump system to cool the soil





Figures 9 and 10 - Soil Temperatures vs. Depth for 2000, 1999, 1997 and 1994 beneath the house is also shown in figures 9 and 10. Near the surface the soil temperatures rose by 8°C by the time of the second circulating pump replacement, but by March 2000 the temperature had dropped to below the 1997 value in the top layers below the cooling grid.

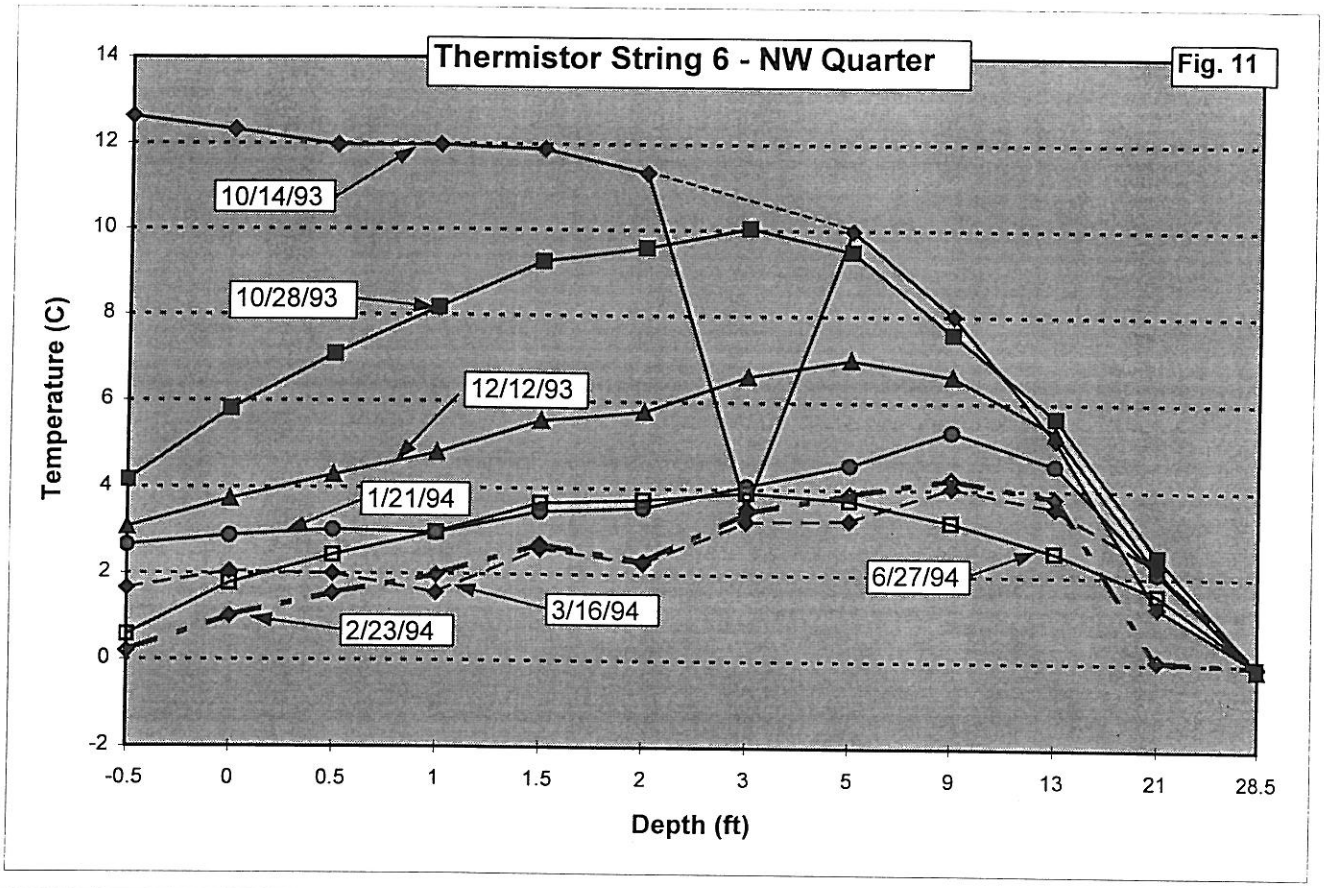
The performance of the heat pump/cooling grid system in capturing the heat entering the soil through the floor has been very promising. Figures 11 & 12 show the soil temperatures vs. depth for the six-month period after the heat pump was installed and activated in Oct. 1993. Heat from deeper layers flows to the cooler surface layers where the cooling grid removes it and carries it back to the heat pump which in turn removes it from the cooling fluid and distributes it to the basement and living room to help heat the house in the winter. In the summer the heat can be discharged to the outside when it is not needed in the house.

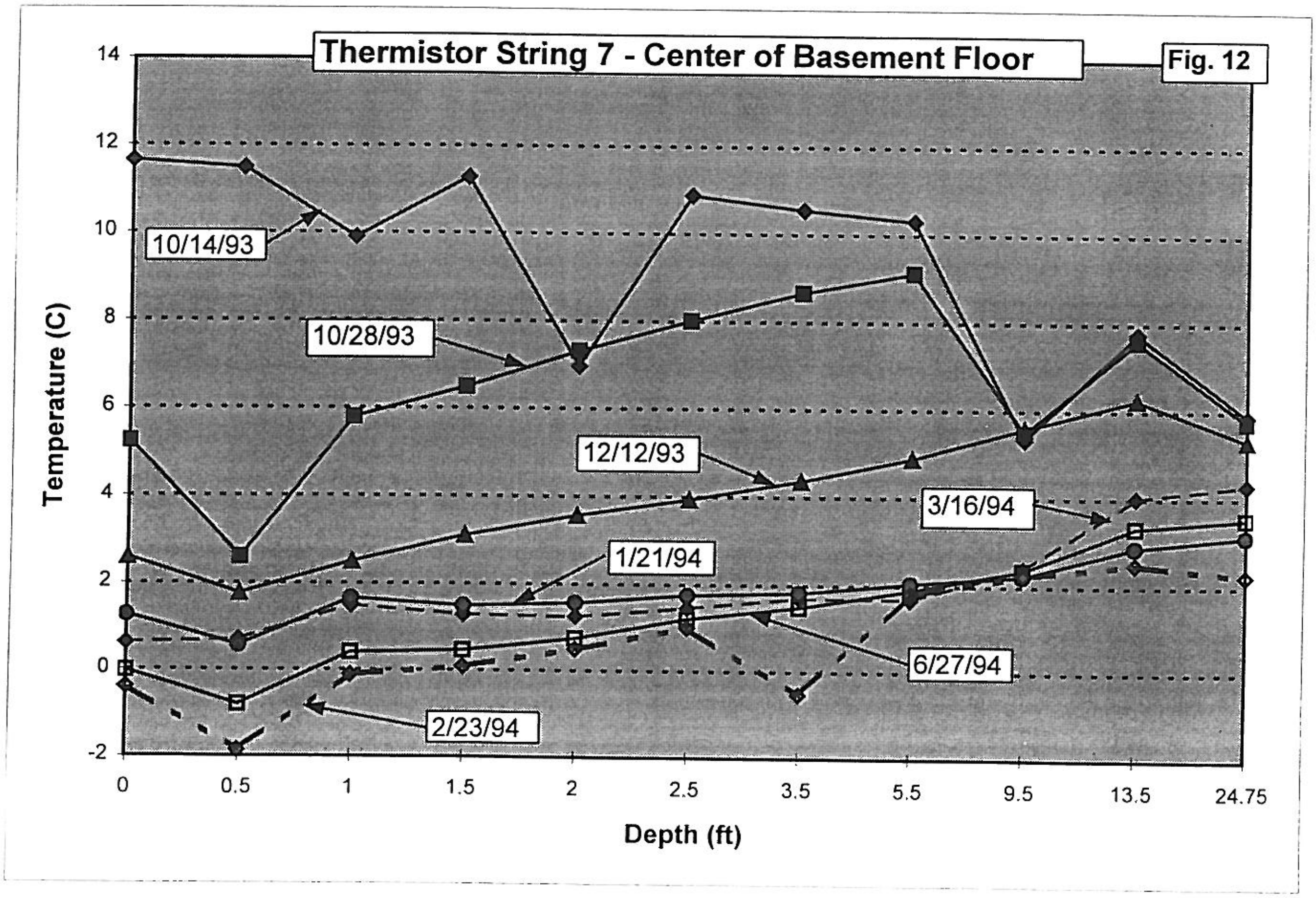
The temperatures of the soil near the surface respond rapidly to the heat pump, as can be seen in the temperature data. Within 4 weeks in figures 11 and 12, temperatures at the surface in the center of the basement dropped by 9°C (16°F), and as deep as the 13.5 ft level below the center of the basement floor, temperatures dropped by over 5°C (9°F) within about four months (fig. 12). As the soil temperatures approached freezing, the "on" cycle time was shortened to reduce the heat pump cooling. This resulted in a fluctuation of the temperatures until an acceptable cycle program was established. This is shown by the March and June 1994 temperature curves on figures 11 and 12.

The effect of the cooling loop that circumscribes the footing on the outside of the house (loop #5) can be seen from the soil temperatures recorded by thermistor strings 1 and 2; plotted in figures 13 and 14. Although the effect of the loss of cooling during the summer of 1999 is evident, temperatures between 5 and 30 ft deep are substantially colder than they were at the beginning of the cooling-grid operation in 1993. At 10 feet and below, even August temperatures are colder than October temperatures were in 1993. At the 15 to 25 ft depths, which are generally below the effects of the widely fluctuating surface temperatures, soil temperatures have dropped substantially through August 2000. The exterior cooling grid loop appears to be performing as designed and to be mitigating the devastating effect that summer weather normally has on permafrost.

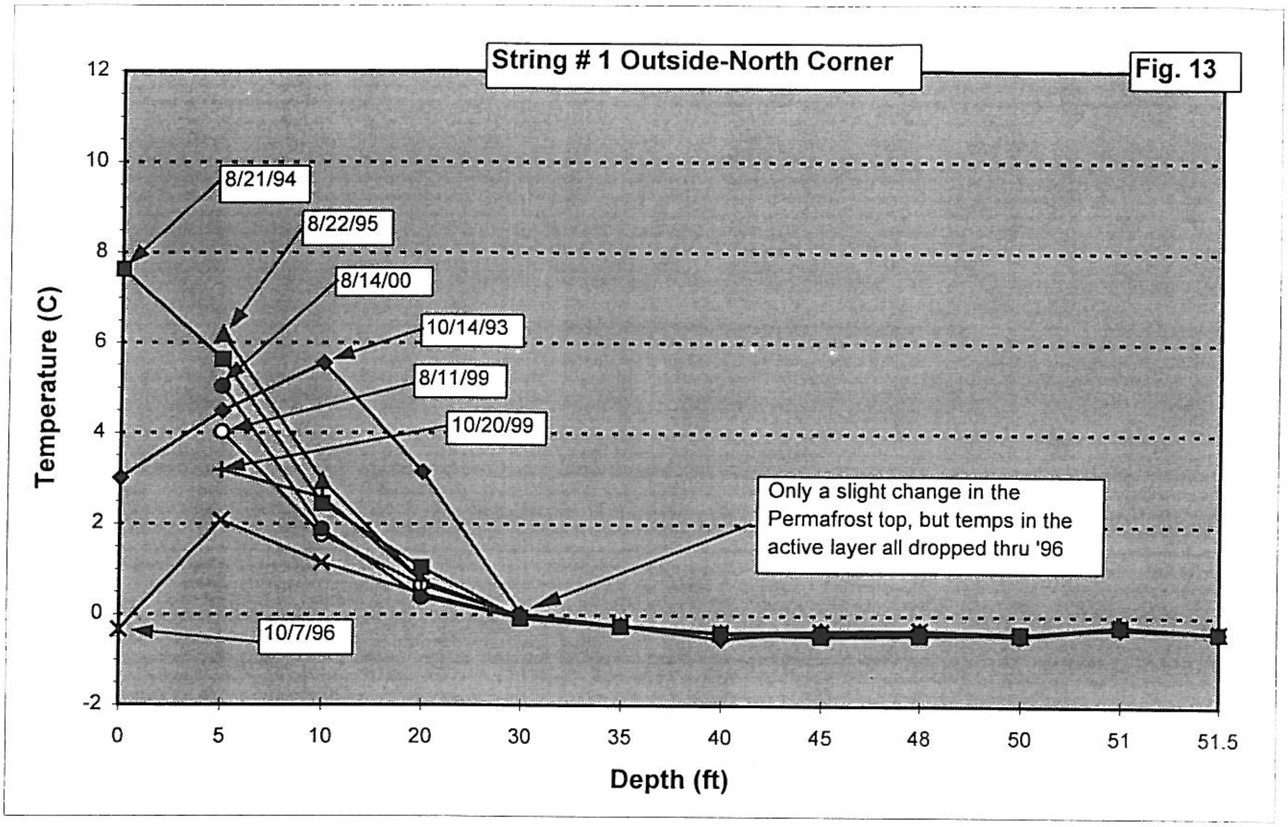
Floor level

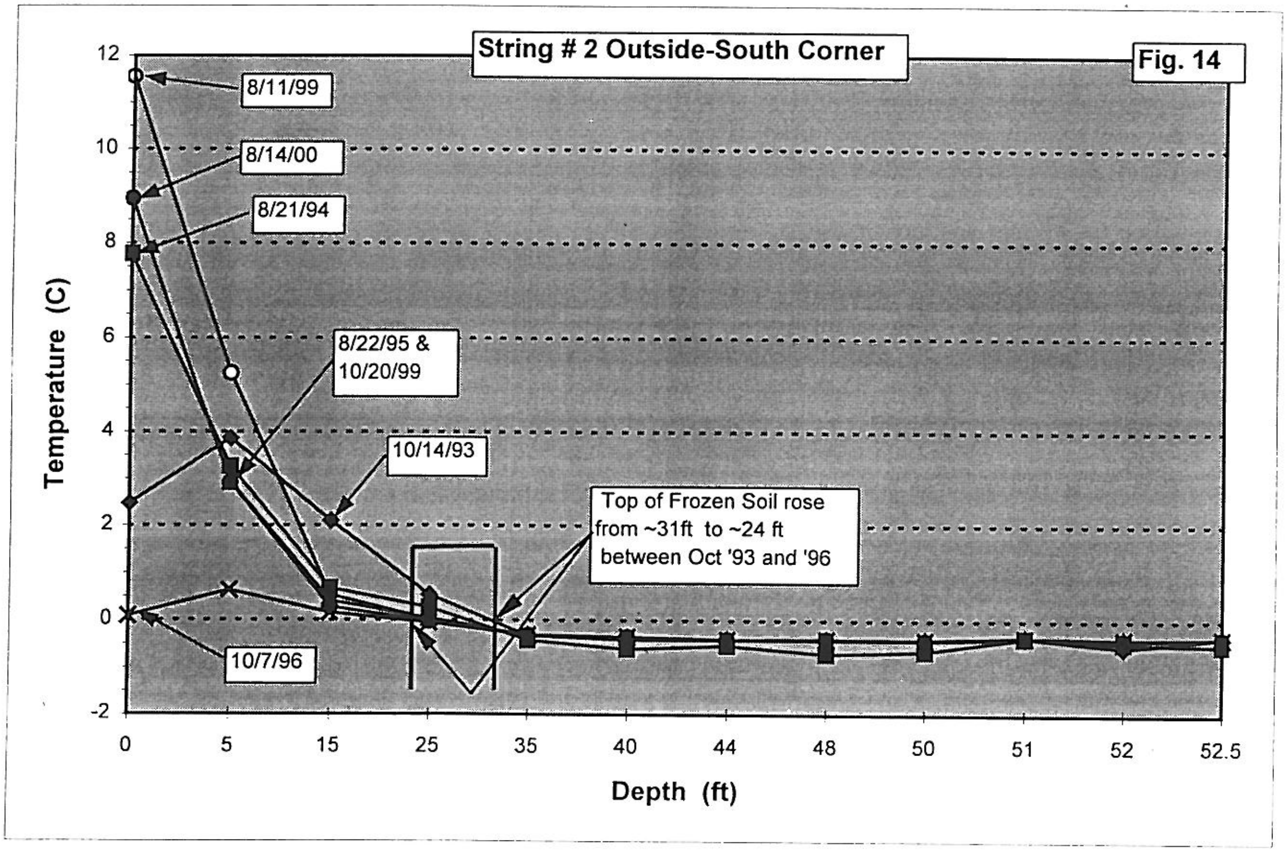
As detailed above, the level of the floor in the basement was monitored to detect any changes in the initial level that would be caused by further subsidence due to continued permafrost thawing. The level measurements would also detect heaving of the floor due to the formation of ice lenses under the house as the soil was cooled. The initial elevations at each of 39 locations were measured on October 30, 1993 after the house was leveled and the heat pump was installed. Level measurements were collected from October 1993 to August of 2000. This database contains information on the floor level history during that period (6 years 10 months). Figure 15 shows a floor plan of the basement of the house with each of the 39 locations measured. The initial elevation,



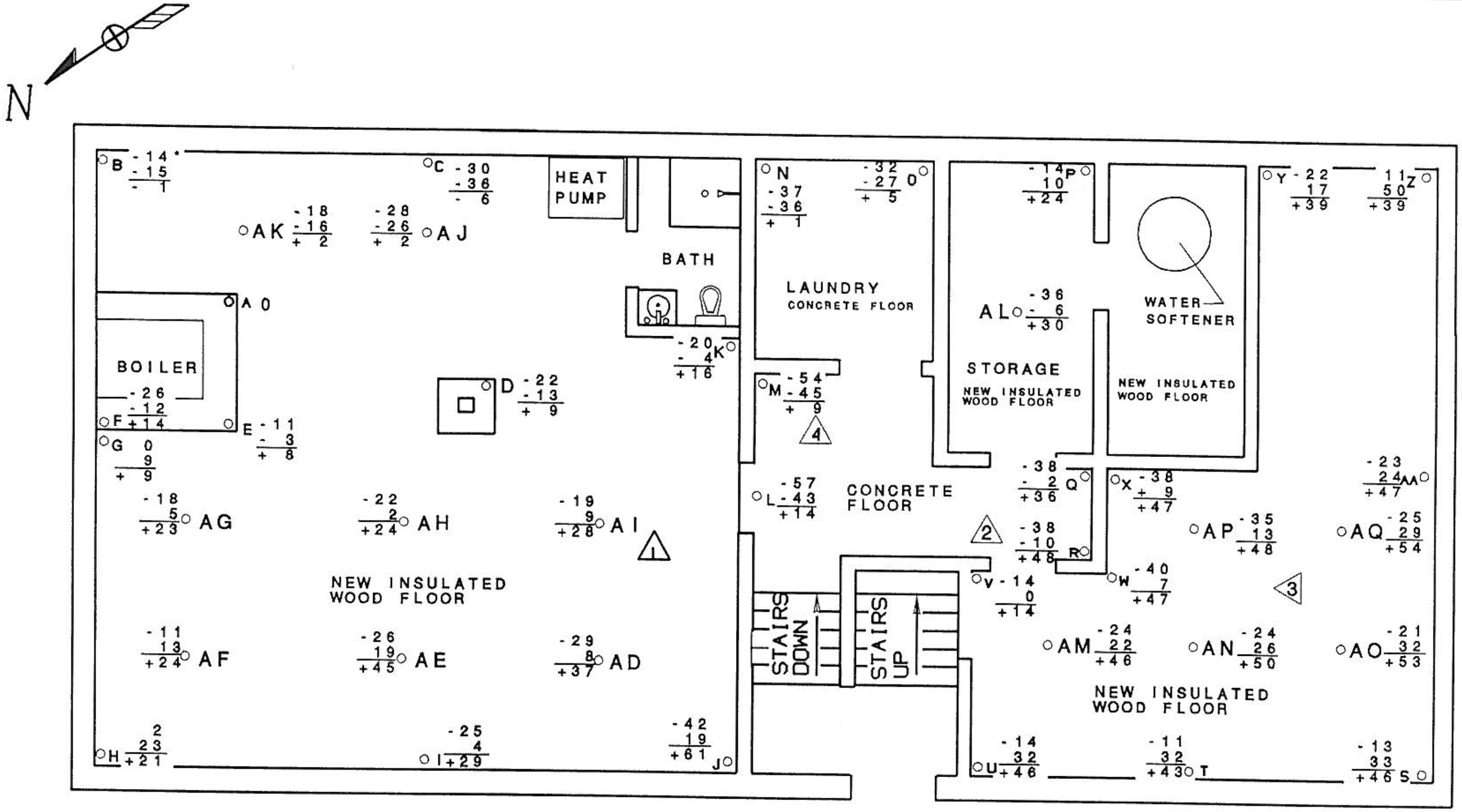


Figures 11 and 12 - Soil Temperatures vs Depth During the First Eight Months Operation of the Heat Pump





Figures 13 and 14 - Soil Temperature vs. Depth for Thermistor Strings 1 and 2 - Located Outside the House



KEY

○AH LOCATION OF LEVEL DATA MEASUREMENTS AND THEIR IDENTIFICATION LETTER(S). THOSE LOCATIONS THAT WERE ADDED AFTER THE INSTALLATION OF THE HEAT PUMP ARE: POINTS AD THROUGH AQ AND POINT D.

-11 —10/30/93 LEVEL (IN mm) W.R.T POINT A (UNLESS NOTED BY *)
14 —8/01/2000ELEVATION (IN mm) W.R.T POINT A
+25 —ELEVATION DIFFERENCE (mm) AFTER 5 YEARS 9+MONTHS

* ELEVATION OF POINT B ON 4/01/94

PERMAFROST TECHNOLOGY FOUNDATION

728 CONSTITUTION, FAIRBANKS, AK

FLOOR LEVEL COMPARISON BETWEEN
10/30/93 AND 8/01/2000

FIG. 15

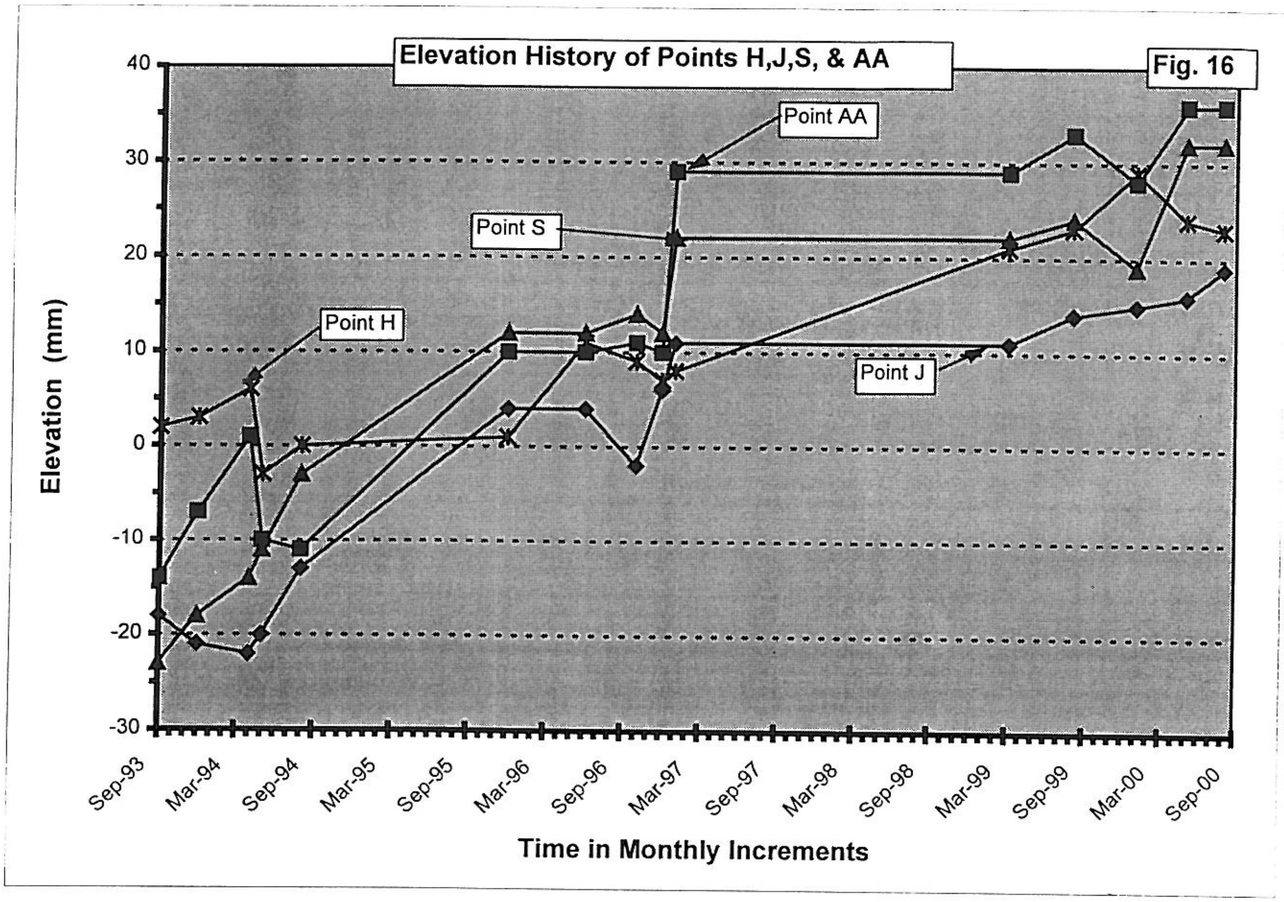
final elevation, and the difference between the two elevations are shown in mm beside each location. As seen in figure 15, the level changes are all positive with respect to point "A" except for points B and C. All of the rest of the points on the floor are higher than point A in 1999 than they were at the time the heat pump was installed in 1993. This situation could be the result of several possible causes:

