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Colegio San Luis Espinal Septic System Evaluation and Design Recommendations

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This document was produced as a class project by engineering students from the United States and must be thoroughly checked by a local design professional prior to implementation.

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Table of Contents

List of Figures

List of Tables

Executive Summary

Spam Jammel Engineering (SJE) evaluated the feasibility of several on-site wastewater treatment systems and made a final recommendation for Colegio San Luis Espinal (CLE), a school located in district 12 of Santa Cruz, Bolivia. The school was founded in 1986 and has grown substantially to today when they serve 3500 students each day. The existing septic systems are traditional Bolivian designs and have not been functioning properly, if at all, for several years. The malfunctioning systems currently allow raw wastewater to collect on the surface of the schoolyard posing a significant health risk to students and faculty at the school.

A site assessment was performed through a combination of interviews, direct observation, soil testing, water testing and surveying. From these interviews it was learned that the most recent septic system to be constructed, about 3 years ago, had functioned for less than 6 months before failing. It was also speculated that the system failed due to a design that was too small for the school population and because of clay soil. Soil analysis and a percolation test confirmed that the soil within the schoolyard is not compatible with a traditional Bolivian septic design due to clay content and a water table depth of <2 meters. Water testing at the site indicated that the standing water in the schoolyard, surface soils and the groundwater were all highly contaminated from

the failing septic systems. All of these activities were performed to gather data for a new design solution to the current systems.

SJE considered many alternative design solutions before evaluating the three deemed most viable for the site. The three systems, a recirculating sand filter with drainage to canal, septic tank with a gravity drainfield and septic tank with a pressure distribution drainfield, were examined in detail before arriving at a final recommendation. Due to the limitations of the soil within the schoolyard the drainfield options would require that they be built on the sports field on the south side of the school grounds. The use of the sports field for the septic system was a sensitive topic due to the fact that the sports field is a community green space that is not completely controlled by the school. Due to the fact that the soils within the schoolyard are impermeable, and therefore incompatible with most septic systems, the more favorable soils of the sports field were considered as an option.

SJE recommends the construction of 2 new systems, one for each existing toilet building, consisting of a septic tank, dosing tank and pressurized drainfield located in the sports field. This design was chosen due to its proven effectiveness, ease of construction, ease of maintenance and estimated lifespan of 10 years in addition to its relatively low cost ($197,000,bs) when compared to systems that could be constructed within the schoolyard ($1.4 million,bs). The new systems have been designed to accommodate the current population at the school as well as the projected growth in population over the next 10 years.

SJE further recommends that the school make connection to sanitary sewer lines as soon as they become available. SJE learned that the current plans estimate sanitary sewers will be available in the area within 7-10 years.

1. Introduction

In May 2008, a group of 10 students from Michigan Technological University (MTU), along with mentors and a professor, traveled to Santa Cruz, Bolivia. The two week trip was designed as partial fulfillment for the International Senior Design courses CE 4990 and CE 4905, which satisfy ABET criteria for a senior design course while simultaneously providing appropriate design solutions for clients in Santa Cruz. Spam Jammel Engineering (SJE), consisting of Joe Dammel, Pam Brushaber and Steve Wright, assessed the septic system at the Colegio San Luis Espinal (CLE), and then designed a feasible treatment option upon returning to the United States.

CLE is a public school with approximately 3,500 total students attending classes in 3 separate sessions. CLE has been in operation since 1986 and is located in District 12 Santa Cruz, Bolivia. Currently, there are two toilet room buildings, each with eight toilets and two sinks. Each building is connected to a separate wastewater treatment system consisting of a septic tank connected to a dry well system. Neither of the septic systems are currently functioning properly, creating health issues for students and staff due to unsanitary conditions from standing wastewater.

This report outlines potential design options for a sanitary treatment system for CLE. Included in the report are collected data, design calculations, estimated costs, a feasibility discussion for different possible solutions and a final recommendation and system design. The contents of this report are intended to be used as design documents for members of the school administration, local government, construction personnel, and professionals interested in a small-scale onsite wastewater treatment system.

2. Background

Bolivia is a land locked country in central South America surrounded by the countries of Peru, Chile, Brazil, Paraguay and Argentina. Bolivia encompasses a variety of terrains from the Andes Mountains of La Paz in the west to the fertile lowlands of Santa Cruz in the Southeast. Santa Cruz experiences a distinct wet season from December to March and dry season from April to November. The country is divided into nine departments, including Santa Cruz, and each department is further separated into municipalities and then districts which are lead by a subalcalde or sub-mayor. Additionally, districts are divided into unidades vecinales (UVs) or neighborhood groups, each with a president, who are directed by a single UV president.

Figure 1: Map of South America, Santa Cruz, Bolivia highlighted

Figure 2: Map of Santa Cruz highlighting location of Colegio San Luis Espinal

The current president of Bolivia is Juan Evaristo Morales Ayma, popularly known as Evo Morales, who was elected in 2005 by a majority vote of 53.7%. This was the largest percentage of votes received by any candidate in recent elections and evidence of his widespread popularity. Evo Morales is the first fully indigenous Bolivian president.

There is a growing political movement towards autonomy for the departments of Bolivia. The popularity of this movement is evident in a May 4th, 2008 vote in which 85% of the residents of Santa Cruz voted for that departments' autonomy. Autonomy would give the departments more control over their finances and therefore allow public projects to be prioritized by the importance assigned by the local people rather than the central government. The septic system project at Espinal is regarded as important by the local community and district 12 officials. In this circumstance autonomy may allow for the project to be funded earlier than it might be under the current political structure. The city of Santa Cruz is home to 1.5 million people and is Bolivia's largest city. The city is divided into eight rings surrounding the city's center. Santa Cruz is currently divided into 16 districts. CLE is located between the 6th and 7th rings in District 12 and straddles UV 178 and 179. District 12 is one of the newest districts within the municipality of Santa Cruz and emerged from an adjacent district, District 9, on May 14, 1999. District 12 is home to 170,000 community members living in 42 UVs and 76 barrios. The population of District 12 is growing at a rate of 3% annually. Primary areas of concern within the district are a lack of adequate water drainage, lack of sanitary sewer systems, and a high water table.

Founded in 1986, CLE is named after Father Luis Espinal who was tortured and murdered in 1980 after speaking out against the injustices of the government. Classes at CLE are divided into three sections; morning (1,500 students), afternoon (1,500 students), and evening (500 students). Students attending CLE in the morning and afternoon sessions range from grades 1 to 12, while the evening classes are for adults. There is a separate kindergarten on the site as well. Each section is run by a director who oversees up to 150 teachers. Due to a number of factors, including rapid enrollment growth and the presence of clay soils, the existing septic systems of the school are malfunctioning. This has resulted in health issues stemming from contact with the standing wastewater prevalent at the site. In 2007 the school reported a large outbreak of typhoid fever involving the children and some staff. Typhoid fever is transmitted by the ingestion of food or water contaminated with feces from an infected person. The lack of proper sanitary facilities may have been a compounding factor in the spread of Typhoid fever at CLE.

Figure 3: Existing septic tank with standing water

SJE worked with local government, local engineers, school administrators and teachers at CLE, district engineers, engineering professors from Santa Cruz and Cochabamba, water and sanitation professionals from Saguapac (the local water and sanitation cooperative), the head of the parent association for CLE and other members of the local community to gather and analyze data while in Bolivia.

The goal of this project is to assess the current septic system and provide a solution for improving sanitary facilities at CLE for the current students and staff as well as the expected growth of the school over the next 7-10 years. This timeline is important because Saguapac plans to have sanitary sewers installed in this area of district 12 within 7-10 years. By providing a design for an appropriate onsite wastewater system for the school SJE aims to help improve the health and welfare of the students and staff at CLE.

3. Methods and Procedures

This section details the methods and procedures employed by SJE to collect and analyze the data used in this report. Data gathered from these procedures provided the information required for understanding the physical, environmental and societal aspects of this project.

The following is a brief outline of the methods and procedures SJE followed when gathering data for this report:

- Personal interviews with school officials
- Soil borings and water table determination
- A topographic survey
- Water tests to determine presence of coliforms
- Data was gathered to determine volume of waste water generated
- A percolation test

The detailed methods and procedures used are discussed in this section.

Figure 4: Steven Wright (left) and Lic. Carmen Arias interview Architect Roberto Añez Limpias (right)

4.1 Personal Interviews

Interviews were conducted with Lic. Anna Maria Rivadeueira, the morning director, Dir. Jose Raul Silva Cordero, the Director of the afternoon session, Dir. Jose Raul Silva Cordero, the head of the parents association, Sr. Teodareo Andia, the head of the teacher's association, Prof. Mary Gutierrez, English teacher and founding member of CLE, Fabian, the school's "portero" or gate keeper, and students from a variety of grades. These interviews were conducted in person, with the help of a translator, and documented with notes taken by SJE.

SJE was unable to secure documents or designs for the existing septic systems and so the primary sources of information about the existing systems were direct observation along with interviews from Lic. Anna Maria Rivadeueira and Sr. Fabian, the porter, both of whom worked at the school when the septic systems were installed.

One interview, by means of a questionnaire list, was given to 81 students, in grades 1, 6 and 12. The interview contained four questions:

- How many times a day do you use the bathroom at school?
- How often do you wash your hands after using the bathroom?
- How often do you have upset stomach?
- Are you a boy or a girl?

These results were tallied and used to calculate the design wastewater flow as detailed in section 6.2.

4.2 Soil boring and groundwater table determination

Soil boring at CLE was performed on May 19th by SJE and Sr. Theodoro Gandarillas, a local well driller. 2 soil borings were taken. The first boring was taken inside the school courtyard and was centrally located in the area of the existing septic systems. The second boring was conducted outside the school walls in the sports field south of the existing toilet rooms.

Each soil boring was drilled using a manual soil auger with a diameter of 10.16cm (4inches). The auger was screwed vertically into the soil at the chosen location. The auger and soil samples were pulled from the hole at regular intervals and the soil was laid sequentially on the ground for examination and classification. Depths of each stratum were noted on the soil boring log, Appendix G, along with descriptions and field classifications. SJE, in conjunction with Eng. Carlin Fitzgerald, performed field classification of the soils and collected representative samples from each stratum for further testing and classification off-site.

Figure 5: Pam Brushaber and Theodoro Gandarillas collecting a soil sample while children watch

Each boring was continued to a depth that exceeded the initial level of the groundwater table. The initial depth of the groundwater table was noted on the soil boring log and boring continued for approximately one additional meter of depth. Once boring was completed, the water level was immediately checked by weighting a string and lowering it into the hole until the water level was reached. The depths of the water was determined by measuring the distance between the surface of the soil, as marked on the string, and the level of water, as noted by wetness on the string.

Due to safety concerns for students, the bore hole inside the courtyard was immediately refilled after testing with the removed soil. To allow for checking the groundwater table depth after 24 hours, the bore hole in the sports field was left empty and covered with a brick that was found on-site. However, 24 hours later the hole had been filled in by an unknown person, therefore the 24-hour water level was not measured in either soil boring.

Figure 6: Soil samples

4.4 Topographic survey

SJE used the following equipment to conduct a topographic survey of CLE:

- Topcon GTS-225 Total Station
- TDS Ranger Data Collector
- Prism rod
- Tripod
- Metric measuring tape

SJE conducted a survey of CLE grounds inside its brick walls. The purpose of the survey was to determine building locations and dimensions, location of paved areas and the existing septic system. Standard US surveying practices were implemented, detailed by MTU Professor Paul Buda. The instructions provided by Professor Buda are found in Appendix A.

The initial point for setup of the total station was chosen for its optimal vantage point of the school grounds. The first benchmark was set on a fixed point, on the corner of the stairs and other traverse points were selected in order to capture views obstructed from the first setup (see Figure 10 for the location of benchmark). Traverse points were located by driving nails, with pink nylon strips tied around them, into the soil. The data points gathered were downloaded into the Foresight program, converted to a TXT file, imported into AUTOCAD Civil 3D 2008 Software which was used to generate the site layout.

After completion of the original survey, a local engineer, Ing. Erick G. Selaez Tapia, provided SJE with access to existing official benchmarks. Ing. Tapia previously surveyed the site upon request of Directora Rivadeueira. Ing. Tapia shared his survey data and site layout with SJE.

Figure 7: Steve and Joe setting up the surveying equipment

4.3 Water Quality Testing

Water tests for coliforms (fecal and total) were performed on water obtained from:

- Bathroom faucet
- Ground water
- standing water from the schoolyard
- soil samples from inside the schoolyard

SJE used different types of 3M™ Petrifilm™ coliform count to characterize contamination from the different locations.

The following outlines the three days of testing and analysis.

Day One: At CLE, four locations were selected to take water samples: sink water (drinking water), standing water near the bathrooms, water on the floor of the boys' bathroom, and water taken from the water table outside of the school grounds from the sports field bore hole. Samples were kept in clean water bottles and in smaller, new liquid carry-on bottles. The samples were collected in the morning and were taken to Saguapac's water testing laboratory in the afternoon to be incubated. Plate preparation and incubation were followed per documentation provided by 3M™ found in Appendix C, with the exception of SJE's utilization of a 48-hour incubation time per guidance from Dr. Susan Bagley, a microbiologist at MTU. The drinking water sample was tested using the high sensitivity coliform counting plates in addition to the standard coliform count plates so that any coliform presence in the drinking water would be noted and quantified.

Day 2: Approximately 100 ml of clean drinking water was flushed through three soil samples from 0.0-0.3m, 0.7-1.2m, and 2.0-2.5m, held in a cotton filter to reduce sediments in the water. This test was performed to verify the level of contamination in the soil at different depths in the school courtyard. The water was analyzed the Saguapac laboratory using rapid coliform count plates that require less than 24 hours of incubation time. These plates were selected so that only one return trip was necessary to count the resulting coliform colonies.

Day 3: A final trip to Saguapac's lab was taken to count the colonies growing on the incubated plates. Standard coliform counting procedures were followed – if there appeared to be more than 300 colonies on the plate, the plate is considered to be contaminated in numbers "too numerous to count". In some instances, fecal coliforms appeared as a colony with a gas bubble surrounding it. For these occurrences, a separate count was performed to quantify the fecal coliform contamination. A summary of the results is found in Table 1. Assistance was provided each day by Ing. Elias Avila Castellon, an employee of Saguapac.

4.5 Sanitary flow/usage rate determination

Five sets of information were considered to determine the usage and flow rates of the sanitary system:

- Typical engineering values
- Direct observations
- Toilet tank dimension sizing
- Student and teacher population
- Student questionnaire

4.5.1 Population assumption

To calculate a design flow rate for the new system, the population of the school was assumed to be that of the section with the highest enrollment staying at the school for a period of 12 hours. This would provide the most conservative estimate of flow for design. This initial number was increased by using the student population growth rate provided by Lic. Anna Maria Rivadeueira. This information was then modified for a 10-year timescale with a cap of total enrollment based on SJE's estimate for the maximum capacity of CLE.

4.5.2 Typical sanitary flow rates

An average sanitary flow rate of 60 L/p·day was provided by Ing. Rufino Arano, the former sub-mayor for District 10. A second sanitary flow rate is provided by the EPA and ranges between 19 to 64 L/ p·day.

4.5.3 Other methods of calculating sanitary flow rate

Three methods for calculating a sanitary flow rate were used by SJE to obtain a set of values to make an engineering decision for the design sanitary flow rate. The three methods are detailed below:

- Toilet tank dimensions were measured in order to estimate the volume of water per flush. The total flow was estimated from observation of usage during a half hour period of high use (recess period). Using the observations and the estimated flush volume based on past ISD reports, local observations, and U.S. standards, a per capita flush rate was estimated. This per capita flush rate was multiplied by the student population to determine the overall sanitary flow rate.
- Interviews were conducted with several student groups (*see* **4.**7 and Appendix D) and the information was analyzed to determine an average number of toilet uses per student each day. The average number of toilet uses per day was multiplied by the student population to determine the overall sanitary flow rate.
- The portero supplied a recent water bill from Saguapac that showed the total amount of water purchased each month for the most recent 12 months. Because there are no kitchens or showers at CLE, this quantity was assumed to equal the amount of water used in the toilets and sinks. The average per capita usage rate was determined by averaging the water use for the 12 month period and dividing by the population. This per capita usage rate was used to find the overall sanitary flow rate.

4.5.4 Design sanitary flow rate

The final design sanitary flow rate was determined by comparing and analyzing the five different values obtained. The typical engineering flow rates provided by Ing. Arano and the US EPA were higher than all three calculated sanitary flow rates. SJE used a safety factor of 1.5 and applied it to the calculated per capita sanitary flow rates. This safety factor, in addition to a peaking factor of 1.5, gives a per capita sanitary flow rate close to the rate provided by the US EPA. Assumptions and detailed calculations are located in Appendix E.

4.6 Percolation Test

SJE performed a percolation test on the soils located in the area of the existing septic systems within the school yard. The percolation test procedures SJE followed were developed from the Arizona Department of Environmental Quality Engineering Bulletin 12, June 1989. The complete procedure is located in Appendix F. SJE used the following variations when completing the percolation test:

- The bottom of our test hole was covered with broken clay roof tiles found on site rather than gravel as specified in the test procedure
- The hole was dug so that the bottom was at a depth of 1 meter

- The portero at our site was recruited to keep the test hole filled to a depth of 12" for the first 4 hours of the procedure

SJE returned to the site the following day, after the required 24 hours of soil saturation had passed, to complete the percolation test. The portero informed us that only a small amount of water had to be added during the initial 4 hour saturation period. Upon measuring the depth the water had only dropped from 12" to 7" in the 24 hours. With the slow rate of infiltration observed, coupled with our soil examination indicating that the layer we were testing was predominantly clay; it was decided to conclude the testing. Due to time and safety concerns the test hole was filled and the data collected from the test was used to provide an appropriate basis for the design considerations.

Figure 8: Steve surveying a kindergarten classroom

5. Existing Conditions

5.1 Site Layout

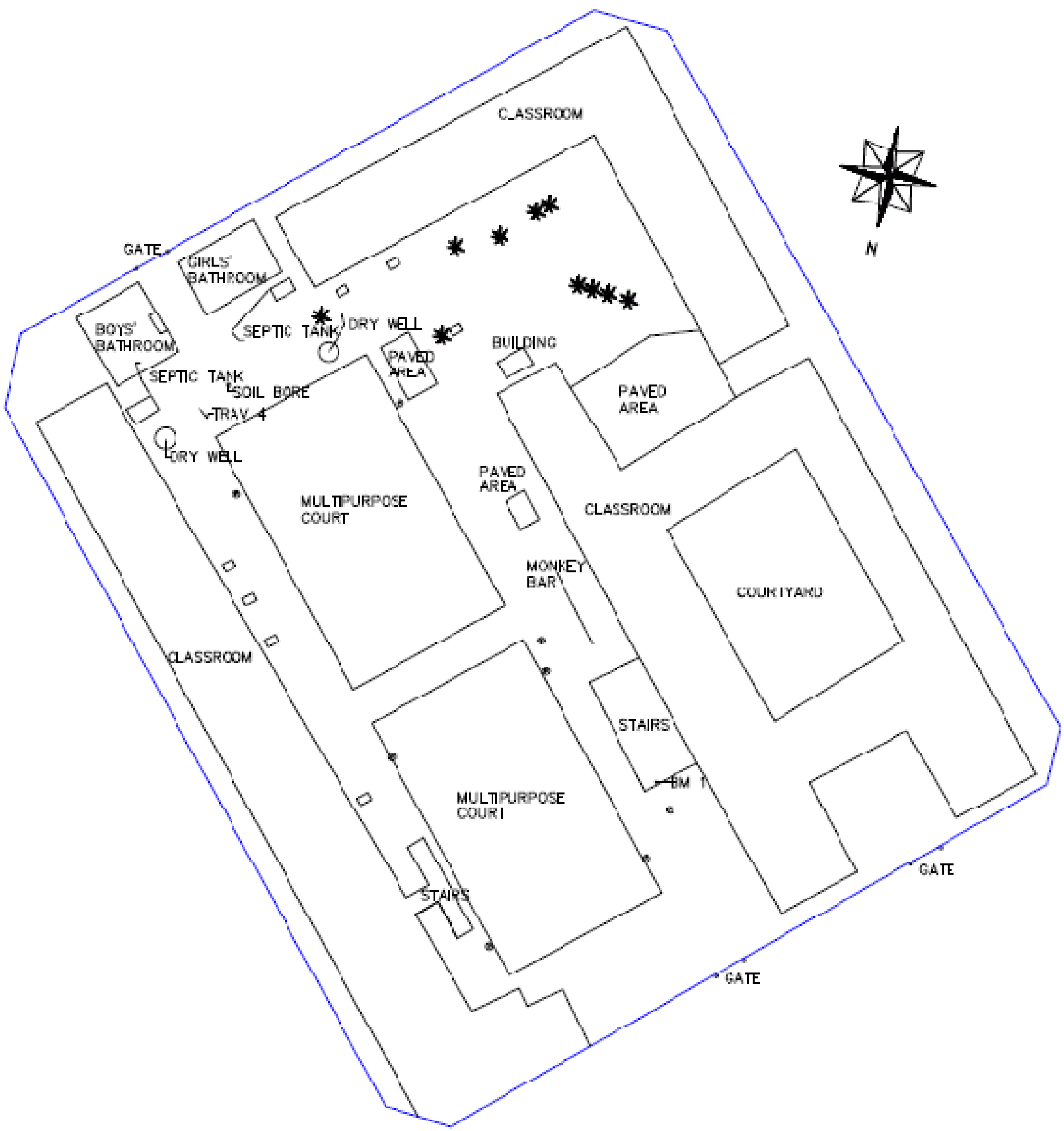

Figure 9: Site layout of CLE

There are two traditional Bolivian septic systems currently in use at CLE, one for each toilet building. These systems consist of a septic tank and dry well, or pozo ciego, in series. The boys' toilet room has a system that was financed and constructed by the District 12 mayor's office approximately five years ago. The system for the girls' building is older than the boy's, but its construction date is unknown. The newer system functioned properly for approximately six months before failing and causing wastewater to seep out of the dry well.

Figure 10: School grounds. Toilet room facilities are located in far right picture, in the back.

Figure 11: Boys toilet room **Figure 12: Girls toilet room**

Both toilet room buildings are concrete structures with 2 separate chambers, each containing 4 toilets, sinks, and a urinal in the boy's toilet room. Each toilet room building currently has one locked chamber that is being used for storage.

The boy's septic tank has dimensions of 3.5 x 1.7 x 1.3 m (L x W x D) and the dry well has a diameter of 2.2 m and a depth of 4 m. The second system has a septic tank with dimensions of 2.4 x 1.4 x 1 m tank and a dry well 2 m in diameter and 3 m deep.

In the boy's toilet room, there are four tank and bowl toilets with dimensions of 15 x 46 x 30 cm. No toilet is operational in this building, leaving waste to accumulate in the bowls. Standing water was present at a depth of less than 2 cm and the floor drain located in the middle of the floor was not functioning.

Figure 13: Inside of boy's toilet room

Figure 14: Toilet in the boys toilet room (left) girls toilet room (right)

The girl's toilet room shares a layout similar to the boys' but differs in the type of toilets. Instead of tank and bowl toilets, the toilet room has pull-string toilets with tank dimensions of 30 x 30 x 15 cm, shown in Figure 14 above. Two out of the four toilets had intact pull-strings and one toilet was flushed for observation. Standing water was also present in the facility and the sinks were not functional.

Observational data recorded during a peak usage time, recess, indicates that the boy's toilet room is used twice as often as the girls. This is no reason to assume that this is due to a difference in preference of either toilet room. There is one functioning sink basin at CLE, containing four spigots. The basin is connected to the wall of the boy's toilet room facility and is emptied via pipe into a small ditch outside of school grounds. The contribution of the sink to the septic system is therefore negligible and only contributes through surface overflow infiltrating the tank.

5.2 School Organization

The school is structured so there are three different sessions of classes consisting of a morning session from 7:45am to 12:50 pm, an afternoon session from 2 pm to 6 pm and evening sessions for teenagers from 7:00 pm to 9:30 pm and adults from 7 pm to 10 pm. From an interview with Prof. Mary Gutierrez, an English teacher at CLE, the morning session consists of approximately 1500 students, from grades kinder to the twelfth grade. The afternoon session is approximately 1500 students, again from grades kinder to the twelfth grade. The evening session is for adults, mothers age fifteen or older, or married persons. The school currently serves approximately 3500 total students per day. Each session is controlled by its own Director, and as a result of the timing of each session the Directors rarely make contact with one another.

Each Director governs their sessions independently of one another and institute rules, regulations and payments per student as they deem necessary. The morning and afternoon directors have founded an organization of teacher's and a parent's association.

Figure 15: The morning directora, Lic. Anna Maria Rivadeueira, (middle front) marching in a District 12 anniversary parade on May 16, 2008

5.3 Budget

The law for a public school in Bolivia requires that 10 Bolivianos be paid per year for each student enrolled in the school. The funding consists of 5 Bolivianos paid to the school in cash and 5 Bolivianos withheld for maintenance which is administered by the district mayor. In the case of CLE, the morning Director has stated this money for maintenance has been withheld for four years, despite inquiries to the mayor's office. The morning directora has required three Boliviano's per month from her parent's association in order to pay for two disciplinarians, a librarian, and social worker. No information was collected on the evening session's extra organizations.

Due to the large initial cost, the school could not fund a new septic system without additional money from the government. However, with active parent's associations in both the morning and afternoon sessions, both Directors have stated that funding for maintenance and operation of an appropriate system, if installed, would be provided.

5.4 Soil Conditions

The soil conditions for CLE were determined by soil borings, soil classification and a percolation test. The soil borings and classifications were done at 2 separate locations: near the existing septic systems inside the schoolyard, and in the sports field that lies directly adjacent to the south side of the schoolyard. Soil composition within the schoolyard and the sports field were found to be significantly different.

The soil boring within the schoolyard showed a high percentage of clay within the soils beginning less than 0.7 meters below the surface and continuing to 1.15 meters below the surface. This layer of soil was predicted to be the least permeable through analysis and classification of the samples. Based on this information SJE chose this layer of soil to perform a percolation test. The soil boring and percolation test showed a clear layer of rubbish, brick and construction debris from the surface to a depth of 0.5meters.

The soil boring from the sport field showed a more favorable soil profile than that found within the schoolyard. The sport field soil boring showed no impermeable soil layer as was found in the schoolyard. The sport field was also lacking in the layer of rubbish, brick and other debris that was found within the schoolyard.

6. Testing Results

6.1 Water Testing Results

SJE performed water quality tests to determine the presence of fecal and total coliforms. The test results are shown in Table 1 below

Location of Sample	Total Coliforms	Fecal Coliforms	Coliform Forming Units(CFU)/100ml
Tap Water	-	-	-
Standing water from schoolyard	Too Numerous to Count(TNC)	-	TNC
Standing water from toilet room	TNC	-	TNC
Soil depth 0.0-0.3m	320	40	32,000
Soil depth 0.7-1.15m	7	0	700
Soil depth 2.0-2.5m	42	3.5	4,200
Water table	89	-	8,900

Table 1: Water Quality Testing Results

These tests show that the failure of the current septic systems is a health concern for students and teachers at CLE. The water provided to the school by Saguapac is free of contamination, but all other samples show significant coliform contamination. One major concern is the presence of significant coliform contamination within the water table. This contamination is a concern for anyone relying on this groundwater for human consumption.

6.2 Design Wastewater Flow

SJE performed 3 different calculations to determine the volume of wastewater that will need to be treated. These calculations were based on: water use from the previous 12 months, observation of toilet use and interview data about toilet use. Additionally, SJE calculated the wastewater flow by using Bolivian and United States standard engineering values. The results of these calculations are summarized in this section.

Water Usage Calculation – Averaging the data for water purchased over the most recent 12 months SJE calculated the total wastewater volume as 5.1 liters per day per student (L/d·student).

Observation of Toilet Use – The number of students observed using the toilet rooms over a 30 minute period was extrapolated to a 12 hour period and multiplied by the estimated wastewater volume per use to arrive at a total wastewater volume of 7.3L/d·student.

Interview Data About Toilet Use – The average number of times students indicated, during the interviews, use of the toilet facilities each day was multiplied by the student population to arrive at a total wastewater volume of 7.7 L/d·student.

Bolivian Engineering Values – Ing. Arano provided SJE with an engineering value of 60 L/d·student for estimating total wastewater volume.

United States Engineering Values – The U.S. Environmental Protection Agency provides a range of engineering values, for a school with no kitchen or showers, between 19 and 64L/d·student.

The five values were compiled in a table to assess each value's validity. The three calculated flow rates were very close in value with the interview data providing the highest total flow. This value for the total wastewater flow was used because it was the most conservative of the calculated values. Details and assumptions for these calculations are located in Appendix E.

SJE determined the design flow rate to be 36,000 liters per day (9,500 gallons per day).

6.3 Soils

SJE conducted soil borings and analysis on 2 locations, schoolyard and sports field, at CLE. These tests showed that the schoolyard soil contained a layer between the depths of 0.7 to 1.7m that has high clay content. The high clay layer from 0.7 to 1.7m was determined to be the limiting layer and was the depth the percolation test was performed. The percolation test confirmed the soils within the schoolyard are highly impermeable with a percolation rate of just 0.011cm per minute (.25 inches/hr).

7. Discussion

SJE initially evaluated 19 possible design solutions against 5 primary limiting factors. Based on interviews with various stakeholders SJE determined that an ideal system would meet the following 5 criteria:

- Function in an area with clay soil
- Handle a wastewater volume of at least 36,000Lpd
- Function with a water table depth of 1.5m
- Fit within the 1275m^2 area available within the schoolyard
- Inexpensive to construct, operate and maintain

SJE initially examined the following 19 systems against the primary criteria and rated them as feasible, not feasible or possibly feasible with modification. The systems and their initial rating are shown in Table 2 below.

System	Initial Determination
Traditional Bolivian Septic System	Not Feasible
Bolivian System with Galleria Filtration	Not Feasible
Septic with Gravity Drainfield	Possibly Feasible
Septic with Pressure Distribution Drainfield	Possibly Feasible
Septic with Dripline Effluent Drainfield	Possibly Feasible
Septic with Mound Style Drainfield	Possibly Feasible
Dry Composting Toilets	Not Feasible
Constructed Wetlands	Not Feasible
Vegetated Submerged Bed	Not Feasible
Septic with Pirana System	Feasible
Sand Filter with Drainfield	Not Feasible
Recirculating Sand Filter with Drainfield	Possibly Feasible
Split Bed Recirculating Sand Filter with Drainfield	Possibly Feasible

Sand Filter with Drainage to Canal	Not Feasible
Recirculating Sand Filter with Drainage to Canal	Possibly Feasible
Split Bed Recirculating Sand Filter with Drainage to Canal	Possibly Feasible
Biogas Digester	Feasible
Pre-packaged On-site Treatment Plant	Not Feasible
Holding Tank	Not Feasible
Wastewater Recycling and Reuse	Possibly Feasible

Table 2: Design Alternatives Considered by SJE for CLE

After the initial evaluation process, SJE eliminated 9 possible solutions from further consideration based on the primary limiting factors. The remaining 10 options were then researched further to determine which options would be pursued.

7.1 Traditional Bolivian System

A traditional Bolivian septic system design is comprised of a septic tank connected to a dry well, or pozo ciego.

The wastewater flows into the septic tank where the solids are settled out and the liquid effluent then flows into the pozo ciego. The pozo ciego is designed to allow the wastewater to infiltrate into the soil through designed openings in the walls. These systems work very well in soils with a high infiltration rate or applications with a low loading rate.

In the case of CLE, a traditional Bolivian system is inappropriate based on the amount of wastewater generated and the predominance of clay in the soils within the schoolyard. The impermeable layer of clay within the soils prevents the wastewater from flowing out of the pozo ciego which will cause the system to eventually fill with wastewater and ultimately fail.

7.2 Modified Bolivian System

Traditional Bolivian system designs have been modified to allow for additional wastewater loading capacity by adding a galleria filtration to the pozo ciego. These systems consist of a septic tank, a pozo ciego and drainage lines that extend from the pozo ciego out into the surrounding soil thereby increasing the wastewater infiltration.

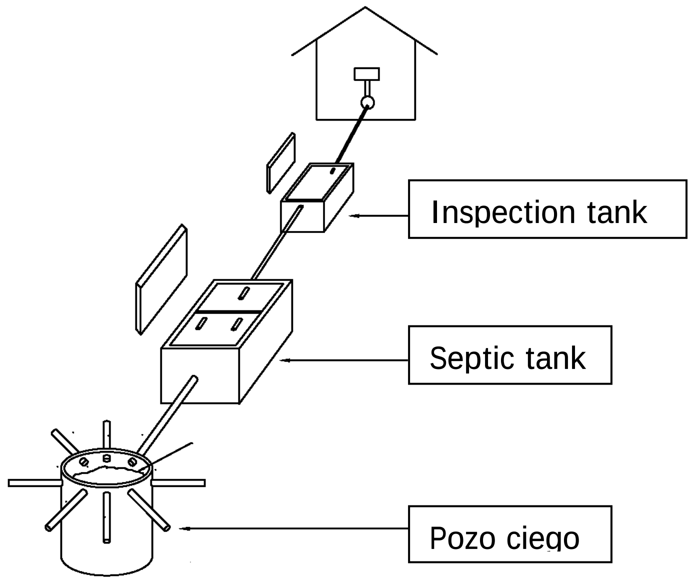

Figure 16: Modified Bolivian System

These systems, like the traditional Bolivian systems, require that the soils have sufficient infiltration capacity in order to function correctly. The soils within the CLE grounds do not have sufficient infiltrative capacity for a modified Bolivian system to function correctly.

7.3 Wastewater Reuse

The options of single pass or recirculating sand filters involved the need for a method of water discharge. Wastewater reuse was researched as an option. In order to allow this option to be feasible, as it had to be more economical than the other options, the water had to be in a closed system. In a closed system, all the water would be recycled and there would be no outlet for discharge, only an inlet for city water when needed.

Building an open system, or a method for discharge and a piping system for reuse of the water, would not be economical as the system could work with only one of these systems if built properly thus the extra expenses could be avoided.

A negative to a closed system, as well, is the potential for system overflow, as more water will be entering the system due to sink usage than will be leaving, as the re-use will be for toilet flushing alone. Also, mechanisms for the prevention of backwater flow would be needed.

The main constraint would be the quality of the effluent sent back through the pipes and the toilet tanks. If the suspended solid limit is too large the water could clog the openings in the toilet tank. Also, since there is a large possibility of human contact, the effluent must be disinfected to remove fecal coliforms, and if chlorination was used, it must be de-chlorinated before sent through the system again. Re-use of wastewater for toilet flushing is uncommon in the Unites States as well as other countries due to the extensive treatment it must go through.

Another constraint would be a tank suspended on a roof top or at a high elevation in order to provide sufficient pressure for the system flushing. This tank needs to be able to hold at least 36,000 liters of water, required by our minimum design flow. Elevating a tank this size is a safety hazard. Due to the extensive water treatment needed, the tank size, and the need for a closed system, the option of wastewater reuse is dismissed.

7.4 Single-pass Filter

A single pass sand filter system combines a standard septic tank with a sand filter bed and then flows into a dispersal field. These systems are designed to provide secondary treatment of wastewater, reducing the nutrient content and BOD of the effluent, prior to dispersal into the soil.

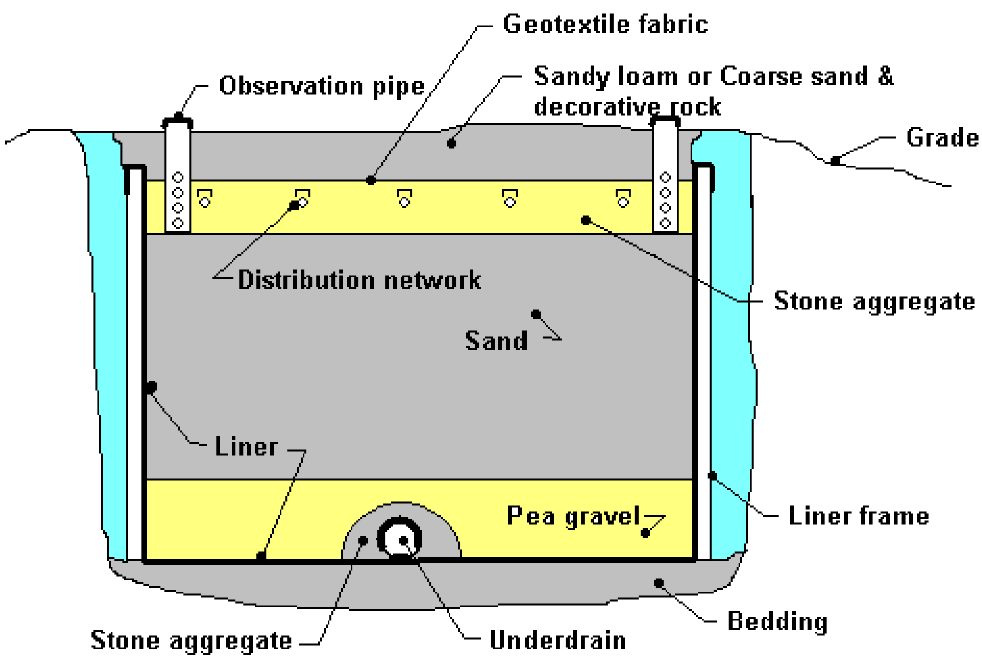

Figure 17: Single Pass Sand Filter Bed (WI Dept. of Commerce, Doc. SBD-10595-P)

Single pass sand filters are primarily used to treat water that is high in nitrogen prior to discharging into a drainage field. A single pass sand filter designed to handle to wastewater flow from CLE would require a surface area of over 670 square meters. This large area requirement makes it impractical for use at CLE. Since the courtyard at CLE has a total unpaved surface area of roughly 1275 square meters, the sand filters would occupy an unacceptably large percentage of available area within the school grounds.

7.5 Recirculating Sand Filter

The recirculating sand filter method is feasible, although a dispersal field, or surface water body, is needed. A drainage field allows the water to percolate through the soil, the soil acting as a filter to clean the water and the water eventually settling in the ground water. However, the time needed for percolation of large volume water used by the school is not possible in the school ground's clay soil.

Another method of discharge must be utilized. SJE determined the next available route for discharge would be to the city canal, approximately 150 meters away. The minimum requirements include a pump, excavation of the city's unpaved road and treatment of the effluent water that would meet Bolivian environmental water quality standards for discharge into a surface body of water.

7.6 Split Bed Recirculating Sand Filter

The split bed recirculating filter system is designed to provide increased nitrogen removal and optimized performance and reliability of the sand filter process. Split bed recirculating sand filters provide secondary treatment of wastewater by recirculating the effluent through a 2-stage sand filter. This process allows for a smaller sand filter while still achieving excellent treatment of the wastewater.

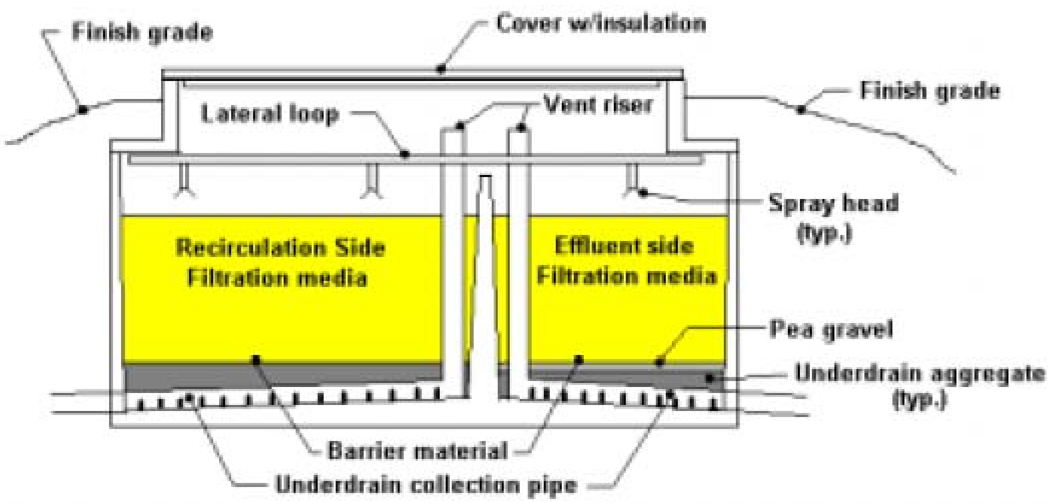

Figure 18: Split Bed Recirculating Sand Filter (WI. Dept. of Commerce, Doc. SBD-10656-P)

The split bed recirculating sand filter design offers some distinct advantages over other systems, such as: relatively small area, 120 square meters, required for filters and high quality effluent suitable for discharge to surface waters, if disinfection is added to destroy coliforms. However, the challenges to installing this system at CLE are substantial. They include the need for multiple pumps and distribution valves, the loss of 120 square meters of schoolyard, added expense for construction of a distribution tank that is large enough to handle the significant volume of wastewater generated by CLE, high level of maintenance required for the system and the challenges with discharging effluent into a surface water body, as previously described. It is the opinion of SJE that these challenges make the installation of a split bed circulating sand filter system at CLE impractical.

7.7 Drip Line Effluent

The drip line effluent system is a dispersion field design which utilizes sophisticated pressure distribution technology coupled with a large array of small diameter tubing placed directly into the existing soils generally at a depth of <0.5 meters.