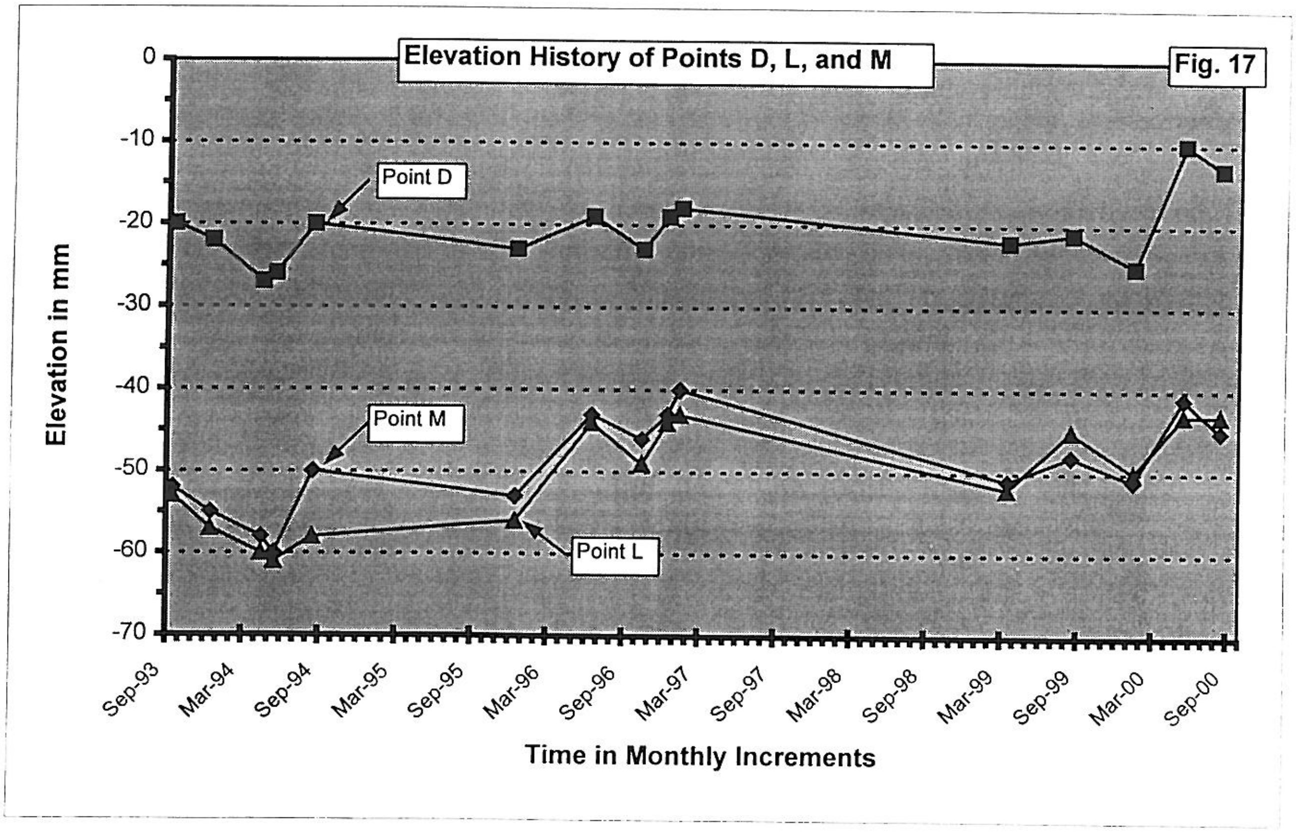
1. most of the floor has undergone some frost heaving or
2. point A and the immediate vicinity have subsided or
3. the entire house subsided differentially with point A and vicinity subsiding the most and the northeast-southwest wall subsiding the least.

Figures 16 and 17 show the history of the elevation changes of selected points on the floor from October 1993 to August 2000. One of the largest elevation changes occurs on the plywood floor in the southwest room (points S and AA). These indicate substantial heaving of the floor of approximately 55 mm (~2¼ inches) as seen in figure 16. However, the plywood floor floats on the insulation and the ground and it is not rigidly attached to the foundation. When walked across, the plywood floor could be described as "springy," thereby drawing into question the accuracy of points located on it since the weight of the data takers would deflect the floor yielding distorted elevation values.

Of more interest, therefore, are the points on the concrete floor strip and the concrete pad under the furnace. These points are more firmly associated with the foundation of the house and are considered more accurate. The elevation changes of these points are less than 10mm (~½ in.) over the measurement period (figure 17). In 6 years 10 months during which the levels were monitored, a change this small is nearly inconsequential. It may be enough to cause some minor hairline cracks in the wallboard (and some hairline cracks were noticed and repaired when the interior was painted in the summer of 2000) but little else. If the differential elevation change were to continue at this rate (½ in. every seven years) and not be corrected as was done at the beginning of the project (see section 2), the foundation might begin to show distress after about 40 to 45 years as the accumulated differential approached approximately 75mm (~ 3 inches). However, many homes will shift this much in 40 years due to material shrinkage, settlement etc. Note that with respect to the heaving of the plywood floor, most heaving occurred during the first half of the time period and little heaving is seen after March 1997. This suggests that if there were heaving under the plywood floor, it has now nearly stopped and the plywood floor may be reaching stability.

To determine the absolute elevation of point A requires a stable surveyor's benchmark, and no benchmark was available at this site. A quasi-stable reference was established using a nail in the lower trunk of a mature spruce tree. It was hoped that the spruce would concentrate its growth at the top of the tree and that the trunk would only increase in girth, not in height. Therefore the nail, although subject to seasonal frost heave, might remain relatively stable. Unfortunately the measurements of the elevation between the nail and point A yield a somewhat erratic record. This is at least partially due to the number of different researchers who collected the data (teams of engineering students were involved in the data collection). Subsequent investigation has shown that there is





Figures 16 and 17 - Elevation of Selected Points on the Basement Floor with reference to Point A more than one nail in the trees surrounding the house, any one of which could have been used by different groups of data collectors. Nevertheless, figure 18 shows the elevation history of the most likely nail with respect to point A from the beginning of the project to the present, and keeping the question of its accuracy fully in mind, at the very least, the data is useful in showing trends. The first and the final elevation measurements were made using instrument setups that bypassed the springy plywood floor, and therefore should be somewhat more accurate. In figure18 it is seen that the total overall change in the elevation between the nail and point A is only 38mm (1½ inches) over the period from October 1992 to August 2000. This is suggestively close to the differential elevation change between point A and point L and may indicate settlement of that amount by the furnace slab. If this is the case, the east corner of the building has also subsided about the same amount since the elevation of point B in the east corner of the floor has closely followed point A. The rate of settlement indicated in figure 18 is less than 6 mm per year (less than ¼ inch per year).

The physical condition of a foundation wall is another indicator of settlement distress. Concrete and concrete block foundations are rigid, brittle structures whose purpose is to transfer and distribute the weight of the building to the ground on which they sit. The concrete is subjected to compression between the building and the soil, a stress mode in which concrete is very strong. If the ground support beneath the footing is lost because of settlement beneath part of the footing, the foundation wall/footing will be subjected to bending and tension. Concrete is notably weak under either bending or tensile loading. As the weight of the building overstresses the part of the foundation wall that has lost its support, it will fail, and cracks will develop. One of the first and most obvious indications of permafrost settlement failure is the appearance of cracks in the foundation wall. In block foundation walls, the cracks first show up in the mortar joints between the blocks, and these cracks are an early warning of foundation distress. At the conclusion of the project in the summer of 2000, a careful inspection of the foundation of this building showed that there were no cracks in the above ground portion of the foundation wall at that time. Nor were there any visually obvious indications of settlement or of heaving.

The Frost Heave Scenario

One possible explanation for the floor level differential between point A and points D, J, L, M, S or AA in figures 15 - 17 could be frost heave of the soil at the surface just beneath the cooling-tube grid. Since frost heaving requires freezing soil temperatures, analysis of the soil temperatures during the time period in question is in order. Thermistor strings #3 through #8 measure temperature at various depth intervals down to as deep as 28 ft (string #3). Although these strings show an overall decline in the temperature of the soils at most depths, only very small changes in the height of the top of the permafrost are found (figures 19 through 24 show plots of the temperatures vs. depth for thermistor strings #3 through #8 at representative dates during the study). Note that thermistor strings 1 and 2 are outside the house and measure temperatures to a depth of 50+ ft in increments of several feet (figs. 13 and 14), whereas strings #3 through

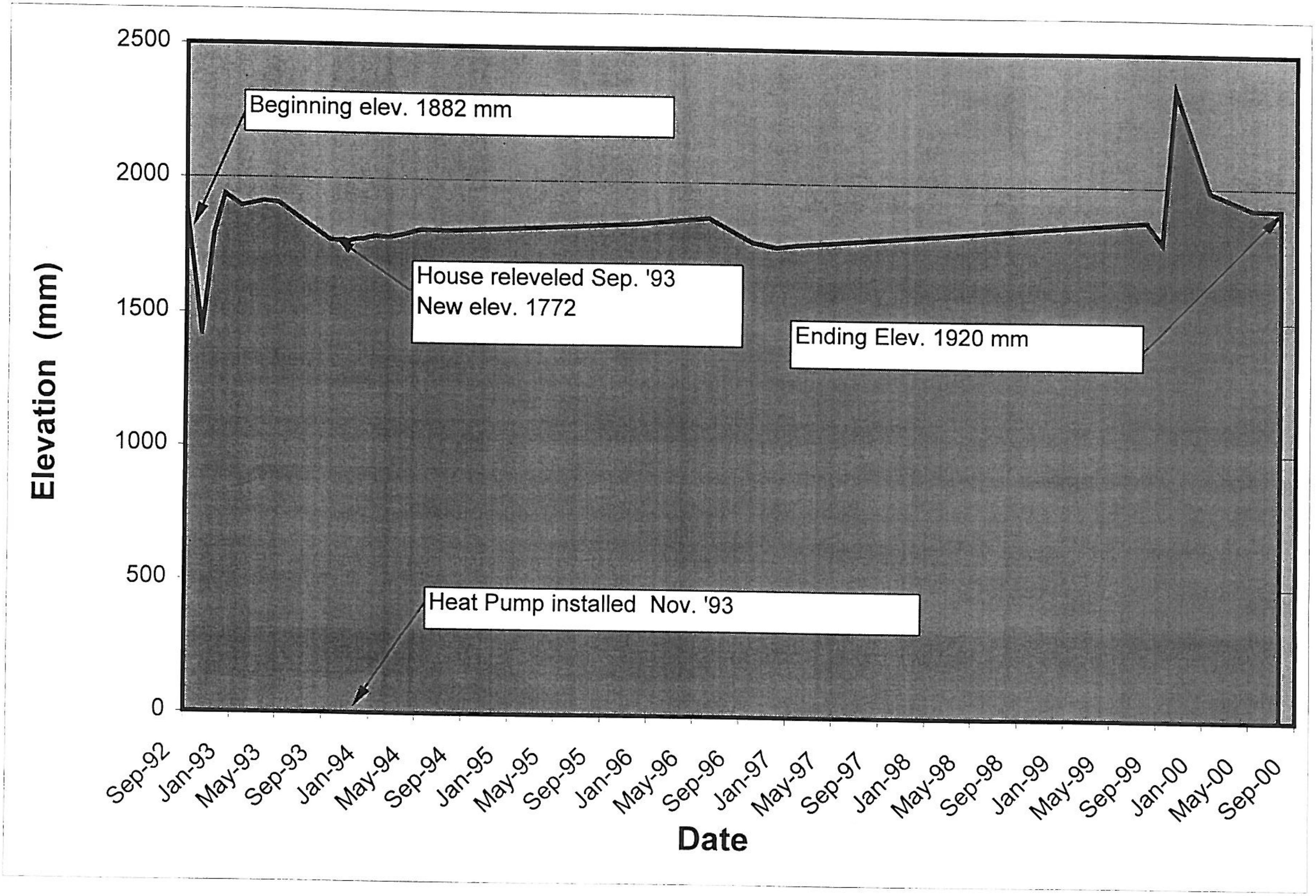


Figure 18 - Elevation difference between point A and the reference nail benchmark for the duration of the project

Fig. 19 - Thermistor String #3

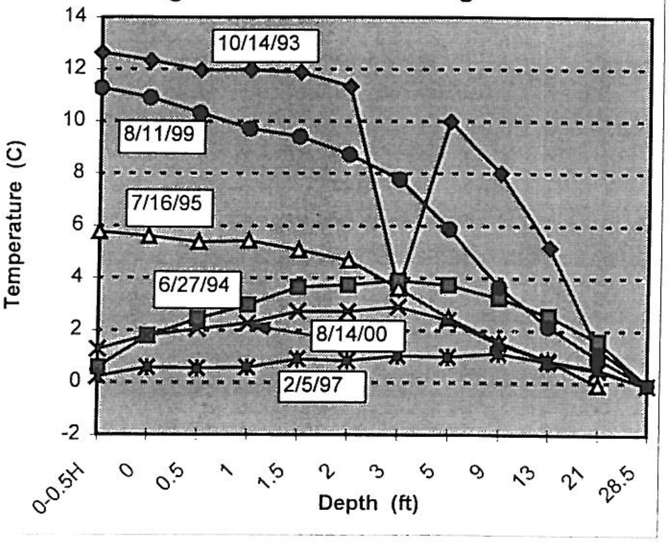


Fig. 20 - Thermistor String # 4

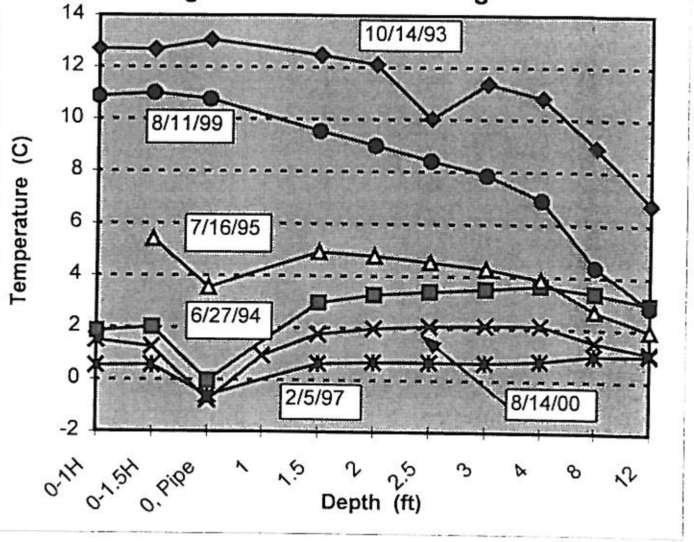


Fig. 21 - Thermistor String # 5

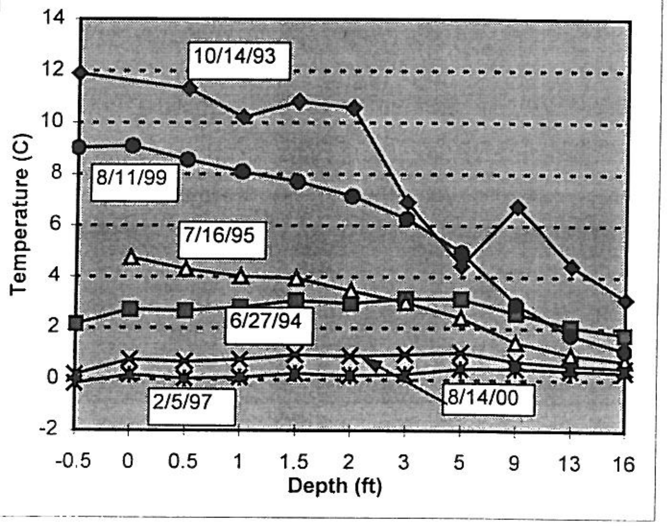


Fig. 22 - Thermistor String # 6

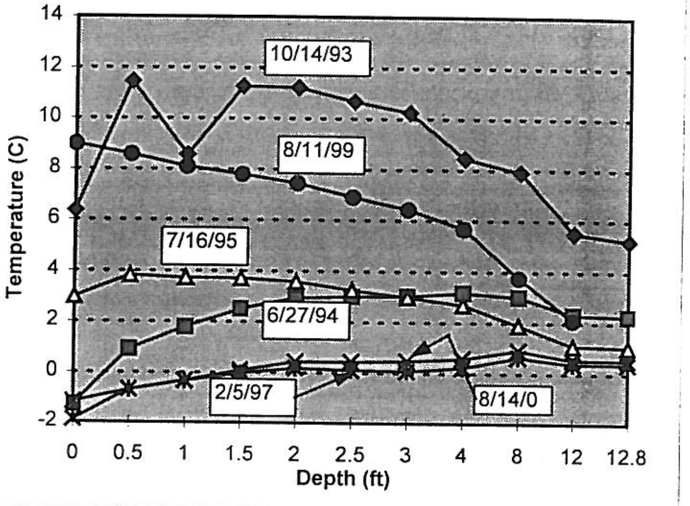


Fig. 23 - Thermistor String # 7

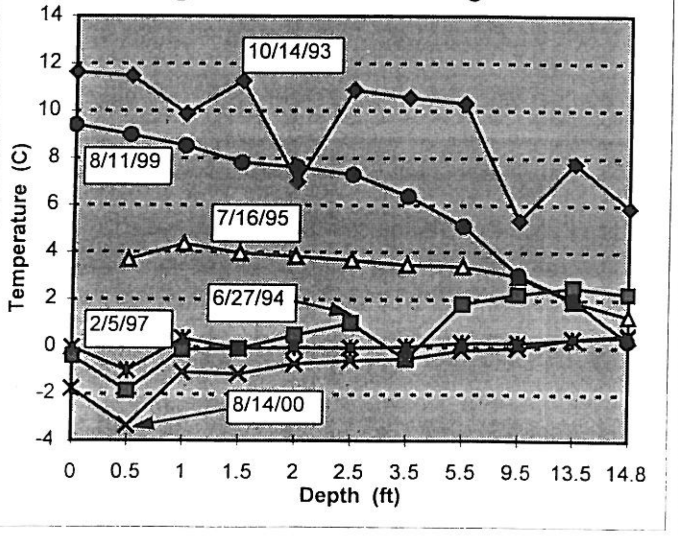
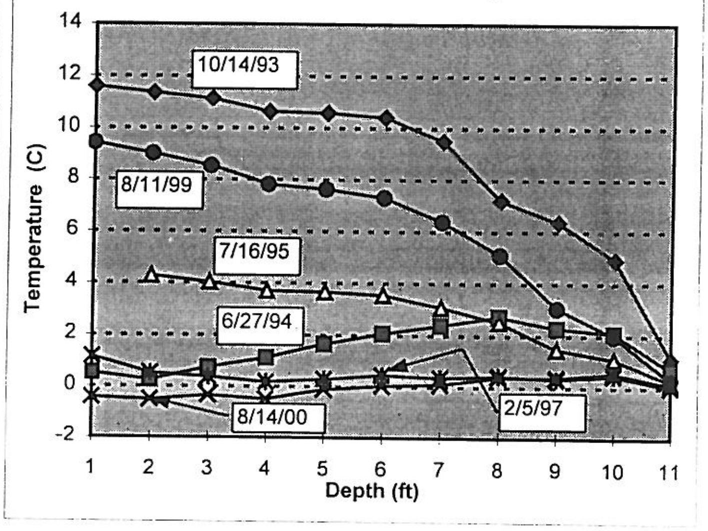


Fig. 24 - Thermistor String # 8

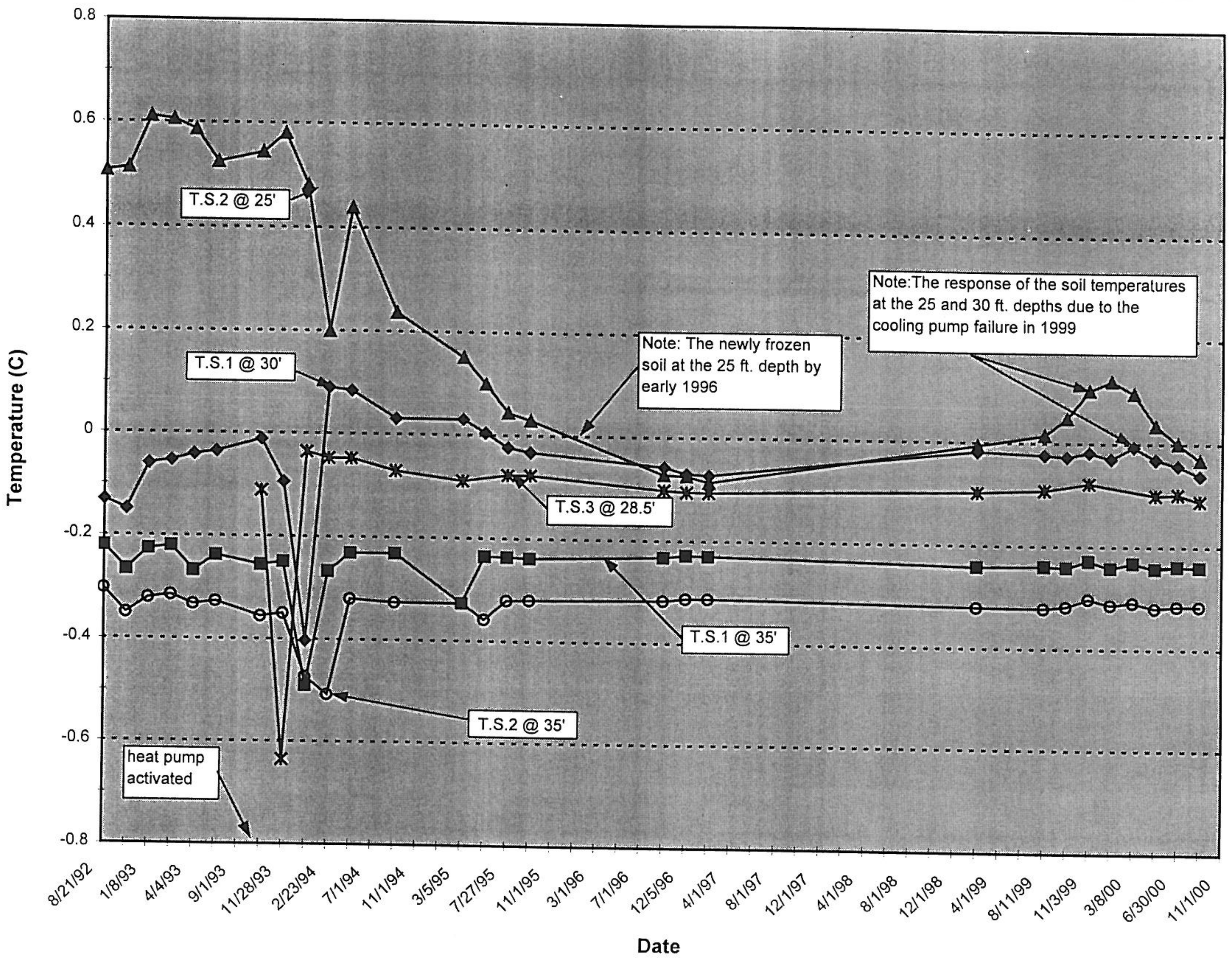


Figures 19 through 24 - Soil temperatures in the soil layers beneath the house

#8 are all inside the house and measure soil temperature beneath the floor at smaller, more frequent intervals but to much shallower depths (12 to 28 ft). String #9 measures the temperature of the cooling-grid fluid and air temperatures at various locations. Examining the temperature histories shown in figures 19 through 24, a frost heave scenario must be considered possible but it could be argued that it is unlikely since little increased frozen area is in evidence. However, strings #4 and #6 show a small amount of freezing at the surface and the temperatures at the deep end of each thermistor string are all declining, indicating that the bottom of the active thawed soil above the permafrost may be freezing (i.e. the permafrost is growing). If we concentrate on the temperatures near the bottom of the thawed soil above the permafrost, as is shown in figure 25, we see that string #2 shows that there is five feet of newly frozen soil at its location starting in early 1996 and lasting until the pump failure in 1999. This along with the moisture content noted in the drill logs certainly argues for the possibility of frost heave, at least in the small amount that has been measured. On the other hand, the amount of newly frozen material at the surface is small and disappeared during the circulating pump failure of 1999 without producing a corresponding, definitive reduction in the elevation differentials that indicate heaving (although points D, L, and M do show a small reduction in elevation difference in March of 1999 after the pump failure and a subsequent increase in March of 2000 after the pump had been reactivated for nearly nine months, see figure 17). So, although a plausible argument can be made for frost heaving, it can neither be conclusively ruled out nor confirmed. However, if frost heaving should ever cause problems in the future, several options are open to the owner.

Frost Heave Solutions: When frost heaving causes a floor elevation change, the magnitude of the heaving is directly dependent on a supply of water to the freezing front from the soils beneath the house. This site is in an area where soil moisture is high. Stutzmann Engineering reported moistures from 21% to 41% at the site in 1988. Soil moisture is continually replenished by seasonal rain and snow, and drainage is poor in this locality. These are all contributing factors in frost heaving. For frost heaving to be large enough to cause a problem, water must be carried by osmosis (commonly called "wicking") through the soil from a nearby source. The amount of water in the soil beneath the house is high but not considered sufficient to cause enough frost heaving to be a serious problem. The water table was not reported on top of the permafrost in either of the two bore logs (See appendix) nor was it reported on the Stutzman Engineering bore hole logs. Stutzman Engineering reported that the soil moistures were between 30 and 40%; this is enough to cause some mild frost heaving but not enough to be a problem. Keep in mind that frost heaving can be eliminated by removing **any one** of the three necessary contributing factors, i.e., 1) water, 2) wicking action in the soil, or 3) below freezing temperatures.

Water: By reducing the availability of water in the soil beneath the house, heaving could be reduced or even stopped. This might be done by a combination of drainage and a protective membrane system around the house to carry away rain and snowmelt that



Note: The newly frozen soil at the 25 ft. depth by early 1996

Note:The response of the soil temperatures at the 25 and 30 ft. depths due to the cooling pump failure in 1999

Figure 25 - Soil Temperatures Near the Top of the Permafrost

recharges the soil moisture. An impermeable membrane approximately 15 to 20 ft wide installed around the perimeter of the house and covered with a protective layer of gravel and a perimeter drainage system would stop or reduce any further water influx from rain and melting snow.

Installing gutters and downspouts that carry the water from the roof to the outer edge of the protective membrane would eliminate that contributor of moisture. Finally a perforated drain pipe buried in a shallow trench around the periphery of the membrane to carry all water arriving at the edge of the membrane to a lower elevation location even farther away from the house would virtually eliminate recharge of soil moisture from the soils beneath the house. Wicking action is only able to draw water for about 10 to 15 feet, so more distant wet soils are of little consequence.

Wicking Action in the Soil: It would be difficult to remove the wicking action of the soil beneath the house. This is usually accomplished by replacing fine-grained soil with a coarse soil such as clean gravel or clean coarse sand. Not an economically viable option in this case, but remember only one of the three contributing factors needs to be eliminated to eliminate the frost heaving effect.

Freezing Soil Temperatures: In Alaska, this is also a difficult factor to eliminate, however some control is available. Since preventing the further thawing of the permafrost beneath the house is the object of the heat pump system, freezing temperatures must be maintained at the depth of the permafrost. However, the heat pump thermostat can be adjusted to keep the temperature of the thawed soil beneath the house just slightly above freezing. This will reduce the frost heaving potential without risking permafrost thawing. (The only way to completely stop the permafrost from melting is to create below-freezing temperatures in the soil above it). With careful control of the heat pump thermostat, the amount of heat arriving at the permafrost can be limited to a very small amount, and thus thawing of the permafrost and associated subsidence also would be very small. This type of control, although possible, is difficult and requires an owner who is willing to frequently (at least monthly) monitor the soil temperatures and adjust the thermostat on the heat pump accordingly (the installation of a feedback control system that automatically adjusts the heat pump to maintain the required soil temperature could be installed but it would be an added expense of several hundred dollars).

Since elimination of only one of the three causal factors is needed to prevent frost heave, we are in the fortunate situation of having multiple ways to control any future frost heave. Control of the temperatures of the soil beneath the house and removal of the water as outlined above will mitigate frost heaving and/or permafrost thawing and will keep the thermal conditions beneath the house in an acceptable balance that will have a positive affect on the stability of the foundation.

Cost of Operation of the Heat Pump

Although operating cost was not studied in depth, a wattmeter was installed which records the power usage by the heat pump system. Measurements indicate that during a period of relative inactivity (such as might be expected once the system has cooled the soil mass and only needs to remove heat leaking through the four inches of floor insulation) it uses around 2 kW per day. When running at near maximum cooling (as when recovering from the period of down time after the circulating pump failure) the heat pump system uses about 40 kW per day. At today's electric power price, that rate of power usage translates to a cost of between 20 cents and $4.00 per day. It also must be noted that much of this cost is recovered in lower heating fuel cost during the winter when the heat pump discharges the recovered heat back into the house. However, during the warmer parts of summer when the extra heat is unwanted, it will be diverted to outside the house and the cost recovery will be nil.

Conclusions

The above information and data analysis suggest that settlement of the foundation since the releveling in 1993 has been nominal, and some of that can probably be attributed to normal compaction of the fill placed under the footing during the releveling. The temperature data show that there has been no further thawing of the permafrost, and most of the thermistor strings indicate that there is some newly frozen soil at the top of the permafrost. The heat pump has provided a substantial reservoir of cold soil beneath the house that will protect the permafrost from further thawing and will provide an adequate buffer of protection to last through a period of up to several weeks should the heat pump ever need to be shut-down while awaiting repair. Based on this evidence, it can be argued that the foundation is stable and that as long as the heat pump is operated properly, settlement will be minimal and the foundation will perform without problems.

Analysis of the database for this experiment suggests that minor settlement or frost heaving continued for several months after the house was releveled and the heat pump was installed. Based on floor level measurements referenced to the nail in the tree outside the house, the maximum settlement/frost heave (which occurred at point B) was 39 mm (~1½+ inches). This small elevation change has several possible causes. It could have been a creep failure of the soil beneath the foundation, allowing it to settle, or it could have been a combination of settlement coupled with frost heaving around the cooling grid. Of course, over an eight-year period, part of the 39 mm could be growth of the tree containing the nail. Freezing temperatures near the top of the permafrost have shown a slight but significant decrease indicating that any thawing of the permafrost has now stopped (figure 25, TS1 and TS2 outside the house at 35 ft and TS3 beneath the house at 28.5 ft.).

The author's opinion is that the settlement/frost heave found by monitoring the floor level of the house was caused by a combination of effects including settlement into the soft, high-moisture content soil, compaction of the gravel placed under the footing during the 1992 releveling, and a small amount of frost heaving in the soil beneath the cooling grid. Based on the last four years' data, he believes that the foundation will now remain stable as long as the heat pump is operated properly. This requires that the heat pump thermostat is adjusted as needed so that it intercepts the heat entering the soil beneath the house before it can get to the permafrost, but without allowing the cooling-grid fluid to become too cold which would cause substantial new freezing of the soils beneath the house.

The temperatures from thermistor strings #1 and #2, located outside the house, show a slight decline in temperature, especially in the mid layers between the surface and the permafrost. This indicates that the cooling effect of the heat pump extends somewhat beyond the boundaries of the foundation to give added protection to the permafrost from the effects of summer weather. This, in conjunction with the above data, yields a very positive outlook for the future health of the foundation.

The heat pump system has suffered three operational problems during its seven-year operation that are not normally experienced with this type of system. These problems include three circulation pump failures (the cause of which has now been established and corrected), air locks in the cooling grid lines (caused by low cooling fluid level), and a shutdown of the heat pump due to a clogged air filter. Although none of the failures has been serious, they have interrupted the cooling process, once for a few months although not long enough to allow re-melting of the permafrost below the house. The effect of these failures has or can be eliminated by frequent operational checks by the owner (to see that the unit is still running), periodic inspection by a qualified refrigeration service company and routine maintenance (replacing the air filter when it becomes dirty and topping off the cooling fluid reservoir when needed). During the project, renters who have resided in the house have been unable or (in some cases) unwilling to care for the system as an owner would. To ensure adequate care of the system the Permafrost Technology Foundation now has a commercial refrigeration firm, (Altrol Inc., Fairbanks, AK) scheduled to visit the house for maintenance checks on the system every two months. With a concerned owner watching the unit, these checks could probably be spaced out to once per year just as the furnace is inspected annually before the approach of winter.

A concerned owner who is willing to spend a few minutes each month to monitor the soil temperatures and check the heat pump system for proper operation, and to change the air filter when needed. This coupled with an annual check up by a professional refrigeration service should be able to keep the heat pump system running for the life of the house. This will protect the permafrost and supplement the heating system to reduce the heating costs. If these things are done, it is the author's opinion there should be no further problems with the stability of the foundation.

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Appendix

Bore Hole Logs

SOIL DESCRIPTION

SURFACE ELEVATION:

BROWN SILT W/ TRACE OF GRAVEL MOIST

BROWN TO GRAY SILT W/ TRACE ORGANICS (WOOD AND ROOTS) MOIST

GRAY TO BROWN SILT, MOIST

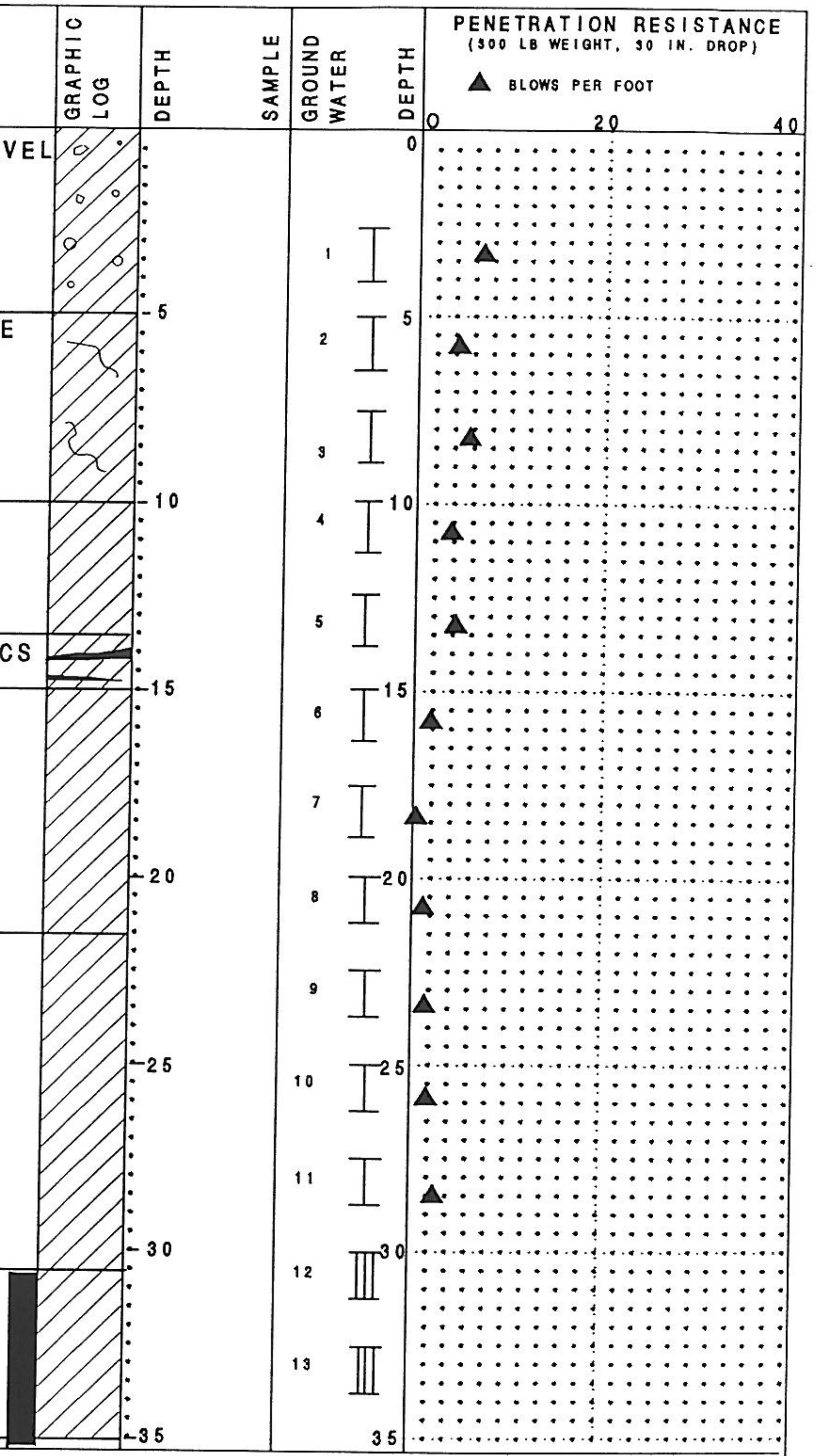
GRAY SILT, MOIST W/ ORGANICS BLACK LAMENTATIONS

GRAY TO BLACK ORGANIC SILT VERY MOIST

ORGANIC ODOR

GREY TO BLACK ORGANIC SILT VERY MOIST TO WET. SAMPLE LIQUID IN PLACES ORGANIC ODOR.

BROWN TO GREY SILT Nbn. VS LENSES 1-2mm THICK 6%-7% VISIBLE ICE



LEGEND

▨ SILT
GRAVEL
SAND
CLAY
PEAT
ORGANIC CONTENT
FROZEN GROUND

IMPERVIOUS SEAL
WATER LEVEL
SCREENED INTERVAL
Ⓣ THERMISTOR
3 IN O.D. SPLIT SPOON SAMPLE
G GRAB SAMPLE
P 3 IN. O.D. THIN-WALL SAMPLE
3 IN. O.D. DRY CORE RUN

● % WATER CONTENT

BORING LOG

NAME: 728 CONSTITUTION
LOCATION: 4.8'N & 1'W OF NORTH CORNER
PAGE: ONE OF TWO
DATE: JULY 6, 1992

PERMAFROST TECHNOLOGY FOUNDATION

SOIL DESCRIPTION

SURFACE ELEVATION:

BROWN ORGANIC SILT Nbn

BR.ORG.SILT.VS LENSES1-2mm

BROWN ICE W/SILT INCLUSIONS

BROWN TO GREY SILT Nbn TO VC VISIBLE ICE< 1%

BROWN TO GREY SILT Nbn TO Vr. ICE IN NEAR VERTICAL PLANES 3-4mm THICK ~ 1%-2%

GREY SILT Vc-Vs. VISIBLE ICE 15%-20%. SOME ORGANICS

BROWN ICE W/ SILT INCLUSIONS

GREY SILT ORGANIC ODOR. Vs TO Vr
Vs UP TO 2mm THICK (HORIZONTAL)
Vr UP TO 4mm THICK (VARIES) 5%-15%

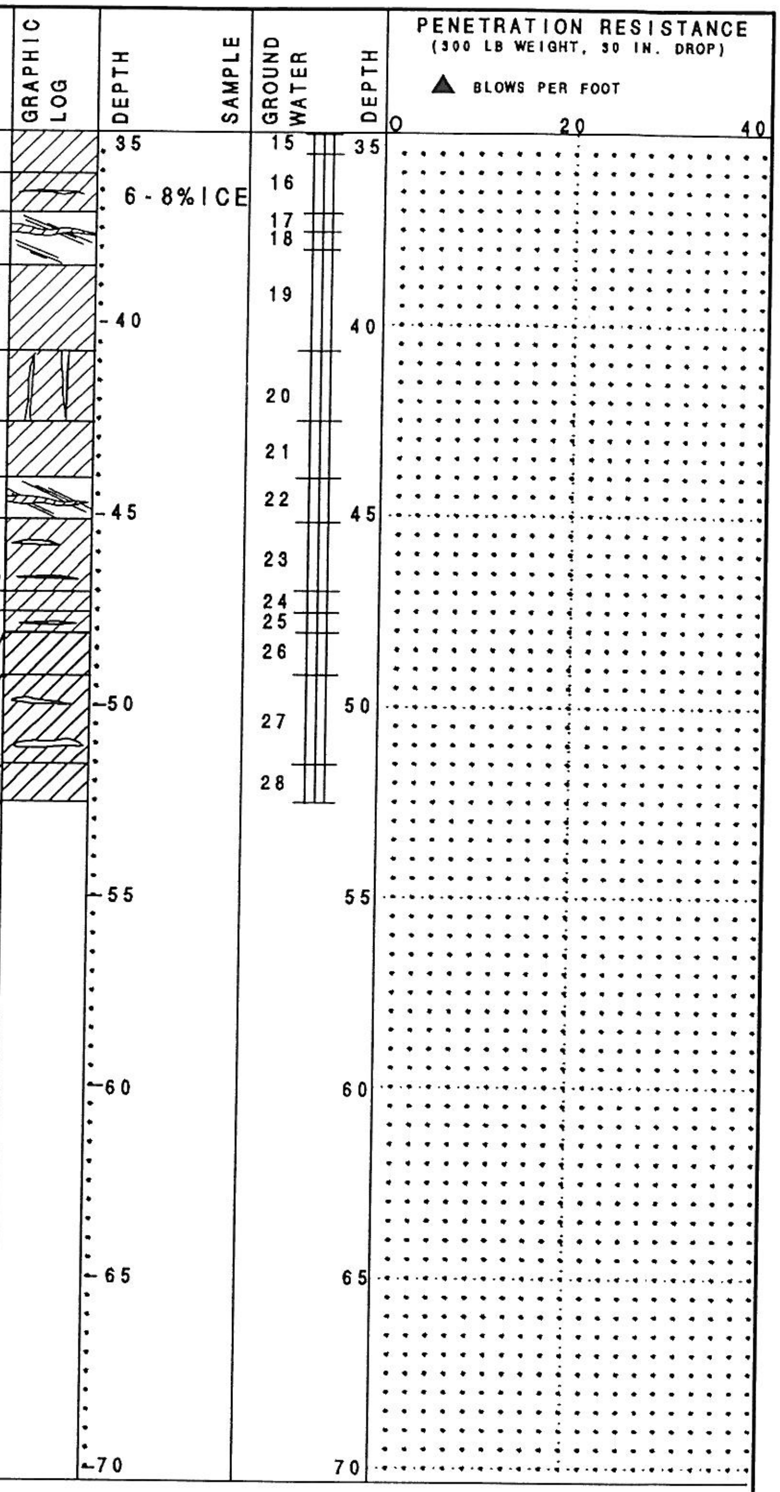
GREY TO BROWN SILT Nbn

BROWN TO GREY SILT. Vr VEIN UP TO 10mm THICK. vISIBLE ICE 2% Nbn AWAY FROM VIEW.

BROWN TO GREY SILT Nbn

BROWN TO GREY SILT Nbn TO Vr, ICE VEINS UP TO 15mm 5%VI

BROWN SILT Nbn W/ SLIGHT Vr 1%-2% VI



LEGEND

SILT

GRAVEL

SAND

CLAY

PEAT

ORGANIC CONTENT

FROZEN GROUND

IMPERVIOUS SEAL

WATER LEVEL

SCREENED INTERVAL

THERMISTOR

3 IN O.D. SPLIT SPOON SAMPLE

GRAB SAMPLE

3 IN. O.D. THIN-WALL SAMPLE

3 IN. O.D. DRY CORE RUN

● % WATER CONTENT

BORING LOG

NAME: 728 CONSTITUTION

LOCATION: 4.8' N & 1'W OF NORTH CORNER

PAGE: TWO OF TWO

DATE: JULY 6, 1992

PERMAFROST TECHNOLOGY FOUNDATION

SOIL DESCRIPTION

SURFACE ELEVATION:

BROWN SANDY SILTY GRAVEL, SLIGHTLY MOIST (ALLUVIUM)

BROWN SILT, MOIST, SOME SAND

BROWN SILT W GRAVEL, GRAVEL FINE MEDIUM, ROUNDED, MOIST

REDDISH BROWN TO BROWN SILT, MOIST

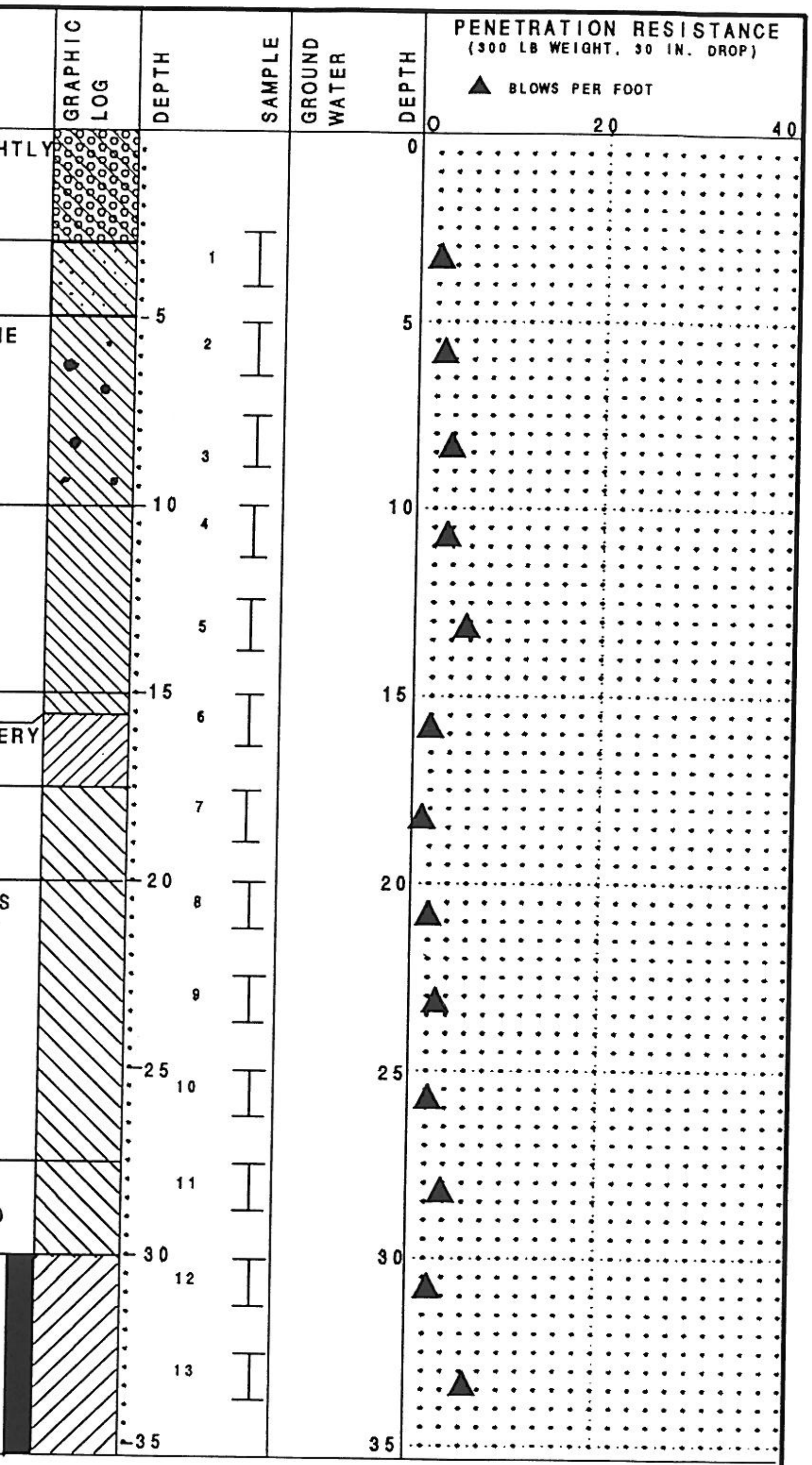
0.5' OF REDDISH BROWN TO BROWN SILT; MOIST, OVER 1'GREY SILT, VERY MOIST, ORGANIC SMELL

GREY TO BLACK SILT, VERY MOIST, SLIGHT ORGANIC ODOR

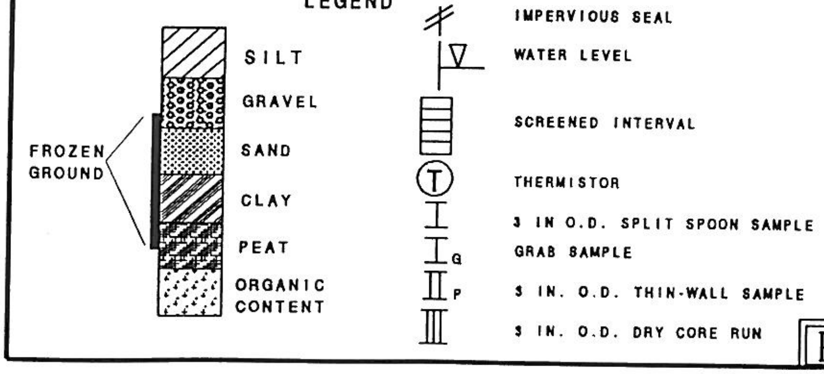
GREY TO BLACK SILT WITH ORGANICS (TRACE) WEAK ORGANIC ODOR, VERY MOIST

GREY TO BLACK SILT W/ TRACE ORGANICS, ORGANIC ODOR, MOIST TO WET (WATER ON TOP OF SPOON)

GREY SILT W/ TRACE ORGANICS
Nbn



LEGEND



● % WATER CONTENT

BORING LOG

NAME: 728 CONSTITUTION
BOREHOLE #2
LOCATION: SOUTH CORNER
PAGE: ONE OF TWO
DATE: JULY6, 1992

PERMAFROST TECHNOLOGY FOUNDATION

SOIL DESCRIPTION

SURFACE ELEVATION:

GREY SILT W TRACE ORGANICS Nbn

BROWN TO GREY SILT, VS UP TO 11mm THICK. VI-6%

BROWN GO GREY ICE W/ SILT INCLUSIONS

BROWN TO GREY SILT VS LENSES UP TO 2mm THICK, VI5%

BROWN TO GREY SILT TO ICE W/SILT INCLUS. VI~50%, LENSES TO 3mm

BROWN TO GREY SILT Vc 7 Vs VI~5%-6%

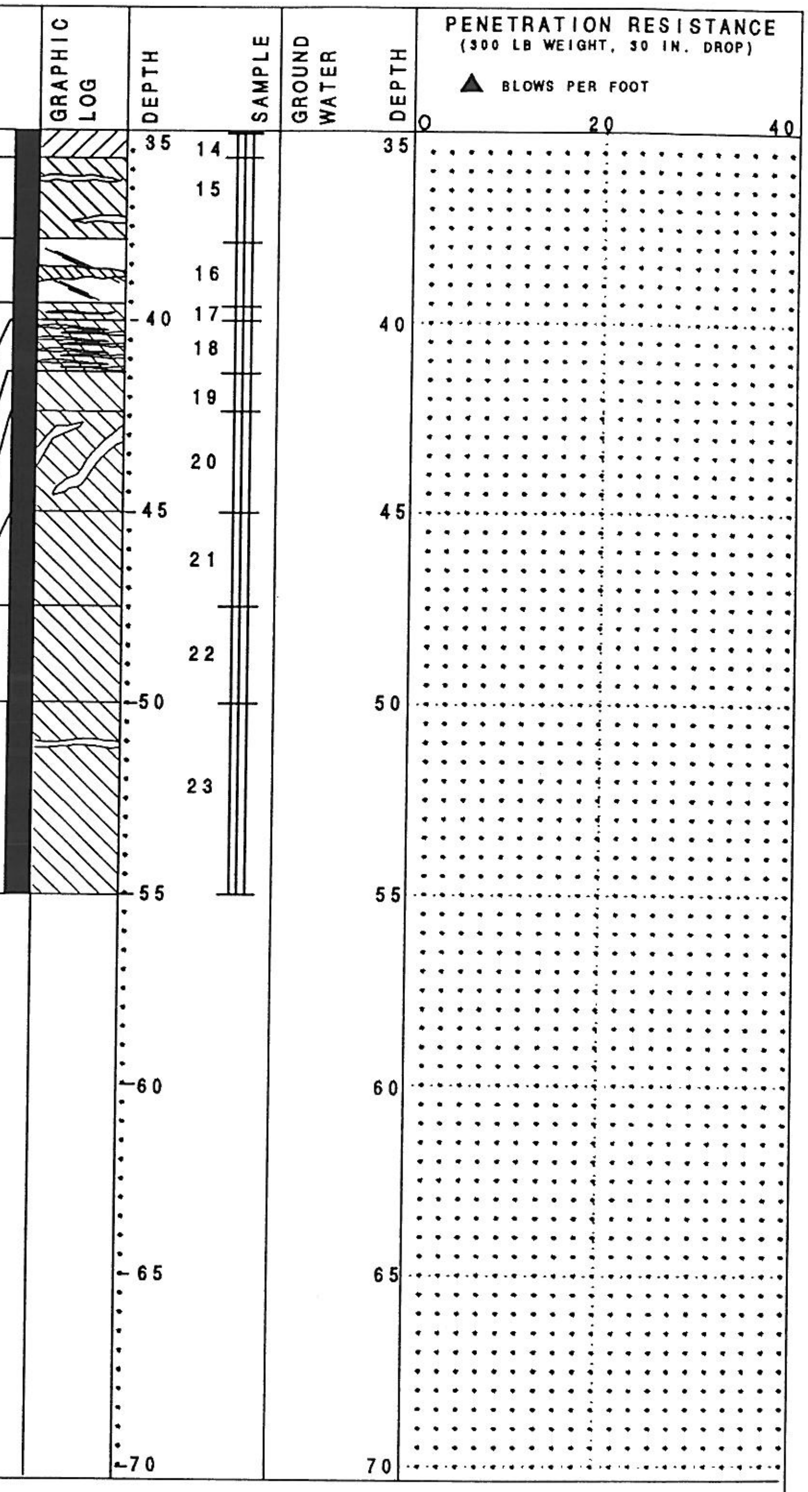
BROWN TO GREY SILT, Vs TO Vr LENSES UP TO 2mm THICK, VEINS @ 45 5mm THICK, VI 20%

BROWN TO GREY SILT, Vs W/ TRACE Vr, VI 0-5%

BROWN TO GREY SILT Nbn W/ OCCASIONAL Vs, VI<1%

BROWN TO GREY SILT Nbn W/ TRACE Vr, ICE VEIN 6mm THICK @ ~51 FT.

BOH @ 55 FT.



LEGEND

SILT

GRAVEL

SAND

CLAY

PEAT

ORGANIC CONTENT

FROZEN GROUND

IMPERVIOUS SEAL

WATER LEVEL

SCREENED INTERVAL

THERMISTOR

3 IN O.D. SPLIT SPOON SAMPLE

GRAB SAMPLE

3 IN. O.D. THIN-WALL SAMPLE

3 IN. O.D. DRY CORE RUN

● % WATER CONTENT

BORING LOG

NAME: 728 CONSTITUTION
BOREHOLE #2
LOCATION: SOUTH CORNER
PAGE: TWO OF TWO
DATE: JULY 6, 1992

PERMAFROST TECHNOLOGY FOUNDATION

Temperature Measurements

CN Thermistor Temperture Log

Operator T & R McFadden
Date: 8/14/00

					String #2			String # 3	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0		**#NUM!**	0	10470	**8.946**	0,-0.5H	15,310	**1.263**
2	5	12677	**5.033**	5	14090	**2.911**	0	14910	**1.786**
3	10	14840	**1.880**	15	16104	**0.268**	0.5	14714	**2.049**
4	20	16015	**0.376**	25	16352	**-0.032**	1	14558	**2.260**
5	30	16377	**-0.062**	35	16591	**-0.316**	1.5	14234	**2.708**
6	35	16527	**-0.240**	40	16620	**-0.350**	2	14226	**2.719**
7	40	16667	**-0.405**	44	16666	**-0.404**	3	14101	**2.895**
8	45	16659	**-0.396**	48	16653	**-0.389**	5	14469	**2.382**
9	48	16621	**-0.351**	50	16680	**-0.421**	9	15141	**1.482**
10	50	16700	**-0.444**	51	16634	**-0.367**	13	15640	**0.842**
11	51	16524	**-0.237**	52	16664	**-0.402**	21	15890	**0.530**
12	51.5		**#NUM!**	52.5	16636	**-0.369**	28.5	16419	**-0.112**

		String #4			String #5			String #6	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0, -1H	15122	**1.507**	0, -0.5H	16166	**0.192**	0, -.8S.L	17372	**-1.213**
2	0, -1.5H	15316	**1.255**	0	15697	**0.771**	0, 0 PIPE	17985	**-1.886**
3	0, PIPE	17003	**-0.795**	0.5	15763	**0.688**	0.5	16919	**-0.698**
4	1	15575	**0.924**	1	15691	**0.778**	1	16604	**-0.331**
5	1.5	14931	**1.759**	1.5	15543	**0.965**	1.5	16256	**0.083**
6	2	14766	**1.979**	2	15583	**0.914**	2	15982	**0.417**
7	2.5	14696	**2.073**	3	15529	**0.983**	2.5	15967	**0.435**
8	3	14674	**2.103**	5	15477	**1.049**	3	15936	**0.473**
9	4	14659	**2.123**	9	15734	**0.724**	4	15859	**0.569**
10	8	15127	**1.500**	13	15864	**0.562**	8	15583	**0.914**
11	12	15437	**1.100**	16	15938	**0.471**	12	15875	**0.549**
12	12.75		**#NUM!**			**#NUM!**	12.752	15889	**0.531**

		String #7			String #8			String #9	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0	17876	**-1.768**	0	16685	**-0.426**	1OUT	22412	**-6.090**
2	0.5	19404	**-3.349**	1	16762	**-0.516**	2OUT		**#NUM!**
3	1	17253	**-1.079**	1	16615	**-0.344**	3OUT		**#NUM!**
4	1.5	17322	**-1.157**	2	16739	**-0.490**	4OUT		**#NUM!**
5	2	16944	**-0.727**	2.5	16418	**-0.111**	5OUT		**#NUM!**
6	2.5	16818	**-0.582**	3	16288	**0.045**	1IN	17220	**-1.042**
7	3.5	16758	**-0.512**	3.5	16244	**0.098**	2IN	21243	**-5.077**
8	5.5	16449	**-0.148**	4	16013	**0.379**	3IN	18680	**-2.618**
9	9.5	16353	**-0.033**	5	16021	**0.369**	4IN	18340	**-2.264**
10	13.5	16030	**0.358**	9	15866	**0.560**	5IN	16890	**-0.665**
11	24.75	15902	**0.515**	13	16240	**0.103**	FLOOR	7996	**14.624**
12			**#NUM!**			**#NUM!**	FLOOR	7830	**15.074**

CN Thermistor Temperture Log

Operator: **T & R McFadden**

Date: **8/1/00**

		String #1				String #2				String # 3	
Therm #	Depth (ft)	R (avg)	**Temp (C)**		Depth (ft)	R (avg)	**Temp (C)**		Depth (ft)	R (avg)	**Temp (C)**
1	0		**#NUM!**		0	10333	**9.219**		0,-0.5H	11,624	**6.795**
2	5	12942	**4.615**		5	14186	**2.775**		0	11954	**6.224**
3	10	15186	**1.423**		15	16137	**0.227**		0.5	12360	**5.546**
4	20	16011	**0.381**		25	16351	**-0.031**		1	12764	**4.895**
5	30	16378	**-0.063**		35	16596	**-0.322**		1.5	12977	**4.561**
6	35	16531	**-0.245**		40	16624	**-0.355**		2	13402	**3.913**
7	40	16671	**-0.410**		44	16673	**-0.412**		3	13933	**3.135**
8	45	16656	**-0.392**		48	16660	**-0.397**		5	14792	**1.944**
9	48	16625	**-0.356**		50	16686	**-0.428**		9	15292	**1.286**
10	50	16705	**-0.450**		51	16640	**-0.374**		13	15646	**0.835**
11	51	16529	**-0.243**		52	16671	**-0.410**		21	15873	**0.551**
12	51.5		**#NUM!**		52.5	16643	**-0.377**		28.5	16420	**-0.113**

		String #4				String #5				String #6	
Therm #	Depth (ft)	R (avg)	**Temp (C)**		Depth (ft)	R (avg)	**Temp (C)**		Depth (ft)	R (avg)	**Temp (C)**
1	0, -1H	12082	**6.007**		0, -0.5H	15482	**1.042**		0, -.8S.L	16502	**-0.211**
2	0, -1.5H	12160	**5.877**		0	15053	**1.597**		0, 0 PIPE	16216	**0.132**
3	0, PIPE	12457	**5.387**		0.5	15331	**1.236**		0.5	16509	**-0.219**
4	1	6150	**20.346**		1	15453	**1.079**		1	16545	**-0.262**
5	1.5	13365	**3.968**		1.5	15427	**1.113**		1.5	16314	**0.013**
6	2	13687	**3.491**		2	15547	**0.960**		2	16038	**0.348**
7	2.5	14021	**3.009**		3	15599	**0.894**		2.5	16028	**0.360**
8	3	14324	**2.583**		5	15600	**0.893**		3	16013	**0.379**
9	4	14740	**2.014**		9	15758	**0.694**		4	15955	**0.450**
10	8	15341	**1.223**		13	15845	**0.586**		8	15613	**0.876**
11	12	15466	**1.063**		16	15916	**0.498**		12	15855	**0.574**
12	12.75		**#NUM!**				**#VALUE!**		12.752	15865	**0.561**

		String #7				String #8				String #9	
Therm #	Depth (ft)	R (avg)	**Temp (C)**		Depth (ft)	R (avg)	**Temp (C)**		Depth (ft)	R (avg)	**Temp (C)**
1	0	16445	**-0.143**		0	16050	**0.333**		1OUT	6850	**17.972**
2	0.5	16874	**-0.646**		1	16477	**-0.181**		2OUT	6000	**20.894**
3	1	16249	**0.092**		1	16579	**-0.302**		3OUT	9000	**12.108**
4	1.5	16825	**-0.590**		2	16759	**-0.513**		4OUT		**#NUM!**
5	2	16745	**-0.497**		2.5	16430	**-0.125**		5OUT		**#NUM!**
6	2.5	16773	**-0.529**		3	16301	**0.029**		1IN	6760	**18.262**
7	3.5	16761	**-0.515**		3.5	16274	**0.062**		2IN	7187	**16.926**
8	5.5	16457	**-0.157**		4	16042	**0.343**		3IN	6841	**18.001**
9	9.5	16369	**-0.052**		5	16014	**0.378**		4IN	6969	**17.596**
10	13.5	16038	**0.348**		9	15843	**0.588**		5IN	6833	**18.027**
11	24.75	15880	**0.543**		13	16231	**0.113**		FLOOR	6782	**18.191**
12			**#NUM!**				**#NUM!**		FLOOR	7000	**17.499**

CN Thermistor Temperture Log

Operator: **T & R McFadden**

Date: **6/30/00**

		String #1			String #2			String # 3	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0		**#NUM!**	0	10425	**9.035**	0,-0.5H	16155	**0.205**
2	5	15561	**0.942**	5	15315	**1.256**	0	15709	**0.756**
3	10	15755	**0.698**	15	16144	**0.219**	0.5	15601	**0.891**
4	20	15961	**0.443**	25	16325	**0.000**	1	15518	**0.997**
5	30	16361	**-0.043**	35	16591	**-0.316**	1.5	15232	**1.364**
6	35	16526	**-0.239**	40	16622	**-0.353**	2	15270	**1.314**
7	40	16665	**-0.403**	44	16667	**-0.405**	3	15146	**1.476**
8	45	16650	**-0.385**	48	16655	**-0.391**	5	15281	**1.300**
9	48	16623	**-0.354**	50	16682	**-0.423**	9	15310	**1.263**
10	50	16700	**-0.444**	51	16636	**-0.369**	13	15567	**0.934**
11	51	16523	**-0.236**	52	16665	**-0.403**	21	15801	**0.641**
12	51.5		**#NUM!**	52.5	16637	**-0.370**	28.5	16408	**-0.099**

		String #4			String #5			String #6	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0, -1H	15797	**0.646**	0, -0.5H	16503	**-0.212**	0, -.8S.L	17305	**-1.138**
2	0, -1.5H	15729	**0.731**	0	16059	**0.322**	0, 0 PIPE	17842	**-1.731**
3	0, PIPE	16719	**-0.466**	0.5	16130	**0.236**	0.5	16992	**-0.782**
4	1	15916	**0.498**	1	16049	**0.335**	1	16718	**-0.465**
5	1.5	15655	**0.823**	1.5	15890	**0.530**	1.5	16370	**-0.054**
6	2	15586	**0.910**	2	15929	**0.482**	2	16117	**0.252**
7	2.5	15574	**0.926**	3	15850	**0.580**	2.5	16121	**0.247**
8	3	15581	**0.917**	5	15673	**0.801**	3	16102	**0.270**
9	4	15516	**0.999**	9	15688	**0.782**	4	16010	**0.382**
10	8	15407	**1.138**	13	15755	**0.698**	8	15544	**0.964**
11	12	15393	**1.156**	16	15834	**0.600**	12	15755	**0.698**
12	12.75		**#NUM!**			**#NUM!**	12.752		**#NUM!**

		String #7			String #8			String #9	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0	17815	**-1.702**	0	16933	**-0.715**	1OUT	19700	**-3.639**
2	0.5	19010	**-2.955**	1	17027	**-0.822**	2OUT	15000	**1.667**
3	1	17393	**-1.236**	1	16822	**-0.586**	3OUT		**#NUM!**
4	1.5	17509	**-1.366**	2	16800	**-0.561**	4OUT	14900	**1.800**
5	2	17132	**-0.942**	2.5	16391	**-0.079**	5OUT		**#NUM!**
6	2.5	16927	**-0.708**	3	16257	**0.082**	1IN	16627	**-0.358**
7	3.5	16781	**-0.539**	3.5	16223	**0.123**	2IN	20500	**-4.400**
8	5.5	16427	**-0.122**	4	15976	**0.424**	3IN	17836	**-1.725**
9	9.5	16317	**0.010**	5	15924	**0.488**	4IN	17721	**-1.599**
10	13.5	15958	**0.446**	9	15748	**0.707**	5IN	16265	**0.072**
11	24.75	15786	**0.659**	13	16189	**0.164**	FLOOR	7629	**15.634**
12			**#NUM!**			#NUM!	FLOOR	7700	**15.434**

CN Thermistor Temperture Log

Operator **McFadden, T & R.**
Date: **5/18/00**

		String #1			String #2			String # 3	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0		**#NUM!**	0	15459	**1.072**	0,-0.5H	13882	**3.208**
2	5	16134	**0.231**	5	15819	**0.618**	0	13962	**3.093**
3	10	15764	**0.687**	15	16096	**0.277**	0.5	14225	**2.721**
4	20	15885	**0.536**	25	16296	**0.035**	1	14471	**2.380**
5	30	16351	**-0.031**	35	16594	**-0.320**	1.5	14478	**2.370**
6	35	16529	**-0.243**	40	16624	**-0.355**	2	14730	**2.027**
7	40	16668	**-0.407**	44	16668	**-0.407**	3	14909	**1.788**
8	45	16652	**-0.388**	48	16657	**-0.394**	5	15263	**1.324**
9	48	16625	**-0.356**	50	16683	**-0.424**	9	15245	**1.347**
10	50	16701	**-0.445**	51	16636	**-0.369**	13	15436	**1.101**
11	51	16526	**-0.239**	52	16666	**-0.404**	21	15707	**0.758**
12	51.5		**#NUM!**	52.5	16640	**-0.374**	28.5	16410	**-0.101**

		String #4			String #5			String #6	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0, -1H	14045	**2.975**	0, -0.5H	15835	**0.598**	0, -.8S.L	16508	**-0.218**
2	0, -1.5H	14055	**2.961**	0	15465	**1.064**	0, 0 PIPE	16290	**0.042**
3	0, PIPE	14744	**2.008**	0.5	15695	**0.773**	0.5	16522	**-0.235**
4	1	14755	**1.994**	1	15748	**0.707**	1	16527	**-0.240**
5	1.5	14690	**2.081**	1.5	15668	**0.807**	1.5	16261	**0.077**
6	2	14847	**1.870**	2	15749	**0.706**	2	16007	**0.386**
7	2.5	15029	**1.629**	3	15724	**0.737**	2.5	16012	**0.380**
8	3	15190	**1.418**	5	15575	**0.924**	3	15994	**0.402**
9	4	15339	**1.225**	9	15549	**0.957**	4	15905	**0.512**
10	8	15356	**1.204**	13	15604	**0.888**	8	15403	**1.143**
11	12	15247	**1.344**	16	15714	**0.749**	12	15587	**0.909**
12	12.75		**#NUM!**			**#NUM!**	12.752		**#NUM!**

		String #7			String #8			String #9	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0	16370	**-0.054**	0	15990	**0.407**	1OUT	14646	**2.141**
2	0.5	16863	**-0.634**	0.5	16428	**-0.123**	2OUT	12600	**5.156**
3	1	16196	**0.156**	1	16513	**-0.224**	3OUT	9000	**12.108**
4	1.5	16758	**-0.512**	2	16672	**-0.411**	4OUT	400	**94.454**
5	2	16671	**-0.410**	2.5	16346	**-0.025**	5OUT	1004	**66.040**
6	2.5	16687	**-0.429**	3	16212	**0.136**	1IN	14765	**1.980**
7	3.5	16673	**-0.412**	3.5	16163	**0.196**	2IN	16390	**-0.078**
8	5.5	16359	**-0.040**	4	15882	**0.540**	3IN	15366	**1.191**
9	9.5	16251	**0.089**	5	15769	**0.681**	4IN	15627	**0.859**
10	13.5	15826	**0.610**	9	15580	**0.918**	5IN	14644	**2.143**
11	24.75	15616	**0.872**	13	16137	**0.227**	FLOOR	7941	**14.772**
12			**#NUM!**			**#NUM!**	FLOOR	7230	**16.796**

CN Thermistor Temperture Log

Operator: **Roy Fenner**
Date: **3/8/00**

		String #1			String #2			String # 3	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0	N/A	**#VALUE!**	0	21355	**-5.177**	0,-0.5H	16405	**-0.095**
2	5	16000	**0.395**	5	15710	**0.754**	0	15895	**0.524**
3	10	15450	**1.083**	15	15925	**0.487**	0.5	15800	**0.642**
4	20	15748	**0.707**	25	16244	**0.098**	1	15682	**0.789**
5	30	16330	**-0.006**	35	16585	**-0.309**	1.5	15340	**1.224**
6	35	16520	**-0.232**	40	16610	**-0.338**	2	15310	**1.263**
7	40	16660	**-0.397**	44	16660	**-0.397**	3	15013	**1.650**
8	45	16640	**-0.374**	48	16650	**-0.385**	5	14845	**1.873**
9	48	16615	**-0.344**	50	16672	**-0.411**	9	14635	**2.156**
10	50	16690	**-0.432**	51	16628	**-0.360**	13	14966	**1.712**
11	51	16515	**-0.226**	52	16657	**-0.394**	21	15560	**0.943**
12	51.5	N/A	**#VALUE!**	52.5	16630	**-0.362**	28.5	N/A	**#VALUE!**

		String #4			String #5			String #6	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0, -1H	15885	**0.536**	0, -0.5H	16345	**-0.024**	0, -.8S.L	16940	**-0.723**
2	0, -1.5H	15695	**0.773**	0	15920	**0.493**	0, 0 PIPE	17560	**-1.422**
3	0, PIPE	16625	**-0.356**	0.5	15960	**0.444**	0.5	16801	**-0.562**
4	1	15740	**0.717**	1	15825	**0.611**	1	16395	**-0.084**
5	1.5	15508	**1.009**	1.5	15616	**0.872**	1.5	15970	**0.432**
6	2	15411	**1.133**	2	15600	**0.893**	2	15680	**0.792**
7	2.5	15356	**1.204**	3	15416	**1.127**	2.5	15650	**0.830**
8	3	15306	**1.268**	5	15088	**1.551**	3	15585	**0.912**
9	4	15116	**1.515**	9	15035	**1.621**	4	15419	**1.123**
10	8	14706	**2.060**	13	15252	**1.338**	8	14836	**1.885**
11	12	14710	**2.054**	16	15510	**1.007**	12	8752	**12.699**
12	12.75	N/A	**#VALUE!**		#N/A	**#N/A**	12.752	N/A	**#VALUE!**

		String #7			String #8			String #9	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0	17170	**-0.985**	0	16345	**-0.024**	1OUT	20608	**-4.500**
2	0.5	18460	**-2.390**	0.5	16502	**-0.211**	2OUT	18170	**-2.084**
3	1	16783	**-0.541**	1	16378	**-0.063**	3OUT	N/A	**#VALUE!**
4	1.5	16952	**-0.736**	2	16423	**-0.117**	4OUT	N/A	**#VALUE!**
5	2	16620	**-0.350**	2.5	16034	**0.353**	5OUT	N/A	**#VALUE!**
6	2.5	16488	**-0.194**	3	15839	**0.593**	1IN	16504	**-0.213**
7	3.5	16426	**-0.121**	3.5	15691	**0.778**	2IN	19848	**-3.783**
8	5.5	16000	**0.395**	4	15300	**1.276**	3IN	17410	**-1.255**
9	9.5	15785	**0.661**	5	15176	**1.436**	4IN	17440	**-1.289**
10	13.5	15210	**1.392**	9	15148	**1.473**	5IN	16685	**-0.426**
11	24.75	15091	**1.548**	13	16061	**0.320**	FLOOR	8220	**14.033**
12		#N/A	**#N/A**		#N/A	**#N/A**	FLOOR	N/A	**#VALUE!**

CN Thermistor Temperture Log

Operator: ROY FENNER
Date: 02/16/00

		String #1			String #2			String # 3	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0	N/A	**#VALUE!**	0	17880	**-1.772**	0,-0.5H	15322	**1.247**
2	5	15851	**0.579**	5	15751	**0.703**	0	15221	**1.378**
3	10	15459	**1.072**	15	16251	**0.089**	0.5	15130	**1.496**
4	20	15770	**0.679**	25	16650	**-0.385**	1	14995	**1.674**
5	30	16401	**-0.091**	35	16780	**-0.537**	1.5	14892	**1.810**
6	35	16660	**-0.397**	40	16621	**-0.351**	2	14781	**1.959**
7	40	16782	**-0.540**	44	16801	**-0.562**	3	14424	**2.444**
8	45	16677	**-0.417**	48	16848	**-0.616**	5	14401	**2.476**
9	48	16900	**-0.676**	50	16790	**-0.549**	9	14432	**2.433**
10	50	16745	**-0.497**	51	16681	**-0.422**	13	14715	**2.047**
11	51	16688	**-0.430**	52	16720	**-0.467**	21	15601	**0.891**
12	51.5	N/A	**#VALUE!**	52.5	N/A	**#VALUE!**	28.5	N/A	**#VALUE!**