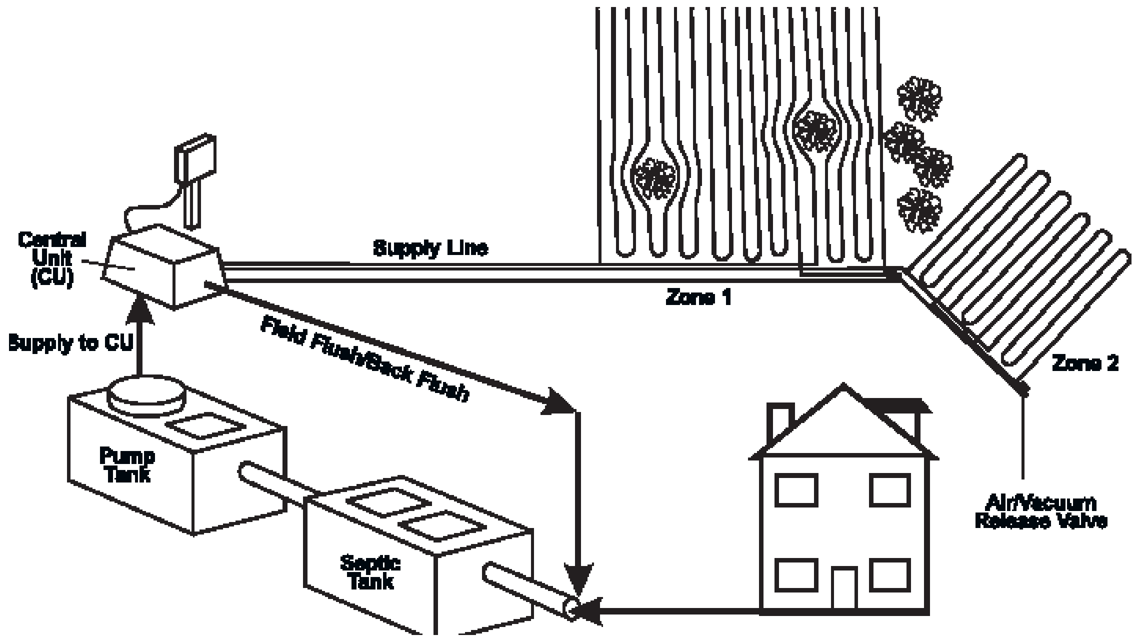

Figure 19: Drip Line Effluent Dispersal System (EPA Doc. EPA 625/R-00/008)

Drip line effluent systems have several advantages over a standard drainfield, such as: no need for large excavation, use of existing soils, functions with a high water table and allows for the continued use of the surface as a sports field. However, the drip line effluent systems are relatively complex due to the need for pumps, timers and distribution valves to properly disperse the effluent into the system. The additional expense and technological challenges outweigh the possible benefits of this system when examined for use at CLE. The potential for expensive maintenance and component failure was determined to be unacceptably high for the system to be recommended.

7.8 Mound system

The mound system is a modified traditional drainfield. The mound system accommodates for high water tables, shallow soils and soils with poor infiltration rates by laying the drainage field at, or near, the ground surface and then constructing a mound with desired infiltration characteristics above the drain pipes.

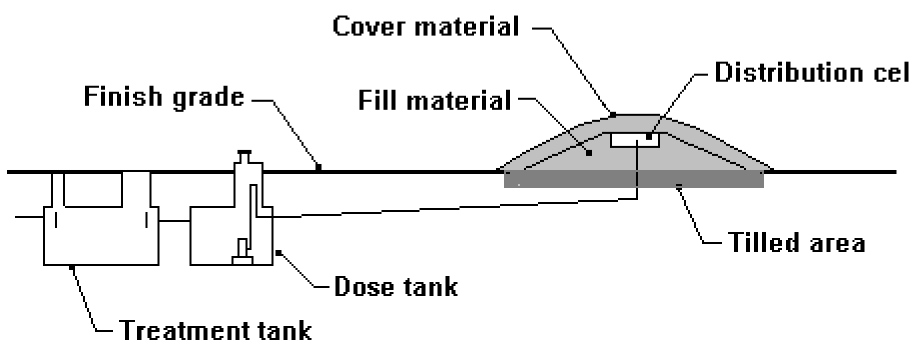

Figure 20: Mound Effluent Dispersion System (WI Dept. of Commerce, doc. SBD-10691-P)

The mound system was considered for CLE due to the layer of impermeable soil within the school yard. Due to the large volume of wastewater to be handled the mound system would require a surface area of 650 square meters. Since the mound systems rely on proper aeration of the wastewater in the soils as well as sufficient infiltration, the mounds are susceptible to a loss of effectiveness if the soils are compacted or disturbed excessively. This means that the 650 square meters needed would become unavailable for any other use and would also require additional measures to ensure that children could, and would, not be able to access the tops of the mounds. The loss of a significant portion of the available schoolyard area as well as the logistics of keeping children off of the mounds makes a mound system impractical for CLE.

7.9 Biogas Digester

A biogas digester is designed as an anaerobic treatment plant for wastewater and organic waste. The anaerobic digestion process aids in pathogen destruction while simultaneously generating biogas, a combustible gas comprised primarily of methane, which can be used for cooking, generating electricity, lighting or heat. The effluent generated by a biogas digester can be used to fertilize crops as it is high in nutrients and hummus which enhance soil fertility and structure.

Biogas digesters are relatively simple structures which consist of a digestion chamber and a gas storage area. In the fixed-dome style, currently the most common design for larger than household use, the fixed dome covering the digestion chamber serves to store the gas for use.

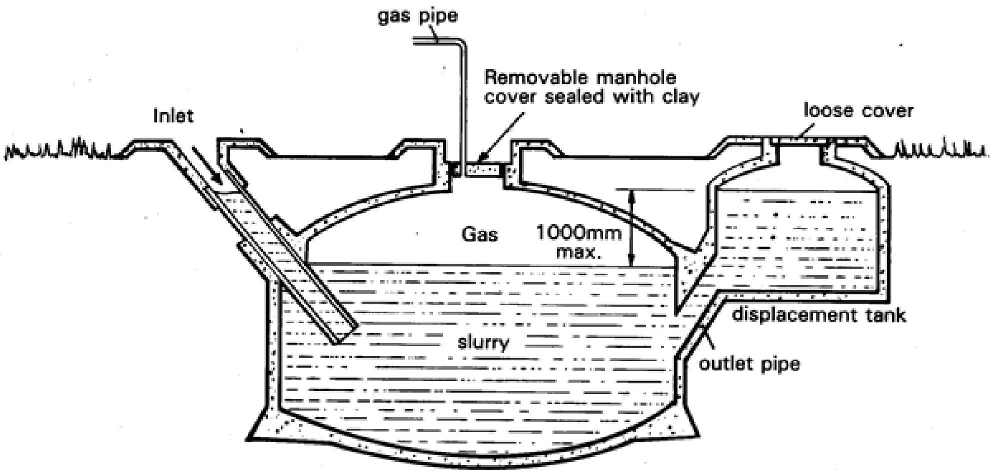

Figure 21: Fixed Dome Biogas Digester (FAO Irrigation and Drainage Paper 43)

Biogas digesters can be an excellent option for wastewater treatment in agricultural areas, areas with livestock populations and areas where cheap and clean energy sources are needed. CLE currently has access to reliable electricity, has no kitchen on site, no livestock on premises and no apparent ready use for the effluent. Additionally, biogas digesters are relatively complex and expensive to construct. Skilled masons are required to construct the digester to ensure the dome is water and air tight.

A biogas digester was not deemed appropriate for CLE. This determination was based on the high relative cost of construction, the need for daily removal and disposal of the effluent, the sensitivity of the anaerobic digestion process to factors such as pH, C:N ratio and uniform loading, as well as the minimal need for biogas production at the school. After these factors were considered it was clear that a biogas digester, while technically possible, is not the most economical and efficient design for CLE.

7.10 Holding Tank

The holding tank option features a large tank that simply stores the incoming wastewater until it is pumped out by a professional service. This method is used when conventional systems are not well suited. Holding tanks are commonly installed in second homes located in an environmentally sensitive area (EPA 2002). A holding tank will not be feasible for CLE because the size required for adequate storage would be too large and the cost required for regular pumping would be prohibitive.

7.11 Package System

A common package system employs a sequential activated sludge process known as a sequential batch reactor, or SBR. SBR systems provide for a high quality effluent and are typically found in small communities or cluster applications (EPA 2002). The system requires advanced understanding of the process to operate and maintain, EPA recommends close interaction with qualified personnel for proper startup of the system. Furthermore, cost may be prohibitive; installation and capital costs are substantial, maintenance costs include electricity costs, sludge removal, and equipment servicing.

Because of this system's complex operation and high cost, SJE does not consider a package system suitable for CLE.

7.12 Pirana System

The Pirana system is a proprietary system developed by a manufacturer in Petoskey, Michigan. The system is designed for installation in existing septic systems and provides increased aerobic treatment of wastewater. The system relies on the in-place effluent dispersal method; a pozo ciego, in the case of CLE. The existing soil characteristics at CLE prohibit the suitability of this system. Additionally, the proprietary nature of this system prevents easy access to the technology and technicians for maintenance. For these reasons SJE does not consider the Pirana system a feasible option for CLE.

7.13 Standard Drainfield

A drainfield system is a method of effluent dispersal that relies on soil and fill material to treat wastewater from the septic tank through physical and biochemical processes. A network of perforated PVC pipes spreads over the area of infiltration. Soil type and the location of the water table are important considerations to investigate when considering a drainfield system. A drainfield located within school grounds near the existing septic system is not feasible due to the clayey soil and limited area. The sports field adjacent to the school is a better option because the usable area is greater and the soils are sandier. One potential barrier to this location is the ownership status of the land; conflicting reports were given to SJE regarding this problem. In spite of the concerns, SJE decided to use this land in its designs due to the favorable site conditions of the sports field compared to the schoolyard.

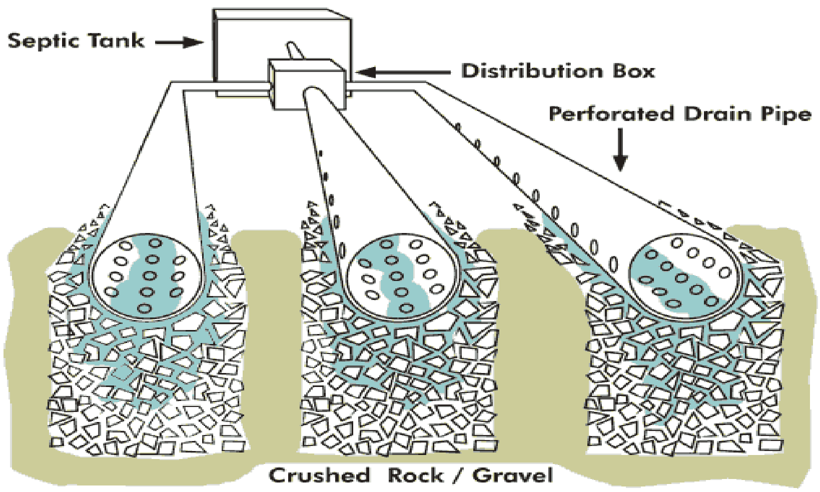

Figure 22: Gravity Drainfield

7.13.1 Drainfield with Pressure Distribution

A gravity drainfield's efficiency and longevity can be increased by using a pressure distribution system to force the wastewater throughout the system in uniform doses at specific time intervals. The basic structure of this system is similar to a standard gravity drainfield but with the addition of a dosing tank, distribution valve and a pump.

The wastewater flowing from the septic tank is filtered to remove particulate as it flows into the dosing tank. When the tank reaches a specified level of water the pump is activated and forces a measured amount of wastewater into the drainfield system where it infiltrates into the soils. The sports field adjacent to CLE provides adequate area and acceptable soil structure for this type of system. The pressure distribution ensures that the entire drainfield is used equally to reduce the possibility of localized failure due to ponding of wastewater at lower spots within the system.

7.14 Viable Options Discussion

SJE compiled data on many possible design solutions before conducting a critical comparison to reduce the number of possible options to the 3 designs that showed the most viability. The 3 design options that were considered to be the most viable are:

- Standard septic tank with a gravity drainfield located in sports field

- Standard septic tank with a pressure distribution drainfield located in the sports field
- Recirculating sand filter with disposal into the Antiguo Canal

These designs were examined individually to determine their advantages, disadvantages and create an initial estimate of construction costs. SJE used this information to decide on its final design recommendation for CLE.

7.14.1 Standard Septic Tank with Gravity Fed Drainfield

SJE researched standard septic tank systems with gravity fed drainfield's as a primary option for handling wastewater at CLE. These systems have many advantages including:

- Simple to construct
- Inexpensive to construct
- Simple maintenance and operation
- Proven technology
- Inexpensive to maintain and operate

This system also presented some disadvantages:

- Requires sandy soils only found in the sports field at CLE
- Large volumes of wastewater may not disperse evenly within the system leading to early failure
- Failure can cause surface to become saturated and unusable
- System would require a pump to move water to the sports field and elevate to the level of the drainfield due to the groundwater level located at 2meter depth
- System requires significant excavation due to the size of the drainfield required to handle volume of wastewater generated by CLE

7.14.2 Standard Septic Tank with Pressurized Drainfield

SJE examined a standard septic tank system with a pressurized drainfield as an alternative to the gravity fed system. The pressure distribution offers many of the same advantages as the gravity system while eliminating some of the disadvantages. The primary advantages of a pressure distribution drainfield are:

- Simple to construct
- Inexpensive to construct
- Proven technology
- Inexpensive to maintain and operate
- Reduced chance of failure from localized overloading of the drainfield

While the pressurized drainfield offers many advantages, there are also several disadvantages to be noted, such as:

- Requires sandy soils only found in the sports field at CLE
- Failure can cause surface to become saturated and unusable
- System would require a pump and distribution valve to most efficiently distribute the wastewater into the pressurized drainfield
- Requires significant excavation due to the size of the drainfield required to handle volume of wastewater generated by CLE
- Use of pumps and distribution valves increases the complexity of the system as well as potential maintenance

7.14.3 Recirculating Sand Filter with Disposal to Drainage Canal

SJE determined that a recirculating sand filter with subsequent disposal of treated effluent to the drainage canal was a potentially viable option. Some of the primary advantages noted were:

- Eliminates the need to construct in the sports field
- Proven technology

The disadvantages of the recirculating sand filter system are noted as:

- Sand filters would occupy a large portion of the schoolyard area that would need to be protected from foot traffic and other disturbances
- Sand filters require regular inspection to ensure proper operation
- System would require excavation from school to drainage canal for water disposal
- Disposing of effluent into drainage canal requires meeting government standards and regulations for wastewater treatment quality
- Potential for discharge of harmful pathogens, nutrients and bacteria into surface waters
- System would require several pumps to recirculate the wastewater through filters as well as moving the water to the drainage canal.

7.15 Cost-Benefit Analysis

SJE considered the difference in costs to construct each system and weighed those differences against the pros and cons of each option. Costs were created by using detailed design calculations for each system to generate a component list for both parts and labor for each design. The cost estimates for each system are shown in Table 3.

System	Cost w/hired labor	Cost w/volunteer labor
Gravity Drainfield	$187,386	$174,862
Pressure Drainfield	$197,716	$184,616
Recirculating Sand Filter	$1,397,947	$1,397,861

Table 3: Cost Estimates for 3 Designs Considered Viable for CLE in Bolivianos

SJE noted the extraordinary expense of installing a recirculating sand filter system at CLE compared to the other 2 options being considered. The high cost of construction, difficulty with construction, high level of maintenance required and use of a large portion of the schoolyard were the main factors which led to the elimination of the recirculating sand filter from consideration. The only positive for this system was that it did not use the sports field and so the negatives far outweighed that one benefit for this system.

SJE then compared the costs and benefits of the 2 styles of drainfield. The pressurized drainfield has an estimated cost that is 6% higher than a gravity system. This slightly higher cost is offset by the benefits that the pressurized system offers over a gravity system. These benefits are:

- ability to maintain or repair individual components without shutting the entire system down
- reduced chance of drainfield failure due to localized overloading
- longer life span for the system

SJE determined that the benefits of the pressurized drainfield outweighed the nominal increase in cost, especially when considered against the potential for serious negative consequences, financial and social, if the system were to fail prematurely.

8. Final Recommendation and Conclusion

8.1 Recommended design

SJE has carefully considered the many options for a wastewater handling system at CLE and after balancing the positive and negative factors for each option recommends the implementation of a standard septic tank system with a pressurized drainfield located in the adjacent sports field. This system was selected based on the following factors:

- simple to construct
- capable of handling current and projected future wastewater volumes
- proven technology
- relatively inexpensive to construct
- projected life-span of 7-10 years
- allows for continued use of sports field after installation
- low level of maintenance required

SJE acknowledges that the use of the sports field is considered questionable by some stakeholders, but SJE also accepts that with the other limiting factors being considered (such as: high water table, large volume of wastewater, poor soil structure within schoolyard, budget limitations and the negative impact on students and faculty from a non-functioning toilet system) the use of a portion of the sports field is viewed as the most practical compromise to ensure an effective design.

SJE assumed the legal right and ability to use the sports field for construction based on information which indicates the sports field is a part of the school but is also a community resource due to its use and unrestricted boundaries (i.e. no fence). This assumption must be verified with the appropriate legal and government authorities prior to construction. Securing appropriate legal rights to construct a drainfield on this site should be the first course of action towards project implementation.

Due to constraints of time and financial resources SJE was only able to conduct one soil boring in the area of the sports field. SJE also notes that this single soil boring is not adequate to properly determine the soil structure throughout the area of the field that will be needed to construct the new system. It is highly recommended that a professional perform several more soil borings and classifications prior to beginning construction. A minimum of 3 soil borings should be performed across the proposed drainfield site to determine if the soil profile presented in the test boring is consistent throughout the proposed construction area. The rectangular proposed area should be roughly marked by using a measuring tape. The soil borings should be taken 5-10 meters diagonally from the southern corners of the proposed site and the last boring should be from near the center of the area. If these soil borings are consistent with the test boring provided by SJE, then the entire construction site can be assumed to be uniform and construction can begin. If the soil borings show a soil profile that is inconsistent with the test boring from SJE a design professional must be consulted before construction can begin.

8.2 System Description

The proposed design for CLE is designed so that each toilet building will have its own wastewater handling system. This design will allow for periodic maintenance of one system without the total loss of toilet facilities while maintenance or repairs are being conducted. This redundancy was seen as an important consideration after observing the conditions at CLE when there was a total lack of properly functioning toilet facilities. The systems will consist of 4 main parts:

- Newly constructed septic tanks will be connected to existing outlet pipes from the toilet buildings near the existing inspection covers
- Newly constructed dosing tanks will be connected between the septic tank and the distribution system
- Newly constructed distribution systems will provide a pump and distribution valve to pressurize and evenly distribute the septic tank effluent to the drainfield

- Newly constructed pressurized drainfield’s will disperse the effluent into the soils of the sports field

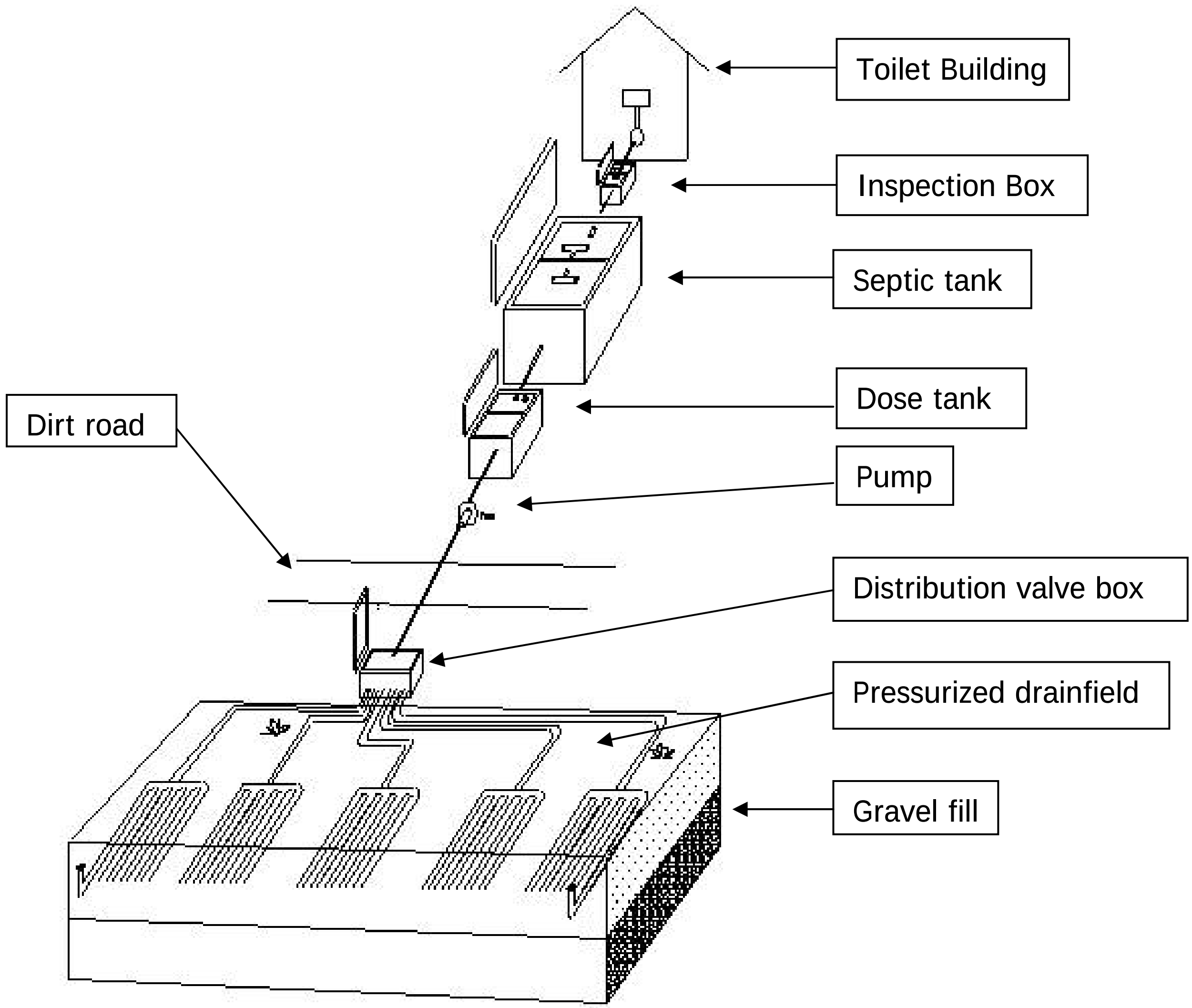

Figure 23: Perspective drawing of proposed septic system design for CLE

Existing septic tanks and pozo ciego’s should be drained by a professional septic service and filled with material from the excavation for the new septic tanks and dosing tanks.

The new septic tanks will consist of 2 chambers separated by a full height wall. The raw wastewater would enter the first chamber where settling and biological processes would take place. Treated effluent would flow into the secondary chamber through a pipe connection made of 2, 4" diameter PVC T-fittings with openings oriented to be vertical, connected through the wall by a short length of pipe. This design helps prevent any floating material from entering the rest of the system from the main septic chamber and will increase the reliability and lifespan of the system.

The treated effluent will flow from the secondary septic chamber through a filter array before flowing into the dosing tank. The filters are designed to reduce the size and amount of particulate matter entering the distribution system. The filters will protect the pump, distribution valve and the drainfield from potential failure due to clogging from solids. The regular cleaning of these filters is a critical piece of maintenance that will help protect the system and enhance the long-term performance of the entire system.

Once the effluent enters the dosing tank it will be held until the water level reaches a specified depth. Once the required depth is reached, the floating switch will activate the pump and the effluent will be forced from the dosing tank into the drainfield. The effluent will be pumped from the dosing tank, under the road, and into the distribution valve box. When the water level drops to the preset minimum level, the float switch will turn the pump off until the dosing tank is refilled.

The distribution valve will route the effluent to alternating cells within the drainfield. This intermittent dosing of the field will ensure even distribution of the effluent within the drainfield thereby reducing the potential for localized failure within the drainfield. This method of periodic dosing also allows for individual cells within the drainfield to be taken offline for repair or maintenance without shutting the entire system down.

The effluent will flow from the distribution valve into individual cells within the drainfield. These cells will receive a specific volume of effluent with each cycle of the pump. The pressure aids in the dispersal of effluent into the soils of the drainfield while ensuring that no ponding or localized overloading occurs due to incorrect leveling of the distribution pipes. Each distribution cell will be equipped with observation pipes to check for system overload or failure.

Properly performed and timely maintenance is critical to the long-term proper operation of any on-site treatment system and therefore must be considered carefully. SJE recommends a maintenance schedule as follows:

- Daily monitoring of toilets to observe proper operation
    - Visually observe that when flushed the toilet empties and does not back up into toilet room
- Daily monitoring of pump performance
    - Check the observation port every morning prior to students arrival to see that the water level in the dosing tank is at or near the bottom of the pit

  - If water level is near the top of the dosing tank the system may need repair
- Weekly monitoring of drainfield
  - Visually look into the observation ports to look for signs of water or biological build-up within the drainfield.
  - If the problems are observed, determine what area of the field is affected
  - Turn off valve, in the distribution box, that leads to the affected portion of the field to prevent further damage and begin repairs
- Monthly monitoring of the septic tank filters
  - Observe the level of water in the second chamber of the septic tank, in the morning, to determine if it is higher than the outlet and filters
  - If the water level is higher, the filters may need to be cleaned
  - Carefully remove the filters and clean per manufacturer's instructions before replacing
- Annual, or more often if needed, emptying of the septic tank by a professional service
  - Immediately before or after classes stop for summer break the system should be emptied by a professional service

Care should be taken by anyone performing maintenance on the system to avoid direct contact with wastewater and other contaminants. Proper protective gear such as gloves and eyewear should be worn and hands should be thoroughly washed after the work is complete.

8.4 Future Recommendations

SJE considers the suggested design to be an appropriate solution for a school population of no more than 5000 students and for a time of not more than 10 years. It is the recommendation of SJE that money be budgeted for the future connection of the school to sanitary sewers as soon as they are available. Connection to the sanitary sewer system will provide the most appropriate long-term solution for wastewater disposal at CLE.

8.5 Conclusion

SJE realizes there is a high level of need for a functioning sanitary system at CLE and this project is seen as a high priority for school and government officials. SJE has worked to provide a solution for the current lack of sanitary facilities at CLE within the constraints imposed by economic, physical, political and social factors. Detailed construction drawings and specifications are included with this report.

References:

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Appendices

Appendix A:

MTU Survey Procedures

Fieldwork

This handout will explain how to get started using the TDS Ranger data collector to collect data from the Topcon Total Station. It is assumed that you are familiar with the operation of the total station.

The first section describes the backsight setup procedures. The next section walks you through the steps involved to setup and perform a simple side shot and traverse shot.

When beginning any job, the setup is the same; you need to establish an occupy point and a backsight.

The occupy point is the point where you will setup the total station. The coordinates for the occupy point must exist in the current job. They can be assumed coordinates or known coordinates. Any point in the current job can be an occupy point.

Once an occupy point is established, the second reference you need is a backsight point or direction. This can be in the form of a point stored in the current job, or an azimuth or bearing.

The horizontal angles recorded during data collection are relative to the backsight. If a point is not available in the job to use as a backsight, you can assume a backsight direction.

The scenario below will describe defining a backsight.

Scenario

You have one point established on your project and you know the azimuth to an observable reference.

Solution:

1. Create a job using the coordinates of the established point for the first point. If the coordinates are unknown, accept the default coordinates.
2. From the Backsight Setup screen, set the Occupy Point field to the point that was just created.
3. Setup the total station over the established point.
4. Toggle the BS Direction BS Point button to BS Direction and enter the azimuth to the observable reference here.
5. Aim the total station toward the observable reference, zero the horizontal angle on the instrument, and tap Solve , then Close .

Summary

In general, you would follow these steps when you begin working on a job.

1. Create a new job or open an existing job.
2. Setup over the Occupy Point.
3. Aim the total station toward the backsight and zero the horizontal angle on the instrument.
4. Fill in the Backsight Setup screen and tap Solve , then Close .
5. Start your survey.

Most data collection is performed from the Traverse / Sideshot screen. When you take a shot using the Traverse button, the routine expects that you will eventually be occupying the foresight that you are shooting and backsighting your current occupy point. When you are ready to setup on the next point, the occupy, foresight and backsight points will automatically be updated accordingly.

After taking a shot using the Side Shot button, the routine does not expect the total station to be moved before the next shot and will therefore only automatically advance the foresight point.

Data Collection Example

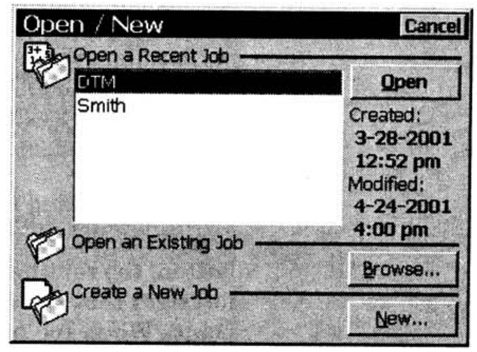
The section that followsillustrates the necessary setup and usage of the Traverse / Side Shot screen, which is the primary screen used during data collection.

Setup

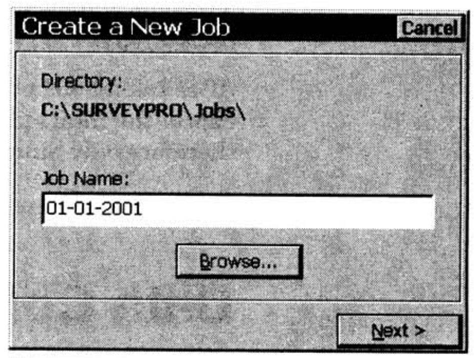
1. Create a new job.

   a. From the Main Menu, select **File**, **Open / New**.

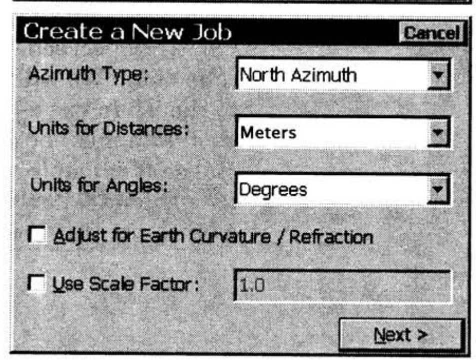
   b. Tap **New...** to open the Create a New Job screen

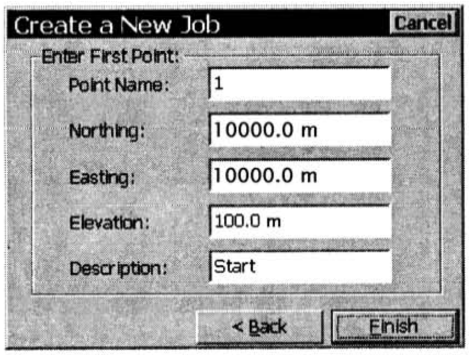


   c. Enter any job name that you wish in the Job Name field and tap **Next >**.



   d. For this example, simply accept the default job settings and tap **Next >**.





e. Accept the default coordinates for the first job point by tapping [Finish].

2. Check the Job Settings.

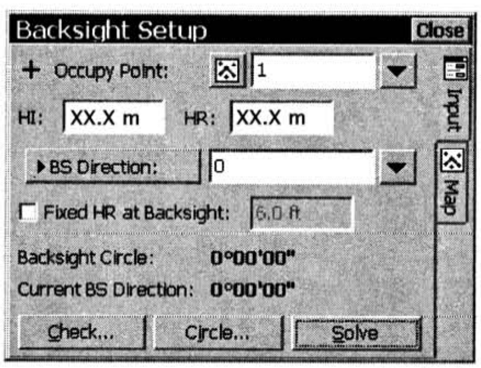
   a. Tap [Job], [Settings] from the Main Menu to open the Settings screen.

   b. Tap the Instrument tab and make sure both the Brand and Model fields are set to ......

      Brand: Topcon
      Model: GTS Series
      Serial Port: COM1
      Baud Rate: 1200
      Parity: Even

   c. Tap [OK] to save the job settings.

3. Setup your backsight. In this example, we will setup on Point 1 and backsight an object with a known azimuth. When connected to a total station, you would setup over your occupy point, aim toward the backsight and zero the horizontal angle in the total station before continuing.



   a. Access the [Survey], [Backsight Setup] screen from the Main Menu.

   b. In the Occupy Point field, enter **1** as the point name.

   c. Toggle the [BS Direction] / [BS Point] button to [BS Direction] and enter **0** as the backsight azimuth.

   d. Enter an HI and HR.

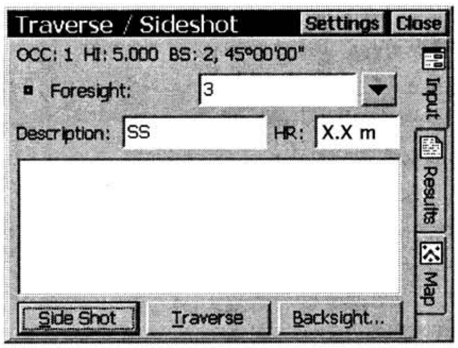
   e. Leave the Fixed HR at Backsight field unchecked.

   f. Confirm that the Backsight Circle value is zero. If it displays a non-zero value, tap the [Backsight Circle] button and set it to zero.

   g. Tap [Solve]. A map view will open that shows a graphical representation of the occupy point and backsight direction. Tap [Close] to continue.

Performing a Side Shot

4. Access the Survey, Traverse / Sideshot screen and fill in the appropriate fields. The backsight information is displayed at the top of the screen. At this point, it is assumed that your total station is over the occupy point and its horizontal angle was zeroed while aiming toward the backsight.



a. In the Traverse / Sideshot screen, enter the following data:
   Foresight: *(Use default value)*
   Description: **SS** *(Will be changed later)*
   HR: *(Keep, unless rod height changed)*
   These values will define the point name, description, and rod height for the next point that is stored.

b. Assuming that the total station is aiming toward the prism, which is located over the foresight, tap Side Shot. This would trigger the total station to take a shot, compute coordinates for the new point and store it.

You will hear a series of beeps being emitted from the total station:

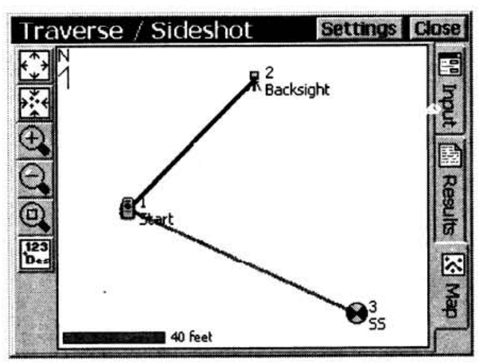
- First you will hear two single beeps followed by ...
- a double beep, and then a multiple beep (the "multiple beep" signals that the shot has been taken and the person on the prism pole can move to the next point).

The New Point dialog box will appear on the data collector, in which you can key in:

- ❑ an abbreviated point description in the **Description:** window
- ❑ a new rod (prism pole) height **if it was changed** in the **HR:** window

Tap the OK button to accept the data and prepare for the sighting of the next point.

d. You can see a graphical representation of the previous shot, as shown here, by tapping the Map tab.



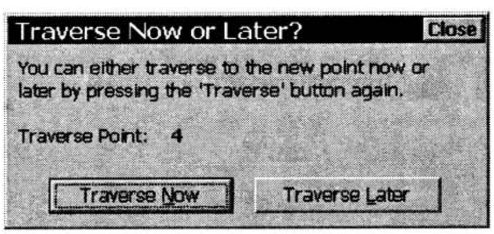
Performing a Traverse Shot

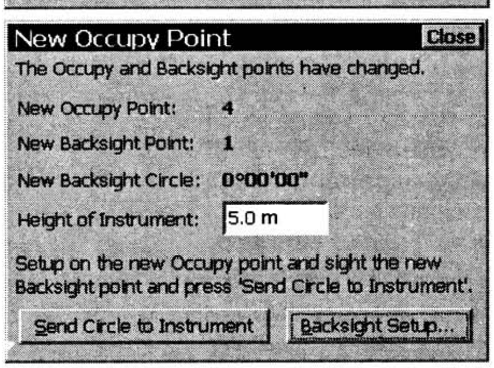
5. **The steps involved in performing a traverse shot are nearly identical to performing a side shot. The difference is you must specify if you plan to move the total station to the current foresight point after the shot is taken.**
   a. **Tap the** Input **tab of the** **Traverse / Sideshot.** **The Foresight point should now be updated.**
   b. **Assuming that you are now aiming the total station at a prism located over the foresight point, tap** Traverse**. This would trigger the total station to take a shot, compute coordinates for the new point and store it.**

Again you will hear a series of beeps being emitted from the total station:
- First you will hear two single beeps followed by ...
- a double beep, and then a multiple beep (the "multiple beep" signals that the shot has been taken and the person on the prism pole can move to the next point).

The New Point dialog box will appear on the data collector, in which you can key in:
- ❑ an abbreviated point description in the **Description:** window
- ❑ a new rod (prism pole) height **if it was changed** in the **HR:** window

Tap the OK button to accept the data.





d. **The new point is computed and stored and the Traverse Now or Later prompt will open, shown here, asking if you want to advance to the new point now or later. For this example, tap the** Traverse Now **button. The New Occupy Point dialog box will open, shown here, which displays details of the new setup. You can see that the previous foresight point is now the current occupy point and the previous occupy point is now the current backsight point.**

When out in the field, you would now move your total station over the new occupy point, aim it toward the previous occupy point (the current backsight), enter the correct instrument height in the Height of Instrument field and tap [Send Circle to Instrument]. This would update the Traverse / Side Shot screen and set the total station's horizontal angle to zero where you are then ready to collect more data.

You have now created a job, checked the settings, setup a backsight and collected data in the form of a side shot and a traverse shot. If at any time you want to view the coordinates of your points, you can do so from the [Job], [Edit Points] screen.

FIRST STEP - Start up ForeSight DXM Software:

A - Set up the laptop:

- ❑ Connect the appropriate end of the TDS Ranger cable into the com1 port in the back of the laptop.
- ❑ Carefully connect the other end of the TDS Ranger cable into the back of the TDS Ranger.
- ❑ Insert the purple colored USB hardware lock/key into the back of the laptop.

B - Start up ForeSight DXM by double clicking the icon on the desktop of the laptop.

- ❑ When ForeSight is first started, the ***Welcome to ForeSight DXM*** dialog box will open.

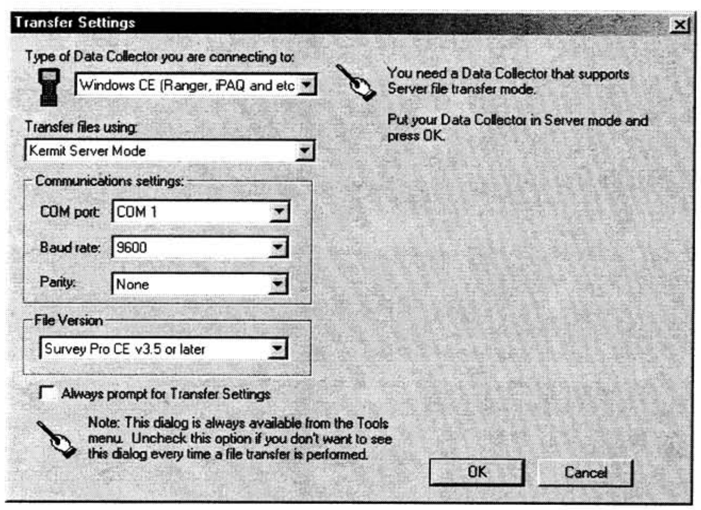
- ❑ Click on the **Launch ForeSight DXM** button.

SECOND STEP - Setting up ForeSight for Transferring the Data:

A - On the left side of the screen you will see the **Project Navigator** window.

- ❑ Locate the **Tools** directory
- ❑ Locate the option **Transfer Files**
- ❑ Click on the link, **Transfer Files**.

B - Having performed step A , the ***Transfer Settings*** dialog box will appear [shown below]:



Make sure everything is set up <u>exactly</u> as shown above, but do <u>**NOT**</u> click on the **OK** button!

THIRD STEP - Setting up the TDS Ranger for Transferring the Data:

A - Turn on the TDS Ranger and make sure you are in the Survey Pro program, and that you are in the correct job for which you want to transfer data from.

B - On the **TDS Ranger**, select the **File** menu, and click on the **Transfer** option as shown in the graphic below:

- The following **Transfer** screen should come up - make sure the Communication Settings are set as shown below:

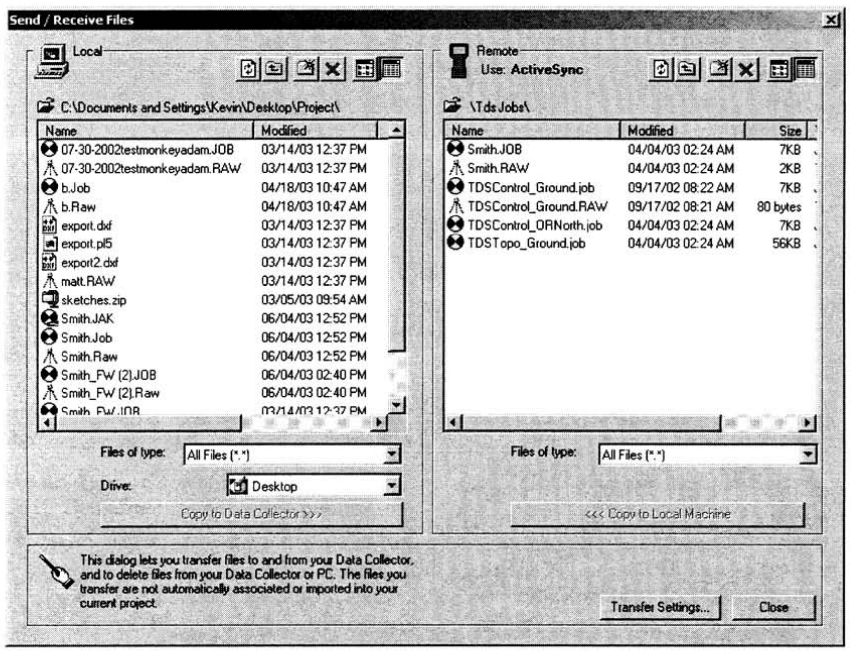
- Press the **Enter Server Mode…** button [at the bottom of the Transfer screen] and a ***Transfer*** screen will appear on the data collector.

FOURTH STEP - Transferring the Data:

A - From **Transfer Settings** screen [on the laptop] click on **OK** button at the bottom of the dialog box

B - While the transfer from the TDS Ranger to ForeSight is taking place you should see a graphic on the PC screen saying "Changing the Data Collector Directory to \"

C - Below is a sample graphic of the dialog box that will display on the laptop screen:



D - See page **87** of the ForeSight DXM User's Manual for detailed instructions on the use of the above dialog box.

FIFTH STEP - Converting the Data:

Read pages **97-101** of the ForeSight DXM User's Manual for detailed instructions on converting from one file format to another

Appendix B:

Calculation Worksheets

PRESSURE DISTRIBUTION COMPONENT MANUAL FOR PRIVATE ONSITE WASTEWATER TREATMENT SYSTEMS (VERSION 2.0)

January 30, 2001

State of Wisconsin
Department of Commerce
Division of Safety and Buildings

SBD-10706-P (N 01/01)

TABLE OF CONTENTS

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I. INTRODUCTION AND SPECIFICATIONS

This Private Onsite Wastewater Treatment System (POWTS) component manual provides design, construction, inspection, operation, and maintenance specifications for a pressure distribution component. However, these items must accompany a properly prepared and reviewed plan acceptable to the governing unit to help provide a system that can be installed and function properly. Violations of this manual constitute a violation of chs. Comm 83 and 84, Wis. Adm. Code. The design provides equal distribution of effluent from a dose tank into a distribution cell of a soil treatment or dispersal component. To ensure that equal distribution is achieved, specifications in Tables 1, 2, and 3 must be met.

Note: Detailed plans and specifications must be developed and submitted for review and approval by the governing unit having authority over the plan for the installation. Also, a Sanitary Permit must be obtained from the department or governmental unit having jurisdiction. See Section XI for more details.

Table 1
FLOWS AND LOADS

Design Wastewater Flow (DWF)	≤ 5000 gal/day
Number of effluent doses	Must conform to the requirements of the receiving component design.
Wastewater particle size	≤ 1/8 inch diameter
Volume of a single dose to a distribution cell	≥ 5 times the void volume of the distribution lateral(s) and ≤ 20% of the Design Wastewater Flow
Head pressure at distal end of lateral(s)	≥ 2.5 ft. for 1/4 and 3/16 inch orifices, ≥ 3.5 ft. for 5/32 inch orifices, and ≥ 5 ft. for 1/8 inch orifices
Network pressure compensation for fittings	= Distal head pressure **x** 30 percent
Flow velocity in force main and manifold	≥ 2 ft/sec and ≤. 10 ft/sec

Table 2
SIZE AND ORIENTATION

Diameter of force main	≤ 6 inch
Diameter of manifold	≥ 1-1/4 inch, but not > 3 inch
Diameter of lateral	≥ 3/4 inch, but not > 3 inch
Diameter of discharge orifice	= 1/8, 5/32, 3/16 or 1/4 inch
Distance between laterals	≤ 4 feet within same cell
Distance from lateral to edge of distribution cell	≤ 1/2 the distance between laterals, but not >2 feet
Distance from discharge orifice to end of distribution cell	≥ 6 inches, but not > 2 feet

Table 2 **SIZE AND ORIENTATION** (continued)	
Elevation of laterals	Level or ≤ 1 inch slope back to manifold
Location of orifices for laterals in stone aggregate	Bottom of lateral if orifice shields are not provided or top of lateral if orifice shields are provided
Location of orifices for laterals not in stone aggregate	Bottom or top of lateral, if orifice shields are provided or other means are provided to prevent soil erosion of the infiltrative surface

Table 3 **OTHER SPECIFICATIONS**	
Spacing between pipe supports for horizontal pipe	Meets requirements of s. Comm 82.60, Wis. Adm. Code
Material specifications	Meet requirements of s. Comm 84.30, Wis. Adm. Code
Joint specifications	Meets requirements of s. Comm 84.40, Wis. Adm. Code
Connection to manifold or laterals	By use of tee patterned fitting or 90° elbow
Turn ups	Provide a means of flushing out all laterals in accordance with Section V of this manual. Turn-ups are installed in a protective enclosure
Pump	Rated by pump manufacturer as an effluent or sewage pump
Siphon	Rated by siphon manufacturer as an effluent or sewage siphon
Septic tank effluent pump system	Meets requirements of s. Comm 84.10, Wis. Adm. Code and this component manual
Dose tank or compartment volume employing one pump	≥ Volume of a single dose + reserve capacity[a] + drain back volume[b] + (6 inches x average gal/inch of tank)[c] Notes: a: Reserve capacity ≥ the estimated daily flow. b: Drain back volume ≥ Volume of wastewater that will drain into the dose tank from the distribution cell. c: Four inches of this dimension ≥ vertical distance from pump intake to bottom of tank. Two inches of this dimension ≥ vertical distance between pump on elevation and high water alarm activation elevation.
Dose tank or compartment volume employing duplex pumps	≥ Volume of a single dose + drain back volume[a] + (6 inches x average gal/inch of tank)[b] Notes: a: Drain back volume ≥ Volume of wastewater that will drain into the dose tank from the force main. b: Four inches of this dimension ≥ vertical distance from pump intake to bottom of tank. Two inches of this dimension ≥ vertical distance between pump on elevation and high water alarm activation elevation.

Table 3 OTHER SPECIFICATIONS (continued)	
Siphon tank or compartment volume	≥ What is required to accommodate volumes necessary to provide dosing as specified in this manual
Pump controls	Meet requirements of chs. Comm 83 and 84, Wis. Adm., Code
Electrical equipment and wiring	Meet requirements of ch. Comm 16 and 83, Wis. Adm. Code
Access to pump	Means of removing pump while maintaining compliance with confined space entry requirements must be provided
Alarm or warning system	Meets requirements of ch. Comm 83, Wis. Adm. Code
Duplex pumps	Meet requirements of ch. Comm 83, Wis. Adm. Code
Installation inspection	In accordance with ch. Comm 83, Wis. Adm. Code
Management	Meets requirements of ch. Comm 83, Wis. Adm. Code and this manual

II. DEFINITIONS

Definitions unique to this manual are included in this section. Other definitions that may apply to this manual are located in ch. Comm 81 of the Wis. Adm. Code or the terms use the standard dictionary definition.

A. "Distribution line" means the total length of two laterals that are connected to a manifold at a common point.

B. "Distribution network" means the piping of the pressurized system that include manifold(s) and lateral(s).

C. "Drain back" means the amount of treated effluent that will drain from the forcemain to the dose tank after a single dosing event.

D. "Force main" means the piping from the pump or siphon to the manifold or to the lateral tee or coupling connecting laterals to the force main.

E. "Lateral" means the length of perforated pipe starting at the point of effluent entry to the distal end orifice.

F. "Manifold" means the piping between the force main and the laterals.

G. "Network pressure compensation" means the pressure loss due to fittings in the pressure distribution network.

H. "Orifice shield" means a device that dissipates the energy of the orifice discharge and/or that protects the orifice from blockage due to aggregate.

I. "Septic tank effluent pump system" means a septic tank which has a pump installed in the tank that will pump effluent from the clear zone.

J. “Turn ups” means a means of providing a full size opening in the downstream end of laterals to allow for flushing of the system.

III. DESCRIPTION AND PRINCIPLE OF OPERATION

Pressure distribution is a method to provide a specific volume of effluent to a specific area with each dosing cycle. The design of a pressure distribution component on one elevation is such that the volume of water passing out each hole in the network is approximately equal. This is achieved by designing for 75 to 85 percent of the total head loss in the network to be lost when liquid passes through the distribution hole and only 10 to 15 percent of the total head loss to occur in the delivery piping.

The component consists of a dosing chamber (containing a pump or siphon with appropriate controls) that discharges effluent into a network of small diameter perforated pipes designed to discharge equal amounts of effluent from each orifice.

In a pressure distribution component using a pump, partially or fully treated wastewater enters a dose chamber through the inlet. As liquid begins to fill the dose chamber, it raises the “off” float. When the liquid level in the tank is lifted to the “pump on” level, the “on” float activates the pump and the predetermined dose is pumped from the pump chamber through the force main to the distribution network. The “on” and “off” float may be one float.

In a pressure distribution component using a siphon, partially or fully treated wastewater enters a dose chamber through the inlet. When the liquid level reaches a pre-determined depth in the dose chamber, the siphon discharges the liquid through a forcemain to the distribution network. Although the siphon functions without any moving parts, it does require monitoring. Studies have shown that the siphon may begin to “trickle” when the bell loses it’s air charge due to an air leak around the snifter tube, if this problem is not corrected, the holes and laterals may foul or it reverts to gravity discharge.

The laterals are designed to fill quickly to provide equalization throughout the system. Air is pushed ahead of the liquid through the force main, manifold (if a manifold is required), laterals, and discharged through the drilled holes, entering the distribution cell.

A properly designed and installed pressure distribution component uniformly distributes effluent over the entire distribution cell. This strives to prevent the soil from becoming overloaded in one area. It also allows for a period of time between doses to drain the infiltrative surface to maintain unsaturated flow conditions in the soil.

The primary application of a pressure distribution component is in locations where it is desirable to:

1. Maintain a uniform effluent application rate throughout the distribution cell;
2. Aid in mitigating the potential contamination of groundwater in areas of excessively permeable soils;
3. Improve the performance and increase the life span of a dispersal cell; and
4. Reduce the chance of breakout or seepage on slopes.

Pressure distribution components are used in at-grades, in-ground soil absorption, mounds, single pass sand filters and other components. Also pressure distribution may be appropriate for larger dispersal cell components.

This manual specifies the design, construction, inspection, operation, and maintenance criteria for one method of providing equal distribution of wastewater in a soil treatment and/or dispersal component. The designer must also be familiar with the requirements of the component for which the pressure distribution component will be used in order to have a complete system design that will meet the Wisconsin Administrative Code.

IV. DESIGN

The following steps need to be followed to design a pressure distribution component:

1. Determine soil treatment and/or dispersal component layout - This is based on the type of component and the design soil application rate.

2. Determine lateral length and spacing in accordance with the soil treatment/dispersal component design or Table 2, if not specified in the soil treatment/dispersal component design. See Figure 1.

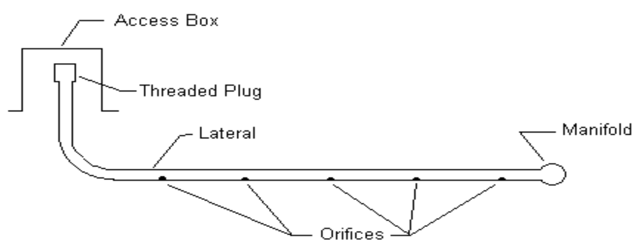


Figure 1 – Lateral Length

3. Determine manifold length and location.

4. Determine number of orifices in a lateral. How many orifices should be drilled in a lateral depends on the type of system, area allowed per orifice, and the design loading rate of the distribution cell. The number of orifices is determined by using the following equation. See figure 2.

$$n = L/x + .5$$

Where: n = number of orifices
L = lateral length
x = orifice spacing

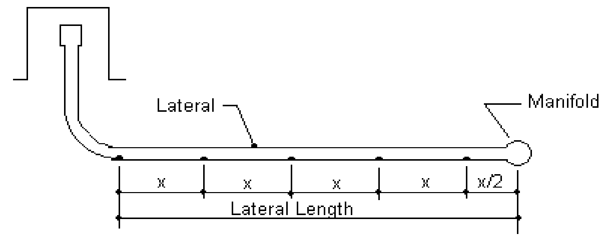


Figure 2 – Number of Orifices in a Lateral

5. Determine the number of orifices in a distribution lateral. The number of orifices is determined by using the following equation. See figure 3.

$$n = d/x + 1$$

Where: n = number of orifices
d = distribution lateral length
x = orifice spacing

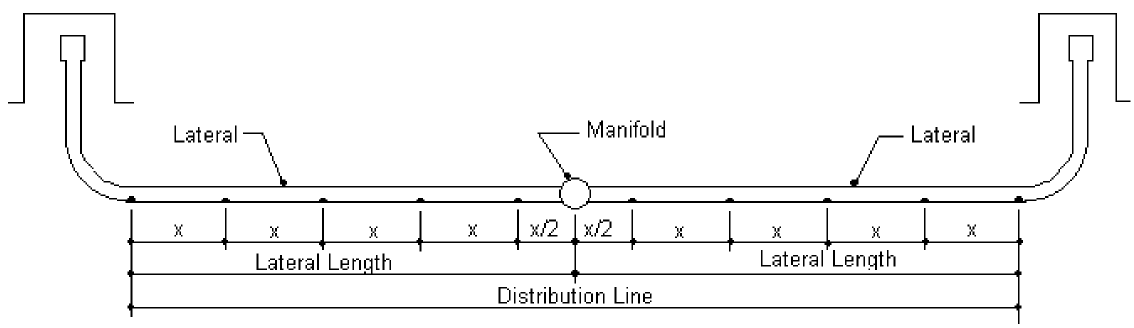


Figure 3 – Number of Orifices in a Distribution Line

6. Select orifice size of 1/8, 5/32, 3/16, or 1/4 inch.

7. Determine lateral diameter - Using Graphs 1 through 8.

8. Select distal pressure - A design option based on site specific elevations and effluent delivery preferences and requirements of Tables 1 through 3.

9. Calculate lateral discharge rate using Table 4. (orifice discharge rate at selected distal pressure multiplied by the number of holes per lateral).

10. Determine manifold diameter - Determined by using Table 5.

11. Calculate component discharge rate - By multiplying the lateral discharge rate by the number of laterals.

12. Select a pipe size for the force main by using the calculated discharge rate and Table 6.

13. Determine the void volume of the distribution laterals by multiplying the summation of the laterals by the volume given in Table 7 for the diameter of the laterals.

    If a pump is selected follow step #14.

    If a siphon is selected proceed to step # 16

14. Determine volume of dose chamber for components pressurized by a pump. (Volume of a septic tank effluent pump system is determined by department plumbing product approval.)

    The dose chamber employing one pump shall contain sufficient volume to dose the distribution cell as required by its system design, retain drain back volume, contain a one day reserve zone, provide minimum 2 inch separation between alarm activation and pump-on activation, and allow for protection of the pump from solids.

    A reserve capacity is required on a system with only one pump. Other reserve capacities may also be required by the manual for the component type the dose chamber serves.

    The reserve volume is at least equal to the estimated daily flow from for the building. Reserve capacity may be calculated based using 100 gallons per bedroom per day for one and two family residences. Reserve capacity must also meet requirements in the manual for a component type, which contains the pressure distribution component.

    The dose volume shall be included in the sizing of the dose chamber.

    The pump alarm activation point must be at least 2 inches above the pump activation point.

    Allow "dead" space below the pump intake to permit settling of solids in the pump tank. This can be accomplished by placing the pump on concrete blocks or other material that can form a pedestal.

    The pump manufacturer requirements shall be followed. This may include the "pump off" switch located high enough to allow for complete immersion of the pump in the tank.

15. Select a pump that will provide an average flow equal to or greater than the total discharge rate of the orifices at a pressure equal to or greater than the sum of the distal pressure, network pressure compensation, and pressure loss due to friction in the force main. The system head will be insufficient if the perforation discharge rate is greater than the pump discharge rate.

16. Select a siphon that will provide an average flow equal to or greater than the total discharge rate of the orifices at a pressure equal to or greater than the operational pressure plus the friction loss of the force main. The system head for components using automatic siphons must be developed in the force main. The difference in the elevation from the bottom of the siphon bell to the lateral must be greater than or equal to the force main friction loss plus the system head required.

If the perforation discharge rate is greater than the siphon discharge rate, the system head will be insufficient.

17. Determine volume of dose chamber for components pressurized by a siphon.

    The dose chamber shall contain sufficient volume to allow the siphon to dose the component as required by the soil treatment and/or dispersal component design and allow for protection of the siphon from solids.

V. SITE PREPARATION AND CONSTRUCTION

Procedures used in the construction of a pressure distribution component are just as critical as the design of the treatment and/or dispersal component. A good design with poor construction results in failure. Construction procedures for a pressure distribution component are as follows:

1. Review design and installation requirements for the type of treatment and/or dispersal component for which the pressurized system is to be installed.

2. Drill holes for the orifices at the locations required by the design. Remember it is very important to use a sharp drill bit and to remove all burrs from the pipe and orifices in order for the system to work as designed.

3. Assemble the distribution network as determined by the pressure distribution component design, making sure to solvent cement all joints in the system.

4. Extend the end of each lateral up with the use of long turn or 45° fitting to a point within six inches of the final grade. Terminate the ends of the laterals with a valve, threaded cap or threaded plug. Provide access from final grade for the valve, threaded cap or threaded plug.

5. Install the pump or siphon as required by ch. Comm 83 of the Wis. Adm. Code.

VI. OPERATION, MAINTENANCE AND PERFORMANCE MONITORING

A. The component owner is responsible for the operation and maintenance of the component. The county, department or POWTS service contractor may make periodic inspections of the components, checking for sludge accumulation in the dose chamber, condition of electrical components, alarms, dose rate, dose volume and frequency, etc.

   The owner or owner's agent is required to submit maintenance records routinely to the county or other appropriate jurisdiction and/or the department.

B. Design approval and site inspections before, during, and after the construction is accomplished by the county or other appropriate jurisdictions in accordance with ch. Comm 83 of the Wis. Adm. Code.

C. Other routine and preventative maintenance aspects are:

1. Dose chambers are to be inspected routinely and maintained when necessary in accordance with their approvals.
2. Inspection of the component performance is required at least every three years. Inspection includes checking the dose rate, volume and frequency.
3. Partial plugging of the distribution network may be detected by extremely long dosing times. The ends of the distribution laterals should be exposed and the pump activated to flush out any solid material. The liquid that is flushed out of the laterals is to be directed back into the distribution cell. The liquid may also be directed into an acceptable container and disposed of properly. If necessary, the laterals can be cleaned.

D. User's Manual: A user's manual is to accompany the pressure distribution component. The manual is to contain the following as a minimum:

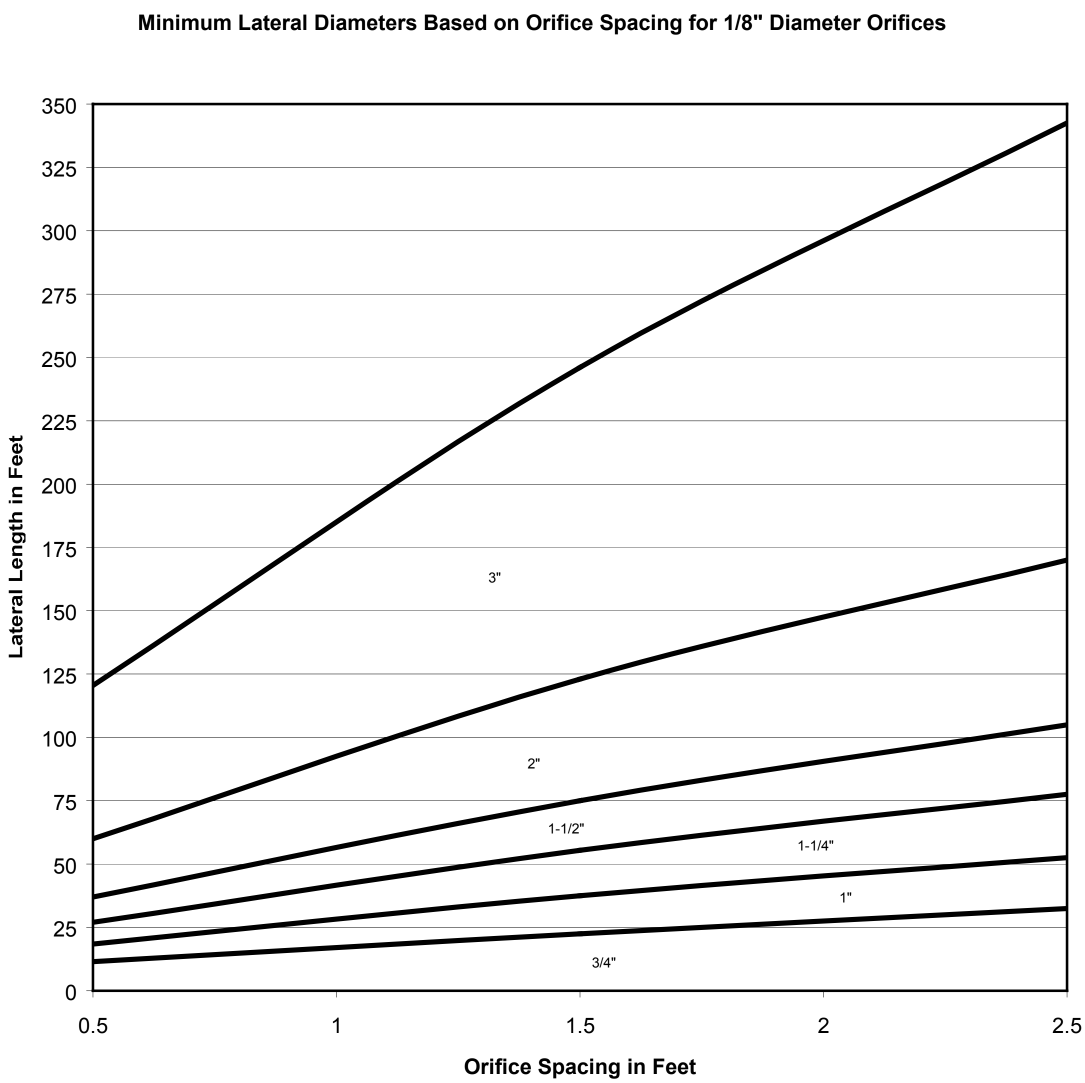
1. Diagrams of all components and their location. This should include the location of the access ports for cleaning and/or flushing the component.
2. Specifications for all electrical and mechanical components.
3. Names and phone numbers of local health authority, component manufacturer or management entity to be contacted in the event of a failure.
4. Information on the periodic maintenance of the component, including electrical/mechanical components.

E. Performance monitoring must be performed on pressure distribution systems installed under this manual.

1. The frequency of monitoring must be:
   a. At least once every three years following installation and,
   b. At time of problem, complaint, or failure.
2. Reports are to be submitted in accordance with ch. Comm 83, Wis. Adm. Code.

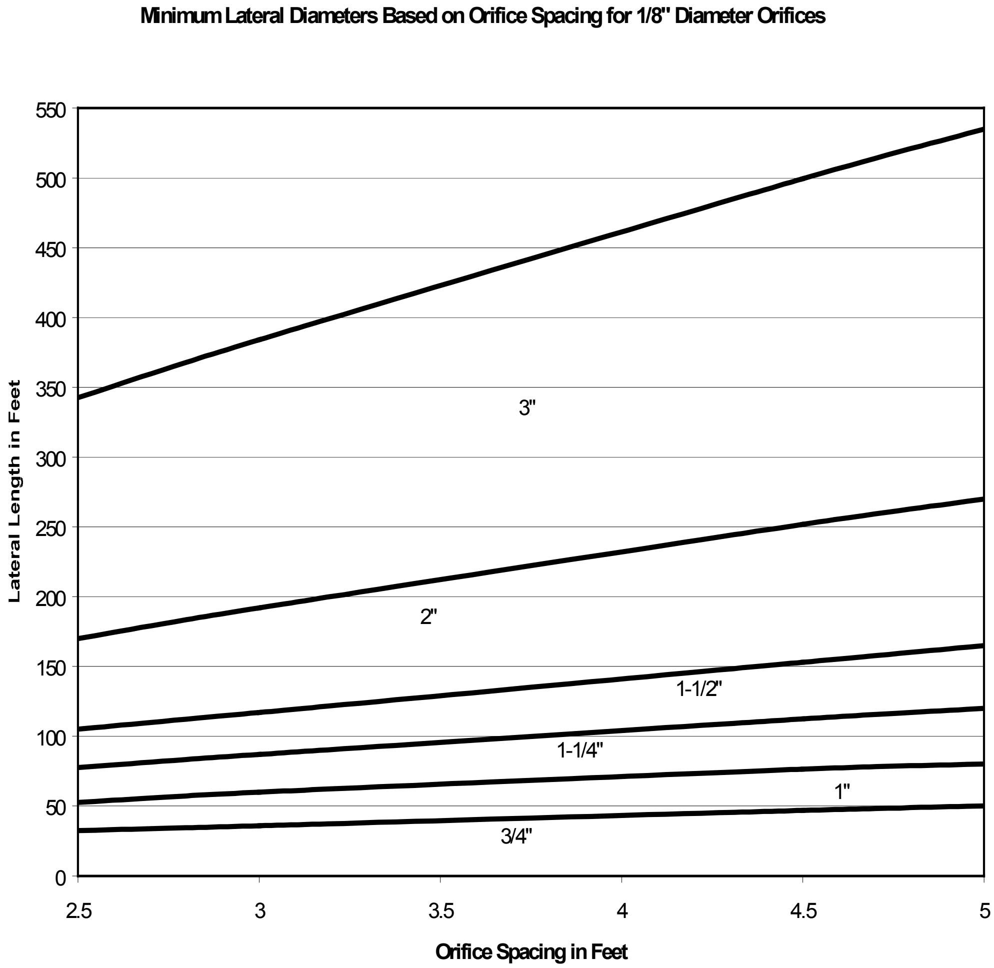
VII. GRAPHS

Graph 1



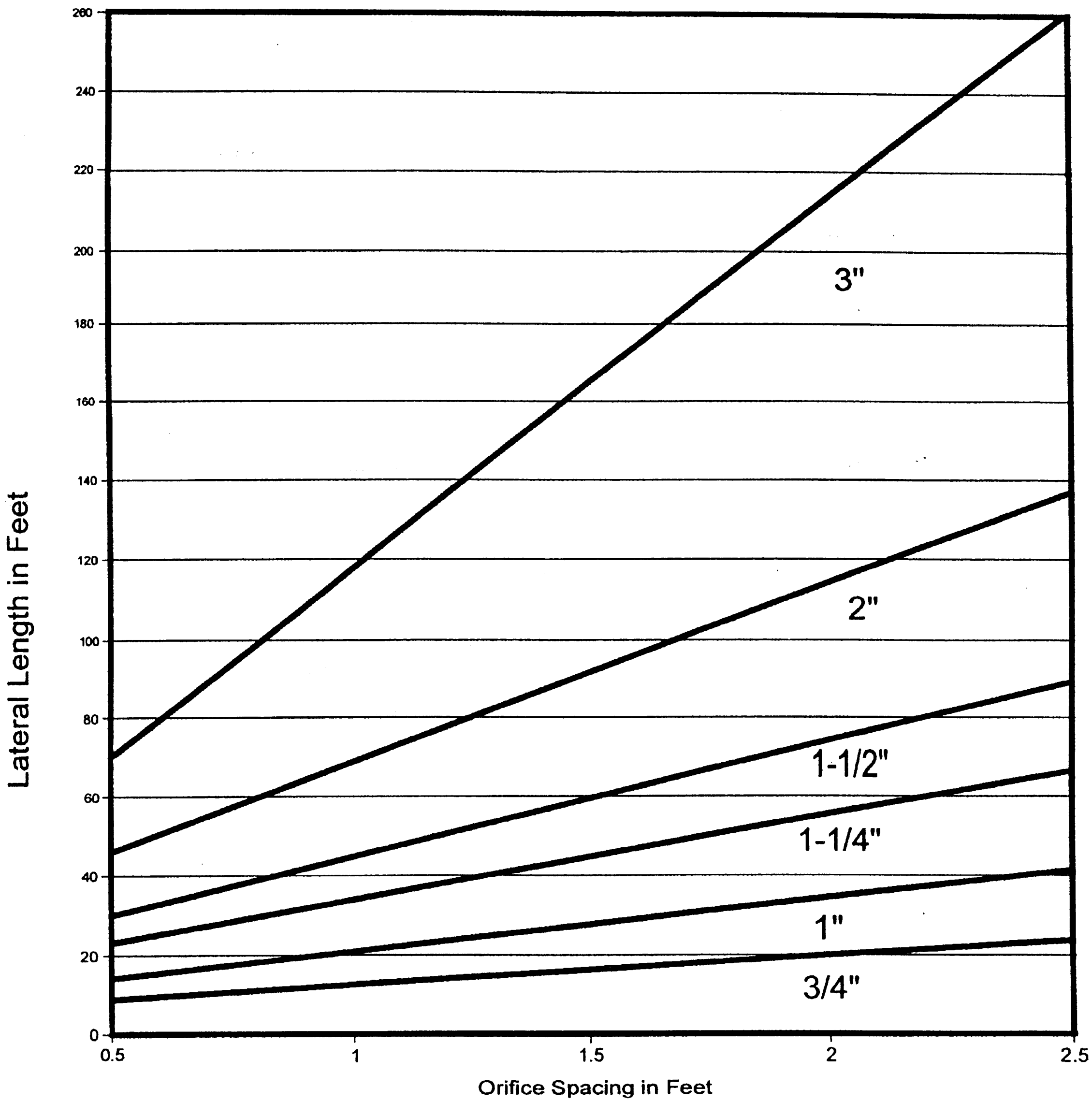
Graph 2

2"

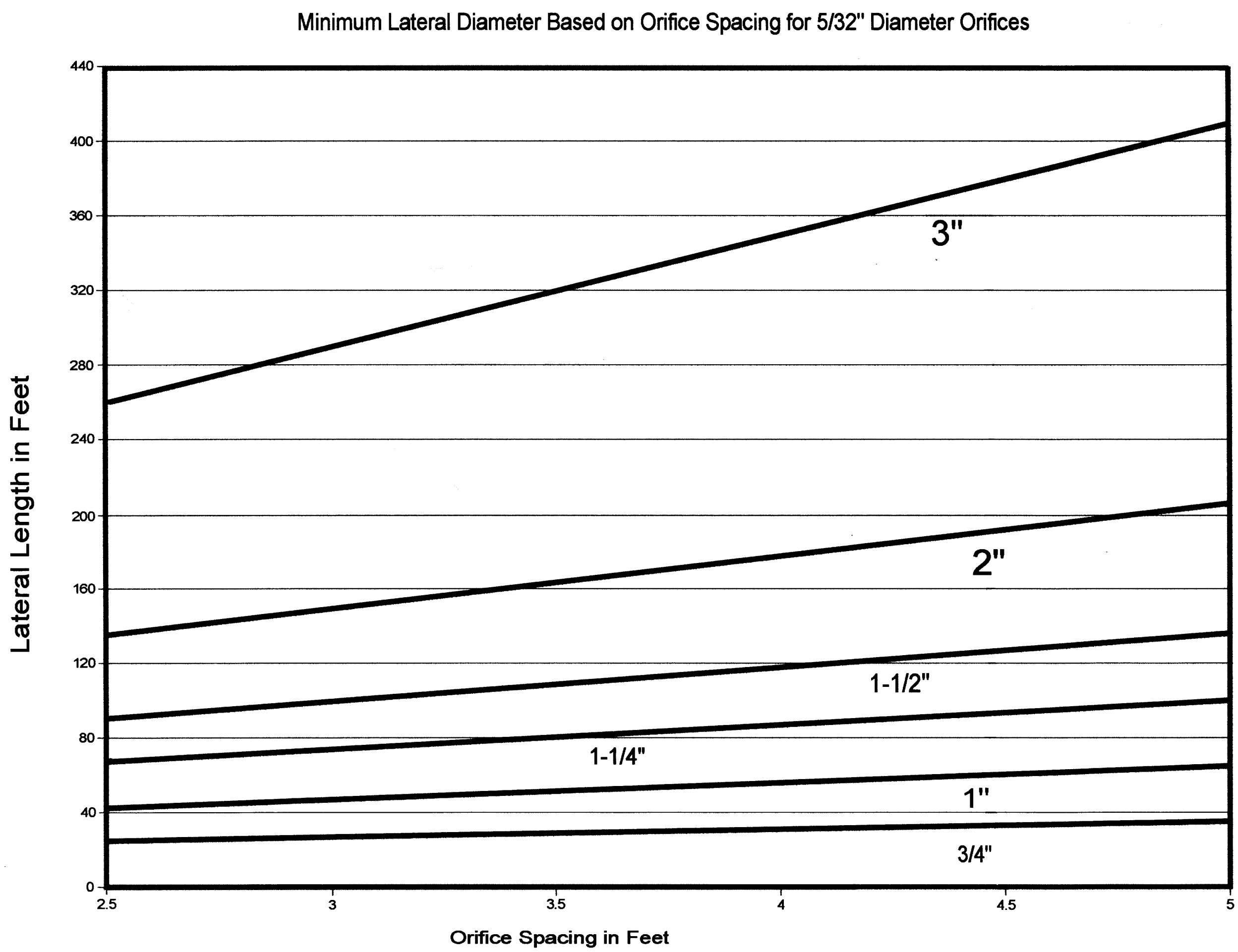

Minimum Lateral Diameters Based on Orifice Spacing for 1/8" Diameter Orifices
Lateral Length in Feet
Orifice Spacing in Feet
550
500
450
400
350
300
250
200
150
100
50
0
2.5
3
3.5
4
4.5
5
3"
2"
1-1/2"
1-1/4"
1"
3/4"

Graph 3

Minimum Lateral Diameter Based on Orifice Spacing for 5/32" Diameter Orifices

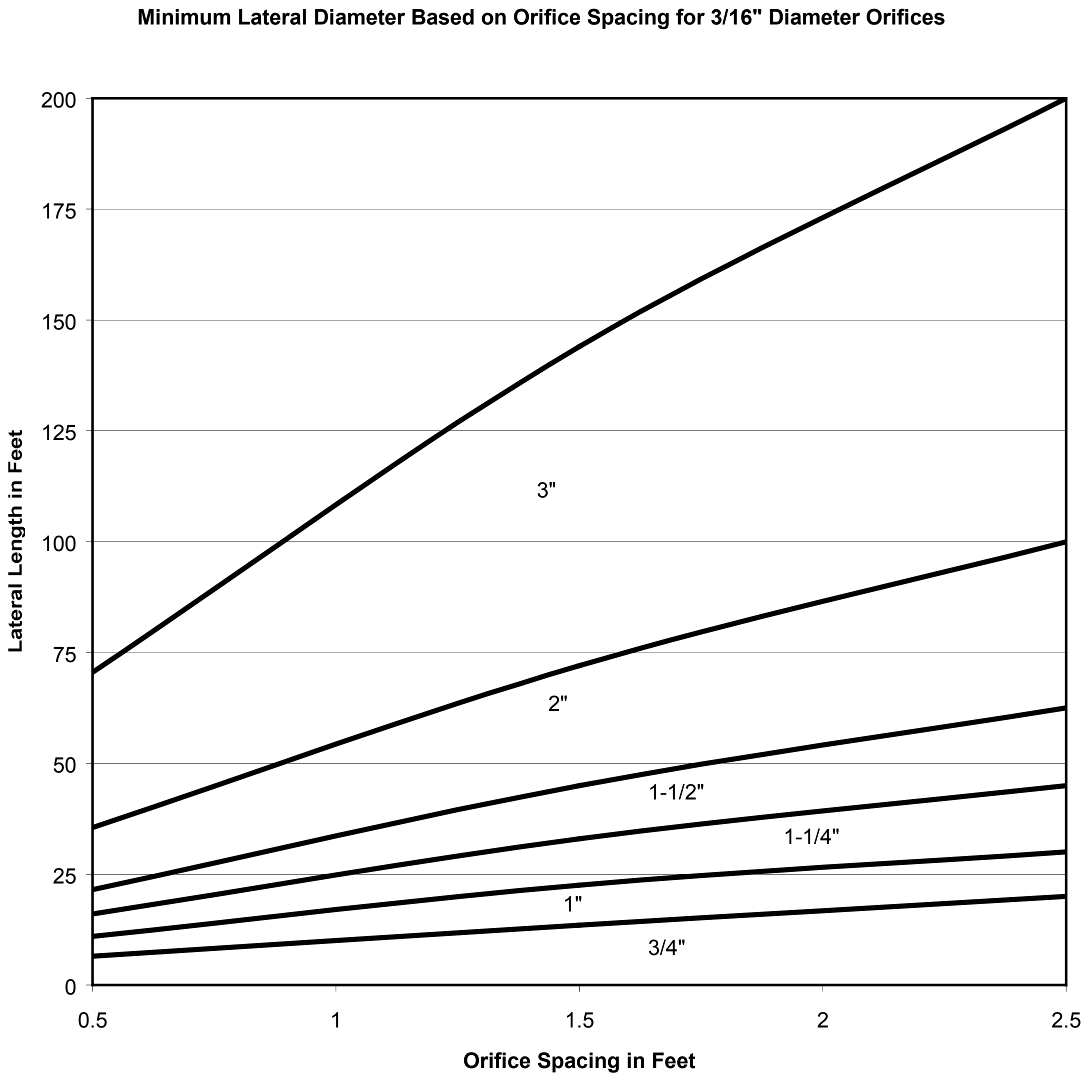


Graph 4

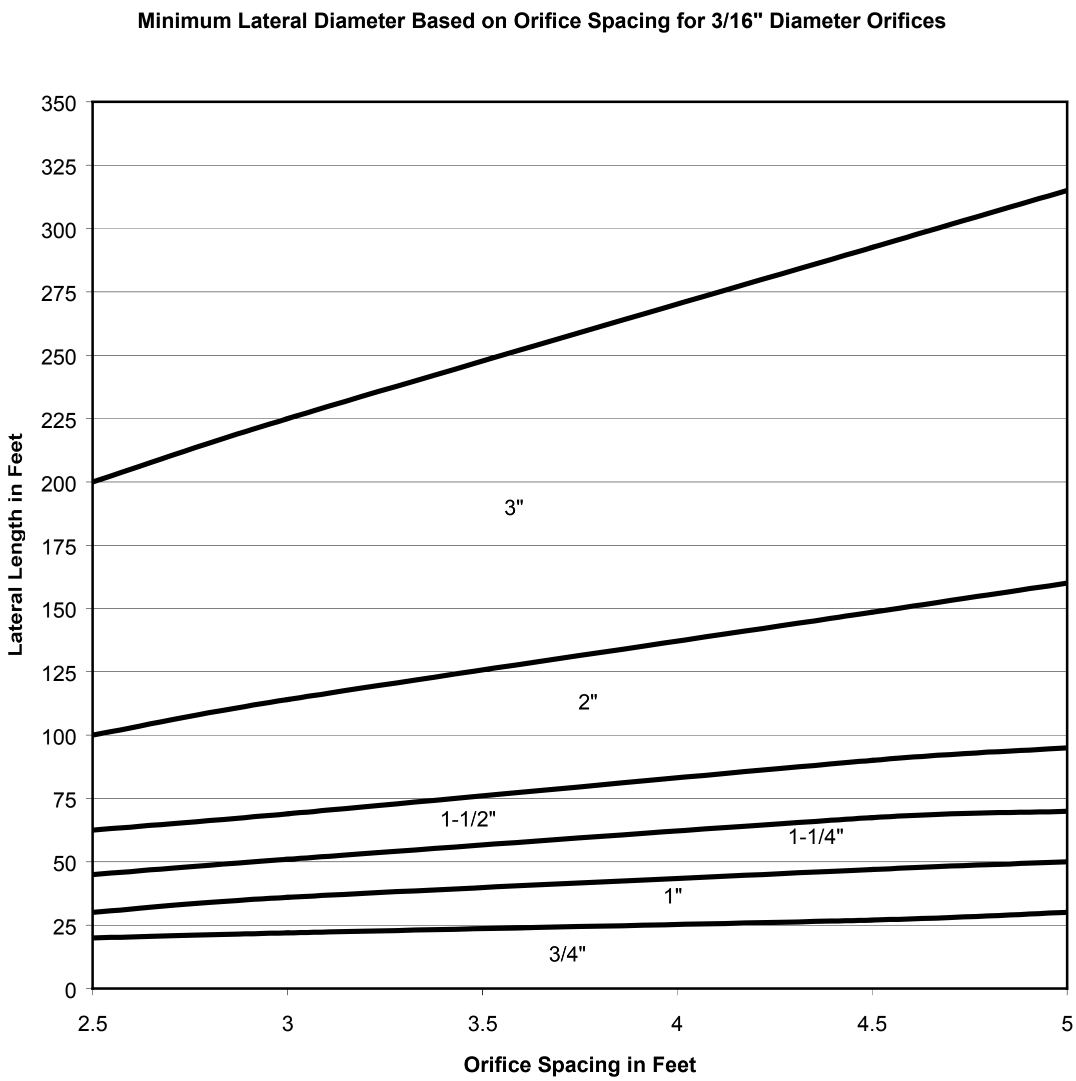


Minimum Lateral Diameter Based on Orifice Spacing for 5/32" Diameter Orifices
Lateral Length in Feet
Orifice Spacing in Feet
0
40
80
120
160
200
240
280
320
360
400
440
2.5
3
3.5
4
4.5
5
3"
2"
1-1/2"
1-1/4"
1"
3/4"