		String #4			String #5			String #6	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0, -1H	15250	**1.340**	0, -0.5H	16880	**-0.653**	0, -.8S.L	16982	**-0.771**
2	0, -1.5H	14601	**2.202**	0	15621	**0.866**	0, 0 PIPE	16990	**-0.780**
3	0, PIPE	14870	**1.840**	0.5	15450	**1.083**	0.5	16354	**-0.035**
4	1	14701	**2.066**	1	15020	**1.641**	1	16660	**-0.397**
5	1.5	14660	**2.122**	1.5	15100	**1.536**	1.5	15781	**0.666**
6	2	14771	**1.972**	2	15151	**1.469**	2	15350	**1.211**
7	2.5	14201	**2.754**	3	14890	**1.813**	2.5	15301	**1.274**
8	3	14351	**2.545**	5	14660	**2.122**	3	14990	**1.680**
9	4	14330	**2.574**	9	14720	**2.041**	4	14982	**1.691**
10	8	14440	**2.422**	13	15223	**1.375**	8	15100	**1.536**
11	12	14691	**2.080**	16	N/A	**#VALUE!**	12	14880	**1.826**
12	12.75	N/A	**#VALUE!**		#N/A	**#N/A**	12.752	N/A	**#VALUE!**

		String #7			String #8			String #9	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0	16994	**-0.785**	0	16109	**0.261**	1OUT	N/A	**#VALUE!**
2	0.5	18109	**-2.019**	0.5	16421	**-0.115**	2OUT	15421	**1.120**
3	1	16742	**-0.493**	1	16439	**-0.136**	3OUT	N/A	**#VALUE!**
4	1.5	16850	**-0.619**	2	15842	**0.590**	4OUT	N/A	**#VALUE!**
5	2	16201	**0.150**	2.5	15665	**0.811**	5OUT	N/A	**#VALUE!**
6	2.5	15991	**0.406**	3	15331	**1.236**	1IN	16501	**-0.210**
7	3.5	N/A	**#VALUE!**	3.5	15201	**1.404**	2IN	18976	**-2.921**
8	5.5	15760	**0.692**	4	14995	**1.674**	3IN	17251	**-1.077**
9	9.5	15207	**1.396**	5	15100	**1.536**	4IN	17286	**-1.116**
10	13.5	14880	**1.826**	9	15324	**1.245**	5IN	17120	**-0.929**
11	24.75	14990	**1.680**	13	15981	**0.418**	FLOOR	7998	**14.618**
12		#N/A	**#N/A**		#N/A	**#N/A**	FLOOR		**#NUM!**

CN Thermistor Temperture Log

Operator **Roy Fenner**
Date: **1/26/00**

		String #1			String #2			String # 3	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0	N/A	**#VALUE!**	0	19647	**-3.588**	0,-0.5H	14991	**1.679**
2	5	15740	**0.717**	5	15319	**1.251**	0	14530	**2.299**
3	10	15125	**1.503**	15	15820	**0.617**	0.5	14548	**2.274**
4	20	15680	**0.792**	25	16224	**0.122**	1	14382	**2.502**
5	30	16350	**-0.030**	35	16589	**-0.314**	1.5	14086	**2.917**
6	35	16528	**-0.242**	40	16618	**-0.348**	2	14083	**2.921**
7	40	16660	**-0.397**	44	16665	**-0.403**	3	13883	**3.206**
8	45	16644	**-0.378**	48	16674	**-0.414**	5	13911	**3.166**
9	48	16618	**-0.348**	50	16620	**-0.350**	9	14148	**2.829**
10	50	16692	**-0.435**	51	16656	**-0.392**	13	14753	**1.996**
11	51	16517	**-0.229**	52	16692	**-0.435**	21	15500	**1.019**
12	51.5	N/A	**#VALUE!**	52.5	N/A	**#VALUE!**	28.5	N/A	**#VALUE!**

		String #4			String #5			String #6	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0, -1H	14497	**2.344**	0, -0.5H	15530	**0.981**	0, -.8S.L	16733	**-0.483**
2	0, -1.5H	14309	**2.604**	0	15080	**1.562**	0, 0 PIPE	17233	**-1.057**
3	0, PIPE	15770	**0.679**	0.5	15100	**1.536**	0.5	16216	**0.132**
4	1	14355	**2.540**	1	14944	**1.741**	1	15648	**0.832**
5	1.5	14170	**2.798**	1.5	14716	**2.046**	1.5	15121	**1.508**
6	2	14102	**2.894**	2	14678	**2.097**	2	14785	**1.953**
7	2.5	14080	**2.925**	3	14500	**2.340**	2.5	14708	**2.057**
8	3	14065	**2.946**	5	14294	**2.624**	3	14643	**2.145**
9	4	13986	**3.059**	9	14650	**2.135**	4	14493	**2.349**
10	8	14039	**2.983**	13	15106	**1.528**	8	14329	**2.576**
11	12	14443	**2.418**	16	N/A	**#VALUE!**	12	14479	**2.369**
12	12.75	N/A	**#VALUE!**		#N/A	**#N/A**	12.752	N/A	**#VALUE!**

		String #7			String #8			String #9	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0	16664	**-0.402**	0	15780	**0.667**	1OUT	N/A	**#VALUE!**
2	0.5	18006	**-1.908**	0.5	15966	**0.436**	2OUT	15007	**1.658**
3	1	16350	**-0.030**	1	15750	**0.704**	3OUT	N/A	**#VALUE!**
4	1.5	16373	**-0.057**	2	15631	**0.854**	4OUT	N/A	**#VALUE!**
5	2	15980	**0.419**	2.5	15145	**1.477**	5OUT	N/A	**#VALUE!**
6	2.5	15733	**0.726**	3	14875	**1.833**	1IN	16228	**0.117**
7	3.5	N/A	**#VALUE!**	3.5	14632	**2.160**	2IN	19384	**-3.329**
8	5.5	15062	**1.586**	4	14315	**2.595**	3IN	17075	**-0.877**
9	9.5	14753	**1.996**	5	14640	**2.149**	4IN	17160	**-0.974**
10	13.5	14436	**2.428**	9	14961	**1.719**	5IN	16701	**-0.445**
11	24.75	14760	**1.987**	13	16029	**0.359**	FLOOR	7.491	**294.086**
12		#N/A	**#N/A**		#N/A	**#N/A**	FLOOR	N/A	**#VALUE!**

CN Thermistor Temperture Log

Operator: **Roy Fenner**
Date: **11/3/99**

		String #1			String #2			String # 3	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0	N/A	**#VALUE!**	0	16502	**-0.211**	0,-0.5H	12700	**4.996**
2	5	14376	**2.511**	5	14137	**2.844**	0	12815	**4.814**
3	10	14428	**2.439**	15	15635	**0.849**	0.5	12981	**4.555**
4	20	15688	**0.782**	25	16240	**0.103**	1	13141	**4.308**
5	30	16340	**-0.018**	35	16580	**-0.303**	1.5	13059	**4.434**
6	35	16517	**-0.229**	40	16620	**-0.350**	2	13160	**4.279**
7	40	16667	**-0.405**	44	16651	**-0.387**	3	13058	**4.435**
8	45	16632	**-0.364**	48	16643	**-0.377**	5	13135	**4.317**
9	48	16608	**-0.336**	50	16664	**-0.402**	9	13573	**3.658**
10	50	16686	**-0.428**	51	16619	**-0.349**	13	14436	**2.428**
11	51	16510	**-0.220**	52	16651	**-0.387**	21	15486	**1.037**
12	51.5		**#NUM!**	52.5	N/A	**#VALUE!**	28.5	16391	**-0.079**

		String #4			String #5			String #6	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0, -1H	12879	**4.714**	0, -0.5H	14363	**2.529**	0, -.8S.L	15444	**1.091**
2	0, -1.5H	12826	**4.797**	0	14122	**2.866**	0, 0 PIPE	14249	**2.687**
3	0, PIPE	13161	**4.277**	0.5	14225	**2.721**	0.5	14738	**2.016**
4	1	13185	**4.241**	1	14159	**2.813**	1	14757	**1.991**
5	1.5	13201	**4.216**	1.5	13982	**3.064**	1.5	14445	**2.415**
6	2	13247	**4.146**	2	13955	**3.103**	2	14158	**2.815**
7	2.5	13290	**4.081**	3	13771	**3.368**	2.5	14079	**2.926**
8	3	13307	**4.056**	5	13613	**3.599**	3	13988	**3.056**
9	4	13244	**4.151**	9	14156	**2.818**	4	13829	**3.284**
10	8	13405	**3.908**	13	14838	**1.882**	8	13788	**3.344**
11	12	13994	**3.047**	16	15315	**1.256**	12	14631	**2.161**
12	12.75		**#NUM!**		#N/A	**#N/A**	12.752	N/A	**#VALUE!**

		String #7			String #8			String #9	
Therm #	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**	Depth (ft)	R (avg)	**Temp (C)**
1	0	16052	**0.331**	0	14750	**2.000**	1OUT	N/A	**#VALUE!**
2	0.5	15652	**0.827**	0.5	15002	**1.665**	2OUT	11610	**6.820**
3	1	15331	**1.236**	1	15035	**1.621**	3OUT	N/A	**#VALUE!**
4	1.5	15689	**0.781**	2	15023	**1.637**	4OUT	N/A	**#VALUE!**
5	2	15425	**1.115**	2.5	14580	**2.230**	5OUT	N/A	**#VALUE!**
6	2.5	15206	**1.397**	3	14294	**2.624**	1IN	13040	**4.463**
7	3.5	6053	**20.699**	3.5	14015	**3.017**	2IN	14606	**2.195**
8	5.5	14506	**2.331**	4	13693	**3.482**	3IN	13700	**3.472**
9	9.5	14148	**2.829**	5	14125	**2.861**	4IN	13792	**3.338**
10	13.5	16845	**-0.613**	9	14630	**2.162**	5IN	13140	**4.309**
11	24.75	14325	**2.581**	13	16030	**0.358**	FLOOR	7993	**14.632**
12		#N/A	**#N/A**		#N/A	**#N/A**	FLOOR	8121	**14.292**

CN Thermistor Temperture Log

Operator T & R McFadden
Date: Sept 8, 1999

		String #1				String #2				String # 3	
Therm #	Depth (ft)	R (avg)	Temp (C)		Depth (ft)	R (avg)	Temp (C)		Depth (ft)	R (avg)	Temp (C)
1	0		#NUM!		0	12511	5.300		0,-0.5H	12956	4.593
2	5	12808	4.825		5	12721	4.963		0	12495	5.325
3	10	14476	2.373		15	15756	0.697		0.5	12274	5.687
4	20	15779	0.668		25	16295	0.036		1	12113	5.955
5	30	16347	-0.026		35	16593	-0.318		1.5	11832	6.433
6	35	16526	-0.239		40	16620	-0.350		2	11834	6.430
7	40	16664	-0.402		44	16664	-0.402		3	11793	6.501
8	45	16646	-0.381		48	16655	-0.391		5	12300	5.644
9	48	16620	-0.350		50	16677	-0.417		9	13382	3.943
10	50	16696	-0.439		51	16630	-0.362		13	14505	2.333
11	51	16521	-0.233		52	16660	-0.397		21	15557	0.947
12	51.5		#NUM!		52.5	16637	-0.370		28.5	16401	-0.091

		String #4				String #5				String #6	
Therm #	Depth (ft)	R (avg)	Temp (C)		Depth (ft)	R (avg)	Temp (C)		Depth (ft)	R (avg)	Temp (C)
1	0, -1H	12546	5.243		0, -0.5H	13404	3.910		0, -.8S.L	14659	2.123
2	0, -1.5H	12525	5.277		0	12843	4.770		0, 0 PIPE	15285	1.295
3	0, PIPE	14022	3.007		0.5	12801	4.836		0.5	14246	2.691
4	1		#NUM!		1	12639	5.094		1	13498	3.769
5	1.5	12072	6.024		1.5	12452	5.395		1.5	12898	4.684
6	2	11962	6.211		2	12459	5.384		2	12580	5.188
7	2.5	11940	6.248		3	12481	5.348		2.5	12540	5.253
8	3	11959	6.216		5	12823	4.802		3	12546	5.243
9	4	12052	6.058		9	13958	3.099		4	12637	5.097
10	8	12985	4.548		13	14856	1.858		8	13427	3.875
11	12	14129	2.856		16	15374	1.180		12	14588	2.219
12	12.75		#NUM!				#NUM!		12.752		#NUM!

		String #7				String #8				String #9	
Therm #	Depth (ft)	R (avg)	Temp (C)		Depth (ft)	R (avg)	Temp (C)		Depth (ft)	R (avg)	Temp (C)
1	0	14753	1.996		0	13570	3.663		1OUT	14759	1.988
2	0.5	16252	0.088		0.5	13450	3.841		2OUT	12540	5.253
3	1	14215	2.735		1	13041	4.462		3OUT	8000	14.613
4	1.5	13910	3.168		2	12815	4.814		4OUT		#NUM!
5	2	13387	3.935		2.5	12411	5.462		5OUT		#NUM!
6	2.5	13037	4.468		3	12218	5.780		1IN	14565	2.251
7	3.5	12850	4.759		3.5	12240	5.743		2IN	16631	-0.363
8	5.5	12423	5.443		4	12596	5.163		3IN	15554	0.951
9	9.5	12351	5.560		5	13823	3.293		4IN	15236	1.358
10	13.5	13224	4.181		9	14638	2.152		5IN	13782	3.352
11	24.75	14217	2.732		13	16078	0.299		FLOOR	7344	16.457
12			#NUM!				#NUM!		FLOOR		#NUM!

CN Thermistor Temperture Log

Operator T & R McFadden
Date: Aug. 11, 1999

		String #1				String #2				String # 3	
Therm #	Depth (ft)	R (avg)	Temp (C)		Depth (ft)	R (avg)	Temp (C)		Depth (ft)	R (avg)	Temp (C)
1	0		#NUM!		0	9240	11.554		0,-0.5H	9364	11.274
2	5	13330	4.021		5	12544	5.246		0	9532	10.901
3	10	14927	1.764		15	15895	0.524		0.5	9799	10.323
4	20	15791	0.653		25	16313	0.015		1	10093	9.707
5	30	16345	-0.024		35	16596	-0.322		1.5	10241	9.404
6	35	16527	-0.240		40	16622	-0.353		2	10586	8.718
7	40	16666	-0.404		44	16665	-0.403		3	11088	7.763
8	45	16646	-0.381		48	16657	-0.394		5	12160	5.877
9	48	16625	-0.356		50	16678	-0.418		9	13567	3.667
10	50	16697	-0.441		51	16630	-0.362		13	14647	2.139
11	51	16523	-0.236		52	16665	-0.403		21	15566	0.936
12	51.5		#NUM!		52.5	16636	-0.369		28.5	16403	-0.093

		String #4				String #5				String #6	
Therm #	Depth (ft)	R (avg)	Temp (C)		Depth (ft)	R (avg)	Temp (C)		Depth (ft)	R (avg)	Temp (C)
1	0, -1H	9548	10.865		0, -0.5H	10441	9.003		0, -.8S.L	10582	8.726
2	0, -1.5H	9487	11.000		0	10400	9.085		0, 0 PIPE	10448	8.989
3	0, PIPE	9600	10.752		0.5	10678	8.539		0.5	10659	8.576
4	1		#NUM!		1	10916	8.084		1	10912	8.092
5	1.5	10177	9.534		1.5	11124	7.696		1.5	11069	7.798
6	2	10449	8.987		2	11437	7.127		2	11262	7.443
7	2.5	10751	8.398		3	11934	6.258		2.5	11564	6.901
8	3	11041	7.850		5	12728	4.952		3	11835	6.428
9	4	11556	6.915		9	14072	2.936		4	12284	5.671
10	8	13098	4.374		13	14936	1.752		8	13509	3.753
11	12	14125	2.861		16	15404	1.142		12	14677	2.099
12	12.75		#NUM!			#N/A	#N/A		12.752		#NUM!

		String #7				String #8				String #9	
Therm #	Depth (ft)	R (avg)	Temp (C)		Depth (ft)	R (avg)	Temp (C)		Depth (ft)	R (avg)	Temp (C)
1	0	10302	9.281		0	10236	9.414		1OUT		#NUM!
2	0.5	10517	8.853		0.5	10444	8.997		2OUT		#NUM!
3	1	10272	9.341		1	10686	8.523		3OUT		#NUM!
4	1.5	10630	8.632		2	11061	7.813		4OUT		#NUM!
5	2	10763	8.375		2.5	11163	7.624		5OUT		#NUM!
6	2.5	11033	7.865		3	11341	7.300		1IN		#NUM!
7	3.5		#NUM!		3.5	11864	6.378		2IN		#NUM!
8	5.5	11387	7.217		4	12634	5.102		3IN		#NUM!
9	9.5	11875	6.359		5	13994	3.047		4IN		#NUM!
10	13.5	13370	3.961		9	14757	1.991		5IN		#NUM!
11	24.75	14374	2.513		13	16100	0.272		FLOOR		#NUM!
12		#N/A	#N/A			#N/A	#N/A		FLOOR		#NUM!

CN Thermistor Temperture Log

Operator T. McFadden
Date: 3/2/99

		String #1			String #2			String # 3	
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	24830	-8.010	0	22250	-5.953	0,-0.5H	11595	6.846
2	5	16155	0.205	5	15770	0.679	0	11623	6.797
3	10	15130	1.496	15	16015	0.376	0.5	11845	6.411
4	20	15590	0.905	25	16330	-0.006	1	12100	5.977
5	30	16340	-0.018	35	16595	-0.321	1.5	12140	5.910
6	35	16528	-0.242	40	16620	-0.350	2	12390	5.496
7	40	16660	-0.397	44	16665	-0.403	3	12626	5.114
8	45	16649	-0.384	48	16658	-0.395	5	13170	4.264
9	48	16620	-0.350	50	16675	-0.415	9	13780	3.355
10	50	16695	-0.438	51	16628	-0.360	13	14560	2.258
11	51	16520	-0.232	52	16668	-0.407	21	15538	0.971
12	51.5	0	#NUM!	52.5	0	#NUM!	28.5	16407	-0.098

		String #4			String #5			String #6	
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0, -1H	11558	6.912	0, -0.5H	11800	6.488	0, -.8S.L	11725	6.619
2	0, -1.5H	11312	7.352	0	11784	6.516	0, 0 PIPE	11680	6.697
3	0, PIPE	11300	7.374	0.5	12033	6.090	0.5	11870	6.368
4	1		#NUM!	1	12200	5.810	1	12049	6.063
5	1.5	11758	6.561	1.5	12317	5.616	1.5	12133	5.922
6	2	11982	6.177	2	12560	5.220	2	12245	5.735
7	2.5	12225	5.768	3	12898	4.684	2.5	12486	5.340
8	3	12440	5.415	5	13368	3.964	3	12696	5.003
9	4	12745	4.925	9	14288	2.633	4	12998	4.528
10	8	13504	3.761	13	15024	1.636	8	13768	3.373
11	12	14133	2.850	16	15492	1.030	12	14764	1.981
12	12.75	0	#NUM!		#N/A	#N/A	12.752	0	#NUM!

		String #7			String #8			String #9	
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	11550	6.926	0	11590	6.855	1OUT		#NUM!
2	0.5	11780	6.523	0.5	11722	6.624	2OUT		#NUM!
3	1	11540	6.943	1	11914	6.292	3OUT		#NUM!
4	1.5	11834	6.430	2	12239	5.745	4OUT		#NUM!
5	2	11944	6.241	2.5	12285	5.669	5OUT		#NUM!
6	2.5	12170	5.860	3	12404	5.474	1IN		#NUM!
7	3.5	0	#NUM!	3.5	12808	4.825	2IN		#NUM!
8	5.5	12414	5.457	4	13318	4.039	3IN		#NUM!
9	9.5	12784	4.863	5	14297	2.620	4IN		#NUM!
10	13.5	13824	3.292	9	14882	1.824	5IN		#NUM!
11	24.75	14555	2.264	13	16160	0.199	FLOOR		#NUM!
12		0	#NUM!		0	#NUM!	FLOOR		#NUM!

CN Thermistor Temperature Log

Operator : Sara/B-O
Date : 2/5/97

	String #1			String #2			String #3		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	23736	-7.169	0	24463	-7.732	0, -0.5H	16137	0.227
2	5	16342	-0.02	5	17704	-1.581	0	15852	0.577
3	10	15752	0.702	15	16270	0.066	0.5	15870	0.555
4	20	15954	0.451	25	16398	-0.087	1	15857	0.571
5	30	16386	-0.073	35	16588	-0.313	1.5	15597	0.896
6	35	16518	-0.23	40	16617	-0.347	2	15650	0.83
7	40	16654	-0.39	44	16662	-0.4	3	15491	1.031
8	45	16624	-0.355	48	16654	-0.39	5	15521	0.993
9	48	16595	-0.321	50	16666	-0.404	9	15420	1.121
10	50	16673	-0.412	51	16612	-0.341	13	15677	0.796
11	51	16505	-0.214	52	16644	-0.378	21	15942	0.466
12	51.5	16620	-0.35	52.5	16630	-0.362	28.5	16415	-0.107

	String #4			String #5			String #6		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0, -1H	15893	0.527	0, -0.5H	16463	-0.165	0, -.8 S.L	16810	-0.572
2	0, -1.5H	15863	0.564	0	16176	0.18	0, 0 PIPE	17342	-1.179
3	0, PIPE	16846	-0.614	0.5	16294	0.038	0.5	16916	-0.695
4	1	#N/A	#N/A	1	16254	0.086	1	16618	-0.348
5	1.5	15817	0.621	1.5	16128	0.238	1.5	16347	-0.026
6	2	15763	0.688	2	16194	0.158	2	16187	0.167
7	2.5	15767	0.683	3	16146	0.216	2.5	16239	0.104
8	3	15772	0.677	5	15977	0.423	3	16266	0.071
9	4	15705	0.761	9	15971	0.43	4	16145	0.218
10	8	15526	0.986	13	16027	0.362	8	15807	0.633
11	12	15504	1.014	16	16080	0.297	12	16006	0.387
12	12.75	#N/A	#N/A		#N/A	#N/A	12.75	16021	0.369

	String #7			String #8			String #9		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	16352	-0.032	0	15402	1.145	1out	15936	0.473
2	0.5	17194	-1.013	0.5	15900	0.518	2out	12444	5.408
3	1	16024	0.365	1	16019	0.371	3out	16042	0.343
4	1.5	16388	-0.075	2	16176	0.18	4out	#N/A	#N/A
5	2	16350	-0.03	2.5	16006	0.387	5out	#N/A	#N/A
6	2.5	16365	-0.048	3	15945	0.462	1in	16486	-0.192
7	3.5	16303	0.027	3.5	16030	0.358	2in	16971	-0.758
8	5.5	16184	0.17	4	15963	0.44	3in	16837	-0.604
9	9.5	16177	0.179	5	16062	0.319	4in	16013	0.379
10	13.5	16047	0.337	9	15942	0.466	5in	16499	-0.207
11	24.75	15956	0.449	13	16316	0.011	floor	8862	12.435
12		#N/A	#N/A		#N/A	#N/A	floor	7843	15.038

CN Thermistor Temperature Log

Operator : Sara/B-O
Date : 10/2/96

	String #1			String #2			String #3		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	#N/A	#N/A	0	#N/A	#N/A	0, -0.5H	#N/A	#N/A
2	5	14578	2.233	5	15704	0.762	0	13598	3.621
3	10	15209	1.394	15	16213	0.135	0.5	14163	2.808
4	20	15951	0.455	25	16386	-0.073	1	13843	3.264
5	30	16374	-0.058	35	16592	-0.317	1.5	14180	2.784
6	35	16521	-0.233	40	16621	-0.351	2	13887	3.201
7	40	16656	-0.392	44	16676	-0.416	3	13965	3.089
8	45	#N/A	#N/A	48	#N/A	#N/A	5	#N/A	#N/A
9	48	16635	-0.368	50	16696	-0.439	9	14975	1.7
10	50	16676	-0.416	51	16624	-0.355	13	15588	0.908
11	51	16512	-0.223	52	16645	-0.38	21	15953	0.452
12	51.5	16620	-0.35	52.5	16632	-0.364	28.5	16411	-0.103

	String #4			String #5			String #6		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0, -1H	#N/A	#N/A	0, -0.5H	#N/A	#N/A	0, -.8 S.L	#N/A	#N/A
2	0, -1.5H	13854	3.248	0	14913	1.782	0, 0 PIPE	16381	-0.067
3	0, PIPE	15289	1.29	0.5	15153	1.466	0.5	16166	0.192
4	1	15188	1.421	1	15242	1.351	1	15999	0.396
5	1.5	14092	2.908	1.5	15232	1.364	1.5	15775	0.673
6	2	14113	2.878	2	15379	1.174	2	15638	0.845
7	2.5	14194	2.764	3	15469	1.059	2.5	15705	0.761
8	3	#N/A	#N/A	5	#N/A	#N/A	3	16255	0.084
9	4	14393	2.487	9	15798	0.644	4	15682	0.789
10	8	14886	1.818	13	15969	0.433	8	15602	0.89
11	12	15325	1.243	16	16037	0.349	12	15944	0.464
12	12.75	#N/A	#N/A		#N/A	#N/A	12.75	15965	0.438