Graph 5

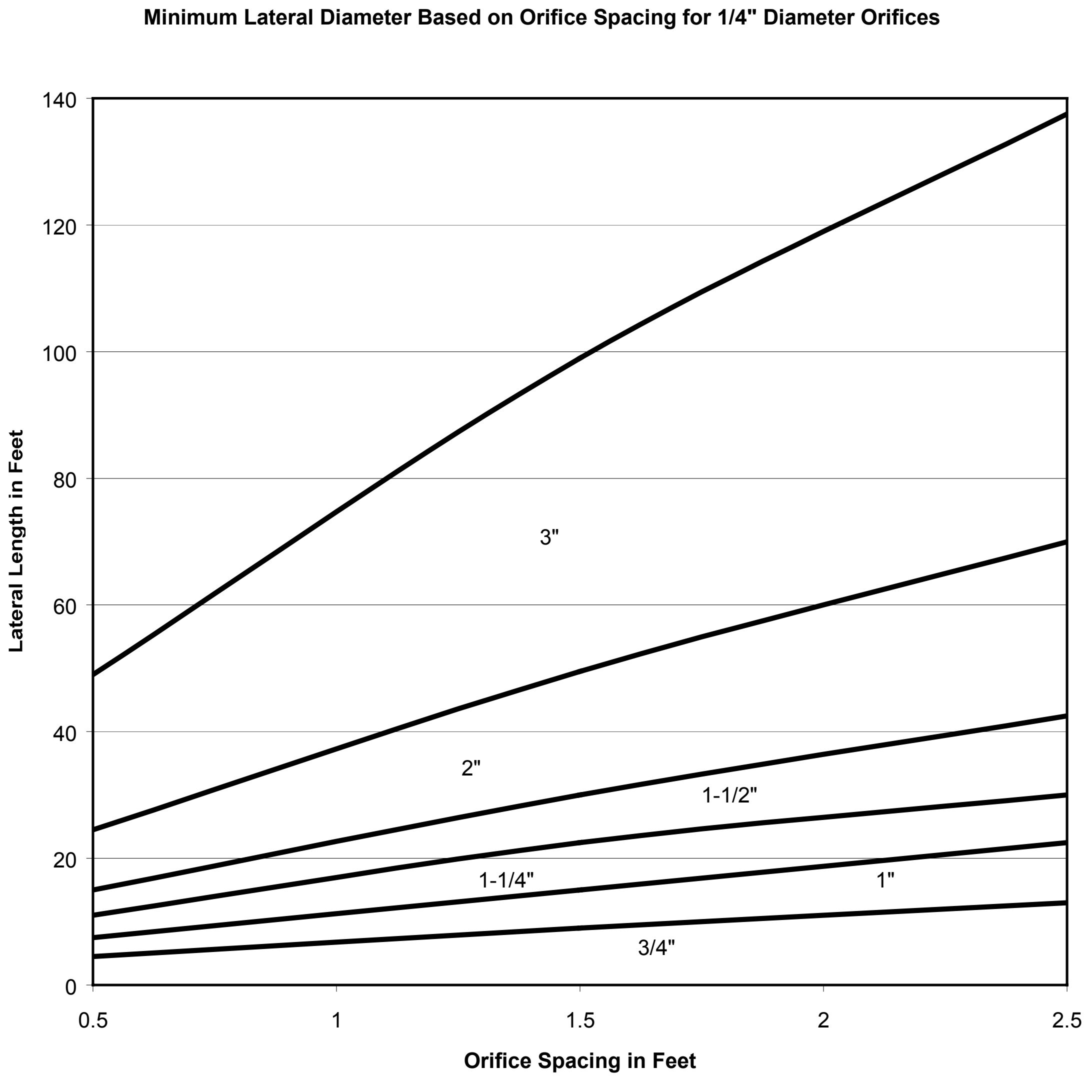

Minimum Lateral Diameter Based on Orifice Spacing for 3/16" Diameter Orifices
Lateral Length in Feet
Orifice Spacing in Feet
0
25
50
75
100
125
150
175
200
0.5
1
1.5
2
2.5
3"
2"
1-1/2"
1-1/4"
1"
3/4"

Graph 6



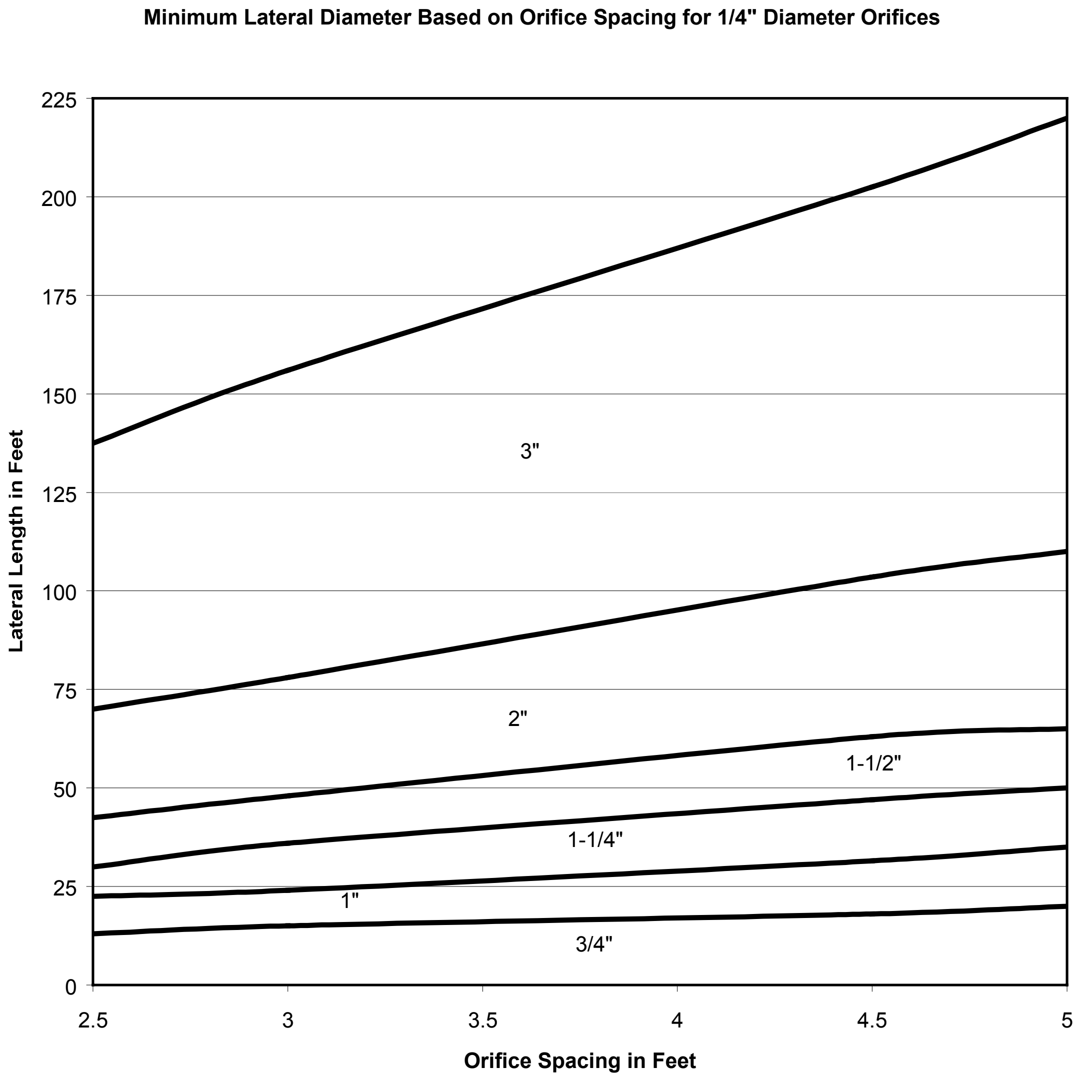
Minimum Lateral Diameter Based on Orifice Spacing for 3/16" Diameter Orifices
Lateral Length in Feet
Orifice Spacing in Feet
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
2.5
3
3.5
4
4.5
5
3"
2"
1-1/2"
1-1/4"
1"
3/4"

Graph 7



Minimum Lateral Diameter Based on Orifice Spacing for 1/4" Diameter Orifices
Lateral Length in Feet
140
120
100
80
60
40
20
0
0.5
1
1.5
2
2.5
Orifice Spacing in Feet
3"
2"
1-1/2"
1-1/4"
1"
3/4"

Graph 8



Minimum Lateral Diameter Based on Orifice Spacing for 1/4" Diameter Orifices
Lateral Length in Feet
225
200
175
150
125
100
75
50
25
0
3"
2"
1-1/2"
1-1/4"
1"
3/4"
2.5
3
3.5
4
4.5
5
Orifice Spacing in Feet

VIII. TABLES

Table 4

Discharge Rates in Gallons per Minute from Orifices[a]

Pressure in feet	Orifice Diameter			
	1/8	5/32	3/16	1/4
2.5	NP	NP	0.66	1.17
3	NP	NP	0.72	1.28
3.5	NP	0.54	0.78	1.38
4	NP	0.58	0.83	1.47
4.5	NP	0.61	0.88	1.56
5	0.41	0.64	0.93	1.65
5.5	0.43	0.68	0.97	1.73
6	0.45	0.71	1.02	1.80
6.5	0.47	0.73	1.06	1.88
7	0.49	0.76	1.10	1.95
7.5	0.50	0.79	1.14	2.02
8	0.52	0.81	1.17	2.08
8.5	0.54	0.84	1.21	2.15
9	0.55	0.86	1.24	2.21
9.5	0.57	0.89	1.28	2.27
10	0.58	0.91	1.31	2.33

Note a: Table is based on - Discharge in GPM = 11.79 x Orifice Diameter^2 in inches x (Pressure in Feet)$^{1/2}$

NP means not permitted

Table 5

Maximum Manifold Length Based on Individual Lateral Flow Rates and Lateral Spacing

Individual Lateral Discharge Rate		1-1/4" Diameter Manifold						1-1/2" Diameter Manifold					
End	Center	Lateral Spacing						Lateral Spacing					
Manifold	Manifold	1.5	2	2.5	3	3.5	4	1.5	2	2.5	3	3.5	4
10	5	4.5	6	7.5	9	10.5	8	7.5	8	10	12	14	12
20	10	3	4	5	6	7	8	4.5	6	7.5	6	7	8
30	15	3	4					3	4	5	6	7	8
40	20							3	4	5	6		
50	25							3	4				
60	30							3					

Individual Lateral Discharge Rate		2" Diameter Manifold						3" Diameter Manifold					
End	Center	Lateral Spacing						Lateral Spacing					
Manifold	Manifold	1.5	2	2.5	3	3.5	4	1.5	2	2.5	3	3.5	4
10	5	12	14	15	18	21	20	22.5	28	32.5	36	38.5	44
20	10	7.5	8	10	12	14	12	15	18	20	24	24.5	28
30	15	6	6	7.5	9	10.5	12	12	14	15	18	21	20
40	20	4.5	6	7.5	6	7	8	9	12	12.5	15	17.5	16
50	25	4.5	4	5	6	7	8	7.5	10	12.5	12	14	16
60	30	3	4	5	6	7	8	7.5	8	10	12	14	12
70	35	3	4	5	6	7	8	6	8	10	9	10.5	12
80	40	3	4	5	6	7		6	8	7.5	9	10.5	12
90	45	3	4	5	6			4.5	6	7.5	9	10.5	12
100	50	3	4	5				4.5	6	7.5	9	10.5	12
110	55	3	4					4.5	6	7.5	9	10.5	8
120	60	3						4.5	6	7.5	6	7	8
130	65	3						4.5	6	5	6	7	8
140	70							4.5	6	5	6	7	8
150	75							4.5	6	5	6	7	8
160	80							4.5	4	5	6	7	8
170	85							4.5	4	5	6	7	8
180	90							3	4	5	6	7	8
190	95							3	4	5	6	7	8
200	100							3	4	5	6	7	8

Table 6

FRICTION LOSS (FOOT/100 FEET) IN PLASTIC PIPE[a]

Flow in GPM	Nominal Pipe Size 3/4	1	1-1/4	1-1/2	2	3	4	6
1								
2								
3	3.24							
4	5.52							
5	8.34	2.05						
6	11.68	2.88						
7	15.53	3.83						
8	19.89	4.91	1.65					
9	24.73	6.10	2.06					
10	30.05	7.41	2.50					
11	35.84	8.84	2.99					
12	42.10	10.39	3.51	1.44				
13	48.82	12.04	4.07	1.67				
14	56.00	13.81	4.66	1.92				
15		15.69	5.30	2.18				
16		17.68	5.97	2.46				
17		19.78	6.68	2.75				
18		21.99	7.42	3.06				
19		24.30	8.21	3.38				
20		26.72	9.02	3.72	0.92			
25		40.38	13.63	5.62	1.39			
30			19.10	7.87	1.94			
35			25.41	10.46	2.58			
40			32.53	13.40	3.30			
45				16.66	4.11	0.57		
50				20.24	4.99	0.69		
60					7.00	0.97		
70					9.31	1.29		
80					11.91	1.66	0.41	
90					14.81	2.06	0.51	
100					18.00	2.50	0.62	
125						3.78	0.93	
150						5.30	1.31	
175						7.05	1.74	
200						9.02	2.23	0.31
250							3.36	0.47
300							4.71	0.66
350							6.27	0.87

Velocities in this area are below 2 feet per second

Velocities in this area Exceed 10 feet per second, which is too great for various flow rates and pipe diameter

Note a: Table is based on – Hazen-Williams formula: $h = 0.002082L \times (100/C)^{1.85} \times (gpm^{1.85} \div d^{4.8655})$

Where: h = feet of head

L = Length in feet

C = Friction factor from Hazen-Williams (145 for plastic pipe)

gpm = gallons per minute

d = Nominal pipe size

Table 7 VOID VOLUME FOR VARIOUS DIAMETER PIPES BASED ON NOMINAL I.D.[a]	
Nominal Pipe Size	Gallons per Foot
¾	0.023
1	0.041
1-1/4	0.064
1-1/2	0.092
2	0.163
3	0.367
4	0.65
6	1.469

Note a: Table is based on - $\pi(d/2)^2$ x 12"/ft ÷ 231 cu.in./cu.ft.
Where: d = nominal pipe size in inches

IX. REFERENCES

Department of Industry, Labor and Human Relations 1994, "Pressure Distribution Manual"
Small Scale Waste Management Project, University of Wisconsin – Madison, 1981, R.J. Otis, "Design of Pressure Distribution Networks for Septic Tank-Soil Absorption Systems."

X. PRESSURE DISTRIBUTION WORKSHEET

Information needed for Pressure Distribution Design:

Daily wastewater flow = 9,500 **gal/day**

Design loading rate = 0.6 **gal/ft^2/day** * Value per WI Comm. Table 83.44-2 most restrictive soil horizon

System Configuration:

1. ~85 **ft.** system width

2. ~150 **ft.** system length

Proposed Lateral Layout:

3. 50 number of laterals

4. end central or end manifold

5. 14 **ft.** manifold length

6. >/= 5 **ft.** distal pressure requirement (Based on orifice diameter, see Table 1)

7. 1/8" **in.** orifice diameter

8. 90 **ft.** estimated lateral length

Choose the Orifice Spacing:

9. 2.1 **ft.** orifice spacing divided by 12 to convert to feet.

10. 46 number of orifices per lateral

$$n = L/x + .5$$

Where: n = number of orifices
L = lateral length, in feet
x = orifice spacing, in feet

Note: Networks with central manifold have laterals on each side of the manifold. Therefore the number of laterals are two times as many as a network with an end manifold.

Re-evaluate the Lateral Length:

11. ~90 **ft.** final lateral length
(# of orifices x orifice spacing - 1/2 orifice spacing = optimal length)

Choose the Lateral Diameter:

12. 1.5 **in.** (Graphs 1-8)

Calculate the Lateral Discharge Rate:

13. 20 **gpm** lateral discharge rate. * rate depends on the pressure (5-10 ft)
Discharge rate per orifice x # of orifices per lateral = lateral discharge rate.

Choose the Manifold Diameter:

14. 3 **in.** (Table 5)

Calculate the System Discharge Rate:

15. 100 **gpm** (# of laterals x lateral discharge rate)

Calculate the Force Main Friction Loss (for each segment of different diameter or between tees in the force main):

16. 82 **ft.** force main length

17. 3 **in.** force main diameter (Table 6)

18. 100 **gpm** system discharge rate (from #15)

19. 2.5 **ft.** friction loss in ft/100 ft. x length ÷ 100 ft. (Table 6)

Calculate the Total Dynamic Head:

20. 6 **ft.** distal pressure #6

21. 1.5 **ft.** network pressure compensation [losses due to fittings, etc. (0.3 x distal pressure)]

22. ~6 ft **ft.** vertical lift (pump off to lateral elevation)

23. 2.5 **ft.** friction loss (in the force main in feet #19)

24. ~25 **ft.** Total Dynamic Head (TDH) (sum of #20 through #23)

Calculate the Dose Volume:

25. 190 **gal.** based on system type. *20% of design system flow

26. 67 **gal.** - drain back *Void volume of pipes in system

27. 257 **gal.** - actual dose volume (#25 + #26)

Pump Selection:

28. 100 **gpm** pump discharge rate at TDH (#24)
(not less than system discharge rate, #15)

Dose Chamber Sizing: (Sizing of dose chamber serving a sand filter may have different requirements. See component manual or manufacturer's or designer's specifications for sizing criteria.)

29. ________ **in.** tank bottom to "off" switch ________ gal.

30. ________ **in.** dose volume (from #27) ("off" to "on" switch) ________ gal.

31. ________ **in.** "on" switch to alarm switch ________ gal.

32. ________ **in.** reserve capacity (residential = 100 gal/BR) ________ gal.

33. ________ **in.** dose chamber capacity 5000 gal.

Dose tank dimensions are:
2.5 m long
2.5 m wide
3 m deep

18.8 cubic meters vol.

On/off level switch loc. must be sufficient to allow for specified dose volume (~250 gal) for tank size

XI. PLAN SUBMITTAL AND INSTALLATION INSPECTION

A. Plan Submittal

In order to install a system correctly, it is important to develop plans that will be used to install the system correctly the first time. The following checklist may be used when preparing plans for review. The checklist is intended to be a **general guide**. Not all needed information may be included in this list. Some of the information may not be required to be submitted due to the design of the system. Conformance to the list is not a guarantee of plan approval. Additional information may be needed or requested to address unusual or unique characteristics of a particular project. Contact the reviewing agent for specific plan submittal requirements, which the agency may require that are different than the list included in this manual.

General Submittal Information

- Photocopies of soil reports forms, plans, and other documents are acceptable. However, an original signature is required on certain documents.
- Submittal of additional information requested during plan review or and questions concerning a specific plan must be referenced to the Plan Identification indicator assigned to that plan by the reviewing agency.
- Plans or documents must be permanent copies or originals.

Forms and Fees

- Application form for submittal, provided by reviewing agency along with proper fees set by reviewing agent.

Soils Information

- Complete Soils and Site Evaluation Report (form # SBD-8330) for each backhoe pit described; signed and dated by a certified soil tester, with license number.
- Separate sheet showing the location of all borings. The location of all borings and backhoe pits must be able to be identified on the plot plan.

Documentation

- Architects, engineers or designers must sign, seal and date each page of the submittal or provide an index page, which is signed, sealed and dated.
- Master Plumbers must sign, date and include their license number on each page of the submittal or provide an index page, which is signed, sealed and dated.
- Three completed sets of plans and specifications (clear, permanent and legible); submittals must be on paper measuring at least 8-1/2 by 11 inches.
- Designs that are based on department approved component manual(s) must include reference to the manual(s) by name, publication number and published date.

Plot Plan

- Dimensioned plans or plans drawn to scale (scale indicated on plans) with parcel size or all property boundaries clearly marked.
- Slope directions and percent in system area.
- Benchmark and north arrow.
- Setbacks indicated as per appropriate code.
- Two-foot contours or other appropriate contour interval within the system area.
- Location information; legal description of parcel must be noted.
- Location of any nearby existing system or well.

Plan View

- Dimensions for distribution cell(s).
- Location of observation pipes.
- Dimensions of dispersal/treatment component.
- Pipe lateral layout, which must include the number of laterals, pipe material, diameter and length; and number, location and size of orifices.
- Manifold/force main locations, with materials, length and diameter of each.

Cross Section Of System

- Include tilling requirement, distribution cell details, percent slope, side slope, and cover material.
- Lateral elevation, position of observation pipes, dimensions of distribution cell, and type of cover material such as geotextile fabric, if applicable.

System Sizing

- For one- and two-family dwellings, the number of bedrooms must be included.
- For public buildings, the sizing calculations must be included.

Tank And Pump / Siphon Information

- All construction details for site-constructed tanks.
- Size and manufacturer information for prefabricated tanks.
- Notation of pump or siphon model, pump performance curve, friction loss for force main and calculation for total dynamic head.
- Cross section of dose tank / chamber to include storage volumes; connections for piping, vents, and power; pump “off” setting; dosing cycle and volume, high water alarm setting, and storage volume above the highwater alarm; and location of vent and manhole.
- Cross section of two compartment tanks or tanks installed in a series must include information listed above.

B. Inspections.

Inspection shall be made in accordance with ch. 145.20, Wis. Stats and s. Comm 83.26, Wis. Adm. Code. The inspection form on the following two pages may be used. The inspection of the system installation and/or plans is to verify that the system at least conforms to specifications listed in Tables 1 - 3 of this manual.

POWTS INSPECTION REPORT

(ATTACH TO PERMIT)

GENERAL INFORMATION

Permit Holder's Name	☐ City ☐ Village ☐ Town of	County	Sanitary Permit No.
State Plan ID No.	Tax Parcel No.	Property Address if Available	

TREATMENT COMPONENT INFORMATION			**SETBACKS (FT)**				
TYPE	MANUFACTURER AND MODEL NUMBER	CAPACITY	P/L	WELL	WATER LINE	BLDG.	VENT
SEPTIC							
DOSING							
AERATION							
HOLDING							
FILTER							

PUMP / SIPHON INFORMATION

Manufacturer:	Model No.	Demand in GPM	TDH - Design

FORCE MAIN INFORMATION			**FRICTION LOSS (FT)**			
Length	Diameter	Dist. To Well	Component Head	Force Main Losses	Vert. Lift	TDH - As Built

SOIL ABSORPTION COMPONENT

TYPE OF COMPONENT:			COVER MATERIAL:			
Cell Width	Cell Length	Cell Depth	Cell Spacing	No. of Cells		
LEACHING CHAMBER OR UNIT		Manufacturer			Model No.	
SETBACK INFO. (FT)	Property Line	Bldg.	Well		Water Line	OHWM

DISTRIBUTION COMPONENT

Elevation data on back of form

Header / Manifold		Distribution Lateral(s)			Orifice size	Orifice Spacing	Obs. Pipes Inst. & No.
Length	Dia.	Length	Dia.	Spacing			

SOIL COVER

Depth over center of cell:	Depth over edge of cell:	Depth of Cover material	Texture	Seeded / Sodded	Mulched

DEVIATIONS FROM APPROVED PLAN

DATE OF INST. DIRECTIVE:	DATE OF ENFORCEMENT ORDER:
DATE OF REFERRAL TO LEGAL COUNSEL:	

COMMENTS (Persons present, discrepancies, etc.)

COMPONENTS NOT INSPECTED

Plan Revision Required ☐ Yes ☐ No	Date:	Signature of Inspector:	Cert. Number

Sketch on other side

ELEVATION DATA

Point	Back sight	Height of instrument	Foresight	Elevation	Comments
Bench mark					
Bldg. sewer					
Tank inlet					
Tank outlet					
Tank inlet					
Tank outlet					
Dose tank inlet					
Bottom of dose tank					
Dist. lateral 1					
System elev. 1					
Dist. lateral 2					
System elev. 2					
Dist. lateral 3					
System elev. 3					
Grade elev. 1					
Grade elev. 2					
Grade elev. 3					

SKETCH OF COMPONENT & ADDITIONAL COMMENTS

DRAINFIELD WITH PRESSURE DISTRIBUTION

ID	ACTIVITY	RATIO	COST	UNIT	QUANTITY								TOTAL COST
					LENGTH	*Unit*	*WIDTH*	*Unit*	*DEPTH*	*Unit*	**TOTAL**	**Unit**	
	MOBILIZATION/SITE LAYOUT	*TOTAL*	**3936.48**										
DRE 001	MOBILIZATION - SEPTIC	-	3402.70	GL.	-	-	-	-	-	-	1	GL.	3402.70
INS 001	MOBILIZATION	1.00	3150.00	GL.							1	GL.	
AL 350	BRICK LAYER	11.00	8.20	h							11	h	
AL 355	HELPER	25.00	6.50	h							25	h	
DRE 002	SITE LAYOUT (SEWERS, CANALS, BRIDGES)		10.68	m	50	m	-	-	-	-	50	m	533.78
MA 019	WOOD STAKES 2"X2"X30cm	1.00	3.00	PZA							50	PZA	
PT 002	PAINTING LATEX	0.01	72.00	gal							0.5	GAL	
HI 001	INDENTED IRON	0.01	11.55	kg							0.5	kg	
AL 365	TOPOGRAPHER	0.20	12.00	h							10	h	
AL 366	PAINTER	0.20	8.20	h							10	h	
MQ 022	TOPOGRAPHIC TEAM	0.07	40.00	h							3.5	h	
	EXCAVATION OF EXISTING SYSTEM	*TOTAL*	2250.67										
DRE 004	EXCAVATION WITH MACHINERY	-	14.40	m^3	3.5	m	1.7	m	1.3	m	7.735	m^3	111.38
AL 361	BACKHOE OPERATOR	0.32	6.00	h							2.48	h	
AL 362	ASSISTANT	0.32	6.50	h							2.48	h	
MQ 007	BACKHOE 85/100 HP	0.04	200.00	h							0.31	h	
MQ 008	WATER SPRAYER OF 4"	0.12	20.00	h							0.93	h	
EXC 002	EARTHWORK (REMOVE EXISTING TANK)	-	9.25	m^3	3.5	m	1.7	m	1.3	m	7.74	m^3	71.55
AL 355	ASSISTANT	0.50	6.50	h							3.87	h	
MQ 007	BACKHOE 85/100 HP	0.02	200.00	h							0.15	h	
MQ 009	BUCKET 10 m^3	0.01	200.00	h							0.08	h	
EXC 006	LEVEL AND COMPACT EXISTING GROUND	-	16.35	m^3	3.5	m	1.7	m	1.3	m	126.47	m^3	2067.74
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							265.58	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							18.97	h	
	INSPECTION TANK INSTALLATION	*TOTAL*	1198.84										
EXC 002	EARTHWORK	-	9.25	m^3	1	m	1	m	1	m	1	m^3	9.25
AL 355	ASSISTANT	0.50	6.50	h							0.5	h	
MQ 007	BACKHOE 85/100 HP	0.02	200.00	h							0.02	h	
MQ 009	BUCKET 10 m^3	0.01	200.00	h							0.01	h	
EXC 006	LEVEL AND COMPACT EXISTING GROUND	-	16.35	m^3	1	m	1	m	1	m	1	m^3	16.35
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							2.1	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							0.15	h	
SAN030	CLEAN INSPECTION TANK AND PIPES		287	GBL							1	GBL	287
AL350	BRICK LAYER	35	8.20	h									
SAN089	INSPECTION TANK (.60x.60 m)		367.27	PZA							2	PZA	734.537
AG001	SAND SELECTION	0.18	60.00	m^3							0.36	m^3	
AG002	CLEAR DEBRIS	0.1	140.00	m^3							0.2	m^3	
AG901	CEMENT	75	0.94	kg							150	kg	
MU001	BRICK CURING	130	0.57	PZA							260	PZA	
HI002	INDENTED IRON	8	11.55	kg							16	kg	
HI003	MOORING WIRE	0.2	12.73	kg							0.4	kg	
AG004	STONE	0.15	155.00	m^3							0.3	m^3	
AL350	BRICKLAYER	7	8.20	h							14	h	
AL355	HELPER	7	6.50	h							14	h	
SAN082	CONSTRUCTION OF TANK LID		75.85	PZA							2	PZA	151.7
AG001	SAND SELECTION	0.05	60.00	m^3							0.1	m^3	
AG002	CLEAR DEBRIS	0.08	140.00	m^3							0.16	m^3	
AG901	CEMENT	12	0.94	kg							24	kg	
MU001	BRICK CURING	4	0.57	PZA							8	PZA	
HI002	INDENTED IRON	2	11.55	kg							4	kg	
AL 350	BRICKLAYER	1.7	8.20	h							3.4	h	
AL 355	HELPER	1.7	6.50	h							3.4	h	
	SEPTIC TANK INSTALLATION	*TOTAL*	30399.93										
PA 011	MANUAL EXCAVATION	-	11.05	m^3	6.5	m	2.5	m	2	m	65	m^3	718.25
AL 355	HELPER	1.70	6.50	h							110.50	h	
	REMOVE OLD PIPING		19.50	GBL							1	GBL	19.50
AL 355	HELPER	3	6.50	h							6	h	
EXC 006	LEVEL AND COMPACT EXISTING GROUND	-	16.35	m^3	6.5	m	2.5	m	2	m	65	m^3	1062.75
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							136.5	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							9.75	h	
SAN096	SEPTIC TANK (1.5x1.5x3.0m)		5255.00	PZA	6	m	2	m	1.5	m	28030.16	PZA	28030.16
AG901	CEMENT	500	8	kg							10680.0	kg	
AG001	SAND	1.6	60	m^3							256.3	m^3	
AG002	CLEAR DEBRIS	1.6	140	m^3							598.1	m^3	
HI001	NAIL	3.2	12.72	kg							108.7	kg	
HI003	MOORING WIRE	1.28	12.73	kg							43.5	kg	
HI002	INDENTED IRON	40	11.55	kg							1233.5	kg	
AL350	BRICKLAYER	20	2	m^2							106.8	m^2	
AL355	HELPER	20	6.5	h							347.1	h	
HO901	MIXER OF 500 Lts	6	25	h							400.5	h	
VI001	VIBRATOR .75"	4.8	20	h							256.3	h	
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							33.6	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							10.0	h	
SAN082	CONSTRUCTION OF TANK LID		75.85	PZA							3	PZA	227.55
AG001	SAND SELECTION	0.05	60.00	m^3							0.1	m^3	
AG002	CLEAR DEBRIS	0.08	140.00	m^3							0.16	m^3	
AG901	CEMENT	12	0.94	kg							24	kg	
MU001	BRICK CURING	4	0.57	PZA							8	PZA	
HI002	INDENTED IRON	2	11.55	kg							4	kg	
AL 350	BRICKLAYER	1.7	8.20	h							3.4	h	
AL 355	HELPER	1.7	6.50	h							3.4	h	
AIS001	WATERPROOFING FOR BRICK WALLS		11.99	m							28.5	m	341.715
AI006	POLYETHYLENE 200µ	0.3	3	m^2							8.55	m^2	
AG001	SAND	0.009	60	m^3							0.2565	m^3	
AG901	CEMENT	1	8	kg							28.5	kg	
AI001	TAR	0.3	8.5	kg							8.55	kg	
	DOSE TANK	*TOTAL*	89881.50										
PA 011	MANUAL EXCAVATION	-	11.05	m^3	4	m	4	-	2.5	-	80.00	m^3	884.00
AL 355	HELPER	1.70	6.50	h							136.00	h	
DRE 004	EXCAVATION WITH MACHINERY	-	14.40	m^3	4	m	4	m	2.5	m	80	m^3	1152.00
AL 361	BACKHOE OPERATOR	0.32	6.00	h							25.6	h	
AL 362	ASSISTANT	0.32	6.50	h							25.6	h	
MQ 007	BACKHOE 85/100 HP	0.04	200.00	h							3.2	h	
MQ 008	WATER SPRAYER OF 4"	0.12	20.00	h							9.6	h	
SAN 012	UNDERGROUND TANK CONSTRUCTION (.5X.5X.6m) (.15m^3)	-	323.17	PZA	3	m	3	m	2.1	-	252	PZA	81442.45
AG 001	SAND	0.1	60.00	h							920	h	
AG 002	CLEAR DEBRIS	0.1	140.00	h							0.28	h	
AG 901	CEMENT	65.0	0.94	kg							260	kg	
MU 001	BRICK CURING	150.0	0.57	PZA							600	PZA	
HI 002	INDENTED IRON	6.0	11.55	kg							24	kg	
HI 003	MOORING WIRE	0.1	12.73	kg							0.4	kg	
AG 004	STONE	0.1	155.00	m^3							0.4	m^3	
AL 350	BRICKLAYER	5.0	8.20	h							20	h	
AL 355	HELPER	5.0	6.50	h							20	h	
RSMEANS	WATERPROOF COATING		0.15	m							19	m	2.85
	CONNECTING PIPES (SEPTIC TO DOSE)												
SAN 001	PROVIDE AND PLACE SANITARY PIPE (4")	-	35.30	m		m	-	-	-	-	6	m	3306.00
HS 058	4 IN SANITARY PIPE	1.050	22.00	m							420	m	
HS 061	GLUE FOR PVC	0.04	80.00	kg							16	kg	
PL 010	PLUMBER	0.60	8.50	h							240	h	
AL 355	HELPER	0.60	6.50	h							240	h	
HS012	PIPE ELBOW 45Deg, 4" PVC	0.25	2.3	PZA							4	PZA	9.20
RSMEANS	3" PVC, PUMP TO VALVE	1.0	1.23	m							2	m	2.46
	FLOAT SYSTEM	1.0	30.00	PZA							2	PZA	60.00
	KVALVE	1.0	1209.60	PZA							2	PZA	2419.20
	"T" FITTINGS, 4" PVC	1.0	5.00	PZA							4	PZA	20.00
SAN082	CONSTRUCTION OF TANK LID		75.85	PZA							2	PZA	151.7
AG001	SAND SELECTION	0.05	60.00	m^3							0.1	m^3	
AG002	CLEAR DEBRIS	0.08	140.00	m^3							0.16	m^3	
AG901	CEMENT	12	0.94	kg							24	kg	
MU001	BRICK CURING	4	0.57	PZA							8	PZA	
HI002	INDENTED IRON	2	11.55	kg							4	kg	

DRAINFIELD WITH PRESSURE DISTRIBUTION

ID	ACTIVITY	RATIO	COST	UNIT	QUANTITY								TOTAL COST
					LENGTH	*Unit*	*WIDTH*	*Unit*	*DEPTH*	*Unit*	**TOTAL**	**Unit**	
AL 350	BRICKLAYER	1.7	8.20	h							3.4	h	
AL 355	HELPER	1.7	6.50	h							3.4	h	
AIS001	WATERPROOFING FOR BRICK WALLS		11.99	m							36	m	431.64
AI006	POLYETHYLENE 200μ	0.3	3	m^2							8.55	m^2	
AG001	SAND	0.009	60	m^3							0.2565	m^3	
AG901	CEMENT	1	8	kg							28.5	kg	
AI001	TAR	0.3	8.5	kg							8.55	kg	
	DRAINAGE FIELD INSTALLATION	*TOTAL*	65543.25										
PA 011	MANUAL EXCAVATION	-	11.05	m^3	-	m	-	-	0.56	-	822.00	m^3	9083.10
AL 355	HELPER	1.70	6.50	h							1397.40	h	
DRE 004	EXCAVATION WITH MACHINERY	-	14.40	m^3	-	m	-	m	-	m	822	m^3	11836.80
AL 361	BACKHOE OPERATOR	0.32	6.00	h							263.04	h	
AL 362	ASSISTANT	0.32	6.50	h							263.04	h	
MQ 007	BACKHOE 85/100 HP	0.04	200.00	h							32.88	h	
MQ 008	WATER SPRAYER OF 4"	0.12	20.00	h							98.64	h	
EXC 006	LEVEL AND COMPACT EXISTING GROUND	-	16.35	m^2	-	m	-	m	-	m	450	m^2	7357.50
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							945	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							67.5	h	
TRA036	FILTER MATERIAL (STONE AND GRAVEL)		24.1	m^3							25	m^3	602.5
AG005	MATERIAL FILTRANTE	1	11.1	m^3							12	m^3	
AL355	HELPER	2	6.50	h							50	h	
EXC009	GRAVEL FILL	-	23.00	m^3	-	m	-	-	-	-	822	m^3	18906.00
AG 017	GRAVEL SELECTION	0.30	30.00	m^3							246.6	m^3	
AG 018	SAND SELECTION	0.20	70.00	m^3							164.4	m^3	
AL 350	BRICKLAYER	1.00	8.20	h							822.0	h	
AL 355	HELPER	3.00	6.50	h							2466.0	h	
SAN113	VENTILATION PIPE		47.807	PZA							1	PZA	47.81
HS140	2" PVC VENTILATION TUBE	6	7	m							6	m	
HS012	ELBOW	0.25	2.3	PZA							0.25	PZA	
HS061	GLUE FOR PVC	0.05	80.00	kg							0.05	kg	
AG901	CEMENT	0.8	0.94	kg							0.8	kg	
AG001	SAND	0.008	60.00	h							0.008	h	
SAN 001	PROVIDE AND PLACE SANITARY PIPE (3")	-	35.30	m		m	-	-	-	-	400	m	14120.00
HS 058	4 IN SANITARY PIPE	1.05	22.00	m							420	m	
HS 061	GLUE FOR PVC	0.04	80.00	kg							16	kg	
PL 010	PLUMBER	0.60	8.50	h							240	h	
AL 355	HELPER	0.60	6.50	h							240	h	
SAN 002	PROVIDE AND PLACE SANITARY PIPE (1.5")	-	36.75	m		m	-	-	-	-	70	m	2572.50
HS 056	2 IN SANITARY PIPE	1.05	22.00	m							504	m	
HS 061	GLUE FOR PVC	0.03	80.00	kg							14.4	kg	
HS 062	CLEANER FOR PVC	0.03	45.00	LT							14.4	LT	
PL 010	PLUMBER	0.75	8.50	h							360	h	
AL 355	HELPER	0.75	6.50	h							360	h	
	GEOTEXTILE PLASTIC LINING	-	8.32	m^2	-	m	-	m	-	-	122.30	m^2	1017.05
	ROAD REPAIR	*TOTAL*	248.25										
EXC 002	EARTHWORK	-	9.25	m^3	3	m	2	m	1	m	6	m^3	55.50
AL 355	HELPER	0.50	6.50	h							3	h	
MQ 007	BACKHOE 85/100 HP	0.02	200.00	h							0.12	h	
MQ 009	BUCKET 10 m^3	0.01	200.00	h							0.06	h	
EXC 006	LEVEL AND COMPACT EXISTING GROUND	-	16.35	m^3	3	m	2	m	1	m	6	m^3	98.10
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							12.6	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							0.9	h	
EXC 003	FILL & COMPACT WITH PLATE	-	15.78	m^3	3	m	2	m	1	m	6	m^3	94.65
AL 355	HELPER	1.85	6.50	h							11.1		
HO 902	PLATE COMPACTOR	0.15	25.00	h							0.9		
	PUMP/ HYDRAULICS	*TOTAL*	11791.70										
PA 011	MANUAL EXCAVATION	-	11.05	m^3	5	m	3	-	1.7	-	25.50	m^3	281.78
AL 355	HELPER	1.70	6.50	h							43.35	h	
DRE 004	EXCAVATION WITH MACHINERY	-	14.40	m^3	5	m	3	m	1.7	m	25.5	m^3	367.20
AL 361	BACKHOE OPERATOR	0.32	6.00	h							8.16	h	
AL 362	HELPER	0.32	6.50	h							8.16	h	
MQ 007	BACKHOE 85/100 HP	0.04	200.00	h							1.02	h	
MQ 008	WATER SPRAYER OF 4"	0.12	20.00	h							3.06	h	
Gould	PUMP (ESTIMATION)		250.00	PZA							2	PZA	500.00
	PLACE FILTERS (ESTIMATION)		1.00	GBL							1	GBL	1.00
Zabel	FILTERS		2646.00	PZA							4	PZA	10584.00
AL 355	HELPER	3.00	6.50	h							3	h	19.50
	ELECTRIC WIRING		320.00	GBL							1	GBL	320.00
	CONNECTION TO MAIN SERVICE BOX		300.00	GBL							1	GBL	
	WIRE TO ELECTRIC BOX		10.00	m							10	m	
AL 370	ELECTRITIAN		10.00	h							10	h	
	REPLANTING	*TOTAL*	3032.40										
OT 014	BLACK DIRT	-	30.00	m^3	28	m	28	m	0.1	m	78.4	m^3	2352.00
	FERTILIZER		1.68	m^2		m		m	-	m	90	m^2	151.20
	SEED		0.86	m^2		m		m	-	m	350	m^2	302.40
	MULCH		1.13	m^2		m		m	-	m	200	m^2	226.80
AL 355	HELPER	1.00	6.50	h							10	h	65.00
	MAINTENANCE	*TOTAL*	2805.85										
SAN115	CLEAR CLOGGING IN SANITARY PIPE		36.85	PZA							1	PZA	36.85
PL010	PLUMBER	2.5	8.50	h									
AL355	HELPER	2.4	6.50	h									
	CLEAN and/or REPLACE FILTERS											h	17
PL010	PLUMBER		8.50	h							2	h	
	SEPTIC TANK PUMPING (3X / year)		2752.00	GBL							1	GBL	2752.00

BOTH SYSTEMS	Bolivianos	TOTAL:	$ 198,425.76
	Dollars		$ 26,246.79
	TOTAL w Manual Excavation		$ 195,574.45
	Dollars		$ 25,869.64