	String #7			String #8			String #9		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	#N/A	#N/A	0	#N/A	#N/A	1out	#N/A	#N/A
2	0.5	15935	0.475	0.5	14777	1.964	2out	12595	5.164
3	1	14893	1.809	1	14901	1.798	3out	15632	0.852
4	1.5	15191	1.417	2	15075	1.569	4out	15599	0.894
5	2	15179	1.433	2.5	14968	1.709	5out	#N/A	#N/A
6	2.5	15220	1.379	3	14949	1.735	1in	15348	1.214
7	3.5	15212	1.39	3.5	15119	1.511	2in	16474	-0.178
8	5.5	15157	1.461	4	15253	1.336	3in	#N/A	#N/A
9	9.5	15252	1.338	5	15727	0.733	4in	15287	1.292
10	13.5	15522	0.991	9	15827	0.608	5in	14915	1.78
11	24.75	15738	0.719	13	16289	0.044	floor	8591	13.093
12		#N/A	#N/A		#N/A	#N/A	floor	8753	12.697

CN Thermistor Temperature Log

Operator : fu
Date : 7/27/95

		String #1			String #2			String #3	
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	#N/A	#N/A	0	#N/A	#N/A	0, -0.5H	#N/A	#N/A
2	5	12602	5.153	5	14876	1.832	0	12291	5.659
3	10	14764	1.981	15	16070	0.309	0.5	12383	5.508
4	20	15743	0.713	25	16289	0.044	1	12491	5.332
5	30	16345	-0.024	35	16595	-0.321	1.5	12435	5.423
6	35	16524	-0.237	40	16624	-0.355	2	12622	5.121
7	40	16657	-0.394	44	16667	-0.405	3	12	260.269
8	45	#N/A	#N/A	48	16659	-0.396	5	13440	3.856
9	48	16602	-0.329	50	16670	-0.409	9	14294	2.624
10	50	16647	-0.382	51	16621	-0.351	13	15055	1.595
11	51	16504	-0.213	52	16645	-0.38	21	15647	0.833
12	51.5	16615	-0.344	52.5	16634	-0.367	28.5	16390	-0.078

		String #4			String #5			String #6	
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0, -1H	#N/A	#N/A	0, -0.5H	#N/A	#N/A	0, -.8 S.L.	#N/A	#N/A
2	0, -1.5H	12494	5.327	0	#N/A	#N/A	0, 0 PIPE	13619	3.591
3	0, PIPE	13746	3.405	0.5	13094	4.38	0.5	13441	3.854
4	1	#N/A	#N/A	1	13260	4.127	1	13484	3.79
5	1.5	12738	4.936	1.5	13362	3.973	1.5	13476	3.802
6	2	12812	4.819	2	13602	3.616	2	13544	3.701
7	2.5	12945	4.611	3	13915	3.16	2.5	13765	3.377
8	3	#N/A	#N/A	5	14347	2.551	3	13948	3.113
9	4	13302	4.063	9	15102	1.533	4	14147	2.83
10	8	14125	2.861	13	15523	0.99	8	14755	1.994
11	12	14733	2.023	16	15722	0.739	12	15415	1.128
12	12.75	#N/A	#N/A		#N/A	#N/A	12.75	15461	1.069

		String #7			String #8			String #9	
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	#N/A	#N/A	0	#N/A	#N/A	1out	#N/A	#N/A
2	0.5	13728	3.431	0.5	13199	4.219	2out	13168	4.267
3	1	13184	4.242	1	13334	4.015	3out	13425	3.878
4	1.5	13410	3.901	2	13542	3.704	4out	13406	3.907
5	2	13480	3.796	2.5	13555	3.685	5out	19824	-3.76
6	2.5	13579	3.65	3	13615	3.596	1in	13372	3.958
7	3.5	13691	3.485	3.5	13930	3.139	2in	13975	3.074
8	5.5	13723	3.438	4	14314	2.597	3in	13471	3.81
9	9.5	13989	3.054	5	15100	1.536	4in	13391	3.929
10	13.5	14750	2	9	15412	1.132	5in	12828	4.794
11	24.75	15238	1.356	13	16161	0.198	floor	8128	14.273
12		#N/A	#N/A		#N/A	#N/A	floor	7707	15.415

CN Thermistor Temperature Log

Operator : fu/michael
Date : 3/5/95

	String #1			String #2			String #3		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	#N/A	#N/A	0	#N/A	#N/A	0, -0.5H	#N/A	#N/A
2	5	16300	0.03	5	17300	-1.132	0	16300	0.03
3	10	15500	1.019	15	15900	0.518	0.5	16200	0.151
4	20	15400	1.147	25	16200	0.151	1	16000	0.395
5	30	16300	0.03	35	16600	-0.327	1.5	15700	0.767
6	35	16600	-0.327	40	16600	-0.327	2	15600	0.893
7	40	16700	-0.444	44	16700	-0.444	3	15200	1.405
8	45	16600	-0.327	48	16800	-0.561	5	15000	1.667
9	48	#N/A	#N/A	50	22000	-5.74	9	14500	2.34
10	50	16600	-0.327	51	16600	-0.327	13	14700	2.068
11	51	16500	-0.208	52	16600	-0.327	21	15300	1.276
12	51.5	16600	-0.327	52.5	16600	-0.327	28.5	16400	-0.09

	String #4			String #5			String #6		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0, -1H	#N/A	#N/A	0, -0.5H	#N/A	#N/A	0, -.8 S.L.	#N/A	#N/A
2	0, -1.5H	16400	-0.09	0	16200	0.151	0, 0 PIPE	16800	-0.561
3	0, PIPE	16800	-0.561	0.5	16300	0.03	0.5	16800	-0.561
4	1	16300	0.03	1	16200	0.151	1	16600	-0.327
5	1.5	16000	0.395	1.5	15900	0.518	1.5	16200	0.151
6	2	15900	0.518	2	15900	0.518	2	16000	0.395
7	2.5	15800	0.642	3	15700	0.767	2.5	15900	0.518
8	3	15600	0.893	5	15300	1.276	3	15900	0.518
9	4	15400	1.147	9	15000	1.667	4	15700	0.767
10	8	14700	2.068	13	15200	1.405	8	14900	1.8
11	12	14500	2.34	16	15400	1.147	12	15100	1.536
12	12.75	#N/A	#N/A		#N/A	#N/A	12.75	15100	1.536

	String #7			String #8			String #9		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	#N/A	#N/A	0	#N/A	#N/A	1out	#N/A	#N/A
2	0.5	17800	-1.685	0.5	16700	-0.444	2out	15200	1.405
3	1	16900	-0.676	1	16500	-0.208	3out	16000	0.395
4	1.5	17000	-0.792	2	16500	-0.208	4out	16200	0.151
5	2	16800	-0.561	2.5	16200	0.151	5out	21000	-4.858
6	2.5	16600	-0.327	3	16100	0.272	1in	16200	0.151
7	3.5	17000	-0.792	3.5	15900	0.518	2in	16600	-0.327
8	5.5	16200	0.151	4	15500	1.019	3in	16400	-0.09
9	9.5	16100	0.272	5	15300	1.276	4in	16500	-0.208
10	13.5	15400	1.147	9	15100	1.536	5in	16000	0.395
11	24.75	15100	1.536	13	16000	0.395	floor	7750	15.295
12		#N/A	#N/A		#N/A	#N/A	floor	6750	18.294

CN Thermistor Temperature Log

Operator : ma
Date : 6/27/94

		String #1			String #2			String #3	
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	9635	10.676	0	10650	8.593	0, -0.5H	15855	0.574
2	5	15700	0.767	5	16440	-0.137	0	14920	1.773
3	10	15060	1.588	15	15760	0.692	0.5	14430	2.436
4	20	15310	1.263	25	16030	0.358	1	14050	2.968
5	30	16270	0.066	35	16595	-0.321	1.5	13580	3.648
6	35	16520	-0.232	40	16625	-0.356	2	13525	3.729
7	40	16660	-0.397	44	16665	-0.403	3	13405	3.908
8	45	16595	-0.321	48	16675	-0.415	5	13520	3.737
9	48	16590	-0.315	50	16680	-0.421	9	13860	3.24
10	50	16625	-0.356	51	16620	-0.35	13	14340	2.56
11	51	16510	-0.22	52	16655	-0.391	21	15055	1.595
12	51.5	16605	-0.333	52.5	16640	-0.374	28.5	16380	-0.066

		String #4			String #5			String #6	
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0, -1H	14855	1.86	0, -0.5H	14640	2.149	0, -.8 S.L	15445	1.09
2	0, -1.5H	14735	2.02	0	14230	2.714	0, 0 PIPE	17440	-1.289
3	0, PIPE	16350	-0.03	0.5	14260	2.672	0.5	15590	0.905
4	1	#N/A	#N/A	1	14155	2.819	1	14910	1.786
5	1.5	14050	2.968	1.5	13975	3.074	1.5	14380	2.505
6	2	13840	3.268	2	14055	2.961	2	14070	2.939
7	2.5	13745	3.406	3	13920	3.153	2.5	14025	3.003
8	3	13675	3.508	5	13930	3.139	3	14010	3.025
9	4	13580	3.648	9	14325	2.581	4	13915	3.16
10	8	13760	3.384	13	14705	2.061	8	14020	3.01
11	12	14040	2.982	16	14930	1.76	12	14515	2.319
12	12.75	#N/A	#N/A		#N/A	#N/A	12.75	14560	2.258

		String #7			String #8			String #9	
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	16660	-0.397	0	15900	0.518	1out	20420	-4.325
2	0.5	17965	-1.864	0.5	16110	0.26	2out	20245	-4.161
3	1	16430	-0.125	1	15720	0.742	3out	20545	-4.442
4	1.5	16260	0.078	2	15425	1.115	4out	21035	-4.89
5	2	15925	0.487	2.5	15010	1.654	5out	26120	-8.951
6	2.5	15510	1.007	3	14700	2.068	1in	15840	0.592
7	3.5	16765	-0.52	3.5	14470	2.381	2in	17805	-1.691
8	5.5	14890	1.813	4	14220	2.728	3in	17210	-1.031
9	9.5	14575	2.237	5	14540	2.285	4in	16815	-0.578
10	13.5	14370	2.519	9	14670	2.108	5in	15610	0.88
11	24.75	14570	2.244	13	15765	0.686	floor	5730	21.922
12		#N/A	#N/A		#N/A	#N/A	floor	4410	27.887

CN Thermistor Temperature Log

Operator : ma
Date : 2/13/94

	String #1			String #2			String #3		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	24665	-7.886	0	25035	-8.163	0, -0.5H	15255	1.334
2	5	15420	1.121	5	16320	0.006	0	14730	2.027
3	10	14170	2.798	15	15145	1.477	0.5	14410	2.464
4	20	14675	2.101	25	15830	0.605	1	14170	2.798
5	30	16250	0.09	35	16605	-0.333	1.5	13795	3.334
6	35	16525	-0.238	40	16635	-0.368	2	13735	3.421
7	40	16665	-0.403	44	16655	-0.391	3	13430	3.871
8	45	16605	-0.333	48	16660	-0.397	5	13190	4.233
9	48	16600	-0.327	50	16675	-0.415	9	12840	4.775
10	50	16650	-0.385	51	16620	-0.35	13	13180	4.248
11	51	16500	-0.208	52	16730	-0.479	21	14470	2.381
12	51.5	16615	-0.344	52.5	16635	-0.368	28.5	16360	-0.042

	String #4			String #5			String #6		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0, -1H	14700	2.068	0, -0.5H	13960	3.096	0, -.8 S.L	14810	1.92
2	0, -1.5H	14635	2.156	0	13650	3.545	0, 0 PIPE	15835	0.598
3	0, PIPE	15510	1.007	0.5	13755	3.392	0.5	14835	1.886
4	1	#N/A	#N/A	1	13735	3.421	1	14355	2.54
5	1.5	14000	3.039	1.5	13620	3.589	1.5	13965	3.089
6	2	13830	3.283	2	13660	3.53	2	13750	3.399
7	2.5	13885	3.204	3	13570	3.663	2.5	13740	3.413
8	3	13645	3.552	5	13310	4.051	3	13695	3.479
9	4	13420	3.886	9	13220	4.187	4	13505	3.759
10	8	12895	4.689	13	13560	3.678	8	13000	4.525
11	12	12845	4.767	16	14100	2.897	12	13350	3.991
12	12.75	#N/A	#N/A		#N/A	#N/A	12.75	13395	3.923

	String #7			String #8			String #9		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	15565	0.937	0	14720	2.041	1out	14945	1.74
2	0.5	16515	-0.226	0.5	14930	1.76	2out	14945	1.74
3	1	15240	1.353	1	14740	2.014	3out	15330	1.237
4	1.5	15170	1.444	2	14655	2.128	4out	15275	1.308
5	2	14985	1.687	2.5	14415	2.457	5out	10690	8.516
6	2.5	14735	2.02	3	14240	2.7	1in	14910	1.786
7	3.5	14610	2.19	3.5	14110	2.883	2in	15435	1.102
8	5.5	14395	2.484	4	13790	3.341	3in	15380	1.173
9	9.5	14210	2.742	5	13600	3.619	4in	15500	1.019
10	13.5	13670	3.516	9	13615	3.596	5in	15125	1.503
11	24.75	13520	3.737	13	15745	0.711	floor	6530	19.022
12		#N/A	#N/A		#N/A	#N/A	floor	6015	20.839

CN Thermistor Temperature Log

Operator : JIM, MA
Date : 10/28/93

	String #1			String #2			String #3		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	16790	-0.549	0	15925	0.487	0, -0.5H	13175	4.256
2	5	18650	-2.587	5	35420	-14.49	0	12290	5.661
3	10	14020	3.01	15	14735	2.02	0.5	29785	-11.363
4	20	16700	-0.444	25	18610	-2.546	1	10860	8.19
5	30	23970	-7.352	35	18765	-2.706	1.5	36070	-14.814
6	35	17435	-1.283	40	21935	-5.684	2	12610	5.14
7	40	16660	-0.397	44	37620	-15.563	3	10320	9.245
8	45	16630	-0.362	48	16685	-0.426	5	11865	6.376
9	48	16655	-0.391	50	16695	-0.438	9	11445	7.113
10	50	16820	-0.584	51	16665	-0.403	13	20710	-4.594
11	51	17585	-1.45	52	21965	-5.71	21	14350	2.547
12	51.5	17165	-0.98	52.5	19555	-3.498	28.5	16830	-0.595

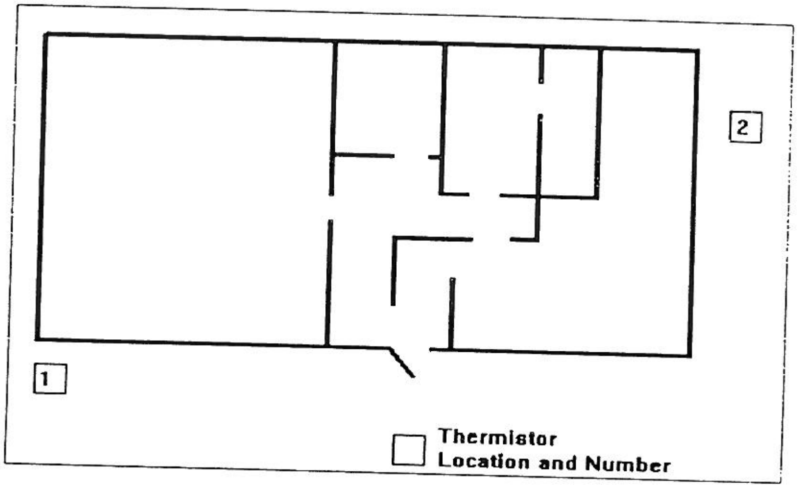
	String #4			String #5			String #6		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0, -1H	13180	4.248	0, -0.5H	12050	6.061	0, -.8 S.L	11345	7.292
2	0, -1.5H	43655	-18.18	0	19225	-3.171	0, 0 PIPE	14830	1.893
3	0, PIPE	12915	4.657	0.5	14455	2.402	0.5	16560	-0.279
4	1	15585	0.912	1	11135	7.676	1	16785	-0.543
5	1.5	33675	-13.585	1.5	10510	8.867	1.5	11540	6.943
6	2	16250	0.09	2	11300	7.374	2	10730	8.439
7	2.5	9895	10.119	3	16005	0.389	2.5	10735	8.429
8	3	14020	3.01	5	10055	9.785	3	23410	-6.909
9	4	11040	7.852	9	10035	9.827	4	11070	7.796
10	8	12275	5.686	13	10595	8.7	8	11730	6.61
11	12	14350	2.547	16	14030	2.996	12	13600	3.619
12	12.75	21900	-5.654		#N/A	#N/A	12.75	28090	-10.291

	String #7			String #8			String #9		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	12525	5.277		11860	6.385		16285	0.048
2	0.5	14470	2.381		39795	-16.557		33280	-13.372
3	1	12240	5.743		14755	1.994		20220	-4.138
4	1.5	13535	3.715		12615	5.132		22550	-6.206
5	2	11300	7.374		11255	7.456		90215	-30.338
6	2.5	10875	8.162		12030	6.095		20390	-4.297
7	3.5	10985	7.955		11085	7.768		16985	-0.774
8	5.5	10890	8.133		12475	5.358		17880	-1.772
9	9.5	10675	8.545		31095	-12.145		21090	-4.94
10	13.5	18035	-1.939		31100	-12.148		25075	-8.193
11	24.75	12420	5.447		15680	0.792		19505	-3.449
12		#N/A	#N/A		#N/A	#N/A		9945	10.014

CN Thermistor Temperature Log

Operator : zhang
Date : 6/24/93

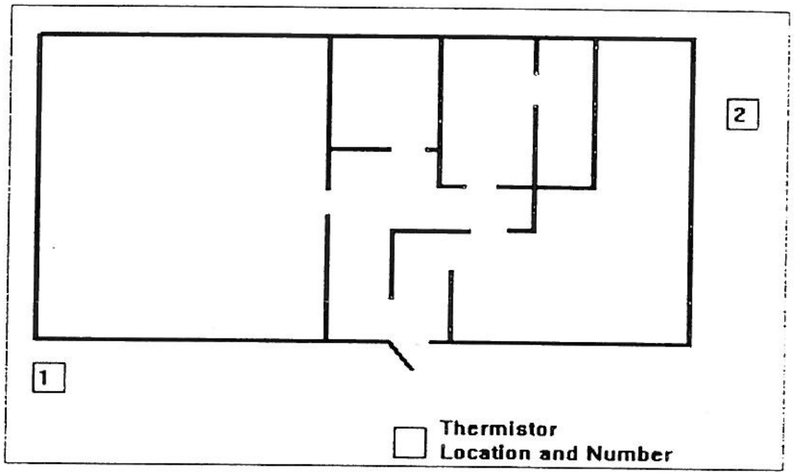
	String #1			String #2		
Therm #	Depth (ft)	R (avg)	Temp (C)	Depth (ft)	R (avg)	Temp (C)
1	0	8520	13.269	0	9540	10.883
2	5	11690	6.68	5	14220	2.728
3	10	13440	3.856	15	15270	1.314
4	20	14935	1.753	25	15895	0.524
5	30	16355	-0.036	35	16600	-0.327
6	35	16525	-0.238	40	16630	-0.362
7	40	16655	-0.391	44	16670	-0.409
8	45	16590	-0.315	48	16660	-0.397
9	48	16600	-0.327	50	16675	-0.415
10	50	16655	-0.391	51	16625	-0.356
11	51	16505	-0.214	52	16640	-0.374
12	51.5	16610	-0.338	52.5	16630	-0.362



CN Thermistor Temperature Log

Operator : zhang
Date : 8/26/93

		String #1				String #2	
Therm #	Depth (ft)	R (avg)	Temp (C)		Depth (ft)	R (avg)	Temp (C)
1	0	10420	9.045		0	10840	8.228
2	5	10350	9.185		5	12140	5.91
3	10	12145	5.902		15	14940	1.747
4	20	14865	1.846		25	15910	0.506
5	30	16335	-0.012		35	16605	-0.333
6	35	16525	-0.238		40	16635	-0.368
7	40	16660	-0.397		44	16670	-0.409
8	45	16595	-0.321		48	16660	-0.397
9	48	16595	-0.321		50	16675	-0.415
10	50	16650	-0.385		51	16625	-0.356
11	51	16500	-0.208		52	16645	-0.38
12	51.5	16605	-0.333		52.5	16630	-0.362



Level Measurements

	Constitution Level Data			
	Operator:	T.& R. McFadden		
	Previous	New	New	Elevation
	Elevation	reading	Elevation	Difference
Date	**8/1/00**	**8/14/00**	**8/14/00**	**8/14/00**
A (1)	0	775	0	0
B (1)	-16			
C (1)	-42			
D(1)	-10	775	0	10
E (1)	-2	773	-2	0
F (1)	-15	760	-15	0
G (1)	9	766	-9	-18
H (1)	24			
I (1)	4			
J (1)	16			
K (1)	-8			
L (1)	-43			
AD (1)	26			
AE (1)	12			
AF (1)	13			
AG (1)	0			
AH (1)	4			
AI (1)	21			
AJ (1)	-27			
AK (1)	-20			
L(2)*	-43	724	-51	-8
M(2)	-41	730	-45	-4
N(2)	-671			
P(2)	6			
Q(2)	0			
R(2)	4			
AL(2)	-7			
S(2)	35			
S(3)**	\		\	
T (3)	47			
U (3)	46			
V (3)	3			
W (3)	24			
X (3)	10			
Y (3)	28			
Z (3)	57			
AA (3)	32			
AQ (3)	39			
AP (3)	23			
AO (3)	43			
AN (3)	53			
AM (3)	31			
L (4)*	\			
AC (4)	-16	1754	979	995
O (4)	-22	753	-22	0
AC (5)	\	897	\	
NAIL (5)	-78	1827	1909	1987

Constitution Level Data
Operator: T.& R. McFadden

	Previous Elevation	New reading	New Elevation	Elevation Difference
Date	**5/18/00**	**8/1/00**	**8/1/00**	**5/00-8/00**
A (1)	0	592	0	0
B (1)	-16	577	-15	1
C (1)	-42	556	-36	6
D(1)	-10	579	-13	-3
E (1)	-2	589	-3	-1
F (1)	-15	580	-12	3
G (1)	9	601	9	0
H (1)	24	615	23	-1
I (1)	4	596	4	0
J (1)	16	611	19	3
K (1)	-8	588	-4	4
L (1)	-43	549	-43	0
AD (1)	26	623	31	5
AE (1)	12	611	19	7
AF (1)	13	605	13	0
AG (1)	0	597	5	5
AH (1)	4	594	2	-2
AI (1)	21		-592	-613
AJ (1)	-27	566	-26	1
AK (1)	-20	576	-16	4
L(2)*	\	556	\	\
M(2)	-41	554	-45	-4
N(2)	-671	563	-36	635
P(2)	6	609	10	4
Q(2)	0	601	2	2
R(2)	4	609	10	6
AL(2)	-7	600	1	8
S(2)	35	635	36	1
S(3)**	\	593	\	\
T (3)	47	604	47	0
U (3)	46	596	39	-7
V (3)	3	557	0	-3
W (3)	24	583	26	2
X (3)	10	566	9	-1
Y (3)	28	584	27	-1
Z (3)	57	610	53	-4
AA (3)	32	589	32	0
AQ (3)	39	602	45	6
AP (3)	23	586	29	6
AO (3)	43	601	44	1
AN (3)	53	621	64	11
AM (3)	31	601	44	13
L (4)*	\	596	\	\
AC (4)	-16	1419	780	796
O (4)	-22	612	-27	-5
AC (5)	\	46	\	#VALUE!
NAIL (5)	-78	1186	1920	1998

9/22/99	8/11/99	8/99-8/00
0	0	0
-16	-18	3
-40	-38	2
-20	-21	8
-3	-2	-1
-13	-15	3
7	10	-1
23	23	0
3	2	2
13	14	5
-4	-10	6
-56	-45	2
8	8	23
6	6	13
11	14	-1
1	6	-1
1	1	1
5	9	-601
-25	-23	-3
-17	-16	0
\	\	\
-50	-48	3
9	\	\
4	9	1
-8	-6	8
-4	-1	11
-10	-6	7
28	33	3
\	\	\
26	32	15
27	32	7
-5	3	-3
4	7	19
-4	-1	10
12	17	10
49	50	3
22	24	8
22	29	16
15	13	16
30	32	12
21	26	38
15	22	22
\	\	\
774	1089	-309
-24	-19	-8
\	\	\
2404	2112	-192