ID	ACTIVITY	RATIO	COST	UNIT	QUANTITY								TOTAL COST
					LENGTH	Unit	WIDTH	Unit	DEPTH	Unit	TOTAL	Unit	
GRAVITY DRAINFIELD													
	MOBILIZATION/SITE LAYOUT	TOTAL	**3936.48**										
DRE 001	MOBILIZATION - SEPTIC	-	3402.70	GL.	-	-	-	-	-	-	1	GL.	3402.70
INS 001	MOBILIZATION	1.00	3150.00	GL.							1	GL.	
AL 350	BRICK LAYER	11.00	8.20	h							11	h	
AL 355	HELPER	25.00	6.50	h							25	h	
DRE 002	SITE LAYOUT (SEWERS, CANALS, BRIDGES)		10.68	m	50	m	-	-	-	-	50	m	533.78
MA 019	WOOD STAKES 2"X2"X30cm	1.00	3.00	PZA							50	PZA	
PT 002	PAINTING LATEX	0.01	72.00	gal							0.5	GAL	
HI 001	INDENTED IRON	0.01	11.55	kg							0.5	kg	
AL 365	TOPOGRAPHER	0.20	12.00	h							10	h	
AL 366	PAINTER	0.20	8.20	h							10	h	
MQ 022	TOPOGRAPHIC TEAM	0.07	40.00	h							3.5	h	
	EXCAVATION OF EXISTING SYSTEM	TOTAL	**2250.67**										
PA 011	MANUAL EXCAVATION	-	11.05	m^3	3.5	m	1.7	-	1.3	-	7.74	m^3	85.47
AL 355	HELPER	1.70	6.50	h							13.15	h	
DRE 004	EXCAVATION WITH MACHINERY	-	14.40	m^3	3.5	m	1.7	m	1.3	m	7.735	m^3	111.38
AL 361	BACKHOE OPERATOR	0.32	6.00	h							2.4752	h	
AL 362	ASSISTANT	0.32	6.50	h							2.4752	h	
MQ 007	BACKHOE 85/100 HP	0.04	200.00	h							0.3094	h	
MQ 008	WATER SPRAYER OF 4"	0.12	20.00	h							0.9282	h	
EXC 002	EARTHWORK (REMOVE EXISTING TANK)	-	9.25	m^3	3.5	m	1.7	m	1.3	m	7.735	m^3	71.55
AL 355	ASSISTANT	0.50	6.50	h							3.87	h	
MQ 007	BACKHOE 85/100 HP	0.02	200.00	h							0.15	h	
MQ 009	BUCKET 10 m^3	0.01	200.00	h							0.08	h	
EXC 006	LEVEL AND COMPACT EXISTING GROUND	-	16.35	m^3	3.5	m	1.7	m	1.3	m	126.47	m^3	2067.74
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							265.58	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							18.97	h	
	INSPECTION TANK INSTALLATION	*TOTAL*	1198.84										
EXC 002	EARTHWORK	-	9.25	m^3	1	m	1	m	1	m	1	m^3	9.25
AL 355	ASSISTANT	0.50	6.50	h							0.5	h	
MQ 007	BACKHOE 85/100 HP	0.02	200.00	h							0.02	h	
MQ 009	BUCKET 10 m^3	0.01	200.00	h							0.01	h	
EXC 006	LEVEL AND COMPACT EXISTING GROUND	-	16.35	m^3	1	m	1	m	1	m	1	m^3	16.35
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							2.1	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							0.15	h	
SAN030	CLEAN INSPECTION TANK AND PIPES		287	GBL							1	GBL	287
AL350	BRICK LAYER	35	8.20	h									
SAN089	INSPECTION TANK (.60x.60 m)		367.27	PZA							2	PZA	734.537
AG001	SAND SELECTION	0.18	60.00	m^3							0.36	m^3	
AG002	CLEAR DEBRIS	0.1	140.00	m^3							0.2	m^3	
AG901	CEMENT	75	0.94	kg							150	kg	
MU001	BRICK CURING	130	0.57	PZA							260	PZA	
HI002	INDENTED IRON	8	11.55	kg							16	kg	
HI003	MOORING WIRE	0.2	12.73	kg							0.4	kg	
AG004	STONE	0.15	155.00	m^3							0.3	m^3	
AL350	BRICKLAYER	7	8.20	h							14	h	
AL355	HELPER	7	6.50	h							14	h	
SAN082	CONSTRUCTION OF TANK LID		75.85	PZA							2	PZA	151.7
AG001	SAND SELECTION	0.05	60.00	m^3							0.1	m^3	
AG002	CLEAR DEBRIS	0.08	140.00	m^3							0.16	m^3	
AG901	CEMENT	12	0.94	kg							24	kg	
MU001	BRICK CURING	4	0.57	PZA							8	PZA	
HI002	INDENTED IRON	2	11.55	kg							4	kg	
AL 350	BRICKLAYER	1.7	8.20	h							3.4	h	
AL 355	HELPER	1.7	6.50	h							3.4	h	
	SEPTIC TANK INSTALLATION	*TOTAL*	30399.93										
PA 011	MANUAL EXCAVATION	-	11.05	m^3	6.5	m	2.5	m	2	m	65	m^3	718.25
AL 355	HELPER	1.70	6.50	h							110.50	h	
	REMOVE OLD PIPING		19.50	GBL							1	GBL	19.50
AL 355	HELPER	3	6.50	h							6	h	
EXC 006	LEVEL AND COMPACT EXISTING GROUND	-	16.35	m^3	6.5	m	2.5	m	2	m	65	m^3	1062.75
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							29431669.54	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							2102262.11	h	
SAN096	SEPTIC TANK (1.5x1.5x3.0m)		5255.00	PZA	6	m	2	m	1.5	m	28030.16	PZA	28030.16
AG901	CEMENT	500	8	kg							14015080.7	kg	
AG001	SAND	1.6	60	m^3							44848.3	m^3	
AG002	CLEAR DEBRIS	1.6	140	m^3							44848.3	m^3	
HI001	NAIL	3.2	12.72	kg							89696.5	kg	
HI003	MOORING WIRE	1.28	12.73	kg							35878.6	kg	
HI002	INDENTED IRON	40	11.55	kg							1121206.5	kg	
AL350	BRICKLAYER	20	2	m^2							560603.2	m^2	
AL355	HELPER	20	6.5	h							560603.2	h	
HO901	MIXER OF 500 Lts	6	25	h							168181.0	h	
VI001	VIBRATOR .75"	4.8	20	h							134544.8	h	
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							58863.3	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							4204.5	h	
SAN082	CONSTRUCTION OF TANK LID		75.85	PZA							3	PZA	227.55
AG001	SAND SELECTION	0.05	60.00	m^3							0.1	m^3	
AG002	CLEAR DEBRIS	0.08	140.00	m^3							0.16	m^3	
AG901	CEMENT	12	0.94	kg							24	kg	
MU001	BRICK CURING	4	0.57	PZA							8	PZA	
HI002	INDENTED IRON	2	11.55	kg							4	kg	
AL 350	BRICKLAYER	1.7	8.20	h							3.4	h	
AL 355	HELPER	1.7	6.50	h							3.4	h	
AIS001	WATERPROOFING FOR BRICK WALLS		11.99	m							28.5	m	341.715
AI006	POLYETHYLENE 200µ	0.3	3	m^2							8.55	m^2	
AG001	SAND	0.009	60	m^3							0.2565	m^3	
AG901	CEMENT	1	8	kg							28.5	kg	

GRAVITY DRAINFIELD

ID	ACTIVITY	RATIO	COST	UNIT	QUANTITY								TOTAL COST
					LENGTH	Unit	WIDTH	Unit	DEPTH	Unit	TOTAL	Unit	
AI001	TAR	0.3	8.5	kg							8.55	kg	
	DISTRIBUTION TANK	*TOTAL*	77884.81										
PA 011	MANUAL EXCAVATION	-	11.05	m^3	-	m	-	-	-	-	40.00	m^3	442.00
AL 355	HELPER	1.70	6.50	h							68.00	h	
DRE 004	EXCAVATION WITH MACHINERY	-	14.40	m^3	-	m	-	m	-	m	40.00	m^3	576.00
AL 361	BACKHOE OPERATOR	0.32	6.00	h							12.8	h	
AL 362	ASSISTANT	0.32	6.50	h							12.8	h	
MQ 007	BACKHOE 85/100 HP	0.04	200.00	h							1.6	h	
MQ 008	WATER SPRAYER OF 4"	0.12	20.00	h							4.8	h	
SAN 012	UNDERGROUND TANK CONSTRUCTION (.5X.5X.6m) (.15m^3)	233	323.17	PZA	-	m	-	m	-	-	1	PZA	75302.16
AG 001	SAND	0.1	60.00	h							920	h	
AG 002	CLEAR DEBRIS	0.1	140.00	h							0.28	h	
AG 901	CEMENT	65.0	0.94	kg							260	kg	
MU 001	BRICK CURING	150.0	0.57	PZA							600	PZA	
HI 002	INDENTED IRON	6.0	11.55	kg							24	kg	
HI 003	MOORING WIRE	0.1	12.73	kg							0.4	kg	
AG 004	STONE	0.1	155.00	m^3							0.4	m^3	
AL 350	BRICKLAYER	5.0	8.20	h							20	h	
AL 355	HELPER	5.0	6.50	h							20	h	
RSMEANS	WATERPROOF COATING		0.15	m							19	m	2.85
	CONNECTING PIPES (SEPTIC TO DOSE)												
SAN 001	PROVIDE AND PLACE SANITARY PIPE (4")	-	35.30	m		m	-	-	-	-	6	m	886.80
HS 058	4 IN SANITARY PIPE	1.050	22.00	m							420	m	
HS 061	GLUE FOR PVC	0.04	80.00	kg							16	kg	
PL 010	PLUMBER	0.60	8.50	h							240	h	
AL 355	HELPER	0.60	6.50	h							240	h	
HS012	PIPE ELBOW 45Deg, 4" PVC	0.25	2.3	PZA							4	PZA	9.20
RSMEANS	3" PVC, PUMP TO VALVE	1.0	1.23	m							2	m	2.46
	FLOAT SYSTEM	1.0	30.00	PZA							2	PZA	60.00
	"T" FITTINGS, 4" PVC	1.0	5.00	PZA							4	PZA	20.00
SAN082	CONSTRUCTION OF TANK LID		75.85	PZA							2	PZA	151.7
AG001	SAND SELECTION	0.05	60.00	m^3							0.1	m^3	
AG002	CLEAR DEBRIS	0.08	140.00	m^3							0.16	m^3	
AG901	CEMENT	12	0.94	kg							24	kg	
MU001	BRICK CURING	4	0.57	PZA							8	PZA	
HI002	INDENTED IRON	2	11.55	kg							4	kg	
AL 350	BRICKLAYER	1.7	8.20	h							3.4	h	
AL 355	HELPER	1.7	6.50	h							3.4	h	
AIS001	WATERPROOFING FOR BRICK WALLS		11.99	m							36	m	431.64
AI006	POLYETHYLENE 200μ	0.3	3	m^2							8.55	m^2	
AG001	SAND	0.009	60	m^3							0.2565	m^3	
AG901	CEMENT	1	8	kg							28.5	kg	
AI001	TAR	0.3	8.5	kg							8.55	kg	
	DRAINAGE FIELD INSTALLATION	*TOTAL*	65543.25										
PA 011	MANUAL EXCAVATION	-	11.05	m^3	-	m	-	-	0.56	-	822.00	m^3	9083.10
AL 355	HELPER	1.70	6.50	h							1397.40	h	
DRE 004	EXCAVATION WITH MACHINERY	-	14.40	m^3	-	m	-	m	-	m	822	m^3	11836.80
AL 361	BACKHOE OPERATOR	0.32	6.00	h							263.04	h	
AL 362	ASSISTANT	0.32	6.50	h							263.04	h	
MQ 007	BACKHOE 85/100 HP	0.04	200.00	h							32.88	h	
MQ 008	WATER SPRAYER OF 4"	0.12	20.00	h							98.64	h	
EXC 006	LEVEL AND COMPACT EXISTING GROUND	-	16.35	m^2	-	m	-	m	-	m	450	m^2	7357.50
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							945	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							67.5	h	
TRA036	FILTER MATERIAL (STONE AND GRAVEL)		24.1	m^3							25	m^3	602.5
AG005	MATERIAL FILTRANTE	1	11.1	m^3							12	m^3	
AL355	HELPER	2	6.50	h							50	h	
EXC009	GRAVEL FILL	-	23.00	m^3	-	m	-	-	-	-	822	m^3	18906.00
AG 017	GRAVEL SELECTION	0.30	30.00	m^3							0.0	m^3	
AG 018	SAND SELECTION	0.20	70.00	m^3							0.0	m^3	
AL 350	BRICKLAYER	1.00	8.20	h							0.0	h	
AL 355	HELPER	3.00	6.50	h							0.0	h	
SAN113	VENTILATION PIPE		47.807	PZA							1	PZA	47.81
HS140	2" PVC VENTILATION TUBE	6	7	m							0	m	
HS012	ELBOW	0.25	2.3	PZA							0	PZA	
HS061	GLUE FOR PVC	0.05	80.00	kg							0	kg	
AG901	CEMENT	0.8	0.94	kg							0	kg	
AG001	SAND	0.008	60.00	h							0	h	
SAN 001	PROVIDE AND PLACE SANITARY PIPE (3")	-	35.30	m		m	-	-	-	-	400	m	14120.00
HS 058	4 IN SANITARY PIPE	1.05	22.00	m							0	m	
HS 061	GLUE FOR PVC	0.04	80.00	kg							0	kg	
PL 010	PLUMBER	0.60	8.50	h							0	h	
AL 355	HELPER	0.60	6.50	h							0	h	
SAN 002	PROVIDE AND PLACE SANITARY PIPE (1.5")	-	36.75	m		m	-	-	-	-	70	m	2572.50
HS 056	2 IN SANITARY PIPE	1.05	22.00	m							0	m	
HS 061	GLUE FOR PVC	0.03	80.00	kg							0	kg	
HS 062	CLEANER FOR PVC	0.03	45.00	LT							0	LT	
PL 010	PLUMBER	0.75	8.50	h							0	h	
AL 355	HELPER	0.75	6.50	h							0	h	
	GEOTEXTILE PLASTIC LINING	-	8.32	m^2	-	m	-	m	-	-	122.30	m^2	1017.05
	ROAD REPAIR	*TOTAL*	248.25										
EXC 002	EARTHWORK	-	9.25	m^3	3	m	2	m	1	m	6	m^3	55.50
AL 355	ASSISTANT	0.50	6.50	h							3	h	
MQ 007	BACKHOE 85/100 HP	0.02	200.00	h							0.12	h	
MQ 009	BUCKET 10 m^3	0.01	200.00	h							0.06	h	
EXC 006	LEVEL AND COMPACT EXISTING GROUND	-	16.35	m^3	3	m	2	m	1	m	6	m^3	98.10
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							12.6	h	

GRAVITY DRAINFIELD

ID	ACTIVITY	RATIO	COST	UNIT	QUANTITY								TOTAL COST
					LENGTH	*Unit*	*WIDTH*	*Unit*	*DEPTH*	*Unit*	**TOTAL**	**Unit**	
HO 902	PLATE COMPACTOR	0.15	25.00	h							0.9	h	
EXC 003	FILL & COMPACT WITH PLATE	-	15.78	m^3	3	m	2	m	1	m	6	m^3	94.65
AL 355	ASSISTANT	1.85	6.50	h							11.1		
HO 902	PLATE COMPACTOR	0.15	25.00	h							0.9		
	REPLANTING	*TOTAL*	3032.40										
OT 014	BLACK DIRT	-	30.00	m^3	28	m	28	m	0.1	m	78.4	m^3	2352.00
	FERTILIZER		1.68	m^2		m		m	-	m	90	m^2	151.20
	SEED		0.86	m^2		m		m	-	m	350	m^2	302.40
	MULCH		1.13	m^2		m		m	-	m	200	m^2	226.80
	MAINTENANCE	*TOTAL*	2805.85										
SAN115	CLEAR CLOGGING IN SANITARY PIPE		36.85	PZA							1	PZA	36.85
PL010	PLUMBER	2.5	8.50	h									
AL355	HELPER	2.4	6.50	h									
	CLEAN and/or REPLACE FILTERS											h	17
PL010	PLUMBER		8.50	h							2	h	
	SEPTIC TANK PUMPING (3X / year)		2752.00	GBL							1	GBL	2752.00

BOTH SYSTEMS Bolivianos TOTAL $ 187,385.95
Dollars $ 24,786.50

TOTAL w Manual Excavation $ 174,861.76
Dollars $ 23,129.86

RECIRCULATING SAND FILTER

ID	ACTIVITY	RATIO	COST	UNIT	QUANTITY								TOTAL COST
					LENGTH	*Unit*	*WIDTH*	*Unit*	*DEPTH*	*Unit*	TOTAL	Unit	
	MOBILIZATION/SITE LAYOUT	TOTAL	**1802.00**										
DRE 001	MOBILIZATION - SEPTIC	-	3402.70	GL.	-	-	-	-	-	-	1	GL.	3402.70
INS 001	MOBILIZATION	1.00	3150.00	GL.							1	GL.	
AL 350	BRICK LAYER	11.00	8.20	h							1	h	
AL 355	ASSISTANT	25.00	6.50	h							1	h	
DRE 002	SITE LAYOUT (SEWERS, CANALS, BRIDGES)		10.68	m	1200	m	-	-	-	-	1200	m	12810.60
MA 019	WOOD STAKES 2"X2"X30cm	1.00	3.00	PZA							10	PZA	
PT 002	PAINTING LATEX	0.01	72.00	gal							12	GAL	
HI 001	INDENTED IRON	0.01	11.55	kg							12	kg	
AL 365	TOPOGRAPHER	0.20	12.00	h							240	h	
AL 366	PAINTER	0.20	8.20	h							240	h	
MQ 022	TOPOGRAPHIC TEAM	0.07	40.00	h							84	h	
	EXCAVATION OF EXISTING SYSTEM	*TOTAL*	2250.67										
PA 011	MANUAL EXCAVATION	-	11.05	m^3	3.5	m	1.7	-	1.3	-	7.74	m^3	85.47
AL 355	HELPER	1.70	6.50	h							13.15	h	
DRE 004	EXCAVATION WITH MACHINERY	-	14.40	m^3	3.5	m	1.7	m	1.3	m	7.735	m^3	111.38
AL 361	BACKHOE OPERATOR	0.32	6.00	h							2.4752	h	
AL 362	ASSISTANT	0.32	6.50	h							2.4752	h	
MQ 007	BACKHOE 85/100 HP	0.04	200.00	h							0.3094	h	
MQ 008	WATER SPRAYER OF 4"	0.12	20.00	h							0.9282	h	
EXC 002	EARTHWORK (REMOVE EXISTING TANK)	-	9.25	m^3	3.5	m	1.7	m	1.3	m	7.74	m^3	71.55
AL 355	ASSISTANT	0.50	6.50	h							3.87	h	
MQ 007	BACKHOE 85/100 HP	0.02	200.00	h							0.15	h	
MQ 009	BUCKET 10 m^3	0.01	200.00	h							0.08	h	
EXC 006	LEVEL AND COMPACT EXISTING GROUND	-	16.35	m^3	3.5	m	1.7	m	1.3	m	126.47	m^3	2067.74
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							265.58	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							18.97	h	
	INSPECTION TANK	TOTAL	20.16										
DRE 004	EXCAVATION WITH MACHINERY	-	12.00	m^3	3	m	2	m	2	m	12	m^3	144.00
AL 361	BACKHOE OPERATOR	0.32	6.00	h							3.84	h	
AL 362	ASSISTANT	0.32	6.50	h							3.84	h	
MQ 007	BACKHOE 85/100 HP	0.04	200.00	h							0.48	h	
SAN030	CLEAN INSPECTION TANK AND PIPES		287	GBL							1	GBL	287
AL350	BRICK LAYER	35	8.20	h									
SAN082	CONSTRUCTION OF TANK LID		75.85	PZA							2	PZA	151.7
AG001	SAND SELECTION	0.05	60.00	m^3							1.16025	m^3	
AG002	CLEAR DEBRIS	0.08	140.00	m^3							1.8564	m^3	
AG901	CEMENT	12	0.94	kg							278.46	kg	
MU001	BRICK CURING	4	0.57	PZA							92.82	PZA	
HI002	INDENTED IRON	2	11.55	kg							46.41	kg	
AL 350	BRICKLAYER	1.7	8.20	h							39.4485	h	
AL 355	HELPER	1.7	6.50	h							39.4485	h	
	SEPTIC TANK	TOTAL	21196826.50										
PA 011	MANUAL EXCAVATION	-	11.05	m^3	3.5	m	1.7	-	1.3	-	23.21	m^3	256.42
AL 355	HELPER	1.70	6.50	h							39.45	h	
	REMOVE OLD PIPING		19.50	GBL							1	GBL	19.50
AL 355	HELPER	3	6.50	h							3.00	h	
EXC 006	LEVEL AND COMPACT EXISTING GROUND	-	16.35	m^3	3.5	m	1.7	m	1.3	m	23.205	m^3	379.40
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							48.7305	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							3.48075	h	
SAN096	SEPTIC TANK (1.5x1.5x3.0m) (6.75 m^3)	-	5255.00	PZA	6	m	2	m	1.5	m	42040.51	PZA	42040.5
AG901	CEMENT	500	8	kg							21020256.35	kg	
AG001	SAND	1.6	60	m^3							67264.82	m^3	
AG002	CLEAR DEBRIS	1.6	140	m^3							67264.82	m^3	
HI001	NAIL	3.2	12.72	kg							134529.64	kg	
HI003	MOORING WIRE	1.28	12.73	kg							53811.86	kg	
HI002	INDENTED IRON	40	11.55	kg							1681620.51	kg	
AL350	BRICKLAYER	20	2	m^2							840810.25	m^2	
AL355	HELPER	20	6.5	h							840810.25	h	
HO901	MIXER OF 500 Lts	6	25	h							252243.08	h	
VI001	VIBRATOR .75"	4.8	20	h							201794.46	h	
SAN082	CONSTRUCTION OF TANK LID		75.85	PZA							3	PZA	227.55
AG001	SAND SELECTION	0.05	60.00	m^3							1.16025	m^3	
AG002	CLEAR DEBRIS	0.08	140.00	m^3							1.8564	m^3	
AG901	CEMENT	12	0.94	kg							278.46	kg	
MU001	BRICK CURING	4	0.57	PZA							92.82	PZA	
HI002	INDENTED IRON	2	11.55	kg							46.41	kg	
AL 350	BRICKLAYER	1.7	8.20	h							39.4485	h	
AL 355	HELPER	1.7	6.50	h							39.4485	h	
AIS001	WATERPROOFING FOR BRICK WALLS		11.99	m							54	m	647.46
AI006	POLYETHYLENE 200µ	0.3	3	m^2							42	m^2	
AG001	SAND	0.009	60	m^3							1.26	m^3	
AG901	CEMENT	1	8	kg							140	kg	
AI001	TAR	0.3	8.5	kg							42	kg	
	SAND FILTER	TOTAL	326740.00										
PA 011	MANUAL EXCAVATION	-	11.05	m^3	-	m	-	m	-	m	42.00	m^3	464.10
AL 355	HELPER	1.70	6.50	h							71.40	h	
SAN 012	UNDERGROUND TANK CONSTRUCTION (.5X.5X.6m) (.15m^3)	280	323.17	PZA	-	m	-	m	-	m	1400	PZA	452442.20
AG 001	SAND	0.1	60.00	m^3							168	m^3	
AG 002	CLEAR DEBRIS	0.1	140.00	m^3							98	m^3	
AG 901	CEMENT	65.0	0.94	kg							91000	kg	
MU 001	BRICK CURING	150.0	0.57	PZA							210000	PZA	
HI 002	INDENTED IRON	6.0	11.55	kg							8400	kg	
HI 003	MOORING WIRE	0.1	12.73	kg							140	kg	
AG 004	STONE	0.1	155.00	m^3							140	m^3	
AL 350	BRICKLAYER	5.0	8.20	h							7000	h	
AL 355	HELPER	5.0	6.50	h							7000	h	
EXC009	GRAVEL FILL (for ABSORPTION WELL)	-	173.20	m^3	-	m	-	m	-	m	695.00	m^3	120374.00

ID	ACTIVITY	RATIO	COST	UNIT	QUANTITY								TOTAL COST
					LENGTH	*Unit*	*WIDTH*	*Unit*	*DEPTH*	*Unit*	TOTAL	Unit	
RECIRCULATING SAND FILTER													
AG 016	GRAVEL SELECTION (Stone Agregate, ASTM standard C33, Si	0.700	175.00	m^3							45.0	m^3	
AG 017	GRAVEL SELECTION (PEA GRAVEL, ASTM standard C33, Size	0.30	30.00	m^3							11.0	m^3	
AG 018	SAND SELECTION (1.5-2.5 mm)	0.20	70.00	m^3							83.0	m^3	
AL 350	BRICKLAYER	1.00	8.20	h							10.0	h	
AL 355	HELPER	3.00	6.50	h							10.0	h	
	SAND FILTER LINER	1.00	0.00	m^2							270	m^2	0.00
	PLYWOOD FOR TANK WALLS	1.00	0.00	m^2							270	m^2	
EXC 006	LEVEL AND COMPACT EXISTING GROUND	-	16.35	m^2	-	m	-	m	-	m	210	m^2	3433.50
AL 360	COMPACTOR OPERATOR	2.10	6.00	h							441	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							31.5	h	
	RECIRCULATING TANK	TOTAL	335172.00										
DRE 004	EXCAVATION WITH MACHINERY	-	14.40	m^3	50	m	11.8	m	2	m	1180	m^3	16992.00
AL 361	BACKHOE OPERATOR	0.32	6.00	h							377.6	h	
AL 362	ASSISTANT	0.32	6.50	h							377.6	h	
MQ 007	BACKHOE 85/100 HP	0.04	200.00	h							47.2	h	
MQ 008	WATER SPRAYER OF 4"	0.12	20.00	h							141.6	h	
SAN 012	UNDERGROUND TANK CONSTRUCTION (.5X.5X.6m) (.15m^3)	-	323.17	PZA	-	m	-	m	30 m^3	-	1150	PZA	371648.95
AG 001	SAND	0.1	60.00	h							920	h	
AG 002	CLEAR DEBRIS	0.1	140.00	h							98	h	
AG 901	CEMENT	65.0	0.94	kg							91000	kg	
MU 001	BRICK CURING	150.0	0.57	PZA							210000	PZA	
HI 002	INDENTED IRON	6.0	11.55	kg							8400	kg	
HI 003	MOORING WIRE	0.1	12.73	kg							140	kg	
AG 004	STONE	0.1	155.00	m^3							140	m^3	
AL 350	BRICKLAYER	5.0	8.20	h							7000	h	
AL 355	HELPER	5.0	6.50	h							7000	h	
SAN 042	ACCESSERIES FOR TANK INSTALLATION	-	590.00	GBL	-	m	-	-	-	-	100	m	59000.00
HS 101	HYDRAULIC ACCESSORIES	1.000	500.00	GBL							120	GBL	
PL 010	PLUMBER	6.00	8.50	h							720	h	
AL 355	HELPER	6.00	6.50	h							720	h	
EXC 003	FILL & COMPACT WITH PLATE	-	15.78	m^3	50	m	2	m	0.5	m	50	m^3	788.75
AL 355	HELPER	1.85	6.50	h							92.5	h	
HO 902	PLATE COMPACTOR	0.15	25.00	h							7.5	h	
HOR 045	REINFORCED CONCRETE SLAB LID	-	1751.45	m^3	25	m	2	m	0.2	m	10	m^3	70058.00
AG 901	CEMENT	350.00	0.94	kg							3500	kg	
AG 001	RIVER SAND	0.65	60.00	m^3							6.5	m^3	
AG 002	WASHED DEBRIS	0.85	140.00	m^3							8.5	m^3	
HI 002	INDENTED IRON	50.00	11.55	kg							500	kg	
MA 001	BOARD OF WOOD	60.00	2.80	ft^2							600	ft^2	
HI 001	NAIL	1.00	12.72	kg							10	kg	
HI 003	MOORING WIRE	1.00	12.73	kg							10	kg	
AL 350	LABORER	39.00	6.50	h							390	h	
AL 355	ASSISTANT	35.00	6.50	h							350	h	
HO 901	MIXER OF 350 LTS	0.50	25.00	h							5	h	
SAN 002	PROVIDE AND PLACE SANITARY PIPE (2")	-	36.75	m	-	m	-	m	-	m	10	m	441.00
HS 056	2 IN SANITARY PIPE	1.050	22.00	m							10.5	m	
HS 061	GLUE FOR PVC	0.03	80.00	kg							0.3	kg	
HS 062	CLEANER FOR PVC	0.03	45.00	LT							0.3	LT	
PL 010	PLUMBER	0.75	8.50	h							7.5	h	
AL 355	HELPER	0.75	6.50	h							7.5	h	
SAN 001	PROVIDE AND PLACE SANITARY PIPE (4")	-	35.30	m		m	-	m	-	m	174.5	m	6159.85
HS 058	4 IN SANITARY PIPE	1.050	22.00	m							183.225	m	
HS 061	GLUE FOR PVC	0.04	80.00	kg							6.98	kg	
PL 010	PLUMBER	0.60	8.50	h							104.7	h	
AL 355	HELPER	0.60	6.50	h							104.7	h	
Gould	PUMP (ESTIMATION)		250.00	PZA							3	PZA	750.00
Zabel	FILTERS (ESTIMATION)		2646.00	PZA							2	PZA	5292.00
	UNDERGROUND CONNECTION TO ANTIGUO CANAL	TOTAL	4603.10										
DRE 004	EXCAVATION WITH MACHINERY	-	14.40	m^3	200	m	3	m	2	m	1200	m^3	17280.00
AL 361	BACKHOE OPERATOR	0.32	6.00	h							384	h	
AL 362	ASSISTANT	0.32	6.50	h							384	h	
MQ 007	BACKHOE 85/100 HP	0.04	200.00	h							48	h	
MQ 008	WATER SPRAYER OF 4"	0.12	20.00	h							144	h	
SAN104	CONNECTION WITH SEPTIC TANK/ OR RECIRC TANK		33.34	PZA							1	33.34	33.34
HI017	ABRASADERA DE FoGo a D=4"	1	7.84	PZA							1	PZA	
PL010	PLUMBER	3	8.5	h							3	h	
DRE 026	DELIVERY & PLACEMENT OF REINFORCED CONCRETE PIPE (1.2 m DIAMETER)	-	876.07	m	-	m	-	-	-	-	150	m	157692.60
AG 001	RIVER SAND	0.034	60.00	m^3							5.1	m^3	
AG 901	CEMENT	9.00	0.94	kg							1350	kg	
HS 145	RC PIPE (1.5 m ϕ)	1.02	796.00	m							153	m	
AL 350	LABORER	1.80	6.50	h							270	h	
AL 355	HELPER	3.30	6.50	h							495	h	
MQ 013	TELESCOPIC CRANE	0.10	205.00	h							15	h	
	ROAD REPAIR	*TOTAL*	1597877.46										
EXC 002	EARTHWORK	-	9.25	m^3	200	m	3	m	2	m	1200	m^3	11100.00
AL 355	(MP) ASSISTANT	0.50	6.50	h							600	h	
MQ 007	(T&E) BACKHOE 85/100 HP	0.02	200.00	h							24	h	
MQ 009	(T&E) BUCKET 10 m^3	0.01	200.00	h							12	h	
EXC 006	LEVEL AND COMPACT EXISTING GROUND	-	16.35	m^3	200	m	3	m	2	m	1200	m^3	19620.00
AL 360	(MP) COMPACTOR OPERATOR	2.10	6.00	h							2520	h	
HO 902	(T&E) PLATE COMPACTOR	0.15	25.00	h							180	h	
EXC 003	FILL & COMPACT WITH PLATE	-	15.78	m^3	200	m	3	m	2	m	1200	m^3	18930.00
AL 355	(MP) ASSISTANT	1.85	6.50	h							2220		
HO 902	(T&E) PLATE COMPACTOR	0.15	25.00	h							180		
	REPLANTING	*TOTAL*	2442.00										
OT 014	BLACK DIRT	-	30.00	m^3	28	m	28	m	0.1	m	78.4	m^3	2352.00
	FERTILIZER		20.00	m^2		m		m	-	m	90	m^2	20.00
	SEED		40.00	m^2		m		m	-	m	350	m^2	40.00

RECIRCULATING SAND FILTER

ID	ACTIVITY	RATIO	COST	UNIT	QUANTITY								TOTAL COST
					LENGTH	*Unit*	*WIDTH*	*Unit*	*DEPTH*	*Unit*	**TOTAL**	**Unit**	
	MULCH		30.00	m^2		m		m	-	m	200	m^2	30.00
	MAINTENANCE												
SAN030	CLEAN INSPECTION TANK AND PIPES		287	GBL							1	GBL	287
AL350	BRICK LAYER	35	8.20	h									
	CLEAN and/or REPLACE FILTERS											h	
PL010	PLUMBER		8.50	h							2	h	17
	SEWAGE PUMPING		2753.6	GBL							1	GBL	2753.6
	FENCING TO KEEP OUT CHILDREN		20	m							150	m	3000
											Bolivianos	TOTAL	$ 1,403,702.87
											Dollars		$ 185,674.98

Appendix C:

Water Testing and 3M Petrifilm Plate Procedures

	Sample ID	Time at incubation	Date of incubation	Test type	Vol. sample (ml)	Raw TC#	Raw FC #	CFU / 100ml
Espinal	Faucet Water 1	1530	19-May-08	H. Sens.	5	0	--	**0**
	Faucet Water 2	1530	19-May-08	CC	1	0	--	**0**
	Faucet Water 3	1530	19-May-08	CC	1	0	--	**0**
	Standing Water Schoolyard	1530	19-May-08	CC	1	TNC+	--	**TNC+**
	Standing Water from Bathroom	1530	19-May-08	CC	1	TNC+	--	**TNC+**
	Water table	1530	19-May-08	CC	1	89	--	**8,900**
	Soil depth 0 - 0.3m	1415	20-May-08	RCC	1	320	40	**32,000**
	Soil depth 0.7 - 1.15m	1415	20-May-08	RCC	1	7	0	**700**
	Soil depth 2.0 - 2.5m	1415	20-May-08	RCC	1	42	3.5	**4,200**

Note

+ TNC "Too Numerous to Count"

P-Front soil, P - Ground water, P - Back soil, and E- 2 -2.5 represent averages of two counts

H Sens = High sensitivity coliform count plate

CC = Coliform count plate

RCC = Rapid coliform count plate

3M Petrifilm™ Plates — Environmental Monitoring Procedures

3M™ Petrifilm plates are a convenient and reliable way to detect environmental microbial contamination. The construction of Petrifilm plates allows them to be used for direct contact or swab contact monitoring procedures, as well as air sampling procedures.

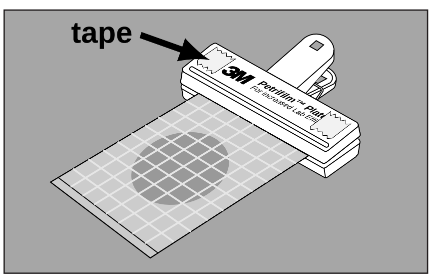
Hydration Procedures for Air or Direct Contact Methods

Petrifilm Plate	Procedure	Hydration*
Aerobic Count Coliform Count E. coli/Coliform Count Rapid Coliform Count Enterobacteriaceae Count	Air or Direct Contact Method	Hydrate plates with 1 mL of appropriate sterile diluent. Allow hydrated plates to remain closed for a minimum of 1 hour before use.
Staph Express Count	Air or Direct Contact Method	Hydrate plates with 1 mL of appropriate sterile diluent. Refrigerate hydrated plates for a minimum of 3 days before using.
Yeast and Mold Count Rapid S. aureus Count	Air Method Only	Hydrate plates with 1 mL of appropriate sterile diluent. Allow hydrated plates to remain closed for a minimum of 1 hour before use.
Yeast and Mold Count	Direct Contact Method Only	Hydrate yeast and mold plates with 1 mL of sterile **letheen broth only**. Place letheen inoculated plates into sealed bag and incubate at 30-37°C (86-99°F) for 24 hours. After incubation, store sealed bag of plates in refrigerator for a minimum of 4 hours to allow gel to solidify. Petrifilm plates hydrated with letheen will have a mottled appearance.

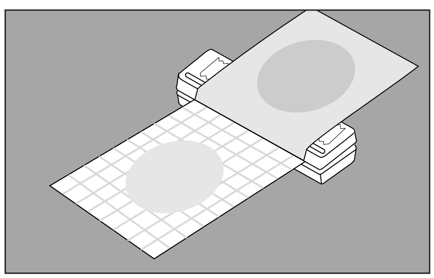
Hydrated Plates Storage Procedures: Store all hydrated Petrifilm plates in sealed pouch or plastic bag. Protect plates from light and refrigerate at 2-8°C (36-46°F). Hydrated Petrifilm Aerobic Count plates may be refrigerated up to 14 days, all other hydrated Petrifilm plates may be refrigerated up to 7 days.

**See relevant Petrifilm plate package insert for details and listing of appropriate diluents. If sanitizers are present, use letheen broth for both the direct contact and swab contact methods.*

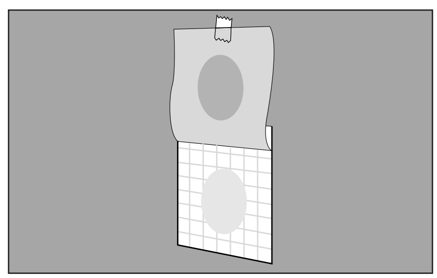
Air Sampling Method



1 Use a Petrifilm plate clip in combination with double-sided tape. Position hinged edge of hydrated Petrifilm plate into clip. Apply a small piece of double-sided tape to each end of the clip handle.

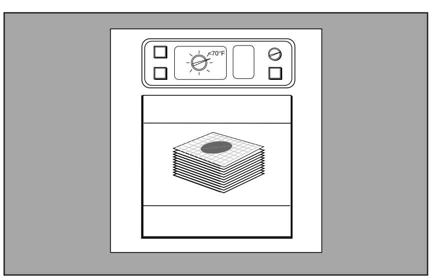


2 **Without touching circular growth area**, lift top film portion of hydrated plate and peel back until outer portion of film adheres to the tape. Make sure top film lies flat across clip.



3 Double-sided tape can also be used with or without clip for positioning of Petrifilm plates for air sampling.

Expose Petrifilm plate to air for no longer than 15 minutes. Remove tape and rejoin the top and bottom films.



4 Incubate and enumerate as directed in package inserts. Refer to 3M *Petrifilm Plate Interpretation Guide* when enumerating results.

Air Sampling Method Results

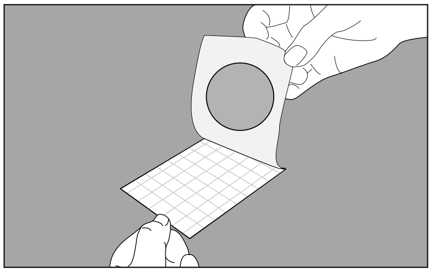
Petrifilm plate result is count/**40 cm^2** for:

- Aerobic Count
- Coliform Count
- E.coli/Coliform Count
- Rapid Coliform Count
- Enterobacteriaceae Count

Petrifilm plate result is count/**60 cm^2** for:

- Yeast & Mold Count
- Staph Express Count
- Rapid S. aureus Count

Direct Contact Method

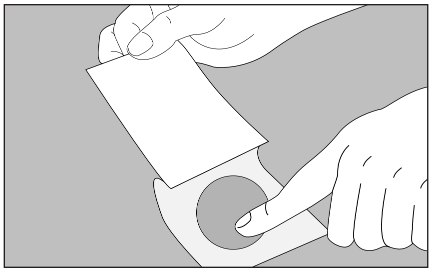


1 Using a hydrated Petrifilm plate, carefully lift top film. Avoid touching circular growth area. Gel will adhere to top film. Go to step 2a for the surface method or 2b for the finger method.

Petrifilm Yeast and Mold Count Plates

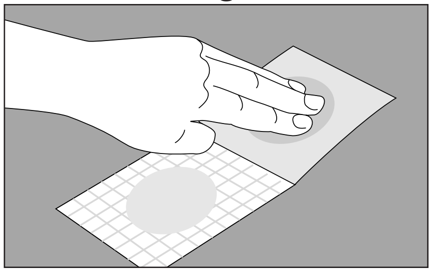
On occasion, the gel may split (adhering to both the top and bottom films) when the top film is lifted. If this happens, the plate with gel splitting may still be used for air testing, but is not recommended for direct contact use.

Surface



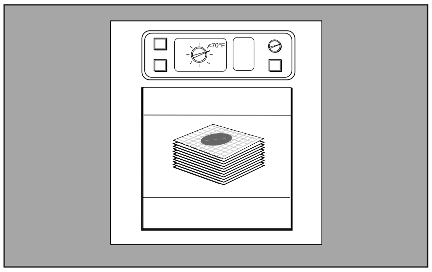
2a Allow the circular gel portion of the top film to contact the surface being tested. Gently rub fingers parallel to the surface over the outer film side of the gelled area to ensure good contact with surface. Rejoin the top and bottom films.

Finger



2b Touch finger or portion of hand to hydrated gel area. Rejoin the top and bottom films. Wash hands after finger or hand plating.

All Petrifilm plates except Yeast and Mold Count plates and the High-Sensitivity Coliform Count plates can be used for finger or hand plating. The Rapid S. aureus Count plates are not suitable for finger, hand or direct contact method plating.



3 Incubate and enumerate as directed in package inserts. Refer to 3M *Petrifilm Plate Interpretation Guide* when enumerating results.

Direct Contact Method Results

Petrifilm plate result is count/**20 cm^2** for:

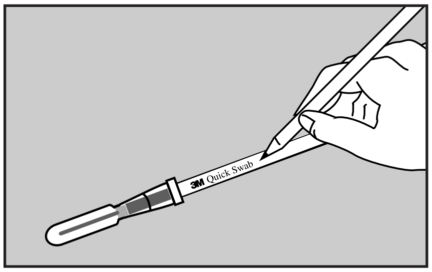
- Aerobic Count
- Coliform Count
- Enterobacteriaceae Count
- E.coli/Coliform Count
- Rapid Coliform Count

Petrifilm plate result is count/**30 cm^2** for:

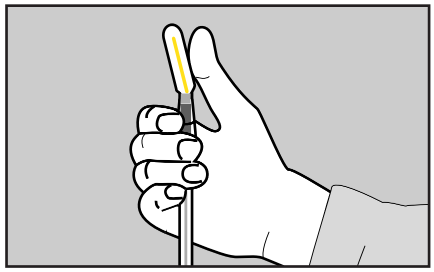
- Yeast & Mold Count
- Staph Express Count

Swab Method

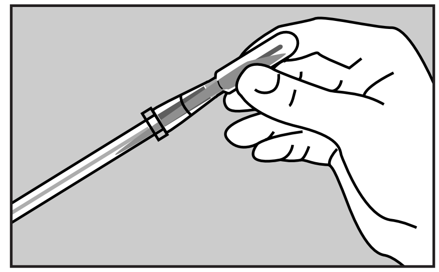
3M Quick Swab (wet swabbing method)*



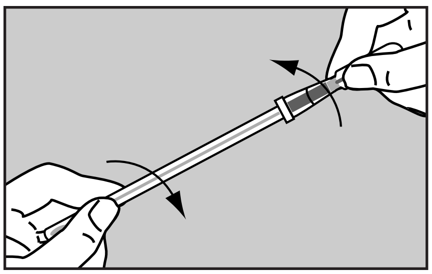
1 Remove the desired quantity of 3M Quick Swabs from the resealable plastic bag. Label the swab.



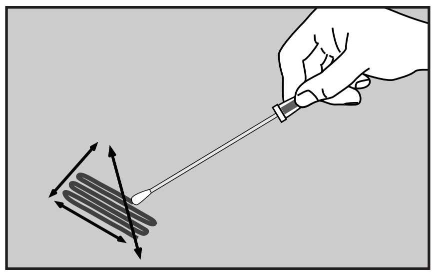
2 **At the sampling location**, prepare the swab by holding it with the bulb end near your thumb. Bend the red snap valve at a 45° angle until you hear the valve break. This allows the letheen broth to flow into the tube and wet the swab head.



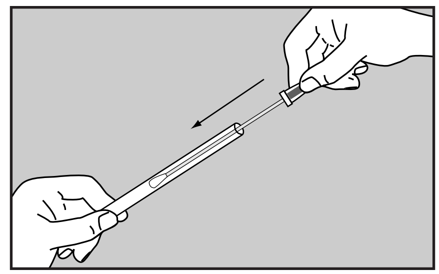
3 Squeeze the bulb of the swab to transfer all of the letheen broth to the tube end of the swab.



4 Twist and pull apart the bulb end of the swab from the tube end of the swab which contains the letheen broth.



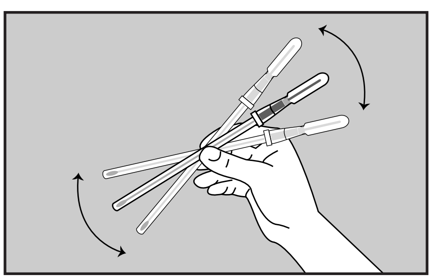
5 Hold the swab handle to make a 30° angle with the surface. Firmly rub the swab head slowly and thoroughly over the desired surface area. Rub the head of the swab three times over the surface, reversing direction between alternating strokes.



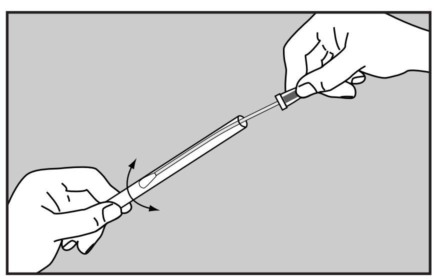
6 After sampling is complete, securely insert the swab head back into the swab tube and transport to the lab for plating. Plate the letheen broth swab solution as soon as possible.

Inoculation Procedures

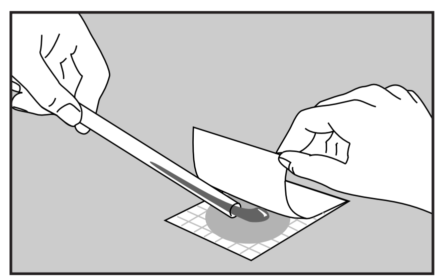
1 mL



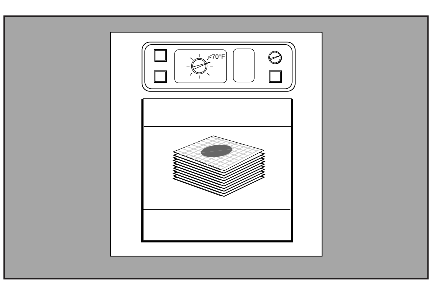
7 In the lab, vigorously shake or vortex the swab for 10 seconds, to release bacteria from the swab tip.



8 Wring out the contents of the swab tip by pressing and twisting the swab against the wall of the tube.



9 Carefully pour entire contents of the tube onto a 1mL 3M Petrifilm plate. Follow current industry standards for disposal.



10 Incubate and enumerate as directed in package inserts. Refer to 3M *Petrifilm Plate Interpretation Guide* when enumerating results.

Swab Contact Method Results

Petrifilm plate count x volume of diluent (1 mL) = total count/area sampled

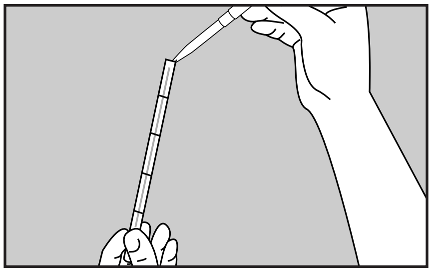
Example
If area tested was 5 cm^2 and number of colonies on plate after incubation was 100, your result would be: 100 CFU x 1 mL = 100 CFU/5 cm^2

* For 3M Quick Swab dry swabbing method, see Quick Swab package insert.

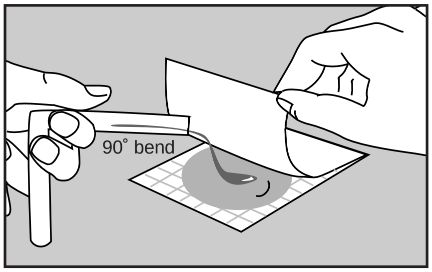
Inoculation Procedures *(continued)*

Multi-mL

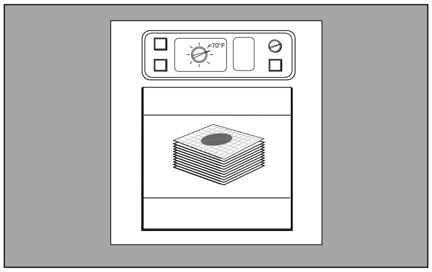
1 Complete steps 1-6 for the wet swabbing method from previous page.



2 Remove the swab from the tube. Add 1-3 mL's of sterile diluent to the swab tube. Replace the swab in the tube. Complete steps 7 & 8 of the 1 mL Inoculation Procedure from previous page.



3 Use your thumb to bend the swab tube at a 90˚ angle at the highest mark that has diluent above it. Pour off a 1 mL aliquot onto a Petrifilm plate. Repeat onto new plate until the entire sample is used.



4 Incubate and enumerate as directed in package inserts. Refer to *3M Petrifilm Plate Interpretation Guide* when reading results.

Quick Swab Multi-mL Method Results

Petrifilm plate count x volume of diluent (1 mL + added) = total count/area sampled

Example

If area tested was 5 cm^2, number of mLs added was 2 (for total of 3) and number of colonies after incubation was 100, your result would be: 100 CFU x 3 mL = 300 CFU/5 cm^2

Alternative Swab Method

Petrifilm plates can be used with other swabbing techniques, however the rinse solution used must be compatible with Petrifilm plates. (See Petrifilm plate package insert for listing of appropriate diluents).

Additional Information

3M Microbiology offers a full line of products to accomplish a variety of your microbial testing needs. For more product information, visit us at **www.3M.com/microbiology.**

- Questions? U.S., call **1-800-328-6553**.
  To order Petrifilm plates, call **1-800-328-1671.**
- Canada, call **1-800-563-2921** for technical service.
- Latin America / Africa and Asia Pacific regions, call **1-651-733-7562.**

For detailed WARNING, CAUTIONS, DISCLAIMER OF WARRANTIES / LIMITED REMEDY, LIMITATION OF 3M LIABILITY, STORAGE AND DISPOSAL information, and INSTRUCTIONS FOR USE see Product's package insert.

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Interpretation Guide

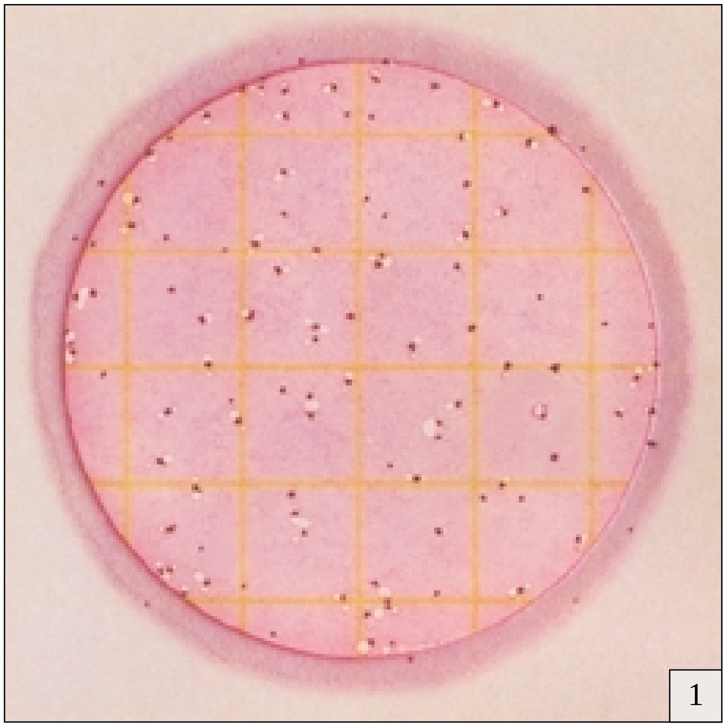
Petrifilm™

Coliform Count Plate

This guide familiarizes you with results on 3M™ Petrifilm™ Coliform Count plates. For more information, contact the official 3M Microbiology Products representative nearest you.

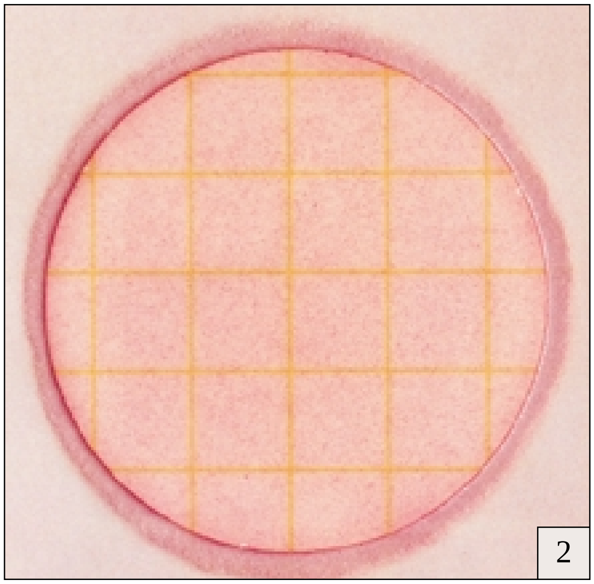
Petrifilm Coliform Count (CC) plates contain Violet Red Bile (VRB) nutrients, a cold-water-soluble gelling agent, and a tetrazolium indicator that facilitates colony enumeration. The top film traps gas produced by the lactose fermenting coliforms.

AOAC INTERNATIONAL and U.S. FDA Bacteriological Analytical Manual (BAM) define coliforms as gram-negative rods which produce acid and gas from lactose during metabolic fermentation. Coliform colonies growing on the Petrifilm CC plate produce acid which causes the pH indicator to deepen the gel color. Gas trapped around red coliform colonies indicates confirmed coliforms.


1

The identification of coliforms may vary by country (see Reminders for Use section for incubation times and temperatures):

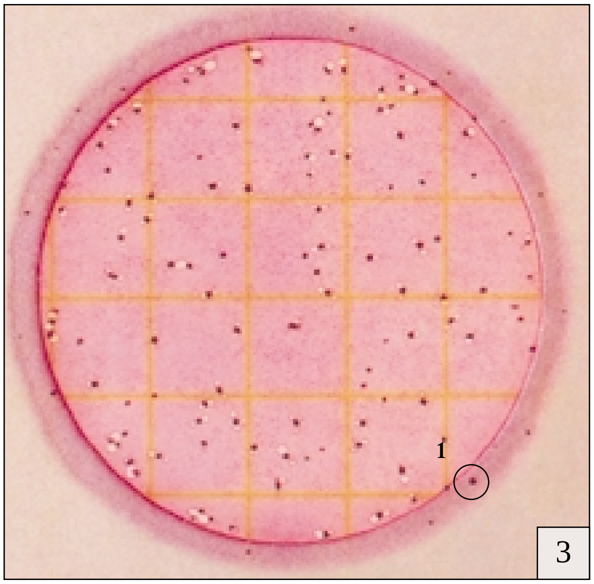
AOAC INTERNATIONAL validated method
Total coliform = 69 (colonies with gas)



No growth = 0

Notice the changes in gel color in figures 2 through 5. As the coliform count increases, the gel color deepens.

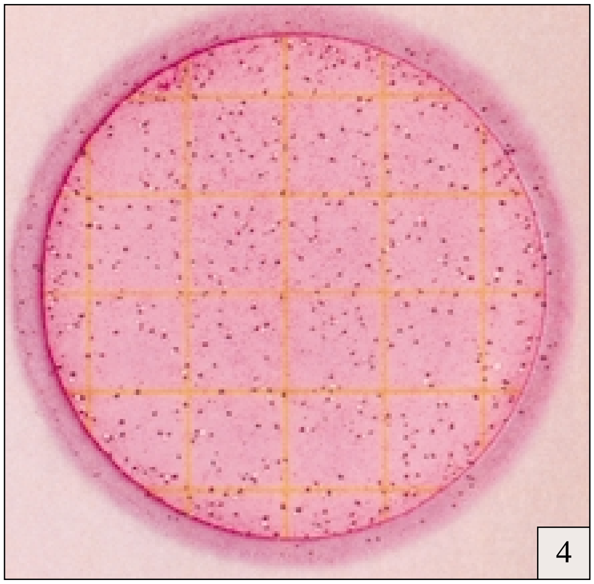
Background bubbles are a characteristic of the gel and are not a result of coliform growth.



Total coliform count = 79

The counting range for the total population on Petrifilm CC plates is 15–150.

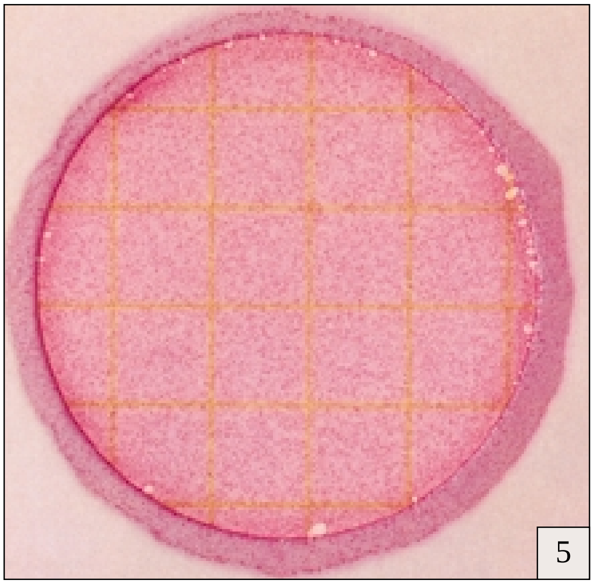
Do not count colonies that appear on the foam barrier because they are removed from the selective influence of the medium. See circle 1.



Estimated total coliform count = 220

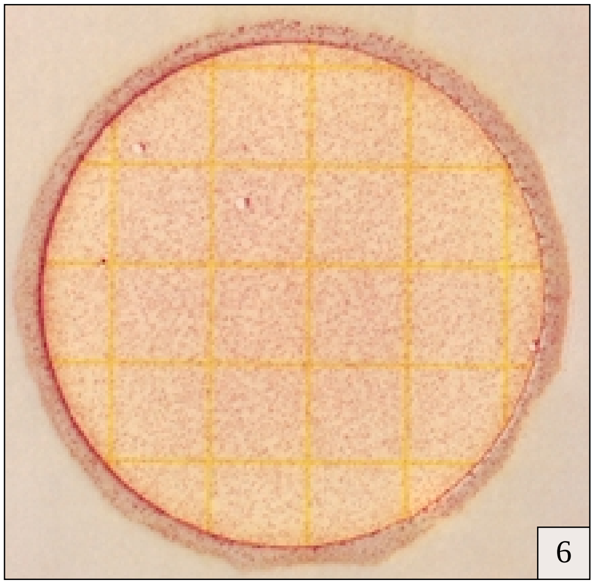
The circular growth area is approximately 20 cm^2. Estimates can be made on plates containing greater than 150 colonies by counting the number of colonies in one or more representative squares and determining the average number per square. Multiply the average number by 20 to determine the estimated count per plate.

Further dilution of the sample is recommended for an accurate count.



TNTC

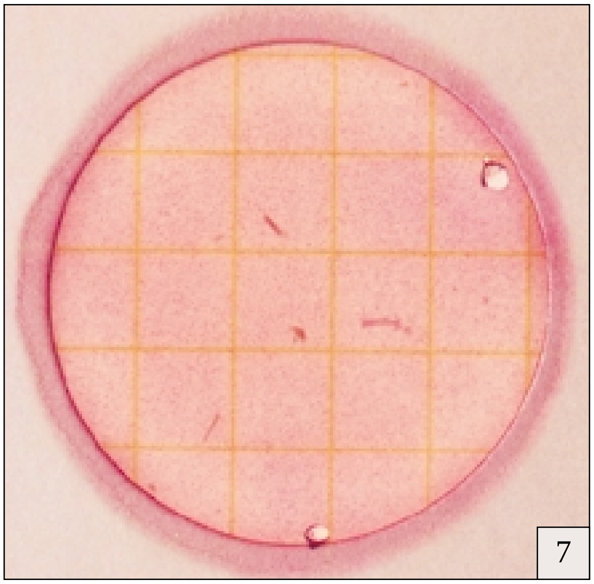
Petrifilm CC plates with colonies that are TNTC have one or more of the following characteristics: many small colonies, many gas bubbles, and a deepening of the gel color.



6

Actual count = 4

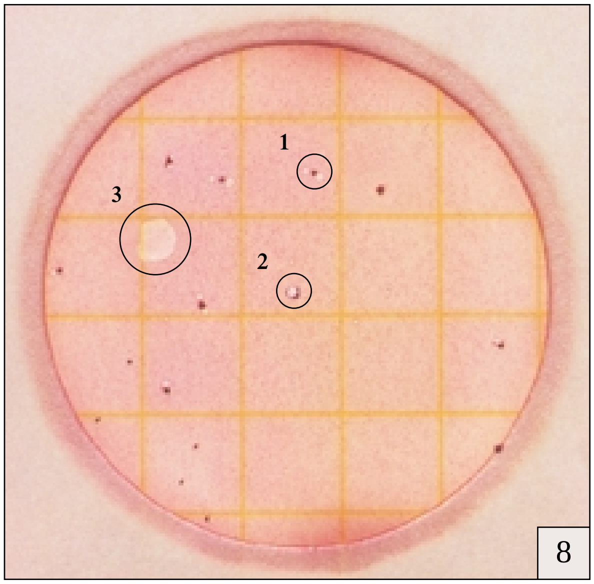
When high numbers of non-coliform organisms such as *Pseudomonas* are present on Petrifilm CC plates, the gel may turn yellow.



7

Total coliform count = 2

Food particles are irregularly shaped and are not associated with gas bubbles.

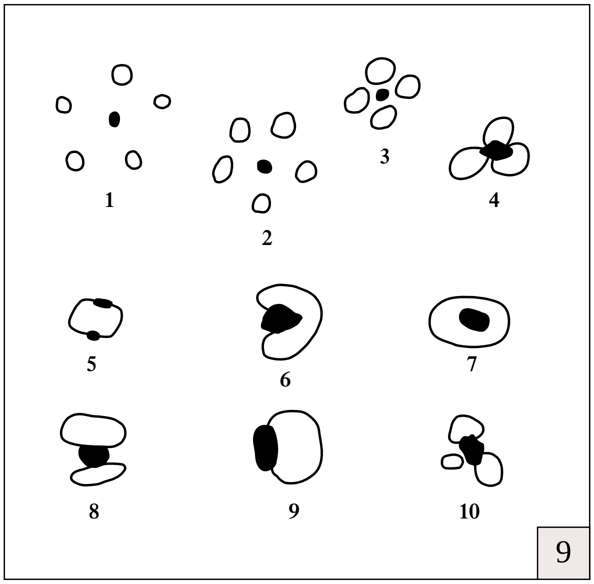


8

Total coliform count = 8

Bubble patterns may vary. Gas may disrupt the colony so that the colony "outlines" the bubble. See circles 1 and 2.

Artifact bubbles may result from improper inoculation or from trapped air within the sample. They are irregularly shaped and are not associated with a colony. See circle 3.



9

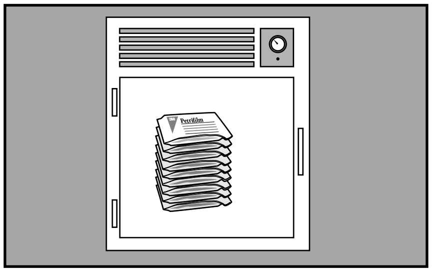
Examples 1–10 show various bubble patterns associated with gas producing colonies. All should be enumerated.

3M Petrifilm™ Coliform Count Plates

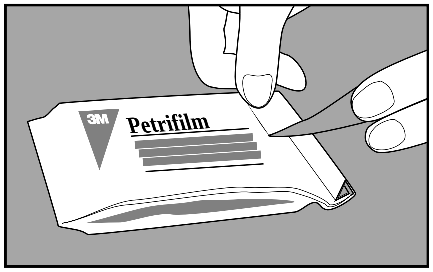
Reminders for Use

For detailed WARNING, CAUTIONS, DISCLAIMER OF WARRANTIES / LIMITED REMEDY, LIMITATION OF 3M LIABILITY, STORAGE AND DISPOSAL information, and INSTRUCTIONS FOR USE see Product's package insert.

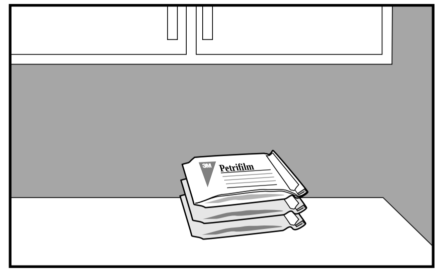
Storage



1 **Store** unopened packages at ≤8°C (≤46°F). Use before expiration date on package. In areas of high humidity where condensate may be an issue, it is best to allow packages to reach room temperature before opening.

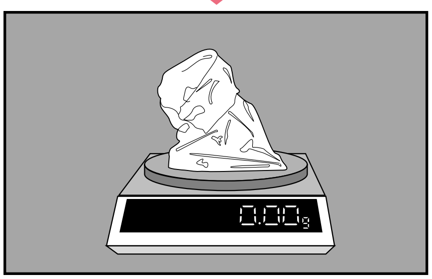


2 To seal opened package, fold end over and tape shut.



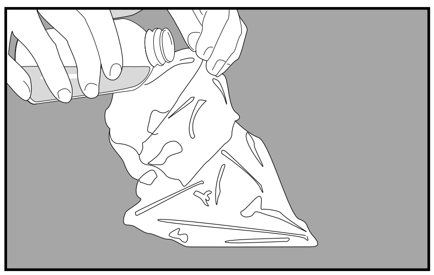
3 **Do not refrigerate opened packages.** Use Petrifilm plates within one month after opening.

Sample Preparation



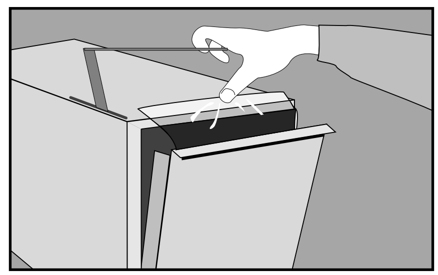
4 Prepare a dilution of food product.* Weigh or pipette food product into an appropriate container such as a stomacher bag, dilution bottle, Whirl-Pak® bag, or other sterile container.

*See *Petrifilm Use with Dairy and Juice Products* sheet for recommended dilutions.



5 Add appropriate quantity of one of the following sterile diluents: Butterfield's phosphate buffer (IDF phosphate buffer, 0.0425 g/L of KH_2PO_4 adjusted to pH 7.2), 0.1% peptone water, peptone salt diluent (ISO method 6887), buffered peptone water (ISO method 6579), saline solution (0.85-0.90%), bisulfite-free letheen broth, or distilled water.

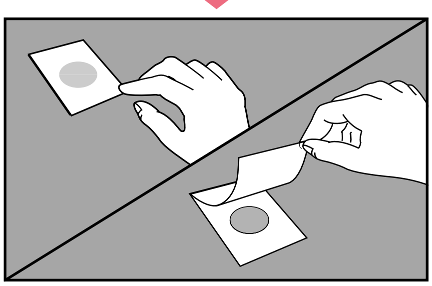
Do not use buffers containing citrate, bisulfite, or thiosulfate; they can inhibit growth.



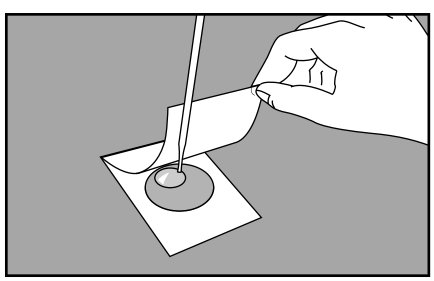
6 Blend or homogenize sample per current procedure.

Adjust pH of the diluted sample between 6.6 and 7.2 :
- for acid products, use 1*N* NaOH,
- for alkaline products, use 1*N* HCl.

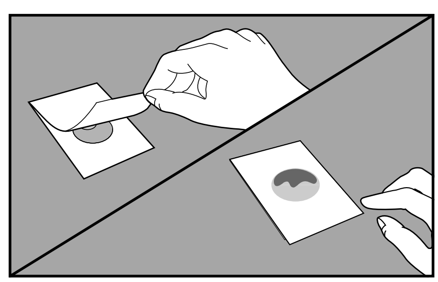
Inoculation



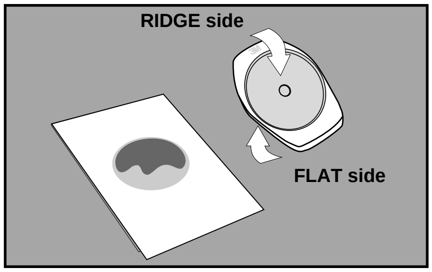
7 Place Petrifilm plate on **level** surface. Lift top film.



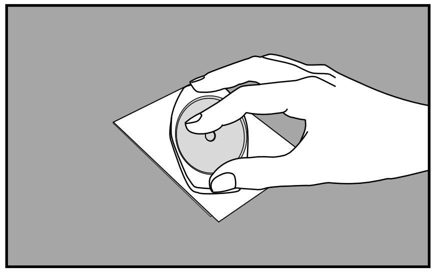
8 With pipette **perpendicular** to Petrifilm plate, place 1 mL of sample onto center of bottom film.



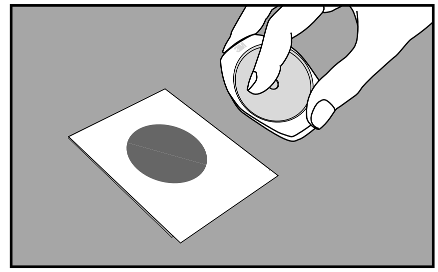
9 Carefully **roll** top film down to avoid entrapping air bubbles. Do **not** let top film drop.



10 With **flat** side down, place spreader on top film over inoculum.

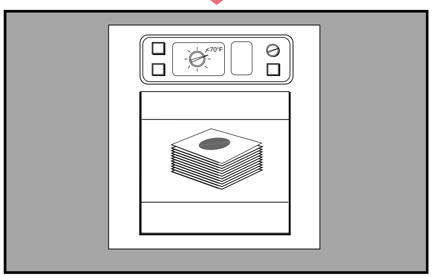


11 **Gently** apply pressure on spreader to distribute inoculum over circular area before gel is formed.
Do not twist or slide the spreader.



12 Lift spreader. Wait a minimum of one minute for gel to solidify.

Incubation



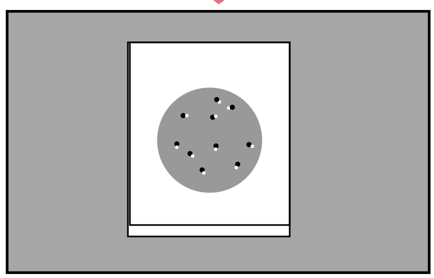
13 Incubate plates in stacks of up to 20.

Incubation time and temperature varies by method. Most common approved methods:

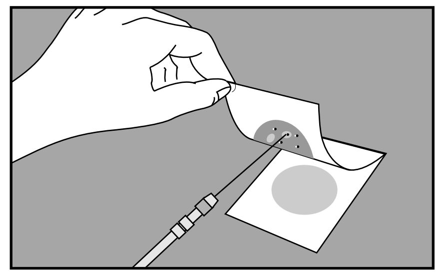
Total coliforms
- AOAC Official Methods 986.33 and 989.10 (milk, raw milk, other dairy products):
Incubate 24h ± 2h at 32°C ± 1°C.
- AOAC Official Method 991.14 (foods):
Incubate 24h ± 2h at 35°C ± 1°C.
- NMKL Method 147.1993:
Incubate 24h ± 2h at 37°C ± 1°C.
- AFNOR validated methods 3M 01/2 - 09/89A and B (all food types except shellfish):
Incubate 24h ± 2h at 30°C ± 1°C.

Thermotolerant (fecal) coliforms
- AFNOR validated method 3M 01/2 - 09/89C (all food types):
Incubate 24h ± 2h at 44°C ± 1°C.
Incubator humidification is required at this elevated temperature.

Interpretation



14 Petrifilm plates can be counted on a standard colony counter or other illuminated magnifier. Refer to the *Interpretation Guide* section when reading results.



15 Colonies may be isolated for further identification. Lift top film and pick the colony from the gel.

Additional Comments

- Questions? U.S., call **1-800-328-6553**, Canada, call **1-800-563-2921** for technical service.
- To order Petrifilm plates in the U.S., call **1-800-328-1671.**
- Latin America / Africa and Asia Pacific regions, call **1-651-733-7562.**

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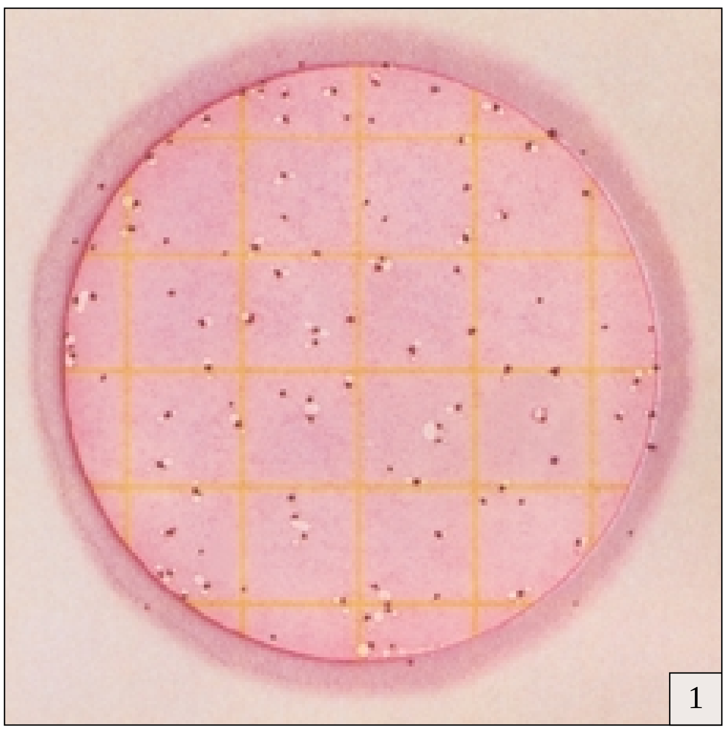
Interpretation Guide

Petrifilm™
Coliform Count Plate

This guide familiarizes you with results on 3M™ Petrifilm™ Coliform Count plates. For more information, contact the official 3M Microbiology Products representative nearest you.

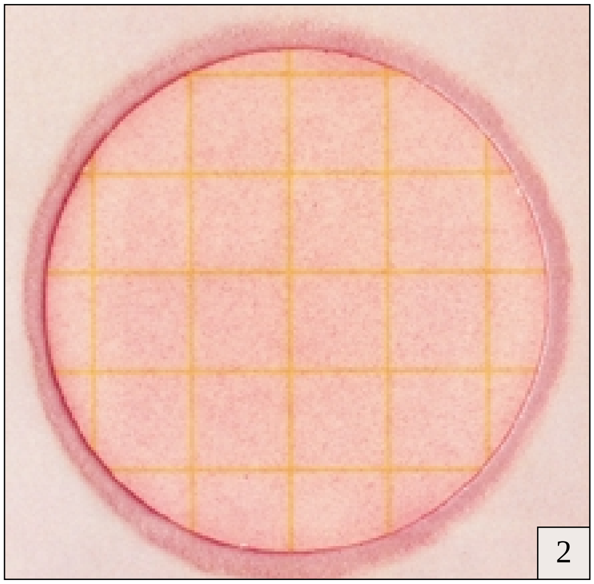
Petrifilm Coliform Count (CC) plates contain Violet Red Bile (VRB) nutrients, a cold-water-soluble gelling agent, and a tetrazolium indicator that facilitates colony enumeration. The top film traps gas produced by the lactose fermenting coliforms.

AOAC INTERNATIONAL and U.S. FDA Bacteriological Analytical Manual (BAM) define coliforms as gram-negative rods which produce acid and gas from lactose during metabolic fermentation. Coliform colonies growing on the Petrifilm CC plate produce acid which causes the pH indicator to deepen the gel color. Gas trapped around red coliform colonies indicates confirmed coliforms.


1

The identification of coliforms may vary by country (see Reminders for Use section for incubation times and temperatures):

AOAC INTERNATIONAL validated method
Total coliform = 69 (colonies with gas)

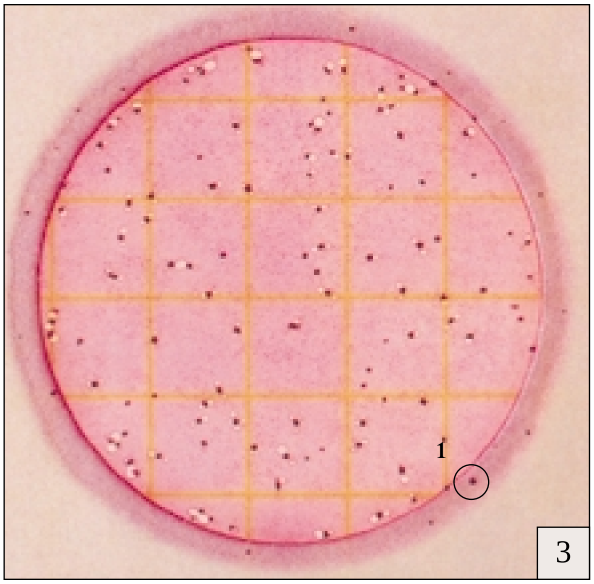


2

No growth = 0

Notice the changes in gel color in figures 2 through 5. As the coliform count increases, the gel color deepens.

Background bubbles are a characteristic of the gel and are not a result of coliform growth.

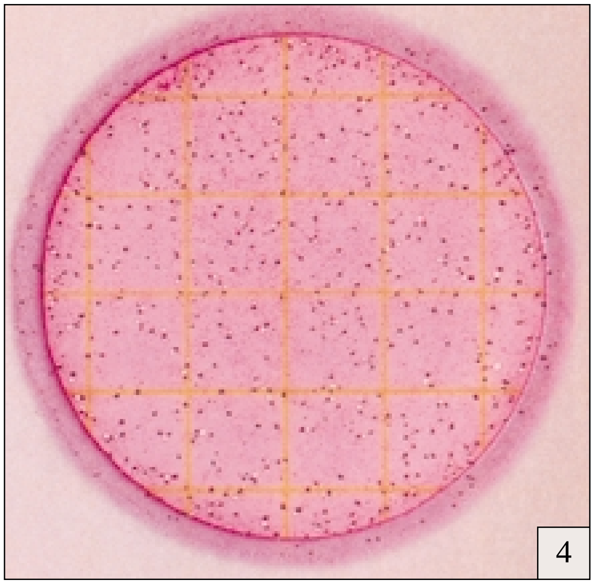


3

Total coliform count = 79

The counting range for the total population on Petrifilm CC plates is 15–150.

Do not count colonies that appear on the foam barrier because they are removed from the selective influence of the medium. See circle 1.

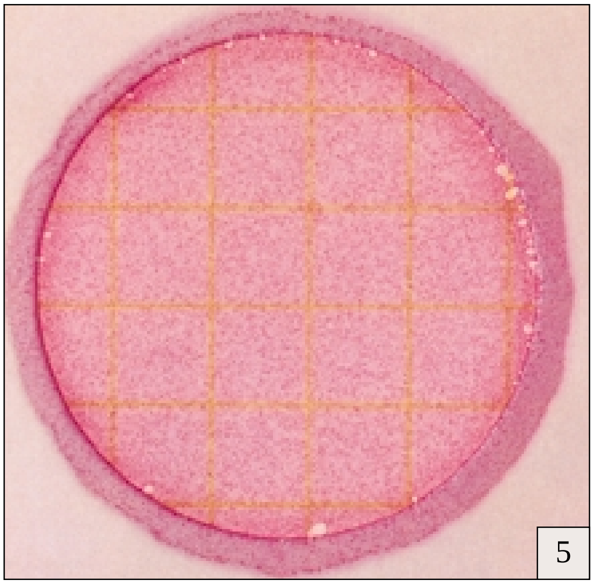


4

Estimated total coliform count = 220

The circular growth area is approximately 20 cm². Estimates can be made on plates containing greater than 150 colonies by counting the number of colonies in one or more representative squares and determining the average number per square. Multiply the average number by 20 to determine the estimated count per plate.

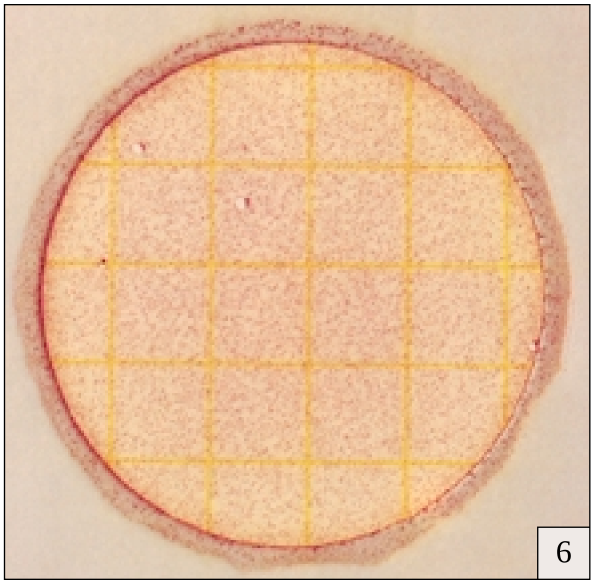
Further dilution of the sample is recommended for an accurate count.



5

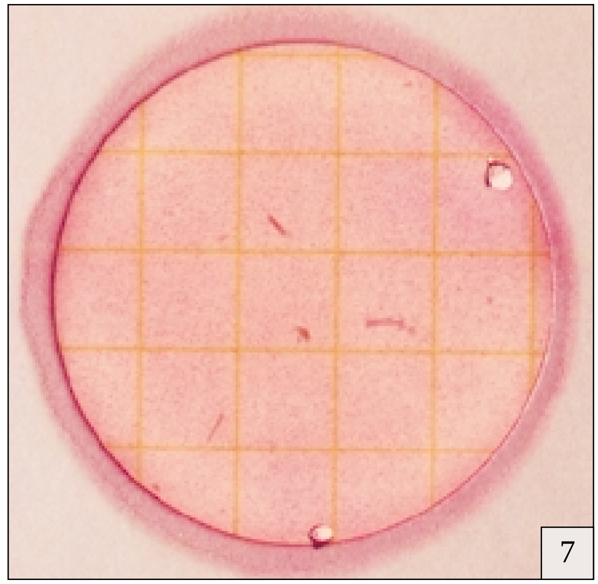
TNTC

Petrifilm CC plates with colonies that are TNTC have one or more of the following characteristics: many small colonies, many gas bubbles, and a deepening of the gel color.