Constitution Level Data
Operator: T.& R. McFadden

	Previous Elevation	New reading	New Elevation	Elevation Difference
Date	**9/22/99**	**5/18/00**	**5/18/00**	
A (1)	0	660	0	0
B (1)	-16	644	-16	0
C (1)	-40	618	-42	-2
D(1)	-20	650	-10	10
E (1)	-3	658	-2	1
F (1)	-13	645	-15	-2
G (1)	7	669	9	2
H (1)	23	684	24	1
I (1)	3	664	4	1
J (1)	13	676	16	3
K (1)	-4	652	-8	-4
L (1)	-56	617	-43	13
AD (1)	8	686	26	18
AE (1)	6	672	12	6
AF (1)	11	673	13	2
AG (1)	1	660	0	-1
AH (1)	1	664	4	3
AI (1)	5	681	21	16
AJ (1)	-25	633	-27	-2
AK (1)	-17	640	-20	-3
L(2)*	\	628	\	
M(2)	-50	630	-41	9
N(2)	9		-671	-680
P(2)	4	677	6	2
Q(2)	-8	671	0	8
R(2)	-4	675	4	8
AL(2)	-10	664	-7	3
S(2)	28	706	35	7
S(3)**	\	629	\	
T (3)	26	641	47	21
U (3)	27	640	46	19
V (3)	-5	597	3	8
W (3)	4	618	24	20
X (3)	-4	604	10	14
Y (3)	12	622	28	16
Z (3)	49	651	57	8
AA (3)	22	626	32	10
AQ (3)	22	633	39	17
AP (3)	15	617	23	8
AO (3)	30	637	43	13
AN (3)	21	647	53	32
AM (3)	15	625	31	16
L (4)*	\	624	\	
AC (4)	774	1651	984	210
O (4)	-24	645	-22	2
AC (5)	\	793	\	
NAIL (5)	2404	1731	1922	-482

Constitution Level Data
Operator: Roy Fenner

	Previous Elevation	New reading	New Elevation	Elevation Difference
Date	**10/27/99**	**1/26/00**	**1/26/00**	**1/26/00**
A (1)	0	444	0	0
B (1)	-12	425	-19	-7
C (1)	-42	404	-40	2
D(1)	-22	419	-25	-3
E (1)	-2	440	-4	-2
F (1)	83	432	-12	-95
G (1)	8	453	9	1
H (1)	23	473	29	6
I (1)	4	450	6	2
J (1)	15	459	15	0
K (1)	-10	434	-10	0
L (1)	-47	394	-50	-3
AD (1)	9	455	11	2
AE (1)	8	460	16	8
AF (1)	17	470	26	9
AG (1)	2	448	4	2
AH (1)	-2	443	-1	1
AI (1)	-3	445	1	4
AJ (1)	-41	412	-32	9
AK (1)	-20	425	-19	1
L(2)*	\	421	\	\
M(2)	-47	420	-51	-4
N(2)	14	467	-4	-18
P(2)	8	480	9	1
Q(2)	0	465	-6	-6
R(2)	-1	467	-4	-3
AL(2)	-6	468	-3	3
S(2)	35	499	28	-7
S(3)**	\	480	\	\
T (3)	25	478	26	1
U (3)	29	476	24	-5
V (3)	1	450	-2	-3
W (3)	7	457	5	-2
X (3)	-2	448	-4	-2
Y (3)	14	465	13	-1
Z (3)	39	497	45	6
AA (3)	24	471	19	-5
AQ (3)	22	473	21	-1
AP (3)	12	461	9	-3
AO (3)	28	465	13	-15
AN (3)	20	468	16	-4
AM (3)	15	463	11	-4
L (4)*	\	442	\	\
AB (4)	1381	1865	1373	-8
O (4)	-15	467	-25	-10
AB (5)	\	460	\	\
NAIL (5)	2112	1073	1986	-126

Constitution Level Data

Operator: Terry and Ruth McFadden

	Previous Elevation	New reading	New Elevation	Elevation Difference
Date	**3/2/99**	**8/11/99**	**8/11/99**	**8/11/99**
A (1)	0	624	0	0
B (1)	-15	606	-18	-3
C (1)	-41	586	-38	3
D(1)	-22	603	-21	1
E (1)	-3	622	-2	1
F (1)	-17	609	-15	2
G (1)	5	634	10	5
H (1)	21	647	23	2
I (1)	0	626	2	2
J (1)	11	638	14	3
K (1)	-10	614	-10	0
L (1)	-52	579	-45	7
AD (1)	4	632	8	4
AE (1)	4	630	6	2
AF (1)	11	638	14	3
AG (1)	3	630	6	3
AH (1)	-6	625	1	7
AI (1)	2	633	9	7
AJ (1)	-25	601	-23	2
AK (1)	-19	608	-16	3
L(2)*	\	586	\	\
M(2)	-51	583	-48	3
N(2)	-41		#VALUE!	#VALUE!
P(2)	0	640	9	9
Q(2)	-7	625	-6	1
R(2)	-9	630	-1	8
AL(2)	-14	625	-6	8
S(2)	29	664	33	4
S(3)**	\	632	\	\
T (3)	24	631	32	8
U (3)	22	631	32	10
V (3)	-5	602	3	8
W (3)	-3	606	7	10
X (3)	-10	598	-1	9
Y (3)	8	616	17	9
Z (3)	42	649	50	8
AA (3)	22	623	24	2
AQ (3)	16	628	29	13
AP (3)	1	612	13	12
AO (3)	19	631	32	13
AN (3)	18	625	26	8
AM (3)	12	621	22	10
L (4)*	\	614	\	\
AC (4)	#VALUE!	1748	1089	#VALUE!
O (4)	-26	640	-19	7
AC (5)	\	360	\	\
NAIL (5)		1292	2021	2021

Constitution Level Data
Operator: T&R McFadden

	Previous Elevation	New reading	New Elevation	Elevation Difference
Date	1/30/97	3/2/99	3/2/99	3/2/99
A (1)	0	606	0	0
B (1)	-14	591	-15	-1
C (1)	-44	565	-41	3
D(1)	-18	584	-22	-4
E (1)	-4	603	-3	1
F (1)	-9	589	-17	-8
G (1)	6	611	5	-1
H (1)	8	627	21	13
I (1)	-6	606	0	6
J (1)	3	617	11	8
K (1)	-5	596	-10	-5
L (1)	-43	554	-52	-9
AD (1)	20	610	4	-16
AE (1)	8	610	4	-4
AF (1)	18	617	11	-7
AG (1)	8	609	3	-5
AH (1)	5	600	-6	-11
AI (1)	15	608	2	-13
AJ (1)	-38	581	-25	13
AK (1)	-21	587	-19	2
L(2)*	\	561	\	\
M(2)	-40	562	-51	-11
N(2)	-40	572	-41	-1
P(2)	-5	613	0	5
Q(2)	-16	606	-7	9
R(2)	-13	604	-9	4
AL(2)	-13	599	-14	-1
S(2)	10	642	29	19
S(3)**	\	612	\	\
T (3)	6	607	24	18
U (3)	2	605	22	20
V (3)	-10	578	-5	5
W (3)	0	580	-3	-3
X (3)	-12	573	-10	2
Y (3)	8	591	8	0
Z (3)	27	625	42	15
AA (3)	12	605	22	10
AQ (3)	10	599	16	6
AP (3)	6	584	1	-5
AO (3)	22	602	19	-3
AN (3)	22	601	18	-4
AM (3)	2	595	12	10
L (4)*	\	579	\	\
AC (4)	1413		#VALUE!	#VALUE!
O (4)	-29	605	-26	3
AC (5)	\		\	\
NAIL (5)	2088		#VALUE!	#VALUE!

Constitution Level Data

Operator : Sara/B-O

	Previous Elevation	New Reading	New Elevation	Elevation Difference
Date	12/10/96	1/30/97	1/30/97	(mm)
A (1)*	0	334	0	0
B (1)	-16	320	-14	2
C (1)	-42	290	-44	-2
D (1)	-19	316	-18	1
E (1)	-3	330	-4	-1
F (1)	-11	325	-9	2
G (1)	7	340	6	-1
H (1)	7	342	8	1
I (1)	-4	328	-6	-2
J (1)	6	337	3	-3
K (1)	8	329	-5	-13
L (1)	-44	291	-43	1
AD (1)	12	354	20	8
AE (1)	9	342	8	-1
AF (1)	19	352	18	-1
AG (1)	5	342	8	3
AH (1)	3	339	5	2
AI (1)	25	349	15	-10
AJ (1)	-38	296	-38	0
AK (1)	-21	313	-21	0
L(2)*	\	353	\	\
M(2)	-43	356	-40	3
N (2)	-40	356	-40	0
P (2)	-2	391	-5	-3
Q (2)	-14	380	-16	-2
R (2)	-11	383	-13	-2
AL (2)	-10	383	-13	-3
S (2)	10	406	10	0
S (3)**	\	355	\	\
T (3)	12	351	6	-6
U (3)	6	347	2	-4
V (3)	-12	335	-10	2
W (3)	5	345	0	-5
X (3)	-11	333	-12	-1
Y (3)	8	353	8	0
Z (3)	28	372	27	-1
AA (3)	12	357	12	0
AQ (3)	13	355	10	-3
AP (3)	6	351	6	0
AO (3)	26	367	22	-4
AN (3)	18	367	22	4
AM (3)	5	347	2	-3
L(4)*	\	351	\	\
AC(4)	1416	1807	1413	-3
O(4)	-27	365	-29	-2

Constitution Level Data

Operator : danielle/michael

	Previous Elevation	New Reading	New Elevation	Elevation Difference
Date	12/2/95	6/15/96	6/15/96	(mm)
A (1)*	0	435	0	0
B (1)	-15	420	-15	0
C (1)	-42	394	-41	1
D (1)	-23	416	-19	4
E (1)	-6	434	-1	5
F (1)	-12	429	-6	6
G (1)	-4	447	12	16
H (1)	1	446	11	10
I (1)	-13	434	-1	12
J (1)	-12	439	4	16
K (1)	-18	429	-6	12
L (1)	-56	391	-44	12
AD (1)	-8	452	17	25
AE (1)	-7	446	11	18
AF (1)	3	458	23	20
AG (1)	2	446	11	9
AH (1)	0	439	4	4
AI (1)	-5	453	18	23
AJ (1)	-33	402	-33	0
AK (1)	-20	415	-20	0
L(2)*	\	416	\	\
M(2)	-53	417	-43	10
N (2)	-42	422	-38	4
P (2)	-12	456	-4	8
Q (2)	-24	444	-16	8
R (2)	-20	448	-12	8
AL (2)	-22	442	-18	4
S (2)	1	470	10	9
S (3)**	\	443	\	\
T (3)	6	446	13	7
U (3)	10	450	17	7
V (3)	-19	419	-14	5
W (3)	-6	433	0	6
X (3)	-21	418	-15	6
Y (3)	-2	434	1	3
Z (3)	19	462	29	10
AA (3)	5	445	12	7
AQ (3)	1	444	11	10
AP (3)	-2	435	2	4
AO (3)	18	457	24	6
AN (3)	2	438	5	3
AM (3)	-4	435	2	6
L(4)*	\	399	\	\
AC(4)	1299	1738	1295	-4
O(4)	-33	417	-26	7

Constitution Level Data

Operator : fu,ma

	Previous Elevation	New Reading	New Elevation	Elevation Difference
Date	10/30/93	8/5/94	8/5/94	(mm)
A (1)*	0	721	0	0
B (1)	#N/A	711	-10	#N/A
C (1)	-30	685	-36	-6
D (1)	-22	701	-20	2
E (1)	-11	715	-6	5
F (1)	-26	710	-11	15
G (1)	0	722	1	1
H (1)	2	721	0	-2
I (1)	-25	711	-10	15
J (1)	-42	708	-13	29
K (1)	-20	705	-16	4
L (1)	-57	665	-56	1
AD (1)	-29	710	-11	18
AE (1)	-26	711	-10	16
AF (1)	-11	719	-2	9
AG (1)	-18	714	-7	11
AH (1)	-22	722	1	23
AI (1)	-19	725	4	23
AJ (1)	-27	698	-23	4
AK (1)	-18	704	-17	1
L(2)*	\	689	\	\
M(2)	-54	695	-50	4
N (2)	-37	704	-41	-4
P (2)	-14	736	-9	5
Q (2)	-38	725	-20	18
R (2)	-38	726	-19	19
AL (2)	-36	731	-14	22
S (2)	-13	734	-11	2
S (3)**	\	701	\	\
T (3)	-11	719	7	18
U (3)	-14	719	7	21
V (3)	-14	692	-20	-6
W (3)	-40	707	-5	35
X (3)	-38	699	-13	25
Y (3)	-22	715	3	25
Z (3)	11	726	14	3
AA (3)	-23	709	-3	20
AQ (3)	-25	723	11	36
AP (3)	-35	712	0	35
AO (3)	-21	n/a	#VALUE!	#VALUE!
AN (3)	-24	740	28	52
AM (3)	-24	732	20	44
L(4)*	\	447	\	\
AC(4)	1394	1899	1396	2
O(4)	-32	466	-37	-5

Constitution Level Data

Operator : eric,ma

	Previous Elevation	New Reading	New Elevation	Elevation Difference
Date		10/30/93	10/30/93	(mm)
A (1)*		473	0	0
B (1)		#N/A	#N/A	#N/A
C (1)		443	-30	-30
D (1)		451	-22	-22
E (1)		462	-11	-11
F (1)		447	-26	-26
G (1)		473	0	0
H (1)		475	2	2
I (1)		448	-25	-25
J (1)		431	-42	-42
K (1)		453	-20	-20
L (1)		416	-57	-57
AD (1)		444	-29	-29
AE (1)		447	-26	-26
AF (1)		462	-11	-11
AG (1)		455	-18	-18
AH (1)		451	-22	-22
AI (1)		454	-19	-19
AJ (1)		446	-27	-27
AK (1)		455	-18	-18
L(2)*		462	\	\
M(2)		465	-54	-54
N (2)		482	-37	-37
P (2)		505	-14	-14
Q (2)		481	-38	-38
R (2)		481	-38	-38
AL (2)		483	-36	-36
S (2)		506	-13	-13
S (3)**		485	\	\
T (3)		487	-11	-11
U (3)		484	-14	-14
V (3)		464	-34	-34
W (3)		458	-40	-40
X (3)		460	-38	-38
Y (3)		476	-22	-22
Z (3)		509	11	11
AA (3)		475	-23	-23
AQ (3)		473	-25	-25
AP (3)		463	-35	-35
AO (3)		477	-21	-21
AN (3)		474	-24	-24
AM (3)		474	-24	-24
L(4)*		380	\	\
AC(4)		1831	1394	1394
O(4)		405	-32	-32

Constitution Level Data

Operator : z/m

	Previous Elevation	New Reading	New Elevation	Elevation Difference
Date	5/11/93	7/7/93	7/7/93	(mm)
A (1)*	0	468	0	0
B (1)	#N/A	#N/A	#N/A	#N/A
C (1)	-153	309	-159	-6
D (1)	-176	289	-179	-3
E (1)	-56	411	-57	-1
F (1)	-48	413	-55	-7
G (1)	-15	450	-18	-3
H (1)	21	490	22	1
I (1)	44	513	45	1
J (1)	-59	413	-55	4
K (1)	-31	436	-32	-1
L (1)	13	479	11	-2
M (1)	13	377	-91	-104
E (2)**	\	348	\	\
N (2)	-66	335	-70	-4
O (2)	-71	331	-74	-3
P (2)	74	479	74	0
Q (2)	72	475	70	-2
R (2)	83	487	82	-1
S (2)	137	540	135	-2
S (3)**	\	406	\	\
T (3)	127	399	128	1
U (3)	123	394	123	0
V (3)	75	344	73	-2
W (3)	90	360	89	-1
X (3)	75	344	73	-2
Y (3)	74	343	72	-2
Z (3)	102	371	100	-2
AA (3)	115	384	113	-2
E (4)	\	381	\	\
AB (4)	1442		#VALUE!	#VALUE!
AB (5)	\		\	\
AC (5)	538	1880	#VALUE!	#VALUE!
AC (6)	\	59	\	\
NAIL (6)	1907	1437	#VALUE!	#VALUE!
PVC (6)	538		#VALUE!	#VALUE!

	E(1) - E(2)	63
	S(2) - S(3)	134
E(1) - E(2)	S(2) - S(3)	197

Constitution Level Data

Operator : ZHANG, MA

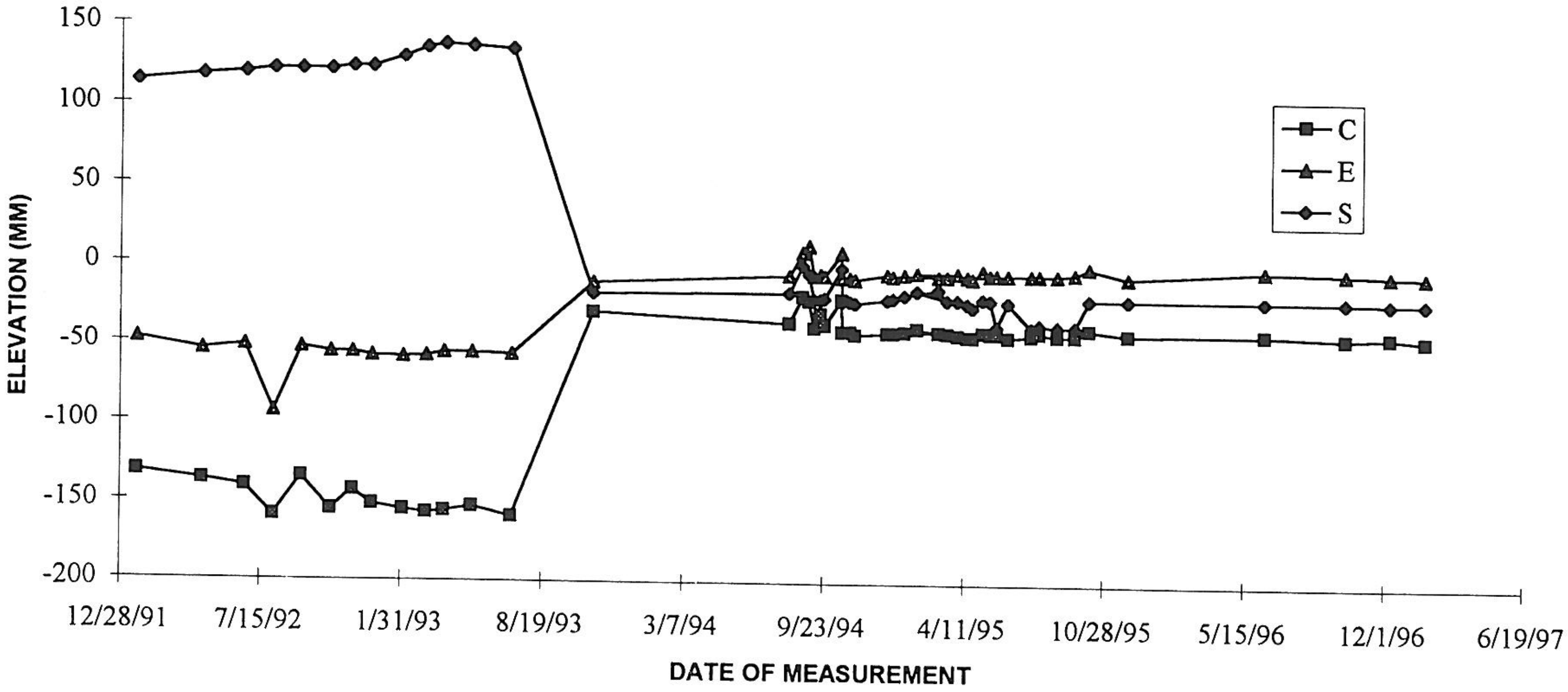
	Previous Elevation	New Reading	New Elevation	Elevation Difference
Date	4/23/92	6/23/92	6/23/92	2 Months
A (1)*	0	461	0	0
B (1)	#N/A	#N/A	#N/A	#N/A
C (1)	-137	320	-141	-4
D (1)	-134	306	-155	-21
E (1)	-55	409	-52	3
F (1)	-49	410	-51	-2
G (1)	-15	446	-15	0
H (1)	15	477	16	1
I (1)	32	494	33	1
J (1)	-72	390	-71	1
K (1)	-45	418	-43	2
L (1)	20	479	18	-2
M (1)	-91	371	-90	1
E (2)**	\	363	\	\
N (2)	-63	354	-61	2
O (2)	-62	352	-63	-1
P (2)	69	488	73	4
Q (2)	62	481	66	4
R (2)	73	490	75	2
S (2)	118	535	120	2
S (3)**	\	451	\	\
T (3)	111	448	117	6
U (3)	#N/A	440	109	#N/A
V (3)	70	399	68	-2
W (3)	80	411	80	0
X (3)	66	398	67	1
Y (3)	69	397	66	-3
Z (3)	93	422	91	-2
AA (3)	102	436	105	3

	E(1) - E(2)	46
	S(2) - S(3)	84
E(1) - E(2)	S(2) - S(3)	130

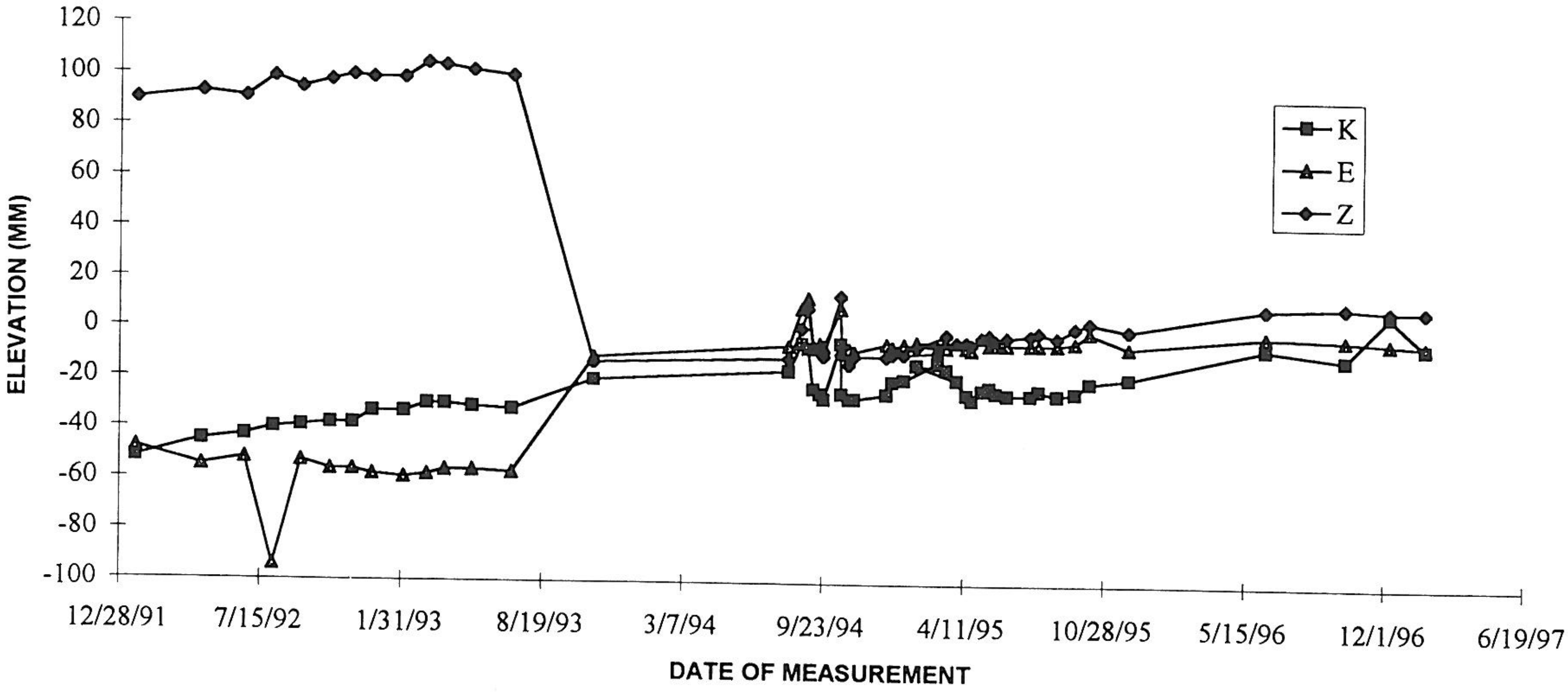
* Point "A (1)" should be the first point measured in the house This point then becomes the datum from which all other points are referenced.