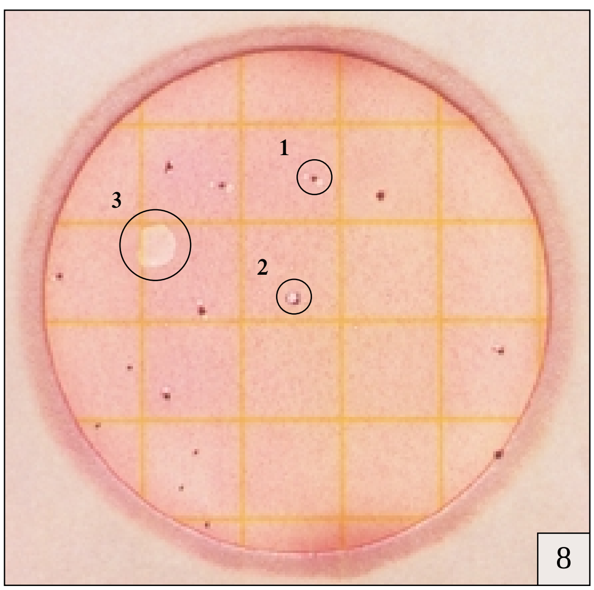
Actual count = 4

When high numbers of non-coliform organisms such as *Pseudomonas* are present on Petrifilm CC plates, the gel may turn yellow.



Total coliform count = 2

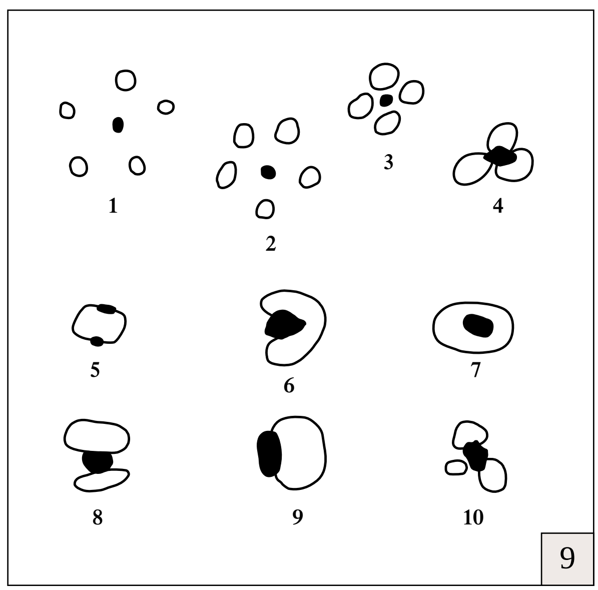
Food particles are irregularly shaped and are not associated with gas bubbles.



Total coliform count = 8

Bubble patterns may vary. Gas may disrupt the colony so that the colony "outlines" the bubble. See circles 1 and 2.

Artifact bubbles may result from improper inoculation or from trapped air within the sample. They are irregularly shaped and are not associated with a colony. See circle 3.



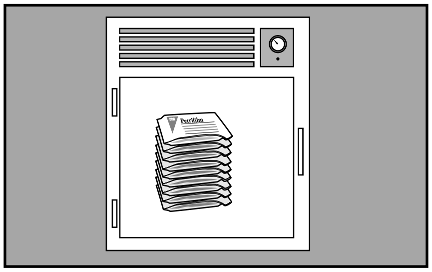
Examples 1–10 show various bubble patterns associated with gas producing colonies. All should be enumerated.

3M Petrifilm™ Coliform Count Plates

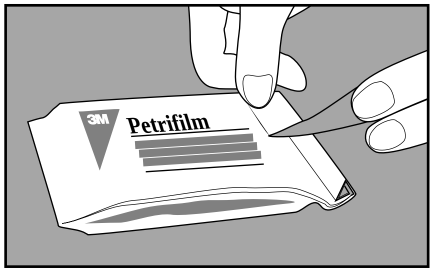
Reminders for Use

For detailed WARNING, CAUTIONS, DISCLAIMER OF WARRANTIES / LIMITED REMEDY, LIMITATION OF 3M LIABILITY, STORAGE AND DISPOSAL information, and INSTRUCTIONS FOR USE see Product's package insert.

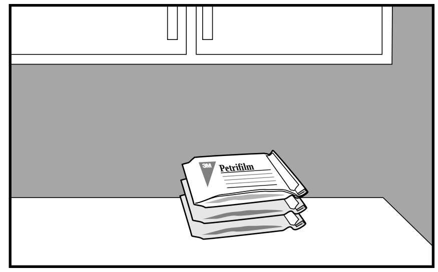
Storage



1 **Store** unopened packages at ≤8°C (≤46°F). Use before expiration date on package. In areas of high humidity where condensate may be an issue, it is best to allow packages to reach room temperature before opening.

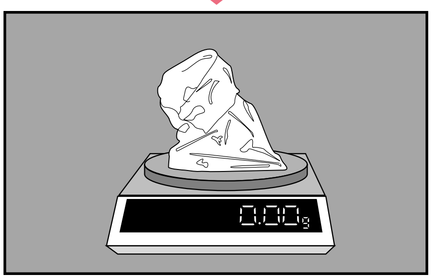


2 To seal opened package, fold end over and tape shut.



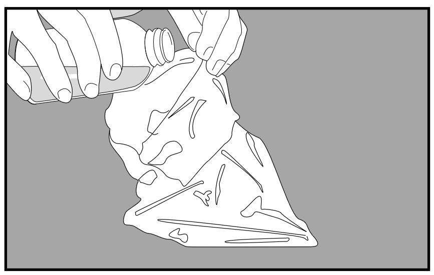
3 **Do not refrigerate opened packages.** Use Petrifilm plates within one month after opening.

Sample Preparation



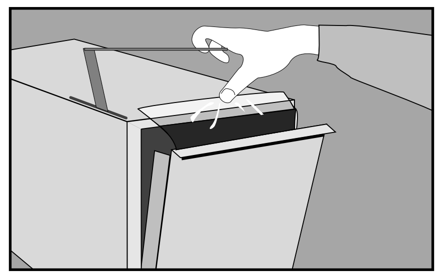
4 Prepare a dilution of food product.* Weigh or pipette food product into an appropriate container such as a stomacher bag, dilution bottle, Whirl-Pak® bag, or other sterile container.

*See *Petrifilm Use with Dairy and Juice Products* sheet for recommended dilutions.



5 Add appropriate quantity of one of the following sterile diluents: Butterfield's phosphate buffer (IDF phosphate buffer, 0.0425 g/L of KH_2PO_4 adjusted to pH 7.2), 0.1% peptone water, peptone salt diluent (ISO method 6887), buffered peptone water (ISO method 6579), saline solution (0.85-0.90%), bisulfite-free letheen broth, or distilled water.

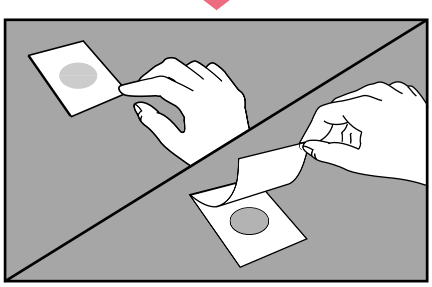
> Do not use buffers containing citrate, bisulfite, or thiosulfate; they can inhibit growth.



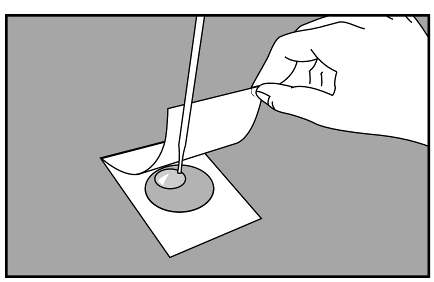
6 Blend or homogenize sample per current procedure.

> Adjust pH of the diluted sample between 6.6 and 7.2 :
> - for acid products, use 1*N* NaOH,
> - for alkaline products, use 1*N* HCl.

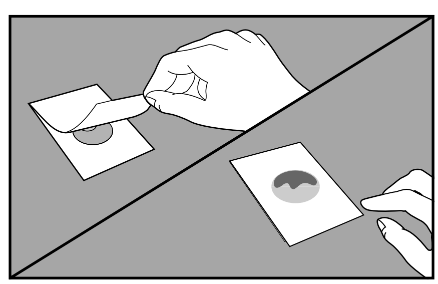
Inoculation



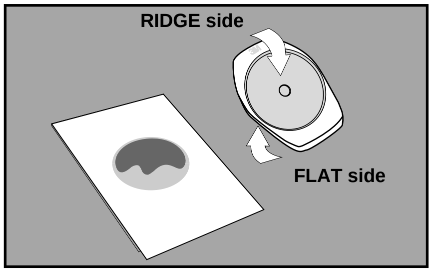
7 Place Petrifilm plate on **level** surface. Lift top film.



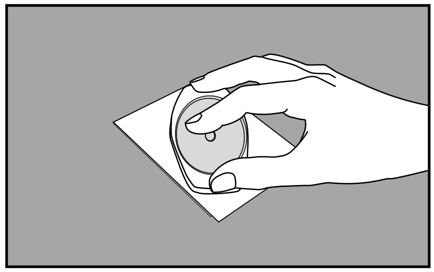
8 With pipette **perpendicular** to Petrifilm plate, place 1 mL of sample onto center of bottom film.



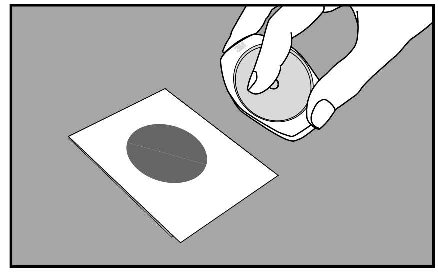
9 Carefully **roll** top film down to avoid entrapping air bubbles. Do **not** let top film drop.



10 With **flat** side down, place spreader on top film over inoculum.

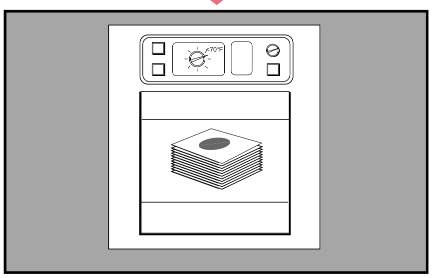


11 **Gently** apply pressure on spreader to distribute inoculum over circular area before gel is formed.
Do not twist or slide the spreader.



12 Lift spreader. Wait a minimum of one minute for gel to solidify.

Incubation



13 Incubate plates in stacks of up to 20.

Incubation time and temperature varies by method. Most common approved methods:

Total coliforms
• AOAC Official Methods 986.33 and 989.10 (milk, raw milk, other dairy products):
Incubate 24h ± 2h at 32°C ± 1°C.
• AOAC Official Method 991.14 (foods):
Incubate 24h ± 2h at 35°C ± 1°C.
• NMKL Method 147.1993:
Incubate 24h ± 2h at 37°C ± 1°C.
• AFNOR validated methods 3M 01/2 - 09/89A and B (all food types except shellfish):
Incubate 24h ± 2h at 30°C ± 1°C.

Thermotolerant (fecal) coliforms
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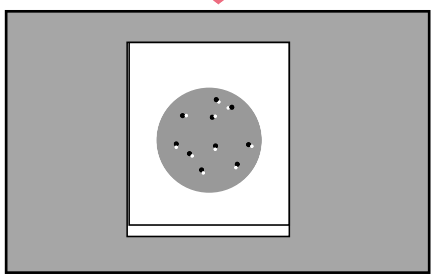
Incubate 24h ± 2h at 44°C ± 1°C.
Incubator humidification is required at this elevated temperature.

Interpretation



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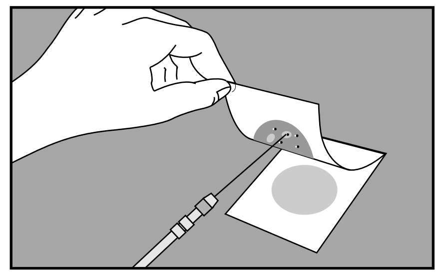

15 Colonies may be isolated for further identification. Lift top film and pick the colony from the gel.

Additional Comments

- Questions? U.S., call **1-800-328-6553**, Canada, call **1-800-563-2921** for technical service.
- To order Petrifilm plates in the U.S., call **1-800-328-1671.**
- Latin America / Africa and Asia Pacific regions, call **1-651-733-7562.**

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3M Petrifilm™ Plates — Environmental Monitoring Procedures

3M™ Petrifilm plates are a convenient and reliable way to detect environmental microbial contamination. The construction of Petrifilm plates allows them to be used for direct contact or swab contact monitoring procedures, as well as air sampling procedures.

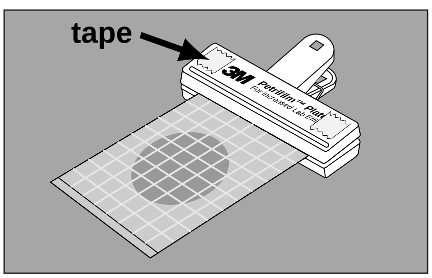
Hydration Procedures for Air or Direct Contact Methods

Petrifilm Plate	Procedure	Hydration*
Aerobic Count Coliform Count E. coli/Coliform Count Rapid Coliform Count Enterobacteriaceae Count	Air or Direct Contact Method	Hydrate plates with 1 mL of appropriate sterile diluent. Allow hydrated plates to remain closed for a minimum of 1 hour before use.
Staph Express Count	Air or Direct Contact Method	Hydrate plates with 1 mL of appropriate sterile diluent. Refrigerate hydrated plates for a minimum of 3 days before using.
Yeast and Mold Count Rapid S. aureus Count	Air Method Only	Hydrate plates with 1 mL of appropriate sterile diluent. Allow hydrated plates to remain closed for a minimum of 1 hour before use.
Yeast and Mold Count	Direct Contact Method Only	Hydrate yeast and mold plates with 1 mL of sterile **letheen broth only**. Place letheen inoculated plates into sealed bag and incubate at 30-37°C (86-99°F) for 24 hours. After incubation, store sealed bag of plates in refrigerator for a minimum of 4 hours to allow gel to solidify. Petrifilm plates hydrated with letheen will have a mottled appearance.

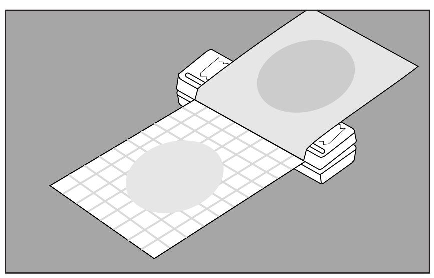
Hydrated Plates Storage Procedures: Store all hydrated Petrifilm plates in sealed pouch or plastic bag. Protect plates from light and refrigerate at 2-8°C (36-46°F). Hydrated Petrifilm Aerobic Count plates may be refrigerated up to 14 days, all other hydrated Petrifilm plates may be refrigerated up to 7 days.

**See relevant Petrifilm plate package insert for details and listing of appropriate diluents. If sanitizers are present, use letheen broth for both the direct contact and swab contact methods.*

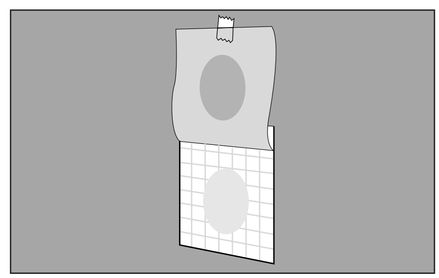
Air Sampling Method



1 Use a Petrifilm plate clip in combination with double-sided tape. Position hinged edge of hydrated Petrifilm plate into clip. Apply a small piece of double-sided tape to each end of the clip handle.

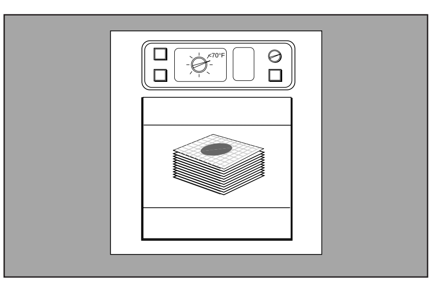


2 **Without touching circular growth area**, lift top film portion of hydrated plate and peel back until outer portion of film adheres to the tape. Make sure top film lies flat across clip.



3 Double-sided tape can also be used with or without clip for positioning of Petrifilm plates for air sampling.

Expose Petrifilm plate to air for no longer than 15 minutes. Remove tape and rejoin the top and bottom films.



4 Incubate and enumerate as directed in package inserts. Refer to 3M *Petrifilm Plate Interpretation Guide* when enumerating results.

Air Sampling Method Results

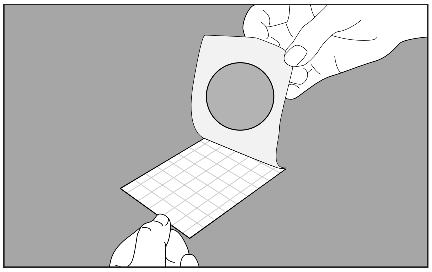
Petrifilm plate result is count/**40 cm^2** for:

- Aerobic Count
- Coliform Count
- E.coli/Coliform Count
- Rapid Coliform Count
- Enterobacteriaceae Count

Petrifilm plate result is count/**60 cm^2** for:

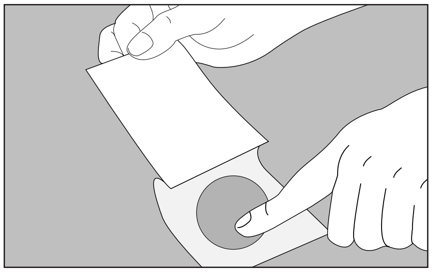
- Yeast & Mold Count
- Staph Express Count
- Rapid S. aureus Count

Direct Contact Method



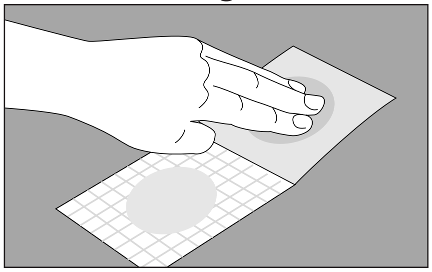
1 Using a hydrated Petrifilm plate, carefully lift top film. Avoid touching circular growth area. Gel will adhere to top film. Go to step 2a for the surface method or 2b for the finger method.

Surface



2a Allow the circular gel portion of the top film to contact the surface being tested. Gently rub fingers parallel to the surface over the outer film side of the gelled area to ensure good contact with surface. Rejoin the top and bottom films.

Finger

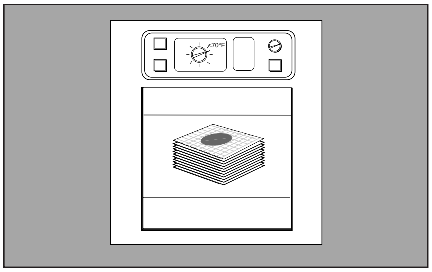


2b Touch finger or portion of hand to hydrated gel area. Rejoin the top and bottom films. Wash hands after finger or hand plating.

All Petrifilm plates except Yeast and Mold Count plates and the High-Sensitivity Coliform Count plates can be used for finger or hand plating. The Rapid S. aureus Count plates are not suitable for finger, hand or direct contact method plating.

Petrifilm Yeast and Mold Count Plates

On occasion, the gel may split (adhering to both the top and bottom films) when the top film is lifted. If this happens, the plate with gel splitting may still be used for air testing, but is not recommended for direct contact use.



3 Incubate and enumerate as directed in package inserts. Refer to 3M *Petrifilm Plate Interpretation Guide* when enumerating results.

Direct Contact Method Results

Petrifilm plate result is count/**20 cm²** for:

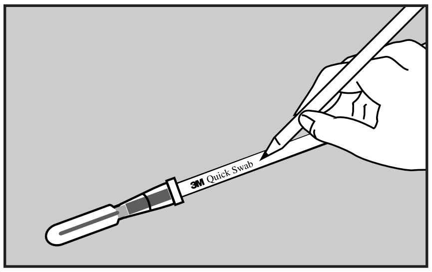
- Aerobic Count
- Coliform Count
- Enterobacteriaceae Count
- E.coli/Coliform Count
- Rapid Coliform Count

Petrifilm plate result is count/**30 cm²** for:

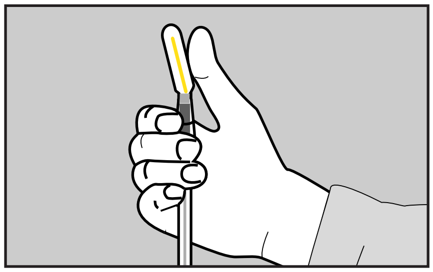
- Yeast & Mold Count
- Staph Express Count

Swab Method

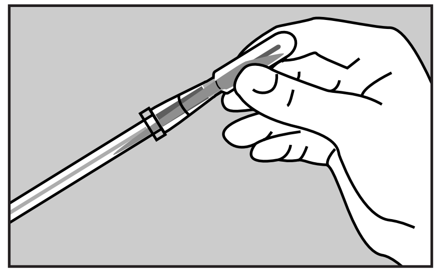
3M Quick Swab (wet swabbing method)*



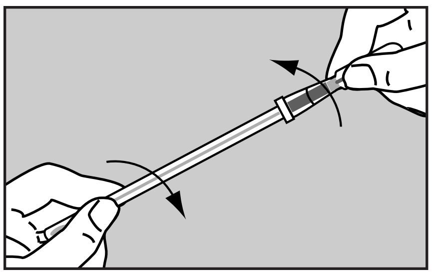
1 Remove the desired quantity of 3M Quick Swabs from the resealable plastic bag. Label the swab.



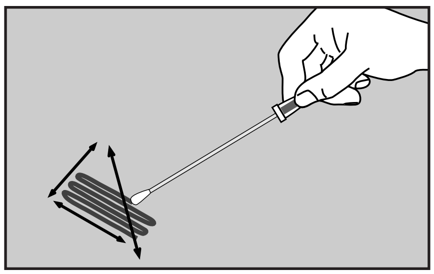
2 **At the sampling location**, prepare the swab by holding it with the bulb end near your thumb. Bend the red snap valve at a 45° angle until you hear the valve break. This allows the letheen broth to flow into the tube and wet the swab head.



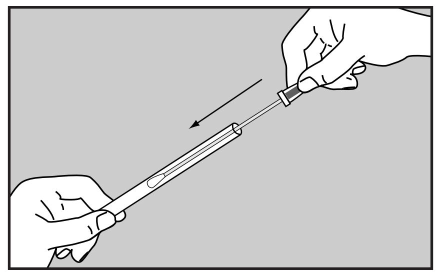
3 Squeeze the bulb of the swab to transfer all of the letheen broth to the tube end of the swab.



4 Twist and pull apart the bulb end of the swab from the tube end of the swab which contains the letheen broth.



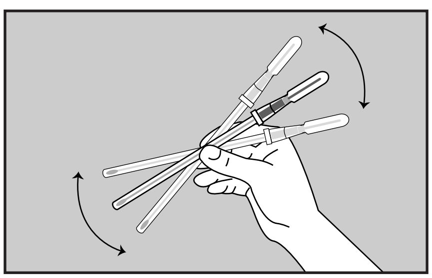
5 Hold the swab handle to make a 30° angle with the surface. Firmly rub the swab head slowly and thoroughly over the desired surface area. Rub the head of the swab three times over the surface, reversing direction between alternating strokes.



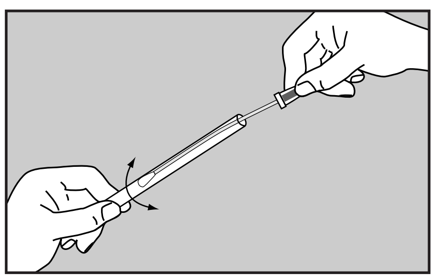
6 After sampling is complete, securely insert the swab head back into the swab tube and transport to the lab for plating. Plate the letheen broth swab solution as soon as possible.

Inoculation Procedures

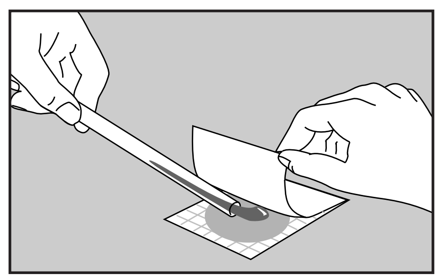
1 mL



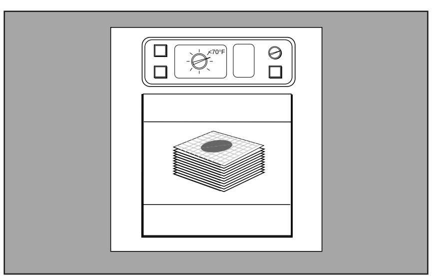
7 In the lab, vigorously shake or vortex the swab for 10 seconds, to release bacteria from the swab tip.



8 Wring out the contents of the swab tip by pressing and twisting the swab against the wall of the tube.



9 Carefully pour entire contents of the tube onto a 1mL 3M Petrifilm plate. Follow current industry standards for disposal.



10 Incubate and enumerate as directed in package inserts. Refer to 3M *Petrifilm Plate Interpretation Guide* when enumerating results.

Swab Contact Method Results

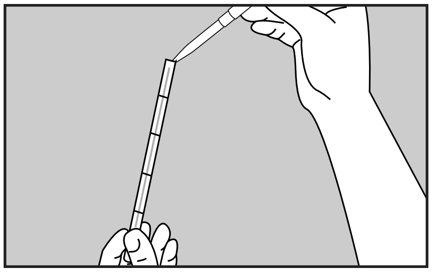
Petrifilm plate count x volume of diluent (1 mL) = total count/area sampled

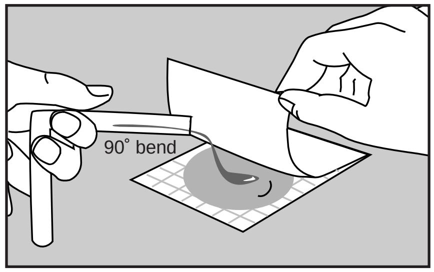
Example
If area tested was 5 cm^2 and number of colonies on plate after incubation was 100, your result would be: 100 CFU x 1 mL = 100 CFU/5 cm^2

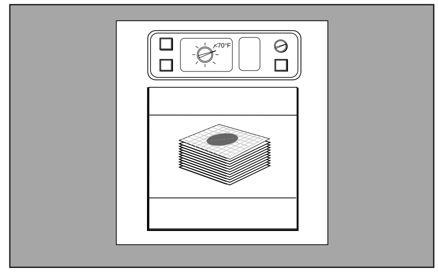
* For 3M Quick Swab dry swabbing method, see Quick Swab package insert.

Multi-mL

1 Complete steps 1-6 for the wet swabbing method from previous page.







2 Remove the swab from the tube. Add 1-3 mL's of sterile diluent to the swab tube. Replace the swab in the tube. Complete steps 7 & 8 of the 1 mL Inoculation Procedure from previous page.

3 Use your thumb to bend the swab tube at a 90˚ angle at the highest mark that has diluent above it. Pour off a 1 mL aliquot onto a Petrifilm plate. Repeat onto new plate until the entire sample is used.

4 Incubate and enumerate as directed in package inserts. Refer to *3M Petrifilm Plate Interpretation Guide* when reading results.

Quick Swab Multi-mL Method Results

Petrifilm plate count x volume of diluent (1 mL + added) = total count/area sampled

Example
If area tested was 5 cm^2, number of mLs added was 2 (for total of 3) and number of colonies after incubation was 100, your result would be: 100 CFU x 3 mL = 300 CFU/5 cm^2

Alternative Swab Method

Petrifilm plates can be used with other swabbing techniques, however the rinse solution used must be compatible with Petrifilm plates. (See Petrifilm plate package insert for listing of appropriate diluents).

Additional Information

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- Questions? U.S., call **1-800-328-6553**.
  To order Petrifilm plates, call **1-800-328-1671.**
- Canada, call **1-800-563-2921** for technical service.
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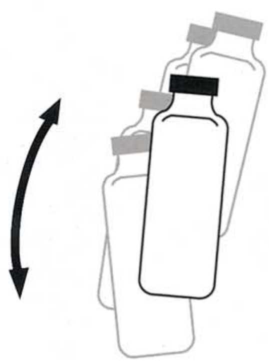
3M™ Petrifilm™ Plates

Liquid Sample

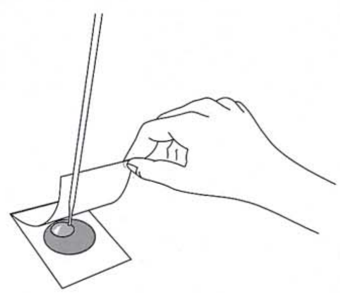
Add sample to dilution buffer[1]

Adjust pH?[2]

Shake[3]



Plate[5]

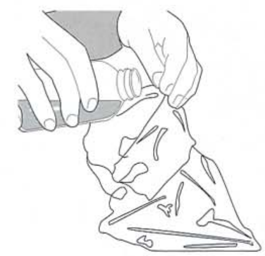


Viscous or Solid Sample

Weigh sample[1]

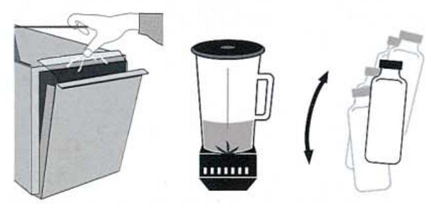
NOTE: Use of a stomacher bag with filter makes any "settle" step unnecessary.

Add dilution buffer[1]



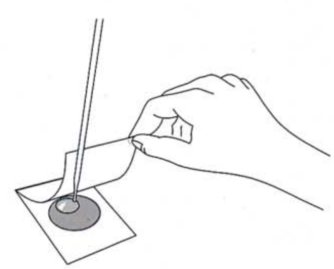
Adjust pH?[2]

Stomach or blend or shake



Settle[4]

Plate[5]



References

1. Petrifilm Plate Guide to Dilution Preparation

2. Adjust pH so that the final pH is between pH 6.6 - 7.2.
   Note: Once a protocol has been developed,
   pH adjustment can become routine at this step.

3. Shake. Milk Guidelines: Make 25 complete up and down
   (or back and forth) movements of about 30cm in 7 seconds.

4. Settle. Some samples may need a few minutes to settle before inoculation. Settling makes pipetting easier and minimizes the number of food particles on the plate.

5. Petrifilm Plate package insert.
   Petrifilm Plate Reminders for Use.

Additional Comments

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- To order Petrifilm Plates in the U.S., call **1-800-328-1671.**
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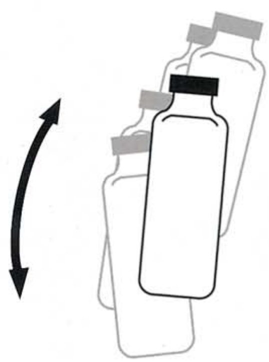
Sample Preparation

Liquid Sample

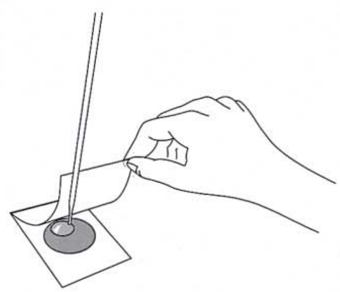
Add sample to dilution buffer[1]

Adjust pH?[2]

Shake[3]



Plate[5]



References

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3. Shake. Milk Guidelines: Make 25 complete up and down (or back and forth) movements of about 30cm in 7 seconds.
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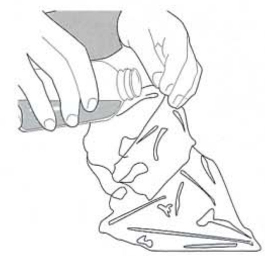
5. Petrifilm Plate package insert. Petrifilm Plate Reminders for Use.

Viscous or Solid Sample

Weigh sample[1]

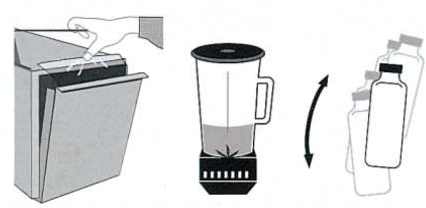
NOTE: Use of a stomacher bag with filter makes any "settle" step unnecessary.

Add dilution buffer[1]



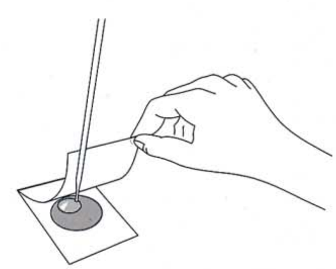
Adjust pH?[2]

Stomach or blend or shake



Settle[4]

Plate[5]



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Appendix D:

Student Interview Data

Escuela Espinal Health Survey
6th Grade

Q1	How many times a day do you use the bathroom at school?		
1a	0		7
1b	1		1
1c	2		3
1d	>2		0

Total 11

Avg 0.64

Q2	How often do you wash your hands after using the bathroom?		
2a	Never		0
2b	Sometimes		7
2c	Always		4

Total 11

Avg

Q3	How often do you have upset stomach?		
3a	never		7
3b	1/yr		3
3c	1/month		0
3d	1/week		1
3e	>1/week		0

Total 11

Avg

Q4	Sex		
4a	boy		10
4b	girl		1

Escuela Espinal Health Survey
1st Grade

Q1	How many times a day do you use the bathroom at school?		
1a	0		0
1b	1		4
1c	2		5
1d	>2		9

Total 18

Avg 2.28

Q2	How often do you wash your hands after using the bathroom?		
2a	Never		0
2b	Sometimes		11
2c	Always		7

Total 18

Avg

Q3	How often do you have upset stomach?		
3a	never		2
3b	1/yr		0
3c	1/month		7
3d	1/week		4
3e	>1/week		0

Total 13

Avg

Q4	Sex		
4a	boy		1
4b	girl		7

Escuela Espinal Health Survey
Age - 16 yrs old

Q1	How many times a day do you use the bathroom at school?		
1a	0		7
1b	1		13
1c	2		4
1d	>2		5

Total 29

Avg 1.24

Q2	How often do you wash your hands after using the bathroom?		
2a	Never		1
2b	Sometimes		5
2c	Always		23

Total 29

Avg

Q3	How often do you have upset stomach?		
3a	never		7
3b	1/yr		3
3c	1/month		15
3d	1/week		4
3e	>1/week		0

Total 29

Avg

Q4	Sex		
4a	boy		17
4b	girl		12

Escuela Espinal Health Survey
12th grade

Q1	How many times a day do you use the bathroom at school?			
1a	0		3	
1b	1		17	
1c	2		3	
1d	>2		0	

Total 23

Avg 1.00

Q2	How often do you wash your hands after using the bathroom?			
2a	Never		0	
2b	Sometimes		0	
2c	Always		23	

Total 23

Avg

Q3	How often do you have upset stomach?			
3a	never		3	
3b	1/yr		6	
3c	1/month		8	
3d	1/week		2	
3e	>1/week		4	

Total 23

Avg

Q4	Sex			
4a	boy		11	
4b	girl		12	

Appendix E:

Design Sanitary Flow Rate Calculations

And

Assumptions

Sanitary flow determination for Colegio Luis Espinal

1. Population growth determination

A. **Define current population in largest section**

Largest section: 1,500 students

B. Project population using growth rate provided by morning director

Growth rate: 5 students/classroom/year

classrooms: 38

Increased # students / year: 190

Design lifespan: 10 years

Projected increase in students over lifetime: 1,900

C. Set population cap at an estimated level for school

Cap: approximately 2,000 students / section

D. Determine new growth rate

$$\text{Growth rate} = \frac{2{,}000\ \text{students} - 1{,}500\ \text{students}}{10\ \text{years}} = \frac{1.5\text{students}}{\text{class/year}}$$

E. Calculate design population

$$\begin{aligned} \textit{Design population} &= \textit{Current population} \\ &+ (\textit{growth rate} * \#\ \textit{classrooms} * \ \textit{design years}) \\ &= \mathbf{1{,}500 + (1.5 * 38\ \textit{classrooms} * 10\ \textit{years}) = \ 2{,}070\ \textit{students}} \end{aligned}$$

2. Flush rate determination

1. Boys toilet room

A. Tank dimensions

15 x 30 x 46 cm

21 liter volume capacity of tank

B. Flush volume assumptions

Unlikely that the entire volume of the tank will be filled and flushed, but all tanks in boys toilet room were inoperable in May, so an assumed flush volume of 6L is used for each flush. This value is taken from flush volumes seen in the U.S. and in other settings in Bolivia, and is similar to the volume used in past ISD reports.

2. Girls toilet room

A. Tank dimensions

30 x 30 x 15cm

14 liter volume capacity of tank

B. Flush volume assumption

Same as assumption for boys toilet room tanks except that the girls toilet room had toilets with pull-string toilets of which several were operable however a flush volume was not taken when on site.

3. Saguapac water bill flow calculation

A. Calculate daily water demand from monthly total

$$\text{daily demand May 08} = \frac{\text{monthly total}}{\#\ \text{days}} = \frac{312\ m^3}{31\ \text{days}} = 10.1 m^3/\text{day}$$

B. Determine per capita water daily water usage

$$\text{per capita} = \frac{\text{daily usage rate}}{\#\ \text{students}} = \frac{10{,}064\ \text{L}}{1500} = \mathbf{6.7\ Lpd/student}$$

C. Final value

Final value is taken by averaging the monthly usage rates for the year, **5.1 Lpd / student**

D. Assumptions

Because so few of the toilets are in working condition, the water usage is lower than it will be when toilets become operational. Much of the usage currently comes from the single sink.

4. Observed sanitary flow

Toilet room use observations were taken for a half-hour period during recess in the morning, from 10-10:30. A tally of students entering both toilet rooms and using the sink was taken and extrapolated to find the daily usage rate. The length of time used for extrapolation is 12 hours, approximately the duration of use per day at the site.

A. Volume used during observation period

$$\text{Vol. period (boys)} = \text{est. flush vol.} * \#\text{ uses} = \frac{6L}{\text{use}} * 47\text{ uses} = 282L$$

$$\text{Vol. period (girls)} = \text{est. flush vol.} * \#\text{ uses} = 6L/\text{use} * 27\text{ uses} = 162\text{ L}$$

$$\text{Vol. period (sink)} = \text{est. use vol.} * \#\text{ uses} = 1L/\text{use} * 93\text{ uses} = 93\text{ L}$$

B. Daily toilet room flow

$$\text{Toilet rooms daily flow} = \text{period flow rate (30 min.)} * \# \frac{\text{periods}}{\text{day}} = 444L * \frac{24\text{periods}}{\text{day}} = \mathbf{13,100\ L/day}$$

C. Per capita flow rate

$$\text{Per capita flow rate} = \frac{\text{Daily toilet room flow (from B.)}}{\#\, students} = \mathbf{7.3\ Lpd/student}$$

5. Questionnaire flow calculation

A questionnaire was taken including 81 students in four age groups. A daily flow was obtained using average responses to the number of bathroom uses per day.

A. Total sanitary flow rate

$$\text{Total flow} = \text{Ave. \# uses per day} * \text{Ave. flush vol.} = 1.3\frac{\text{uses}}{day} * 6L = \mathbf{7.7\ Lpd/student}$$

6. "Typical" flow from Bolivian engineer

A daily per capita flow value of 60 Lpd was provided by a Bolivian engineer.

7. "Typical" flow from U.S. EPA

A flow range of 19 – 64 Lpd was provided in a U.S. Environmental Protection Agency design manual

8. Determining design flow rate

The five values were compiled in a table to assess each value's validity. The three calculated flow rates were all very similar to one another, and the highest value of that, the questionnaire flow (step 5) was used to be conservative.

A. Safety factor

A safety factor of 2.5 was originally used so the value would reach the lower end of the EPA range of 19 Lpd. After discussion with an engineer, this was lowered to 1.5 to minimize the size of the resulting system.

B. New per capita flow

$$\text{Per capita flow} = \text{per capita flow} * \text{safety factor} = 7.7\frac{\text{Lpd}}{\text{student}} * 1.5 = 11.6\frac{\text{Lpd}}{\text{student}}$$

C. Design system flow rate

$$\text{Design system flow rate} = \text{per capita flow} * \text{design population} = 11.6\frac{\text{Lpd}}{\text{student}} * 2070\text{ students} = \mathbf{24,000\ Lpd} = \mathbf{6,300\ Gpd}$$

Summary of bathroom flow calculations						
Estimation method	**Per capita (Lpd)**	**Safety factor**	**Design per capita rate (Lpd)**	**Total flow / day (Lpd)**	**Design total flow / day (Lpd)**	**Design total flow / day (gpd)**
Saguapac water bill	5.1	1.5	7.7	11,475	15,836	4,184
Observation	7.3	1.5	11.0	16,425	22,667	5,989
Questionnaire	**7.7**	1.5	**11.6**	17,325	**23,909**	**6,317**
Bolivian estimate	--	--	60	--	124,200	32,814
EPA (19-64 Lpd)	--	--	19	--	39,330	10,391

S GUAPAC
El agua de todos

AVISO DE COBRANZA
Por Servicios de Agua Potable y Alcantarillado Sanitario
Cooperativa de Servicios Públicos Santa Cruz Ltda. "SAGUAPAC"
Av. Rio Grande Nº 2323 (Tanque Elevado) Teléfono 352-2323
NO VÁLIDO PARA CRÉDITO FISCAL

112005300

NOMBRE:
COMP.EDUC. RVDO.P.LUIS ESPINAL C.