** Points "E" and "S" are the common points used to correlate data from all points to point "A".

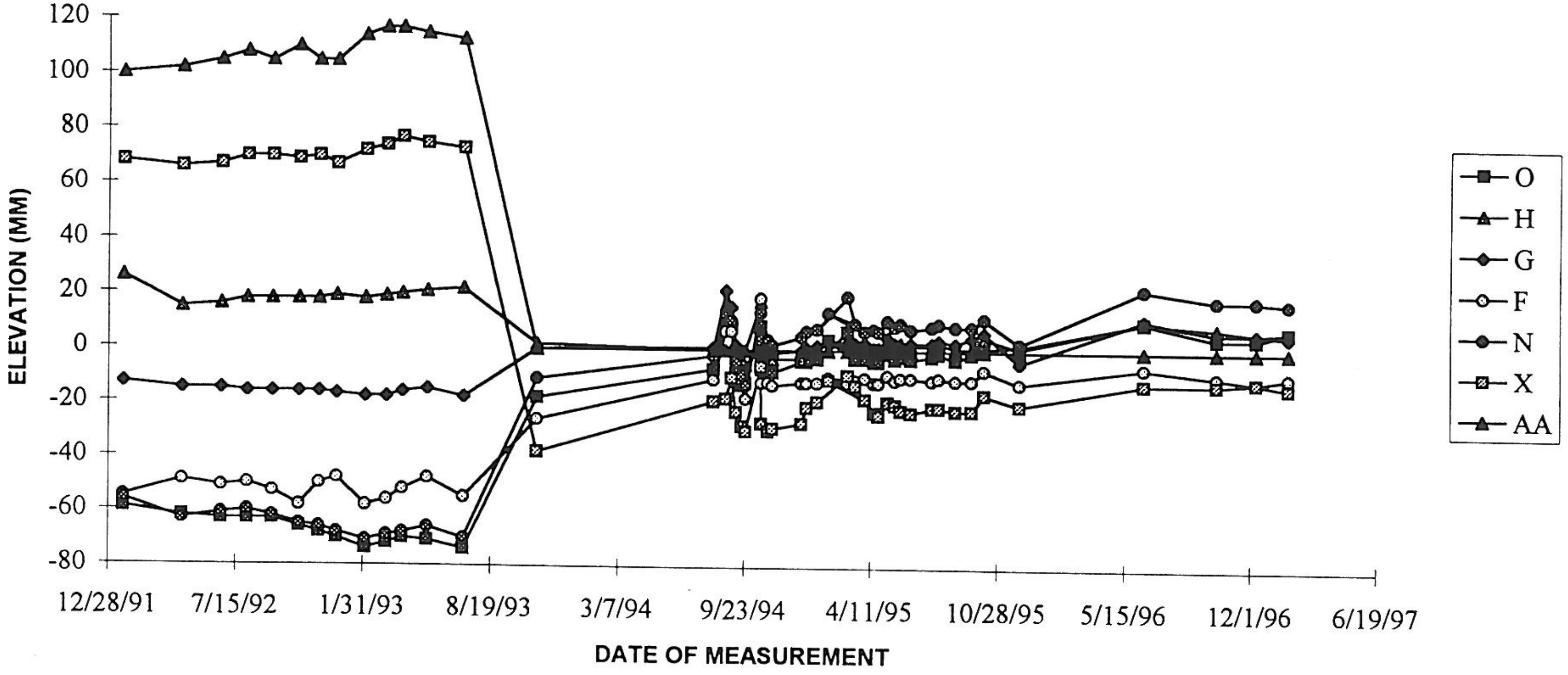
CONSTITUTION CHART 1



CONSTITUTION CHART 2



CONSTITUTION CHART 3



Engineering Reports

Emergency Number: 1-800-767-4647

CRYOTECH
Deicing Technology

Material Safety Data Sheet

Cryotech GS4 Heat Transfer Fluid

This Material Safety Data Sheet contains environmental, health and toxicology information for your employees. Please make sure this information is given to them. It also contains information to help you meet community right-to-know/emergency response reporting requirements under SARA Title III and many other laws. If you resell this product, this MSDS must be given to the buyer or the information incorporated in your MSDS. Discard any previous edition of this MSDS.

Revision Date: October 1992

1. PRODUCT IDENTIFICATION

Cryotech GS4 Heat Transfer Fluid

CAUTION! — MAY CAUSE EYE IRRITATION

PRODUCT INFORMATION: (800)346-7237

2. FIRST AID MEASURES

EMERGENCY NUMBER (24 hr): 1-800-767-4647

EYE CONTACT:
Flush eyes immediately with fresh water for at least 15 minutes while holding the eyelids open. Remove contact lenses if worn. No additional first aid should be necessary. However, if irritation persists, see a doctor.

SKIN CONTACT:
No first aid procedures are required. As a precaution, wash skin thoroughly with soap and water. Remove and wash contaminated clothing.

INHALATION:
Since this material is not expected to be an immediate inhalation problem, no first aid procedures are required.

INGESTION:
If swallowed, give water or milk to drink and telephone for medical advice. DO NOT make person vomit unless directed to do so by medical personnel. If medical advice cannot be obtained, then take the person and product container to the nearest medical emergency treatment center or hospital.

3. IMMEDIATE HEALTH EFFECTS - (ALSO SEE SECTIONS 11 AND 12)

EYE CONTACT:
This substance is slightly irritating to the eyes and could cause prolonged (days) impairment of your vision. The degree of the injury will depend on the amount of material that gets into the eye and the speed and thoroughness of the first aid treatment. Signs and symptoms may include pain, tears, swelling, redness, and blurred vision.

SKIN IRRITATION:
This substance is not expected to cause prolonged or significant skin irritation.

DERMAL TOXICITY:
The systemic toxicity of this substance has not been determined. However, it should be practically non-toxic to internal organs if it gets on the skin.

RESPIRATORY/INHALATION:
This material does not present an inhalation hazard.

INGESTION:
If swallowed, this substance is considered practically non-toxic to internal organs. Ingestion may cause irritation of the digestive tract which may result in nausea, vomiting and diarrhea.

4. PROTECTIVE EQUIPMENT

EYE PROTECTION:
Do not get this material in your eyes. Eye contact can be avoided by wearing chemical goggles.
SKIN PROTECTION:
No special skin protection is usually necessary. Avoid prolonged or frequently repeated skin contact with this material. Skin contact can be minimized by wearing protective clothing.
RESPIRATORY PROTECTION:
No special respiratory protection is normally required.
VENTILATION:
No special ventilation is necessary.

5. FIRE FIGHTING MEASURES

FLASH POINT: NA
AUTOIGNITION: NA
FLAMMABILITY LIMITS (% by volume in air): Lower: NA Upper: NA
Non-flammable
EXTINGUISHING MEDIA:
NA — Material is not flammable
FIRE RIGHTING PROCEDURES:
This material normally will not burn. However, dehydrated residue will burn.
COMBUSTION PRODUCTS:
Normal combustion forms carbon dioxide and water vapor.
NFPA RATINGS: Health 1; Flammability 0; Reactivity 0; Special NDA:
(Least-0, Slight-1, Moderate-2, High-3, Extreme-4). These values are obtained using the guidelines or published evaluations prepared by the national Fire Protection Association (NFPA) or the National Paint Coating Association.

6. STORAGE, HANDLING, AND REACTIVITY

HAZARDOUS DECOMPOSITION PRODUCTS:
None known.
STABILITY:
Stable.
HAZARDOUS POLYMERIZATION:
Polymerization will not occur.
INCOMPATIBILITY:
May react with strong acids or strong oxidizing agents, such as chlorates, nitrates, peroxides, etc.
SPECIAL PRECAUTIONS:
READ AND OBSERVE ALL PRECAUTIONS ON PRODUCT LABEL.

Store away from strong oxidizing materials.

7. PHYSICAL AND CHEMICAL PROPERTIES

SOLUBILITY: Completely miscible in water.
APPEARANCE: Clear, green colored liquid
BOILING POINT: 100°C (approximately)
MELTING POINT: <-40°C
EVAPORATION: NDA
SPECIFIC GRAVITY: 1.275 @ 20°C
VAPOR PRESSURE: NDA
PERCENT VOLATILE (VOLUME %): NDA
VAPOR DENSITY (AIR=1): NDA
VISCOSITY: 6.5 cP @ 20°C

8. ENVIRONMENTAL CONCERNS, SPILL RESPONSE AND DISPOSAL

EMERGENCY NUMBER (24 hr): 1-800-767-4647
SPILL/LEAK PRECAUTIONS:
This material is not expected to be toxic to aquatic organisms. This material is not expected to present any environmental problem.

DISPOSAL METHODS:
Based on information available to General Atomics ISC, this product is neither listed as a hazardous waste nor does it exhibit any of the characteristics that would cause it to be classified or disposed of as a RCRA hazardous waste.

If product should spill or be otherwise unsuitable for normal antifreeze applications, it may be disposed of in sanitary landfill unless state or local regulations prohibit such disposal.

9. EXPOSURE STANDARDS, REGULATORY LIMITS AND COMPOSITION

The percent compositions are given to allow for the various ranges of the components present in the whole product and may not equal 100%.

PERCENT/CAS#	**COMPONENT/REGULATORY LIMITS**
100%	CRYOTECH GS4 Heat Transfer Fluid
CONTAINING	
50%	POTASSIUM ACETATE
CAS127082	
	AND
< 1.0%	CORROSION INHIBITORS
	IN
50%	WATER
CAS7732185	

TLV - Threshold Limit Value
STEL - Short-term Exposure Limit
RQ - Reportable Quantity
CAS - Chemical Abstract Service Number

TWA - Time Weighted Average
TPQ - Threshold Planning Quantity
CPS - CUSA Product Code

10. REGULATORY INFORMATION

DOT SHIPPING NAME: NOT DESIGNATED AS A HAZARDOUS MATERIAL BY THE FEDERAL DOT
DOT HAZARD CLASS: NOT APPLICABLE
DOT IDENTIFICATION NUMBER: NOT APPLICABLE

SARA 311 CATEGORIES:

1.	Immediate (Acute) Health Effects:	YES
2.	Delayed (Chronic) Health Effects:	NO
3.	Fire Hazard:	NO
4.	Sudden Release of Pressure Hazard:	NO
5.	Reactivity Hazard:	NO

REGULATORY LISTS SEARCHED:

01 = SARA 313
02 = MASS RTK
03 = NTP Carcinogen
04 = CA Prop. 65
05 = MI 406
06 = IARC Group 1
07 = IARC Group 2A
08 = IRAC Group 2B
09 = SARA 302/304
10 = PA RTK
11 = NJ RTK
12 = CERCLA 302.4
13 = MN RTK
14 = ACGIH TLV
15 = ACGIH STEL
16 = ACGIH Calculated TLV
17 = OSHA TWA
18 = OSHA STEL
19 = Chevron TLV
20 = EPA Carcinogen
21 = TSCA Sect 4(e)
22 = TSCA Set 5(a)(e)(f)
23 = TSCA Sect 6
24 = TSCA Sect 12(b)
25 = TSCA Set 8(a)
26 = TSCA Sect 8(d)
28 = Canadian WHMIS
29 = OSHA CEILING

None of the components of this material are found on the regulatory lists indicated.

11. TOXICOLOGICAL INFORMATION

EYE IRRITATION:
The Draize Eye Irritation Score (range, 0-110) in rabbits is 8.1.

SKIN IRRITATION:
No product toxicology data available. The hazard evaluation was based on data from similar materials.

DERMAL TOXICITY:
No product toxicology data available. The hazard evaluation was based on data from similar materials.

RESPIRATORY/INHALATION:
No product toxicology data available. The hazard evaluation was based on data from similar materials.

INGESTION:
The oral LD50 in rats is greater than 5.0 g/kg.

12. ADDITIONAL HEALTH DATA

ADDITIONAL HEALTH DATA COMMENT:
This product contains potassium salts. Ingestion of large amounts (25 or more grams) of potassium salts usually causes a person to vomit. If the person is not suffering from a preexisting kidney condition the absorbed potassium is rapidly excreted in the urine. However, very young children or individuals with compromised kidney and/or cardiac function could experience the following effects after ingesting excessively large doses of potassium salts: irritation and inflammation of the stomach lining, muscular weakness, burning, tingling and numbness sensations of hands and feet, slower heart beat, reduced blood pressure, irregular heart beat and cardiac arrest.

****

The above information is accurate to the best of our knowledge. However, since data, safety standards, and government regulations are subject to change and the conditions of handling and use or misuse are beyond our control, ***Cryotech Deicing Technology, a division of General Atomics International Services Corporation makes no warranty, either express or implied, with respect to the completeness or continuing accuracy of the information contained herein and disclaims all liability for reliance thereon.*** *Cryotech Deicing Technology, a division of General Atomics International Services Corporation assumes no responsibility for any injury or loss resulting from the use of the product described herein. User should satisfy himself that he has all current data relevant to his particular use.*

STUTZMANN ENGINEERING ASSOC., INC.
P.O. BOX 1429
FAIRBANKS, ALASKA 99707
(907) 452-4094

September 14, 1988

Coldwell Banker
105 Adak
Fairbanks, Alaska 99701

Attn: Tom Hovenden

Re: AHFC #72971
728 Constitution Drive
Lot 1, Block B, Twin Moose Subdivision

Gentlemen:

Per your request, we investigated the foundation and subsurface conditions of the subject dwelling. The investigation revealed future, probable foundation problems which are discussed herein. Our recommendations for avoiding these problems are also presented.

SUBSURFACE INVESTIGATION

The subsurface investigation consisted of logging three test holes (TM-1, TM-2 and TM-3, see attached logs) drilled by Alsinco. TM-1 was drilled on August 8, 1988, with a Mobile Model B-47 drill and a 4 inch solid stem, continuous flight auger. Wet, fine, gray silt was encountered from 12 feet to the end of boring at 39 feet in TM-1. The silt was frozen and saturated below 32 feet. All samples were grab samples from the auger flights. Photo 5 shows cuttings from TM-1 several days after drilling.

TM-2 and TM-3 were drilled on August 17, 1988 using the same drill with an 8 inch, hollow stem, continuous flight auger. Samples were taken at five foot intervals using a split spoon sampler. TM-2 was drilled to 49 feet. Permafrost was from 30 feet to the end of boring with 6" of pure ice and intermittent, visible, interstitial ice encountered. TM-3 was drilled to a depth of 38 feet. Permafrost was from 30 feet to the end of boring with pure ice from 34 feet to the end of boring. Both TM-2 and TM-3 contained fine, gray silt with a strong organic odor and high moisture content below 13 feet. TM-3 contained dark brown silt with organic odor and intermittent, visible, interstitial ice from 34.5 feet to 44.5 feet.

STRUCTURE INVESTIGATION

On August 12, 1988, the dwelling was inspected for readily apparent foundation problems or construction deficiencies. Photo Nos. 1 through 12 were taken during the inspection.

The house is 24' x 44'. The upper level walls are framed with 2"x 6" studs and the floor is 23/32" APA rated Sturdi-Floor Plywood supported on 12" "TJI" joists spaced 16" C-C, spanning 12 feet from the outer wall to a 5"x 12" Glu-Lam. The lower level is a daylight basement with the above ground portion being 2" x 8" stud framing, spaced 16" C-C and resting on a concrete block foundation wall below ground. The block wall is supported by a continuous concrete footing estimated to be 24" wide by 8" thick and resting on silt.

The house currently shows few, if any, signs of settlement. There are no apparent cracks in the sheetrock. The floor on the upper level was checked for level and the elevations at various spots are shown on the attached drawing. The greatest difference between any two locations on the floor is about 0.09' or one inch.

EXPECTED PROBLEMS

The construction identified above would be adequate if the dwelling was founded on suitable ground but the three test borings drilled around this dwelling indicate the soil conditions to be totally inadequate for this type of conventional foundation. Heat from the house and warming of the ground caused by removal of vegetation will likely begin to degrade the permafrost beneath the house. As massive ice is melted, large voids will be created which may induce rapid destructive settlement of portions of the foundation. The same problems are likely to occur with the sewage disposal system to the East of the house.

POSSIBLE REMEDIES

1. Place On Post-On-Pad Foundation

This alternative would involve raising the upper level off the lower level, demolishing the lower level, constructing an insulated gravel pad beneath the upper level and supporting the upper level on posts resting on concrete pads. In addition, the existing stairway opening in the upper level floor would have to be eliminated, expanding the living room, the furnace would have to be either moved upstairs or placed in some attached furnace room and some type of heated, suspended crawl space would have to be constructed to prevent pipes from freezing and still maintain ventilation beneath the house.

Although this alternative would greatly reduce the rate of permafrost degradation, it may not stop it altogether. The ability to adjust the post and pad for gradual settlement may be totally useless if the settlement associated with massive ice thawing is rapid and immediately destructive to the house. For these reasons and because of the cost, we recommend against this alternative.

2, Refrigerate Soil Beneath Foundation

This alternative would involve insulating the floor of the daylight basement and installing some type of either active or passive refrigeration system beneath the insulation to prevent the permafrost from thawing. Because of the cost associated with an active refrigeration system (cooling pipes, compressors, coolant, etc.), this option was eliminated. Passive refrigeration devices, such as those used in piles along the Trans-Alaska Pipeline, have met with limited success in the interior of Alaska where the permafrost is relatively warm. If enough of these passive devices were installed to keep the permafrost from thawing, we may reach a point where we begin to freeze back some or all of the thawed ground from beneath the footing to the permafrost at a 30 foot depth. If this occurs, there is a chance of causing damage to the dwelling from frost heave rather than thaw settlement. The cost associated with passive refrigeration devices is expected to be quite high.

3. Place On Deep Pile Foundation

This would involve raising the upper level off the lower level, demolishing the lower level, driving eight steel pipe piles 60 feet into the ground, and constructing a network of beams and girders to transfer the load of the upper level to the piles. All of the "in addition" items mentioned previously in the post-on-pad alternative would also need to be done.

This alternative is probably the best "fix" of the three mentioned, but because of the difficulty in predicting the behavior of permafrost, we cannot insure that the foundation will remain perfectly stable during the life of the dwelling. It is our opinion that the depth of thaw will not exceed 50 feet during the next 30 years, in which case the pile will still be embedded ten feet into the permafrost and no stability problems should arise.

Our estimate of the probable cost for performing the above mentioned work with this alternative is $35,000.00

4. Move To Another Location

Moving the dwelling to another location where thaw stable soils exist is the final alternative. If moved, the lower level above the block foundation could also be moved. Then the whole house could be placed on an identical foundation elsewhere. A house mover should be consulted to determine the cost of moving the dwelling.

RECOMMENDATIONS

Because of the problems associated with the first and second alternatives, only the third and fourth alternative justify further consideration.

Alternative 4 is the only one which presents a solution to problems which might arise with the sewage disposal system. It is also the only one we feel guarantees a stable foundation for the life of the dwelling.

Alternative 3 will most likely provide a stable foundation for the life of the structure and may also prove to be less costly. A cost comparison should be performed to determine which option is most beneficial.

If desired, we will develop details for constructing a pile foundation or assist in planning for moving the house.

Our recommendations are based on the assumption that the three bore holes drilled adjacent to the house are representative of the soil beneath the house. The inspection of the dwelling was limited to those items addressed herein. This report is not meant to address the structural adequacy of the remainder of the dwelling. Hidden structural defects or deficiencies which may exist and have not manifested themselves through some movement or failure were likely to not have been identified with the inspection.

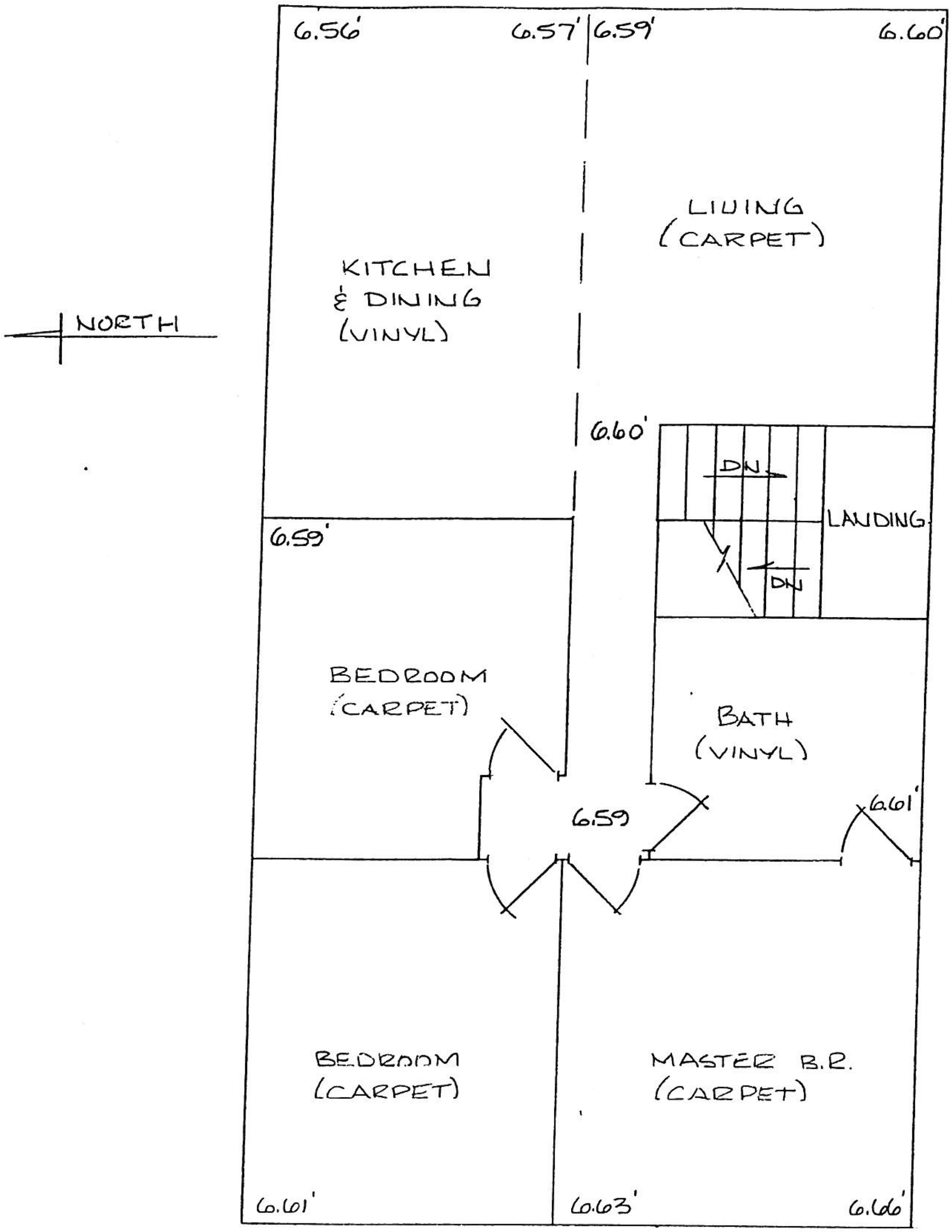
If you have any questions concerning our report and recommendations, please call.

Sincerely,

STUTZMANN ENGINEERING ASSOC., INC.

John Johansen, P.E.

40/s



NOT TO SCALE
ELEVATIONS BASED ON
ARBITRARY DATUM

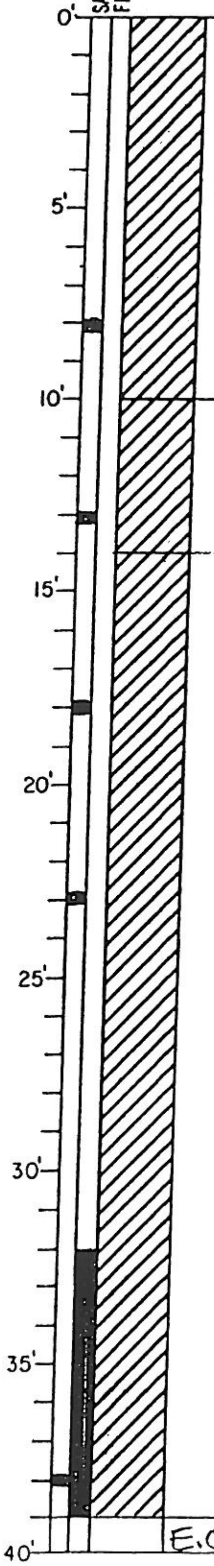
UPPER LEVEL ELEVATIONS

728 CONSTITUTION DRIVE

PREPARED BY: STUTZMANN ENGINEERING 8/23/88 [illegible]

STUTZMANN ENGINEERING ASSOC., INC.
P.O. BOX 1429, FAIRBANKS, ALASKA 99707 — (907) 452-4094

CLIENT: Coldwell Banker
JOB No. AHFC # 72971
HOLE No.: TM-1
DATE 8/8/88
LOCATION: 728 Constitution Drive
Lot 1, Blk. B Twin Moose
DRILLER: Alsinco - Gary Halmstad
LOGGED BY: J. Johansen
SAMPLE LOCA. FROZEN 5' N., 3' E. of S.E. House Corner
SHEET No. 1 OF



SOIL DESCRIPTION	SAMPLE DATA
SILT, brown, slightly damp	W= 21.5%
SILT, damp, dark brown	W=30.7%
SILT, fine, gray, wet, slight organic odor. More moisture w/ depth. Sat. @ 32' auger pushes in w/ no rotation and little pressure 30' to 30'	W= 34.3% W = 38.2% W = 41.2%
E.O.B.	

LEGEND

ORGANIC MATERIAL
SILT
SAND
GRAVEL
CLAY
SCHIST
WATER TABLE ▼
FROZEN ■

N = SPT blows/ft. 3" O.D. spoon 300#, 18" drop
W = % Moisture
GSS = % Gravel / Silt/Sand

Proof
copy
Has defects.