CATEGORÍA: 4

FECHA EMISIÓN: 13-05-2008

DIRECCIÓN:
B.FORTALEZA MZ.68 UV UV-178 Mzn 68

MES/AÑO: 05/2008

FECHA VENCIMIENTO: 13-06-2008

DISTRITO: 7

FECHA LECTURA	LECTURA	CONSUMO m³	OBS.
10-04-2008	7969	312	6.00
12-03-2008	7657	284	6.00

DEUDA ATRASADA Bs	Nº DE MESES	CORTE
718.52	1	SI

Si pagó, ignore este mensaje

HISTÓRICO

MES	CONSUMO m³	IMPORTE Bs	ESTADO
2008-05	312	798.72	IMPAGA
2008-04	284	718.52	IMPAGA
2008-03	231	579.81	
2008-02	228	567.72	
2008-01	200	494.00	
2007-12	284	695.80	
2007-11	280	680.40	
2007-10	217	522.97	
2007-09	166	396.74	
2007-08	178	423.64	
2007-07	215	509.55	
2007-06	201	474.36	
OTAL DEUDA Bs			1,517.24

DATOS DE LA FACTURA

ITEM	DETALLE	IMPORTE Bs
1	Serv. agua potable	798.72
IMPORTE TOTAL FACTURA Bs		798.72

INFORMACIÓN AL CONSUMIDOR

- Amigo Cooperativista, para pagar su factura diríjase a nuestros Agentes de Cobranza autorizados, indicados al reverso del presente.
- Al pagar, exija el respectivo sello y firma del Agente de Cobranza en la factura. Sólo así le servirá como comprobante de pago.
- El reclamo por alguna factura podrá ser realizado hasta la fecha de vencimiento de ésta (30 días posterior a la fecha de su emisión).

12

COMUNÍQUESE CON SAGUAPAC

̶eclamos y Emergencias (24 horas)	168 y 353-1115
̶úmero Piloto (horario de oficina)	
Oficina Central - Av. Río Grande Nº 2323 (Tanque Elevado)	352-2323
Agencia Sucursal Sur - Av. El Palmar	352-2323 Int. 141
Agencia Sucursal Norte 1 - Av. 2 de Agosto	352-2323 Int. 142
Agencia Sucursal Norte 2 - Av. Santa Rosa	352-2323 Int. 143
Agencia Sucursal Norte 3 - Ciudadela Satélite Norte	370-3046

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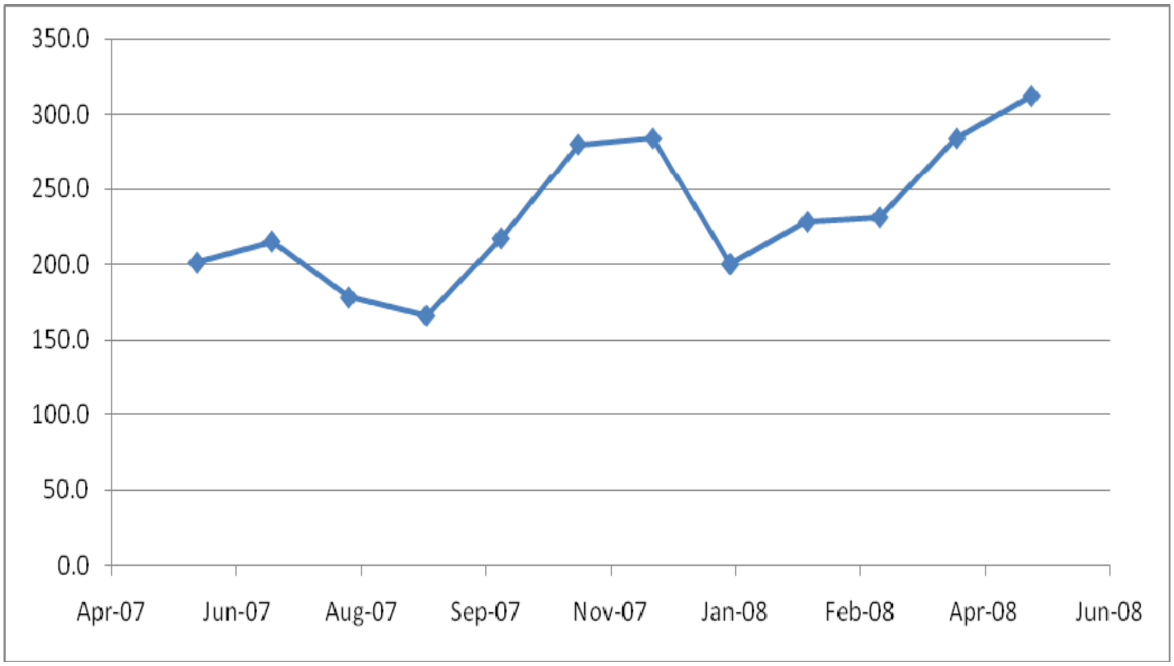
AGENTES DE COBRANZA

Banco Mercantil Santa Cruz	Cooperativa Jerusalén	Cooperativa San Martín
Banco Nacional de Bolivia	Farmacias FarmaCorp	Cooperativa 1 de Septiembre
Banco de Crédito	América Home Center	Cooperativa 4 de Noviembre
Banco Ganadero	Joyeria Tauro	Cooperativa Buen Samaritano
Banco Bisa	El Cedro	Cooperativa La Trinidad
Banco Sol	Cooperativa La Merced	Cooperativa N. Sra. de Cotoca
Banco Económico	Cooperativa Jesús Nazareno	Cooperativa Santa Rosa
Banco Unión	Cooperativa San Gabriel	Cooperativa Piraí
Fondo Financiero Fassil	Cooperativa San Luis	Cooperativa Sudamérica
Fondo Financiero FIE	Cooperativa 4 de Agosto	
Fortaleza Fondo Privado	Cooperativa 2 de Junio	



CLE Water Usage in cubic meters by month from Saguapac bill

Summary of bathroom flow calculations							
Estimation method	**Per capita (gpd)**	**Safety factor**	**Peaking Factor**	**Design per capita rate (Lpd)**	**Total flow / day (Lpd)**	**Design total flow / day (Lpd)**	**Design total flow / day (gpd)**
Saguapac water bill	1.3	1.5	1.5	11.5	17,213	23,753	6,276
Observation	1.9	1.5	1.5	16.4	24,638	34,000	8,983
Questionnaire	**2.0**	**1.5**	**1.5**	**17.4**	26,056	**35,958**	**9,500**
Bolivian estimate	–	–	–	60	–	124,200	–
EPA (19-64 Lpd)	–	–	–	19	–	39,330	–

20% design flow, gallons
1,900

Espinal water monthly water usage from Saguapac water bill								
Month	Usage, m^3	Usage, L	Usage, gal	Daily usage, m^3 / day	Daily usage, L / day	Daily usage, gal / day	Per capita (gpd/person)	Per capita (Lpd/person)
May-08	312.0	312,000.0	82,421.0	10.1	10,064.5	2,658.7	1.8	**6.7**
Apr-08	284.0	284,000.0	75,024.3	9.5	9,466.7	2,500.8	1.7	**6.3**
Mar-08	231.0	231,000.0	61,023.3	7.5	7,451.6	1,968.5	1.3	**5.0**
Feb-08	228.0	228,000.0	60,230.8	7.9	7,862.1	2,076.9	1.4	**5.2**
Jan-08	200.0	200,000.0	52,834.0	6.5	6,451.6	1,704.3	1.1	**4.3**
Dec-07	284.0	284,000.0	75,024.3	9.2	9,161.3	2,420.1	1.6	**6.1**
Nov-07	280.0	280,000.0	73,967.6	9.3	9,333.3	2,465.6	1.6	**6.2**
Oct-07	217.0	217,000.0	57,324.9	7.0	7,000.0	1,849.2	1.2	**4.7**
Sep-07	166.0	166,000.0	43,852.2	5.5	5,533.3	1,461.7	1.0	**3.7**
Aug-07	178.0	178,000.0	47,022.3	5.7	5,741.9	1,516.8	1.0	**3.8**
Jul-07	215.0	215,000.0	56,796.6	6.9	6,935.5	1,832.1	1.2	**4.6**
Jun-07	201.0	201,000.0	53,098.2	6.7	6,700.0	1,769.9	1.2	**4.5**
								5.1

Water usage observations, 23 May 10:00 - 10:30 AM				
	Boys Bathroom	Girls Bathroom	Sink	**Total**
# uses	47.0	27.0	93.0	
Flush vol. (estimated, L)	6.0	6.0	1.0	
Flush vol. (estimated, gal)	1.6	1.6		
Usage vol. (gal)			0.3	
Total vol. in obs. (gal)	75.2	43.2	24.2	
Total vol. in obs. (L)	282.0	162.0	93.0	
Total daily vol. (gal)	1,804.8	1,036.8	580.3	**3,421.9**
Total daily vol. (L)				**13,161.2**
Bathroom daily vol. (gal)				**2,841.6**
Bathroom daily vol. (L)				**10,929.2**
per capita (gpd)				**1.9**
per capita (Lpd)				**7.3**

Half hour data was extrapolated for a 12-hour active usage time per day

Population Data		
Parameter	**Value**	**Unit**
Current enrollment for largest section (morning/afternoon)	1,500	students
Projected increase per classroom for next 5-10 years	2	students / classroom
# Classrooms	38	classrooms
Design Years	10	years
# Increase / section, design	570	students
Design Population	**2,070**	students

Usage Rate		
Boys bathroom toilet dimensions (approximate)	6 x 12 x 18	inches
Boys bathroom toilet dimensions (approximate)	15 x 30 x 46	cm
Total # toilets in bathroom	8	toilets
# toilets in use (May 2008)	4	toilets
# toilets operational (May 2008)	0	toilets
Approximate volume, full tank	21	liters
Flush volume (assumed)	6	liters
Boys bathroom toilet type	Tank & Bowl	
Girls bathroom toilet dimensions (approximate)	12 x 12 x 6	inches
Girls bathroom toilet dimensions (approximate)	30 x 30 x 15	cm
Total # toilets in bathroom	8	toilets
# toilets in use (May 2008)	4	toilets
# toilets operational (May 2008)	2	toilets
Approximate volume, full tank	14	liters
Flush volume (assumed)	6	liters
Girls bathroom toilet type	Pull Chain	
Ratio of bathroom usage:sink usage	4.9	vol:vol

Indicates design variable

Notes:

The rate of increase is per a discussion with the Directora on 20 May, where she indicated a growth rate of 5 students per classroom per year. There are 38 classrooms at Colegio Luis Espinal (CLE). The Directora did not specifiy a maximum amount of students, but with the current site, an increase of 1,900 students in the next decade seems unlikely.
Both the girls and the boys bathrooms were split in construction, with an assumed equal number of toilets on each side, but this was not confirmed by SJE. Also, only one side of each bathroom is currently in use; the other halves are used as storage space. No further information was gathered regarding these sides indicating future use or operational capacity.
The tank sizes are approximate, but are consistent to other toilets of the same design. No tank and bowl toilets were in operation, so no flush volume could be determined. The assumed flush volume is taken by consulting previous year's reports (Ernesto Engineering) and using a typical flush volume for the U.S. and a toilet in Bolivia at MCC. Two of the girl's toilets have an intact chain and one was flushed, but no specific flush volume was obtained during the flush test.

Appendix F:

Percolation Test Procedure

The following procedures were developed from the Arizona Department of Environmental Quality Engineering Bulletin 12, June 1989.

The percolation test procedure is as follows:

1. Prepare a test hole 15" diameter or 12" square. Remove smeared soil on sidewalls and clean all loose material on bottom. Provide gravel on the bottom to prevent scouring. Provide support for sidewall if required and adjust the calculations for displaced water.
2. Presoak test hole by filling the hole 12" deep with water. The time for all the water to seep away shall be measured. Repeat the procedure twice for a total of three readings. If readings are all less than 60 minutes then the long term presoaking procedure in step three may be skipped.
3. Long term presoaking shall be done on soils, generally clays, that do not meet the criteria set in step two. The water level in the test hole shall be maintained at 12" for a period of 4 hours. No further filling shall be done. The soil shall be allowed to swell for 16 to 30 hours.
4. Remove any soil that sloughed off into the bottom of the test hole. Refill the hole to a depth of 6" and measure the time until the water level drops to 5". Refill and repeat the test procedure at least two times and preferably until a stabilized percolation rate is attained (10% maximum difference in last 3 percolation rates). A spreadsheet is available to calculate the stabilized percolation rate from the data if it is not possible to continue the test until a stabilized rate is reached.

Along with the percolation test some soils information is required. A soil log shall be prepared for each disposal site. The log shall note depth in feet and soil type and characteristics. (EPA “Design Manual, Onsite Wastewater Treatment and Disposal Systems” contains a description for soil characteristics.) Rock content should be noted as above 50% if applicable. Groundwater or the potential for season groundwater shall be commented on. The following table provides terminology on particle size that should be used in descriptions for rock when it exceeds 10% of the soil content:

Type	Designation	Minimum Size (in)	Maximum Size (in)	Minimum Size (mm)	Maximum Size (mm)
Soil	Clay	---	0.000197	---	0.005
	Silt	0.000197	0.001970	0.005	0.050
	Sand	0.001970	0.078700	0.050	2.000
Rock	Gravel	0.08	3.94	2	100
	Cobble	3.94	9.84	100	250
	Boulder	9.84	---	250	---

If necessary a perforated 5 gallon bucket can be used in the percolation test hole in place of the gravel. The bucket should be inserted into the hole and pea gravel shall fill all voids between the bucket and the soil walls. The testing procedures will continue as normal.

Infiltration Rate = Drop in water level $\div$ time

IR=12.7cm $\div$ 24hrs=0.53cm/hr or 0.053mm/hr

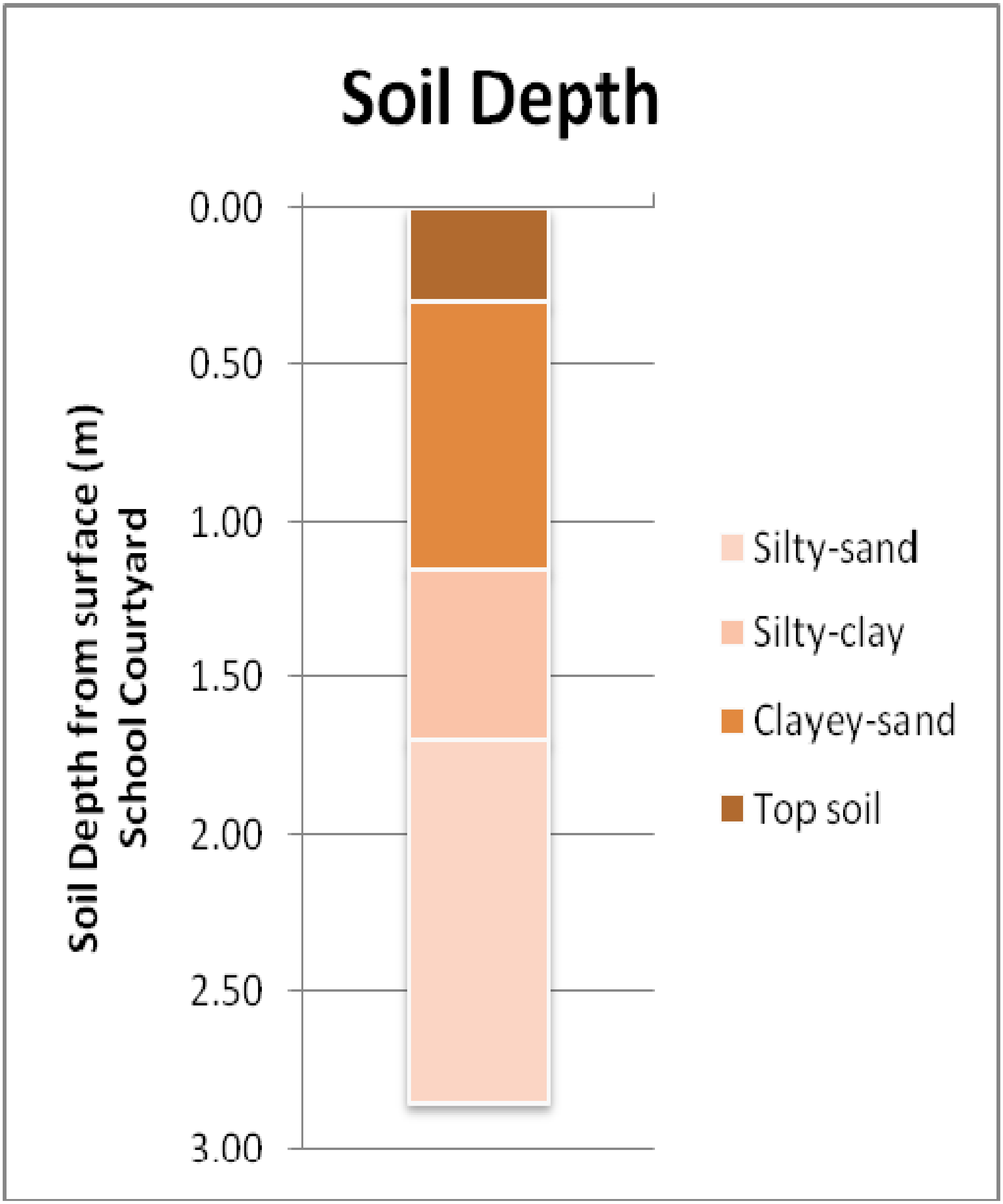
The infiltration rate of the soil within the courtyard of CLE is .053mm/hr.

Appendix G:

Soil Boring Log

And

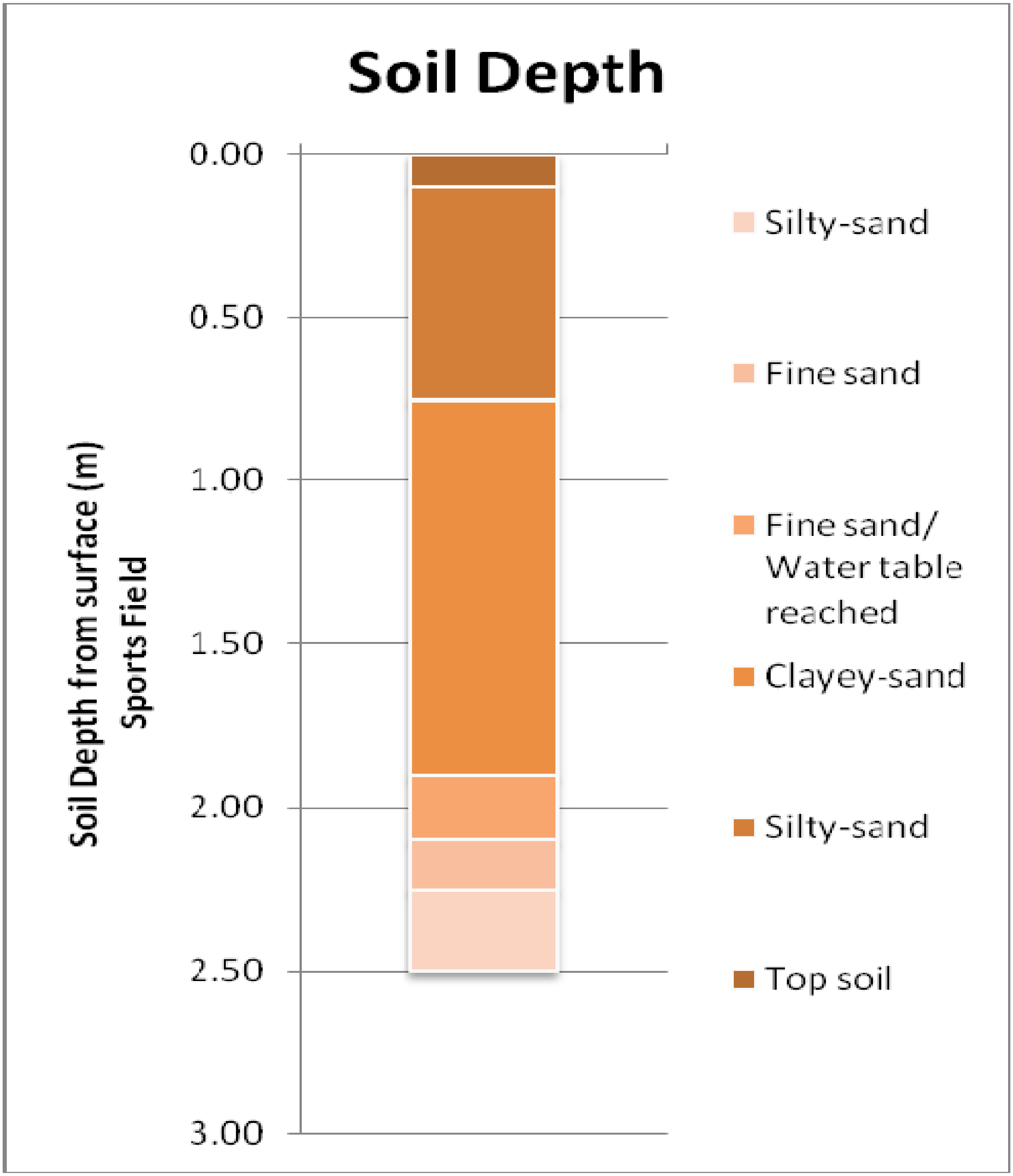
Soil Profile Drawing


Soil Depth
0.00
0.50
1.00
1.50
2.00
2.50
3.00
Soil Depth from surface (m)
School Courtyard
Silty-sand
Silty-clay
Clayey-sand
Top soil

Escuela San Luis Espinal Soil Boring from Courtyard	
Depth Range (meters)	**Soil Description**
0-0.3	Fill; topsoil, dk. Brown, silty sand, tr. Clay ith some gravel & brick; moist
0.3-0.5	Fill; black, sandy clay, tr. Trash & gravel; moist
0.5-0.68	Fill; black, sandy clay, tr. Silt, tr. Organics; moist; no scent of contamination
0.68-0.9	clayey sand, dk. Brown, tr. Organics; moist-wet; no scent of contamination
0.9-1.1	clayey sand, same as above
1.1-1.15	Same as above
1.15-1.2	silty clay, brown, tr. Sand, tr. Organics & gravel; moist-wet
1.2-1.3	Same as above, soft-med clay
1.3-1.4	same as above; soft
1.4-1.6	Reddish-brown; same as above
1.6-1.77	silty-sand, fine-med, tr. Clay, gravel, varved brown/gray sand, wet
1.77-1.9	same as above; tr. Organics, saturated
1.9-2.0	Same as above
2.0-2.3	silty sand, fine-coarse, brown, saturated
2.3-2.75	Same as above
End of Boring @ 2.75m	

1.7m	Water level during boring

May 19th	**Boring conducted by Ray's Well Drilling**
	Samples classified by Spam Jammel and Carlin Fitzgerald



Soil Depth
Soil Depth from surface (m)
Sports Field
0.00
0.50
1.00
1.50
2.00
2.50
3.00
Silty-sand
Fine sand
Fine sand/ Water table reached
Clayey-sand
Silty-sand
Top soil

Escuela San Luis Espinal Soil Boring from Soccer Field	
Depth Range (meters)	**Soil Description**
0.0-0.1	Topsoil
0.1-0.2	Silty-sand, fine to medium, tr. Organics, brown, moist
0.2-0.3	Same as above
0.3-0.45	Same as above
0.45-0.6	Same as above
0.6-0.75	Same as above; gray & brown, wet
0.75-0.9	clayey-sand, fine-med, tr. Silt, tr. Organics, wet
0.9-1.05	Same as above
1.05-1.25	Same as above
1.25-1.8	Same as above
1.8-1.9	Same as above; clayey-sand, brown to gray
1.9-2.1	Fine sand; Water table reached
2.1-2.25	fine sand, saturated
2.25-2.5	silty-sand, fine, brown, saturated
End of Boring @ 2.5m	
2.1m	Water level during boring
1.55m	Water level after boring
May 19th	**Boring conducted by Ray's Well Drilling**
	Samples classified by Spam Jammel and Carlin Fitzgerald

Appendix H:

Distribution Valve Information

K-RAIN ROTORS AND SPRAYS FOR RECLAIMED WATER

Worldwide regulations frequently require reclaimed water useage sites to use components identified with a purple cap or collar. K-rain manufactures an entire line of rotors, sprays and indexing valves to help you adhere to these rules.

The RCW series is designed specifically for use on reclaimed water systems. Flexibility in system design, achieved through a wide selection of nozzles, guarantees matched precipitation.

RCW models are available in the ProPlus and the K-Spray models. See relative pages for detailed specifications.

MODELS

K-RAIN K-SPRAY RCW SERIES

73001-RCW	3" Pop-Up
74001-RCW	4" Pop-Up
76001-RCW	6" Pop-Up
71201-RCW	12" Pop-Up

KRAIN PRO*PLUS* RCW

11003-RCW	Pro*Plus* for Reclaimed Water w/Low Angle Nozzle

FEATURES/BENEFITS

The ProPlus RCW Rotors

- Heavy Duty Rubber Cover (purple) – Protects against physical injury, positively identifies the use of reclaimed water reducing liability.

The K-Sprays

- Using a low angle nozzle ensures the correct trajetory of reclaimed water.

PRO*PLUS*™ RCW

Tough, proven and advanced, the PRO*PLUS*™ is the leader in it's class. *Set it and forget it.* Arc Memory Clutch returns the rotor to its preset position.

MODELS

4000-RCW Four Outlet Models	
4400-RCW	No Cam
4402-RCW	Cammed for 2 Zone Operation
4403-RCW	Cammed for 3 Zone Operation
4404-RCW	Cammed for 4 Zone Operation
4000-RCW Six Outlet Models	
4600-RCW	No Cam
4602-RCW	Cammed for 2 Zone Operation
4603-RCW	Cammed for 3 Zone Operation
4604-RCW	Cammed for 4 Zone Operation
4605-RCW	Cammed for 5 Zone Operation
4606-RCW	Cammed for 6 Zone Operation
6000-RCW Four Outlet Models	
6402-RCW	Cammed for 2 Zone Operation
6403-RCW	Cammed for 3 Zone Operation
6404-RCW	Cammed for 4 Zone Operation
6000-RCW Six Outlet Models	
6605-RCW	Cammed for 5 Zone Operation
6606-RCW	Cammed for 6 Zone Operation

FEATURES/BENEFITS

- Available in 4 and 6 Outlet Models–Can quickly and easily change from two to six watering zones.
- Simplicity of Design–Valves are easily maintained and serviced for long product life.

The 4000 RCW Indexing Valve

- ABS Polymer Construction–High-strength, non-corrosive body for long product life.
- Operates at Low 10 GPM at Pressures of 25-75 PSI– Reliably automates multiple zoned residential and small commercial wastewater systems.

The 6000 RCW Indexing Valve

- Metal Die-Cast Body–Durable, long lasting, and capable of high pressure applications.
- Operates at 15 GPM at Pressures of 25-150 PSI – Ideal for onsite pump-fed wastewater and effluent water applications.
- Built-in Atmospheric Vacuum Breaker–Releases any vacuum created between the pump and the valve on shut down.

6000-RCW INDEXING VALVE
The 6000 line of indexing valves offers exceptional reliability and durability even under the dirtiest water conditions.

4000-RCW INDEXING VALVE
The 4000 offers a reliable, economical way to automate multiple zoned residential and small commercial irrigation systems.

K-RAIN INDEXING VALVES FOR RECLAIMED WATER

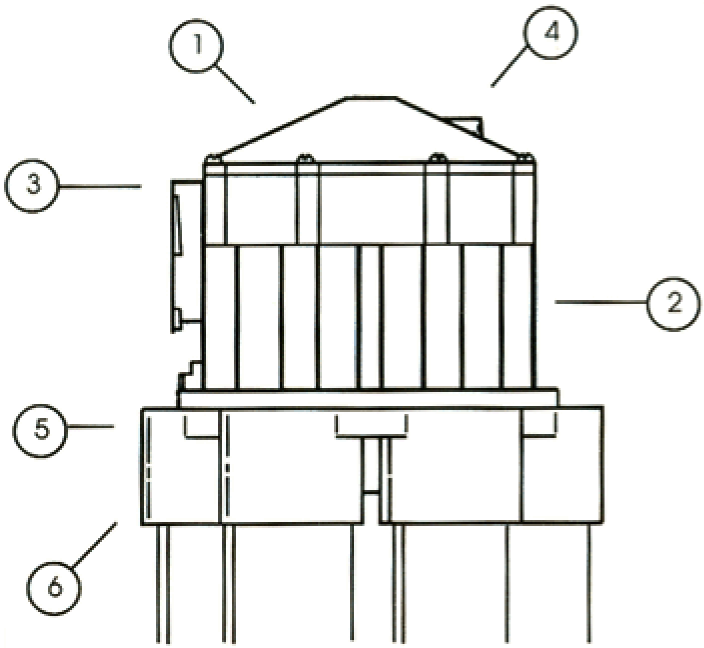
The 4000-RCW Indexing valve offers a reliable, economical way to automate multiple zoned residential and small commercial wastewater systems. The simplicity of design and a minimum of moving parts ensures ease of maintenance and long service life.

These patented valves allow for the number of watering zones to be changed quickly and easily. They are ideally suited for pump applications, onsite wastewater or effluent water applications.

The 6000-RCW Indexing valve offers exceptional reliability and durability even under the dirtiest water conditions. With a metal die-cast body, the 6000-RCW valves are capable of high pressure applications and are recommended to be used on pump fed systems. The 6000-RCW series is ideal for onsite wastewater and effluent water applications.

HYDROTEK® 6000

VALVE FUNCTIONS



1. Valve Top: A high strength metal die cast top which is secured to the valve body by eight stainless steel screws.

2. Valve Body: A high strength metal die cast housing.

3. Inlet: Female 1 ½" NPT inlet for connection to water source.

4. Vacuum Breaker Port: Used to prevent back-siphon of water to source.

5. Valve Bottom: High strength ABS plastic bottom which is secured to valve body with 6 stainless steel screws.

6. Outlets: Allows for slip and glue connection to 1 ½" PVC pipe.

CAM REPLACEMENT INSTRUCTIONS

Replacement cams are available to increase or decrease the number of outlets to be used on the HYDROTEK® 6000 Series Valve

6400 Series four outlet valves have interchangeable cams for two, three or four zone operation.

6600 series six outlet valves have interchangeable cams for five or six zone operation.

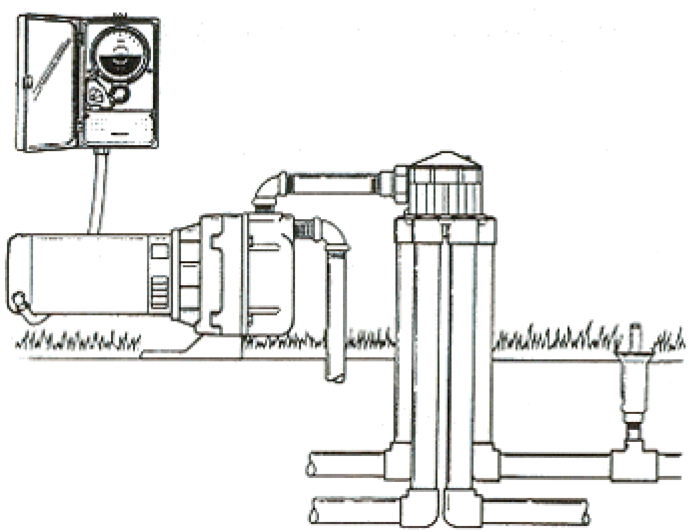
To replace cam,first remove valve top by removing eight valve top retaining screws. Remove two cam retaining screws which hold cam on the underside of the valve top.

Insert replacement cam into valve top, ensuring that the wide notch on cam is aligned with notch on valve top, and secure with two cam retaining screws.

Replace top, ensuring body seal is in place.

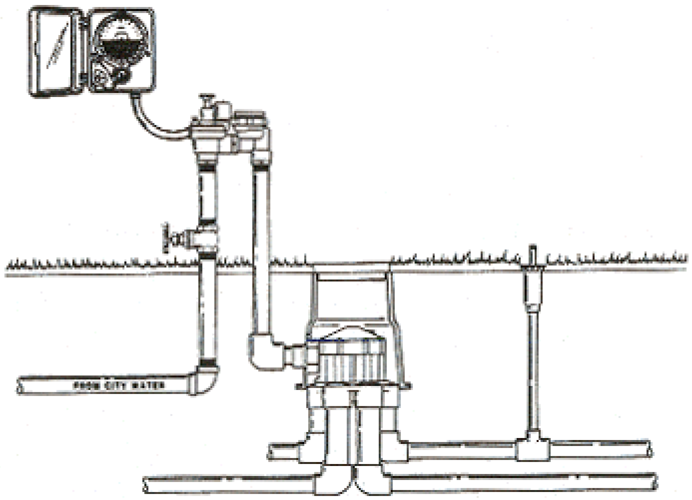
VALVE APPLICATIONS

Pump Fed application



For direct pump - fed installations, the HYDROTEK® 6000 Series Valve is directly connected to the discharge side of the pump and is cycled from one zone to the next by turning the pump off and on . Install the valve as close to the pump as possible and ensure suction line to the pump has a proper check valve installed and all joints are completely sealed.

In-line Valve Application



For high flow city water supplied installations using and in-line valve, ensure the HYDROTEK® Valve is installed as close to the in-line valve as possible. The 6000 Series Valve may be mounted below ground in a valve box (do not direct bury). Ensure backflow prevention is in compliance with local codes.

VALVE INSTALLATION

Prior to installation of HYDROTEK® 6000 Series Valve,make sure that the system is designed using adequate pipe sizes and control valves to ensure maximum performance of the valve.

For installation with large terrain elevations, or applications with high lift requirements such as overhead systems in greenhouses, the valve should be installed at the highest point in the system, or check-valves should be installed near the valve in the elevated lines to prevent the back-flow of water from the higher locations to the lower zones.

When connecting the lines to the valve outlets, ensure that the correct cam is installed. See diagram for proper zone hookup of outlets.

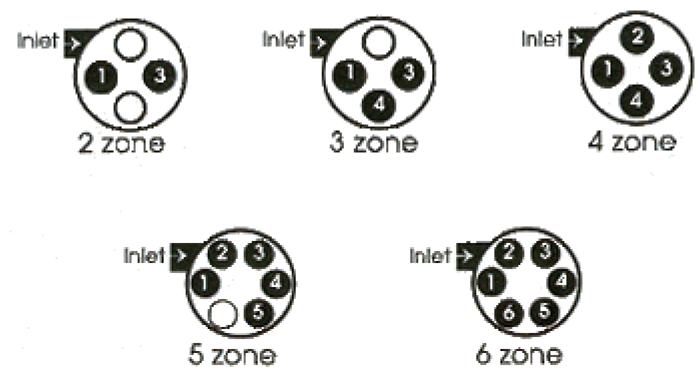
Do NOT turn the valve upside down when gluing the lines into the valve outlets. Glue may run down into the valve and interfere with valve operation. Allow glue to dry for at least two hours before operating or testing the valve. For best results, use a multi-purpose glue which is compatible with ABS plastic.

To seal off any unused outlets, install a piece of PVC pipe at least six inches in length to the outlet and cap the pipe .This will allow additional zones to be added easily at a later time.Make sure proper cam is installed for number of zones to be used.

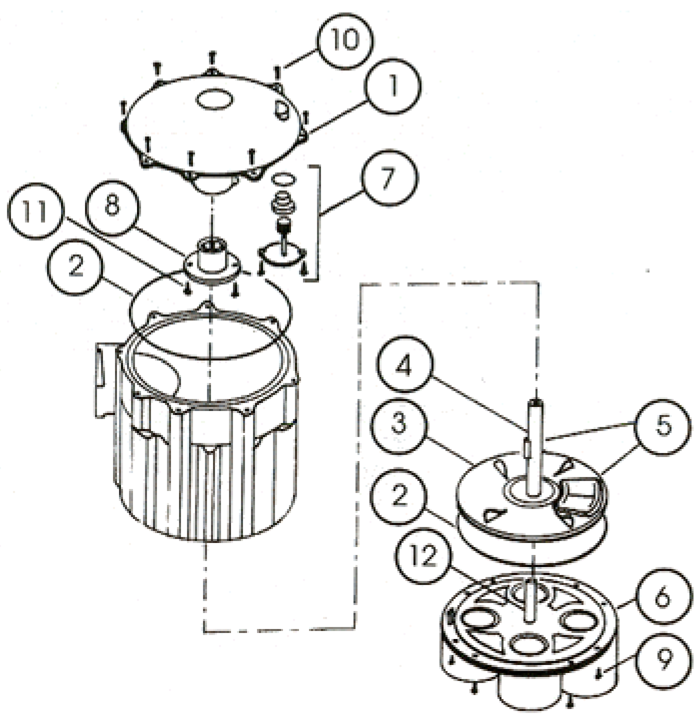
In regions of the country where winter temperatures may cause damage to exterior pipes, the HYDROTEK® 6000 Series Valve should be winterized. To protect the control valve and other irrigation components from damage, the entire system should be drained or cleared using compressed air. Contact your K-Rain dealer for information on the winterization requirements in your area.

Active Zone Diagram

Black dots indicate active outlets for cam being used



HYDROTEK® 6000 VALVE PARTS



1	4 Outlet valve top 6 Outlet valve top	8002804 8002806
2	Valve body seal	8600000
3	Rubber flap disk	8003000
4	Stem with .032 spring Stem with .028 spring	8004002 8004003
5	Stem/disk assy.with .032 spring Stem/disk assy.with .028 spring	8003050 8003051

6	4 Outlet valve bottom 6 Outlet valve bottom	8002704 8002706
7	Vacuum breaker assy.	8005001
8	Two zone, 4 outlet cam Three zone, 4 outlet cam Four zone, 4 outlet cam Five zone, 6 outlet cam Six zone, 6 outlet cam	8002902 8002903 8002904 8002905 8002906
9	Valve bottom screws (6) (10-24 x3/4 Phil Pan SS)	8004410
10	Valve top screws (8) (10-24 x5/8 Slt.phst SS)	8004412
11	Cam retaining screws (2) (6 x1/2 Phil Pan SS)	8004414
12	Valve bottom S.S Pin (1/4" dia.)	8600001

TROUBLESHOOTING

1. Problem: Valve Does Not Change or Cycle to Next Zone or Outlet

Cause: Debris or foreign objects preventing proper movement of stem and disk assembly.

Solution: Remove valve top and check for foreign objects. Clean build-up from walls of valve as necessary.

Solution: Check for freedom of movement of stem and disk assembly up and down over the center pin in bottom of valve. Scale deposits may build up on the pin and hold stem and disk assembly down. Clean pin and again check for freedom of movement.

Cause: Disk may have expanded and is rubbing against inside walls of body.

Solution: Replace disk and clean build-up from walls of valve as necessary.

Cause: Restriction of flow causing pressure in valve to build up, preventing valve from cycling.

Solution: Be sure that all operating outlets are not capped and that the flow to operating zones is not restricted in any manner.

Solution: The backflow of water from uphill lines may be preventing the valve from cycling properly. This can happen when the valve is placed too far below an elevated irrigation line. If the valve cannot be placed close to the high point of the system, a check valve should be installed near the valve in the outlet line that runs uphill from the valve.

2. Problem: Water Comes Out of all the Valve Outlets

Cause: Stem and disk assembly not seating properly on valve outlet.

Solution: Check for sufficient water flow . A minimum of 15 GPM is required to properly seat the disk.

Solution: Remove the valve top and clean the inside walls as necessary to ensure that nothing is interfering with the up and down movement of the stem and disk assembly inside the valve.

Solution: Make sure that the operating outlets are not capped and that the flow to the operating zones is not restricted in any manner.

Solution: Replace disk if necessary.

Cause: Too many sprinkler heads on a zone will cause insufficient pressure for disk to seat firmly over valve outlet.

Solution: Reduce the number of heads on the zone to obtain the proper sprinkler operating pressure.

3. Problem: Valve Skips Outlets or Zones.

Cause: For a pump installation, the pump may be losing its prime, causing the water flow to surge. This will cause the valve to cycle quickly several times, skipping one or more zones. Verify that the flow to the valve is constant by turning ON after having been OFF for at least 15 minutes. The flow should be steady and uninterrupted.

Solution: Seal any pump suction line leaks.

Solution: Replace or install suction line check valve to prevent pump from losing its prime.

Cause: The stem and disk assembly is being advanced past the desired outlet.

Solution: Ensure that the correct cam for the desired number of zones is installed and that the outlet lines are installed to the correct outlet ports of the valve.

TECHNICAL INFORMATION

Valve Top and Body Construction:	Die Cast Metal
Valve Bottom Construction:	ABS High Strength Plastic
Flow Range:	15-100 G.P.M
Inlet:	Threaded 1 1/2" NPT
Outlets:	Allows for 1 1/2" PVC pipe slip and glue connection

FLOW AND PRESSURE LOSS CHARACTERISTICS

6400 Series 4 Outlet Valve

FLOW (GPM)	15	20	30	40	50	60	70	80	90	100	110	120	130	140	150
PSI LOSS	2.0	2.5	3.0	3.5	4.0	5.0	6.0	7.5	9.0	10.0	10.5	11.0	12.0	12.5	13.0

6600 Series 6 Outlet Valve

FLOW (GPM)	15	20	30	40	50	60	70	80	90	100	110	120	130	140	150
PSI LOSS	2.0	3.0	3.5	4.0	5.0	6.0	7.5	9.0	10.0	11.0	11.5	12.0	12.5	13.0	14.0